



THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF HOME AFFAIRS
FIRE AND RESCUE FORCE



**STANDARD OPERATING
PROCEDURE MANUAL**

Second Edition

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HAZMAT OPERATION

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HAZMAT OPERATIONS

1.0 INTRODUCTION

HAZMAT is an abbreviation for “hazardous materials” substances in quantities or forms that may pose a reasonable risk to health, property, or the environment. HAZMATs include such substances as toxic chemicals, fuels, nuclear waste products, biological, chemical, and radiological agents. HAZMAT is may be released as liquids, solids, gases, or a combination or form of all three, including dust, fumes, gas, vapor, mist, and smoke.

HAZMAT caused health problems, injuries, and even death in people and animals have damaged buildings, homes, property, and the environment. Given such direct consequences, it is reasonable to conclude that one may not encounter HAZMATs on a daily basis. The truth, however, is that many products containing hazardous chemicals are routinely used and stored in homes, and are transported every day on the nation's highways, railroads, waterways, and pipelines.

The Hazardous Materials Operations SOPs (HAZMAT Ops) provides responders with the knowledge, skills, and abilities necessary to analyze, plan, and implement performance-defensive response actions for hazardous materials (HAZMAT) incidents.

1.1 Hazardous Materials Incident Response

This standard defines the parameters of the FRF efforts to manage the hazardous materials problem within the community; it promulgates the establish guidelines to be followed by the FRF for managing an incident that involves a hazardous material.

- a) The fiscal resources of this Force do not allow operating beyond the first-responder operational level, *Professional Competence of Responders to Hazardous Materials Incidents*.

- b) At the operational level, members are responsible for protecting people, property, and the environment from the effects of a hazardous material. Members will operate in a defensive role to contain the incident and prevent a release of a hazardous material from spreading.

- c) All Fire stations (Training Officers) shall conduct pre-planning of hazardous material buildings and sites in their respective Regional. A building or site pre-fire plan shall be completed with special precautions to take in the event of a fire or spill at that location. The following are step by step procedure to follow when responding to a hazmat incident:

1.2 Responsibility:

It is the duty of the Fire and Rescue Force to save lives and protect property. This responsibility extends to the efficient handling of hazardous materials incidents within our jurisdiction.

It is the mission of Fire and Rescue to contain and stabilize the hazardous material until such time the proper officials require the owner of the produce to properly dispose of the material.

All fire-fighters shall be trained and certified to a minimum of the Hazardous Material Awareness Level.

- a) Hazardous materials defined as any explosive, flammable liquid, oxidized, poison, etiologic agent, radioactive, corrosive, or other substance or material in quantity of form that may pose an unreasonable risk to health and safety or property. Although no two hazardous material incidents are the same, the following general plan of operation shall be placed into effect when any hazardous material is involved.
- b) The first arriving officer at an incident involving hazardous materials shall report the following information to dispatch:
 - i) The exact location of the incident
 - ii) The type and quantity of the materials involved, if known.
 - iii) The extent of damage and the number and types of injuries.
 - iv) The name of the carrier if a vehicle is involved.
 - v) Any other pertinent information such as the hazardous material entering the storm drain or sanitary sewer system.
- c) The first arriving officer shall also request any additional resources that may be needed, establish command, and begin securing the incident scene to prevent

additional injuries or contamination.

- d) The area shall be evacuated if necessary. This function should be turned over to the police once sufficient law enforcement resources arrive on the scene.
- e) Dispatch shall provide the incident commander with the temperature, wind speed and direction, and humidity as soon as it is possible to do so.
- f) The incident commander's objectives will be containment and stabilization. Final extinguishment and cleanup of incidents that exceed the capabilities of the department will be the responsibility of the private vendor who responds to the incident.

1.3 Operations procedure

There are three recognized levels of response:

Level I: The least serious and is within the capabilities of the FRF. Evacuation, if required, will be limited to the immediate area.

Example: a gasoline or diesel spill. (Level of response Awareness)

Level II: Beyond the capabilities of the FRF, a Level II incident requires the service of a formal Hazmat Response Team.

Examples: the rupture of a pipeline or a fire with the threat of a BLEVE. (Level of response-Operational)

Level III: The most serious type, requiring resources from public and private agencies. It will require a large-scale evacuation and implementation of the jurisdiction's Emergency Operations Plan. Example: an incident that extends across jurisdictional boundaries. (Technician)

- a) Operations will be either defensive or offensive.
 - i) Defensive operations focus on confinement without directly contacting the hazardous materials creating the problem.
 - ii) Offensive operations focus on aggressive actions on the material, container, or process, and they may result contact with the materials. Offensive

operations are not be conducted unless the incident commander can determine that the risk is worth the benefit.

- b) Personnel are not be allowed to enter the warm zone or the hot zone without the proper level of training and personal protection.
- c) Personnel are not be permitted to leave the warm zone or the hot zone without undergoing proper decontamination.
- d) The safety officer will appoint a medical surveillance team. The team will be responsible for monitoring members for indicators of toxic exposure effects, including:
 - i) Change in complexion, skin discoloration
 - ii) Lack of coordination
 - iii) Changes of demeanor
 - iv) Excessive salivation, papillary response
 - v) Changes in speech pattern
 - vi) Headaches
 - vii) Dizziness
 - viii) Blurred vision
 - ix) Cramps
- e) Irritation of eyes, skin, or respiratory tract a member exposed to a hazardous material shall complete a Hazardous Materials Exposure Form. A copy of the form is be placed in the member's medical file.
- f) The incident commander shall also appoint a rehab officer. The rehab officer shall establish a rehab sector. Members are be rotated through the rehab sector in accordance with the department SOG/SOP's.
- g) Upon receiving a report of a potential hazardous material incident from the 114 Centre or the first arriving Department, the IC shall initiate a hazardous material response.
 - i) The RFO/DFO
 - ii) One fire tender
 - iii) One Tanker

Confirmed hazardous material incident will include response from:

- a) The RFO/DFO and Training Officer
- b) One Rescue Vehicle
- c) Air Re-servicing Vehicle
- d) One additional Pumper
- e) HazMat vehicle
- f) Hazmat Units if need is determined
- g) Subsequent Fire Units and Personnel shall be requested as needed to adequately handle the incident.
- h) It must be remembered that a hazardous material incident may present a number of problems not present in most fire ground operations (i.e., large areas affected by toxic gases, evacuation due to explosive materials, etc.).
- i) The Incident Command Procedure, as adopted by Fire and Rescue Force, shall be used at a major Hazardous material incident. Major emergencies or incidents shall be defined as those requiring the resources and coordination with agencies outside the Fire Service for ultimate resolution.
- j) The Incident Commander shall establish the command post upwind and uphill from the accident site and notify the 114-control room of the location of the command post.
- k) The Incident Commander shall determine which areas are safe and which shall be restricted areas.
- l) Personnel and equipment not immediately required will be maintained in a ready condition in the staging area.
- m) Law enforcement agencies shall be called upon as needed to maintain these restricted areas.

The Incident Commander shall ensure that the situation is continually monitored to detect any change in spill run-off, or vapour cloud. Subsequently, additional evacuation or other measures should be ordered as needed.

- n) The Incident Commander will consider wind direction and velocity every fifteen minutes or more if necessary.
- o) All responding Agencies will approach the scene from uphill and upwind.

- p) Fire Vehicles are not to enter a vapour cloud or otherwise contaminated area until it has been shown safe or proper protective clothing is used.
- q) Emergence Medical Supply Units are to remain at the staging area. Only as directed by the Incident Commander shall they enter any area to provide medical service?
- r) A minimum number of people, but not less than two, shall form the Hazmat Entry Team. A back-up team shall be provided.
- s) The Entry Team will operate within all safest guidelines and follow special operating procedures as they have been trained.
- t) Careful determination will be made as to the specific decontamination procedures necessary to handle a particular product.
- u) Prior to any personnel entering a contaminated area, the decontamination area shall be set up.
- v) During decontamination, close attention shall be given to water runoff. Whenever possible, this water shall be collected and properly disposed of.
- w) The primary operational goal of Fire and Rescue Force when dealing with hazardous materials shall be isolation, confinement, and stabilization of the product.
- x) All fire department personnel to insure minimum exposure shall exercise extreme caution.
- y) All available specialized tools, equipment, and apparatus shall be used to provide maximum protection and efficiency.
- z) Only those persons specifically trained in Hazmat Operation and Technician Levels shall be used during a Hazardous Material Incident.

1.4 Incident Command System for Hazardous Materials Response:

Fire and Rescue Force shall adopt and use this Incident Command System (ICS) for all responses involving Hazardous Materials. This ICS based on the Eight Step Incident Management Process for Hazardous Material Incidents described in the International Fire Service Training Association and the GEMA Hazardous Material Training Program.

1) Site Management and Control:

- a) The first arriving officer at a Hazmat Incident will advise the 114 Centre that he/she is assuming command and control until relieved by a more Senior Officer.
- b) The Incident Commander (IC) will advise all responding units of the route to take to the incident and what their responsibility will be. All responses should be parking their appliances uphill and upwind.
- c) The IC shall establish a staging area for additional equipment responding to the incident. A Staging Officer shall also be appointed to monitor the staging area and to advise the IC of what equipment he/she has available.
- d) The IC shall have law enforcement personnel establish a security perimeter around the site. To secure area will be based on hazardous material is involved.
- e) The IC shall establish Hazard Control Zones to assure safe work area's for emergency responders and supporting resources.
- f) The area immediately surrounding a Hazardous Material Incident will extend far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone.
- g) The control zone at a hazardous material incident site where personnel, equipment decontamination, and hot zone support take place. It includes control points from the access corridor, helping to reduce the spread of contamination.
- h) The safety control zone at a Hazardous Material Incident that contains the command post and other support functions required to control the incident.
- i) The IC shall size up the need for rescue of any persons still in the area and start implementing initial Public Protection Plan (evacuation or protection in place) No matter what decision is made; the Public Relations Officer shall work with the Government Speaker to alert the community affected on what steps to take to protect themselves.

2) Identify the Problem:

The following step shall be taken in the Identification process:

- a) Recognition – Recognize the presence of hazardous material
- b) Identification – Identify the hazardous material involved
- c) Classification – Determine the general hazard class or chemical family.

The above action can be completed by using the D.O.T. Emergency Response Guide Book; sheets shipping papers, placards, monitoring and detection equipment and the user.

3) Hazard and Risk Evaluation:

The IC shall realize the evaluation of hazard information and the assessment of the relative risks is one of the most critical decision-making points in the successful management of the Hazmat Incident. The (IC) shall have the control rooms contact CHEMTREC to find out all the information he/she can about the hazardous material involved also the manufacture and user can be a valuable source of information.

a) Selecting Personal Protective Equipment

The IC shall consider if he is equipped to handle the hazardous material involved. If the level of protection is greater than what he can provide, he/she shall contact other agencies for assistance. Fire and Rescue can handle most Hazardous Material Incident's that requires level of protection.

b) Information Management and Resource Coordination

The IC shall use all available information concerning the hazardous material involved before a plan of action can be established. The following are five basic functions that an IC must accomplish at a Hazmat Incident:

- i) Use a minimum of Three (3) information sources in developing your hazard and risk recommendations.
- ii) The IC shall use all data and information to coordinate with the Hazmat Sector Officer, the Safety Officer, Decontamination Officer, and Operation Officer.
- iii) The IC will instruct the personnel gathering the information about the chemical and use a Hazardous Material Data Sheet to record all information that will be needed
- iv) The IC shall coordinate the development of recommendations for the use of protective clothing within the hot, warm, and cold hazard zones, including chemical compatibility concerns.

4) Resource Coordination:

a) Hazardous Material Incidents are unique because of the resources required to mitigate the problem. The following areas shall be coordinated between the IC and Operation Officer:

- i) The IC shall coordinate with the Operation Officer and advise him/her, what type of operation to be conducted and what equipment and resources will be needed to accomplish the task.
- ii) The IC or Operation Officer shall appoint an onsite resource monitor to manage all equipment and other resources coming to the incident site.
- iii) The IC coordinating with the Site Resource Monitor (SRM) shall ensure all supplies, tools, and equipment required for entry operations shall be located in the warm zone, at or near the entry point of the hot zone.
- iv) An Equipment staging area utilizing a salvage cover shall be set up at this location and the following shall be accomplished:
 - A. The SRM shall ensure all expendable items must be monitored and replaced/resupplied.
 - B. The SRM shall ensure all contaminated items remaining in the hot zone must be identified.
 - C. The SRM shall ensure all equipment utilized throughout the incident is appropriately handled

5) Implementing Response Objectives:

- a) The IC shall implement the best available strategic goals and tactical objectives, which will produce the most favorable outcome during this phase of the operation. The IC should remember that the outcome measured in terms of fatalities, injuries, property and environmental damage, and systems disruption.
- b) The three basic areas the IC must understand before he/she can implement a response are:
 - i) What has occurred?
 - ii) What is occurring now?
 - iii) What will happen in the future?
- c) The IC shall design his/her strategic goals and realize some of them may be pursued simultaneously, the following shall be the basic for establishing an

incident strategic goal:

- i) Rescue
 - ii) Public Protective Action
 - iii) Spill Control
 - iv) Leak Control
 - v) Fire Control
 - vi) Recovery
- d) Once the IC has selected his/her strategy the tactical portion of the operation shall begin. The IC shall appoint a Tactical Officer to oversee this part of the operation. The Tactical Officer will have control over this part of the incident based on what the IC has established as the strategic goals.
- e) The IC and the Tactical Officer must continually monitor and evaluate the Incident Action Plan, for changes in tactical operation.

6) Decontamination:

- a) The IC must ensure during this step of the Hazmat Incident that proper procedures are followed to ensure the safety of everyone involved and the public.
- b) The IC will appoint a Deacon Officer, he/she will ensure a Deacon area is set-up and staffed before an entry team enters. In addition, the Deacon Officer will be responsible for coordinating all efforts through the IC from the time the area is set up until the incident is terminated.
- c) The size of the Deacon Area will be based on the incident and the chemicals involved.
- d) The Deacon Officer will ensure all Deacon Team members are protected to the appropriate level of protection.
- e) The Deacon Officer will ensure no one leaves the hot area unless they go through the Deacon Corridor.

7) Terminating the Incident:

- a) The termination process of a Hazmat Incident is divided into three phases:
 - i) Debriefing
 - ii) Post Incident Analysis

iii) Critique

8) Debriefing:

The debriefing of personnel involved should include the following:

- a) Inform personnel involved exactly what hazards they were exposed to and sign and symptoms.
- b) Identify damaged equipment requiring servicing, replacement, or repair.
- c) Identify equipment or expended supplies that will require special decontamination or disposal.
- d) Identify unsafe site conditions which will impact the clean-up and recovery phase. Owners and contractors should be formally briefed before responsibility for the site is turned over to them.
- e) Assign information gathering responsibilities for a post-incident analysis and critique.
- f) Assess the need for a Critical Incident Stress Debriefing.

9) Post Incident Analysis:

The Post Incident Analysis is the reconstruction of the incident to establish a clear picture of the events that took place during the emergency. It is conducted to:

- a) Assure that the incident has been properly documented and reported
- b) Determine the level of financial responsibility
- c) Establish a clear picture of the emergency response for further study.
- d) Provide a foundation for the development of formal investigation which is usually conducted to establish the probable cause of the accident.

10) Critique:

The Critique of the Incident will be handled by the IC, RFO/DFO. The primary purpose of the critique is to develop recommendations for improving the emergency response system rather than to find fault with the performance of individuals. The critique promotes:

- a) System dependent operations rather than people dependent organizations.
- b) A willingness to cooperate through teamwork.

c) Sharing information among emergency response organizations.

Note: Members who are trained to the level of Hazmat Tech may assist established Hazmat Response Agencies, so long as they do not go beyond their individual level of training and are under the supervision of the established

SOP 1. RESPONSE TO CBRN INCIDENTS

1.0 Nuclear and radiological incidents

1.1 General information on nuclear and radiological agents

Ionizing radiation is odorless and invisible. However, the source of radiation itself may be visible. There is alpha, beta, and gamma radiation. **Note:** More information on radiation resources should be sought in manuals on nuclear and radiation safety and protection.

Organic reaction to ionizing radiation may be delayed for a period of time; however, in the event of life-threatening injuries immediate rescue and medical treatment must not be postponed.

A radioactive material may enter an organism through the respiratory and digestive system by:

- Inhalation
- Ingestion
- Absorption through skin, i.e. open wound or through sketched skin
- Injection

In most cases, fire protection suits and SCBA systems provide first responders with sufficient protection.

To limit the radiation level, the period of exposure should be as short as possible with the maximum distance from the source of radiation.

Signs and symptoms of exposure to radiation:

- Psychosomatic reactions
- Panic
- Trauma and injuries caused by incendiary and explosive devices,
- possible burns, headaches, nausea and vomiting, feel of thirst.

Indicators of use of nuclear and radiological agents

- Open threat with nuclear/ radiological agents
- Groups claiming responsibility for the attack
- Use of aerosol

1.2 Recommended actions

- Consider the wind direction when choosing a line of approach to the incident site, or locations for casualty collection points (upwind, uphill or along a creek);
- Isolate the risk zone with a safety distance established in all directions; keep it under surveillance. The recommended distance is >100 meters. Use a radiological dosimeter to check the level of radiation; the level in the inner safety perimeter (hot zone) should not exceed 100 micro-Sievert per hour ($\mu\text{Sv/h}$);
- For safety reasons, prohibit access to unauthorized persons, individual or group access (mass gathering control);
- Keep the distance from the source of radiation. The more powerful the source is the larger the distance should be. Keep in mind that during a 'dirty bomb' detonation the radioactive material spreads to a wider area, which needs to be isolated;
- Consider immediate evacuation from the incident site, down the wind; in the event of fire – to a distance of 300 meters; in the absence of fire – to at least 100 meters;
- Warn the others about possible presence of small explosive devices with a radioactive content;
- Report the incident to other relevant local and higher authorities who participate in the response (counterterrorist and relief), support and investigation (other first response protection and rescue services, Civil Protection, hospitals and clinics, prosecution, BiH Armed Forces and relevant international organization through the state authorities);
- In action of removal of consequences engage a specialist in radiation protection and rely on his/her expertise regarding radiation effects and decontamination of people and equipment (specialist is supposed to be handy to On-Site Commander for efficiency of quick decisions and actions to take);
- Minimize the period of exposure, keep the distance from the radiation source and use solid structures as a shield;

- Never touch suspicious substances. Do not linger in the vicinity of a visible smoke or gas. If possible, cover the energy emitting object or place with sand or canvas to prevent and minimize further radiation;
- To prevent contamination, warn the rescuers not to consume food and water, and to refrain from smoking or consuming anything prior to inspection and decontamination;
- Check the level of radiation and keep control of radiation even outside the suspicious area/ zone (consult a radiology expert);
- Continue by checking the presence and level of radiation in other rescuers;
- Gather all radiation contaminated/ exposed persons at the first medical aid point. Provide them with a simple respiratory protection (a filter mask or ordinary dust protection mask);
- Even if the risk of secondary contamination is limited, you need to keep in mind that the rescuers must always use their personal protection equipment while helping people who have been exposed to radioactive substances. The casualties must be decontaminated prior to their transport to hospital for further treatment; otherwise, the vehicles, hospital premises and medical staff will be exposed to secondary contamination;
- Check and establish whether all rescuers and casualties on the site are contaminated prior to seeking permission to leave the contamination zone. In deciding about the inspection and decontamination, rely on the opinion of a radiology expert.

1.3 Important note

The On-Site commander or security officer on scene is responsible for safekeeping and delivering the evidence required for further investigation and forensic testing to the relevant authorities (prosecutors and crime technicians may only enter the site following the final CBRN ground clearance).

1. 4 Personal protection

- Minimum stay, exposure and contact with the substance;
- Keep the recommended distance (at least 100 meters from the source);
- Hide behind artificial and natural covers (buildings, vehicles, etc.);
- Rescuers' protection: NBC level C protective suit, firefighting suits with respirators, a particle filter mask;
- Technical assets and equipment: radiology detector for detecting the presence of nuclear/ radiological radiation.

1.5 INCIDENTS INVOLVING CHEMICAL AGENTS

1.5.1 General information on the characteristics of chemical agents

- In the event of accidental release or application of chemical agents, a large number of exposed individuals will most probably have similar symptoms in the first phase of contamination;
- The signs of exposure are as follows:
 - A large number of contaminated persons have a difficulty breathing;
 - Unconscious persons with minimal injuries or without any physical injuries;
 - Contaminated persons exhibit SLUDGEM signs/symptoms;
 - Red skin rash or skin blisters;
- The clothing of persons that have been exposed to chemical agents must be immediately taken off and the exposed individuals must undergo the decontamination process and receive first aid and the appropriate antidote. It is important to remember that certain agents require the application of specific decontamination agents;
- In case of the presence of some chemical agents, all persons suspected to have been exposed to contamination are to be gathered together at the point for the primary nursing of the injured and the sick until it has been determined what agent they were exposed to;
- The external indications of contamination are as follows:

- Incident/accident, or disaster, with major consequences for people but minimal or no damage to buildings, etc. The injured individuals do not have any signs of external trauma (as if they were sleeping);
- Injured or dead rescuers;
- Similar symptoms experienced by the contaminated individuals;
- Dead animals and destroyed vegetation;
- Unusual odors, smoke of unusual color, clouds of gas/steam, or possible presence of unusual metal residues;
- The most typical methods of expansion are as follows:
 - By way of the air conditioning system;
 - By way of mist generating systems or aerosols;
 - By way of atomizers (sprays);
 - By way of gas cylinders;
 - By use of a dirty bomb;
- Routes of exposure: inhalation, absorption through skin, ingestion;
- Signs and symptoms (see the Attachment to the Handbook).

1.5.2 Recommended actions

- Pay attention to wind direction when selecting the direction of access (upwind, uphill or upstream) and the location for nursing the exposed individuals;
- Isolate and maintain the safety zone and prevent access by unauthorized persons (at least 300 meters in all directions);
- Be aware of the presence of chemical agent dispersion devices;
- For security reasons, prohibit access by unauthorized persons, individual or group access (control of mass gatherings);
- Consider immediate evacuation from the place of the incident/accident, upwind, to the distance of:
 - 1.5 kilometers during the day and 30 kilometers at night – in case of blistering and nerve-paralyzing agents (including herbicides and insecticides causing the same symptoms as these agents);

- 300 meters at the minimum by day and 3 kilometers by night – in case of blood agents;
- Up to 300 meters in all directions in case of fire – in the event of blood agents;
- 400 meters at the minimum by day and 30 kilometers by night – in case of choking agents;
 - Up to 600 meters at the minimum, in case of fire – if choking agents are used;
 - 100 meters at the minimum – in case of an irritant agent;
- In case of knowledge or suspicion that a chemical agent is present, you are to immediately forward such piece of information to representatives of emergency medical services as well as to other authorized bodies, institutes and institutions at all levels which are involved in the response system;
- Do the decontamination before the transport in order to prevent secondary contamination by chemical agents (as in the attachments);
- Without delay and as soon as possible, inform hospitals on the chemical agents whose presence is suspected and on the actions that have been taken, as well as on other needs (additional number of antidotes, admission and triage, additional personnel, available beds and decontamination of the exposed individuals, and similar).

Important remark:

The Commander takes care of the keeping and submission to relevant authorities of evidence for further investigative actions and expert reports (prosecutors and crime technicians may access the site only once the final CBRN clearance of the ground has been done).

1.5.3 Individual protection measures

- Minimum stay near or exposure to and contact with the substance;
- Keep the recommended distance (100 meters at the minimum, upwind, until the presence of an agent is detected; in case of irritant agents up to 50 meters will suffice). Only the personnel in protective suits of the appropriate level of protection against steam/aerosol agents may enter the hot contamination zone

(the highest-level risk zone). ***Once the agent has been identified, the security level may change.***

- The level of protection of the rescuers (depending on the type of the chemical agent):
 - In the event of nerve-paralyzing, blistering and choking agents:
 - A rescuer's Self-Contained Breathing Apparatus (SCBA system) for respiratory protection and a protection suit consisting of a level B suit for outdoors situations, and a level A suit for indoors situations; or
 - A firefighting suit modified using duct tape to seal the cuffs and SCBA system for a brief stay and work outdoors or rescue activities (up to 30 minutes at the maximum);
 - In the event of irritant agents: suits of B and C levels of protection or firefighting suits with respiratory protection;
 - Technical assets and equipment:
 - Test indicator paper for liquids + steam/aerosols indicator set;
 - Poison gas and industrial gas detector – the gas meter;
 - Colorimetric tubes for agent tests;
 - Joint technical assets and equipment are not the subject of description herein.

1.5.4 Important remarks:

- There is no guarantee that 100 per cent of agents will be removed from the protective suits of the rescuers by the field decontamination;
- It is important to pay attention that not even a slightest damage is done to protective gear or otherwise the rescuer will definitely get contaminated;
- By taking off the contaminated clothing from the contaminated individuals 80 per cent of contaminants are removed.

1.6.0 INCIDENTS INVOLVING BIOLOGICAL AGENTS

1.6.1 General information on the characteristics of chemical agents

Biological agents are odorless and invisible. When the consequences of effects of a microbiological agent are visible, the agent has already gone;

Indications of biological contamination are as follows:

- Preceded by a threat or there is publicly claimed responsibility for an obvious and open attack;
- Unusual number of sick or dead people or animals;
- A suspicious incident involving an explosive device with a small damage from explosion or fire;
- Unannounced or unusual spreading of a cloud of spray;
- An abandoned sprayer or a spraying device;
- Laboratory containers;
- Labels marking biohazard culture or culture medium;
- Radial expansion of victims in the direction of wind.

Ways of biological contamination:

- By sprinkling of the agent with a spray;
- By way of contaminated postal consignments (letters, parcels);
- Bio-terrorist attack on vital facilities (water supply system, food, crops, water ways and similar);
- By way of dead or sick animals' bodies or contaminated food articles of animal origin;
- By way of a biological incident in a laboratory or a facility of pharmaceuticals industry;
- By way of detonation of small explosive devices (explosives of high destructive effect are less likely for high temperatures are harmful to microorganisms);
- Or some other (un)intentional way.

All microbiological agents have a certain period of incubation which renders it difficult to confirm a biological incident if no threat has been received (other epidemiological situations are monitored by authorized epidemiological institutes which carry out the

established and planned procedures in cooperation with clinics and large chemist's shops, which is not the subject of a separate consideration herein);

Due to the incubation period, the contagion is first discovered when the gravely ill seek medical assistance.

Therefore, the establishment of the primary nursing point is not relevant for biological incidents. If people are evacuated because of a (bioterrorist or similar) threat, they are, thus, to be isolated in a safe place until the contagion phase is over, in accordance with the instructions of the authorized specialist – infectologist and/ or microbiologist;

Unlike chemical agents, in the event of biological incidents, the contaminated individuals do not have to immediately take off their clothing and undergo decontamination. However, there are certain exceptions such as anthrax. The authorized physician (specialized in epidemiology – microbiologist/virologist) determines the decontamination procedure (when, who, in which order);

Transfer of contamination (with a microbiological agent) can take place by way of aerosol droplets from coughs (Fliget's droplets, and similar) or through a contact between a contaminated and an uncontaminated person. The common trait of all agents is that the entry point of contamination is usually the respiratory tract (refresh your knowledge of Vogralik's chain and the part on the biological agent symptoms given in Attachment 4), but they can also enter the body through consumption of food and water and through the skin – by skin contact;

The following categories of people are most risk prone to contamination with biological agent/pathogen microorganism and as such have the first priority for vaccination:

- Persons working directly with microorganisms in laboratories;
- Police and customs officers on border crossings during inspections of merchandise and people;
- Experts (veterinarians) who, due to the nature of their work, get in contact with infected animals and food articles of animal origin;

- Members of response teams who due to the nature of their mission and tasks enter the contamination zone (fire fighters, medical staff, police officers, members of specialized team for biological protection – detection, sample taking and identification, as well as members of the armed forces if they render assistance to civil forces).

1.6.2 Recommended actions

- Always pay attention to the wind direction when selecting the direction of approach to and entry into the contaminated zone (upwind, uphill or upstream);
- In the event of contagion or if there is an explicit threat thereof, isolate and secure the area of the indicated contagion at issue. The size of the risk zone depends on the type of contagion that is suspected (minimal distance from the contagion source in all directions is 100 meters).
- If an incident happens in a building, it is necessary to:
 - Seal the building;
 - Close the windows and doors;
 - Turn off air-conditioning equipment;
- Gather together in one place all those who may have been exposed to contamination, keep them in temporary isolated place till “distance nursing” is organized (involving safety of responders, safety of facilities and transportation means, organization of isolators and quarantine and bio decontamination of vehicles, personnel and facilities);
- Collect information on:
 - The veracity of threat;
 - Type of agent and its physical form (powder, aerosol or spray);
 - How the agents came to the incident site/location;
 - The location where the agent is present – where is the agent?
- Immediately thereafter call the authorized physician specialized in epidemiology /microbiology – the virologist, or some other specialist, for the purpose of estimating the risk and receiving instructions for action. Inform other relevant authorities at the local and other levels at which the response is organized and

support is lent (hospitals, the Prosecutor's Office, Civil Protection Authority, relevant ministries, non-governmental organizations – the Red Cross, and others), for the purpose of organizing the transport and the reception of and giving group medical care to the contaminated individuals;

- When treating the contaminated individuals in the contamination zone, in the initial phase take samples for the identification of the suspected microbiological agent. The samples are to be taken from the environment as well (like, for example, for the identification of anthrax);
- Refer the contaminated individuals to the medical staff who will nurse them in accordance with the instructions of the authorized physician specialized in epidemiology /microbiology - the virologist (except in cases where the incident commander is himself such a specialist);
- Do the decontamination in case of suspected or confirmed exposure to contamination with an agent, i.e. anthrax:
 - Do the decontamination with warm water and soap in a shower cabin;
 - Put the personal belongings of the contaminated individuals in the marked plastic bag and seal it for the further decontamination or destruction in case of the inability of reliable decontamination (the minutes should be made thereof);
- Avoid contact with pools, wet surfaces, and similar;
- Check the inlet and outlet installations of air conditioners, etc., in order to detect traces of microbiological agents or their spreading vehicles.
- Allow for the access to the incident site only by the authorized persons who have the protective gear and who are members of the response teams, while other authorized persons (the Prosecutor's Office and other investigative bodies) are allowed to enter the incident site only once the incident site has been cleared, i.e. once the CBRN clearance of the ground has been done.

1.6.3 Important remarks

- In the event that a suspicious object, substance or consignment is discovered in a timely manner, the police and the relevant CBR protection service are to isolate

the area (using the prescribed protection gear), and safely remove the object at issue and secure the evidence for further analysis and expert reports;

- At any rate, the incident commander is responsible for safekeeping the **evidence and forwarding them for further procedure**;
- The organization of teams and the estimate of required forces and measures for the recommended actions will be done by the incident commander.

1.6.4 Personal protection measures

- Spending minimal time at the site, minimal exposure to or contact with the substance;
- Keep the recommended distance (100 meters at the minimum, upwind, until the agent is detected and identified). Only the staff with protective suits of the required protection level are allowed to enter the risk zone;
- The level of protection of the rescuers:
 - Rescuer's Self-Contained Breathing Apparatus (SCBA system) and the suit of B or C level of protection from biological agents;
 - Or firefighting suits with respiratory protection;

(Following the information on a biological incident one is always to wear adequate protection gear when entering the contaminated zone);
- Technical assets and equipment:
 - Universal CBR detector;
 - Instrument for on-the-spot sample analysis.
 - Accessories for taking bio sampling and equipment for transportation of dangerous materials.

1.6.5 Important remarks concerning protection measures:

- ⇒ There is no guarantee that 100 per cent of agents will be removed from the protective suits of the rescuers by the field decontamination;
- ⇒ It is important to pay attention that not even a slightest damage is done to protective gear or otherwise the rescuer will definitely get contaminated;
- ⇒ The persons contaminated with a biological agent are in principle treated following a special procedure of a distance bio treatment (distance nursing).

1.7.0 INCIDENTS INVOLVING EXPLOSIVE DEVICES OF HIGH DESTRUCTIVE EFFECTS

1.7.1 General information on explosive devices

- Explosive devices may be designed so as to sprinkle/spread radioactive, chemical and biological agents;
- Explosive devices may involve secondary risks such as unstable building structure, installation damage, parts of a wrecked building still standing, and other physical hazards;
- They can contain different elements intended for killing people such as nails, various fragments or other materials;
- External indications of explosives:
 - Consider the imagined scenarios. Does it appear to you that something is wrong in the area at hand?
 - Has an oral or written threat been received?
 - Is there a packaging/container/vehicle that does not fit into the site at hand?
 - Are there any devices that have the shape or remind of a gas cylinder, cylinder with flammable liquid, pipe-like packaging or various other packaging containing chemicals or other hazardous materials?
 - Is there any pressure- or tripwire-activated mines?
 - Are there any obvious parts or remains of explosive devices (timers, dynamo chargers, detonating cords or blasting caps, explosive caps, tripwires or similar)?
 - Large packages with stains of oil, odor of chemicals, visible wires, large postal parcel boxes without the sender's address;
 - Are there any suspicious postal consignments (parcel boxes, containers) or abandoned vehicles which reasonably do not belong to the site;
- External indications of inflammable devices:
 - Has an oral or written threat been received?
 - Fires burning at several locations;

- Presence of containers with inflammable liquid;
- Can any fire-setting and fire-spreading stimulators be detected (agents for accelerating the spreading of fire, a typically high temperature, unusual presence of materials or open sources instigating burning and explosion, and similar)?
- Charge residuum;
- Signs of forcible entrance and/or blocked exits;
- Household appliances or other household objects that are atypical for the place where they are found, and similar.
- In the event of a terrorist threat it is required to act cautiously if the caller that planted the explosive says that the explosion is imminent. There is a great possibility that the device will go off before the set time.
- The deadly/ damaging effects of explosive and inflammable devices are as follows:
 - Mechanical effect – ejecting the victim;
 - Chemical effect (a possibility in case of inflammable devices);
 - Thermal effect (in case of both explosives and inflammable devices);
 - Possible etiologic effect (in case of explosives);
 - Possible radiological effect (in case of explosives);
 - Possible suffocation effect (in case of inflammable devices).
- Signs and symptoms:
 - Mechanical injuries (i.e. a blunt blow);
 - Burned or carbonized clothing;
 - Injuries caused by a missile, impaired hearing;
 - Temporary or permanent blindness;
 - Bleeding from ears;
 - Skin and respiratory tract burns;
 - Traumatic shock and coma.

1.7.2 Recommended actions

Recommended actions concern actions in the event of unexploded explosive ordnance, active explosive ordnance and inflammable devices. The Incident Command Site is to be located outside the area where these types of explosive ordnance may possibly be located, depending on specific indications listed above.

a) Explosive ordnance (EO)

- Approach the site with great caution (upwind and having turned off devices at hand emitting signals and other similar devices for you still do not know what type of explosive device is deployed);
- Distribute the arriving response teams:
 - Away from the area close to the suspicious or positively dangerous device;
 - Away from the buildings with a lot of glass surfaces;
 - In such a way that the existing buildings and/or natural barriers can be used as a shield.
- Isolate and mark the risk zone/prevent unauthorized entries (300 meters at the minimum in all directions from the place where the device is located);
- Mark the outer safety perimeter considering the size/amount of explosive ordnance. Consider the need for the evacuation of teams and citizens to a distance of at least 1 kilometer in all directions as well as the introduction of a limited restriction of the air space;
- Try to learn important information on the unexploded ordnance:
 - What kind of threat does it pose?
 - Place and location;
 - Time when it was detected;
 - Packaging;
 - Type of ordnance/device;
- If you are the Commander or Safety Officer issue the order to turn off all devices operating in the internal safety zone which emit signals (radio devices, cell phones, etc.
- Estimate the security situation (risk zone) at the site:

- External safety zone > 1,000 meters; depending on the neighboring area this distance may decrease (buildings, local protection, etc.);
- Car bomb = 450 meters (increase the distance for large vehicles);
- Parcel bomb = 300 meters (increase the distance for large parcels);
- Tube bomb = 300 meters (increase the distance depending on the size of the bomb and the thickness of the tube);
- If you are the Incident Commander or Safety Officer forbid the access of unauthorized personnel (the police will take measures to control the crowds);
- If you are the Commander) inform hospitals and other authorized bodies at the local and/or higher levels of response and support (depending on the evaluation of the situation, consequences and needs);
- Organize a quick medical treatment, admission, triage and further massive medical nursing (assess the need for additional transport means);
- Secure and keep evidence, and facilitate the further investigation activities only after having created a safe environment for the arrival of representatives of the Prosecutor's Office and other investigative bodies;

Important remark:

When handling explosive ordnance, do not ever act in a casual and routine manner. Every such ordnance is a potential booby trap.

b) Unexploded ordnance (UxO)

The Incident Command post is to be located outside the area where these types of explosive devices may possibly be located, depending on specific indications listed above.

- Always be prepared for secondary explosive devices;
- Assess the situation at the site and the required human and material and technical resources;
- If possible, evacuate all inhabitants and effected persons from the risk zone;
- Find, secure and keep the evidence;
- Act further as in the case of unexploded explosive ordnance.

c) Inflammable ordnance

The Incident Command post should be located outside the zone in which, according to indicators, incendiary devices could be located.

- It is necessary to always consider the safety of personnel; an incendiary device may include additional threats which are not perceivable in the initial phase, including:
 - a. Fast propagation,
 - b. High temperatures,
 - c. Multiple sources,
 - d. Risk of destruction of facilities or cave-in of facilities,
 - e. Explosion risk,
 - f. Chemical effects,
 - g. Booby traps planted for responders.
- Consider safety at the site and secure, i.e. isolate, a large enough zone to prevent further casualties in the event that incident propagates beyond the presumed direction of propagation (at least 100 meters in all directions).
- Consider the safety of the injured - they must be immediately evacuated to a safe location.
- Consider immediate evacuation of persons in danger (unprotected responders, workers or local population) in the following way:
 - Downwind if there is no fire, at a distance of at least 300 meters from the device,
 - In the event of fire, at least 850 meters from the device.
- Consider rescuers and equipment safety; rescuers and their equipment may be terrorists' or criminals' targets.
- Warn all the rescuers of the potential presence of booby traps and other potential hazards.
- Beware of possible secondary incendiary devices.
- Prohibit (incident commander or safety officer) access to unauthorized personnel (police take mass control measures)

- In the event it is necessary, mark the device located, do not take any individual action, inform responsible bodies (TPDF, TPF, and FRF) and request specialists to handle the high-risk device.
- Inform (if you are incident commander) hospitals and other relevant local or higher-level response and support organizations (in accordance with the commander's and medical assessment of the situation, consequences and needs).
- Organize a quick priority medical assistance, reception, triage and further mass medical care (assess the need for additional transport means)
- Secure and protect evidence and facilitate further investigation; only once the secure climate is ensured, a prosecutor and other investigative authorities may come to the site

1.7.3 Measures of personal protection against explosive and incendiary devices

- Minimum stay, exposure to or contact with substances.
- Maintain the recommended distance (minimum 100 m upwind for incendiary devices or 300m for explosive devices until the device/ substance is detected and identified). Only persons with adequate protective clothing may enter the risk zone.
- Use a strong and safe shelter (a building, a vehicle or similar).
- Protection levels for rescuers:
Fire suit with rescuer's Self-Contained Breathing Apparatus (SCBA system) or some other type or adequate respiratory protection,
Protective anti-bomb or demining equipment (Kevlar helmet with vizier), reinforced protective clothing and shoes.
- Technical means and equipment
 - EOD metal detectors
 - Demining or bomb squad's UxO kit
 - Gas meter (to monitor the concentration of incendiary substances in the air, the lower explosive limit, and the concentration of CO in working areas) – for incendiary devices

- Colorimetric reading tubes for incendiary devices
- Sample collection kit for laboratory analyses for explosive and incendiary devices and means
- Other detection methods: Explosive detection dogs

1.8.0 FIRE INCIDENCE FIRST RESPONDER

Principally, following establishment of safety on scene, fire fighters shall always be the first to enter risky zone and determine nature of occurred incident and type of hazard. Incident commander should be firefighter (starting event for response to incident is delivered information on type of an incident and on visible indicators).

When firefighters are first at the site, the unit commander:

- Selects an appropriate access route to the site, under the following conditions:
 - Enters the site with the utmost caution and upwind,
 - Enters the area of the indicated CBRNE attack/ industrial incident and verifies if agents are present (indicator tapes and adequate instruments),
 - Determines an assembly point for incoming response units (according to quick survey of the scene organizes back up pairs that would enter risky zone);
- Isolates the initial risk zone (outer and internal safety perimeter) and prevents entry in the risk zone:
 - The width of the risk zone must be constantly reassessed (note: for the entire duration of the operation and until terrain clearance).
- In accordance with the initially established risk zone, in consultations with medical team leader determines the primary casualty collection point (within the 'golden' 10 minutes) where a medical team will provide priority decontamination and medical treatment (***in accordance with the instructions for medical team procedures***).
- Assesses the safety of response actions/operations in light of the incident/accident that has occurred.

- Provides for the safety of CBNRE rescuers on the ground, i.e.:
 - Sets up a safety distance,
 - Shortens the time of exposure to the agent in question,
 - Uses available local facilities for protection (buildings etc.),
 - ***Ensures that all rescuers have adequate protective equipment.***
- Reduces the number of people exposed to negative effects of CBRN means.
- Prepares and organizes the work on setting up mobile decontamination stations for rescuers in the contamination zone (all who found themselves in the contamination zone must undergo decontamination, which is the commander's responsibility and the responsibility of the person in charge of safety).
- Organizes reconnaissance, detection, identification and measuring of concentrations of CBRN agents within contaminated area (in lack of their own tents, CBRN reconnaissance teams can rely on use of decon tents of other operating teams for dressing protection suits and subsequent decontamination).
- Collects information on the incident and its consequences (number of victims, etc.)

If the firefighters are in command of the site, the incident commander:

- Establishes a joint command post for all the involved responders to coordinate actions/operations (if the police arrived first at the site and established the outer safety perimeter, the firefighter in charge will take over the site and learn about the situation and consequences.)
- Organizes and launches local population rescue actions/operations, i.e.
 - Assistance in lifesaving operations (for example delivery and assistance in the use of civil protection kits etc.),
 - Evacuation of casualties to the primary casualty collection point for further medical and decontamination treatments,
 - Determines the need to alarm and warn citizens of the CBRN danger.
- Marks other dangerous and suspicious items and calls specialist teams for their safe removal (Police anti-bomb unit, TPDF, etc.)

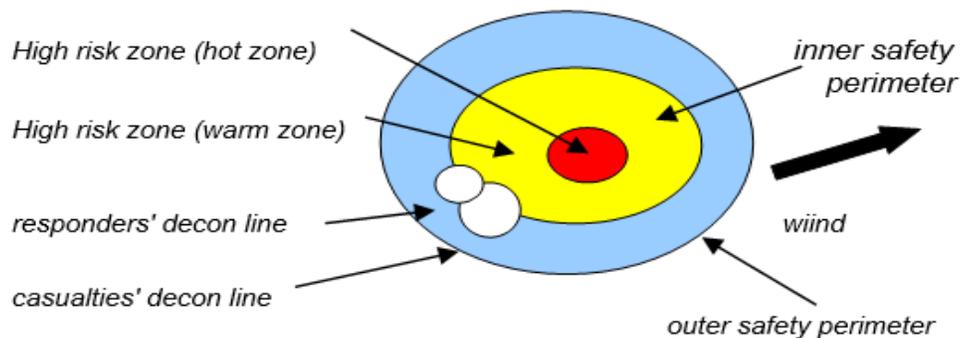
- Informs other relevant bodies, services and organizations (operational centers and civil protection headquarters and, through them, hospitals and other institutions) on the situation and needs.
- Requests additional resources (for example CBRNE experts, mobile laboratories, etc.),
- Coordinates with medical, police and rescue team leaders,
- Directs, and, if necessary, is personally involved in the initial triage, nerve paralyzing poison antidote administration and provision of emergency medical assistance.

1.9.0 DECONTAMINATION REQUIREMENTS

Rescue personnel, equipped with the minimum required personal protective equipment (fire protection suit) and SCBA system, may approach the injured people and extract them from the vicinity of the contamination source until the decontamination zone is established (protection level for the rescuers depends on the nature of agent).

The decontamination zone must be established along the inner safety perimeter and in the direction of the wind (facing the wind), as illustrated on picture. Both decontamination zones (for the rescuers and for the injured) are established along the inner perimeter and, preferably, near each other. In the event of a terrorist attack, each injured civilian should be accompanied by a police officer (member of the anti-terrorist unit), because **in the event of terrorist attack all individuals found at the site will be considered suspects until the investigation procedure has been completed!**

Establishment of risk zones and decontamination lines should be as below:



Legend:

- Red area in the inner safety perimeter – contamination hot zone,
- Yellow area in the inner safety perimeter - contamination warm zone,
- Blue area in the outer safety perimeter – no contamination – cold zone.

Note: Unauthorized personnel must not stay in the area immediately outside the outer safety perimeter. This perimeter is protected by regular Police force, and the area immediately outside the perimeter is reserved for vehicles transporting injured and the victims.

If in accidental scale there are more contaminated civilians then decon line for civil population should be established as well

During decontamination of affected people on incident location (or mass decontamination of local inhabitants in case of an accident), it is necessary to consider cultural differences among people, if any.

CBRN specialists (from a university or an institute – a rescue and protection service, who can develop models and predict possible affected areas based on the nature of the detected agent and weather conditions) and the safety officer (usually from the police or fire department, or even a civil protection agency) assist the incident commander in establishment and control of the safety perimeters. To ensure efficiency, it is advisable to have already assigned personnel to these positions.

1.8.2 Decontamination instructions for rescuers

With regard to general instructions, immediately after the establishment of contamination/risk zones, decontamination must be conducted in accordance with the following instructions:

- Gather intoxicated and contaminated personnel at the decontamination zone near the decontamination line;
- Evaluate contamination signs/ symptoms to determine the nature of the agent (use tables with physical, chemical and toxic properties of chemical agents).
- Conduct checks of the **rescuers' personal protective equipment before they enter the contaminated area (*no damage to equipment*)** and make sure that the equipment is used properly inside the decontamination area;
- Provide appropriate first aid treatment in the decontamination zone:
 - as soon as possible, remove clothing (and/or protective equipment) to prevent further exposure to agents and provide warm blankets,
 - ensure decontamination material in the event of exposure to chemical weapons,
 - rinse eyes, nose and mouth with clean water to reduce exposure of respiratory system and mucus membrane to agents,
 - wash face, scalp and hand with water,
 - keep away and avoid contact with contaminated clothes of the injured;
- Perform full decontamination of the injured before their transport to avoid spreading of contamination. If necessary, provide simple respiratory protection (filter masks or dust-protection masks);
- When the situation calls for improvisation, organize ad-hoc decontamination at improvised decontamination site and use warm water from fire engine water tanks. When applying improvised solutions, always respect the privacy of the injured (**consider cultural differences in the process of decontamination**);
- In case of a large number of civilian victims, lifesaving operations must be given priority over collecting water resulting from decontamination. In such cases, when possible, and depending on emergency of case, consider conducting

decontamination in an area where decontamination waste water can be safely discharged;

Note: If response time allows, it is always necessary to dissolve released CBRN agent in an adequate chemical process, making thus CBRN agent harmless for environment and people.

- Clothes of the victims should be kept in personal plastic bags with labels. The same applies to any valuable belongings of the victims;
- After decontamination, dry up the injured and protect them from cold (provide clean clothes or blankets);
- After decontamination, take the victims to the unit for further treatment of all injured and uninjured persons;
- Make sure that the victims do not enter the decontamination showers with their clothes on. There is a significant risk of increased exposure to contamination because the agents dissolved in water may come in contact with skin and cause additional contamination;
- the rescuers in the risk zone (contaminated area) must also be decontaminated;
 - The rescuers who cannot perform self-decontamination and their protective equipment should have a priority in decontamination. This especially applies to rescuers using „A“ level protection, with limited oxygen container capacity (prioritized decontamination after maximum of 40 minutes inside contaminated area);
- If assessment of situation on incident site requires, to consider option of establishment of additional decontamination lines, and particularly:
 - decontamination lines for local population and casualties (slightly or severely injured persons exposed to contamination),
 - additional decontamination line for responders,
 - to consider option of involvement of robust decontamination systems, if major number of civilians (workers and local people) exposed to contamination.
- A decontamination station can also be located outside the hospital building, for the victims who seek individual treatment and care.

SOP 2. EMERGENCY RESPONSE GUIDEBOOK (ERG)

2.1 Introduction

The Emergency Response Guidebook (ERG) provides summary information on potential hazards, public safety and emergency response to unintended releases of goods being transported by road, rail, air, water or pipeline.

The *ERG* helps personnel to quickly identify hazardous materials at an incident site; recognize the potential hazards associated with the material(s); gather public safety guidance; and execute recommended emergency response actions. It allows personnel to quickly and effectively identify hazards based on UN numbers, labels, colors, markings, and container shapes. Use of the ERG is required for all levels of responders.

The Guidebook should not be considered as a substitute for emergency response training, knowledge or sound judgement. It is important to carefully consider your personal actions before committing. If you deem personal action appropriate, the incident site should be approached from upwind, uphill, and upstream. Make every effort to avoid contact with spills, vapors, fumes, smoke, and other potential hazards.

The ERG is issued every four years as a book and is also available in digital format for access on a computer, tablet, or smartphone (Android and iPhone).

2.2 Objectives

- Identify hazard information using the ERG
- Identify response actions based on scenario provided
- Identify changes in tactical operations as conditions change

2.3 Review of the ERG

The placards and labels are required on hazardous materials during transportation. It is important to understand the systems which are used to identify hazardous materials. Hazard information is included on placards fixed to large containers (trailers, rail cars,

tanks) and manufacturer labels fixed to small containers (drums, packages, boxes). The system looks like Diamond-shaped.

Caution must be exercised, because labels and placards may be missing, incorrect, or difficult to read.

Color-coded.

| Color | Hazard |
|--------------------------------|---|
| Orange | Explosive |
| Red | Flammable or combustible |
| Green | Non-flammable gas |
| Yellow | Reactive oxidizer or organic peroxide |
| White | Toxic/Poisonous or infectious substance |
| White and red vertical stripes | Flammable solid |
| White top with black bottom | Corrosive |
| Blue | Dangerous when wet |
| Yellow top with white bottom | Radioactive |
| White top with red bottom | Spontaneously combustible |

Below is an example of the placard for flammable or combustible (red)



2.4 Word-coded (hazard class name)

- Explosives
- Corrosive
- Dangerous (may be used with mixed loads)

The placard for a radioactive hazard



Symbol-coded

| Symbol | Hazard |
|--------|--------|
|--------|--------|

| | |
|----------------------|-----------------------------------|
| Bursting ball | Explosive |
| Flame | Flammable/organic peroxide |
| W with slash | Dangerous when wet |
| Skull and crossbones | Poisonous |
| Circle and flame | Oxidizing material |
| Cylinder | Non-flammable gas |
| Propeller/Trefoil | Radioactive |
| Test tube/hand/metal | Corrosive |
| Special symbol | Infectious (discussed previously) |

The placard with the symbol for a corrosive hazard



Number- coded

A **four-digit UN** number in the **center** identifies a specific compound. These numbers are identified in the ERG. For example, 1223 is kerosene. This number may be in the center of the placard or on an orange-colored panel below the placard.

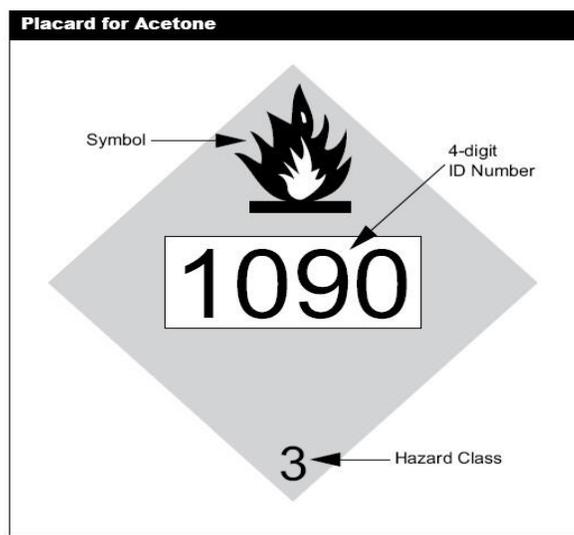
The placard above has the number 1760, which identifies it as one of several corrosive liquids. The **one-digit** number at the **bottom** is the Hazard Identification Code.

1.5. Hazard Class

1. Explosives
2. Gases (compressed, liquefied, or dissolved under pressure)
3. Flammable liquids
4. Flammable solids or substances, spontaneously combustible materials, and dangerous when wet materials/ water-reactive materials.
5. Oxidizing substances and Organic peroxides
6. Poisonous and infectious substances
7. Radioactive substances
8. Corrosives

9. Miscellaneous dangerous substances/ organisms

The placard below is red with white symbols except for the black four-digit number. It tells the substance is Flammable (the flame and red background), a Flammable Liquid (Hazard Class 3), and Acetone (the four-digit number 1090).



The acetone placard is called a “number placard,” which means that the number in the center of the placard specifies the exact contents of the container. “Word placards” are so named because a word designating a type of hazard (e.g., flammable) will be printed in the middle of the placard. Number placards must be displayed on large portable tanks, tank trucks, and rail cars. A word placard means that drums or smaller containers are present.

2.6 Using the ERG Book

To use the guidebook, you need to know either the chemical name or the identification number.

The Guidebook is divided into five sections, including white instruction pages at the front. The borders of the pages are colored so that you can plainly see the sections. These sections are used to determine the appropriate response for the hazardous material or dangerous good that is involved in an emergency:

1. **Yellow Pages- Identification Number Index:** This index allows you to look up the hazardous material or dangerous good *by UN or ID number*. It provides the material name, and directs you to the proper response guide in the Guide Number Index (Orange Pages).
2. **Blue Pages- Material Name Index:** This index allows you to look up the hazardous material or dangerous good *by name*. This directs you to the proper response guide in the Guide Number Index (Orange Pages), and provides the UN/ID number.
3. **Orange Pages- Guide Number Index:** This section contains the safety guides that form the basis of an emergency response. Each category of hazardous material corresponds to a numbered response guide in the Guide Number Index. The guides contain details on:
 1. the hazards and health risks of the material;
 2. appropriate public safety measures, such as evacuation;
 3. emergency response actions, such as what to do in the event of fire or spills;
 4. appropriate first aid and more.
4. **Green Pages- Initial Isolation and Protective Action Distances Index:** Evacuation distances for some very hazardous materials. The Green Pages consist of three tables to consult when the material involved is highlighted in green in either the Yellow or Blue pages:
 - Table 1: Initial Isolation and Protective Action Distances
 - Table 2: Water-Reactive Materials Which Produce Toxic Gases
 - Table 3: Initial Isolation and Protective Action Distances for Large Spills of Different Quantities of Six Common Toxic Inhalation Hazard Gases
5. **White Pages- Additional Information:** These pages describes the Instructions for using the guide This section includes:
 1. a glossary of terms,
 2. a user guide, and
 3. other helpful information.

2.7 Caution

When you look at the orange and green pages, it is obvious that much of the information is **NOT** meant for people trained at awareness level, which is the level of this training. For example, the orange guides may say to put on an air tank (SCBA) and spray water or foam on the spill--you're not going to do that!

The same principle applies to the green pages. You should move to a safe distance and stop people from going towards the spill, but you aren't going to go door-to-door and evacuate people in the immediate area of the incident.

2.7.1 Looking up a material

Step 1: Identify the material involved in the emergency. This will help direct you to the appropriate response guide within the Orange Pages.

a) Check the container for an explosive placard or label.

- If there is an explosive placard in Division 1.1, 1.2, 1.3 or 1.5 - Refer to GUIDE 112 in the Orange Pages for further instructions.



- If there is an explosive placard in Divisions 1.4 or 1.6 - Refer to GUIDE 114 in the Orange Pages for further instructions.



b) If you know the UN/ID# for the material:

ID numbers are listed in numerical order in the Yellow Pages section of the ERG. As an example, if the material is UN1013, find that ID number in the Yellow Pages. The listing in the Yellow Pages will direct you to the correct Guide Number in the Orange Pages, in this case Guide 120.

| ID No. | Guide No. | Name of Material |
|--------|-----------|----------------------------|
| 1013 | 120 | Carbon dioxide |
| 1013 | 120 | Carbon dioxide, compressed |

| GUIDE 120 | GASES - INERT (INCLUDING REFRIGERATED LIQUIDS) |
|---|--|
| POTENTIAL HAZARDS | |
| HEALTH | |
| • Vapors may cause dizziness or asphyxiation without warning. | |

c) If you know the name of the material:

Names are listed in alphabetical order in the Blue Pages. As an example, if the material is “Carbon dioxide,” find that name in the Blue Pages section of the ERG. The listing in the Blue Pages will direct you to the correct Guide Number in the Orange Pages, in this case Guide 120.

| Name of Material | Guide No. | ID No. |
|----------------------------|-----------|--------|
| Carbon dioxide | 120 | 1013 |
| Carbon dioxide, compressed | 120 | 1013 |

| GUIDE 120 | GASES - INERT (INCLUDING REFRIGERATED LIQUIDS) |
|---|--|
| POTENTIAL HAZARDS | |
| HEALTH | |
| • Vapors may cause dizziness or asphyxiation without warning. | |

d) If you do NOT know the ID# OR the name of the material:

- Check for markings, labels, and placards on the container of hazardous material or dangerous goods. Refer to the “Table of Markings, Labels and Placards” pages near the front in the ERG. The number inside the black circle next to each group of placards will direct you to the correct guide in the Orange Pages.

Step 2: Green-highlighted materials and polymerizing materials

If, in either the Yellow or Blue Pages, the material's Guide Number is followed by a "P," this indicates that that material may be subject to violent polymerization. This means the container may rupture or explode.

- If the "P" material IS NOT also highlighted in green, proceed to the appropriate guide in the Orange Pages:

2983 **131P** Ethylene oxide and Propylene
oxide mixture, with not more
than 30% Ethylene oxide

Letter "P" but NO green = OK to proceed to Guide 131 in the Orange Pages

- If the "P" material name IS also highlighted in green, an initial isolation and protective action distance will apply to that material; check TABLE 1 in the Green Pages.

1082 **119P** Refrigerant gas R-1113
1082 **119P** Trifluorochloroethylene,
stabilized

Letter "P" AND green = Consult Table 1 in Green Pages AND Guide 131 in Orange Pages

- If the material highlighted in green IS ON FIRE:
 - First use the appropriate guide in the Orange Pages for EVACUATION distances;
Then protect in a downwind direction according to TABLE 1 of the Green Pages.
- If the material highlighted in green IS NOT ON FIRE:
 - First check TABLE 1 in the green pages for isolation and protective action distances;
 - Then consult the appropriate guide in the Orange Pages.

- If the material's name in TABLE 1 includes the notation (when spilled in water), consult TABLE 2 in the Green Pages for a list of generated gases, check the appropriate guide number, and DO NOT USE WATER as an extinguishing agent if the material catches fire.

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TABLE 1 - INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES

| ID No. | Guide No. | NAME OF MATERIAL | SMALL SPILLS (From a small package or small leak from a large package) | | | LARGE SPILLS (From a large package or from many small packages) | | |
|--------|-----------|---|---|---|-----------------------------|--|---|-----------------------------|
| | | | First ISOLATE in all Directions Meters (Feet) | Then PROTECT persons Downwind during | | First ISOLATE in all Directions Meters (Feet) | Then PROTECT persons Downwind during | |
| | | | | DAY Kilometers (Miles) | NIGHT Kilometers (Miles) | | DAY Kilometers (Miles) | NIGHT Kilometers (Miles) |
| 1162 | 155 | Dimethyldichlorosilane (when spilled in water) | 30 m (100 ft) | 0.1 km (0.1 mi) | 0.2 km (0.2 mi) | 60 m (200 ft) | 0.6 km (0.4 mi) | 1.8 km (1.1 mi) |

TABLE 2 - WATER-REACTIVE MATERIALS WHICH PRODUCE TOXIC GASES

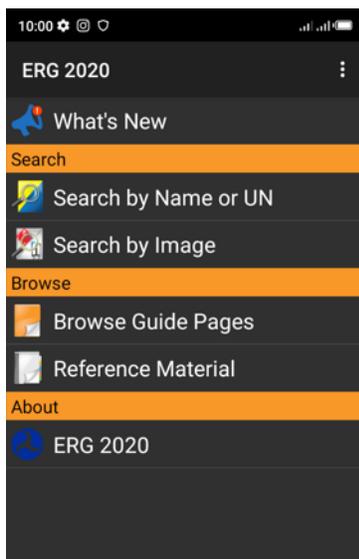
Materials Which Produce Large Amounts of Toxic-by-Inhalation (TIH)
(PIH in the US) Gas(es) When Spilled in Water

| ID No. | Guide No. | Name of Material | TIH Gas(es) Produced |
|--------|-----------|------------------------|----------------------|
| 1162 | 155 | Dimethyldichlorosilane | HCl |
| 1183 | 139 | Ethyldichlorosilane | HCl |
| 1196 | 155 | Ethyltrichlorosilane | HCl |
| 1242 | 139 | Methyldichlorosilane | HCl |

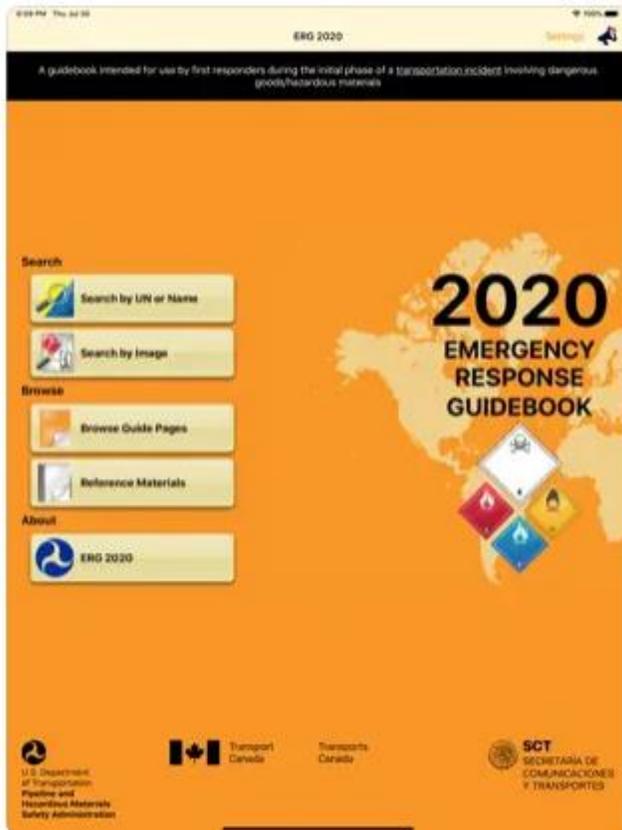
Using the ERG App

When first opening the app or software, the home page will look different depending on the device you are using, but will basically work the same way. Here is what each home pages will look like:

Home page for Smartphone (Android or iPhone)



Home page for Windows



2.7.2 Using the Emergency Response Guide

The ERG is divided into sections, each with its own color. The typical starting point is looking up a substance by name (blue pages), ID (UN) number (yellow pages) or image (placard, rail car, trailer).

YELLOW: The yellow pages list chemicals in numerical order based on their assigned ID number (UN number). If you are reading a placard or label which has a four-digit number in the center, you can look up the chemical name in the yellow pages, which will tell you the name of the chemical and the Guide number. When using the app, you simply type the number into the Search by Name or UN field.

BLUE: The blue pages list chemicals alphabetically by their name. From this listing you can determine each chemical's ID number and the Guide number. When using the app, you simply enter the chemical name into the Search by Name or UN field.

ORANGE: The orange pages are called the Guides. These pages are of use in determining the potential hazards of the chemical in question, with the greatest concern listed first. Additionally, the Guides give a brief description of the emergency action that should be taken by appropriate emergency response personnel. When using the book, you must first find the appropriate Guide Number by looking in the yellow or blue pages or referring to the Table of Placards. When using the app, you are immediately taken to the appropriate Guide Number when you select the chemical name, ID number, or placard (Note: with some chemicals you may receive guidance based on if a fire is involved before proceeding to the Guides).

GREEN: Some chemicals are also included in the green pages. The green pages indicate the Table of Initial Isolation and Protective Action Distances. This section of the ERG describes the distances necessary for initial isolation around a chemical incident as well as the distance downwind that persons must be protected.

Book: Chemicals that are highlighted green in the blue and yellow pages will be found in Table 1 (green pages). If the name of the material in Table 1 is followed by “(when spilled in water)”, consult Table 2 for toxic gases produced. If there is an asterisk next to the ID number in Table 1, also consult Table 3.

Smartphone: If a chemical has green page you will see at the top of the screen the words Initial Isolation and Protective Distances. You can access the green pages by pressing those words or swiping left.

iPad: The green pages information will automatically appear on the right side of the screen.

Windows: The green pages information will automatically appear at the bottom of the Guide.

In addition to the Protective Distance information found in Table 1 (green pages) some chemicals have information about toxic gases produced “when spilled in water” (Table 2). When using the app, this information is listed at the bottom of the green section, “TIH gas(es) produced when spilled in water”.

Six common TIH gases have additional information provided by type of container (Table 3). When using the app, this Table 3 information will be available at the same location as the other Protective Distance information.

PLACARD: The Windows app also allows you to search by image of Placard, Railcar, or Trailer by selecting this option on the home screen or navigator bar at the top. With your smartphone or iPad, select Search by Image and then swipe down to select the placard of interest. You can navigate to the Railcar and Trailer sections by swiping left (smartphone) or buttons at top (iPad).

PROTECTIVE DISTANCE MAPPING: Digital formats will display protective action distances in real time using your devices GPS location. From the Guide or green page, select the distance cone icon or ‘Map.’ You will be asked about the spill location, wind direction and speed, size of spill, container type, and time of day. You will then be able to view the protective distance area on the actual map of the spill area.

Other notes when using digital format:

- You can review the orange pages by selecting “Browse Guide Pages” on the home screen.
- You can look at the white and green reference pages and ‘How to use this app’ by selecting Reference Material on the home screen.
- When using a smartphone or iPad, selecting the picture of a book at the top of the screen will open the ‘User Guide’
- When using a smartphone, select the 3 dots at the top to return to the home screen.
- When using an iPad, use the back arrow (<) at the top right to return to the home screen.

- When using Windows, use the symbols at the top or 'Search by' to navigate.
-

2.8 Emergency Response Guidebook

Key Points

- 1) The Guides given in the Emergency Response Guidebook (ERG) are only general minimum recommendations.
- 2) The ACTIONS described in the orange and green sections are for firefighters or HazMat teams only!
- 3) The yellow and blue sections help you identify materials and point you to a Guide in the orange section.
- 4) The Orange section of the NAERG Guidebook provides information on health, fire and explosion hazards and a guide for emergency action.
- 5) The Green section tells you how far to stay away from a spill or release.
- 6) If a "DANGEROUS" placard is displayed or no placard can be found, follow Guide Number 111, as you continue to seek more specific information about the hazardous material.

SOP 3. ACETYLENE CYLINDERS

3.1 Introduction

FRF personnel attending incidents involving acetylene need to appreciate the dangers involved with the gas so that operational decisions can be made which will not prejudice the safety of those personnel dealing with the incident or others in the vicinity.

3.2 Acetylene General Properties

Acetylene is a colorless, nontoxic, highly flammable gas with an ether type smell. Industrial grade acetylene has garlic like odour. It is slightly lighter than air. What distinguishes acetylene from other flammable gases is its unstable nature, and ability to decompose in the absence of air or oxygen into its constituent elements, carbon and hydrogen, with the evolution of large amounts of energy in the form of heat and light, and accompanied by loud explosions.

Acetylene is a particularly highly flammable compound. The flammability limits are particularly wide at 2.5 to 80%, wider than any other commonly found flammable gas. (With oxygen the upper limit rises to 93%). The ignition energy is very low and the burning velocity and flame temperatures are exceedingly high. The minimum ignition energies for acetylene (and hydrogen) in air are the lowest measured for all combustibles. Acetylene can be ignited by a wide range of sources including:

- Direct flame
- A static discharge from a human finger or clothing
- Sparks from Aluminium rubbing on rusty steel
- Friction
- Shock

An acetylene/air mixture, in common with other fuel gases, will explode violently in the open and with even more intensity when confined. Pure acetylene is not toxic but in high concentrations may cause asphyxiation. In low concentrations it may be cause narcotic effects, symptoms may include dizziness, nausea and loss of co-ordination. It is an aesthetic in high concentrations. Loss of consciousness may result, leading to

convulsions, coma and death. The main hazard however is from combustion and decomposition.

3.3 General Information on Cylinders

Cylinder storage design Acetylene is identifiable by a maroon colour across the length of the cylinder. Acetylene is only slightly soluble in water but is much more soluble in many organic liquids especially acetone, which is the main solvent commonly used by the acetylene industry. Due to the instability of acetylene under pressure, it is stored in cylinders containing a porous mass. This mass is an inert filler and absorbs the acetone. This prevents the formation of pockets of acetylene inside the main body of the cylinder. It also acts as a stabilizer.

The combination of solution in the acetone is uniformly dispersed throughout the cylinder and is thus stable. Withdrawal of acetylene results in the gas being released from the solvent as the cylinder pressure falls. For each bar of pressure the acetone solvent absorbs 25 times its own volume of acetylene. Larger acetylene cylinders contain approximately 20 ltrs. of acetone and therefore contain approximately 7,500 litres of dissolved acetylene in solution when nominally charged to 15 Bar. $20 \text{ litres (acetone)} \times 25 \text{ (volume acetylene/bar)} \times 15 \text{ bar (gauge pressure)} = 7500 \text{ litres dissolved acetylene}$. From this calculation it can be seen that for each bar of pressure reduction 500 litres of acetylene will be given off.

It should be noted that due to atmospheric pressure the acetone will still contain 500 litres of dissolved acetylene even though the gauge reads zero and the cylinder is considered empty. **Accordingly, an “Empty” Cylinder Still Represents a Danger in a Fire.**

3.4 Pressure Relief Devices

Many acetylene cylinders (the useable life of acetylene cylinders can be more than 50 years) are fitted with pressure relief devices such as fusible plugs or bursting discs. These are designed to release the gas if the temperature or pressure rises excessively. In general steel welded type cylinders are fitted with two fusible plugs in the shoulder of the cylinder, whilst those drawn from solid ingots are fitted with rusting discs, usually in the

valve group. Some older cylinders may still be fitted with fusible plugs in the base. Regardless of the type and location of the pressure relief device, its operation must **NOT** be taken as a signal that the cylinder is in a safe condition.

3.5 Cylinder Use

Oxygen and acetylene together produce a flame temperature of 3,150 degrees centigrade. They are the only combination of gases, which can generate the temperature to weld steel. This ability to weld, cut, braze and solder means that acetylene cylinders can be found in many different types of premises.

These can include:

- Garages
- Engineering workshops
- Laboratories
- Construction and demolition sites
- Factories
- Steelworks
- Domestic property

Acetylene cylinders are normally used in conjunction with oxygen cylinders. The presence of oxygen cylinders increases the hazard presented by the catastrophic failure of acetylene cylinder(s), as the explosion may propel them or involve them.

3.6 Incidents

For as long as any cylinder is exposed to direct heat in a fire there is a risk of catastrophic failure. If acetylene cylinders are involved, then the risk of explosive detonation remains for some time after the cylinders have been heat affected. The unique feature of acetylene is its ability to decompose with massive energy release after any fire has been extinguished but whilst the cylinder is still hot. It is important to assess whether the cylinder has been sufficiently heat damaged for decomposition to be initiated by exposure to intense heat. It requires heat in excess of 400°C to initiate decomposition. This is normally only achieved by direct flame impingement on a cylinder.

There are signs, which can be used to detect possible heating:

- Do any of the cylinder labels appear burnt?
- Have any of the plastic rings around the cylinder valve melted in any way?
- Is the cylinder paintwork burnt or blistered?

3.7 Wetting Test

It is important to try to identify if an acetylene cylinder has undergone internal decomposition due to flash back or excessive heating. The wetting test will give evidence of whether the outer shell is hot and should be used together with other indicators and information when conducting a risk assessment.

The wetting test involves:

- Getting a clear view of the cylinders from a safe location, protected from any possible blast.
 - Spraying sufficient water on to the cylinder to wet the entire surface of it.
 - Stopping the spray and looking for signs of steam rising from the surface of the cylinder.
 - If the steam is not seen rising, does the wetted surface dry out quickly? The test is also a useful indicator to show the progress of the cooling down operation
- Circumstances that Initiate Decomposition Incidents involving acetylene cylinders can arise in any one or a combination of the following circumstances:
- Flashback from a cutting/welding torch into the cylinder.
 - Hot work residue, which can burn into the supply tubes and burn back into the cylinder.
 - Cylinders in the vicinity of a fire.
 - Cylinders that have been subjected to direct or indirect heat.

A hot cylinder that is dropped or otherwise suffers severe mechanical shock may potentially fail catastrophically. In addition, if decomposition has started it can be aggravated by leaks from the heated cylinder's safety device (where fitted) or valve or associated equipment, whether the gas has been ignited or not.

Decomposition of the acetylene contained within the cylinder takes place and will continue until all of the acetylene is consumed or until the cylinder is effectively cooled. Acetylene

cylinders are designed and tested to withstand such decompositions and will normally cool naturally without any problem; the porous mass is designed to assist with this.

Cooling will slow the reaction and allow it to self-extinguish. In the worst case, inadequate cooling (perhaps caused by shielding) can lead to potential catastrophic failure due to the weakening of some parts of the steel wall of the cylinder. Even when a hot acetylene cylinder appears to have been cooled externally, a residual internal hot spot could be present.

If there is also a large internal cavity due to damage of the internal mass, movement of the cylinder may accelerate decomposition and result in catastrophic failure without warning. Decomposition within the cylinder cannot always be detected therefore it follows that equipment such as thermal imaging cameras or infrared thermometers may only provide an initial indicator that the surface of the cylinder is hot.

They cannot and must not be relied upon as indicators of safety. An acetylene cylinder that has been heated and is leaking gas presents the greatest danger of catastrophic failure. This is due to the fact that fresh acetylene will be constantly released by the acetone.

This fresh acetylene will travel through the internal mass of the cylinder and if a reaction is taking place may provide additional fuel for decomposition, ultimately leading to catastrophic failure. There is at present no practical reliable means of detecting decomposition deep within an acetylene cylinder.

3.8 The Effects of Catastrophic Failure

Post incident investigation into events that have resulted in the catastrophic failure of acetylene cylinders have provided evidence of the nature of the hazards that are presented.

These hazards include:

- A blast wave.
- Fireball of up to 25 metres.
- Cylinder may be thrown up to 150 metres.
- Large fragments which have large looping trajectories.
- Flying shrapnel, valve assembly, and ancillary equipment which may be thrown up to 200 metres.
- Flying glass and other structural material.
- Structural damage to other buildings in the vicinity.
- The spread of asbestos particulates either from the filler mass or building materials.

The severity of any or each of the above hazards is dependent upon the exact circumstances of each case. It is clear that the hazards caused by the catastrophic failure of an acetylene cylinder will put both members of the public and operational personnel in the vicinity of the incident at risk.

Experience has shown that the outcomes of each of the above effects can lead to a range of injuries including:

- 1) Death.
- 2) Blast injuries.
- 3) Flash burns.
- 4) Permanent hearing damage.
- 5) Concussion.
- 6) Bruising.
- 7) Post-incident trauma.

3.9 Operational Procedures – Incident Command

a. Identifying the Hazard Zone

Firefighter and public safety are of paramount importance. Incidents involving acetylene cylinders will be protracted. When considering safety and resource implications it may be necessary to consider these as being major incidents. The immediate dynamic risk assessment will determine the tactical mode of operations.

Extreme caution should be exercised at any incident where it is considered likely that acetylene is used or in use within the property, but where no information is available. When it is suspected that an acetylene cylinder(s) is or has been involved in fire, an initial “Hazard Zone” extending to a maximum of 200 metres radius from the cylinder(s) should be considered in liaison with the police. The assessment of the hazard zone has been based on the possible travel distance of fragments from an exploding acetylene cylinder in open air.

The actual area of the hazard zone required will be determined by a number of factors including the type and extent of adjacent structures and the local topography. It is important that immediate steps are taken to:

- Establish if the cylinders have been exposed to heating.
- Establish the identity of the cylinder concerned.

This will require observation from a safe location for signs of blistered paint, melted components or rings, burnt labels or obvious involvement in fire. Following an assessment of the hazard zone and using any available shielding in order to reduce risks to operational Personnel, the Incident Commander should establish a Hot Zone to control access to the vicinity of the cylinder.

The size of the hazard zone may be reduced following consideration of the protection provided by the surrounding environment and the topography and/or the cooling process. Consideration should also be given to the use of any substantial, portable materials that might offer shielding between the hazard and a public highway, railway or other thoroughfare. As with all cylinder incidents, consideration must be given to evacuation of the public and non-essential personnel. Liaison with the police will be necessary if evacuation is required.

Where evacuation is not possible, or is considered inappropriate, all those remaining in the hazard zone should be warned of the risks and should be advised to stay away from

doors and windows and make full use of all available shielding. Personnel required to carry out tasks within the Hot Zone should make use of all available shielding. Personal protective equipment appropriate to the immediate hazard should be worn, such as gloves, flashoods and eye protection in addition to full firefighting kit.

b. Maintaining the Cordon

Once the Hot Zone has been established a further Warm Zone should be set up to ensure the incident ground is controlled and firefighter/public safety is maintained. Close liaison with the police should be established to ensure that the cordon is maintained throughout the duration of the incident. The size of the cordon may be reassessed if circumstances change during the incident, for example, the provision of suitable shielding or evidence that the cylinder walls are cool, i.e. they remain wet. Safe systems of work cylinders not affected by heat

Where cylinders are in the proximity of a fire but show no signs of direct heating such as paint damage or melting plastic guards or neck rings, they are likely to be safe to move. However, before doing so the coolness of the cylinder walls should be checked by spraying with water and seeing whether they remain wet. Personnel must be made aware of the manual handling problems associated with moving an unheated acetylene cylinder to a safe location. Acetylene cylinders are comparatively heavy in relation to other cylinders and are awkward to carry, especially when wet.

Where it has been decided not to remove unaffected cylinders they may be protected from radiated heat or direct heat by the use of cooling sprays. Cylinders that have been subjected to severe shock (for example falling from an upper storey to the ground) should be treated in the same way as those affected by heat, as there is the potential to initiate decomposition.

Cylinders affected by Heat Where a cylinder is found involved in a fire or suspected of having been subjected to heat, the Incident Commander should balance the dangers posed by the heated cylinder(s) against the need to deal with the incident. If a decomposing cylinder is leaking or is moved, the rate of decomposition and heat

generated may be increased to an extent that the cylinder walls are weakened abnormally and rupture.

Greater safety can be achieved if the decomposition process is slowed or arrested by cooling. The period of greatest risk is when the cylinder shell is hot, so every effort should be made to cool it comprehensively taking full advantage of the use of monitors and/or mainline branches. There may be circumstances where attempts to apply cooling water would expose firefighters to unacceptable levels of risk that outweigh the benefit likely to be gained. In such circumstances the alternative would be to leave the cylinder in situ without applying water.

An example of this situation is:

- Where no shielding is available: and
- There is no immediate danger to life.

Heated acetylene cylinders cannot be considered safe until at least 24 hours after initial cooling has commenced (whether this is via cooling water or allowing the cylinder to cool naturally). Whilst the application of water is considered to be the most suitable method of cooling a cylinder it is appreciated that the application of this medium might have to be interrupted or ceased dependent on the Incident Commander's dynamic risk assessment.

This assessment should consider factors such as:

- The nature of the incident
- The nature of the surrounding/adjacent risks.
- The risk to firefighters providing cooling jets.
- The adequacy of any shielding.
- The nature and effects of any cooling water runoff.
- The environmental impact.
- Whether the cylinder walls are cool.

Acetylene cylinders should therefore be left in situ (original place) for a minimum period of 24 hours following removal of any heat source, with cooling water being applied for this duration where the situation permits. If it is not possible to continually apply cooling water,

cylinders should be left alone in situ to cool naturally for at least 24 hours. The application of water will result in the cylinder shell cooling quicker and ultimately slow down any internal decomposition process occurring inside the cylinder.

As a consequence of this, cordon size could be reduced as determined appropriate by the Incident Commander after undertaking a risk assessment and account of the points mentioned above. Prior to the reducing the cordon size, the Incident Commander should consider the use of a “**wetting test**”, the purpose of this being to determine whether the cylinder shell remains wet after the interruption of cooling water.

This test is not to be interpreted as an indicator of total safety; it is simply an additional tactic that the Incident Commander can use when carrying out a risk assessment in order to test the feasibility of reducing cordon size. Once the walls of the cylinder remain wetted for some time after the application of water has ceased, it can be assumed that they have regained their tensile strength in which case a catastrophic failure is highly unlikely. The hazard zone can then be reduced appropriately and cooling spray(s) or jet(s) reintroduced for the remainder of the 24hour cooling period.

Leaking Cylinders (Pre & Post Fire Situation) where leakage of acetylene gas is suspected, the possibility of an explosive atmosphere could exist and therefore the following should be considered:

- Evacuation of immediate area.
- Elimination/separation of ignition sources.
- Water sprays to assist in the dispersal of gas.

Leakage of acetylene from a cylinder may intensify decomposition in the cylinder resulting in it becoming hot. Always check to ensure that heating is not occurring by using the wetting test.

c. Closing the Incident

Acetylene cylinders cannot be considered safe until at least 24 hours after the removal of any external heat source and commencement of water or natural cooling. It may be necessary to maintain a presence at the incident throughout the 24 hours or if possible make arrangements to hand the incident over (including the management of the hot zone) to a competent agency or organisation. Considerations for Incident Commander (Acetylene cylinders heated or involved in fire) ***“Actions on arrival”***

- Siting of Appliances
- Gather information to determine the likelihood of acetylene cylinders being involved and heated
- Assess potential risk in order to determine operational actions
- Operation of pressure release devices
- Determine 200m hazard zone
- Consider shielding
- Establish inner cordons
- Consider evacuation

As the incident develops

- Appoint Safety Officers
- If possible apply cooling water
- Determine *“Tactical Mode”*, any firefighting should be undertaken from behind shielding
- Use of ground monitors and / or lashed branches
- Wetting test
- If cylinder remains cool consider reducing the hazard

3.10 Key Actions

Action Identify initial 200m hazard zone



Carry out “Dynamic Risk Assessment” within hazard zone



Establish Cordons



Apply Water



Re-assess risk and consider reducing hazard/zone cordons



After 24 hours hand over to occupier / cylinder owner or another agency



3.11 FIRE BRIGADE INCIDENT CLOSED

Gas supplier to recover Consider:

- Type of structure
- Topography
- Public Safety
- Firefighter Safety
- Liaise with Police
- Accessibility of cylinder
- Environmental Impact
- Operational restraints
- Cylinder remains wetted and is not leaking
- Shielding
- Earlier handover if suitable, safe and secure arrangements can be maintained

SOP 4. BIOHAZARDS

4.0 Introduction

Biohazards arise from exposure to a range of pathogenic organisms. Acute or chronic infectious diseases may be caused by bacteria, viruses, protozoa or fungi. The pathogen may enter the body via skin contact, through puncture wounds or cuts. They may also enter by inhalation from aerosols or dusts. Ingestion can occur via contaminated food and drink.

4.1 Pathogenic Organisms

Bacterial diseases are tuberculosis (TB), anthrax, tetanus and bubonic plague. Most biological hazards arise from single-celled organisms of various types, which are collectively referred to as “pathogenic organisms (i.e. disease causing)”. The main types will be mentioned together with some important aspects of each.

4.2 Bacteria

Bacteria are about 0.01mm in length. Bacteria cannot stand high temperatures - half an hour at 60°C kills most of them. The spores of the most resistant ones are killed by several hours at 1000°C. Large doses of gamma radiation also kill bacteria - certain methods of sterilization are based on this fact. Fire kills bacteria.

Many bacteria are harmless; some are necessary and beneficial - like certain soil bacteria. Some species exist within, or on human / animals' bodies. They may be harmless but some may produce very poisonous substances called toxins, which cause symptoms of disease. Bacteria enters the body by the following methods;

- Infected food materials
- Invasion of wounds (dirty wound dressings etc.)
- Skin contact (especially broken skin)
- Droplet infection (coughs and sneezes)

- Bites from animals suffering disease

4.3 Viruses

These micro-organisms are much smaller than bacteria and consist of material (DNA or RNA), surrounded by a complex outer coat of protein; they can pass through filters designed to hold back bacteria. Typical virus diseases are Lassa fever, herpes, poliomyelitis, influenza, colds, AIDS, hepatitis (A & B), smallpox, German measles and rabies.

3.4 Protozoa

These are large single-celled organisms, rather more complex in some ways than bacteria. They behave in a similar way in many respects. Typical protozoan diseases are malaria and amoebic dysentery. They are often water-borne - e.g. amoeba, paramecium.

4.5 Single-celled Fungi

Typical fungal diseases are thrush (*Candida albicans*), certain diseases of the outer ear, “athlete’s foot” (*Tania pedis*) and “ringworm” (*Tinea captious*).

4.6 Biological Substance locations of biohazards

It is important to realize that we live in a world where bacteria, viruses, protozoa and fungi are almost everywhere. For example, your skin has on it a considerable number of bacteria of the variety called “staphylococcus”, together with a range of other micro-organisms. Biohazards occur where there are very large numbers of micro-organisms which exceed what may be called an ‘ineffective dose’, so that anyone exposed to them will be very likely to become ill as a consequence.

Some common locations of biohazards are:

- Hospitals
- Isolation wards
- Post mortem rooms
- Medical schools

- Clinical laboratories
- Research laboratories
- Universities
- Veterinary laboratories
- Pharmaceutical laboratories
- Government establishments
- Quarantine kennels
- Farms

Group 4

'Extremely hazardous to laboratory workers and which could cause serious epidemic disease' Example; Smallpox virus. Group 4 pathogens can only be handled (not normally routinely) with the Endorsement of the Health and Safety Executive (HSE). The use of these pathogens is regulated by the COSHH Regulations, 1994. Here the HSE must be notified 30 days in advance of intention to use or transport them.

The following details are required: -

- Name, address, location & laboratory facilities
- Pathogen, supplier & work detail
- Qualifications of handlers & safety reps to be informed

Group 3

'Offers special hazards to laboratory workers. Special accommodation and conditions for containment must be provided'.

Among the more common examples of category 3 agents are;

- Mycobacterium tuberculosis
- Salmonella typhoid
- HIV or the causative agent AIDS
- Hepatitis B virus
- Rabies virus

Other agents are included in the list, together with fungi and pathogenic amoeba. Clinical specimens may contain specified pathogens requiring Category 3 containment.

Group 2

Examples within this group are;

- Legionellaceae (causative organism of
- Legionnaires disease)
- Candida albicans (thrush)
- Measles virus
- Mumps virus
- Polio virus
- Herpes simplex virus

Group 1

The best example is *Bacillus subtilis*, which is an aerobic spore bearer and is quite ubiquitous and found everywhere.

4.7 Notification

Until the publication of the Howe Code and the Dangerous Pathogen Regulations, fire services had to virtually discover these pathogens on 1.1.d visits. A 'Safe Working Document' recommends the appointment of a Safety Officer whose duties include;

- Notifying local fire services in advance of substances being handled
- Responsibility for decontamination procedures

4.8 Pre-planning

As with any risk, pre-planning is an essential part of any operational response.

The following are points which should be considered in any pre-plan;

4.8.1 Contact

As stated it's not mentioned, establishments handling Group 4 organisms are required to appoint a Safety Officer with whom contact should be made. Most laboratories and research establishments generally have a rote of knowledgeable persons, some work on an 'Alert' basis, during which times the substances are present. Staff must stay on the premises in case of emergency.

4.8.2 Nature of Hazards

The type, amount and level of hazard will no doubt determines pre-planning. There may be toxins with an immediate hazard to human life – e.g. typhoid, tetanus. There may only be a hazard to marine life or plants, with no direct hazard to man. The physical state of the organism presents differing levels of risks. Some may be frozen and stored in plastic bags. Some kept in water which boils in the event of fire, sterilizing them. Some are kept in their dry state in glass phials or bottles, and here the risk is through aerosolization and subsequent inhalation of the powder. Some may be found in bulk - usually glass or stainless-steel vessels.

4.8.3 The Extent

The extent of the potential hazard to firefighters from such material, in the event of a fire or other incident, may vary - most micro-organisms are killed in temperatures in excess of 60°C but some are thermopiles - living and multiplying in higher temperatures than this. Expert guidance, normally on site, should be sought to ascertain how they react in fire, and possibly, how long the fire would need to burn before destruction.

4.8.4 The Exact Location

In some laboratories the main concentration of pathogens would be found in the main laboratory, but other smaller concentrations may be found elsewhere, e.g. freezers, cold stores or incubation rooms where temperatures may be controlled. Culture collections of freeze-dried materials may also be present.

4.8.5 The Safety Arrangements

All establishments handling infectious substances are required to have a safety manager and emergency plans. These vary from - returning all substances to cabinets, to the sealing of rooms and evacuation in hospitals; patients cause a great deal of worry for the authority's if they have to evacuate - nurses may have to dress in protective clothing (time consuming) - where to remove to - then what to do with them?

4.8.6. Expert Assistance

In premises where Group 4 agents are in use, expert advice will be available at all times. In other premises, they may be 'hazard free' 99% of the time, and when they go on 'Alert' staff generally live on the premises. These premises should be identified by means of certification and at application to operate. The information be stored at the Fire Station whose area covers the risk and the crews made aware of the hazard and the SOP.

Contact details should be made available also in case of any incident. These should be kept on record and the Operations control room should call the contacts as soon as possible following mobilization. Location & Meaning of Signs Many establishments will display the international biohazard sign. However, the use made of this sign varies considerably.

The sign is normally displayed as a triangle, consisting of a black symbol on a yellow background. Often found on doors and refrigeration units. It is not usually found externally.



Other signs may relate to specific animals 'Do not remove', 'May be removed in cages. The sign also appears as black on white. If in doubt, the meaning should be sought during familiarization visits.

4.9 OPERATIONAL CONSIDERATIONS

There are a number of operational considerations which should be taken into account at incidents involving biohazards.

4.9.1 Fires

Unless contrary advice has been received in the course of pre-planning, fires should be dealt with in the normal way. This stems from the fact that most of these premises, which cost a great deal of money to build or convert, are not used for the most time. It would be unreasonable to allow them to burn down when they are "On Alert", so any fire action now should be on the basis of prior discussion with the Safety Officer or other medical advisers.

4.9.2 Water

The amount of water used on fires should be limited, to prevent the hazard entering the drains. Although it is worth noting - most micro agents require special media or human hosts in which to multiply, and are not affected by water. Considerations should be given to the presence of sewer rats and that several places now re-cycle Sewer water. The use of high-pressure hose is recommended for firefighting Rescues of persons trapped should

only be attempted using full PPE and BA. The advice of available medical personnel should be followed. Some establishments are prepared to douse firefighters in disinfectant prior to entry but this depends upon availability.

4.9.3 Protection

Gas Tight Suits and BA provide adequate protection for all biological hazards including Group 4.

4.9.4 Decontamination

The normal decontamination procedures set out in accordance with SOP (Decontamination Procedures). Contaminated clothing should not be removed from the incident until thoroughly disinfected and only then on medical advice - particularly if Group 4 substances are involved.

4.9.5 Animals

Work with biohazards can involve the use of animals. Types of animals used depend upon the nature of the study. Usually mice, rats and rabbits, also cattle (foot and mouth), goats, fish, insects, dogs and monkeys can be used for human related experiments. Animals fall into 2 classes;

- Infected
- Non-infected

4.9.6 Infected

Animals may be infected with many microorganisms presenting a direct hazard to man. The animals are kept in security cages, designed to prevent the animals escape or in the case of monkeys - opening the cages themselves. Generally, kept in separate rooms or buildings, secured and indicated. Often there are rodent barriers in place.

4.9.7 Non-Infected

Some laboratories breed their own animals so, they can check on hereditary disease. Normally housed in stock pens / cages away from infected animals.

4.9.8 Rescue of Animals

Because of the hazard to firefighters and the public, infected animals should not be rescued or released unless expert advice has been given with complete assurance that it is safe to do so.

4.9.9 Up Draught

Where the fire is of some intensity, it is possible that organisms might become airborne because of the convection currents. Evacuation of all occupants, together with appliances and unprotected personnel, to areas upwind may be necessary.

4.9.10 Eating

It is important that no one should be allowed to eat, drink or smoke at these incidents. Interiors of masks should not be touched with hands or gloves which may be contaminated.

4.9.11 Restricted Areas

Where justified by prior assessment of the hazards or on medical advice, a restricted area should be established and cordoned off. The extent of such an area would depend upon the hazards involved and the expected limits of fire spread. It might be confined to part of a building or extended to the whole of the premises. Where a restricted area has been established, movement into and out of should be strictly controlled.

4.9.12 Records

Records should be kept of anyone directly exposed to bio-materials during operations, together with details of the organism and exposure to it. The incident commander shall collate and record the relevant information on forms within the mobile control unit. Health & Safety forms should also be completed including 'near miss' reports as exposure to the hazard could lead to injury. Medical advice should be sought on any personnel who suffer any ill-effects within 21 days of the incident. Advice at the incident may suggest inoculation of exposed crews (ideally, inoculation should take place before the incident, if that is possible).

4.9.13 Transportation

Regulations should require through the HSE. To have 30 days' notification if Group 4 materials are to be transported. Exceptions are where they are transported urgently for diagnostic purposes or if transported within the cartilage. These regulations should state that a private vehicle is used, in the case of road transport and that it should be accompanied by another person in a separate car, who is familiar with the pathogen carried. An adequate supply of suitable disinfectant should be carried for emergency purposes.

Large amounts of group 3 materials are transported using recognized security transport agencies. The outer wrapping of any package should bear a warning that the package should neither be opened nor touched. Immediately beneath the outer package there should be an indication of the nature of the contents (by name or by a warning such as 'danger from infection'), together with the name & address of both the consignor & consignee. The latter details should also be provided with the package.

SOP 5. CHLORINE

5.0 Introduction

"Chlorine" is defined as liquid or gaseous molecular chlorine. Occupational exposure to chlorine is defined as exposure to airborne concentrations of chlorine at or above one - half of the recommended workplace environmental limit. Chlorine is a yellowish green gas with a distinctive, irritating odor. Also, Chlorine;

- Danger! Hazardous Gas or Liquid Under Pressure
- Extremely Irritating
- May Be Fatal If Inhaled
- Causes Burns
- Severe Eye Hazard

Do not breathe gas; use only with adequate ventilation. In case of inhalation, remove to uncontaminated atmosphere, get medical attention immediately. If breathing has stopped, start artificial respiration. Do not get in eyes, on skin, or on clothing. In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes, and get medical attention immediately.

A warning sign should be affixed in a readily visible location at or near entrances to areas in which chlorine is present in containers or systems. This sign shall be printed both in English and In the predominant language of non-English speaking workers.



All employees shall be trained and informed of the hazardous areas, with special instruction given to illiterate workers.

Open containers must be treated with care after securing the connection to the distribution line into which the gas is to pass. Have supplied air respirators or self-contained breathing apparatus available for emergency. Do not heat containers. Avoid contact with other materials. Store only in authorized areas.

5.1 Caution!

Chlorine hazard area unauthorized persons keep out causes burns, severe eye hazard may be fatal if inhaled protective masks for chlorine located at **(specific locations to be supplied by employer) Specific Gravity of Chlorine Gas)**

Chlorine is about 2.5 times as heavy as air. Therefore, in the absence of air currents, leaking chlorine tends to accumulate in low spots. Storage areas are normally constructed with this property in mind, eliminating low spots unless they are specifically engineered for the purpose of chlorine collection.

Evacuation plans should consider the slope of the terrain and the prevailing wind direction when organizing evacuation routes and sites. Ventilation systems should remove contaminated air at the lower levels of rooms and replacement air should enter at the higher levels.

All chlorine piping systems shall be plainly marked for positive identification in accordance with National Standard. Associated vessel and critical shut off valves shall be conspicuously labeled. Chlorine containers in use shall be plainly marked "in use" to distinguish them from those not in use. No container shall ever be presumed to be empty and therefore non-hazardous. All shipping containers of chlorine shall bear label in addition to, or in combination with, labels required by other International statutes, regulations.

5.2 Medical

If it is suspected that a Firefighter has been exposed to high concentrations of chlorine and if he exhibits signs or symptoms of respiratory tract irritation, he shall be referred to a physician for complete medical examination.

5.3 Operational Tactics

Procedures shall include assignment of individual or team responsibilities and prearranged plans for:

- a. Immediate evacuation and Rescue of workers with signs or symptoms of adverse effects resulting from exposure to chlorine.
- b. Handing over to Ambulance Crews for transportation of injured persons to medical facilities.
- c. In all cases full information should be given to medical crews as to the possible exposure to Chlorine so they may alert medical facilities of the impending arrival of injured persons or to people who have been identified as being able to provide assistance.

Non-essential employees shall be evacuated from exposure to OUTSIDE the outer cordon areas during emergencies. Perimeters of areas of hazardous exposure shall be delineated, posted, and secured by Police.

Personnel who cannot be evacuated shall keep upwind of spills or leaks, if possible. Personnel who have appropriate training in the procedures and who are adequately protected against the attendant hazards shall take appropriate control action, eg, leak isolation and repair, cleanup of spills, etc.

5.3.1 If involved in fire

In case of fire, chlorine containers shall be removed to a safe place or cooled with water if leaks do not exist. Fusible plugs in chlorine containers melt at 70—74°C. Every effort shall be made to prevent containers from reaching this temperature. Water may not be used on chlorine leaks because accelerated corrosion, resulting from the formation of hydrochloric acid when water is present, may quickly make the leak worse. Water spray or fog may, however, be used to help suppress the size of a chlorine cloud near the leak.

Containers leaking liquid chlorine should be oriented so that gaseous chlorine is discharged through the leak until it is controlled. If possible, in emergency situations chlorine should be discharged to the industrial process through the regular chlorination

equipment or by running a line directly to the consuming equipment or other control vessel or equipment.

If the process cannot handle chlorine under emergency conditions, a standby alkali absorption system shall be made available for emergency use. Chlorine in contact with skin or eyes shall be removed by immediate washing with copious quantities of water, and immediate medical attention shall be obtained.

Remove contaminated clothing immediately. If chlorine is inhaled, remove victim to uncontaminated atmosphere, give artificial respiration if required, and get immediate medical attention. Local exhaust ventilation may also be effective, either when used alone or in combination with process enclosure.

Ventilation systems shall be used to maintain airborne chlorine concentrations within the limits of the recommended environmental limit to prevent accumulation of chlorine in the workroom, and to remove chlorine from the breathing zones of an incident. TAKE CARE THAT there is no mix of materials: Incompatible materials which may react badly and violently with chlorine such as hydrogen, ammonia, acetylene, fuel turpentine, most hydrocarbons, finely divided metals.

Take care also that there are no LOW spots in Storage areas in which chlorine could accumulate in case of a leak, unless such places have been designed and constructed for such a purpose.

5.4 Incident Commanders

Incident Commanders and / or First Responding Officers should always:

- Assess the scene on arrival.
- Find and discuss the Hazard and Risks involved.
- Understand the Life Risk, persons trapped or effected.
- Care full Size-Up, Evaluation must be carefully considered with the priority for a Dynamic

Risk Assessment, before committing crews.

- Pass on to Operations Room as soon as possible information about the material “Chlorine” involved and request immediately the Haz-Mat Vehicle.
- Urgently set up cordons and request Police to control these points.
- Position appliances and crews ‘UPWIND’
- No entry to anyone into the inner cordon ‘Hot Zone’ without Full PPE.
- Request assistance for BA process
- Establish Staging area and equipment holding area
- ALWAYS have emergency teams on Stand-By with Full BA
- Set up Incident Command point and invite the Police, Ambulance and the senior responsible person from the incident address.

Remember:

Chlorine if heated and exposed has destructive corrosion abilities, so storage areas can almost decompose in front of your eyes. Be aware in developed fires and if necessary, get crews out and withdraw to a safer distance.

Some examples of Industry and processes where Chlorine could be found in considerable quantities:

- Aerosol propellant manufacturers
- Iron detinners
- Alkali salt makers
- Iron dezinkers
- Aluminum purifiers
- Laundry workers
- Benzene hexachloride process
- Methyl chloride processes
- Bleachers
- Paper bleachers
- Bleaching powder processes

- Petroleum refinery
- Bromine process
- Phosgene process
- Photographic process
- Carpet manufacturers
- Pulp bleachers
- Chemical synthesizers
- Rayon process
- Calcium chloride processes
- Refrigerant processes
- Chlorinated solvent
- Rubber process
- Chlorinated hydrocarbon
- Sewage treaters
- Insecticide processes
- Silver extractors
- Sodium hydroxide process
- Color mixing process
- Disinfectant
- Sugar refiners
- Dyemakers Sulfur processes
- Chloride processes
- Ethylene glycol process
- Swimming pool maintenance
- Ethylene oxide process
- Flour bleachers
- Tetraethyl lead process
- Fluorocarbon makers
- Textile bleachers
- Gasoline additive

- Tin recovery
- Gold extractors
- Vinyl chloride manufacture
- Ink manufacturers
- Vinylidene chloride plants
- Iodine manufacture or treatment
- Water treatment plants
- Zinc chloride manufacture

SOP 6. LIQUEFIED PETROLEUM GAS (L.P.G.)



6.0 Introduction

This Standard Operating Procedure (SOP) considers hazards, risks and control measures for FRF personnel attending incidents involving Liquefied Petroleum Gas (LPG).

6.1 Scope

Liquefied Petroleum Gas (LPG) is a hydrocarbon-based substance derived from the refining of crude oil, and marketed as domestic and industrial fuel. LPG is a generic term that includes commercial propane, commercial butane and mixtures of both. LPG is a gas at normal atmospheric temperature and pressure but can be liquefied under moderate pressure.

Typically, LPG is either **100% propane**, **60% propane and 40% butane**, or **35% propane and 65% butane**, depending on the country and region. Other gases that are also potential LPG gas mixture constituents include ethane, ethylene, propylene, butylene and isobutylene.

As liquid LPG (propane and butane) occupies only 1/250th of the space occupied if it were stored as gases, from a commercial point of view it is more practical to store and

transport the hydrocarbons as liquids. The risks associated with LPG apply whether the LPG exists in small hand-held cylinders used for camping, upright domestic cylinders used for heating and cooking, large bulk storage tank farms or containers transported via the road.

N.B. *Natural gas (NG), liquified petroleum gas (LPG), and liquified natural gas (LNG) are made up of the same elements in different quantities.*

6.3 Specific Risks

6.3.1. Frost Burns

LPG liquid vapourises rapidly when it is released from a cylinder/vessel. This vapourisation causes a lowering of the temperature in the immediate area of release, potentially causing severe frost burns to skin if in contact with the cylinder/container.

6.3.2. Asphyxiation

LPG is an anaesthetic when inhaled in significant quantities over a prolonged period. If inhaled at higher concentrations, the vapours produce nausea and headache. Inhaled in extremely high concentrations, asphyxiation can result. For this reason LPG is usually odourised before distribution producing its characteristic smell, and enabling detection by smell down to one fifth of the lower limit of flammability.

6.3.3 Accumulating Vapours

LPG vapour is heavier than air and will flow along the ground and sink to the lowest level of the surroundings. These vapours may accumulate in locations such as drains, cellars, pits, basements etc. resulting in flammable atmospheres in these areas.

6.3.4. Unconfined Vapour Cloud Explosion (UVCE)

This event occurs where a flammable fuel/air cloud burns in free space, generating shock waves. The combustion mechanism is not completely understood, but probably starts from a point of ignition source, with the flame front accelerating from a low initial velocity to sonic velocity. Explosive vapours may travel long distances, be ignited at a remote

location and flash back. The explosion Centre may be a substantial distance from the incident (up to 5km) due to cloud drift.

6.3.5. Cylinder Explosion

If a gas cylinder is heated it becomes subjected to high internal pressures, which may cause it to rupture or burst with explosive force, irrespective of whether the contents are flammable or not. Potential hazards experienced when cylinders explode may include:

- Blast pressure wave;
- Cylinder may be thrown up to 200 meters (potentially greater distances for larger cylinders/vessels);
- Production of large fragments that have high looping trajectories;
- Flying debris including shrapnel, valve assembly, carrying trolley and other ancillary equipment, which may be thrown up to 200 metres;
- Flying glass and other structural material;
- Structural damage to buildings in the vicinity of the explosion;
- The spread of asbestos particulates from building materials;
- The potential release of hazardous material.

6.3.6. Fireballs

The catastrophic failure of LPG cylinders would result in a fireball. The size of the fireball will be dependent on the size of the cylinder involved, and it is likely that personnel caught within the fireball would suffer fatal injuries.

6.3.7. Boiling Liquid Expanding Vapour Explosion (BLEVE)

A BLEVE has been defined as 'an explosion resulting from the failure of a vessel containing a liquid at a temperature significantly above its boiling point at normal atmospheric pressure

This refers to two almost simultaneous events involving compressed liquids stored within containers:

Event 1

Failure of the containment due to:

- A rise in vapour pressure of the liquid due to external heating;
- A rise in vapour pressures due to internal heating e.g. exothermic reaction;
- An impact e.g. crash, damage to tanker vehicles;
- Overfilling (expansion of liquid contents generating hydraulic pressure on cylinder/container walls);
- A crack growth from a cylinder/container defect;
- Corrosion, resulting in the weakening of a cylinder/container.

Event 2

The flash evaporation of the liquid gas due to:

- Sudden release of LPG from the container causing rapid boiling of the liquid and resulting in an expansion of the gases above the liquid;
- The energy stored within the liquid, plus the energy released by the conversion of liquid to gas, causing severe pressure effects. When LPG cylinders/containers are heated in a fire, there is a very real potential for a BLEVE to occur unless adequate cooling is implemented to reduce the likelihood of failure of the cylinder/container.

6.3.8. The hazards created by a BLEVE will include:

- A blast;
- A flash;
- A fireball;
- Projectiles;
- Burning droplets.

6.3.9. Pre-planning

Station personnel should take every opportunity to gather information on premises that are likely to contain any type of gas cylinders on their station ground.

This may include:

- Visits to ensure that information 24x7 data is correct and updated
- Utilizing local knowledge;
- Producing or amending Operational Tactical Plans (OTPs);
- identifying Rendezvous Points (RVP) for identified premises;
- Liaison with the Fire Safety Department as appropriate.

6.4.0 Cordons

For clarification, the following definitions will be used when referring to cordons:

- **Outer Cordon** - the area surrounding the incident - Emergency services personnel only.
- **Inner Cordon** – the area is located between the Outer Cordon and Hazard Zone - Essential personnel only
- **Hazard Zone** – the area that would be directly affected by a fireball.

6.4.1. Establishing cordons

A Hazard Zone (minimum 50 metres) and Outer Cordon (200 metres) should be established according to the incident severity.

6.4.2. Cordon management

Once the Outer Cordon has been established, Safety Officers should be appointed to manage this area to maintain crew/public safety. Close liaison with the Police should be established to ensure that the Outer Cordon is maintained throughout the incident. The size and shape of the Outer Cordon may be re-assessed where substantial cover is available. Crews working within the Inner Cordon should be kept to a minimum and all available substantial cover should be utilised to protect against shrapnel in the event of a BLEVE or cylinder explosion. Any personnel carrying out specific tasks within the Hazard Zone such as snatch rescues, setting up monitors etc, must wear full firefighting kit with Breathing Apparatus (including flash hoods).

NOTE: Partition walls, fences, vehicles including fire appliances do not constitute substantial cover.

6.4.3. Evacuation of Cordoned Areas

Where vessels cannot be cooled then members of the public (within the determined Outer Cordon), should be evacuated to an area of safety beyond the Outer Cordon. Close liaison with Police will be essential to manage this evacuation. Details of members of the public who refuse to be evacuated should be held by the senior Police Officer at the scene. If evacuation is not possible or appropriate, members of the public should be warned of the risks and issued with safety advice.

6.4.4. Reducing size of Cordoned Areas

Once the cylinder is cool and has passed a thermal image camera check and the wetting test, there is no potential for the cylinder to explode, and the cordon size may be reduced accordingly.

6.4.5. Additional Considerations for Cordoned Areas

The difficulty of evacuating large numbers of the public from places of entertainment, homes and places of work, and of maintaining the Outer Cordon throughout the incident, should be assessed in consultation with the police when making decision on evacuation.

6.4.6. Containment

Where possible, un-ignited liquids flowing back from the LPG cylinder/containers should be contained as quickly as possible to prevent migration of the liquid and consequent danger to the public, as well as damage to the environment.

6.5.0. Operational Procedures

6.5.1. Considerations en Route

In addition to the work undertaken through the pre-planning process, the IC should also consider the following whilst en route to known LPG incidents:

- Surrounding risks;

- Additional information received from Fire Control;
- Safe approach, cordon sizes and siting of appliances;
- Building construction of premises where cylinders are located.

6.5.2. Actions on Arrival

- Establish Outer Cordon – 200 metre radius from the affected vessels;
- Determine Inner Cordon as part of IC's Dynamic Risk Assessment (DRA) considering the size and nature of the incident and availability of substantial cover;
- Establish size of Hazard Zone. This will be reflected by the size of the LPG vessels involved (see Aide Memoire 'B'). When it is known that any LPG cylinder(s) are involved, a message must be sent to the Operations Control Room stating '**LPG Cylinders involved**'.

The IC must carry out a DRA to assess whether the benefits of committing personnel outweighs the risks involved. Consideration should be given to moving unaffected LPG cylinders.

6.5.3. Personal Protective Equipment (PPE)

The minimum standard of PPE (for all personnel within the Inner Cordon) at incidents involving LPG cylinders/containers is full firefighting kit including flash hoods. Helmet visors should be kept down, and safety glasses / goggles worn at all times. Personnel working within the Hazard Zone must be kept to a minimum and must wear full firefighting kit with breathing apparatus donned. Due to the high burning velocity, flame temperature and possible fireball, exposure of any body tissue should be avoided.

6.5.4. Exposure of LPG Equipment to Fire

Where LPG cylinders/containers are involved in fire or suspected of having been subjected to heat, the IC should balance the dangers posed by the heated cylinders/containers against the need to commit personnel.

The period of greatest risk of explosion is when the LPG cylinder/container is hot as the steel cylinder/container shell will have lost some of its tensile strength. In such

circumstances, and in line with the IC's DRA, efforts should be directed towards cooling the LPG cylinder/container comprehensively and continuously, using monitors and/or lashed branches on spray Setting.

Whilst the application of water is considered to be the most suitable and effective method of cooling and preventing the explosion of any cylinder, it is possible that the application of this medium might not be appropriate dependent upon the ICs DRA.

This assessment should consider factors such as:

- Whether persons are involved;
- The nature of surrounding risks;
- The risk to firefighters in establishing cooling water sprays, taking account of adequate shielding;
- The nature and effects of any cooling water runoff, including the environmental impact;
- Other considerations associated with the application of water (e.g. volatile or water reactive materials in vicinity of cylinders/containers).

There may be circumstances where attempts to apply cooling water would expose firefighters to unacceptable levels of risk that outweigh the benefit likely to be gained. In such circumstances the alternative would be to leave the cylinder to cool naturally in situ without applying water.

Hazards/issues associated with the application of water may include:

- Environment I damage from water runoff;
- Reaction of water with other hazardous substances in vicinity;
- Spreading hazardous substances into the area of operations;
- Water damage concerns to other parts of the property involved;
- Flooding of low-lying areas in the vicinity;
- Fall/trip hazards concealed beneath water;
- Over-running of drains and interceptors.

6.5.5. Un-ignited Leaks

If escaping gas is not on fire, attempts should be made to close the LPG cylinder/container valve, to stop or reduce the flow of gas. Small lines such as copper tubing may be flattened to stop the flow. If a bulk storage cylinder or a road vehicle is involved in an accident consult the plant operator or driver, regarding the possibilities of shutting off the supply or leakage. Where LPG vapour or liquid is escaping and has not been ignited, it should not be purposely ignited, as the gas vapour may have travelled a considerable distance from the leak.

All ignition sources within the vicinity of the leak should be eliminated in order to prevent ignition of the gas vapour. As the vapour is heavier than air and will flow along the ground, eliminating ignition sources at a lower level than the leak should be a priority. Where an accumulation of gas vapour is suspected in a confined space such as a building, or a lower lying area, dispersal of the gas may be achieved by ventilation or purging with water spray.

Where large concentrations of gas vapours have accumulated in the open air as from large cylinders or road tankers, the gas vapour may be dispersed by the use of water spray/fog (pattern). This should be done as soon as possible using ground monitors or lashed branches, directing the water fog across the gas vapour path and dispersing into a safe location. If the incident involves a pipeline containing LPG, no valve on that pipeline should be closed except by agreement with the Pipeline Control Centre.

NOTE: In the event of a larger scale leak (e.g. road tanker), the IC must request Operations Control Room to notify the Operational Officer, especially if evacuations are likely to take place.

5.6. Ignited Leaks

If a leakage of LPG is on fire, the action will depend on the circumstances but the first consideration must be to stop the leakage or shut off the gas supply. Extinguishing an LPG fire without the means of stopping the leakage or shutting off the gas supply may lead to a more dangerous situation.

If gas is escaping in large quantities and has been ignited, then crews will need to apply water to all surfaces in the form of a jet, spray or fog. Static cylinders should be approached from the sides of the vessel, not the ends. If the pressure relief valve operates, the rate of water application should be greatly increased and the area should be evacuated in line with the Aide Memoire 'B' note immediately. Branches /monitors should be secured and crews withdrawn.

NOTE: If sufficient cooling water is not applied to the surface of the vessel above the vapour space, extreme radiant heat or direct flame impingement will cause the vessel to rupture and may result in a BLEVE.

6.5.7. Wetting Test

A wetting test will indicate whether the outer shell of a LPG cylinder/container is hot. This should be conducted in conjunction with Thermal Image Camera monitoring as part of the IC's ongoing DRA.

Wetting Test Procedure

- establish clear view of LPG cylinder/container from a safe location, protected from any possible blast;
- spray sufficient water on to the cylinder/container to wet its entire surface;
- stop the water application and look for signs of steam rising from the surface of the cylinder/container;
- where steam is seen rising, the wetting test has failed;
- where no steam rises, look for signs that the wetted cylinder surface dries off quickly. If the cylinder surface does dry off quickly, the wetting test has still failed and the size of the hazard zone should not be reduced. The Wetting Test is also a useful indicator to show the progress of the cooling operation.

NOTE: There is no requirement to submerge LPG cylinders in a dam of water once the wetting test is satisfactory.

6.5.8. Transferring Responsibility

Once the cylinder is cool and not leaking, the IC may transfer the responsibility to either:

- the owner of the cylinder;
- the occupier of the premises involved;
- the Fire.

The IC must ensure that the individual taking over responsibility is advised that the cylinder must not be used and should be collected by the company that owns the cylinder as soon as possible.

6. 6.0. Additional Considerations

6.6.1. Characteristics of LPG

- LPG is a gas and will normally be encountered as a liquid stored under pressure;
- leakage of liquid will result in the generation of significantly volumes of flammable gas;
- a very small proportion of LPG as a gas in air can give rise to a flammable mixture (the limits of flammability are approximately 2% - 10%);
- in liquid form, LPG is approximately half the weight of water. Filled LPG cylinders will float;
- rapid vaporisation of released LPG liquid results in lowering of the temperature and cause severe frost burns if in contact with the skin.

6.6.2. Physical Properties of LPG

Propane

- Specific Gravity of Liquid: 0.5.
- Density of Gas: 1.5.
- Boiling Point of Liquid: -42°C.
- Flammability Range in Air: 2% - 10%.
- Critical Temperature: 97°C
- Expansion Ratio Liquid to Vapour: 274:1

Butane

- Specific Gravity of Liquid: 0.5.

- Density of Gas: 2.0.
- Boiling Point of Liquid: -0.5°C.
- Flammability Range in Air: 1.5% - 9%.
- Critical Temperature: 152°C.
- Expansion Ratio Liquid to Vapour: 233:1

6.6.3. Storage of LPG

LPG is stored and transported as a liquid under pressure in pressure vessels. These vessels are designed to withstand all pressures likely to be met in service and any ambient temperature. Bulk storage vessels for LPG range from those for major industrial users and refineries of 1000 tonnes or more, down to small industrial uses of 1 tonne. Smaller vessels, down to 380 litres capacity are used for domestic purposes i.e. heating and cooking.

6. 6.4. LPG (dual fuel) Vehicles

There are now increasing numbers of vehicles that are fitted with LPG fuel systems. In addition to this a growing trend to convert vehicles in line with Environmental initiatives. The popularity of retro-fit systems has increased due to a government scheme encouraging conversions, to help in reducing CO₂ emissions of vehicles, thus also reducing the impact of global warming. Invariably the LPG storage tanks are generally located in the rear section or boot compartment of vehicles.

However, they may be located in the engine compartment, alongside the wings or in the cargo space immediately behind the front seats in commercial vehicles. There may also be more than one tank. Many vehicle owners wishing to enjoy the benefits of 'dual fuel' will aim to undertake the conversion at a minimal cost and on occasions take their vehicles to unregistered installers.

Such installations are likely to pose a greater risk to firefighting crews as safety features may have been missed, or substandard, leading to catastrophic results when involved in Road Traffic Collisions (RTC's) or fire.

Currently, there is no legislation governing the fitting of alternative fuel systems to motor vehicles and therefore they may be fitted in the following ways:

- factory fitted systems;
- vehicles converted post-delivery by approved specialists;
- vehicles converted by non-approved installers;
- systems installed by individuals using DIY kits.

Should take note that some manufacturers do not have a secondary fuel filler located elsewhere on the vehicle. Some Volvo models install the LPG filler behind the alternative fuel filler, and only one outer filler cap is provided.

6. 6.5. Incidents involving Road or Rail Tankers

A road or rail incident involving a larger LPG container may pose particular hazards as if the tanker has overturned, the pressure relief valve normally at the top of the tank in the gas phase could be brought into the liquid phase and any release would be of liquid, rather than the gas (the pressure relief valve is designed to relieve gas pressure). If the incident is in a built up area, there is a possibility of the liquid entering the drains. It may be possible to divert liquid away from drains and culverts by the use of sand or other suitable material, but if this is unsuccessful the appropriate authority (Municipality) must be informed and the relevant precautions taken to warn people of the danger downstream.

6.6.6. Incidents at Large LPG Tank Farms

For storage areas, the major firefighting effort will be provided by mobile equipment laying down large blankets foam and/or applying large volumes of water for cooling purposes. Large tank facilities are usually fitted with drenchers and bunded areas. A decision to apply a foam blanket should be weighed against the environmental impact.

6.6.7. Incidents Involving Pipelines

A leak from a pipeline containing LPG may occur as a result of careless excavation. In most circumstances, the leak will not ignite unless there is a ready source of ignition. The pipeline operator should be contacted as a matter of urgency to isolate the supply.

6.6.8. Cylinder Safety Devices

Normally a pressure regulator which may incorporate an isolation valve is connected directly to the outlet of the cylinder/cartridge valve, and connection from the regulator to the appliance is by flexible hose or copper tubing

6. 6.9. Manual Handling

LPG cylinders come in various weights and sizes, and are invariably heavy and awkward to handle. The correct manual handling techniques must be adhered to eg. ERG Manual.

6.6.10. Environmental Considerations

Due to the time period necessary for a cooling spray to be applied to a cylinder in a fire situation, the IC must consider the possibility of pollution damage to the environment. Therefore, any steps available to alleviate environmental damage should be adopted. Therefore, if the risk to life or property caused by an exploding cylinder would be greater than the risk or cost to the environment, then the application of cooling water can be justified.

6.6.11. Typical Locations of LPG Cylinders

ICs must consider the involvement of LPG at a wide range of premises and locations. These can include incidents involving:

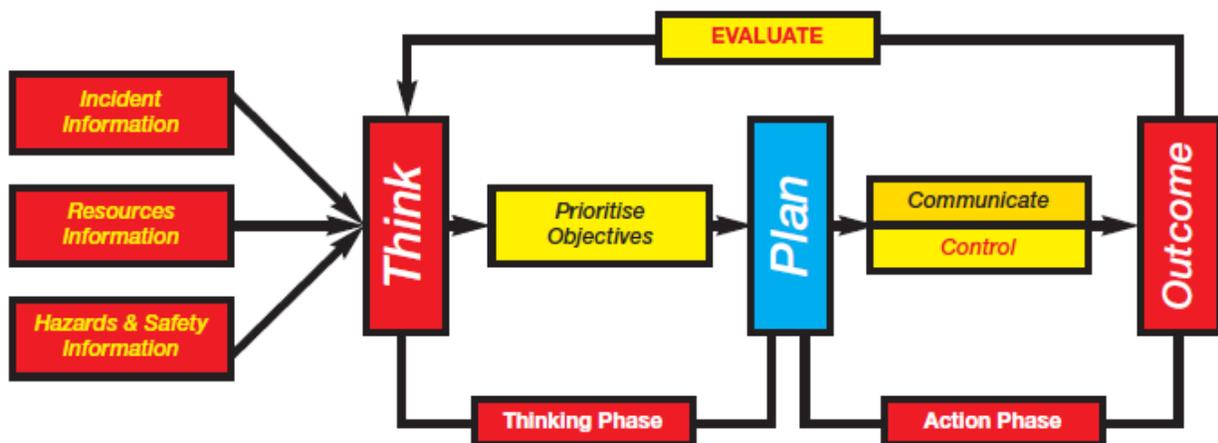
- Fork lift trucks;
- Caravans;
- Garages/workshops;
- Mobile kitchens;
- Boats.

This list is a guide to possible locations, and is in no way comprehensive.

6.6.12. Fully Wrapped Composite Cylinders

A recent development in cylinder technology which has been available since 2008 is the fully wrapped composite cylinder. At present they are aimed at caravanners due to their lightweight nature and their translucent design which makes the gas level visible. These bottles are currently available in 5kg and 10kg sizes. These bottles are to be treated the same as any LPG vessel involved in a fire situation, and the correct cordons/safety measures must be implemented to ensure the safe conclusion of an incident.

Operational Tactics



Send Message - LPG involved

Site appliance uphill and upwind in a safe location maximizing use of cover.

I.C. to determine:

- Size of vessel involved;
- If vessel is or has been involved in fire/heating;
- If leak is ignited or un-ignited;
- Members of public in affected area (downhill & downwind);
- Nature of surrounding risks.

Establish a 200 metre Outer Cordon – request police to manage. Minimum number of emergency personnel within Cordon. Establish Hazard Zone (minimum 50 metres).

Personnel working inside the Hazard Zone must wear full firefighting PPE including flash hood and have Breathing Apparatus donned.

Vessel must be cooled as soon as possible to prevent a BLEVE. Apply water spray from position of safety or behind substantial cover. Consider using monitors or lashing off branches.

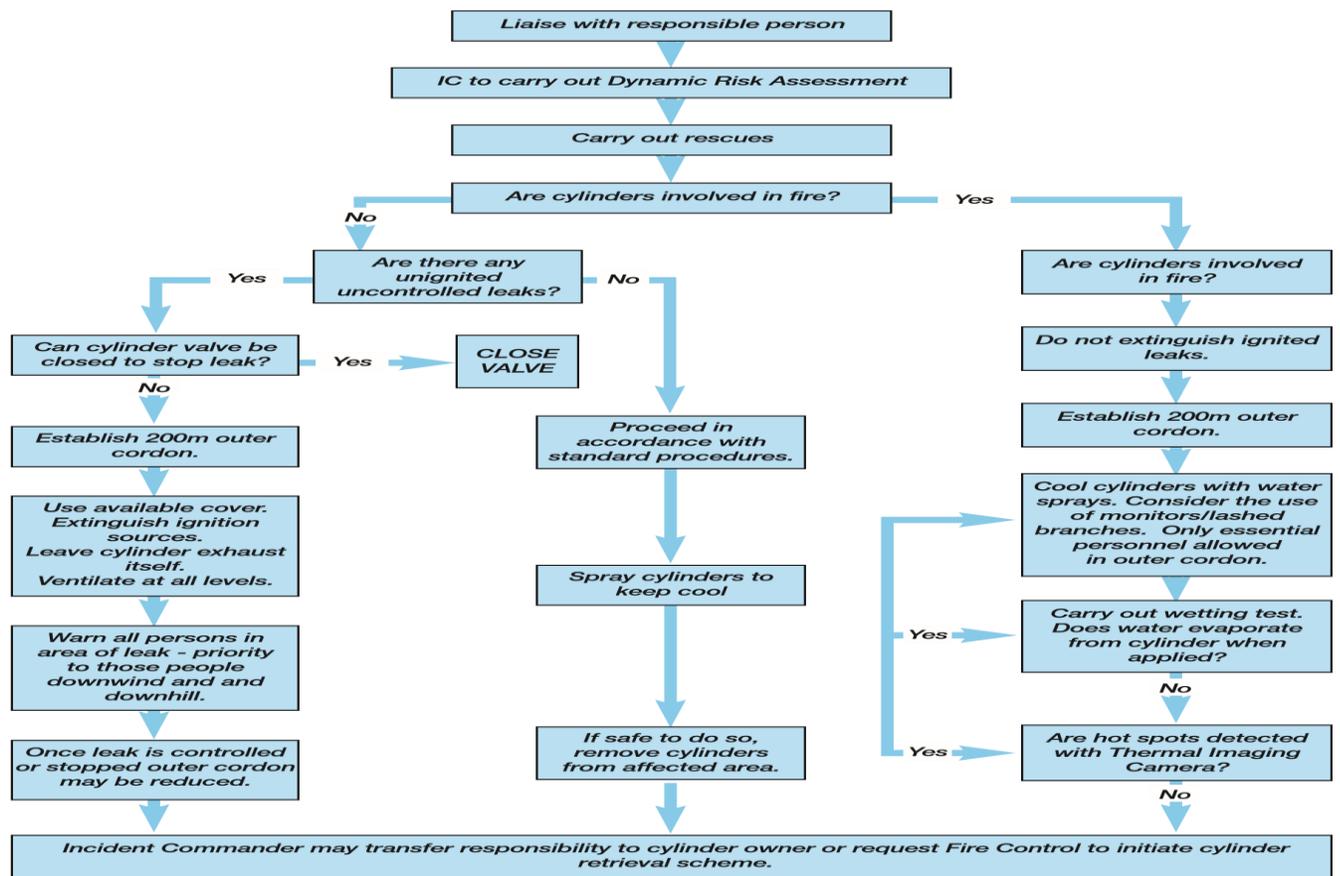
Partition walls, fences, vehicles including fire appliances do not constitute substantial cover. Extinguishing an LPG fire without means of stopping the leakage or shutting off gas supply may lead to a more dangerous situation.

Heated LPG cylinders should be able to be cooled rapidly. Before reducing any cordon, carry out wetting test. The outer cordon size may be reduced once vessel is cool and confirmed not leaking, IC may then transfer responsibility to owner or use retrieval system.

Weigh the benefits of immediate action against the potential risk to personnel

| Vessel | Description | LPG mass/volume | Fireball diameter |
|---------------|----------------------------------|-------------------------|--------------------------|
| 1 | Small cylinder | 9kg / 19 litres | 15 metres |
| 2 | Medium cylinder | 15kg / 32 litres | 20 metres |
| 3 | Large cylinder | 45kg / 95 litres | 25 metres |
| 4 | Commercial/Residential Container | 907kg / 1893 litres | 60 metres |
| 5 | Bulk Vessel | 18144kg / 37850 litres | 150 metres |
| 6 | Large LPG Tank Farm2 | 769230kg/1600000 litres | 520 metres |

Liquefied Petroleum Gas (LPG) Flowchart



Weigh the benefits of immediate action against the potential risk to persone

SOP 7. PETROLEUM AND STORAGE TANKS

7.0. Introduction

Fires in storage tanks involving petroleum or hydrocarbon products require a great deal of pre-fire planning and prior to any firefighting attempt careful consideration as to the correct type of firefighting media, an appropriate amount of the media is available to complete the attempt of extinguishing the fire and of course the safety implications of any attack on the fire within the inner cordon.

7.2. TYPES OF STORAGE TANKS

Storage tanks will be found in a number of shapes and sizes, the majority at oil refineries and petrochemical sites are vertical cylindrical tanks ranging in sizes from 8 metre diameters to tanks of 90 metre diameter and a height of up to 22 m.

Primarily crude oil tanks and those for volatile refined products, such as gasoline have roofs in the form of a pontoon so designed to float on the surface of the liquid to alleviate any ullage (or outage) space and are provided with a seal round the periphery to prevent flammable vapour escaping. These seals reduce the risk of fire, help to avoid loss of product through evaporation, and minimise the unpleasant odour of the oil in its natural state.

Types of cylindrical tank recommended for storage of hydrocarbons and their classification:

Class 'A' (flash point below 22.8°C)

- (a) Floating Roof
- (b) Non-Pressure fixed roof with internal floating deck.
- (c) Pressure fixed roof.

Class 'B' (flash point between 22.8 and 65.6°C)

- (a) Floating roof
- (b) Non-pressure fixed roof with internal floating deck.
- (c) Non-pressure fixed roof with atmospheric vents.

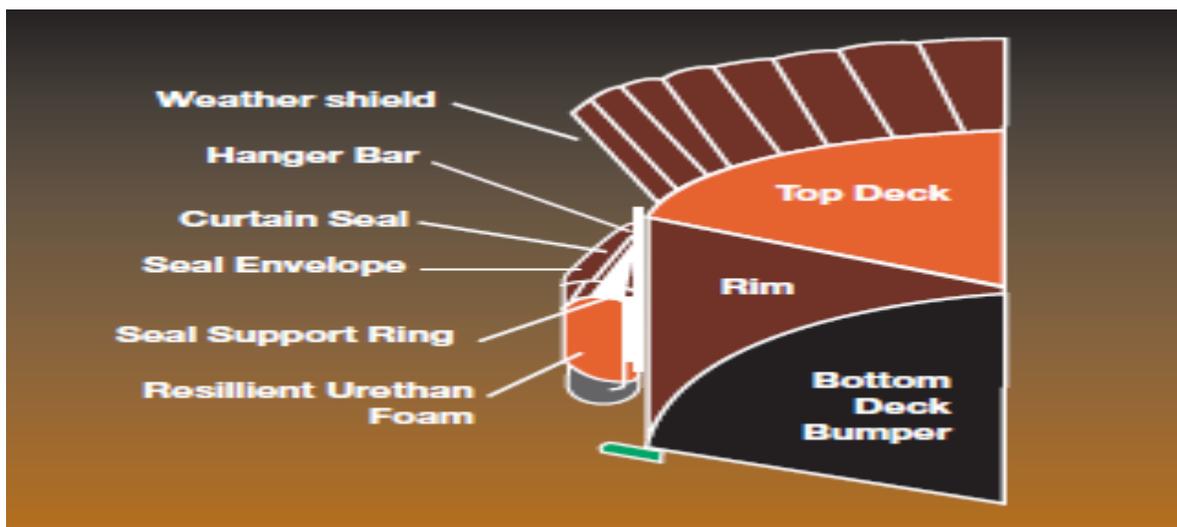
Class 'C' (flash point above 65.6°C)

'Non-pressure' fixed roof with atmospheric vents (Tanks which contain heavy fuel oils or bitumens are insulated and heated.)

7.2.1 Floating Roof Tanks

Because the pressure fixed roof tank is limited in size, larger tanks require a different construction. The floating roof tank provides economical storage of volatile liquids with a high degree of safety and floating roof tanks of 300ft (91m) in diameter and 70ft (22m) high are becoming commonplace in refineries; these are capable of holding the full cargo of a V.L.C.C. (Oil Tanker Ship).

The steel roof floats oil and rises or falls as the liquid is pumped in and out of the tank. The essential feature of this type of roof is a vapour-tight seal between the periphery of the roof and the tank shell.



The first line of fire fighting with these tanks is usually in the form of a 'Rim Seal' fixed foam system, that should quickly and efficiently extinguish any vapour leak.

7.2.2. Pressurized Storage Tanks

Standard tanks are not suitable for the storage of liquefied petroleum gases, such as propane or butane, owing to the high pressures required to maintain these gases in a liquid state; they are therefore stored in special pressure vessels. The ideal shape for a pressure vessel is spherical, as the internal pressure is the same at any point, but long, heavily-built small diameter horizontal tanks with rounded ends are also used.

7.2.3. Spheres

Spheres are used at oil refineries for the storage of LPG. in bulk, for ammonia or for ethylene under pressure. They are made of steel plates welded together in the same manner as for circular tanks, but they are supported on six or more steel legs, the number depending on the overall size of the vessel.

7.3 Storage Tank Protection

Flammable liquid storage tanks and associated facilities can be protected with a variety of fire protection systems. (Reference document NFPA. 11 low expansion foam extinguishing systems.) This document categorises storage tank fire protection systems as fixed and semifixed systems.

Fixed systems (direct) are complete installations usually piped from a central foam station that discharges foam through fixed foam delivery outlets onto the hazard protected. The installation will be designed to have its own foam concentrate tank complete with foam concentrate pump (electrically or water driven).

These systems may be activated by a fire detection system or be manually operated. Many such installations will have an unlimited water supply utilising the ring main principle. Semi-fixed (indirect) relates to the type of distribution system where the hazard is equipped with foam discharge outlets connected to delivery piping which terminates at

a safe distance from the hazard with pumping in connections for Fire Brigade use. Foam concentrate and water requires transporting to the incident.

Installed fixed fire protection for storage tanks will include the following: foam chambers, these are fixed discharge outlets attached to the outside tank shell, so designed to apply foam directly onto the surface of the burning fuel. These systems are commonly used for the protection of both cone roof, open top floating roof and covered (internal) floating roof tanks. As outlined in NFPA 11, the number of foam chambers required on a tank will depend on the tank diameter.

Foam chambers will be installed at equally spaced positions around the tank just below the roof to shell joint. For example, an 180 to 200 foot (54m to 60m) diameter tank would require six discharge outlets to provide foam flow uniformly. Foam chambers are connected to a series of piping designed to transport the pre-mix foam water solution from the proportioning source located outside the tank dike wall to the foam chamber. The foam chamber may be supplied from either a fixed or semi-fixed foam system.

7. 4. Foam and other Media

Over the years the size of oil storage tanks has increased dramatically and this means that if a fire occurs (large open top full surface area fire) very large quantities of foam will be required to maintain a successful extinguishment. Although it is possible that chemical foam powders may still be found in some countries, modern methods rely on the use of mechanically produced foams, primarily protein based and synthetic foam concentrates. (see Foam SOP).

Foam concentrates can be stored in bulk quantities, it is easier to transport in 45-gallon (200 litre) drums and bulk foam tanks carrying up to 5000 gallons (22,500 liters). Whilst serious fires in oil storage tanks are not frequent, storage tanks of 300 ft (90m) diameter are now common, marine tankers in excess of 350,000 tons (352,000 tonnes) capacity present a huge demand for foam concentrate should one become involved in fire. It is therefore not practical to use 5-gallon (227 liter) cans. Facilities and Companies will have

in their Emergency plans how to transport large quantities of Foam concentrate to the scene of operations.

Incident Commanders should always liaise with the Companies I.C. on arrival and not consider a foam attack of any nature until a collective decision has been made as to the amount of resource required and the type of attack necessary. DCD fire and rescue personnel who have the responsibility of attending an incident at the petrochemical storage facility must ensure that they are fully familiar with the resources available and have exercised in the appropriate methods to be used.

7.4.1. Foam Making Equipment

Most petrochemical plants will be equipped with specialist designed first line firefighting vehicles, in many cases these vehicles will carry foam concentrate in varying capacities and may well be fitted with large output foam monitors. Water pumps ranging from 1000 gpm (4,500 litres) to 2,200 gpm (9,900 litres) being accepted as an industry standard. Large foam producing monitors of varying design for dealing with major fires in oil storage tanks and other risks, as well as a vast variety of smaller foam making branches, generators, inductors etc., will form a significant part of the firefighting inventory.

Large capacity foam monitors will usually be trailer units that can be towed by a fire appliance or other commercial vehicles. Similarly, a variety of bipod foam monitors will be included in the inventory; these monitors can be transported by hand. Large capacity foam monitors vary considerably in their output capacities 900 gpm (4000 litres) 1800 gpm (8000 litres) 3,500 gpm (16,000 litres) 12,500 gpm (56,000 litres) are now considered as Industry norms. Availability of this equipment would be based on a quantified risk assessment of the plant or refinery to be protected.

7.5 Use of Water on Petroleum Fires

Water is the best and most effective agent for controlling oil fires. However, compared to the use of water on solid material fires there are differences in the way it should be used, and in the things, it can accomplish. Water is cheap, usually comparatively plentiful, and has a higher specific heat than other liquids, which gives it excellent cooling properties.

In the burning of most substances, the actual combustion takes place only after the solid or liquid fuel has been vaporized or decomposed by heat to produce gas or vapour, and the visible flame is the burning gas. When water is applied to a fire in wood or other similar combustible material, its principal effect is to cool off the unburned wood, stop the evolution of vapour from it and thus starve the flame which feeds upon this vapour. Ultimately it will quench the red hot embers to complete extinguishment.

Certain oils behave in an entirely similar manner. Consider heavy fuel oil, lubricating oil or asphalt. At normal temperatures and pressures, none of these produce vapour in a significant amount until heated to a high temperature. This why they are said to have a high flash point temperature.

Once a fire is started in these high flash products, the supply of vapour is maintained, because the flame continues to supply heat to the oil surface to create more vapour. If no preventative steps are taken, the fire will continue until the fuel is all consumed. However, if water, preferably in the form of light spray, is applied to the surface, the surface will be cooled down, the release of vapour to feed the flame will cease, and the fire will be extinguished.

Therefore, for fire in some kinds of oil, water is well suited for extinguishment, and accomplishes extinguishment in much the same way as it does with wood or other ordinary combustible materials. For heavy oils in the 'high flash' category, cooling is a means of reducing vapours which feed the fire. Use water in the form of fog or a fine spray, **never use a jet**.

In considering the lighter flammable liquids in the 'low flash' category a very different situation prevails. These oils give off sufficient vapour to burn at ambient conditions. Any water reaching the oil surface will not boil; it will probably sink to the bottom without being greatly heated, hence its cooling effect is negligible.

The principal effect which it will have will occur within the flame itself, where of course any small drops will be vaporised and will remove heat. But here we are fighting the flame, not the fire. **In general water is ineffective as an extinguishing means** of fires fed by gases or vapours from volatile oils.

However, there are important functions that water can perform. Consider what will happen if as a result of an accident, a pipe is broken and gasoline leaks out at the rate of say 45 litres per minute. \

Assume that this gasoline is ignited immediately. The fire area will be small at first, but will speedily enlarge until the area is sufficient to consume all of the fuel just as it escapes. (The burning rate will be approximately 6 litres per min per m².) A leak of 45 litres per minute will produce a fire area of at least 7.5 sq.m. It could grow no larger because the fuel is being burned up as fast as it is supplied; it will not grow smaller because just this much fire area is required for air access, heat transfer and vaporisation, to balance the feed rate.

What will happen if a water stream is applied?

Some of the water will be in small drops even if a straight stream is used. Some of the small drops will be evaporated to absorb heat from the flame, thus slightly decreasing the rate of heat transfer to the oil surface. The water reaching the surface will slightly cool it, decreasing the vapour release. Both effects will be to decrease the burning rate per square metre. Since the fire is being fed, the fire (if not stopped by bund walls, etc.) will expand its area to make up for the decreasing burning rate.

The fire will spread. Of course, if it is so restrained that it cannot spread, the level will rise until the enclosing walls cease to be able to contain it. Remember, this is a gasoline fire, most of the water used on such a fire will end up beneath the oil, floating it so as to raise the level; this also will tend to make it overflow any existing restraining walls.

In summary, water is an effective extinguishing agent for 'heavy' oils, but it cannot extinguish a fire involving gas or light oils, except under highly unusual circumstances.

7.5.1 Cooling

Water is used to cool or protect buildings, structures, tanks etc., from heat or flame impingement. Flame contact may heat steel structures so they weaken and ultimately fail. Water properly applied (in the form of fog or spray) and in sufficient quantity (generally estimated at 10.2 litres per min per m²) can absorb the heat and prevent damage. It is important to remember that many of the liquid petroleum products which will be encountered have boiling points well below 100°C. Gasoline and kerosene start to boil below 100°C, the boiling point of water.

If a tank or vessel contains such an oil, the part of the shell which is below liquid level will be kept cool by the liquid inside. Even though the liquid contained in the tank is boiling, the steel which it contacts cannot get very hot. Water applied to the lower oil-wetted parts of a tank may run off barely warmed, and thus be largely wasted. Water does its most effective job of cooling when it is converted into steam as far as steel tanks and other similar petroleum equipment are concerned, the working rule is that priority cooling must be given to equipment that is being touched by the flames.

The parts of the equipment that are invisible because they are in the flame are the parts which need the protection; the equipment which can be seen is less likely to be endangered. For cooling of adjacent tanks one third of the surface area should be used for calculation purposes.

However, the roof of floating tanks should not be considered for water cooling because of the inherent danger of sinking the roof.

7.5.3. Water Application

Water applied to an oil fire may be used in two principal forms - spray (or fog) and straight stream, and each has its particular advantages, disadvantages, and scope of application. In general, the straight stream has the greatest range of driving force, the wide angle spray (or fog) has short range and affords the maximum protection for the firefighter.

An in between position, which combines the two, will in most cases be the most desirable. A dense spray of water may be used as a barrier between flame and firefighters, to protect

them against radiant heat, thus permitting closer approach for such important steps as closing a valve to shut off the flow of fuel feeding the fire. The object is to get the water, in the right form, to the place where it will have the most effect as a cooling or extinguishing agent. The mechanical effects are almost of equal importance. The place where oil burns may be very important.

Oil floats on water, and flooding a fire area may cause burning oil to flow over to an area where it could cause further fire escalation and damage to the plant. Or, it might be diverted into an area where it could burn without doing any damage at all.

This may be accomplished by the combined effects of floating and the force of hose streams. If a container develops a bottom leak, injecting water may float the oil above the level of the leak. This method has been used to stop the flow of product feeding an otherwise uncontrollable fire. Water for this purpose can be supplied at any level, but DO NOT overflow the tank. The rate of water addition must match the rate of leakage once the bottom water level has been established. **Careful monitoring is essential.**

7.6. Use of Foam

It is generally accepted that for major fires requiring the use of large volumes of foam concentrate, foam equipment should not be brought into operation until logistics have been met, e.g. water supply – foam concentrate supply, suitable equipment to project foam onto the fire are adequate and assured to extinguish the fire. A premature attack would not reduce the fire potential; indeed, it would only waste valuable and limited foam stocks.

The object in the use of foam is to provide a nonflammable layer between the surface of the fuel and the burning vapour above. The primary purpose of this layer is to cut off the radiant heat emitted by the zone of combustion which heats the surface of the liquid and causes the evolution of vapour – the only source of fuel for the flames. Secondary effects of the foam layer may also be the restriction of air supply and cooling of the liquid surface.

7.6.1. Mounting a Foam Attack

In general, conditions at hydrocarbon fires vary so widely that it becomes difficult to generalize on the methods of applying foam. As has been documented, ample quantities of foam concentrate must be available to enable a foam attack to be mounted and whilst further stocks are being accumulated and equipment positioned, fire exposures should be protected with cooling streams (preference for oscillating monitors) reducing the risk to personnel.

7.6.2. Extinguishing Petroleum Fires

Many fires at large storage depots are often successfully dealt with by the refinery firefighting personnel, and the role of the FRF is generally one of reinforcing refinery firefighters when larger fires occur. \

Prevention of fire spread often determines the success of extinguishing efforts. This involves the protection of tanks, other structures and pipelines that are affected by radiant heat or by direct flame impingement. Cooling streams of water should be directed so as to give adequate water coverage without waste. The maintenance of adequate drainage of a fire area will prevent floating blazing oil igniting unfired areas, and often provides a means of removing fuel with consequent salvage of product and plant.

The construction of temporary drains, ditches and dykes is also a phase of fire control which is especially valuable if a boil-over becomes imminent. Blanketing unignited pools of oil with foam will also guard against fire spread. Fires in storage tanks can be extremely hazardous, and as a general rule firefighting personnel should NOT be allowed to go on to the roof of a tank which is on fire, unless it is essential for rescue purposes. Refinery personnel with their technical knowledge will sometimes deal with small fires in tanks, particularly at the seal of floating roof tanks, at roof level; generally they will try to deal with the fire from the wind girder at the perimeter, using a single or multi-pour foam system, or failing that using handlines.

Conditions on the top of a floating roof tank can be dangerous, especially when the pontoon is low, as vapour can collect above the pontoon if there has been a leak at the seal, standard operational procedures for rim seal fires should be actioned.

The following factors need to be considered before going onto the roof of an external floating roof tank: Have all measures to extinguish the fire without having to go onto the roof been taken? i.e. direct or indirect foam system operated.

- What extent of seal fire?
- Have tank operations ceased?
- Position of fire, is it below the access to internal ladder?
- Position of floating roof, high or low?
- Possibility of escalation, e.g. pontoon explosion (if flammable vapour/air mixture present within pontoons).
- Is product on the roof?
- Is a fixed system available for fire suppression?
- Are landing valves available for handline operation?
- Weather conditions prevailing.
- Availability of protective clothing/breathing apparatus.
- Safe access to the roof to size up the extent of the seal fire. Are there alternate routes of escape from the roof?

A floating roof lower than eight feet (2.5m) from the top should be treated as a confined space.

- Is a foam dam fitted?
- What is the availability of safety-harness and lines? Successful fire extinguishment results from the systematic application of planned procedures.

Those born of panic often add to the seriousness of the emergency, and at every stage, expert advice should be sought from operatives or refinery fire personnel who have a much greater and more intimate knowledge of the processes and risks involved. Refinery personnel will attend to such control procedures as elimination of fuel supplies by closing

pipeline blocks or by re-routing flow elsewhere, depressurizing systems, blowing down a complete unit or pumping out tanks.

A water displacement procedure may be suggested whereby water could be introduced into equipment from which flammable liquid is leaking, although this can only be done if the temperature of the hydrocarbon is below the boiling point of water, such action will be closely monitored by plant operations supervision.

7.7 Fixed Roof Tank Fires

On tanks from which the roof has blown or on which a seam has opened, foam should be used. Where fixed foam facilities exist, these should be used in the first instance if possible, providing sufficient foam concentrate is available, but if foam cannot be applied immediately, the tank shell should be protected, particularly near the fixed foam chambers and riser with cooling water, until foam is ready to be used through this equipment.

If there are no fixed chambers or risers but portable foam towers are available, foam should be applied through these and discharged over the rim of the tank in sufficient quantity to maintain the recommended minimum delivery rate i.e., **at least 1 gallon of foam per square foot (50 l/m) of surface area per minute.**

Advantage can also be taken of fixed multi-pour foam systems on floating roof tanks, directly exposed to flame contact or radiated heat, to assist with suppression of hydrocarbon vapours within the seal area. Foam towers should not be erected and placed over burning tanks until such time as the equipment necessary to produce foam is ready. Without the cooling effect of the foam passing through the towers, they will be liable to rapid overheating and collapse.

With some types of tower, foam should not be pumped through them until they are resting against the tank shell, as they are not designed to handle the hydraulic load without the support from the shell. Normally, however, portable towers are only supplied at a refinery to replace fixed chambers that may be damaged in an initial explosion, so there may not be sufficient available to give the required rate of foam application. If portable towers are

not available in sufficient number, foam monitors should be used. Initially, fires burning outside the tank should be extinguished to avoid heat being applied to the tank shell.

Fires in banded areas, however, associated with tank fires are infrequent. Cooling water should be applied to the tank shell above the liquid level and to any intact portion of the roof of the burning tank, provided that the water running off does not enter the tank. Water streams should on no account be directed into the tank as this will destroy the foam blanket and possibly cause a slop-over or a boil-over.

Any tanks within 150ft (45m) downwind of the tank on fire should be cooled with water streams. Cooling a tank, the contents of which have not ignited but which is exposed to the heat of an adjacent fire, by means of water applied to the roof and/or shell, will prevent excessive evaporation and will lessen the danger of fire spread. Alternatively, screens of water can perhaps be projected downwind between tanks at risk. The spray must be angled as wide as possible and should be at a height sufficient to prevent flames passing over the top of the spray curtains.

If the tank contains asphalt or other heavy stock and the roof has blown clear, one method of extinguishment which is suggested by some refinery personnel is that water streams should be directed high into the air upwind so that the spray will fall through the flames into the burning oil. This will cause foaming and may extinguish the flames. Such an application of water, however, must be done very carefully in intermittent waves to avoid an extensive slop-over. If foam is used in attempting extinguishment, it should be introduced at one point only and must be shut off immediately if a slop-over occurs.

7.7.1. Slop-overs

The probability of slop-overs should be reckoned with under the conditions conducive to producing them. Sometimes when the tank is almost full and has little outage at the beginning of a fire, the thermal expansion of the oil or violent boiling on top of the cool oil due to the presence of a little water may cause sufficient increase in the volume of the oil so that the contents overflow. These preliminary overflows are referred to as 'slop-overs' and although they may look serious they are usually small in extent.

Slop-overs may occur at almost any time during the fire. They may occur spontaneously with 'wet' oil (i.e., oil containing a percentage of water); they may occur from the sudden application of foam; from rain or sprays from branches, or they may result from the thermal Expansion of the oil as it heats or from boiling of the surface. Warning of a slop-over is given by the lighter color of the smoke at the top of the tank on the windward side owing to the formation of steam, while a sizzling sound indicates wetness in the oil.

If conditions are such that a slop-over is likely, preparations should be made to extinguish any burning oil which may reach the bunded area by water from hose lines equipped with fine spray nozzles. All firefighting personnel should be withdrawn to outside the bund wall whilst such conditions prevail.

7.7.2. Boil-overs

Some crudes and unrefined oils when burning develop a 'heat wave' that travels downward from the burning surface at a rate of from 15 to 20 in. (380 to 1,270 mm) per hour. The temperature of the oil in this heat wave may reach 250°C to 300°C that is well above the boiling temperature of water. When this heat wave reaches the bottom water or reaches the bottom oil in which sufficient water is suspended, a violent 'boil-over' will occur.

A boil-over is a sudden eruption under the liquid whereby some of the liquid is carried out with the generated steam. Since water flashed into steam increases in volume 1,700 times, if the steam be entirely held by the oil, one gallon of water would produce 1,700 gallons of froth. Unless this frothy steam can break out on the surface in large bubbles, it becomes entrained in the oil and a wave of burning oil which may amount to several hundred tons is thrown out. The burning oil first violently erupts and then falls, possibly spreading beyond the bund walls of the tank.

Pre-fire planning should consider that up to four tank diameters could become involved.

Three conditions must exist simultaneously if a boil over is to occur, namely:

1. water must be present;
2. the oil must produce a heat wave;
3. the oil must be viscous enough to form a froth when the heat wave hits the water and turns it into steam.

An oil containing fractions of widely differing gravities and boiling points can be expected to cause a heat wave as it burns, and the production of this heat wave and its rate of travel is mainly caused by the impurities and free carbon in it. Distilled oils, such as petrol, kerosene, diesel and lubricating oils with their narrower boiling ranges and lack of impurities do not produce a heat wave.

The daily oil inventory which is maintained at each refinery should be consulted to determine the product in the tank, and bottom water gauges will confirm if and when a boil-over is expected. A boil-over is usually preceded by a marked heightening and brightening of the flames for a period of a few minutes, and the officer in charge should always be on the lookout for these warnings (or should delegate an officer for this purpose) so that positions of safety can be sought (Safety of personnel).

The signs of warning of a boil-over are somewhat similar to those for a 'slopover'. A vertical stripe of temperature paint can be used on tanks to indicate the progress of the heat wave, use of thermal imaging camera could be an advantage. Where no indicator paint is available, water thrown on the side of the tank will indicate the bottom of the hot layer. The location of the heat wave can also be determined from the wavy appearance of the air adjacent to the shell of the tank at the depth to which the hot oil has reached.

It may be possible to use the draining pipes at the base of the tank to remove water, and so reduce the chances of a boilover. There is a danger in using this procedure as it may not be possible to close the drain valves once they have been opened, with the result that oil could escape into the bund and possibly ignite. Any action decided in this connection should only be taken after close consultation with the refinery officials.

After a boil-over has occurred, the oil at the base of the tank will have been cooled, but subsequently it will again be heated by conduction from above. A second heat wave may occur and if there is any water at the bottom, a second boil-over will occur. This sequence can continue so long as there is any water in the tank. Incident Commanders should therefore continually be on their guard against the possibility of successive boil-overs.

Exact figures for the rate of expansion of the heat wave cannot be given, but the figures shown give some guidance in estimating the time in which a boil-over may be expected. Also given are the burning rates for oil in a tank burning at the surface only; they are not applicable for oil in a tank involved in a bund fire.

7.7.3. Floating Roof Tanks

Because there is no vapour space beneath the roof of a floating roof tank, there should be no danger of explosion. A certain leakage of vapour will occur through the seal where the roof meets the shell, and this may become ignited, causing the seal to burn. Fire can also occur through diphoses, if they are left open. However, a floating roof tank is vulnerable to fire and/or explosion when the roof is standing on the jacks and there is a vapour space beneath it.

Small seal fires are generally extinguished by refinery personnel with portable dry powder equipment, but re-ignition due to the heated metal or smouldering seal fabric may occur. Foam can be applied from small portable foam branches on to the seal area. When foam is applied by refinery personnel, it is normally done from the wind girder or top gantry, as application from the ground is difficult and possibly ineffective.

Very fine water spray can be used to cool the exposed metal to avoid re-ignition, and possibly to extinguish the fire itself. If the fire extends over a larger portion around the rim, the task of extinguishment can be speeded by applying two foam streams working from opposite directions around the wind girder. Cooling water should be applied to the shell of any hot spot which will be indicated by blistered paint. It can be applied to the outside of the shell, or, if care is used, to the inside of the shell, it is important to avoid directing heavy water streams into the flammable material at the roof edge, as this may splash the burning product on to the roof and increase the seriousness of the fire.

The same precautions should be taken for any possible fires outside the tank, and the necessity for cooling adjacent tanks if the heat of the tank on fire is of such a magnitude to affect other tanks. Floating roof tank seal fires are not, however, usually of great

magnitude. Should the floating roof have been displaced by explosion or fire, the fire should be tackled with foam as for a fire in an open tank.

7.7.4. Storage Tank Vent Fires

If a fire at a tank vent is burning with a yellow / orange flame emitting black smoke this indicates a vapour-rich condition within the tank that is above the flammable or explosive limits. This type of fire is usually dealt with by refinery personnel by smothering with steam, dry powder, carbon dioxide or wet blankets. Danger of an explosion is not indicated under these conditions.

If a fire at a tank vent burns with a snapping blue-red nearly smokeless flame this indicates a vapour-air mixture within the tank that is within the flammable range. There is danger of an explosion should the flame reach the inside of the tank and **no one should go on to the roof while this condition exists**. The vapour space of the tank might be converted into a vapour-rich condition by refinery operatives pumping liquid into the tank, thereby maintaining a positive pressure, or by the introduction of fuel gas or other light flammable products.

When a vapour-rich condition is indicated by a change in the flame character to a smoky or yellow-orange flame, danger of an explosion has subsided. Extinguishment can then be attempted by smothering with steam, water spray, dry powder or wet blankets. Any action to convert the vapour space within the tank into a vapour-rich condition should not be attempted by firefighters without prior consultation and agreement with responsible officials at the refinery, and then every precaution must be taken to prevent exposure of personnel to the danger of explosion.

Note:

Any attempt to extinguish a tank vent fire using only dry chemical must take into consideration that the pressure vacuum valve may have been damaged by heat from the fire and may not close after the flames have been extinguished. Under these conditions a P/V valve failed in the open position could enable FLASH-BACK into the. Flashback

into a tank containing a flammable vapour/air mixture could produce an internal explosion resulting in the roof being blown off or severely damaged, with possible fragmentation.

7.8.0. Factors Influencing Level of Risk

Some factors that influence the level of risk at a tank fire will include the following:

- The flammable liquid on fire (hydrocarbon or polar solvent)
- Flash point of product (high or low)
- Temperature of product
- Level of product in the tank Status of tank e.g. was the tank being filled or emptied at the time of fire?
- Any direct flame impingement on the shell, valves, piping, flanges resulting from a dike fire
- Weather conditions (high wind, wind direction, raining or not)
- Status of dikes, drainage, any penetrations in dike walls
- Availability of water and foam supplies
- Coned or floating roof (position of roof)
- Direct exposures (cooling priorities)
- Condition of fixed foam facilities.

Following evaluation and risk assessment, the incident commander must then decide what action must be taken using pre-incident plans. Extinguish the fire using fixed foam systems (should they be intact) or a combination of remaining fixed systems supported by portable foam monitors for over the top foam application.

Cooling of exposures take top priority

The foam selected, proportioning percentages and foam application rates will depend on several factors:

- Size of tank
- Tank capacity
- Flammable liquid involved.

- Presence of fixed fire protection systems.

The following general guidelines should be referenced. NFPA 11. Recommended Minimum foam application rates. 0.10 gpm/ft (4.1 lpm/m) fixed systems application for hydrocarbon fuels (cone roof tanks with foam systems. Foam chambers – subsurface) 0.16 gpm/ft (6.5 lpm/m) portable application for hydrocarbon storage tanks. (Portable foam cannons). A foam application rate of 0.18 to 0.20gpm/ft (7.3 to 8.0 lpm/m) has been used to successfully extinguish hydrocarbon fires in a large diameter tank.

7.8.1. Covered (Internal Floating Roof Tank)

Methods of extinguishing an internal floating roof tank fire will primarily depend on the type of fire presented to the emergency responder. Potential fire scenarios can include seal fires, surface fires with the internal floating roof partially sunken or a full surface fire where the fixed roof has been blown off, and internal pan roof sunk. Options available to the incident commander:

Seal Fire

- Foam Pourers (Top Application).
- Portable foam monitors from elevated platforms.
- Portable foam tower/ foam wands.

Full Surface Fire

- Foam Pourers (if intact).
- Portable Foam Monitors.
- Portable Foam Towers.

Subsurface and semi-subsurface foam injection systems are not normally recommended for protection of internal floating roof tanks. The tactical problem of dealing with an internal floating roof tank fire is that the fixed roof prevents direct access to the internal floating roof seal area. Rim seal fires in these tanks are very rare but can be extremely difficult to deal with if a fixed foam system is not installed.

7.9.0. General Tactical Options

The following operational tactics should be considered when dealing with a Fire and / or managing an internal floating roof seal fire:

- Protect the structural integrity of the exposed tank shell above the seal fire with cooling spray, being careful not to direct water through tank side vents.
- Extinguish seal fires using fixed foam protection systems.
- Extinguish any dike fire. Where roof to shell seam has parted the use of foam towers or foam wands may be an option.

Firefighting should be continuously monitored from a safe elevated position. One option to be considered is the use of subsurface foam injection through a product line, whilst this method is not recommended by NFP A 11, it has been used during an internal floating roof tank fire with some success, supported with the use of foam wands, however, it should be made clear that on the tank involved, the internal roof had partially sunk.

Under no circumstances should firefighters be committed to the DIKE AREA of a crude oil tank total surface area fire.

SOP 8. RADIATION

8.0 Scope

This Standard Operating Procedure (SOP) considers hazards, risks and control measures for FRF personnel attending incidents involving Radiation. It prepares an action list for dealing with ionizing radiation and the procedures required when involved in an incident that may have the potential for contact with radioactive materials.

8.1.1. Ionizing Radiation

Ionizing radiation is a general term used to describe the electromagnetic waves and high-energy particles emitted by radioactive substances. Ionizing radiation can have serious adverse effects on health. Any reference to 'radiation' within this document refers to ionizing radiation.



8.1.2. Potential for Contact with Radioactive Materials

The quantity of radioactive materials now used in industry, health care, education etc. and their transportation by road or rail, in addition to the emerging threat of a 'New Dimension' dirty-bomb type radiation incident, increases the possibility of firefighters attending incidents where radiation is present.

8.2.0 Specific Hazards & Risks

8.2.1. Penetrative Power of Ionizing Radiation

Radiation is said to be ionizing if it has enough energy to ionize atoms, that is, to knock electrons from them, thereby changing their chemical or biological properties. There are five main types of ionizing radiation - alpha, beta, gamma, neutron and X-ray, each having different effects and penetrative power.

8.2.2. Irradiation

Irradiation occurs when high-energy particles or rays emitted by a radiation source strike, penetrate and are absorbed by the human body. An irradiated person will not be radioactive, although damage to tissue might have occurred.

8.2.3. Contamination

External contamination occurs when the radiation source itself, e.g. liquid, dust, vapour, gas etc. is present on a person's skin, clothing or protective equipment. If radioactive material is ingested through breathing, swallowing or injection (including through wounds), the person is said to be internally contaminated. During the period that the contamination is present on or inside the person, the radiation emitting from the contaminating material can irradiate (damage) tissue.

8. 2.4 Sealed, Unsealed and Shielded Radiation Sources

Sealed (or 'closed') sources are designed to allow radiation to escape while retaining the radioactive material itself. Sealed sources pose only an irradiation risk except where they are directly affected by fire, explosion or impact.

Unsealed (or 'open') sources are those contained in non-robust containers such as test tubes, glass jars, steel drums or even plastic bags, etc. and are most likely to be of relatively low activity. The main risk will be from contamination as the contents of such containers can easily be spilt or dispersed if disrupted, especially during a fire.

Shielding is designed to absorb the radiation emitted by a source, so ensuring safe handling and transportation. It can consist of a variety of materials ranging from plastic through to lead and depleted uranium. When a source is not in use it will be shielded, and when it is in use it will normally be unshielded.

8.3.0 Health Effects of Ionizing Radiation

Each organ of the body is composed of tissues, which are made up of cells. Ionizing radiation causes damage to these cells. Cells that are reproducing that are more sensitive to radiation, thus the different tissues in the body vary widely in sensitivity. The most

sensitive tissues include the reproductive organs, and skin and blood forming cells in the bone marrow. If women are exposed to high levels of radiation, it could have a damaging effect upon any future offspring, with pregnant women particularly at risk of damage to the unborn child.

When a person is exposed to ionizing radiation, there is no direct physical indication of the radiation, i.e. sound, sight or smell, and there may be no immediate sign of any damage to the body. The greater the dose of radiation that is received, the greater the damage. The period over which a radiation dose is accumulated and the area of the body exposed also has a considerable effect on the degree of damage to the body. Higher doses of ionizing radiation can lead to death, skin burns, hair loss, nausea, sterility, or genetic mutations in future generations. The main risks associated with lower doses of radiation are cataracts, cancers developing later in life or genetic mutations.

8.4.0. Key Control Measures

Time, Distance and Shielding to Protect/Limit Exposure Where it is known that the only radiation at an incident is from a sealed source i.e. There is no contamination risk, protection will depend upon a combination of:

- **Time** - the shorter the duration of exposure the smaller the accumulated dose
- **Distance** - the greater the distance from the source of radiation, the lower the dose rates
- **Shielding** - in general the higher the density and greater the thickness of the shielding, the better the protection

Doubling the distance from a radiation source quarters the dose received.

FIREFIGHTERS MUST NEVER HANDLE A RADIATION SOURCE:

Radioactive materials, which are 'loose' in the air, may be taken into the body by ingestion, inhalation, through the skin or through cuts and abrasions. Whenever radiation or radioactive contamination is suspected it is essential that breathing apparatus and appropriate protective clothing is worn.

8.5.0. Units of Measurement

8.5.1 The Strength of a Radiation Source

The source strength or activity of a radioactive source is normally expressed in Becquerel's (Bq). One Becquerel (one disintegration per second) represents a very small source strength and so multipliers of Becquerel's will usually be used when source strength is expressed:

- Kilo-Becquerel's (KBq) – 1000 Bq
- Mega-Becquerel's (MBq) – 1,000,000 Bq
- Giga-Becquerel (GBq) – 1,000,000,000 Bq
- Tera-becquerels (TBq) – 1,000,000,000,000 Bq

8.5.2 The Radiation Dose Received by a Person

For Operational Firefighters purposes the sievert (Sv) is the unit of measurement of the dose of radiation absorbed in human body tissue (this is referred to as the 'Equivalent Dose'). Since one sievert (Sv) represents a large dose, it is more common to show doses in millisieverts (mSv) or even microsieverts (μ Sv).

- 1000 microsieverts (μ Sv) = 1 millisievert
- 1000 millisieverts (mSv) = 1 sievert

8.5.3 The Dose Rate

This is the rate at which radiation from a radioactive source will be absorbed over a set period of time. Dose rate will usually be expressed in:

- Microsieverts per hour (μ Sv/hr)
- Millisieverts per hour (mSv/hr).

The dose rate will be reduced by any effective shielding that is in place, and also by increasing the distance from the source; doubling the distance from the source will quarter the dose rate (this is known as the Inverse Square Law)

A Simple Analogy

Dose and Dose Rate may be compared with a journey in a car;

- The Dose a firefighter has received can be compared to how far (how many miles) you have travelled as shown the Car's odometer.
- The Dose Rate can be compared to how fast you are travelling at any given moment as shown on the car's speedometer

8.5.4. Working Duration Calculations

The source strength can be used to determine the dose that will be received at different distances from the source over different time periods, using the formula;

$$\text{Gbq}/2d^2 = \text{mSv/hr}$$

Where;

Gbq = source strength

d = distance from source in meters

Example;

A firefighter could work 1 meter from a 40 Gbq radiation source for 30 minutes Without exceeding a 10mSv dose.

$$40/ 2 \times 1^2 = 20 \text{ mSv per hour} = 10 \text{ mSv in 30 Minutes}$$

8.5.4 Radiation Dose Limits

It is the view of the enforcing authority (Tanzania Atomic Energy Commission) that the Ionizing Radiation Regulations 1998 (IRR) and Radiation (Emergency Preparedness and Public Information) Regulations 2003 (REPPIR) apply to legitimate users of radioactive materials (e.g. nuclear power stations) but not to the malicious use or dispersal of radioactive materials nor emergency work in general.

The Ionizing Radiation Regulations 1998 specify maximum dose limits for employees of 20 mSv per year per person with an additional dose limit of 13 mSv in any consecutive three-month period for women of reproductive capacity. In accordance with the principle

of keeping doses As Low as Reasonably Practicable (ALARP), FRF has adopted a DOSE CONSTRAINT of 10 millisieverts (mSv) per employee per year.

8.5.4.1. Dose Limit for Radiation Emergencies / Terrorist Events Radiation Emergencies –

(The Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR) permit an ‘emergency exposure’ in the event of a ‘radiation emergency’). An emergency exposure is an exposure to radiation in excess of IRR limits. Such an exposure may only be permitted during a radiation emergency.

The HAZMAT Advisor should be satisfied that an intervention is justified and that:

- Lives can only be saved by an emergency exposure; or
- There is a direct threat of catastrophic Proportions.

In these two instances, the Incident Commander may consider a single emergency exposure not exceeding 100 mSv, where the exposure has first been authorized by a HAZMAT Advisor and where expert advice (i.e. from an RPA) is available.

Terrorist Events

F.A.N.A. applies to premises and transportation where a known source of certain strength exists. This is clearly not the case in a terrorist attack involving a radiation source at other premises. In this case therefore, the IRR Regulations cannot legally be misapplied. “Terrorist incidents are not considered by HSE to be applicable to either the Ionizing Radiation Regulations 1999 (IRR99) or F.A.N.A. However F.A.N.A. Does provide a good framework which can be used for planning and management of risk with regard to intervention at this type of incident.

At terrorist incidents, FRF has determined that a single emergency exposure not **exceeding 100 mSv** may be considered by the Incident Commander, where the

exposure has first been authorized by a HAZMAT Advisor. As with a radiation emergency, the HAZMAT Advisor should be satisfied that an intervention is justified.

For both radiation emergencies and terrorist incidents involving radiation, Firefighters will be considered for an emergency exposure to radiation up to a maximum of 100 mSv. Personnel have received a briefing on the precautions that should be taken to limit exposure and the possible health effects of such an exposure. In the case of both radiation emergencies and terrorist events the Incident Commander, in consultation with the Hazmat Advisor, should adjust tactics to ensure that absorbed doses are kept to a least possible level.

8.6.0. Radiation Monitoring Equipment Carried by FRF

The type of ionizing radiation involved in an incident will determine the detection/monitoring equipment to be used. The following radiation detection/monitoring equipment is provided within Fire and Rescue Force:

CHECK HAZMAT VEHICLE – Al Qouz & Al Qusais Electronic Personal Dosimeters (EPDs). The EPDs carried on appliances are battery-operated compact units that detect and measure gamma and X-ray radiation. The EPD is capable of displaying equivalent doses of radiation in both microsieverts (μSv) and millisieverts (mSv) and dose rates in microsieverts per hour ($\mu\text{Sv/hr}$) and millisieverts per hour (mSv/hr).

The EPD is calibrated to sound an audible alarm at three pre-set levels.

100 microsieverts per hour (μSv per Hour) – initial dose rate alarm NOTE: the alarm (intermittent double beep) cancels

- i. After 20 seconds
- ii. If the dose rate falls to below $90\mu\text{Sv}$ per hour or below
- iii. If the EPD operating button is pressed

Crews should expect to hear this tone every time a dose rate of $100 \mu\text{Sv}$ per hour is reached. For example, if a crew emerges from behind substantial shielding their EPDs may sound the initial dose rate alarm again.

- 5 millisieverts (mSv) – dose constraint alarm (dual tone slow)

- 100 millisieverts (mSv) – exceptional dose alarm (continuous single tone)

The audible alarm prompts wearers to check the reading on the unit and act accordingly. Full details of the function, specifications, methods of use, and limitations of the EPD are contained in A&E/-7.

Provision of EPDs Personal Metres

Recommended on appliances

- 6 EPDs – all Water ladders
- 6 EPDs - Rescue Pumps
- 6 EPDs – CIU
- 2 EPDs – Rescue Tenders
- 2 EPDs – Hydraulic Platforms
- 2 EPDs – Foam Tenders

RADOS RDS-200 Universal Survey Meter the RADOS RDS-200 Survey Meter carried on appliances in DCD is a portable, self-monitoring, battery-operated, multi-purpose survey meter, capable of detecting and monitoring Gamma and Beta radiation. For Gamma radiation, it measures the dose rate in microsieverts or millisieverts per-hour. With the Beta probe attached the RADOS RDS-200 Universal Survey Meter can also measure Beta particles of sufficient energy in 'counts-per-second'.

Full details of the function, specifications, methods of use, and limitations of the RADOS RDS-200 Survey Meter are contained in Operating Manuals Nuclear Enterprises Portable Contamination Meter This device should be kept on the HAZ-Mat and Emergency Tenders.

8.7.0. Previous Dose History – Quick Access Records at Incidents

Other than normal medical exposures, operational personnel may also have been exposed to radiation at a previous incident, in primary or secondary occupations outside FRF or before joining the Service. Details of such exposures are to be recorded on a helmet label that is stuck to the rear inner face of the helmet by the Operational Risk Management

Normal medical exposures to radiation during dentistry or for broken limbs etc. do not constitute dose history in these circumstances. Any personnel worried about any other medical radiation exposure they are to have (e.g. Chemotherapy) or any medical treatment they are having that may be affected by workplace exposure to radiation, should first discuss it with the physician in charge of the treatment, and then with FRF's Occupational Health Department as appropriate. Personnel who have received any radiation dose during the last five calendar years, other than normal medical exposures, should not be committed.

8.8.0. Pre-Planning for Known Radiation Risks

Inspections are an important element in the preparation for incidents involving radioactive materials. The Environment Agency NEMC & Fire Rescue Force holds a register of premises handling/using ionizing radiation sources and should advise the Operations department of the premises. A database of premises registered to handle/use radioactive substances is maintained by the FRF.

Note: Firefighters should also be aware that the construction and fabrication industry use radioactive sources for the purpose of weld testing. Such radiation sources are intended to be mobile and a record of their location is unlikely to be held by Fire Rescue Force

8.9.0. Operational Procedures

Where the Operations Control Room (Fire Control) receive information that radioactive materials are believed to be involved at an incident, appliances, tactical and a HAZMAT Officer will be mobilized in accordance with SOP. A defensive mode of tactical operations must be employed until the arrival of the required resources.

Informative messages to the Operations Control Room (Fire Control) should state 'RADIATION SUSPECTED' when involvement is suspected, and "RADIATION CONFIRMED" when radiation is known to be involved.

On receipt of either of these messages, Operations Control Room (Fire Control) must inform all appliances/crews/managers that they are attending the incident. The Incident Commander must establish a marshalling/rendezvous point. This should be at a distance of at least 45 meters and upwind of the incident if there is a risk of airborne contamination.

All appliances and FRF managers should approach from upwind of the incident to avoid airborne contamination. Appliances deployed from the marshalling / rendezvous point are to be sited outside any restricted area that has been established.

All FRF personnel should attach an EPD to the outside of their fire tunics and monitor its readings to ensure that they are not inadvertently exposed to radiation above background rate. Tactical Managers should collect their EPD from an appliance (all water ladders carry 6 EPDs).

The Incident Commander should initially attempt to establish the following information:

- the nature of the source involved (sealed or unsealed)
- the source material involved e.g. Strontium 90
- the type or types of ionizing radiation emitting e.g. Alpha, Beta, Gamma, Neutron, X-ray or any combination of these
- whether or not any shielding is in place
- whether any fire, explosion or impact has affected the radiation source

The accuracy of any information held by FRF Operations should be checked by liaising with the site manager and/or specialist adviser i.e. the site Radiation Protection Supervisor (RPS) or the site Radiation Protection Adviser (RPA).

The incident commander should consider 'non-intervention' For example, a spillage of radioactive material in a closed room where there is no immediate risk to the environment will normally be the responsibility of the occupier – not Fire and Rescue Force.

8.9.1 Determining a Restricted Area

If a radioactive source

- Becomes involved in fire
- Has been involved in an explosion
- Has been broken up, spilled or damaged then the Incident Commander must establish a restricted area.

In the early stages of an incident the boundaries of the restricted area may be based on an estimate of the maximum extent of contamination, but this should be verified as soon as possible with a survey meter. The boundary of the restricted area should be established using a survey meter to determine the background radiation rate. The background rate will normally be a reading of no more than 0.2 μSv per hour (micro Sieverts per hour).

When the restricted area is established, movement in and out must be strictly controlled. Traffic tape and cones, or a rope barrier, should be used to define the boundary. Restricted area notices, if available, should be placed in strategic positions. The police should be in attendance at the boundary to prevent unauthorized entry and exit. The dose rate at the boundary to the restricted area should be checked periodically with a survey meter.

8.9.2. Entry and Protection within the Restricted Area

If it is necessary to deploy firefighters within a restricted area then the Incident Commander must implement Stage 2 BA Control. The Incident Commander should attempt to determine the location of the radiation source and plan a route that will involve the least exposure to firefighters. Only the smallest essential number of personnel (i.e. Crews) should be deployed on any task that might expose them to radiation. Operations should be conducted as far as possible from behind any available cover/shielding.

A BA crew of 3 (including a Crew or Watch Manager) wearing EPDs, fire kit and Gas Tight Suits should be deployed, with the Crew/Watch Manager operating at the front of the team with the survey meter. All crew members must regularly check their EPDs to determine the dose they have received. Crews must be briefed by the HAZMAT Advisor before entry to the restricted area. They must switch on and read their EPDs before entry. It is the responsibility of the BAECO to record individual readings on the reverse side of the BA tally.

When crews are committed, if the survey meter reading reaches a dose rate of 100 mSv/hour or above, crews should withdraw to an area (taking advantage of available shielding) where readings are below this level. The BAECO, under the supervision of the HAZMAT Advisor, must record radiation doses received – “Incident Record of Personnel Exposed to Hazardous Substances”, when crews exit the restricted zone.

It is important that EPDs do not become contaminated with radioactive dust or liquid. The EPD should be attached in the upper central chest area of the fire tunic. If GTS are worn, the EPD should be secured inside the suit in the upper central chest area.

Note: Gas Tight Suits are to be worn when there is a risk of contamination. The suits do not give greater protection but make subsequent decontamination easier to carry out. Even if no radiation is detected in building which display the ‘Trefoil’ sign,



Firefighters entering the restricted area must wear EPDs and BA, fire kit & gloves or Gas Tight Suits until specialist staff confirm that no radiation is involved.

EPDs are compact devices that measure the radiation dose rate levels that an emergency responder may receive during an operational period.

8.9.3 Decontamination

The level of Personal Protective Equipment (PPE) required by firefighters will be influenced by the category of risk e.g. Contamination or irradiation. Decontamination will only be necessary where contamination has occurred or is Suspected.

External contamination occurs when the radioactive source itself, e.g. liquid, dust, vapor, gas etc. is present on a firefighter's skin, clothing or protective equipment. During the period that the contamination is present on the firefighter, the radiation emitting from the contaminating material can cause damage to tissue.

The contamination risk persists until the radioactive material is removed i.e. the firefighter or equipment is decontaminated. Decontamination should take place in accordance with OPS/SOP/Decontamination. Where it is not possible to decontaminate personnel on the incident ground before they are transported to hospital, their breathing apparatus, gloves and outer clothing should be removed in the open air before entering the transport vehicle. This should be done with care to avoid disturbance of any dust that may be adhering to them, and they should be provided with spare clothing or wrapped in blankets etc. The vehicle used for transport should be checked with a contamination meter on arrival at the hospital.

8.10.0 First Aid / Medical Procedures

The hazard to firefighters from the ingestion of radioactive dust or smoke is very serious, and personnel must not be allowed to eat, drink or smoke in a restricted area. It is also important to ensure the complete protection of any cuts and abrasions received whilst working in a restricted area, in order to avoid contaminated dust or particles entering the blood stream.

Any personnel who suffer cuts etc. should be withdrawn and instructed to wash the injury thoroughly before proceeding for medical attention. It is particularly important that the nose, mouth and eyes, or the interior of a BA facemask should not be touched with hands or gloves suspected of being contaminated. A firefighter exposed to a radiation dose of 6

millisieverts or more, or who complains of feeling unwell, should undergo a medical examination at The Designated Hospital. If it is suspected that a firefighter may have ingested radioactive material, immediate medical aid should be sought.

8.10.1. Recording Radiation Doses Received

Details of any radiation dose received by a firefighter is to be recorded as follows:

- Form 0-10 – Incident Record of Personnel Exposed to Hazardous Substances
- Form 0-10a – Consent to Emergency Exposure – Ionizing Radiation
- Form 0-12 – Record of Exposure to Toxic Fumes / Chemicals / Radiation

Biohazards: Form 0-13 Hazardous Substance Exposure Notification.

Before personnel are transported to hospital, Form 0-11 (Hospital Transit Sheet) is to be completed and handed to the Ambulance Service. The Ionizing Radiation Regulations require an employer to investigate and ensure that medical surveillance is provided when an employee receives a dose of 6 millisieverts for the first time in any calendar year.

If a firefighter receives a dose of more than 20 millisieverts in a period of one year, an investigation must be carried out with the help of the Radiation Protection Adviser and the HSE must be advised of the findings. The Hazmat Team Leader will instigate this investigation. Due to the legal requirement for the HSE to be advised of the findings of the investigation it is extremely important that the recording procedures detailed in this paragraph are strictly observed. It is crucial that the microsievert (μSv) values and millisievert (mSv) values are not confused when recording radiation doses.

8.11.0 New Dimension Type Radiation Incidents

There could be threat of a large scale terrorist attack in the UAE. The scope of this threat has been recognized as including Chemical, Biological, Radiological or Nuclear (CBRN) –colloquially termed a ‘New Dimension’ type incident. A ‘New Dimension’ CBRN radiation

incident could, for instance, occur as a result of a 'dirty bomb' detonated by terrorists to disperse radioactive contamination across an area.

The FRF would usually be one of the first responders to an explosion. Where initial intelligence from the police suggests that the explosion may be terrorist related, or where there is any doubt as to the cause of the explosion, all FRF personnel in attendance will wear EPDs to monitor radiation dose, and a restricted area will be established by use of a survey meter in line with this procedure.

8.12.0 Environmental Considerations

The Health Protection Agency is responsible for coordinating the monitoring of air quality at radiological or nuclear incidents.

As far as possible firefighting water should be contained. TANESCO and the Environment Agency must be advised if there is a release of radioactive material during a fire which is likely to enter the drains. Turning over operations should not be carried out if a radiation source exists or is suspected until the location of the source has been identified. Once the radioactive source has been identified, any further operations in this area will only be undertaken after consultation with available specialist advice.

8.12.1 Additional Considerations; Types of Radiation

1. Alpha Particles

These are relatively large energy particles that travel up to 50mm in air. They are easily stopped by a very thin layer of solid material, i.e. paper or skin and therefore present no significant external radiation hazard. However, the risk should the radioactive material be inhaled or ingested is substantial.

2. Beta Particles

These are much smaller than those emitted an alpha source and can travel up to three meters in air. They can be stopped by a few millimeters of metal or centimeters of plastic

or layers of heavy clothing. As with alpha particles, there is a significant risk of damage to internal organs should substances emitting beta radiation be breathed in or swallowed.

3. Gamma Rays

These rays are electromagnetic radiation and travel at the speed of light. They are not appreciably absorbed in air and will the whole body may be irradiated. They require dense, thick material such as lead or concrete to substantially reduce their intensity. Also, where a radioactive substance primarily emits alpha and or beta particles, gamma rays are also often emitted. Gamma radiation has the potential to cause internal and external damage to humans.

4. Neutron Particles

Neutrons can penetrate the body and are far more damaging than either Beta or Gamma. They can only be absorbed by dense material e.g. lead or concrete. Neutron emitters may be used for commercial applications such as road surface depth gauges or moisture probes. Neutrons have a similar affect to gamma rays, although they are not detected by normal radiation detection equipment. Neutron emitters should therefore be treated as gamma sources but should only be approached if a life risk is involved.

5. X-Rays

Artificially produced by electrical machines and widely used in medical or industrial radiography. Their penetrating power depends on their energy, which is related to the electrical energy used in their production. X-rays pose similar risks to humans as gamma rays. The method for dealing with the risk from X-rays will normally be to switch off the electrical power. Once this is accomplished, no further risk will exist. Transportation of

Radioactive Substances Pleading of Vehicles Carrying Packages radioactive packages are required to display a diamond-shaped placard on all four sides of the vehicle.

Vehicle Warning Notice



A Vehicle Warning Notice shown shall be securely posted in the vehicle, in clear view of the driver and shall only be exhibited when the vehicle is carrying radioactive material. It is white with bold black lettering and is fireproof.

The notice will state clearly that:

- the vehicle is carrying radioactive materials
- in case of accident the police should be contacted the name, address and telephone number of the owner or operator

Labeling of Packages
Unless the package is an excepted package (in which case it is unlabelled), all packages are labeled according to the external radiation hazard associated with the individual package as represented by the maximum radiation dose rate at the surface of the package. This rate of surface radiation is defined by the term 'Transport Index' (TI). TI is used to express the external radiation hazard arising from a package in practical terms. The TI is determined by measuring the radiation dose rate at 1 meter from the package in $\mu\text{Sv/hr}$ and dividing the measured value by 10.

Packages must be labeled on two opposite sides in categories from one to three. Each of these categories has its own distinctive label marked with one two or three (highest risk) red bars as appropriate to simplify recognition (see below).

For the purpose of labeling, packages are divided into three categories:

- Category 1 – White
- Category 2 – Yellow
- Category 3 – Yellow



The use of the word 'RADIOACTIVE' is optional to allow the alternative of displaying the appropriate substance identification number. Transport Index and Dose Rates

The dose rate (in $\mu\text{Sv/hr}$) at 1 meter from the surface of the package = $\text{TI} \times 10$

| Category | Dose Rate at Surface ($\mu\text{Sv/hr}$) | Dose Rate at 1 metre ($\mu\text{Sv/hr}$) | Transport Index (TI) |
|--------------|--|--|----------------------|
| I - white | maximum 5 | - | - |
| II - yellow | greater than 5 to a maximum of 500 | greater than 0 to a maximum of 10 | 0-1.0 |
| III - yellow | greater than 500 to a maximum of 2000 | greater than 10 to a maximum of 100 | 1.0-10 |

Where radioactive materials are being transported, the packaging will be designed to provide adequate shielding and will resist most minor accidents. FRF personnel should not remain in the immediate vicinity of labeled packages unless a Hazmat Advisor provides appropriate guidance. The Possibility of an accident involving a Nuclear weapon is very remote, however, this note for information only.

Hazards

The dominant radioactive hazard involved in a nuclear weapon accident would come from the plutonium, an element that emits Alpha radiation. **Plutonium** is a chemical element; it has symbol **Pu** and atomic number 94. It is an actinide metal of silvery-gray appearance that tarnishes when exposed to air, and forms a dull coating when oxidized.

Therefore, unless the casing of the weapon itself is breached (which is extremely unlikely) there is no danger even to those in close proximity to it. Other radioactive materials such as uranium and tritium or toxic materials such as beryllium and lithium may be present. There is a further high explosive and projectile hazard arising from the conventional explosives in a warhead.

Operational Procedures

- Approach upwind where possible.
- Liaise with the senior military officer present.
- Wear Gas Tight Suits, BA and EPDs if it is absolutely necessary to move into close proximity to the incident i.e. for rescue purposes or to prevent hazardous escalation.
- Priority is to be given to rescue of casualties, extinguishing the fire and cooling weapons or containers NB: Do not disturb weapons or containers.
- Cooling should continue even after fires are extinguished, spray-branches being fixed in position or monitors used where possible. The Military Commander will advise when this is no longer necessary.
- In cases of aircraft crash, military personnel may not be first on the scene. Where this is the case, it must be assumed that munitions are present. Where fire is hazarding the load, FRF personnel should withdraw immediately to a distance of at least 600m and take cover. If explosion is thought to be imminent,

residents within a 45° arc, up to 5km downwind should be advised via police to shelter indoors.

- Radios should not be used within 50 metres of any nuclear weapon.
- Transport Emergency Cards are carried on road vehicles to remind personnel of the actions to be taken.
- Maintain close liaison with the Military Commander on site. They will be specialists in the field of radioactivity and will advise on all matters, including decontamination (see also OPS/SOP/Decontamination Procedures)

For comparison purposes only, the above cancer risks should be viewed as in addition to the average citizen's cancer risk of a 1 in 4 chance of developing cancer in one's lifetime.

8.13.0 Glossary of terms ALARP

A term used in the Ionizing Radiation Regulations meaning As Low As Reasonably Practicable.

Background Rate

The radiation dose rate due to environmental radioactivity.

Counts per second (CPS)

The number of electrical pulses counted by an instrument and proportional to the level of radioactivity.

Contamination

The process whereby radioactive material is unconfined leading to a threat to the human environment.

Dose

A general term for a quantity of radiation absorbed.

Dose Constraint

A dose value adopted by an organization, commensurate with its operations, to make sure all doses are ALARP.

Dose Limit

For the purposes of this glossary, the limits specified in the Ionizing Radiation Regulations.

Dose Rate

The dose being/to be absorbed per unit time.

Emergency Exposure

The exposure of an employee to a dose in excess of the Ionizing Radiation Regulations dose limits in accordance with REPPIR.

Equivalent Dose

The quantity obtained by multiplying the absorbed dose by a factor to allow for the different effectiveness of the various ionizing radiations in causing harm to tissue. Measured in severest.

Ionizations

The process by which a neutral atom or molecule acquires or loses an electric charge - the production of ions.

Ionizing Radiation

radiation that produces ionization in matter.

Irradiation

An event where matter has been subjected to ionizing radiation.

Radiation-

The process of emitting energy as waves or particles.

Radiation Emergency

As defined in REPPIR; an event likely to lead to a member of the public receiving a dose of 5 mSv in the year following the event.

Radiation Employer

An employer who carries out work with ionizing radiation (further defined in the Ionizing Radiation Regulations).

Radiation Protection Supervisor

A person of sufficient authority and training to supervise employees with respect to observance of local rules.

Radiation Protection Adviser

A person engaged by a radiation employer to advise on the observance of legislation appertaining to radiation.

Radioactivity

The spontaneous emission of ionizing radiation.

Radioactive Material

A solid, liquid or gas which spontaneously emits ionizing radiation.

Sealed (or closed) - a radioactive source sealed within impermeable material.

Source - a source of radioactivity.

Time-distance-shielding

Summary of the three conditions to limit a radiation dose i.e. minimizes exposure time, maximize distance from source and take maximum advantage of available shielding.

Unsealed (or open)

A radioactive source not confined within Impermeable material.

Transport Index (TI)

The maximum dose equivalent rate at one meter from the surface of a package containing radioactive material

SOP 9. AMMONIA

9.1.0 Introduction

Ammonia, Chemical symbol NH_3 , can take the form of a strong-smelling liquid or gas. Even in low concentrations, inhaling ammonia or getting the solution on your skin can cause burning, fainting, or death, so always use caution when handling this chemical and especially if involved in Fire.



Ammonia has one Nitrogen atom and three Hydrogen atoms tightly bonded. A tiny amount of ammonia forms when organic matter decomposes, so the gas can be found naturally in our atmosphere. Most of the ammonia used is produced through artificial means and by bonding the four atoms together by sheer force, the gas can be pressurized to form a liquid for easy distribution to manufacturing plants.

As a gas, ammonia is **lighter** than air, so it won't pool indoors like other dangerous gases, such as Propane. While it has a very pungent, distinctive odor, it's clear and difficult to combust unless highly concentrated. This makes ammonia safer than other chemicals and why it is widely used for household use, as most people will recognize the smell and leave a toxic area to prevent fainting.

Since ammonia gets easily absorbed into water as a solution, it's used in many cleaners. Many window sprays, oven foam, toilet bowl cleansers, wax removers, and other household cleaners contain around 5-10% ammonia. Care must be taken in an environment where several types of cleaning agents can come together. Different types of cleaners should never be mixed in the same application.

For example, ammonia and bleach form a very dangerous gas, called chloramine, that shouldn't be inhaled. BA should always be used in these incidents and a proper cordon set up. Commercial cleansers, with 25-30% ammonia, are extremely dangerous due to their corrosive nature. Liquid ammonia is also used to etch metal like Aluminium and Copper, refrigerate rooms or trucks, and dissolve other elements in chemistry labs. Large quantities of the ammonia produced goes to fertilizing crops by providing absorbable nitrogen to plants.

Manufacturers of plastics, pesticides, and dyes use the liquid at some point in their synthesizing process.

9. 2.0 Definitions and Abbreviations

| Abbreviations | Definitions |
|-----------------|--|
| CO ₂ | Carbon Dioxide |
| IDLH | Immediately dangerous to life and health |
| PPE | Personnel Protective Equipment |
| PPM | Parts per million |
| PICWS | Person in Charge of the Work site |
| RPE | Respiratory Protective Equipment |
| SCBA | Self-Contained Breathing Apparatus |
| STEL | Short-Term Exposure Limit |
| TWA | Time Weighted Average |
| WES | Workplace Exposure Standards |

9.3.0 Ammonia Hazards

Ammonia is colorless irritating gas with a sharp suffocating odour. It is toxic, whether inhaled, absorbed through the skin, or ingested. It is corrosive and can burn the skin or damage mucous membranes such as eyes, and the nasal cavity.

Ammonia is categorised in the Kapuni Safety Case as a major accident hazard at Kapuni.

Ammonia is used in the Kapuni process as a refrigerant and is a liquid at cryogenic temperatures. Auto-refrigeration occurs when ammonia is released to atmosphere.

Contact with the very cold liquid or inhalation of cold gas can cause cryogenic burns. Liquified Ammonia can expand 850 times when released to ambient air and can form a large vapour cloud. Even though the gas is normally lighter than air, it may form droplets with the moisture in the air and behave as a dense gas. In this form, it may spread along the ground and collect in low-lying areas with poor ventilation.

Ammonia gas dissolves easily in water to form ammonia hydroxide liquid, a caustic solution that can cause burns when in contact with the skin.

Ammonia has a relatively low heat of combustion. The flammable range of ammonia is 15.5-25%.

9.3.1 Routes of entry into the body

Ammonia can enter the body from inhalation, the act of breathing and the most common route, from absorption through the skin and eyes (burns), there is a possibility of ingestion from liquids but not a relevant route for gas.

9.4.0 Operational Considerations

Ammonia is considered a high health hazard because it is corrosive to the skin, eyes, and lungs. Exposure to 300 ppm is immediately dangerous to life and health. Ammonia is also flammable at concentrations of approximately 15% to 28% by volume in air. When mixed with lubricating oils, its flammable concentration range is increased.

It can explode if released in an enclosed space with a source of ignition present, or if a vessel containing anhydrous ammonia is exposed to fire. Whilst Ammonia in general terms does not readily support combustion and will not present a dangerous fire hazard, when mixed with other chemicals or violently heated, precautions have to be taken.

- The wearing of full PPE and respiratory protection, i.e. Positive Pressure Breathing Apparatus
- Stop source if possible
- Exposure concerns are present, stay upwind and use water spray downwind of leak source to absorb ammonia gas and dilute.

CAUTION: Adding water **directly** to liquid spills will increase volatilization of ammonia, thus increasing possibility of exposure.

9.4.1 Waste Disposal

Listed as hazardous substance under NEMC as a hazardous waste under Substance control programs, in order to comply with such programs and regulations, suitably diluted product may be disposed of on agricultural land as fertilizer. BUT YOU MUST - Keep spill from waterways and entering the sea or lakes.

9.5.0 Special Protection and Procedures

9.5.1 Ammonia Working Limits:

- Safe Working Level 1: < 25 ppm Breaking into Ammonia process equipment.
- Safe Working Level 2: >25ppm - <300ppm working with, and the potential for splashes.
- Safe Working Level 3: >300ppm - <1000ppm working with and the potential for splashes.
- Safe Working Level 4: >1000ppm or unknown is for Emergency Response and containment of events.
- At >300ppm you must STOP Work and review the task, SCBA is required.
- Implement controls as necessary.

N.B

Parts per million (ppm) is a unit typically used to express the concentration of a substance in a solution or mixture. (ppm is equal to 1 mg/L)

9.5.2 Exposure Limits

Work safe Guidelines, Workplace Exposure Standards and Biological Exposure Indices for: Ammonia

- 25 ppm for 8-hour Time Weighted Average (TWA)
- 35 ppm Short-Term Exposure Limit (STEL) up to a fifteen-minute excursion.
- 300 ppm or more, Immediately Dangerous to Life and Health (IDLH).

The Workplace Exposure Standards (WES) and Biological Exposure Indices (BEI) are intended to be used as guidelines for health risk management by people qualified in occupational health practice.

9.5.3 Emergency Response – Ammonia escape hoods

Ammonia escape hoods are located around the site and at the primary muster locations, onsite they are stored in green emergency PPE boxes which are labelled for identification.



When working onsite ensure you know the location of any emergency equipment, including the ammonia escape hoods.

For further information on ammonia escape hoods refer to the uniform Standard Operation Procedure

| | | |
|---|---|---|
|  |  | <p>The PARAT® escape hood is easily deployed in an emergency.</p> <ul style="list-style-type: none"> • When the case is opened, the filter plug automatically releases and the filter moves into operational position so the escape hood can be immediately donned. • The self-adjusting internal head harness requires no additional tightening. • All you have to do is open the packaging, remove, and don the hood—and leave the danger zone. • Once donned, make your way to the closest muster point. |
|---|---|---|

9.5.4 Procedure

Pre-Work

- Prior to engaging, in any work activity where ammonia might be present a review of the work programme should be undertaken to determine where the breaking of systems will occur and whether there is the potential for any ammonia to be present.
- The permit applicant must prepare a permit to work with supporting documentation
- The work permit provided must document the required standard of PPE for performing the task within the job hazard analysis.

9.5.5 Ventilation:

Local exhaust sufficient to keep ammonia gas below a workable and breathable Exposure Limits.

9.6.0 Protective Equipment

FULL PPE MUST be worn at all incidents where Ammonia is detected. Any non-FRF personnel that have to be inside the inner cordon, such as Police, Ambulance and Specialist personnel should wear as a minimum Splash-proof suits, chemical safety goggles, rubber gloves and boots to prevent contact with skin.

9.6.1 RPE and PPE Requirements

| | | | | | |
|--|---|--|--|--|---|
| <p>Safe Working Level 1 < 25 ppm</p> | <p>RPE, Full face mask with a specific or combination filter that have an</p> |  <p>Standard site PPE (Including gloves)</p> | <p>For the breaking of Ammonia process equipment, breathing zone & area testing, Todd standard PPE requirements plus RPE.</p> <p>Note: Where there is the potential for splashes an apron or splash suit must be worn regardless of the ppm level.</p> | | |
| <p>Safe Working Level 2 >25ppm TWA. < 300 ppm</p> | <p>Ammonia K (P3) rating.</p>  | <p>Chemical apron or Microchem 5000 splash suit or equivalent splash protection must be available, worn if required.</p>   | <p>Chemical Resistant Gloves and gumboots</p>  | <p>Working with, and the potential for liquid</p> | <p>Portable Gas Detection</p>  |

| | | | | |
|---|---|--|---|---|
| <p>Safe Working Level 3 > 300 ppm < 1000 ppm</p> | <p>Breathing Apparatus SCBA</p>  <p>Worn over the splash suit.</p> | <p>Microchem 5000 splash suit or equivalent splash protection must be worn.</p>  |  | <p>splashes in Ammonia process equipment.</p> |
| <p>Safe Working Level 4 > 1000 ppm or Unknown</p> | <p>Gas Tight Breathing Apparatus Suit</p>  | <p>Breathing Apparatus SCBA</p>  <p>SCBA must be worn within this level 4 gas tight suit, the wearer will require assistance to gear up and for the removal of the equipment.</p> | | <p>Level 4 is for emergency response and for the containment of events.</p> <p>SCBA will confirm to PTW requirements, e.g., back up team and BA board.</p> |

Note:

- Respirators must be carried or worn whenever a worker goes into a restricted area such as the CO2 Plant.
- RPE / PPE requirements may vary depending on the risk of the activity e.g., consider potential for escalation, size, and duration of release.

9.6.2 PPE Information

| | |
|---|--|
| <p>Respiratory Protection</p> <p>>12.5 ppm for 12-hour period</p> <p>> 25 ppm during an 8-hour period</p> <p>>35 ppm up to a 15-minute excursion.</p> | <p>Full-face Respirators must be worn whenever working on Ammonia process as per safe working level 1.</p> <p>Full-face Respirators must be worn at >25ppm and follow safe working level 2.</p> <p>Always remember that concentrations can spike suddenly. If the concentration of ammonia is greater than 300 ppm, Filter cartridges cannot be worn, and a self-contained breathing apparatus (SCBA) and a Microchem 5000 splash suit or equivalent splash protection must be worn.</p> <p>Filter cartridges must be replaced after use in a hazardous atmosphere.</p> |
| <p>Skin Protection</p> <p>>25ppm</p> | <p>Working with Ammonia and potential for liquid splashes in Ammonia process, workers must wear, gumboots, chemical resistant gloves a chemical apron or a full-body splash suit. When gumboots are worn protective splash suit must be worn over the boot to prevent any possible liquid from entering the boot.</p> <p>Work must stop at 300 ppm, and Level 3 Respiratory and Personnel Protection precautions put in place.</p> <p>300ppm or more causes immediate irritation of moist body areas. (Ammonia reacts instantly with moisture.)</p> |
| <p>Eye Protection</p> <p>All work</p> | <p>Eye protection starts with the use of a Full-Face respirator for levels 1 & 2 leading to breathing apparatus at level 3 and a gas tight suit and breathing apparatus for level 4.</p> |

| | |
|---|---|
| <p>Self-Contained Breathing Apparatus >300ppm</p> | <p>When a leak has been identified, assess if a reading can be taken with full-face respirator or it can be quickly stopped with the use of a full-face respirator (e.g., a small leak) to prevent a larger release.</p> <p>Should it be deemed to be unsafe to take readings, it is to be treated as immediately dangerous to life or health, workers must use a self-contained breathing apparatus (SCBA) and level 4 gas tight suit when the ammonia concentration is unattainable (Unknown) task.</p> <p>Under normal working circumstances the wearing of SCBA requires a Permit to Work and adhere to PTW requirements, under emergency situations the PIC/Incident Controller will follow STA-01.14 Use of Breathing Apparatus operating procedure.</p> <p>When managing an ammonia release under an emergency response event follow the requirements of the TENZ Emergency Management Plan.</p> |
| <p>Self-Contained Breathing Apparatus and level 4 gas tight suit >1000ppm</p> | <p>10000 ppm is sufficient to cause skin damage and be caustic to the throat.</p> <p>Emergency response procedures are invoked at this level. Breathing apparatus and a level 4 gas tight suit must be worn when the concentration is unknown or >1000ppm</p> |

9.7.0 Advice & Special Precautions

9.7.1 Storage and Handling

Store in cool, well-ventilated area with containers tightly closed

9.7.2 Work-Place Protective Equipment

As discussed above protective equipment should be placed near, but outside of ammonia area. Eyewash and safety shower in immediate vicinity.

9.7.3 Disposal

Ammonia is listed as a hazardous substance under International Regulations and there are strict controls for the WASTE DISPOSAL. of such products under the Environmental Acts, these are Classified as Hazardous waste due to corrosively.

9.7.4 Personal

Avoid unnecessary exposure. Use protective equipment as needed. **Do not wear contact lenses.**

9.7.5 Incident Commander

First Response – Officer in Charge

On arrival at scene, find responsible person, Lead Warden or Duty Manager to get all relevant details of the incident, the life risk and all hazards. Carry out initial 'Size-up' (evaluation) and a Dynamic Risk Assessment (DRA) – Decide on 'Tactical Mode' (Aggressive, Defensive or Transitional). That will assist the decision whether or not to commit crews into the building or not.

9.7.8 Safety Officer

The Incident Commander should consider, at a very early stage, setting up support officers at the incident, either sector commanders and / or safety officers, to monitor the incident specifically the health & safety aspects. The Safety Officer will monitor the buildup of any gas and the prevailing wind direction, giving clear advice to the Incident Commander as to which location the vehicles and any support crews and equipment should be. Also, the Safety Officer will directly liaise with the Police in order to advise the Position and distance for the cordons.

All non-essential and unprotected personnel should be moved outside the outer cordon.

9.8.0 Decontamination of RPE/PPE

- For safe working level 1 workers will be able to clean their own RPE/PPE by following applicable methods below.
 - For safe working level 2 & 3 workers may or may not be able to decontaminate their own RPE/PPE before disrobing. If they feel unsafe to carry out their own decontamination and assistance is required, they will contact the Control Room Operator who will assemble a team to assist with the decontamination. The decontamination team will wear level 2 RPE/PPE and follow the decontamination methods below.
 - For emergency response level 4 a decontamination area is to be set up, a team of personnel will be made available for decontamination of workers that have been wearing RPE & PPE in hazardous atmospheres, they will be required to wear chemical splash suits, gumboots, rubber gloves and full-face masks with specific or combination filter of a (ammonia) K (P3) rating, level 2 RPE/PPE.
 - The gas tight suits go through the initial first stage of decontamination while being worn, the wearer is disrobed, and after disrobing the suits can have a more thorough clean, allowed to dry before they are stored for future use. The MiniRea 3000 Ammonia detector can be used to determine if RPE/PPE is still required to be worn for the second stage of cleaning of the gas tight suits.
 - SCBA will go through the initial first stage of decontamination, once removed will have a more thorough clean before being stored for future use. The MiniRea 3000 Ammonia detector can be used to determine if RPE/PPE is still required to be worn for the second stage cleaning of the SCBA.
1. Re-usable chemical aprons, splash suits, gumboots, and chemical gloves can be washed and cleaned for re-use if they are in good condition.
 2. A hand-held hose on a spray setting or one of the site shower eye wash stations can be used for decontamination, using a medium density bristle brush/broom for the cleaning of RPE/PPE.

3. Washing down is to be undertaken in a bunded area where the wastewater can be collected and disposed of by appropriate means.
4. Ensure that the wastewater does not enter any drain system that leads to the stream.
5. Respirators should go through the same cleaning process as other reusable RPE & PPE, then taken off and cleaned in a cleaning solution or by alcohol-free cleaning wipes and left to dry for re-use.
6. Disposable splash suits should be tested using the Mini Rea 3000 Ammonia detector to determine if they have been contaminated.
7. Uncontaminated suits can be disposed of in the general waste bin.

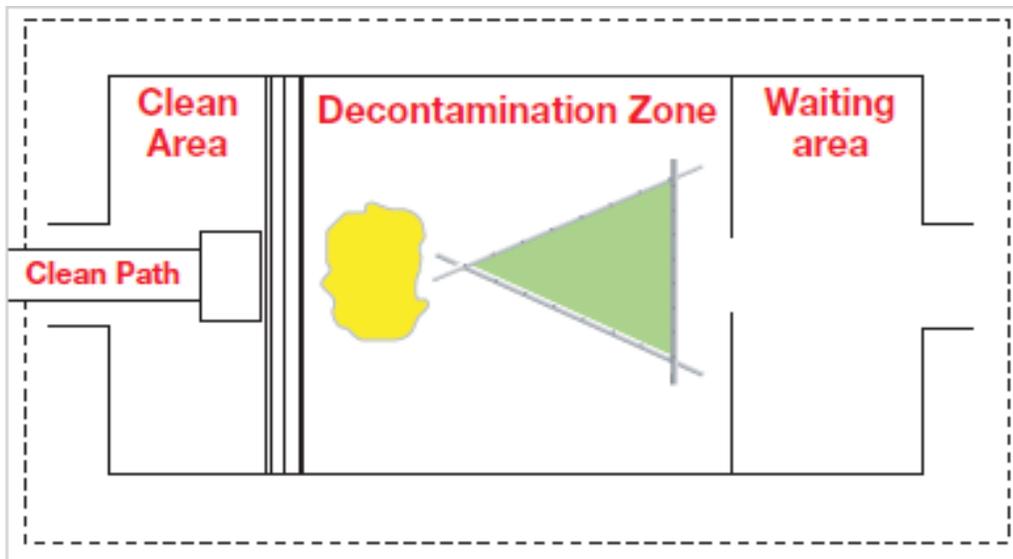
SOP 10. DECONTAMINATION

10.1.0 Scope

Decontamination procedures in this standard operation procedure are aimed at minimizing the risk to Firefighters when doffing (removing) protective suits following exposure to a hazardous substance, and subsequently cleaning and reinstating the suits for operational use. The general principles also apply in circumstances where members of the other emergency services or the public, have become contaminated by a hazardous substance.

10.1.1 Initial and Post Incident Decontamination

The procedures make provision for initial decontamination and post incident decontamination; both procedures are wet, as dry decontamination is not considered to be operationally effective. Initial decontamination will usually be carried out in an area of the incident ground remote from the scene of the release, and post incident decontamination where advised, will be carried out on return to the station.



The advice of Fire and Rescue Force Hazmat Officer should be followed for both procedures, although it will be recognized that this may not always be possible in the very early stages of initial decontamination. In these circumstances the OIC must decide the best course of action based on the information available.

As the amount of contamination remaining on a suit after exposure is an unknown factor, the FRF bases its procedures on the estimation that in a worst case scenario, one liter of contaminant will remain on the suit after exposure, this being equal to the wearer having been totally immersed in the substance. It will be recognized that in the majority of circumstances, this is well in excess of what can normally be expected. Initial decontamination may be carried out using a hose reel or shower, however, the important factor is achieving a dilution rate of 2000-1, this figure having been agreed as the International norm and with the water authorities for all hazardous substances.

This does not mean that the wearer has to remain exposed to the water stream until the dilution factor is achieved. Due to the polymer construction of the Responder fabric, substances do not readily adhere to, or are absorbed by, the material. Consequently, in the worst case scenario, as soon as the whole suit has been exposed to the water stream, only dilute traces if any, of the substance will remain and the wearer can safely proceed to the doffing area.

10.2.0 The Decontamination Zone

All decontamination must take place within a designated zone, and selection of the site should take the following into account:

- a. The zone needs to be upwind of the release site and in a quieter area of the incident ground. The position of drains or water courses to run diluted contaminant to waste.
- b. Weather conditions and exposure which may affect personnel or equipment.
- c. The comfort and protection of personnel who have undergone initial decontamination.
- d. The location of pumps providing water supplies and equipment resources.
- e. In the early stages, command of the decontamination zone will be dependent on the rank of the officers available, however, in protracted or larger scale operations, the minimum rank should be Station Commander.
- f. Where decontamination assistants dressed in gas tight suits are provided, it is desirable to maintain radio contact with the OIC of the zone.

- g. If the resources of one decontamination zone are insufficient, another zone or additional equipment should be set up.
- h. The zone must be identified and secured to prevent unauthorized entry.

10.3.0 Initial Decontamination

Dependent on the nature of the incident and resources available, initial decontamination may be carried out using a hose reel or shower.

10.3.1 Small or Limited Resource Incidents:

The method of decontamination will most likely be with a hose reel, with the wearers undressing each other. The best location for the initial decontamination site is adjacent to a drain where the runoff water can be run to waste. The equipment requirements for this level of decontamination is a water supply to the pump, a high-pressure hose reel spray operating at pump idle speed, the decontamination bag and the securing tie. If it is not possible to locate over a drain, charged lengths of fire hose may be used to direct water to the drainage point.

10.3.1.1 BA Procedures at a decontamination Incident:

In the case of an incident that requires de-contamination the normal BA control procedures are not always adhered to and unless the BAECO (Breathing Apparatus Entry Control Officer) is remote from the decontamination zone and other wearers are being committed, the control of the wearers tally should remain with the original BAECO. In such cases the wearers tally will be transferred to an assistant firefighter dressed in fire gear and disposable gloves who shall be assigned to direct the wearers through the area designated for decontamination and to assist with preparing and removing the decontamination bags.

10.3.2 Doffing Preparation:

Decontamination assistant – Lay out each of the suit decontamination bags alongside each other in the doffing area.

10.4.0 Doffing Procedures:

- a. Wearers - wash each other from the head down, the wearer being washed to stand with arms and feet apart to ensure the whole suit is covered by the water stream.
- b. Wearers - proceed to the doffing area.
- c. Wearers - stand inside decontamination bags.
- d. Wearers - remove one arm from sleeve and pull helmet visor down, replace arm in sleeve.

Doffing wearers do not remove arms from suit during following procedure.

- e. Wearers - face each other and unzip each other's suits.
- f. 1st Wearer - hold head of 2nd wearer's suit and remove suit over head.
- g. 2nd Wearer - turn around with back to 1st wearer.
- h. 1st Wearer - pull up cylinder carrier and head of suit and remove over BA cylinder.

Repeat procedures e, f, g and h for 2nd wearer.

Both Wearers - remove arms from suit.

- i. Wearers - unfasten BA set waist belt and suit waist belt.
- j. Wearers - fold suit down to ankle level and remove feet from wellingtons and suit booties. If necessary stand with one foot inside the suit whilst the second foot is removed.
- k. Wearers - step from decontamination bags to clean area, give cotton gloves to assistant.
- l. Wearers - proceed to the BAECO to collect the BA tally.
- m. Assistant - secure decontamination bags with the plastic ties provided.
- n. Assistant - locate correct responder bag for each suit, place cotton gloves inside and attach Responder bag to decontamination bag ties.

- o. Assistant - pass decontamination bag to holding area for return to the Fire Station for post incident decontamination.

10.5.0 Distress Signal Units

These must be decontaminated on return to the station on the advice of a HAZMATS Officer.

10.6.0 Transporting Contaminated Suits

So long as the contaminated suit is contained in the decontamination bag, it can be transported back to the fire station in the appliance; however, as an additional precaution disposable gloves should be worn when handling the bag.

10.7.0 Large Incidents with Supporting Resources:

The method of decontamination will most likely be with a shower, with the wearers being undressed by two decontamination assistants, themselves donned in gas tight suits. An assistant outside the contaminated zone and dressed in fire gear and disposable gloves is to be provided to assist with supplying and removing contaminated suits from the deco.

Zone and to ensure the correct Responder bag and logbook are attached to each suit. As with the initial decontamination, the best location for the site is adjacent to a drain where the runoff water can be run to waste. Equipment requirements for this level of decontamination is, a fire appliance water supply to the shower, salvage sheets to define the path through the dirty to clean area, suction hose to separate the clean and dirty areas, traffic tape to cordon off the area, the decontamination bag and securing tie.

As the incident BAECO is most likely to be remote from the decontamination zone, another BA entry control point should be set up near to the decontamination zone and the wearers tallies relocated on this BA board. If more than one decontamination zone is required, two decontamination assistants dressed in gas tight suits and one assistant outside, shall be provided for each decontamination zone.

- A recommended layout of a large scale decontamination zone is detailed in **Appendix 1** to this instruction.
- Preparation (outside zone assistants): Assistants - place decontamination bags at the edge of the zoned area (for collection by Decontamination Assistants)
- Assistants - as wearers proceed through decontamination and doffing, identify numbers of wearers suit from BA tally, locate correct Responder bag and log book for each suit.

10.8.0 Procedures (Wearers and Decontamination Assistants)

1. Assistants - collect and lay out a decontamination bag in the doffing area.
2. Wearers - proceed through the shower (if hose reel is in use, wearers wash each other as described in small incident Decontamination).
3. Wearers - proceed to doffing area.
4. Wearers, one at a time - stand inside decontamination bag.
5. Assistants - hold the suit gloves to assist the wearer to remove both arms from the suit.
6. Wearers - pull helmet visor down.
7. Assistants - unzip suit.
8. Assistants - hold the head of the suit and remove it over the wearers head.
9. Assistants - pull up cylinder carrier and head of suit and fold down to waist level.
10. Wearer - unfasten BA set and suit waist belts.
11. Assistants - Fold suit down to below waist level
12. Wearer - remove radio from suit.
13. Assistants - hold legs of suit as wearer steps from wellingtons and suit booties onto clean area (if necessary, wearer stand with one foot inside suit whilst second foot is removed). Assistant - make up decontamination bag and pass to edge of the decontamination area.

10.8.1. Outside the Decontamination Zone:

Assistant –collect and secure decontamination bag with the plastic tie.

Assistant- collect UHF (Ultra Higher Frequency) radio from wearer check it is switched off and return to the donning area.

Assistant – attach Responder bag to tie, reverse log book in cover to read contaminated, attach cover to tie.

Assistant- pass decontamination bag to equipment holding area for return to the Fire Station for post incident decontamination.

10.8.2 Transportation of contaminated suits.

So long as the contaminated suit is contained in the decontamination bag, it can be transported back to the fire station in the appliance; however, as an additional precaution disposable gloves should be worn when handling the bag.

Decontamination of assistants (inside Zoned area).

When the decontamination assistants have reached the end of their working duration, or when the last wearer has been doffed, the decontamination assistants should follow the procedures as in small incident decontamination detailed above.

10.8.3 Post Incident Decontamination

These procedures are aimed at ensuring that any traces of diluted contaminant are removed from the suit and equipment will be carried out on return to home station.

Post incident decontamination, including the dress for personnel, will only be undertaken on the advice of a FRF Hazmat Officer. Suits that have received a light or moderate exposure to known substances may be considered for decontamination, but may not be recommended where the chemical is unknown, very toxic or carcinogenic.

It is incumbent on the FRF Hazmat Officers to understand the problems and issues relating to decontamination, in order to make an informed decision and recommendations for post incident decontamination.

If, on the advice of the FRF Hazmat Office, post incident decontamination is not recommended, the decontamination bag should be labeled For Disposal - Return to FRF Supplies Department, and the Technical Support Department advised.

10.9.0 Decontamination Zone:

The zone will be in the station drill yard where water can be run to drain. In extreme weather conditions a position in the appliance room, adjacent to the station doors, may be used, but the water used for decontamination must be prevented from invading the station.

1. Supervision of post incident decontamination may be by a junior officer, or by a firefighter acting as the attending Appliance commander.
2. Post incident decontamination is carried out using a mild detergent, warm water and sponges; if the containment is difficult to remove a soft brush may be used.

Procedures:

- a. Remove the suit and ancillary equipment from the decontamination bag.
- b. Rinse out the decontamination bag with a hose reel, remove excess water, fold and secure the bag and dispose of it with the station waste.
- c. Zip up the suit and place it full length on a salvage sheet, rinse the suit and ancillary equipment thoroughly with a hose reel.
- d. Remove and place the ancillary equipment in a bucket of soapy water, wash, rinse with clean water and remove the excess water with a cloth.
- e. Replace the DSU (**Distress Signal Unit**) on the BA set.
- f. Hand wash the whole of the outside of the suit.
- g. Rinse the suit with clean water and remove excess water with a cloth.
- h. Place the suit and cleaned ancillary equipment in the black bin liner bag and place this inside the Responder bag.

Complete the log book and place it in the cover showing For Inspection and Testing, attach the log book to the Responder bag and inform Technical Support the suit is ready for collection.

10.9.1. Decontamination of Unprotected Persons

1. These procedures are aimed at reducing the effect of hazardous substances which have been ingested, inhaled or lodged on the skin, and where necessary, preparing the casualty for transport to hospital. The appropriate dress for FRF personnel carrying out the decontamination of persons is dependent on the substance involved and the degree to which the casualty has been contaminated. The advice of the FRF Hazmat Officer should be followed.
2. The same general procedures for initial decontamination and the protection of FRF personnel involved in the decontamination should be followed.

Procedures:

1. All contaminated clothing on the casualty must be removed.
2. A hose reel spray with the pump pressure set at idle speed pressure should be used to wash the contaminant from the body. If the pump pressure is still too high, the branch on/off control should be adjusted to reach the desired setting.
3. If the casualty has an open wound, care must be taken to ensure that the contaminant is not washed into the wound.
4. If the wound is already contaminated, the worst of the contaminant should be washed out.
5. Contaminant which has lodged on unbroken skin should be carefully washed from the affected area.
6. To enable the casualty to be transported to hospital without contaminating the ambulance, the casualty should be placed inside a bag similar to the FRF decontamination bags, leaving only the face clear. If there are insufficient Ambulance Service resources, consideration may be given to using FRF equipment's.
7. If the casualty is having breathing difficulties, oxygen therapy should be administered. It is important that the following Information is passed to the receiving hospital:

- i) The name of the contaminating Substance
- ii) The degree of exposure
- iv) An estimate of the exposure time
- v) Treatment, including the Decontamination method given at the scene.

10.10.0 CONTAMINATION FRF PERSONNEL

1. **Forms HS1** for recording exposure and subsequent treatment is held on each Incident Support Unit. Forms may also be assessed from station admin files.

Procedure:

Four copies of the HS1 form are required and to be distributed as follows:

(2) To be retained by the casualty

- 1) For Hospital records
- 2) To FRF file
- 3) To FRF Medical Advisor- Forward to

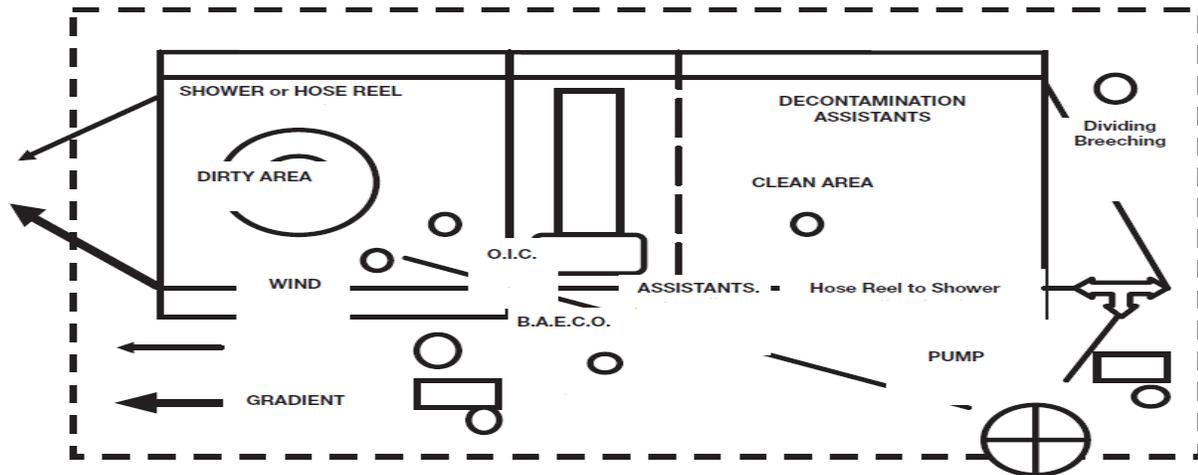
HR development in a sealed envelope marked "Medical Confidential"

10.10.1 Mobilizing

As part of the PDA for incidents which may require decontamination ie Chemical Spillage or on request from the OIC of the incident for decontamination operations control room will mobilize the Incident Support Unit and an additional Supervisory Officer for decontamination.

Appendix '1'

Initial Decontamination - Large Incident CORDON



Equipment Required

1. Lengths Suction
2. Salvage Sheets
3. Lengths 64mm hose
4. Controlled Branches
5. 1 Controlled Breaching
6. 1 Hose Reel

SOP 11. SAFETY IN CONFINED SPACES

11.1.0 Scope

These Safety Rules and Procedures provide direction on how confined space working is to be managed at sites and in work situations, which are under the control of the FRF. They are to be read in conjunction with OPS/SOP/Dynamic Risk Assessment and OPS/SOP/Incident Command Requirements.

Purpose:

- a) Prohibit entry into a confined space to carry out work unless there is no other reasonably practicable method to carry out the work
- b) Require any such work in a confined space to be carried out in accordance with a safe system of work
- c) Require adequate arrangements to be made for the rescue of any person in the event of an emergency.

These Safety Rules and Procedures are therefore produced to enable the FRF to fulfil the requirement to operate under a system of work that is safe. This SOP and Safety Rules are mandate the appointment of key individuals with specific responsibilities for the management and / or execution of work in confined spaces.

These are summarized as follows:

- a) The Work Team or Crew: a team of competent individuals who may be permitted to enter and carry out work in a confined space
- b) The Person in Charge: the designated person in charge of the Work Team or OIC of fire engine
- c) The Authorized Person (Confined Spaces): a member of the Rescue Crew with a minimum rank of Junior Officer or the Incident Commander who gives authority to the Person in Charge of the Work Team to enter a confined space.

11.2.0 Exclusions

These Safety Rules and Procedures and SOPs do not apply to:

- a) Normal shipboard activities aboard a sea-going ship, carried out solely by the ships crew under the direction of the master
- b) Diving operations to which the Diving at Work Regulations apply.

11.3.0 Risks

The following are considered to be examples of a Permanent Confined Space:

- All foul and storm water sewerage systems
- All wet well pumping stations
- Collapsed construction or excavations
- All boilers / similar vessels into which man entry is required as part of an inspection
- Underground service tunnels / cable ducts where no element of ventilation is
- Provided.

The above list is not exhaustive and other locations, sites and installations may also fall under this categorization

11.4.0 Known Hazardous Environments

Where a confined space is part of a pressure system, flue-way, pressure vessel etc. **No Person** is to enter the space without a clear Permit to Work or full Dynamic Risk assessment being undertaken by the Incident Commander in close liaison with the on-site Mechanical Engineer or site safety officer.

Where a confined space is suspected of containing or having contained a petroleum product, the Incident Commander must carry out a risk assessment to determine if a Permit to Work (Petroleum) is required. In the event that this is deemed necessary, the rules defined in SOP/Dynamic Risk Assessment take precedence.

Where the Confined Space is at height (e.g. a water tower) the Incident Commander should also consider that full understanding of the SOP (Working at Height) to be adopted and measured over the access arrangements.

For hazardous smoke environments see OPS/SOP/Working in confined spaces in smoke and fire.

Incidents involving 'collapse' requires careful consideration with regards to:

- Numbers (Personnel) around collapse area
- Secure sides of area / pit etc. by wedging and packing
- Stand away from edges and WATCH (D.R.A. Dynamic Risk Assessment)

11.5.0 Role of the incident commanders / officers in charge (Confined Spaces)

The role of the Incident Commanders and/or Officers in charge, is to co-ordinate all Confined Space work activity required within a site, group of sites / establishments or geographical area(s) required for the effective implementation of strict tactics that follow DCD Safety Rules and Procedures.

Duties of the Officers in Charge (OIC) when dealing with incidents involving Confined Spaces include:

- a) Acting as the focal point for all Confined Space working activity
- b) Ensuring that all documents related to Confined Space working are current and kept up to date in accordance with DCD policy and site safety procedure
- c) Ensuring that any accident or Dangerous Occurrence connected with Confined Space working are immediately notified to the Operations Control Room
- d) Ensuring that any equipment that is required for Confined Space work, and for which crews are responsible, is maintained and kept in calibration, with appropriate records retained, i.e. BA Control Boards & Watches.

11.6.0. Duties of the Incident Commander (Confined Spaces) include:

- a) Ensuring, so far as is reasonably practicable, that all persons on site, comply with this SOP and any subsequent Safety Rules and Procedures
- b) Reviewing all prospective Confined Space working and determining the appropriate level of control
- c) Ensuring that a Risk Assessment for each Confined Space operation is prepared
- d) Ensuring that a Safety Programme for each Confined Space operation is prepared

- e) Reviewing the Risk Assessment and Safety programme for each confined Spaces operation, prepared by others satisfying himself / herself that prospective Confined Space entrants are competent to carry out the work ascribed to them
- f) Witnessing and verifying the initial peak reading monitoring of the atmosphere (gas test if required) of a Confined Space
- g) Liaising with Authorized Persons on incident site issuing Permits to Work or extra control procedures for Confined Spaces
- h) Preparation of Routine Instructions (ALWAYS BE PREPARED FOR DYNAMIC RISK ASSESSMENT REVIEW) for Potential Confined Areas
- i) Cancelling or amending work tactics on completion of task
- j) Informing the Incident Commander (Confined Spaces) and / or the Officer in Charge (Confined Spaces) of any accident or Dangerous Occurrence relating to Confined Space working that occurs
- k) Informing the Incident Commander (Confined Spaces) and / or the Officer in Charge (Confined Spaces) of any difficulties or unusual circumstances encountered or discovered during the execution of a confined spaces task.

11.7.0 Officers in Charge (Confined Spaces): Defined Role

The role of the Officer in Charge (Confined Spaces) is to directly control the entry into a confined space.

Persons in Charge of Confined Spaces working are to:

- a) Ensure that adequate emergency arrangements are in place before commencing the works.
- b) Ensure that all necessary safety equipment is available, safe and suitable for use prior to entry into the confined space.
- c) Ensure that all members of the DCD crew are adequately trained and medically fit to carry out the work required in such environments. Regular training sessions should be carried out to ensure all crew members are confident and competent.
- d) Be fully conversant and able to ensure compliance with the conditions set out in the Permit to Work and agreed Safety Programme.

- e) Ensure that the crews are aware of the method of work set out in the agreed Safety Programme; the means of communication; the emergency arrangements and the requirements of these Safety Rules and Procedures.
- f) Carry out a peak reading 'pre-entry' gas test (if required) and complete the appropriate section on the Permit to Work in accordance with the site safety rules.
- g) Be prepared to stop work and withdraw all personnel, tools, plant and equipment from the confined space if for any reason the conditions of the Safety Programme or DRA (Dynamic Risk Assessment) cannot be met.
- h) report to the Officer in Charge any accident, dangerous occurrence, defects found or other exceptional incidents occurring during occupation of the confined space
- i) Always be present at the confined space work site when any work within the confined space is being carried out.

11.8.0 Safety Points & Considerations

The following Safety Points & Considerations should be followed at incidents where confined space working is necessary:

- A description of the confined space precise site details and access
- A description of the work to be carried out plant and equipment to be taken out of service (where applicable)
- Arrangements for isolation from gases, liquids and flowing materials (if applicable).
- Arrangements for isolation from mechanical and electrical equipment (if applicable)
- The minimum number of personnel in the Crew / Work Team and competencies required including any specialist training or skill requirements
- Any Personal Protective Equipment (PPE), Respiratory Protective Equipment (RPE) or other equipment
- Methods of ventilation, cleaning, and purging of the confined space possible duration of the task
- A schematic diagram of the isolation, venting and testing arrangements (if applicable)

- The method of communication
- The emergency procedures and rescue arrangements
- Any other special instructions and / or safety measures
- Ambulance / First-Aid standing-by and Emergency rescue crew, in full P.P.E. standing- by at ALL times during operations.
- Continually Monitor situation (D.R.A.) and be prepared to amend tactics accordingly.
- Proceed with care & caution, slowly, re-assured and in complete control.

11.9.0 Medical Requirements

All staff who may have cause to enter Confined Spaces or Potential Confined spaces area are expected to have a reasonable standard of physical fitness. The level of fitness will depend upon the task to be performed. For work in the close confines of a Confined Space, consideration must be given to the physical build of Confined Space personnel.

As a guide, an operative who regularly works in Permanent Confined Spaces and / or wears breathing apparatus should be free from:

- history of fits and blackouts
- heart disease
- deafness and / or perforated eardrums
- Meniere's disease involving loss of balance
- tendency to claustrophobia
- severe or recurrent back pain
- severe visual impairment
- lack of sense of smell
- any temporary disability which may restrict normal duties.

A person, who has to work in a confined space and as part of their duties may have to wear breathing apparatus in an emergency situation, also requires a reasonable standard of fitness.

A person, who is required to enter or work in a confined space must be deemed capable to do so by their employer. If the employer is aware of any medical concerns about an individual, then medical advice should be sought before a decision is made about their suitability for the work.

11.9.1. Bacterial and Viral Infection

Any person, who is likely to come into contact with sewage and / or wastewater, must consider having inoculations against the bacterial and viral infections associated with this work. This may include:

- a) Typhoid
- b) Tetanus
- c) Poliomyelitis
- d) Hepatitis A.

Any person likely to come into contact with sewage, contaminated water, soil or infected animals must be aware of the symptoms of Weil's disease (Leptospirosis) should seek urgent medical advice. A number of substances have been proved to cause dermatitis including: mineral oils (e.g. diesel and other fuels), certain industrial chemicals (e.g. alkalis, nickel salts, mercury compounds), insecticides, formaldehydes, synthetic resins, glass fibre, solvents and degreasers (e.g. paraffin or turpentine), tar pitch or other coal tar products

Any person working in confined spaces must be made aware that personal hygiene measures, skin care and cleanliness greatly reduce the risk of bacterial and viral infections and industrial dermatitis.

11.9.2. Medical Examinations and Physical Fitness

The level of fitness required to undertake confined space operations and required to work in Confined Space environments should include an examination of the:

- a) respiratory system (to exclude chronic respiratory disorders)
- b) cardiovascular system

- c) skin (to eliminate any chronic skin condition, which may be aggravated by the wearing of Personal Protective Equipment).

11.10.0 Confined Space Risk Assessment – Guidance

TABLE 1 – Likelihood of Injury

| Likelihood | Criteria | Rating Value |
|---------------|---------------------------------|--------------|
| Most Unlikely | Probably Close to Zero | 1 |
| Unlikely | Injury a conceivable Occurrence | 2 |
| Likely | High Possibility of Injury | 3 |
| Most Likely | Injury Probable | 4 |

TABLE 2 – Severity of Injury

| Severity | Criteria | Rating Value |
|----------|--|--------------|
| Trivial | Injuries that could be treated by local First-Aiders from a First-Aid Box | 1 |
| Slight | Injuries that may require more expert treatment, administered at a medical centre/ Hospital A&E department | 2 |
| Serious | Injuries involving Urgent Hospital treatment | 3 |
| Major | Injuries involving major Trauma or Death | 4 |

TABLE 3 – Risk Rating and Action Required

| Risk Rating | Action Required |
|-------------|--|
| 1 or 2 | Existing Control measures may be considered adequate |
| 3 or 4 | Consider introduction of additional controls or supervision |
| 6 or Higher | Additional controls are required in the form of a Safety Programme and Incident Command System |

