

## SOURCE OF DAMAGE DETERMINED FOR GAS TURBINE ENGINES

An ESi investigation proving manufacturer defect prior to transport damage results in a reduced claim settlement for the client.

### SITUATION

Three aeroderivative gas turbine packages were shipped via sea and land from the United States of America (USA) to Australia.

Aeroderivative gas turbines are lighter weight versions of a gas turbine. They are designed so that fuel and air are mixed and then ignited to provide power. These three turbine packages were valued at approximately US\$7 million each. For transport, they were placed inside containers with a turbine-specific transport cradle to reduce shock and vibration.

On the final leg of the journey, the containers were transported on trailers without air-ride suspension, which was in violation of the transport specifications.

The units were rejected and shipped back to the USA for evaluation. ShockWatch® sensors were installed to record any vibration and shock events on their return journey.

After their arrival to the USA, an evaluation by others determined that bearing damage had occurred and was related to the transport in Australia on the non air-ride trailers.

ESi was asked by the insurer to evaluate the condition of the three turbines, determine causation of any detected damage, and advise on proper disposition of the three turbines.

**Practice:** Mechanical

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#### Services Utilized:

- Microscope
- Videoscope
- Design Analysis
- Data Analysis
- Vibration Analysis

#### About ESi

For over 30 years, ESi has leveraged it's multidisciplinary team of engineers, scientists, and professional technical staff to investigate many major accidents and disasters. Our technical expertise, hands-on experience and state-of-the-art facilities, combined with diagnostic, analytical and physical testing capabilities create an ideal environment for quickly identifying and interpreting the facts of a case.

#### Contact ESi

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## SOLUTION

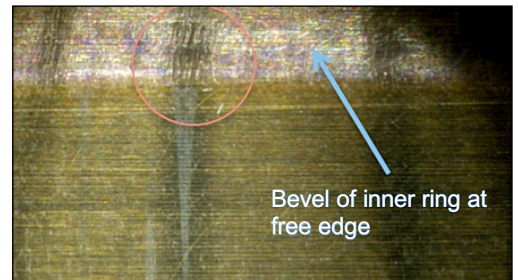
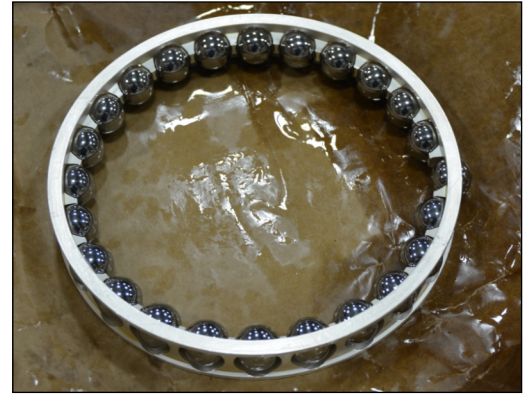
After an initial visual inspection of the partially disassembled units, the manufacturer removed and disassembled all five roller bearings and two ball bearings from each turbine.

ESi utilized a portable microscope and videoscope to inspect each bearing component at magnifications of up to 250x. The components inspected included the inner ring, outer ring, balls and cylinders.

This inspection showed distinct marks related to the installation of the units in the form of brinelling, or permanent indentations, and sliding marks on the inner ring, emanating from the free edge of the inner ring towards the raceway. It also indicated brinelling marks on the inner ring's raceway due to shock loading. ESi also identified false brinelling and fretting, or wear and corrosion, on the inner ring and rollers relating to vibratory transport damage.

The ESi data analysis including a Fast Fourier Transformation (FFT) analysis of the recorded shock and vibration data revealed severe loading conditions in excess of the transportation specification during the return trip.

The observed shock and vibration damage could have been related to either the delivery or return trip. However, the observed sliding damage and circumferential dimpling of rollers was clearly related to original assembly and test operation of the units. The vibration analysis also addressed some erroneous data filtering statistics produced by the insured.



## RESULTS

ESi determined that the primary damage to the turbines was related to installation, followed by subsequent damage to the rollers and raceway during their factory test run, where scratches formed on the rollers and pear skin was observed on the most damaged inner raceways.

These damage patterns were then later supplemented by some shock load related damage. In some cases this caused a single brinelling mark while in other cases multiple marks were clustered into a multitude of narrow bands on the raceway of each bearing. The identification of brinelling marks on the main thrust bearing indicated a severe shock load event commensurate with an event recorded on the return trip.

Due to the detection of manufacturing defects and the severe loading conditions the three units experienced during the return trip, the insurer was able to settle the claim at a cost significantly below the purchase price contrary to the initial visual inspections that solely identified false brinelling related to the transport.



Engineering Consulting  
and Forensic Investigation

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- Fluid Mechanics
- Fracture Mechanics
- Heat Transfer
- HVAC Analysis
- Risk & Reliability Analysis
- Safety Analysis
- Stress Analysis
- Testing & Instrumentation
- Thermodynamics
- Vibration & Modal Analysis