DNSR/22/11/2

4 Nov 09

SUCCESSOR SSBN

SAFETY REGULATORS' ADVICE ON THE SELECTION OF THE PROPULSION PLANT IN SUPPORT OF THE FUTURE DETERRENT REVIEW NOTE

Issue

1. Safety Regulators' advice to support decisions to be made impacting the design and progress of the successor SSBN.

Background

2. In response to a request from the SRO, this advice has been prepared by Cdre Andrew McFarlane (the Defence Nuclear Safety Regulator - DNSR), with a ship safety contribution from Mr Gavin Rudgley (the Naval Authority). It has been reviewed with Mr Howard Mathers (the Chairman of both the Defence Nuclear and the Ship Environment and Safety Boards), with the independent Defence Nuclear Safety Committee[1] and with Dr Mike Weightman (HM Chief Inspector of Nuclear Installations)[2].

3. The aim is to set out the legal and policy framework within which the project must propose and the Department must in due course decide on the appropriate propulsion plant for the successor SSBN, and against which both the statutory and internal MOD regulators will review the safety of the acquisition, operation and support of the deterrent, to inform their permissioning of specific activities. It is informed by the analysis and emerging evidence provided by the project of the options under consideration, and the formal review of this undertaken by the Reactor Plant Safety Committee and the Project's Platform Safety Committee.

The Legal and Defence Policy Position

4. The most significant legislation is the Health and Safety at Work Act (HSWA). Among the many provisions of the Act, two are fundamental.

- There is a duty on employers to ensure, so far as is reasonably practical, the safety of employees, and of others who may be affected by their undertaking.

- There is a duty on suppliers to ensure, so far as is reasonably practicable, that equipment will be safe when it is being used.

These provisions are underpinned by a large body of case law. In summary it is always a legal requirement to reduce risks to people so far as is reasonably practical which is commonly expressed as reducing risk as low as is reasonably practical (ALARP).

5. Among the many regulations made under the HSWA, two are particularly significant. The Ionising Radiations Regulations set out the basis on which the radiation risk to employees must be reduced ALARP, and the Radiation Emergencies (Preparedness and Public Information) Regulations set out the basis on which the potential consequences from a radiation emergency are to be managed, in order to protect both employees and members of the public.

6. The Nuclear Installations Act (NIA) (which is a statutory provision of the HSWA) defines the process to be followed to demonstrate that the risks to people from nuclear plant are reduced ALARP. The Environment

[1] This will be reviewed by DNSC members at their meeting on 10 Nov 09.
[2] This was undertaken at the Senior Operational Liaison Meeting on 3 Nov 09.

Act and the Radioactive Substances Act (RSA) require that the environmental impact of nuclear plant is minimised to the best practicable environmental option using best available techniques – this is synonymous with reducing the effect on the environment ALARP.

7. There are defence exemptions from some aspects of this legislation (notably from the licensing requirements of the NIA when the submarine reactor plant is intact or under direct crown control, and from the RSA when under direct crown control), but there is no general exemption from the HSWA. Thus the statutory regulators, the Nuclear Installations Inspectorate (currently part of the HSE), the Environment Agency (EA) and Scottish Environment Protection Agency (SEPA) have statutory responsibilities with accountability to the UK or Scottish Ministers and Parliament. Where there are exemptions, the SofS policy is that arrangements will be adopted which are, so far as is reasonably practicable, at least as good as the requirements of the legislation: these are regulated by the internal MOD regulators with accountability through 2nd PUS to SofS. The MOD regulators work closely with their statutory counterparts to achieve coherent regulation. In summary, the legal requirement is unequivocally to reduce the risks to all people and to the environment ALARP.

8. The legal interpretation on what is expected of an employer to reduce risk ALARP is contained in case law, but the HSE has published guidance based on this. The 2001 document "Reducing Risks Protecting People" (R2P2) sets out the strategic position and the basis of HSE's decision making process. There are particular societal concerns relating to nuclear hazards, as recognised in a number of public enquiries, notably the Sizewell B public enquiry which completed in 1988. This led to the publication of "The Tolerability of Risk from Nuclear Power Stations" (TOR) last revised in 1992. This guidance was updated in the publication of revised "Safety Assessment Principles for Nuclear Facilities" (SAPs) in 2006. DNSR worked closely with HSE in this revision and subsequently adopted them so that SAPs now provide formal guidance to both the HSE/NII and to DNSR on their regulatory decision making. In line with UK practice they are non-prescriptive in nature, and leave the onus on the duty-holder to demonstrate ALARP[3]. But from this guidance some key principles can be drawn.

ALARP – What is it? How is it assessed?

9. The starting point in assessing whether risk has been reduced ALARP is to compare the practice with others undertaking similar activities. From this it is possible to identify "best practice" in any particular field. But while best practice is likely to be delivered by only one or a few leading organisations, it is also possible to identify "relevant good practice" – the practice that is recognised by those in the field as an expectation. Sometimes this will be published by an industry association or by the HSE in an Approved Code of Practice (ACOP). There is, however, no ACOP on nuclear safety in submarines. The regulators' clear expectation is that any new plant must conform to relevant good practice, or demonstrate a comparable level of risk, without any reference to cost benefit analysis[4]. There are, however, societal expectations which change over time and standards are likely to increase. Thus in the future relevant good practice may well improve to include today's best practice. The requirement therefore is to conform to relevant good practice, but also to examine best practice and where reasonably practicable, to adopt it.

10. Having adopted relevant good practice, it is also essential to test whether this has reduced risk ALARP. **To do this it is necessary to consider a wide range of possible options to further reduce risk. For each option, the risk that would be averted by its implementation must be balanced against the sacrifice (in money time & trouble) incurred in implementing the option.** The case law position is that unless the

[3] It is the dutyholder (who may be a nuclear Licensee or Authorisee), who must decide whether an activity is ALARP. Regulators may review this decision, and may agree or otherwise that the activity should proceed, and accordingly may seek to influence the decision from an early stage, but the decision is the dutyholder's.
[4] HSE advice, based on case law, is clear on this point, that this requirement is not influenced by cost. This point was emphasised by Dr Weightman.

sacrifice can be shown to be grossly disproportionate to the risk averted, then the improvement must be implemented[5].

11. SAPs also contain a large number of engineering principles[6]. Among them is the guidance that safety should be secured by measures as near as possible to the top of the following hierarchy:

- Conservative design and passive safety measures that do not rely on control systems or human intervention;
- Active engineered safety measures that are initiated automatically;
- Active engineered safety measures that must be initiated manually;
- Administrative safety measures and procedures;
- Mitigation measures to minimise the consequence of failure.

And What is "Relevant Good Practice" in Nuclear Submarine Design and Operation?

12. For the last 50 years UK submarine design and operation has developed its own "relevant good practice" largely in isolation from peers. In recent years the opportunity for greater technology interchange with the US, and greater benchmarking with the UK civil nuclear power generation industry has allowed more comparison. Some aspects of the UK submarine programme represent best practice, for example submarine pressure hull structural design, and the protection against fire. But in a number of areas it is clear that the UK programme currently falls short of current relevant good practice. The FSM team have conducted a limited benchmarking exercise to identify relevant good practice and best practice in nuclear submarine operation, which has been reviewed by the project safety committee.

13. From this, there are two major areas of discrimination where current UK practice falls significantly short of benchmarked relevant good practice.

Control of submarine depth. For all submarine operations, depth is controlled by a combination of hydrostatic lift (by adjusting the ballast of the submarine) and dynamic lift (using speed through the water and control surfaces). [redacted]

Loss of (reactor) Coolant Accident (LOCA). 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 power plants have systems for safety injection of coolant into the reactor pressure vessel head and passive core cooling systems. [redacted] UK submarines

[5] This is discussed further later at para 20

[6] The SAPs provide advice to regulators on expectations for relevant good practice. But they are not mandatory, nor are they intended to be used as design or operational standards – this is for the dutyholder to define.

compare poorly with these benchmarks, with the ability to tolerate only a structural failure equivalent to a

[redacted]

[redacted]

Risk Probability Targets – a Cautionary Note

21. Excessive attention is often paid to probabilistic risk targets. Both R2P2 and SAPs set out targets in terms of the acceptability of the risk of individual or gross fatalities, and probabilistic safety analysis can be used to compare against these targets. A brief summary of the targets is provided at Annex A. This is useful for illustration to compare, within a hazard area, the probability of different events which may result in fatalities. But, to re-iterate, there is no legal requirement to meet these targets – the legal requirement is to reduce risk ALARP, primarily by use of sound engineering and conservative design. And although illustrations of risk probability may suggest that the risk of multiple fatalities resulting from loss of depth control may be orders of magnitude greater than the risk of fatalities from a LOCA, this does not obviate the legal requirement to reduce the nuclear risk ALARP.

Conclusion

22. he legal requirement on both MOD as the operator and on industry as the suppliers is to reduce the risk to people[7] and the environment as low as is reasonably practicable (ALARP). To achieve this it is necessary to demonstrate compliance with relevant good practice, and to implement additional safety improvements until it is judged that the sacrifice associated with making any further safety improvements is disproportionate to the safety benefit. [redacted]

[redacted]

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Annexes:

A. Probabilistic Safety Targets.
B. Assessment of Gross Disproportion.

[7] Throughout this document, the risk to people refers to the ship's company, the local nuclear site workforce, and to members of the public, except where these are separately identified.

ANNEX A

PROBABILISTIC SAFETY TARGETS

1. This annex provides an additional summary of probabilistic safety targets in support of the discussion in paragraph 21.

2. Two targets are defined in HSE documentation.

3. The **Basic Safety Level** (BSL) is the generally regarded limit of acceptability: if the risk is greater than the BSL it is highly likely that additional safety improvements would be possible, and a very high degree of disproportion would be required to justify not implementing such measures. It is also highly likely that the application of ALARP will drive the risk lower. For the risk of an individual fatality, R2P2 sets a BSL of 10^{-3} per year for workers and 10^{-4} for a member of the public. But for nuclear activities, as workers are exposed to radiological risk during normal operations, SAPS sets the BSL for a worker from accidents lower at 10^{-4} per year. The BSL for gross fatalities (more than 100) is 10^{-5} per year.

4. The **Basic Safety Objective** (BSO) is a benchmark that reflects modern safety standards and expectations. But an ALARP position may be reached at a greater risk than the BSO and conversely if further improvement measures are available that are not grossly disproportionate, then it may be necessary to drive the risk lower. R2P2 and SAPs set the BSO for both workers and members of the public at 10^{-6} per year. The BSO for gross fatalities is 10^{-7} per year.

Risk per year	Workers generally	Nuclear workers from accidents	Member of the public	Gross Fatalities (>100)
Basic Safety Level (BSL)	10^{-3}	10^{-4}	10^{-4}	10^{-5}
Basic Safety Objective (BSO)	10^{-6}	10^{-6}	10^{-6}	10^{-7}

ANNEX B

ASSESSMENT OF GROSS DISPROPORTION

(This is an extract of guidance on the HSE website on the assessment of gross disproportion in making ALARP decisions.)

What is Gross Disproportion?

The concept of gross disproportion requires duty-holders to weigh the costs of a proposed control measure against its risk reduction benefits. Specifically, it states that a proposed control measure must be implemented if the "sacrifice" (or costs) are not grossly disproportionate to the benefits achieved by the measure. Translation into monetary costs is often uncertain and should be justified by the dutyholder. The costs should be offset by any savings as a result of the measure, such as reduced operational costs. The benefits should include all reduction in risk to members of the public, to workers and the wider community, including avoidance of fatalities or injuries, environmental damage, and the avoidance of countermeasures such as evacuation and post-accident decontamination.

Why do we use Gross Disproportion?

The Courts (notably in Edwards v. National Coal Board (1949) have decided that, in judging whether dutyholders have done enough to reduce risks, practicable measures to reduce risk can be ruled out as not 'reasonable' only if the sacrifice (in money, time trouble or otherwise termed costs) involved in taking them would be grossly disproportionate to the risk.

How do we assess Gross Disproportion?

There is no authoritative guidance from the Courts as to what factors should be taken into account in determining whether cost is grossly disproportionate.

The dutyholder needs to take account of both the level of individual risk and the extent and severity of the consequences of major accidents.

For a given benefit, the higher these risks, the higher the degree of disproportion (ie the ratio of costs to benefits) can be before being judged 'gross'.

HSE has not formulated an algorithm which can be used to determine, in any case, when the degree of disproportion can be judged as 'gross'; the judgement must be made on a case by case basis.

But the following 'rule of thumb' has been adopted by the HSE Nuclear Directorate (with a similar approach used by the Hazardous Installations Directorate which regulates explosives, on shore and offshore chemicals, mines and diving).

This takes as its starting point the HSE submission to the 1987 Sizewell B Public Inquiry that a factor of up to 3 (ie costs 3 times larger than benefits) would apply for risks to workers; for low risks to members of the public a factor of 2, and for high risks (such as those involving a risk of fatality of a member of the public) a factor of 10.

GLOSSARY

ACOP	Approved code of practice
ALARP	As low as is reasonably practicable
BSL	Basic Safety Level
BSO	Basic Safety Objective
DNSR	Defence Nuclear Safety Regulator
EA	Environment Agency
FSM	Future Submarines (team in DE&S)
HSE	Health and Safety Executive
HSWA	Health and Safety at Work Act
IAEA	International Atomic Energy Authority
LOCA	Loss of coolant accident
NIA	Nuclear Installations Act
NII	Nuclear Installations Inspectorate
NRPA	Naval Reactor Plant Authorisee
PSR	Preliminary Safety Report
PWR2	Pressurised Water Reactor 2
PWR3	Pressurised Water Reactor 3
R2P2	Reducing Risks Protecting People (HSE publication)
RPSC	Reactor Plant Safety Committee
RPV	Reactor Pressure Vessel
RSA	Radioactive Substances Act
SAPs	Safety Assessment Principles for Nuclear Facilities
SEPA	Scottish Environment Protection Agency
SFAIRP	So far as is reasonably practicable