The Dismantling of Nuclear Submarines in North-West Russia
An Overview of two projects and the end products

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ABSTRACT

This paper explains the background to the projects, and the setting up of the contracts to dismantle two Oscar-I submarines and one Victor-III submarine. As a pre -cursor to the dismantling, Russian documentation covering environmental, safety, operational and technical issues had to be prepared and submitted to the Russian regulatory bodies for approval, including a full Environmental Impact Assessment (EIA) of the projects. In addition to the dismantling projects, funds were also made available for shipyard infrastructure improvement projects necessary to ensure the safe and efficient completion of the projects.

The paper describes these aspects as well as the submarines themselves and gives an overview of the dismantling process. It also describes the nature of the wastes produced, including handling and processing together with the safety and environmental issues. Project Management and monitoring contracted to RWE NUKEM by the U.K. Department of Trade and Industry (DTI) is described emphasizing the importance of strong working relationships between British and Russian teams. Finally the paper discusses the “end products” of the Oscar-I and Victor-III dismantling and how the projects have provided a useful, high-profile platform on which to demonstrate the success of the DTI and their contractors in helping the U.K. meet its commitments under the Global Partnership Initiative.

INTRODUCTION

The environmental and nuclear material proliferation risks presented by the general purpose submarines of the Russian Submarine Fleet, became of concern not only to the Russian Federation but the also to the international community at large. To address these and other concerns, it was agreed at the G8 summit meeting in Kananaskis in June 2002 that a Global Partnership would be formed and a financial commitment made to counteract the threat of proliferation of Weapons and Materials of Mass Destruction from the Former Soviet Union (FSU). The safe treatment and disposal of decommissioned submarines and the associated radioactive and toxic materials was highlighted as one of the priorities of the Global Partnership programme.

The U.K. made its contribution through its “Nuclear Legacy Programme”, funded through the Department of Trade and Industry (DTI). The DTI contracted a British based team from RWE NUKEM to manage the projects and negotiations were completed with the Russian Ministry of Atomic Energy (now Rosatom) and the FSUE PO Sevmash shipyard of Severodvinsk to fund the dismantling of two Oscar-I Class cruise missile submarines in 2003, and with the FSUE SRY Nerpa shipyard of Snezhnagorsk, near Murmansk, to fund the dismantling of a Victor-III submarine in 2005. Keel Marine, also of the U.K., was subcontracted by RWE NUKEM to provide marine expertise and support during the dismantling process. In Severodvinsk the final dismantling work was carried out at FSUE MP Zvezdochka shipyard.

Fig. 1. Map of North West Russia showing relative locations of shipyards

It is important to distinguish between “decommissioning” a submarine and “dismantling” it. The Navy itself “decommissions” the vessel, i.e. takes it out of commission, such that it is no longer considered part of the operational fleet. It is then laid up, generally within one of the Naval bases. Eventually it is passed over to (usually) civilian control so that it can be defuelled and “dismantled” at a shipyard as described in this paper.

About 100 submarines have been decommissioned from the Navy (Northern Fleet), of which around 23 are still awaiting dismantling. These are generally stored afloat, many in poor condition and with fuel still on board.

CONTRACT NEGOTIATIONS

Initial discussions and preparatory meetings commenced in January 2003 to establish the submarine dismantling programme. Internal meetings held by RWE NUKEM and Keel Marine to develop the issues focused on the whole lifecycle of the submarine dismantling and decommissioning, highlighting key areas of concern such as buoyancy, maintenance, safe transportation, defuelling, Spent Nuclear Fuel (SNF) handling and management, radioactive waste management, regulatory issues, environmental issues, toxic waste issues and so forth.

Attendance at a Contact Expert Group (CEG) workshop held on submarine dismantling in Severodvinsk, NW Russia, gave a good introduction to the issues and also allowed contacts to be established with the Russian Ministry and shipyard personnel.

The programme of work in the FSU dealing with nuclear legacy issues is implemented using the U.K./Russian Federation Supplementary Agreement of 2003 to the existing bilateral agreement of 1996. As part of the implementation process for this supplementary agreement, it is a requirement for Rosatom of Russia to request the U.K. to support a particular project and to nominate its contractor to undertake the work.

In these cases, the FSUE PO Sevmash shipyard based in Severodvinsk was nominated to manage the dismantling of two Oscar-I Class NPS and the FSUE SRY Nerpa Shipyard in Sneznagorsk near Murmansk was nominated to manage the dismantling of one Victor-III Class submarine. In the case of dismantling the two Oscars, a joint venture, the first of its kind, was undertaken between the FSUE PO Sevmash and FSUE M P Zvezdochka Shipyards to undertake the dismantling on a collaboration basis.

Two visits to Severodvinsk for negotiation in September 2003 resulted in the price for dismantling the two Oscars and for the documentation package to gain the required approvals being significantly reduced. Subsequently the contracts were signed the offices of RWE NUKEM in Harwell in the U.K. on 1 December 2003. Negotiations for the dismantling of the Victor-III Class Nuclear Powered Submarine (NPS) began in 2004, and were concluded in early 2005, culminating in the signing of contracts at a ceremony hosted by DTI in London in April.

DOCUMENTATION

Availability of Existing Documentation

The “documentation package” was not fully understood during the initial stages of the Oscars project. In particular, it was not understood what proportion of the package could be “cherry-picked” from previous submarine dismantling projects and what proportion had to be rewritten or prepared. Available information was complex and required explanation. The documentation package was prepared by design bureau ONEGA, whose offices are in Severodvinsk. ONEGA arranged to give a one-day Workshop in Moscow in order to explain more fully the content and function of the documentation package, and to give indications of the approvals of various documents that would be necessary. This workshop took place on the 10th June 2004.

The documentation package is split into several parts:

- Feasibility Study (optioneering of the dismantling methodology)
- Dismantling Programme (overall work breakdown of the selected option).
- Transportation (of the submarine to the shipyard).
- Design Documentation (drawings, justifications and specifications of what to do).
- Organisational Documentation (drawings and procedures of how to do it, safety issues, waste management, resource management).
- EIA

The documents within the documentation package fall into seven categories:

- Those which are specific to the shipyard.
- Those which are specific to the individual submarine at that shipyard.
- Those which are specific to the individual submarine.
- Those which are specific to the Class of submarine.
- Those which are specific to the variant of the Class of Submarine.
- Those which are applicable to all submarines in all Shipyards.

Clearly, few documents were available for use without any modification. At the beginning of the Oscar project, this was not fully understood, and the team was initially surprised at the amount of work that would be necessary in the preparation of the documentation.

Cost of Documentation

A price was negotiated for the documentation package at FSUE PO Sevmash and this covered some 12,000 pages of documents and drawings, and all fees payable to the different review and approval bodies of which there were around 20. The cost was initially perceived as being very high but as the process was gradually more understood, the full extent of what was required for the two submarines and the review and approval process became evident.

At FSUE SRY Nerpa, the documentation contract was jointly funded between the U.K. and Norway since Norway were dismantling a Victor -III (#297) at the same time as the U.K. (#296) and a jointly funded approach was beneficial to both parties. This proved to be an interesting contract with the U.K. being the lead participant and assessing all documentation, and the main Norwegian support focusing on the EIA and associated documents.

INFRASTRUCTURE

In addition to the major dismantling contracts, supporting contracts were also placed at both locations for infrastructure items that were required in support of the dismantling of the submarines.

At FSUE MP Zvezdochka, the U.K. provided additional gas cutting stations and containers for transporting scrap

metal around the yard. The U.K. also provided toxic waste containers for long term storage and solid radioactive waste (SRW) containers for securing in the Reactor Compartment. (See Launching on page 14) At FSUE SRY Nerpa, toxic waste containers, additional scrap containers and SRW containers were also provided.
U.K. also supplied some radiation monitoring equipment to enable characterization of the waste and monitoring of exhaust air from the dismantling hall.

All these infrastructure items were funded by the DTI in support of the submarine dismantling contracts. During visits to the Shipyards representatives of the DTI were able to see for themselves the need for the additional infrastructure and the items being put to good use as part of the dismantling work.

THE SUBMARINES

OSCAR - I Class

Design number 929 -Submarine Serial Numbers #605 “Archangelsk” and #606 “Murmansk”.

Only two Oscar-I submarines were built, between 1980 – 1982, when they were superseded by the slightly longer Oscar-II. (the “Kursk” which sank in August 2000 with the loss of 11 8 lives after a torpedo accident was an Oscar-II).

#605 and #606 were de-commissioned from the Russian Navy in 1996/97 and were afloat at the FSUE MP Zvezdochka shipyard in Severodvinsk (defuelled) when the dismantling contract was put in place in late 2003.

Victor - III Class

Design Number 671 RTM -Submarine Serial Number #296.

26 Victor-III submarines were built between 1977 and 1991 (after 15 Victor-I and 7 Victor-II). This particular submarine was built in 1980 and decommissioned in 1999.

It had been stored afloat at the naval base Vidyaevo Bay, with nuclear fuel still on board, until 2004, when it was transferred to the FSUE SRY Nerpa shipyard, near Murmansk.

After it had arrived at FSUE SRY Nerpa, it was offered to DTI as a possible dismantling project, and a contract was in place by May 2005.

A Comparison

A comparison between the two types is given in Table I below:

Table I. Properties of Oscar-I and Victor-III Class Submarines

	OSCAR-I	**VICTOR-III**
Design	929	671 RTM
Serial number	#605 and #606	#296
Date	1980 – 1982	1980
Length	145m	104m
Beam	18m	10m
Draft at surface	9m	7m
Displacement submerged	17000 tonnes	6000 tonnes
Missiles	24 x SSN19	12 x SSN16
Torpedoes	28 and 6 tubes	2 and 2 tubes
Crew	107	94
Speed (submerged)	31 knots	28 knots
Max depth.	600m	400m
Propellers	2	1 + 2 'creep' units
Reactors	2 x OK-650B	2 x VM – 4P
Power	98,000 hp	30,000 hp

THE DISMANTLING PROCESS

The Dismantling Process

The dismantling of a nuclear submarine is a little bit more complex than the simple and familiar beaching and "gas-axe" demolition of a steel structure. This section describes the stages in the process and the way the reactor core is treated during that process.

Towing to the Shipyard

Transporting a decommissioned nuclear submarine, especially one that has been laid up for years, demands careful consideration. Maintaining adequate buoyancy and safety of such a submarine is essential.

- The pressure hull and the buoyancy tanks which ensure flotation of the submarine at the surface, need to be maintained "intact". If there is any slight leakage, this could possibly be contained with the help of a high-pressure air supply from shore or fro m an attendant vessel. Minor mechanical damage (possibly caused by corrosion and ice abrasion) might be the cause of such leakage.
- If the buoyancy is considered inadequate, then the filling of the buoyancy tanks with a buoyant material such as expanded polystyrene granules is a possible option.
- A more sophisticated option is to transport the submarine using a heavy-lift semi-submersible ship. This option is the subject of current study, but has its own disadvantages such as the depth of water required and also the difficulty of getting access for a foreign vessel and crew to an operating Russian Na val base.
- If the submarine is in a seriously compromised state, then the attachment of buoyancy pontoons to the submarine is another option. Success depends very considerably on the adequacy of the pontoon attachments and lashings, and their ability to withstand bad weather without causing even more damage to the submarine. Since the K-159 incident this option is being critically re-assessed.

Whatever methods are used, strict adherence to correct operating procedures such as those that the Russian authorities already have in place is of paramount importance.

However, in both projects addressed in this paper, the subject submarines had already been delivered to the dismantling yards before contract start.

Towing within the shipyard

In order to get the submarine to the defuelling facility in the shipyard, and then from there to the dismantling location, a tow within the shipyard is necessary.

The considerations outlined above also apply to this activity. However, the circumstances are much more controlled (daylight and fair weather only, short distance, no other vessel movements allowed etc.) and the associated risks are therefore less.

De-fuelling

This is the operation with the greatest potential risk to both personnel and the environment. Each submarine Reactor Compartment contains several hundred fuel elements which need to be carefully withdrawn and placed into safe and shielded containment.

- The top is cut from the Reactor Compartment and a prefabricated steel ‘coaming’ is fitted over the opening. Inside this structure the fuel element withdrawal takes place.
- The fuel elements are withdrawn upwards into a ‘flask’, each flask normally accommodating seven elements.
- When full, the flask is transferred either directly to a transport ‘cask’ (usually a solid stainless steel TK-18 or a concrete and steel TUK-108) or to temporary storage in a pond for subsequent transfer to a cask. Each cask accommodates seven flasks.
- When the cask is full, it is placed into temporary storage to await transport for final storage and processing.

The de-fuelling operation is normally carried out afloat. Any small changes in the attitude of the submarine in the water (heel, trim) due to removing final elements can be compensated by ballast movements to ensure perfect alignment for withdrawing the fuel into the flasks.

At FSUE MP Zvezdochka (2 x Oscar-I Class), the de-fuelling facilities are quite modern and located at a quayside, where all these operations are carried out.

At FSUE SRY Nerpa (Victor-III Class), the submarine wa s moored alongside a Nuclear Service Vessel, and this vessel used its own cranes and flask storage ponds. This vessel (the IMANDRA) is owned by Murmansk Shipping Co (MSCo -who run the nuclear ice-breaker fleet) and it was subsequently used to transport the flasks back to MSCo base in Murmansk for transfer into transport casks.

The Primary Circuit cooling water from the submarine may have low levels of radioactivity. It is removed from the submarine at this stage and processed as Liquid Radioactive Waste (LRW).

The Dismantling Berth

Once the fuel has been removed, the dismantling can begin.

At FSUE MP Zvezdochka, the two Oscar-I boats were towed into a large concrete “flooding dock”. Here the water level was raised by pumping water in from the river, and the submarines moved onto prepared raised berths. The water level was then released and the submarines settled down onto cradles, ready for dismantling.

At FSUE SRY Nerpa, the Victor-III was lifted in a floating dock, equipped with a multi-wheel hydraulic transporter (‘ship-train’). The dock was towed to a transfer location outside a large covered dismantling hall, and the submarine was winched into the hall on the transporter.

Conventional Dismantling

Fig. 2 shows the 3 sections into which the sub marine is divided.

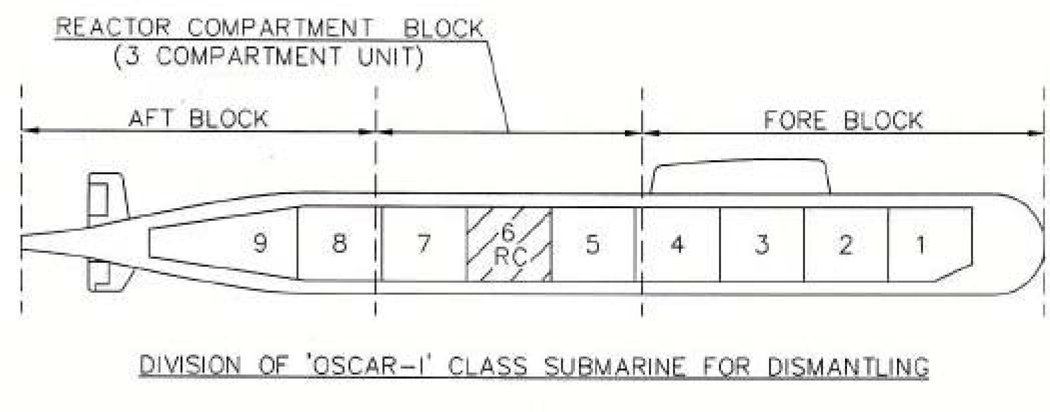

Fig 2. Division of Oscar-I class submarine for dismantling

The ‘conning tower’ or ‘fin’ is removed first. The Aft Block and Forward Block are then dismantled however there are additional complications. The entire hull of each of these submarines is covered in a thick layer of rubber. This is in the form of tiles approximately 500mm square and 50mm thick, bonded on to the steel hull. This coating is for acoustic damping, and achieves a dramatic reduction in the sonar ‘signature’ of t he submarine. The bonding is extremely strong and the tiles are difficult to remove, with manual methods (hammer and chisel) being the most effective. While all these tiles have to be removed during the dismantling, this is generally a gradual process, with the main ‘cut lines’ of the hull being exposed first in order that cutting can proceed.

- The main cut lines separating the three blocks are generally made first.
- Each compartment of the submarine has an opening cut in the top.
- All equipment, machinery, cable, piping etc., from each space within the submarine is removed in large pieces, for further size reduction elsewhere in the shipyard.
- The steel structure of the forward and aft blocks is then cut away in large pieces, for further size reduction elsewhere in the shipyard.
- The last piece left on the berth is the “3-Compartment Unit”, with the Reactor Compartment at its centre.

Further size -reduction is described more fully in Scrap Products on page 8

There is a constant danger of fire in any ship dismantling activity, more so than in shipbuilding because of the greater amount of heat involved and the ‘destructive’ rather than ‘creative’ nature of the work. This fire risk is compounded not only by the presence of all the rubber tiles, but also by the residue of various types of oils in various tanks throughout the submarine. It is essential that every space that has contained oil is drained, steam-cleaned and gas-freed before any dismantling activities start. Planning, procedures, and safety awareness are, therefore very important features of the dismantling process.

The 3-Compartment Unit

The 3 compartments that remain include the Reactor Compartment and the two adjacent compartments which provide buoyancy for storage afloat.

The final work in preparing this unit is described more fully in Reactor Compartment on page 10. Fig. 3 shows one of the Oscar-I Class submarines with the forward block completely removed.

Fig. 3. An Oscar-I Class submarine with the forward block completely removed and the forward bulkhead of the 3-compartment unit being prepared

SCRAP PRODUCTS

Size Reduction

Once large pieces of equipment and structure have been removed from the submarine, they are transported to various areas in the shipyard for size reduction. The saleability of scrap metal depends on it being in a form that can readily be used as an input material for re-cycling. For instance, this means that steel has to be in pieces not more than 1500 x 500 x 500 mm which can be fed directly into a smelting furnace.

The 3 main methods of size reduction are:-

- **Mechanical** – use of crushing and shearing techniques (even for high tensile steel from the pressure hull). At both FSUE MP Zvezdochka and FSUE SRY Nerpa Shipyards, the US has provided a large hydraulic crusher and shears manufactured in the US by Harris. A smaller shear operated from a Caterpillar has also been provided. At each of these two yards the US has also installed a cable shredding plant which removes insulation from the kilometres of cable extracted from a submarine and produces granulated pure copper for resale and shredded rubber/plastic (treated as toxic waste).
- **Thermal** – oxy-acetylene cutting (the Shipyards tend to manufacture their own acetylene but buy in the oxygen)
- **Manual** – disassembly of equipment and machinery

Table II. Size Reduction Methods

Material	Mechanical	Thermal	Manual
Machinery		v	v
Electrical equipment	v		v
Electrical cable	v		
Mild Steel	v	v	
Stainless Steel	v	v	
High Tensile Steel	v	v	
Copper	v		
Titanium		v	
Brass, Bronze		v	
Aluminium Alloys	v	v	
Precious Metals			v

Scrap Metal Quantities

Table III. Scrap Metal Quantities in Tonnes

	Oscar – I		Victor – III	
	Anticipated	**Actual**	**Anticipated**	**Actual**
High Strength Steel	3194	3168	1364	1211
Other steel	3013	2933	207	233
Copper	75	72	56	56
Titanium	572	608	89	101
Other non-ferrous	443	532	127	157
Total	**7297**	**7313**	**1843**	**1758**

Generally, high strength steel, titanium and copper are sold to Russian buyers. Mild steel and, to a lesser extent, aluminium are exported to foreign buyers usually in neighbouring European countries such as Finland.

Income from Scrap

At the start of each dismantling project, the shipyard entered into a contract with Rosatom to collect the income from the sale of scrap materials and place it in a specially arranged Rosatom bank account. These funds would then be available to Rosatom for use in other “Nuclear Legacy” projects. The value of these scrap materials at the time of sale is, of course, dependant on global commodity prices and these can fluctuate wildly. This was especially true during 2002 – 2004 when world prices rose sharply due largely to massive economic expansion in China and consequent rise in demand for steel. This price rise applied not only to steel and iron ore (and hence scrap for recycling) but also spread to other metals including aluminium, titanium and copper. At the time that the Oscars were dismantled in Severodvinsk, this change in scrap value caused a three-fold increase in the funds derived from these two submarines.

WASTE PRODUCTS

S pent Nuclear Fuel (SNF)

The defuelling operation has been described in Defuelling on page 5.

While the two Oscar-I Class submarines had already been de-fuelled prior to the dismantling contract, the Victor-III had not. Fuel from the Victor was loaded from storage in flasks on the “IMANDRA” into TK -18 transport casks on board Nuclear Service Ship “LOTTA” at the MSCo . site to await the arrival of the special SNF train.

This train consists of four SNF wagons, each of which carries three TK-18 or TUK-108 casks stowed vertically.

Behind and in front of these wagons are two “sacrificial” store wagons to offer a degree of impact protection. A living coach for the permanent crew and two diesel locomotives complete t he train.

The SNF from the Victor-III occupied ten TK-18 casks, the other two slots on the train being occupied by fuel from other sources. All marine SNF, including that from the ice breaker fleet, is taken to a storage and re -processing facility at Mayak in Central Russia, a journey by train of some 6 to 8 days.

An audit trail for the SNF was provided giving flask and cask ID and location at every stage throughout the operation from the submarine right through to arrival and acceptance at Mayak.

Liquid Radioactive Waste (LRW)

LRW comes from several sources in the submarine dismantling process.

- Primary Circuit cooling water from the reactors. The quantity is not great (about 15m^3 from an Oscar-I, 10m^3 from a Victor-III .) Activity levels would normally be described as low, although neutron activation products will be present. However, depending on the history of the reactor in terms of accidents, fuel leakage etc. the LRW can be of intermediate level.
- Waste water from health physics facilities, from showers and laundry.
- Decontamination fluids from fuel handling equipment and other tooling, including handling and processing of SRW.

In all, about 400m^3 of LRW was produced for each Oscar, and 120m^3 for the Victor.

At FSUE MP Zvezdochka, the LRW storage and treatment plant has been recently rebuilt with American and Norwegian funding. The treatment plant includes filtration, ion exchange resins, distillation, ozone treatment, reverse osmosis and evaporation, with storage for 2000m^3 of LRW. The actual treatment process can be tailor made after an analysis of the make-up of the particular LRW stream in terms of activity, salinity, oil and detergent content etc. The waste from the two Oscars was pumped directly to the storage tanks at the plant, and resulted in a few m^3 of solid residue, placed in drums and stored in cylindrical SRW storage and transport containers. The clean effluent product was analysed and pumped directly to the river. The criteria for passing this effluent as fit for discharge to the environment are very stringent, and strictly applied.

At Atomflot(MSCo) the LRW storage and treatment plant is older, smaller and less flexible in terms of the character of the waste that it can treat. The LRW from the Victor was discharged into storage tanks on the “IMANDRA”, at the time of the de-fuelling operation. Waste from Health Physics and decontamination was collected in a floating storage barge (PEK-50), and subsequently pumped to the “IMANDRA”. “IMANDRA” then transported the LRW to the plant at Atomflot, at the same time as the SNF.

Solid Radioactive Waste (SRW)

During the dismantling process, especially when stripping out equipment and systems from the Reactor Compartment, a certain amount of solid radioactive material is identified (contaminated piping systems, tooling, glass, plastics, filters, personal protection and clothing etc.)

The material is cut, when necessary, and compressed where possible, and loaded into steel containers with hinged lids. The capacity of these containers is about 2m^3.

The containers are welded into the Reactor Compartment of the 3-Compartment Unit for storage. See below.

Toxic Waste

Russian regulations consider almost all wastes as toxic waste, graded in toxicity from 1 (highly toxic) to 5 (virtually non-toxic). A large proportion of the toxic waste comes from the outer hull coating of the submarines, which is made up of thick rubber tiles to provide acoustic damping. These are graded as Category 4.

Other toxic substances produced in the dismantling process are lubricants, oils, refrigerants, insulation materials, mercury from lamps and asbestos -based lagging.

Although asbestos is considered to be of relatively low risk under Russian regulations, the safe storage of such materials has been carefully considered. Indeed, a new long-term store for closed containers of non-treatable toxic waste was nearing completion at FSUE MP Zvezdochka as the two Oscars were being dismantled.

Mercury from the lamps is graded as Category 1 and recovered by specialist companies and recycled. Oils are generally used in the shipyard for heat generation by incineration; rubber is sometimes granulated and used in road surfacing. The remaining rubber is simply stored in open compounds. Insulation, asbestos, plastics and other toxic waste is containerised and kept in long term toxic waste storage.

REACTOR COMPARTMENT – THE “END PRODUCT”

Preparation of the 3-Compartment Unit

Conventional Dismantling on page 6 and The 3-Compartment Unit on page 7 describe how the 3-Compartment Unit is created. Its main job is to provide safe interim floating storage for the de-fuelled reactors of submarines.

While the forward and aft blocks of the submarine are being cut up, a lot of preparation work goes on in the 3-Compartment Unit as well.

- The end two bulkheads are completely sealed, all doors and penetrations for pipes and cables are welded up and x-ray tested,
- The two buoyancy compartments are sealed up, with access panels rewelded and then pressure -tested with air.
- An access walkway is added on top of the unit, with handrails and additional access rungs on the hull.
- All deck access manholes to the 3 compartments are bolted up watertight.
- Mooring and towing arrangements are fitted.
- Cathodic corrosion protection is fitted to the end bulkheads.
- All new steelwork and the end bulkheads are fully painted.
- Draft marks and a full waterline are painted on to the outside of the hull, according to the detailed weight and stability calculations that have been carried out by the shipyard.

During the dismantling, of course, this area is treated as an “active” area, in terms of radiation safety and monitoring. All equipment, cabling, piping etc. from these 3 compartments is also removed. All scrap from the submarine is monitored for any activity or contamination, of course, but particular attention is paid to material from these three compartments. Any material that is found to be contaminated is separated and processed as SRW.

Installation of SRW

At some stage during the preparation work described in Preparation of the 3-Compartment Unit on page 10, additional work is carried out in the Reactor Compartment itself.

One of the functions of the 3-Compartment Unit is to provide a secure interim storage for SRW. To this end, SRW is secured in closed steel containers in the available deck areas around the reactors. This is not only SRW derived from the submarine itself, but will also include SRW from other sources. The 3-Compartment Unit can be used as a convenient way of taking SRW away from over-subscribed land sites. Typically, only about 30% of the SRW placed in the Reactor Compartment comes from the submarine itself. For example, only 4 of the 15 containers secured in the Victor-III Reactor Compartment came from the Victor-III. Each container has a unique ID number and a passport which records its weight, contents, activity level etc.

Once the SRW containers are in position and welded down, the access plate is then welded back on the top of the Reactor Compartment. The welding procedure for replacing the access plates on all three of these compartments is to the same standard as would be used on the pressure hull of the submarine in service.

Launching

Once all preparations are complete, the 3-Compartment Unit is launched. In the case of the Oscars, the flooding dock was filled, and with the Victor, the floating dock was used. Fig. 4 shows the "launch" of one of the Oscar units.

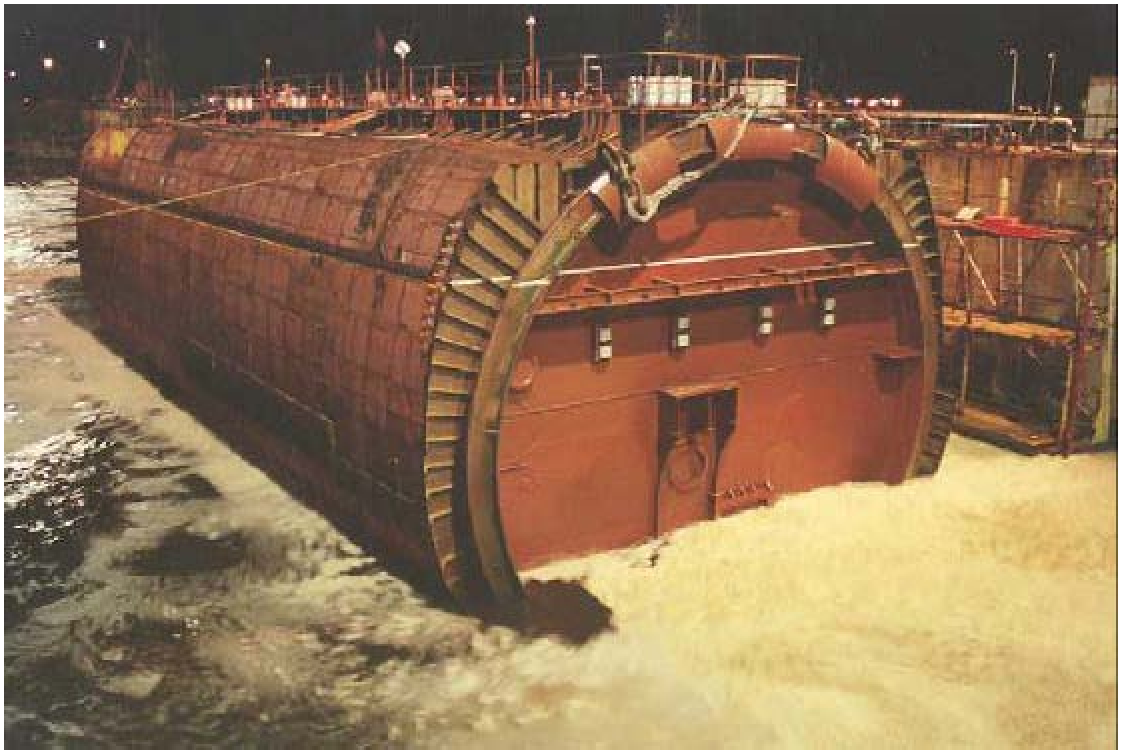

Fig 4. Launch of one of the Oscar 3-compartment units

Storage at Saida Bay

One of the fjords north of Murmansk is called Saida Bay. The location has good weather protection, and even during winter, the ice thickness is not severe. Saida Bay has become the designated Storage Site for 3-Compartment units in North West Russia, and the site is operated and managed by FSUE SRY Ne rpa shipyard. There are currently over sixty 3-Compartment Units stored there, moored to five floating jetties. The site is now stated to be "full". Clearly, storage of these units afloat cannot be regarded as the long term solution. Periodic maintenance of each of them is required, as for any floating structure, and a daily routine of monitoring radiation levels and draft readings is carried out.

Conversion to Single Compartment Units.

Land based storage would be better than storage afloat also, on land, there is no need for the buoyancy compartments either side of the reactor, and hence both the volume and weight of the units can be reduced.

An important infrastructure development is currently in progress at Saida Bay, funded by the German Government and due for completion in 2006/7. This development provides an extensive land storage facility for up to 120 single Reactor Compartments.

The process of conversion to single compartment units has already started.

3-Compartment Units will be towed back from Saida Bay to FSUE SRY Nerpa shipyard, lifted in the floating dock on to a 'shiptrain' and taken ashore. Here the buoyancy compartments will be removed and re-cycled as scrap and the remaining Reactor Compartment re -coated. Once the new facility at Saida Bay is ready to accept the first units, single Reactor Compartments will be returned to Saida Bay in the floating dock, and transported to the land storage.

Here they will remain for 50 to 100 years during which time the activity will decay, perhaps to the point where the reactors themselves can be removed and taken for disposal.

The Final Solution

Disposal of SRW has both technical and political considerations. Identifying and developing suitable sites for disposal is an on-going process. Many n ations who have a nuclear industry, or a nuclear fleet, still have this hurdle to overcome.

SAFETY AND ENVIRONMENTAL ISSUES

The dismantling of the submarines clearly raises a number of safety and environmental issues. Not only does the shipyard have to contend with the normal hazards associated with ship recycling but extra risk is introduced with the handling, treatment, storage and disposal of a variety of radioactive and toxic wastes removed from the submarine.

Detailed risk assessments for both projects were carried out at an early stage. These risk assessments comprised of both a project based risk assessment and also an assessment based on the operations at the yard. Trained facilitators were used to run risk assessment workshops both in the UK and at the Shipyards. To conduct the assessments, the projects were split into the various operational areas e.g. towing and refuelling (at FSUE SRY Nerpa only) waste management, dismantling of the bow and stern etc. Threats were then identified for each area and the risk assessment process then carried out for pre and post mitigation scenarios. Using this technique, areas of high risk were identified and checks could be made that the appropriate mitigations were in place. The "Risk Register" appeared as a regular item on the agenda for the monthly monitoring meeting allowing the opportunity for the Shipyards to add risks as they arose, hence ensuring the process continued through the project lifetime.

At both Shipyards the usefulness of the process as a project management tool was appreciated and both RWE NUKEM and DTI were impressed by the commitment shown by the personnel.

Conventional safety issues were addressed by the Shipyards in the normal way. (Boots, hard-hats, goggles, ear defenders and face ma sks etc.)

Radiological safety was closely monitored throughout the projects in a number of ways. In the early stages of each project, a radiological risk assessment was carried out. No unexpected anomalies were found. The Shipyards' own practices and p rocedures in Radiation Protection were found to be adequate, and similar to equivalent U.K. standards. Personal dosimeters were issued to staff visiting the shipyard, which were then analysed on return to the U.K. No significant levels were identified during either project.
Health Physics facilities were located close to the submarines during dis mantling. These facilities included 'clean' and 'dirty' changing areas, showering and laundry facilities, separation barrier, radiation monitoring and security. Protective overshoes and clothing were provided to all staff by the shipyard when visiting SNF, SRW and LRW handling and treatment areas.

Environmental issues were detailed and addressed in the EIA documentation.

PROJECT MONITORING

During the early stages of negotiation with the Shipyards, it was agreed that representatives from RWE NUKEM would make visits to the yard on a monthly basis to monitor progress and assess milestone achievement claims. To make the milestone payments significant without being too large it was decided that about 20 milestones would be required for each submarine. The frequency of these payments ensured that the yards would not be placed under undue financial pressure which may encourage them to "cut corners" jeopardising safety to bring forward large payments. This was also reinforced by the frequency of the visits which meant that if the yard were to miss a milestone or if a claimed milestone was rejected, it need be only a month before it could be resubmitted. Both projects were continually tracked by both the Russian and the British sides using Microsoft Project in a schedule linking the dismantling process to the milestones, and well-defined criteria for assessing each milestone.

In addition to the monthly monitoring, regular progress reports were sent to RWE NUKEM by a local representative. In the early stages of the projects, these reports were invaluable in assessing likely compliance with the programme.

The monthly monitoring visits were usually carried out by two people, generally one representative from RWE NUKEM and one from Keel Marine. The visit would take the form of a shipyard tour followed by a progress meeting. The agenda for each progress meeting had to be presented well in advance, as translation was required and the attendees had to obtain security clearance.

This approach to the monitoring of the projects meant that any potential problems were highlighted well in advance of them becoming major issues , and despite some minor delays in certain areas, the overall objectives were successfully achieved on budget and ahead of schedule.

CONCLUSION

The successful completion of both projects was due not only to the technical achievements but also due to the working relationships formed between the Russian and U.K. parties, and also RWE NUKEM and it customer, the DTI.

The monitoring team recognized the professional competence of the Shipyards and themselves developed a “firm but fair” strategy in carrying out their activities. This fostered considerable mutual respect between the two sides. At both FSUE MP Zvezdochka and FSUE SRY Nerpa, all those involved in the monthly monitoring visits developed professional working relationships which enabled the projects to move smoothly to completion.

Future work in dismantling would benefit greatly from using a similar approach in achieving the project objectives.

The completion of the Oscar project has provided a useful and high-profile platform on which to demonstrate the success of the DTI and their contractors in helping the UK meet its commitments under the G8 Global Partnership Initiative. The subsequent contract to dismantle the Victor-III has reinforced this commitment and at the same time demonstrated the very good working relationships and coordination between Global Partnership donors, epitomised by the collaboration between the UK and Norway at the Nerpa Shipyard.