# Technical Report

BERAN

Proven Condition Monitoring Solutions

## Vibration as a Condition Monitoring Parameter

Generating more power from turbo-alternators is of increasing importance in today's competitive generation market. Some of the ways this can be achieved are by plant modifications or enabling each unit to generate for longer periods between maintenance. Plant maintenance based on need, rather than preventative maintenance can prove effective at keeping the plant operational, whilst saving significant sums of money. In order to adopt this strategy, it is necessary to be able to determine the condition of the plant in a cost-effective and non-invasive manner. There are a number of ways of doing this, but one of the most effective for rotating plant is vibration analysis.

### Vibration Monitoring

Vibration monitoring can be carried out using two main philosophies, depending upon the degree of diagnostic facilities required. The first is monitoring of overall level, which tends to be a measurement normally monitored as a minimum in Station control rooms via a chart recorder. The second is monitoring the individual components and phase that make up the overall level, i.e. "decoding" the overall level (see Figure 1).

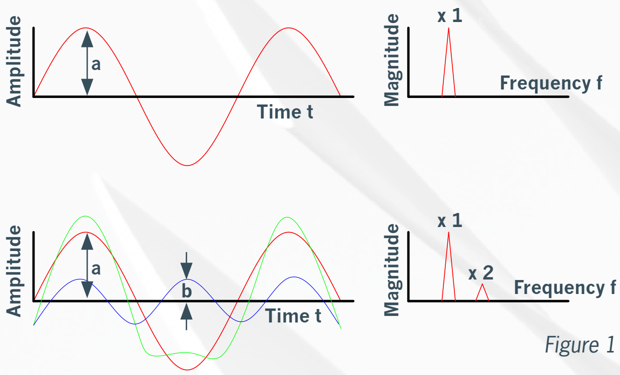



*Figure 1*

Any repetitive and continuous waveform can be broken down into a number of sine waves, each uniquely defined by its amplitude, frequency and phase. It is from these individual components, that significant condition information can be extracted. Beran PlantProtechTM vibration monitoring equipment provides the facility to decode the overall signal into the component parts. These component parts are periodically acquired and stored, along with DC signals such as MW, MVARS, temperatures, pressures, etc., from each machine. The DC signals are vital if the machine condition is to be correctly established as, often, a vibration level is linked to a process parameter. For example, vibration will legitimately change with load, or can be related to a temperature or a pedestal expansion. Having the vibration and process parameters simultaneously available in time or RPM increments, ensures that meaningful correlation can occur.

*Image courtesy of British Energy Group plc.*

### Polar Plots

The Polar plot in Figure 2 shows the vector change of dynamic data during a run up. Enabling colour trace and automatic annotation assists with the interpretation of the data.

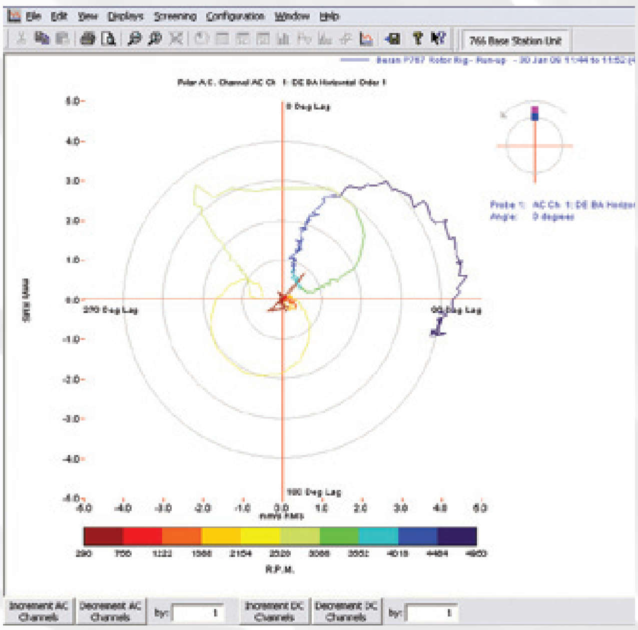


*Figure 2*

# Technical Report

## Common Causes of Vibration

Table 1 below details some common causes of vibration. As can be seen, a significant amount of condition information can be established from the decoded components of the overall vibration signal.

| |
|---|
| RPM x1 Imbalance |
| RPM x1 Rubbing - phase change possible dependant on type of rub |
| RPM x1 Rotor bend |
| RPM x2 Looseness, Misalignment |
| RPM x2 Shaft crack - predominantly detected during variable speed conditions |
| RPM x Teeth Worn / Damaged Gears |
| RPM x 30-50% Oil Whirl i.e. Lightly loaded bearings |

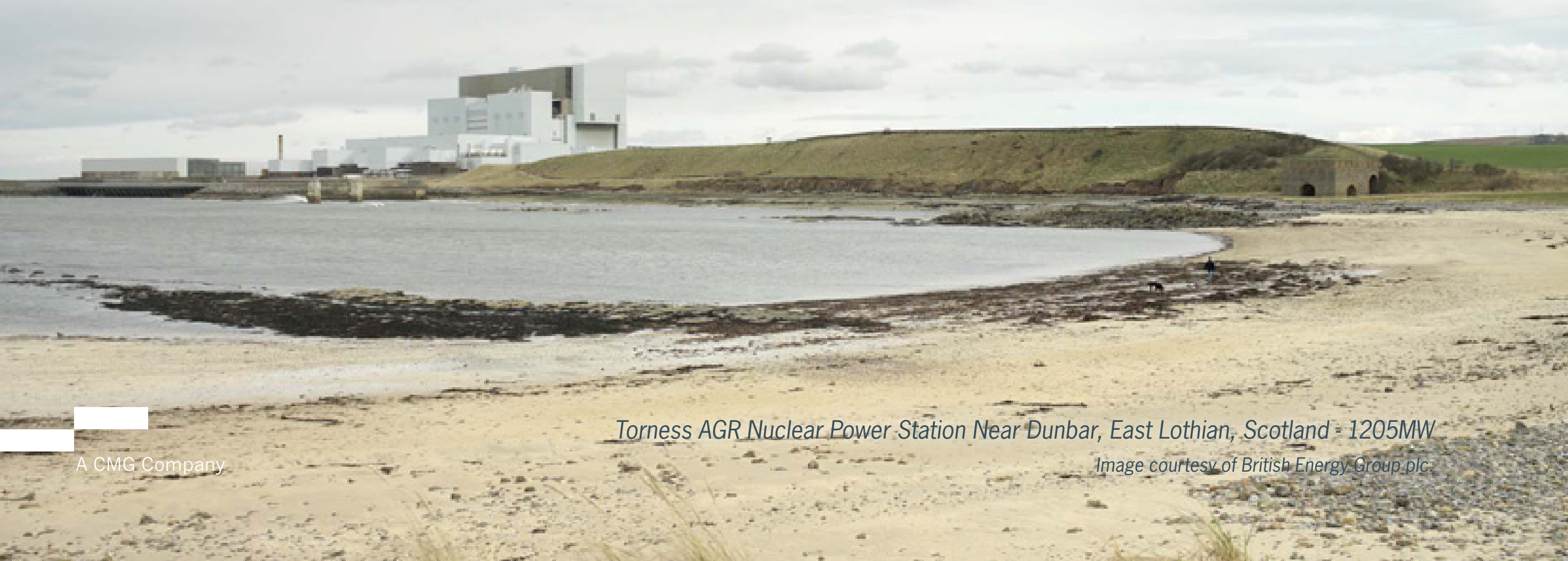
*Table 1*

As previously stated, for diagnostic purposes it is important to consider vibration levels along with other process parameters, and in some cases, other vibration parameters. For example, a change in the RPM X 1 level, with a phase change and temperature increase on the bearing house, is likely to be due to a rubbing in that bearing. Of particular importance when a fault occurs, is to have acquired vibration and process parameters at small time increments prior to the fault. Modern systems have the ability to automatically store the previous one hour of information when a fault occurs. The information in this file is acquired once every ten seconds and continually refreshed i.e. as a set of new readings is acquired, the set acquired one hour previously is discarded. Normally, this file is not stored unless a machine fault occurs. Thus, the specialist engineer has all the information leading up to the machine fault, which is invaluable in diagnosing the cause and the corrective action.

## Predictive Maintenance

In addition to aiding in fault diagnosis, vibration parameters can aid in planning and prediction of maintenance requirements. Once information has been acquired over a period of time, the rate-of-change can be determined. From this rate-of-change, sensible predictions can be made about when the vibration will reach levels where maintenance should be carried out. Further to this, it is possible to adjust process parameters to slow the rate of increase to prolong plant life. Many UK power stations have now extended the time between maintenance operations as a result of the increased information about the internal health of their plant. This information in turn leads to increased confidence to continue running past the normal fixed periodic periods previously performed.

*Image courtesy of British Energy Group plc.*



*Torness AGR Nuclear Power Station Near Dunbar, East Lothian, Scotland - 1205MW*

*Image courtesy of British Energy Group plc.*

# Technical Report

## CASE STUDIES

The following two case studies show how the use of Vibration Condition Monitoring equipment has increased availability in the two stations concerned.

### Case Study Number 1

Operations staff noticed a step-change increase in vibration on HP and IP cylinders on one of the station's 500MW units. Using the RPM X 1 facility on the permanently installed Condition Monitoring equipment, the station staff suspected blade loss in either HP or IP cylinder, but were unsure which. Specialist help was sought from the company's generation support staff, not based at the station.

Using a remote communications system with real-time capability, the specialists were able to view the vibration information at the remote location and advise the station as to which action to take. As the incident occurred during November during base loading, the stations priority was to keep the unit running. Blade loss increased the chance of further faults occurring, due to the lost blades scoring or chipping other blades, therefore the unit was closely monitored by the remotely based specialists.

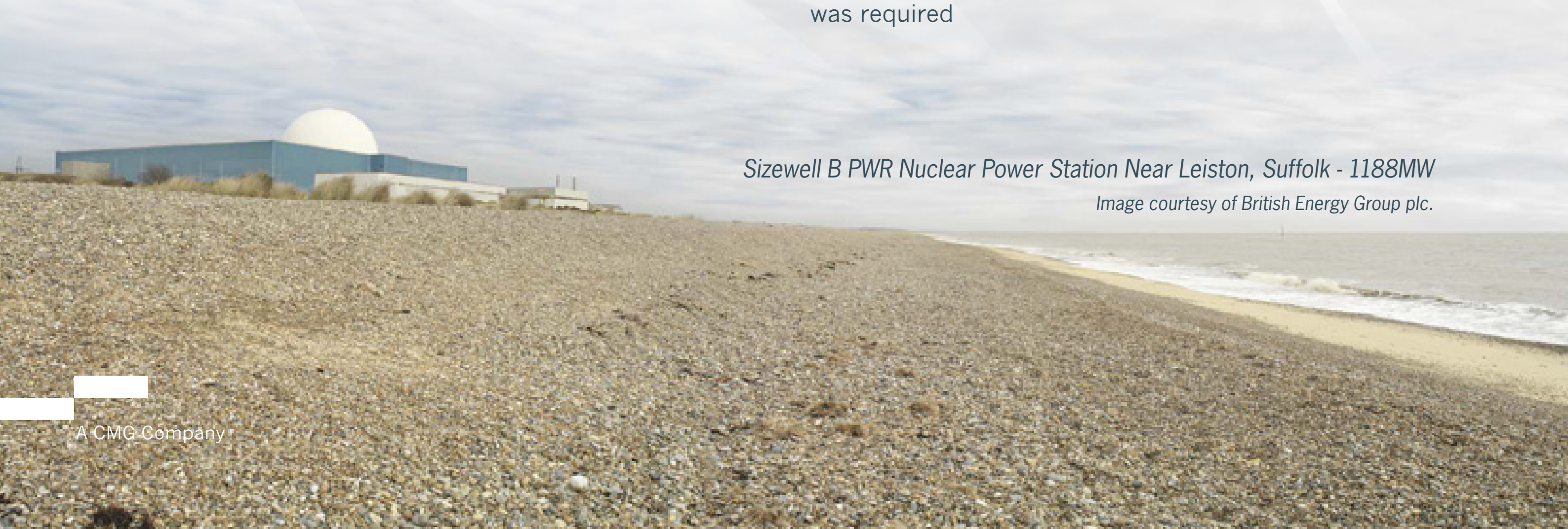
Whilst the Condition Monitoring equipment was not the sole reason for the station continuing to run the unit for a further 27 days, it provided a significant contribution to this. In particular, the fact that specialist engineers could monitor changing vibration conditions remotely, gave the station staff increased confidence to run, knowing the specialists were both periodically monitoring the unit and were there to provide rapid advice in the event of any further changes.

### Case study number 2

A unit at a station was due for an outage for overhaul and the station noticed changes in the machine behaviour. In particular, the station wished to ascertain if the HP cylinder needed to be removed for inspection. Condition Monitoring equipment logged the vibration data and some easily obtainable process parameters. The data was recorded for a number of run-ups /run-downs and periods of on-load running. The data was compared with previous data from two years ago. It was soon apparent that there was little change between run-downs over the two years, but changes in the on-load levels had occurred. In particular, the vibration level appeared to increase before the machine reduced load and then reduced with load. It almost seemed as if the vibration was anticipating the drop in load by about 30 minutes.

In order to assist in diagnosis, additional parameters were monitored, including expansion and tilt of the HP pedestal. The data was transferred via a remote link to the generation support laboratories where further processing was carried out, including the difference between the left and right pedestal expansions (pedestal crab). When the vibration data was compared with both the pedestal crab and tilt, it was clear that both of these measurements were indicating change when the vibration increased. This skewing and tilting of the pedestal alters the position of the rotor within the casing, causing rub and subsequent vibrational behaviour. The reason for this change in the pedestal behaviour, prior to the load drop, was found to be due to the steam pressure being reduced before dropping the load. This reduction in temperature caused the HP pedestal to contract, but in a non-uniform manner.

It had been shown that the deterioration was caused by expansion problems on the HP pedestal and not by deterioration in the HP rotor/cylinder. There was no need to open the HP cylinder during the overhaul, but a thorough inspection of the pedestal sliding elements was required



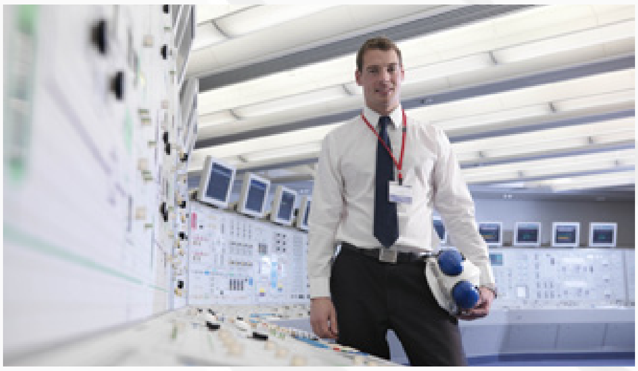
*Sizewell B PWR Nuclear Power Station Near Leiston, Suffolk - 1188MW*

*Image courtesy of British Energy Group plc.*

# Technical Report

## Conclusions

As shown, Vibration as a Condition Monitoring parameter can be used as an aid to assist with increasing unit availability. The two case studies show how increased knowledge of a turbine's vibration characteristic, increases the station's confidence to continue to generate after an incident. It also provides the ability for more precise fault finding, avoiding unnecessary timely investigations. With a 500MW unit typically generating $750,000 per day, it can be seen that increased availability is certainly financially significant. In case study 1, the Vibration Condition Monitoring equipment assisted in both extended generation and fault location. Case study number 2 showed how the equipment (in conjunction with the process parameters) assisted in avoiding a costly HP cylinder strip down. Both case studies made use of a remote link to maximise the efficiency of specialist staff, by removing the need to always travel to the station to provide assistance.



A case study of a station using the equipment to extend the time between scheduled maintenance periods could not be authorised, due to the competitive nature of the UK power industry. The author is aware of a number of stations successfully achieving this. It is worth noting that in excess of 85% of all normally running UK generators above 250MW have Vibration Condition Monitoring fitted, with a growing number of smaller Industrial Turbines following suit. This is due, not only to the falling cost of equipment, but as a result of the competitive Power Trading market and improvements to station operating efficiencies and planning requirements.

## Beran Instruments

Decrease risk and increase your revenues with our Proven PlantProtech™ Condition Monitoring Solutions.

Speed up testing with our ISO standard noise and vibration TransCal™ Systems.

PlantProtech™ is Beran's platform for Condition Monitoring of rotating machinery, built on over twenty five years of industrial experience and innovation.

The PlantProtech hardware / software family is in use throughout the global power industry, installed on Nuclear, Fossil, Hydro, CCGT and Combined Cycle industrial plant.

Originally designed to meet the requirements of the UK Power Generation Industry, our PlantProtech systems have been proven to pay for themselves many times over.

As user requirements have increased, the PlantProtech range has developed accordingly.

By means of continuous on-line vibration monitoring, changes in the health of the plant may be detected early.

Powerful analysis tools allow the root cause of the problem to be identified, enabling operators to make crucial decisions, and in many cases, plant can be run with confidence through to planned outage or scheduled maintenance.

The PlantProtech range of integrated hardware and software products provides you with a solid foundation, which can be expanded as required, ensuring the safe and efficient continued operation of your assets

**Beran Instruments Ltd. is registered to BS EN ISO 9001/AS9100**



**Beran Instruments Ltd.**
Hatchmoor Industrial Estate
Torrington, Devon EX38 7HP
United Kingdom

Phone +44 (0) 1805 624304
Fax +44 (0) 1805 624093
www.beraninstruments.com

Registered in England & Wales
Reg. No. 01802762
VAT Reg. No. GB 762 442 630

**Beran USA**
190 Gordon Street
Elk Grove Village
IL 60007, USA