

**NATO HANDBOOK ON THE MEDICAL ASPECTS
OF NBC DEFENSIVE OPERATIONS
AMedP-6(B)**

PART I - NUCLEAR

ANNEX B

HAZARDS OF NUCLEAR WEAPONS ACCIDENTS

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ANNEX B

HAZARDS OF NUCLEAR WEAPONS ACCIDENTS

SECTION I - GENERAL

B.01. Introduction.

Nuclear weapons accidents can be a peacetime and wartime problem, and all elements of a military medical service should be prepared to provide the medical support required if they occur. To accomplish this most effectively, all medical facilities should have specific procedural guides readily available, so that even personnel who have not been specifically trained in the hazards of nuclear weapons can perform necessary actions effectively and safely with minimal supervision. To help accomplish these objectives, detailed information is included in the several sections of Annexes B and C. The sections of this Annex include general information concerning accidents and their hazards. The three sections in Annex C include information specifically organized to facilitate the development of procedural guidelines for the various departments and services of a medical facility. In wartime, the rigorous peacetime responses to accidents may not be fully implemented.

B.02. Accidental Detonations.

- a. *High Explosive Detonations.* All nuclear weapons contain high explosive material. In any accident, there is a risk of either explosion of this material or fire. Either may occur immediately at the time of the accident or later if a weapon is severely damaged and fragments of high explosive and nuclear material are scattered. All personnel at an accident site must be aware of these hazards and conduct all operations and duties under the direction of experienced ordinance disposal personnel.
- b. *Nuclear Detonations.* This is not considered to be a credible event.

B.03. Types of Radiation.

- a. The principle fissionable materials in nuclear weapons (^{235}U and ^{239}Pu) are basically alpha particle emitters. However, there are several weak (up to 185 KeV) x and gamma ray emissions associated with alpha particle decay. The radiation intensity of x and gamma radiations at an accident site is generally low.
- b. The weak x and gamma radiations from unfissioned bomb material are not very penetrating. The intensity is reduced by approximately one half by 5 mm of tissue or water. The principal hazard is from airborne alpha particle emitters.

B.04. Early Rescue and Evacuation of the Injured to Medical Facilities.

- a. The victims of such accidents may have serious injuries, frequently multiple, requiring early, skilled treatment. These will include burns, fractures, head injuries, etc., typical of those sustained in serious accidents of all types.
- b. Significant radiation injury will not be present. Contamination of the injured with varying amounts of radioactive material may be present, but this contamination should not be a serious, immediate hazard to either the injured or to personnel caring for them.
- c. The number of accident victims may vary from very few to a large number depending on the circumstances of the accident. Immediate medical care should be obtained from the closest medical facility, either military or civilian.

SECTION II - GENERAL HAZARDS

B.05. Explosive and Fire Hazards.

- a. As noted above, there is a significant risk of high explosive detonations and/or fire at a nuclear weapons accident site. This is increased in vehicular or aircraft accidents where oil or gasoline is present; and, as a result, burns would be a frequent and serious problem among the casualties of a nuclear weapons accident.
- b. If there is a fire, the smoke will contain a large variety of burned material from the weapons, the transport vehicle, and the environment. Some of these materials can be dangerous if inhaled. The particle sizes in the smoke from a fire will be important; a percentage of particles smaller than about 10 microns, if inhaled, may penetrate deeply into the respiratory system where the probability of retention is high. This can result in significant damage to the lungs. The respiratory hazard is discussed more fully in Section III.

B.06. Contamination of the Injured with Hazardous Material.

Contamination of injured personnel may be due to either radioactive or toxic materials. In general, the hazard to both the patient and attending medical personnel will be so negligible that

NECESSARY MEDICAL OR SURGICAL TREATMENT MUST NOT BE DELAYED BECAUSE OF POSSIBLE CONTAMINATION.

Decontamination should be done as soon as possible during the care of such patients, and ideally, prior to admission to a hospital. However, this will not always be possible, and decontamination procedures should be part of the operational plans and guides of all divisions and departments of medical facilities, not just of emergency room or teams. This insures flexibility of response and action and will prevent delay in needed medical treatment. The simple removal of outer clothing and shoes will, in most instances, affect a 90-95% reduction in the patient's contamination.

B.07. Contamination of Hospital Facilities, Equipment, and Personnel.

- a. Since the treatment of injured, contaminated personnel may result in the contamination of almost any part of a medical facility, a large number of the medical personnel procedures must be able to set up to accomplish the following:
 - (1) Minimize the degree of contamination.
 - (2) Identify and measure the extent of contamination.
 - (3) Remove the contamination.
- b. The removal of contamination is a two-part problem and includes decontamination of personnel as well as decontamination of equipment and facilities. The former must be started as soon as possible, even if monitoring facilities are not available. Standardized procedures of decontaminating personnel must be established and instituted. Personnel must not be released before they have been monitored and decontaminated completely. The monitoring capability would be obtained from the technical teams working at the accident site. This requires coordination and communication with the authorities responsible for overall management of the nuclear accident.

B.08. Contamination of Geographical Area Around Accident with Potential Hazard to Local Population.

Medical personnel may be called upon to give advice as to the nature and degree of public hazard associated with a given type and level of contamination. This hazard will rarely be an acute one but may well be a significant long term one. The advice given will be an essential factor in determining what methods are used to minimize and remove the hazard.

- a. The most probable hazard will occur downwind from an accident site due to airborne particles of radioactive material which could be inhaled. Early after an accident, adequate information may not be available to determine the exact degree of the hazard from airborne contamination. As a result, a decision to evacuate an area close to an accident location may have to be made by local authorities without waiting for radiation measurements. No precise guidance can be given for these types of situations.
- b. A much less frequent hazard would be contamination of water supplies if an accident occurred near a river source or reservoir. Dilution and settling of insoluble materials would further reduce this small hazard, and simple monitoring measures by trained personnel could be obtained before condemning the water supply. Water from other locations can be used temporarily until adequate measurements are made to determine whether there has been contamination or not. However, drinking water contaminated by plutonium is an insignificant hazard.

B.09. Decontamination Operations.

Exposure level criteria used in accident related operations are basically the same as peacetime industrial exposure limits, as defined by the laws of the country in which the accident occurs or by international agreement (wartime exposure limits may be higher). Emergency

exposures exceeding specified limits must be restricted as much as possible to those truly critical operations such as rescue of the injured. Once the emergency phase of a nuclear accident is over, decontamination must be carried out under strictly controlled medical supervision. This is a separate operation from care of the injured and requires the presence of specially trained physicians and health physicists.

SECTION III - INTERNAL HAZARDS

B.10. General.

- a. At the typical accident site, there will be no significant external radiation hazard. A significant internal hazard can be present both early and late. The inhalation hazard is more serious immediately after an accident and during a fire, or following an explosion of conventional explosives when the plume may contain a percentage of respirable particles.
- b. These particles settle to the ground but can be resuspended. They are diluted by dispersion. They may be inhaled if they are resuspended as dusts into the atmosphere by winds or movement of people and vehicles. The concentration of particles per unit volume of air under these circumstances will be much less than that in the smoke of the burning weapon, and the particle size distribution will be different.
- c. The actual substances which may be inhaled include a wide variety of both radioactive and nonradioactive materials.

B.11. Radioactive Materials.

- a. *Plutonium.* Plutonium (Pu) is a heavy metal (atomic number 94), which is artificially produced in reactions by bombardment of uranium 238 with neutrons. Most Pu so produced is ²³⁹Pu. However, relatively small quantities of other isotopes are also produced, and ²⁴¹Pu, ²⁴²Pu, and ²⁴⁴Pu will be present in small quantities in the plutonium used in weapons.

- (1) If plutonium particles are inhaled, they will be deposited at all levels of the respiratory system, depending on their size. The larger particles are deposited in the nasopharynx or high in the tracheobronchial tree. Only the very small particles, 10 microns in diameter or smaller, are deposited in the alveolar air sacs. The plutonium deposited in the terminal bronchioles above the alveolar air sacs will be cleared from the lungs by the action of the ciliated epitheliums making up the respiratory mucosa. These particles do not present any significant hazard. The possibility of any significant radiation damage while they are in transit out of the lungs or subsequently during their passage through the gastrointestinal system is almost nonexistent. Any cells which are damaged by radiation would be sloughed off and replaced during the normally high rate of cell turnover which occurs in these tissues.

- (2) The plutonium remaining in the alveoli can cause damage, since much of it will remain there essentially for the lifetime of the individual. The rate of

removal of plutonium deposited in the air sacs is difficult to estimate, but animal experimentation has indicated that it would take at least several years for significant amounts to be removed. Some of the plutonium particles are phagocytized and picked up by the lymphatic system, but they will not be transported far since a large proportion will be trapped in regional lymph nodes of the lung. Only very negligible quantities will reach the blood stream.

- (3) Radiation from plutonium and its daughter products trapped in the lung tissue can cause an inflammatory response and eventual fibrosis. The degree of fibrotic scarring will depend upon the amount of plutonium deposited and time. The overall reserve capacity of the lungs is so great, however, that this would only rarely become a serious problem. Carcinogenesis must also be considered the main hazard, but it is of small relevance in war. Most cells damaged by alpha radiation will be lethally damaged. A very small percentage will be non-lethally damaged. However, there is some x-ray and gamma radiation associated with plutonium and its impurities. The hazard of this radiation to an organ like the lungs is difficult to assess, but it is penetrating and must also be considered as a potential producer of both fibrosis and cancer. This x-ray or gamma radiation has a very low energy level (17 KeV and 60 KeV respectively) and is difficult to detect at low concentrations with standard x-ray sensitive instruments. Special probes are available as accessories to some alpha sensitive detection instruments and are of value in monitoring contamination by plutonium.

b. *Uranium.* Uranium (U) is also a heavy metal (atomic number 92) and an alpha emitter. On a gram for gram basis, the typical uranium alloy has only about 1/500 the radioactivity of an equivalent amount of ²³⁹Pu. Therefore, the radiation hazard associated with uranium is much less than that associated with plutonium. Otherwise, the same factors governing deposition and retention in the pulmonary system apply to uranium. Uranium metal can cause chemical toxicity (heavy metal toxicity) at exposures of 0.1 mg/kg body weight. This is seen as damage to the cells of the lower portion of the proximal convoluted tubules of the kidney. There is usually a lag period of 6 hours to several days followed by chemical necrosis. Even after levels which cause necrosis, the kidneys show evidence of regeneration within 2 to 3 days, depending on the severity of the initial exposure. Both ethylenediaminetetraacetic acid (EDTA) and DTPA have been used to increase excretion in experimental animals.

c. *Tritium.*

- (1) Tritium is an isotope of hydrogen. There are two other isotopes, protium or normal hydrogen (¹H) which has one proton in its nucleus and no neutrons, and deuterium (²H) which has one neutron in its nucleus in addition to the proton. Deuterium is not radioactive and occurs in small quantities naturally. Tritium (³T) is radioactive, emitting a low energy beta particle. It is extremely rare in nature and must be made artificially in reactors to meet the requirements for its scientific, industrial, and military uses. Tritium has a physical half life of 12.26 years. It can be readily absorbed into the body and

becomes diffusely distributed throughout the body water. It may be inhaled, ingested, or absorbed transcutaneously. If a large amount is incorporated into the body accidentally, there is a serious risk of whole body beta irradiation and acute radiation sickness as described in Chapter 6 in this handbook.

(2) If patients are seen with suspected tritium contamination, the best treatment is to shorten the turnover time of the body water with forced fluid intake and diuretics. This essentially "flushes out" the tritium and can materially reduce the exposure time and the total dose of radiation received. Fortunately, tritium would not be a hazard in the usual accident situation because it dissipates so rapidly. Generally, it will not accumulate in an outside area, although tritium contamination of metal or other surfaces can be persistent. It would be a hazard if an accident occurred in an enclosed space so that dispersion could not occur.

d. *Magnesium-thorium alloys.* Magnesium-thorium alloys should also be considered as radioactive hazards since radioactive thorium is an alpha emitter. Many aircraft and missile structures contain significant amounts of magnesium-thorium (up to 4% of thorium), therefore, in an accident the radioactive thorium must be recovered and disposed as radioactive waste.

B.12. Non-Radioactive Materials.

In any modern weapon system, a fire involving the various components of airplanes, missiles, etc., will release a large variety of non-radioactive toxic materials into the atmosphere. Among these, beryllium is the most important because of the severity of the clinical effects which may be associated with any exposure to this quite hazardous material. This material is far more important than any others and is discussed first.

a. *Beryllium.* Beryllium is a light, gray-white metal. It is not radioactive. However, it is one of the most toxic metals known. If beryllium in any form is inhaled, a particularly severe pneumonitis (berylliosis) may follow. The resulting pulmonary disability is progressive and frequently fatal, either within a few months or after a period of several years. There is no specific treatment. In addition, beryllium can be a hazard if it contaminates wounds. Such contamination results in a severe local inflammatory response and the development of persistent granulomatous lesions, requiring surgical excision. Since beryllium is not radioactive, its presence at an accident site cannot be detected readily with radiac instrumentation. It should be suspected if accident victims have any symptoms or signs of pneumonitis.

b. *Lithium and Plastics.* Lithium, the lightest of all metals, is used extensively in the field of nuclear technology, often in the form of a hydride. If lithium hydride is exposed to water and carbon in the presence of a fire, a chemical reaction occurs which produces acetylene gas. This in turn increases the intensity of the fire. Also, a wide variety of plastics are used in modern military weapon systems. Many of these, if burned, produce toxic fumes.