HARTLEPOOL

NUCLEAR POWER STATION

HARTLEPOOL Nuclear Power Station

Hartlepool power station is situated near Seaton Carew on the Tees Estuary, four miles south of Hartlepool and five miles north east of Teesside in the County of Cleveland. The station is one of the Central Electricity Generating Board's five advanced gas-cooled reactor (AGR) nuclear power stations.

The design of the power station was a development of the highly successful magnox nuclear power stations which first supplied electricity in 1962. When at full power the two 660 megawatt units at Hartlepool are able to supply nearly twice the maximum power demanded for the County of Cleveland.

MAIN ENTRANCE & SECURITY GATE HOUSE

SITE

The site on the Tees Estuary was considered a good area for building a power station because of certain important characteristics.

The Tees Estuary was able to provide the necessary condenser cooling water supply needed at the station.

The site was ideally situated to reinforce the National Grid in North East England and help guarantee security of supply to the consumer.

The area had good access and spent nuclear fuel could be transported easily and safely by rail to the reprocessing plant at Sellafield in Cumbria.

Work on the Hartlepool site started in October 1968 by British Nuclear Design and Construction, a consortium of power plant manufacturers under the supervision of the Board's construction experts.

Hartlepool and its sister station, Heysham I, are unique in certain design aspects, particularly the boiler and gas circulator arrangements. The massive concrete pressure vessels and diverse safety systems make Hartlepool so safe that even in the case of a major site incident it is very unlikely that there would be any radiological consequence outside the site boundary.

Hartlepool's first reactor/turbine unit supplied electricity to the National Grid on August 1st 1983. The second unit followed on October 31st 1984 and both have since made significant contributions to electricity supplies.

Since construction was started, Hartlepool power station has provided over 20,000 man-years of work with much of the work force coming from the Teesside area.

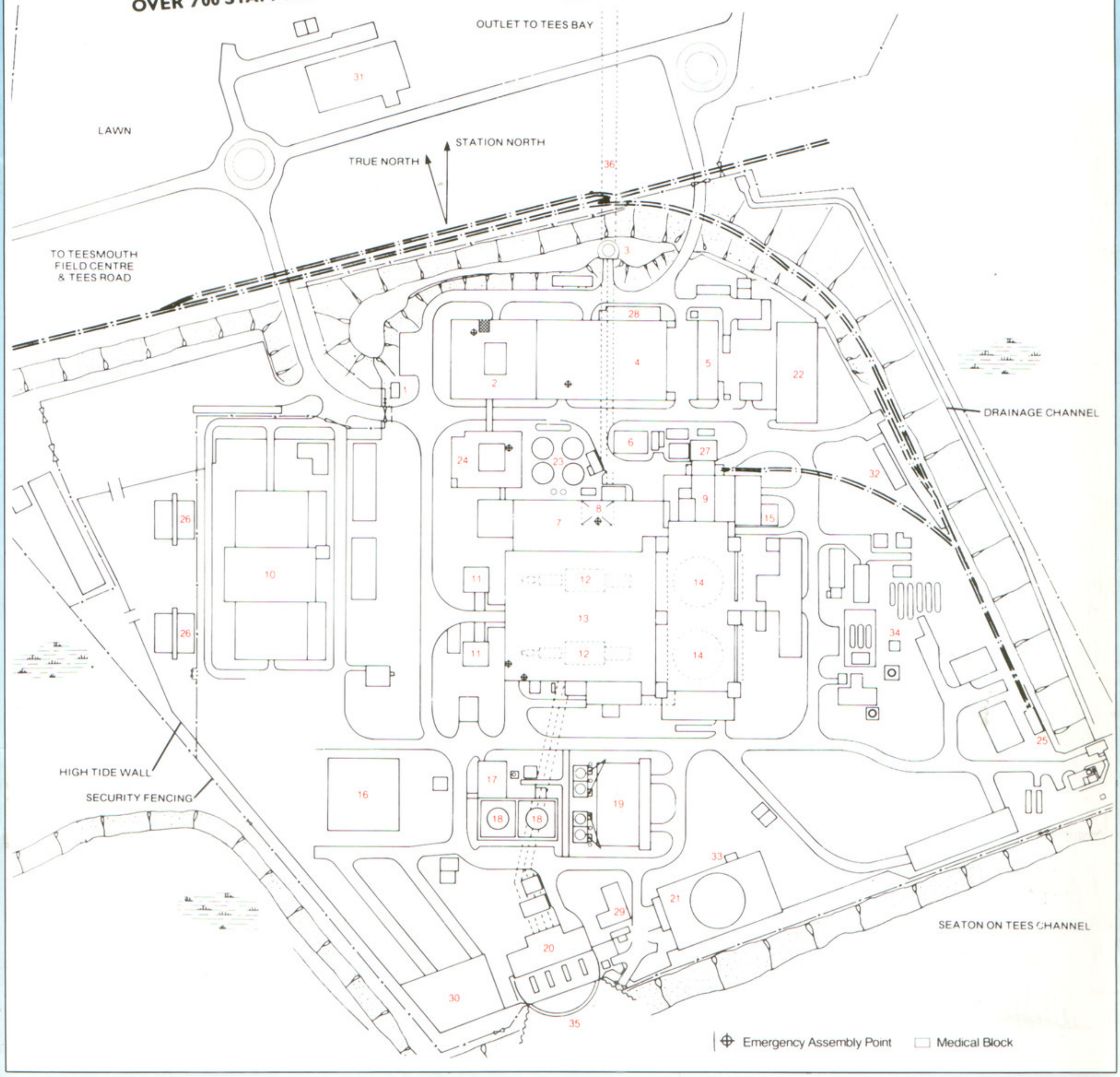
Staffing

Over 700 people are employed on the site, the majority of whom live locally.

These include Scientists, Engineers, Operations Staff, Mechanical, Electrical and Instrument Craftsmen, Health Physics Personnel, Administration, Canteen and Cleaning Staff.

ENGINEERING STAFF AT WORK

OVER 700 STAFF ARE EMPLOYED ON SITE



1 Gate House
2 Administration and Canteen Building
3 Surge Chamber
4 Workshops and Stores
5 Garages and Fire Station
6 Reverse Osmosis Plant
7 Services Building
8 Control Room
9 Fuel Handling Block
10 Grid Switch House
11 Generator Transformer
12 Turbo Generators
13 Turbine Hall
14 Reactors
15 Radio Active Chemical Laboratory
16 Reservoir
17 Auxiliary Boiler House
18 Fuel Oil Tank
19 Gas Turbine House
20 Cooling Water Pumphouse
21 Oil Storage Tank
22 Heavy Store and Workshop
23 R.F.W. Tanks
24 Administration Building
25 Locomotive Shed
26 Transmission Towers
27 Irradiated Fuel Storage Pond
28 Statutory Records Building
29 Electro-Chlorination Building
30 Helicopter Landing Pad
31 Energy Information Centre
32 Main Fuel Store
33 Clean Laundry
34 Gasses Plant
35 CW Inlet
36 CW Outlet Culvert

THE DEMAND for electricity

The production and distribution of electricity depends on order and control, organisation and planning. Perhaps the most impressive aspect is the way in which the national daily demand is met so efficiently.

In most cases, the demand for electricity from each home, school, office or factory is not actually met by the power station nearest to it. All the power stations in the country — whether coal, oil, hydro or nuclear — are linked by the National Grid and it is the job of the Central Electricity Generating Board to make sure there is always enough electricity being fed into that Grid to supply every consumer at the flick of a switch.

Demand varies from place to place and according to the time of day, the time of year and the weather conditions. The highest demand peaks are usually in winter around tea time when a lot of people are at home using lights, cookers and fires while others are still at work in factories and offices.

If the CEGB — through its National and Area Control Centres — failed to make sure its power stations were producing enough electricity, then someone somewhere would have to go without.

But, producing electricity costs money. So the Control Centres also have to ensure that throughout the day and night they are not running more generators than they need. So they aim to keep the most economic power stations — that is the nuclear and the large coal-fired ones — operating continuously, bringing in the others as demand increases.

In addition the massive pumped storage hydro-electric power station at Dinorwig in the North Wales mountains provides an almost instantaneous source of reserve power. This means that the CEGB can plan for — and respond to — a huge increase in demand as electric kettles and cookers are switched on at the same moment throughout the country.

The network of CEGB power stations located strategically throughout England and Wales is capable of generating more than 50,000 megawatts of electricity. The network called The National Grid System, has links to Scotland and France.

This arrangement provides all three systems with reserves for the benefit of consumers on both sides of the Channel.

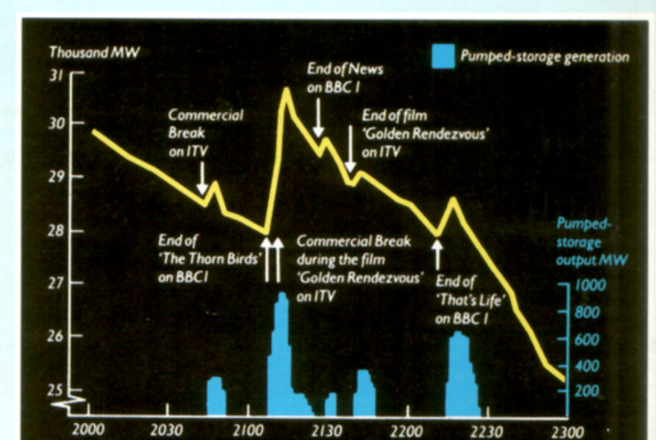
DINORWIG PUMPED STORAGE STATION

PRIVATISATION

The responsibility for generation and transmission of power for England and Wales rests at present with the Central Electricity Generating Board, a public utility. If legislation going through Parliament at the time this publication was printed is approved, the CEGB will move into the private sector as two competing generating companies and a transmission company. The two generating companies will be called National Power Company and The Power Generation Company (PowerGen) and the transmission company will be called The National Grid Company.

NATIONAL CONTROL CENTRE

The latest information technology is used by the National Control Centre (left) in its round-the-clock supervision of the production and distribution of electricity. Long experience and a wide range of information sources enable the Centre to plan far in advance of any likely surge or downfall in demand caused by weather conditions, major national events or a few million kettles being switched on during the course of a major television series i.e. January 22nd 1984 (see graph right).



PRODUCING electricity

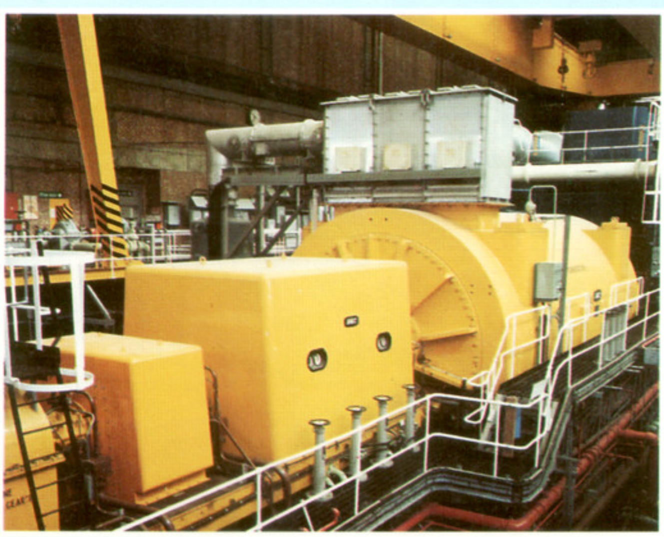
The diagram shows the Advanced Gas cooled reactor (AGR) and its associated turbo-generator and main plant. Hartlepool has two such reactors and turbo-generators.

The reactor consists of a core (1) of graphite blocks containing vertical channels in which the fuel assemblies (2) are located. Each fuel assembly consists of eight fuel elements and a plug unit connected together by a central tie bar.

Channels are also provided for boron steel control rods (3) which absorb neutrons and are raised and lowered by electric motors (4) thus enabling the reactor power to be varied. The reactor is shut down completely by lowering In the event of a power failure the rods will fall into the core under the action of gravity which causes the reactor to shut down immediately.

The reactor is contained within a pre-stressed concrete pressure vessel (5) which also acts as a biological shield to protect against radiation from the reactor. The vessel is pre-stressed by a continuous steel wire winding in each of the 34 troughs around the reactor (6) and also by tendons from top to bottom. The stressing is regularly checked and can be increased if necessary. The concrete is water-cooled and its interior is steel lined. It is also protected from excessive temperature by insulation attached to the steel liner.

After the fuel has spent a long period in the reactor its energy output decreases and it must be replaced by new fuel. This process, called 'refuelling', is carried out, one channel at a time, by a fuelling machine (7), operating from the top of the reactor. This machine is also used for exchanging control rods for routine maintenance to be carried out in the active maintenance facility (8).



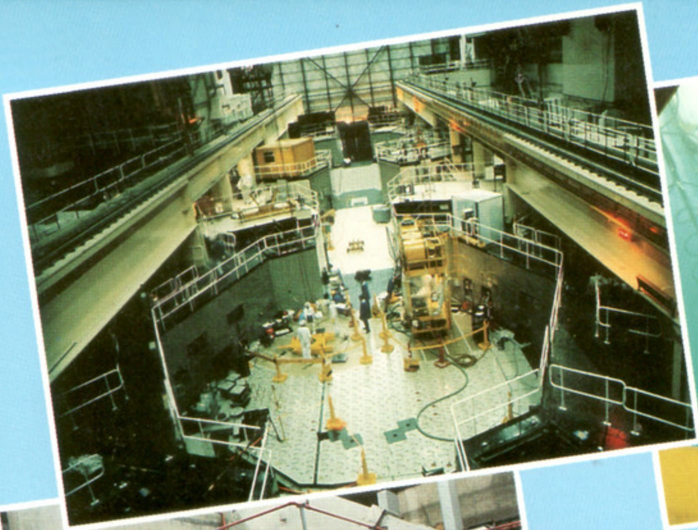
MAIN GENERATOR

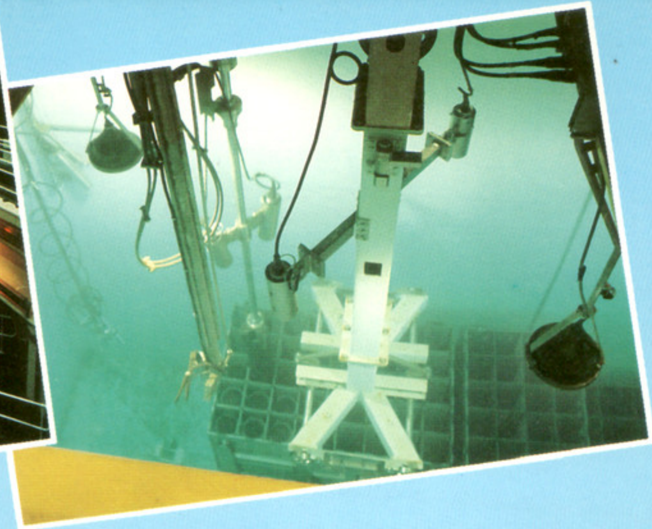
The spent fuel element assemblies, when removed from the reactor by the fuelling machine, are stored in a special chamber for about a week. They are then dismantled in the irradiated fuel discharge facility (9) and the fuel elements lowered down a chute into a pond of water (10) where they remain packed in fuel skips (11). They are then removed from the station in a shielded transport flask and taken by rail to British Nuclear Fuels' works at Sellafield for re-processing.

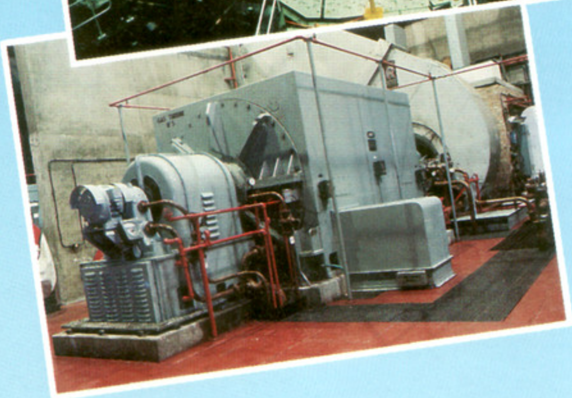
Eight new fuel elements are assembled into a fuel stringer in the new fuel assembly area (12). The stringer is then moved to the active maintenance facility (8) where it is connected to a plug unit to form a complete assembly. The new fuel assembly is then picked up by the fuelling machine which places it in the reactor.

Inside the reactor carbon dioxide (CO_2) gas is circulated by eight motor-driven gas circulators (13) which force the gas through the reactor core to pick up heat generated by the nuclear fuel. On leaving the core the hot gas passes into the boilers (14) where it gives up its heat to the water in the boiler tubes thus generating steam which drives the turbine. After passing through the boilers, the gas re-enters the core through the gas circulators. It is therefore totally contained in the pressure vessel throughout the complete circuit. Reactor power output is controlled by movement of the control rods and variation of the gas flow.

The steam passes via control valves to the high pressure turbine (15) where it is discharged through nozzles onto the turbine blades. The energy of the steam striking the blades makes the turbine rotate. After passing through the high pressure turbine, the steam is returned to the boilers for reheating before passing into the intermediate pressure turbine (16) and from there to the three low pressure turbines (17). Having exhausted its useful energy in turning the turbine at 3000 rev/min, the steam passes to the condenser (18) where it is turned to water by passing it over thousands of cupro-nickel tubes through which cold sea water (C.W.) flows at a rate of a quarter million gallons per minute. The sea water is taken from Seaton-on-Tees channel and passes via rotary drum screens (19), which remove any debris, to the C.W. pumps (20). After passing through the condensers, the C.W. is returned to the sea. The increase in the sea water temperature during its passage throughout the condenser is about 11°C. The condensed steam, which is called the condensate, is pumped by the extraction pump (21) to the condensate polishing plant (22) where any impurities which may be present in the water are removed. The clean condensate then passes into a vessel called the turbine extraction condenser (23) from which it is pumped (24) to the feed heaters (25). In the feed heaters the water is mixed with steam taken from the turbine in order to increase its temperature which results in an improvement in the efficiency of the cycle.







The warmed water is then pumped (26) to a large vessel called the deaerator (27) where any gases remaining in the water are removed. From the deaerator the water passes to the boiler feed pumps (28) which pump it back to the boiler to be converted to steam by heat from the reactor coolant gas.

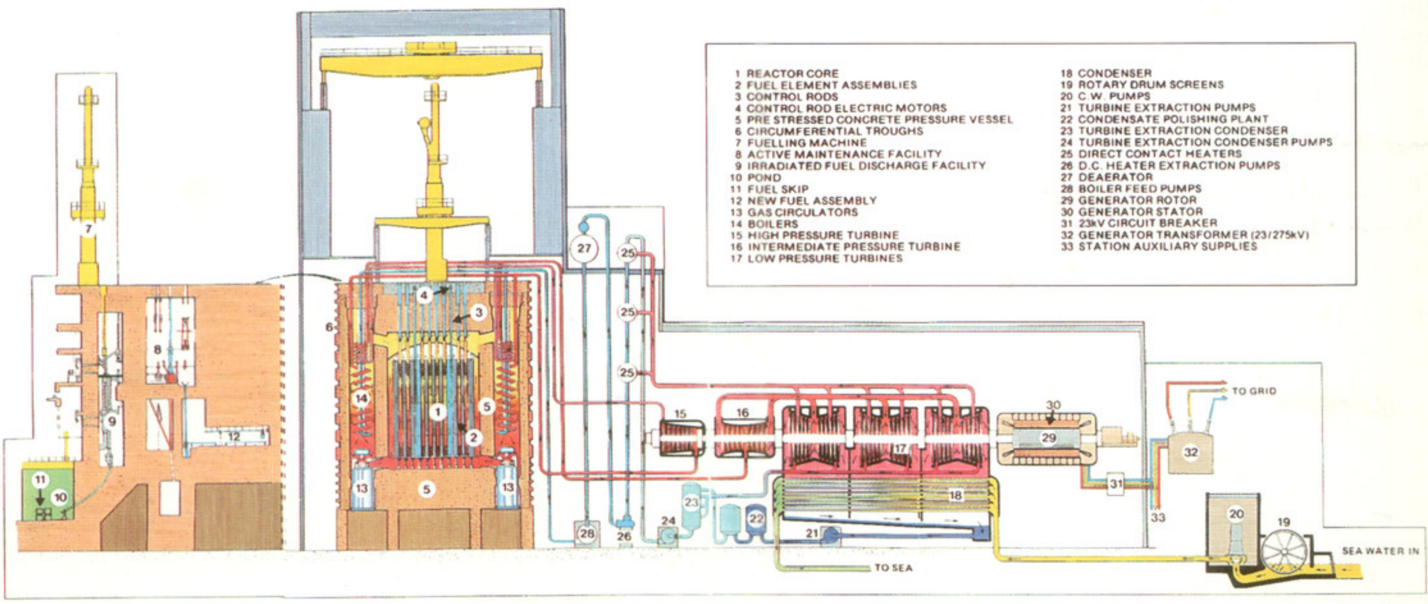
The turbine is directly connected to the rotor (29) of the generator — a large cylindrical electro-magnet — so that when the turbine rotates the generator rotor rotates with it at 3000 rev/min. The generator rotor is enclosed in a water-cooled electrical winding called the stator (30). The interior of the generator is cooled by hydrogen. Electricity is produced in the stator copper bars by the rotation of the magnetic field created by the rotor electro-magnets. Up to 666 mega watts (M.W.) of electricity is produced at a voltage of 23,000 volts and is supplied via the circuit breaker (31) to the generator transformer (32) which increases the voltage to 275,000 volts which is suitable for transmission on the overhead power lines of the grid system. Power supplies for the station (33) are taken off between the circuit breaker and generator transformer so that when the generator is out of service the station's auxiliary plant may be supplied direct from the grid.

In the event of the failure of electrical supplies to the power station four gas turbine driven generators start up automatically and re-establish power to the station's internal electrical systems.

Each of these machines is driven by an Olympus gas turbine, similar to those used on Concorde, and is capable of generating 17.5 MW.

Although four gas turbines are provided, the output of a single machine is sufficient for the needs of the power station.

SCHEMATIC DIAGRAM OF GENERATION



GAMMA COUNTING ENVIRONMENTAL SAMPLE

COLLECTION OF LOCAL MILK FOR ANALYSIS

LOCAL FISH SAMPLE PREPARATION

BETA COUNTING ENVIRONMENTAL SAMPLE

T.E.Z. SHADES FOR AIRBORNE PARTICULATE SAMPLING

ENVIRONMENT

The CEGB carries out regular surveys to monitor background radiation levels around Hartlepool Power Station.

Measurements are taken by experts in the field of radiation monitoring at distances up to 15 kilometres from the station and were started in 1976 before the power station became operational. These established the naturally occurring radiation levels present in the environment, against which current survey results can be compared.

In these comprehensive surveys samples for monitoring are taken from fixed sites around the power station, of milk, grass, soil, fish and mud and measurements of gamma radiation and airborne particles are also made. The results of the CEGB surveys are sent regularly to Government Departments responsible for issuing relevant authorisations. (Dept. of the Environment, and the Ministry of Agriculture, Fisheries and Food.) These Departments, in common with the CEGB, also have professional staff expert in the field of radiological monitoring. In addition, duplicate samples chosen on a random basis are regularly sent to the Departments for check analyses, and the Departments themselves also operate their own sampling and analysis schemes.

Summaries of the results of the monitoring programmes are published and passed onto the members of the power station's Local Community Liaison Council (LCLC).

Local people are represented on the council by members and officers from local district, town and parish councils and voluntary organisations.

As well as members of the local police force, fire service and health authority, statutory bodies such as water, river and ports are represented together with officials from the Department of the Environment and Ministry of Agriculture, Fisheries and Food.

The council is the interface between the power station and people living in the area on all matters relating to the station which affect them including the arrangements in the event of an emergency.

An Emergency Planning Consultative Committee (EPCC) has also been established at the station to deal with all matters relating to the statutory emergency planning requirements. The committee, comprising of those authorities with relevant statutory responsibilities, regularly presents its conclusions to the Local Community Liaison Council.

Copies of the emergency plan which specify the actions to be followed by the CEGB and other organisations in the event of an emergency together with the minutes of the LCLC are available in public libraries in the Hartlepool area.

SAFETY

Throughout the electricity industry it is essential to set standards of protection to safeguard both workers and the general public. British nuclear power stations are very carefully designed to prevent accidents and also to reduce to the absolute minimum any discharge of radioactivity.

Exposure to radioactivity as a result of discharges from our nuclear power stations in normal operation is much less than you encounter in other ways. Such discharges are all well under one per cent of the average background radiation level in which we live and are made under authorisations set by government ministries.

Major accidents releasing large quantities of radioactivity are virtually inconceivable at Hartlepool. This is because all the key components are designed and manufactured to a very high standard.

Even so in the event of their failure there are safety devices to ensure automatically that the reactor is shut down safely.

The 'in depth' protection means that even if a safety device itself fails there are several other successive lines of protection to back it up.

Staff are protected by a combination of safe working procedures, plant design, safeguards such as adequate radiation shielding (enclosing plant in concrete cells or boxes lined with lead), the use of the remote handling equipment where necessary and extensive ventilation systems.

Their working environment is regularly monitored and checked for radioactive contamination.

For staff working in some controlled areas special protective clothing is provided before entry via the changing rooms. On leaving these areas staff remove this clothing and, after washing, follow a radiation monitoring procedure. Dosemeter badges that assess external radiation doses are the most widely used of the monitoring instruments and are issued to employees and everyone visiting the radiologically controlled area.

In the mid-summer of 1984 a worldwide television audience of millions watched as a diesel train travelling at 100 mph crashed into a nuclear fuel flask. The diesel was destroyed. The flask — carrying steel rods to simulate nuclear fuel — was unscathed. The Central Electricity Generating Board — which organised the demonstration to show its total confidence in the immense strength of these containers — had proved its point.

INFORMATION Centre

Sited alongside Hartlepool power station is the CEGB's unique computer controlled audio-visual Energy Information Centre. Since it was opened in September 1985 the centre has attracted tens of thousands of visitors, mainly school parties.

The Generations of Energy exhibition uses the very latest techniques to tell the story of energy and electricity. Visitors are led by video guide through an historical journey tracing how energy resources such as coal, oil and uranium have been developed as fuels for electricity, the development of electricity and how it is produced, distributed and used today.

It uses sound, light, images and working models to present its story in a dramatic way.

A section of the exhibition is devoted to Hartlepool Power station and visitors can see into the heart of the station by remote cameras linked into the reactor and turbine halls. Also featured is the simulation of an electricity supply system and the operation of a nuclear reactor by computer using a standard BBC microcomputer programme.

The centre has been built to cater for increasing interest which the public in general and schools in particular show in energy topics.

Hartlepool was chosen for the first centre because it is near the large urban populations of Teesside, Durham, Wearside and Tyneside.

The centre caters for school parties, families and casual visitors of any age, with a presentation lasting about an hour. Entry is free.

FIELD Centre

Also on the Hartlepool site is the Teesmouth Field Centre which is visited by thousands of school children each year.

Hartlepool power station is bounded on three sides by sites of special scientific interest. Appreciating the educational value of studying the effects of building and operating a power station in such an area the Board offered to provide accommodation to be used as a centre for field studies.

The original centre was opened in 1970 and moved to larger premises in 1984.

It is leased to the Cleveland Nature Conservation Trust by the CEGB and grants to equip and run the centre are provided by Cleveland County Education Authority. Assistance is also given by the Nature Conservancy Council and local industry.

To introduce people of all ages to Teesmouth and its ecology a nature trail is followed where the various component habitats of a sand dune system are examined, discussed and recorded. It starts at the field centre and takes half a day.

Also undertaken is a tour of Teesmouth starting at the Transporter Bridge and ending at the field centre.

TECHNICAL Information

General
Type: Advanced gas-cooled reactor
Number of reactors: 2
Electrical output (net): 1249 MW (2 x 625)
(gross): 1332 MW (2 x 666)
Gas turbines: 70 MW (4 x 17.5)
Thermal efficiency: 41.6%

Reactor
Reactor heat: 1500 MW
Reactor coolant: CO_2
Reactor gas inlet temperature: 286°C
Mean channel gas inlet temperature: 317°C
Mean channel gas outlet temperature: 648°C
Total gas mass flow at reactor outlet: 3650 kg/s (8047 lb/s)
An equilibrium:
Weight of uranium: 110 tonne (108 ton)

Pressure Vessel
Material: Concrete, reinforced and pre-stressed, lined with mild steel
Internal diameter: 13.1 m (43 ft)
Internal height: 18.3 m (60 ft)
External diameter: 25.9 m (85 ft)
External height: 29.3 m (96 ft)
Design gas pressure: 44.4 bar (643.9 lb/in^2)

Core
Moderate or reflector material: Graphite
Mean diameter of active core: 9.3 m (30.5 ft)
Active core height, cold: 8.2 m (27 ft)
Number of fuel channels: 324
Number of control rod channels: 81

Fuel Element
Number of elements per channel: 8
Material:
Hollow UO_2 pellets, stainless steel clad
Type: 36 pin cluster in graphite sleeve
Element length: 1041 mm (41 in)

Circulators
Type: Centrifugal with integrated canned motor
Number per reactor: 8
Drive: Squirrel cage induction motor
Flow control: Constant speed variable inlet guide vanes
Speed: 2970 rev/min
Electrical power consumption (8 motors) per reactor: 35.3 MW

Boilers
Type: Helically wound, integrally finned pod boiler
Number of pod units: 8
Power transferred to steam/reactor: 1521 MW
Gas inlet temperature: 639°C
Gas outlet temperature: 278°C
Steam generation/reactor: 482 kg/s (3825 klb/h)

Charge/Discharge Machine
Function: On-load replacement of fuel assemblies, control rod assemblies and flux measuring assemblies
Number per station: 1
Mode of trasport: Electrically-operated gantry
Number of channels serviced per cycle: 1
Design refuelling rate: 2.2 channels per week per reactor
1 control rod per week per reactor
Time to refuel a channel: 6-8 hours (approximately)
Shielding: Cast iron
Height: 28.8 m (94.4 ft) + 0.457 m lift (1.5 ft)
Weight: 336.3 tonne (331 ton)

TURBO GENERATOR
Turbine
Manufacturer: G.E.C. TURBINE GENERATORS LTD.
M.C.R.: 666 MW
Steam pressure (TSV): 159 bar (2306 lb/in^2)
Steam temperature (TSV): 537°C
Mean condenser vacuum: 951.5 mbar (28.1 in Hg)
Final feedwater temperature: 156°C
Speed: 3000 rev/min

Generator
Manufacturer: G.E.C. TURBINE GENERATORS LTD.
Type: Rotor hydrogen cooled, stator water cooled
Output: (MVA): 776
Current (kVA): 19.5
Terminal voltage: 23kV
Power factor: 0.858
Efficiency: 98.6

Condenser
Manufacturer: G.E.C. TURBINE GENERATORS LTD.
Type: Axial, single pass integral
Exhaust pressure (M.C.R.): 51.8/39.2/31.5 mbar
Cooling water (M.C.R.): 15.9 m^3/s (565 ft^3/s)
Surface area: 36.27 m^2 (390.41 ft^2)

TRANSFORMERS
Generator Transformers
Manufacturer: G.E.C.
Number: 2
Voltage ratio: 23/300 kV
Rating: 735 MVA
Type: 3 phase, 50 Hz OFW cooling, on-load tap changing

FEED SYSTEM
Main boiler feed pump
Manufacturer: WEIR PUMPS LTD.
Capacity: 524 kg/s (4159 klb/h)

Main Feed Pump Turbine
Manufacturer: G.E.C. TURBINE GENERATORS LTD.
Type: Single cylinder, bled and live steam driven
Design rating: 15 700 kW
Speed: 7100 rev/min

C.W. SYSTEM
Main C.W. Pumps
Manufacturer: WEIR PUMPS LTD.
Type: Vertical, mixed flow
Capacity: 8.33 m^3/s (294.2 ft^3/s)
Generated head: 14.6 m (48 ft)
Pump speed: 198.4 rev/min
Motor output: 1566 kW

Drum Screens
Manufacturer: F. W. BRAKETT & CO. LTD.
Number: 4
Capacity 8.71 m^3/s

GAS TURBINES
Gas Generator
Manufacturer: ROLLS ROYCE (1971) LTD.
Type: 2066 Olympus M/2

Power Turbine
Type: RR2103, independent two stage
Shaft power output: 24 400 s.h.p.

A. C. Generator
Manufacturer: G.E.C. TURBINE GENERATORS LTD.
Type: Air cooled turbo-generator cylindrical rotor
Speed: 3000 rev/min
Power factor: 0.8
Enclosure: Air cooled, duct ventilated
Voltage: 11 kV
Output: 17.5 MW, 21 874 kVa