LILCO, July 7, 1983

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
LONG ISLAND LIGHTING COMPANY	)	Docket No. 50-322 (OL)
	)	
(Shoreham Nuclear Power Station, Unit 1)	)	

AFFIDAVIT OF
RICHARD A. PRATT

Richard A. Pratt, duly sworn, deposes and says as follows:

1. My name is Richard A. Pratt and I am employed by Transamerica Delaval Inc. (TDI) as the Manager of Customer Service. My professional qualifications are set forth in Attachment A to this Affidavit.

2. As Manager of Customer Service for TDI, my principal duties and responsibilities include management and supervision of the department responsible for installation, testing, startup and acceptance of TDI manufactured products, including diesel generators. In this connection, I have had occasion to observe and to be involved in the installation and startup testing activities associated with TDI diesel generators installed at a number of nuclear power plants, including

(1) San Onofre Nuclear Generating Station, Unit 1,

(2) Comanche Peak Nuclear Station,

(3) Grand Gulf Nuclear Power Station,

(4) Taiwan Power Kousheng and Maanshan Nuclear Stations,

(5) Midland Nuclear Power Station,

(6) Perry Nuclear Power Station,

(7) Bellefonte Nuclear Power Station, and

(8) Shoreham Nuclear Power Station.

3. In connection with my involvement in the Shoreham diesel generator installation and preoperational test program, I have had numerous occasions to inspect the Shoreham diesel generators1/ and to observe them in operation under a variety of circumstances. In addition, I am familiar with matters relating to model R-4 diesel generator cylinder heads originally installed with the Shoreham diesel generators, including the manufacturing processes and quality assurance processes used in connection with these diesel generator heads. I am also personally familiar with the manufacturing and quality assurance procedures used in connection with current production model R-4

1/ There are three identical TDI model DSR-48 diesel generators at Shoreham designated by LILCO as DG-101, DG-102 and DG-103.

cylinder heads. In addition, I personally participated in the failure analysis conducted at TDI on the three Shoreham cylinder heads which had minor water leaks.

4. Early in the preoperational testing process at Shoreham, minor leaks were detected in three of the 24 diesel generator cylinder heads. Analysis indicated that these leaks were the result of small cracks caused by casting imperfections. The three cylinder heads have been replaced with current production model cylinder heads which are produced employing improved casting and inspection techniques designed to prevent or detect any such casting imperfections. LILCO has committed to replace all of the remaining original model cylinder heads with improved, current production model cylinder heads. At present, I am advised that replacement of all heads will be on a schedule consistent with preoperational testing and fuel load and may not be completed until after fuel load. In the interim, and until this is accomplished, LILCO intends to implement a surveillance or "barring over" procedure to ensure detection of leaks. As this Affidavit demonstrates

(i) there is reasonable assurance that the original model cylinder heads remaining on the Shoreham diesels are unlikely to contain any casting imperfections which might develop into leaks;

(ii) there is reasonable assurance that even if such casting imperfections should exist and develop into leaks, the implementation of the surveillance or "barring over" procedure provides adequate assurance that such leaks would be detected in a timely fashion and that there would be no effect on the reliability, operability or quick start capability of the diesels; and

(iii) the casting techniques and quality assurance procedures employed in the manufacture of the current model diesel generator cylinder heads provide ample assurance that casting imperfections that may have existed in the previous model diesel generator cylinder heads either will not occur, or will be detected and remedied in the manufacturing process.

5. Analysis of Shoreham diesel cylinder heads returned to TDI from Shoreham indicated that the three leaks detected emanated from cracks caused by operating stresses (created by cylinder firing pressure) that occurred at stress risers resulting from casting imperfections. Attachments B and C to this Affidavit are my memoranda reflecting the results of this failure analysis of the Shoreham diesel generator cylinder heads.

6. Delaval's experience with operating diesel generators using identical cylinder heads to those originally supplied with the Shoreham diesel generators gives ample assurance that any additional casting imperfections or cracks are unlikely to exist in the remaining original diesel generator cylinder heads at Shoreham. In the first place, it is Delaval's experience that these casting imperfections occur in only a very small percentage (less than two percent) of these original model cylinder heads. Although the percentage of heads at Shoreham that exhibited these casting imperfections is higher than the very small percentage noted above for all such cylinder heads in service, Delaval has evaluated the manufacturing and operating history of the Shoreham heads and has concluded they are not different from other cylinder heads of this type and vintage. Significantly, there are currently approximately 3500 such cylinder heads in use in a variety of applications, including nuclear. A total of 152 cylinder heads identical to those originally supplied with the Shoreham diesel generators have been in successful operation at other operating nuclear power plants for as long as 4 1/2 years with no problems encountered.

7. In addition, it is Delaval's experience that after 600 hours of operation, it is unlikely that the remaining

original cylinder heads would develop any cracks similar to those previously experienced at Shoreham. This conclusion is based on experience and knowledge of the type of crack found at Shoreham. As already noted, a casting defect or flaw must be present from the manufacturing process for this type of crack to develop. These flaws are not created during the operation of the diesels. Cracks develop at these flaws (or stress risers) when subjected to the operating stresses created by cylinder firing pressure. Thus, once a cylinder head is subjected to full power operation with the associated maximum cylinder firing pressure, cracks would be expected to appear, if at all, soon thereafter. As already noted, it is Delaval's experience that cracks similar to those found at Shoreham occur, if at all, prior to completion of 600 hours of operation. The cracks in the Shoreham heads developed in the range of 100 to 300 hours of operation. Each of Shoreham's diesel generators now has over 600 hours of operation and this substantially increases the likelihood that there are no additional casting imperfections or cracks in the cylinder heads at Shoreham other than those already detected. Confidence that further cracks will not occur is strengthened given that a substantial portion of the more than 600 hours of operating time for each diesel generator at Shoreham was conducted under high load or high power conditions.

8. Although Delaval is confident that additional cracking of cylinder heads is unlikely at Shoreham, Delaval has recommended and Shoreham has adopted a surveillance or "barring over" procedure designed to detect in timely fashion any cylinder head leaks. This barring over procedure is a well accepted procedure in the industry for accomplishing this purpose. In fact, "barring over" is a standard industry procedure conducted prior to all manual starts of diesels, including Shoreham's. It ensures that water leakage will be detected. I am familiar with the draft Shoreham procedure on barring over, SP # 27.307.02, "Emergency Diesel Generator Cylinder Leak Detection Test." This procedure is effective to detect leaks in a timely fashion and gives added assurance that operation of the diesel generators with the remaining originally supplied cylinder heads will result in reliable operation and start capability.

9. As the analysis of the Shoreham diesel generator cylinder heads returned to TDI from Shoreham indicated,2/ the cracks developed from casting imperfections and the cracks were self-relieving and nonpropagating. In addition, the cracks involved admitted only small amounts of jacket water into the combustion chamber which had no effect on the combustion process and were simply blown out of the exhaust system along with

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2/ See Attachments B and C.

other combustion by-products. This conclusion is also confirmed by the observation during operation of one of the diesel generators that included one of the three leaking cylinder heads. The observation noted a leakage rate of 9.25 gallons/hour from the jacket water system. This leakage was blown out of the exhaust system during operation of the diesel and did not affect its operation.

10. The cracks found in the three Shoreham heads also would not affect the rapid starting capability of the engine. Although a leak rate of 9.25 gallons/hour was observed during the operation of one of the engines, this rate would fall substantially immediately following shutdown of the engine. The small cracks detected in the cylinder heads were opened by the stresses induced by the combustion process. After engine shutdown, stresses on the heads are reduced substantially, allowing the crack to close. Stresses on the head are further reduced when the cylinder head cools. Thus, only very small amounts of jacket water would leak into the combustion chamber after shutdown with no adverse effect on the rapid starting capability. This conclusion is confirmed by the observations made on the Shoreham diesels. After leakage was detected from the jacket water system, the diesel generator was shut down and the cylinders were checked for water. Less than a cupful of water was

found in the combustion chamber. This small amount would not affect or impair the rapid start capability of the diesel generator. The conclusion that there would be only a small amount of seepage, if any, occurring after shutdown is also confirmed by the results of the hydrostatic test conducted as part of the failure analysis. The hydrostatic test of the cold head at 100 psi resulted in only slight seepage from the crack. Following shutdown of the engine, the jacket water system would also be shut down, reducing the system pressure to essentially 0 psig (during operation, the system operates at approximately 30 psig). Thus, not even the slight seepage noted in the hydrostatic test would occur in the event a crack did develop in a cylinder head.

11. As noted, the leaks detected in the Shoreham diesel cylinder heads were caused by casting imperfections. In the nine years since LILCO's engines were manufactured, TDI has continued to develop and improve the casting and manufacturing processes employed in producing the four valve steel cylinder heads like those originally supplied with the Shoreham cylinders. TDI has also improved and developed techniques to detect flaws in the casting and manufacturing processes. These improvements employ more extensive inspection and testing (magnetic particle inspection, both AC and DC, ultrasonic testing

and dye penetrant testing), stress relief techniques, air, gas and watertight hydrostatic testing (at higher pressures than used in connection with the cylinder heads originally supplied with the Shoreham diesel engines) and pickling. These improvements result in cylinder heads of even higher quality and reliability than the quality and reliability of the cylinder heads originally supplied with the Shoreham diesel generators.

12. The reliability record of the improved, current production cylinder heads provides additional assurance that these cylinder heads are free from the casting imperfections detected in the three Shoreham diesel generator original cylinder heads. Current production cylinder heads installed in six marine DMR V12-4 TDI diesel engines have accumulated over 19,000 hours of reliable operation without any evidence of similar casting imperfections or head cracking failures having occurred.

Richard A. Pratt

Richard A. Pratt

Subscribed and sworn to before me this 8th day of July, 1983.

Ruth E. Silva

Notary Public

OFFICIAL SEAL
RUTH E. SILVA
NOTARY PUBLIC - CALIFORNIA
COUNTY OF ALAMEDA
My Commission Expires June 4, 1985

ATTACHMENT A

Professional Qualifications

RICHARD A. PRATT

Manager, Customer Service

Transamerica Delaval Inc. (TDI)

Born August 5, 1943

Bachelor of Science, Mechanical Engineering
U.S. Naval Academy, 1967

1967-75 -- Lieutenant, USN

1975-77 -- Liaison engineer, TDI

Duties and responsibilities included review and resolution of engineering matters and issues that arose in connection with the design and manufacture of the entire line of TDI products and vendor supplied components.

1977-79 -- Project Engineer, TDI

Duties and responsibilities focused on technical issues relating to contract engineering administration.

1979-81 -- Manager of Product Engineering, TDI

Duties and responsibilities included the management and supervision of 50 engineers and draftsmen in the preparation of detailed engineering drawings of TDI engines and preparation and publication of TDI instruction manuals.

1981-83 -- Manager of Customer Service, TDI

Duties and responsibilities include the management and supervision of 50 field service engineers and representatives in the installation, startup and testing of TDI manufactured products.

FAILURE ANALYSIS REPORT
TRANSAMERICA DELAVAL INC. ENGINE & COMPRESSOR DIVISION

Attachment "B"

Customer	Engine No.	Part or Assembly No.	RMR No.	Date	F.A. No.
LILCO	74010/012	03-360-03-OF	9496	March 28, 1983	0150

ELEMENTS OF FAILURE:

Cylinder Head P/N 03-360-03-OF
S/N E94
H/N 488P

SYMPTOMS OF FAILURE

Fire deck water leak; water detected in combustion chamber.

EXAMINATION OF ELEMENTS:

1. The cylinder head was returned with a suspected water leak for failure analysis and rework - if possible.

2. The head was visually inspected and the fire deck was found to be coated with a mixture of rust and carbon, characteristic of a water leak.

3. The head was then hydrostatically tested at 100 psi. A seepage leak was noted and marked between the intake and valve seats (see figure 1).

4. A 1-3/4" X 2-3/16" section of the fire deck containing the crack was removed from the fire deck by milling.

5. After a visual inspection, the sample was forced open. Microscopic inspection revealed a quench crack (hot tear), which probably resulted from shrinkage of the casting during cooling. (See Photo 1). The tear covered about 80% of the sample section. Products of oxidation and corrosion filled the cracked region, typical of a hot tear. Microscopic examination confirmed this crack ran in all three planes. There was no evidence of propogation of the crack past the original hot tear, nor was there any sign of fatigue failure.

6. The sample section measured 7/16" thick. Drawing specification for this section is 3/4". Evidently, a core print broke off, allowing the core to float and the fire deck section was cast thin. This thin section cooled at a more rapid rate than the surrounding metal and the hot tear resulted. Ultrasonic testing confirms the fire deck is thin in other areas also.

7. The thin section will be milled out of the fire deck and material of the correct thickness will be welded in place. Since the head is dispositioned as suitable for repair, further destructive testing will not be done.

SUMMARY OF ANALYSIS:

Typically, cracks in the fire deck are not encountered between the intake valve seats. Something unusual must happen, such as the core print breaking, for a hot tear to occur. Sporadic hot tears were encountered in cylinder heads manufactured in the early and mid 1970's. Subsequent improvements in casting techniques (gating, chills, new risers, etc.) have effectively eliminated this problem.

SUMMARY OF ANALYSIS (continued) Page 6 of 9

The cores and pattern have been revised and rebuilt to eliminate problems such as the broken coreprint.

These heads were not originally stress relieved and were hydr-tested at a lower pressure (75 psi). Thus, the hot tear went undetected. With stress relief, higher pressure hydro test, ultrasonic testing and other current production/inspection techniques - such a defect would normally be detected.

CONCLUSION:

The failure of this head is attributed to a casting defect, undetected in the manufacturing process, which evidenced itself only after considerable firing cycles had occured. Prevention/detection of such defects has improved, so they are now located and corrected in the manufacturing process.

This crack would not have caused a catastrophic failure of the engine or compromised its ability to carry full load, as the water leak rate is very slow. The head is repairable, and will be processed under the factory cylinder head rework program.

Date: _____

3/30/83
Signature-Failure Analysis Engineer

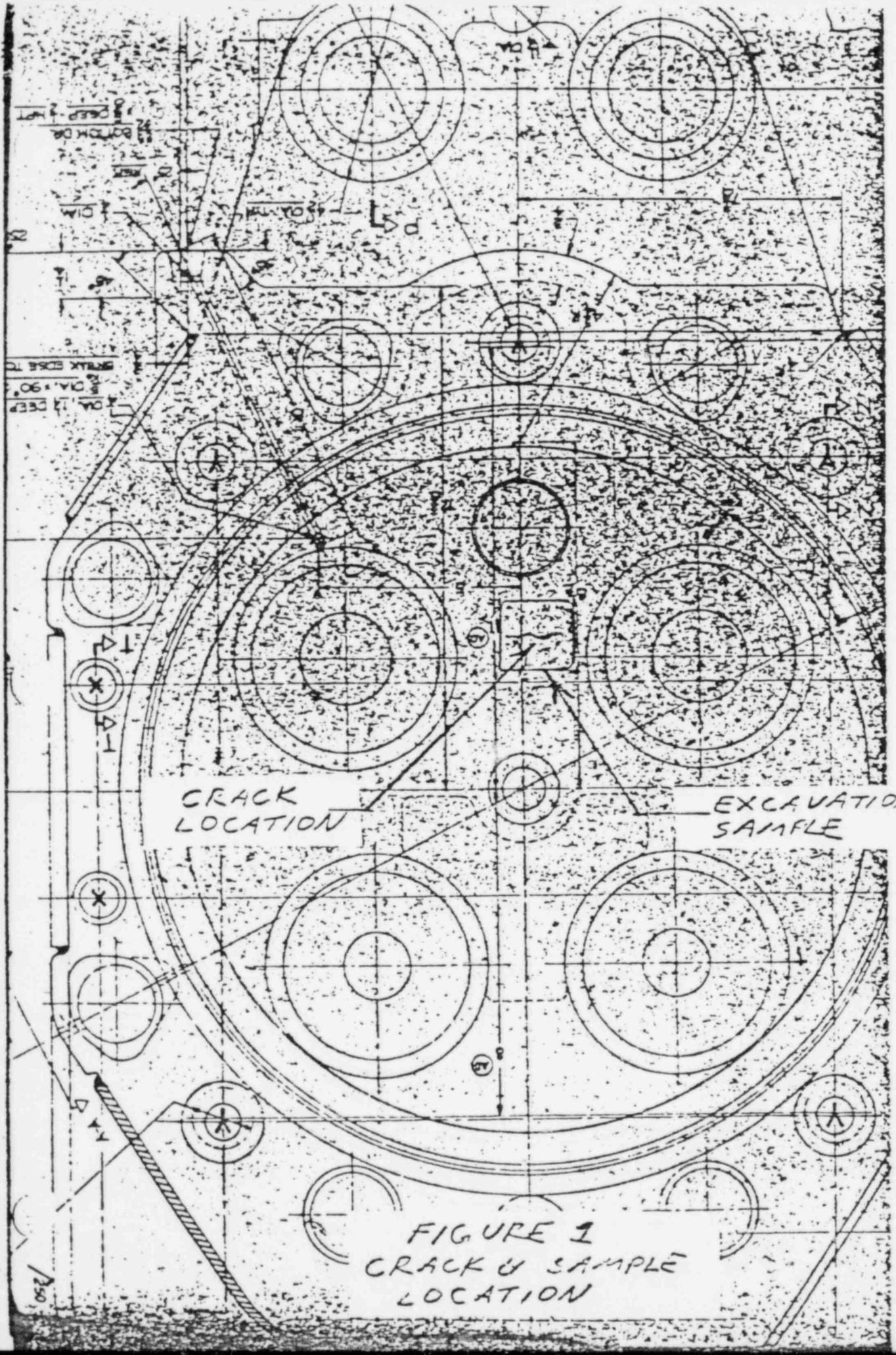

FIGURE 1
CRACK & SAMPLE
LOCATION

Attachment "C"

FAILURE ANALYSIS REPORT
TRANSAMERICA DELAVAL INC. ENGINE & COMPRESSOR DIVISION

Customer	Engine No.	Part or Assembly No.	RMR No.	Date	F.A. No.
Lilco	74010/12	03-360-03-OF	9496	March 28, 1983	0151

ELEMENTS OF FAILURE:

Cyilnder Head P/N 03-360-03-OF
S/N E31 E27
H/N 92P 73P

SYMPTOMS OF FAILURE:

Exhaust passage water leak.

EXAMINATION OF ELEMENTS:

1. The cylinder heads were returned with known cracks, to be reworked.

2. Inspection of the fire decks revealed they were coated with a mixture of water and rust, typical of leaking heads.

3. The heads were hydrostatically tested. A water leak was noted in the exhaust passage near the flange in each head, (See photo & Fig.1), and was marked.

4. The head was dispositioned as suitable for rework preventing any destructive analysis. The leaking section of the head was ground out. Examination of the metal filings revealed inclusions of sand (from the core) in the metal.

5. All of the poor metal was ground out until only sound base metal remained. The section was then repaired by welding per standard shop procedure.

SUMMARY OF ANALYSIS:

Exhaust passage leaks are not normally encountered so close to the exhaust flange. However sporadic core breakage and resultant inclusions are not unusual in cylinder heads manufactured in the early 1970's, when these heads were made. Subsequent improvements in casting techniques have eliminated these sort of problems.

Also, these heads were not stress relieved and were originally water tested at a lower pressure than is now standard, allowing the cracks to originally go undetected. With stress relieving and high pressure water testing, which more accurately simulate service conditions, such cracks no longer go undetected.

CONCLUSION:

The failure of this head occured due to a typical manufacturing defect. Detection of such defects has improved so they are now located during the manufacturing process for reworked heads. Manufacturing techniques have improved such that these defects no longer occur in production heads.

CONCLUSION -(continued)

In no way would this crack have caused a catastrophic failure of the engine or compromised its availability in stand-by service.

The head is repairable provided no new unrepairable cracks are detected in final stress relieving.

Date: _____

D H Pratt 3/30/83
Signature-Failure Analysis Engineer