C33 Unusual Failure Modes of Large Diesel Generators in Bangladesh

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After attending this presentation, attendees will have a better appreciation of difficult operating environments for these very large engines, and the local challenges in a developing country such as Bangladesh. Furthermore, classic investigating techniques are still useful even in the face of extreme destruction.

This presentation will impact the forensic science community by emphasizing how conventional forensic engineering techniques still yield results even if the odds are poor.

Large diesel engines operating on compressed natural gas or heavy fuel oil are used in electrical generating stations. These engines operate at a nominal 500rpm, are turbocharged and intercooled, and can generate on the order of 17MW per engine.

One such installation utilizes eight engines and is located on a barge in Bangladesh, providing 118MW of power to the local grid. Due to local power dispatch requirements, these engines are often stopped and re-started as load demand fluctuates. These engines accumulate many hours and many start-stop cycles. This project had accumulated some 500,000 operating hours, and 69,000 stop-start cycles during a fourteen-year operating history.

One engine had failed four years earlier, and two more engines failed catastrophically over a period of several months, and in spite of investigations by the manufacturers and other parties to the project, no satisfactory root cause was determined.

After the most recent catastrophic event in February of 2011, an investigator was sent to Dhaka, Bangladesh, to investigate the most recent failure.

The debris field was preserved for this investigation and will be shown through diagrams and photographs. The presentation will systematically present the general scene and then guide the discussion to the preliminary findings. A catastrophic failure is characterized by connecting rod separation, ejected pistons, ejected counterweights, fractured blocks, and damage to adjacent engines. A massive failure of this type requires the replacement of the entire block, a very difficult and expensive process, especially in a relatively remote location with logistic challenges. As in many such cases, the preservation of the evidence and failure artifacts is paramount.

A surprising twist occurred in this investigation. Although the investigation was to focus only on the most recent failure, in fact, the two previous failures were re-examined in light of the findings. A common failure mode was then developed, namely hydro-locking of these massive engines on start-up. But what was unknown, and a unique aspect of this work, was that multiple instances of hydro-locking could contribute successively to failures that were occurring seemingly at random.

The presentation will review other contributing factors and phenomena that, although independently would not be seen as causative factors, when confounded proved to be important elements in the failure matrix. The key to linking these events was the chance discovery and examination of artifacts from prior failures.

As in many cases, determined detailed examination of failure artifacts, in this case the cylinder liner, proved that the hydro-locking phenomenon was not a single cycle overload event, but rather that these instances could accumulate from multiple occurrences, and that the time of ultimate failure was not easily predictable. This investigation concluded with evidence of the root cause and methodology that would monitor potential failure modes, as well as preventative procedures to mitigate the likelihood of these multi-million dollar failures.

This presentation will show by photographs the important elements of the fact finding, segregation of the engine debris field, metallurgical failure modes, and the final evidence of multiple hydro-lock events.

Diesel, Hydro-lock, Wartsila

 ** Presenting Author*