Cooper-Bessemer Reciprocating Products Division
Cooper Industries, Inc.
Grove City, PA

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Torsional Vibration Analysis of Repaired Crankshaft
KSV-20-T SN-7187
Arizona Public Service Company
Palo Verde Nuclear Generating Station
Diesel Generator III-B

The number nine (9) crankpin of the crankshaft in this engine was damaged as a result of the master connecting rod failure on 12-23-86. In order to restore the bearing surface of this crankpin to original specifications, the diameter was remachined from its original value of 11.499±0.001 inches to 11.323±0.001 inches. This report addresses the effect of this change on the torsional vibration characteristics of the engine, as well as the effects of off-design operation immediately following the failure.

Off-Design Operation

Immediately following the master rod failure, the engine operated for approximately 45 minutes at a speed of about 296 rpm, due to the inability to isolate the damaged engine from all potential sources of air and fuel. There was no load on the engine during this period.

A torsiograph test was performed on an identical diesel generator, SN-7183, in 1978. This test indicated the engine mode natural frequency for these units is 1430 cycles/minute, which would place the major 5th order critical at 286 rpm. Calculations have been made for the crankshaft stress at the peak of this 5th order critical under no load conditions. These calculations indicate the maximum vibratory stress in the crankshaft would be ±1.93 ksi. Since this value is well below the normal limit of ±5.0 ksi for continuous operation there would be no damage to the crankshaft from operation under these conditions.

Reduction in Pin Diameter

The reduction in the diameter of the #9 crankpin from 11.499 inches to 11.323 inches is a change of 1.53 percent. The change in the torsional stiffness of this crankpin will be 5.9 percent, but this pin represents less than 10 percent of the total effective stiffness of the shaft, so the effective stiffness will only be reduced about 0.6 percent. This will alter the torsional natural frequency by less than 0.3 percent, which is insignificant.

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The reduction in diameter will increase the torsional stress in the crankpin by 4.7 percent. From the 1978 torsiograph test results, the maximum crankshaft stress at any speed within 10 percent of rated speed was ±3.75 ksi. This stress occured at the 2-1/2 order peak at 570 RPM With the reduction in diameter, the stress from this critical will be ±3.93 ksi. This is still well below the normal limit of ±5.0 ksi, so the reduction in crankpin diameter will have no adverse effect on the performance of this crankshaft.

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