Maritime Affairs
Naval Officers Association of Canada

Hazardous Duty

Nuclear Submarine Accidents

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Serving in submarines has always been hazardous duty. Advances in technology have gradually minimized the risks from toxic fumes, battery explosions and accumulations of carbon dioxide. Exacting standards in training and maintenance have reduced the incidences of crew error-induced accidents and catastrophic component failures. However, it remains a high risk occupation and accidents still happen. Nowhere is this more evident than in the navy of the former Soviet Union.

The advent of nuclear power for submarines in the 1950s transformed undersea warfare. Freed from dependence on air from the surface to supply the diesel engines which charged the batteries, the nuclear-powered submarine could take advantage of speed and total covertness. The ample power available from th steam generated by the nuclear "boiler" could generate more electrical power to provide for better sensors and an improved internal environment. The only limitation on endurance was that of the crew itself.

But nuclear power brought a new hazard as deadly and invisible as carbon dioxide gas--radiation. In the Western navies that embraced nuclear-powered submarines, the US, the British and the French, stringent standards in the construction and maintenance of the reactors were developed and implemented. Crew training went far beyond the rigorous and unforgiving approach used for basic submarine qualification. While neither the British nor the French adopted the tyrannical methods of the American Admiral Rickover, they did and still do, subscribe to his philosophy of rigid quality control in construction and repair, consistent application of training and qualification standards and a central authority overseeing all technical aspects of the nuclear navy.

WESTERN LOSSES

This methodology has proven itself in the record of the western navies in regard to nuclear submarine accidents. Only two US Navy submarines have been lost and there have been no other fatal incidents.

USS *Thresher*

In April 1963 the attack-type (SSN) submarine USS *Thresher* was lost in the Atlantic some 100 miles east of Cape Cod with all hands. During post-refit sea trials when deep, a high pressure seawater line failed and caused uncontrollable flooding. The submarine ended up in six pieces at a depth of 2600 metres and 129 men were lost. The reactor compartment has remained intact and no leaks of radiation have been detected. Design modifications to the follow-on ships of the class cured this particular failing.

USS *Scorpion*

The second loss was *Scorpion* in May 1968 which disappeared during a submerged transit from Gibraltar to Norfolk. The wreck was discovered in two pieces about 500 miles southwest of the Azores in a depth of 360 metres. All 99 members of her crew were lost. The cause has not been fully explained publicly but speculation has centred on two possibilities--that due to a navigation error, she was off the planned track an struck a seamount at speed when deep or she suffered a torpedo explosion. Again, there has been no detectable radiation leakage from the reactor or from the nuclear warheads in two of her torpedo load.

SOVIET PROBLEMS

The Soviet Navy had a very different record. Until recently, the true extent of the accidents and incidents involving nuclear submarines of the former Soviet Navy remained a closely guarded secret. In two instances the accidents were embarrassingly obvious to the world in general as two submarines sank in the North Atlantic under the gaze of Western observing aircraft but what actually happened was uncertain. Only recently, in the post-Cold War era, has some of the detail emerged. The Bellona Foundation, a Norwegian-based Non Governmental Organisation which monitors the environmental impact of the horrendous problem of the disposal and safeguarding of decommissioned Russian nuclear reactors, has published a monster report. This report, published in July 1996, among other things, provides details of the majority of the various incidents which occurred in nuclear submarines in the era of the Soviet Navy and is a primary source for the events described in this article. (The complete report, together with a full list of bibliographical references, ca be found at the Foundation's website at, http://www.grida.no.) It makes for chilling reading; not only in empathy for those who had to endure the events but also for the terrible issues facing the Russians as they try to deal with a massive problem of decommissioning nuclear submarine reactors. Ironically, in October thi report was effectively banned from open circulation within Russia.

There have been more than 500 deaths due to accidents in Soviet nuclear submarines since 1960. Three submarines sank following an accident or incident onboard and another was deliberately scuttled because repair was impossible and decommissioning was too expensive. Four submarines suffered major reactor accidents at sea but stayed afloat. Eight other incidents have occurred in which there was a release of radioactive gas or material when the submarine was in dockyard hands for repair or refuelling. And there were four incidents of serious fires in the Northern Fleet which did not result in the loss of the submarine but did result in the loss of human life. The following paragraphs describe some of the incidents documented.

K-8

The earliest documented seagoing incident involved the November- class1 SSN K-8 on exercise in the Barents Sea on 13 October 1960. A leak in the primary steam generator system developed and subsequent damage occurred in piping in the reactor coolant circuit. The automatic system for bypassing such leaks and maintaining reactor coolant circulation was also damaged so the crew was forced to build a jury rig to supply water as coolant and fix the leaks with traditional damage control methods. Unfortunately, large amounts of radioactive gas leaked from the reactor even though the heroic efforts of the crew prevented a reactor meltdown. The reactor compartment apparently was not sealed off and the entire submarine was contaminated by the radioactive gas. The true level of the contamination and the dosage received by individuals could not be determined at the time because of the inadequacy of the fitted instrumentation. Wha is known is that three of the crew suffered visible radiation injuries and it was later determined that others ha suffered potentially fatal doses of radiation. Obviously premature deaths of these exposed crewmen must have happened at a later date but no data is available.

K-19

Less than a year later on 4 July 1961, the Hotel-class missile submarine K-19 was in the North Atlantic when a leak developed in a pipe in the pressure regulating circuit of the primary cooling system of the reactor. The sudden drop in pressure as a result of the leak triggered the reactor emergency alarms as the coolant suppl diminished and excess heat began to build within the reactor core.

In this class of submarine there was no backup system to supply coolant in such circumstances. Thus the crew were forced to resort to jury rigging a coolant supply while attempting to plug the original leak, which ju happened to be in the least accessible part of the reactor space. This work was carried out in the presence contaminated steam and gas. The crew was exposed to substantial doses of radiation and eight of them die of acute radiation sickness. The level of radiation they were exposed to was50 times higher than those in K-After the situation was brought under control, the surviving crew were transferred to another submarine and K-19 was towed back to the Kola Peninsula.

K-27

Commissioned on 30 October 1963, K-27 was a one-off, modified November-class SSN equipped with two VT-1 type, liquid metal (lead-bismuth) cooled reactors with a capacity of 146 MW and 35,000 shaft horse-power. A new steam boiler, requiring considerably less electrical power in the start phase and during cooling was developed especially for this submarine.

During sea trials on 24 May 1968, a sudden and unexplained loss of reactor power occurred. The crew were unable to restore power levels and radioactive gases began to leak into the reactor compartment. Dangerously high levels of gamma radiation were reached in the reactor compartment and the level of radiation in the rest of the submarine increased. Eventually the crew managed to shut down the reactor but there was major damage to the fuel rod assemblies. The cause of the incident has been attributed to failures in the liquid metal coolant system within the reactor core. Nine members of the crew died from radiation sickness.

K-27 was never returned to service. She was deemed beyond safe and economic repair and was eventually towed to sea and scuttled in relatively shallow water off Novaya Zemlaya in 1981.

K-8

Exercise "Okean", which took place in early 1970, was the first major fleet exercise ever conducted out-of-area by the former Soviet Navy and its scope and level of participation surprised Western observers. One of the participants was the November-class SSN K-8, the same K-8 which suffered the first accident, which wa operating in the Atlantic south west of the UK.

On 8 April 1970, fire broke out in two separate compartments of the submarine. The submarine surfaced as the crew attempted to put out the fires. For the next two days the crew struggled to keep the vessel afloat an fight the fires. The automatic safety systems had shut down the reactor so radiation was not a problem. However, this meant no electrical power was available and the emergency diesel generators could not be started. By 10 April, all the stored compressed air which was being pumped into the ballast tanks to keep the ship afloat had been exhausted. Late on that day most of the crew were transferred to one of the surface ships which had arrived to help. Finally, at 0620 on 11 April, K-8 sank and went to the bottom in 4,680 metre of water. The Commanding Officer and 51 of his crew died in this accident. For many years thereafter, a Soviet "sentinel" ship remained on station over the wreck--presumably to prevent any attempt by the West to examine or salvage the submarine.

K-219

In October 1986, North American newspapers and television carried pictures of a Soviet Yankee-class ballistic missile submarine on the surface, obviously in great difficulty, in the western Atlantic east of Bermuda. The pictures showed smoke and steam issuing from one of the 16 missile tubes on the after part the vessel. Part of the strategic missile force, K-219 was on a regular patrol off the North American coast when an explosion happened in one of the loaded missile tubes. The subsequent damage caused the missil compartment to leak and the submarine was forced to surface. Then fire broke out in the damaged missile tube despite the inrushing sea water. While the crew was trying to deal with this problem, an electrical short tripped off the emergency systems and one of the reactors shut down. At this point the submarine began to lose buoyancy as water began to enter the main ballast tank. The final blow occurred when the second reactor shut down and left the submarine without power. Most of the crew abandoned ship and were rescue by a nearby ship. The Captain and nine others remained in the sail structure until the bow went under and then they too left the stricken vessel. K-219 sank at 1103 on 6 October. All but four of her crew survived and were rescued.

The cause of the explosion is remains unknown. It has been speculated that a fault in the missile itself caused the explosion. It has also been postulated that fire broke out following a submerged collision with an American submarine. We will never know.

K-192 (formerly K-131)

On June 25, 1989, the Echo-II class submarine K-192 suffered an accident involving one of the two reactors on board. At the time the submarine was in the Norwegian Sea, about 60 nautical miles north-west of Senja i Troms, Norway, returning to base in the Kola Inlet. A leak was discovered in the primary coolant circuit, and the submarine surfaced immediately. The leak caused the reactor coolant level to drop and the crew hooked up a hose from the submarine's fresh water tanks. The reactor was not immediately shut down. The contaminated water from the leak was pumped out into the sea. When K-192 exhausted its fresh water, a hose was connected from the Soviet freighter *Konstantin Yuon*, which had arrived on-scene, to maintain a supply of coolant to the reactor.

Releases of radioactive iodine were detected in the areas immediately surrounding the submarine, and sometime later, at a monitoring post at Vardþ in northern Norway. The Soviet Northern Fleet service ship *Amur*, which had a treatment facility on board for liquid radioactive waste, also came to the assistance of K-

192. *Amur* took over the task of supplying coolant to the reactor and the reactor core temperature started to come down. The crew of K-192 then made an attempt to seal the leaky pipe. In order to accomplish this, the supply of coolant from *Amur* was shut off. It is not known how long the coolant supply was shut off; however, the individual in charge of monitoring the coolant supply "forgot" to turn it on again when he left his post to go and eat dinner. This person later claimed that he had not in fact forgotten, but was waiting for orders to turn on the supply again. These orders did not come before dinner.

Due to the loss of coolant, the temperature in the reactor increased again and the alarm sounded. The suppl of coolant was immediately was immediately restored but it was too late.. The cold coolant caused the overheated fuel assemblies to crack, and water came into contact with the uranium fuel. The heavily contaminated water being pumped over to Amur overloaded the treatment plant and caused a breakdown. Water directly from the sea was substituted and then simply cycled overboard, contaminating the sea.

At this point, the vessel was in international waters somewhere between the North Cape and the Kola Coast, more than 12 nautical miles off the coast. Eventually the efforts succeeded and the reactor was shut down. The submarine then ran on diesel engines towards the Kola Peninsula. On 28 June, K-192 arrived at the Ara Bay base. Apart from the contamination released into the sea, the crew who worked on the repair received doses of radiation which could cause premature death.

K-192 was laid up at the base facility in the Ara Bay until 1994 when it was towed to Navy yard No. 10 - Shkval. Compressed air is now pumped into the hull to maintain buoyancy. The fuel assemblies in the damaged reactor cannot be removed by standard procedures.

Komsomolets

Komsomolets (K-278) was one of the very few named submarines in the Soviet Navy. She was also the only vessel in her class, known in the West as the Mike-class, and entered service in the Northern Fleet in 1984. Displacing 6,400 tons, her hull was built of titanium to give great strength with relatively light weight and provided for a maximum operating depth in the order of 1,000 metres. Two liquid-metal cooled reactors produced high power to weight ratios and her top speed has been estimated at more than 38 knots.

On 7 April 1989, *Komsomolets* was submerged at a depth of 160 metres in the Norwegian Sea some 100 nautical miles south of Bear Island on passage back to her Northern Fleet base. Shortly after 1100 fire broke out in one of the aft compartments. Eleven minutes after discovery of the fire, the submarine was on the surface with the crew fully engaged in fighting the fire. They were not having much success and the fire spread and caused electrical short circuits. The power failures triggered the emergency systems which automatically shut down the reactor. The intensity of the fire then caused a rupture in the main compressed air system which fed the fire further and compounded the problem. The loss of the compressed air and the lack of power to produce more meant that *Komsomolets* started to lose buoyancy and water entered the hull By 1700 that day, the crew began to evacuate the ship and shortly after that *Komsomolets* sank taking the Captain and 41 of the crew with her to the bottom. 25 survivors and five corpses were picked up by a rescue ship which arrived on scene after the sinking.

Again, the true cause of the fire is unknown. However, this submarine left a deadly legacy. She had been carrying two torpedoes armed with nuclear warheads. Apparently an internal explosion had occurred either during the descent to the bottom or when she hit the seabed at a depth of 1685 metres. This had split the hu open and damaged the two torpedoes. The potential for environmental damage from plutonium leaking from corroded torpedo casing was obvious.

On 24 June 1995 a scientific mission set out from St Petersburg with the objective of sealing the hull of the sunken submarine and preventing any leakage of hazardous radioactive material into the sea. This mission resulted from an internal campaign in Russia in which the designer of the submarine actively participated. Th Russian Government approved the project and the objective was achieved at the end of July 1996. The hull i said to be safe for at least 20 to 30 more years.

SHIPYARD INCIDENTS

Many more incidents happened while submarines were in shipyard hands under repair, refuelling or regular maintenance periods. At least four of these involved breaches of established procedures and uncontrolled reactor start-up which resulted in the release of radioactive steam. In two of these incidents, fires also broke out and compounded the problem. At least 10 deaths can be directly attributed to these accidents.

WHY?

Apart from the incidents which took place in the shipyards, there is a common thread of equipment failure. Unlike the accidents in which occurred when the submarines were in dockyard hands, in most cases incompetence or lack of appropriate action on the part of the crews was not a factor in the losses or severity of the damage. In fact the opposite appears to be the case. In every documented incident, the individual submarine crews made heroic efforts to save their vessel. Some lost their lives working in an environment contaminated with radiation knowing full well the effect that would have on themselves. They continued their work in the hope that their sacrifice could save the ship and their shipmates.

Many of these lives were lost because of a system which failed because of its very structure. The Soviet Nav never achieved first claim on resources despite its forward defence role in the strategic posture of the former Soviet Union. The bureaucracy associated with centralized planning never placed a priority on the safety of the ship and her crew as did Western navies. Infighting, gross incompetence among shipyard staff and political priorities often resulted in sub-standard materials being used in ship construction and repair--frequently despite the objections of the naval staff involved. Piping in particular and electrical switchboards, culprits in many of the incidents, are prime examples.

Regrettably, the legacy of the Soviet era is still claiming the lives of sailors. In 1996, the year in which the Russian Navy is celebrating its 300th Anniversary, five more sailors died as the result of an accident at sea. The Kirov-class nuclear-powered cruiser *Pyotr Velikiy* (Peter the Great) was at sea in October on its first voyage after commissioning earlier this year. A high-pressure steam line ruptured killing one crewman immediately and severely burning several others--including the four who died later. The official investigation blamed "technological flaws". The pipe which ruptured had been installed in 1989 (at the end of the Soviet era) while the ship was being built. The investigation decided that the age of the piping may have caused it t deteriorate. It did not conclude that sub-standard materials may have been used in the pipe or that better quality control might have detected flaws and prevented the accident.

Russia is still trying to adjust to the post-Cold War era. In the transition, will the Russian Navy manage to wrest control over matters that western submariners take for granted and take steps to reduce the risk of further accidents? For their sake, and the sake of the environment, I sincerely hope so.

NOTES

1. The NATO designation of Soviet submarines is used throughout. Soviet usage applied Project numbers to a class: e.g Project 627 was the November-class, 667 the Yankee-class and so on. Back to text

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