Devonport and nuclear submarines: what are the risks?

Dr Philip Webber, SGR, highlights a range of significant health, safety and environmental risks arising at the Devonport naval base from the storage of several aged nuclear submarines and a recent major submarine refit.

The Royal Navy has been operating out of Devonport naval base, next to the city of Plymouth (known officially as HMNB Devonport), for over 300 years. In recent decades, it has become the place where Britain's nuclear-powered submarines come for maintenance, refuelling, refitting and dismantling. Here I cover the background to several accidents involving submarine nuclear reactors, how the risks are assessed and managed by the navy and private contractors, and future plans for the radioactive materials.

There are 12 old nuclear-powered submarines docked afloat at Devonport (with a further seven at Rosyth in Scotland). Eight of these obsolete submarines *still contain fuelled nuclear reactors,* with a further four having had their reactors removed.[1,2] In 2002, all reactor dismantling was halted by the official nuclear regulator (ONR) because the site was not judged safe or adequate to do the job.[3] The eight fuelled nuclear reactors are powered down and have to be continuously cooled using external power and water to avoid overheating which could lead to a fire, melt-down and/or a release of radioactive particles and gases. Some have been in this state now for over ten years awaiting a new facility at 14 Dock.

There are also risks associated with the maintenance of the UK's operational submarines. There are 11 of these vessels, including the four Vanguard class that carry Britain's nuclear weapons.[4] When on patrol, these submarines carry eight Trident missiles and 40 nuclear warheads.

The HMS Vengeance refit – an example of the technical complexities

Between 2012 and 2015, HMS Vengeance – one of the UK's four Trident submarines – underwent a major refit at Devonport. It is worth giving some technical detail about this refit to illustrate the complexity and difficulty of the engineering tasks that are being undertaken at Devonport. This description is summarised from several technical summaries.[5]

'Refit' is a rather bland term for what was in fact a major engineering challenge costing £350m inside a huge dry dock facility managed by Babcock International Ltd[6] and part of a larger £5bn contract to refit all the Trident submarines. HMS Vengeance had its nuclear reactor partially rebuilt following the detection of unexpected levels of radiation in the water-cooling circuit of an identical naval reactor running at the Dounreay nuclear site on the northern coast of Scotland. The existence of unusual levels of radiation in the cooling water indicated that there was a breach between the intensely radioactive nuclear core and the primary high pressure water circuit. This water circuit in turn transfers heat to a steam circuit that drives turbines which provide electrical and motive power. The leak was kept secret for two years until the Defence Secretary announced the refit to parliament in 2014.

Trident missiles and nuclear warheads were removed at the Faslane naval base near Glasgow before the refit began. Once the submarine docked at Devonport, external cooling was fitted to the core ready for shut down. The reactor control rods were then inserted to slow the nuclear reaction and the core cooled down over several hours. Repairs included a great deal of cutting into large metal structures – reactor pressure vessel and associated pipework and valves weighing up to 120 tonnes – using welding equipment and powerful cutting tools. Radioactive cooling water needed to be prevented from escaping.

During the 'refuelling' part of the process, the radioactive fuel rods are completely removed and replaced once the reactor cooling circuits, pressure vessel and shielding have been re-assembled and repaired. Continuous water cooling of the reactor core is required even when it is shut down to avoid dangerous overheating and radioactive gas release. Hence the whole assembly requires a continuous supply of water and electrical power.

The refit also included replacement of electrical and guidance systems, missile and torpedo tubes, testing of hull and other equipment.

Dismantling nuclear submarines: ignoring serious risks

As one might hope, the Ministry of Defence (MoD) produced public consultation documents[7] about the risks of reactor dismantling in the naval dockyard and their plans for dealing with an eventual total of 27 submarines and associated nuclear reactor parts. However, to my surprise, the public reports concerning submarine dismantling, defueling and refuelling specifically *exclude* the most risky parts of the process. The risks associated with removing and replacing the highly radioactive fuel rods are excluded from the Strategic Environmental Assessments and associated documents on the very dubious ground that the used fuel rods are not 'waste' because they can be re-used as nuclear fuel!

The MoD[8] blandly states that "comments on safety and environmental aspects of defueling are outside the SDP (Submarine Dismantling Project) scope and engagement is best continued through the established channels for HMNB Devonport and Devonport Dockyard." Also "the MoD's position remains that defueling has to remain outside the scope of the SDP. It is a separate and pre-established activity, and upgraded defueling facilities at Devonport are already being built as part of the Future Nuclear Facilities programme. It would therefore be neither feasible nor beneficial to bring defueling within the scope of the project".[9]

The fact that the most risky elements of the dismantling and servicing process were excluded from the risk assessments is of serious concern. But what is of even more concern is that these risks were excluded when there are eight aged nuclear reactors berthed in very close proximity to the population of Plymouth.

The potential risks of an accident or incident are rather starkly set out in the Devonport Off-Site Emergency Plan (DOSEP).[10] This plan includes various contingencies such as: exclusion zones of 2 - 10km, the latter enclosing all of Plymouth (population 326,000); the issuing of potassium iodate tablets; keeping people indoors (including children in schools); closing of major roads and rail links; population evacuation; and farming restrictions up to 30km downwind. Thus while there is a major incident plan covering these very serious possibilities, the MoD public consultation documents deliberately avoid considering the activities most likely to cause them.

But the MoD *did* consider a much worse risk in a document that they presumably thought would escape public attention. In the declassified and heavily redacted minutes[11] of a Defence Board meeting in 2011, recently unearthed via a freedom of information request, the MoD's senior nuclear safety regulator, Commodore Andrew McFarlane stated the following.

"All pressurised water reactors are potentially vulnerable to a structural failure in the primary circuit, causing a rapid depressurisation and boiling-off of most of the cooling water. This results in failure of the fuel cladding and a release of highly radioactive fission products outside the reactor core.

"While the further containment provided by the submarine's pressure hull may contain the majority of this material inside the submarine, some leakage is likely to occur and, in any event, the radioactive 'shine' from the submarine poses a significant risk to life to those in close proximity, and a public safety hazard out to 1.5km from the submarine. Current designs of UK and global civil nuclear power plants have systems for safety injections of coolant into the reactor pressure vessel head and passive core cooling systems. [sentence redacted] UK submarines compare poorly with these benchmarks. [2 page section redacted]"

In the event of such a failure happening in dock in Plymouth, the radioactive 'shine' would impact several areas of population. The obsolete submarines are in fact moored only 500m from the dockyard railway station, Morice Town Primary School and residential areas with 32,000 residents.[12,13] It is hard to imagine that this state of affairs has been the case since 2002, or to imagine why the siting of eight aged nuclear reactors in or near a centre of population has not received much higher criticism.

This risk is far from theoretical. During the defueling process the fuel rods have to be removed from the highly radioactive reactor core. At this point a heavy shielding cap has been removed and the reactor core is exposed inside the dry dock. The risk exists of the release of particulate or gaseous matter to the atmosphere. The risk is higher at this stage as the reactor is outside of normal operating bounds and any mistake can be very dangerous. For example, if moderating rods are removed by mistake instead of the fuel rods, the core will become intensely radioactive. This would likely cause an explosion or serious fires, release radiation, and could result in the deaths of personnel. This happened to a Russian Echo class nuclear submarine during nuclear refuelling in Vladivostok harbour in 1985 resulting in 10 immediate deaths and 49 radiation injuries.[14] Rods can also become jammed or breach, releasing their contents with the possibility of localised intense fission reactions (hot spots). This type of risk will be higher for extremely aged reactors up to 10 years old.

Accidents have already happened at Devonport

There were some serious engineering errors during the HMS Vengeance refit. According to the Office for Nuclear Regulation, "ONR followed up DRDL's [Devonport Royal Dockyard Ltd] investigation into an event in November [2012] involving the removal of reactor compartment salvage valves from HMS Vengeance, inadvertently creating a breach in the reactor's primary containment boundary".[15] This happened "through a series of misunderstandings regarding the significance of these valves".[16]

There have also been other serious incidents. For example, on 29th July 2012, there was a failure of both the primary (electrical) and back up (diesel) power to parts of the Dockyard. These power supplies are vital for the continuous cooling of stored reactor core material. For 90 minutes the base had to deploy emergency fire hoses to provide this cooling.[17]

And finally, as if all these deficiencies weren't worrying enough, the Strategic Environmental Assessment (SEA) discounts the serious risk factor of fire. Fire is a very real risk factor in a complex engineering operation involving high temperature cutting equipment, explosive gas cylinders, angle grinders etc. The SEA states in several places that: "the risk of such an event [fire] occurring is exceptionally low".[18] They state that the relevant materials are large blocks of steel which are inherently non-flammable and also that there are no liquids that can escape. And, as already stated, the SEA excludes the most serious risks posed by the radioactive core itself.

Misleading the public?

The MoD response to consultation – dated March 2013 – concluded that "no plausible scenario has been identified by the MoD, or any other party, that results in a meaningful threat to public health from dismantling a de-fuelled submarine".[19] They certainly did not identify any such plausible scenario – but from my investigations this is a result of a seemingly deliberate avoidance of the most significant risk factors. In my view, the MoD public consultation documents seriously misled the public. The risks due to the planned de-fuelling of eight aged nuclear reactors still berthed in submarines remain critical. This complex and difficult task is expected to take at least another 12 years. As a result, active nuclear risks will continue at Devonport and in close proximity to residents for many years to come.

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