



دانشگاه سیستان و بلوچستان

University of Sistan and Baluchestan

Chabahar International Campus

M.Sc. Thesis in Chemical Engineering, Process Design

Title:

**Hazard Evaluation of Unit 500(Slug Catcher and Gas
Condensate Stabilization and Dehydration Unit) of
Parsian Gas Refinery Using HAZOP Procedures**

Supervisors:

Dr. Farhad Shahraki

Advisor:

Mr Mohammadreza sardashti birjandi

Research by:

Kaveh Rezaei

January 2012



University of Sistan and Baluchestan

Chabahar International Campus

In the Name of God

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Chemical Engineering, Process Engineering, by Kaveh Rezaei.

Title: “**Hazard Evaluation of Unit 500(Slug Catcher and Gas Condensate Stabilization and Dehydration Unit) of Parsian Gas Refinery Using HAZOP Procedures**”

Citation of any material from this thesis is allowed for educational purposes with proper referencing and written permission from the Office of Graduate Education, University of Sistan and Baluchestan.

This thesis is accepted as Credits, which is evaluated and approved by the referees committee on and is marked and graded as (.....).

Full name

Signature

Date

Supervisor: Dr. Farhad Shahraki

Supervisor:

Advisor: Mr Mohammadreza sardashti birjandi

Examiner 1: Dr. Hosain Atashi

Examiner 2: Dr. Farshad Farshchi

Representative of the Graduate Office:

Dr.



University of Sistan and Baluchestan
Chabahar International Campus

Authenticity Commitment Letter

The undersigned, **Kaveh Rezaei**, a graduate student in Chemical Engineering – Process Design, student N. 8803624 guarantees that material written in this thesis are the result of my own original studies and work. Any reference from any other source have been properly cited and acknowledged.

If plagiarism is detected in any part of this thesis the University of Sistan and Baluchestan has the right to withdraw or cancel my certification according to its rules and regulations.

Student's Name and Surname: Kaveh Rezaei

Signature:

Date:

Representative of the Graduate Office: Dr.

Signature:

Date:

*I do hereby present all the thing which
I have achieved from the results of this
research*

*To the affectionate looks of my mother
And to the supporting hands of my father
, The hands and the looks , surely being
the bridge of success.*

Acknowledgements

But at the end of this long way with its ups and downs , I feel obliged to thank Almighty God and all dear ones who helped me without any expectations .

First of all, I cordially thank my dear Supervisors professor Farhad Shahraki and my dear Advisor Mr Mohammadreza Sardashti birjandi and a long note of thanks is extended to the members of engineering research and recommendation group Mr Ghodratolah Kavayani, Mr Majid Yaghobi and Mr Alireza Rezaei.

I am very much indebted to my professors ' helpful hints for any strong points in this thesis if there are any and I accept the responsibility of all the errors and flaws if there are any.

Kaveh Rezaei

Abstract

Safety is a matter of up-most importance in industrial and chemical facilities .Looking at statistics, it is realized that annual scale of human, environmental and economical damages & losses due to industrial accidents is very high. In addition, basically some of these impacts not are compensated. Therefore to prevent these damages, detect hazards leading to these damages and risk analysis of industrial units, specific measures should be taken and systematic approaches are required. In this study, hazard evaluation and risk analysis of Slug Catcher and Gas Condensate Stabilization and Dehydration unit in Parsiyan Gas Refinery (500) has been investigated. In order to identify hazards, Hazard and operability Analysis (HAZOP) technique has been adopted in which operability problems are also detected. Deviations have been considered by HAZOP team. This project terminates to recommendations from HAZOP study to reduce the risk and increase the safety coefficient in Slug Catcher and Gas Condensate Stabilization and Dehydration unit. Based on the expertise works, the efficiency of stabilization unit and absorption is strongly depended to the function of parts of kilns and towers because whatever we keep the kiln's temperature (Heat Medium) in the appropriate high degree, the reboiler of stabilizing tower helps with better separation of productions in the bottom and the above of tower and productions are generated with high quality and more separation. The most important suggestions provided in this study consist of installation and operation of ethane and butane extraction. In addition based on the findings of this study the guide lines of operation of the unit were modified.

Key Words: HAZOP, Safety, Hazard Identity, Slug Catcher Gas Condensate Stabilization and Dehydration Unit, Risk, Gas Refinery

Contents

Title	Number
Preface	16
Chapter 1: An introduction to safety and Hazard Identification methods	19
1.1.The history of the safety in the industry	20
1.1.2. Health and safety movement, from past to present	20
1-1-3- The primary improvements in safety	21
1-1-4- Incidents and their effects on the industry	21
1-1-5- The accidents costs	22
1-2-An overview of the past major industrial disasters	22
1-2-1- The Massive Chernobyl Disaster	23
1-2-2- Fire at the Assaluyeh petrochemical complex campus	23
1-2-3- France Feyzin disaster	24
1-2-4- Fire and blast in the North Sea oil platform, Piper Alpha:	24
1-2-5- The Bhopal disaster	25
1-2-6- The explosion at Khark Petrochemical Complex	25
1-3-Definitions	25
1-3-1- Risk	25
1-3-2- Hazard	26
1-3-3- Incident	26
1-3-4- Accident	26
1-3-5- Safety:	26
1-3-6- Tolerable Risk:	26
1-4-Risk measuring criteria	27
1-4-1- The Risk indicator	27
1-4-2- The average casualties	27

1-4-3- Individual Risk	27
1-4-4- Societal Risk:	27
1-5-Risk Assessment	28
1-6-Identification of hazards	29
1-6-1- Safety review	29
1-6-2- Checklist Analysis	30
1-6-3- Question Analysis	30
1-6-4- Process Material and Critical Condition Analysis	31
1-6-5- Preliminary Hazard Analysis (PHA)	31
1-6-6- Hazard and Operability Study (HAZOP)	32
1-6-7- Hazard Analysis	32
1-6-8- Fault and effects analysis	33
1-7-The Consequence modeling	33
1-8-Quantitative risk studies	34
1-8-1- Fault trees analysis	34
1-8-2- Event trees analysis	34
1-9-Risk measurement	35
1-9-1- F-N curve	36
1-9-2- Risk acceptance criteria	37
1-10- Risk reduction	38
1-11- Conclusion	38
Chapter2 Hazard analysis and system administration	40
2.1.Introduction	41
2-2 - Definition of HAZOP	41
2-3-Reasons for the comprehensiveness of HAZOP procedure	42
2-4 - Description of Activities in the HAZOP Procedure	42
2-5 - Data required for starting the work	42
2-6 - Stages of HAZOP	42
2-7- HAZOP Group	44
2-8- HAZOP Table	45

2-8-1 - HAZOP table entries (inputs) are as follows:	46
2-9- Applied softwares and reasons for their use.	49
2-10 - The main disadvantages of the HAZOP procedure	52
2-11 - Risk Matrix	52
2-12 - Mathematical model integration as a proposed solution to improve the disadvantages (faults) of the HAZOP procedure	55
2-13 - conclusion:	55
Chapter 3:Unit Description	57
3-1-Introduction	58
3-2 – The Fields' Information	58
3-2-1- Shanoul field:	58
3-2-2- Varavi Field:	58
3-2-3- Homa Field	59
3-2-4- Tabnak Field	59
3-3- The fourth national gas pipeline	60
3-4- Description of the process of unit 500 of the Parsian gas refinery	61
3-4-1- Slug Catcher:	61
3-5- the slug catcher and condensate processing and dehydration unit (500)	63
3-5-1- Receiving facilities (401)	63
3-6- Description of the process	63
3-6-1- Systems used in the receiving facilities	64
3-6-2- Condensate separation and Processing (402)	65
3-7- Description of the process	65
3-8- Dehydration Unit (403)	69
3-8-1- Description of the process	70
3-9- Regeneration Cycle	71
3-9-1- Heating	72
3-9-2- Cooling	72

3-9-3- Stand By:	73
3-9-4- Systems used in regenerative gas system	73
3-9-4-1- The regenerative gas exchanger E-403-201	73
3-9-4-2- The air coolers of regenerative gas (E-403-202 A/B)	73
3-9-4-3- The regenerative gas scrubber (V-403-201):	73
3-9-4-4- The regenerative gas compressors (C-403-204 A/B):	74
3-10- System heat medium (404):	74
3-10-2- Description of the process	76
3-11- The systems used in Heating system	76
3-11-1- Heater heat medium	76
3-11-2- The hot oil pumps (P-404-201 A/B/C)	77
3-11-3- Heat medium expansion tank	77
Chapter 4: Introduction HAZOP Studies of Slug Catcher and Gas Condensate Stabilization and Dehydration Unit	78
4-1 Introduction	79
4-2-HAZOP Studies Documents of Slug Catcher, Gas Condensate Stabilization and Dehydration Unit	80
4-2-1- HAZOP team members	80
4-2-2- List of number of drawings used in HAZOP	81
4-2-3 -Lists of Nodes	82
4-2-4 - Review of deviations in each node	82
4-2-5- HAZOP Tables: It includes all the finalized Worksheet	82
4-2-5-1- Comment on A-10 Table. Increase of pressure in condensate collection and stabilized condensate system	83
4-2-6- List of proposals presented in HAZOP meetings	84
4-3- Assumptions and considerations in HAZOP studies	84
4-4- Effective approaches to reduce risk in flood retention, gas condensate stabilization and dehydration uni	86

4-4-1- Personal protective equipment (PPE)	86
4-4-2- Process materials	86
4-4-3- Occupational health	87
4-4-4- Accidents	87
4-4-5- Training	87
4-4-7- Maintenance	87
4-4-8- Process	88
4-4-9- Safety	88
4-4-10- Management	88
4-5- Conclusion	88
Chapter 5: Conclusion and suggestions	89
5.1. Introduction	90
5.2. General Suggestions	90
5-3 Study results of hazards and HAZOP	92
5-3-1 Hardware suggestions	92
5-3-2- Instruction-recommendation suggestions	98
5-3-3- Study and research suggestions	100
5-4-Suggestions for the future work	102
Reference	103
HAZOP Work Sheet Report	107

Tables

Title	Number
Table 1-1- Hazard Identification Methods	30
Table 1-2- Probabilities related to the previous even tree	35
Table 1-3: Regions of F-N curve	37
Table 2-1- Basic principles of HAZOP	41
Table 2-2 - The HAZOP Procedure	44
Table 2-3 : HAZOP table	45
Table 2-4 -Parameters existed in the HAZOP procedure	47
Table 2-5- keywords of HAZOP procedure	48
Table 2-6- Values of nodes complexity	50
Table 2-7 - Complexity of devices values	51
Table 2-8 - Values of Design level factor	51
Table 2-9 - Values of variables E1 -E7 which are existed in the equation	52
Table 2-10. Qualitative explanations for the severity of damage to human	54
Table 2-11. Qualitative definitions of probability	54
Table 2-12. Definitions of risk	54
Table 3-1: Fields' information	59
Table 3-2: The design parameters of the receiving facilities of the unit	63
Table 3-3- Designing parameters of the stabilization process	65
Table 3-4- The design parameters of the dehydration unit	69
Table 3-5: the design parameters of gas regeneration system	71
Table: 3-6: The design parameters of system heat medium (404)	74
Table 3-7: Oil physical and chemical properties	75
Table 4-1 HAZOP team members	80
Table 4-2- List of number of drawings used in HAZOP	81

Table 4-3- Review of deviations in each node	82
Table 4-4- Comment on A-10 Table. Increase of pressure in condensate collection and stabilized condensate system	83
Table A-some of HAZOP Worksheet Report	107
Table B-Summary of study in unit	133

Figures

Title	Number
Figure 1-1: Piper Alpha platform explosion	24
Figure 1-2- stages of the risk assessment	28
Figure 1-3: F-N curve	36
Figure 2-1- Stages of HAZOP procedure	43
Figure 2-2- each member's role in HAZOP studies	45
Figure 2-3- Risk matrix	53
Figure 3-1: Control system of slug catcher in control room	61
Figure 3-2: An overview of the slug catcher and condensate processing and dehydration unit(500)	62
Figure 3-3- An overview of the K.O.D unit	64
Figure 3-4- Overview of the distillation (stabilization) tower	66
Figure 3-5- Overview of the four absorption towers	70
Figure 3-6: overview of the heater heat medium unit	77

Preface:

Nowadays making a secure environment which all deleterious agents are identified, assessed, deleted or controlled to warrant health of people and facilities is of highest priorities of industrial managers. The science of safety same as traditional viewpoint of safety is based on reaction i.e. not before the accidents to be happened, managers would have not fallen into finding and solving problems. During recent decades conscience and ethics considerations of industry proprietors in addition to obligations made by law and insurance commitments, have placed safety science in a specific situation. In this regard effect of safety on profitability and competition with rivals should not be ignored. So a look at safety as a preventive viewpoint toward accidents especially in oil, gas and petrochemical which are prone to high potential human and environmental accidents are at the center of attention.

Gas industry in Iran as for huge reservoirs of gas is of great importance. Gas refineries are considered as one of the most important parts of this industry and improvement of the safety in this section is one of the most important concerns of everybody, since any minor problem in this industry can lead to not only great environmental and human disasters but also irreparable economic effects on the country.

Various methods are being used to improve ongoing processes in gas industry that hazard and HAZOP study is one of the best methods of those. Using this method in industrial countries is obligatory. Performing this system in developing countries is strongly recommended and in many oil, gas and petrochemical industries is used. HAZOP implementation in Iran refineries has become one of the most important activities in these plants to improve safety of systems and have already been used in many industries related to oil, gas and petrochemical.

Among the activities which have done in this industry, HAZARD study and risk assessment can be mentioned which have been executed in Shiraz petrochemical Urea plant, sweetening units of Razi petrochemical complex, Ethylene oxide unit of Arak petrochemical complex, Fluor production unit of Esfahan UCF, Sodium Bicarbonate

unit of Shiraz petrochemical complex, LPG regeneration unit of Kangan refinery, Poly stiren production unit of Tabriz petrochemical complex, Dehloran and Danan upstream units, Sea water intake unit of Mobin petrochemical complex, and isomax unit of Bandar Abbas oil refinery company. However activities done in this area are various and are progressive and every day more unit of petrochemical plants are going under these studies.[1]

The reasons on urgency and justification of project performance in Parsian Gas Refinery:

1. It has been more than 7 years since this unit was assembled and operated while no research has been performed on identifying the risks through HAZOP studies except from initial HAZOP studies on this unit that its documents are not even existent and available.
2. Persian Gas Refinery is the biggest sweet gas refinery in the Middle East which supplies a large volume of national Pipeline, so its evaluation through performing this method seems to be necessary.
3. Governmental centers and individuals are always resistant against the changes. Presenting a scientific, modern and reasonable solution by a group of experts applying the experiences of the own staff of the company, would pave the way to improve the safety level operational systems at the earliest convenience.

The direct and indirect expenses derived by the accidents, divert considerable financial and corporal harms to industries of the country and gas refining in particular due to its risky nature, thus, to prevent such accidents, applying a systematic method to identify the hidden risks in industrial unites and their continuous revision seem to be necessary.

Many managers and experts consider the attention to safety matters as a providence of time and capital. Performance of security programs in industrial units, identification of potential risks and providing performable solutions to prevent and reduce the harms caused by such accidents, can be followed by a lot of economical

advantages and time optimization. The following items can be mentioned as some of these advantages:

- ✚ Reducing the expenses related to:
 - ❖ Equipment destruction
 - ❖ Work suspension
 - ❖ Reoperation and coming to an steady status in incessant processes
 - ❖ Transmission and treatment of injured employees
 - ❖ Training new personnel
- ✚ Increasing the output of resources and economical profitability of the company as a result
- ✚ Improving the organizational prestige due to observing safety principles and work sanitation

This thesis includes 5 chapters, in the first chapter contains some definitions related to safety and a concise explanation of different common methods to identify the risks. Then, in the second chapter, the HAZOP method has been represented entirely and based on present standards in order to accustom the honorable readers and coworkers of the project. The Condensate Stabilization unit and drying process along with some explanations on flood embanking entrance section of the unit and the controlling issues are widely described in third chapter. In the fourth chapter, the performance of HAZOP studies in Slug Catcher and Condensate Stabilization and Drying units are indicated along with its hypothesis and considerations; and in the fifth chapter, a general conclusion and some suggestions are discussed in details.

Chapter 1

An introduction to safety and Hazard Identification methods

1-1-The history of the safety in the industry [1 &2]

1-1-2 - Health and safety movement from past to present

From a long time ago, the necessity of promoting safety was usually noticed when lack of it resulted in conditions with social or economical adverse consequences. The incidents in industrial facilities and technologic systems illustrates the necessity of continuous evolution in safety researches in the fields of safety standards, event and incident rooting, improving the methods of safety assessment and hazard identification and the role of effective elements on safety. Usually following the shock of an incident, the industrial facility and technological systems' management, decide to ponder the roots of the causing factors of the adverse condition. If these evaluations are not done properly the active causative roots of the incidents remain in the system intact and in other opportunities, combining with certain operating conditions, hardware failure, human errors and organizational deficiencies brings out another incident.

The national safety association has grown comprehensively since the modest activities in a small Chicago office in 1913, expanding through thousands of members in business, industry, agriculture, education, labor and government parties. The safety movement's progress in America was parallel and simultaneous to National Safety Society (NSC). In early 1900, the industrial incidents in this country were considered commonplace; for instance, in 1907, more than 3200 people were killed in mining accidents. At the same time, law, history and public opinion were all concentrated on management. There was little support for the safety of workers. Nowadays, industrial workers are in much better condition than their counterparts in the past. Industrial fatal accidents are less than half of their predecessors in the last 60 years. According to NSC, the common death rate from work-related injuries is approximately 4 out of every 100,000 people or less than one third of it 50 years ago. The safety improvement from before is the result of putting pressure on the law for promoting health and safety. The growing costs have always been related to incidents, injuries and professionalizing safety as a job. The future improvements

would probably be like a great outcome of awareness about the effects of cost and a competitive advantage of a healthy and safe plant.

A first aid box or supplies shall be available and the health and safety director should consult a physician about selecting the material. Unfortunately, medical specialists are reluctant for such consults maybe that is because they abhor the future involvement in courts about the incidents related to lack of sufficient effective material.

1-1-3- The primary improvements in safety

It is essential for industrial health and safety apprentices to start their studies in retrospect. Understanding the past can help test the health and safety in past and future professionally. The new improvements in health and safety are contiguous to the past and they are not discrete and independent, they are relatively the long section of continuous progress in health and safety movement.

This has been going on narrowly from the ancient Egypt that we can observe how industrious Egyptians were, judging from the permanent pyramids and temples. Many workers were slaves and there are ample evidences that they did not have proper condition. They needed better terms and proper treatment from strict masters.

One of these cases took place in the reign of Ramses II who was to build a great edifice. To provide proper protection of the workers who built that great temple in his name, he constructed an industrial medical service to take care of the workers. They needed daily bath in the Nile and regular medical examinations. The sick workers were quarantined.

1-1-4- Incidents and their effects on the industry

A long history of debate in America is related to the effects of accidents on the industry (workers and companies) and the prevention costs. The historical predominant view was that the prevention programs were costly as well. Most modern theories argue that while the incidents are costly, preventing them is