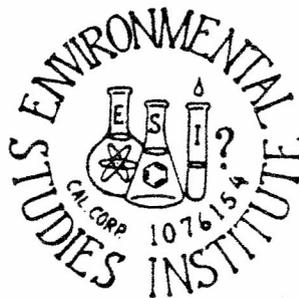


NUCLEAR ACCIDENT ABOARD A MILITARY VESSEL BERTHED IN JAPANESE PORTS

**Quantitative Analysis of Hypothetical
Accident Scenarios
for Yokosuka, Sasebo and Kure**

by

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ABSTRACT

This study uses the established methodology of the United States Nuclear Regulatory Commission to calculate quantitatively the impacts of hypothetical severe nuclear accidents aboard warships berthed in Yokosuka, Sasebo, and Kure, Japan. The consequence of such accidents would include dispersion of radioactive materials over densely populated urban areas, with casualties up to tens of thousands of persons, as well as enormous and widespread property damage. Under the least favorable accident conditions, immediate evacuation of the affected area would be required pending decontamination. Local and regional economies would come to a standstill until decontamination were complete, with attendant impacts on the national economy. Cleanup—if indeed feasible—could take as long as several months and cost up to an estimated one hundred and fifty billion U.S. dollars. Visits of U.S. warships to Japan are governed by "The U.S. General Statement of Assurances" (Appendix I). This document does not specify the liability for decontamination and compensation in the event of such accidents. The present study furnishes the scientific and technical basis for several policy recommendations, including reconsideration of the cost/benefit ratio of accepting port visits by nuclear warships, in light of the present analysis of possible nuclear accidents. If such visits continue, several additional recommendations follow. These include the performance of detailed environmental impact analyses that include prospective nuclear accidents; development and rehearsal of emergency evacuation plans for the impact zones; development of decontamination plans; economic impact analyses of prospective nuclear accidents; and establishment of liability and compensation regimes.

EXECUTIVE SUMMARY

This paper describes a quantitative, site-specific analysis of several hypothetical nuclear accident scenarios aboard military vessels berthed at three ports in Japan, namely, Yokosuka, Sasebo and Kure. Scenarios include both a nuclear weapon accident and a naval propulsion nuclear reactor accident for Yokosuka and Sasebo, and a nuclear weapon accident for Kure.

The nuclear weapon accident scenario analyzed is incineration of a single nuclear warhead containing 5 kg of plutonium-239 in a three-hour shipboard fire. The reactor accident analyzed is a meltdown and breach of containment accident that releases a small fraction of the radioactive core to the environment over a period of four hours.

The consequences of both of these hypothetical accidents are estimated utilizing conventional methodology promulgated by the United States Nuclear Regulatory Commission (NRC) for regulating the U.S. civilian commercial nuclear industry. Bracketing assumptions—i.e., assumptions that lead to accident consequences that are likely to encompass those of a real accident—are combined with conservative assumptions to assess the impact of the accident on the environment, human health and (briefly) the economy of the affected regions of Japan.

Yokosuka: Nuclear Weapon Accident

A nuclear weapon accident aboard a naval vessel anchored in Yosuka would produce a radioactive cloud containing particulate and aerosolized plutonium-239. The most probable summer wind direction would carry the radioactive cloud north and east, directly over Tokyo (Figure 2). The lateral boundaries of the plume were calculated for the bracketing conditions of the most stable and the least stable atmosphere, producing the narrowest and the widest radioactive plume, respectively. The narrowest plume would pass through the heart of downtown Tokyo, leaving a swath of radioactivity approximately 2 km wide. The widest plume would encompass most of the urbanized region of Tokyo in a radioactive path approximately 10 km in width (Figure 3).

The total impact zone for significant radioactive contamination and casualties is more than 100 km in diameter (Figure 4), encompassing such major cities as Yokohama, Tokyo, Funabashi, Chiba, Kawaguchi, Kawasaki, Fujisawa, Hachioji, Omiya, Tsuchiura, Kawagoe and Hiratsuka.

The air concentration of plutonium-239 in the plume was calculated for the two extremes of atmospheric stability, namely unstable (Pasquill category A) and stable (Pasquill category F). Calculations were likewise carried out for two extremes of thermal loft, namely, no thermal loft of the radioactive cloud created by the ship fire, and 100 meters of thermal loft. These calculations show that, under the least favorable conditions, the air concentration of plutonium in the plume would exceed existing U.S. federal limits by up to ten thousand times near the scene of the accident, and between ten and one hundred times the U.S. limits throughout Tokyo. Air concentration of plutonium would remain elevated above U.S. limits up to 100 km from the site of the accident (Figure 7).

As the radioactive cloud generated by this hypothetical accident is transported downwind, plutonium contained within it would deposit on all exposed surfaces, in the form of fallout. Plutonium would also be drawn into all skyscrapers, office buildings, schools, hospitals and other buildings with forced ventilation systems. The calculated deposition on external surfaces would exceed U.S. federal limits by as much as one million times near the accident site, and by an average of one thousand times throughout Tokyo, for the least favorable conditions (Figure 8). Under the least favorable accident conditions, plutonium ground contamination would exceed U.S. federal limits to a distance of more than 110 km (the greatest distance for which calculations have been carried out here).

The concentration of individual radionuclides (such as iodine-131) would in some cases exceed U.S. limits throughout the city of Tokyo (Figure 14). Surface deposition of single radionuclides would, under the least favorable conditions, exceed U.S. federal limits by several hundred times (cesium-137; Figure 15) and ten thousand times (iodine-131; Figure 16) throughout Tokyo and out to more than 110 km from the accident site.

Radiation exposure to persons in the path of the cloud would take the form of cloudshine, inhalation and groundshine. Exposure via any of these pathways would exceed U.S. federal exposure limits (Figures 17-22), and total exposure for each affected individual would exceed U.S. limits throughout Tokyo and to approximately 100 km from the accident site (Figure 23). Short-term casualties from such an accident, in the form of latent cancer fatalities incurred, would occur as far as 110 km and would number as high as 24,971 (Figure 25), with an equal number of additional casualties from severe genetic damage.

Medium- and long-term exposure from fallout (groundshine) would cause up to additional 25,565 fatalities for the first week (Figure 27), and up to an additional 26,994 casualties in the following year (Figure 29), with equal numbers of casualties from severe genetic damage. Casualties from latent cancer fatalities alone assuming no evacuation for one year would therefore equal 77,530, with an equal number of casualties from severe genetic damage. These findings underscore the necessity of immediate evacuation and decontamination before the affected zone could be reinhabited.

Such an accident would cause enormous property damage, in the form of radioactive contamination. The economic impacts would be similar to a nuclear weapon accident, requiring tens of billions of U.S. dollars and an undetermined amount of time to clean up. As in the case of a nuclear weapon accident, the legal liability to compensate such damages is not specified and would be subject to negotiation between the U.S. and the host country through diplomatic channels.

The probability of such a naval propulsion nuclear reactor accident is unknown, but may be similar to the probability of a severe accident in the commercial industry. In this case, accepting port visits by nuclear powered warships at Yokosuka entails a risk on the same order of magnitude as that of constructing a nuclear power reactor in the middle of Tokyo.

Sasebo: Nuclear Weapon Accident

A nuclear weapon accident aboard a naval vessel berthed in Sasebo would have effects similar to those described above for Yokosuka/Tokyo. Air concentrations of plutonium and resultant fallout would be similar to Yokosuka, although the exact pattern of dispersion and distribution would be expected to vary with different meteorological and microgeographic climatic variations in Sasebo.

Casualties would be expected to be less owing to the smaller population density in comparison with Tokyo. Casualties would nonetheless be significant—calculated at up to 2,033 for the least favorable conditions (Figure 36). Evacuation and decontamination of cities in the 110 km major impact zone would be required, and economic losses would be proportionate to those summarized above for Yokosuka/Tokyo.

Sasebo: Naval Propulsion Nuclear Reactor Accident

A severe propulsion nuclear reactor accident at Sasebo would be expected to have similar environmental and medical consequences to those summarized above for Yokosuka/Tokyo, although the absolute damage would be smaller owing to the lesser concentrations of persons and property. Calculated casualties under the least favorable conditions are: short-term, 2,705 (Figure 38); medium-term from one week of groundshine alone, 2,172 (Figure 40); and long-

term from an additional year of groundshine, 3,036 (Figure 42). In each case an equal number of casualties from severe genetic damage would be anticipated. Evacuation and decontamination would therefore be required in Sasebo and the surrounding affected area, with proportionate economic impacts.

Kure: Nuclear Weapon Accident

A nuclear weapon accident aboard a naval vessel anchored at Kure would have effects similar to those described above for Yokosuka/Tokyo, although the absolute magnitude of the damage would again be smaller owing to the lesser concentration of persons and property. Casualties under the least favorable conditions are calculated at 1,363 (Figure 48). Evacuation and decontamination would again be essential, with corresponding economic impact.

General Recommendations Based on This Study

The results of this study suggest a need to re-evaluate the cost/benefit ratio of accepting port visits by nuclear capable and nuclear powered warships. Possible risks associated with these visits include those of low-probability but extraordinarily high-consequence nuclear accidents. The people and government of Japan need to consider carefully whether the benefits of accepting visits by nuclear warships outweigh the prospective costs to human health and the Japanese economy of a nuclear accident. In the event such visits are contemplated for the future, prospective costs can be more clearly appreciated, assessed and limited through the following actions:

- **RECOMMENDATION # 1:** *The environmental impacts of possible nuclear accidents consequent to berthing nuclear capable vessels in Japan should be analyzed in detail. Included in such analyses should be the impacts of such accidents on the terrestrial and aquatic environments, and on the water supply to urban populations.*

- **RECOMMENDATION # 2:** *The full resources of the host cities and the Japanese National Government should be brought to bear in producing an exhaustive analysis of nuclear accident scenarios and their medical consequences before further consideration of berthing nuclear capable or nuclear powered vessels in Japanese ports.*

- **RECOMMENDATION # 3:** *The host cities, together with Japanese National Agencies that are responsible, should determine whether an effective emergency evacuation plan can be developed for the affected cities in the event of a severe nuclear accident aboard a naval vessel berthed in a Japanese port.*

- **RECOMMENDATION # 4:** *Any such emergency evacuation plan should be rehearsed periodically to demonstrate and develop its effectiveness.*

- **RECOMMENDATION # 5:** *City and National Government officials and agencies should work with the visiting military to develop a realistic decontamination plan. Included in such plan should be assignment of responsibilities, cost and duration, and answers to questions of legal liability and indemnity.*

- **RECOMMENDATION # 6:** *Economic analyses of the possible impacts of nuclear accidents in Japan should be undertaken in connection with prospective visits by nuclear-capable and nuclear powered warships. Linkages with the national and international economy should be taken into account in this analysis.*

- **RECOMMENDATION # 7:** *City and National Government authorities should insist on obtaining from the military sufficient data to assess accurately the probability of nuclear accidents like the ones modeled here. Such accidents should be taken into account in arriving at an informed policy regarding berthing of nuclear capable and nuclear powered vessels in densely populated urban centers such as Yokosuka/Tokyo, Sasebo and Kure.*