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IDENTIFICATION OF POTENTIAL RISKS TO HYDROCARBON OPERATION ASSOCIATED WITH THE USE OF VARIOUS TYPES OF EQUIPMENT

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Abstract- Article presents a generalized analysis of safety equipment's use and type optimization that been undertaken on a number of projects. On those projects, similarity of risks has been identified and mitigating measures developed. Analyses enable to understand route cause of the gaps left during design that may lead to potential failures during facility exploitation. Main focus was to determine and achieve common vision, hence unified approaches to hazards and risks identification can be applied and mitigation measures developed aimed at minimizing identified risks. The lessons learned during analyses of cases provided herewith in the article, allows to extend our knowledge, generalize approaches and use as guidelines during future projects. The study work results related to identification of potential hazards and development of solutions enabling enhance of protection means and achievement of more reliable and safe transportation, unloading, storage and offloading hydrocarbon operations, are provided in the article. The study reveals that often conventionally perceived solutions may not be appropriate in certain cases and hazardous analyses may suggest more appropriate solutions, which can significantly minimize the risks of failures. The study methods and methodologies are discussed and supporting cases are provided described, indicating towards the outcomes showing how the safer operations can be achieved, are provided.

Keywords: Operation and Safety, Hazards and Risks Identification, Monitoring and Control.

I. INTRODUCTION

Big volumes of hydrocarbons are widely used in power generation systems. Despite all other useful capacities, Hydrocarbon operations are hazardous by their nature. This is why their operational parameters and conditions (pressure, flow, temperature, flammability etc.) require serious analyses of risks involved during their storage and transportation.

Transportation of hydrocarbons includes complicated operations through changes of system parameters like flow, pressure and temperature. Their uncontrolled critical change initiated by such risks as system malfunctioning, human factor or design inconsistences, can lead to fatal results.

To minimize such risks and increase efficiency of such operations hazardous studies are undertaken that enable to predict possible system incapacities and inconsistences through scenario analyses and other approaches. Conduct of such studies is particularly important in view of increased complexity of the facilities and control systems.

Large storage facilities and related supporting systems being integral part of any contemporary Oil and Gas and petrochemical industries contain large amounts of hydrocarbons. Day-to-day operations of these facilities are potential sources of hazard.

In order to prevent the systems from failures and their consequences, and be able to react to the hazardous situations within the systems due to unexpected / unpredicted events and emergencies, these facilities have to be so designed and operated as to enable actions to control, timely react and effectively eliminate hazards at the early stages. Studies must be undertaken in order to envisage hazardous situations and develop optimal solutions for design of hydrocarbon transportation and storage facilities and provision of minimized risks, reliable and continuous operations.

Taking into consideration the fact that engineering companies are focused on delivering safer design of such facilities, the improvement of means and measures for evaluation, mitigation of risk and hazards and conduct of safe operations become extremely significant.

II. HAZARDS IDENTIFICATION PHILOSOPHIES

There is a vast variety of hazard identification methodologies that allow identification of hazards and based on that, developing operational processes with minimized risks to people, facilities and environment. This however, indicates that every case may require an individual approach and development of appropriate to the case methodologies.

Accordingly, this article focuses on the certain cases where methods of analysis of results of small parameter fluctuations and consequences require tailor made approaches. Such type analyses can serve the designer and operator as proof that facilities are designed and operated in such a way that potential hazards for environment, employees, industry and third parties have been minimized and potential consequences of unexpected events are under control.

Specifically, the analyses were applied to the storage and transportation systems and facilities and were concerning the existing systems in order to consider possibilities to increase the reliability of their operation.

Methodological application of such hazards identification analyses are a strong tool to design and operate safer systems, but also enables operator undertake studies of the system safety and durability to faults following the stage of startup, during operational changes.

III. STUDY METHODOLOGY

In our study we considered a number of cases, for which we developed specific approaches and their combinations. The main issue was to be able to overview and oversea possible risks and hazards during operation and consider way to prevent from negative outcomes while supporting stable operations.

Generally, selection of the appropriate methodology is dependent on type of operation, schematic specifics and, what is most important, scale of operation, its specificities (agents used, parameters, ratings etc.) and accuracy requirements. The level of accuracy achieved through the selected methodology of the hazards identification process must be identified and controlled.

Subject study methodology comprised the following steps:

- Scenario analysis and Identification of the Hazards;
- Identification of risks to operation and critical items/equipment;
- Consequences analysis;
- Establishment of appropriate protective measures.

These conduct of each step will of course require certain definition of accuracy requirements.

IV. IDENTIFICATION OF HAZARDS AND RISKS TO OPERATION

Prior to start undergoing the step according to methodology, we must split the system into subsystems. By doing this, we can regulate over the degree of accuracy of analyses. Correspondingly, mitigation measures for the sudden system changes and fluctuations caused by potential hazards and risks can be developed in a more precise way. By doing this we also obtain fluctuations and deviations much better traceable and consequences - predictable.

The hazards then are converted into the analyses of the risks to the operation. At this stage major risks are identified and can be traced further towards the subsequent outcomes.

Analysis of such complex facility as hydrocarbon transportation system involves in-depths study of operating conditions and their possible changes, plus considerations of functional behavior of equipment and devices within the system. A number of necessary toolsets enable operator to manage the operation process and product, to quickly and easily monitor and navigate the relationships existing between closely integrated system elements.

Operations for hydrocarbon transportation via pipeline and their further reloading into transportation means, assume the use of combination of such sub-system elements as pump stations, main transportation pipeline, distributions system, loading facilities (loading and unloading gantry, road car filling station and etc.), safety related equipment and devices and monitoring & control system etc. etc.

As substantiated above, the systems are further considered as separate operational parts, as:

- Hydrocarbons transportation via pipeline and unloading into storage facilities;
- Hydrocarbons offloading from the storage facility into road, railroad and marine transportation means

Correspondingly, they are subject to review from technical and operational safety point of view. As an outcome of the analysis undertaken, system deficiencies leading to future potential unexpected operational failures are identified.

Further analyses are gathered around the cases related to the most vulnerable elements.

V. CONSEQUENCE ANALYSIS

This is the phase where threats, vulnerabilities and the associated risks are identified. This process has to be systematic and comprehensive enough to ensure that no risk is unwittingly excluded. It is very important that during this stage all risks are identified and appropriate changes has been made to provide system adequate operation.

Main approach is to generate a comprehensive list of deficiencies in design and associated risks that might have an impact on the achievement of each of the objectives as identified in the design. Such record keeping (for example: lessons learned) provides adequate design background information and helps to avoid similar design lacks in future.

VI. CASES

A. Case 1

Case 1 is based on analysis of the crude oil export facilities which provide pumping of crude oil into the export pipeline. The system includes export pumps, pigging facilities and a number of protection means including overpressure protection and etc.. Subject pipeline is maintained via pigging operations which include launching and receiving of pig appropriately using pig launching and receiving chambers. These traps are routinely pressurized and depressurized during pigging operation.

The objective of this case study was to analyse reliability of the solution to include the pressure safety valve into the system as a protection means to the pig launcher depressurization operation. In our case, depressurization line was consisting of main and extra depressurization lines interconnecting pig launching unit and HP (high pressure) flare system. The lines provided pressurization of the pig launcher when internal pressure reaches 32 barg. In case pressure in pig trap exceeds 32 barg, extra depressurization line joins operation via activation of pressure safety valve (PSV) installed downstream main depressurization line.

System operation parameters were studied and pressure ratings were identified. As per results of the analysis, PSV was considered as conventional means of protection. This however is valid in case backpressure downstream PSV is under 10% of PSV's set pressure. In subject case back pressure was equal to 50% of PSV's set pressure. In case such solution is applied, this may lead to serious consequence such as failures and damages in system.

As per outcomes of the assessments the type of PSV was changed from conventional to balanced bellows. Application of balanced bellows PSV provides normal operation of PSV at outlet backpressures up to 50% of set point. The following are the spotting-up from schematic and documentations reflecting design diagram prior to study and the changes made.

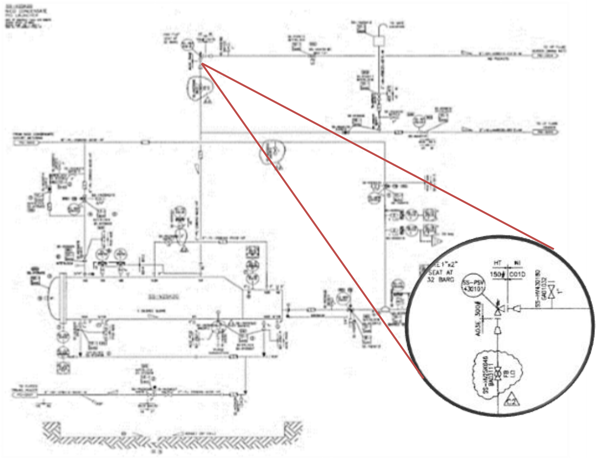

Figure 1. PID 1: Prior to study

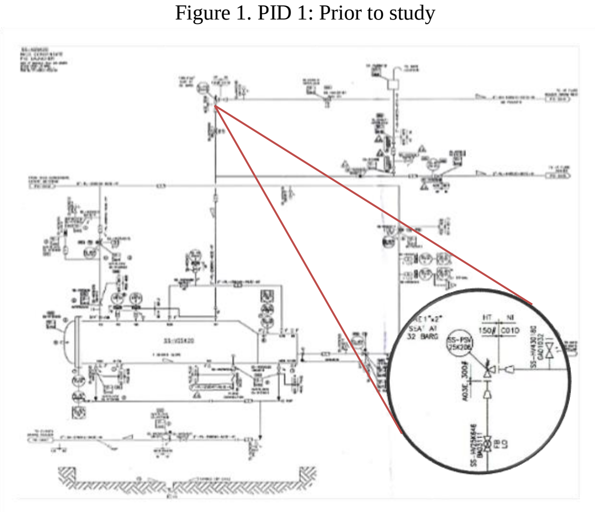

Figure 2. PID 2: After study

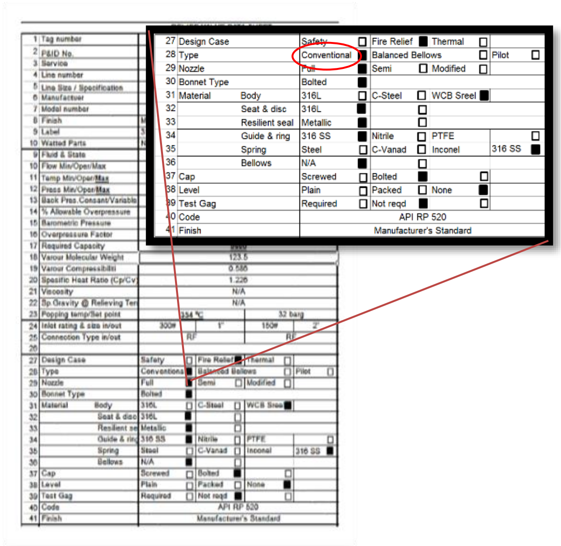

Figure 3. Valve datasheet 1: Prior to study

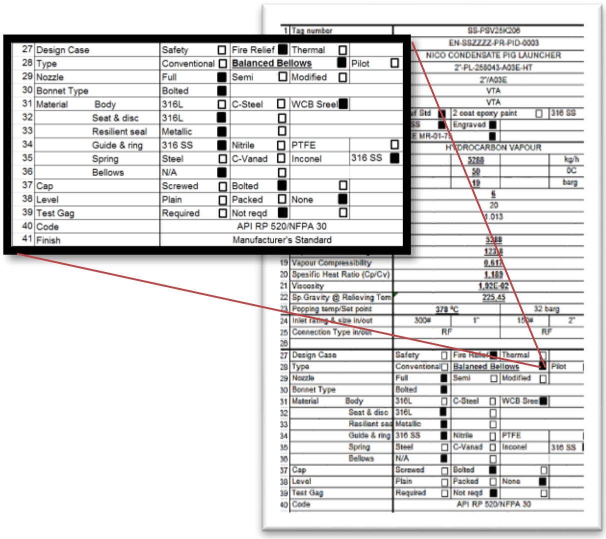

Figure 4. Valve datasheet 2: After study

B. Case 2

The second case is based on analysis of the gas condensate transportation facilities. These include transportation of gas condensate between two terminals. Terminals have interconnected emergency shutdown and control system. Control interface of this system is located in the upstream terminal. Control system is designed to control potential leakages and via sending appropriate signals to shut down the facilities engaged in gas condensate transportation operation.

One of the operation elements in this system is pressure control valve. This valve controls pressure of the condensate transported via pipeline. This valve is located at downstream terminal. Hazards identification methodology help us to identify that during emergency shutdown of the system initiated by high pressure it is required to provide full blocking of the interconnection between terminals in order to prevent storage facilities located in downstream terminal. For this PCV valves fail state should be indicated as fail close on PID.

Appropriate changes were made to the next revision of the document via provision of the necessary note on the PID.

The following are the spotting-up from schematic and documentations reflecting situation prior to study and the changes made.

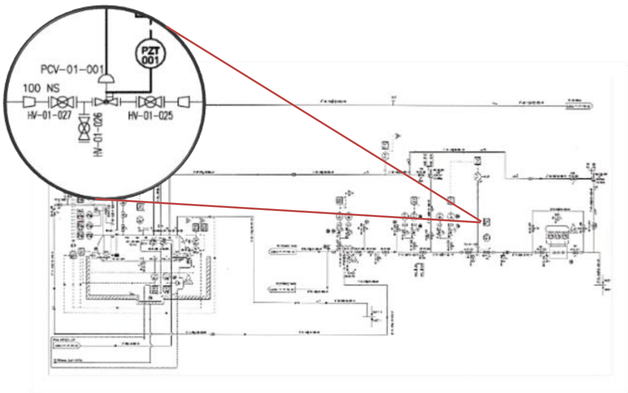

Figure 5. PID 3: Prior to study

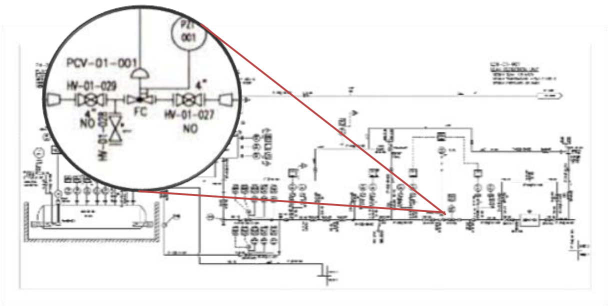

Figure 6. PID 4: After study

C. Case 3

The third case study is based on analysis of condensate offloading facilities. Condensate offloading facilities consist of condensate storage tanks, condensate offloading pump station interconnection piping, pressure relief system, condensate loading gantry and related system elements and interconnecting piping. One of the elements of the system is open drain tank (ODT). This tank is provisioned for assembling condensate released via pressure relief valves which is generated via over pressure in the system. When the level of the condensate in the open drain tank reaches high level, open drain tank's valve start is initiated via level switch. This pump transfer condensate from ODT to main condensate storage tanks for further injection into the system.

Results of the conducted hazards identification study showed that, taking into consideration that condensate derived from ODT is re-injected to the system via inlet manifold of the main storage tanks, there is possibility that there can occur back flow into the ODT. This case will lead to reverse flow that will fill ODT and cause overflow of the condensate. In order to prevent this unexpected consequence, changes to the design of the system were initiated. Check valves were installed on the outlet line of the ODT which prevents reverse flow case.

The following are the spotting-up from schematic reflecting situation prior to study and the changes made.

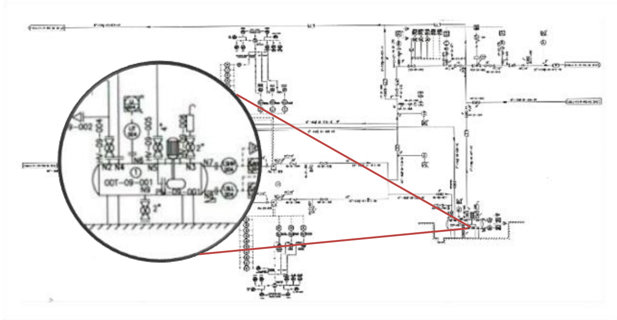

Figure 7. PID 5: Prior to study

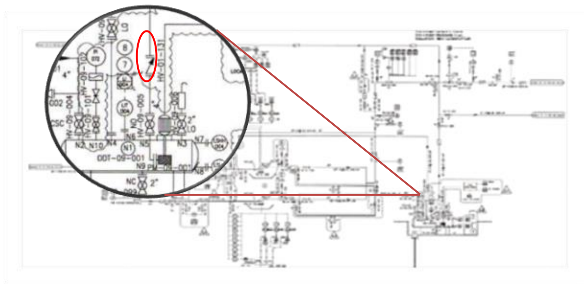

Figure 8. PID 6: After study

VII. CONCLUSIONS

As per conducted conventional base case studies there were identified and recorded the following outcomes:

• Case 1: Pressure ratings of the system have to be studied and calculated in order to include to the design appropriate types of the pressure safety equipment. This case have to be considered during design of the pressurized systems.

• Case 2. System safety critical elements have to be considered for termination of the operation in emergency cases. Considerations have to be reflected on the project schematics and appropriate documentation.

• Case 3. System design have to be adapted as per piping layout in order to prevent back flow in the system. For this purposes it is required to provision equipment for preventing backflow.

Conventional base case studies undertaken for design review of the systems reflected in above sections provides possibility to study hazard elements and share knowledge/vision. This provides possibility to ensure best performance of the design developed by the company.

The following general recommendations are considered as an outcome relative to described base cases.

• System pressure ratings to be considered in calculation of system safety elements;

• Emergency termination devices to designed as per system requirements

• Physical obstacles to be considered in design (slopes; elevation and etc.) of piping systems and layout preparation;

REFERENCES

[1] R. Sinnot, G. Towler, "Chemical Engineering Design" 2nd and 5th Edition.

[2] "Guidelines for Risk Based Process Safety", Center for Chemical Process Safety (CCPS).

BIOGRAPHIES

Murad B. Mammadov was born in Baku, Azerbaijan, 1987. He received the B.Sc. and M.Sc. degrees from Process Engineering Department, Azerbaijan State Oil Academy, Baku, Azerbaijan in 2008 and 2010, respectively. Currently, he is a Process Lead Engineer in Encotec Company, Baku, Azerbaijan.

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