CHAPTER 3

REACTOR ACCIDENTS - ASSESSING THE RISKS

Need to Evaluate the Reference Accident

3.1 The concept of planning on the basis of a reference accident, and the particular accident selected for this purpose, were identified in the previous chapter. The Committee considered whether it should interpret its terms of reference so as to limit its inquiry to the adequacy of the planning made on the basis of the reference accident currently used. A wider interpretation could lead to an examination of that reference accident, and thus the basis on which the current planning rested.

3.2 As indicated in chapter one, much of the correspondence and discussion prior to the original reference by the Senate in September 1986 suggested that the main concerns related to uncertainty over the roles of Federal and State agencies, the lack of uniformity between States, and the role in the event of an emergency of the country to which the visiting warship belonged. These concerns could be addressed by the more limited inquiry.[1]

3.3 Any wider inquiry would inevitably involve highly technical issues. A significant proportion of the technical information needed to address these issues is classified as secret and as such is not available to the Committee. Therefore the Committee had to consider whether it had the technical expertise to undertake a wider inquiry. Even if it did, it also

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1. cf. Senate, Hansard, 5 May 1986, p. 2388-89, where in the course of debate Senator McIntosh stressed these points but also raised the issue of 'the rationale behind safety planning for only a limited radiation accident'.

had to consider whether the available information would permit it to reach reliable conclusions.

3.4 On the other hand, if the concept of planning on the basis of a single reference accident is faulty, or the particular accident chosen is inappropriate, any resulting plans will almost certainly be flawed. The Committee saw little merit in evaluating the adequacy of current contingency planning by reference to what might be a faulty benchmark.

3.5 The Committee took the view that it should attempt to satisfy itself that the current reference accident provided an appropriate benchmark. If the Committee were to consider it flawed in any way, the Committee took the view that it should identify a more appropriate basis for contingency planning. Only after this had been done would the Committee consider it appropriate to evaluate the adequacy of current contingency planning.

3.6 In reaching this conclusion the Committee took account of views put in submissions from those who considered the present planning inadequate. Most of the strongly presented arguments in these submissions either explicitly or implicitly regarded the current reference accident as insufficiently severe, and therefore as inappropriate. In other words, if the current reference accident could be shown to be an appropriate basis for planning, a considerable part of the criticism directed at present planning would be groundless.

Not All Risks Necessitate Contingency Planning

3.7 The conventional approach to identifying relevant accidents, both nuclear and non-nuclear, was outlined in chapter 2, when describing how the current basis for planning was determined. After the elimination of types of accidents that are physically impossible, the process of selecting a reference accident involved excluding other physically possible accidents as a basis of planning. Exclusion might be on the grounds that their consequences would be trivial or would be catered for by planning for a more serious accident, or that their probability was too remote.

3.8 In attempting to identify relevant accidents, the Committee did not consider accidents affecting only the occupational health and safety of the reactor operators. Planning for accidents of this kind is a matter for the country to which the warship belongs.

3.9 An assumption is often made that planning in place to deal with the serious accident selected as the reference accident is also adequate to deal with less serious accidents of the same general type. Some submissions suggested that the reference accident used in current contingency planning provided an inadequate basis on which to plan for less serious reactor accidents. This criticism is considered in chapter 7.

3.10 The more controversial aspect of the conventional approach to accident planning was the proposition that the likelihood of some physically possible accidents occurring was too remote to justify contingency planning. In the language of the conventional approach outlined in chapter 2, these accidents are regarded as 'incredible'. Such a conclusion is arrived at after calculating both the probability of a specific accident occurring and the harm that would result if it were to occur.[2] The worst accidents that are physically possible are often not considered credible enough to form the basis of planning because their probability is assessed as being too remote.[3]

3.11 This conclusion is generally accepted in planning for non-nuclear accidents.[4] No submission expressly compared reactor accidents with non-nuclear accidents in terms of risk of or need

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2. Submission fom ANSTO, Addendum, p. 1 (Evidence, p. 379): risk is a combination (usually taken as the product) of consequences and likelihood, and the most serious consequences multiplied by a remote likelihood often gives a lower risk than less serious consequences multiplied by a higher likelihood. See also APS Study Group, 'Report to the American Physical Society of the study group on radionuclide release from severe accidents at nuclear power plants', Reviews of Modern Physics, July 1985, vol. 57(3)(partII), p. S32: 'The risk to the public is a combination of the frequency of the occurrence of adverse events ... and the magnitude of the consequence of the event'; International Atomic Energy Agency, Radionuclide Source Terms from Se·· ·e Accidents to Nuclear Power Plants with Light Water Reactors: Report by the International Nuclear Safety Advisory Group, (IAEA, Vienna, 1987), p. 3: in relation to contingency planning to protect the public 'risk is defined as the probability of occurrence of a postulated sequence multiplied by its off-site consequences'.
3. Submission from ANSTO, Addendum, p. 1 (Evidence, p. 379).
4. e.g. for contingency planning relating to floods, a floodplain is often defined as an area covered by a flood with a probability of 1 in 100 of being equalled or exceeded in any year: see D. I. Smith and J. W. Handmer, Flood Warning in Australia, (Centre for Resource and Environmental Studies, Canberra, 1986), p. 4. Areas where floods are less probable are excluded from consideration, even though floods there are not impossible.

for planning.[5] Some submissions indicated a strong reluctance to accept that the non-nuclear approach applied equally to nuclear accidents, and proposed that the most serious possible accident should provide the basis of contingency planning.

3.12 The reasoning underlying the adoption of this view is perhaps best encapsulated by the following description of concerns in the United States over nuclear power generation.

> What will happen under the worst conceivable circumstances is considered important by many people, despite assurances that the probability that these circumstances will arise is very low. Some analysts insist that concern with maximum harm irrespective of its probability is irrational, but people know that low-probability events of all kinds do occur, and they rightly consider the 'worst-case' outcome to be part of the burden of any energy choice. They are justifiably uneasy about assurances that the probability of a given event is 'one in a million' or 'one in a billion', because they know, at least

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5. cf. 'Expert: N-ship risks limited', West Australian, 22 May 1986, citing Dr Ted Maslen, chairman of the University of Western Australia's radiation safety committee, to the effect that oil tankers or cargo ships carrying explosive materials were a far bigger hazard than nuclear powered warships; A. C. McEwan, 'Health Physics Aspects of Nuclear Issues in New Zealand over the Last Decade', Australasian Physical & Engineering Sciences in Medicine, April-June 1986, vol. 9(2), p. 79: allowing for the emergency planning related to nuclear ship visits:

   > port residents face much higher risks from oil tankers and hazardous cargoes such as LPG and chlorine and in addition face risks associated with storage depots commonly associated with ports. Regular visits to ports by nuclear powered ships would then make no material change to the overall risks already experienced by port residents.

   See also US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975), chapter 6, 'Comparison of Nuclear Risks to Other Societal Risks', para. 7.5(c) of which concludes:

   > Nuclear accident risks are relatively low compared to other man-made and natural risks. All other accidents, including fires, explosions, toxic chemical releases, dam failures, earthquakes, hurricanes, and tornadoes, that have been examined in this study are more likely to occur and can have consequences comparable to or greater than nuclear accidents.

instinctively, that the probability that the analyst is wrong is often significant in such cases.[6]

3.13 The Committee shares the concern that experts may be seriously in error in their risk assessments. Any basis for contingency planning must include an adequate margin for error. Alternatively it must have built into it pessimistic assumptions on points where reasonable scientific certainty is lacking.

3.14 The Committee does not accept, however, that it would be appropriate to go beyond this and to insist that contingency planning be based on the worst physically possible accident, regardless of its likelihood. The Committee does not consider that, even after making due allowance for the particularly serious potential consequences of nuclear accidents, planning for these accidents should rest on different principles from planning for non-nuclear catastrophes.

3.15 It follows from rejection of the worst physically possible accident as the planning basis that the Committee is prepared to accept some degree of risk. It was put to the Committee that the Australian Government should be able to guarantee that 'there is absolutely no risk'.[7] No government is in a position to give this type of guarantee with respect to non-nuclear accidents. The Committee does not consider that the risk of nuclear accidents should be treated differently.

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6. J. P. Holdren, 'Energy Hazards: What to Measure, What to Compare', Technology Review, April 1982, p. 35 (emphasis in original).
7. Submission from Mr M. Lynch, p. 6 (Evidence, p. 879). cf. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 4.22: 'It is not sufficiently appreciated that there is no such thing as absolute safety.' The eight-volume Layfield Report resulted from a public inquiry, held between January 1983 and March 1985, into a proposal to build a pressurised water reactor at Sizewell in Suffolk, England. The reactor is to be used for commercial electricity generation, and its basic design is of United States origin.

A More Serious Case as a Reference Accident

3.16 The more common criticism in submissions was not that planning should be based on the worst case regardless of probability. Rather it was that the selection of the current reference accident was defective in that the probability of a worse accident had been seriously underestimated. On this view, the reference accident should be an uncontained, rather than a contained, full core meltdown. The meaning of the distinction is made clear in the following chapter, where the technical features of reactors are described.

3.17 There seemed to the Committee to be a general consensus that the choice of a reference accident lay between these two types, the present reference accident or the more serious, uncontained accident. No sustained argument was put to the Committee that it would be appropriate to adopt as a reference accident anything markedly less serious than the current reference accident. Accordingly the Committee did not canvass that possibility.

Assessment Methodology

3.18 The Committee had to determine the ways open to it to assess the probability of either a contained or uncontained core meltdown occurring to a naval reactor during an Australian port visit. Two approaches appeared to be available, in addition to reliance on assurances from overseas. One was to rely on the historical accident record. The other was to consider hypothetical ways in which the relevant accidents might occur, and attempt to evaluate each.

3.19 To perform the latter evaluation there appeared in principle to be two broad methods. One was the traditional method of relying on engineering and common-sense judgment to make a qualitative assessment.[8] The other was to attempt to apply one or some of the more recently developed techniques of quantitative assessment.

3.20 These ways open to the Committee were not seen, of course, as mutually exclusive. Nor were they as distinct as the above outline might suggest. In addition, due to military secrecy, there were restrictions on the Committee's ability to pursue any of these methods to the fullest extent. The effect of these restrictions was such that quantitative risk assessment techniques could not be used at all.

Inability to Quantify the Accident Risks

3.21 Sophisticated techniques have been developed in an effort to quantify the risks of accidents in hazardous industries for which adequate overall historical data are lacking and for which it is considered that reliance on engineering judgment would be inadequate.[9] One of these, probabilistic risk assessment, first came to public prominence when used to provide the basis for the United States Nuclear Regulatory Commission's 1975 study into the safety of reactors used for civilian power

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8. This method is sometimes referred to as deterministic or involving the use of a design base accident, and is perhaps more accurately thought of as encompassing a number of different techniques. A 'design base accident' is one that has been foreseen by the designer and for which the design provides. Assuming the provision is adequate and operates as intended, the occurrence of a design base accident in the reactor context should not result in any significant release of radiation to the environment. In this parlance, a beyond design base accident is a major accident that has not been foreseen at all or, more commonly, one that has been evaluated and found to be so unlikely that it can be disregarded for planning purposes. In the latter sense a beyond design base accident is roughly the same as one regarded as 'incredible': see para. 2.17 above on 'incredible' accidents.
9. One recent survey identified eight different techniques for evaluating risks in quantified terms: see J. C. Consultancy Ltd, Risk Assessment for Hazardous Installations, (Pergamon Press for the Commission of the European Communities, Oxford, 1986), p. 67.

generation.[10] This technique has also been used in other countries such as Britain and the Federal Republic of Germany, and has been applied to more than 20 nuclear plants.[11] Probabilistic risk assessment and other quantitative risk assessment techniques are widely accepted in the nuclear power industry as having a degree of validity,[12] although the details of particular techniques and their application in particular cases remain controversial.[13]

3.22 In broad terms and glossing over differences between techniques, the object of quantitative risk assessment techniques is to identify all the possible sequences of events in the component parts of a system that may lead to a failure of the system. Probabilities are then assigned to the occurrence of each event or fault. The probabilities may be derived from historical data if the particular component, for example a pump, has been widely used in other plants over a sufficient period of time. Otherwise, component failure probabilities are estimated on the

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10. US, Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants, (WASH-1400, NRC, Washington, 1975). The study is often referred to as the Rasmussen Report, after the name of the person who lead the study group. In the context of this Committee's inquiry, it is relevant to note that the study commenced in mid-1972 and the final report was issued in October 1975. The study cost about $US 4 million.
11. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 17.3.
12. See for example US, General Accounting Office, Nuclear Regulation: Financial Consequences of a Nuclear Plant Accident, (interim, 16 July 1986) p. 5 (the report is incorporated in US, H of R, Committee on Science and Technology, Subcommittee on Energy Research and Production, Supplemental Legislative Inquiry on the Price-Anderson Act, November 1986, pp. 73-99): 'probabilistic risk analysis is considered the best tool available for analyzing potential accidents'. The US General Accounting Office monitors government expenditures on behalf of Congress, and also conducts reviews of government programs. It is broadly the equivalent to the Australian Auditor-General.
13. e.g. see UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), paras. 17.28-17.48; L. Cave, 'Why do estimates of core melt probabilities differ?', Nuclear Engineering International, March 1988, pp. 40-41.

basis of engineering judgment.[14] It is hoped that by combining these probabilities the probability of overall system failure can be calculated.

3.23 Quantitative techniques are useful to plant designers and operators as well as to safety assessors and regulators because they help in identifying weak points in the design. For example, a pump whose operation is critical to plant safety may be identified, thereby allowing a backup pump to be incorporated in the design. The fact that several seemingly independent safety features are in fact dependent on, say, a common power source can be identified and an alternative power source provided as back-up.

3.24 A great deal of detailed information is required in order to carry out any type of quantitative risk assessment. As one recent survey has observed:

> a prerequisite of any worthwhile attempt to quantify the risks is that the analyst must have a detailed knowledge of the the plant to be assessed. This knowledge must include details of the form of the plant, exactly how it is constructed, the temperature and pressure conditions it will operate under, the materials it contains, an understanding of any reactions that will be taking place within the plant, how the plant will be operated, the capability of the people who will operate the plant, the life of the plant, and the inspection and maintenance patterns.[15]

3.25 Much of the relevant information on the design, safety features and operating standards of United States Navy reactors

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14. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 17.7. Chapter 18 ibid. explains in some detail what is meant by the term 'engineering judgment', and shows the ways in which it involves more than unfounded expressions of opinion.
15. J. C. Consultancy Ltd, Risk Assessment for Hazardous Installations, (Pergamon Press for the Commission of the European Communities, Oxford, 1986), p. 68. See also the submission from Dr T. P. Speed, p. 4 (Evidence, p. 627).

is classified as secret. As such, little of it is available to the Australian Government or to the Committee. The United States has declared that it:

> does not make technical information on the design or operation of the nuclear powered warships available to host governments in connection with port entry. The United States Government cannot, therefore, permit the boarding of its nuclear powered warships for the purposes of obtaining technical information concerning their propulsion plants or operating instructions.[16]

Visitors to United States warships during foreign port visits are not allowed into the area containing the nuclear reactor.[17]

3.26 The Department of Defence told the Committee that, while it has a good deal of relevant information, its access to naval nuclear reactor information is limited. The Australian Nuclear Science and Technology Organisation (ANSTO) informed the Committee:

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16. 'Standard Statement' by the United States Government relating to visits by nuclear powered warships to foreign ports, para. 2(e). This statement does not appear ever to have been formally published. The text is set out as Appendix 1 to Department of Defence, The Environmental Impact of Visits by Nuclear Powered Warships to Australia, (July, 1974). A copy obtained in New Zealand using the Official Information Act was also supplied to the Committee through Mr R. Bolt and a copy was appended to the submission of Senator J. Vallentine (Evidence, pp. 1078-79). The statement is undated, but appears to have existed since at least 1967. The Committee was told that the contents of the statement continue to apply: Evidence, p. 184 (Department of Defence). The United Kingdom 'Standard Statement' contains a provision in virtually identical terms to the passage quoted in the text: for the full text of the statement, see 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared for the Committee by the Australian Department of Defence, July 1988), Annex A (Evidence, p. 1300.16). The statement does not appear to have been formally published by the UK Government.
17. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1988 - Hearings, 11 March 1987, p. 891 (Admiral K. R. McKee). The rules permit exceptions so that a head of state or secretary of state equivalent can be shown the whole ship, provided they are not technically inclined: ibid.

> In relation to military reactors, such as those used in warships, ... [ANSTO] relies primarily on published information and on inference from civilian reactor technology, including the few nuclear powered merchant ships built or planned. We have, at best, very limited access to restricted information from the countries operating nuclear warships. ... Where we are able to obtain basic information from ... [these countries] we do not use this information in a direct, and public way. Rather we use this privileged information to ensure that our assumptions based on civil plant are as conservative as we intended them to be.[18]

3.27 During the course of the inquiry it became apparent to the Committee that ANSTO had rather more information than it was able to disclose.[19] Nonetheless it is clear that neither the Committee nor the Australian Government has the data necessary to quantify in a comprehensive way[20] the risk of an accident to the reactor of a United States warship.[21]

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18. Evidence, p. 367 (ANSTO).
19. e.g. see Evidence, p. 1300.52 (Department of Defence):

    > When it first made its assessments of the strength of NPW reactor containments, the AAEC (now ANSTO) possessed significant information on the design of NPWs from confidential sources.

20. Australia, <u>Environmental Considerations of Visits of Nuclear Powered Warships to Australia</u>, (May 1976), para. 35 (Evidence, p. 132) refers to a core meltdown of a naval reactor as having been 'calculated to have a probability of occurrence of less than one in ten thousand per reactor per year'. Insofar as this refers to calculations done in Australia, it refers to calculations done in respect of a pipework failure only: see Evidence, p. 1267 (ANSTO).
21. For the sake of completeness, it should be noted that the Committee was referred to a hybrid type of risk assessment which took as its point of departure the historical record of events that might have developed into accidents but in fact did not: see submissions from Dr T. P. Speed, p. 4 (Evidence, p. 627): Mr R. Bolt, p. 8 (Evidence, p. 958). These 'precursor' events are used to identify accident sequences, which are then subject to something akin to the theoretical assessment involved in probabilistic risk assessment. As Dr Speed told the Committee, to use this technique one would need access to the past operating experiences of naval reactors: ibid., p. 4 (Evidence, p. 627). Because the Committee lacked this data it could not adopt this approach. Therefore it did not pursue the validity of this hybrid approach to risk assessment.

3.28 There appears to be no evidence in the public domain that United States Navy reactors have ever been the subject of sophisticated quantitative risk assessment. The British Government has stated that the probability of a contained reactor meltdown on one of its submarines 'is assessed to be no greater than 1 in 10,000 years'; the probability of an uncontained accident 'is estimated to be no greater than 1 in 1,000,000 years'.[22]

3.29 The Committee has no information on how this assessment or this estimate were made. Therefore, in addition to not being able to conduct its own risk assessment, the Committee is not in a position to review the adequacy of whatever methodology has been used by the vessels' designers or operators to assess naval reactor safety.

Significance of Lack of Quantitative Risk Assessment

3.30 The Committee's inability to have any quantitative risk assessment carried out must be balanced against the criticisms levelled at this type of assessment.[23]

Wider Significance of Lack of Information

3.31 The lack of information which prevents any quantitative risk assessment had implications for the extent to which the Committee could make any worthwhile qualitative risk assessment.

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22. UK, Parliamentary Debates (Commons), 6th series, vol. 112, Written Answers, 20 March 1987, cols. 634-35 (Evidence, p. 1300.19). To put these figures in some sort of perspective, it was calculated for 1979-80 that the risk of at least one major oil spill (more than 120,000 litres) in an Australian port was 1 : 20 per year: Australia, Bureau of Transport Economics, Marine Oil Spill Risk in Australia, (Report No. 53, AGPS, Canberra, 1983), p. 138.
23. e.g. see Evidence, pp. 673-74 (Dr T. P. Speed); pp. 852-55 (Scientists Against Nuclear Arms). See also submissions from Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822); Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 8 (Evidence, p. 794); Prof W. J. Davis, p. 121, (Evidence, p. 568).

For any detailed qualitative assessment to be undertaken would require access to much the same sort of classified information as that required for a quantitative risk assessment. As explained in chapter 5, the historical safety record is not sufficiently extensive to support firm conclusions if taken on its own. Therefore the threshold issue for the Committee was whether, on the basis of the incomplete information available, it could reach useful conclusions on the risk of a reactor accident.

3.32 Some submissions expressed concern that Australian authorities (and by implication, the Committee) did not have access to necessary technical information on naval reactors, thereby making impossible any independent Australian evaluation of the risks involved in nuclear powered warship visits.[24] It was suggested that experiences with items other than naval reactors indicate that official United States risk estimates are not necessarily reliable.[25]

3.33 Two analogies are relevant in considering the significance of the overall lack of information publicly available to Australian authorities and to the Committee. One is with land-based civil reactors. The other is with nuclear powered merchant ships.

3.34 A visiting nuclear powered warship places a relatively small nuclear reactor in an Australian port. If a large nuclear power plant were to be built in Australia for electricity generation it seems clear from recent overseas experience that its owner and operator would carry out some form of sophisticated quantitative risk assessment as part of the process of designing and locating the plant. Again relying on overseas experience in

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24. e.g. submissions from Scientists Against Nuclear Arms (ACT), p. 1 (Evidence, p. 779); Medical Association for the Prevention of War Australia (NSW), p. 1; Prof W. J. Davis, p. 85 (Evidence, p. 532); Milton-Ulladulla People for Peace, p. 3.
25. e.g. submissions from Scientists Against Nuclear Arms (ACT), p. 1 (Evidence, p. 779); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822).

countries comparable to Australia, it seems clear that local regulatory authorities would insist on verifying the validity of the assessment technique and the rigour with which it was applied.[26] Access to the relevant data would have to be provided to the regulators.[27]

3.35 This contrasts with the information available to Australian authorities on the nuclear plant aboard a visiting warship.

3.36 A second analogy that can be made is with nuclear powered merchant ships. Such ships have never visited Australia. In the 1960's and 1970's, the United States,[28] the Federal Republic of Germany[29] and Japan,[30] each developed a civilian-operated nuclear powered merchant ship. These ships, and proposals for other similar ships, led the international maritime and nuclear safety communities to agree on some standards relating to port visits by nuclear powered merchant ships. The need to rely upon these standards has been minimal, primarily because nuclear powered merchant ships are not now regarded as

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26. For example, in the United States the information required by 42 USC 2232(a), and regulations made pursuant to that provision, would have to be supplied to the Nuclear Regulatory Commission.
27. cf. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 47.10: the need to observe commercial confidentiality imposed only minimal restraints on the information available to his inquiry into the proposed construction of a civil nuclear power station.
28. The NS Savannah reactor was first 'taken critical' in December 1961 and the ship operated as a commercial cargo ship between 1965 and 1970: J. G. Collier, 'Light Water Reactors' in W. Marshall (ed.), Nuclear Power Technology, (Clarendon, Oxford, 1983), vol. 1, pp. 222-23.
29. The NS Otto Hahn entered service in 1968 and was decommissioned in the late 1970's. During this period only about 30 ports were prepared to admit the ship, due to environmental concerns: 'End of the road for nuclear ships', New Scientist, 28 February 1980, vol. 85, p. 639.
30. The NS Mutsu was ready for sea trials in 1972 but these were delayed for two years by a blockade by local fishermen. The ship experienced problems on its first trial and has never operated in commercial service: 'Japan's vessel still adrift', Nature, 16 August 1984, vol. 330, p. 531.

economically viable. Hence the extent to which many countries would in practice accept the standards remains largely unknown.

3.37 The standards highlight differences between nuclear powered warships and merchant ships. The latter would be built to and operated under internationally agreed standards.[31] For merchant ships, a safety assessment, not necessarily quantitative, would be required and host-port authorities would be entitled to inspect the safety assessment[32] and the operating logs relating to the nuclear power plant, radioactive waste disposal and safety tests.[33] In addition port authorities would be entitled to inspect the reactor and to conduct independent monitoring on board the vessel.[34] In the 1960's the United States

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31. The main instruments are: the International Convention for the Safety of Life at Sea, London, 17 June 1960, (United Nations Treaty Series, 1965, vol. 536, p. 27) Chapter VIII: the similarly titled 1974 successor to this Convention, the text of which forms Schedule 1 to the Navigation Act 1912, and Chapter VIII of which deals with nuclear ships; the International Maritime Organization, Code of Safety for Nuclear Merchant Ships, (IMO, A XII/Res.491, 18 June 1982); and the Inter-Governmental Maritime Consultative Organization and International Atomic Energy Agency, Safety Recommendations on the Use of Ports by Nuclear Merchant Ships, (IMCO, London, 1980).
32. International Convention for the Safety of Life at Sea, 1974, Chapter VIII, reg. 7, part (b) of which provides: 'The Safety Assessment shall be made available sufficiently in advance to the Contracting Governments of the countries which a nuclear ship intends to visit so that they may evaluate the safety of the ship'. The format or methodology of the safety assessment is not defined in the Convention.
33. Inter-Governmental Maritime Consultative Organization and International Atomic Agency, Safety Recommendations on the Use of Ports by Nuclear Merchant Ships, para. 5.2.
34. ibid.

accepted similar standards in respect of the merchant ship NS Savannah.[35]

3.38 Australian authorities have far less information on visiting nuclear powered warships. In considering this comparison, it is important to stress that Australia's ability to obtain information relating to the construction, operation etc. of a visiting conventionally powered warship is much less than with a conventionally powered merchant ship.[36]

3.39 In the absence of access to classified information the Committee of necessity had to rely on five other sources:

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35. The United States entered into a series of bilateral treaties on port entry requirements for the NS Savannah. See for example the Agreement between the United States of America and the United Kingdom Relating to the Use of United Kingdom Ports and Territorial Waters by the NS Savannah, London, 19 June 1964 (United Nations Treaty Series, 1965, vol. 530, p. 99) Annex 1, article 2 (US shall provide 'detailed technical information concerning her design, construction, operation and the safeguards incorporated into the ship's nuclear plant and an analysis of hypothetical accidents'), article 7 (UK authorities to 'have reasonable access to N. S. Savannah for the purpose of inspecting and monitoring her and her records and programme data while she is within the territorial waters of United Kingdom territory and determining whether she is in a safe condition and is being operated in accordance with the Ships's Operating Manual'), and article 11(b) (UK authorities 'shall have the right to undertake such radiological monitoring in N. S. Savannah as they may consider necessary during her stay in any port in United Kingdom territory' - emphasis added). Other articles of the Annex set out further conditions.

36. e.g. much of the International Convention for the Safety of Life at Sea, 1974 does not apply to warships. In 1979 the US State Department responded to a request from the Egyptian Embassy for information on the international agreements relating to nuclear powered ships by stating in part (Digest of United States Practice in International Law, 1979, p. 1084):

> In recognition of the sovereign nature of warships, the United States permits their entry into U. S. ports without special agreements or safety assessments. Entry of such ships is predicated on the same basis as U. S. nuclear-powered warships' entry into foreign ports, namely, the provision of safety assurances on the operation of the ships, assumption of absolute liability for a nuclear accident resulting from the operation of the warship's reactor, and a demonstrated record of safe operation of the ships involved ... .

- information relating to nuclear power plants used to generate electricity for civil purposes. A vast body of literature is available on all aspects of civilian reactors, including actual and potential accidents, and contingency planning. The main issue for the Committee was the extent to which this information is relevant to warship reactors.

- information relating to actual or proposed civilian-operated nuclear powered merchant ships. The planning for these ships led not only to a body of technical literature and some internationally agreed standards but also to assessments of the need for, and production of, accident contingency plans.[37] A similar issue of relevance arose.

- publicly available information on the design, operation and safety record of nuclear powered warships. More information is available than is generally realised. One critic stated to the Committee his belief that it is sufficient to enable informed judgements to be made about the nature of naval reactors.[38] This information, apart from its direct

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37. See for example J. C. Chicken and M. A. King, 'Port Entry Arrangements' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), pp. 423-26: port of Southampton (UK) safety scheme for visits of nuclear powered merchant ships is based on experience gained from visits by these types of ships and from 'the numerous visits of various nuclear powered warships to ports in the United Kingdom' (p. 423).

38. Submission from Prof W. J. Davis, p. 54 (Evidence, p. 501). In 1983, the US Navy stated that officials involved in its Nuclear Propulsion Program 'have testified before congressional committees in open session over 100 times, amassing more than 5,000 pages of testimony on the procurment, design, and operation of naval nuclear powered ships': US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, p. 194 (Appendix D, 'Navy Response to Article Entitled "The Nuclear Navy"', 20 July 1983), (Evidence, p. 1300.59).

usefulness, assists in assessing the degree to which naval reactors are the same as civilian ones, and therefore the extent to which data on the latter are relevant to the risks arising from naval reactors.

- publicly available information on contingency planning in the United States and the United Kingdom. The scope of this material is discussed in chapter 6.

- assurances from those who have had access to all the relevant information. In effect, this means agencies and officials of the United States and United Kingdom Governments. These assurances can be supplemented by information both publicly available and informally obtained by Australian officers from colleagues overseas.[39]

Information Available to the Committee - Conclusions

3.40 The Committee acknowledges that its having to rely on these sources was considerably less than ideal. However in combination with the information available on the historical record of reactor safety the Committee considered that these sources provided a basis sufficient to enable worthwhile conclusions to be drawn.

Difficulties in Assessing Accident Consequences

3.41 It was noted at the beginning of this chapter that the calculation of a risk involves assessing the probability that accidents will occur and also the consequences of those accidents. The Committee faced problems of a different order in assessing consequences.

3.42 There is an abundance of publicly available information

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39. e.g. Evidence, pp. 193, 199, 201 (Department of Defence).

on the dispersion of radioactive material from reactor accidents and the effects of the dispersed material on people and the environment. There is considerable expertise on these matters available to the Australian Government which the Committee was able to draw on.

3.43 The difficulty for the Committee was that there is clearly much scientific uncertainty over what would be dispersed from a given reactor accident, how far it would be dispersed, and what its effects, especially in low doses, would be. This difficulty is not novel. In some respects it has confronted nuclear regulatory authorities since scientists first became aware of the risk posed by ionising radiation. The Committee's response mirrored that of regulatory authorities: where significant scientific doubt exists, safety-oriented assumptions should be made. The specific ways in which this has been done are indicated in later parts of this report.

Onus of Proof

3.44 The Committee did not regard it as appropriate to import the formal legal notion of the onus (or burden) of proof into its inquiry. However, the lack of critical information relating to accident likelihood and the scientific uncertainty relating to aspects of accident consequences limited the ability of both planners and objectors to present conclusive arguments on many key points. In this situation it becomes significant whether the planners are required to demonstrate that their plans are adequate, or if objectors are required to show that the plans are inadequate.

3.45 The Committee considered that it would be unreasonable to place the burden of making out their case onto the objectors.[40] Relative to the resources available to government, objectors are poorly equipped to locate and analyse even the

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40. See the submission from Mr P. Gilding, p. 3 (Evidence, p. 1336).

information that is publicly available. The Committee took the view that it was more appropriate to place the burden on the planners of proving that their plans were adequate.[41] The Committee was conscious that it was necessary to give effect to this view in a reasonable way. The planners were being asked in some respects to demonstrate a negative - that particular accident scenarios would not eventuate.[42] The Committee took into account the difficulties of doing this.

41. cf. UK, Department of Energy, Sizewell B Public Inquiry: Report by Sir Frank Layfield, (HMSO, London, 1987), para. 47.3(g): the onus of proof was on the electricity authority to show that Sizewell B nuclear power station would be safe rather than on objectors to show the contrary.

42. cf. Evidence, p. 858 (Senator McMullan).