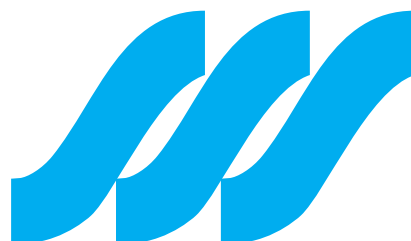


# One year on: Enfield is the definitive GT26B



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The combined cycle at Enfield, north London, was the first example of the GT26B to come into service and was the first to be modified to cure the overheating problem in the second stage LP turbine shroud. As it enters its C inspection one year after the modification it can look back on 99% availability in a sustained period of base load operation.

Enfield is built on the site of a former coal-fired power station in the Lea Valley in the rural northern fringe of London. As a single-shaft block of ALSTOM Power's GT26B it is the leading unit of the type in operation and was due to be shut down for the C-inspection on November 11 after 7657 fired hours.

As the first GT26 to experience the blade shroud cooling problem it was the first to be modified at the end of 2000, and was set up to run at a higher

temperature than the other modified GT26B's and for the past year has operated under close scrutiny of the ALSTOM commissioning team, who remain on site until the plant is officially handed over to Enfield Energy Centre, expected in January 2002.

Enfield Energy Centre Ltd, the owner of the plant, is a joint venture of Indeck Energy Services, of Buffalo Grove, Illinois, and Enfield Holdings BV, a Dutch registered partnership of NRG Energy Services, and El Paso Energy

Co, who also have an interest in several of the GT24 combined cycles in the United States.

The Enfield district of north London is right on the rural fringe of the Capital. For this reason the plant design has been dictated by environmental issues. The 25 cell air condenser was required instead of taking cooling water from the river Lea as the original coal-fired plant had done for its cooling towers. It is nowadays a mainly residential area with some light industry, but is only 3 km from the M25 orbital motorway, which is the main source of air pollution. The power plant feeds into the existing 132kV substation so that no additional transmission lines had to be built and it was near to a main gas supply.

## Experience to date

During this past year the Enfield plant has operated in base load with occasional planned outages at weekends for a detailed borescope inspection of the modified LP turbine section. These outages are not counted in determining availability which is normally calculated on the basis of forced outages, and there have been remarkably few of these, and all concerned with the balance of plant.

There were only three items of note according to ALSTOM's site manager to cause the plant to shut down unexpectedly. An oil leak from the tap changer of the generator transformer was due to a problem with a relief valve, which was changed in a weekend



**Fig.1 Enfield power station in the Lea Valley on the rural fringe of London. This is an important recreational area, popular with walkers and fishermen. Environmental issues have played an important role in the overall design of the station**

outage. A more time-consuming search was for a vacuum leak in the air condenser due to the large number of valves covering the 25 cells in the unit. Minor damage to the internal insulation at a joint in the exhaust duct was also detected and easily carried until it could be repaired during another weekend inspection outage.

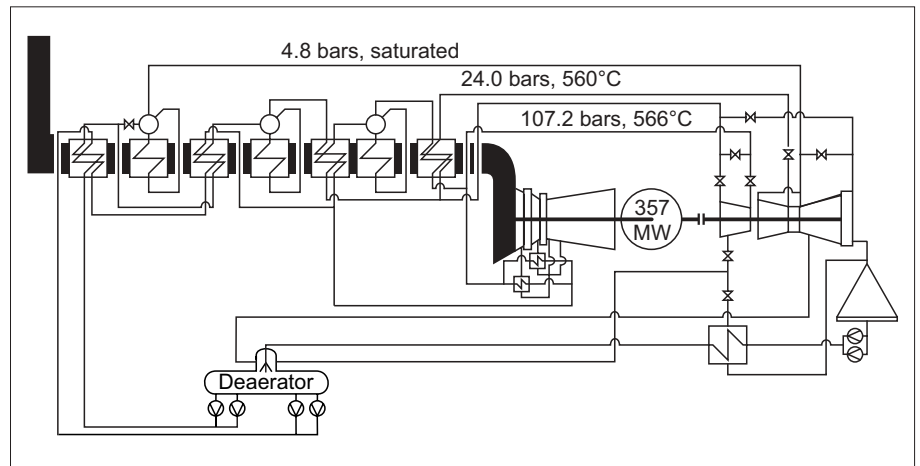
As is already well known the blade cooling problem has concerned the distribution of cooling air to the second stage blade shroud in the low pressure power turbine. This has affected only the B-rated blading of both GT26 and GT24. Relatively few machines were in service in mid 2000 when the problem first came to light and most of them were GT24 combined cycles in Mexico and the United States. Of GT26B, there are five machines in operation, the others being at Tocopilla Chile, and Senoko, Singapore, Chiba, Japan, and Shoreham in the UK. All the other gas turbines of type GT24 and GT26 have been modified.

Initially, all but four of these modified units have been operated at a lower temperature. Enfield and three GT24's, two at Monterrey, in Mexico, and Agawam, MA, the lead unit in the United States, have been run hotter in a thorough test of the modified cooling system. The argument was that if the modification ran into problems it would only be four of some 80 units around the world, which would be affected. But as more experience has been gained with the lead units ALSTOM have felt confident enough to raise the operating temperature to the same values on selected other units.

The B rated machines are different from the initial design, of which, in the case of GT26A, there are six running in Germany, the UK, New Zealand and Argentina.

The B machines have a retractable burner design which enables them to be accessed from outside the machine to facilitate inspection and maintenance. Also the number of burners in the HP stage has been reduced from 30 to 24, the same number as for the SEV burners in the second stage. Modified blading has been applied to the turbine stages. (This blading change has also been made to the six A-rated machines to allow higher firing temperatures which were all scheduled for upgrading at a convenient inspection outage.)

These changes mean that the fuel input is unchanged in the first stage and increased in the SEV burners, resulting



**Fig.2 Schematic of Enfield follows standard ALSTOM practice with conventional deaerator supplying two pressures with the LP flow bled off the IP. Extra condensate heating allows for limited operation on liquid fuel up to 20 days/year.**

in an exhaust temperature some 20 degC higher. This has the advantage that the additional power derives from the fuel burnt in the SEV burner which because of the depleted oxygen level does not add to the already low overall NOx level. Also, by keeping the same temperature in the first stage combustor the cooling air demand for the single turbine stage, which has single-crystal blades, is not stretched in a congested area where it would be mechanically difficult to add cooling air were the temperature to be raised. The temperature increase is confined to the SEV burners and the LP turbine section

Natural gas is taken from the local Transco network which is nominally at

57 bars and this is passed to a reducing station to give the 47.5 bars required to fire the gas turbine. To cover peak demand on the gas network there are two Borsig gas compressors which automatically come into operation if the gas pressure drops to 43 bars.

The complete power train is ALSTOM's standard single-shaft arrangement for the 50 Hz machine. The steam turbine is a conventional two-cylinder design with a separate HP and a combined IP and LP cylinder, and exhausting to a 25-cell air condenser from Balcke Dürr. The power train is an indoor design to reduce noise levels to about 50 dB at the plant boundary.

The steam turbine drives through an



**Fig.3 Control room with equipment supplied by by ABB Power Automation is located alongside the turbine hall, visible through windows, and is operated by a 3-man shift crew with supervisor and two control engineers .**



**Fig.4**The GT26 viewed from the exhaust end showing the fuel manifolds for the SEV burners. On November 12, when this picture was taken, the gas turbine had been shut down 12 hours and was cooling in readiness for the C-inspection

SSS Clutch to a 400 MVA 23 kV hydrogen-cooled generator. This is stepped up to 132 kV and output by cable to the existing Enfield substation next door to the site.

The steam cycle follows standard ALSTOM practice with a separate deaerator supplying the IP and HP pressures. LP is throttled down from the IP after the first economiser stage. To ensure high availability all pumps carry

100% redundancy with two parallel units at each position. Because the plant is required to burn light distillate fuel for up to 20 days a year, there is a condensate preheater supplied with steam from the HP cylinder, this same bleed is also the main source of heat for the deaerator. Pegging steam also comes from a bleed at 2.8 bars from the LP cylinder.

The HRSG is a horizontal, natural



**Fig.5** In this power plant, to guarantee high availability 100% redundancy is carried on all pumps. Here can be seen the IP boiler feed pumps supplied by Flowserve from the former Byron Jackson nuclear power factor at Etten Leur, Netherlands.

circulation design by CE which is mounted indoors, again for environmental reasons. Steam conditions are: HP, 116 bars, 574°C; IP 23.4 bars 384°C (24 bars, 574°C at the reheater outlet); and LP 4.12 bars, saturated. These were the reported steam conditions at the time of *Turbomachinery International's* site visit on October 23. At that time the plant was generating 350 MW at an efficiency of 58%. Ambient conditions were at 16.1°C and 79% relative humidity. All 25 cells in the air condenser were running.

### The new trading regime

The plant operations are determined by contracts under the NETA trading system which came into effect in April this year. Instead of bidding into a pool and being selected on merit order, each power plant has to make a contract with an Energy Trader who sells it on to the consumer. The amount to be supplied and the duration of the contract is agreed at the start and the plant is responsible for any shortfall if it cannot deliver for any reason. Similarly, if the ambient temperature suddenly falls, causing the gas turbine output to rise, unless there is provision for this in the contract, the excess power must be sold to National Grid at a derisory Spillage Rate which sometimes does not even cover the cost of the gas needed to produce it.

This is not always the case and although there is in the generating community a lot of hostility to the new NETA arrangements, Howard Dray, Enfield Energy's station manager is comfortable with it and is pleased with the way ALSTOM engineers have been able to work NETA arrangements to obtain long periods of operation at full power and exploit times of high spillage prices. "This was important for us because although our contracted output requires us to run at a lower output, the longer we can go up to full load the better we can see how the blade modification has stood up. In fact for the last month before the C-inspection outage, the plant has run at up to 376 MW."

Under the new system all power plants are effectively merchant plants offering their output not, as before, into the grid but to Energy Traders who sell it on to the distributors. This means that Enfield and all the other plants now have to perform some of the guessing games which were practiced by National Grid under the old Pool

system. They must look to weather forecasts, television schedules and the other factors that affect electricity demand and factor these into their power supply contracts.

For example, the October contract at Enfield was for 350 MW, but it would have defined when this output could be exceeded to say 380 MW to allow for sudden changes in demand of their customer or a prolonged cold spell. What it means is that the output of the plant must be held as close as possible to the contracted value at any time. In an ideal situation a graph of output versus time would be a straight line but there will always be small variations either side within the tolerance of the control system.

The experience of one year's operation with the modified cooling arrangement for stage 2 of the LP turbine has shown that there is sufficient cooling and the gas turbine can run at the higher temperatures.

Because of the 30:1 pressure ratio, a feature of GT26 is the once through coolers which recover heat to the steam path from the air taken from the compressor for blade cooling. There are two coolers which are connected in parallel with the main steam path between the final HP economiser section and the HP superheater outlet. Cooling air is taken from the compressor at two points.

Under the reported operating conditions above, the HP cooler, which supplies the HP power turbine blading, was taking air from the final compressor stage while the LP cooler took air from the 19th of the 24 stages. The blade cooling air is now at about 340°C while on the steam side the combined outputs go back to the superheater outlet of the HRSG. The total steam flow through the coolers is about 12 kg/s which compares with the total HP flow of 69 kg/s at the observed operating condition.

### Importance of the clutch

Since the modification of the cooling path at the end of 2000 the gas turbine has performed at 99% availability and the steam turbine at 100%. It is very important under the new trading arrangements to be able to maintain high availability. The borescope inspections have been undertaken about every six weeks at weekends, which involves shutting down on a Friday evening and restarting on the following Monday morning



**Fig.6 The steam turbine is a 2-cylinder design with combined IP and single flow LP cylinder , which is mounted in a n acoustically lined enclosure. The unit exhausts to a 25-cell air condenser.**

That regular weekend inspection outages have been possible is thanks to the SSS clutch which is placed between the generator and the steam turbine. Without it, the entire power train would have to come completely to rest which would take two or three days longer with a rigidly coupled shaft.

A normal SSS clutch acts as a tooth-type freewheel and will always engage when the steam turbine speed overtakes that of the generator. In this case the clutch is of a modified design specially for the single-shaft combined cycle and the engaging mechanism is ineffective at low speed. This enables the steam turbine to separate and continue turning on its barring gear while the gas turbine and generator are at rest.

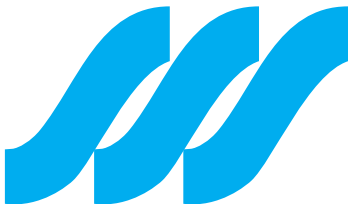
A typical outage lasts from 11 pm on Friday evening to 10.00 am the following Monday morning. First the steam turbine is shut down and as soon as it drops the clutch separates. The gas turbine fuel is then shut off and as it continues to run down, the generator is powered to act as a motor to keep the gas turbine turning at 270 rpm so as to draw cold air through it for rapid cool down. After about 18 hours the gas turbine comes to rest and it is now cool enough to withdraw the SEV burners so as to access the turbine section for a borescope inspection.

All the while this is going on the steam turbine is turning on its barring gear as it continues to cool down. The

reassembled gas turbine is ready to start again at 4.00 am on Monday. When the gas turbine is up to temperature it is able to start generating steam which is dumped to the condenser until the right quality is achieved. It can then be supplied to the steam turbine which then starts to accelerate. Once it reaches full speed the clutch engages to couple the steam turbine back into the power train which then continues to load up. By 10.00 am the plant is back to full output again.

These outages were all planned according to an agreed schedule for observation of the modified turbine stage and look for signs of any unexpected condition. None has been found. The unit was shut down for the planned inspection November 11. This inspection is now in progress and is aimed to bring the gas turbine back to as new condition. This will be followed by recommissioning so that by the end of December the plant can be brought back into service for the final performance test.

Until now the power plant has been ALSTOM Power's, but Enfield Energy Centre operating staff have been responsible for day to day operation and maintenance under their supervision. If the final performance test, which will be a 30-day run ending in January, is successful, then the plant will be judged to be complete and will be handed over to the customer.



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