ANNEX F TO
JSP538

NUCLEAR WEAPON SAFETY PRINCIPLES AND SAFETY CRITERIA

CONTENTS

NUCLEAR WEAPON SAFETY PRINCIPLES AND SAFETY CRITERIA

INTRODUCTION

1. The safety of Nuclear Weapon (NW) Systems requires special consideration because of their political and military importance, their destructive power and the potential consequences of an accident or unauthorised act. NW Systems shall be designed with far greater margins of safety than those applied to conventional systems. An underlying aim of the NW Safety Principles and Safety Criteria (SPSC) is to take account of modem standards and to specify Safety Criteria so that the individual and societal risk posed during each Life Cycle Phase (LCP) for a NW System, is no greater than, and in many cases less than, the corresponding limits imposed by Nuclear Installation Inspectorate Safety Assessment Principles (NII SAPs) on a single civil nuclear power plant. Importantly, the principle of multiple independent Lines of Defence (LOD) is used to underpin confidence in the safety of the design.

2. This document sets out the MoD SPSC for NW Systems and provides the framework within which all other related criteria should be derived. The NW SPSC comprise:

a. Fundamental Safety Aims Those top-level objectives required to ensure acceptable levels of NW safety.

b. Safety Principles Design requirements that shall be fulfilled to meet the Fundamental Safety Aims.

c. Safety Criteria Criteria expressed in numerical terms, which are intended to set individual dose limits during routine operations and to set risk limits for the frequency of accidents.

SCOPE

3. The NW SPSC shall be applied to the assessment of both new and existing NW Systems. The NW SPSC shall be applied to the physics package, and to any component or evolution associated with the NW System where a malfunction, accident, energetic explosive reaction or exposure to an adverse environment could lead to release of RA material or nuclear yield[1] from the physics package. The SPSC do not apply to Radioactive (RA) or explosive WH components when they are not part of a fully or partially complete warhead (WH) or a nuclear assembly. The risk criteria set out in this document are only part of the overall risk assessment for a NW System and therefore associated conventional hazards and risk need to be comprehensively addressed and compared against the appropriate criteria. It is recognised that a Safety Management System (SMS) should be in place to ensure that the NW SPSC outlined in this document are fully complied with. However, details of how the SMS should be structured and managed are outside the scope of this document.

1 For each type of NW system, the precise period when there is potential for release of RA material or yield will need to be defined.

4. Hazards associated with security issues and deliberate malevolent acts are not addressed.

APPLICATION

5, Adherence to the NW SPSC shall be demonstrated or assessed, before the system goes into service. Although an existing NW System may have been designed initially against different criteria, a formal review of system safety shall be routinely conducted [2]. The review shall be against the criteria set out in this document and where shortfalls are identified, a decision made on what, if any, action needs to be taken in accordance with the As Low As Reasonably Practicable (ALARP) principle. Planned refurbishment activity may offer the opportunity to make improvements to safety.

MANAGEMENT SYSTEMS

6. A Safety Management System (SMS) shall be established for each LCP to manage both nuclear and conventional hazards and to demonstrate compliance with the appropriate safety criteria. It shall include both conventional explosive hazards and risks from RA material when not part of a fully or partially complete WH. The SMS will enhance and support the safety initiatives and interactions of all managers, personnel and organisations involved in the safety activities associated with the NW System. The commitment to safety management shall be demonstrated by a written safety policy which is implemented appropriately at all levels and in which safety performance is monitored.

7. All items and functions that have a bearing on safety shall be identified and the duties of personnel responsible defined. Quality assurance arrangements for safety critical items of the NW System shall be established and implemented. All individuals responsible for safety, shall be Suitably Qualified and Experienced Personnel (SQEP).

FUNDAMENTAL NUCLEAR WEAPON SAFETY AIMS

8. The Fundamental Nuclear Weapon Safety Aims (FNWSA) are identified as follows:

a. FNWSA I Nuclear weapon systems shall not produce nuclear yield[3] except when used in an authorised operational role.

b. FNWSA 2 Nuclear weapon systems shall not release RA material into the environment except when used in an authorised operational role.

c. FNWSA 3 Residual risks[4] associated with yield and release of RA material shall be ALARP.

2 In line with the recommendations of the Oxburgh report titled 'The Safety of UK Nuclear Weapons* reference CSA 42/5/1/1 (46/92) dated 12 Feb 1992. This was a report of a review conducted by a woridng group lead by MOD'S Chief Scientific Advisor Professor E R Oxburgh FRS.

3Nuclear yield is defined as anuclear energy release greater than 2kg ofTNT equivalent. The value of2kg ofTNT equivalent is selected as it is approximately the level of yield at which the prompt radiation hazard exceeds the hazard from the conventional explosive.

4 This recognises that, notwithstanding the aims of FNWSA I and FNWSA 2, no activity can ever be designed to be entirely free of risk.

INTRODUCTION TO NW SAFETY DESIGN PRINCIPLES AND RISK BASED SAFETY CRITERIA

9. NW Systems[5] have the potential to create hazards, specifically nuclear yield and the release of RA material, the overall consequences of which are significantly more severe than those associated with conventional weapons and most other hazards in society. The likelihood of an accident involving a NW should therefore be significantly lower than for a conventional weapon.

10. The NW Safety Design Principles form the core objectives of the design; their adoption is mandatory and compliance shall be explicitly demonstrated in NW safety cases. These are supported by a set of NW Safety Guidelines which are the suggested methods of meeting the NW Safety Design Principles, based upon expert advice and assessments of available technology. The NW Safety Guidelines are, however, not intended to constrain design options which should, where practicable, incorporate any additional features or design approaches which increase, or have the potential to increase, the overall safety of the system.

11. The list of the NW Safety Design Principles, related to the FNWSA, together with the amplifying Guidelines, is at Annex G.

12. The NW Safety Design Principles are underpinned by the requirement for the provision of multiple independent LOD to provide the necessary level of assurance against inadvertent nuclear yield and release of RA material in any credible circumstances. Although this approach is primarily qualitative, both the effectiveness and the number of LOD can be specified in broad numerical terms. Guidance on this concept is at Annex H. This approach offers the advantage of avoiding over reliance upon absolute values for extremely low probabilities whilst providing a basis for numerical estimation of risk levels.

13. The safety of NW Systems shall be ensured by adherence to the NW Safety Design Principles. The NW Risk Based Safety Criteria are additional to the NW Safety Design Principles and provide the quantitative framework within which risk can be assessed and compared against pro-determined levels of tolerability in order to influence the decision making process inherent in reducing the overall risk to ALARP. To comply with NW SPSC both the Safety Design Principles and Risk Based Safety Criteria shall be satisfied.

NW SAFETY DESIGN PRINCIPLES – GENERAL

NW SYSTEM ENVIRONMENT CATEGORIES

14. A set of NW System Environment Categories shall define the conditions that the NW System may encounter, either during normal operations or in any credible accident scenario. Throughout the life of the NW System, the proposed deployment shall be analysed thoroughly to produce a comprehensive, accurate and up to date specification of each Environment Category to which the NW System might be exposed either intentionally or unintentionally. This approach assists the designer and the safety assessor to ensure that appropriate safety and

5; The NW system includes support equipment such as the TCHD and containers that are designed to safeguard against insults to the WH but which are not necessarily in place for all the MTDS.

protection features have been designed into the system and that any necessary restrictions upon its deployment in the Manufacture to Target or Disposal Sequence (MTDS) [6] have been adequately defined.

15. Where a requirement exists to link the terms used in qualitative assessments to the numerical values used in quantitative assessments, the convention shown in Table F-l is used.

Qualitative Term	Probability (Events per Demand or Consequences per Insult)	Frequency[7] (Events per Year)
Unlikely	$\leq 10^{-3}$	$\leq 10^{-3}$
Very Unlikely	$\leq 10^{-6}$	$\leq 10^{-6}$
Extremely Unlikely	$\leq 10^{-9}$	$\leq 10^{-9}$

Table F-l - LINK BETWEEN QUALITATIVE TERMS AND QUANTITATIVE VALUES

16. The Environments to which the NW System may be exposed during its MTDS are categorised as follows:

a. Normal Environment This is the range of environments to which the NW System or elements of the system are likely to be subjected during the MTDS. It includes any credible insult to theWH which is predicted to occur at a frequency greater than 10^{-3} per year. Within the Normal Environment the system is required to remain safe and suitable for service throughout the entire MTDS. It is recognised that during the post-launch phase, layers of protection against inadvertent nuclear yield may be removed progressively in order to permit intentional yield [8]

b. Specified Abnormal Environment This is the range of environments to which elements of the NW System could be subjected in reasonably foreseeable accident scenarios. For inclusion in the Specified Abnormal (rather than the Normal) Environment, an environment shall be ***Unlikely*** to occur during a particular LCP. In the Specified Abnormal Environment the NW System is required to remain safe but not necessarily serviceable, it should not produce nuclear yield or release RA material and the risk shall be ALARP.

c. Severe Abnormal Environment This includes environments to which elements of the system could be subjected in accident scenarios more severe and less probable than those identified in the Specified Abnormal Environment. For inclusion in the Severe Abnormal Environment, an environment shall be ***Very Unlikely*** to occur.

6 The MTDS starts at the point during assembly when the high explosive is placed in close proximity to the fissile material such that there is potential for release of RA material or yield, and ends when the high explosive is separated *from* the fissile material or when delivered to the target. Earlier phases in the assembly process and later phases in the disassembly process do not fall within the scope of these NW SPSC.
7 The frequency refers to events per year affecting any weapon *or* weapons within the stockpile of one weapon system during a LCP. This differs from N446(2) which stated frequencies in terms of events during the MTDS of each WH. For typical UK stockpile size and life, the frequency per year from the stockpile is approximately equivalent to ten times the frequency per life for one WH. (10^{-6} events per WH life is approximately equal to 10^{-5} events per year per LCP)
8 The exact moment in the post-launch phase at which the Normal Environment safety requirement ceases to apply must be identified in project requirement documentation.

Combinations of independent [9] Specified Abnormal Environments are also included in the Severe Abnormal. In the Severe Abnormal Environment the system should not produce nuclear yield. It may not be possible to eliminate the inadvertent release of RA material, however this risk shall be ALARP.

LINES OF DEFENCE

17. In the context of NW Systems, multiple independent LOD shall be used to provide the required level of assurance against inadvertent yield or release ofRA material in any credible circumstance. The use of LOD is consistent with the approach used in civil nuclear power systems. A LOD may be an engineered item or procedure that either reduces the probability of a particular threat happening or protects against the consequence of a hazardous event.

18. A LOD may be effective against a variety of threats/environments or against only one. LOD may be characterised as either 'Full' or 'Partial', depending upon the effectiveness of their response to a particular threat/environment:

a. Full LOD To qualify as a Full LOD it shall meet the three requirements specified at Annex H. It shall either be demonstrated that the probability of failure on demand is less than 10^{-3}or substantive evidence provided that at least this level of reliability has been achieved. Because of the uncertainty when evaluating a LOD, it is not permitted to aggregate a Full LOD that is better than 10^{-3} with a LOD that fails to meet the requirements of a Full LOD, to make two Full LOD.

b. Partial LOD A Partial LOD shall be capable of reducing the risk by at least one order of magnitude. Partial LOD should normally only be used to support the ALARP principle, and it shall be noted that no number of Partial LOD can supplant the requirement for a Full LOD unless collectively they conform to all the characteristics of a Full LOD and in particular clearly demonstrate their independence.

19. Examples of Trident Full LOD are:

a. the specialist protective container used during transportation which is designed to protect the WH against the most severe credible fire in the warhead road transport vehicle (Truck Cargo Heavy Duty) (TCHD);

b. the exclusion region within the WH to isolate any extraneous electrical signals from the firing circuits;

c. the configuration of the WH high explosive and nuclear reactive components such that, if the explosive were initiated at any single point, a nuclear reaction leading to yield could not occur.

20. Examples of Trident Partial LOD are:

a. the use of HE which is less sensitive to Abnormal Environments;

9 "Independent" is to be interpreted as having no common cause and no mechanism where the failure of one LOD could impact on the integrity of another. Hence the probability of each can be combined by multiplication to give the probability of the combination.

b, the provision of a fire tender as part of a nuclear convoy to protect against the potential consequences of a fire;

c. safety procedures used when handling and maintaining NWs.

21. The LOD concept develops the previous requirement in N446(2) that there shall be at least *2* ***Unlikely*** and independent safety failures before inadvertent release ofRA material can occur, and that there shall beat least 3 ***Unlikely*** and independent safety failures before inadvertent yield can occur.

22. Annex H outlines the concept of LOD as applied to NW Systems.

23. Annex H provides guidance on the relationship between Environments and the number of LOD required. Two examples of design using LOD to protect against specified environments are given.

24. Annex H uses the Enhanced Nuclear Detonation Safely (ENDS) system as an example of the use of LOD in the design of a WH.

YIELD AND RELEASE OF RA MATERIAL

25. The NW Safety Principles to prevent inadvertent yield and release of RA material are as follows:

a. to combat any credible threat to the NW, there shall be at least 3 demonstrably independent Full LOD to prevent inadvertent yield and major release of RA material [10]. There shall be at least 2 independent Full LOD to prevent release of RA material from the physics package and at least one Full LOD, ideally more, to prevent release of RA material from components external to the physics package. Not more than one procedural Full LOD may be used to protect against a specific threat. It must be emphasised that the use of a procedural Full LOD against yield is not the preferred approach and is to be avoided whenever practicable. If this approach has to be used, substantial Human Factors evidence will be required to underpin its status as a Full LOD;

b. only one Full LOD can be claimed for any single safety feature irrespective of the reliability of that feature. Full LOD shall be supplemented by a number of Partial LOD as appropriate to reduce the risk to ALARP;

c. adherence to the LOD Safety Design Principle is consistent with the achievement of the Risk Based Safety Criteria.

10 Such as the detonation of one or more missiles in a submarine with subsequent release of RA material from WHs.

RELATIONSHIP BETWEEN ENVIRONMENTS AND LOD

26. The required number of Full LOD shall be provided to protect the NW and NW System from all environments, which are likely to pose a threat to NW safety. However, if there is incontrovertible evidence that an environment is ***Unlikely*** to occur, ie the specified abnormal environment, the number of Full LOD can be reduced by one. Similarly, if the environment is ***Very Unlikely,*** ie the severe abnormal environment, the requirement for Full LOD can be reduced by two. The combination of the likelihood of the hazardous event occurring and the probability of failure of the Full LOD will achieve the required levels of safety.

27. The Safety Design Principles for the number of Full LOD required against yield and release ofRA material are represented graphically at Figure F-l.

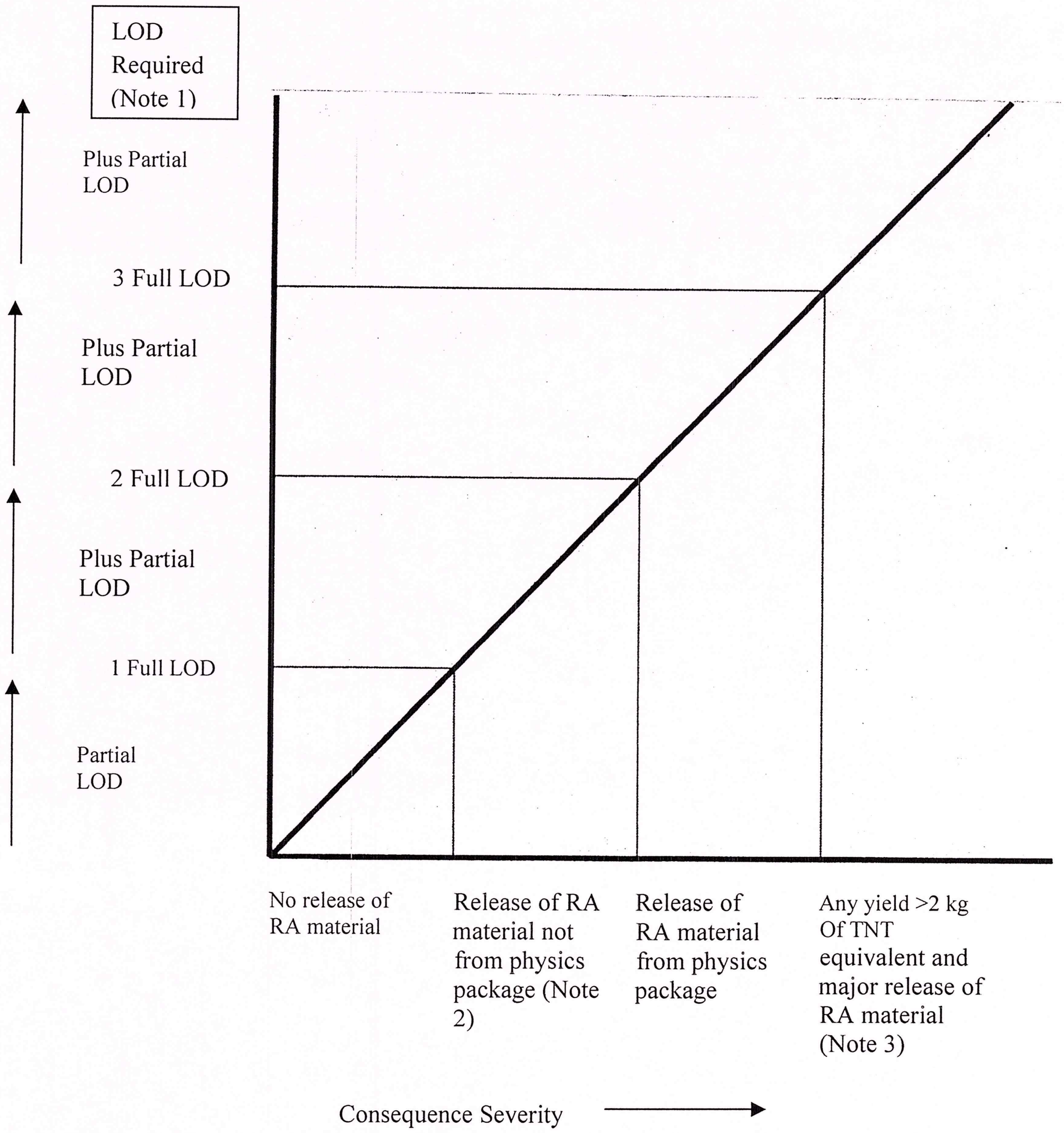


Figure F-l - NW SAFETY DESIGN PRINCIPLES
SCHEMATIC ILLUSTRATION OF RELATIONSHIP OF LOB TO YIELD AND RELEASE OF RA MATERIAL

NOTES

1. The NW System design shall include sufficient Full LOD to provide protection against the consequences from all credible accident conditions. As the predicted consequence of the event increases in severity, the number of Full and Partial LOD shall be increased in accordance with the ALARP principle.
2. As part of a NW System there may be a number of RA components with the potential to release low levels of RA material, eg parts of the External Neutron Initiators (ENI) or a small Tritium leak. There shall beat least one Full LOD, ideally more, to prevent a release of RA material from these components.

3. An example is the detonation of one or more missiles in a submarine with subsequent release of RA material from WHs

SINGLE POINT SAFETY

28. Nuclear WH designs shall always take into account the possibility that the inadvertent detonation of the supercharge at a single point could, in principle, lead to inadvertent nuclear yield rather than a release of RAmaterial.

29. It shall be shown that the Nuclear WH (in the service configuration) is Single Point Safe (SPS), assuming that:

a. the initiation is at the most vulnerable point in the supercharge;

b. the External Neutron Initiator (ENI) does not function;

c. theoretical assessment may have to be used if a practical demonstration is not possible.

30. This Safety Design Principle shall be applied to all configurations that occur during normal assembly and disassembly processes.

31. Nuclear WH designs shall be SPS such that in the event of inadvertent detonation of the supercharge initiated at a single point anywhere in its volume, the probability of any nuclear yield exceeding more than 2kg of TNT equivalent shall be less than 10^{-6} [11]

MULTI-POINT SAFETY

32. In principle increased nuclear safety can be achieved by designing a WH to be Multi-point Safe (MRS). Whilst theoretically possible, physical or technical impracticality has prevented MRS being achieved in current WH designs.

33. It shall be a design objective for nuclear WHs to be MRS. The probability of inadvertent detonation of the high explosive (HE) supercharge, initiated at any number of points and a consequent nuclear yield exceeding more than 2kg of TNT equivalent shall be ***Extremely Unlikely***.

POPCORNING

34. Popcorning can result from a sequence of accidental detonations of nuclear WHs in close proximity in which it is possible for a very small nuclear yield from one WH to enhance the yield of another WH in the detonation sequence. The potential for popcorning can only exist when there is a precise timing relationship between detonations. Although each WH may individually be SPS, popcorning may have the potential to produce a significant nuclear yield,

11 Clearly the WH or nuclear explosive must be protected from an insult such that the probability of single point initiation and the probability of other initiation modes are minimised to ensure that inadvertent nuclear yield is ***Extremely Unlikely.***

35. The probability of yield from pop coming depends on the array geometry and the SPS Characteristics of the individual WHs. The WH designs hall take into consideration that W may be stored in close proximity to each other. If it is not possible to control the popcorning probability by design, it shall be reduced to ALARP by procedural controls such as careful management of the weapon storage arrangements and handling procedures.

36. The WH and the WH processing, handling, transportation and stowage arrangements shall be designed so that the probability of a series of WH detonations in close proximity and a consequent nuclear yield in excess of 2 kg of TNT equivalent is ***Extremely Unlikely***.

NW SAFETY CRITERIA - GENERAL

37. The Health and Safety Executive (HSE) have developed guidelines for risk assessment, known as the Tolerability of Risk (TOR), for deciding whether risks are intolerable, tolerable or broadly acceptable. The NII SAPs use this approach in setting the safety criteria for nuclear installations. This defines risk in terms of the annual frequency of accidents giving rise to different levels of radiological consequence based on the effective dose to a representative individual member of the public. Other criteria in SAPs place limits on the individual risk to workers, the frequency of specified large releases of radioactivity (as a surrogate measure for societal risk) and the frequency of accidental criticality excursions.

38. The NW Risk Based Safety Criteria presented here adopt a similar approach to the NII SAPs for determining risk limits. A comparison between NII SAPs and NW SPSC criteria is provided at Annex K.

39. The NW Risk Based Safety Criteria are intended to place limits on the risks posed during each LCP of a NW System throughout the MTDS. Any changes in the design and/or build specification, material state, or operational usage shall require the safety of the system to be reviewed. The effect of ageing shall also be periodically assessed.

FORMULATION OF NW SAFETY CRITERIA

40. The NW Safely Criteria for both Routine and Accident Conditions are expressed in terms of Basic Safety Limits (BSL) and Basic Safety Objectives (BSO). The BSL represents the level of risk which is considered to be the limit of tolerability. Activities or designs which lead to risks greater than the BSL shall not normally be permitted. Below the BSO the level of risk is broadly acceptable whilst recognising the fact that no activity is entirely free of risk.

41. Other than in exceptional circumstances the less restrictive BSL shall be satisfied. In cases where the BSO is not met, it shall be demonstrated that the risk is ALARP. Risk reduction measures shall be weighed against the resources required to achieve that reduction. Only if there is gross disproportion between the cost and benefits of reducing the risk can the risk reduction measures be considered not reasonably practicable. Under these circumstances the justification for not reducing the risk shall be clearly stated. Further risk reduction measures are not normally required if it is shown to be below the BSO. However, if a simple low cost measure will further reduce the risk below the BSO this shall be given appropriate consideration. In the case of inadvertent yield, any risk of yield shall be demonstrated to be ALARP.

BALANCE BETWEEN QUANTITATIVE AND QUALITATIVE ASSESSMENT

42. When conducting a quantitative safety assessment of a NW System, where the probability of failure is low and the consequence of failure is high, there is danger of placing over-reliance on figures that cannot be justified with confidence. Additionally any NW System accident has significant political implications and these are even more difficult to quantify. The NW Risk Based Safety Criteria have been set at a level that reflect these qualitative factors.

LIFE CYCLE PHASES

43. The responsibility for NW System safety is held by a number of management units, each responsible for a defined LCP of the MTDS. It is more practical to apply the same Risk Based Safety Criteria to each LCP, instead of attempting to apportion risk to different areas. Providing that the number of LCPs is small, this approach does not lead to a significant relaxation of safety standards.

44. The boundary for each LCP shall be carefully defined and agreed to ensure that the totality of the MTDS is covered. As an example for the Trident System, the MTDS has been generally divided into the following LCPs:

a. R&D, manufacture, assembly, disassembly, handling and storage at AWE;

b. logistic transport (including staging posts) between AWE Burghfield and RNAD Coulport;

c. storage, processing and handling at RNAD Coulport and whilst aboard SSBN in the Clyde Submarine Base;

d. aboard SSBN elsewhere.

APPLICATION OF THE ALARP PRINCIPLE

45. The ALARP principle shall be applied by following a systematic procedure in order to standardise the process of decision making and to ensure that all practicable options have been properly considered. The ALARP assessment shall initially be made qualitatively and then be supported by a quantitative assessment. It is important to recognise that a numerical risk assessment may not be sufficient in itself to ensure that actual risk is ALARP. Safety enhancements shall be considered even if the benefits are not easily quantifiable.

46. The ALARP principle shall be applied to reduce risk in each LCP.

47. Guidance on the application of the ALARP principle is at Annex 1.

THE NW SAFETY CRITERIA

48. NW Safety Criteria are defined for the following conditions:

[blank page]

a. Routine Conditions These are the conditions pertaining to the Normal Environment when routine activities associated with the MTDS may lead to low levels of radiation exposure under controlled conditions. These NW Safety Criteria are expressed in terms of dose limits.

b. Accident Conditions Any unintentional event which results in, or has the potential to result in, a release of RA material or nuclear yield which in turn may give rise to significant, uncontrolled radiation exposure. Isolated incidents that result in individual doses of less than 0.1 mSv are included as part of routine conditions. These NW Safety Criteria are expressed in terms of risk based limits.

SAFETY CRITERIA-ROUTINE CONDITIONS

INDIVIDUAL DOSE CRITERIA

49. There shall be adequate control measures in the workplace to ensure that the total effective dose received by individuals, from all workplace sources is recorded and that statutory radiation dose limits are not exceeded. Under normal conditions, the individual radiation dose for personnel associated with NW Systems shall not exceed that specified by the Ionising Radiation Regulations 1999 (IRR99). BSO and BSL have been set for persons working with ionising radiation, workers on the nuclear site [12] and the general public, as shown at Table F-2. These criteria are directly applicable to assembly/disassembly, storage, transport, processing and operational activities associated with NW. The BSL is consistent with the statutory dose limits in the IRR99 Exceptionally when life saving activities are undertaken or when it is necessary to take action that will prevent the escalation of a situation, that could lead to even greater risk, exposure to ionising radiation of intervention workers may be necessary to put emergency plans into effect. The dose received by workers involved in the response to the radiation emergency are the subject of the Radiation (Emergency Preparedness and Public Information) Regulations 2001 [13]

	Effective Dose per year	
	BSL	BSO
Radiation Workers	20 mSv	2 mSv
Other Workers on site	5 mSv	0.5 mSv
Public	1 mSv	0.02 mSv

Table F-2 -INDIVIDUAL DOSE LIMITS

SURFACE DOSE RATE LIMITS

50. For the majority of its life a NW is assembled. In this configuration radiation is transmitted from the fissile material through the body of the weapon. To provide enhanced protection, a maximum surface dose rate for new bare weapons is set as shown in Table F-3.

12 In the case ofNW, nuclear site workers equate to those associated with a Life Cycle Phase
13 Radiation (Emergency Preparedness and Public Information), Regulation 14.

BSL	BSO
2 mSv/h	0.002 mSv/h

Table F-3 -EFFECTIVE SURFACE DOSE RATE LIMITS

51. The BSL for the surface dose rate is set at the level recommended for radioactive substances "not in use" [14] For NW this shall be interpreted as being applicable in all LCPs excluding assembly or disassembly at AWE. A WH with a surface dose rate at or near the BSL would create a significant but not insurmountable operational and maintenance hazard. Current designs lie more closely to the BSO and a robust ALARP argument would be required if a WH design were proposed which did not achieve, or nearly achieve the BSO. The BSO is set such that, below this level, the dose to nearby personnel will be of minimal concern, regardless of the duration of exposure. This estimated that the effective dose rate received by a person working on the WH is likely to be about a quarter of the surface dose rate. Thus, working for a full working year of 2000 hours, with a WH having the surface dose rate at the BSO, would lead to an annual effective dose of l mSv.

RISK BASED SAFETY CRITERIA -ACCIDENT CONDITIONS

RTSK TO WORKERS

52. The total predicted individual risk of death (early or delayed) to any worker associated with the NW System attributable to exposure of radiation or yield from accidents shall be less than the values specified in Table F-4.The NW SPSC have adopted the same criteria as the Nil for risk to workers.

BSL	BSO
10^{-4} /year	10^{-6} /year

Table F-4 - INDIVIDUAL WORKER RISK OF DEATH

53. The BSO and BSL defined in Table F-4 do not apply to workers returning to perform recovery operations after an accident, see paragraph 49.

INADVERTENT YIELD

54. It is intended that the Risk Based Safety Criteria in respect of inadvertent yield shall be no less stringent than previous criteria set out in N446(2). This is not entirely straightforward, as the N446(2) criteria were expressed in terms of events per WH life and the NW SPSC criteria in terms of an annual risk per LCP. However, for a typical UK stockpile size and WH life, the requirement shall be broadly satisfied byspecifying a single BSL value of 10^{-8} per year for yield events greater than 2kg of TNT equivalent per LCP, Table F-5.

14 "Working with Ionising Radiation" Ionising Radiation Regulations 1999. Approved Code of Practice. (Regulation 29. Guidance Paragraph 503.)

55. It is not practicable to achieve a convincing quantitative demonstration of a BSO significantly below this level. Consequently, for yield, only a BSL is specified, with arider emphasising the importance of applying the ALARP principle. Although a single BSL value is applicable for all levels of yield, it is recognised that different levels of yield would have widely differing consequences. BSLs have not been set for different yield events because of the difficulty of accurately predicting the magnitude of yield. A BSL of 10^{-8} yield events per year is 2 orders of magnitude more stringent than the BSL for a major release ofRA material.

BSL
10^{-8}/year

Table F-5-BSL FOR ALL NUCLEAR YIELD EVENTS

RADIOACTIVE RELEASES

56. In formulating the Risk Based Safety Criteria for NW Systems, the BSL for release of RA material has been set at a factor of 10 more stringent than the Nil SAPs, see Annex K, at a level that corresponds with criteria inherent in ESTC Prescription No 2 Edition I. The criteria reflect the perceived enhanced public concern associated with NW [15] and the corresponding BSO has been set at a factor of 1000 below the BSL. The rationale is that it is considered to be reasonably achievable and when the BSO has been met, the loss of one LOD will not result in the risk being above the BSL.

57. The Risk Based Safety Criteria for RA releases are shown graphically at Figure F-2, supported by Table F-6 which provides examples specific to the Trident System. The BSL and BSO are defined in terms of event categories and an associated range of consequences from a minor to a major release of RA material.

58. The Risk Based Safety Criteria set out in Figure F-2 set limits on the frequency of events within defined event categories. In the first instance, events shall be assigned to an event category on the basis of potential radiological consequences, within an Event Category Table, taking the effective dose to a nominal individual at a distance of I km from the accident as a surrogate measure of the overall radiological impact. A typical Event Category Table is shown at Table F-6 and the relationship between the quantity of plutonium released into the atmosphere and the effective dose is described in Annex J. Where a safety case postulates an accident sequence that is not readily assigned to an event category, an assessment shall be made of the radiological impact and the event allocated to the most appropriate category. In the case of releases of RA material, the release/dose relationship established at Annex J may be used. It should be noted, however, that other non-radiological detrimental consequences (eg political impact of the accident) may be taken into account. However, any reallocation of category shall be such that a more stringent criterion is applied; that is, the event assigned to a higher category than would be determined on the basis of dose estimates alone.

59. The Risk Based Safety Criteria are defined so that the individual and societal nuclear risk posed by a NW System, is no greater than, and in most cases significantly less than, the corresponding limits placed on the risk from a single civil nuclear power reactor or a single submarine reactor. For each NW System, the Risk Based Safety Criteria place limits on the

15 Reference: Risk: Analysis, Perception and Management Report of a Royal Society Study Group pages 103-104, dated Oct 2001

frequency of a range of accidents resulting in a release of RA material or yield occurring within any LCP, irrespective of the number of weapons within each phase. Thus, given that the number of NW systems is likely to be small, the criteria effectively place limits on the total risk posed by the entire NW programme. A detailed comparison between the Nil SAPs criteria and the NW SPSC is given at Annex K.

THE EVENT CATEGORY TABLE

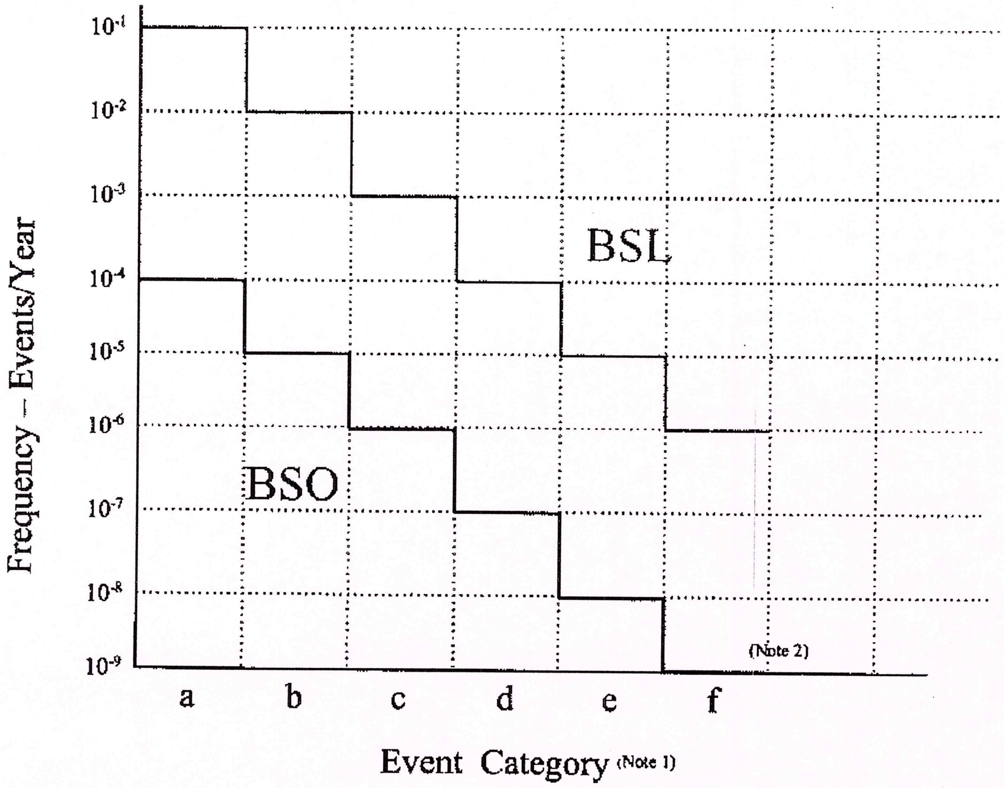
60. The following guidelines should also be considered when allocating event categories:

a. events that have a low probability of causing injury to workers or the public but are undesirable should be in Category 'a";

b. events that are likely to cause a worker serious injury or have the potential to cause life threatening injury or death should be in at least Category 'b\ Events that have the potential to jeopardise the health of the general public should also be in at least Category 'b";

c. events that pose a high risk of death to a worker should be in at least

d. for an event where containment is achieved the event category should be one below that for a similar uncontained event.



Event Category (Note 1)

Figure F-2 - RA RELEASE NW RISK BASED SAFETY CRITERIA - ACCIDENT CONDITIONS

NOTES

1. A specific table of event categories is required for each NW System. A representative set of Event Categories for Trident is at Table F-6.

2. It is not considered possible to quantify, meaningfully, frequencies of less than 10^{-9} events per year and the chart at Figure F-2 is therefore terminated at that level.

Category	Examples of Events	Effective Dose at lkm for range of listed events (Note 1)
N/A	1. Any event where no significant RA material is released.	< 0.lmSv
a	1. One or more WH consumed in fire but RA material effectively contained within a facility. (Note 2) 2. Limited Trithim leak.	0.1-1 mSv
h	1. Up to 4 WHs consumed in fire. 2. Large partial HE event. 3. Total Tritium reservoir failure.	1 – 10 rnSv
c	1. 1or more WH detonations with RA material contained within a facility. (Note 2) 2. More than 4 WHs consumed in fire. 3. 1 or more WHs consumed in fire, subsequent low energy criticality of debris when flooded.	10- 10^2mSv
d	1. Uncontained WH detonation (up to 3 WHs). 2. 1 or more WH consumed in fire and subsequent high energy criticality of debris when flooded causing additional release of RA material. (Note 3)	$10^2 – 10^3$mSv
e	UncontamedWH detonations (4-30 WHs) (Note 4)	1 -10 Sv
f	Detonation of one or more missiles in a submarine with subsequent release of RA material from WHs.	10 – 100 Sv (Note 5)

Table F-6 - RA RELEASE EVENT CATEGORIES - TRIDENT

NOTES

1. The principles used to estimate effective dose from the release of RA materials and the associated societal effects are explained at Annex J.
2. The nature of these events is such that they have been classified in a higher category than would have been allocated were effective dose to be the sole criterion.
3. The principal effect of a high energy criticality is to enhance the release of RA material.
4. For events involving more than 30 WHs the category shall be reassessed.
5. Doses of 10 Sv and above aroused primarily to indicate the scale of the accident rather than the radiation effect. are used

POST ACCIDENT CONDITIONS

61. Specific circumstances associated with an accident are difficult to predict and consequently the immediate action to be taken by the senior responsible officer at the scene is left to his knowledge and judgement. The response will depend on the hazards created and the associated risk. If the physics package retains a credible capability of producing yield the

immediate response should be to restore, as far as possible, 3 Full LOD to prevent yield and 2 Full LOD to prevent release of RA material. If the accident has resulted in release of RA material the senior responsible officer at the scene shall take appropriate action to stabilise the situation. Account shall be taken of the requirement to protect the general public from further risk whilst minimising the dose received by personnel making the immediate response. Once the situation has been stabilised the dose received by the Explosive Ordnance Disposal (EOD) personnel involved should, wherever possible, be within the limits specified for classified radiation workers in IRR99. Post accident activities shall always follow the principle that risks are reduced to ALARP.

62. Instructions, facilities and personnel shall be available to provide an EOD infrastructure capable of managing any credible NW accident scenario during all LCPs. Exercises are to be carried out on a regular basis to confirm that adequate levels of capability and readiness are maintained. MOD policy for the planning and management of NW accidents is contained in JSP 471 Defence Nuclear Accident Response produced by D SEF Pol.