BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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In the matter of)
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(Shoreham Nuclear Power Station,)
Unit 1))

DEPOSITION OF ROBERT TAYLOR, P.E.

May 10, 1984

REPORTED BY:
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COMPUTERIZED TRANSCRIPT

CYLINDER BLOCK AND LINER

I. COMPONENT DESCRIPTION AND APPLICABILITY

A cylinder clock is one of the key structural components of an engine. It forms the framework of the engine. Among other attributes a cylinder block supports the cylinder liners, provides passages around the cylinder liner for liquid cooling, reacts the firing loads, and supports the cam shaft.

Cylinder blocks are comparable within engine classes and in the block top region are comparable across classes.

II. COMPONENT HISTORY

Cylinder blocks are being studied because cylinder block cracks have been reported in the data base. Cracks have been found in the block top on the M/V Columbia and cracks have been found in the block top and cam bearing supports on the SNPS engines.

Two types of block top cracks are reported in the data base: radial cracks extending outward from the cylinder bore in the vicinity of the cylinder head studs and circumferential cracks extending outward from the corner of the block top support for the cylinder liner. Both types of cracks were reported for the engine in the M/V Columbia; only the radial cracks have been found in the SNPS engines.

EXHIBIT 1
TAYLOR
MAY 10, 1984
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III. SUMMARY TASK DESCRIPTION

The analysis of block cracks began with review of SNPS engine inspection reports. Cylinder block cracks were identified using visual, liquid penetrant, ultrasonic and eddy current techniques. Existing cracks have been characterized by location and configuration.

Analysis of block top cracks will include analytical modeling of block loads to determine steady state and alternating stresses in the cracked regions. Sources of stress in the block top are due to preload and operational loads. Two sources of preload are cylinder head stud forces and cylinder head/cylinder liner vertical forces. Operational loads include firing pressure and thermal gradients.

Analytical values of stress will be compared to those values measured experimentally using strain gauge techniques on SNPS engine 103.

Fracture mechanics will be used to predict crack growth rates under conditions of predicted stress states for engines based on existing crack dimensions.

IV. SUMMARY OF WORK DONE TO DATE

Accomplishments to date include inspection of SNPS engine

IV. SUMMARY OF WORK DONE TO DATE (Continued)

blocks 101, 102 and 103 after an endurance run of 100 hours at full load. Bloc, top cracks have been accurately mapped for the three engines. Subsequently one engine, 102, was cycled through 100 starts and was then reinspected. Preexisting cracks did not measurably propagate during the 100 starts.

The between cylinder regions of cylinder block 103 were strain gauged and stresses recorded during slow starts, quick starts to full load, a LOOP/LOCA simulation, and steady state operation at 0, 873, 1500, 2000, 2500, 3500, and 3792, KW. Results of strain gauge testing quantified stresses relevant to radial block top cracks. Significant influences on this type of crack were confirmed to be cylinder head stud preload and thermally induced loads. Measured stress levels increased with increasing power.

The analytical effort is nearing completion. Computation of stresses near the cylinder bore will be used to predict expected crack growth during operation for engines with radial cracks and inspection frequency for engines currently without such cracks.

A second analytical model is being used to determine the effect of cylinder liner protrusion above the cylinder block top

IV. SUMMARY OF WORK DONE TO DATE (Continued)

and its effect on circumferential cracks.

A previously prepared report describing the sources of cam galley bearing support cracks by Isleib, and TDI performed cam galley stress measurements have been reviewed. Based on inspected size of cam galley cracks on SNPS engines the expected crack growth rates have been computed. Crack growth rates are small at full load and are negligible at and below 2625 kw. These cam galley cracks are not a concern for interim operation.

V. INSPECTIONS CONDUCTED TO DATE

Cylinder blocks 101, 102, and 103 at SNPS have been inspected for block top cracks. Each block was inspected after the 100 hours full power endurance run. Each block had radial block top cracks and block 103 had a between stud crack on the exhaust side between cylinders 4 and 5. No circumferential cracks have been found.

Subsequently engine 103 was run extensively at full load. While running at full load it also experienced an abnormal load condition when offsite power was lost. This load cycle was not representative of LOOP/LOCA condition, but was more severe. Afterwards while running at 3900 kw additional block top cracking was noted. The block top was inspected and between stud radial cracks were found to exist at six locations.

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V. INSPECTIONS CONDUCTED TO DATE (Continued)

Two cylinder blocks at Commanche Peak have been inspected for cracks. Shallow indications of radial type cracks were identified. This engine has approximately 85 hours. Metallurgical examination of crack surfaces has shown them to be casting induced rather than service induced.

Cylinder blocks at Catawba are currently being inspected and so far no cracks have been found. These engines have experienced approximately 850 hours of operation.

VI. PRELIMINARY CONCLUSIONS AND OWNER GROUP RECOMMENDATIONS

For radial block top cracks the predominate influence is thermal stress and the secondary influence is preload caused by the cylinder head stud. This conclusion is based on analytical and experimental results performed to date. Based on analysis and inspections to date, we believe preliminarily that the V-engine blocks are adequate for interim operation. The R-48 blocks may also be adequate for interim use but further analysis is required.

Circumferential cracks at the liner landing appear to be caused by high vertical loads imposed on the cylinder liner by the cylinder head. This preliminary conclusion is based on analytical models. TDI recommends reduction of liner protrusion

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VI. PRELIMINARY CONCLUSIONS AND OWNER GROUP RECOMMENDATIONS (Continued)

above the cylinder block from previous specified liner heights to .000 to .003 inches to conform with current practice. Analysis of the beneficial effect of this modification is incomplete, but it is noteworthy that this type of crack has not been identified on engines at Shoreham, Commanche Peak or Catawba.

VII. REMAINING WORK AND SCHEDULE FOR COMPLETION

The following work remains to be completed. The anticipated completion date is May 15th.

1. Analytical model of radial block top cracks.
2. Fracture mechanics predictions of crack growth rates for engines with block top cracks.
3. Fracture mechanics predictions of inspection frequency for engines without radial block top cracks.
4. Analytical model of circumferential block top cracks and the effect of liner heights.
5. Development of recommendations for reducing block top stresses.
6. Finish analysis of cam galley bearing support bearing support crack growth rates.
7. Fracture toughness testing of SNPS cylinder block 103.
8. Documentation of metallurgical examinations of fracture surfaces from the casting induced flaws in the engine block at Commanche Peak.

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VII. REMAINING WORK AND SCHEDULE FOR COMPLETION (Continued)

9. Complete report describing experimental test results from strain gauge test of engine 103 at SNPS..

10. Prepare a report summarizing cylinder block analyses.