# The Russian Northern Fleet
# Nuclear submarine accidents

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# Nuclear submarine accidents

From 1961 up to the present, there have been a number of accidents and incidents involving Soviet/Russian nuclear submarines. At least 507 people have died in accidents on submarines throughout this period. [567] The most serious accidents have been caused by fires that have resulted in the sinking of the submarine, or by severe damage to the nuclear reactor following overheating of the reactor core (loss of coolant accidents) and a number of smaller incidents in which radioactivity has been released. Most of the vessels affected by accidents have belonged to the Russian Northern Fleet. This chapter discusses only those accidents that have resulted in the loss of life and/or in releases of radioactivity.

There have also been a number of other incidents in which Northern Fleet submarines have been involved. These include collisions with other submarines, fires at naval bases and shipyards, submarines that have become entangled in trawler nets, accidents during test launches of submarine launched missiles, collisions with icebergs and so forth.[568]

## 8.1 Sunken nuclear submarines

As a consequence of either accident or extensive damage, there are six nuclear submarines that now lie on the ocean floor: two American vessels (*USS Treasure* and *USS Scorpion*) and four Soviet (K-8, K-219, K-278 *Komsomolets* and K-27). The two American submarines and three of the Soviet nuclear submarines sank as a result of accident; the fourth Soviet vessel was scuttled in the Kara Sea upon the decision of responsible authorities when repair was deemed impossible and decommissioning too expensive. All four of the Soviet submarines belonged to the Northern Fleet.[569]

Despite the differences in time and in location, the Soviet submarine accidents all followed a similar pattern:[570]

1. Fire while submerged on return from patrol.
2. Surfacing of the submarine. Attempts made to salvage the submarine, both in submerged and surface position. By the time of surfacing, vessel had already lost power and possibility for outside contact.
3. Penetration of outside water into the vessel.
4. Command post loss of control over submarine's essential systems.
5. Loss of buoyancy and stability of pitch.
6. Capsize and sinking.

It was not always an accident involving the nuclear reactor that caused these submarines to sink. On all of the Soviet vessels that have sunk, the reactor's shut-down mechanism had been engaged. For extra security, the control rods were lowered manually to their lowest position, an operation entailing such great risk of radiation that it presented a real threat to life.[571]

There have been a number of incidents involving naval nuclear reactors of the Northern Fleet that have had serious consequences. Among them are accidents that have resulted in the deaths or overexposure to radiation of the crew, as well as extensive damage to the submarine. The damage was expensive and difficult to repair; and in some instances, the damage to the vessel was so comprehensive that future use was impossible.

The three most serious accidents involving Soviet nuclear submarines are described below. The two American submarine wrecks are discussed in the Appendix.

### 8.1.1 K-8

The first accident involving a Soviet nuclear submarine involved the Project 627 A - November class vessel K-8, which sank in the Bay of Biscaya on April 8, 1970 while returning from the exercise *OKEAN*. Two fires started simultaneously in both the third (central) and eighth compartments. The submarine surfaced, but the crew was unable to extinguish the fires. The reactor emergency systems kicked in, leaving the submarine with virtually no power. The auxiliary diesel generators could not be started either. The control room and all the neighbouring compartments were filled with fumes from the fire. Air was pumped into the aft most main ballast tanks in an attempt to keep the vessel afloat. By April 10, the air tanks had been emptied, and water began to flow into the seventh and eighth compartments. On the evening of April 10, part of the crew was evacuated to an escorting ship. On the morning of April 11 at 06:20, the submarine sank at a depth of 4680 metres following a loss of stability in pitch. Fifty two people died, including the captain of the vessel. Details of this accident were kept secret until 1991.[572]

### 8.1.2 K-219

In October 1986, the strategic nuclear submarine K-219 (Project 667 A - Yankee class) sank in the Atlantic ocean north of Bermuda with ballistic missiles on board after an explosion in one of the missile tubes. The explosion caused a leak in the fourth compartment (missile compartment). Steam and smoke from the missile fuel began to stream out of the damaged missile tube. At the time of the explosion, only one of the vessel's two reactors was running. The submarine surfaced and the other reactor was started up. Despite the fact that water was beginning to come in, a fire broke out in the fourth compartment. A short in the electrical system tripped off one of the submarine's emergency systems. One life was lost in the struggle to lower the control rods. Though still in a surfaced position, the buoyancy of the submarine was steadily impaired when water filled the main ballast tank. When the second reactor broke down, the crew was transferred to a rescue vessel. The captain and nine crew members remained in the conning tower, but when the bow began to sink, they were obliged to abandon ship. On October 6, at 11:03, the submarine sank with a loss of four lives.[573]

The reason for the explosion in the missile tube is unclear. There are two theories of how the accident happened: a defect in the missile tube itself or a fire that broke out following a collision with an American submarine.[574] The submarine had two nuclear reactors and carried 16 nuclear missiles.[575]

### 8.1.3 K-278 (*Komsomolets*)

In April, 1989, the nuclear submarine K-278, *Komsomolets*, (Project 685 - Mike class) sank in the Norwegian Sea following a fire. *Komsomolets* was a unique titanium-hulled submarine that could dive to depths of 1000 metres. On the morning of April 7, 1989, the vessel was on the way back to her base at Zapadnaya Litsa, positioned at a depth of 160m approximately 180km south of Bear Island. At 11:03 the alarm sounded due to a fire in the seventh compartment. Eleven minutes after the fire had broken out, the vessel surfaced. However, the fire had caused short circuits in the electrical system which set off the reactor's emergency systems. The fire was so fierce that a leak was sprung in the compressed air system, and this led in turn to a spreading of the fire. Attempts by the crew to extinguish the flames were futile. The submarine lost power, and finally ran out of compressed air. By 17:00, the leak had worsened, and the submarine lost buoyancy and stability. The crew began to be evacuated into life rafts, but there were not enough rafts. The life rafts that were lowered were too far away for the crew to reach. At 17:08, the submarine sank at a depth of 1685 meters, with a loss of 41 lives and her commander. The ship *Aleksandr Khlobystsov* which came to the rescue after 81 minutes took aboard 25 survivors and 5 fatalities. The exact cause of the fire is unknown. One speculation is that the concentration of oxygen in the seventh compartment was too high, setting off short circuits in the electrical system.[576]

Illustration 17 kb

Illustration, 17 kB.

*The nuclear submarine Komsomolets sank in the Norwegian Sea on April 7, 1989, south of Bear Island. The submarine sank with its reactor and two nuclear warheads on board, and lies at a depth of 1 685 metres.*

It has also been asserted that shortly before the accident, the vessel had completed a test that indicated it was not seaworthy.[577] Others claim that K-278's crew was not qualified to serve on the *Komsomolets*.[578]

# 8.2 Reactor Accidents

The most serious accident in which radioactivity is released is the meltdown of the reactor core on board the submarine. This is called a nuclear accident. There have been a number of both major and more minor incidents involving naval reactors. These accidents can be grouped into three categories according to the degree of severity:

1. Nuclear accidents;
2. Reactor accidents.

## 8.2 Nuclear accidents

Nuclear accidents are classified either as "loss of control" (loss of regulation) accidents in which an uncontrolled chain reaction may occur, or as "loss of coolant accidents". There have been ten nuclear accidents in the entire period that Soviet nuclear submarines have been in operation, one of which occurred in 1970 during the construction of K-329, a vessel of the Charlie-I class. There were two incidents during refuelling operations on K-11 and K-431, another during repairs of a naval reactor at the shipyard (K-140), one during modifications of the submarine (K-222), four during operations at sea, and one during reactor shut down (K-314). Two of the accidents occurred on Pacific Fleet submarines, seven at the Northern Fleet, and one at the shipbuilding yard in Nizhny Novogorod.[579]

### K-19

The first nuclear accident to occur on a Russian submarine was on the Northern Fleet's ballistic missile submarine K-19 (Project 658 - Hotel class). On July 4, 1961, during exercises in the North Atlantic, a leak developed in an inaccessible part of the submarine K-19's primary cooling circuit. The leak was specifically located to a pipe regulating the pressure within the primary cooling circuit. The leak caused a sudden drop in pressure, setting off the reactor emergency systems.[580]

To prevent overheating of the reactor, superfluous heat must be removed, and this is done by continually circulating coolant through the reactor. There was no built-in system for supplying coolant to the primary circuit, and it was feared that an uncontrolled chain reaction might start. An improvised system to supply coolant to the reactor was devised. This required officers and midshipmen to work for extended periods under radioactive conditions in the more remote areas of the reactor compartment as they attended to the leak in the primary circuit.[581] The radiation in this case came from noxious gases and steam. All of the crew were exposed to substantial doses of radiation, and eight men died of acute radiation sickness after having undergone doses of 50 to 60 Sv (5000 - 6000 rem). The crew was evacuated to a diesel submarine, and K-19 was towed home to base on the Kola Peninsula.[582]

### K-11

The second nuclear accident to occur was in February 1965 aboard the Project 627 - November class submarine K-11. The submarine lay in dock at the naval yard in Severodvinsk and work was underway to remove the reactor core (Operation No. 1). On February 6, the reactor lid was opened, and the following day, the lid was lifted without having first secured the control rods.[583] Releases of radioactive steam were detected with an abrupt deterioration of conditions. Radiation monitors were going off scale, and all personnel were withdrawn. No work was done on the submarine over the course of the next five days while the specialists tried to discover the reason for the problem. The wrong conclusions were drawn, and the raising of the reactor lid was attempted again on February 12. Once again, the control rods had not been secured, and when the reactor lid was raised, there were releases of steam and a fire broke out. There are no data on radioactive contamination levels or radiation exposure of the personnel. The reactor was finally retired and replaced.[584]

**K-27**

On May 24, 1968, the nuclear submarine K-27 (Project 645) was out at sea. During sea trials, the nuclear reactor had operated at reduced power, and on May 24, power inexplicably suddenly dropped. Attempts by the crew to restore power levels failed. Simultaneously, gamma radiation in the reactor compartment increased to 150 R/h. Radioactive gases were released to the reactor compartment from the safety buffer tank, and radiation on board the submarine increased. The reactor was shut down, and approximately 20% of the fuel assemblies were damaged. The incident was caused by problems in the cooling of the reactor core.[585] The entire submarine was scuttled in the Kara Sea in 1981.[586]

**K-140**

In August 1968, the Project 667 A - Yankee class nuclear submarine K-140 was in the naval yard at Severodvinsk for repairs. On August 27, an uncontrolled increase of the reactor's power occurred following work to upgrade the vessel. One of the reactors started up automatically when the control rods were raised to a higher position. Power increased to 18 times its normal amount, while pressure and temperature levels in the reactor increased to four times the normal amount. The automatic start-up of the reactor was caused by the incorrect installation of the control rod electrical cables and by operator error. Radiation levels aboard the vessel deteriorated.[587]

**K-429**

In 1970, while the brand new Project 670 - Charlie class submarine K-329 lay in harbour at the shipbuilding yard Krasnoe Sormovo in Nizhny Novgorod, there was an uncontrolled start up of the ship's reactor. This led to a fire and the release of radioactivity.[588]

**K-222**

On September 30, 1980, the submarine K-222 was at the factory in Severodvinsk due for a thorough reactor check. During the course of work, the submarine's crew left for lunch leaving the factory personnel on board the vessel. As a result of a breach in the pertinent procedural instructions, power was sent through the safety rod mechanisms without the controls also being engaged. Following a failure in the automatic equipment, there was an uncontrolled raising of the control rods with a subsequent uncontrolled start up of the reactor. As a result of this, the reactor core was damaged.[589]

Photo.

*This is one of the Pacific Fleet's Echo-I class nuclear submarines. This vessel suffered a leak of radioactivity following a fire while it lay off the coast of Japan on August 21, 1980. The crew on deck have put on protective clothing against the radioactive gasses from the reactor compartment. Nine*

*have put on protective clothing against the radioactive gasses from the reactor compartment. Nine crew members died in the fire and three others were injured.*
Due to copyright restraints this photograph is only available in the printed version. The printed version can be ordered from us.

**K-123**

On August 8, 1982, while on duty in the Barents Sea, there was a release of liquid metal coolant from the reactor of the Project 705 - Alfa class submarine K-123. The accident was caused by a leak in the steam generator. Approximately two tons of metal alloy leaked into the reactor compartment, irreparably damaging the reactor such that it had to be replaced.[590] It took nine years to repair the submarine.[591]

**K-314**

On August 10, 1985, the Project 671 - Victor-I class submarine K-314 was at the Chazhma Bay naval yard outside Vladivostok. The reactor went critical during refuelling operations because the control rods had been incorrectly removed when the reactor lid was raised. The ensuing explosion led to the release of large amounts of radioactivity, contaminating an area of 6km in length on the Shotovo Peninsula and the sea outside the naval yard. Ten people working on the refuelling of the vessel died in the accident. The damaged reactor compartment still contains its nuclear fuel.[592]

**K-431**

In December 1985, the reactor of the nuclear submarine K-431 (Project 675 - Echo-II class) overheated while the vessel was returning to base outside Vladivostok. It is now laid up at the naval base in Pavlovsk.[593]

**K-192 (formerly K-131) [594]**

On June 25, 1989, while on the way back to its base at Gadzhievo on the Kola Peninsula, the Project 675 - Echo-II class class submarine K-192 suffered an accident involving one of the two reactors on board. At the time of the accident, the submarine was in the Norwegian Sea, about 100 km north-west of Senja in Troms and approximately 350 km south of Bear Island. A leak was discovered in the primary circuit, and the submarine surfaced immediately. Because of the leak, the levels of coolant in the primary circuit had dropped, and the crew hooked up water 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, but there is no information about its activity level. When the vessel's fresh water supplies had been consumed, a hose was connected from the Soviet freighter *Konstantin Yuon* to maintain a supply of coolant to the reactor. Afterwards, the reactor was shut down, and the submarine ran on its diesel engines around the Finnmark coast towards the Kola Peninsula. The temperature of the coolant was at 150°C on the morning of June 26, 120°C the same evening, and 108°C on June 27.[595]

Releases of radioactive iodine were detected in the areas immediately surrounding the submarine, and sometime later, also at a monitoring post at Vardø in Finnmark.[596] The Northern Fleet service ship *Amur* also came to the assistance of K-192, and the radioactive contaminated coolant was transferred to *Amur* which had a treatment facility on board for liquid radioactive waste. On June 26, the crew of K-192 made an attempt to close the leak in the pipe from the cooling system, and 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 forgotten, but was waiting for orders to turn on the supply again. These orders did not come before dinner.[597]

Due to the loss of coolant, the temperature in the reactor increased and the alarm went. The supply of coolant was immediately switched on again, but too late. The supply of cold coolant led to the cracking of the overheated fuel assemblies, and water came into contact with the uranium fuel. The heavily contaminated water being pumped over to *Amur* led to the breakdown of the treatment plant. Subsequently, water was taken in directly from the sea and pumped out into it again. The total activity and amounts of contaminated water released from K-192 into the sea is not known. At this point, the vessel was positioned in international waters somewhere between the North Cape and the Kola Coast, more than 12 nautical miles off the coast. On June 28, K-192 arrived at the Ara Bay base facility belonging to the naval base at Gadzhievo.[598] At base the activity of the contaminated coolant was estimated at 0.3 Ci/l, totalling 74 TBq, 2 000 Ci.[599] The submarine's crew received doses of up to 40 mSv (4 rem).[600]

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.[601] (See Chapter 6 on the decommissioning of nuclear submarines).

**K-8**

On October 13, 1960, one of the most serious accidents involving a naval reactor occurred on a Northern Fleet vessel. The incident was caused by a loss of coolant to the reactor, and is classified accordingly. The Project 627 - November class submarine K-8 was on exercise in the Barents Sea when a leak developed in the steam generators and in a pipe leading to the compensator reception. The equipment for blocking these leaks was also damaged such that the crew itself began the work of stopping the leak. They mounted a provisional system for supplying water to the reactor to ensure cooling of the reactor and thereby avoid the risk of a core melt in the reactor. Large amounts of radioactive gases leaked out which contaminated the entire vessel. The true activity of the gases could not be determined because the instrumentation only went to a certain level. Three of the crew suffered visible radiation injuries, and according to radiological experts in Moscow, certain crew members had been exposed to doses of up to 1.8 - 2 Sv (180 - 200 rem).[602]

**Some SSN nuclear power units failure and accidents causing radiation discharge**

**Text version of table 12**

| SSN | Time | Incident |
|---|---|---|
| K-386 | 1976 | Main condenser breakage (2 persons injured to death) |
| TK-208 | 1986/87 | Cleaning unit leakage |
| K-279 | 1984 | Leaky steam generator |
| K-447 | 1985 | Leaky steam generator |
| K-508 | 1984 | Leaky steam generator |
| K-208 | 1985 | Leaky steam generator |
| K-210 | 1984 | Leaky steam generator |
| K-216 | 1984 | Leaky steam generator |
| K-316 | 1987 | Leaky steam generator |

| | | |
|---|---|---|
| K-462 | 1984/86 | Critical underspace leakage of primary circuit |
| K-38 | 1984/86 | Critical underspace leakage of primary circuit |
| K-37 | 1984/86 | Critical underspace leakage of primary circuit |
| K-371 | 1986 | Critical underspace leakage of primary circuit |
| K-367 | 1985 | Automatic control break |

Table 12: *Some SSN nuclear power units failure and accidents causing radiation discharge*

## 8.3 Fires resulting in loss of life

In addition to the accidents involving fires whereby the vessels themselves were lost, there have been four serious accidents involving fires on Northern Fleet nuclear submarines that have resulted in the loss of human life.

**K-3**

On September 8, 1967, while sailing in the Norwegian Sea on the way home to its base on the Kola Peninsula, a fire broke out on board the nuclear submarine K-3 (Project 627 A - November class). The fire started in the submarine's hydraulic system, and crew members in the compartment when the fire broke out had to evacuate the compartment. This resulted in the flames spreading to other parts of the submarine. The automatic extinguishers were based on $CO_2$ gas, and this gas killed the crew members who were in the first and second compartments foremost in the submarine. When the dividing door in the bulkhead from the third compartment was opened to see what had happened to the people in the second compartment, the gas spread, and more people lost consciousness. The foremost compartments were then completely sealed off, and the submarine surfaced. Four days later, K-3 had returned to base. A total of 39 crew members died in the fire.[603]

**K-19**

On February 24, 1972, while the vessel was on patrol in the North Atlantic, a fire broke out in the ninth compartment on board the Project 658 - Hotel class submarine K-19. The fire started at 10:23 AM, and the ninth compartment was immediately closed off to prevent the fire from spreading to other parts of the vessel. Twelve crew members in the tenth compartment aft in the submarine were thereby isolated, and were not rescued until March 18, after 24 days of fighting the fire. A total of 28 people died in the fire which was caused by a break in one of the hydraulic pipes. Over 30 ships were involved in the rescue of K-19, and the submarine finally returned to base on the Kola Peninsula on April 4.[604]

**K-47**

On the 26 of September 1976 when the submarine K-47 was in the Barents Sea on its way to the home port fire broke up in the 8-th compartment. 8 crew members died of injuries.

**K-131**

On June 18, 1984, a fire broke out in the eighth compartment aboard the Project 675 - Echo-II class submarine K-131. This submarine too was returning to base on the Kola Peninsula. The cause of the accident was that the clothes of one of the crew members caught fire while he was working on some electrical equipment. The fire spread to the seventh compartment and caused the death of 13 crew members.[605]

**Some emergencies on SSNs**

**Text version of table 13**

| SSN | Time | Incident |
|---|---|---|
| K-508 | Apr. 1984 | Fire |
| K-38 | March 1985 | Fire |
| K-279 | Dec. 1986 | Fire caused by shot circuitry in electrical equipment |
| K-255 | March 1985 | Fire caused by shot circuitry in electrical equipment |
| K-369 | Dec. 1985 | Fire |
| K-239 | Dec. 1987 | Fire |
| K-42 | Apr. 1984 | Fire |
| K-517 | May 1984 | Fire |
| K-192 | 1985 | Oil heater explosion |
| K-298 | 1985 | Fire |
| K-503 | Jan. 1984 | Water penetration into the reactor compartment |
| K-475 | 1984 | Water penetration into the reactor compartment |

Table 13: *Some emergencies on SSNs*

# 8.4 Causes of Accident [606]

The complex "man-machine" system represented in the modern nuclear submarine, increases the risk of accidents. The causes of the various accidents depend to a large extent on both the qualities of the reactor and the situation leading up to the accident.

The existing framework of project development, building and delivery of military technology (navy) and ammunition is not regulated by law, but by decree of defunct authorities, such as the Central Committee of the Communist Party, various councils of Soviet ministers, the military-industrial complex, as well as joint decisions handed down by the Ministry of Ship Building and the Ministry of the Navy. The administrative body of the military industrial complex, led by the vice-chairman of the council of ministers, itself issued the documents that established the norms, and it was this same body that monitored and enforced the norms that it had itself created. The practice of merging the functions of public agencies contributed to the fact that the Navy itself did not take part in working out quality control and safety requirements for nuclear submarines. Even if the Navy politely refused to receive equipment that they knew in advance to be defective, it could nonetheless be forced to accept it through a common resolution issued by the authorities.

This structure of resolutions and decrees has followed the delivery of all new nuclear submarines to the Soviet Navy. Soviet nuclear submarines were built under enormous time constraints. If the Central Committee of the Communist Party had determined that a particular submarine was to be built by the close of a certain year or a particular season, the submarine yards could not postpone delivery, even if the vessel had not been completed or undergone sea trials. Hence nuclear submarines were often delivered to the Navy without all the necessary safety equipment having been installed. Furthermore, the procedural guidelines and the specifications of the contract were modified and simplified. It was not uncommon for a nuclear submarine to be delivered to the Navy from the building yard with missing or defective parts. In 1989 there were 529 complaints of nuclear submarines being delivered with faulty equipment. In 1990-91 a new nuclear submarine was returned to the building yard due to numerous defects in the mechanical equipment. Another submarine was delivered without light switches having been installed in the cabins or in the missile compartment.[607]

The servicing and repair of nuclear submarines was carried out at naval yards that fell under the jurisdiction of different authorities. This system was established at the dawning of the age of nuclear submarines and it came to the full during the cold war. Almost 25 nuclear submarine projects were initiated and developed during this period. The lack of sufficient standardisation led to problems in the planning stage, in the competence levels of the crew and in an unavailability of spare parts. The quality and safety of the equipment was compromised, and this has been one of the most important contributing factors to the higher incidence of accidents amongst Soviet nuclear submarines as compared to for example American vessels.

There were also many common factors in the accidents on board Russian nuclear submarines, reflected again and again in the accident statistics:

1. The frequency of accidents was increased as early as the planning stage due to technological deficiencies in a number of areas (information, securing secrets of propulsion and means of carrying out research) and deficiencies in construction. One of the main problems was the poor quality of the metals and materials that were used.
2. At the construction stage, breaches in the technological standards by the builders affected the quality of the finished product such that the finished submarines that were actually delivered to the Navy fell short of the quality of their design.. Furthermore, the schedule for delivery of various systems and parts, as well as the order in which operations were completed and breaches in the proper technical procedures, all contributed to lowering the quality of the submarine. The quality of the work was poor due to a lack of technical understanding amongst the workers. In some instances, there was not even enough technical equipment at the navy shipyards and floating bases.
3. During the testing and approval stage, there were interruptions to the schedule due to delays in deliveries and installation of parts and systems. Under outside pressure from concerned parties, the submarines were approved even before the equipment on board had been tested.
4. The frequency of accidents also increased during the submarines' operational life due to poor maintenance, a disregard of the directions for use and improper procedures for technical equipment and ammunition. The crew were assigned to tasks other than their direct responsibilities, and therefore were lacking in training, especially with regards to measures designed to ensure the survivability of the submarine. At one time, one submarine commander sent in a complaint that eleven of the 28 new members of the crew could not speak Russian and therefore were not qualified to work with the nuclear reactor. Many of the new crew for the nuclear submarines had received only six months training, training that often was insufficient or irrelevant to the situations they might confront on a nuclear submarine.[608] There was a widespread irresponsible attitude from incompetent outside specialists. The crews were too inexperienced to be able to foresee potential dangers that could lead to critical situations while the submarine was in operation. The search and rescue bases, which have shown a lack of co-ordination in conducting searches, weakened overall preparedness in a number of accidents. The absence of formal conclusions at inquests and a lack of ready information in response to the questions about the nature of the accidents and their frequency resulted in a failure to implement measures to improve the conditions on board the nuclear submarines.

A number of general measures could be implemented to reduce the frequency of accidents, including the following:

1. Transition and transformation into a professional navy.
2. Reform of the governing powers in the military industrial complex; division into legislative, executive and administrative functions. Development, production and delivery of ships and military technology regulated by law.

Without implementing these types of reforms, it will be difficult to reduce the frequency of accidents.

There are three main factors contributing to the safe operation and use of nuclear submarines:

1. The quality of the design and construction of the vessel, its ammunition and technical equipment;
2. Skill in the operation of nuclear submarines and in the use of pertinent technology over the course of the vessel's operational lifetime;
3. Professional training of the crew and professional administration of work on nuclear submarines.

Russia continues to lead the world in the field of submerged speed and deep-diving submarines. The shipbuilding industry in the former Soviet Union expended considerable resources and employed experienced and highly skilled personnel to build its submarines. This made it possible to build submarines at a rapid pace; however, there were hardly any vessels, submarines or surface vessels, that were delivered to the Navy free of flaws. The deficiencies were often serious. As a rule, nuclear submarines were delivered from the shipbuilding yards at the end of the year. Regardless of the circumstances, the shipbuilding yard had to guarantee that the vessel would be delivered no later than December 31. Tremendous pressure was put on the chairman of the State Committee for Approval from the whole hierarchy of the Ministry of Shipping and Industry, and strange though it may seem, he was also pressured by the Chief Commander of the Navy. The chairman faced a choice between telling the truth about the condition of the submarines - and thereby lose his job - or else avoiding the question. The latter course of action was invariably chosen.

Regardless of incompletion or missing parts, nuclear submarines were delivered to the Navy as long as they were capable of operating under their own steam. Every so often, a submarine might remain at the building yard until it was capable of operating independently. A special contract was established entitled *Joint Decisions of the Ministry of Shipping and the Navy*, where the building yards promised to improve or amend faults and deficiencies within a certain period of time. The Navy also agreed to this.

Any submarine that formally entered service with the Navy could be assigned to any kind of assignment or mission within the Navy's sphere of operation, including battle. However, there was no sense of concern or organised plan for conditions of storm or chaos; nor were there any preparations made for such emergencies. It was precisely here that accidents could happen. A serious consequence of this lack of concern was its unfortunate effect on the attitude of the crew - rather than feeling a sense of responsibility themselves, they simply signed on for duty on incomplete nuclear submarines and hoped for the best.

The day-to-day running of a nuclear submarine involves a whole series of routine procedures and operations, ranging from weekly monitoring and overhaul to varying and more extensive service procedures at the shipyard. The execution of such work requires a sufficient number of naval yards and repair shops, as well as spare parts and operative materiel. The bulk of the Northern Fleet's resources was allocated to the development and construction of its main components: ships and ammunition. The rest received what was left - but this was very little. By the end of the 1980s, the Soviet Union had more nuclear and diesel submarines than all the other nations of the world combined. Yet Russia's submarines barely achieved half of the American operational life. The useful life of the Russian submarine was shortened by the limited possibilities for repair and an underdeveloped industry.

The division of labour aboard the nuclear submarines could also have been better. Today, the vessel's commanding officer has total responsibility. He is also liable for mistakes made by his subordinates, even when it is apparent that another individual's poor judgement has caused the error. The problem is that the commanding officer seldom has the opportunity to discharge this responsibility. Furthermore, the crew of submarines, especially officers, work under conditions of constant physical and psychological overload, with irregular working hours and rest periods.

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# Endnotes

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*Written by: Thomas Nilsen, Igor Kudrik and Alexandr Nikitin*
*Last updated: Aug. 29 1996*
bellona@sn.no