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OVERVIEW OF THE 1995 NATO ARW ON NUCLEAR SUBMARINE DECOMMISSIONING AND RELATED PROBLEMS

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The NATO Advanced Research Workshop on Nuclear Submarine Decommissioning and Related Problems was held in Moscow June 19-22, 1995. It was preceded by a visit to the Zvezdochka Shipyard at Severodvinsk, a repair and maintenance yard for Russian nuclear submarines, for a subgroup of the workshop attendees. Attendance at the workshop was approximately 115 with participants from Russia, United States, France, Norway, Canada, Denmark, Sweden, Estonia, and Germany. Most of the material in this paper is drawn directly from the workshop proceedings.[1]

Slightly less than 500 nuclear ships and submarines (the vast majority are submarines) have been constructed by the countries with nuclear navies. This includes approximately 250 by Russia, 195 by the United States, 23 by the United Kingdom, 11 by France and 6 by China. By the year 2000 it is expected that approximately one-half of these nuclear vessels will be removed from service and in various states of decommissioning. A newspaper account in June 1997 indicated that 156 Russian nuclear submarines had been removed from service. In August 1996 it was reported that 55 reactor compartment sections from U.S. nuclear submarines were already in long-term storage at Hanford. Overall the dismantlement of nuclear submarines and the processing, storage and disposal of nuclear fuel, activated components and section of the hulls, and the liquid and solid radioactive and hazardous wastes is an enormous problem. This problem has been exacerbated by the accelerated decommissioning schedule associated with treaty obligations.

U.S. and French Decommissioning Strategy

Strategy and procedures for decommissioning nuclear submarines in the United States and France were presented. The U.S. procedure, presented by MacKinnon and Burritt, includes:

- All weapons are removed prior to arrival at Puget Sound Naval Shipyard.

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- Loose material and equipment is removed, many gas and fluid systems are drained or removed, and other systems are deactivated.
- The ship is drydocked, defueled, and the reactor fluid systems are drained.
- The reactor compartment (RC) is cut from the ship, sealed and placed on a barge.
- The barge is towed through Puget Sound, out to sea and up the Columbia river to the Hanford site. Here it is placed in an open burial trench. It will eventually be covered.
- The remainder of the submarine can be disposed of by normal procedures.

The French strategy, presented by Masurel, includes:

- The nuclear fuel is unloaded at the shipyard.
- The RC is isolated from the submarine and all removeable equipment, small diameter piping and combustibles are removed from the RC. RC fluid systems are drained and sealed.
- The RC is sealed and cut out of the submarine.
- Any systems in the rest of the submarine possibly radioactively contaminated are removed. The remainder of the submarine can be disposed of by normal procedures.
- The RC is dry stored at DCN Cherbourg for 15-20 years at a weather protected site.
- The reactor is then dismantled and conditioned (packaged) for surface storage by ANDRA.

Russian Decommissioning Strategy

A decommissioning strategy similar to that used by the U.S. at Puget Sound and Hanford was evaluated by Russian specialists and found not to be practical due to differences in coastal geography and climate. An alternate approach to decommissioning and recycling, discussed by Shunkov, was approved by Russian Federation government decree in 1992.

It includes:

- Creation of facilities for unloading, temporary storage and transportation of spent nuclear fuel.
- Facilities for storage, reprocessing and burial of liquid and solid radioactive waste.
- Specialized underground storage facilities for reactor compartments.
- Production capacities for cutting-out of reactor compartments, preparation for extended storage and complete recycling of bow and aft ends of the nuclear submarines.
- A complex of hoisting and transportation facilities for handling assemblies and units of nuclear submarines in the course of recycling (transport ships equipped with cranes, transfer and transportation docks, transborder trucks, etc.)

Creation of the special facilities and engineering means needed to implement the above strategy is only beginning and it is doubtful that adequate financial resources to complete the scheme can be made available before the year 2000. Several of the Russian papers addressed the implementation of the Russian decommissioning strategy as discussed below. In some cases temporary technologies are being employed until the new facilities are created. Current Russian shipyard decommissioning operations can only handle 4-6 submarines per year. This is a serious problem, however, due to the many nuclear submarines being removed from service. At this rate many of the submarines removed from service will await many years before completion of decommissioning.

Several of the Russian papers listed inadequate funding as the key problem in delaying the decommissioning activities. Others listed the absence of approved decisions in important technical areas as also impeding programs.

Alternate Approaches to Dismantlement and Recycling

The approved concept for handling Russian nuclear submarines removed from service includes removal of the spent nuclear fuel and otherwise inactivation of systems, cutting out of the reactor compartment, disassembly of the bow and aft sections, extended storage of the RC, and eventual recycling and/or disposal. Key questions addressed by several of the papers were the preparation for and the sites or type of structures for extended storage of RCs (50-70 years). Storage alternatives for RCs included open sites, inside industrial type structures, in trenches, in new underground tunnels, in available underground tunnels, and underwater in a coastal water area. Weather conditions in Russia's North and Far East do not permit open storage, and there are many unanswered questions regarding underwater storage. The preferred alternative currently is in available tunnels (on concrete supports).

Two major alternatives to this concept were put forward. In the first of these it was proposed that extended storage of RCs is not practical and that ship disassembly radiation and technological complexes (SDRTC) should be constructed to allow near term recycling of the RCs. The requirements for the SDRTC's were discussed in some detail. It is proposed that the SDRTCs would include facilities for vessel disassembly, equipment for cutting piping and other objects, facilities for the complete processing of liquid radioactive wastes (LRW) and solid radioactive wastes (SRW), equipment for recycling metals and other materials as well as lifting cranes as needed and appropriate robotic capabilities. Other papers indicated that near-term recycling of RCs was not practical due to the high radiation levels of the RC components.

In the second alternative it was observed that the facilities for extended storage of RCs were unlikely to be constructed soon and waterborne storage (e.g., three compartment units) for 20-25 years would be both necessary and acceptable (based on corrosion rates for the submarine hulls). The RC would then be recycled using SDRTCs. The possibility of using decommissioned nuclear submarines as floating power plants for remote sites was also discussed.

Spent Nuclear fuel Storage and Transport

Reports from the shipyards indicated that facilities for the interim storage of spent nuclear fuel from submarines are nearly filled or in some cases completely filled. At the time of the 1995 ARW it was reported that approximately 125 Russian nuclear submarines had been removed from service, but the fuel had not been removed from 85 of these submarines due to the shortage of spent fuel storage facilities at the shipyards. Problems were being encountered in transporting the spent fuel to the Mayak reprocessing plant. The new shipping casks, which meet international standards, were too heavy for some of the available transportation facilities, and approval had not been obtained for temporary use of the old, lighter shipping casts. In addition, non-standard nuclear fuel and damaged fuel assemblies can not be processed at Mayak. They must be stored until procedures for handling them (either processing or disposal) are developed.

The submarines with the fuel still on board are being maintained afloat with a few key systems operational (e.g., to remove decay heat from the spent fuel) by a small crew. Both the crowded spent fuel storage facilities and the submarines with spent fuel still on board represent safety risks and risks to the environment. When the spent fuel is removed from the submarines and sent to reprocessing both the safety risk and the environmental risk are dramatically reduced.

Liquid and Solid Radioactive Waste

It was reported that the facilities for the storage of both solid and liquid radioactive waste at the Zvezda Far Eastern plant were nearly filled and that radioactive waste is being produced much more rapidly than it can be processed in the Northern shipyards. Facilities for the temporary storage of LRW were a problem.

Three types of LRW were identified: primary circuit liquid, decontamination solutions, and contaminated sea water. New or modified technologies are needed to address these wastes since they are not the same as the wastes addressed by most existing Russian LRW facilities.

Remelting was the preferred method for addressing solid metal radioactive wastes. Volatile radioactive isotopes are driven off and much of the radioactivity is concentrated in the slag. Significant decontamination factors can be achieved, sometimes resulting in metal that can be released for unlimited use.

Submarines with Damaged Nuclear Fuel

There are reported to be four submarines with severely damaged nuclear fuel in the cores. This includes one in the Northern fleet and three in the Pacific fleet. Three of these submarines suffered loss-of-coolant accidents and one was involved in a criticality accident during refueling. One workshop paper also indicated that there are a number of additional submarines that have cores in "deplorable" conditions, but it is not known if these cores are

a defueling problem. All of the submarines with severely damaged fuel were, at the time of the 1995 ARW, in waterborne storage with the nuclear fuel still in the core. This is a situation that has existed for several years because procedures for unloading the damaged fuel have not been fully developed, and the damaged elements cannot be processed at Mayak. The unloading of the damaged core will be difficult and risky due to concerns about radiation levels, contamination levels, and recriticality. One U.S. paper described the procedure used to unload the damaged fuel from the TMI-2 reactor core. This was primarily a manual operation using long handling tools conducted under a thick layer of water for radiation protection.

Several papers discussed the use of sections of high strength submarines hulls as containers for RCs with damaged fuel. In one case it was implied that the damaged fuel was removed prior to this storage while in another case it was not to be removed. In any case it was assumed that these RC's were highly contaminated and that the hull of the submarine with the damaged fuel was the primary containment for the nuclear contamination. Placement in the second hull section then provided double containment. Use of submarine hull sections for extended storage of solid radioactive waste was also proposed.

Overall the submarines with damaged fuel represent several problems including the safety and contamination risks associated with unloading the damaged fuel, the risks associated with extended waterborne storage of the submarines prior to unloading of the fuel, and the risks of extended storage of the still highly contaminated RCs.

Decommissioning Technologies

Several new or modified technologies for dismantlement, disposal or recycling were discussed in a number of the papers. These included explosive cutting and dismantlement techniques, abrasive water jet and laser cutting, more aggressive decontamination solutions (since surface damage is not an issue), procedures for remelt bulk decontamination, and cementation as a process for sealing contamination in components and compartments. One paper discussed the disposal of high-level nuclear wastes by utilizing underground nuclear explosives in the Novaya Zemlya Archipelago. Areas in need of better technologies were discussed.

The overall consensus seemed to be that adequate decommissioning technologies were available, although some of the new technologies could help. The key problem was funding, however.

Radioecology Issues

The radioactive contamination in the costal areas in or immediately adjacent to some of the Pacific fleet bases was discussed. Many local areas exceeded maximum permissible concentrations (sometimes by several factors of 10) but only one area, that resulting from the submarine refueling accident mentioned previously, had levels that were actually health

threatening. Normal submarine operations and normal extended waterborne storage do not lead to environmental contamination. Reactor core unloading operations and the extended storage of submarines with severely damaged cores have both been observed to lead to environmental contamination, but it is generally quite localized. Poor training of workers and the use outdated equipment and technologies can also lead to contamination.

International studies indicate that the radioactive contamination of the Barents and Kara Seas is low, and that the most important sources of contamination in these seas are the atmospheric and underwater nuclear tests conducted at Novaya Zemlya. Radioactive contamination of these seas also results to some extent from discharges of rivers that flow in the vicinity of Russian nuclear facilities far inland (e.g., Mayak) and from the discharges of the reprocessing plant at Sellafield and to a lesser extent from the nuclear facilities at Dunreay and Cap de la Hague.

It was reported the 6.6 reactors with fuel and 9.4 reactors without fuel were dumped along the east coast of Novaya Zemlya. These included both submarine and ice breaker cores. Little activity has been measured so far near these sites. Activity in the vicinity of the sunken nuclear submarine Komsomolets has been monitored and found to be very low. The Komsonnolets is not expected to be a long-term problem.

The major concerns in the Northern fleet area are not from near-term leakage of radioactive materials or from the radioactivity already present in the environment. More important are the risks and consequences of a possible accident (e.g., fire, explosion, accidental criticality) in one of the nuclear facilities, since huge inventories of radioactivity are present in some of these facilities. The crowded spent fuel storage facilities are a concern.

References

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