CHAPTER 11

NUCLEAR WEAPONS - BACKGROUND

NEED FOR SAFETY PLANS

Differing Views

11.1 The absence of specific plans for dealing with a nuclear weapon accident in an Australian port was noted in chapter 2. The Department of Defence does not consider as credible the risk of nuclear detonation during a visit to an Australian port. It considers:

> the risks of even the worst credible nuclear weapons accident on a visiting warship are extremely low. It would not be sensible for emergency planners to attempt to develop plans to deal with every emergency that may conceivably, but not credibly, arise. ... we consider that it would be ... unrealistic to prepare in detail for a nuclear weapon accident on a warship making a routine port call. The general plans for dealing with disasters in our ports and harbours would be appropriate to deal with the initial phase of any major nuclear weapons accident ... The additional requirements of a nuclear weapons accident - such as radiation monitoring equipment and personnel trained in use of that equipment - would need to be obtained from Commonwealth authorities and perhaps also from the other government involved but there is no reason to believe that this would involve major problems of coordination or that undue delays would be encountered in making those resources available. The task of cleaning up after any nuclear weapons accident would moreover be one in which prompt assistance would be forthcoming from the country on whose

vessel the accident occurred.[1]

11.2 In contrast, the Victorian Government suggested greater precautions might be justified for visits by nuclear armed warships.[2] The majority of non-government submissions that addressed the issue considered that the current position underestimated the risk, that is, the likelihood of and/or consequences of a nuclear weapon accident, and hence underestimated the need for specific planning.

11.3 In its submission, the Australian Ionising Radiation Advisory Council (AIRAC) stated its belief that appropriate control and emergency procedures should be in place for ports visited by nuclear weapons capable vessels.[3] However, AIRAC stressed that it had not calculated the probability of a nuclear weapon accident in an Australian port or developed a reference accident.[4] Rather it was suggesting that a series of accident scenarios should be constructed and examined to determine the probability of their occurrence.[5]

The Committee's Methodology

11.4 In order to assess whether the absence of specific contingency plans was acceptable, it was necessary for the Committee to consider the types of accidents which might occur. The concepts of risk assessment, 'credible accident' and 'reference accident' were discussed in chapters 3 and 7 in the context of reactor accidents. The Committee considered these concepts and the general approach it adopted in relation to reactor accidents to be equally applicable to assessing the risk

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[1] Submission from the Department of Defence, pp. 26-27 (Evidence, pp. 31-32. Note also the second supplementary submission from the Department of Defence, pp. 24-25 (Evidence, pp. 238.279-80); Senate, Hansard, 2 May 1986, p. 2292 and 27 September 1988, pp. 753-54.

[2] Submission from the Victorian Government, pp. 6-7.

[3] Submission from AIRAC, p. 6 (Evidence, p. 700).

[4] Evidence, pp. 714, 721, 725 (AIRAC).

[5] Evidence, p. 713, (AIRAC).

of nuclear weapon accidents.

11.5 Hence, to assess the overall risk, and thereby establish the need for contingency planning, the Committee considered both accident likelihood and accident consequences. In assessing accident likelihood, the Committee considered both the historical record of accidents involving nuclear weapons and the theoretical means by which an accident might happen.

11.6 After considering the adequacy of the information available to the Committee, the remainder of this chapter summarises the information available to the Committee on: the types of nuclear weapons likely to be aboard visiting warships; the hazards posed by the plutonium in these weapons; the safety-related features of the design and storage of the weapons; and the accident record for nuclear weapons. Based on this information, chapter 12 deals with hypothetical accident scenarios involving nuclear weapons on board visiting warships.

11.7 While the Committee's general approach to assessing the risk of both weapon and reactor accidents is the same, the range of hypothetical accidents differs. For reactor accidents, the Department of Defence and its advisers assessed the likelihood and consequences of a range of scenarios. The reference accident which resulted from this assessment indicated to the authorities that there was a need for contingency planning and provided a basis upon which to plan. A consistent view in submissions opposed to the current position was the need to plan for a more serious reactor accident.

11.8 In contrast, assessment of weapon accident scenarios has led the Department of Defence to the conclusion that there is no accident whose combination of likelihood and consequences (ie. risk) requires specific contingency planning. In other words, the Department's assessment has not led to a reference accident being developed in respect of nuclear weapons.

11.9 In submissions opposing this conclusion, there was no single alternative position clearly put forward. This again was in contrast to the case with regard to planning for nuclear powered warship visits. Rather the Committee was presented with scenarios ranging from nuclear detonation through to simple loss of an intact weapon in a sunken vessel. There was considerable focus on fire and non-nuclear explosion as credible risks. However, there were differing views in the submissions on whether planning should be based on the separate occurrence of fire or non-nuclear explosion, or on their combined effect.

Information available to the Committee

11.10 Given official secrecy on nuclear weapons, the adequacy of the information available to the Committee was a threshold issue in its consideration of the risk of a nuclear weapon accident. Adequate information is essential in the use of either the historical method or the theoretical method of assessing accident likelihood.[6]

11.11 In respect of the historical safety record, considerable official data are available on United States Navy nuclear weapons accidents and incidents. The Committee is aware of the criticism that the data may well be less than comprehensive.[7]

11.12 The Committee considers that even if the official figures are incomplete they provide a useful guide to the types of accidents that have occurred. It is improbable that a nuclear detonation has been omitted, because the consequences of such a detonation would almost certainly have become public knowledge.

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[6] The methods are not mutually exclusive: see paras. 3.20, 3.22.

[7] e.g. see the submissions from Prof W. J. Davis, p. 52 (Evidence, p. 499); Greenpeace Australia (NSW) Ltd, p. 18. See also Stockholm International Peace Research Institute, World Armament and Disarmament: SIPRI Yearbook 1977, (MIT Press, Cambridge, Mass., 1977), pp. 53-54; S. Talbot, 'The H-Bombs Next Door', The Nation (USA), 7 February 1981, p. 144.

Moreover, the type of less serious accidents most relevant in the present context, magazine fires and chemical explosions while in port, are relatively difficult to conceal.[8] Official statistics are therefore unlikely to be deficient in this regard, even if it is true that other types of accidents are under-reported.

11.13 In respect of the second method, rigorous theoretical assessment of the likelihood of an accident involving a nuclear weapon requires precise knowledge of, among other things, the design and construction of the weapon, and the way in which it is maintained and stored. The amount of information available to either the Australian Government or the Committee on these matters is limited.[9]

11.14 There is much publicly available information relating to civilian nuclear powered merchant ships and land-based reactors which can, if used judiciously, assist in filling the gaps in public information relating to naval reactors. There are no corresponding sources for nuclear weapons, as there are obviously no civilian devices employing the physical principles, design and technology of nuclear weapons.

11.15 The Department of Defence pointed out to the Committee:

> As a non-nuclear weapons state that is party to the Nuclear Non-Proliferation Treaty, Australia has undertaken not to manufacture or otherwise acquire nuclear weapons and not to seek or receive any assistance in their manufacture.[10] These undertakings mean that the Government's direct knowledge of nuclear weapons design and construction is necessarily

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[8] cf. Evidence, p. 712 (AIRAC).

[9] e.g. see the second supplementary submission from the Department of Defence, p. 23 (Evidence, p. 238.278).

[10] Treaty on the Non-proliferation of Nuclear Weapons, Washington/London/Moscow, 1 July 1968, (Australia, Treaty Series, 1973, No. 3), article 2.

limited.[11]

11.16 Nonetheless the Department considered that:

> a good deal of reliable information is available about safety standards and procedures applied in the relevant NATO countries to nuclear weapons manufacture, handling and storage. This information is sufficient for the Government to be assured not only that the risk of a nuclear weapon accident during a visit to an Australian port by a foreign warship is extremely low, but also that the consequences of any such accident would be localised rather than widespread and would not pose a major health hazard to the Australian population.[12]

11.17 The Committee accepts that the lack of information available to it makes any formal, comprehensive risk assessment by the Committee impossible.[13] The Commonwealth Government is clearly in no better position. Some submissions argued that a necessary precondition to visits by nuclear armed vessels is that all relevant data should be available to Australian authorities. On this view, visits should only be permitted following the outcome of a full, independent risk assessment by Australian authorities or, in default, by making the most safety-directed or

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[11] Submission from the Department of Defence, p. 22 (Evidence, p. 27). See also the second supplementary submission from the Department of Defence, p. 23 (Evidence, p. 238.278), and the submissions from AIRAC, p. 5 (Evidence, p. 699); Australian Radiation Laboratory p. 5 (Evidence, p. 1009); ANSTO, p. 5 (Evidence, p. 243).

[12] Submission from the Department of Defence, pp. 22-23 (Evidence, pp. 27-28).

[13] cf. submission from Prof W. J. Davis, p. 52 (Evidence, p. 499); Evidence, pp. 590-95 (Prof W. J. Davis), and pp. 726-27 (AIRAC). Note also the view of the Department of Defence (Evidence, p. 1300.58):

> The statistical probability of either an accident involving a naval nuclear weapon that is in secure stowage or an accidental explosion in the magazine of a conventionally armed warship do not appear susceptible to calculation.

conservative estimates of risk.[14]

11.18 The Committee does not accept this view. In many other situations the Australian Government does not conduct its own independent safety assessment, but instead relies on the good faith of, or assurances from, other governments. Examples are visits by conventional warships and military aircraft.[15]

11.19 The Committee considers that the information available to it, while imperfect, does not prevent it making an assessment of the likelihood of an accident involving a nuclear weapon on board a visiting warship.

11.20 Australian authorities are better informed on accident consequences: that is on matters such as radiation dispersal mechanisms, the health and environmental effects of radiation, and the remedial measures required.[16] The Australian Radiation Laboratory, an agency within the Health portfolio, informed the Committee that it could acquire the facilities needed to deal with an accident involving the rupture of a nuclear warhead, if required to do so and subject to funding.[17] The Australian Ionising Radiation Advisory Council indicated that it would be available to examine appropriate control and emergency procedures if requested to do so.[18]

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[14] Submission from Scientists Against Nuclear Arms (ACT), p. 2 (Evidence, p. 780). See also the submissions from the Medical Association for the Prevention of War Australia (NSW), p. 4; Milton-Ulladulla People for Peace, p. 3; Scientists Against Nuclear Arms (Tas), p. 2 (Evidence, p. 821).

[15] cf. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May, 1976), p. 7 (Evidence, p. 124).

[16] Submission from ANSTO, p. 1 (Evidence, p. 243: See also pp. 417-18).

[17] Submission from the Australian Radiation Laboratory, p. 5 (Evidence, p. 1009).

[18] Submission from AIRAC, p. 5 (Evidence, p. 699).

TYPES AND NUMBERS OF NUCLEAR WEAPONS ABOARD WARSHIPS

Weapon Types

11.21 It is highly unlikely that warships carrying ballistic (ie. strategic or inter-continental) missiles will visit Australia.[19] As a result of official secrecy, there are no concise official data on the size of the United States Navy's stockpile of theatre (ie. non-strategic or tactical[20]) nuclear weapons, on the numbers of weapons of each type in the stockpile, or on the number aboard any particular ship.[21] However, a considerable amount of information on the United States Navy's theatre nuclear weapons has become public in piecemeal fashion over the years, largely in reporting to the United States Congress and its various committees. Commentators are able to state with some confidence the types and characteristics of nuclear weapons deployed by the United States Navy. The published data on British and French naval nuclear weapons are less comprehensive.

11.22 The following table sets out what is believed by commentators to be the United States Navy's theatre nuclear weapons arsenal. Because of the nature of the sources on which it is based, the figures in the table should be treated as a guide rather than a precise statement.

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[19] See para. 2.51.

[20] On this division between strategic and theatre nuclear weapons, see for example W. Arkin, The Nuclear Arms Race at Sea, (Neptune Papers, No. 1, Greenpeace/Institute of Policy Studies, Washington, 1987), p. 5. The Tomahawk cruise missile has, for the limited purpose of the Committee's report, been treated as a theatre weapon. For some other purposes, it might possibly be more appropriately classed as strategic, given its long range.

[21] The US regards as classified the percentage of its naval vessels that actually have nuclear weapons on board: US, H of R, Committee on Foreign Affairs, Subcommittee on Asian and Pacific Affairs, Security Treaty between Australia, New Zealand, and the United States - Hearing, 18 March 1985, p. 179 (J. A. Kelly, Department of Defense).

US Naval Theatre Nuclear Weapons[22]

Weapon system	War-head	Yield (kt)	No. in stockpile	Year 1st deployed	Period produced
Carrier aircraft bombs	B43	1000	{1000	1960	1960s
	B57	1-20		1964	1960s
	B61	1-345		1975[23]	1968 on
Terrier surface to air missiles	W45	1	285	1958	unknown: now ceased
Anti-submarine rockets(ASROC)	W44	1	575	1961	1960s
Submarine rockets (SUBROC)	W55	1-5	285[24]	1965	1964-74
Tomahawk sea-launched cruise missiles (SLCM)	W80	5-150	150	1984	current

11.23 British and French theatre nuclear naval arsenals appear to be confined to bombs capable of being delivered by carrier-based aircraft and anti-submarine warfare helicopters.[25] The

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[22] Sources: T. B. Cochran and others, Nuclear Weapons Databook, Volume 1: U.S. Nuclear Forces and Capabilities, (Ballinger, Cambridge, Mass., 1984); Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987) Table 1.2; the Bulletin of the Atomic Scientists, June 1988, vol. 44(5), p. 56. There are minor variations in the data given by these several sources, with considerable differences regarding weapon yields. For consistency, all yields have been taken from the last named source. Omitted from the table are land-based, long-range maritime surveillance aircraft capable of deploying B57 nuclear depth bombs, because they are not relevant to the Committee's inquiry.

[23] Date taken from the Bulletin of the Atomic Scientists, June 1988, vol. 44(5), p. 56, where it is noted that non-naval versions of the B61 were first produced in 1966.

[24] Bulletin of the Atomic Scientists, June 1988, vol. 44(5), p. 56 gives this total of 285, with the annotation 'scheduled for retirement in 1989'. Recent Congressional testimony stated that the SUBROC has already been taken out of service: US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1989 - Hearings, 23 March 1988, p. 1326 (Admiral K. R. McKee).

[25] Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987), pp. 25 and 30; UK, Secretary of State for Defence, Statement on the Defence Estimates 1986, (Cmnd. 9763-1, HMSO, London, 1986), vol. 1, p. 28.

number of nuclear warheads is relatively small.[26]

Number of Weapons on Each Visiting Warship

11.24 The Committee did not regard the issue of the number of weapons which may be on board a visiting warship as being of major significance in its inquiry because, in this limited context, it was prepared to make 'worst-case' assumptions.[27] If a given risk arises with each weapon, it follows that the total risk increases as the number of weapons that are on board any one visiting vessel increases. In the Committee's view, its conclusions on nuclear weapons remain valid even if the maximum design load of weapons were to be on board each visiting nuclear weapons capable warship.

11.25 The Committee considers it useful briefly to note two factors which, while by no means conclusive, suggest that the number of nuclear weapons entering Australian ports may be lower than often assumed by those opposing the present position on contingency planning. One concerns the relationship between the number of launchers for a particular weapon on a vessel, the size of the overall stockpile of that weapon, and the number (if any) of that type of weapon likely to be on board the vessel. The second factor is the distinction between nuclear weapons capable and nuclear weapons certified warships. In the majority of the submissions made to the Committee neither of these factors was

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[26] Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987), p. 25 states that some sources put the maximum number of British tactical nuclear warheads at 105 (25 depth bombs, 80 gravity bombs). The equivalent French total is given as 40: ibid., p. 30. D. Campbell, 'Too Few Bombs to go Round', New Statesman, 29 November 1985, p. 10 claims that the Royal Navy has only 25 tactical nuclear weapons. See also S. Gregory, 'The Command and Control of British Tactical Nuclear Weapons', Defense Analysis, 1988, vol. 4(1), p. 49: total stockpile for all British armed services is only about 120 tactical nuclear weapons.

[27] Many submissions suggested that the Committee should make assumptions of this kind. See for example, submissions from Scientists Against Nuclear Arms (ACT), p. 6 (Evidence, p. 784); Senator J. Vallentine, p. 18 (Evidence, p. 1061).

considered, and they are often overlooked in public discussion.[28]

11.26 In relation to the first of these factors, assertions were put to the Committee that, for example, 'there could be as many as 200 nuclear warheads on board a US battlegroup',[29] and that 'hundreds of new tactical nuclear weapons are deployed on ships visiting Australia'.[30] One of the accident scenarios put to the Committee by Professor Jackson Davis rests on the assumption that there would be 100 nuclear weapons on a visiting nuclear weapons capable warship.[31]

11.27 The delivery systems for theatre nuclear weapons are often capable of also delivering a non-nuclear version of the same weapon.[32] There is no necessary correlation between the number of launchers on a vessel and the number of nuclear

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[28] It may in some contexts be unnecessary to make any distinction between nuclear weapons capable and certified warships. For example, in estimating war-fighting potential, the distinction might be largely irrelevant, as capable ships may be able to be rapidly certified. The distinction is, however, of significance for peacetime visits to Australian ports.

[29] Submission from Senator J. Vallentine, p. 20 (Evidence, p. 1063).

[30] Submission from Greenpeace Australia (NSW) Ltd, pp. 31-32. See also the submission from Mr R. Addison, p. 1. cf. Tasmania, Assembly, Debates, 9 December 1987, p. 5580 (Dr R. Brown): 120 nuclear weapons would be aboard aboard the cruiser USS Long Beach when it visited Hobart.

[31] Evidence, p. 593.

[32] For example, the US Navy as at March 1986 planned the eventual deployment on 91 surface vessels and 107 submarines of 3994 Tomahawk missiles, of which 758 were planned to be the nuclear version: Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987), p. 14. See also US, H of R, Committee on Armed Services, Defense Department Authorization and Oversight - Hearings on H. R. 1872, 13 March 1985, p. 519 (Rear Admiral S. Hostettler): from the perspective of launch devices, the nuclear and non-nuclear versions of Tomahawk

> missiles are identical, and so there is no difference in the magazines. You can put any nuclear round in any hole of a box launcher or any torpedo tube. You can put the conventional varient in the same launcher or tube, so they are completely interchangeable.

Modifications are made, however, to the firing software, safety devices, etc. in order to ensure nuclear weapon safety and surety: ibid.

weapons, if any, that are carried.[33] For example, one recent source states that there are 575 ASROC [anti-submarine rocket] warheads in the United States nuclear stockpile which are deployed on 159 nuclear capable surface vessels.[34] Assuming these figures are correct, they give an average of less than four warheads per vessel, yet the vessels are mainly equipped with 8-tube ASROC launchers.[35] A similar situation exists with the nuclear version of Tomahawk missiles.[36]

11.28 This position does not appear to prevail for all vessel/weapon types. For example one source gives figures of 900 United States nuclear weapons capable carrier-borne aircraft with 1000 nuclear weapons stockpiled for them.[37] The only weapon for which there appear clearly to be more weapons carried than there

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[33] Contrast Tasmania, Assembly, Debates, 23 September 1986, p. 2593 and 25 September 1986, p. 2863 for suggestions that the USS Missouri carries 32 nuclear weapons. This is apparently based on it having 32 Tomahawk missile launchers. In J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/ Institute of Policy Studies, Washington, 1988), p. 44 it is stated that the 'nominal nuclear-armed TOMAHAWK (TLAM/N) loading is eight per ship' for the USS Missouri and the other ships of the same class.

[34] J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), p. 8.

[35] ibid. Tables on pp. 44-50 indicate that no vessel carries more than three ASROCs with nuclear warheads. In order to reconcile the numbers, it appears necessary to assume that some nuclear ASROCs are stored on land, being refurbished, etc.

[36] For example, in 1986 there were 21 US attack class submarines which were certified to carry the nuclear version of the Tomahawk, with some having capacity for 8 missiles, others for 20: N. Friedman, 'US Naval Weapons and Combat Systems Development in 1986', in US Naval Institute, Proceedings, May 1987, p. 90. The total number of Tomahawk nuclear warheads then believed to be in the US Navy stockpile, 110, would have been insufficient to utilise all these launchers, quite apart from the Tomahawk launchers on surface vessels. For the submarines having capacity for 8 missiles, one source states that 'two of the eight nominally are nuclear-armed': J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/ Institute of Policy Studies, Washington, 1988), p. 40, note 16.

[37] Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1987, (OUP, Oxford, 1987), Table 1.2. But compare R. Fieldhouse, 'Nuclear Weapons at Sea', Bulletin of the Atomic Scientists, September 1987, vol. 43(7), p. 22 where figures of 1500 nuclear bombs stockpiled for 900 carrier-borne aircraft are given.

are launchers on board is the Terrier missile.[38]

11.29 The calculations in the previous two paragraphs, and many similar ones made by commentators,[39] assume that all or most of the stockpile of each nuclear weapon type is deployed at sea. This assumption may not be valid. Reportedly official figures, leaked to the media in 1983, showed that, for example, less than half the Terrier missiles in the stockpile were deployed on ships.[40]

Nuclear Weapons Capable and Nuclear Weapons Certified

11.30 A significant proportion of the United States fleet is

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[38] J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), p. 46: a total of 189 Terrier missiles nominally carried amongst a total of 21 cruisers. The cruisers have either 1 or 2 twin rail-launchers, and each ship has a nominal loading of 9 missiles: ibid., p. 44, note 34. The ratio of misslies to launchers is said to be similar for Terrier-armed destroyers: ibid., p. 48.

[39] e.g. ibid., uses the concept of 'nominal' loads of nuclear weapons carried aboard particular vessel-types. The figures often, though not always, appear to be obtained by dividing the total assumed stockpile of a particular weapon by the number of vessels equipped to deploy that weapon.

[40] 'Report to Congress Provides Figures for Nuclear Arsenal', New York Times, 15 November 1983, p. A15. The figures for Terrier are 135 at sea of a total of 290; for ASROC, 350 of 575; and SUBROC 175 of 285. All the US Navy's 720 nuclear bombs are listed as being deployed at sea. Weapons deployed at sea may not all be stored on combat vessels. In J. R. Hill, Arms Control at Sea, (Routledge, London, 1989), p. 115 it is claimed that many of the US theatre nuclear weapons held at sea are stored on underway replenishment vessels.

said to possess nuclear weapons capability.[41] However, before any United States vessel having this capability is permitted to actually carry nuclear weapons, it must undergo a costly process to gain and maintain certification to deploy nuclear weapons.[42] This involves crew training, proficiency and inspection, as well as provision for armed guards and other safety and security features.[43]

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[41] Commentators differ as to the precise proportion. For example, Rear Admiral E. J. Carroll jr USN (Ret.) in 1986 gave a figure of 'approximately 85%': US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Hearings on H. R. 4181 to Authorize Certain Construction at Military Installations for FY 1987, 26 February 1986, p. 143. A figure of 70% is given in J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), p. 1. A table in Bulletin of the Atomic Scientists, September 1988, vol. 44(7), p. 64 shows a total of 284 US vessels as being nuclear capable. As US fleet size is not far short of its one-time goal of a 600-ship Navy, this equates to about 50% of the total fleet. For figures in submissions on the percentage of nuclear capable vessels of the total US vessels visiting Australia, see above, para. 2.3. To be meaningful in the context of port visits to Australia, ballistic-missile submarines would need to be excluded from any calculation, as these do not visit.

[42] To avoid possible confusion, note that this certification process relates to the vessel. The nuclear weapons are also certified by the design laboratories as to their safety and other characteristics: US, H of R, Committee on Foreign Affairs, Subcommittee on Arms Control, Proposals to Ban Nuclear Testing - Hearings and Markup on House Joint Resolution 3, 8 May 1985, p. 85 (D. Kerr, Los Alamos National Laboratory).

[43] e.g. see US, H of R, Committee on Armed Services, Defense Department Authorization and Oversight - Hearings on H. R. 1872, 13 March 1985, p. 532 (Rear Admiral S. Hostettler). This describes the procedures relating to the naval nuclear version of the Tomahawk missile, but the procedures appear to be standard for all naval nuclear weapons. Before the missile is loaded, ships have to undergo Nuclear Weapons Acceptance Inspections (NWAI) which verify that security requirements such as alarms, armed guards, and the 2-man rule are in place.

> In order to insure each surface ship is properly trained and ready to safely operate with and employ Tomahawk, a certification program has been implemented. Prior to loading a nuclear Tomahawk, in addition to an NWAI, each ship must receive a Tomahawk Safety/Material certification which verifies the Tomahawk weapon system installation is correct and meets safety requirements. It also certifies the ability of the ship crew to operate and maintain the system. Subsequently, a demanding Tactical Qualifiaction Evaluation is conducted with the ship underway to verify individual and team proficiency ... When all these examinations are passed successfully, the ship is certified for Tomahawk operations. Periodic re-examinations are conducted throughout the operating cycle. (ibid., pp. 532-33)

11.31 There appears no reliable information on what proportion of nuclear weapons capable vessels are certified at any one time.[44] Given the expense and inconvenience of the certification process, it may be that not all are certified.[45] On the other hand, these same factors suggest that once a vessel has been certified, it actually carries nuclear weapons.[46]

Age of the Weapons

11.32 As indicated in the table earlier in this chapter, a number of the types of nuclear warheads which may be aboard visiting United States warships are of 1950's and 1960's design

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[44] Greenpeace claimed that each of the four US warships to visit Sydney for the 1988 Bicentennial Naval Review was nuclear weapon certified: 'A hundred Hiroshimas in harbour: Greenpeace', Sydney Morning Herald, 24 September 1988, p. 4. The claim was reported as being based on publicly available documents and documents obtained using the US Freedom of Information Act.

[45] e.g. J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute of Policy Studies, Washington, 1988), p. 33, note 99:

> As of December 1987, of the 98 SSNs [ie. US attack class submarines], 51 have been, or are shortly being, converted to a Tomahawk SLCM [sea launched cruise missile] capability, but only 31 of these 51 are Tomahawk certified submarines. (emphasis in original)

For Sturgeon class attack submarines, although '19 are listed as TOMAHAWK-capable, only six submarines are TOMAHAWK-certified as of December 1987': ibid., p. 40, note 16. The authors note that the numbers change from month to month as submarines enter overhauls, undergo conversions, new submarines are commissioned, etc: ibid., p. 33, note 99. Many of the reasons why a capable vessel might not certified at a given time would not be relevant to vessels on extended deployment, such as those visiting Australia.

[46] cf. Andrew Mack, head of the Peace Research Centre at the Australian National University, quoted in 'A hundred Hiroshimas in harbour: Greenpeace', Sydney Morning Herald, 24 September 1988, p. 4:

> You don't go to the considerable trouble of certifying a ship which is nuclear capable unless you intend it to carry nuclear weapons. A great deal of paperwork is involved and there has to to be provision for people trained and certified to handle nuclear weapons.

and manufacture.[47] The designs of the older weapons incorporate fewer safety features than those of the later weapons.[48] These safety features are noted later in this chapter.

11.33 The nuclear warheads of earlier design are being phased out of service and being replaced with later designs,[49] or in some cases with non-nuclear weapons.[50] Moreover, there has been some retrofitting of safety features to older weapons.[51] Nonetheless older weapons such as Terrier missiles and ASROC's may be on United States warships visiting Australian ports.

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47. cf. US, Senate, Committee on Armed Services, Department of Defense Authorization for Appropriations for FY 1988/1989 - Hearings (Part 4), 31 March 1987, p. 2469 (Dr R. B. Barker): 'the [US] Navy tactical nuclear weapons stockpile is probably the oldest fraction or close to the oldest fraction' of the current US nuclear stockpile.

48. See para. 11.105 for the argument, made in the arms control context, that older nuclear weapons are nonetheless sufficiently safe. See also US, Senate, Committee on Armed Services, Subcommittee on Arms Control, FY 1981 Department of Energy Authorization for National Security Programs, 28 April 1980, p. 75 (Dr M. Sparks, Sandia Laboratories): noting the desirability of modernising the stockpile:

> Now I don't want to mislead you. The old weapons are as safe as they have ever been and they are very, very safe, but we now have new design capabilities and new requirements.

The reasons why the USN stockpile has not been completely modernised are varied, and not all relate to safety. But on safety grounds, the need to modernise is a relatively low priority as the risk of an accident is regarded as relatively low compared to that relating to some other types of nuclear weapons. See para. 11.94, footnote 142, for example, on the reason why PAL's are not fitted to US Navy tactical nuclear weapons.

49. See, for example, the table in Bulletin of the Atomic Scientists, June 1988, vol. 44(5), p. 56.

50. e.g. it appears as if the replacement for submarine launched rockets (SUBROCS), which have nuclear warheads, is the non-nuclear version of the Sea Lance anti-submarine weapon, as the US Congress has declined to approve funding for a nuclear version of the Sea Lance: J. Handler and W. M. Arkin, Nuclear Warships and Naval Nuclear Weapons: A Complete Inventory, (Neptune Papers, No. 2, Greenpeace/Institute for Policy Studies, Washington, 1988), p. 8. See also 'US Navy is quietly phasing out short-range N-missiles', the Age, 1 May 1989, p. 8: SUBROC, Terrier and the nuclear version of the ASROC to be phased out of use by about 1991.

51. See for example US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, National Defense Authorization Act for FY 1988/1989 - H. R. 1748 - Hearings, 24 February 1987, pp. 67, 68 (Dr R. Barker, Department of Defense): B61 bombs have been retrofitted with insensitive high explosive; enhanced electrical safety devices can be fitted as modifications very easily.

POTENTIAL HAZARDS OF NUCLEAR WEAPONS

Nuclear Detonation

11.34 Clearly the most serious hazard that needs to be considered in relation to a nuclear weapon is that of accidental nuclear detonation.

Plutonium Hazards

11.35 Most nuclear weapons in the United States stockpile, and all presently in development, contain plutonium.[52] Nuclear detonation apart, the potential for serious consequences from a nuclear weapon accident arises mainly due to the presence of plutonium.[53] The Committee was told that it would be appropriate in the context of such an accident to focus its inquiry on plutonium.[54]

11.36 A nuclear reactor accident could result in the release and dispersal of a wide variety of fission products, many of which emit gamma and beta radiation. In a nuclear weapon accident, so long as there is no nuclear detonation, the primary radiological hazard is from plutonium dispersal. Sufficient quantities of beta/gamma radiation to pose a significant health problem will not be present.[55]

11.37 Plutonium-239, the primary isotope used in nuclear

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52. US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. I-6.
53. Evidence, p. 733 (AIRAC). See also US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), p. 79: 'plutonium is considered the most significant radiological hazard associated with an accident involving nuclear weapons containing plutonium'.
54. Evidence, p. 733 (AIRAC).
55. US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), p. 3. See also Evidence, pp. 732-33 (AIRAC).

weapons, has a half-life of over 24,000 years. This was a matter of considerable concern to many of those making submissions because they believe plutonium dispersal has the potential to 'not only affect this generation, but generations to come'.[56]

11.38 Plutonium-239 is radioactive, emitting alpha radiation. This has such a low penetrating power that it is strongly absorbed by air and is incapable of penetrating clothing or the outer layer of unbroken skin. Normally alpha emitters can cause harm only if they are inhaled, ingested, or absorbed into the blood stream (e.g. through a wound).[57] The presence of an emitter of alpha radiation in the body has the potential to cause malignant change. It is clear that the toxicity of plutonium is related solely to its radioactivity.[58]

11.39 The Committee was told that if plutonium comes into

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[56] Submission from Senator J. Vallentine, p. 30 (Evidence, p. 1073). See also for example submissions from People for Nuclear Disarmament, p. 4 (Evidence, p. 1306); Ms A. Tubnor, p. 2.

[57] US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), p. 3. See also Royal Commission into British Nuclear Tests in Australia, Report, (Parl. Paper No. 483/1985), vol. 2, pp. 574-78.

[58] G. A. Williams and others, 'Plutonium Contamination at Maralinga', Chemistry in Australia, April 1987, vol. 54(4), p. 122; J. C. Nenot and H. Metivier, 'Biological Behaviour and Toxicology of Plutonium and Trans-plutonics', Inorganica Chimica Acta, 1984, vol. 94, p. 167. The latter gives a useful balance to some of the more alarmist statements made to the Committee on the toxicity of plutonium (p. 165):

> The toxic properties of this element are known more than for any other poison. Paradoxically, since its discovery in December 1940 ... no unquestionable direct relationship, 40 years later, has been established between its toxicity and human death. ... all of the knowledge acquired on its toxicity comes from animal experiments. Any extrapolation to man is always subject to controversy.

Although the sample is too small to support firm conclusions, a group of 26 men contaminated by plutonium during World War II, mainly by inhalation, have had a subsequent medical profile no different to other Americans and have had a mortality rate below the national average (p. 168). For a controversial view that the hazards from plutonium have been overstated, see B. L. Cohen, 'The Myth of Plutonium Toxicity' in K. O. Ott and B. I. Spinrad (eds.), Nuclear Energy: A Sensible Alternative, (Plenum, New York, 1985), pp. 355-65.

contact with water, no immediate significant hazard results.[59] Nor is there any hazard to marine life as plutonium is not an element that accumulates within biota (ie. marine, animal and plant life) to any degree.[60] Plutonium dispersal resulted from the crash onto sea ice near Thule, Greenland in 1968 of a plane containing nuclear weapons. Studies were made by Danish scientists of the marine environment. Concentrations of plutonium were found in samples of marine life but not at levels that posed any hazard to higher animals or persons.[61]

11.40 The toxic effects of plutonium depend on its particle size, chemical form and isotopic composition. Within limits, the smaller the particles, the greater the danger they present. Large pieces of plutonium are unlikely to be absorbed, ingested or inhaled, and so present little radiological hazard. Plutonium in the form of contaminated fragments, such as might result from an explosion, does not represent an inhalation hazard unless 'over a period of time, surface degradation (e.g. rusting of steel), releases particles of plutonium of respirable size'.[62] It is for this reason that an accident scenario involving the aerosolisation of plutonium is considered to be the most hazardous weapon accident short of nuclear detonation.[63]

11.41 A number of submissions portrayed the plutonium hazard in terms more dramatic than instructive. For example, the Peace

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[59] Evidence, p. 717 (AIRAC).

[60] Evidence, p. 718 (AIRAC).

[61] A. Aarkrog, 'Radio-Ecological Investigations', USAF Nuclear Safety, 1970, vol. 65(1) part 2, p. 79; A. Aarkrog, 'Further Studies of Plutonium and Americium at Thule, Greenland', Health Physics, January 1984, vol. 46(1), pp. 29-44.

[62] G. A. Williams and others, 'Plutonium Contamination at Maralinga', Chemistry in Australia, April 1987, vol. 54(4), p. 124.

[63] US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 50: US Department of Defense and Department of Energy officials believe that airborne contaminants present the primary health risk following a nuclear weapon accident, and 'the greatest danger to the public from plutonium would be inhalation of aerosolized particles during passage of a cloud created by fire or HE detonation, though the chance of this happening is low'.

Squadron (Sydney) assumed the smallest weapon to contain 5 kg of plutonium and stated:

> Given a uniform distribution of the 5 kg of plutonium over the Sydney area, and a lethal inhaled dose of .001 g, this would be sufficient to kill 142% of the population of Sydney in a 'worst case' accident involving a single nuclear weapon of the smallest size.[64]

This ignores the fact that there is no possible mechanism of achieving this sort of uniform distribution.[65]

11.42 Any calculation of the degree of dispersal of plutonium and its eventual internalisation by humans is very complex because of the large number of variables that need to be considered. Some of these are the amount of plutonium in the weapon(s); the weather at the time of the accident and subsequently; the particle size dispersed; and the population density and topography of the area affected. These and other

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64. Submission from the Peace Squadron (Sydney), pp. 4-5. See also for example the submission from Scientists Against Nuclear Arms (Tas), p. 4 (Evidence, p. 823); Scientists Against Nuclear Arms (ACT), p. 5 (Evidence, p. 783). cf. Evidence, p. 869 (Scientists Against Nuclear Arms).

65. cf. R. K. Mullen, 'Mass Destruction and Terrorism', Journal of International Affairs, 1978, vol. 32(1), p. 82. This deals with a scenario of a terrorist attempting to cause mass deaths through plutonium dispersal, not a weapon accident. The following comments, however, have some relevance:

> Making some extremely simplistic calculations, and extrapolating directly from the animal data, it may be shown that milligram quantities of insoluable reactor grade plutonium, deposited in the pulmonary region of the human lung, will cause a short-term fatality in that individual so exposed. Such calculations do not, however, take into consideration any of the previously mentioned physical factors which tend to degrade the performance of any aerosol; the environmental factors which affect the time and space occupancy characteristics of any aerosol; the physiological factors which require an aerosol to possess certain characteristics if it is to be effective; and other factors which make any attempt to cause numbers of short-term fatalities from a plutonium aerosol, an undertaking of great uncertainty. ... Frequently seen statements that small quantities of plutonium, dispersed into undefined environments, in some undefined manner, and made without consideration of the problems involved in creating an aerosol, much less those of maintaining its integrity once discharged from the aerosol generator, causing thousands of deaths, are simply incredible.

factors such as the effect of a particular dose on a particular person and the psychological effects of possible exposure need to be considered when calculating the consequences of various nuclear weapon accident scenarios involving plutonium dispersal.

Non-Radiological Hazards

11.43 Most concerns put to the Committee about a nuclear weapon accident related to the potential radiological hazards. However, other hazards could also exist,[66] including, for example pieces of unexploded high explosive thrown out in a detonation of conventional explosive. But these hazards are identical to those arising from conventional munitions aboard Australian or visiting warships, unless insensitive high explosive[67] is involved. No information was brought to the Committee's notice that suggests insensitive high explosive is more dangerous in a non-nuclear accident than conventional explosive.

11.44 If there is a fire involving a nuclear weapon toxic hazards may result from poisonous substances that might be included in the weapons, such as beryllium, lithium, lead and plastics.[68] While the Committee does not wish to play down the hazards that these substances might pose, it considers that the hazards are within the range of those encountered in industrial accidents. As such they do not provide the basis for requiring special contingency plans for nuclear weapons.[69]

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[66] See for example, Evidence, pp. 732 and 734 (AIRAC).

[67] See para. 11.55 on the use of insensitive high explosive.

[68] US, Defense Nuclear Agency, Nuclear Weapons Accident Response Procedures Manual, (Washington, 1984), pp. 113–14. See also New York City, Mayor's Emergency Control Board, Staten Island Homeport Plan, (Draft, June 1988) pp. 15–16: 'There are no toxic hazards from conventional HE [high explosive] or propellants used in naval weapons'.

[69] See para. 12.68, for the Committee's recommendation with respect to Australian port plans for dealing with general shipping accidents, including those involving hazardous cargo.

SAFETY FEATURES

Safety Design[70]

11.45 Those involved in designing, handling and storing nuclear weapons are, of course, well aware of the harm that might result from a nuclear weapon accident. Extensive precautions are taken to avoid any accident.[71] Two major factors relevant to assessing accident likelihood are the design of the nuclear weapons and the way in which they are stored in warships visiting Australia.

11.46 United States nuclear weapons are designed, maintained and stored 'so as to incorporate maximum safety consistent with operating requirements'.[72] The arming, fusing and safing features

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[70] For the physics and basic design of nuclear weapons, see for example Joint Committee on Foreign Affairs and Defence, Disarmament and Arms Control in the Nuclear Age, (Parl. Paper No. 337/1986), pp. 189–195; T. B. Cochran and others, Nuclear Weapons Databook, Volume 1: U.S. Nuclear Forces and Capabilities, (Ballinger, Cambridge, Mass., 1984), chapter 2.

[71] e.g. see US, General Accounting Office, Nuclear Weapons: Emergency Preparedness Planning for Accidents Can Be Better Coordinated, (GAO/NSIAD-87-15, February 1987), p. 55: 'prevention of accidents is paramount in D[epartment] o[f] D[efense] and DoE[nergy] nuclear weapon programs ...'.

[72] US, General Accounting Office, Observations on Navy Nuclear Weapon Safeguards and Nuclear Weapon Accident Emergency Planning, (GAO/NSIAD-85-123, 29 July 1985), Appendix 1, p. 5. Safety is achieved by compliance with four safety standards, requiring positive measures to:

- prevent nuclear weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear yield;
- prevent deliberate prearming, arming, launching, firing, or releasing of nuclear weapons except upon execution of emergency war orders or when directed by competent authority;
- prevent inadvertent prearming, arming, launching, firing, or releasing of nuclear weapons in all normal and credible abnormal environments; and
- ensure adequate security of nuclear weapons.

A positive measure is a design feature, safety device, or procedure that exists solely or principally to provide nuclear system safety: ibid. For an indication of how these standards were given effect with regard to the Tomahawk missile, see ibid., p. 6. The standards are also set out in US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident – Hearings, 14 June 1979, p. 218 (Department of Defense).

vary from weapon to weapon. Not all the details are publicly available, but the following description relating to a nuclear bomb gives an idea of what is involved in, and of the meaning of, terms such as 'prearming' and 'arming' in relation to a specific weapon.[73]

> With bombs, preflight operations include prearming by insertion of arming plugs, removal of safing wires that prevent closure of release switches, and connection of 'pull-out wires' that pull out when the bomb falls from the plane, activating the switches. Prior to release, the pilot activates a reversible arm-safe switch. After release all functions are automatic. An environmental sensing device monitors a number of different 'environments' that can be duplicated only in the flight of the bomb: close-to-zero gravity accelerations (that is, free fall), changes in barometric pressure, and deceleration caused by deployment of a parachute to slow the bomb's descent. Timers are used in some cases to ensure that these environments occur in the proper sequence and time frame. Arming and safing features ensure that a weapon is in a proper and safe trajectory before arming is completed and fuzing can occur.
>
> Fuzing ... components include altitude-measuring devices ... or inertial devices that measure a distance along a trajectory. ... Pressure sensitive switches (hydrostats) are used in depth bombs for subsurface bursts in water.[74]

11.47 Other weapons have similar devices, all of which have to

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[73] These terms, and the term 'un'armed', can only be given a precise meaning by reference to the design of a specific weapon. For a general definition of 'unarmed', see Evidence, p. 1254 (Department of Defence).

[74] D. R. Cotter, 'Peacetime Operations: Safety and Security' in A. B. Carter and others, Managing Nuclear Operations, (Brookings Institution, Washington, 1987), pp. 43–45.

operate as intended to produce a nuclear detonation.[75] For example, 'a sea-launched cruise missile will experience a period of acceleration for a known period of time. Unless this acceleration occurs, the weapon cannot be detonated.'[76]

11.48 A major concern for nuclear weapon designers has been to ensure safety in the event the weapon is involved in a crash, fire, or other accident. A declassified part of a 1984 report to the United States President on nuclear weapons safety states:

> Our modern ... weapon electrical systems are designed with multiple safety features so that in accident environments (fire, crash, lightning, etc.), selected components necessary for arming and fuzing are reliably destroyed before the safety devices fail.[77]

11.49 The Department of Defence told the Committee:

> In the case of fission weapons, high voltage detonators are used which do not contain any sensitive primary explosives. This ensures that individual detonators will not function unless the correct high voltage pulse is

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[75] See for example US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, p. 219 (Dr J. P. Wade, Department of Defense):

> Special safety features include electrical, mechanical, and environmental devices specifically designed for each nuclear weapon or nuclear weapon system. Failure of one of those safety features will cause the weapon to remain nonoperable: that is, there would be no nuclear explosion. For each weapon, these safety features are included in a sequence of steps which must be accomplished for the weapon to operate.

[76] D. Caldwell, 'Permissive Action Links for Sea-Based Nuclear Weapons?', NATO's Sixteen Nations, February/March 1988, vol. 33(1), p. 48.

[77] US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. I-4. Declassified parts of this report were released under the US Freedom of Information Act. In the passage quoted a word or words after 'modern' was deleted on security grounds from the released document. For details of some of these features, see for example D. R. Cotter, 'Peacetime Operations: Safety and Security' in A. B. Carter and others, Managing Nuclear Operations, (Brookings Institution, Washington, 1987), pp. 45-46. A schematic diagram, ibid., p. 47, indicates how one of the safety devices, the 'weak link - strong link', works.

> supplied; they will not function from static discharge or stray electric currents.[78]

11.50 Nuclear weapons contain chemical high explosive as part of the trigger mechanism.[79] Safety features have been incorporated into modern nuclear weapons to prevent nuclear detonation in the unlikely event that the chemical explosive detonates. The Australian Department of Defence informed the Committee it was not aware of:

> any evidence to dispute the advice we have been given that, in a nuclear weapons accident - even one involving detonation of its conventional explosives - it would be almost impossible for the materials in the nuclear weapon to form a critical mass to cause fission or fusion of a measurable nuclear yield.[80]

11.51 The United States Departments of Defense and Energy jointly reported in 1984:

> United States nuclear warheads are currently designed to be inherently one-point safe. This means that if the high explosive surrounding the nuclear material were somehow detonated in a localized region, there is less than one chance in one million that there would be a nuclear yield exceeding four pounds trinitro-

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[78] Submission from the Department of Defence, p. 24 (Evidence, p. 29). cf. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, National Defense Authorization Act for FY 1988/1989 - H. R. 1748 - Hearings, 24 February 1987, p. 63 (Dr R. Barker, Department of Defense): for a weapon employing insensitive high explosive, 'it takes energy akin to a lightening bolt to cause the intended initiation of the high explosive. It will not detonate in violent accidents.' Contrast the concerns of Senator J. Vallentine on the possible effects of stray electric currents, etc: Evidence, p. 1209.

[79] In simplistic terms, a nuclear weapon can be thought of as a sphere with the nuclear material in the centre, surrounded by conventional explosive. The function of the latter is to compress the nuclear material into a critical mass. Unless all the explosive is detonated at precisely the right time, the weapon will be blown apart rather than compressed and no critical mass will be formed.

[80] Second supplementary submission from the Department of Defence, p. 24 (Evidence, p. 238.279).

toluene (TNT) equivalent.[81]

Knowledge of whatever methodology and data were used to arrive at the figure of 1 in 1 million is not publicly available.[82]

11.52 The Committee was referred to a passage in an article which critically evaluated the definition of one-point safe:

> This definition allows for nuclear yields with less than four pounds of TNT equivalent and/or lesser probabilities. Not all nuclear weapons incorporate 'one-point safe' design, allowing the possibility that nuclear yields may exceed four pounds with a higher probability than one in one million.
>
> While US officials insist that such events are highly unlikely, such statements are strictly meaningless since it is impossible to predict precisely either the origin or the sequence of events in a real accident.[83]

11.53 The Committee does not accept this claim that statements as to accident likelihood are 'meaningless'. The Committee sees nothing illogical in accepting an accident likelihood as small even though it is not possible to define precisely all the elements in all possible accident scenarios involving the weapon. In any event, the premise for the scenarios raised is a chemical explosion, itself a very unlikely event for reasons set out below. Moreover, the Committee notes that there has never been any reported partial nuclear detonation involving a United States

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[81] US, Departments of Defense and Energy, Nuclear Weapons Surety: Annual Report to the President 1984, p. I-4. See also US, H of R, Committee on Armed Services, Subcommittee on Military Installations and Facilities, Civil Defense Aspects of the Three Mile Island Nuclear Accident - Hearings, 14 June 1979, pp. 219, 226, 236 (Department of Defense).

[82] See para. 12.14, footnote 19 on probability figures in the context of the risk of nuclear detonation. For a brief description of what is publicly known of tests conducted to determine if specific weapon designs were one-point safe, see S. Fetter, 'Stockpile Confidence under a Nuclear Test Ban', International Security, Winter 1987/88, vol. 12(3), pp. 136-38.

[83] L. Zarsky and others, 'Nuclear Accidents', Current Affairs Bulletin, June 1986, vol. 63(1), p. 10 (Evidence, p. 813).

weapon.[84]

11.54 The Committee inquired as to the effect of a nuclear yield of less than the equivalent of 4 pounds of TNT. It was told by the Australian Ionising Radiation Advisory Council (AIRAC) that the health hazard as a result of a fission of this size would be 'extraordinarily small'.[85] AIRAC said that the dose rate from the fission products would be about one hundredth of the background level.[86]

11.55 The use of insensitive chemical high explosive[87] as a trigger device in modern nuclear weapons is an additional safety feature in these weapons. A report to the United States President in 1984 noted:

> The possibility of an accidental or deliberate detonation of a nuclear weapon's chemical high explosives, with resultant dispersal of plutonium as a hazardous aerosol, can be

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[84] 'U.S. Nuclear Weapons Accidents', Strategic Digest, November 1981, vol. 11(11), p. 921.

[85] Evidence, p. 740 (AIRAC).

[86] Evidence, p. 739 (AIRAC).

[87] For the tests an explosive has to pass in order to meet US Department of Energy (DOE) criteria for insensitive high explosive, see R. J. Slape, IHE Material Qualification Tests: Description and Criteria, (MHSMP-84-22, Mason & Hanger - Silas Mason Co. Inc., Amarillo, Tex., June 1984). These tests include dropping, application of friction and of sparks, burning and heating, firing projectiles containing IHE at armour plate, and bullet-impact tests. See also R. R. McGuire and R. P. Guarienti, DOE Hazard Classification for Insensitive High Explosives, (UCRL-91420, Lawrence Livermore Nat. Lab., Livermore, Calif., August 1984), p. 2:

> [IHE] is truly insensitive to impact, friction, spark, or thermal stimulus under any reasonable confinement condition. Only high amplitude shocks induce detonation and we have not found sustained lower level reactions. ... [But] we are speaking about materials that are by definition mass detonable explosives. They will detonate if the proper high amplitude shock pulse is provided. Therefore, if they are stored, handled, or transported in conjunction with more sensitive materials that could supply that pulse, they must be counted as hazard class 1.1. ... It is only when they are stored alone or with other IHE's that they can be considered as insensitive.

This paper also summarises how the claim that 'there is no reasonable probability of the accidental delivery of sufficient energy to cause initiation' of IHE (p. 2) is verified: pp. 2-5.