Emergency Preparedness & Response in Case of a Fire Accident with (UF_6) Packages Tracking Suez Canal

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Abstract

Egypt has a unique problem - the Suez Canal. Radioactive cargo passing regularly through the canal carrying new and spent reactor fuel. Moreover there are also about 1000 metric tons of uranium hexaflouride (UF_6) passing through the canal every year. In spite of all precautions taken in the transportation, accidents with packages containing (UF_6) and shipped through the Suez Canal, accidents may arise even though the probability is minimal. These accidents, may be accompanied by injuries or death of persons and damage to property. Due to the radiation and criticality hazards of (UF_6) and its high risk of chemical toxicity. The probability of a fire accident with a cargo carrying (UF_6) during its crossing the Suez Canal can cause serious chemical toxic and radiological hazards, particularly if the accident occurred close or near to one of the three densely populated cities (Port-Said, Ismailia, and Suez), which are located along the Suez Canal, west bank.

The government of Egypt has elaborated a national radiological emergency plan inorder to face probable radiological accidents, which may be arised inside the country.

Arrangements have been also elaborated for the medical care of any persons who, might be injured or contaminated, or who, have been exposed to severe radiation doses.

The motivation of the present paper was undertaken to visualize a fire accident scenario occurring in industrial packages containing UF_6 on board of a Cargo crossing the Suez Canal near Port-Said City. The accident scenario and emergency response actions taken during the different phases of the accident are going to be presented and discussed. The proposed emergency response actions taken to face the accident are going to be also presented.

The work presented had revealed the importance of public awareness will be needed for populations located in densely populated areas along Suez Canal bank inorder to react timely and effectively to avoid the toxic and radiological hazards araised in such type of accidents. Moreover up grading capabilities of civil deference and fire-fighting personnel is also requested.

1. Introduction

Many millions of packages carrying radioactive materials are transported safely each year throughout the world, but occasionally accidents and incidents occur during some of these shipments. Some of these events may have the potential to cause increased radiation exposure of workers and the public. However, these consequences would normally be limited by the safety features designed into the package, and other controls that are required for transport. The experience of transport operations over a number of decades shows that significant exposures from such events are extremely rare. [1]

Since 1971 there have been more than 20.000 shipments of spent fuel and high-level wastes (over 50.000 tones) over more than 30 million kilometers. There has never been any accident in which a container with highly radioactive material has been breached, or has leaked.

It is well known that uranium hexaflouride (UF_6) is an important intermediate product in the manufacture of new reactor fuel from ore concentrates. Because of its low activity, (UF_6) enriched to less than 1% can be carried in industrial packages, however the packages must fulfill the tests for demonstrating ability to withstand normal conditions of transport. Moreover during its transportation by sea (UF_6) is loaded in containers under pressure of about 4 bar and at a temperature of about 100^oC. Under these conditions (UF_6) is in the form of a liquid. Moreover it is well known that (UF_6) has a very high risk of both radiation hazard and chemical toxicity during accidents involve large fire and breaches. [2]

2. Scope of the Problem

There are lot of cargo passing regularly through the Suez Canal, carrying new and spent reactor fuel, moreover there are also about 1000 metric tons of (UF_6) crossing the canal every year. The probability of a fire accident of long duration and high intensity, with a Cargo carrying (UF_6) during its crossing the canal, can cause serious chemical toxic and radiological hazards, particularly if this accident occurred close or nearby one of highly density populated cities namely (Port-Said, Ismailia and Suez) located along the Suez Canal west bank.

The present paper was presented to visualize a hypothetical fire accident scenario occurring in industrial package containing (UF_6) on a board of a Cargo crossing the Suez Canal nearby Port-Said City.

In the frame of the national radiological emergency planning in Egypt. [3] The accident scenario, as well as, the emergency actions taken during the different phases of the accident were presented and discussed.

3. The Suez Canal Zone

The Suez Canal is an artificial waterway running north to south across the isthmus of Suez in the north eastern of 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 Suez Canal area.

Table (1) Population Density in Suez Canal Area

Governorate	Area (km^2)	Density Inhabitant/km^2 2003 Census
Port Said	1351.14	6512
Ismailia	4483	496
Suez	10056.4	46

The Canal is passing through zone of considerable business, agricultural, and industrial activities. The zone consists of three highly density populated cities, Port Said, Ismailia and Suez. (Table 2) shows the main characteristic of Suez Canal. The Canal is cutting through three lakes, the Lake Manzala, in the north, the Lake Timsah in the middle, and the Bitter Lake further south. The Bitter Lakes makes almost 30-km of the total length.

Table (2) Characteristics of the Suez Canal

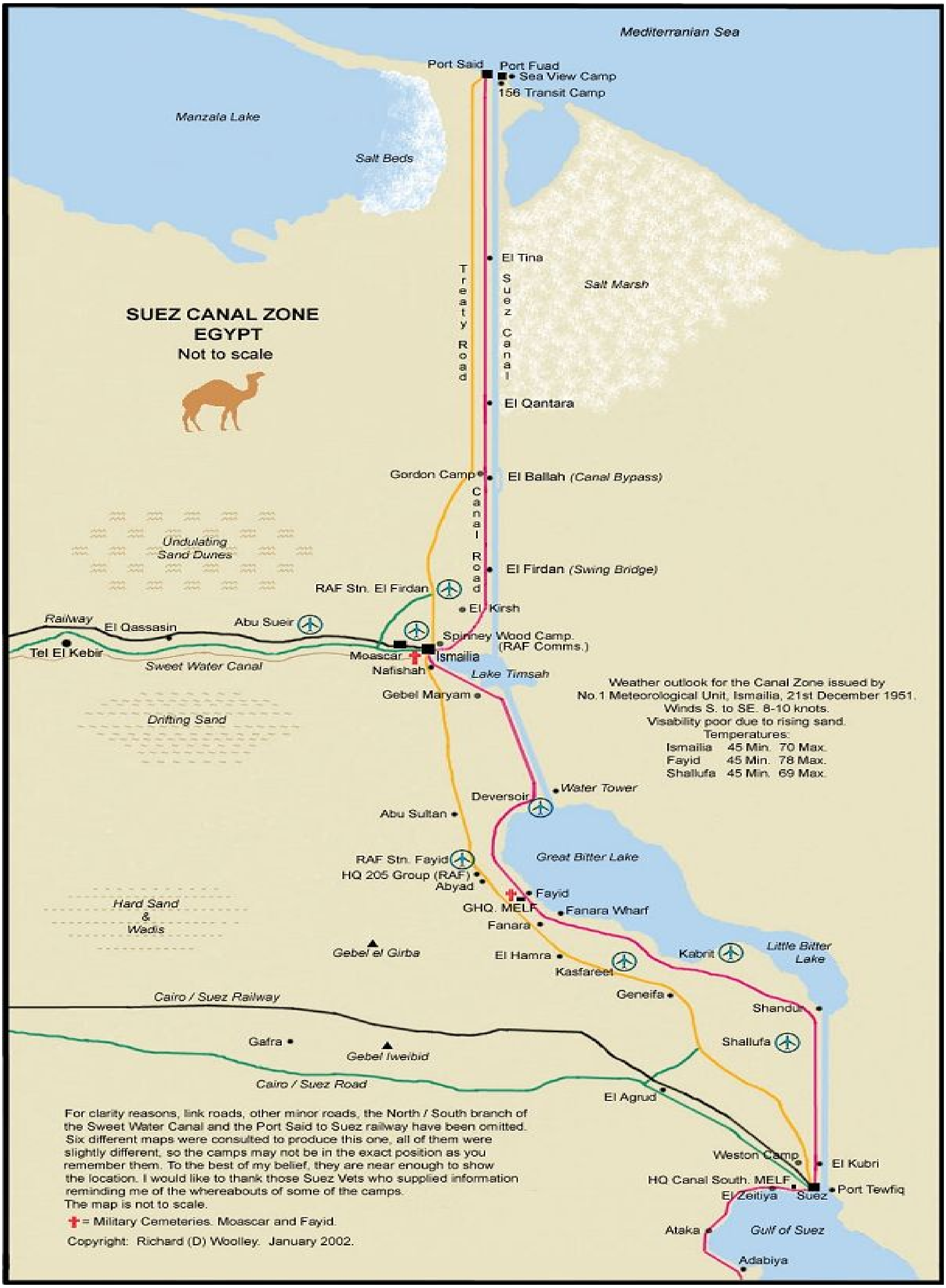
Overall length	192 km
Length from Port Said to Ismailia	78 km
Length from Ismailia to Port Tewfik	84 km
Width of the Canal at water surface	300/400 m
Minimum bottom width	60 m
Depth of the Canal	19.5/20 m

The Canal can accommodate ships as large as 150,000 dead weight tons fully loaded. Most of the Canal is limited to single lane of traffic but several passing bays exists, and twalane bypasses are located in the Bitter Lakes between Al-Qantrah and Ismailia. Fig.1 shows a map for Suez Canal Zone.

The Suez Canal Authority (SCA) also imposes a speed limit in the Canal, ranges from 13 to 16 km per hour. In the southern sector it varies between 11 and 16 km per hour, depending on the speed and direction of the tidal current. On the average, a ship takes an average time (24 hours) to transit the canal, including waiting time. Beside that, several wireless communication networks are available also along the canal that keep contact between one site and another.

4. Properties and Health Hazards of (UF_6)

At ambient temperature (UF_6) is a crystalline solid but at temperature of 56.4^oC it sublimates (becomes a gas). Chemically (UF_6) is very reactive with water (atmospheric humidity); it form the extremely corrosive hydrofluoric acid (HF) and the highly toxic urnylflouride (UO_2F_2). The hydrofluoric acid causes skin burns and after inhalation damages the lungs. Also, high concentrations of (HF) may cause life threading if exposure exceeds one hour. Further health hazards result from the chemical toxicity of the uranium to kidneys, as well as, from the alpha radiation of the uranium. The external radiation hazard from (UF_6) is higher than from uranium are concentrate, since uranium's alpha radiation produces neutron radiation in an (alpha, n) reaction with fluorine. [4]. Exposure to ionizing radiation is administratively controlled by limiting the distance and the time workers spend within the area.


Mediterranian Sea
Port Said
Port Fuad
Sea View Camp
156 Transit Camp
Manzala Lake
Salt Beds
El Tina
Salt Marsh
Treaty Road
Suez Canal
SUEZ CANAL ZONE
EGYPT
Not to scale
El Qantara
Gordon Camp
El Ballah (Canal Bypass)
Canal Road
Undulating
Sand Dunes
El Firdan (Swing Bridge)
RAF Stn. El Firdan
El Kirsh
Railway
El Qassasin
Abu Sueir
Spinney Wood Camp.
(RAF Comms.)
Tel El Kebir
Moascar
Ismailia
Sweet Water Canal
Nafishah
Lake Timsah
Weather outlook for the Canal Zone issued by
No.1 Meteorological Unit, Ismailia, 21st December 1951.
Winds S. to SE. 8-10 knots.
Visability poor due to rising sand.
Temperatures:
Ismailia 45 Min. 70 Max.
Fayid 45 Min. 78 Max.
Shallufa 45 Min. 69 Max.
Gebel Maryam
Drifting Sand
Deversoir
Water Tower
Abu Sultan
Great Bitter Lake
RAF Stn. Fayid
HQ 205 Group (RAF)
Abyad
Fayid
Hard Sand
&
Wadis
GHQ. MELF
Fanara Wharf
Fanara
Gebel el Girba
El Hamra
Kasfareet
Kabrit
Little Bitter
Lake
Cairo / Suez Railway
Geneifa
Shandur
Gafra
Gebel Iweibid
Shallufa
Cairo / Suez Road
El Agrud
For clarity reasons, link roads, other minor roads, the North / South branch of the Sweet Water Canal and the Port Said to Suez railway have been omitted. Six different maps were consulted to produce this one, all of them were slightly different, so the camps may not be in the exact position as you remember them. To the best of my belief, they are near enough to show the location. I would like to thank those Suez Vets who supplied information reminding me of the whereabouts of some of the camps.
The map is not to scale.
= Military Cemeteries. Moascar and Fayid.
Copyright: Richard (D) Woolley. January 2002.
Weston Camp
El Kubri
HQ Canal South. MELF
Port Tewfiq
El Zeitiya
Suez
Ataka
Gulf of Suez
Adabiya

5. Hypothetical Accident Scenario

In preparing emergency response to a hypothetical accident involving packages containing (UF_6) it would be useful to consider entirely hypothetical accident that have very low probability of occurrence and therefore would not come within the scope of the package design basis.

An assumption is made that a type H(M) packages (does not meet the thermal design requirements) loaded with 12.500 kg of natural (UF_6) is involved in a large fire and breaches, on a Cargo crossing Suez Canal closed to Port-Said City.

The temperature of the (UF_6) is assumed to have reached 120°C, at which temperature it is already liquefied, having a vapour pressure of 0.675 MPa (6.75 kgf/cm^2). Once the package is ruptured, (UF_6) can be expected to escape in a gaseous form. Under this set of conditions approximately 65% of the contents (8000-kg), will be released within a period of approximately one hour.

The escaping gases are going to have, according to this scenario, a relatively low effective release height. If the release were to occur concurrently with the fire, the release height would be greater, followed by a large dispersion and dilution.

The escaping (UF_6) reacts with the humidity in the atmosphere, producing UO_2F_2 and HF. The amount of water necessary to hydrolyse (8000-kg) of (UF_6) is 800 kg (this amount of water represents the contents of some 50.000m^3 of air at 25°C and 50% relative humidity). It is obvious, therefore, that as the plume of (UF_6) expands and travels downwind. At downwind distances ranging between 1-2 km from the city, residents in Port Said City will remain within the plume during its passage with high concentrations of (HF) as the prevailing wind direction is always towards the North East. This reaction is going to continue until all the (UF_6) is reacted. UO_2F_2 is a toxic substance and HF is a corrosive substance. The risk associated with breathing non-hydrolysed (UF_6) is slightly higher than the risk associated with breathing UO_2F_2 and HF combined.

Also, from the standpoint of contamination, it should be noted that gaseous HF does not deposit on the ground; surface contamination can only be caused by particulate UO_2F_2. Hydrate HF, which tends to settle slowly, may have some corrosive effects, but does not represent a significant health hazard. Non-hydrolysed (UF_6) may settle, especially near the source, and react with moisture.

Thus the principal hazards will be mainly from breathing and contamination, and are generally governed by chemical rather than radiological risks. A release of 8000 kg of (UF_6) at the end of a fire, in stable weather conditions and with a mild wind (of about 2m/s), may cause severe poisoning (mostly by HF) at a downwind distance of 1-2 km for people remaining within the plume during its passage. It is; however, very unlikely that people irritated by the fumes of HF would voluntarily remain in the plume for sufficient time to cause poisoning. The people at risk therefore are those who are near the point of the release, where the concentrations are very high, or those who are forced to stay in the plume area without protective breathing devices because they are somehow incapacitated.

As the plume moves with the wind, the solid UO_2F_2 will begin to settle and deposit on the ground, resulting in contamination. Ground contamination is not and immediate issue to be dealt with during the course of the accident. Its impacts are from a long-term exposure to low level radiation and possible resuspension and the consequent inhalation of the radioactive material if proper measures to control the spread of contamination are not taken. The areas that could require decontamination may extend to several kilometers. While the decontamination of flat solid surfaces is quite easy, the cleaning of soils contaminated with a soluble uranium compound poses a serious problem. The use of water to avoid resuspension is not recommended, as the solutions so formed could penetrate into the ground, which may then necessitate the removal of much higher quantities of soil. If possible, lime solution should be used to ‘fix’ the contamination.

6. Emergency Response Actions

The emergency response actions taken during this accident is going to be covered through the national radiological emergency plane issued by the country of Egypt to face any radiological emergency accidents in side the country. In this plane four national agencies namely the Atomic Energy Authority (AEA) and the Ministry of Interior (MOI), which contains the Civil Defense Authority (CDA), the Crisis Management Centre (CMC) and the Suez Canal Authority (SCA). AEA and CDA are the principal response agencies. Moreover a supreme council of ministers has the decision authority in the response.

We may notify that emergency planning during accidents occurring on board of ship should comply with relevant regulations of the ships flag state, as well as the regulations of countries which might be involved. General preliminary guideline to deal with accidents at sea is published by the International Martine Organization (IMO) [5].

In the frame of the convention on early notification and assistance in case of nuclear accident [6], IAEA has to be early notified about the accident and its possible consequences. Assistance from IAEA would be available on request.

In the following we are going to summarize different phases of the emergency response action taken to face this accident:-

Phase 1: the initial phase:

(Eins) Cool containers that are exposed to flames with water from the side until fire is out, if this is impossible withdraw from area and let fire burn.

(Zwei) Water should not be allowed to come into contact with (UF_6). The reaction of (UF_6) with water is exothermic and therefore enhances the release. A Water fog or water curtain, is very effective if used, at some distance downwind, to reduce the concentration of HF and UO_2F_2 in the plume and to minimize the area that may eventually require decontamination.

(c) Positive pressure breathing apparatus should be used by all emergency teams near the site of the accident. Regular respirators do not provide any protection from (UF_6) and provide very little protection from HF. However, they do provide adequate protection from UO_2F_2 and therefore can be used during the decontamination process.

(d) People in the downwind sector should be warned, and if the release is of significant magnitude their evacuation should be considered, for distances of 300 meters in all directions.

(e) All rescue personnel involved in the accident should be monitored for external and internal contamination after the emergency is over. Equipment and safety gear should be cleaned before it is returned to unlimited use.

(f) For warning communication with news media should be carried out by professional personnel in the emergency response organization.

Phase 2: the accident control phase

For the accident control phase a monitoring team is on the scene. The team should be equipped with suitable instruments for the measurement of uranium contamination. The recommended instruments are either alpha monitors (usually based on gas proportional counters) or scintillation counters capable of measuring the weal gamma radiation of uranium. Air sampling devices should be placed in appropriate locations to measure airborne uranium aerosols.

Using these instruments, the monitoring team should be able to make a contour map of limited access and cordoned-off areas and to recommend what locations should be evacuated, if any and where decontamination actions are most urgent.

In most cases the monitoring team should be responsible for monitoring all the individuals involved in the operation.

Phase 3: the post accident phase

The post accident phase is the cleanup stage. Compared with the two pervious stage it cannot be done quickly. Before proceeding with this stage, thorough 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 a possibility of a further dispersion of the contaminates?
- To what level should the decontamination be done?

It is very important to have one individual or one agency responsible for the operation. Monitoring team(s) should also be present during this phase in order to provide feedback information and to monitor personnel. Air sampling should be performed at all times during the campaign. Moreover evaluation of the RAD plan adopted at the site in comparison with the previously prepared plan. Also notification of IAEA about the degree of the accident according to the International nuclear event scale.

7. Medical Care Arrangements

In the frame of the arrangement elaborated in the radiological emergency plan for medical care of any persons who might be injured or contaminated or exposed to severe radiation. Medical treatment actions are going to be managed according to the nature of injuries.

- Medical problems most take priority over radiological concerns.
- Use first aid treatment according to the nature of the injury.

- Do not delay care and transport of a seriously injured person.
- Apply artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes.
- Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed.
- Injured persons contaminated by contact with released material are not a serious hazard to health care personnel, equipment or facilities.
- Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves and prevent spread of contamination.

8. References

[1] Regulations for the Safe Transport Radioactive Material (ST-1, 1996 edition, safety standard series No. TS-R-1, IAEA, Vienna), (2000).

[2] Recommendations for providing protection during safe transport of uranium hexaflouride, IAEA-TECDOC-608, Vienna (1991).

[3] Salama M. et. al, on the need for a national radiological plan in Egypt (Sixth Topical Meeting on Emergency Preparedness Response, vol.1 , ANS, April 22-25 San Francisco, California, USA), (1997).

[4] Okamoto, T., Kiyose, R. Evaluation of UF_6 vapour release in a postulated accident, J. Nucl. Sci. Technol. 15 (1978).

[5] International Maritime Dangerous Goods Code, IMDG code, 2000 edition, IMO. London (2000).

[6] Convention on Early notification of a nuclear accident and convention on Assistance in Case of a Nuclear Accident or Radiological Emergency, Legal Series No. 14, IAEA, Vienna (1987).