RELATED CORRESPONDENCE

LILCO, August 14, 1984

DOCKETED
USNRC

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

Before the Atomic Safety and Licensing Board

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

## TESTIMONY OF DAVID O. HARRIS, DUANE P. JOHNSON, ROGER L. McCARTHY, FRANZ F. PISCHINGER, CRAIG K. SEAMAN, LEE A. SWANGER AND EDWARD J. YOUNGLING ON BEHALF OF LONG ISLAND LIGHTING COMPANY OF SUFFOLK COUNTY CONTENTION REGARDING AE PISTON SKIRTS ON DIESEL GENERATORS AT SHOREHAM

Testimony and Attachments

Volume 1 of 2

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## I. Introduction of Witnesses

1. Please state your names, employers and business addresses.

A. (Harris) My name is Dr. David O. Harris. I am employed by Failure Analysis Associates (FaAA), 2225 East Bayshore Road, Palo Alto, California 94303.

(Johnson) My name is Dr. Duane P. Johnson. I am also employed by FaAA, 2225 East Bayshore Road, Palo Alto, California 94303

(McCarthy) My name is Dr. Roger L. McCarthy. I am President of FaAA, 2225 East Bayshore Road, Palo Alto, California 94303.

(Pischinger) My name is Dr. Franz F. Pischinger. I am President of FEV (Research Society for Energy, Technology and Internal Combustion Engines) and full professor at the University of Aachen, Institute of Applied Thermodynamics. My address is Erkfeld 4, Aachen, West Germany.

(Seaman) My name is Craig K. Seaman. I am employed by Long Island Lighting Company (LILCO), North Country Road, Wading River, New York 11792.

(Swanger) My name is Dr. Lee A. Swanger. I am also employed by FaAA, 2225 East Bayshore Road, Palo Alto, California 94303.

(Youngling) My name is Edward J. Youngling. I am also employed by LILCO, North Country Road, Wading River, New York 11792.

2. Please state your responsibilities in your current employment relevant to the AE pistons at Shoreham and your educational and professional backgrounds.

A. (Harris) I am a Managing Engineer and manager of the fracture mechanics section of FaAA. I am responsible for the stress analysis and fracture mechanics analysis of various mechanical components. I am the principal investigator in a number of fracture mechanics contracts in which FaAA is involved, including one analysis of cracking in nuclear reactor piping that is being funded by the Nuclear Regulatory Commission. FaAA has also recently begun work on development of a computer code for NASA that will predict crack growth under a very wide variety of conditions. I have been involved in fracture mechanics analysis of crack growth for many years and, as can be seen from my resume (Attachment 1), have numerous technical publications in this area. I am the task leader for pistons for the TDI Owners Group. I am responsible for the stress and fracture mechanics of TDI pistons. My educational and professional backgrounds are detailed in my resume, Attachment 1 to this testimony.

(Johnson) I am nondestructive testing manager for FaAA responsible for all of its nondestructive testing. I am a qualified Level III inspector in eddy current and ultrasonic test methods. I supervised the eddy-current inspections of the AE pistons at TDI before shipment to LILCO and the inspections of the AE piston skirts after operation. My educational and professional backgrounds are detailed in my resume, Attachment 2 to this testimony.

(McCarthy) I am a registered professional engineer specializing in mechanical design. I am principal design engineer at FaAA. I have five degrees, culminating in a Ph.D. in Mechanical Engineering from MIT. My specialization and Ph.D. thesis was in mechanical and thermal design. My role in the piston program was to personally inspect various piston types at FaAA. I had executive oversight responsibility for FaAA's performance and performed final technical review of all the reports. I have ultimate management responsibility for the quality and caliber of FaAA's technical product My educational and professional backgrounds are detailed in my resume, Attachment 3 to this testimony.

(Pischinger) I am familiar with the design, function and operation of pistons as a result of 26 years of experience in diesel engine design and testing. Specifically, FEV reviewed the pistons, cylinder liners and piston rings in the EDGs at Shoreham as a part of Phase II of the TDI Owners Group Design Review Quality Revalidation (DRQR) program. My educational and professional backgrounds are detailed in my resume, Attachment 4 to this testimony.

(Seaman) I am the Project Engineer with the Shoreham Nuclear Power Station. As Program Manager for the TDI Owners Group Program my responsibilities for the AE pistons included: review and approval of the quality revalidation task descriptions and Phase I and Phase II reports; review of component (AE piston) reports both for Phase I and Phase II reports; chairing the Component Selection Committee charged with the responsibility for selecting the pistons for inclusion into the DRQR Program and establishing minimum review requirements; and managing the overall program which included the design review and inspections on the AE pistons. My educational and professional backgrounds are detailed in my resume, Attachment 5 to this testimony.

(Swanger) I am a Managing Engineer for FaAA specializing in materials science. My responsibilities in reviewing the AE piston skirts included, to some extent, evaluation of metallurgical aspects, evaluation of manufacturing techniques, assessment of interaction with other components, specifically piston rings, cylinder liners, piston pin and piston pin bushing and the influence of diesel engine operation on the pistons. My educational and professional backgrounds are detailed in my resume, Attachment 6 to this testimony.

(Youngling) I am Manager of the Nuclear Engineering Department for LILCO. Since May 1984, I have held the position of Manager of the Nuclear Engineering Department reporting to the Vice President, Nuclear Operations. In this capacity, I am responsible for engineering support of the Shoreham station, including the three TDI Emergency Diesel Generators. From 1981 through 1984 as Startup Manager, I was responsible for implementing the preoperational test program for the Shoreham station. In particular, I was responsible for implementing initial operation and check out and subsequent preoperational testing of the TDI diesel generators. After the failure of the EDG 102 crankshaft, I was designated as the Recovery Manager for the repair and requalification of the diesel generators. My educational and professional backgrounds are detailed in my resume, Attachment 7 to this testimony.

3. What issues have you been asked to address in your testimony?

A. (Harris, Johnson, McCarthy, Pischinger, Seaman, Swanger, Youngling) We have been asked to address the specific contentions admitted by the Board's July 17, 1984 Memorandum and Order regarding the AE piston skirts on the emergency diesel generators (EDGs) at Shoreham Nuclear Power Station (Shoreham):

> 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.

Our testimony, in summary, is that:

(1) The FaAA conclusion that cracks may or may not initiate in the AE piston skirts, but if initiated, will not grow, is based on crack initiation and growth analyses considering the important loads and displacements reflected in the actual operating conditions to be experienced by the Shoreham EDGs.

(2) Actual operating experience shows no relevant indications in AE piston skirts.

(3) The side thrust load on the AE piston skirts is not excessive. Side thrust load is not a design or operation problem with the AE piston skirt.

(4) The tin-plated design of the AE piston skirt is intended to act as a protective covering for the piston skirt and is not the source of any excessive scuffing that could lead to failure. No known failures of pistons have been caused by tin plating.

4. Are you familiar with the testimony filed by the County on July 31, 1984 in support of its contentions regarding the pistons in this proceeding?

A. (Harris, Johnson, McCarthy, Pischinger, Seaman, Swanger, Youngling) Yes.

## II. Background

5. Before proceeding to the specific points to be discussed in your testimony, please describe the AE piston skirts.

A. (Harris, Swanger, Youngling) Exhibit P-1 is a photograph of an AE piston skirt. The skirt is a cylindrical casting manufactured of 100-70-03 grade ASTM A536 ductile iron. The piston skirt fits within the cylinder and transmits the loads resulting from the combustion cycle of the EDG to the wrist pin and connecting rod, thereby exerting loads that produce torque to drive the crankshaft. The mechanical link between the crankshaft and the piston are the connecting rod and the wrist pin (connected to the piston skirt).

The complete piston consists of the piston skirt and a piston crown. Exhibit P-2 shows the top of the skirt and crown with studs that extend through the skirt to attach the crown to the skirt. Exhibit P-3 shows the crown to skirt mounting. At room temperature when no pressure is applied, the crown contacts the skirt only over an inner ring located just inside the stud bolt circle. To compensate partially for normal thermal distortion of the crown due to temperature differential, the crown is manufactured so that there is a cold clearance or gap between 0.007 and 0.011 inch between the outer contact rings on the crown and the skirt. The gap at the outer ring will close under certain pressure and temperature conditions thereby transmitting a portion of the load from the piston crown to the piston skirt through the outer contact ring. This provides a corresponding reduction in the load on the inner contact ring. In turn, this results in a reduction in the stresses in the stud boss region of the skirt where the stresses are the highest.

6. Were the gap sizes between the outer contact ring on the crown and skirt in the AE pistons at Shoreham measured?

A. (Seaman, Youngling) Yes. The gap size is measured as a standard practice pursuant to piston reassembly guidelines. For instance, gap sizes were measured when the AE piston skirts were installed in November 1983. More recently, the gaps in the ten pistons inspected during the DRQR program were measured during reassembly and were determined to be within the 0.007 and 0.011 inch range. Documentation of those measurements is included in Exhibit P-4.

7. Please describe the critical stresses on the piston skirts.

A. (Harris, McCarthy, Swanger) The pistons experience 1.35 million cycles of stress every 100 hours of engine operation. Therefore, cyclic stress levels that may produce crack initiation under high cycle fatigue conditions are of primary concern in evaluating a piston's ability to withstand operating stresses. The fatigue failure of metals, which involves the initiation of cracks, has been experimentally observed to occur as the result of repeated cycling between different stress levels. Therefore, the maximum and minimum stresses during a stress cycle are of primary interest in a fatigue analysis.

8. Please describe the factors that determine the minimum and maximum stresses in the Shoreham piston skirts.

A. (Harris, McCarthy, Swanger) Stresses in pistons are produced by various loads. The loading on the piston consists of pressure in the combustion chamber, friction and inertia. The largest loads that the piston sees occur at the top and bottom dead center. At top dead center and bottom dead center there is no relative motion between the piston and cylinder liner. Frictional forces are very small at these positions, and frictional loads are, therefore, not considered in analyzing minimum and maximum stresses. The minimum stress (largest negative or compressive stress) in the skirt is caused by the firing pressure, which occurs close to top dead center of the power stroke. The maximum stress (largest positive or tensile stress) occurs due to inertia at top dead center of the exhaust stroke. The stresses due to inertia at top dead center of the exhaust stroke are insignificant in the analysis of crack initiation, but do serve to define the opposite end of the stress cycle, i.e., the maximum stresses. Other factors such as thermal distortion, gap size and inertia loading also influence the minimum stress. The most influential factor, however, is the peak firing pressure. Gap size, thermal distortion, stud pre-load and the influence of these parameters on the possibility of momentary lift-off of the crown from the skirt are also other factors influencing the maximum stress, but the most influential factor is the inertia loading.

9. How did FaAA determine that peak firing pressure occurred at top dead center of the power stroke?

A. (Harris, Swanger) FaAA developed a pressure/crank angle diagram that shows the firing pressure for various crank angles. The largest firing pressure occurs close to top dead center of the power stroke, which corresponds to zero degree of crank angle. Exhibit P-5 is a copy of the pressure/crank angle diagram.

10. How was it determined that the maximum inertia loading on the piston occurs at the top dead center position?

A. (Harris) A kinematic analysis of the piston, connecting rod, and crankshaft assembly revealed that the maximum piston acceleration occurs at the top dead center position. The top dead center position at exhaust is of primary interest only because this is one of the loadings that influences the cyclic stresses.

11. Why did LILCO replace the AF design piston skirts with AE design piston skirts?

A. (Seaman, Youngling) In November 1983, LILCO replaced the AF skirts with the AE skirts. At that time, the Owners Group analysis of the AF piston skirt to determine the possible extent of crack propagation which could result from continued operation had not been performed. Although cracking had been observed in the AF skirts, no failures had been experienced in the Shoreham type AF skirts in nuclear operation. LILCO, however, in consideration of its engine rebuild schedule and the time required to complete the AF analysis, decided to replace the AF skirts with the improved AE design. The analysis (which was completed later) verified through optical metallography, scanning electron microscopy and fracture mechanics analysis that the cracks in the AF skirt had arrested.

12. What are the major differences in the design between the AE piston skirt now in the EDGs at Shoreham and the AF design originally in place at Shoreham?

A. (Harris, Seaman, Swanger) The major differences between the AF and AE designs are in the boss regions through which studs extend to attach the crown to the skirt. The stud attachment bosses are considerably enlarged in the AE design. The thickness of the material around the stud hole for the AE design was increased by 82% over the AF design. The extent of the thickened area around the stud hole was also increased. In addition to the modifications to enlarge the stud attachment bosses, the following changes were made:

(1) Thickening of the walls of a cavity that extends from the top of the wrist pin boss to the top of the skirt.

(2) Thickening and filling in the material around the wrist pin hole.

(3) Thickening and tapering of the circumferential rib that runs between the wrist pin bosses.

The major differences between the AF and AE designs are shown on Exhibit P-6.

13. Did the Owners Group review both the AE and AF piston skirts?

A. (Harris, McCarthy, Seaman) Yes. Even though the AE skirts had not demonstrated design or operational problems, the Owners Group decided to verify that the AE skirt design was, in fact, an improvement over the AF skirt design. The analyses showed that cracks in the AE skirt might not even initiate, but if they did, they would not propagate.

## III. FaAA's Crack Initiation And Growth Analyses Show Cracks In The AE Piston Skirts Might Initiate, But Will Not Grow

### A. General Approach And Assumptions

14. Please describe the FaAA analyses of crack initiation and growth in the AE piston skirt.

A. (Harris, McCarthy) The analyses included basically three steps. First, the minimum and maximum stresses in the stud boss region of the AE piston skirts were evaluated by both experimental procedures (strain gage measurements) and numerical procedures (finite element analysis). The stresses were determined for peak firing pressure and inertia at top dead center of the power stroke and for inertia loading at top dead center of the exhaust stroke. These two loading conditions provide the maximum and minimum stresses in the stud boss region and, therefore, serve fully to define the cyclic stress levels. The second step was to input these two sets of stresses into the fatigue analysis using a "modified Goodman diagram." The use of the experimental stresses, in combination with the modified Goodman diagram, predicted that cracks would not initiate in the piston skirt. Similar procedures using the numerical stresses, however, predicted that cracks could possibly initiate in the stud boss region. Therefore, a third step was necessary, i.e., a fracture mechanics analysis, to determine the growth behavior of the hypothesized initiated cracks. Fracture mechanics analysis would also determine growth behavior from any possible initial imperfections in the skirt. The growth behavior of the hypothesized cracks was evaluated from information on stresses in the uncracked piston skirt in combination with fracture mechanics procedures. The analysis showed that any cracks that could possibly initiate in the stud boss region would not grow.

15. Why were both experimental and numerical procedures used to evaluate the stresses in the stud boss region?

A. (Harris, McCarthy) The experimental observations provided checks on the accuracy of the idealizations of the finite element analyses and verified that they provided conservative results. The use of the two approaches provided cross-checks and, therefore, provided results in which we have more confidence. Furthermore, a combination of experimental and numerical procedures was believed to be necessary to provide a complete understanding of the stresses in the critical regions of the skirt and to provide information on the combined behavior of the crown/skirt assembly.

16. Please describe why stresses in the stud boss region were considered as opposed to other areas of the piston skirt.

A. (Harris, McCarthy, Swanger) The numerical analysis did consider stresses in the entire piston skirt, but the analysis was concentrated in the stud boss region. The stresses derived from the experimental procedures also considered several regions of the skirt, but also concentrated on the stud boss region. The stud boss region was emphasized for two reasons. First, inspection of all of the AF piston skirts originally installed in the Shoreham EDGs disclosed linear indications in one or more of the skirt-to-crown stud attachment bosses in each of these skirts. Second, a stress coat test performed on the AE skirt identified precisely this region as the most highly stressed area of the AE skirt.

17. Please describe the stress coat test.

A. (Harris, Swanger) The stress coat test consisted of applying a brittle lacquer on the inside of the piston skirt, stressing the skirt with hydraulic pressure and looking for cracks in the lacquer. The lacquer used is commercially available and is specifically intended for experimental determination of the location of maximum stresses. The regions where the lacquer first cracks as pressure is applied are the regions of highest stress. The piston was subjected to hydraulic pressures as high as 2,000 psig, well above any reported for the Shoreham EDGs. Only the lacquer in the stud boss region cracked, thereby indicating this region to be the most highly stressed.

18. What is wrong with the County's five criticisms of the assumptions it alleged FaAA made in its fracture mechanics analysis?

A. (Harris, McCarthy, Swanger) The County criticized FaAA's fracture mechanics analysis because it assumed (1) "complete adherence to TDI drawing dimensions;" (2) AE piston material free from imperfections; (3) "a non-corrosive operating environment free of gasses, water or vapor;" (4) a maximum peak firing pressure of 1,670 psi; and (5) a uniform skirt temperature. First, FaAA did not make the assumptions alleged by the County in (1) and (2). Second, the assumptions in (3) through (5) are reasonable.

19. Why is the County's allegation wrong that the FaAA analysis assumed "complete adherence to TDI drawing dimensions?"

A. (Harris, McCarthy, Swanger) FaAA made measurements from an actual AE piston skirt in addition to reviewing dimensions on TDI drawings. Furthermore, FaAA verified some of the dimensions used in its analysis with actual field measurements of AE piston skirts made during the engine rebuild program and the DRQR program. Representative measurements taken by these programs are included in Exhibit P-7.

20. Why is the County's allegation incorrect that FaAA assumed the AE piston material was free from any small imperfections?

A. (Harris, Johnson, McCarthy, Seaman, Swanger) Fracture mechanics analysis will actually show what level of imperfection can be tolerated in the material. The FaAA fracture mechanics analysis of the AE piston skirt, which will be discussed in detail below, showed that a crack up to 1/2 inch deep would not propagate. This also means that cracks would not grow from any possible initial imperfection under 1/2 inch in size. In addition, to preclude any significant imperfections, all AE piston skirts were inspected by liquid dye penetrant and eddy-current at the TDI factory in Oakland prior to shipment to LILCO. TDI performed the liquid dye penetrant inspections which were witnessed by LILCO and Stone & Webster. FaAA performed the eddy-current testing. Piston skirts were rejected, prior to shipment to Shoreham, for any linear indications for which the liquid dye penetrant exceeded 1/32 inch in length. Exhibit P-8 includes documentation regarding the liquid dye penetrant testing, the certificates of compliance and the receipt inspections for the AE piston skirts at Shoreham.

21. Did FaAA consider the effect of corrosion in the operating environment in its fracture mechanics analysis?

A. (Harris, McCarthy, Swanger) Yes, and FaAA concluded that the environmental conditions inside the crankcase are not expected to have an influence on the crack growth characteristics of the piston skirt material. The vapors present in the crankcase are not the type that are commonly observed to accelerate crack growth. Furthermore, environmental enhancement of crack growth is not expected at the higher frequency (225 cycles per minute) experienced by the Shoreham EDGs.

22. Does LILCO have procedures to control the environmental conditions in the crankcase that might lead to corrosion?

A. (Youngling) Yes. LILCO takes routine oil samples from the Shoreham EDGs to check for any acidity and moisture.

23. Did the AF piston skirts in the Shoreham EDGs show any signs of corrosion?

A. (Youngling) No. After 600-800 hours of operation, the AF piston skirts in the EDGs at Shoreham showed no signs of corrosion.

24. Is 1,670 psig a reasonable representation of the peak firing pressures actually experienced by the Shoreham EDG's?

A. (Harris, Youngling) Yes. The 1,670 psig peak firing pressure is reasonable based on independent FaAA and Stone & Webster measurements, TDI factory tests and the preoperational qualification test procedures.

25. Please describe the FaAA and Stone & Webster measurements of the peak firing pressures.

A. (Swanger) FaAA and Stone & Webster conducted a joint test to measure the pressure versus crank angle relationship which included measuring the peak firing pressure. A piezo-electric transducer was used directly to measure the pressure inside the combustion chamber. The angle of the crankshaft was recorded simultaneously on a separate channel of the instrumentation recording the firing pressures. The position at top dead center was recorded for every revolution.

Measurements were also taken simultaneously at the pressure cocks on the side of the cylinder using a Kiene gage to measure the cylinder firing pressure. Exhibit P-5 is the pressure/crank angle diagram developed by FaAA.

26. What peak firing pressures did TDI measure in their factory tests as reported to LILCO in the TDI instruction manual?

A. (Seaman, Youngling) The County's Exhibit 46, Document No. 6 (DSR-48, Engine No. 74011) details these measurements. During actual operation of an engine, peak firing pressure was measured at 25%, 50%, 75%, 100%, and 110% of rated power. These measurements were made for each cylinder and provided to LILCO as a part of the TDI instruction manuals supplied with the engines. The maximum pressure shown on Document No. 6 for 100% is 1,650 psig. The County incorrectly characterized some TDI measurements as high as 1,750 for 100%. As shown on the County's Exhibit 46, Document No. 6, the 1,750 psig value was actually taken at 110%. The County used this erroneous interpretation of the TDI measurements to help support its conclusion that the Shoreham EDG peak firing pressure was as high as 1,750 to 1,800 psig.

27. Please describe the measurement of peak firing pressure in the preoperational qualification test procedures.

A. (Youngling) During the preoperational qualification test, the engine was run at 3,500 kW, and a full set of firing pressures was taken at each of the eight cylinders using a Kiene gage. Exhibit P-9 includes the peak firing pressures measured before and after the crankshaft replacement. Exhibit P-9 also includes an example of the preoperational test procedures. These recorded data indicate a range of average firing pressures between 1,522.5 psig and 1,671 psig.

28. Did the FaAA analysis consider peak firing pressure under overload conditions?

A. (Harris, Swanger) The static experimental procedures considered pressures as high as 2,000 psig, which is well in excess of reported peak firing pressure. Contrary to the County's understanding, strain gage measurements were not limited to a maximum of 1,600 psig and strains corresponding up to 2,000 psig were reported on Figures 3-5 through 3-8 of the FaAA Piston Report. These figures are included in Exhibit P-10. In its numerical procedures, FaAA did not consider peak firing pressure at overload because the engine operates a relatively small amount of time under overload conditions and, therefore, would have little effect on the initiation and growth of cracks.

Subsequent analyses, using the crown/skirt interaction model described below, were performed on the cracking behavior of AE piston skirts subjected to higher hypothesized firing pressures. It was found that pressures above 2,200 psig are required before possible initiated cracks could grow.

Therefore, the conclusion drawn in the initial analysis that employed a peak firing pressure of 1,670 psig is valid for pressures up to 2,200 psig, which is well above any reported peak firing pressures in TDI R-4 engines, even under overload conditions.

29. Why is it reasonable to assume a uniform skirt temperature?

A. (Harris, McCarthy, Swanger) Temperatures measured by TDI, and independently verified by FaAA as being reasonable, indicate temperatures on the bottom of the crown are nearly constant and equal to about 200° F. This suggests the piston skirt is nearly isothermal under steady-state operating conditions where the surrounding cooling water and oil range in temperature between 190° F and 160° F.

30. How were the temperatures measured by TDI independently verified by FaAA?

A. (Harris, Swanger) TDI measured peak temperatures in the crown and furnished those temperatures to FaAA in the form shown on Exhibit P-11. FaAA made independent calculations using transient radiative and convective heat transfer analysis to verify these measurements. The analysis utilized reasonable values for coolant temperatures, convective heat transfer coefficients and combustion gas temperatures derived from the pressure/crank angle diagram (Exhibit P-5). Key features of the calculated temperature field, including peak temperature and temperature gradient through the central portion of the crown, were in agreement with TDI measurements of temperature.

31. Did the FaAA analyses consider the operating conditions experienced by the EDGs at Shoreham?

A. (Harris, McCarthy, Swanger) Yes. FaAA determined the critical loads and areas to be studied and applied the analyses and procedures to predict and evaluate the stresses in these areas. The FaAA analyses contain assumptions that closely approximate the key factors concerned with the operating conditions at Shoreham relevant to a determination of cyclic stress levels and cracking behavior. As the procedures and analyses are described below, it will become clear that the factors considered produced a realistic evaluation of the stresses experienced under operating conditions.

## B. Experimental Procedures

32. Please describe the experimental procedures used to evaluate the maximum and minimum stresses in the stud boss region of the AE piston skirts.

A. (Harris, Swanger) Foil resistance strain gage rosettes were mounted on the piston skirts in several areas including those of highest stress reflected by the stress coat test described above. Exhibit P-12 shows the location of the strain gages. The gages were connected to data acquisition and recording equipment. An actual cylinder liner was used in the test with two opposing pistons placed crown-to-crown within the liner. The region between the crowns was pressurized with a hydraulic pump to as high a pressure as 2,000 psig. The pressure load on the instrumented skirt was reacted through the wrist pin and a short piece of connecting rod to a support plate. The connecting rod was in a vertical position, thereby simulating the top dead center position of the piston.

Two separate test series were conducted using this procedure. One series was conducted with a conventional crown, and one series was conducted with a crown that was modified to widen the gap at the outer ring between the crown and the skirt so that it would not close under the applied maximum pressure of 2,000 psig.

33. What conclusions did you draw from a comparison of the experimental results from the conventional and modified crown?

A. (Harris) A comparison of the strains observed at one of the stud bosses in the piston shown in Exhibit P-9 indicates that the crown-skirt gap closes at approximately 1,000 psig and distributes about 12% of the load at peak firing pressure on the outer ring. Strain gage measurements at numerous locations on the AE skirt also shows that the gap closed nearly simultaneously around the circumference of the piston, because the inflection point in the strain-pressure results always occurred at about 1,000 psig. This measured information showed gap closure at pressures below the 1,670 psig peak firing pressure measured for Shoreham and showed simultaneous closure around the ring. These experimentally observed results provided guidance in the construction of the crown/skirt interaction model discussed below. Exhibit P-13 summarizes the experimental observations related to the closure of the gap due to pressure and stress reduction due to gap closure in the AE piston skirt.

34. Under what temperature conditions were the experimental procedures performed?

A. (Harris) The experimental procedures were conducted at room temperature or, in other words, under isothermal conditions.

35. Why was this a reasonable condition when the pistons do not operate at room temperature?

A. (Harris, McCarthy) Apart from contributing to the closure of the gap and consequent redistribution of the gas firing pressure load, temperature gradients play a relatively minor role in the analysis because they do not contribute to the cyclic stress range. At operating temperatures, the top of the crown is hotter than the underside of the crown, thereby producing thermal distortion that will tend to close the gap. This results in more load being transmitted through the outer ring as is seen by the comparison of the modified and normal crown experimental results. Since the stress on the stud attachment boss is governed by the load applied to the inner contact ring, thermal distortion reduces the peak stresses due to firing pressure at the critical point (the stud boss region). A numerical analysis of thermal distortion of the crown discussed below confirmed that thermal distortion decreases the portion of the firing load carried on the inner ring and, therefore, reduces the cyclic stresses in the stud boss region.

36. What were the results of the experimental testing?

A. (Harris, Swanger) Exhibit P-14 summarizes the strain readings and calculated stresses for the complete stud boss gage rosettes. The principal strains and stresses were calculated from the rosette strain readings using the conventional equations for rectangular rosettes specified in Experimental Stress Analysis and Motion Measurement by R. C. Dove and P. H. Adams. Exhibit P-14 describes the significant stress value, the sigma III or the third (algebraic minimum) principal stress. The fracture initiation analysis showed that the experimentally derived stress would not cause cracks to initiate.

## C. Numerical Procedure

37. Please describe the numerical procedure used to determine the maximum and minimum stresses in the stud boss region.

A. (Harris, McCarthy) The numerical analysis consisted of three-dimensional finite element calculations. The finite element method is an approximate technique to apply the theory of elasticity to determine how a body will perform in response to specific loads or displacements applied to it. Those loads or displacements are termed "boundary conditions" and they define what factors come into play on the boundary of the piston skirt.

38. Please give some examples of the use of finite element analysis.

A. (Harris, McCarthy) Finite element analysis has been used in the design of a very wide range of structures such as the New York World Trade Center, the space shuttle, various commercial aircraft and nuclear reactor pressure vessels and piping.

39. Please describe the finite element analyses of the AE piston skirts.

A. (Harris) The finite element analyses of the piston skirt were composed of the following two parts:

Part 1. Isothermal Analysis: An isothermal analysis of a piston skirt with a crown mounted on it was performed. Closure of the gap at the outer contact ring and thermal distortion were not considered. This part of the analysis provided base line stresses for a skirt with a pressurized crown. These stresses were adjusted for gap closure and thermal distortion by use of a crown/skirt interaction model described in Part 2.

Part 2. Crown/Skirt Interaction Model: The second part of the finite element analysis provided a means of accounting for thermal distortion, gap closure and possible momentary lift-off of the crown from the skirt. This part of the analysis consisted of the following steps:

a. Construction of a crown/skirt interaction model to provide a means of calculating cyclic stresses in the stud boss region from information on the crown and skirt stiffnesses. This model considered the crown and skirt as coupled elastic springs, whose stiffnesses were evaluated by the finite element analyses described in b. below.

b. Evaluation of the stiffnesses used as inputs to the crown/skirt interaction model. This process involved

  i. Evaluation of the relevant stiffnesses of the skirt.

  ii. Evaluation of the stiffnesses and thermal distortion of the crown when subjected to steady-state operation temperature.

c. Evaluation of the peak stress when momentary lift-off of the crown from the skirt occurs.

The crown/skirt interaction model of Part 2 used the stress information from Part 1 to provide cyclic stresses under steady-state operating conditions.

40. What is the major value of the crown/skirt interaction model?

A. (Harris, McCarthy) The major value of the crown/skirt interaction model is its ability to predict cyclic stresses in a piston skirt at operating temperatures.

### 1. Isothermal Analysis

41. What boundary conditions were involved in the FaAA isothermal finite element calculations?

A. (Harris) The following boundary conditions were assumed:

(1) a rigid wrist pin;

(2) displacement on the inner contact ring between the skirt and the crown varying linearly with the radial position at any value of angular coordinates;

(3) frictionless interface between the top of the skirt and the crown; and

(4) frictionless interface between the piston assembly and cylinder wall.

42. Please discuss why the boundary condition of a rigid wrist pin is reasonable.

A. (Harris, Swanger) A rigid wrist pin exhibits no deformation. The wrist pin in actual operation is elastic and, therefore, exhibits some deformation thereby redistributing stresses in the stud boss area. A rigid wrist pin is actually conservative in the present case, because it assumes that the deformation will occur in the piston and not in the wrist pin.

Furthermore, the wrist pin in reality is actually thicker than the piston and, therefore, more resistant to deformation than the piston.

Modeling an elastic wrist pin in finite element analysis results in a more complicated model. Therefore, FaAA made the conservative rigid wrist pin assumption initially based on constructing a tractable, but reasonable finite element model. A subsequent analysis assuming a soft wrist pin confirmed that this assumption is conservative. The soft wrist pin analysis showed that peak stresses in the stud boss of the piston skirt assuming a soft wrist pin are decreased in comparison to the stresses assuming a rigid wrist pin.

43. Please describe the comparative analysis performed using the assumed types of wrist pins.

A. (Harris) In the original analysis with a rigid wrist pin, the boundary condition in the area of contact between the wrist pin and the piston skirt was a uniform displacement (i.e., a rigid wrist pin). In order to estimate the influence of elasticity of the wrist pin, another analysis was performed in which the boundary condition in the area of contact between the wrist pin and the piston skirt was a uniform pressure. This is the opposite extreme from a rigid wrist pin and represents a soft wrist pin. The calculated peak stud boss stresses in the AE piston skirt were reduced by 39% when a soft wrist pin was used. This demonstrates the conservative nature of the assumption of a rigid wrist pin.

44. Please decribe the reasonableness of the assumption that the displacement on the inner contact ring between the crown and the skirt varies linearly with the radial position at any value of the angular coordinate.

A. (Harris) This assumption provides a simplification of the boundary conditions that is accurate because the approximate 1 inch width of the support ring is small relative to the 17 inch piston diameter. The assumption of linearity provides a good approximation over such a small distance.

45. Please discuss why the assumption of a frictionless interface between the piston skirt and crown and the piston assembly and cylinder wall is reasonable.

A. (Harris) The inner contact ring between the crown and skirt is clean upon assembly of the piston, and the region is well lubricated during operation of the engine. Therefore, the assumption of no friction at the crown-skirt interface is reasonable. Assuming no friction between the piston and cylinder wall is also reasonable because the relative velocity between these two components is very low at the top dead center position of interest.

46. What other factors were considered in the finite element procedure?

A. (Harris) The magnitude of the pressure load (379,000 pounds) created by the peak firing pressure was considered. At top dead center of the power stroke, this pressure load is somewhat offset by the inertia load (9,727 pounds), which is exerted by the crown on the top of the skirt. The inertia force, therefore, was subtracted from the magnitude of the gas pressure load to determine a maximum net force on the top of the skirt of 369,300 pounds, which corresponds to an effective pressure of 1,627 psig.

47. What were the major results of of the isothermal finite element analysis using the boundary conditions described above?

A. (Harris) The peak stress (sigma III) in the stud boss region of the AE piston skirt at top dead center of the power stroke for a rigid wrist pin was calculated to be -68.1 ksi. The corresponding cyclic stress was evaluated by determining the stress at top dead center of the exhaust stroke and accounting for gap closure during the power stroke. The stress at top dead center of the exhaust stroke was determined by multiplying the top dead center power stroke stress value by the ratio of the inertia load to the pressure-minus-inertia load. Gap closure was accounted for by multiplying the finite element stress value by 88% (in accordance with Exhibit P-9).

48. How do the results from the numerical procedures compare with those from the experimental procedures?

A. (Harris) The cyclic stress levels under isothermal conditions in the AE piston skirt that were estimated from the experimental and numerical results are presented in Exhibit P-15. As you can see, the numerical values are higher than the experimental values and, therefore, more conservative.

49. Can you explain why there is a difference, albeit on the conservative side, between the numerical and experimental results?

A. (Harris) The assumption of a rigid wrist pin is the main reason for the variance. As was described above, this assumption is conservative because an elastic or soft wrist pin would result in decreasing the stresses in the stud boss region. In fact, as shown in Exhibit P-16, the assumption of a soft wrist pin results in numerical stresses smaller than those experimentally measured.

## 2. Crown/Skirt Interaction Model

50. Please describe the crown/skirt interaction model.

A. (Harris) The numerical procedures that were described above analyzed stress levels under isothermal conditions. Load transfer between the skirt and the crown is influenced by thermal distortion of the crown and the initial size of the gap between the crown and the skirt. FaAA directly measured the effect of the gap on piston stresses in its experimental work, and used the experimental results on gap closure to adjust the numerical results to reflect gap closure. These were considered reasonable assumptions to evaluate the stresses, erring, if at all, to overestimate the stresses.

As time permitted, the crown/skirt analysis was conducted to consider directly the influence of thermal distortion and initial gap on cyclic stress levels and the possibility of momentary lift-off of the crown from the skirt. These factors were estimated by combining the results of the isothermal finite element stress analysis with a crown/skirt interaction model.

51. Please describe the crown/skirt interaction model used to determine the influence of thermal distortion on the load split between the loading rings and the possibility of momentary lift-off of the crown from the skirt during the exhaust stroke.

A. (Harris) The crown skirt interaction model is a simple engineering model that accounts for all the factors influencing the maximum and minimum stresses such as initial outer ring gap, thermal distortion of the crown, pressure loading, inertia loading, stud preloads and possible momentary lift-off of the crown from the skirt during the exhaust stroke. Finite element results alone do not directly provide this information. Thermal distortion was included as a thermally-induced displacement or boundary condition that was calculated by finite elements using a steady-state temperature field in the piston assembly based on experimental measurements. The interaction model treated the crown and the skirt as springs whose stiffness was estimated by finite element techniques based on the assumption that the loading rings on the crown and skirt remain parallel to one another. The stiffnesses and crown thermal distortion result from the finite element analyses provided the necessary inputs to the crown/skirt interaction model.

52. What were the basic conditions in the crown/skirt interaction model?

A. (Harris) Two basic conditions were considered in the interaction model:

(1) top dead center of the compression stroke (or beginning of the power stroke) where the maximum compressive stresses in the piston skirt occur; and

(2) top dead center of the exhaust stroke where momentary lift-off of the crown may occur.

Isothermal and steady-state operating temperatures were considered for both of these load cases.

53. Please describe the boundary conditions employed in the finite element steps in the crown/skirt interaction analysis of the skirt.

A. (Harris) This analysis of the skirt utilized the following three sets of boundary conditions:

(1) Uniform vertical displacement on the inner crown/skirt contact ring of a magnitude to react the load corresponding to 1627 psig effective pressure on the crown;

(2) Uniform vertical displacement on the outer crown/skirt contact ring of a magnitude to react the load corresponding to 1627 psig effective pressure on the crown; and

(3) A stud load applied on the stud washer landing area and reacting on the outer loading ring which is constrained to have a uniform vertical displacement.

The results of the analyses using boundary conditions (1) and

(2) above provided estimates of the skirt spring constants or stiffnesses that were required for the crown/skirt interaction model. Boundary condition (3) provided the stress levels due to inertia at top dead center of the exhaust stroke appropriate for crown/skirt lift-off. In the isothermal analysis no lift-off between the crown and skirt was considered. Therefore, the peak stress due to inertia could be obtained from the peak stress due to firing pressure simply by multiplying by the ratio of the inertia force to the peak pressure-minus-inertia force (changing the sign to account for the different direction of the loads).

54. Why is the boundary condition regarding uniform vertical displacement reasonable?

A. (Harris) A uniform vertical displacement boundary condition is simply a convenience for calculating the stiffnesses of the skirt, and this assumption is not key to the FaAA evaluation of stresses. Comparison with finite element calculations where the displacement was not required to remain uniform provides similar results. In addition, the experimental results shown in Exhibit P-10 indicate that gap closure will occur uniformly around the circumference of the piston/skirt.

55. In addition to the three sets of boundary conditions, were any other factors considered in the expanded finite element analysis of the skirt?

A. (Harris) There were basically three other factors. First, a rigid wrist pin was assumed in the first and second sets of boundary conditions. No wrist pin was utilized for the third set, i.e., stress when momentary lift-off occurs. Second, all of the finite element runs on the skirt models were performed for uniform temperature, reflecting the true operating condition of the skirt. Third, a stud preload of 6,600 pounds was used based on strain gage measurements obtained by measuring the strain in a stud when a crown was mounted on a skirt in accordance with manufacturer's specifications. This measurement was made by FaAA using strain gages.

56. Please describe the finite element analysis of the crown performed as a portion of the development of the crown/skirt interaction model.

A. (Harris) Three parameters related to the crown were of interest in the crown/skirt interaction model. These were the stiffness of the crown when subjected to pressure on the combustion side, stiffness of the crown when subjected to a load on the outer contact ring and thermal distortion of the crown when subjected to steady-state operating temperature. The stiffnesses of the crown were evaluated by finite elements by subjecting the crown to the load of interest (pressure or load on the outer ring) and calculating the resulting movement of the outer contact ring relative to the inner contact ring. The stiffness (or spring constant) is then equal to the load divided by the corresponding displacement.

The thermal distortion (as measured by the thermally induced relative displacement of the two concentric load rings) was calculated to be 0.0106 inch. This value was obtained by using the experimentally determined crown surface temperature measurements as boundary conditions for a steady-state heat conduction analysis of the temperatures in the interior of the crown. These temperatures were then used in a finite element thermoelastic calculation of the thermally induced displacement in the crown.

57. What were the major results drawn from the crown/skirt interaction model?

A. (Harris) The major results drawn from the crown/skirt intereaction model were the cyclic stress levels in a piston skirt at isothermal and steady-state operating temperatures considering the influences of the initial gap and the possibility of momentary lift-off of the crown from the skirt. Exhibit P-17 summarizes the isothermal and steady-state operating temperature cyclic stresses for an AE piston skirt with various initial gap sizes. Results are presented for several sets of estimated skirt stiffnesses.

58. How do the cyclic stresses under isothermal and steady-state operating temperatures compare?

A. (Harris) The results presented in Exhibit P-17 show that the cyclic stresses are less severe under steady-state operating conditions, because the minimum stresses are increased (less compressive) without a corresponding increase in the maximum stress. Therefore, the cyclic stresses are actually largest under isothermal conditions.

59. How do the gap closure pressures and load splits evaluated for the crown/skirt interaction model compare to those observed experimentally as a result of the strain gage measurements?

A. (Harris) The gap closure pressure and load split between the rings were calculated from the crown/skirt interaction results by an equation that assumes the peak stress is governed by the load on the inner ring. Exhibit P-18 shows that this assumption is a good approximation because the stresses for a given load that are applied by a uniform displacement on the inner ring are much higher than the corresponding values for the loading on the outer ring. Exhibit P-19 summarizes the calculated gap closure pressure and load split at nominal, minimum and maximum values in comparison to the experimental observations. The nominal, minimum, and maximum values in the column of experimental results provide the range of values actually observed. The corresponding values in the column of calculated values were calculated using the nominal, minimum, and maximum values of the initial gap. The comparison between the experimental and numerical results can also be made by estimating skirt stiffness from experimentally observed load splits and gap closure pressures by using equations developed for the crown/skirt interaction model. Exhibit P-20 compares the results of the estimated skirt stiffness from experimentally observed results with the finite element stiffnesses. Experimental values of the outer skirt stiffness are generally lower than the numerical value. Overall, the agreement between the experimental and numerical sets of data are quite good, which verifies the validity of the crown/skirt interaction model.

60. How do the different sets of stiffnesses affect the important results drawn from the crown/skirt interaction model?

A. (Harris) The calculated cyclic stresses, which are the most important results of the crown/skirt interaction model, are not strongly dependent on the values of the skirt stiffnesses. This can be seen from Exhibit P-17 which presents calculated cyclic stresses in the stud boss region for various initial gap sizes and loading conditions that were calculated using different sets of skirt stiffnesses. For a given gap and loading condition, the cyclic stresses are nearly the same for each of the sets of stiffnesses.

## D. Fatigue Crack Initiation Analysis

61. What was the next step in the evaluation of the integrity of the piston once the cyclic stresses had been defined?

A. (Harris, McCarthy) The next step was to determine if cracks can initiate when the material is subjected to these cyclic stresses.

62. Please describe the analysis you performed to determine whether cracks would initiate in the AE piston skirts.

A. (Harris, McCarthy) As noted, the pistons experienced 1.35 million stress cycles every 100 hours of operation. Therefore, crack initiation under high cycle fatigue conditions is the main consideration. The fatigue property called the endurance limit of the material is of primary interest. The Iron Castings Handbook, edited by C. F. Walton and T. J. Omyer, indicates that the endurance limit of ductile cast iron with the properties of the 100-70-03 material used in the AE piston skirt is conservatively 30 ksi. Comparison of this fatigue property of the skirt material with the cyclic stresses evaluated from experimental measurements and finite element calculations allowed us to predict whether cracks would or would not initiate.

63. Please explain the procedure you followed to predict crack initiation behavior.

A. (Harris, McCarthy) The endurance limit of a material is directly applicable to the case where the mean stress is zero and the stress system is uniaxial. In order to perform the analysis on the AE piston skirt, procedures to account for a non-zero mean stress were employed. Non-zero mean stress was treated in the standard manner using a modified Goodman diagram. The Goodman diagram is the means by which the allowable cyclic stress for infinite life (or no crack initiation) for a given mean stress can be plotted. These conditions are summarized in Exhibit P-21. The results in Exhibit P-21 are for uniaxial stress, and are directly applicable to the current problem because the experimental results discussed above show that stresses are nearly uniaxial in the highly stressed region of the stud boss area. The crack initiation criterion was used in combination with the cyclic stresses shown on Exhibit P-17 to evaluate the possibility of crack initiation for various gap sizes. The mean stress and stress amplitude for a given condition were plotted on a figure such as the one shown in Exhibit P-21. If the plotted point falls inside the solid lines (stress envelope) then crack initiation will not occur. An endurance limit of 30 ksi was used, and a modified Goodman diagram was used to adapt this endurance limit for cases other than zero mean stress. This same procedure was utilized in evaluating crack initiation from the experimental measurements and finite element results from both the isothermal and crown/skirt interaction calculations.

64. Please describe the modified Goodman diagram?

A. (Harris, McCarthy) The modified Goodman diagram is a plot defining the relationship of mean stress and cyclic stress for an infinite life. It is primarily based on experimental observations of the failure of fatigue specimens that were subjected to a given cyclic and mean stress. A considerable amount of experimental data has been generated over the last several decades that provides the basis for using the modified Goodman diagram for analysis of fatigue with non-zero mean stress. In developing the modified Goodman diagram, failure (or crack initiation) was considered to occur if the material permanently deforms (plastically deforms or yields) as opposed to actually breaking.

65. Please describe the results of the fatigue analysis using the stresses evaluated from the experimental measurements and the isothermal finite element calculations.

A. (Harris) Exhibit P-22 is a plot of the allowable stress envelope for infinite life with the stresses at various gap sizes indicated. The stresses for isothermal conditions are shown. Exhibit P-22 shows that cracks are predicted not to initiate in AE skirts under cyclic stresses corresponding to the experimental results for any gap size and that cracks may or may not initiate under cyclic stresses corresponding to the finite element results depending on the yield strengths and gap size. The modified Goodman diagram is drawn for the range of values of yield strength from 63.5 to 70.5 ksi that bound the results of measurements of the yield strength of material taken from an AE skirt drawn from the lot of skirts now in use at Shoreham.

66. Did the results of the fatigue analysis using the stresses evaluated from the crown/skirt interaction model confirm that isothermal conditions are more severe than steady-state operating conditions?

A. (Harris) Yes. Exhibit P-23 shows the results for 0.007 and 0.011 inch initial gaps for isothermal and steady-state temperature distribution conditions. The results on Exhibit P-23 show that conditions for crack initiation are more severe under isothermal conditions. Therefore, cracks are more likely to initiate under isothermal than steady-state conditions. Exhibit P-23 also shows that cracks might initiate in the AE skirts under certain conditions, such as under isothermal conditions with a 0.011 inch gap in a piston of relatively low yield strength. A smaller initial gap is beneficial in reducing the cyclic stress under isothermal conditions, but contributes to the possibility of momentary crown lift-off. Such lift-off is not detrimental, however, because it does not have an adverse influence on the operation of the AE piston skirt at Shoreham and does not increase the cyclic stress.

67. Do the results of the finite element analyses showing that isothermal conditions are more severe than steady-state operating conditions support a conclusion that the experimental results are applicable to operating temperature conditions?

A. (Harris) Yes. The overall conclusion based on the experimental measurements is that cracks will not initiate in the stud boss region of the AE piston skirt. The fact that the crown/skirt interaction model predicted lower cyclic stresses under steady-state temperatures supports a conclusion that the experimental results showing no cracks under isothermal conditions also applies to operating temperature conditions.

## E. Fatigue Crack Growth Analysis

68. Does the initiation of a crack mean that the piston will eventually fail?

A. (Harris, McCarthy, Swanger) No. The initiated crack may or may not grow. Even if it does grow, it may do so only for awhile and then arrest before growing to the point where the piston would fail. Fracture mechanics analysis is commonly employed to make this determination. Fracture mechanics is the body of engineering knowledge that is applicable to the analysis of the growth and stability of cracks in solids.

69. What is the purpose of fracture mechanics analysis?

A. (Harris, McCarthy) Modern design analysis is able to insure the safe operation of such structures as aircraft, spacecraft, pipelines and turbines, etc. through the application of engineering fracture mechanics. It is now common to design and operate critical structural components in such a manner that the initial presence of crack-like defects is assumed, and the possible growth of the defects due to fatigue is calculated. For example, even the highly-stressed rotating parts of military aircraft gas turbine engines are designed assuming the presence of small cracks that grow in fatigue. In fact, the United States Air Force has a formal procedure that expressly requires the manufacturer to adopt this design approach. Many other structures, i.e., civil, mechanical and marine, are designed with the same philosophy. This philosophy merely reflects the fact that all materials and structures contain crack-like defects on some scale and that the primary objective of design analysis is, therefore, not to prevent initiation but to assure that such cracks cannot grow to significant size. Fracture mechanics analysis provides this assurance.

70. Please describe the methodology FaAA employed to determine whether cracks would grow in AE piston skirts.

A. (Harris) Because the crack initiation analysis using the conservative numerical finite element results predicted that crack initiation could possibly occur, a fracture mechanics analysis of the growth (and possible arrest) behavior of the hypothesized initiated cracks was performed. Not all crack tips are unstable, contrary to the County's testimony, and fracture mechanics provides the means of analyzing the stability and possible growth of cracks in solids. In the case of the AE piston skirt, the solid was considered as an elastic body. Standard linear elastic fracture mechanics procedures were used to evaluate the stresses near the tip of the crack from information on stresses in the uncracked skirt. The stress intensity factor provided the measure of the stresses near the crack tip. Elastic-plastic behavior of the material in the highly stressed region of the stud boss was accounted for by appropriate procedures. The fracture mechanics properties of the AE piston material were compared with the fracture mechanics parameters computed by the finite element analyses, stress and fracture mechanics evaluation.

71. What were the fracture mechanics properties required in this analysis?

A. (Harris, McCarthy) Two fracture mechanics properties were necessary for this analysis: the fracture toughness of the material and the fatigue growth crack characteristics of the material.

72. Please describe the fracture toughness property utilized in this analysis?

A. (Harris) Exhibit P-24 summarizes some relevant fracture toughness data from the literature. A fracture toughness of KIC of 40 ksi-in 1/2 was considered a reasonable, but conservative, value of fracture toughness. This value is conservative because it represents a temperature of 70°F. Fracture toughness of cast iron is influenced by temperature within a range (room temperature to approximately 300°F). As temperature increases, the fracture toughness increases. As noted above, actual measurements of temperature during operation indicated that the temperature of the piston skirt is a uniform 200°F. Therefore, the use of a value measured at 70°F is conservative.

73. Please describe the fatigue crack growth characteristics used in this analysis.

A. (Harris) For a given material operating in a given environment, the rate at which a fatigue crack will grow is dependent mainly on the cyclic value of the stress intensity factor (Delta K = Kmax - Kmin). Other factors, such as the mean value of the stress intensity factor (represented as R = Kmin/Kmax) also influence, to a lesser degree, the rate at which a fatigue crack grows. The threshold cyclic stress intensity factor below which cracks will not propagate is expressed as Delta Kth. The Delta Kth of a particular material is a function of the R-value. The Foreman relation for crack growth (which is a widely used relationship in fracture mechanics analysis) was combined with the treatment of the influence of the R-value on Delta Kth from Metallurgical Transactions by A. Yuen, S. J. Hopkins, G. R. Leverante and C. A. Rau, to determine the influence of R on Delta Kth. Cracks are considered not to propagate for a given Delta K and R if Delta K is less than the Delta Kth at the given R-value.

74. Please describe the procedures used to perform the fracture mechanics analysis.

A. (Harris) The fracture mechanics properties described above and the calculated stress intensity factors from the finite element stresses were used in this analysis. The finite element results represented elastically calculated stresses.

The plastically redistributed stresses corresponding both to the isothermal and steady-state operation were analyzed. Two sets of calculations were performed, one for nominal tensile properties and one for poorer case tensile properties bound from the measurements of tensile strengths of the AE skirt drawn from the lot of skirts now at Shoreham. The BIGIF fracture mechanics code was used to obtain the elastic-plastic redistributed stress fields that exist after yielding. Residual tensile stresses were predicted by the use of BIGIF in the localized region where the cracks could possibly initiate. The BIGIF calculations accounted for the variation in Delta Kth with the stress ratio, the R-value. BIGIF was also used to calculate the stress intensity factor range, Delta K.

75. What is the BIGIF fracture mechanics code?

A. (Harris, McCarthy) BIGIF is a general purpose fracture mechanics code that is used in the analysis of crack stability and fatigue crack growth. It is based on linear elastic fracture mechanics, but does contain capabilities for treating contained plastic deformation. BIGIF is used by many different organizations on a wide variety of problems. In addition to its use on pistons and crankshafts of the TDI engines, it has been applied to cracking problems in pressure vessels, pipes, steam turbine and generator rotors, spacecraft components and gear teeth. Its great versatility makes it applicable to a very wide range of problems.

76. Did the fracture mechanics calculations show that the cracks that could possibly initiate in the AE piston skirts would not grow?

A. (Harris) Yes. For the AE skirt, the fracture mechanics calculations revealed that the Delta K and R values for all crack depths do not exceed the threshold conditions. Therefore, the cracks in the AE skirt that were predicted possibly to initiate based on the conservative finite element results were shown not to grow under isothermal or steady-state conditions. Exhibit P-25 shows the representative values of R and Delta K for various hypothesized crack depths for an AE piston skirt with a 0.007 inch gap operating under steady-state temperature conditions. This is the most severe condition from a crack propagation standpoint. Exhibit P-25 also shows the corresponding threshold condition for crack growth. It is seen that the operating conditions are always below the threshold condition. Therefore, any cracks that may initiate will never grow, even if they were as deep as 1/2 inch. Furthermore, contrary to the County's erroneous hypothesis, any imperfections introduced during fabrication of the piston also would not grow, even if they were as deep as 1/2 inch.

77. Do you consider your analytical results to reflect the possibility of crack growth under actual operating conditions?

A. (Harris, McCarthy, Swanger) Yes. The stresses upon which the fracture mechanics analysis was based considered the major loads and displacements actually influencing the piston skirts under operating conditions. Assumptions required in the analytical process were conservative and resulted in overestimating the stresses. Those assumptions have been discussed above and include, for instance, the use of a rigid wrist pin. The conservative nature of the assumptions can be seen by comparing the experimental results with the finite element results. The finite element stresses were invariably higher. Even the use of these conservative stresses indicated that cracks will not grow in the AE piston skirt. FaAA also considered the operating environmental conditions inside of the crankcase of the Shoreham EDGs and concluded that they would not be expected to have an influence on the crack growth characteristics of the piston skirt material.

## IV. Operating Experience

78. Are you aware of any failures of AE piston skirts in operation?

A. (Harris, Seaman, Swanger) No. The DRQR created a computerized component tracking system to gather nuclear and non-nuclear experience on TDI R-4 engines, as well as additional information on other EDGs in nuclear service. No AE piston failures were reported in the component tracking system.

79. Have inspections of AE piston skirts after operation been conducted?

A. (Johnson, Seaman, Swanger, Youngling) Yes.

Inspections using eddy-current and liquid dye penetrant were performed on a total of fourteen skirts including ten AE piston skirts from the Shoreham EDGs and four AE piston skirts at two non-nuclear installations.

80. What was the significance of these inspections?

A. (Harris, McCarthy) Each inspection added an additional piece of information that the AE piston skirts are successfully operating without developing cracks. These inspections are merely data points and are not used to prove, but do serve to confirm, the validity of the fatigue crack initiation or fracture mechanics analyses. Conclusions from these analyses stand on their own.

81. What is a liquid dye penetrant inspection?

A. (Johnson, Swanger) Liquid dye penetrant inspection is a method of nondestructive testing used to detect and indicate discontinuities that are open to the surface. It can be used for the inspection of most structural materials. Examination by liquid penetrant testing is accomplished in five basic steps:

1) Precleaning. Each item to be inspected must have contaminants, such as dirt and oil, removed form the surface to be inspected.

2) Applying the penetrant which is colored red for high visibility.

3) Removing the penetrant quickly after it is set. Penetrant will be left within the discontinuities for lack of time to escape.

4) Applying the developer. As the penetrant is pulled into the developer an indication appears.

5) Visual examination and interpretation. Qualified inspectors can tell whether an indication is from a crack, lamination, lack of fusion, porosity, etc.

This test method is sensitive to imperfections such as cracks, shrinkage cracks, surface porosity, cold shuts, grinding and heat-treat cracks, seams, forging laps and bursts, cold lap, lack of fusion, etc.

82. What is an eddy-current inspection?

A. (Johnson, Swanger) Eddy-current tests are high-resolution NDE procedures that were used on the AE piston to determine if a liquid dye penetrant indication corresponded to a significant size crack-like defect or not. FaAA used its Procedure NDE 11.5, Rev. 0 in its inspection of the EDG 102 pistons and NDE 11.5, Rev. 1 in its inspections of the EDG 101 and 103 pistons. Because of the purpose of eddy-current tests, its use was limited to portions of the skirt where liquid dye penetrant had revealed an indication that needed further examination. In this case, a penetrant indication 1/32 inch or longer required eddy-current examination.

The eddy-current test itself involved scanning a coil over the test area and monitoring the electrical impedence of the coil. Material defects cause a change in the coil impedence which generates a signal. A signal generated from a crack or a simulated crack was used as the crack standard. When the material at issue was scanned, all eddy-current crack indications exceeding a specified fraction of the crack standard were recorded.

83. Why it is reasonable to apply the 1/32 inch length criteria to determine what indications shown from the liquid dye penetrant will be subjected to further analysis?

A. (Harris, Johnson, Swanger) The presence of small imperfections in any cast material is normal. Contrary to the County's assertion, indications smaller than 1/32 inch in length cannot contribute significantly to the possibility of crack initiation and propagation. This is supported by the results of the fracture mechanics analysis of crack growth, which predicted that cracks less than 1/2 inch deep would not grow. Cracks of 1/2 inch depth would be expected to be at least 1 inch in surface length.

84. Please describe why it is reasonable to record signals exceeding a certain fraction of the signal from the crack standard.

A. (Harris, Johnson) For instance, the crack standard for piston skirt inspection per NDE 11.5, Rev. 1 is 1/16 inch in length by 1/32 inch in depth. At the rejection level of fifty percent of the signal from the standard specified in Rev. 1, subcritical defects (1/2 inch deep by 1 inch long) are easily detected. The Rev. 0 inspection was approximately a factor of two more sensitive than the Rev. 1 inspections.

85. Please describe the inspections of the ten AE piston skirts from Shoreham.

A. (Johnson, Seaman, Youngling) After 300 hours total operation, including 100 hours at 100% load, liquid dye penetrant and eddy-current inspections were conducted of the stud boss region of AE piston skirts from EDGs 101, 102 and 103. LILCO and Stone and Webster performed the liquid dye penetrant test at the stud boss attachment areas for all three engines utilizing approved LILCO procedures. The results of those inspections are included in Exhibit P-26. FaAA conducted the eddy-current inspections which were observed by representatives from LILCO. The results of these inspections for all three engines and the FaAA eddy-current procedures are included in Exhibit P-27. The inspections revealed no relevant indications.

86. Describe the characterization of a nonrelevant indication.

A. (Harris, Johnson, McCarthy) It is important to remember that some surface liquid dye penetrant indications are common in all iron castings. They can result from superficial features such as tool marks, pits, inclusions and other irregularities in the surface of the casting. These indications do not have any effect on fatigue behavior of an AE piston at Shoreham due to their bluntness and/or small depth.

87. Why are inspection results after 100 hours at 100% load meaningful in assessing the reliability of the AE piston skirts?

A. (Harris, McCarthy, Swanger) Each AE piston skirt incorporates 8 individual highly-stressed fillets in the intersections of the four stud attachment bosses with the wrist pin bosses. There are, as in all cast articles, minor variations in material composition, dimensions and physical properties as well as minor differences in stresses that result from the expected variations in temperature and pressure in the cylinders, stud preload and machining tolerances. Thus the 192 highly-stressed areas (24 piston skirts x 8 boss fillets) in the 3 Shoreham EDGs represent a population of similar fatigue samples with a distribution of endurance limits, i.e., stress levels below which the samples exhibit infinite fatigue lifetime. Conventionally, the endurance limit is accepted to be the stress level corresponding to 10 million stress reversals. Information contained in the Iron Castings Handbook, by Walton and Olpar, 1981, (p. 341) (Exhibit P-29) shows that the cyclic stress for cracking in 10 million cycles is 93% of the cyclic stress for cracking in 1.35 million cycles. Scatter of 7% on stress is commonly observed in fatigue data. Therefore, it is likely that cracking indications would be observed in the population of inspected stud bosses if they had been operated for 1.35 million cycles at stresses above the endurance limit.

88. Please describe the inspections performed on the AE pistons in non-nuclear operation.

A. (Johnson) FaAA inspected two AE skirts from a RV-16-4 engine at Kodiak Electric Association in Alaska. This engine had experienced over 6,000 hours of service at an average peak firing pressure reported by the utility to be approximately 1,200 psi. FaAA also inspected two AE piston skirts from the TDI R-5 prototype engine after approximately 622 hours of operation at 2,000 psi. Neither the Kodiak nor the R-5 prototype engine inspections revealed any relevant indications. These inspection reports are included in Exhibit P-29.

89. Are the AE pistons in the TDI R-5 engine significantly different from those in the EDG's at Shoreham?

A. (Harris, Johnson, Swanger) No. There are variations reflecting design evolution between the R-5 AE piston skirts and the Shoreham piston skirts. These variations involve an area that is irrelevant to the analysis of crack initiation in the stud boss region. The County specifically stressed the fact that the R-5 engine has an operating speed of 514 RPM while the operating speed of the Shoreham EDG's is 450 RPM.

The increased inertia associated with the increased RPM reduces the effective peak firing pressure. For the R-5 engine, the effective peak firing pressure at 450 RPM would be 1,957 psig as opposed to its actual value of 1,944 psig at 514 RPM. The effective peak firing pressure on the R-5 engine at 450 RPM is still approximately 20% higher than the Shoreham peak firing pressure. The County ignored the more important point, i.e., the fact that the R-5 has operated successfully for over 622 hours at 2,000 psig. The fact that an AE piston skirt in the R-5, which represents an earlier stage in the evolution of the design, withstood that operation without relevant indications is the more persuasive point about the integrity of the AE piston skirts at Shoreham.

90. Please describe why the Kodiak operating experience is meaningful in evaluating the suitablity of the AE piston skirt for safe operation at Shoreham.

A. (Harris, McCarthy) As mentioned above, the Kodiak experience with AE piston skirts involved 6,000 hours at a reported average peak firing pressure of 1,200 psi. In spite of the lower peak firing pressure, this experience is relevant because it involves a large number of stress cycles (about 80 million). The fact that no indications of excessive wear or fatigue cracking were observed after so many cycles provides additional evidence of the integrity of the AE piston skirt.

## V. Side Thrust Load
## Is Not A Design Or Operation Problem With The AE Pistons At Shoreham.

### A. Shoreham AE Piston Skirt

91. Please describe side thrust load.

A. (Pischinger, Swanger) All piston engines generate a side thrust load between the piston and the cylinder as the result of the balance of forces between the piston, the connecting rod and the cylinder wall. During the power stroke, as the piston descends in the cylinder from the top dead center position, the motion of the connecting rod causes it to assume an increasing angle greater than zero degrees with respect to the axis of the cylinder. The longitudinal force in the connecting rod is resolved into axial and transverse components in the piston. The axial component is generated by the net pressure force acting on the piston. The transverse component is the geometric result and is manifested as a force between the piston and the cylinder wall. This latter force, which varies with cylinder gas pressure, speed of the engine and the crankshaft angle, is the piston side thrust.

92. Is side thrust load a significant consideration in the design of a diesel engine?

A. (Pischinger) No. In current diesel engine design, side thrust, much less the excessive side thrust alleged by the County, is simply not a consideration. Proper lubrication incorporated in the piston design makes side thrust load a nonissue. With adequate lubrication, the consequences of side thrust load will never reach the level described by the County. Pistons, including the AE pistons, are designed to lubricate the skirt to reduce friction. Exhibit P-30 details the lubrication system on the Shoreham EDGs.

93. Will side thrust load dramatically increase the temperature on one side of the piston?

A. (Pischinger, Swanger) With an adequately lubricated piston, side thrust will not create a dramatic temperature differential. In order to create the temperature effect described by the County, the piston and skirt would have to come into unlubricated contact. Lubrication minimizes the piston skirt/cylinder contact and facilitates heat flow from the piston to the liner.

94. Has operational experience shown that side thrust load is not a problem with pistons in nuclear service?

A. (Harris, McCarthy, Seaman, Swanger) Yes. The component tracking system does not indicate adverse consequences from side thrust on any pistons in nuclear service. Furthermore, the component tracking system does not indicate any failure on R-4 engines in either nuclear or non-nuclear service. This R-4 experience is helpful because the factors influencing side thrust load, crank angle, reciprocating piston weight and connecting rods, are the same on all R-4 engines and are not affected by individual piston designs.

95. Why do you disagree with the County's dramatic conclusions regarding the effect of piston side thrust load?

A. (Pischinger, Swanger) As described above, current design experience has indicated that side thrust is not a problem. The County characterizes the side thrust as excessive based on an outdated standard. Most modern engines would exceed this outdated standard. It has no meaning to current engine design. The County's standard is drawn from Diesel Engine Design by T.D. Walshaw, 1949 (County's testimony, p. 48, footnote 60). The dated value of this 35 year old source is exemplified by various information drawn from the reference. For example, for a roughly 17 inch bore four stroke diesel, a peak firing pressure of 700 psig (p. 80) and BMEP of 70 psig (p. 71) are given. The County's reference also states that two stroke diesels are "used universally for the higher powers, say above 3000 BHP per unit" (p. 47). These statements are at odds with more modern design practices and show the dated nature of the 85 psi limit on unital side thrust loads. Similar problems are found in the County's other reference on side thrust, Internal Combustion Engine by V. L. Maleev, 1945 (County's testimony, p. 49, footnote 61) when the reported BMEPs (pp. 352, 353, 355) and peak firing pressure (pp. 206, 207, 355) are compared with modern practice. Improved materials in more modern engines allow higher operating pressures to be attained. For instance, Maleev describes cast iron piston material with a tensile strength of 20ksi - 30ksi (p. 499), whereas the nodular iron in TDI engines is approaching 100 ksi in tensile strength. The textual references noted from both references are included in Exhibit P-31.

In summary, the 35-40 year old material from which the County obtained its values of recommended side thrust does not reflect modern design practices. As noted above, design and operating experience indicates that side thrust load is simply not a consideration.

96. Is there any evidence of excessive side thrust on the AE piston in the EDG's at Shoreham?

A. (Seaman, Swanger) No. The County cited several reports by the DRQR of scuffing on the AE piston skirts. These reports, however, include not only a report of scuffing, in some cases, but a conclusion that it was acceptable or normal wear. Copies of the reports cited by the County are attached to this testimony as Exhibit P-32. Furthermore, as the County pointed out, DRQR personnel visually inspected the AE skirts at Shoreham and did not observe excessive side load wear.

97. On what basis did the County challenge the conclusion of the DRQR inspections?

A. (Seaman, Swanger) The County stated that during its June 1984 inspection the County's consultants noticed a "heavy wear pattern" on one AE skirt. The County also indicated it noticed that the tinplated area showed indications of "abraded surfaces and evidence of debris that had been previously imbedded in the plating, but since removed." As will be discussed below, the purpose of the tinplating is to capture and absorb minute particulate material from the combustion chamber so that it will not harm the cylinder liner.

98. Why is the County's belief wrong that there may have been side thrust markings in some of the cylinder liners?

A. (Seaman, Youngling) The only reason the County offered in support of its belief is that its consultants "surmised" that deglazing observed was necessitated by the side thrust markings. The County went on to describe deglazing as "a maintenance operation in which the cylinder liner surface is honed." The County's June 1984 inspection was of EDG 103 during the block replacement. The cylinder liners had just been rehoned at TDI as a part of that engine rebuild. This is normal practice in an engine rebuild and has no relationship to the piston skirt performance prior to the rebuild. The rehoning certainly does not support a conclusion that there have been adverse consequences of side thrust on the AE piston skirt at Shoreham.

99. Was there any evidence of excessive side thrust in the AE skirts in the DSRV-16-4 engine at Kodiak Electric Association in Alaska?

A. (Johnson, Swanger) FaAA observed no evidence of excessive side thrust during the inspections of the Kodiak skirts after more than 6,000 hours of operation.

100. Would you anticipate that adverse effects of side thrust would evidence themselves on the Kodiak engine even at 1,200 psi?

A. (Harris, Swanger) According to the County's standard for acceptable unital side thrust, the Kodiak engine should have experienced excessive side thrust even at 1,200 psi. Assuming the County's calculation of the side thrust load at Shoreham is correct, the side thrust for Kodiak can be derived by multiplying the County's side thrust result times the ratio of the Kodiak and Shoreham peak firing pressures. As noted, Kodiak had not evidenced any symptoms of excessive side thrust.

101. Did inspections of the modified AF piston skirts removed from Shoreham after 600 - 800 hours of operation reveal any indication of excessive side thrust?

A. (Harris, Johnson, Swanger, Youngling) No. Both visual and nondestructive examination revealed no signs of the County's alleged excessive side thrust. The nondestructive evaluation (liquid dye penetrant and eddy current testing) showed that the cracks in the modified AF skirts were randomly distributed on all sides of the skirt in the boss area. The liquid dye penetrant test results are included in Exhibit P-33. If there had been excessive side thrust, the cracks would have shown some side to side variation indicating adverse effects of side thrust load. The same side loads were experienced on the AF piston skirts as the AE pistons skirts because the factors affecting side loading, _i.e._, firing pressure and the geometry of the crank connecting rod and piston, are the same in both skirts.

102. Is the side thrust load on the Shoreham piston acceptable?

A. (Pischinger) Yes. Based upon the dimensions of the piston skirt, crank radius and the connecting rod length, I conclude that the Shoreham piston is an extremely low side-load piston. Moreover, based on current design practice, side thrust should not even be an issue in this proceeding.

## B. FaAA Analysis

103. Did FaAA consider side thrust load in its analysis of the stresses on the AE piston skirt?

A. (Harris, McCarthy) No. As discussed above, cyclic stresses were the key factor FaAA considered in analyzing crack initiation in the AE piston skirts. The cyclic stresses are the differences in the minimum and maximum stresses. Pressure and stress have a linear relationship. Side thrust load is produced when the connecting rod angle varies from zero degrees. In this case, a portion of the load due to pressure on the piston is reacted through the wrist pin at an angle as contrasted to directly through the connecting rod to the crankshaft as would occur at top dead center. The pressure/crank angle diagram that FaAA developed (Exhibit P-5) shows that peak firing pressure during the power stroke occurs near the position when the connecting rod is vertical and parallel to the cylinder axis, a position corresponding to top dead center. The minimum load (inertia) is exerted when the piston is at top dead center of the exhaust stroke, which also corresponds to a zero degree angle between the connecting rod and crankshaft.

104. Would side thrust load change the cyclic stress amplitude?

A. (Harris, McCarthy, Swanger) No, not significantly. The pressure/crank angle diagram shows that the pressure drops off rapidly as the piston moves away from top dead center. Therefore, the forces on the piston decrease rapidly away from top dead center, and consequently the stresses in the stud boss region decrease. The side thrust load is zero at top dead center, which is close to where the peak pressure loading occurs. By the time the crank angle has increased to the point where the side component of the load is appreciable, the pressure has decreased to the point where the total pressure load has greatly descreased.

105. Would the FaAA conclusions that cracks in the AE piston skirts at Shoreham may initiate, but would not grow under operating conditions, be changed if side thrust load were considered a significant contributor to cyclic stresses?

A. (Harris) No. In the unlikely event that side thrust loads were determined to be a significant contributor to cyclic stresses in the stud boss region, such increases would not alter the FaAA conclusions. This is borne out by calculations made by FaAA on cracking of the AE skirt when subjected to peak firing pressure as large as 2,400 psig. These calculations, performed using the methodology described above, revealed that crack growth would not occur even at pressures of 2,200 psig. The maximum and minimum stresses and fracture mechanics analysis results from these calculations are shown on Exhibit P-34.

The small increases in estimates of cyclic stresses that may possibly occur if side thrust loads were included in the analysis would certainly be insufficient to increase the cyclic stresses to levels corresponding to 2,200 psig. Therefore, explicit consideration of side thrust loads would not alter our conclusions regarding the possibility of crack initiation but no growth of cracks in the AE piston skirt.

## VI. The Tin Plating On The AE Pistons At Shoreham Will Not Lead To Failure

106. Please describe the purpose of the tin plating on the AE piston skirts.

A. (Pischinger, Swanger) Tin is a soft, low-friction material electroplated on piston skirts to facilitate a smoother break-in period for an engine. During break-in, piston rings and skirt surfaces are required to adapt themselves to new and non-broken-in cylinder liner and bore surfaces. Soft tin plating provides a low friction run-in surface similar to that provided by the overlay on the connecting rod bearing shells or on main bearing shells. In other words, the tin plating provides a running-in surface between the new skirt and the new liner. In addition, due to its soft quality, the tin plating captures minute particulates created by the running-in process and absorbs these materials. This process, therefore, protects the honed cylinder liner. In summary, the purpose of the tin plating is to provide a smooth break-in period and to protect the cylinder liner and the piston skirt. Contrary to the County's allegation, the purpose of the tin plating on the skirt is not to offset the assumed bad effects of alleged excessive piston side thrust. In fact, the County's own reference, Internal Combustion Engines (p. 498), states that "cast iron pistons produce less cylinder liner wear than aluminum ones, especially if they are tin plated."

107. Does the experience collected in the component tracking system indicate that tin plating of piston skirts is not an operational problem?

A. (Seaman, Swanger) The component tracking system contained no evidence of any failures or adverse operational problems resulting from tin plating of piston skirts in nuclear or non-nuclear service. Furthermore, the County did not document any actual failures or operational problems caused by tin plating. The County was merely theorizing based on incorrect assumptions as to the purpose of tin plating.

108. The County alleged that the scoring it observed can result in gas blow-by and, therefore, perhaps eventual piston seizure. Has excessive gas blow-by ever been experienced in the EDGs at Shoreham?

A. (Seaman, Youngling) No. LILCO monitors crank case pressure which would increase if gas blow-by were experienced. If excessive blow-by were to occur, the pressure sensor would alarm and then trip the unit. Shoreham has never tripped due to excessive gas blow-by.

109. The County was also concerned about alleged problems that might occur from the electroplating process. Why is the County's concern about electroplating ill-founded?

A. (Pischinger, Swanger) The County stated its concern about failure because of enbrittlement caused by hydrogen escaping into the metal during the electroplating. The County stated that hydrogen embrittlement has been responsible "for many dramatic failures of ferrous metals" and is a problem in "all plated metal components." This is incorrect. Hydrogen enbrittlement is not a concern in relatively mild nodular cast iron which had relatively low ultimate tensile strengths as compared to steel. It is a consideration only in high strength steel with ultimate tensile strength in excess of 150,000 psi. The tensile strength values of the AE piston skirt measured by FaAA were 85,360 psi to 90,210 psi. Furthermore, any cathodically charged hydrogen in the piston would diffuse out of the iron matrix in less than 100 hours at the operating temperature of the AE piston at Shoreham.

110. The County seemed concerned about tin plating because of scoring it observed in several cylinders during the County's trips to Shoreham in 1983 and 1984. Was this scoring due to the tin plating?

A. (Seaman, Youngling) No. The County hypothesized, based on its 1983 observations, that the scoring was caused by an accumulation of imbedded material in the tin plated surface of the skirt. The accumulation of material, however, was not caused by the tin plating. In 1983, the Shoreham EDGs had Koppers piston rings which were allowing an excessive amount of carbon build-up on the cylinder liners. As the result of a recommendation of the DRQR program, those rings have been replaced, however, with Muskegon piston rings. The Phase II DRQR of the piston rings concluded the Muskegon rings were appropriate for the intended use at Shoreham and that minor scuffing score marks on the cylinder liners were within an acceptable range indicating acceptable performance. In addition to replacing the Koppers piston rings with Muskegon piston rings to assure freedom from unacceptable scuffing, LILCO has adopted the following practices:

1. Inspection of the cylinder liners at each fuel outage to evaluate liner wear and coat deposits.
2. Use of a high detergent oil.
3. Use of 135° fuel injection tips.

111. Who performed the review of the Muskegon piston rings.

A. (Pischinger, Seaman) FEV performed the Phase II review which included an evaluation of the service conditions versus the ring design specification and an analysis of the actual performance of the rings, pistons and liners.

112. How was this review performed?

A. (Pischinger, Seaman) FEV considered the results of quality revalidation inspections and numerous task evaluation reports. Furthermore, FEV performed detailed engineering inspections at Shoreham, and more general inspections at Catawba, the TDI Manufacturing Plant in Oakland, California and the Muskegon Piston Ring (MPR) Manufacturing Plant in Muskegon, Michigan.

113. Please describe the inspections performed of the Shoreham pistons, rings and liners.

A. (Pischinger, Seaman, Youngling) The Shoreham rings, pistons and liners were inspected following a 24-hour test run and a 7-day test run and after about 100 hours at greater than or equal to full load. In addition, the components on EDG 102 were reinspected following a 100 start test.

114. What were the results of the FEV evaluation of the service conditions against the ring design specifications?

A. (Pischinger) FEV concluded that the design specifications for the MPR piston rings used on the Shoreham engines are typical of industry practice and conservatively rated for turbocharged and aftercooled medium speed diesel engines and are, therefore, appropriate for the intended use at Shoreham.

115. What were the results of the FEV inspection of the Shoreham pistons, rings and liners?

A. (Pischinger) Buildup of coke in the upper area of the liner and piston down to the second compression ring was noted. The coke buildup resulted in wear on the ring and the liner, and minor scuffing score marks were observed on them. Linear wear was also present, as well as some mirror-like bright areas on a high percentage of the cylinder liners. The magnitude and types of wear observed on the rings and liners, however, are within acceptable ranges, indicating acceptable performance.

116. Based upon the FEV review, do you conclude that the MPR piston rings are adequate for their intended function at Shoreham?

A. (Pischinger) Yes.

117. Does the tin plating in any way reflect a design deficiency?

A. (Pischinger, Swanger) No. The tin plating is an accepted mechanism to facilitate engine break-in and to protect the piston and cylinder liner from scoring from minute particulates escaping from the combustion chamber. There is simply no support for the allegation that tin plating has ever led to scoring, much less that it has caused excessive blow-by affecting the operation of the piston.

## VII. Conclusion

118. In light of the County's piston contentions, is it your conclusion that the AE piston skirts are safe and reliable for their intended service?

A. (Harris, McCarthy, Swanger) Yes. The analysis of AE piston skirts using the higher, more conservative stresses predicted that fatigue cracks could possibly initiate. The analysis by engineering fracture mechanics predicted that these cracks cannot grow in the Shoreham EDGs. These same design analysis procedures have been successfully applied in other industries, including highly sophisticated aircraft gas turbine engines, as well as to other critical components of nuclear power plants.

119. Is it unusual to operate structural components where the presence of fatigue cracks is assumed?

A. (Harris, McCarthy) It is now common to design and operate critical structural components such that the initial presence of crack-like defects is assumed and the growth of these defects in fatigue is calculated. The possibility of fatigue crack initiation in the stud attachment bosses of piston skirts poses no new or unusual problems when compared to common design practice in other industries, such as aerospace. For example, even the highly-stressed rotating parts of military aircraft gas turbine engines are designed assuming the presence of small cracks that can grow in fatigue. As noted above, the

United States Air Force has a formal procedure that expressly requires the manufacturer to adopt this design approach. Many other structures - civil, mechanical, marine - are designed with the same philosophy. This philosophy merely reflects the fact that all materials and structures contain crack-like defects on some scale and that the primary objective of design analysis is therefore not to prevent "initiation" but to ensure that such cracks cannot grow to a significant size. It is important to appreciate the fact that all critical structural components in our common experience, such as aircraft, bridges, pipelines, tanks--even elevator cables--contain such defects. Modern design analysis is able to ensure the safe operation of all these structures through the application of engineering fracture mechanics. Contrary to the County's contention, the fracture mechanics analysis of AE piston skirts showed that they are safe and reliable.

Attachment 1

Failure
Analysis
Associates

**DAVID O. HARRIS**

**Specialized Professional Competence**

Fracture mechanics analysis and testing, fatigue and stress corrosion cracking in nuclear reactor piping, probabilistic fracture mechanics, stress analysis, acoustic emission testing and applications.

**Background and Professional Honors**

Ph.D. (Applied Mechanics), Stanford University
M.S. (Mechanical Engineering), University of Washington
B.S. (Mechanical Engineering), University of Washington

Managing Engineer, Fracture Mechanics Group,
Failure Analysis Associates
Division Manager,
Science Applications, Inc.
Director of Research,
Dunegan/Endevco
Mechanical Engineer,
Lawrence Radiation Laboratory

Member, American Society of Mechanical Engineers
Member, American Society for Testing and Materials
Member, Acoustic Emission Working Group
Member, Tau Beta Pi, National Engineering Honorary Society
Member, Sigma Xi, Scientific Research Honorary Society

**Selected Publications**

"Characterization of Acoustic Emission from Crack Growth in Steam Turbine Rotor Steels," to appear as Electric Power Research Institute Report, Palo Alto, California (with D. D. Dedhia and T. C. Mamaros).

"Stress Intensity Factors for Surface Cracks in Pipes: A Computer Code for Evaluation by Use of Influence Functions," Electric Power Research Institute Report NP-2425, Palo Alto, California (June 1982) (with D. D. Dedhia).

"Stress Corrosion Crack Growth in the Presence of Residual Stresses," *Residual Stress and Stress Relaxation*, 28th Sagamore Army Materials Research Conference, Plenum Press (1982).

"Probabilistic Analysis of the Influence of Vibratory Stresses on Piping Reliability," *Reliability and Safety of Pressure Components*, pp. 17-34, PVP—Vol. 62, American Society of Mechanical Engineers, New York (1982) (with E. Y. Lim).

"Fracture Mechanics Models Developed for Piping Reliability Assessment in Light Water Reactors," Report NUREG/CR-2301, U.S. Nuclear Regulatory Commission, Washington D.C. (1982) (with E. Y. Lim and D. D. Dedhia).

"Application of a Fracture Mechanics Model of Structural Reliability to the Effects of Seismic Events on Reactor Piping," *Progress in Nuclear Energy*, Vol. 10, (1) pp. 125-159 (with E. Y. Lim).

"The Influence of Nondestructive Inspection on the Reliability of Pressurized Components," *Fracture Tolerance Evaluation, Proceedings of U.S.-Japan Joint Symposium on Fracture Tolerance Evaluation*, Honolulu, Hawaii (December 1981) pp. 257-265.

"Applications of a Probabilistic Fracture Mechanics Model to the Influence of In-Service Inspection on Structural Reliability," to appear in the *Proceedings of ASTM Symposium on Probabilistic Methods for Design and Maintenance of Structures* (with E. Y. Lim).

"Approximate Influence Functions for Part-Circumferential Interior Surface Cracks in Pipes," presented at 14th National Symposium on Fracture Mechanics, Los Angeles, California (June 1981) (with E. Y. Lim and D. D. Dedhia).

Attachment 2

Failure
Analysis
Associates

**DUANE P. JOHNSON**

### Specialized Professional Competence

Nondestructive evaluation and structural monitoring methods; production line inspection system development, field inspection and monitoring services, inspection and monitoring reliability analysis, nondestructive inspection procedure development and review, inspection level and interval optimization, eddy current instrument development, advanced electromagnetic sensor development, advanced signal processing, R&D on advanced nondestructive inspection and monitoring methods.

### Background and Professional Honors

B.S. (Electrical Engineering), University of Minnesota, with High Distinction
M.S. (Physics), University of Washington
Ph.D. (Physics), University of Washington

Manager, Nondestructive Evaluation and Monitoring,
  Failure Analysis Associates
President and Co-Founder,
  Reluxtrol, Inc.
Supervisor, Nondestructive Inspection,
  Pratt & Whitney Aircraft
Associate Professor of Physics,
  American University, Cairo, Egypt

Member, American Society for Nondestructive Testing
Member, American Physical Society
Member, Institute of Electrical and Electronics Engineers

### Selected Publications

"Review of State of the Art Inspections of Steam Turbine Blades," EPRI Steam Turbine Blade Reliability Workshop (1982) (with E. K. Kietzman).

"Electromagnetic Testing of Ceramic Materials," EPRI Report (1981) (with L. Y. L. Shen).

"Controlled Reluctance Eddy Current Inspection of Steam Turbine Components," EPRI Workshop on NDE of Steam Turbine and Electrical Generator Components (1980) (with S. Sarian and E. K. Kietzman).

"Assessment of Current NDI Techniques for Determining the Type, Location and Extent of Fossil-Fired Boiler Tube Damage," EPRI Report (1980) (with E. R. Reinhart and S. Sarian).

"Production Line Nondestructive Evaluation of Continuous Formed Metal Parts Using Controlled Reluctance Eddy Current Probes," ASNT Spring Conference (1979) (with S. Sarian).

"Reliability of Flaw Detection by Nondestructive Inspection," Metals Handbook, Vol. 11 (with several authors).

"Economics and Managerial Aspects of Nondestructive Testing Evaluation and Inspection in Aerospace Manufacture," Appendix C, National Academy of Science Publication NRAB-337 (with T. L. Toomay).

"Determination of Nondestructive Inspection Reliability Using Field or Production Data," Materials Evaluation, Vol. 36 (1978).

"Estimation of Defect Detection Probability Using ASME Section XI UT Tests on Thick Section Steel Weldments," ASM/ASTM/ASNT/ANS International Conference NDE in Nuclear Industry (1978) (with T. L. Toomay and C. S. Davis).

"A Workable Approach for Extending the Life of Turbine Rotors," Fatigue Life Technology, ASME Symposium (1977) (with P. M. Besuner).

"Optimizing NDI Sensitivity," Metals Progress, Vol. 112 (1977).

"Inspection Uncertainty: The Key Element in Nondestructive Inspection," Materials Evaluation, Vol. 39 (1976).

Attachment 3

Failure
Analysis
Associates

## ROGER L. McCARTHY

### Specialized Professional Competence

Mechanical, machine, and mechanism design. Dynamic mechanical system design, analysis modeling, control (including dedicated computer control), and failure analysis. Custom product design. Human factors engineering and testing; design analysis of man/machine interface. Design analysis research. Risk analysis; quantification of hazards posed by design and construction of mechanical components, products, or system failure in the industrial and transportation environments. Design analysis through large scale accident data analysis and evaluation, including vehicle design and collision performance. Evaluation of mechanical/electrical design-related explosion hazard; heat transfer design. Reinforced polymer composite design analysis, including tires. Patent analysis relating to mechanical design.

### Background and Professional Honors

A.B. (Philosophy), University of Michigan, with High Distinction
B.S.E. (Mechanical Engineering), University of Michigan, summa cum laude
S.M. (Mechanical Engineering), Massachusetts Institute of Technology
Mech.E. (Mechanical Engineering), Massachusetts Institute of Technology
Ph.D. (Mechanical Engineering), Massachusetts Institute of Technology

President,
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    Proctor & Gamble Company, Inc.

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Phi Beta Kappa, Sigma Xi, James B. Angell Scholar
National Science Foundation Fellow
Outstanding Undergraduate in Mechanical Engineering, University of Michigan

Member, American Society of Metals, American Society of Mechanical Engineers, Society of Automotive Engineers, American Welding Society, National Safety Council, American Society for Testing and Materials
Member, American Society of Safety Engineers
Member, Human Factors Society, System Safety Society, National Society of Professional Engineers
Member, American Society of Heating, Refrigeration, and Air-Conditioning Engineers
Member, National Fire Prevention Association

### Selected Publications

"School Bus Wheel Rim Safety—Multipiece vs. Single Piece," National School Bus Report, Springfield, Virginia (December 1982) (with G. E. McCarthy).
"Warnings on Consumer Products: Objective Criteria For Their Use," 26th Annual Meeting of the Human Factors Society, Seattle, Washington (October 25-29, 1982) (with J. N. Robinson, J. P. Finnegan and R. K. Taylor).
"Average Operator Inaction Characteristics with Lever Controls—Study of the Column Mounted Gear Selector Lever," 26th Annual Meeting of the Human Factors Society, Seattle, Washington (October 25-29, 1982) (with J. P. Finnegan, G. F. Fowler and S. B. Brown).
"Catastrophic Events: Actual Risk versus Societal Impact," 1982 Proceedings, Annual Reliability and Maintainability Symposium, Los Angeles, California (January 26-28, 1982) (with J. P. Finnegan and R. K. Taylor).

"Product Recall Decision Making: Valid Product Safety Indicators," Proceedings of the Fourth International System Safety Conference, San Francisco, California (July 9-13, 1979). Published by Professional Engineer Magazine (March 1981).

"Large Vehicle Wheel Servicing: Reduction of Risk Through Implementation of An OSHA Standard Governing Multipiece and Single Piece Rims: Phase IV," Published by the National Wheel and Rim Association (March 1981) (with J. P. Finnegan).

"Program to Improve Down Hole Drilling Motors: Task 2, Lip Seal Design," Failure Analysis Associates Report FAA-81-7-6 to Sandia National Laboratories (October 1980) (with V. Pedotto).

"A Safety and Fracture Mechanics Analysis of the Pneumatic Tire: A Perspective on the Firestone 500 Radial Tire," Presented at the International Conference on Reliability, Stress Analysis and Failure Prevention, of the American Society of Mechanical Engineers, San Francisco, California (August 18-21, 1980) (with W. G. Knauss).

"Multipiece and Single Piece Rims: The Risk Associated with Their Unique Design Characteristics: Phase III," Published by the National Wheel and Rim Association (June 1980) (with J. P. Finnegan).

"An Engineering Safety Analysis of the Steel Belted Radial Tire," Society of Automotive Engineers Paper #800840 (June 9-13, 1980).

"A Simple Technique to Improve the Allocation of Safety Inspection Resources," Proceedings of the Fourth International System Safety Conference, San Francisco, California (July 9-13, 1979) (with P. M. Besuner).

"An Engineering Analysis of the Risk Associated with Multipiece Wheels," National Highway Traffic Safety Administration, ANPR Docket No. 71-19, Number 7 (June 1979) (with J. P. Finnegan).

"Planar Thermic Elements for Thermal Control Systems," Journal of Dynamic Systems, Measurement and Control, Vol. 99, Series G, No. 1 (March 1977) (with B. S. Buckley).

Attachment 4

## CURRICULUM VITAE

Professor Dr. techn. Franz F. Pischinger
Date of Birth: 18.07.1930, Waidhofen/Thaya, Austria

1948 to 1952 studies and graduation in mechanical engineering at Graz Technical University. From 1953 to 1958 (1954 doctors degree) technical assistant at Graz Technical University. Then Head of Research Department of AVL (Institute for Internal Combustion Engines, Professor List, Graz). 1958 habilitation. 1962 to 1970 leading positions in research and development at Klöckner-Humboldt-Deutz AG, Köln (last position: Director of Research and Development Department). Since 1970 Director of the Institute for Applied Thermodynamics at Aachen Technical University. Supervising Research and Teaching in the field of internal combustionengines and thermodynamics of combustion. Also (1978) president of the FEV Forschungsgesellschaft für Energietechnik und Verbrennungsmotoren mbH, Anchen.

Attachment 5

CRAIG K. SEAMAN
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## SUMMARY

An aggressive, results-oriented engineer with extensive background in engineering supervision, mechanical and structural engineering, and construction. Most recent assignment requires management of 150 engineering, professional and technical personnel assigned to resolve design and quality concerns with a nuclear standby diesel generator manufacturer.

## LONG ISLAND LIGHTING COMPANY
SHOREHAM NUCLEAR POWER STATION
(1979 - PRESENT)

### AS PROGRAM MANAGER

. Established a program to provide an in-depth design review and quality revalidation of Transamerica Delaval diesel generators to qualify these units for nuclear emergency standby power. This program was required as a result of numerous engine failures and negative NRC audits of the vendor.

. Responsible for presentations to utility executives to enlist participation in the program - results: 11 of 11 utilities with operating licenses or active construction programs are contributing and participating.

. Managed the program utilizing a team concept involving over 150 personnel including engineers, scientists, diesel consultants, quality control inspectors and clerical support.

### AS SENIOR PROJECT ENGINEER

. Managed an on-time and budget Pre-Service Inspection Program including providing expert testimony for the Atomic Safety and Licensing Board.

. Responsible for coordination of utility/architect engineer response to an Independent Design Review resulting in a clean bill of health for Shoreham.

. Supervised an engineering section responsible for all mechanical engineering, power systems, structural engineering, piping (including ASME) and pipe supports engineering.

### AS ASSISTANT PROJECT ENGINEER

. Responsible for plant betterment program - one example is a radwaste system modification to back flushable etched disc filters which resulted in an over $200,000 savings.

. Assisted in development of the first domestic Induction Heating Stress Improvement Program for mitigation of stress corrosion cracking in Reactor Recirc System piping including coordination with NRC, G.E. and international firms.

. Engineering responsibilities included NSSS systems, radwaste systems, ASME piping and supports, and structural disciplines.

DANIEL INTERNATIONAL CORPORATION
ENRICO FERMI UNIT II
(1978 - 1979)

AS PROJECT ENGINEER

- Assigned to the Walbridge Aldinger Company (WACo) to establish the firm's ability to perform piping and mechanical installations. As a direct result, the WACo contract was increased 100% to $40,000,000.
- Supervised an engineering office responsible for ANSI B31.1 piping, fire protection piping, the biological shield wall and temporary facilities.

AS CONSTRUCTION ENGINEER

- Assigned to a task force established to review three quality assurance manuals and 40 construction procedures for effectiveness and efficiency - this effort resulted in a 20% increase in productivity in the field.
- Responsible for drywell piping including planning, engineering, materials procurement, and management of offsite programs in Michigan and California.

LONG ISLAND LIGHTING COMPANY
SHOREHAM NUCLEAR POWER STATION
(1975 - 1978)

AS CONSTRUCTION SUPERVISOR

- Responsible for the first on-time completion of a mechanical system at Shoreham - the Reactor Recirculation System in the Primary Containment.
- Established a coordinated construction team for piping and mechanical equipment installation in the Primary Containment including - contractor supervision, labor, quality control, cost engineering and scheduling.
- Assigned to a task force established to evaluate the construction program - the result was a major construction reorganization with significant improvements in progress, scheduling and cost control.

AS CONSTRUCTION COORDINATOR

- Provided a recommendation to purchase previously rented heavy construction equipment which resulted in a savings of over $500,000.
- Monitored civil/structural construction and field engineering activities including detailed reporting to management.

EDUCATION

| | |
|---|---|
| Cornell University | B.S. Engineering |
| Brooklyn Polytechnic | 18 Credits toward<br>M.S. in Nuclear Engineering |

PERSONAL

Age - 31 Height - 5'9" Weight - 160
Married - 1 Child Health - Excellent

Attachment 6

Failure
Analysis
Associates

**LEE A. SWANGER**

**Specialized Professional Competence**

Failure analysis of materials; metallurgical engineering, physical and mechanical metallurgy, and thermodynamics; foundry process development including ferrous and non-ferrous castings; powder metallurgy and powder rolling; electrochemistry, including electroplating and corrosion; materials testing, fatigue, and fracture; metal matrix and polymer matrix composites; tribology, friction, wear, and lubrication; internal combustion engine and compressor component design and testing; sleeve bearing design, manufacture, and failure analysis.

**Background and Professional Honors**

Ph.D. (Materials Science and Engineering), Stanford University, with Distinction
M.B.A. (Marketing/Finance), Cleveland State University
M.S. (Materials Science and Engineering), Stanford University
B.S. (Metallurgy), Case Institute of Technology, with Highest Honors

Managing Engineer,
    Failure Analysis Associates
Director, Research and Development,
    Imperial Clevite Inc.
Associate Director, Product Development,
    Gould Inc., Engine Parts Division
Manager, Tribology and Bearing Research,
    Gould Laboratories, Materials Research
Associate Senior Research Metallurgist,
    General Motors Research Laboratories
Lecturer, Metallurgical Engineering,
    Cleveland State University
Visiting Research Associate, Metallurgical Engineering,
    Ohio State University

Registered Professional Engineer, State of Ohio, #44024
Member, Tau Beta Pi, Engineering Honorary Fraternity
Member, Sigma Xi, Scientific Research Honorary Fraternity
Member, Beta Gamma Sigma, Graduate Business Honorary Fraternity
National Merit Foundation Scholarship
Xerox Corporation Fellowship
IBM Corporation Fellowship
Hertz Foundation Fellowship
Member, American Society for Metals
Member, Society of Automotive Engineers
Interviewer, Hertz Foundation Fellowship Project

**Selected Publications**

U.S. Patent No. 4,333,215: "Bearing Material and Method of Making," issued June 8, 1982.
"Compacted Graphic Cast Iron Components for Improved Thermal Fatigue Resistance," Imperial Clevite Inc., Internal Report (January 1982).
"Marketing Strategies to Achieve Cash Flow Objectives," M.B.A. thesis, Cleveland State University (June 1982).
"Squeeze-Cast Pistons for Heavy-Duty Applications," Gould Inc., Internal Report (February 1981).
"Evaluation of Graphite-Epoxy and Graphite-Babbitt Composite Sleeve Bearings," Gould Laboratories, Phase Report (October 1977).
"Environmentally Induced Blistering of Aluminum P/M Components," Gould Laboratories, Project Completion Report (December 1976).

Attachment 7

Edward J. Youngling
Manager, Nuclear Engineering Department

Assigned as Manager, Nuclear Engineering Department in May 1984. Report to the Vice President, Nuclear. Responsible for the overall operation of the Nuclear Engineering Department. The Nuclear Engineering Department is charged with providing the technical direction for engineering, fuel management, and radiation protection for the purpose of maintaining the design basis of the Shoreham Nuclear Power Station.

Responsible for the organizational development of the Nuclear Engineering Department and the definition of functions and responsibilities of the Nuclear Systems Engineering, Nuclear Fuel, Nuclear Project Engineering, Engineering Assurance and Radiation Protection Divisions.

Provide timely technical support to Shoreham plant operating staff for routine and abnormal operations in areas of nuclear engineering, core analysis, radiation protection, health physics, chemistry and radiochemistry. Administer programs and approve procedures to provide engineering and engineering management for plant modifications and engineering studies. Establish reliability and risk assessment capability aimed at improving plant safety and availability. Provide engineering support to Shoreham in the disciplines of thermal-hydraulics, heat transfer, stress analysis, systems engineering, instrumentation and controls, materials engineering, nuclear fuel design, core physics, safety and reliability analysis, risk assessment, radiation protection, shielding, health physics, radiation chemistry, non-destructive examination, corrosion analysis, and nuclear waste technology. Direct engineering work to the Office of Engineering on matters encompassing the disciplines of electrical, civil, power and environmental engineering for projects related to Shoreham. Direct activities related to nuclear fuel cycle management and establish nuclear material accountability. Establish core analysis systems to provide core follow support and advice on control rod withdrawal patterns. Provide technical direction for the Company's Radiological Environmental Monitoring Program. Provide radiation protection engineering and health physics technology assessments for incorporation in the Company's ALARA radiation dose reduction program. Responsible for the Company's ALARA radiation dose reduction program. Participate with Nuclear Operations Support and Plant Operating Staff in the development and implementation of the Corporate Licensing Policy.

Prepare and approve all budgets related to departmental activities necessary to comply with Corporate requirements. Prepare testimony and participate in appearances before federal, state and local hearing boards as required (PSC Prudency, PSC Rate Case, NRC Hearings, etc.). Administer R&D efforts within the Department in support of the Corporate R&D program.

Edward J. Youngling

Responsible for the finalization of the Shoreham Delaval Diesel Generator Design Review/Quality Revalidation Program.

Graduated from Lehigh University in 1966 with a Bachelor of Science Degree in Mechanical Engineering. From June 1966 to March 1968 attended Union College and achieved credits towards a Masters of Science Degree in Nuclear Engineering. Successfully completed the following training courses:

"Introduction to Nuclear Power" by NUS Corp., July 1970
"Boiler Control Fundamentals" by General Electric Co., January 1972
"Fundamentals of BWR Operation" by General Electric Co. at the GE Dresden Simulator, August 1972
"Process Computer Concepts and Practices" by General Electric Co., February 1973
"Shoreham Research Reactor Training Program" at Brookhaven National Laboratory Medical Research Reactor (NRC SROC License candidate research reactor training requirement), May 1975
"Planning for Nuclear Emergencies" by Harvard School of Public Health, May 1976
"Interagency Course in Radiological Emergency Response Planning in Support of Fixed Nuclear Facilities" by Nuclear Regulatory Commission, September 1978
"Customer Engineer Training Program in the Methods Used to conduct Maximum Turbine Capacity Tests and Analyze Results to Detect and Correct Cycle Losses" by the General Electric Co., Large Steam Turbine Division, September 1979
"Shoreham Nuclear Power Station On-Site Training Program" (NRC SROC license candidate plant systems training requirement), January - April 1979
"LILCO Advanced Supervisory Workshop", April 1979
"Assertiveness Training Workshop", November 1980
"LILCO Management Workshop", December 1980
"Shoreham General Employee Training", 1983

Achieved a Senior Operator Certification from the General Electric Company on the Duane Arnold Energy Center Boiling Water Reactor.

March 1981 - May 1984

Assigned as Startup Manager in March 1981. Responsible for the Preoperational test activities for the Shoreham Nuclear Power Station. Report to the Vice President-Nuclear. Responsible for coordinating all Checkout and Initial Operations and Preoperational Testing. Set initial construction priorities by system/subsystem and monitor construction progress as it relates to the startup schedule. Had the authority to modify construction schedule as conditions demand. Chaired construction release meetings at which status of construction, as it relates to systems scheduled to be released, was discussed. Member of the Joint Test Group. Ensured that the established procedures of documentation control were followed. Responsible for the review, monitoring, supervision and approval of Checkout and Initial Operations Tests, Preoperational Tests, and Acceptance Tests, review of all test results summaries and recommend acceptance, rejection or modification by the JTG according to results. Responsible for the production of all the software required for testing of Shoreham. Certified Level III per ANSI N45.2.6 - 1978.

In August 1983 named as Manager for the Shoreham Delaval Emergency Diesel Generator Crankshaft Failure Recovery Program. Responsible for coordinating the failure analysis, rebuilding, retesting and requalification of the three diesel generator units.

Prepared testimony, was depositioned and testified before the Atomic Safety and Licensing Board regarding Shoreham contentions dealing with quality assurance, startup testing and emergency diesel generators. Prepared testimony and testified before the New York State Public Service Commission. Responsible for direct interface with NRC Resident, Regional and Staff personnel for matters related to the preoperational test program and emergency diesel generators recovery effort.

May 1979 - March 1981

Assigned as Nuclear Services Supervisor in May 1979, reporting to the Manager, Nuclear Operations Support Division. Responsible for the management and coordination of those support services required by LILCO Nuclear Power Stations. These support services included coordination of major station modifications, performance of operational design reviews, coordinating the resources of other LILCO Departments and outside consultants to achieve a desired result assigned to the Division, coordinating long-range planning activities associated with plant maintenance, fuel cycle strategy and budget and cost control, monitoring overall plant and individual equipment performance, maintaining a current knowledge of federal regulations, industry codes and standards, and changes thereto applicable to the facility.

Participated on the LILCO Corporate Task Forces assessing Shoreham design and operations, corporate communications, crisis management and overall company emergency preparedness following the Three Mile Island Unit 2 accident. Chairman of the Shoreham Review Task Group, responsible for developing action plans for implementing post TMI recommendations. Responsible for the Shoreham Control Room human factors design review.

Developed the corporate policy manual defining interdepartmental responsibilities for the LILCO Nuclear Program.

February 1975 - May 1979

Assigned as Chief Technical Engineer of the Shoreham Nuclear Power Station - Unit 1 in January 1975. Responsible for the activities of the Instrumentation and Control, Health Physics, Radiochemistry and Reactor Engineering Sections of the plant staff, including the development of administrative and technical programs and procedures to meet regulatory, company and industry requirements; and the training of professional personnel and technicians to satisfy qualification standards. Served on the plant Review of Operations Committee (ROC) and when designated acted as Chairman of the ROC in the Plant Manager's absence. Served as a member of the plant Licensed Source User's Committee as stipulated in NRC Nuclear Material License No. 31-17432-01, February 1977.

August 1974 - January 1975

Reassigned to the plant staff as the Instrumentation and Control Engineer, then Acting Chief Engineer-Technical. Responsible for manpower planning and the development of the technical training programs for subordinate personnel. Participated in generating portions of the Shoreham Safety Analysis Report, and in the review and approval of plant operating procedures, lesson plans and system descriptions.

July 1973 - July 1974

Named the Instrumentation and Control Engineer for Shoreham Nuclear Power Station and assigned to the General Electric Company Startup, Test and Operations (STO) organization at the Duane Arnold Energy Center in Cedar Rapids, Iowa. Participated in the preoperational test program in the areas of in-core nuclear process radiation and reactor vessel (pressure, level and temperature) instrumentation. Acted as G.E. shift engineer during fuel loading operations and as assistant to G.E. shift engineer during startup testing and power ascension program. Participated in the G.E. shift engineer training program and sat for the G.E. Certification Examination for DAEC.

August 1972 - June 1973

Reassigned to Shoreham Nuclear Power Station Project as the Assistant Project Engineer, then Project Engineer. Responsible for overall plant design control. Coordinated design effort between LILCO, Stone and Webster Engineering Corporation, General Electric Co. Nuclear Energy Division, various major equipment suppliers and regulatory agencies.

November 1971 - July 1972

Reassigned to the Northport Power Station to participate in the startup of Northport Unit No. 3. Directly responsible for the startup of the boiler for this 380MW unit including the fuel safety system, the combustion and feedwater control systems and associated mechanical equipment. Assumed overall plant shift operations responsibility during the latter stages of startup. Was an instructor in the Unit No. 3 systems training program given to plant supervisors, operators, technicians, and mechanics.

November 1969 - October 1971

Assigned to the Shoreham Nuclear Power Station Project in the Nuclear Engineering Department. Participated in the engineering review of the Shoreham plant design in the following areas: plant equipment layout, equipment specifications, equipment selection, main control board design, plant operations logic, plant instrumentation, plant computers. Review included contacts with the A-E, Stone and Webster, NSSS supplier, General Electric Company, various vendors and visits to several nuclear stations.

April 1968 - October 1969

Employed by the Long Island Lighting Company and assigned to the Northport Power Station. During the period, assisted in the startup of Northport Unit 2, assisted in the station maintenance section supervising route and shutdown maintenance activities and acted as the station Results Engineer responsible for the repair and calibration of the station instrument and control systems and for monitoring station performance.

June 1966 - March 1968

Employed by the General Electric Company at the Knolls Atomic Power Laboratory. Stationed at the West Milton Site as a Mechanical Test Engineer on the S3G Prototype "USS Triton" submarine. While at the S3G plant my responsibilities were to prepare procedures for tests and operations which were not in accordance with normal plant operations; supervise the actual tests, analyze the results and issue reports to the AEC. The following specific activities were engaged in: completed selected sessions of the Engineering Officer of the Watch Training Course, participated in numerous plant tests including routing low power physics testing including directing reactor control rod movements through Navy reactor operators, maneuvering transients, main coolant pump tests, power runs, various engine room tests and ultrasonic testing to trend pipeline degradation. Participated in the Advanced Reactor Control Program as Lead Shift Test Engineer, including completion of required training program, and performing preoperational tests and integrated plant acceptance testing.

Member - American Nuclear Society. Held a Guest Associate Engineer appointment in the Reactor Division at Brookhaven National Laboratory. Member - Pi Tau Sigma. Hold an Engineer in Training Certificate - State of Pennsylvania (State Registration Board for Professional Engineers).

RELATED CORRESPONDENCE LILCO, August 14, 1984

DOCKETED
USNRC

'84 AUG 15 A9:57

OFFICE OF SECRETARY
DOCKETING & SERVICE
BRANCH

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) )

# TESTIMONY OF DAVID O. HARRIS, DUANE P. JOHNSON, ROGER L. McCARTHY, FRANZ F. PISCHINGER, CRAIG K. SEAMAN, LEE A. SWANGER AND EDWARD J. YOUNGLING ON BEHALF OF LONG ISLAND LIGHTING COMPANY ON SUFFOLK COUNTY CONTENTION REGARDING AE PISTON SKIRTS ON DIESEL GENERATORS AT SHOREHAM

Exhibits 1 through 34

Volume 2 of 2

Original photographs

LILCO, August 14, 1984

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) )

## AE PISTON SKIRT EXHIBITS

## TESTIMONY OF DAVID O. HARRIS, DUANE P. JOHNSON, ROGER L. McCARTHY, FRANZ F. PISCHINGER, CRAIG K. SEAMAN, LEE A. SWANGER AND EDWARD J. YOUNGLING ON BEHALF OF LONG ISLAND LIGHTING COMPANY ON SUFFOLK COUNTY CONTENTION REGARDING AE PISTON SKIRTS ON DIESEL GENERATORS AT SHOREHAM

| | |
|---|---|
| P-1 | Photograph of piston skirt with mounted crown and rings |
| P-2 | Photograph of a piston from a Shoreham EDG showing skirt and crown |
| P-3 | Cross section of crown and skirt indicating the two areas of load transfer from the crown to the skirt |
| P-4 | Piston reassembly guidelines showing measurement of cold gap |
| P-5 | Gas pressure versus crank angle diagram |
| P-6 | Comparison of all AE and AF piston skirts in the region of the stud attachment bosses |
| P-7 | Representative dimension checks shown on Task Evaluation Reports Q-338, 310, 194, 203 and 182 |
| P-8 | Trip report on nondestructive examination of AE piston skirt and a copy of AE piston skirt, inspection, requirements, certificates of compliance and receipt inspection documentation |
| P-9 | A sample preoperational test procedure and Appendix F showing peak firing pressures taken before the crankshaft failure and after the crankshaft replacement |

P-26 Liquid dye penetrant inspection results after 100 hours operation for EDGs 101, 102, 103

P-27 Eddy current test results after 100 hours operation for EDGs 101, 102, 103; FaAA Procedure NDE 11.5, Rev. 0 and Rev. 1

P-28 Iron Castings Handbook, page 34

P-29 Results of inspection of AE pistons on the Kodiak Electric Association engine and the TDI R-5 prototype engine

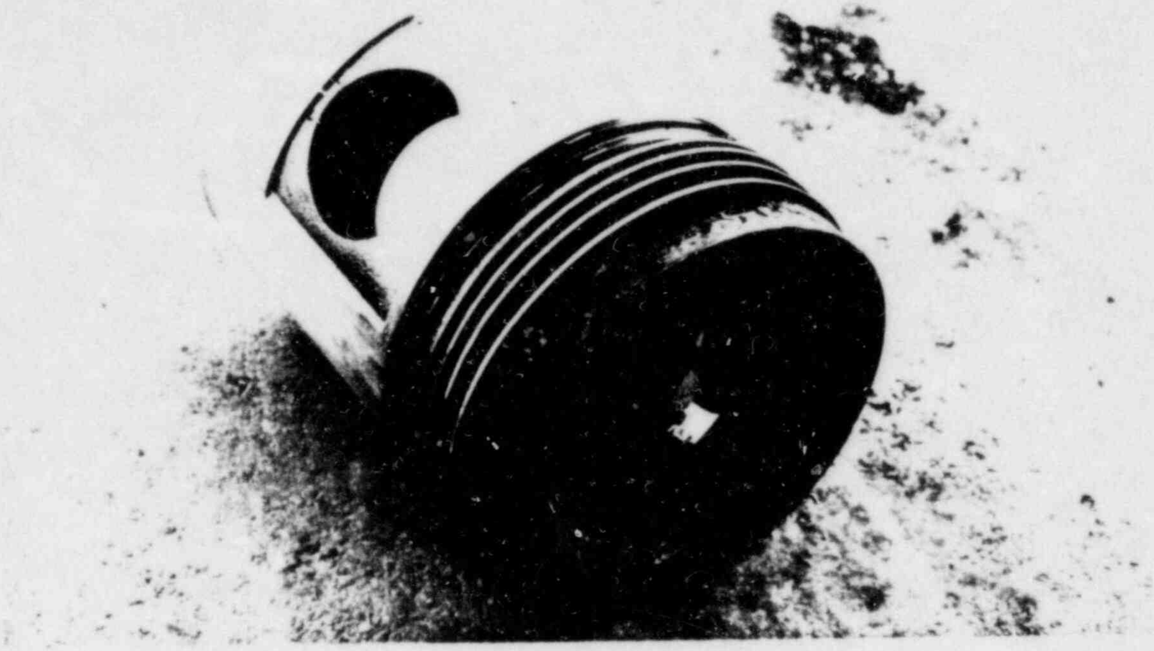
P-30 Volume I, TDI Owners Manual (sections discussing engine lubrication)

P-31 Excerpts from Diesel Engine Design by T.D. Walshaw and Internal-Combustion Engines by V. L. Maleev

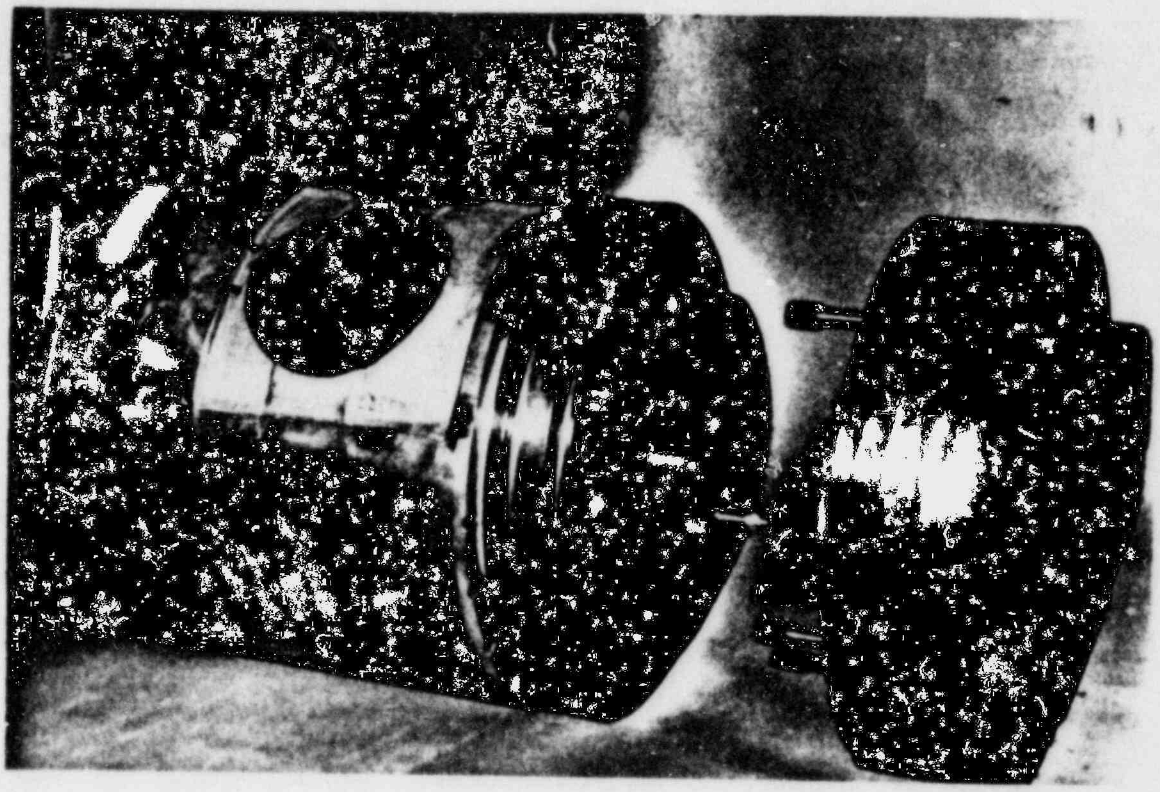
P-32 Task evaluation reports and LILCO deficiency reports which discuss the DRQR's visual inspections of AE piston skirts

P-33 Liquid dye penetrant test results for AF piston skirts

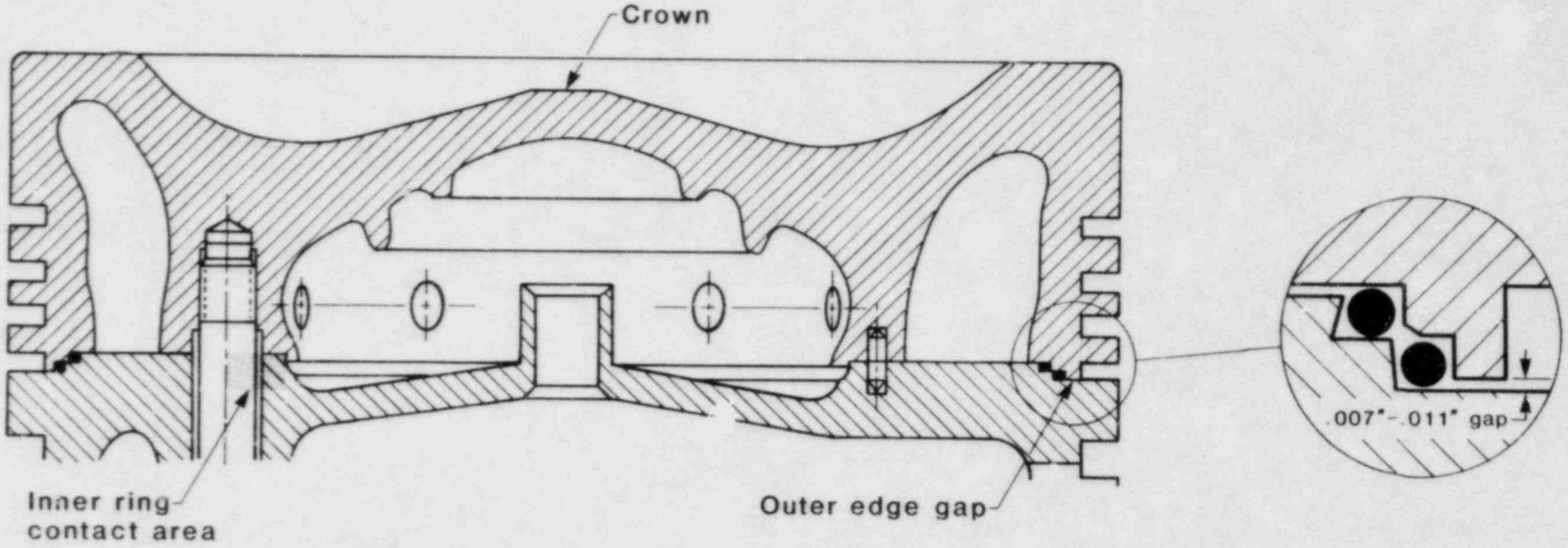
P-34 Minimum and maximum stresses in AE piston skirt for various peak firing pressures for isothermal and steady state operaing conditions; applied values of Delta K and R as a function of crack depth and corresponding values of Delta $K_{th}$ (2,200 psig)



Photograph of piston skirt with mounted crown and rings.



Photograph of a piston from the Shoreham Nuclear Power Station emergency diesel generator piston skirt (left) and crown (right).



Cross section of crown and skirt indicating the two areas of load transfer from the crown to the skirt.

EDG 101

For Information Only

NUCLEAR POWER STATION
STARTUP FORM 7.6

T.B.

February 18, 1981
Revision 12

Shoreham Nuclear Power Station - Unit 1

REPAIR/REWORK REQUEST

1. Request: R43-1627 Initiated By: C C Fuller 2/16/84 System # : 1R43A
Test Engineer/Date

RSD 3-15-84

Work performed under jurisdiction of: ( ) Unico Construction (✓) LILCO Startup

Work to be performed by: ( ) Unico Construction (✓) LILCO Startup

Quality Assurance function to be performed by: (✓) OQA ( ) FQC ( ) Work Supervisor

System or Subsystem Description: EDG 101

QA Category: I Completion Date Required:

Perform the following work: Emergency Diesel Generator 101 outage Disassembly for Inspection Tasks

Reason for Work: Diesel Generator Quality Revalidation

2. Work to be performed in accordance with the following applicable construction or maintenance procedur : SHI-089, SUI #5 and attached Guidelines

3. Notify W. Cook ext 360 WD Cook prior to performing work.
Startup Engineer

4. Request Approved: 3/15/84 R. Lawson 3/15/84
Lead Startup Engineer / Date S&W Lead Advisory Eng./Date

5. This form must be signed and returned to the party requesting the work when the work is completed.

The above work has been completed. A work summary and necessary documentation is attached.

C C Fuller 4/8/84 4/26/84
Supervisor/Date Field QC or Operational QA/Date

6. The following retest(s) are required and completed: EDG 101 Run-in (P.T #97)

4/26/84 4/9/84
LILCO Operational QA Engineer/Date Startup Engineer/Date

DISTRIBUTION: Original to: Organization Performing Work: ( ) Unico Construction Superintendent (via Turnover Coordinator), or ( ) LILCO Startup.

Copies To: Organization Not Performing Work: ( ) Unico Construction Superintendent (via Turnover Coordinator), or ( ) LILCO Startup
Operational QA
Field QC

NOTED APR 2 8 1984 R. Lawrence
X08501

RER 1627

## PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 5

**NOTE:** This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine.

### A. DISASSEMBLY

1. Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.

### B. REASSEMBLY

1. Verify the following inspections are complete and do not restrain reassembly.

   Task description no. 03-341A

   a. Release received [illegible]
   TE Date

   Remarks LDR'S 2266 & 2277

   LDR'S 2266, 2275 [illegible]

   b. Corrective action complete (N/A if not required).

   [illegible]
   TE Date

2. Reassemble piston as follows.

   a. Place crown on skirt. Measure cold gap at point "X". (4 places only. See attached copy of portion of TDI dwg. 03-341-7319). Should be .007/.011. Remove crown.

   .009
   Record Gap

   Feeler Gauge N/A
   M&TE # Cal. Due Date

   [illegible]
   TE Date

   R Bernardo 3/25/84
   OQA Date

## PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 7

NOTE: This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine.

A. DISASSEMBLY

1. Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.

B. REASSEMBLY

1. Verify the following inspections are complete and do not restrict reassembly.

Task description no. 03-341A

a. Release received

______ 3/25/84
QC Date

Remarks LDR's 2266 & 2275

LDR's 2266 & 2275 Accept as is

b. Corrective action complete (N/A if not required).

______ 3/25/84
QC Date

2. Reassemble piston as follows.

a. Place crown on skirt. Measure bolt gap at point "X", 4 places only. See attached copy of portion of TDI dwg. [illegible]. Should be .007/.011. Remove crown.

1200 - .010, 0300 - .011, 0600 - .010, 0900 - .009   1200 = Alignment Pin
Record Gap

Feeler Gauge
M&TE #   Cal. Due Date

______ 3/25/84
QC Date

______ 3/25/84
QA Date

## PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 8

**NOTE:** This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine.

A. DISASSEMBLY

1. Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.

B. REASSEMBLY

1. Verify the following inspections are complete and do not restrain reassembly.

Task description no. 03-341A

a. Release received William Bennett 3/25/84
TE Date

Remarks LDR'S 2266 & 2275

LDR'S 2266 & 2275 Accept As Is

b. Corrective action complete (N/A if not required).

William Bennett 3/25/84
TE Date

2. Reassemble piston as follows.

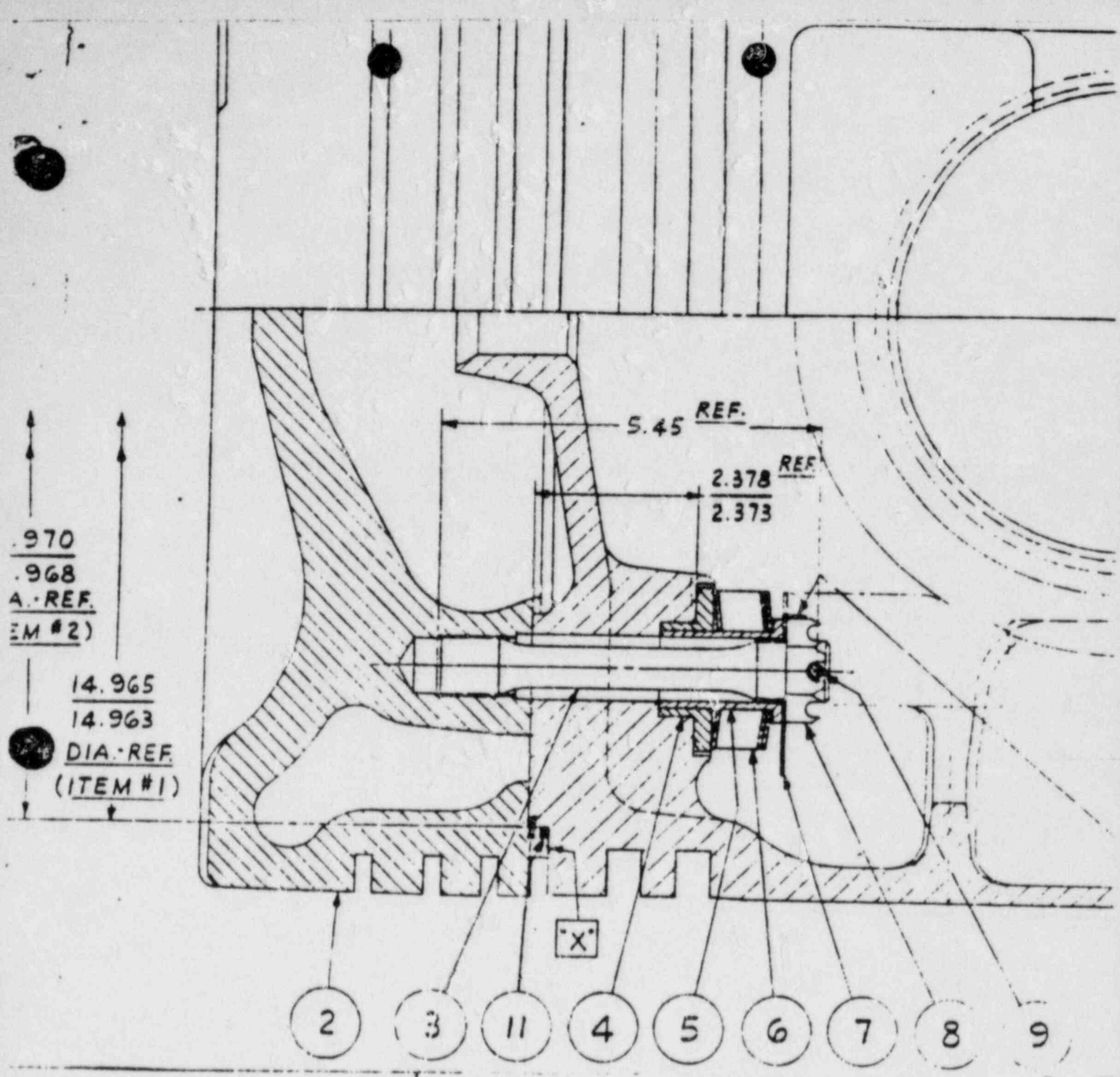
a. Place crown on skirt. Measure cold gap at point "X". (4 places only. See attached copy of portion of TDI dwg. 03-341-7319). Should be .007/.011. Remove crown.

1200 - .011, 0300 - .010, 0600 - .009, 0900 - .010 1200 = Alignment Pin
Record Gap

Feeler Gauge N/A
M&TE # Cal. Due Date

William Bennett 3/25/84
TE Date

R Bennard 3/25/84
QA Date



DO NOT SCALE DRAWING.

**Transamerica Delaval**

Transamerica Delaval Inc
Engine and Compressor Division
Oakland, California 94621

NOV 9 1983

PISTON ASSEMBLY - TWO PC.
(R/RV-4 ENGINES)

. AND HARDNESS
M. ABOVE

APP | DWN
1/2

03-341-7319

EDG 102

UNCONTROLLED
For Information Only

SHOREHAM 1
NUCLEAR POWER STATION
STARTUP FORM 7.6

CSW

February 18, 1981
Revision 12

Shoreham Nuclear Power Station - Unit 1

## REPAIR/REWORK REQUEST

1. Request: 1883-1433 Initiated By: C Fuller 2/6/84 System # : R43B
   Test Engineer/Date

Work performed under jurisdiction of: ( ) Unico Construction ☒ LILCO Startup

Work to be performed by: ( ) Unico Construction ☒ LILCO Startup AT 2/6/84

Quality Assurance function to be performed by: ☒ OQA ( ) FQC ( ) Work Supervisor

System or Subsystem Description: DIESEL GENERATOR 102

QA Category: I Completion Date Required: 2/17/84

Perform the following work: EMERGENCY DIESEL ENGINE 102 OUTAGE DISASSEMBLY GUIDLINES FOR INSPECTION TASKS

Reason for Work: DIESEL GENERATOR QUALITY REVALIDATION

2. Work to be performed in accordance with the following applicable construction or maintenance procedure: SUI #5 AND ATTACHED GUIDELINES, SHI-89, TDI MANUAL (R43-12D) + OQA 83-304.

3. Notify T. McCarthy ext 361 prior to performing work.
   Startup Engineer

4. Request Approved: MM Kelly 2/6/84 [illegible] 2/6/84
   Lead Startup Engineer / Date S&W Lead Advisory Eng./Date

5. This form must be signed and returned to the party requesting the work when the work is completed.

   The above work has been completed. A work summary and necessary documentation is attached.

   3/21/84 4/22/84
   Supervisor/Date Field QC or Operational QA/Date

6. The following retest(s) are required and completed: EDG 102 RUN-IN complete 2/11/84 8.7 R43-89

   4/27/8 MM Kelly 4/7/84
   LILCO Operational QA Engineer/Date Startup Engineer/Date

DISTRIBUTION: Original to: Organization Performing Work: ( ) Unico Construction Superintendent (via Turnover Coordinator), or ☒ LILCO Startup.

Copies To: Organization Not Performing Work: ( ) Unico Construction Superintendent (via Turnover Coordinator), or ☒ LILCO Startup

Operational QA

Field QC

RT PURCELL (x)
ISEG (x)
OGQRG (x)
SWG (X)-2

NOTED APR 28 1984 R.Lawrence

RRR 1433

## PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 5

NOTE: This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine. Inspection requirements remain in steps VII, VIII and IX of the disassembly guidelines.

1. Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.
2. Perform piston, piston rings, and piston pins Inspection Task Guidelines. (Steps VII, VIII and IX).

N/A

______ DGQRG ______ Date

3. Reassemble piston as follows.

   a. Place crown on skirt. Measure cold gap at point "X" (4 places only. See attached copy of portion of IDI dwg. 03-341-7519). Should be .007/.011. Remove crown.

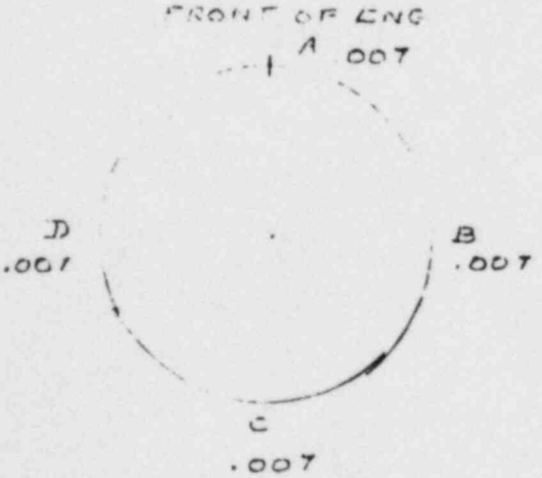
SEE BELOW
Record Gap

N/A  2-15-84  FEELER GAGE
M&TE #  Cal. Due Date

M+TE 1" MIKE  6-27-84
2-53-129

Bart Salter 2/15/84
TE  Date

William J. 2/15/84
OQA  Date



## PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 6

NOTE: This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine. Inspection requirements remain in steps VII, VIII and IX of the disassembly guidelines.

1. ~~Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.~~

2. ~~Perform piston, piston rings, and piston pins Inspection Task Guidelines. (Steps VII, VIII and IX).~~

N/A

________________ DGQRG ________________ Date

3. Reassemble piston as follows.

   a. Place crown on skirt. Measure cold gap at point "X" (4 places only. See attached copy of portion of TDI dwg. 03-341-7319). Should be .007/.011. Remove crown.

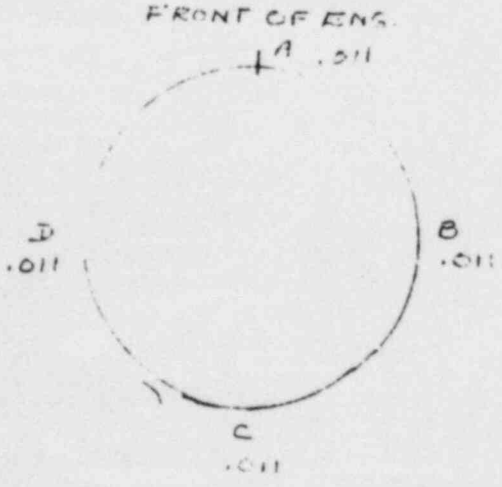
SEE-BELOW
Record Gap

FEELER GUAGE
M&TE # Cal. Due Date

1" MIKE
M&TE # 2-53-129
CAL DUE 6-29-84

TE 2/[illegible]/84 Date

OQA 2-16 84 Date



## PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 7

**NOTE:** This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine. Inspection requirements remain in steps VII, VIII and IX of the disassembly guidelines.

1. Remove the four (4) crown to skirt nuts. Record breakaway ~~torque~~ on attached sheet.

2. Perform piston, piston rings, and piston pins Inspection Task Guidelines. (Steps VII, VIII and IX).

N/A

______________________ DGQRC ______________ Date

3. Reassemble piston as follows.

   a. Place crown on skirt. Measure cold gap at point "X" (4 places only. See attached copy of portion of TDI dwg. 03-341-7319). Should be .007/.011. Remove crown.

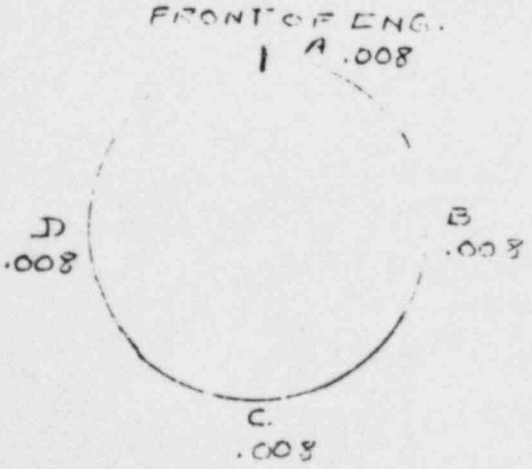
SEE BELOW
Record Gap

FEELER GUAGE
M&TE # Cal. Due Date

1" MIKE
M&TE #Z-53-129
CAL DUE 6-29-84

TE 2/16/84 Date

QQA 2-16-84 Date



PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 8

NOTE: This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine. Inspection requirements remain in steps VII, VIII and IX of the disassembly guidelines.

1. Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.
2. Perform piston, piston rings, and piston pins Inspection Task Guidelines. (Steps VII, VIII and IX).

N/A

______________________ DGQRG ______________________ Date

3. Reassemble piston as follows.

   a. Place crown on skirt. Measure cold gap at point "X" (4 places only. See attached copy of portion of TDI dwg. 03-341-7319). Should be .007/.011. Remove crown.

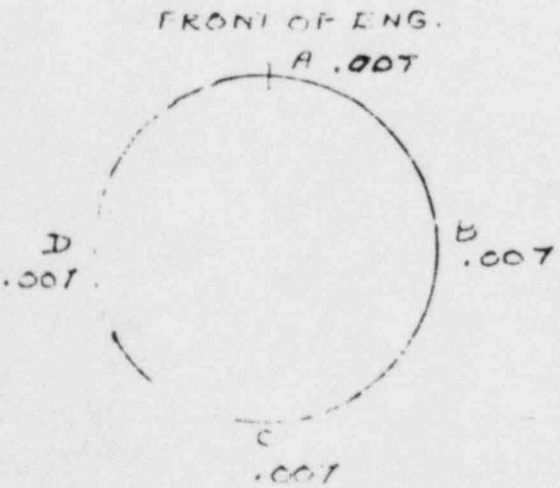
SEE BELOW
Record Gap

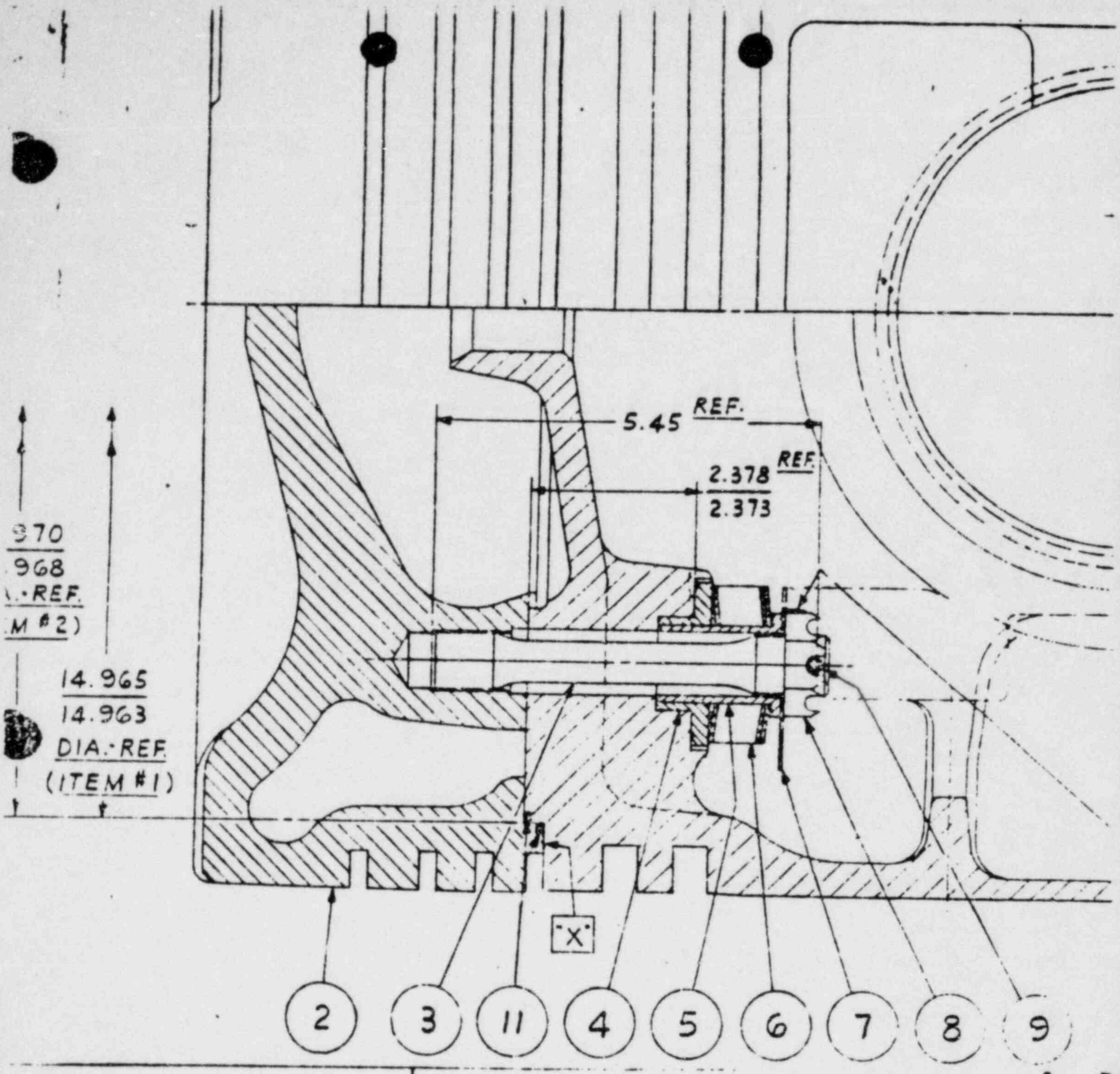
FEELER GUAGE
M&TE # Cal. Due Date

1" MIKE
M&TE #Z-53-129
CAL. DUE 6-27-84

Bart Fulton 2/16/84
TE Date

2-16-84
OQA Date





1 DO NOT SCALE DRAWING.

**Transamerica Delaval**

Transamerica Delaval Inc
Engine and Compressor Division
Oakland, California 94621

NOV 9 1983

PISTON ASSEMBLY - TWO PC.
(R/RV-4 ENGINES)

AND HARDNESS
M. ABOVE

APP
DWN
SCALE 1/2
CKD

03-341-7319

EDG 103

SHOREHAM 1
NUCLEAR POWER STATION
STARTUP FORM 7.6

T.E.

February 18, 1981
Revision 12

/ UNCONTROLLED
For Information Only

Shoreham Nuclear Power Station - Unit 1

## REPAIR/REWORK REQUEST

1. Request: 243-1562 Initiated By: M. Tucker 2/22/84 System # : 1R43C
Test Engineer/Date

Work performed under jurisdiction of: ( ) Unico Construction ☒ LILCO Startup

Work to be performed by: ( ) Unico Construction ☒ LILCO Startup ( ) Catalytic

Quality Assurance function to be performed by: ☒ OQA ( ) FQC ( ) Work Supervisor

AT 3/3/84

System or Subsystem Description: EDG 103

QA Category: I Completion Date Required:

Perform the following work: Emergency Diesel Generator 103 Complete Disassembly for Inspection Tasks

Reason for Work: Diesel Generator Quality Revalidation

2. Work to be performed in accordance with the following applicable construction or maintenance procedure: SAI-089 SUIT #5 And Attached Guidelines

JOQA 83-304

3. Notify M. DeGraff x361 / prior to performing work.
Startup Engineer

4. Request Approved: M McCarthy 3/2/84 William M Watzek 3/2/84
Lead Startup Engineer / Date S&W Lead Advisory Eng./Date

MPS 3/2/5

5. This form must be signed and returned to the party requesting the work when the work is completed.

The above work has been completed. A work summary and necessary documentation is attached.

CC Fuller 4/22/84 5-2-84
Supervisor/Date Field QC or Operational QA/Date

6. The following retest(s) are required and completed: EDG 103 Run-in

@ 4/23

for AM 5/2/84 Timothy McCarthy 4/23/84
LILCO Operational QA Engineer/Date Startup Engineer/Date

DISTRIBUTION: Original to: Organization Performing Work: ( ) Unico Construction Superintendent (via Turnover Coordinator), or ( ) LILCO Startup.

Copies To: Organization Not Performing Work: ( ) Unico Construction Superintendent (via Turnover Coordinator), or ( ) LILCO Startup
Operational QA
Field QC

NOTED MAY 4 1984 R.Lawrence

A10934

UNCONTROLLED
For Information Only

EDG 103

R43 1562

## REWORK SUPERVISOR WORK SUMMARY

**BRIEF DESCRIPTION OF WORK:** Took The Following Cold Gap Readings at 4 places on Pistons #5, #7, & #8 step 2A of Piston Disassembly/Reassembly Guidelines:

Skirt placed on Crown Guide pin being 1200 looking into Piston Boss Area

| | 1200 | 300 | 600 | 900 |
|---|---|---|---|---|
| Piston #5 | .009 | .009 | .009 | .009 |
| #7 | .009 | .009 | .008 | .008 |
| #8 | .010 | .009 | .009 | .009 |

OQA - 3/17/84

Step 2.B Crown and skirt pilot readings Recording I.D. and O.D Respectively and documented

**COMPONENTS REPLACED (IF APPLICABLE):**

**MST. CALIBRATED TOOLS UTILIZED:**

**ADDITIONAL COMMENTS:**

3/17/84
Rework Supervisor Signature/Date

R43-1562

## PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 5

NOTE: This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine.

A. DISASSEMBLY

1. Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.

B. REASSEMBLY

1. Verify the following inspections are complete and do not restrain reassembly.

Task description no. 03-341A

a. Release received 3/15/84

TE Date

Remarks LOC 3198 outstanding - Dispositioned acceptable as-is 3/1

b. Corrective action complete (N/A if not required).

N/A

TE Date

2. Reassemble piston as follows.

a. Place crown on skirt. Measure cold gap at point "X". (4 places only. See attached copy of portion of TDI dwg. 03-341-7319). Should be .007/.011. Remove crown.

See attached summary sheet

Record Gap

Feeler Gage used

M&TE # Cal. Due Date

3/15/84

TE Date

OQA Date

R43-1862

# PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 7

**NOTE:** This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine.

## A. DISASSEMBLY

1. Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.

## B. REASSEMBLY

1. Verify the following inspections are complete and do not restrain reassembly.

   Task description no. 03-341A

   a. Release received

   TE 3/15/84 Date

   Remarks LDR 2198 outstanding - dispositioned acceptable as-is on 3/17/84

   b. Corrective action complete (N/A if not required).

   N/A
   TE Date

2. Reassemble piston as follows.

   a. Place crown on skirt. Measure cold gap at point "X". (4 places only. See attached copy of portion of TDI dwg. 03-341-7319). Should be .007/.011. Remove crown.

   See Attached works summary sheet
   Record Gap

   Feeler Gage used
   M&TE # Cal. Due Date

   TE 3/17/84 Date

   Paul Kugler 3/17/84
   OQA Date

R43-1562

# PISTON DISASSEMBLY/REASSEMBLY GUIDELINES

Piston No. 8

**NOTE:** This guideline provides piston disassembly/reassembly instructions following removal of the piston assembly from the engine.

## A. DISASSEMBLY

1. Remove the four (4) crown to skirt nuts. Record breakaway torque on attached sheet.

## B. REASSEMBLY

1. Verify the following inspections are complete and do not restrain reassembly.

   Task description no. 03-341A

   a. Release received

   3/15/84
   TE Date

   Remarks EDR 2198 outstanding - dispositioned acceptable as-is on [illegible]

   b. Corrective action complete (N/A if not required).

   N/A
   TE Date

2. Reassemble piston as follows.

   a. Place crown on skirt. Measure cold gap at point "X". (4 places only. See attached copy of portion of TDI dwg. 03-341-7319). Should be .007/.011. Remove crown.

   See Attached work summary sheet
   Record Gap

   Feeler Gage used
   M&TE # Cal. Due Date

   3/17/84
   TE Date

   3/-/84
   OQA Date

HOREHAM I
UCLEAR POWER STATION
ARTUP FORM 7.6

E DG 103

September 4, 1979
REVISION 0

PAGE R43 1562

## REWORK SUPERVISOR WORK SUMMARY

RIEF DESCRIPTION OF WORK: Took The Following Cold Gap Readings at 4 places on Pistons #5, #7, #8 step 2A of piston Disassembly/Reassembly Guidelines:

Skirt placed on crown

Guide pin being used locking into piston boss threads

| | | 1200 | 300 | 600 | 900 |
|---|---|---|---|---|---|
| Piston | #5 | .009 | .009 | .009 | .009 |
| | #7 | .009 | .009 | .008 | .008 |
| | #8 | .010 | .009 | .009 | .009 |

CVR 3/7/84

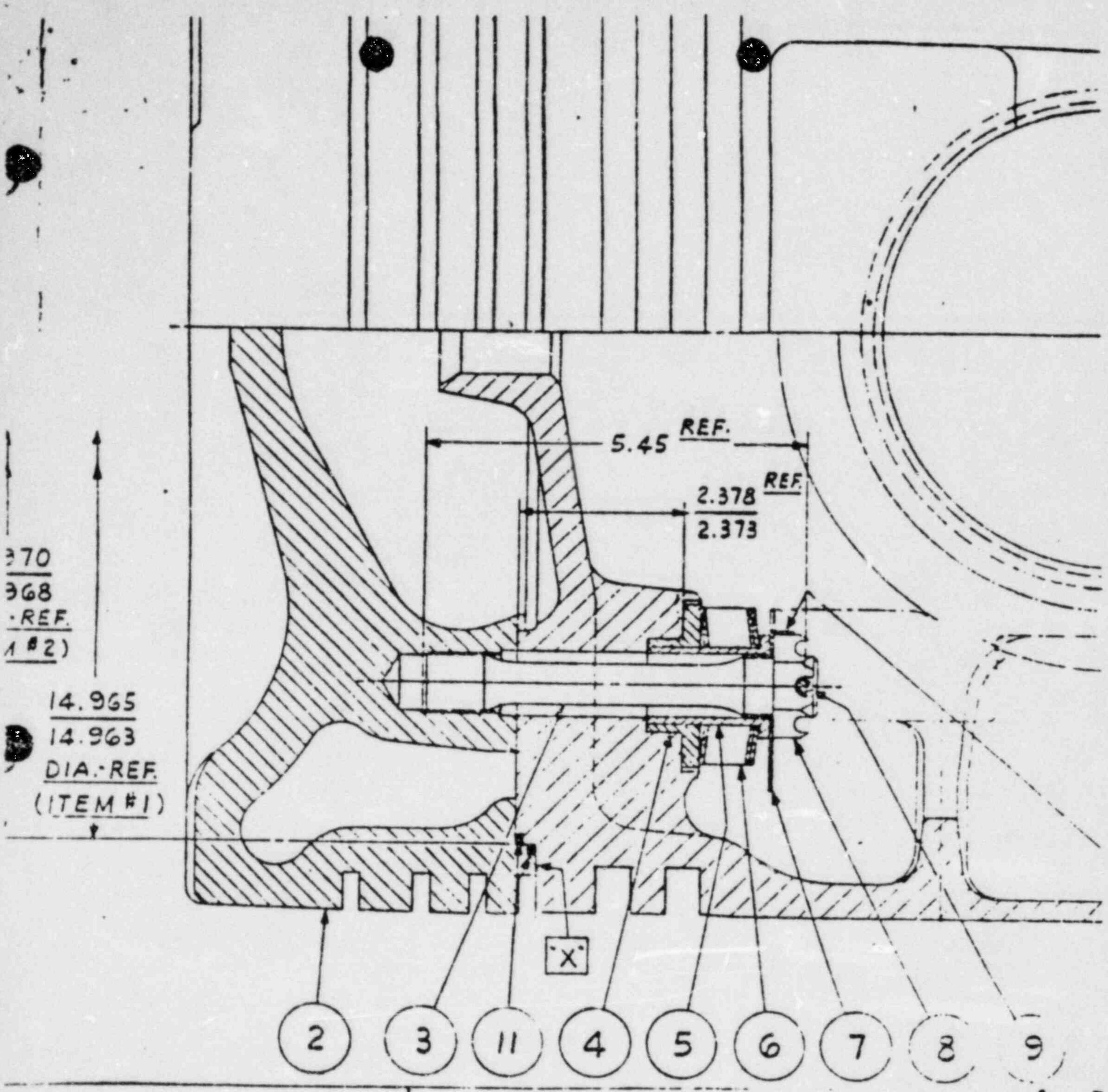
OMPONENTS REPLACED (IF APPLICABLE):

Step 2.B Crown and skirt pilot readings recording I.D and O.D respectively and documented

E, CALIBRATED TOOLS UTILIZED:

DITIONAL COMMENTS:

3/7/84
Rework Supervisor Signature/Date



1 DO NOT SCALE DRAWING.

**Transamerica Delaval**

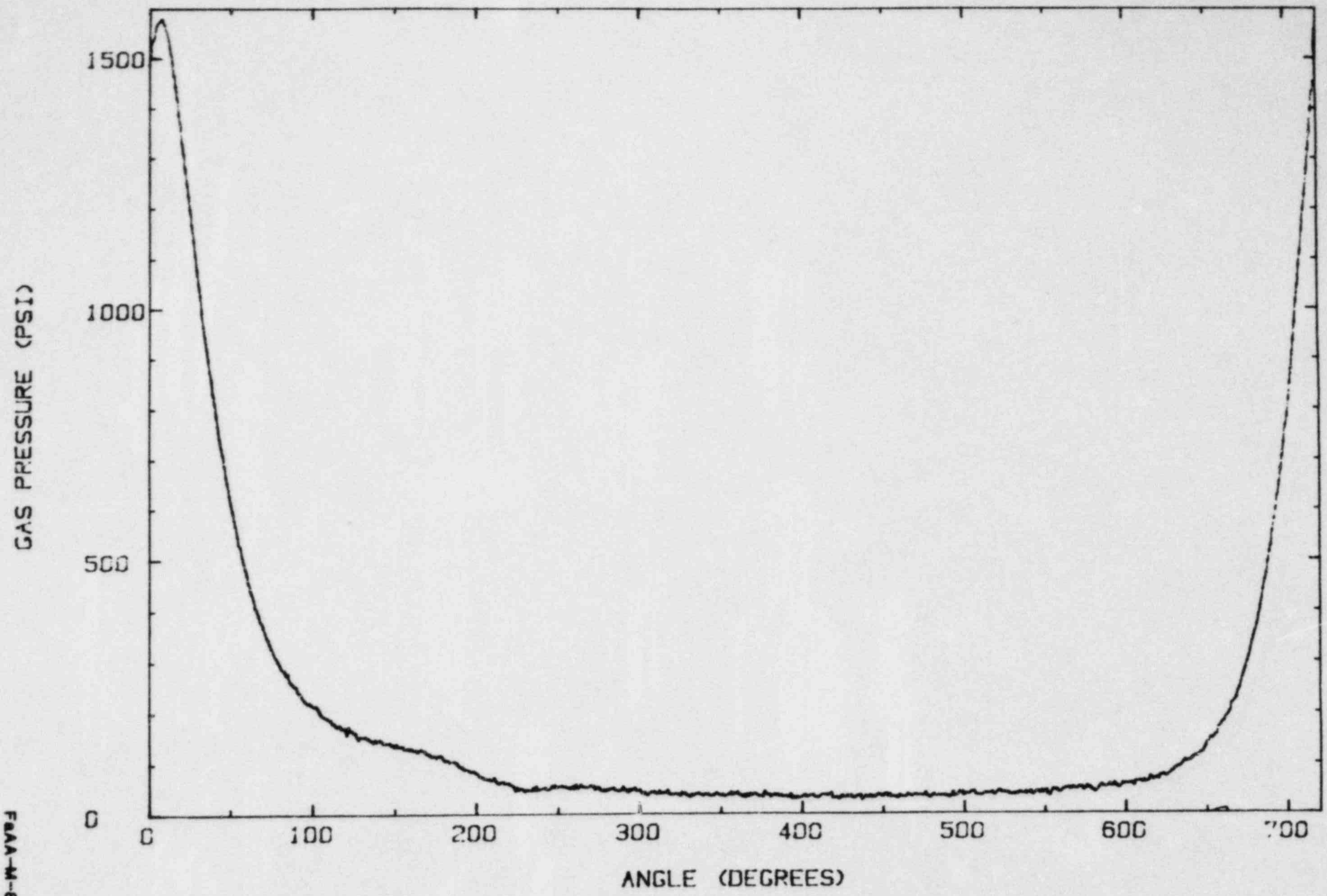
Transamerica Delaval Inc
Engine and Compressor Division
Oakland, California 94621

NOV 9 1983

PISTON ASSEMBLY - TWO PC.
(R/RV-4 ENGINES)

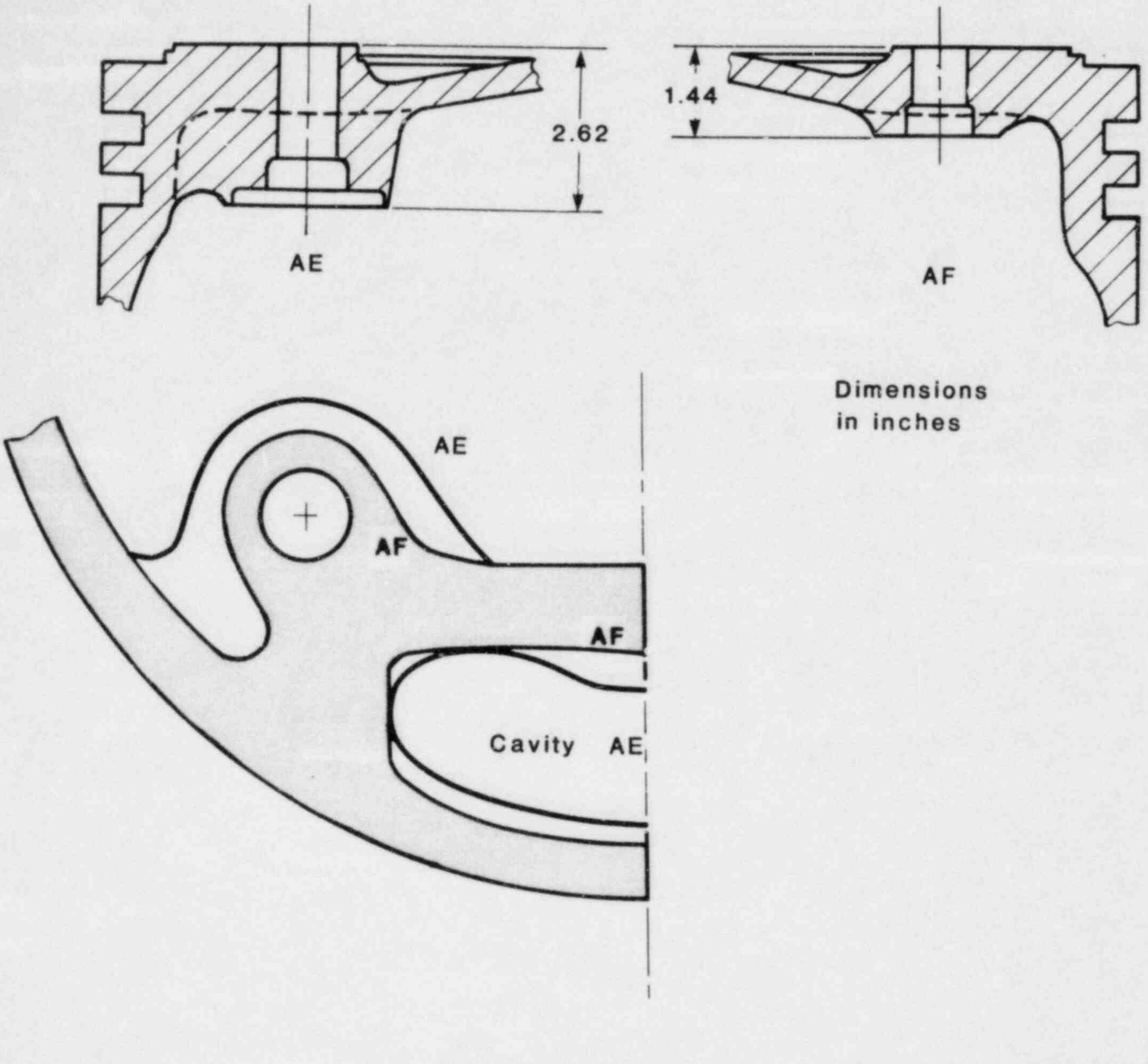
AND HARDNESS
M. ABOVE

| | | |
|---|---|---|
| APP J R Fillen | DWN | 03-341-7319 |
| SCALE 1/2 | CKD | |



Gas pressure versus crank angle (0°corresponds to top dead center).

FaAA-M-84-8-1



Comparison of AE and AF piston skirts in the region of the stud attachment bosses.

FaAA-M-84-8-1

CDG 101

TER # Q-338

1/4

NOTED MAR 26 1984

# COMPONENT TASK EVALUATION REPORT

Att #4

| STEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
|---|---|---|---|---|
| DG101<br>03-341A | 1A-6522<br>03-341A | GD Chika<br>SIGNATURE | 3-20-84 | ☐ENGINEERI<br>☒QUALITY |

NDITION DETAILS: ATTACHED INSPECTION REPORT ( 2 PAGES) GENERATED BY BR Williams DATED 3/20/84 IS CONSIDERED INFORMATIONAL AS NO ACCEPTANCE CRITERIA WAS PROVIDED PRIOR TO THE PERFORMANCE OF THE INSPECTION.

COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR EVALUATION AND ALSO TO SEO AND LSU FOR INFORMATION ONLY. Attached IR is informational only - see sheet 2 for reconnended disposition

:QUIRED COMPLETION DATE:

## ASSIGNMENT

| :ION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ENGINEERING ☐ QUALITY | Michael S Curry<br>SIGNATURE | 3-20-84 |

## DISPOSITION

ISPOSITION DETAILS: FOLLOW PROCEDURE 1 OUTLINED ON PAGE 2

ISPOSITION ASSIGNED TO ☒ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| UPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
| K. Dolan | 3-21-84 | K Dolan<br>RESP. CHAIRPERSON | 3-21-84 | PROGRAM MANAGER | 3-25-84 |

## ACTION

| CTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| C. Wells | K Dolan for C Wells | 3-29-84 |

CKS/GWR/RJN/EFM
TER LOG

A14466

RECOMMENDED
INFORMATION TER DISPOSITION

TER # Q-338
PAGE 2 OF 4

Distribution for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-338", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

STONE & WEBSTER ENGINEERING CORPORATION

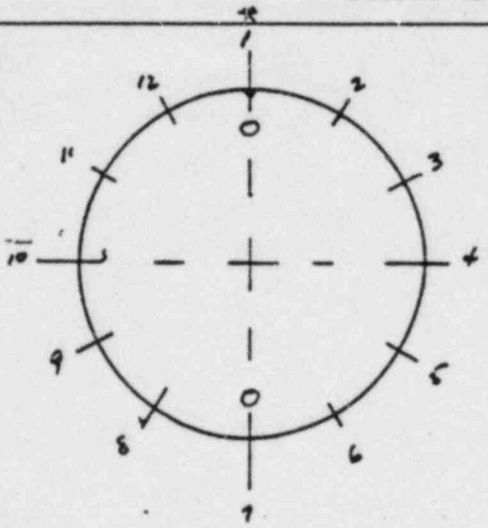
# QUALITY CONTROL INSPECTION REPORT

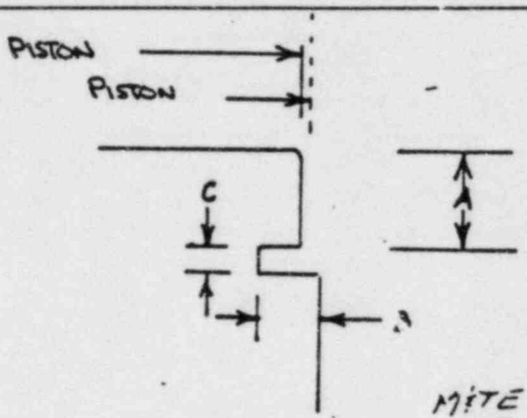
JOB NUMBER: 11600.37

DATE: 3/20/84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| 03-341 A ~~+ B~~<br>PISTON<br>DIMENSION VERIFICATION | ENGINE 101 | SH; 089<br>IP # 14 REV. 4<br>CHG. 0 |

| DWG. NO. OR P.O. | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 4 | 2 | |





MITE 2-54-18
DUE 8/7/84
MITE 2-51-03
5-6-84

PISTON # 5

GDG 3/20/84 ADDED LETTER DESIGNATIONS

| | | A | B | C |
|---|---|---|---|---|
| * | 1 | 2.272 | .570 | .255 |
| | 2 | 2.146 | .570 | .255 |
| | 3 | 2.148 | .572 | .255 |
| | 4 | 2.275 | .570 | .255 |
| | 5 | 2.144 | .570 | .25~~0~~5 |
| | 6 | 2.145 | .569 | .255 |
| | 7 | 2.271 | .570 | .255 |
| | 8 | 2.147 | .568 | .255 |
| | 9 | 2.144 | .570 | .255 |
| | 10 | 2.274 | .572 | .255 |
| | 11 | 2.145 | .569 | .255 |
| | 12 | 2.144 | .570 | .255 |

PISTON # 7

GDG 3/20/84

| | | A | B | C |
|---|---|---|---|---|
| * | 1 | 2.258 | .568 | .255 |
| | 2 | 2.143 | .569 | .256 |
| | 3 | 2.143 | .569 | .256 |
| | 4 | 2.260 | .569 | .255 |
| | 5 | 2.142 | .568 | .256 |
| | 6 | 2.142 | .569 | .255 |
| | 7 | 2.259 | .569 | .255 |
| | 8 | 2.139 | .569 | .255 |
| | 9 | 2.139 | .569 | .255 |
| | 10 | 2.260 | .569 | .255 |
| | 11 | 2.140 | .569 | .255 |
| | 12 | 2.140 | .568 | .255 |

~~* LOCATION OF THE PISTON NOTCH~~

REVIEWED: H.I. Stott

| QUALITY CONTROL INSPEC./ENG. | DATE | PAGE |
|---|---|---|
| B.L. Williams | 3/20/84 | 1 OF 2 |

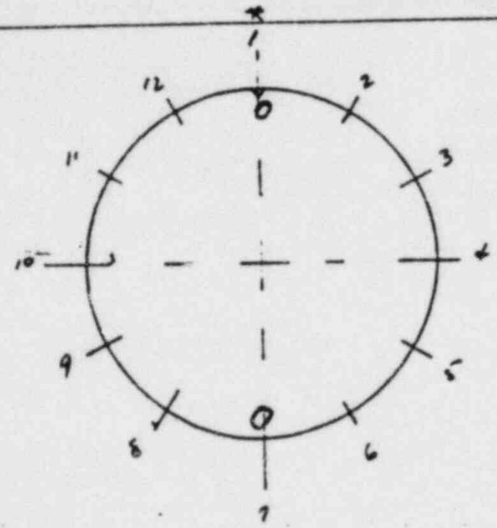
**STONE & WEBSTER ENGINEERING CORPORATION**

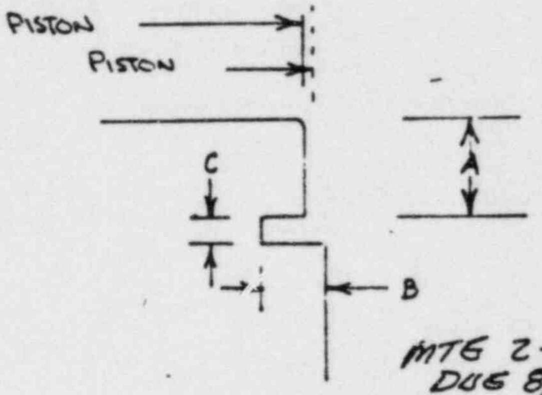
**UALITY CONTROL**
**CTION REPORT**

JOB NUMBER: 11600.37
DATE: 3/20/84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| 03-341 A ~~+B~~<br>PISTON<br>DIMENSION VERIFICATION | ENGINE 101 | SHI-089<br>IP# 14 REV. 4<br>CHG. 0 |

| DWG NO OR PO | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 4 | 4 | |





MTE 2-54-18
DUE 8/9/84
MTE 2-51-03
DUE 5-6-84

PISTON # 8

| | A | B | C |
|---|---|---|---|
| * 1 | 2.264 | .570 | .255 |
| 2 | 2.145 | .568 | .255 |
| 3 | 2.146 | ,568 | ,255 |
| 4 | 2,264 | ,569 | .255 |
| 5 | 2.148 | ,568 | ,255 |
| 6 | 2.147 | ,568 | .255 |
| 7 | 2.264 | ,568 | ,255 |
| 8 | 2.146 | .569 | ,255 |
| 9 | 2.147 | .568 | ,255 |
| 10 | 2.264 | .568 | .255 |
| 11 | 2.148 | .569 | .255 |
| 12 | 2.146 | .569 | .255 |

PISTON # RING 1ST.

| | #5 | #7 | #8 |
|---|---|---|---|
| * 1 | .250 | .250 | .250 |
| 2 | 250 | .250 | .250 |
| 3 | .250 | .250 | .250 |
| 4 | 250 | .250 | .250 |
| 5 | .250 | .250 | .250 |
| 6 | 250 | .250 | .250 |
| 7 | .250 | .250 | .250 |
| 8 | .250 | .250 | .250 |
| 9 | .250 | .250 | 250 |
| 10 | .250 | 250 | .250 |
| 11 | .250 | .250 | .250 |
| 12 | .250 | .250 | .250 |

A.1.4.159

~~* LOCATION OF THE PISTON NOTCH~~ 3-20-84
REVIEWED: V.E. Stuth

QUALITY CONTROL INSPEC/ENG: BR Williams
DATE: 3/20/84
PAGE 2 of 2

D. This inspection report is acceptable for design review.

Q-338
03-341A

K. Kola for C Wells
3/29/84

EDG 101

TER # Q-310

1/4

OTED MAR 26 1984

# COMPONENT TASK EVALUATION REPORT

| STEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
|---|---|---|---|---|
| '01 03.341A | 03.341A | R. Tompkins<br>SIGNATURE | 3-20-84 | ☐ ENGINEERI<br>☒ QUALITY |

NDITION DETAILS: ATTACHED INSPECTION REPORT ( 2 PAGES) GENERATED BY D. SMITH DATED 3-20-84 IS CONSIDERED INFORMATIONAL AS NO ACCEPTANCE CRITERIA WAS PROVIDED PRIOR TO THE PERFORMANCE OF THE INSPECTION.

COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR EVALUATION AND ALSO TO SEO AND LSU FOR INFORMATION ONLY.

Attached IR is informational only.
See Sheet 2 for recommended Disposition.

QUIRED COMPLETION DATE: 3-20-84

## ASSIGNMENT

| ION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| NGINEERING ☐ QUALITY | R. Fraser<br>SIGNATURE | 3-20-84 |

## DISPOSITION

ISPOSITION DETAILS: FOLLOW PROCEDURE 1 OUTLINED ON PAGE 2

ISPOSITION ASSIGNED TO ☒ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| UPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
| K Solon | 3-21-84 | K. Solon<br>RESP. CHAIRPERSON | 3-21-84 | PROGRAM MANAGER | 3/25/84 |

## ACTION

| CTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| C. Wells | K Solon for C. Wells | 3-29-84 |

CKS/GWR/RJN/EFM
TER LOG

A19471

## RECOMMENDED
## INFORMATION TER DISPOSITION

TER # Q-310
PAGE 2 OF 4

Distribution for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-310", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

STONE & WEBSTER ENGINEERING CORPORATION

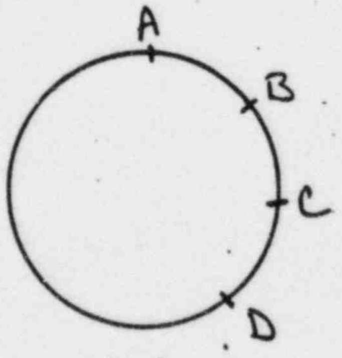
QUALITY CONTROL
INSPECTION REPORT

JOB NUMBER 11600.37

DATE 3-20-84

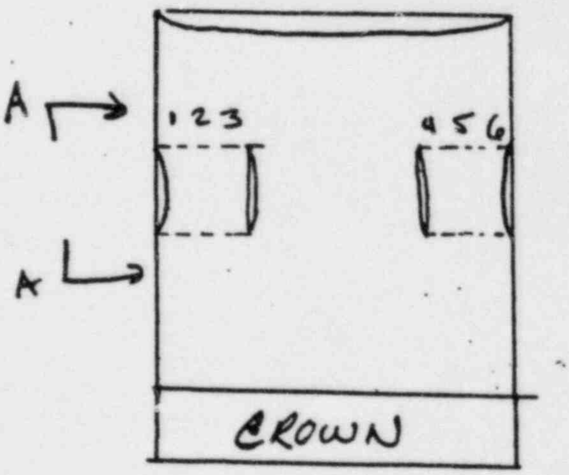
| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME:<br>PISTONS<br>COMPONENT NO. 03-341A | DG- 101 | I.P. NO. 14 REV. 4 CHG 0<br>TER # DR-239<br>LILCO LP PROC. ____ REV. ____<br>DWG. NO. ____ |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
|  | 5 | 3 | PERFORMED DIMENSIONAL INSPECTION OF PISTON PIN BORE DIAMETER AT 45° INTERVALS AROUND THE CIRCUMFERENCE (IE; 4 MEASUREMENTS) AND PERFORMED THE INSPECTION AT THREE BORE DEPTHS ON BOTH SIDES OF THE PISTONS FOR CYLINDERS 5, 7, AND 8.<br>(SEE BELOW AND ATTACHED) |



A-A

FACING EXHAUST SIDE



M0073

M&TE NO. 2-52-11, ____, ____, ____,
DUE 12-22-84, ____, ____, ____.

QUALITY CONTROL INSPEC./ENG. | DATE | PAGE

STONE & WEBSTER ENGINEERING CORPORATION

**QUALITY CONTROL INSPECTION REPORT**

JOB NUMBER 11600.37

DATE 3-20-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: PISTONS<br>COMPONENT NO. 03-341A | DG- 101 | I.P. NO. 14 REV. 4 CHG 0<br>TER # ____<br>LILCO LP PROC. ____ REV. ____<br>DWG. NO. ____ |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CYL #5 | | | | | | CYL #7 | | | | | | |
| | | | | 1 | 2 | 3 | 4 | 5 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | |
| | — | | A | 6.751 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.751 | 6.750 | 6.750 | 6.751 | 6.750 | 6.750 | |
| | | | B | 6.751 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.751 | 6.751 | 6.750 | |
| | | | C | 6.751 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.751 | 6.750 | 6.750 | 6.750 | 6.751 | 6.750 | |
| | | | D | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.750 | 6.751 | 6.750 | |
| | | | | | | CYL #8 | | | | | | | | | | |
| | | | A | 6.750 | 6.750 | 6.750 | 6.751 | 6.751 | 6.751 | | | | | | | |
| | | | B | 6.750 | 6.750 | 6.750 | 6.751 | 6.751 | 6.751 | | | | | | | |
| | | | C | 6.750 | 6.750 | 6.750 | 6.751 | 6.751 | 6.751 | | | | | | | |
| | | | D | 6.750 | 6.750 | 6.750 | 6.751 | 6.751 | 6.751 | | | | | | | |

M&TE NO. *2-52-11, ____, ____, ____,

Due 12-22-84, ____, ____, ____.

QUALITY CONTROL INSPEC./ENG. | DATE | PAGE

This inspection report is acceptable for design review.

Q-310
03-3411A

K. Asla for C Wells
3/29/84

ATT #4

TER # Q-194
Page 1 of 5
EDG 103

# COMPONENT TASK EVALUATION REPORT

| | | | | |
|---|---|---|---|---|
| STEM/COMPONENT NO.<br>03-341A<br>D.G.103 | TDI PART NO.<br>1A-6522 | INITIATOR<br>SIGNATURE | DATE<br>3-13-84 | ORGANIZATI<br>☐ENGINEERI<br>☒QUALITY |

NDITION DETAILS: ATTACHED INSPECTION REPORT ( 3 PAGES) GENERATED BY J. Dolan
DATED 3-12-84 IS CONSIDERED INFORMATIONAL AS NO ACCEPTANCE CRITERIA WAS PROVIDED PRIOR TO THE PERFORMANCE OF THE INSPECTION.

COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR EVALUATION AND ALSO TO SEO AND LSU FOR INFORMATION ONLY.

ATTACHED IR IS INFORMATIONAL ONLY - See sheet 2 for recommended disposition.

QUIRED COMPLETION DATE:

## ASSIGNMENT

| | | |
|---|---|---|
| SITION ASSIGNED TO<br>GINEERING ☐QUALITY | RESPONSIBLE CHAIRPERSON<br>SIGNATURE | DATE<br>3/14/84 |

## DISPOSITION

ISPOSITION DETAILS: FOLLOW PROCEDURE 1 OUTLINED ON PAGE 2

ISPOSITION ASSIGNED TO ☒ENGINEERING ☐QUALITY ☐NONE REQUIRED

| | | | | | |
|---|---|---|---|---|---|
| UPPLIED BY<br>K. Aslan | DATE<br>3-14-84 | REVIEWED BY<br>K. Aslan<br>RESP. CHAIRPERSON | DATE<br>3-14-84 | APPROVED BY<br>PROGRAM MANAGER | DATE<br>3/15/84 |

## ACTION

| | | |
|---|---|---|
| CTION ASSIGNED TO<br>C. Wells | ACTION COMPLETED BY<br>K. Aslan for C. Wells | DATE<br>3-15-84 |

CKS/GWR/RJN/EFM
TER LOG

## RECOMMENDED
## INFORMATION TER DISPOSITION

TER #Q-194
Page 2 of 5

Distribution for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-194", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

STONE & WEBSTER ENGINEERING CORPORATION

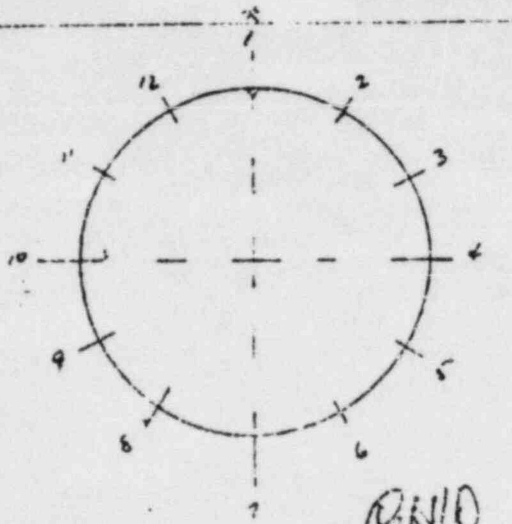
TER # Q-194
Page 3 of 5

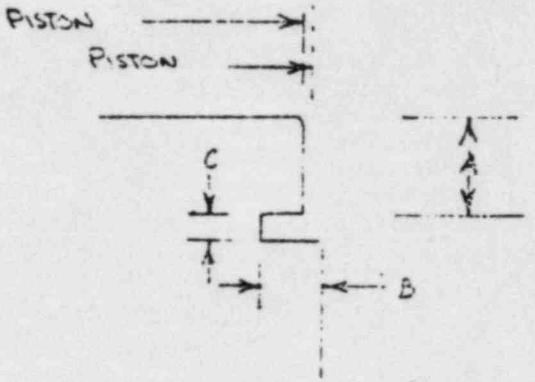
ALITY CONTROL
SPECTION REPORT

JOB NUMBER: 11600.37
DATE: 3/12/84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| 03-341 (A) ~~& B~~ EHA 3/12/84<br>PISTON<br>DIMENSION VERIFICATION | ENGINE<br>DG 103 | IP NO 14, REV. 3<br>~~SH-039~~ EHA 3/12/84 |

| S NO PO | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
|  | 4 | 1 |  |





PISTON # 8 EHA 3/12/84

|  | A | B | C |
|---|---|---|---|
| * 1 | ~~2.309~~ | ~~0.567~~ | ~~0.251~~ |
| 2 | ~~2.185~~ | ~~0.571~~ | ~~0.254~~ |
| 3 | ~~2.135~~ | ~~0.570~~ | ~~0.254~~ |
| 4 |  | ~~0.570~~ | ~~0.254~~ |
| 5 |  |  |  |
| 6 |  |  |  |
| 7 |  |  |  |
| 8 |  |  |  |
| 9 |  |  |  |
| 10 |  |  |  |
| 11 |  |  |  |
| 12 |  |  |  |

PISTON # 5

|  | A | B | C |
|---|---|---|---|
| * 1 | 2.245 | .566 | .255 |
| 2 | 2.125 | .566 | .254 |
| 3 | 2.125 | .565 | .254 |
| 4 | 2.243 | .567 | .254 |
| 5 | 2.125 | .568 | .254 |
| 6 | 2.125 | .567 | 254 |
| 7 | 2.248 | .566 | .253 |
| 8 | 2.125 | .566 | .254 |
| 9 | 2.125 | .568 | .255 |
| 10 | 2.245 | .567 | .253 |
| 11 | 2125 | .568 | .253 |
| 12 | 2.124 | .567 | .253 |

* LOCATION OF THE PISTON NOTCH

reviewed by [illegible] MTE NO 2-54-18, Due - 8/9/84

QUALITY CONTROL INSPEC ENG: [illegible]
DATE: 3/12/84
PAGE 1 of 3

A. 05396

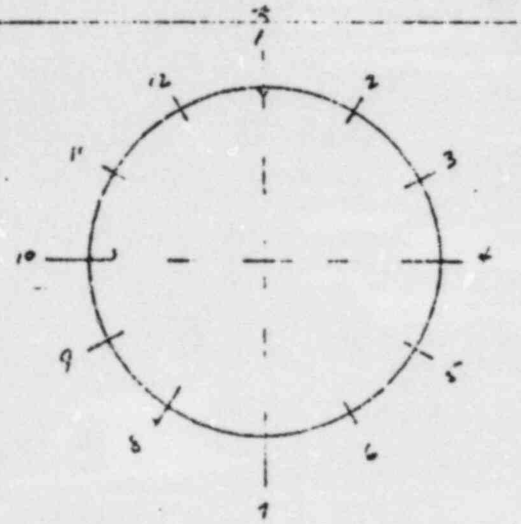
STONE & WEBSTER ENGINEERING CORPORATION TER #Q-194 Page 4 of 5

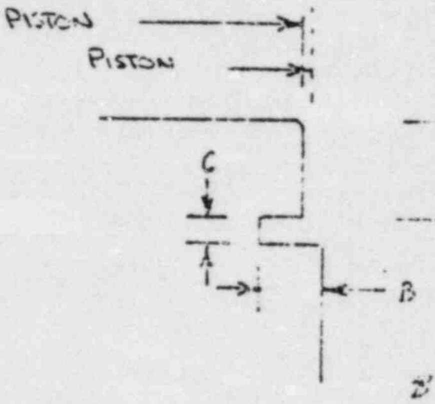
ITY CONTROL
PECTION REPORT

| JOB NUMBER | DATE |
|---|---|
| 11600.37 | 3-12-84 |

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| EHW 3/12/84<br>03-341 (A) ~~+B~~<br>PISTON<br>DIMENSION VERIFICATION | BJ 3-12-84<br>ENGINE # 103 | 1P No. 14 REV. 3<br>~~SH-089~~ EHW 3/12/84 |

| S NO PO | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
|  | 4 | 2 |  |





B/C Piston 7&8 3/12/84

PISTON # 8

|  | A | B | C |
|---|---|---|---|
| * 1 | 2.300 | .570 | 0.255 |
| 2 | 2.176 | .569 | 0.255 |
| 3 | 2.176 | 0.569 | 0.255 |
| 4 | 2.298 | 0.570 | 0.255 |
| 5 | 2.176 | 0.570 | 0.254 |
| 6 | 2.176 | 0.569 | 0.255 |
| 7 | 2.299 | 0.569 | 0.256 |
| 8 | 2.175 | 0.571 | 0.255 |
| 9 | 2.176 | 0.571 | 0.255 |
| 10 | 2.298 | 0.570 | 0.256 |
| 11 | 2.180 | 0.570 | 0.256 |
| 12 | 2.177 | 0.570 | 0.255 |

PISTON # 7

|  | A | B | C |
|---|---|---|---|
| * 1 | 2.250 | 0.570 | 0.255 |
| 2 | 2.123 | 0.569 | 0.255 |
| 3 | 2.120 | 0.570 | 0.255 |
| 4 | 2.250 | 0.570 | 0.255 |
| 5 | 2.120 | 0.569 | 0.255 |
| 6 | 2.125 | 0.570 | 0.255 |
| 7 | 2.250 | 0.569 | 0.254 |
| 8 | 2.125 | 0.569 | 0.254 |
| 9 | 2.1[illegible] | 0.569 | 0.254 |
| 10 | 2.252 | 0.569 | 0.255 |
| 11 | 2.125 | 0.571 | 0.255 |
| 12 | 2.126 | 0.571 | 0.255 |

3/12

* LOCATION OF THE PISTON NOTCH

MTF No. 2-5[illegible] [illegible] 5/3/84

| QUALITY CONTROL INSPECTOR/ENG | DATE | PAGE |
|---|---|---|
|  | No 8597 | 2 of 3 |

STONE & WEBSTER ENGINEERING CORPORATION

TER #G-194
Page 3 of 5

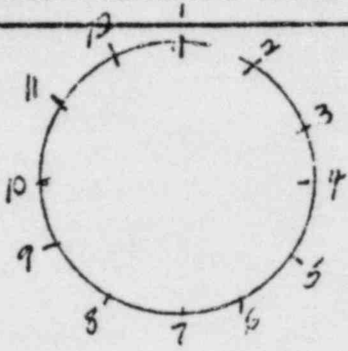
## ...ALITY CONTROL
## ...SPECTION REPORT

JOB NUMBER 11600.37

DATE 3/12/84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: Piston<br>COMPONENT NO. 03-341A | DG- 103 | I.P. NO. 14 REV. 3 CHG ____<br>TER # ________<br>LILCO LP PROC. ______ REV. ____<br>DWG. NO. ________ |

| DWG. NO. OR P.C. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
|  | 4 | 3 | (2nd PART) |



| | Cyl 5 | 7 | 8 |
|---|---|---|---|
| 1 | .246 | .246 | 249 |
| 2 | .246 | .246 | 249 |
| 3 | .246 | .246 | .249 |
| 4 | .246 | .246 | .249 |
| 5 | .246 | .246 | 249 |
| 6 | .246 | .246 | 249 |
| 7 | .246 | .246 | .249 |
| 8 | .246 | 246 | 249 |
| 9 | .246 | 246 | 249 |
| 10 | .246 | 246 | 249 |
| 11 | .246 | .246 | 249 |
| 12 | 246 | .246 | .249 |

A14598

M&TE NO. 2-53-116 (Due 8/1/84), ________, ________, ________

________, ________, ________, ________, ________

QUALITY CONTROL INSPEC/ENG.

DATE 3/12/84

PAGE 3 of 5

Q-194
03-341A

NO FURTHER INFORMATION IS REQUIRED FOR DESIGN REVIEW

K. Lolan for C. Wells 2/19/84

A14599

STONE & WEBSTER ENGINEERING CORPORATION

# QUALITY CONTROL INSPECTION REPORT

JOB NUMBER 11600.37

DATE 3/12/84

SYSTEM(S) OR PART(S) NAME: 03-341 Ⓐ ~~+ B~~ ENHW 3/12/84
PISTON
DIMENSION VERIFICATION

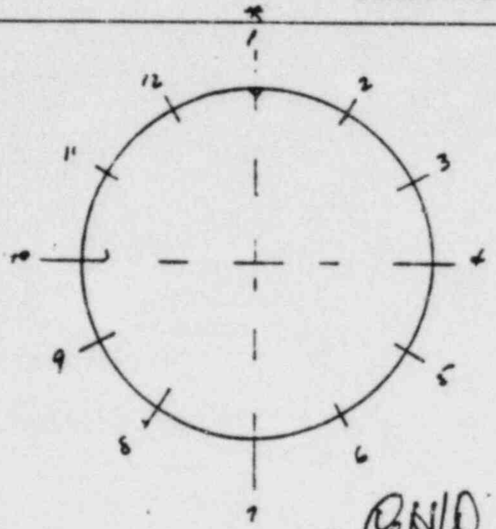
LOCATION(S): ENGINE
DG 103

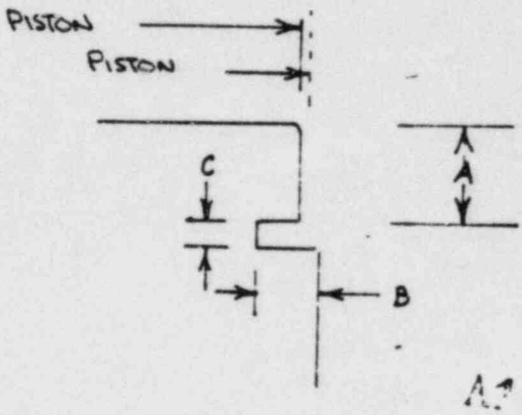
REFERENCE DOCUMENT(S): IP NO 14, REV. 3
~~SH-089~~ ENHW 3/12/84

DWG NO OR PO:

ITEM 4 QTY 1

DESCRIPTION(S) AND INSPECTION REMARK(S)





A**600

PISTON # 8 ENHW 3/12/84

| | | A | B | C |
|---|---|---|---|---|
| * | 1 | ~~2.307~~ | ~~0.567~~ | ~~0.251~~ |
| | 2 | ~~2.185~~ | ~~0.571~~ | ~~0.254~~ |
| | 3 | ~~2.186~~ | ~~0.570~~ | ~~0.254~~ |
| | 4 | | ~~0.570~~ | ~~0.254~~ |
| | 5 | | | |
| | 6 | | | |
| | 7 | | | |
| | 8 | | | |
| | 9 | | | |
| | 10 | | | |
| | 11 | | | |
| | 12 | | | |

PISTON # 5

| | | A | B | C |
|---|---|---|---|---|
| * | 1 | 2.245 | .566 | .255 |
| | 2 | 2.125 | .566 | .254 |
| | 3 | 2.125 | .565 | .254 |
| | 4 | 2.243 | .567 | .254 |
| | 5 | 2.125 | .568 | .254 |
| | 6 | 2.125 | .567 | 254 |
| | 7 | 2.248 | .566 | .253 |
| | 8 | 2.125 | .566 | .254 |
| | 9 | 2.125 | .568 | .255 |
| | 10 | 2.245 | .567 | .253 |
| | 11 | 2125 | .568 | .253 |
| | 12 | 2.124 | .567 | .253 |

* LOCATION OF THE PISTON NOTCH

QUALITY CONTROL INSPEC/ENG: John P Dolan ~~Due 8/9/84~~

DATE 3/12/84

PAGE 1 of 3

Reviewed by P. Dean MTE NO. 2-54-18 ,

STONE & WEBSTER ENGINEERING CORPORATION

# QUALITY CONTROL INSPECTION REPORT

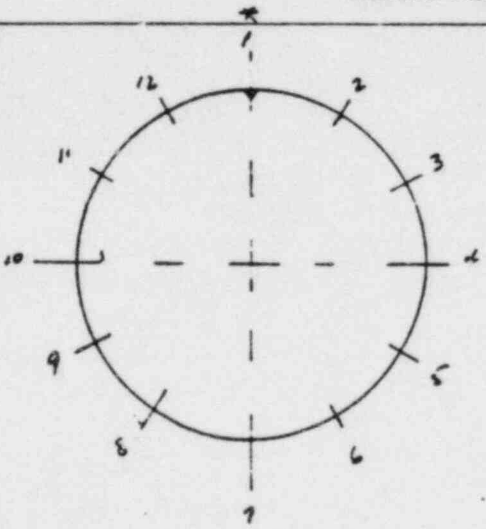
1040.26

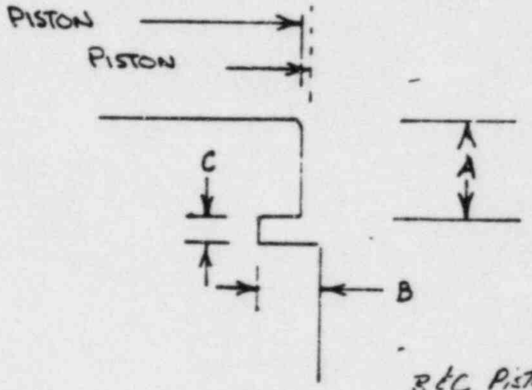
JOB NUMBER: 11600.37

DATE: 3-12-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| 03-341 Ⓐ ~~-B~~ EHW 3/12/84<br>PISTON<br>DIMENSION VERIFICATION | BJ 3-12-84<br>ENGINE # ~~1~~103 | IP No. 14 REV. 3<br>~~SH. 089~~ EHW 3/12/84 |

| DWG NO OR PO | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 4 | 2 | |





B&C PISTON 7&8 Brickelbaw 3/12/84

A14601

PISTON # 8

| | | A | B | C |
|---|---|---|---|---|
| * | 1 | 2.300 | .570 | 0.255 |
| | 2 | 2.176 | .569 | 0.255 |
| | 3 | 2.176 | 0.569 | 0.255 |
| | 4 | 2.298 | 0.570 | 0.255 |
| | 5 | 2.176 | 0.570 | 0.254 |
| | 6 | 2.176 | 0.569 | 0.255 |
| | 7 | 2.299 | 0.569 | 0.256 |
| | 8 | 2.175 | 0.571 | 0.255 |
| | 9 | 2.176 | 0.571 | 0.255 |
| | 10 | 2.298 | 0.570 | 0.256 |
| | 11 | 2.180 | 0.570 | 0.256 |
| | 12 | 2.177 | 0.570 | 0.255 |

PISTON # 7

| | | A | B | C |
|---|---|---|---|---|
| * | 1 | 2.250 | 0.570 | 0.255 |
| | 2 | 2.123 | 0.569 | 0.255 |
| | 3 | 2.120 | 0.570 | 0.255 |
| | 4 | 2.250 | 0.570 | 0.255 |
| | 5 | 2.120 | 0.569 | 0.255 |
| | 6 | 2.125 | 0.570 | 0.255 |
| | 7 | 2.250 | 0.569 | 0.254 |
| | 8 | 2.125 | 0.569 | 0.254 |
| EHW 3/12 | 9 | 2.126 | 0.569 | 0.254 |
| | 10 | 2.252 | 0.569 | 0.255 |
| | 11 | 2.125 | 0.571 | 0.255 |
| | 12 | 2.125 | 0.571 | 0.255 |

* LOCATION OF THE PISTON NOTCH

MTE NO 2-54-18 Due 8/9/84

QUALITY CONTROL INSPEC/ENG: John P Dolan

DATE:

PAGE: 2 OF 3

STONE & WEBSTER ENGINEERING CORPORATION

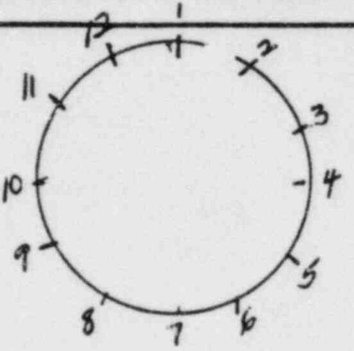
**QUALITY CONTROL INSPECTION REPORT**

JOB NUMBER 11600.37

DATE 3/12/84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: PISTON<br>COMPONENT NO. 03-341 A | DG- 103 | I.P. NO. 14 REV. 3 CHG ___<br>TER # ___<br>LILCO LP PROC. ___ REV. ___<br>DWG. NO. ___ |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 4 | 3 | (2nd PART) |



| | Cyl 5 | 7 | 8 |
|---|---|---|---|
| 1 | .246 | .246 | .249 |
| 2 | .246 | .246 | .249 |
| 3 | .246 | .246 | .249 |
| 4 | .246 | .246 | .249 |
| 5 | .246 | .246 | .249 |
| 6 | .246 | .246 | .249 |
| 7 | .246 | .246 | .249 |
| 8 | .246 | .246 | .249 |
| 9 | .246 | .246 | .249 |
| 10 | .246 | .246 | .249 |
| 11 | .246 | .246 | .249 |
| 12 | .246 | .246 | .249 |

A14602

M&TE NO. 2-53-116 (Due 8/1/84)

QUALITY CONTROL INSPEC./ENG. John P Dolan

DATE 3/12/84

PAGE 3 of 3

ATT #5

TER # Q-203

1/6

EOG 103

# COMPONENT TASK EVALUATION REPORT

| 'STEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI( |
|---|---|---|---|---|
| 03-341A<br>D.G.103 | 1A-6522 | Kevin M. Fahy<br>SIGNATURE | 3-13-84 | ☐ENGINEERI<br>☒QUALITY |

›NDITION DETAILS: ATTACHED INSPECTION REPORT (3 PAGES) GENERATED BY B. Hayes DATED 3-13-84 IS CONSIDERED INFORMATIONAL AS NO ACCEPTANCE CRITERIA WAS PROVIDED PRIOR TO THE PERFORMANCE OF THE INSPECTION.

:COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR EVALUATION AND ALSO TO SEO AND LSU FOR INFORMATION ONLY.

Attached IR is informational only.
See Sheet 2 for recommended disposition.

:QUIRED COMPLETION DATE: 3-15-84

## ASSIGNMENT

| 'ION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ☒GINEERING ☐QUALITY | R. Fraser<br>SIGNATURE | 3-14-84 |

## DISPOSITION

ISPOSITION DETAILS: FOLLOW PROCEDURE 1 OUTLINED ON PAGE 2

ISPOSITION ASSIGNED TO ☒ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| UPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
| K. Adm | 3-14-84 | K. Adm<br>RESP. CHAIRPERSON | 3-14-84 | PROGRAM MANAGER | 3/15/84 |

## ACTION

| CTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| C. Wells | K. Adm for C. Wells | 3-19-84 |

CKS/GWR/RJN/EFM
TER LOG

A14618

Q - 2/6

## RECOMMENDED
## INFORMATION TER DISPOSITION

Distribution for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-203", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

3/6

STONE & WEBSTER ENGINEERING CORPORATION

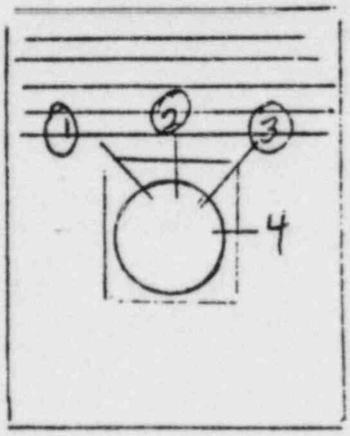
# UALITY CONTROL SPECTION REPORT

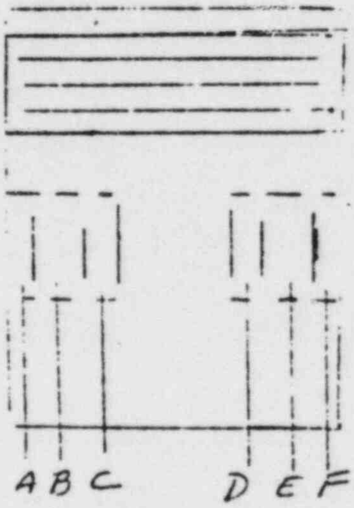
JOB NUMBER 11600.37

DATE 3-13-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: Pistons CYL. 5<br>COMPONENT NO. 03-341A | DG-103 | I.P. NO. ~~4~~ 14 N.F.S. 3/13/84 REV. 3 CHG 0<br>TER # DR-257<br>LILCO LP PROC. ______ REV. ___<br>DWG. NO. ______ |

| WG. NO OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
|  | 1/4 | 3 |  |





|  | ① | ② | ③ | ④ |
|---|---|---|---|---|
| A | 6.750 | 6.750 | 6.751 | 6.751 |
| B | 6.750 | 6.751 | 6.751 | 6.751 |
| C | 6.750 | 6.750 | 6.751 | 6.750 |
| D | 6.751 | 6.751 | 6.750 | 6.750 |
| E | 6.751 | 6.751 | 6.750 | 6.751 |
| F | 6.751 | 6.750 | 6.750 | 6.751 |
|  |  |  |  |  |

A14020

M&TE NO. 02-002-11, Due 12/22/84, ______, ______.

______, ______, ______, ______.

Reviewed [illegible] 3/13/84

QUALITY CONTROL INSPECTOR(S) | DATE | PAGE

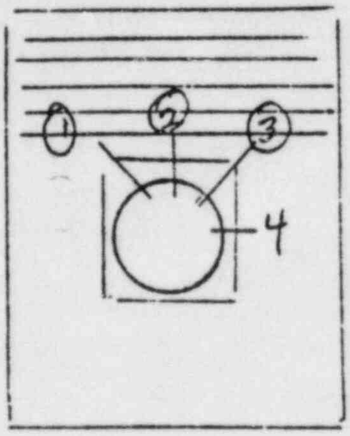
STONE & WEBSTER ENGINEERING CORPORATION 4/6

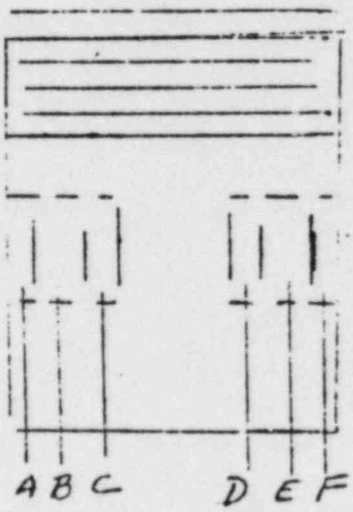
**JALITY CONTROL SPECTION REPORT**

| JOB NUMBER | DATE |
|---|---|
| 11600.37 | 3-13-84 |

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: PISTONS, CYL. 7<br>COMPONENT NO. 03-341A | DG-103 | I.P. NO. ~~1~~ 14 (3/13/84) REV. 3 CHG 0<br>TER # [illegible]<br>LILCO LP PROC. ______ REV. ___<br>DWG. NO. ______ |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| N/A | | | |





| | ① | ② | ③ | ④ |
|---|---|---|---|---|
| A | 6.750 | 6.751 | 6.751 | 6.751 |
| B | 6.750 | 6.750 | 6.751 | 6.751 |
| C | 6.750 | 6.750 | 6.751 | 6.750 |
| D | 6.751 | 6.750 | 6.750 | 6.751 |
| E | 6.751 | 6.751 | 6.750 | 6.751 |
| F | 6.751 | 6.751 | 6.750 | 6.751 |

A1.0621

M&TE NO. ·2·550 11, Due 12/22/84

| QUALITY CONTROL INSPECTOR(S) | DATE | PAGE |
|---|---|---|
| [illegible] | | |

REVIEWED 3/13/84

5/6

STONE & WEBSTER ENGINEERING CORPORATION

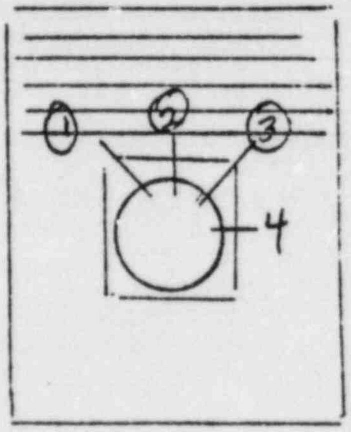
ALITY CONTROL
SPECTION REPORT

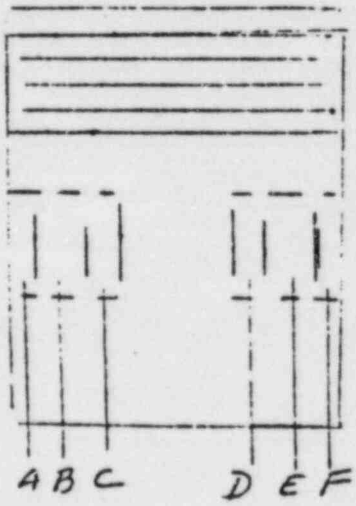
JOB NUMBER 11600.37

DATE 3-13-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME:<br>PISTONS<br>CYL 8<br>COMPONENT NO. 03-341A | DG- 103 | I.P. NO. ~~2~~ 14 W.E.O. 3/13/84 REV. 3 CHG 0<br>TER # 83 [illegible]<br>LILCO LP PROC. ______ REV. ___<br>DWG. NO. ________ |

| G. NO P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | N/A | — | |





| | ① | ② | ③ | ④ |
|---|---|---|---|---|
| A | 6.750 | 6.750 | 6.750 | 6.750 |
| B | 6.750 | 6.750 | 6.750 | 6.750 |
| C | 6.750 | 6.750 | 6.750 | 6.750 |
| D | 6.750 | 6.750 | 6.750 | 6.750 |
| E | 6.750 | 6.750 | 6.750 | 6.750 |
| F | 6.750 | 6.750 | 6.750 | 6.750 |

M&TE NO. 22211, Due 12/22/84

Reviewed 3/13/84

QUALITY CONTROL INSPECTING | DATE | PAGE

6/6

# COMPONENT TASK EVALUATION REPORT

| EM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZAT |
|---|---|---|---|---|
| 03-341A | 03--341A | SIGNATURE | 3/12/84. | ☒ENGINEER<br>☐QUALITY |

NDITION DETAILS: IP No 14 needs clarification on LP Test requirements for the Pist lso, dimensional inspections of the piston pin bore area are needed.
hese requirements are for cylinders #5, 7 & 8.

COMMENDATIONS: Revise IP No 14 to delete the LP test of the piston pin boss area. The LP test of the piston skirt at the bosses for bolt attachment of crown is requ
In addition, the following dimensional inspection is to be added to IP No. 14:
Perform Dimensional Inspection of the Piston Pin Bore Diameter at 45° intervals aroun the circumference (ie. 4 measurements) and perform the inspection at 3 bore depths on both sides of the pistons.

QUIRED COMPLETION DATE: 3/12/84

## ASSIGNMENT

| SITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ENGINEERING ☑QUALITY | for GWR<br>SIGNATURE | 3/12/84 |

## DISPOSITION

SPOSITION DETAILS: M. Curry - Revise T.D. accordingly
EFM - Revise CTS
B. Murray - Revise IP
INSpections to proceed T.D update if required

SPOSITION ASSIGNED TO ☐ ENGINEERING ☒ QUALITY ☐ NONE REQUIRED

| ORLVED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
|  | 3-12-84 | RESP. CHAIRPERSON | 3-12-84 | PROGRAM MANAGER | 3/12/8 |

## ACTION

| TION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| MSC, EFM, B Murray<br>INFO: MHS<br>S'Brinnon |  |  |

: CKS/GWR/RJN/EFM
TER LOG

A10673

Q-203
c2-341A

NO FURTHER INFORMATION IS REQUIRED FOR DESIGN REVIEW

K. Solon for C. Wells 3/19/84

M 0574

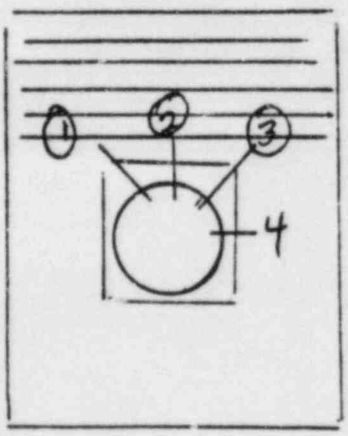
STONE & WEBSTER ENGINEERING CORPORATION

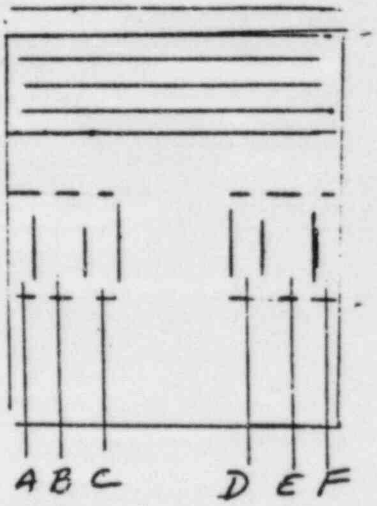
# QUALITY CONTROL INSPECTION REPORT

| JOB NUMBER | DATE |
|---|---|
| 11600.37 | 3-13-84 |

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| **COMPONENT NAME:** PISTONS CYL. 5<br>**COMPONENT NO.** 03-341A | DG- 103 | I.P.- NO. ~~2~~ 14 N.T.B. 3/13/84 REV. 3 CHG 0<br>TER # DR-239<br>LILCO LP PROC. ____ REV. __<br>DWG. NO. ____ |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
|  | N/A | 3 |  |





|  | ① | ② | ③ | ④ |
|---|---|---|---|---|
| A | 6.750 | 6.750 | 6.751 | 6.751 |
| B | 6.750 | 6.750 | 6.751 | 6.751 |
| C | 6.750 | 6.750 | 6.751 | 6.750 |
| D | 6.751 | 6.751 | 6.750 | 6.750 |
| E | 6.751 | 6.751 | 6.750 | 6.751 |
| F | 6.751 | 6.751 | 6.750 | 6.751 |
|  |  |  |  |  |

M0675

M&TE NO. 2-52-11, DUE 12/22/84, ____, ____, ____

Reviewed [illegible] 3/13/84

| QUALITY CONTROL INSPEC./ENG. | DATE | PAGE |
|---|---|---|
| [illegible] | 3-13-84 | 1 of 3 |

STONE & WEBSTER ENGINEERING CORPORATION

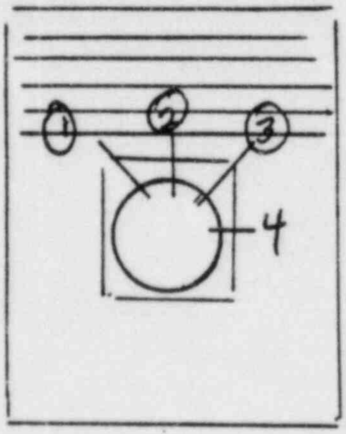
QUALITY CONTROL
INSPECTION REPORT

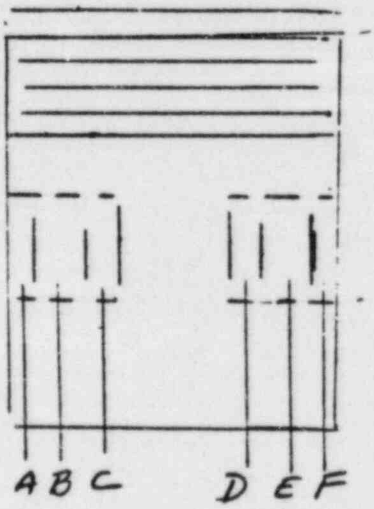
JOB NUMBER 11600.37

DATE 3-13-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: PISTONS CYL. 7<br>COMPONENT NO. 03-341A | DG- 103 | I.P. NO. ~~7~~ 14 R.C.B. 3/13/84 REV. 3 CHG 0<br>TER # DR-239<br>LILCO LP PROC. ______ REV. ____<br>DWG. NO. ______ |

| DWG. NO OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | N/A | | |





| | ① | ② | ③ | ④ |
|---|---|---|---|---|
| A | 6.750 | 6.750 | 6.751 | 6.751 |
| B | 6.750 | 6.750 | 6.751 | 6.751 |
| C | 6.750 | 6.750 | 6.751 | 6.750 |
| D | 6.751 | 6.750 | 6.750 | 6.751 |
| E | 6.751 | 6.751 | 6.750 | 6.751 |
| F | 6.751 | 6.751 | 6.750 | 6.751 |
| | | | | |

M 4576

M&TE NO. 252-11, DUE 12/22/84

Reviewed 3/13/84

QUALITY CONTROL INSPEC./ENG

DATE 3-13-84

PAGE 2 OF 3

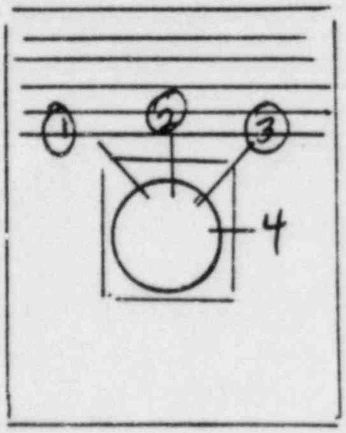
STONE & WEBSTER ENGINEERING CORPORATION

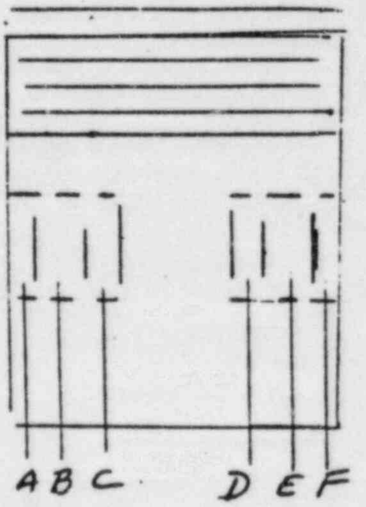
# QUALITY CONTROL INSPECTION REPORT

JOB NUMBER: 11600.37
DATE: 3-13-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: PISTONS CYL. 8<br>COMPONENT NO. 03-341A | DG-103 | I.P. NO. ~~2~~ 14 W.I.B. 3/13/84 REV. 3 CHG 0<br>TER # DB 239<br>LILCO LP PROC. ______ REV. ___<br>DWG. NO. ______ |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | N/A | | |





| | ① | ② | ③ | ④ |
|---|---|---|---|---|
| A | 6.750 | 6.750 | 6.750 | 6.750 |
| B | 6.750 | 6.750 | 6.750 | 6.750 |
| C | 6.750 | 6.750 | 6.750 | 6.750 |
| D | 6.750 | 6.750 | 6.750 | 6.750 |
| E | 6.750 | 6.750 | 6.750 | 6.750 |
| F | 6.750 | 6.750 | 6.750 | 6.750 |

M&TE NO. 2-52-11, Due 12/22/84, ______, ______

Reviewed 3/13/84

QUALITY CONTROL INSPEC/ENG: Barbara D. Hauser
DATE: 3-13-84
PAGE: 3 - 3

I.Nfo

DG 102, Book 2

Page 1 of 2

NOTED FEB 20 1984

## COMPONENT TASK EVALUATION REPORT

ATT #5

DR182.

| M/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
|---|---|---|---|---|
| PISTON (PISTON)<br>03-341-A | 1A-6522 | F. Bernard<br>SIGNATURE | 2/18/84 | ☑ENGINEERI<br>☒QUALITY |

CONDITION DETAILS:

ADDITIONAL INSPECTION PER TERQ-21 PISTON 5 AND 7

RECOMMENDATIONS:

SUBMITTED FOR FAA REVIEW & ACTION AND SEO - ~~[illegible]~~ FOR ~~[illegible]~~ INFO.

REQUIRED COMPLETION DATE: 2/19/84

### ASSIGNMENT

| POSITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ☒ ENGINEERING ☐ QUALITY | Nestor A. Saleta<br>SIGNATURE | 2/19/84 |

### DISPOSITION

DISPOSITION DETAILS:

Send copy to C. Wells/FaAA, and SEO for information only.

DISPOSITION ASSIGNED TO ☒ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| SUPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
| Robert R Scheibe | 2/19/84 | S. Reil for G.W. Rogers<br>RESP. CHAIRPERSON | 2/19/84 | C.K. Fearney<br>PROGRAM MANAGER | 2/20/84 |

### ACTION

| ACTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| C. Wells/FaAA | C. Wells | 2/27/84 |

CC: CKS/GWR/RJN/EFM
TER LOG

ATT #6

M4560

**STONE & WEBSTER ENGINEERING CORPORATION**

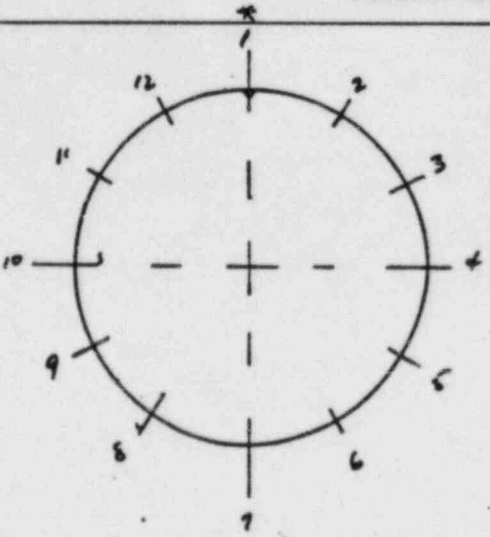
**QUALITY CONTROL INSPECTION REPORT**

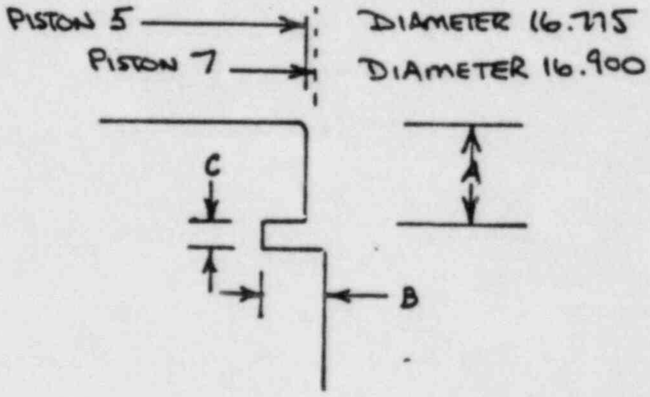
JOB NUMBER: 11600.37

DATE: 2/17/84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| 03-341 A & B Rev 1<br>PISTON<br>DIMENSION VERIFICATION | ENGINE 102 | SH1 089<br>TER-Q-21<br>M&TE USED:<br>2-54-06 DUE 9/10/84<br>2-51-03 DUE 8/6/84<br>2-54-18 DUE 8/9/84 |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 5 | | |





PISTON # 5

| | | A | B | C |
|---|---|---|---|---|
| * | 1 | 2.240 | .570 | .255 |
| | 2 | 2.105 | .570 | .255 |
| | 3 | 2.105 | .570 | .255 |
| | 4 | 2.240 | .570 | .255 |
| | 5 | 2.115 | .570 | .255 |
| | 6 | 2.115 | .570 | .255 |
| | 7 | 2.240 | .570 | .255 |
| | 8 | 2.115 | .570 | .255 |
| | 9 | 2.115 | .510 | .255 |
| | 10 | 2.240 | .570 | .255 |
| | 11 | 2.115 | .570 | .255 |
| | 12 | 2.110 | .570 | .255 |

PISTON # 7

| | | A | B | C |
|---|---|---|---|---|
| * | 1 | 2.280 | .569 | .255 |
| | 2 | 2.150 | .568 | .255 |
| | 3 | 2.150 | .568 | .255 |
| | 4 | 2.280 | .567 | .255 |
| | 5 | 2.150 | .567 | .255 |
| | 6 | 2.150 | .568 | .255 |
| | 7 | 2280 | .568 | .255 |
| | 8 | 2.150 | .569 | .255 |
| | 9 | 2.150 | .569 | .255 |
| | 10 | 2.280 | .569 | .255 |
| | 11 | 2.150 | .569 | .255 |
| | 12 | 2.150 | .570 | .255 |

* LOCATION OF THE PISTON NOTCH

NOTED FEB 17 1984

QUALITY CONTROL INSPEC./ENG.:

DATE: 2/17/84

PAGE 1 OF 1

DR-182

This inspection report is acceptable for design review

Carol Bobroff for Cliff Wells
personal comm. 2/27/84

DATE: 2-18-84

**TO:** E. J. Youngling
LSU Manager

**FROM:** C. K. Seaman
DR/QR Program Manager

**SUBJECT:** RELEASE FOR REASSEMBLY FROM DR/QR PROGRAM
COMPONENT NO. 03-341A
COMPONENT TITLE PISTONS
EMERGENCY DIESEL GENERATOR NO. 102

This is to advise you that the subject component no./title for the stated Emergency Diesel Generator Unit has been released by the Design Review/Quality Revalidation (DR/QR) Program for completion of its Quality Revalidation inspections, to LILCO Start-up (LSU) for reassembly. This release is acknowledged by the signatures shown below.

C. K. Seaman
DR/QR Program Manager

Gary W Rog

G. W. Rogers
Design Review Group Chairperson

J C Kammeyer 2/18/84

J. C. Kammeyer
Stone & Webster Engineering Corp. (SEO

Note: This release is applicable only to the satisfactory completion of DR/QR Program component inspection requirements. Outstanding LDR's, E&DCR's, etc. and their satisfactory resolution are not covered under this release. Furthermore, completion of the Design Review portion of the DR/QR Program _may_ result in additional component inspection requirements.

cc: W.J. Museler
M.H. Milligan
E.F. Montgomery
M.H. Schuster
R.J. Najuch
R. Bernard
K. Murrow

M45,63

November 14, 1983

03-341 A

TO: J. M. Kelly

FROM: E. J. Nicholas

Subject: Trip Report On Nondestructive Examination(PT) of Piston Skirt

On November 9, 1983 I was requested to visit Transamerica Delaval in Oakland, California to witness the Liquid Penetrant(PT)Nondestructive Examination performed on the piston skirt bolt holes. The extent of the examination is as identified in Engineering & Design Coordination Report (E&DCR) F-46324 Section II (Ref. Attach. I). Attachment II identifies the piston skirts which were examined and witnessed by myself and the results.

Surface defects were removed utilizing TDI's "Spring Boss, Two Pc. Piston Skirt Repair Procedure for Removing Surface Defects Observed after Penetrant Inspection (PT)" (Attachment III). Defect removal was verified by Liquid Penetrant Examination of the ground areas, in addition dimensional inspections of the Trust Collar area were performed. These inspections were performed by the S&W PQA inspector and witnessed by myself. The results of the Liquid Penetrant Examinations were photographed. These photographs will be turned over to OQA.

E. J. Nicholas

E. J. Nicholas
Field QA Section Supervisor

EJN/rc

cc: A. R. Muller - OQA
J. Kammeyer - SEO
M. Schuster - UNICO
R. Perra - S&W FQC OPS

→ FQA FILE

83-0638

Attachment I

*Δ5210.498 .3

STONE & WEBSTER ENGINEERING CORPORATION

# ENGINEERING & DESIGN COORDINATION REPORT

PAGE 1 OF 4

NO. F-46324

**PROJECT / CLIENT:** SHOREHAM NUCLEAR POWER STATION UNIT 1
LONG ISLAND LIGHTING COMPANY

**JOB NO.** 11600.11

**REFERENCES:** LDR-1811 R43 A+G

**PROBLEM DESCRIPTION:**

Inspections performed on piston skirts for Engine 101 revealed numerous indications in the machined area on Boss around bolt holes, reference LDR-1811.

TELECOPY DATES (REQUESTING PARTY)
Sent:
Rcv'd:

| Requested By: | Dept. or Div. | Tele. Ext. | Date | Needed By: |
|---|---|---|---|---|
| R. MARTIN | 520 | 556 | 11/9/83 | |

**PROBLEM SOLUTION:**

To expedite the arrival of new piston skirts on site, should it be determined that new skirts are required, LSS will issue a purchase requisition for a complete set of piston skirts, part no. 03-341-04-AE, for each engine plus two spares (total-26). Purchase of new piston skirts is on a risk basis pending results of failure analysis by FaAA, and submittal and evaluation of required documentation by TDI. Inspection and Documentation requirements per attached pages 2 to 4.

TELECOPY DATE. (RESPONDING PARTY)
Sent:
Rcv'd:

AFFECTS WORK UNDER SPECIFICATION SH1- 089

IMPLEMENTATION VERIFICATION ☐ IS ☒ IS NOT REQUIRED

VERIFIED BY

Furnished By: Date 11/9/83

Responsible Lead Engr. JCKammeyer for R Nujnicki Date 11/9/83

☐ INFORMATION ONLY
☒ ~~DRAWING~~ CHANGE MANUAL
☒ SPECIFICATION CHANGE
☐ PROCEDURE CHANGE
☐ ENG. SERV. SCOPE OF WORK CHANGE

Change ☒ will / ☐ will not be incorporated in the following documents:
SH-089 R43-1 Vol II

☒ Nuclear Safety Related (QA Cat I)
☐ Not Nuclear Safety Related (☐ QA Cat II ☐ QA Cat III)

Project Design Engr. NR Date

Equipment Specialist Takun JCKammeyer for L Frasconi Date 11/9/83

Qual Systems or Eng. Assur Div. R. Besnard Date 11/9/83

Materials Engr. NR Date

Project Engineer Approval & Date JCKammeyer for PJ Holden 11/9/83

ESAR CHANGE ☐ Yes ☒ No

CLIENT APPROVAL
☒ Required ☐ Not Rqd.
Obtained Date: 11/2/85
Reference: C.K.

CLIENT DISTRIBUTION-CLIENT HEADQT
☐ Engineering
☐ Project Manager
☐
☐

HEADQUARTERS
☒ Proj. Engr.
☒ Proj Des. Engr
☒ Resp. Engr.
☒ Equip Spec.
☐ Mat'ls Engr
☒ QA-Qual Sys. D.
☒ QA-PQC Div
☐ Chief ___ Engr
☐ Chief ___ Des. Engr
☐ Supt Const Serv
☐ Ch Engr-EA Div
☒ R. Jahjeck
☒ L. Frasconi
☒ J. Pizzi

FIELD DISTRIBUTION
☐ Originator
☐ Client QA Mgr
☐ Client Const Insp
☐ SEW FQC
☐ S&W Res Engr
☐ Fld. Des Engr
☐ Head. Fld Eng. C
☒ J. Kammeyer
☒ M. Milligan
☒ J. Judge
☒ C. Youngling
☒ M. Hellings
☒ T. Brown
☒ J. Smith

CONST SUPERVISORS
☐ Structural
☐ Mechanical
☐ Electrical
☐ Piping
☒ Welding
☐ Instrument
☐ Planning
☒ LSS
☒ TDI Project
☒ QA Rec Project
☐
☐
☐
☐

ATTACHMENT TO E&DCR # F-46324
PAGE 2 OF 4

Attachment to E&DCR F-46324

Page 1

## I - Shop Inspections/Verifications:

Prior to shipment, the engineer's inspector shall perform the inspections and verifications as described below. A Certificate of Conformance to specification SH1-089 is required for all parts:

### (A) General:

#### (1) NDE

Verify all NDE documented on Shop routing ledger has been performed and results acceptable. Verify and document that NDE procedures used are the same as those approved for use in accordance with SH1-089 original requirements. If any procedure deviates from those approved under original contract (either revision level or alternate procedure) the procedure actually used shall become part of the as shipped documentation package on a risk basis and shall be submitted to S&W for review. Inspector shall provide a list of applicable discrepancies (i.e. procedure used but not approved) to S&W Boston directly.

Verify that personnel certified to appropriate SNT-TC-1A levels have performed NDE as required.

#### (2) HEAT TREATMENT

Verify that any heat treatment as documented on the Shop routing ledger has been performed and accepted. Procedures used shall be reviewed for changes (revision level or alternate procedure) from those approved for use under SH1-089. If any procedure deviates from those approved under original contract, the procedure actually used shall become part of the as shipped documentation package on a risk basis and shall be submitted to S&W for review. Inspection shall provide a list of applicable discrepancies (i.e. procedure used but not approved) to S&W directly.

#### (3) SHOP ROUTING LEDGER SHEETS

Verify Shop Routing Ledger Sheet has been properly filled out and each applicable station task has been performed. Review in detail for any non-conformance or rework required during the manufacturing-testing process. Complete details of any such defect/resolution acceptance criteria and final acceptance shall be obtained and become part of the as shipped documentation package on a risk basis. Copies of all such documentation, as well as the shop routing ledger shall be provided to S&W Boston for review.

(4) SHIP CLEANING SHIPPING/CRATING

The inspector shall review and verify the method of cleaning, shipping and crating is appropriate and acceptable in accordance with SH1-089.

(5) VISUAL INSPECTION

The inspector shall perform a complete visual inspection of all parts for obvious defects and/or deviation from the detail shop fabrication drawings. A dimensional check of a sufficient number of points shall be performed to verify the parts are in accordance with the shop drawings.

All items checked shall be documented. Any deviations should be brought to the immediate attention of the engineers.

Surface finish as specified on the shop drawing shall be verified.

(6) NDE TEST REPORTS

All NDE Test Reports shall be reviewed for completeness and accuracy and shall become part of the documentation package.

(7) CMTRs (if applicable)

Certified Material Test Reports shall be reviewed for completeness and shall become part of the documentation package.

## II Shoreham Specific NDE Requirements

In addition to the Standard TDI piston skirt NDE, a color contrast penetrant test will be performed on each piston skirt by TDI personnel, in accordance with approved procedures. This may be supplemented by the use of LILCO NDE procedures/personnel.

The location to be inspected is the machined area on the boss around the four bolt holes inside the piston skirt, with particular emphasis on the vertical blended radii surfaces.

The penetrant test will be witnessed by SWEC PQA & LILCO FQC. Acceptance criteria will be per TDI procedures
⑧ or LILCO procedures as applicable, however linear
indications will not be accepted without SWEC Engineering approval. All indications will be mapped by LILCO FQC personnel, clearly identifiable to the piston in question.

ATTACHMENT TO E&DCR #F-46324
PAGE 4 OF 4

## III DOCUMENTATION

(A) The following documentation will be included with the shipment:

1. C of C to specification SH1-089
2. CMTRs if applicable
3. Heat Treatment records
4. Shop routing sheets
5. Results of MPI

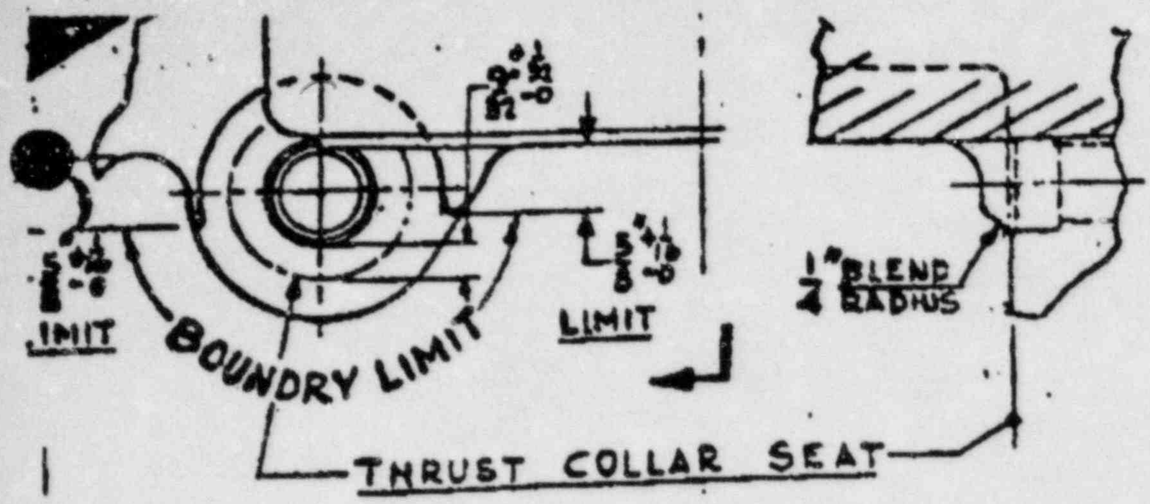
(B) Documentation to be supplied by TDI, following shipment:

1. Seismic qualification per SH1-089
2. IEEE-387 qualification; analysis or testing per Section 5.4.4.
3. Inst. Manual Inserts.
4. Nonconformance & disposition records
5. 341-AE piston service history. To included details of both shop testing and field history (number in field, operating hours, etc).
6. TDI to perform review and document the effects, if any, of piston skirt changeout on the ability of the unit to achieve rated load and speed in the required time, and on the "Torsional and Lateral Critical Speed Analysis".

# ATTACHMENT II

| Serial No. | Heat No. | Accept/Reject |
|---|---|---|
| 1. C88X | 827J | Accept |
| 2. C89 | 811J | Accept |
| 3. D42 | 937J | Accept |
| 4. D49 | 937J | REJECT |
| 5. E5 | 104K | REJECT |
| 6. E8 | 104K | accept |
| 7. F7 | 181K | Accept |
| 8. F12 | 181K | Accept |
| 9. F15 | 200K | Accept |
| 10. F18 | 200K | Accept |
| 11. F21 | 200K | Accept |
| 12. F24 | 200K | Accept |
| 13. F27 | 205K | REJECT |
| 14. F29 | 205K | REJECT |
| 15. F32 | 205K | REJECT |
| 16. F35 | 205K | Accept |
| 17. F53 | 256K | REJECT |
| 18. F56 | 256K | Accept |
| 19. F58 | 256K | Accept |
| 20. F87 | 289K | Accept |
| 21. F97 | 289K | Accept |
| 22. F98 | 289K | Accept |
| 23. G1 | 298K | Accept |
| 24. G2 | 298K | Accept |
| 25. G4 | 298K | Accept |
| 26. G5 | 298K | Accept |
| 27. G26 | 312K | Accept |
| 28. G29 | 312K | Accept |
| 29. G30 | 312K | Accept |
| 30. G33 | 312K | Accept |
| 31. G34 | 312K | Accept |
| 32. G35 | 312K | Accept |

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



## SPRING BOSS, TWO PC. PISTON SKIRT
## REPAIR PROCEDURE FOR REMOVING SURFACE DEFECTS
## OBSERVED AFTER PENETRANT INSPECTION (PT)

S.W.E.C. QCA INSPECTED 214

### - MINOR -

1) HAND GRIND EACH DEFECT WITHIN BOUNDRY LIMITS CAREFULLY REMOVING ALL SHARP EDGES WITH BLEND RADII.
2) FINISH POLISH ALL REPAIRS WITH "CRATEX #1350C" GRINDING WHEEL. -
3) DO NOT VIOLATE 9/32" LIMITING DIMENSION SHOWN FOR THRUST COLAR SEATING SURFACE.
4). DO NOT EXCEED 5/8" LIMITS SHOWN FROM CAST SURFACES. -

### - MAJOR -

1) MULTIPLE DEFECTS MAY BE COMPLETELY REMOVED BY HAND GRINDING ENTIRE LIP WITHIN BOUNDRY LIMITS.
2) USE THE SAME GRIND AND POLISH PROCEDURE AND OBSERVE ALL LIMITS SPECIFIED FOR SINGLE DEFECTS.

LILCO P.O. 310652-SF
SHOREHAM NUCLEAR POWER STATION-UNIT 1
PART No. 03-241-04-AE PISTON SKIRTS

D-4991

# LONG ISLAND LIGHTING COMPANY

JRCHASE
ORDER J:0. 11600.83
1678.19

OPS

| ☐ ☐ ☐ | ☐ ☐ ☐ | | | | F77679/I.Brown | 11/10/83 | 310552-32 |
|---|---|---|---|---|---|---|---|

UED TO

TRANSAMERICA DELAVAL, INC.
550 85th Ave.
P.O. Box 2161
Oakland Calif. 94621
(415) 577-7400

TERMS ☐ NET 30 DAYS ☐ 2% 10 DAYS

FILE NO.

BUYER AF:gr

*ALL CASH DISCOUNTS ARE TAKEN STARTING WITH DATE OF INVOICE OR RECEIPT OF MERCHANDISE WHICHEVER IS LATER

☐ DELIVERED Shipping Point

SHIP VIA ☐ YOUR DELIVERY Air Freight

NDOR'S SHIPPING PROMISE
rtial - November 12, 1983
alance - November 30, 1983

VENDOR'S QUOTE REFERENCE
Telecon of November 10, 1983

P TO AND SEND ACKNOWLEDGEMENT AND/OR SHIPPING INFORMATION → LONG ISLAND LIGHTING COMPANY AT MARK: 310552-32

ACCEPTANCE OF TH ORDER IS SUBJECT TO THE TERMS AND CONDITIONS PRINTE ON THE REVERSE SIDE HEREOF. THE TYPED MATERIAL CONTAINED HEREIN AND ANY FURTHER INSTRUCTIONS AND MATERIALS ATTACHED HERETO

| DESCRIPTION | M & S CODE | QUANTITY ORDERED | PRICE |
|---|---|---|---|
| CONFIRMING:DO NOT DUPLICATE-START-UP | | | |
| Modify our Purchase Order 310552 for Diesel Generator Sets (Spec. 1-089) for Shoreham Nuclear Power Station Unit No. 1 to incorporate the following additions: | | | |
| 1.) Piston Skirt P/N D3-341-04-AE 8 11/12 - 1 REJ (7 CR #445)<br>11 11/13 - C/R #447<br>7 11/16 - C/R #448 | | 26 ea. | $6,323.00/ea. |
| 2.) Thrust Collar P/N D3-341-04-AC | | 104 ea. | 35.95/ea. 64 11/12<br>40 11/16 |
| 3.) Spring Guide P/N 03-341-04-AF | | 104 ea. | 53.60/ea. 64 11/12<br>40 11/16 |
| 4.) Lock Tab P/N D3-341-04-ad | | 104 ea. | 6.90/ea. 64 11/12<br>40 11/16 |
| 5.) Lock Pin P/N GC-023-000 | | 104 ea. | 1.00/ea 64 11/12<br>40 11/16 |
| 6.) Cotter Pin GC-002-055 64 (ID) CR #446 11/12 | | 100 ea. | 1.00/ea. 100 11-23 |
| 7.) Stud P/N 03-341-04-AB | | 104 ea. | 86.55/ea. 64 11/12<br>40 11/16 |

Certificate of Compliance is required to state the material supplied is in accordance with Spec. SH1-089. PQA inspection is required only for item 1. Piston Skitt.

Q.A. CATEGORY: I
LILCO ESC-7D detailing reporting requirements under 10CFR21 attached hereto forms a part of this order.

SHOREHAM NUCLEAR POWER STATION
APPROVED
NOV 10 1983
FIELD QUALITY CONTROL
By D. L.

MONTHLY REPORT FORM PREPARED ☑ YES (FC-8574) DATE ☐ NOT REQUIRED

BPO RECORD - CATEGORY

BPO EXPIRATION FOLLOW-UP DATE

EXTRA COPIES OF P.O. TO
~~CONTRACTED PROJECTS~~
☐ ~~INSURANCE DIV.~~
☐ PROPERTY RECORDS
☐ ADMINISTRATIVE SERV
☐ OFFICE SERVICES
☐ ENGINEERING
☐ TAX

PURCHASE ORDER NO
~~310552-32~~

PK 11/1/83 2

C-1679.8

# LONG ISLAND LIGHTING COMPANY

175 E OL OUNTRY ROAD HICKSVILLE, N YO 11801

PURCHASE
ORDER

| DESCRIPTION | M & S CODE | QUANTITY ORDERED | PRICE |
|---|---|---|---|

PQA Inspection/Documentation requirements in accordance with E&DCR F46324, copy of which is attached

IMPORTANT This order is issued subject to the following stipulations:

Nothing in this Order or Supplement shall be deemed to release or prejudice any claims or causes of action (whether in contract, tort or otherwise) or to waive any prior rights or remedies that LILCO may have against Transamerica Delaval. LILCC expressly reserves the right to pursue any such claims, causes of action, rights and remedies that it may have, including but not limited to damages or claims for refund of monies paid pursuant to this order.

All other terms and conditions remain the same as stated in the original purchase order.

COPIES ONLY:

| | |
|---|---|
| TOTAL ESTIMATED LUMP SUM COST OF THIS ORDER THRU SUPPLEMENT 31. . . | $4,953,664.80 |
| TOTAL LUMP SUM COST OF THIS SUPPLEMENT . . . . . . . . . . . . . . . . | 183,634.00 |
| TOTAL ESTIMATED LUMP SUM COST OF THIS ORDER TO DATE . . . . . . . . . . | 5,137,298.80 |
| TOTAL AUTHORIZED VALUE OF THIS PURCHASE ORDER . . . . . . . . . . . . . | 2,173,000.00 |

SHEET 2 OF 2

310552-32
PURCHASE ORDER NO.

ONE & WEBSTER ENGINEERING CORP.
ELD PURCHASE REQUISITION

SHOREHAM NUCLEAR POWER STATION
LONG ISLAND LIGHTING COMPANY

| BUYER ASSIGNED | DATE REQUIRED | J.O. NUMBER | NO. |
|---|---|---|---|
| | [illegible] | 11600.[illegible] | F 77679 |

| ITEM | QUANTITY | UNIT | DESCRIPTION | TO BE USED FOR | ACCT. NO | VENDOR | UNIT PR | TOTAL | CASH DIS. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 20 | EA | PISTON - SKIRT<br>03.341-04-AE | [illegible] | 24 . 470 . 50 (T) 404/265 | [illegible] | 632.[illegible] | [illegible]4398 | [illegible] |
| 2 | | | ~~O-RING~~<br>~~IF-023-000~~ | | | | | | |
| 3 | [illegible] | EA | Thrust Collar<br>03-341-09-~~AD~~ CC | | | | 35.95 | 3738 | 80 |
| 4 | [illegible] | EA | SPRING GUIDE<br>03-341-04-AF | | | | 53.60 | 5574 | 40 |
| 5 | [illegible] | EA | LOCK TAB<br>03-341-09-AD | | | | 6.90 | 717 | 60 |
| 6 | [illegible] | EA | LOCK PIN<br>GC-023-000 | | | | 1.[illegible] | 104 | 00 |
| 7 | [illegible] | EA | COTTER PINS<br>GC-002-055 | | | | 1.[illegible] | 150 | 00 |
| 8 | [illegible] | EA | STUD<br>03-341-04-AB | | | [illegible]<br>11/8/83 | 86.55 | 9001 | 20 |
| 9 | | | ITEM # 1 ONLY -<br>C of C To SHI-89, PQA Inspection Required | | | [illegible] T. ESPER<br>F-46324 for inspection<br>[illegible] station [illegible] | | 18363.[illegible]<br>~~[illegible]~~ | 00 |

ADDITIONAL REQUIREMENTS

QA CAT [illegible]

ESC07D APPLIES ☒

ESC07D DOES NOT APPLY ☐

QUALITY CLAUSE [illegible]

PRF REQUIRED ☑

PRF NOT REQUIRED ☒

ESTIMATED COST $ 115.[illegible]

ASME MATERIAL ☐

NON ASME MATERIAL ☐

BASIS OF PURCHASE: [illegible]1-089

| ITEM NO. | DEL'Y DATE | SHIP VIA | F.O.B. | P.O. NO. ASSIGN |
|---|---|---|---|---|
| [illegible] | 11/13/83 | [illegible] | [illegible] | [illegible] |
| [illegible] | 11/9/83 | | | |

| REQUESTED BY | DATE | APPROVED (QUALITY CONTROL ENGINEER) |
|---|---|---|
| T. Brown | 11/8/83 | [illegible] 11/9/83 |

| APPROVED (JOB MANAGEMENT) | APPROVED (CLIENT) |
|---|---|
| | [illegible] 11/[illegible]/83 |

QUALITY CONTROL COPY

FIELD PURCHASE REQUISITION

LONG ISLAND LIGHTING COMPANY

NO. 77575

| | | | | | | |
|---|---|---|---|---|---|---|
| | QUANTITY | UNIT | DESCRIPTION | | | |
| 1 | 26 | EA | PISTON - SKIRT<br>03-341-04-AE | | | [illegible] |
| 2 | | | ~~O-RING~~<br>~~IE-[illegible]~~ | | | |
| 3 | 104 | EA | Thrust Collar<br>03-341-04-AD | | 75.?? | 373?. |
| 4 | 104 | EA | SPRING GUIDE<br>03-341-04-AF | | 23?. | 3??? |
| 5 | 104 | EA | LOCK TAB<br>03-341-04-AD | | 6.90 | 717 |
| 6 | 104 | EA | LOCK PIN<br>GC-023-000 | | 1.00 | 104 |
| 7 | [illegible] | EA | COTTER PINS<br>GC-002-055 | | 1.?? | 1?? |
| 8 | 104 | EA | STUD<br>03-341-04-AB | | 86.45 | 16.1?? |
| 9 | | | | | | |

C of C To SH-59, PO# Inspection Required

ADDITIONAL REQUIREMENTS

QA CAT I

ESC-7D APPLIES ☒

ESC-7D DOES NOT APPLY ☐

QUALITY CLAUSE [illegible]

PRF REQUIRED ☐

PRF NOT REQUIRED ☒

ESTIMATED COST $ [illegible]

ASME MATERIAL ☐

NON ASME MATERIAL ☒

BASIS OF PURCHASE:

SH1-089

| | ITEM NO. | DEL'Y DATE | SHIP VIA | F.O.B. | PO NO. ASSIGN |
|---|---|---|---|---|---|
| DELIVERY DATA | | | | | |

REQUESTED BY: T. Greco

DATE: 11/8/83

APPROVED QUALITY CONTROL ENGINEER: O.J. [illegible] 11/?/83

Δ5210.49B

## STONE & WEBSTER ENGINEERING CORPORATION
## ENGINEERING & DESIGN COORDINATION REPORT

PAGE 1 OF 4

NO. F-46324

PROJECT / CLIENT: SHOREHAM NUCLEAR POWER STATION-UNIT 1
LONG ISLAND LIGHTING COMPANY

JOB NO. 11600.03

REFERENCES: LDR-1811

R43 A+B

**PROBLEM DESCRIPTION:**

Inspections performed on piston skirts for Engine 101 reveale numerous indications in the machined area on Boss around bolt holes, reference LDR-1811.

TELECOPY DAT
(REQUESTING

Sent:

Rec'd:

Requested By: P. [illegible]

Dept. or Div. 560

Tele. Ext. 5516

Date [illegible]

Needed By:

**PROBLEM SOLUTION:**

To expedite the arrival of new piston skirts on site, should it be determined that new skirts are required, LSU will issue a purchase requisition for a complete set of piston skirts, part no. 03-341-04-AE, for each engine plus two spares (total-26). Purchase of new piston skirts is on a risk basis pending results of failure analysis by FaAA and submittal and evaluation of required documentation by TDI. Inspection and Documentation requirements per attached pages 2 to 4 .

IMPLEMENTATION VERIFICATION: ☐ IS ☐ IS NOT REQUIRED

VERIFIED BY

Date

Responsible Lead Engr.

Date

☐ INTERNAL USE ONLY

☐ DRAWING CHANGE

☐ SPECIFICATION CHANGE

☐ PROCEDURE CHANGE

☐ ENG. SERV. SCOPE OF WORK CHANGE

Change will ☐ be incorporated in the
will not ☐ following documents

SH-CP1 R43-1 [illegible]

☒ Nuclear Safety Related (QA Cat. I)

☐ Not Nuclear Safety Related (☐ QA Cat. II ☐ QA Cat. III)

Project Design Engr.

Equipment Specialist

Date

Chief Engr. Quality Assur. Div.

Date

Materials Engr.

Date

Project Engineer Approval & Date

SAR CHANGE ☐ Yes ☒ No

CLIENT APPROVAL

☒ Required ☐ Not Req'd

Furnished Date

Reference:

CLIENT DISTRIBUTION-CLIENT HEAD

HEADQUARTERS

☐ Proj. Engr.

☐ Proj. Des. Engr.

☐ Resp. Engr.

☒ Equip. Spec.

☐ Matls. Engr.

☒ QA-Mat. Div.

☒ QA-FCC Div.

☐ QA-FQC Div.

FIELD DISTRIBUTION

☐ Originator

☐ Client QA Mgr.

☐ Client Const. Mgr.

☐ S&W FQC

☐ S&W Res. Engr.

☐ Fld. Des. Engr.

☐ Head Fld. Engr.

CONSULTANTS

☐ Structural

☐ Mechanical

☐ Electrical

☐ Piping

☐ Instrument

☐ Planning

## I - Shop Inspections/Verifications:

Prior to shipment, the engineer's inspector shall perform the inspections and verifications as described below. A Certificate of Conformance to specification SH1-089 is required for all parts:

### (A) General:

#### (1) NDE

Verify all NDE documented on Shop routing ledger has been performed and results acceptable. Verify and document that NDE procedures used are the same as those approved for use in accordance with SH1-089 original requirements. If any procedure deviates from those approved under original contract (either revision level or alternate procedure) the procedure actually used shall become part of the as shipped documentation package on a risk basis and shall be submitted to S&W for review. Inspector shall provide a list of applicable discrepancies (i.e. procedure used but not approved) to S&W Boston directly.

Verify that personnel certified to appropriate SNT-TC-1A levels have performed NDE as required.

#### (2) HEAT TREATMENT

Verify that any heat treatment as documented on the Shop routing ledger has been performed and accepted. Procedures used shall be reviewed for changes (revision level or alternate procedure) from those approved for use under SH1-089. If any procedure deviates from those approved under original contract, the procedure actually used shall become part of the as shipped documentation package on a risk basis and shall be submitted to S&W for review. Inspection shall provide a list of applicable discrepancies (i.e. procedure used but not approved) to S&W directly.

#### (3) SHOP ROUTING LEDGER SHEETS

Verify Shop Routing Ledger Sheet has been properly filled out and each applicable station task has been performed. Review in detail for any non-conformance or rework required during the manufacturing-testing process. Complete details of any such defect/resolution acceptance criteria and final acceptance shall be obtained and become part of the as shipped documentation package on a risk basis. Copies of all such documentation, as well as the shop routing ledger shall be provided to S&W Boston for review.

ATTACHMENT TO E & D CR # F46324
PAGE 3 OF 4

### (4) SHIP CLEANING SHIPPING/CRATING

The inspector shall review and verify the method of cleaning, shipping and crating is appropriate and acceptable in accordance with SH1-089.

### (5) VISUAL INSPECTION

The inspector shall perform a complete visual inspection of all parts for obvious defects and/or deviation from the detail shop fabrication drawings. A dimensional check of a sufficient number of points shall be performed to verify the parts are in accordance with the shop drawings.

All items checked shall be documented. Any deviations should be brought to the immediate attention of the engineers.

Surface finish as specified on the shop drawing shall be verified.

### (6) NDE TEST REPORTS

All NDE Test Reports shall be reviewed for completeness and accuracy and shall become part of the documentation package.

### (7) CMTRs (if applicable)

Certified Material Test Reports shall be reviewed for completeness and shall become part of the documentation package.

## II Shoreham Specific NDE Requirements

In addition to the Standard TDI piston skirt NDE, a color contrast penetrant test will be performed on each piston skirt by TDI personnel, in accordance with approved procedures. This may be supplemented by the use of LILCO NDE procedures/personnel.

The location to be inspected is the machined area on the boss around the four bolt holes inside the piston skirt, with particular emphasis on the vertical blended radii surfaces.

The penetrant test will be witnessed by SWEC FQA & LILCO FQC. Acceptance criteria will be per TDI procedures or LILCO procedures as applicable, however linear indications will not be accepted without SWEC Engineering approval. All indications will be mapped by LILCO FQC personnel, clearly identifiable to the piston in question.

ATTACHMENT TO E & D CR # F-46324
PAGE 4 OF 4

## III DOCUMENTATION

(A) The following documentation will be included with the shipment:

1. C of C to specification SH1-089 ✓
2. CMTRs if applicable
3. Heat Treatment records
4. Shop routing sheets ✓
5. Results of MPI

(B) Documentation to be supplied by TDI, following shipment:

1. Seismic qualification per SH1-089
2. IEEE-387 qualification; analysis or testing per Section 5.4.4.
3. Inst. Manual Inserts.
4. Nonconformance & disposition records
5. 341-AD piston service history. To included details of both shop testing and field history (number in field, operating hours, etc).
6. TDI to perform review and document the effects, if any. of piston skirt changeout on the ability of the unit to achieve rated load and speed in the required time, and on the "Torsional and Lateral Critical Speed Analysis".

415 577 7573

P.O. 310552-32 TransAmerica DeLaval
7ea. Piston Skirts P/N 03-341-04-AE
S/N's. F15, F24, F18, 042, F12, F21, F35

Cat I SHI-089

# RECEIVING INSPECTION REPORT

SHOREHAM NUCLEAR POWER STATION
UNIT - I
STONE & WEBSTER ENGINEERING CORPORATION

DATE RECEIVED 11-12-83
MRR NUMBER 83-05046
PARTIAL ☒
COMPLETE ☐
STORAGE LEVEL A [✓ B] C D
QC HOLD/REJECT TAG NO N/A
N&D REPORT NO 6108

| | IDENTIFICATION | DOCUMENTATION | CONDITION |
|---|---|---|---|
| SOURCE INSPECTED<br>YES ☒<br>NO ☐<br>S.R.T 47258 | | | |
| SAT | ☒ | * | ☒ |
| UNSAT | | | |

RELEASED FOR CONSTRUCTION USE [✓ YES] NO
FORM NO T-38

DOCUMENTATION REVIEW
☑ SAT *
☐ UNSAT
SIGNATURE D L Ferony
DATE 11/12/83

REMARKS * PQA Doc Lacking Ht Treat. Records - Mat'l Conditionally Released

Inspected IAW P.O., Preplan, Lilco TP 12.019.99 and E!DCR F-46324

C.R. #445

INSPECTOR SIGNATURE D L Ferony
DATE 11/12/83

QC CONTROL NO. (if required) N/A

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

R-33615
83-155

## CERTIFICATE OF COMPLIANCE

TO: Long Island Lighting Company
℅ Stone & Webster Engineering Corp.
P.O. Box 604
Wading River N.Y. 11792

S.W.E.C.
PQA
INSPECTED-214

SHOREHAM NUCLEAR POWER STATION - UNIT 1

REFERENCE PURCHASE ORDER NUMBER: 310552-32

SUPPLIER: Transamerica Delaval Inc.

WE HEREBY CERTIFY THAT THE PRODUCTS OR SERVICES FURNISHED ON THE ABOVE REFERENCE PURCHASE ORDER MEET THE REQUIREMENTS OF THE APPLICABLE DRAWINGS AND/OR SPECIFICATIONS. SH1-89

☐ PARTS LISTED ON THE ATTACHED PACKING LIST ARE SPECIFICALLY COVERED BY THIS CERTIFICATE.

☒ PARTS LISTED BELOW ARE SPECIFICALLY COVERED BY THIS CERTIFICATE.

☐ DOCUMENTATION IN MANUFACTURERS FILE TO BE SUBMITTED AS REQUIRED AT A LATER DATE.

☐ DOCUMENTATION ATTACHED/SHIPPED SEPARATELY.

(ITEM 3 ONLY)
☒ PART NUMBER(S) 03-341-04-AE IS/ARE EQUAL TO OR BETTER THAN THAT WHICH WAS ORIGINALLY ORDERED.

L. L. Mills
L. L. MILLS, MANAGER - Quality Engineering　　11-11-83
TRANSAMERICA DELAVAL, INC. REPRESENTATIVE　　DATE

N/A　　N/A
CUSTOMER REPRESENTATIVE　　DATE

PURCHASE ORDER NUMBER:

R-33615

Oakland, California 94621
(415) 677-7400 Telex 335-304

R-33615
OUR NUMBER
REV. 1

DATE ENTERED 11/10/83

MAIL TO: 5415
LONG ISLAND LIGHTING CO.
C/O STONE & WEBSTER ENG. CORP.
P.O. BOX 604
WADING RIVER, N.Y. 11792

ATTN:

SHIP TO:
LONG ISLAND LIGHTING CO.
SHOREHAM NUCLEAR POWER STATION
1/2 MI. EAST OF WILLIAMS FLOYD
PARKWAY, HIGHWAY 25A
SHOREHAM, L.I. NEW YORK 11786

MARKINGS:

INVOICE NO:
INVOICE DATE:
SHIPPING TAG:
DATE SHIPPED:
CARRIER:
B/L:
PACKAGING: DOMESTIC AIR

CUSTOMER REF NUMBER: 310552-~~33~~32
REQUESTED SHIP DATE: 11-11-83
RESALE NO OR TAX CODE:
TERMS: NET 30 DAYS
F.O.B. POINT: FACTORY OAKLAND
ROUTING REQUEST: AIR FREIGHT

| ENGINE MODEL | SERIAL NUMBERS | CODE | SALES TAX | PRODUCT | S/C | TERRITORY | REMKS | STATE | PARTIAL SHIP | SHIP | PPD/COL | NO. INV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DSR-48 | 74010 12 | | 0 | 55508 | 491 | 20 25 58 | | 33 | YES | NO | PPD | 04 |

REV. 01-11-09-83 CHG. QTY'S
ITEMS 1-6, ADD ITEM 7, TOTAL,
CHG. CUST. P.O. & REQ. DATE.

INVOICE CUSTOMER FOR FREIGHT

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 104 | 03-341-04-AC | COLLAR, THRUST | 35.95 | | 3,738.80 |
| 2 | 104 | 03-341-04-AD | LOK-TAB | 6.90 | | 717.60 |
| 3 | 26 | 03-341-04-AE | SKIRT | 6,323.00 | D8 18 | 164,398.00 |
| 4 | 104 | 03-341-04-AF | GUIDE, SPRING | 53.60 | | 5,574.40 |
| 5 | 104 | GC-023-000 | GROOVER, PIN | 1.00 | | 104.00 |
| 6 | 104 | 03-341-04-AB | STUD | 86.55 | | 9,001.20 |
| 7 | 100 | GC-002-005 | COTTER PIN 1/16 X 1 1/4 | 1.00 | | 100.00 |
| | | | TOTAL | | | 183,634.00 |

ACCOUNTING INFORMATION

65,201 N-344-3

NUCLEAR

S.W.E.C. PQA INSPECTED-214

ITEM (3) ONLY

ORDER WRITER: LP

We hereby certify that these goods were produced in compliance with all applicable requirements of Sections 6, 7 and 12 of the Fair Labor Standards Act, as amended, and of regulations and orders of the United States Department of Labor issued under Section 14 thereof. No goods returned without our written permission. Deliveries contingent upon strikes, fires, accidents or other delays beyond our control. Goods proving defective will be replaced. No claims for damages or labor will be allowed. We are not responsible for loss of patterns due to fire.

The Attached "Conditions Of Sale" Are Part Of This Document.

PAGE NUMBER 1

## STONE & WEBSTER ENGINEERING CORPORATION
## QUALITY ASSURANCE DEPARTMENT
## PRODUCT QUALITY CERTIFICATION

T-376A-

PAGE OF

| | | | |
|---|---|---|---|
| PURCHASER<br>Long Island Lighting Company | J.O.<br>11600.37 | P.O. NO.<br>310552 | CHANGE NO.<br>—32— |
| PROJECT<br>Shoreham Nuclear Power Station #1 | SPEC. NO.<br>SH1-89 | REVISION<br>2 1-26-83 | ADDENDA<br>N/A |
| SELLER/ADDRESS<br>Transamerica Delaval, Inc. 550 85th. Avenue Oakland, CA. 94621 | | | |
| DOCUMENTATION REQUIRED<br>YES ☒ NO ☐ | QA CAT.<br>1 | SHIPPING RELEASE TAG NUMBER(S)<br>47258 | |

I HEREBY CERTIFY THE PRODUCT(S) IDENTIFIED HEREIN HAVE BEEN INSPECTED IN ACCORDANCE WITH S&W PROCUREMENT QUALITY ASSURANCE REQUIREMENTS AND ARE ACCEPTABLE FOR SHIPMENT.

CHECK BLOCKS AS APPLICABLE

☒ AUTHORIZED DEVIATIONS AND NONCONFORMANCES HAVE BEEN NOTED BELOW.

☒ ALL SPECIFIED SUPPORTING DOCUMENTATION HAS BEEN REVIEWED AND FORWARDED TO S&W PROCUREMENT QUALITY ASSURANCE FOR DOCUMENTATION REVIEW.

☐ DOCUMENTATION PREVIOUSLY SUBMITTED.

☐ DOCUMENTATION TO REMAIN IN SELLER'S FILES.

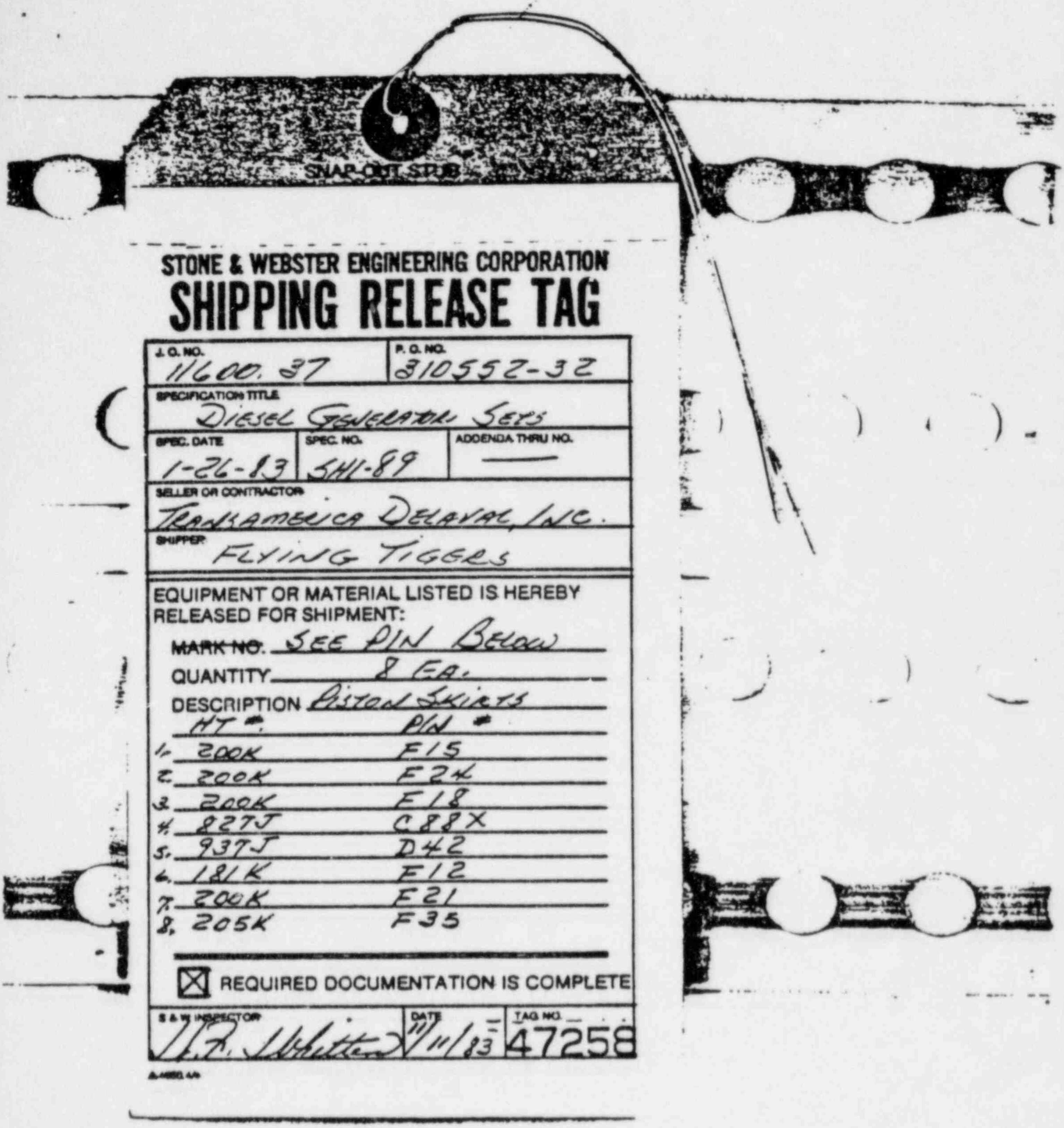
| ITEM NO. | | QUANTITY |
|---|---|---|
| 3 | P/N 03-341-04-AE | 8 EA. |

| | HT. NO. | SERIES |
|---|---|---|
| 1. | 200K | F15 |
| 2. | 200K | F24 |
| 3. | 200K | F18 |
| 4. | 827J | C88X |
| 5. | 937J | D42 |
| 6. | 181K | F12 |
| 7. | 200K | F21 |
| 8. | 205K | F35 |

NAME (PRINTED) W.F. Whitten TITLE District Manager

NAME (SIGNED) W.R. Whitten DATE 11/11/83 IR NO. 51105529011

AUTHORIZED DEVIATIONS AND NONCONFORMANCES
E&DCR #F-40324, DTD. 11-9-83



SNAP-OUT STUB

**STONE & WEBSTER ENGINEERING CORPORATION**

# SHIPPING RELEASE TAG

J. O. NO. 11600. 37

P. O. NO. 310552-32

SPECIFICATION TITLE Diesel Generator Sets

SPEC. DATE 1-26-83

SPEC. NO. SHI-89

ADDENDA THRU NO. ——

SELLER OR CONTRACTOR TransAmerica Delaval, Inc.

SHIPPER FLYING TIGERS

EQUIPMENT OR MATERIAL LISTED IS HEREBY RELEASED FOR SHIPMENT:

~~MARK NO.~~ SEE P/N Below

QUANTITY 8 Ea.

DESCRIPTION Piston Skirts

|  | HT #. | P/N # |
|---|---|---|
| 1. | 200K | F15 |
| 2. | 200K | F24 |
| 3. | 200K | F18 |
| 4. | 827J | C88X |
| 5. | 937J | D42 |
| 6. | 181K | F12 |
| 7. | 200K | F21 |
| 8. | 205K | F35 |

☒ REQUIRED DOCUMENTATION IS COMPLETE

S & W INSPECTOR W.R. Whitten

DATE 11/11/83

TAG NO. 47258

ISSUED TO __________ DATE __________

* QA INSPECTED D L Yerdey DATE 11/12/83

P.O. NO. 310552-32 REQ. NO. F77679 OF __________

VENDOR TRANSAMERICA DELAVAL

SHIPPER TRANSAMERICA DELAVAL SHIPPERS NO: R-33615

DATE REC'D 11/12/83 CHECKED BY B D'Ambrosio MRR NO. 05046

SHIPPED VIA FLYINGTIGERS

PRO NO. 6311-4100 NO. OF CTNS 9 WEIGHT 2,688

STORAGE LOCATION __________ STORE REQ NO. __________

*Conditionally Released CR # 445 - NED 6108

| P.O. ITEM NO. | QTY | DESCRIPTION | COMP. ID |
|---|---|---|---|
| 1 | 7 | PISTON SKIRT P/N 03-341-04-AG | |

P.O 310552-32 Trans America DeLaval

11ea. Piston Skirt P/N 03-341-04-AE

S/N's G33, G34, G4, G2, G1, F87, F58, F56, F7, E8, C89

Cat I SH1-089

# RECEIVING INSPECTION REPORT

SHOREHAM NUCLEAR POWER STATION
UNIT-1
STONE & WEBSTER ENGINEERING CORPORATION

| | | | |
|---|---|---|---|
| DATE RECEIVED<br>11-13-83 | MRR NUMBER<br>83-5047 | PARTIAL ☒<br>COMPLETE ☐ | |
| STORAGE LEVEL<br>A [✓ B] C D | QC HOLD/REJECT TAG NO<br>N/A | N&D REPORT NO<br>6110 | |

SOURCE INSPECTED
YES ☒
NO ☐
S.R.T 47260

| | IDENTIFICATION | DOCUMENTATION | CONDITION |
|---|---|---|---|
| SAT | ☒ | * | ☒ |
| UNSAT | | | |

RELEASED FOR CONSTRUCTION USE [✓ YES] NO

FORM NO [illegible]

## DOCUMENTATION REVIEW

☒ SAT

☐ UNSAT

SIGNATURE Dl Feraby for: R. Perra

DATE 11-13-83

REMARKS * PQA Doc lacking Ht. Treat. Records - Mat'l. Conditionally Released

Inspected IAW P.O., Preplan, Lilco TP12.019, 99 and E;DCR F-46324

C.R. #447

INSPECTOR SIGNATURE Dl Feraby for: R. Perra

DATE 11-13-83

QC CONTROL NO (if required) N/A

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

R-33615

83-756

(ORIGINAL
OOQA)

## CERTIFICATE OF COMPLIANCE

TO: Long Island Lighting Company
% Stone & Webster Engineering Corp.
P.O. Box 608
Wading River N.Y. 11792

S.W.E.C.
PQA
INSPECTED-214

SHOREHAM NUCLEAR POWER STATION – UNIT 1

REFERENCE PURCHASE ORDER NUMBER: 310552-32

SUPPLIER: Transamerica Delaval Inc.

WE HEREBY CERTIFY THAT THE PRODUCTS OR SERVICES FURNISHED ON THE ABOVE REFERENCE PURCHASE ORDER MEET THE REQUIREMENTS OF THE APPLICABLE DRAWINGS AND/OR SPECIFICATIONS. 5/11-89

☐ PARTS LISTED ON THE ATTACHED PACKING LIST ARE SPECIFICALLY COVERED BY THIS CERTIFICATE.

☒ PARTS LISTED BELOW ARE SPECIFICALLY COVERED BY THIS CERTIFICATE.

☐ DOCUMENTATION IN MANUFACTURERS FILE TO BE SUBMITTED AS REQUIRED AT A LATER DATE.

☐ DOCUMENTATION ATTACHED/SHIPPED SEPARATELY.

(ITEM 3 ONLY)

☒ PART NUMBER(S) 03-341-04-AE IS/ARE EQUAL TO OR BETTER THAN THAT WHICH WAS ORIGINALLY ORDERED.

R. L. Mills

R. L. MILLS, MANAGER – Quality Engineering

TRANSAMERICA DELAVAL, INC. REPRESENTATIVE

11-12-83

DATE

N/A

CUSTOMER REPRESENTATIVE

N/A

DATE

PURCHASE ORDER NUMBER:

5

# STONE & WEBSTER ENGINEERING CORPORATION
## QUALITY ASSURANCE DEPARTMENT
## PRODUCT QUALITY CERTIFICATION

T-376A-

PAGE 1 OF 1

| | | | |
|---|---|---|---|
| PURCHASER<br>Long Island Lighting Company | J.O.<br>11600.37 | P.O. NO.<br>310553 | CHANGE NO.<br>M/C 32 |
| PROJECT<br>Shoreham Nuclear Power Sta. #1 | SPEC. NO.<br>341-89 | REVISION<br>2 1-26-83 | ADDENDA<br>N/A |
| SELLER/ADDRESS<br>Transamerica Delaval Inc 550 85th. St. Oakland, Ca. 94621 | | | |
| DOCUMENTATION REQUIRED<br>YES ☒ NO ☐ | QA CAT.<br>1 | SHIPPING RELEASE TAG NUMBER(S)<br>47260 | |

I HEREBY CERTIFY THE PRODUCT(S) IDENTIFIED HEREIN HAVE BEEN INSPECTED IN ACCORDANCE WITH S&W PROCUREMENT QUALITY ASSURANCE REQUIREMENTS AND ARE ACCEPTABLE FOR SHIPMENT.

CHECK BLOCKS
AS APPLICABLE

☒ AUTHORIZED DEVIATIONS AND NONCONFORMANCES HAVE BEEN NOTED BELOW.

☒ ALL SPECIFIED SUPPORTING DOCUMENTATION HAS BEEN REVIEWED AND FORWARDED TO S&W PROCUREMENT QUALITY ASSURANCE FOR DOCUMENTATION REVIEW.

☐ DOCUMENTATION PREVIOUSLY SUBMITTED.

☐ DOCUMENTATION TO REMAIN IN SELLER'S FILES.

ITEM NO. 3 P/N 03-341-04-AE QUANTITY 11 EA.

| S/N. No. | HT. No. |
|---|---|
| G33 | 312K |
| G34 | 312K |
| G4 | 298K |
| G2 | 298K |
| G1 | 298K |
| F87 | 298K |
| F58 | 256K |
| F56 | 256K |
| F7 | 181K |
| E8 | 104K |
| C89 | 811J |

NAME (PRINTED) W.F. Whitten TITLE District Manager

NAME (SIGNED) W.F. Whitten DATE 11-12-83 IR NO. S1105529012

AUTHORIZED DEVIATIONS AND NONCONFORMANCES

2

STONE & WEBSTER ENGINEERING CORPORATION

# SHIPPING RELEASE TAG

J. O. NO. 11600.37

P. O. NO. 310552-32

SPECIFICATION TITLE Diesel Generator Sets

SPEC. DATE 1-26-83

SPEC. NO. SH1-89

ADDENDA THRU NO. N/A

SELLER OR CONTRACTOR Transamerica Delaval, Inc

SHIPPER American Airlines

EQUIPMENT OR MATERIAL LISTED IS HEREBY RELEASED FOR SHIPMENT:

MARK NO. See S/N Below

QUANTITY 11 EA.

DESCRIPTION Piston Skirts

S/N No. HT. No.

1. G33 - 312K
2. G34 - 312K
3. G4 - 298K
4. G2 - 298K
5. G1 - 298K
6. E87 - 298K
7. E58 - 256K

S/N No. HT. No.

8. F56 - 256K
9. E7 - 181K
10. E8 - 104K
11. C89 - 811J

☒ REQUIRED DOCUMENTATION IS COMPLETE

S & W INSPECTOR W. R. Whitten

DATE 11/12/83

TAG NO 47260

[illegible]

ORIGINAL
KAYNE COLE

ISSUED TO Martha Lutte DATE 11/13/83

QQA INSPECTED ____________ DATE 11/13/83

P.O. NO. 310552-32 REQ. NO. F77679 OF T. BROWN

VENDOR TRANS. AMERICA. DE LAVAL.

SHIPPER TRANS. AM. DE LAVAL SHIPPERS NO: 20338.

DATE REC'D 11-13-83 CHECKED BY J. Lawler MRR NO. 05047

SHIPPED VIA. AMERICAN AIRLINES.

PRO NO. 001 SFO 5658745 NO. OF CTNS 11 WEIGHT 3553.

STORAGE LOCATION ____________ STORE REQ NO. ____________

NCD 6110 INITIATED DUE TO DOC. MISSING - HEAT TREAT-CYCLE INFO MISSING - CONDITIONAL RELEASE 447- INITIATED TO RELEASE All 11 SKIRTS -

| P.O. ITEM NO. | QTY | DESCRIPTION | COMP. ID |
|---|---|---|---|
| 1 | 11 | PISTON SKIRT.<br>P/N. 03-341-04 AE. | |

Transamerica Delaval

R-33615

Engine and Compressor Division
550 85th Avenue
P.O. Box 2181
Oakland, California 94621
(415) 577-7400 Telex: 335-304

1

TAG
R-33615
OUR NUMBER

DATE ENTER
117097

MAIL TO: 5415
LONG ISLAND LIGHTING CO.
C/O STONE & WEBSTER ENG. CORP.
P.O. BOX 604
WADING RIVER, N.Y. 11792

ATTN:

SHIP TO:
LONG ISLAND LIGHTING CO.
SHOREHAM NUCLEAR POWER STATION
1/2 MI. EAST OF WILLIAMS FLOYD
PARKWAY, HIGHWAY 25A
SHOREHAM, L.I. NEW YORK 11786

MARKINGS:

INVOICE NO.:
INVOICE DATE:
CUSTOMER REF. NUMBER: L. MCHUGH
SHIPPING TAG:
DATE SHIPPED: 11-12-83
REQUESTED SHIP DATE: 11-11-83
CARRIER: American Airlines 001 SFO 56687751
RESALE NO. OR TAX CODE:
B/L: OAK 11717
TERMS: NET 30 DAYS
PACKAGING: DOMESTIC AIR
F.O.B. POINT: FACTORY OAKLAN

| ENGINE MODEL | SERIAL NUMBERS | CODE | SALES TAX | PRODUCT | SIC | TERRITORY | RENEG | STATE | PARTIAL SHIP | GOVT INSP | PPD/COL | NO. INV | ROUTING REQUEST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DSR-48 | 74010 12 |  | 0 | 55508 | 491 | 20 25 58 |  | 33 | YES | NO | PPD | 04 | AIR FREIGHT |

| ITEM | QTY | PART NUMBER | DESCRIPTION | SCHEDULED DATE | UNIT PRICE | QTY SHIPPED | ORDER BALANCE | BOX NO. | EXTENDED PRIC |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | INVOICE CUSTOMER FOR FREIGHT |  |  |  |  |  |  |
| 1 | 96 | 03-341-04-AC | COLLAR, THRUST |  |  |  |  |  |  |
| 2 | 96 | 03-341-04-AD | LOK-TAB |  |  |  |  |  |  |
| 3 | 24 | 03-341-04-AE | SKIRT |  |  |  |  |  |  |
| 4 | 96 | 03-341-04-AF | GUIDE, SPRING |  |  | 11 @ 3553 lbs. |  |  |  |
| 5 | 96 | GC-023-000 | GROOVER, PIN |  |  |  |  |  |  |
| 6 | 96 | 03-341-04-AB | STUD |  |  |  |  |  |  |
|  |  |  | ACCOUNTING INFORMATION |  |  |  |  |  |  |
|  |  |  | 65,201 N-344-3 |  |  |  |  |  |  |

NUCLEAR

MRR-05047
310 5-52-52
F 77679
T. Brau k.

ORDER WRITER
LP

We hereby certify that these goods were produced in compliance with all applicable requirements of Sections 6, 7 and 12 of the Fair Labor Standards Act, as amended, and of regulations and orders of the United States Department of Labor issued under Section 14 thereof. No goods returned without our written permission. Deliveries contingent upon strikes, fires, accidents or other delays beyond our control. Goods proving defective will be replaced. No claims for damages or labor will be allowed. We are not responsible for loss of patterns due to fire.

The Attached "Conditions Of Sale" Are Part Of This Document.

PAGE NUMB
1

P.O. 310552-32 TransAmerica Delaval

7 ea. Piston Skirt # 03-341-04AE
S/N's F-97, F-98, G-5, G26, G29, G30
and G35

Cat. I SN1-089

RECEIVING INSPECTION REPORT
SHOREHAM NUCLEAR POWER STATION
UNIT-1
STONE & WEBSTER ENGINEERING CORPORATION

DATE RECEIVED 11-16-83
MRR NUMBER 83-05053
PARTIAL ☒
COMPLETE ☐
STORAGE LEVEL A [✓ B] C D
QC HOLD/REJECT TAG NO N/A
NBD REPORT NO 6115

SOURCE INSPECTED
YES ☒
NO ☐
SRT # 47261

|  | IDENTIFICATION | DOCUMENTATION | CONDITION |
|---|---|---|---|
| SAT | ☒ | * | ☒ |
| UNSAT |  |  |  |

RELEASED FOR CONSTRUCTION USE [✓ YES] NO

FORM NO I-58

DOCUMENTATION REVIEW
☒ SAT
☐ UNSAT
SIGNATURE D L [illegible] for R. Perra
DATE 11-16-83

REMARKS POA Doc. Lacking Ht. treat. Record
Mat'l Conditionally Released

Inspected IAW P.O., Preplan,
Lilco TP 12.019.99 and E&DCR
F-46324

C.R. #448

INSPECTOR SIGNATURE D L [illegible] for: R. Perra
DATE 11-16-83

QC CONTROL NO (if required) N/A

R-33615

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

## CERTIFICATE OF COMPLIANCE

TO: Long Island Lighting Company
c/o Stone & Webster Engineering Corp.
P.O. Box 604
Wading River N.Y. 11792

S.W.E.C.
PQA
INSPECTED 214

SHOREHAM NUCLEAR POWER STATION - UNIT 1

REFERENCE PURCHASE ORDER NUMBER: 310552-32

SUPPLIER: Transamerica Delaval Inc.

WE HEREBY CERTIFY THAT THE PRODUCTS OR SERVICES FURNISHED ON THE ABOVE REFERENCE PURCHASE ORDER MEET THE REQUIREMENTS OF THE APPLICABLE DRAWINGS AND/OR SPECIFICATIONS. SH1-89

☐ PARTS LISTED ON THE ATTACHED PACKING LIST ARE SPECIFICALLY COVERED BY THIS CERTIFICATE.

☒ PARTS LISTED BELOW ARE SPECIFICALLY COVERED BY THIS CERTIFICATE.

☐ DOCUMENTATION IN MANUFACTURERS FILE TO BE SUBMITTED AS REQUIRED AT A LATER DATE.

☐ DOCUMENTATION ATTACHED/SHIPPED SEPARATELY.

☒ PART NUMBER(S) 03-341-04-AE (ITEM #3 ONLY) IS/ARE EQUAL TO OR BETTER THAN THAT WHICH WAS ORIGINALLY ORDERED.

L. L. Mills

L. L. MILLS , MANAGER- Quality Engineering — 11-15-83

TRANSAMERICA DELAVAL, INC. REPRESENTATIVE — DATE

N/A — N/A

CUSTOMER REPRESENTATIVE — DATE

PURCHASE ORDER NUMBER:

STONE & WEBSTER ENGINEERING CORPORATION
QUALITY ASSURANCE DEPARTMENT

# PRODUCT QUALITY CERTIFICATION

T-376A- PAGE 1 OF 1

| PURCHASER | J.O. | P.O. NO. | CHANGE NO. |
|---|---|---|---|
| Long Island Lighting Company | 11600.37 | 310552 | M/C 32 |
| **PROJECT** | **SPEC. NO.** | **REVISION** | **ADDENDA** |
| Shoreham Nuclear Power Sta. #1 | SH1-59 | 2 1-26-83 | N/A |

SELLER/ADDRESS
Transamerica Delaval, Inc. 550 85th. Avenue Oakland Ca. 94621

| DOCUMENTATION REQUIRED | QA CAT. | SHIPPING RELEASE TAG NUMBER(S) |
|---|---|---|
| YES ☒ NO ☐ | I | 47261 |

I HEREBY CERTIFY THE PRODUCT(S) IDENTIFIED HEREIN HAVE BEEN INSPECTED IN ACCORDANCE WITH S&W PROCUREMENT QUALITY ASSURANCE REQUIREMENTS AND ARE ACCEPTABLE FOR SHIPMENT.

CHECK BLOCKS
AS APPLICABLE

☒ AUTHORIZED DEVIATIONS AND NONCONFORMANCES HAVE BEEN NOTED BELOW.
☒ ALL SPECIFIED SUPPORTING DOCUMENTATION HAS BEEN REVIEWED AND FORWARDED TO S&W PROCUREMENT QUALITY ASSURANCE FOR DOCUMENTATION REVIEW.
☐ DOCUMENTATION PREVIOUSLY SUBMITTED.
☐ DOCUMENTATION TO REMAIN IN SELLER'S FILES.

| ITEM NO. | | | QUANTITY |
|---|---|---|---|
| 3 | P/N-03-341-04-AE | | 7 EA. |
| | S/N-F97 | HT-289K | |
| | S/N-F98 | HT-289K | |
| | S/N-G5 | HT-298K | |
| | S/N-G26 | HT-312K | |
| | S/N-G29 | HT-312K | |
| | S/N-G30 | HT-312K | |
| | S/N-G35 | HT-312K | |

NAME (PRINTED) W.F. Whitten TITLE District Manager

NAME (SIGNED) W. F. Whitten DATE 11-15-83 IR NO. S110552-9013

AUTHORIZED DEVIATIONS AND NONCONFORMANCES
E&DCR F-46324, Dtd. 11-9-83

ISSUED TO ASerna DATE

QA INSPECTED DATE 11-16-83

P.O. NO. 310 552-32 REQ. NO. F77679 OF

VENDOR Transamerica Delaval Inc

SHIPPER Transamerica Delaval Inc SHIPPERS NO: l- 33615

DATE REC'D 11-16-83 CHECKED BY K. Alk MRR NO 83-05053

SHIPPED VIA Flying Tigers

PRO NO. 6311 4052 NO. OF CTNS. 8 WEIGHT 2337 (lbs)

STORAGE LOCATION STORE REQ NO.

CONDITIONAL RELEASED ON #448

REQUIRE HEAT CERTS. ASerna 11/16/83

| P.O. ITEM NO. | QTY | DESCRIPTION | COMP. ID |
|---|---|---|---|
| 1 | 7 | Piston Skirt #03-341-04AE | |

Transamerica Delaval

R-33615

Transamerica Delaval Inc.
Engine and Compressor Division
550 85th Avenue
P.O. Box 2161
Oakland, California 94621
(415) 577-7400 Telex 335-304

SHIPPING TAG
R-33615
OUR NUMBER
REV. 02

DATE ENTERE
11/10/

MAIL TO: 5415
LONG ISLAND LIGHTING CO.
C/O STONE & WEBSTER ENG. CORP.
P.O. BOX 604
WADING RIVER, N.Y. 11792

ATTN:

SHIP TO:
LONG ISLAND LIGHTING CO.
SHOREHAM NUCLEAR POWER STATION
1/2 MI. EAST OF WILLIAMS FLOYD
PARKWAY, HIGHWAY 25A
SHOREHAM, L.I. NEW YORK 11786

MARKINGS:

| INVOICE NO. | INVOICE DATE | CUSTOMER REF. NUMBER |
|---|---|---|
| | | 310552- 32 |

| SHIPPING TAG | DATE SHIPPED | REQUESTED SHIP DATE |
|---|---|---|
| | 11-15-83 | 11-11-83 |

CARRIER: FLYING TIGERS
8 BOXES @ 2,337#
B/L 11742

RESALE NO. OR TAX CODE:

TERMS: NET 30 DAYS

PACKAGING: DOMESTIC AIR

F.O.B. POINT: FACTORY OAKLAND

| ENGINE MODEL | SERIAL NUMBERS | CODE | SALES TAX | PRODUCT | B/C | TERRITORY | | STATE | PARTIAL SHIP | CUST INSP | PPD/COL | NO. REV | ROUTING REQUEST |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DSR-48 | 74010 12 | | 0 | 55508 | 491 | 20 25 58 | | 33 | YES | NO | PPD | 04 | AIR FREIGHT |

| ITEM | QTY | PART NUMBER | DESCRIPTION | SCHEDULED DATE | UNIT PRICE | QTY SHIPPED | ORDER BALANCE | BOX NO. | EXTENDED PRICE |
|---|---|---|---|---|---|---|---|---|---|
| | | | REV. 01-11-09-83 CHG. QTY'S ITEMS 1-6, ADD ITEM 7. TOTAL. CHG. CUST. P.O. & REQ. DATE. | | | | | | |
| | | | INVOICE CUSTOMER FOR FREIGHT | | | | | | |
| ① | 104 | 03-341-04-AC | COLLAR, THRUST | | | ㊵ | | | |
| ② | 104 | 03-341-04-AD | LOK-TAB | | | ㊵ | | | |
| ③ | 26 | 03-341-04-AE | SKIRT | | | ⑦ | | | |
| ④ | 104 | 03-341-04-AF | GUIDE, SPRING | | | ㊵ | | | |
| ⑤ | 104 | GC-023-000 | GROOVER, PIN | | | ㊵ | | | |
| ⑥ | 104 | 03-341-04-AB | STUD | | | ㊵ | | | |
| 7 | 100 | GC-002-005 | COTTER PIN 1/16X 1 1/4 | | | | 40 | | |
| | | | ACCOUNTING INFORMATION | | | | | | |
| | | | 65.201 N-344-3 | | | | | | |

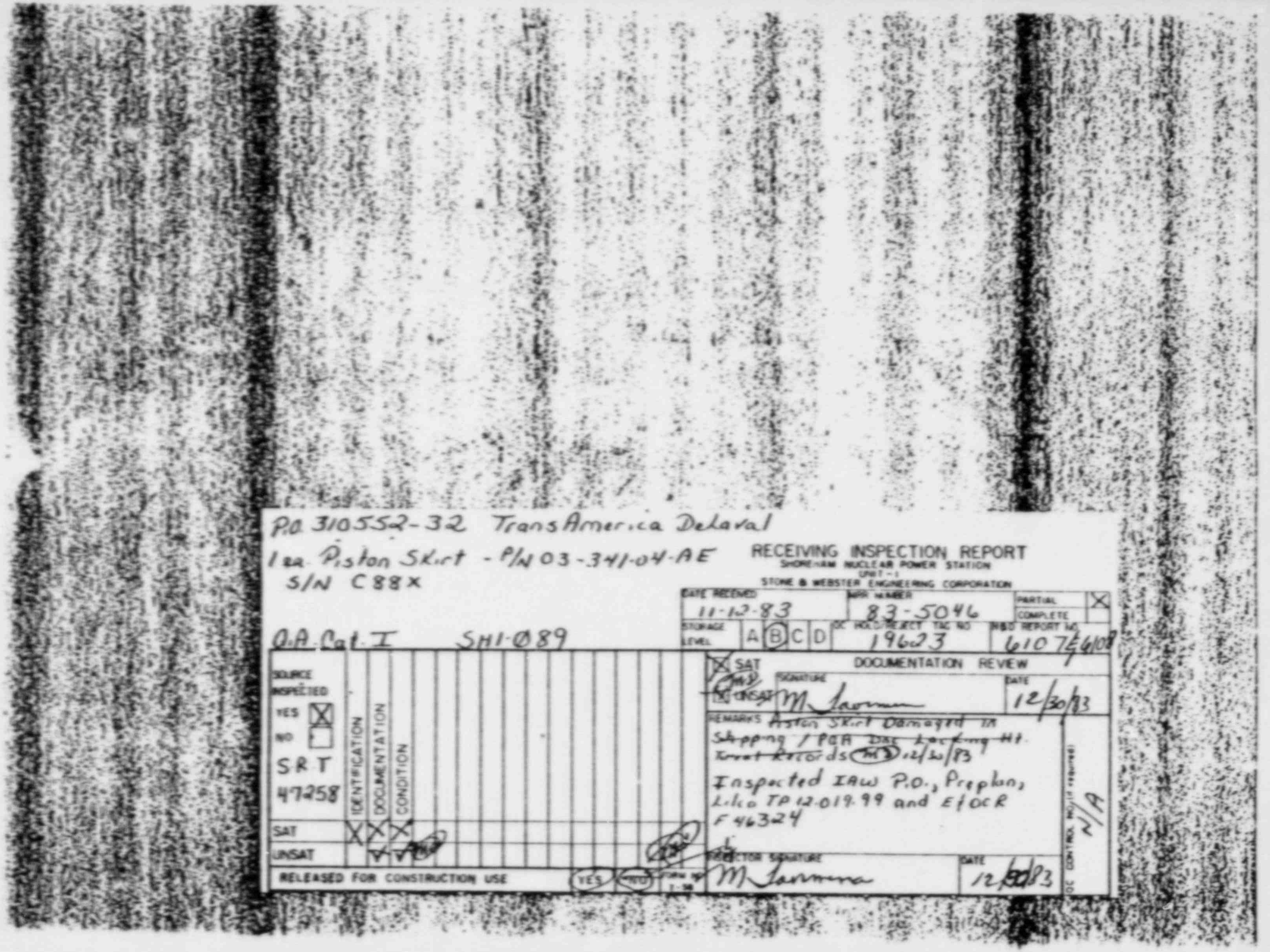
NUCLEAR

MRR-83-050
310552-
F7X
1 Box

ORDER WRITER
18

We hereby certify that these goods were produced in compliance with all applicable requirements of Sections 6, 7 and 12 of the Fair Labor Standards Act, as amended, and of regulations and orders of the United States Department of Labor issued under Section 14 thereof. No goods returned without our written permission. Deliveries

PAGE NUMBER
1



P.O. 310552-32 TransAmerica Delaval

1 ea. Piston Skirt - P/N 03-341-04-AE

S/N C88X

Q.A. Cat. I SH1-Ø89

# RECEIVING INSPECTION REPORT

SHOREHAM NUCLEAR POWER STATION

UNIT - 1

STONE & WEBSTER ENGINEERING CORPORATION

| | | | |
|---|---|---|---|
| DATE RECEIVED<br>11-12-83 | MRR NUMBER<br>83-5046 | PARTIAL ☒<br>COMPLETE ☐ | |
| STORAGE LEVEL A [✓ B] C D | QC HOLD/REJECT TAG NO<br>19623 | N&D REPORT NO<br>6107 & 6108 | |

SOURCE INSPECTED YES ☒ NO ☐

S.R.T 47258

| | IDENTIFICATION | DOCUMENTATION | CONDITION |
|---|---|---|---|
| SAT | X | X | X |
| UNSAT | | ✓ | ✓ |

RELEASED FOR CONSTRUCTION USE [✓ YES] NO

FORM NO 1-38

DOCUMENTATION REVIEW

☒ SAT

☐ ~~UNSAT~~

SIGNATURE M. Iaronne DATE 12/30/83

REMARKS ~~Piston Skirt Damaged In Shipping / PQA Doc Lacking Ht. Treat Records~~ MJ 12/20/83

Inspected IAW P.O., Preplan, Lilco TP 12.019.99 and E&DCR F46324

INSPECTOR SIGNATURE M. Iaronne DATE 12/30/83

QC CONTROL NO (if required) N/A

## STONE & WEBSTER ENGINEERING CORPORATION
## QUALITY ASSURANCE DEPARTMENT
## PRODUCT QUALITY CERTIFICATION

T-376A-

PAGE OF

| | | | |
|---|---|---|---|
| PURCHASER<br>Long Island Lighting Company | J.O.<br>11600.37 | P.O. NO.<br>[illegible] | CHANGE NO.<br>-32- |
| PROJECT<br>Shoreham Nuclear Power Station #1 | SPEC. NO.<br>SH1-89 | REVISION<br>2 1-26-83 | ADDEND.<br>NA |
| SELLER/ADDRESS<br>Transamerica Delaval, Inc. 550 85th Avenue Oakland CA 94621 | | | |
| DOCUMENTATION REQUIRED<br>YES ☒ NO ☐ | QA CAT.<br>1 | SHIPPING RELEASE TAG NUMBER(S)<br>[illegible] | |

I HEREBY CERTIFY THE PRODUCT(S) IDENTIFIED HEREIN HAVE BEEN INSPECTED IN ACCORDANCE WITH S&W PROCUREMENT QUALITY ASSURANCE REQUIREMENTS AND ARE ACCEPTABLE FOR SHIPMENT.

CHECK BLOCKS
AS APPLICABLE

☒ AUTHORIZED DEVIATIONS AND NONCONFORMANCES HAVE BEEN NOTED BELOW.

☒ ALL SPECIFIED SUPPORTING DOCUMENTATION HAS BEEN REVIEWED AND FORWARDED TO S&W PROCUREMENT QUALITY ASSURANCE FOR DOCUMENTATION REVIEW.

☐ DOCUMENTATION PREVIOUSLY SUBMITTED.

☐ DOCUMENTATION TO REMAIN IN SELLER'S FILES.

| ITEM NO. | | QUANTITY |
|---|---|---|
| 2 | P/N 03-341-04-AE | 8 EA. |

| HT. No. | Series |
|---|---|
| 1. 200K | F15 |
| 2. 200K | F24 |
| 3. 200K | F18 |
| 4. 827J | C88X |
| 5. 937J | D42 |
| 6. 181K | F12 |
| 7. 200K | F21 |
| 8. 205K | F35 |

NAME (PRINTED) W.F. Whitten TITLE District Manager

NAME (SIGNED) W.F. Whitten DATE 11/11/83 IR NO. 5110552 9011

AUTHORIZED DEVIATIONS AND NONCONFORMANCES
E&DCR # F-40324, DTD. 11-9-83

STONE & WEBSTER ENGINEERING CORPORATION

J.O. NO. 11600.37

P.O. NO. 310997-32

SPECIFICATION TITLE Diesel Generator [illegible]

SPEC. DATE 1-26-73

SPEC. NO. [illegible]

ADDENDUM/CHANGE NO. ——

SELLER OR SUBCONTRACTOR Transamerica Delaval Inc.

SHOP LOCATION [illegible]

EQUIPMENT OR MATERIAL LISTED IS HEREBY RELEASED FOR SHIPMENT:

MARK NO. See List Below

QUANTITY 8 Pcs.

DESCRIPTION [illegible]

| | HT # | PC # | |
|---|---|---|---|
| 1. | 200K | F15 | |
| 2. | 200K | F24 | |
| 3. | 200K | F18 | 1L |
| 4. | 227J | C28X | |
| 5. | 937J | D42 | |
| 6. | 181K | F12 | |
| 7. | 200K | F21 | |
| 8. | 205K | F35 | 5 |

☒ REQUIRED DOCUMENTATION IS COMPLETE

| S & W INSPECTOR | DATE | TAG NO |
|---|---|---|
| W. R. Whitten | 11/11/83 | 47258 |

A-4650.4A

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

K-33615
83-155

# CERTIFICATE OF COMPLIANCE

TO: Long Island Lighting Company
Stone & Webster Engineering Corp.
[illegible]
[illegible]

S.W.E.C.
PQA
INSPECTED

[illegible]

REFERENCE PURCHASE ORDER NUMBER: [illegible]

SUPPLIER: Transamerica Delaval Inc.

WE HEREBY CERTIFY THAT THE PRODUCTS OR SERVICES FURNISHED ON THE ABOVE REFERENCE PURCHASE ORDER MEET THE REQUIREMENTS OF THE APPLICABLE DRAWINGS AND/OR SPECIFICATIONS. [illegible]

☐ PARTS LISTED ON THE ATTACHED PACKING LIST ARE SPECIFICALLY COVERED BY THIS CERTIFICATE.

☒ PARTS LISTED BELOW ARE SPECIFICALLY COVERED BY THIS CERTIFICATE.

☐ DOCUMENTATION IN MANUFACTURERS FILE TO BE SUBMITTED AS REQUIRED AT A LATER DATE.

☐ DOCUMENTATION ATTACHED/SHIPPED SEPARATELY.

☒ (ITEM 3 ONLY)
PART NUMBER(S) 09-374-04-AE IS/ARE EQUAL TO OR BETTER THAN THAT WHICH WAS ORIGINALLY ORDERED.

R. L. Mills

R. L. MILLS, Manager Quality Engineering — 11-11-83

TRANSAMERICA DELAVAL, INC. REPRESENTATIVE — DATE

N/A — N/A

CUSTOMER REPRESENTATIVE — DATE

[illegible] ORDER NUMBER:

L.I [illegible]
R-33615

P O Box 2161
Oakland, California 94621
(415) 577-7400 Telex: 335-304

ORDER
R-33615
OUR NUMBER
REV. 1

DATE ENTERED
11/10/83

MAIL TO: 5415
LONG ISLAND LIGHTING CO.
C/O STONE & WEBSTER ENG. CORP.
P.O. BOX 604
WADING RIVER, N.Y. 11792

ATTN:

SHIP TO:
LONG ISLAND LIGHTING CO.
SHOREHAM NUCLEAR POWER STATION
1/2 MI. EAST OF WILLIAMS FLOYD
PARKWAY, HIGHWAY 25A
SHOREHAM, L.I. NEW YORK 11786

MARKINGS:

CUSTOMER ORDER NUMBER: 310552-[illegible]
REQUESTED SHIP DATE: 11-11-83
TERMS: NET 30 DAYS
SHIP VIA: DOMESTIC AIR
F.O.B. POINT: FACTORY OAKLAND
ROUTING: AIR FREIGHT

ENGINE MODEL: DSR-48
SERIAL NUMBERS: 74010_12

REV. 01-11-09-83 CHG. QTYS
ITEMS 1-6, ADD ITEM 7. TOTAL.
CHG. CUST. P.O. & REQ. DATE.

INVOICE CUSTOMER FOR FREIGHT

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 104 | 03-341-04-AC | COLLAR, THRUST | 35.95 | | 3,738.80 |
| 2 | 104 | 03-341-04-AD | LOK-TAB | 6.90 | | 717.60 |
| 3 | 26 | 03-341-04-AE | SKIRT | [illegible] | | [illegible].00 |
| 4 | 104 | 03-341-04-AF | GUIDE, SPRING | [illegible] | 18 | 5,278.40 |
| 5 | 104 | GC-023-000 | GROOVER, PIN | 1.00 | | 104.00 |
| 6 | 104 | 03-341-04-AB | STUD | 86.55 | | 9,001.20 |
| 7 | 100 | GC-002-005 | COTTER PIN | 1.00 | | 100.00 |
| | | | TOTAL | | | 133,634.00 |

ACCOUNTING INFORMATION

65.201 N-366-3

NO CHARGE

S.W.E.C. FQA INSPECTED 214

ITEM (3) ONLY

ORDER WRITER
LP

We hereby certify that these goods were produced in compliance with all applicable requirements of Sections 6, 7 and 12 of the Fair Labor Standards Act, as amended, and of regulations and orders of the United States Department of Labor issued under Section 14 thereof. No goods returned without our written permission. Deliveries contingent upon strikes, fires, accidents or other delays beyond our control. Goods proving defective will be replaced. No claims for damages or labor will be allowed. We are not responsible for loss of patterns due to fire.

The Attached "Conditions Of Sale" Are Part Of This Document.

PAGE NUMBER
1

ISSUED TO Timothy McCaffrey DATE 12/9/83

QA INSPECTED M. Iacono DATE 12/8/83

P.O. NO. 310552-32 REQ. NO. E77679 OF

VENDOR TRANSAMERICA DELAVAL

SHIPPER TRANSAMERICA DELAVAL SHIPPERS NO: R-33615

DATE REC'D 11/12/83 CHECKED BY B D'AMBROSIO MRR NO. 05046

SHIPPED VIA FLYING TIGERS

PRO NO. 6311-4100 NO. OF CTNS 9 WEIGHT 2,688

STORAGE LOCATION STORE REQ NO.

Rejected - Tag# 19623 - NiD 1610T dj 11/12/83

| P.O. ITEM NO. | QTY | DESCRIPTION | COMP. ID |
|---|---|---|---|
| 1 | 1 | PISTON SKIRT P/N 03-341-04-AE<br>Released to el. 03 for check out 11/23/83<br>OPS x271 | |

**Transamerica Delaval**

Transamerica Delaval Inc
Engine and Compressor Division
550 85th Avenue
P.O. Box 2161
Oakland California 94621
(415) 577 7400

2

03-341A

Tag
&
cc

R.F. [illegible]
[illegible]

C. [illegible]
J.C. [illegible]

JCK (orig)
WJM
MHM
CKS
E. Rogers
[illegible] Walls
[redacted]
RDD/File
R. Fanly / H. Fanly

March 13, 1984

Stone & Webster Engineering Company
P.O. Box 2325
Boston, Massachusetts 02107

Attention: Mr. S. W. Wakefield

Subject: Shoreham Nuclear Power Station - Unit 1
Standby Diesel Generator Sets 74010/12
Long Island Lighting Company
W080-48923

Reference: Certificate of Compliance - crankshaft replacements
your letter dated October 20, 1983.

Gentlemen:

Please find four (4) copies of our Certificate of Compliance for the recent field modifications to your engines. As part of the certificate of compliance, we have included back-up data and justification comparing the original as delivered components with that of the replacement components.

Should you have questions or comments, please feel free to contact us.

Very truly yours,

TRANSAMERICA DELAVAL INC.
Engine & Compressor Division

NOTED MAR 24 1984 A.J. ASHUINO

John F. Gee

John F. Gee
Project Engineer

JFG:np

Encl: 4

cc: R. Boyer
R. Yang
V. Dilworth

**Transamerica**
**Delaval**

# CERTIFICATE OF COMPLIANCE

REFERENCE: SPECIFICATION NO. SH1-89

Stone & Webster Engineering Corp.

FOR Shoreham Nuclear Power Station

Unit #1 Long Island Lighting Company

Long Island, New York

SUPPLIER: Transamerica Delaval Inc. - Engine & Compressor Division

COMPONENTS: Emergency Diesel Generator Engines fitted with:

| | | |
|---|---|---|
| 3 ea. | 1A-7046 | Crankshaft Assembly |
| 24 ea. | 03-341-04-AE | Skirts, Piston |
| 24 ea. | 1A-5718 | Con Rod Assembly |
| 48 ea. | 03-340-05-AE | Shells, Con Rod |
| 2 ea. | 03-310-03-AE | Shell, Rear Main .080" O.S. on O.D. |
| 24 ea. | 03-441-01-OP | Pipe, Cyl. Head to A/S Manifold |
| 96 ea. | 02-390-01-OJ | Rocker Arm Shaft Bolt |
| 3 ea. | AK-007-000 | Coupling |
| 3 ea. | 03-402-04-AA | Coupling Adapter |
| 3 ea. | 03-402-04-AB | Governor Drive Coupling |
| 3 ea. | 102568 | Idler Gear Locknut (Field Rework). |

We have reviewed the above drawings and made comparisons to those originally supplied. Since the engine generator system as originally supplied was covered by a Certificate of Compliance, this document will address only the above listed parts.

As detailed in the attachments, we conclude that the new components either retain or improve on their functional and seismic adequacy over those originally supplied. The attachments consist of eleven pages.

Date 3-6-84

Roland T.M. Yang
Manager, Applied Mechanics

Date 3-6-84

G.E. Trussell
Manager, Engineering & Customer Service

NOTED MAR 2 4 REC'D A. J. ASQUINO

**Transamerica Delaval** Engine Calculations

| | | |
|---|---|---|
| 74010 | | |
| ENGINE | ASSY | NO |

SHEET 1 OF 2

COMPARISON OF AS DELIVERED ENGINE COMPONENTS WITH REPLACEMENT ENGINE COMPONENTS

DATE January 9, 1984

PART NO. PISTON SKIRT

BY David Beck

The engine components compared will be denoted as:

Old = As delivered engine components

New = Replacement engine components

| Old: | New: |
|---|---|
| 03-340-04-AF | 03-341-04-AE |
| Wall thickness at ring grooves: .75" | Wall thickness at ring grooves: .97" |
| Boss radius at piston pin: 4.375" | Boss radius at piston pin: 4.5" |
| Pin bore hardness: 217-270-BHN | Pin bore hardness: 255-293 BHN |

Material is the same for both piston skirts. Changes were made to improve rigidity, reduce stress and facilitate casting:

> Section C-C on drawing 03-341-04-AE shows the boss outside radius to be 4-1/2", (from 4-3/8" for the old design). This was done to eliminate the rib in the old design and still maintain structural integrity.
>
> Section Y-Y on drawing 03-341-04-AE shows the increased "Tie" between the bolt boss and the skirt. This was done to improve the bolt boss rigidity and reduce stress concentration.
>
> Section C-C on drawing 03-341-04-AE shows a tapered rib to the left of the piston pin centerline. This tapered rib was added to improve the rigidity of the piston skirt.

The nodular iron skirt has passed through several design changes. The following identifies and describes several design iterations of the piston skirts:

1. "AF" piston, 03-340-04-AF
   a. This design was supplied in the LILCO/Shoreham, Southern California Edison/San Onofre and Mid South Energy/Grand Gulf engines.

During field testing several "AF" modified skirts at LILCO were found to have linear indications and one was found to have a crack near a stud bore. This crack finding is the reason for our 10CFR21 letter of November 16, 1983. At this writing, four (4) skirts have been examined at Grand Gulf where linear casting indications were found on two (2) skirts. The indications were easily removed by light grinding and polishing. There is absolutely no evidence of cracks with any depth.

Linear indications should not be taken lightly, however they should not be regarded indiscriminately as "failures". Indications may be casting surface imperfections, scratches, or machining marks. They could contribute to fatigue cracks and should therefore be tested by grinding or polishing. Generally faint indications are not crack contributors and through experience may be left as found. Overly zealous inspections with very sensitive instruments often mislead one to assume there are cracks were none exist.

NOTED MAR 2 4 [illegible] A. J. ASGUINO

**Transamerica Delaval** Engine Calculations

74010 ENGINE | ASSY | NO

COMPARISON OF AS DELIVERED ENGINE COMPONENTS WITH REPLACEMENT ENGINE COMPONENTS.

SHEET 2 OF 2

DATE January 9, 19

PART NO. PISTON SKIRT

BY David Beck

2. All "AF" style piston skirts were cast using the following heat treatment.

   a. Heat to 1750 degrees F. (near the upper critical temperature) for 3 hours. Normalized (air cooled) in still air. Result: a pearlitic structure and 100,000 PSI tensile strength.

   b. Re-heat to 1050 degrees F. (slightly below the lower critical temperature) for 3 hours and cool in still air. This is a tempering process used to produce the desired ductility in the nodular iron.

3. "AE" 03-341-04-AE

   This is the present standard R-4 piston skirt design. The design incorporates the knowledge we have gained through our field experience on the R-4 series engine as well as from our uprated R-5 series engine, just concluding research and development testing.

   All "AE" skirts are heat treated to product stress relieved 100,000 PSI tensile strength nodular iron. Successful operating experience with the "AE" skirts includes a 16 cylinder R-4 unit rated 7000 kw, 450 rpm, 225 bmep which has accumulated over 7000 hours of operating without a problem, and 687 hours operation on the R-5 test engine at 514 rpm, and 302 bmep.

   The "AE" style skirt is interchangeable with existing R-4 piston crown and requires only minor hardware changes.

   The connection of the bolt boss to the skirt wall with a more substantial section on piston skirt "AE" is an improvement designed to eliminate the indications found in this area on skirt "AF".

   The new piston skirt's adequacy is improved as noted above and offers a substantial refinement in the "AE" skirt design.

Engine Cylinder Pressure Logs

EDG 101, 102, 103

Pre-crankshaft Failure

TCN #1

TABLE V

Data Reviewed by WJCole 7/5/83

## ENGINE CYLINDER PRESSURE LOG

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Step Number<br>Date/Time | 6/19/83<br>STEP 8.8.2 | | | | | | | |
| ENGINE CYLINDER PRESSURE | | | | | | | | |
| 1 | 1530 | | | | | | | |
| 2 | 1500 | | | | | | | |
| 3 | 1550 | | | | | | | |
| 4 | 1550 | | | | | | | |
| 5 | 1560 | | | | | | | |
| 6 | 1550 | | | | | | | |
| 7 | 1570 | | | | | | | |
| 8 | 1530 | | | | | | | |
| | | | | | | | | |
| LOAD | | | | | | | | |

Data recorded by 6/19/83

UNCONTROLLED
For Information Only

PT.30[illegible]B-1

TCN [illegible]1

TABLE V

## ENGINE CYLINDER PRESSURE LOG

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Step Number<br>Date/Time | 8.82 | | | | | | | |
| ENGINE CYLINDER PRESSURE | | | | | | | | |
| 1 | 1550psi | | | | | | | |
| 2 | 1610psi | | | | | | | |
| 3 | 1600psi | | | | | | | |
| 4 | 1540psi | | | | | | | |
| 5 | 1620psi | | | | | | | |
| 6 | 1630psi | | | | | | | |
| 7 | 1680psi | | | | | | | |
| 8 | 1670psi | | | | | | | |
| | | | | | | | | |
| LOAD | 3.5mw | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

LILCO QA
REVIEWED
BY
DATE [illegible]

LILCO QA
REVIEWED
BY
DATE 7/8/82

UNCONTROLLED
For Information Only

TABLE V

UNCONTROLLED
For Information Only

## ENGINE CYLINDER PRESSURE LOG

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Step Number | STEP 8.2 | | | | | | | |
| Date/Time | 8. | | | | | | | |
| ENGINE CYLINDER PRESSURE | | | | | | | | |
| 1 | 1550<br>jk ~~1600~~ | | | | | | | |
| 2 | 1490 | | | | | | | |
| 3 | 1520 | | | | | | | |
| 4 | 1530 | | | | | | | |
| 5 | 1580 | | | | | | | |
| 6 | 1500 | | | | | | | |
| 7 | 1500 | | | | | | | |
| 8 | 1510 | | | | | | | |
| | | | | | | | | |
| LOAD | 3.5mw | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

M.J. DeGraff
6/23/83

# Engine Cylinder Pressure Logs

EDG 101, 102, 103

Post-crankshaft Replacement

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For Information Only

## APPENDIX F

## ENGINE CYLINDER PRESSURE LOG

| | | |
|---|---|---|
| Step No. | 8.8.2 | |
| Date | 4/11/84 | |
| Time | 2200 | |
| ENGINE/CYLINDER PRESSURE (PSIG) | EDG 101 | |
| 1 | 1720 | |
| 2 | 1640 | |
| 3 | 1640 | |
| 4 | 1640 | |
| 5 | 1650 | |
| 6 | 1700 | |
| 7 | 1680 | |
| 8 | 1700 | |
| Gen. Load (KW) | 3500 | |
| Var Loading (KVAR) | 2700 | |

12

Data taken by:

JTG APPROVED NOV 8 1983

EDG 102

PT.307.004B-3

UNCONTROLLED
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APPENDIX F

## ENGINE CYLINDER PRESSURE LOG

| | | |
|---|---|---|
| Step No. | 8.14.2 | |
| Date | 3-17-84 | |
| Time | 02:25 | |
| ENGINE CYLINDER PRESSURE (PSIG) | | |
| 1 | 1620 | |
| 2 | 1630 | |
| 3 | 1680 | |
| 4 | 1650 | |
| 5 | 1620 | |
| 6 | 1600 | |
| 7 | 1650 | |
| 8 | 1620 | |
| GEN Load (KW) | 3528 | |
| Var Loading (KVAR) | 2625 | |

Data taken by: John W. McGready John M Welch

STG APPROVED JAN 26 1984

UNCONTROLLED
For Information Only

## APPENDIX F

## ENGINE CYLINDER PRESSURE LOG

| | | |
|---|---|---|
| Step No. | 8.8.2 | |
| Date | 4-10-84 | |
| Time | 0555 | |
| ENGINE CYLINDER PRESSURE (PSIG) | | |
| 1 | 1620 | |
| 2 | 1640 | |
| 3 | 1680 | |
| 4 | 1500 | |
| 5 | 1590 | |
| 6 | 1680 | |
| 7 | 1550 | |
| 8 | 1670 | |
| Gen Load (KW) PC | 3595 | |
| Var Loading (KVAR) CR | 2675 | |

12

Data taken by:

RACK SETTING
43.0 mm
#3 DIESEL TEST

UTG APPROVED NOV 8 1983

# Sample Preoperational Test Procedure

UNCONTROLLED
For Information Only

Oct. 1, 1975
REVISION 0

SHOREHAM I
NUCLEAR POWER STATION
STARTUP FORM 8.3

## Preoperational Test Results Review and Approval

1. System No. R43A
2. Preoperational Test No. PT.307.004.A-2
3. System EDG 101 Qualification Preoperational Test
4. Test Engineer William J. Cook
5. Lead Startup Engineer M.W. Herlihy
6. Attached for your review are:

Preoperational Test Results and Analysis

William J Cook 4/19/84
Prepared By/Performed By

FC Clifford 4/19/84
Reviewed By

M W Herlihy 4/19/84
Reviewed By

4/23/84
Startup Manager Approval, Date

Preoperational Test Approval/Release For Performance (Startup #8.1)

System Checkout & Initial Operations Tests

Test Change Notice(s) (Startup #8.2)

7. Preoperational Test Results attached are Approved by the JTG

4/23/84
GE Site Operations Manager

William M Matejek 4/23/84
S&W Advisory Operations Engineer

4/23/84
Startup Manager

JTG Chairman

4/23/84
Date

A13522

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SHOREHAM
NUCLEAR POWER STATION

July 29, 1982

REVISION 17

START-UP FORM 8.3 PT.307.004A-2 (WPM)

8. Preoperation Test Results attached are DISAPPROVED for the following reasons: ______________________

______________________

______________________

______________________

______________________

JTG Chairman: Date

9. Authorization granted to STARTUP MANAGER to review complete system status and area status for purpose of negotiating system turnover to Production Department.

JTG Chairman: Date

10. System described herein has been thoroughly reviewed regarding testing, status of outstanding items, etc., and is ACCEPTED by the Production Department for conditional operation. 17

Startup Manager Date

Plant Manager Date

Distr: Original - Preoperational Test Procedures
Copies - JTG Chairman
Startup Manager
Lead Startup Engineer
Test Engineer
S&W Lead Advisory Engineer
GE Operations Manager
Vice President - Nuclear
OQA Engineer

17

UNCONTROLLED
For Information Only

# TRANSMITTAL RECORD

TO: J. RIVELLO

DATE: 11/9/83

LOCATION: SHOREHAM NUCLEAR POWER STATION - UNIT NO. 1

W.O. NO. 44430

BRIEF: STARTUP TEST PROCEDURE

PROJECT NO.: K.71.340

| ITEM NO. | NO. OF COPIES | BILLS OF MATERIAL, DRAWINGS, SPEC, PERMITS, ETC. | TITLE |
|---|---|---|---|
| | 2U | PT.307.004A-2 | EMERGENCY DIESEL GENERATOR QUALIFICATION TEST |

**Remarks:** Controlled copy issued to responsible Test Engineer, must be returned to PRC, as Test Engineers responsibility changes.

TCN #1 4/6/84 C. Slater

| | TYPE | ITEMS |
|---|---|---|
| G. BISHOP (G.E.) | U | 1 Ea. |
| L. BETTENHAUSEN (NRC) | U | 1 Ea. |
| C. SLATER (PRC) | U | 2 Ea. |
| C. SLATER (PRC) | O | 1 Ea. |
| E.J. YOUNGLING /T.E. | C | 1 Ea. |
| M.W. HERLIHY /L.S.E. | C | 1 Ea. |

O - ORIGINAL
WC - WORKING COPY
C - CONTROLLED
U - UNCONTROLLED

Department: LILCO STARTUP

By: C. SLATER

Transmittal Number: 10219

Forwarded To:

By:

Date:

Remarks:

FC-2017.4

A13524

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SHOREHAM I
NUCLEAR POWER STATION
STARTUP FORM 8.1

REVISION 0

Preoperational Test Approval/Release

For Performance

1. System No. R43A

2. Preoperational Test No. PT.307.004A-2

3. System: Emergency Diesel Generator 101 Qualification Preoperational Test

4. Test Engineer: William J. Cook

5. Lead Startup Engineer: M. W. Herlihy

6. Attached Preoperational Test Procedure is submitted for your Approval of content, format, acceptability and/or revision.

JTG Meeting Date Scheduled

Startup Manager Date

7. Preoperational Test Approved by Operational Q.A.

Operational QA Engineer Date

8. Preoperational Test Approved by JTG for content, format, acceptability and/or revision.

G.E. Site Operations Mgr.

S&W Advisory Operations Engr

Startup Manager

Approval:
JTG Chairman Date
(constitutes JTG approval)

Disapproval:
JTG Chairman

Date

Remarks

9. Attached Preoperational Test Procedure and completed Check-out & Initial Operations Tests with pertinent documents and comments are submitted for your "RELEASE FOR PERFORMANCE".

William J Cook
Test Engineer

4/2/84
Date

10. Preoperational Test attached RELEASED FOR PERFORMANCE.

Approval: 
Lead Startup Engineer

4/9/84
Date

Disapproval: ______________________
Lead Startup Engineer

______________________
Date

Remarks*: ______________________

*Recommendations For Partial Preop. Test, Revisions, Clarification, etc.

Distr: Original - Startup Manager
Copies - Plant Manager, S&W Lead Advisory Engineer, GE Operations Manager, Lead Startup Engineer, LILCO Operational Q.A.

UNCONTROLLED
For Information Only

PROCEDURE REVISION TRANSMITTAL - ATTACHMENT 2
PT.307.004A-2

September 12, 1983

E. J. Youngling

RECOMMENDATION TO VOID EDG PREOPERATIONAL TEST RESULTS
Shoreham Nuclear Power Station - Unit 1
W. O. No. 44430/48923

In view of the recent crankshaft failure of the 102 emergency diesel generator, a recovery program has been established to teardown and inspect all three (3) emergency diesel generators. This is being done to determine the extent of the crankshaft problems with these engines. This requires that all three (3) engine/generators be removed from their rooms, be totally disassembled, reassembled with the appropriate new parts and reinstalled back into their respective rooms.

Based on the above scope of work, it is recommended that the following preoperational test results be voided:

| | | |
|---|---|---|
| PT.307.001A-1 | EDG-101 | Mechanical Preop Test |
| PT.307.001B-1 | EDG-102 | Mechanical Preop Test |
| PT.307.001C-1 | EDG-103 | Mechanical Preop Test |
| PT.307.003A-1 | EDG-101 | Electrical Preop Test |
| PT.307.003B-1 | EDG-102 | Electrical Preop Test |
| PT.307.003C-1 | EDG-103 | Electrical Preop Test |
| PT.307.004A-1 | EDG-101 | Reliability Qualification |
| PT.307.004B-1 | EDG-102 | Reliability Qualification |
| PT.307.004C-1 | EDG-103 | Reliability Qualification |
| PT.307.005A | EDG-101 | Load Test |
| PT.307.005B | EDG-102 | Load Test |
| PT.307.005C | EDG-103 | Load Test |

These preoperational test results should be maintained on file wit their cover sheets marked void or some suitable means to identify this action. It is also recommended that the above preoperational tests be revised accordingly to incorporate, as required, the many test change notices and exceptions taken against them.

In closure, I suggest that the above recommendations be presented to the full Joint Test Group for consideration. The minutes of thi meeting would provide the formal direction to the Startup Organizat for proceeding with these actions in accordance with the Startup Manual.

William M. Matejek
Project Advisory Engineer

WMM:eom
cc: W. R. Klein
M. W. Herlihy

JTG APPROVED NOV 8 1983

A13527

Revision 17
July 29, 1982

UNCONTROLLED
For Information Only

## PROCEDURE REVISION TRANSMITTAL

Messrs: Startup Manager
Plant Manager
S&W Lead Advisory Engineer
GE Operations Manager
Operating Quality Assurance Engineer

Date: October 12, 1983

Procedure Type: P eoperational Test

Approved Procedure # PT.307.004A-1

Revised Procedure # PT.307.004A-2

Procedure Title: ~~EMERGENCY DIESEL GENERATOR QUALIFICATION TEST~~

Shoreham Nuclear Power Station - Unit 1

The subject approved procedure has been revised (the new revision number is indicated above) and is being transmitted for your review in black on pink form. The procedure changes are identified in the margin. Listed below are the changes and the reasons for the changes. See attachments to this letter.

This transmittal will serve as the approval form and will be routed to OQA, if required, for signoff before being submitted to the JTG for approval.

After the change has been approved, revised pages will be issued in black on white form.

Should you have any comments, please notify the undersigned before: October 26, 1983

E. J. Youngling EJYoungling
Test Engineer/Date

Not Required: ______
Lead Startup Engineer

OQA Approved: for Arnmuller 11/7/83

Required: 11/7/83
Lead Startup Engineer

11/8/83
GE Operations Manager

Approved: K.Terry 11/8/83
JTG CHAIRMAN Date

William M Matejek 11/8/83
S&W Lead Advisory Engineer

Remarks: ______

R Purcell for EJY 11-8-83
Startup Manager

FIGURE 4.16

4-13d

JTG APPROVED NOV 8 1983

A13528

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For Information Only

## PROCEDURE REVISION TRANSMITTAL
## ATTACHMENT 1
## PT.307.004A-2

Revision 2 to PT.307.004A incorporates TCN numbers 1 and 2 and appropriate exceptions taken against Revision 1. In addition, certain procedural requirements were added such as requirements to perform cylinder head leak check at 4, 8, and 12 hours after shutdown, update references, measure diesel room humidity before and during testing, and document baseline diesel generator performance at 0.8 power factor.

JTG APPROVED NOV 8 1983
A13529

UNCONTROLLED
For Information Only

# TRANSMITTAL RECORD

| | | | |
|---|---|---|---|
| | J. RIVELLO | DATE | 04-06-83 |
| LOCATION: | SHOREHAM NUCLEAR POWER STATION - UNIT NO. 1 | W.O. NO. | 44430 |
| BRIEF: | STARTUP TEST PROCEDURE | PROJECT NO.: | K.71.340 |

| ITEM NO. | NO OF COPIES | BILLS OF MATERIAL, DRAWINGS, SPEC, PERMITS, ETC. | TITLE |
|---|---|---|---|
| | 2U | PT.307.004A-1 | EMERGENCY DIESEL GENERATOR QUALIFICATION |

Remarks: Controlled copy issued to responsible Test Engineer, must be returned to PRC, as Test Engineers responsibility changes.

TCN #1 CS 6/13/83
TCN #2 CS 6/15/83

| | TYPE | ITEMS |
|---|---|---|
| G. BISHOP (G.E.) | U | 1 Ea. |
| L. BETTENHAUSEN (NRC) | U | 1 Ea. |
| C. SLATER (PRC) | U | 2 Ea. |
| C. SLATER (PRC) | O | 1 Ea. |
| WM. Cook /T.E. | C | 1 Ea. |
| WM. Krejin /L.S.E. | C | 1 Ea. |

O - ORIGINAL
WC - WORKING COPY
C - CONTROLLED
U - UNCONTROLLED

Department: LILCO STARTUP
By: C. SLATER / J. BARONE
Transmittal Number: 9942

Forwarded To:
By:
Date:

Remarks:

A13530

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Revision 17
July 29, 1982

PROCEDURE REVISION TRANSMITTAL

Date: 2/22/83 17

Messrs: Startup Manager
Plant Manager
S&W Lead Advisory Engineer
GE Operations Manager
Operating Quality Assurance Engineer

Procedure Type: Preoperational Test

Approved Procedure # PT.307.004A

Revised Procedure # PT.307.004A-1

Procedure Title: Emergency Diesel Generator Qualification

Shoreham Nuclear Power Station - Unit 1

The subject approved procedure has been revised (the new revision number is indicated above) and is being transmitted for your review in black on pink form. The procedure changes are identified in the margin. Listed below are the changes and the reasons for the changes.

This transmittal will serve as the approval form and will be routed to OQA, if required, for signoff before being submitted to the JTG for approval.

After the change has been approved, revised pages will be issued in black on white form.

Should you have any comments, please notify the undersigned before: March 4, 1983

William J Cook 2/22/83
Test Engineer/Date

Not Required: ____________ 17
Lead Startup Engineer

OQA Approved: 4/5/83 Required: W. R. Klein 4/5/83
Lead Startup Engineer

4/5/83 Approved: J. Rivello 4/5/83
GE Operations Manager JTG CHAIRMAN Date

William M Matejek 4/5/83 Remarks: ____________
S&W Lead Advisory Engineer

4/5/83
Startup Manager

VOID

FIGURE 4.16

✓ UNCONTROLLED
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# TRANSMITTAL RECORD

TO: J. RIVELLO

LOCATION: SHOREHAM NUCLEAR POWER STATION - UNIT 1

BRIEF: STARTUP TEST PROCEDURE

DATE: 11/9/81

W.O. NO: 4430

PROJECT NO: K.71.340

| ITEM NO. | NO. OF COPIES | BILLS OF MATERIAL, DRAWINGS, SPEC, PERMITS, ETC. | TITLE |
|---|---|---|---|
| ✓ | 2U | PT.c'17.00.4A | EMERGENCY DIESEL GENERATORS (QUALIFICATION) |

Remarks: Controlled copy [illegible] d to responsible Test Engineer, must be returned to PRC [illegible] Test Engineers responsibility changes.

| | TYPE | ITEMS |
|---|---|---|
| ✓ R. PULSIFER (G.E.) | U | 1 Ea. |
| ✓ L. Bettenhausen (NRC) | U | 1 Ea. |
| ✓ C. Slater (PRC) | U | 2 Ea. |
| ✓ C. Slater (PRC) | O | 1 Ea. |
| ✓ Wm J. Cook /T.E. | C | 1 Ea. |
| ✓ Wm R. Klein /L.S.E. | C | 1 Ea. |

O - ORIGINAL C - CONTROLLED
WC - WORKING COPY U - UNCONTROLLED

Department: LILCO STARTUP

By: C. SLATER

Transmittal Number: 9536

Forwarded To:

By:

Date:

Remarks:

FC-2011.4

A13532

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SHOREHAM I
NUCLEAR POWER STATION
STARTUP FORM 8.1

Oct. 1, 1975
REVISION 0

## Preoperational Test Approval/Release

## For Performance

1. System No. R43

2. Preoperational Test No. PT 307.004A

3. System: EMERGENCY DIESEL GENERATORS QUALIFICATION

4. Test Engineer: William J Cook

5. Lead Startup Engineer: William R Klein

6. Attached Preoperational Test Procedure is submitted for your Approval of content, format, acceptability and/or revision.

November 9, 1981
JTG Meeting Date Scheduled

11/2/81
Startup Manager — Date

7. Preoperational Test Approved by Operational Q.A.

A R Muller 11/2/81
Operational QA Engineer — Date

8. Preoperational Test Approved by JTG for content, format, acceptability and/or revision.

11/9/81
G.E. Site Operations Mgr.

William 11-9-81
S&W Advisory Operations Engr

11-9-81
Startup Manager

Approval: 11/9/81
JTG Chairman — Date
(constitutes JTG approval)

Disapproval: ____________
JTG Chairman

____________
Date

Remarks ____________

JTG APPROVED NOV 9 1981
A13533

9. Attached Preoperational Test Procedure and completed Checkout & Initial Operations Tests with pertinent documents and comments are submitted for your "RELEASE FOR PERFORMANCE".

Lead Startup Engineer/Test Engineer ______ Startup Manager ______ Date ______

10. Preoperational Test attached RELEASED FOR PERFORMANCE.

G.E. Site Operations Mgr ______

S&W Advisory Operations Engr ______

Startup Manager ______

Approval: ______
JTG Chairman
(constitutes JTG approval)

Date ______

Disapproval: ______
JTG Chairman

Date ______

Remarks*: ______

*Recommendations For Partial Preop. Test, Revisions, Clarification, etc.

Distr: Original - Startup Manager
Copies - Plant Manager, S&W Lead Advisory Engineer, GE Operations Manager, Lead Startup Engineer, LILCO Operational Q.A.

JTG APPROVED NOV 9 1981

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For Information Only

PT.307.004A-2

## TEST ENGINEER'S ANALYSIS REPORT

## EMERGENCY DIESEL GENERATOR 101 QUALIFICATION PREOP TEST

This revised Qualification Preoperational Test was "released for performance" on April 9, 1984 subsequent to the crankshaft replacement in the fall of 1983. The purpose of this test was to meet the testing requirements of USNRC Regulatory Guide 1.108, Rev. 1 section C.2.a (9) i.e. to demonstrate the ability of EDG101 to start, accept load, maintain load (greater than 50% of rated load) and to shutdown, without trips, 23 consecutive times.

Documentation of test parameters was accomplished via the use of General Electric's Transient Recording System (GETARS) which monitored and plotted start times and system parameters. GETARS produced numerical data (histograms) at selected periods during each of the 23 engine runs (i.e. start of 1 hour run, ½ hr. interval and 1 hour interval). GETARS plotted all engine shutdowns to verify no anomalies occurred which could have been interpreted as a failure of EDG101. Also during each engine run, operational logs (Appendix D) were maintained utilizing the process computer print out as the instrument of record for KW loads and GETARS as the instrument of record for all other electrical parameters (except Generator Field Voltage and Current) and engine speed. The remaining operating parameters were taken from local and control room indicators or M&TE instruments. During engine operation, the Run Log (Appendix D) intervals were determined by use of a stop watch (M&TE) and not the engine hour meter.

All twenty-three (23) starts were completed in a successful consecutive manner. The "Quick Start" requirements (engine loaded $>$ 3500 KW $\leq$ 60 seconds) were met during Start 13, as a loading time of 21.4 seconds was obtained. All engine parameters were acceptable for operating conditions and no other items of concern were notes.

There were nine (9) exceptions taken against this procedure. These are summarized below. Full details of these exceptions are contained within the body of the procedure.

### EXCEPTIONS 1, 5, 7, 9

These exceptions were taken to identify typographical errors, minor deviations from procedural step, and references that were updated. The "intent" of this procedure was not violated by these exceptions.

EXCEPTIONS 2 & 3

These exceptions were taken to identify recorded values (Appendix D) which did not meet acceptable limits (Normal Operating Parameters (Table 1)). Since, these deviations, within acceptable limits, were only slight, they were dispositioned "accept as is" because test results were not impacted.

EXCEPTION 4

This exception was taken to identify that temporary test equipment was not removed because of additional testing requirements. The removal of temporary test equipment is to be tracked by Step 9.2 of PT.307.002-2 (IET) and is not an open item to this procedure.

EXCEPTION 6

This exception was taken to explain that TCN #1 was voided because additional testing requirements will be performed as part of PT.307.003A-2 (EDG101 Electric Preop).

EXCEPTION 8

This exception clarified the interpretation of the Technical Specification surveillance requirement criteria regarding engine loading to 3500 KW in less than 60 seconds (Quick Start).

Based on the results of this test and the above analysis, it is this test engineer's opinion that twenty-three (23) starts were successfully completed in accordance with Regulatory Guide 1.108 Rev. 1 Section C.2.a (9).

William J Cook 4/19/84
William J. Cook
Test Engineer

Francis C Clifford 4/[illegible]/84
Francis C. Clifford
Test Results Reviewer

WJC/FCC:jl

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SHOREHAM 1
NUCLEAR POWER STATION
TARTUP FORM 8.2

May 15, 1980
REVISION 11

Page 1 of 4

## TEST CHANGE NOTICE #1 *Exception #6*

1. System Number: R43
2. Test Procedure Number: PT.307.004A-2
3. System Description: Emergency Diesel Generator 101 Qualification Test
4. Prepared By: R. I. Samson    4/6/84
   Cognizant System Test Engineer    Date
5. Approved By:    4/6/84
   Lead Startup Engineer    Date

| Item | Test Step and Procedure Page Number Affected | Modification Reason | LILCO System Test Engineer/ Date |
|---|---|---|---|
| 1 | Insert pages 16a & 16b | Adding Section 8.9 for Post Outage load run. | 4/10/84 |
| 2 | Remove page 18.<br>Insert new page 18. | Provide Acceptance Criteria for Section 8.9. | 4/10/84 |
|  |  |  |  |
|  |  |  |  |

This form is attached to the original master copy of the test procedure.

Distribution: ORIGINAL: Project Resource Center
COPY TO: Test Procedure (Test Engineer Copy)
Cognizant Lead Startup Engineer
Startup Manager
JTG (For JTG approved procedures only)

QA Initials (If required): WMM 4/6/84 4/6/84 4/6/84 JHR 4/6/84

A13537

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## 10.0 ACCEPTANCE CRITERIA

10.1 The Emergency Diesel Generator 101 successfully completed 23 consecutive valid tests with no failures as defined in Regulation Guide 1.108, Rev. 1 paragraph C.2.e. A valid test shall be defined as achieving a successful start, followed by a loading to at least 50% of continuous rating and continued operation for at least one hour, as per reference 2.26.

Verified ____________________ Date

OQA Witness ____________________ Date

NOTE: All charts will be available to backup readings of Appendix D. These charts will be submitted to the PRC with the approved procedure.

VOID

PER TCN #1

# EMERGENCY DIESEL GENERATOR QUALIFICATION PREOPERATIONAL TEST

2

TOTAL PAGES 37

JTG APPROVED NOV 8 1983

A13539

## 1.0 PURPOSE

1.1 The purpose of this procedure is to verify the qualification of emergency diesel generator 101 with respect to starting and loading reliability following repairs due to the failure of the crankshaft. 2

1.2 This procedure will consist of starting the diesel, loading the diesel to at least 1,750 kW, and operating the diesel at load for at least one hour 23 consecutive time without a failure.

1.3 This procedure in conjunction with PT.307.003A-2 and PT.307.002 satisfies the intent of Regulatory Guide 1.108 (August 1977), Periodic Testing of Diesel Generator Units used as On-Site Electrical Power Systems at Nuclear Power Plants. 2

1.4 At least one of the qualification runs will be used to demonstrate that the diesel generator is capable of performing its monthly surveillance requirement per Reference 2.27. 2

NOTE: All equipment mark numbers are prefixed by 1R43, unless otherwise noted.

## 2.0 REFERENCES

2.1 FSAR Sections 8.3 and 14.1.3.7.24

2.2 FM-44A-15, Fuel Oil Transfer System

2.3 FM-44B-4, Diesel Generator Air Start System

2.4 LILCO Startup Manual

2.5 LILCO Safety Manual

2.6 ESK-5R2209-14, Elementary Diagram, Emergency Bus Normal Supply ACB 101-1

2.7 ESK-5R2210-15, Elementary Diagram, Emergency Bus Reserve Supply ACB 101-2 2

2.8 ESK-5R4301-19, Elementary Diagram, Emergency Generator Breaker ACB 101-8

2.9 ESK-6R4301-6, Elementary Diagram, G-101 Starting Air Compressors

2.10 ESK-6R4304-11, Elementary Diagram, G-101 Fuel Oil Transfer Pump

JTG APPROVED NOV 8 1983

2.11 ESK-6R4307-~~5~~ 6 ats 4/10/84, Elementary Diagram, G-101 Before and After Lube Oil Pump and Heater

2.12 ESK-6R4310-~~5~~ 6 ats 4/10/84, Elementary Diagram, G-101 Jacket Water Heater and Pump

2.13 ESK-6R4313-2, Elementary Diagram, Diesel Generator G-101 Protection

2.14 ESK-8R4301-~~13~~ 14 ats 4/10/84, Elementary Diagram, Emergency Diesel Generator G-101 Protection

2.15 ESK-8R4304-7, Elementary Diagram, Emergency Diesel Synchronizing Circuit

2.16 ESK-8R4305-11 13 ats 4/10/84, Elementary Diagram, G-101 Voltage Regulator

2.17 ESK-11R4301-~~6~~ 7 ats 4/10/84, Elementary Diagram, Emergency Diesel Generator 101 Sheet 1

2.18 ESK-11R4302-~~12~~ 14 ats 4/10/84, Elementary Diagram, Emergency Diesel Generator 101 Sheet 2

2.19 ESK-11R4307-~~8~~ 7 ats 4/10/84, Elementary Diagram, Fuel Booster Pump

2.20 Manufacturer's Drawings

- 2.20.1 11600.02-1.12-5H, Lube Oil Piping Schematic
- 2.20.2 11600.02-1.12-6M, Starting Air Piping Schematic
- 2.20.3 11600.01-1.12-7~~L~~ N ats 4/10/84, Jacket Water Piping Schematic
- 2.20.4 11600.02-1.12-74M, Engine Pneumatic Schematic
- 2.20.5 11600.02-1.12-75~~L~~ M ats 4/10/84, Panel Pneumatic Schematic
- 2.20.6 11600.02-1.12-~~91C~~ 73J ats 4/10/84, Panel Installation
- 2.20.7 11600.02-1.12-93~~L~~ M ats 4/10/84, Panel Electrical Schematic
- 2.20.8 11600.02-1.12-94P, Panel Electrical Schematic
- 2.20.9 11600.02-1.51-94J, Front View Layout for BOP Main Control Board
- 2.20.10 11600.02-1.12-43G, Wiring Diagram Static Exciter

2.21 System Description (S/D 1020.307), Emergency Diesel Generators Revision 1

2

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EXCEPTION #1

2.22 Operating Procedure (SP.23.307.01), Emergency Diesel Generators Revision ~~5~~ 8 ATS

2.23 Operating Procedure (SP.23.309.01), 4,160 V Emergency Bus Distribution Revision 4

2.24 Shoreham Specification SH1-89, Diesel Generator Sets, Revision 2, January 26, 1983

2.25 Manufacturer's Instruction Manual, R43-1 Volume I, II and III

2.26 Regulator Guide 1.108 "Periodic Testing of Diesel Generator Units as on site Electrical Power Systems at Nuclear Plant". Rev. 1 August, 1977. (Paragraphs C.2.a.9 and C.2.e)

2.27 SNPS Proof and Review Copy Tech Spec 3.8.1.1 and 4.8.1.1.2 dated July 22, 1983.

2.28 Operating Procedure (SP.27.307.02) Emergency Diesel Generator Cylinder Head Leak Detection Test, Revision 1.

NOTE: All personnel signing this procedure must fill out the following information for future reference:

2

| Name (Written/Printed) | Initials (Written/Printed) | Title/ Organization | Level of Qualification I, II, III |
|---|---|---|---|
| / L. DiLoreto | L.D / L.D | TE/LSU | II |
| / A.T. Semma | ATS / ATS | TE/LSU | II |
| / H. RAYMOND SALK | / H.R.S. | TE / LSU. | II |
| E. Hassell / E. Hassell | EH / E.H. | OQA | II |
| / C. NOWISZANSKI | CSN / CSN | OQA | II |
| M.D Bove' / M.D BOVE' | MDB / MDB | TE/LSU | II |
| / James A. Maby | JAM / JAM | OQA | II |
| REGINALD A VANDERMARK<br>Reginald A Vandermark | RAV / RAV | TE/LSU | II |
| / S Y Aitha | SYA / SYA | TE/LSU | II |
| E.S. LILIMPAKIS | ESL / ESL | TE / LSU | II |
| FC Clifford / FC Clifford | FCC / FCC | TE / LSU | II |

A13542

JTG APPROVED NOV 8 1983

PT. 307.004A-2

| NAME (printed) | NAME (signed) | INITIALS PRINTED/WRITTEN | TITLE | LEVEL OF QUALIFICATIO |
|---|---|---|---|---|
| MICHAEL M GORGENYI | Michael M Gorgenyi | MMG / MMG | OQA | II |
| TERRY MORELAND | [illegible] | TM / [illegible] | TECH / ESU | I |
| Stephen Cummings | Stephen Cummings | SC / SC | Tech LSU | I |
| TONY C. MASSETTI | Tony C. Massetti | TCM / TCM | TECH LSU | I |
| AL MEYER | Al Meyer | AM / AM | TECH LSU | I |
| RAYMOND SIMON | Raymond Simon | RS / RS | Tech LSU | I |
| PAUL WARNTZ | Paul Warntz | P.W / P.W | TECH LSU | I |
| ROBERT T SMITH JR | Robert T. Smith Jr | RTS / RTS | TECH LSU | I |
| Richard T. Quit | Richard T. Quit | RTQ RTQ | Tech LSU | I |
| DOUGLAS E. Campbell | Douglas E. Campbell | DEC DEC | FOREMAN TECHS. / LSU | II |
| WILLIAM P. [illegible] | William P. [illegible] | WPY / WPY | TECH / LSU | I |
| REGINALD A VANDER[illegible] | Reginald A. Vander[illegible] | RAV RAV | TECH LSU | II |
| A. C. Todoro | [illegible] | AT [illegible] | OQA | III |

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A135-43

## 3.0 PREREQUISITES

3.1 The master punch list contains no deficiencies that will affect this test. List any exceptions in Section 11.0. | 2

4/10/84
Verified Date

3.2 Verify applicable C&IO tests have been performed, and have been approved.

4/10/84
Verified Date

3.3 The Lead Startup Engineer has released test for performance (SU Form 8.1).

A. J. Sonnema 4-10-84
Verified Date

3.4 Emergency Diesel Generator Mechanical Preoperational Test Procedure PT.307.001A-2 and the Emergency Diesel Generator Electrical Preoperational Test Procedure PT.307.003A-2 have been completed. | 2

4/10/84
Verified Date

3.5 Notify the Watch Engineer and OQA prior to performing test.

A. J. Sonnema 4-10-84
Verified Date

3.6 Notify the LILCO System Operator prior to performing test.

A. J. Sonnema 4-10-84
Verified Date

3.7 Notify DeLaval representative that this procedure is about to commence.

A. J. Sonnema 4-10-84
Verified Date

3.8 Establish communication between an operator at the Emergency Diesel Control Panel and an operator in the Main Control Room at the Emergency Diesel Generator portion of Panel 1H11*MCB-01.

A. J. Sonnema 4-10-84
Verified Date

3.9 Diesel engine inputs to the process computer need not be verified if the computer is not available.

Computer [✓ is]/is not available.

A J Somma 4-10-84
Verified Date

3.10 Ensure all documents used at time of this test are of the latest revision.

Exception #1
Verified Date

3.11 Verify valve lineup in accordance with Appendix A.

A J Somma 4-10-84
Verified Date

## 4.0 PRECAUTIONS

4.1 A sudden increase in lubrication oil temperature and amount of vapor from the crankcase ventilating discharge can indicate some overheated internal part of the engine. This could signal an approaching piston seizure and a possible crankcase explosion. A sudden increase in lube oil temperature requires immediate unloading and shutdown of the diesel.

4.2 Sustained operation of the diesel below 875 KW (critical load) should be avoided. However, when unloading unit, reduce load between 100 - 200 KW prior to opening diesel generator output breaker.

4.3 Sustained operation of the diesel in the range of 250 to 400 rpm (critical speed) should be avoided.

4.4 When starting a cool engine after shutdown, observe the manufacturer's starting procedure in Section 4 of Volume I of the manufacturer's instruction manual.

4.5 Ear protection should be worn by personnel in the Diesel Generator Room during diesel operation.

4.6 An operator should continuously monitor the operation of the diesel and auxiliary equipment throughout the entire test. At least one set of log readings should be taken whenever the diesel is started.

4.7 Diesel Room air temperature and humidity should be frequently monitored during diesel testing (especially in the vicinity of the air dryers and fuel oil day tanks).

4.8 Any fuel oil or lube oil spills should be wiped up as soon as possible to avoid fire hazards.

4.9 Portable fire extinguishing equipment should be readily available during diesel testing.

4.10 When leaving a diesel generator room, ensure that the fire doors between individual diesel generator rooms are closed.

4.11 Lube oil strainers should be cleaned when the differential pressure across them reaches 20 psid.

4.12 Lube oil filters should be changed when the differential pressure across them reaches 20 psid.

4.13 Fuel oil strainers should be cleaned when the differential pressure across them reaches 2.0 psid.

4.14 Fuel oil filters should be changed when the differential across them reaches 20 psid.

4.15 Lube oil pressure should not exceed 65 psig, or drop below 50 psig.

4.16 Jacket water pressure should not exceed 30 psig, or drop below 20 psig.

4.17 Fuel oil pressure should not exceed 35 psig.

4.18 Lube oil and jacket water temperatures should not exceed 200°F.

4.19 The exhaust temperature limits for sustained operation is 150°F between any two cylinders at full load. The maximum temperature limit at any load is 1100°F. Should these limits be reached, reduce load and notify Test Engineer.

4.20 For sustained operation, 200 psig is maximum firing pressure difference between any two cylinders at any load. Should these limits be reached, reduce load and notify Test Engineer.

4.21 Turbocharger lube oil pressure should not drop below 25 psig.

4.22 If the diesel is to be shutdown for greater than 4 hours during any portion of this test, perform a cylinder head leakage surveillance per Reference 2.28 (SP.27.307.02). 2

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## 5.0 INITIAL CONDITIONS

5.1 Engine 101 is shutdown ready for testing and its output breaker 1R22*SWGR101-8 ACB is open.

AJ Sonnema 4-10-84
Verified Date

5.2 Verify equipment is energized in accordance with Appendix B, System Component Power Supply Checklist, by initialing next to each step.

AJ Sonnema 4-10-84
Verified Date

5.3 Service Water System is in operation to supply cooling water to the Jacket Water Cooler.

AJ Sonnema 4-10-84
Verified Date

5.4 Emergency Diesel Generator 101 HVAC System is in operation.

AJ Sonnema 4-10-84
Verified Date

5.5 Fire Protection (Cardox System) is available in diesel room 101, or Fire Watch has been provided in case of fire.

AJ Sonnema 4-10-84
Verified Date

5.6 Verify *ENG101 has been barred over using barring device within one hour of first diesel start, and no presence of water was found.

AJ Sonnema 4-10-84
Verified Date

5.7 Diesel Generator Fuel Oil Storage and Transfer System is in operation.

AJ Sonnema 4-10-84
Verified Date

5.8 At emergency switchgear 1R22*SWG101, check the following at diesel generator supply breaker ACB 101-8 compartment:

5.8.1 Local control switch midposition.

AJ Sonnema 4-10-84
Verified Date

5.8.2 Circuit Breaker closing springs charged.

AJ Somma 4-10-84
Verified Date

5.8.3 GREEN (Open) indication shown for breaker.

AJ Somma 4-10-84
Verified Date

5.8.4 Primary protection lockout relay 86P-101-8 reset.

AJ Somma 4-10-84
Verified Date

5.8.5 Backup protection lockout relay 86B-101-8 reset.

AJ Somma 4-10-84
Verified Date

5.9 Place or check the following switches at the emergency diesel generator *G101 local diesel control panel *PNL-DG1 in the positions indicated:

5.9.1 Mode selector switch in REMOTE.

AJ Somma 4-10-84
Verified Date

5.9.2 Before and after LO pump/heater (*P-226A) and *H-015A in AUTO.

AJ Somma 4-10-84
Verified Date

5.9.3 Fuel booster pump *P-109A in AUTO.

AJ Somma 4-10-84
Verified Date

5.9.4 Jacket Water pump/heaters (*P-238A and *H-014A and D in AUTO.

AJ Somma 4-10-84
Verified Date

5.9.5 Both starting air compressors *C-003A and *C-004A in AUTO.

~~EXCEPTION #1~~
AJS AJ Somma 4-10-84
Verified Date

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For Information Only

5.9.6 Primary fuel oil transfer pump *P-201A in AUTO.

A J Somma 4-10-84
Verified Date

5.9.7 Secondary fuel oil transfer pump *P-202A in AUTO.

A J Somma 4-10-84
Verified Date

5.9.8 White control power available light ON.

A J Somma 4-10-84
Verified Date

5.10 Verify starting air pressure as indicated on local diesel control panel *PNL-DG1 is greater than 220 psig.

A J Somma 4-10-84
Verified Date

5.11 Verify Before and After Lube Oil Pump *P-226A is operating.

A J Somma 4-10-84
Verified Date

5.12 Verify Jacket Water Heater Circulating Pump *P-238A is operating.

A J Somma 4-10-84
Verified Date

5.13 Verify lube oil temperature is above 140°F.

A. J. Somma 4-10-84
Verified Date

5.14 Verify jacket water standpipe level is greater than 10 o'clock and jacket water temperature is greater than 140°F. 2

A J Somma 4-10-84
Verified Date

5.15 At diesel generator *G-101 hydraulic actuator/governor, record the following settings:

5.15.1 Speed Droop (0 - 10) 0 Initials AJS

5.15.2 Load Limit Max Initials ajs
(Fuel Setting)
(Min - Max)

5.15.3 Speed Setting 14.08 Initials ajs
(0 - 23)

5.16 Check air dryers *AD-002A and *AD-003A to ensure they are both running and that the cooling fin air passages are not blocked.

A.J. Somma 4-10-84
Verified Date

5.17 Ensure the fire doors between the diesel generator rooms are closed.

A.J. Somma 4-10-84
Verified Date

5.18 At the diesel generator *G-101 section of control room control panel 1H11*MCB-01, place or verify the following switches are in the positions indicated:

5.18.1 Diesel generator *G-101 start control switch in AUTO.

A.J. Somma 4-10-84
Verified Date

5.18.2 *G-101 governor speed changer in mid position.

A.J. Somma 4-10-84
Verified Date

5.18.3 Bus 101 program reset to RESET.

A.J. Somma 4-10-84
Verified Date

5.18.4 Bus 101 program test switch in NORMAL.

A.J. Somma 4-10-84
Verified Date

5.18.5 *G101 voltage regulator control switch in mid position.

A.J. Somma 4-10-84
Verified Date

5.18.6 Jacket Water cooler *E-013A outlet valve 1P41*AOV-016A in AUTO.

A.J. Somma 4-10-84
Verified Date

5.18.7 125V Bus A dc volts greater than or equal to 125 volts.

A.J. Somma 4-10-84
Verified Date

E. Hassell 4/10/84
OQA Witness Date

5.18.8 125V dc Bus A battery ground detector lights are both dim and alarm point 0357 (125V Bat A Ground) is not annunciated.

A.J. Somma 4-10-84
Verified Date

Carl Hassell 4/10/84
OQA Witness Date

5.19 Verify emergency bus 101 is being supplied from the NSST (101-1 closed) ✓ or RSST (101-2 closed) ________. Check one. | 2

A.J. Somma 4-10-84
Verified Date

5.20 Verify the Honeywell Visi recorder and/or the GE Transient Analysis Response Computer is connected to record the following 7 inputs as follows: | 2

Channel 1 - Engine Speed (RPM) @ output of tachometer
Channel 2 - Generator AC Voltage @ *PNLGP1
Channel 3 - Generator AC Current (Amps ) @ 1H11*MCB01
Channel 4 - Generator Load (Watts) @ 1H11*MCB01
Channel 5 - Generator ACB 101-8 closure @ SWGR 101-8
Channel 6 - Diesel start from start circuit Exception #7
Channel 7 - Generator freq. from 1H11*MCB01

Indicate: Visirecord ________, GETARS ✓ or Both ________ recording inputs. | 2

A.J. Somma 4-10-84
Verified Date

5.21 Wire a temporary selector switch (capable of handling 6 RTD's) to the Generator Winding RTD's. Connect the output off the selector switch to a digital volt meter. This setup will be used to determine the hottest Generator winding temperature. Record temporary hookup in SNPS lifted lead and jumper program. 2

4/10/84
Verified Date

5.22 Verify no abnormal alarms are initiated, which would prevent a successful start.

4-10-84
Verified Date

5.23 Connect a micromite to the output of the generator pedestal bearing RTD to permit measurement of bearing temperature. Record any necessary temporary connections in the lifted lead and jumper program. 2

4/10/84
Verified Date

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## 6.0 ENVIRONMENTAL CONDITIONS

6.1 Diesel room temperature below 120°F.

6.2 Diesel room humidity below 80% relative humidity.

At start of test:

Diesel Room Temperature: 90 °F

Diesel Room Humidity : 18 %

Verified Date 4-10-84

2

## 7.0 SPECIAL TEST EQUIPMENT

7.1 Stop watches.

7.2 High speed visirecorder with at least 7 channels.

7.3 Getars computer (if available).

7.4 Temporary RTD measuring switch box.

7.5 Psychrometer

7.6 Digital Voltmeter

7.7 Micromite

2

NOTE: All above used test equipment should be recorded on Table III.

JTG APPROVED NOV 8 1983

## 8.0 PROCEDURE

NOTE: All KVAR values specified are lagging vars. | 2

8.1 All prerequisites in Section 3.0 and initial conditions in Section 5.0 have been satisfied. Any exceptions are listed in the Exception Section, Section 11.0.

4-10-84
Verified Date

4-10-84
OQA Witness Date

8.2 Verify that the emergency diesel shutdown parameters were recorded on Appendix D just prior to the next diesel start, are within tolerances per Table II, and engine is ready to be restarted. (If engine has been shutdown for more than 12 hours the initial conditions of paragraph 5.0 have been reverified).

8.3 Start emergency diesel generator 101 and load to at least 1750KW and 700 KVars.

8.4 Run the diesel generator at load for at least one (1) hour while completing all the data in Appendix D. The one (1) hour run at load shall be timed using a stop watch. | 2

NOTE: The time to start, load and shutdown the engine shall not be included in the one hour.

8.5 Reduce generator load to 100 - 200 KW, run at this load for 2 min to allow unit cooldown, open its output breaker 101-8 and then shutdown the diesel engine by depressing stop pushbutton.

NOTE: Prior to shutdown from the 23rd start, perform step 8.8.

8.6 Verify that the engine was successfully started, loaded to constitute a valid test and that the data recorded on Appendix D conforms to the ranges of Table I and Table II.

8.7 Repeat steps 8.2 through 8.6 until twenty three consecutive successful starts and qualification runs are accomplished.

NOTE 1: Sign-off of the above steps will be done in Appendix C. Should a start be considered a failure (per reference 2.26) indicate such on Appendix C, correct the problem and begin the first qualification start again. Any failures will be explained as an exception in Section 11.0.

8.7 - continued

Exception #8

NOTE 2: At least one of the 23 consecutive starts should verify the diesel generator is capable of being ~~started~~, synchronized, loaded to greater than or equal to 3500KW/1500KVars in less than or equal to 60 seconds, and operated with this load for at least 60 minutes.

SFC 4/11/84

8.8 Final Baseline Data at Various Diesel Load Levels

8.8.1 Verify the emergency diesel generator is running at approximately full load (3500KW/ 2625 K Vars) then record running data in Appendix E. 2

Verified 4/11/84 Date

Jane A. Mosley 4/11/84
OQA Witness Date

8.8.2 While still at full load, record cylinder pressure data in Appendix E. 2

Verified 4/11/84 Date

Jane A. Mosley 4/11/84
OQA Witness Date

8.8.3 Reduce load to approximately 75% load, (2600KW/2000 K Vars) long enough for parameters to stabilize, then record data in Appendix E. 2 2

Verified 4/11/84 Date

Jane A. Mosley 4/11/84
OQA Witness Date

8.8.4 Reduce diesel generator load to approximately 50% (1750 KW/1300 K Vars), run long enough to stabilize parameters, then record data in Appendix E. 2 2

Verified 4/11/84 Date

Jane A. Mosley 4/11/84
OQA Witness Date

8.8.5 Reduce diesel generator load to approximately 25% (900 KW/650 K Vars), run long enough to stabilize parameters, then record data in Appendix E. | 2 | 2

Bove' 4/11/84
Verified Date

James A. Moody 4/11/84
OQA Witness Date

8.8.6 Shutdown diesel generator in accordance with SP.23.307.01, paragraph 8.1.6 and leave engine in standby or as directed by test engineer.

Bove' 4/11/84
Verified Date

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TCN #1

PT.307.004A-2

## 8.9 Post Outage Load Run (5 hours)

8.9.1 Start the Diesel Generator and parallel to its emergency bus. Load the Diesel to approximately 3500KW and 2000 KVARS as monitored by the main control room meters. Establish engine equilibrium conditions prior to continuing test.

Verified ______ Date ______

OQA Witness ______ Date ______

8.9.2 Block the governor load limit setting on the hydraulic actuator. Raise the electric speed setting above 4000KW.

Slowly raise the load limit until the load stabilizes at 3900KW + 0.25% - 1.0% (i.e. load between 3861KW and 3910KW) as measured by the watt hour meter over a minimum three minute time interval. The control room operator should simultaneously increase the Var loading to obtain a final reading between 2800 KVARS - 2900KVARS.

Verified ______ Date ______

OQA Witness ______ Date ______

Voided Except 6 Tce 4/15/84

OQA 4/16/84 EX#6 Noted

TCN #1

PT.307.004A-2

8.9.3 Run at this load for one hour, recording all parameters in Appendix E every 15 minutes. Cross out the existing step numbers on Appendix E and fill in step no. 8.9.3 for this run. Ensure generator field current does not exceed 305 amps and field resistance is less than .395 ohms.

Verified ________ Date ________

OQA Witness ________ Date ________

8.9.4 Reduce load to a value greater than or equal to 3500KW and 1900KVAR. Run at this load for at least four hours. Record all parameters listed in Appendix E every 20 minutes for the first two hours. For the remaining two hours record data every 30 minutes. Cross out the existing step numbers on Appendix E and fill in step no. 8.9.4 for this run.

Verified ________ Date ________

OQA Witness ________ Date ________

8.9.5 At the end of the 4 hour run, change the diesel load or shut down the diesel engine as directed by the Test Engineer.

Verified ________ Date ________

OQA Witness ________ Date ________

Voided by
Except
FCC 4/13/84
OQA 4/16/84
EX#6 NOTED

## 9.0 SYSTEM RETURN TO NORMAL

9.1 Place the diesel generator in its normal standby condition as directed by Test Engineer.

Verified 4/12/84 Date

James A Mosley 4/12/84
OQA Witness Date

9.2 Indicate in Appendix A the as left condition of each valve at the completion of this test.

Verified 4/12/84 Date

Carl S 4/12/84
OQA Witness Date

9.3 Ensure all temporary test equipment has been removed.

Exception #4
Verified 4/12/84 Date

4/12/84
OQA Witness Date

9.4 Perform a cylinder head leakage surveillance per SP.27.307.02 (Ref. 2.28) at 4, 8 and 12 hours after shutdown.

After 4 hours: sat ✓ unsat ______

Verified 4/12/84 Date

James A. Mosley 4/12/84
OQA Witness Date

After 8 hours: sat ✓ unsat ______ 2

Verified 4/12/84 Date

James A. Mosley 4/12/84
OQA Witness Date

After 12 hours: sat ✓ unsat ______

A J Sommer 4/12/84
Verified Date

Carl S 4/12/84
OQA Witness Date

## 10.0 ACCEPTANCE CRITERIA

10.1 The Emergency Diesel Generator 101 successfully completed 23 consecutive valid tests with no failures as defined in Regulation Guide 1.108, Rev. 1 paragraph C.2.e. A valid test shall be defined as achieving a successful start, followed by a loading to at least 50% of continuous rating and continued operation for at least one hour, as per reference 2.26.

Al Somma 4-12-84
Verified Date

4/16/84
OQA Witness Date

NOTE: All charts will be available to backup readings of Appendix D. These charts will be submitted to the PRC with the approved procedure.

10.2 During the post outage load run, the diesel generator ran continuously for 5 hours at loads ~~of~~ 3900KW (1 hour), and 3500KW (4 hours), (Section 8.9).

TCN#1

Verified Date

4/16 Noted
OQA Witness Date

Voided by Exception 6
JCC
4/12/84

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## 11.0 EXCEPTION SHEET

| Item | Description of Exception | Initial/ Date | Disposition | Initial/ Date |
|---|---|---|---|---|
| EXCEPTION #1 | STEP 3.10 | | | |
| | References indicated on | | Updated references | |
| | pages 2 and 3 of | | as indicated on pages | |
| | procedure are not of | | 2 and 3 of | |
| | the latest Revision | | procedure [illegible] effect - Test | |
| | number. | AJS 4-10-84 | Results. Accept as is. | AJS 4-10-84 |
| | | | | |
| Exc. #2 | QUAL RUN #, 12, 13, 14, Data Sheets | NRB | LILCO Grid feed was | |
| | STEP 8.6 - | 4/11/84 | transferred from the NST | |
| | Generator Voltage out of | | The RST to support | |
| | spec per Table I | | plant maintenance on | |
| | | | the NST. Grid disturbances | |
| | | | on the RST feed caused | |
| | | | the Generator Voltage | |
| | | | to be slightly high | |
| | | | No effect on testing. | |
| | | | Since this voltage can | |
| | | | only be changed by | |
| | | | LILCO System load | |
| | | | dispatcher, it will be | |
| | | | accepted as is. | NRB 4/11/84 |
| | | | QA | 4/12/84 |
| | | | | |
| | | | | |

## 11.0 EXCEPTION SHEET

| Item | Description of Exception | Initial/ Date | Disposition | Initial/ Date |
|---|---|---|---|---|
| | | | | |
| Exc #3 | Qual Run #14. Data sheets | | Due to the small initial | |
| | Step 8.6 | 4/11/84 | loading (only about 800KW) | |
| | J.W temp slightly out of | | on the Auto UV start | |
| | spec per Table I | | the JW did not heat up. | |
| | | | After synching to grid and | |
| | | | loading to 2000 KW and | |
| | | | running at this load the | |
| | | | J.W. temp came into spec | |
| | | | Accept as is | |
| | | | OPA 4/16/84 | 4/11/84 |
| Exc #4 | PT 307.004 A-2 page 17 | | TEMPORARY | |
| | step 9.3; All TEMPORARY | 4/12/84 | test equip- | |
| | test equipment will | ORA | ment is being | |
| | not be removed at this | | left installed | |
| | Time. | | to support the | |
| | | | Integrated Elec. | |
| | | | Test (PT 307.002-2) | |
| | | | and will be removed | |
| | | | when the IET has | |
| | | | been successfully | |
| | | | Completed | |
| | | | | 4/17/84 |
| | | | TEMPORARY TEST EQUIPMENT TO BE REMOVED [illegible] STEP [illegible] | |

OF PT.307.002-2, see attached sheets

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## 11.0 EXCEPTION SHEET

| Item | Description of Exception | Initial/ Date | Disposition | Initial/ Date |
|---|---|---|---|---|
| 5 | App D page 2 of 3/App E page 2 of 2 | | | |
| | The Generator Winding Temp | FCC | Type, description (App D, E) | |
| | is being monitored by RTD | 4/12/84 | changed to indicate the | |
| | and the Bearing Temp is | | correct temp monitoring | |
| | being monitored by TE073A | | device. Accept as is, does | |
| | | | not affect test results | |
| | | | FCC 4/12/84 | |
| | | | OQA | 4/19/84 |
| | | | | |
| 6 | PT.307.004A-2 TCN #1 pgs 2,3+4 | | | |
| | Section 8.9 'Post Outage Load Run (5hrs) | | Post Outage Load Runs | |
| | The referenced section will not | FCC | will be performed by | |
| | be performed as part of the | 4/12/84 | Stop/Restart #5 and | |
| | Qual Test (PT307004A-2) | | TCN #1 to PT.307.007A-2 | |
| | | | (EDG [illegible] Electrical Preop | |
| | | | These addition engine runs | |
| | | | will be reviewed and | |
| | | | approved with PT307.004A-2 | |
| | | | Accept as is, Post Outage | |
| | | | load runs were initiated | |
| | | | by Lilco ~~as an~~ to verify ~~addition~~ FCC the five | |
| | | | reliability requirements. This is not | |
| | | | an open item to this procedure FCC 4/12/84 | |
| | | | OQA | 4/16/84 |

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## 11.0 EXCEPTION SHEET

| Item | Description of Exception | Initial/ Date | Disposition | Initial/ Date |
|---|---|---|---|---|
| 7 | Step 5.20 Channel #6 | | | |
| | GETARS did not monitor | TCC | GETAR operator | |
| | the diesel start automatically | 4/16/84 | will coordinate all | |
| | | | DG starts with | |
| | | | Control Room operator | |
| | | | and will manually | |
| | | | initiate an event | |
| | | | marker to indicate | |
| | | | when start occurred. | |
| | | | Accept as is | TCC 4/16/84 |
| | | | [illegible] | 4/19/84 |
| | | | | |
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## 11.0 EXCEPTION SHEET

| Item | Description of Exception | Initial/ Date | Disposition | Initial/ Date |
|---|---|---|---|---|
| 8 | Step 8.7 Note 2: | | | |
| | The start time is | FCE | The Tech Spec | |
| | incorrectly included in | 4/17/84 | Surveillance Requirements | |
| | the "Quick Start" | | (Section 4.8.1.1.2a.5) | |
| | (60sec.) criteria. | | do not include the | |
| | | | start time in the | |
| | | | "Quick Start" requirements; | |
| | | | see attached sheet. | |
| | | | FCE 4/18/84 | |
| | | | POQA 4/19/84 | |
| | | | | |
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Test Procedure # PT.307.004A-2

EXCEPTION SHEET
Test Procedure Section # 11.0
Page 6 of 6

| Description of Exception | Init./ Date | Disposition | Init./ Date |
|---|---|---|---|
| Exception 9<br>Appendix A&B | | | |
| TK 807 Fill and Drain Valve have incorrectly referenced valve number | TEC 4/16/84 | Typo, the correct valve #'s are x02V-0218A (Fill) and x02V-3216A (Drain) Accept as is, Ref Drawing 1.12-7N<br>TEC 4/16/84 | |
| P201A Discharge valve has incorrectly referenced valve number | TEC 4/16/84 | Typo, the correct valve # is x02V-0202A. Accept as is, Ref Drawing MFSK-44A-9<br>TEC 4/16/84 | |
| Power Supply for PNL-DC-1 and 1R22*SWGR 101 is incorrectly referenced CKT 5 for 125 V DC for DG101 ACB 101-8 is incorrect. | TEC 4/16/84 | Typo, the correct power supply designation is 1R42* PNL-A1. CKT 11 is correct for 125 V DC for DG101 ACB 101-8. Accept as is, Ref Drawing FE15F-8<br>TEC 4/16/84 | |

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EXC#

# MINCO

## RESISTANCE TEMPERATURE TABLE
COPPER
RESISTANCE THERMOMETER
9.035 OHMS AT 32°F.

## TABLE 17-9

7300 Commerce Lane | Minneapolis, Minnesota 55432 | TWX: 910-576-2848 | Telephone: (612) 786-3121

| T(F) | R(OHMS) | T(F) | R(OHMS) | T(F) | R(OHMS) | T(F) | R(OHMS) |
|---|---|---|---|---|---|---|---|
| -400 | | -360 | | -320 | 1.242 | -280 | 2.158 |
| -399 | | -359 | | -319 | 1.265 | -279 | 2.181 |
| -398 | | -358 | | -318 | 1.288 | -278 | 2.204 |
| -397 | | -357 | | -317 | 1.311 | -277 | 2.227 |
| -396 | | -356 | | -316 | 1.334 | -276 | 2.250 |
| -395 | | -355 | | -315 | 1.357 | -275 | 2.272 |
| -394 | | -354 | | -314 | 1.380 | -274 | 2.295 |
| -393 | | -353 | | -313 | 1.403 | -273 | 2.318 |
| -392 | | -352 | | -312 | 1.426 | -272 | 2.341 |
| -391 | | -351 | | -311 | 1.449 | -271 | 2.364 |
| -390 | | -350 | | -310 | 1.472 | -270 | 2.386 |
| -389 | | -349 | | -309 | 1.495 | -269 | 2.409 |
| -388 | | -348 | | -308 | 1.518 | -268 | 2.432 |
| -387 | | -347 | | -307 | 1.541 | -267 | 2.455 |
| -386 | | -346 | | -306 | 1.564 | -266 | 2.477 |
| -385 | | -345 | | -305 | 1.587 | -265 | 2.500 |
| -384 | | -344 | | -304 | 1.609 | -264 | 2.523 |
| -383 | | -343 | | -303 | 1.632 | -263 | 2.546 |
| -382 | | -342 | | -302 | 1.655 | -262 | 2.568 |
| -381 | | -341 | | -301 | 1.678 | -261 | 2.591 |
| -380 | | -340 | | -300 | 1.701 | -260 | 2.614 |
| -379 | | -339 | | -299 | 1.724 | -259 | 2.637 |
| -378 | | -338 | | -298 | 1.747 | -258 | 2.660 |
| -377 | | -337 | | -297 | 1.770 | -257 | 2.682 |
| -376 | | -336 | | -296 | 1.793 | -256 | 2.705 |
| -375 | | -335 | | -295 | 1.816 | -255 | 2.727 |
| -374 | | -334 | | -294 | 1.839 | -254 | 2.749 |
| -373 | | -333 | | -293 | 1.861 | -253 | 2.773 |
| -372 | | -332 | | -292 | 1.884 | -252 | 2.795 |
| -371 | | -331 | | -291 | 1.907 | -251 | 2.818 |
| -370 | | -330 | | -290 | 1.930 | -250 | 2.841 |
| -369 | | -329 | | -289 | 1.953 | -249 | 2.863 |
| -368 | | -328 | 1.058 | -288 | 1.976 | -248 | 2.886 |
| -367 | | -327 | 1.081 | -287 | 1.999 | -247 | 2.909 |
| -366 | | -326 | 1.104 | -286 | 2.021 | -246 | 2.931 |
| -365 | | -325 | 1.127 | -285 | 2.044 | -245 | 2.954 |
| -364 | | -324 | 1.150 | -284 | 2.067 | -244 | 2.977 |
| -363 | | -323 | 1.173 | -283 | 2.090 | -243 | 2.999 |
| -362 | | -322 | 1.196 | -282 | 2.113 | -242 | 3.022 |
| -361 | | -321 | 1.219 | -281 | 2.136 | -241 | 3.044 |

| T(F) | R(OHMS) | T(F) | R(OHMS) | T(F) | R(OHMS) | T(F) | R(OHMS) |
|---|---|---|---|---|---|---|---|
| -240 | 3.067 | -200 | 3.968 | -160 | 4.862 | -120 | 5.747 |
| -239 | 3.090 | -199 | 3.991 | -159 | 4.884 | -119 | 5.769 |
| -238 | 3.113 | -198 | 4.013 | -158 | 4.906 | -118 | 5.791 |
| -237 | 3.135 | -197 | 4.035 | -157 | 4.928 | -117 | 5.813 |
| -236 | 3.158 | -196 | 4.058 | -156 | 4.950 | -116 | 5.835 |
| -235 | 3.180 | -195 | 4.080 | -155 | 4.973 | -115 | 5.857 |
| -234 | 3.203 | -194 | 4.103 | -154 | 4.995 | -114 | 5.879 |
| -233 | 3.225 | -193 | 4.125 | -153 | 5.017 | -113 | 5.901 |
| -232 | 3.248 | -192 | 4.148 | -152 | 5.039 | -112 | 5.923 |
| -231 | 3.271 | -191 | 4.170 | -151 | 5.061 | -111 | 5.945 |
| -230 | 3.293 | -190 | 4.192 | -150 | 5.084 | -110 | 5.967 |
| -229 | 3.316 | -189 | 4.215 | -149 | 5.106 | -109 | 5.989 |
| -228 | 3.338 | -188 | 4.237 | -148 | 5.128 | -108 | 6.011 |
| -227 | 3.361 | -187 | 4.259 | -147 | 5.150 | -107 | 6.033 |
| -226 | 3.384 | -186 | 4.282 | -146 | 5.172 | -106 | 6.055 |
| -225 | 3.406 | -185 | 4.304 | -145 | 5.194 | -105 | 6.077 |
| -224 | 3.429 | -184 | 4.327 | -144 | 5.217 | -104 | 6.099 |
| -223 | 3.451 | -183 | 4.349 | -143 | 5.239 | -103 | 6.121 |
| -222 | 3.474 | -182 | 4.371 | -142 | 5.261 | -102 | 6.143 |
| -221 | 3.496 | -181 | 4.394 | -141 | 5.283 | -101 | 6.165 |
| -220 | 3.519 | -180 | 4.416 | -140 | 5.305 | -100 | 6.187 |
| -219 | 3.541 | -179 | 4.438 | -139 | 5.327 | -99 | 6.209 |
| -218 | 3.564 | -178 | 4.461 | -138 | 5.350 | -98 | 6.231 |
| -217 | 3.586 | -177 | 4.483 | -137 | 5.372 | -97 | 6.253 |
| -216 | 3.609 | -176 | 4.505 | -136 | 5.394 | -96 | 6.275 |
| -215 | 3.631 | -175 | 4.527 | -135 | 5.416 | -95 | 6.297 |
| -214 | 3.654 | -174 | 4.550 | -134 | 5.438 | -94 | 6.319 |
| -213 | 3.676 | -173 | 4.572 | -133 | 5.460 | -93 | 6.341 |
| -212 | 3.699 | -172 | 4.594 | -132 | 5.482 | -92 | 6.362 |
| -211 | 3.721 | -171 | 4.617 | -131 | 5.504 | -91 | 6.384 |
| -210 | 3.744 | -170 | 4.639 | -130 | 5.526 | -90 | 6.406 |
| -209 | 3.766 | -169 | 4.661 | -129 | 5.548 | -89 | 6.428 |
| -208 | 3.789 | -168 | 4.684 | -128 | 5.571 | -88 | 6.450 |
| -207 | 3.811 | -167 | 4.706 | -127 | 5.593 | -87 | 6.472 |
| -206 | 3.834 | -166 | 4.728 | -126 | 5.615 | -86 | 6.494 |
| -205 | 3.856 | -165 | 4.750 | -125 | 5.637 | -85 | 6.515 |
| -204 | 3.879 | -164 | 4.773 | -124 | 5.659 | -84 | 6.537 |
| -203 | 3.901 | -163 | 4.795 | -123 | 5.681 | -83 | 6.559 |
| -202 | 3.923 | -162 | 4.817 | -122 | 5.703 | -82 | 6.581 |
| -201 | 3.946 | -161 | 4.839 | -121 | 5.725 | -81 | 6.603 |

| T(F) | R(OHMS) | T(F) | R(OHMS) | T(F) | R(OHMS) | T(F) | R(OHMS) |
|---|---|---|---|---|---|---|---|
| -80 | 6.625 | -40 | 7.490 | 0 | 8.348 | 40 | 9.207 |
| -79 | 6.647 | -39 | 7.512 | 1 | 8.370 | 41 | 9.228 |
| -78 | 6.668 | -38 | 7.533 | 2 | 8.391 | 42 | 9.250 |
| -77 | 6.690 | -37 | 7.555 | 3 | 8.413 | 43 | 9.271 |
| -76 | 6.712 | -36 | 7.576 | 4 | 8.434 | 44 | 9.292 |
| -75 | 6.734 | -35 | 7.598 | 5 | 8.456 | 45 | 9.314 |
| -74 | 6.756 | -34 | 7.619 | 6 | 8.477 | 46 | 9.335 |
| -73 | 6.777 | -33 | 7.640 | 7 | 8.499 | 47 | 9.357 |
| -72 | 6.799 | -32 | 7.662 | 8 | 8.520 | 48 | 9.378 |
| -71 | 6.821 | -31 | 7.683 | 9 | 8.542 | 49 | 9.400 |
| -70 | 6.843 | -30 | 7.705 | 10 | 8.563 | 50 | 9.421 |
| -69 | 6.865 | -29 | 7.726 | 11 | 8.584 | 51 | 9.443 |
| -68 | 6.886 | -28 | 7.748 | 12 | 8.606 | 52 | 9.464 |
| -67 | 6.908 | -27 | 7.769 | 13 | 8.627 | 53 | 9.486 |
| -66 | 6.930 | -26 | 7.791 | 14 | 8.649 | 54 | 9.507 |
| -65 | 6.952 | -25 | 7.812 | 15 | 8.670 | 55 | 9.528 |
| -64 | 6.974 | -24 | 7.834 | 16 | 8.692 | 56 | 9.550 |
| -63 | 6.995 | -23 | 7.855 | 17 | 8.713 | 57 | 9.571 |
| -62 | 7.017 | -22 | 7.876 | 18 | 8.735 | 58 | 9.593 |
| -61 | 7.039 | -21 | 7.898 | 19 | 8.756 | 59 | 9.614 |
| -60 | 7.061 | -20 | 7.919 | 20 | 8.778 | 60 | 9.636 |
| -59 | 7.082 | -19 | 7.941 | 21 | 8.799 | 61 | 9.657 |
| -58 | 7.104 | -18 | 7.962 | 22 | 8.820 | 62 | 9.679 |
| -57 | 7.126 | -17 | 7.984 | 23 | 8.842 | 63 | 9.700 |
| -56 | 7.147 | -16 | 8.005 | 24 | 8.863 | 64 | 9.722 |
| -55 | 7.169 | -15 | 8.027 | 25 | 8.885 | 65 | 9.743 |
| -54 | 7.190 | -14 | 8.048 | 26 | 8.906 | 66 | 9.764 |
| -53 | 7.211 | -13 | 8.070 | 27 | 8.928 | 67 | 9.786 |
| -52 | 7.233 | -12 | 8.091 | 28 | 8.949 | 68 | 9.807 |
| -51 | 7.254 | -11 | 8.112 | 29 | 8.971 | 69 | 9.829 |
| -50 | 7.276 | -10 | 8.134 | 30 | 8.992 | 70 | 9.850 |
| -49 | 7.297 | -9 | 8.155 | 31 | 9.014 | 71 | 9.872 |
| -48 | 7.319 | -8 | 8.177 | 32 | 9.035 | 72 | 9.893 |
| -47 | 7.340 | -7 | 8.198 | 33 | 9.056 | 73 | 9.914 |
| -46 | 7.362 | -6 | 8.220 | 34 | 9.078 | 74 | 9.936 |
| -45 | 7.383 | -5 | 8.241 | 35 | 9.099 | 75 | 9.958 |
| -44 | 7.404 | -4 | 8.263 | 36 | 9.121 | 76 | 9.979 |
| -43 | 7.426 | -3 | 8.284 | 37 | 9.142 | 77 | 10.000 |
| -42 | 7.447 | -2 | 8.306 | 38 | 9.164 | 78 | 10.022 |
| -41 | 7.469 | -1 | 8.327 | 39 | 9.185 | 79 | 10.043 |

| T(F) | R(OHMS) | T(F) | R(OHMS) | T(F) | R(OHMS) | T(F) | R(OHMS) |
|---|---|---|---|---|---|---|---|
| 80 | 10.065 | 120 | 10.923 | 160 | 11.781 | 200 | 12.639 |
| 81 | 10.086 | 121 | 10.944 | 161 | 11.803 | 201 | 12.661 |
| 82 | 10.108 | 122 | 10.966 | 162 | 11.824 | 202 | 12.682 |
| 83 | 10.129 | 123 | 10.987 | 163 | 11.846 | 203 | 12.704 |
| 84 | 10.151 | 124 | 11.009 | 164 | 11.867 | 204 | 12.725 |
| 85 | 10.172 | 125 | 11.030 | 165 | 11.888 | 205 | 12.747 |
| 86 | 10.194 | 126 | 11.052 | 166 | 11.910 | 206 | 12.768 |
| 87 | 10.215 | 127 | 11.073 | 167 | 11.931 | 207 | 12.789 |
| 88 | 10.236 | 128 | 11.095 | 168 | 11.953 | 208 | 12.811 |
| 89 | 10.258 | 129 | 11.116 | 169 | 11.974 | 209 | 12.832 |
| 90 | 10.279 | 130 | 11.138 | 170 | 11.996 | 210 | 12.854 |
| 91 | 10.301 | 131 | 11.159 | 171 | 12.017 | 211 | 12.875 |
| 92 | 10.322 | 132 | 11.180 | 172 | 12.039 | 212 | 12.897 |
| 93 | 10.344 | 133 | 11.202 | 173 | 12.060 | 213 | 12.918 |
| 94 | 10.365 | 134 | 11.223 | 174 | 12.082 | 214 | 12.940 |
| 95 | 10.387 | 135 | 11.245 | 175 | 12.103 | 215 | 12.961 |
| 96 | 10.408 | 136 | 11.266 | 176 | 12.124 | 216 | 12.983 |
| 97 | 10.430 | 137 | 11.288 | 177 | 12.146 | 217 | 13.004 |
| 98 | 10.451 | 138 | 11.309 | 178 | 12.167 | 218 | 13.026 |
| 99 | 10.472 | 139 | 11.331 | 179 | 12.189 | 219 | 13.047 |
| 100 | 10.494 | 140 | 11.352 | 180 | 12.210 | 220 | 13.068 |
| 101 | 10.515 | 141 | 11.374 | 181 | 12.232 | 221 | 13.090 |
| 102 | 10.537 | 142 | 11.395 | 182 | 12.253 | 222 | 13.111 |
| 103 | 10.558 | 143 | 11.416 | 183 | 12.275 | 223 | 13.133 |
| 104 | 10.580 | 144 | 11.438 | 184 | 12.296 | 224 | 13.154 |
| 105 | 10.601 | 145 | 11.459 | 185 | 12.318 | 225 | 13.176 |
| 106 | 10.623 | 146 | 11.481 | 186 | 12.339 | 226 | 13.197 |
| 107 | 10.644 | 147 | 11.502 | 187 | 12.360 | 227 | 13.219 |
| 108 | 10.666 | 148 | 11.524 | 188 | 12.382 | 228 | 13.240 |
| 109 | 10.687 | 149 | 11.545 | 189 | 12.403 | 229 | 13.262 |
| 110 | 10.708 | 150 | 11.567 | 190 | 12.425 | 230 | 13.283 |
| 111 | 10.730 | 151 | 11.588 | 191 | 12.446 | 231 | 13.304 |
| 112 | 10.751 | 152 | 11.610 | 192 | 12.468 | 232 | 13.326 |
| 113 | 10.773 | 153 | 11.631 | 193 | 12.489 | 233 | 13.347 |
| 114 | 10.794 | 154 | 11.652 | 194 | 12.511 | 234 | 13.369 |
| 115 | 10.816 | 155 | 11.674 | 195 | 12.532 | 235 | 13.390 |
| 116 | 10.837 | 156 | 11.695 | 196 | 12.554 | 236 | 13.412 |
| 117 | 10.859 | 157 | 11.717 | 197 | 12.575 | 237 | 13.433 |
| 118 | 10.880 | 158 | 11.738 | 198 | 12.596 | 238 | 13.455 |
| 119 | 10.902 | 159 | 11.760 | 199 | 12.618 | 239 | 13.476 |

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## 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, manually and automatically, 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 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 tank.
4. Verifying the diesel starts from ambient condition and accelerates to at least 450 rpm in less than or equal to 13 seconds. The generator voltage and frequency shall be 4160 ± 420 volts and 60 ± 3.0 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 setpoint
    - (d) An ESF actuation test signal by itself Exception #8
5. Verifying the diesel generator is synchronized, loaded to greater than or equal to 3500 kw 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.
7. Verifying the pressure in all diesel generator air start receivers to be greater than or equal to 215 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 tank.

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Exception #4

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PT.307.002-2

## 9.0 SYSTEMS RETURN TO NORMAL

9.1 Inform the Watch Engineer that the Integrated Electrical Test is complete and that the plant may be returned to Normal in accordance with station procedure at his direction.

Verified ______________________ Date

9.2 Remove all temporary test equipment installed by section 5.10 and initial those portions of Appendix C. Attach a completed copy of Repair/Rework R43-713 to APPENDIX C as attachment C2.

Verified ______________________ Date

9.3 Remove temporary test fixture installed in step 5.9 via Repair/Rework E32-6[illegible] and initial Appendix C. Attach completed copies of Repair/Rework E32-67 and MWR 83-0851 to Appendix C as attachment C1.

Verified ______________________ Date

OQA Witness ______________________ Date

9.4 Return LOCA level transmitter isolation valves to normal service position and initial as required:

| 1H21*PNL-04 | INITIAL/DATE | 1H21*PNL-05 | INITIAL/DATE |
|---|---|---|---|
| 1B21*LT-155A | | 1B21*LT-155C | |
| 1B21*LT-154A | | 1B21*LT-154C | |
| 1B21*LT-157A | | 1B21*LT-155D | |
| 1B21*LT-157C | | 1B21*LT-154D | |
| 1B21*LT-154B | | 1B21*LT-157B | |
| 1B21*LT-155B | | 1B21*LT-157D | |

CAUTION: When returning transmitter to service operate instrument valves slowly to preclude spurious LOCA signals.

Verified ______________________ Date

Exception #4

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PT.307.002-2

5.9 The loss of offsite power (LOOSP) event is initiated by simultaneously tripping the NSS and RSS transformer Primary Protection.

The loss of coolant (LOCA) event is initiated by simulating HIGH DRYWELL PRESSURE for Test 8.1 and by simulating LOW reactor water level for tests 8.2 through 8.5. Both LOOSP and LOCA events are selectable at the TEMPORARY TEST FIXTURE to be used as follows: The event must be selected by enabling LOOSP or LOCA or both. The event is then initiated by placing the event switch to the INITIATE position. Verify circuit modification is installed according to MWR #83-0851 and Repair/Reworks E32-067 (Appendix C) and initial Appendix C.

Verified Date

OQA Witness Date

5.10 Verify temporary cables for instrumentation are installed in accordance with Repair/Rework R43-713 (APPENDIX C2) and temporary test instrumentation test results (Appendix E2) to provide temporary GETARS computer points listed in Appendix A2 and initial Appendix C.

Verified Date

OQA Witness Date

5.11 Calibrate the GETARS computer points listed in Appendix A2 and attach the calibration data as Attachment E4.

Verified Date

OQA Witness Date

STG APPROVED MAR 16 1984

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( TEMPORARY work

Exception #4

February 18, 1981
Revision 12

SHOREHAM 1
NUCLEAR POWER STATION
STARTUP FORM 7.6

Shoreham Nuclear Power Station - Unit 1

REPAIR/REWORK REQUEST w/Task

1. Request: R43-713 Initiated By: W Maloney 1/19/83 System # : R43
Test Engineer/Date

Work performed under jurisdiction of: ( ) Unico Construction (X) LILCO Startup

Work to be performed by: ( ) Unico Construction (X) LILCO Startup 1/19/83

Quality Assurance function to be performed by: (X) OQA ( ) FQC (X) Work Supervisor

System or Subsystem Description: INTEGRATED ELECTRICAL TEST

QA Category: I Completion Date Required:

Perform the following work: INSTALL TEMPORARY CABLES AND REMOVE AFTER TEST

Reason for Work: TO SUPPORT PT 307.002

2. Work to be performed in accordance with the following applicable construction or maintenance procedure: TEST ENGINEER DIRECTION AND ATTACHED SHEETS
373 EOQA 83-307

3. Notify W Maloney prior to performing work.
Startup Engineer

4. Request Approved: 1/19/83 R Lawrence 1/19/83
Lead Startup Engineer / Date S&W Lead Advisory Eng./Date

5. This form must be signed and returned to the party requesting the work when the work is completed.

The above work has been completed. A work summary and necessary documentation is attached.

Supervisor/Date

Field QC or Operational QA/Date

6. The following retest(s) are required and completed:

LILCO Operational QA Engineer/Date

Startup Engineer/Date

DISTRIBUTION: Original to: Organization Performing Work: ( ) Unico Construction Superintendent (via Turnover Coordinator), or (X) LILCO Startup.

Copies To: Organization Not Performing Work: (X) Unico Construction Superintendent (via Turnover Coordinator), or ( ) LILCO Startup
Operational QA

A13571

## TABLE I

## EDG NORMAL OPERATING PARAMETERS

| Parameter | Range |
|---|---|
| Generator Voltage | 4,160 + 190 volts, -310 volts |
| Generator Frequency | 60 ± 1.2 Hz |
| Lube Oil Pressure | 50 to 65 psig |
| Turbo Oil Pressure | 25 to 35 psig |
| Jacket Water Pressure | 20 to 30 psig |
| Fuel Oil Pressure | 20 to 35 psig |
| Lube Oil Temperature (Outlet) | 170°F to 180°F |
| Jacket Water Temperature (Outlet) | 160°F to 170°F |
| Generator Winding Temperature | less than 320°F |
| Generator Bearing Temperature | less than 180°F |
| Generator Load | greater than 1750 KW |
| Generator Vars | greater than 700 KVar |
| Generator Current | greater than 250 Amps |
| Combustion Air Pressure | greater than 20" Hg |
| Diesel Generator Room Temperature | less than 120°F |
| Diesel Generator Room Humidity | less than 80% relative humidity |

2

## TABLE II

## EDG SHUTDOWN/PRESTART PARAMETERS

| Parameter | Range |
|---|---|
| Lube Oil Inlet Temperature | 140°F - 170°f |
| Lube Oil Level | less than 10" from S/D mark |
| Jacket Water Inlet Temperature | 140°F - 170°F |
| Jacket Water Level | 9 - 1 o'clock |
| Starting Air Pressure | greater than 200 PSIG |
| Group I Shutdown Pressure | greater than 50 PSIG |

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## TABLE III

## TEST EQUIPMENT LOG

| Test Equipment Used | M&TE#/ cal. due date | Parameter Measured/Procedure Step No. |
|---|---|---|
| STEP 5.21<br>Digital Voltmeter | 613/ 8-8-84 | Gen Winding Temp. / STEP 5.21 |
| STEP 5.23<br>Micrometer | 315/ 10-7-84 | Gen Brgn Ped. Temp / step 5.23 |
| STOP WATCH | 457/5-22-84 | Running Time / 8.4 |
| psychrometer | 218/ 3-16/85 | Relative humidity APP. D Sht 3 |
| | | |
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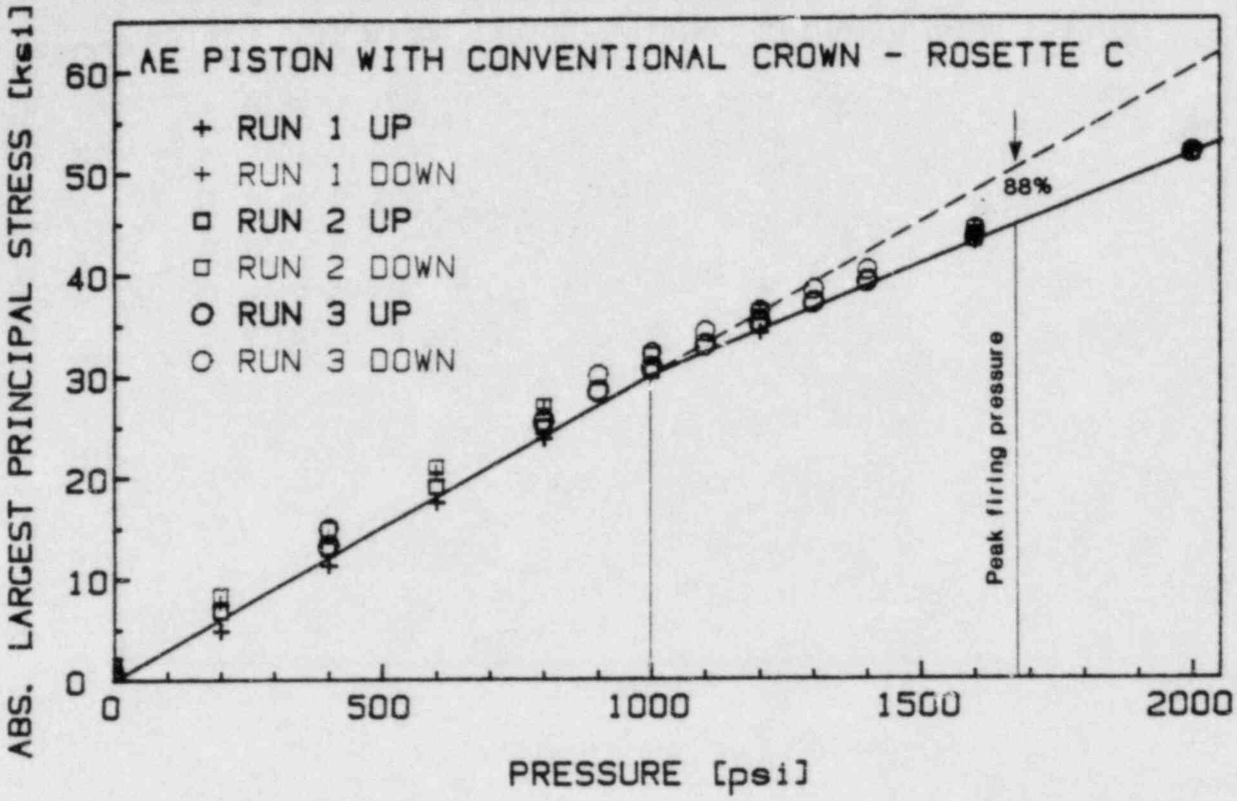
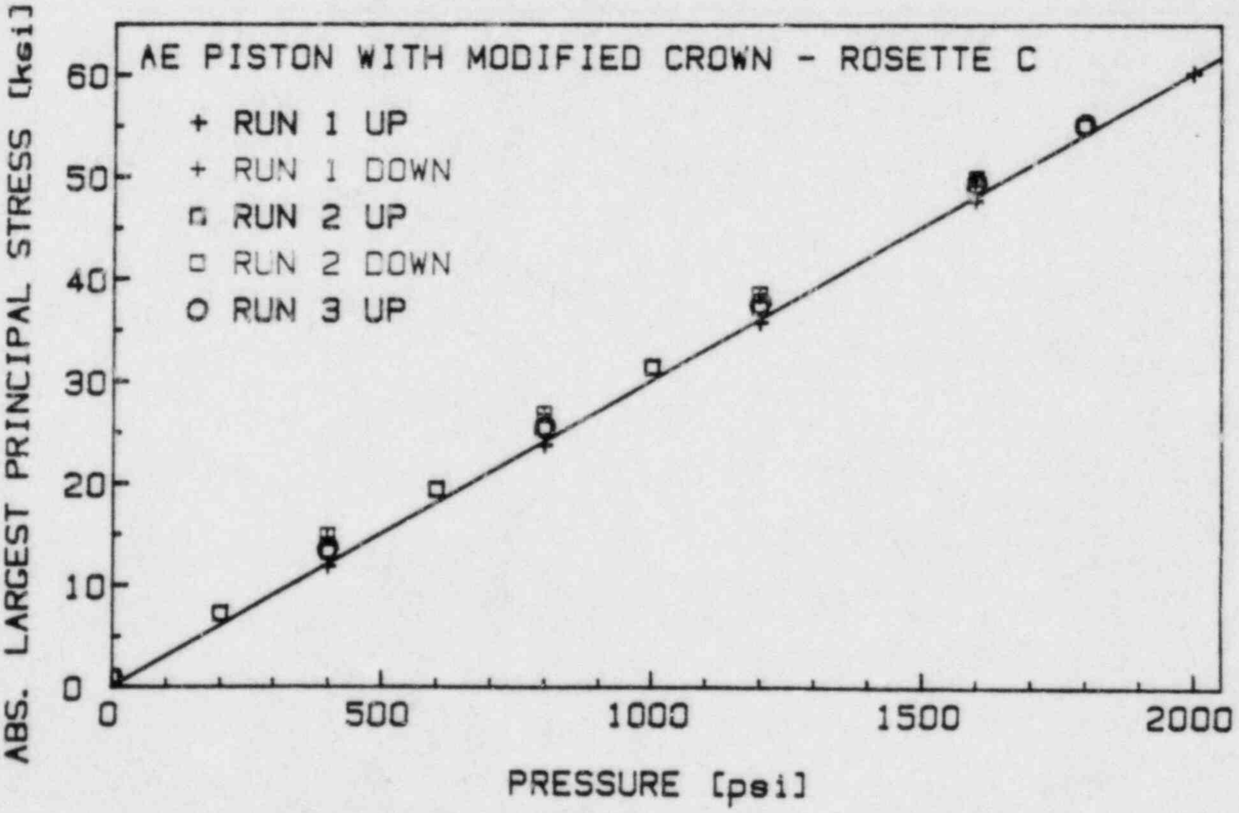
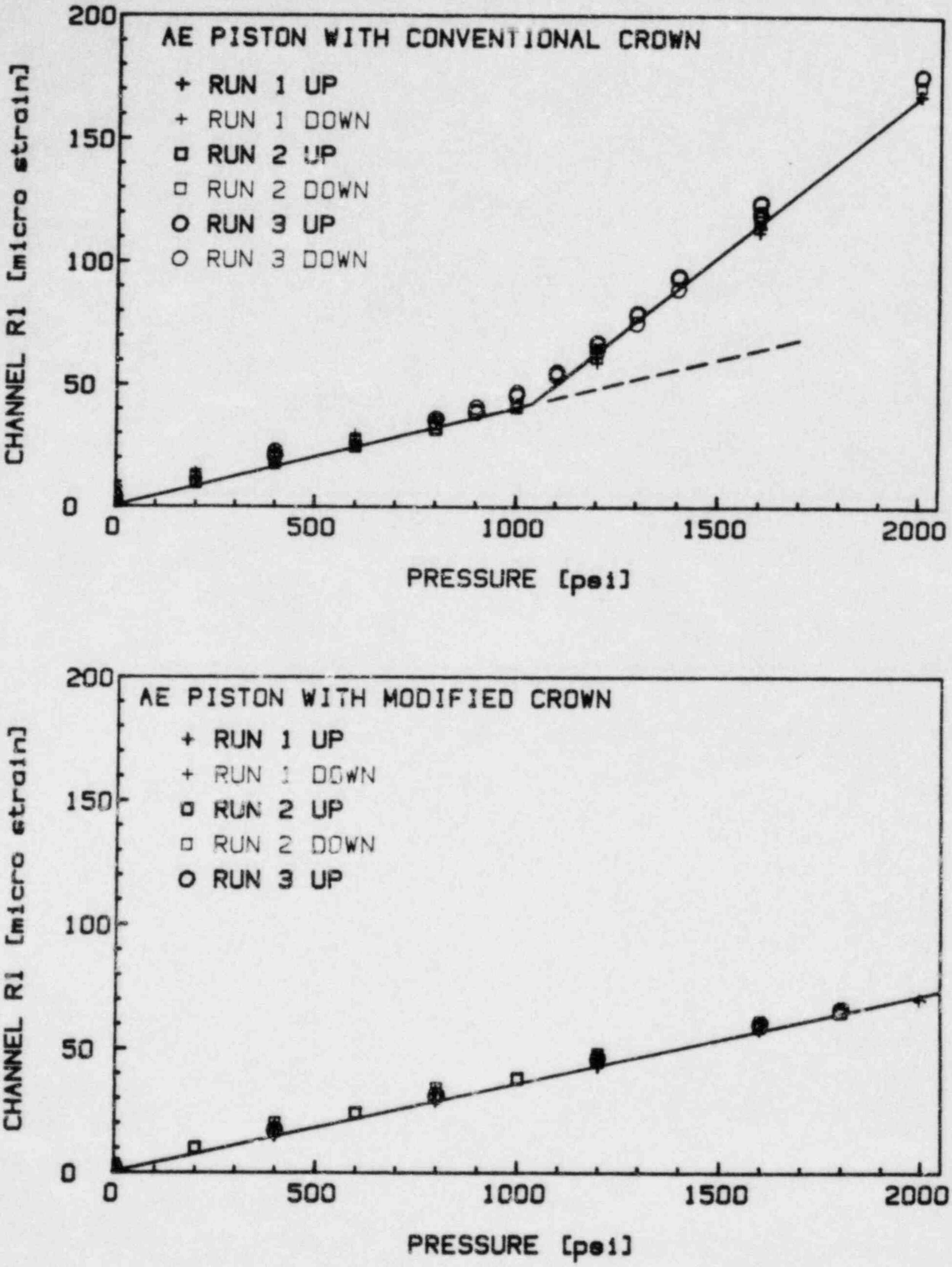
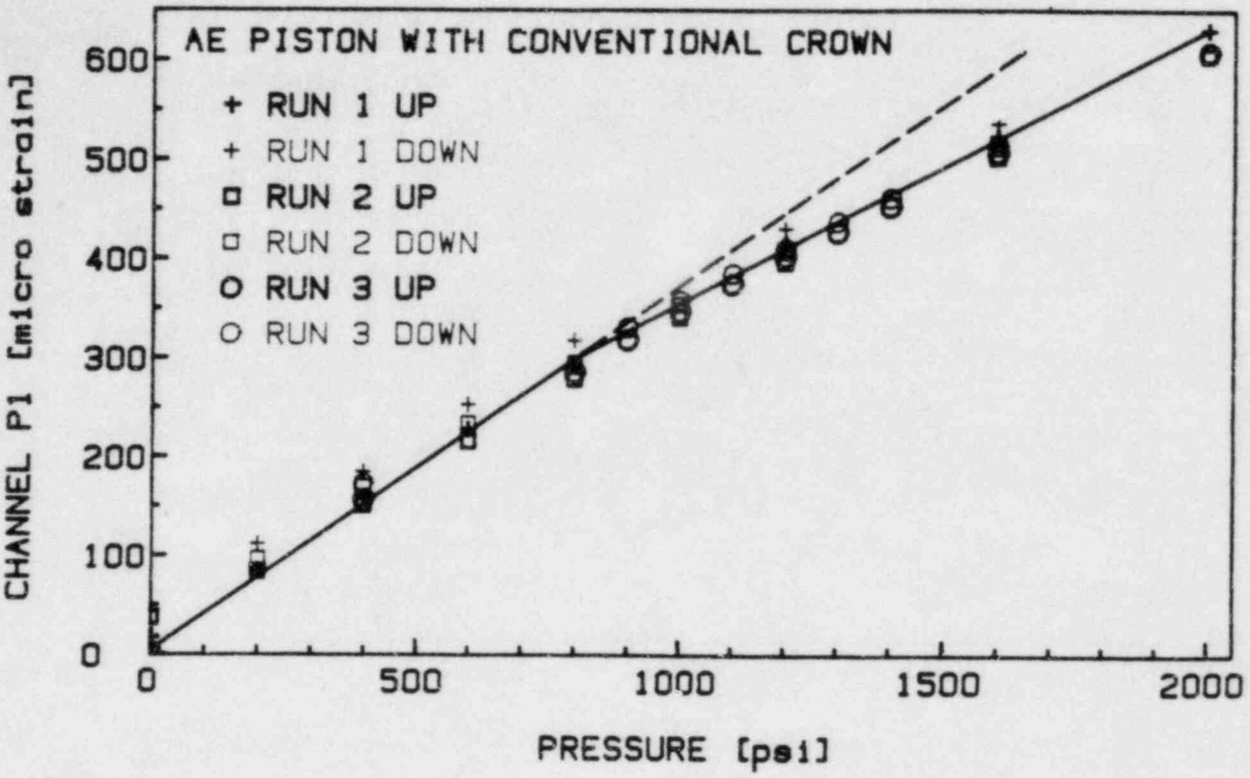




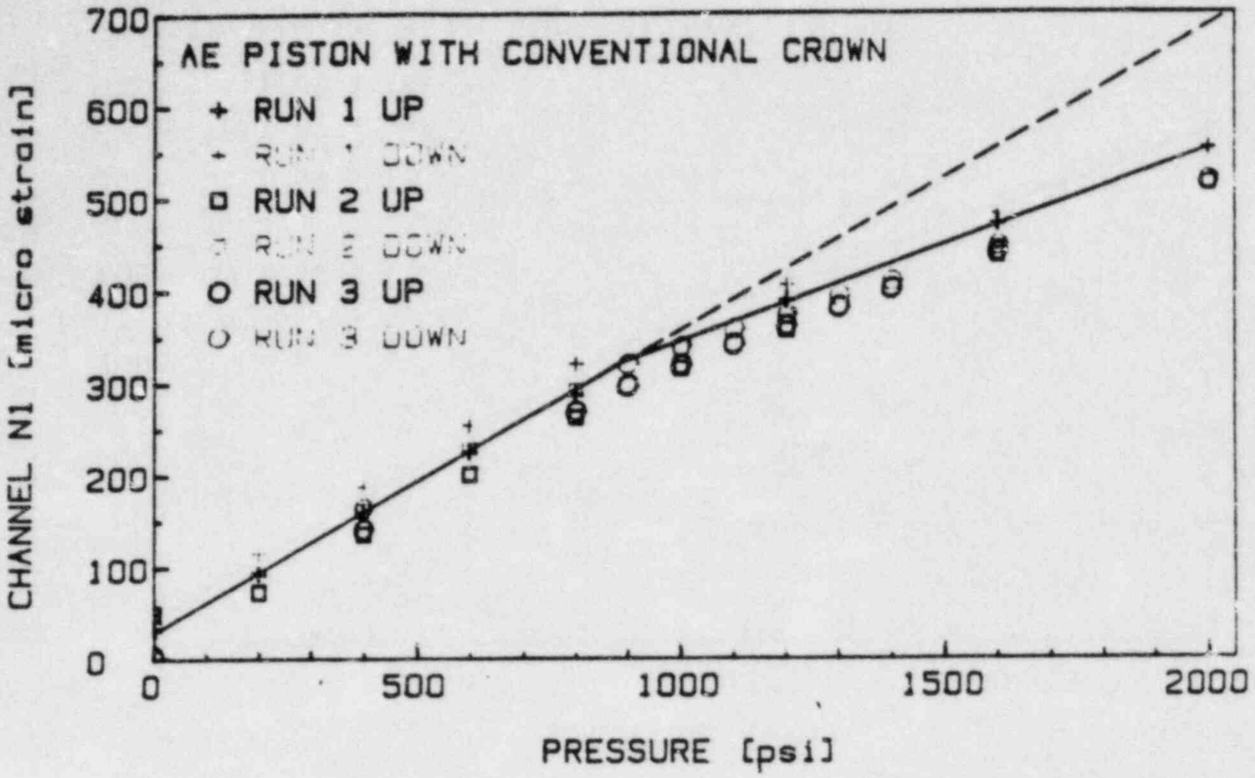
$\sigma_{III}$ as a function of pressure for stud boss rosette C with conventional and modified crown.



Axial strain as a function of pressure for strain gage rosette R located at outer portion of wrist pin cavity.



Axial strain as a function of pressure for strain gage rosette P located at inner portion of wrist pin cavity.



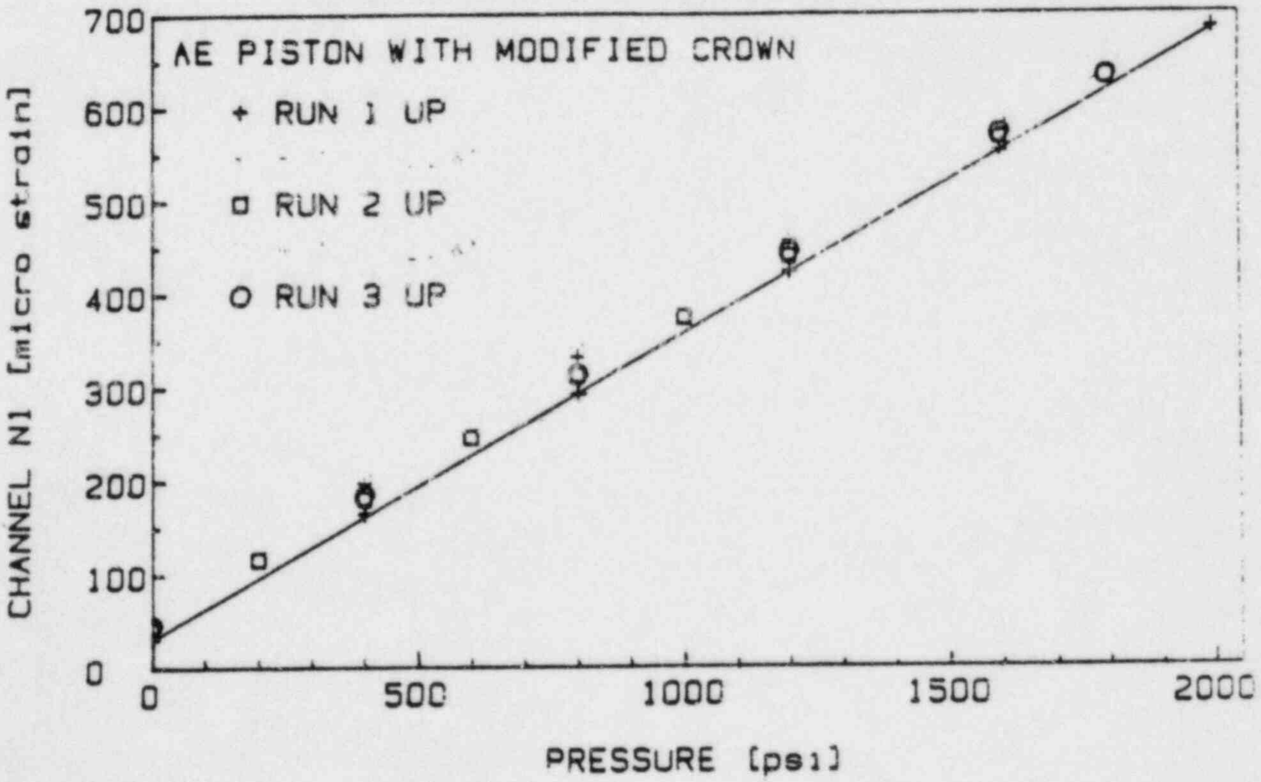
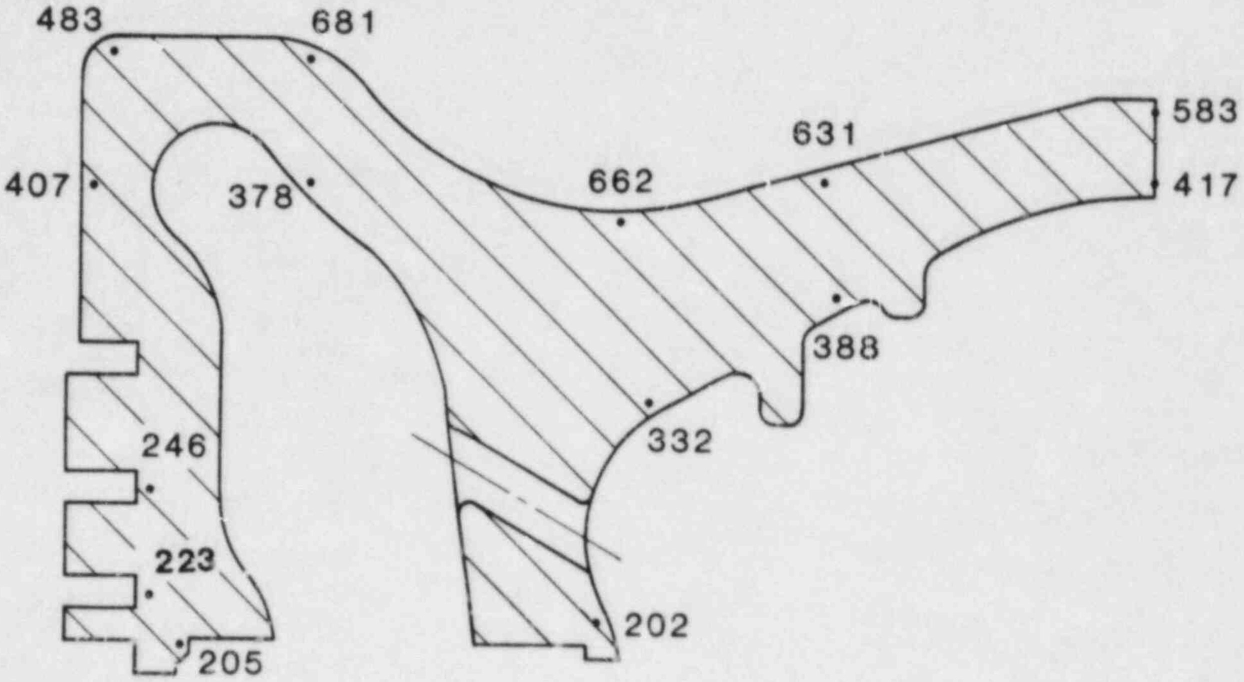
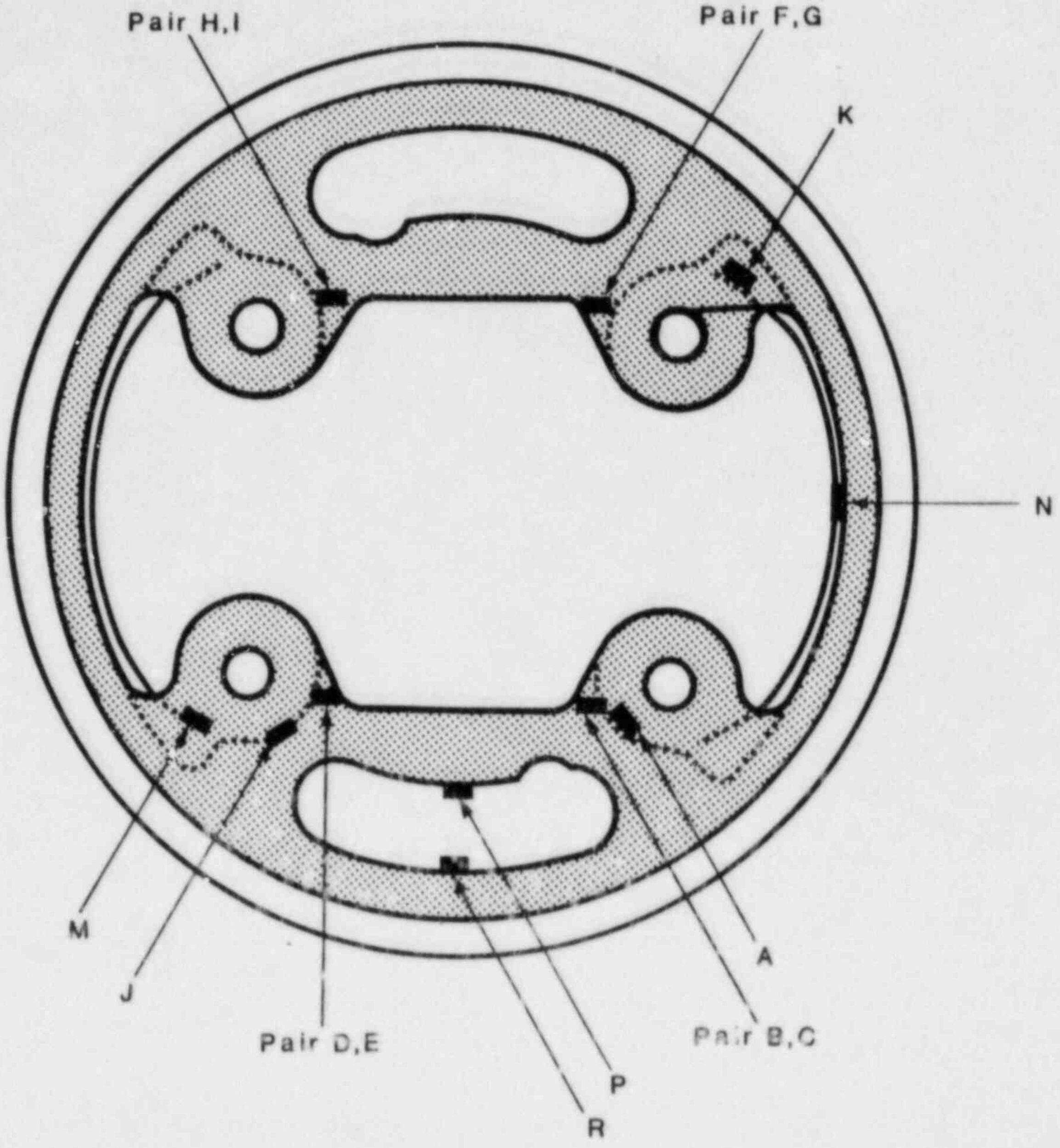


Figure 3-8. Axial strain as a function of pressure for strain gage rosette N located near outer ring at 90° from wrist pin cavity



Results of templug measurements of peak temperature as a function of position on crown (supplied by TDI).



Location of strain gage rosettes on instrumented AE skirt.

## SUMMARY OF EXPERIMENTAL OBSERVATIONS
## RELATED TO CROWN/SKIRT INTERACTION

| | | AE |
|---|---|---|
| Gap, $g_o$, mils | nominal | 7.5 |
| | min | 7.0 |
| | max | 8.0 |
| Gap closure pressure, p*, psig | nominal | 1000 |
| | min | 820 |
| | max | 1050 |
| $\sigma_{closure}/\sigma_{(no\ closure)}$ at 1670 psig | nominal | 0.88 |
| | min | -- |
| | max | -- |

## STRAIN READINGS AND CALCULATED STRESSES FOR AE PISTON SKIRT FOR THE COMPLETE STUD BOSS ROSETTES AT 1600 PSIG WITH A CONVENTIONAL CROWN

(all strain values are in μin/in)

| | C | D | E | F | H |
|---|---|---|---|---|---|
| $\epsilon_z$ | -1740 | -1668 | -1722 | -1605 | -1583 |
| $\epsilon_\theta$ | 270 | 366 | 304 | 270 | 246 |
| $\epsilon_{45}$ | -732 | -787 | -815 | -602 | -632 |
| $\epsilon_I$ | 270 | 375 | 310 | 272 | 247 |
| $\epsilon_{II}$ | -1740 | -1677 | -1728 | -1607 | -1584 |
| $\sigma_{II}$, ksi | -6.5 | -3.3 | -5.4 | -5.5 | -5.9 |
| $\sigma_{III}$, ksi | -43.0 | -40.6 | -42.4 | -39.6 | -39.24 |

The reported values are for 1600 psig, which differs slightly from the effective firing pressure of 1627 psig. This 1.7% difference in pressure is considered to be negligible.

# COMPARISON OF EXPERIMENTAL AND NUMERICAL VALUES OF CYCLIC STRESSES FOR THE AE PISTON SKIRT

$g_0$ = 0.0075 inch
load split = 88%

| | Numerical | Experimental | |
|---|---|---|---|
| | | largest observed value | smallest observed value |
| $^*\sigma_{III}$ | -68.1 | -44 | -54 |
| $\sigma_{min}$ (= 0.88 $\sigma_{III}$) | -60.0 | -38.7 | -47.5 |
| $\sigma_{max} = \left[- \frac{\text{inertia load}}{\text{pressure load minus inertia load}}\right] \times \sigma_{III}$ | 1.77 | 1.1 | 1.4 |
| $\sigma_a \left[= \frac{1}{2} (\sigma_{max} - \sigma_{min})\right]$ | 30.9 | 19.9 | 24.5 |
| $\sigma_m \left[= \frac{1}{2} (\sigma_{max} + \sigma_{min})\right]$ | -29.1 | -18.8 | -23.0 |

*Only sigma$_{III}$ was observed. All other values were calculated.

# COMPARISON OF EXPERIMENTAL OBSERVATIONS OF PEAK STRESS AT 1627 psig FOR AE PISTON SKIRT WITH CORRESPONDING FINITE ELEMENT RESULTS USING EXTREMES OF WRIST PIN BEHAVIOR

| | | $\sigma_{III}$, ksi |
|---|---|---|
| rigid wrist pin | | 68.1 |
| experimental, | max | 54 |
| | min | 44 |
| | ave | 49 |
| soft wrist pin | | -41.4 |

# CYCLIC STRESSES IN AE PISTON SKIRTS UNDER ISOTHERMAL AND STEADY-STATE CONDITIONS

| | | | | AE | | | |
|---|---|---|---|---|---|---|---|
| | | Notes | | F.E. | nominal | min | max |
| | $\sigma_{min}$ | 1 | | <------------ -68.1 -----------> | | | |
| $\sigma_{max}$ | lift-off | 1 | | <------------ 7.32 -----------> | | | |
| | no lift-off | 1 | | <------------ 1.77 -----------> | | | |
| | $k_i'$ | 2 | | 96.9 | 83.7 | 45.7 | 121 |
| | $k_o'$ | 2 | | 118 | 24.0 | 7.95 | 283 |
| | | | $g_o$ | | | | |
| | $\delta_L$ | 3 | 7 | 1.999 | 1.403 | 0 | 2.140 |
| | | | 9 | 0.157 | 0 | 0 | 0.285 |
| | | | 11 | 0 | 0 | 0 | 0 |
| | $\sigma_{min}$, isothermal | 4 | 7 | -57.5 | -59.7 | -60.3 | -58.4 |
| | | | 9 | -62.1 | -62.9 | -62.0 | -63.4 |
| | | | 11 | -66.7 | -66.2 | -63.8 | -68.1 |
| | $\sigma_{min}$, steady-state | 4 | 7 | -33.0 | -42.7 | -50.9 | -31.5 |
| | | | 9 | -37.6 | -45.9 | -52.7 | -36.6 |
| | | | 11 | -42.2 | -49.1 | -54.4 | -41.6 |
| | $\sigma_{max}$, steady-state | 5 | 7 | 7.91 | 7.74 | 1.77 | 7.96 |
| | | | 9 | 7.37 | 1.77 | 1.77 | 7.40 |
| | | | 11 | 1.77 | 1.77 | 1.77 | 1.77 |

all stresses in ksi, $g_o$ and $\delta_L$ in mils

Notes:

1. From isothermal finite element calculations of skirt with crown, no gap closure.
2. From finite element calculations and estimates based on experiments.
3. Maximum crown/skirt lift-off distance in mils based on crown/skirt model.
4. From crown/skirt interaction model.
5. Equals $\sigma_{max}$ with no lift-off if $\delta_L = 0$, adjusted from finite element $\sigma_{max}$ with lift-off if $\delta_L > 0$ by use of crown/skirt interaction model.

### COMPARISON OF PEAK STRESS IN STUD BOSS REGION OF AE PISTON SKIRT FOR LOADS APPLIED ON INNER AND OUTER CONTACT RINGS.

(Values calculated by finite element)

| | $-\sigma_{III}$, ksi |
|---|---|
| force pA applied by uniform displacement on: | |
| inner ring | 43.3 |
| outer ring | 3.3 |

$p$ = 1627 psig
A = bore area

## COMPARISON OF EXPERIMENTAL AND NUMERICAL GAP CLOSURE AND LOAD SPLIT

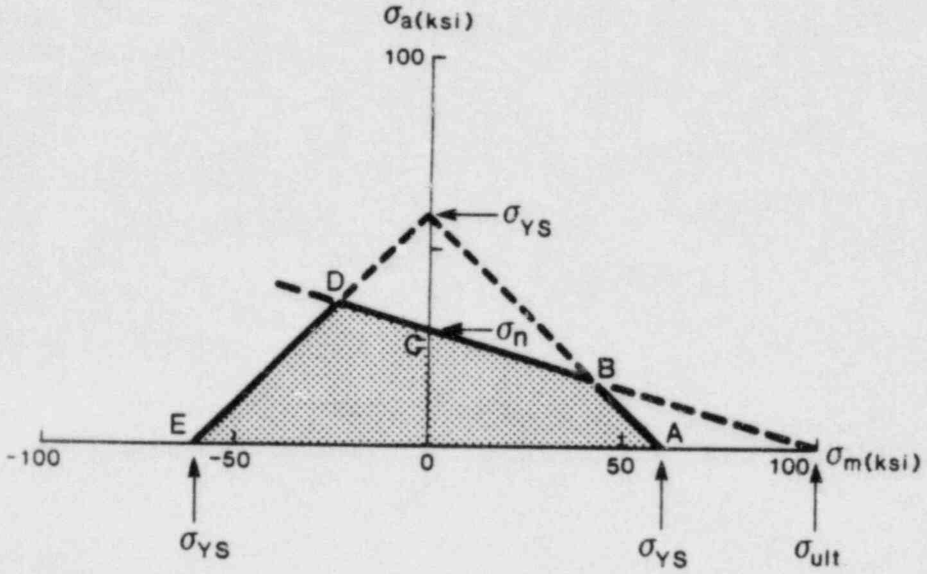
| | | Experiment | Calculated |
|---|---|---|---|
| Gap, $g_0$, mils | nominal | 7.5 | -- |
| | min | 7.0 | -- |
| | max | 8.0 | -- |
| Gap Closure Pressure, psig | nominal | 1000 | 1040 |
| | min | 820 | 970 |
| | max | 1050 | 1110 |
| Load Split at 1670 psig | nominal | 88% | 85% |
| | min | -- | 83% |
| | max | -- | 87% |

# COMPARISON OF SKIRT STIFFNESSES AS EVALUATED FROM EXPERIMENTAL OBSERVATION AND CROWN/SKIRT INTERACTION MODEL WITH CORRESPONDING FINITE ELEMENT VALUES

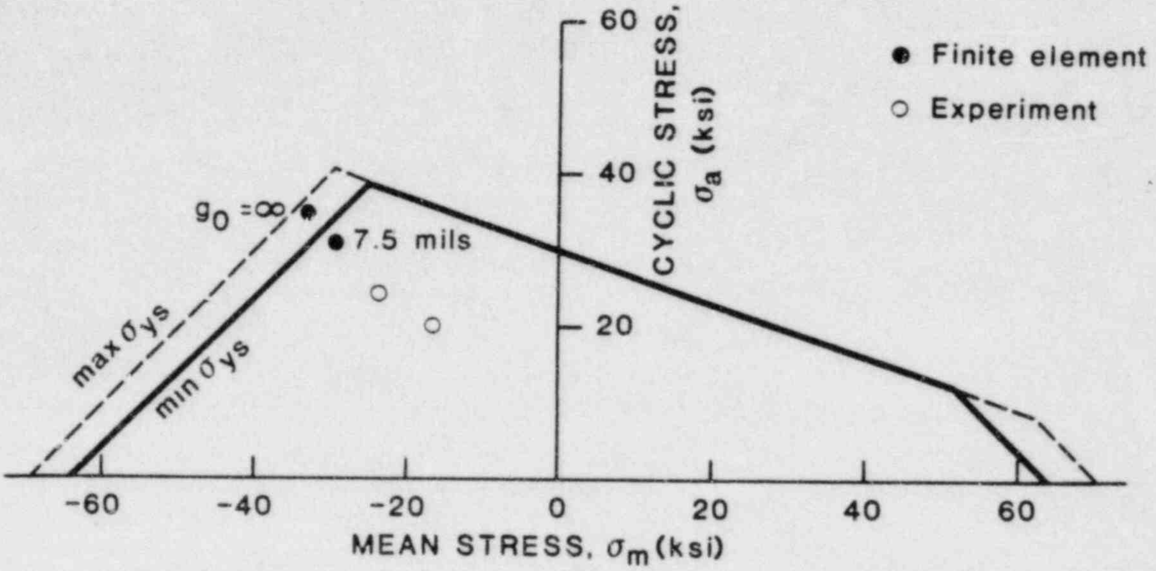
| | | | AE |
|---|---|---|---|
| EXPERIMENTS | $k_i'$, kips/mil | nominal | 83.7 |
| | | min | 45.7 |
| | | max | 121 |
| | $k_o'$, kips/mil | nominal | 7.95 |
| | | min | 24.0 |
| | | max | 283 |
| FINITE ELEMENTS | $k_i$ | | 81.2 |
| | $k_o$ | | 95.3 |
| | $k_{io}$ | | 500 |
| | $k_i'$ | | 96.9 |
| | $k_o'$ | | 118 |

$$\frac{1}{k_i'} = \frac{1}{k_i} - \frac{1}{k_{io}}$$

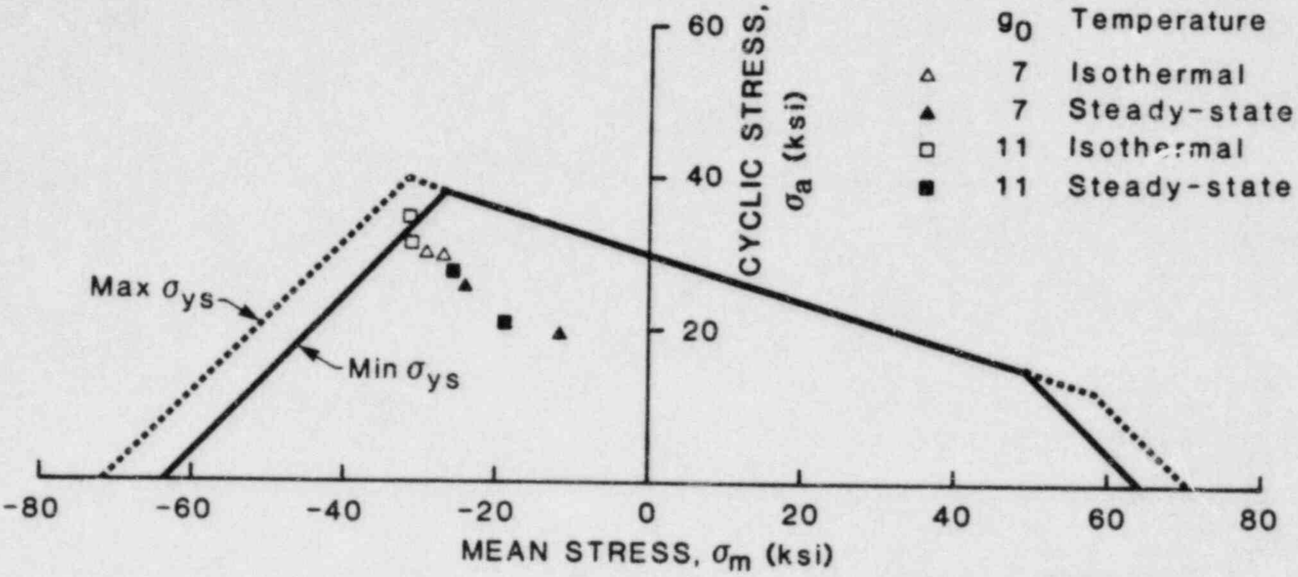
$$\frac{1}{k_o'} = \frac{1}{k_o} - \frac{1}{k_{io}}$$



Mean and cyclic stresses for infinite fatigue life. The shaded region shows the combination of stress amplitude ($\sigma_a$) and mean stress ($\sigma_m$) that will not initiate cracks.



Stress states for isothermeal AE piston skirt for various gap sizes plotted on graph of allowable stress amplitude as a function of mean stress.

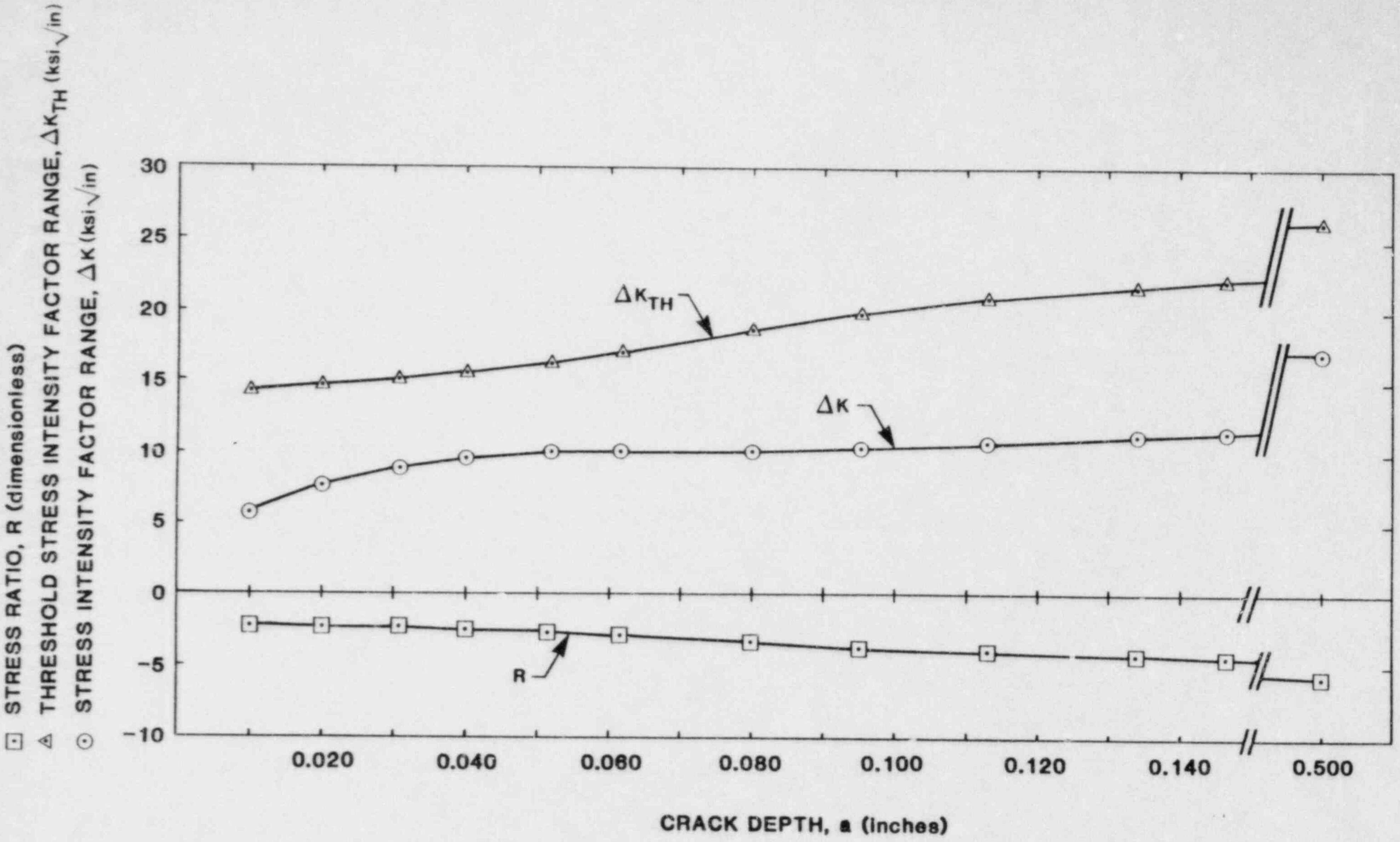


Stress states for AE piston skirt for various conditions plotted on graph of allowable stress amplitude as a function of mean stress for various gap sizes and for isothermal and steady-state temperature conditions.

## SUMMARY OF FRACTURE TOUGHNESS DATA FROM THE LITERATURE FOR NODULAR CAST IRON WITH STRENGTH LEVELS SIMILAR TO 100-70-03

| $K_{Ic}$, ksi-in$^{1/2}$ | T, °F | $\sigma_{ult}$, ksi | $\sigma_{ys}$, ksi | Elong. % | Reference |
|---|---|---|---|---|---|
| 41 | 70 | 133 | 80 | 3.6 | 6-6 |
| 36 | 70 | 85.3 | 76 | 1.6 | 6-6 |
| 48 | 220 | 116 | 90 | -- | 6-7 |
| 40 | 70 | 116 | 90 | -- | 6-7 |
| ~85 | 70 | 90 | 58 | -- | 6-7 |
| 25 | 75 | >80 | >62 | >3.0 | 6-1 |
| 47 | 75 | -- | 104 | -- | 6-1 |

Nominal value for calculations: 40 ksi-in$^{1/2}$.


⊡ STRESS RATIO, R (dimensionless)
△ THRESHOLD STRESS INTENSITY FACTOR RANGE, $\Delta K_{TH}$ (ksi$\sqrt{in}$)
⊙ STRESS INTENSITY FACTOR RANGE, $\Delta K$ (ksi$\sqrt{in}$)
30
25
20
15
10
5
0
-5
-10
$\Delta K_{TH}$
$\Delta K$
R
0.020
0.040
0.060
0.080
0.100
0.120
0.140
0.500
CRACK DEPTH, a (inches)

FaAA-M-84-8-1

EDG 101

EDG 101

# INTEROFFICE CORRESPONDENCE

| | | |
|---|---|---|
| TO: DISTRIBUTION | LOCATION SNPS-1 | SUBJECT / REFERENCE / J.O. NO.<br>11600.37 Component No. 03-341A |
| FROM: R. MURRAY | LOCATION QEG | TRANSMITTAL OF SAT I.R.'s Att. 1 |

MESSAGE: —

Att #1

ATTACHED PLEASE FIND one SATISFACTORY INSPECTION REPORTS GENERATED BY THE QUALITY REVALIDATION INSPECTION GROUP AND REVIEWED BY THE QUALITY ENGINEERING GROUP. THEY ARE FORWARDED TO YOU FOR YOUR INFORMATION IN ACCORDANCE WITH EDG QR/DR PROGRAM MEMO R. NAJUCH

3-21-84
DATE

SIGNATURE

564
TELEPHONE

REPLY:

DIST. R. NAJUCH (IOC ONLY)
G. ROGERS DRG W/ ATTACHMENTS
J. E. KELLY LILCO FQA (NDE RELATED IR's ONLY) W/ATTACHMENTS.

DATE

SIGNATURE

TELEPHONE

A 040138

SENDER DETACH AND RETAIN THIS COPY

UALITY CONTROL
ISPECTION REPORT

JOB NUMBER 11600.37

DATE 3-21-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME:<br>Pistons<br>COMPONENT NO. 03-341A | DC-101 | I.P. NO. 14 REV. 4 CHG 0<br>TER # N/A<br>LILCO LP PROC. 6.2 REV. 1<br>DWG. NO. N/A |

| WG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 1 | 2 | Performed LP on Piston Pin Bosses<br>Cylinder Nos 5 & 7 SAT<br>No Recordable Indications |

M&TE NO. ________, ________, ________, ________,
________, ________, ________, ________.

REVIEWED: H. E. Stottler
3/21/84

QUALITY CONTROL INSPEC./ENG.

DATE 3-21-84

PAGE 1 of 2

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

Page 2 of 2

PT

COMPONENT I.D. 03-341.A Piston Pin Bosses

SYSTEM R-43

PLANT/LOCATION

|  |  |  |
|---|---|---|
| A. MATERIAL<br>Carbon Steel | TYPE N/A | FABRICATED PROCESS ☐ WELDED ☒ CAST ☐ WORKED |
|  | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: |  |
| CROSS SECTION THICKNESS | MAX N/A<br>MIN | PIPE DIA. N/A |
| SURFACE CONDITION | ☒ MACHINED ☐ GROUND<br>☐ AS FABRICATED ☐ OTHER |  |

B. NDE PROCEDURE No. 6.2 Rev 1

SURFACE/MAT'L. TEMP. 78°F

M&TE. NO. 9-11-708

MWR/RR. No.

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 84A028 |
| 2. PENETRANT | Spotcheck | SKL-HF/SKL-S | 81E180 |
| 3. EMULSIFIER AND/OR REMOVER | Magnaflux | SKC-NF/ZC-7B | 84A028 |
| 4. DEVELOPER | Magnaflux | SKD-NF/ZP-9B | 83HC-11 |
| 5. POST EXAMINATION CLEANER | Magnaflux | SKC-NF/ZC-7B | 84A028 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

DG-101

LP on cylinders #5 & #7 Piston Pin Bosses

No Recordabl. Indications

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |

D. ACCEPTANCE CRITERIA 4.2

OPERATOR Leo Breidenstein

Level II Date 3-21-84

E. ATTEST

Leo Breidenstein — II — 3-21-84

RESPONSIBLE CERTIFIED PERSONNEL — LEVEL — DATE

EDG 101

# INTEROFFICE CORRESPONDENCE

| | | |
|---|---|---|
| TO:<br>DISTRIBUTION | LOCATION<br>SNPS-1 | SUBJECT / REFERENCE / J.O. NO.<br>11600.37 DG 101 C.3-341A |
| FROM:<br>R. MURRAY | LOCATION<br>QEG | TRANSMITTAL OF SAT I.R.'s ATT # 1 |

MESSAGE: —

ATTACHED PLEASE FIND 1 SATISFACTORY INSPECTION REPORTS 2pgs GENERATED BY THE QUALITY REVALIDATION INSPECTION GROUP AND REVIEWED BY THE QUALITY ENGINEERING GROUP. THEY ARE FORWARDED TO YOU FOR YOUR INFORMATION IN ACCORDANCE WITH EDG QR/DR PROGRAM MEMO R. NAJUCH

3-22-84
DATE

R D Murray
SIGNATURE

562
TELEPHONE

REPLY:

DIST. ✓R. NAJUCH (IOC ONLY)
✓G. ROGERS DRC W/ ATTACHMENTS
✓ E. KELLY LILCO FQA (NDE RELATED IR's ONLY) W/ATTACHMENTS.

DATE

SIGNATURE

TELEPHONE

A 040138

SENDER DETACH AND RETAIN THIS COPY

STONE & WEBSTER ENGINEERING CORPORATION

## UALITY CONTROL
## NSPECTION REPORT

2040.19

JOB NUMBER 11600.37

DATE 3-22-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| **COMPONENT NAME:** Piston Cyl #8<br>Reinspection Boss #1<br>**COMPONENT NO.** 03-341A | DG- 101 | I.P. NO. 14 REV. 4 CHG 0<br>TER # NA<br>LILCO LP PROC. G.1/G.2 REV. 2/1<br>DWG. NO. NA |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 1 | 1 | PT performed per request of LILCO representative. |
| | | | * Witnessed By Nelson C. Irvine LILCO LII |
| | | | Nelson C Irvine L III<br>3-22-84 |

**M&TE NO.** 7-11-708

| QUALITY CONTROL INSPEC./ENG. | DATE | PAGE |
|---|---|---|
| Carl Larsen | 3-22-84 | 1 of 2 |

**LILCO** LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 03-3C'A

SYSTEM Diesel Generator 101

PLANT/LOCATION Shoreham 1

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD | ☒ OTHER: |
| CROSS SECTION THICKNESS | MAX 6"<br>MIN 1/8" | PIPE DIA. NA | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☒ AS FABRICATED ☐ OTHER |

B. NDE PROCEDURE No. 61/62

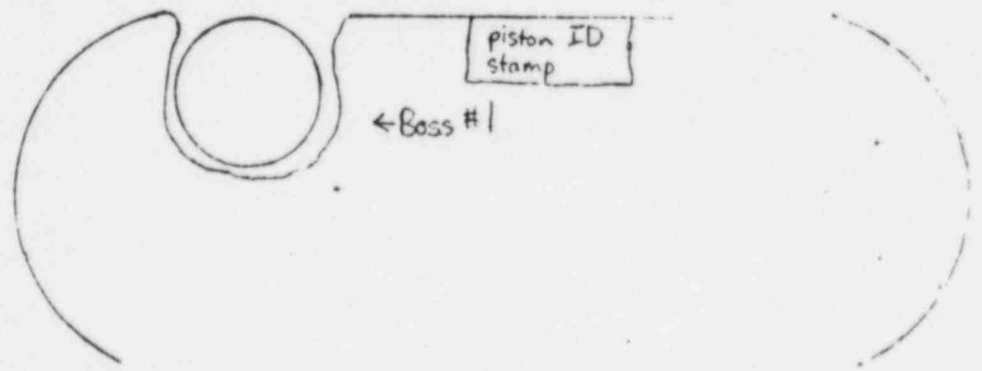
SURFACE/MAT'L. TEMP. 73° F

M&TE. NO. 7-11-78

MWR/RR. No.

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 84A028 |
| 2. PENETRANT | Magnaflux | SKL-HF/SKL-S | 81E180 |
| 3. EMULSIFIER AND/OR REMOVER | Magnaflux | SKC-NF/ZC-7B | 84A028 |
| 4. DEVELOPER | Magnaflux | SKD-NF/ZP-9B | 83HC41 |
| 5. POST EXAMINATION CLEANER | Magnaflux | SKC-NF/ZC-7B | 84A028 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY



C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 | | | No relevant indications exceeding |
| 2 | | | acceptance criteria, no linear |
| 3 | | | indications. |
| 4 | | | |

D. ACCEPTANCE CRITERIA proc. 6.2 para, 4.2

OPERATOR Carl Jansen

Level II Date 3-22-84

E. ATTEST

RESPONSIBLE CERTIFIED PERSON

III Lilco
LEVEL

3-22-84
DATE

EDG 101

# INTEROFFICE CORRESPONDENCE

| | | |
|---|---|---|
| TO: DISTRIBUTION | LOCATION SNPS-1 | SUBJECT / REFERENCE / J.O. NO. 11600.37 Component No. 03-341A |
| FROM: R. MURRAY | LOCATION QEG | TRANSMITTAL OF SAT I.R.'s Attr. 1 |

MESSAGE: —

ATTACHED PLEASE FIND one SATISFACTORY INSPECTION REPORTS GENERATED BY THE QUALITY REVALIDATION INSPECTION GROUP AND REVIEWED BY THE QUALITY ENGINEERING GROUP. THEY ARE FORWARDED TO YOU FOR YOUR INFORMATION IN ACCORDANCE WITH EDG QR/DR PROGRAM MEMO R. NAJUCH

3-26-84
DATE

RD Murray
SIGNATURE

564
TELEPHONE

REPLY:

DIST. R. NAJUCH (IOC ONLY)
G. ROGERS DRG W/ ATTACHMENTS
J. E. KELLY LILCO FQA (NDE RELATED IR's ONLY) W/ATTACHMENTS.

DATE

SIGNATURE

TELEPHONE

A 646138

SENDER DETACH AND RETAIN THIS COPY

# UALITY CONTROL
# NSPECTION REPORT

JOB NUMBER 11600.37

DATE 3-26-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: Piston<br>COMPONENT NO. 03-341A | DG-101 | I.P. NO. 14 REV. 4 CHG 0<br>TER # Q91<br>LILCO LP PROC. 6.2 REV. 1<br>DWG. NO. N/A |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 1 | 1 | Performed a LP exam on Piston # 8 Bosses A, C+D,<br>SAT |

M&TE NO. N/A

REVIEWED: A.W.
3-21-84

QUALITY CONTROL INSPEC./ENG.

DATE 3-26-84

PAGE 1 OF 2

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

page 2 of 2

PT

COMPONENT I.D. C33-341A Piston

SYSTEM R43

PLANT/LOCATION DG 101

|  |  |  |  |
|---|---|---|---|
| A. MATERIAL<br>Carbon Steel | TYPE | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
|  | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: |  |
| CROSS SECTION THICKNESS | MAX<br>MIN N/A | PIPE DIA. N/A | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☒ AS FABRICATED ☐ OTHER |

|  |  |  |  |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.2 | SURFACE/MAT'L. TEMP. 80°F | M&TE. NO. 7-11-708 | MWR/RR. No. N/A |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 84A028 |
| 2. PENETRANT | Spotcheck | SKL-HF/SKL-S | 81E180 |
| 3. EMULSIFIER AND/OR REMOVER | Magnaflux | SKC-NF/ZC-7B | 84A028 |
| 4. DEVELOPER | Magnaflux | SKD NF/ZP-9B | 83H041 |
| 5. POST EXAMINATION CLEANER | Magnaflux | SKC-NF/ZC-7B | 84A028 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Performed L.Pen. exam of Piston #8, Bosses A, C, D

Sat

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 |  |  | A |
| 2 |  |  |  |
| 3 | N |  |  |
| 4 |  |  |  |

|  |  |  |
|---|---|---|
| D. ACCEPTANCE CRITERIA | 4.2 | OPERATOR<br>Level II Date 3/26/84 |

E. ATTEST

RESPONSIBLE LILCO PERSONNEL — LEVEL II — DATE 3/26/84

| | | | | |
|---|---|---|---|---|
| 1 | **LILCO**<br>**DEFICIENCY REPORT** | ☒ FIELD<br>☐ OTHER | LDR RESPONSIBILITY<br>M Herlihy<br>LSU | LDR NUMBER<br>2266<br>101 OUTAGE |
| 2 | SYSTEM/COMPONENT<br>Emer Diesel Gen | SYSTEM DESIGNATOR<br>1R43 | MARK NO.<br>1R43*EDG 101 | DATE 3/21/84 Q CLASS ☒ I ☐ II ☐ III |
| 3 | MFG./CONTRACTOR<br>TDI | P.O.<br>310552 | MATERIAL LOCATION<br>TB 63' laydown area | REJECT TAG NO. 492 ☒ YES ☐ NO |
| 4 | SPEC. VIOLATED<br>SH1-089 | DRAWING VIOLATED<br>N/A | PROCEDURE VIOLATED<br>N/A | CODE/STANDARD VIOLATED<br>N/A |

5 CONDITION DETAILS TDB 9-335 (03-341A) reports unsat conditions. Attached QCER and LP exam report for piston Cyl #8 show conditions requiring engineering evaluation.

03-341A

FOR INFORMATION ONLY

6 ORIGINATOR C Solano 3.21.84
SIGNATURE DATE

OQAE for Alon 3/21/84
SIGNATURE DATE

7 RESPONSIBILITY ☐ LSU ☒ S & W ENG. SIGNATURE/LEAD SU ENG. DATE 3/21/84

8 ACTION ☒ ACCEPT AS IS ☐ SCRAP ☐ REWORK ☐ REPAIR ☐ MANUAL ☐ PROCEDURE ☐ FSAR ☐ OTHER

9 DISPOSITION DETAILS ACCEPT AS IS. AREA OF CONCERN, BOLT HOLE BOSS AREA, WAS REEXAMINED. REFERENCE ATTACHED INSPECTION REPORT DATED 3/22/84. NO RELEVANT INDICATIONS WERE IDENTIFIED.

10 APPROVALS 3/24/84
S & W LEAD ENG./LSU TEST ENG./DATE

K Kammeyer for J Carney 3/24/84
PROJECT ENGINEER DATE

11 MM Herlihy 3/24/84
LILCO SU ENG. DATE

3/27/84
LILCO SITE OQA DATE

REPAIR/REWORK REQUEST NO. N/A

12 ENG. COMPLETE/DATE N/A

RRR COMPLETE N/A
CONST. SUPT./DATE

N/A
LILCO SU/DATE

REWORK INSPECTION ☐ SAT. ☐ UNSAT. N/A
LILCO SITE OQA/DATE

13 LDR CLOSED for Alon 3/27/84
LILCO SITE OQA/DATE

NEW LDR REPORT NO. ISSUED N/A

REMARKS N/A

FC-0369

## COMPONENT TASK EVALUATION REPORT

1/4

| YSTEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATION |
|---|---|---|---|---|
| CYL.#8 DG<br>03-341A 101 | 1A-6522<br>03-341A | GOGluka<br>SIGNATURE | 3-20-84 | ☐ENGINEERING<br>☒QUALITY |

)NDITION DETAILS: ATTACHED INSPECTION REPORT ( 2 PAGES) GENERATED BY C.LARSON DATED 3-20-84 REPORTS UNSATISFACTORY INSPECTION RESULTS FOR THIS PART.

:COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR DISPOSITION. IR Attached is unsatisfactory - see sheet 2 for recommended disposition

:EQUIRED COMPLETION DATE:

### ASSIGNMENT

| )SITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ✓ENGINEERING ☐QUALITY | Michael SCurry<br>SIGNATURE | 3-20-84 |

### DISPOSITION

:SPOSITION DETAILS:

:SPOSITION ASSIGNED TO ☐ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| JPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
|  |  | RESP. CHAIRPERSON |  | PROGRAM MANAGER |  |

### ACTION

| :TION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
|  |  |  |

:: CKS/GWR/RJN/EFM
.ER LOG

# UNSAT TER DISPOSITION

Distribute for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-335", for each component affected.

2) SPO (J. Kammeyer) - distribute for information.

3) LSU/ODA - review for applicability and issue LDR as needed.

4) M. Schuster - obtain LDR number as issued for component files and closeout.

STONE & WEBSTER ENGINEERING CORPORATION

## QUALITY CONTROL INSPECTION REPORT

JOB NUMBER 11600.37

DATE 3-20-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: [illegible]<br>COMPONENT NO. [illegible] | DG-101 | I.P. NO. 14 REV. 4 CHG 0<br>TER # NA<br>LILCO LP PROC. [illegible] REV. 1<br>DWG. NO. NA |

| DWG NO OR P.O | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 1 | 1 | [illegible] |

NOTE NO. ______, ______, ______, ______,
______, ______, ______, ______

[illegible]

QUALITY CONTROL INSPEC/ENG.

DATE

PAGE

# LIQUID PENETRANT EXAMINATION REPORT

4/4

PT

COMPONENT I.D.

| | | | |
|---|---|---|---|
| **A. MATERIAL** | TYPE CS | FABRICATED PROCESS | ☐ WELDED ☐ CAST ☒ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: | | |
| CROSS SECTION THICKNESS | MAX 6"<br>MIN 1/4" | PIPE DIA. NA | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☒ AS FABRICATED ☐ OTHER |

B. NDE PROCEDURE No: [illegible]

SURFACE/MAT'L. TEMP. [illegible] F

M&TE. NO. [illegible]

MWR/RR. No.

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | [illegible] | SKC-NF/ZC-7B | [illegible] |
| 2. PENETRANT | " | SKL-HF/S | [illegible] |
| 3. EMULSIFIER AND/OR REMOVER | " | See 1 | – |
| 4. DEVELOPER | " | SKD-NF/ZP-9B | [illegible] |
| 5. POST EXAMINATION CLEANER | " | See 1 | |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

SYSTEM

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 | See sketch | | Reject |
| 2 | | | |
| 3 | | | |
| 4 | | | |

PLANT/LOCATION

D. ACCEPTANCE CRITERIA [illegible]

OPERATOR [illegible]

Level [illegible] Date [illegible]

E. ATTEST [illegible]

STONE & WEBSTER ENGINEERING CORPORATION

# QUALITY CONTROL INSPECTION REPORT

JOB NUMBER 11600.37

DATE 3-22-84

SYSTEM(S) OR PART(S) NAME

LOCATION(S)

REFERENCE DOCUMENT(S)

COMPONENT NAME: G1 #8

COMPONENT NO. 03-341A

DG- 101

I.P. NO. 14 REV. 4 CHG 0

TER # NA

LILCO LP PROC. 6.1.2 REV. 2

DWG. NO. NA

| DWG NO. OR P.O. | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 1 | 1 | PT performed per request of LILCO representative. |
| | | | * Witnessed By Nelson C. Irving Lilco III |
| | | | Nelson C. Irving LIII<br>3-22-84 |

DATE NO. 7-11-709

QUALITY CONTROL INSPEC./ENG.

DATE

PAGE

LILCO

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 03-341A

SYSTEM Diesel Generator 101

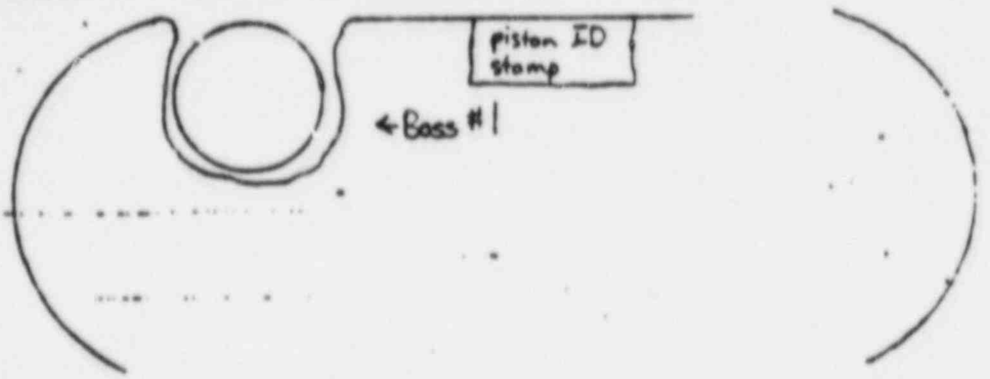
PLANT/LOCATION Shoreham 1

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: | | |
| CROSS SECTION THICKNESS | MAX 6"<br>MIN 1/2" | PIPE DIA. NA | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☒ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.1/6.2 | SURFACE/MAT'L. TEMP. 72° F | M&TE. NO. 7-1-78 | MWR/RR. No. |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 84AC28 |
| 2. PENETRANT | Magnaflux | SKL-4F/SKL-S | 81E180 |
| 3. EMULSIFIER AND/OR REMOVER | Magnaflux | SKC-NF/ZC-7B | 84AD28 |
| 4. DEVELOPER | Magnaflux | SKD-NF/ZP-9B | 83H041 |
| 5. POST EXAMINATION CLEANER | Magnaflux | SKC-NF/ZC-7B | 84AD28 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY



C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 | | | No relevant indications exceeding |
| 2 | | | acceptance criteria; no linear |
| 3 | | | indications. |
| 4 | | | |

| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | proc. 6.2 para. 4.2 | OPERATOR<br>Level II Date 3-22-84 |
| E. ATTEST | | III 3-22-84 |

EDG 102

EDG 102

# INTEROFFICE CORRESPONDENCE

1.0 Ⅱ

| | | |
|---|---|---|
| TO:<br>DISTRIBUTION | LOCATION<br>SNPS-1 | SUBJECT / REFERENCE / J.O. NO.<br>11600.37 03·341 4 |
| FROM:<br>R. MURRAY | LOCATION<br>QEG | TRANSMITTAL OF SAT I.R.'s |

**MESSAGE: —**

ATTACHED PLEASE FIND 2 SATISFACTORY INSPECTION REPORTS GENERATED BY THE QUALITY REVALIDATION INSPECTION GROUP AND REVIEWED BY THE QUALITY ENGINEERING GROUP. THEY ARE FORWARDED TO YOU FOR YOUR INFORMATION IN ACCORDANCE WITH EDG QR/DR PROGRAM MEMO R. NAJUCH

2·23-84
DATE

R D Murray
SIGNATURE

TELEPHONE

**REPLY:**

DIST. R. NAJUCH (IOC ONLY)
G. ROGERS FAAA W/ ATTACHMENTS
J. KAMMEYER SEO W/ ATTACHMENTS
E. YOUNGLING LSU W/ ATTACHMENTS

ATT #2 LF 5, 6, 7 & 8

DATE

SIGNATURE

TELEPHONE

A 040.138

SENDER DETACH AND RETAIN THIS COPY

## QUALITY CONTROL
## NSPECTION REPORT

P.O. NUMBER: 1160037
DATE: 2-12-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| PISTON<br>03-341A REV0 | DG-102 | IP NO. 14<br>PROC 62 REV2<br>PER REQUEST OF MEL SCHUSTER CYL 6 WAS TESTED |

| DWG NO OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
|  | 2 | ~~4~~<br>3<br>[illegible] | PERFORMED A LP TEST OF PISTON SKIRT AT BOSSES FOR BOLT ATTACHMENT OF CROWN ALSO L.P TESTED THE PISTON PIN BOSS<br><br>SAT NO INDICATIONS FOUND |

QUALITY CONTROL INSPEC./ENG.: Edward F Do[illegible]
DATE: 2/11/84
PAGE OF

[illegible] LIQUID PENETRANT EXAMINATION REPORT 0

PT

COMPONENT I.D. C3-34-F

SYSTEM DG-102 PISTON SK[illegible] AT BOSSES FOR BOLT ATTACHMENT PISTON PIN [illegible] AREA

PLANT/LOCATION [illegible]

**A. MATERIAL** CARBON STEEL

TYPE

FABRICATED PROCESS: ☐ WELDED ☒ CAST ☐ WORKED

GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER:

CROSS SECTION THICKNESS: MAX / MIN N/A

PIPE DIA. N/A

SURFACE CONDITION: ☐ MACHINED ☐ GROUND ☑ AS FABRICATED ☐ OTHER

**B. NDE PROCEDURE** No. LP 61+62 REV 1

SURFACE/MAT'L. TEMP. 72°F

M&TE. NO. 7-17-449

MWR/RR. No. N/A

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | SPOTCHECK | SKC-NF/ZC-7B | 83H095 |
| 2. PENETRANT | SPOTCHECK | SKL-HF/SKL-S | 81E180 |
| 3. EMULSIFIER AND/OR REMOVER | SPOTCHECK | SKC-NF/ZC-7B | 83H095 |
| 4. DEVELOPER | SPOTCHECK | SKD-NF | 81L092 |
| 5. POST EXAMINATION CLEANER | SPOTCHECK | SKC-NF/ZC-7B | 83H095 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

PISTON 5,7&8 PERFORMED LP TEST OF PISTON SKIRT AT BOSSES FOR BOLT ATTACHMENT [illegible] ALSO LP TESTED THE PISTON PIN BOSS

**C. EVALUATION** REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 no indications | | | ACCEPT |
| 2 N/A | | | |
| 3 N/A | | | |
| 4 N/A | | | |

**D. ACCEPTANCE CRITERIA** -

OPERATOR [illegible]

Level II Date [illegible]

**E. ATTEST**

[illegible]

Rodney J. Berner

| RESPONSIBLE CERTIFIED PERSONNEL | LEVEL | DATE |
|---|---|---|
| Rodney J. Berner | II | [illegible] |

STONE & WEBSTER ENGINEERING CORPORATION

## QUALITY CONTROL
## NSPECTION REPORT

| JOB NUMBER | DATE |
|---|---|
| 11600.37 | 2-12-84 |

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| #6 Piston Assembly<br>03-341 A<br>Rev 0 | DG-102 | Per Request of M. Schuster |

| WG NO OR PO | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 2 | 1 | Performed L.P. inspection on #6 piston pin boss.<br>No Indications found. |

| QUALITY CONTROL INSPEC / ENG | DATE | PAGE |
|---|---|---|
| | 2-12-84 | 1 of 2 |

[illegible] LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D.

SYSTEM #6 Piston Assembly

PLANT/LOCATION DG-102

| | | | |
|---|---|---|---|
| **A. MATERIAL** | TYPE | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD | ☒ OTHER: |
| CROSS SECTION THICKNESS — MAX<br>MIN | PIPE DIA. | SURFACE CONDITION | ☒ MACHINED ☐ GROUND<br>☒ AS FABRICATED ☐ OTHER |

B. NDE PROCEDURE No. ____

SURFACE/MAT'L. TEMP. 72°F

M&TE. NO. 7-11-699

MWR/RR. No. ____

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Spotcheck | SKC-NF/ZC-7B | 83H095 |
| 2. PENETRANT | Spotcheck | SKL-HF/SKL-S | 81E180 |
| 3. EMULSIFIER AND/OR REMOVER | Spotcheck | SKC-NF/ZC-7B | 83H095 |
| 4. DEVELOPER | Spotcheck | SKD-NF | 81G092 |
| 5. POST EXAMINATION CLEANER | Spotcheck | SKC-NF/ZC-7B | 83H095 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Performed L.P. inspection on #6 piston pin boss, per request M. Schuster. No Indications found.

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 NA | | | |
| 2 NA | | | |
| 3 NA | | | |
| 4 NA | | | |

D. ACCEPTANCE CRITERIA —

OPERATOR ____

Level ____ Date ____

E. ATTEST

RESPONSIBLE CERTIFIED PERSONNEL ____ LEVEL I ____ DATE 2-12-84

EDG 103

EDG 103

# INTEROFFICE CORRESPONDENCE

103

| | | |
|---|---|---|
| TO:<br>DISTRIBUTION | LOCATION<br>SNPS-1 | SUBJECT / REFERENCE / J.O. NO.<br>11600.37 03 341A |
| FROM:<br>R. MURRAY | LOCATION<br>QEG | TRANSMITTAL OF SAT I.R.'s ATT #1 |

MESSAGE: —

ATTACHED PLEASE FIND 1 SATISFACTORY INSPECTION REPORTS (2pgs) GENERATED BY THE QUALITY REVALIDATION INSPECTION GROUP AND REVIEWED BY THE QUALITY ENGINEERING GROUP. THEY ARE FORWARDED TO YOU FOR YOUR INFORMATION IN ACCORDANCE WITH EDG QR/DR PROGRAM MEMO R. NAJUCH

3/12/84
DATE

R D Murray
SIGNATURE

564
TELEPHONE

REPLY:

DIST. R. NAJUCH (IOC ONLY)
G. ROGERS DRG W/ ATTACHMENTS

DATE

SIGNATURE

TELEPHONE

A 040138

SENDER DETACH AND RETAIN THIS COPY

## QUALITY CONTROL INSPECTION REPORT

JOB NUMBER 11600.37

DATE 3-12-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| COMPONENT NAME: PISTONS<br>COMPONENT NO. 03-341A | DG- 103 | I.P. NO. 14 REV. ~~4~~ 3 CHG 0<br>TER # ______<br>LILCO LP PROC. [illegible] REV. 1<br>DWG. NO. ______ |

| DWG. NO OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | ~~3~~ ~~2~~ 1 | 3 | PERFORMED LP EXAM ON PISTION SKIRT AT THE BOSSES FOR BOLT ATTACHMENT OF CROWN<br>DG 103 PISTIONS # 5,7&8<br>SAT. |

M&TE NO. 7-11-708 ____, ____, ____, ____,

QUALITY CONTROL INSPEC./ENG. [illegible]

DATE 3-12-84

PAGE 1 .. 2

Reviewed by [illegible] , 3-[illegible]

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

[illegible]

| | | |
|---|---|---|
| PT | COMPONENT I.D. PISTONS [illegible] | SYSTEM [illegible] | PLANT/LOCATION DG103 |

| | | |
|---|---|---|
| A. MATERIAL<br>CARBON | TYPE | FABRICATED PROCESS ☐ WELDED ☐ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☐ OTHER: | |
| CROSS SECTION THICKNESS MAX<br>MIN N/A | PIPE DIA. N/A | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 62 REV 1 | SURFACE/MAT'L. TEMP. 71° | M&TE. NO. 71170[illegible] | MWR/RR. No. |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | MAGNAFLUX | SKC-NF/ZC-7C | 83H100 |
| 2. PENETRANT | SPOTCHECK | SKL-HF/-S | 81E130 |
| 3. EMULSIFIER AND/OR REMOVER | MAGNAFLUX | SKC-NF/ZC-7B | 83H100 |
| 4. DEVELOPER | MAGNAFLUX | SKD-NF/ZP-9B | 83H041 |
| 5. POST EXAMINATION CLEANER | MAGNAFLUX | SKC-NF/ZC-7B | 83H100 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

EPD 3-12-84

DG103 ~~CYLINDER HEAD~~ PISTONS # 5, 7+8

PERFORMED L.P OF PISTON SKIRT AT THE BOSSES FOR BOLT ATTACHMENT OF CROWN

| | |
|---|---|
| C. EVALUATION | REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE. |

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 NO INDICATIONS | N/A | N/A | ACCEPT |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | – | OPERATOR ______<br>Level ______ Date ______ |

E. ATTEST

Ed [illegible] ______ RESPONSIBLE CERTIFIED PERSONNEL

II ______ LEVEL

3-13-84 ______ DATE

EDG 101

EDG-101

# INTEROFFICE CORRESPONDENCE

| | | |
|---|---|---|
| TO: DISTRIBUTION | LOCATION SNPS-1 | SUBJECT / REFERENCE / J.O. NO.<br>11600.37 Component No. 03-341A<br>TRANSMITTAL OF SAT I.R.'s Att. 3 |
| FROM: R. MURRAY | LOCATION QEG | |

**MESSAGE:—**

ATTACHED PLEASE FIND one SATISFACTORY INSPECTION REPORTS GENERATED BY THE QUALITY REVALIDATION INSPECTION GROUP AND REVIEWED BY THE QUALITY ENGINEERING GROUP. THEY ARE FORWARDED TO YOU FOR YOUR INFORMATION IN ACCORDANCE WITH EDG QR/DR PROGRAM MEMO R. NAJUCH

DATE 3-26-84

SIGNATURE R D Murray

TELEPHONE 564

**REPLY:**

DIST. R. NAJUCH (IOC ONLY)
G. ROGERS DRG W/ ATTACHMENTS
J. E. KELLY LILCO FQA (NDE RELATED IR's ONLY) W/ATTACHMENTS.

DATE

SIGNATURE

TELEPHONE

A 040 139

SENDER DETACH AND RETAIN THIS COPY

FORWARD WHITE AND PINK COPIES. RETAIN PINK COPY FOR FILE.

# INTEROFFICE CORRESPONDENCE

TO: Ken Morrow

LOCATION:

FROM: Don Johnson

LOCATION: FaAA

SUBJECT / REFERENCE / J.O. NO. FaAA Report # 840321-2

ET of DG 101 Pistons #5,7,&8

**MESSAGE:** —

Attached is FaAA Report # 840321-2, Eddy Current Examination of DG 101 Pistons # 5, 7, & 8.

No relevant indications were observed.

3/21/84
DATE

Don Johnson
SIGNATURE

582
TELEPHONE

**REPLY:**

DATE

SIGNATURE

TELEPHONE

▲ 040.138

Analysis
Associates

# EDDY CURRENT EXAMINATION REPORT

ET

Component I.D. PISTONS # 5, 7, 8

Job name & no. PISTON INSPECTION

Plant/location DG 101

**Material** NODULAR IRON

**Type:** PISTON

**Fabricated process:** ☐ Welded ☒ Cast ☐ Worked

**Geometry:** ☐ Pipe ☐ Plate ☐ Rod ☒ Other:

**Cross section thickness:** Max. N/A Inch Min. N/A Inch

**Surface condition:** ☒ Machined ☐ Ground ☐ As fabricated ☐ Other:

**NDE Procedure no.** 11.5

**Job no.** ~~03341A~~ 03-341A

**Report no.** 840321-2

Test condition: Ver ______ Hor ______

Unit # ______ Sen ______ Frq ______

Full-on ______ Full-off ______

Reference no. ______ Probe type ______

______ Unit at ______ Lo

______ Unit at ______ Lo

______ Unit at ______ Lo

______ Unit at ______ Lo

| Indication no. | Magnitude of indication | Length of indication | Remarks |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Specific examination area**

BOSS AREA For BOLT HOLES

ALL PISTONS SAT.

**Sketch or other data (use other side)**

**Acceptance criteria** –

**Operator:**

**Level:** II **Date:** 3-21-84

**Attest** Dan Johnson II 3-21-84
Responsible certified personnel Level Date

FaAA-M-84-2-7

Associa

# EDDY CURRENT CALIBRATION REPORT

Job No. 03340A Date 3-21-84 Report No. 830321-2

Material Description NODular I RON

Code or Specification NDE 11.5 REV. 1 Full On N/A Full Off N/A

Reference Standard PAO-C-1 Instrument MIZ 17 S/N B123867

## Instrument

Freq. 2MHz Gain 30 Volts/div 0.5 Phase 210

Test Probe FaAA ECP 100P S/N 100P

Reference Probe FaAA ECP 100P S/N 100P-1

## CALIBRATION

4 units @ -1.5 L/O

4 units @ -0.75 L/O

3.5 ~~[illegible]~~ units @ +0.2 ~~[illegible]~~ L/O

2.6 ~~1.6~~ units @ +1.25 L/O

## STRIP CHART RECORDER

Type N/A S/N N/A

| Channel 1 | | Channel 2 | |
|---|---|---|---|
| Sen | N/A | Sen | N/A |
| Position @ Null Point | N/A | Position @ Null Point | N/A |
| Chart Speed | N/A mm/sec | | |

## Calibration Check

| | | | | | |
|---|---|---|---|---|---|
| Time | 12:21 PM | Phase | 210 | Gain | 30 |
| Time | 12:27 | Phase | 210 | Gain | 30 |
| Time | 12:35 | Phase | 210 | Gain | 30 |
| Time | 12:41 EOT | Phase | 210 | Gain | 30 |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |

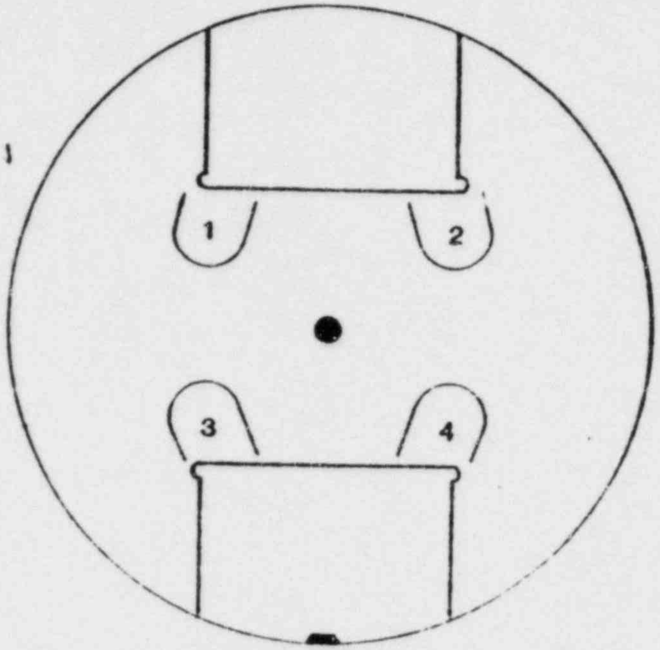
Examiner Level II Examiner Level

R&D-KR-3

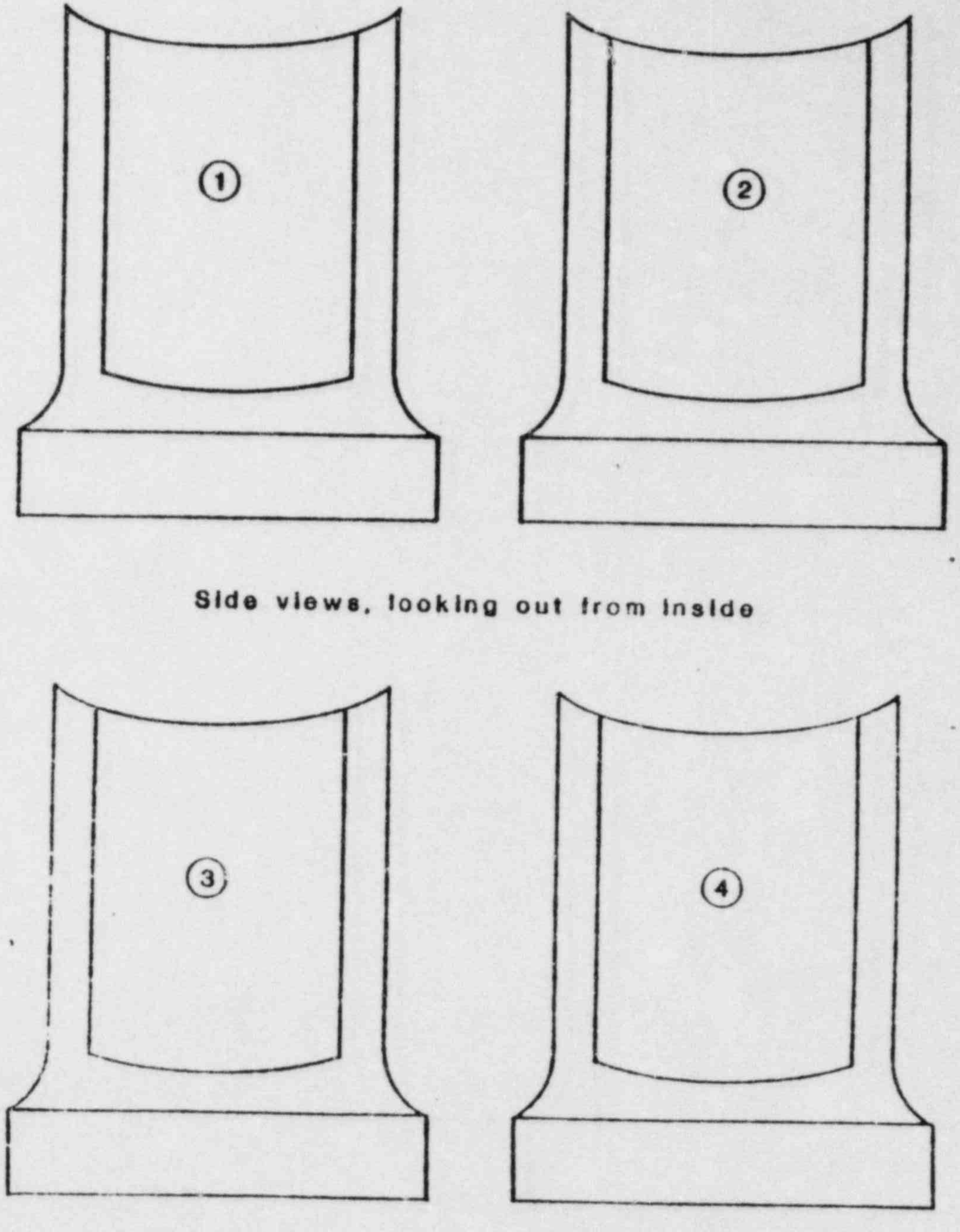
Diesel engine # DG101

Piston # 8

Condition SAT



Overhead view

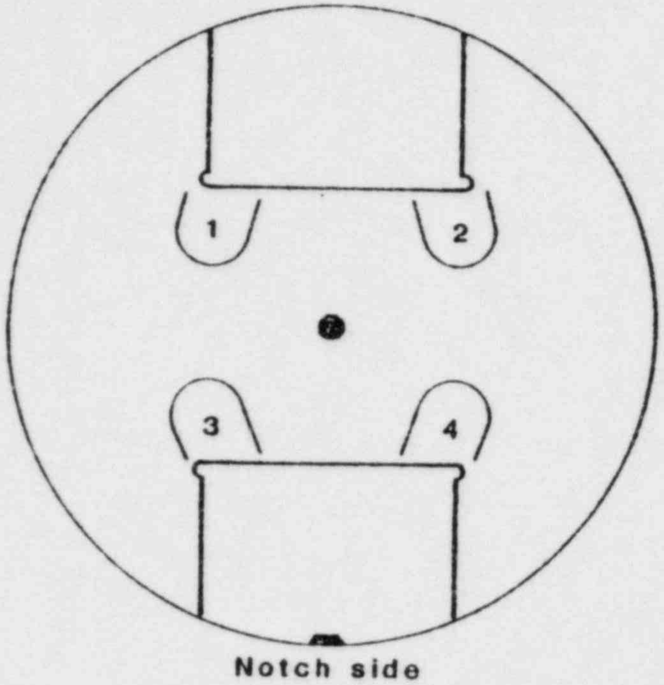


Side views, looking out from inside

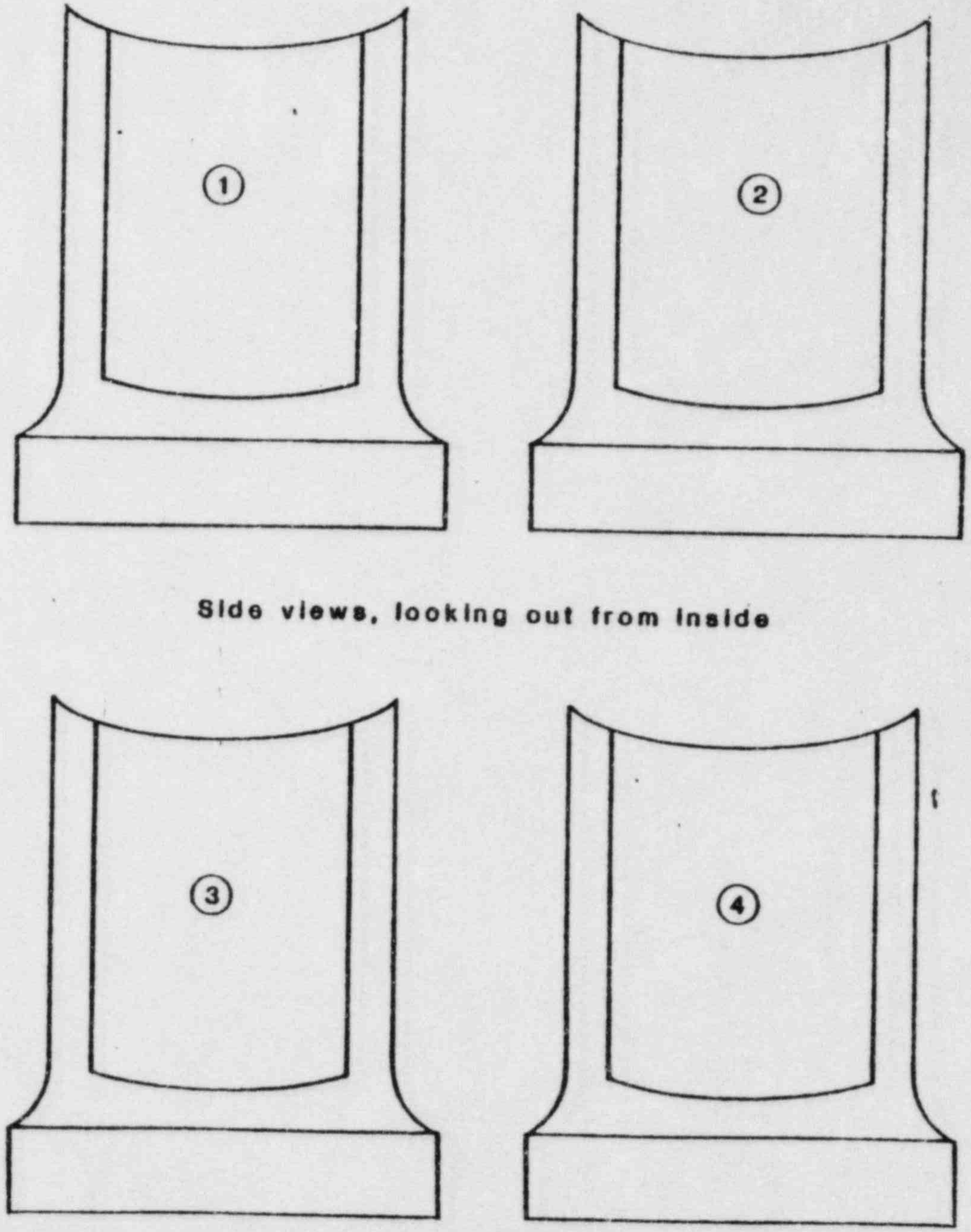
Diesel engine # DG101

Piston # 7

Condition SAT



Overhead view

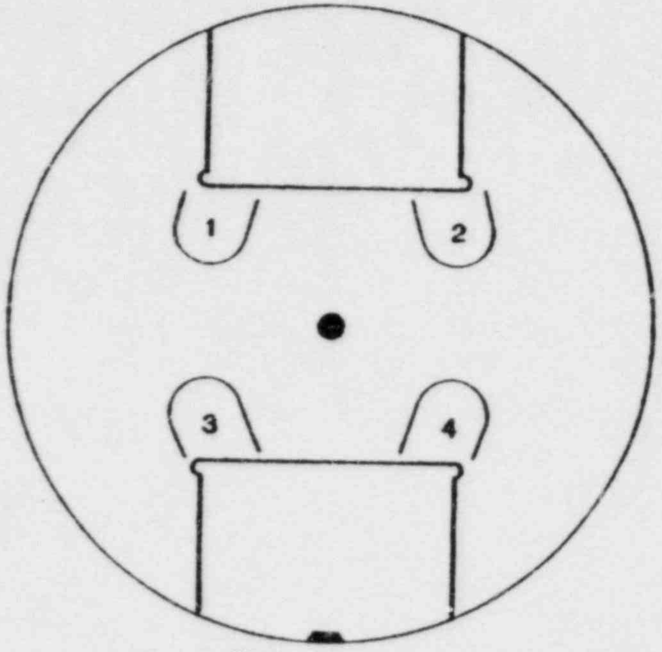


Side views, looking out from inside

Diesel engine # DG 101

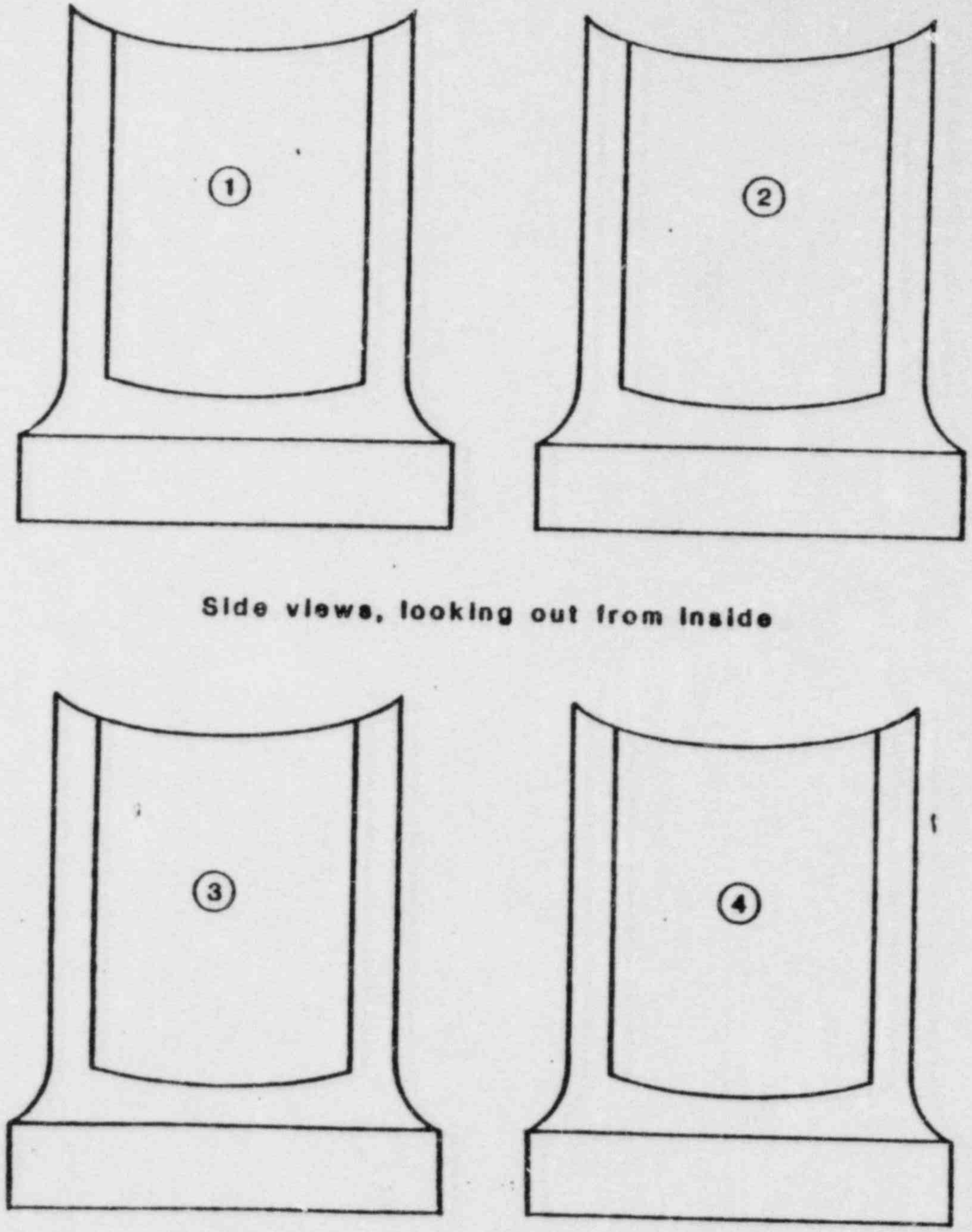
Piston # 5

Condition – SAT



Notch side

Overhead view



Side views, looking out from inside

EDG 102

Q-38 S.P.

INFO

# COMPONENT TASK EVALUATION REPORT

ATT #4

| | | | | |
|---|---|---|---|---|
| TEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
| )3-341A | 1A-6522 | SIGNATURE | 2/20/84 | ☐ ENGINEERI<br>☒ QUALITY |

)NDITION DETAILS: ATTACHED INSPECTION REPORT (5 PAGES) BY D. O. JOHNSON ᴬᵀ D2-14-84 WAS GENERATED AS INFORMATIONAL, AS NO ACCEPTAN 2I.TERIA WAS PROVIDED PRIOR TO THE PERFORMANCE OF THE INSPEC .ON. SUBJECT I.R. GENERATED BY F.a.A.A. (EDDY CURRENT.

:COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR EVALUATION .ND ALSO TO SEO AND LSU FOR INFORMATION ONLY.

:QUIRED COMPLETION DATE: 2/21/84

## ASSIGNMENT

| | | |
|---|---|---|
| )SITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
| ENGINEERING ☐ QUALITY | R. Fraser<br>SIGNATURE | 2-21-84 |

## DISPOSITION

.OSITION DETAILS: Send copy to C. Wells / FaAA, SEO, and ~~LSU~~. See TER No. Q-50. gnf

I.POSITION ASSIGNED TO ☐ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| | | | | | |
|---|---|---|---|---|---|
| UPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
| Watson | 2/23/84 | S Reiss for G.W. Rodgers<br>RESP. CHAIRPERSON | 2/23/84 | for C.K. Seaman<br>PROGRAM MANAGER | 2/25/84 |

## ACTION

| | | |
|---|---|---|
| CTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
| C Wells / FaAA | | 03-06-84 |

C: CKS/GWR/RJN/EFM
TER LOG

E.T. FOR 5, 6, 7 & 8

[illegible]

11.1.10

Failure
Analysis
Associates

# EDDY CURRENT CALIBRATION REPORT

03-341 AmB 2/14/84

Job No. PAO 7396 Date 2-13-84 Report No. 831302-1
Material Description NoDular Cast IRON PISTON SKIRTS
Code or Specification NDE 11.5 Full On -1.5 Full Off +1.5
Reference Standard PAO-C-1 Instrument MIZ 17 S/N 8133867

## Instrument

Freq. 2 MHz Gain 30 Volts/div 0.5 Phase 218
Test Probe FaA ECP-100-P-1 S/N ECP100-P1
Reference Probe FaA ECP-100 B-1 S/N ECP 100 B1

## CALIBRATION

4 units @ -1.5 L/O
3.5 units @ -1 L/O
3.2 units @ -0 L/O
2.6 units @ +1 L/O

## STRIP CHART RECORDER

Type N/a S/N N/a

**Channel 1**
Sen N/A
Position @ Null Point N/A
Chart Speed N/A mm/sec

**Channel 2**
Sen N/A
Position @ Null Point

## Calibration Check

Time 11:20 Phase 218 Gain 30
Time 11:23 Phase 218 Gain 30
Time 11:26 Phase 218 Gain 30
Time 11:32 Phase 218 Gain 30
Time 11:35 Phase 218 Gain 30
Time 11:40 Phase 218 Gain 30
Time 11:45 Phase 218 Gain 30
Time Phase Gain
Time Phase Gain
Time Phase Gain

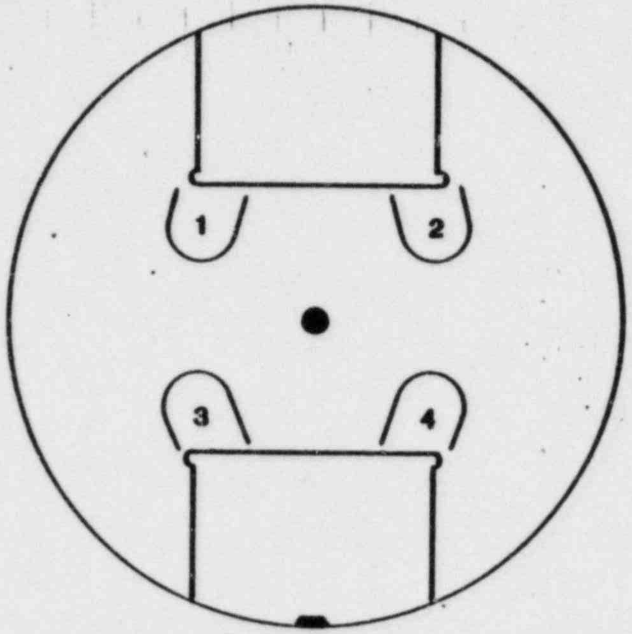
Examiner Dan O Johnson Level II Examiner Level
R&D-KR-3

M10535

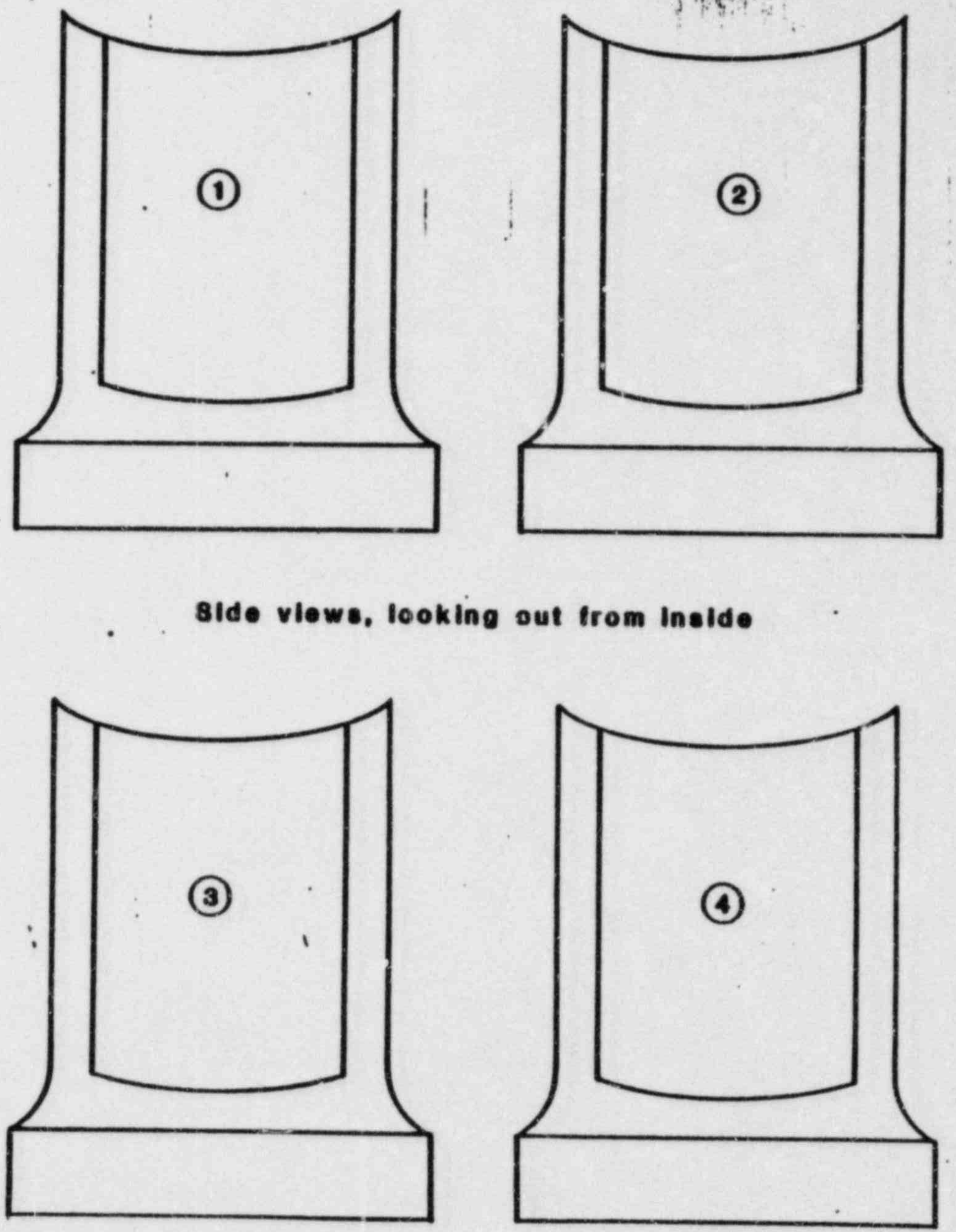
03-341A

Diesel engine # DG 102

Piston # 8



Overhead view



Side views, looking out from inside

RELEVANT NON INDICATION
EXAM IS SAT

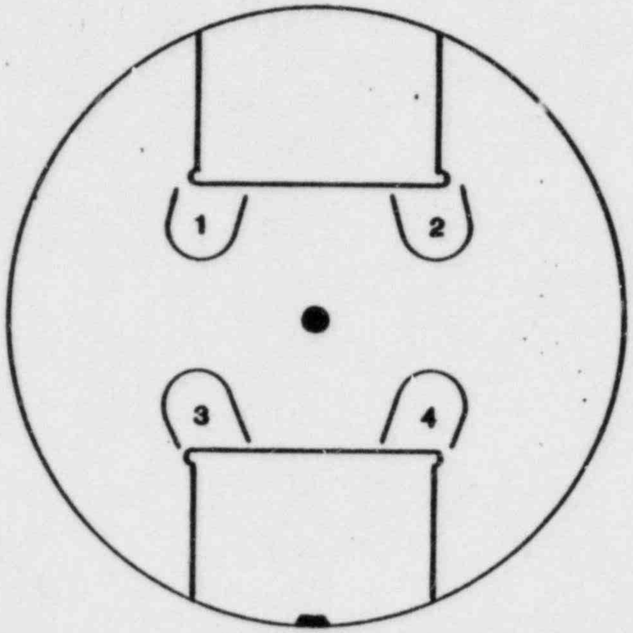
M4536

DQf 2-13-84

03-341A

**Diesel engine #** DG 102

**Piston #** 7

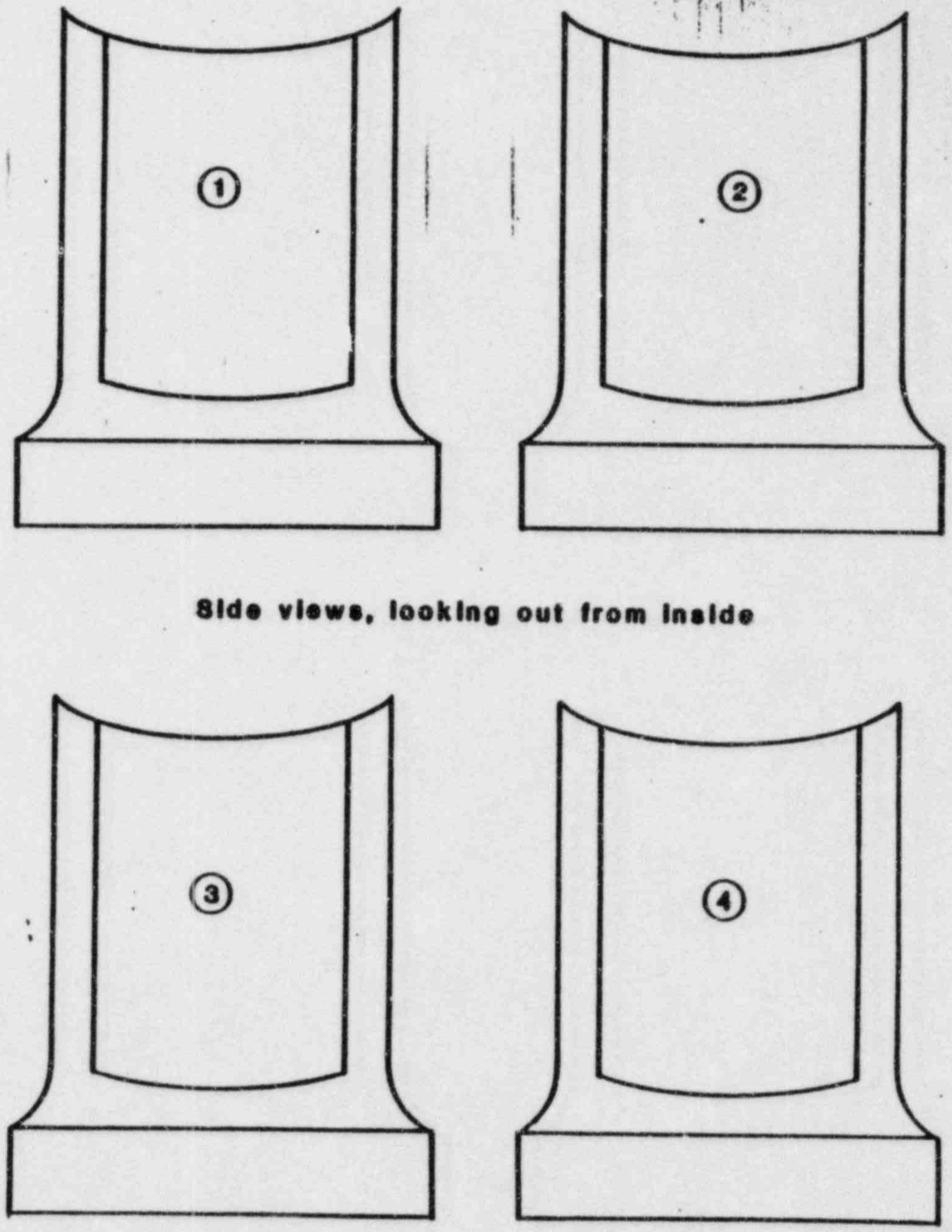


**Notch side**

**Overhead view**

Relevant
NONINDICATION
EXAM is SAT

WDf 2-13-84



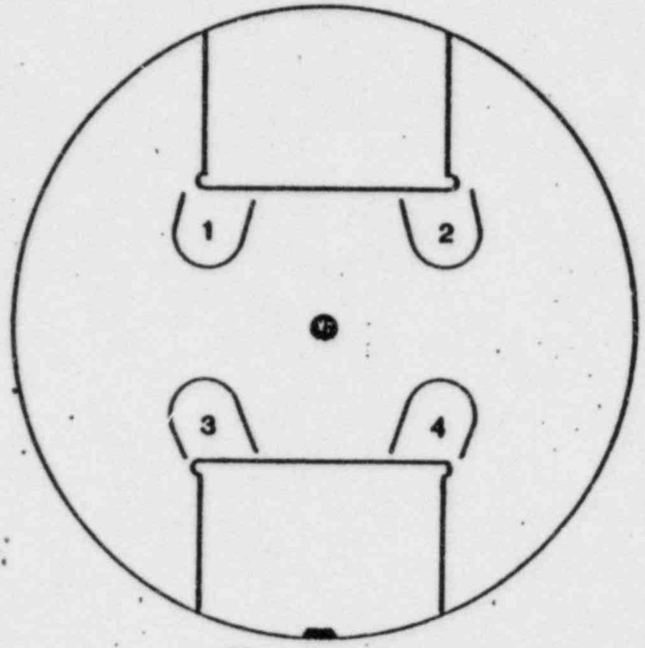
**Side views, looking out from inside**

AA05337

03-341A

Diesel engine # DG 102

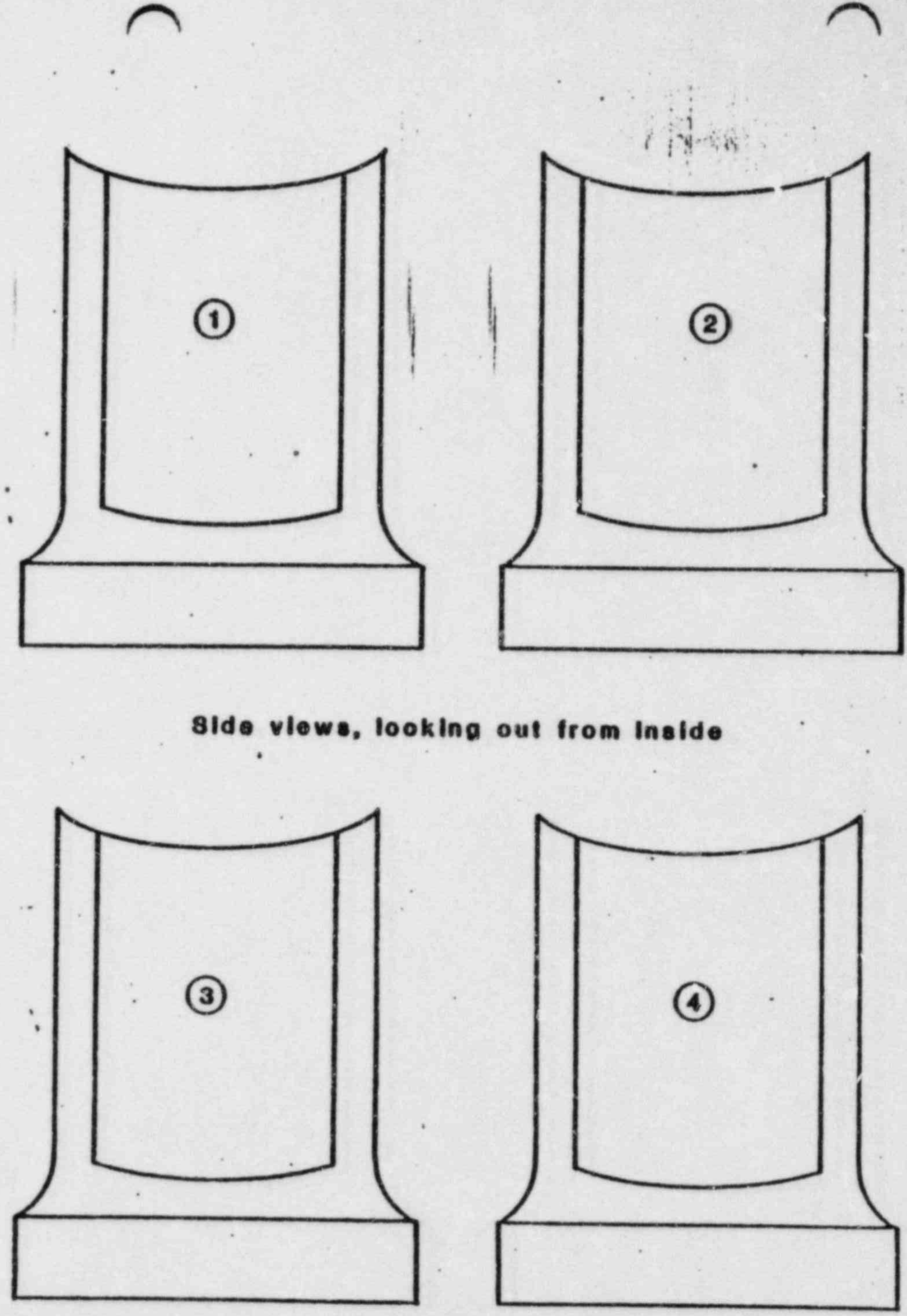
Piston # 5



Overhead view

RELEVANT
NONINDICATION
EXAM IS SAT.

DOf 2-13-84



Side views, looking out from inside

11.1.10

Failure
Analysis
Associat

# EDDY CURRENT CALIBRATION REPORT

03-341A

Job No. PAO 7396 Date 2-13-84 Report No. 83 1302-2
Material Description Nodular Cast Iron Piston Skirts
Code or Specification NDE 11.5 Full On -1.5 Full Off +1.5
Reference Standard PAO-C-1 Instrument MIZ 17. S/N 5133867

## Instrument

Freq. 2 MHz Gain 30 Volts/div 0.5 Phase 218
Test Probe FaAA ECP-100-P-1 S/N ECP-100-P-1
Reference Probe FaAA ECP-100-B-1 S/N ECP-100-B-1

## CALIBRATION

4 units @ -1.5 L/O
3.5 units @ -1 L/O
3.2 units @ -.6 L/O
2.6 units @ +.1 L/O

## STRIP CHART RECORDER

Type N/A S/N N/A

| Channel 1 | Channel 2 |
|---|---|
| Sen N/A | Sen N/A |
| Position @ Null Point N/A | Position @ Null Point N/A |
| Chart Speed N/A mm/sec | |

## Calibration Check

| | | | | | |
|---|---|---|---|---|---|
| Time | 2:21 PM | Phase | 217 | Gain | 30 |
| Time | 2:25 PM | Phase | 217 | Gain | 30 |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |

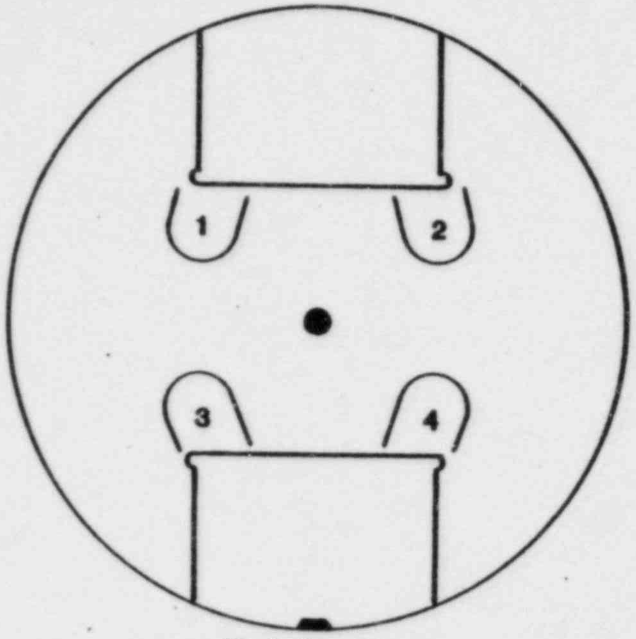
Examiner Don D Johnson Level II Examiner 405539 Level

R&D-KR-3

03-341A

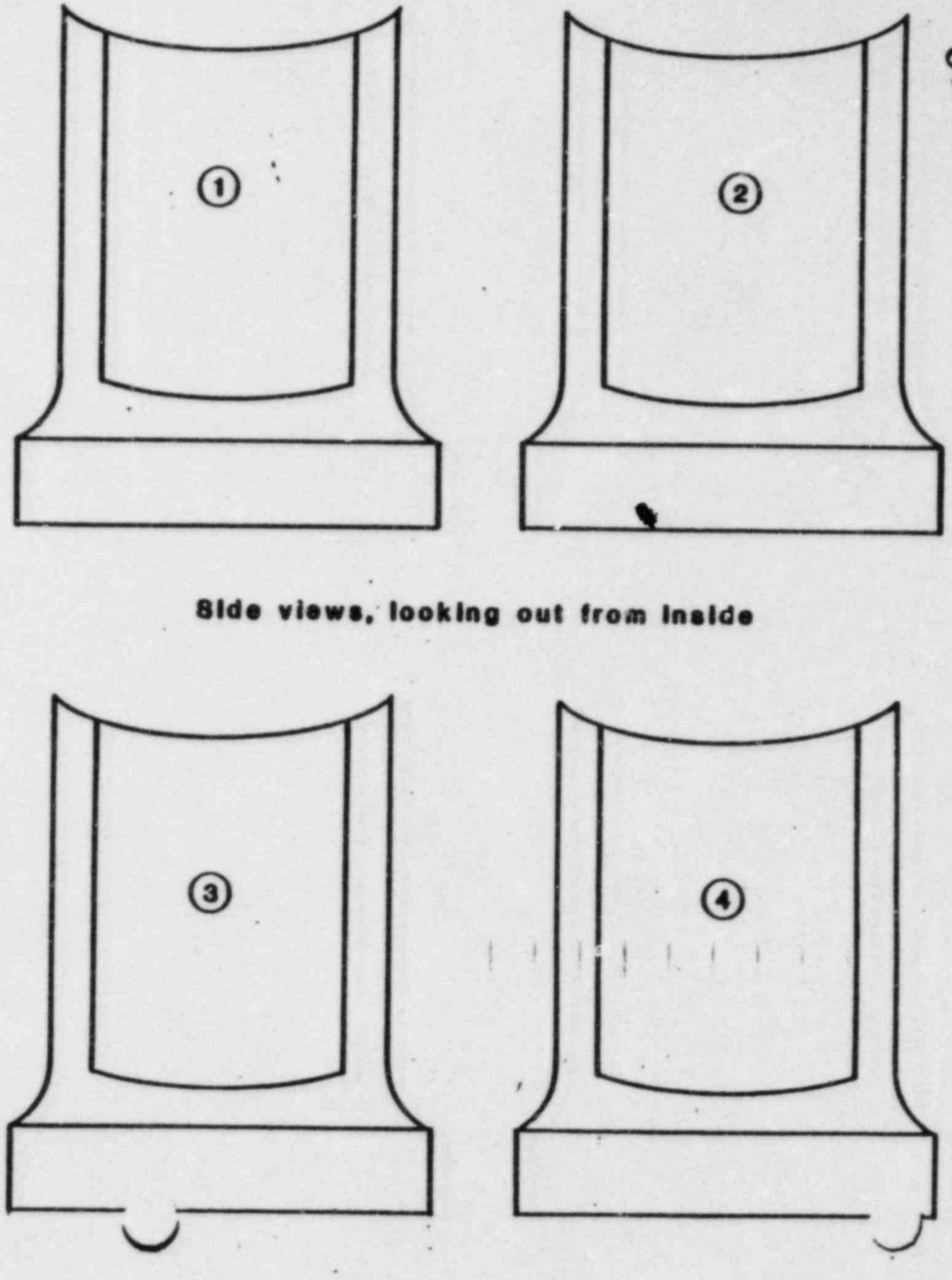
**Diesel engine #** DG 102

**Piston #** 6



**Notch side**

**Overhead view**



**Side views, looking out from inside**

NO REVElant INDICations

Exam is SAT.

WOf 2-13-84

Q-38
03-341A

This inspection report is acceptable for design review

K. Solen for C Wells
Conversation 3/6/84

EDG 103

EDG 103

# INTEROFFICE CORRESPONDENCE

| | | |
|---|---|---|
| TO:<br>DISTRIBUTION | LOCATION<br>SNPS-1 | SUBJECT / REFERENCE / J.O. NO.<br>11600.37 Component No. 03-341A |
| FROM:<br>R. MURRAY | LOCATION<br>QEG | TRANSMITTAL OF SAT I.R.'s |

MESSAGE: —

ATTACHED PLEASE FIND One SATISFACTORY INSPECTION REPORTS GENERATED BY THE QUALITY REVALIDATION INSPECTION GROUP AND REVIEWED BY THE QUALITY ENGINEERING GROUP. THEY ARE FORWARDED TO YOU FOR YOUR INFORMATION IN ACCORDANCE WITH EDG QR/DR PROGRAM MEMO R. NAJUCH

3-13-84
DATE

RD Murray
SIGNATURE

TELEPHONE

REPLY:

DIST. R. NAJUCH (IOC ONLY)
G. ROGERS DRC W/ ATTACHMENTS

DATE

SIGNATURE

TELEPHONE

640.138

SENDER DETACH AND RETAIN THIS COPY

# EDDY CURRENT CALIBRATION REPORT

Job No. 03341A Date 3-13-84 Report No. 840313-1

Material Description NODULAR IRON PISTON SKIRTS

Code or Specification NDE 11.5 Full On -1.5 Full Off +1.5

Reference Standard PN07396-840227 Instrument MIZ 17 S/N 033833

## Instrument

Freq. 2 MHz Gain 30 Volts/div 0.5 Phase 202

Test Probe FaAA ECP100P S/N 100P

Reference Probe FaAA ECP100P S/N 100 P-1

## CALIBRATION

2.2 units @ 0 L/O

2.0 units @ +1 L/O

1.8 units @ +1.5 L/O

1.6 units @ +2.0 L/O

## STRIP CHART RECORDER

Type N/A S/N N/A

Channel 1

Sen N/A

Position @ Null Point N/A

Chart Speed N/A mm/sec

Channel 2

Sen N/A

Position @ Null Point N/A

## Calibration Check

Time 16:37 Phase 202 Gain 30

Time 16:45 Phase 202 Gain 30

Time 16:52 Phase 202 Gain 30

Time Phase Gain

Time Phase Gain

Time Phase Gain

Time Phase Gain

Time Phase Gain

Time Phase Gain

Time Phase Gain

Examiner Level II Examiner Level

R&D-KR-3

Failure
Analysis
Associates

# EDDY CURRENT EXAMINATION REPORT

ET

**Material** NODULAR IRON PISTON SKIRT

**Type:** PISTON SKIRT

**Fabricated process:** ☐ Welded ☒ Cast ☐ Worked

**Geometry:** ☐ Pipe ☐ Plate ☐ Rod ☒ Other: counter BORE

**Cross section thickness:** Max. N/A Inch Min. N/A Inch

**Surface condition:** ☒ Machined ☐ Ground ☐ As fabricated ☐ Other:

**Component I.D.** PISTON SKIRTS ON DG103 #5 #7 #8

**NDE Procedure no.** 11.5

**Job no.** 03341A

**Report no.** 841313-1

**Test condition:** Ver + 1 VOLT Hor 0

Unit # 033823 Sen 30 Frq 3MHZ

Full-on -1.5 Full-off +1.5

Reference no. 100P-1 Probe type 100 P

2.2 Unit at 0 Lo

2.0 Unit at +1 Lo

1.8 Unit at +1.5 Lo

1.6 Unit at +2.0 Lo

**Job name & no.** PISTONS 03341A

**Plant/location** DIESEL Generators ELV. 63

| Indication no. | Magnitude of indication | Length of indication | Remarks |
|---|---|---|---|
| | | | NO RECORDABLE INDICATIONS |

**Specific examination area**

SCAN AREA IN SIDE BELLVILLE WASHER AERA, AROUND RADIUS.

Sketch or other data (use other side)

**Acceptance criteria** INDICATION Greater than 50% of REFERENCE STANDARD

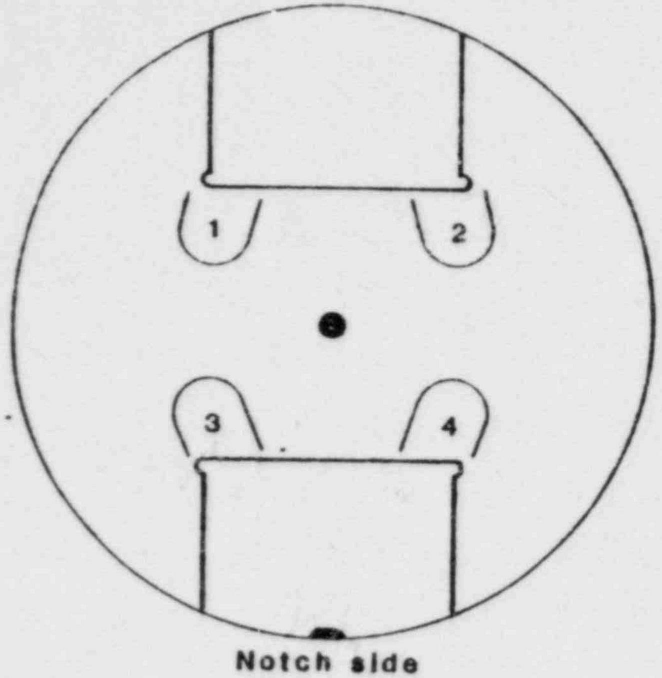
Operator: DOU Johnson
Level: II Date: 3-~~14~~-84 13 RKS

**Attest**

Responsible certified personnel
Level II
Date 3-~~14~~-84 13 RKS 3/13/84

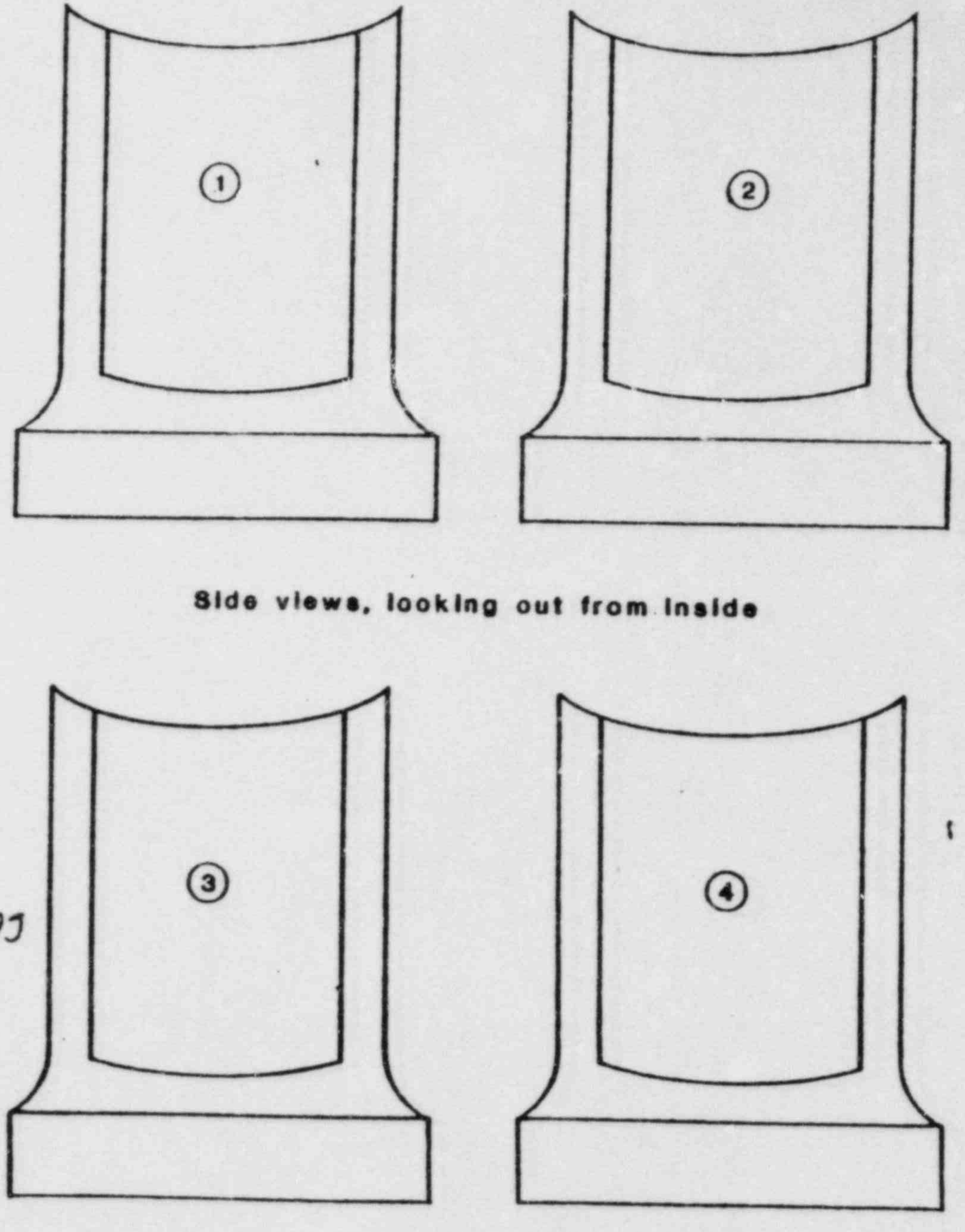
Diesel engine # 103

Piston # 5



Overhead view

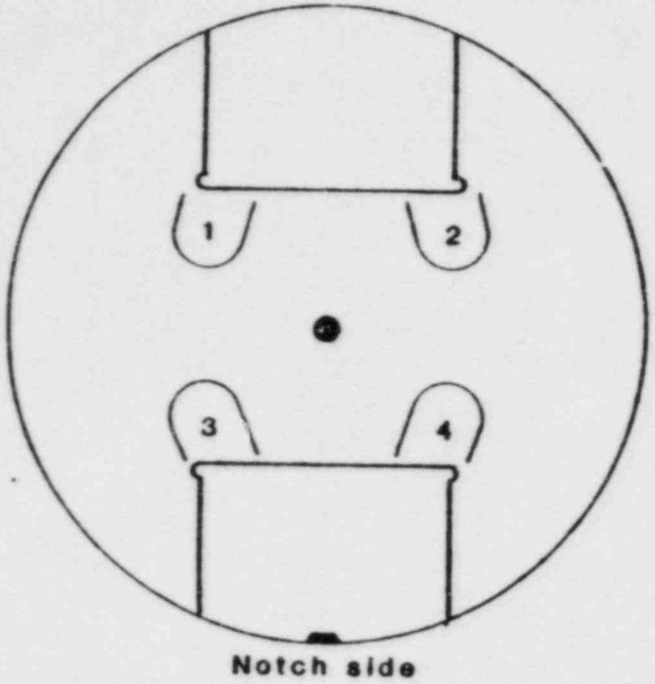
NO RELEVANT INDICATIONS



Side views, looking out from inside

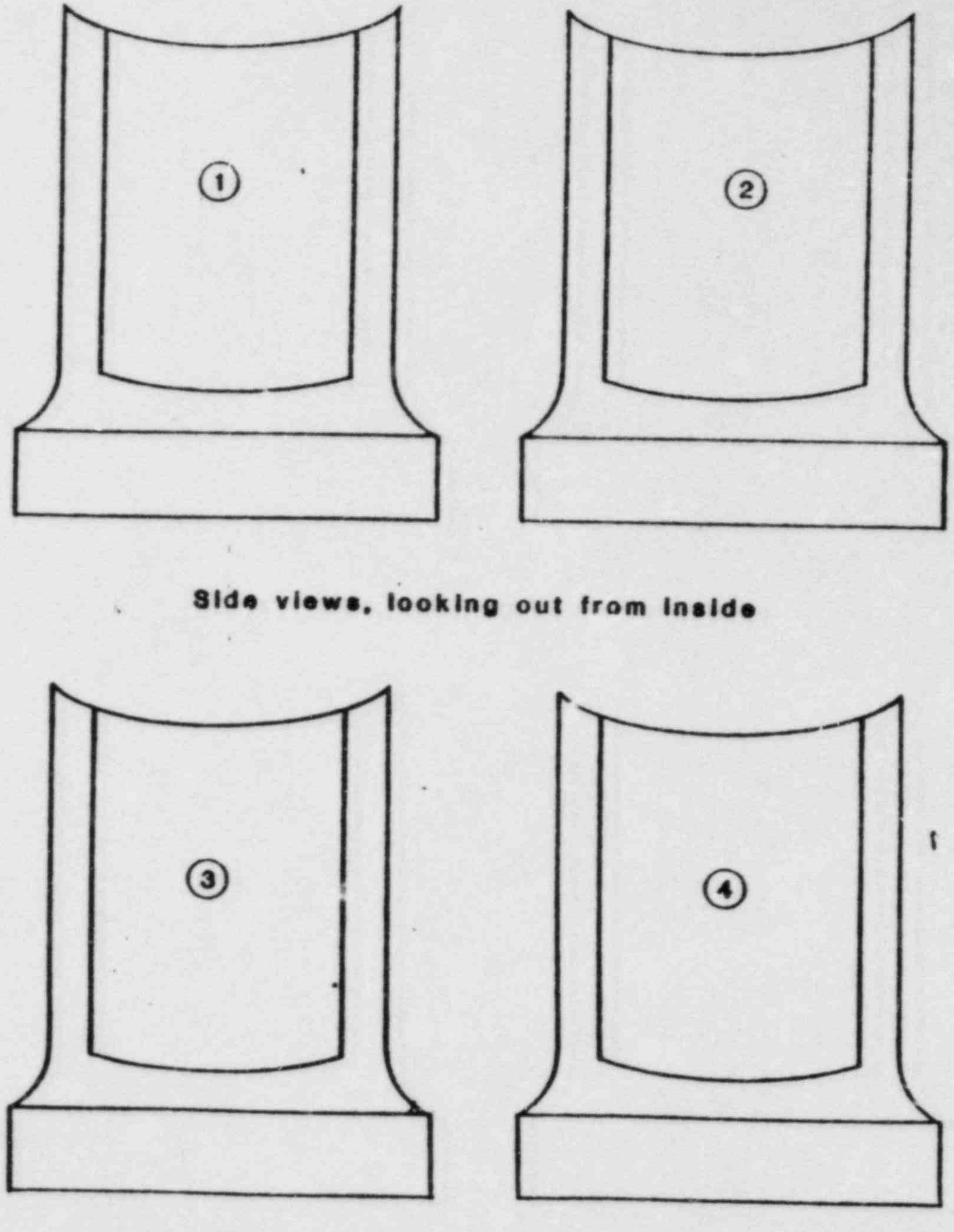
Diesel engine # 103

Piston # 7



Overhead view

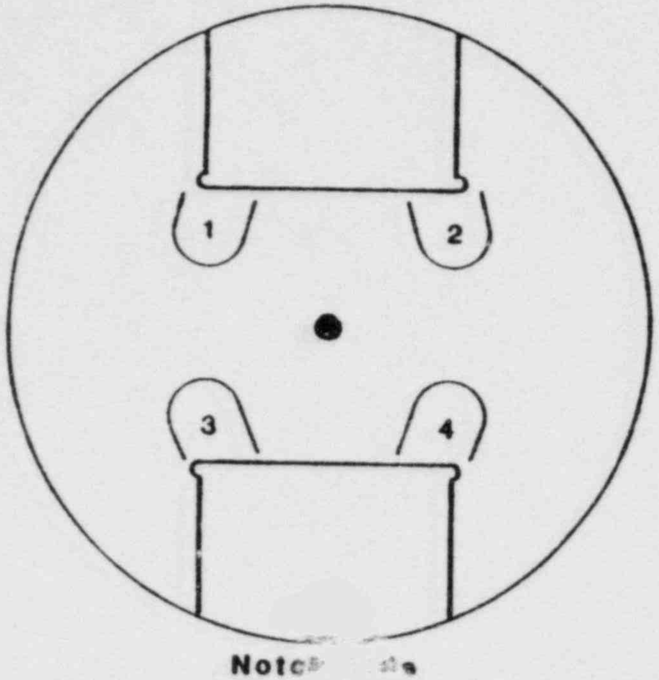
NO RELEVANT INDICATIONS



Side views, looking out from inside

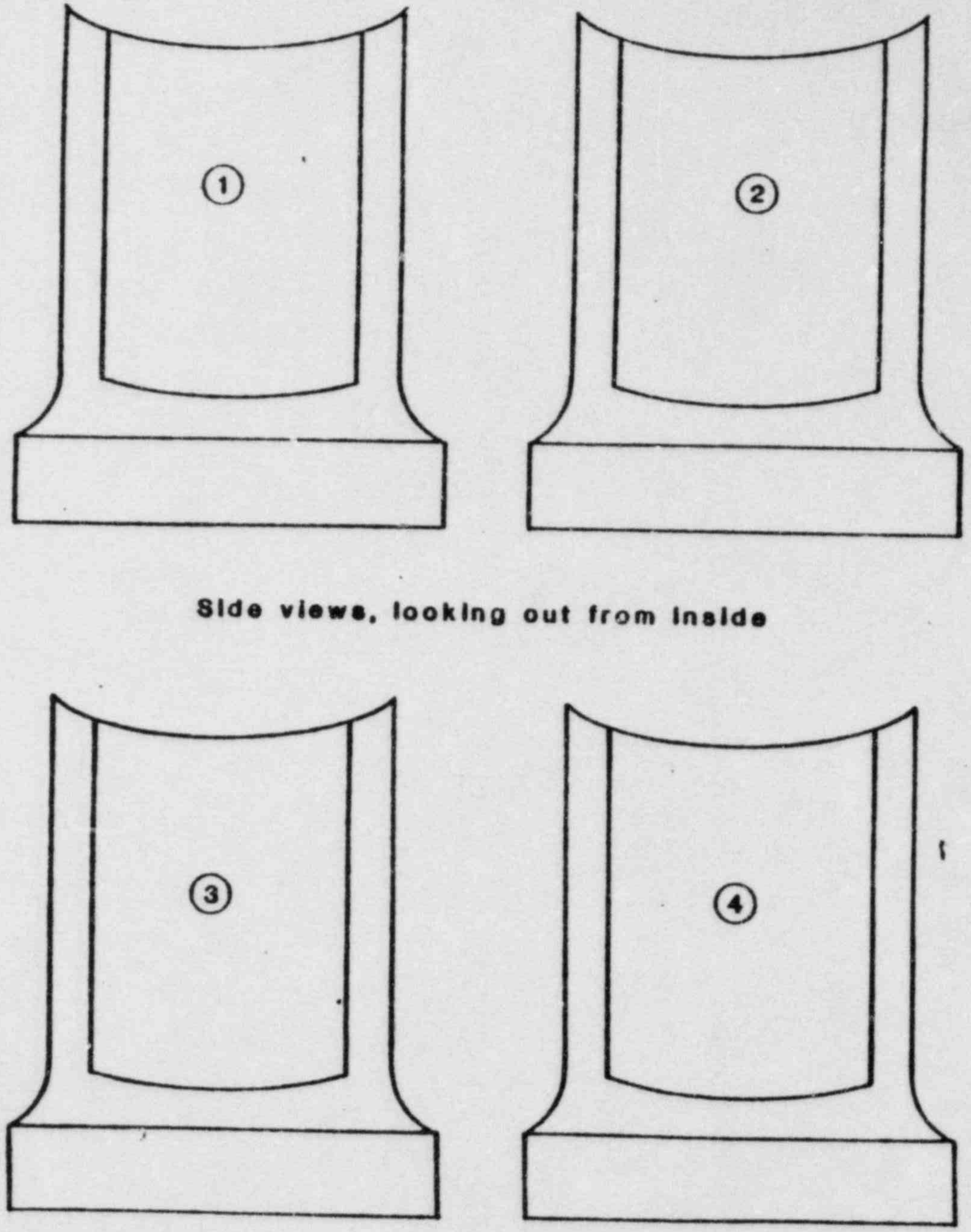
Diesel engine # 103

Piston # 8



Overhead view

NO RELEVANT INDICATIONS



Side views, looking out from inside

FaAA NDE Procedure

11.5, Rev. 0

Failure
Analysis
Associates

NONDESTRUCTIVE EXAMINATION PROCEDURE

NDE: 11.5

Title: EDDY CURRENT INSPECTION PROCEDURE FOR NODULAR PISTON SKIRTS

Page 1 of 2

Revision: 0

Date: 11/02/83

Reviewed - NDE Level III: Duan P. Johnson

Date: 11-18-83

## 1.0 Purpose and Scope

1.1 To establish calibration, scanning and evaluation techniques for eddy current examination of nodular iron piston-skirts.

1.2 This instruction covers the eddy-current examination of the boss areas near the 4-bolt-holes inside the piston skirt.

## 2.0 Personnel Certification

2.1 Personnel performing eddy-current examination shall be certified to SNT-TC-1A Level II.

## 3.0 Equipment

3.1 Eddy-current instrument used with this nstruction shall be an impedance-plane display instrument.

3.2 The eddy-current test probe shall be a FaAA-ECP-100-P or FaAA-ECP-200-P.

3.2.1 The reference crack standard shall be PAO-C-1.

## 4.0 Examination Surface

4.1 Only those surfaces that have a machined or ground finish shall be tested.

## 5.0 Calibration Procedure

5.1 Set frequency to 2 MHz for ECP-100P probe or to 500 KHz for ECP-200P probe.

5.2 Set volts per division at 0.5.

5.3 Set gain at 30.

5.4 Adjust vertical and horizontal positioning controls such that balance point is at (0v, 1v).

5.5 Balance with probe on test piece.

5.6 Adjust horizontal attenuator such that horizontal saturation is greater than 1.5v and less than -1.5v.

5.7 Adjust phase angle such that probe lift-off causes the beam to move horizontally to the right on the CRT.

5.8 Adjust gain such that the crack in reference standard PAO-C-1 gives a 2v ± 0.2v negative signal at the horizontal center of the CRT.

5.9 Repeat steps 5.4 through 5.8 until items 5.4 through 5.8 are accomplished without further instrument adjustments.

## 6.0 Examination

6.1 Examination shall be of machined areas on the boss where color contrast penetrant show linear indications greater than 1/32 inch.

## 7.0 Recording Criteria

7.1 All indication showing a crack indication greater than 10% of the crack signal in the reference standard PAO-C-1 shall be recorded.

7.2 The length and orientation of the indication shall be recorded.

## 8.0 Records

8.1 The results of the examination shall be recorded on eddy current examination reports. All required entries shall be addressed. A "N/A" shall indicate when a response is not applicable.

8.2 All recorded signals shall be located by measurement from a specific point to center of probe.

8.3 All calibration data sheets and examination records shall be filed according to job number.

FaAA NDE Procedure

11.5, Rev. 1

Failure
Analysis
Associates

NONDESTRUCTIVE EXAMINATION PROCEDURE

Title: EDDY-CURRENT INSPECTION PROCEDURE
FOR NODULAR IRON PISTON-SKIRTS

NDE: 11.5
Page 1 of 3
Revision: 1
Date: 11/02/83

Approved by NDE Manager: Duane P. Johnson Date: 1/31/84
Reviewed - NDE Level III: Duane P. Johnson Date: 1/31/84

## 1.0 PURPOSE AND SCOPE

1.1 To establish calibration, scanning and evaluation techniques for eddy-current examination of nodular iron piston-skirts.

1.2 This instruction covers the eddy-current examination of the boss areas near the 4-bolt-holes inside the piston skirt.

## 2.0 PERSONNEL CERTIFICATION

2.1 Personnel performing eddy-current examination shall be at least a certified Level II Eddy-Current Inspector, as per "FaAA Practice for Certification and Qualification of NDT Personnel."

## 3.0 EQUIPMENT

3.1 Eddy-current instrument used with this instruction shall be an impedance-plane display instrument.

3.2 The eddy-current test probe shall be a FaAA-ECP-100-P.

3.2.1 The reference standard shall be PAO-7396-831230.

## 4.0 EXAMINATION SURFACE

4.1 Only those surfaces that have a machined or ground finish shall be tested.

## 5.0 CALIBRATION PROCEDURE

5.1 Set frequency at 2.0 ± 0.2 MHz.

5.2 Set volts per division at 0.5.

5.3 Set gain at 30.

5.4 Adjust horizontal and vertical positioning controls such that balance point is at (0 V, 1 V).

**NONDESTRUCTIVE EXAMINATION PROCEDURE**

**Title:** EDDY-CURRENT INSPECTION PROCEDURE
FOR NODULAR IRON PISTON-SKIRTS

**NDE:** 11.5
**Page** 2 **of** 3
**Revision:** 1
**Date:** 11/02/83

5.5 Balance with probe on test piece.

5.6 Adjust horizontal attenuator such that horizontal saturation is greater than 1.5 V and less than -1.5 V.

5.7 Adjust phase angle such that probe lift-off causes the beam to move horizontally to the right on the CRT.

5.8 Adjust gain such that the 1/16 × 1/32 inch EDM notch in reference standard PAO-7396-831230 gives a 1.0 ± 0.1 V negative signal at the horizontal center of the CRT.

5.9 Repeat steps 5.4 through 5.8 until steps are accomplished without further instrument adjustments.

5.10 Recalibration shall be completed at least once an hour.

5.11 Eddy-current instrument should be on at least 10 minutes before calibration or testing.

## 6.0 EXAMINATION

6.1 Examination shall be of the legs on the boss where color contrast penetrant show linear indications greater than 1/32 inch length.

## 7.0 RECORDING CRITERIA

7.1 All eddy-current crack indications with signal magnitude greater than 50% of the signal magnitude obtained from the 1/16 × 1/32 inch EDM notch in the reference standard PAO-7396-831230 shall be recorded.

7.2 The magnitude, location and orientation of the indication shall be recorded.

## 8.0 RECORDS

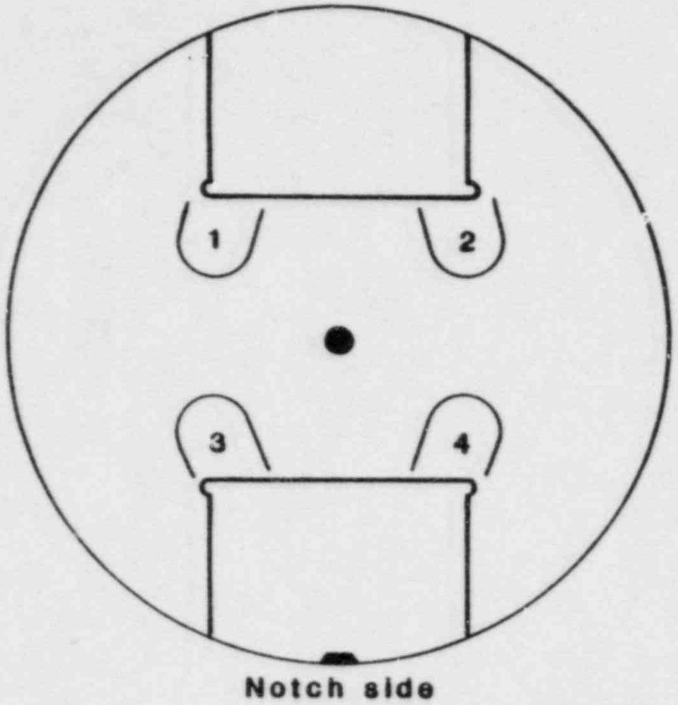
8.1 Set-up and calibration shall be recorded on report form 11.1.10.

8.2 All recordable indication shall be recorded on report form 11.5.8.4 (see next page).

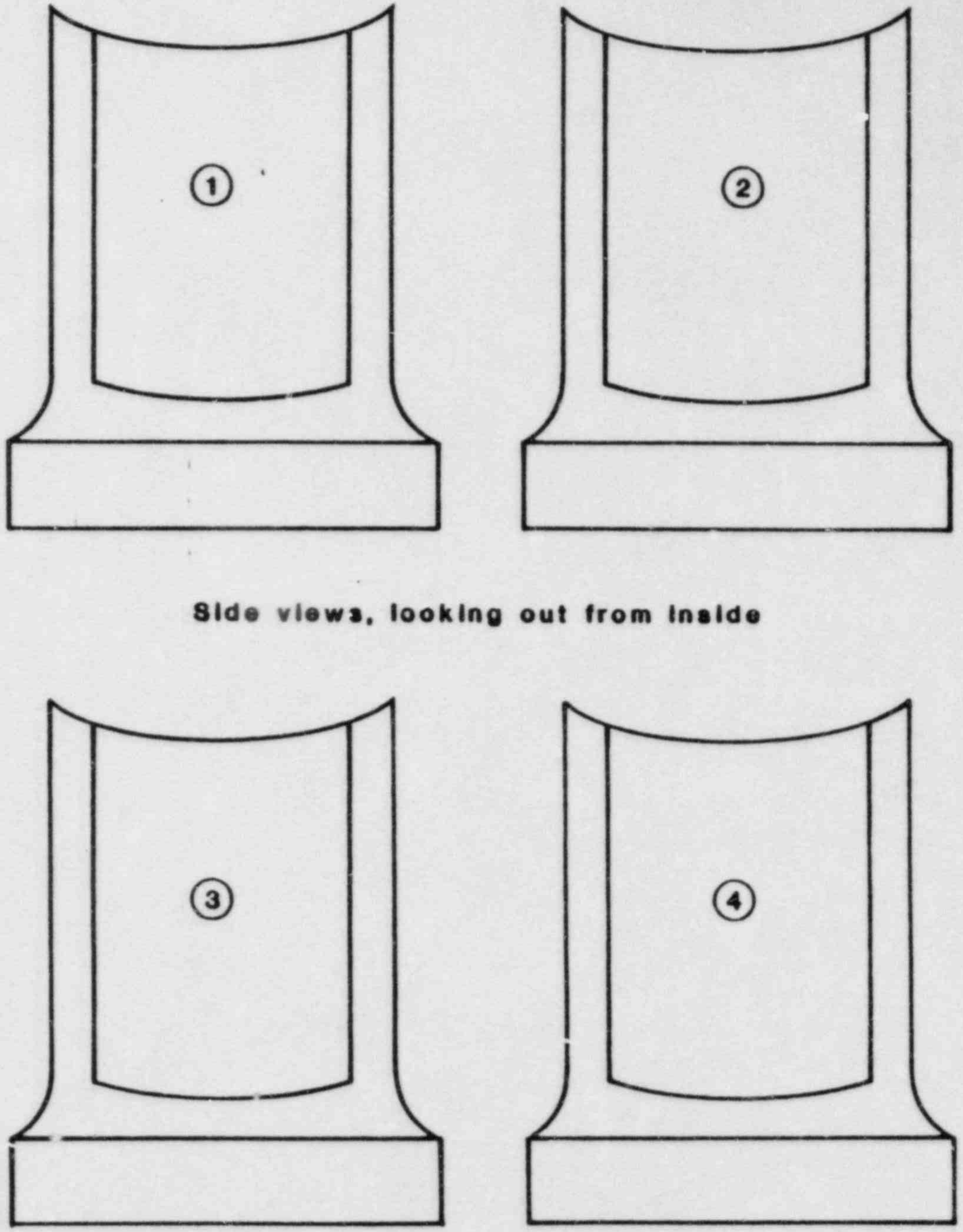
8.3 All records shall be filed according to job number.

Diesel engine # ____________

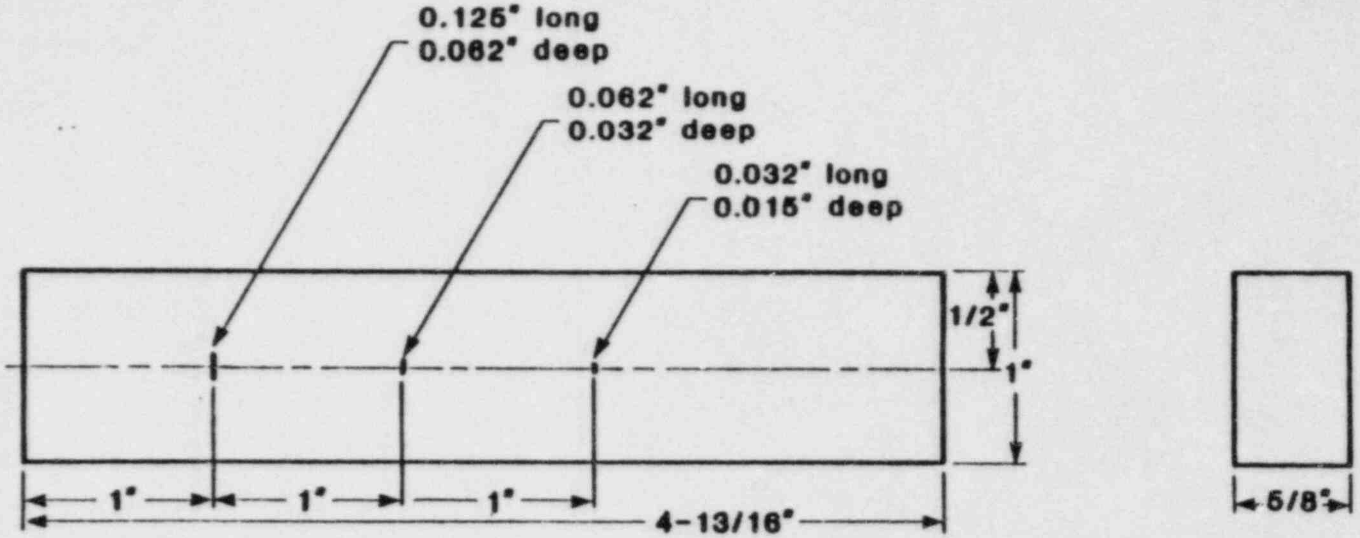
Piston # ________________



Overhead view



Side views, looking out from inside



| Chemical Analysis | |
|---|---|
| Iron | 92.568% |
| Carbon | 3.46% |
| Silicon | 2.43% |
| Other | 1.542% |

Slot width less than 0.005"

Fractions ± 1/64"

Note: Material from TDI piston skirt.

**DESCRIPTION:** Nodular iron reference standard

PA0-7396-831230

EDM on machine surface

TOLERANCES UNLESS OTHERWISE SPECIFIED
X.XX - ±
X.XXX- ± 0.002"

DRAWN

CHECKED

APP'D

**Failure Analysis Associates**
2225 East Bayshore Road
P.O. Box 51470
Palo Alto, California 94303

DATE 1-3-84

CASE PA07396

DWG. 831230

# Iron Castings Handbook

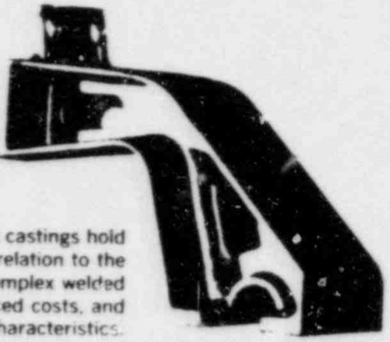
*Covering data on Gray, Malleable, Ductile, White, Alloy and Compacted Graphite Irons*

*Edited by*
**Charles F. Walton**
*Iron Castings Society*

*Co-Editor*
**Timothy J. Opar**
*Iron Castings Society*

*Published by*

**Iron Castings Society, Inc.**



Two of these ductile iron truck mount castings hold the cab-over-engine cab in proper relation to the truck frame. This redesign from a complex welded steel fabrication resulted in reduced costs, and improved strength and fatigue characteristics.

mental to fatigue life but the speed of the loading cycle and the occurrence of rest periods are not significant.

As the maximum stress is reduced, the number of cycles necessary to produce a failure becomes much larger. The highest stress at which the number of cycles for failure approaches infinity (generally in excess of ten million cycles) is called the *endurance limit*. The *endurance ratio* is the relation between the endurance limit and the tensile strength. Most of the data on fatigue strength have been obtained with the rotating beam type test where the maximum stress alternates between tension and compression. A typical S-N curve on which the stress is plotted against the number of cycles to failure[16] is shown in Fig. 13. From these results, the unnotched endurance limit is indicated to be 28,000 psi (193 MPa). This is the maximum stress at which a fatigue failure should not occur under similar conditions in any number of cycles. Since this particular ductile iron has a tensile strength of 68,500 psi (472 MPa), its endurance ratio is 0.41.

The effect of stress raisers on the endurance limit has been evaluated by the use of notched test bars. For this purpose, a notch is usually turned into the circumference of an oversize bar so that the base of the notch leaves a cross-section equal to the regular unnotched bars to which the notched bars are compared. The ratio of the unnotched to the notched endurance limit is termed the notch sensitivity factor or the dynamic stress concentration factor. Several investigations have obtained endurance ratios of from .33 to .52 for the different types of ductile iron. The endurance limit increases with tensile strength, but as with other ferrous metals, the increase is less than proportional. The relation between tensile strength and the endurance ratio is different for the annealed, ferritic irons than for the irons with a matrix of pearlite or tempered martensite[17,18], Fig. 14.

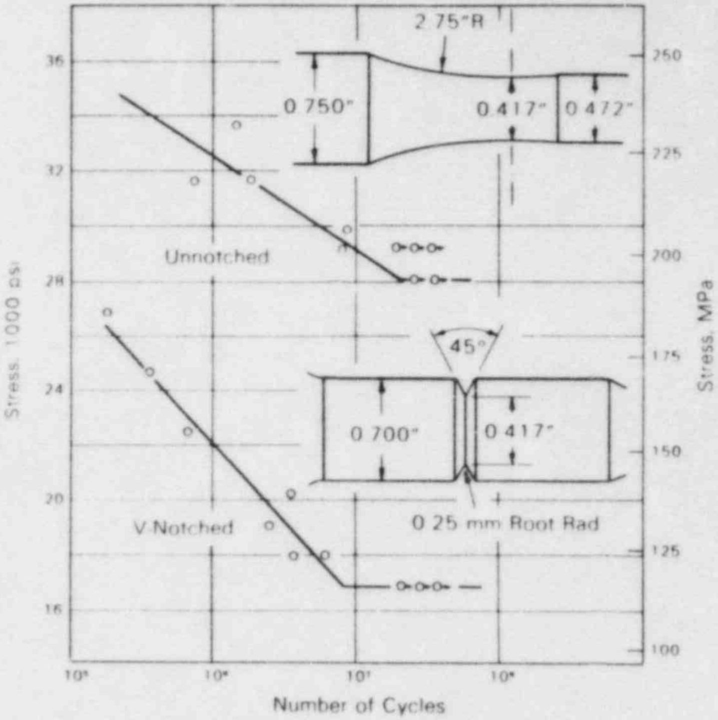


Fig. 13
The unnotched and notched fatigue properties of an annealed ductile iron[16] with a tensile strength of 65,800 psi (454 MPa). The endurance ratio is .41 and the notch sensitivity ratio is 1.67.

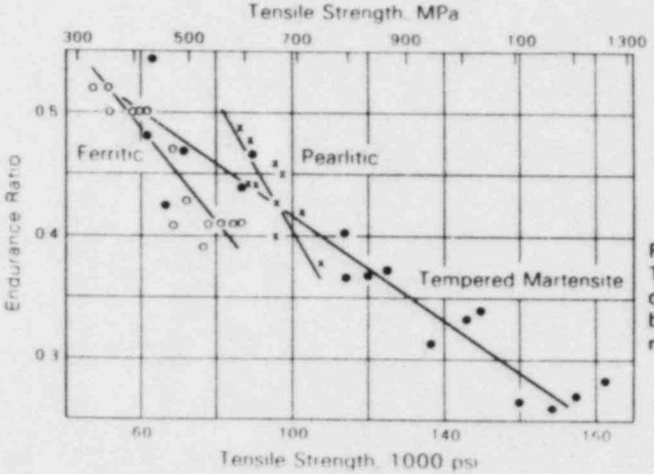


Fig. 14
The endurance ratios for ductile irons as influenced by tensile strength and matrix microstructure[17,18].

Failure
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ENGINEERING AND METALLURGICAL CONSULTANTS
2225 EAST BAYSHORE ROAD
PO BOX 51470, PALO ALTO, CALIFORNIA 94303 (415) 856-9400

# MEMORANDUM

**TO:** Mike Milligan
Bill Judge

**DATE:** February 17, 1984

**FROM:** Donald O. Johnson DOJ

**RE:** Shoreham Nuclear Power Station
FaAA Job # PA07396

**SUBJECT:** Report on trip to Kodiak Electric Association, Inc. on January 22 to 27, 1984.

---

The trip to Kodiak, Alaska, with Bill Judge from Long Island Lighting Project Office (LILCO) at the Shoreham Nuclear Power Plant Station included inspection of AE pistons and gathering of operating information on their Transamerica Delaval (TDI) diesel engines.

The people we contacted at Kodiak Electric Association, Inc. (KEA) were Rosahul Baldurn and Carl Gronn. They were very helpful in our inspection and gathering of information.

The piston skirts that were examined came from engine number 4, serial number 79026-3029, model DSRV 16-4, date of manufacturing 8 August 1980, horse power 8750BHP, RPM 450. There were two pistons that were pulled for inspection, one piston was for LILCO and the other for TDI to inspect. I did an informational inspection on the replacement pistons for KEA. I found no crack-like indications above the recording threshold.

The AE piston that was designated for LILCO was penetrant tested to NDE-6.2 and Eddy-Current tested to NDE-11.5. The penetrant test was the first part of the inspection and eddy-current was to verify any penetrant indications.

The inspection was of the boss areas as directed by NDE Procedures 6.2 and 11.5. One area was found to have a penetrant indication 3/4" long. Upon inspection with eddy-current there were no crack-like indications noted. The piston was shipped to Palo Alto to be examined at FaAA's lab. In the laboratory, I reinspected the piston to both NDE-6.2 and NDE-11.5 and found no crack-like indications.

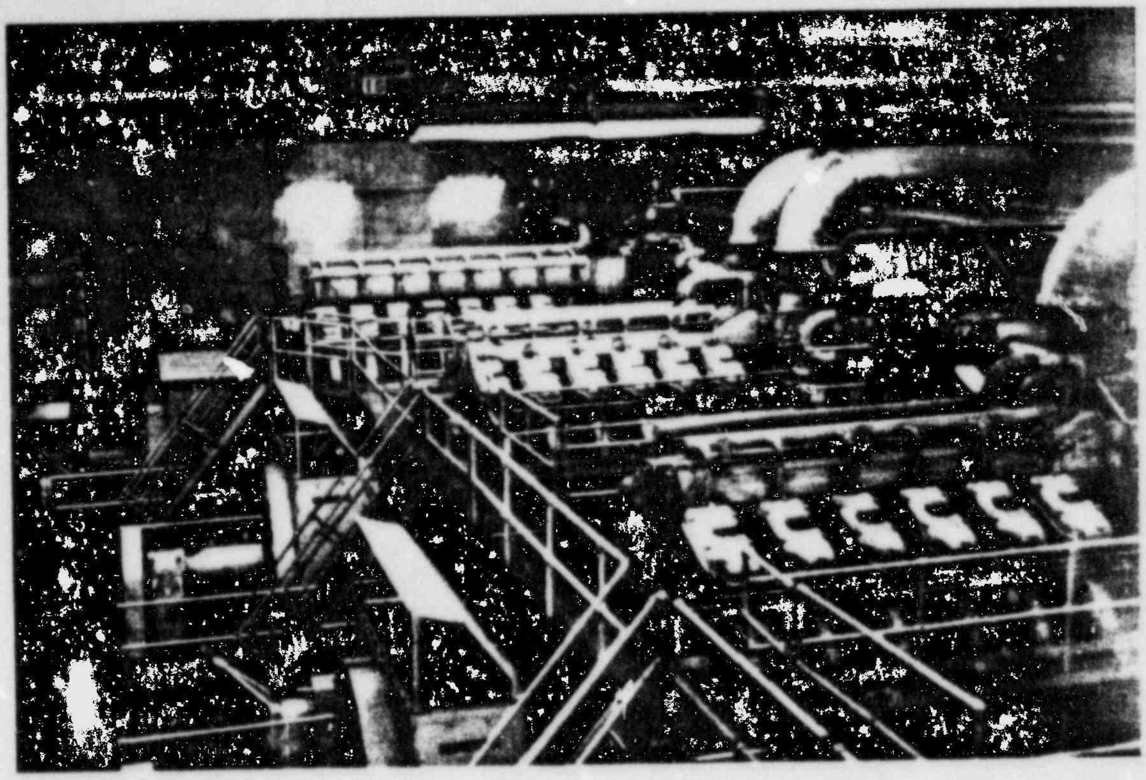
# PEAK FIRING PRESSURE ON ENGINE #4

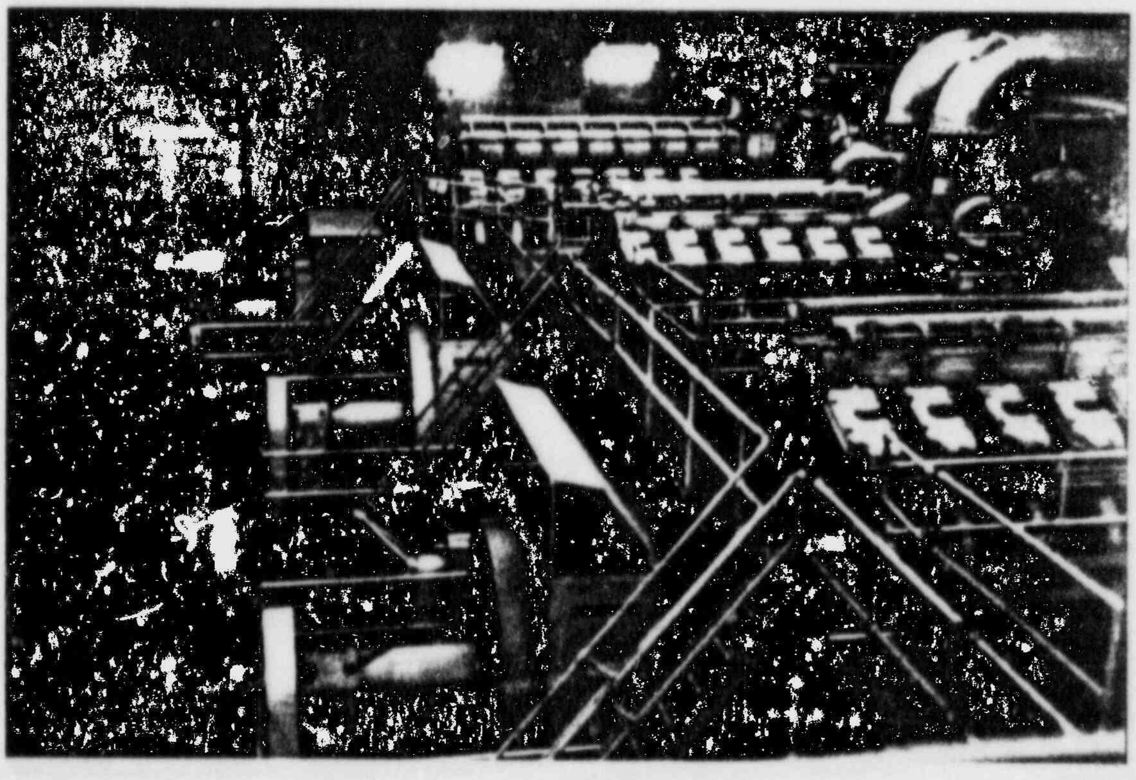
March 31, 1983, 4000 kW, 7200 hours

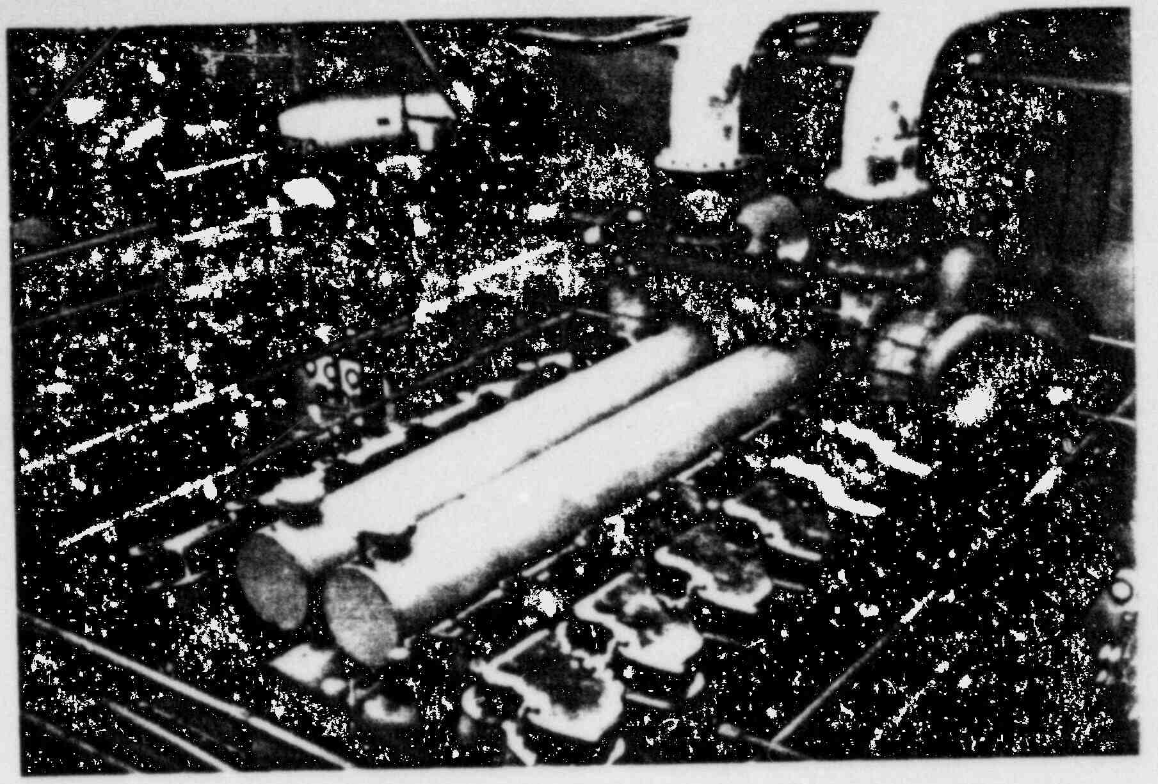
| | | | |
|---|---|---|---|
| 1R | 890 | 1L | 970 |
| 2R | 790 | 2L | 960 |
| 3R | 1000 | 3L | 980 |
| 4R | 970 | 4L | 940 |
| 5R | 990 | 5L | 920 |
| 6R | 990 | 6L | 930 |
| 7R | 890 | 7L | 910 |
| 8R | 930 | 8L | 920 |

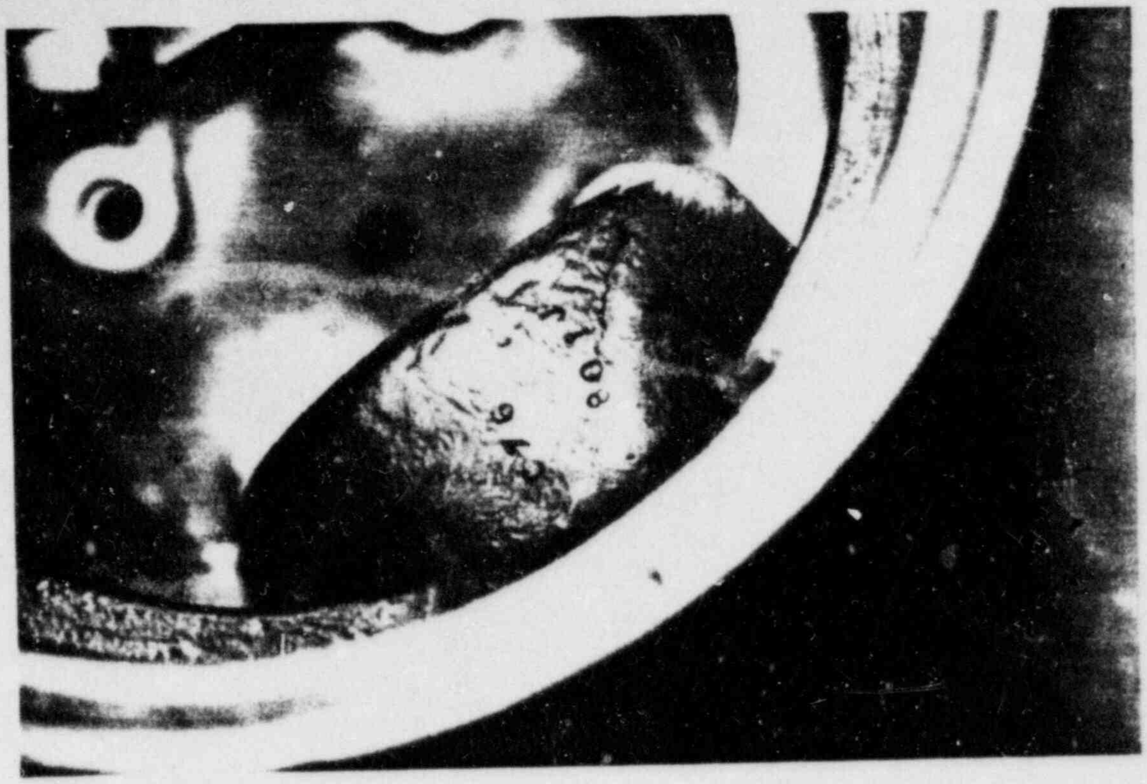
March 2, 1982, 5600 kW, 4201 hours

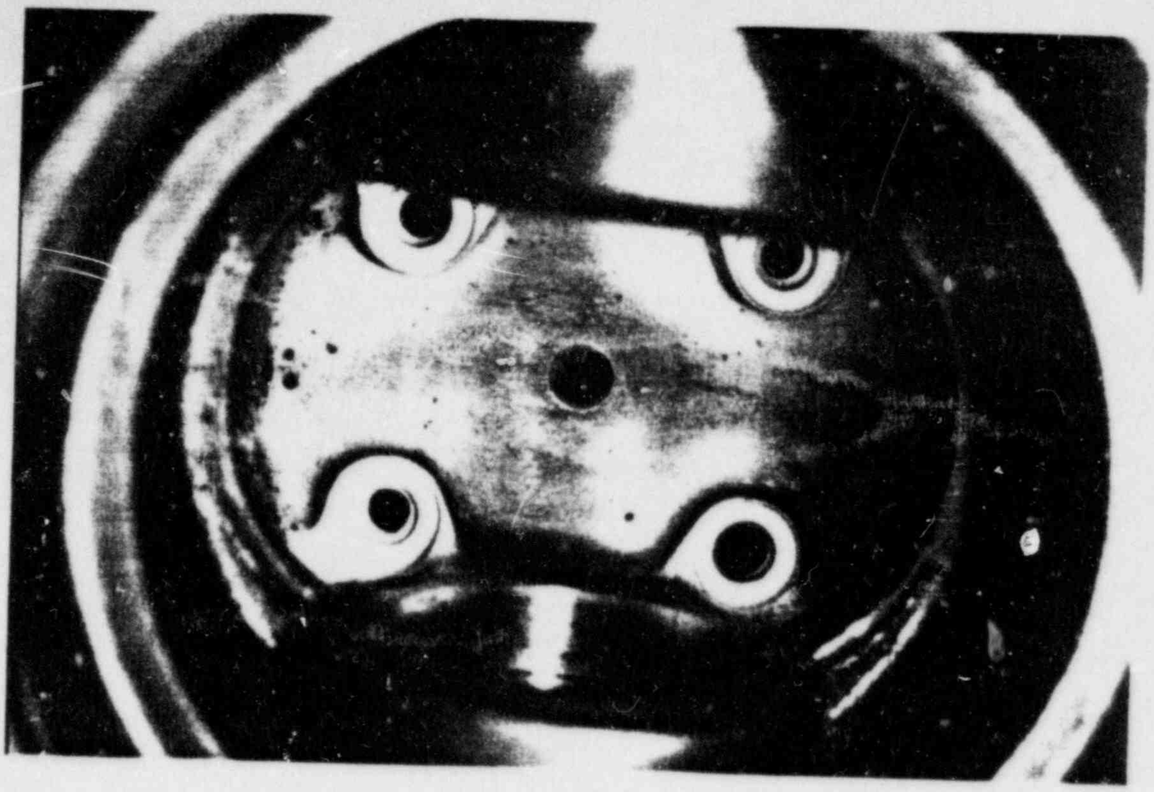
| | | | |
|---|---|---|---|
| 1R | 1320 | 1L | 1320 |
| 2R | 1300 | 2L | 1280 |
| 3R | 1300 | 3L | 1280 |
| 4R | 1310 | 4L | 1260 |
| 5R | 1340 | 5L | 1300 |
| 6R | 1300 | 6L | 1240 |
| 7R | 1340 | 7L | 1240 |
| 8R | 1300 | 8L | 1240 |

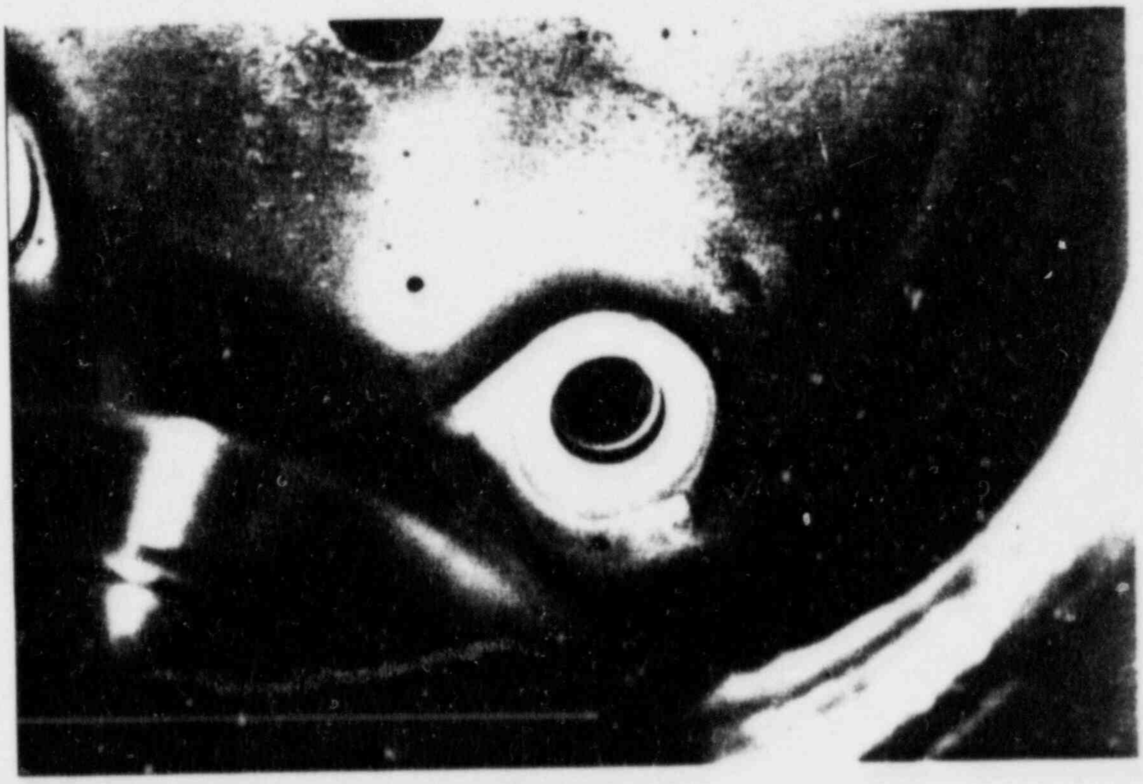


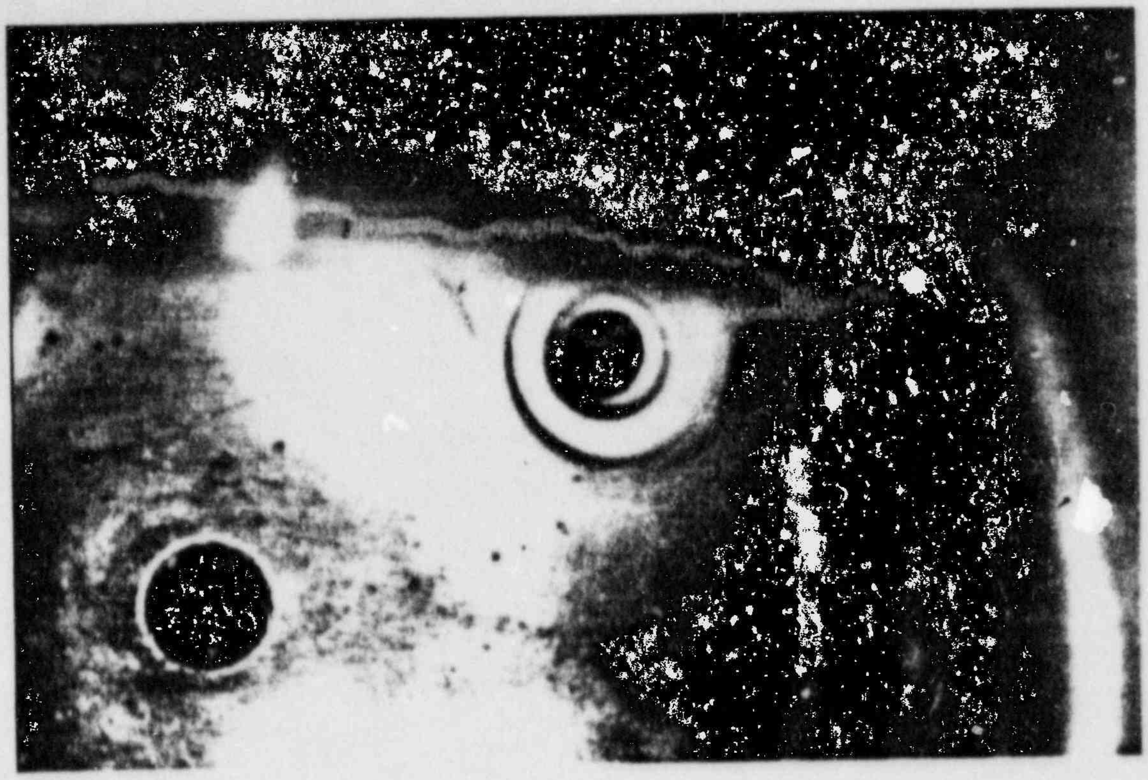


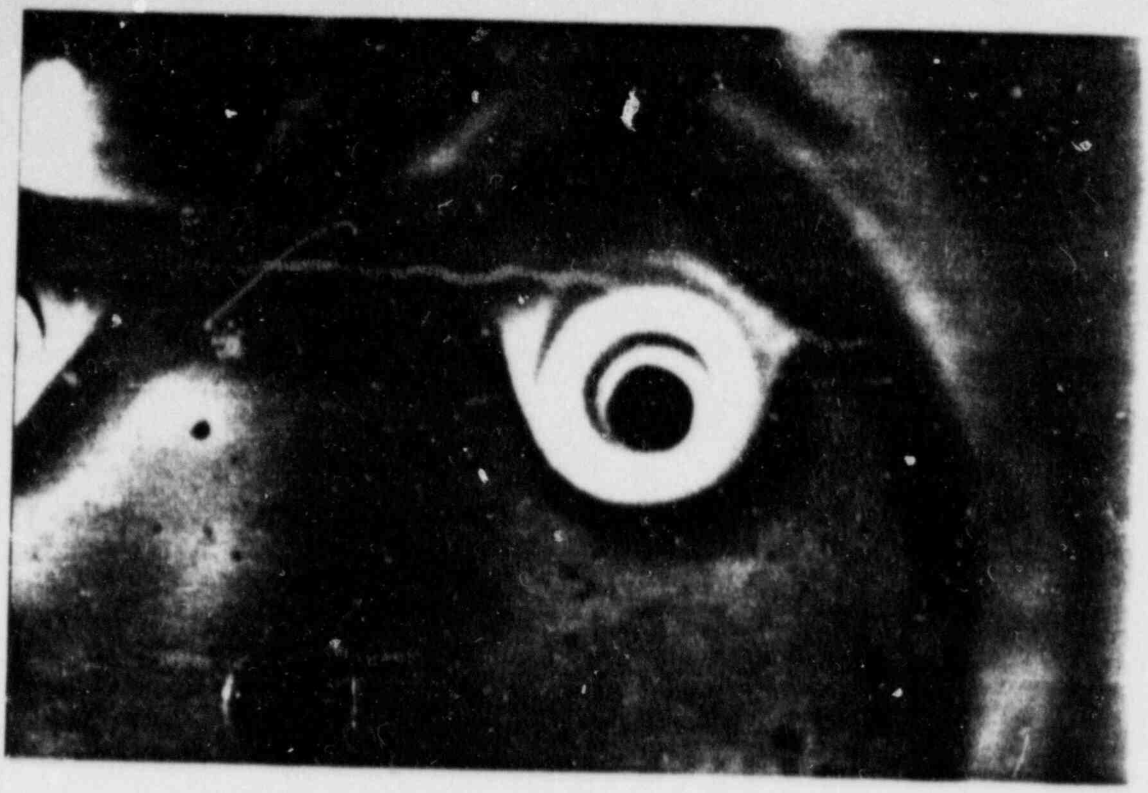


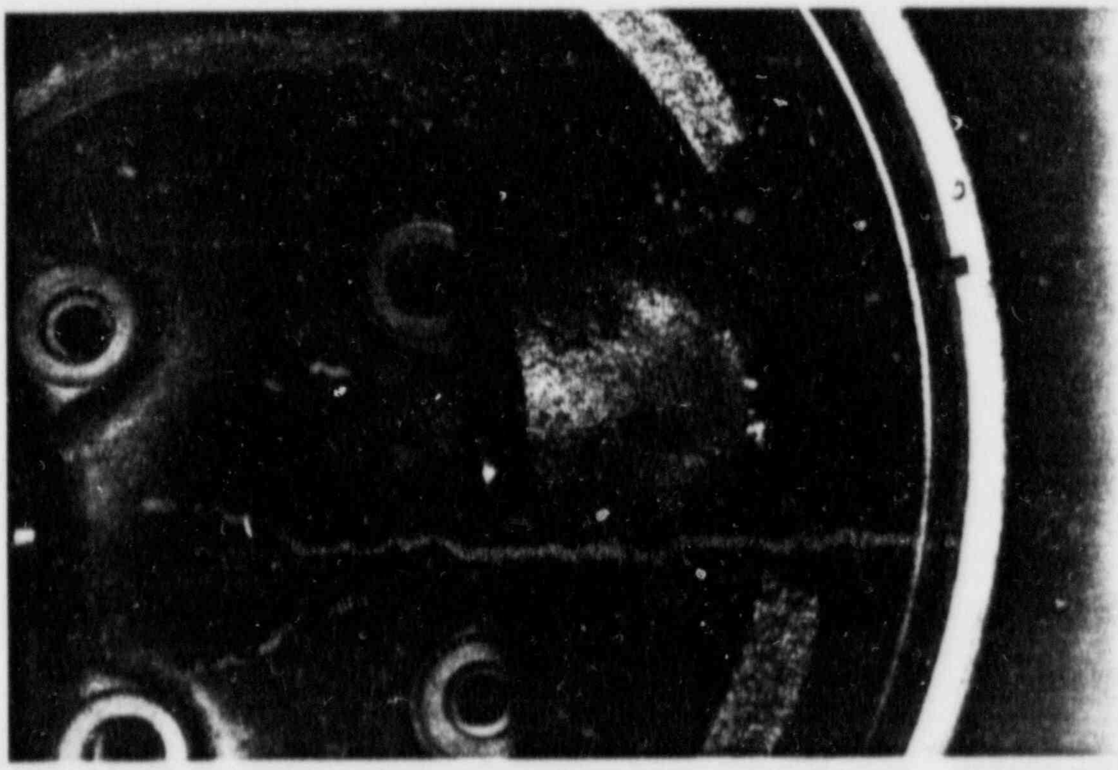


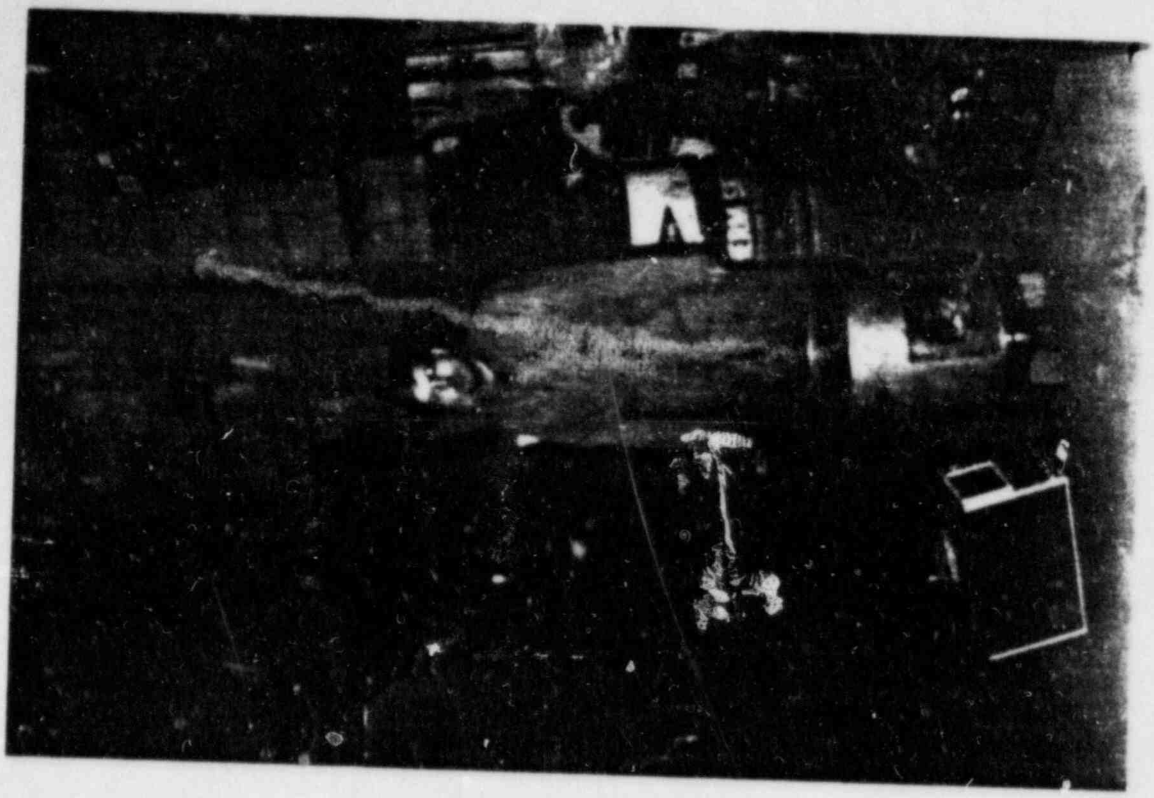












# EDDY CURRENT CALIBRATION REPORT

Job No. 03341A Date 3-13-84 Report No. 840313-1

Material Description NODUlar IRON PISTON SKIRTS

Code or Specification NDE 11.5 Full On -1,5 Full Off +1,5

Reference Standard PH07396-840227 Instrument MIZ 17 S/N 033833

## Instrument

Freq. 2 MHz Gain 30 Volts/div 0.5 Phase 202

Test Probe FaAA ECP100P S/N 100P

Reference Probe FaAA ECP100P S/N 100P-1

## CALIBRATION

| | |
|---|---|
| 2.2 units @ 0 L/O | 1,8 units @ +1,5 L/O |
| 2.0 units @ +1 L/O | 1,6 units @ +2,0 L/O |

## STRIP CHART RECORDER

Type N/A S/N N/A

| Channel 1 | Channel 2 |
|---|---|
| Sen N/A | Sen N/A |
| Position @ Null Point N/A | Position @ Null Point N/A |
| Chart Speed N/A mm/sec | |

## Calibration Check

| | | |
|---|---|---|
| Time 16:37 | Phase 202 | Gain 30 |
| Time 16:45 | Phase 202 | Gain 30 |
| Time 16:52 | Phase 202 | Gain 30 |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |

Examiner Dan Johnson Level II Examiner Level

R&D-KR-3

11.1.11

Failure
Analysis
Associates

# EDDY CURRENT EXAMINATION REPORT

ET

Component I.D. PISTON SKIRTS ON DG103 #5 #7 #8

Job name & no. PISTONS 03341A

Plant/location DIESEL Generators ELV, G3

Material NODULAR IRON PISTON SKIRT

Type: PISTON SKIRT

Fabricated process: ☐ Welded ☒ Cast ☐ Worked

Geometry: ☐ Pipe ☐ Plate ☐ Rod ☒ Other: Counter BORE

Cross section thickness: Max. N/A Inch Min. N/A Inch

Surface condition: ☒ Machined ☐ Ground ☐ As fabricated ☐ Other:

NDE Procedure no. 11.5

Job no. 03341A

Report no. 840313-1

Test condition: Ver + 1 volt Hor 0

Unit # 033823 Sen 30 Frq 2MHz

Full-on -1.5 Full-off +1.5

Reference no. 100P-1 Probe type 100 P

2.2 Unit at 0 Lo

2.0 Unit at +1 Lo

1.8 Unit at +1.5 Lo

1.6 Unit at +2.0 Lo

| Indication no. | Magnitude of indication | Length of indication | Remarks |
|---|---|---|---|
| | | | NO RECORDABLE |
| | | | INDICATIONS |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

## Specific examination area

SCAN AREA IN SIDE BELVILLE WASHER AREA, AROUND RADIUS.

Sketch or other data (use other side)

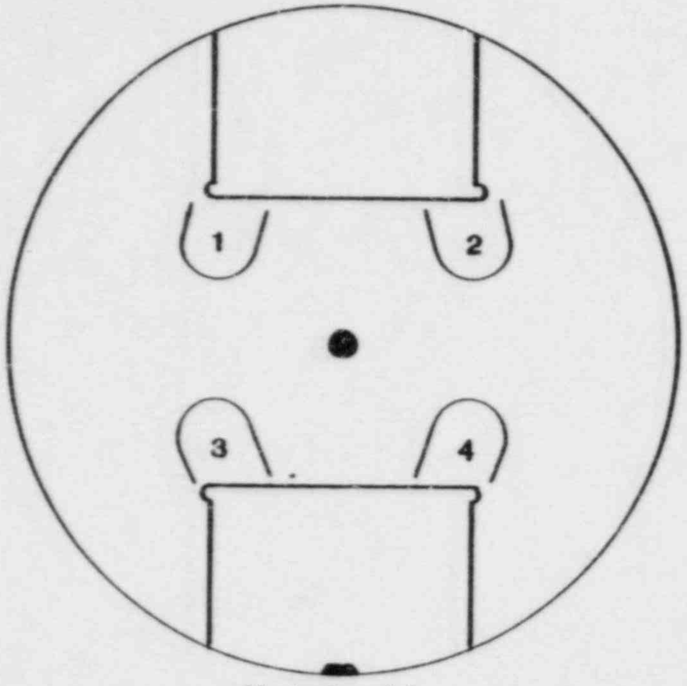
Acceptance criteria: INDICATION Greater than 50% of REference STandard

Operator: Don Johnson
Level: II Date: 3-14-84

Attest: Donald Dverfelt
Responsible certified personnel
Level: II
Date: 3-14-84

Diesel engine # 103

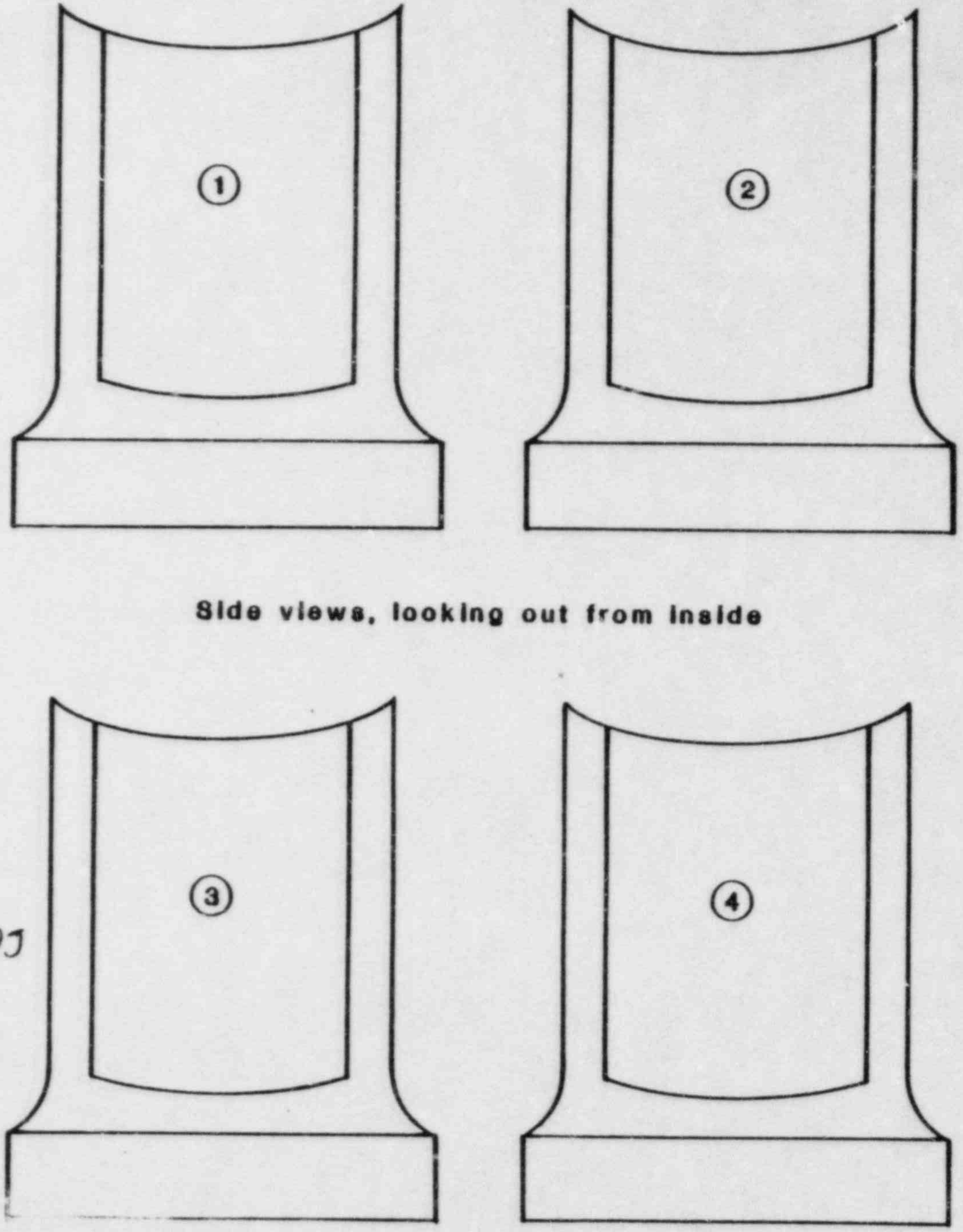
Piston # 5



Notch side

Overhead view

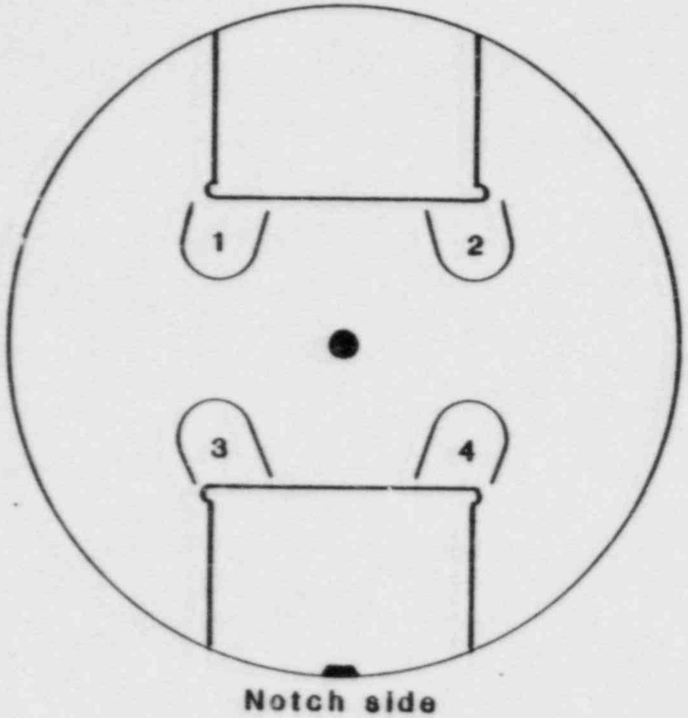
NO RELEVANT INDICATIONS



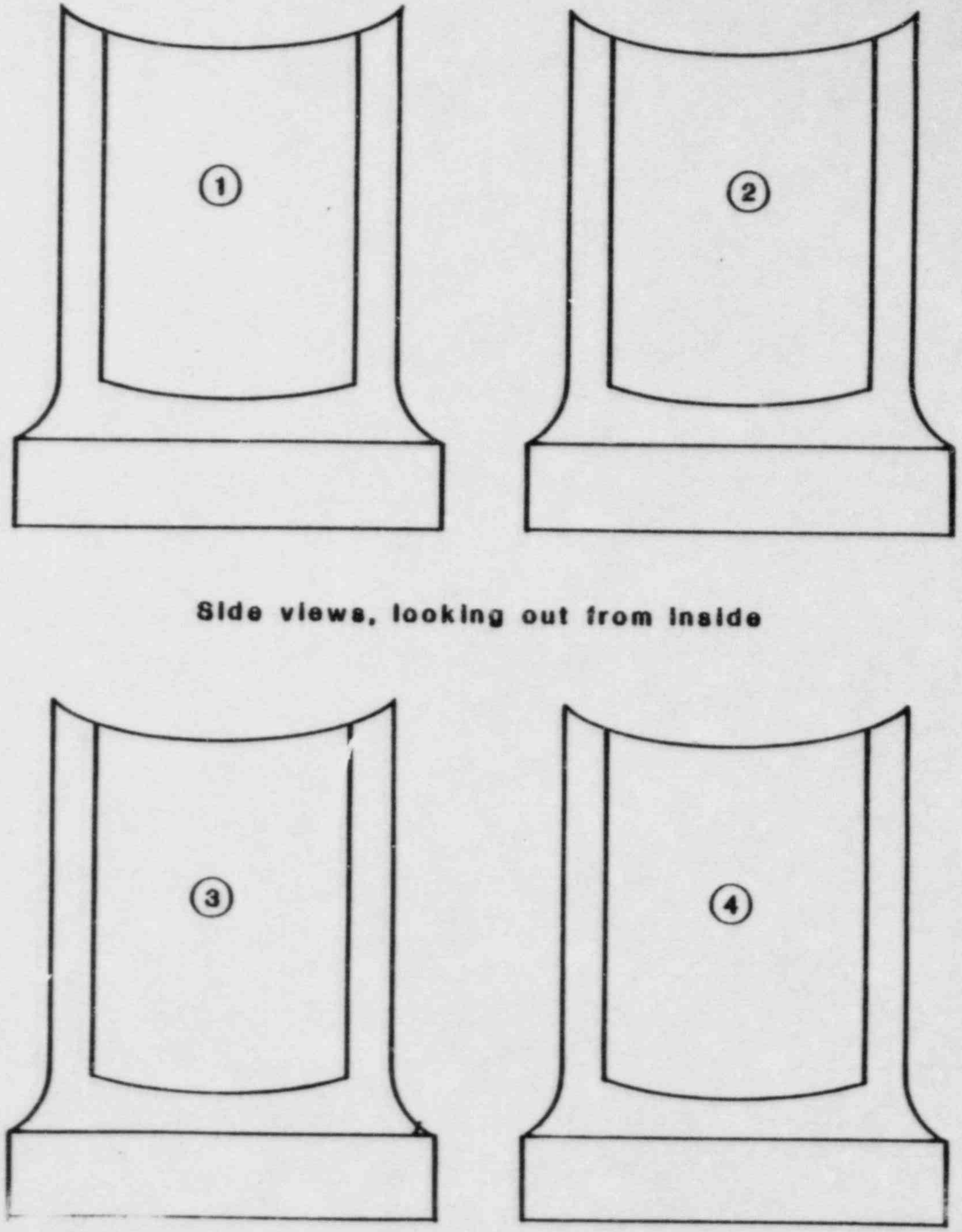
Side views, looking out from inside

Diesel engine # 103

Piston # 7



Overhead view

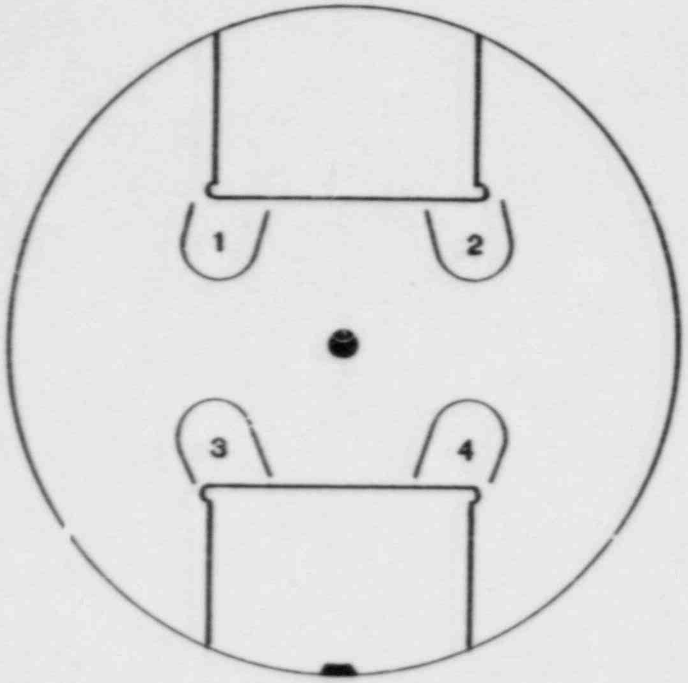


Side views, looking out from inside

NO RELEVANT INDICATIONS

**Diesel engine #** 103

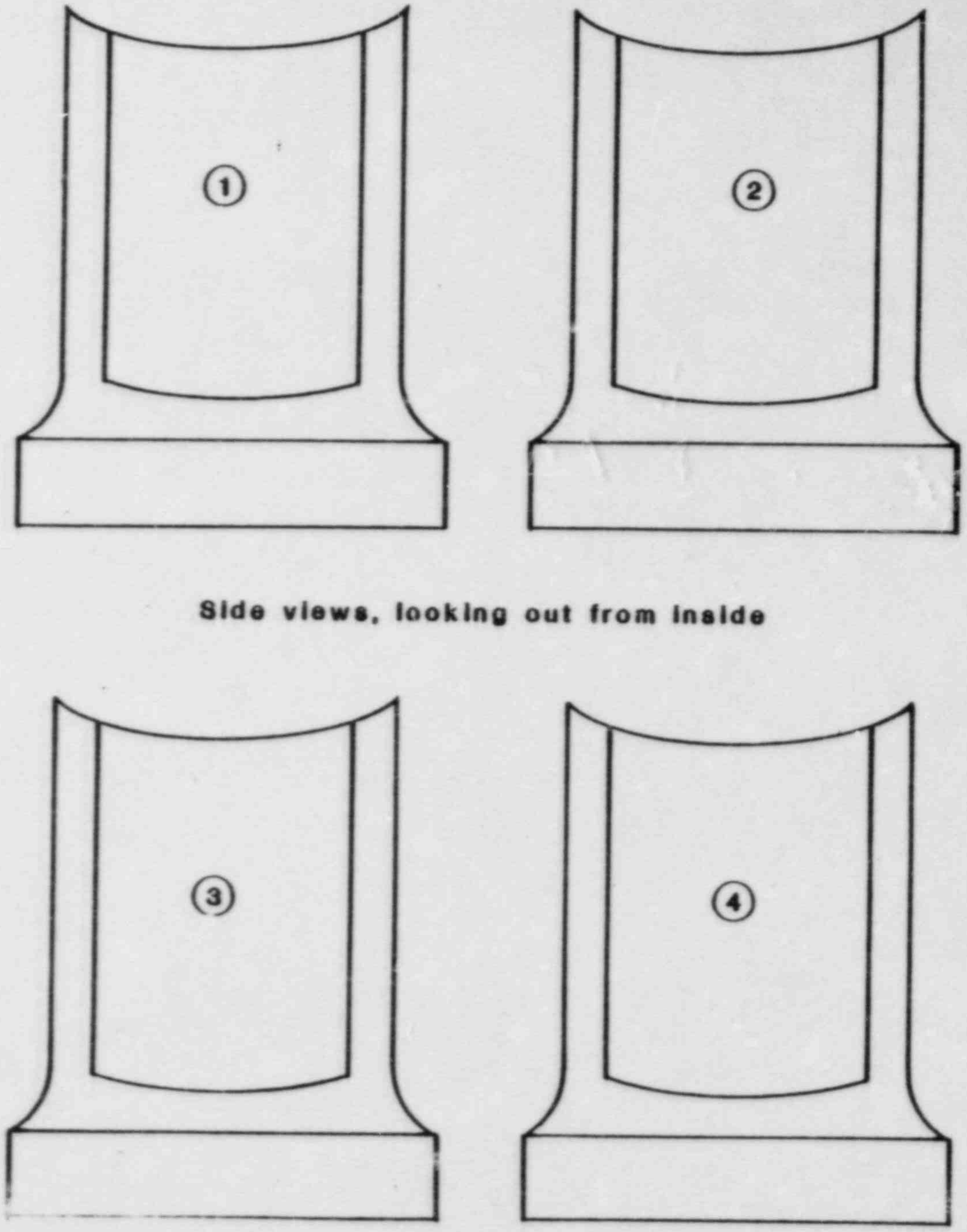
**Piston #** 8



Notch side

Overhead view

No Relevant Indications



Side views, looking out from inside

# MEMORANDUM

**TO:** Mike Milligan
Nelson Irvine

**DATE:** February 3, 1984

**FROM:** Donald O. Johnson

**RE:** Shoreham Nuclear Power
Station FaAA Job # PA07396

**SUBJECT:** Report of Trips on 1/10/84 to Transamerica Delaval,
Oakland, California

---

I went to Transamerica Delaval (TDI) in Oakland on January 10, 1984, to inspect two AE-type piston as representative of Long Island Lighting Company (LILCO). I used a color contrast penetrant method of inspection described in the FaAA Nondestructive Examination Procedure, NDE 6.2, Revision 0, dated October 12, 1983. The procedure was accepted by LILCO's Nelson Irvine, Level III inspector of their Field Quality Assurance Division.

Al Fleischer at [illegible] arranged the tests of two pistons that were run 687 hours. The two pistons were crated when we went to their training center to do the inspection. There was a description of the material on top of one crate.

R5 Test Pistons - 03-341-04-AE

Piston Skirts were tested in R5-V12 for 687 hours at 302 BMEP and 514 RPM. Testing included 51 start-and-stop sequences. Heat numbers were 7085 C-31 and 7085 C-33. The crates were opened, and I photographed the pistons showing the heat numbers and other markings. I noted that these pistons were the old style: the wrist pin boss area was thin, and the first rib above the boss area where the crown bolts to the skirt was very narrow, the same as the AN-type pistons.

The next step was to complete the color contrast penetrant test to FaAA Procedure, NDE 6.2. During the inspection I observed that there was a layer of plating on the inside of the skirt and that the casting was very smooth, different from general production runs of cast material. The inside of the skirt was cleaned, and all the flash was removed. The boss area was very smooth, as if polished by cratex, and all the ground areas were very carefully polished, with smooth radius into boss.

There were no indications noted according to our acceptance criteria. The next step was to use eddy-current to inspect the boss areas and the lower web. I also checked plating inside and out. There was evidence of plating on the inside below normal areas. The plating was very thin, approximately 0.0005 inch to 0.0001 inch.

I found three indications with eddy-current on piston C-31 as shown on drawing 11.5.8.4. The attached reports and a photo pack will document the report.

11.1.10

Failure
Analysis
Associate:

## EDDY CURRENT CALIBRATION REPORT

Job No. PAO7396 Date 1-10-84 Report No. PAO7396-841001

Material Description NODular CAST IRON

Code or Specification NDE 10.5 Full On -1.5 Full Off +1.5

Reference Standard PAO-C-1 Instrument MIZ 17 S/N

### Instrument

Freq. 2MHz Gain 30 Volts/div 0.5 Phase 218

Test Probe FaAA EEP-100-P-1 S/N ECP-100-P-1

Reference Probe FAA ECP-100 B-1 S/N ECP 100 B-1

### CALIBRATION

| | | | |
|---|---|---|---|
| 4 units @ -1.5 L/O | | 3.2 units @ -0 L/O | |
| 3.5 units @ -1 L/O | | 2.6 units @ +1 L/O | |

### STRIP CHART RECORDER

Type N/A S/N N/A

| Channel 1 | | Channel 2 | |
|---|---|---|---|
| Sen | N/A | Sen | N/A |
| Position @ Null Point | N/A | Position @ Null Point | N/A |
| Chart Speed | N/A mm/sec | | |

### Calibration Check

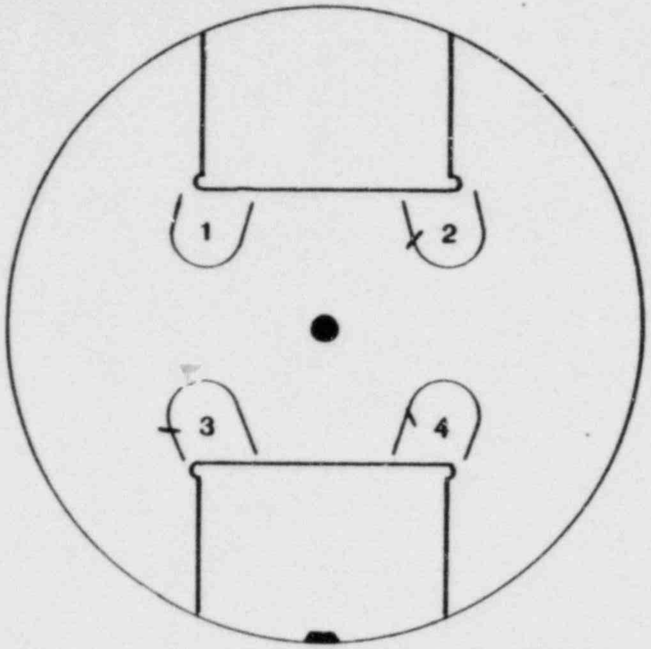
| | | |
|---|---|---|
| Time 2 PM | Phase 218 | Gain 30 |
| Time 2:15 PM | Phase 218 | Gain 30 |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |
| Time | Phase | Gain |

Examiner Level Examiner Level II

R&D-KR-3

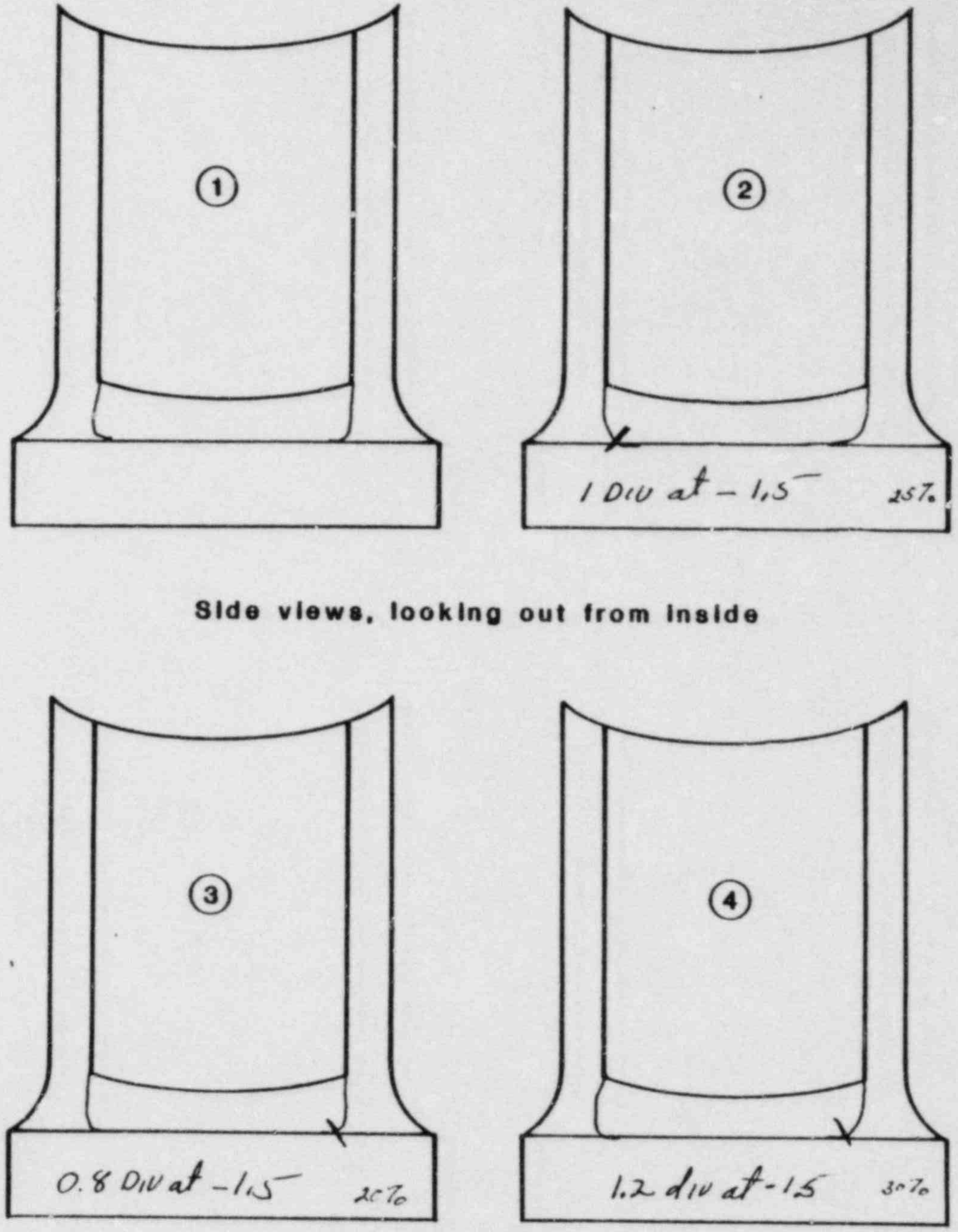
Diesel engine # N/A

Piston # C-31



Notch side

Overhead view



Side views, looking out from inside

Failure
Analysis
Associates

# LIQUID PENETRANT EXAMINATION REPORT

PT

**A. Material**

Type: NODular CAST IRON

Fabricated Process: N/A ☐ Welded ☑ Cast ☐ Worked

Geometry: ☐ Pipe ☐ Plate ☐ Rod ☑ Other: AE PISTON SKIRT

Cross Section Thickness: N/A | Max N/A Inch | Min N/A Inch

Surface Condition: ☒ Machined ☐ As Fabricated ☐ Ground ☒ Other: AS CAST

Component I.D. N/A

**B. NDE Procedure** No. 6.2

Surface/Mat'l. Temp. 11°C

M & TE. No. N/A

MWR/PR. No. N/A

| Inspection Materials | Brand | Designation | Batch No. |
|---|---|---|---|
| 1. Pre-Cleaner | arDrox | 9 PR55-1 | C-846 |
| 2. Penetrant | '' | 966 | 01-3557 |
| 3. Emulsifier and/or Remover | | 9 PR551 | C-864 |
| 4. Developer | | 9D6 | 1032 |
| 5. Post Examination Cleaner | | 9 PR551 | C-864 |

Sketch or other detail (use other side if necessary):

PisTON # C31

PisTON # C33

System EMERGENCY Diesel Generator PisTON SKirTS

**C. Evaluation**

Report below those indications observed and the pertinent information required. Where additional space is required, use other side.

| Location | Size (Inches) | Description | Action (Accept/Reject, and comment as necessary) |
|---|---|---|---|
| 1. NONE found | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |

Plant/Location TDI - OAKLAND CA.

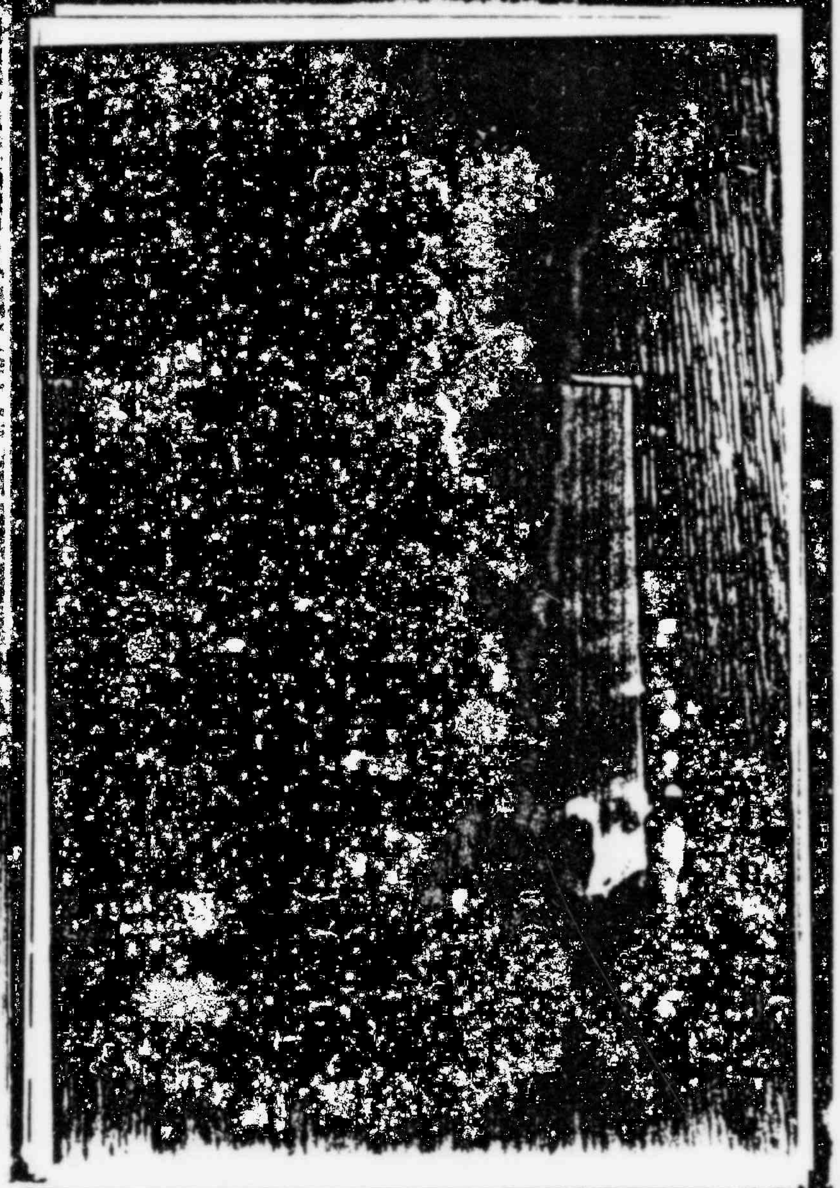
**D. Acceptance Criteria** NDE 6.1 + 6.2

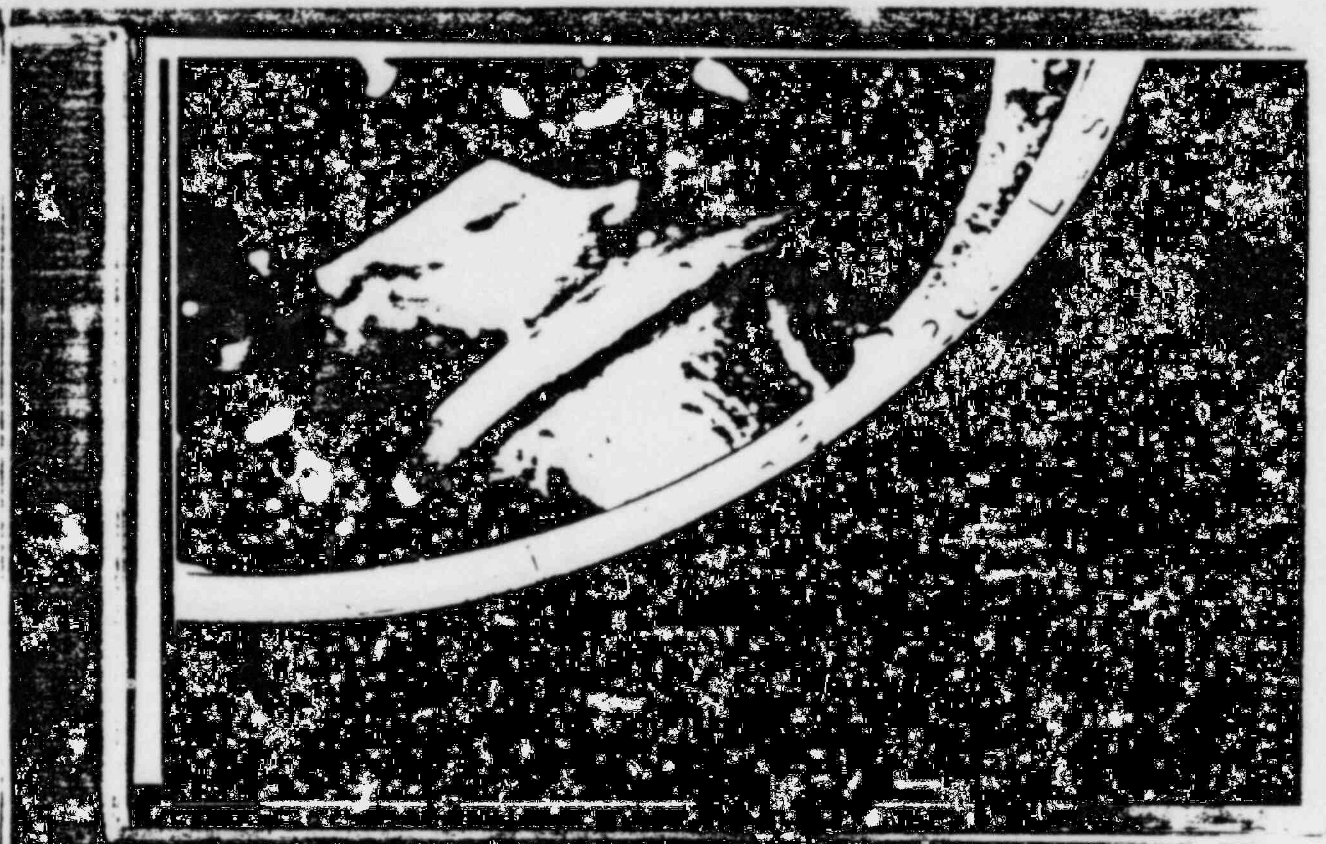
Operator: D O Johnson
Level: II Date: 1-10-84

**E. Attest**

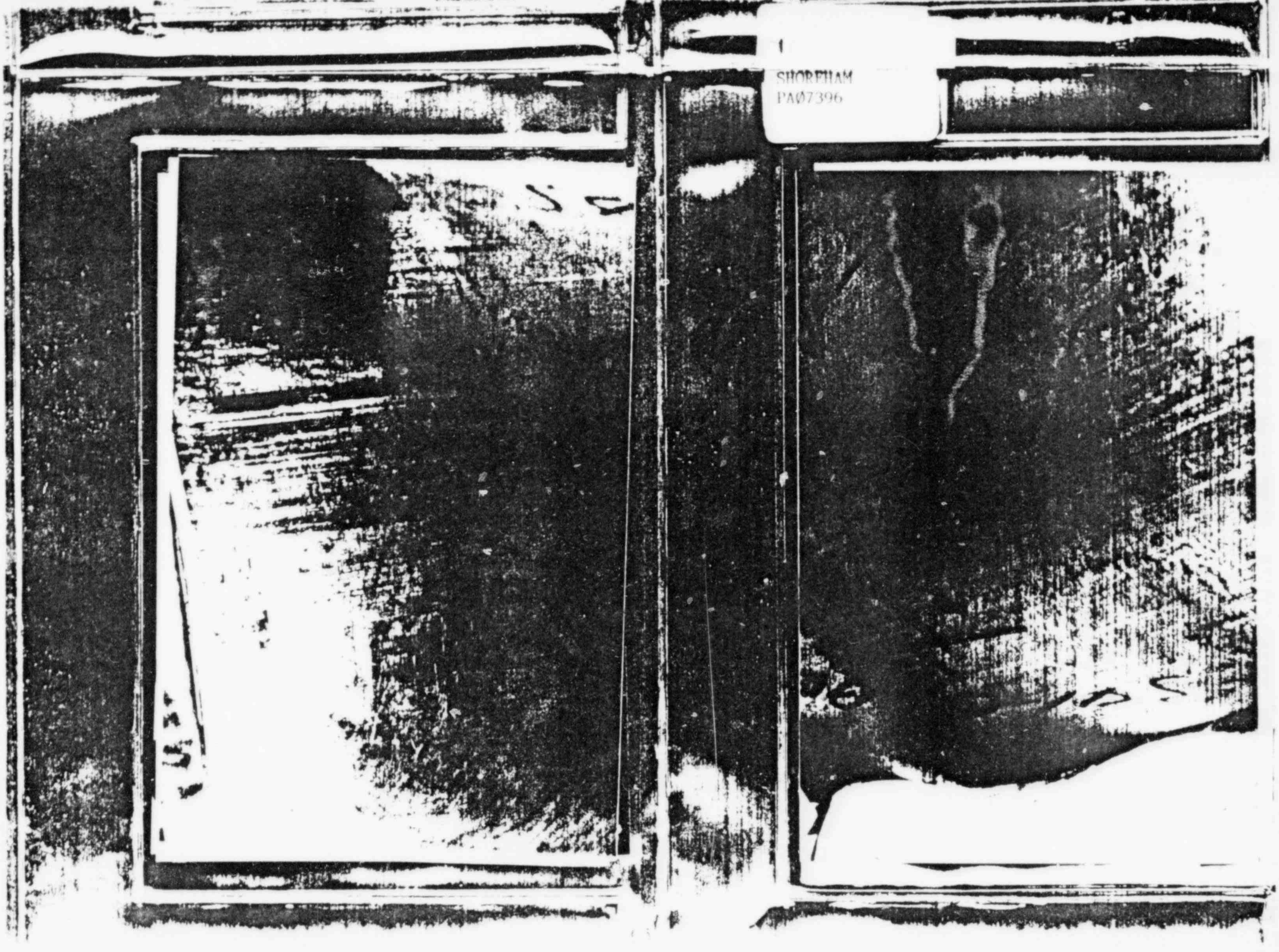
Responsible Certified Personnel ____ Level ____ Date ____

[illegible]
PA07396

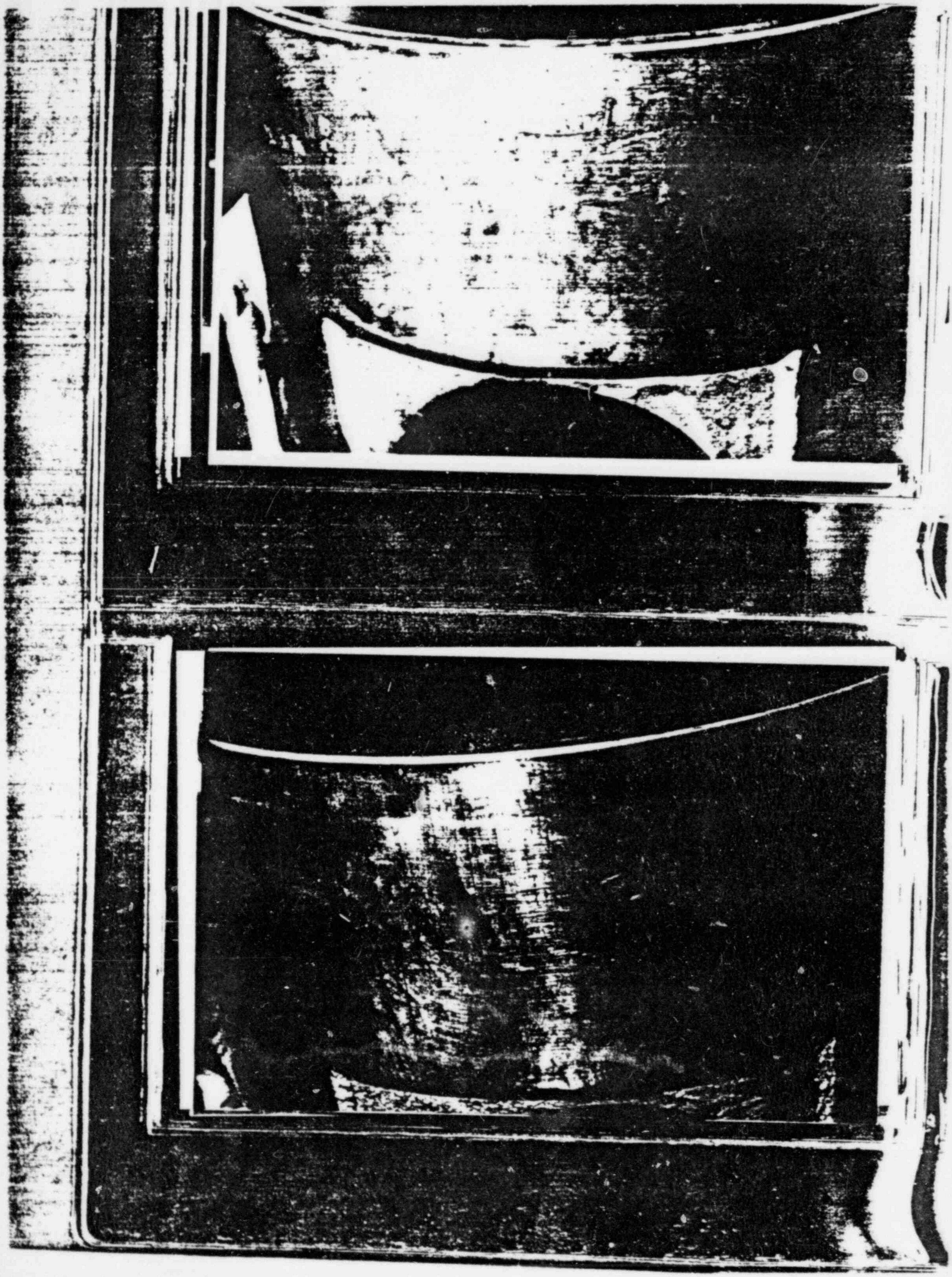


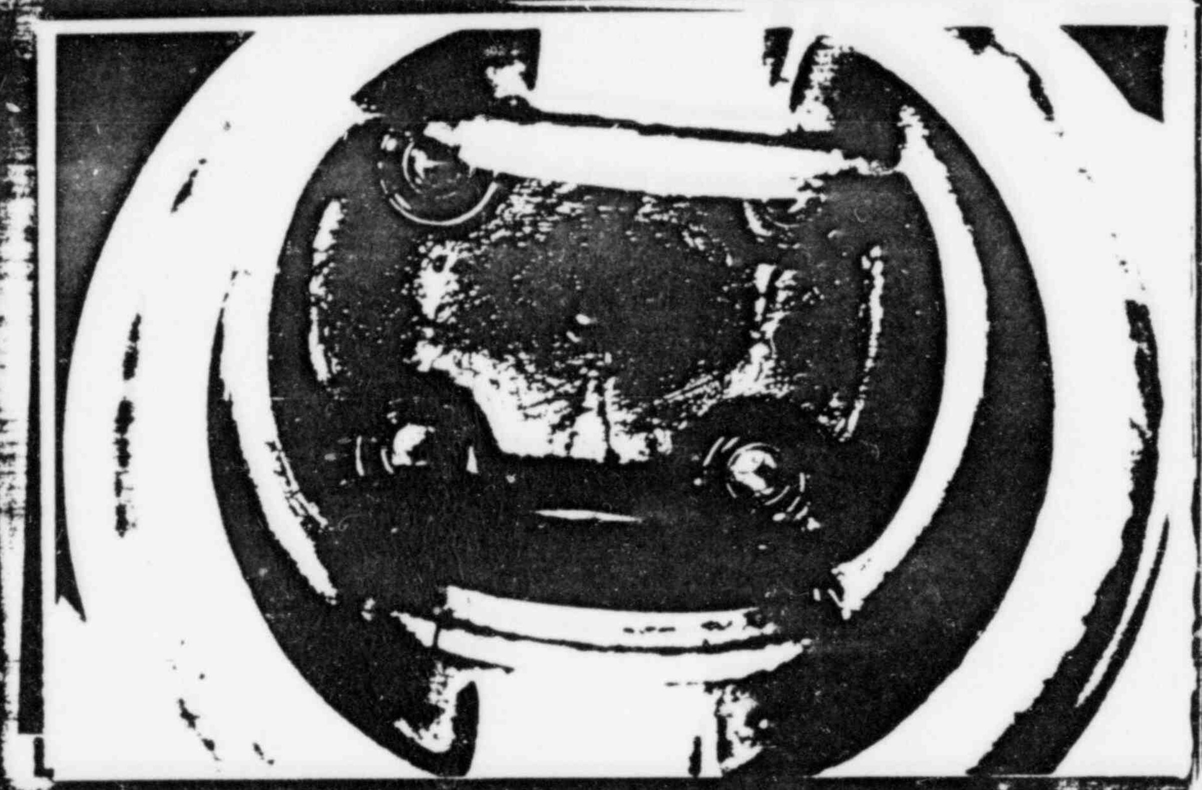



26

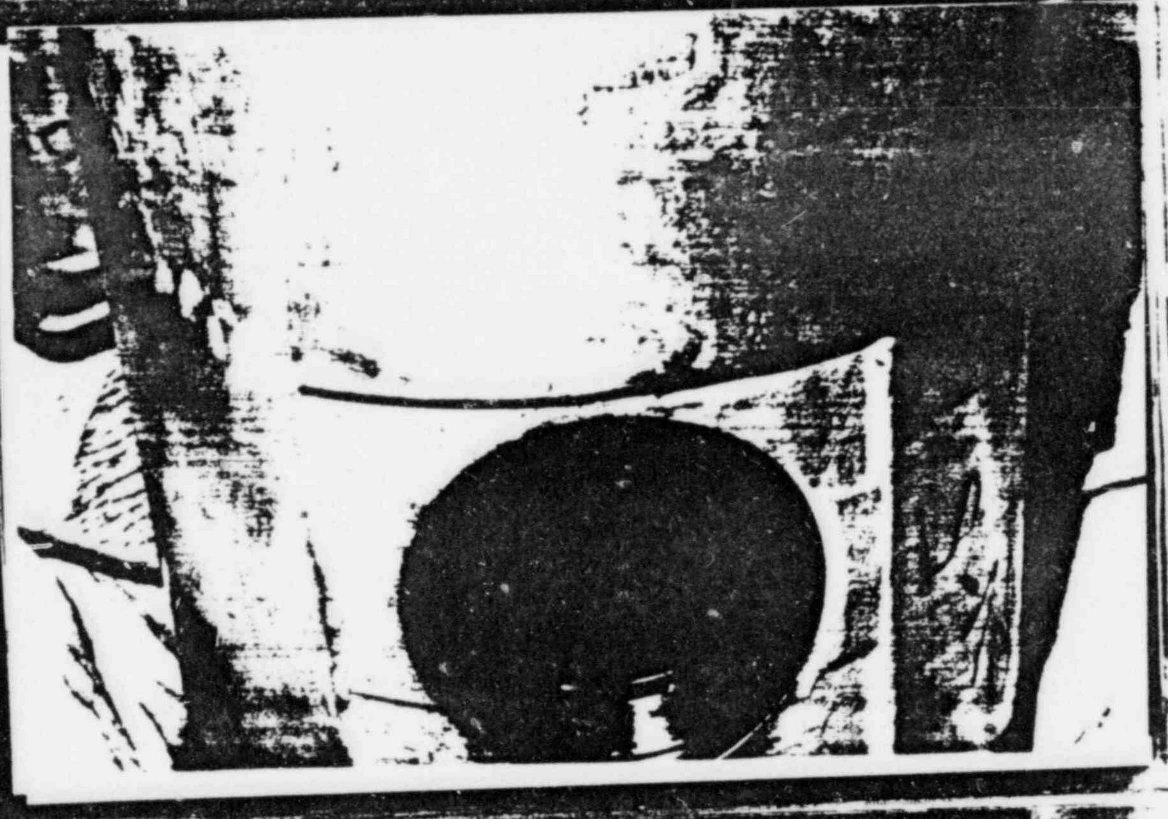


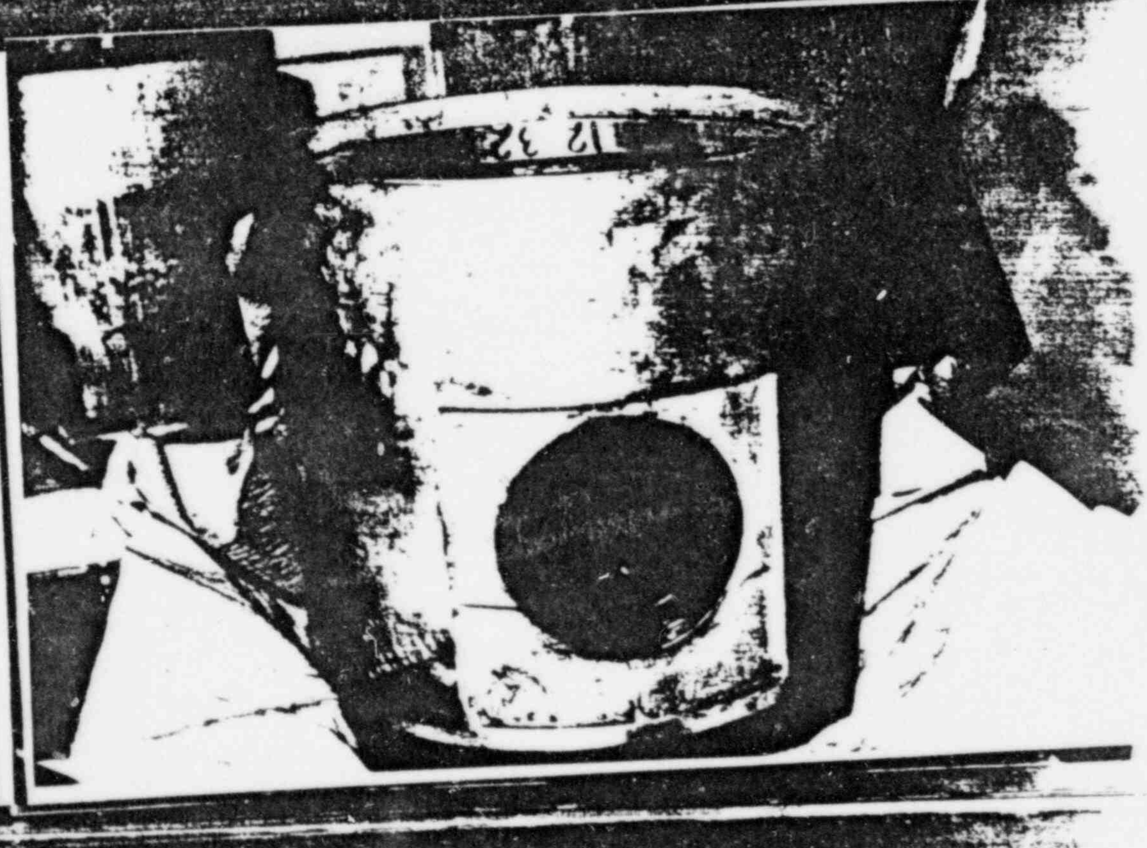
SHOREHAM
PA07396

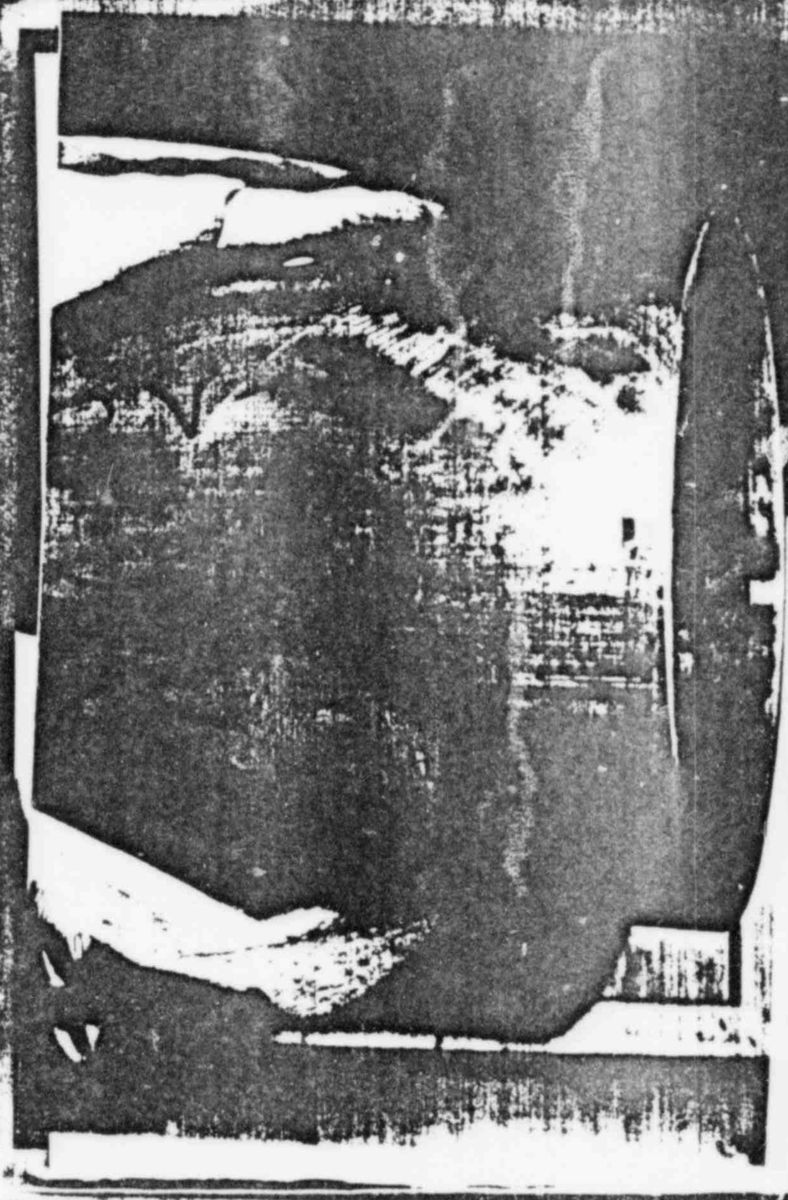


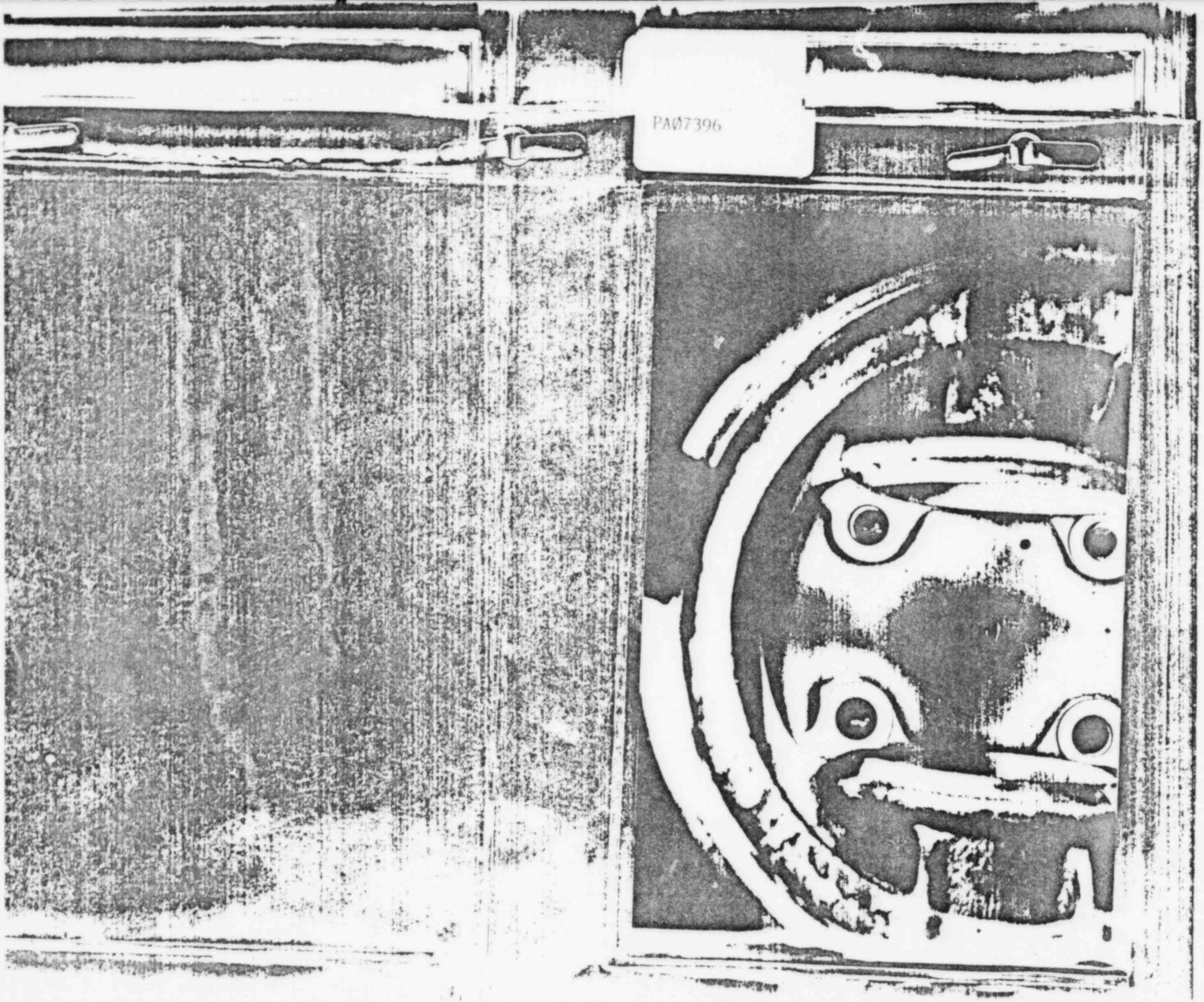


PA07396








PA07396


PA07396

11.1.10

Failure
Analysis
Associates

# EDDY CURRENT CALIBRATION REPORT

Job No. PAO 7396 Date 1-13-84 Report No. PAO 7396-841301

Material Description NoDular IRON PISTON SKirT

Code or Specification NDE 11.5 Full On -1.5 Full Off +3

Reference Standard ______ Instrument MIZ 17 S/N B133867

## Instrument

Freq. 2 MHz Gain 15 Volts/div 0.5 Phase 218

Test Probe 100 ECP-1 S/N 100-P-1

Reference Probe 100 ECP S/N ~~B~~ 100-B-2

## CALIBRATION

| Large | | med | |
|---|---|---|---|
| 2.4 | units @ -1.5 L/O | 2 | units @ -1.5 L/O |
| 2.0 | units @ -1 L/O | 1.4 | units @ +1 L/O |

## STRIP CHART RECORDER

Type N/A S/N N/A

| Channel 1 | Channel 2 |
|---|---|
| Sen N/A | Sen N/A |
| Position @ Null Point N/A | Position @ Null Point N/A |
| Chart Speed N/A mm/sec | |

## Calibration Check

| | | | | | |
|---|---|---|---|---|---|
| Time | 2:20 PM | Phase | 218 | Gain | 15 (No Change) |
| Time | 2:45 PM | Phase | 218 | Gain | 15 (No Change) |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |
| Time | | Phase | | Gain | |

Examiner D O Johnson Level II Examiner ______ Level ______

R&D-KR-3

# COMMENTS

These two pistons were plated on the inside completely

1. Machine areas were very smooth in boss area.

2. Grinding was done very carefully on boss area.

3. Piston # C33 one of the boss areas where lip on outside show smashing like a washer hit edge. The edge was rolled over.

4. These castings look better visually in boss area. Also I could not see any cast material without coating.

| | |
|---|---|
| C-31 | Cylinder #6 |
| C-33 | Cylinder #4 |

| | |
|---|---|
| John Gee | 577-7000 |

01/10/83

PA07396

Penetrant Inspection at TDI Oakland.

1) Meet with Al Fleisher
2) Inspected 2 Pistons
3) Could Not Pick Up Blue Prints
4) Tested Pistons No Relevant Indication

Piston Temperature 11°C

Note on Crate

## R5 TEST PISTON

03-341-04-AE Piston Skirt
Tested in R5-V12 for
687 hours at 302 BMEP & 514 RPM
and Stop Sequences

Heat Numbers

708 J

Piston# C-31
or
Piston# C-33

Time of Penetrant was 3:00 p.m. on piston C-31, 3:10pm on piston C-33

cleaming till rag showed no oil
Drying time for cleamer after light wiping 15 minutes before penetrant applied

## LUBRICATING OIL SYSTEM.

The lubricating oil system is of the dry sump type which has a sump tank for holding the oil supply. Oil is circulated through the system by an engine-driven pump. Refer to the lubricating oil piping schematic drawing in the "Drawings" section of this manual for the specific details of the system, relative location of major components, direction of flow, and notes relative to installation of the system.

## FLOW PRINCIPLE.

Pump suction draws the lubricating oil from the sump tank and discharges it to the lubricating oil cooler. Flow from the cooler is through a lubricating oil filter and pressure strainer to the engine main headers. A branch line from the strainer takes oil to the turbochargers. Return is by gravity flow from the engine base to the sump tank. Separate lines direct return flow from the turbochargers from the sump tank. A relief valve, set at 70 psi, provides protection to the system, and pressure regulating valves regulate the system pressure.

## KEEP WARM CIRCUIT.

A "keep warm" circuit is provided to maintain the lubricating oil charge, and thereby the engine, in a warmed and lubricated condition when in the standby status. Heaters at the sump tank warm the oil which is then pumped by the keep-warm pump to the keep-warm filter and strainer and then to the main engine lubricating oil header. To prevent flooding of the turbochargers, there is no supply to the turbochargers in this circuit. The lubricating oil heater thermostat should be set at 150° F.

## PLACING LUBRICATING OIL SYSTEM IN SERVICE.

Before the engine is first started, the assembled lubricating oil piping system must be thoroughly flushed with oil. Disconnect the pipe at the pressure strainer inlet and arrange a temporary bypass from this pipe to the sump tank. The bypass will permit oil circulation through the pipes without filling the internal lubricating oil system of the engine. Several thickness of cloth sack should be secured to the outlet of the bypass to catch debris as it is flushed out. The sump tank and engine base must be thoroughly cleaned before being filled. The auxiliary lubricating oil pump, or any other continuous duty pump of sufficient capacity, can be used to pump oil during flushing operations. Flushing should continue for at least eight hours if care was exercised during fabrication of the system. As much as 24 hours of flushing may be required for a dirty system. When oil is circulating through the system, the pipes should be thoroughly pounded several times with a heavy hammer to loosen dirt and debris. Hot flushing oil will clean better than cold oil. Piping around the oil cooler requires special attention to insure that the pipes and oil cooler are properly flushed. Precautions must be taken to insure the complete removal of testing fluids, water or other liquids before attempting to flush the cooler.

### Note

> Engines may be received with the strainer mounted on the engine and connected to the engine lubricating oil header. If it is certain that the connections between the strainer and the engine oil header have not been disconnected since the engine left the factory, the following paragraph may be omitted.

Disconnected jumper tubes between the engine lubricating oil header and the main bearings, and between main headers and auxiliary headers. Secure a fine screen such as a nylon stocking over each main header fitting to catch debris that may be washed through as the system is flushed. Cover main bearing fittings and open ends of auxiliary header feeders to prevent the entry of dirt. Engine oil should be pumped through the open system for at least four hours to be sure that any foreign material remaining in the headers is removed. Reassemble internal tubes and brackets as required.

## PART K – LUBRICATING OIL SYSTEM

### FILTERS AND STRAINERS.

The full flow filter continuously filters all of the lubricating oil from the pump before it passes to the oil strainer. The length of time that the lubricating oil and the filter elements may remain in service can best be determined by carefully watching the result of oil analysis and the pressure drop across the oil filter. Change period will vary with the operating conditions to which each individual engine is subjected. During the first two or three days of engine operation after initial installation, or after a major overhaul, the strainer at the pump suction and the strainer at the oil header inlet should be checked and cleaned as necessary to remove any debris and other foreign matter that may be present. If at any time the oil pressure gauge shows a low reading, the following should be done to the degree necessary to correct the situation.

a. Check the oil level in the sump tank.

b. Inspect strainer, filter and lubricating oil cooler. A leak in the cooler may be detected by a sudden increase in oil consumption, and by the presence of oil in the cooling water system. Leakage may occur in the packing between the tubes and the tube sheet, or may be due to tube erosion, depending on the construction of the cooler.

c. Inspect all external and internal piping for tightness and freedom from obstructions.

d. Dismantle and inspect pump.

### LUBRICATING OIL PUMP.

The engine-driven lubricating oil pump is a positive displacement, rotary type. As the pump rotates, the unmeshing of the teeth of the two gears produces a vacuum which draws oil between the tooth spaces. Oil is confined in the space between the gear teeth and the housing, and is carried to the discharge side of the pump. The meshing of the gears forces the oil into the discharge line by displacing the oil from the tooth spaces as the opposite gear enters the space. The pump is mounted on the engine gearcase by means of an adapter, and is driven by the idler gear through a gear carrier assembly. A spline on the pump shaft engages internal splines on the gear carrier shaft coupling. Refer to figure 6-K-1 for mounting details.

### REMOVING PUMP.

To remove the pump from the engine, do the following.

a. Remove the inlet and discharge piping as well as any other interfering piping or accessories.

b. Position a sling on the pump and attach to a chainfall and take up the slack.

c. Remove the capscrews that secure the pump to the adapter and pull the pump directly away from the engine until it is clear.

## PART K – LUBRICATING OIL SYSTEM (Continued)

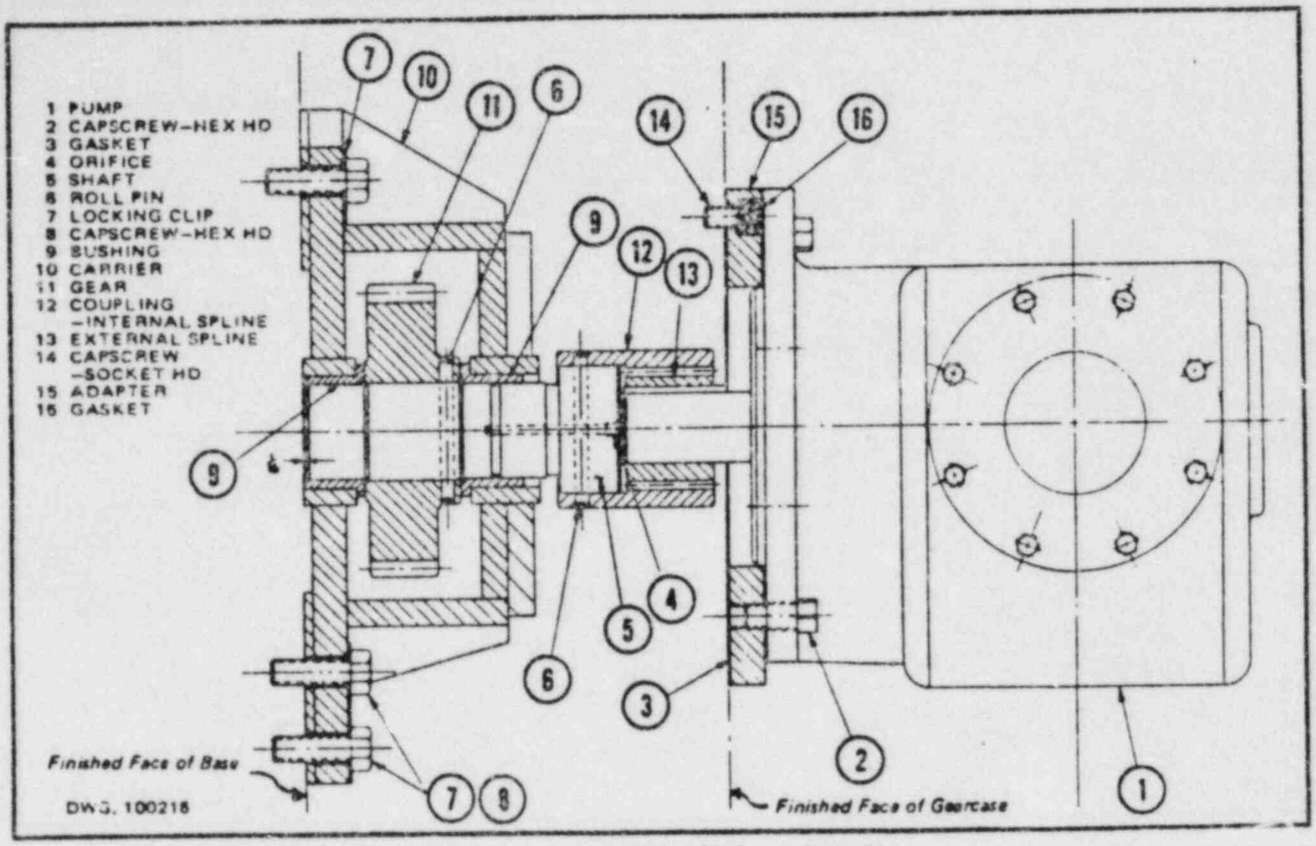


*Figure 6-K-1. Lubricating Oil Pump Assembly*

**PUMP DISASSEMBLY (See Figure 6-K-1).**

If it is necessary to disassemble the pump, exercise care to keep the parts clean so that no dirt, grit or other foreign matter will be present when the pump is assembled. Disassemble as follows.

a. Remove spline from pump shaft, taking care not to exert any internal forces on the pump parts.

b. Remove hex head screws from the faceplate end of the pump and remove the faceplate which contains two bearings.

c. Remove idler gear and shaft, then the drive gear and shaft.

d. Remove hex head screws from backplate end of pump housing and remove backplate which contains two bearings.

e. Carefully examine the surfaces of the gears. Slight burrs or feather edges may be removed with a hand stone.

f. Examine bearings and clean oil grooves and passages.

g. Remove burrs and foreign matter on gasketed surfaces of end plate and case.

h. Check bearing wear, using the table of clearances provided on next page.

## PART K – LUBRICATING OIL SYSTEM (Continued)

### TABLE OF CLEARANCES

Roper Pump Company Figure 2877 Type 1

| | |
|---|---|
| **SHAFT OUTSIDE DIAMETER TO BEARING INSIDE DIAMETER*** | |
| Bearing Inside Diameter | 2.0050" – 2.0055" |
| Shaft Outside Diameter | 2.0000" – 1.9995" |
| Diametric Clearance | 0.0050" – 0.0055" |
| Maximum permissible operating clearance | 0.0100" |
| *NOTE: Wear can occur in bearing ID or shaft OD. Total of both not to exceed 0.010".* | |
| **GEAR OUTSIDE DIAMETER TO CASE BORE*** | |
| Case Bore | 5.667" – 5.669" |
| Gear Outside Diameter | 5.658" – 5.657" |
| Initial Clearance | 0.009" – 0.012" |
| **PUMP LATERAL CLEARANCE**** | |
| Case Width | 8.751" – 8.750" |
| Gear Width | 8.750" – 8.749" |
| Total Compressed Gasket Thickness | 0.014" – 0.016" |
| Total Initial Lateral Clearance | 0.018" – 0.014" |

*Not considering roundness, concentricity and positioning tolerance.

**Not considering squarness, perpendicularity and positioning tolerance.

### PUMP REASSEMBLY.

Assembly is the reverse of disassembly. The spline must be mated to the shaft without exerting any internal forces on the pump parts. The tapered end of the idler gear should be meshed to the opposite end of the drive gear. Taper ends are designated by the letter "T" appearing in the root area of the gear teeth.

### INSTALLATION OF PUMP.

Before mounting pump on engine, make sure pump rotates freely. Mount pump to adapter, engaging dowel and the pump shaft spline with that of the gear carrier shaft. Use a gasket between the pump and the adapter. Assemble nuts on studs, and capscrews. Tighten. Lubricate pump through ports with any good grade of light weight oil to insure pump will not be dry at the time of initial starting. When installing piping, do not force as the strain imposed will cause undue wear on the pump. No external lubrication is required as the pump is self lubricated by the oil it pumps during operation.

### PUMP GEAR CARRIER ASSEMBLY.

The pump gear carrier assembly consists of a shaft, supported by two bronze bushings, pressed in the carrier assembly with their flanges to the inside. The pump end of the shaft has an internally splined adapter, attached to the shaft with a roll pin, which accepts the spline on the pump shaft. The drive gear is mounted on the shaft between the two bushings and engages the idler gear. The carrier assembly is secured to the engine block by capscrews and locking clips.

## PART K – LUBRICATING OIL SYSTEM (Continued)

### DISASSEMBLY AND ASSEMBLY OF GEAR CARRIER ASSEMBLY.

To remove the pump gear carrier assembly, the pump must be removed as outlined above, then the gearcase removed.

a. Remove lubricating oil lines from carrier assembly.

b. Bend back locking clips and remove capscrews. Remove carrier assembly.

c. To remove gear, shaft and bushings from carrier assembly, remove gear-to-shaft roll pin then press shaft out of gear. With shaft and gear removed, press bushings out of drive bracket.

d. Assembly is the reverse of disassembly. Use new locking clips.

PART K – LUBRICATING OIL SYSTEM (Continued)

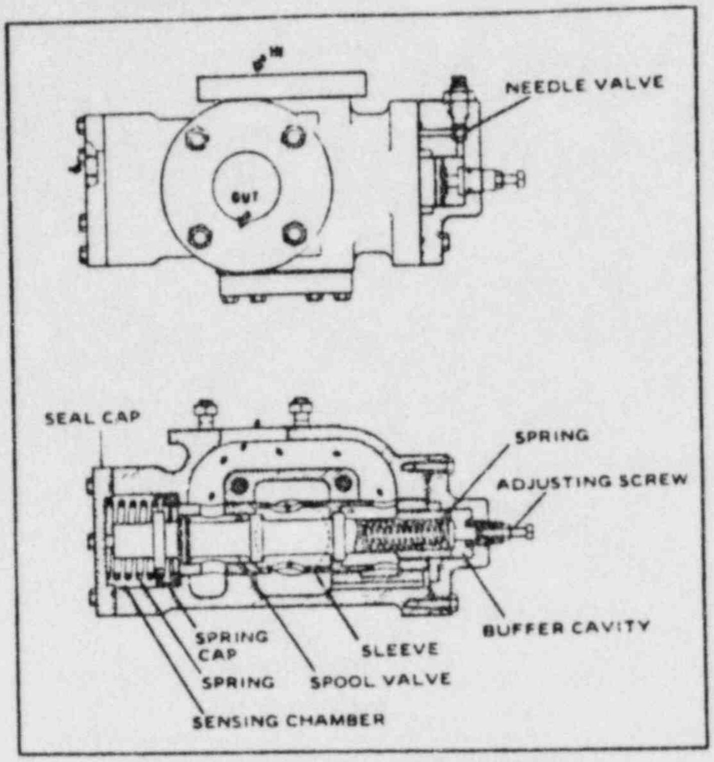


*Figure 6-K-2. Oil Pressure Regulating Valve*

## PRESSURE REGULATING VALVE.

Lubricating oil header pressure in the engine is regulated by a pressure regulating valve, mounted on the pump discharge piping so that the pump discharge is directed to this valve before reaching any other system components. Set at 50 psig, it senses header pressure and regulates the bypass volume to maintain the set header pressure. Besides regulating header pressure, the valve protects the system from excessive pressure during starts with cold oil, or when flow in the system is restricted between the pressure regulating valve and the header pressure sensing point. The functioning of the valve is as follows.

a. The "IN" port of the valve is connected to the pump discharge line and the "OUT" port is connected to a bypass line leading back to the engine base. A sensing tube, connecting the valve seal cap to a point on the main engine oil header, applies header pressure to the valve pressure sensing chamber.

b. The pressure in the sensing chamber acts against the end of a spool valve, compressing a spring at the adjusting screw end of the assembly. If the sensed pressure rises above the set point, the lands of the spool valve will clear the lands on a sleeve. Oil then flows from the inlet section to the outlet-section of the regulating valve and back to the engine base to bypass a part of the pump discharge to reduce the pressure in the header.

c. A drilled passage connects the inlet section of the valve to the annular space around the spool valve at the adjusting screw end. This allows pump discharge pressure to act against the end of the sleeve and oppose the spring force at the other end. When an excessive pressure differential exists between the pump discharge and the header pressures, such as when starting with cold oil, or because of an obstruction in the system between the regulating valve and the header pressure sensing point, the sleeve is forced towards the sensing chamber end, compressing the spring. This will uncover the lands of the spool valve and the excess oil will bypass through the spool valve and the excess oil will bypass through the outlet side of the valve back to the engine base.

## PART K – LUBRICATING OIL SYSTEM (Continued)

d. The oil in the annular space around the spool valve, at the adjusting screw end, will leak past the sealing grooves of the spool valve and into a cavity in the cap. This cavity functions as a buffer chamber. To stop valve oscillation, an adjustable needle valve controls oil spillage from the buffer cavity to the outlet-section of the valve.

e. The oil header pressure is set by increasing or decreasing the spring force acting against the header pressure in the valve sensing chamber. Turning the adjusting screw in will increase header pressure, and backing it out will decrease pressure.

f. Normal lubricating oil pressure is 50 psi, measured between the engine lubricating oil strainer and the engine oil header which is also the pickup point for all gauges and other instrumentation that show or indicate engine lubricating oil pressure. Lubricating oil pressure shutdown devices may take their sensing point at the opposite end of the engine in which case the shutdown set pressure will take into account the normal change in pressure between the supply end of the engine and the shutdown sensor under all conditions of engine speed and lubricating oil temperature.

### ADDING LUBRICATING OIL.

The lubricating oil sump tank is provided with a fill connection and a dipstick, located on the top of the intake section of the tank. A level indicator may be provided at the control panel for monitoring purposes, however, the level in the sump tank should be verified by means of a visual reading of the dipstick before oil is added to the system, and the expected rise in the level in the sump tank must be verified by means of the dipstick. Oil may be added to the system with the engine running or with the engine stopped. The dipstick has two sets of marks, one for the static condition and one for the running condition. The markings are "Full Static" and "Low Static" on one side of the dipstick, and "Full Run" and "Low Run" on the other. Before oil is added, it should be determined that the correct oil is available. Appendix VI of this manual contains the recommended specifications for the lubricating oil to be used.

**CAUTION**

Oil must never be added from any location other than the fill connection on the sump tank. Do not overfill. Attempting to fill from any other location could result in oil reaching other than design locations.

## PART K – LUBRICATING OIL SYSTEM (Continued)

### SELECTION OF A LUBRICATING OIL.

The selection of a lubricating oil to be used in the engine is a complex matter, and is very important to the engine's successful operation. The recommendations of both the oil supplier and the engine manufacturer should be carefully considered. Transamerica Delaval's recommendations for a suitable lubricating oil are stated in Section 8, Appendix VI. Other factors to be considered include the price, service life, load factor and fuel sulphur content as well as the filtration and oil purification system used.

### CHANGING LUBRICATING OIL.

Once an oil has been selected the engine user, in consultation with the oil supplier, should map out a plan for periodic sampling and laboratory analysis of the oil. A careful review of these results by the owner, the oil supplier and the testing laboratory can then become the basis for deciding whether or not the oil needs to be changed. Transamerica Delaval recommends that oil be changed on the basis of condition of the used oil rather than on a time schedule.

### ANALYSIS OF OIL.

Various chemical and physical tests have been developed to classify and identify new oil, and to determine what changes have occured in these oils while in service. The American Society for Testing Materials (ASTM) has standardized these tests, and certain of these tests have been approved as an American National Standard by the American National Standards Institute, Inc. (ANSI). Transamerica Delaval, as stated in Section 5, recommends that representative oil samples be submitted to a qualified laboratory for analysis on a monthly basis, or oftener if operating conditions indicate. The following tests should be conducted.

a. OIL VISCOSITY – Tested in accordance with ASTM D88, D445, ANSI Z11.2 and ANSI Z11.107. The viscosity test will indicate whether the proper grade of oil is being used, and will indicate oxidation (by increased viscosity) or fuel dilution (decreased viscosity). The oil supplier can provide advice regarding the significance of the specific values obtained.

b. WATER/GLYCOL CONTAMINATION – A measure of water and/or glycol contamination of the oil can give warning of potential problems. Water or glycol contamination can come from liner seals, turbocharger casings or faulty lubricating oil heat exchangers.

c. NEUTRALIZATION VALUE – Test in accordance with ASTM D664, D974, ANSI Z11.59 and ANSI Z11.131. Engine oils are intentionally formulated slightly alkaline so that they are capable of neutralizing the acidic compounds that form from products of combustion and of oil oxidation. Generally this reserve alkalinity is depleted and the weak organic acids that attack bearing surfaces can be destructive. Periodic evaluation of Total Base Number (TBN) and Total Acid Number (TAN) are an important measure of oil degradation. As time goes on, TBN is depleted and TAN begins to rise.

d. PENTANE AND BEZINE INSOLUBLES – ASTM D893. This test is a measure of oil insoluble materials, oil resinous matter from oil or additive degradation, external contamination, fuel carbon and highly carbonized materials from degradation of fuel, oil, additives, engine wear and corrosive materials.

e. SPECTROGRAPHIC ANALYSIS – This test is used to measure quantitively the mineral elements in the oil, including wear or corrosion metals such as aluminum, chromium, iron, copper, silver, lead and tin. Also, dirt contaminants from the coolant such as boron, potassium and sodium.

**Note**

> The Transamerica Delaval Customer Service Department in Oakland, California will welcome any correspondence regarding oil selection and/or testing. Although Transamerica Delaval cannot recommend a specific lubricant, nor accept any responsibility for the performance of the lubricant selected by the owner, it will be pleased to discuss its experience with a given oil product, or review your oil analysis and offer comments.

## PART K – LUBRICATING OIL SYSTEM (Continued)

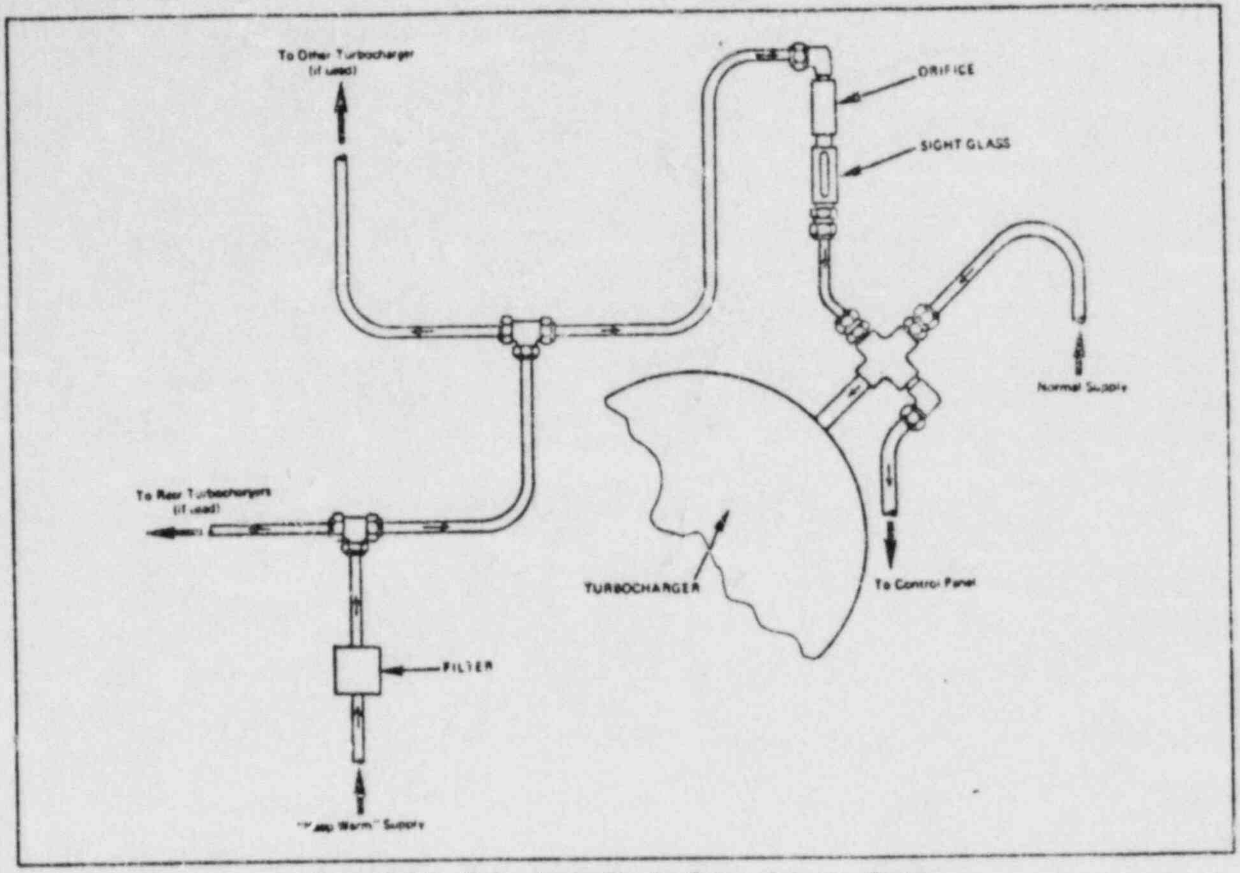


*Figure 6-K-5. Turbocharger Bearing Drip Lubrication System*

### TURBOCHARGER BEARING LUBRICATION.

The turbocharger bearings are lubricated by the engine lubricating oil system during normal engine operation. On the other hand, when the engine is in standby status oil is not circulated to the turbocharger. The design features of the Elliott BCO 90G turbocharger are such that the prolonged circulation of oil to the bearings while the turbocharger is at rest will result in oil intruding past the bearings into the turbine section. To prevent failure of the bearings during a start, however it is essential that the bearings be properly lubricated during prolonged periods in standby. A drip lubrication system is provided to perform this function (see figure 6-K-3). Lubricating oil from the "keep warm" supply is passed through a 60 micron filter then through a 0.014 inch diameter orifice to a sight glass. The sight glass, one for each turbocharger, provides a means for positive determination of oil flow to the bearings. This flow is sufficient to provide for proper lubrication of the bearings without flooding the turbocharger. Little maintenance should be required other than the possible replacement of filter elements.

# DIESEL ENGINE DESIGN

By

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*With 290 Illustrations*
*and 31 Engine Sections*

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## Chapter 3

# ENGINE TYPES

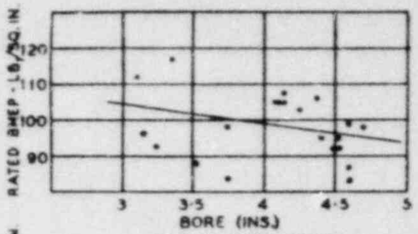
DIESEL engines may be classified roughly into the following categories :

(1) Two-stroke or four-stroke working cycle.
(2) High, medium, or low-working speed.
(3) Single or double-acting.
(4) Vertical, horizontal, vee, opposed piston, etc.
(5) Duty – generating, marine, locomotive, road vehicle, etc.
(6) Supercharged or unsupercharged.

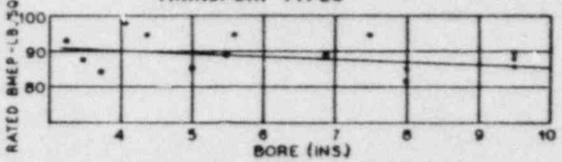
Considering these in more detail ;

### (1) Two-stroke or Four-stroke Working Cycle

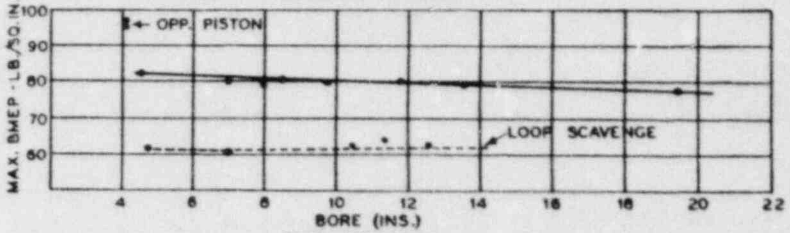
Classification as to the mechanical cycle followed is, of course, general. At one time it was usual to assume all engines to be four-strokes " unless otherwise stated," but to-day it is necessary to be quite clear on the point, as there are as many of one type as the other. The fundamental difference between the two types is that in the case of the two-stroke, a separate pump is required to recharge the cylinder with air, whilst in the four-stroke engine the working cylinder itself performs that duty. This fundamental difference leads to a host of consequent problems, most of which are concerned with the twin subjects of higher rate of heat flow and the shorter time available for exhaust and air induction in the two-stroke. Owing to the fact that a firing impulse is received twice as frequently in a two-stroke, and that valves can be done away with, this type of engine is used universally for the higher powers, say above 3,000 B.H.P. per unit. Between 1,000 and 3,000 B.H.P., the supercharged four-stroke and the two-stroke are in equal competition, the two-stroke being possibly the favourite. Below 1,500 B.H.P. the four-stroke holds the field at present, chiefly owing to lower fuel and lubricating-oil consumption, but the new highly rated valve-exhausted two-strokes are rapidly gaining favour. It will be noted that in all cases of high-duty two-strokes, up to 1,000 B.H.P. at any rate, exhaust valves have been found to be essential, and it can no



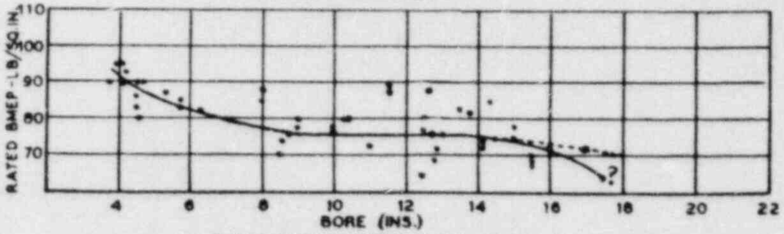
TRANSPORT TYPES



HIGH-SWIRL STATIONARY ENGINES



TWO-STROKES



DIRECT INJECTION FOUR-STROKES

*Fig.* 4-1

pump power. **A great deal will depend on scavenging efficiency.** The old-fashioned "crankcase compression" engine rarely exceeded a B.M.E.P. of 60 lb./sq. in., whilst engines built under the Kadenacy patents have exceeded 120 lb./sq. in. on test. A plot of two-stroke B.M.E.P. is also shown in Fig. 4-1, but it should be noted that these are on the one-hour rating.

## Piston Speeds

As the piston speed, $N_p = 2LN$, the horse-power expression may be rewritten :

TABLE IX

| | | | | | | |
|---|---|---|---|---|---|---|
| Bore, in. | 16 | 12 | 10 | 8 | 6 | 4 |
| Speed, r.p.m. | 300 | 428 | 500 | 600 | 800 | 1,250 |
| Max. pressure, lb./sq. in. | 700 | 740 | 790 | 850 | 900 | 1,050 |
| Compression pressure, lb./sq. in. | 420 | 430 | 440 | 460 | 490 | 510 |
| Cylinder pressure at half stroke lb./sq. in. | 75 | 75 | 80 | 90 | 90 | 100 |

The figures for compression pressure will, of course, depend to some extent on the pressure at the beginning of compression, but may be taken as a fair approximation. Similarly, the values for pressure at half stroke will depend on the value of " *n* " (and on the expansion ratio), but they have some interest, as it is near this point that the transverse stress due to the inertia of the connecting rod is a maximum.

The cylinder pressure ought to be regarded as a shock load when designing the running gear. Some reference has already been made to the rate of pressure rise in the cylinder, and from the point of view of fatigue stressing, the rates of rise per *second*, even in cases where the rise per degree is small, are quite serious. At 1,200 r.p.m., a rate of pressure rise of 40 lb./sq. in./degree is not far short of 300,000 lb./sq. in./sec. As will be pointed out later, under these conditions the *shape* of the part is almost as important as its strength if serious concentrations of stress are to be avoided.

### (2) Inertia and Centrifugal Loads

Inertia forces increase with the *square* of the speed. Those due to the piston and connecting rod are in *opposition* to the gas loading at top dead centre, and their effect is to reduce the downward loading on the connecting rod and bearings. On T.D.C. of the exhaust stroke in four-strokes, the inertia forces introduce a *tension* load in the rod, and this means that the rod has to withstand some reversal of stress.

In the valve gear, almost the whole of the load is due to inertia, and the effect is cumulative. High accelerations require heavy valve springs to cope with them. This means that stronger gear is required to resist the stress due to spring forces, and this in turn increases the inertia loading. The exhaust-valve system of two-stroke engines is particularly troublesome in this respect.

Centrifugal forces due to rotating unbalanced masses impose loads on the bearings which travel round the bearing with the rotation of the crankshaft. They are often in opposition to the gas loading, but cause stresses in other parts of the engine, due to

# INTERNAL-COMBUSTION ENGINES

## THEORY AND DESIGN

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period is the third stage or *gradual*, or *controlled, combustion*. The fourth stage, or *afterburning*, is burning of the fuel after injection terminates. This stage cannot be controlled and is very undesirable as its efficiency is comparatively low.

Figure 10-1 illustrates the process by a pressure-time diagram: the fuel is injected at point 1, but ignition does not start until point 2. Angle *a* represents the delay period also called *ignition lag*. For a certain engine the delay period depends upon many factors, as will be shown later. From point 2 to point 3, corresponding to a crank angle *b*, the flame spreads from the initial nucleus to the main body of the fuel charge. Similar to the conditions of spark-ignition engines, the flame velocity and the pressure rise depend upon turbulence; this second phase of the process is very important for a smooth operation of an engine. During the third stage, crank angle *c*, from point 3 to 4, the fuel burns as it leaves the fuel nozzle and the pressure may either increase, remain constant, or decrease, depending upon the rate at which it is delivered to the combustion chamber. The angle *c* is a function of the load which the engine is carrying. The fourth stage, afterburning, is not apparent on the indicator diagram. On a diagram taken from an engine, the dividing points 2, 3, and 4 are not pronounced, and the four stages merge one into another gradually.

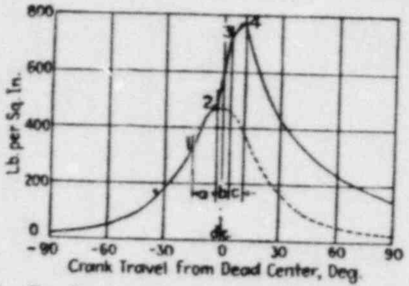

Fig. 10.1—Combustion diagram of a high-speed oil engine.

**10-3. Delay Period.**—This period itself is made up of two parts: a heating period when the cold fuel droplets are heated, vaporized, and brought up to their ignition temperature and a period of true ignition delay that ends when the first particles actually ignite. However, in engines it is difficult to distinguish between these two periods, so the delay period is measured from the beginning of the injection to the moment of ignition.

The delay period presents a great interest, as it materially influences the operation of an engine: A shorter delay period gives a smoother operation; a longer delay period results in a rougher and noisier running engine. The factors that influence the length of the delay period are:

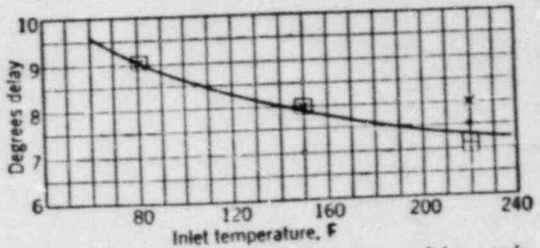

Fig. 10-2.—Effect of inlet temperature on delay angle.

(*a*) temperature of the air charge,
(*b*) pressure of the charge,
(*c*) atomization of the fuel,
(*d*) timing of injection,
(*e*) engine speed, and finally,
(*f*) ignition quality of the fuel, its cetane number.

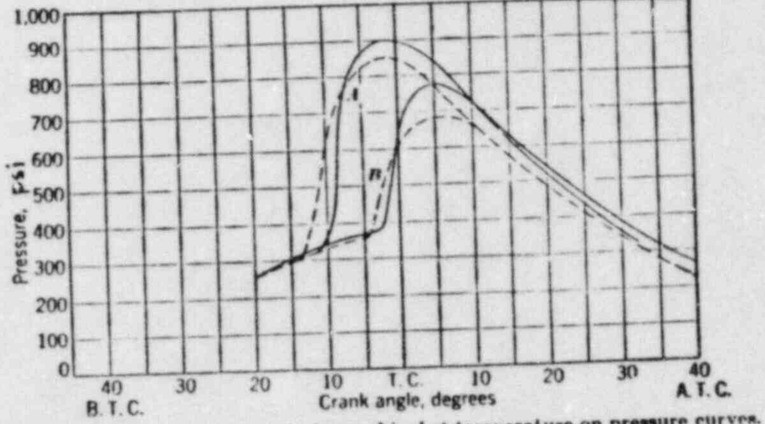

Fig. 10-3.—Effect of injection timing and jacket temperature on pressure curves. Curves *A* and *B*—injection starts 20 and 10° B.T.C., respectively; solid and broken-line curves—jacket temperature 150 and 300F, respectively.

*Temperature.*—Figure 10-2 shows the typical effect of inlet temperature on the delay angle of an experimental engine.[1] The same condition is confirmed by another engine, Fig. 10-7.

---

[1] Rothrock, A. M., *SAE Journal*, vol. 34, June, 1934.

Cooper-Bessemer compression-ignition oil engine equipped with a Buchi-Elliot turboblower. In this engine the mep when supercharged was limited not by available air but by the fuel-pump delivery.

Finally, Fig. 19-8 presents data about the increase of bmep in two compression-ignition aircraft oil engines as a function of the supercharging pressure.[1] Curve *c* gives the same data in respect to a large oil engine running at 300 rpm with an unchanged valve overlap of 30°.[2]

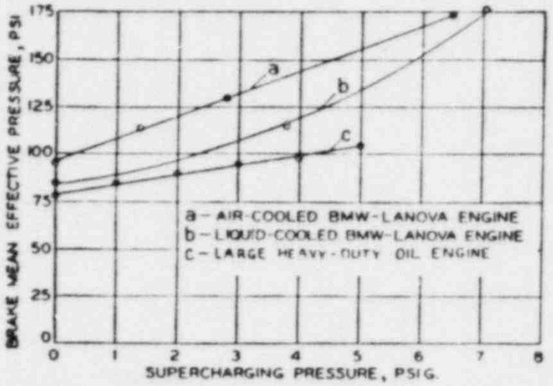

Fig. 19-8.—Effect of supercharging pressure on mean effective pressure.

*Mechanical Efficiency.*—The increase of friction losses with a supercharger driven by the engine itself is considerably smaller than the power gained through supercharging. As a result the mechanical efficiency, referred to the maximum load, increases with supercharging. Figure 19-9 shows the mechanical efficiencies of a 7-in. × 10-in. six-cylinder compression-ignition Cummins engine at different speeds and mean effective pressures when operating, supercharged with a Roots blower.[3] The mechanical efficiency of the same engine with natural aspiration at 1000 rpm when developing a bmep of 84 psi was found to be 73 per cent. The influence of supercharging upon the mechanical efficiency of two aircraft engines is brought out by Fig. 19-10.

---

[1] Maleev, V. L., *Mech. Eng.*, vol. 63, p. 446, 1941.

[2] *Diesel Power*, vol. 18, p. 877, October, 1940.

[3] Knudsen, H. L., Problems and Possibilities of Mechanical Supercharging of Diesel Engines, *Diesel Power*, vol. 19, p. 856, October, 1941.

*Fuel Economy.*—Owing to better combustion because of increased turbulence, better mixing of the fuel and air, and of an increased mechanical efficiency, the specific fuel consumption in most cases, though not in all, is lowered by supercharging.

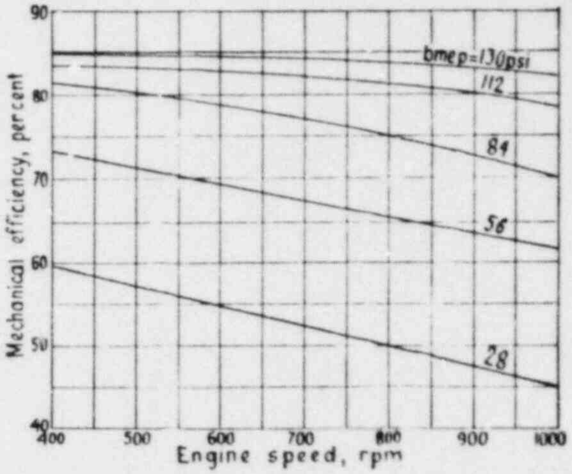

Fig. 19-9.—Mechanical efficiencies of a Cummins supercharged oil engine.

Figure 19-11 gives an interesting comparison of the performance of a three-cylinder $9\frac{1}{2}$-in. × $10\frac{1}{2}$-in. Alco oil engine at 1000 rpm: curve *c*, unsupercharged; curve *d* supercharged with a Roots blower, power increase about 75 per cent, fuel consumption 5 per cent lower; curve *e* supercharged by a Buchi turboblower, power increase about 87 per cent, fuel consumption 13 per cent lower than in the unsupercharged engine.

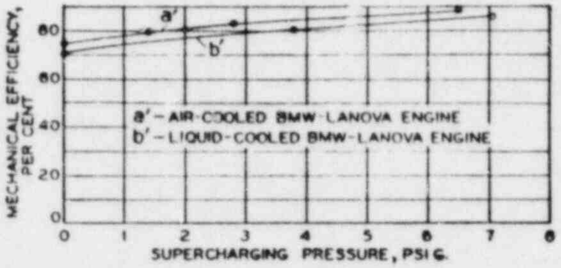

Fig. 19-10.—Effect of supercharging on mechanical efficiency of compression-ignition aircraft engines.

Curves *a* and *b* show also how the performance of this engine was improved by putting in turbulence-creating pistons.

Figure 19-6, on the other hand, shows that the fuel consumption of that particular gasoline engine was improved very little and only at the maximum supercharged horsepower.

*Fuel Knock.*—In compression-ignition oil engines, increasing the inlet pressure decreases the ignition lag and consequently the rate of pressure rise in the cylinder, which results in an increasing smoothness of operation.[1] On the other hand, in a gasoline engine, if the engine is operated with a compression ratio that causes incipient detonation when supercharging and if a fuel with the same antiknock characteristics is used, in order to prevent objectionable detonation, the compression ratio must be lowered so that the compression pressure of the supercharged engine will remain about the same as before supercharging. This will slightly lower the thermal efficiency, but the power output will be increased, as a greater amount of fuel will be burned. An engine operating with natural aspiration with a compression ratio 7:1, when supercharged should have a compression ratio about 6:1.

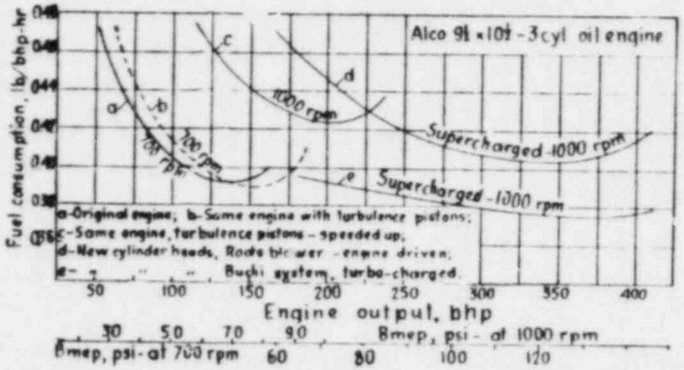

FIG. 19-11.—Performance development of Alco 9½-in. × 10½-in. engine.

**19-4. Limitations.**—The permissible amount of supercharging depends upon the ability of the engine to withstand the increased pressure and heat stresses.

*Pressures.*—The increase of the mean effective pressure naturally increases the mean bearing pressures and mechanical friction losses. On the other hand, the maximum pressures and temperatures will go up too. Thus a six-cylinder 12-in. × 15-in. by 650 rpm Enterprise oil engine unsupercharged develops continuously 670 bhp, or a bmep of 80 psi, with a maximum pressure of about 680 psi. When equipped with a Buchi turbine-driven blower, the engine can develop a maximum bmep of 162 psi and a continuous bmep of 125 psi, or a power increase of 56 per cent; the maximum pressure goes up to about 850 psi, the specific fuel consumption goes down from 0.40 lb/hp-hr to 0.375 lb/hp-hr, or an improvement of 6 per cent.

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[1] *NACA Tech. Notes* 509, 1936, p. 8.

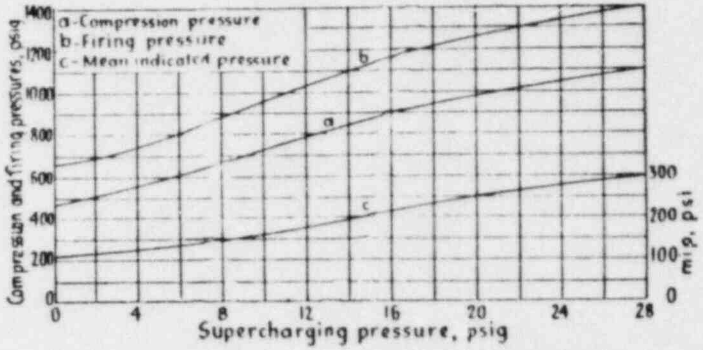

FIG. 19-12.—Effect of supercharging pressure on various characteristic pressures.

Figure 19-12 gives the relation between supercharging pressures, compression pressures, maximum combustion pressures, and obtained mean indicated pressures for sea-level operation. The curves represent computed values but are corrected on the basis of corresponding test data and give an idea of the limit of supercharging.

*Temperatures.*—The above-mentioned Enterprise engine has an exhaust temperature of 720 F unsupercharged and 960 F supercharged. The Cummins engine mentioned before has exhaust temperatures as shown on Fig. 19-13; Fig. 19-14 shows the temperatures for the Alco three-cylinder 9½-in. × 10½-in. engine at different loads.[1] Finally Fig. 19-15 gives a very complete picture of the performance of a six-cylinder 12½-in. × 13-in. Alco engine, which supercharged is rated 1000 bhp at 740 rpm. The exhaust temperature goes up from 720 F, at 80 psi mep, to 1100 F, at 120 psi mep.

---

[1] *Diesel Power*, vol. 19, p. 864, October, 1941.

# CHAPTER 27

## RUNNING GEAR

**27-1. Trunk Pistons.**—*The functions* of a trunk piston are:

1. To transmit the gas pressure to the crankshaft.
2. To take the side pressures due to angularity of the connecting rod.
3. To seal the inside of the cylinder from the crankcase.
4. To dissipate heat absorbed by the piston top during combustion and early part of expansion stroke.

*Design Objects.*—In designing a piston to meet these requirements the following objects must be sought:

1. Strength of the piston, particularly of its head.
2. Sufficient projected side area, and rigidity of the barrel.
3. Minimum work of friction.
4. Sealing of the working space against escape of gases.
5. Preventing the entrance of lubricating oil into the combustion space.
6. Good dissipation of the heat to the cylinder walls.
7. Minimum weight.

The design objects are listed not in the order of their importance but to conform with the order of functions as listed above. Good heat dissipation is one of the most important design requirements.

*Materials* used to make trunk pistons are in the order of their importance: cast iron, cast aluminum, forged aluminum, cast steel, and forged steel.

Cast iron is an excellent material; its main drawback is that it gives a slightly heavier piston than aluminum. However, with a proper design the difference is only about 10 to 20 per cent. Cast-iron pistons produce less cylinder-liner wear than aluminum ones,[1] especially if they are tin-plated.

---

[1] *Automotive Ind.*, Jan. 16, 1937, p. 81; *Z. Ver. deut. Ing.*, vol. 81, p. 610, 1937.

Cast aluminum alloy gives better heat dissipation and lighter weight but costs considerably more than cast iron. The strength is about the same as that of cast iron.

Forged-aluminum pistons are stronger and still lighter. They are used for aircraft engines and heavy-duty high-speed compression-ignition oil engines.

Alloy cast-steel pistons are used in some automotive engines and require liners of great surface hardness. The same is true of forged-steel pistons used in some aircraft engines.

*Piston Head.*—The thickness $t_1$ of the head or crown can be computed, considering it a flat round plate of uniform thickness fixed at the edges, from the formula

$$t_1 = 0.43D\sqrt{p/S} \qquad (27\text{-}1)$$

where $D$ is the cylinder bore, in.,
$p$ is the maximum pressure during combustion, psi,
$S$ is the allowable stress in bending, psi.

A stress of 5500 psi can be allowed when using a good close-grained cast iron or an aluminum alloy with an ultimate tensile strength of 20,000 psi. If the material used has an ultimate strength of 30,000 psi, such as nickel cast iron, semisteel, or special aluminum alloy, normalized, then $S$ can be taken as 8000 psi. For forged-steel heads $S$ can be raised to 12,000 psi. The piston head has often four or six radial ribs $a$, Fig. 27-1, of a thickness $t_2$, one-third to one-half the thickness $t_1$ of the head, but it is safer not to consider these ribs when computing $t_1$.

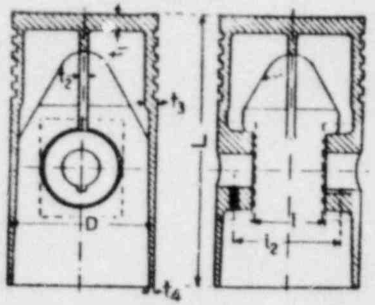

Fig. 27-1. Trunk piston of a gas engine.

Table 27-1.—Thickness of Piston Head

| Type of engine | Piston material | Four-stroke | Two-stroke |
|---|---|---|---|
| Compression-ignition oil engines | Cast iron | 0.11D–0.13D | 0.16D–0.18D |
| Compression-ignition oil engines | Aluminum | 0.13D–0.16D | 0.17D–0.20D |
| Spark-ignition gas engines | Cast iron | 0.12D–0.14D | 0.20D–0.23D |

PRIORITY

TER# Q-326

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UNSAT

## COMPONENT TASK EVALUATION REPORT

ED MAR 2 1984

DG 101 Pistons, Book

| M/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATION |
|---|---|---|---|---|
| 03-341A D.G. 101 | 03-341A | SIGNATURE | 3-21-84 | ☐ENGINEERING<br>☒QUALITY |

NDITION DETAILS: ATTACHED INSPECTION REPORT ( 1 PAGES) GENERATED BY B. Hayes DATED 3-21-84 REPORTS UNSATISFACTORY INSPECTION RESULTS FOR THIS PART.

COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR DISPOSITION.

Attached IR is unsatisfactory

See Sheet 2 for recommended disposition.

QUIRED COMPLETION DATE: 3-21-84

### ASSIGNMENT

| SITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ENGINEERING ☐ QUALITY | R. Fraser<br>SIGNATURE | 3-21-84 |

### DISPOSITION

SPOSITION DETAILS: FOLLOW PROCEDURE 1 OUTLINED ON PAGE 2

SPOSITION ASSIGNED TO ☒ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| PPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
| K Dolan | 3-21-84 | K. Dolan<br>RESP. CHAIRPERSON | 3-21-84 | PROGRAM MANAGER | 3/25/84 |

### ACTION

| TION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| C. Wells | K Dolan for C Wells | 3-29-84 |

: CKS/GWP/RJN/EFM
TER LOG

RECOMMENDED
UNSAT TER DISPOSITION

TER # Q-326
PAGE 2 OF 3

Distribute for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-326", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

3) LSU/OQA - review for applicability and issue LDR as needed.

4) M. Schuster - obtain LDR number as issued for component files and closeout.

STONE & WEBSTER ENGINEERING CORPORATION

# QU···ITY CONTROL IN ·CTION REPORT

JOB NUMBER 11600.37

DATE 3-20-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| **COMPONENT NAME:** Pistons<br>**COMPONENT NO.** 03-341A | DG- 101 | I.P. NO. 14 REV. 4 CHG 0<br>TER # N/A<br>LILCO LP PROC. N/A REV. N/A<br>DWG. NO. N/A |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 2 | 3 | A VISUAL INSPECTION OF THE SKIRT AND CROWN O.D. FOR SCUFFING, AND THE COMBUSTION BOWL IN CROWN FOR PITTING WAS PERFORMED. THE FOLLOWING WAS NOTED:<br>COMBUSTION BOWL - CYL 5 AND 7 VERY SLIGHT SIGNS OF PITTING. CYLINDER 8 DISPLAYS A MORE SUBSTANTIAL AMOUNT OF PITTING.<br>PISTON SKIRT - CYLINDERS 5, 7, AND 8 ALL DISPLAYED SIGNS OF SCUFFING |

[illegible]

N&TE NO. N/A

QUALITY CONTROL INSPEC./ENG. DATE PAGE

This inspection report is acceptable for design review.

Q-326
03-341A

K. [illegible] for C Wells
3/29/84

102 Pistons Book 1

| | | | |
|---|---|---|---|
| DEFICIENCY REPORT | ☒ FIELD<br>☐ OTHER | LDR RESPONSIBILITY<br>M. HERLIHY | LDR NUMBER<br>2275 |
| MPONENT<br>Diesel Gen | SYSTEM DESIGNATOR<br>R43A | MARK NO.<br>1R43*EDG-101 | DATE<br>3/22/84 |
| | | | Q CLASS<br>☒ I ☐ II ☐ III |
| NTRACTOR<br>TDI | P.O.<br>310552 | MATERIAL LOCATION<br>TB 63' ELEV | REJECT TAG NO. ______ ☐ YES ☒ NO |
| OLATED<br>SHI-089 | DRAWING VIOLATED<br>NA | PROCEDURE VIOLATED<br>NA | CODE/STANDARD VIOLATED<br>NA |

ION DETAILS

TER Q-326 (03-341A) REPORTS UNSATISFACTORY CONDITIONS ON
ONS. THE COMBUSTION BOWLS OF PISTONS 5, 7 AND 8 DISPLAY
RTAIN AMOUNTS OF PITTING. PISTON SKIRTS ON PISTONS 5, 7 AND 8
E SCUFFED. QCIR ATTACHED.

(03-341A) 102

TOR A.R. Solano 3.22.84
SIGNATURE DATE

QOAE W. McAdam 3/22/84
SIGNATURE DATE

SIBILITY ☐ LSU ☒ S&W ENG

A.R. Solano
SIGNATURE LEAD SU ENG.

DATE 3.22.84

☒ ACCEPT AS IS ☐ SCRAP
☐ REWORK ☐ REPAIR
☐ MANUAL ☐ PROCEDURE
☐ FSAR ☐ OTHER

TION DETAILS IN ACCORDANCE WITH THE ATTACHED TDI
MO THE ABOVE CONDITION IS ACCEPTABLE AS IS.
DITION IS NOT DETRIMENTAL. COMPONENTS
ULD BE CLEANED AND REINSTALLED.

3/24/84
S&W LEAD ENG SITE ENG/DATE

R. Jaszewski for J. Carney (Bldg Office) 3/24/84
PROJECT ENGINEER DATE

U ENG. DATE
LILCO SITE QQA DATE
REPAIR/REWORK REQUEST NO.

MPLETE/DATE
CHR COMPLETE
CONST. SUPT./DATE
LILCO SU/DATE

REWORK INSPECTION
☐ SAT.
☐ UNSAT.
LILCO SITE QQA/DATE

M 4513

LILCO SITE QQA/DATE
NEW LDR REPORT NO. ISSUED
REMARKS

**Delaval**

P.O. Box 2161
Oakland, California 94621

1-704-26

ATTACHMENT TO
LDR 3198
PAGE 5 of 5

Fm. LFR

Date: March 17 1984

To: [illegible]

From: [illegible]

Subject: Diesel Generators, TDI S/N 74010/11 74010 Piston Assemblies

Reference: LDR 2198

Referenced LDR reports unsatisfactory conditions found during inspection of numbers 5, 7 and 8 piston assemblies due to scuffing, pitting and scratches. The number 5 piston has scuffing evident to the tin plating on the piston skirt in the normal thrust surfaces. The condition is attributed to the excessive wear found in that cylinder and reported in LDR 2188. No machining is evident on the piston skirt and sufficient tin plate remains to provide an adequate break-in to a new liner. Scuffing to a lesser degree is also noted on the number 8 skirt and is not an unusual condition to occur during break-in. Pitting reported in the combustion bowls and circumference of the 5, 7 and 8 piston crowns was found to be very minor and an acceptable condition for a steel casting. Scratches in the combustion bowl of number 8 piston crown are attributed to handling and are not detrimental to the crown.

Recommended Disposition: Clean component and return to service.

# Memo

Form C-1066-0 (R-1) 3/81

cc: [illegible]

08-10-84 FRI 16:17:38 FM ** **** NO.01

[redacted]

DG 102 Pistons, Book 2

## COMPONENT TASK EVALUATION REPORT

TER NO. Q-4

UNSAT

| COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
|---|---|---|---|---|
| -341 A | 03-341-04-AE | SIGNATURE | 2/20/84 | ☒ENGINEERI<br>☑QUALITY<br>-RTF |

NDITION DETAILS: ATTACHED INSPECTION REPORTS (4 PAGES) BY M. TAORMINA / H. ATED 2-11-84. 2/13/84 WAS GENERATED AS INFORMATIONAL, AS NO ACCEPTAN RITERIA WAS PROVIDED PRIOR TO THE PERFORMANCE OF THE INSPEC ON.

MENDATIONS: FORWARD TO DESIGN REVIEW FOR EVALUATION

RED COMPLETION DATE: 2/21/84

### ASSIGNMENT

| SITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| NGINEERING ☐ QUALITY | R Fraser<br>SIGNATURE | 2-21-84 |

### DISPOSITION

SITION DETAILS: See attached sheet 2 of 6

Attached IR. is UNSAT

ISPOSITION ASSIGNED TO ☑ ENGINEERING ☒ QUALITY ☐ NONE REQUIRED

| UPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
| R Fraser | 2/22/84 | R Fraser<br>RESP. CHAIRPERSON | 2/22/84 | C J Montgomery C/o<br>PROGRAM MANAGER | 2/22/84 |

### ACTION

| CTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| Schuster, E Youngling<br>Prm. G Rogers<br>NED: J Kammeyer | | |

C: CKS/GWR/RJN/EFM
TER LOG

A14480

## [illegible] TER DISPOSITION

Distribute for action as follows:

1) Design Review (G. Rogers) - Review as part of site experience. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER_____", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

3) LSU/OCA - review for applicability and issue LDR as needed.

4) M. Schuster - obtain LDR number as issued for component files and closeout.

## STONE & WEBSTER ENGINEERING CORPORATION

3 of 6

ROL
REPORT

| JOB NUMBER | DATE |
|---|---|
| 11600 67 | 2-11-84 |

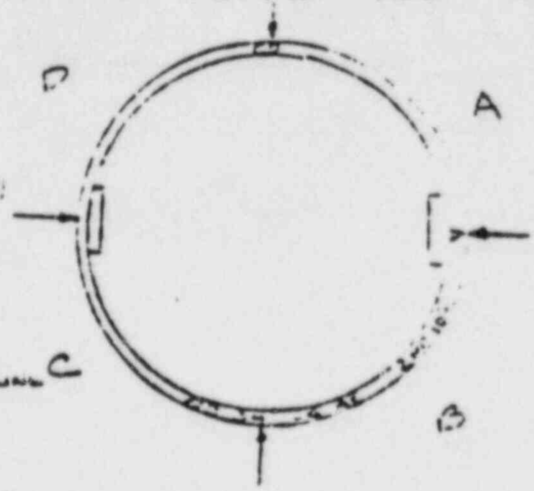
| STEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| STON SKIRT<br>5 (03-341-04-AE)<br>UAL INSP.<br>280 lh | DG. 102 | SHI-089<br>I.P. ~~-03-341-A~~<br>-14 2/12/84 |

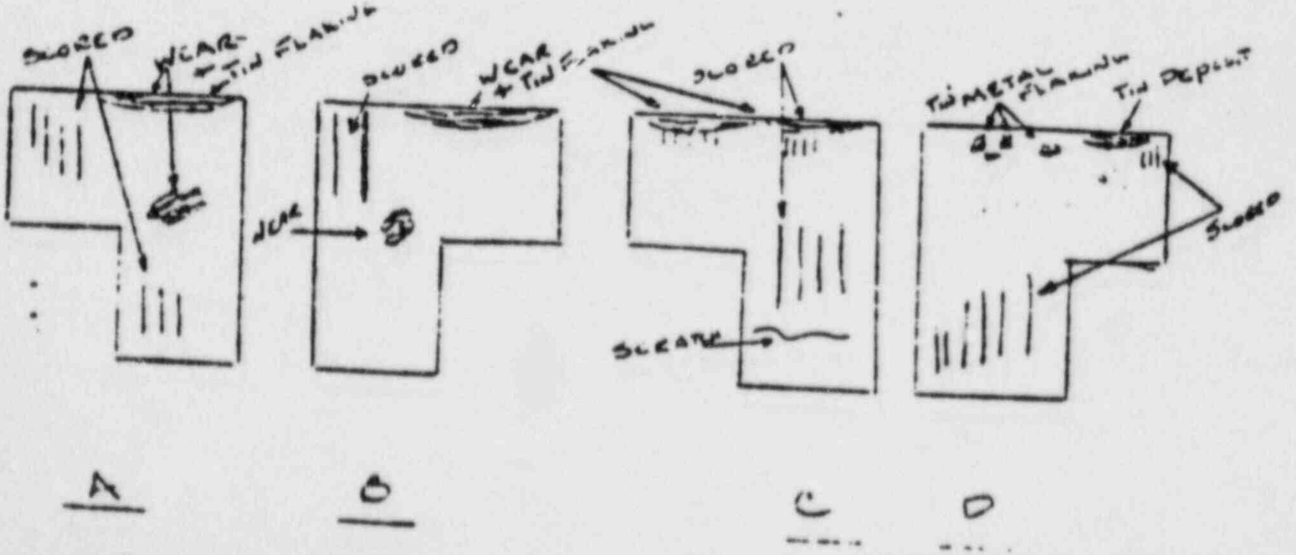
ITEM QTY

DESCRIPTION(S) AND INSPECTION REMARK(S)

PERFORMED VISUAL INSP. ON O.D. OF PISTON SKIRT AREA FOR ABOVE REF. PISTON BELOW FIND THE INSP. RESULTS.

O.D. SURFACE
SLIGHT WEARMARKS,
SMALL SCORED & SCRATCHED
AREA'S ALONG WITH
SURFACE TINNING FLAKING





PORT.

JOB NUMBER 116[illegible]37 | DATE 2-11-84

| ITEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| ION SKIRT<br>(03-3H1-04-AE)<br>VISUAL INSP.<br>273 lbs | DG 102 | SH1-089<br>I.P. - ~~03-3H1-A~~ -14 2/12/84 |

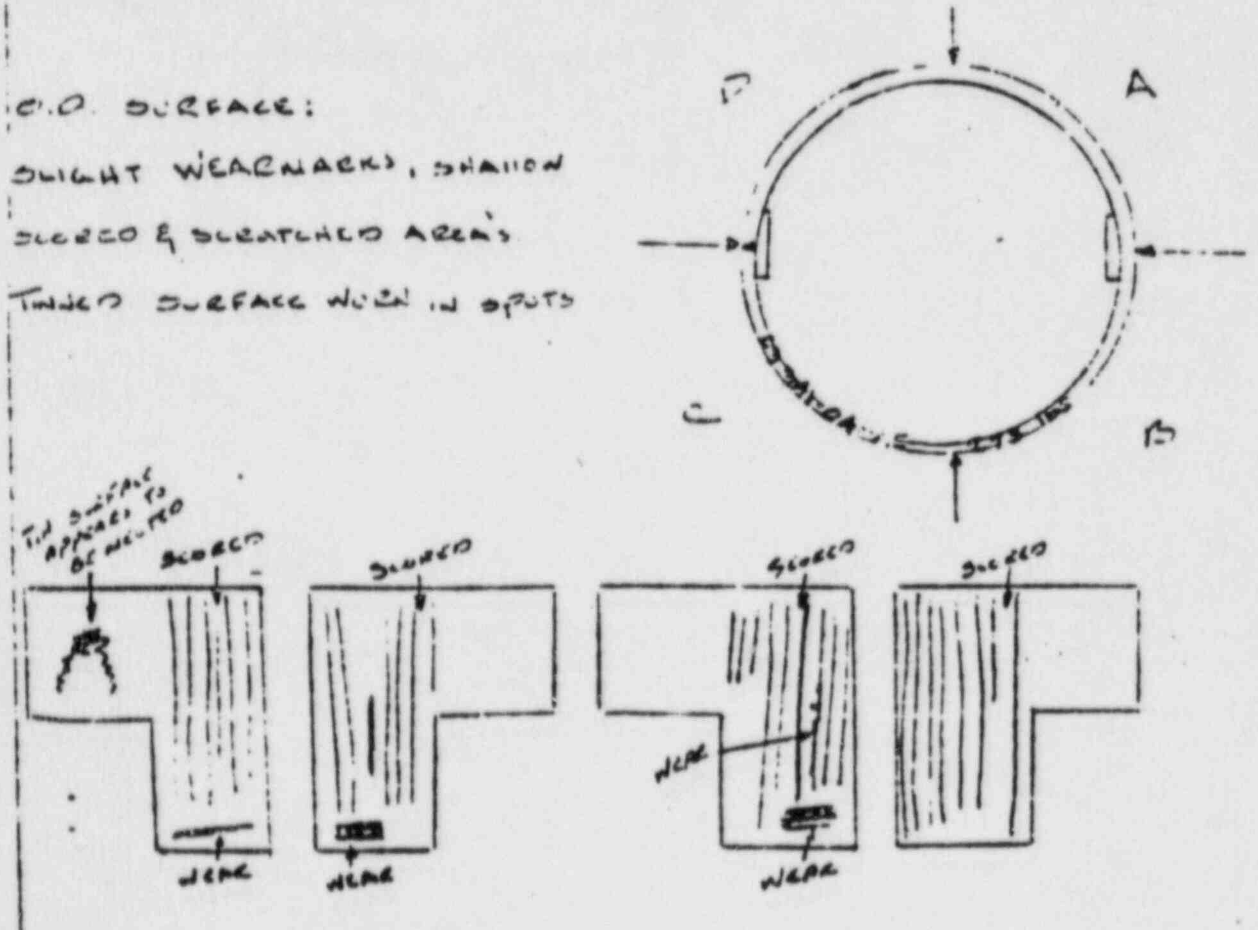
ITEM QTY | DESCRIPTION(S) AND INSPECTION REMARK(S)

PERFORMED VISUAL INSP ON O.D OF PISTON SKIRT AREA FOR ABOVE REF. PISTON. BELOW FIND THE INSP. RESULTS.

O.D. SURFACE:

SLIGHT WEARMARKS, SHALLOW SCORED & SCRATCHED AREA'S

TINNED SURFACE WORN IN SPOTS



ROL
REPORT

| | | | |
|---|---|---|---|
| | | JOB NUMBER<br>1 | DATE<br>2/11/84 |
| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) | |
| PISTON SKIRTS<br>#7 (03-341-04-AE)<br>VISUAL INSP.<br>275 lbs. | DG. 102 | SHI-089<br>IP-~~03-341-A~~ -14 QHP. 2/12/84 | |

| NO. | ITEM QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|
| | | PERFORMED VISUAL INSP. ON O.D. OF PISTON SKIRT AREA. FOR ABOVE REF. PISTON. BELOW FIND THE INSP. RESULTS |
| | | BOTTOM SECTION - LENGTHWISE CONTAINS SHALLOW SCRAT ON THE O.D. ( 4" TO 15½" LONG - HEAVIEST ON SIDES BETWEEN WRIST PIN HOLES, SOME SCUFFING ALSO EVID WITH MINOR METAL UPSET. |

N° 2484

PAGE

ROL
REPORT

| NUMBER | DATE |
|---|---|
| 11600.71 | 2/2/84 |

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| 03-341 A<br>Pistons | DG-102 | I.P. NO 14 |

| ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|
| 3 | 1 | During our inspection of pistons no. 5, 7, and 8 it was noted that the crown on number 6 piston was dropped on the floor during disassembly. A visual inspection was performed on the crown only. A gouge was noted in the radius next to a eye bolt hole ½" long x ¼" wide x 1/16 deep. |

A1 4485

| QUALITY CONTROL INSPECTOR | DATE | PAGE |
|---|---|---|
| S. R[illegible] | [illegible] | 1 |

**Transamerica Delaval**

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

S-42

Date: 1 MARCH 1984

To: JOHN KAMMEYER

From: DON SCHMITZ

Subject: EMERGENCY DIESEL GEN #103 - SN 74011
MECHANICAL WEAR ON VARIOUS COMPONENTS
LDR-2147, 2146, 2145, 2144, 2143

THE WEAR REPORTED ON SUBJECT LDR'S WAS INSPECTED BY MR. H. LOWREY OF DELAVAL ENGINEERING AND A DETERMINATION WAS MADE THAT THE WEAR WAS NORMAL AND COMPONENT SHOULD BE USED IN THE "AS IS" CONDITION.

Donald L Schmitz

A14486

# Memo

Q-82

Q82

# COMPONENT TASK EVALUATION REPORT

UNSAT

ATT #3

Pg 1/8

ATT #3

| EM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZ |
|---|---|---|---|---|
| 350C<br>3 341A | 02-350-01-0A<br>03-341-04-AE | R. Fraser for<br>S. Rotkiewicz<br>SIGNATURE | 2/28/84 | ☐ENGINE<br>☒QUALIT |

ONDITION DETAILS: The attached I.R. by E. Kuhns and J. Dolan, dated 2/15/84 (pg 2,3 attached) was transmitted as Information. It is an unsatisfactory Inspection Report (03-350C, DR-175)

The attached I.R. by M. Taormina/E. Hess dated 2/11/84, and 2/13/84 (pgs 4-7 attached) was transmitted as Information. It

OMMENDATIONS: is an unsatisfactory Inspection Report (03-341A, DR-183)

This TER supercedes DR-175, DR-183) in its entirety.

ORWARD to Design Group for evaluation and SEO-LSU for INFO.

QUIRED COMPLETION DATE:

## ASSIGNMENT

| SITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ENGINEERING ☒ QUALITY | R. Fraser<br>SIGNATURE | 2-28-84 |

## DISPOSITION

OSITION DETAILS: The attached I.R.s (referenced above) are unsatisfactory. See Sheet 2.

THIS TER SUPERCEDES TERs DR-175 & DR-183 IN THEIR ENTIRETY

OSITION ASSIGNED TO ☒ ENGINEERING ☒ QUALITY ☐ NONE REQUIRED

| PLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DA |
|---|---|---|---|---|---|
| Stanley E. Rotkiewicz | 2/28/84 | R. Fraser<br>RESP. CHAIRPERSON | 2/28/84 | C.K. [illegible]<br>PROGRAM MANAGER | 2/28/84 |

## ACTION

| ON ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| Rogers, M. Schuster,<br>se, E. Youngling<br>EO: I. Kammeyer | | 03-06-84 |

: CKS/GWR/RJN/EFM
TER LOG

VISUAL 5,7 & 8
2/13/84

M4515

Q-82
2/8

## UNSAT TER DISPOSITION

Distribute for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-82", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

3) LSU/OQA - review for applicability and issue LDR as needed.

4) M. Schuster - obtain LDR number as issued for component files and closeout.

STONE & WEBSTER ENGINEERING CORPORATION

082

# QUALITY CONTROL INSPECTION REPORT

A 2040.29

| JOB NUMBER | DATE |
|---|---|
| 11600.37 | 2/13/84 |

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| PISTON CROWN<br>COMPONENT 03-341A REV 0 | DG 102 | DG INSP PLAN #14 |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
|  | 3 | 3 | Performed a visual inspection of the crown outside diameter and combustion bowl. All surfaces were found satisfactory. No signs of pitting or scuffing were noticed. NUMBERS 5,7, AND 8 |

A18517

| QUALITY CONTROL INSPEC./ENG. | DATE | PAGE |
|---|---|---|
| / | 2/13/84 | 1 OF 1 |

Q-82
03-350C
03-341A

This inspection report is acceptable for design review

K. Solon for C. Wells
Conversation 3/6/84

~~[illegible]~~ Qny

102 Pistons Book 1

Q-83

1/4

# COMPONENT TASK EVALUATION REPORT

11

ATTR. #3

| SYSTEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
|---|---|---|---|---|
| PISTON<br>03-341-A | 1A-6522 | R Bernard<br>SIGNATURE | 2/18/84 | ☐ENGINEERI<br>☑QUALITY |

CONDITION DETAILS:
VISUAL INSPECTION PERFORMED ON PISTON SKIRTS
INSPECTION REPORTS FOR SKIRT #5, 7, 8 ATTACHED.

RECOMMENDATIONS:
SUBMIT FOR FAA REVIEW & ACTION and SEO-LSU
FOR INFO

REQUIRED COMPLETION DATE: 2/19/84

## ASSIGNMENT

| POSITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ☐ ENGINEERING ☒ QUALITY | R. Fraser<br>SIGNATURE | 2-28-84 |

## DISPOSITION

DISPOSITION DETAILS: Attached I.R. is unsatisfactory.
See Sheet 2.

THIS TER SUPERCEDES TER # DR-183 IN ITS ENTIRETY

DISPOSITION ASSIGNED TO ☒ ENGINEERING ☒ QUALITY ☐ NONE REQUIRED

| SUPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
| R. Fraser | 2/28/84 | R. Fraser<br>RESP. CHAIRPERSON | 2/28/84 | [illegible] for C. K. Seaman<br>PROGRAM MANAGER | 2/29/84 |

## ACTION

| ACTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| [illegible], P. Schuster,<br>[illegible]<br>cc [illegible] | K. Solon for C. Wells | 3/1/84 |

CC: CKS/GWR/PJN/EFM
TER LOG

DUPLICATE ISSUE OF
IRS ON Q-41

M4529

Q-8
2/4

UNSAT TER DISPOSITION

Distribute for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-83 ", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

3) LSU/OQA - review for applicability and issue LDR as needed.

4) M. Schuster - obtain LDR number as issued for component files and closeout.

3/4

STONE & WEBSTER ENGINEERING CORPORATION

UALITY CONTROL
NSPECTION REPORT

| | |
|---|---|
| JOB NUMBER | DATE 2/11/84 |

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| Piston skirts<br>#7 (03-341-04-AE)<br>Visual insp.<br>278 lbs. | DG. 102. | SHI-089<br>1P-~~03-341-A~~ CHA<br>-14 2/12/54 |

| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | | | Performed Visual insp. on O.D. of Piston skirt Area. For Above Ref. Piston. Below find the insp. Results.<br>Bottom section - Lengthwise contains shallow scratc on the O.D. (4" to 15½" long - Heaviest on sides between wrist pin holes, some scuffing also eviden with Minor Metal upset. |

[illegible]

| QUALITY CONTROL INSPECTOR / ENG. | DATE | PAGE |
|---|---|---|
| [illegible] | [illegible] | 1 |

4/4

STONE & WEBSTER ENGINEERING CORPORATION

**QUALITY CONTROL INSPECTION REPORT**

A 5040.78

| JOB NUMBER | DATE |
|---|---|
| 11600.37 | 2-11-84 |

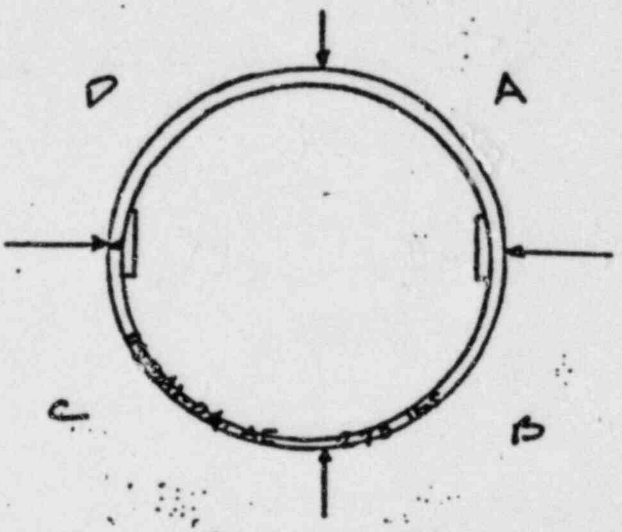
| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| Piston skirt<br>#8 (03-341-04-AE)<br>Visual insp.<br>273 lbs. | DG 102 | SH1-089<br>I.P. - ~~03-341-A~~ -14 2/12/84 |

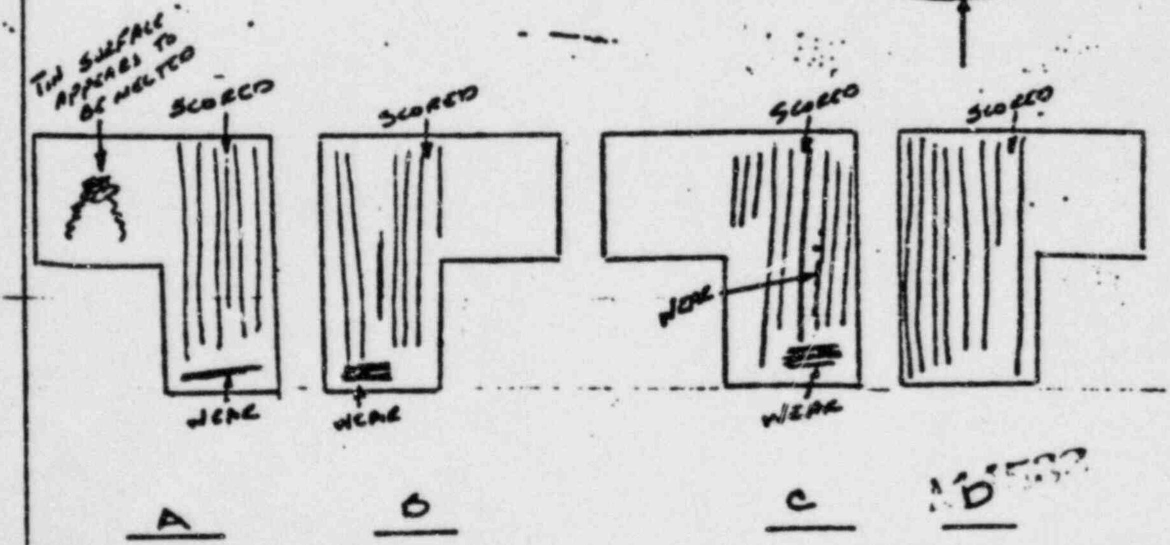
| DWG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | | | Performed visual insp. on O.D. of Piston skirt area for above ref. Piston. Below find the insp. results. |

O.D. surface:

Slight wearmarks, shallow scored & scratched area's.

Tinned surface worn in spots.





QUALITY CONTROL INSPEC/ENG DATE PAGE

No More Information is required for Design Review

K. Solon for C. Wells
Conversation 3/1

·INFO

QAE 30-25

COMPONENT TASK EVALUATION REPORT

1

Q-109
1/3

| STEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
|---|---|---|---|---|
| 3-341 A | 1A-6522 | B. Halyes<br>SIGNATURE | 3-6-84 | ☐ENGINEERI<br>☐QUALITY |

NDITION DETAILS: ATTACHED INSPECTION REPORT ( 1 PAGES) BY ATED 2-13-84 WAS GENERATED AS INFORMATIONAL, AS NO ACCEPTANCE RITERIA WAS PROVIDED PRIOR TO THE PERFORMANCE OF THE INSPECTION.

COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR EVALUATION

Attached IR is informational only
See Sheet 2 for recommended disposition.

QUIRED COMPLETION DATE: 3-7-84

## ASSIGNMENT

| SITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ENGINEERING ☐ QUALITY | R. Fraser<br>SIGNATURE | 3-7-84 |

## DISPOSITION

SPOSITION DETAILS: FOLLOW PROCEDURE 1 OUTLINED ON PAGE 2

SPOSITION ASSIGNED TO ☒ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| JPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
| Kenny Aelon | 3-7-84 | Kenny Aelon<br>RESP. CHAIRPERSON | 3-7-84 | for C. K. Seaman<br>PROGRAM MANAGER | 3/8/84 |

## ACTION

| CTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
| C. Wells<br>Info: K. Sdon | C. Wells | 03-09-84 |

C: CKS/GWR/RJN/EFM
TER LOG

VISUAL 5, 7 & 8

2/13/84

M4519

DUPLICATE ISSUE OF
IR's ON Q-82
CHANGED FROM INFO Q109
TO UNSAT ON Q 82

Q-109
2/3

# RECOMMENDED
# INFORMATION TER DISPOSITION

Distribution for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-109 ", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

3/3

STONE & WEBSTER ENGINEERING CORPORATION

ALITY CONTROL
ECTION REPORT

| | |
|---|---|
| JOB NUMBER | 11600-37 |
| DATE | 2/13/84 |

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| PISTON CROWN<br>OMPONENT 03-341A REV 0 | DG 102 | DG INSP PLAN #14 |

| NG. NO. OR P.O. | ITEM | QTY. | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 3 | 3 | Performed a visual inspection of the crown outside diameter and combustion bowl. All surfaces were found satisfactory. No signs of pitting or scuffing were noticed. NUMBERS 5,7, AND 8 |

A14521

| QUALITY CONTROL INSPEC./ENG. | DATE | PAGE |
|---|---|---|
| / | 2/13/84 | 1 OF 1 |

Q-109[illegible]
03 - 341A

This Inspection Report is satisfactory for design Review

A14522

MHS 03-341 A

| | | | | |
|---|---|---|---|---|
| 1 | **LILCO**<br>**DEFICIENCY REPORT** | ☒ FIELD<br>☐ OTHER | LDR RESPONSIBILITY<br>M. Herlihy<br>LSU | LDR NUMBER<br>2147<br>~~1047~~ |
| 2 | SYSTEM/COMPONENT<br>Emer. Diesel Gen. | SYSTEM DESIGNATOR<br>1R43B | MARK NO.<br>1R43*ENG-02 | DATE 2/29/84<br>Q CLASS ☒ I ☐ II ☐ III |
| 3 | MFG./CONTRACTOR<br>TDI | P.O.<br>310552 | MATERIAL LOCATION<br>EDG-102 Rooms | REJECT TAG NO. ☐ YES ☒ NO |
| 4 | SPEC. VIOLATED<br>SHI-089 | DRAWING VIOLATED<br>N/A | PROCEDURE VIOLATED<br>N/A | CODE/STANDARD VIOLATED<br>N/A |

5 CONDITION DETAILS

The enclosed DGQRG TER#Q-41 dated 2/22/84 identifying discrepancies on pistons #5, #7, & #8 for Diesel Generator #102 requires resolutions.

6 ORIGINATOR M M Herlihy 2/29/84
SIGNATURE DATE

OQAE 2/29/84
SIGNATURE DATE

7 RESPONSIBILITY ☐ LSU ☒ S & W ENG. M M Herlihy
SIGNATURE/LEAD SU ENG.
DATE 2/29/84

8 ACTION ☒ ACCEPT AS IS ☐ SCRAP ☐ REWORK ☐ REPAIR ☐ MANUAL ☐ PROCEDURE ☐ FSAR ☒ OTHER * SEE BELOW FOR PISTON #6

9 DISPOSITION DETAILS

THE CONDITIONS IDENTIFIED ON THE ATTACHMENTS ARE ACCEPTABLE AS IS.

CONDITIONS HAVE BEEN EVALUATED AND ARE ~~NOT~~ CONSIDERED TO BE NORMAL WEAR, NOT UNSATISFACTORY CONDITIONS. ~~BUT~~ ~~NORMAL~~

REFERENCE: THE ATTACHED TDI MEMO.

* NOTE - THE CONDITION DESCRIBED FOR THE #6 PISTON WAS ADDRESSED ON LDR-2081

10 APPROVALS 3/1/84
S & W LEAD ENG./LSU TEST ENG./DATE

K. Sterling FOR J CARNEY 3/1/84
PROJECT ENGINEER DATE

11 LILCO SU ENG. DATE
LILCO SITE OQA DATE
REPAIR/REWORK REQUEST NO

ENG. COMPLETE/DATE
RRR COMPLETE
CONST. SUPT./DATE
LILCO SU/DATE
REWORK INSPECTION ☐ SAT. ☐ UNSAT.
LILCO SITE OQA/DATE

13 LDR CLOSED
LILCO SITE OQA/DATE
NEW LDR REPORT NO. ISSUED
REMARKS A14478

FC-9350

Transamerica
Delaval

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

Date: 1 MARCH 1984 S-42

To: JOHN KAMMEYER

From: DON SCHMITZ

Subject: EMERGENCY DIESEL GEN #103 - SN 74011 MECHANICAL WEAR ON VARIOUS COMPONENTS LDR-2147, 2146, 2145, 2144, 2143

THE WEAR REPORTED ON SUBJECT LDR'S WAS INSPECTED BY MR. H. LOWREY OF DELAVAL ENGINEERING AND A DETERMINATION WAS MADE THAT THE WEAR WAS NORMAL AND COMPONENT SHOULD BE USED IN THE "AS IS" CONDITION.

Donald L Schmitz

A14456

Memo

TER # Q - 159

1/3

# COMPONENT TASK EVALUATION REPORT

| TEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
|---|---|---|---|---|
| 03-341A<br>D.G. 103 | 1A-5522 | SIGNATURE | 3-12-84 | ☐ENGINEERI<br>☑QUALITY |

CITION DETAILS: Attached Inspection Report (1 page) by B Hayes
ted 3-12-84 was generated as informational, as no acceptance
iteria was provided prior to the performance of the inspection

OMMENDATIONS:
Forward to Design Review for evaluation.
Attached IR is unsatisfactory.
See Sheet 2 for recommended acc. criteria

UIRED COMPLETION DATE: 3-12-84

## ASSIGNMENT

| ITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| NGINEERING ☐ QUALITY | B. Fraser<br>SIGNATURE | 3-12-84 |

## DISPOSITION

SPOSITION DETAILS:

SPOSITION ASSIGNED TO ☐ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| PPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
|  |  | RESP. CHAIRPERSON |  | PROGRAM MANAGER |  |

## ACTION

| TION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
|  |  |  |

: CKS/GWR/RJN/EFM
TER LOG

ATTACHMENT TO LDR 2198
PAGE 2 OF 5

A15121

Q - 159
2/3

## RECOMMENDED
## UNSAT TER DISPOSITION

Distribute for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-159", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

3) LSU/OQA - review for applicability and issue LDR as needed.

4) H. Schuster - obtain LDR number as issued for component files and closeout.

ATTACHMENT TO LDR 2198
PAGE 3 OF 5

A15122

STONE & WEBSTER ENGINEERING CORPORATION Q-159 3/3

LITY CONTROL
ECTION REPORT

JOB NUMBER 11600.37 DATE 3-12-84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| PONENT NAME:<br>Pistons | DG- 103 | I.P. NO. ~ REV. 3 CHG 0<br>TER #<br>LILCO LP PROC. REV.<br>DWG. NO. |
| MPONENT NO. [illegible] | | |

ATTACHMENT TO LDR 2198
page 4 of 5

| NO. | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|
| | 2 | 2 | A VISUAL WAS PERFORMED ON THE SKIRT AND CROWN O.D FOR SCUFFING AND THE COMBUSTION BOWL FOR PITTING THE FOLLOWING WAS NOTED.<br>CYLINDER 5 - SCUFFING ON INTAKE AND EXHAUST SIDE OF SKIRT - ONE SIDE SHOWS SCORE THE OTHER NOTED BY SHINY AREA. CROWN O.D HAS VARIED AMOUNTS OF PITTING AND THE COMBUSTION BOWL IS VERY SLIGHT IN PITTING.<br>CYLINDER 7 - SKIRT AND CROWN O.D APPEAR SATISFACTORY BUT COMBUSTION BOWL HAS VERY SLIGHT PITTING<br>CYLINDER 8 - SCUFFING APPEARS ON INTAKE AND EXHAUST SIDE OF SKIRT, CROWN SOME MINOR SCUFFING. COMBUSTION BOWL SHOWS THREE SMALL SCRATCH MARKS RANGING FROM 1/8 TO 3/8" |

M&TE NO. _____, _____, _____,
_____, _____, _____.

Reviewed 5/12/84

QUALITY CONTROL INSPEC./ENG. Barbara D. Mayo

DATE 3-12-84

PAGE 3

A15

1 **LILCO**

## DEFICIENCY REPORT

☑ FIELD
☐ OTHER

LDR RESPONSIBILITY: M. Herlihy LSU

LDR NUMBER: 2198 ~~1098~~ 103 Outage

2 SYSTEM/COMPONENT: Emerg. Diesel Gen.
SYSTEM DESIGNATOR: 1R43C
MARK NO.: 1R43 * EDG-103
DATE: 3/12/84
Q CLASS: ☑ I ☐ II ☐ III

3 MFG./CONTRACTOR: TDI
P.O.: 310552
MATERIAL LOCATION: TB elev 63'
REJECT TAG NO. N/A ☐ YES ☑ NO

4 SPEC. VIOLATED: SH1-089
DRAWING VIOLATED: N/A
PROCEDURE VIOLATED: N/A
CODE/STANDARD VIOLATED: N/A

5 CONDITION DETAILS

TER Q-159 (03-341A) reports unsatisfactory Conditions. QCIR for #5, 7 & 8 pistons identifies scuffing of piston skirts, pitting on piston crowns and ~~bow~~ #8 combustion bowl and scratch marks on #8 piston combustion bowl. Evaluation of these conditions is required.

6 ORIGINATOR: BJ Beyti 3/12/84
SIGNATURE DATE

OQAE: for A.R. Muller 3-12-84
SIGNATURE DATE

7 RESPONSIBILITY ☐ LSU ☑ S & W ENG. BJ Beyti
SIGNATURE/LEAD SU ENG.
DATE 3/12/84

8 ACTION ☒ ACCEPT AS IS ☐ SCRAP ☐ REWORK ☐ REPAIR ☐ MANUAL ☐ PROCEDURE ☐ FSAR ☐ OTHER

9 DISPOSITION DETAILS

THE ABOVE CONDITIONS DESCRIBED FOR PISTONS #5, 7, & 8 ARE ACCEPTABLE AS IS PER ATTACHED TDI MEMO.

PISTON COMPONENTS TO BE CLEANED BEFORE REASSEMBLY IN ACCORDANCE WITH TDI MANUAL. VOL I.

10 APPROVALS William J Bleam 3/17/84
S & W LEAD ENG./LSU TEST ENG./DATE

R. Jaquinto for T. Carney 3/17/84
PROJECT ENGINEER DATE

11 BJ Beyti 3/17/84
LILCO SU ENG. DATE

3/20/84
LILCO SITE OQA DATE

REPAIR/REWORK REQUEST NO. ~~N/A~~ R43-1571

12 ENG. COMPLETE/DATE: SEO 3/17/84

RRR COMPLETE: N/A
CONST. SUPT./DATE

5/14/84
LILCO SU/DATE

REWORK INSPECTION ☑ SAT. ☐ UNSAT. 5/12/84
LILCO SITE OQA/DATE

13 LDR CLOSED 5/14/84
LILCO SITE OQA/DATE

NEW LDR REPORT NO. ISSUED: N/A

REMARKS: N/A

AI3120

FC-9350

**Transamerica Delaval**

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

ATTACHMENT TO
LDR 2198

Date: March 17, 1984 PAGE 5 OF 5

To: John Kammeyer

From: Robert Johnston

Subject: Diesel Generators, TDI S/N 74010/12
74012 Piston Assemblies

Reference: LDR 2198

Referenced LDR reports unsatisfactory conditions found during inspection of numbers 5, 7 and 8 piston assemblies due to scuffing, pitting and scratches. The number 5 piston has scuffing evident in the tin plating on the piston skirt in the normal thrust surfaces. The condition is attributed to the excessive wear found in that cylinder and reported in LDR 2188. No overheating is evident on the piston skirt and sufficient tin plate remains to provide an adequate break-in in a new liner. Scuffing to a lesser degree is also noted on the number 8 skirt and is not an unusual condition to occur during break-in. Pitting reported in the combustion bowls and circumference of the 5, 7 and 8 piston crowns was found to be very minor and an acceptable condition for a steel casting. Scratches in the combustion bowl of number 8 piston crown are attributed to handling and are not detrimental to the crown. Recommended Disposition: Clean components and return to service.

# Memo

A15 1984

Form C-1066-2 (R-1) 3/81

cc Mike Herlihy

TER # Q-500

Pg 1/3

# COMPONENT TASK EVALUATION REPORT

DG 103R..

| TEM/COMPONENT NO. | TDI PART NO. | INITIATOR | DATE | ORGANIZATI |
|---|---|---|---|---|
| Pistons -<br>03-341 | 1A-6522 | E. Hess<br>SIGNATURE | 5/14/84 | ☐ENGINEERI<br>☒QUALITY |

NDITION DETAILS: ATTACHED INSPECTION REPORT ( / PAGES) GENERATED BY J. Swartz DATED 4/30/84 IS CONSIDERED INFORMATIONAL AS NO ACCEPTANCE CRITERIA WAS PROVIDED PRIOR TO THE PERFORMANCE OF THE INSPECTION.

COMMENDATIONS: FORWARD TO DESIGN REVIEW FOR EVALUATION AND ALSO TO SEO AND LSU FOR INFORMATION ONLY. Attached IR is unsatisfactory - See pg 2 for Recommended disposition

QUIRED COMPLETION DATE:

## ASSIGNMENT

| SITION ASSIGNED TO | RESPONSIBLE CHAIRPERSON | DATE |
|---|---|---|
| ✓ENGINEERING ☐QUALITY | SIGNATURE | 5/15/84 |

## DISPOSITION

SPOSITION DETAILS:

ISPOSITION ASSIGNED TO ☐ ENGINEERING ☐ QUALITY ☐ NONE REQUIRED

| UPPLIED BY | DATE | REVIEWED BY | DATE | APPROVED BY | DATE |
|---|---|---|---|---|---|
|  |  | RESP. CHAIRPERSON |  | PROGRAM MANAGER |  |

## ACTION

| CTION ASSIGNED TO | ACTION COMPLETED BY | DATE |
|---|---|---|
|  |  |  |

C: CKS/GWR/RJN/EFM
TER LOG

A15790

COMME
UNSAT TER DISPOSITION

TER # Q-500

PAGE 2 OF 3

Distribute for action as follows:

1) Design Review (G. Rogers) - Review as part of Design Review Task. Return to Quality Group a statement of acceptability (i.e., inspection information is sufficient for Design Review Group and no further inspections are required) or provide further detailed inspection/criteria, and add to Task Description "review information provided on TER Q-500", for each component affected.

2) SEO (J. Kammeyer) - distribute for information.

3) LSU/OQA - review for applicability and issue LDR as needed.

4) M. Schuster - obtain LDR number as issued for component files and closeout.

Pg 3/3 Q-500

STONE & WEBSTER ENG. EERING CORPORATION

LITY CONTROL
PECTION REPORT

JOB NUMBER 11600.37

DATE 4/30/84

| SYSTEM(S) OR PART(S) NAME | LOCATION(S) | REFERENCE DOCUMENT(S) |
|---|---|---|
| OMPONENT NAME:<br>Pistons<br>1 thru 8<br>OMPONENT NO. 03-341 | DG- 103 | I.P. NO. ____ REV. ___ CHG ___<br>TER # ______<br>LILCO LP PROC. _____ REV. __<br>DWG. NO. ______ |

| NO PO | ITEM | QTY | DESCRIPTION(S) AND INSPECTION REMARK(S) |
|---|---|---|---|

During visual inspection of the assembled Pistons 1 through 8 from Engine 103, the following has been observed.

Carbon caking has been found along the outside edge of the crown and down along the top ring typical on all pistons. The #6 piston had a bit heavier carbon crusting and the top ring was bound at about 2 oclock looking down from the top with the notch at 6 oclock.

On the #2 Piston the top ring was wearing off center to the top edge of the ring.

No unusual skuffing or scratching was observed on the outboard portions of the Piston and Piston skirts.

A15792

Photographic documentation taken all Pistons

M&TE NO. N/A.

NOTED APR 30 1984

Reviewed By - E. F. Hawking

QUALITY CONTROL INSPEC/ENG. DATE 4/30/84 PAGE of

1 **LILCO**

**DEFICIENCY REPORT**

☒ FIELD
☐ OTHER

LDR RESPONSIBILITY: M Herlihy LSU

LDR NUMBER: 2407

2 SYSTEM/COMPONENT: Emer Diesel Genr
SYSTEM DESIGNATOR: 1R43
MARK NO.: R43#EDG 103
DATE: 5/16/84
Q CLASS ☐ I ☐ II ☐ III

3 MFG./CONTRACTOR: TDE
P.O.: 310552
MATERIAL LOCATION: TB W' lay down area
REJECT TAG NO. N/A ☐ YES ☒ NO

4 SPEC VIOLATED: SH1-084
DRAWING VIOLATED: N/A
PROCEDURE VIOLATED: N/A
CODE/STANDARD VIOLATED:

5 CONDITION DETAILS

TER # Q-500 (03-341A) Reports unsat conditions. Attached QCIR for pistons 1-8 reports various conditions requiring evaluation

6 ORIGINATOR: 5/16/84
SIGNATURE DATE

OQAE:
SIGNATURE DATE

7 RESPONSIBILITY ☐ LSU ☒ S & W ENG.
SIGNATURE/LEAD SU ENG.
DATE 5/21/84

8 ACTION
☐ ACCEPT AS IS ☐ SCRAP
☒ REWORK ☐ REPAIR
☐ MANUAL ☐ PROCEDURE
☐ FSAR ☐ OTHER

9 DISPOSITION DETAILS

ALL PISTON ASSEMBLIES WILL BE CLEANED TO REMOVE CARBON DEPOSITS PRIOR TO REASSEMBLY. UPON REASSEMBLY OF ALL PISTON ASSEMBLIES, ALL RING SETS WILL BE REPLACED WITH NEW MUSKEGIN RING SETS.

10 APPROVALS
S & W LEAD ENG./LSU TEST ENG./DATE: 5/23/84
PROJECT ENGINEER DATE: 5/23/84

11 LILCO SU ENG. DATE: 5/24/84
LILCO SITE OQA DATE: 6/5/84
REPAIR/REWORK REQUEST NO. R43-1844

12 ENG. COMPLETE/DATE: N/A
RRR COMPLETE
CONST. SUPT./DATE: N/A
LILCO SU/DATE: 7/9/84
REWORK INSPECTION
☑ SAT.
☐ UNSAT. R Catrone 7-9-84
LILCO SITE OQA/DATE

13 LDR CLOSED
LILCO SITE OQA/DATE

NEW LDR REPORT NO. ISSUED N/A

REMARKS

FC-9350

A15737

EDG 101

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

AF PISTONS

PT

COMPONENT I.D. Piston Skirt 101 Diesel #SPARE

SYSTEM 1R43*Emerg. Dies. Gen.

PLANT/LOCATION SNPS-1/Turb Deck

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE C/S | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |
| B. NDE PROCEDURE No. 6.1+6.2 | TEMP./MAT'L. TEMP. 73°F | P.O. No. 367 Due 4/22/84 | REPORT No. Supp-1 R43-11.42 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | | SKL-HF/SKL-S | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | | SKC NF/ZC7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area ~~around~~ on c.i. boss.

101 Diesel Piston- SPARE

| C. EVALUATION | REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE. |
|---|---|

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 | N/A | None | Accept (No relevant inds) |
| 2 | | | |
| 3 | | | |
| 4 | | | |

| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | Lilco NDE 6.2<br>Para 4.2.2 | EXAMINER E. Hassell/Asst J. Fink<br>LEVEL II<br>DATE 11/4/83 |

E. ATTEST Earl Hassell — II — 11/4/83

RESPONSIBLE CERTIFIED PERSONNEL — LEVEL — DATE

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 101 Diesel Piston Skirt #1A

SYSTEM 1R43 Emergency Dies Gen.

PLANT/LOCATION SNPS-1/Turbine Deck

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☐ OTHER: Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.1 + 6.3 | SURFACE/MAT'L. TEMP. 73° F | 367<br>Due 4·22·84 | R43-1142 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

101 Diesel

Examined machined area ~~around~~ on ℄ ¼ boss. Piston 1A

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | N/A | None | Accept |
| 2 | 1/4" ~~line~~ C.N. | linear | Reject (L.D.R. Issued) |
| 3 | N/A | None | Accept |
| 4 | 5/32 | linear | Reject (LDR Issued) |

| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | Lilco NDE 6.2 Para 4.2.2 | Earl Hassell / Asst. by J. Pink<br>II<br>11/4/83 |

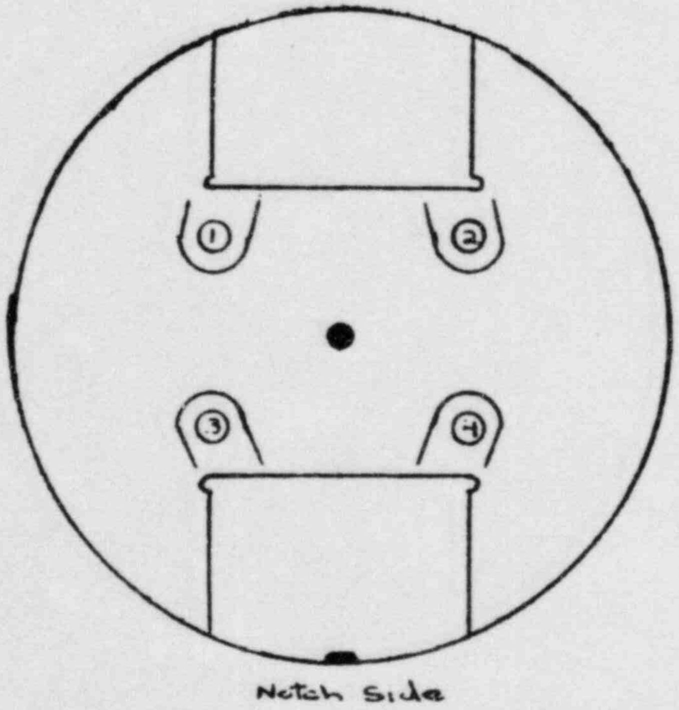
E. ATTEST

Earl Hassell — RESPONSIBLE CERTIFIED PERSONNEL

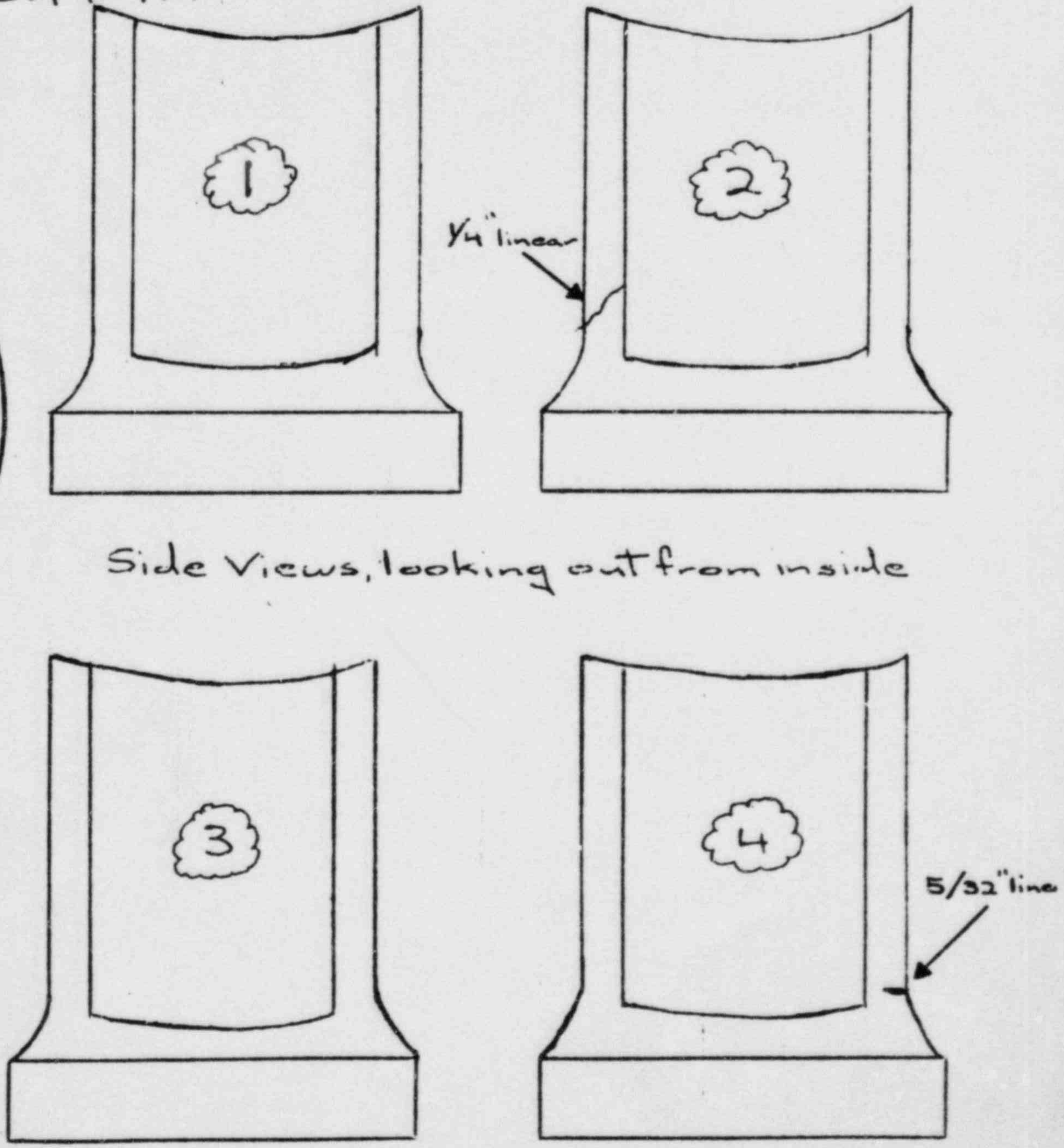
II — LEVEL

11/4/83 — DATE

## Diesel #101 Piston #1A



Overhead View



Side Views, looking out from inside

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 101 Diesel Piston Skirt #2A

SYSTEM 1R43*Emerg Dies. Gen.

PLANT/LOCATION SNPS-1/Turbine Deck

**A. MATERIAL**

TYPE c/s

FABRICATED PROCESS ☐ WELDED ☒ CAST ☐ WORKED

GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt

CROSS SECTION THICKNESS MAX — INCH MIN — INCH

SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER

**B. NDE PROCEDURE** No. 6.1 + 6.2

SURFACE/MAT'L. TEMP. 73° F

. . .369 Due: 4-22-84

. . . No. R43-1142

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area ~~around~~ on E.H. boss 101 Diesel Piston-2A

**C. EVALUATION**

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | 1/4 | linear | Reject (LDR Issued) |
| 2 | N/A | None | Accept |
| 3 | 1/8, 3/16 | linear | Reject (LDR Issued) |
| 4 | N/A | None | Accept |

**D. ACCEPTANCE CRITERIA** Lilco NDE 6.2 Para 4.2.2

E. Hassell/Asst. J. Pink

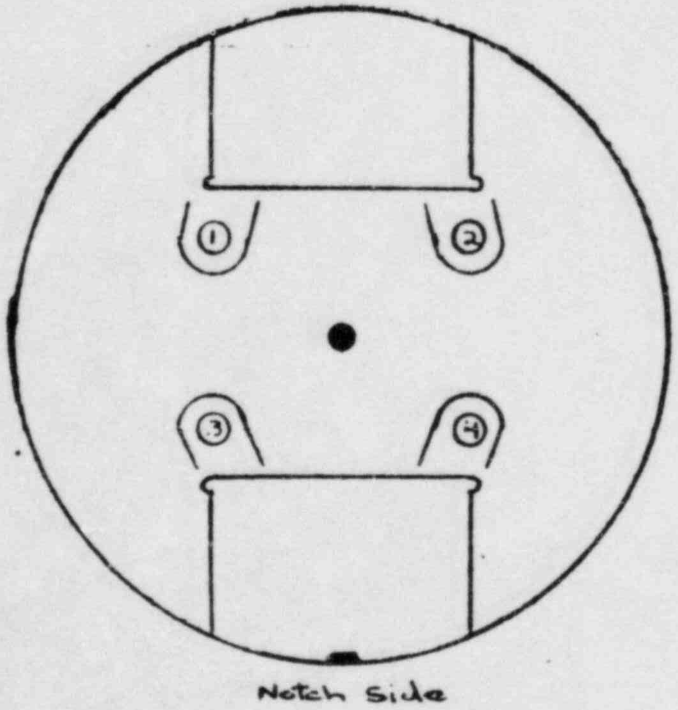
II

11/4/83

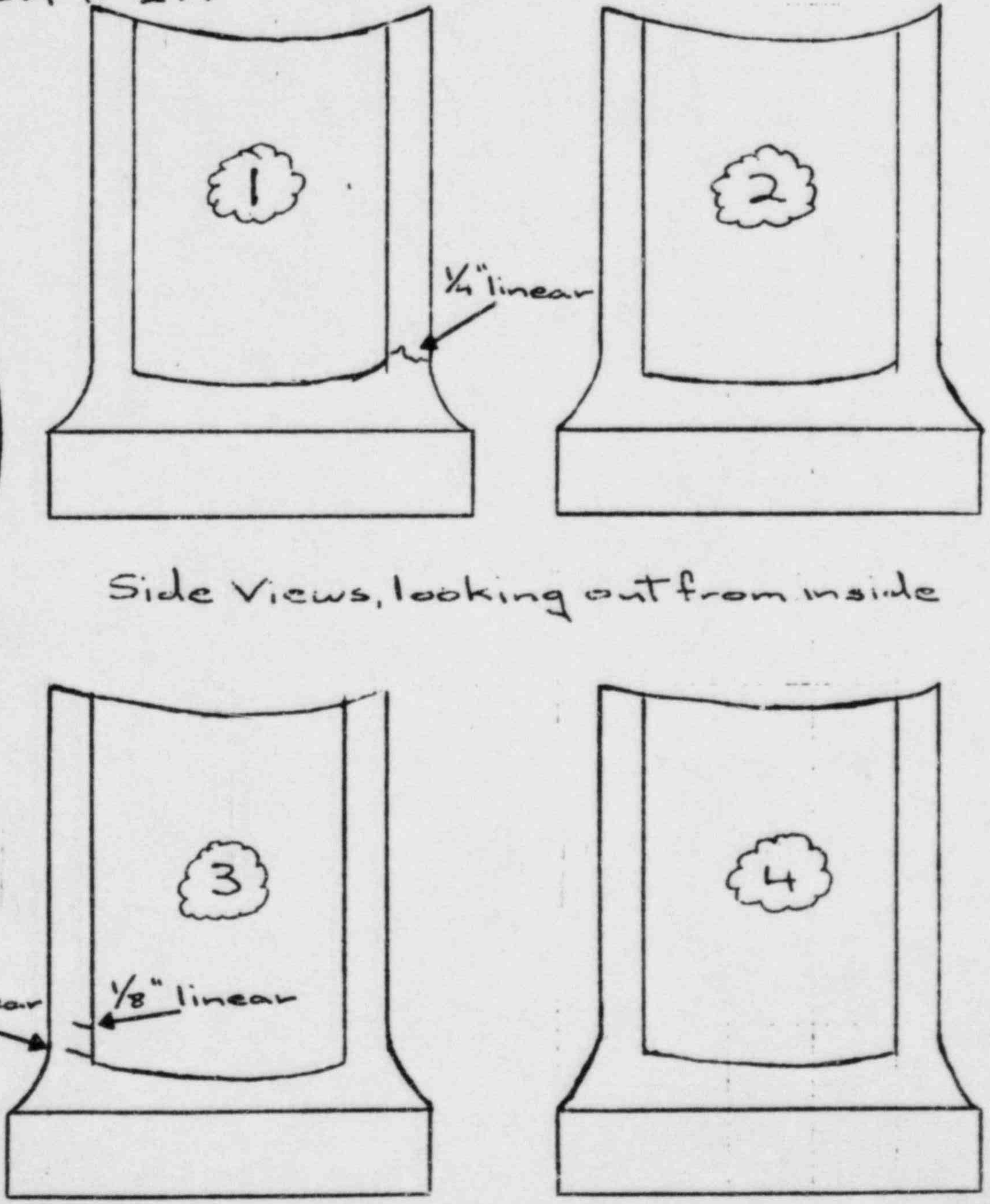
**E. ATTEST** Earl Hassell II 11/4/83

RESPONSIBLE CERTIFIED PERSONNEL LEVEL DATE

# Diesel #101 Piston #2A



Overhead View



Side Views, looking out from inside

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 101 Diesel Piston Shirt #3A

SYSTEM 1R43 * Emergency Dies Gen.

PLANT/LOCATION SNPS-1 / Turbine Deck

| | | | |
|---|---|---|---|
| **A. MATERIAL** | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Shirt | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| **B. NDE PROCEDURE** No. 61 + 62 | SURF. /MAT'L. TEMP. 73°F | 364<br>Due: 4-22-84 | R43 1142 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | magnaflux | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

101 Diesel Piston. 3A

Examined machined area ~~around~~ on E.H. boss.

**C. EVALUATION** REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | N/A | N/A | Accept |
| 2 | 3/16 | linear | Reject (LDR Issued) |
| 3 | N/A | N/A | Accept |
| 4 | N/A | N/A | Accept |

| | | |
|---|---|---|
| **D. ACCEPTANCE CRITERIA** | Lilco NDE 6.2 Para 4.2.2 | E. Hassell / Asst. J. Pink<br>II<br>11/4/83 |

**E. ATTEST**

Earl Hassell

RESPONSIBLE CERTIFIED PERSONNEL

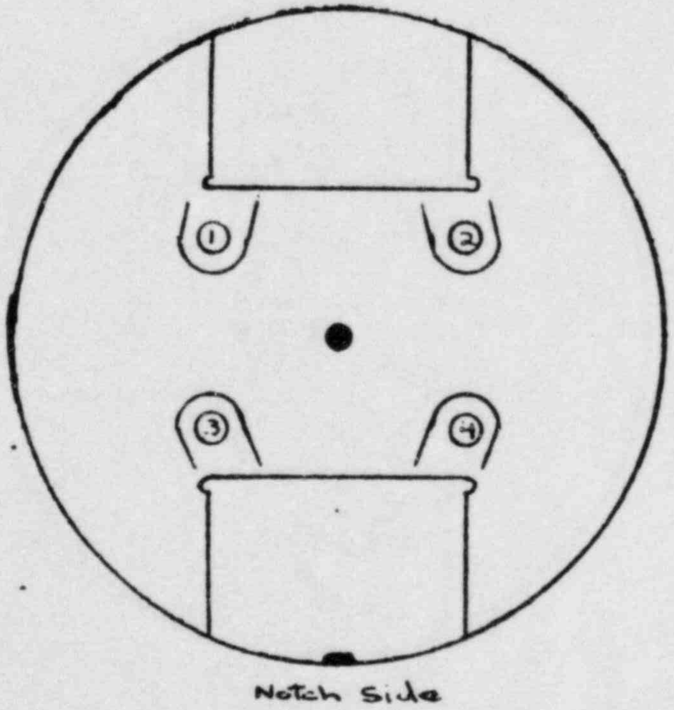
II

LEVEL

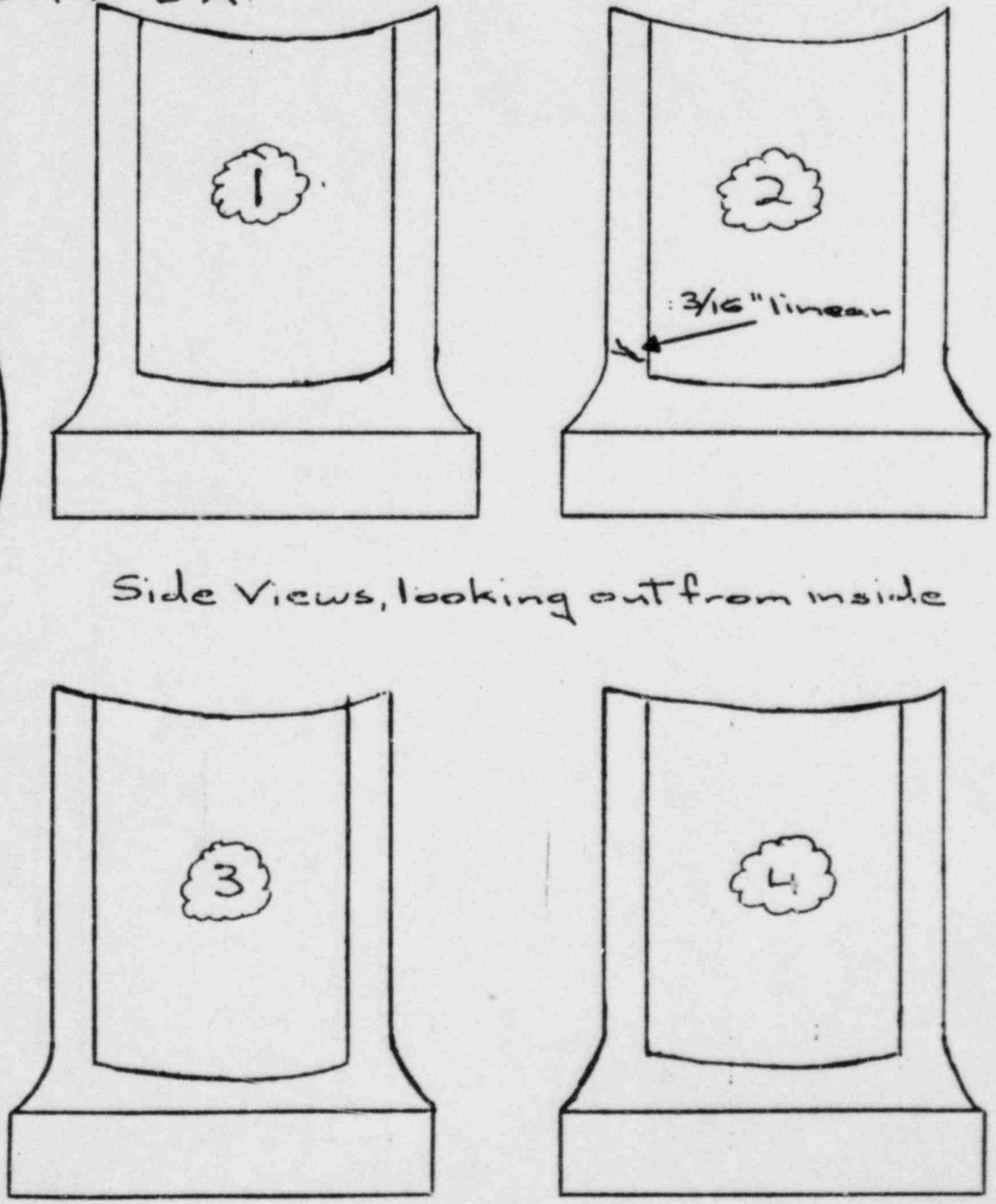
11/4/83

DATE

# Diesel #101 Piston # 3A



Overhead View



Side Views, looking out from inside

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 101 Diesel Piston Skirt #4A

SYSTEM 1R43 Emerg Dies Gen.

PLANT/LOCATION SNPS-1 / Turbine Deck

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE C/S | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.1 + 6.2 | SURFACE/MAT'L. TEMP. 73°F | [illegible] 364 Due: 4/22/84 | SER/SN. No. R43-1142 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | | SKL-HF/SKL-S | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY 101 Diesel

Examined machined area ~~around~~ on C.W. boss. Piston-4A

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | (2) 3/16, (2) 1/2, 1/4 | linear | Reject (LDR Issued) |
| 2 | 1/8 | | |
| 3 | 3/16, 7/16 | | |
| 4 | 1/4 | | |

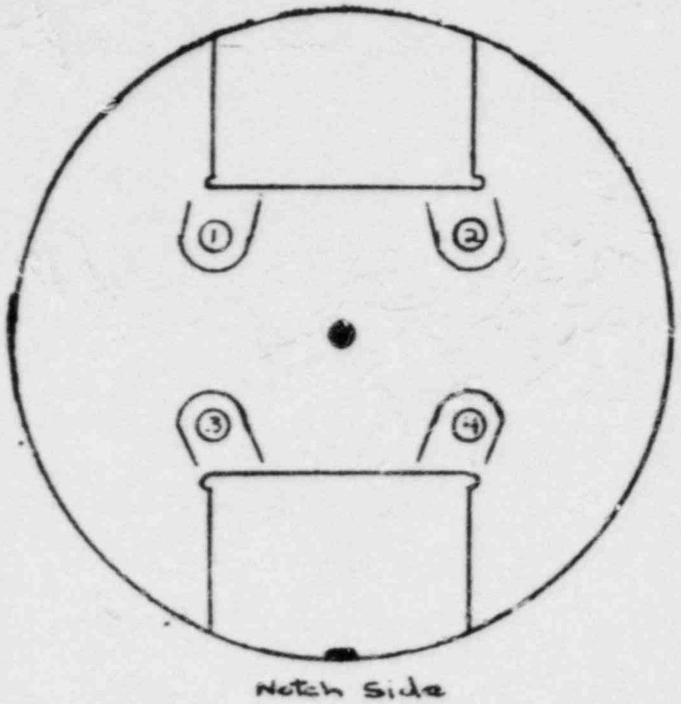
| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | Lilco<br>NDE 6.2 Para 4.2.2 | E. Hassell/Asst. J. Pink<br>II<br>11/4/83 |

E. ATTEST

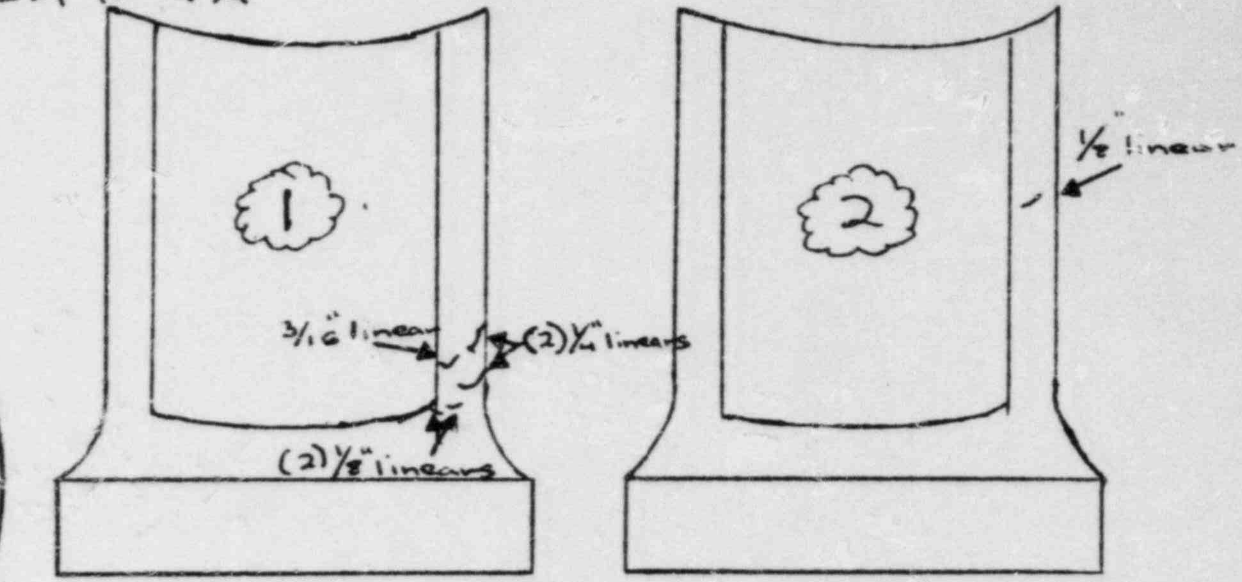
Earl Hassell — II — 11/4/83

RESPONSIBLE CERTIFIED PERSONNEL — LEVEL — DATE

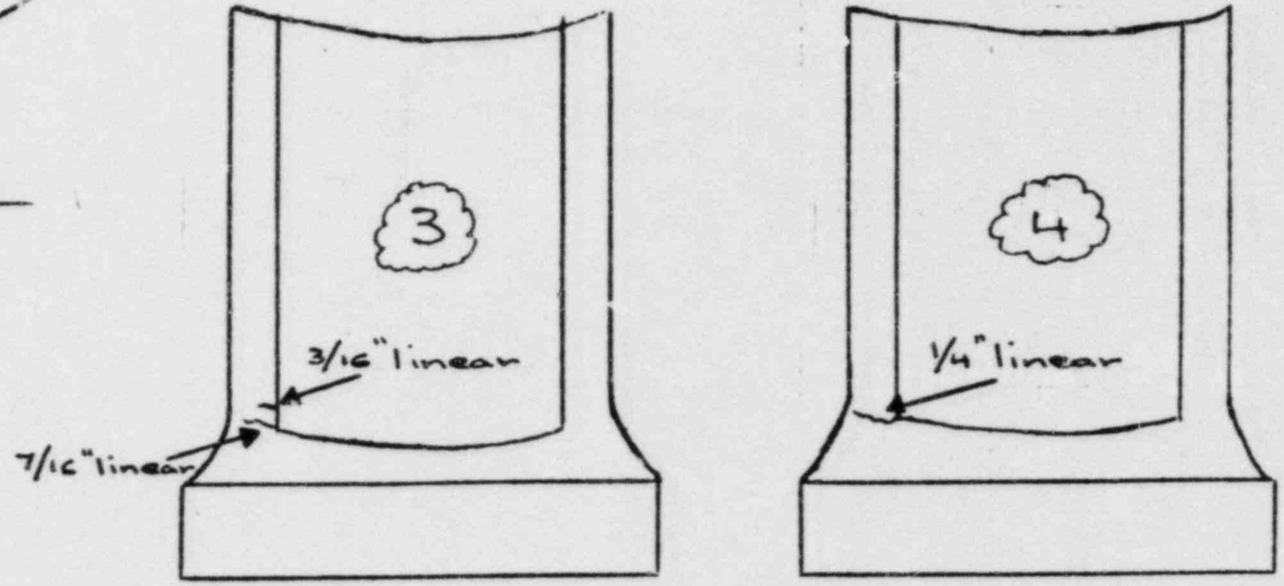
# Diesel #101 Piston #4A



Overhead View



Side Views, looking out from inside



LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. Piston Skirt #5A 101 Diesel

SYSTEM 1R43 + Emerg. Dies. Gen

PLANT/LOCATION SNPS-1 / Turb. Deck

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD | ☒ OTHER: Piston Skirt |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.1+6.2 | SURFACE/MAT'L. TEMP. 73° F | [illegible] 367 Due 4/22/84 | [illegible] No. R43-1142 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC/NF/ZC-7B | 82D119 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY 101 Diesel

Examined machined area on C.H. ~~around~~ boss. Piston-5A

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | N/A | None | Accept |
| 2 | 5/16 | Linear | Reject (LDR Issued) |
| 3 | N/A | None | Accept |
| 4 | N/A | None | Accept |

| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | Lilco NDE 6.2<br>Para 4.2.2 | [illegible] E. Hassel / Asst. J. Pink<br>[illegible] II [illegible] 11/4/83 |

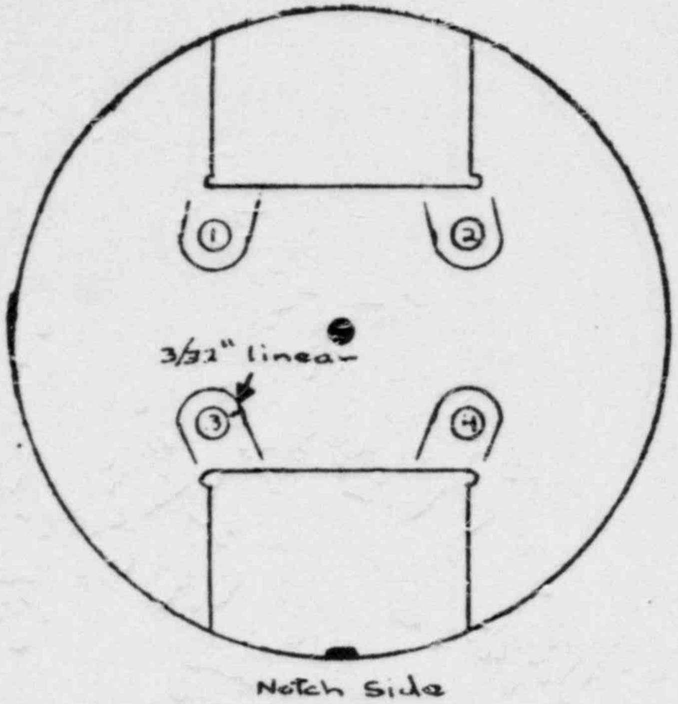
E. ATTEST

Earl Hassell — RESPONSIBLE CERTIFIED PERSONNEL

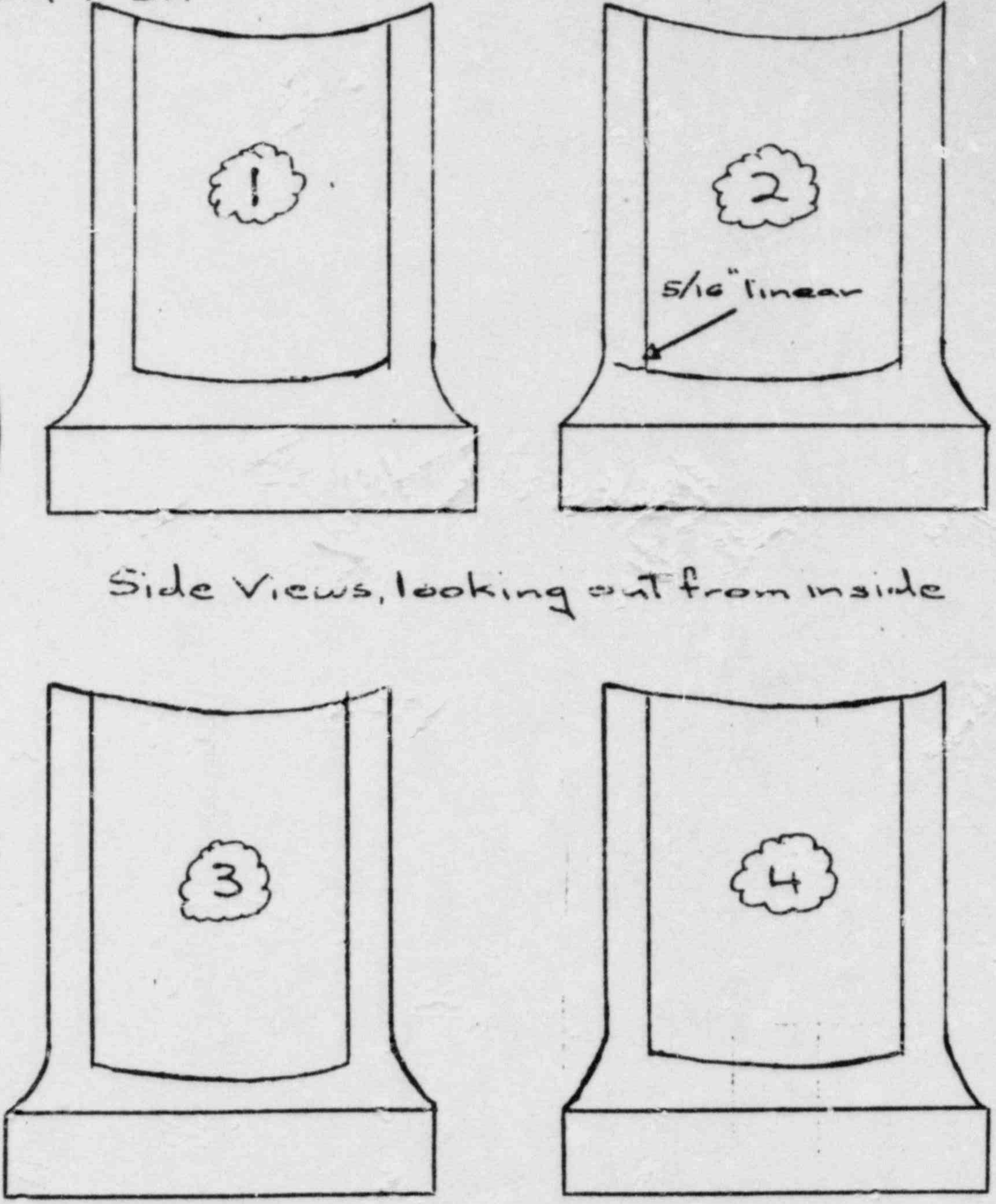
II — LEVEL

11/4/83 — DATE

# Diesel #101 Piston #5A



Overhead View



Side Views, looking out from inside

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 101 Diesel Piston Skirt #6A

SYSTEM 1R43 Emerg Dies Gen.

PLANT/LOCATION SNPS-1 / Turb. Deck.

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE C/S | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.1 + 6.2 | SURFACE/MAT'L. TEMP. 73°F | .367<br>Due 4/22/84 | NO. R43-1142 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | ↓ | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | ↓ | SKC-NF/ZC7B | 82D119 |
| 4. DEVELOPER | ↓ | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | ↓ | SKC-NF/ZC7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

101 Diesel

Examined machined area ~~around~~ on C.H. boss. Piston-6A

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | N/A | None | Accept |
| 2 ↓ | (2) 7/32, 1/8 | Linear | Reject (LDR Issued) |
| 3 ↓ | 1/8 | ↓ | ↓ |
| 4 ↓ | 3/16, 1/4 | ↓ | ↓ |

D. ACCEPTANCE CRITERIA: Lilco NDE 6.2 Para 4.2.2

EXAMINER E. Hassell/Asst. J. Pink

LEVEL II DATE 11/4/83

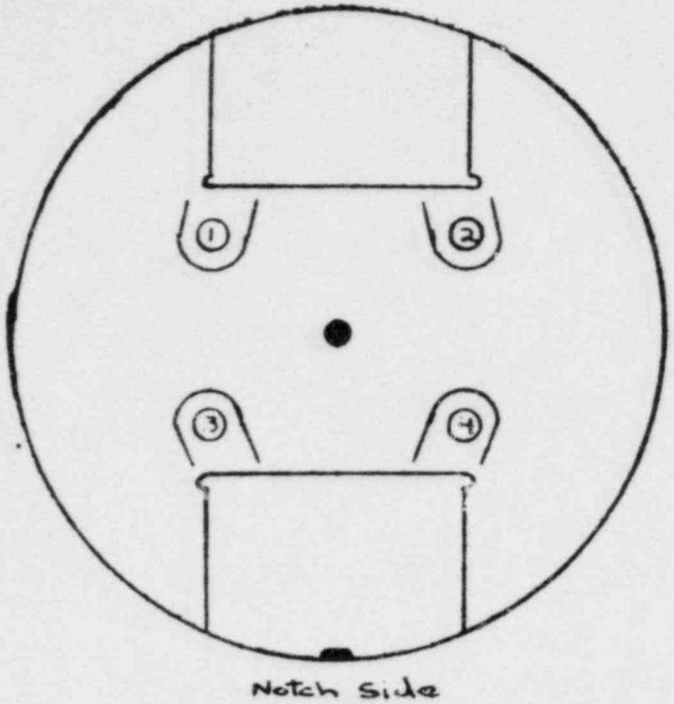
E. ATTEST

Earl Hassell — RESPONSIBLE CERTIFIED PERSONNEL

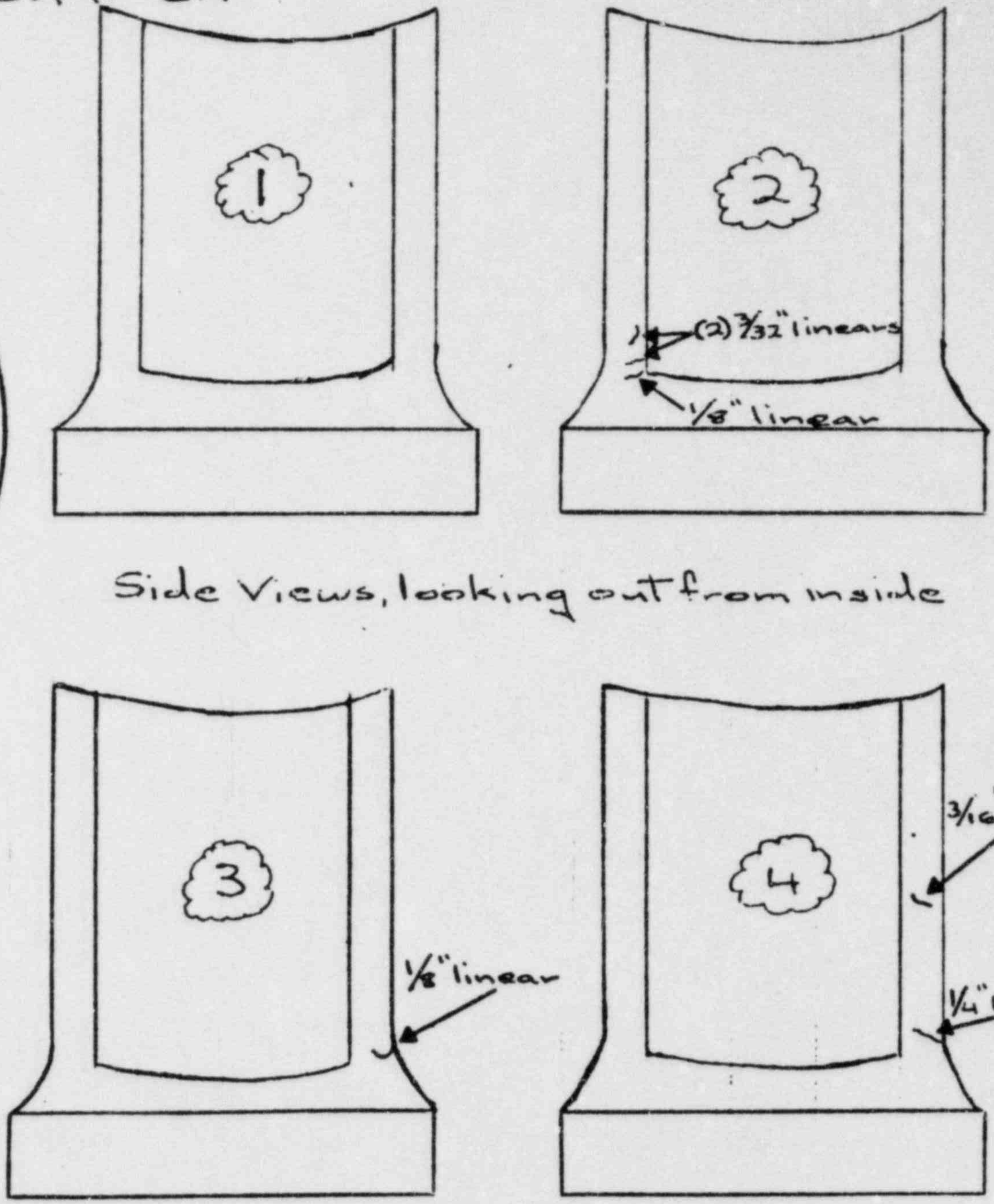
II — LEVEL

11/4/83 — DATE

Diesel #101 Piston # 6A



Overhead View



Side Views, looking out from inside

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 101 Diesel Piston Skirt # 7A

SYSTEM 1R43*Emerg. Dies. Gen.

PLANT/LOCATION SNPS-1/Turb Deck

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.1 + 6.2 | SURFACE /MAT'L. TEMP. 73°F | . . . 367<br>Due 4/22/74 | No. R43-1142 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | magnaflux | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

101 Diesel

Examined machined area ~~around~~ on it boss. Piston - 7A

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole 1 See sketch | N/A | None | Accept |
| 2 | 3/16, 5/32 | Linear | Reject (LDR Issued) |
| 3 | N/A | None | Accept |
| 4 | N/A | None | Accept |

| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | Lilco NDE 6.2<br>Para 4.24 | E. Hassell / asst. J. Pink<br>II<br>11/4/83 |

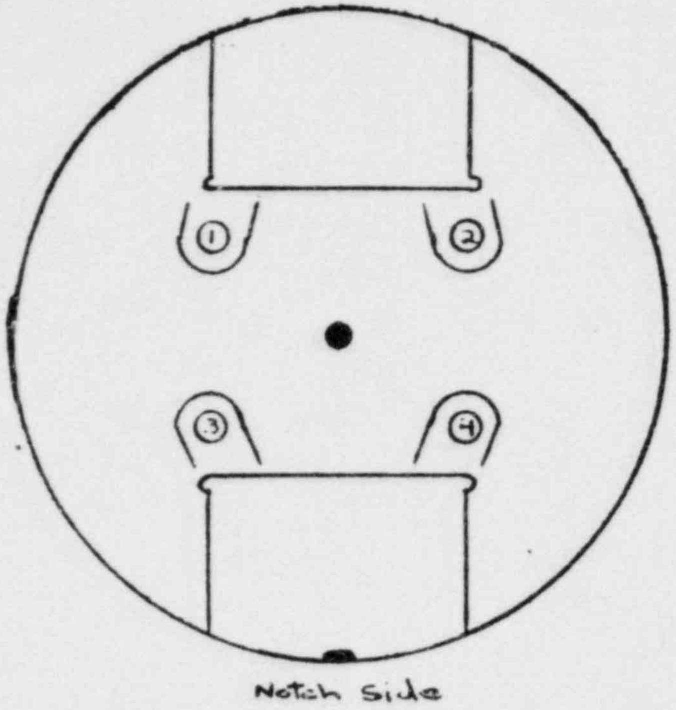
E. ATTEST

Earl Hassell — RESPONSIBLE C... ...ED PERSONNEL

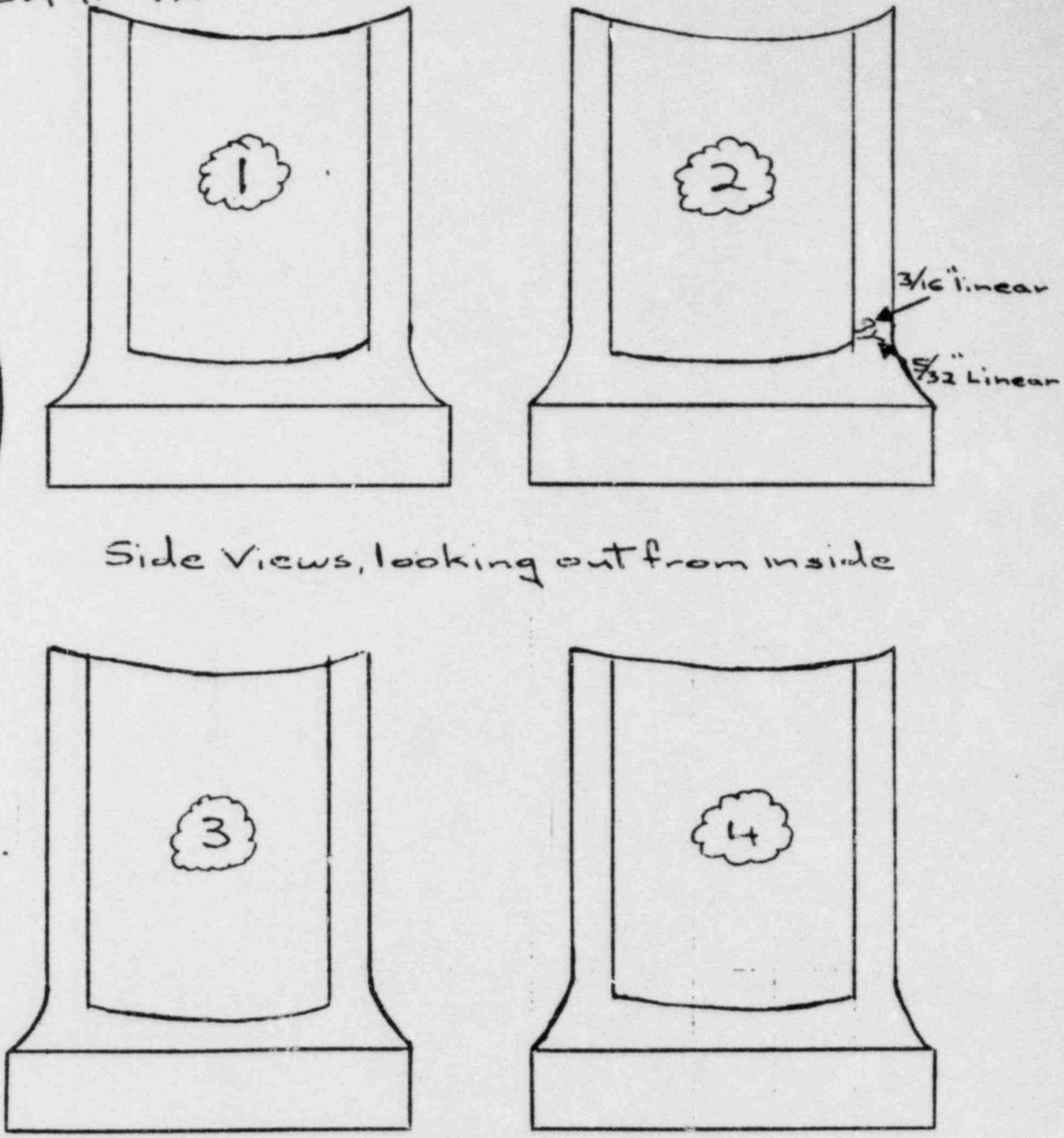
II — LEVEL

11/4/83 — DATE

# Diesel #101 Piston #7A



Overhead View



Side Views, looking out from inside

# LIQUID PENETRANT EXAMINATION REPORT

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: PISTON SKIRT | |
| CROSS SECTION THICKNESS | MAX 2" INCH | MIN 2" INCH | SURFACE CONDITION ☐ MACHINED ☒ GROUND ☐ AS FABRICATED ☐ OTHER |
| 6.2 | MAT'L TEMP. 72° | M+TE # .367 Due 4/22/84 | Supp #1 R43-1142 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | MAGNAFLUX | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | " | SKL-HF/SKL-S | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | " | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | " | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | " | SKC-NF/ZC-7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

PERFORMED L.P. INSPECTION IN ACCORDANCE WITH ATTACHED IOC #34 AFTER GRINDING AND BUFFING ON PREVIOUSLY REJECTED AREA (SEE ATTACHED SKETCH)

C. EVALUATION — REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 N/A | | | |
| 2 BOLT HOLE #2 | 2 - 1/16"<br>4 - 1/32" | 6 ROUNDED INDICATIONS | ACCEPTABLE ROUNDED INDICATIONS MEET WITH ACCEPTANCE CRITERIA OF NDE 6.2 |
| 3 N/A | | | |
| 4 N/A | | | |
| | NDE 6.2 | | DENNIS PIETROWSKI II 11/5/83 |

E. ATTEST D. Pietrowski — RESPONSIBLE CERTIFIED PERSONNEL — II LEVEL — 11/5/83 DATE

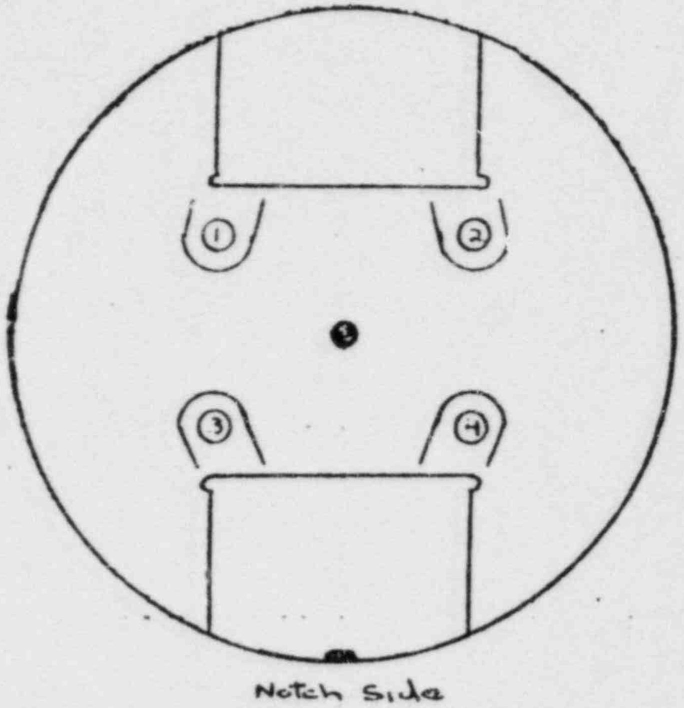
PT

COMPONENT I.D. 101 DIESEL PISTON SKIRT #7A

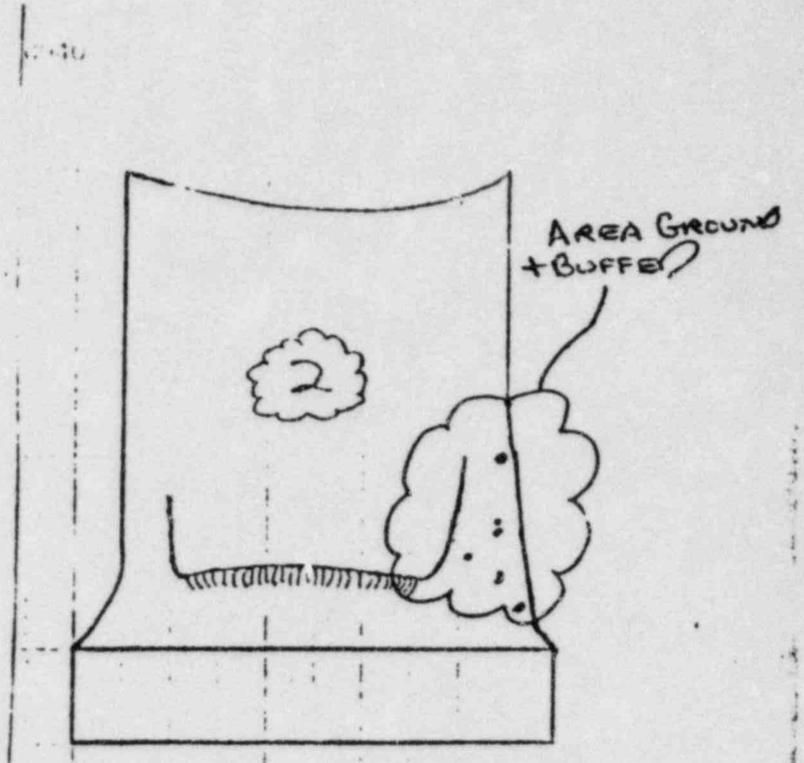
SYSTEM 1R43*

PLANT/LOCATION SNPS / 63' TURBINE DECK

Diesel # 101 Piston # 7A



Overhead View



Side View, looking out from inside

# INTEROFFICE CORRESPONDENCE #34

| | | |
|---|---|---|
| TO<br>M. Herlihy | LOCATION | SUBJECT / REFERENCE / J.O. NO.<br>EDG 101 Piston Skirt Inspection |
| FROM<br>J. C. Kammeyer | LOCATION | |

MESSAGE: —

The purpose of this memo is to provide guidelines for NDE to be performed on the piston skirts for the 101 engine. Note, upon disassembly of the piston assemblies for inspection, breakaway torques will be recorded for piston crown to skirt hold down studs.

Piston inspection will be as follows:

1. OQA will perform a color contrast penetrant test. Reference attached FaAA memo.
2. FaAA will perform an informational focused field eddy current test to confirm any rejectable indications found during PT. Reference attached FaAA memo.
3. Based on the information provided by the FaAA inspection, SEO will determined whether or not indications can be removed by additional surface preparation and cleanup.
4. OQA should perform another inspection after completion of any additional surface preparation and cleanup to determine if indications still exist.

If you have any questions, please call me.

11/4/83
DATE

J C Kammeyer
SIGNATURE

X404
TELEPHONE

REPLY:

CC MHM WJM
EJY G Rogers
PJH
R Noyicki
P Martin.

After review of indications documented on LDR #1811, the #7A piston indication (which appear to be casting related) will be explored as required. Final LP to be documented. Work to be supervised by M. Schuster.

11/5/83 J C Kammeyer

DATE SIGNATURE TELEPHONE

A-040 138

SENDER DETACH AND RETAIN THIS COPY

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. 101 Diesel Piston Skirt # 8A

SYSTEM 1R43* Emerg. Dies. Gen.

PLANT/LOCATION SNPS-1 / Turb. Bldg.

**A. MATERIAL**

TYPE c/s

FABRICATED PROCESS ☐ WELDED ☒ CAST ☐ WORKED

GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt

CROSS SECTION THICKNESS MAX — INCH MIN — INCH

SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER

**B. NDE PROCEDURE** No. 6.1 + 6.2

SURFACE/MAT'L. TEMP. 73°F

[illegible] 367 Due 4/22/83

[illegible] R43-1142

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82D119 |
| 2. PENETRANT | ↓ | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | ↓ | SKC-NF/ZC-7B | 82D119 |
| 4. DEVELOPER | ↓ | SKD-NF/ZP-9B | 83C042 |
| 5. POST EXAMINATION CLEANER | ↓ | SKC-NF/ZC-7B | 82D119 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area ~~around~~ on ck boss.

101 Diesel
Piston - 8A

**C. EVALUATION** REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole 1 See Sketch | (2) 7/16, 3/32 | Linear | Reject (LDR Issued) |
| 2 | N/A | None | Accept |
| 3 | ↓ | ↓ | ↓ |
| 4 | ↓ | ↓ | ↓ |

**D. ACCEPTANCE CRITERIA** Lilco NDE 6.2 Para 4.2.2

E. Hassell / Asst. J. Pink

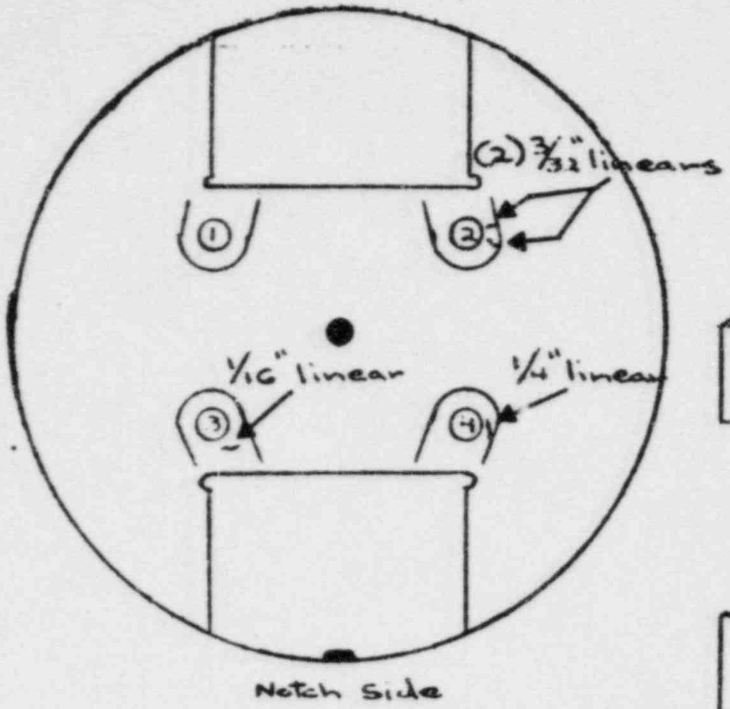
LEVEL II

DATE 11/4/83

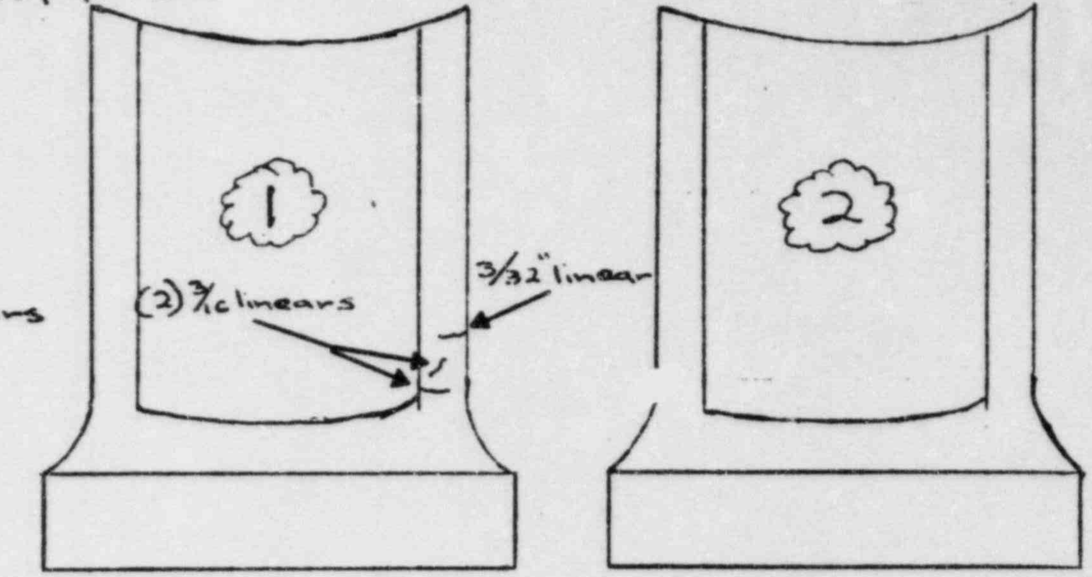
**E. ATTEST** Earl Hassell — II — 11/4/83

RESPONSIBLE C[illegible]ED PERSONNEL LEVEL DATE

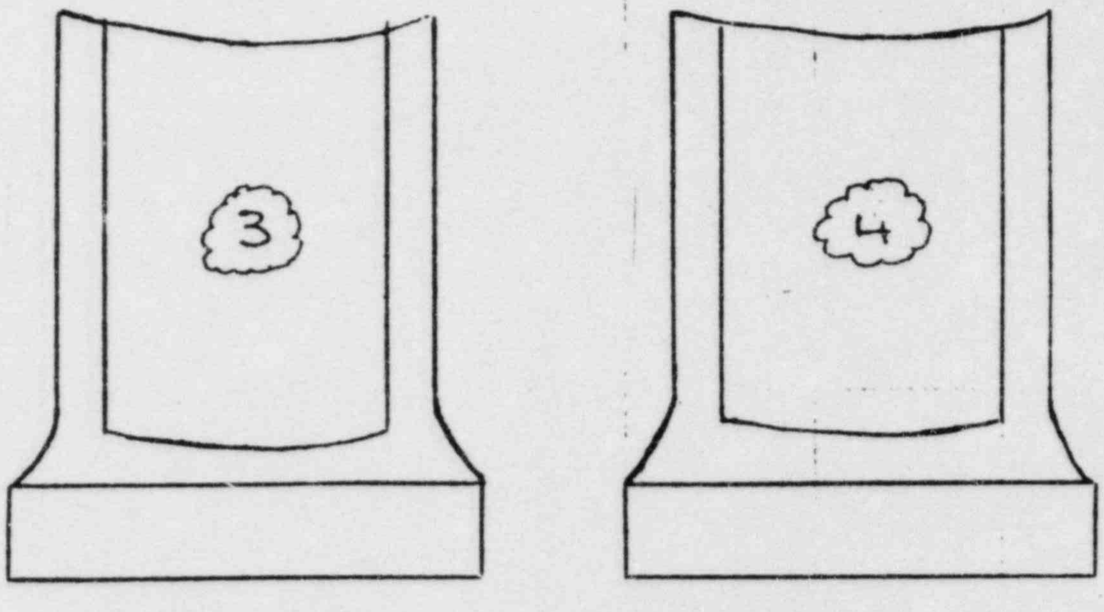
# Diesel #101 Piston # 8A



Overhead View



Side Views, looking out from inside



EDG 102

LILCO LONG ISLAND LIGHTING

## LIQUID PENETRANT EXAMINATION REPORT

AF PISTONS

PT

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 61 + 6.2 | TEMP. 69° F | .367<br>Due 4/22/84 | Supp. 2<br>No. R43-1144 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82T083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82T083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area on boss.

102 Diesel
Piston #1B

C. EVALUATION — REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole<br>1 See Sketch | 3/16" | Crack | Reject (LDR Issued) |
| 2 | N/A | None | Accept |
| 3 | 1/4" Ø | Rounded | Reject (LDR Issued) |
| 4 | N/A | None | Accept |

| | | |
|---|---|---|
| D. ACCEPTANCE STD. | Lilco NDE 6.2<br>Para 4.2.2 | E. Hassell<br>II 11/8/83 |

E. ATTEST

Earl Hassell — RESPONSIBLE CERTIFIED PERSONNEL

II — LEVEL

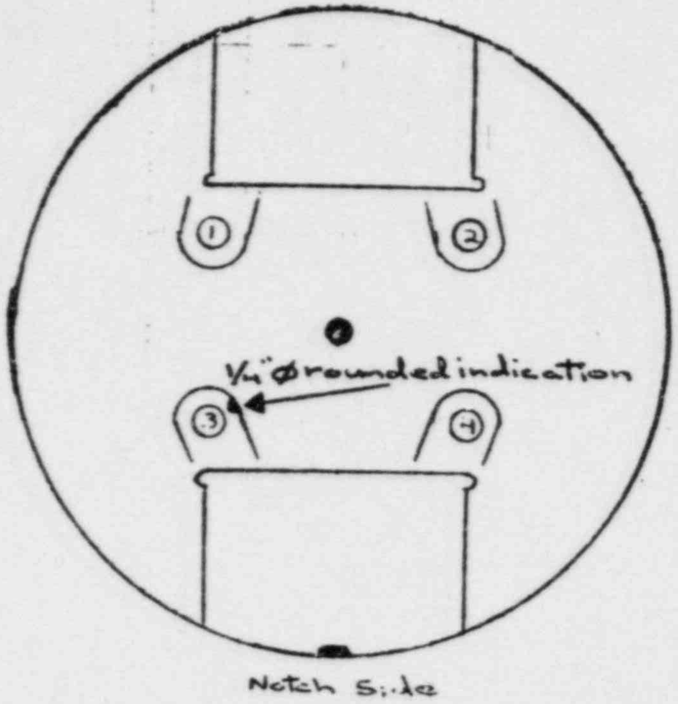
11/8/83 — DATE

COMPONENT I.D. Piston Skirt #1B

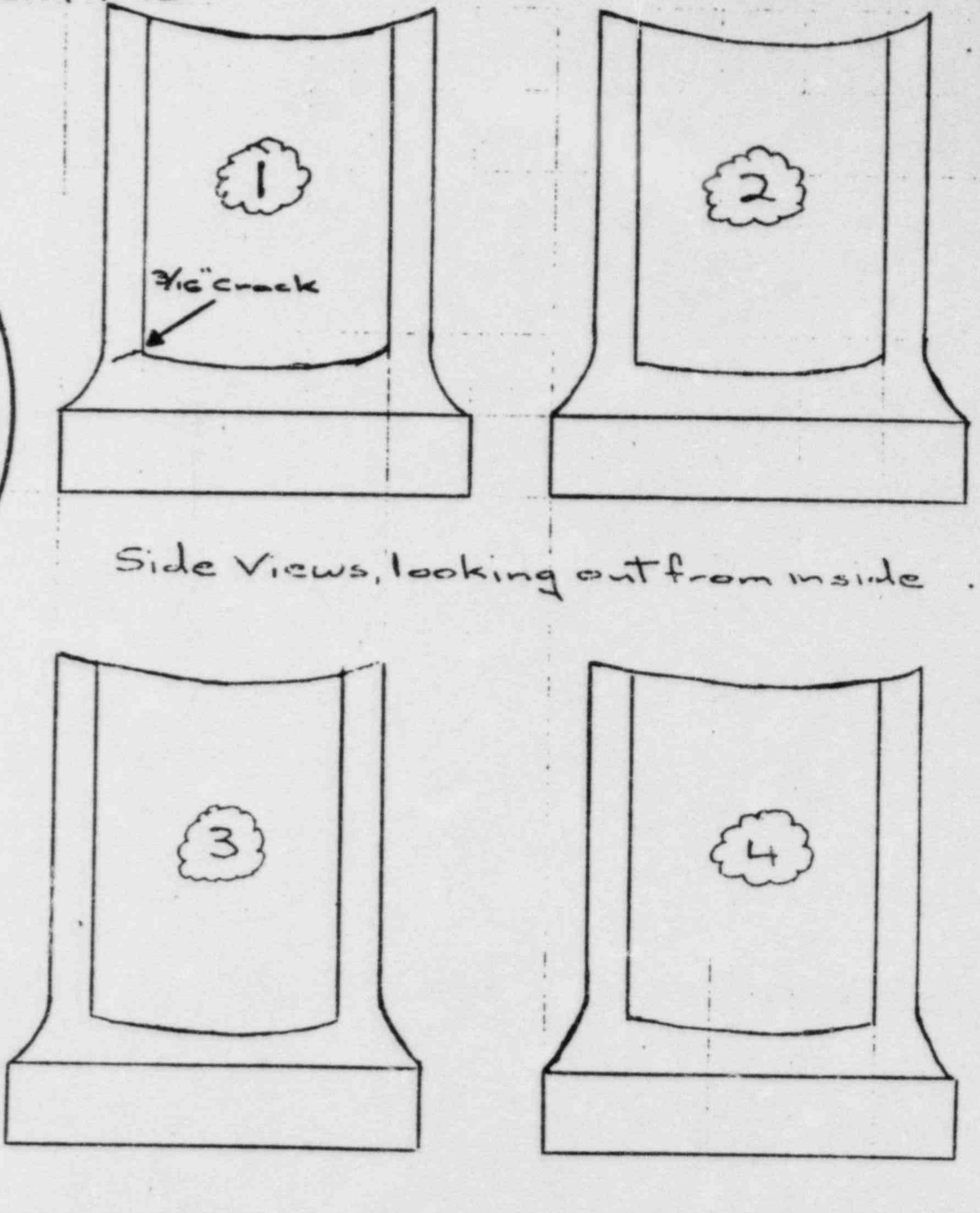
SYSTEM 1R43*EDG-102B

LOCATION SNPS-1/Turb. Deck El. 63.

# Diesel #102 Piston #1B



Overhead View



Side Views, looking out from inside

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D.: Piston Skirt #2B

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. [illegible] 6.1+6.2 | [illegible] /MAT'L. TEMP. 69° F | .367 Due 4/22/84 | .Supp.2 .R43-1144 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area on boss

102 Diesel
Piston #2B

SYSTEM: 1R43*EDG-102B

**C. EVALUATION** REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole<br>1 See Sketch | N/A | None | Accept |
| 2 | 1/4" | Crack | Reject (LDR-Issued) |
| 3 | 1/8" | Linear | Reject (LDR Issued) |
| 4 | N/A | None | Accept |

| | | |
|---|---|---|
| D. [illegible] | Lilco NDE 6.2<br>Para 4.2.2 | E. Hassell<br>II 11/8/83 |

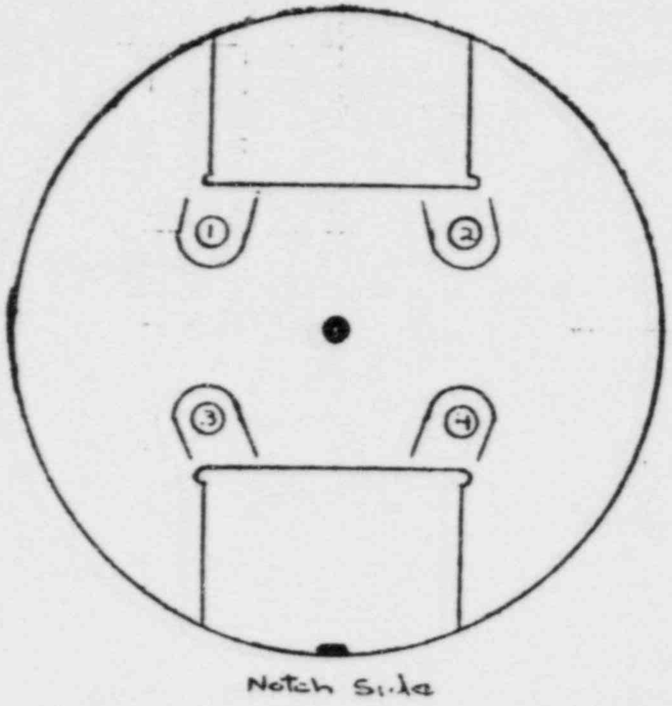
E. ATTEST

Earl Hassell — II — 11/3/83

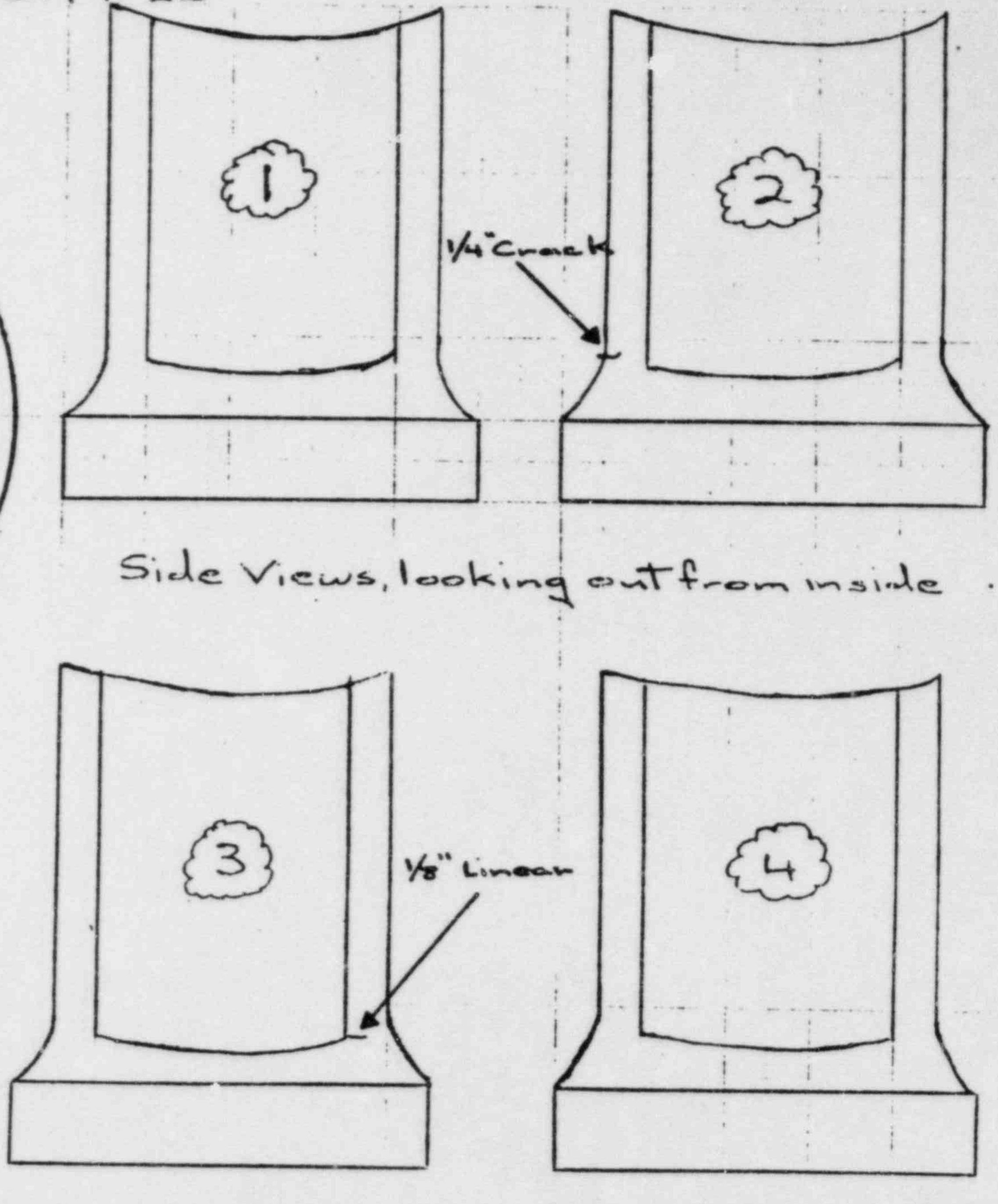
RESPONSIBLE CERTIFIED PERSONNEL — LEVEL — DATE

LOCATION: SNPS-1/Turb. Deck El. 63'

Diesel #102 Piston #2B



Overhead View



Side Views, looking out from inside.

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D.: Piston Skirt #3B

SYSTEM: 1R43*EDG-103B

LOCATION: SNPS-1/Turb. Bk. El. 63'

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD | ☒ OTHER: Piston Skirt |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. [illegible] No. G1+G.2 | [illegible] MAT'L TEMP 69° F | [illegible] .367<br>Due 4/22/84 | Supp. 4<br>R43-1144 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | ↓ | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | ↓ | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | ↓ | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | ↓ | SKC-NF/ZC-7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area on boss.

102 Diesel
Piston #3B

**C. EVALUATION** REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | 1/4" | Crack | Reject (LDR Issued) |
| 2 ↓ | N/A | None | Accept |
| 3 ↓ | 1/4" x 1/2" | Rounded | Reject (LDR Issued) |
| 4 ↓ | N/A | None | Accept |
| D. [illegible] | Lilco NDE G.2<br>Para 4.2.2 | | [illegible] E. Hassell<br>II 11/8/83 |

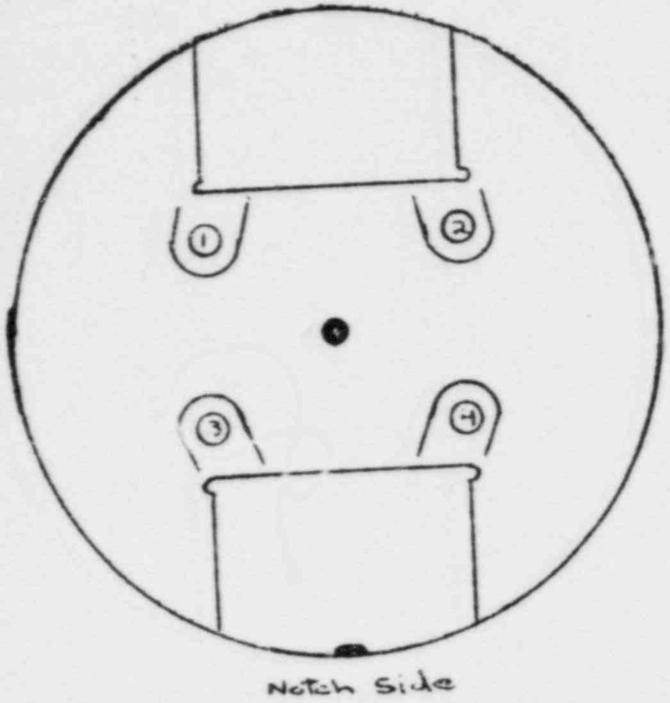
E. ATTEST

Earl Hassell — RESPONSIBLE CERTIFIED PERSONNEL

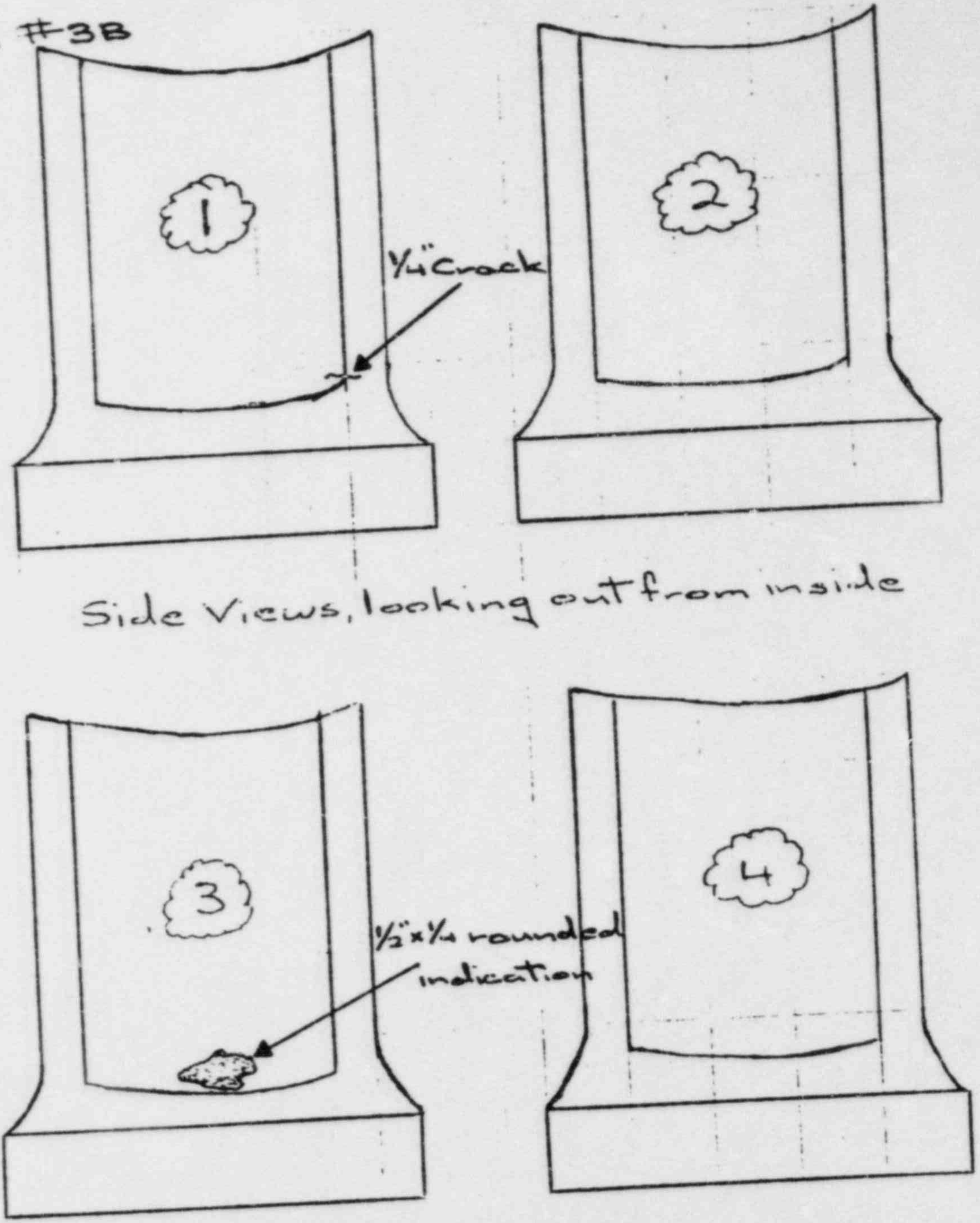
II — LEVEL

11/8/83 — DATE

Diesel #102 Piston #3B



Overhead View



Side Views, looking out from inside

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. Piston Skirt #4B

SYSTEM 1R43*EDG-102B

LOCATION SNPS-1/Turb Bldg El. 63'

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |
| A. NDE PROCEDURE # 6.1 + 6.2 | [illegible] /MAT'L. TEMP. 69°F | .367 Due 4/22/83 | [illegible] Supp. 4 . R43-1144 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area on boss.

102 Diesel
Piston #4B

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | 3/16" | Crack | Reject (LDR Issued) |
| 2 | 9/16" | Crack | Reject (LDR Issued) |
| 3 | N/A | None | Accept |
| 4 | N/A | None | Accept |

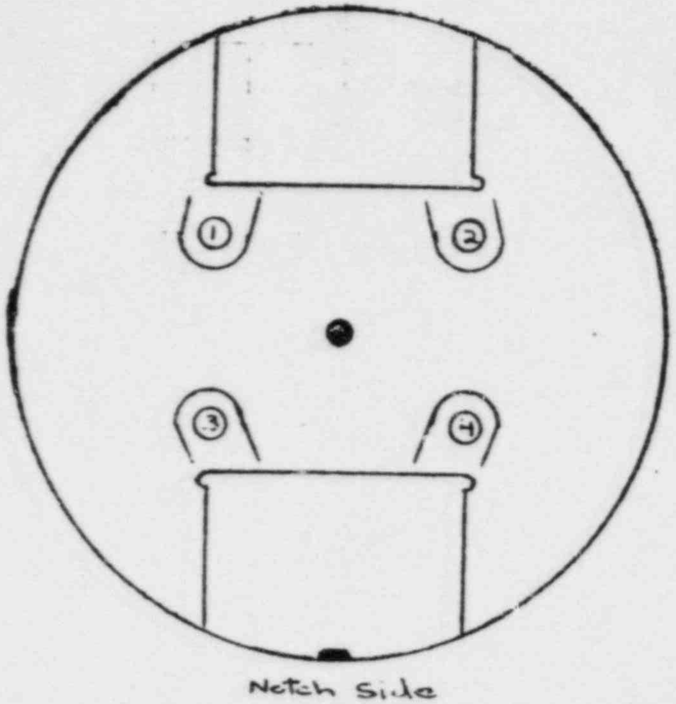
| | | |
|---|---|---|
| [illegible] | Lilco NDE 6.2<br>Para 4.2.2 | [illegible] E. Hassell<br>[illegible] II [illegible] 11/3/83 |

E. ATTEST

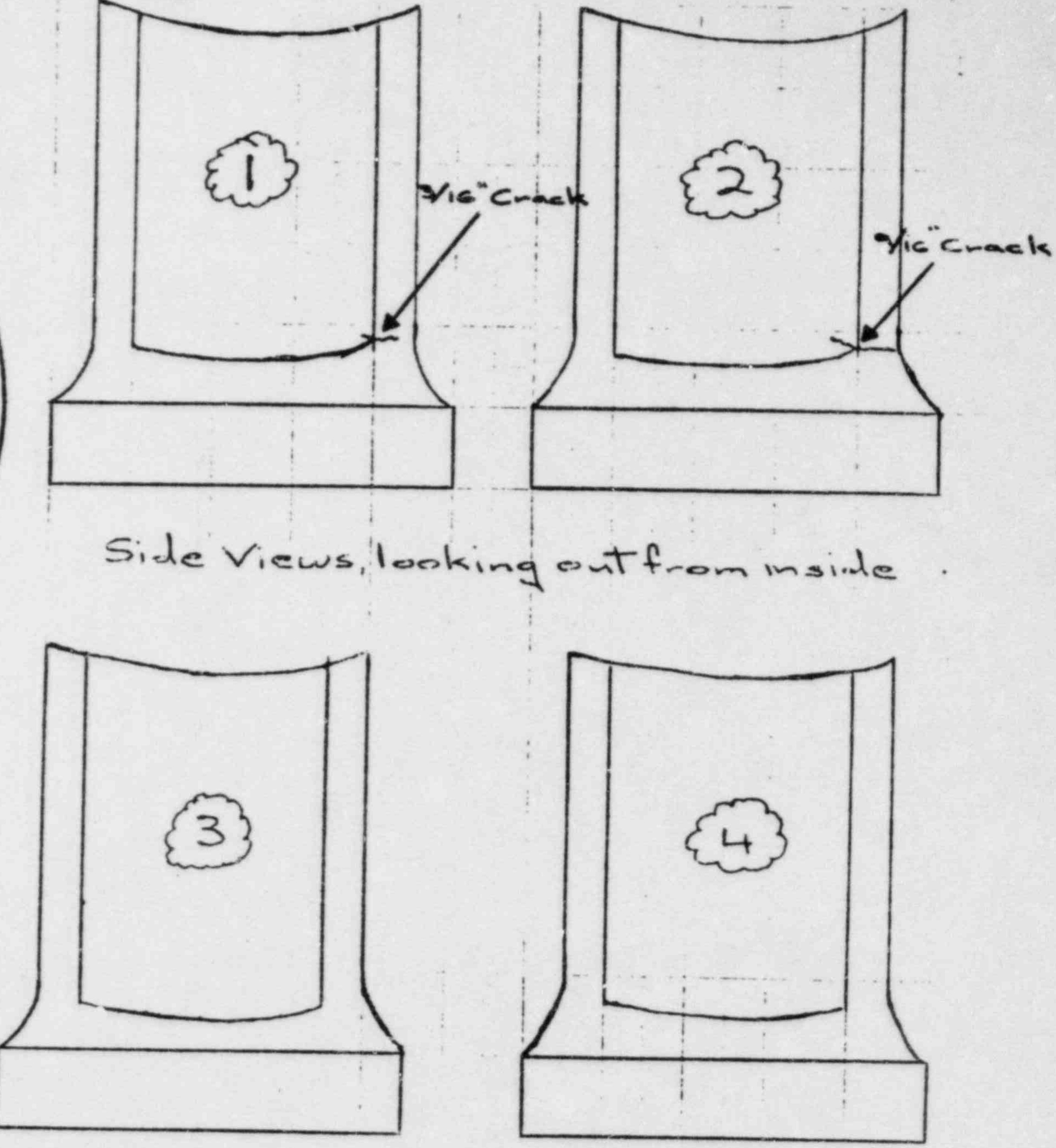
Earl Hassell — II — 11/3/83

RESPONSIBLE CERTIFIED PERSONNEL — LEVEL — DATE

# Diesel #102 Piston #4B



Overhead View



Side Views, looking out from inside

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. Piston Skirt #5B

SYSTEM 1R43*EDG-102B

[illegible]/LOCATION SWPS-1/Turb Pk. G1.G3.

**A. MATERIAL**

TYPE c/s

FABRICATED PROCESS ☐ WELDED ☒ CAST ☐ WORKED

GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER Piston Skirt

CROSS SECTION THICKNESS MAX —— INCH MIN —— INCH

SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER

**B.** [illegible] No. G1 + G2

[illegible]/MAT'L. TEMP. 69°F

[illegible] .357 Due 4/22/84

Supp 2 [illegible] 842-1144

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area on boss.

102 Diesel
Piston #5B

**C. EVALUATION**

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole<br>1 See Sketch | 5/8" | Crack | Reject (LDR Issued) |
| 2 | 5/16" | | |
| 3 | 1/2" | | |
| 4 | N/A | None | Accept |

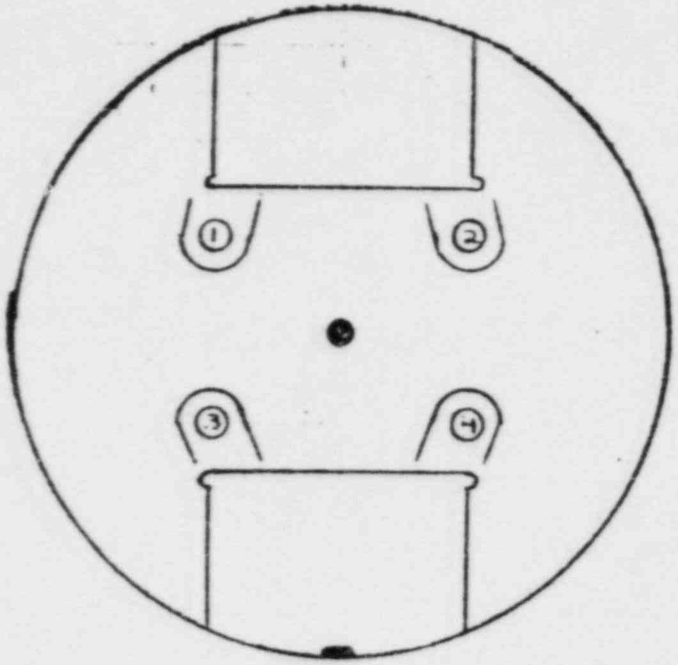
[illegible] Lilco NDE G2 Para 4.2.2

[illegible] E. Hassell
[illegible] II
[illegible] 11/3/83

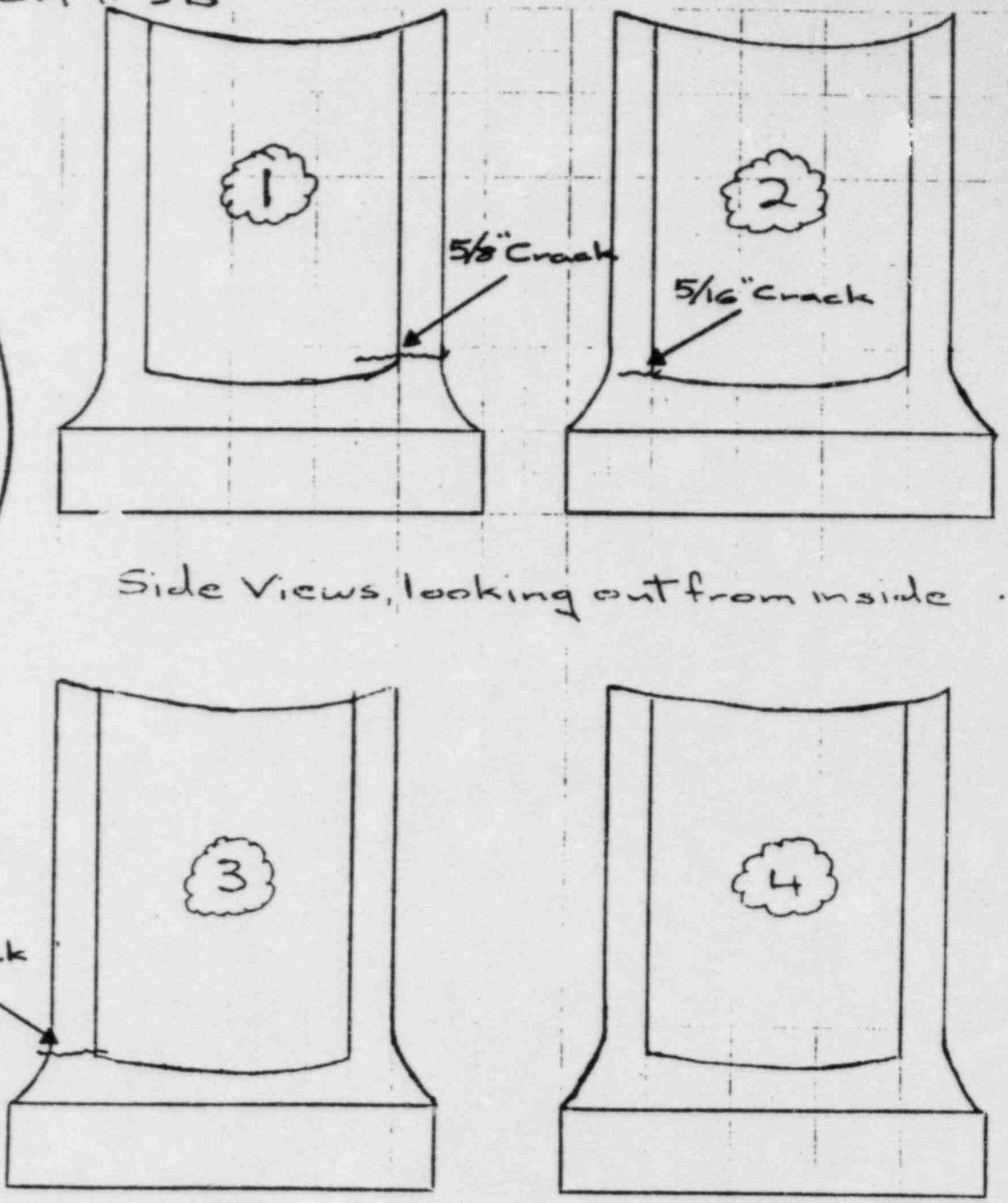
**E. ATTEST** Earl Hassell II 11/3/83

[illegible]ONSIBLE CERTIFIED PERSONNEL LEVEL DATE

Diesel #102 Piston #5B



Overhead View



Side Views, looking out from inside

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. Piston Skirt #6B

SYSTEM 1R43*EPG-102

[illegible]ATION SNPS-1 / Turb Deck El 63.

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE C/S | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD | | ☒ OTHER: Piston Skirt |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.1 + 6.2 | MAT'L. TEMP. 69°F | .367 Due 4/22/84 | Supp. 2 R43-1144 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKL-S | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area on boss.

102 Diesel
Piston #6B

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole 1 See Sketch | N/A | None | Accept |
| 2 | 5/16 + 5/8 | Crack | Reject (LDR Issued) |
| 3 | 7/8 | Crack | |
| 4 | 7/8<br>3/16 | Crack<br>Linear | |

| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | Lilco NDE 6.2 Para 4.2.2 | EXAMINER E. Hassell<br>LEVEL II DATE 11/3/83 |

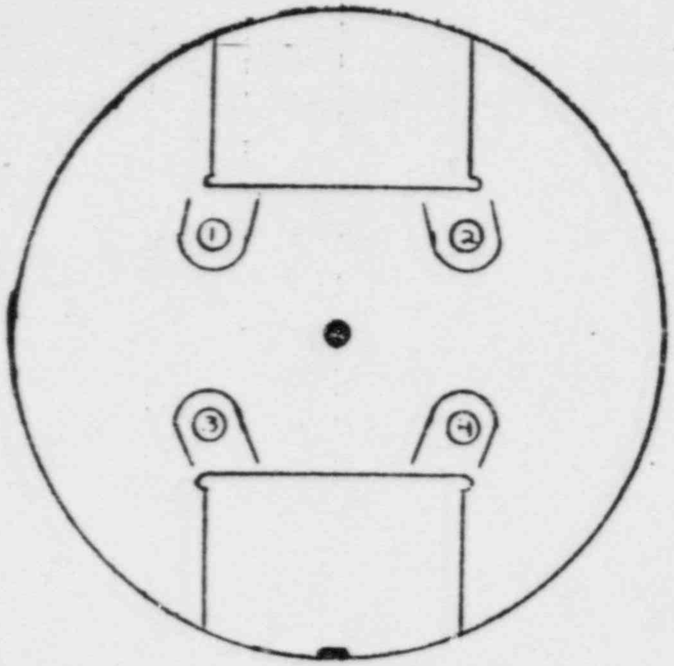
E. ATTEST

Earl Hassell — RESPONSIBLE CERTIFIED PERSONNEL

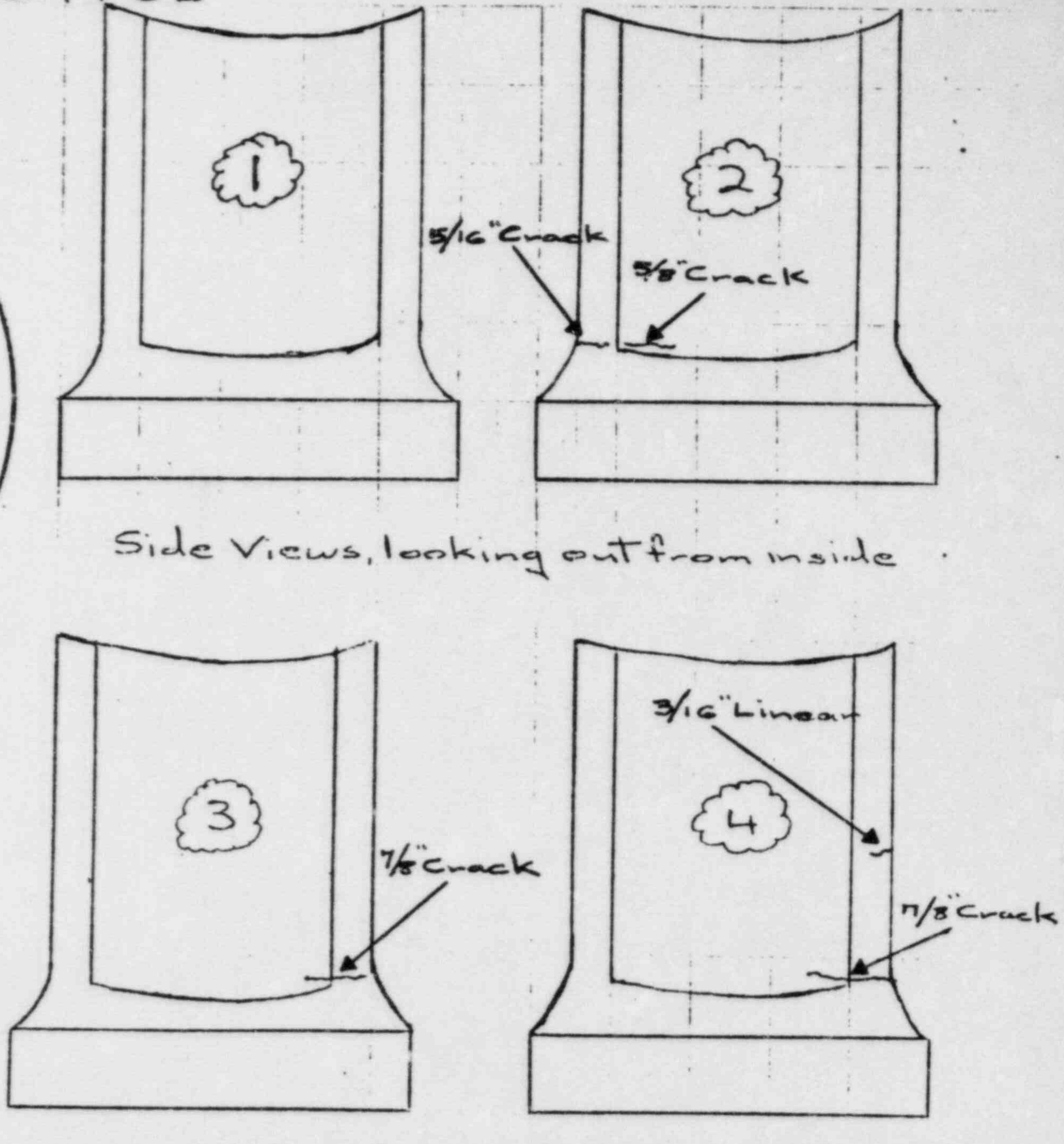
II — LEVEL

11/3/83 — DATE

Diesel #102 Piston #6B



Overhead View



Side Views, looking out from inside

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |
| B. [illegible] No. 61+62 | MAT'L. TEMP. 69°F | .367 Due 4/22/83 | Supp 2 . R43-1144 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82J83 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area on boss.

102 Diesel
Piston #7B

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | 1/2 | Crack | Reject (LDR Issued) |
| 2 | N/A | None | Accept |
| 3 | 1 | Crack | Reject (LDR Issued) |
| 4 | N/A | None | Accept |

| | | |
|---|---|---|
| D. AC[illegible] | Lilco NDE 6.2<br>Para 4.7.2 | [illegible] E. Hassell<br>[illegible] II [illegible] 11/3/83 |

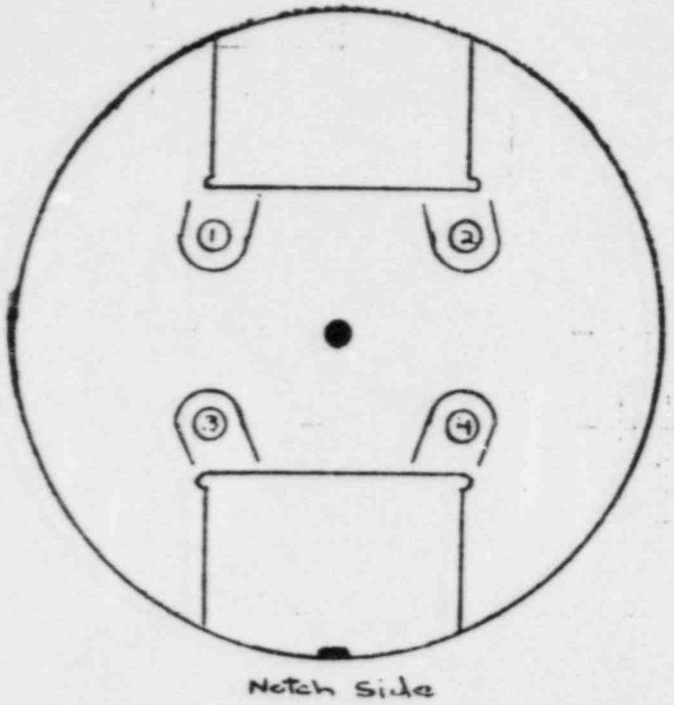
E. ATTEST Earl Hassell — II — 11/3/83
RESPONSIBLE CERTIFIED PERSONNEL — LEVEL — DATE

COMPONENT I.D. Piston Skirt #7B

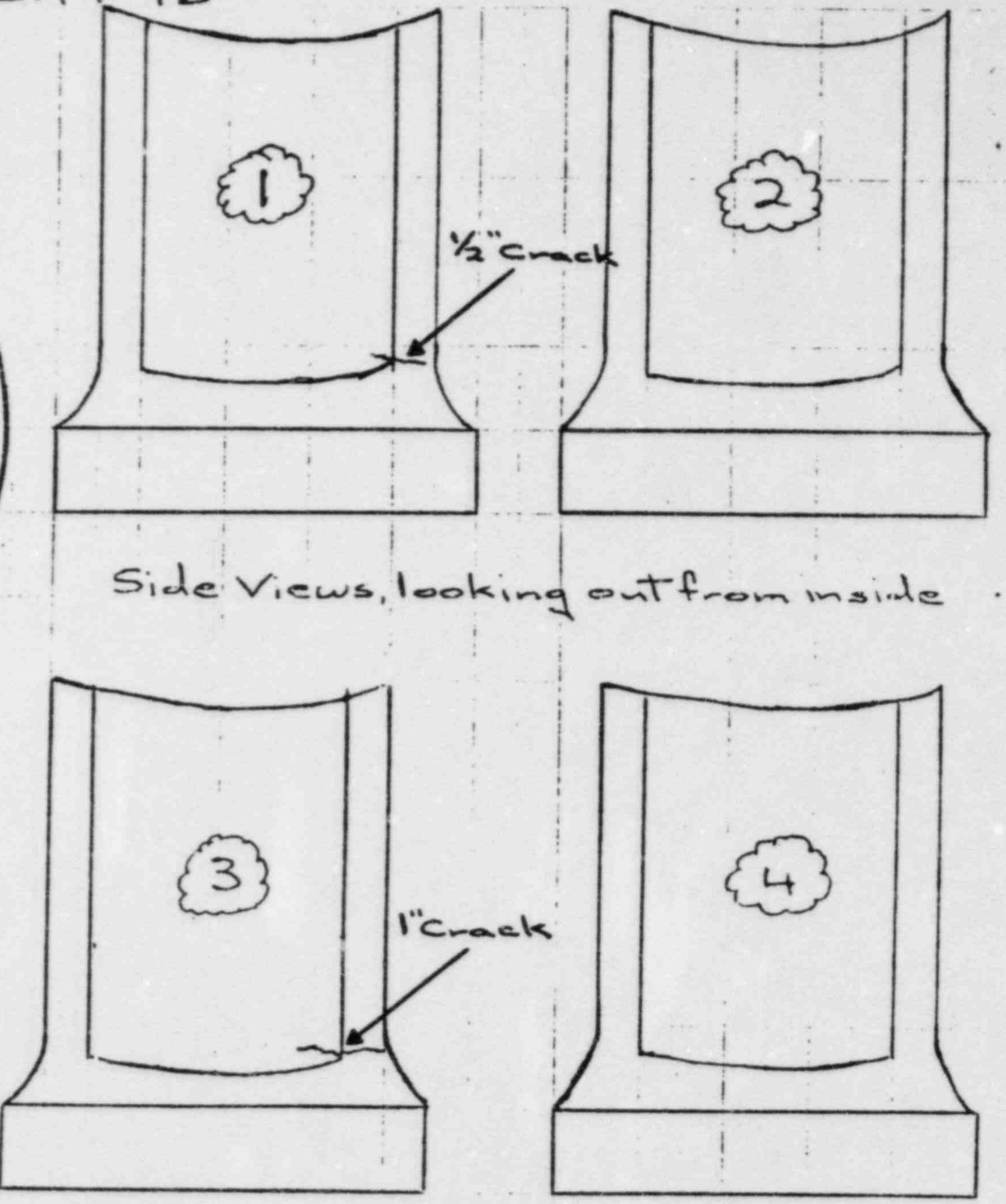
SYSTEM 1R43* EDG-102

LOCATION SWPS-1/Turb. Bk El. 63'

# Diesel #102 Piston #7B



Overhead View



Side Views, looking out from inside

LONG ISLAND LIGHTING LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. Piston Skirt #8B

SYSTEM 1R43*EDG-102

PLANT/LOCATION SNPS-1/Turb Bldg El. 63'

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. NDE PROCEDURE No. 6.1 + 6.2 | /MAT'L. TEMP 69°F | .367 Due 4/22/84 | Supp. 2 R43-1144 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area on boss.

102 Diesel
Piston #8B

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| | LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|---|
| 1 | Bolt Hole<br>See Sketch | 1/8<br>3/16 | Linear<br>Crack | Reject (LDR Issued) |
| 2 | | N/A | None | Accept |
| 3 | | | | |
| 4 | | | | |

| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | Lilco NDE 6.2<br>Para 4.2.2 | E. Hassell<br>II<br>11/8/83 |

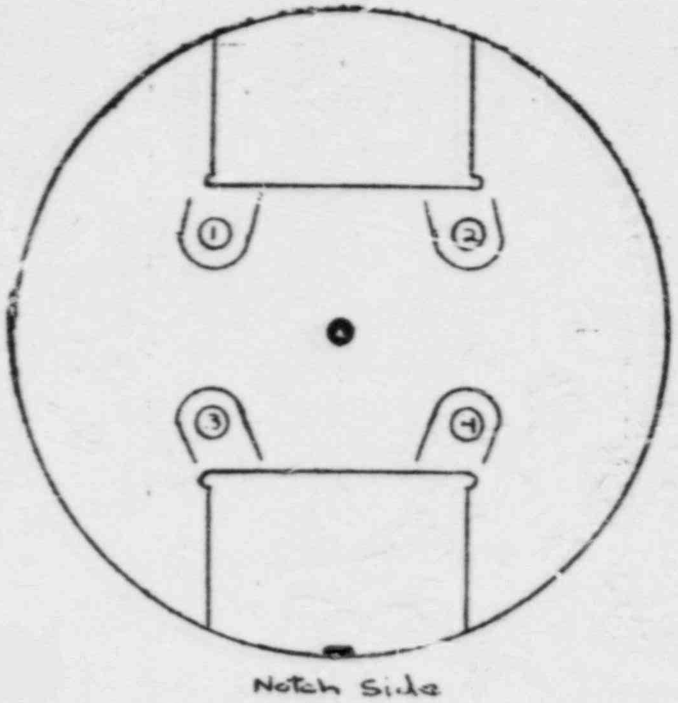
E. ATTEST

Earl Hassell — RESPONSIBLE CERTIFIED PERSONNEL

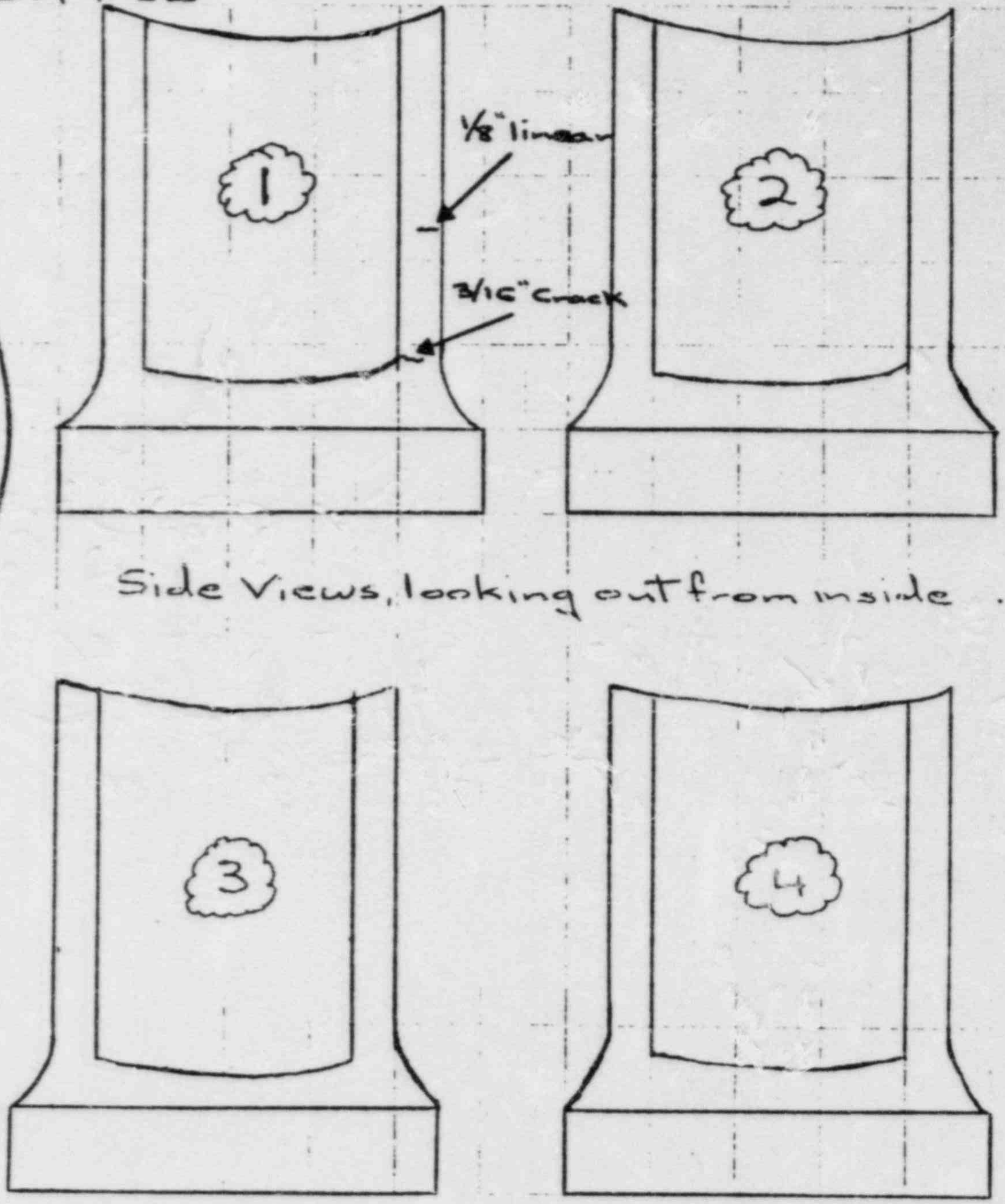
II — LEVEL

11/8/83 — DATE

Diesel #102 Piston #8B



Overhead View



Side Views, looking out from inside.

EDG 103

AF PISTONS

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE C/S | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD | ☒ OTHER Piston Skirt |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| 61+62 | TEMP 69°F | 367 Due 4/23/94 | Supp 2 R43.1143 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | magnaflux | SKC-NF/ZC7B | 82J033 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC7B | 82J033 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC7B | 82J033 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area around boss

103 Diesel
Piston #2C

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

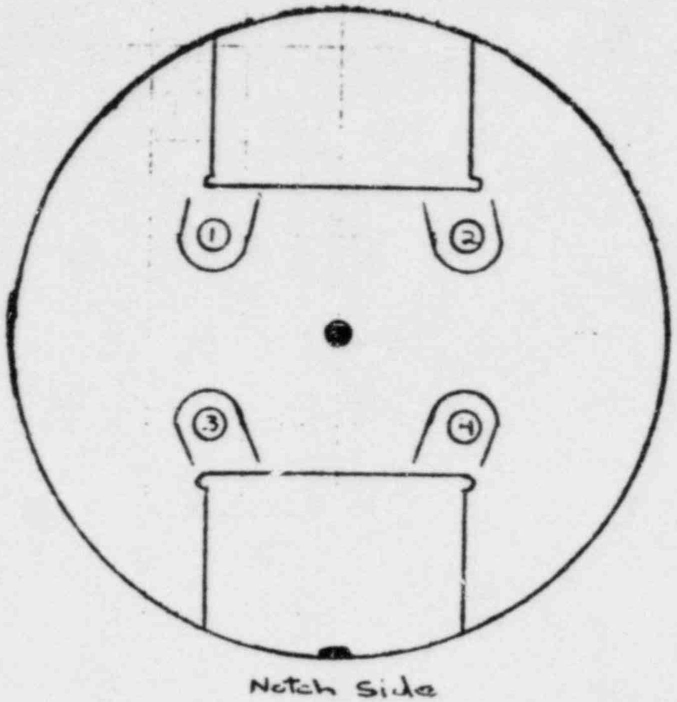
| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | (3) 3/32, 1/16, 1/8 3/16, 1/4 | linears | Reject (LDR Issued) |
| 2 | 3/8 | crack | |
| | 1/4 x 3/16 | rounded | |
| 3 | 5/32 | linear | |
| | 3/8 | crack | |
| 4 | 1/8 | linear | |
| | 3/32, 5/16 | cracks | |
| | Lilco NDE 62<br>Para 4.2.2 | | E. Hassell / II<br>Asst. J. Colazzo J Pink 11/9/93 |
| E. ATTEST | Earl Hassell | | II 11/9/93 |

COMPONENT I.D. Piston Skirt #2C

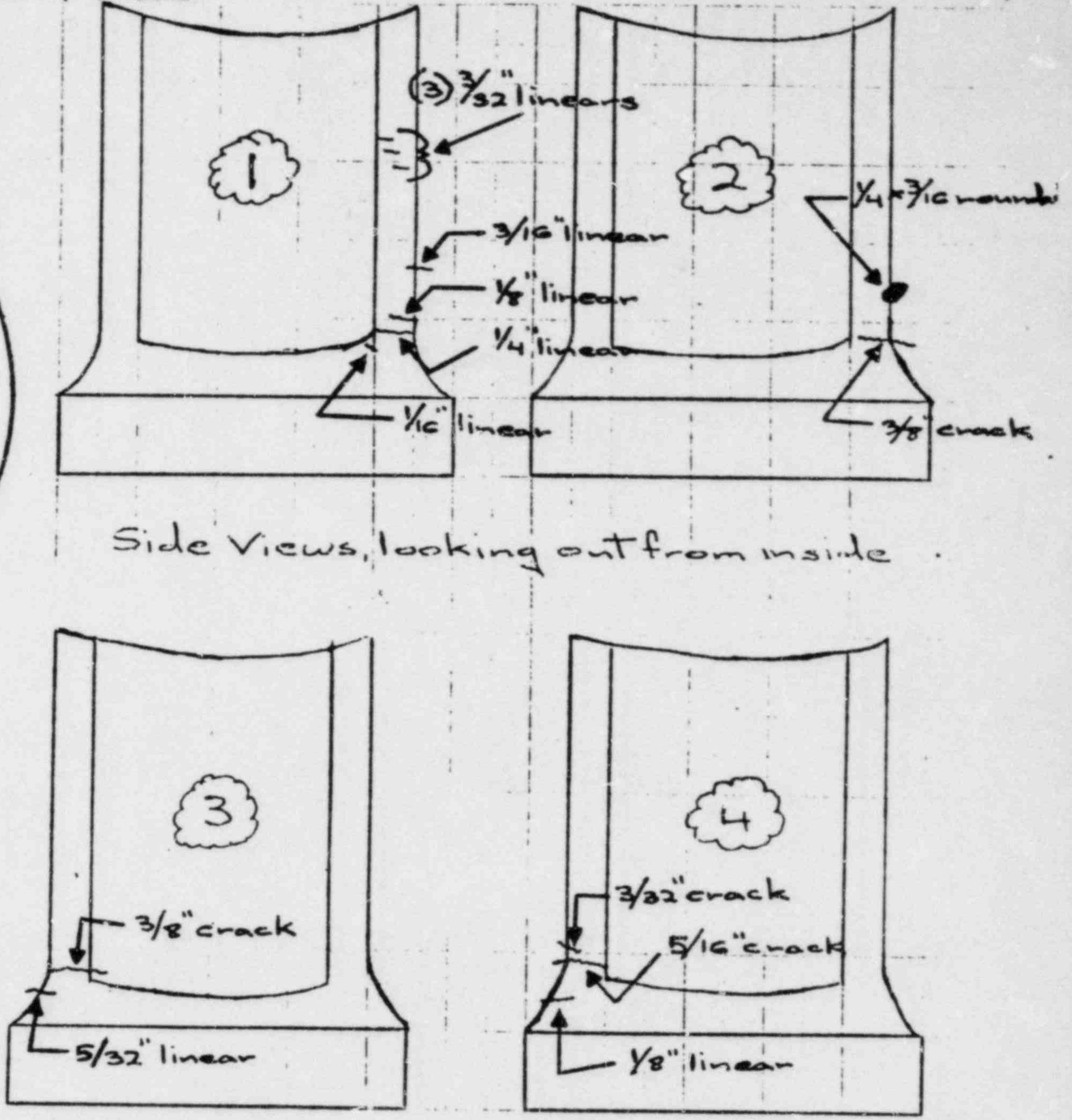
SYSTEM 1R43*EDG-103

LOCATION SNPS-1/Tech Pk. El.

Diesel #103 Piston #2C



Overhead View



Side Views, looking out from inside.

3

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. Piston Skirt #1C

| | | | |
|---|---|---|---|
| A: MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. [illegible] No. 6.1 + 6.2 | [illegible] /MAT'L. TEMP. 69°F | [illegible] 367 Due 4/22/84 | [illegible] Supp. 2 [illegible] R43-1143 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKL-S | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area around boss

103 Diesel
Piston #1C

SYSTEM 1R43*EDG-103

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole 1 See Sketch | N/A | None | Accept |
| 2 | N/A | None | Accept |
| 3 | 3/16 | Linear | Reject (LDR Issued) |
| 4 | N/A | None | Accept |

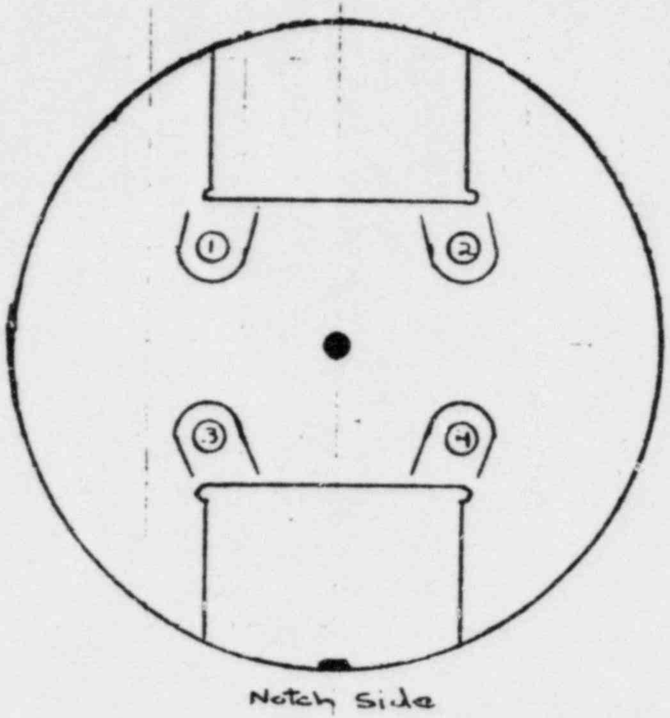
| | | |
|---|---|---|
| D. ACCEPTANCE CRITERIA | Lilco NDE 6.2 Para 4.3.2 | [illegible] E. Hassell / Asst. J. Cavuzzo, J. Pink<br>[illegible] II<br>[illegible] 11/9/83 |

E. ATTEST Earl Hassell — II — 11/9/83

RESPONSIBLE CERTIFIED PERSONNEL — LEVEL — DATE

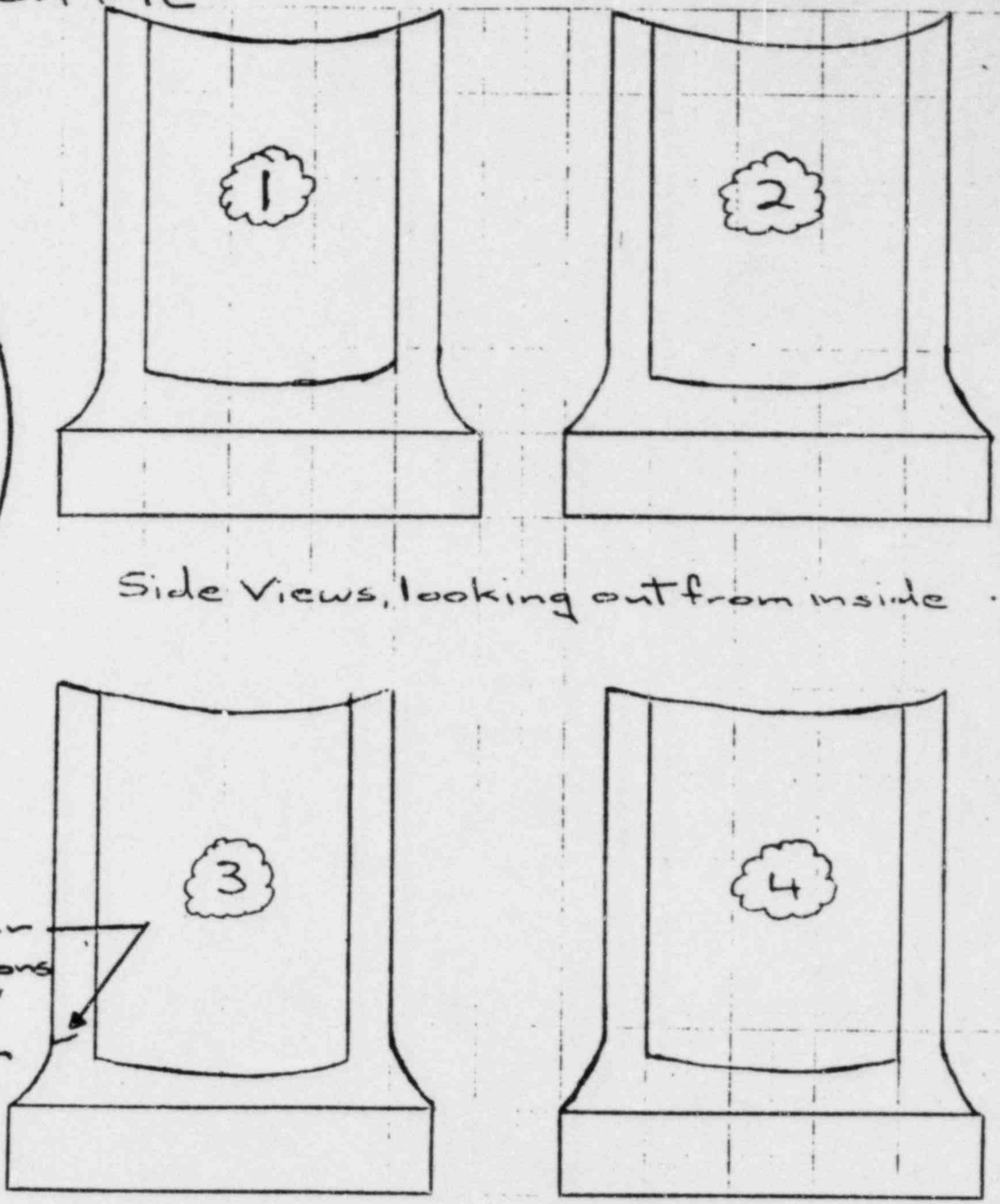
PLAN. ...TION SNPS-1/Turb P E1.67

# Diesel #103 Piston #1C



Overhead View

**Note**: Started as 2 indications that bled into one "distinct" linear indication after 5 min dwell Time.



Side Views, looking out from inside.

3/16" Linear

LILCO LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY | ☐ PIPE ☐ PLATE ☐ ROD | ☒ OTHER: Piston Skirt |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. [illegible] No. 6.1 + 6.2 | /MAT'L. TEMP. 69°F | [illegible] 367 Due 4/22/84 | [illegible] Supp.2 [illegible] R43.1143 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC-7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC-7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82P111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC-7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area around boss

103 Diesel
Piston #1C

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole<br>1 See Sketch | N/A | None | Accept |
| 2 | N/A | None | Accept |
| 3 | 3/16 | Linear | Reject (LDR Issued) |
| 4 | N/A | None | Accept |

| | | |
|---|---|---|
| D. [illegible] | Lilco NDE 6.2<br>Para 4.2.2 | OPERATOR E. Hassell / ASST. J. Cocuzza<br>J. Pink<br>LEVEL II DATE 11/9/83 |

| | | | |
|---|---|---|---|
| E. ATTEST | Earl Hassell | II | 11/9/83 |
| | RESPONSIBLE CERTIFIED PERSONNEL | LEVEL | DATE |

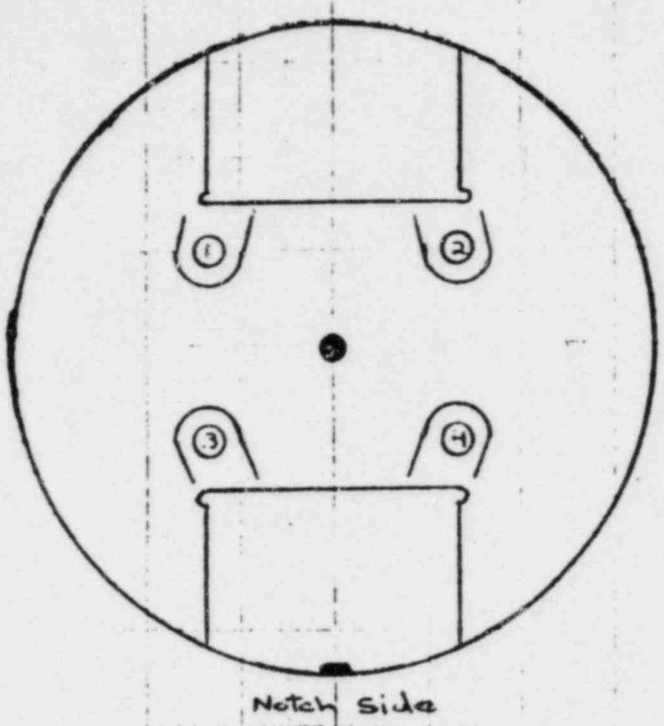
PT

COMPONENT I.D. Piston Skirt #1C

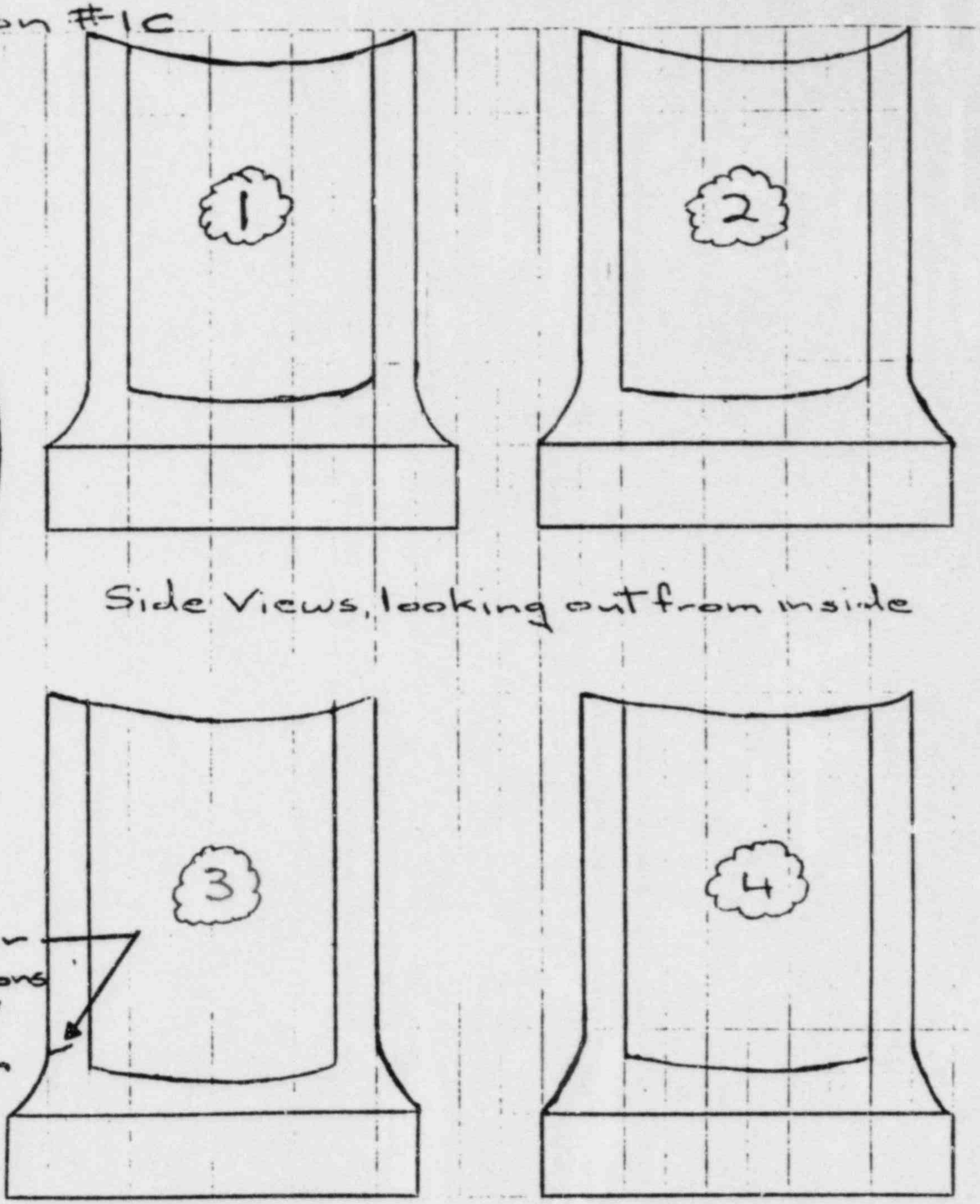
SYSTEM 1R43*EDG-103

PLAN. ATION SWP3-1/Turb Dk. El. 63'

# Diesel #103 Piston #1C



Overhead View



Side Views, looking out from inside

3/16" Linear

**Note:** Started as 2 indications that bled into one "distinct" linear indication after 5 min dwell time.

LONG ISLAND LIGHTING

# LIQUID PENETRANT EXAMINATION REPORT

PT

COMPONENT I.D. Piston Skirt #1C

SYSTEM 1R43*EDG-103

PLAN. .TION SWP3-1/Turb PK. El.67'

| | | | |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
| | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt | | |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

| | | | |
|---|---|---|---|
| B. ... 6.1 + 6.2 | /MAT'L. TEMP. 69°F | .367 Due 4/22/84 | .Supp.2 .R43.1143 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | magnaflux | SKC-NF/ZC7B | 82J083 |
| 2. PENETRANT | ↓ | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | ↓ | SKC-NF/ZC7B | 82J083 |
| 4. DEVELOPER | ↓ | SKD-NF | 82P111 |
| 5. POST EXAMINATION CLEANER | ↓ | SKC-NF/ZC7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area around boss

103 Diesel
Piston #1C

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE.

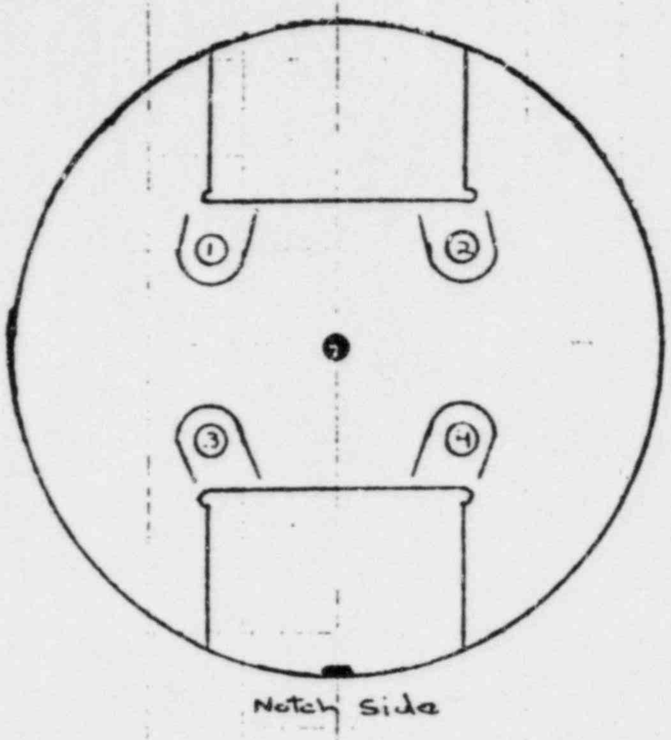
| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole<br>1 See Sketch | N/A | None | Accept |
| 2 | N/A | None | Accept |
| 3 | 3/16 | Linear | Reject (LDR Issued) |
| 4 | N/A | None | Accept |

| | | |
|---|---|---|
| D. ... | Lilco NDE 6.2<br>Para 4.2.2 | OPERATOR E. Hassell / Asst. J. Cocuzza J. Pink<br>LEVEL II DATE 11/9/83 |

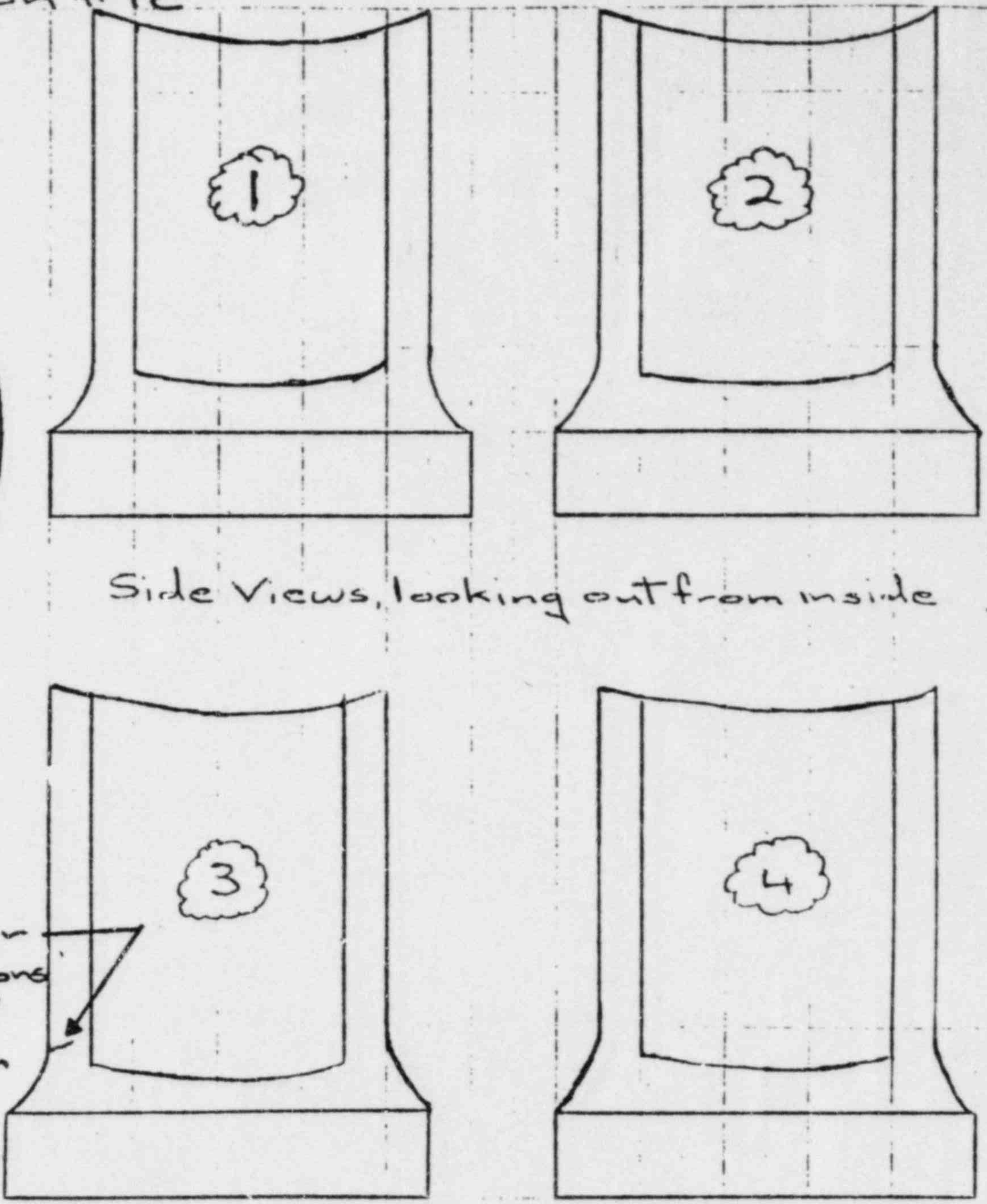
E. ATTEST Earl Hassell — II — 11/9/83

RESPONSIBLE CERTIFIED PERSONNEL — LEVEL — DATE

# Diesel #103 Piston #1C



Overhead View



Side Views, looking out from inside

3/16" Linear

**Note**: Started as 2 indications that bled into one "distinct" linear indication after 5 min dwell Time.

[illegible] LIQUID PENETRANT [illegible] REPORT

**A. MATERIAL**

TYPE: C/S

FABRICATED [illegible]: ☐ WELDED ☒ CAST ☐ WORKED

GEOMETRY: ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER: Piston Skirt

CROSS SECTION THICKNESS: MAX — INCH MIN — INCH

SURFACE CONDITION: ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER

[illegible] 61+62

TEMP 69°F

367 Due 4/22/84

Supp 2 RH3.1143

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH # |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC7B | 82J083 |
| 2. PENETRANT | | SKL-HF/SKL5 | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER | | SKC-NF/ZC7B | 82J083 |
| 4. DEVELOPER | | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | | SKC-NF/ZC7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area around boss

103 Diesel

Piston #3C

**C. EVALUATION**

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS [illegible] USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole<br>1 See Sketch | N/A | None | Accept |
| 2 | 5/32<br>5/32 | linear<br>Crack | Reject (LDR Issued) |
| 3 | 1/8<br>3/16.1/4 | linear<br>Crack | Reject (LDR Issued) |
| 4 | N/A | None | Accept |

[illegible] Lilco NDE 62 Para 4.2.2

E. Hassell / ASST. J Colarezzi J Pink II 11/9/83

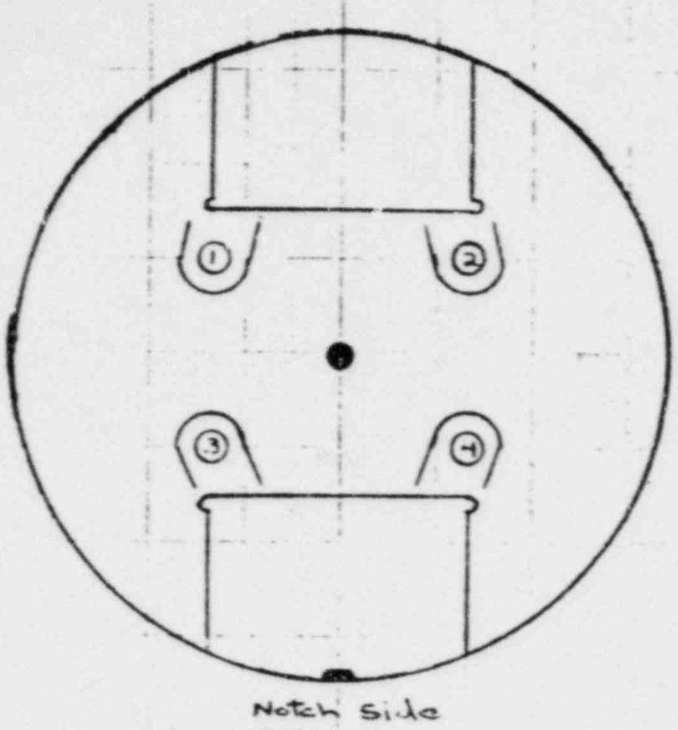
E. ATTEST Earl I Hassell II 11/9/83

COMPONENT I.D. Piston Skirt #3C

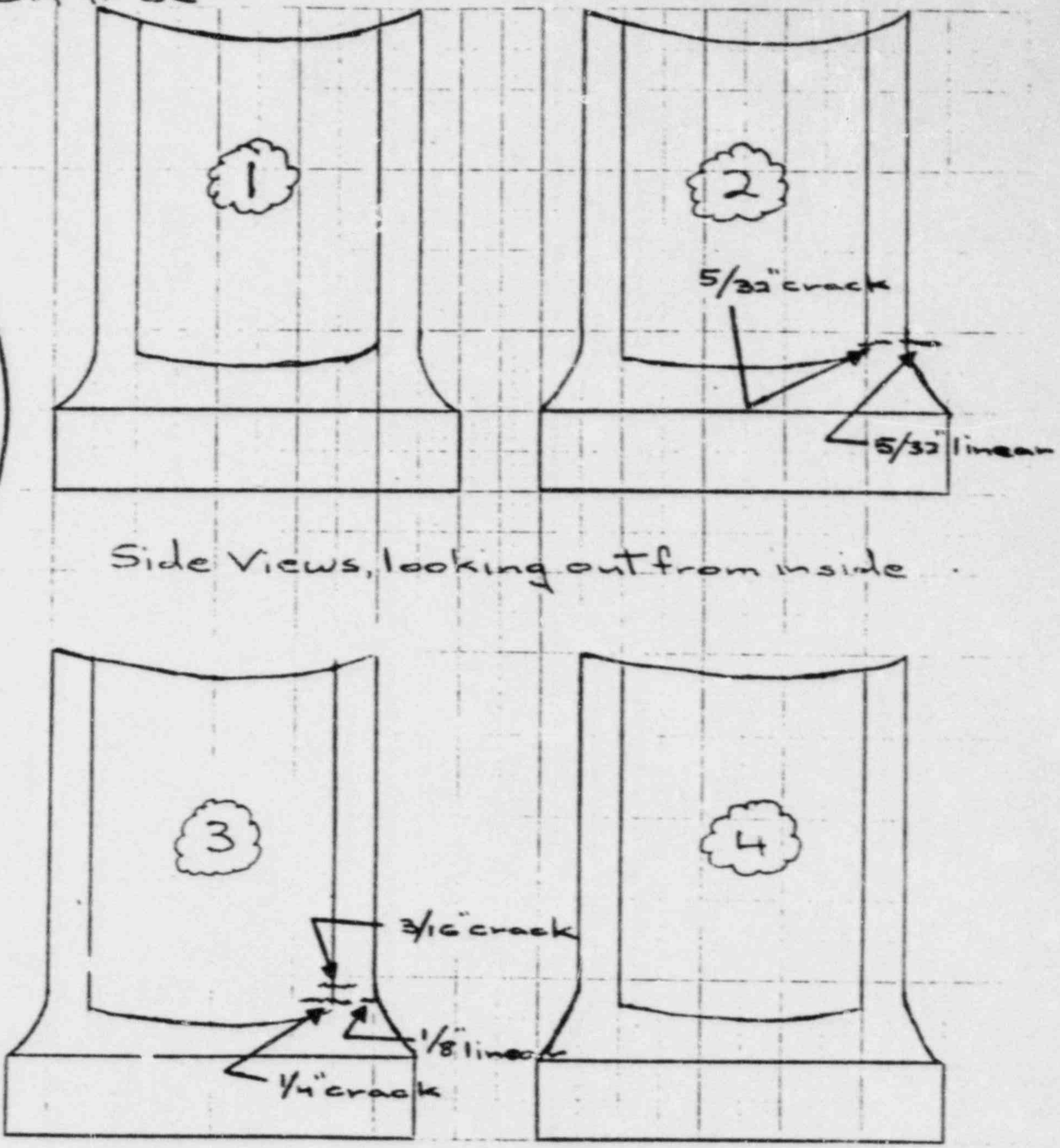
SYSTEM 1R43*EDG-103

LOCATION SWP3 1/Turb Pk E1 6

# Diesel #103 Piston #3C



Overhead View



Side Views, looking out from inside

LIQUID PENETRANT EXAMINATION REPORT

|  |  |  |  |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED PROCESS | ☐ WELDED ☒ CAST ☐ WORKED |
|  | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER Piston Skirt |  |  |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |

|  |  |  |  |
|---|---|---|---|
| 61+62 | TEMP 67°F | 367<br>Dre 4/22/84 | Supp 2<br>R43.1143 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC7B | 82J083 |
| 2. PENETRANT | ↓ | SKL-HF/SKL5 | 7Dc73 |
| 3. EMULSIFIER AND/OR REMOVER | ↓ | SKC-NF/ZC7B | 82J083 |
| 4. DEVELOPER | ↓ | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | ↓ | SKC-NF/ZC7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area around boss

103 Piece 1

Piston #4C

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS NEEDED USE OTHER SIDE.

| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT IF NECESSARY) |
|---|---|---|---|
| 1 Bolt Hole See Sketch | N/A | None | Accept |
| 2 ↓ | 3/32, 3/16 | linear | Reject (LPR Issued) |
| 3 ↓ | 1/4 | linear | ↓ |
| 4 ↓ | 7/16 | Crack | ↓ |

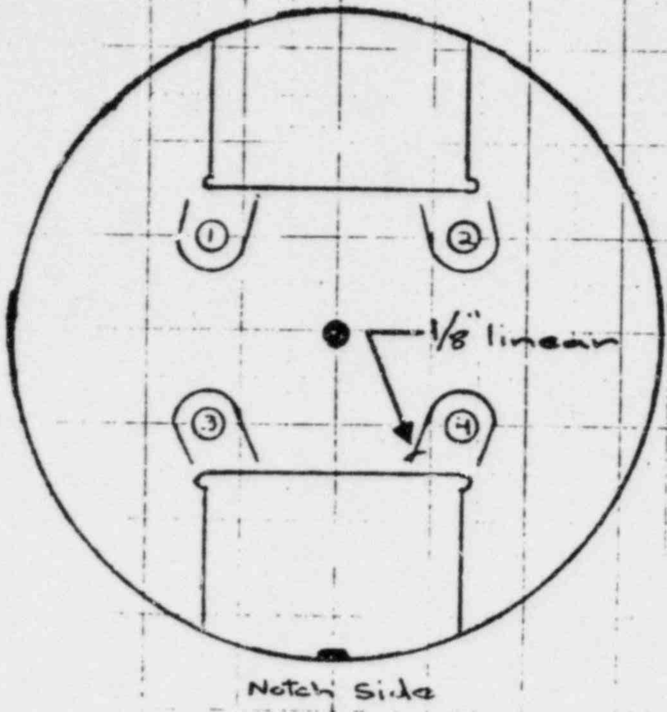
|  |  |  |  |
|---|---|---|---|
| D. | Lilco NDE 62<br>Para 4.2.2 | E. Hassell / II | Asst. J Cruzzu<br>J Pink<br>11/9/83 |
| E. ATTEST | Earl Hassell | II | 11/9/83 |

COMPONENT I.D.: Piston Skirt #4C

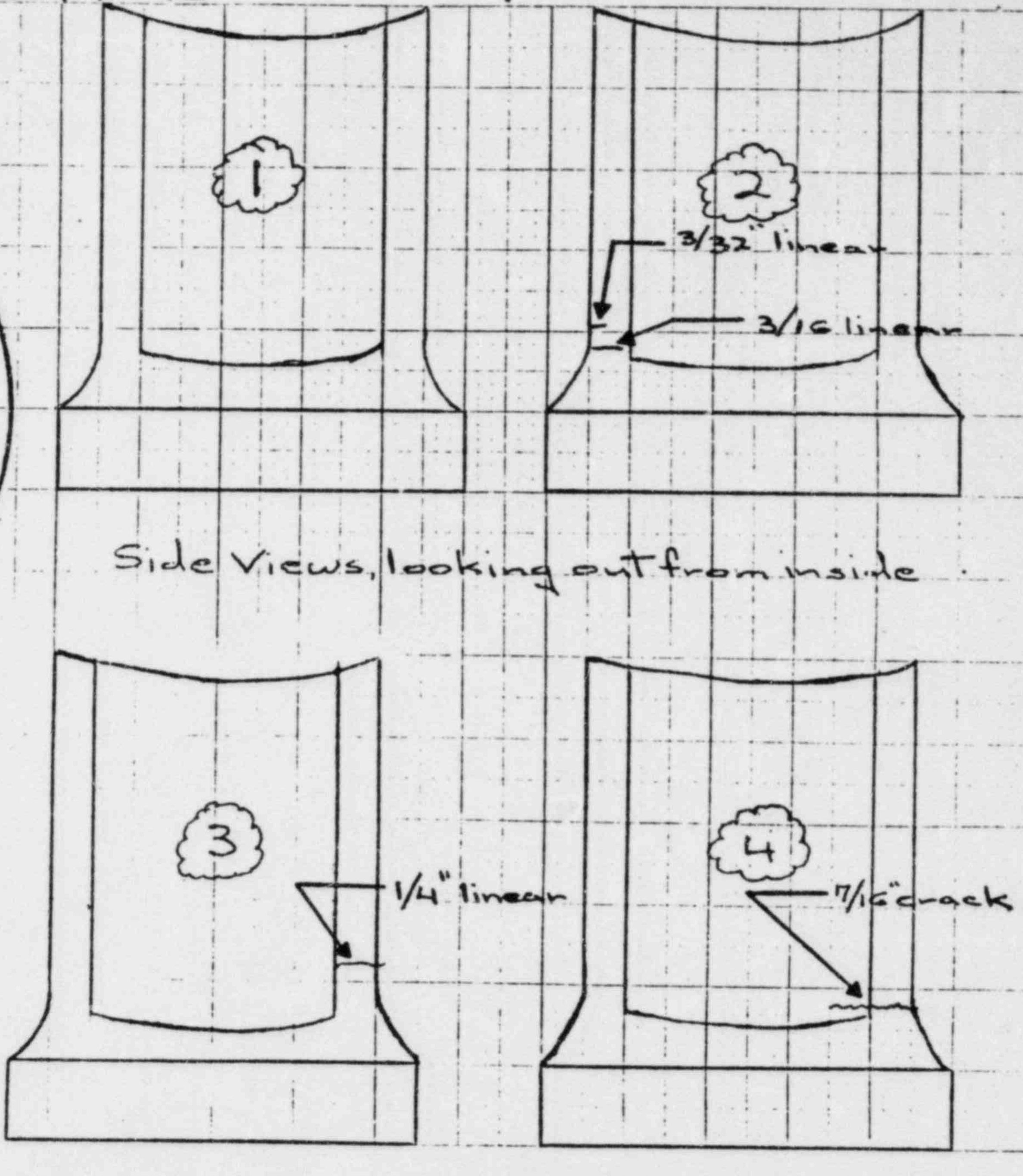
SYSTEM: 1R43*EDG-103

W.A. [illegible]TION: SNP3-1/Tech PR. E1.G3

Diesel #103 Piston #4C



Overhead View



Side Views, looking out from inside

[illegible]

|  |  |  |
|---|---|---|
| A. MATERIAL | TYPE C/S | FABRICATION PROCESS ☐ WELDED ☒ CAST ☐ WROUGHT |
|  | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER Piston Skirt |  |

| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION | ☒ MACHINED ☐ GROUND<br>☐ AS FABRICATED ☐ OTHER |
|---|---|---|---|---|

|  |  |  |  |
|---|---|---|---|
| 61 + 62 | TEMP. 69°F | 367<br>Due 4/22/84 | Supp 2<br>R43 1143 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | Magnaflux | SKC-NF/ZC7B | 82J083 |
| 2. PENETRANT |  | SKL-HF/SKLS | 7D073 |
| 3. EMULSIFIER AND/OR REMOVER |  | SKC-NF/ZC7B | 82J083 |
| 4. DEVELOPER |  | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER |  | SKC-NF/ZC7B | 82J083 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area around boss

103 Diesel

Piston #5C

| C. EVALUATION | REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS REQUIRED USE OTHER SIDE. |
|---|---|

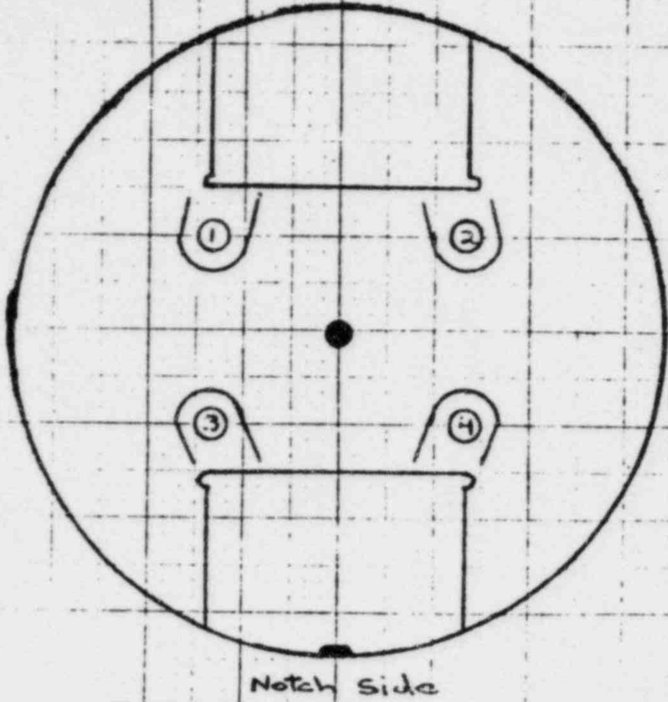
| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENT AS NECESSARY) |
|---|---|---|---|
| Bolt Hole<br>1 See Sketch | 1/8, 1/4 | Cracks | Reject (LDR Issued) |
| 2 | 1/16<br>5/16 | linear<br>Cracks | Reject (LDR Issued) |
| 3 | N/A | None | Accept |
| 4 | 3/16, 1/4 | Cracks | Reject (LDR Issued) |
| D. | Lilco NDE 62<br>Para 4.2.2 | E. Hassell / Asst. J Crozza, J. Pink<br>II | 11/9/83 |
| E. ATTEST | Earl Hassell | II | 11/9/83 |

COMPONENT I.D. Piston Skirt #5C

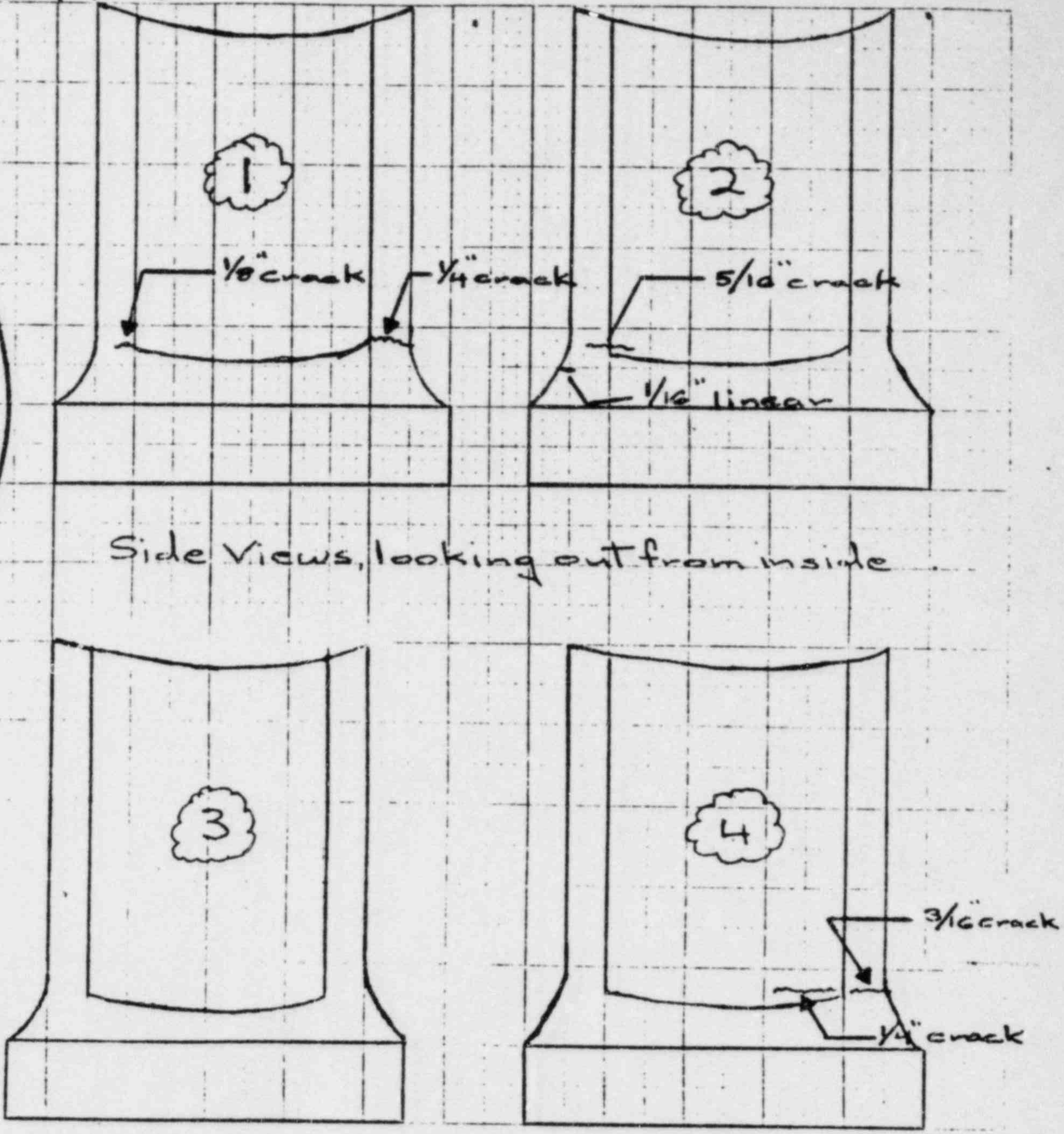
SYSTEM 1R43*EDG-103

LOCATION SNPS-1/Turb Pk 61, 62

# Diesel #103 Piston # 5C



Overhead View



Side Views, looking out from inside

|  |  |  |  |
|---|---|---|---|
| A. MATERIAL | TYPE c/s | FABRICATED [illegible] | ☐ WELDED ☒ CAST ☐ WROUGHT |
|  | GEOMETRY ☐ PIPE ☐ PLATE ☐ ROD ☒ OTHER Piston Skirt |  |  |
| CROSS SECTION THICKNESS | MAX — INCH | MIN — INCH | SURFACE CONDITION ☒ MACHINED ☐ GROUND ☐ AS FABRICATED ☐ OTHER |
| 61+62 | TEMP 69°F | 367<br>Dae 4/22/84 | Supp 2<br>R43.1143 |

| INSPECTION MATERIALS | BRAND | DESIGNATION | BATCH NO. |
|---|---|---|---|
| 1. PRE-CLEANER | magnaflux | SKC-NF/ZC7B | 82JO83 |
| 2. PENETRANT | ↓ | SKL-HF/SKL5 | 7DC73 |
| 3. EMULSIFIER AND/OR REMOVER | ↓ | SKC-NF/ZC7B | 82JO83 |
| 4. DEVELOPER | ↓ | SKD-NF | 82D111 |
| 5. POST EXAMINATION CLEANER | ↓ | SKC-NF/ZC7B | 82JO83 |

SKETCH OR OTHER DETAIL: USE OTHER SIDE IF NECESSARY

Examined machined area around boss

103 Diesel
Piston #6C

C. EVALUATION

REPORT BELOW THOSE INDICATIONS OBSERVED AND THE PERTINENT INFORMATION REQUIRED. WHERE ADDITIONAL SPACE IS NEEDED USE OTHER SIDE.

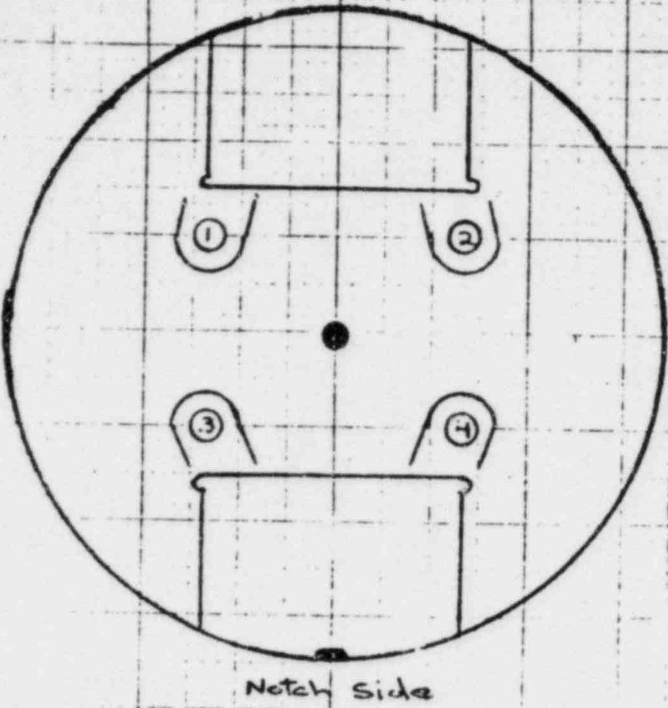
| LOCATION | SIZE (INCHES) | DESCRIPTION | ACTION (ACCEPT/REJECT, AND COMMENTS IF NECESSARY) |
|---|---|---|---|
| Bolt Hole | 1/8, 3/16 | linears |  |
| 1 See Sketch | 3/8 | Crack | Reject (LDR Issued) |
| 2 ↓ | 3/32 | linear | ↓ |
| 3 ↓ | 3/8 | Crack | ↓ |
| 4 ↓ | N/A | None | Accept |
|  | Lilco NDE 62<br>Para 4.2.2 |  | E. Hassell / Asst. J. Colazzo, J. Pink<br>II 11/9/83 |
| E. ATTEST | Earl Hassell | II | 11/9/83 |

COMPONENT I.D. Piston Skirt #6C

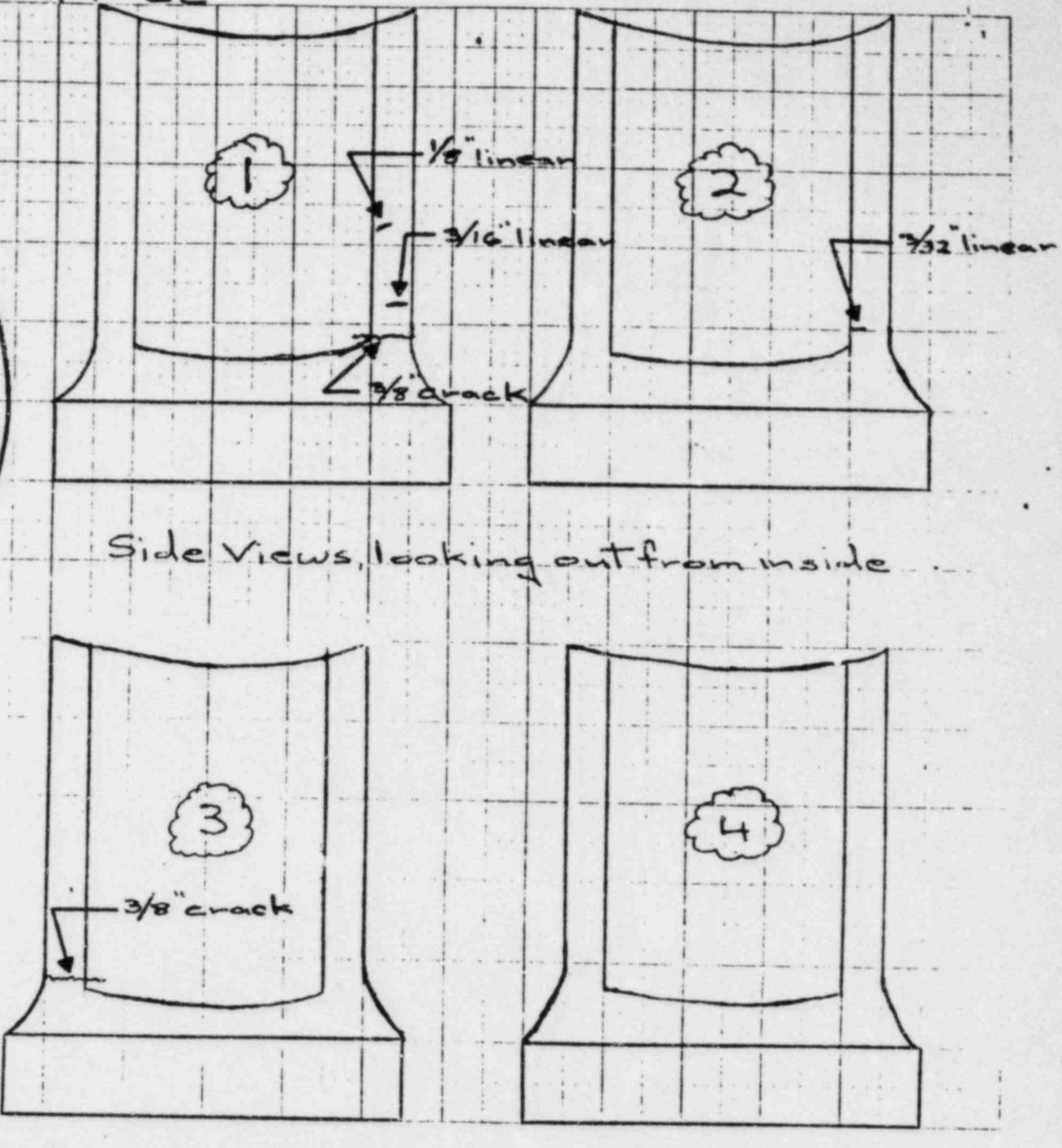
SYSTEM 1R43*EDG-103

LOCATION SNPS 1/Turb Pk El 63

Diesel #103 Piston #6C



Overhead View

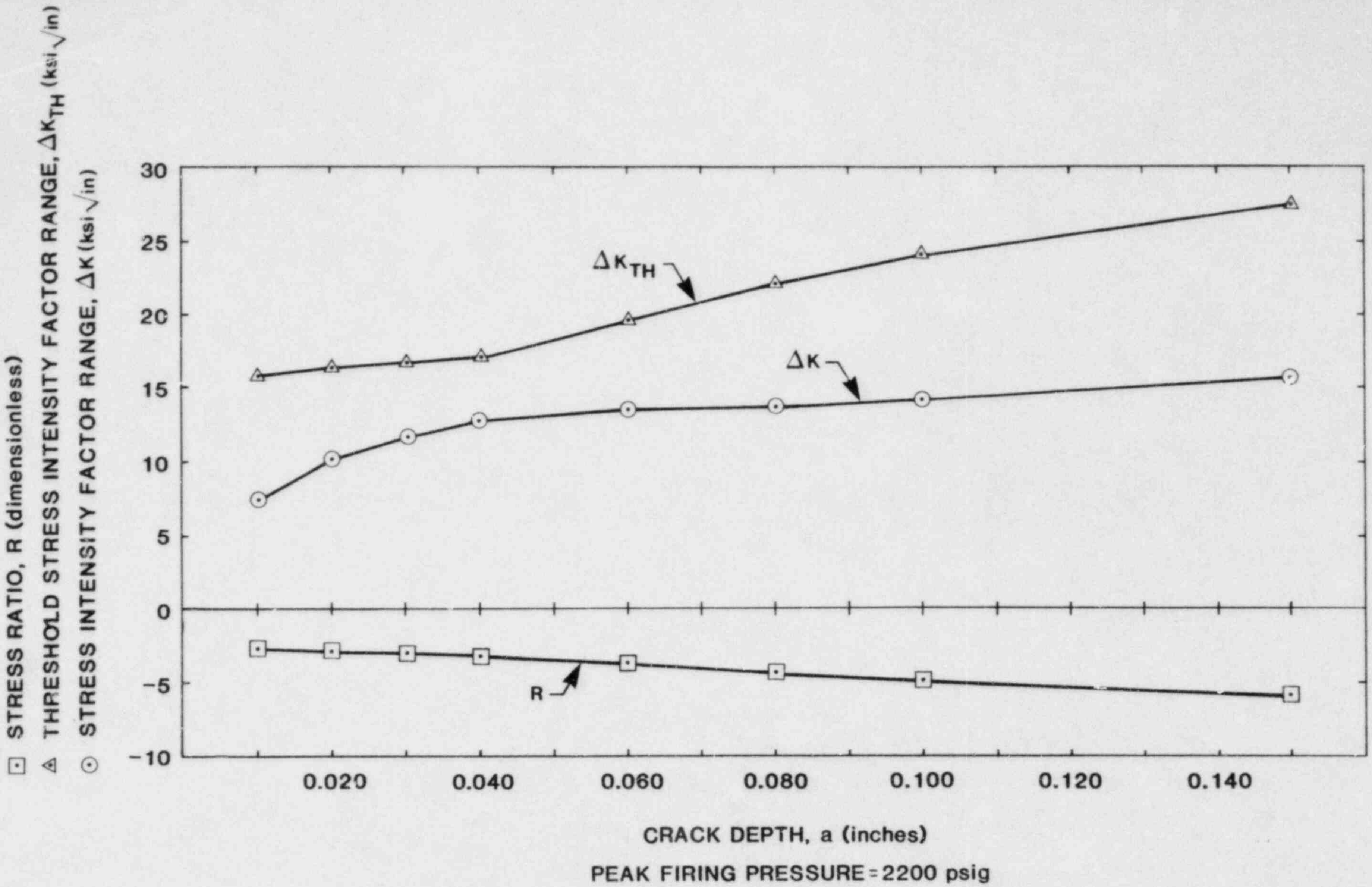


Side Views, looking out from inside

## MINIMUM AND MAXIMUM STRESSES IN AE PISTON SKIRT FOR VARIOUS PEAK FIRING PRESSURES FOR ISOTHERMAL AND STEADY-STATE OPERATING CONDITIONS

(initial gap equals 0.007 inch, uses "nominal" stiffnesses)

| | isothermal | | steady-state | |
|---|---|---|---|---|
| peak firing pressure, psig | $\sigma_{min}$ ksi | $\sigma_{max}$ ksi | $\sigma_{min}$ ksi | $\sigma_{max}$ ksi |
| 1670 | -59.7 | 1.77 | -42.7 | 7.74 |
| 2000 | -69.4 | 1.77 | -52.3 | 7.74 |
| 2200 | -75.1 | 1.77 | -58.1 | 7.74 |


⊡ STRESS RATIO, R (dimensionless)
△ THRESHOLD STRESS INTENSITY FACTOR RANGE, $\Delta K_{TH}$ (ksi$\sqrt{in}$)
⊙ STRESS INTENSITY FACTOR RANGE, $\Delta K$ (ksi$\sqrt{in}$)
30
25
20
15
10
5
0
-5
-10
$\Delta K_{TH}$
$\Delta K$
R
0.020
0.040
0.060
0.080
0.100
0.120
0.140
CRACK DEPTH, a (inches)
PEAK FIRING PRESSURE=2200 psig

FaAA-M-84-8-1