



**National Steering Committee of  
Nuclear Free Local Authorities**

Planning and Environmental Health Department  
Manchester City Council  
Town Hall  
Manchester M60 2LA

Secretary: Stewart Kemp BA(Hons) MSc

Tel: 0161-831 9108  
Fax: 0161-835 3645  
Email: [nfnscc@gn.apc.org](mailto:nfnscc@gn.apc.org)

To: DIS, SEND, JW, WPCND

① via Nettle to us attribution please. F. 7.1. / *concern*

27/4

Stwsk

With Compliments

*27 PWR plants  
2 prototype*  
*ABH  
→ 2<sup>nd</sup> core (higher power)  
Vanguard "H" core  
Batch 2 Trafalgar*  
**Security Note** *Enriched uranium fuel rods → substituted into machine core structure.*

The detailed design and the manufacturing processes used in the production of UK naval reactor cores are subject to restrictions under the Official Secrets Act. Members of NuSAC are asked to consider this when examining this summary Paper in advance of the presentation to the Committee on 12<sup>th</sup> March, 1998.

## ARRANGEMENTS FOR THE MANUFACTURE OF SUBMARINE FUEL

by Ian Gray and Ian Evans, Rolls-Royce and Associates Ltd, Derby

### 1) Introduction

In 1954, the first nuclear powered submarine, the USS Nautilus was launched by the US Navy. This transformed the submarine concept from a slow under water vessel with limited endurance to a high speed warship capable of many weeks of submerged operation. The achievement was not lost on the UK government of the day which instituted a nuclear submarine development programme. The programme received a significant boost in 1958 when the US/UK bilateral Agreement for Cooperation on the uses of Atomic Energy for Mutual Defence Purposes was signed.

Amongst other things, the Agreement provided for the supply of a complete S5W propulsion plant as fitted to the then latest US Skipjack submarine class and also the transfer of the basic reactor technology and the manufacturing expertise from Westinghouse to Rolls Royce. Rolls-Royce and Associates (RRA) was formed in 1959 with the "Associates" being Vickers, Foster Wheeler and Babcock & Wilcox. The Associates' shareholdings were subsequently bought out and RRA is now fully owned by Rolls-Royce plc. The first UK nuclear submarine, HMS Dreadnought, was launched in 1960 and incorporated the American supplied S5W plant.

Offices, laboratories, a zero-power reactor (Neptune) and a core manufacturing plant (Nuclear Components Division) were constructed on the RRA site in Derby. The core plant was a close copy of the original Westinghouse manufacturing facility in the US. The naval reactor test facility, Vulcan was established adjacent to the UKAEA fast reactor site at Dounreay and went critical with the first all British reactor core (Core A) in 1965.

Since that time RRA has developed a series of cores and reactor designs based on the original US technology, but now very different from the plants which power the US Navy.

Following the original transfer, there has been only limited interchange between the US and the UK on naval reactor technology and the current reactor plant and cores may be regarded as essentially UK designs.

## 2) Core Design

The evolution of the reactor plant has always been driven by safety and availability considerations with the core life showing a progressive upward trend with successive designs. For example, the latest core design (Core H) will allow the new Astute Class, previously known as Batch 2 Trafalgar, to operate without refuelling for the whole of the vessel lifetime whereas the early cores were exhausted after a few thousand hours of full power operation. The Ministry of Defence requires that, where practicable, the safety of its naval reactors and the associated processes and activities be to the same high standards as are adopted in the UK civil nuclear industries.

The operating parameters for naval reactors are significantly more onerous than those of civil plant in that they must be able to respond to rapid changes in power demand over the whole life of the core and be resistant to possible externally imposed shock loadings. A measure of the robust nature of the core generic design is the total absence of fuel failure during the whole of the UK naval reactor programme. This includes both operational vessels and the prototype cores which are subject to demanding test conditions in the Vulcan facility.

The design of the UK Naval PWR plant differs in a number of significant respects from its civil counterparts. The fuel elements incorporate Zircaloy and enriched uranium with a Zircaloy clad. Burnable poisons are incorporated to assist reactivity control through life. The core is of modular construction. Reactor reactivity control and shutdown functions are achieved with control rods. The overall reactor temperature coefficient is negative and the core is designed to be self regulating and able to follow flexibly turbine steam demands without the need for rod movements.

*hafnium control rods - shutdown trim only as fuel burnt up*  
*emergency core cooling in later designs - none in earlier*

## 3) Core Manufacture

The Rolls-Royce Core Manufacturing Plant was built in the late 1950s to the original Westinghouse design. Due to the nature of the processes and the relatively small throughput, manufacture is not highly automated. However, design tolerance requirements have become

*Primary circuits have isolation valves. Decay heat cooling system is different from commercial reactors*  
*temperature transients override is life limited as in*

much more demanding and inspection techniques are highly sophisticated and where appropriate, automated to meet very demanding quality controls.

The essence of the manufacturing processes involves incorporating enriched uranium with Zircaloy, reducing the fuel material to the required dimensions and cladding the fuel with Zircaloy to form elements which are then assembled into core modules. Core components containing burnable poison are manufactured in a similar manner to that of the elements. In addition, the control rods and all the non-fuelled Zircaloy core components are fabricated within the Plant. The Plant also includes the capability for the manufacture of steel components required for control rod mechanisms, valves and other specialist components of the reactor plant.

The methods of core manufacture are dominated by the requirements for the fabrication of highly chemically reactive materials and the overriding need to maintain close manufacturing tolerances of the complex components and assemblies. In many respects, there is much in common with industrial processes which, for example, melt and fabricate titanium alloys for the aerospace industry.

The manufacturing tolerance requirements also impinge upon the component nuclear performance and quality control measures are required which measure and confirm that reactivity and poison disposition match the design intent. Confirmatory measurements of core physics performance may be conducted in the Neptune zero power test reactor. The high power density of naval cores and the tight dimensional tolerances require that each core is individually characterised prior to entering service. The process of confirmation of core characteristics continues throughout life to ensure that safety parameters are correctly set as the core is progressively burnt up.

The nature of the fuel demands working practices which minimise the risk of criticality accidents, the control of dose uptake by the workforce and releases to the external environment. Manufacturing activities which may release airborne contamination are as far as possible undertaken within enclosures designed to contain the local process environment. The hazards are mainly due to alpha emitters\*. Ventilation extract systems are employed which incorporate absolute filtration, discharge monitoring and alarms. Movements of fissile components within the plant are governed by strict administrative controls augmented by equipment designed specifically to assist the workforce and to eliminate criticality hazards.

Derby plant is mimic of original Westinghouse plant.

Hazard from airborne contam. with  $\alpha$  emitters  
& criticality

There is recognition and control of sources of moderating materials such as water, lubricating and hydraulic oils and polyethylene.

Storage of completed fuel assemblies prior to shipment to the Naval bases or to the Vulcan test facility is carefully controlled. Each module has its control rod locked in place and the storage facility takes account of accidents which could change the fuel configuration and introduce moderator.

Scrap materials and arisings are as far as practicable recycled within the facility. The nature of the materials handled requires that strict accountancy measures are adopted for all fissile materials on the site. Periodic audits of the inventory of fissile material are undertaken by the Ministry of Defence.

#### **4) Regulation**

All activities are subject to civil regulation by the Nuclear Installations Inspectorate. Arrangements are in place to discharge the Generic Licence Conditions in a manner similar to other civil licenced sites. The Neptune zero power reactor is subject to separate civil licencing by the NII. The Vulcan Test facility remains subject to regulation by the MoD. A Safety Committee, chaired by the General Manager of the Nuclear Components Division, operates as required by the Site Licence. The liquid and gaseous discharges from the plant are authorised by the Environment Agency. The disposal of solid low level waste material is undertaken at the Rolls Royce licenced disposal site at Crich in Derbyshire. The BNFL Drigg disposal site is not used for wastes from the manufacturing processes. Transport of fuel components to naval sites is regulated by the Department of Transport which approves both the fuel containers and the transport arrangements.

Standard MoD approved security is maintained on the site with the whole workforce subject to security vetting by the Ministry of Defence.