RISK ASSESSMENT OF LPG STORAGE UNIT USING HAZOP AT HINDUSTAN ORGANIC CHEMICALS LIMITED

KOCHI

Final Year Project Report

Submitted by

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In partial fulfillment for the award of the degree of

MASTER OF TECHNOLOGY IN

HEALTH SAFETY ENVIRONMENTAL ENGINEERING

Under the guidance of

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2015

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(भारत सरकार का उद्यम)
HINDUSTAN ORGANIC CHEMICALS LIMITED
(A Govt. of India Enterprise)
अम्बलमुगल : Ambalamugal - - 682 302
एरणाकुलम जिला : Ernakulam Dist. केरल : Kerala भारत : India

ISO 9001-2000 BUREAU VERITAS Certification
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CERTIFICATE

Certified that ***Mr. SANJU ZACHARIAH, M.Tech (Health, Safety & Environmental Engineering)*** *student of* ***University of Petroleum & Energy Studies, Dehradun*** *has successfully completed his Project Work titled "HAZOP STUDY AND DEVELOPING PROCESS SAFETY INDICATORS AND RISK ASSESSMENT OF LPG STORAGE UNIT" in our Fire & Safety Department for a period Three months with effect from 02.02.2015.*

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Acknowledgement

I thank **Mr. Anwar Nihal Siddiue**, Head of the Department of hse department who inspired me by his discussions and showed me the right course to pursue.

I take this opportunity to extend my sincere thanks to Hindustan Organic Chemicals Limited Asia Services Ltd. for offering me a unique platform to earn exposure and garner knowledge in the field of HSE (Health, Safety and Environment) Management.

I wish to extend my sincere and heartfelt gratitude to my guide MR. Sandeep CS HSE Specialist, Hindustan Organic Chemicals Limited Asia Services Ltd., who guided, supported and encouraged me during the entire tenure of the project. I would also like to thank Mr. Shaji Jacob (HSE Manager), Mr. Vijaykumar (Facility manager,), Mr sanalkumar Training Specialist), Ms Sindhu (HSE & Environmental Specialist), for their co-operation and valuable advice throughout the course of my project. I am able to say with conviction that I have immensely benefited from the prestigious association with Hindustan organic chemicals

I also wish to thank Mr Dharani Kumar my faculty guide from hse department upes. who extended with constant support and help that helped in accomplishing the objectives of the project. There are many who I may have left out in the acknowledgement, but whose co-operation no doubt went a long way in the project completion..

ABSTRACT

Hindustan Organic Chemicals Limited is one of the best petro chemical company . It has principle offices in Mumbai. Hindustan Organic Chemicals Limited deals with production of acetone and hydrogen peroxide from lpg.. All new projects embody some element of change but in the chemical industry. Propylene Recovery. one plant to the next is often considerable. It-is important to recognize that the body of established experience expressed in codes, etc is limited by the extent of existing knowledge and can only be relevant to the extent to which it is possible to apply it to new products, new plants and new methods of operation involved in the new design. It has become increasingly clear in recent years that although codes of practice are extremely valuable, it is particularly important to supplement them with an imaginative anticipation of hazards when new projects involve new technology. Risk assessment tool provides a detailed description, and user guidance for the environmental management tools established by the Safety Standard. Studying and understanding these standards and guidelines and thereby preparing hazop study plan and Worksheet(hazop) register was the major deliverable of the project. This study is intended to carry out HAZOP study of Propylene Recovery Unit in accordance with BS: 61882 & EPSC-HAZOP. The purpose of this report is to identify deviations from the design intent, identify potential hazards and operability problems associated with the deviations; and to recommend ways to mitigate the identified problems or to identify areas that need to be further investigated.

Keyword: *HAZOP, LPG Tank Risk Assessment, Process*

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List of Abbreviations

ALARP	As Low As Reasonably Practicable
HAZID	Hazard Identification
HARC	Hazard Analysis And Risk Control
HAZOP	Hazard and operability study
LPG	Liquefied Petroleum gas
PRU	Propylene recovery unit
HOCL	Hindustan Organic Chemicals Limited

CHAPTER 1
Introduction

1.1General

The technique originated in the Heavy Organic Chemicals Division of ICI, which was then a major British and international chemical company. The history has been described by Trevor Kletz who was the company's safety advisor from 1968 to 1982, from which the following is abstracted. In 1963 a team of 3 people met for 3 days a week for 4 months to study the design of a new phenol plant. They started with a technique called critical examination which asked for alternatives, but changed this to look for deviations. The method was further refined within the company, under the name operability studies, and became the third stage of its hazard analysis procedure (the first two being done at the conceptual and specification stages) when the first detailed design was produced. In 1974 a one-week safety course including this procedure was offered by the Institution of Chemical Engineers (IChemE) at Teesside Polytechnic. Coming shortly after the Flixborough disaster, the course was fully booked, as were ones in the next few years. In the same year the first paper in the open literature was also published. In 1977 the Chemical Industries Association published a guide. Up to this time the term HAZOP had not been used in formal publications. The first to do this was Kletz in 1983, with what were essentially the course notes (revised and updated) from the IChemE courses. By this time, hazard and operability studies had become an expected part of chemical engineering degree courses in the UK. Hazard and Operability Analysis (HAZOP) is a structured and systematic technique for system examination and risk management. In particular, HAZOP is often used as a technique for identifying potential hazards in a system and identifying operability problems likely to lead to nonconforming products. HAZOP is based on a theory that assumes risk events are caused by deviations from design or operating intentions. Identification of such deviations is facilitated by using sets of “guide words” as a systematic list of deviation perspectives. This approach is a unique feature of the HAZOP methodology that helps stimulate the imagination of team members when exploring potential deviations. As a risk assessment tool, HAZOP is often described as:

A brainstorming technique

A qualitative risk assessment tool

An inductive risk assessment tool,

1.1About the Company:

Hindustan Organic Chemicals Limited (HOCL) is Government of India owned company based in mumbai maharashtra It was established in 1960 to indigenise manufacture of basic chemicals and to reduce country's dependence on import of vital organic chemicals. Its products are Phenol, Acetone, Nitrobenzene, Aniline, Nitrotoluenes, Chlorobenzenes & Nitrochlorobenzenes. Basic Organic Chemicals includes Pesticides, Drugs & Pharmaceuticals, Dyes & Dyestuffs, Plastics, Resins & Laminates, Rubber Chemicals, Paints, Textile Auxiliaries & Explosives

1.2 Aim

The aim of the project is to conduct a rigorous risk assessment study using Hazard And Operability Study Technique of the LPG storage unit of Hindustan Organic Chemicals Limited

1.3 Objectives

- To analyse operating phase of the plant and its associated hazard identification
- To understand various hazards associated with the storage unit
- To identify various safeguards that has to be placed to aviod hazard
- To understand various hazards associated with the storage unit in normal operating and extreme operation conditions
- To document and record various results identified

1.4 Scope

The scope of the study is within the boundary of the lpg storage unit where various components like pumps tanks and associated valves of the systems are taken for the purpose of the study at Hindustan Organic Chemicals Limited

CHAPTER 2

LITERATURE SURVEY

2.1. GENERAL

The chemical industry is critical for the economic development of any country, providing products and enabling technical solutions in virtually all sectors of the economy. But the working conditions in the chemical industries around the world increasingly demand special attention and effort from the international trade union movement. Every year, some two million men and women lose their lives through accidents and diseases linked to their work. In addition, workers suffer 270 million occupational accidents and 160 million occupational diseases each year.The failure of many governments to enforce health and safety standards means that efforts to improve working conditions in one country can be undermined by the flight of production to countries where workplace safety is ignored. Ignoring occupational health and safety is one way by which international market operators can minimize costs, engaging in a form of "social dumping" at the real costs of workers' lives

Hazard and operability (HAZOP) analysis. (2014)

Jordi Dunjó, Vasilis Fthenakis, Juan A. Vílchez, Josep Arnaldos

Hazard and operability (HAZOP) methodology is a Process Hazard Analysis (PHA) technique used worldwide for studying not only the hazards of a system, but also its operability problems, by exploring the effects of any deviations from design conditions. Our paper is the first HAZOP review intended to gather HAZOP-related literature from books, guidelines, standards, major journals, and conference proceedings, with the purpose of classifying the research conducted over the years and define the HAZOP state-of-the-art.

Development of a Hazard and Operability-based method for identifying safety management vulnerabilities in high risk systems (2015)

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In recent years there has been widespread acknowledgement of the significance of managerial and organisational failures in the causation of accidents. The activities and processes involved in managing safety have come under increasing scrutiny via the development of approaches for safety management and safety culture assessment. This paper argues, however, that current approaches do not fully or explicitly address how safety management systems will actually fail in practice. Therefore, the Safety Culture Hazard and Operability (SCHAZOP) approach is described as a means by which specific safety management vulnerabilities, and targeted resolution of such vulnerabilities can be identified. The development of the method, examples of its application, and the way forward with this methodology are discussed.

Computer Aided HAZOP Analysis Based on SDG

LI An-feng, XIA Tao, ZHANG Bei-ke, ZHANG Zhao-qian, WU Chong-guang (College of Information Science and Technology, Beijing University of Chemical Technology, Beijing 100029, China) (2011)

Hazard and Operability (HAZOP) analysis is widely used and recognized as the preferred safety analysis approach in the process systems. However, the manual HAZOP analysis is time consuming, strenuous and costly. A computer aided HAZOP analysis system based on SDG is introduced. SDG qualitative model is used in this system. As process model is built by unit models in the model base, the system is very adaptive. Besides, it can handle the huge amount of specific process information. Compared with the manual HAZOP analysis, the system has many advantages, such as good maturity, time saving, effort saving, money saving, systematic result, and so on

HAZard and OPerability (HAZOP) analysis for identification of information requirements for sewer asset management (2009)

Nikola Stanić, Jeroen G. Langeveld & François H.L.R. Clemens

Asset management is a prerequisite for maintaining the required level of serviceability of urban drainage systems. The required asset management effort to achieve a certain level of service is unclear due to limited knowledge on sewer systems process and structure complexity. Sewer failure mechanisms explain the structural/operational failures of sewer elements. This paper describes a method for assessing sewer failure mechanisms as a first step to identify information needed for sewer asset management. In order to be able to identify the main processes and defects responsible for the structural/operational failures of sewer elements, as well as the possibility of obtaining the information about them, a HAZard and OPerability (HAZOP) approach was applied. HAZOP results were, due to the nature of the analysis, rearranged in such a way that they can be applied in Failure-Tree Analysis (FTA) for the purpose of further risk estimation

Social HAZOP at an Oil Refinery (2009)

S.F. ÁvilaF.L.P. Pessoa and J.C.S. Andrade

Several tools are used in the maintenance of process safety at industry [e.g., Preliminary Risk Analysis (PRA) and Hazards Operation Assessment (HAZOP)]. Each tool or technique can prevent that hazards becoming accidents through project improvements and managerial decisions. The project of equipment and process of chemical industries include technical specifications that work better if human behavior in operation has a pattern without great variations. The HAZOP study indicates top human errors in the control process activities, only identifies common human error of slip (it does not discuss), memory mistake, rules and, consequently, the wrong decision. The Social HAZOP (SH) discusses cognitive processing and the commitment level of the operator in task execution. The SH includes these activities: building of team to investigate human error, identification of critical situations at process with integration with social/human aspects, establish social nodes, analysis of social/human factors, choose items after comparison of standards and subjective measurements, analysis of deviations from social and human processes, recommendations of the SH. An exercise of SH application was done involving level control at separation equipment in a refinery. The recommendations suggest actions in different levels (strategic, tactic, routine, and

CHAPTER 3
METHODOLGY

3.1 Project Methodology / Approach

- Understand **Hazop standards and risk analysis tools and guidelines in HOCL**

- Frame a team and assign responsibilities of Hazop study

- General study and baseline work

- Attending monthly Safety meetings & Gap Analysis on various elements LPG storage unit

- Developing a well written study plan and get piping and instrumentation diagram

- Divide the system into nodes such that main components are taken for hazop study

- Take a discussion with the hazop team

- Document the details into a hazop worksheet

The management of the environmental aspects and impacts of Hindustan Organic Chemicals Limited's activities, products and services is achieved through the implementation of an Environmental Management System (EMS). The EMS is part of Hindustan Organic Chemicals Limited's Health, Safety and Environmental (HSE) system, which in turn is part of Hindustan Organic Chemicals Limited's business management system

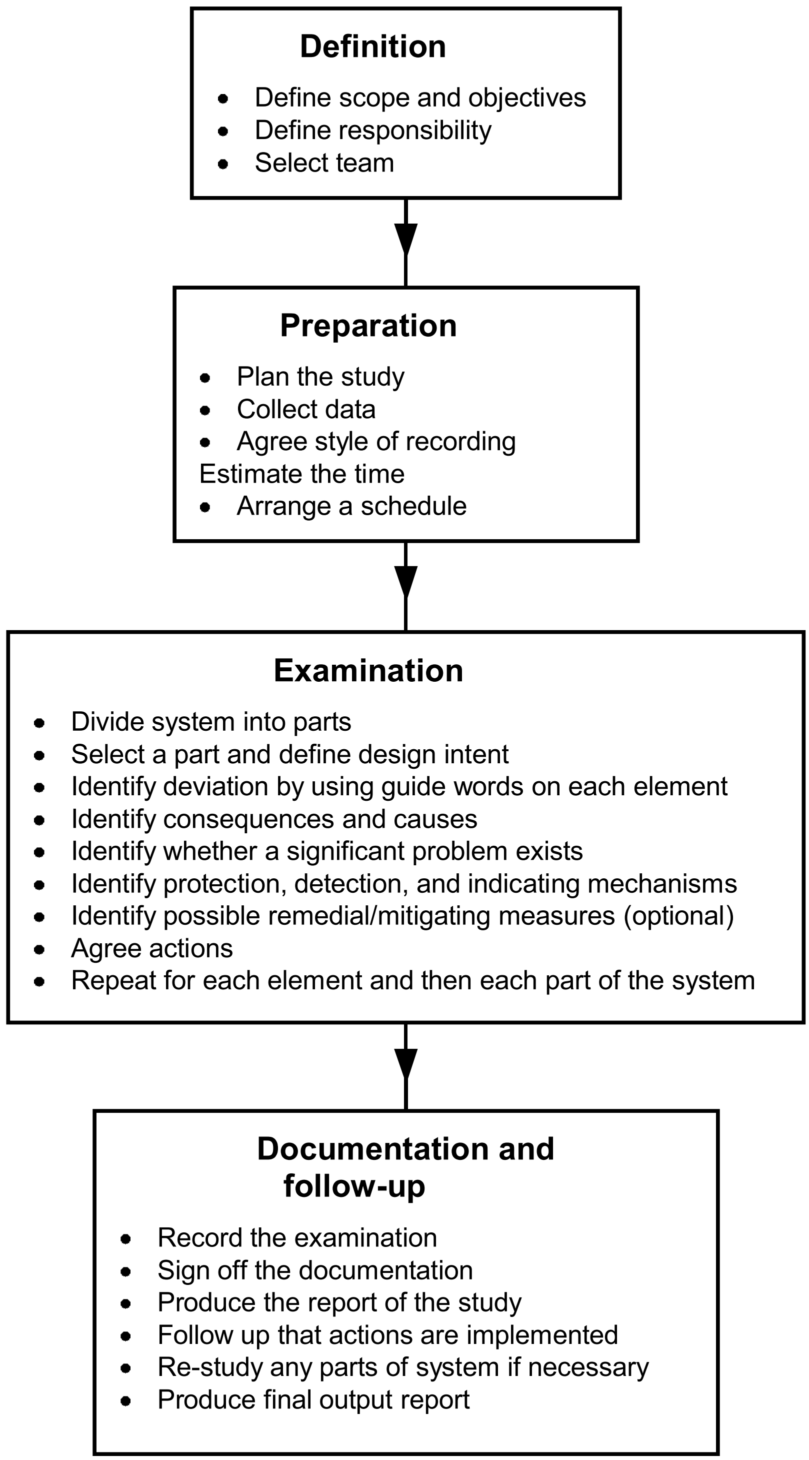

Figure 1 – The HAZOP study procedure

3.6.1 Principles of examination

The basis of HAZOP is a “guide word examination” which is a deliberate search for deviations from the design intent. To facilitate the examination, a system is divided into parts in such a way that the design intent for each part can be adequately defined. The size of the part chosen is likely to depend on the complexity of the system and the severity of the hazard. In complex systems or those which present a high hazard the parts are likely to be small. In simple systems or those which present low hazards, the use of larger parts will expedite the study. The design intent for a given part of a system is expressed in terms of elements which convey the essential features of the part and which represent natural divisions of the part. The selection of elements to be examined is to some extent a subjective decision in that there may be several combinations which will achieve the required purpose and the choice may also depend upon the particular application. Elements may be discrete steps or stages in a procedure, individual signals and equipment items in a control system, equipment or components in a process or electronic system, etc.

In some cases it may be helpful to express the function of a part in terms of:

- the input material taken from a source;
- an activity which is performed on that material;
- a product which is taken to a destination.

Thus the design intent will contain the following elements: materials, activities, sources and destinations which can be viewed as elements of the part.

Elements can often be usefully defined further in terms of characteristics which can be either quantitative or qualitative. For example, in a chemical system, the element “material” may be defined further in terms of characteristics such as temperature, pressure and composition. For the activity “transport”, characteristics such as the rate of movement or the number of passengers may be relevant. For computer-based systems, information rather than material is likely to be the subject of each part.

The HAZOP team examines each element (and characteristic, where relevant) for deviation from the design intent which can lead to undesirable consequences. The identification of deviations from the design intent is achieved by a questioning process using predetermined “guide words”. The role of the guide word is to stimulate imaginative thinking, to focus the study and elicit ideas and discussion, thereby maximizing the chances of study completeness. Basic guide words and their meanings are given in Table 1.

Table 1 – Basic guide words and their generic meanings

Guide word	Meaning
NO OR NOT	Complete negation of the design intent
MORE	Quantitative increase
LESS	Quantitative decrease
AS WELL AS	Qualitative modification/increase
PART OF	Qualitative modification/decrease
REVERSE	Logical opposite of the design intent
OTHER THAN	Complete substitution

Additional guide words relating to clock time and order or sequence are given in Table 2.

Table 2 – Guide words relating to clock time and order or sequence

Guide word	Meaning
EARLY	Relative to the clock time
LATE	Relative to the clock time
BEFORE	Relating to order or sequence
AFTER	Relating to order or sequence

There are a number of interpretations of the above guide words. Additional guide words may be used to facilitate identification of deviation. Such guide words may be used provided they are identified before the examination commences. Having selected a part for examination, the design intent of that part is broken into separate elements. Each relevant guide word is then applied to each element, thus a thorough search for deviations is carried out in a systematic manner. Having applied a guide word, possible causes and consequences of a given deviation are examined and mechanisms for detection or indication of failures may also be investigated. The results of the examination are recorded to an agreed format (see 6.6.2).

Guide word/element associations may be regarded as a matrix, with the guide words defining the rows and the elements defining the columns. Within each cell of the matrix thus formed will be a specific guide word/element combination. To achieve a comprehensive hazard identification, it is necessary that the elements and their associated characteristics cover all relevant aspects of the design intent and guide words cover all deviations. Not all combinations will give credible deviations, so the matrix may have several empty spaces when all guide word/element combinations are considered.

There are two possible sequences in which the cells of the matrix can be examined, namely column by column, i.e. *element first*, or row by row, i.e. *guide word first*. The details of examination are outlined in 6.5 and both sequences of examination are illustrated in Figures 2a and 2b. In principle the results of the examination should be the same.

3.6.2Design representation

3.6.3 General

An accurate and complete design representation of the system under study is a prerequisite to the examination task. A design representation is a descriptive model of the system adequately describing the system under study, its parts and elements, and identifying their characteristics. The representation may be of the physical design or of the logical design and it should be made clear what is represented.

The design representation should convey the system function of each part and element in a qualitative or quantitative manner. It should also describe the interactions of the system with other systems, with its operator/user and possibly with the environment. The conformance of elements or characteristics to their design intent determines the correctness of operations and in some cases the safety of the system.

The representation of the system consists of two basic parts:

- the system requirements;
- a physical and/or logical description of the design.

The resulting value of a HAZOP study depends on the completeness, adequacy and accuracy of the design representation including the design intent. Care should be taken, therefore, in preparation of the information package. If HAZOP is being conducted in the operational or disposal phase, care should be taken to ensure that any modifications are reflected in the design representation. Before starting the examination, the team should review this information package, and if necessary have it revised.

3.6.4 Design requirements and design intent

The design requirements consist of qualitative and quantitative requirements which the system has to satisfy, and provide the basis for development of system design and design intent. All reasonable use and misuse conditions which are expected by the user should be identified. Both the design requirements and resulting design intent have to meet customer expectations.

On the basis of system requirements a designer develops the system design, i.e. a system configuration is arrived at, and specific functions are assigned to subsystems and components. Components are specified and selected. The designer should not only consider what the equipment should do, but also ensure that it will not fail under any unusual set of conditions, or that it will not wear out during the specified lifetime. Undesirable behaviour or features should also be identified so they can be designed out, or their effects minimized by appropriate design. The above information provides the basis for identifying the design intent for the parts to be examined.

The “design intent “ forms a baseline for the examination and should be correct and complete, as far as possible. The verification of design intent (see IEC 61160), is outside of the scope of the HAZOP study, but the study leader should ascertain that it is correct and complete to allow the study to proceed. In general most documented design intents are limited to basic system functions and parameters under normal operating conditions. However provisions for abnormal operating conditions and undesirable activities which may occur (e.g. severe vibrations, water hammer in pipes, voltage surges which may lead to failure) are rarely mentioned, but should be identified and considered during the examination. Also deterioration mechanisms such as ageing, corrosion and erosion and other mechanisms which cause deterioration in material properties are not specifically stated. However they have to be identified and considered in a study using appropriate guide words.

Expected life, reliability, maintainability and maintenance support should also be identified and considered together with hazards which may be encountered during maintenance activities, provided they are included in the scope of the HAZOP study.

Applications of HAZOP

3.6.5 General

Originally HAZOP was a technique developed for systems involving the treatment of a fluid medium or other material flow in the process industries. However its area of application has steadily widened in recent years and for example includes usage for:

- software applications including programmable electronic systems;

- systems involving the movement of people by transport modes such as road and rail;
- examining different operating sequences and procedures;
- assessing administrative procedures in different industries;
- assessing specific systems, e.g. medical devices.

HAZOP is particularly useful for identifying weaknesses in systems (existing or proposed) involving the flow of materials, people or data, or a number of events or activities in a planned sequence or the procedures controlling such a sequence. As well as being a valuable tool in the design and development of new systems, HAZOP may also be profitably employed to examine hazards and potential problems associated with different operating states of a given system, e.g. start-up, standby, normal operation, normal shutdown, emergency shutdown. It can also be employed for batch and unsteady-state processes and sequences as well as for continuous ones. HAZOP may be viewed as an integral part of the overall process of value engineering and risk management.

3.6.6 Relation to other analysis tools

HAZOP may be used in conjunction with other dependability analysis methods such as Failure mode and effects analysis (see IEC 60812) and Fault tree analysis (see IEC 61025). Such combinations may be utilized in situations when:

- the HAZOP analysis clearly indicates that the performance of a particular item of equipment is critical and needs to be examined in considerable depth; the HAZOP may then be usefully complemented by an FMEA of that item of equipment;
- having examined single element/single characteristic deviations by HAZOP, it is decided to assess the effect of multiple deviations using FTA, or to quantify the likelihood of the failures, again using FTA.

HAZOP is essentially a system-centred approach, as opposed to FMEA which is component-centred. FMEA starts with a possible component failure and then proceeds to investigate the consequences of this failure on the system as a whole. Thus the investigation is unidirectional, from cause to consequence. This is different in concept from a HAZOP study which is concerned with identifying possible deviations from the design intent and then proceeds in two directions, one to find the potential causes of the deviation and the other to deduce its consequences.

3.6.7 HAZOP limitations

Whilst HAZOP studies have proved to be extremely useful in a variety of different industries, the technique has limitations that should be taken into account when considering a potential application.

- HAZOP is a hazard identification technique which considers system parts individually and methodically examines the effects of deviations on each part. Sometimes a serious hazard will involve the interaction between a number of parts of the system. In these cases the hazard may need to be studied in more detail using techniques such as event tree and fault tree analyses.
- As with any technique for the identification of hazards or operability problems, there can be no guarantee that all hazards or operability problems will be identified in a HAZOP study. The study of a complex system should not, therefore, depend entirely upon HAZOP. It should be used in conjunction with other suitable techniques. It is essential that other relevant studies are co-ordinated within an effective overall safety management system.

- Many systems are highly inter-linked, and a deviation at one of them may have a cause elsewhere. Adequate local mitigating action may not address the real cause and still result in a subsequent accident. Many accidents have occurred because small local modifications had unforeseen knock-on effects elsewhere. Whilst this problem can be overcome by carrying forward the implications of deviations from one part to another, in practice this is frequently not done.
- The success of a HAZOP study depends greatly on the ability and experience of the study leader and the knowledge, experience and interaction between team members.
- HAZOP only considers parts that appear on the design representation. Activities and operations which do not appear on the representation are not considered.

3.6.8 Hazard identification studies during different system life cycle phases

HAZOP studies are one of the structured hazard analysis tools most suitable in the later stages of detailed design for examining operating facilities, and when changes to existing facilities are made. Application of HAZOP and other methods of analysis during the various lifecycle phases of a system is described in more detail below.

3.7.1 Concept and definition phase

In this phase of a system's life cycle, the design concept and major system parts are decided but the detailed design and documentation required to conduct the HAZOP do not exist. However, it is necessary to identify major hazards at this time, to allow them to be considered in the design process and to facilitate future HAZOP studies. To carry out these studies, other basic methods should be used. (For descriptions of these methods, see IEC 60300-3-9.)

3.7.2 Design and development phase

During this phase of a life cycle, detailed design is developed, methods of operation are decided upon and documentation is prepared. The design reaches maturity and is frozen. The best time to carry out a HAZOP study is just before the design is frozen. At this stage the design is sufficiently detailed to allow the questioning mechanism of a HAZOP to obtain meaningful answers. It is important to have a system that will assess the implications of any changes made after the HAZOP has been carried out. This system should be maintained throughout the life of the system.

3.7.3 Manufacturing and installation phase

It is advisable to carry out a study before the system is started up, if commissioning and operation of the system can be hazardous and proper operating sequences and instructions are critical, or when there has been a substantial change of intent in a late stage. Additional data such as commissioning and operating instructions should be available at this time. In addition, the study should also review all actions raised during earlier studies to ensure that these have been resolved.

3.7.4 Operation and maintenance phase

The application of HAZOP should be considered before implementing any changes that could effect the safety or operability of a system or have environmental effects. A procedure should also be put in place for periodic reviews of a system to counteract the effects of "creeping change". It is important that the design documentation and operating instructions used in a study are up to date.

3.7.5 Decommissioning or disposal phase

A study of this phase may be required, due to hazards that may not be present during normal operation. If records from previous studies exist, this study can be carried out expeditiously. Records should be kept throughout the life of the system in order to ensure that the decommissioning issues can be dealt with expeditiously.

3.8 The HAZOP study procedure

3.8.1 Initiation of the study

The study is generally initiated by a person with responsibility for the project, who in this guide is called “project manager”. The project manager should determine when a study is required, appoint a study leader and provide the necessary resources to carry it out. The need for such a study will often have been identified during normal project planning, due to legal requirements or company policy. With the assistance of the study leader, the project manager should define the scope and objectives of the study. Prior to the start of a study, someone with an appropriate level of authority should be assigned responsibility for ensuring that actions/recommendations from the study are implemented.

3.8.2 Definition of scope and objectives of the study

The objectives and scope of a study are inter-dependent, and should be developed together. Both should be clearly stated, to ensure that:

- the system boundaries, and its interfaces with other systems and the environment are clearly defined;
- the study team is focused, and does not stray into areas irrelevant to the objective.

3.8.3 Scope of the study

The scope of the study is within the boundarty of lpg storage unit,and the analyse any previous standards are applicable for the purpose od the study variou components like pumps and tanks are analysed form the design documents to ensure normal operating condition of the lpg stoage unit at HOCL KOCHI

6.2.2 Objectives of the study

In general, HAZOP studies seek to identify all hazards and operating problems regardless of type or consequences. Focusing a HAZOP study strictly on identifying hazards will enable the study to be completed in shorter time and with less effort.

The major Objectives of the Hazop study of LPG storage unit at HOCL are,

*To understand various hazrads associated with the storage unit in normal operating conditions and extreme operation condition

*The operating phase of the plant and its associated hazard identification

*To identify various safeguards that has to be placed to aviod hazard

*To understand various personnel involved in various extreme conditions

* To document and record various results identified

operability problems, including effects on product quality;

- the standards required of the system, both in terms of safety and operational performance.

3.8.4 Roles and responsibilities

The role and responsibilities of a HAZOP team should be clearly defined by the project manager and agreed with the HAZOP study leader at the outset of the study. The study leader should review the design to determine what information is available and what skills are required from the study team members. A programme of activities should be developed, which reflects the milestones of the project, to enable any recommendations to be carried out in a timely fashion.

It is the study leader's responsibility to ensure that an appropriate communication system is set up and is used for transferring the result of the HAZOP study. It is the responsibility of the project manager to ensure that the results of the study are followed up and decisions regarding implementation made by the design team are properly documented.

The project manager and the study leader should agree whether the HAZOP team activity is to be confined to identification of hazards and problem areas (which are then referred back to the project manager and design team for resolution) or whether they are also to suggest possible remedial/mitigating measures. In the latter case there also needs to be agreement as to the responsibility and mechanism for selecting preferred remedial/mitigating measures and securing appropriate authorization for action to be taken.

A HAZOP study is a team effort, with each team member being chosen for a defined role. The team should be as small as possible consistent with the relevant technical and operating skills and experience being available. This will generally involve at least four persons and rarely more than seven. The larger the team, the slower the process. Where a system has been designed by a contractor, the HAZOP team should contain personnel from both the contractor and the client.

Recommended roles for team members are as follows:

- Study leader: not closely associated with the design team and the project. Trained and experienced in leading HAZOP studies. Responsible for communications between project management and the HAZOP team. Plans the study. Agrees study team composition. Ensures the study team is supplied with a design representation package. Suggests guide words and guide word – element/characteristic interpretations to be used in the study. Conducts the study. Ensures documentation of the results.
- Recorder: documents proceedings of the meetings. Documents the hazards and problem areas identified, recommendations made and any actions for follow-up. Assists the study leader in planning and administrative duties. In some cases, the study leader may carry out this role.
- Designer: explains the design and its representation. Explains how a defined deviation can occur and the corresponding system response.
- User: explains the operational context within which the element under study will operate, the operational consequences of a deviation and the extent to which deviations may be hazardous.
- Specialists: provide expertise relevant to the system and the study. May be called upon for limited participation with the role revolving amongst different individuals.
- Maintainer: maintenance staff representative (when required).

The viewpoint of the designer and user are always required for the study. However depending on the particular phase of the life cycle in which the study is carried out, the type of specialists most appropriate to the study may vary.

3.8.5 Preparatory work

3.8.6 General

The study leader is responsible for the following preparatory work:

a) obtaining the information;

b) converting the information into a suitable format;

c) planning the sequence of the meetings;

d) arranging the necessary meetings.

In addition, the study leader may arrange for a search to be made of databases, etc. to identify incidents which have occurred with the same or similar technologies.

The study leader is responsible for ensuring that an adequate design representation is available. If the design representation is flawed or incomplete, it should be corrected before the study begins. In the planning stage of a study, the parts, elements and their characteristics should be identified on the design representation by a person familiar with the design.

The study leader is responsible for the preparation of a study plan that should contain the following:

- objective and scope of the study;
- a list of participating members;
- technical details:
  - a design representation divided into parts and elements with defined design intent and for each element a list of components, materials and activities and their characteristics;
  - a list of proposed guide words to be used, and the interpretation of guide word – element/characteristic combinations
- a list of appropriate references;
- administrative arrangements, schedule of meetings, including their dates and times and locations;
- form of recording required
- templates that may be used in the study.

Adequate room facilities and visual and recording aids should be provided to facilitate efficient conduct of the meetings.

The briefing package consisting of the study plan and necessary references should be sent to the study team members in advance of the first meeting to allow them to familiarize themselves with its content. A physical review of the system is desirable.

The success of the HAZOP study strongly depends on the alertness and concentration of the team members and it is therefore important that the sessions are of limited duration and that there are appropriate intervals between sessions. How these requirements are achieved is ultimately the responsibility of the study leader.

3.9Design Description

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The area selected fo the HAZOP study is the LPG storage area of the hindustan organic chemicals limited.Where the boundaries are marked with the presence of the proplyene recovery unit

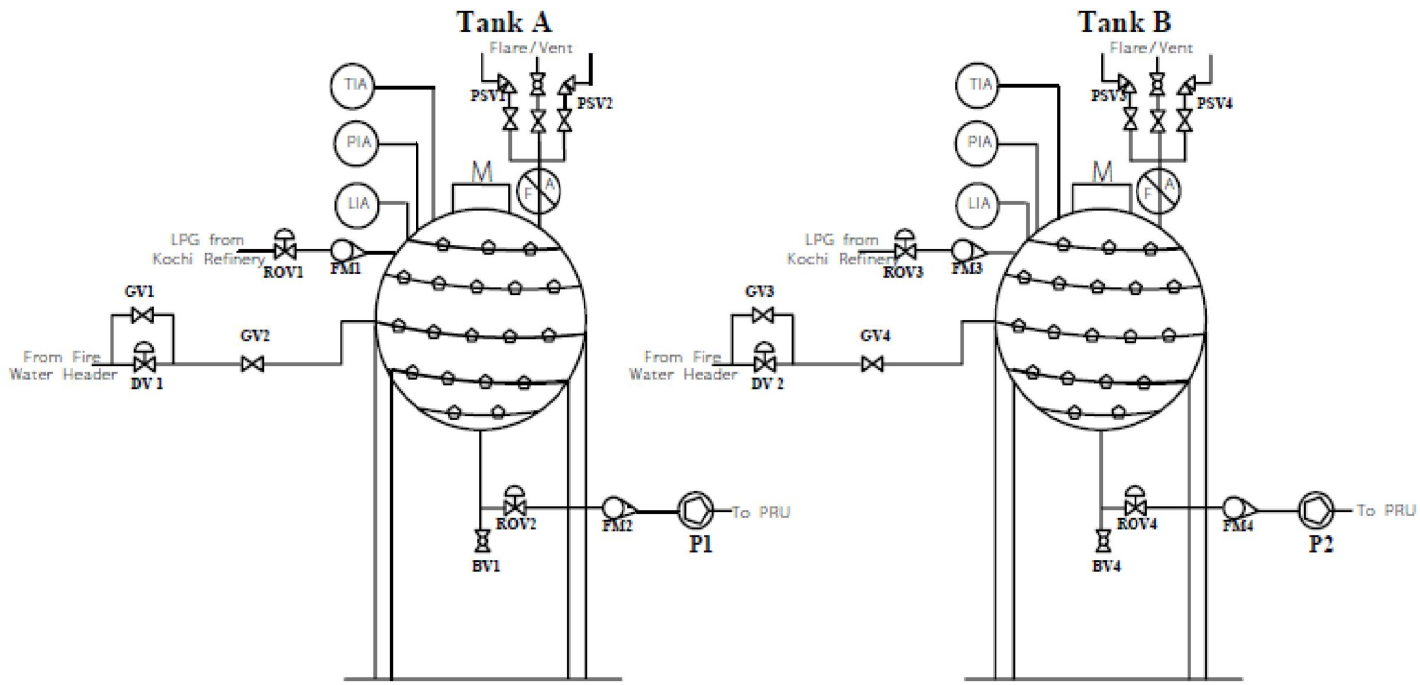
The design of the storage section is in such a way that it has four storage tanks with two being identical and the other two being of smaller size, capacity of the tanks are 70000ltrs and 50000ltrs .And the similar tanks are inter connected the top and bottom , this is to ensure same filling and same removal of the material from both the tank

The tanks are kept in such a way that there are ample spacing between all the four tank helping enough man movement between them for inspection of any leakages or other related impact due to the storage of LPG.It is also provided with various safety devices which will be explained in the later sections .

The plant recieves lpg from Bharat Petroleum corporation which is situated with 1 kilometre distance where lpg is being pumped from the source that is BPCL and the lpg is transported to the storage section with the help of piplines that runs from Bharat Petroleum corporation till the recieving tank of the lpg storage unit in hindustan organic chemicals limited,The setup is in such a way that the lpg is pumped from BPCL and it runs through the pipline system and reaches the recieving tank where the lpg get stored in this tank .

The stored lpg will be send to the propylene recovery unit to extract the propylene present in the lpg for the production of acetone and hydrogen peroxide ,And the extracted lpg will be sent back to BPCL where the lpg which has to be sent back will be stored in the storage tank of lesser size (50000ltrs).From this tanks the lpg will be sent to BPCL through another set of pipline which orginates from the tank that stores extacted lpg which runs till BPCL.

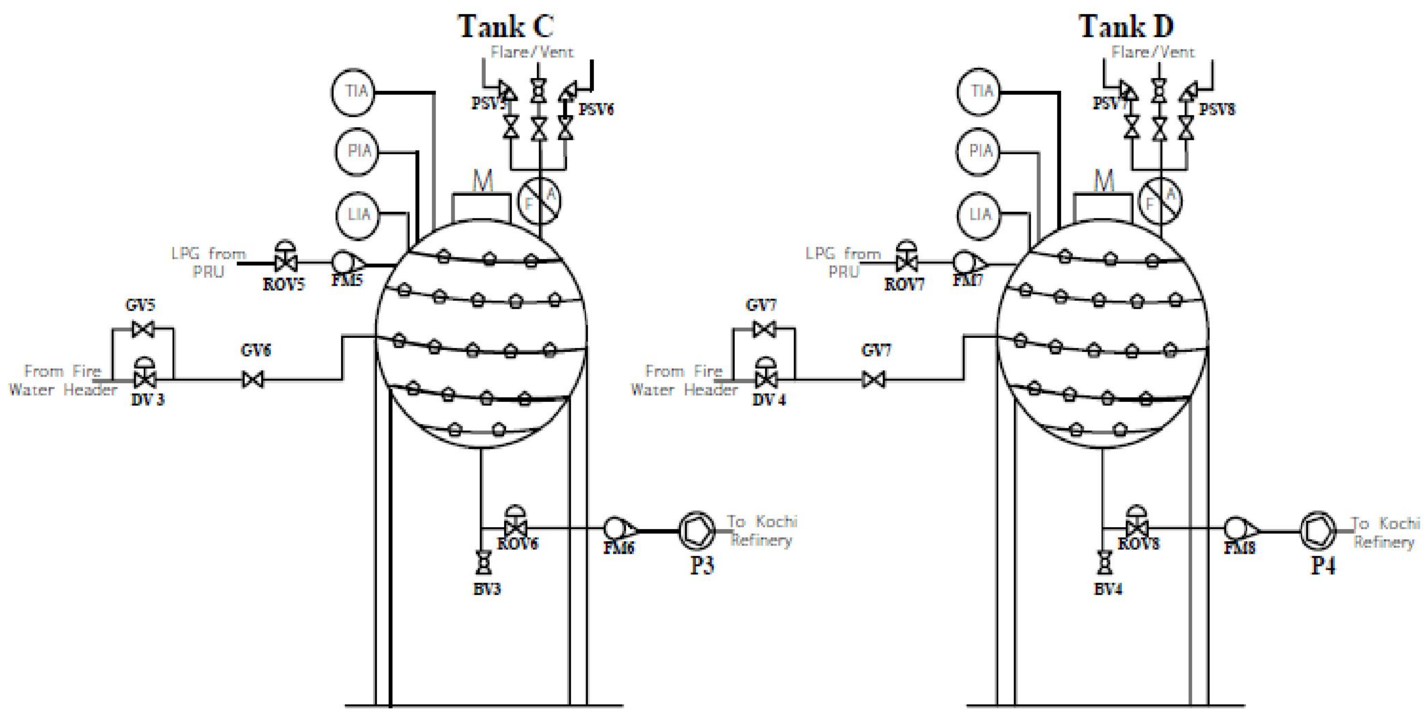
P&ID of Storage Tank for recieving of LPG from Kochi Refinery



P&ID of Storage Tank for recieving of LPG from Kochi Refinery

Company	HOCL		
Date	12.02.2015		Rev:1
Checked By:			

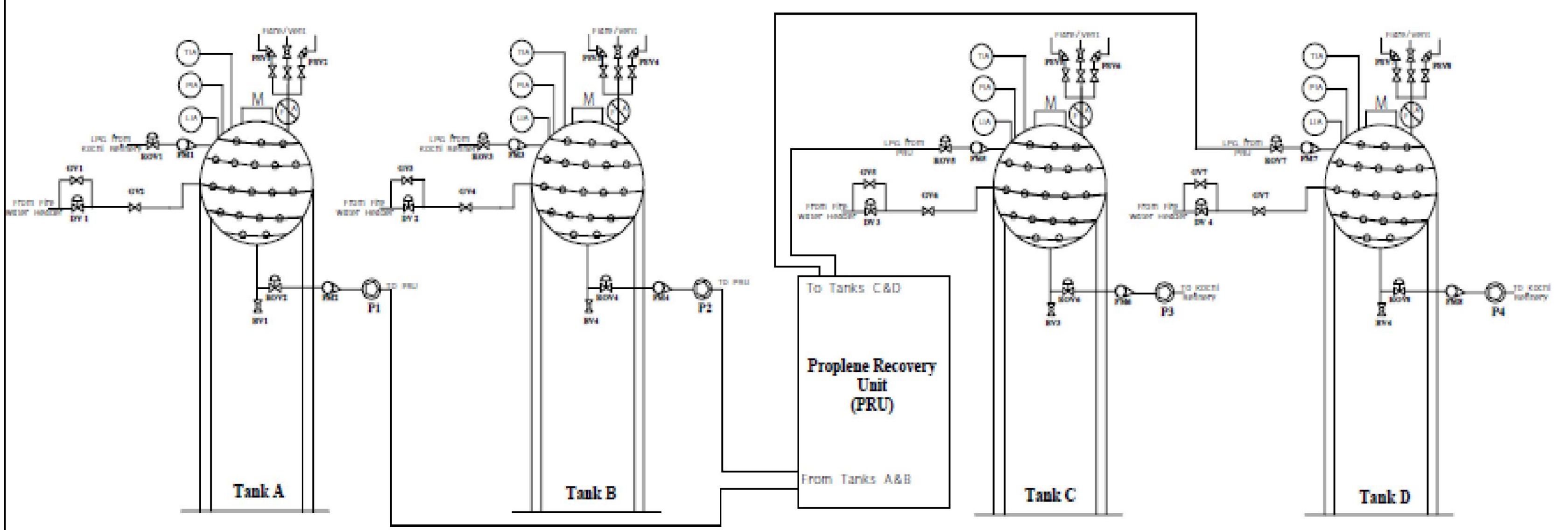
P&ID of Storage Tank for delivery of LPG to Kochi Refinery



P&ID of Storage Tank for delivery of LPG to Kochi Refinery

Company	HOCL	
Date	14.02.2015	Rev:1
Checked By:		

P&ID of Storage Tanks



P&ID for Storage Tank

Company	HOCL	
Date	14.02.2015	Rev:1
Checked By:		

Guide Word ,Deviation and worksheet

Table for common guide word and deviation

Deviation type	Guide word	Example interpretation for process industry	Example interpretation for a Programmable Electronic System, PES
Negative	NO	No part of the intention is achieved, e.g. no flow	No data or control signal passed
Quantitative modification	MORE	A quantitative increase, e.g. higher temperature	Data is passed at a higher rate than intended
	LESS	A quantitative decrease e.g. lower temperature	Data is passed at a lower rate than intended
Qualitative modification	AS WELL AS	Impurities present Simultaneous execution of another operation/step	Some additional or spurious signal is present
	PART OF	Only some of the intention is achieved, i.e. only part of an intended fluid transfer takes place	The data or control signals are incomplete
Substitution	REVERSE	Covers reverse flow in pipes and reverse chemical reactions	Normally not relevant
	OTHER THAN	A result other than the original intention is achieved, i.e. transfer of wrong material	The data or control signals are incorrect
Time	EARLY	Something happens early relative to clock time, e.g. cooling or filtration	The signals arrive too early with reference to clock time
	LATE	Something happens late relative to clock time, e.g. cooling or filtration	The signals arrive too late with reference to clock time
Order or sequence	BEFORE	Something happens too early in a sequence, e.g. mixing or heating	The signals arrive earlier than intended within a sequence
	AFTER	Something happens too late in a sequence, e.g. mixing or heating	The signals arrive later than intended within a sequence

Guide word – element/characteristic combinations may be interpreted differently in studies of different systems, at different phases of the system life cycle, and when applied to different design representations. Some of the combinations may not have meaningful interpretations for a given study and should be disregarded. The interpretation of all guide word – element/characteristic combinations should be defined and documented. If a given combination has more than one sensible interpretation in the context of the design, all interpretations should be listed. On the other hand, it may also be found that the same interpretation is derived from different combinations. When this occurs, appropriate cross references should be made.

3.9.1 The examination

The examination sessions should be structured, with the study leader leading the discussion following the study plan. At the start of a HAZOP study meeting the study leader or a team member who is familiar with the process to be examined and its problems should

- outline the study plan, to ensure that the members are familiar with the system and objectives and scope of the study;

- outline the design representation and explain the proposed elements and guide words to be used;
- review the known hazards and operational problems and potential areas of concern.

The analysis should follow the flow or sequence related to the subject of the analysis, tracing inputs to outputs in a logical sequence. Hazard identification techniques such as HAZOP derive their power from a disciplined step by step examination process. There are two possible sequences of examination: “Element first” and “Guide word first”, as shown in Figures 2a and 2b respectively. The element first sequence is described below.

a) The study leader starts by selecting a part of the design representation as a starting point and marking it. The design intent of the part is then explained and the relevant elements and any characteristics associated with these elements identified.

b) The study leader chooses one of the elements and agrees with the team whether the guide word should be applied directly to the element itself or to individual characteristics of that element. The study leader identifies which guide word is to be applied first.

c) The first applicable guide word interpretation is examined in the context of the element or characteristic being studied in order to see if there is a credible deviation from the design intent. If a credible deviation is identified, it is examined for possible causes and consequences. In some applications it is found useful to categorize the deviations either in terms of the potential severity of the consequences or in terms of a relative risk ranking based on the use of a risk matrix. The use of risk matrices is further discussed in IEC 60300-3-9.

d) The team should identify the presence of protection, detection and indication mechanisms for the deviation, which may be included within the selected part or form a portion of the design intentions of other parts. The presence of such mechanisms should not stop the potential hazard or operability problem being explored or listed or attempts being made to reduce the probability of its occurrence or mitigating its consequences.

e) The study leader should summarize the results that are documented by the recorder. Where there is a need for additional follow-up work, the name of the person responsible for ensuring that the work is carried out should also be recorded.

f) The process is then repeated for any other interpretation for that guide word; then for another guide word; then for each characteristic of the element under examination (if analysis at the characteristic level has been agreed for that element); then for each element of the part under study. After a part has been fully examined, it should be marked as completed. The process is repeated until all parts have been analysed.

An alternative method of guide word application to that described above, is to apply the first guide word to each of the elements within a part in turn. When this has been completed, the study proceeds with the next guide word which again is applied to all elements in turn. The process is repeated until all the guide words have been used for all the elements in that particular part before moving on to another part. (See Figure 2b.)

The selection of which sequence to be followed in any particular study should be made by the study leader and his team. It is influenced by the detailed manner in which the HAZOP examination is conducted. Other factors involved in the decision include the nature of the technologies involved, the need for flexibility in the conduct of the examination and, to some extent, the training which the participants have received.

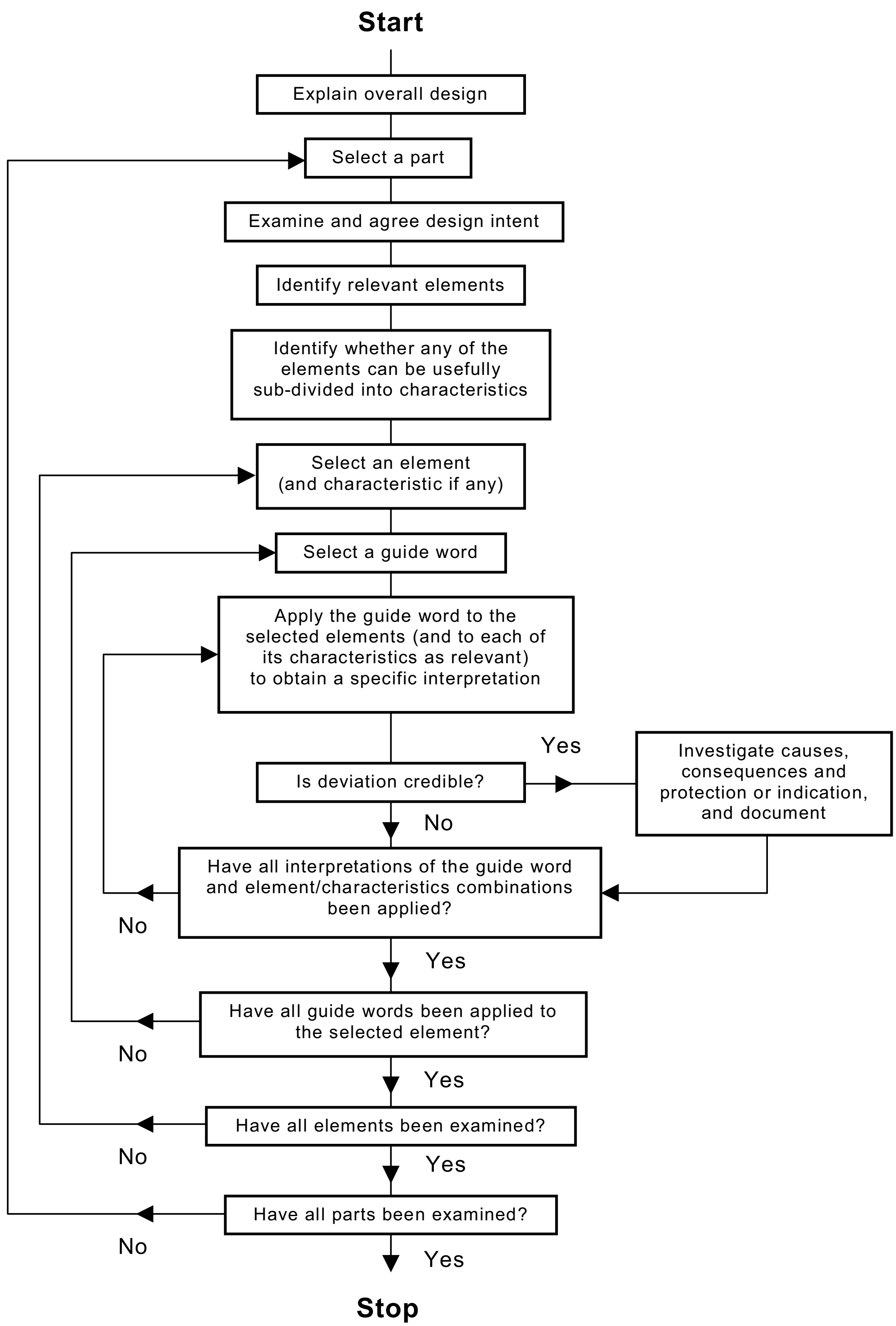


Figure 2a – Flow chart of the HAZOP examination procedure – Element first sequence

Audit

The program and results of HAZOP studies may be subjected to internal company or regulatory authority audits. Criteria and issues which may be audited should be defined in the company's procedures. These may include: personnel, procedures, preparations, documentation and follow-up. A thorough check of technical aspects should also be included.

CHAPTER 4

RESULTS AND DISCUSSIONS

At the end of the hazop study ,the way how deviation are distributed can be seen.the plant was divided in to 2 nodes and subdivided in to 8 components which in turn were divided into elements or parametres .The components ,deviations recommendations were recorded and tabulated in to various hazop worksheets

The node with more deviation was the 1st but the node with more compets was he 2nd this reflected higher number and higher complexity of the valves between the storage tanks .Those are subjected to human operations and possible errors in addition there are no safety equiptments or alarams to prevent unsafe operation .The installation of manual valves limit switches as a recommedation can eliminate most of those deviation

Risk assessment allowed to achive a quantitaive evaluation of deviation Risk level III classified as high was found in the node one .The deviation that produce this type of risk levels are mostly related to possible ruptures in pipe,valves storage taks and injuries to the worker that can occur from the operations.risk level I and II classified as very unlikely or remote were found in all nodes these risks were caused by several circumstances as they are classified as acceptable there are no need of further classification

Inorder to control or eliminate all the hazards found ,recommendations were made ,It was created by a set of recommendation for identified hazardsAll recommendations proposed in the study lowered the risks to acceptable levels

Some faults in the orginal plant deign can lead to severe risks, however the predominant cause of this higher deviations is related to human interventions in several critical operations .

CHAPTER 5

CONCLUSION

We can conclude that HAZOP is an extremely useful tool in the evaluation or an LPG storage and distribution facility which made possible the overall evaluation of the current state of the plant .

- It promoted a higher synergy of the individual and increased creativity to the identification of possible hazard scenario and the proposal of control measure to its mitigation
- It was concluded that even when a plant without any events registered during its life time can have hidden hazards that can occur at any time leading to terrible accidents
- It is possible to identify and correct potential hazards and operability problems to ensure a more secure installation and safer operation.
- Hazop recommendations are implemented in order to eliminate those potential hazards improving and increasing the overall safety of this particular facility.
- Hazop study helps us to improve and identify various hazards associated with with lpg storage unit which receives lpg from kochin refineries
- Various threats has been recorded and recommendations has been formulated for a much safer operation and working of the plant
- The study ensures overall safety and accident free environment of the LPG unit

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ANNEXURE

HAZOP
Worksheet

Company : HOCL
Faciltiy : Tank A1- LPG Storage
Date 10-02-15
Revision : 1
Node : Tank A for recieving of LPG from Kochi Refinery
Drawings : P& ID for recieving LPG facility

Parameter : Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
No	No Flow	a) Pump Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
		c) Blockage in Pipelines	Process delay	i)Automated system ii) Alarm iii) Periodic Maintenace & testing of pump & pipelines			
Low	Less Flow	a) Pump Fault	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump	) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
More	More Flow	a) Pump failure	Pressurisation of tanks	i)Automated system ii) Alarm & Sirengs iii) Maintenace of pump	i) Provide the DP o/p signal to contol system ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Periodic testing of alarms		HOCL

Parameter : Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	High Pressure	a) Pump Fault	i) Release of containment into atmosphere through PSV's of Vent lines ii) Rupture of tank iii)Release of containments through weakpoint in line that may cause fire	i) Pump failure alarm provided to control system, ii) Maintenance of pump	i) Periodc Maintenance of pump & valves, ii) Periodic Testing of alarms provided, iii) Periodic calibrations of Pressure transmitters, iv) Provision of Flame arresters in vent lines, v) Providing DP signal into safety interlock system, vi) Provide trainings & awarness for employees		HOCL
		b) Improper closing & Open valves		Sequencing the Timing of valves at I/P & O/P			
		c) Blockages in lines		i) Periodic Cleaning of lines to avoid blockages ii) ESD provided for sudden pressure drops			
Low	Low Pressure	a) Pump Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) Providing DP signal into safety interlock system,		HOCL

Parameter : Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
More	More Level	a) High Level sensor failure	Overflow of containment resulting in environment to be hazardous in nature	i) Calibration of level sensors ii) ESD, iii) Emrgency Preparedness	i) Provide LPG Leakage detectors, ii) Pump Tripping systems for level sensor failure		HOCL
Less	Less Level	a) Low Level sensor failure	Process delay	Periodic Calibration of level sensor	i) use of smart level sensor for greater accuracy & faster calibration		HOCL

Parameter : Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	More Temperature	i) Failure of High Temperature sensor ii) friction of containment due to sudden discharge iii) external source	i) Fire due to high temperature that may result in a bleve or sudden explostion of tank ii) excess pressurisation of tank resulting in venting out of LPG vapours causing hazardous environment in the vicinity iii) leakage through the weak points	i)Temperature sensor, ii) LPG gas sensor iii) Fire sensor, iv) PRV, Flame arrestor, v) ESD	i) Automatic Tripping system, ii) Regularise the flow rate by controlling the input valve, iii) use of smart sensors, iv) use of fire suppression systems		HOCL

HAZOP
Worksheet

Company : HOCL
Faciltiy : Tank A- LPG Storage

Date 18-02-15 Revision : 1
Node : Tank D for delivering of LPG to Kochi Refinery
Drawings : P& ID for LPG facility

Parameter : Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
No	No Flow	a) Pump (P4) Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump (P4)	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
		c) Blockage in Pipelines	Process delay	i)Automated system ii) Alarm iii) Periodic Maintenace & testing of pump & pipelines			
Low	Less Flow	a) Pump (P4) Fault	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump (P4)	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
More	More Flow	a) Pump (P4) failure	Pressurisation of tanks	i)Automated system ii) Alarm & Sirengs iii) Maintenace of pump	i) Provide the DP o/p signal to contol system ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Periodic testing of alarms		HOCL

Parameter : Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	High Pressure	a) Pump (P4) Fault	i) Release of containment into atmosphere through PSV's of Vent lines ii) Rupture of tank iii)Release of containments through weakpoint in line that may cause fire	i) Pump failure alarm provided to control system, ii) Maintenance of pump	i) Periodc Maintenance of pump & valves, ii) Periodic Testing of alarms provided, iii) Periodic calibrations of Pressure transmitters, iv) Provision of Flame arresters in vent lines, v) Providing DP signal into safety interlock system, vi) Provide trainings & awarness for employees		HOCL
		b) Improper closing & Open valves		Sequencing the Timing of valves at I/P & O/P			
		c) Blockages in lines		i) Periodic Cleaning of lines to avoid blockages ii) ESD provided for sudden pressure drops			
Low	Low Pressure	a) Pump (P4) Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) Providing DP signal into safety interlock system,		HOCL

Parameter : Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
More	More Level	a) High Level sensor failure	Overflow of containment resulting in environment to be hazardous in nature	i) Calibration of level sensors ii) ESD, iii) Emrgency Preparedness	i) Provide LPG Leakage detectors, ii) Pump Tripping systems for level sensor failure		HOCL
Less	Less Level	a) Low Level sensor failure	Process delay	Periodic Calibration of level sensor	i) use of smart level sensor for greater accuracy & faster calibration		HOCL

Parameter : Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	More Temperature	i) Failure of High Temperature sensor ii) friction of containment due to sudden discharge iii) external source	i) Fire due to high temperature that may result in a bleve or sudden explostion of tank ii) excess pressurisation of tank resulting in venting out of LPG vapours causing hazardous environment in the vicinity iii) leakage through the weak points	i)Temperature sensor, ii) LPG gas sensor iii) Fire sensor, iv) PRV, Flame arrestor, v) ESD	i) Automatic Tripping system, ii) Regularise the flow rate by controlling the input valve, iii) use of smart sensors, iv) use of fire suppression systems		HOCL

HAZOP
Worksheet

Company : HOCL
Faciltiy : Tank B- LPG Storage

Date 12-02-15 Revision : 1
Node : Tank B for recieving of LPG from Kochi Refinery
Drawings : P& ID for recieving LPG facility

Parameter : Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
No	No Flow	a) Pump (P2) Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump (P2)	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
		c) Blockage in Pipelines	Process delay	i)Automated system ii) Alarm iii) Periodic Maintenace & testing of pump & pipelines			
Low	Less Flow	a) Pump (P2) Fault	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump (P2)	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
More	More Flow	a) Pump (P2) failure	Pressurisation of tanks	i)Automated system ii) Alarm & Sirengs iii) Maintenace of pump	i) Provide the DP o/p signal to contol system ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Periodic testing of alarms		HOCL

Parameter : Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	High Pressure	a) Pump (P2) Fault	i) Release of containment into atmosphere through PSV's of Vent lines ii) Rupture of tank iii)Release of containments through weakpoint in line that may cause fire	i) Pump failure alarm provided to control system, ii) Maintenance of pump	i) Periodc Maintenance of pump & valves, ii) Periodic Testing of alarms provided, iii) Periodic calibrations of Pressure transmitters, iv) Provision of Flame arresters in vent lines, v) Providing DP signal into safety interlock system, vi) Provide trainings & awarness for employees		HOCL
		b) Improper closing & Open valves		Sequencing the Timing of valves at I/P & O/P			
		c) Blockages in lines		i) Periodic Cleaning of lines to avoid blockages ii) ESD provided for sudden pressure drops			
Low	Low Pressure	a) Pump (P2) Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) Providing DP signal into safety interlock system,		HOCL

Parameter : Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
More	More Level	a) High Level sensor failure	Overflow of containment resulting in environment to be hazardous in nature	i) Calibration of level sensors ii) ESD, iii) Emrgency Preparedness	i) Provide LPG Leakage detectors, ii) Pump Tripping systems for level sensor failure		HOCL
Less	Less Level	a) Low Level sensor failure	Process delay	Periodic Calibration of level sensor	i) use of smart level sensor for greater accuracy & faster calibration		HOCL

Parameter : Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	More Temperature	i) Failure of High Temperature sensor ii) friction of containment due to sudden discharge iii) external source	i) Fire due to high temperature that may result in a bleve or sudden explostion of tank ii) excess pressurisation of tank resulting in venting out of LPG vapours causing hazardous environment in the vicinity iii) leakage through the weak points	i)Temperature sensor, ii) LPG gas sensor iii) Fire sensor, iv) PRV, Flame arrestor, v) ESD	i) Automatic Tripping system, ii) Regularise the flow rate by controlling the input valve, iii) use of smart sensors, iv) use of fire suppression systems		HOCL

HAZOP
Worksheet

Company : HOCL
Faciltiy : Tank C- LPG Storage

Date 17-02-15 | Revision : 1
Node : Tank C for delivering of LPG to Kochi Refinery
Drawings : P& ID for LPG facility

Parameter : Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
No	No Flow	a) Pump (P3) Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump (P3)	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
		c) Blockage in Pipelines	Process delay	i)Automated system ii) Alarm iii) Periodic Maintenace & testing of pump & pipelines			
Low	Less Flow	a) Pump (P3) Fault	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump (P3)	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
More	More Flow	a) Pump (P3) failure	Pressurisation of tanks	i)Automated system ii) Alarm & Sirengs iii) Maintenace of pump	i) Provide the DP o/p signal to contol system ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Periodic testing of alarms		HOCL

Parameter : Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	High Pressure	a) Pump (P3) Fault	i) Release of containment into atmosphere through PSV's of Vent lines ii) Rupture of tank iii)Release of containments through weakpoint in line that may cause fire	i) Pump failure alarm provided to control system, ii) Maintenance of pump	i) Periodc Maintenance of pump & valves, ii) Periodic Testing of alarms provided, iii) Periodic calibrations of Pressure transmitters, iv) Provision of Flame arresters in vent lines, v) Providing DP signal into safety interlock system, vi) Provide trainings & awarness for employees		HOCL
		b) Improper closing & Open valves		Sequencing the Timing of valves at I/P & O/P			
		c) Blockages in lines		i) Periodic Cleaning of lines to avoid blockages ii) ESD provided for sudden pressure drops			
Low	Low Pressure	a) Pump (P3) Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) Providing DP signal into safety interlock system,		HOCL

Parameter : Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
More	More Level	a) High Level sensor failure	Overflow of containment resulting in environment to be hazardous in nature	i) Calibration of level sensors ii) ESD, iii) Emrgency Preparedness	i) Provide LPG Leakage detectors, ii) Pump Tripping systems for level sensor failure		HOCL
Less	Less Level	a) Low Level sensor failure	Process delay	Periodic Calibration of level sensor	i) use of smart level sensor for greater accuracy & faster calibration		HOCL

Parameter : Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	More Temperature	i) Failure of High Temperature sensor ii) friction of containment due to sudden discharge iii) external source	i) Fire due to high temperature that may result in a bleve or sudden explostion of tank ii) excess pressurisation of tank resulting in venting out of LPG vapours causing hazardous environment in the vicinity iii) leakage through the weak points	i)Temperature sensor, ii) LPG gas sensor iii) Fire sensor, iv) PRV, Flame arrestor, v) ESD	i) Automatic Tripping system, ii) Regularise the flow rate by controlling the input valve, iii) use of smart sensors, iv) use of fire suppression systems		HOCL

HAZOP
Worksheet

Company : HOCL
Faciltiy : Tank D- LPG Storage

Date 18-02-15 Revision : 1
Node : Tank D for delivering of LPG to Kochi Refinery
Drawings : P& ID for LPG facility

Parameter : Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
No	No Flow	a) Pump (P4) Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump (P4)	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
		c) Blockage in Pipelines	Process delay	i)Automated system ii) Alarm iii) Periodic Maintenace & testing of pump & pipelines			
Low	Less Flow	a) Pump (P4) Fault	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump (P4)	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Audits to ensure environmental compliance		HOCL
		b) Leakage	Loss of Containment Environmental Pollution	i)Automated system ii) Alarms & Hooter			
More	More Flow	a) Pump (P4) failure	Pressurisation of tanks	i)Automated system ii) Alarm & Sirengs iii) Maintenace of pump	i) Provide the DP o/p signal to contol system ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) ESD v) PPE's vi) Periodic testing of alarms		HOCL

Parameter : Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	High Pressure	a) Pump (P4) Fault	i) Release of containment into atmosphere through PSV's of Vent lines ii) Rupture of tank iii)Release of containments through weakpoint in line that may cause fire	i) Pump failure alarm provided to control system, ii) Maintenance of pump	i) Periodc Maintenance of pump & valves, ii) Periodic Testing of alarms provided, iii) Periodic calibrations of Pressure transmitters, iv) Provision of Flame arresters in vent lines, v) Providing DP signal into safety interlock system, vi) Provide trainings & awarness for employees		HOCL
		b) Improper closing & Open valves		Sequencing the Timing of valves at I/P & O/P			
		c) Blockages in lines		i) Periodic Cleaning of lines to avoid blockages ii) ESD provided for sudden pressure drops			
Low	Low Pressure	a) Pump (P4) Trip	Process delay	i)Automated system ii) Alarm iii) Maintenace of pump	i) Implement low low alarm ii) Employees Awarness & Tranings iii) Schedule for periodic maintenance of pump iv) Providing DP signal into safety interlock system,		HOCL

Parameter : Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
More	More Level	a) High Level sensor failure	Overflow of containment resulting in environment to be hazardous in nature	i) Calibration of level sensors ii) ESD, iii) Emrgency Preparedness	i) Provide LPG Leakage detectors, ii) Pump Tripping systems for level sensor failure		HOCL
Less	Less Level	a) Low Level sensor failure	Process delay	Periodic Calibration of level sensor	i) use of smart level sensor for greater accuracy & faster calibration		HOCL

Parameter : Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARD	RECOMMENDATIONS	REMARKS	BY
High	More Temperature	i) Failure of High Temperature sensor ii) friction of containment due to sudden discharge iii) external source	i) Fire due to high temperature that may result in a bleve or sudden explostion of tank ii) excess pressurisation of tank resulting in venting out of LPG vapours causing hazardous environment in the vicinity iii) leakage through the weak points	i)Temperature sensor, ii) LPG gas sensor iii) Fire sensor, iv) PRV, Flame arrestor, v) ESD	i) Automatic Tripping system, ii) Regularise the flow rate by controlling the input valve, iii) use of smart sensors, iv) use of fire suppression systems		HOCL