Study the Best Method of Emergency Response Plan for Chlorine Gas Facility at Integrated Shrimp Pond Area

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***Abstract*— Chlorine is a type of chemical substance that possessed a hazardous and toxic characteristic. It may affect the human health as well as other living organisms in case were directly in contact with the substance. The effect on human health shall be concern as it will leads to the badly damages the respiratory system. Lung will experience the loss of most it tissues as the chlorine will enhance the degradation process if the sufficient amount of chlorine is inhaled (Sofia Jonasson, 2013). It will lead to the difficulties in breathing and for the worst may lead to fatal. It is therefore importance to prevent and for the best is to avoid the release of these toxic chemical from spreading into the atmosphere that will bring the unfortunate event towards the human races. Plant facilities that may containing the handling and storing a large amount of chlorine needs to be well design and also having an efficient of emergency response plan in case of the release of chlorine cannot be avoided. By having an emergency response plan will at least minimizing the risk of injuries and human exposed on chlorine. In this research, the passed accidental release of chlorine is studied to determine the impacts on environment and human upon released and also the root cause of the disaster also measured to avoid the same mistakes occur in the future. Besides, various emergency responses are studied based on their actions on tackling the emergency situation to be implied on the selected chlorine facility, shrimp pond owned by Isharp Sdn Bhd located in Terengganu.**

***Keywords*— Accidental Chlorine Release, Emergency Response Plan, Emergency Response Team, Hazard Identification, Risk Estimation, Individual Risk, Societal Risk,**

I. INTRODUCTION

The emergency response plan is crucial as the action to be taken when the disaster happen. It is therefore important for every chlorine facility to have an effective emergency response plan to encounter emergency situation as an ineffective emergency response plan may lead to unclear flow of actions taken and inaccurate in decision making from emergency response team. The scope of study is on the action to be taken, the role and responsibilities of personnel in emergency response team and the flow command of effective emergency response plan to encounter the event of accidental chlorine release cause by leakage of pipeline or rupture of the storage chlorine tank. The objective of study is to identify the possible causes of chlorine release accident, understand the purpose of emergency response plan and role of emergency response team, constructing a suitable and effective emergency response plant to be implemented at the chlorine storage facility. Besides, the suitable measure towards constructing the effective emergency response plan is planned. The mitigating factors also measured to reduce the impact of chlorine release toward human and environment. The key elements in emergency response plan is identified as well as their limitation for each of passed design emergency response plan in order to find the most effective ways to improve the plan.

II. METHODOLOGY

Accidental release of toxic gas rarely happen in Malaysia but the probability of occurrence is possible. Therefore, a method in reduce the risk of accidental occurrence as well as planning to encounter the risk and effects if the accidental release happen is need to prepare. Emergency response plan is one of the most practical methods until nowadays it is still relevant used as a counters measure if any emergency accident occur in the plant. In this section the procedure of constructing a good emergency response plan will be detailed out.

A. Study of Previous Incident to Find Root Cause

Previous study analysis is a must to be carried out purposely to identify the root causes of the past incidents and the possible hazards that may present in the chlorine storage facility. All the past incidents need to be studied and compared in terms of their differences and similarities. From the result of it, a suggestion in improvement can be taken reacted to the problems and prevention method can be proposed before-hand to avoid repeating the same mistakes in conducting chlorine storage facility. All possible events that may lead to the accidental release is being list out. The cause of each event is analyzed. Their consequences arise from the incident event also predicted and measure to ensure minimum damages receive if emergency situation occur.

1) Chlorine Release at Flix, Spain (1996)

The plant owned by Erkimia Corporation is a plant producing chloromethane as a main product. Chlorine used as an intermediate material in manufacturing this chloromethane. The accidental release happen is when the pipe stream transporting liquid chlorine from intermediate storage tank weight 6000 kg is released to the atmosphere. [4]

2) Chlorine Release at Jefferson County, Missouri (2002)

The incident happened within the DPC Enterprise facility whereby the transfer hose sized of 1 inch used for rail tank car unloading operation suddenly ruptured lead to a massive leakage of high toxic substance release from the rail tank to the surrounding. It happened on the morning around 9.20 a.m. of 14 August 2012. The root cause of this tragedy is because of the failure of the fabricator and manufacturer of the hose transfer chlorine which is Branham Corporation to meet the safety requirement in producing a specific hose for transferring chlorine substance.[1]

3) Chlorine Leakage at West Bengal (1987)

A chlorine leakage also was happen in the year 1987 where is the

large amount of chlorine escaped from the bonnet of a valve in a bullet. A chloro-alkali plant placed in west Bengal are having four dish-end cylindrical storage tank insulated by the thermo-cool. The storage are in 21 mm thickness with 12.55 m in length and 2.74 m of inner diameter made by mild steel sheet as the material of construction of the tank. The internal volume of the storage tank is 71 m3.[2]

Based on the studies, major causes of emergency event occur especially for accidental chlorine release is because of the failure of the equipment in process instrumentation. This is due to the lack in concern in supervising and maintaining of equipment. The low quality of equipment as well as unsuitable equipment used also contributing to failure of equipment.

B. Predict the Possibility of Incident by Checklist Procedure or HAZOP Study

Possible problems and responsible area can be checked by using process hazards checklist. Operators will be provided with the list of the potential problem areas for extra concern. Checklist is effective ways in identifying hazards arising in the aspect of process design, plant layout and storage of chemicals. HAZOP study is one of the hazard identification techniques as it is the most effective and relevant technique used mainly to identify the failure of equipment that may be occurred in the processing system. From the possible failure detection, preventive measures can be prepared and implanted.

C. Selection of Consequences Analysis Tool to Calculate Toxic Gas Release and Dispersion

Series of calculation need to be done in order to measure and estimate the risk toward single individual and society regarding the releasing of chlorine from iSHARP chlorine facility. This to make sure the facility located at suitable location with minimal risk.

1) Discharge Rate Calculation

The accidental release of chlorine can came out in three ways which are vapor chlorine discharge from facility, liquid chlorine discharge from facility and vapor discharge from rail car relief valve due to explosion. The discharge rate is important to measure the catastrophic scale due to the toxic release. The holes diameter that causes the chlorine discharge is assume to be 3cm. The discharge rate is calculated using equation below.

a) Liquid Discharge Rate

$$mass\ flow\ rate\ liquid\ release\ \left(\frac{kg}{s}\right) = \rho A C_d \sqrt{2\left(\frac{g_c P_g}{\rho}\right) + g h_L}$$

Where,

$m_L = liquid\ rate\ discharge\ \left(\frac{kg}{s}\right)$

$\rho = density\ chlorine\ \left(\frac{m^3}{kg}\right)$

$A = cross - sectional\ area\ of\ hole\ (m^2)$

$C_D = discharge\ coefficient\ (0.61\ for\ chlorine)$

$P_g = Pressure\ upstream\ \left(\frac{N}{m^2}\right)$

$g = gravititional\ acceleration\ \left(\frac{m}{m^2}\right)$

$h_L = liquid\ head\ (m)$

b) Vapor Discharge Rate

$$mass\ flow\ rate\ vapour\ release = C_D A P_1 \sqrt{\frac{k g_c M}{R_g T_1}\left(\frac{2}{k+1}\right)\frac{(k+1)}{(k-1)}}$$

Where,

$m_{choked} = gas\ rate\ discharge\ \left(\frac{kg}{s}\right)$

$C_d = discharge\ coefficient\ (1\ for\ gasess)$

$A = cross - sectional\ area\ of\ hole\ (m^2)$

$P_1 = pressure\ upstream$

$M = molecular\ weight\ of\ chlorine\ \left(\frac{kg}{kmol}\right)$

$R = gas\ constant\ \left(J.\frac{kmol}{°K}\right)$

$T = temperature\ upstream\ (18\ °C, 291\ °K)$

$k = heat\ capacity\ ratio\ (1.32)$

c) Vapor Discharge Rail Car Relief Valve

$$Q_f = 34500 F A^{0.82} (2.91E-4)$$

$$rate\ release\ \left(\frac{kg}{s}\right) = \frac{Q_f}{h_{fg}}$$

Where,

$m = gas\ rate\ discharge\ \left(\frac{kg}{s}\right)$

$Q_f = heat\ input\ through\ wall\ of\ vessel\ \left(\frac{kJ}{s}\right)$

$A = total\ surface\ area\ (ft)$

$F = environment\ factor (0.3\ for\ insulated\ tank)$

$h_{fg} = latent\ heat\ of\ vaprization\ at\ relief\ valve\ \left(\frac{kj}{kg}\right)$

2) Dispersion Calculation

Dispersion calculation concern in estimating the concentration of toxic release in ppm based on the distance dispersed of toxic gas. The toxic gas are able to disperse to the environment with the help of wind factor exist. The direction of dispersion of toxic gas which is chlorine will depend on the wind direction and the time of dispersion will affected by the wind velocity. In this section, the concentration of chlorine at several distances centered from source which is chlorine facility is affected by the wind velocity and the distance travel from source.

$$C\ (ppm) = \frac{G}{\pi \sigma_y \sigma_z u}\left[\frac{RT}{MP} \times 10^6\right]$$

$$\sigma_y = Exp\left[4.23 + 0.9222 \ln\frac{x}{1000} - 0.0087\left[\ln\frac{x}{1000}\right]^2\right]$$

$$\sigma_x = Exp\left[3.414 + 0.7371 \ln\frac{x}{1000} - 0.0316\left[\ln\frac{x}{1000}\right]^2\right]$$

Where,

$x = distance\ from\ source\ (m)$

$R = gas\ constant\ (atm.m^3/kmol.°K)$

$T = temperature\ (°K)$

$M = molecular\ weight\ \left(\frac{kg}{kmol}\right)$

$P = pressure\ (atm)$

$\sigma_y = y - axis\ direction\ parameter$

$\sigma_z = z - axis\ direction\ parameter$

3) *Chlorine Toxicity*

This calculation is important to determine the relationship of toxicity to be used in fatalities estimation as a result from the vapor chlorine exposure. In this study, the assumption being made is that the al the person within a cloud inside the boundaries are defined by LC90 which means the concentration fatal to 90% of people who already expose to the chlorine are killed and survived for people living outside the boundary.

$$P_r = -8.29 + 0.92 \ln(C^2 t)$$

Where,

C = concentration of chlorine (ppm)

T = time exposure (min)

Pr = probit value

4) *Incident Frequency Estimation*

The frequency of the incident can be identified and estimated. The failure data of the process equipment such as flanges, valve and hoses can be obtain by past industrial record history. The data must be relevant with the local condition such as pressure, temperature, and corrosivity. In this study, the judgment based on historical record of frequency of failure for pipe, valve, and hoses is taken. Therefore, the estimation of frequency of incident can obtain by summing the failure frequency of all individual component exist in incident situation.

$$F_i = \sum_{j=1}^{n} f_i$$

Where,

$F_i = frequency\ of\ incident\ occurence\ (yr^{-1})$

$i = incident$

$f_i = component\ frequency\ of\ failure\ (yr^{-1})$

5) *Risk Estimation*

Risk estimation performed in order to measure the potential risk resulted from the different accidental release of chlorine. Two type of risk estimation need to be concern here which the risk of potential hazard towards individual living people if they are present in certain distance from the source of release and towards societal risk whereby the residential area is taken into account in estimating the affected people.[3]

a) Individual Risk

Estimation of individual risk can be done by measuring the three representative incidents related to chlorine facility including their frequency of occurrence, effect zones, and the distribution of wind direction. Mitigation factor such as evacuation are no need to be considered. Based on the frequency of occurrence for all three type of incidents, the direction factor also need to be included in as the incidental release would likely affected the area by direction of the wind. The risk contour is then constructed to see the risk of an individual would receive if he or she happened to be at the contour line. [3]

$$f_{i,d} = f_i \left[\frac{\theta_i}{360}\right]$$

Where,

$f_{i,d} = individual\ risk\ contour\ (yr^{-1})$

$f_i = frequency\ of\ incident\ occurrence\ (yr^{-1})$

b) Social Risk

The societal risk is a calculation used to estimate the number of people killed by each as a result for each of the incident. The number of estimated people killed is based on the particular location exposure. The wind direction also is taken into account in determining the affected area as the chorine released would likely to disperse to the atmosphere in the same direction as the direction of wind. The F-N curve is needed to be developed as the graph will show the number of people killed as well as their frequency of risk in certain location. Eight point of wind direction is to be studies as it will show the direction of chlorine dispersed towards the neighbouring area. The direction of dispersed are North (N), North East (NE), East (E), South East (SE), South (S), South West (SW), West (W) and North West (NW).

$$N_i = P_i p_{f,i}$$

Where,

$N_i = number\ of\ fatilities\ for\ the\ incident\ outcome\ i$

$P_i = total\ number\ of\ people\ within\ effect\ zone\ for\ incident\ outcome\ i$

$p_{f,i} = probability\ of\ fatility\ within\ effect\ zone\ of\ incident\ outcome\ i$

D. *Apply Step (C) for the worst case scenario*

A worst case scenario is a sequence of events/actions/accidents for a certain place (site) and time which happened when the first and so forth preventive action failed to constrain the accident causes the worst magnitude of an accident. Usually, the worst cases accidents are having very low probability to happen as a basis for planning likelier-but-less-catastrophic scenarios are used. The worst case scenarios assumed to happen when the maximum people are within the accidental area at the maximum storage of chlorine is held at the time of the incident.

E. *Define the Size Impact of the Emergency*

After all the steps above already been taken care of, the size of the impact resulted from the accidental release is to be determined.by doing that, the emergency response prior to the situation can be determined. All the questions is about how far the dispersion can spread based on wind speed, how many people will get involved and will it needed to involved the off-site ERP will be answered. Hence, the most suitable emergency response plan for the emergency can be developed based on the size impact of the incident.

III. RESULTS AND DISCUSSION

A. *Affected Zone and Frequency of Occurrence on Individual Risk Estimation*

In estimating the affected zone base on the accidental release of chlorine from iSHARP chlorine storage facility, the graphical method is needed to estimate the risk of personal within the selected radius from away from the chlorine soure,The risk estimated in the radius of 1000m, 2200m and 5000m away from the source. Three incident of chlorine release selected in this studies which are the chlorine discharge as a liquid from the facility, chlorine discharge as a vapor from facility, and vapor discharge from the rail car relief valve. The table 1 shows that the flow rate of chlorine, frequency of occurrence per year and individual risk contour.

Table 1: Summary of Individual Risk Estimation

Incident	Chlorine Discharge (kg/s)	Direction Factor	Incident Frequency of Occurrence (yr^{-1})	Distance to LC_{50} (m)	IR Contour (yr^{-1})
1	17.46	4.17×10^{-2}	5.8×10^{-4}	1000	7.25×10^{-5}
				2200	4.83×10^{-5}
				5000	2.42×10^{-5}
2	1.7	4.17×10^{-2}	6.6×10^{-4}	1000	8.25×10^{-5}
				2200	5.50×10^{-5}
				5000	2.75×10^{-5}
3	2.54	4.17×10^{-2}	3.0×10^{-6}	1000	3.75×10^{-7}
				2200	2.50×10^{-7}
				5000	1.25×10^{-7}

Figure 1: Individual risk contours for incident 1 around 1000m, 2200m 5000m chlorine storage facility

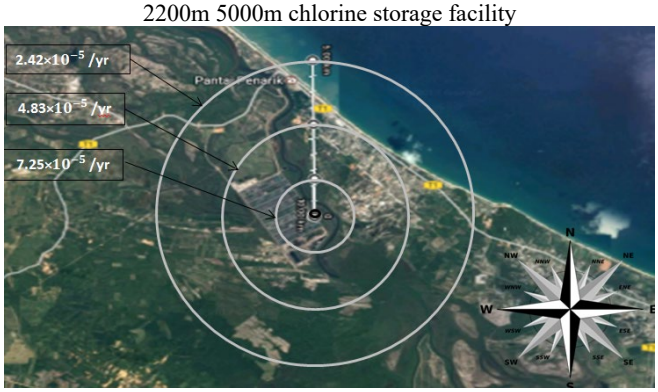


Figure 2: Individual risk contours for incident 2 around 1000m, 2200m 5000m chlorine storage facility

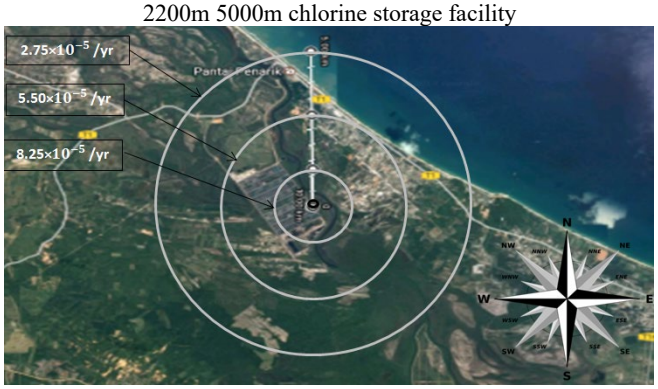
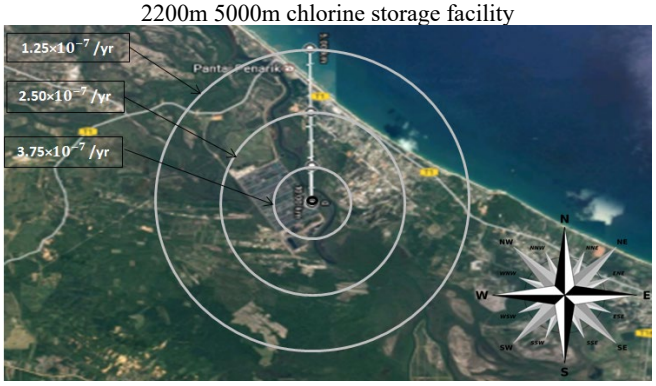


Figure 3: Individual risk contours for incident 3 around 1000m, 2200m 5000m chlorine storage facility



The 1st boundary (inner) will possessed the highest individual risk than the 2nd and 3rd boundary because of the personnel location is closest to the source of release if the accidental release happened. Therefore, the farthest the distance of personnel from the incident location, the risk of exposure towards the chlorine can be reduced

Based on the Incident Risk Contour, the layout through mapping on the chlorine facility can be done. Top view taken from the Google Earth is taken and the risk contour radius is drawn. This is to show the risk of the individual estimated through graphical method.

The guideline of IRC for different country used different guideline as the reference for minimum acceptance IRC. In Malaysia, the IRC must has the value of less than $1.0\times10^{-6}/yr$. This is the minimum acceptance of individual risk contour allocated in Malaysia. Based on the study in three incidents for chlorine released at iSHARP chlorine facility, incident 3 has the IRC in range $1.00\times10^{-7} < 1.0\times10^{-6}$ falls on the acceptance level of individual risk contour and can be ignored. Meanwhile, Incident 1 and incident 2 fall on the unacceptable level of individual risk contour as the IRC in the range $1.00\times10^{-5} > 1.0\times10^{-6}$. Therefore, more precaution and attention is needed in action preparing the emergency step for incident which related to the vapor and liquid discharge from the unit chlorine facility.

B. Affected Zone and Frequency of Fatalities on Societal Risk Estimation

Figure 4: Affected zone consist of residential area based on possible wind direction (social risk calculation)

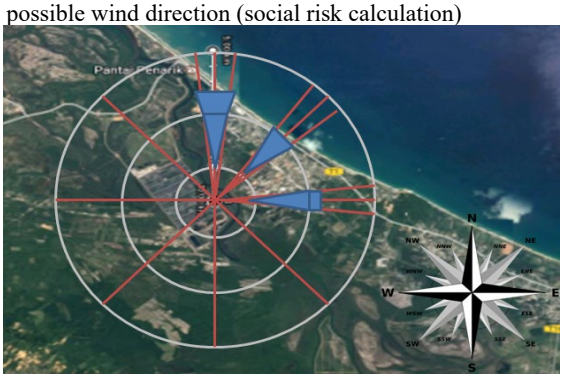
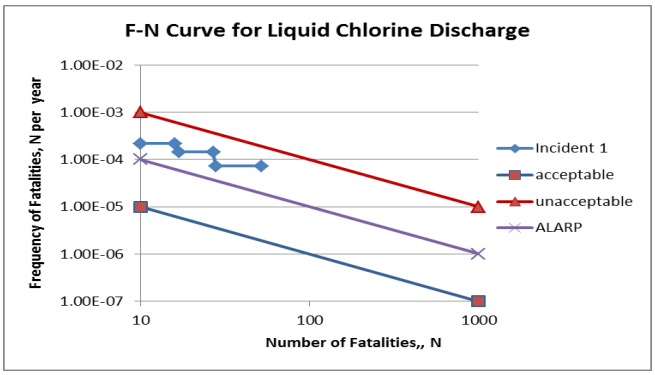


Table 2: Fatalities Frequency Per Year and The Number of Fatalities on Affected Area

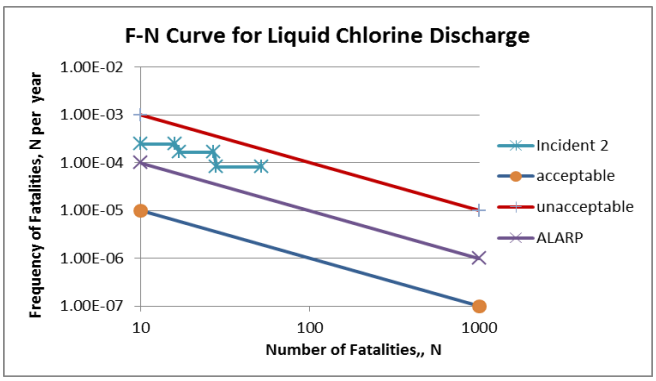
Incident	Incident outcome	Incident Frequency (yr^{-1})	Estimated Number of fatalities
1	1N	7.25E-05	52
	1NE	7.25E-05	16
	1E	7.25E-05	27
2	2N	8.25E-05	52
	2NE	8.25E-05	16
	2E	8.25E-05	27
3	3N	3.75E-07	52
	3NE	3.75E-07	16
	3E	3.75E-07	27

Figure 5: The F-N curve for incident 1 (liquid chlorine discharge) from iSHARP chlorine facility



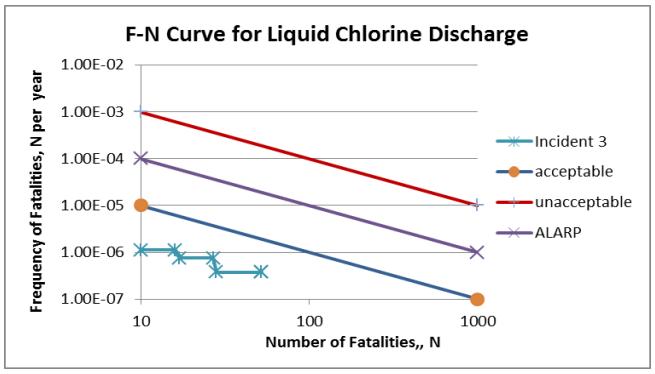
The graph shows that the incident 1 frequency fatalities lie in the ALARP region. The societal risk is slightly high above the acceptable region but the frequency of fatalities per year is still tolerable and can be accepted. But, attention and precaution need to be concern and taken seriously as the impacts still gives significant value towards society area living within the 5000m away from source. Any safety measures and emergency responses need to be revised so that the impact for liquid chlorine discharge if happen at the iSHARP shrimp pond area can be minimized.

Figure 6: The F-N curve for incident 2 (vapor chlorine discharge) from iSHARP chlorine facility



Same goes to incident 2 which is liquid chlorine discharged, it shows that the frequency of fatalities per year it is lies on the ALARP region. The vapor chlorine discharge also brings a slightly significant impact on the vapor chlorine discharge toward the area around 5000 radius from iSHARP chlorine facility. The emergency response techniques need to be emphasized and the safety equipment implementation and design need more attention.

Figure 7: The F-N curve for incident 3 (vapor chlorine discharge from rail car relief valve)



For incident 3 which is the vapor chlorine discharge from rail car relief valve, the frequency of fatalities lies in between acceptable region and ALARP region. Therefore, any incident regarding the release of vapor chlorine within the iSHARP chlorine storage facility can be ignored. This is because of the incident does not resulting any significant impacts and damages toward the surrounding area of the facility. Even if the accidental release happened, the emergency response plan can cope with the emergency situation.

*The risk matric is compared with HSE UK

C. *Emergency Response Plan*

1) Announcing Level of emergency situation

There are three level of announcing activated on certain situation. All of the workers who work inside the facilities need to know and understand all the three stages of announcing level in order they can take proper action based on the level of announcing activating by the commanding leader of emergency response.

- First stages

The accident can still be controlled within the facility department and associated department. The incident commander needs to arrive at the incident site to identify the problem and then take the appropriate action to solve it before getting worst.

- Second stages

The needs of mobilized the emergency response plan to the incident site is crucial for containing the release and evacuating process.

- Third stages

The mobilized of all personnel including the emergency response team out from the facility to reduce the degree of hazards.

2) Emergency Control Center

Emergency control center need to be built as a center of transferring the command, decision making and updating the status based on current situation of emergency. Information team and Coordinator will be post here when the emergency situation is happened. It is therefore needed for this facility to have a good communication system such as telephone and radio for communication purposes. This place also can be used to store safety equipment used for rescue process. A computer with the accessory is needs to simulate the dispersion level and to calculate the wind direction and speed for calculating the risk of release toward the neighbor residence.

3) Off-site emergency response plan

The head or chief that played the role leader of on-site and off-site of emergency response plan were the Government Liaison. Right after the alarm rise, the onsite emergency control center would informed to Government Liaison to contacting the agency from several local department agencies such as Pollution Control Officer, Police Superintendent, Fire Officer and Medical Officer about the situation on the so that the proper action of emergency can be carried on.

Government Liaison with advices from the onsite emergency controller will declare the emergency and arrangement in action to inform the public living near the facility by rising the siren, public address system, and media such as radio. Government Liaison also has the responsible to announcing the declaration when the emergency was ended also with the advised of onsite emergency control.

For short release of chorine such first and second stages of announcing level, the action need to be taken by the resident is only to stay and remain calm in their respective houses with doors and windows is shut and closed and also the air conditioner is shut off. The evacuation of the resident people away from the disaster area need to be done only if the released of chlorine last for more than 30 minutes. The evacuation necessities and also the evacuation distance away from the source of the release is depend on the intensity of the released of gas. The Government Liaison will inform the residence about the necessity of it by announcement and siren. The evacuation need to be done as fast as possible. The plant also had a mock drill before to test their process flow of Emergency Response Plan to test their capability towards the emergency situation.

4) On-site emergency response plan

a) Emergency Response Team

i. Incident Commander
ii. Coordinator
iii. Government Liaison
iv. Rescue Team
v. Information Team
vi. Safe and Security Team
vii. Medical Team
viii. Spokesperson

b) Role and responsibilities

Response Team/ Organization	Role and responsibilities
Incident Commander	• Visit the incident site and assess the level of incident • Act as the leader in assigning the flow of movement the emergency response team • Assigning the manpower needed for an assignment incident • In command of announcing the alarm to activate the emergency response • Providing the budget for process rescue
Coordinator	• Coordinating the command from the incident commander to the respective team for action of measures • Assist the incident commander in the emergency response • Assess on wind direction and the dispersion distance of toxic substance
Government Liaison	• Contact the government agencies about the incident if necessary • Provide the fire fighter and rescue team information about the chemical substance • Contact on information team to request safety and health and communication equipment
Rescue Team	• Assist the fire fighter on rescue and evacuating process out form the incident site • Protect the staff and deal with the toxic release by stopping the leakage and attempt to repair the damages.
Information Team	• Provide the communication and safety equipment. • Ensure the availability of those equipment all the time • Record the rescue information at the assembly site • Assist the analyzing of the incident
Safe and Security Team	• Guide the flow of evacuation of staffs toward the assembly point • Act as a crowd control to keep a calm situation all the time • Secure the incident site by making a cordon • Control the flow of vehicles in and out from the facilities
Medical Team	• Provide the first aid of victims • Arrange the transport of injured personnel to the nearby hospital. • Keep the record based on the nature of injuries taken by the personnel for further treatment
Spokesperson	• Setting and participate in press conference • Explaining about the situation to the public • Explaining the status and proses of emergency response [5]

Figure 7: Structure of Emergency Response Team

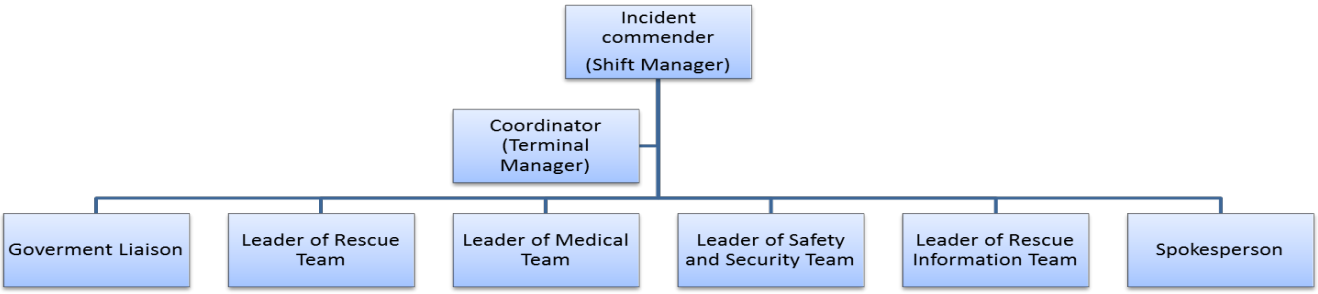
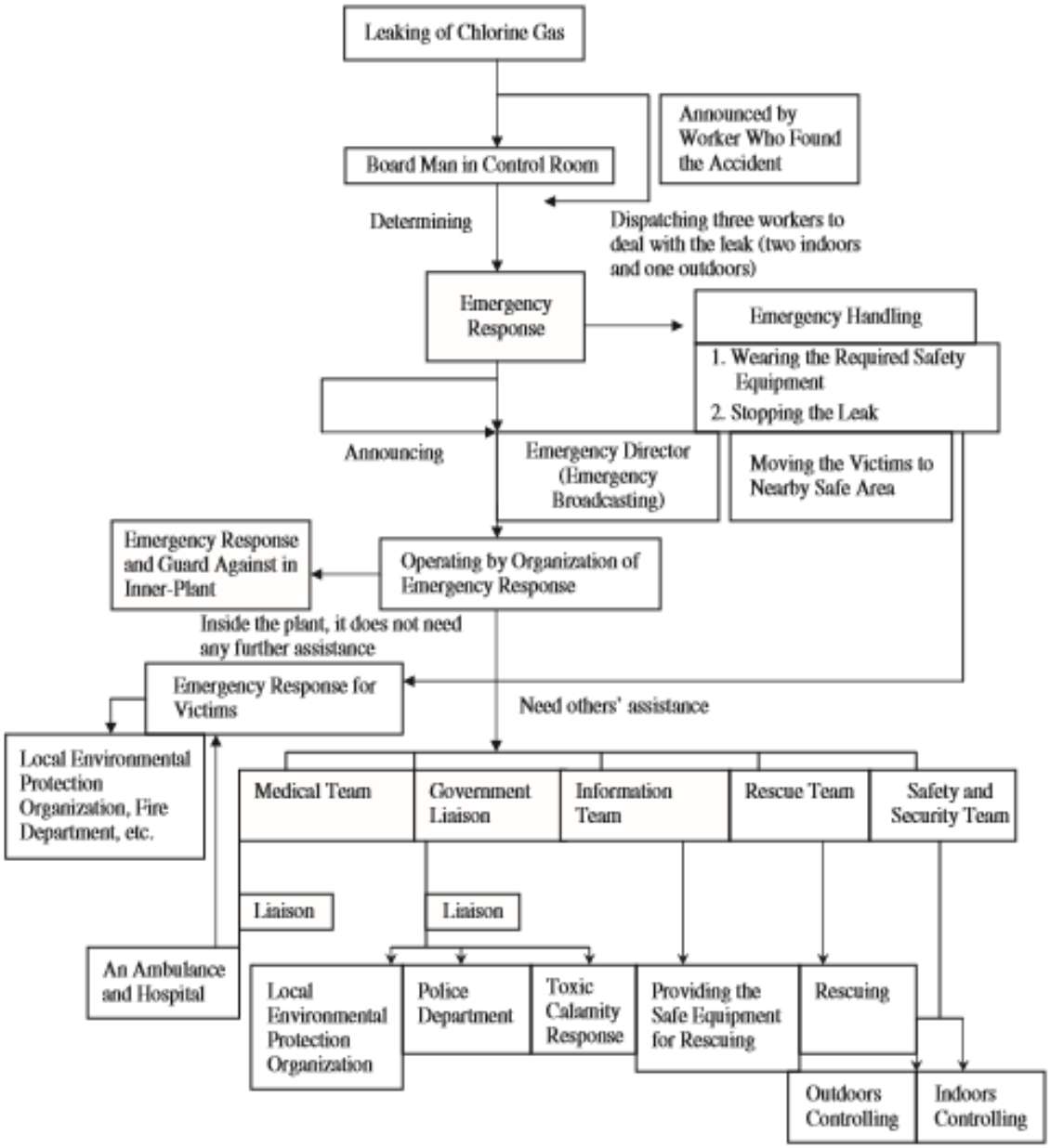


Figure 8: Emergency Response Steps in Chlorine Release. [5]



5) Process of Emergency Response Plan

Step 1: Announcement of emergency conditions.
Operator heard the alarm rang from the detection of leakage in certain piping or process vessel occurred or witness the leakage before the alarm detection. Operator need to inform the supervisor about the situation. Supervisor is the go and visit the source of leakage and try to repair if it situation is manageable. If the situation cannot be handled on the spot and the leakage cannot be contained, supervisor need to inform the shift manager about the problem, cause of leakage and the status of incident weather it is worse or not. In case of level three emergency activated, shift manager will act as incident commander and should visit the source of leakage to identify the situation. The incident commander should ask the information regarding the wind direction and weather condition such as humidity and wind speed from the information team. Then the incident commander will need to inform all the emergency response team by broadcast and radio to move to safe location for short assembly. [5]

Step 2: Gathering all of the members of the ERT and isolating the disaster area.
Based on the current scale of incident, all the emergency response team need to be assemble at the Emergency Response Centre. The rescue team consist emergency response team from rescue department gather and prepared with the safety equipment and walkie-talkie. The medical team also prepared with the first aid equipment, medicines, personal protective equipment and large amount of water at the safe location to treat the injuries. Safety and security team is moved to certain post to ensure there is no movement of people going into the plant. All the vehicles and employees should be evacuated toward the assemble point. They need to cordon the area of leakage to isolate it. The information team before-hand must prepare all the equipment needed for the medical team and rescue team. Risk assessment report book need to set out the drawing of the inner route of plant. Government Liaison must report and contact the related agency for help. [5]

Step 3: Leak prevention, emergency closure, protection of the rescue team
The rescue team leader will split the rescue team into two group which is the first group will wear class A personal protective equipment and also carrying ammonia water and tools to enter the leak area from up-wind in attempt to repair the damages in order to stop the leak. The appropriate steps are indicated as follows:

- Ammonia water is used to detect the chlorine leakage in the pipeline or vessel. The presence of white-smoke will appear as the source of leak to be found.
- The opening faces of the leaking cylinder will be orient upwind to avoid the leakage of the liquid chlorine.
- The correct and suitable methods and tools are required to stop the leaks.

Both of the assigning members need to prior their safety first while carrying the repairing process and avoid actions that can endanger them. If any of them is affected by chlorine, the infected one must be immediately evacuate from the scene. The communication with the team leader is crucial along the process whether by sight or by signals. Another group of rescue team will focusing on rescuing the trapped staffs inside the disaster site and guide them for evacuate. [5]

Step 4: Reporting to the incident commander
The rescue team leader crucially informed about the current status of repairing process to the incident commander about the members whose enter the leak area to begin the leakage control procedure.

Step 5: Initiating water mist facility
The activating of the water mist facility will begin if the leakage starts to escapes the building. The leader of rescue team will inform the incident commander about the necessaries of using the water mist. The incident commander will instruct the information team leader and the fire control members to start setting up the water mist at the appropriate places. [5]

Step 6: Medical treatment, first aid and care of the injured
The rescue team members involve in the treatment of affected by the chlorine. The injured must be evacuated from the scene immediately and brought to the safer location. Emergency shower is required to be taken before entering the safe location by using a large amount of water to remove the chlorine from in contact with the patients. A group of medical team also needed to be moved together with the rescue team for medical back up with the permission of incident commander. The medical team must be ready near the leak area to give first aid to the injured while the ambulance is ready to transfer the patient to the nearby hospital for further treatment. All of the information from the rescue team is reported to the incident commander for formulating the next order. [5]

Step 7: Evaluation of a disaster
The information team uses the risk assessment report book to predict the affected area and then informs to the incident commander regarding the status of the present situation. The distance of dispersion area can be measure by calculating the wind speed and the affected area can be predict by looking at the wind direction at that moment. The rate of dispersion can be measure based on humidity of the atmosphere.

Step 8: Communicating outside the plant (off-site emergency)
Incident commander receives the incidents report, the communication centre must contact the related agencies outside the plant to look for support, establishing contacts, making arrangements for the public in the disaster area and maintaining order.

- EPA: inform the location of the accident, the time, the degree of hazard and the status of the disaster.
- Fire department: ask for assistance in enhancing water mist to stop the leak.
- Local science-park: ask for additional manpower and personal protective equipment support.
- The joint defence team: inform the other plants in the neighbourhood of the need for additional equipment and manpower.
- Police department: ask for support in evacuation of the nearby residents.
- Medical department: request for ambulances, doctors, nurses and medicines.
- Labour inspection department: inform the disaster status and casualties.
- Affected community: inform the disaster category, the evacuation order and the gathering places. The first step in estimating evacuation demand is to assess the size of the evacuating population

Step 9: Eliminating the disaster
The fire fighters together the joint defence team will assemble at the main entrance of the plant. They enter the plant with the

guidance of the safety and security team to report for duty to the incident commander. If the leakage is can be properly controlled and the repair is successful, the rescue team leader will enter the incident area by wearing class A personal protective equipment to inspect the situation. Then, the EPA members or the members of the labour inspection department will use the toxic-gas detector to ensure that the chlorine gas is totally eliminated. In addition, a security check and the incident investigation to determine the cause of the accident must be initiated.

Step 10: Dealing with problems or difficulties arising from the incident and treatment of wastewater
The incident commander needs to offer his gratitude to all the in-source and out-source ERTs members involved. Then a press conference needs to be held to explain the whole process of handling the incident. Finally, the incident commander, by various approaches, needs to placate the neighbouring citizens and reassure the victims. [5]

IV. Conclusion

In conclusion, the overall studies show that proper and effective emergency response plan is important in managing and handling the emergency situation. Especially in controlling the situation regarding the released of toxic gas which can bring deadly impact toward human and living thing. The emergency response plan need to be well organized and the flow of the event is understandable so that when the emergency situation is at the peak, all the staff and personnel within the facility is already well known about the important steps need to be taken care of. An effective emergency response plan regarding onsite and offsite emergency may safe many life and property. Therefore, all personnel need to be emphasized and well trained by undergo emergency drills to be able to cope with the emergency situation effectively. In constructing an effective emergency response plan to be implemented to the iSHARP shrimp pond area, the pass histories on accidental release need to be study. The root cause and consequences from each incident is compared and their limitation on emergency response plan is reviewed. Next, risk estimation is measured to determine the impact of chlorine released from the facility. The impact toward the individual and societal impact within the impact zone is measured.

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