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# Assessment of Perception of Management Related to Safety in Flammable and Combustible Liquid Storage Terminals

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The consequence of accidents in the industry can be more severe than in others economic sectors. Chemical industry, or other similar facilities involving production, storage, processing and handling of reactive and unstable substances, requires a deeper focus on prevention and protection of equipment, persons, and environment. Brazil, in particular, has several storage and handling terminals which can be classified as terrestrial or waterway. In these terminals, tank farms containing liquids subject to ignition and fire comprise a huge quantity of equipment of storage that requires maintenance and inspection for assurance of their physical integrity and accessories thereof, which could fail. In this work, it is presented techniques for social research for assessment of safety perception of workers of storage terminals, and the survey submitted by e-mail, using a 5 points Likert scale. The research was based on Operational Safety Management System guidelines of ANP (Petroleum, Gas and Bio-fuels National Agency), which is numbered as Resolution #5/2014. It is important to highlight that the cited resolution is directed to oil refineries but could be used as reference to such work. In brief, the results of the survey application shows a high perception of safety by the group of managers, followed by health, safety and environment, HSE professionals, maintenance, operation and, then, administrative. It also shows the importance of training for operational safety improvement in this type of industry.

## 1. Introduction

The occurrence of industrial accidents can produce consequences and impact on companies, bringing losses to production, business profits, people safety, company image and environment. Industrial accidents can be caused, for example, by natural factors (Necci et al., 2014).
Amongst factors related to production, on which are based the strategies of competitive companies, maintenance has a considerable importance due to guaranty of reliability and availability of systems (Faccio et al., 2014).Thus, the focus on loss prevention is important to daily activities of an industry. A systematic program of maintenance contributes for loss reduction, but it will only be effective if it is established within a strong training program (De Martini Júnior, Figueiredo and Gusmão, 2005, cap 3).
In a workplace where professionals are instructed in risks identification for hazards situations, the emergency response can be more effective and the number of incidents and its severity can also be reduced (AIChE, 2003). The occurrence of accidents in oil and derivative facilities, with flammable and combustible products, as the one that happened in Buncefield in 2005 (Gant and Atkinson, 2011), (Atkinson et al., 2015), causing reverberating impacts on economic and environmental aspects in which people are victims, justifies studies and reflections about this theme. Although the detrimental consequences thereof, it is still not an academic or professional common topic, even being immediately and massively reported by the media. (Argyropoulos et al., 2012). The evaluation of risks of fire in storage tank farms in refineries enables improved prevention measures and enhances the safety and operational reliability (Zhao, Li, Bai, 2017).
Studies show the application of safety operational methodology and fire risk evaluation at large atmospheric storage tanks. The main events are fire in seal, leakage in roof followed by fire, fire at full liquid surface and fire at containment dam (Crippa et al., 2009).

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The event of fire in a terminal of storage of combustible liquids in a company located at port of Santos, Brazil, shows that disasters can last for days before it is extinguished, and that it shall be considered an adequate preparation to prevent occurrences, monitoring risks conditions and fight during emergency situations (Folha de São Paulo, 2015).

Cheker et al. (2015) studied the influence of uncertainty in the assessment of piping internal roughness in water firefighting systems, giving important contribution to maintenance of these systems.

The regulation and surveillance of economic activity of petroleum, derivatives, natural gas and bio-fuels are held by Brazilian National Agency of Petroleum and Bio-fuels, ANP. By the publication of resolutions, it is established technical, economic and legal requirements that authorized companies to operate in this activity must comply with. Hence, in 2014, this surveillance authority established criteria to implementation and operation of Management System of Operational Safety, SGSO, to petroleum refineries, in a similar way as previously established, in 2007, when applied a SGSO to Drilling and Production Installation of oil and natural gas (ANP, 2014).

Brazil has tens storage and handling terminals that can be classified as terrestrial and waterways. The following table considers only combustible liquids, ethanol, bio-fuels, lubes, vegetable oils, petrochemicals, corrosive and caustics. The sum of tanks from studied companies are a total of 1,649 in the performed sampling, that not ends here, because there are terminal operating companies that were not considered, because the information was not available on companies websites listed at Brazilian Association of Terminals of Liquids, ABTL (ABTL, 2016), and shown in Table 1.

In addition, there are tanks of storage of liquefied gases from petroleum, inside refineries, petrochemical plants, bio-fuels plants, retailing and distributing fuels tank farms and companies. The facilities and pieces of equipment, with their accessories and operational instruments, need be inspected and maintained, so as to assure the reliability of operational conditions and safety.

The location of these terminals are predominant at southeast region of the country, due to industrial development, economic and social growing of this region, what rendered such region the most economically influent in the country. The Brazil's southeast region concentrates 32 terminals in 4 states of federation, while the south region concentrate 12 terminals in 3 states of federation and the northeast region follow ones with 16 terminals in 9 states of federation, according to context of data collection.

*Table 1: Liquid terminals in operation in Brazil.*

| Company | Terminals Quantity | Tanks Quantity | Capacity ($m^3$) |
|---|---|---|---|
| A | 49 | 505 | 10,011,648 |
| B | 1 | 76 | 104,800 |
| C | 2 | 142 | 309,819 |
| D | 3 | 97 | 376,000 |
| E | 4 | 172 | 241,120 |
| F | 1 | 23 | 69,949 |
| G | 1 | 89 | 133,725 |
| H | 6 | 376 | 838,451 |
| I | 2 | 54 | 56,524 |
| J | 1 | 112 | 159,817 |

The distribution of terminals coincides with the process of industrialization that occurred in the country. As a factor of economic development, the industrialization can be associated with energetic consuming growing, that justifies the increasing of fuel consuming and the decision of companies to invest in potential consumers markets of their products (Cherniwchan, 2012), (Szirmai, 2012).

## 2. Discussion

Likert scale is largely used in social research studies due to its simplicity and ease data analysis. However, can the Likert scale be considerate an interval scale?

This question of high importance involves the type of method associated with subsequent data treatment. The Likert scale has ordering character, than it is ordinal, at least. Nevertheless, it can be also considered an interval, if the measured options were equally spaced in a continuous and linear concordance level of affirmative scale.

The literature is divided about its use, having several authors that attack the use of Likert scale as interval, while lots of others defend its interpretation as interval. Jamieson (2004) defends that there are no arguments

that support the Likert scale as interval, and because it is ordinal, non-parametric tests can be used to valid results, only.

Murray (2013) Apud Carifio e Perla (2008) highlight that the ordinal point of view of Likert scale does not consider the abundance of empiric research that have supported intervals visions, and is perfectly correct use totalized scales to conduct parametric experiments.

Harpe (2015) talks about previous studies showing change of level of measurement, from ordinal to interval, or the change of distances between categories in ordinal measurements are relatively without of importance.

Harpe (2015) Apud Stevens (1946), says, concerning statistics point of view, that an interval level of measurements is suggested. Instead of analyzing the items individually, the Likert scale combine individual items by summarizing or using the arithmetic mean. Using the sum or the mean of a group of items, the Likert scale can be an interval level measure, according to the measurement framework of Stevens.

Once again, according to Harpe (2015), since the measurement framework has been proposed by Stevens, the controversy about its uses lasts. A large variety of studies has been conducted on examination the statistical properties form data of summarized scales and individual items with diversified values. Nevertheless, general agreements are that the use of parametric statistical methods for data analysis is potentially appropriate. The following Table 2 show some studies using Likert scale.

*Table 2: Published safety and risk related studies using Likert scale.*

| Authors | Field of study | Technic | Scale | Answers | Analysis |
|---|---|---|---|---|---|
| Harpe (2015) | Teaching (Pharmacy) | Review | Likert (5 points) | - | ANOVA, T-test, |
| Murray (2013) | Teaching (Business and Management) | Survey | Likert (5 points) | 111 | Pearson Correlation, Spearman Correlation, Kendall tau_b |
| Gittleman et al. (2010) | Civil construction, safety development | Survey | Likert (6 points) | 1,219 of 5,268 | ANOVA, T-test, Multivariate Analysis |
| Hendricks, Jordaan, Lambert (2012) | Sportive Medicine, injury prevention | Survey | Likert (5 points) | 164 of 220 | ANOVA, T-test |
| Sprung, Britton (2016) | Safety, behaviour and motivation | Survey | Likert (5 points) | 434 | Chi-square, Pearson Correlation |
| Boccara et al (2011) | Traffic (Instruction), Risk Perception | Survey | Likert (7 points) | 150 | ANCOVA, Chi-square, Pearson Correlation |
| Bellet, Banet (2012) | Traffic, hazards identification | Experiments (Short videos) | Likert (0-100%) | 48 | ANOVA |
| Paschold, Sergeev (2009) | Occupacional Health (Whole body vibration on industries sector) | Survey | Likert (5 points) | 2,764 of 21,292 | Mean, Standard Deviation |
| Håvold et al. (2015) | Naval Offshore (Human Factors) | Survey | Likert (7 points) | 369 of 500 | ANOVA, Linear Regression |

From studies shown in Table 2, follow two that are depicted for better understanding.

Bellet and Banet (2012) in the study about evaluation of criticality of situational ability of motorcyclists, used Likert scale without graduation, being the non-existent critically the value zero, and the highest criticality the value 100%. The decision was taken to collect the situational criticality as a dependent variable in form of continuous values from 0 to 100, that are required to statistical analysis based on non-parametric tests, in contrast to discret variables collected with graduated scale.

Hendricks, Jordaan and Lambert (2012) in the study about attitudes and behaviour of juniors players from union of rugby, due to the competitiveness during training and games, used the follow Likert scale of five points: to evaluate the importance level of attitude of players (1 = without importance, 2 = few importance, 3 = neutral, 4 = some importance, 5 = importance) to measure the training frequency (1 = never, 2= rarely, 3 = sometimes, 4 = frequently, 5 = ever). The Likert scale used show regular intervals of value equal 1.

This study used Likert scale with 5 points (1 = Full Disagree, 2 = Partial Disagree, 3 = Neither Disagree nor Agree, 4 = Partial Agree, 5 = Full Agree), admitting that one could be considered interval.
The next table show some related studies, whatever were used the Likert scale. A large number of evaluations have relations with safety or risk perception.
Otherwise, in recent years, the number of publications about this theme has increased. However, the ones about safety evaluations are still not enough, justifying this study.
The general consensus is that uses of parametric statistics tests are potentially appropriate to analyze data form scales of measurements (Harpe, 2015).
There are objective evidences that justify the robust of parametric statistical tests for data collected by Likert scale, even with small size sampling and non-normal distribution (Wadgave e Khairnar, 2016).

## 3. Methodology

Based on references, the authors opted for the application of a survey that was submitted to workforce that work in industrial segment of flammable and combustible storage liquids. The goals were that each question was answered according to the perception of importance to be attributed by participants.
The survey was applied from 2016/20/12 to 2017/06/01, by email with a link to participant access and answer questions. The system used allowed that at deadline, the results were exported to a spreadsheet from Excel ©.
Were distributed 1,464 e-mails, corresponding at sum of own workforce from 28 consulted terminals, among 70 terminals showed at Table 1. The selection of terminals was done in accordance with the location, in the way to be presented installation at all geographic regions from country, according to the distribution of terminals, due to pursuit the proportion of quantity of terminals among the number of terminals per regions and the number of workforce by regions.
The survey was generated based on a legal resolution for industrial systems, the ANP Resolution #5/2014, that establishes practices to management for the SGSO in refineries of petroleum, being adopted to elaborate the survey in this study. For terminals, there are no dedicated resolution issued by ANP yet, to treat about SGSO, but, due to similarity between terminals and activities of storage and handling in refineries, such resolution could be used. ANP Resolution #5/2014 establishes sixteen practices of management for refineries that possess within their activities of handling petroleum and derivatives (ANP, 2014) in three groups:
Group 1: Workplace and functions of workforce, Chapter 2 from Resolution (Safety culture, Leadership commitment; Personal involving; Qualification, training and personal performance; Workplace and human factors; Selection, control and management of contracted companies; Assessment and continuous increasing performance; Audit; Information management and documentation; Accident investigation).
Group 2: Technology and installation, Chapter 3 from Resolution (Operational safety critical elements; Risks identification and analysis; Mechanical integrity; Planning and management of large emergencies).
Group 3: Operational practices, Chapter 4 from Resolution (Operational procedures; Management of change; Work safety practices and procedures for control of special activities).
The questions (in number of third one) of Survey were divided for each group 1 (twelve questions), 2 (ten ones) and 3 (nine ones). The Survey was answered by following workforce classes:

- Management, Coordination and Supervision (GCS);
- Operation and Production (OP);
- Maintenance (MAN);
- Safety, Environmental and Health (SMS);
- Administrative and Others (AO).

AO is composed by workforce from support activities as human resources, accounting, finance, information technology, and others.
The answers were analyzed by Pearson Correlation, a method of linear dependency of two random variables, $X_{c_m}$ e $X_{c_n}$. The coefficient may vary from -1 to 1, and if positive means that one variable is direct related with other, while if negative means that one is inverse related with other. It is the most used to evaluate these variables. (Zhou et al., 2016). By definition, the Pearson Coefficient of two variables X e Y is the covariance from two variables divided by its standards deviation products.

## 4. Results

At the end, 244 responses were received. According to the answers, the number of respondents for classes of workforce can be represented by following relation:

$$SMS \approx \frac{AO}{2} \approx \frac{GCS}{2} \approx \frac{OP}{4} \approx \frac{MAN}{4}$$

The analysis by Pearson Coefficients amongst classes, are indicated at Table 3. The classes GCS and SMS are more strongly related than others. In the other hand, classes OP and AO shows inverse relations with GCS and SMS. The class MAN didn't show correlation with others.

*Table 3: Pearson Correlation for average of answers.*

| Classes | OP | MAN | SMS | AO |
|---|---|---|---|---|
| **GCS** | -0.81 | 0.01 | 0.71 | -0.83 |
| **OP** | | -0.07 | -0.81 | 0.66 |
| **MAN** | | | -0.37 | 0.12 |
| **SMS** | | | | -0.84 |

## 5. Conclusions

This analysis shows that there are different perceptions related to safety among classes of employees that form workforce in companies that operates Brazilian Terminals of Storage, Handling and Expedition of liquids flammable and combustible.

Even having being supported by a Brazilian National Petroleum and Biofuels Agency regulatory decree for refineries, the application of basis of decree due to build a survey for employees of operators of Terminals, the results could be analyzed and some conclusions can be assumed.

First of all, there are differences amongst classes of workers as shown before.

Secondly, companies must implement training in operational and industrial safety procedures to increase process safety and to prevent losses.

Finally, this study suggests the need to implement procedures for operational practices, improving training, and to increase preventive maintenance in order to avoid the occurrence of hazard events.

Thus, it is recommend Regulatory Authority to issue specific rules for Terminals, to compel companies to establish internal HSE politics and technical guidelines to reduce losses and to keep welfare of workers, continuity of operations and social responsibility, assuring combustible supply for community wherein operates and promotes local development.

### References


ABTL. Associação Brasileira de Terminais de Líquidos. <http://www.abtl.org.br>. Accessed 28.02.2016.

AIChE. 2003, Guidelines for Fire Protection in Chemical, Petrochemical, and Hydrocarbon Processing Facilities. 1 ed. AIChE, New York, USA.

Argyropoulos, C. D.; Christolis, M. N.; Nivolianatou, Z.; Markatos, N. C., 2012, A hazards assessment methodology for large liquid hydrocarbon fuel tanks. Journal of Loss Prevention in the Process Industries, 25, 329-335.

Atkinson, G.; Coldrick, S.; Gant, S. Cusco, L., 2015, Flammable vapour cloud generation from overfilling tanks: Learning the lessons from Buncefield. Journal of Loss Prevention in the Process Industries, 35, 329-328.

Bellet, T. Banet, A., 2012, Towards a conceptual model of motorcyclists' Risk Awareness: A comparative study of riding experience effect on hazard detection and situational criticality assessment. Accident Analysis and Prevention, 49, 154-164.

Boccara, V.; Delhomme, P.; Vidal-Gomel, C.; Rogalski, J., 2011, Time course of driving-skill self-assessments during French driver training. Accident Analysis and Prevention, 43, 241-246.

Brasil. Agência Nacional de Petróleo, Gás Natural e Biocombustíveis. Resolução n° 5, de 29 de janeiro de 2014. Aprova o Regulamento Técnico do Sistema de Gestão de Segurança Operacional para Refinarias de Petróleo. Diário Oficial da União, Brasília, DF, 30.01.2014. Seção 1, 103-106.

Carifio, J.; Perla, R., 2008 Resolving the 50-year debate around using and misusing Likert scales. Med. Educ. 42, 1150–1152, Apud Jamielson, S., 2004, Likert scales: how to (ab)use them. Medical Education, 38, 1212-1218.

Cheker, D. C. R. S.; Freitas, J. S.; Braga, E. R.; Nascimento, G. S. Q. H. Análise de incerteza na obtenção do fator C da equação de Hazen-Williams na avaliação de linhas de sistema de combate a incêndio. In: Congresso Internacional da Abrisco, 2., 2015, Rio de Janeiro.

Cherniwchan, J., 2012, Economic growth, industrialization, and the environment. Resource and Energy Economics, 34, 442-467.

Crippa, C.; Fiorentini, L; Rossini, V.; Stefanelli, R.; Tafaro, S.; Marchi, M., 2009, Fire risk management system for safe operation of large atmospheric storage tanks. Journal of Loss Prevention in the Process Industries. 22, 574-581.

De Martini Júnior, L. C.; Figueiredo, M. A. G.; Gusmão, A. C. F., 2005, Redução de resíduos industriais: como produzir mais com menos. 1. ed. Aquarius, Rio de Janeiro, Brazil.

Faccio, M.; Persona, A.; Sgarbossa, F.; Zanin, G., 2014, Industrial maintenance policy development: A quantitative framework. Int. J. Production Economics, 147, 85-93.

Freitas, J. S., 2017, Avaliação da percepção da gestão relacionada à segurança em terminais de armazenamento de líquidos inflamáveis e combustíveis, MSc Dissertation, Rio de Janeiro State University, Institute of Chemistry, Rio de Janeiro, Brazil.

Folha de São Paulo. Jornal diário. Edição digital 14 de abril de 2015. <http://www1.folha.uol.com.br/cotidiano/2015/04/1616201-sindicato-indicou-falhas-na-ultracargo-7-meses-antes-de-incendio-em-santos.shtml>. Accessed 29.06.2016.

Gant, S.; Atkinson, G. T., 2011, Dispersion of the vapour cloud in the Buncefield Incident. Process Safety and Environment Protection, 89, 391-403.

Gittleman, J. L.; Gardner, P. C.; Haile, E.; Sampson, J. M.; Cigularov, K. P.; Ermann, E. D.; Stafford, P.; Chen, P. Y., 2010, [Case Study] CityCenter and Cosmopolitan Construction Projects, Las Vegas, Nevada: Lessons learned from the use of multiple sources and mixed methods in a safety needs assessment. Journal of Safety Research, 21, 263-281.

Harpe, S. E., 2015, How to analyze Likert and other rating scale data. Currents in Pharmacy Teaching and Learning, 7, 836-850.

Håvold, J. I.; Nistad, S.; Skiri, A.; Ødegråd, A., 2015, The human factor and simulator training for offshore anchor handling operators. Safety Science, 75, 136-145.

Hendricks, S.; Jordaan, E.; Lambert, M., 2012, Attitude and behaviour of junior rugby union players towards tackling during training and match play. Safety Science, 50, 266-284.

Jamieson, S., 2004, Likert scales: how to (ab)use them. Medical Education, 38, 1212-1218.

Murrat, J., 2013, Likert data: What to use, parametric or non-parametric data? International Journal of Business and Social Science. 4, 258-264.

Necci, A.; Argenti, F.; Landucci, G.; Cozzani, V., 2014, Accidents scenarios triggered by lightning strike on atmospheric storage tanks. Reliability Engineering and System Safety, 127, 30-46.

Paschold, H. W.; Sergeev, A. V., 2009, Whole-body vibration knowledge survey of U.S. occupational safety and health professional. Journal of Safety Research, 40, 171-179.

Sprung, J. M.; Britton, A. R., 2016, The dyadic context of safety: An examination of safety motivation, behavior, and life satisfaction among farm couples. Safety Science, 85, 1-8.

Stevens, S. S., 1946, On the theory of scales of measurement. Science. 103, 677–680, Apud Harpe, S. E., 2015, How to analyze Likert and other rating scale data. Currents in Pharmacy Teaching and Learning, 7, 836-850.

Szirmai, A., 2012, Industrialization as an engine of growth in developing countries, 1950-2005. Structural Changing and Economic Dynamics, 23, 406-420.

Wadgave, U.; Khairnar, M .R., 2016, Parametric tests for Likert scale: For and against. Asian Journal of Psychiatry. 24, 67-68.

Zhao, J.; Li, W.; Bai, C., 2017, Risk evaluation for fire and explosion accidents in the storage tank farm of the refinery. Chemical Engineering Transactions, 62, 1345-1350.

Zhou, H.; Deng, Z.; Xia, Y.; Fu, M., 2016, A new sampling method in particle filter based on Pearson correlation coefficient. Neurocomputing. 216, 208-215.