Three scenarios for Kursk reactors

Bellona's expert looks into the possible scenarios, which might develop at the *Kursk* nuclear installation.

Nils Bøhmer, 2000.08.21 15:43

The currently available information about the sunken nuclear submarine *Kursk* tells us about serious damages in the bow part of the submarine. Recent information indicates that all sections of the submarine are flooded with water. Most probably this means that the reactor section is flooded with water as well. What implications can that have for the marine environment?

According to the seismic stations in Norway and Finland, been two seismic events were detected at the time of the accident on Saturday, August 12. A small event was followed by a larger event equaling to 3,5 at the Richter's scale. The second event can be compared with an underwater explosion corresponding to 1-2 tons of TNT. Regardless of what caused this, the damage of the submarine must be severe.

The two reactors on *Kursk* are equipped with an automatic shutdown system. This system performs an automatic shutdown of the reactors in case of an explosion or other disturbances. Most probably this system activated and the reactors were shut down. After shutdown the remaining heat in the rectors is cooled down by a passive cooling system. The possible scenarios for the reactor after the shutdown are as follows:

1) **The passive cooling system fails**. There will be no way to transfer the heat away from the still hot reactor core. The temperature in the reactor core will rise. In a worst-case scenario this will melt away the control rod. In that case, the reactor will go critical, which means that more heat will be produced and the reactor core will become even warmer. In case no cooling is provided, the cores will start melting its way through the reactor vessel and in the worst case also the hull of the submarine. If the core melts through the reactor vessel it will be in direct contact with the seawater inside the reactor compartment, and then it will be cooled down. The cooling down of the melted, or partly melted, reactor core will release a large portion of radioactivity in the reactor core to the seawater

large portion of radioactivity in the reactor core to the seawater inside the reactor compartment. The possibility for this scenario is quite slim, but cannot be ruled out. The chances of the reactors overheating are also decreasing with each day that goes, since they were closed down.

2) **The passive cooling system fails and the reactor room is flooded with water**. The cold seawater will act as cooling for the reactors, and will most likely prevent a meltdown. On the other hand, there will be a high possibility that radioactivity will leak to the seawater inside the reactor room, through broken pipes and other fractures. This is the most likely scenario, if the first cooling circuit is broken.

3) **The passive cooling system works**. This will provide a safe shutdown of the reactor. Radioactivity can leak out to the seawater though broken pipes and other fractures. If the reactor room is flooded with water, the seawater will be more easily contaminated. Even if the reactor core is sealed at the moment, corrosion and other processes could later lead to leaks of radioactivity.

Kursk has been in operation for five and a half-years, but it's not known how long it has been since, or even if, the fuel rods have been changed. This will affect the isotope composition in the reactors. In addition, information regarding the lengths of time the reactors had been operating on the fatal cruise may have great significance for the temperature in the reactors after the shutdown. Unconfirmed Russian report says that the *Kursk* had only been out in the sea since August 10, giving a reactor operation of only two – three days before they where shut down at the time of the accident.

It is highly unlikely that the reactors can re-start by themselves, but the heat-development in the reactor core can involve that the fuel elements will get cracks in the cladding. If the fuel elements are damaged in this way, radioactivity from the fuel elements can contaminate the seawater.

The seawater can be contaminated with radioactivity mainly through the first cooling circuit. This circuit is in direct contact with the reactor core. In operating reactor this cooling water will be radioactive. In the case of cracking of the fuel cladding, the cooling water will be more contaminated. If the reactor room is flooded with water and the first cooling circuit is leaking, contamination of the seawater will take place.

At present, little information is available on the radioactive inventory for the two reactors on board *Kursk*. So far, it is only know that the submarine started its mission on August 10.

Information from the Kurchatov Institute about the *Komsomolets* reactor states that the Sr-90 inventory was 2800 TGq, and for Cs-137 the amount was 3100 TBq, shortly after shutdown of the reactor. The reactor on board *Komsomolets* is of a similar type (OK-650 b-3) as reactor on board *Komsomolets* is of a similar type (OK-650 b-3) as the two reactors on board *Kursk* (OK-650 b). Using the numbers for the *Komsomolets* reactor, the inventory of the *Kursk* reactors should be 5600 TBq for Sr-90 and 6200 TBq for Cs-137.

There is, indeed, very little information so far about the real situation onboard *Kursk*, but the given numbers about the amount of cesium and strontium should give some idea of the amount of radioactivity, which can contaminate the seawater. Most likely an area around the wreck site can be contaminated. This may, in worst case, lead to contamination of the fish caught in the area.

When it comes to radioactive contaminations, the Barents Sea is one of the cleanest oceans on the northern hemisphere. The measurements of radioactivity in fish (cod) from the Barents Sea, shows levels of about 1 Bq/kg for Cs-137 and Sr-90. This is low compared to other oceans and seas, like the in the Baltic Sea and the Irish Sea levels on about 20 Bq/kg fish are typical levels. During the heaviest fallout from testing of nuclear weapons in the early 60'ies the levels of Cs-137 in fish from the Barents Sea reached 10 Bq/kg.

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Publisher: Bellona Foundation, President: Frederic Hauge
Information: info@bellona.no, Technical contact: webmaster@bellona.no
Telephone: +47 23 23 46 00 Telefax: +47 22 38 38 62 * P.O.Box 2141 Grunerlokka, 0505 Oslo, Norway