EMERGENCY PREPAREDNESS AND RESPONSE IN CASE OF A HYPOTHETICAL ACCIDENT WITH NUCLEAR POWERED VESSEL TRAVERSING SUEZ CANAL

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ABSTRACT:
Egypt has unique problem the, Suez Canal, there is a major problem concerning the passage of the nuclear powered and possibly nuclear armed vessels and submarines through the canal several times each year escorted by Egyptian vessels. The passages of these vessels and submarines have been subject to a political agreement with the government of Egypt and their passage is not under the regulatory control of the Egyptian regulatory body.

In spite of all safety precautions that are taken, in the nuclear powered vessels and submarines from the point of view of the rugged design of the reactor plant, multiple safety systems, fully trained and capable crew and operation with exceptional consideration for safety, also their sophisticated safety systems are designed to protect not only the ship and its personnel but also the public and environment. Nevertheless a potential for a serious accident may does arise, even though its probability is minimal. These accidents could also involve incineration of a single nuclear warhead in a ship- board fire.

The Government of Egypt has established a national radiological emergency plan inorder to deal with any radiological accidents which may arise inside the country.

Suez Canal passes through a zone of considerable business, agriculture and industrial activities. According to Suez Canal authority regulations, it is not allowed for the nuclear powered vessels to be landed in port.

The motivation of the present paper was undertaken to discuss a hypothetical fire accident scenario occurred in a single nuclear warhead on board of a nuclear powered vessel during its passage along the Suez Canal close to Port Said City. Such an accident would produce a radioactive cloud containing plutonium-239.

In this type of accidents contamination and causality zones could extend to several kilometers from the accident site.

The accident scenario and emergency response actions taken during the different phases of the accident are going to be presented and discussed.

The paper is going to highlight on the importance of public awareness for populations located in densely populated areas along the Suez Canal Bank.

INTRODUCTION
Nuclear power is particularly suitable for vessels which need to be at sea for long periods without refueling or, for powerful submarine propulsion. Over than 150 ships are powered by more than 220 small nuclear reactors and more than 12.000 reactor

years of marine operation has been accumulated. Nuclear Powered Warships (NPWs) have been safely operated for more than 50 years without experiencing any release of radioactivity that hurt human health or has an adverse effect on marine life. Naval reactors commonly used have been pressurized water types. They have long core lives recently, so that; refueling is needed only after 10 years in carriers and after 30-40 years in submarines [1].

SCOPE OF THE PROBLEM

There are number of nuclear powered vessels and submarines having different nationalities traversing Suez Canal each year escorted by Egyptian vessels. The passage of these vessels is governed by some political aspects and is not under the control of the Egyptian regulatory body. These vessels and submarines are equipped with a number of nuclear weapons. In these vessels incineration of a single nuclear warhead or more in a ship board fire could occur. Such accident might occur in areas where, weapons are assembled and stored.

The scope of this paper assumes the occurrence of a hypothetical radiological accident aboard a military nuclear vessel passage during its traverse close to (Port Said City), one to of the densely populated cities located along the west bank of the Suez Canal.

In the frame of the accident scenario, as well as, the national radiological emergency planning in Egypt [2]; the accident scenario, health hazards as well as, the emergency actions which are going to be taken during the different phases of the accident are going to be presented and discussed. Such type of accidents could increase seriousness of:

- Possible burning of the high explosives in the weapons leading to melting of the fissile material core.
- Detonation of the explosive leading to aeroslization of part of the fissile material Plutonium $T_{½}$ 240000 years and its airborne disposal dispersal.

The paper analyses the risks of such accident, focusing especially on the intermediate stage involving; the dispersal of plutonium as well as health and environmental consequences of such an accident.

SUEZ CANAL ZONE

The Suez Canal is an artificial waterway running north to south across the Isthmus of Suez in north eastern stage Egypt. The Canal connects the Mediterranean Sea with the Gulf of Suez, an arm of the Red Sea. This Egyptian waterway is an important international trade route. Table 1. gives the population density in the Suez Canal area.

The canal passes through a zone of considerable business, agricultural and industrial activities. The zone consists of three densely populated cities: Port Said, Ismailia and Suez. Table 2 shows the main characteristics of the Suez Canal. The canal cuts through three lakes: Lake Manzal, in the north, Lake Timsah in the center and Bitter Lakes further to the south. Bitter Lakes makes up almost 30 km of the total length of the canal.

Table 1. Population density in Suez Canal area

Governorate	Area (km^2)	Population density, 2006 census (inhabitants/km^2)
Port Said	72	7 705
Ismailia	1.442	624
Suez	17.840	28

Table 2. Characteristics of the Suez Canal

Overall length	193 km
Length from Port Said to Ismailia	78.5 km
Length from Ismailia to Port Tawfik	65 - 83 km
Width of the Canal at the water surface	300 / 365 m
Width between buoys	180 / 205 m
Minimum bottom width	60 m
Depth of the canal	21 m
Cross sectional area	3900 / 4300 m^2
Being increased to	4000 / 4500 m^2

PROPERTIES AND HEALTH HAZARDS OF PLUTONIUM

When plutonium has dispersed into the atmosphere, the main way in which it is likely to enter the body in the short term is by the inhalation of dust particles; small particles of Pu are particularly dangerous as they can remain in the lung and be transferred to other parts of the body, where they remain for many years. Particle size is very important. Particles larger than 10 microns are likely to be cleared from nasal airways and swallowed. If the particles are smaller than 10 microns then the smaller they are the greater the proportion deposited in the lung. Large amounts of plutonium which are taken into the body can have serious toxic effects; in addition to the effects of radiation. Moreover, alpha particles are emitted from plutonium for thousands of years. While there is a risk from inhalation of plutonium, there is also a risk particularly in the long term; that a significant proportion will find its way into the food chain. The proportion of ingested plutonium; which remains in the body is small. It may be pointed out also that higher amounts will be absorbed if the plutonium is in a soluble form, or if the particles are extremely small [3, 4, 5].

The alpha particles emitted from plutonium can only travel a very short distance, and cannot penetrate the dead layer of the skin around the body. However emitted alpha radiation, which is inhaled and absorbed, can have a considerable effect on live cells in its immediate vicinity. The relative effectiveness of alpha particles is greater than gamma radiation or beta particles by a factor of 20. A particle of plutonium can damage human cells with diameter ranging between 10 and 50 microns. These cells have an ability to divide and create more cells. In this way the anhilation of plutonium dust, can induce cancer in the bones, lungs and other parts of the body. There are also more risks concerning genetic damage. This can result; in genetic abnormalities in the offspring of the person who is exposed to radiation. The risk factor for fatal cancer is given by ICRP as 0.05 per Sv. The risk factor for all cancers casualties is approximately to be 0.075 per Sv. The risk factor for heredity effects for all future generations is given by ICRP as 0.01 per Sv for all ages and 0.006 per Sv for people of a working age.

HYPOTHETICAL ACCIDENT SCENARIO

In preparing an emergency response to a hypothetical accident involving radiological release from nuclear powered vessel or submarine traversing through Suez Canal it is considered entirely a hypothetical accident that have very low probability of occurrence. The assumption is made aboard a military vessel traversing the Suez Canal, close to Port Said City, Egypt. The proposed accident scenario is given as the incineration of a single nuclear warhead in a ship board fire, which will led to the possibility of burning of the high explosives in the weapon.

It is well known that nuclear weapons are designed with great care to explode only when deliberity armed and fired. Nevertheless there is always a possibility that as a result of accidental circumstance, an explosion will take place inadvertently.

A typical weapon may have 5 kilograms (kg) of plutonium and in the accidental scenario, subject to detonation or fire, the plutonium pit of the warhead will aerosolize into small particles that are readily borne aloft and dispersed in the atmosphere. In the immediate aftermath of the incident where the high explosive has detonated or burnt, the plutonium particles are available to direct inhalation by individuals downwind. In the short, medium and longer terms the plutonium particles deposited on the ground, on buildings and other surfaces will be also could enter the human metabolism by ingestion, open wounds and other routes or, if re-suspended by disturbance, inhaled.

Such an accident would produce a radioactive cloud containing plutonium-239 which would be carried towards the northeast, directly over Port Said City, by the most probable prevailing winds. During this accident the plutonium concentration in the cloud would exceed U.S. federal (NRC) limits for air contamination (10 CFR 20) by up to ten thousand times [6]. Moreover ground contamination from fallout would exceed also U.S. federal (NRC) limits for unrestricted public use by up to one million times. Radiation Exposure from inhalation of the plutonium would exceed federal limits for routine releases by up to one hundred times. Prompt fatalities have not been considered; instead causalities calculated here would take the form of latent cancer fatalities and genetic defects. It is assumed that latent cancer fatalities incurred during the accident will depend on thermal lofting, atmospheric stability and the radiation risk factor used with an equal number of additional fatalities from severe genetic effects.

The primary task of the emergency services in dealing with a nuclear weapon accident is evacuating people out of the zone where inhalation hazard prevails. An immediate total evacuation zone of 2 km is going to be adopted. A 10 km zone in which respirator protection is required, where sheltering is in place and evacuation should be considered, also a zone extending to 40 km where the expectation is that the general public exposure will exceed the annual whole body dose and where sheltering is recommended. Obviously the accidentally burning or explosive breakup of a single nuclear weapon could result in a release of plutonium (and other radioactive substances) requiring an emergency response in attempt to mitigate the health consequences to the population over a relatively large area which could extend in excess of 40 km from the scene of the event .

It is expected that the greatest contamination would occur nearest to the accident site, although both air and ground contamination would remain well above the NRC limits up to 50 kilometer from the accident site and beyond. Causalities would be concentrated within 5 kilometers of the accident, but could extend out to several tenths of kilometers from the accident site, under unfavorable meteorological conditions. The ecological and economic impacts of such an accident on surrounding water bodies have not been considered here but it could also be significant. The risk to the Egyptian public from this accident is the product of the consequences and probability of the accident. Although the consequences can be estimated under idealized accident conditions, the probability of the accident occurrence requires information that is not without the public domain. Such information includes the number of nuclear warheads aboard ship, the frequency and intensity of shipboard fires, the fire resistance of warheads, the accident history and the operating characteristics of naval propulsion reactors. In the absence of this information the probability of the accidents modeled cannot be calculated and hence the risk associated with passage of nuclear powered vessels or submarines cannot be assessed accurately.

EMERGENCY RESPONSE ACTIONS

The emergency response actions taken during the different phases of this accident are going to be covered by the national radiological emergency plan issued by the country of Egypt to face any radiological emergency accidents inside the country. The plan involves various national agencies, namely the Atomic Energy Authority (AEA) and the Ministry of Interior (MOI) which contains Civil Defense Authority (CDA), the Crisis Management Centre (CMC) and the Suez Canal Authority (SCA). Moreover a Supreme Council of Ministers has decision making authority in the response plan [2]. The following actions are going to be taken:

Planning Prior to a Fire:

The potential hazards surrounding a fire involving a nuclear weapon, and the protective measures which can be taken, vary widely. The time, during which a fire can be fight before detonation of the high explosive component becomes a possibility, will be critical in some cases. Therefore, it is important that situations in which a weapon may become involved in a fire be anticipated to the maximum extent feasible. Written plans of actions or standing operating procedures should be prepared and should be familiar to all personnel who may become involved.

Emergency Procedures

The first observer of the fire should:

1. *Assist:* Give immediate assistance to personnel where possible. However, except for the saving of lives, keep away from the fire. There is always the danger of a detonation of the high explosive component. Remain upwind from the fire. In saving lives, use any available method to prevent smoke from entering your eyes, nose, and throat.

1. *Report:* Report the fire immediately to the nearest fire department in the city. Upon arrival at the scene, the police or fire department should be asked to notify the Egyptian Atomic Energy Authority.

2. *Clearing the Area:* One of the first actions in any fire involving nuclear weapons is to clear the area of all personnel which are not actually needed or engaged in the firefighting operation. Where nuclear weapons are involved, the

minimum clearance distance (600 meters). Even at this distance injury from flying objects is possible.

3. *Time Factor.* If the fire or its impact does not immediately detonate the high explosive, the period of time available to fight the fire before such detonation might occur varies from a few minutes to an indefinite period, depending on the physical characteristics of the weapon casing, and the intensity and proximity of the fire.

a) Fire fighting

If there is a fire in the immediate vicinity of the warhead then fire crews could be in great danger. If the weapon is jetting, hoses should be tied down onto the warhead before fire crews withdraw. Elsewhere the guidelines for installation or modification of fire sprinkler systems (Mod) [7] say that if the weapon is jetting the high explosive may be about to detonate. By remaining in the area to fix hoses fire crews may reduce the chance of a major nuclear accident, but they will be at great personal risk if the warhead was going to explode, both from the explosion as well as from radiation. In addition fire crews may not be able to tell whether it is the high explosive or other materials which are on fire. Approaching the fire must be from upwind and at maximum angle that might be involved since the heat of flames might fire them.

b) Detection of alpha radiation

Detection of alpha radiation would be a major problem. Local authorities would have to rely on detection equipment most of which would not arrive until 24 hours after the accident. The immediate response would be based on computer predictions rather than on readings taken on the ground. The actual dispersion would vary from that calculated by the computer model. It would also be difficult to assess how much plutonium been have inhaled by public. It is not possible to detect particles of plutonium from outside the body. Plutonium intake, is normally assessed by measuring the amount of plutonium which is removed from the body in urine. Moreover the immediate area around a nuclear weapons accident. Must be evacuated as quickly as possible. However there is also concern that people and vehicles leaving the area would be contaminated with plutonium dust. Decontamination facilities would be set up to process everyone and all vehicles before they left the area. The demands of immediate evacuation and of contamination are not easily reconciled.

c) Actions After Fire Extinguishment

- Immediately upon extinguishment of the fire all personnel will be withdrawn to a minimum distance of (600 meters). The area in which the weapon is located will be kept clear of all personnel, other than the specially trained disposal and decontamination teams, until it is designated safe by the agency having such responsibility.
- When the fire is extinguished, personnel and all equipment that may have become contaminated from the smoke of a burning nuclear weapon will be congregated and isolated in an area; at least (600 meters) from the weapon. This isolation is necessary to prevent further possible contamination and will be maintained until release is authorized by specially trained and equipped monitoring and decontamination personnel. In fact monitoring activities

immediately around the weapons accident site are likely to dominate the initial stage of the emergency response to any the accident.

The post accident phase is the cleanup stage compared with the two previous stages, it cannot be cleaned quickly. Before proceeding with this stage preparation and planning should be undertaken. The factors to be considered are:

- What is the degree of contamination?
- What is the relative importance of the contaminated areas?
- Is there is a possibility of further dispersion of the contaminates?
- To what level should the contamination be done?

It is important to have one agency responsible for this operation. Monitoring teams should also be present during this phase inorder to provide feedback information and to monitor personnel. Notification of the IAEA concerning the degree of the accident according to the International Nuclear Event Scale should also be undertaken [8].

Medical care arrangements

In the framework of the arrangements details in the radiological emergency plan for medical care of the persons who might be injured or contaminated or exposed to severe radiation, medical treatment actions must be managed according to the nature of injuries. One may point out that, medical problems must take priority over radiological concerns.

Discussion and Conclusion

Emergency preparedness for a nuclear accident in Egyptian ports is inadequate to cope with the scale of possible nuclear powered vessel Egyptian regulatory body exercise no licensing, no oversight authority over the technical aspects of such military reactors and weapons.

If the government of Egypt decides nonetheless to proceed with passage of nuclear powered vessels and submarines, a number of additional recommendations must be followed. These are:

- Emergency evacuation must be extended to at least 5 kilometers from the accident site for densely populated urban areas.
- Evacuation plans should be established, coordinated and rehearsed periodically.
- Decontamination plans in the event of an accident should likewise be formulated.
- The data needed to ascertain empirically the probability of nuclear accidents should be obtained from the military authorities of governments having nuclear powered vessels passing through Suez Canal, so that the risk to the Egyptian public can be estimated as closely as possible.
- Detailed liability and indemnity regimes in the event of and accident should be negotiated in advance.
- The high annual casualties from continued long term habitation of the city indicate the need for decontamination prior to re-habitation.
- These emergency procedures are ineffectual in that contamination and causality zones could extend to several km from the accident site.

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