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Social HAZOP at an Oil Refinery

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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 emergency) and different types (policies, team, managerial aspects, leadership, human and social aspects, stress process at job, risk management, and root cause). © 2013 American Institute of Chemical Engineers Process Saf Prog 32: 17–21, 2013

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INTRODUCTION

Process safety in the industry has used several tools to avoid risks and failures (e.g., PRA, PHA, FMEA, HAZOP, and QRA). Each tool or technique can prevent the transformation of hazard events to accidents by design improvements.

In the designing of chemical processes, the specification of equipments is important to ensure no leakage to the external environment. The basis for setting safety limits for equipments are defined by intrinsic safety of the equipment, operation control within reasonable standards, and the process critical variables with little dispersion.

The history of the chemical industry [1, 2] demonstrates that most of the flaws in the production are of human nature, and the loss of reliability in these types of companies produces fatalities and investment loss. Thus, the management of a chemical industrial activity requires efforts to improve human reliability.

The HAZOP study allows a discussion by specialists, together in a meeting, where, the number and the quality of these professionals vary depending on the type of equipment, instrument, or operation. A good discussion is made in the HAZOP study about the controls required for operability of industrial plants and including manual controls and operations that depend on human vigilance in the field and on the panel. The failure analysis indicated by the HAZOP discusses lightly human factors considering that the man may fail on the procedure or in the perception of the alarm. The best recommendations indicate necessity for reviewing procedures, worker training, and automation of process. So, classic HAZOP does not discuss aspects related to cognitive processing and the commitment of the operator in carrying out its task; this is a limitation of the HAZOP in operations.

The studies of operability and risk assessment in the chemical industry, with the HAZOP technique has grown over time and has been required by government environmental control around the world [3]. The application of HAZOP methodology [4], with specific focus for the assessment of human error, can be of fundamental importance to the real increase in the industrial reliability, and thus in the search for operational excellence.

There are many techniques for likelihood estimation in human error, subject most complex, requiring highly specialized specialist for its application. All require at first, the characterization "of what can be done wrong" in a given task. The human role is discussed in industrial accidents [5] but human error is not discussed.

Man is considered, by the resilience engineering, the most important factor of the process and can, through their creativity, keep operability of systems although, the automatic control instruments are not working well. So when the employee is committed to the goal of the task is possible to keep personal and environmental safety, thus reducing the risk of process and operational risks.

The main human error in chemical industries is the omission [1,6] caused by slips or memory lack. These cognitive traps are caused by: (a) tasks with high load of information affecting memory; (b) step barely visible or inaccurate; (c) weak or ambiguous signals initiates steps; (d) steps functionally isolated from others; (e) steps to follow, after reaching the main goal of the task (attention); (f) steps that are repeated and there may be minor adjustments unnoticed; (g) change in routine, take steps leading to earlier; and (h) steps that follow after unexpected interruptions.

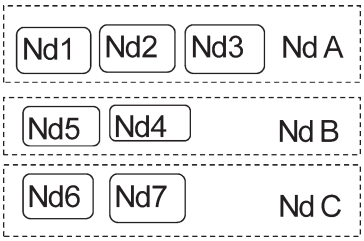

Figure 1. Technical and social nodes.

The Social HAZOP (SH) in a systemic view understands all the agents inside the failure, including equipment, instruments, and people, who develop, operate, modify, and, improve organizations. This article: discusses aspects about human error nature [7]; shows a case of technical performance applied in a refining process; determines actions to reduce the assessed risks; and review the cognitive aspects.

THE SOCIAL HAZOP METHODOLOGY

SH is performed only if there are risks that can cause loss control in the equipments and in the processes. The SH initiates after classic HAZOP is done. Another important feature is that the analysis of Technical HAZOP (TH) about equipment and processes while the SH is about people who control the operations of equipments and processes. SH involves the analysis of behavior based on observation of discourse of the participants in the risk analysis.

In Figure 1, it is indicated that the technical nodes 1 to 3 are controlled by social group, or social node A, that the technical nodes from 4 to 5 are handled by social node B, technical nodes 6 and 7 are handled by social node C. The SH methodology is divided by planning, classification of items, study of deviations, and actions of recommendation, which are showed in Figure 2.

The planning steps include: (1o) integration of technical hazards in the operations, as possibilities of product leakage from equipments and the impact to people, nature, and patrimony; (2o) choice of specialist to study cognitive processing, projects, and social items; and (3o) establish social nodes or people involved in the maintenance of the systems by TH.

The classification steps are: (4o/5o) analysis of human and social factors that can trigger the SH study. This classification is a result from comparison between ideal standards suggested by team and real measurements discussed by team opinion. The factors that may cause human error are classified as: sufficient level of competence; reliability in direct and contractor management; appropriate organizational environment; appropriate technology; psychological quality of staff and operators; and task planed/performed properly. For each of these types of factors are established criteria for the HAZOP study. The decision (6o) of items to be studied depends on the difference between expected standard and real behavior. This analysis may be changed after opinion of present specialists.

The choice items can be analyzed (7o) by SH when including keywords to change normal situation. Recommendations of SH indicate corrective action or preventive action as: training needs, review of standards, review the signs that indicate a failure process, and, control and automation for the operation of equipment. Some other SH recommendations innovate with the following suggestions: changing communication tools; management action in case of very high stress; symbiotic relationship between the company and contracted; allocation analysis; psychological quality of worker; and other recommendations.

THE APPLICATION OF THE SH METHODOLOGY IN AN OIL REFINERY

Integration of SH and TH

The process stream after oil desalination goes to the fractional distillation. The stream of fractional distillation is sent to the vacuum distillation that is separated in two phases, water and gas in the top. The instrumentation studied in the TH tries to control the level of the boot [level valve (LV) of V48] and the operation context has some risky properties (inflammability, high pressure, LPG contents).

TH indicated that the main causes for lower level are: control valve and/or transmission failure; inadequate opening of LV bypass; and undue opening of manual valve at drain system. The technical recommendations are not sufficient to avoid improper opening of bypass of valve (LV) and undue opening of manual valve to drain system. Human errors [7] happen independent of the presence of technical safeguards.

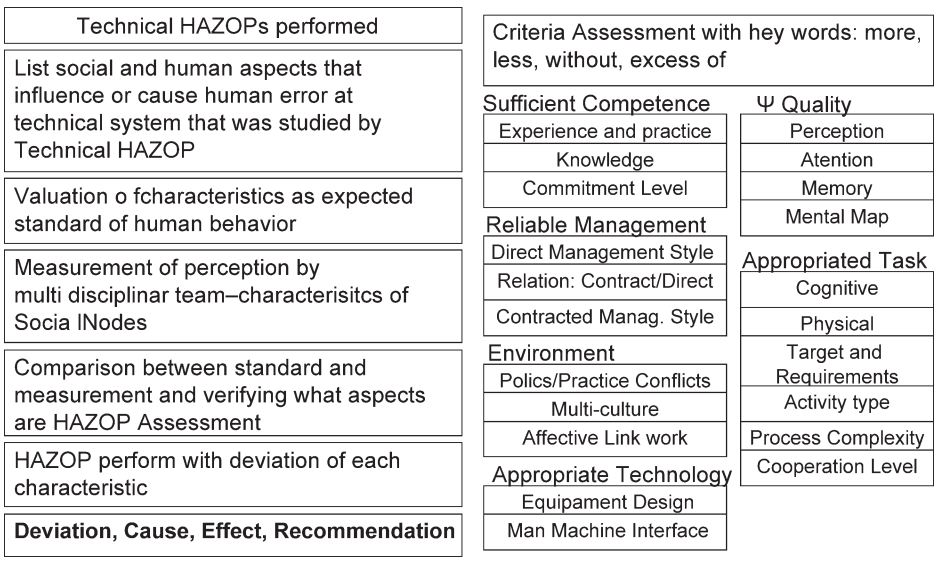

Figure 2. Steps of SH and social processes assessed.

Table 1. Characteristics or human factors

	Characteristics or Human Factors		Stand	Measure	HAZOP (Y/N)
A1	Sufficient	Practice and experience	4	4	NO
A2	Competence	Knowledge	3	3	NO
A3		Commitment level	3	2	**YES***
B1	Reliable	Direct manager style	3	2	**YES***
B2	Management	Multifunctional team	3	2	YES
B3		Relation contracted/direct	2	3	YES
B4		Contracted manager style	3	1	**YES***
C1	Psychological quality	Sense perception	3	2	YES
C2		Attention	4	2	**YES***
C3		Memory	4	4	NO
C4		Mental map	4	3	YES
D1	Environment	Politic and practice conflict	NA	NA	**YES***
D2		Multi regional culture	NA	NA	**YES***
D3		Job affective link	NA	NA	NO
E1	Appropriated	Equipment design	3	2	YES
E2	Technology	Man Machine interface	3	3	NO
F1	Appropriated	Cognitive effort	2	2	NO
F2	Task	Physical effort	2	3	NO
F3		Requirement/target task	2	2	NO
F4		Activity type	2	3	NO
F5		Process complexity	2	2	NO
F6		Cooperation level	3	2	**YES***

YES* most important between chosen characteristics.

Establishing the Specialties to Compose SH and Identifying Social Nodes

In the case of LPG leakage to the atmosphere, there is a great possibility of fire in pool with financial losses, burned people, and fatalities. Then this risk analysis needs technical and social functions participating. The social node is field operator who performs activities and panel operators in this technical area (10 workers).

Social and Human Standards and Measured Values and Decisions

The human factors analyzed by the SH if adjusted can change operation performance (LV of V48). The priority is defined based on highest differences between desired situation (we need) and measured situation (we have). Another form to define priority is subjective concerns of the specialists. In Table 1, a classification is done in the beginning of HAZOP study.

Knowledge

A1. Experience and practice: Impact of accident over healthy worker requires high level of expertise. The team has sufficient experience in this kind of task. NO. A2. Knowledge: There is not much complexity to perform this task. The team has sufficient knowledge. NO. A3. Level of commitment: The operation must be highly committed to prioritize effort in the task. However, the commitment of the team is variable due to new challenges of production. YES.

Reliable management

B1. Style of Direct Manager: The manager must know about the risks and must win the team confidence through delegation. But this profile owner is not aware about the risks. YES. B2. The team is cross-functional: The manager is able to manage different types of people and know how to manage cross-functional teams. However, in fact, managers are not trained properly for multifunctionality. YES, but it is not very important! NO! B3. Relationship between the number of workers contracted and the number of employees of the company: if the ratio exceeds 2, the item is analyzed. YES but not very important! NO. B4. Contractor Manager Style: We need contracted company managers who know the risks and win the confidence of the team. However, we have: managers who are not trained properly for multifunctionality, do not know properly the risks involved, and do not know how to establish the commitment. YES.

Psychological quality of worker

C1. Perception: We need to accomplish the task at field. A good standard of visual, auditory, and olfactory perceptions are expected. But the perception of staff is not satisfactory. People are very self-confident. YES but not very important! NO! C2. Attention: We need from good to high attention; the group discusses and changes their requirements to attention: from 3 to 4. We have: a team that has unsatisfactory level of attention to the risks. YES. C3. Memory: The group considers that forgetting is serious flaw in V48 activities. We have: a team that has a good working memory. NO. C4. Mental map: We need clear mental map. We have a team that has not got a good mental map. YES but not very important! NO!

Natural and organizational environment

The SH specialists confirm the conflict between policy and practice. There are workers from different regions. Workers need inclusion and justice sense. There are difficulties with several codes of language. Conflict politic & practice—YES. Multiregional culture—YES. Bad job affective relation—NO.

Appropriate technology

E1. Equipment Project: We need control technologies that reduce complexities in the task. We have: The lack of

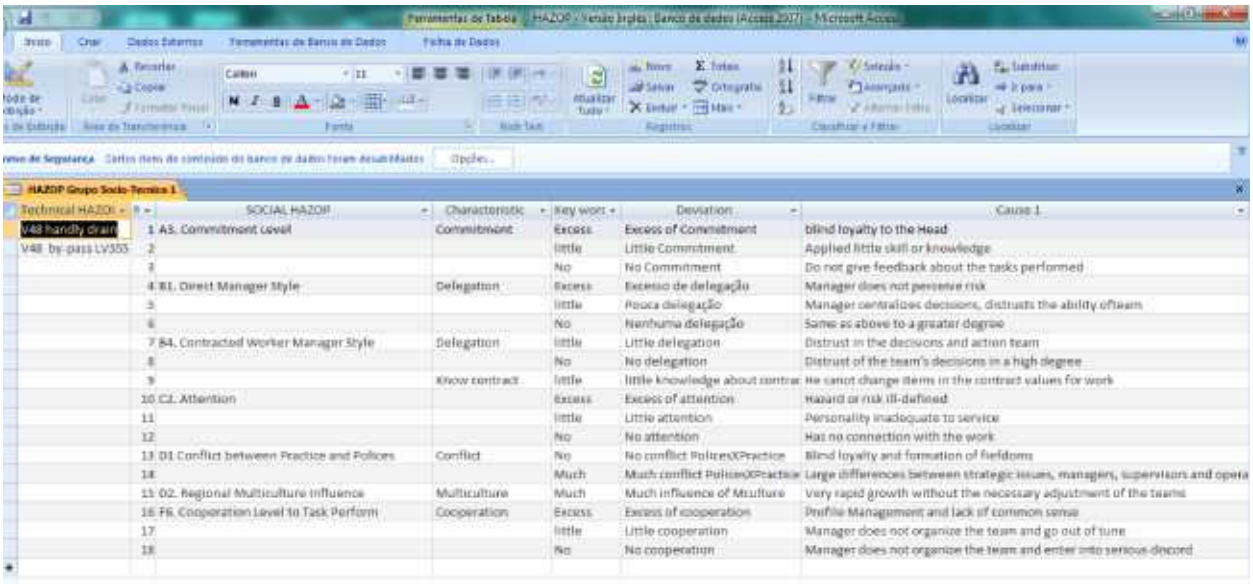

Figure 3. Access example of application. [Color figure can be viewed in the online issue, which is available at **wileyonlinelibrary.com**.]

knowledge and difficulties of communication giving poor projects. YES but not very important! NO! E2. Man–machine Interface (MMI): We need a good alarm management. We have MMI project that meets expectations. NO.

Appropriate task

F1. Cognitive Effort: We need average and have medium capacity cognitive effort. NO. F2. Physical Effort: We need medium and we have good ability physical efforts. NO. F3. Goals and Requirements: We have simple plans with no necessity of auxiliary memory. We have medium capacity to meet goals and establish requirements. NO. F4. Type of activity: This is an activity of search and action with simple model for decision, and, we have good competencies to these activities. NO. F5. Complexity of the Process: We need low complexity and we have medium ability to understand complex processes. NO. F6. Level of cooperation: We need the operator of panel attuned with the field operator. We have medium level of cooperation. YES.

Social Processes Deviation Assessment

Studying speeches

Some symbolic speeches are observed from staff and managers. These discussions treat about some emergent sensations or actions from the social, technical, and human aspects. As example a repetitive speech is "Let's be careful to do not shoot yourself in the foot!"

Access, software application

Using this software it is possible to do HAZOP evaluation. The study is done in seven characteristics in a total of 18 deviations of these characteristics. The study includes their causes, their consequences/impacts, and a discussion about corrective and preventive actions. The keywords used to construct deviations are: excess, little, no, and much (Figure 3).

The cause assessment after SH study indicates important subjects to avoid human error: managerial subjects; psychological items; task and team aspects; technological environment; and economic environment. The principal managerial aspect discussed was the excess of centralization in the manager profile causing blind loyalty and difficulties in read the different cultural codes of language. The psychological subjects are: personality type, and tasks demanded; the needed speed for adjustment of worker profile; and the differences in risk perception. When discussing in cause assessment we found aspects about task and team: parallel activities; low quality of communication; and vices at team. In the technology and economic environment: inadequate focal point, unknown technology, conflict between production and safety, and the market demands with high speed changes to treat cash difficulties.

The consequence assessment after SH indicate these priorities to be investigated: worker, task planning, task execution, team and cooperation, manager's profile, skills, competences, perception to hazard, and the history of failure. When discussing about the team, workers have the habit to think criticality loss about risk and do not think about general context. Important characteristics to be discussed are: the task execution by habituation; give up easily of the goals; fix attention on unique point; neglect in the steps of activities; and high stress causing fatigue.

The consequence assessment treats about task planning (little commitment with targets) and task execution (no questions, tacit agreements in the field and forgetting certain details of the task). When discussing the team: lack of commitment of employees towards the goals, state of distrust of leaders, unsafe situations, excessive self-reliance, doubt in the decision, low productivity in the team by poor cooperation, and lack of harmony.

The excess of cooperation can cause inertia (no competition). The lack of cooperation causes poor communication. The managers must prioritize to analyze the phenomenon of the worker isolation or exclusion of worker out from the team. The skills and competences are aspects to be studied: lack or excess of skill and competence to the job, loss of risk perception, and loss of awareness of skills at team. Some characteristics were found in the perception to hazard (false sense of safety).

Recommendations of SH

The recommendation to avoids cause, or mitigate consequences, defines a program of action applied in different times (short, medium, long, and very long) with different ways (intermittent, task force, continuous). The principal actions in the corrective and preventive program are divided in several subjects: policies, people, management, leadership, team, stress, risks, and root-cause investigation. These actions follow proposed techniques in strategic, managerial, and operational levels as: Team Profile Assessment, Punishment (Consequence) policy, Ambience Review, Selection workers based on Decision, and Review behavior and decisions to quick development.

CONCLUSION

This tool adds human factors as one of the criteria to analyze about the expectations of intrinsic safety project and process safety, and if they are superior when comparing with a standard. The social aspects bring the view that it is possible to override the chance of accident.

SH can assist in the identification and treatment of social and human factors that have caused damage to the development of these processes or have brought some type of risk to the production, in chemical, petrochemical, petroleum, etc.

The work showed the possibility of application of the SH in the chemical/petroleum industry and can give a kick-off for use in other industries. The procedure was used throughout the classic HAZOP, developed for equipment and operation, with application of HAZOP Social developed for those that operates the equipment evaluating operability.

It was observed that the hazards in the activities of chemical and refine industry depends more on the experience of the staff responsible for them than for any equipment [8]. This implies a need for greater commitment by employees performing the task than the failure modes of procedures executed by operators.

LITERATURE CITED

1. M. Llory, Acidentes Industriais: O Custo do Silêncio. Rio de Janeiro: Multimais, 1999.
2. J.M. Ramiro and P.A. Braña, Análisis y Reducción de Riesgos en La Industria Química. Fundación MAPFRE, Madri.
3. R.R. Serpa, Estudos de análise de risco e o licenciamento ambiental: gerência de risco e seguros. Revista Gerencia de Riesgos y Seguros, Madrid, a. 24, n. 98 (2007), 78–82.
4. J.L. Alves, A técnica HAZOP, como ferramenta de aquisição de dados para avaliação da confiabilidade humana na indústria química, 1997. Mestrado em Qualidade. UNICAMP.
5. T. Kletz, Hazop and Hazan, Identifying and Assessing Process Industry Hazards, 3rd ed, Instutition of Chemical Engineers, Chapter 2, 1992.
6. I.M. Almeida and M.C.P. Binder, Cognitive traps: the case of omission in the genesis of work-related accidents. Cad. Saúde Pública, Rio de Janeiro 20 (2004), 1373–1378.
7. D.K. Lorenzo, (1994). Um guia do gerente para redução de erros humanos: melhorando o desempenho humano nos processos industriais. Washington, DC: EQE, International INC., 2001.
8. D.P. Barbosa, D.F. Harguenauer. A influência do fator humano nos cenários acidentais de uma refinaria de petróleo. V Congresso Nacional de Excelência em Gestão. Niterói, 2009. Disponível em: **http://www.excelenciaemgestao.org/Portals/2/documents/cneg5/anais/T8_0152_0769.pdf**. Acesso em: 14 de jan. 2012.