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

February 13, 1984

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Docket Nos: 50-416
50-312

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

FROM: Darrell G. Eisenhut, Director
Division of Licensing
Office of Nuclear Reactor Regulation

SUBJECT: REPORT OF MEETING OF REPRESENTATIVES OF THE
TRANSAMERICA DELAVAL, INC. (TDI) EMERGENCY
DIESEL GENERATORS OWNERS' GROUP
(BOARD NOTIFICATION 84-020)

In accordance with procedures for Board Notifications, the following information is being provided directly to the Commission. The appropriate boards and parties are being informed by a copy of this memorandum. This information is relevant to all facilities that have diesel generators manufactured by TDI (see Enclosure 1), including Rancho Seco, which is before the Commission, and Grand Gulf (an uncontested case), which is scheduled to come before the Commission for full power authorization in the near future.

On January 26, 1984, members of the NRC staff met with representatives of the TDI Owners' Group to discuss problems related to emergency diesel generators manufactured by TDI. A list of attendees is included in Enclosure 2. The staff provided a brief summary of TDI operating experience for both nuclear and non-nuclear applications. For the remainder of the meeting, the TDI Owners' Group described details of their Program Plan, the purpose of which is to provide reasonable assurance that TDI diesels will perform their intended function. Enclosure 3 contains the meeting handouts and slides. The transcript of the meeting is included as Enclosure 4.

Darrell G. Eisenhut, Director
Division of Licensing
Office of Nuclear Reactor Regulation

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Enclosures:
As stated

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Delaval Diesel Generator Operation Experience

U. S. Nuclear Experience

In 1974, the Long Island Lighting Company (LILCo) contracted with TDI to purchase three emergency diesel generators for the Shoreham Nuclear Power Station. This was the first order received by TDI to provide an EDG for a commercial nuclear power station. In the next seven years, engines for 14 other plants were ordered from TDI.

San Onofre 1

- ° Two TDI Diesel Engines Installed in 1976 - DSRV-20
- ° Serial No. 75041/42, Rated at 6000KW (nominal)
8800KW (peak)
- ° Engine Run Time to Date - 450 hours per engine

The first plant to actually place a TDI engine into nuclear service was San Onofre Unit 1 (SONGS 1), which purchased two V-20 units to provide emergency power for its feed pumps, which also serve as Emergency Core Cooling System pumps.

The engines at SONGS 1 were installed in 1976, and declared operational in April 1977. Since then, SONGS has experienced some problems with the operation of the engine turbochargers, a lube oil pressure sensing line failure which resulted in a fire, and several other minor problems. Because SONGS did not commit to meet the guidelines of Regulatory Guide 1.108, but rather Regulatory Guide 1.9, the program it used to test the engines before they were placed in service was more abbreviated than for a new plant. A detailed list of problems to date follows.

<u>Date</u>	<u>Problem</u>	<u>Cause/Solution</u>
12/80	Excessive Turbocharger thrust bearing wear.	No lube oil during standby. Lube oil system modified. 10 CFR Part 21 report issued because problem generic.
7/81	Lube oil leak and fire.	Excessive vibration of a lube oil test line which had inadvertently been left installed by the licensee. Line removed.
12/81	Piston modification to prevent crown separation.	Pistons reworked by TDI to respond to Part 21 report. Problem identified at Grand Gulf.
9/83	Unqualified instrument cable.	Replaced in accordance with Part 21 report.

Grand Gulf

- ° Two TDI engines installed - Model DSRV-16
- ° Serial No. 74033/34, Rated at 7000KW
- ° Operating Hours to Date - Division I = 1100 hours; Division II = 700 hours

In 1981, Mississippi Power & Light (MP&L) commenced pre-operational testing of two V-16 engines installed at Grand Gulf Unit 1. They represent the first V-16 units ordered from TDI, and in fact, one of the Grand Gulf engines was used to qualify the entire TDI V-16 line of machines for nuclear applications.

The Grand Gulf engines have experienced significant problems in completing the pre-operational test program, have had several major failures, including a fuel line break which caused a fire, and many minor failures. A detailed list of problems at Grand Gulf follows.

<u>Date</u>	<u>Problem</u>	<u>Cause/Solution</u>
11/81	Piston crown separation during operation.	Holddown studs failed. Pistons returned to TDI for rework. Generic problem.
3/81	Excessive turbocharger thrust bearing wear.	No lube oil during standby. Lube oil system modified.
6/11/82	Air starting valve capscrews replaced. Too long for holes.	Response to Part 21 report.
8/23/82	Flexible drive coupling material incompatible with operating environment.	Replaced with different material.
8/82	Latching relay failed during testing.	Relay replaced.
3/8/82	Air start sensing line not seismically supported.	Sensing line relocated and properly supported.
1/29/82	Governor lube oil cooler located too high. Possibility of trapping air in system.	Lube oil cooler relocated to lower elevation.
3/23/82	Engine pneumatic logic improperly design. Could result in premature engine shutdown.	Pneumatic logic design corrected.

<u>Date</u>	<u>Problem</u>	<u>Cause/Solution</u>
4/29/81	Non-Class 1E motors supplied with EDG auxiliary system pumps.	Motors replaced with Class 1E qualified motors.
3/15/82	Crankcase cover capscrew failed. Head lodged in generator and shorted it out.	Capscrews replaced with higher strength screws. Lock tab washers installed. Generator screens installed.
8/2/83	High pressure fuel injection line failed.	Manufacturing defect in tubing. Tubing replaced.
9/4/83	Fuel oil line failed. Caused major fire.	High cycle fatigue of Swagelock fitting. Additional tubing supports to be installed.
8/11/83	Cracks in connecting push rod welds.	All push rods replaced.
1983	Turbocharger vibration.	Turbocharger replaced.
1983	Cracked jacket water welds.	Excessive turbocharger vibration. Cracks re-welded.
1983	Turbocharger mounting bolt failures.	Excessive turbocharger vibration. Bolts replaced.
7/83	Air start valve failures.	Cause unknown. System cleaned and several valves replaced. More frequent maintenance scheduled.
10/28/83	Fuel oil leak. Cracked push rod weld.	Tubing replaced. Push rod replaced.
During EDG Installation	Cylinder head cracks.	Head replaced.
12/83	Cylinder head cracks.	Two heads replaced.
12/83	Cracks in piston skirts on Division II EDG.	All Division II pistons replaced. Division I pistons to be inspected.
9/83	Unqualified instrument cable.	Replaced in response to Part 21 report.

Shoreham

- ° Three TDI Diesel Engines installed, Model DSR-48
- ° Serial No. 74010-12, Rated at 3500KW
- ° Operating hours at time of crankshaft failure (8/83)
 - #101 = 646 (cracked crankshaft)
 - #102 = 718 (failed crankshaft)
 - #103 = 818 (cracked crankshaft)

The engines at Shoreham are the first straight-8 units to be placed in nuclear service in the U. S. One of the Shoreham engines (#101) was used to qualify the straight-8 series (R48) diesel engine for nuclear service.

Pre-operational testing of the engines at Shoreham started in late 1981 and continued until the major failure of the #102 crankshaft on August 12, 1983. After the performance of extensive tests in late September and early October, which were observed by staff members from NRR and Region I, as well as an NRC consultant, LILCo presented the results of its crankshaft failure investigation in a meeting on November 3, 1983. It reported that the crankshaft had been improperly designed, and had failed because the loading function used in the original design calculations was too small. LILCo also reported that it was investigating four failed connecting rod bearings which were discovered when the EDGs were disassembled. Their preliminary finding was that the failures occurred because the bearing material did not meet specifications, and the bearing loads had not been properly accounted for. A detailed list of the EDG problems at Shoreham follows.

<u>Date</u>	<u>Problem</u>	<u>Cause/Solution</u>
3/81	Excessive turbocharger thrust bearing wear.	No lube oil during standby. Lube oil system modified.
12/81	Piston modifications to prevent crown separation.	Pistons reworked by TDI to respond to Part 21 report. Problem identified at Grand Gulf.
9/82	Engine jacket water pump modifications.	Water pumps reworked by TDI.
6/82	Air starting valve capscrews replaced. Too long for holes.	Response to Part 21 report.
9/82	Engine jacket water pump shaft failed by fatigue.	Pump shafts redesigned and replaced.
Spring/1983	Cracks in engine cylinder heads.	Fabrication flaws. All heads replaced.

<u>Date</u>	<u>Problem</u>	<u>Cause/Solution</u>
3/83	Two fuel oil injection lines ruptured.	Manufacturing defect in tubing. Tubing replaced with shielded design.
3/83	Engine rocker arm shaft bolt failure.	High stress cycle fatigue. Bolts replaced with new design.
8/12/83	Broken crankshaft. Cracks in remaining crankshafts.	Inadequate design. Replaced with larger diameter crankshafts.
9/83	Cracked connecting rod bearings.	Inadequate design and substandard material. Replaced with new design.
10/83	Cracked piston skirts.	Replaced all piston skirts with new design. Generic problem.
11/83	Broken cylinder head stud nuts.	Replaced all head stud nuts.
9/83	Cracked bedplates in area of main journal bearings.	Cracks evaluated by LILCo and determined to not be significant.
9/83	Unqualified instrument cable.	Replaced in response to Part 21 report.

Operating Experience - Non-Nuclear

Marine Applications

Besides being used for stationary electric power generation, TDI diesel engines have been placed in service as propulsion units on commercial cargo vessels. As part of the Shoreham operating license hearing, an intervenor, Suffolk County, requested and was granted by the Licensing Board, subpoenas for the State of Alaska, U. S. Steel, and Titan Navigation, Inc. These three organizations operate vessels which use TDI V-16 diesel engines which are very similar to most of the TDI units installed in nuclear power plants. The responses which were received indicate that the TDI engines in marine service for these organizations have experienced severe reliability problems. Most have related to faulty cylinder heads, but they have also included problems with pistons, cylinder liners, turbochargers, cylinder blocks, connecting rods, connecting rod bearings, main journal bearings, and camshafts. A detailed experience list follows. The staff is reviewing this material to see how much of it is applicable to engines in nuclear service.

Marine Experience with TDI Diesel Generators

State of Alaska, M. V. Columbia

- ° Vessel fitted with two DMRV-16-4 Engines - Serial No. 72033/34
- ° Rated at 9200 HP (6900 KW) at 450 RPM
- ° Vessel and engines placed in service in June 1974.
- ° Each engine has approximately 30,000 hours of operating time to date.

Document Date

Problem Description

12/76

All cylinder liner seals replaced. All cylinder heads have been removed, reinstalled, or renewed at least three times.

All pistons have been removed and reinstalled at least once.

Turbochargers have been removed, repaired and reinstalled, or renewed 16 times due to leaking oil seals, vibration, rotor damage, or defective bearing seal housing.

Exhaust manifolds have been removed and reinstalled because of frozen expansion joints and resulting cylinder head flange face damage.

Lube oil consumption is excessive.

6/15/78

Rapid deteriorations of fire seal rings causing blowby across gasket surface of cylinder heads.

Very low lube oil filter life (40 hours). Caused by blowby of pistons and valve guides.

Stainless steel exhaust bellows burn out rapidly. Installed backwards by TDI.

11/28/78

(Letter to Alaska from TDI).

Recommends timing changes to improve turbocharger performance.

Document Date

Problem Description

1/31/79

Valve seats and valve guides not concentric. Results in bad valve contact.

Defective piston rings shipped as replacement parts.

Reworked cylinder head received from TDI without all required modifications and with damaged gasket face.

Newly furnished cylinder liners received with incorrect surface finish (twice).

Connecting rod bearings furnished as spare parts were wrong size - 13" vice 12".

Turbocharger exhaust flex section incorrectly furnished by TDI.

2/2/79

Chrome plating failure of piston rings. Caused heavy scoring of cylinder liner. Associated cylinder head found cracked.

Seven cylinder heads replaced during 15 weeks of operation.

Excessive lube oil filter change out rate. Due to piston blowby.

Fuel injector spray tips changed at TDI recommendation to reduce carbon buildup and eliminate washing of liner walls with fuel oil.

Three major overhauls of engines in 5 years of operation.

Carbon accumulations in rocker box areas.

Excessive oil vapor discharge from engine crankcases.

Heavy carbon deposits on valve springs. Suspect valve blowby.

When exhaust valve guides were modified by TDI, they did not follow the procedure outlined in their SIM (Service Information Memo).

Document Date

Problem Description

	Loose piston pin end caps.
	Incorrect piston crown to skirt bolt torque.
	Bad connecting rod bearings. Excessive wear, cracks.
	Damaged connecting rod bolts.
	Valve push rods cracked at weld of ball to pipe. QC problem.
	Crankshaft size changed after engines for ship installed. No notice to owners of reason for change.
	Excessive main bearing wear.
	Camshaft lobe hard facing worn.
	TDI recommended the installation of a new flexible exhaust duct which was too short (new design). Installation attempted at insistence of TDI. Unit damaged by attempt and returned to TDI for repair.
3/19/79	QC or material problems with respect to non-concentricity/out-of-round valve seats, push rods, rod bolts, bearing shells, valve stem plating.
6/14/79	Thermal growth and cracking of exhaust manifold.
12/26/79	Failure of new connecting bearings. Cracks of 25% of connecting rods.

Document Date

Problem Description

1/16/80

Ten (10) new cylinder heads have cracks. This includes 8 that were previously repaired.

Fifteen (15) valves are defective with chrome flaking off the valve stems.

Valve stems are being deformed.

Five additional push rods have cracks.

Turbocharger air cooler inlet housing is cracked for fourth time.

Internal bracing in engine intercoolers is cracked.

2/5/80

Piston rings installed improperly because mistake by TDI in the drawing used by TDI shop.

2/29/80

Piston crown-to-skirt nut torque inconsistent among nuts on various pistons.

Excessive link rod bushing bail wear caused by improperly relieved, drilled oil passages on the matching link rod pins.

3/24/80

Abnormal carbon deposits and formations noted on pistons and cylinder head assemblies.

Fretting of jaw areas of connecting rods.

Insufficient turbo (manifold) air except at near full speed operation.

Cracked exhaust manifold end plates.

Cracking of connecting rod boxes.

Cracking of newly installed connecting rod bearing shells at 4500/hours.

Document Date

Problem Description

Fretting of link rod and link rod pins at their attachment together.

Fretting between link rod bushings and link rod bushing bore.

Galling of link rod bushings in way of link rod pin outer drilled oil passages.

Improper wear/contact pattern on newly installed connecting rod bearings at 4500/hours. Four-point loading.

Insufficient connecting rod bearing wear/contact area to journal wherein it is less than 15% of the total bearing area.

Upsetting of stems in valve keeper area.

Damage to number four piston ring and ring groove on all pistons modified during the 1978-79 engine teardown and rebuilt after 4500/hours operation.

Fretting between piston crown and skirts at 4500/hours since piston modifications.

Variations in piston bolt torque, beyond specified limits, at 4500/hours since piston modifications.

Damage to rod bolts, including cracking, and damage to threads on both the bolt and in the rod boxes.

4/18/80

Exhaust manifold conversion kits received with cuts and grooves in finished surface. Required rework by owner before installation.

5/12/80

New connecting rods received without required code (American Bureau of Shipping) approval. TDI did not have record of which rods were shipped with approval or without approval.

Some new connecting rods shipped with oversize bearings but no note to customer informing of difference.

Document Date

Problem Description

5/14/80

Cylinder head returned to TDI has been lost by TDI. Cannot be located.

5/15/80

Customer received new connecting rod bolt in rusty condition with damaged threads.

5/27/80

Customer received reworked cylinder heads with lip left on exhaust seats which prevents valves from seating.

Customer noted that it now was in possession of two cylinder heads with the same serial number.

Could not install lockwire in new connecting rod cap screw. Hole drilled partway through with drill broken off in center of hole. Also noted that edges of lockwire holes on other screws had not been rounded to prevent damage to lockwire.

5/29/80

Discovered leaks in newly installed exhaust manifold head plates.

9/4/80

(Meeting Summary)

TDI says that all cylinder head problems should be corrected by new design.

TDI reports that connecting rod bearing cracks could have resulted from bad bearing alloy makeup by vendors. TDI looking at different bearing materials.

TDI stated that they had erred on piston modifications. Effected others besides COLUMBIA.

9/30/80

Eleven remaining master connecting rods to be sent to TDI to have oversize bearings and other modifications installed.

Many of the original cylinder heads that were returned to TDI for rework were exchanged for other used heads.

Document Date

Problem Description

11/6/80

Cylinder head changed due to heavy external water leakage.

Severe smoke causing excessive lube oil contamination and engine room atmosphere problems. Engine secured to prevent possible crankcase explosion.

12/10/80

All connecting rods removed. New rod cap screws and washers to be installed because increased torque specified by TDI caused galling.

New connecting rod bearing shell found cracked.

Heavy wear noted on piston side thrust areas. Heavy hard carbon buildup noted in area of compression rings. Fourth ring groove area to be reworked by TDI due to design/machine error by TDI during previous modifications.

Nineteen (19) of 32 cylinder liners exceed spec for out-of-round. TDI to modify limits to permit continued usage.

Twenty-one (21) of 32 liners lost crush. New phenomena. Repairs require machining of engine block.

Fuel injectors removed and to be changed from 140° spray pattern to 135° pattern. Original nozzles had 150° pattern.

1/16/81

Cylinder block bores found to be distorted.

Four new engine camshafts installed.

Document Date

3/13/81

Problem Description

Reworked cylinder heads were returned to the customer without removing the grinding compound from the valves and valve seats.

Two reworked pistons returned to customer without roll pins, which lock the securing nuts in place.

Cylinder liner delivered with wrong surface finish.

Cracks found in cylinder blocks. All replaced.

Main engine blocks found to be cracked and warped. The main block-to-base through bolts appear to have been improperly torqued during initial assembly.

One "new" camshaft found to be a rebuilt unit containing several damaged bearing journal areas.

The threaded head stud holes in the new cylinder blocks were not counterbored deeper, as TDI had indicated they currently do. This was to eliminate cracking of the block near the stud holes. The customer re-machined each of the 256 head studs to accomplish the same intent.

4/9/81

Several reworked pistons were returned without groove pins.

In response to a request for 20 1/4" capscrews and washers, TDI supplied 1 7/8" capscrews.

Drawings furnished by TDI for head stud modifications were not applicable to the studs in question.

50% of the fuel pump bases would not fit onto the new cylinder blocks because of slight changes in the design of the blocks.

Document Date

Problem Description

4/29/81

Two new cylinder liners provided with incorrect surface finish.

One new cylinder liner provided with flange thickness larger than manufacturer's maximum tolerance.

New connecting rod capscrews were found to be galled and unfit for use.

Service manual showed incorrect installation of engine camshafts.

2/3 of fuel cam tappet assemblies on one engine could not be installed on one engine because the new cylinder blocks had not been properly counterbored.

Cylinder liner counterbore depths were off to such an extent that difficulty experienced in establishing proper liner crush.

Weld spatter noted on many seating surfaces.

Dirt, sand, and metal showings found in passages and holes which should have been clean.

Cylinder head water port outlet locations varied considerably, causing a water flow restriction.

Air start distributor not properly assembled at factory.

6/1/81

Exhaust manifold head plate developed a leak. Cracks found around 2 of 3 tie rods due to poor initial welding.

11/19/81

Defective valve springs found on one engine.

7/29/82

Valve rotator failed.

Cracks discovered in the intercooler.

Document Date

Problem Description

7/29/82

"In nine years of operation every basic engine component has been modified or replaced with an improved item, at least once, with the exception of the crankshaft (which is obsolete and has not been used for years), the engine base, the fuel pumps and the governor. The last two items are not manufactured by TDI."

10/15/82

Turbochargers replaced.

Exhaust valve lubricating system to be installed.

3/9/83

Cracks discovered in three cylinder heads.

Reworked cylinder returned to customer with tap broken off in threaded hole. Others returned with internal cracks and damaged flange faces.

Titan Navigation, M. V. Pride of Texas

- Vessel fitted with two DMRV-12-4 engines, Serial No. unknown
Rated at 7800 HP at 450 RPM
- Engines installed 1981 - no information on total engine hours to date.

Document Date

Problem Description

7/16/82

Catastrophic piston failure. Due to crack in piston skirt. Engine had 5791 hours of operation.

4/1/82

Cylinder block broken and cracked.

Cylinder head cracked.

Cylinder liner cracked.

Piston skirt fractured.

Suspect that all of above problems caused by water leaking into cylinder from air intake manifold. Leaking tubes found in air intercooler.

8/19/82

Cracks discovered in six piston skirts.

7/22/82

Cracked exhaust valve seats in cylinder heads. Engine had 3000 hours service.

Camshaft lobe design appears to be deficient. Causes excessive stress on fuel cam lobe and roller.

Tappet assembly rollers severely galled. Believed to be due to camshaft and lobe placement and inadequate heat treatment.

Fuel cam lobes have failed twice due to improper heat treatment.

Chrome plating lost from one piston wrist pin.

All four intercoolers have failed because of erosion due to high fluid velocity.

Air start valves have suddenly ceased to function, for no apparent reason.

Document Date

Problem Description

4/1/83

Plugs in crankshaft oil ways may be cracking because improper material used. Under investigation.

Fuel oil return lines have failed. To be replaced with heavier wall tubing.

Exhaust valves fail after about 2000 hours of use. Serious problems with cylinder head cracks.

Turbochargers experiencing difficulty supplying sufficient air.

U. S. Steel, MV E. H. Gott

- Vessel fitted with two DMRV engines (model unknown)
Engine Serial No. 75039-40
- No information on engine hours to date.

<u>Document Date</u>	<u>Problem Description</u>
11/13/80	Cracked cylinder head. Replaced.
11/1/79	Cracked cylinder head. Replaced.
6/1/80	Cracked cylinder head. Replaced.
10/8/81	Cracked cylinder head. Replaced.

Note: This information was summarized from documents provided by U. S. Steel in response to a subpoena which asked specifically for information about cylinder head failures. Many other portions of the documents were deleted by U. S. Steel, and it appears that the deleted portions referred to problems with other engine parts.

Other Applications

The staff understands that other TDI engines are in service as stationary electric power generators. The operating history of these engines will be taken into consideration during the staff assessment of TDI engines.

Reference List

Shoreham

Letter dated 1/6/84 from B. McCaffrey (LILCo) to H. Denton (NRC)
Board Notification 83-160 dated 10/21/83
Board Notification 83-160 dated 11/17/83
Letter dated 12/9/83 from J. Smith (LILCo) to T. Muley (NRC)
Letter dated 12/9/83 from A. Schwencer (NRC) to M. Pollock (LILCo)
Letter dated 12/29/83 from A. Schwencer (NRC) to M. Pollock (LILCo)
Letter dated 12/16/83 from C. Matthews (TDI) to T. Novak (NRC)
Letter dated 12/16/83 from J. Smith (LILCo) to T. Murley (NRC)
Letter dated 12/16/83 from A. Dynner (Suffolk County) to A. Earley (LILCo)
Letter dated 10/20/83 from A. Earley (LILCo) to L. Brenner (NRC)
Letter dated 10/16/83 from R. Boyer (TDI) to NRC
Letter dated 11/17/83 from A. Earley (LILCo) to L. Brenner (NRC)
IE Information Notice 83-51, dated 8/5/83
IE Inspection Report 99900334/83-01, dated 10/3/83
IE Information Notice 83-58, dated 8/30/83

Grand Gulf

Letter dated 11/15/83 from L. Dale (MP&L) to H. Denton (NRC)
Letter dated 10/19/83 from L. Dale (MP&L) to H. Denton (NRC)
LER 50-416/83-171/03L-0 dated 11/28/83
Letter dated 10/26/83 from L. Dale (MP&L) to H. Denton (NRC)
LER 50-416/83-082/01T-0
LER 50-416/83-126/01T-0

San Onofre Unit 1

LER 50-206/81-017 dated 8/12/81

Letter dated 9/15/81 from H. Ray (SCE) to R. Engelken (NRC)

LER 50-206/80-039 dated 12/23/80

Letter dated 6/8/81 from J. Haynes (SCE) to R. Engelken (NRC)

Marine Applications

Letter dated 12/21/83 from A. Dynner (Suffolk County) to A. Earley (LILCo)

Includes many other individual documents.