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Development of Permit to Work System for the Effective Hazard Communication and Controls

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ABSTRACT

Oil & Gas industries, Production/Manufacturing industrial, and Construction Industries are comprised of high-risk activities which need to be controlled, for the safety of those carrying out the work and to maintain a safe workplace. A permit-to-work (PTW) system is a formal communication written system designed to control all types of work (construction / maintenance) that are identified as potentially hazardous.

The aim of this project is to contribute to the understanding of the implementation issues with the PTW system. This project identifies PTW system issues and proposes the best practices for effective implementation and controls on hazards through PTW system.

The project carried out by reviewing articles on PTW systems and analysing accidents that resulted from poor implementation of PTW systems using case studies and previous literature review on PTW implementation issues. Outcomes from the reviewed case studies that gaps in the PTW implementation are key hazards and control measures are not appropriately captured and the communication was failed. The best practices provide invaluable indications for procedure of an effective PTW system practice and improvements in future research.

I. INTRODUCTION

Most of the Incidents from various industries (Manufacturing / Construction / O&G and Chemical) are associated with high-risk activities which are monitored and controlled by the Permit To Work (PTW) procedure which is compliance of OISD (Oil Industry Safety Directorate) Standard 105. OISD is technical directorate functioning under Ministry of Petroleum and Natural Gas, India. OISD formulates serious of self-regulatory measures aim to improving the Safety in O&G industry in India.

Permit to Work (PTW) is the key document to control work such as construction, maintenance, inspection, modification, and non-routine high-risk activities to prevent a major accident. It is one of the elements of the Industrial Safety Management. The current issue of the O&G and chemical process industry is that the accident rate has not decreased even though Safety Management are widely implemented in the various industries.

1.1. Permit To Work (PTW)

The purpose of the Permit to Work System is to ensure that a safe working environment is achieved by task force and management of control over the various activities which may have hazardous. The system provides a formal and controlled process that identifies and communicates risks and hazards associated with planned activity and ensure that appropriate precautions and measures are implemented so that the job can proceed and be completed safely.

It is important to note that a Permit to Work is not a permission to carry out a hazardous job but is an essential part of a procedure that provides instruction on how to carry out a hazardous job safely and in a managed and controlled way.

Key features of the procedures are below:

- Overall site safety to be aware of the various hazardous activities and to take a systematic overview which identifies interactions and allows priorities to be set for conflicting work tasks.
- It reduces the potentially harmful effect of the actions of the person doing the work by specifying safety precautions and setting limits to the duration and extent of the work.
- It encourages formal and careful attention to safe systems of working by requiring the signature of specified individuals who must confirm that all hazards have been identified and effective precautions taken.

Permit to Work procedure is to ensure that the responsibility and accountability for safe working practices is followed by the permit authorities. to those responsible for the work being carried out at any given time and ensures that specified and effective safeguards are provided. It is designed to achieve the involvement of competent and responsible persons as well as the applications of safety measures in a controlled sequence.

1.2. OISD (Oil Industry Safety Standard)

The Permit to Work procedure contains the minimum safety requirements/ standards acceptable to OISD. These standards may be increased at the discretion of the Safety Management if necessary, but not decreased. Deviation from the rules and regulations in the Permit to Work procedure may be necessary in an emergency, but the safety of personnel, the environment and property must not be jeopardised. Once the emergency is contained, the rules and regulations in the PTW procedure must be re-applied.

All persons involved in the Permit to Work process should understand that it is not the work permit itself that ensures that work is carried out safely but the control over the work and the precautions taken. Other necessary elements, as follows, contribute to safe working:

- Good communications between all involved personnel.
- Detailed planning of work.
- Systematic identification and communication of hazards and risks.
- Effective implementation of required precautions and close supervision of the work.
- A skilled, trained, and dedicated workforce.

The rules and regulations in the PTW procedure represent the latest accepted practices in the Petroleum Industry. Changes and temporary alternatives to the rules and regulations in the Permit to Work procedure are allowed ONLY with the written approval of the Management and with Safety Personnel and where a risk assessment to be conducted to ensure that safety standards have not been compromised.

II. TYPES OF WORK PERMITS

In general, the following type of PTW to be issued:

- Hot Work permit - HWP
- Cold Work Permit - CWP
- Isolation Confirmation Certificate - ICC
- Confined Space Entry Certificate - CSEC
- Excavation Certificate - XC
- Radiography Certificate – RC

2.1. Hot work Permits (HWP)

It must be issued for any work requiring high-energy sources of ignition (naked flame, hot tapping, welding, cutting, grinding, burning, or heat treatment using electrical coils, etc.) irrespective of area classification.

A HWP must also be issued for all works involving the use of any local ignition source (heat – flame – spark) within Restricted Areas. This includes grit/shot blasting, Pressure testing, soldering, gasoline or diesel driven vehicles and/or equipment, open electrical equipment housings, non-intrinsically safe electrical equipment, Pyrophoric materials, drilling, hammering by ferrous metals, concrete cracking, X radiography by introducing a high potential electric source, handling of Pyrophoric Iron Sulphide scales, etc. A HWP must be issued for vehicle entry into a Hazardous Area.

2.2. Cold Work Permit (CWP)

A CWP is required for any work in a Restricted Area, which does not involve the use of equipment with the potential for producing sparks or other ignition sources.

2.3. Isolation Confirmation Certificates (ICC)

An Isolation Confirmation Certificate must be issued when the unexpected operation of electrical/mechanical/process/control equipment that can be started by automatic, manual, or remote control may result in injuries to persons working on the equipment or who are in the vicinity due to release of stored energy.

Lockout and tag-out devices such as locks, tags, multi-hasps, and chains shall be installed on all energy isolating devices, including blinds, valves, slide gates, circuit breakers, disconnect switches and double block and bleed systems to prevent the transmission or release of stored energy sources.

2.4. Confined Space Entry Certificate (CSEC)

A Confined Space Entry Certificate is required for the protection of personnel entering vessels, tanks, furnaces, sewers, pits over one meter deep and other confined spaces within the ADCO Oil Field/Terminal areas regardless of area designation. Protection is required against hazards such as flammable vapours, oxygen deficiency, toxic atmospheres, excessive temperatures, power driven equipment, etc.

Confined Space Entry is one of the most hazardous activities undertaken within petroleum production operations. Care and attention must be paid to all aspects of the work plan and procedure. Particular emphasis must be placed on communication. Since person's lives are directly at risk, pre-job work planning meetings, procedure review meetings, Job Hazard Analysis (JHA) and Toolbox Talk (TBT) are essential pre-requisites. It is recommended that prior to each Confined Space Entry work that all persons familiarise themselves with the Confined Space Entry procedures as detailed in this procedure prior to issuing PTW/Certificates and commencing the job.

2.5. Excavation Certificate

An Excavation Certificate must be issued for any excavation work within the brown field (Oil Field/Gas Terminal areas) regardless of area designation. All excavation work should follow approved excavation procedures. A Confined Space Entry Certificate must be issued in all areas if personnel are to work in excavations over 2 meters deep having a width to depth ratio of less than 2.0 (excavation width divided by excavation depth is less than 2.0) (e.g., trenches, pits, tunnels, etc.)

III. CASE STUDIES ON THE IMPLEMENTATION ISSUES WITH A PTW SYSTEM

3.1. Case study 1: The North Sea Piper Alpha Disaster

Descriptions: On July 6, 1988, Piper Oilfield, North Sea: As shifts changed and the night crew aboard Piper Alpha assumed duties for the evening, one of the platform's two condensate pumps failed. The crew worked to resolve the issue before platform production was affected. But unknown to the night shift, the failure occurred only hours after a critical pressure safety valve had just been removed from the other condensate pump system and was temporarily replaced with a hand-tightened blind flange. As the night crew turned on the alternate condensate pump system, the blind flange failed under the high pressure, resulting in a chain reaction of explosions and failures across Piper Alpha that killed 167 workers in the world's deadliest offshore oil industry disaster.

Conclusion: Piper Alpha's inadequate permit and lockout/tagout system resulted in gaps in multiple levels of safety. While second shift engineers earnestly believed that all documents were accounted for before beginning Pump A start-up, a decentralized system inhibited the sharing of critical information. A lack of informal "between shift" talks compounded lax communication issues. The reliance on individual safety practices in lieu of strong system safety culture allowed errors to find holes in the layers of controls.

3.2. Case study 2: Human Error Analysis in Permit To Work system

Descriptions: According to investigations on industrial accidents, human errors account for 90% of accidents in industries, 80% of accidents in chemical industries, 75% of accidents in Oil & Gas and 70% of accidents in Constructions. Human errors also constitute one of the direct causes of some of the most shocking industrial accidents which have occurred around the world such as Bhopal in India (1984), Texaco Refinery in Wales (1994).

Conclusion: To analyse and quantify potential human errors and extract the required measures necessary to reduce error probabilities in a PTW system. Based on the results, the following suggestions are provided to reduce the likelihood of errors (i) employing a qualified person for gas testing. In this way the dependency level of tasks conducted by site men will be reduced. (ii) providing a specific appropriate procedure for the task of "flammable gas testing". (iii) revising the PTW procedure for detailed explanation of responsibility of all operators involved in PTW issuance and its related work activities and (iv) as a simple and appropriate solution the automation of the PTW issuance procedure can be very effective in preventing and reducing the probability of human errors.

3.3. Case study 3: Permit to work System- A Case Study of Bangora Gas Plant.

Descriptions: In process plants, reliable and productive plant operations are as important as occupational safety that requires employees be safeguarded from accidents in the work site. Ambiguous work plans weaken the quality of work management and give rise to misunderstandings between workers, which may lead to an incident. According to the Health and Safety Executive (HSE) (Health and Safety Executive, 1987), 30% of the accidents which occur in the chemical industries are maintenance related. The Accident Database of Institution of Chemical Engineers shows that over 700 accidents of the 5000 listed were maintenance-related, which are typically controlled by permits-to-work (PTW). Permits-to-work (PTW) is essentially a management tool for coordinating and controlling non-routine work processes, such as maintenance, start-up, and trial runs etc. in a potentially hazardous environment [Health and Safety Executive, 1996]. The accident database also reveals that the PTW systems in place were either poor or not followed when the incidents took place.

Conclusion: The issued permits-to-work, although had specific purposes, helped improving the safety scenario of the working environment. It was also found that the hazards could not be eliminated completely. Most of these hazards were related to safety culture of workers and contractors. Thus, creation of safety awareness through advocacy and trainings needs to be integrated with safe working systems to get the maximum benefits. The concept of Permit-to-work system in chemical industries is not a new one. However, it has not yet been seriously considered in local industries. This paper presents a real case of PTW application in a local plant that demonstrates the effectiveness of such system and encourages introduction of safe work practice at large in our country.

3.4. Case study 4: More Effective PTW Systems

Descriptions: According to the Health and Safety Executive 1 (HSE), 30% of the accidents which occur in the chemical industries are maintenance related. A quick check of the Institution of Chemical Engineers' Accident Database reveals that over 700 accidents of the 5000 listed were maintenance related. Some of these were due to the way in which the maintenance was carried out, but most were due to errors in the way the equipment was prepared for maintenance or handed over. Sometimes the permit-to-work (PTW) system was poor, sometimes it was not followed.

Conclusion: To conclude, the application of computers to the problems of PTW systems promises a variety of benefits information appropriate to the user' s situation but which he has not actually asked for. Collectively, these enhancements promise to make PTWs far more effective. Hopefully, this should go a long way towards improving plant safety well as improving business efficiency Ð in the chemical-industrial workplace. It is unlikely, however, that any system will be able to render maintenance safe: the HSE has noted that in many cases workers have failed to do what their permits correctly told them they should, either considering the completion of a permit as an end in itself unrelated to actual work practice, or for some other reason. Computerizing the process is unlikely to change this singularly human pattern of behaviour.

IV. THE GAP IN THE IMPLEMENTATION OF PTW SYSTEM

O&G, Petroleum, Chemical and Construction industries handle large quantities of flammable and toxic materials, so the potential for serious accidents is clear. Over the years, engineering and design improvements have improved safety procedures and reduced the rates of accidents but permit-to-work system remains as an important safety practice. Although several fatal and serious accidents in the past were due to faulty or weak permit-to-work systems operated during high-risk activities.

The frequent PTW failure is caused by not checking system adequately, not identifying hazards adequately, unclear of correct type of personal protective equipment needed, poor isolation of energy source and inadequate formal hand back of plant upon completion of maintenance work.

From the study on the investigation reports, the main factors contributed to each PTW type failure are identified as below.

1. The nature of activities are not clearly briefed in the PTW.
2. Description of the hand tools / power tools which will be used to perform the activity and it protentional hazards are not included in the PTW.
3. Correct locations of the job performance are failed to mention in the PTW.
4. In general Risk assessment are performed by the Operational Managers / Engineers/ supervisors / Safety personnel but the risk assessment is not

attached with the PTW hence the following identified hazard may miss out.

a. Selection of PTW types
b. Selection of applicable potential hazards
c. Selection of PPE
d. Requirements of gas test / gas test frequency
e. Safe distance calculating for pressure test.
f. Selection of fall arrestors / Safety nets for work at height with respect to dropped objects impact calculations.
g. Selection of hazardous zone area for hot work
h. Clear description of roles and responsibilities for the PTW authorities.

V. BEST PRACTICES FOR EFFECTIVE IMPLEMENTATION OF A PTW SYSTEM

5.1. Permit Authorities specify and clear roles and responsibilities.

5.1.1. General Responsibilities

All personnel carrying out work within the PTWS have general responsibilities, which include:

- Ensuring all work is undertaken in accordance with the specified work scope and conditions defined on the PTW.
- Being aware of other work going on in the same area and of the potential for hazardous interactions.
- Knowing the location of the nearest fire extinguishers, communications equipment, manual alarm, and emergency shutdown points.
- Being aware of changes in environmental/process conditions at the workplace.
- Knowing the emergency assembly points, wind direction and escape routes from the work area.
- Knowing the emergency procedures and emergency contact numbers.
- Listening for general alarms, knowing the significance of different tones and warning/hazard status lights.
- Using the appropriate Personal Protective Equipment (PPE) and tools for all work activities.

5.1.2. Job Initiator:

- Nominates the Permit Receiver (Job Supervisor) who will be responsible to carry out the task.
- Completes, in conjunction with the Permit Receiver and Contractor Job Supervisor, the PTW/Certificate parts indicated as "Permit Request by Job Initiator", ensuring that the correct type of PTW has been selected, that the task description is complete and thorough, and that copies of relevant area/equipment drawings and procedures are attached as required.
- Checks the work on completion and signs for Permit Cancellation/ Close-out in PTW.

5.1.3. Permit Receiver (Job Supervisor)

- Aware of PTW and HSE rules and regulations, work procedures, job locations, equipment to be worked on, tools and equipment to be used and defining the anticipated start and finish time / date and no. of days.
- Signs in the PTW accepting the conditions of the PTW and attached Certificates.
- Is directly responsible for the safety and quality of work and must ensure that the conditions specified on the PTW/Certificates are adhered to at all time.
- Ensures that no other activity/ tool is performed/ used except as specifically described on the PTW.
- Implements the Work Site Precautions to be taken by the Permit Receiver (Job Supervisor) as identified by the Permit Issuer on the PTW.
- Visibly displays the signed Original of the permit at the worksite during the duration of the work.
- Remains at the worksite during the duration of the work and obtains Job Initiator/ Permit Issuer signature.

- Conducts a Toolbox Talk (TBT) immediately before commencing the job.
- Adheres to and maintains the worksite precautions identified by the Permit Issuer on the PTW/ Certificate throughout the duration of the job.
- Immediately suspends work in the event of the Emergency Siren or General Alarm being activated.
- Returns the permit to the Job Initiator on suspension of work, at end of the working day, or on completion of the work. On completion or suspension of the job he must ensure that the work site is left in a clean - clear and safe condition.

5.1.4. Permit Issuer

- Determines the type of permit required - HOT/COLD and indicates additional certificates required.
- Undertakes hazard assessment (and JHA if required) and identifies site preparedness/ precautions.
- Ensures other work being performed in the vicinity simultaneously with the work covered by the PTW will not cause a hazard.
- Defines and arranges for Gas Tests. Nominates the Gas Tester if he is a contractor. Determines whether it is necessary to repeat gas tests during and before resuming work after being stopped. Recommends continuous gas testing in case of naked flame work or highly intensive source of ignition.
- Defines and stored energy calculations and safe Distance for the pressure test.
- Defines and calculate the impact of dropped object during work at height.
- Defines and issues Area Permits where required to cover several activities within a designated area under his responsibility.
- Defines and select the Hazardous area for Hot work.
- Consults with the Area Safety Officer for Confined Space Entry Certificates, Area Permits and high-risk jobs.
- Stamps or writes relevant site Emergency Response number onto the PTW/Certificate.

5.1.5. Gas Tester (GT):

- Conducts gas testing as stipulated on the PTW.
- In consultation with the Permit Receiver (Job Supervisor), sets up continuous gas monitor(s) as required by the permit. Advises the Job Supervisor on the operation and alarm functions of the monitor.

5.2. Pneumatic Test Stored Energy & Safe Distance Calculation.

Safe Distance and Stored energy calculation during pressure test in the selected loops. Stored energies greater than 100 kJ are high hazard. Calculate minimum safe distances between piping system being pneumatically tested and personnel/plant facilities using ASME (American Society of Mechanical Engineers) PCC (Post Construction Committee)-2 Mandatory Appendix 501-II and III equations.

The calculation is based on air or nitrogen being used as test medium with specific heat ratio of k = 1.4. Patm = absolute atmospheric pressure = 101,000 Pa. The stored mechanical energy of a gas may be calculated using the Baker Equation:

E = Ptest V / k -1 (1 –(Patm / Ptest) (k-1)/k)

E= Stored Energy of test

V= test volume

Patm = absolute pressure of test

Ptest = absolute pressure of test

K = ratio of specific heats

- If E <= 1,35,500 KJ, the safe distance to be maintained is greater of 30m.

- If E > 1,35,500 KJ and less than equal to 2,71,000 KJ, the safe distance to be maintained is greater of 60m.

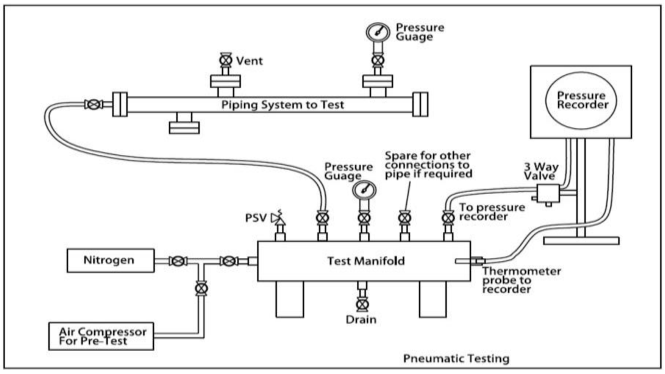

Figure 1 Typical Pneumatic Testing Illustration

Reference of Figure 1:

https//:pipingengineer.org%2Fpneumatic-testing-of-piping-systems

Control measures: Proposed recommendations for the Pneumatic Testing as below:

- Safe Distance to be determined and it should be mentioned in the PTW accordingly the safe distance to be followed.
- Pressure Monitoring devices to be placed in the safe zone.
- Pressure Controlling systems to be operated from safe zone and avoid or reduce personnel entries into the hazardous zone during pressure test.
- Motor operated Valve to be used.

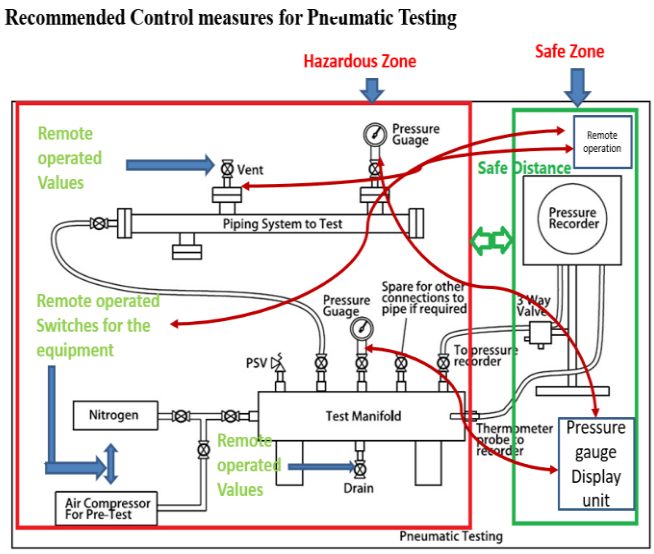

Figure 2 Recommended Control measures for Pneumatic Testing

5.3. Dropped Object impact Calculation for Work At Height

The energy developed by dropped objects (DO) shall be expressed in Joules and calculated using the following formula: DO force = m x g x h

Where:

m = mass of the dropped object (kg)

h = distance the dropped object fell (m)

g = gravity (9.81m/s2)

The consequence of Dropped Objects is estimated using the below calculator & graph.

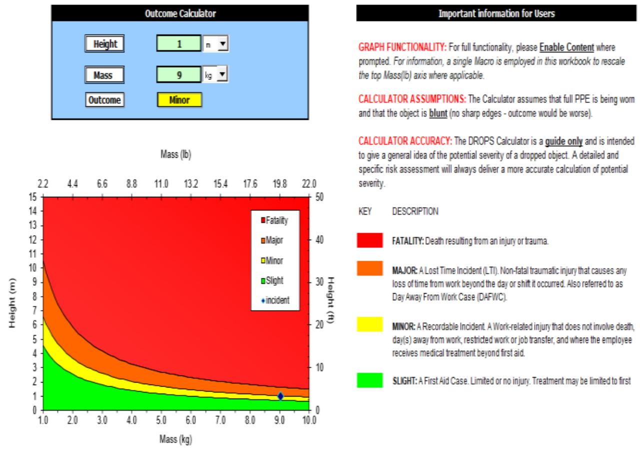

Figure 3 Dropped Objects calculator

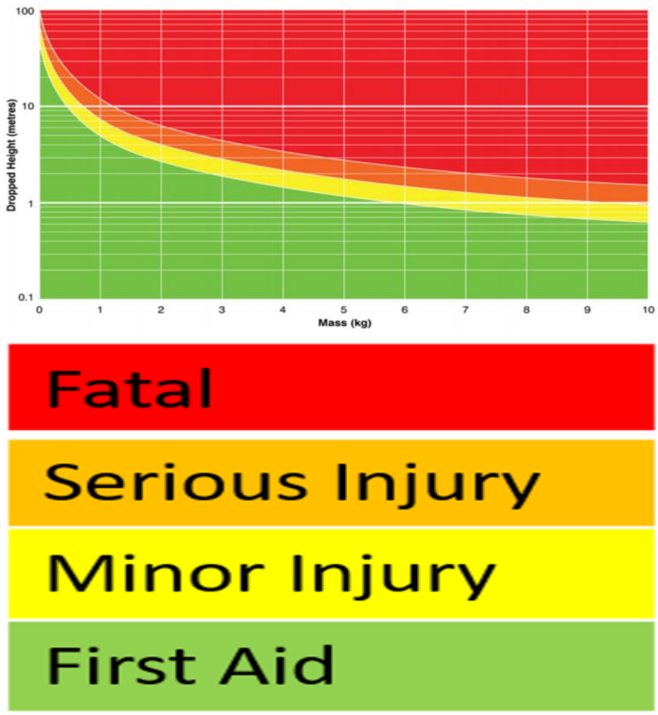

Figure 4 Dropped Object Graph Height VS Mass

Reference of Figure 3 & 4 Reference: Literature review - Dropped Object Impact Analysis of Subsea Tree Frame. Kumarswamy Karpanan & Craig Hamilton-Smith FMC Technologies Houston, TX, USA craig.hamilton-smith@fmcti.com

Considering the severity, the following precaution may recommend in the PTW.

- ➢ Work at height should be considered as high-risk activity for the below least conditions.
- ❖ 1kg weight at height 10 meters
- ❖ 10kg weight at height 1.2 meters

Control measures: Recommend the following.

- Requirements of Safety nets / tools lanyards.
- Selection of Scaffold types.
- Simultaneous operations (SIMOPS)
- Lifelines / Self-retracting Lifelines.
- Fall Restraint Systems.

5.4. Hazardous Zone Selection for Hot Work.

Hazardous area classification identifies locations where flammable atmospheres can exist on process plant. Approach to hazardous area classification risk assessment of the coincidence of ignition sources and flammable atmospheres to conducted. Determine the consequences of such an ignition, heat or spark to point the way to controlling flammable atmospheres as well as ignition sources. If neither can be sufficiently controlled, then explosion protection or other means to reduce the risk to an acceptable level can be chosen.

Ignition sources possible on Oil and Gas / Refinery plant

- flames (open fire) and hot gases
- hot surfaces
- electrical installations and equipment
- static electricity
- lightning
- mechanical sparks and welding sparks
- chemical reactions
- adiabatic compression, shock waves, flowing gases.
- optical radiation
- HF electromagnetic radiation
- ionising radiation
- ultrasound
- stray current

Zone—

The Zone defines the probability of the hazardous material, gas or dust, being present in sufficient quantities to produce explosive or ignitable mixtures.

Zone 0—

Ignitable concentrations of flammable gases or vapours which are present continuously or for long periods of time.

Zone 1—

Ignitable concentrations of flammable gases or vapours which are likely to occur under normal operating conditions.

Zone 2—

Ignitable concentrations of flammable gases or vapours which are not likely to occur under normal operating conditions and do so only for a short period of time.

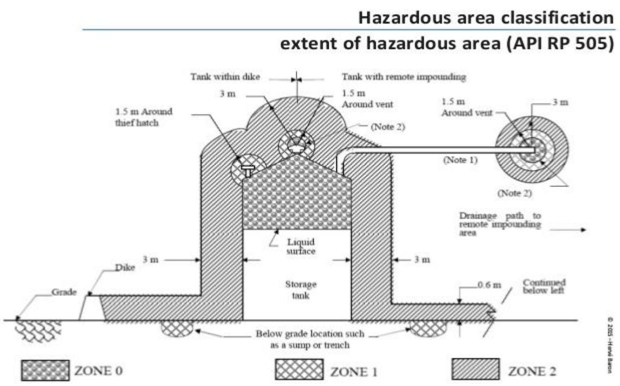

Figure 5 Hazardous Area Classification

Reference of Figure 5 Literature review - Area Classification as a tool for risk assessment.

P. Reupke and J.P. Zeeuwen, Chilworth Technology Ltd, Beta House, Chilworth

5.5. Deep Excavation – Confined Space Entry Procedure

Definition for Confined Space: Confined space is not designed for continuous occupancy. Any space meeting the below criteria will be considered as Confined spaces.

- Limited or restricted means of entry or exit.
- Lack of Ventilation and illumination.
- Possible to Toxic / flammable gas leak.
- Lack of Oxygen

If any of the above criteria applicable for the excavation, then confined space procedure to be implemented along with the Hot work/ Cold work.

Figure 6 Deep Excavation trench collapse – Confined Space Entry

Reference of Figure 6 Deep Excavation pictures from Internet.

Considering every excavation as a potential confined space can expose hidden hazards. Excavations present many of the hazards associated with confined spaces. Excavation more than 4 feet deep should be looked at a confined space, unless they have some sort of staircase or sloping in that excavation that gives them decent access for rescue.

One of the greatest hazards of confined spaces is generally present in excavations is air quality. This includes flammable or explosive gases, the presence and concentration of airborne chemical substances and oxygen enrichment or deficiency. The most common toxic concerns include carbon monoxide (CO), nitrogen dioxide and hydrogen sulphide (H2S). If there has been a fuel spill, there may be a combustible gas, and an LEL (lower explosive limit).

Control measures: Unauthorised persons should not enter in the deep excavation if it is classified as confined space. Precautions to be identified through risk assessment sessions and the recommendations needs to be captured in the PTW system. Excavation permit needs to recommend the Confined space entry permits and it implementations.

VI. CONCLUSION

Based on the above identified weakness and gaps the stored energy and safe distance to be calculated and the safe distance, Hazardous Zone identification and the Hot work safety precautions, dropped object impact to be calculated and the appropriate safety equipment, Confined Space hazards applicability for the deep excavation to identified and Confined space entry permits to be recommended, while the PTW system implementations. If this weakness from the PTW and its hazard are eliminated or implemented reduced with safety control measures ALARP as low as practicable and acceptable (ALARP) the PTW system will be the safest operation to perform the high-risk activities in the construction filed or Brown fined (Operational site).

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