DOUNREAY

UK ATOMIC ENERGY AUTHORITY

Dounreay occupies a site of about 200 acres, including an airfield, making it one of the biggest industrial sites in the Highlands. It is situated 10 miles west of Thurso (population 9,400), and is served by road from Inverness, by rail from Inverness to Thurso, and by air from either Inverness or Aberdeen to Wick.

There is a direct air charter service linking the establishment with the UKAEA's Northern Division HQ, which is situated at Risley in Cheshire.

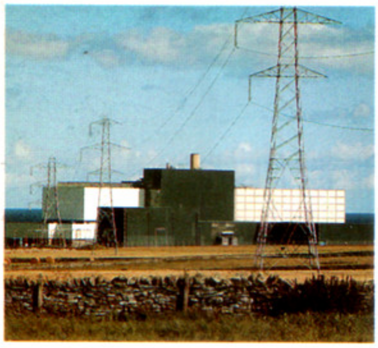
Laboratories at Risley, and the two other Northern Division sites at Springfields and Windscale, provide research, development, and support facilities for many aspects of the fast reactor fuel cycle programme.

FURTHER INFORMATION

Further information on all aspects of Dounreay's work can be obtained from:

Public Information Office
Dounreay Nuclear Power Development Establishment
UKAEA
Thurso
Caithness KW14 7TZ
Telephone 0847 62121, ext 7255

The establishment has a wide range of literature, and organises a comprehensive series of talks and visits. Close liaison is maintained with Scottish schools, and teachers' packs and visiting speakers are available on request.



The 250 MW(e) Prototype Fast Reactor supplies electricity to the Grid – enough to power a city the size of Aberdeen.

DOUNREAY Nuclear Power Development Establishment in Caithness is Britain's principal centre for the development of Fast Reactors, the largest single UKAEA research programme. The site operates the Prototype Fast Reactor (PFR), and its associated Reprocessing Plant. Developed since 1955, the establishment has operated two complete fuel cycles; one for the Dounreay Materials Testing Reactor (DMTR), commissioned in 1958, and another for the Dounreay Fast Reactor (DFR, the familiar sphere) which in 1962 became the first fast reactor in the world to supply electricity to a national grid.

FAST REACTORS

Fast reactors have been under development, in a number of countries, for over 40 years – and for much of that time Dounreay has been in the forefront of the technology, developing reactor systems, advanced fuel, reprocessing and waste management techniques. Recognised as British technology at its best, the site receives visits every year from scientists and engineers, together with thousands of tourists keen to see for themselves the nuclear power system of the 21st century. But why are Fast Reactors so special?

Fission

The fuel in a nuclear reactor is made of uranium or plutonium, or a mixture of both. The heavy atoms can be made to split apart – nuclear fission – giving out heat, which can then be used to produce steam, which in turn drives a conventional turbine, as in any other large power station. The nuclear fission process also produces gamma radiation, and "fast" neutrons, which have a speed of about 27,000 miles per second.

Thermal Reactors

Most of the world's reactors use as their fuel Uranium-235, which makes up less than 1% of the naturally-occurring uranium mined from the earth's crust. The rest is U-238, which does not fission easily. These "thermal" reactors contain material which slows the fast neutrons down by repeated collisions – "moderators"– in order to achieve the most effective fission in U-235. Although the proportion of U-235 is artificially enhanced in thermal reactor fuel, they still only "burn up" about 2% of the uranium.

Fast Reactors

Fast reactors use plutonium as fuel, which needs unmoderated, or "fast" neutrons to sustain the fission process – hence the name. The reactor is designed to use mixed plutonium/uranium-238 fuel in its core – the heart of the reactor, where the heat is generated – and the core is surrounded by more U-238. The U-238 absorbs some of the spare neutrons produced by fission – more are created than are needed to continue the chain reaction – and the U-238 then becomes plutonium.

Some of this new plutonium is fissioned where it is formed, but some remains in the spent fuel when this is removed from the reactor. Reprocessing will then extract it, making it available to be made into new fuel.

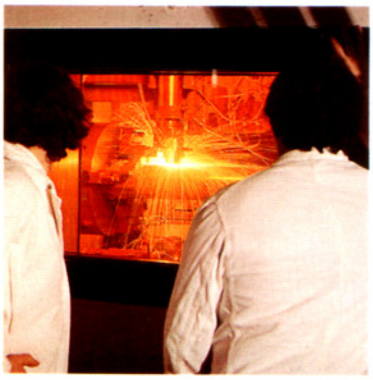
Irradiated fuel being transferred from PFR to the Reprocessing Plant in a shielded transit flask.

Breeder Reactors

"Breeding" plutonium in this way makes use of U-238 which is otherwise waste, and it means that such reactors can extract 60 times as much energy from uranium as thermal reactors do. The term "Fast Breeder Reactor", though, is misleading. The breeding process itself is slow – and in fact a fast reactor will actually produce less plutonium than a similar sized thermal reactor. In its lifetime of some 30 years, a fast reactor will produce enough plutonium to fuel its own successor reactor – and, of course, once started it can supply its own plutonium needs for life. It could also be used as a net consumer of plutonium.

REPROCESSING

Reprocessing, in which the uranium and plutonium are separated from the so-called "fission products" for recycling into new fuel assemblies, is thus the key to the fast reactor's success. Without it, the system's enormous potential for energy production would be wasted. Although the fast reactor is much more efficient than thermal reactors, after 10%-20% of the plutonium-uranium mixture is fissioned, metallurgical and physical changes in the fuel necessitate its removal from the reactor. It is then cooled, and reprocessed. After each fuel assembly is cut open, the fuel is dissolved, and the valuable elements separated from the waste products by standard chemical processes.



The end of a PFR hexagonal-shaped fuel assembly's outer wrapper is removed by laser cut, exposing the fuel pins.

Dounreay has reprocessed all the fuel from the site's two fast reactors. Research is concentrated on improving the efficiency of the process, and on developing advanced waste management techniques which minimise environmental impact, and reduce overall costs of the fast reactor fuel cycle. As the world's finite resources of coal, oil, gas and even uranium are used up, the Fast Reactor will become ever more important, using as it does the plutonium and U-238 which are virtually unusable in other reactors, and are left as a result of thermal reactor operations. In the UK, we have over 20,000 tons of U-238 in store. If used in fast reactors, this represents an energy source comparable to all our usable coal resources. By utilising other reactors' waste, and maximising the energy potential of uranium, while reducing the need for uranium mining and minimising the production of waste, fast reactors open up the prospect of a cleaner world with an abundant energy supply.

THE 1980s

Through the 1980s, Dounreay's development work has taken significant strides forward.

1980 – New PFR Reprocessing Plant operational, achieving better than 99.5% recovery of reusable plutonium.

1982 – The first reprocessed PFR plutonium is reloaded in the reactor; the fuel cycle is closed.

1984 – Britain signs an International Memorandum of Understanding, laying the foundation for a joint European development programme, in which Dounreay plays a leading role.

1985 – PFR settles into a pattern of long full-power runs.

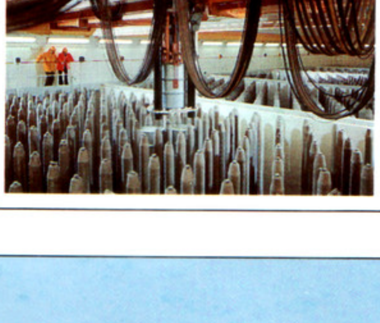
1986 – The original 'burn-up' target for PFR fuel (7½%) is more than doubled; this leads to lower costs, less fuel needing to be fabricated, less to be reprocessed, and less waste.

1987 – Cementation Plant commissioned; this will solidify liquid waste from early DMTR reprocessing operations, pointing the way ahead.

WASTE MANAGEMENT

Waste management has a high priority at Dounreay. Engineered interim retrievable storage facilities incorporate the latest technology, and advanced non-destructive assay (NDA) techniques together with attention to "housekeeping" combine to minimise secondary waste generation. High- and intermediate-level wastes are safely stored pending solidification and permanent disposal, and low-active liquid waste is discharged to the sea. Dounreay's development work has ensured that these discharges are kept extremely low, leading to a radiation dose to even the most exposed member of the public of about a hundredth of internationally-recommended levels.

Engineered Retrievable Waste Store, which commenced operation in 1980. Here, low-active solid waste with trace plutonium contamination is kept in dry storage.



SAFETY

Dounreay has, in all respects, an outstanding safety record. Before the nuclear power industry even began, risks associated with radiation were well understood. So, from the beginning, it was possible to ensure that workers and the general public alike were fully protected from the effects of radiation. Stringent examination of the design and construction of all reactors and associated plant is carried out by the UKAEA's Safety & Reliability Directorate. In all operations radioactive materials are excluded from the working environment by several protective barriers, and independent monitoring and safety systems continuously check each area. This is so effective at Dounreay that the site has a self-imposed limit for radiation workers which is three times lower than nationally-permitted levels.

Health Physics staff routinely checking salmon nets at Sandside Bay.

This approach to safety is reflected in other ways, too. Each year since 1964, the establishment has received the British Safety Council's Award for Industrial Safety – and the public are protected by a comprehensive environmental monitoring programme, which checks everything from grass and seaweed to the air and sea itself. This confirms that Dounreay's discharges have a negligible effect. In fact, the UK population as a whole receives a radiation dose from Dounreay which is many times smaller than the radiation dose they receive from any large coal-fired power station!

DOUNREAY PEOPLE...

...are not a race apart! 2,300 people work at the Establishment, including a large number of qualified scientists and engineers, and most live in the neighbouring town of Thurso and its surrounding villages – some continue to run small family farms, too. A Local Liaison Committee, set up in 1957, keeps the community informed on operational amd safety matters, and each summer the site's Public Exhibition is open seven days a week, attracting tourists from all over the world.

In the last 25 years, over 400,000 people have visited it, and seen everything from part of the original core of the first fast reactor, now completely decontaminated, to a device known as a cloud chamber, where you can actually see radiation in action. Each year, thousands take the tour of the Prototype Fast Reactor – the highlight for many is the moment when you stand on top of the reactor as it generates 600 megawatts of thermal power.

THE FUTURE

The Fast Reactor has proved itself to be a system which is not only technically attractive, but an elegant method of obtaining the maximum energy from uranium. It has outstanding inherent safety characteristics, and minimal environmental impact. Dounreay will continue to play a major role, as the research and develoment programme enters its final phase, where the accent is increasingly on demonstrating the commercial possibilities. PFR will take fuel to 20% "burn-up" and possibly beyond; the site's waste management teams will develop systems for reducing still further the radiological impact of storage or discharge methods. The Marshall Plutonium Development Laboratory, opened in 1986, keeps Dounreay at the forefront of reprocessing technology, using pulsed plate column techniques – and all this work will combine to ensure the success of the first European commercial demonstration fast reactors, leading to the large-scale use of fast reactors in the 21st Century.

Alpha Pulsed Column rig in the Marshall Laboratory – the future in fast reactor reprocessing, being developed at Dounreay today.