STATEMENT OF MATERIAL FACTS AS TO WHICH A GENUINE ISSUE EXISTS

1. Issue #16 in this proceeding states:

> Applicant has not demonstrated that it can reliably generate emergency on-site power by relying on four Transamerica Delaval diesel generators, two for each of its Perry units.

2. TDI diesel engines have a history of failure; virtually every major engine component has experienced failure in nuclear, stationary non-nuclear, and marine service.

3. TDI has a faulty quality assurance program, by the assessment of both Applicants and Staff.

4. Nuclear facilities using TDI DGs to generate emergency on-site power are not in compliance with GDC 1 and GDC 17.

5. Applicants have joined the TDI Owners Group, which has a program purporting to ensure TDI DG reliability. The true purpose of the Owners Group is to gain NRC acceptance of the TDI DGs and not to determine the actual suitability of the DGs for nuclear service.

6. The NRC Staff has stated that the Owners Group Program contains the essential elements for compliance with GDC 1 and GDC 17; these elements are Phase I, review of the 16 known problems; Phase II, DR/QR; engine testing and inspection; and an enhanced maintenance and surveillance program. BN-84-152.

7. It will not be possible to determine whether the PNPP DGs are suitable for nuclear service until the results of the operational tests and inspections are available. This will not be until June 1985. See Exhibit 7.

8. Applicants are continuing to rely on TDI for technical

evaluations, which are of unknown accuracy and validity.

9. Applicants have not demonstrated that the crankshaft is suitable for nuclear service, in that they admit that it has a critical speed of 438 rpm, within 5% of the operating speed of 450 rpm; crankshaft adequacy has not been demonstrated by an evaluation of known conservatism, such as the rules of the marine Classification Societies, which consider many variables affecting crankshaft adequacy, including engine misfiring; the stresses produced by the 4th order critical are likely to be greater than those predicted by FaAA since they used ideal, best-case assumptions; and the adverse experience with TDI V-16 crankshafts indicates that they are vulnerable to failure.

10. Applicants have not demonstrated that the piston assemblies are suitable for nuclear service in that the Owners Group evaluation has not addressed adverse experience with piston crowns and rings; there is no assurance that the AE piston skirts will not experience stud boss cracking as has been observed in other skirt types; insufficient experience exists with AE skirts under the conditions existing in nuclear service to conclude that they will not fail; FaAA's analysis has assumed ideal conditions and has neglected the effects of piston side thrust and tin skirt plating; it has not been demonstrated that the AE skirts are defect-free; and the DR/QR Report has evaluated the AH skirt and not the AEskirt.

See Exhibit 29.

11. Applicants have not demonstrated that the cylinder heads are suitable for nuclear service in that they have an extensive history of failure; the heads were produced in a period in which Applicants admit there were poor manufacturing processes; a conservative analysis of the adequacy of the heads has not been performed; it has not been demonstrated that the heads are free of flaws, including subsurface flaws; the heads are of inadequate design and manufacture to withstand the loads to which the are subjected; cracked heads are very dangerous and can cause catastrophic failure; and leak detection the methods proposed by Applicants will not prevent damage caused by cylinder head water leaks. See Exhibit 33.

12. Applicants have not demonstrated that the connecting rods are suitable for nuclear service in that it has not been shown that the FaAA analysis was conservative, nor did it adequately address all the adverse operational experience; the FaAA analysis indicates that the rods are marginal; failures of 1-1/2 inch rods have occurred; and damage to the PNPP connecting rods, was observed (but not evaluated).

13. Applicants have not been demonstrated that the connecting rod bearing shells are suitable for nuclear service in that a complete and conservative analysis addressing all the adverse operational experience has not been performed; and Applicants have used as-is bearings exhibiting indications deemed rejectable by the Owners Group, but the bearings were accepted

by TDI and Applicants without further evaluation.

14. Applicants have not demonstrated that the engine base and bearing caps are suitable for nuclear service in that a conservative analysis addressing all the adverse operating experience has not been performed; and linear indications are present in the #5 bearing saddle; these indications have not been evaluated for cause, nor corrective actions taken.

15. Applicants have not demonstrated that the turbochargers are suitable for nuclear service in that operating experience and FaAA's analysis indicates that nozzle ring vane failure is likely; it has not been demonstrated that such failures will not cause damage to the turbocharger; FaAA's analysis has not addressed all the adverse operating experience; damage to the PNPP turbochargers has not been evaluated for root cause; the replacement turbochargers are likely to experience excessive vibration due to misalignment.

16. Applicants have not demonstrated that the cylinder blocks and liners are suitable for nuclear service in that FaAA's analysis, which may not be conservative, indicates that the blocks will crack due to an inherently defective design; FaAA's analysis has not addressed all the adverse operational experience; there is no evidence that the fatigue damage index methodology will accurately predict crack growth rates or that correct operational experience input will be used; it has not been demonstrated (and cannot be demonstrated with the sampling

technique employed) that the PNPP blocks do not contain substandard microstructure and properties; block cracks are very dangerous;

the reduction of liner proudness has not bee recommended by FaAA, and may lead to other problems, such as fretting or loss of crush; and it has not been demonstrated that the liner is able to resist side thrust forces. See Exhibit 54.

17. The DR/QR program relies heavily on the "lead engine" concept. This assumes that all V-16 engines are identical, and that favorable experience on the lead engines means that inspections and testing can be relaxed in the follow-on engines. As a result, only 11 of 171 components received a unique DR, and many components received no QR.

18. The "lead engine" concept depends on the assumption that there is consistent quality and design among engines. This assumption is false.

19. The DR/QR has not considered the most conservative standards and practices; for example, compliance with the ASME code is not considered mandatory; it is considered acceptable to wait for a marginal component to leak before upgrading it; some components have not been evaluated at all, when their failure in a seismic event could damage other components; the DR/QR has not considered the root cause of component failures, and has failed to ensure that components will not fail and adversely affect engine operation (e.g., intake and exhaust valves).

20. A potentially serious problem with the engine foundation chock plates has been ignored, when this problem has caused failures elsewhere and can cause excessive crankweb deflection, which can result in catastrophic crankshaft failure. It has not been demonstrated that TDI's evaluation of the problem is conservative.

21. Reliance upon 'successful' operation of lead engines as an indication of the reliability of PNPP engines is improper, as there is no evidence that these engines are of the same quality as the PNPP DGs.

22. To comply with PNL's criterion for operation to 1E7 cycles without failure, each of the Perry DGs should operate for 750 hours, in addition to the testing required by Reg. Guide 1.108.

EDO 14439

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

OFFICE OF THE
COMMISSIONER

May 18, 1984

EXHIBIT 1

MEMORANDUM FOR: WILLIAM J. DIRCKS

SUBJECT: GRAND GULF ELECTRICAL POWER SUPPLIES

Bill

I would like to know whether the electrical power supply systems at Grand Gulf meet General Design Criterion 17? Please provide an explanation. Please respond by Wednesday, May 23, 1984.

Victor Gilinsky

cc: Chairman Palladino
Commissioner Roberts
Commissioner Asselstine
Commissioner Bernthal
SECY

MAY 24 1984

Com Cor

MEMORANDUM FOR: Chairman Palladino
Commissioner Gilinsky
Commissioner Roberts
Commissioner Asselstine
Commissioner Bernthal

FROM: William J. Dircks
Executive Director for Operations

SUBJECT: GRAND GULF ELECTRICAL POWER SUPPLIES

In a memorandum dated May 18, 1984, Commissioner Gilinsky requested information concerning whether the electrical supply systems at Grand Gulf meet General Design Criterion 17. Following the Commission's guidance in the Shoreham proceeding, CLI-84-8 (May 16, 1984), the staff has concluded, on the basis of the problems associated with TDI diesel engines, that the onsite electrical supply systems at Grand Gulf do not meet GDC 17. Accordingly, Mississippi Power and Light had a meeting with staff on May 18, 1984 and was directed to submit a request for an exemption to GDC 17 for operation at power levels up to 5% full power, or at any higher power level it thought could be justified under Commission Shoreham decision of May 16, 1984. The Company responded that such a request would be submitted in about one week. The staff has had concerns about the reliability of the TDI diesel engines for some time, but has not taken action to suspend low-power operation at Grand Gulf because our safety evaluation has shown that the risk of such low-power operation is exceptionally small, and that the risk is not significantly increased by the total loss of the TDI diesel.

The current onsite power supply system at Grand Gulf in addition to two TDI diesels includes one EMD diesel dedicated to the high pressure core spray system and three gas turbines capable of producing a total of 6200 KW. The offsite power supply system consists of two 500 KV lines and one 115 KV line.

Prior to supporting plant operation above 5% of full power, the staff will require the TDI diesel generator issue to be appropriately addressed.

(Signed) William J. Dircks

William J. Dircks
Executive Director for Operations

50-416
50-417

cc: SECY
OPE
OGC

| Contact: | DL/LB#4* | DL/LB#4* | DL/AD/L* | OELD* | DIR/DL* | DIR/NRR& |
|---|---|---|---|---|---|---|
| DHouston, NRR | DHouston | EAdensam | TNovak | MEWagner | DEisenhut | HRDenton |
| 49-29358 | 5/22/84 | 5/22/84 | 5/22/84 | 5/22/84 | 5/22/84 | 5/22/84 |

| NRR/DSI* | EDO | (REVISED IN EDO PER E. CASE 5/23/84) |
|---|---|---|
| LRubenstein | WJDircks | *SEE PREVIOUS CONCURRENCE SHEET |
| 5/22/84 | 5/24/84 | |

EXHIBIT 2

WELDING

NR, 10-25-82 P039-1186
INADEQUATE SUPPORTS FOR DG PIPING ASSY; TDI ONLY TACK WELDED

NR, 11-17-82 P039-1260
DG PIPE SUPPORTS NOT COMPLETELY WELDED

NR, 6-15-82 P039-0734
DG AIR INTAKE SUPPORT CRADLES TACK WELDED ONLY

NR, 12-13-82 P039-1326
DAY TANK: MT CAN'T BE PERFORMED; VISUAL DEFECTS: WELD SPATTER, UNDERCUT, ARC STRIKES, LACK OF FUSION, SLAG

NR, 1-18-84 P039-2623
PIPE SPOOL HAS LACK OF FUSION & SUCK BACK ON 4 INCHES OF WELD; ID OF WELD ON ELBOW; FACTORY WELD BY VENDOR; FOUND WHEN PIPE WAS CUT & REWORKED PER ANOTHER NR

NR, 1-10-83 P039-1423
PIPE SUPPLIED BY TDI HAD PAINT ON ID AND UNDERCUT, OVERLAPPED WELDS; USED AS IS SINCE NONCODE; QUALITY OK FOR PURPOSE

NR, 1-17-84 P039-1605
INDICATIONS IN SEAM WELD MADE BY MANUFACTURER; POOR WORKMANSHIP; ENGINE TO LUBE OIL SUMP DRAIN

NR, 7-29-84 CQC-2554
POOR WORKMANSHIP ON DG SHROUD STUDS; POROSITY, UNDERCUT, LACK OF FUSION

NR, 12-1-83 CQC-3012
DG STUDS: INCOMPLETE WELDS; LACK OF FUSION; OVERLAP

NR, 1-25-84 CQC-3099
DAY TANKS, UNIT 2: WELD DEFECTS, OUT OF TOLERANCE FLANGES

NR, 12-13-78 CQC-1049
STARTING AIR RECEIVER: NO DOC & MATERIAL CERT; UNDERCUT ON NAMEPLATE INTO TANK

NR, 9-25-80 RECI-067
INCOMPLETE WELDS ON DG PIPE; PIPE FOR 2816 RETURNED AS OVERSHIPMENT; PIPE FOR 2815 REASSIGNED TO 2817; REWORKED

TOLERANCES

NR, 7-5-83 P039-1918
DG AUX PUMPS/ PIPING; TOLERANCES NOT OBTAINABLE; VENDOR SUPPLU PROBLEM

NR, 7-5-83 P039-1919
DG AUX SKID PUMPS/ PIPE; ALIGNMENT TOLERANCES ONT OBTAINABLE; VENDOR SUPPLY PROBLEM

NR, 1-25-84 CQC-3099
DAY TANKS, UNIT 2: WELD DEFECTS, OUT OF TOLERANCE FLANGES

NR, 1-23-84 P044-2641
CONNECTIONS FOR PIPE ON DG NOT ON DESIGNED LOCATIONS

NR, 7-7-82 P039-0887
INTERFERENCE WITH FLYWHEEL GUARDS AND BARRING DEVICES + 3 ENGINES NEEDED REWORK; 1 OK; TDI CHANGED DESIGN

NR, 1-6-83 P039-1401
SUPPORT ASSY TOO LONG

NR, 9-14-81 P039-0161
HOLES NOT DRILLED IN DG RAILS

NR, 4-30-80 GE39-0005
AIR TANK: DIMENSIONS DON'T CONFORM TO DRAWING

NR, 5-2-80 GE39-0008
AIR TANK: DIMENSIONS DON'T CONFORM TO DRAWING

NR, 10-26-81 P044-0223
FUEL TANK: PIPES NOT PLUMB, MISALIGNED

NR, 12-7-81 P044-0223, REV.1
FUEL TANK: 4 PROBLEMS WITH ALIGNMENT/TOLERANCES

NR, 12-9-81 P044-0223, REV. 2
4 PROBLEMS WITH FUEL TANK

NR, 11-3-83 P090-2462
LEVEL SWITCH FLOAT DIA. TOO LARGE

NR, 9-23-83 P039-2200
DAY TANK FLANGE WARPAGE DUE TO FACTORY WELDING

NR, 1-10-83 P039-1427
JW DRAIN PIPE FLANGE NOT PERPENDICULAR

NR, 1-26-83 P039-1471
PIPE TOO LONG

NE, 3-9-83 P039-1586
DG SKID MOUNTED TANKS DO NOT MEET DRAWING REQUIREMENTS

NR, 3-15-83 P039-1604
PIPE TOO LONG

NR, 8-19-83 P039-2089
LO SUMP VENT PIPE NOT LEVEL

NR, 8-5-83 P039-2036
DG CRANKCASE VENT FAN FLANGE NOT LEVEL

NR, 3-18-83 P039-1614
DG PIPE CAN'T BE INSTALLED; VENDOR SUPPLIED TACK WELDED PIPE; INC. DRAWING; TDI LETTER OF 6-17-82 **; ACCEPTANCE CRITERIA FOR TDI FABRICATIONS * ; TDI SPEC NO. 100-W-29

NR, 3-24-83 P039-1632
DG SKID MOUNTED TANKS OUT OF PLUMB

NR, 1-20-83 P039-1457
ENGINE SOLEPLATES: INSUFFICIENT BEARING, < 85%. USED AS IS; DEFLECTION CHECKS PRIOR TO STARTUP AND AFTER 20 HRS AND 168 HRS; TDI CALCULATIONS INDICATE OK; GE I&SE MET ALL ALIGNMENT REQUIREMENTS IN TDI VENDOR MANUAL; BEARING REQUIREMENT NOT SPECIFIED UNTIL AFTER GROUTING BY TDI REP. **

ALIGNMENT

NR, 12-22-82 P039-1329
FO BOOSTER PUMP-MOTOR ALIGNMENT: VENDOR DRILLED HOLES IN WRONG PLACES

NR, 10-25-82 P039-1189
DG TANKS: SKID LOCATIONS?

NR, 10-27-82 P039-1206
GENERATOR: ANCHOR BOLT HOLES MUST BE ELONGATED

NR, 11-9-82 P039-1241
JACKET WATER PIPE MISALIGNED; FLANGE NOT WELDED ON @ 90 DEGREES

NR, 11-18-82 P039-1261
PUMP MOTORS CANNOT BE ALIGNED; HOLES NOT DRILLED OR IN WRONG LOCATION

NR, 9-19-82 P039-1109
BOLT HOLES IN JW PUMP SKID DON'T MATCH

NR, 5-11-82 P039-0721
JW STANDPIPE: BOLTS WON'T FIT: HOLE ELONGATED

NR, 3-19-82 P039-0538
BOLT HOLES DON'T MATCH

NR, 12-13-82 P039-1325
DG SKID MOUNTED TANKS: NOT AT DESIGN LOCATIONS

NR, 1-6-83 P039-1402
PIPE FLANGE HOLES DON'T MATCH

NR, 10-6-81 P039-0190
DG AUX SKID: HOLES MISMATCHED

NR, 10-26-83 GE39-0352
FO DRIP RETURN PUMP: BOLT HOLES MISALIGNED

NR, 6-7-82 P044-0791
AIR FILTER: BOLT HOLES DON'T MATCH NUT POSITIONS

NR, 11-9-81 P044-246
EXHAUST SILENCERS OUT OF ALIGN. CENTERLINE OFF

NR, 10-12-83 P039-2246
DIESEL ENGINE: EXCESSIVE GAP BETWEEN BRACKETS; BOLT HOLES MISALIGNED

NR, 10-17-83 P039-2271
JW KEEPWARM PUMP: BOLT HOLES IN WRONG LOCATION; CODE PLATE UNDER BOLT

NR, 11-16-83 P039-2431
FO BOOSTER PUMP: CAN'T OBTAIN ALIGNMENT

NR, 1-18-84 P039-2624
FO PIPING: WON'T BOLT UP

NR, 1-12-83 P039-1432
LO KEEPWARM MOTOR-PUMP BOLT HOLES MISALIGNED

NR, 1-18-83 P039-1448
JW PIPE FLANGE NOT WELDED ON @ 90 DEG. TO PIPE CENTERLINE

NR, 1-18-83 P039-1449
AIR INTAKE CRADLES OUT OF POSITION

NR, 3-16-83 P039-1605
PIPE TOO LOW; COUPLING CAN'T BE INSTALLED

NR, 3-16-83 P039-1606
CATWALK SUPPORT: I BEAM INSTALLED 1' OFF LOCATION

NR, 5-17-83 P039-1786
DG AIR DRYER CAN'T BE INSTALLED

NR, 7-27-83 P039-1994
JW KEEPWARM PUMP MOTOR SPACERS CAN'T BE INSTALLED, HOLES MISALIGNED

NR, 4-25-83 P039-1719
DG TURBO DRAIN LINE CAN'T BE INSTALLED

NR, 7-19-83 P039-1954
STARTING AIR ELBOWS CONTACT CATWALKS

NR, 2-7-84 P039-2708
PIPE SUPPORT CAN'T BE INSTALLED, EXCESSIVE GAP, BOLT HOLE MISMATCH

DOCUMENTATION

NR, 9-24-82 P039-1081
NO MATERIAL CERT FOR TDI-SUPPLIED DG CODE FITTINGS

NR, 8-9-82 P039-0989
CODE DATA REPORT FOR JACKET WATER STAND PIPE OVERFLOW DRAIN MISSING; TDI SAID THAT DOCUMENTATION DIDN'T EXIST

NR, 11-19-82 P039-1267
JACKET WATER KEEP WARM PUMP: CODE DATA REPORT DISCREPANCIES: NON-EXISTANT MATERIAL GRADE LISTED; INSPECTOR SIGNED REPORT 4-6 MOS BEFORE INSPECTING PUMP **

NR, 10-14-81 P039-0203
CODE DATA REPORT MISSING FOR PIPE: TDI FAILED TO PROVIDE PAPERWORK

NR, 6-15-81 OPQC-0052
PUMPS & MOTORS: NO DOCUMENTATION RECEIVED

NR, 7-9-81 OPQC-057
ENGINE PARTS?? NO COI OR DOCUMENTATION RECEIVED

NR, 9-29-81 OPQC-1111
COI DIDN'T COVER ALL PARTS

NR, 9-30-81 OPQC-115
NO COI TO COVER ALL ITEMS ON PACKING LIST

NR, 10-26-81 OPQC-120
NO DOCUMENTATION FOR SPARE DG PARTS

NR, 12-23-81 OPQC-142
COI & COC DON'T SPECIFY EQUIP RECEIVED: DIESEL ENGINE PARTS

NR, 2-16-82 OPQC-166
INADEQUATE DOCUMENTATION FOR TC CABLE; 750' EXTRA SHIPPED; SHOULD HAVE BEEN FOR ENGINE 2817

NR, 7-22-82 OPQC-261
GASKETS: NO DOC PACKAGE OR COI; GAI PROVIDED A SPECIAL COI WAIVER FOR SMALL PARTS *

NR, 10-30-82 OPQC-310
NO COC FOR MISC HARDWARE

NR, 11-17-82 OPQC-331
NO COI OR COC

NR, 11-20-82 OPQC-333
WIRE: NO COI OR COC

NR 11-29-82 OPQC-337
NO COI OR COC

NR, 12-9-82 OPQC-346
NO COI OR COC FOR CURRENT TRANSFORMERS

NR, 1-20-83 OPQC-369
PRESSURE GAUGES: UNAPPROVED DOCUMENTATION; PQS ENGINEER TO REVIEW DOC TO AVOID NRS OF THIS TYPE

NR, 2-23-83 OPQC-391
GASKETS: NO COC OR COI; NO ID ON MATERIAL; PARTS SHIPPED DIRECTLY FROM SUBVENDOR AT CEI'S REQUEST FOR EXPEDITION OF DELIVERY; TDI TOLD TO REQUEST SPECIAL COI WAIVER *

NR, 12-13-78 CQC-1049
STARTING AIR RECEIVER: NO DOC & MATERIAL CERT; UNDERCUT ON NAMEPLATE INTO TANK

NR, 12-13-78 CQC-1050
STARTING AIR RECEIVER: NO DOC OR MATERIAL CERTS

NR, 12-14-78 CQC-1056
STARTING AIR RECEIVERS: NO TEST REPORTS & OTHER VENDOR CERTS

NR, 12-15-78 CQC-1057
AIR DRYERS: NO COI

NR, 1-9-79 CQC-1070
EXPANSION ?: NO COI; NR SUPERCEDED BY REV.1

NR, 1-5-79 CQC-1076
AIR FILTERS: NO COI

NR, 6-29-79 CQC-1237
DAY TANKS: NO MILL CERTS, NDE RECORDS, OR CODE DATA REPORTS

NR, 3-3-80 CQC-1613
BEARING: NO DOC PACKAGE; UNDERSIZED

NR, 7-23-79 CQC-1269
COMPRESSOR ACC: NO DOC RECEIVED

NR, 4-14-80 CQC-1640
GENERATOR: NO DOC

NR, 5-21-80 CQC-1672
ENGINE CONTROL PANELS, MOTORS, FANS, ETC.: NO DOCUMENTATION

NR, 6-23-80 CQC-1724
CONTROL & POWER PANEL(S): NO DOC PACKAGE OR COI

TRACEABILITY AND IDENTIFICATION

NR, 5-5-82 P039-0688
DG VALVES: CODE PLATES NOT MARKED WITH YEAR BUILT

NR, 4-12-82 P039-0603
DG BOLTING: MATERIAL SPEC; DOES NOT MEET SPEC; SCRAPPED

NR, 10-27-81 P039-0219
AIR DRYERS: TAG NOS. DON'T AGREE WITH CODE DATA REPORTS; TDI INCORRECTLY STAMPED CODE DATA REPORTS

NR, 10-28-81 P039-0235
AIR DRYERS: TAGS DON' AGREE WITH CODE DATA REPORTS

NR, 6-15-81 OPQC-0049
MOTORS & PUMPS: ID TAGS DON'T MATCH VENDOR PARTS LIST; TDI SAYS THAT THEY MAY BE INTERCHANGED

NR, 9-25-81 OPQC-107
AUX SUB BASES HAVE WRONG LUBE OIL FILTERS INSTALLED, BY TDI

NR, 7-16-82 OPQC-257
WRONG ID OF BEARING FOR DG ROTOR; TDI TOLD TO VERIFY THAT DOCUMENTATION IS CORRECT

NR, 2-23-83 OPQC-392
GASKETS: VENDOR FAILED TO TAG MATERIAL WITH ID NOS

NR, 11-7-80 CQC-1930
DG STATOR INCORRECTLY IDENTIFIED

NR, 5-14-82 P05-009
STARTING AIR COMPRESSOR; MPL NOS. ON TAGS DON'T MATCH DOCUMENTATION

NR, 9-25-80 RECI-059
INCORRECT MPLS ON COIS AND EQUIP TAGS

NR, 9-16-80 RECI-046
WRONG MPL NO. ON EXHAUST SILENCER

DEFECTIVE MATERIAL

NR, 10-22-82 P039-1167
JACKET WATER PIPE IS LAMINATED

NR, 9-16-82 P039-1073
INTERIOR OF PIPE PAINTED

NR, 11-30-83 GE39-0354
JACKET WATER PIPE HAD BASE METAL EXTRUSION MARK

NR, 10-13-83 P039-2257
DAY TANK: BASE METAL INDICATION

NR, 10-19-83 P039-2282
DAY TANK: INDICATION ON INSIDE SURFACE OF FLANGE, 1.5 INCHES LONG; BY RT ONLY

NR, 8-30-83 P039-2120
SLAG POCKET IN INTERIOR OF DAY TANK; FOUND DURING WELD REPAIRS

SHIPPING

NR, 5-21-81 PQC-0033
CORROSION ON DG PARTS; TDI TOLD TO PACK FOR WATER TIGHTNESS

NR, 10-1-81 PQC-113
DAY TANK LEVEL GAGE DAMAGED; TDI TO TAKE PRECAUTIONS IN SHIPPING

NR, 10-23-81 PQC-118
SUPPORT BRACE BENT; CAN'T TELL IF NONCONFORMING UNTIL INSTALLED

NR, 5-10-82 PQC-218
BARRING DEVICE FOUND DAMAGED; TDI NOTIFIED OF IMPROPER CRATING

NR, 9-21-78 CQC-928
ENGINE: OIL LEAK FOUND, HEX BOLTS SHEARED OFF; DAMAGE DURING RAIL SHIPMENT

NR, 9-26-78 CQC-930
ENGINE: STUDS SHEARED ON TEMPORARY OIL PAN COVER; OIL & WATER LEAKING; DAMAGE DURING RAIL SHIPMENT

NR, 3-2-79 CQC-1133
LUBE OIL COOLER: ANGLE IRON BENT; RETURNED TO TDI FOR REWORK

NR, 8-17-82 P039-1007
CRANKSHAFT THRUST CLEARANCE: DAMAGE TO DOWEL PIN IN SHIPPING; DG UNIT 1 NO 2

HANDLING

NR, 12-21-81 P039-0317
DAMAGED DG PIPE: TDI ASKED FOR ADDITIONAL SHIPPING PROTECTION

NR, 12-9-82 PQC-347
TRANSFORMERS ROUGHLY HANDLED

NR, 3-1-79 CQC-1071
JACKET WATER COOLER: DAMAGE DUE TO CHAINS; UNCLEAR WHO'S AT FAULT

NR, 3-2-79 CQC-1134
PLATFORM DAMAGED BY MISHANDLING; WHO'S FAULT UNCLEAR

NR, 3-13-79 CQC-1139
PIPES DAMAGED BY CHAINS; FAULT UNCLEAR

NR, 4-10-79 CQC-1143
FUEL OIL DRIP TANK: PIPE CONNECTION HAS DISTORTED FLANGE; FAULT UNCLEAR

NR, 6-29-79 CQC-1236
FUEL OIL DAY TANK: DAMAGE TO PAINT; FLANGE COVERS DAMAGED; HATCH COVER MISSING

NR, 3-24-80 CQC-1627
FUEL OIL DAY TANKS: RUSTED, WELDS SUSPECT DUE TO ROUGH HANDLING; TDI TOLD TO ASSURE BETTER PACKAGING

TDI QA

NR, 9-14-81 P039-0131
HOLES NOT DRILLED IN DG RAILS

NR, 10-12-81 P039-0197
KEEP WARM FILTERS: HANDWHEELS MISSING

NR, 10-21-81 P039-0211
JW COOLER BOLTS LOOSE; WOULD NEED ADJUSTMENT ANYWAY?

NR, 2-1-84 P039-2680
LO PIPE SUPPORT: MOUNTING PAD ON SUPPORT NOT WELDED BY VENDOR

NR, 2-1-84 P039-2694
JW PIPING SUPPORT PAD NOT WELDED ON SKID

NR, 1-10-83 P039-1422
HALF COUPLINGS NOT INSTALLED; LUBE OIL DRAIN PIPE

NR, 1-13-83 P039-1433
DG PIPING ASSY SUPPORTS INADEQUATE

NR, 8-12-83 TA5-0054
USE OF NONCLASS 1E CABLE; DAR 139

NR, 8-12-83 TA5-0053
USE OF FUSES TO ISOLATE NON IE RECORDER FROM CLASS 1E TRANSMITTER; DAR 138

NR, 2-15-83 P039-1530
DG AUX SKID PIPE SUPPORTS NOT BUILT TO ASME CODE; DAR 117

NR, 2-14-84 P039-1530, REV. 2
SKID PIPING NOT TO CODE?

NR, 2-14-84 P039-2737
DG PIPING NOT BUILT TO ASME CODE

GENERATOR

NR, 3-18-82 P033-530
BEARING JOURNAL: PITTING, FOREIGN SUBSTANCE

NR, 4-30-82 P033-685
RUST PITS ON ROTOR JOURNAL

NR, 6-1-82 P033-772
LIGHT SCRATCHES ON ROTOR

NR, 6-1-82 P033-773
NICKS ON ROTOR

NR, 6-7-82 P033-788
SCRATCHES & PITS IN BEARING

NR, 6-7-82 P033-789
NO BEARING INSTALLED; SHIPPED SEPARATELY BY TDI; 'NR SHOULDN'T HAVE BEEN WRITTEN

NR, 6-16-82 P033-818
SCRATCHES & FOREIGN MATERIAL FOUND ON ROTOR

NR, 6-17-82 P033-825
ROTOR SHAFT UNDERSIZED

CRANKSHAFT

NR, 9-21-83 P039-2191
CRANKSHAFT DEFLECTION ON UNIT 2, NO. 2 DG AT CYL #7, POS. 3 NOT WITHIN ACCEPTANCE CRITERIA, BUT MEETS TDI REQUIREMENTS

NR, 9-21-83 P039-2190
DG UNIT 1, # 1: CRANKSHAFT DEFLECTION NOT WITHIN LIMITS AT CYL # 6, POS. 3; BUT MEETS TDI REQUIREMENTS

QR Results
ATTACHMENT 4 p. 1 of 3

REPORT REQUESTED BY G.GAYTON

| | INIT ORG. | NR NO | REV | ITEM NAME | ITEM NUMBER | DESCRIPTION | ISSUE DATE | VERIFIED DATE |
|---|---|---|---|---|---|---|---|---|
| 086 | OQC | 01520 | 00 | CYL. LINER | 1R43C0001A | MATCH MARKS WERE NOT REALIGNED | 121284 | 12/26/84 |
| 086 | OQC | 01525 | 00 | TURBOCHAR. | 1R43C0001A | PROPER TORQUE INDETERMINATE | 121384 | 0/00/00 |
| NTS | OQC | 01536 | 00 | ROD BOLT | 1R43C0001A | CONNECTING ROD BOLT NUT FROZE | 121584 | 1/25/85 |
| NTS | OQC | 01537 | 00 | BEARING | 1R43C0001B | MAIN BEARING HAS SEVERAL GOUGES | 121284 | 0/00/00 |
| 086 | OQC | 01541 | 00 | PISTNSKRT | 1R43C0001B | PISTON SKIRT OUT OF ROUND | 121884 | 1/21/85 |
| NTS | OQC | 01543 | 00 | SUB-ASSY. | 2R43C0001B | SUBCOVER HAS HOLES DRILLED OFF LOCATION | 121884 | 0/00/00 |
| NTS | OQC | 01546 | 00 | JACKET WT | 1R46C0004 | IMPELLER RUBBING ON VOLUTE WEAR RING | 122084 | 1/25/85 |
| NTS | OQC | 01556 | 00 | BOLT HOLE | 1E22S0001 | INADEQUATE CLEARANCE | 122184 | 1/25/85 |
| NTS | OQC | 01558 | 00 | ROCKERARM | 1R43C001A | ROCKER ARM ADJUSTING SCREW CHIPPED | 122284 | 0/00/00 |
| NTS | OQC | 01559 | 00 | ROCKERARM | 1R43C001B | ROLL PIN ON INTAKE ROCKER ARM SPLIT | 122284 | 0/00/00 |
| NTS | OQC | 01560 | 00 | LUB OIL HT | 2R47D0004B | LUBE OIL HEATING ELEMENT DAMAGED | 122284 | 1/08/85 |
| 086 | OQC | 01566 | 00 | BAFF,ASSY. | 1R46A0003A | STAND PIPE BAFFLE PLATE W/ DMGD THREADS | 123084 | 0/00/00 |
| NTS | OQC | 01577 | 00 | EDUCATOR | 1R45D0001A | EDUCATOR TOO SHORT | 010385 | 1/05/85 |
| 086 | OQC | 01603 | 00 | CYL. HEAD | 1R43C0001B | FUEL INJECTOR HOLE DRILLED OFF CENTER | 010885 | 0/00/00 |
| 086 | OQC | 01604 | 00 | ROCKER ARM | 1R43 | BOLTS HAVE DAMAGED THREADS | 122084 | 0/00/00 |
| 086 | OQC | 01613 | 00 | DIESEL HD | 1R43C0001 | DELAVAL DIESEL HEAD WAS DROPPED | 010885 | 0/00/00 |
| 08 | OQC | 01614 | 00 | T-FITTING | 1R33P0054A | T-FITTING W/ LEAKAGE & THREAD DAMAGE | 010885 | 0/00/00 |
| N. | OQC | 01618 | 00 | TURBOCHARG | 1R43C0001A | T-CHARGE SENSING LINE HAS DMGD FITTINGS | 010585 | 0/00/00 |
| NTS | OQC | 01620 | 00 | CONROD BRG | | SPARE CONNECTION ROD BEARINGS DAMAGED | 122184 | 0/00/00 |
| 086 | OQC | 01632 | 00 | PIPESPOOL | 1R43C0001B | PIPE FLANGES MISALIGNED | 010985 | 0/00/00 |
| 086 | OQC | 01690 | 00 | FLANGE | 1R43C0001B | 5 CASTING PITS ON FACE OF FLANGE | 011885 | 0/00/00 |
| TS | OQC | 01750 | 00 | BELLOWS | 1R48 | TURBO CHARGER EXHAUST BELLOWS DAMAGED | 012885 | 0/00/00 |
| 44 | P044 | 04477 | 00 | PIPING | 1E22 | VENDOR SUPPLY PROBLEM W/ WELDED PIPE | 123184 | 0/00/00 |

TOTAL

EXHIBIT 3

OPEN NR'S FOR NONCONFORMANCE CODE

REPORT REQUESTED BY G.GAYTON

SPEC INIT ORG. NR NO ... ISSUE VERIFIED

QR Results
ATTACHMENT 4 p. 2 of 3

REPORT REQUESTED BY . . . AYTON

| CODE | SPEC | INIT ORG. | NR NO | REV | ITEM NAME | ITEM NUMBER | DESCRIPTION | ISSUE DATE | VERIFY DATE |
|---|---|---|---|---|---|---|---|---|---|
| 113 | 086 | OQC | 01448 | 01 | CON,RODS | 1R43 | ROD BOX THREADS,SLIGHT GALLING | 120284 | 0/00/ |
| 113 | 086 | OQC | 01449 | 00 | BEARINGS | 1R43C001A | CRACKS&LEAD PITTING IN BEARINGS | 120184 | 0/00/0 |
| 113 | 086 | OQC | 01450 | 00 | BEARINGS | 1R43C001B | BEARINGS REJ.DUE TO INDICATIONS | 120184 | 0/00/0 |
| 113 | 086 | OQC | 01454 | 00 | LINER BORE | 1E22S0001 | VENDOR SUPPLY PROBLEM | 112984 | 1/28/8 |
| 113 | 086039 | OQC | 01455 | 00 | FUEL PUMP | 1R45C0001B | INADEQUATE MAINTENANCE | 120284 | 1/18/8 |
| 113 | 086 | OQC | 01460 | 00 | BEARINGS | 1R43C001B | LINEAR INDICATIONS | 120484 | 12/08/8 |
| 113 | 086 | OQC | 01461 | 00 | BEARINGS | 1R43C001A | LINEAR INDICATIONS | 120484 | 12/08/8 |
| 113 | NTS | OQC | 01462 | 00 | PISTON PIN | 1R43C001A | CHIPPED CHRIME PLATING | 120384 | 0/00/0 |
| 113 | 086 | OQC | 01463 | 00 | DIESEL | 1R43C001A | LINE HAS A LEAK | 120384 | 0/00/0 |
| 113 | 086 | OQC | 01464 | 01 | SUB COVER | 1R43C001A | LINEAR INDICATIONS | 120484 | 0/00/0 |
| 113 | 086 | OQC | 01465 | 01 | SUB COVER | 1R43C001B | LINEAR INDICATIONS | 120484 | 0/00/0 |
| 113 | 086 | OQC | 01466 | 01 | TUBRO CHGR | 1R43C0001B | TURBO BASE PLATE DOES NOT ALIGN | 120484 | 0/00/0 |
| 113 | 086 | OQC | 01470 | 00 | BEARINGS | | CRACK LIKE INDICATIONS OR POROSITY | 120484 | 0/00/0 |
| 113 | 086 | OQC | 01485 | 00 | BEARINGS | 1R43C0001B | LINEAR INDICATIONS | 120684 | 12/08/8 |
| 113 | 086 | OQC | 01486 | 00 | BEARINGS | 1R43C0001A | LINEAR INDICATIONS | 120684 | 12/08/8 |
| 113 | 086 | OQC | 01487 | 00 | BEARING | 1R43C0001B | INDENTATIONS ON MATING SURFACE | 120684 | 0/00/ |
| [illegible] | 086 | OQC | 01491 | 00 | PISTON | 1R43C0001B | PITTING ON PISTON | 120884 | 0/00/ |
| 113 | 086 | OQC | 01492 | 00 | BEARING | 1R43C0001A | EXCESSIVE SCORING | 120984 | 0/00/ |
| 113 | NTS | OQC | 01498 | 00 | BEAR STUD | 1R43C0001A | GALLED THREAD ON BEARING STUD #3 MAIN | 121084 | 12/11/8 |
| 113 | NTS | OQC | 01500 | 00 | ROCKER | | ROLL PINHOLE REAMED OVERSIZE | 121184 | 0/00/0 |
| 113 | 086 | OQC | 01501 | 00 | ROCKER | | ROCKER ARM ASSEMBLY SWIVEL PADS GOUGED | 121184 | 0/00/0 |
| 113 | 086 | OQC | 01508 | 00 | CYL,LINER | 1R43C001A | CASTING DEFECT FOUND | 121184 | 1/28/8 |
| 113 | NTS | OQC | 01509 | 01 | SUB COVER | | LINEAR INDICATIONS | 121184 | 0/00/0 |
| 113 | 086 | OQC | 01512 | 01 | TURBO LFT | 1R43C0001B | TURBO MOUNTING BRACKET HOLES,OFFSET | 121184 | 1/14/8 |
| 113 | 086 | OQC | 01515 | 00 | CRANKSHAFT | 1R43C0001B | SCORRING ON CRANK SHAFT | 121284 | 1/28/8 |

/85

OPEN NR'S FOR NONCONFORMANCE CODE

REPORT REQUESTED BY G.CAYTON

REPORT REQUESTED BY G.GAYTO

QR Results
ATTACHMENT 4 p.3 of 3

| : | INIT ORG. | NR NO | REV | ITEM NAME | I.D. NUMBER | DESCRIPTION | ISSUE DATE | VERIFIED DATE |
|---|---|---|---|---|---|---|---|---|
| PPD | OQC | 01180 | 00 | CYL HEAD | 1R43C0001A | POOR HANDLING TECHNIQUES | 100984 | 11/13/84 |
| 086 | OQC | 01265 | 00 | ROCKEVARM | 1R43C001A&B | DAMAGE TO INTAKE AND EXHAUST | 102784 | 0/00/00 |
| NTS | OQC | 01268 | 00 | AIR START | 1R43C001A&B | LAPPING OF AIR START VALVES W/OUT PROC. | 102384 | 10/24/84 |
| NTS | OQC | 01318 | 00 | PISTON | 1R43C0001B | STUD & NUT DAMAGED | 110484 | 0/00/00 |
| NTS | OQC | 01345 | 00 | CON BOLT | MULTIPLE | EVIDENCE OF GALLING PRESENT | 111084 | 0/00/00 |
| 086 | OQC | 01354 | 00 | CONN.RODS | 1R43 | FRETTING ON RACK TEETH ON CONNECTING ROD | 111384 | 12/17/84 |
| 086 | OQC | 01356 | 00 | SUB COVER | 1R43C0001A | SUB COVER ASSY.HAS A CRACK | 111384 | 0/00/00 |
| NTS | OQC | 01357 | 00 | SUB COVER | 1R43C0001A | SUB COVER ASSY.CONTAIN REJECTABLE INDIC. | 111384 | 0/00/00 |
| NTS | OQC | 01382 | 00 | DIESEL | 1R43C0001A | SCORING &/OR GALLING ON CONN. ROD BEAR. | 112184 | 11/30/84 |
| 086 | OQC | 01383 | 00 | AIR START | MULTIPLE | FAILED REVAL.INSPECTION | 112484 | 11/30/84 |
| 086 | OQC | 01384 | 00 | SCREW | 1R47F0545A | SCREW BENT ON OIL REGULATOR | 112484 | 1/04/85 |
| 086 | OQC | 01385 | 00 | OIL RGLR. | 1R47F0545B | EXCESSIVE RUST AND CORROSION | 112484 | 0/00/00 |
| NTS | OQC | 01386 | 00 | OIL RGLTR. | 1R47F0546B | RUST AND SURFACE PITTING | 112484 | 0/00/00 |
| NTS | OQC | 01399 | 00 | TURBO | 1R43C001 | 8 RING BLADES W/SLIGHTLY BENT ENDS | 112684 | 0/00/00 |
| NTS | OQC | 01412 | 01 | TURBO | 1R43C001 | TURBO FAILED REVALIDATION INSPECTIONS | 112884 | 0/00/00 |
| NTS | OQC | 01413 | 00 | TURBO | 1R43C001 | TURBO FAILED REVALIDATION INSPECTIONS | 112884 | 0/00/00 |
| [illegible] | OQC | 01414 | 00 | TURBO | 1R43C001 | TURBO FAILED REVALIDATION INSPECTIONS | 112884 | 0/00/00 |
| [illegible] | OQC | 01417 | 00 | JOURNALS | 1R43C0001A | INDICATIONS EXCEED RECORDING THRESHOLD | 112984 | 1/28/85 |
| 086 | OQC | 01421 | 01 | TURBOCASE | 1R43C0001A | MOUNTING BASE HOLES,STRIPPED OUT | 112884 | 0/00/00 |
| NTS | OQC | 01422 | 00 | DIESEL | 1R43C001B | SCORING&GALLINE,DUE TO WEAR | 112384 | 12/06/84 |
| NTS | OQC | 01431 | 01 | SKIRTS | 1R43C001 | LINEAR INDICATIONS IN PISTON SKIRTS | 113084 | 0/00/00 |
| 086 | OQC | 01432 | 01 | ROCKER | 1R43C001B | EXHAUST ROCKER ARM SWIVEL PAD DAMAGED | 113084 | 0/00/00 |
| 086 | OQC | 01433 | 00 | CON ROD | 1R43C001A | CONNECTING ROD BOLTS GOULED,NUT FROZE | 113084 | 1/25/85 |
| NTS | OQC | 01434 | 00 | JKT.WATER | 1R46C004 | BEARING OIL HOLES FILLED,EXCESSIVE GROOV | 113084 | 0/00/00 |
| 086 | OQC | 01447 | 00 | SUB.COVER | 1R43C0001A | STUD PART NO.346 BROKEN OFF | 120284 | 1/14/85 |

NO. 1618

The Cleveland Electric Illuminating Company

DAR [illegible]

PA1501 ORIGINAL AS OF
Date 8/15/83 Int's KCK

# PERRY NUCLEAR POWER PLANT
# DEVIATION ANALYSIS REPORT

DATE 0 8 1 2 8 3

| AFFECTED ITEM/SYSTEM/ACTIVITY | LOCATION | QUANTITY |
|---|---|---|
| R43 System | Diesel Generator Bldg. | 4 |
| RESPONSIBLE ORGANIZATION | PROJ. NON-COMPLIANCE DOC. NO. | 10CFR21 NOTIFICATION REC'D. |
| PAQS | NR TAS 54 | ☑ NO ☐ YES (Attached) |

DESCRIPTION OF CONDITION Use of non-class 1E control power to operate control devices, and use of non-class 1E control components in the control circuits which provide control signals to the safety related building ventilation systems. An analysis by Gilbert Associates' Project Electrical Engineer postulates that failure of these circuits could adversely affect operation of the diesel generators.

PREPARED BY: [signature] CONCURRENCE: [signature] 8/12/83
NQAD GENERAL SUPERVISING ENGINEER/DATE

NUCLEAR ENGINEERING AND CONSTRUCTION DIVISION EVALUATION (RE: PA1501)

See attachment.

EXHIBIT 4

☒ FURTHER EVALUATION REQUIRED: CONDITION REPORTABLE

☐ FINAL EVALUATION; ☐ CONDITION REPORTABLE OR ☐ CONDITION NOT REPORTABLE

EVALUATION BY: E.C. Christiansen 8/16/83 CONCURRENCE: Frank P. Stead 8/16/83
NAME/DATE — NECD GEN. SUPERVISING ENGINEER/DATE

NUCLEAR QUALITY ASSURANCE EVALUATION ADDITIONAL COMMENTS ATTACHED ☐ YES OR ☑ NO

POTENTIAL SIGNIFICANT DEFICIENCY [10 CFR 50.55(e)] ☑ YES ☐ NO

POTENTIAL REPORTABLE DEFECT/NONCOMPLIANCE [10CFR21] ☐ YES ☑ NO

NQAD PARTICIPANT: Tom Swansiger 8/16/83 MANAGER, NQAD Cyril M. Shuster
NAME/DATE — NAME/DATE

FOLLOW UP ASSIGNED TO: Tom Swansiger 8/16/83
NAME OF INDIVIDUAL OR N/A

ATTACHMENT

DEVIATION ANALYSIS REPORT 139

The condition identified above was brought to the vendor's (Transamerica DeLaval Inc. (TDI)) attention via a September 30, 1982 correspondence, PY/SO-14036. A copy of that correspondence is attached. Since that submittal several other correspondences were transmitted between TDI, GAI and the Project Organization identifying the same condition. The transmittals requested an analysis of the circuits involved to determine if the condition as stated was in fact a design problem.

Because the final payment on the contract between TDI and CEI has been completed, additional funds have been requested by TDI before they will perform the circuit analysis. To resolve questions that require additional work since the completion of the contract, a task force was initiated in May. This task force is resolving commercial differences and technical questions to allow TDI to perform work such as the circuit analysis required in this condition. Since TDI has not completed a design review of the circuits in question, in response to our request, no significant deficiency has been reported to date.

A recent substantial backcharge was submitted to the vendor to cover other previously identified problems. Because of this event in our commercial relationship with TDI we now feel the cooperation between the parties may be difficult. Recognizing that we have experienced 10 DAR's in the last three years which were reportable and the most recent IE Information Notice on industry problem with diesel-generators (Ref. 83-51) we now feel it is necessary to report this condition with further evaluation required.

To our knowledge, TDI has not yet reported this item under 10 CFR part 21. We will notify them of our 50.55e report and continue to work with TDI on resolving all outstanding technical questions.

**Gilbert/Commonwealth** engineers and consultants

GILBERT ASSOCIATES, INC., P. O. Box 1498, Reading, PA 19603/Tel. 215-775-2600/Cable Gilasoc/Telex 836-431

RECEIVED
APR 30 1982
PNPP
DOCUMENT CONTROL

EXHIBIT 5

April 12, 1982

PY-VEN-3142-QA
INFORMATION

RECEIVED
APR 30 1982
PERRY PROJECT
QUALITY ENGINEERING

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

ATTN: Mr. Dick Boyer

Re: Perry Nuclear Power Plant
Units I & II
Purchase Order P-1152-K
Diesel Generators per SP-562

Dear Mr. Boyer:

Attached please find the report for the audit conducted at your facility on February 23-25, 1982. Due to the status of the work on this contract, no findings were issued; however, deficiencies found during the audit are noted in this report.

Should you have any questions concerning this, please call me.

Yours truly,

Dennis P. Weaver

Dennis P. Weaver
Program Engineer
Quality Assurance Divison

DPW:ama

cc: R.L. Farrell - w/
T.F. Swansiger - w/
P.B. Gudikunst - w/
J.W. Mehaffey - w/
F.J. Yurich - w/
NED-SP-562 - w/
H.F. Mayhew - w/
A. Lambacher - w/
T. Solomon - w/
A. Pusateri - w/
H.A. Manning - w/
Howard Wong - Delaval - w/
Geoff King - Delaval - w/
A.E. Nance - Delaval - w/

301 (010) 9.2 - w/
301 (010) .1 - w/

Name: DBoyer
File Code: 562
Toss
Reviewed: D Boyer
QUALITY ASSURANCE
DEPARTMENT

Gilbert Associates, Inc.
Quality Assurance Division

Manufacturing Audit
February 23-25, 1982

CLIENT: Cleveland Electric Illuminating Company

UNIT: Perry Nuclear Power Plant - Units I & II

AUDIT AREA AND DATE: Delaval, Engine and Compressor Division, February 23-25, 1982

AUDIT TEAM MEMBERS:
D.P. Weaver - GAI/QAD Program Engineer - Team Leader
A. Lambacher - CEI/QA Quality Engineer - Team Member
T. Solomon - CEI/QA Quality Engineer - Team Member

PERSONNEL CONTACTED:

| | |
|---|---|
| Lance R. Block | Q.E. Manager |
| R.E. Boyer | Q.A. Manager |
| Howard Wong | Project Manager |
| A.E. Nance | Quality Engineer |
| Albert Louie | Project Engineer |
| John Witt | Purchasing Manager |
| Geoff King | Product Engineer |
| Ken Kropf | Q.C. Supervisor |
| A. Marchus | Lead Receiving Inspector |

I. INTRODUCTION:

All equipment has been shipped to the site, but has not been assembled, and Delaval has been paid for the equipment. Since this is the case, no Action Requests or Corrective Action Requests were issued to Delaval. This report is not in the standard audit report format since it is felt that its purpose is better served as organized below. The results of this audit will not be used to effect a change in Delaval's QA Program, but to evaluate the program under which the CEI equipment was built. Follow-up action by Cleveland Electric Illuminating will be determined at a later date.

II. PURPOSE:

A. Determine Delaval's level of compliance with quality assurance requirements specification SP-706 in the areas of:

1. Design Control, particularly as related to Engineering preparation and review of:

1. Drawings

2. Specifications

3. Nonconformance's, and incorporation of nonconformances into design and manufacturing documents.

2. Procurement Document Control, primarily to verify that Delaval transmitted the CEI specification requirements to subvendors and that changes to procurement documents are controlled the same as the original document. In addition, Delaval's system for control of approved suppliers will be reviewed.

B. Verify corrective action implementation of AAR's 1 and 4 from Audit #2 conducted at Delaval on May 1-3, 1978.

C. Determine how Delaval controls the potential significant deficiencies identified to clients as required by 10CFR21.

D. Review indoctrination and training records for personnel who perform functions related to assuring the quality of the product.

E. Method of handling spare parts - Determine how Delaval verifies that spare parts are the same as the parts supplied under the original order.

III. CONTRACT HISTORY AND AUDIT BACKGROUND INFORMATION:

A. A Pre-Award Survey was conducted on September 3-4, 1975. Eleven findings were issued as a result of this audit. These are briefly described below:

1. Change order to purchase orders not being reviewed by Q.A.

2. No Qualified Supplier's List available in the Purchasing Department.

3. Obsolete drawing revision being used in manufacturing.

4. Corrective Action system was not being utilized. Corrective Action Requests are not answered and no follow-up system is in place.

5. Annual independent audit is not being performed.

6. The internal audit program is not being effectively implemented due to:

   a. No close-out of findings issued.

   b. Incomplete distribution of audit reports.

   c. No auditor training/qualification.

7. No follow-up of findings on supplier audits is performed.

8. Welder qualifications not being maintained.

9. Non-conforming material not being controlled.

10. Final piece inspection was not being performed as required by the manufacturing process sheet.

11. Equipment calibration is not current.

Response to all of the above findings was made by Delaval on September 10, 1975 and accepted by CEI on September 23, 1975.

A post-award conference was held at Delaval on April 27th and 28th, 1976. At this meeting, the Q.A. requirements of SP-706 were reviewed with Delaval personnel, the procedures to be submitted for approval were identified, and corrective action implementation as a result of pre-award survey findings was accomplished.

On November 9, 1977, a QA business meeting was held at Delaval because Delaval had fabricated and shipped equipment to the Perry site without receiving a GAI Certificate of Inspection.

On December 13, 1977, during inspection trip 010-03, three Audit Action Requests were written at Delaval which are summarized below:

AAR010-03-01 Manufacturing route sheet was revised without being reviewed.

AAR010-03-02 Vendor material test reports were not being used in the shop.

AAR010-03-03 Uncalibrated measuring equipment was being used in the shop.

On January 11, 1978, during inspection trip number 010-04, four Audit Requests were issued to Delaval as summarized below:

AAR010-04-04 The incorrect heat number was stamped on Engine Number One.

AAR010-04-05 Test equipment is not being calibrated and records are not being maintained.

AAR010-04-06 The drawing being used by production was not the latest revision. The current revision contained major revisions.

AAR010-04-07 Drawing in use on the floor had not been properly reviewed and approved.

On February 17, 1978, during inspection trip number 010-05, four Audit Action Requests were issued to Delaval as summarized below:

AAR010-05-01 Torque wrench not calibrated.

AAR010-05-02 E7018 weld rod was not controlled and properly stored. This same rod was later used by an unqualified Delaval welder.

AAR010-05-03 Delaval's QA Manual had been reviewed but not submitted to CEI for review. Inspection procedures were revised but not submitted to GAI for review.

AAR010-05-04 Management was not aware that only approved welders could perform welding.

On February 15, 1978, during inspection trip 010-06, Audit Action Request 010-06-01 was issued to Delaval because a hold point had been bypassed for inspection of a control panel.

On February 24, 1978, during inspection trip number 010-07, Audit Action Request AAR07-01 was issued to Delaval for widespread welding deficiencies present in ASME welds.

On February 28, 1978, GAI/QA issued CAR0240 to Delaval for failure to meet the requirements of SP-706 as evidenced by the repeated and widespread deficient conditions identified by the GAI/QA inspector.

On March 1, 1978, during inspection visit 010-08, Audit Action Request 010-08-01 was issued to Delaval for using uncalibrated measuring and test equipment.

On March 8, 1978, during inspection visit 010-09, three Audit Action Requests were issued to Delaval as summarized below:

AAR010-09-01 Weld rod was uncontrolled. Welder qualification was incorrect.

AAR010-09-02 Documentation not in accordance with SP-562 for PNPP identification.

AAR010-09-03 Unauthorized specification deviations on the generator and engine control panel.

On March 10, 1978 Cleveland Electric Illuminating Company issued Stop Work Notification No. V005 to Delaval due to the many outstanding non-conforming items identified by CAR 0240 and AAR's 010-09-01, 010-09-02, and 010-09-03.

On March 29, 1978, during inspection trip 010-10, three Audit Action Requests were issued to Delaval as summarized below:

AAR010-10-01 Continued welding over unprepared structural members and piping surfaces.

AAR010-10-02 Delaval failed to notify GAI/QA of Hold point inspection.

AAR010-10-03 Control Panel tested to an unapproved test procedure and prior to issuance of a release by GAI.

On April 3, 1978, during inspection trip 010-11, three Audit Action Requests were issued to Delaval as summarized below:

AAR010-11-01 Widespread welding deficiencies.

AAR010-11-02 Crankshaft had incorrect heat number identification stamp.

AAR010-11-03 Instrumentation used in torsional test not calibrated.

On May 1-3, 1978 an audit of Delaval was conducted by GAI/QA. Four Audit Action Requests were issued as summarized below:

AAR02-01 There is no system to assure that the design calculations have been approved prior to issuance of fabrication drawings.

AAR02-02 Calibration of measuring and test equipment is not being controlled.

AAR02-03 Personal tools are not maintained in accordance with a calibration program.

AAR02-04 No system exists to assure that obsolete drawings are not being used in the shop.

On May 4, 1978, during inspection trip number 010-13, five Audit Action Requests were issued to Delaval as summarized below:

AAR010-013-01 Welding deficiencies identified on ASME piping on the Engine 1, Unit 1 auxiliary skid.

AAR010-013-02 Welding deficiencies identified the Engine 1, Unit 1 auxiliary skids structural members.

AAR010-013-03 Welding deficiencies identified on the Engine 2, Unit 1 ASME Piping. Unauthorized weld repairs made.

AAR010-013-04 Welding deficiencies identified on the Engine 2, Unit 1 ASME Piping.

AAR010-013-05 Welding deficiencies identified on the Engine 2, Unit 1 auxiliary skid structural members.

On June 6, 1978, during inspection trip number 010-16, two Audit Action Requests wer issued to Delaval as summarized below:

AAR010-016-01 Uncontrolled E7018 weld electrode found on Engine 75052 where weld repairs had been made.

AAR010-016-02 Welding deficiencies noted on Engines 75051, 75052 and 75053.

On June 12, 1978, during inspection trip number 010-17, the GAI inspector identified more problems associated with welding. Delaval personnel could not identify which welding procedures had been used, the welding procedures were not included on the shop route sheet (traveler). No Audit Action Requests were written during this visit to document this because Delaval requested that the GAI inspector leave the shop and not return.

On 12/7/78, 1978, during inspection trip number 010-18, four Audit Action Requests were issued to Delaval as summarized below:

AAR010-018-01 No NDE performed on ASME Section III, Class 3 Pipe Category C and D for four diesel engines.

AAR010-018-02 No NDE performed on ASME Section III, Class 3 Storage Tanks.

AAR010-018-03 Inadequate visual inspection of ASME Section III welds. "Use-as-is" disposition by Delaval does not meet minimum ASME standards for "Use-as-is."

AAR01-018-04 Delaval unable to determine if radiographic requirements of welds were met.

At this point, several inspection trips were made to Delaval to review final documentation packages. Many deficiencies in the documentation were found, however Audit Action Requests were not written.

Upon receipt of the material at the job site, problems with identification were found consistently. Much correspondence was generated regarding this problem, and several trips by Delaval and site personnel were made to attempt to resolve the problem. A multitude of site nonconformances were generated regarding identification, painting, welding and documentation problems. The number of the nonconformances is to great to list them individually in this report.

A problem was identified with the anchor bolts for the generator termination cabinet which is described in PY-GAI/VEN-2162-QA, dated 10/23/79, from J.C. Rovansek to R.A. Pratt. This was a result of the failure of Delaval to incorporate subvendor equipment changes into the design drawings and seismic calculations. During investigation of this problem GAI determined that Delaval had not submitted revised drawings to GAI Engineering and had not incorporated comments made to drawings during previous GAI review.

CEI began making preparations for assembly of the equipment from Delaval in 1981, however several problems were incurred which held up progress:

1. Delaval had not supplied assembly drawings and procedures as required by the following sections of SP-562:

   a. "Section 1:09.7 Instruction Books and Spare Parts Lists

      (1.) ... Instruction books shall include but no necessarily be limited to:

         a. Installation instructions.
         b. Start-up procedures.
         c. Operation, including schematic diagrams.
         d. Dissassembly and assembly procedures.
         e. Outline drawing.
         f. Assembly drawing.
         g. Maintenance.
         h. Calibration procedures.

      (2.) Instruction books are not considered design manuals, and if any descrepancies between the successful bidders drawings and instruction books, or items omitted from the drawings which are contained in the instruction books cause the installation to be different from the instruction book recommendations, the successful bidder shall amend the instruction books or modify the installation at his own expense, whichever is deemed by the OWNER as giving the most proper and operative final installation.

(3.) The successful bidder shall modify any standard instruction book sections to agree with the engineered product and its installation. Tabular data shall be marked to identify the model supplied. When assembly, alignment, and/or erection is required in the field, the successful bidder shall furnish procedures and instructions for this work.

b. Section 2:15.3

"The VENDOR shall provide all special installation and assembly instructions. These instructions shall be part of the instruction books."

2. The documentation supplied by Delaval was insufficient, incorrect or improperly identified in many cases. These deficiencies were identified on PNPP site nonconformance reports.

3. Insufficient quantities of items were supplied by Delaval. A Delaval Service Representative went to the site in August, 1981 to survey the equipment. As a result of this, several items were re-ordered. In addition, items which had been improperly prepared for shipment and had received damage in transit from Delaval were reviewed. Recommendations for repair were made by the Service Representative.

4. A large part of the equipment was incorrectly identified. An extensive tagging system had been devised to facilitate ease of installation of the equipment at the site. This system was deemed useless as a result of the marking.

5. Most of the site nonconformances which required a response by Delaval had not been answered.

A meeting was held at Delaval on December 7-10, 1981 to attempt to resolve the above problems. The minutes of this meeting are contained in PY-SO/562-9967, dated 12/15/81 from A.P. Pusateri to Howard Wong.

Delaval has notified the Nuclear Regulatory Commission of several potential significant deficiencies in accordance with 10CFR Part 21. In one of these, Delaval was unable to determine whether there was a deficiency or not, since it depended on the final location of a piece of equipment on the engine. GAI/QA questioned Delaval concerning the maintenance of as-built drawings, or whether the engine was constructed and inspected in accordance with an assembly drawing. There response was that although there is a basic assembly drawing, no two engines are alike, and many items are shop-fit or field-fit. No record of this type of layout change is kept. No determination is made by Engineering or Quality Assurance as to the effect of shop changes on equipment performance, seismic analyses, etc.

As a result of the items described above and the past performance of Delaval on this contract; it was described that an audit of Delaval was deemed necessary to determine the adequacy of their QA program, basically in the areas of Design Control, Procurement of Safety Related Equipment and Nonconformance Control.

Summary - The audit was hampered initially by a lack of organization with Delaval personnel. The Project Manager did not have the required personnel available as requested in the agenda. The Project Engineer refused to be contacted by the audit team until convinced by the Plant Manager that this was necessary. Also, unfortunately, the first day of the audit coincided with the arrival of the Boodmobile at Delaval, which added confusion to the situation, since personnel were continually called away from the audit.

During the course of the audit, many areas were touched upon by the audit team which were outside the original purpose of the audit. The information obtained thus is reported in the section which was being investigated.

Throughout the course of the audit, when documentation presented by Delaval was insufficient in meeting the specification requirements, the audit team informed the Delaval representative of this. The Delaval representative stated in each case that the documentation supplied to the audit team was all that was in existence.

Cleveland Electric Illuminating Company (CEI) specification SP-562, Section 2:01 states, in-part, "This specification sets forth the essential information required by the VENDOR (Delaval, Inc.) for the design, fabrication, testing, documentation and delivery of four complete, Class 1E diesel generator units, as defined by IEEE Standard 308." Section 2:14 of SP-562, titled "Quality Assurance" states, "The equipment to be provided under this Specification is to be designed, fabricated, analyzed, tested and documented under Quality Assurance Requirements as given by attached Specifications SP-706-4549-00 and SP-750-4549-00."

Delavals design is divided into two groups, one for items manufactured at Delaval, and one for "Memo III" items, or items which are purchased from subvendors. The Engineering Department Operating Procedures and Division Standard Practices provide the design control. The Engine Specification is prepared by the Product Engineer for parts manufactured at Delaval. Purchased Material Specifications are prepared by the Project Engineer for Memo III items. No documented evidence exists for the review of either of these items against the CEI specification or the therein referenced codes and standards. No documentation of independent design verification exists. Nor are there controlled procedures for performing design or design review. The procedures in the Engineering Operating Procedures Manual and Division Standard Practices Manual are primarily administrative instruction. One exception is Engineering Operating Procedure #3 which describes the engineering of ASME Section III, Class 3 equipment. However nothing addresses the remaining safety related equipment. Personnel interviewed had only a vague knowledge of the requirements contained in the above manuals. Many errors were noted in the manuals concerning controlled distribution and incorporation of procedure revisions.

Documentation of review of design changes did not exist; through interviews with the Project Engineer and Project Engineer, it was determined that none is performed.

No attempt is made to assure that revisions to parts drawings are incorporated into the manufacturing process sheets.

There is no system in place to assure that revisions to Purchased Material Specifications are incorporated into purchase orders, and there is no documented review of change orders prior to issuance. Procurement records indicated that purchasing personnel had authorized changes in the technical content of the specifications without review and approval by the Project Engineer and incorporation into the purchase order.

There is no effective program for assuring the Delaval's subvendors have a quality assurance program which meets the requirements of SP-706. Vendors are entered on Delaval's Approved Suppliers List by completing and returning to Delaval a one page questionnaire. Completing the questionnaire again after a specified time period requalifies them for continued supply of safety-related parts. Occasionally, a Delaval inspector performs a survey at a vendor's plant. Two of these surveys were performed in 1981. The audit team reviewed these two surveys and found them to be incomplete.

The Approved Suppliers List is divided into three sections: ASME Code suppliers, non-Code safety related suppliers, and non-Code, non-safety related suppliers. Purchase orders (not changes to purchase orders) are reviewed by Quality Assurance prior to issuance, however, the Quality Engineer stated that the purchase order does not indicate whether the parts are ASME code, safety-related, or non safety-related.

Two findings were issued during the May, 1978 audit performed at Delaval in the area of Design Control. Corrective action had not been implemented as a result of either finding.

Several potential significant deficiencies have been identified to the Nuclear Regulatory Commission by Delaval under 10CFR21. The audit team determined that Delaval has no established procedure for reporting and tracking items reportable under 10CFR21.

Indoctrination and training records for personnel in engineering where reviewed. No documented evidence of the indoctrination of personnel to Division standards, CEI specification requirements or Q.A. Manual requirements were available.

When an order for spare parts is received by Delaval, they simply initiate a requisition for parts to the shop or vendors by the referenced part number. The part many actually be produced to a later revision of a drawing or specification, since this is not indicated. No documented review is performed to verify that the part is equivalent to the one originally supplied.

In summary, the audit team feels that the quality assurance program in effect at the time work was performed for CEI and the one presently in place at Delaval does not meet the requirements contained in SP-562 and SP-706. Even if the program described in the Q.A. Manual was effectively implemented it would not meet the requirements of SP-562. The attitude towards quality assurance is one of tolerance, not support. It is evident from review of the contract history presented above that this has been the case since the contracts' inception.

AUDIT DETAILS

A. Design Control

Delaval's method of procedurally controlling design and design review was investigated. Engineering procedures are contained in the "Division Standard Practices" (DSP) manual and the "Engineering Operating Procedures" (EOP) manual.

The following are the sections related to Engineering in the Division Standard Practices Manual:

Section 4.001 - Establishing New Engine and Compressor Ratings

Section 4.101 - Engineering Department Absorption Procedure

Section 4.202 - Engineering Change Procedure

Section 4.203 - Shippable Bill of Materials Procedure

The following are the sections in the Engineering Operating Procedures Manual:

1. Communications and Responsibilities
2. Red Lining of Drawings
3. ASME Section III, Class 3 Equipment
4. Analysis by the Design Group
5. Analysis by the Piping Group
6. Analysis by the Applied Mechanics Group
7. Engineering Releases and Revisions
8. Shippable Bill of Materials

Both the Division Standard Practices Manual and the Engineering Operating Procedures Manual are intended to be controlled documents. A controlled distribution list for the DSP Manual could not be located, nor is a receipt of acknowledgement system used.

The DSP Manual in the possession of Geoff King was reviewed for correctness. The Table of Contents requires that obsolete revisions of DSP's must be destroyed. This manual contained DSP4.101, dated 9/15/69, which is obsolete. The Table of Contents does not give the revision level for the procedures, so it was not possible to determine the current revision level. DSP4.201 was still in the manual, although DSP4.202 specifically states that it supercedes DSP4.201.

The Engineering Operating Procedures manuals assigned to Lance Block (#3) and G.E. Trussel - Chief Engineer (#28) were reviewed. Manual #23 was still assigned to Lance Block and maintained in Engineering although he no longer works in that department. The index dated 12/14/78 says that the index should be dated 11/11/75 and consist of pages A1 through A15. In actuality, the section consisted of:

| PAGE | DATE | PAGE | DATE | PAGE | DATE |
|---|---|---|---|---|---|
| A1 | 4/20/81 | A17 | 3/17/78 | A33 | NOT IN BOOK |
| A2 | 4/20/81 | A18 | 3/17/78 | A34 | NOT IN BOOK |
| A3 | 4/20/81 | A19 | 3/17/78 | A35 | NOT IN BOOK |
| A4 | 4/20/81 | A20 | 3/17/78 | A36 | 11/11/80 |
| A5 | 4/20/81 | A21 | 4/19/78 | A37 | 11/11/80 |
| A6 | 4/20/81 | A22 | 4/20/78 | A38 | 11/11/80 |
| A7 | 4/20/81 | A23 | 4/20/78 | A39 | 11/11/80 |
| A8 | 4/20/81 | A24 | 4/20/78 | | |
| A9 | 4/20/81 | A25 | 4/20/81 | | |
| A10 | 4/20/81 | A26 | 4/20/81 | | |
| A11 | 4/20/81 | A27 | NOT IN BOOK | | |
| A12 | 4/20/81 | A28 | NOT IN BOOK | | |
| A13 | NOT IN BOOK | A29 | NOT IN BOOK | | |
| A14 | NOT IN BOOK | A30 | NOT IN BOOK | | |
| A15 | NOT IN BOOK | A31 | NOT IN BOOK | | |
| A16 | 4/15/81 | A32 | NOT IN BOOK | | |

Section B, "Drafting Room Practices"; of the EOP Manual has an index dated 5/25/70, however, the index gives no revision level or issusance date, nor does it list all the pages in Section B.

The Control List for the "Engineering Standards Books" (apparently the Engineering Operating Procedures manual) lists #23 as being assigned to Kirk, Engineering, 4/23/73; however, the manual itself was assigned to Lance Block, who no longer works in Engineering. The Control List does not include any method for assuring issuance of or acknowledged receipt of the EOP manuals.

Based on the above evidence and interviews and the Product Engineering Manager and the Project Engineer, it is obvious that the design control procedures available at Delaval are not working documents, nor are the personnel familiar with the documents.

The Engineering Operating Procedures manual provides instructions for analysis by the Design group, Piping Group and the Applied Mechanics Group. However, no instructions are available to govern the work performed by the Project Engineer and the Product Engineer. The procedure "Communication and Responsibilities", although primarily an administrative in nature, does require certain design control functions to be performed and documented by the Project Engineer. No records that these functions had been performed could be found by the Project Engineer. For example, the minutes of the Engineering Pre-Release Meeting, and documentation of his verification of contractual design requirements could not be found. Also, this procedure states that the Project Engineer is responsible for designing the auxiliary piping systems and transmitting the resulting schematics to Product Engineering. No evidence of this having been accomplished could be found.

The indoctrination and training records for Engineering personnel were reviewed. The records indicated that a one-hour training session had been held during which all of the following subjects were covered:

1. Delaval ASME Q.A. Manual
2. 10CFR21
3. Welding Procedures
4. IEEE 323-1974
5. IEEE 344-1975
6. NUREG 0588

There is no evidence of training or indoctrination in customer requirements, Delaval standards, Engineering standards, ANSI standards or 10CFR50, Appendix B.

A report on a training session on Quality Assurance, a copy of which is attached, was presented to the audit team. This session was attended by the Chief Engineer on January 23, 1981 and indicates the attitude Delaval personnel have concerning Quality Assurance.

The audit team performed a review of Delavals internal audit program in the area of Design Control for the past three years. The concern in this area is that the Product Engineer stated that there was no recall system for obsolete prints, although the internal audits indicated that there was a recall system. Question #17 appeared on the internal audit dated 3/21/80 as follows, "Are obsolete specifications and drawings systematically recalled from point of use and distribution?" This was answered, "Accept-Depending on status of change." The audit team expressed a concern that items were being fabricated to obsolete drawings after a significant change had been made.

It was also noted that no deficiencies had been found in the area of design control in the past three years. The next internal audit is scheduled for March, 1983.

Two findings in the area of Design Control had been issued during a manufacturing audit conducted in May, 1978. Following are the observations and responses.

AAR02-01

Observation: No documented system assures that design calculations have been completed and reviewed before Design Engineering issues drawings for fabrication of ASME Section III items or systems.

Delaval Response: Engineering procedures now provide for a summary report to be delivered to the Manager of Design Engineering prior to releasing equipment for manufacture.

AAR02-04

Observation: No documented system or procedure exists to assure obsolete drawings or procedures are destroyed when revised drawings or procedures are issued to the shop for fabrication.

Delaval Response: Each issuing sub-division now maintains distribution lists for instructions and drawings. When revisions to instructions and drawings occur, instructions to destroy obsolete documents will accompany distribution.

The audit team questioned the Product Engineer, Project Engineer, and Quality Engineer concerning implementation of the response to these findings. None of them had any knowledge of these corrective actions being implemented, nor any knowledge of forthcoming procedural changes.

The audit team reviewed Delaval's method for processing design document changes. Delaval Q.A. Manual, Section 3.4.1 references Engineering Procedure #7 for instructions. This procedure provides administrative instructions to be followed in processing a revision. This procedure does not contain requirements for reviewing changes for impact or items already manufactured or tested.

Upon receipt of an order for diesel engines, Delaval prepares an Engine Specification for each engine. This Engine Specification is just a list of the part numbers which make up the engine. The drawing number is listed for the parts, however, the revision of the drawing is not listed. When a drawing is revised, no change is made on the Engine Specification. The Product Engineer reviews part drawing changes for impact on past and present engine orders. This review is performed based on his memory of the requirements of old orders. The audit team expressed the concern that it seems unlikely that one person's memory can be complete enough to include review against many different customs and code requirements for performance materials seismics design, etc.

When a order is received for spare parts by Delaval, the Engine Specification for the original order is reviewed. The Product Engineer takes the part number and drawing number off of the Engine Specification. However, there is no way to determine what revision of that drawing the original part was manufactured to.

Delaval's Engineering Operating Procedure #2, "Red Lining of Drawings" contains instructions for making shop changes by fabrication personnel, which must be authorized by the Product Engineer prior to use. Changes such as these can be made without review by the original design group or a change in the title block on the drawing indicating that a revision had been made. There is no system to assure that changes such as these are incorporated into the final design and do receive the proper review. The Product Engineer stated that a shop change similar to this is what led to the potential significant deficiency concerning the lube oil system governor location.

The method by which Purchased Material Specifications are prepared and transmitted to the vendor was reviewed with the Project Engineer. Purchased Material Specifications are prepared by the Project Engineer for components to be supplied by vendors. These are to include Delaval design requirements, customer specification requirements, code requirements and Q.A. requirements. No independent review of these documents is performed by Engineering to assure inclusion of all of the above requirements. The Quality Engineer provides the input to the Project Engineer for the Q.A. requirements section of the specification. Revisions to the Purchased Material Specification are handled in the same manner and are transmitted to Purchasing and Quality Assurance by Engineering memo. The audit team expressed a concern that these documents received no technical review prior to issuance. Several Purchased Material Specifications were cursorily reviewed at this time. It was noted on one that ASME pressure-retaining part had been specified incorrectly as ASME A325, instead of ASME SA-325. The Specification for a shut-off valve, part number 75051-154 invokes ASME Code Case 1717 and ASME Code Edition 1974 with addenda of Winter 1976. SP-562 does not allow use of this Code Case and the specified Code Addenda is not as stated above.

The following Purchased Material Specifications were picked at random in order to verify through Purchasing that all the applicable requirements had been properly transmitted to the vendors.

| Purchased Material Specification | Revision | Item | Purchase Order |
|---|---|---|---|
| 75051-107 | G | Air Dryer | 62637 |
| 75051-115 | D | Lube Oil Heat Exchanger | 62640 |
| 75051-117 | L | Jacket Water Keep Warm Pump | 62642 |
| 75051-124 | B | Fuel Oil Drip Return Pump | 62638 |

The files in the Purchasing Department were made available to the audit team. The Quality Engineer and Purchasing Manager stated that these were the complete files for each of the above purchase orders. The contractual history of each Purchased Material Specification was reviewed with the following results.

75051-107

The Purchased Material Specification was included in purchase order 62637, dated 9/24/76. Hold and Witness Points and testing requirements were identified.

Seven revisions to this Purchased Material Specification were made during the course of the contract, none of which were contractually incorporated into the purchase order. Each of the revisions had been sent to the vendor for review only.

Review of the purchase order was indicated by the Quality Engineer's initials on the first page. No indication of review was found on change orders.

75051-115

Purchase Order 62640 was issued including revision A of the Purchased Material Specification to Thermxchanger. A letter was sent to Thermxchanger on 10/14/76 sending revision B for review for cost impact only. This revision was never included in the purchase order. Revisions C and D were never sent to Thermxchanger. Revision C changed the Quality Control documentation requirements. Revision D changed the "Construction" section requirements.

75051-117

Purchase Order 62642 was issued to Buffalo Forge with Purchased Material Specification revision B. Revisions C, H, J, and K were transmitted to Buffalo Forge for review only, and were not imposed contractually. In addition Revision M was sent to Buffalo Forge, although Engineering only had record of revisions through L.

A Delaval memo was on this file from C. Hermann (Delaval Buyer) to R. Pratt and Al Louie (both Delaval Engineering) dated 5/2/79 informing them that he had authorized Buffalo Forge to work to the summer, 1978 addenda of the ASME Code for sections NF1110, NF1111 and NF1112. A letter from C. Hermann to W. Maslowsky (Buffalo Forge), dated 3/7/79 authorized this.

A letter was also in the file from Hartdegen (Buffalo Forge) to Guntrum (Delaval) dated 6/2/78 which requested use of tubing which met the ASME 1977 Edition, winter 1977 Addenda in lieu of the 1974 Edition, winter 1975 Addenda as required in the CEI specification.

75051-124

Purchase Order 62638 was issued on 10/14/76. The checklist for codes and standards in the Purchased Material Requisition did not have 10CFR50, appendix B checked. One revision to the Purchased Material Specification was made but not incorporated into the purchase order.

The above evidence indicates that the design and quality assurance requirements of SP-562 were not accurately transmitted to Delaval's subvendors. Lack of control is evident in that Purchased Material Specifications received no design review, and some were found to be inaccurate in a cursory review, Purchased Material Specifications were not transmitted to the vendors when amended, and it is unlikely that Receipt Inspection reviewed the equipment to the same revision it was manufactured to.

None of the Purchased Material Specifications reviewed contained ASME Certification Sheets or Design Specification Data Sheets.

Due to this lack of control, Delaval would be unable to assure that spare parts which had been supplied by subvendors would be manufactured to the same requirements as the original parts.

## B. PROCUREMENT CONTROL

The audit team reviewed Delaval's vendor qualification program. The Approved Suppliers List is maintained in accordance with Delaval procedure ASL-1. This procedure provides for three groups of suppliers: ASME Code items, non-ASME safety related items, and non-ASME non-safety related items. Each list contains the following information for each vendor:

1. Vendors name
2. Rating
3. Next audit date
4. Equipment supplied
5. Last purchase date
6. Q.A. Programs committed to
7. Comments

The vendor rating system is based on the subjective rating of receipt inspections over the previous six months on a 1-10 scale. A rating of less than 7.5 results in removal of the vendor from the Approved Suppliers List.

In order to be placed on the Approved Suppliers List, a prospective vendor completes the "short form" (P-268) questionnaire. On this form are several commercial questions and also a space for the vendor to check off which criteria of 10CFR50, Appendix B his Q.A. Program meets. The completed form is reviewed by Delaval and the vendor is placed on the Approved Suppliers List. When the vendor must be requalified to remain on the ASL, this short form is mailed to them to be completed again. Occasionally, a "long form" survey is performed when it is convenient for a Delaval inspector to do this while in the vendors shop. The Quality Engineer stated that two "long form" audits and 16 "short form" audits were performed in 1981. He also stated that these surveys were not performed regularly due to budget cuts.

Vendors removed from the ASL are placed on the "Exceptions" list. However, material can be procured from vendors on the "Exceptions" list after completion of the form "Qualified Suppliers List Waiver to QSL Exceptions List."

The ASL is issued every six months, however, changes to the ASL are made almost daily. Therefore, the only copy which is current is the one maintained in Quality Assurance. Purchase Orders (not change orders) are approved by Q.A. prior to issuance. This is signified by the Quality Engineers' or clerks' initials on the purchase order. The Quality Engineer stated that when a review is performed, they do not know if the purchase order is for parts which are ASME Code, safety related, or non-safety related.

The following vendors on the Approved Suppliers list were reviewed:

ASME Code Suppliers

Buffalo Forge

Non-ASME Code, Safety Related Suppliers

3 - D Instruments, Inc.
Acipco Steel Production

Non-ASME Code, Non-Safety Related Suppliers

Ecodyne/MRM Division

All vendors had receipt inspection ratings above the minimum 7.5 required. All, except Ecodyne, were scheduled to have the "short form" questionnaire submitted to them in 1982 or 1984, while the last purchases to be placed with any of these vendors was in 1980 or 1981.

When problems are identified during receipt inspection an audit is performed, using a standard checklist form (F-324). This checklist provides for "Yes", "No" or "Not Applicable" answers, with space provided for comments. Several audits were reviewed with the following observations:

William Powell Co. - January 24th & 25th, 1977

No findings were issued, but in examining the checklist it was determined that the area of "In-process Control and Inspection" was checked as inadequate. The checklist did not provide for documenting objective evidence and it was not indicated what corrective action, if any, was to be taken by Wm. Powell Co. As indicated above, Powell was listed as an approved supplier in 1981.

Elwood City Forge - January 29, 1976

No findings were issued during the audit, however the following sections of the checklist indicated that certain inadequacies in the Q.A. Program existed:

Section II, "Quality Control System and Procedures"; question b - Is the Q.C. System derived from a quality specification such as:

ASME Section III

10CFR50, Appendix B (AEC 18 criteria)

Other

This quesiton is checked "No"

Section XIV; "Audits"

"a. Are there written provisions for planned and periodic audits?"

This was answered "No".

"b. Do procedures provide for:

Checklists
Training of audit personnel
Reports
Correction Action"

This was answered "No".

Section XII, "Special Processes"

"a. List of Special Processes"

Heat Treatment

"b. Are gauges calibrated?"

This was answered "Yes".

"c. Are records maintained?"

This was answered "No".

"d. Are personnel and equipment certified?"

This was answered "No" and "Not Applicable".

Section VIII, "NDE Methods"

"a. List of NDE Methods"

UT, MP, LP

"b. Are procedures used?"

This was answered "Yes".

"c. Are NDE personnel qualified to SNT-TC-1A?"

This was answered "Yes, with?"

"d. Are personnel records, resumes and qualification records of NDE personnel on file?"

This was answered "No".

"e. Are records of NDE maintained?"

This was answered "No."

Parsons Peebles - E.P. Clarkstone - September 30, 1981

No findings were issued as a result of this audit. The audit checklist was not completed in all areas. The checklist indicates that the position of "Head of Quality Control" was "Vacant at this time". The Quality Engineer indicated that an analyst was performing his duties. Section X, Drawing and Change Control, was not completed. The section on "Audits" was completed and a "Yes" checkmark indicated that there were written provisions for internal and external audits. However, the Quality Engineer stated that this was not the case. Also, "Yes" was checked to indicate that audit checklists, personnel training, written reports and corrective action systems were implemented. The Quality Engineer stated that this was not done either. This deficiency was identified during the 12/7/77 audit.

C. NONCONFORMANCE CONTROL

Several potential significant deficiencies have been identified to the Cleveland Electric Illuminating Company as required by 10CFR21. Delaval could not present a reporting procedure for this to the audit team. Also, Delaval has no formal tracking system for these deficiencies.

Shop nonconformances are documented on Inspection Reports, which are reviewed by the Product Engineer and Quality Control Supervisor.

The repair instructions, if applicable, are also included on the Inspection Report. However, when special processes are included in the instructions, no procedure and revision is referenced.

Shop routers for the following parts were reviewed and associated deficiencies found:

| Part | Pt. No. | Dwg. Rev. | Job | Comments |
|---|---|---|---|---|
| Skirt (Two Piece Piston) | 03-341-02-AM | J | 53198 | Operation #120 - Inspection - Not performed |
| Modular Iron Casting | 03-341-02-AM | J | 51771 | Operation #120 - Inspection - Not performed |
| Crankshaft | 02-310-07-AA | A | 54141 | Operation #50 - UT - Not stamped MT - Not stamped |

The router for the crankshaft had the Drawing Revision crossed out and changed in ink, without no formal review and approval of the router revision. Also, the crankshaft router did not indicate any NDE procedures or revisions. The Quality Control Supervisor did not know how this information was transmitted to the shop.

Ultrasonic Test Report #659 was reviewed for UT of part #02-310-08-AE, an RV-16 crankshaft. The UT procedure stated "ASTM A503" (not a Delaval procedure) and the acceptance standard stated "D-4774". No indications were found. The NDE inspector was "Wm. G. Rowe, Level II", however the "Reviewed by" section was not completed.

It was also noted, while in the shop, that many special processes were not required to be performed to approved procedures.

D. RECEIPT INSPECTION OF SPARE PARTS

The process of receiving parts at Delaval does not have special provisions for spare parts.

The Delaval system for receiving parts is as follows:

1. All parts come to receiving inspection with a packing slip attached. Safety related items, or as Delaval calls them, control items, are color coded to indicate special handling.

2. Receiving inspection reviews ASL print-out for Vendor name and part number then calls Quality Engineering to review and stamp paperwork to indicate compliance to purchase order requirements and to assign trace number.

3. Receiving then forwards material to be identified with trace number as indicated by the Quality Engineer.

4. Upon the return of the material from being identified, Receiving Inspection then performs the inspection by sample plan and verifies trace number, then records information on Vendor Cards. These serve as a vendor inspection reports that list Vendor name and quantity accepted and rejected.

5. Prior to sending parts to stores the receiving inspector lead man records part number, purchase order number, trace number and quantity on the daily inspection stock record. He then forwards the packing slip and receiving report to Purchasing for placement on the computerized inventory control record.

6. Receiving inspector then makes out a move ticket to send parts to controlled storage.

After the review of this process no problems or concerns can be found.

Prepared by: Dennis P. Weaver
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Program Engineer
Quality Assurance Division

Reviewed by: Frank J. Yurich
Frank J. Yurich
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Transamerica
Delaval

# MEMO

Transamerica Delaval Inc
Engine and Compressor Division

INTER-OFFICE CORRESPONDENCE

To: Bud Trussell

Date: January 23, 1981

From: M.H. Lowrey

Subject: Trip/Training Report - Technical Seminars Inc - Dallas, Texas

Introduction: On 1/18/81 Dick Pratt and I went to Dallas, Tex. to attend a Seminar entitled "Quality Assurance & Auditing of Nuclear Power Plants", presented by Marc Bresseler of TVA, and Bill Gibbons of Nutech. Both are highly code qualified; both serve in high places on the Boiler & Pressure Vessel Committees of ASME. Mr. Bresseler seemed to be more field and materials oriented, with a strong "real world" interpretation, while Mr. Gibbons was a bona fide member of the Q.A. empire. I was extremely underwhelmed by the pure Q.A. aspects for the sake of paper. However, I learned several things about the code as it affects design and quality. I will elaborate, hoping this results in action and not merely a report for the training file.

A: Why Section III Class 3 for our system, the major part of which cannot be built to the code - ie - the engine?

I gathered from the presentations that the ASME B & PV code, initially written to keep people from getting killed by exploding boilers, is in fact, the ONLY code which receives worldwide acceptance in professional and governmental circles. It is embraced as Law in 38 States and the Federal Government. It is the quality verification by third parties in this code which makes it unique as opposed to the ANSI B-31 Codes. The Blizzard of paper required to infuse an air of responsibility into design, builder, inspector and owner is a sad commentary on the state of american craftsmanship and business and technical ethics. Because of the above, I don't think there's much chance of my non-section III/3 systems flying in the ANS Code I have written.

B: How can we control Design?

The intent of the code is to establish documented checks and reviews in the design of a system. The initiating document is the owners design specs. (content outline of which is attached) which I have never seen in this form yet. Note that a "design" in the eyes of ASME is

Transamerica Delaval

# MEMO

Transamerica Delaval Inc
Engine and Compressor Division

INTER-OFFICE CORRESPONDENCE

To: Bud Trussell

Date: January 23, 1981

Page: 2

From: M. Lowrey

Subject: Trip/Training Report - Technical Seminars
Inc - Dallas, Texas

a set of detailed drawings depicting parts and assemblies, the configuration of which is supported by a "design report", which are calculations assuring that the owner's spec. and the provisions of the code with respect to stresses, are met. Nowhere are layouts or parts lists addressed as parts of a "design". Complete "designs" must be reviewed by an independant reviewer who may not be the designer's supervisor (NRC Ruling).

Complete "designs" may be separated into parts and reviewed thusly, ie , drawings can be reviewed independantly, and the stress report can also be reviewed so, but by people without direct payroll-type vested interest in the result. As I see it, we could do this as follows:

1. A design engineer prepares a layout, which is transmitted (after illegal review) by me to Pratt, who causes details and Isometrics to be made and checked. (not reviewed)

2. Pratt or me transmitts these details to Roland, who causes one of his men to analyze it, stresswise, per the provisions of the code. This man thereby is forced to become familiar with the geometry, materials, and stresses inherent in the system.

3. When the calculations are done, Roland's other man, familiar with the calculation procedure, can legally review the stress report and the drawings. This man can legally sign documents verifying the adequacy of the total design with respect to both the code, and the owner's spec. Nowhere is it said he must be familiar with the operational suitability of the system. The code does not address operational parameters as the ANS codes do.

4. If the design report certifier, i.e. one of Roland's men, is not a P.E., then the stress analysis cannot take advantage of ASME allowable stress multipliers i.e., it must be analyzed as "Service Level A". If allowable stress multipliers must be used, then a registered P.E. must certify the design report. (see NCA-2146, b & NCA 4134.4 a,b,c).

To: Bud Trussell

Date: January 23, 1981

Page: 3

From: M. Lowrey

Subject: Trip/Training Report - Technical Seminars Inc - Dallas, Texas

I believe the above system is legal, and so does Marc Bresseler, however, suitable documentation (more forms) must be made up, & the QA manual must be changed.

C: What's the design report for?

Obviously, it verifies the system won't break under the conditions specified by the owner. Further, when submitted to the owner (required) he reviews it for compliance to the design spec (also required) and forwards his findings to us. In the opinion of Bill Gibbons, ONLY THEN are we allowed to N stamp systems & ship, since only then is the required Data Report form complete. Obviously this many month delay (perhaps years) simply won't satisfy our Business Plan. I don't know how to solve this. Note that the owner's spec does not address fatigue due to engine excitation.

D: Is there a way to do all this more cost effectively?

I had it driven home this week that there are many systems & parts that can be legally made from materials without traceability i.e., outside the rules of NCA-3800. Only a certificate of compliance is required. Such systems & parts are:

1. Pipe runs, Pumps, Valves 2" nominal pipe size or less.
2. NF Supports less than 2 square inches in steel area; Bolts less than 2" dia.
3. Bar stock & bolts in Piping less than 1" dia.

Such are "size excluded" materials. In order to save the roughly 30% in material costs, the shop must first set up means of controlling COC material; to not do this means steel without any paper at all could find its way into code components.

Summary: I went to Dallas expecting to learn nothing applicable to design. I was wrong. If we must remain in this business, a commiment to QA is essential, and it seems

# APPROVED SUPPLIERS LIST

## PROCEDURE



Issued By: REBoyer 12/10/81
R. E. Boyer, Manager
Quality Assurance Department

Reviewed By: R.E.Boyer for
L. L. Mills, Manager
Purchasing Department

Approved By: CSMathews
C. S. Mathews,
General Manager

The General Manager's approval of this procedure is the authority to release for implementation the program outlined herein.

Date: 12-14-81

Transamerica Delaval

# MEMO

Transamerica Delaval Inc.
Engine and Compressor Division

INTER-OFFICE CORRESPONDENCE

To: Distribution

Date: December 21, 1981

From: Carolyn Bagnes

Subject: Approved Suppliers List Procedure
Dated December 14, 1981

Attached is a copy of the revised Approved Suppliers List Procedure dated, December 14, 1981. Please destroy any out-of-date copies of this procedure you may have on file.

Carolyn Bagnes

Carolyn Bagnes
Quality Assurance Dept.

cc: R. E. Boyer

Distribution:

Purchasing - L. L. Mills, W. E. Borza
Receiving Inspection
ASL File ✓

SEND TO DENNIS
WEAVER GAI/QAD

1. Purpose

1.1 The Approved Suppliers List, (ASL) is established for determining the acceptability of suppliers and sub-contracted services in accordance with Transamerica Delaval's Quality Assurance Manual.

2. General Procedure

2.1 The ASL is maintained by Quality Control interfacing with the Purchasing Department and Receiving Inspection. Suppliers for parts and services destined to become a part of the product shall be listed in the ASL.

2.2 The ASL consists of the following:

2.2.1 A listing of ASME Suppliers

2.2.2 A listing of suppliers who furnish components/parts which are non-code safety related.

2.2.3 A listing of suppliers who furnish stock/parts/components which are non-code, non-safety related.

2.2.4 Exceptions List. The Exceptions List indicates those suppliers whose rating has fallen below the minimum requirements.

2.2.5 The name of the supplier and a multi-digit Supplier I.D. Code assigned by Purchasing in conjunction with Accounting.

2.2.6 Rating. An average of all ratings made by the Receiving Inspectors for the previous six months followed by the number of inspections or parts that made up the rating. A rating of 7.5 or less will enter the supplier on the ASL Exceptions List.

2.2.6.1 Receiving Inspectors assign a rating of 0 to 10 for each inspection performed with 10 being the highest rating obtainable.

2.2.7 Last Activity. A date indicating the last time any parts or services were indicated as being received by Transamerica Delaval. Vendors may be removed from ASL lists if inactive for purchases for more than three years.

2.2.8 Audited-Surveyed

2.2.8.1 Short Form, (P-268), is completed by the supplier or by a TDI representative and returned to Quality Control. Upon receipt, the form is evaluated. If the evaluation is satisfactory, the supplier is entered on the ASL indicating pertinent information. If the supplier has been approved for code equipment, Purchasing may also consider the vendor for non-code, non-safety related and/or safety related equipment.

2.2.8.2 Long Form, (P-324), is completed by a Transamerica Delaval Quality Assurance Audit Team. One of the following entries will be made:

→ NOT ON FORM, ON ASL

a. Date - Indicates when the supplier is to be re-audited. If the supplier is not approved, he will be placed on the Exceptions List and the code NA will appear under the audited column. The supplier shall be notified of his status. If no response is received from Purchasing or the supplier within two months, the supplier will be removed from all listings of the ASL. A supplier may request a re-audit of his facility concurrent with his submittal of completed corrective action reports indicating resolution of discrepancies from the Q.A. Audit.

b. Inp. - Audit in process.

3. Purchasing: Purchasing shall receive a copy of all listings of the ASL. Quality Control shall inform Purchasing in writing of any supplier that is removed from the ASL. Quality Control will maintain the ASL distribution log.

3.1 Implementation. Purchasing will use only those suppliers listed in the ASL. Orders may be placed to suppliers on the Exceptions List by submitting a waiver request to Quality Control. Quality Control will develop an inspection plan to assure the quality of the product received from that supplier does not fall below the minimum acceptable requirements.

3.2 To add a supplier to the ASL, Purchasing shall request (Form P-325) approval from Quality Control.

3.3 Purchasing will place the Supplier I.D. code number on each Purchase Order.

4. Receiving

4.1 All receivers forwarded to Receiving Inspection must include the supplier identification number. When receivers are issued for partial lots received, the supplier identification code must be transferred to the partial receiver.

5. Receiving Inspection

5.1 Receiving Inspection will be responsible for completing the Vendor Inspection Report (Form P-313). This includes a supplier rating for each part inspected.

5.2 Vendor Inspection Reports are filed in numerical order by supplier I.D. numbers. The inspector shall assure that the supplier I.D. number is recorded on each set of receiving paperwork. In the event the receiving paperwork is incomplete, the inspector will refer the matter to his supervisor.

6. Quality Control

6.1 Quality Control is responsible for the maintenance of the ASL.

6.1.1 The ASL shall be issued every six months.

6.1.2 Quality Control is responsible for the production and distribution of the ASL. The master list and distribution record will be maintained by Quality Control. Distribution will be: Purchasing, Receiving Inspection, and the master copy for Quality Control.

6.1.3 Suppliers will make all requests for inclusion on the ASL through Purchasing. The supplier will not be included on the ASL until a survey or audit is complete.

6.1.4 Suppliers may be removed from the ASL for the following:

6.1.4.1 When the supplier rating falls below the acceptable level.

6.1.4.2 When the supplier fails as a result of a re-audit.

6.1.5 Purchasing shall be notified by Quality Control in writing of suppliers being considered for removal from the ASL.

6.2 Quality Control's review of purchase orders will include verification of the ASL status of the supplier.

# JALITY PROGRAM SURVEY

I in all applicable blocks)

| | |
|---|---|
| npany Name | Prepared by: |
| Iress | Title |
| wn / State / Zip | Telephone No. |
| NUFACTURER ☐ DISTRIBUTOR ☐ PRESENTATIVE ☐ SERVICE ORGANIZATION ☐ | QA/QC Manager |

duct(s) or Service(s) contracted by DELAVAL Turbine Inc., Engine and Compressor Division?

Do you have an inspection and/or Quality Program and Facilities adequate to assure consistent delivery of materials to DELAVAL conforming to specifications? ☐ YES ☐ NO

To whom does the person in charge of Quality Control report?

| Name | Title |
|---|---|
| | |

3. Do you have a Quality Control Manual? ☐ YES ☐ NO If Yes please supply DELAVAL with a copy.

Is your program in compliance with any of the following specifications?

10CFR50 APP. B ☐ ANSI N45.2 ☐ ASME III (NA-3700 ☐) OR (NA-4000 ☐)

MIL-Q-9858A ☐ MIL-I-45208A ☐ ANSI B31.1 ☐ ANSI N45.2.2 ☐

LIST ANY OTHERS:

ASME Authorization

SEC. III CLASS 3 ☐

SEC. III CLASS 2 ☐

SEC. VIII DIV. I ☐

Is your Quality Program presently under a Government Agency surveillance?

Total full time Quality Control and Inspection Personnel

7. Number of Production Personnel

Does your Quality Program include established functions and written procedures for the following:

| | | | |
|---|---|---|---|
| I. | Organization | ☐ YES | ☐ NO |
| II. | Quality Assurance Program | ☐ YES | ☐ NO |
| III. | Design Control | ☐ YES | ☐ NO |
| IV. | Procurement Document Control | ☐ YES | ☐ NO |
| V. | Instructions, Procedures and Drawings | ☐ YES | ☐ NO |
| VI. | Document Control | ☐ YES | ☐ NO |
| VII. | Control of Purchased Material, Equipment and Services | ☐ YES | ☐ NO |
| VIII. | Identification and control of Material, Parts and Components | ☐ YES | ☐ NO |
| IX. | Control of special processes | ☐ YES | ☐ NO |
| X. | Inspection | ☐ YES | ☐ NO |
| XI. | Test Control | ☐ YES | ☐ NO |
| XII. | Control of Measuring and Test Equipment | ☐ YES | ☐ NO |
| XIII. | Handling, Storage and Shipping | ☐ YES | ☐ NO |
| XIV. | Inspection, Test and Operating Status | ☐ YES | ☐ NO |
| XV. | Non Conforming Materials, Parts or Components | ☐ YES | ☐ NO |
| XVI. | Corrective Action | ☐ YES | ☐ NO |
| XVII. | Quality Assurance Records | ☐ YES | ☐ NO |
| XVIII. | Audits | ☐ YES | ☐ NO |

Are your welders certified to ASME SEC. IX ☐ AWS Standards OTHER ☐

May your facilities be surveyed to supplement the above information? ☐ YES ☐ NO

pplier's Comments:

ELAVAL Comments:

2554

rm P 268 (R-1) 1/77

EXHIBIT 6

The Phase I effort, generic component [illegible] the Owners Group. Each of the Phase I reports has been submitted to the NRC for review. Purpose of the Phase I Program was to establish a basis for licensing plants with TDI diesel generators prior to completion of the Design Review and Quality Revalidation (DR/QR) program (Phase II). Based on the results from these reports, the Owners Group has concluded that provided the Phase I recommendations have been implemented the TDI diesel generators can reliably perform their intended function.

The Phase II DR/QR review has also been completed by the Owners Group for PNPP. This review was performed to show that critical components, other than those examined in Phase I, were adequately designed and fabricated. Implementation of the DR/QR field inspection provided further assurance of the reliability of the TDI engines as qualified safety related devices.

The third function of the Owners Group was to establish specific component tests and inspections. The Owners Group technical staff, during their review of the engine components established special inspections, preventive maintenance, and surveillance recommendations. These recommendations, when implemented, will give added assurance that the engines will perform their intended function over the life of the plant.

PNPP has committed to implement the requirements of the Owners Group. All up-grades required by Phase I and inspections required by Phase II will be completed prior to fuel load. Any additional tests required by the Owners Group will be completed and evaluated in the same time frame. A maintenance program that will assure the TDI engines will perform their intended function for the life of the plant will also be in place.

Based on the above, it can be concluded that the TDI engines will perform their safety related function throughout the life of PNPP. With the implementation of all the Owners Group's requirements and with the establishment of a comprehensive maintenance program, the TDI diesel generators installed at the Perry Nuclear Power Plant will meet the requirements for a full power license.

Program Plan Schedule

| Milestone | Goal | Actual |
| --- | --- | --- |
| - Join Owners Group | | 12-21-83 |
| - Component selection for Phase II | | 3-6-84 |
| - Submit PNPP-specific responses to NRC questions | | 10-26-84 |
| - Receive Lead Engine Phase I Reports | | Various |
| - Begin work on Initial Engine Teardown and Inspection | | 9-24-84 |
| - Receive completed DR/QR reports (Phase II) from Owners Group | | 1-4-85 |
| - Complete work on Initial Engine teardown and inspection | | 1-11-85 |
| - Submit PNPP Diesel-Generator Program Plan | | 1-17-85 |
| - Submit DR/QR Reports to NRC | | 1-17-85 |
| - Submit results of Initial Inspection to NRC | 2-15-85 | |
| - Begin Engine Pre-Operational Testing | 3-19-85 | |
| - Complete Engine Testing | 5-9-85 | |
| - Begin Supplemental Engine Inspections | 5-10-85 | |
| - Submit Engine Load Verification to NRC | 5-21-85 | |
| - Finish Supplemental Engine Inspections | 5-24-85 | |
| - Submit Supplemental Engine Inspection results to NRC | 6-1-85 | |

EXHIBIT 7

EXHIBIT 8

## Pistons

LILCO has also discovered linear indications in 23 of 24 pistons inspected during the disassembly effort. These pistons had been field modified to remove spherical washers from the crown to skirt bolting assembly and replace them with bellevue washers. A 10CFR21 was issued as a result of the discovery.

## Morning Wrapup

After FAA's presentation, a motion was made, seconded and approved to utilize EPRI/NSAC for administrative management of the User's Group. The scope, task and costs of the services are to be determined and approved by the utility executives. The meeting was divided into two groups for the afternoon session; one group to prepare a proposed charter, the other to prepare questions for the Transamerica Delaval meeting on 11/30/83.

## Afternoon Session

The charter group and the T.D.I. question formulation group separated for the afternoon meeting. A rough draft of the charter was formulated. It was agreed that the User's Group should consist of a technical committee reporting to an executive committee of corporate leadership. Funding for projects is proposed to be by those utilities who wish to participate in these projects. Each utility should have one vote regarding User's Group activities. No decisions should be made by the User's Group that could affect diesel generator manufacturer competition in the future. The charter will expire 12/31/84 but may be extended at that time if deemed necessary by corporate executives. The charter is being completed by Mr. H. Wyckoff of EPRI. The User's Group proposes a meeting of corporate executives in mid-January 1984 for review and approval of the charter.

The T.D.I. question group completed and agreed upon a selection of pertinent questions to be presented to TDI officials on 11/30/83. The questions are attached to these minutes. The meeting was adjourned for the day.

## Minutes of User's Group Meeting With Transamerica Delaval 11/30/83

After assembling at the TDI facility, TDI officials gave a brief outline of their organizational structure and introduced management personnel in attendance. These managers and their titles are as follows:

- Ron Pabers - Assistant General Manager
- Al Fleischer - Manager, Project Engineering
- Morris Lowrey - Manager, Research and Development
- Alan Barich - Manager, Customer Service
- Roland Yang - Manager, Applied Mechanics
- Richard Boyle - Manager, Quality Assurance
- Greg Beshouri - Research and Development Engineer

LILCO
LONG ISLAND LIGHTING COMPANY
SHOREHAM NUCLEAR POWER STATION
P.O. BOX 604, NORTH COUNTRY ROAD • WADING RIVER, N.Y. 11792

February 17, 1984

EXHIBIT 9

To: All TDI Owners' Group Executives, Alternates, and Site Representatives

Subject: NRC Developments

References:
1. Response of Governor Mario Cuomo to Suffolk County's Motion to Admit Supplemental Diesel Generator Contentions on the Shoreham Docket (Attached)
2. NRC Staff Response to Suffolk County's Motion to Admit Supplemental Diesel Generator Contentions (Attached)

As you know, we have been attempting to work very openly and directly with the NRC staff in order to expedite the progress of the Owners' Group Program and to obtain NRC concurrence on the substance of the Program elements. Another very important objective of this approach has been to obtain NRC concurrence on our proposal to permit plant licensing on the basis of Phase I of the Program (resolution of the 16 known problems).

In addition to the generic Owners' Group efforts, Mississippi Power & Light, because of its readiness to resume power ascension, is proposing to the NRC a further accelerated schedule in their case based on work that they have done coupled with accelerated work in certain areas on the part of the Owners' Group. For those plants in ASLB litigation, we have been urging the staff to commence litigation on an issue-by-issue basis (that is component-by-component) in order to get procedings started wherever possible.

Our approach in working with the staff has been to provide preliminary information wherever possible, to discuss issues at NRC meetings even if those issues are still under study by FaAA, SWEC, or other Owners' Group elements, and to establish a professional working relationship. As you know, all meetings with the NRC have been transcribed, and intervenors have been present. These developments have had a chilling effect on the exchange of information between the staff and the Owners' Group. In addition, the intervenors have made numerous self-serving and negative remarks on the record.

The positions outlined in the two attachments to this letter, coupled with NRC statements made at yesterday's Owners' Group meeting, now make it clear that our approach to dealing with the NRC on the diesel generator issues will have to be substantially modified. Despite the forementioned efforts to convince the staff to reach preliminary conclusions on the basis of early inspection and analytical results, the chilling effect of conducting business in a "fishbowl" indicates that this will not be possible. This is illustrated by the referenced documents which generally take the following positions adverse not only to Shoreham, but to Grand Gulf and any of the other units in litigation as well.

NRC Positions on D.G. Licensing Schedules

1. Litigation for the diesel generator issues should not start until all 16 of the known problems (Owners' Group Phase I) have been resolved - this means, as confirmed by discussions with the NRC, final reports will have to be submitted and evaluated by the NRC prior to proceeding with the hearings.

2. The NRC intends to issue individual SERs for each utility on the diesel generator issues 45 days after the receipt of the last final report of Phase I.

3. Litigation on the diesel generator problems should not begin until all Phase I reports have been submitted and the SER for each individual case issued as outlined above.

4. The staff review cannot proceed because no formal program plan has been submitted by the Owners' Group (this despite several presentations, and a significant amount of material which has been provided to the staff).

The last point is particularly irritating since the Owners' Group has lost considerable time in the preparation of a formal program plan and Phase I final reports in order to meet with the staff on numerous occasions to answer large numbers of questions. Unfortunately, this sacrifice in schedule, which we had been willing to absorb in order to be responsive, has not helped us achieve a prompt review of issues by the NRC staff.

In an effort to achieve prompt and efficient review, we are, therefore, taking the following steps:

1. We have requested that no meetings be held for the next three weeks at least so that the Owners' Group can concentrate on finalizing and submitting the following items:

1, (Cont'd.)

a. Final Approve Task Descriptions for all Phase I problems (16).

b. Submit final approved Owners' Group Program plan.

c. Submit final reports on a number of Phase I items (crankshafts, pistons, and bearings as a minimum).

2. Information on analyses or inspection results will generally be provided to the NRC only in final form.

3. The Owners' Group will limit any technical meeting discussions to those items which have been finally reviewed and formally submitted to the NRC.

4. We will continue to respond to NRC requests for information regarding the Program; however these requests will be funneled through a central point in the Owners' Group (Mr. John Murphy, SWEC, the Licensing Manager for the Owners' Group) to ensure that adequate oversight is maintained.

It is unfortunate that the outside pressures on the staff have forced us to take these steps. Given the circumstances, the measures outlined above are, in my judgement, required in order to protect all of our interests.

If you have any comments or concerns regarding how we intend to proceed with regard to NRC interface, please call me at (516) 929-6774.

W J Museler

W. J. Museler
Technical Program Director
TDI Owners' Group

WJM/mm
Attachments

cc: M. S. Pollock, M. H. Milligan, C. K. Seaman, J. Kammeyer, R. Najuch, J. Murphy, G. Rogers, C. Wells, B. R. McCaffrey, R. A. Kubinak, W. Baranowski/E. J. Brabazon, SR2

DUKE POWER COMPANY
GENERAL OFFICES
422 SOUTH CHURCH STREET
CHARLOTTE, N. C. 28242

P. O. BOX 33189

TELEPHONE: AREA 704
373-4011

EXHIBIT 10

TDI Diesel Generator Owners Group

OGTP-109-0-56

Re: July 11, 1984 Meeting between NRC/PNL/
TDI Diesel Generator Owners Group

The main topic of the subject meeting was a discussion of the PNL Report on the Owners' Group Program Plan. This report is attached for your information.

The major point of contention with the PNL Report is in the area of endurance testing to $10^7$ cycles (approximately 750 hrs.). This endurance testing would be required for lead engines at high power levels. Even though we discussed two components (AE Piston and Crankshaft) in detail, the report implies all components are required to undergo the endurance test.

One of the key arguments we made was that the loading requirements of the engine is much less than the rated load. The NRC was very receptive to this argument and requested more information regarding site specific diesel engine loading requirements.

Attached to this letter is a LILCO submittal which discusses loading requirements for SNPS diesels. In general, FSAR tables exist for each plant similar to the table attached to the LILCO submittal. However, this table has proven to be ultra-conservative in many cases. Also, very little credit is taken for operator action to reduce engine loads after 10 minutes into the accident.

Our plan is to develop curves for each plant similar to the one for SNPS (attached). Thus, the following information is needed for each utility.

For the limiting transient/accident on the highest loaded engine.

1. Identify the transient/accident.
2. Identify the engine (Train A or B)
3. Initial peak load
4. All load decreases due to sequencing of loads or operator action or other reasons.
5. A brief explanation of the reason for decreasing the load.
6. Source of the information (FSAR, Preop testing, etc.)

If possible, the above information should be as realistic as possible and not a repeat of ultra-conservative FSAR information.

If you have any questions, please call Bill Coleman at 704-373-3488.

Very truly yours,

C. L. Ray, Jr.

C. L. Ray, Jr.
Technical Program Director
TDI Diesel Generator Owners Group

yds

cc: Alternates
Licensing Contacts

January 10, 1985

OGTP-733

Memo to File

EXHIBIT 11

Re: TDI Diesel Generator Owners Group
Executive Committee Meeting Minutes
January 9, 1985
File: MTS-4086

The subject meeting was held in Dallas, Texas. Those individuals present are identified in Attachment 1. The meeting agenda (as amended during the meeting) is provided as Attachment 2.

<u>TECHNICAL SESSION</u>

I. A. J. B. George called the meeting to order at 10:00 a.m. CST. Mr. George recapped the Executive Chair's meeting with H. R. Denton of the NRC on November 29, 1984. Mr. George stated that Mr. Denton was advised that the Owner's Group intended to close and disperse the Technical Staff in February 1985. He also noted that the NRC should give favorable attention to applications requesting less stringent maintenance and surveilliance requirements from those in the DR/QR reports if supported based on additional site experience. Mr. Denton noted that such applications would get appropriate consideration. C. L. Ray continued that in later discussions with C. H. Berlinger of the NRC, Mr. Berlinger felt that enough support has already been provided to NRC to relax the 185 BMEP interim licensing restriction. Mr. Berlinger noted that NRC would not issue a singular action lifting this requirement; rather this would be accounted for in each plant specific SER. Mr. Berlinger further stated than an endurance run for Comanche Peak, as had been previously requested by NRC, should not be necessary in light of the hours already logged on the Catawba engines. The Catawba runs should serve as the performance test for the V-16 engine.

B. C. L. Ray presented the status and schedule of the Phase I and II effort (Attachments 3 through 7). A copy of the most recent NRC status report was distributed. Little change from the previous month's NRC status was noted. Mr. Ray stated that indications from PNL personnel are that dates listed in the status report are not achievable. (For more details on this item see II A.)

C. C. S. Mathews noted that TDI is on schedule for implementing MAC recommendations to enhance TDI's QA Program.

Much discussion centered on recently found problems with the cylinder heads to be provided for TUGCO by TDI. (Found some dimensions out of tolerance per TDI drawings. Investigation of problem by TDI and TUGCO revealed that areas where dimensions were not within tolerance would not result in any problems based on a design review and operating experience to date of other engines.) The problem was evaluated under 10CFR Part 21 and found to be not reportable. TDI does not plan to issue any form of service bulletin since no problems have occurred or are anticipated.

D. R. Kascsak noted that fuel load for Shoreham is scheduled to be complete the week ending 1/8/85. NRC Commissioners are scheduled to meet 1/24/85 to vote on issuance of 5% power license for Shoreham. FEMA has cancelled the Emergency Planning drill scheduled in February, 1985. No reasons were cited and the drill has not been rescheduled. Shoreham's SER has been issued (incorporating results of endurance run) noting that the TDI diesels are satisfactory for issuing a license. Two items on the diesels remain for hearings (concerning the block and qualified load) and will be heard before the ASLB beginning 2/15/85.

John Bobbitt of SMUD noted that disassembly and inspections are ongoing on the Rancho Seco engines with completion scheduled for mid-March. Bobbitt requested that the technical staff review the DR/QR reports to verify that all inspection requirements have defined acceptance criteria to permit those utilities that have not completed their inspections to do so and document the results at a later date.

G. W. Hallman of Duke reported that Catawba Unit 1 has a 5% power license and achieved criticality on 1/7/85. Unit 2 diesels will have AN piston skirts replaced by AE's by mid-year but testing will be done with AN's.

MP&L reported no problems with the unit operating well.

TVA noted that they were 25% complete with inspection on one engine.

Vogtle has the Unit 2 engines disassembled and is awaiting delivery of one new block before reassembly can begin. Inspection has identified a gouge in the block (dimensions approx. 1 1/2" vertical, 1/16" wide, 1/4" deep) that may present a potential water leak problem. This is under investigation.

WNPS reported that Unit 1 has been mothballed until 1988. Unit 3 work will restart no earlier than 1986.

Perry has not encountered any problems with the inspections since the last report. The first engine should be ready for testing on 2/5/85. Fuel load is currently scheduled for 6/15/85.

Riverbend reported a crack in the expansion bellows of the exhaust pipe past the turbochargers. This problem is felt to be associated with engines having a vertical exhaust. The bellows has been replaced with a slip joint and is working fine.

Comanche Peak reported on the dimensional problems with the heads noted already in item I.D.

## EXECUTIVE SUMMARY

This report summarizes the status of the TDI Diesel Generator Owners Group Technical Program as of February 1, 1985.

As reported in the January status report, all Phase I work was completed 12/11/84. NRC/PNL has requested a meeting with the Technical Staff on February 11, 1985 to discuss the results of PNL's Phase I review. Any remaining Phase I questions can be answered at that time. PNL plans to issue all Phase I TER's within one week of that meeting with NRC to issue the SER's 30 days hence.

The Phase II reports for Vogtle and WNPS-1 were issued 1/11/85 and 1/22/85 respectively (Attachment 1). Signoff of all Bellefonte reports and deletion justifications is complete with printing in progress. Bellefonte is on target to be issued 2/4/85 as scheduled. Revisions to the Shoreham and Comanche Peak reports were issued 12/21/84 and 1/24/85 respectively. All other revisions should be issued by 2/15/85.

The Executive Chair Committee met with H. R. Denton on 1/10/85 to discuss work on Phase I and Phase II. Mr. Denton requested the meeting on 2/11/85 previously discussed. Mr. Denton indicated that the Owners should utilize the maintenance recommendations in the DR/QR reports for a period and request changes based on successful operation of the engines. Mr. Denton also noted that he saw no problem with allowing the TDI engines to operate at 225 BMEP and this consideration would be given in conjunction with the site specific SER's.

The Technical Staff is on target for an orderly closure February 28, 1985. Since no further inspection results can be incorporated into the Phase II reports (for sites that have not completed their initial inspections) inspection schedule monitoring has been deleted. The final status report for the Owners Group Technical Program will be issued February 28, 1985.

EXHIBIT 12

Executive Committee Meeting
January 9, 1985

PROPOSAL FOR CLOSURE OF TDI OWNERS GROUP

There are two distinct organizations which should be treated somewhat independently when considering closure of the TDI Owners Group. These are the TDI Owners Group Technical Staff and the TDI Owners Group Executive Committee. The TDI Owners Group was formed to collectively address the generic concerns raised due to the failure of the crankshaft at Shoreham and the subsequent loss of confidence in the TDI QA Program by the NRC. The TDI Owners Group Technical Staff was formed to provide the engineering services required to address these concerns and works under the direction of the Executive Committee.

The TDI Owners Group Program Plan provided for the Design Review and Quality Revalidation (DR/QR) of the TDI diesel generators to be performed in two phases. Phase I to be a design review of 16 generic components and Phase II being a DR/QR of 170± components on a plant specific basis for each of the member utilities. Phase I was to be the basis of interim licensing and operation of near term plants and Phase II was to establish the long term reliability of the TDI diesel generators. Phase I has been completed by the Technical Staff with the only outstanding item being receipt of final SER's from the NRC on the 16 generic components. The last of the Phase II DR/QR reports is scheduled for completion by February 4, 1985 and progress to date indicates that the schedule is realistic. This means that the base load work scope of the Technical Staff will be completed by the end of January 1985 and only the orderly closeout of files, etc. is anticipated for February, 1985. This schedule and work scope is the basis for the current budget projection.

The only function of the Technical Staff that could be anticipated to continue is the addressing of plant specific problems, inspection results, non-conformances, etc. Because of the availability of the Technical Staff, this work scope was superimposed on the Phase I and Phase II effort but invoiced on a plant specific basis. Because of the intermittent nature of this work, it is not practical to maintain a full-time Technical Staff to perform this plant specific work scope.

Based on the above, it is recommended that the Technical Staff proceed to close out and appropriately archive the files and data upon transmittal of the last Phase II DR/QR Report. It is fully expected that this would be accomplished no later than the end of February 1985. At that time, funding of a full-time Technical Staff would be terminated.

This closure of the Technical Staff would be similar to the NRC plans for closing out the TDI Project Group headed by Carl Berlinger and placing responsibility for review of remaining diesel generator issued in the plant specific project groups. Mr. Harold Denton advised the TDI Owners Group Executive Steering Committee in a meeting on December 9, 1984 that it was his intention to dissolve the TDI Projects Group upon completion of their review of Phase I.

EXHIBIT 13

The recommended alternative for addressing plant specific problems, inspection results, non-conformances, etc. subsequent to closure of the Technical Staff is to utilize the provisions, with any needed amendments, of the existing Utility-Duke MATS and Duke MATS-Consultant contracts which are currently in effect through June 1985. In effect, the contracts would become continuing services agreements with no specified scope or budget and would be exercised on an as-needed basis by the specific utility requesting services. The advantage of this approach is to maintain continuity which would serve to take full advantage of work performed thus far and minimize the risk of unnecessarily raising any additional generic concerns. These contracts could be renegotiated and extended as needed beyond June 1985.

The TDI Owners Group Executive Committee has considerably more flexibility in deciding its future. The recommended alternative is to continue meeting on a periodic basis through June 1985 to share experiences and discuss concerns. This could be done with the existing executive members or it could be decided to replace the existing representation with people who have more hands-on technical experience. The need for meetings beyond June 1985 would be considered at the June meeting. One point to consider in making a decision on this alternative is that the visibility of the Owners Group sets the TDI diesel generators apart from other make diesel generators and other plant equipment as needing special consideration.

C. L. Ray, Jr.
Technical Program Director

# PROFESSIONAL SERVICES NOTIFICATION

NO. 3641 REV. 5-82

| | | |
|---|---|---|
| DATE INITIATED | AWARD DATE | |
| DATE FWD TO ACCOUNTING | SRM 25100 | |

**VENDOR**

NAME: Southwest Research Institute

ADDRESS: P. O. Drawer 28510, 6220 Culebra Rd., San Antonio, Texas 78284

**PERIOD**

FROM (STARTING DATE): April 16, 1984

TO (COMPLETION DATE): December 31, 1984

**TYPE**

☐ VERBAL AGREEMENT ☐ LETTER OF AGREEMENT * [X] FORMAL WRITTEN AGREEMENT *

**SCOPE** DESCRIBE BRIEFLY SERVICES TO BE RENDERED.

For consulting services to review the data generated by the Transamerica DeLaval, Inc. (TDI) Diesel Generators Owner's Group formed to assess the adequacy of TDI engines in nuclear standby applications. In addition to the review, an expert witness will be made available to testify on behalf of CEI on the results from the TDI Owner's Group.

EXHIBIT 14

**PAYMENT** DESCRIBE HOW OR WHAT COSTS WILL BE REIMBURSED AND FREQUENCY OF BILLING.

☐ VENDOR TO SUBMIT MONTHLY INVOICES TO BE PAID WITHIN 30 DAYS OF RECEIPT

[X] OTHER (PLEASE DESCRIBE IN DETAIL)

An initial payment of upon acceptance of the proposal with additional payments based upon invoices submitted every four weeks. Payment of invoices to be made within thirty days from date of invoice.

| TOTAL ESTIMATED COST | ACCOUNT OR JOB ORDER NO. | FUNCTION NO. |
|---|---|---|
| | 51000 | 6312 |

**IS THIS A REVISION?** YES NO

IF REVISION: ORIGINAL DATE — NUMBER OF THIS REVISION —

ORIGINAL ESTIMATED COST $

REASON FOR REVISION

**ORIGINATOR**

NAME (PRINT): JML ARX ECC J. Lastovka/E. Christiansen

SIGNATURE: J M Lastovka

ELEMENT: NUC. CONST. ENG.

**APPROVAL**

PRESIDENT OR EXECUTIVE VICE PRESIDENT: [signature] — DATE 4/30/84

VICE PRESIDENT: [signature] — DATE 4/28/84

DEPARTMENT MANAGER: [signature] — DATE 4/23/84

COMPRESSOR DIVISION
550 85TH AVENUE
P.O. BOX 2161
OAKLAND, CA 94621
PHONE 415 577-7400



November 11, 1977

EXHIBIT 15

Gilbert Associates
P. O. Box 1498
Reading, Pennsylvania 19603



Attention: Project Service Department

Subject: Perry Nuclear Power Plant
Standby Diesel Generator
W.O. No. 044549-000
Order P-1152S - Spec No. 562
Delaval Job No. 75051/54

Gentlemen:

The enclosed drawing transmittal contains the resubmittal of our Qualification Testing Procedure. Referencing your letter of October 4, 1977 on this subject, we have incorporated your comments 1 through 6 and 8a through 8e and portions of 8i. We have not changed the loading sequence since we have not received the new loading sequence.

Also included in this drawing transmittal are calculations which cover your comments 8f through 8h.

As far as your item 8i in your letter, it is difficult to prove mathematically or through testing that the engine will meet the conditions spelled out in paragraph 2:07.1 of the specification, except for us to assure you that the engine is capable of operating under those conditions specified. The best proof is the successful operation of our engines of similar design over many years of service under varying operating conditions. Our engines have been used for power generation for municipalities where they have had to perform over a wide load range and also be paralleled to the grid network bus system. These engines are frequently started and stopped as many are used for peaking service, and sometimes go for days without use but are then called into service and do successfully perform.

Also, many engines are used in marine service which is very demanding since they frequently run at an overload condition to meet time schedules.

We ask for approval of these documents soon since the test time quickly approaches.

Very truly yours,

DELAVAL TURBINE INC.
Engine & Compressor Division

C. W. Doersom

C. W. Doersom
Project Engineer

CWD:ljj

cc: L. O. Beck - CEI
A. W. Inverso
H. G. Towers
S. W. Learn

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509) 375-2780
Telex 15-2874

April 18, 1984

EXHIBIT 16

Mr. Carl Berlinger
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Berlinger:

CONTENT OF OWNERS GROUP REPORTS ON GENERIC PROBLEMS - DIESEL ENGINE OPERABILITY/RELIABILITY

The Owners Group reports on generic problems received to date have not provided sufficient information to permit a meaningful technical review. These reports will provide a large part of the basis for resolution of generic issues. Therefore, they should be, as much as possible, stand alone documents which will allow the NRC to assess the appropriateness of the proposed actions.

To provide an adequate basis for review and comment, the reports should include as a minimum the following items:

- a definition of the generic problem being addressed
- the methods used to determine the cause of the problem
- the corrective actions to be taken to resolve the problem
- pertinent information from references not readily available.

The first item required in each report is the definition of the generic problem being addressed. The report should state what was wrong with the component and why it was included in the list of Phase I generic problems. A description of the component is needed. This description should include sketches with dimensions and an explanation of the function of the component and the loadings it sees. The materials used should be listed. Any requirements for conformance to industry codes and standards should be included. If photographs are included, originals should be included in all review copies. Drawings must be fully legible.

Reported failures and causes should be listed and categorized as from nuclear and/or nonnuclear experience. Consequences of failure should be noted. All reports reviewed to date have investigated the design adequacy of the components. Other possible causes of failures such as inadequate quality control in manufacturing processes or assembly, the use of inappropriate parts, inadequacies during installation, or incorrect operation should be considered. If the design of the component does not require modification, then the problem must have been related to other causes and the methods used to determine these causes must be identified with sufficient clarity to permit evaluation of plans for corrective action.

Once the cause of the problem is determined, the corrective actions to be taken should be addressed. If a new design is indicated, the applicability of the new design should be defined. The TDI engines for which the new design applies (or not) should be listed. The impact of any corrective actions on other components must be determined. Any operating experience with redesigned components should be specified. Sufficient supporting data needs to be supplied for interested parties to follow-through to the conclusions.

Evaluation of analyses requires a description of the analytical approach, calculational models or methods used, and basic assumptions and the rationale for the assumptions. Boundary conditions used for analysis must be included. Use of references for the bulk of these matters does not permit the reader to follow-through to the conclusions.

Test program plans need to be more explicit. Clarification is needed about whether or not plant unit tests or special component tests will be conducted. Rationale should be provided if test engines or engines of different configuration or service demands are to be used. How will the functional capability of the components be demonstrated by the proposed test program? How will the loading conditions and number of stress cycles experienced by the components during the tests demonstrate the components' acceptability? What will be the qualifying results of the tests for this component? What will be considered a failure of the tests for this component?

In addition to the testing requirements, the quality revalidation of these components should be addressed, especially for those components where inappropriate or inadequate parts have been used. The steps that will be taken in the form of operational surveillance and maintenance programs to address a specific generic problem should be presented along with steps to prevent operator errors that could adversely affect the component.

Many of the above items will probably not require a great deal of backup analyses or information. However, an adequate discussion must be included to permit the reviewer to reach the same conclusions.

A statement should be included that the generic report has the approval of the Owners Group and is in compliance with the Owners Group Plan.

If the above issues are adequately addressed in each report, a substantial improvement in overall communication efficiency is anticipated. This will considerably reduce the need for exchanges of questions and answers at Owners Group meetings. Further, the overall review cost, complexity and time required will be reduced.

Very truly yours,

Walt Laity

Walter W. Laity
PNL Project Manager

WWL/bc

cc: M. J. Plahuta, DOE-RL

with the San Onofre's? EXHIBIT 17

MR. JOHNSTON: The only other engine that we've actually measured is Shoreham because as you know we did an extensive test program there of both torsiograph and strain gauging. From those measurements we found that the largest stresses during a fast start at Shoreham were lower than the stresses, steady state stresses, at full load operation at Shoreham.

So we actually had those measurements at Shoreham and found that during both coast down and start-up all the transient conditions we considered. The largest stresses are below the full load steady state operational stresses.

Now, the reason for that is fairly apparent and Clarence Ray addressed this earlier on when he indicated that the V-20 is unique in that it has 2 or 3 criticals that are the worst criticals in the 200 to 300 rpm range whereas for example, at Shoreham the largest order that one is concerned with is the fourth order which resumates at 580 rpm. So you never get there during a start-up ordering coastal.

MR. MURPHY: What about the V-16's?

MR. JOHNSTON: The V-16's also have their largest torsional above the full load operation. The three and one-half order of critical, I don't remember the exact frequency but it's in the 500 rpm area. I'm not quite sure of the exact number but again it is above the steady full load operational speed.

MR. MURPHY: Were there any criticals done around 420-430?

MR. JOHNSTON: There is a fourth order critical at about 420 or 430 as you mentioned on the V-16. That critical -- the forcing function for that is relatively small because it's only due to the imbalance between the left and the right cylinders.

In fact, in our torsiograph testing at Catawba in order to determine the natural frequency where you run steady state response at different speeds, we captured that fourth order and with the low forcing function first of all due to the fact that there's only this imbalance -- only due to this imbalance between the left and right banks and secondly in the fact that we're looking at a very low load at that time even in a fast start, the racks have receeded a lot once you get up fairly close to 450 rpm.

If you look at the pressure profile, you get a lot of pressure at the beginning and then it decays off. So you have a very low forcing function at the

# EXHIBIT 18

ENGINE AND COMPRESSOR DIVISION OAKLAND, CALIFORNIA — POWER ENGINE FACTORY TEST LOG — LOG 1 A

CUSTOMER CLEVELAND ELECTRIC  MODEL DSRV-16-4  TEST STAND NUCLEAR  JOB NO 2814  ENGINE NO 75051  FULL LOAD RATING 9717 BHP @ 450 RPM 224 BMEP

| Line | Date | Time On Load | Time Log | % Load | RPM | Scale | BHP | BMEP | Disc Revs | Time | Power Factor | AC Volts | AC Amps | KW | Gen Eff | BHP (Corr) | BMEP | Gov Load Limit | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R | Line |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-29 | 1900 | 2000 | 50 | 450 | | | | | | 1.0 | 4160 | 485.7 | 3500 | .955 | 4915 | 113.4 | | 24.5 | 24.5 | 24.5 | 24.5 | 24.5 | 24.5 | 24.5 | 24.5 | | | 24.5 | 24.5 | 24.5 | 24.5 | 24.5 | 24.5 | 24.5 | 24.5 | | | 1 |
| 2 | 3-29 | 2020 | 2120 | 75 | 450 | | | | | | 1.0 | 4160 | 728.6 | 5250 | .963 | 7311 | 169 | | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | | | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | 29.0 | | | 2 |
| 3 | 3-30 | 0300 | 0400 | 100 | 450 | | | | | | 1.0 | 4160 | 971.5 | 7000 | .966 | 9717 | 224 | | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | | | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | | | 3 |
| 4 | 3-30 | 0400 | 0500 | 100 | 450 | | | | | | 1.0 | 4160 | 971.5 | 7000 | .966 | 9717 | 224 | | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | | | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | 37.0 | | | 4 |
| 5 | 3-30 | 0505 | 0605 | 25 | 450 | | | | | | 1.0 | 4160 | 242.9 | 1750 | .943 | 2488 | 57.4 | | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | | | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | | | 5 |
| 6 | 3-30 | 0610 | 0710 | 110 | 450 | | | | | | 1.0 | 4160 | 1068.7 | 7700 | .966 | 10689 | 246 | | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 | | | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 | 41.0 | | | 6 |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 7 |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 8 |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 9 |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 10 |

TURBOCHARGER PRESSURES / TURBOCHARGER TEMPERATURES / AIR FLOW NOZZLE SIZE

| Line | Air Manif. LB | Air Manif. RB | Turbine Inlet (LF/RF/LR/RR) | Turbine Exhaust (LF/RF/LR/RR) | Blower Inlet (°F) | Blower Discharge (°F) | Air Manif. (°F) | Turbocharger RPM | Nozzle | Air Flow SCFM Total | Ambient Baro (in Hg) | Ambient Air (°F) | Line |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20 | 20 | | | | | | | | | 29.82 | | 1 |
| 2 | 31.5 | 31.5 | | | | | | | | | 29.82 | | 2 |
| 3 | 50 | 50 | | | | | | | | | 29.82 | | 3 |
| 4 | 51 | 51 | | | | | | | | | 29.82 | | 4 |
| 5 | 85 | 85 | | | | | | | | | 29.82 | | 5 |
| 6 | 59 | 59 | | | | | | | | | 29.82 | | 6 |
| 7 | | | | | | | | | | | | | 7 |
| 8 | | | | | | | | | | | | | 8 |
| 9 | | | | | | | | | | | | | 9 |
| 10 | | | | | | | | | | | | | 10 |

FUEL OIL DATA / DIESEL BSFC / FUEL GAS DATA / GAS BSFC / DUAL FUEL BSFC

| Line | Wate Temp | API Gravity | °F | Corr. API | Btu/lb | lbs Meas | Time (sec) | lb/hr | (Corr) gal/hr | (Corr) lb/bhp hr | Manif. | LHV | To Gas Meter | Corr. Factor | ft³ Meas | Time | ft³ (Corr) | Btu/bhp hr | Pilot | Gas | Total | Remarks | Line |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 32.5 | 34.2 | 78 | 32.5 | 18335 | 1270 | 2574 | 17762 | 247.2 | .364 | | | | | | | | | | | | | 1 |
| 2 | 30.8 | 34.9 | 79 | 32.8 | 18350 | 1020 | 1452 | 25289 | 352.7 | .349 | | | | | | | | | | | | | 2 |
| 3 | [illegible]8.5 | 35.0 | 80 | 32.8 | 18350 | 1150 | 1187 | 34878 | 486.4 | .362 | | | | | | | | | | | | | 3 |
| 4 | [illegible]8.5 | 35.3 | 82 | 32.8 | 18350 | 1100 | 1142 | 34676 | 483.6 | .360 | | | | | | | | | | | | | 4 |
| 5 | 35.0 | 35.3 | 82 | 32.8 | 18350 | 360 | 1302 | 9954 | 138.8 | .404 | | | | | | | | | | | | | 5 |
| 6 | 27.5 | 35.5 | 82.5 | 32.8 | 18350 | 1100 | 997 | 39719 | 554.0 | .375 | | | | | | | | | | | | | 6 |
| 7 | | | | | | | | | | | | | | | | | | | | | | | 7 |
| 8 | | | | | | | | | | | | | | | | | | | | | | | 8 |
| 9 | | | | | | | | | | | | | | | | | | | | | | | 9 |
| 10 | | | | | | | | | | | | | | | | | | | | | | | 10 |

22 LB 27 RB

OPERATOR G LEVERING
ENGINEER M. [illegible]

DATE 3-29-78
LOG 1 A
JOB 2814

C.E.I.
P.O. NO. P-1152-S
P.N.P.P. UNIT NO. 1
G.A.I. B/M ITEM 1R43C001A

GILBERT/COMMONWEALTH 2710

00106

ENGINE AND COMPRESSOR DIVISION OAKLAND CALIFORNIA

**POWER ENGINE FACTORY TEST LOG** LOG 1 B

CUSTOMER CLEVELAND ELECTRIC MODEL DSRV-16-4 TYPE SERVICE NUC. STBY. GEN. JOB NO. 2814 ENGINE NO. 75051 DIRECTION OF ROTATION (AS VIEWED FROM FLYWHEEL END) CW

**EXHAUST TEMPERATURES - °F**

Turbine inlet (T - top, B - bottom): no entries recorded on lines 1–10.

| Line | Turbine Exhaust LF | RF | LR | RR | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 720 | 790 | | | 800 | 797 | 818 | 867 | 774 | 735 | 761 | 784 | | |
| 2 | 781 | 842 | | | 875 | 903 | 906 | 974 | 837 | 799 | 797 | 826 | | |
| 3 | 842 | 864 | | | 960 | 1018 | 1009 | 995 | 949 | 931 | 928 | 953 | | |
| 4 | 840 | 861 | | | 958 | 1015 | 1004 | 989 | 944 | 928 | 929 | 962 | | |
| 5 | 634 | 647 | | | 723 | 705 | 722 | 731 | 700 | 673 | 720 | 695 | | |
| 6 | 877 | 899 | | | 1020 | 1070 | 1063 | 1039 | 1013 | 992 | 981 | 1025 | | |
| 7 | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | |

| Line | Exhaust Elbows 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 835 | 898 | 892 | 941 | 763 | 943 | 830 | 962 | | | 838 |
| 2 | 880 | 998 | 952 | 1010 | 807 | 973 | 870 | 1033 | | | 903 |
| 3 | 941 | 1036 | 996 | 1004 | 913 | 986 | 971 | 1016 | | | 975 |
| 4 | 942 | 1032 | 994 | 1005 | 915 | 988 | 969 | 1016 | | | 974 |
| 5 | 713 | 705 | 743 | 687 | 764 | 720 | 721 | 769 | | | 718 |
| 6 | 1005 | 1084 | 1043 | 1053 | 956 | 1030 | 1017 | 1062 | | | 1028 |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |

| Line | Engine Water PSIG at Engine | To Engine °F | From Engine °F | Turbocharger Water Outlet LF | RF | LR | RR | Aftercooler Water Inlet F | R | Outlet F | R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 12 | 153 | 162 | | | | | | | | |
| 2 | 11.5 | 161 | 178 | | | | | | | | |
| 3 | 11.5 | 153 | 161 | | | | | | | | |
| 4 | 11.5 | 160 | 166 | | | | | | | | |
| 5 | 11.5 | 158 | 163 | | | | | | | | |
| 6 | 11.5 | 156 | 166 | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |

**FIRING PRESSURES - PSIG**

| Line | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 820 | 830 | 820 | 820 | 830 | 800 | 780 | 820 | | | 800 | 800 | 770 | 890 | 800 | 820 | 790 | 860 | | | 816 |
| 2 | 1130 | 1150 | 1140 | 1150 | 1140 | 1140 | 1150 | 1130 | | | 1130 | 1140 | 1100 | 1240 | 1120 | 1160 | 1100 | 1220 | | | 1146 |
| 3 | 1430 | 1470 | 1460 | 1440 | 1500 | 1420 | 1430 | 1450 | | | 1470 | 1440 | 1390 | 1490 | 1470 | 1410 | 1420 | 1460 | | | 1447 |
| 4 | 1430 | 1460 | 1450 | 1440 | 1480 | 1400 | 1420 | 1440 | | | 1455 | 1430 | 1380 | 1475 | 1460 | 1390 | 1400 | 1400 | | | 1432 |
| 5 | 580 | 580 | 590 | 580 | 630 | 550 | 560 | 570 | | | 580 | 570 | 590 | 600 | 600 | 560 | 570 | 580 | | | 581 |
| 6 | 1570 | 1580 | 1570 | 1590 | 1620 | 1550 | 1560 | 1570 | | | 1610 | 1580 | 1520 | 1640 | 1615 | 1560 | 1580 | 1620 | | | 1583 |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | |

| Line | Lubricating Oil Pressure PSIG: From Pump | To Engine | Cam Header | To Turbocharger LF | RF | LR | RR | Lubricating Oil Temperature °F: To Engine | From Engine | Turbocharger Drain LF | RF | LR | RR | Crank Case Press. | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 51.5 | | 28 | 25 | | | 157 | 175 | | | | | | |
| 2 | | 52.0 | | 26.5 | 24.5 | | | 162 | 176 | | | | | | |
| 3 | | 57.0 | | 26.5 | 28.5 | | | 158 | 177 | | | | | | |
| 4 | | 50.5 | | 26.0 | 23.5 | | | 157 | 178 | | | | | | |
| 5 | | 50.0 | | 28.0 | 25.0 | | | 165 | 172 | | | | | | |
| 6 | | 51.0 | | 26.0 | 23.0 | | | 153 | 179 | | | | | | |
| 7 | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | |
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| 10 | | | | | | | | | | | | | | | |

C.E.I.
P.O. NO. P-1162-S
P.N.P.P. UNIT NO. 1
G.A.I. S/N ITEM [illegible]

GILBERT/COMMONWEALTH 2710 6/8-QA

TURBOCHARGER MAKE & MODEL: [illegible]

OPERATOR G. LEVERING DATE 3-29-78
ENGINEER M. ESCHELMAN LOG 1 B
WITNESS JOB 2814

EA-5278

ENGINE AND COMPRESSOR DIVISION OAKLAND CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 1 A

CUSTOMER: CLEVLAND, ELECTRIC — MODEL: DSRV-16-4 — TEST STAND: 22 — JOB NO: 2814 — ENGINE NO: 75051 — FULL LOAD RATING: 9717 BHP 450 RPM 224 BMEP

| Line | Date | Time Start | Time Stop | % Load | RPM | Scale | BHP | BMEP | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2/1 | 2155 | 2255 | 25 | 200 | 5296 | 1092 | 57.4 | 19 | | | | | | | | 19 | | | | | | | |
| 2 | 3/1 | 2900 | 1000 | 25 | 270 | 5296 | 1493 | 57.4 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| 3 | 3/1 | 1110 | 1210 | 25 | 330 | 5296 | 1531 | 57.4 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| 4 | 3/1 | 1215 | 1315 | 25 | 360 | 5575 | 2185 | 57.4 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| 5 | 3/1 | 1320 | 1420 | 50 | 400 | 10593 | 4230 | 113.4 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 |
| 6 | | | | | | | | | END OF SHOP test | | | | | | | | | | | | | | | |
| 7 | 3/2 | 1855 | 1910 | | | | | | 15 MIN HT. CHECK OK RHV. | | | | | | | | | | | | | | | |
| 8 | 3/2 | 1930 | 2035 | 25 | 200 | 5296 | 1092 | 57.4 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 | 19 |
| 9 | | | | | | | | | END OF Dyno Test | | | | | | | | | | | | | | | |

AIR FLOW NOZZLE SIZE: 12 12

| Line | LF | RF | Blower D LF | Blower D RF | Manif LB | Manif RB | Blower Inlet LF (°F) | Blower Inlet RF (°F) | Blower Discharge LF | Blower Discharge RF | Air Manif LB (°F) | Air Manif RB (°F) | Nozzle LF | Nozzle RF | Baro (Corr) in Hg | Air (°F) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .6 | .5 | .8 | .8 | .6 | .6 | 67 | 67 | 74 | 74 | 74 | 74 | .6 | .5 | 29.72 | 67 |
| 2 | 1.0 | 1.1 | 2.0 | 2.0 | 1.8 | .3 | 68 | 68 | 87 | 86 | 82 | 82 | .9 | 1.0 | 29.44 | 68 |
| 3 | 1.2 | 1.2 | 3 | 2.3 | 2.1 | 2.1 | 70 | 70 | 89 | 89 | 85 | 87 | 1.1 | 1.1 | 29.42 | 70 |
| 4 | 2.3 | 2.3 | 5.3 | 5.3 | 5.1 | 5.1 | 68 | 68 | 109 | 1025 | 104 | 107 | 2.1 | 2.2 | 29.43 | 68 |
| 5 | 4.6 | 4.0 | 15.0 | 15.1 | 14.6 | 14.6 | ~~109~~ ~~105~~ 67 | 67 | 158 | 161 | 126 | 126 | 4.4 | 4.0 | 29.43 | 67 |
| 8 | .5 | .5 | .9 | .9 | .8 | .8 | 70 | 70 | 78 | 78 | 75 | 75 | .5 | .5 | 29.63 | 70 |

FUEL OIL DATA / DIESEL BSFC

| Line | Manif | | | | | Lbs Meas | Time | lb/hr | (Corr) lb/bhp-hr |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 33 | | | | | | | | |
| 2 | 36.5 | 34.4 | 65 | 18169 | 18190 | 392 | 2704 | .522 | .352 |
| 3 | 34.5 | 34.5 | 73 | 18220 | 18190 | 412 | 2741 | .541 | .357 |
| 4 | 40.0 | 34.6 | 77 | 18225 | 18190 | 610 | 2723 | .804 | .372 |
| 5 | 35.6 | 35.0 | 80 | 18270 | 18190 | 720 | 1700 | 1.525 | .325 |
| 8 | 34 | | | | | | | | |

REMARKS

STARTENGINE 2041 - 2056 15 MIN HECK OK

Dropped Load for cold compression with a KIENE Gauge

Shut Down to check out Op II shut Down

HAVE A Bad Line to RB low L.O. Trip

220 / 270

AIR FLOW NOZZLE COEFFICIENT: LF 12783 RF 12783

OPERATOR: RHV / [illegible] 2-5 — DATE: 2-27-78 — JOB: 2814 — A

WITNESS: [illegible], BAIBERT ASSOC.

C.E.I. P.O. NO. P-1352-S P.N.P.P. UNIT NO. 1 G.A.I. S/N ITEM [illegible]

POWER ENGINE FACTORY TEST LOG

ENGINE AND COMPRESSOR DIVISION, OAKLAND CALIFORNIA

CUSTOMER: CLEVELAND, ELECTRIC  MODEL: DSRV-16-4  TYPE SERVICE: GEN.  JOB NO. 2814  ENGINE NO. 75051

LOG 1 B  DIRECTION OF ROTATION: CW

EXHAUST TEMPERATURES °F

| | Turbine Exhaust LF | RF | LR | RR | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 400 | | | 456 | 455 | 455 | 448 | 459 | 464 | 480 | 470 | 546 | 548 | 530 | 515 | 500 | 515 | 500 | 470 |
| 2 | 484 | 450 | | | 500 | 482 | 492 | 480 | 478 | 491 | 479 | 508 | 560 | 581 | 550 | 555 | 530 | 533 | 551 | 510 |
| 3 | 472 | 439 | | | 504 | 481 | 490 | 478 | 478 | 493 | 481 | 510 | 561 | 572 | 552 | 551 | 531 | 532 | 541 | 604 |
| 4 | 572 | 531 | | | 601 | 582 | 597 | 581 | 562 | 597 | 578 | 630 | 673 | 670 | 660 | 661 | 638 | 640 | 650 | 642 |
| 5 | 751 | 700 | | | 730 | 731 | 750 | 732 | 728 | 770 | 730 | 760 | 850 | 744 | 801 | 851 | 811 | 812 | 840 | 768 |
| 6 | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | |
| 8 | 410 | 430 | | | 508 | 532 | 515 | 500 | 486 | 488 | 496 | 450 | 470 | 464 | 466 | 458 | 458 | 469 | 452 | 460 |

FIRING PRESSURES - PSIG

| | Engine Water | | | Turbocharger Water Outlet LF | RF | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 9 | 100 | 103 | 103 | 103 | | | | | | | | | | | | | | | | |
| 2 | 9 | 110.5 | 112.5 | 104 | 104 | 580 | 600 | 580 | 580 | 600 | 560 | 580 | 580 | 540 | 520 | 530 | 570 | 550 | 540 | 540 | 550 |
| 3 | 9 | 101.5 | 106 | 104 | 104 | 580 | 600 | 580 | 570 | 600 | 570 | 580 | 570 | 550 | 540 | 540 | 575 | 560 | 550 | 550 | 560 |
| 4 | 11.0 | 121 | 127 | 128 | 128 | 595 | 600 | 595 | 580 | 610 | 570 | 580 | 580 | 570 | 550 | 550 | 580 | 560 | 560 | 560 | 570 |
| 5 | 11.5 | 149 | 154.5 | 159 | 159 | 860 | 830 | 830 | 830 | 850 | 800 | 820 | 800 | 790 | 740 | 740 | 820 | 740 | 760 | 740 | 820 |
| 8 | 10 | 124 | 125 | 127 | 127 | | | | | | | | | | | | | | | | |

| | Lube Oil Press. From Pump | To Engine | Turbocharger LF | RF | Lube Oil Temp. To Engine | From Engine | Crank Case Press | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | 50.5 | 49 | 28 | 28 | 96 | 100 | 0 | 2310 BROUGHT DOWN LOAD TO TAKE COLD COMP. |
| 2 | 55 | 54 | 32 | 30.5 | 127 | 131 | 2.1 | ALL 4 AIR START VALVES CHECKED & BOTH AIR START DIST. WORKING PROPERLY |
| 3 | 56 | 55 | 33 | 31 | 144 | 145.5 | 2.1 | |
| 4 | 55 | 54 | 32.5 | 31 | 147 | 154 | 2.0 | |
| 5 | 54 | 53 | 31.8 | 30 | 156 | 167 | 1.5 | Pulled #2 link rod changed pin. Pulled #6 liner Replaced with new liner. |
| 6 | ~~51~~ | ~~50~~ | ~~28~~ | ~~27.5~~ | ~~107~~ | ~~107~~ | | |
| 8 | 51 | 50 | 28 | 27.5 | 107 | 107 | -2.2 | |

C.E.I.
P.O. NO. P-1152-S
P.N.P.P. UNIT NO. 1
G.A.I. B/M ITEM [illegible]

COMMONWEALTH 2710

OPERATOR: [illegible]  DATE: 2-17-78  LOG 1 B
ENGINEER:
WITNESS: [illegible]

00109

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 1 A

CUSTOMER CLEVELAND ELECTRIC MODEL DSAV-16-4 TEST STAND NUCLEAR JOB NO. 2815 ENGINE NO. 75052 FULL LOAD RATING 9687 BHP @ 450 RPM 223 BMEP

| Line | Date | Wall Clock Time On Load | Wall Clock Time This Log | % Load | RPM | Dyna Scale | BHP (Corr) | BMEP | Disc Revs | Time | Power Factor | AC Volts | AC Amps | KW | Gen Eff | BHP (Corr) | BMEP | Gov Load Limit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3-29 | 0110 | 0200 | 50 | 450 | 57364 | 4915 | 113 | | | | | | | | | | |
| 2 | 3-29 | 0940 | 1040 | 75 | 450 | 85162 | 7296 | 168 | | | | | | | | | | |
| 3 | 3-29 | 1115 | 1215 | 100 | 450 | 113068 | 9687 | 223 | | | | | | | | | | |
| 4 | 3-29 | 1215 | 1315 | 100 | 450 | 113058 | 9687 | 223 | | | | | | | | | | |
| 5 | 3-29 | 1320 | 1420 | 25 | 450 | 29143 | 2497 | 58 | | | | | | | | | | |
| 6 | 3-29 | 1425 | 1525 | 110 | 450 | 124367 | 10656 | 245.8 | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | |

Fuel Pump Rack Position (MM)

| Line | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | | | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | | |
| 2 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | | | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | | |
| 3 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | | | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | | |
| 4 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | | | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | | |
| 5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.6 | 20.5 | | |
| 6 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | | | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | | |
| 7 | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | |

Turbocharger Pressures

| Line | Blower Inlet (in. H2O) LF | RF | LR | RR | Blower Discharge (in. Hg) LF | RF | LR | RR | Air Manif. (in. Hg) LB | RB | Turbine Inlet (in. Hg) LF | RF | LR | RR | Turbine Exhaust (in. H2O) LF | RF | LR | RR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5.7 | 6.2 | | | 20.0 | 20.2 | | | 20.1 | 20.1 | | | | | | | | |
| 2 | 10.0 | 10.9 | | | 33.1 | 33.4 | | | 32.8 | 32.9 | | | | | | | | |
| 3 | 16.9 | 17.9 | | | 49.9 | 50.0 | | | 49.2 | 49.8 | | | | | | | | |
| 4 | 16.2 | 16.8 | | | 49.9 | 49.9 | | | 49.2 | 49.8 | | | | | | | | |
| 5 | 3.1 | 3.1 | | | 8.5 | 8.5 | | | 8.4 | 8.4 | | | | | | | | |
| 6 | 19.2 | 20.3 | | | 56.0 | 54.9 | | | 55.8 | 55.9 | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | |

Turbocharger Temperatures / Air Flow

| Line | Blower Inlet (°F) LF | RF | LR | RR | Blower Discharge (°F) LF | RF | LR | RR | Air Manif. (°F) LB | RB | Turbocharger RPM LF | RF | LR | RR | Nozzle Δh (in. H2O) LF | RF | LR | RR | Air Flow SCFM Total | Ambient Baro (Corr) in. Hg | Ambient Air (°F) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 72 | 68 | | | 186 | 187 | | | 128 | 129 | | | | | 5.9 | 6.0 | | | 14177 | 29.78 | 72 |
| 2 | 68 | 66 | | | 221 | 237 | | | 129 | 129 | | | | | 10.1 | 10.7 | | | 18828 | 29.83 | 68 |
| 3 | 71 | 67 | | | 305 | 303 | | | 128 | 129 | | | | | 16.1 | 17.2 | | | 23759 | 29.84 | 71 |
| 4 | 72 | 69 | | | 309 | 306 | | | 133 | 133 | | | | | 15.8 | 16.8 | | | 23505 | 29.83 | 71 |
| 5 | 73 | 71 | | | 133 | 136 | | | 131 | 131 | | | | | 3.0 | 3.0 | | | 5033 | 29.83 | 73 |
| 6 | 75 | 71 | | | 334 | 338 | | | 129 | 131 | | | | | 18.4 | 20.0 | | | 25412 | 29.83 | 75 |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | |

Fuel Oil Data / Diesel BSFC

| Line | Manif. (psig) | API Gravity As Meas. | @ °F | API Corrected to 60°F | LHV (Btu/lb) | Lbs Meas. | Time (sec) | lb/hr | (Corr) gal/hr | (Corr) lb/bhp-hr |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 36.0 | 34.5 | 72 | 33.7 | 18350 | 610 | 1206 | 1821 | 255.4 | .374 |
| 2 | 38.5 | 34.8 | 76 | 33.7 | 18350 | 1700 | 2425 | 2524 | 340.1 | .349 |
| 3 | 36.5 | 34.6 | 73 | 33.7 | 18350 | 1700 | 1775 | 3448 | 483.6 | .359 |
| 4 | 36.5 | 34.7 | 75 | 33.6 | 18345 | 1700 | 1779 | 3440 | 482.1 | .358 |
| 5 | 42.5 | 34.7 | 75 | 33.6 | 18345 | 670 | 2443 | 987 | 136.4 | .399 |
| 6 | 35.5 | 35.3 | 82 | 33.8 | 18355 | 1700 | 1591 | 3847 | 539.9 | .364 |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |

Fuel Gas Data: Manif. | LHV Btu/ft³ | To Gas Meter: Press (in. Hg) | °F | Corr Factor | Gas BSFC: ft³ Meas | Time (sec) | ft³/hr (Corr) | Btu/bhp-hr | Dual Fuel BSFC: Pilot Btu/bhp-hr | Gas Btu/bhp-hr | Total Btu/bhp-hr — (no entries)

Remarks:

C.E.I.
P.O. NO. P-1152-S
P.N.P.P. UNIT NO. 1
G.A.I. B/M ITEM 1R43C001B

GILBERT/COMMONWEALTH 2710 Q/C-QA

22° LB 21° RB

#2 DIESEL - STANDARD

SHELL

AIR FLOW NOZZLE COEFFICIENT LF 12283 RF 12283 LR RR

OPERATOR G. MEIER / R. VITAL DATE 3-29-78

ENGINEER R. KAISER LOG NO 1 A

WITNESS R. Heller - GILBERT ASSOCIATES INC JOB NO 2815

000599

ENGINE AND COMPRESSOR DIVISION OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 1 B

CUSTOMER CLEVELAND ELECTRIC MODEL DSRV-16-4 TYPE SERVICE NUCLEAR STANDBY JOB NO. 2815 ENGINE NO. 750

DIRECTION OF ROTATION (AS VIEWED FROM FLYWHEEL END) CW

EXHAUST TEMPERATURES - °F

| Line | Turbine Inlet (T - Top, B - Bottom) LFTL | LFTR | LFB | RFT | RFB | LRT | LRB | RRTL | RRTR | RRB | Turbine Exhaust LF | RF | LR | RR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | 640 | 638 | | |
| 2 | | | | | | | | | | | 662 | 668 | | |
| 3 | | | | | | | | | | | 701 | 711 | | |
| 4 | | | | | | | | | | | | 718 | | |
| 5 | | | | | | | | | | | | 501 | | |
| 6 | | | | | | | | | | | | 748 | | |
| 7 | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | |

| Line | Exhaust Elbows 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 802 | 780 | 791 | 854 | 835 | 811 | 842 | 839 | | | 809 | 809 | 810 | 835 | 827 | 875 | 806 | 862 | | | 824 |
| 2 | 887 | 872 | 883 | 929 | 847 | 870 | 847 | 894 | | | 830 | 907 | 880 | 957 | 824 | 943 | 801 | 946 | | | 883 |
| 3 | 956 | 992 | 1005 | 984 | 918 | 963 | 919 | 946 | | | 926 | 1012 | 970 | 1036 | 954 | 1009 | 939 | 979 | | | 969 |
| 4 | 961 | 1004 | 1012 | 990 | 922 | 959 | 921 | 951 | | | 932 | 1013 | 974 | 1035 | 956 | 1012 | 941 | 982 | | | 973 |
| 5 | 694 | 691 | 674 | 707 | 720 | 709 | 722 | 713 | | | 676 | 669 | 715 | 666 | 742 | 693 | 694 | 675 | | | 698 |
| 6 | 1002 | 1047 | 1054 | 1023 | 960 | 1005 | 956 | 992 | | | 979 | 1060 | 1024 | 1080 | 1004 | 1047 | 995 | 1019 | | | 1015 |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | |

| Line | Engine Water PSIG to Engine | To Engine (°F) | From Engine (°F) | Turbocharger Water Outlet (°F) LF | RF | LR | RR | Aftercooler Water Inlet (°F) F | R | Outlet (°F) F | R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26 | 163 | 166 | 168 | 168 | | | 141 | | 143 | |
| 2 | 24 | 161 | 166 | | 168 | | | 139 | | 141 | |
| 3 | 24 | 167 | 173 | | 176 | | | 138 | | 140 | |
| 4 | 24 | 170 | 176 | | 178 | | | 133 | | 145 | |
| 5 | 24 | 158 | 161 | | 161 | | | 100 | | 103 | |
| 6 | 24 | 169 | 176 | | 178 | | | 141 | | 145 | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |
| 9 | | | | | | | | | | | |
| 10 | | | | | | | | | | | |

FIRING PRESSURES - PSIG

| Line | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 880 | 880 | 880 | 875 | 880 | 870 | 870 | 880 | | | 870 | 840 | 850 | 830 | 850 | 890 | 840 | 890 | | | 870 |
| 2 | 1180 | 1180 | 1150 | 1140 | 1170 | 1170 | 1150 | 1170 | | | 1160 | 1160 | 1160 | 1190 | 1120 | 1210 | 1120 | 1220 | | | 1170 |
| 3 | 1480 | 1510 | 1480 | 1440 | 1490 | 1510 | 1490 | 1480 | | | 1510 | 1510 | 1530 | 1520 | 1520 | 1530 | 1540 | 1520 | | | 1500 |
| 4 | 1480 | 1510 | 1480 | 1440 | 1490 | 1510 | 1490 | 1480 | | | 1510 | 1510 | 1530 | 1520 | 1520 | 1530 | 1540 | 1520 | | | 1500 |
| 5 | 600 | 610 | 590 | 580 | 620 | 620 | 600 | 590 | | | 590 | 590 | 610 | 600 | 600 | 600 | 600 | 590 | | | 600 |
| 6 | 1580 | 1620 | 1590 | 1580 | 1600 | 1600 | 1560 | 1580 | | | 1620 | 1610 | 1620 | 1610 | 1630 | 1620 | 1630 | 1640 | | | 1610 |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | |

| Line | Lubricating Oil Pressure - PSIG From Pump | To Engine | Cam Header | To Turbocharger LF | RF | LR | RR | Lubricating Oil Temperature °F To Engine | From Engine | Turbocharger Drain LF | RF | LR | RR | Crank Case Press. " H2O | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 58 | 65 | | 35.5 | 33.0 | | | 158 | 173 | | | | | -1.9 | |
| 2 | 57.5 | 54 | | 34.0 | 32.0 | | | 157 | 173 | | | | | -1.5 | |
| 3 | 57.5 | 54 | | 33.5 | 31.8 | | | 159 | 177 | | | | | -1.5 | |
| 4 | 57 | 64 | | 33.0 | 32.0 | | | 161 | 181 | | | | | -1.5 | |
| 5 | 58 | 55 | | 35.5 | 33.7 | | | 158 | 169 | | | | | -1.9 | |
| 6 | 57 | 54 | | 33.0 | 31.5 | | | 160 | 180 | | | | | -1.2 | |
| 7 | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | |

INFORMATION ONLY

GILBERT/COMMONWEALTH 2710 Q/C-QA

C.E.I.
P.O. NO. P-1152-S
P.N.P.P. UNIT NO. 1
G.A.I. B/M ITEM 1R43C001B

TURBOCHARGER MAKE & MODEL LF EL BC090 RF EL BC090

OPERATOR G. MEIER / R. VITAL DATE 3-29-78
ENGINEER R. KAISER LOG 1 B
WITNESS R. Heller - GILBERT ASSOCIATES INC. JOB NO. 2815

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

POWER ENGINE FACTORY TEST LOG — LOG 1 A

CUSTOMER: CLEVELAND ELETRIC  MODEL: DSRV-16-4  TEST STAND: 23  JOB NO: 2815  ENGINE NO: 75052  FULL LOAD RATING: 9687 BHP @ 450 RPM 223 BMEP

| LINE | DATE | WALL CLOCK TIME ON LOAD | WALL CLOCK TIME THIS LOG | % LOAD | DYNAMOMETER RPM | SCALE | BHP (Corr) | BMEP | DISC REVS | TIME | POWER FACTOR | A.C. VOLTS | A.C. AMPS | KW | GEN EFF. | BHP (Corr) | BMEP | GOV LOAD LIMIT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3/28 | 1510 | 1510 | 25 | 210 | 29143 | 1165 | 58 | | | | | | | | | | |
| 2 | 3/28 | 1750 | 1850 | 25 | 210 | 29143 | 1165 | 58 | | | | | | | | | | |
| 3 | 3/28 | 2200 | 2300 | 25 | 270 | 29143 | 1498 | 58 | | | | | | | | | | |
| 4 | 3/28 | 2300 | 2400 | 25 | 380 | 29143 | 2109 | 58 | | | | | | | | | | |
| 5 | 3/29 | 2400 | 0100 | 50 | 400 | 57361 | 4369 | 113 | | | | | | | | | | |
| 6 | 3/29 | 0110 | 0800 | 50 | 450 | 57361 | 4915 | 115 | | | | | | | | | | |
| 7 | 3/29 | 0940 | 1040 | 75 | 450 | 85522 | 7296 | 168 | | | | | | | | | | |
| 8 | 3/29 | 1115 | 1215 | 100 | 450 | 113058 | 9687 | 223 | | | | | | | | | | |
| 9 | 3/29 | 1215 | 1315 | 100 | 450 | 113078 | 9687 | 223 | | | | | | | | | | |
| 10 | 3/29 | 1320 | 1420 | 25 | 450 | 29143 | 2497 | 58 | | | | | | | | | | |

FUEL PUMP RACK POSITION (MM)

| LINE | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | | | | | |
| 2 | 19 | | | | | | | | | | 19 | | | | | | | | | |
| 3 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | | | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | | |
| 4 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | | | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 | | |
| 5 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | | | 26 | 26 | 26 | 26 | 26 | 26 | 26 | 26 | | |
| 6 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | | | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | 26.5 | | |
| 7 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | | | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | 30.5 | | |
| 8 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | | | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | | |
| 9 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | | | 37 | 37 | 37 | 37 | 37 | 37 | 37 | 37 | | |
| 10 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | | | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | | |

TURBOCHARGER PRESSURES

| LINE | BLOWER INLET (in H2O) LF | RF | LR | RR | BLOWER DISCHARGE (in Hg) LF | RF | LR | RR | AIR MANIF (in Hg) LB | RB | TURBINE INLET (in Hg) LF | RF | LR | RR | TURBINE EXHAUST (in H2O) LF | RF | LR | RR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | | | |
| 2 | .6 | .6 | | | 1.1 | 1.1 | | | 1.1 | 1.1 | | | | | | | | |
| 3 | 1.1 | 1.1 | | | 2.4 | 2.4 | | | 2.4 | 2.4 | | | | | | | | |
| 4 | 2.0 | 2.1 | | | 5.3 | 5.5 | | | 5.3 | 5.3 | | | | | | | | |
| 5 | 4.5 | 4.7 | | | 15.7 | 16.0 | | | 15.7 | 15.7 | | | | | | | | |
| 6 | 5.7 | 6.2 | | | 20.0 | 20.2 | | | 20.1 | 20.1 | | | | | | | | |
| 7 | 10.0 | 10.4 | | | 33.1 | 33.4 | | | 32.8 | 32.9 | | | | | | | | |
| 8 | 16.9 | 17.4 | | | 49.9 | 50.0 | | | 49.2 | 49.8 | | | | | | | | |
| 9 | 16.2 | 16.8 | | | 49.9 | 49.9 | | | 49.2 | 49.8 | | | | | | | | |
| 10 | 3.1 | 3.1 | | | 8.5 | 8.5 | | | 8.4 | 8.4 | | | | | | | | |

TURBOCHARGER TEMPERATURES / AIR FLOW (AIR FLOW NOZZLE SIZE ► 12" 12")

| LINE | BLOWER INLET (°F) LF | RF | LR | RR | BLOWER DISCHARGE (°F) LF | RF | LR | RR | AIR MANIF (°F) LB | RB | TURBOCHARGER RPM LF | RF | LR | RR | NOZZLE ΔP (in H2O) LF | RF | LR | RR | AIR FLOW SCFM TOTAL | AMBIENT BARO (Corr) in Hg | AIR (°F) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | | | | | | |
| 2 | 67 | 66 | | | 81 | 72 | | | 80 | 81 | | | | | .6 | .6 | | | | 29.77 | 67 |
| 3 | 68 | 68 | | | 92 | 93 | | | 90 | 91 | | | | | 1.1 | 1.1 | | | | 29.76 | 68 |
| 4 | 71 | 68 | | | 112 | 113 | | | 110 | 111 | | | | | 2.0 | 2.1 | | | | 29.78 | 71 |
| 5 | 71 | 68 | | | 165 | 166 | | | 133 | 134 | | | | | 4.5 | 4.7 | | | | 29.78 | 71 |
| 6 | 72 | 68 | | | 186 | 187 | | | 128 | 129 | | | | | 5.9 | 6.0 | | | | | 72 |
| 7 | 68 | 66 | | | 221 | 237 | | | 129 | 129 | | | | | 10.1 | 10.9 | | | | 29.83 | 68 |
| 8 | 71 | 67 | | | 305 | 303 | | | 128 | 129 | | | | | 16.1 | 17.2 | | | | 29.84 | 71 |
| 9 | 72 | 69 | | | 309 | 306 | | | 133 | 133 | | | | | 15.8 | 16.8 | | | | 29.83 | 71 |
| 10 | 73 | 71 | | | 133 | 134 | | | 131 | 131 | | | | | 3.0 | 3.0 | | | | 29.83 | 73 |

FUEL OIL DATA / DIESEL BSFC

| LINE | MANIF Temp | API GRAVITY AS READ | @ °F | API Corrected to 60°F | LHV (Btu/lb) | LBS MEAS | TIME (sec) | lb/hr | Btu/bhp hr | (Corr) lb/bhp hr |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | |
| 2 | 41 | | | | | | | | | |
| 3 | 39.5 | | | | | | | | | |
| 4 | 38.5 | | | | | | | | | |
| 5 | 36.5 | | | | | | | | | |
| 6 | 36.0 | 34.5 | 72 | 18890 | 18350 / 18201 | 610 | 1206 | | | .373 / .376 |
| 7 | 38.5 | 34.8 | 76 | 18190 | 18165 | 1700 | 2425 | 2524 | | .349 |
| 8 | 36.5 | 34.6 | 73 | 18190 | 18150 | 1700 | 1775 | 3448 | | .359 |
| 9 | 36.5 | 34.7 | 75 | 18190 | 18150 | 1700 | 1779 | 3440 | | .358 |
| 10 | 42.5 | 34.7 | 75 | 18190 | 18330 | 670 | 2443 | 987 | | .399 |

FUEL GAS DATA / GAS BSFC / DUAL FUEL BSFC: (no entries)

REMARKS

STARTED unit At 1355-1410 FOR 15 MIN - Heat check. OK Gurn
Line 1 shut down to Reset All Valves
Shut Down to check L.O. Trip, will not Reset - installed New one
Unit shut Down High J.W. Temp Do to the stack Being over the locate of the trip

22" 21"
#2 Diesel STANDARD
Shell

AIR FLOW NOZZLE COEFFICIENT: LF 12243  RF 12283

OPERATOR: Gurn VH 2-5
ENGINEER: P. [illegible] 3/28/78
[illegible] 3/29/78
DATE: 3-28-78  LOG NO: 1 A  JOB NO: 2815

ENGINE AND COMPRESSOR DIVISION, OAKLAND, CALIFORNIA

# POWER ENGINE FACTORY TEST LOG

LOG 1 B

CUSTOMER CLEVELAND MODEL DSRV-16-4 TYPE SERVICE Stationary JOB NO 2815 ENGINE NO 75052 DIRECTION OF ROTATION (AS VIEWED FROM FLYWHEEL END) C.W

## EXHAUST TEMPERATURES - °F

### Turbine Inlet (T - Top, B - Bottom)

| Line | LFTL | LFTR | LFB | RFT | RFB | LRT | LRB | RRTL | RRTR | RRB |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |

### Turbine Exhaust and Exhaust Elbows

| Line | Turbine Exhaust LF | RF | LR | RR | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | 354 | | | 505 | 496 | 478 | 477 | 496 | 496 | 504 | 440 | | | 499 | 486 | 495 | 462 | 521 | 503 | 483 | 474 | | | |
| 3 | 390 | 386 | ~~390~~ | | 536 | 524 | 510 | 516 | 533 | 529 | 551 | 529 | | | 525 | 513 | 524 | 492 | 552 | 528 | 519 | 513 | | | |
| 4 | 462 | 453 | | | 621 | 546 | 581 | 607 | 619 | 618 | 633 | 630 | | | 611 | 581 | 620 | 574 | 633 | 615 | 600 | 609 | | | |
| 5 | 610 | 603 | | | 762 | 757 | 722 | 758 | 758 | 766 | 783 | 784 | | | 732 | 757 | 759 | 757 | 764 | 784 | 772 | 769 | | | |
| 6 | 640 | 638 | | | 802 | 780 | 791 | 854 | 835 | 811 | 842 | 899 | | | 809 | 809 | 810 | 855 | 827 | 875 | 806 | 862 | | | |
| 7 | 662 | 668 | | | 887 | 872 | 883 | 929 | 847 | 870 | 847 | 894 | | | 830 | 907 | 880 | 957 | 834 | 943 | 801 | 946 | | | |
| 8 | 701 | 711 | | | 956 | 992 | 1005 | 984 | 918 | 963 | 919 | 946 | | | 924 | 1012 | 970 | 1036 | 954 | 1009 | 939 | 979 | | | |
| 9 | N/A | 718 | | | 961 | 1004 | 1012 | 990 | 922 | 959 | 921 | 961 | | | 932 | 1013 | 974 | 1035 | 956 | 1012 | 941 | 982 | | | |
| 10 | N/A | 501 | | | 694 | 691 | 674 | 707 | 730 | 709 | 722 | 713 | | | 676 | 669 | 715 | 666 | 742 | 693 | 694 | 675 | | | |

### Engine Water, Turbocharger Water and Aftercooler Water

| Line | Engine Water PSIG to Engine | To Engine (°F) | From Engine (°F) | Turbocharger Water Outlet (°F) LF | RF | LR | RR | Aftercooler Water Inlet (°F) F | R | Outlet (°F) F | R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | |
| 2 | 9.5 | 151 | 152 | 155 | 155 | | | 68 | | 68 | |
| 3 | 10. | 158 | 161 | 162 | 162 | | | 112 | | 94 | |
| 4 | 22.5 | 142 | 145 | 145 | 145 | | | 68 | | 69 | |
| 5 | 24 | 161 | 163 | 165 | 165 | | | 138 | | 139 | |
| 6 | 26 | 163 | 166 | 168 | 168 | | | 141 | | 173 | |
| 7 | 24 | 161 | 166 | N/A | 168 | | | 139 | | 141 | |
| 8 | 24 | 167 | 173 | N/A | 176 | | | 138 | | 140 | |
| 9 | 24 | 170 | 176 | N/A | 178 | | | 133 | | 145 | |
| 10 | 24 | 158 | 161 | N/A | 161 | | | 100 | | 103 | |

### FIRING PRESSURES - PSIG

| Line | 1L | 2L | 3L | 4L | 5L | 6L | 7L | 8L | 9L | 10L | 1R | 2R | 3R | 4R | 5R | 6R | 7R | 8R | 9R | 10R | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | | | | | | |
| 2 | 600 | 600 | 585 | 575 | 590 | 600 | 590 | 595 | | | 590 | 570 | 580 | 560 | 590 | 570 | 575 | 570 | | | |
| 3 | 590 | 590 | 580 | 575 | 570 | 595 | 600 | 590 | | | 570 | 560 | 585 | 560 | 575 | 570 | 580 | 570 | | | |
| 4 | 600 | 590 | 580 | 575 | 585 | 600 | 595 | 590 | | | 580 | 570 | 590 | 565 | 580 | 570 | 580 | 570 | | | |
| 5 | 840 | 840 | 835 | 810 | 825 | 840 | 835 | 840 | | | 810 | 800 | 840 | 825 | 810 | 820 | 840 | 830 | | | |
| 6 | 880 | 880 | 880 | 825 | 880 | 870 | 870 | 850 | | | 870 | 840 | 850 | 850 | 850 | 890 | 840 | 890 | | | |
| 7 | 1180 | 1180 | 1150 | 1140 | 1120 | 1120 | 1150 | 1170 | | | 1160 | 1160 | 1160 | 1190 | 1120 | 1210 | 1120 | 1220 | | | |
| 8 | 1480 | 1510 | 1480 | 1440 | 1490 | 1510 | 1490 | 1480 | | | 1510 | 1510 | 1530 | 1520 | 1620 | 1530 | 1540 | 1510 | | | |
| 9 | 1480 | 1510 | 1480 | 1440 | 1490 | 1510 | 1450 | 1480 | | | 1510 | 1510 | 1530 | 1520 | 1510 | 1530 | 1540 | 1520 | | | |
| 10 | 600 | 610 | 590 | 580 | 620 | 620 | 600 | 590 | | | 590 | 590 | 610 | 600 | 600 | 600 | 600 | 590 | | | |

### Lubricating Oil Pressure - PSIG, Lubricating Oil Temperature °F, Crank Case Press

| Line | Lub. Oil Press. From Pump | To Engine | Cam Header | To Turbocharger LF | RF | LR | RR | Lub. Oil Temp. To Engine | From Engine | Turbocharger Drain LF | RF | LR | RR | Crank Case Press " $H_2O$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | |
| 2 | 58 | 55 | | 36 | 34 | | | 127 | 129 | | | | | -2.4 |
| 3 | 58 | 55 | | 36 | 34 | | | 152 | 153 | | | | | -2.2 |
| 4 | 55 | 52 | | 33.5 | 31.5 | | | 158 | 164 | | | | | -2.0 |
| 5 | 58 | 56 | | 36 | 33 | | | 158 | 169 | | | | | -1.9 |
| 6 | 58 | 55 | | 35.5 | 33 | | | 158 | 173 | | | | | -1.9 |
| 7 | 57.5 | 54 | | 34.0 | 32 | | | 159 | 173 | | | | | -1.5 |
| 8 | 57.5 | 54 | | 33.5 | 31.8 | | | 159 | 177 | | | | | -1.5 |
| 9 | 57 | 54 | | 33 | 32 | | | 161 | 181 | | | | | -1.5 |
| 10 | 58 | 55 | | 33.5 | 33.7 | | | 158 | 169 | | | | | -1.9 |

REMARKS

BROUGHT DOWN LOAD & SPEED FOR COLD COMP.

C.E.I.
P.O. NO. P-1152-S
P.N.P.P. UNIT NO. 1
G.A.I. B/M ITEM 1R45C001B

GILBERT/COMMONWEALTH 2710 Q/C-QA

INFORMATION ONLY

TURBOCHARGER MAKE & MODEL
LF RF
LR RR

OPERATOR R. Lomme VW, TS DATE 3-25-78
ENGINEER R. Vern 3/27/78 LOG 1 B
WITNESS [illegible] 3/23/78 JOB NO 2815

EXHIBIT 19

# ANALYSIS OF FIRING PRESSURES FOR PNPP DIV. 1 + 2 ENGINES (FROM FACTORY TEST RECORDS)

(All pressures in psig)

| Engine | AVG. PRESSURE, LB | AVG. PRESSURE, RB | Pmax | Pmin | ΔP |
|---|---|---|---|---|---|
| DIVISION 1, No. 75051 | 815 | 816 | 860 | 770 | 90 |
| | 1141 | 1151 | 1240 | 1100 | 140 |
| | 1450 | 1444 | 1500 | 1390 | 110 |
| | 1440 | 1424 | 1480 | 1380 | 100 |
| | 580 | 581 | 630 | 550 | 80 |
| | 1576 | 1591 | 1640 | 1520 | 120 |
| | | | | | |
| | 583 | 543 | 600 | 520 | 80 |
| | 581 | 553 | 600 | 540 | 60 |
| | 589 | 563 | 610 | 550 | 60 |
| | 828 | 769 | 860 | 740 | 120 |
| DIVISION 2, No. 75052 | 877 | 858 | 890 | 830 | 60 |
| | 1164 | 1168 | 1220 | 1120 | 100 |
| | 1485 | 1522 | 1540 | 1440 | 100 |
| | 1485 | 1522 | 1540 | 1440 | 100 |
| | 601 | 598 | 620 | 580 | 40 |
| | 1589 | 1623 | 1640 | 1560 | 80 |
| | | | | | |
| | 592 | 572 | 600 | 560 | 40 |
| | 589 | 571 | 600 | 560 | 40 |
| | 589 | 574 | 600 | 565 | 35 |
| | 834 | 822 | 840 | 800 | 40 |
| | 873 | 858 | 890 | 830 | 60 |
| | 1164 | 1168 | 1220 | 1120 | 100 |
| | 1485 | 1523 | 1540 | 1440 | 100 |
| | 1485 | 1523 | 1540 | 1440 | 100 |
| | 601 | 598 | 620 | 580 | 40 |

## APPENDIX II

## OPERATING PRESSURES AND TEMPERATURES

### PRESSURES

The following pressures should be present for starting:

| | | |
|---|---|---|
| Starting Air Supply | 250 psi | 17.6 kg/sq cm |
| Starting Air Header | 250 psi | 17.6 kg/sq cm |

While running at rated speed, the operating pressures should be as follows:

| | psi | in.-hg | kg/sq cm |
|---|---|---|---|
| Lubricating Oil* | 50 — 55 | 101.8 — 112.0 | 3.52 — 3.87 |
| Lubricating Oil at Turbocharger Inlet | 20 — 25 | 40.7 — 50.9 | 1.41 — 1.76 |
| Jacket Water | 10 — 30 | 20.4 — 61.1 | 0.70 — 2.11 |
| Fuel Oil | 20 — 30 | 40.7 — 61.1 | 1.41 — 2.11 |

### TEMPERATURES

While running under rated load, the outlet temperatures should be as follows:

| | |
|---|---|
| Lubricating Oil out of Engine* | 170° F — 180° F (76.6° C — 82.2° C) |
| Jacket Water out of Engine | 170° F — 180° F (76.6° C — 82.2° C) |

### EXHAUST TEMPERATURES.

The exhaust temperatures shown on the "Factory Test Results" page are the average for all cylinders during factory test under *local ambient conditions*. Temperatures in the field, therefore, may exceed this average temperature. Exhaust temperatures may be considered normal if within plus or minus 50° F of the average taken for all cylinders. Temperatures, high or low, exceeding this range should be investigated (see Section 7).

### FIRING PRESSURES.

Firing pressures may be considered normal if within plus or minus 75 psi of the average for all cylinders. High or low pressures exceeding this range should be investigated (see Section 7).

### NOTES.

Operating pressures and temperatures listed are established as a guide to proper operation. Except as noted for exhaust temperatures and firing pressures, they should be held to within plus or minus 10 percent. Sudden changes in readings require immediate investigation and correction.

When making adjustments as a result of a high or low cylinder exhaust temperature, or firing pressure, both temperature and pressure readings must be taken into account when determining the proper corrective action.

*When using SAE 40 lubricating oil in engine.

**COMPONENT WEIGHTS.**

The component weights listed below are approximate, and are intended to assist in handling and assembly operations. Suitable weight handling equipment of sufficient weight lifting capacity must always be used when handling heavy and unwieldy parts and assemblies.

| Item | Approximate Weight (lbs) |
|---|---|
| Cylinder head | 1100 |
| Piston and rings (less pin) | 600 |
| Piston pin | 120 |
| Master rod | 624 |
| Link rod and box | 700 |
| Cylinder liner | 600 |
| Cylinder head sub-cover | 365 |
| Cylinder head cover | 30 |
| Camshaft (less cams) RV-12 | 675 |
| RV-16 | 750 |
| Cams (average) | 20 |
| Main bearing caps: Front | 370 |
| Intermediate | 200 |
| Front rear | 300 |
| Rear rear | 300 |

EXHIBIT 21

## PART C – PISTONS AND RODS

### GENERAL.

The design features of the Enterprise® Model RV engine makes it possible to remove the pistons and their attached rods by pulling them straight out through the cylinder liners. Normal procedure is to remove the link rod and piston first, then the master rod and its piston. It is possible, however, to remove either rod without having to remove the other, including its cylinder head. The procedure for removing the master rod without first removing the link rod is slightly different than if the link rod were removed. Connecting rod bearings may be removed without removing either rod and piston, and without having to remove either cylinder head.

**WARNING**

The procedures in the following paragraphs involve the handling of heavy and unwieldy parts in a confined space. All weight handling equipment must be inspected before use, and extreme care must be exercised to insure that the weight of the parts being handled is under complete control at all times. *Under no circumstances should any person to extend any part of his body under any suspended part.*

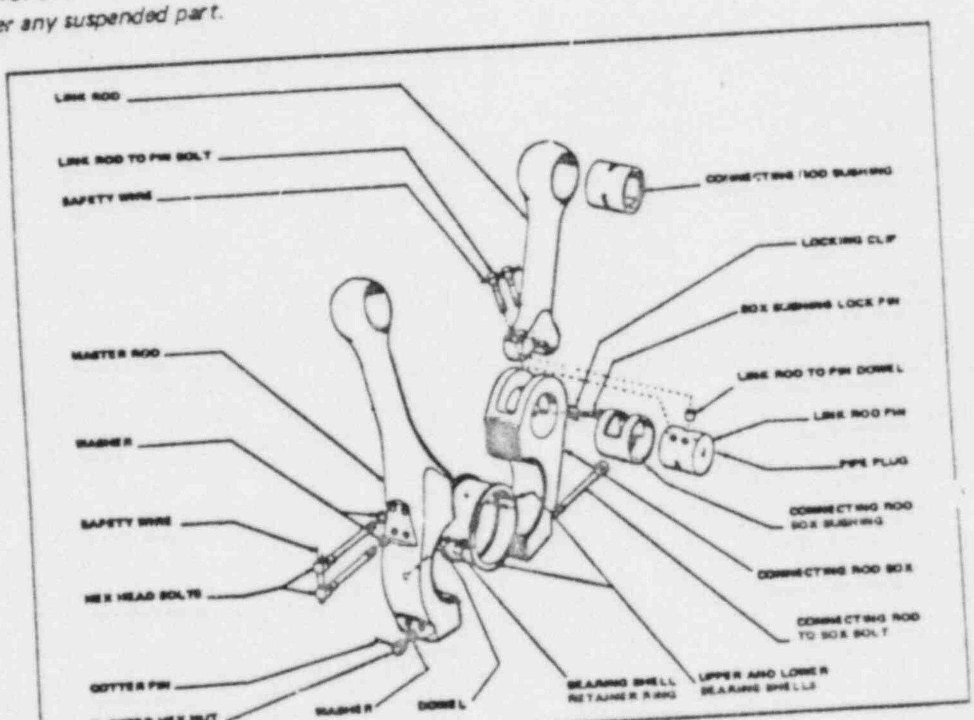


*Figure 6-C-1. Connecting Rod and Bearings*

### PARTS LISTS.

Refer to the below listed group parts lists in the ***Parts Manual*** for a breakdown of the parts covered in this part of the manual.

a. 340 Group Parts List, Connecting Rods.

b. 341 Group Parts List, Pistons.

c. 315 Group Parts List, Cylinder Block and Liners.

d. 590 Group Parts List, Special Tools

MR. JOHNSTON: Well, our position is -- has been that the imbalance that results between the articulated side versus the master side is due to a number of effects, one of which is the difference in the physical geometry of the articulated rod itself, another is due to the difference in the time versus volume in the cylinder, and thus there would be minor differences in the cylinder pressure as a function in time, and also due to the fact that -- which we believe is the biggest fact -- that cylinder pressures typically do not fire exactly evenly, even in one cylinder, let alone in more than one cylinder, and all of those variations, some are more deterministic than others.

For example, the request of Mr. Sarsten for calculating the motion of the articulated rods certainly can be done, but are believed to be small in comparison with the other considerations.

Thus, the way to determine what kind of an imbalance, what kind of response one could get is to perform a torsiograph test and actually measure the response at the particular frequency of concern, the fourth order frequency.

That is what we have proposed to do, and I will be doing on each of the installations.

MR. SARSTEN: This has been done in one of

EXHIBIT 22

EXHIBIT 23

Here we have more of a problem of something being theoretically in balance, but with problems for perhaps drastical stresses if we have a slight imbalance between the cylinders, or if we calculate the motion of the link piston more accurately.

The report just mentions that one is to refrain from running below 440 rpm, except during start and stop, of course, but does not perhaps specifically address the problems that one has there.

If you run briefly through the report, you' not really sure why you should keep above the speed. We really here have a problem if there's imbalance between the two banks, because in theory, of course, if we had identical rods and weight there would be no input exitation at all at that -- at the fourth order.

Perhaps the report should more address the balance between the left and right banks, what will happen if one cylinder misfires; for example, which stresses could we then run into, how long would we be able to operate the engine with one cylinder misfiring, for example.

MR. DINGEE: Has that been a consideration, the lack of balance in the potential for misfiring?

MR. JOHNSTON: The lack of balance has been a concern, and that is the reason why we have requested that each plant conduct a torsiograph test to -- so that the fourth order, the order of concern, the one that is critical at 430 rpm, can in fact be measured.

Specific calculations have not been made assuming either one or more than one cylinders are not firing.

MR. SARSTEN: I think it would improve the report if this was included.

Secondly, we have the problem of the true motion of the link piston.

MR. RAY: Excuse me. Is that something that's typically done in the industry, for all crankshafts, you assume a cylinder misfires, and calculate the stress? Is that a DEMA requirement?

MR. SARSTEN: That's not a DEMA requirement. It is a requirement of Norske Verritas, for example. They automatically have it in their program, a check for a similar misfiring. That's on marine installations.

MR. RAY: Is that an industry standard practice?

MR. SARSTEN: That's standard practice on marine engine installations, yes. But if it would be required here, that is an open question. But because of the severity of the problem, the potential severity if the cylinder misfires, perhaps it should be addressed in this report and strengthen the requirement that you should not go below 440 rpm, for example.

MR. RAY: How do we strangthen when we've --

MR. SARSTEN: What I'm saying is that the --

MR. RAY: We specifically said no, and we've also concluded that the -- on these stationary application they do not, they cannot run at that when they are matched into the grid. I don't think the statement can be any stronger, we don't run at that speed.

MR. SARSTEN: What --

MR. RAY: You can't stay in phase with the grid run at that speed.

MR. SARSTEN: No, but the problem is here, when you're not in phase with the grid, you can't -- can drop both below and above the speed in an emergency situation where you do not have a grid.

MR. COLEMAN: Paul, you might -- maybe you ought to correct me, but we did tests and experienced the rapid load, the pickup and drop of the engine, and looked at the speed range, at least at the Shoreham engine, I know. What did you find there? I think you did put it in the report.

MR. JOHNSTON: The ability of the engine to maintain its speed as controlled by the governor was tested on the Shoreham engines by imposing a step load to the engine while not connected to the grid, to see what various crankshaft analyses. Is that one of those?

MR. SARSTEN: Yes. That was included.

MR. DINGEE: I'm not certain in my own mind how they closed out the concern for imbalances. Where is that --

MR. SARSTEN: No, we didn't close it out.

MR. DINGEE: I think that we were going to rely on their measurement of the engines, but that's something that we need to debate among ourselves how much of that we felt was necessary.

MR. LOUZECKY: Can I bother you for just a minute? Would it pay the owners to have an analysis made of misfiring of one cylinder, particularly the 16? The 16 looks like it could be a serious problem if for any reason one cylinder misfired.

The only way you balance an engine is by checking the rack setting and the exhaust temperature. Other ways get very complex, so I was wondering, would it be worthwhile to have that as a backup production for the Owners Group?

MR. DINGEE: I'd have to ask the consultants what the probability of that event occurring is to see whether we're in never-never land or high-probability land.

MR. HENRIKSEN: One cylinder misfiring? That's very likely to --

MR. DINGEE: Very likely?

MR. HENRIKSEN: We have a report from Grand Gulf that they had a pump stuck. That will do it.

MR. DINGEE: How do you feel about that?

MR. SARSTEN: I feel this report should at least address it and show how large the stresses would be in this case. It would be normal practice for marine engines in Europe.

MR. DINGEE: So we judge that to be important and would like to make that request, then.

MR. SARSTEN: Yes. Because it could lead to a recommendation the engine be shut down, operated at lower power or below a certain power if such a condition occurs.

MR. DINGEE: Have we closed 1-E out, incidentally, this -- the fact that the critical is at 430, which is closer than five percent to the 450, and what the significance of that is?

MR. BUSH: Isn't that tied to the misfiring, to a degree?

MR. HENRIKSEN: It's tied to misfiring, yes.

MR. DINGEE: So it's all part of that same action.

MR. HENRIKSEN: Yes.

MR. DINGEE: Okay.

EXHIBIT 24





# PART H – ENGINE BALANCING

## GENERAL.

The load on a diesel engine should be evenly divided between all cylinders. If it is not, one or more of the cylinders will be forced to carry more than their share of the load while other cylinders loaf with a resulting loss in operating economy and the possibility of experiencing one or more of the following conditions.

a. Scored pistons and liners.

b. Excessive vibration.

c. Excessive piston, valve, bearing and crankshaft wear.

d. Excessive fuel consumption.

e. Excessive lubricating oil usage.

## CYLINDER BALANCE.

The balance between power cylinders on Enterprise diesel engines is obtained by having all the fuel injection pumps read the same millimeter of rack position when the governor is in a position equivalent to full load. In order to accomplish this it is essential that all fuel pumps be calibrated in accordance with the fuel pump manufacturer's specifications. The fuel pump rack levers are adjusted during factory test and the lever clamps are then doweled to the fuel rack shaft.

**CAUTION**

This setting should not be changed in the field, nor should shimming ever be used between the fuel rack lever clamp and the fuel rack lever to change fuel rack settings for individual cylinders. Also, the female rod end which connects the fuel rack lever to the fuel rack should not be adjusted. When a variation in cylinder exhaust temperatures indicates on overloaded or an underloaded cylinder, this condition should not be remedied by changing the individual fuel rack settings. Rather, the real cause of the malfunction should be determined and corrected.

## FUEL INJECTION EQUIPMENT.

Clean fuel is essential to the operation of a diesel engine. Injection equipment is manufactured with close working tolerances and, therefore, dirt or other impurities in the fuel can cause pumps or spray nozzles to malfunction. Small depressions in injector valve seats, some so small they are not visible to the naked eye, may be caused by small particles of dirt and will affect spray patterns in the combustion chamber. Pumps and valves must be checked and cleaned periodically. The frequency of cleaning can best be determined from experience, however, care must be taken not to wait too long before cleaning. Fuel pumps should deliver exact amounts of fuel according to the millimeter settings of their fuel pump racks. If they do not, obviously the balance of the cylinders will be affected and the problem must be corrected. It is recommended that whenever a fuel pump is disassembled for any reason, it be recalibrated in accordance with the manufacturer's specifications.

## ENGINE OUT OF TUNE.

Spray nozzles are usually suspect if an engine is out of tune or smoking. There are other factors which may also contribute to these conditions. All of them should be considered when evaluating engine performance.

PART H — ENGINE BALANCING (Continued)

a. Ignition timing.

b. Short or long burning lag in some fuels.

c. Cetane rating of the fuel.

d. Low compression pressure due to leaking valves.

e. Worn piston rings and/or liners.

f. A change in fuel oil.

g. Defective fuel injection pump(s).

h. Valve or linkage maladjustment.

PREVENTIVE MAINTENANCE.

All available operating information should be used as diagnostic tools for determining the condition of an engine and in planning preventive maintenance actions to maintain the engine in peak operating condition. Among the conditions to be considered, peak firing pressures and cylinder exhaust temperatures are very valuable indicators of the condition of a cylinder. The pyrometer and thermocouples provide individual cylinder exhaust temperature information. There are a number of commercial instruments available to take peak firing pressures and cold compression pressures, and the manufacturer of the model selected can provide detailed instructions for its use. The engine log is also an excellent tool for use in recording engine performance and making diagnostic evaluations for preventive maintenance purposes. Readings should be taken and recorded hourly and be supplemented with written observations of all pertinent factors.

TROUBLE SHOOTING.

When trouble shooting the engine, all available information should be used to determine the cause of a malfunction. The trouble shooting tables in Section 7 can be of assistance, as well as the preventive maintenance curves and the engine logs.

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EXHIBIT 25

SUFFOLK COUNTY, 7/31/84

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

| | |
|---|---|
| In the Matter of<br><br>LONG ISLAND LIGHTING COMPANY<br><br>(Shoreham Nuclear Power Plant, Unit 1). | Docket No. 50-322-OL |

JOINT DIRECT TESTIMONY OF DR. ROBERT N. ANDERSON, PROFESSOR STANLEY G. CHRISTENSEN, G. DENNIS ELEY, ANEESH BAKSHI, DALE G. BRIDENBAUGH AND RICHARD B. HUBBARD REGARDING SUFFOLK COUNTY'S EMERGENCY DIESEL GENERATOR CONTENTIONS

INTRODUCTION

Q. Dr. Anderson, please state your name, address and occupation.

A. My name is Robert N. Anderson, and my business address is Department of Materials Engineering, San Jose State University, San Jose, California. I am a Professor of Materials Engineering at San Jose State University.

Q. Please describe your qualifications and experience which are relevant to the matters you address in this testimony.

## Standards for Crankshaft Design

Q. Are there any standards governing the design of crankshafts in diesel engines?

A. There is no single set of engineering standards governing the design of crankshafts in diesel engines. However, the various ship classification societies have adopted standards for evaluating the adequacy of the design of crankshafts in diesel engines in marine applications. We believe that these standards provide minimum guidance for applications where reliability is a significant evaluation factor. The ship classification societies include Lloyd's Register of Shipping ("Lloyd's"), the American Bureau of Shipping ("ABS"), Nippon Kaiji Kyokai ("NKK"), Det Norske Veritas, and Germanischer Lloyd.

Q. What are ship classification societies?

A. To assure the safety of their vessels, shipowners require shipyards to build and equip their vessels in compliance with the rules of classification societies. Those rules include limitations on propulsion equipment such as diesel engines. Engine builders use these rules as design criteria when designing new engines and major engine components, when increasing the rating of an engine, and when changing the design of major engine components. Prudent engine builders ensure that their engines comply with these rules.

As reported by the NRC's Consultant, Franklin Research Center ("FRC"):

> "Ship classification associations such as the American Bureau of Shipping and Lloyd's Register of Shipping, represent possibly the oldest machinery review and evaluation associations functioning today. Lloyd's Register began operations in 1760 and published its first set of rules in 1834. As ships and ship propulsion systems became more sophisticated, the classification associations served as design review agents to evaluate functional adequacy and safety. Considerable experience in the review and evaluation of diesel engines was realized from the long-term use of diesel engines for propulsion and electric power generation in ships. The ship classification rules probably represent the most extensive experience in large diesel engines available."122/

Q. Why do you believe that the standards set by ship classification societies should be applied to determine the adequacy and reliability of the replacement crankshafts at Shoreham?

---

122/ Evaluation of Diesel Generator Failure at Shoreham Unit 1, Final Report, Failure Cause Evaluation, April 6, 1984, by Franklin Research Center ("FRC Report") at 33-34. (Exhibit 35).

A. Because these standards embody the only comprehensive collections of meaningful guidelines controlling crankshaft design in diesel engines to be used in applications where reliability is a controlling factor. There are no other adequate standards.

Q. The purchase specifications for the EDGs required that the crankshafts conform to the guidelines of the Diesel Engine Maufacturers Association ("DEMA"). Aren't those guidelines a reasonable alternative set of design standards by which adequacy of the design of the replacement crankshafts can be measured?

A. No. Those guidelines are not a design code. As the foreward to the DEMA guidelines explicitly states, "[I]t is not the purpose of this book to attempt to set forth basic design criteria for engines because such approach would be impossible within this volume and yet do justice to the many types of engines on the market, notwithstanding the fact that many technical texts are available to the student who may be undertaking the design criteria aspects of engines in general."123/

---

123/ Standard Practices for Low and Medium Speed Diesel and Gas Engines, 6th ed., 1972 at iii.

Q. Generally speaking, what factors do the classification societies take into consideration in evaluating the adequacy of crankshafts on diesel engines?

A. The various classification societies evaluate the adequacy of the design of diesel engines in different ways and in varying degrees of detail. For instance, Lloyd's rules evaluate the adequacy of the design by calculating the maximum power rating for engines. This calculation takes into consideration 26 inputs, including the manufacturing or forging process of the crankshaft, the strength of the crankshaft material and the existence of fillet radii. Lloyd's rules also calculate the maximum allowable torsional vibration stresses. In addition, unlike most other rules, Lloyd's rules require that auxiliary oil engines that are coupled to electrical generators must be capable under service conditions of developing the power to drive the generators for 15 minutes at an overload power of not less than 10 percent. Lloyd's rules also consider misfiring in the cylinders.

The ABS rules evaluate the adequacy of crankshaft design by calculating the minimum allowable dimensions of the crankshaft pins and journals, and crankshaft webs. These calculations take fewer inputs into consideration than Lloyd's rules.

For example, the ABS rules do consider the strength of the crankshaft material, but do not consider the forging process nor do they directly consider the existence of fillet radii. The ABS rules also calculate the maximum allowable torsional vibration stresses. The ABS rules, however, make no provision for operating an engine at an overload condition.

The draft rules of the International Association of Classification Societies ("IACS"), which are used by some of the classification societies, are somewhat unique in that they consider the adequacy of the crankshafts on the assumption that the most highly stressed areas are the fillet transitions between the crankpin and crankshaft web as well as between the journal and the web. Rather than calculating the adequacy of crankshaft dimensions or torsional vibrations, the IACs rules calculate a factor of safety based upon torsional and bending stresses and stress concentration factors.

Q. Do you believe that the rules of any particular classification society should be adopted to evaluate the adequacy of the replacement crankshafts?

A. No. We do not believe that any particular classification society has the "ideal" standard. However, it is pertinent that Lloyd's generally is considered to be the most conservative of the major classification societies, hence providing the greatest margin of safety. In view of the potentially catastrophic consequences resulting from the failure of the EDGs at Shoreham, we believe that, at a minimum, the crankshafts should be compatible with the rules of all of the major classification societies.

Q. Professor Christensen, have you performed any calculations under Lloyd's rules to determine the adequacy of the design of the replacement crankshafts at Shoreham?

A. Yes. I have performed calculations under Lloyd's rules for maximum allowable horsepower for the replacement crankshafts at Shoreham. Those calculations show that for 1680 psi, the highest peak firing pressure assumed by FaAA in its studies at full load (3500 kW), the allowable horsepower permitted under Lloyd's rules is just under 4621 HP. Using the actual measured peak firing pressure of 1750 psi, the allowable maximum horsepower under Lloyd's rules is 4422 HP. In addition, my calculations also show that for 1800 psi, the peak firing pressures at overload (3900 kW), the allowable horsepower under Lloyd's rules is just under 4252 HP. Shoreham's horsepower rating of 4890 HP at full load and 5379 HP at overload exceeds the allowables for horsepower under Lloyd's rules. A copy of my calculations is attached as Exhibit 36.

EXHIBIT 26

DR-03-341A-1

PISTONS
PART NO. 03-341A

Classification A
Completion 03/05/84

PRIMARY FUNCTION: The pistons react to the cylinder firing pressure and provide a reciprocating mechanism for converting combined inertia and combustion pressure forces into mechanical torque through the wrist pin, connecting rod, and crankshaft.

FUNCTIONAL ATTRIBUTES:

1. The piston crown must have sufficient strength to resist the high temperature and pressure firing loads.

2. The load transfer between the piston crown and skirt structure must not produce alternating stresses sufficient to cause failure of the skirt.

3. The wall structure of the skirt must be resistant to pressure-induced deformation which could result in skirt fatigue in proximity to the stiffening ribs.

4. Preload in the crown studs must be sufficient to preclude failures of studs/nuts/washers.

5. The piston skirt must provide a suitable sliding surface against the cylinder liner.

6. The piston ring groove must be sufficiently wear-resistant to provide sufficient ring life.

SPECIFIED STANDARDS: None

EVALUATION:

1. Determine the historical evolution of the AF, AF-modified, AH, AN, and AE piston designs, including casting, heat treatment, dimensional, and material changes.

2. Determine maximum firing pressures and temperatures for DSR-48, DSRV-16-4, DSRV-12-4, and DSRV-20-4 designs.

3. Develop finite element models for AF-modified and AE piston designs with pressure loading (static conditions).

4. Conduct thermo/mechanical analysis to determine thermally-induced load transfer due to crown distortion.

5. Perform metallurgical examination of fracture AF piston skirts.

6. Perform eddy current examination of AE piston skirts from TDI DSR-42 and R-5 engines, and Alaska stationary diesel generator.

7. Conduct fracture mechanics analysis of possible crack propagation in AF-modified and AE designs with differing stress conditions.

8. Conduct experimental static isothermal stress distribution test on AE skirt.

9. Evaluate the effect of piston skirt loading on wear.

10. Perform LP and eddy current inspection of SNPS AE pistons following 100 hours at 100% load.

11. Assess the similarity of the AF-modified, AH, and AN piston designs.

12. Complete report on AF-modified, AH, AN, and AE pistons.

13. Review information provided on TER's Q-159, Q-194, Q-203, Q-310, Q-326, Q-335, Q-338, Q-393, Q-412, Q-413, Q-419, and Q-422.

REVIEW TDI ANALYSES:

1. Examine TDI strain gage testing (static) on skirt stud boss region.

INFORMATION REQUIRED:

1. TDI drawings for AN and AE designs including studs, Belleville washers, preload, and material specifications.

2. Historical information on casting changes, heat treatment changes.

3. Maximum cylinder firing pressure and temperature for DSR-48, DSRV-16-4, DSRV-12-4, and DSRV-20-4.

EXHIBIT 27 R85-1477 p3 OF 22

PNPP NO. 6287

# QUALITY ASSURANCE CHECKLIST

## PERRY NUCLEAR POWER PLANT

CHECKLIST NO. QR 038

REVISION 0

SHEET 1 OF 10

☑ INSPECTION ☐ DOCUMENT REVIEW

☐ WORK PKG. REVIEW ☐ ______

☐ ELECTRICAL ☐ CIVIL/STRUCTURAL

☑ MECHANICAL ☐ I & C

☐ ADMINISTRATIVE ☐ TEST

PREPARED BY Mark Palmer

APPROVED BY JKR [signature]

DATE 10-31-84

| ITEM | TITLE Piston - Pin Assembly<br>1R43C0001A DIVISION ONE | Cyl. | SAT | UNSAT |
|---|---|---|---|---|
| 1. | Visual inspection of pin assembly. | | | |
| 1A. | Perform visual inspection of pin assembly for signs of distress such as scoring, galling, pitting, and chipped chrome plating. | 1L | | ✓ |
| | | 2L | ✓ | |
| | | 3L | ✓ | |
| | Acceptance is to be determined by the Owners Group. | 4L | ✓ | |
| | | 5L | ✓ | |
| | Record inspection details below. Document with photographs. | 6L | ✓ | |
| | | 7L | ✓ | |
| | | 8L | | ✓ |
| | CHIPPED CHROME WAS FOUND ON 8 RIGHT, 2 RIGHT, NICK ON 1 Left, 2 RIGHT, & 8 LEFT. | 1R | ✓ | |
| | | 2R | | ✓ |
| | | 3R | ✓ | |
| | | 4R | ✓ | |
| | NR-OQC-1462 WAS dispositioned "USE AS IS" ON 1 Left, 2 Right & 8 LEFT. | 5R | ✓ | |
| | | 6R | ✓ | |
| | | 7R | ✓ | |
| | 8 RIGHT WAS SCRAPED. JKR 12/16/84 | 8R | | ✓ |
| | | | [signature] 12-19-84 | |
| 2. | Dimensional check. | | | |
| 2A. | Record the as-built dimensions on one space pin (see sketch below). Record any identifying marks on pin.<br>Acceptability to be determined by site engineering. | | | |

VERIFIED N/A RPT # MP INIT. 12/3/84 DATE PNPP-OQS

PERFORMED BY [signature] * item 6 [signature] 11/11/84 [signature] 1-11-85

DATE

APPROVED BY * item 6 [signature]

DATE 0 2 0 4 8 5

EXHIBIT 28

TEXAS UTILITIES

TASK DESCRIPTION NO. QR-10-02-341C

COMPONENT REVALIDATION CHECKLIST

COMPONENT Piston-Pin Assembly DOCUMENT NO CR-1

PART NUMBER 02-341C SCHEDULED FOR COMPLETION ______

SNPS PART NUMBER 03-341C

TASK DESCRIPTION:

SEE PAGE 2

ATTRIBUTE TO BE VERIFIED: SEE PAGE 2

ACCEPTANCE CRITERIA: SEE PAGE 2

REFERENCES: SEE PAGE 2

DOCUMENTATION REQUIRED: SEE PAGE 2

GROUP CHAIRPERSON [signature] PROGRAM MANAGER [signature]

COMPONENT REVIEW:

RESULTS AND CONCLUSIONS: CPSES Unit 1, Train A (Serial No. 76001)
5 wrist-pins showed evidence of chrome blistering or chipping, 1 pin showed some scarring. These were replaced with acceptable spares or pins from the TDI factory. All pins showed some evidence of wear.

GROUP CHAIRPERSON ______ PROGRAM MANAGER ______

EXHIBIT 29

implemented, whic[illegible] starts on a single engine, or a minimum of 100 starts on each of the three engines.

Q. Has the replacement of the pistons, cylinder heads, crankshafts and EDG 103 cylinder block solved the problems experienced by the EDGs in the past?

A. No. The EDGs are still over-rated and undersized, improperly designed and not satisfactorily manufactured. The reasons for this conclusion will be presented in detail in our testimony concerning each of the current four major components of the EDGs.

MODEL AE PISTONS

Q. How does Suffolk County's Contention relate to the TDI pistons in use at Shoreham?

A. The EDG Contention provides that its first paragraph is supported because:

> All AF piston skirts in the EDGs were replaced with TDI model AE piston skirts. The replacement AE pistons are of inadequate design and manufacturing quality to satisfactorily withstand operating conditions because:
>
> (a) The FaAA report conclusion that cracks may occur but will not propagate improperly depends on a fracture mechanics analysis of an

ideal situation which is not valid for the actual conditions which may be experienced by the Shoreham diesels,

(b) excessive side thrust load, which could lead to catastrophic failure, has not been considered adequately, and

(c) the analysis does not adequately consider that the tin-plated design of the pistons could lead to scoring causing excessive gas blow-by, and thereby causing a failure of proper operation.

Q. Why were the AE model piston skirts installed in the EDGs?

A. The AE piston skirts were installed after 23 TDI model AF piston skirts in the EDGs were discovered to have linear indications, that is, cracks, in the crown-to-skirt stud attachment bosses. Failure Analysis Associates ("FaAA"), an organization retained by LILCO (through its attorneys) and the TDI Owners' Group, has published a report entitled "Investigation of Types AF and AE Piston Skirts" dated May 23, 1984 (the "FaAA Piston Report"),23/ which concluded that the cracks in the AF piston skirts were fatigue cracks.

Q. What are the bases for your conclusions that the AE pistons at Shoreham are inadequately designed and

23/ FaAA Report 84-2-14. (Exhibit 8).

unsatisfactorily manufactured, as set forth in the EDG Contention?

A. The bases for our conclusions are described in detail below.

Cracking of AE Piston Skirts

Q. Did FaAA conclude that the AE piston skirts might crack?

A. FaAA conducted a finite element stress analysis of the AE piston skirt, which showed that cracks may initiate in the skirt.[24] FaAA also carried out experimental measurements of strain under static load in the AE piston skirt,[25] which predict that cracks will not initiate in the skirt under the cyclic stress levels obtained in the experiments.[26] The disagreement between the finite element analysis and the experimental results is 28%, which FaAA maintains is "quite good" agreement.[27]

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24/ FaAA Piston Report at 6-1.

25/ Id., Section 3.

26/ Id. at 6-1.

27/ Id. at 5-1. The disagreement between an earlier finite element analysis and the experimental results was 33%. Initial FaAA Piston Report, February 27, 1984, at 5-7.

Q. Do you agree that the 28% disparity is "quite good"?

A. No. That disparity is the difference between two opposite conclusions -- cracking or structural integrity -- which are critical to the results of FaAA's study.

Q. Which is more reliable -- the finite element analysis result or the experimental results?

A. The usual methodology is to confirm the finite element analysis by the stress experiments. The finite element analysis, when properly done, may be an excellent tool for evaluating a structure. It tends to be non-conservative (that is, it would be expected to show <u>less</u> likelihood of cracking than experiments) because it averages the properties of the piston skirt material and ignores possible imperfections in the material. Because the experimental results differed significantly from the finite element analysis results, it would appear to us that the experiments were inadequate. The experiments should have been carried out until crack initiation was shown, and then analyzed. Where, as in this case, the experiments do not confirm the analysis, additional work is required. Instead of doing that additional analysis, FaAA concludes that the 28% disagreement of the results is acceptable and <u>could</u> be accounted for by incorrect assumptions in the finite element model, omissions or approximations in the finite element technique, or inaccuracies in the experiments, or all of the above.28/ This is not a helpful conclusion, because the two results -- that cracks will initiate or will not occur -- are opposing. We believe that this conflict has not been adequately investigated. We note, for example, that an unstated number of strain gauges in the stud boss area did not work.29/ Since no attempt has been reported to qualify the relative accuracies of the analytical and experimental techniques, and given the importance of the conclusion in terms of the safety requirements for Shoreham, we believe the greater weight must be given to the results of the finite element analysis -- that cracks are predicted to initiate.

Q. Do you believe the FaAA Piston Report underestimates the probability that cracks will initiate in the AE skirt?

A. Yes. FaAA determined for purposes of its finite element analysis and experiments that "The maximum stresses in the piston skirt under peak firing pressure are of primary interest. This pressure is approximately 1670 psig as independently measured by FaAA and reported by TDI."30/ To justify a peak

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28/ Id.

29/ FaAA Piston Report at 3-6.

30/ Id.; see also Id. at 4-1.

firing pressure of 1670 psig, FaAA cites only TDI reported values for a DSRV-16-4 engine at Grand Gulf Nuclear Station,[31] and FaAA pressure measurements of 2 cylinders at Shoreham which FaAA has acknowledged to be unreliable and too low.[32] In fact, the peak firing pressure in cylinders of the EDGs at full load (3500 kW) is known to be as high as 1750 psig, and at overload (3900 kW) the peak firing pressure is at least 1800 psig. The stresses on the AE piston skirt used by FaAA in its analysis and experiments are thus understated.

Q. What evidence do you have that the peak firing pressures in the EDGs are as high as 1750 to 1800 psig?

A. Test documents for the EDGs and for other DSR-48 diesel engines establish these maximum peak firing pressures. These documents are attached as Exhibit 46.[33] The test data show numerous peak firing pressure readings of greater than 1670 psig for the Shoreham engines at 100% load (the 1/24/76 run on EDG 102 shows 1750 psig, for example) and pressures as

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31/ Id. at 3-14 (Ref. 3-1) and at 4-7 (Ref. 4-2).

32/ Id. at 4-7 (Ref. 4-1); Emergency Diesel Generator Crankshaft Failure Investigation, Shoreham Nuclear Power Station, FaAA, October 31, 1983 (FaAA 83-10-2) at 4-9.

33/ See Exhibit 46 at documents 5-9.

high as 1800 psi are reported for the overload condition (3/19/76 run on EDG 103. This evidence contrasts with the readings on an EDG taken by FaAA. One must also remember that firing pressures differ from cylinder to cylinder and engine to engine. TDI gives no specific authoritative peak firing pressure for the DSR-48. Rather, it; manual for operation of the EDGs permits a variance in peak firing pressures of the cylinders in one engine of ± 100 psi.[34] This means that any single peak firing pressure read in one cylinder may be exceeded in another cylinder by 200 psi, so that firing pressures may be even greater than 1800 psi in the EDGs.

Q. What is the impact of the higher actual peak firing pressure on the FaAA Piston Report?

A. The higher actual peak firing pressures mean that cracks are more likely to initiate in the AE piston skirts in the EDGs than FaAA predicts. FaAA underestimates the crack initiation in 3 respects concerning firing pressures. First, FaAA uses a too-low peak pressure of 1670 psig for its finite element analysis and the reported strain gauge tests. FaAA tested the pistons to 2000 psig, but only reported the data at

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34/ TDI Instruction Manual at 8-3 (Exhibit 9) the 1600 psig point. Second, certain strain gauge measurements are limited to a maximum of 1600 psig.[35] Third, FaAA made no analysis or strain gauge experiments at overload (3900 kW), even though the EDGs have a 2 hour per each 24 hour overload rating and an actual maximum peak load of 3881 kW. TDI has testified that the peak firing pressure of the EDGs at 3900 kW is about 1800 psi.[36] These factors would, if taken into consideration by FaAA, result in a much greater likelihood of AE piston skirt crack initiation than predicted in the FaAA Piston Report.

Q. Aside from the peak firing pressure, are any other issues of particular concern to FaAA's conclusions concerning crack initiation?

A. The initial size of the gap between the outer ring of the AE skirt and the crown is, according to FaAA, important in predicting whether or not cracks will initiate in the skirt.[37] The FaAA Piston Report states:

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35/ FaAA Piston Report at 3-6 to 3-7, 3-16 and 3-17, 3-19.

36/ Deposition of Gerald Edgar Trussell (May 7, 1984) ("Trussell Deposition"), at 128-29. (Exhibit 10).

37/ FaAA Piston Report at 8-1; see, also Figure 3-2 for an illustration of this gap.

> The experimental results of Section 3 showed that the stresses due to pressure are dependent on the initial gap size, $g_o$, because this parameter influences the gap closure pressure and load transfer between inner and outer load rings. As shown in Figure 3-2, the initial gap can vary from 0.007 to 0.011 inch and still be within TDI specified tolerance.[38/]

Neither FaAA nor the TDI Owners Group personnel has measured the initial gaps present in the AE pistons in the EDGs.[39/] Based upon foundry practices and the lack of effective quality assurance at TDI, discussed below, it is quite likely that the TDI tolerances may be exceeded. Actual measurements of the gaps in the AE pistons at Shoreham would be useful in testing FaAA's assumption that all AE pistons have gaps within TDI's tolerances.

Another factor bearing upon the likelihood of crack initiation is the tensile properties of the skirts.[40/] We do not know the actual tensile properties of the AE skirts at Shoreham, but we note that the range of values reported for

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38/ *Id.* at 6-4.

39/ "Design Review and Quality Revalidation Report, TDI Diesel Generators For Shoreham," TDI Diesel Generator Owners Group, June 29, 1984 (the "DRQR Report"), Vol. 5, Pistons, at B1 to B6. (Exhibit 11).

40/ FaAA Piston Report at 6-5.

typical material used at TDI shows ultimate tensile strengths as low as 85 Ksi.41/ If such a piston were subjected to the higher firing pressures possible (1750 psig or higher), the conclusions regarding crack initiation would certainly be invalid.

Q. Do you agree with FaAA's conclusions that even if cracks do initiate in the AE piston skirt, they will not propagate?

A. No, because that conclusion is based upon a highly theoretical fracture mechanics analysis which does not take all potential effects into account for predicting crack growth under the actual conditions that will be experienced at Shoreham. The FaAA analysis assumes:

(1) complete adherence to TDI drawing dimensions of the AE skirt (and crown);

(2) the AE piston material is isotropic, meaning it is free of any small inperfections such as sand inclusions or grinding marks, and with no subsurface defects such as hot tears or slag

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41/ Id. at 2-7

inclusions, with the ultimate tensile strength uniform in all directions;

(3) a non-corrosive operating environment free of gases, water or vapor;

(4) stresses resulting from a maximum peak firing pressure of 1670 psi; and

(5) a uniform skirt temperature, both circumferentially and axially.42/

Each of these idealized assumptions is incorrect in terms of the "real world."

Q. Explain why each assumption is incorrect, and the impact of the error on FaAA's crack propagation analysis.

A. (1) The dimensions of each AE piston at Shoreham are not perfect. Only a very limited dimensional check on a sampling basis was made on piston groove and ring height and piston pin bore diameter and depths on the AE pistons at Shoreham. No dimensional check was made of other parts of the piston

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42/ FaAA did not independently measure the thermal gradience in the AE piston skirt. Harris Deposition at 41. (Exhibit 12).

skirt, including the thickness of the boss areas or the gap between the piston skirt and crown.[43] Even relatively small dimensional differences in the skirt and in the assembly of the skirt and crown would change the mathematics of FaAA's analysis, and could influence the results.

(2) The AE piston skirts in the EDGs are not free of defects. They are known to have some small defects, and it is highly likely that many more imperfections are present. At Shoreham, only 10 of the 24 AE piston skirts were subjected to liquid penetrant tests at the bosses for bolt attachment to the crown.[44] These tests did disclose some defects, but in any case were totally inadequate to determine whether there are small imperfections on the surface or subsurface of the AE skirts. Such small imperfections are likely to be present in the skirts in the EDGs. TDI does not use vacuum processes to ensure a dirt-free casting. Indeed, the foundry is poorly lighted and has a dirt floor, which increases the likelihood of sand or slag inclusions. Control of scrap material for castings is rather informal. Effective quality control is absent,

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43/ DRQR Report, Vol. 5, Pistons, at B1-B6.

44/ Id. Eddy-current inspections were conducted by FaAA on 12 skirts on the EDGs. See FaAA Piston Report at 7-1 and discussion below.

so that small imperfections are unlikely to be discovered. Mr. William Foster of the NRC's Vender Inspection Program staff, who had participated in a number of NRC inspections at TDI, stated recently that the nature and number of violations and non-conformances at TDI indicated to him that the TDI QA system was "ineffective."45/ The presence of even a small imperfection would permit a crack to initiate and propagate at stress levels below those predicted by FaAA as necessary for initiation and propogation. If a crack initiates in an area of the skirt where imperfections are present, its growth may be entirely different than as calculated by FaAA, which assumed no flaws in the material. With the presence of some imperfections, FaAA's fracture mechanics analysis is invalid.

(3) The environment of the piston during EDG operation is not a vacuum. Combustion gases are present, and there may be small amounts of water or vapor. If a crack initiates in the skirt, these gases will tend to corrode the crack edges and hasten crack propagation. Corrosion products formed on the crack opening of a skirt during EDG operation will act as wedge when the crack closes (after EDG operation ceases),

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45/ Deposition of William Foster (May 22, 1984) ("Foster Deposition"), at 16. (Exhibit 13).

producing additional crack growth. The FaAA fracture mechanics analysis does not consider these factors at all.

(4) FaAA's analysis postulates stresses resulting from a peak firing pressure of 1670 psi. The proper maximum peak pressure of 1800 psi, as discussed above, would result in greater stresses and a higher likelihood of crack propagation.

(5) The temperature around the skirt is not uniform. Actually, the side of the piston skirt taking the piston thrust on the firing downstroke becomes much hotter during EDG operation than the side taking the piston thrust on the compression upstroke. The temperature of these TDI pistons will be even higher than is normally expected in other makes of engines where the initial side thrust is designed to be much lower, as discussed below. FaAA assumes that the piston skirt is "nearly isothermal",46/ when in fact, one side of the skirt runs at a much higher temperature than the opposite side. Estimates for the piston skirt temperatures were provided by TDI based on "templug" measurements taken on a non-Shoreham engine operating at only 213 BMEP.47/ The EDGs operate at 225 BMEP,

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46/ "The Influence of Thermal Distortion in the Fatigue Performance of the AF and AE Piston Skirts", June 1984 (FaAA-84-5-18) (the "FaAA Piston Thermal Distortion Report"), at 2-7.

47/ Id. at 2-6, 2-7.

and would therefore have higher piston skirt temperatures.

Q. Given all of these variations from FaAA's idealized assumptions, is it possible to predict accurately how cracks in the AE skirt will propagate?

A. No. It is not possible to make accurate predictions of crack propagation in the AE skirts, given all of the possible variables. However, the FaAA analysis would have been far more useful if actual properties of the AE piston skirts in the EDGs had been recorded, to the extent possible, and sensitivity analyses performed to account for a range of potential variables. Thus, the principal dimensions of each AE skirt at Shoreham could have been measured, especially in the boss area. The gap between the outer ring of each skirt and the attached crown could have been measured. Each AE piston skirt in the EDGs could have been inspected for imperfections, especially in the boss area, by liquid penetrant tests, magnetic particle tests, eddy current examination and radiographic inspection. The tensile properties of each skirt could have been sampled. The analysis could then have been performed using a range of more realistic peak firing pressures (up to 1800 psi) and including the combined effects of maximum side thrust and its corresponding gas pressure, temperatures, and environmental conditions. The analysis could have included sensitivity tests to take into consideration the potential for undiscovered dimensional variations, defects in the skirt and differences in tensile strength, and the possibility of multiple cracks. Such analyses would give a far better prediction of crack propagation than the idealized study performed by FaAA.

Q. What else, besides the inspections and crack propagation analyses you suggest, would be necessary to give adequate confidence that the AE piston skirts are adequate for operation at Shoreham?

A. First, an adequate crack initiation analysis should be performed, using actual data as to dimensions, tensile properties, imperfections, and gap sizes of the AE skirts at Shoreham, and the appropriate peak firing pressures of up to 1800 psi. Experimental stress tests should confirm the results of finite element analyses, or a more refined finite element analyses or better experiments should be performed. The AE pistons could be instrumented and tested during EDG operation for additional experimental data. These analyses could predict multiple cracks initiating with larger initial sizes, thereby affecting the crack propagation analyses. The design deficiencies involving excessive piston side thrust load and tin plating of the skirt would have to be considered, as discussed below. Finally, the AE piston skirts would have to be tested and inspected adequately in the EDGs.

Q. Does FaAA believe the AE piston skirts have been adequately tested and inspected?

A. Yes. FaAA has concluded that on the basis of the results of its stress analyses (which were contradictory as to crack initiation) and "the results of inspections of engine-operated AE skirts," the AE piston skirts "are adequate for unlimited life."48/ We strongly disagree that the AE skirts have been adequately tested or inspected to justify any conclusions about their expected life.

Q. What inspections was FaAA referring to?

A. FaAA was referring to inspections of 15 AE skirts, as follows:

(1) 12 AE skirts of the 24 skirts were subjected to eddy-current inspections after over 300 hours of total operation each (including 100 hours at full load), and no "relevant indications" were found;

(2) One skirt in an RV-16-4 engine was inspected after over 6,000 hours of

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48/ FaAA Piston Report at 8-1.

operation at a peak firing pressure of about 1200 psi, with no "relevant indications" found; and

(3) Two skirts from a TDI R-5 development engine were inspected after operating at a peak pressure of 2000 psi or more after over 600 hours, with no finding of "relevant indications."49/

Q. Why don't you believe this experience and these inspections are adequate to support FaAA's conclusions?

A. For several reasons. First, fifteen skirts is simply too small a number from which to reach any general conclusions, particularly without a valid statistical analysis.

Second, the inspection of only 50%, rather than 100%, of the AE skirts on the EDGs is inadequate. Mr. William Foster, the NRC Staff official with responsibility for vendor inspections of TDI, has testified that TDI has an ineffective quality control program, and consequently inspection on a sampling plan basis of TDI components "would not tell you anything."50/ In fact, Mr. Foster testified that even a 100% inspection of TDI components would not identify all defects.51/ We agree.

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49/ Id. at 7-1.

50/ Foster Deposition at 14-16, 54-55, 82. (Exhibit 13).

51/ Id. at 55.

Third, the number of hours and the amount of full loads and overloads run on each AE skirt at Shoreham are insufficient to reach conclusions about their expected life. To meet the rating specifications of the EDGs, the AE skirts must be capable of running many thousands of hours, including significant hours at overload at 3900 kW. The AE piston is supposed to last the lifetime of the Shoreham plant -- 40 years.52/ Testing them for only 300 hours without significant, if any, overload does not begin to be adequate. It is also important to note that TDI did not test the AE piston before supplying it to customers in the field.53/

Fourth, the AE skirt in the RV-16-4 engine was operated at a peak firing pressure of only 1200 psi, while the EDGs have a peak firing pressure of about 1700 to 1800 psi at full load and overload. Thus, the operation of that single skirt was at such low stress as to be useless for purposes of reaching any conclusions relevant to the AE skirts in the EDGs.

Fifth, the two piston skirts operated in the TDI R-5 engine are of limited relevance. The R-5 engine is significantly

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52/ Trussell Deposition at 111-13. (Exhibit 10).

53/ Id. at 107.

different from the EDGs, including its operating speed (514 RPM). This would change the inertia effects which in turn lowers the piston lateral loading. Therefore, before determining the impact of the R-5 skirts on the Shoreham AE skirt report, a study would have to be made analyzing the effects of the different parameters.

Sixth, the referenced inspections were incomplete and the standards for acceptance were unsatisfactory.

Q. Please be more specific about your last point.

A. FaAA stated that only eddy current examination was performed on the Shoreham piston skirts.[54/] Further, only certain portions of the skirt were subjected to the eddy current examination, namely, "machined areas on the boss where color contrast penetrant show (sic) linear indications greater than 1/32 inch."[55/] This means that linear indications smaller than 1/32 inch, non-linear indications such as sand or slag inclusions, and areas of the boss which were not machined were omitted from consideration. As we noted earlier, even small

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54/ FaAA Piston Report, at 7-1.

55/ FaAA NDE Procedure 11.5, November 2, 1983, para. 6.1. (Exhibit 14).

imperfections could significantly increase the possibility of crack initiation and propagation. Finally, the only indications which were to be recorded were cracks "greater than 10% of the crack signal in the reference standard PAO-C-1."56/ Unfortunately, FaAA does not indicate, nor does the NDE procedure specify, the size of the flaw contained in the reference standard, so there is no way to judge the sensitivity of this screening processing. In our opinion a crack eliminated from further consideration by these criteria could be relevant to issues of crack initiation and propagation. Accordingly, we have no way of knowing how many cracks or other imperfections there may actually be on the 12 AE skirts at Shoreham.

Q. What about the inspections of the skirts in the RV-16-4 and R-5 engines?

A. On the RV-16-4 piston skirt, a liquid penetrant test showed an indication 3/4 inch long. This indication was subjected to eddy-current examination and FaAA determined that there were "no crack-like indications."57/ The two AE skirts from the TDI R-5 engine were not of the same design as the skirts at Shoreham.58/ Three indications were found on one of

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56/ Id. at para. 7.1.

57/ Memorandum from D. Johnson (FaAA) to M. Milligan and B. Judge (LILCO), Feb. 17, 1984. (Exhibit 15).

58/ Memorandum from D. Johnson (FaAA) to M. Millig[illegible] nd N. Irvine (LILCO), Feb. 3, 1984. (Exhibit 16).

the skirts, but FaAA decided these were "of no consequence to structural integrity of the skirt."59/ For the reasons given above, we believe the eddy current inspections do not support FaAA's conclusions that the AE skirts can be expected to have unlimited life. FaAA's standards for a "relevant indication" permit the presence of imperfections which could increase the likelihood of crack initiation and propagation; thus such defects should have been considered by FaAA in its analyses.

Q. What might happen if cracks in the boss area of the AE piston skirts do propagate?

A. Given the many variables and unknown factors, we cannot give any meaningful estimates of how cracks will propagate, or how rapidly they will do so. We do know that the tip of a crack is unstable. It is at higher energy than the surrounding material and will tend to corrode or link with impurities, inhomogeneities or imperfections in the metal to lower its energy. Corrosion will increase crack propagation. At some point a crack, unless arrested by a sufficiently thick area or by physical movement of material allowed by the crack reducing the stress, will reach a critical point beyond which crack

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59/ Memorandum from Wells and Johnson (FaAA) to Milligan and Irvine (LILCO), Feb. 9, 1984. (Exhibit 17).

growth will be very rapid. Circumferential crack propagation could lead to crown separation from the skirt with disastrous results. Axial crack propagation, depending on location, could reduce piston clearance, adversely affect lubrication, and result in piston seizure or crankcase explosion or both.

Q. Please summarize your conclusions about the probability of AE piston skirt cracking.

A. FaAA's conclusion that the AE skirts are adequate for unlimited life is inadequately substantiated and invalid. Cracks are even more likely to initiate in the AE skirts than FaAA's finite element analysis predicts, because the peak firing pressures in the EDGs are significantly higher than those used by FaAA. FaAA's experiments do not confirm the finite element analysis and should be reanalyzed to explain the significant 28% discrepancy. FaAA's conclusion that cracks initiate but will not propagate in the AE skirts is based on theoretical idealized assumptions which are unrealistic. Under actual operation cracks which initiate are likely to propagate due to such factors as variations in dimensions of the skirts, the presence of imperfections in the skirt material, the operating environment in the cylinder, and actual firing pressures and temperatures. Finally, the tests and inspections of AE skirts cited by FaAA are insufficient to support conclusions that the skirts are adequate for nuclear service.

Excessive Piston Side Thrust

Q. What is piston side thrust?

A. Piston side thrust occurs at all positions of the piston during operation except top dead center and bottom dead center. In all of those other positions, the connecting rod is at an angle to the vertical line of the piston stroke. The side thrust on the piston is the result of the force acting to the line of piston stroke.

Q. Have you calculated the piston side thrust of the AE piston in the EDGs?

A. Yes. The calculations for piston side thrust of the AE piston are shown attached as Exhibit 18. These calculations show that at the first two midordinate positions the mean unital thrust on the AE piston at Shoreham is over 123 psi and 111 psi respectively.

Q. Is that unital side thrust excessive?

A. Yes it is. An upper unital limit of 85 psi has been prescribed in a standard design text.60/ Another source states

60/ Diesel Engine Design, T.D. Walshaw, Newnes, London, 1949, at 140.

that side thrust should not exceed 30 to 40 psi for slow speed diesel engines and 70 psi for high speed engines.61/ Medium speed engines like the EDGs should fall within these two limits. In most engines with which we are familiar built by other manufacturers, the unital side thrust does not exceed 85 psi and we have reviewed the design of an engine comparable to the EDGs which has a unital side thrust of 35 psi. Thus, the calculated mean unital side thrust of the AE piston of 123 psi exceeds the upper value by 44 percent. We believe that the actual maximum unital side loading of the AE piston will be more than the calculated figure, because the piston pin in the AE piston is located above the vertical center of the effective piston skirt height. The additional increase will depend upon the stiffness of the skirt.

Q. What affect does this excessive side thrust load have on the EDGs?

A. The excessive side thrust increases the temperature differences around the circumference of the piston skirt, by causing the side of the piston bearing the higher side thrust to run hotter than if side thrust were normal. This

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61/ Internal Combustion Engines, V.L. Maleev, McGraw-Hill, 1945, at 501-02.

temperature non-uniformity will be exacerbated by minor inbalances, minor gas leakage past the piston rings, or lesser lubrication availability after fitting new oil control rings. As the temperature differences in the circumference of the skirt increase, piston distortion begins. Distortion further reduces the arc of contact between the piston skirt and the cylinder liner. As this contact is decreased, the effective area of the skirt sustaining the side load is drastically reduced, causing the unital thrust to increase. The increase of thrust increases the friction between the side of the skirt and the liner, further increasing the temperature differences. Once the temperature differences increase above a certain critical point, partial and complete piston seizure occurs very rapidly -- in just minutes or seconds -- and usually without warning. Piston seizure, if complete, will almost always cause catastrophic EDG failure.

Q. Why can piston seizure occur so quickly?

A. The breakdown can occur very rapidly because of the combined effect of distortion of the piston in both the vertical and horizontal plane caused by the differences in temperature in the circumference of the piston skirt. The vertical distortion causes the piston to bend to the shape of a banana, with the hot side rubbing on the liner at the outer part of the curve in the banana shape. As clearance between the skirt and the liner further decreases, the top and bottom parts of the inner side of the curve on the cool side of the skirt rub the liner, the effective clearance approaches zero, and the piston seizes.

Q. Are your calculations for piston side thrust in the EDGs at full load or overload?

A. Our calculations were based upon 4890 HP of the EDGs, the full load. At the rated overload of approximately 110%, the horsepower is 5379 and the maximum and mean gas pressure increases considerably. Under such conditions, the danger of piston seizure is even greater.

Q. Is the piston side thrust load affected by the fast start requirements of the EDGs?

A. Yes. During the required acceleration of the EDGs to rated speed in 10 seconds the piston inertia forces go from zero to running "normal" while the firing pressures are high almost immediately. Since the inertial forces are subtractive from the side thrust imposed by the piston pressure, the lateral load on the piston is substantially increased during the fast start portion of the cycle. This load condition occurs while the engine is still "cold" and before lubrication is fully established.

Q. Are you aware of any evidence of excessive AE piston side thrust in the EDGs or elsewhere?

A. According to the DRQR Report for Shoreham, the TDI Owners' Group inspections were supposed to verify "lack of scuffing at the piston skirt" in all three EDGs.[62/] Scuffing was reported in the DRQR Report on a number of AE piston skirts,[63/] but we have not yet had an adequate opportunity to examine LILCO's deficiency and disposition reports cited in the DRQR Report to see how these conditions were evaluated. These reports were only received a few days ago, so our review of them has necessarily been preliminary and cursory. If our more complete review discloses significant information, we will file supplementary testimony. The DRQR Report concludes that "inspections performed on AE skirts have not revealed excessive side load wear."[64/] Based upon our preliminary review of the

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62/ DRQR Report, Vol. 5, Pistons, at B2. (Exhibit 11).

63/ Id. at B4-5, referencing TER Q-326; LDR 2275; TERs Q-41, Q-82, Q-83: LDR 2147; TER Q-159; LDR 2198.

64/ Id. at 3.

inspection data and personal inspections of some AE skirts at Shoreham, we disagree.

Q. What inspections did you make?

A. During June of 1984, we inspected one AE skirt at Shoreham which showed a heavy wear pattern. The worn area of the skirt was completely devoid of any tin plating or sandwich layer plating. The appearance of the damaged area showed the light mottled patterning and surface roughness consistent with micro seizure. We believe this abrasion of the skirt most likely resulted from heavy side loading resulting in localized distortion. The profile of the skirt indicated local distortion. During this same inspection, we examined seven other AE piston skirts. While these skirts did not show the same heavy wear pattern described above, they did show signs of distress in the tin-plated area (abraded surfaces and evidence of debris that had previously been embedded in the plating, but since removed).

Q. Are you certain the AE skirt you have described was damaged by excessive piston side thrust?

A. We cannot be absolutely certain, but that is the probable cause. Evidence of excessive side thrust is usually also evident on the cylinder liner against which the skirt has rubbed. All of the liners we inspected at Shoreham showed evidence of heavy deglazing, which obliterates any markings associated with high side thrust loading from the skirt. We might surmise that side thrust markings made the heavy deglazing necessary. Deglazing is a maintenance operation in which the cylinder liner surface is honed in a criss-cross pattern leaving relatively deep "scratches" for the purpose of maintaining better lubrication of the piston rings, skirt, and liner.

Q. Did the FaAA Piston Report address the issue of piston side thrust loading?

A. FaAA has never addressed this issue, notwithstanding that it is both a "functional attribute" and "evaluation" factor in the TDI Owners' Group Program Plan Component Design Review for Pistons, Part No. 03-341 (DR-03-341-1). Under "Evaluations," item 9 states: "Evaluate the effect of piston side loading on wear." We were surprised that FaAA chose to ignore this matter, not only because of its importance to reliable EDG operation and the physical evidence of excessive side load described above, but also because of the impact of this issue on FaAA's crack initiation and propagation analyses.

Q. What is the effect of excessive AE piston side thrust on FaAA's analyses?

A. As explained above, excessive piston side thrust causes localized and later more widespread uneven overheating of the skirt. The resulting higher thermal stress will generally contribute to crack initiation and propagation, especially where the higher surface temperature of the skirt is on the other side of the section where the crack is located. The hot side increases the tensile loads on the cold side, contributing to propagation of any crack there. FaAA supplemented the FaAA Piston Report with a second report documenting an investigation of the thermal effect on the AE skirt. This report concluded that the influence of thermal distortion does not change the conclusions of the FaAA Piston Report as to the AE piston skirts.65/ The FaAA Piston Thermal Distortion Report, however, does not address the issue of piston side thrust at all and deals principally with effects of thermal distortion of the piston crown. Proper consideration by FaAA of the effects of excessive piston side thrust in the AE piston would likely change the analytical conclusions and probably would have shown crack initiation and propagation in the AE skirt to be more likely.

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65/ FaAA Piston Thermal Distortion Report at 5-1.

Q. Was evidence of excessive side thrust in AE skirts found in the TDI R-5 engine or the DSRV-16-4 engine referred to in the FaAA Piston Report?

A. We don't know. If the DSRV-16-4 ran at a peak pressure of only 1200 psi, excessive side load would be highly unusual.

Q. What do you conclude with regard to the piston skirt side thrust condition on the EDGs?

A. We conclude that the piston side thrust is excessive and that the AE piston is inadequately designed to accommodate this load. The FaAA reports have totally failed to address this concern. There is, therefore, no assurance that the EDGs will not experience serious failures induced by this condition. Accordingly, the EDGs have not been shown to be adequately designed to satisfactorily perform the service intended.

Tin Plating of AE Piston Skirt

Q. Did FaAA consider the potential effect of the tin plating of the AE skirt in the context of its design?

A. No. FaAA did not address this issue despite the fact that a functional attribute for the Task Description for pistons was

5. The piston skirt must provide a suitable sliding surface against the cylinder liner.

Q. What are your concerns about the tin plated design of the AE piston skirt?

A. During trips to Shoreham in 1983 and 1984, we observed relatively heavy vertical scoring in a sufficient number of cylinders to rule out a "case of one" phenomenon. The scores were vertical grooves located in line with the location where maximum side thrust takes place. Examination of pistons during a visit in 1983 showed accumulations of detritus embedded in the tin plated surface of the skirt. The scoring was visible despite heavy deglazing of the liner. We believe this scoring results from detritus which tends to collect in the soft tin plated surface of the skirt. The scoring in the liner caused by detritus embedded in the tin plating of the skirt can result in gas blow-by. If the cylinder liner is scored, small grooves or deep scratches are made in the liner surface. The piston rings "bridge" the groove or deep scratch and high pressure gases blow down the groove on the outside of the piston ring.

This action in turn leads to piston ring distortion which will allow more gas "blow-by". When this occurs, the piston skirts tend to overheat. This situation is potentially dangerous in the EDGs, where the piston design causes a high side thrust on the skirt. The high side thrust causes the AE piston to run hotter leaving little reserve for a further temperature rise from gas blow by. Small amounts of gas blow by may therefore lead to an early piston seizure.

Q. Why are the AE piston skirts tinned?

A. The piston skirts may be tinned to offset the bad effects of very high unital side thrust. This is yet another indication of over-rating of the EDGs.

Q. Aside from the liner scoring potential described above, does the tin plating present any other detrimental effects to reliable operation?

A. Yes. Tin and copper/tin plating of the AE skirts could initiate two types of failure mechanisms. If the tin (or copper/tin) is electroplated on the piston skirt, catastrophic failure could occur through the mechanism of hydrogen embrittlement. The plating process liberates hydrogen at the cathode which enters the metal structure. This classical embrittlement mechanism has been responsible for many dramatic failures of ferrous metals. It is difficult to detect and a hazard in all plated metal components. It is difficult, therefore, to predict if or when such a failure may occur. If the tinning is applied by a "dipping" process, the resulting structure at the plating interface can contain an intermetallic compound that forms when the tin matter comes into contact with the iron. This compound is covalent so it acts as a ceramic. This material, if present in significant quantities, can behave in an abrasive manner and thus contribute to scoring of the cylinder liner and piston skirt. Such liner scoring could lead to the failures resulting from gas blow-by and piston seizure described in the side thrust discussion above.

Q. What do you then conclude regarding the "tinned" AE piston skirts?

A. We conclude that the EDG rating is well in excess of the design limitation of the AE piston. Accordingly, there is no reasonable assurance that they will perform satisfactorily in service.

REPLACEMENT CYLINDER HEADS

Q. What is the purpose of this part of your testimony?

A. This part of our testimony addresses the County's concerns regarding cylinder heads; the relevant portion of the EDG Contention states:

EXHIBIT 30

GILBERT/COMMONWEALTH
QUALITY ASSURANCE DIVISION
INSPECTION SERVICES REPORT

0454-84-87

Dec. 04 - 07, 1984

CLIENT: Cleveland Electric Illuminating Co.

UNIT: Perry Nuclear Power Plant - Unit 1 & 2

VENDOR: Transamerica Delaval, Inc. (TDI)

LOCATION: Oakland, CA

VENDOR PURCHASE ORDER: Q-3003-69, Chg. 2

PRINCIPAL CONTACT: Doug Stuart

EQUIPMENT SPECIFICATION TITLE: Class IE Diesel Generator Units

SPECIFICATION NO.: SP-562-4549-00, Rev IV

INTRODUCTION & PURPOSE:

G/C, Inc. was notified that the seventeen piston skirts and forty-eight piston ring sets (balance of order) were ready for inspection. The skirts were to be magnetic particle examined, and visually and dimensionally inspected. The ring sets were to be visually inspected.

The purpose of this visit was to witness the magnetic particle examinations, perform visual and dimensional inspection of the skirts on a sample basis, perform a visual inspection of the piston ring sets on a sample basis, review the documentation, and issue a Certificate of Inspection upon final acceptance.

SUMMARY:

G/C, Inc. witnessed the magnetic particle examinations performed by TDI on seventeen piston skirts in accordance with Procedure 600-30, Rev. 2 with D4995. G/C, Inc. performed a final visual and dimensional inspection of the piston skirts on a sample basis. G/C, Inc. verified cleanliness, preservation, handling and tagging, and packaging. G/C, Inc. performed a documentation review. All piston skirts and piston ring sets were found to be satisfactory. G/C, Inc. issued a Certificate of Inspection.

ACTION REQUIRED:

None

Dimensional (Cont'd.)

The following piston skirts were dimensionally inspected:

| SERIAL NO. | HEAT NO. |
|---|---|
| N34 | 765K |
| N31 | 765K |
| N41 | 765K |
| N42 | 765K |
| N50 | 771K |

The following calibrated inspection devices were used:

| DESCRIPTION | SERIAL NO. | CALIBRATED | DUE |
|---|---|---|---|
| Standard (17 In.) | 087-A | 05/84 | 05/85 |
| Dial Bore Gage (6-12 1/8") | 061-S | 07/84 | 01/85 |
| Standard (16 In.) | 086-A | 05/84 | 05/85 |
| Thickness Calipers (Dail) | 360-A | 05/84 | 11/84* |
| Bridge Gage | 061-AD | 05/84 | 11/84* |
| Master Ring Gage (8-7510) | 330-A | 10/84 | 04/85 |
| Depth Gage Set | 030-C | 10/84 | 01/85 |
| Vernier - 26 In. | 026-B | 10/84 | 04/85 |
| Blade Mic. (15-16) | 016-B | 10/84 | 01/85 |
| Micrometer (16-17) | 017-H | 10/84 | 01/85 |
| GO/NO/GO Gage (501-503) | 297-R | 08/84 | 02/85 |
| Set Ring (6-7495-XX) | 325-D | 08/84 | 02/85 |
| Dial Bore Gage (6-12) | 061-AJ | 10/84 | 04/85 |

* TDI Calibration system allows for a two week grace period on calibration due dates.

Nondestructive Examinations

G/C, Inc. witnessed the magnetic particle examination of the machined thrust collar seat and the adjoining radii at the four bosses (inside the piston skirt) on all seventeen piston skirts listed under the "Visual" section of this report. The examination was conducted in accordance with TDI procedure 600-30, Rev. 2 and the acceptance criteria of D-4995, Rev. (12/21/83) using the direct contact method (circular) in accordance with para. 7.7 and 7.2 (each part examined twice 90 degrees apart) with wet flourescent particles with blacklight. The particles were applied by flowing using the continuous sequence operation (para. 7.8). No demagnetization was required. The areas examined were found to be acceptable with no unacceptable indications noted. All the piston skirts did require blending with a grinder to remove linear indications - approximately ¼ inch long. The indications were removed, and blended areas were re-examined using the same method and found to be acceptable.

**DELAVAL** ENGINE AND COMPRESSOR DIVISION

DATE 3-30-78

TIME 1030

D Cline

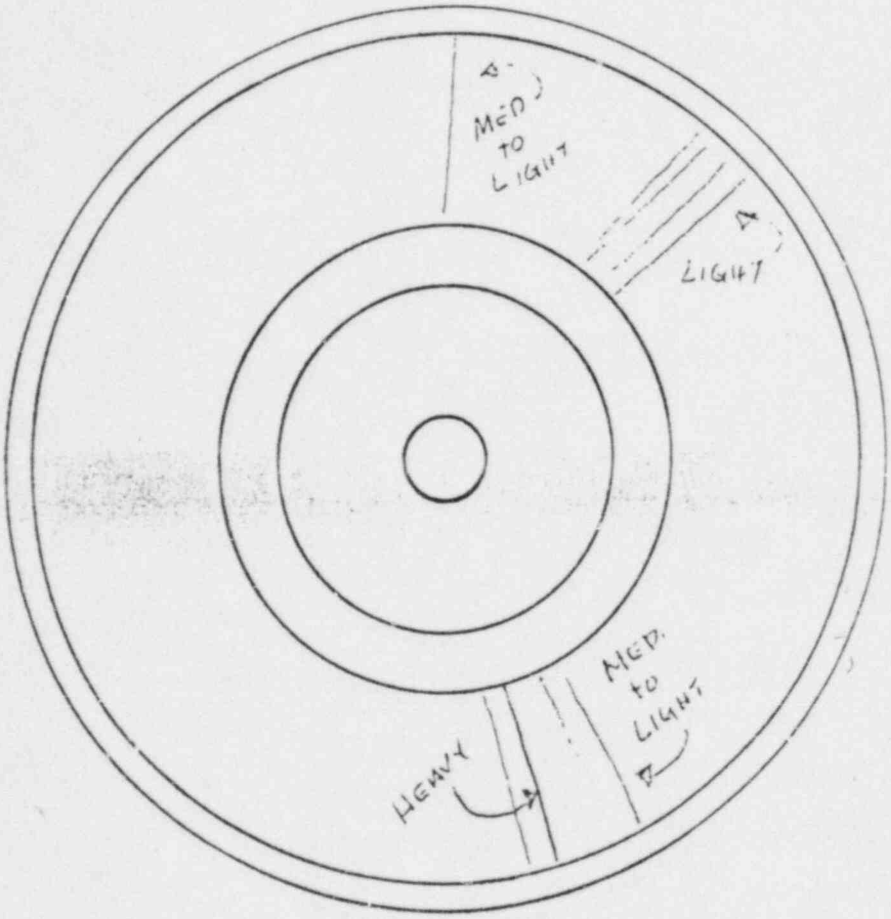
ENGINE NO. 75051-2814

CYLINDER NO. # 3LB

HOURS END OF SHOP TEST (NUCLEAR TEST S...

## CYLINDER WITH PISTON

EXHIBIT 31




Cam Side



RING IDENTIFICATION

TOP ____________

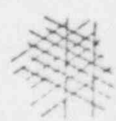
2ND ____________

3RD ____________

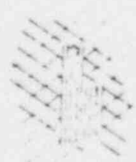
4TH ____________

5TH ____________

6TH ____________

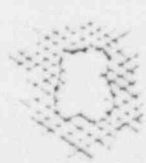


SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS. CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL. CROSS HATCH PATTERN CAN NOT BE SEEN.





BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

00210

**DELAVAL**
ENGINE AND COMPRESSOR DIVISION

DATE 3-30-78

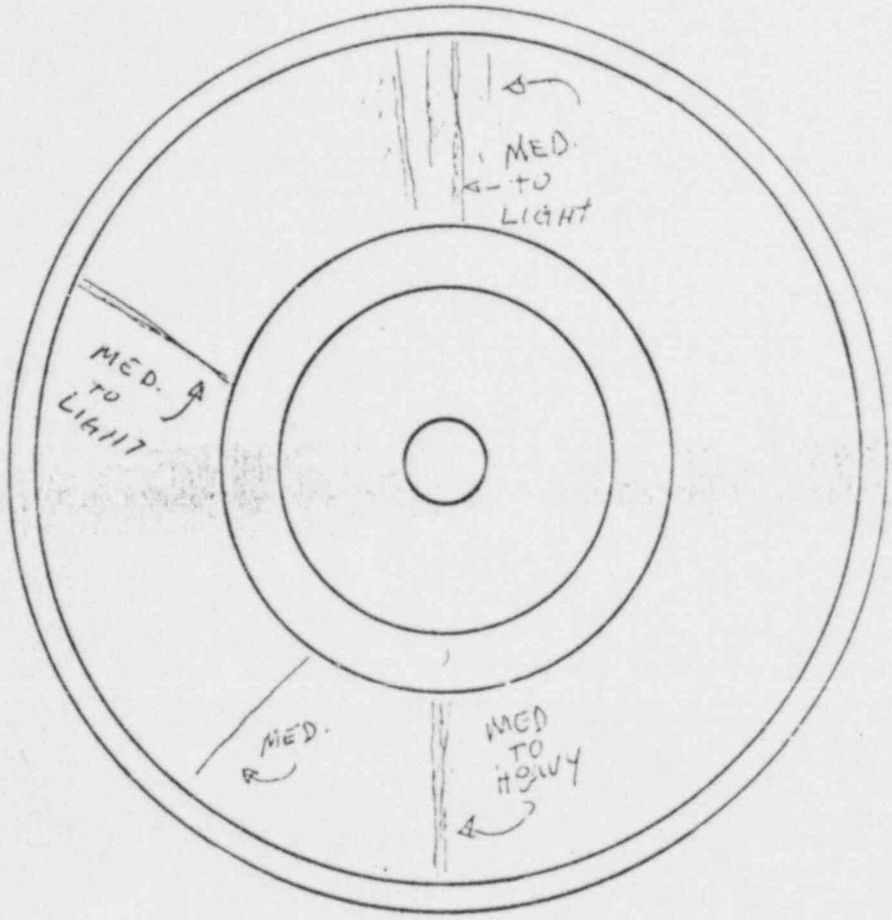
TIME 1030

ENGINE NO. 75051-2814

CYLINDER NO. #6 1B

HOURS END OF SHOP TEST (NUCLEAR T.S)

## CYLINDER WITH PISTON




1057

Cam Side

2710

**RING IDENTIFICATION**

TOP ____________

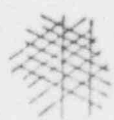
2ND ____________

3RD ____________

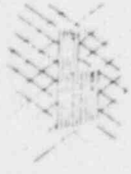
4TH ____________

5TH ____________

6TH ____________

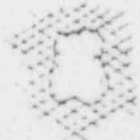


SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS. CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL. CROSS HATCH PATTERN CAN NOT BE SEEN.

INFORMATION ONLY



BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

00182

DELAVAL
ENGINE AND COMPRESSOR DIVISION

DATE 3-30-78

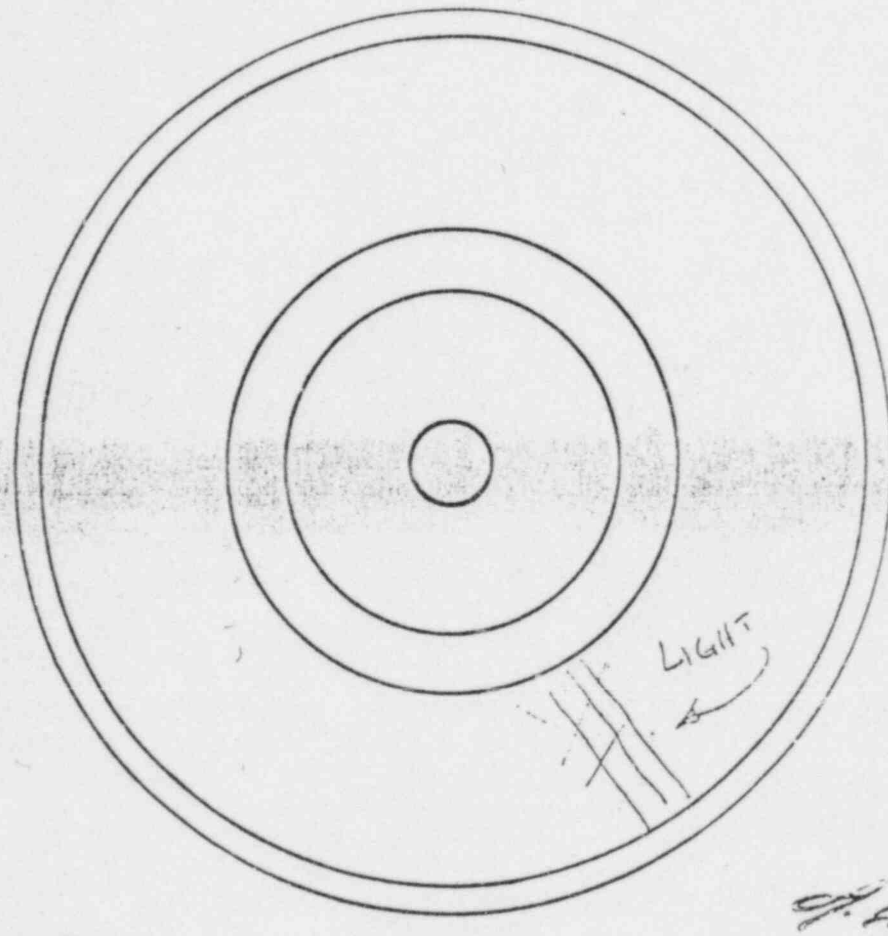
TIME 1024

ENGINE NO. 75051-2814

CYLINDER NO. #2 RB

HOURS END OF SHOP TEST (NUCLEAR T.S.)

# CYLINDER WITH PISTON




Cam Side

C.E.I.
P.O. NO. P-1152-S
P.N.P.P. UNIT NO. 1
G.A.I. B/M ITEM 1R49C001A

GILBERT/COMMONWEALTH 2710 8/10/84

INFORMATION ONLY

**RING IDENTIFICATION**

TOP ______

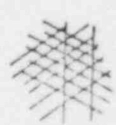
2ND ______

3RD ______

4TH ______

5TH ______

6TH ______



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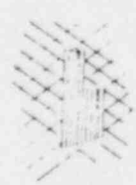
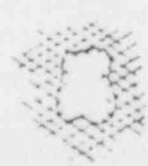


SCUFFING – CAUSED BY PISTON AND/OR RINGS CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL CROSS HATCH PATTERN CAN NOT BE SEEN.



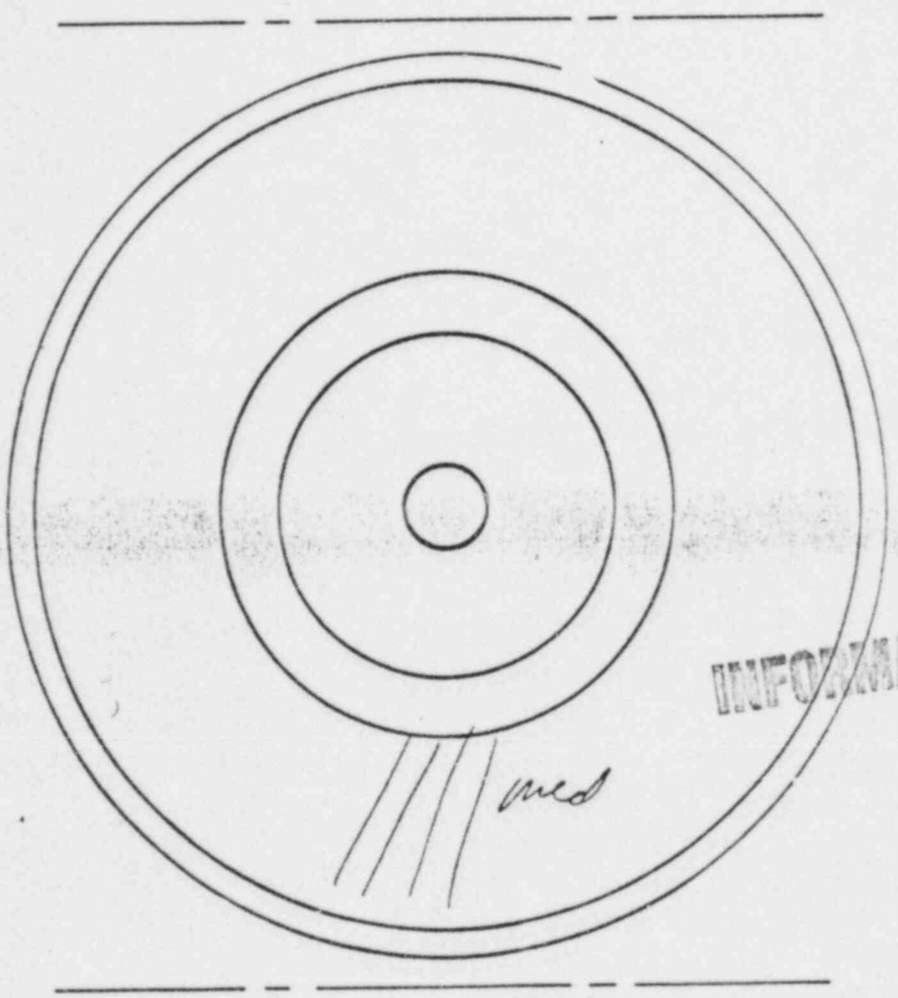
BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

DELAVAL
ENGINE AND COMPRESSOR DIVISION

DATE 3-31-78
TIME 1350
Jeurn

ENGINE NO. 2815
CYLINDER NO. L3
HOURS EOT

CYLINDER WITH PISTON




Cam Side





RING IDENTIFICATION

TOP ____________________

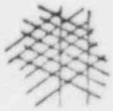
2ND ____________________

3RD ____________________

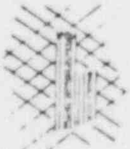
4TH ____________________

5TH ____________________

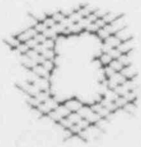
6TH ____________________



SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL CROSS HATCH PATTERN CAN NOT BE SEEN.



BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

DELAVAL ENGINE AND COMPRESSOR DIVISION

DATE 3-31-78

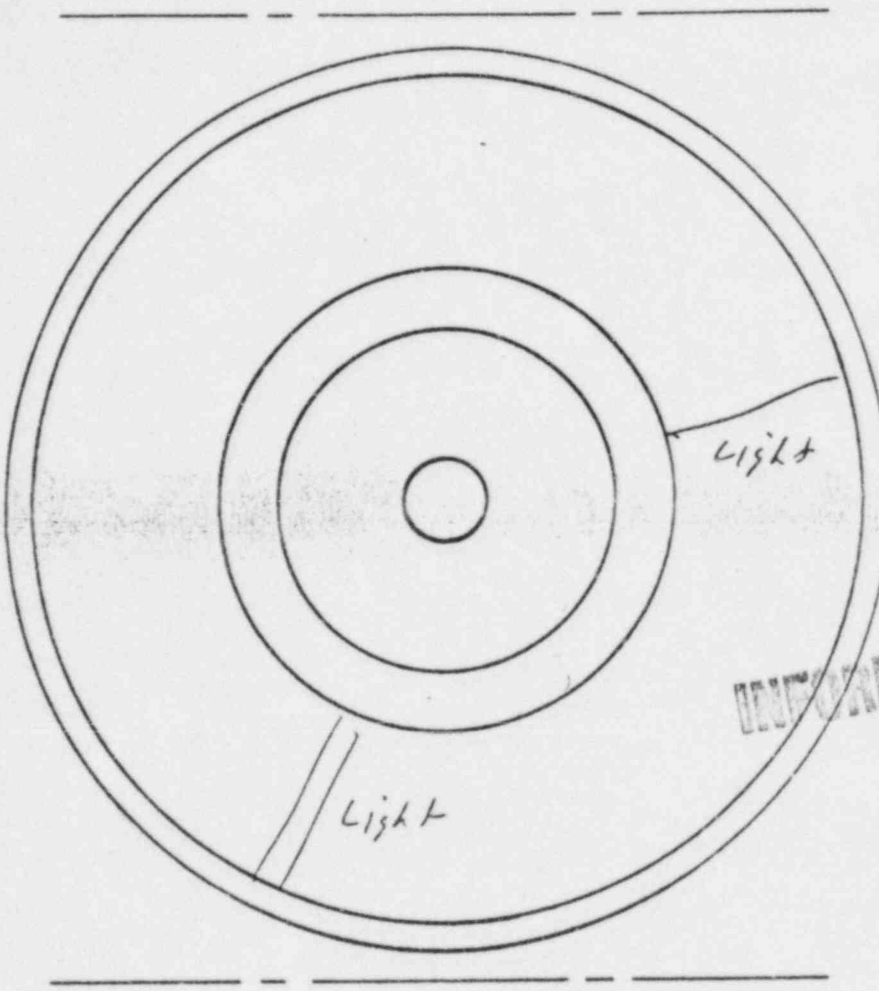
TIME 1350 (Jwm)

ENGINE NO. 2815

CYLINDER NO. L4

HOURS EOT

## CYLINDER WITH PISTON




INFORMATION ONLY

GILBERT/COMMONWEALTH 2710 G/C-QA

RING IDENTIFICATION

TOP ______

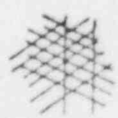
2ND ______

3RD ______

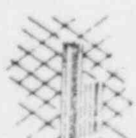
4TH ______

5TH ______

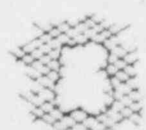
6TH ______



SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS. CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL. CROSS HATCH PATTERN CAN NOT BE SEEN.



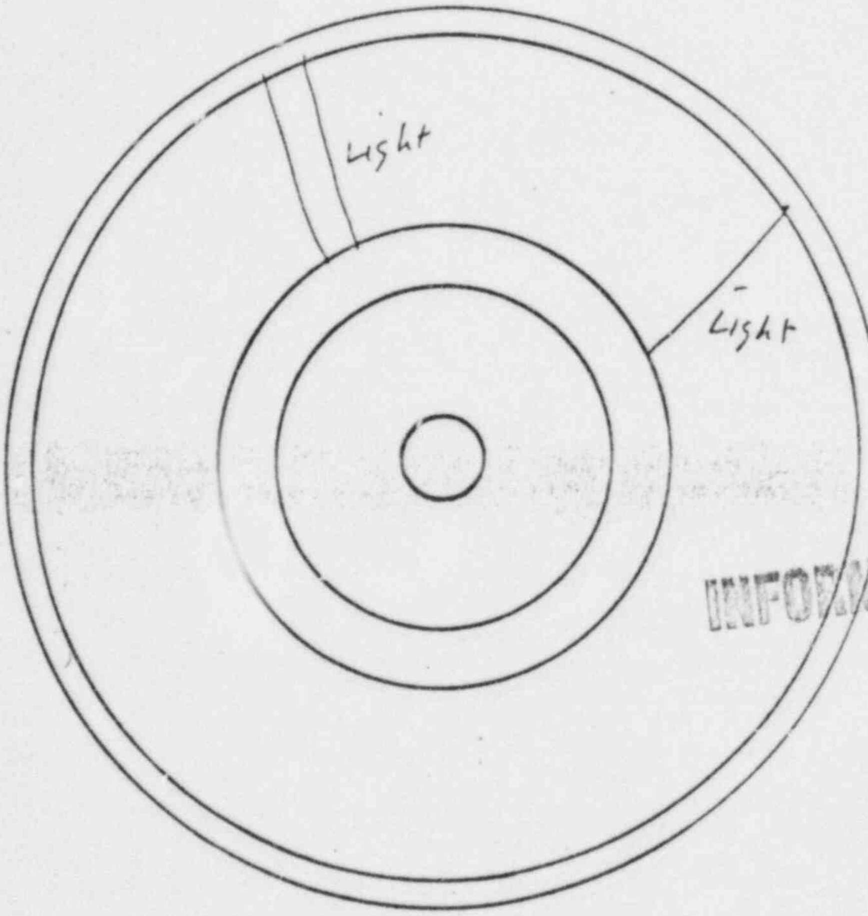
BRIGHT SPOT – BEARING THROUGH CROSS HATCH. CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

**DELAVAL**
ENGINE AND COMPRESSOR DIVISION

DATE 3-31-78
TIME 1350
Gwm

ENGINE NO. 2815
CYLINDER NO. L5
HOURS EOT

## CYLINDER WITH PISTON



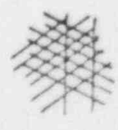

Cam Side

INFORMATION ONLY

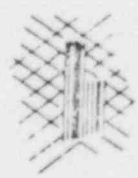


**RING IDENTIFICATION**

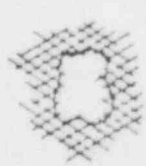
TOP ______
2ND ______
3RD ______
4TH ______
5TH ______
6TH ______



SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS. CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL. CROSS HATCH PATTERN CAN NOT BE SEEN.



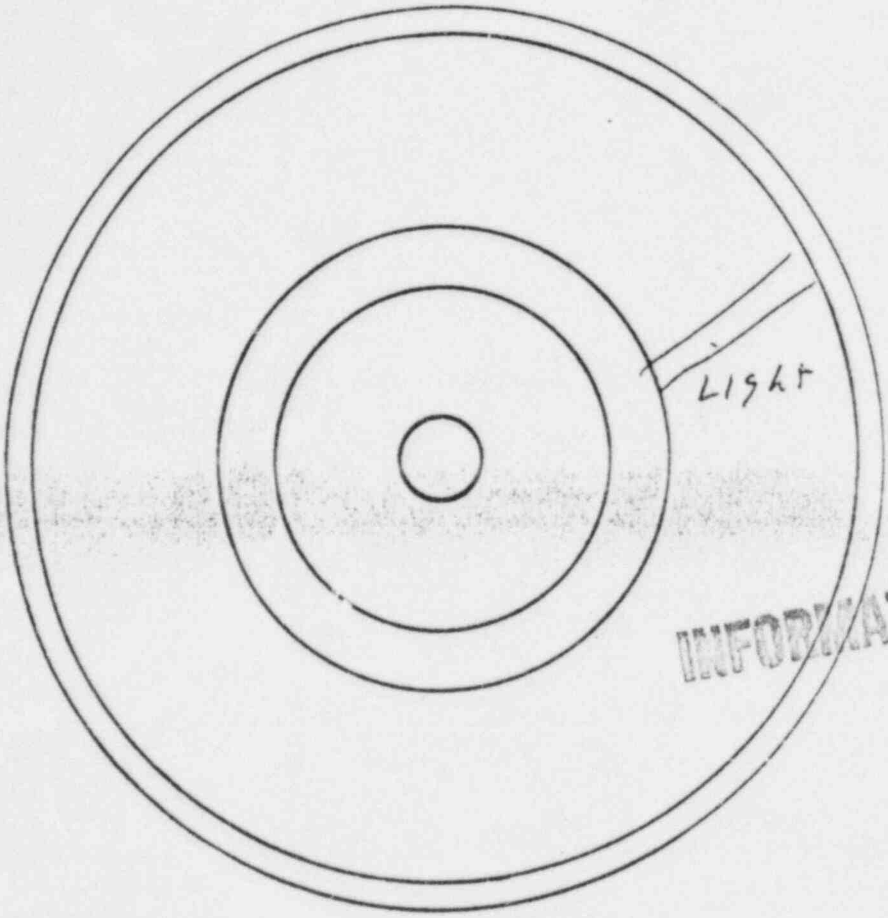
BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

**DELAVAL**
ENGINE AND COMPRESSOR DIVISION

DATE 3-31-78
TIME 1350
Kurus

ENGINE NO. 2815
CYLINDER NO. 6b
HOURS EOT

## CYLINDER WITH PISTON



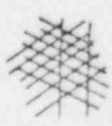




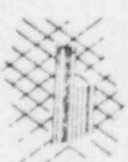

Cam Side

**RING IDENTIFICATION**

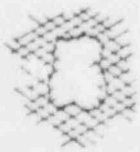
TOP ______________
2ND ______________
3RD ______________
4TH ______________
5TH ______________
6TH ______________



SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL. CROSS HATCH PATTERN CAN NOT BE SEEN.



BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

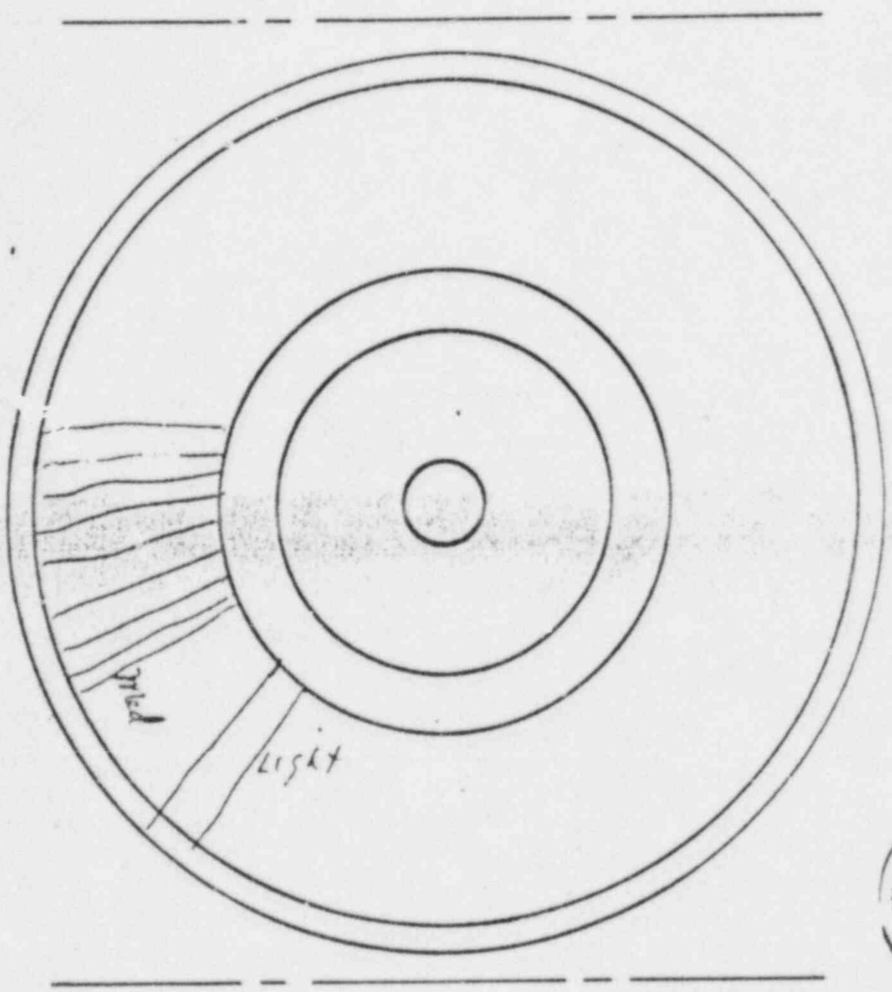
**DELAVAL**
ENGINE AND COMPRESSOR DIVISION

DATE 3-31-78
TIME 13.50

ENGINE NO. 2815
CYLINDER NO. R.B1
HOURS EOT

## CYLINDER WITH PISTON

1059




cAm Side

GILBERT/COMMONWEALTH 2710 G/C-QA

**RING IDENTIFICATION**

TOP ______

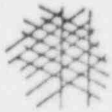
2ND ______

3RD ______

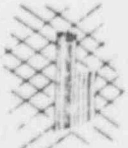
4TH ______

5TH ______

6TH ______



SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS. CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL. CROSS HATCH PATTERN CAN NOT BE SEEN.

INFORMATION ONLY

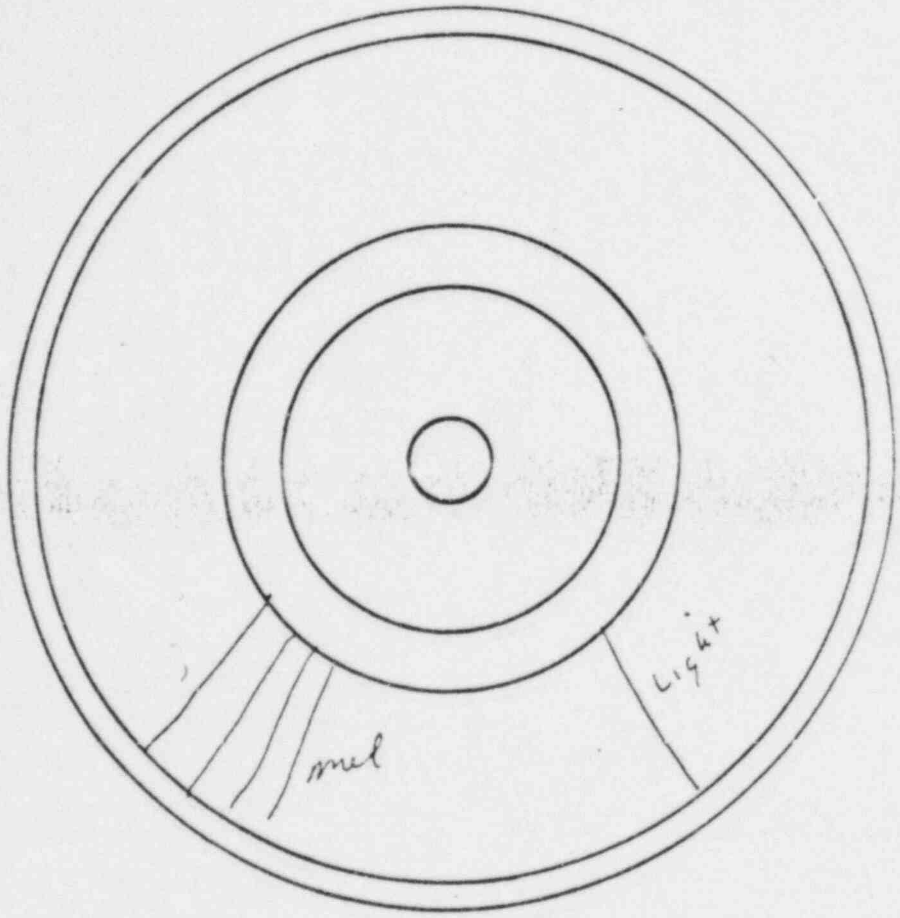
BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

DELAVAL
ENGINE AND COMPRESSOR DIVISION

DATE 3-31-78
TIME 1350
Gurn

ENGINE NO. 2805
CYLINDER NO. RB 2
HOURS EOT

## CYLINDER WITH PISTON




CAm Side





**RING IDENTIFICATION**

TOP ______

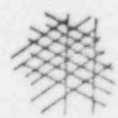
2ND ______

3RD ______

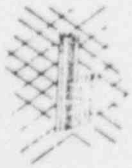
4TH ______

5TH ______

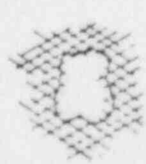
6TH ______



SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS. CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL. CROSS HATCH PATTERN CAN NOT BE SEEN.



BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

00116

**DELAVAL**
ENGINE AND COMPRESSOR DIVISION

DATE 3-31-78

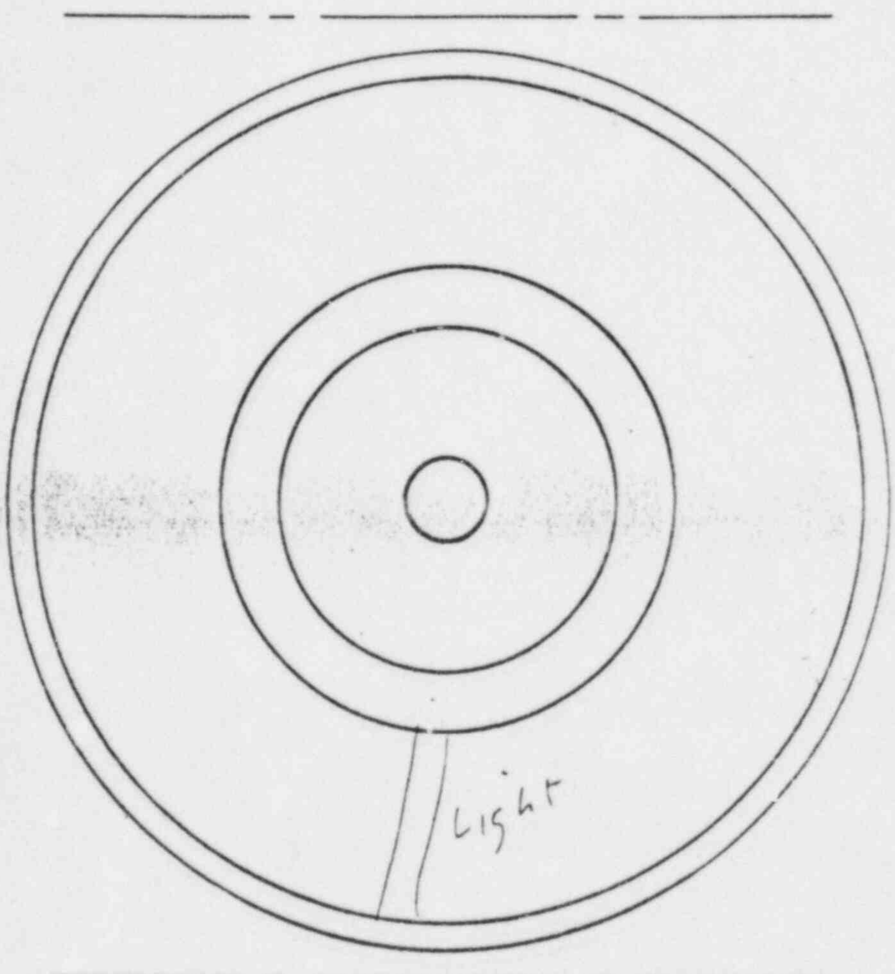
TIME 1250

ENGINE NO. 2815

CYLINDER NO. RB 4

HOURS ~~RB4~~ 505

## CYLINDER WITH PISTON




CAM Side

INFORMATION ONLY

GILBERT/COMMONWEALTH 2710 G/C-QA

RING IDENTIFICATION

TOP ____________

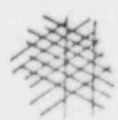
2ND ____________

3RD ____________

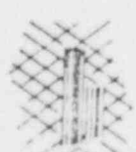
4TH ____________

5TH ____________

6TH ____________



SCRATCHES – LONG NARROW GROOVES USUALLY CAUSED BY FOREIGN MATERIAL. CROSS HATCH PATTERN RUNS THROUGH.



SCUFFING – CAUSED BY PISTON AND/OR RINGS CAN START BELOW OIL RING AND RUN UP THROUGH UPPER COMPRESSION RING TRAVEL. CROSS HATCH PATTERN CAN NOT BE SEEN.

BRIGHT SPOT – BEARING THROUGH CROSS HATCH CAN APPEAR ANYWHERE. PROBABLE CAUSE HEAVY BEARING BY BUILDUP ABOVE TOP RING LAND.

EXHIBIT 32

R85-1486 p. 10 of 26

GILBERT/COMMONWEALTH
QUALITY ASSURANCE DIVISION
INSPECTION SERVICES REPORT

0454-84-81

Nov. 26 - 30, 1984

CLIENT: Cleveland Electric Illuminating Co.

UNIT: Perry Nuclear Power Plant - Unit 1 & 2

VENDOR: Transamerica Delaval, Inc. (TDI)

LOCATION: Oakland, Ca.

VENDOR PURCHASE ORDER: Q-3627-6?, Chg. 2

PRINCIPAL CONTACT: Doug Stuart

EQUIPMENT SPECIFICATION TITLE: Class IE Diesel Generator Units

SPECIFICATION NO.: SP-562-4549-00, Rev IV

INTRODUCTION & PURPOSE:

G/C, Inc. was notified that 128 valves (intake & exhaust) were ready for re-inspection (see ISR 0454-84-79, 11/19 - 11/23, 84); that seven (7) reworked heads were ready for the final magnetic particle, liquid penetrant examinations and UT-thickness check; that at least seven (7) cylinder heads were ready for final assembly, painting, coating and preparation for shipment; and that the procedure qualification for 100-W-17, Rev. 4 (hard facing) would be ready for G/C, Inc. review and acceptance prior to shipments.

The purpose of this visit was to witness the magnetic particle and liquid penetrant examinations, perform a final dimensional re-inspection of the 128 valves, perform a final visual inspection of the reassambled cylinder heads, and to review the procedure qualification record (PQR) for hardfacing procedure 100-W-17, Rev. 4.

SUMMARY:

G/C, Inc. witnessed the magnetic particle examinations on nineteen (19 heads after rework. Five (5) heads were rejected due to unacceptable indications in the fire deck areas. G/C, Inc. witnessed the liquid penetrant examination of the fourteen accepted heads. No unacceptable indications were noted. G/C, Inc. performed the final dimensional inspection of 128 valves which were satisfactory. G/C, Inc. reviewed the PQR and Rev. 5 to hardfacing procedure 100-W-17, which was satisfactory. G/C, Inc. performed a final inspection of the fourteen (14) acceptable heads during this period and of the two (2) heads found to be acceptable during the period 11/19/84 - 11/23/84 (a total of 16 reworked cylinder heads). G/C, Inc. issued a Certificate of Inspection for the 16 of 32 acceptable reworked cylinder heads after a satisfactory packaging, identification and documentation review.

Dimensional:

G/C, Inc. performed a dimensional inspection, along with the TDI shop inspector, on 128 valves (intake and exhaust). This was a reinspection of the rejections noted on ISR 0454-84-79 (11/19/84-11/23/84). The valves were checked for final dimensions and a visual of workmanship prior to assembly of the cylinder heads. The shaft O.D. and concentricity, the chrome plating, and the T.I.R. (within .003) were checked and found to be satisfactory.

Note: Forty-two (42) valves required regrinding.

The 128 valves were found to be acceptable and in accordance with TDI drawing 03-360-02-OD, Rev. L.

The following calibrated inspection devices were used:

| DESCRIPTION | SERIAL NO. | CALIBRATED | DUE |
|---|---|---|---|
| Snap Cage (1-2) | DTE-062-E | 10/84 | 01/85 |
| Gage Block Set | 034-F | 03/84 | 03/87 |
| Dial Indicator | 060-0 | 07/84 | 01/85 |
| Dial Indicator (valve seat run-out fixture) | 060-G | 10/84 | 04/85 |
| Micrometer (0-1) | 001-X | 10/84 | 01/85 |
| Dial Caliper (0-6) | 4231 | 07/84 | 06/85 |

NONDESTRUCTIVE EXAMINATIONS:

G/C, Inc. witnessed the magnetic particle examination of the fire deck excluding the seat area) on nineteen (19) completed reworked/reconditioned cylinder heads which were dispositioned as follows:

ACCEPTED HEADS

| SERIAL NO. | HEAT NO. |
|---|---|
| B87 - 7R | 965T |
| C42 - 4L | 90U |
| C88 - 1R | 287U |
| A54 - 5R | 754T |
| B51 - 5L | 887T |
| C84 - 2L | 281U |
| C3 - 6R | 994T |
| C34 - 7 - L | 64U |
| C29 - 3 - L | 60U |
| C89 - 2R | 287U |
| B25 - 6 L | 851T |
| C47 - 8L | 91U |
| C79 - 3R | 203U |
| L33 - 4R | 628K |

REJECTED HEADS

| SERIAL NO. | HEAT NO. | REMARKS |
|---|---|---|
| C63 | 134U | Lack of fusion |
| C95 | 321U | Hot tear |
| D12 | 391U | Inclusions |
| B6 | 818T | Hot tear |
| B99 | 988T | Hot tear |

Note: The rejected heads were excavated, re-tested and sent back for repair.

EXHIBIT 33

The replacement cylinder heads on the Shoreham EDGs are of inadequate design and manufacturing quality to withstand satisfactorily thermal and mechanical loads during EDG operation, in that:

(a) the techniques under which the replacement cylinder heads were produced have not solved the problems which caused the cracking of the original cylinder heads on the Shoreham EDGs;

(b) the "barring over" surveillance precedure to which LILCO has committed will not identify all cracks then existing in the replacement cylinder heads (due to symptomatic water leakage);

(c) the nature of the cracking problem and stresses exacerbating the cracks are such that there can be no assurance that no new cracks will be formed during cold shutdown of the EDGs;

(d) there can be no assurance that cracks in the replacement cylinder heads and concomitant water leakage occuring during cold shutdown of the EDGs (which would not be detected by the barring-over procedure) would not sufficiently impair rapid start-up and operation of the EDGs such that they would not perform their required function;

(e) there can be no assurance that cracks in the replacement cylinder heads occurring during operation of the EDGs would not prevent the EDGs from performing their required function;

(f) variations in the dimensions of the firedeck [and water deck] of the replacement cylinder heads create inadequate cooling, where too thick, and inadequate resistance to mechanical loads, where too thin, and create stress risers at their boundaries;

(g) the design of the replacement cylinder head is such that stresses are induced due to non-uniform bolt spacing [and the different lengths of the bolts];

[(h) the replacement cylinder head design does not provide for adequate cooling of the exhaust valves];

(i) at least one replacement cylinder head at Shoreham has an indication;

[(j) the design of the replacement cylinder heads provides inadequate cooling water for the exhaust side of the head]; and

(k) the replacement cylinder heads at Shoreham were inadequately inspected after operation, because:

(1) a liquid penetrant test was done on the exhaust and intake valve seats and firedeck area between the exhaust valves on only 9 of 24 cylinder heads, and such tests were done after only 100 hours of full power operation;

(2) ultrasonic testing was done on the firedeck areas of only 12 cylinder heads;

(3) visual inspections were performed on the valve seat areas of only 32 of the 98 valves, and on only 7 firedecks of the 24 cylinder heads for indications of surface damage.

The bracketed portions of the foregoing contentions are deleted and not addressed in this testimony.

Q. What are your conclusions regarding the adequacy of the design and manufacture of the replacement cylinder heads?

A. Contrary to the conclusions reached by FaAA in its report evaluating TDI cylinder heads66/ and by the DRQR Report on cylinder heads, we conclude that:

(a) The replacement cylinder heads are inadequate for their intended service due to the potential for cracks to initiate and to propagate in the heads, leading to leaks into the cylinders.

(b) The potential for flaws in replacement heads of the EDGs still exists, since the manufacturing techniques for casting, inspecting, and testing the replacement heads have not been demonstrated to resolve the deficiencies which resulted in the cracking of the original heads.

(c) Cracks in the replacement heads could leak water into the cylinders of the EDGs during cold shutdown. The "barring over" surveillance procedure, dated August 5, 1983, proposed by LILCO will not preclude the presence of water in the cylinders.

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66/ "Evaluation of Cylinder Heads of Transamerica Delaval, Inc. Series R-4 Diesel Engines," FaAA 84-5-12, May, 1984 (the "FaAA Head Report"). (Exhibit 19).

Water in the cylinders could impair or prevent rapid startup and operation of the EDGs.

(d) The casting process at TDI is not reproducible. Thus, there is no assurance that each casting will exhibit identical or even similar characteristics.

(e) The inspections of the replacement heads after operation were inadequate in that the operating time was insufficient (only 100 hours). Further, the sampling inspections utilized were not appropriate since it was not demonstrated that the population of heads was homogeneous.

(f) The stress analysis performed by FaAA failed to demonstrate that the predicted deformation of the replacement heads due to thermal and mechanical loads will not progress to the point of impacting acceptability of the heads.

In addition, as a result of our evaluation, we concur with the Owners Group conclusion in the DRQR Report for Shoreham that:

> The absence of detectable flaws in the Shoreham cylinder heads does not preclude the eventual propagation of a crack from a subsurface defect or a defect in an inaccessible location.67/

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67/ DRQR Report, Vol. 8, Cylinder Heads, at 3. (Exhibit 20).

Indeed, Dr. Wells of FaAA acknowledged at the June 22 meeting between the Owners' Group and PNL that:

> not knowing the distribution of flaws below the surface of these heads, that we would in fact acknowledge the possibility that cracks would grow and leaks would develop, and confidence in the -- or lack thereof, in the behavior of these heads really has to be established by inspection and by examining the causes of leaks . . . ."68/

Based on the preceding conclusions, we do not believe that the replacement cylinder heads are adequate for nuclear service, and thus, there can be no assurance that the EDGs will perform satisfactorily in service.

Q. What prompted Suffolk County's concern with the cylinder heads in the EDGs?

A. Three of the original cylinder heads in the EDGs developed cracks in their firedecks which allowed cooling water to leak into the cylinders. Subsequently, the County filed a contention in these proceedings, which was admitted by the Board, and discovery concerning the cylinder heads commenced. LILCO then committed to replace all of the original cylinder heads in the EDGs prior to fuel load of Shoreham with heads of allegedly superior manufacturing quality.69/

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68/ Meeting Transcript (June 22, 1984) at 124.

69/ Affidavit of Edward J. Youngling, July 22, 1983, para. 3. (Exhibit 21).

Q. Did LILCO replace all of the cylinder heads in the EDGs?

A. It is unclear that they did. FaAA states in one part of its cylinder head report of May 19‚4 ‚hat "all but two (E71 and F64)" of the original heads h replaced with heads cast by TDI after September, 1980 (hereinafter called the "Group III heads"); elsewhere in the report FaAA says that all of the original heads in the EDGs h‚‚ been replaced with Group III heads.70/ The DRQR Report asserts that all heads have been replaced with Group III heads.71/

Q. Are the failures of three f the original cylinder heads at Shoreham and of other pre-Group III heads relevant to your conclusions?

A. Yes. FaAA acknowledges that pre-Group III TDI heads were subject to numerous defects, but asserts that these defects were caused only by inadequate manufacturing processes and/or poor quality control at TDI.72/ Based upon information given by TDI as to changes in manufacturing techniques,73/ FaAA

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70/ FaAA Head Report, at 1-3 and ii.

71/ DRQR Report, Vol. 8, Cylinder Heads, at 3. (Exhibit 20).

72/ FaAA Head Report at ii 1-2 to 1-4.

7‚/ Id. at 1-5 to 1-6.

has concluded that Group III heads (including the replacement heads at Shoreham) are "adequate for their intended service."74/ However, FaAA has not independently examined this data and in fact stresses its data "has not been verified as normally required under FaAA's quality assurance procedures."75/ FaAA also concluded that "there is a potential for cracks to propagate from pre-existing flaws in the head leading to leaks into cylinders," but that "the potential for the pre-existing flaws in Group III heads is significantly less than for" heads cast earlier.76/

Q. Do you agree with FaAA's conclusions stated above?

A. No. The replacement heads are not adequate. The FaAA conclusions are based in large part upon TDI's reviews of pre-Group III heads and *ad hoc* changes in TDI's manufacturing processes. While we agree with FaAA that cracks may well propagate from pre-existing flaws in the heads, causing water leaks into the cylinder, we do not agree that the likelihood of such flaws existing in the Group III heads has been demonstrably

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74/ *Id*. at 4-1.

75/ *Id*. at 1-5.

76/ *Id*. at 4-1.

reduced by changes in TDI's manufacturing processes. Our testimony will also address the fact that cracks may occur in the replacement heads for reasons other than the presence of casting flaws, including deficiencies in the design of the replacement heads.

Q. Are the Group III cylinder heads in the EDGs of the same design as the original Shoreham heads and others cast prior to September, 1980?

A. Basically yes. All of these TDI cylinder heads are of the same design, except for a change to weld thicker covering plates over the core holes in the head, according to the TDI drawing of the head. This change is not significant to any of our conclusions as to the head designs.

Q. How is this portion of the testimony organized?

A. First, we will show that various deficiencies exist in the design of the replacement heads at Shoreham which may lead to failures. These deficiencies are unacceptable variations in dimensions of the firedeck and non-uniform bolt spacing which induce stresses. Second, we will demonstrate that changes introduced by TDI in manufacturing techniques have not solved or significantly diminished problems which result in

IMAGE EVALUATION
TEST TARGET (MT-3)

150mm

6"

flaws or cracks in the replacement heads. Third, we will document that the replacement heads in the EDGs have not been adequately inspected and include at least one flawed head. Fourth, we will examine the nature and effects of crack initiation and propagation in the replacement heads, and explain why the "barring over" procedure adopted by LILCO will not identify all leaks and make the use of the replacement heads sufficiently safe for nuclear service.

Inadequate Design

Q. What are the major design issues with cylinder heads in large medium speed diesel engines like the EDGs?

A. The cylinder head is one of the most intricate and difficult-to-design components in the engine. It must be strong enough to withstand the mechanical stress to which it is subjected during engine operation, but must also provide sufficient cooling through numerous water passages in the head to permit thermal stresses to be handled. Thus, the two major general design concerns are to provide sufficient strength and adequate cooling.

We were therefore surprised to discover that TDI did not change the design of the cylinder head when it increased the horsepower of the R-4 series diesel, because a significant increase in horsepower also increases thermal and mechanical loads.

Q. What changes were made in the TDI R-4 engines to increase horsepower?

A. In 1966-1967 the R-4 series diesel was developed. Compared to its predecessor, the TDI R-3 series engine, the R-4 increased engine speed from 375 to 400 RPM, and increased fuel and air supply to raise its brake mean effective pressure (BMEP) from 165 to 185 psi.77/ At the same time, changes were made in the design of the pistons, connecting rods, cylinder block, bed plate, cylinder liners and cylinder heads.78/

In 1970-71 the horsepower of the R-4 series engine was boosted to that of the EDGs (about 610 HP per cylinder) by increasing engine speed from 400 to 450 RPM.79/ The BMEP increased from 185 to 225. To deal with the consequent higher thermal loading, the piston design was changed from a one-piece iron cast to a two-piece steel casting and flanges were removed

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77/ Trussell Deposition at 81-82. (Exhibit 10).

78/ *Id*. at 74-81.

79/ *Id*. at 82.

from connecting rod bearings, but no design changes were made in the cylinder head.80/ The replacement heads at Shoreham are thus of the same design as the heads designed for an engine with a speed of only 400 RPM and horsepower per cylinder of only 445 HP, as compared to over 610 HP per cylinder in the EDGs.

Q. What deficiencies have you noted in the design of the firedeck of replacement heads?

A. TDI permits wide variations in the thickness of the firedeck. The acceptance standard for the thickness across the firedeck was 0.500 inch ± .005 inch instrument accuracy and ± .010 inch per applicable drawing.81/ On July 28-29, 1983, NRC inspectors measured the firedeck thickness in thirteen replacement heads at Shoreham and found variations from 0.460 to 0.881 inch.82/ TDI takes the position that the minimum acceptable firedeck thickness is 0.400.83/ Apparently TDI designers

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80/ Id. at 85-87.

81/ NRC Inspection Report No. 50-322/83-25, August 11, 1983 ("I&E Report 83-25") at 3. (Exhibit 22).

82/ Id. with attachments thereto.

83/ Transmittal letter dated August 15, 1983, for I&E Report 83-25. (Exhibit 23).

do not apply any acceptance standards for maximum firedeck thickness.

Q. What are the consequences of the wide variations in firedeck thickness?

A. Where the firedeck is too thin, it is susceptible to cracking from the high mechanical stresses imposed on the firedeck during EDG operation, particularly at higher horsepower and loading. Firing pressure could cause stress which exceeds the material strength. Where the firedeck is too thick there may be insufficient cooling; the diminished heat transfer increases stress. Where there are wide variations in the thickness of the firedeck, as in the replacement heads, a stress gradient is created at the boundary of a thick and thin portion, which makes cracking more likely to occur.

Q. Has TDI conducted any studies or analyses to determine when the firedeck wall is too thick or too thin?

A. No. Mr. Lowery, TDI's manager of design engineering and research and development, has testified that "no calculations have been done to determine what the firedeck [thickness] should be."84/ The only documentation supporting the reduction

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84/ Deposition of Maurice H. Lowrey (May 11, 1984) ("Lowrey Deposition") at 85. (Exhibit 24).

of the acceptance criterion for minimum firedeck thickness to only 0.400 (from 0.500) is an inspection report dated February 21, 1981, covering the firedeck inspection of four heads and bearing the notation "Functionally Acceptable (.400 Min. Tolerance),"85/ and an internal TDI memorandum, prepared after the NRC inspectors had measured the firedeck thickness of 13 heads at Shoreham in July, stating "The smallest nominal firedeck thickness is specified as 1/2 inch. This dimension is allowed to vary to a minimum of 0.400 inches" (sic.)86/ Neither of these documents is an adequate engineering evaluation of minimum firedeck thickness.

TDI ignores the maximum firedeck thickness standard, which should be 0.515 inch with tolerance allowances, except between the intake valve ports, where .765 inch with allowed tolerances is required.87/ Both of these maximum thickness requirements are exceeded on at least 20 measured areas of the firedecks of 18 replacement cylinder heads at Shoreham.88/

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85/ TDI Inspection Report No. Q-0783. (Exhibit 25).

86/ Memorandum dated August 1, 1983, from G. King (then TDI, now FaAA) to R. Boyer and E. Wilson (TDI). (Exhibit 26).

87/ I&E Report 83-25 did not refer to the special thickness specification between the intake valve ports.

88/ I&E Report 83-25 (Exhibit 22); FaAA Head Report at 1-8.

Q. Please describe the bases for your belief that the non-uniform head stud spacing induces stresses in the replacement heads.

A. When the cylinder head studs are pretensioned the head is stressed due to the bending moments arising from the tension in the studs. The bending moments in the head are balanced by the bending moments in the block and the liner. The bending moments in the block are induced from the tensile stress in the studs. When the head stud spacing is non-uniform, the bending moments set up around the circumference of the head are also non-uniform. The stud location is such that the bending moment on the head from stud pretensioning is greater in the transverse direction (90 degrees to crankshaft polar axis) than in the direction of the crankshaft axis. This non-uniformity of bending moment means that head deflection from pretensioning is greater in the transverse direction. The head is further deflected by thermal distortion resulting from the thicker dimension of the firedeck between the intake valves. The deflection of the head may lead to exhaust valve leakage and problems attendant with valve leakage.

Q. Did FaAA adequately review the design of the replacement cylinder heads?

A. No. FaAA did not address all of the functional attributes of the cylinder head as set forth in the Task Description for the cylinder head design review.89/ Rather FaAA limited its design review to an evaluation of thermal and pressure stresses on the firedeck, using an extremely simplified idealized version of the firedeck and making assumptions which invalidate the conclusions of the review. We believe the FaAA analyses is unreliable, and the TDI Owners Group apparently agrees. Mr. Coleman of the Owners Group agreed that no reliance could be placed in the design analysis of the FaAA Head Report in his statement to PNL at the June 22, 1984 meeting that: "The idea that we're trying to give you today is that we didn't depend on the [cylinder head] report either from the standpoint of the analysis, other than to give us some idea of what's going on there, but our conclusions of our recommendations are based on the fact that we did not have enough information in our analysis. We were unable to do the complicated analysis necessary to get that."

Q. Why do you believe the results of the FaAA analytical evaluation of thermal and pressure stresses are invalid?

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89/ FaAA Head Report, Appendix B.

A. Dr. Wells of FaAA stated that "these are approximate calculations only intended to show the general levels of thermal and pressure stress."90/ We agree for the following reasons. First, FaAA used an idealized one-dimensional model of a flat plate for the firedeck, and therefore assumed a uniform thickness of the plate.91/ Solutions in the thermal analysis were obtained for 3 different uniform plate thicknesses.92/ The actual firedeck is non-uniform and has many thickness variations in a single firedeck. The temperature distribution in the firedeck is significantly affected by these thickness variations, as explained above. Second, FaAA assumed a peak firing pressure of 1600 psi.93/ The actual peak pressure is about 1800 psi. This large difference between the assumed and the actual firing pressure would substantially alter the results of both the thermal and pressure stress evaluations by FaAA. Third, FaAA's pressure stress analysis idealizes the firedeck as if it were a plate uniformly clamped at its outer boundary.94/ In reality, the bolts holding down the head are

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90/ Transcript of June 22, 1984 meeting between PNL and the TDI Owners Group, at 136.

91/ FaAA Head Report at 3-1.

92/ Id. at 3-3.

93/ Deposition of Clifford H. Wells (May 14, 1984) ("Wells Deposition") at 130-31. (Exhibit 27).

94/ FaAA Head Report at 3-5.

not uniformly spaced. FaAA admits that "the local stresses in the critical areas ... defy analysis because of the complexity of the geometry."95/ Fourth, the underlying data in support of the calculations is not provided and thus the report's conclusions are inscrutable. For instance, the conclusion that "provided the range of stress does not exceed twice the yield stress, the fire deck should be dimensionally stable even if yielding occurs . . . ." is not supported by calculations. Finally, the FaAA evaluations assume a perfect cylinder head material free of any defects or imperfections. The strength of the actual casting and the presence of imperfections will affect the ability of the firedeck to withstand mechanical and thermal stresses.

## Changes in Manufacturing Techniques

Q. Do you believe that the cracks in the three original Shoreham heads and in other heads cast prior to September 1980 are the result of casting flaws, as suggested in the FaAA Head Report?96/

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95/ Id. at 3-6.

96/ Id. at 1-2 to 1-4.

A. Yes. From the two TDI failure analyses of the three Shoreham head failures,97/ we believe there is evidence of casting defects in those heads. But there is no basis for eliminating other contributory causes of failures of these and other TDI heads referred to in the FaAA Head Report, including the design defects described above.

The causes of cracks in any 4-cycle engine cylinder head are generally related to a combination of stresses from cylinder pressures, thermal stresses from cooling strains (set up during the solidification and the cooling of the castings), and stresses arising from bolting the heads onto the engine frame. Failures such as the ones that have occurred at Shoreham can come about from fatigue and from the fact that stresses affect the endurance limit of the castings. Failures can also occur if there is thinning in the casting process, even if the thinning is insufficient to cause porosity or hot tears in the casting, since gas pressure loads can then overstress the thin areas. Failures can also occur if there is a thickening of critical areas of the cylinder heads due to core shift. The reduction in working stresses from the thickened material does

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97/ TDI Failure Analysis Reports No. 0150 and 0151, March 28, 1983, signed by R. A. Pratt. (Exhibit 28).

not generally compensate for the increase in thermal stress, and failure usually occurs, starting with cracks developing within the cooling water space and moving outward.

Q. Will cracks develop if there is porosity or hot tears in the casting process?

A. Porosity, hot tears, shrinkage and sand or slag inclusions are all examples of casting defects which can result in cracking of the cylinder heads. For this reason, it is appropriate to discuss not only the cracks that were found in the three original Shoreham cylinder heads, but also the kinds of casting defects which can cause cracking.

Q. Hasn't the cause of the cracks in the three Shoreham cylinder heads been established?

A. Based upon the failure analyses performed by TDI, LILCO asserts that the cracks in the three original cylinder heads were caused by operating stresses acting upon latent casting defects -- hot tears and shrinkage in the case of cylinder head S/N E94 and sand inclusions in the case of cylinder heads S/N E27 and E31. This assertion, however, is unjustified because the failure analyses are inadequate and of insufficient completeness. The analyses do not rule out possible contributory causes of the failures. Complete failure analyses would have included metallography, bulk chemical analysis, scanning electron microscopy, and perhaps localized chemical analysis of the fractured surfaces. Metallography would have disclosed whether the heads had been suitably heat treated. Metallography would also have revealed information about the grain structures of the casting at the failure site. It would have detected the presence of coring material, which can be deleterious to the integrity of the casting, and could have indicated the presence of residual stresses. Scanning electron microscopy would have identified the site of crack initiation and therefore would have helped reveal the mode of failure. Localized chemical analysis would have confirmed the type of casting defect present. Without these tests and analyses, TDI could not have accurately ascertained the cause or causes of the cracks. For example, while a hot tear can generally be recognized on a clean and fresh casting surface, the cracks experienced at Shoreham, when sent back to TDI for analysis, were corroded. Thus, the cracks should have been cleaned and examined by appropriate means such as scanning electron microscopy. Among other things, examination of the corrosion products would have given an indication of how long the crack had existed. However, none of this was done. With respect to the sand inclusions, chemical analysis of the filings would have differentiated sand from slag inclusions. While TDI performed a microscopic assessment of filings, they failed to chemically analyze the material to establish its true origin. Moreover, metallography would have shown if "sand inclusions" were concealing other defects, such as gas porosity. Again, however, these tests were not performed.

Q. Why is a complete failure analysis necessary?

A. Because until the actual cause (or causes) of the cracks is determined, judgments regarding the adequacy of sol tions to the problems which permitted the cracking to occur cannot be made with any degree of assurance.

Q. Is it possible to determine with any confidence whether the changes in manufacturing techniques adopted by TDI have solved the casting problems with cylinder heads?

A. No. Since 1976 there have been over 74 changes which TDI has reported it made in its casting techniques and foundry procedures.98/ Not all of the changes were in response to specific problems. Indeed, many of the changes were made in response to production costs.99/ However, the multiplicity of

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98/ "4 Valve Steel Head -- 03-360-03-OF" (undated) (Exhibit 29).

99/ See Deposition of Edward S. Dobrec (August 3, 1983), at 52-62. (Exhibit 30).

changes and the interrelationship between changes, makes an assessment of the total effects of the process changes impossible. Thus, the changes claimed by TDI do not reflect a clear evolution in techniques and procedures, but rather an ad hoc "hit or miss" approach. In addition, TDI had no detailed foundry practice procedures at the time the original cylinder heads at Shoreham were produced, so the original and the replacement head casting processes cannot be accurately compared.

Q. The FaAA Head Report refers to particular manufacturing procedures to support its conclusion that, although the replacement heads might crack due to pre-existing flaws, they are less likely to do so than the pre-September 1980 heads. Do you agree?

A. No. FaAA states that TDI's casting problems of inadequate mold quality, core shifting, and poor gaging procedures in machining the firedeck "were apparently addressed" by:

(1) "Improvements" in mold and core design, and

(2) "Changes" in materials used for mold and core fabrication, especially use of a sodium silicate ester sand for the mold and use of core shells.100/

100/ FaAA Head Report at 1-5 to 1-6.

Second, FaAA says that unsatisfactory flow and supply of liquid metal to the mold and the inadequate solidification pattern in the mold "were apparently addressed" by:

(3) "Modification" of gates and risers, and

(4) Use of chills.101/

FaAA does not conclude that these changes have solved TDI's casting problems, because FaAA could not support such a conclusion. FaAA has undertaken no analysis of the changes in the techniques which it mentions. It does not describe, and admits it has not verified, what techniques were used by TDI prior to the current ones. Without a careful analysis of both the current and the previous casting procedures, one simply cannot conclude that the changes are "improvements."

Q. Please explain your views as to each particular matter referred to by FaAA in the previous answer.

A. (1) The "improvements" in mold and core design are not described. This is a purely conclusory statement with no supporting analysis; we don't know what changes FaAA believes were made in mold and core design, so we can't evaluate whether

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101/ Id. at 1-6.

or not they were improvements. Our own investigation disclosed that TDI never used design drawings of molds, so accurate comparisons of current and older mold and core designs could not be made. As TDI experimented with different mold and core designs, improvements may have resulted, but poorer results could also have occurred with equal probability.

(2) The change to sodium silicate ester sand for molding sand can increase the chances for gas porosity in the casting since sodium silicate ester sand is more resistant to gas flow and the gas can be trapped in the casting.

(3) The manner in which gates and risers were modified is not described by FaAA, and there is no information to serve as a basis to determine whether the changes effectively addressed the casting problems. For example, placing a gate in a mold may reduce the rate of metal flow so that the flow is too slow, thereby permitting metal already in the mold to cool before the casting is complete. A riser which is too small can contribute to shrinkage defects.

(4) The use of chills may reduce the likelihood of hot tears in some instances. Chills also increase the likelihood of gas porosity in the casting.

The claim that these changes in casting methods and techniques have successfully addressed TDI's casting problems is belied by the extremely high rate of defects in cylinder heads produced since all of these changes were made. TDI documents[102/] for foundry rework on cylinder heads show that nearly all of the heads cast in 1982-83 had defects and required reworking.

Q. What other changes in cylinder head manufacturing processes were referred to by FaAA?

A. FaAA refers to a 1978 TDI procedure to post weld heat treat the heads after deposition of the Stellite valve seat overlay and to a 1980 TDI Service Information Memo changing valve seat weld repair procedures.[103/] The changes are not analyzed as to their adequacy, implementation, or effects. We have no basis to believe that these changes have solved the cracking of the Stellite weld deposits seen in TDI heads at Grand Gulf.

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102/ TDI Documents, "Casting and Machining Problems with RV-4 Cylinder Heads." (Exhibit 31).

103/ FaAA Head Report at 1-5.

FaAA also states that TDI claims that all heads cast after October 1978 received a second stress relief treatment. Stress relieving, or normalizing, can reduce stresses in the casting, but does not eliminate or affect geometrically-induced stress, gas porosity, inclusions, shrinkage or hot tears, each of which can cause cracking of the heads and increase crack propagation.

FaAA raises the problem of poor gaging procedures during firedeck machining, but does not state how TDI addressed that problem. Given the large variations in firedeck thickness in the replacement heads at Shoreham, we believe TDI has not addressed this problem. Moreover, in our opinion it is not a gaging problem; firedeck thickness is rather a design, manufacturing, and quality control problem.

Q. Does the operating history of the Group III heads (including the replacement heads at Shoreham) support FaAA's conclusion that the replacement heads are adequate for nuclear service and are significantly less likely to have pre-existing flaws than earlier heads?

A. No. The only operating history of Group III heads verified by TDI is that pertaining to 16 replacement cylinder heads at Shoreham, out of 311 Group III heads TDI says it has produced.104/ FaAA states that Messrs. Trussell and Pratt of

104/ FaAA Head Report at 1-2; Wells Deposition at 103. (Exhibit 27).

TDI said in December, 1983, that "there have been only five instances of water leaks in Group II and Group III cylinder heads that have resulted in water in the cylinders...."105/ However, Mr. Mathews, vice president and general manager of TDI, testified in May 1984 that TDI had never in the past two years conducted any review of its files to ascertain failure rates of cylinder heads.106/ There is simply insufficient evidence from TDI's operating history to conclude that Group III cylinder heads will not crack or will have any less likelihood of cracking than pre-group III heads.

<u>Inspections of Replacement Heads</u>

Q. Have the inspections of the replacement cylinder heads at Shoreham ensured that they are adequate for nuclear service?

A. No. The inspections performed on the Shoreham replacement heads have been inadequate in a number of respects. First, there can be no confidence in inspections carried out by TDI before the heads were delivered. Second, the inspections

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105/ FaAA Head Report at 1-4.

106/ Deposition of Clinton S. Mathews (May 8, 1984) ("Mathews Deposition") at 79-82. (Exhibit 32).

of the replacement heads performed at Shoreham after 100 hours of operation were insufficient because inspections were done on a sampling basis, not all of the inspection techniques necessary to detect flaws were used, and the inspection standards were inadequate.

Q. What inspections is TDI supposed to have performed on the replacement cylinder heads?

A. TDI has written procedures for carrying out visual inspections, magnetic particle inspections, liquid dye penetrant testing and hydrostatic testing.107/ However, these procedures are seriously deficient. The magnetic particle inspection procedure does not specify which areas of the cylinder heads are to be inspected. Indeed, the procedure is only a general procedure "for the testing of ferromagnetic parts and assemblies," and is not specifically written for cylinder head inspection. In fact, TDI did not inspect the replacement heads by magnetic particle techniques, because it only started to use this procedure on cylinder heads in April 1984.108/ The hydrostatic test procedure, which is written for use in "welded

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107/ Respectively, TDI QC Procedures 600-10, 600-30, 600-20 and 600-70.

108/ FaAA Head Report at ii.

assemblies and cast products," is not expressly applicable to cylinder heads. TDI interprets its inspection procedures to permit acceptance of a cylinder head which fails a visual inspection (by having a visible indication), so long as it does not leak during the hydrostatic test.109/ A further example of TDI's inadequate test and inspection procedures is the in-process inspection procedure (I.P.-300), which directs the QA inspector to use the same gauge blocks as the machinist and sets forth no measures for ensuring that the gauges are properly controlled, calibrated and adjusted so as to maintain accuracy. Mr. Mathews of TDI testified that TDI may well deliver cylinder heads to nuclear plants that have cracks or sand inclusions.110/

Q. Are TDI's inspections and testing techniques, if they are properly performed, capable of detecting all casting defects and cracks in the replacement cylinder heads?

A. No. It is unlikely that any of the techniques used by TDI will detect cracks or other casting defects more than 1/4 inch beneath the surface of the casting. Visual

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109/ I&E Report 83-25 at 4. (Exhibit 22).

110/ Mathews Deposition at 86-87. (Exhibit 32).

inspections and dye penetrant testing, if done correctly by trained personnel, will only reveal surface cracks. Hydrostatic testing only discloses through-wall cracks in or around the cylinder head passageways that are tested, and will not detect subsurface cracks. Magnetic particle inspections can reveal subsurface cracks or other casting defects, but only to an approximate depth of 1/4 inch.

Q. What inspections were subsequently carried out on the replacement heads at Shoreham?

A. A liquid penetrant test was done on the exhaust and intake valve seats and firedeck area between the exhaust valves on 9 of the 24 cylinder heads, after 100 hours of full power operation. Ultrasonic measurements were taken of the firedeck areas of 12 cylinder heads. Finally, visual inspections were performed on the valve seat areas of 32 of the 98 valves, and on 7 firedecks of the 24 cylinder heads for indications of surface damage.111/

Q. Were these inspections adequate to conclude that the replacement cylinder heads at Shoreham are qualified for "unlimited operation"112/ in nuclear service, as FaAA

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111/ DRQR Report, Vol. 8, Cylinder Heads, at B3-B4. (Exhibit 20).

112/ FaAA Head Report at iii.

concludes?

A. Absolutely not. In fact, the DRQR Report for Shoreham states

> The absence of detectable flaws in the Shoreham cylinder heads does not preclude the eventual propagation of a crack from a subsurface defect or a defect in an inaccessible location.113/

We agree with this statement, but we also believe that the inspections were not sufficient to detect even all relevant flaws and defects in accessible areas of the replacement heads. Accordingly, the probability of cracking of the replacement heads may be much higher than indicated in the DRQR Report.

Q. What are your reasons for concluding that these inspections did not sufficiently disclose even surface defects in the replacement heads?

A. First, only a limited number of samples of the replacement heads were inspected. As described above in our discussion of the AE piston skirt inspections, a sampling inspection is particularly inappropriate because of TDI's ineffective QA/QC program. Region IV of the NRC informed TDI that results of NRC Vendor inspections of TDI show

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113/ DRQR Report, Vol. 8, Cylinder Heads, at 3. (Exhibit 20).

> [s]erious deficiencies have existed in the implementation of your committed quality assurance program for manufacture of emergency diesel generators. What concerns us greatly is that certain of these findings are of a nature which brings into question both the adequacy of existing manufacturing process controls and the level of compliance by manufacturing and quality control personnel.114/

We agree with Mr. Foster of NRC Region IV that TDI's ineffective QA/QC program makes a samplying inspection next to useless and mea.. that even a 100% inspection is unlikely to reveal all defects.115/ However, given the importance of the heads, a 100% inspection should have been performed.

Second, of the sample heads, only selected portions were examined. For example, the liquid penetrant test was performed on the firedeck only in the area between the exhaust valves. Other areas of the firedeck are as likely to have indications or inclusions.

Third, inspections were restricted to visual and liquid penetrant. The ultrasonic measurement was done only to measure firedeck thickness. It is likely that more defects would have

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114/ Letter dated January 17, 1984, from V. Potapovs (NRC) to C. Mathews (TDI). (Exhibit 33).

115/ Foster Deposition at 54-55. (Exhibit 13).

been detected if magnetic particle examination, eddy current examination, and radiograph testing had been employed. The visual examination is unfortunately of limited value.

Q. Why is the visual examination of limited use?

A. Apart from the obvious fact that it is limited to what the naked eye can see, the results of the visual inspection have apparently been ignored. The NRC Staff discovered an indication about 3/8 inch long on the machined bottom part area of replacement head S/N H-34 at Shoreham.116/ TDI advised the staff that this crack was within TDI's acceptance criterion because the head had not leaked under hydrostatic test. LILCO and FaAA have not replaced the cylinder head with this indication, apparently accepting TDI's criterion.

Q. Do you believe that the LILCO response was appropriate?

A. No. A 3/8 inch indication such as on head H-34 may grow under operating stresses and with the effects of corrosion. Yet LILCO, TDI and FaAA would permit one or more small cracks or inclusions in the replacement cylinder heads. This

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116/ I&E Report 83-25 at 4. (Exhibit 22).

is also shown by the acceptance criteria used by LILCO and FaAA.

Q. What is the basis for the FaAA/TDI Owners' Group inspection criteria for cylinder head inspections?

A. No bases are provided for the liquid penetrant inspection or the ultrasonic measurement criteria cited in Appendix A of the FaAA Head Report. For the magnetic particle inspection, no basis is provided to demonstrate that the ASTM criteria are appropriate for the intended service. For the firedeck UT measurement, the thickness is only required to be recorded. No maximum thickness is specified and the technical basis for the minimum thickness is not cited. The bases for all the acceptance criteria should have been provided by TDI and assessed by FaAA. The acceptance criteria bases must be demonstrated because without knowing the distribution of flaws below the surface, any crack or void can be assumed to grow.

## Cracks in Replacement Heads

Q. If cracks similar to those in the three original heads occurred in the replacement cylinder heads at Shoreham, is it true that only a very small amount of water could leak into the cylinders after shutdown of the EDGs?

A. No. This proposition was asserted by LILCO based upon TDI's inadequate and incomplete failure analyses of the original failed heads, which determined that the cracks were caused only by operating stresses acting upon pre-existing casting defects in the cylinder heads.117/ TDI contends that since these operating stresses are caused by the cylinder firing pressure, once the EDG is shut down and operating stresses are substantially reduced, any cracks would close.118/ In addition, TDI asserts that the stresses are further reduced when the cylinder heads cool to a steady-state temperature. Thus, it was concluded that the cracks were self-relieving and would not have propagated.

While the evidence suggests that a cause of the failed cylinder heads was casting defects, there is no support for TDI's assertion that only the operating stresses were acting upon the casting defects and that the cracks were therefore self-relieving and would not have propagated. In fact, cracks

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117/ Affidavit of Edward J. Youngling, dated July 8, 1983 (Exhibit 21).

118/ Contrary to the preceding assertion, PNL consultant Mr. Louzecky stated at the June 22 meeting (Tr. at 129) between PNL and the Owners' Group that ". . . in the cooling-off period, that's usually when your (cylinder head) crack opens up . . . ."

such as those found in the three failed cylinder heads at Shoreham will always propagate and grow, unless arrested by heavy material or a void.

Q. What factors other than operating stresses would cause cracks to propagate and grow?

A. Cracks propagate (i.e., deepen and/or travel) and grow (i.e., lengthen and/or widen) due to operating stresses, residual stresses (i.e., manufactured-in stresses, such as from the casting and welding processes), geometrical stresses (e.g., stresses arising from design, such as stresses which exist at sharply-angled edges) and corrosion. What must be kept in mind is that cracks are stress raisers, and that stresses other than operating stresses will propagate a crack. Residual and geometrical stresses commonly accelerate crack propagation and growth, and corrosion occurs preferentially at cracks. All of these mechanisms (residual stress, geometrical stress and corrosion) will act to propagate a crack even when a diesel is not in operation. Further, the environment may increase the growth of the crack at a higher rate than one would calculate by merely summing the cyclic loads.119/ Indeed, cracks in the

119/ "Introduction to Fracture Mechanics," Kare Hellan, McGraw-Hill, 1984, at 135.

cylinder head by their very nature propagate and grow until they hit a massive part or a void, such as an exhaust valve. When a crack enlarges, the flow of water through the crack will increase. Furthermore, cracks are seldom self-relieving, except perhaps when they split open, and cracks never decrease in dimension, especially when the crack surfaces are covered with corrosion products. Therefore, water can continue to leak into the combustion chamber after shutdown and at any time thereafter.

Q. Could cracks in the replacement cylinder heads first begin to leak during cold shutdown of the EDGs?

A. Yes. For example, a crack which initially occurred from operating stresses may not leak during operation. That same crack may not leak for some time after the EDG is shut down. However, stresses other than operating stresses, such as stresses from corrosion products acting to force the crack apart, may cause the crack to propagate or grow after shutdown.120/ Cracks may grow very slowly for some time, but once a crack reaches its critical size it will grow very rapidly and

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120/ "Analysis of Oxide Wedging During Environment Assisted Crack Growth," S.J. Hudak and R.A. Page, NACE, Vol. 39, No. 7, July, 1983, at 285 to 290.

rupture. Thereafter, the flow of water through the crack could be significant. The amount of such water leakage would depend upon the number and the size of the cracks and their location. The existence and interaction of these factors cannot be predicted. However, depending upon the circumstances, significant leakage could occur in a matter of days or even hours.

Q. Would undetected leakage from a cracked head into the cylinder affect the rapid restart capability of the diesel generators?

A. Yes. If liquid is contained in the cylinders, there will likely be damage to the engines. Quantities of liquid can cause dangerous pressure rise within the cylinders. If liquid is contained in the cylinders, the compression pressure increases and will continue to increase until it equals the firing pressure; the volume of liquid contained in the cylinders then becomes known as the "critical volume." If the liquid in the cylinders is greater than the critical volume but less than the clearance volume, the liquid may not show up during the barring procedure proposed by LILCO, and dangerous pressures may build up during the start period. This very high and dangerous pressure buildup can cause studs holding the head in place to stretch, thereby "blowing" the head gasket. When this occurs, the EDG cannot be operated because of flames blowing out between the head and liner faces.

Water leakage into the cylinder head could also lead to a catastrophic failure should the cylinder head go "solid with water." The Shoreham piston crowns have a dished configuration, and should there be leakage the dish area could fill up and the water overflow down past the piston rings into the lube oil sump. This could cause water contamination of the lube oil. Leakage, even in very small amounts, could also impair lubrication of the cylinder. Scoring of the cylinder liner bores can occur, followed by rapid seizure of the piston and consequential damage.

Catastrophic consequences can also result from cracks in the cylinder head firedeck, even when there is no water leakage. Higher pressure combustion gases can leak into the cooling water space. In the short term, the combustion gases enter the cooling water and may "air lock" the heads. Alternatively, the heat exchangers may not be able to handle the heat input to the cooling water and a rise in temperature could cause a shutdown. A further problem could arise when the cooling water pumps "gas up," causing the cooling water temperature to rise and the engine to shut down.

Q. Could the corrosion inhibitors in the cooling water of the EDGs affect rapid restart if leakage occurred?

A. Yes. These corrosion inhibitors can alter the cylinder liner diameter by building up salts and other corrosion products, if cooling water leaks into the combustion chamber and cylinder space. This, in turn, prevents adequate lubrication and causes a number of dry strokes during the starting of the engine. The dry strokes would result in localized heating, with probable additional failure of lubricant and seizure of the pistons.

Q. But won't the corrosion inhibitors prevent corrosion in the cylinder, should leakage occur?

A. No, the corrosion inhibitors act to passivate a surface by providing a stable film to act as an oxygen barrier. Corrosion would preferentially occur in the space between the cylinder walls and the piston. Thus, it is possible that corrosion products could form that would act as a barrier and prevent the passage of water betweeen the piston and the walls and into the lube oil sump. In other cases, muck, carbonaceous material and detritus from the piston ring grooves can act as a sealant and prevent leakage down the side of the piston. Then, water would collect in the cylinder, causing the cylinder head to go "solid with water."

Q. How fast could this corrosion occur?

A. The passivation occurs immediately on contact with the metal. However, the speed at which subsequent corrosion processes occur is dependent upon a variety of factors and their interaction, including temperature, surface area and driving force. Hence, the speed of corrosion development for this case is inherently unpredictable. What must be kept in mind is that the concern lies not only with corrosion in the cylinder, but also with the effect of corrosion on cracks in the cylinder head. As previously mentioned, corrosion products put a stress on cracks. Thus, a crack may grow slowly until it reaches a critical size. Thereafter, however, it grows much more rapidly. Indeed, cracks can change significantly in a matter of days or even hours.

Q. Will water flow through a crack during cold shutdown even though there is essentially no water pressure to drive the water through the crack?

A. Yes, because the water has substantial driving force through the crack without the water pressure of the cooling system. The cooling water flows into the crack in an effort to dilute the corrosion products and creates an osmotic pressure. In addition, the driving force from the capillary action causes flow through the crack. As the crack grows, the flow of water increases proportionally.

Q. But isn't a steel cylinder head strong enough to resist cracking caused by corrosion?

A. No, it is not. The stresses generated by corrosion products are extremely high. Moreover, the tip of a crack acts as a stress riser and can synergetically exceed the tensile strength of the metal without any additional stresses. In addition, TDI has changed the steel in its cylinder heads to a lower strength alloy (TDI's No. 7 steel) with less carbon content. This reduction in carbon can cause cracks to initiate, to propagate, and to grow.

Q. Could leakage from cracked replacement heads also have an adverse impact on EDG's performance during operation?

A. Yes. Operating stresses could cause the cylinder head to crack or could exacerbate existing cracks' growth. LILCO and TDI contend that there would be no adverse impact on the EDG's performance, since any water leaking into the cylinder during operation would be expelled along with combustion by-products. However, depending upon the location and size of the leak, water in the cylinder could be sufficient to impair lubrication in the cylinder and cause seizure of the piston and fracture of the piston skirt, leading to engine shutdown. In other cases, only partial seizure may occur; however, this can lead to heavy bearing wear and misalignment.

Q. But isn't water sometimes injected into the combustion chambers of diesel engines to improve performance?

A. Yes. Sometimes distilled water in very small amounts is homogenized with fuel and injected into the combustion chambers. This is done to reduce the emissions of nitrous oxides with the exhaust gases. However, this process requires strict control of the quantity of water that is homogenized with the fuel prior to injection. In addition, the cooling water in the EDGs contains corrosion inhibitors. If the cooling water leaks into the combustion chamber and cylinder, the salt residues from these corrosion inhibitors can cause abrasive wear on the cylinder liner bore, thereby reducing piston ring life.

Q. Could cracks in the cylinder heads also cause problems in the long term?

A. Yes. While it is true that water leakage into the cylinders generally flashes to steam and passes out with the exhaust gases, if any water remains it is sprayed out with the exhaust gases and erosion of the turbocharger blading will occur in a manner similar to steam turbine blading erosion. In that event, the turbo blower speed falls and the engine overheats due to a reduction in air flow. Moreover, cracks in the cylinder head firedeck may cause a reduction in cooling water pH value, leading to the formation of acids which attack various parts of the engine cooling system and cause corrosion of the engine. Water leakage may also damage or score the cylinder liner, damage the piston rings, reduce power and allow gases into the cooling water system. The scored liners allow hot combustion gases to blow down between the cylinder and the piston skirt. This causes distortion of the piston, further scoring of the cylinder liner and serious overheating, which may eventually lead to a crankcase explosion.

Q. Has LILCO committed to perform a "barring over" procedure at certain intervals after EDG shut-down to detect water which might have leaked into EDG cylinders due to cracks in the replacement heads?

A. Yes. LILCO intends to use the procedure referenced in SP27.307.02.121/

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121/ DRQR Report, Vol. 8, Cylinder Heads, at 3. See LILCO Procedure SP 27.307.02, Emergency Diesel Generator Cylinder Head Leak Detection Test. (Exhibit 34).

Q. Do you believe that the proposed barring over procedure, if implemented, will ensure that leakage, if it occurs during testing or operation, will be detected?

A. No. LILCO's proposed procedure will not ensure the detection of leakage of water into the cylinders. In fact, given the nature of cracks in cylinder heads, no barring over procedure can ensure that leakage will be detected prior to an emergency rapid startup of the diesels. Cracks which occur during operation may not leak during operation or even within the first 12 hours after shutdown, the time under LILCO's proposed procedure when the EDGs would last be barred over. For example, cracks formed during operation could be focal points for corrosion, which would make it difficult for the cracks to close. Water could therefore leak into the combustion chamber of the EDG after shutdown, including more than 12 hours thereafter, in amounts sufficient to impair an emergency start. Such a leak would not be detected by LILCO's proposed barring over procedure. Even swinging over the engines with starting air might not detect small amounts of water symptomatic of a leak.

Q. Would your concerns with LILCO's barring over procedure be alleviated if the barring over were performed more frequently than proposed by LILCO?

A. Even if barring over were done more frequently, there would be no assurance that leaks which could impair emergency startup of the EDGs would be detected. It is not possible to predict when emergency startup would be needed, and it is therefore impossible to bar the engine over immediately before startup is required. Unless the barring over is done immediately prior to emergency startup, there can be no assurance that water from one or more cracks would not leak into the cylinder of one or more EDGs and impair startup.

CYLINDER HEADS #5 ENGINE

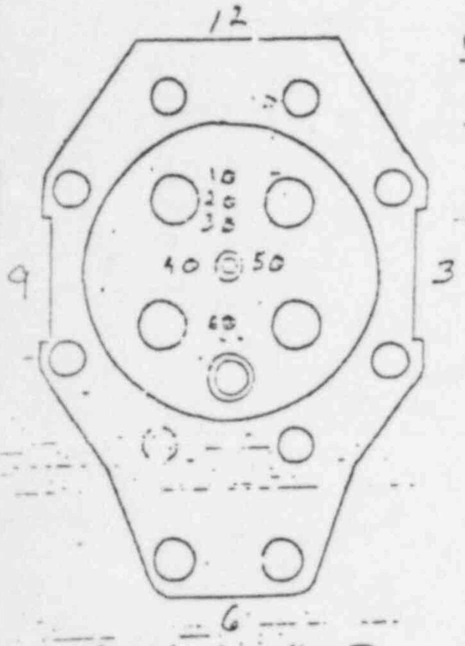
EXHIBIT 34

Ultrasonic Examination of fire deck.

Perform an Ultrasonic Examination of the fire deck in six locations (see sketch below) to determine the thickness between the valve seat area.

The nominal thickness reading is 0.500 inches, with a minimum acceptable thickness reading of 0.400 inches.

Record data and results below.




A216-GR. WCB

Thickness Readings INCHES

| Cyl. No. | 1 | 2 | 3 | 4 | 5 | 6 | SAT |
|---|---|---|---|---|---|---|---|
| 1L | .824 | .570 | .551 | .496 | .489 | .733 | ✓ |
| 2L | .863 | .534 | .536 | .531 | .520 | .767 | ✓ |
| 3L | .862 | .571 | .562 | .569 | .534 | .797 | ✓ |
| 4L | .951 | .473 | .552 | .531 | .524 | .799 | ✓ |
| 5L | .871 | .527 | .571 | .531 | .542 | .787 | ✓ |
| 6L | .853 | .550 | .543 | .533 | .519 | .753 | ✓ |
| 7L | .844 | .526 | .513 | .483 | .498 | .764 | ✓ |
| 8L | .890 | .552 | .563 | .532 | .535 | .795 | ✓ |
| 1R | .811 | .533 | .537 | .607 | .525 | .768 | ✓ |
| 2R | .759 | .538 | .525 | .494 | .487 | .855 | ✓ |
| 3R | .859 | .535 | .527 | .583 | .505 | .746 | ✓ |
| 4R | .776 | .662 | .514 | .489 | .539 | .745 | ✓ |
| 5R | .800 | .533 | .547 | .527 | .534 | .796 | ✓ |
| 6R | .871 | .574 | .565 | .543 | .545 | .811 | ✓ |
| 7R | .869 | .539 | .544 | .524 | .527 | .776 | ✓ |
| 8R | .796 | .515 | .525 | .505 | .499 | .736 | ✓ |

M Elayton

NOTES:
MACHINE. MOD. D, S/N 652 D. MOD. NDT-124D
Calibrated instrument using CYL. # 1R
CAL. #1 .575 CAL. #2 .487 CAL # 3 .232
0-1 mic verified using mic L80-E012 H cal 5-3-84 Due 11-3-84

COMMENTS

FP NO: 6287A CHECKLIST NO. [illegible] REV. 0 SHEET 2 OF

TITLE Cylinder Head, Valves – Cylinder Head CONTINUATION SHEET

| | SAT | U |
|---|---|---|

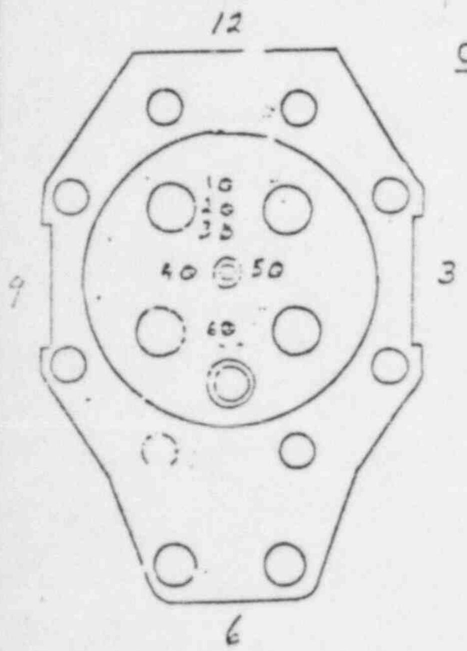
CYLINDER HEADS #7 ENGINE

Ultrasonic Examination of fire deck.

Perform an Ultrasonic Examination of the fire deck in six locations (see sketch below) to determine the thickness between the valve seat area.

The nominal thickness reading is 0.500 inches, with a minimum acceptable thickness reading of 0.400 inches.

Record data and results below.




A216 GR. WCB

Thickness Readings INCHES

| Cyl. No. | 1 | 2 | 3 | 4 | 5 | 6 | SAT |
|---|---|---|---|---|---|---|---|
| 1L | .835 | .476 | .481 | .487 | .480 | .758 | ✓ |
| 2L | .820 | .539 | .532 | .521 | .540 | .792 | ✓ |
| 3L | (+) .523 | .419 | .470 | .439 | .449 | .681 | ✓ |
| 4L | .75n | .546 | .552 | .534 | .573 | .787 | ✓ |
| 5L | .715 | .465 | .447 | .403 | .428 | .709 | ✓ |
| 6L | .735 | .502 | .510 | .505 | .513 | .800 | ✓ |
| 7L | .765 | .496 | .505 | .503 | .492 | .772 | ✓ |
| 8L | .780 | .522 | .566 | .582 | .544 | .835 | ✓ |
| 1R | (+)(+) .650 | .546 | .559 | .544 | .502 | .764 | ✓ |
| 2R | .808 | .554 | .556 | .555 | .511 | .816 | ✓ |
| 3R | .844 | .480 | .469 | .469 | .442 | .742 | ✓ |
| 4R | .885 | .556 | .535 | .524 | .549 | .802 | ✓ |
| 5R | .881 | .490 | .490 | .515 | .462 | .765 | ✓ |
| 6R | .614 | [.406] | .453 | .437 | .436 | .698 | |
| 7R | .769 | .512 | .503 | .497 | .500 | .752 | ✓ |
| 8R | .866 | .538 | .550 | .554 | .528 | .759 | ✓ |

[illegible signature]

NOTES: MACH: NORTEC MOD-D1-652D MCO. NDT-124D (S.RA)
(1.) CALIBRATED INSTRUMENT USING CYL. HEAD #6L, 1L, AND 2R ENG #7.
CAL #1 .565 CAL #2 .404 CAL #3 .239 0-1 mic # L80-E012J. CAL. 5-3-84.
(2) [.406] OUTSIDE INSPECTION POINT BETWEEN 1 O'CLOCK AND 2 O'CLOCK THE THICKNESS MEASUREMENTS VARIED FROM .396 TO .376.

COMMENTS

(+) INSPECTION POINT NON-UT-ABLE DUE TO CORROSION. INSPECTION POINT MOVED 1½" FORWARD POIN[illegible]
(+) INSPECTION POINT NON-UT-ABLE DUE TO CORROSION. INSPECTION POINT MOVED ¾" FORWARD POINT [illegible]

EXHIBIT 35



## CLEAR CYLINDER CHECK

An essential part of the pre-start procedure is to check for the presence of water in the combustion chambers and the intake air manifold. In any water cooled engine there is some possibility of internal water leakage. This may be from the internal passages in the engine, the intercooler(s), or from the turbocharger(s). Other possible causes of water leaks include improper maintenance or repair procedures, faulty installation, or improper handling during shipment and storage. Although the presence of water in a combustion chamber, or the intake manifold in any significant quantity is a rare occurance, the consequence of such a condition can be serious. If the engine is cranked with full starting air pressure, and with water in one or more combustion chambers,, or in the intake air manifold, the result may well be serious damage to the cylinder head and/or block. Therefore, it is essential that the cylinders and intake manifolds be checked and determined to be free of liquids prior to a start. This check may be considered mandatory when starting the engine for the first time after installation, or after a long shutdown or major overhaul, or whenever the engine has been shut down and allowed to cool for eight hours or more. For maximum protection, it is strongly recommended that the check be performed before each engine start. It is recognized that this may not be practical in installations where remote or unattended operation are a part of the design, therefore, in these cases the status of fluid systems and pressure vessels should be regularly monitored to minimize the risks of water leakage problems. The engine should not be rolled on full starting air pressure until such time that it has been determined that there is no liquid in any of the combustion chambers. Barring the engine over to determine this is satisfactory. Briefly, the procedure for checking to determine that the combustion chamber and the intake manifold(s) are free of moisture involves the following sequence of actions.

a. Open indicator cocks on all cylinders.

b. Check for presence of water in the intake air manifold(s). Striking the sides of the manifold with a mallet and listening to the sound is one method of doing this. If water is detected, the source must be found and the condition corrected before proceeding.

c. Place Stop/Run valve on the engine in the STOP position. This will prevent fuel admission to the engine during the subsequent steps.

d. Bar the engine over slowly with the barring device for two complete revolutions of the crankshaft.

### Caution

If any resistance to free turning is encountered, stop cranking and determine cause before proceeding.

e. Check all indicator cocks for presence of moisture. If any liquid has been ejected from any cocks, the source must be found and the defect corrected before proceeding.

f. Roll engine two complete revolutions on starting air then again check all indicator cocks for presence of moisture. If all clear, proceed.

g. Close all indicator cocks.

h. Place Stop/Run valve in RUN.

DUKE POWER COMPANY
GENERAL OFFICES
422 SOUTH CHURCH STREET
CHARLOTTE, N. C. 28242

P. O. BOX 33189

TELEPHONE: AREA 704
373-4011



January 24, 1985

OGTP-773-0-477

Mr. F.R. Stead
Cleveland Electric Illuminating Company
Perry Nuclear Station
P.O. Box 97
Perry, Ohio 44081

copies to

EXHIBIT 36

Re: TDI Diesel Generator Owners Group
Recommendation For Detection of Cylinder
Head Leakage
File: MTS-4086

Dear Mr. Stead:

The Owners' Group Technical Staff has recommended a "blow over" procedure to be used as a surveillance to detect potential water leakage into the combussion chamber. A "blow over" procedure has been recommended since the barring over device depicted in TDI's operating manual is primarily a maintenance device, not a surveillance device.

The "blow over" procedure is a modified air roll, and insures damage to an engine does not occur as a result of rapidly air rolling an engine with a hydraulically locked combustion chamber. The following methods for slowly rotating the engine were recommended to the Owners Group by TDI:

The first method involves the use of a manual actuator on one of the starting air inlet valves on each bank. By manipulating the approximately 18 inch long lever while watching the flywheel, one operator can turn the engine over twice, without building significant crankshaft inertia and without taking the diesel out of the standby mode. A second operator must watch the indicating cocks on the opposite bank for signs of moisture.

If an emergency occurs during this leak detection mode the engine's automatic controls will start the engine in the normal fashion. The operator should close the indicating cocks immediately following an emergency start of the engine. The closing of all cocks should not exceed one minute. As a precautionary measure, the fuel rack should be manually placed in the "fuel off" position, and held there using the lever provided on the rack shaft. If an emergency start were to occur at this point, the governor oil booster will force the rack into the "full fuel position".

The second method recommended, is to arrange for a bypass valve around the starting air inlet valve. TDI has tested this method on their R-46 test engine and reported good control of the engine's slow rotation by operating the bypass valve.

The same as for the first method of leak detection, precautionary measures must be exercised. The fuel rack should be placed in the "fuel off" position and held there using the lever provided on the rack shaft. Should there be an emergency engine start the indicating cock should be closed within one minute, to avoid ceasing. If any of the cocks cease open, a cap should be placed on that cock.

The two methods recommended require operator training and planning. Should you have any questions or if you wish to discuss this further, please contact Mr. John C. Kammeyer at (704) 373-3493.

Richard W Bonsall

for C.L. Ray Jr.
Technical Program Director
TDI Diesel Generator Owners Group

CLR/JCK/ja

cc: Executive Committee
J. Kammeyer
R. Bonsall
V.A. Saleta
M. Curry
K. Fitzpatrick
A.P. Cobb Jr.
Job Book
Alternate Contacts
Licensing Contacts

Exhibit 37

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|
| 03-360A | B | X | X | D | Z | 02-360A |

**************************************************************************

CYLINDER HEAD VALVES - CYLINDER HEAD.

**************************************************************************

PERRY EXPERIENCE:
NONE

**************************************************************************

RECOMMENDED DESIGN REVIEW ATTRIBUTES:

1) EVALUATE DIFFERENCES BETWEEN SNPS GENERATION HEADS AND THOSE AT PNPP.

**************************************************************************

RECOMMENDED QUALITY REVALIDATION ATTRIBUTES:

1) LP HEAD FIRE DECK AND VALVE SEATS (100%).

2) UT FIRE DECK FOR GAUGING THICKNESS (100%).

3) DEVELOP SITE PROCEDURES FOR BARRING ENGINE BEFORE AND AFTER TEST.

**************************************************************************

NUCLEAR INDUSTRY EXPERIENCE:

1) DURING OPERATION, WATER HAS FOUND COMING FROM FUEL TUBE PASSAGE IN CYLINDER HEAD. POROSITY HAS FOUND IN CYLINDER HEAD. NEW HEAD HAS INSTALLED.

| SOURCE: | NOS: | MANUFACTURER: |
|---|---|---|
| LER | PILGRIM 1 293-74000, 740202 | ALCO ENGINE DIV. |
| EPRI | EPRI-NP-2433 6/82 | |

2) ENGINE STARTED WITH PISTON FLOODED WITH WATER. DAMAGE WAS BENT CONNECTING ROD, RUPTURED CYLINDER WALL, AND BROKEN PISTON. EMD DIESEL HAD CRACK IN CYLINDER HEAD WHICH EXTENDED BETWEEN 2 EXHAUST VALVE SEATS AND INTO JACKET WATER WHICH IS HIGH HEAT STRESS AREA.

| SOURCE: | NOS: | MANUFACTURER: |
|---|---|---|
| LER | SURRY 1 280-76000, 760416 | ELECTRO-MOTIVE DIV. OF GM |
| EPRI | EPRI-NP-2433 6/82 | |

3) (DELETED 09/10/84)

4) (DELETED 09/10/84)

5) (DELETED 09/10/84)

6) CRACKED CYLINDER HEADS HAVE BEEN OBSERVED AT THE SHOREHAM NUCLEAR POWER STATION, AS WELL AS OTHER FACILITIES WHICH USE DIESEL GENERATORS MANUFACTURED BY TRANSAMERICA DELAVAL, INC.
DATE: 04/15/83
SOURCE: NOS: MANUFACTURER:

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <I> | X | X | D | Z | 02-360A |

I&E SHOREHAM, NOTICE 83-51 TDI

7) CYLINDER HEAD WATER LEAKS WERE OBSERVED, ON A TDI 8 CYLINDER ENGINE AT KUOSHENG, TAIWAN.
SOURCE: NOS:
OTHER TELEX FROM PEI TO LILCO DATED 11/28/83

8) DURING INSPECTION OF TDI V-16 ENGINE'S CYLINDER HEADS, ONE WAS FOUND TO HAVE CRACKS. THE CRACKS WERE IN THE STELLITE SEAT FOR THE EXHAUST VALVES - ONE CRACK HAS APPARENTLY A THROUGH-WALL CRACK.
SOURCE: NOS: MANUFACTURER:
OTHER TELECON C.SEAMAN(LILCO)&W.ANGLE(MPL)ON 12/13/83.TDI

9) MOD OF VALVE GUIDES TO CONTROL OIL CONSUMPTION.
SOURCE: NOS:
TDI SIM-301, REV. 1

10)INFO-METHOD FOR MEASURING STEM TO GUIDE CLEARANCES.
SOURCE: NOS:
TDI SIM-295

11)INFO-CYL HEAD VALVE SEAT REPAIR PROCEDURE.
SOURCE: NOS:
TDI SIM-249, REV. 2

12)INFO-CYL HEAD OVERHAUL PROCEDURE.
SOURCE: NOS:
TDI SIM-250, REV. 1

13) (DELETED 08/22/84)

14) CYLINDER HEAD ON DIESEL 1A DEVELOPED A MINOR JACKET WATER LEAK WITHIN THE INJECTOR BORE AND ABOVE THE INJECTOR SEAT. ONE CYLINDER HEAD ON DIESEL 1B ALSO DEVELOPED MINOR JACKET WATER LEAK.
SOURCE: NOS: MANUFACTURER:
OTHER CATAWBA-REPORT "EXTENDED OPERATION TESTS AND INSPECTION OF DIESEL GENERATORS DATED 04/05/84 PG 7-2 (FILE NO. T-53) TDI

15) WATER LEAK INTO THE CYLINDERS. TDI REVIEWED THE THREE FAILURES AND ADVISED THAT THE SMALL AMOUNT OF WATER ENTERING THE COMBUSTION CHAMBER IS SIMPLY BLOWN OUT OF THE EXHAUST. LILCO-UPGRADED THE CYLINDER HEADS TO THE IMPROVED TDI DESIGN. (ADDED 08/24/84)
SOURCE: NOS:
10CFR50.55E 10CFR50.55E LILCO LTR SNCR-873 DATED 4/15/83 TO TDI FILE NO.T-69

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NON-NUCLEAR INDUSTRY EXPERIENCE:

1) FIVE HEADS HAVE FAILED-LOCKED UP. CASTING STRESSES IN HEADS, SEVERE AERATION PROBLEM IN STARBOARD ENGINE CONTRIBUTED TO HOT SPOTS IN HEAD. TDI STATED STANDPIPE CAUSED AERATION. (M/V "GOTT")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/30/83) TO C.SEAMAN
OTHER MINUTES OF MEETING WITH TDI AT LAKE SHIPPING OFFICE (11/20/80) (M/V GOTT)

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
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|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

2) TWO HEADS STRESS RELIEVED PICKLED HEADS EXHIBITED VERTICAL CRACKS IN BACK WALL OF EXHAUST PORT. (M/V "GOTT")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/30/83) TO C.SEAMAN
OTHER TDI MEMO FROM G.TRUSSELL TO C.MATTHEWS DATED 02/17/81. (M/V GOTT)

3) FOUR QUANTITY HEADS FAILED WATER TEST. ONE QUANTITY HAS AN SR HEAD. EXPECT 3 MORE HEADS FAILED, BUT PASSED WATER TEST. (M/V "GOTT")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/30/83) TO C.SEAMAN
OTHER MEMO FROM S.SCHUMACHER (TDI) TO G.KING 02/27/81. (M/V GOTT)

4) TDI TELEX-RECONDITIONED HEADS WILL BE ABS INSPECTED -SOME HEADS WILL BE CUT UP FOR EXAMINATION. (M/V "GOTT")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/30/83) TO C.SEAMAN
OTHER TELEX FROM J.BOUNTIN (TDI) TO LINDA BLOCK (01/27/81) (M/V GOTT)

5) HEAD CRACKED THROUGH INTAKE SEAT.
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/30/83) TO C.SEAMAN
OTHER MEMO FROM S.SCHUMACHER (TDI) TO FILE DATED 01/23/82 (M/V GOTT)

6) HEAD LEAKING JACKET WATER INTO EXHAUST CHAMBER -REPLACED HEAD & GASKETS. (M/V "GOTT")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/30/83) TO C.SEAMAN
OTHER USS CORP MECHANICAL REPORT 81-232 (10/08/81) FROM R.HUTTON (M/V GOTT)

7) LIST OF CYLINDER HEADS (TDI) IN SERVICE ON 09/01/83 MANUFACTURED BY TDI SINCE 1978. (M/V "GOTT")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/30/83) TO C.SEAMAN
OTHER USS GRANT LAKES FLEET SERVICE DATED 09/07/83 (M/V GOTT)

8) CYLINDER CRACKED IN WAY OF BRIDGE BETWEEN EXHAUST VALVE CAVITIES. INSTALL CYLINDER HEAD. (M/V "GOTT")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/30/83) TO C.SEAMAN
OTHER USS CORP. MECHANICAL REPORT NO. 80-96 (07/18/80) AND NO. 80-176 (11/13/80)
OTHER TELEX FROM B.LIBERTY (LAKE SHIPS) TO TO B.DURIE (11/18/80)
OTHER TELEX FROM S.SCHUMACHER TO B.LIBERTY (11/18/80)
OTHER USS CORP. MECHANICAL REPORT (11/01/79)
OTHER MEMO FROM TDI DATED 01/23/81, FROM SSCHUMACHER. TELEX 335304 TO LINDA BLOCK FROM JOHN BOUNTIN (01/17/81) (M/V GOTT).

9) ALL 32 CYLINDER HEADS HAVE BEEN REMOVED, REINSTALLED OR RENEWED AT LEAST THREE TIMES FOR REASONS OF LEAKING OR FRACTURED HEADS, UNDER SIZED PISTONS, CRACKED VALVE SEATS, FAULTY LINER SEALS, BROKEN OR STUCK VALVES, BROKEN VALVE GUIDES, ETC. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER-W.R. HUDSON TO D.H.MARTIN- 12/14/76

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|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

10) EIGHT CYLINDER HEADS REMOVED AND RETURNED TO TDI AFTER EVIDENCE OF CRAKS FOUND. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER-M.ZBINDEN TO J.BARICH-07/28/88

11) PRIOR TO THE START OF 1978 SEASON, #7 CYLINDER HEAD ON THE STARTBOARD ENGINE FOUND CRACKED THROUGH THE VALVE BRIDGE. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER-M.E.ZBINDEN TO W.HUDSON-02/0279

12) SEVEN CYLINDER HEADS HAD CRACKS-ONE OF THE HEADS CRACKED IN THE EXHAUST PASSAGE AND PORT AREA JUST ABOVE A RENEWED VALVE SEAT. AND DEFECTS OR BLOWN RINGS. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER FROM M.ZBINDEN (STATE OF ALASKA) TO D.MCLDAVIDSON (FERGUSON & BURDELL) DATED 07/25/80.
OTHER LETTER FROM M.ZBINDEN TO D.MARTINI (TDI) DATED 06/14/79 AND 03/19/79
OTHER LETTER-M.E.ZBINDEN TO W.HUDSON-02/0279

13) ACTION TAKEN SINCE VESSEL DELIVERY-INSTALLED RELIEF PASSAGES IN CYLINDER HEADS TO PERMIT COMBUSTION GASES, LEAKING PAST FIRE RINGS, TO VENT INTO ENGINE ROOM. PRIOR TO THIS, GASES WOULD ENTER JACKECT WATER SYSTEM AND CAUSE AIR BINDING OF CIRCULATING PUMPS. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER TO TDI (D.MARTINI) DATED 03/24/80 FROM M.ZBINDEN (STATE OF ALASKA)

14) ADDITION OF "POSTS" TO EXISTING CYLINDER HEADS SHOULD RESOLVE WARPAGE AT 3 & 9 O'CLOCK POSITIONS AND BURN OUT OF FIRE RINGS. DELAVAL NOW STRESS RELIEVES ALL HEADS AFTER VALVE SEAT REWORK-HEADS SO MARKED SR. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER MEETING BETWEEN TDI (C.MATHEWS) AND ALASKA (R.LIND) ON 09/04/80
OTHER LETTER-GE TRUSSEL TO M.ZBINDEN-11/28/78
OTHER LETTER FROM M.ZBINDEN TO W.HUDSON DATED 02/02/79
OTHER LETTER FROM M.ZBINDEN TO D.MARTINI DATED 03/19/79

15) SUMMARY OF PROBLEMS-WARPAGE OF CYLINDER HEADS AND FIRE RING BURN OUT. CRACKING OF VALVE SEATS AND CYLINDER HEADS. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER TO TDI (D.MARTINI)DATED 03/24/80 FROM M.ZBINDEN (STATE OF ALASKA)
OTHER LETTER FROM M.ZBINDEN TO M.MARTINI DATED 01/16/80
OTHER LETTER FRO M.ZBINDEN TO TDI DATED 07/10/79, 03/29/79 AND 03/19/79
OTHER LETTER FROM M.ZBINDEN TO W.HUDSON DATED 02/02/79

16) DURING OVERHAUL, CYLINDER HEAD WAS REMOVED DUE TO INDICATIONS OF INTERNAL WATER LEAKAGE. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER FROM M.ZBINDEN (STATE OF ALASKA) TO B.DURIE (TDI) DATED 06/17/80

17) (DELETED 08/27/84)

18) SIXTEEN NEW HEADS DEFECTIVE DUE TO CASTING CORE SHIFT WHICH BLOCKED OF COOLING WATER PASSAGE -REPAIRED BY GRINDING & WELDING. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER MEMORANDUM FROM M.ZBINDEN TO R.LIND (STATE OF ALASKA) DATED 06/17/81 AND M.ZBINDEN

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
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|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

TO FILE (STATE OF ALASKA)DATED 06/01/81 AND 04/29/81
OTHER LETTER FROM M.ZBINDEN (STATE OF ALASKA) DATED 09/12/83

19) (DELETED 08/27/84)

20) TDI RECOMMENDS: REBUILD CYLINDER HEAD, NEW EXHAUST VALVE, SPRING ETC. REMOVE CYLINDER HEAD AFTER 5000 HRS OF OPERATION AND CHECK EFFECTS OF PISTON CROWN CUTBACK, WATER WASH SYSTEM, ENHANCED AIR FLOW. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER MEMO FROM S.SCHUMACHER (TDI) TO R.PRATT (07/09/82) PG 1,2.

21) DISCUSSION CONCERNING HEAD-HEAD REMOVED, FIRESEALS IN GOOD CONDITION, EXHASUT VALVES LEAKING ,INTAKE VALVES GOOD-POSSIBLY DUE TO IMPROVEMENT OF COMBUSTION. (M/V "COLUMBIA")
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER MEMO FROM S.SCHUMACHER (TDI) TO R.PRATT (07/09/82), PG 2,3

22) STATE OF ALASKA SENT TDI 4 JUNK HEADS (3 HAVE CRAKS BEYOND REPAIR POSSIBLY CAUSED BY EXHAUST VALVE SEAT RENEWAL). ONE HEAD FROM TDI DAMAGED IN TRANSIT. SOME HEADS RECEIVED HAD BEEN BUTCHERED-CRACKS, TAP BROKEN OFF IN THREADED HOLE, DAMAGED FLANGE FACES. SOME HEADS WELDING SLAY, PITS, BLOW HOLES, RUST. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER MEMORANDUM FROM MAX ZBINDEN (STATE OF ALASKA) TO HUGH MCDONALD (03/09/83)
OTHER LETTER FROM M.ZBINDEN (STATE OF ALASKA) TO B.BAILEY (TDI) (03/01/83 AND 03/07/83)
OTHER LETTER FROM M.ZBINDEN(STATE OF ALAS KA) TO B.BAILEY (TDI) 12/02/8_.

23) FIRE RING DISTRESS AND/OR FAILURE OF HEADS CAUSED BY UNSYMMETRICAL HEAD BOLTING PATTERN CAUSING MOMENTS WITHIN THE HEAD ASSEMBLY. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER SES REPORT NO. 123-01 DATED APRIL 1983, PG 3-10, 4-2

24) CYLINDER HEAD REMOVAL AND FAILURE RATE VERY HIGH DUE TO POOR CASTABILITY OF CAST STEEL AND CLOSER CONTROLLED FOUNDRY TECHNIQUES REQUIRED, THIN CROSS SECTIONS, MISALIGNED COOLING PASSAGES. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER SES REPORT NO. 123-01 DATED APRIL 1983, PGS 3-7, 3-8, 6-3

25) CYLINDER HEADS HAVE EXCESSIVELY HIGH FAILURE RATE-WARPAGE, CRACKING, LOSS OF FIRE RING SEAL, ETC. X-RAYS SHOWED GAS POCKETS FROM CASTING AND INADEQUATE WELD REPAIRS. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER ENGINE REBUILD REPORT FOR STATE OF ALASKA DATED 03/31/81, PGS III, III-2, VI

26) CYLINDER HEAD CRACKED AT INLET VALVE BRIDGE
M/V STAR OF TEXAS
SOURCE: NOS:
OTHER TELEX FROM TITAN NAVIGATION TO R.PRATT (TDI) DATED NOV,'82 (FILE NO.T-36)

27) WATER LEAK ON ONE OF THE CYLINDER HEADS. CAUSED BY RUNNING THIS PARTICULAR HEAD WITH INSUFFICIENT TORQUE ON THE CYLINDER HEAD BOLTS THUS DESTROYING THE RUBBER SEALS FOR THE CYLINDER HEAD WATER PASSAGES.
QURAYAT ELECTRIC/SAUDI ARABIA
SOURCE: NOS:

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
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|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

OTHER LETTER FROM K.BUZEK (TDI) TO Y.AL-BASSAM (ELECTRICITY CORP) DATED 01/14/79 (FILE NO. T-49)

28) SIX CYLINDER HEADS ARE LEAKING OIL. NEW CYLINDER HEAD GASKETS SETS ORDERED.
MAJMAAH ELECTRIC/SAUDI ARABIA.
SOURCE: NOS:
OTHER MEMO FROM K. BUZEK (TDI) TO TDI OAKLAND CUSTOMER SERVICE DEPT DATE MARCH 13,1980 (FILE NO.T-49)

29) CYLINDER HEAD CRACKED ACROSS THE FIREDECK FACE BETWEEN EXHAUST VALVES. ANOTHER CYLINDER HEAD CRACKED ACROSS THE FIREDECK FACE BETWEEN EXHAUST VALVES WITH CRACK EXTENDING INTO ONE OF THE VALVE SEATS.
QURAYAT ELECTRIC/SAUDI ARABIA
SOURCE: NOS:
OTHER MEMO FROM K. BUZEK (TDI) TO TDI OAKLAND CUSTOM SERVICE DEPT DATED MARCH 13,1980 (FILE NO. T-49)
OTHER TDI CUSTOMER SERVICE REPORT BY B. POPE DATED MARCH 9,1980 (FILE NO. T-49)

30) DEFECTIVE CYLINDER HEADS.
QURAYAT ELECTRIC/SAUDI ARABIA
SOURCE: NOS:
OTHER LETTER FROM K.BUZEK (TDI) TO H.RAHMAN (ELECTRICAL WORK & MAINTENANCE) DATED 04/04/79 (FILE NO. T-49)
OTHER LETTER FROM H. RAHMAN (ELECTRICAL WORK & MAINTENANCE) TO K. BUZEK (TDI) DATED MAY 14,1979 (FILE NO.T-49)
OTHER LETTER FROM Y. BASSAM (ELECTRICITY CORP) TO MANAGER, ELECTRICAL WORK & MAINTENANCE DATED 06/18/79 (FILE NO.T-49)
OTHER LETTER FROM J. CLAESSEN (ELECTRICAL WORK & MAINTENANCE) TO K.BUZEK (TDI) DATED MAY 22,1979 (FILE NO. T-49)
OTHER LETTER FROM A. SARD (QURAYAT ELECTRIC) TO TDI (FILE NO.T-49)
OTHER TELEX FROM S. HASSAN TO H. RAHMAN DATED 09/30/79 (FILE NO.T-49)
OTHER LETTER FROM A. GALSTAUN (ELECTRICAL WORK & MAINTENANCE) TO K.BUZEK (TDI) DATED JULY 28,1979 (FILE NO.T-49)
OTHER LETTER FROM K.BUZEK (TDI TO J.CLAESSEN (ELECTRICAL WORK & MAINTENANCE) DTD 05/24/79 (FILE NO. T-49)
OTHER LETTER FROM H. RAHMAN (ELECTRICAL WORK & MAINTENANCE) TO K. BUZEK (TDI) DTD 04/01/79 FILE NO.T- )

31) CYLINDER HEAD FAILURE DUE TO MANUFACTURING PROCESS. THE PROBLEMS IN THE MANUFACTURING PROCESS HAVE BEEN OVECOME.
ELECTRICITY CORP. ARABIA
SOURCE: NOS:
OTHER MINUTES OF DISCUSSION HELD IN THE OFFICE OF ELECTRICITY CORPORATION,RIYADH,ARABIA. DATED 02/18/79 (FILE NO.T-27)

32) CYLINDER HEADS CRACKED UNDER A FATIGUE TYPE BREAK. TESTING SHOWED SUBSTANTIAL STRESS AT THE CRACKED AREA.
M.S.C./BIH-S/L ANTARTIC.
SOURCE: NOS:
OTHER FAILURE ANALYSIS REPORT NO. 0109 DATED 12/28/77 (FILE NO.T-21)

33) CYLINDER HEAD HAD A HOLE IN IT AND THE SPARE HEAD HAS INSTALLED (08/20/75) ENGINE NO. 18

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
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|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

CITY OF HOMESTEAD, FL.
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMESTEAD, FL) DATED 09/30/78 (FILE NO. T-10)

34) FAILURE OF ENGINE CYLINDER HEADS
M/V PRIDE OF TEXAS
SOURCE: NOS:
OTHER LETTER FROM H.R.HASSON (LOVEJOY,HASSON,LUNDGREM & ASHTON) TO C. MATHEWS (TDI) AND J. BARRIOS (LEVINGSTON SHIPBUILDING CO) DATED 06/07/82 (FILE NO.T-44)

35) CYLINDER HEAD CRACKING
M/V PRIDE OF TEXAS
SOURCE: NOS:
OTHER LETTER FROM J. WALLACE (CASE WESTERN RESERVE UNIVERSITY) TO C. MATHEWS (TDI) DATED MAY 19,1982 (FILE NO.T-43)

36) SEVERAL CYLINDER HEADS HAVE CRACKED IN THE AREA OF THE EXHAUST VALVE PORT. THESE CYLINDER HEADS HAVE BEEN REPLACED.
CITY OF HOMESTEAD,FL
SOURCE: NOS:
OTHER LETTER FROM A.MUXO (CITY OF HOMESTEAD) TO C.S. MATHEWS AND R.J. BAZZINI (TDI) DATED MAY 13,1982 (FILE NO. T-10)

37) CYLINDER HEAD FAILURE (CRAKS). THOUGHT TO BE CAUSED BY JACKET WATER FOAMING.
M/V GOTT
SOURCE: NOS:
OTHER INTEROFFICE MEMO FROM S.SCHUMACHER (TDI) TO TDI FILE DATED JAN 23,1981 (FILE NO. T-46)
OTHER INTEROFFICE MEMO FROM S.SCHUMACHER (TDI) TO TDI FILE DATED FEB 10,1981 (FILE NO T-46)
OTHER LETTER FROM S.SCHILLING (TDI) TO J.WALLACE (CASE WESTERN RESERVE UNIVERSITY) DATED FEB 23,1981 (FILE NO T-46)

38) CRACKED CYLINDER HEADS DUE TO HIGH CYCLE FATIGUE FAILURE. ALL CYLINDER HEAD PATTERNS WERE CORRECTED TO ELIMINATE THE THIN WALL SECTIONS. ALSO, THE HEADS ARE NOW ANNEALED AFTER FINAL MACHINING TO ELIMINATE ALL RESIDUAL STRESSES.
M/V GOTT.
SOURCE: NOS:
OTHER PRELIMINARY REPORT FROM FAILURE ANALYSIS DEPT (TDI) TO E.G.DEANE (TDI) DATED 11/02/79 (FILE NO. T-25)

39) HEAD FAILURES EXPERIENCED BY U.S. STEEL
M/V GOTT
SOURCE: NOS:
OTHER LETTER FROM L.H. PIERSON (M/V GOTT) TO B.E. LIBERTY (U.S. STEEL) 10/25/81 (FILE # T-15)

40) CYLINDER HEADS CRACKED DUE TO RESIDUAL STRESSES INTRODUCED BY WELDED CONSTRUCTION & STELLITE APPLICATION. NEW HEADS HAVE CORRECT THICKNESS & PROPER HEAT TREATMENT.
M/V COLUMBIA.
SOURCE: NOS:
OTHER REPORT BY GEORGE G. SHARP, INC "OVERVIEW OF REPORTS, ANALYSIS AND RECOMMENDATIONS RE

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
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| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

MAIN PROPULSION ENGINES M/V COLUMBIA" BY JULY 26,1983

41) CRACKED CYLINDER HEAD IN EXHAUST VALVE AREA. RIYADH
SOURCE: NOS:
OTHER DELAVAL MEMO DTD 28JUN80-YANBU POWER STA FROM KEN BUZEK (TDI) TO BOB BAILEY R&G SN 75057. (FILE #T-64)

42) CYL HEAD CRACKS IN BOTH ENGINES. SEVERE AIR ENTRAINMENT PROBLEM CAUSED BY J.H. STANDPIPE NOT TO DELAVAL SPECIFICATIONS FOR ENG S/N 73040. USA
SOURCE: NOS:
OTHER TDI MEMO DTD 8NOV79 FAILURE ANALYSIS (FA #.0125) US STEEL CYL HEADS S/N 75039/40. (FILE # T-64)

42) NUMEROUS REPORTS OF LEAKING AND CRACKED CYLINDER HEADS FROM 1973 THROUGH 1979 AT VARIOUS LOCATIONS.
SOURCE: NOS:
OTHER CHRONOLOGICAL SUMMARY OF GLENCOE EVENTS - 4 PAGES - DATED 02/20/80 ENG. S/N 72052. (FILE NO. T-57)

43) CRACK IN CYL. HD. (NO. 3) ENG. S/N 79002. HEAD REPLACED.
SOURCE: NOS:
OTHER RAFHA ELECTRICITY CO. & SUBURBS, SAUDI CO. LTD., SAUDI ARABIA DATED 07/12/81. NO ADDRESSEE OR TRANSMITTAL LETTER AVAILABLE. NO. 3 GEN. (FILE NO. T-57)
(RAFHA, SAUDI ARABIA)

44) CYLINDER HEAD CRACK ON FIRE DECK AREA BETWEEN EXHAUST PORTS.
SOURCE: NOS:
OTHER FAILURE REPORT DATED 01/14/76 (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

45) SUMMARY OF ALL U.S. STEEL HEAD FAILURES FROM05/08/79 TO 01/05/81.
SOURCE: NOS:
OTHER U.S. STEEL HEAD FAILURES BY S. SCHUMACHER (TDI) DATED 03/05/81 (FILE NO. T-53)
(U.S. STEEL)

46) CYLINDER HEAD CRACKED CAUSING COMPLETE DAMAGE OF PISTON, LINER, 2-VALVES, CROWN AND SUB-COVER OF CYLINDER HEAD.
SOURCE: NOS:
OTHER TELEX RABIGH ELECTR. DATED 04/30/83 TO TDI ENG. S/N 80002 (FILE NO. T-57)
OTHER TDI MEMO 02/15/83 SCHUMACHER TO R.P RATT (FILE #T-57)

47) DAMAGED CYLINDER HEAD DUE TO EITHER TOO MUCHVALVE LASH OR COLLAPSE OF HYDRAULIC LIFTER.
SOURCE: NOS:
OTHER FAILURE REPORT DATED 03/12/76 (FILE NO. T-49)
(HAIL/SAUDI ARABIA)

48) CYLINDER HEAD CRACKED IN THE BRIDGE BETWEEN EXHAUST AND EXHAUST PORTS. POOR CASTING.
SOURCE: NOS:
OTHER FAILURE REPORT - NO DATE (FILE NO. T-49)
OTHER LETTER FROM Y.ZARO (TDI) TO A.FOLTZ (TDI) DATED 07/05/79, PG 2, (FILE NO. T-49)
(HAIL/SAUDI ARABIA)

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|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

49) CYLINDER HEAD CRACKED.
SOURCE: NOS:
OTHER ENGINE OPERATIONAL STATUS REPORT BY Y. ZARO DATED 06/23/79
(QURAYAT/SAUDI ARABIA)

50) CYLINDER HEAD HAD A FINE CRACK ON FIRE DECK AREA BETWEEN EXHAUST VALVES. CAUSED BY A POOR CASTING OF AREA BETWEEN EXHAUST VALVES.
SOURCE: NOS:
OTHER FAILURE REPORT DATED 06/23/79 (FILE NO. T-49)
OTHER LETTER FROM Y.ZARO (TDI) TO A.FOLTZ (TDI) DATED 07/05/79 PG 3 (FILE NO. T-49)
(QURAYAT/SAUDI ARABIA)

51) INTERNAL POROSITY LEAKS AT THE FUEL NOZZLE IN THE HEAD. CAUSED BY AN INTERNAL CRACK IN THE HEAD.
SOURCE: NOS:
OTHER FAILURE REPORT DATED 06/23/79 (FILE NO. T-49)
OTHER LETTER Y.ZARO (TDI) TO A.FOLTZ (TDI ) DATED 07/05/79 PG 3 (FILE NO. T-49)
(QURAYAT/SAUDI ARABIA)

52) CYLINDER HEAD WITH LARGE CRACK BETWEEN EXHAUST VALVES.
SOUREC: NOS:
OTHER FAILURE REPORT - NO DATE (FILE NO. T- 49)
OTHER LETTER Y.ZARO (TDI) TO A.FOLTZ (TDI) DATED 07/05/79 PG 3 (FILE NO. T-39)
(QURAYAT/SAUDI ARABIA)

53) ENG. S/N 79002 EXPLODED. NO. 3 CYLINDER HEADHAS DAMAGED. ATTRIBUTED TO MULTIPLE HEAD GASKETS (2) DAMAGE TO ENGINE EXTENSIVE AREA OF CYLINDER.
SOURCE: NOS:
OTHER RAFHA ELECTRICITY CO. & SUBURBS, SAUDI CO. LTD., SAUDI ARABIA DATED 07/12/81. NO ADDRESSEE OR TRANSMITTAL LETTER AVAILABLE. NO. 3 GEN. (FILE NO. T-57)
(RAFHA, SAUDI ARABIA)

54) WATER SEAL OF NO. 3 CYL. ENG S/N 79002 LEAKED. REFITTED USING NEW CYL. HD. GASKET KIT.
SOURCE: NOS:
OTHER RAFHA ELECTRICITY CO. & SUBURBS, SAUDI CO. LTD., SAUDI ARABIA DATED 07/12/81. NO ADDRESSEE OR TRANSMITTAL LETTER AVAILABLE. NO. 3 GEN. (FILE NO. T-57)
(RAFHA, SAUDI ARABIA)

55) CYLINDER HEAD FOR CYL. NO. 3 FOUND WITH CRACK IN TOP, BETWEEN TWO EXHAUST VALVES. HEAD REMOVED ADN REPLACED.
SOURCE: NOS:
OTHER RAFHA ELECTRICITY CO. & SUBURBS, SAUDI CO.LTD., SAUDI ARABIA DATED 07/12/81. NO ADDRESSEE OR TRANSMITTAL LETTER AVAILABLE. ENG. NO. 3 S/N 79002-2995 (FILE NO. T-57)
(RAFHA, SAUDI ARABIA)

56) DAMAGE TO CYLINDER #7 INCLUDED TWO EXHAUST VALVES, TWO INTAKE VALVES, TWO EXHAUST VALVE GUIDES, TWO INTAKE VALVE GUIDES.
SOURCE: NOS:
OTHER TELEX FROM RABIGH ELECTR. DATED 02/05/83 TO TDI FOR ENG. S/N 80003-3038 (FILE #T-57)

57) CYLINDER HEAD WAS CRACKED ACROSS FIRE DECK AREA BETWEEN EXHAUST AND EXHAUST VALVES. CAUSED BY A POOR CASTING.

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

SOURCE: NOS:
OTHER FAILURE REPORT DATED 05/27/76 (FILE NO.T-49)
(AL JOUF/SAUDI ARABIA)

58) CRACKED CYLINDER HEAD IN FIRE DECK AREA BETWEEN EXHAUST AND EXHAUST VALVES. CAUSED BY POOR CASTING.
SOURCE: NOS:
OTHER FAILURE REPORT - DATED 10/10/75 (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

59) CRACKED CYLINDER HEAD IN FIRE DECK AREA BETWEEN EXHAUST AND EXHAUST VALVES. CAUSED BY POOR CASTING.
SOURCE: NOS:
OTHER FAILURE REPORT - NO DATE IDENTIFIED (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

60) CYLINDER HEAD CRACKED IN FIRE DECK AREA.
SOURCE: NOS:
OTHER FAILURE REPORT DATED 03/03/76 (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

61) CYLINDER HEAD CRACKED ACROSS FIRE DECK, EXHAUST PORT TO EXHAUST PORT.
SOURCE: NOS:
OTHER FAILURE REPORT DATED 01/27 76 (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

62) POROSITY LEAKS IN CYLINDER HEAD. REASON FOR FAILURE HAS ATTRIBUTED TO POOR CASTING OF HEAD.
SOURCE: NOS:
OTHER FAILURE REPORT DATED 09/24/75 (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

63) DAMAGED FIRE DECK AREA OF CYLINDER HEAD. PLANT PERSONNEL LEFT A NUT OR TOOL ON PISTON AND ON START-UP OF UNIT CYL. HEAD HAS DAMAGED.
SOURCE: NOS:
OTHER FAILURE REPORT DATED 12/19/75 (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

64) CYLINDER HEAD CRACKED BETWEEN EXHAUST BRIDGE
SOURCE: NOS:
OTHER FAILURE REPORT DATED 03/17/76 (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

65) CYLINDER HEAD CRACKED ON THE EXTERNAL SIDE OF CYLINDER. CRACK REPAIRED BY WELDING A PLATE IN CRACKED AREA. CAUSED BY COOLING WATER ON THIS AREA.
SOURCE: NOS:
OTHER FAILURE REPORT - NO DATE (FILE NO. T-49)
OTHER LETTER FROM Y.ZARO (TDI) TO A.FOLTZ (TDI) DATED 07/05/79 PG 3 (FILE NO. T-49)
(HAIL/SAUDI ARABIA)

66) CYLINDER HEAD CRACKED ACROSS FIRE DECK AREA BETWEEN EXHAUST AND EXHAUST VALVES.
SOURCE: NOS:
OTHER MEMO FROM Y. ZARO (TDI) TO A. FOLTZ (TDI) DATED 07/05/79 (FILE NO. T-49) ENGINE

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

OPERATIONAL STATUS REPORT BY Y. ZARODATED 06/12/79 (FILE NO. T-49)
(AL JOUF/SAUDI ARABIA)

67) WATER OOZING FROM THE INDICATOR COCK. BLOW HOLE (1/16") ON THE EXH. PASSAGE VALVE OF THE CYLINDER HEAD. REPLACE WITH NEW CYLINDER HEAD.
SOURCE: NOS:
OTHER BHEL LTD. DATED 08/24/81 FROM M.L. ACHARYA TO TDI, OAKLAND. ENG. NO. 6 S/N 77041, CYLINDER HEAD OF RB-4. (FILE #T-52)
OTHER BHEL LTD FROM M.L.ACHARYA TO G.BESHOURI (TDI) FOLLOW DEFECTS ENG #6-1)WATER LEAK M CYL HEAD RB4; 2)WATER LEAK FROM CYL HD LB4 FROM ENG #1: 1) LEAK FROM CYL HD LB1; 2)LEAK FROM CYL HD LB2 (FILE #T-5 )
OTHER TDI TELEX DATED 09/23/81 TO M.C.ACHARIA FROM B.BAILEY (TDI)
(JIZAN, SAUDI ARABIA)

68) VALVE GUIDES BREAKING OFF AND DAMAGING HEADS DUE TO CARBON BUILD UP. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER SES REPORT #123-01 DATED APRIL 1983,PG 3-8 (ADDED 08/10/84)

69) DIESEL HEADS DISASSEMBLED DUE TO HIGH EXHAUST TEMPERATURES. FOUND GUTTED EXHAUST VALVES AND CRACKED SEATS, AND WATER LEAKAGE IN COMBUSTION CHAMBER. METALURGICAL ANALYSIS REVEALED SERERE CASTING INCLUSIONS AND CRACKS IN CLYINDER HEAD. NOTE: HEADS WERE A.B.S. APPROVED, DMRV 16-4 TDI ENGINE. (M.V. CAL RICE TRANSPORT) (ADDED 08/22/84)
SOURCE: NOS:
OTHER LETTER FROM NAUTILUS SURVEYS INC (D.F. BROWN) TO TEEKAY SHIPPING CO, INC (VINAY PATWARDHAN) DATED 03/16/84.

70) EXHAUST VALVE GUIDES ALL ATTACKED FROM SULFURIC ACID. IN AN EFFORT TO REDUCE THIS SULFUR ATTACK, A VARIETY OF METHODS HAVE BEEN TRIED. THE METHODS USED HAVE BEEN BLOWING AIR DOWN THE EXHAUST GUIDES, PUTTING OIL DOWN THE GUIDES, REDUCING THE AMOUNT OF THE GUIDE IN THE FLOW OF EXHAUST GASSES AND ADDING OIL SEALS TO THE TOP OF THE GUIDE. WITH ALL THESE ATTEMPTS, THERE HAS BEEN NO SIGNIFICANT REDUCTION IN SULFUR ATTACK OF EXHAUST VALVE STEMS. IN A FUTHER ATTEMPT TO REDUCE EXHAUST VALVE STEM CORROSION, TWO NEW TYPES OF EXHAUST VALVES WILL BE INSTALLED IN ONE OF THE ENGINES. THE NEW VALVES WILL HAVE COATINGS OF TUNGSTEN CARBIDE. M/V GOTT (ADDED 08/22/84)
SOURCE: NOS:
OTHER INTEROFFICE MEMO FROM G. MATTUZZI (TDI) TO R. JOHNSTON (TDI) DATED FEB 21,1984 (FILE NO. T-30)
OTHER MINUTES OF MEETING BETWEEN TDI AND USSGLF ON SEPT 20-21, 1982 (FILE NO. T-30)

71) EXHAUST VALVE GUIDE BROKEN OFF-EVEN WITH TOP SURFACE OF CYL HEAD. TITAN NAVIGATION/MV PRIDE OF TEXAS (ADDED 08/22/84)
SOURCE: NOS:
OTHER TDI CUSTOMER SERVICE REPORT BY T. BARGE DATED 10/25/84-10/29/82 (FILE NO. T-33)

72) CRACKED EXHAUST VALVE SEAT. (ADDED 08/22/84)
SOURCE: NOS:
OTHER FAILURE REPORT DATED 06/21/79 BY Y. ZARO (FILE NO. T-49) (AL JOUF/SAUDI ARABIA)

73) CRAKED EXHAUST VALVE SEAT. (ADDED 08/22/84)
SOURCE: NOS:
OTHER FAILURE REPORT DATED 12/09/75 (FILE NO. T-49) (AL JOUF/SAUDI ARABIA)

73) CYLINDER HEAD FAILURES, MV GOTT. HEAD SERIAL NO. P-68, HT. NO. 891E; STRESS RELIEVED & PICK-

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
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EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-360A | <CONTINUED.......> | <N> | X | X | D | Z | 02-360A |

LED; DATE CAST, 2-22-80; OPERATING HOURS @ FAILURE, 9278; FAILURE MODE, HEAD CRACKED; COMMENTS,
SCRAPPED. HEAD P-68 REPLACED HEAD N-30. (ADDED 08/23/84)
SOURCE: NOS:
OTHER TDI LTR 6/26/84 FROM M. LOWREY TO M.LITTMAN. EXCEPT FOR CYLINDER HEAD NO. P68 HT. NO
891E, ALL OTHER EXPERIENCE DATA IS CONTAINED IN "SUMMARY OF U.S. STEEL HEAD FAILURES" S/N 75039/
40 S.G. SCHMACHER REV. 9, 3-5-81, FILE NO. T-53. (FILE NO. T-70)

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
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EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|
| 03-340A | A | X | X | Q | Z | 02-340A |

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CONNECTING RODS - CONNECTING RODS & BUSHING.

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PERRY EXPERIENCE:

1) CHECKED BREAK-AWAY TORQUE VALUE OF LINK ROD BOLTS (GREATER THAN 600 FT/LBS) TO VERIFY ACCEPTABLE LINK ROD DOWEL COUNTERBORE. ALL LINK RODS TORQUED TO 1050 FT/LBS FOLLOWING CHECK. ALL ENGINES.
SOURCE: NOS:
NCR CQC-1965

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RECOMMENDED DESIGN REVIEW ATTRIBUTES:

1) DETERMINE IF COMPONENT IS DIFFERENT FROM THOSE USED ON PREVIOUS DESIGNS. IF SO, REVIEW DESIGN APPLICATION.

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RECOMMENDED QUALITY REVALIDATION ATTRIBUTES:

1) ASSEMBLE AND REVIEW EXISTING DOCUMENTATION.

2) DEVELOP EDDY CURRENT INSPECTION PLAN FOR FEMALE THREADS IN ROD BOX (SAMPLE BASIS IF REQUIRED)

3) DEVELOP MP INSPECTION PLAN FOR CONN ROD BOLTS (SAMPLE BASIS IF REQUIRED)

4) VISUALLY INSPECT CONN ROD BOLT WASHERS AND CONTACT SURFACES FOR GALLING (SAMPLE BASIS IF REQUIRED).

5) VERIFY BOLT TORQUE (SAMPLE BASIS IF REQUIRED)

6) VISUALLY INSPECT RACK TEETH FOR CRACKS (SAMPLE BASIS IF REQUIRED).

7) LP CONN ROD BOX EXTERNAL SURFACES IN AREA BETWEEN CONN ROD BORE AND LINK ROD BORE (SAMPLE BASIS IF REQUIRED).

8) PERFORM HARDNESS TEST ON CONN ROD BOLT WASHERS (SAMPLE BASIS IF REQUIRED)

9) LP LINK ROD BUSHING (SAMPLE BASIS IF REQUIRED).

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NUCLEAR INDUSTRY EXPERIENCE:

1) NORMAL SURVEILLANCE BEING PERFORMED. INVESTIGATION REVEALED ONE OF THE TWO ROD CAP RETAINING BOLTS HAD COME OUT ALLOWING ENGINE TORQUE TO BREAK SECOND RETAINER BOLT WHICH ALLOWED ROD TO SEPARATE FROM CRANKSHAFT.

EXHIBIT 38

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-340A | <CONTINUED.......> | <I> | X | X | Q | Z | 02-340A |

SOURCE: NOS: MANUFACTURER:
LER HATCH 2, 366-81127-1, 811216 FAIRBANKS-MORSE

2) SURVEILLANCE PERFORMED ON DIESEL GENERATOR. INVESTIGATION REVEALED COTTER PINS THAT LOCK CONNECTING RODS IN PLACE IN ONE CYLINDER WERE BROKEN ALLOWING CONNECTING ROD TO SEPERATE FROM CRANKSHAFT RESULTING IN ENGINE FAILURE.
SOURCE: NOS: MANUFACTURER:
LER HATCH 2, 366-80159-1, 801126 FAIRBANKS-MORSE

3) DURING OPERATION, UPPER PISTON CONNECTING ROD BEARING CAP CAPSCREWS SHEARED. THIS RESULTED IN EJECTION OF ROD THROUGH CRANKCASE COVER. THIS WAS PROBABLY CAUSED BY A SERIES OF UNLUBRICATED DRY STARTS.
SOURCE: NOS: MANUFACTURER:
LER MILLSTONE 2,336-76000,761218 FAIRBANKS-MORSE

4) INSPECTION FOUND BOLT HEAD CRACKED ON CONNECTING ROD - #3 D.G. CAUSE UNKNOWN. REPLACED ALL CO NNECTING ROD BOLTS.
SOURCE: NOS: MANUFACTURER:
NPRDS BRUNSWICK 2, 820416, HIT 252 NORBERG

5) (DELETED 08/30/84)

6) INFO-CONN ROD WRIST PIN BUSHINGS LOCKED IN PLACE IF NO OIL GROOVE.
SOURCE: NOS:
TDI SIM 312

7) CYLINDER FAILED. CAUSED BY FAILURE OF PISTON ROD PIN BOLTS. THEIR FAILURE WAS CAUSED BY ART-ICULATING ROD PIN BOLTS AND PISTON PIN BOLTS BEING STRETCHED PROBABLY DURING PARTIAL PISTON SEIZURE. (ADDED 07/18/84)
SOURCE: NOS:
LER COOPER 298-80027 800508

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NON-NUCLEAR INDUSTRY EXPERIENCE:

1) DELAVAL INSPECTED DEFECTIVE CONNECTING ROD BOLTS AND HEAVY FRETTING NOTED IN THE LINK ROD BUS HING BORES. DAMAGED ROD BOLT RECEIVED FROM TDI. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER FROM L.BLOCK (TDI) TO M.ZBINDEN (STATE OF ALASKA) 06/02/80
OTHER LETTER FROM M/ZBINDEN (STATE OF ALASKA) TO M.MARTINI (TDI) DATED 01/16/80
OTHER M/V COLUMBIA-REPAIR PART STATUS (STARTING DATE 07/27/79)

2) (DELETED 10/23/84)

3) COLUMBIA TAKEN OUT OF SERVICE PREMATURELY DUE TO CRACKING OF CONNECTING RODS. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER FROM L.BLOCK (TDI) TO M.ZBINEEN (STATE OF ALASKA) DATED 06/02/80.
OTHER LETTER FROM A.MCDONALD (STATE OF ALASKA) TO J.EIDE (DIV OF MARINE HWY SYSTEMS) DATED

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
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EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVH | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-340A | <CONTINUED.......> | <N> | X | X | Q | Z | 02-340A |

12/26/79.

4) ACTION TAKEN SINCE VESSEL DELIVERY-CHANGED ORIGINAL ROD BOLTS TO THOSE WITH ROLLED AIRCRAFT TYPE THREADS-PROBLEM OF CRACKING CONTINUES. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER TO TDI (D.MARTINI) DATED 03/24/80 FROM M.ZBINDEN (STATE OF ALASKA)

5) CONNECTING ROD CAPSCREWS INSTALLED TO REPLACED CRACKED ONES-INCREASED TORQUE CAUSED MATING SURFACES TO BECOME GALLED. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER MEMO FROM M.ZBINDEN (STATE OF ALASKA) TO FILE 04/09/81.
OTHER MEMO FROM M.ZBINDEN (STATE OF ALASKA) TO R.WARD DATED 12/10/80.

6) TDI FEELS DAMAGE TO LINK ROD BUSHING BAIL AREA CAUSED BY FOREIGN (DIRTY) MATERIAL IN LUBE OIL. STATE OF ALASKA FEELS THAT THE DRILLED OIL PASSAGES WERE NOT PROPERLY MACHINED-THE REMAINED RAISED AREA OR BURR AROUND OIL HOLE IS THE CAUSE OF THE DAMAGE. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER LETTER B.ZURIE (TDI) FROM M.ZBINDEN (STATE OF ALASKA) DATED 02/29/80.

7) DAMAGE TO ROD BOLTS INCLUDING CRACKING. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER TDI (D.MARTINI) DATED 03/24/80 & 03/19/79 FROM M.ZBINDEN (STATE OF ALASKA)
OTHER LETTER FROM M.ZBINDEN TO W.HUDSON DATED 02/02/79.

8) CRACKING OF CONNECTING ROD BOXES AND BEARING SHELLS. FRETTING OF LINK ROD AND LINK ROD PINS AT THEIR ATTACHMENT TOGETHER. INSUFFICIENT CONNECTING ROD BEARING WEAR/CONTACT AREA TO JOURNAL WHEREIN IT IS LESS THAN 15% OF THE TOTAL BEARING AREA. (1979 SEASON) (M/V "COLUMBIA")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER LETTER TO TDI (D.MARTINI) DATED 03/24/80 FROM M.ZBINDEN (STATE OF ALASKA)

9) CRACKING ON CONNECTING RODS USUALLY IN THE LINK PIN AREA BETWEEN THE LINK PIN BUSHING AND SERRATED BUSHING. MODIFICATIONS MADE. ROD BOX HAS DISTRESS IN LINK PIN BUSHING. HIGH LOADING FORCES AT THE SERRATED JOINT BETWEEN MASTER CONNECTING ROD AND CONNECTING ROD BOX. CAUSED BY UNEVEN FIRING, SURFACE FINISHES. CONNECTING RODS SHOULD BE MORE RELIABLE IF ENGINE IS DERATED. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER SES REPORT #123-01 DATED APRIL 1983, PG 3-16 THRU 3-19, 4-4.

10) CONNECTING ROD SPLIT NEAR THE PISTON PIN BUSHING. FAILURE WAS CAUSED BY A STRESS RISER THAT EXISTED AT THE GEAR CASE END OF THE ROD EYE.
SOURCE: NOS:
OTHER FAILURE ANALYSIS REPORT NO. 0117 DATED 11/06/78 (FILE NO. T-18)

11) (DELETED 10/23/84)

12) CONROD FAILURE DUE TO FATIGUE.
SOURCE: NOS:
OTHER INTEROFFICE MEMO FROM H.SCHILLING (TDI) TO E.DEANE (TDI) DATED 08/21/78

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
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EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|
| 03-340A <CONTINUED.......> | <N> | X | X | Q | Z | 02-340A |

(FILE NO. T-32)
(M/V COPPER VALLEY ELECTRIC/GLENN ALLEN)

13) CONNECTING ROD BOX AND BOLT FAILED DUE TO BOLT AND BOX THREAD DAMAGE.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT TO T&S DATED 01/23/79 (FILE NO. T-11)
(M/V BHEL JIZAN)

14) CONNECTING ROD CRACKS THOUGHT TO BE CAUSED BY IMPROPER BOLT TORQUE.
SOURCE: NOS:
OTHER TELEX FROM A.BARICH (TDI) TO J.MOLINA (FALCON SHIPPING) TO C.MATHEWS (TDI) DATED 12/05/83 (FILE NO. T-38)
OTHER TELEX FROM J.MOLINA (FALCON SHIPPING) TO C.MATHEWS (TDI) DATED 12/05/83 (FILE NO. T-38)
(M/V STAR OF TEXAS)

15) CONNECTING ROD BOLT FAILURES.
SOURCE: NOS:
OTHER LETTER FROM J.A.SMITH (CITY OF HOMESTEAD) TO G.E.TRUSSELL (TDI) DATED 06/14/77 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

16) CONNECTING ROD BOLTS #1 & 2 BOTH HAD CRACKED AND STRIPPED THREADS. FAILURE WAS CAUSED BY THE FLEXIBILITY OF THE BOX ASSEMBLY.
SOURCE: NOS:
OTHER FAILURE ANALYSIS REPORT NO. 0115 DATED 06/13/78 (FILE NO. T-20)
(M/V KODIAK ELECTRIC ASSN.)

17) CONNECTING ROD BOLT FAILURES HAVE BEEN ATTRIBUTED TO THREAD FRETTING BETWEEN THE THREADS OF THE BOX AND BOLTS.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT NO. 0136 DATED 01/16/81 (FILE T-35)
(M/V RV-4 OWNERS)

18) LOST BOTH RIGHT & LEFT BANK CONNECTING RODS. (10/07/75) ENGINE NO. 18.
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMESTEAD, FL.) DATED 09/30/78 (FILE NO. T-10)
OTHER LETTER FROM J.A.SMITH (CITY OF HOMESTEAD) TO G.E.TRUSSELL (TDI) DATED 06/14/77 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

19) #3 ROD BEARING BROKEN UP THE UPPER BOLT LEFT SIDE ALSO BROKEN. ROD DAMAGED BOTTOM SIDE OF BOTH LB & RB LINERS AND DAMAGED VALVES IN HEADS.(07/21/78) ENGINE NO. 19.
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMESTEAD, FL.) DATED 09/30/78 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

20) ALL CONNECTING ROD BEARINGS SHOW CRACKS ON BACK OF BEARING SHELL & #8 WAS FOUND TO BE CRACKED & RB LINERS AND DAMAGED VALVES IN HEADS. (07/21/78) ENGINE NO. 19.
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMESTEAD, FL.) DATED 09/30/78 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
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EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-340A | <CONTINUED.......> | <N> | X | X | Q | Z | 02-340A |

21) CONROD BOLT BENT ANOTHER FOUR WERE FOUND TO HAVE CRACKS.
SOURCE: NOS:
OTHER LETTER FROM S.CHANG (TAIWAN POWER CO.) TO M.SANDE (LILCO) DATED 05/24/83 (FILE NO. T-46)
(M/V KUO SHENG/TAIWAN POWER)

22) CONNECTING ROD BOLT FAILURES.
SOURCE: NOS:
OTHER MEMO FROM R.DESRUMEAUX (TDI) TO J.MILLER (FALLS CITY) 03/60/81 (FILE #T-5)
(M/V FALLS CITY)

23) CONNECTING ROD BOX AND BOLTING CRACKED. BOTH THE FAILURE OF THE BOLTS AND ROD BOX WAS CAUSED BY BOLT PRELOAD BEING TOO LOW.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT #0128 TO TDI DATED 02/22/80 (FILE #T-12)
(M/V MARINE TRANSPORT LINES-S/L MEDITERRANEAN)

24) CONROD BUSHING FAILURED AND TURNED CONROD BUSHINGS.
SOURCE: NOS:
OTHER TDI (FAILURE ANALYSIS DEPT) REPORT NO. 0122 DATED 02/20/79 (FILE NO. T-32)
OTHER TDI (FAILURE ANALYSIS DEPT) REPORT NO. 0118 DATED 10/26/78 (FILE NO. T-32)
(M/V VARIOUS LOCATIONS)

25) CATOSTROPHIC FAILURE OF ENGINE THAT THE ROOT CAUSE WAS THOUGHT TO BE AN IMPROPERLY TORQUED LINK ROD BOLT.
SOURCE: NOS:
OTHER TELEX FROM SCHMITZ (TDI) TO PRATT, WUSHER (TDI) DATED 09/82 (FILE NO. T-32)
(M/V NAJRAN POWER STATION)

26) CRACKED CONNECTING ROD BOX AND BOLTS. FAILURE OF THE BOX IS DUE TO A FRETTING FATIGUE STRESS RAISER IN A CYCLE LOW TENSILE STRESSED CONROD BOX. FAILURE OF THE BOLTS ARE DUE TO EITHER OR BOTH, A FRETTING FATIGUE STRESS RAISER OR A CUT THREAD SHARP ROOT STRESS RAISER, IN A CYCLE LOW STRESSED BOLT. BOTH THE FAILURE OF THE BOLTS AND ROD BOX WAS LIKELY CAUSED BY BOLT PRELOAD BEING TOO LOW, POSSIBLY THE RESULT OF INSUFFICIENT TIGHTENING TORQUE.
SOURCE: NOS:
OTHER LETTER FROM R.ASAZAWN (TDI) TO J.MACAULEY (MARINE TRANSPORT LINES) DATED 04/17/80 (FILE NO. T-28)
OTHER TDI (FAILURE ANALYSIS DEPT) REPORT NO. 128 DATED 02/22/80 (FILE NO. T-28)
(M/V SEALIFT MEDITERRANEAN)

27) CONROD BUSHING FAILURE DUE TO LOSS OF LUBE OIL PRESSURE AT 110% LOAD. RECOMMENDATIONS-REDESIGN LUBE OIL SYSTEM FOR BETTER CONTROLS, ADD AN ALARM SYSTEM AND ADD IMPROVED LUBE OIL CENTRIFUGING SYSTEM.
SOURCE: NOS:
OTHER TDI (FAILURE ANALYSIS DEPT) REPORT NO. 0114 DATED 06/07/78 (FILE NO. T-33)
(M/V CLEVELAND)

28) MASTER ROD BOX CRACKS RESULTED IN BEARING SHELL CRACKING.
SOURCE: NOS:
OTHER REPORT BY GEORGE G.SHARP, INC. "OVERVIEW OF REPORTS, ANALYSIS AND RECOMMENDATIONS REMAIN PROPULSION ENGINES M/V COLUMBIA" BY 07/26/83.

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-340A | <CONTINUED.......> | <N> | X | X | Q | Z | 02-340A |

(M/V COLUMBIA)

29) CRACKS IN CON ROD BOLTS AND BOX. CAUSE, BOLTHAS CRACKED AND THE THREADS FRET AGAINST THE BOX - BOLT CRACKING - BOLTS MUST BE TIGHT ENOUGHTO PREVENT MOVEMENT.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT TO G.E. TRUSSELL (TDI) FROM HAROLD V. SCHILLING (TDI) 05/07/82 (FILE NO. T-54)
(P.H.L.)

30) CRACKS IN CON ROD BOLTS AND CON ROD BOX. CAUSED BY LOOSE CON ROD BOLTS.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT NO. 0144DATED 04/29/82 (FILE NO. T-58)
(MEDAN-SUMATRA-INDONESIA)

31) CONNECTING ROD BOLTS - BEARING AND ROD BOX CRACKS - PROBABLE CAUSE IS LOW TORQUING VALVES.
SOURCE: NOS:
OTHER LETTER TO TDI FROM TOWN OF JONESBOROMAYOR J.P. GIMBERS 06/10/77 (FILE NO. T-55)
(TOWN OF JONESBORO)

32) ENG. S/N 79002 EXPLODED. NO. 3 CYL. CONNECTION ROD DAMAGED. ATTRIBUTED TO MULTIPLE HEAD GASKETS.
SOURCE: NOS:
OTHER RAFHA ELECTRICITY CO. & SUBURBS, SAUDI, CO. LTD., SAUDI ARABIA DATED 07/12/81. NO ADDRESSEE OR TRANSMITTAL LETTER AVAILABLE. NO. 3 GEN. (FILE NO. T-57)
(RAFHA, SAUDI ARABIA)

33) TOP 5 INCHES HAS DISCOLORED DUE TO HEAT. SETSCREW SUFFERED FATIGUE FAILURE AT LINE OF SHEAR BETWEEN BUSHING AND CON ROD.
SOURCE: NOS:
OTHER TELEX FROM SCHIMTZ (TDI) TO R. PRATT(TDI) DATED 10/21/82 (FILE NO. T-49)
(RAFHA/SAUDI ARABIA)

34) BROKEN CONROD BOLTS AND BOX, MASTER ROD AND CONROD SHELLS DAMAGED - EVIDENCE SUPPORTS LOW TORQUE - LOW BOLT FORCE WAS CAUSED BY INSTALLINGBOLT WASHER BACKWARDS.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT FROM HAROLD SCHILLING (TDI) TO ED DEANE 08/23/77 (FILE NO. T-56)
(TULIA, TEXAS)

35) CONNECTING ROD BOS AND BOLT FAILURE. CON-RODBOX WAS CAUSED BY INSUFFICIENT RIGIDITY OF CONROD ASSEMBLY.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT FROM HAROLD SCHILLING (TDI) TO ED DEANE (FILE NO.T-56) 06/14/77
(ANAMAX)

36) BROKEN CON ROD BOLTS. CAUSED BY BOLTS NOT TORQUED UP TO CORRECT VALVE.
SOURCE: NOS:
OTHER REPORT "INVESTIGATION OF CON ROD BEARING FAILURES MEDAN -TITI KUNING" BY ROBERT GRAY (FILE NO. T-49)
(TITI KUNING/INDONESIA)

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVH | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-340A | <CONTINUED.......> | <N> | X | X | Q | Z | 02-340A |

37) CON ROD LINK ROD BOXES BROKEN AND CON RODS HAVE BECOME UNUSABLE BECAUSE OF FRETTING.
SOURCE: NOS:
OTHER REPORT "INVESTIGATION OF CON ROD BEARING FAILURES MEDAN -TITI KUNING" BY ROBERT GRAY (FILE NO. T-49)
(TITI KUNING/INDONESIA)

38) VARIOUS REPORTS OF OUT OF ROUND RODS, NEW CON ROD BUSHINGS, ETC.
SOURCE: NOS:
OTHER CHRONOLOGICAL SUMMARY OF GLENCOE EVENTS - 4 PAGES - DATED 02/20/80. ENG. S/N 72052 (FILE NO. T-57)

39) LONGITUDINAL SPLIT ALONG THE OIL HOLE INITIATED IN FATIGUE FROM THE RODEYEBORE IN DSR-46 ENGINE IN GLENNALLEN, ALASKA, OPERATED BY COPPER VALLEY ELECTRICAL ASSOCIATION. (ADDED 07/18/84)
SOURCE: NOS:
OTHER FAA REPORT NO. 84-3-13 "DESIGN REVIEW OF CONNECTING RODS OF TSI INLINE DSR-48 EMERGENCY DIESEL GENERATORS," JUNE 1984. FAILURE ANALYSIS REPORT-DELAVAL ENGINE & COMPRESSOR DIVISION-FOR GLENNALLEN, ALASKA, NOVEMBER 6, 1978

40) REPLACED #6 AND #10 CONNECTING RODS WITH NEW CON RODS DUE TO EXCESSIVE FRETTING AT BEARING FIT. (05/17/77) ENGINE NO. 18. (ADDED 08/24/84)
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMESTEAD , FL.) DATED 09/30/78 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

EXHIBIT 39

## COMPONENT DESIGN REVIEW
## TASK DESCRIPTION

CONNECTING ROD
PART NO. 03-340A

Classification A
Completion 3/20/84

PRIMARY FUNCTION: The connecting rod transmits engine firing forces from the pistons and piston pins through the rods to the crankshaft such that the reciprocating motion of the pistons induces rotation and output torque of the crankshaft.

FUNCTIONAL ATTRIBUTES:

1. The connecting rod must have sufficient column buckling strength and fatigue resistance to withstand cylinder firing forces and inertial loads.
2. In the RV engine design, the three oscillating bearings two (2) wrist pin bearings and one (1) link pin bearing and the rotating crank pin bearing all require support from the connecting rod. In the R-48 design, a single wrist and crank pin bearing are supported. The flexure of the rod must be such that bearings are not unacceptably distorted.
3. Passages within the rod must provide cooling and lubricating oil to the bearings and pistons.
4. Stress levels, both mean and alternating, must fall within the endurance limits for the material utilized.
5. In the RV design, the two bolted joints (link rod to link pin and master rod to link rod box) must maintain sufficient contact pressure. The R-48 design likewise requires sufficient clamping forces on the crank pin bearing cap.
6. The rod cap bolts must support the necessary preload without yielding, fracture or unacceptable thread distortion.

7. The wrist pin (or rod-eye) bushing must acceptably support the gas pressure and inertia forces transmitted by the pistons during the unique nuclear standby required starting cycle and normal operation.

SPECIFIED STANDARDS: None

EVALUATION:

1. Determine the service histories of the connecting rods. In particular, evaluate the two V-style connecting rods (the 1 $^{7}/_{8}$-inch bolt diameter connecting rod and the 1 $^{1}/_{2}$-inch bolt diameter rod) and the R-48 style connecting rod.
2. Incorporate firing load profile data for the crankshaft analysis and the results of the 13-inch diameter rod bearing analyses to produce a connecting rod static load profile, with the addition of inertia loads for a complete time-load map.
3. Evaluate the significance of possible rod bow as it affects bearing centerline angular misalignment.
4. Review and report on failure of connecting rod at Copper Valley Electric, Glenn Allen, Alaska.
5. Conduct journal orbit analysis of the wrist pin bearing.
6. Using examples of fractured rods to focus the area of investigation, develop finite element models of the 1 $^{7}/_{8}$-inch bolt diameter V-type rod, to define deformation and the possibility of crack initiation and propagation.
7. Evaluate the necessary preload and acceptable design requirements (yielding, thread distortion) of the rod cap bolts for the R-48 and RV designs.
8. Evaluate the loading, fabrication and installation requirements of the wrist pin (or rod-eye) bushing for acceptable nuclear standby service.
9. Perform a metallurgical examination of fractured connecting rods in FaAA possession.
10. Complete final report.

REVIEW TDI ANALYSIS:

1. Review any TDI stress analyses or strain gage testing of connecting rods.

INFORMATION REQUIRED:

1. Connecting rod, wrist pin bearing and cap bolt drawings.
2. Engine operating parameters (i.e., speed, firing pressure time history, etc.).
3. Component physical parameters (piston weight, connecting rod reciprocating and rotating weights, etc.).
4. TDI specified rod cap bolt torques and installation procedures.
5. TDI failure history of DSR-48 and DSRV connecting rods.
6. Bushing and connecting rod material specifications.

# PERRY NUCLEAR POWER PLANT
## NONCONFORMANCE REPORT

NO. 1523 REV. 4-78 (NTS-SP86)

| NCR NO. | REV. | SHT. | OF | ITEM IDENT NO. | ITEM NAME | QUANTITY | |
|---|---|---|---|---|---|---|---|
| OQC 11448 | 0 | 1 | | 1R43C001A | CON. RODS | TWO | HOLD TAG #1 & 2 |

1 ISSUED BY — NAME: MARK PALMER — INIT.: MRP — ORGANIZATION: OPERATIONAL QUALITY — DATE: 12 02

3 ITEM/MATERIAL — SOURCE: TRANSAMERICA DELAVAL — CURRENT STATUS: DISASSEMBLED — LOCATION: TURB #1 DIESEL LAYDOWN E6 64-7'

4 RESPONSIBLE ORGANIZATION — NAME: PROJECT ORGANIZATION — SPEC. NO.: SP- NTS — REV./ECN: —

5 NCR TYPE — CATEGORY: ☐ 1 (POSSIBLE SIGNIF) ☒ 2 (MAJOR) ☐ 3 (MINOR)
TYPE: ☒ (E) EQUIP./MAT'L. ☐ (I) INSTALLATION ☐ (P) PROGRAM

6 GOVERNING REQUIREMENT (INCLUDE ACCEPTANCE CRITERIA AND DOC'MT. NOS.) QR-03-02-340A Checklist 34 Item 3A
Eddy Current Exam for female threads in rod box.

7 DESCRIPTION OF NONCONFORMANCE — NC CODE 113 (RELATE TO LINE NO. 6) During the above referenced inspection by FAA the following was recognized: 1) Connecting Rod 6L, Hole #3 Rod box thread has slight galling. 2) Connecting Rod 8L Hole #2 and #3 Rod box thread has slight galling.

8 CAUSE OF NONCONFORMANCE — CAUSE CODE H05 Indeterminate/Unknown

EXHIBIT 40

PROPOSED DISPOSITION: ☐ SCRAP (1) ☐ REWORK (2) ☒ REPAIR (3) ☐ USE AS IS (4)

JUSTIFICATION: Conn Rod bolt holes shall be dressed using male thread chase to remove any loose material or sharp edges. The minor thread galling will not limit load carrying characteristics or bolt torquing.

STEPS TO PREVENT RECURRANCE: NTS-SP86 instructions for Conn Rod Bolt assembly includes cleaning and lubricating threads prior to assembly.

RESP. ORG. APPROVAL — ENG./CONST.: [signature] — QA/QC: — AIA: — DATE: 12 03 84

PNPP REVIEW BOARD — REVIEW REQ'D: ☒ YES ☐ NO — DECISION: ☒ ACCEPT ☐ REJECT
ENGINEER: T.S. Daugherty — DATE: 12/04/84 — QA/QC: [signature] Palmer — DATE: 12 04 84

DISPOSITION VERIFIED — NAME: — TITLE: — DATE:

DISTRIBUTION: 1 - DOCUMENT CENTER 2 - FOLLOW UP 3 - ORIGINATOR

Frank Palmer 11/14/84 NHA

PG. 34.F34.0 285-147

12/7/84

(NTS - 5786)

# PERRY NUCLEAR POWER PLANT
## NONCONFORMANCE REPORT

F.O. 1523 REV. 4-76

| NCR NO. | REV. | SHT. | OF | ITEM IDENT NO. | ITEM NAME | QUANTITY | HOLD TAGS |
|---|---|---|---|---|---|---|---|
| OQC 1,3540 | | 1 | 2 | SEE MPL | CONNECTING RODS | SEE MPL | 1 → 13 |

2 ISSUED BY — NAME: T. HARRISON — INIT: TH — ORGANIZATION: OPERATIONAL QUALITY — DATE: 11 13 ...

3 ITEM/MATERIAL — SOURCE: TRANSAMERICA DELAVAL — CURRENT STATUS: HOLD — LOCATION: TURBINE DECK #1 @ ELEV. 647'

4 RESPONSIBLE ORGANIZATION — NAME: PROJECT ORGANIZATION — SPEC. NO.: SP- N.T.S. — REV./ECN: ——

5 NCR TYPE — CATEGORY: ☐ 1 (POSSIBLE SIGNIF) ☐ 2 (MAJOR) ☒ 3 (MINOR)
TYPE: ☒ (E) EQUIP./MAT'L. ☐ (I) INSTALLATION ☐ (P) PROGRAM

6 GOVERNING REQUIREMENT — (INCLUDE ACCEPTANCE CRITERIA AND DOC'MT. NOS.) QR-03-02-340A

CKLST. QR-034 PARA: 8.A REV/0 WR' NTS-84-6617 & NTS-84-6618

7 DESCRIPTION OF NONCONFORMANCE — NC CODE 1,1,3 — (RELATE TO LINE NO. 6) FRETTING WAS FOUND ON THE RACK TEETH OF THE CONNECTING RODS DURING VISUAL INSPECTION. "SEE PHOTOGRAPHS" THE QUESTIONABLE AREAS APPEAR TO BE COSMETIC AND MINOR INDENTATIONS.

CAUSE OF NONCONFORMANCE — CAUSE CODE H,D,1 VENDOR SUPPLY PROBLEM.

EXHIBIT 41

PROPOSED DISPOSITION — ☐ SCRAP (1) ☒ REWORK (2) ☐ REPAIR (3) ☒ USE AS IS (4)

JUSTIFICATION: Conn Rod teeth do not show signs of fretting. All Rods are acceptable AS-IS. At time of Reassembly teeth may be polished with "Scotch-brite" if it is deemed appropriate.

10 STEPS TO PREVENT RECURRANCE — N/A This is an owners group inspection. Conn Rods do not show signs of excessive wear due to loose conn rod bolts. (aggravated)

| RESP. ORG. APPROVAL | ENG./CONST. | QA/QC | AIA | DATE |
|---|---|---|---|---|
| | [signature] | NA | NA | 12/... |

PNPP REVIEW BOARD — REVIEW REQ'D. ☒ YES ☐ NO — DECISION: ☒ ACCEPT ☐ REJECT

| ENGINEER | DATE | QA/QC | DATE |
|---|---|---|---|
| M. [signature] | 12-7-84 | Michael Mosco... | 12/7/8... |

| DISPOSITION VERIFIED | NAME | TITLE | DATE |
|---|---|---|---|
| | [signature] | ... Level II | 12/7/... |

COPY DISTRIBUTION: 1 - DOCUMENT CENTER 2 - FOLLOW UP 3 - ORIGINATOR

Perry Nuclear Power Plant
MPL ATTACHMENT FOR NRs and DRs

04/12/85
43

PG. 35 of 37 R85-1473

...75 REV. 8-81

| NCR | NO. | REV. | SHT. | OF | DESCRIPTION OF ITEMS |
|---|---|---|---|---|---|
| OQC | 1354 | 0 | 2 | | FRETTING ON RACK TEETH ON CONNECTING RODS |

| | MPL/BM NO. | TAG LOCATION | HOLD TAG | DEF. TAG | CONDITION CLEARED TAG REMOVED (SIG) | DATE |
|---|---|---|---|---|---|---|
| 1 | 1R43C0001A | | | | | |
| 2 | CYL.# 1L & 1R | TURBINE DECK UNIT 1 @ ELEV: 647' | 1 | | | |
| 3 | CYL.# 2L & 2R | ↓ | 2 | | | |
| 4 | CYL.# 3L & 3R | ↓ | 3 | | | |
| 5 | CYL.# 4L & 4R | ↓ | 4 | | | |
| 6 | CYL.# 5L & 5R | ↓ | 5 | | | |
| 7 | CYL.# 6L & 6R | ↓ | 6 | | | |
| 8 | CYL.# 7L & 7R | ↓ | 7 | | | |
| 9 | CYL.# 8L & 8R | ↓ | 8 | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |
| | | | | | | |
| 14 | 1R43C0001B | | | | | |
| 15 | CYL.# 1L & 1R | TURBINE DECK UNIT 1 @ ELEV: 647' | 9 | | | |
| 16 | CYL.# 2L & 2R | ↓ | 10 | | | |
| 17 | CYL.# 3L & 3R | ↓ | 11 | | | |
| 18 | CYL.# 6L & 6R | ↓ | 12 | | | |
| 19 | CYL.# 8L & 8R | ↓ | 13 | | | |
| 20 | | | | | | |
| 21 | | | | | | |
| 22 | | | | | | |
| 23 | | | | | | |
| 24 | | | | | | |
| 25 | | | | | | |
| | | | | | | |
| | | | | | | |

**Transamerica Delaval**

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

C85-1413

Attachment to
NCR 12QC-1354
Rev. 0 Pg. 1 of 2

Date: 12-7-84

To: Tony Pusateri

From: Travis Gilstrap

Subject: NR QQC 1354 Engines 75051/52

I have inspected the listed connecting rods for fretting on the rack teeth and found it to be mostly discoloration of the metal. I recommend that they be used as is or polished with scotch brite and solvent for a better appearance

Travis Gilstrap
TDI Service Rep

# Memo

Form C-1066-2 (R-1) 3/81

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|
| 03-340B | A | X | X | X | Z | 02-340B |

************************************************************************************

CONNECTING RODS - BEARING SHELLS

************************************************************************************

PERRY EXPERIENCE:
NONE

************************************************************************************

RECOMMENDED DESIGN REVIEW ATTRIBUTES:

1) VERIFY SIMILARITY TO GGNS. IF REQUIRED, PERFORM JOURNAL ORBIT ANALYSIS.

************************************************************************************

RECOMMENDED QUALITY REVALIDATION ATTRIBUTES:

1) PERFORM RT/LP OF BEARINGS (SAMPLE BASIS).

************************************************************************************

NUCLEAR INDUSTRY EXPERIENCE:

1) DIESEL TRIPPED DUE TO CHANGES IN OIL AND COOLANT TEMP. AND CRANKCASE PRESSURE CAUSED BY INITIAL FAILURE OF CONNECTING ROD BEARING.
SOURCE: NOS: MANUFACTURER:
LER HATCH 2, 366-82079, 820727 FAIRBANKS-MORSE
OTHER SER 67-82, SOER 83-1

2) CONROD BIG END BEARING FAILED. THE DOWEL PIN FIXING THE BEARING FAILED.
SOURCE: NOS: MANUFACTURER: TDI
OTHER MAANSHAN-SERVICE REPORT TPC NUCLEAR PLANT NO.3-DATED DEC. 9,1983 (FILE NO. T-45)

3) CONNECTING ROD BEARING SHELL DOWEL PIN HAS BROCKEN.
SOURCE: NOS: MANUFACTURER: TDI
OTHER MAANSHAN-SERVICE REPORT TPC NUCLEAR PLANT NO.3-DATED DEC. 9,1983 (FILE NO. T-45)

4) LUBE OIL PLUG ON CYL. NO. 1 HAS TORN FROMSIDE OF BUSHING. (ADDED 08/20/84)
SOURCE: NOS:
OTHER TDI CUSTOMER SERVICE REPORT BY C. OUHEHEAD DATED 08/29/82 (FILE NO.T-49)
(RAFHA/SAUDI ARABIA)

************************************************************************************

NON-NUCLEAR INDUSTRY EXPERIENCE:

1) CONNECTING ROD SHELLS WERE FOUND BADLY WORN OR UNFIT FOR FURTHER USE. DELAVAL ADVISED THAT CONNECTING ROD SHELL CRACKING ON COLUMBIA COULD HAVE RESULTED FROM BAD ALLOY MAKEUP BY THEIR VENDORS. (M/V "COLUMBIA")
SOURCE: NOS:

EXHIBIT 42

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-3408 | <CONTINUED.......> | <N> | X | X | X | Z | 02-3408 |

OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER MEMO FROM M.ZBINDEN TO R.WARD DATED 11/06/80. (MEETING)
OTHER LETTER FROM M.ZBINDEN (STATE OF ALASKA) TO D.MARTINI (TDI) DATED 03/19/79.
OTHER LETTER FROM M.ZBINDEN TO W.HUDSON DATED 02/02/79.

2) LETTER CONTAINS DRAWINGS OUTLINING CONNECTING RODS THAT HAD CRACKED BEARING SHELLS, DAMAGED BOLTS AND/OR THREADS. NEW TORQUE VALUES: LINK ROD TO PIN 1050 FT-LBS; NEW 1.5 IN ROD BOLTS 1700 FT-LBS; OLD ROD BOLTS 2600 FT-LBS; NEW ROD BOX OUT OF ROUNDNESS SPEC: 0.004 IN MAX.
(M/V "COLUMBIA")
SOURCE: NOS:
OTHER HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER MEMO FROM M.ZBINDEN TO FILE DATED 02/05/80.

3) LOST #8 ROD BEARING. (10/07/75) ENGINE NO. 18.
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMSTEAD, FL.) DATED 09/30/78 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

4) #6 CONNECTING ROD BEARING BROKE (01/10/77) ENGINE NO. 18.
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMSTEAD, FL.) DATED 09/30/78 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

5) #5, 7, & 10 CONNECTING ROD BEARINGS BROKEN. REPLACED ALL ROD BEARINGS WITH NEW STYLE BEARINGS. (04/05/76) ENGINE NO. 18.
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMSTEAD, FL.) DATED 09/30/78 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

6) (DELETED 08/24/84)

7) FIVE CONNECTING ROD BEARINGS BROKEN. ONE CON NECTING ROD BEARING ERODED (01/06/76-01/23/76) ENGINE NO. 19.
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMSTEAD, FL.) DATED 09/30/78 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

8) THE CONNECTING ROD BEARING BOX BABBITT SURFACES WERE COMPLERELY WIPED OFF AS A RESULT OF A CRANKSHAFT FAILURE THAT OCCURED DURING A LOW LUBE OIL PRESSURE ALARM.
SOURCE: NOS:
OTHER FAILURE ANALYSIS REPORT NO. 0135 DATED 12/10/80 (FILE NO. T-39)
(M/V GLENCOE MINNESOTA)

9) BROKEN CONNECTING ROD BEARING SHELLS (05/82) ENGINE NO. 19.
SOURCE: NOS:
OTHER INTEROFFICE MEMO FROM E.SIGRIST (TDI) TO G.E.TRUSSEL (TDI) DATED 11/08/82 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

10) CONNECTING ROD BEARING SHELL FAILURES-IN GENERAL.
SOURCE: NOS:
OTHER INTEROFFICE MEMO FROM E.SIGRIST (TDI) TO R.J.PABERS (TDI) DATED 11/01/82

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-340B | <CONTINUED.......> | <N> | X | X | X | Z | 02-340B |

(FILE NO. T-10)
OTHER LETTER FROM A.MUXO (CITY OF HOMESTEAD) TO C.S.MATHEWS AND R.J.BAZZINI (TDI) DATED 05/13/82 (FILE NO. T-10)
OTHER LETTER FROM A.MUXO (CITY OF HOMESTEAD) TO C.S.MATHEWS (TDI) DATED 10/13/82 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

11) CONROD BEARING SHELL ROTATED-CAUSE OF FAILURE WAS SHEARED DOWEL PIN-CRUSH AND SPREAD VALVES OUT OF SPEC.
SOURCE: NOS:
OTHER MEMO FROM H.V.SCHILLING (TDI) G.E.TRUSSELL (TDI) 01/04/82 (FILE #T-4)
(M/V UARK AFB)

12) BROKEN CONNECTING ROD BEARINGS ON UNIT #19.
SOURCE: NOS:
OTHER LETTER FROM R.PRATT (TDI) TO JOHN SMITH (CITY OF HOMESTEAD, FL.) DATED 06/17/82 (FILE NO. T-2)
OTHER TELEX FROM R.J.BAZZINI (TDI) TO C.MATHEWS (TDI) DATED 06/08/82 (FILE NO. T-2)
(M/V CITY OF HOMESTEAD, FL.)

13) CONNECTING ROD BEARING SHELLS ORIGNALLY INSTALLED FAILED AFTER SHORT PERIODS OF OPERATION. A NEW TYPE OF BEARING WAS INSTALLED AND LIKEWISE FAILED. A CONTINUING EFFORT TO DEVELOP ALTERNATE DESIGN CON-ROD BEARING SHELLS WAS BEGUN.
SOURCE: NOS:
OTHER LETTER FROM A.MUXO (CITY OF HOMESTEAD) TO C.S.MATHEWS AND R.J.BAZZINI (TDI) DATED 05/13/82 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

14) CONNECTING ROD SHELLS #10 UPPER & LOWER AND #9 UPPER HAD CRACK INDICATIONS. ALL CRACKS RESULTED FROM FRETTING IN THE CONNECTING ROD BORE.
SOURCE: NOS:
OTHER FAILURE ANALYSIS REPORT NO. 0116 DATED 09/25/78 (FILE NO. T-19)
(M/V HOMESTEAD, FL.)

15) CONNECTING ROD BOLTS & SHELLS FAILED AS A R ESULT OF LOW TORQUE PRELOAD CONDITIONS WHICH ALLOWED THE ASSEMBLY TO FLEX, JOINTS TO SEPERAT E AND PARTS TO FRET AND CRACK.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT NO. 012 7 DATED 01/07/80 (FILE NO. T-23)
(M/V COLUMBIA)

16) CONNECTING ROD BEARING SHELL FAILED WHILE E NGINE WAS OPERATING AT 2500 KW LOAD. FAILURE WAS ATTRIBUTED TO INADEQUATE STONING AND POLISH ING OF THE CRANK PIN SURFACE.
SOURCE: NOS:
OTHER FAILURE ANALYSIS REPORT NO. 0108 DA TED 11/14/77 (FILE NO. T-22)
(M/V TULIA, TEXAS)

17) CON ROD BEARING FAILURES CAUSED BY MOVEMENT BETWEEN THE MASTER ROD AND THE LINK ROD BOX.
SOURCE: NOS:
OTHER REPORT "INVESTIGATION OF CON ROD BEARING FAILURES MEDAN-TITI KUNING" BY ROBERT GRAY (FILE NO. T-49)
(TITI KUNING/INDONESIA)

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVH | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| 03-340B | <CONTINUED.......> | <N> | X | X | X | Z | 02-340B |

18) CON ROD BEARING SHEU FAILURES CAUSED BY RAPID BEARING WEAR FROM INADEQUATE OIL FILTRATION AND NON-RIGID BEARING HOUSING FROM LOOK BOLTS.
SOURCE: NOS:
OTHER TDI FAILURE ANALYSIS REPORT NO. 0144DATED 04/29/82 (FILE NO. T-58)
(MEDAN-SUMATRA-INDONESIA)

19) FAILED CONNECTION ROD BEARINGS.
SOURCE: NOS:
OTHER LETTER G.E. TRUSSELL (TDI) FROM JOHNSMITH (CITY OF HOMESTEAD) 06/14/77 (FILE # T-55)
(CITY OF HOMESTEAD, FLORIDA)

20) VARIOUS REPORTS OF BEARING SHELL FAILURES AND REPLACEMENTS.
SOURCE: NOS:
OTHER CHRONOLOGICAL SUMMARY OF GLENCOE EVENTS - 4 PAGES - DATED 02/20/80 ENG. S/N 72052. (FILE NO. T-57)

21) LUBE OIL PLUG ON CYL. NO. 1 HAS TORN OFF FROMSIDE OF BUSHING. (ADDED 08/20/84)
SOURCE: NOS:
OTHER TDI CUSTOMER SERVICE REPORT BY C. OUHEHAND DATED 8/29/82 (FILE NO. T-49)
(RAFHA/SAUDI ARABIA)

22) FAILURE-CONRAD BEARING SHELLS THAT TURNED DURING TEST STAND BREAK-IN RUNS. CAUSED BY BOHED HOBBING OF THE ROD AND BOX TEETH. LACK OF SHELL CRUSH COULD BE A SECONDARY CAUSE. RECOMMENDATIONS-INCREASE CRUSH ON THE BEARING SHELL. HOBS, ARBOR AND INGERSLL MILL PARTS HAVE BEEN CORRECTED AND NOW GIVE STRAIGHT TEETH ALIGNMENT. INCREASE TORQUE ON CONROD BOLTS. (ADDED 08/27/84)
SOURCE: NOS:
OTHER TDI (FAILURE ANALYSIS DEPT) NO. 131 DATED 07/11/80 (FILE NO. T-29)
(M/V TAIHAN)

RDD-1474 p 25 OF 34

EXHIBIT 43

PAQS ~~NOV 23 '84~~

(N/A)

RY NUCLEAR POWER PLANT
ONCONFORMANCE REPORT

NO. | REVIEWED BY | DATE | DAR #

NO.

| NCR NO. | REV. | SHT. | OF | ITEM IDENT NO. | ITEM NAME | QUANTITY | |
|---|---|---|---|---|---|---|---|
| OQC 101382 | 0 | 1 | 1 | 1RA3.C.000.1A | DIESEL | 16 | DT-1 THRU 16 |

2 ISSUED BY — NAME: GUY B. RAMEY — INIT.: GBR — ORGANIZATION: OQS — DATE: 11/21/84

3 ITEM/MATERIAL — SOURCE: Delaval — CURRENT STATUS: Dissassembled — LOCATION: ~~Turbine Bldg~~ Diesel Gen Bldg 620' EL.

4 RESPONSIBLE ORGANIZATION — NAME: Project Organization — SPEC. NO. SP- N.T.S. — REV./ECN: —

5 NCR TYPE — CATEGORY: ☐ 1 (POSSIBLE SIGNIF) ☑ 2 (MAJOR) ☐ 3 (MINOR)
TYPE ☑ (E) EQUIP./MAT'L. ☐ (I) INSTALLATION ☐ (P) PROGRAM

6 GOVERNING REQUIREMENT (INCLUDE ACCEPTANCE CRITERIA AND DOC'MT. NOS.) DIESEL Revalidation CheckList no# QR035 ITEM 2a: NO Scoring or Galling ~~are~~ Acceptable.

7 DESCRIPTION OF NONCONFORMANCE — NC CODE 1.1.3 (RELATE TO LINE NO. 6) Scoring and or Galling on Connecting Rod bearing shells

FOR INFORMATION ONLY

CAUSE OF NONCONFORMANCE — CAUSE CODE E09 Scoring and Galling Due to Wear

PROPOSED DISPOSITION ☐ SCRAP (1) ☐ REWORK (2) ☐ REPAIR (3) ☒ USE AS IS (4)

JUSTIFICATION: Bearing shell babbit is Acceptable for use and is typical of bearings on an engine which is not fully broken in (Run 12-15 hrs on the Test stand). Bearing shells are being Radiographed L.P.'ed and Eddy Current inspected, per Owners Group Recommendations. This will ultimately determine if the bearings will be used on the engines. Any failures will be written up on a new NCR.

10 STEPS TO PREVENT RECURRANCE
N/A Bearings are not non-conforming, they meet Vendor Recommendations (See Attached Memo)

RESP. ORG. APPROVAL — ENG./CONST.: [signature] — QA/QC — AIA — DATE: 11/30/84

PNPP REVIEW BOARD — REVIEW REQ'D. ☒ YES ☐ NO — DECISION: ☑ ACCEPT ☐ REJECT
ENGINEER: [signature] — DATE: 11-30-84 — QA/QC: [signature] — DATE: 11/30/84

DISPOSITION VERIFIED — NAME: [signature] — TITLE: 11/30/84 QE — DATE: 11/30/84

COPY DISTRIBUTION: 1 - DOCUMENT CENTER 2 - FOLLOW UP 3 - ORIGINATOR

REVIEWED FOR 10CFR50.55 (e) AND 10CFR21 REPORTABILITY.
[signature] 12/6/84 N/A
REVIEWED BY DATE DAR #

NO. 1523 REV. 4-76

# PERRY NUCLEAR POWER PLANT
# NONCONFORMANCE REPORT

(NTS - SP86)

| LINE NO. | | | | | |
|---|---|---|---|---|---|
| 1 | NCR NO.: OQC 14860 | REV.: 0 SHT.: 1 OF 1 | ITEM IDENT NO.: 1R43C001A | ITEM NAME: BEARINGS | QUANTITY: 16 HOLD TAGS: 1-16 |
| 2 | ISSUED BY | NAME: GAYTON [signature] 12-6-84 | INIT.: G.E.G | ORGANIZATION: OPERATIONAL QUALITY | DATE: 12/0... |
| 3 | ITEM/MATERIAL | SOURCE: TDI | CURRENT STATUS: HOLD | LOCATION: TURBINE BLDG 1 | |
| 4 | RESPONSIBLE ORGANIZATION | NAME: PROJECT ORGANIZATION - NTS | SPEC. NO.: SP- NTS | REV/... : - | |
| 5 | NCR TYPE | CATEGORY: ☐ 1 (POSSIBLE SIGNIF) ☑ 2 (MAJOR) ☐ 3 (MINOR) | TYPE: ☑ (E) EQUIP./MAT'L. ☐ (I) INSTALLATION ☐ (P) PROGRAM | | |

6 GOVERNING REQUIREMENT (INCLUDE ACCEPTANCE CRITERIA AND DOC'MT. NOS.) OWNER'S GROUP TASK DESCRIPTION NO. CEI OR-03-02-340B, INSPECTION PLAN OR-035 + PT Procedure NDE-NQADI-941 Rev...

7 DESCRIPTION OF NONCONFORMANCE NC CODE 1.1.3 (RELATE TO LINE NO. 6) DIV-I CON-ROD Bearing SHells contain Linear indications. SHells # 1R-1A, 1L-1A, 2I-1A, 2II-1A, 3L-1A, 3R-1A, 4L-1A, 4R-1A, 5I-1A, 5II-1A, 6R-1A, 6L-1A, 7R-1A, 7L-1A, 8I-1A, + 8II-1A Bearing SHELLS, in addition, do ~~es~~ [initials] 12-6-84 not meet visual acceptance criteria. (evidence of scoring or Galling)

8 CAUSE OF NONCONFORMANCE CAUSE CODE E09 WEAR/ABRASION/EROSION

INFORMATION ONLY

9 PROPOSED DISPOSITION ☐ SCRAP (1) ☐ REWORK (2) ☐ REPAIR (3) ☒ USE AS IS (4)

JUSTIFICATION: Visual and P.T. inspection of each bearing was performed to determine acceptability of the bearings. The P.T. was performed to help identify indications found during Radiograph and eddy current testing. Collectively the P.T., R.T., and E.T. were used to (continued)

10 STEPS TO PREVENT RECURRANCE N/A All bearings are being inspected. This is not a Nonconforming Condition.

| | | | | |
|---|---|---|---|---|
| 11 RESP. ORG. APPROVAL | ENG./CONST.: [signature] | QA/QC: NA | AIA: NA | DATE: 12/0... |
| 12 PNPP REVIEW BOARD | REVIEW REQ'D. ☒ YES ☐ NO — ENG.: [signature] DATE: 12-7-84 | DECISION: ☒ ACCEPT ☐ REJECT — QA/QC: Michael Massner | | DATE: 12/0... |
| 13 DISPOSITION VERIFIED | NAME: Michael Massner | TITLE: Quality Engineer | | DATE: 12/0... |

COPY DISTRIBUTION: 1 - DOCUMENT CENTER 2 - FOLLOW UP 3 - ORIGINATOR

Attachment to
NCR OQC - 1486
Rev. 0 Pg. 1 of 2

Justification continued:

determine acceptability of the bearing shell from a structural standpoint. NCR OQC-1449 was written on those shell which failed that series of testing.

A Visual examination of the bearing shell babbited surface was performed by the TDI service rep. and all conn rod bearings were found to be acceptable. (See Attached Memo)

INFORMATION ONLY

[illegible] OF [illegible]

NCR 0QC-1486

Rev. 0 Pg. 2 of

DATE: 11-28-84

TO: Tony Pusatori

FROM: Travis Halstrap

SUBJECT: Bearings

DELAVAL

75051/54

A Transamerica Company

MEMO

DELAVAL
ENGINE AND COMPRESSOR DIV
INTER-OFFICE CORRESPONDENCE

Attachment to
NCR 0QC-1382
Rev. 0 Pg. 1 of 1

Tony

The bearings used by TDI are machined aluminum with a babbitt coating. The babbit alloy consist of tin with ant[illegible] and copper used as an antifriction for the bearings. The alloy is not smooth in appearance and can feel rough [illegible] the touch.

I have looked at the main and connecting rod bearings. they have the normal appearance and I have found them to be in good condition. The babbit will eventually smooth in after the engines are broke in

Travis Halstrap
TDI Service Rep

INFORMATION ONLY

EXHIBIT 44



PNPP NO. 6287

# QUALITY ASSURANCE CHECKLIST

PERRY NUCLEAR POWER PLANT

CHECKLIST NO. QR 008

REVISION 0

SHEET 1 OF 2

☑ INSPECTION ☐ DOCUMENT REVIEW ☐ WORK PKG. REVIEW ☐

☐ ELECTRICAL ☐ CIVIL/STRUCTURAL ☑ MECHANICAL, NDE ☐ I & C ☐ ADMINISTRATIVE ☐ TEST

PREPARED BY Frank Palmer

APPROVED BY [signatures]

DATE 10/31/84

| ITEM | TITLE Base & Bearing Caps - Base Assembly DIV 1 | SAT | UNSAT |
|---|---|---|---|
| 1. | Assemble and review existing documentation. * SEE REV 1 TO THIS ITEM (initials 1/21/85) | | |
| 1A | Verify that vendor documentation has been reviewed and accepted. Reference PY-GAI/CEI QA. Attach document summary sheet. | N/A* | |
| 1B | Verify that contractor installation documentation has been reviewed and accepted by Construction Quality Section. Reference document disposition letter PY-S/CON QA. | N/A* | |
| 1C | Attach a summary of applicable Nonconformance Reports, Deficiency Reports, Field Questions, Engineering Change Notices, Field Variance Authorizations, and Deviation Analysis Reports. For each document, provide a brief description and indicate current status. | N/A* | |
| 2. | Liquid Penetrant Examination of Base, visual examination of base | | |
| 2A. | Perform a Liquid Penetrant examination of the base, #5 main bearing saddle area (area as indicated on attached sketch), per NQADI 0941. Record all linear indications, or evidence of excessive wear such as fretting, erosion, or corrosion. Acceptability to be determined by the Owners Group. Attach examination reports. Supplement with photographs. * RIGHT SIDE / LEFT SIDE | LINEAR / ✓ | ROUNDED (?) |
| 2B. | Perform a visual examination of #5 cap mating surface on base. An acceptable condition is no evidence of fretting. Detail below. Appears to be surface markings. * ACCEPTABLE BY ENGINEERING [signature] 12/12/84. THE INDICATION IS CONSIDERED AS ~~[illegible]~~ NON-RELEVANT. [signature] | ✓ [signature] 12-12-84 | |

[Stamps: VERIFIED PNPP-003]

PERFORMED BY [signature] 12-26-84 | DATE | APPROVED BY [signature] * item 1 | DATE 0/1/31/85

PNPP NO. 6096 The Cleveland Electric Illuminating Company PERRY NUCLEAR POWER PLANT R85-1448 p.5 of 5

# PT/MT/VE EXAMINATION REPORT

Date 12-7-84 W.O. No. N/A Report No. NDE-0045-DLE Page 1 of 1

System/~~MPL~~ #5 main bearing mating surface ISO/Dwg. No. N/A

| | |
|---|---|
| PT/MT/VE Procedure NQADI-0941 Rev. 0 | Acceptance Standard |
| Surface Temp. 68 °F | ASME III ___ ASME VIII ___ |
| Therm. S/N J-84-07 Cal. Date 1-7-85 | ASME XI ___ ANSI B31.1 ___ |
| Corrective Action Documents Initiated: | AWS D.1.1 ___ |
| | Other: QR-008 #5 Main bearing |

| LIQUID PENETRANT | MAGNETIC PARTICLE |
|---|---|
| Cleaner Batch No. 84H018 | Batch/Lot No. |
| Penetrant Batch No. 84E029 | Particle: Wet ___ Dry ___ |
| Developer Batch No. 84D081 | Color |
| Visible ✓ Fluorescent ___ | Visible ___ Fluorescent ___ |
| Black Light Intensity N/A µM/cm² | Black Light Intensity ___ µM/cm² |
| | Instrument: Method |
| | Current |
| | Machine No. |

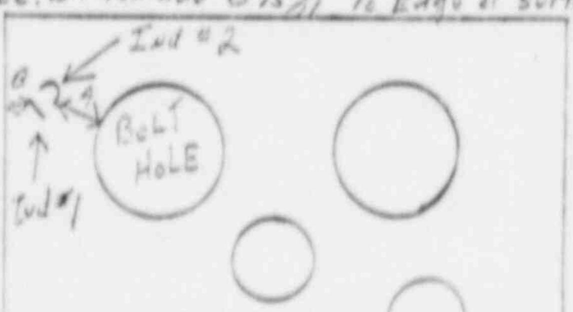
| Item/Weld No. | A | R | Remarks/Indications |
|---|---|---|---|
| #5 Main bearing base | | ✓ | RT. Bank Room #5 2 Indications* |
| #5 Main bearing base | ✓ | | Left Bank Room #5 |
| | | | |
| | | | |
| | | | |
| | | | |

[signature] / [signature] 12/10/84
Examined By Level II Date

[signature] 12/10/84
Reviewed By Date

Distribution: QRF (Original)

Sketch (If necessary) *
Two Linear indications noted, #1 is 1/8", #2 is 1/4" Half Circle. Dimension A is 2 1/2" from Ind. to Bolt Hole. Dimension B is 1/4" to Edge of surface.




NOTE
DO NOT USE CORRECTION FLUID OR TAPE. LINE OUT AND INITIAL CHANGES USING REPRODUCIBLE PEN.

388/D/2/rm

EXHIBIT 45

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| MP-017 | <CONTINUED.......> | <I> | X | X | Ø | Z | MP022/3 |

26) DURING SURVEILLANCE TEST, DG-1A WAS STARTED AND SUCCESSFULLY LOADED TO CARRY FULL EMERGENCY LOAD. DURING LOADING IT TO FULL DESIGN LOAD, SMOKE BEGAN ISSUING FROM THE 1A2 DIESEL TURBOCHARGER. THE DIESEL WAS IMMEDIATELY STOPPED. THE DAMAGED UNIT WAS BEING ANALYZED BY THE VENDOR TO DETERMINE THE EXACT CAUSE OF FAILURE.
SOURCE: NOS: MANUFACTURER:
EPRI ST. LUCIE 1, 092677, DG 1A ELECTRO-MOTIVE DIV. OF GM

27) DURING PT, THE DG WOULD NOT LOAD OVER 2000KW. TURBOCHARGER SEIZED, REDUCING CAPACITY.
SOURCE: NOS: MANUFACTURER:
NPRDS ZION 1, 830131, HIT 62 COOPER-BESSMER

28) INTERNAL OIL FIRE IN TURBOCHARGER OF DG1-2 CAUSED IT TO OVERHEAT AFTER 23 HRS. OIL WAS COMING THRU LOWER CASING JOINT ON TURBO CAUSING A FIRE INTERNALLY.
SOURCE: NOS: MANUFACTURER:
NPRDS DAVIS BESSE 1, 800923, HIT 33 ELECTRO-MOTIVE DIV. OF GM

29) REMOVE TURBOCHARGE TO CHECK FOR DAMAGE MADE BY LOOSE BOLT FRAGMENT FOUND IN CRANKCASE. - SHEARED OFF 5/8 BOLT FOUND.
SOURCE: NOS: MANUFACTURER:
NPRDS DAVIS BESSE 1, 800904, HIT 23 ELECTRO-MOTIVE DIV. OF GM

30) TURBOCHARGER REMOVED FROM DG1-1 BECAUSE OF NOISE; INSTALLED NEW TURBOCHARGER.
SOURCE: NOS: MANUFACTURER:
NPRDS DAVIS BESSE 1, 810414, HIT 25 ELECTRO-MOTIVE DIV. OF GM

31) OVER A PERIOD OF TIME, DIESEL SUBJECT TO BROKEN STAY RODS AND CRACKED BASE METAL IN INTERCOOLER, CRACKED WELDS ON TURBOCHARGER JACKET WATER PIPE, CRACKED METAL ON AIR HEADER FLANGE. PROBLEMS POSSIBLY DUE TO FAULTY TURBOCHARGER CAUSING EXCESSIVE VIBRATION, EVEN THOUGH NO INDICATION OF HIGH VIBRATIONS FROM VIBRATION SENSORS.
SOURCE: NOS: MANUFACTURER:
OTHER GRAND GULF REPORT NO. 83-024, 10/22/83. TDI

32) OIL LEAK UNDER AIR INLET TO TURBOCHARGER. CAUSE - DEFECTIVE TURBOCHARGER.
SOURCE: NOS: MANUFACTURER:
NPRDS AIK NUC GHE-1, 780715, HIT 118 ELECTRO-MOTIVE DIV OF GM

33) TWO TURBOCHARGERS WERE REPLACED DUE TO BROKEN STATIONARY NOZZLE RING VANES ON TDI 8 CYLINDER ENGINES AT KUOSHENG, TAIWAN.
SOURCE: NOS: MANUFACTURER:
OTHER TELEX FROM PEI TO LILCO 11/28/83 TDI

34) OPERATORS NOTED THAT AFTER 15 MIN OF OPERATION THE OUTPUT POWER BECAME ERRATIC AND EXHAUST TEMPS WERE INDICATING HIGH. CAUSE - TURBOCHARGER HAD CAME IN CONTACT WITH THE TURBINE SEVERELY DAMAGING BOTH.
SOURCE: NOS: MANUFACTURER:
NPRDS PEACH BOTTOM 2, 830907, HIT 180 FAIRBANKS-MORSE

35) DURING TEST, DG 1-1 WAS MAKING UNUSUAL NOISES. DG 1-1 WAS DECLARED INOPERABLE AT 1245 HOURS. TURBOCHARGER WAS REPLACED AND DG 1-1 DECLARED OPERABLE FROM 121078 AT 1420 HOURS. DG 1-2 AND AC-OFF AVAILABLE AT ALL TIMES.
SOURCE: NOS: MANUFACTURER:

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| MP-017 | <CONTINUED.......> | <I> | X | X | 0 | Z | MP022/3 |

NPRDS HIT 22, HIT 89 ELECTRO-MOTIVE DIV OF GM
EPRI DAVIS-BEESE, 020878, DG 1-1

36) CLAVERT CLIFFS - 4/7/83 - DURING A ROUTINE INSPECTION OF INTAKE AIR CHECK VALVE ON DG, A SHEARED CHECK VALVE HOLDING PIN WAS FOUND AND THE CHECK VALVE WAS LOOSE. SIMILIAR CRACKS ON OTHER DIESEL CHECK VALVES WERE DISCOVERED IN 1982. CHECK VALVE DIVERTS AIR BETWEEN TURBOCHARGER AND INTERNAL AIR BLOWER. INTERNAL BAFFLES BETWEEN CHECK VALVES AND TURBOCHARGER MADE IT UNLIKELY TO HAVE PIECE OF CHECK VALVE ENTER TURBOCHARGER. FAIRBANKS MORSE MODEL 38TD81/8.
SOURCE: NOS: MANUFACTURER:
I&E NOTICE 83-51 FAIRBANKS-MORSE

37) GM IDENTIFIED POTENTIAL FAILURE MODE OF TURBOCHARGERS USED ON EMD DIESELS. PBS OCCURS IF ENGINE RECEIVES A REPEAT RAPID START WITHIN A MIN. OF 15 MIN. AND MAX. OF 3 HRS AFTER A SHUTDOWN, FROM A PREVIOUS RUN IN WHICH ENGINE REACHED FULL OP. TEMP. THIS CAUSES LACK OF PRIME LUBE OIL SYSTEM PRESSURE WHICH MAY RESULT IN ENGINE DAMAGE.
SOURCE: NOS: MANUFACTURER:
I&E CIRCULAR 79-12, 04/28/79 ELECTRO-MOTIVE DIV OF GM

38) WELD CORE PLUGS TO TURBOCHARGER CASING & INCREASE NUMBER OF BOLTS.
SOURCE: NOS:
TDI SIM 300

39) INFO-PROCEDURE FOR TURBOCHARGER BEARING REPLACEMENT.
SOURCE: NOS:
TDI SIM 269

40) TWO NOZZLE VANES AT THE 4 O'CLOCK POSITION WERE BROKEN. NOZZLE RING WAS DAMAGED BEYOND REPAIR. POSSIBLY CAUSED BY UNEVEN EXPANSION OF MATERIAL AT HIGH EXHAUST TEMPERATURES OR TO MATERIAL DEFECTS DURING MANUFACTURING.
SOURCE: NOS: MANUFACTURER:
OTHER KUOSHEG 2) SERVICE REPORT ON DIV II STANDBY D/G TURBOCHARGER OF NO. 2 TDI
GENERATOR TPL NUCLEAR PLANT NO. 2 06/03/83. (FILE NO. T-45)

41) A TURBOCHARGER TO INTERCOOLER ADAPTOR CRACKED AT THE FLANGE WELD. CAUSED BY A MISALIGNMENT BETWEEN THE TWO COMPONENTS.
SOURCE: NOS: MANUFACTURER:
OTHER CATAWBA-REPORT "EXTENDED OPERATION TESTS AND INSPECTIONS OF DIESEL TDI
GENERATORS DATED 04/05/84 PG 7-3 (FILE NO. T.53)

42) TWO CYLINDER INJECTORS AND A WATER JACKET RELIEF DEVELOPED LEAKS ON #12 DIESEL GENERATOR. THE INJECTORS WERE REPLACED. THE RELIEF WAS REINSTALLED WITH NEW 'O' RING. DURING THIS CORRECTIVE MAINTENANCE, 8 AIR BLOWER DISCHARGE FLANGE BOLTS WERE DISCOVERED BROKEN. ALL 14 BOLTS AND THEIR INSERTS WERE REPLACED. (ADDED 08/30/84)
SOURCE: NOS: MANUFACTURER:
LER CAL. CLIFFS 1, 317-81070-1, 611008 FAIRBANKS-MORSE

****************************************************************************************

NON-NUCLEAR INDUSTRY EXPERIENCE:

1) THESE UNITS HAVE BEEN REMOVED, REPAIRED AND REINSTALLED OR RENEWED A TOTAL OF 16 TIMES FOR REASONS INCLUDING LEAKING OIL SEALS, VIBRATION, ABNORMAL NOISE, ACCUMULATION OF FOREIGN MATTER,

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| MP-017 | <CONTINUED.......> | <N> | X | X | O | Z | MP022/3 |

```
ROTOR DAMAGE AND A DEFECTIVE BEARING SEAL HOUSING. (M/V "COLUMBIA")
SOURCE:     NOS:
OTHER       HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER       LETTER-HR HUDSON TO D.H.MARTINI-12/14/76

2) A HOT SIDE BEARING AND SEALS ON ONE TURBOCHARGER REPLACED DUE TO EXCESSIVE WEAR.
(M/V "COLUMBIA")
SOURCE:     NOS:
OTHER       HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER       LETTER-M.E.ZBINDEN TO H.HUDSON-02/02/79
OTHER       LETTER-M.E.ZBINDEN TO D.MARTINI-03/19/79

3) ACTION TAKEN SINCE VESSEL DELIVERY-MODIFIED TURBOCHARGER NOZZLE RING DESIGN AND BOLTING
CONFIGURATION-NO TURBOCHARGER DAMAGE SINCE. CHANGED ORIGINAL TURBO WITH DEFECTIVE BEARING
SUPPORT HOUSING-NO PROBLEMS SINCE.  ADDED EXTERNAL TURBO AIR SEAL SYSTEM-NO PROBLEMS SINCE.
(M/V "COLUMBIA")
SOURCE:     NOS:
OTHER       HUNT & WILLIAMS (12/29/83) TO C.SEAMAN.
OTHER       LETTER TO TDI (D.MARTINI) DATED 03/24/80 FROM M.ZBINDEN (STATE OF ALASKA)

4) TURBOCHARGERS HAVE OPERATED IN EXCESS OF 4000 HOURS WITHOUT BREAKAGE OF NOZZLE RING SINCE
REVISING NOZZLE RING BOLTING CONFIGURATION. ALSO, NO ABNORMAL BUILDUP OF DEPOSITS OR NO OIL SEAL
LEAKAGE. (M/V "COLUMBIA")
SOURCE:     NOS:
OTHER       HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER       LETTER FROM M.ZBINDEN (STATE OF ALASKA) TO D.MCDAVIDSON (FERGUSON & BUNDELL) DATED
            07/25/80

5) A VOLUTE SECTION OF ONE TURBOCHARGER WAS FOUND CRACKED AND WAS REPLACED USING A SPARE.
(M/V "COLUMBIA")
SOURCE:     NOS:
OTHER       HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER       MEMO FROM M.ZBINDEN (STATE OF ALASKA) TO R.HARD DATED 03/13/81.

6) TDI SUGGESTS REPLACING ELLIOT TURBOS WITH DELAVAL C-17'S. (M/V "COLUMBIA")
SOURCE:     NOS:
OTHER       HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER       MEMO FROM S.SCHUMACHER (TDI) TO R.PRATT (07/09/82), PG. 2.

7) MODIFICATIONS MADE TO TURBOS-CHANGED NOZZLE RING OPENINGS-DID NOT CORRECT DEFICIENT MANIFOLD
AIR PRESSURE. (M/V "COLUMBIA")
SOURCE:     NOS:
OTHER       HUNT & WILLIAMS (12/29/83) TO C.SEAMAN
OTHER       MEMORANDUM FROM M.ZBINDEN (STATE OF ALASKA) TO R.LIND (DEPUTY COMMISSIONER),
            07/09/82, PG. 2

8) TURBOS GOING INTO SURGE-MAY BE DUE TO IMPROPERLY SIZED TURBOS IN RELATION TO THE ENGINE.
(M/V "COLUMBIA")
SOURCE:     NOS:
OTHER       SES REPORT NO. 123-01 DATED APRIL 1983, PG 2-23, 4-10

9) TURBOCHARGERS-LEAKING OIL/AIR SEALS, BEARINGS, NOZZLES, ROTORS/CRACKED CASINGS.
```

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| MP-017 | <CONTINUED.......> | <N> | X | X | O | Z | MP022/3 |

(M/V "COLUMBIA")
SOURCE: NOS:
OTHER SES REPORT NO. 123-01 DATED APRIL 1983, PG. 3-29

10) DESIGN DEFICIENCY-IF TURBOS FAIL, ENGINE MUST BE SHUTDOWN-OTHER ENGINES CAN BE RUN UNDER NORMAL ASPICATED CONDITIONS. (M/V "COLUMBIA")
SOURCE: NOS:
OTHER SES REPORT NO. 123-01 DATED APRIL 1983, PG 4-8

11) SERIOUS PROBLEMS WITH TURBOCHARGER SURGING.
SOURCE: NOS:
OTHER INTEROFFICE MEMO OF MEETING MINUTES FROM R.BAZZINI (TDI) TO A.BARICH, C.WINTER & C.MATHERS (TDI) DATED 11/10/83 (FILE NO. T-37)
(M/V PRIDE OF TEXAS)

12) TURBOCHARGER SEALS LEAKING OIL.
SOURCE: NOS:
OTHER LETTER FROM J.MCGLASHAN (TITAN NAVIGATION, INC.) TO R.PRATT, T.KEMP (TDI) DATED 08/16/83 (FILE NO. T-37)
OTHER INTEROFFICE MEMO FROM R.CRANE (TDI) TO R.PABERS (TDI) DATED 08/23/83 (FILE NO. T-37)
(M/V SPIRIT OF TEXAS)

13) (DELETED 08-08-84)

14) (DELETED 08-08-84)

15) (DELETED 08-08-84)

16) TWO TURBOS DAMAGED FROM LARGE PIPE PLUGS FALLING INTO INTERFERENCE WITH ROTATING ASSEMBLY. (11/18/77) ENGINE NO. 19
SOURCE: NOS:
OTHER ENGINE INCIDENCE REPORT (CITY OF HOMSTEAD, FL.) DATED 09/30/78 (FILE NO. T-10)
(M/V CITY OF HOMESTEAD, FL.)

17) SERIOUS WATER LEAK ON THE COOLING WATER OUT COUPLING ON THE TURBOCHARGER.
SOURCE: NOS:
OTHER LETTER FROM K.BUZEK (TDI) TO Y.AL-BASSAM (ELECTRICITY CORP) DATED 01/14/79 (FILE NO. T-49)
(M/V QURAYAT ELECTRIC/SAUDI ARABIA)

18) TURBOCHARGER COMPLETELY DESTROYED. DAMAGE WAS CAUSED BY PLANT PERSONNEL OVERFILLING THE INTAKE AIR FILTER WITH OIL. THIS WAS COMPLICATED BY THE FACT THAT THE REPLACEMENT OIL WAS DRAWN INTO THE SUCTION OF THE TURBOCHARGER WHICH CONSEQUENTLY DESTROYED ALL THE COMPRESSOR BLADES, BENT THE SHAFT AND CRACKED THE CASING.
SOURCE: NOS:
OTHER LETTER FROM K.BUZEK (TDI) TO U.AL-BASSAM (ELECTRICITY CORP) DATED 01/14/79 (FILE NO. T-49)
(M/V QURAYAT ELECTRIC/SAUDI ARABIA)

19) COAST GUARD HAS BEEN EXPERIENCING CRACKING PROBLEMS WITH THE SHEET METAL STYLE NOZZLE RINGS IN TURBOCHARGER. A NEW, SUPERIOR, PROFILE TYPE NOZZLE RING IS AVAILABLE.
SOURCE: NOS:

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|---|
| MP-017 | <CONTINUED.......> | <N> | X | X | O | Z | MP022/3 |

OTHER LETTER FROM R.E.LANE (USCG) TO G.E.TRUSSELL (TDI) DATED 08/07/79 (FILE NO. T- )
(M/V USCG NORTHWIND)

20) TURBOCHARGER CRACKED. FAILURE DUE TO MISALIGNMENT OF THE EXHAUST STACK.
SOURCE: NOS:
OTHER LETTER FROM R.DESRUMEAUX (TDI) TO L.MUNSON (HOLMES BROTHERS ENTERPRISES INC.)
DATED 01/16/80 (FILE NO. T-2)
(M/V USCG CUTTER NORTHWIND)

21) TURBOCHARGER CASING BADLY DAMAGED DUE TO INTENSE HEAT NECESSITATING A REPLACEMENT OF CASING.
CAUSE WAS INSTALLATION OF 3/4 AND 3/8 NPT SOCKET HEAD PLUGS IN TURBOCHARGER DURING AN OVERHAUL.
SOURCE: NOS:
OTHER LETTER FROM C.L.MUNSON (HOLMES BROTHERS ENTERPRISES, INC.) TO MR. STAUB (TDI)
DATED 12/13/79 (FILE NO. T-2)
(M/V USCG CUTTER NORTHWIND)

22) (DELETED 08/10/84)

22B) FAILURE ON BLOWER SIDE OF TURBOCHARGED DUE TO SOME PIECES OF THE BROKEN EXHAUST VALVE GUIDE
SOURCE: NOS:
OTHER FAILURE REPORT DATED 06/17/84 (FILE NO. T-49). (HAIL/SAUDI ARABIA)

23) (DELETED 08/10/84)

24) TURBOCHARGER FEET BROKEN BY DELAVAL SERVICE REPRESENTATIVE.
SOURCE: NOS:
OTHER TELEX FROM SCHMITZ (TDI) TO R. PRATT(TDI) DATED 10/30/82 (FILE NO. T-49)
(RAFHA/SAUDI ARABIA)

25) DAMAGED TURBOCHARGER ROTOR & DIAPHRAGM - DAMAGED BY VALVE SPRING FAILURE.
SOURCE: NOS:
OTHER TELEX FROM SCHMITZ (TDI) TO R. PRATT(TDI) DATED 06/14/83 (FILE NO. T-29)
(RABIGH ELECTRIC/SAUDI ARABIA)

P. O. BOX 33189

# DUKE POWER COMPANY

GENERAL OFFICES
422 SOUTH CHURCH STREET
CHARLOTTE, N. C. 28242

TELEPHONE: AREA 704
373-4011


November 14, 1984

OGTP-528-0-325

EXHIBIT 46

Ms. Linda Routzahn
Cleveland Electric Illuminating
Perry Nuclear Station
P.O. Box 97
Perry, OH 44081

Re: TDI Diesel Generator Owners Group
TER 99-024, Component # MP-022/3
File No: MTS-4086

Dear Ms. Routzahn:

There have been reported cases where the core plug (hubnut) in the center of the turbocharger nozzle ring worked loose and damaged the turbocharger. Service Information Memo (SIM) # 300 (part A) was issued. Liquid Penetrant (LP) Examination at the Shoreham Nuclear Power Station found that these welds had cracked, therefore, the following inspection has been recommended by the Owners Group. Verify that SIM #300 was implemented and perform an L.P. Inspection of the welds retaining the nut.

Also in addition to the weld inspection, verify if the nut is staked.

If you have any questions, please do not hesitate to contact Gary Ghika at (704) 373-4098.

C. L. Ray, Jr.

C. L. Ray, Jr.
Technical Program Director
TDI Diesel Generator Owners Group

CLR/GDG/yds

cc: J. Kammeyer, V. Saleta, A. P. Cobb, Jr., Job Book 8, R. Bonsall, M. Curry, G. Ghika

EXHIBIT 47

RBS-1442 Sheet 24 of

(SP 582)

N/A

PERRY NUCLEAR POWER PLANT

NONCONFORMANCE REPORT

NO. 1523 REV. 4-78

| LINE NO. | | | |
|---|---|---|---|
| 1 | NCR NO.: OQC14140 REV.: 0 SHT.: 1 OF 1 | ITEM IDENT NO.: 1R43C001AR | ITEM NAME: TURBO / QUANTITY: ONE / DEFF TAG #1 |
| 2 | ISSUED BY — NAME: MARK PALMER | INIT.: MRP | ORGANIZATION: OPERATIONAL QUALITY / DATE: 11 28 84 |
| 3 | ITEM/MATERIAL — SOURCE: TRANSAMERICA DELAVAL | CURRENT STATUS: DISASSEMBLED | LOCAT: 1RP TURB DECK #1 EL 620 647' |
| 4 | RESPONSIBLE ORGANIZATION — NAME: PROJECT ORGANIZATION | SPEC. NO.: SP- NTS | REV./ECN.: — |
| 5 | NCR TYPE — CATEGORY: ☐ 1 (POSSIBLE SIGNIF) ☒ 2 (MAJOR) ☐ 3 (MINOR) | TYPE: ☒ (E) EQUIP./MAT'L. ☐ (I) INSTALLATION ☐ (P) PROGRAM | |
| 6 | GOVERNING REQUIREMENT (INCLUDE ACCEPTANCE CRITERIA AND DOC'MT. NOS.) | REVALIDATION INSPECTION QR-03-02-MP022/3 DELAVAL TDI DIESEL TURBOCHARGER DIV I RIGHT | |
| 7 | DESCRIPTION OF NONCONFORMANCE — NC CODE: 113 (RELATE TO LINE NO. 6) | DURING REVALIDATION INSPECTION OF THE TURBOCHARGER THE FOLLOWING WAS NOTED; 1) IMPELLER INDUCER ASSEMBLY HAS NICKS ON THE INDUCER VANES. 2) THRUST COLLAR HAS LIGHT SCORES ON THE FACE AND SEAL AREA. 3) SHAFT SHOWS SIGNS OF WEAR, 4) DISK ASSEMBLY HAS LIGHT RUB ON LABY SEALS AND HEAVY RUB ON ONE HALF OF DISK BUCKET | |
| 8 | CAUSE OF NONCONFORMANCE — CAUSE CODE: H01 | VENDOR SUPPLIED UNIT IN THIS CONDITION DAMAGE APPEARED TO BE CAUSED AT SHOP RUN/TEST. | |
| 9 | PROPOSED DISPOSITION | ☒ SCRAP (1) ~~☒~~ REWORK (2) ABP 11/29/84 ~~☒~~ REPAIR (3) ABP 11/29/84 ☐ USE AS IS (4) | |
| | JUSTIFICATION: | See Attachment sheets Parts are to be returned to vendor for repairs. | |
| 10 | STEPS TO PREVENT RECURRANCE | Vendor supply problems. Site procedures reflect cleanliness requirements required to avoid turbo damage. | |
| 11 | RESP. ORG. APPROVAL — ENG./CONST.: [signature] | QA/QC: / A/A: | DATE: 11 29 84 |
| 12 | PNPP REVIEW BOARD — REVIEW REQ'D.: ☒ YES ☐ NO; DECISION: ☒ ACCEPT ☐ REJECT | ENGINEER: [signature] DATE: 11-29-84 | QA/QC: [signature] [signature] / DATE: 11 29 84 |
| 13 | DISPOSITION VERIFIED — NAME: | TITLE: | DATE: |

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EXHIBIT 48

RY NUCLEAR POWER PLANT
ONCONFORMANCE REPORT

(NTS-SP8C)

| | NCR NO. | REV. | SHT. | OF | ITEM IDENT NO. | ITEM NAME | QUANTITY | |
|---|---|---|---|---|---|---|---|---|
| | OQC 1,5,1,20 | | 1 | 1 | 1,R43,C,001,B | TURBO, LFT | ONE | DEFICIENCY TAG #1 |
| 2 | ISSUED BY | NAME Mark Palmer | | | INIT. MRP | ORGANIZATION OPERATIONAL QUALITY | | DATE 1,2,1,1,8,4 |
| 3 | ITEM/MATERIAL | SOURCE TRANSAMERICA DELAVAL | | | CURRENT STATUS DISASSEMBLED | | LOCATION DGB ROOM 7 EL 620 | |
| 4 | RESPONSIBLE ORGANIZATION | NAME PROJECT ORGANIZATION | | | | | SPEC. NO. SP- NTS | REV./ECN. — |
| 5 | NCR TYPE | CATEGORY: ☐ 1 (POSSIBLE SIGNIF) ☒ 2 (MAJOR) ☐ 3 (MINOR) | | | | | | |
| | | TYPE: ☒ (E) EQUIP./MAT'L. ☐ (I) INSTALLATION ☐ (P) PROGRAM | | | | | | |
| 6 | GOVERNING REQUIREMENT | (INCLUDE ACCEPTANCE CRITERIA AND DOC'MT. NOS.) TWP-M-~~84~~ 375 | | | | | | |

Section 5.2 Turbocharger mounting QR-03-MP022/3 Checklist # 002

7 DESCRIPTION OF NONCONFORMANCE — NC CODE 1,13 (RELATE TO LINE NO. 6)

During the reinstallation of the Div 2 left bank turbocharger on the above referenced document and section: The turbocharger mounting bracket bolt holes are aprox 1/8" offset in order to provide a good alignment on the inlet and outlet flanges.

CAUSE OF NONCONFORMANCE — CAUSE CODE 1,0,1

Vendor supply problem, Flanges apparently cold sprung during manfactures assembly.

INFORMATION ONLY

9 PROPOSED DISPOSITION: ☐ SCRAP (1) ☐ REWORK (2) ☒ REPAIR (3) ☐ USE AS IS (4)

JUSTIFICATION: Slot or oversize mounting base bolt holes (Not Turbo holes) a MAX. of ~~3/16~~ 1/8". Use a 5/16" thick hardened steel washer on each bolt used on the oversized holes. Per telephone conversation with Service Rep and Engineer. See Memo.

10 STEPS TO PREVENT RECURRANCE: Vendor supply problem. All engines and turbos have already been supplied.

| | | | | | |
|---|---|---|---|---|---|
| 11 | RESP. ORG. APPROVAL | ENG./CONST. [signature] | QA/QC | AIA | DATE 1,2,1,2,8,4 |
| 12 | PNPP REVIEW BOARD | REVIEW REQ'D. ☒ YES ☐ NO | | DECISION: ☒ ACCEPT ☐ REJECT | |
| | | ENGINEER T S Daugherty | DATE 12/12/84 | QA/QC [signature] | DATE 1,2,1,2,8,4 |
| 13 | DISPOSITION VERIFIED | NAME | | TITLE | DATE |

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DATE: 12-4-84

TO: Tony Pusateri

FROM: Travis Gilstrap

SUBJECT: Elliott turbo's

DELAVAL

75051/54

A Transamerica Company

MEMO

DELAVAL
ENGINE AND COMPRESSOR DIVISION
INTER-OFFICE CORRESPONDENCE

Attachment to
NCR 0QC-1512
Rev. 0 Pg. 2 of 2

Tony
The spare Elliott turbochargers being installed on engine 75051 RMS will require the bottom 4 capscrew holes to be elongated approx. 1/4" to allow for fit up of the intercooler flange.
I have checked with TDI Oakland (Lee Duck) and this has been a common occurance to elongate these holes when there is the need to change out the turbochargers. As to telecon he does recommend that a harden steel washer be used with the capscrew 5/8" after elongation of holes.

Travis Gilstrap
TDI Service Rep.

INFORMATION ONLY

ENGINE REBUILD REPORT

Motor Vessel Columbia

Report in its Entirety found in BN-84-018

EXHIBIT 49

for

State of Alaska
Division of Marine Transportation
Department of Public Works

by

Jon O. Jacobson
6869 Woodlawn N.E.
Seattle, WA 98115

for

Todd Pacific Shipyards Corporation
1801 16th Avenue S.W.
Seattle, WA 98124

March 31, 1981

Tables 5 and 6 show the counterbore depth of the starboard engine has increased by .003 inch and .005 inch for the port engine severely compromising the ability of the engine to fix the liners in place.

A design feature of the counterbore and lip may preclude avoiding the problem. The force from the eight studs when torqued to 3600 ft-lbs must be borne on the .250 inch lip face producing a compressive stress in excess of 76,000 psi. This value is above the normal design limits for cast iron and, with the sharp interior corner, will be a source of recurring failure.

Section IV, Nondestructive Testing, discusses the failures observed. These failures led to the decision to replace the original blocks with new units. Because the design stresses were so high, there was no foreseeable way to prevent failures from occurring without a significant redesign of the liner-block landing surfaces.

# IV
# NONDESTRUCTIVE TESTING

The basic structural parts of the engine--the blocks and the bases--were examined by nondestructive testing. Testing began after presentation of a preliminary draft of the January 30, 1981 report.

## Blocks

The top surface of the blocks for both engines was tested. Data from ultrasound examination of the blocks are presented in Figures 12 and 13 (pp. IV-2 and IV-3) with details in Figures 14 and 15 (pp. IV-4 and IV-5).

Fractures seen most frequently were radial cracks extending out from the cylinder counterbore. The radial cracks were either in areas of stress concentrations caused by holes for cooling water passage or stud drillings, or in the inter-web area between cylinders in the center of the block. The most destructive type of fracture was seen in cylinders 2 and 3 of the left bank of the starboard engine. Figure 14 shows the form of the delamination crack where the cylinder liner lip was separating from the block structure. This fracture prevented the liner from being properly installed and could have led to a catastrophic engine failure.

The fracture was caused by the following:

1. high compressive stresses on the counterbore lip,
2. localized stress condition from the combinations of sharp internal corner for lip (1/32 inch radius),
3. nearby drilling for waterjacket or stud,
4. termination of stud threading at the same level,
5. creep deformation, and
6. fatigue.

Because of the delamination cracks, one block was not serviceable, and so both blocks for the starboard engine were renewed.

P O BOX 97 ■ PERRY, OHIO 44081 ■ TELEPHONE (216) 259-3737 ■ ADDRESS-10 CENTER ROAD

*Serving The Best Location in the Nation*
PERRY NUCLEAR POWER PLANT

July 23, 1984
PY/SO-26339

C. L. Ray Jr.
Technical Program Director
TDI Owner's Group
Duke Power Company
P.O. Box 33189
Charlotte, N.C. 28242

EXHIBIT 50

RE: Owner's Group Correspondence
OGTP-109-0-56

Dear Mr. Ray:

The above referenced letter requested information on the loading of our diesel generator engines. A study was recently completed by our consultant as to the expected loading of our engines. This study was not overly conservative and should meet the requirements of your request.

The division one engine (train A) of the first Perry unit will carry the heaviest load. Worst case considered in the loading study was a simultanious loss of offsite power (LOOP) and loss of coolant accident (LOCA). Listed below is the step loading with the time the load will be applied, total load on the engine at that time, plus the percentage of rated full load at each step.

Division I (Train A) Loading Summary

| Time when load is applied | Total load on unit in Kilowatts | Percent of load carried vs. nameplate rating |
|---|---|---|
| t = 0 | 1018 | 15 |
| t = 10 sec. | 3985 | 57 |
| t = 30 sec. | 3936 | 56 |
| t = 60 sec. | 3914 | 56 |
| t = 100 sec. | 4464 | 64 |
| t = 10 mins. | 4453 | 64 |
| t > 10 mins. | 4459 | 64 |

Notes: A.) t = 0 is at closure of generator output breaker.

B.) t > 10 mins. is considered long term loading.

I hope the above information is adequate for your efforts. If additional information is required please contact me at (216) 259-3737, ext. 5467.

Very truly yours,

E. C. Christiansen

E. C. Christiansen
Senior Electrical Construction Engineer

cc: G. R. Leidich
E. M. Root
W. E. Coleman
PO/DC - R290

EXHIBIT 51

DRAFT

SURVEILLANCE REQUIREMENTS

4.8.1.1.1 Each of the above required independent circuits between the offsite transmission network and the onsite Class 1E distribution system shall be:

a. Determined OPERABLE at least once per 7 days by verifying correct breaker alignments and indicated power availability, and

b. Demonstrated OPERABLE at least once per 18 months during shutdown by transferring unit power supply from the normal circuit to the alternate circuit.

4.8.1.1.2 Each of the above required diesel generators shall be demonstrated OPERABLE:

a. In accordance with the frequency specified in Table 4.8.1.1.2-1 on a STAGGERED TEST BASIS by:

1. Verifying the fuel level in the day and engine-mounted fuel tank.

2. Verifying the fuel level in the fuel storage tank.

3. Verifying the fuel transfer pump starts and transfers fuel from the storage system to the day fuel tank.

4. Verifying the diesel starts from ambient conditions and accelerates to at least 441 rpm for Div 1 and Div 2 and 882 rpm for Div 3 in less than or equal to 10 seconds.* The generator voltage and frequency shall be 4160 ± 420 volts and 60 ± 1.2 Hz within 10 seconds after the start signal. The diesel generator shall be started for this test by using one of the following signals:

   a) Manual.
   b) Simulated loss of offsite power by itself.
   c) Simulated loss of offsite power in conjunction with an ESF actuation test signal.
   d) An ESF actuation test signal by itself.

5. Verifying the diesel generator is synchronized, loaded to greater than or equal to 7000 kw for diesel generators Div 1 and Div 2 and 2600 kw for diesel generator Div 3 in less than or equal to 60 seconds,* and operates with this load for at least 60 minutes.

6. Verifying the diesel generator is aligned to provide standby power to the associated emergency busses.

*The diesel generator start (10 sec) and subsequent loading (60 sec) from ambient conditions shall be performed at least once per 184 days in these surveillance tests. All other engine starts and loading for the purpose of this surveillance testing are not required to meet the 10 sec and 60 sec fast start criteria and may be preceded by an engine prelube period and/or other warmup procedures recommended by the manufacturer so that mechanical stress and wear on the diesel engine is minimized.



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SURVEILLANCE REQUIREMENTS (Continued)

7. Verifying the pressure in all diesel generator air start receivers to be greater than or equal to 210 psig.

b. At least once per 31 days and after each operation of the diesel where the period of operation was greater than or equal to 1 hour by checking for and removing accumulated water from the day fuel tank.

c. At least once per 92 days by checking for and removing accumulated water from the fuel oil storage tanks.

d. At least once per 92 days and from new fuel oil prior to its addition to the storage tanks by verifying that a sample obtained in accordance with ASTM-D270-1975 meets the following minimum requirements in accordance with the tests specified in ASTM-D975-1977:

1) A water and sediment content of less than or equal to 0.05 volume percent;

2) A saybolt universal viscosity at 100°F of greater than or equal to 32.6 sus, but less than or equal to 40.1 sus;

3) An API gravity as specified by the manufacturer at 60°F of greater than or equal to 26 degrees but less than or equal to 36 degrees;

4) An impurity level of less than 2 mg of insolubles per 100 ml when tested in accordance with ASTM-D2274-70; analysis shall be completed within 7 days after obtaining the sample but may be performed after the addition of new fuel oil; and

5) The other properties specified in Table 1 of ASTM-D975-1977 and Regulatory Guide 1.137, Revision 1, October 1979, Position 2.a., when tested in accordance with ASTM-D975-1977; analysis shall be completed within 14 days after obtaining the sample but may be performed after the addition of new fuel oil.

e. At least once per 18 months, during shutdown, by:

1. Subjecting the diesel to an inspection in accordance with instructions prepared in conjunction with its manufacturer's recommendations for this class of standby service.

2. Verifying the diesel generator capability to reject a load of greater than or equal to 1400 kw (LPCS pump) for diesel generator Div 1, greater than or equal to 725 kw (RHR B pump or RHR C pump) for diesel generator Div 2, and greater than or equal to 2200 kw (HPCS pump) for diesel generator Div 3 while maintaining voltage at 4160 ± 420 volts and speed plus 75% of the difference between nominal speed and the overspeed trip setpoint or 15% above nominal, whichever is less.



JAN 30 1985

DRAFT



2) Verifying the diesel generator starts on the auto-start signal, energizes the emergency busses with permanently connected loads within 10 seconds, energizes the auto-connected emergency loads through the load sequencer and operates for greater than or equal to 5 minutes while its generator is loaded with the emergency loads. After energization, the steady state voltage and frequency of the emergency busses shall be maintained at 4160 ± 420 volts and 60 ± 1.2 Hz during this test.

b) For division 3:

1) Verifying de-energization of the emergency bus.

2) Verifying the diesel generator starts on the auto-start signal, energizes the emergency bus with its loads and the auto-connected emergency loads within 10 seconds and operates for greater than or equal to 5 minutes while its generator is loaded with the emergency loads. After energization, the steady state voltage and frequency of the emergency bus shall be maintained at 4160 ± 420 volts and 60 ± 1.2 Hz during this test.

7. Verifying that all automatic diesel generator trips are automatically bypassed with an ECCS actuation signal except:

a) For divisions 1 and 2, engine overspeed and generator differential current.

b) For division 3, engine overspeed and generator differential current.

8. Verifying the diesel generator operates for at least 24 hours. During this test, the diesel generator shall be loaded to 7000 kw for diesel generator Div 1 and Div 2 and 2600 kw for diesel generator Div 3. The generator voltage and frequency shall be 4160 ± 420 volts and 60 ± 1.2 Hz within 10 seconds after the start signal; the steady state generator voltage and frequency shall be maintained within these limits during this test. Within 5 minutes after completing this 24-hour test, perform Surveillance Requirement 4.8.1.1.2.e.4.a)2) and b)2)*.

*If Surveillance Requirements 4.8.1.1.2.e(4).a)2 and b)2) are not satisfactorily completed, it is not necessary to repeat the preceding 24 hour test. Instead, the diesel generator Div 1 or Div 2 may be operated at 7000 kw or diesel generator Div 3 may be operated at 2600 kw for one hour or until operating temperatures have stabilized.



JAN 3 0 1985

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TABLE 4.8.1.1.2-1

DIESEL GENERATOR TEST SCHEDULE

| Number of Failures in Last 100 Valid Tests* | Test Frequency |
|---|---|
| ≤ 1 | At least once per 31 days |
| 2 | At least once per 14 days |
| 3 | At least once per 7 days |
| ≥ 4 | At least once per 3 days |

*Criteria for determining number of failures and number of valid tests shall be in accordance with Regulatory Position C.2.e of Regulatory Guide 1.108, Revision 1, August 1977, where the last 100 tests are determined on a per nuclear unit basis. For the purposes of this test schedule, only valid tests conducted after the OL issuance date shall be included in the computation of the "last 100 valid tests." Entry into this test schedule shall be made at the 31 day test frequency. With the exception of the semiannual fast start, no starting time requirements are required to meet the valid test requirements of Regulatory Guide 1.108.

EXHIBIT 52

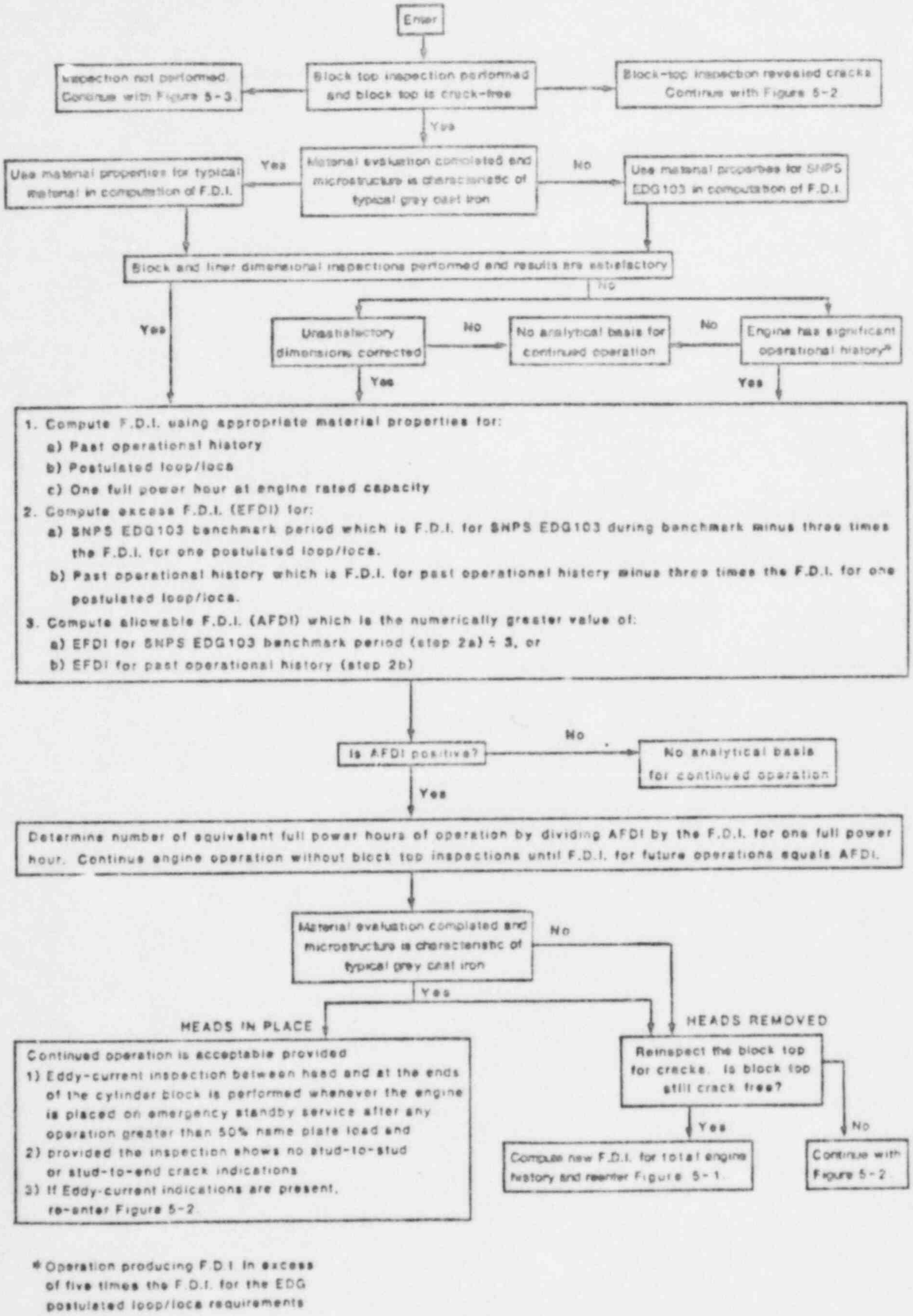


Figure 5-1. Flowchart for application of block top cumulative damage procedure.

DUKE POWER COMPANY
GENERAL OFFICES
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TELEPHONE: AREA 704
373-4011

December 18, 1984

OGTP-653-0-393

Ms. Linda Routzhan
Cleveland Electric Illuminating
Perry Nuclear Generating Station
P.O. Box 97
Perry, OH 44081

EXHIBIT 53

Re: TDI Diesel Generator Owners Group
Component 02-315A, TER 99-050
File: MTS-4086

Dear Ms. Routzhan:

Attached (for information only) please find the acceptance criteria for the cylinder block dimensions. The dimensions specified on the attached drawings (all 3 pages) are tolerances which are acceptable for the recommended dimensional verifications. If you have any questions regarding the above, please do not hesitate to contact Gary Ghika at 704-373-4098.

Very truly yours,

Richard W Bonsall

for C. L. Ray, Jr.
Technical Program Director
TDI Diesel Generator Owners Group

CLR/GDG/yds

cc: J. Kammeyer
R. Bonsall
V. Saleta
M. Curry
A.P. Cobb, Jr.
G. Ghika
JB #8

2 of 4

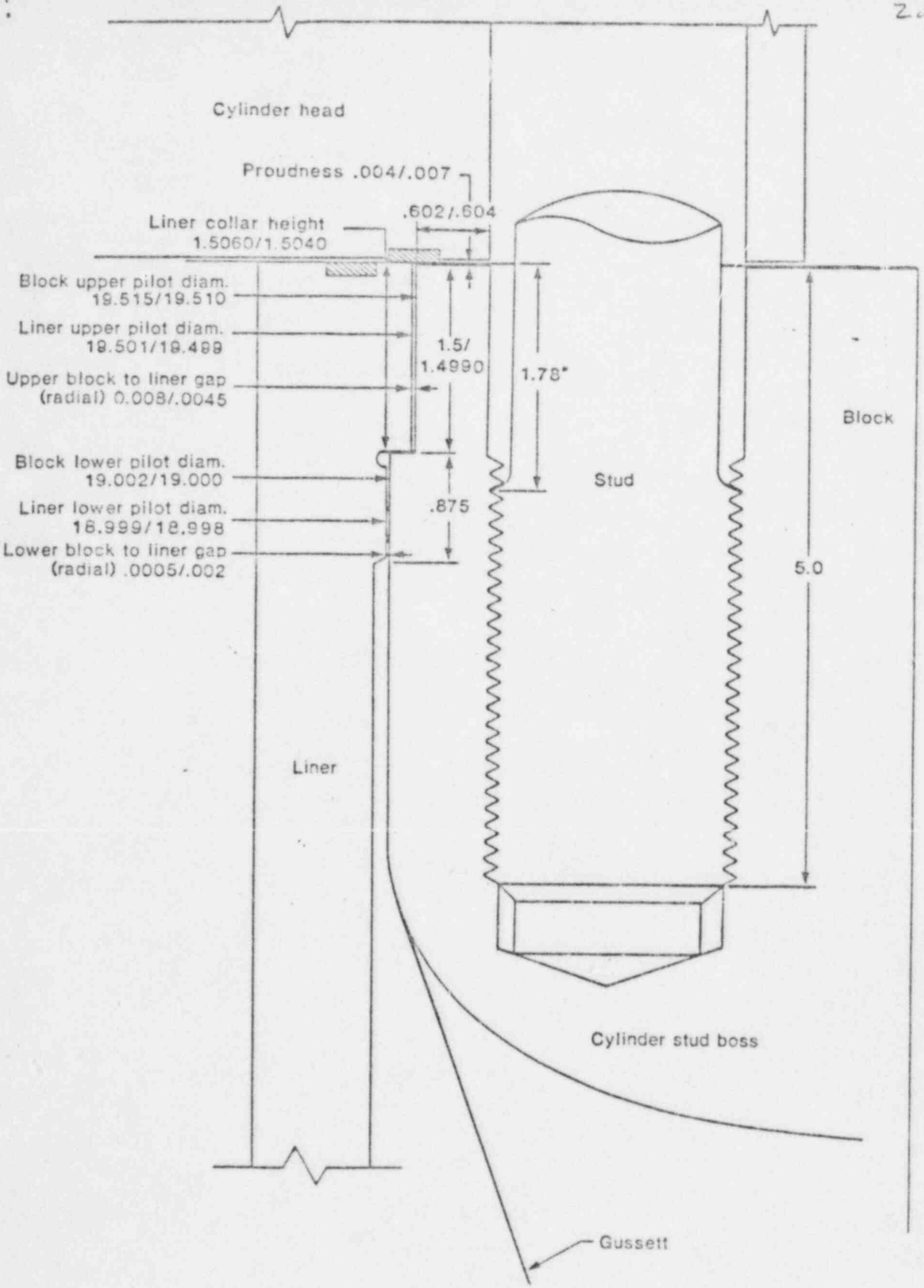


Figure 1-6. Block and liner interface (7/31/68 TDI dimensions). Typical for SNPS EDG101/102 and original EDG103.

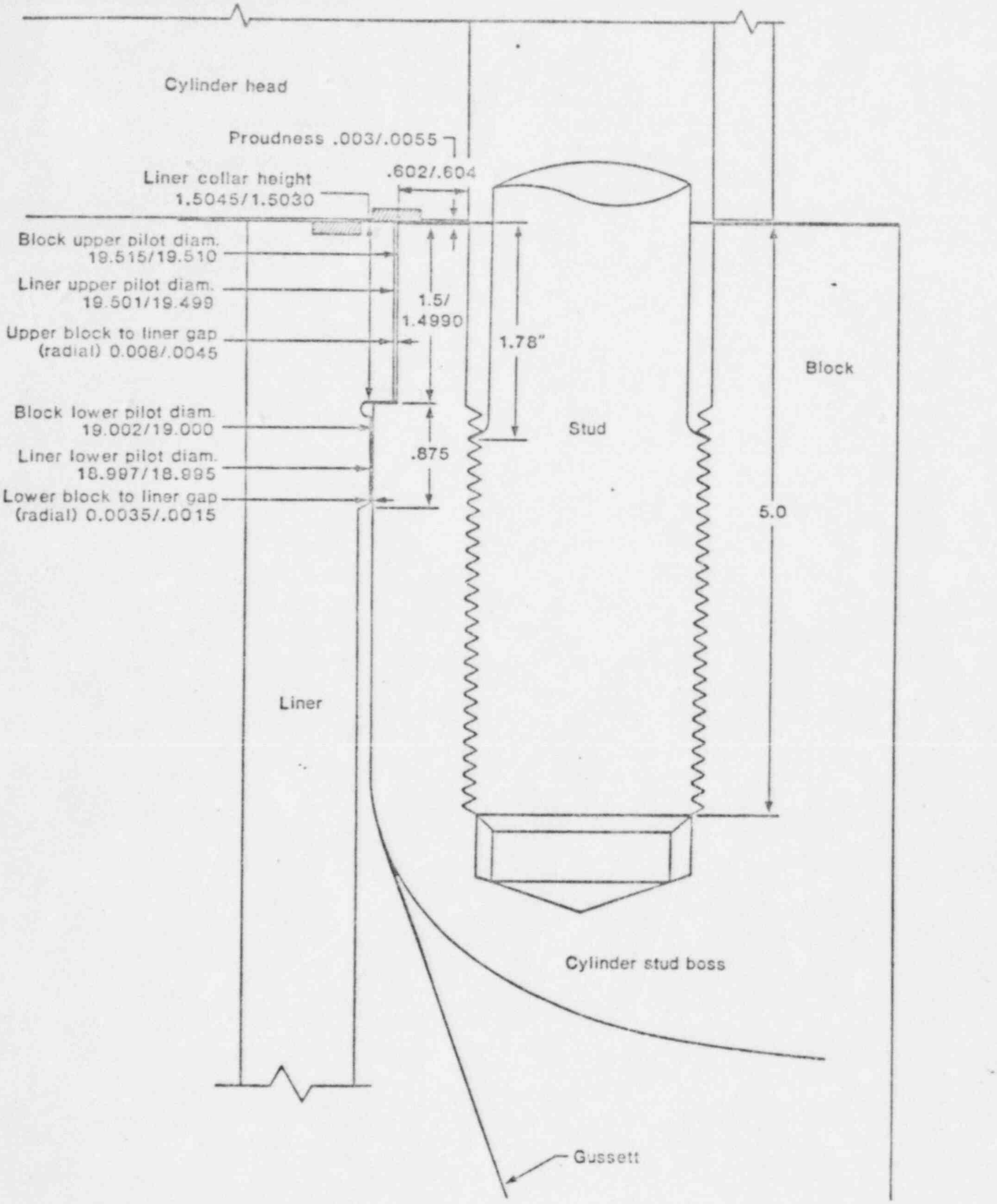


Figure 1-7. Block and liner interface (1/19/78 TDI dimensions).

4&4

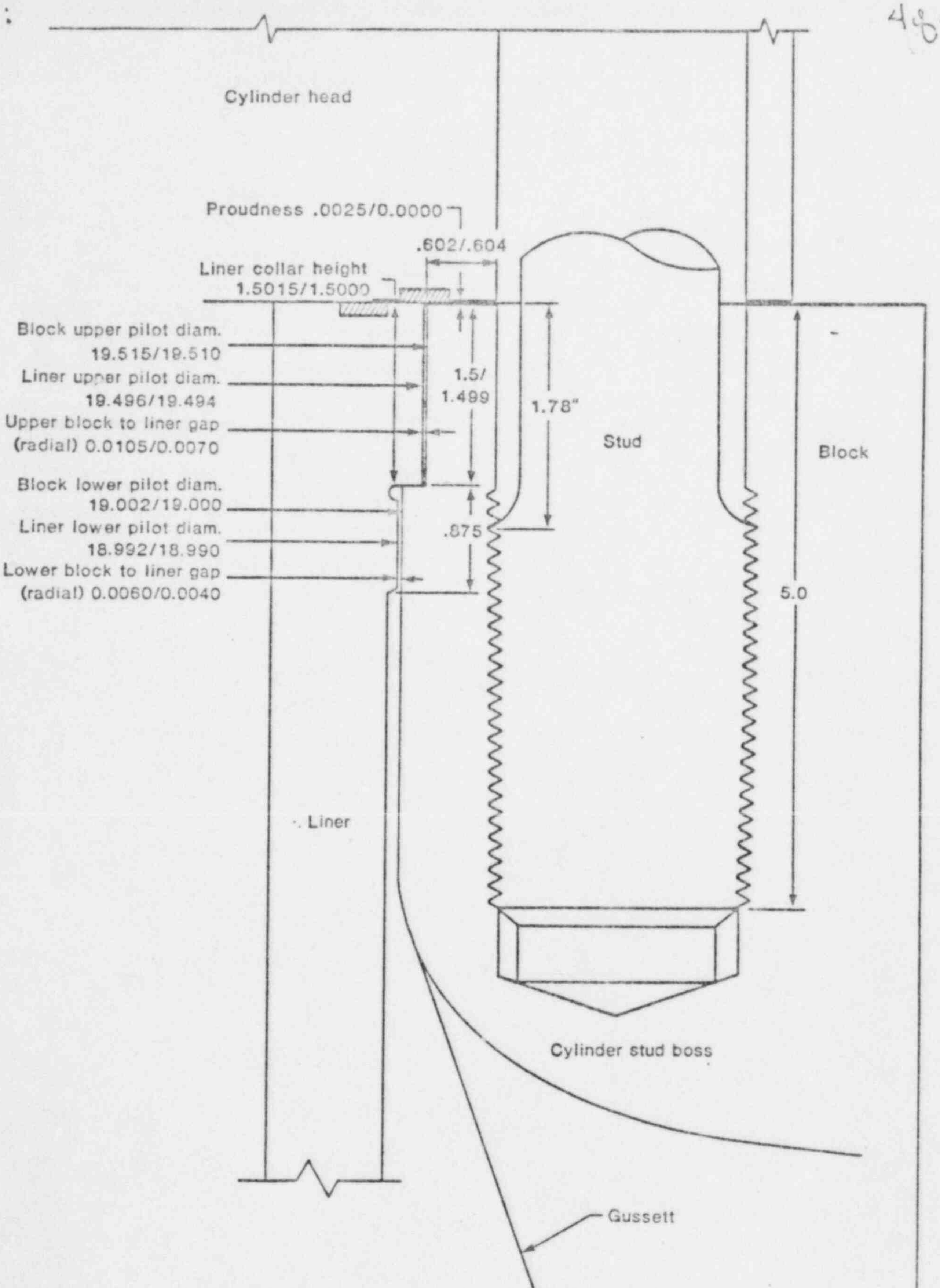


Figure 1-8. Block and liner interface (10/24/83 TDI dimensions).

EXHIBIT 54

CYLINDER BLOCKS

Q. What is the purpose of this testimony?

A. The purpose of this testimony is to set forth the results of our evaluation of that portion of the County's contention which addresses the cylinder block problems of the EDGs. That portion states:

> "Cracks have occurred in the cylinder blocks of all EDGs, and a large crack propagated through the front of EDG 103. Cracks have also been observed in the camshaft gallery area of the blocks. The replacement cylinder block for EDG 103 is a new design which is unproven in DSR-48 diesels and has been inadequately tested."

Q. What are your conclusions regarding the adequacy of the design and manufacture of the cylinder blocks?

A. We believe the block cracks are evidence that the EDGs are over-rated and undersized. The EDG cylinder blocks are not properly designed and manufactured to withstand the stresses to which they are subjected. We are concerned that LILCO proposes to use the cracked blocks of EDGs 101 and 102 for EDGs in nuclear service during the operation of the Shoreham plant. Those blocks are unreliable and are likely to experience crack propagation which can lead to catastrophic failure of the EDGs. The newly designed block for EDG 103 is unproven and inadequately tested.

Contrary to the conclusions reached by FaAA in the cylinder block report[162] and by the Owners' Group DRQR Report on cylinder blocks, we conclude that:

1. The cracks in the ligament between stud holes and liner counterbores of the blocks of the EDGs are not benign and may be lead to catastrophic failure of the engine. Further, the cracks may not be fully contained between the liner and the region of the block top outside the stud hole circle.

2. Field experience in non-nuclear service has not been systematically documented or reviewed in order to demonstrate the extent of ligament cracking or the immediate consequences of such cracking.

3. The deepest crack (5-1/2 inch depth) between stud holes was measured after the immediate shutdown of EDG 103 following crack propagation during overload

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162/ "Design Review of TDI R-4 and RV-4 Series Emergency Diesel Generator Cylinder Blocks and Liners," FaAA-84-5-4, Failure Analysis Associates, June, 1984 (the "FaAA Block Report"). (Exhibit 7).

testing of EDG 103, and contributed to the decision to replace the block. The replacement block has not been adequately tested.

4. Blocks with ligament cracks (those of EDGs 101 and 102) have not been demonstrated to be capable of withstanding a LOOP/LOCA event. While we agree with FaAA's conclusion that cracks between stud holes are likely to occur and propagate in blocks with ligament cracks, we disagree that FaAA can predict with any accuracy when such cracks will initiate or the rate at which they will propagate.

5. The preliminary material evaluation by FaAA of the microstructure of a small region of each block top of the EDGs is not representative of the properties of the entire block and does not demonstrate that the block EDG 103 is significantly weaker than the other two blocks. To reach conclusions regarding the sufficiency of the material strength of the blocks of EDGs 101 and 102 in comparison to that of EDC 103, the material of all three blocks must be adequately evaluated.

6. The cracks in the cam gallery support region of the EDG blocks may be detrimental to the operation of the engine. Further, the assessment of these cracks has failed to demonstrate that the cracks will grow very slowly at full load and not at all at 75 percent load, or that the cracks can be attributed solely to the casting process.

Base on the foregoing, we conclude that it has not been demonstrated that the cylinder blocks of the EDGs will reliably perform their required functions, and thus, there can be no assurance that the EDGs will perform satisfactorily in service.

Q. Please describe the cracks which have occurred in the cylinder blocks of the EDGs.

A. There is no disagreement that numerous cracks exist on the block tops of EDGs 101 and 102, running in the radial/vertical plane between stud holes and the cylinder bores. These cracks are shown in drawings, and some of them are described, in the FaAA Block Report.[163] Similar cracks were found in the top of the block of EDG 103, which also had cracks between stud holes for adjacent cylinders 4 and 5.[164] On

163/ FaAA Block Report at 1-2 to 1-3 and Figures 1-2 and 1-3.

164/ Id. at 1-2 and Figure 1-4.

April 14, 1984, during qualification testing at 3900 kW, a crack was noticed starting under the no. 1 cylinder head and extending across the front of the EDG 103 block and about 5 inches down the front of the engine.165/ Subsequent inspection of the EDG 103 block showed that many existing cracks had propagated, and that additional between-stud hole cracks had developed at four other locations.166/ In addition, there are cracks in the camshaft gallery areas of all three EDG blocks.167/ These cracks have been observed to grow in the EDG 103 block.168/

Q. Does the FaAA Block Report provide a satisfactory design review of the cylinder blocks?

A. No. Rather than a design review of the blocks, it is a summary of FaAA's "investigation of the structural adequacy" of the blocks.169/ FaAA fails to address most of the

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165/ Letter dated April 17, 1984, to Administrative Judges from E.J. Reis (NRC Staff). (Exhibit 54).

166/ FaAA Block Report at 1-2 to 1-3 and Figures 1-5 to 1-8.

167/ *Id*. at 4-6.

168/ Morning Report, NRC Region I, March 20, 1984. (Exhibit 55).

169/ FaAA Block Report at i and ii.

functional attributes of the cylinder blocks set forth in the Task Description for the Component Design Review.170/ We believe it is significant that FaAA does not conclude that the cylinder blocks are adequate for nuclear service and capable of unlimited operation. However, based solely upon the FaAA Block Report and its supporting packages, the TDI Owners Group concluded that the cracked blocks of EDGs 101 and 102 and the replacement block for EDG 103 (pending final material study results for the original and replacement EDG 103 blocks)

> are acceptable for intended function with implementation of routine inspections in accordance with E&DCR F-46505.171/

Q. What does the TDI Owners Group mean by the phrase "acceptable for intended function"?

A. The DRQR Report does not expressly define this phrase, but indications are that it refers to the ability of the cylinder block "to withstand with sufficient margin a LOOP/LOCA event."172/ There is no suggestion of what a "sufficient margin" might be. Mr. William Museler, a vice president

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170/ Id., Appendix.

171/ DRQR Report, Vol. 4, Cylinder Block, at 3. (Exhibit 56).

172/ Id. at 2; see also Id. at C1 and C2.

of LILCO and former technical manager of the TDI Owners Group program, testified that the ad hoc acceptance criterion applied by the Owners' Group program for adequacy of the EDGs was <u>not</u> the performance rating of the EDG established by the FSAR and the contract specification.<u>173</u>/ Rather, the TDI Owners Group criterion was reliable operation during the testing required to be performed plus one LOOP/LOCA event for seven days.<u>174</u>/

Q. Is the TDI Owners Group acceptance criterion intended to be applied to qualify the EDGs only for operation during the approximately 18 month period until the first refueling outage at Shoreham, when the newly purchased Colt EDGs are scheduled to be installed?

A. Not according to Mr. Museler. He testified that although LILCO intends to replace the EDGs with Colt diesels by the first refueling outage, the Owners Group criterion was intended to qualify the EDGs for a period "far beyond the interim period."<u>175</u>/

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<u>173</u>/ Deposition of William J. Museler (May 22, 1984) ("Museler Deposition") at 7-8. (Exhibit 57).

<u>174</u>/ <u>Id</u>. at 14-17.

<u>175</u>/ <u>Id</u>. at 43-46.

Q. Is the criterion used by the TDI Owners' Group appropriate to ensure that the EDGs, and specifically their cylinder blocks, are adequate and reliable enough to meet the requirements of GDC 17?

A. No. The Owners Group criterion is extremely limited, subjective and does not meet the technical requirements of GDC 17. As discussed above, the proper technical standard for GDC 17 is the performance rating for the EDGs set forth in the FSAR. That rating -- 3500 KW continuously for one year and 3900 kW for 2 hours per 24 hour period -- was established by LILCO and approved by the NRC Staff on the basis of the required service for the EDGs. There is no rational or regulatory basis to eliminate that performance standard.

Q. Did the FaAA Block Report use the same improper acceptance criterion as the TDI Owner's Group for determining the adequacy of cylinder blocks?

A. FaAA issued an interim report on the cylinder block and liner, which concluded preliminarily that the DSR-48 cylinder blocks may be adequate "for interim use" depending on further analysis.176/ Mr. Robert Taylor of FaAA, who prepared the

176/ Exhibit 1 to Taylor Deposition. (Exhibit 58).

interim report, testified that in determining "interim use," he used an "intended load profile" for two years of about 260 hours of EDG operation, including 80 hours at full load and less than one hour at 3900 kW.177/ In the final FaAA Block Report no statement is made as to whether or not the cylinder blocks are adequate for interim or any other use, so no acceptance criterion is expressly applied. However, FaAA appears to have further reduced the inadequate and improper criterion of the two year "intended load profile," because the FaAA Block Report only specifically addresses whether an engine block with cracks between the stud holes and cylinder bore (so called "ligament cracks"), but with no stud hole to stud hole cracks, can be predicted to survive a LOOP/LOCA event.178/ This criterion is totally inadequate to satisfy the standards required by GDC 17.

Q. The FaAA Block Report sets forth a number of conclusions and recommendations which are applicable to the EDGs. Do you agree with the FaAA conclusion that the cracks in the ligament between the stud holes and liner counterbore are "benign."179/

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177/ Taylor Deposition at 69-70. (Exhibit 59).

178/ FaAA Block Report at 4-3 to 4-5.

179/ Id. at 5-1.

A. We strongly disagree with FaAA's conclusion that these ligament cracks are "benign." First, FaAA states, and we agree, that one consequence of the ligament cracks might be leakage of coolant (although not into the cylinder).180/ Such leakage is far from "benign," and could lead to catastrophic failure of the EDG.

Q. How could the leaking of coolant lead to a catastrophic failure?

A. The leaking of the coolant could result in temperature increases of the upper part of the cylinder liner and head. The consequent thermal stresses on the cylinder block, cylinder heads, pistons, and other engine components increase the likelihood of cracking. For example, the overheating of the cylinder liner could crack the liner and/or cause a partial piston seizure. A partial piston seizure makes combustion gas blow-by highly probable, which may lead to a crankcase explosion and complete piston seizure. Lack of sufficient coolant could also lead to distortion of the cylinder head, which could cause the exhaust valves to fail to seat completely. Distortion of the cylinder head and the leakage of gases from the

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180/ Id. at ii to iii.

exhaust valves could lead to overspeeding of the turbocharger and damage to the blades and rotor, which would stop the turbocharger. This would result in an insufficient quantity of air supply to the engine, further increased temperatures of the operating parts, and ultimately to a complete piston seizure. Complete piston seizure would cause bent or broken connecting rods, serious overloading and possible cracking of the main bearing shells, cracking in the engine base and stretching of the main bearing hold down studs. A complete piston seizure will almost always stop the EDG.

Q. Can you predict how quickly the coolant would leak from the ligament cracks?

A. Coolant water could leak rapidly from ligament cracks. The coolant water is under pressure of 40 psi. The rate of leakage would depend on the number of cracks and their widths. The leakage becomes critical when the expansion tank (coolant reservoir) either cannot replace the loss of coolant water fast enough or is depleted. A dangerous overheating condition occurs when the temperature is high and the water low so that the circulating coolant mixture consists of liquid and vapor.

Q. Do you agree with FaAA's conclusion that the ligament cracks are benign

> because the cracked section is fully contained between the liner and the region of the block top outside the stud hole circle.181/

A. It is not clear what FaAA means by this description. FaAA describes the ligament cracks accurately as running between the stud holes and the liner counterbore, so the cracks do run to the stud hole itself. We believe that FaAA is referring to the "apparent arrest" of the ligament cracks at the liner landing ledge.182/ This conclusion as to the "apparent arrest" of ligament cracks is based upon observation of ligament crack depth on the EDG blocks, and unconfirmed183/ and incomplete information regarding selected blocks of TDI engines in non-nuclear service.

Q. Were ligament cracks "fully contained" during the testing of the EDGs?

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181/ Id. at 5-1.

182/ Id. at 1-2 and 1-3.

183/ Id. at 1-1.

A. No. The history of the ligament cracks on the EDG blocks does not support the conclusion that they are "fully contained" and therefore "benign." On the contrary, the large 5" crack which occurred on the EDG 103 block during overload testing ran from a stud hole at cylinder No. 1 which already had a ligament crack. Compare Figures 1-4 and 1-8, FaAA Block Report. That comparison also discloses that after the overload test was aborted, nine new stud hole to stud hole cracks had initiated. Thus, even if the ligament cracks on the EDGs had not propagated downward past the liner landing, they cannot be described as benign. If the ligament crack is in fact arrested at the liner landing ledge, it would appear that continuing sufficient operating stress causes cracks to initiate and propagate radially and vertically from the stud hole with the ligament to adjacent stud holes or to the outer wall of the block.184/ Finally, Figure 1-8 contradicts FaAA's assertion that ligament cracks will not grow beyond the 1-1/2" depth of the liner landing ledge, because it shows six ligament cracks with a depth of 2 to 2-1/2."

184/ Note that Figure 1-8 of the FaAA Block Report shows that most of the ligament cracks had reached a depth of at least 1.5", the reported depth to the liner landing.

Q. Doesn't FaAA's data on cracked blocks in non-nuclear service demonstrate that the ligament cracks are "benign" and cannot have adverse "immediate consequences"?185/

A. No. The unconfirmed information given in the FaAA Block Report186/ does not support FaAA's conclusion at all. FaAA concludes that the mechanism of crack initiation in the cylinder block tops are low cycle fatigue during startup to high load levels, high frequency fatigue from firing pressure stresses, and overload rupture occurring at loads above rated power levels.187/ These factors, which also affect crack propagation, are all related to the loads at which an engine is run, that is, the higher the load, the greater the stress and the more likely is crack initiation and rapid propagation. FaAA states the hours which the non-nuclear have run, but does not disclose the loads at which they ran during those hours. We believe it inappropriate that FaAA has relied at all on the marine non-nuclear cases they cite. When asked why FaAA had decided not to examine cracks in blocks other than at Shoreham, Mr. Taylor of FaAA responded:

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185/ FaAA Block Report at 5-1.

186/ Id. at 1-3 to 1-4.

187/ Id. at ii.

> Well, the engines in the Marine service see a different service than shore-based engines. Their load profiles are different. They're operated differently, and just looking at the block for the COLUMBIA without knowing the size of the liners, how much the liners protruded, exact load history, even if I were to go look at that block, I would -- there's a wealth of other data that would be pertinent that I don't have yet and probably would not be able to reconstruct.188/

Mr. Taylor also testified that data such as load factors would make examination of other cracked blocks useful. FaAA concedes that non-nuclear engines generally operate at lower loads and with fewer starts than nuclear diesels.189/

Q. Do you have additional comments on the specific cases of non-nuclear engine block cracks relied upon by FaAA?

A. Yes. The information on the M.V. Gott does not disclose load levels for this DMRV-16-4 engine, the methods by which crack depth was measured, or the fact that as the result of the cracks the engine blocks were repaired and modified.190/ During the telephone conversation on which FaAA relies for its

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188/ Taylor Deposition at 40- 41. (Exhibit 59).

189/ FaAA Block Report at 4-3.

190/ Letter dated November 30, 1983 from Lowrey (TDI) to Blanding (American Bureau of Shipping). (Exhibit 60).

information on the M.V. Gott, the owners also told FaAA that (i) the blocks on the Gott were being machined to reduce stresses, (ii) the engines on the Gott had been so extensively modified they could no longer be considered "stock" TDI diesels, (iii) a maintenance/inspection program for the engines much more comprehensive than the recommended TDI program was being used, and (iv) the design of the TDI blocks, with a cylinder liner placed in a counterbore, "is an old design which nobody uses anymore because of the resulting thermal problems."191/ The FaAA Block Report fails to disclose this information.

The statement on the M.V. Columbia fails to disclose load levels or that the State of Alaska replaced the cracked block and derated the TDI DMRV-16-4 engines by approximately 43%.192/ Further, these engines were originally rated at over 35 HP less per cylinder than the EDGs. Information on the St. Cloud, Copper Valley, Homestead and Bhiel engine blocks do not disclose

191/ FaAA Block Report Ref. 1-3, Memo of June 7, 1984 telephone conversation between Spiegel (FaAA) and Liberty (U.S. Steel). (Exhibit 61).

192/ Evaluation of the Operational and Maintenance History of, and Recent Modifications to, the Main Engines in the M.V. Columbia, SES Report No. 123-01, by Seaworthy Engine Systems, Inc., April 1983, at 2-1. (Exhibit 62).

load levels or other pertinent operating information, such as peak firing pressures. The engine at Homestead is rated at 8800 kW, but is operated at only about 6000 kW. Three of the TDI engines owned by Copper Valley have been derated by 20%. Maintenance history documents obtained by LILCO or FaAA from Copper Valley disclose many problems, including replacement of a block on engine S/N 75011, but do not specifically refer to ligament cracks in the blocks.193/ Finally, FaAA has supplied no information on the block material properties or chemical composition of the cylinder blocks in non-nuclear service. Yet FaAA believes these factors are very important to crack initiation and propagation.194/ In summary, FaAA's information on non-nuclear service does not demonstrate its conclusion that the ligament cracks on the EDGs are "benign."

Q. Do you agree with FaAA's conclusions that ligament cracks and stud hole to stud hole cracks are predicted to occur after operation at high loads and/or engine starts to high load?195/

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193/ Maintenance History on TDI S/N 75011 and 75012, Copper Valley Electric Ass'n. (Exhibit 63).

194/ FaAA Block Report at 4-5 to 4-6, iv.

195/ *Id.* at 5-1.

A. Yes. But FaAA understates the stresses to which the blocks of the EDG are subjected, and thus underestimates the likelihood and rapidity of the initiation of ligament cracks and stud hole to stud hole cracks, and the speed of propagation of those cracks. Thus, FaAA has failed to demonstrate that blocks with ligament cracks are capable of reliably withstanding a LOOP/LOCA event.

Q. Please explain why you believe these stresses are underestimated by FaAA.

A. First, FaAA understates pressure loads on the block by assuming a peak firing pressure of only 1600 psi[196/] rather than the actual value of 1700 psi or greater at 100% load.

Second, FaAA has not properly determined the preloading stress or how much of the preload is borne by the liner collar onto the liner landing ledge and how much is borne by the block.[197/] FaAA states that "much" of the preload is transmitted to the liner collar, depending upon several variables. But it does not address these variables in terms of their importance or give any calculations. The liner collar

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196/ Id. at 2-3.

197/ Id. at 2-1.

protrusion, or "proudness," above the block top on the EDGs is greater than current TDI specifications, and would result in greater preload on the liner landing ledge.198/ FaAA measured the liner proudness for the cylinders of EDG 103; the measurements varied from 1 to 9 mils.199/

Third, FaAA has not calculated the amount of thermal load on the block due to thermal expansion of the liner.200/ FaAA correctly points out that thermal expansion stress of the liner will not all be transferred to the block, depending upon the clearance between the liner and block.201/ But there are no calculations of the optimum clearance or the amounts of stress not transferred under those optimum conditions. Further, there are no calculations of the actual clearances in the blocks of the EDGs, so there is no basis for FaAA's statement that "interference stresses in the block are as small as possible."202/

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198/ Id. at 1-5.

199/ Calculation "Liner Proudness of DG 103, Project No. 03315A", by John H. Lau, dated 6/10/84. (Exhibit 64).

200/ FaAA Block Report at 2-2.

201/ Id. at 2-3.

202/ Id.

Q. Does FaAA's finite element analysis accurately show the effects of stresses on the top of the block?

A. No. The FaAA analysis does not accurately reflect actual probable stress effects. First, it incorrectly assumes a peak firing pressure of only 1600 psi, thereby significantly understating the stresses due to pressures. Second, it assumes the optimum clearance between the liner and block necessary to close the clearance by thermal expansion.203/ If the actual clearance for each cylinder is less than the assumed optimum, the stress effect will be greater. Third, FaAA assumes thermal stresses are symmetric between cylinders. This would only occur if the firing pressure and load in all cylinders were the same. Actually, firing pressures differ significantly from cylinder to cylinder of the same EDG, and TDI's operating manual permits a variance of ± 100 psi. Fourth, FaAA assumes all thermal stresses act radially in the plane of the top of the block. Actually, there are also longitudinal stresses in the upper surfaces of the block, so the thermal stress pattern is an oval shape.

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203/ Id. at 3-3.

Q. Please explain how FaAA's incorrect and/or non-conservative assumptions affect its conclusions that ligament cracks and stud hole to stud hole cracks are predicted to initiate and propagate in the cylinder blocks?

A. FaAA predicts that these cracks could occur in fewer than 100 starts from 0 to 90% power or above and/or steady operation for over 100 hours at 90% or higher power, with a block having minimum material properties.204/ The incorrect and/or non-conservative assumptions of FaAA and its understated peak total stress figure of 33 ksi (as compared to the minimum ultimate tensile strength of 32 ksi for a 2-1/2 section) mean that the cracks might well initiate under FaAA's predicted conditions in blocks having higher than minimum material properties for ASTM A48-64 Class 40 gray cast iron, or at below 90% of power or at steady operation for fewer than 100 hours, or any combination of these factors. It is not possible to state by what percentage the FaAA conclusion is in error because the many variables, such as actual firing pressures, cylinder block and liner clearance, and "proudness" of the liner are impossible to predict without further experimental data for a specific engine.

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204/ Id. at 3-6.

Q. FaAA predicts crack initiation to occur at steady running for more than 100 hours at 90% power or above.205/ Wouldn't one expect that at loads above 90% cracks can initiate at fewer than 100 hours of operation, even taking all of FaAA's incorrect assumptions as correct?

A. Yes. The higher the operating load, the fewer hours would be required before cracks initiate. FaAA does not address this issue.206/ This is a significant omission. A 90% load on the EDGs is only 3150 kW, well below the required actual maximum load of 3881 kW an EDG is required to carry during a LOOP/LOCA event. After 10 minutes into a LOOP/LOCA event, two EDGs must each produce a maximum coincident demand of about 3400 kW, or 97% of rated load.207/ When this factor is combined with accumulated damage from past start-ups and operation, it is apparent that cracks can initiate in a block during a LOOP/LOCA is much less than 100 hours.

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205/ Id.

206/ The FaAA Block Report does state that 110% load "is clearly more damaging relative to 100% load than 100% load is relative to 90% load" (at 4-1).

207/ FSAR Table 8-3.1-1 at 4.

Q. FaAA suggests that stud hole to stud hole cracks might not be dangerous, because "the deepest measured crack in this region (5 1/2-inch depth) did not degrade engine operation or result in stud loosening."208/ Do you agree?

A. No. FaAA fails to state, indeed if it knows, when this crack grew to a 5 1/2 inch depth or how long EDG 103 operated with this crack. Even if we assume that this crack grew during the "abnormal load excursion" affecting EDG 103 on April 14, the engine could only have run less than 2 hours before it was shut down and the crack was discovered.209/ The very deep stud hole to stud hole crack contributed to the decision to replace the block. Such cracks could cause the loosening and breaking of the cylinder head studs, with consequent loss of power and overloading of the remaining cylinders. This condition would probably lead to engine failure.

Q. FaAA concludes that the cracked blocks on EDGs 101 and 102 can survive a LOOP/LOCA event if they have no cracks between stud holes and if the block material of the original

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208/ FaAA Block Report at 5-1.

209/ Id. at 1-2. EDG ran for 10 minutes after the "abnormal load excursion," then was run for 100 minutes before being shut down when the 5" crack running from cylinder no. 1 was noticed.

EDG 103 block "is shown to be sufficiently less resistant to fatigue than typical gray cast iron, class 40."210/ Do you agree?

A. No. The FaAA's conclusion is based upon a purported ability to accurately predict crack initiation and growth in EDGs 101 and 102 by "cumulative damage analysis of the known experience during operation of DG 103 between 3/11/84 and 4/14/84."211/ FaAA's analysis is based upon faulty premises and insufficient data. FaAA cannot accurately predict whether and when the cracks in the blocks of EDGs 101 and 102 may cause a failure during a LOOP/LOCA event.

Q. What are FaAA's faulty premises?

A. FaAA bases its analysis on a "linear cumulative damage approach (presented in Section 4.1) to obtain the total fatigue damage" of a block.212/ The use of the linear fatigue damage index is not limited by FaAA, that is, it is assumed applicable for all ranges of stress, load and duration. Extremely high loads for a short duration are known to result in failures or excessive cracking;213/ this fact is not reflected

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210/ Id. at 5-1.

211/ Id. at 4-3.

212/ Id.

213/ Indeed, FaAA emphasizes that the large crack running from the no. 1 cylinder down the front of the EDG 103 block

(Footnote cont'd next page)

by FaAA's linear damage index. Further, FaAA assumes that the damage index recorded for EDG 103 between 3/11/84 and 4/14/84 is an appropriate benchmark to predict the behavior of other blocks. On this basis, FaAA concluded that:

> A block with no existing stud-to-stud cracks and material properties sufficiently better than those of DG 103 should be able to complete the LOOP/LOCA requirements without any cracks as deep as the 5-1/2 inch crack in DG 103, while continuing to run normally.214/

However, the assumption for this conclusion is erroneous.

Q. What are the errors in the assumption?

A. First, it completely ignores the large crack which appeared in the EDG block during overload testing and ran from cylinder no. 1 about 5 inches down the block front, resulting in aborting the test, shutting down the engine, and ultimately contributing to the decision to replace the block. The damage caused by that crack and its impact on the ability of an EDG "continuing to run normally" is not assessed by FaAA. Second,

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(Footnote cont'd from previous page)

occurred after a 23 second unusually high load. FaAA Block Report at 1-2.

214/ FaAA Block Report at 4-5.

applying FaAA's damage index to EDGs 101 and 102 in comparison to the EDG 103 index for the stated period does not take into account the effects of differing load spectra on the three engines. Crack dynamics are affected by sequence of loads as well as their duration. FaAA provides insufficient evidence that the EDG 103 block damage in the stated period is a worst possible case.

Q. Do you have other concerns with the validity of FaAA's analysis?

A. Yes. Although we have not had an opportunity to review some of FaAA's underlying calculations which were only obtained a few days ago, we are concerned with FaAA's conclusion that an amount of additional damage required to initiate cracks between studs after ligament cracks initiate must at least equal the cumulative damage required to initiate the ligament cracks.215/ This conclusion does not appear to take into account the results of FaAA's finite element analysis, which shows that after ligament cracks have formed, the transverse stress between stud holes doubles.216/ This increase in stress

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215/ Id. at 4-1.

216/ Id. at 3-4.

would appear to cause the damage level to accumulate more rapidly than FaAA considers, and the additional damage required for cracks between studs to initiate would be less than assumed by FaAA.

Second, the quality of the cast iron determines the ease of initiation for a given damage index. This is presented as "n" (Paris law exponent) which is normally an unvarying constant for a given material condition. However, FaAA has considerable trouble in finding the best value of "n" and gives a value of 5.37 to 9.62. The proper value would be determined by testing the metal of the blocks. The conservatively assumed estimates of "n" in the FaAA report have no relation to the actual values for EDG 101, 102, and 103 blocks. The values are expected to be different for each block, because of the significant variance in the TDI casting procedures and its poor quality control. As discussed below, all three blocks should be properly evaluated to determine their material properties, rather than relying upon assumptions which may or may not be correct.

Third, while the FaAA analysis purports to be empirically based on EDG block behavior, it lacks information of significant importance. When did the ligament cracks first initiate in each of the three EDG blocks, and what was the cumulative damage index of each at that point? When did the original crack between the stud holes in the EDG 103 block first initiate, and what was the additional damage index accumulated between the initiation of the ligament cracks in the same block and that point? When and under what conditions did the original crack between the stud holes in the EDG 103 block grow to 5-1/2 inches in depth, and what was its rate of growth? When did the large crack running from cylinder no. 1 down the front of EDG 103 first inititate and at what rate did it propagate? The answers to these questions would provide some meaningful empirical data.

Q. Did FaAA use fracture mechanics techniques to predict the rate of crack growth of the cracked block tops of EDGs 101 and 102?

A. No. The FaAA Block Report does not use a fracture mechanics analysis to predict the growth of ligament cracks or the initiation or growth of stud hole to stud hole cracks. But FaAA does use fracture mechanics to predict the propagation of cracks in the camshaft gallery areas of the blocks and of cracks which may initiate in the AE piston skirts. We believe this is a significant inconsistency in the approach FaAA has used to predict crack growth.

Q. Can the excessive cracking in the original block of EDG 103 be attributed to significantly weaker material than those of EDGs 101 and 102?

A. No. There is insufficient evidence of any actual block material properties. FaAA examined only a small area of each block top.217/ But within the same block the cast iron properties may vary widely due to the presence of trace elements in certain areas. A meaningful analysis of the material properties of a cylinder block would require metallurgical examination of numerous sample areas of the block.

The performance of the EDG cylinder block is dependent on the properties of its materials of construction. FaAA's examination of a "small region of the block tops" of the EDGs was inadequate to characterize the materials of each of the blocks. FaAA has assumed that the block is homogenous, but in actuality the casting is not uniform because of the segregation which naturally occurs during the casting process. Therefore, more than a single small area must be evaluated to determine whether or not there are differences in the entire blocks of EDGs 101, 102 and 103. FaAA states, "Specific materials testing is

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217/ Id. at 4-4.

required to quantify any degradation in fatigue or fracture properties of the thick section block casting."218/ We agree. However, FaAA proposes that only the material of the original block for EDG 103 be completely evaluated. If that block material is "shown to be sufficiently less resistant to fatigue than typical gray cast iron, Class 40,"219/ the blocks of EDGs 101 and 102 would be predicted by FaAA as capable of surviving a LOOP/LOCA event. This assumes that the materials of those blocks are at least as strong as "typical" material. There is no adequate basis for this assumption. To reach conclusions about the material strength of the blocks of EDGs 101 and 102 compared to that of EDG 103, the material of all three blocks must be properly evaluated.

Q. Can the excessive cracking of the EDG 103 block be attributed to the "abnormal load excursion" at Shoreham on April 14?

A. FaAA did not do so. FaAA notes that the power outage affected EDG 103 with an excess load for 23 seconds, and that the large crack from the no. 1 cylinder down the front of EDG

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218/ Id. at 4-5.

219/ Id. at 5-1.

103 occurred after the excess load event. But FaAA refrains from making any causal connection between the two matters. Neither FaAA nor LILCO documents describing the effects of the power outage[220] disclose the amount of the load during the 23 seconds. We do know that EDG 103 ran at test overload for 100 minutes thereafter before the large crack down the block front was noticed. With the available facts we are unable to determine what, if any, effect the 23 seconds had on the block. Two observations are in order. First, the "abnormal load excursion" demonstrates again that accidents happen, even if they are thought to be unlikely. The EDG's and their blocks should be strong enough to survive such an accident, which might have occurred during the inception of a LOOP/LOCA. Second, EDG 103 ran for ten minutes after the 23 second episode in an unloaded condition and without cooling water.[221] That fact, coupled with the subsequent block damage resulting from the overload test, suggests that other components of EDG 103 may have been damaged. LILCO has committed to repeat the entire start-up test program with EDG 103 after installation of its replacement block, and then disassemble and inspect the engine.[222] This

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220/ Letter dated April 24, 1984, from J.A. Notaro to W.E. Steiger. (Exhibit 65).

221/ *Id.* at 2.

222/ LILCO's Response to Suffolk County's Filing Concerning Litigation of Emergency Diesel Generator Contentions, June 21, 1984, at 55.

commitment is very important. The inspection should be subject to the scrutiny of all parties in this proceeding.

Q. Do you agree with FaAA's conclusion that the cracks in the camshaft gallery areas of the blocks will not grow to any significant degree?

A. No. FaAA gave one example applying its formula for fatigue crack growth, which predicted the assumed crack to grow, but at a slow rate.223/ In its analysis, FaAA uses the simple Paris empirical relation, which does not take into account important parameters such as mean stress effects on fatigue crack propagation. In addition, FaAA evaluated the parameters in the Paris evaluation based on gray cast iron without the defects apparently present in the EDG 103 block. The conclusions presented on crack growth are meaningless without presenting the sensitivity of initial crack size to fatigue life and the physical properties of the actual block material. We should also point out that our general comments on the limitations of a fracture mechanics analysis discussed above with regard to the AE piston skirts also apply to the FaAA predictions for the growth of the camshaft gallery area cracks.

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223/ FaAA Block Report at 4-6 to 4-7.

Q. Did you also discover other inconsistencies in the FaAA evaluation of the camshaft gallery cracks?

A. Yes. First, FaAA assigns different values to n (Paris Law exponent) in their cumulative damage index (n = 9.6) and in the camshaft gallery crack analysis (n = 5.37). Since the same material is used in both cases, this change in exponent value confuses the results. Second, the value of "n" should be evaluated for the specific material used in the EDG 103 block and Table 4-1 should be recalculated. FaAA failed to obtain the "n" value from testing of specific block material. Further, FaAA failed to provide the basis for its selection of generic "n" values. Third, crack growth rate is very sensitive to the value of "n." For example, if n = 9.6 is used in the gallery crack growth rate example given on page 4-7 of the FaAA Block Report, the rate is increased by 10,000.

Q. Have the cracks in the camshaft gallery area of the EDG blocks been mapped and measured for propagation?

A. Apparently LILCO did map these cracks and some appeared to have grown.224/ The FaAA Block Report does not

224/ Museler Deposition at 97-99 (Exhibit 57); Morning Report, NRC Region 1, March 20, 1984. (Exhibit 55).

report any empirical data concerning propagation of these cracks.

Q. How could cracks in the camshaft gallery area of the cylinder block affect the operation of the EDGs?

A. If the known cracks propagate (and there is no reported metallurgical evidence that they will not) the first effect will be increased flexing of the camshaft. The flexing will then increase the load on adjacent bearings, which could further increase the propagation rates of cracks at these locations. As flexing of the camshaft takes place, the load on the cylinder where camshaft flexing is occurring will be reduced. Consequently, the loads on the other cylinders will be increased, and cylinder balance will be lost. As there appears to be almost no reserve of power in the EDGs, the ability to take full load will be seriously affected by the unbalance. In the worst case, the cracks could result in a broken camshaft leading to irreparable damage of the cylinder block and loss of engine.

Q. How is the load imbalance evaluated by FaAA?

A. The interaction resulting from changing loads due to crack propagation in one location and increased loading in other locations is not part of the crack growth forecasts made by FaAA.

Q. The DRQR authors conclude that cam gallery support cracks "are predicted to grow very slowly at full load and not at all at 75 percent load."225/ What is the basis for this conclusion?

A. No basis for the conclusion is provided in either the DRQR Report or the FaAA Block Report. Further, the information provided by FaAA does not support, and in fact contradicts, a conclusion that cracks will not grow "at all."

Q. Will FaAA's recommendation that the cracked blocks on EDGs 101 and 102 be examined for cracks between stud holes by eddy current after each operation ensure the safe and reliable operation of the EDGs?226/

A. No. As discussed previously, cracks between stud holes can initiate rapidly during a LOOP/LOCA event and lead to catastrophic failure. Inspection of the block after periodic testing does not therefore ensure reliable operation in an

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225/ DRQR Report Vol. 4, Cylinder Block, at 3. (Exhibit 56).
226/ FaAA Block Report at 5-2.

emergency. Moreover, as discussed above, ligament cracks can cause leakage of coolant which itself can result in catastrophic failure. The propagation of the large crack down the front of EDG 103 running from a stud hold in cylinder no. 1 (which had a ligament crack) demonstrates that unanticipated and dangerous crack propagation, other than of cracks between stud holes, may occur rapidly during a LOOP/LOCA event. Ligament cracks similar to that on the stud hole for cylinder no. 1 currently exist at two stud holes for cylinder no. 8 of EDG 101 and at one stud hole for cylinder no. 8 and another for cylinder no. 1 of EDG 102.227/

Q: Aside from the radial/vertical ligament cracks, the cracks between stud holes, and the cracks in the camshaft gallery area, have other types of cracks been found to occur in the R-4 and RV-4 series TDI cylinder blocks?

A: Yes. The FaAA Block Report refers to cracks in the blocks of TDI DSRV-16-4 engines at Comanche Peak Steam Electric Station. These cracks appear to extend down the counterbore and through the counterbore landing.228/ FaAA also refers to

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227/ Id. at Figures 1-2 and 1-3.

228/ Id. at 1-3.

"circumferential cracks in the liner counterbore at the liner landing ledge."229/

Q: Has FaAA determined the causes of these cracks and addressed whether they could occur in the EDG blocks at Shoreham?

A: No. FaAA states that the cracks at Comanche Peak have been "metallurgically examined and were identified as interdendritic shrinkage or porosity resulting from the casting process."230/ However, FaAA does not state who performed this examination, give any results in detail, or address whether similar cracks might occur at Shoreham. If the conclusion stated by FaAA is correct -- that these cracks are due to casting defects -- it supports our view that castings by TDI, including the blocks, piston skirts, and cylinder heads, are not reliable. FaAA does not discuss the circumferential block cracks at all. When questioned about the circumferential block cracks, Mr. Robert Taylor of FaAA, who headed the block study, testified that the FaAA report would not address the circumferential cracks:

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229/ Id. at 1-1.

230/ Id. at 1-3.

[B]ecause I am receiving pressure from management and LILCO to put a report out so that they can start a dialogue with the NRC. It's my understanding there have been promises made to NLCA (sic -- NRC) a block report will go out in the very new (sic -- near) future. And I just can't -- it just won't be a complete analysis, but it will start things moving.231/

Q: Are you concerned about circumferential cracks developing in the EDG blocks?

A: Yes. Such cracks could be very dangerous and lead to EDG failure. There is no reason to believe they will not develop in the EDGs. The causes of the circumferential cracks have not been determined.

Q: Did FaAA determine the causes of the ligament cracks and stud hole to stud hole cracks in the block tops of the EDGs?

A: Not precisely. FaAA only concluded that these cracks were service-induced and identified "three possible mechanisms of crack initiation (acting separately or in combination) in the block top, . . . low cycle fatigue . . . , high frequency fatigue . . . , [and] overload rupture."232/ These same

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231/ Taylor Deposition at 67. (Exhibit 59).

232/ FaAA Block Report at ii.

mechanisms could cause the intitiation of the circumferential cracks.

Q: Do you agree that the cracks in the block tops of the EDGs were service-induced?

A: All of the evidence available to us certainly supports that theory. We believe these cracks are indications that the EDGs are over-rated and undersized. They cannot operate at rated and required loads without the cracking of the blocks and other components. Dr. Chen, the diesel consultant to LILCO and the TDI Owners Group, testified that the high firing pressure of the EDGs contributes to the block cracking, and recommended that peak firing pressure be reduced to 1,500 to 1,550 psi.233/ Of course, such a reduction in firing pressure would reduce the horsepower of the EDGs to below the required amount for service at Shoreham.

Q. What is the basis for your assertion that the replacement block for EDG 103 is of an unproven design and has not been adequately tested?

233/ Deposition of Simon K. Chen (May 15, 1984) ("Chen Deposition") at 129. (Exhibit 66).

A. Mr. Lowrey of TDI testified that the design of the replacement block was only developed in the last two months of 1983, in an attempt to solve the block cracking problems of the R-4 series engines.234/ The newly designed replacement block was never tested by TDI, according to Mr. Mathews, the general manager.235/ Rather, TDI relied on the fact that the top portion and boss section of the replacement block design was the same design as similar portions of the block of the TDI RV-5 engine, and the RV-5 block had been tested.236/ A block is a single casting. We do not believe that a new design of an engine block is adequately tested simply because a portion of the casting is the same as a portion of an entirely differently designed block.

Q. Do you believe that the replacement block for EDG 103 is likely to crack?

A. Even if the design were adequate, and we believe such has not been demonstrated, the material properties used in all

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234/ Lowrey Deposition at 15-16. (Exhibit 24).

235/ Mathews Deposition at 106-107. (Exhibit 32).

236/ Id. In 1981 TDI decided to use the RV-5 blocks in current production for RV-4 engines, to address the block cracking problems. See Memo dated 4/1/81 from Lowrey to Pratt (TDI). (Exhibit 67).

of FEAA analyses are dependent on the casting process. The casting process can introduce defects such as porosity, tears, inclusions, and degenerate phases which critically effect the results of analysis. From the results of our inspection of the TDI casting processes and review of pertinent documents relating to changes made in those processes, we are not satisfied that TDI can produce a defect-free block. Therefore, any new replacement block must be completely inspected and tested.

Q. Have you recently received documents cited in the "Component Review" section of the DRQR Report on cylinder blocks?

A. Yes. A number of the underlying documents were recently received by the County. We have only had time to preliminarily review these documents. Many are illegible or have missing pages.

Q. What do you conclude based on your initial review of some of these documents?

A. Contrary to the conclusion in the DRQR Report that the "Owners Group has completed its review of the TDI diesel generators installed at SNPS" (p. 4-1) and that the Report provides the results which provide the basis for the conclusion that the EDGs "presently installed are fully capable of reliably performing their intended safety function" (Executive Summary, p. iii), we have discovered that final resolution of a number of unsatisfactory conditions documented on LDRs had not occurred when the Report was issued. Further, our review has disclosed that objective standards were not applied to resolve identified deficiencies. Thus, rather than documenting the completion of the DRQR assessments, the Report in fact provides only a status of the ongoing investigation. Should further review reveal additional information relevant to our testimony, the testimony will be supplemented.

R85-1460 sheet 24 of 31

EXHIBIT 55

PERRY NUCLEAR POWER PLANT

NONCONFORMANCE REPORT

(NTS-5586)

| | | | | | |
|---|---|---|---|---|---|
| NCR NO. OQC 1520 | REV. 0 | 1 OF 2 | ITEM IDENT NO. 1R43C001A | ITEM NAME CYL. LINER | QUANTITY 12 — DEFICIENCY TAGS SEE ATTACHED |
| 2 ISSUED BY | NAME MARK PALMER | INIT. MRP | ORGANIZATION OPERATIONAL QUALITY | | DATE 12/12/84 |
| 3 ITEM/MATERIAL | SOURCE TRANSAMERICA DELAVAL | CURRENT STATUS INSTALLING/WORKING | LOCATION DIESEL GEN BLDG ROOM 5 EL 620 | | |
| 4 RESPONSIBLE ORGANIZATION | NAME PROJECT ORGANIZATION | | SPEC. NO. SP- NTS | | REV./ECN. — |
| 5 NCR TYPE | CATEGORY: ☐ 1 (POSSIBLE SIGNIF.) ☒ 2 (MAJOR) ☐ 3 (MINOR) | TYPE: ☐ (E) ELIMIN. MAT'L ☒ (I) INSTALLATION ☐ (P) PROGRAM | | | |

6 GOVERNING REQUIREMENT (INCLUDE ACCEPTANCE CRITERIA AND DOC'MT. NOS.) TWP-M-0380 - REMOVE AND REPLACE CYLINDER LINERS - CAUTION BEFORE PARAGRAPH 5.2.4 - MATCH MARK

7 DESCRIPTION OF NONCONFORMANCE — NC CODE 113 (RELATE TO LINE NO. 6) PRIOR TO CYLINDER LINER PLACEMENT INTO BLOCK, CAUTION THAT STATES: UPON INSTALLATION, THE CYLINDER LINER BLOCK AND THE CYLINDER LINER MATCHMARKS SHOULD BE REALIGNED; WAS NOT OBSERVED FOR CYLINDER LINERS AS FOLLOWS: 1R out 1/8", 2R out 3/32", 3R out 7/16", 4R out 1/8", 5R out 1/16", 6R out 1/16, 8R out 1/8", 4L out 1/8", 5L out 3/32", 6L out 3/16", 7L out 7/16", 8L out 3/16",

8 CAUSE OF NONCONFORMANCE — CAUSE CODE F01 FAILURE TO FOLLOW PROCEDURE

9 PROPOSED DISPOSITION ☐ SCRAP (1) ☐ REWORK (2) ☐ REPAIR (3) ☒ USE AS IS (4)

JUSTIFICATION: See attached justification

10 STEPS TO PREVENT RECURRANCE See attachment

| | | | | |
|---|---|---|---|---|
| 11 RESP. ORG. APPROVAL | ENG./CONST. [signature] | QA/QC [initials] | AIA [initials] | DATE 12/13/84 |
| PNPP REVIEW BOARD | REVIEW REQ'D. ☒ YES ☐ NO | DECISION ☒ ACCEPT ☐ REJECT | | |
| | ENGINEER [signature] | DATE 12-13-84 | QA/QC [signature] | DATE 12/13/84 |
| 13 DISPOSITION VERIFIED | NAME [signature] | TITLE Lead Inspector | | DATE 12/13/84 |

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2

Attachment to
NCR QRC-1520
Rev. 0 Pg. 1 of 2

Justification:

1. Liner match marks are used to assure that a notch in the lower section of the liner is properly centered to allow clearance for Conn. Rod movement, and reinstallation of Lube Oil tubing.

2. A perfectly centered liner allows for more than 1 inch clearance on either side of the notch.

3. Tubing connections have enough flexibility to allow installation with this minor match mark discrepancy. If necessary tubing may be reworked per standard work procedures and is not considered a part of this NCR.

Steps to Prevent Recurrance

1. Installation crews used care to try an align match marks as close as possible. The nature of this installation causes some movement of the liner as it is being pressed into the cylinder block. PPD (NTS-SPSC) has been asked to use extreme care to minimize misalignment. Installation procedure shall be revised to allow 7/16" tollerance on match mark alignment.

ASP 12/13/84



A

R85-1460 Sheet 27 of 363
UP 02/04/85

DATE: 12-13-84

TO: Tony Pusateri

FROM: Travis Shelton

SUBJECT: Cylinder liners

DELAVAL

75051/54

A Transamerica Company

MEMO

DELAVAL
ENGINE AND COMPRESSOR DIVISION
INTER-OFFICE CORRESPONDENCE

QCC 1520

2 of 2

The cylinder liner punch marks located on liner & engine block is for reference only to align the cutout at the bottom of liner. This is for travel of the connecting Rod. There is no requirement for perfect alignment of the marks. Try and stay with-in 1/4" if possible as the liner will roll on installation.

If you stay with-in this 1/4 inch you will still have a good inch clearance from liner to rod. I have inspected liners that have NR-QQC-1520 & have found them acceptable.

Travis Shelton
TDI Rep.

5

REVIEWED FOR 10CFR50.55 (e) AND 10CFR21 REPORTABILITY. [illegible] 1-24-83 [illegible]

# PERRY NUCLEAR POWER PLANT NONCONFORMANCE REPORT

RECEIVED JAN 2 1 1983

(SP39)

| LINE NO. | | | | | | |
|---|---|---|---|---|---|---|
| 0 | NO. | | | | | |
| 1 | NCR: PD3911457 | 0 1 OF 8 | ITEM IDENT NO.: See Attachment | ITEM NAME: Standby Diesel | QUANTITY: 2 | HT-GEP-2349-50 |
| 2 | ISSUED BY | NAME: D.H. Bryant | | ORGANIZATION: GE/I&SE (GE39-0250) | | DATE: 012083 |
| 3 | ITEM MATERIAL | SOURCE: Owner | CURRENT STATUS: Conditional Release** | LOCATION: D/G Bldg. Rooms 5&7 | | |
| 4 | RESPONSIBLE ORGANIZATION | NAME: Project Organization | | SPEC. NO.: SP-39 | REV./ECN: 2 | |
| 5 | NCR TYPE | CATEGORY: ☐ 1 (POSSIBLE SIGNIF) ☐ 2 (MAJOR) ☐ 3 (MINOR) | TYPE: ☐ (E) EQUIP./MAT'L. ☐ (I) INSTALLATION ☐ (P) PROGRAM | | | |
| 6 | GOVERNING REQUIREMENT | (INCLUDE ACCEPTANCE CRITERIA AND DOC'MT. NOS.) FO 23825 requires a bearing of 85% | | | | |

under all equipment.

| | | | | |
|---|---|---|---|---|
| 7 | DESCRIPTION OF NONCONFORMANCE | NC CODE: 022 | (RELATE TO LINE NO. 6) | See page 3. |

EXHIBIT 56

| | | | |
|---|---|---|---|
| 8 | CAUSE OF NONCONFORMANCE | CAUSE CODE: 005 | Inadequate information from owner and vendor. |

**(Conditional Release-installation may continue. NR must be resolved before turnover of Diesel).

| | | |
|---|---|---|
| 9 | PROPOSED DISPOSITION | ☐ SCRAP (1) ☐ REWORK (2) ☐ REPAIR (3) ☐ USE AS IS (4) |

JUSTIFICATION: See Attachment

D.H. Bryant 2/14/83 — Quality Assurance Approval — Date

ANI Concurrence [illegible] N/A [illegible] 2/14/83

| | | |
|---|---|---|
| 10 | STEPS TO PREVENT RECURRANCE | See Attachment |

INFORMATION ONLY

| | | | | | |
|---|---|---|---|---|---|
| 11 | RESP. ORG'L APPROVAL | ENG./CONST. [signature] 2/3/83 | [signature] 2/4/83 | A/A | DATE |
| 12 | PNPP REVIEW BOARD | REVIEW REQ'D. ☑ YES ☐ NO | DECISION ☑ ACCEPT ☐ REJECT | | |
| | | ENGINEER: [signature] | DATE: 2/8/83 | QA/QC: Mark Palmer | DATE: 020983 |
| 13 | DISPOSITION VERIFIED | NAME | | TITLE | DATE |

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**Perry Nuclear Power Plant**

**MPL ATTACHMENT FOR NRs and DRs**

(Sold)

NO. 5175 REV. 11-80

| MCR | NO. | REV. | SHT. | OF | DESCRIPTION OF ITEMS |
|---|---|---|---|---|---|
| | | 0 | 2 | 8 | Standby Diesel |

| LINE NO. | MPL/QM NO. | ITEM COMP DATE | AUTHORIZED SIGNATURE | DATE |
|---|---|---|---|---|
| 1 | 1R43-C001A | 5/12/83 | [signature] 5/12/83 GE-0 / [signature] | 5-12-83 |
| 2 | 1R43-C001B | 5/12/83 | [signature] 5/12/83 GE-0 / [signature] | 5/12/83 |
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INFORMATION ONLY

GENERAL ELECTRIC

INSTALLATION & SERVICE ENGINEERING DIVISION



The diesels in Rooms 5 & 7 have bearing as indicated on pages 4 and 5 respectively. Diesel 1R43-C001A was grouted on 9/3/82 and Diesel 1R43-C001B was grouted on 8/25/82. Both a GE/I&SE production engineer and QC inspector were present during grouting along with a CQC civil inspector, a Delaval service representative and the CEI responsible engineer. Prior to grouting GE had met all alignment requirements specified by the Delaval vendor manual (96-0239-3-01) SF 39 (and all relevant ECN's), the GE Diesel Generator installation procedure (GEP-IP-0050 Rev. 3) and GE Travelers T1-R43-07 and 8. The bearing requirement was not brought to GE/I&SE's attention until after the grouting of 1R43-C001A, it was brought to our attention after grouting by the Delaval representative and confirmed by the referenced field question received by GE on 11/5/82.

Bearing contact data was taken after diesel engine foundation bolts were torqued to final value (3800 ft-lbs) but before generators were torqued (due to other technical problems). A crankshaft deflection check was also taken after torquing, data for this is presented on pages 6 & 7.

INFORMATION ONLY

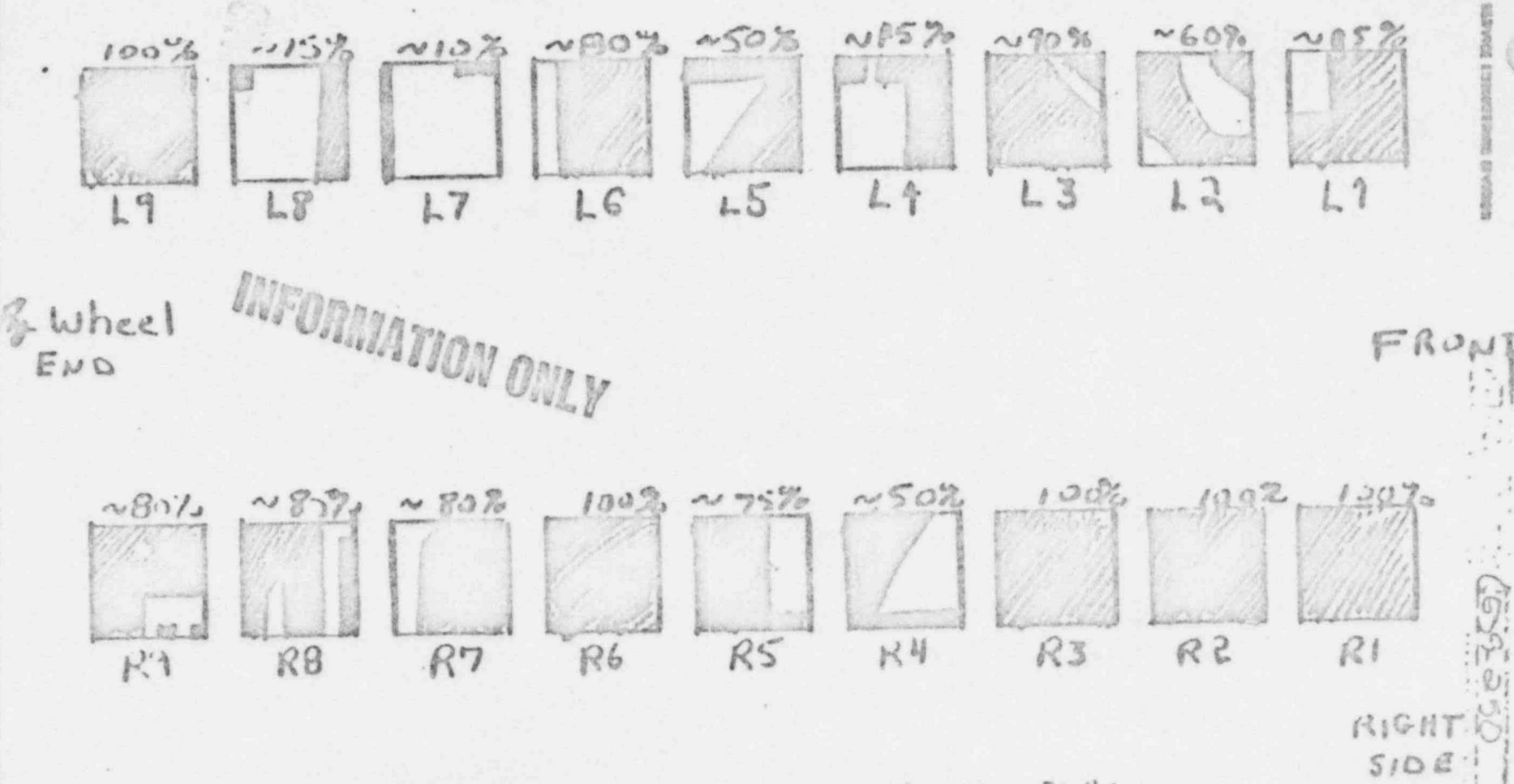
INFORMATION ONLY

Form No. 031180

GENERAL ELECTRIC

INSTALLATION & SERVICE ENGINEERING DIVISION

Engine 75051 - 1R43r001A
Room 5




INFORMATION ONLY

Notes: 1) Engine foundation bolts have final torque of 3800 ft lbs
2) Generator is not torqued.
3) shaded areas show bearing, unshaded area lack contact.

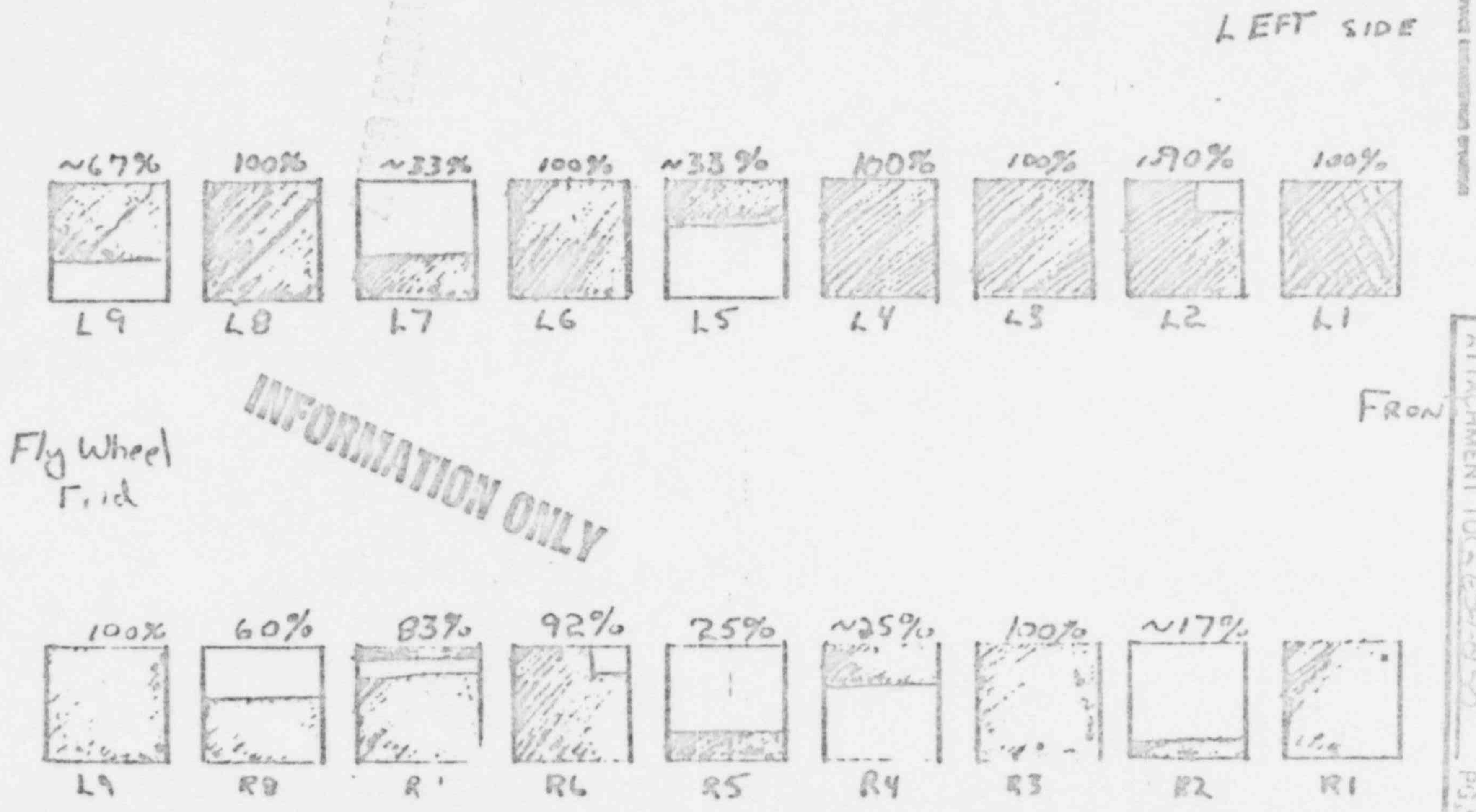
W ——→

Form No. 601103

GENERAL ELECTRIC
INSTALLATION & SERVICE ENGINEERING DIVISION

ATTACHMENT TO [illegible] PG 5 OF 6

Engine 75052 1R43C001B
Room 7




Notes: 1) Engine foundation bolts are torqued to 3500 ft-lbs
2) Generator foundation bolts are not torqued.
3) Shaded areas show bearing, unshaded areas lack contact.

Form No. 601-1C8

GENERAL ELECTRIC

GEP38.390088
CONT ON SHEET 2 SH NO 1

REV 0

GEP38/390088
CONT ON SHEET 2 SH NO. 1

TITLE CRANKSHAFT WEB DEFLECTION AND THRUST CLEARANCE RECORD

FIRST MADE FOR PERRY

REVISIONS
0 KTL 4-25-90

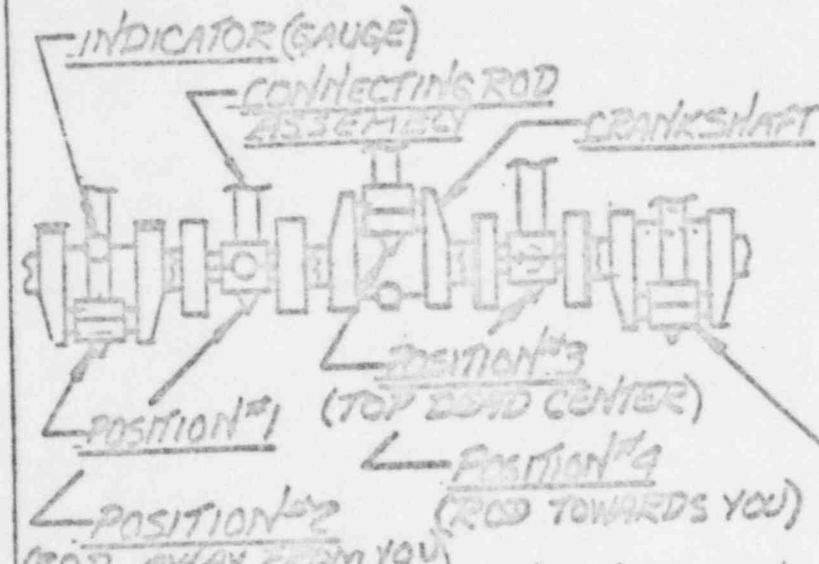
Delaval Form D-1063

# DATA SHEET GEPIP-0050A

PROD. FINAL SIGNATURE DATE

Q.C. FINAL SIGNATURE DATE

Engine 75051
Room 5
1R43C001B A [illegible]




RECORD READINGS IN MILS, I.E., 1¼ RATHER THAN 0.00125 INCHES

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|---|---|---|---|---|---|---|---|---|---|---|---|
| PLACE INDICATOR HERE ONLY | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | [illegible] |
| CRANK TOWARDS CRANK PIN | +1/4 | +1/4 | 0 | 0 | 0 | 0 | 0 | -1/4 | | | [illegible] |
| | +1/4 | 1 | 0 | -1/4 | 0 | -1/2 | +1/4 | -1/2 | | | [illegible] |
| | 0 | +1/2 | +1/4 | 0 | 0 | 0 | 0 | 0 | | | [illegible] |
| | 0 | +1/4 | +1/4 | 0 | 0 | 0 | 0 | +1/4 | | | [illegible] |

INFORMATION ONLY

PRINTS TO

MADE BY KTL 4-25-90 | ISSUED | GC | GEP38/390088

GENERAL ELECTRIC

GEP38/390088 — CONT ON SHEET 2 — SH NO. 1

REV 0

GEP38/390088 — CONT ON SHEET 2 — SH NO. 1

TITLE: CRANKSHAFT WEB DEFLECTION AND THRUST CLEARANCE RECORD

FIRST MADE FOR: PERRY

GE39-[illegible] [illegible]

Del-021 Form D-1063

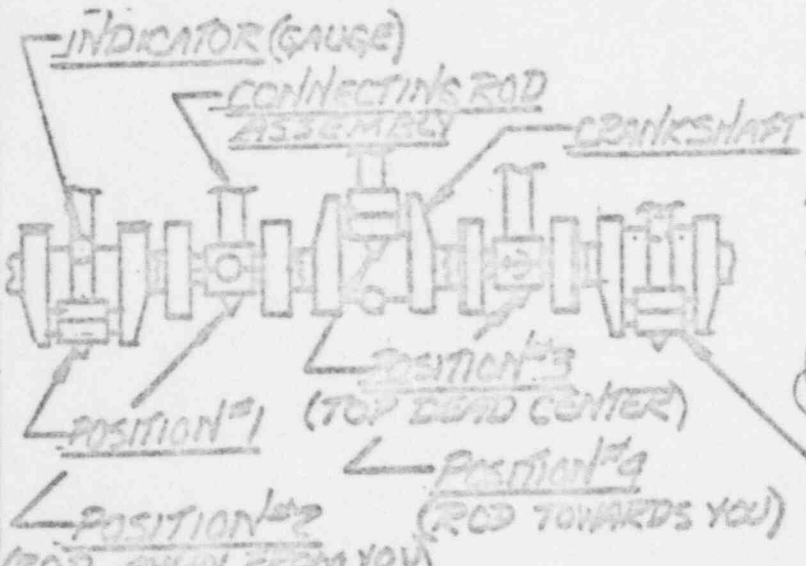
# DATA SHEET GEPIP-0050A

PROD. FINAL SIGNATURE ______ DATE ______

Q.C. FINAL SIGNATURE ______ DATE ______

Engine 75052
Room 7
1R33C001B

REVISIONS: 0 KTL 3-25-90




RECORD READINGS IN MILS, I.E. 1/4 RATHER THAN 0.00125 INCHES

CYLINDER NUMBER STARTING AT [illegible] END

| POSITION | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Position 1 (gauge) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | X | X | [illegible] |
| Position 2 (crank web, crank pin, rod) | 0 | +1/2 | +1/2 | +1/2 | +1/2 | +1/2 | +1/4 | 0 | X | X | [illegible] |
| Position 3 | 0 | +1/2 | +1/2 | +1 | +1/4 | +1/4 | 0 | +1/2 | X | X | [illegible] |
| Position 4 | 0 | +1/2 | +1/2 | +1/2 | 0 | +1/4 | +1/4 | +1 | X | X | [illegible] |
| Position 5 | 0 | +1/2 | +1/4 | 0 | 0 | 0 | +1/2 | +1 | X | X | [illegible] |

INFORMATION ONLY

PRINTS TO

MADE BY: KTL 3-25-90

ISSUED: GEP38/390088

R.L. 3-25-90 — PERRY SITE

[illegible] NUCLEAR POWER PLANT

FIELD [illegible]

No. 26[illegible] Rev. [illegible]/82 SP - 39

3C 226 3-0501 SY - F43

DATE 9/[illegible]

GF-441

ORIGINATOR
T. M. Bryan

ORGANIZATION
General Electric Co. - I & SE

PLANT BLDG. AREA
Diesel Generator Building

REFERENCE DOCUMENTS
VPF # 96-0239-1-01

PROBLEM

Is there a minimum bearing surface for the soleplates for the diesel engines (MPL # 1/2R43-C001A/B)? If so, is this minimum bearing surface to be per soleplate or overall?

ATTACHMENT GE35-580 PG 2 OF 8

DISTRIBUTED TO CONTRACTOR
DATE: 11-5-82

RECOMMENDED SOLUTION

Enfineering to advise.

RECEIVED
SEP 27 1982
PNPP DOCUMENT CONTROL

Robert Spinello
SIGNATURE

ENGINEERING RESPONSE

MATERIAL TO BE PURCH. BY P.O. YES ☐ NO ☐

Minimum bearing surface set forth for the Perry site is 85%. Delaval has provided calculations which provide for a much smaller % bearing Req.'ment. Bearing less than 85% is to be documented on a Nonconformance Report.

BY [signature] 11/5/82 GAI ENGINEER CONTACTED ________ NAME

SIGNATURE DATE

RECEIVED NOV 05 1982

GAI (FIELD ENGR.) CONCURRENCE BY J. Warren 11/5/82

SIGNATURE DATE

ADDED DOCUMENT NEEDED: ☐ FVA ☐ ECN NO. ________

422/J/1/mm

INFORMATION ONLY

Justification:

1.) Per the attached letter from Delaval, there is adequate bearing surface to accept the sole plates AS-IS.

2.) To provide a physical backup to the calculations Engine Deflection checks of the crankshaft are to be taken just prior to start-up and at 20 hrs and 168 hrs of operation. This will be added to the M.D.L. for eventual inclusion in the N.T.S. operating or testing procedures. This N.C.R. is to be closed upon verification of the M.D.L. list.



3) Prior to grouting rotating or non-rotating equipment the contractor is to verify location and correct shimming/bearing and levelness of the equipment. This is a standard engineering practice and is to be done on all equipment as part of normal installation practices. The N.C.R. decription (Line 7) is not to be used to provide a commercial disclaimer.

Deleted Per Rev. 1
[illegible] 4/4/83

Steps to prevent Recurrance:

1./ All Standby Diesel Engines have been grouted at this time.

2./ The Referenced Field Question is dated 11/5/82 and this N.C.R. is dated 01/20/83. SP39 is to provide immediate notification (via an N.C.R.) when a non conforming condition is found. The unit #2 engines were grouted in this time period. (Bearing was verified however).

Transamerica Delaval

Transamerica Delaval Inc
Engine and Compressor Division
550 85th Avenue
P.O. Box 2161
Oakland, California 94621
(415) 577-7400

Attachment to NCR P039-1457
Pg 3 of 5

October 22, 1982

Cleveland Electric Illuminating Company
P.O. Box 97
Perry, Ohio 44081

Attention: A.P. Pusateri

Subject: Perry Power Plant
Units S/N 75051/54

Reference: Your Letter to Sc. Schumacher Dated 10/5/82
(Chock Plate Bearing Area)

Gentleman:

Please find attached the diesel engine minimum load bearing area calculations required per chock plate as you requested in your letter of 10/5/82.

It is recommended that adjustments be made on units 75053/54 prior to grouting. Allowing for maximum contact thereby preventing the possibility of rework.

If you should have any further questions, please do not hesitate to contact this office.

Regards,

Lee Duck
Engineer, Customer Service

LD/vem

CC: E.A. Putre

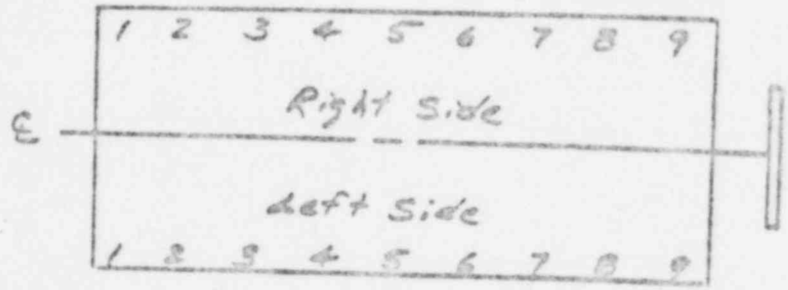
INFORMATION ONLY

INFORMATION ONLY

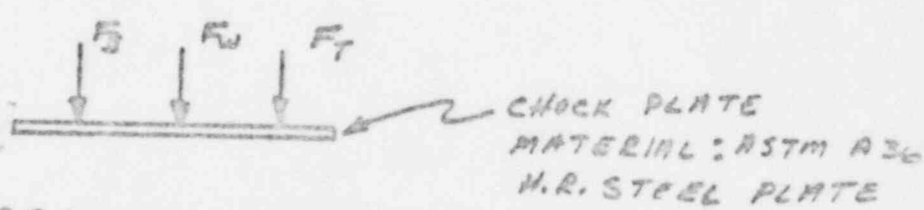
CC: P.B. Ricci(Sales)
Bob Bailey
S. Schumacher
D. Wulf
Travis Gilstrap

| ENGINE CALCULATIONS | 75051/4 ENGINE / ASSY. / NO. |
|---|---|
| SUBJECT: ENGINE 75051/4 CHOCK PLATE BEARING AREA | SHEET 1 OF |
| | DATE 10/12/82 |
| PART NO. | BY |

DETERMINE THE BEARING AREA REQUIRED TO SUPPORT THE ENGINE WEIGHT, BOLT PRELOADING, AND DYNAMIC LOADING.




THERE ARE NINE CHOCK PLATES PER ENGINE SIDE.




$F_B$ = BOLT TORQUEING LOAD

INFORMATION ONLY

$F_W$ = ENGINE WEIGHT/CHOCK PLATE LOAD

$F_T$ = ENGINE TORQUE/CHOCK PLATE LOAD

ENGINE WEIGHT ≅ 300,000 LBS.

$F_W = \frac{300,000}{18} = 16,666$ LBS

$F_B$ = 137,484 LBS. for 3800 ft-lbs. of torque on a 2" bolt using 50-50 mix of graphite and oil

$F_T = \frac{113326 \text{ FT·LBS ENGINE TORQUE}}{3.476 \text{ FT. to CHOCK PLATES} \times 9} = 3625$ LBS.

ENGINE CALCULATIONS

75051/4

SUBJECT: ENGINE 75051/4 CHOCK PLATE BEARING AREA

SHEET 2 OF 2

DATE

PART NO.

BY

$F_{Total} = F_B + F_W + F_T = 180,186$ LBS.

SINCE $F_T$ IS ONLY 2% OF $F_{TOTAL}$, ASSUME $F_{TOTAL}$ TO BE A STATIC LOAD ONLY.

THE YIELD STRENGTH, $S_y$, OF THE CHOCK PLATE IS 32,000 PSI.

FACTOR OF SAFETY = 2.0

$$\text{REQUIRED BEARING AREA} = \frac{F_{TOTAL} \times 2}{S_y}$$

$$= \underline{\underline{11.2616 \text{ IN.}^2}}$$

THE SURFACE AREA OF THE INTERMEDIATE CHOCK PLATES WHERE THE 10% CONTACT IS OCCURRING IS 145.1 IN². TEN PERCENT OF 145.1 IS 14.51 IN². SINCE 11.26 IS LESS THAN 14.51, THE CHOCK PLATES WILL NOT FAIL. ☒

INFORMATION ONLY

10/20/82

# SECTION 2
# INSTALLATION

## GENERAL.

The installation of a DELAVAL Engine and Compressor Division "Enterprise" engine may vary from site to site, therefore, the instructions contained in this section of the manual are representative of a typical installation and not necessarily the exact procedure for a specific site. Certified installation and foundation drawings are furnished to each customer which detail the dimensions and installation requirements for that particular unit.

## FOUNDATION DRAWING.

The foundation drawing will be accurately dimensioned and must be carefully observed. Carelessness in locating foundation bolts, pipes, conduits and drains will cause difficulty during installation and alignment. It is essential that the foundation be constructed to standards of the highest accuracy.

## INSTALLATION DRAWING.

The installation drawing details the measurements for machinery location, distances required for normal maintenance tasks and the overhead clearances necessary for piston removal. In addition the drawing will indicate the location and size of connection points for pipes and the electrical requirements for alarm and control mechanism.

## SYSTEM SCHEMATIC DRAWINGS.

Electrical and flow diagrams are furnished for the various systems. Flow diagrams specify pipe sizes and the type and location of fittings and apparatus. These represent minimum requirements. To insure compatibility, any changes should be approved by DELAVAL Engine and Compressor Division engineers before installation.

## HANDLING AND SHIPMENT.

Care must be exercised during the shipment and handling of the engine and associated equipment during installation to avoid damage. The unit should be lifted only from the lift pads on the side of the engine base (where provided) as indicated on the installation drawing. When securing the engine during shipment or other movement, make sure no binding stresses are imposed on the engine base or crankshaft.

EXHIBIT 57

## FOUNDATION.

Make a foundation bolt template, using the certified foundation drawing to determine the location of the equipment mounting bolts. See figure 2-1 for a suggested method of building the template. Exercise care in locating bolt centers. Place and support the template from the foundation forms. Anchor securely to prevent movement of the template. Thread foundation bolt into lower nut in pipe sleeve being careful not to damage cap at bottom of nut. Insert foundation bolts and sleeves in holes provided in the template then tighten the upper nuts. Sleeves must be securely held in correct position to prevent any movement when pouring concrete. A suggested method is to use reinforcing rods welded to each sleeve or on top of each anchor plate in both rows of bolts, running the length of the engine, and adding "X" bracing between the two rows of bolts. Another suggestion is to tie the bolt assemblies to other reinforcing rods already in the foundation. *Recheck template position, alignment and elevation before pouring concrete.* It is recommended that a DELAVAL Engine and Compressor Division service representative be present to check bolt layout. The foundation is to be poured monolithic and must be suitably reinforced with reinforcing steel. Let concrete set for 10 days before installing equipment, and 30 days before running equipment.

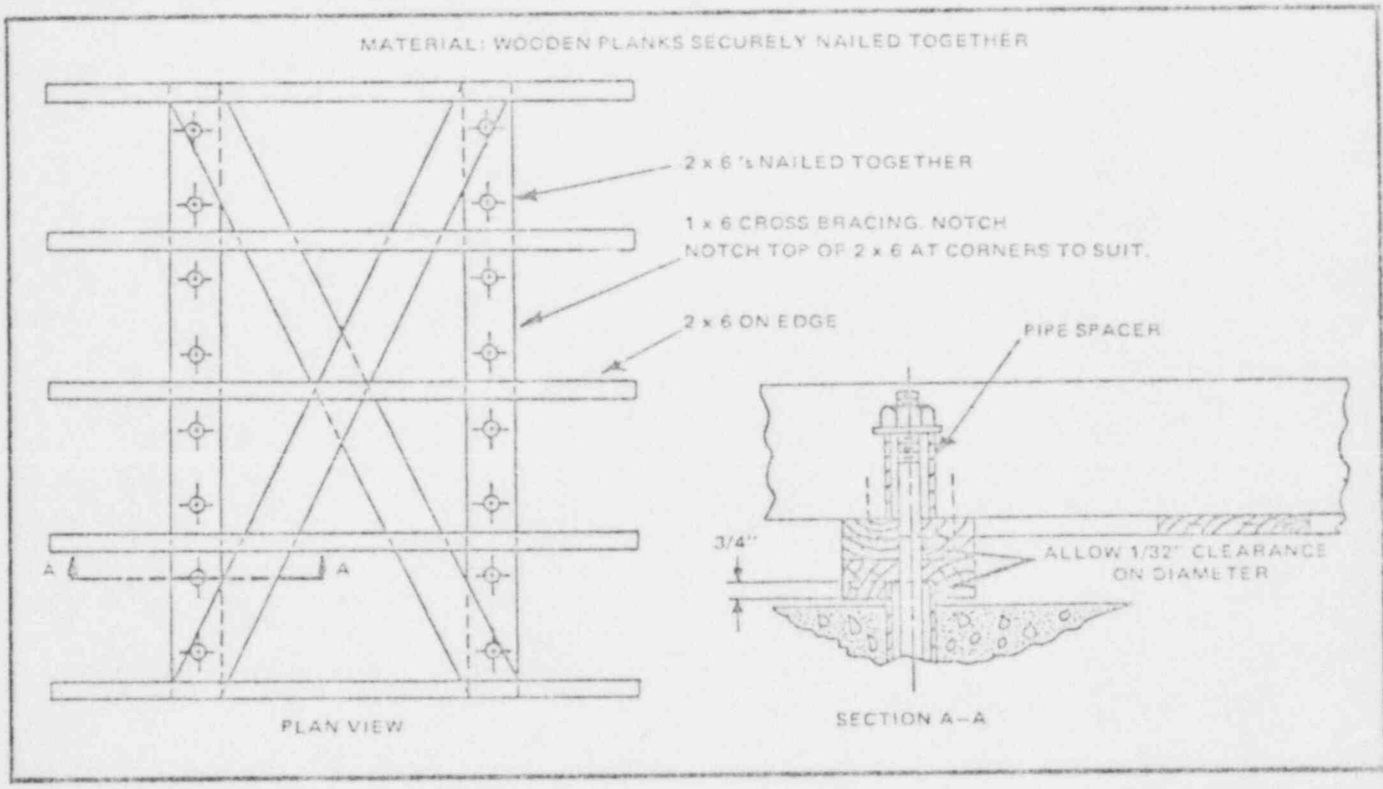



*Figure 2-1. Suggested Foundation Bolt Template*

## FOUNDATION BOLT ASSEMBLIES.

The foundation bolts are so designed that the anchor studs can be removed from the anchors after the foundation has been poured. This permits the engine to be placed over the foundation without any interference or danger of damage to the studs. Once the engine is in place, the studs are installed and screwed into the anchor assemblies.

DELAVAL ENGINE AND
COMPRESSOR DIVISION
550 – 85th AVENUE
OAKLAND, CALIFORNIA 94621



PREPARATION FOR INSTALLATION.

Before landing the unit on the foundation, the surfaces of the foundation must be roughened wherever grout is to be applied. Chip and clean as necessary to remove all laitance and foreign matter so that the clean, dry, sharp aggregate required for a good bond to epoxy grout is exposed. The machined surfaces of the sole plates and chocks must be thoroughly cleaned and the leveling screws waxed to prevent their sticking to the grout. The machined bottom faces of the engine base must also be cleaned thoroughly. Remove engine foundation bolts. Place steel plates at jacking screw locations, level plates and grout in place.

PLACING ENGINE OVER FOUNDATION.

Position engine over foundation and insert four toe jacks, one at each corner of the engine, inboard of the shipping skids. If engine is rolled into position, the ends of the jacking screw shields and foundation bolt shields must be protected to avoid damaging shield ends with the rollers. Do not place jacks in the center of the engine as this could cause damage to the engine base. Insure that the combined capacity of the jacks is at least fifty percent greater than the total weight of the engine. See Installation Drawing for weights.

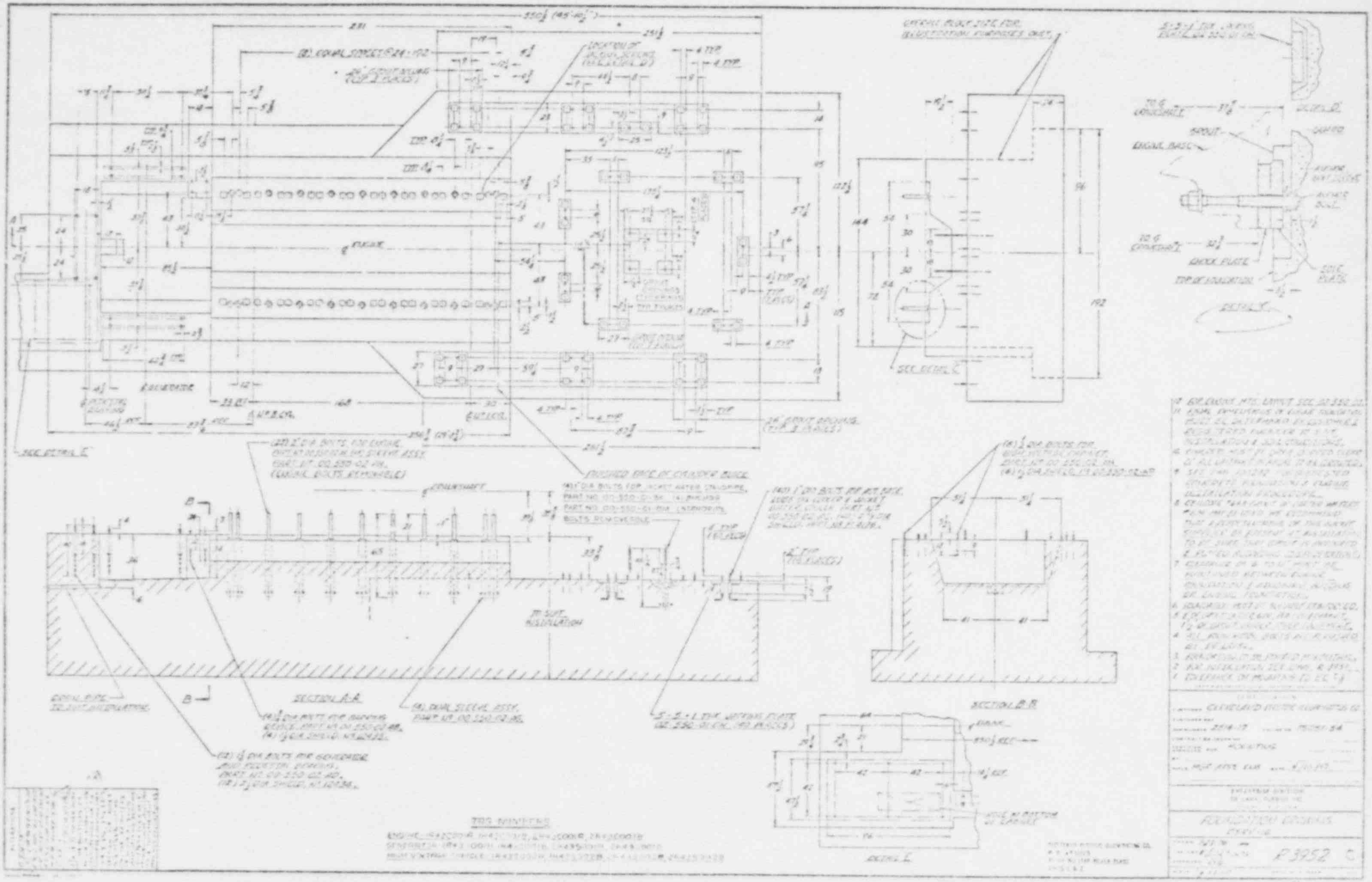
a. Remove shipping skids, thoroughly clean mounting rails and then lower engine to grade. Be sure the foundation bolt holes in the engine base are correctly aligned with the foundation bolt sleeves in the foundation for easy installation of the foundation bolts.

b. Clean sole plates and chocks with a degreasing type solvent. It is recommended that after the sole plates are washed, they be primed with a primer recommended by a grout manufacturer. Lubricate the threads of the jacking screws with a mixture of powdered graphite and engine lubricating oil. The lower end of the jacking screws should be coated with wax to prevent the epoxy grout material from binding to the screws.

c. Place sole plates and chocks in position under the engine as shown in the foundation drawing. Install sole plate retainers on the front and rear sole plates, making sure the sole plates are forced tightly against the shoulder at the inner edge of the engine mounting rails.

d. Lubricate lower threads of the foundation bolts with standard graphite and oil mixture, install bolts in sleeves and screw firmly into the threads at the bottom of the sleeve. Lubricate threads at the upper end of foundation bolts with oil and graphite powder then place washers and nuts on bolts.

e. Level and align the engine. Refer to Section 6, Part D of this manual for the method of taking crankshaft web deflection measurements. Record web deflection measurements on Form D-1063. Insure that all sole plate jacking screws are so adjusted as to distribute the weight evenly on all sole plates. When leveling and alignment is satisfactory, snug down the foundation bolt nuts to prevent movement of the engine during installation of the driven equipment and grouting.



SECTION A-A
SECTION B-B
DETAIL "X"
DETAIL "E"
CLEVELAND DIESEL
2514-17
MOUNTING
FOUNDATION DRAWING
P3952 C

EXHIBIT 5a



# Instruction Manual

## PART D — CRANKSHAFT AND BEARINGS (Continued)

### CRANKSHAFT ALIGNMENT AND THRUST CLEARANCE.

It must be emphasized that excessive crankshaft deflection can lead to an ultimate catastrophic failure of the crankshaft. This is costly in both time and money. It is recommended that crankshaft alignment and thrust clearance be measured immediately after grouting or chocking of the unit, the day before initial start up, after the first seven days of continuous operation, and at six month intervals thereafter. Refer to Transamerica Delaval Engine and Compressor Division Form D-1063 (see figure 6-D-4) for an outline of these procedures. Note that space is provided for recording both deflection and thrust clearance readings. Copies of this form may be obtained from Transamerica Delaval.

### CHECKING THRUST CLEARANCE.

Experience has shown that the feeler gauge method of measuring thrust clearance does not always produce satisfactory results. The dial indicator method is recommended to produce the desired accuracy of readings. A Starrett No. 196, or similar, type dial indicator with magnetic base and extension rod long enough to allow the indicator to be mounted between the engine and flywheel with the spindle bearing on the flywheel. Check thrust clearances as follows:

a. Start auxiliary (B&A) lubricating oil pump. Bar engine over at least one-half revolution to establish an oil film between the main bearings and their journals. This should permit easy movement of the crankshaft.

b. Mount dial indicator on rear of engine frame, between frame and flywheel. Spindle of indicator must bear on flywheel to measure horizontal movement of the crankshaft.

c. The crankshaft may be moved forward and aft in the horizontal plane with a pry bar such as a heavy, spade-type, tempered steel digging bar, approximately six feet long. Make sure bar is clean enough for use inside the engine. Insert bar between rear crank web and nearest frame member inside crankcase. Do not insert bar deeply enough to damage either the main bearing shell or the crankshaft journal.

d. Pry crankshaft forward, towards the gearcase end as far as it will go. If the crankshaft is all the way forward, it should be impossible to insert a 0.0015 inch feeler gauge between the crankshaft rear thrust collar and the rear thrust ring. Zero the dial indicator, allowing for at least 0.050 inch movement towards the minus direction.

**Note**

If crankshaft cannot be moved to the limit of its possible travel by use of the pry bar alone, it may be necessary to bar the engine over with the barring device while at the same time exerting a horizontal force on the crankshaft with the bar to move it.

e. Reposition pry bar to move crankshaft to the rear, towards the flywheel end. Pry crankshaft to the rear as far as it will go as indicated by the inability to insert a 0.0015 inch feeler gauge between the forward crankshaft thrust collar and the forward thrust ring.

f. Observe dial indicator. The number of thousandths (minus) indicated on the dial is the crankshaft thrust clearance. Record reading in the appropriate space on Form D-1063, and compare with previous thrust clearance readings.

**Note**

If there is any doubt as to the accuracy of the reading, repeat procedure.

## PART D – CRANKSHAFT AND BEARINGS (Continued)

### CRANKSHAFT WEB DEFLECTION.

The importance of crankshaft web deflection measurements is such that the care and attention to detail required to obtain and record these measurements cannot be overemphasized. Placement of the dial indicator is vital if accurate readings are to be obtained. Form D-1063 (see figure 6-D-4) illustrates the five positions of the crankshaft at which web deflections are to be measured, and the starting position of the crankshaft for each crank web. Care must be exercised to insure that the dial indicator is positioned in the center of the web, exactly opposite the center of the crankpin, and one-fourth inch from the edge of the crankweb. Take deflections as follows:

a. Remove engine side doors to gain access to the crankcase.

b. Bar engine over in direction of normal rotation with barring device until number one crank is 52 degrees after vertical bottom center.

c. Insert dial indicator between web for number one crank. Double check that crankshaft is properly positioned. If not in correct position, it is possible that the connecting rod will knock the dial indicator out of the web as the engine is barred over to the next position. Insure the two bearing points of the indicator are in a line exactly parallel to the centerline of the crankshaft. If indicator is not parallel, erroneous readings will be obtained. Zero the indicator.

d. With the dial indicator in place and not disturbed, bar the engine over, stopping at each position (2,3,4 & 5) as indicated on form D-1063. Record reading at each position in mils (plus or minus) in the appropriate space for each position.

e. Repeat entire procedure for each crankshaft web and record readings on Form D-1063.

f. Compare all readings with each other and with previous measurements. Evaluate results, based on the standards set forth in the following paragraph, and determine need for corrective action.

### DEFLECTION STANDARDS.

If the deflection in any crank of an engine in service exceeds 3 mils (0.003 inch/0.0762 mm), corrective action is indicated. If the deflection in any web exceeds 6 mils (0.006 inch/0.1524 mm), the engine should be taken out of service until the fault is corrected. Corrective action is also necessary of the total deflection in any pair of adjacent cranks exceeds 3 mils. For example, if the deflection in one crank is plus two mils, and the deflection in an adjacent crank is minus two mils, the total deflection is four mils, and corrective action is indicated.

### CORRECTIVE ACTION.

The nature of the corrective action needed to deal with excessive crankshaft deflections will vary, depending upon the specific cause of the defect. The cause may be worn main bearings, improper foundation bolt torque, the foundation itself, or the grouting, misalignment of the engine and/or driven equipment, or a combination of elements. For instance, excessive deflection at positions two, three or four in the crank web adjacent to the external shafting on engines having a solidly coupled connecting shaft usually indicates misalignment between the connecting shafting and the engine crankshaft. In some cases replacement of main bearings may correct the problem, and often the problem is correctable by realignment of the engine. If one portion of the engine base is found to be lower than other parts, it may be necessary to jack the base with jacking screws and shim the low area. It must be emphasized that engine alignment is a complex, trial and error procedure which should be undertaken only by experienced and qualified personnel who are capable of correctly interpreting the web deflection pattern, and of taking the appropriate measures to correct defects. It is recommended that the Transamerica Delaval Engine and Compressor Division Customer Service Department be consulted prior to undertaking any corrective measures involving a suspected or confirmed crankcase alignment problem.

LIST 30A - SITE AND INDUSTRY COMBINED - BY UTILITY NUMBER
EXPERIENCE ITEMS ADDED TO COMPONENTS AFTER 7/1/84 ARE DATED.
EXPERIENCE ITEMS REMOVED FROM COMPONENTS AFTER 7/17/84 ARE DATED.
EXPERIENCE ITEMS UPDATED AFTER 7/31/84 ARE DATED.

| OWNERS GROUP COMP NO | COMP CLASS | DESIGN RVW | QUALITY RVL | DESIGN ACC | QUALITY ACC | PERRY COMP NO |
|---|---|---|---|---|---|---|
| 03-550 | B | X | X | S | Z | 02-550 |

************************************************************************************************

FOUNDATION BOLTS - ANCHORS, BOLTS, MISC. HARDWARE

************************************************************************************************

PERRY EXPERIENCE:
NONE

************************************************************************************************

RECOMMENDED DESIGN REVIEW ATTRIBUTES:

1) REVIEW SEISMIS QUALIFICATION REPORT.

************************************************************************************************

RECOMMENDED QUALITY REVALIDATION ATTRIBUTES

1) ASSEMBLE AND REVIEW EXISTING DOCUMENTATION.

************************************************************************************************

NUCLEAR INDUSTRY EXPERIENCE:

1) DIESEL GENERATOR TRIPPED. INSPECTION REVEALED DAMAGED ROD, MAIN BEARINGS, CRANKSHAFT, SEVERAL PISTONS. A BASEPLATE MOUNTING SCREW FOUND LOOSE, WHICH MAY HAVE NOT ALLOWED UNIFORM EXPANSION, MAY HAVE CONTRIBUTED TO FAILURE. ANALYSIS FOUND OIL WITHIN SPECIFICATIONS.
SOURCE: NOS: MANUFACTURER:
LER ARKANSAS NUCLEAR 2, 368-78016, 781109 FAIRBANKS-MORSE

************************************************************************************************

NON-NUCLEAR INDUSTRY EXPERIENCE:

1) SEVERAL ENGINE BOLTS SHEARED OFF DUE TO AN EXCESSIVE GAP BETWEEN THE ENGINE SKID AND FOUNDATION PAD. RAFHA/SAUDI ARABIA
SOURCE: NOS:
OTHER TELEX FROM BAILEY (TDI) TO G. KING (TDI) DATED 04/15/81 (FILE #T-42)

2) ENGINE FLEXED ON FOUNDATION CAUSING ENGINE COVER BOLTS TO BREAK. CAUSED BY GAP BETWEEN SKID AND CHOCK PLATES. TDI HAND GROUND CHOCK PLATES TO ACHIEVE FULL FACE CONTACT WITH THE SKID.
SOURCE: NOS:
OTHER TELEX FROM BAILEY (TDI) TO DELAVAL HQ (FILE NO. T-49)
(RAFHA/SAUDI ARABIA)

3) (DELETED 10/31/84)

EXHIBIT 59

DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

EXHIBIT 60

From: [illegible]
To: [illegible]

Subj: Investigation to inquire into the causes of [illegible] failure [illegible] on USCGC NORTHWIND [illegible]

PRELIMINARY STATEMENT

1. This investigation was carried out as an engineering design review coupled with an analysis of maintenance requirements, and an evaluation of the extent to which these requirements were met. The underlying objective was to establish if a design or maintenance problem was the cause of NORTHWIND's main engine casualty, and if so, what corrective action would be needed. The design review involved interfacing with three civilian firms, who were extremely slow in responding to requests for information. Because of their sluggishness, this report was delayed beyond the deadline set in the convening order.

2. No parties were named to the investigation because the evidence did not indicate a potential for disciplinary action or that anyone's personal or professional reputation would be jeopardized.

FINDINGS OF FACT

1. NORTHWIND's Main Diesel Engines (MDE's) are Delaval Enterprise Model DSR-46 rated at 3000 HP @ 450 RPM developing 35,034 ft.-lbs. torque at these operating conditions. The overspeed trip is set @ 510 RPM, each engine weighs about 103,000 lbs.

2. MDE's #1A and #2A are located in the forward engine room, B-1E. MDE's #1B and #2B are located in the aft engine room, B-3E. Each engine drives a different generator in B-2E.

3. The MDE's have nine bearings on the crankshaft with number 5 bearing the center bearing.

4. NORTHWIND's engines were manufactured in 1972 and all applicable Service Information Memorandum (SIM's) were incorporated at that time.

17. Bolts manufactured in accordance with MIL-S-001222G (SHIPS) Grade 1 hot rolled steel have a tensile strength of 60 - 100 ksi; whereas, Grade 8 bolts (less than 2-1/2") would have tensile strength of 150 - 170 ksi.

18. Specifying torque is not a good indication of the tensile force in a bolt due to a wide variance in torque coefficients with lubrication type.

19. The stress in the Chockfast Orange chocks was designed to be 454.29 psi. (See enclosure 49). Engine torque adds an additional ± 10.2 psi of chock loading. This is within the design criteria recommended by Philadelphia Resin Co.

20. Transamerica Delaval's SIM # 230 of 11/4/71 permits the use of Philadelphia Resin Co. #PR-610TC (Chockfast Orange) under marine engines.

21. During initial installation of DSR-46 engines, the Position 3 crankweb deflection at both end throws should be +.002" and at the center throw -.00075" to allow for differential engine and generator growth.

22. Transamerica Delaval SIM # 237 of 4/25/72 states that, for Model "R" engines with 13" crankshaft, if crankweb deflections are in the range of .0045" to .0090", investigate and correct. The engine is to be taken out of service if crankweb deflections exceed .009". DSR-46's are Model R engines.

23. Transamerica Delaval Form D-1063 allows a maximum of .003" crankweb deflection on engines in service before any corrective action is required.

24. Transamerica Delaval Form D-1036 is for use during initial installations, when trying to achieve the best possible alignment.

25. On NORTHWIND the maximum recorded MDE crankweb deflections to date were:

#1A MDE .0055" on 18 Dec 1978

#1B MDE .0032" on 14 Nov 1978

#2A MDE .0085" on 22 Jun 1976 (this is a one-time occurrence; other maximums were .0035" on many occasions)

#2B MDE .0030" on 15 Dec 1978

26. Hot crankweb deflections must be taken in order to get a true picture of engine alignment. The engines must be run under load 8 - 12 hours in order to get hot crankweb deflections.

27. The taking of crankweb deflect[illegible] is required, by par. 9412.5 of CG-413 (NEM), only after each m[illegible] [illegible]erhaul, unless damage is suspected as a result of grounding.

28. NORTHWIND's MDE foundation bolts were sounded more frequently than at the 4100 hours of engine operation recommended by Transamerica Delaval and required by CG-413 (NEM).

29. Loose MDE foundation bolts were found by NORTHWIND's ships force late in February 1978. However, this information was not passed up the chain of command.

30. Sounding of the MDE foundation bolts has at times been done by inexperienced personnel. At times, only the 2" body bound bolts were sounded.

31. The command became aware of loose MDE foundation bolts late in August 1978. However, the Commanding Officer did not fully appreciate the problem until early October 1978.

32. Transamerica Delaval SIM # 64 sets the torque value for main bearing cap bolt nuts at 1500 ft.-lbs., for hot rolled steel foundation bolt nut at 700 ft.-lbs. and for 4140 HT steel foundation bolt nuts at 1400 ft.-lbs.

33. On 30 May 1979, Transamerica Delaval officially notified the Coast Guard in a letter to CDR J. D. Vitkauskas, CCGD5(mmt), of an increase in the recommended torque value for the main bearing cap nuts to 2,050 ft.-lbs. .

34. Transamerica Delaval SIM # 64B states that active bolts, such as foundation bolts, will be broken when the preload is allowed to decrease to the point where movement can occur between bolted parts. Breakage usually occurs in the threaded area. The torque specified is SIM # 64 is sufficient to prevent cyclic stretching and relieving, and must be retained.

35. The chocks removed from under the MDE's carried the impression of the structural foundation roughness and the machine marks on the engine base.

36. Five MDE foundation bolts were chemically and physically tested, the result being that: 1 bolt was similar to AISI 1020 of ASTM-108, 3 bolts were similar to resulfurized AISI 1116 of Fed. Spec. QQ-S-637, and 1 bolt was similar to AISI 1018 of ASTM A-108.

37. Resulfurized steel has a reduced fatigue limit as opposed to conventional steels.

38. Not all the foundation bolts installed on NORTHWIND during re-engining were available when the investigation started. Thirteen 2" bolts, and 23 1-1/2" bolts were recovered. One 1-1/2" bolt had its head broken off.

39. The unthreaded length of 13 of the 16 2" MDE foundation bolts varied from 9.0625" to 9.1875".

40. The unthreaded length of 23 of the 40 1-1/2" MDE foundation bolts varied from 9.4375" to 10" with 12 bolts having unthreaded lengths greater than 9.75".

41. The major thread diameter of 23 of the 40 1-1/2" MDE foundation bolts varied from a maximum of 1.497" to a minimum of 1.491".

42. The major thread diameter of 13 of the 16 2" MDE foundation bolts varied from a maximum of 2.0005" to a minimum of 1.998".

43. As designed, the nominal distance from the top of the engine base to the bottom of the bed plate was 9-1/2".

44. The #5 main bearing saddle on all NORTHWIND's MDE's was fractured in the vicinity of the alignment dowel pin holes and the main bearing cap bolt holes.

45. Repairs to the #5 main bearing saddles involved machining out portion of the saddle and installing steel block in way of the machining.

46. Recent engineering studies done by Transamerica Delaval show that when the DSR-46 engine overspeeds the inertial forces created by the moving parts is of sufficient magnitude to cause relative motion between #5 main bearing cap and saddle. This could initiate cracks in the saddles.

47. To operating personnel, NORTHWIND's MDE's 1B and 2A appeared to vibrate more than the other two MDE's.

48. NORTHWIND experienced the following vibration related casulaties:

a. Fractured 4 turbo charger mounting bracket bolts.

b. Fractured 3 exhaust bellows.

c. Many lube oil and water pump failures, with associated piping failures.

d. One exhaust pipe failure.

e. Three governor failures.

49. The foundation bolts nuts did not require excessive force to remove in October 1978.

50. Dye penetrant checks of one 1-1/2" bolt, which was split in half, did not show any fractures anywhere along the bolt.

DEPARTMENT OF TRANSPORTATION
U.S. COAST GUARD

ACTION MEMO - NAVAL ENGINEERING DIVISION - G-ENE

| ORDER | | | | STAFF SYMBOL | ATTENTION | ORDER | A.T. | INITIAL | DATE | STAFF SYMBOL | ATTENTION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | DIVISION CHIEF | 2 | P | | | 5 | DESIGN BRANCH |
| | | | | 1A | Secretary | | | | | | Secretary |
| | | | | | | | | | | 5A | Asst. Branch Chief |
| | | | | 2 | ASST. DIVISION CHIEF | | | | | 5B | H-M |
| | | | | 2A | Training & Personnel Asst. | 1 | P | JPL 12/1 | | 5C | Machinery |
| | | | | | | | | | | 5D | Conceptual & Arrangement |
| | | | | 3 | SHIPBUILDING BRANCH | | | | | 5E | Electrical |
| | | | | | Secretary | | | | | 5F | Specifications |
| | | | | 3A | Design Project Officers | | | | | | |
| | | | | | | | | | | 7 | MANAGEMENT BRANCH |
| | | | | | | | | | | | Secretary |
| | | | | 3D | | | | | | 7A | |
| | | | | 3E | Planning-Estimation | | | | | 7B | Administrative |
| | | | | | | | | | | | Mail & Files |
| 3 | K | | | 4 | CUTTER MAINTENANCE BR. | | | | | | Plan Files |
| | | | | | Secretary | | | | | | |
| 4 | K | | | 4A | Icebreakers | | | | | 9 | BOAT CONST. & MAINT. BR. |
| | | | | 4B | WHECS | | | | | | Secretary |
| | | | | 4C | WMECS | | | | | 9A | Boat Support |
| | | | | 4D | A-to-N Cutters | | | | | 9B | Boat Technical |
| | | | | 4E | Ordnance | | | | | | |
| | | | | 4F | Special Projects | | | | | G-E | |

EXHIBIT 61

REMARKS

12/1/78 Re: Northwind MDE Foundation

Per verbal request from 4A, DeLaval's Engineering Dept. was contacted concerning recommended bolt torques and steel vs. resin chocks.

Persons contacted: WARREN RHOADES - MANAGER, ENGRG
BURT DURIE - APPLICATIONS ENGR

They would like to see us use steel chocks and 1400 ft-lb on this application. They do give their blessing to resin chocks for customers wishing to use them but recommend the bolt torque at 740-780 ft-lb. They don't seem to pay much attention to area of chock vs. bolt torque (in contrast to Phila. Resins and the Classification Societies).

In short, their reasoning against lower torques, resin chocks, and high torque on larger chocks (resin) were not convincing.

ENE-5 recommendation remains as given in the recent memo, i.e. 900 & 1200 ft-lb on $9\frac{1}{2}" \times 9\frac{1}{2}"$ resin chocks. [initials]

Serial 10 ...

Summary of telephone call with Mr. J. Wilson of Philadelphia Resin Co. on 2 April 1979

1. Chockfast Orange chocks are designed so as to limit compressive stress to 500 psi which is well below the compressive strength of the material (19,000 psi). This design criteria is based on small scale testing done by Lloyds. The tests done are sensitive to specimen size; but retesting using larger specimens so as to increase allowable load was not justified. Failure during Lloyds testing was by creep.

2. A chock removed from NORTHWIND was sent to Philadelphia Resin for testing and found to be within specifications for the material. No edge bulging indicating creep was seen. Satisfied that the chocks performed as expected and did not cause the problem.

3. Commercial vessels fitted with diesel engines often have loose foundation bolts.

4. Shoreside industrial applications are often designed for a continuous load of 1,200 psi and intermittent loads of 5,000 psi.

5. Chockfast Orange is not subject to fatigue failures. The chocks would have a polished appearance if the engines were sliding on the chocks.

6. The maximum possible chock area should be used. The original Wind Class chocks were somewhat small for 1,400 ft.-lbs. foundation bolt torque if the chock loading was to stay below 500 psi. The Coast Guard chose to use less bolt torque against the recommentations of Delaval.

7. Pins should be installed on the foundation in the vicinity of the MDE chocks so as to provide a means whereby any relative motion between the engine bed and the foundation can be measured.

EXHIBIT 62

Enclosure (21)

BY........ DATE........ 

CHKD. BY........ DATE........ FOUNDATION BOLTS & ........ JOB NO........

CHOCKS

CHECKING & BOLTING CRITERIA (BASED ON ... ... )

CHOCKFAST ORANGE FOR 40°F-140°F AMBIENT [REF (e)]

A. MAXIMUM DEADWEIGHT LOADING ≤ 100 PSI

B. MAX DEADWEIGHT + BOLT TENSION ≤ 500 PSI

C. BOLT TENSION ≥ 2.5 × DEADWEIGHT LOADING

R-46 ENTERPRISE ENGINE WEIGHT = 99,150 [REF (f)]

14 CHOCKS, $9\frac{1}{2}" \times 9\frac{1}{2}" = 90.25 \text{ in}^2$ [REF (a)]

10-$1\frac{1}{2}$" BOLTS & 4-2" FITTED BOLTS [REF (a)]

A. $\frac{99150}{14} = 7082 \text{ LB} \qquad \frac{7082}{90.25} = \underline{78.47 \text{ PSI}}$ O.K.

B. $F_i = \frac{T}{Kd} = \frac{600(12)}{(.19)(1.5)}$ 600 FT-LB FOR 1½ BOLTS [REF (a)]

$F_i = 25,263 \text{ LB}$

$\frac{7082+25263}{90.25} = \underline{358 \text{ PSI}}$ O.K.

C. $2.5 \times 7082 = \underline{17705 \text{ LB}}$ O.K.

B. FOR 2" BOLTS (A & C O.K. BY INSPECTION)

$F_i = \frac{850(12)}{.19(2)}$ 850 FT-LB FOR 2" BOLTS [REF (a)]

$F_i = 26846 \text{ LB}$

$\frac{7082+26846}{90.25} = \underline{376 \text{ PSI}}$

FOR 1400 FT-LB ON 1½" GRADE 8 BOLTS: [REF (f)]

B. $F_i = \frac{1400(12)}{.19(1.5)}$ $\qquad \frac{58947+7082}{90.25} = \underline{732 \text{ PSI}}$

$F_i = 58947 \text{ LB}$

EXHIBIT 63

NEW RECOMMENDED TORQUE BASED ON FFF (e)

B. $500 \text{ PSI} = \frac{7082 + F_i}{90.25}$

$F_i = 500(90.25) - 7082$

$F_i = 38043 \text{ LBS}$

$T = K F_i d$

FOR $1\frac{1}{2}$" - 6 UNC BOLTS

$T = .192(38043)(1.5)(\frac{1}{12})$

$T = \underline{912 \text{ FT-LBS}}$

A. & C. O.K. BY INSPECTION

FOR 2" - 4.5 UNC BOLTS

$T = .192(38043)(2)(\frac{1}{12})$

$T = \underline{1217 \text{ FT-LBS}}$

∴ RECOMMEND 900 FT-LBS ON $1\frac{1}{2}$" GRADE 8 BOLTS
& 1200 FT-LBS ON 2" GRADE 8 BOLTS

DIV 2 PNPP NO. 6096 The Cleveland Electric Illuminating Company RES-1475 Sheet 23 of 25
PERRY NUCLEAR POWER PLANT

(PT)/MT/VE EXAMINATION REPORT EXHIBIT 64

Date 11/28/84 W.O. No. N/A Report No. NDE-0035-PT85 Page 1 of

System/~~MPL~~ S/O N-36016 ISO/Dwg. No. N/A

(PT)/MT/VE Procedure NQADE 0941 Rev. 0

Surface Temp. 65 °F

Therm. S/N J84-07 Cal. Date Due 1-7-85

Corrective Action Documents Initiated:

Acceptance Standard

ASME III ____ ASME VIII ____

ASME XI ____ ANSI B31.1 ____

AWS D.1.1 ____

Other: QR-036

LIQUID PENETRANT

Cleaner Batch No. 84K065

Penetrant Batch No. 84E029

Developer Batch No. 84K052

Visible ✓ Fluorescent ____

Black Light Intensity N/A µM/cm²

MAGNETIC PARTICLE (crossed out)

Batch/Lot No. ____

Particle: Wet ____ Dry ____

Color ____

Visible ____ Fluorescent ____

Black Light Intensity ____ µM/cm²

Instrument: Method ____

Current ____

Machine No. ____

| Item/~~Weld No.~~ | A | R | * Remarks/Indications |
|---|---|---|---|
| J33/532 K | ✓ | | Inspection complied with in |
| K25/591K | ✓ | | accordance with QR036 |
| K54/678 K | ✓ | | Section 1B |
| K20/591 K | ✓ | | |
| J15/505 K | ✓ | | |
| J78/553 | ✓ | | |

Virginia M. Brennan 11/29/84
Examined By Date

[signature] 11/29/84
Reviewed By Level II Date

Sketch (If necessary) see page 2

* THESE ARE NEW PISTON SKIRTS AND AT PRESENT ARE NOT ASSIGNED TO a particular DIVISON AS YET
[signature]

Distribution: QRF (Original)

NOTE
DO NOT USE CORRECTION FLUID OR TAPE. LINE OUT AND INITIAL CHANGES USING REPRODUCIBLE PEN.

388/D/2/rm

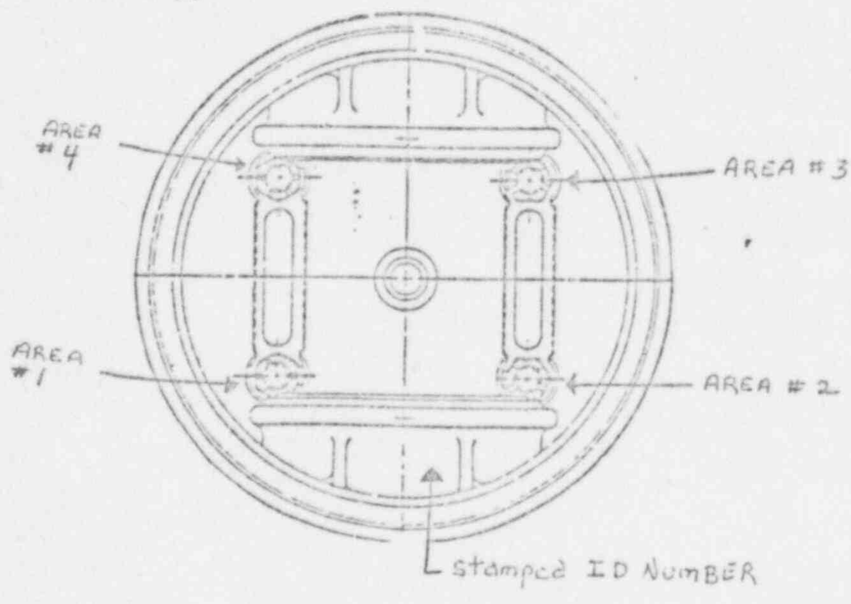
# PT/MT/VE EXAMINATION REPORT

Date 11/29/84 W.O. No. N/A Report No. NDE-0035- Page 2 of

System/MPL ISO/Dwg. No. N/A

| Item/Weld No. | A | R | Remarks/Indications |
|---|---|---|---|
| J53/537 K | ✓ | | |
| K10/582 K | ✓ | | |
| J23/513 K | ✓ | | |
| J47/537 K | ✓ | | |
| J26/513 K | | ✓ | linear indication area #3 photo frames 1 & 2 |
| K30/596 K | | ✓ | linear indication area #2 photo frames 3 & 4 |
| | | | pitting area #3 photo frames 5 & 6 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Sketches (If necessary)




NOTE
DO NOT USE CORRECTION FLUID OR TAPE. LINE OUT AND INITIAL CHANGES USING REPRODUCIBLE PEN.

388/D/3/rm

(14-7)

TEXAS UTILITIES

TASK DESCRIPTION NO. OR-10-02-341A

Train B

COMPONENT REVALIDATION CHECKLIST

COMPONENT Piston DOCUMENT NO OR-1, Rev. 1

PART NUMBER 02-341A SCHEDULED FOR COMPLETION

SNPS PART NUMBER 03-341A

TASK DESCRIPTION:
1) Prior to installation perform LP inspection of new piston skirts. Map all linear indications in stud boss area, document with photographs.
2) Assemble and review any documentation.

NOTE: To be performed on all station eigines.

ATTRIBUTE TO BE VERIFIED: 1) Linear indications at piston skirt and stud boss area. 2) Quality status of component document package.

ACCEPTANCE CRITERIA: 1) No linear indications (see attached) (Document any rejectable indications via photographs) 2) Acceptable document package.

REFERENCES: Piston Assemby Drawing.

DOCUMENTATION REQUIRED: Document Summary Sheet, Inspection Report, Photograph of any cracks.

GROUP CHAIRPERSON Victor [illegible] PROGRAM MANAGER J C Kammeyer

COMPONENT REVIEW:

EXHIBIT 65

RESULTS AND CONCLUSIONS: CPSES Unit 1, Train B (Serial No. 76002)
New type AE pistons to replace old type AH pistons. New No. 8R piston skirt was received with an area of the stud boss lip ground down below the rest of the machined surface (approximately 4/32" deep by 1" long). New No. 7L piston skirt showed one linear indication in the stud boss lip which has been ground out by TUGCO. The ground areas of both of these piston skirts serve no structural purpose and are acceptable for use.

GROUP CHAIRPERSON PROGRAM MANAGER

14-7
Train A

TEXAS UTILITIES
TASK DESCRIPTION NO. CR-10-02-341A

COMPONENT REVALIDATION CHECKLIST

COMPONENT Piston DOCUMENT NO CR-1

PART NUMBER 02-341A SCHEDULED FOR COMPLETION

SNPS PART NUMBER 03-341A

TASK DESCRIPTION:
1) Prior to installation perform LP inspection of new piston skirts. Map all linear indications in stud boss area, document with photographs.
2) Assemble and review any documentation.
IF LP FINDS LINEARS THEN ET

ATTRIBUTE TO BE VERIFIED: 1) Linear indications at piston skirt and stud boss area. 2) Quality status of component document package.

ACCEPTANCE CRITERIA: 1) No rejectable indications (see attached) (Document any rejectable indications via photographs) 2) Acceptable document package.
REFERENCES: Piston Assemby Drawing.

DOCUMENTATION REQUIRED: Document Summary Sheet, Inspection Report, Photograph of any cracks.

GROUP CHAIRPERSON [signature] PROGRAM MANAGER [signature]

COMPONENT REVIEW:

RESULTS AND CONCLUSIONS: CPSES Unit 1, Train A (Serial No. 76001)
New Type AE pistons to replace old type AH pistons. New pistons 5R and 6R had linear indications in stud boss area. These were ground out and the pistons installed.

EXHIBIT 66

GILBERT/COMMONWEALTH
QUALITY ASSURANCE DIVISION
INSPECTION SERVICES REPORT

0454-84-80

Nov. 20 - 23, 1984

CLIENT: Cleveland Electric Illuminating

VENDOR: Transamerica Delaval, Inc. (TDI)

UNIT: Perry Nuclear Power Plant - Unit 1 & 2

LOCATION: Oakland, Ca.

VENDOR PURCHASE ORDER: Q-3003-69, Chg. 2

PRINCIPAL CONTACT: Doug Stuart

EQUIPMENT SPECIFICATION TITLE: Class IE Diesel Generator Units

SPECIFICATION NO.: SP-562-4549-00, Rev IV

INTRODUCTION & PURPOSE:

G/C, Inc. was notified that 20 of 37 skirts were ready for magnetic particle examination (hold point) and for sample inspection of the final dimensions (hold point). Also, twenty (20) piston ring sets were ready for visual inspection.

The purpose of this visit was to witness the magnetic particle examinations of the skirts, perform final dimensional and visual inspections of the skirts and piston ring sets, perform a documentation review, and issue a certificate of inspection upon final acceptance.

SUMMARY:

G/C, Inc. witnessed the magnetic particle examinations performed by TDI on twenty (20) piston skirts in accordance with procedure 600-30, Rev. 2 with D4995. G/C, Inc. performed a final visual and dimensional inspection, on a sample basis, of the twenty (20) piston skirts and ring sets. G/C, Inc. reviewed the documemtation package. Only a certification of heat treatment was provided. The heat treatment records are to follow as authorized by CEI letter PY-SO/000-29249 (11/23/84). G/C, Inc. performed a visual inspection of the cleaning and packaging for shipment. The piston skirts were tagged with metal tags wired to each skirt. The piston ring sets were tagged with paper labels on each of the ring set boxes as authorized by CEI letter (11/23/84). All of the twenty skirts and ring sets were found to be satisfactory. G/C, Inc. issued a Certificate of Inspection.

Dimensional: (Cont'd.)

Five (5) piston skirts were selected. The outside diameter, height, thickness of the skirt, piston, ring grooves, o-ring grooves, wrist pin bores and tin plate surfaces were checked and found to be satisfactory and within the tolerances and surface finish specified in the part number DWG.-03-341-04-AE, Rev. F.

The following piston skirts were dimensionally inspected:

| SERIAL NO. | HEAT NO. |
|---|---|
| M13 | 702K |
| M79 | 750K |
| M86 | 751K |
| M61 | 748K |
| M78 | 750K |

The following calibrated inspection devices were used:

| DESCRIPTION | SERIAL NO. | CALIBRATED | DUE |
|---|---|---|---|
| Depth Gage Set | 030-C | 10/84 | 01/85 |
| Verner - 26 inch | 026-B | 10/84 | 04/85 |
| Blade M/C (15-16) | 016-B | 10/84 | 01/85 |
| Micrometer (16-17) | 017-H | 10/84 | 01/85 |
| Go/No Go Gage (.501-.503) | 297-R | 08/84 | 02/85 |
| Set Ring (6.7495-XX) | 325-D | 08/84 | 02/85 |
| Dial Bore Gage (6-12) | 061-AJ | 10/84 | 04/85 |

NONDESTRUCTIVE EXAMINATIONS

G/C, Inc. witnessed the magnetic particle examination of the machined thrust collar seat and the adjoining radii at the four bosses (inside the piston skirt) on all twenty (20) piston skirts listed under the "Visual Section" of this report. The examination was conducted in accordance with TDI procedure 600-30, Rev. 2 and the acceptance criteria of D-4995, Rev.-(12/21/83) using the direct contact method (circular) in accordance with para. 7.7 and 7.2 (each part examined twice 90 degrees apart) with wet flourescent particles with blacklight. The particles were applied by flowing using the continuous sequence operation (para. 7.8). No demagnetization was required. The areas examined were found to be acceptable with no unacceptable indications noted. Two (2) piston skirts did require blending with a grinder to remove linear indications - approximately ¼ inch long. The serial nos. were N29 (heat 754K) and N5 (heat 752K). The indications were removed, and the blended areas were re-examined using the same method and found to be acceptable. The blending did not affect the minimum wall thickness. The following equipment was used and found in good condition, serviced and calibrated:

CERTIFICATE OF SERVICE

This is to certify that copies of the foregoing were served by deposit in the U.S. Mail, first class, postage prepaid, this 27th day of February, 1986 to those on the service list below.

Susan L. Hiatt

Susan L. Hiatt

* - Express Mail

SERVICE LIST

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ATOMIC SAFETY & LICENSING BOARD
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Washington, D.C. 20555

* Mr. Glenn O. Bright
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hand-delivered to PNPP - Jay Silberg, Esq.
Shaw, Pittman, Potts, & Trowbridge
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Docketing & Service Branch
Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Atomic Safety & Licensing Appeal Board Panel
U.S. Nuclear Regulatory Commission
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