GAS TURBINE CASE STUDY

Castrol Power

Case Study 2
Gas Turbine Control Valve Varnishing

Plant Description: 2 x GE Frame 9FA Gas Turbines
790MW CCGT Power Station (2 x GT / 1 x ST Configuration)

1. Problem

Two GE Frame 9FA gas turbines installed in a 790MW Combined Cycle Gas Turbine Power Station were suffering poor reliability and availability due to malfunction and failure of the Moog servo control valves. Sticking servo-valves were causing frequent trips resulting in unplanned downtime and consequential trading penalties and loss of production.

2. Background

Failure and malfunction of servo-valves due to varnish deposits on the oil-wetted components is a common problem in gas turbine control systems. This can be a particular problem in combined lubrication and hydraulic control systems where the lubricant is subjected to more severe service and often extreme conditions of temperature and pressure.

Varnish formation is the result of a complex inter-reaction of a number of parameters associated with both oil condition and system operation. As a result of extensive testing, it has been shown to be closely linked with the level of total insolubles in the oil which is, in turn, a function of the sludging propensity of the lubricant.

The total insolubles level is quantified by the Gravimetric "Patch Test" filtering the oil through a 0.8 micron filter membrane. Oil in good general condition coupled with a low level of total insolubles normally results in reliable servo-valve operation. On the other hand, a high level of total insolubles almost invariably results in poor reliability of operation.

3. Operational Experience

During the latter part of 2000, just over two years after initial filling of lubricant into the two GE Frame 9FA machines at this power plant, incidence of servo-valve malfunction and failure was becoming more frequent Oil analysis revealed increasing evidence of heavy degradation of the lubricant, in particular, high acidity, depleted antioxidant and high total insolubles levels (as shown in the attached graph). By early 2001, servo-valve failure was a common occurrence resulting in a serious negative impact on reliability and availability. Servo-valves were being regularly exchanged as complete sets and overhauled on a frequent routine basis in order to minimise the otherwise frequent malfunctions and failures resulting in trips of the gas turbines. Electrostatic precipitation oil cleaning units were being employed in an attempt to control the levels of total insolubles but, whilst this had been partially effective in the early stages, they were ultimately unable to maintain total insolubles at acceptable levels to achieve reliable operation.

4. Solution – Castrol Perfecto XPG

The lubricant used in these gas turbines from installation and commissioning was Castrol Perfecto HPT 32. Formulated around 20 years ago, using leading additive and base oil technology of the time, to meet the requirements of GEK 32568 applicable to the GE Frame 9FA units, Perfecto HPT 32 is giving satisfactory service in many GE gas turbines to the present day. However, in more recent times the Perfecto HPT range has been superseded by lubricant grades offering much lower sludging propensity thereby giving rise to improved system cleanliness and reliability of control system servo-valves.

The leading product in the Castrol range of high performance gas turbine lubricants is Castrol Perfecto XPG which has exceptionally low sludging propensity leading to freedom from varnishing of servo-valve components and taking reliability of these units to a new level. The product is based on leading edge, yet well proven base oil and additive technology incorporating carefully balanced, optimised additive systems and a specially selected, highly refined base stock to produce a robust, high performance turbine oil with the ability to maintain extremely low levels of total insolubles in service giving rise to a high degree of system cleanliness.

During a planned outage in July 2001 the oil was changed in both the GE Frame 9FA gas turbines at this power plant, refilling the systems with Castrol Perfecto XPG 32. The BP "Castrol Plus" site service team was engaged to carry out a full oil change including tank clean and system flush.

5. Post Oil Change Operational Experience

- **Impact on Servo-valve Malfunction and Failures:**
  The immediate effect of the change to Castrol Perfecto XPG was the elimination of reported servo-valve malfunction and failures due to deposits and varnish from lubricating oil.

- **Dramatic Reduction in Total Insolubles:**
  At the same time, a dramatic reduction was observed in the levels of total insolubles in the oil as a result of the extremely low sludge forming propensity of Castrol Perfecto XPG 32. Furthermore, this low level of total insolubles has been sustained to the present time as illustrated in the graph (Appendix I).

- **Requirement for Supplementary Cleaning Systems:**
  The extreme cleanliness in service of Castrol Perfecto XPG 32 effectively eliminated the requirement for electrostatic precipitation or any other fluid cleaning/purification technology in the control of total insolubles levels, demonstrated by the extremely low loading of the precipitator collectors following the oil change.

6. Latest Experience – 4 Years On and Going Forward

Following 4 years trouble-free operation on Castrol Perfecto XPG 32, although the lubricant was still in good condition, the opportunity was taken during a major outage in 2005 to change oil in both units. On inspection, zero sludge was observed in main lubricating oil tank and no varnishing whatsoever of servo-valve components or bearings. The oil was changed, replacing it with a new charge of Castrol Perfecto XPG 32. It is a testimony to the extremely low sludge-forming propensity of the product in service that, due to the cleanliness of the systems, no flushing was deemed to be necessary. A further period of trouble-free operation then commenced up to the present time.

7. Cost

It is difficult to be precise in quantifying the cost to the operation of poor reliability due to servo-valve malfunction as this will clearly vary from one plant to another depending on installed generating capacity, trading arrangements and other variables, and indeed will vary substantially from one resulting trip to another on the same plant depending on duration of trip, impact on despatch and applicable trading penalties etc. It is known however that the overall cost of a trip resulting from servo-valve malfunction on a power plant of this size and configuration can be as high as $1m or more, resulting from:

- Lost Revenue
- Trading Penalties
- Impact on Production Schedules
- Excess Maintenance Costs
- Rectification and Repair Costs

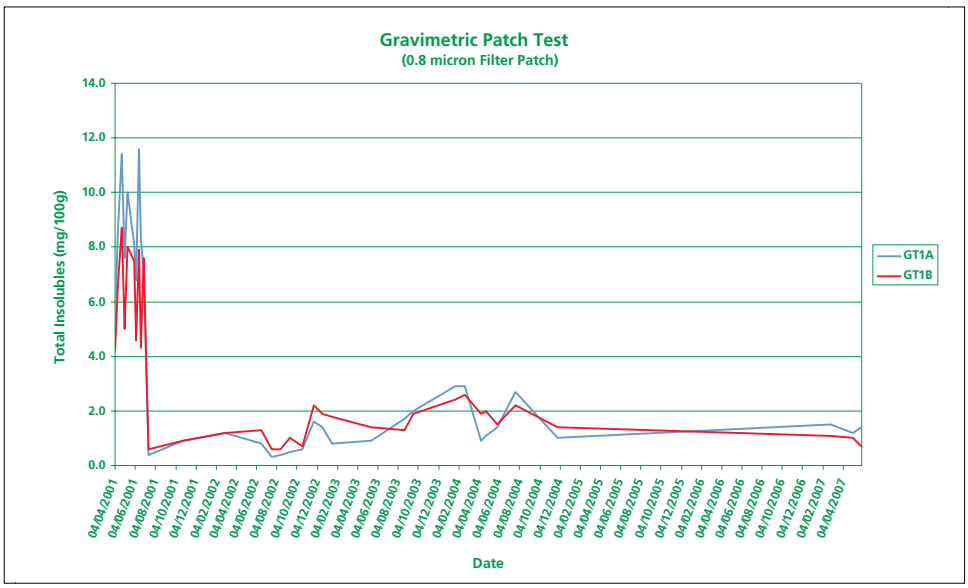
8. Conclusion

Operational experience following the change to Castrol Perfecto XPG 32 saw a dramatic and sustained improvement in reliability and availability making positive and valuable contribution to optimisation of the plant.

Appendix I
GT1A and GT1B Oil Analysis Data

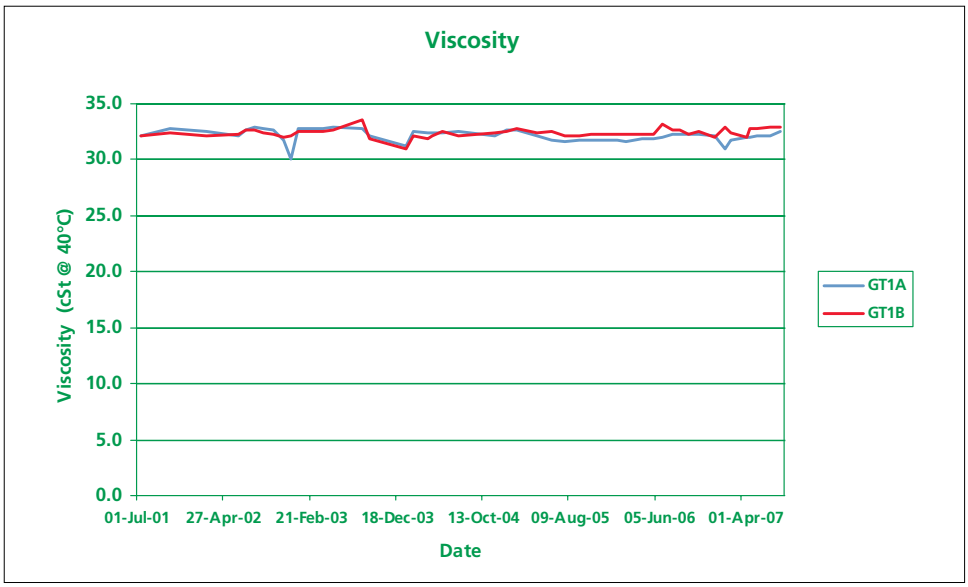
1. Total Insolubles

Note the very high levels of total insolubles (up to 11.6mg per 100g of oil) generated in the systems prior to the oil changes to Perfecto XPG 32, and the sustained low levels (less than 3.0mg per 100g of oil) which followed the first oil change in each unit in July 2001.



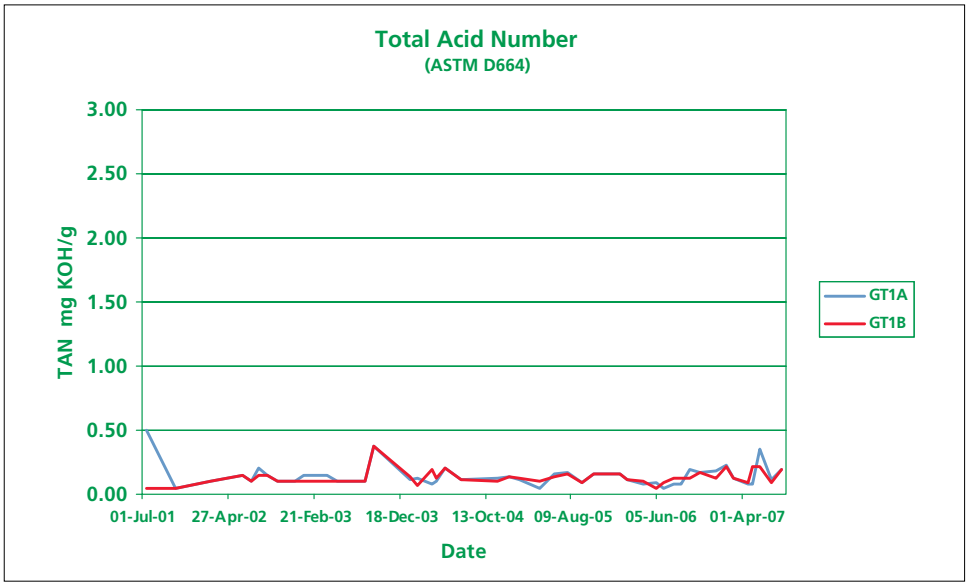
2. Viscosity

Viscosity remained within specification and close to new oil value throughout



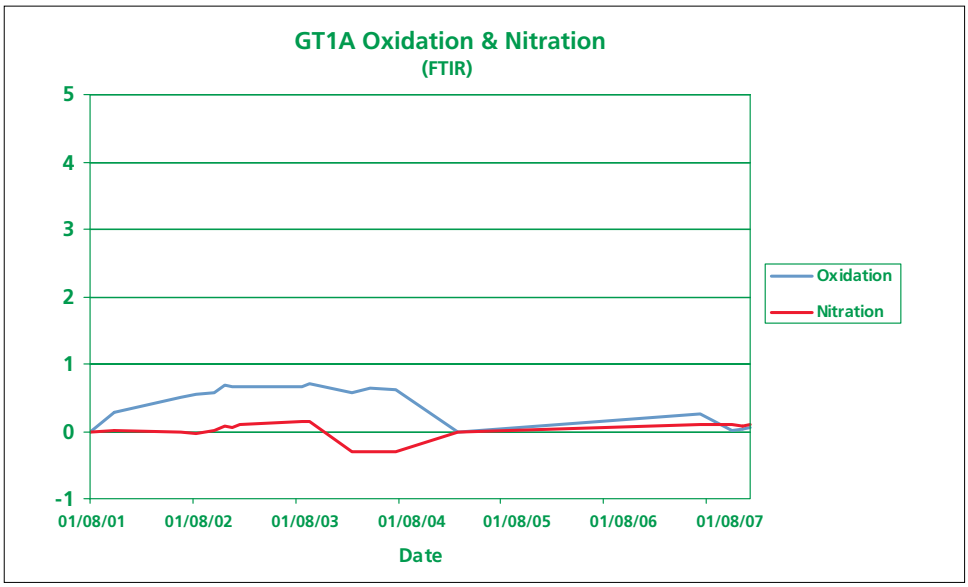
3. Total Acid Number

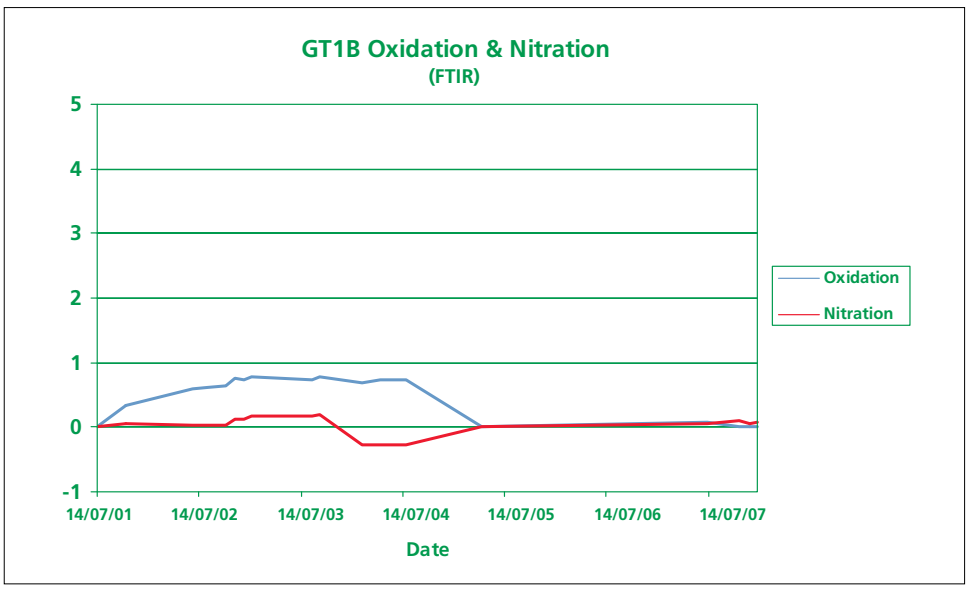
Total Acid Number remained well controlled and trended consistently at a low value throughout



4. FTIR (Oxidation and Nitration)

Both values trended at very low values throughout indicating oil remained in good condition with minimal degradation





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