Alarm management applied to a supervisory system: A process and its results over the activity of work.

Anderson Lima, Francisco Duarte

PEP / COPPE, Universidade Federal do Rio de Janeiro, Rio de Janeiro, BRAZIL

This study inquires the transformation achieved by the implementation of Alarm Management at the supervisory system of a LNG transfer jetty, in terms of change of the activity of work and alarm rates. Yet, it presents a brief description of the process, toward an understanding of its logics and challenges. We shown that, despites all efforts, the interventions at the system take a long time to be implemented and had little impact. Furthermore, the alarm rates vary widely over the months and the way which operators uses the system does not change. Our findings suggests that operators develops strategies to deal with the lack of proper system support; and that new ways to improve alarm systems might be developed.

Practitioner Summary: Operators seems to develop strategies to handle unfriendly systems and reach its goals. It might give the idea that changes are not necessary. However, alarm systems are object of legal obligations and corporative guidelines. Improving it in a quick and safe way would require more than the current literature offers.

Keywords: Ergonomics Work Analysis, Supervisory systems, Alarm Management

1. Introduction

Investment in industrial plants with high automation levels aims to increase the operating efficiency in several aspects. We mention as most important, specifically about plants related to natural gas transport, I) increased reliability, ii) security; and iii) autonomy of the operator. The reliability, which in time may be understood as the rate of operational availability of a system, can be improved from a higher plant capacity control, since it decreases operating deviations and thus reduces the system deterioration. Increased security is given for the same reason - the ability to access the situation, understanding of what happens globally and taking action quickly is not possible in a plant without such resources. The operator autonomy gain is generated by a control system tuned enough to require minimum periodic adjustments. This allows the control operator devote to other tasks such as monitoring and process optimization. To reinforce, investment in automation is an investment in increased efficiency. The supervisory system is the main interface of the control room operator to an automated plant. Since it works as the main access to plant control and assessment, its failure in supporting operational needs could compromise the aimed efficiency levels. One of the subsystems of the supervisory is the alarm system. (CAMPOS AND TEIXEIRA, 2008, MOKHATAB ET AL, 2014).

Poor performances from alarm systems of automated plants are associated to many major accidents in industry. Since early 90’s, a paradigm was created as a corporative solution – The Alarm management: Consisted from heuristics, philosophies and a commission of employees from operations, maintenance and management team with the objective of achieving better performance, measured by alarm metrics – numerical data, e.g. alarms per hour, percentage of critic alarms. (EEMUA, 2013, ISA, 2009)

One of the most recognized publications about alarm management, EEMUMA 191, presents benchmarks in some metrics (called as Key Performance Indicators – KPIs), relating value ranges and work condition (from manageable to overloadded), or target values. Although, the suggested values for metrics are an average consensus, and may cover any sort of plant under continuous process logics - since batch plants have a separated approach. (EEMUA, 2013)

The objective of this research is to verify the impacts of the improvement of some metrics at the activity of the control room operator, trough Ergonomic Analysis of Work. Besides, in order to comprehend how the commission executed the process was made a qualititative inquiry based on interview.
This paper follows showing how the alarm management process is conceived by the literature at the next chapter. Next, some basic concepts about natural gas offshore transport. The fourth section brings the methodological approaches used. The results are presented in two separate sections: For the Ergonomic Work Analysis and for the qualitative inquiry. Ending, the sixth section brings our discussion and conclusion for this study.

2. Alarm Management

Alarms are designed to work with control systems since its early technologies – the old DCS consoles had its lights and buzzers. Alarms usually are sounds and/or visual indications, that calls the attention of the operator. As stated EEMUA (2013), “An alarm will indicate a problem requiring operator attention, and is generally initiated by a process measurement passing a defined alarm setting as it approaches an undesirable or potentially unsafe value.”. For ISA (2009), the alarm system must notify the operator evidence of abnormal process conditions or equipment failure. The efficiency of an alarm system would be the basis of their design, implementation, operation and maintenance.

Nevertheless, with cheaper sensors and ease of configuration of computers, usually the number of alarms are overdesigned – and as the plant is used, it is possible to make the fine tune of the alarm system. This condition would be better than a design with fewer sensors and alarms, considering that further adjusts would require installations of new sensors, probably needing systems shutdowns and longer times to work.

The literature calls “Alarm management” the efforts to systematically adequate alarm systems to help operators to control the plant at optimal, or at least, safe conditions. ANSI / ISA-18.2 - Management of Alarm Systems for the Process Industries is one of the most cited papers in scholarly works on alarm management, including the EEMUA 191. The publication Management of Alarm Systems for the Process Industries bills itself as standard, and defines terminology, the design process and management of an alarm system. Major accidents, as happened at Milford Haven Refinery, Texas City Refinery and Buncefield Oil Storage Site are related to bad alarm systems designs. (EEMUA, 2013; ISA, 2009)

The overall process, as defined by ISA (2009), is represented by a lifecycle that represents all stages and its relationships. (Figure 1)
The philosophy is a group of guidelines and principles, used to guide the entire process. This document is usually applied to all plants of the same corporation.

The grayish area represents the cycle made by the alarm management commission, at local level. Begins with the identification, with determine the state and conditions of the system. It is followed by a rationalization, which identifies the changes required by philosophy. The solutions for the changes aimed are proposed at the detailed design stage. The implementation of these solutions includes, beyond physical and logical changes, alterations at documents and standards, and maybe operators training.

With the operation and maintenance routines, more changes could be proposed – as represented by the lined area, who feeds back the commission.

The overall process must be assessed by audited, in order to confirm its consistency related to the Philosophy.

From the major publications analyzed, were found no significant differences in the constitution of the alarm management as concept.

3. Natural Gas Transport

Natural gas main compound is methane (>85%), and its participation in overseas transport is increasing. Due its composition, it will not turn to liquid state by pressure, like liquid petroleum gas (LPG). In order to be transported over ships, it is cooled to -165ºC, turning to liquid. At this condition, its volume decreases at the rate of 1:600, and it is called Liquid Natural Gas (LNG). Over pipelines, it must be converted to the gas phase again, usually being compressed over 80 bar, and at temperatures over 0ºC, depending on the regional climate and humidity. At these conditions, is called Compressed Natural Gas (CNG). (MOKHATAB ET AL, 2014)

Due its extreme conditions, at each state, these operations requires robust safety standards. Even, overseas LNG transports works in global market level. As automation reduce the operational costs to about 15-30% and costs around 2 to 6% of the investment, its use is imperative to keep the asset in conditions to compete worldwide. (MOKHATAB ET AL, 2014).

4. Method

In order to access the results of the alarm management changes in the activity of work, it was made a work Analysis as described by Béguin et al. (2000), during systematic observations between September 2013 and November 2014, with 80% of the operators.

From the alarm system, alarm logs were taken from the system. Each line of the log was composed by:

1. Date and time;
2. Tag (code) of the alarm;
3. Valor of the variable (if possible);
4. Unit of the variable;
5. Type of the message;
6. Description;
7. Priority;
8. Subsystem who sent the alarm; and
9. Operator logged at the supervisory at the time.

This data were extracted after the Ergonomic Work Analysis, and related to its results.

To understand how the commission of alarm management interacted with the operations team was made a qualitative analysis based upon the framework proposed by Maxwell (2005). For that, was made an interview with two members of the Commission (Operations engineer and Maintenance engineers), focusing on how they dealt with the problems.

5. Results
5.1 EWA

The position chosen to be analyzed was the control room operator, because its intense use of the supervisory system. Usually, there are one or two field operators. There is no official hierarchy, but is normal for the control room operator to take the lead of most situations due its capacity to oversee the whole plant.

The plant studied is a jetty, which have the following features:

- Two berths. One receives a Floating Storage and Regasification Unit (FSRU) – which receives the LNG, turns into CNG and compresses to the pipeline. The other, a carrier vessel, which brings LNG to be transported to the FSRU.
- LNG Loading arms and pipelines: To transport LNG from the carrier to the FSRU
- CNG loading arms and pipelines: To transport CNG to the main pipeline.
- Nitrogen Plant Generator: For purging and blanketing pipelines

The position of the ships and the gas transfers are represented below.

The main operations of the Jetty is to transfer LNG from the carrier vessel to the RFSU vessel (full arrow); and transfer GNC from the RFSU vessel to the pipeline (dotted arrow). From these two operations, we divided each one in similar phases, as stated in the table below:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Operations</th>
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<td>LNG Transfer</td>
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Table 1 Operations phases
While a full phase of LGN transfer happens usually three times a month, the CNG transfer is constant, with disconnections usually only at the Annual maintenance shutdown.

The control room operator is supposed to monitor all operations in course, using the data provided by the supervisory system. Some operations can be done by the control room without field support. Yet, the operator have tasks that are not related to the process itself, as sending emails regarding rates and cargo quantities, filling electronic forms with ship figures and answering the telephone.

We detected that at the pre-transfer and post transfer phases, there were intense communications between the control room and the field. In addition, some alarms are only triggered these phases. The transitional nature related to those activities justifies these results.

The Alarm Management Commission was created at January, and at its first meeting two alarms were chosen to be worked, based at its high monthly rate. The alarm related to the on/off state of the gangway was removed in April´14, due definition – if one operator moves the gangway, there is no action to be taken by the control operator. However, the alarm related to the level of liquid at the knockout drum (that has a minimum and a maximum level and temperature for operating, defined by corporative standard) was not solved, due its relation with the process, something that the maintenance alone could not solve. The Commission meeting, supposed to be monthly, happened only once and until November did not happened again.

Despite the progress made, the alarms rates are still high, and the operators still cannot use it efficiently. The average hourly alarm rates per month are shown in the graphic below.

![Hourly average alarm rate graphic](attachment:image.png)

Figure 3 - Hourly average alarm rate

Was detected were no major changes at the activity, despite the alarm variations. The operators have developed strategies to overcome the lack of system support. Some of the most used and shared are:

- Increasing the size of numbers shown at the screen: in order to be visible at more places of the control room and allow some movement. It was done by opening the alarm configuration window, which shows an increase size of a focused variable – an unpremeditated use of this feature.
• Frequent checks of the process variables: As the system does not calls for operation attention for unwanted conditions, some variables are checked constantly, to avoid reaching out dangerous values.
• Sharing supervision of more complex maneuvers with the field operator: When some operation demands using more than a screen, and the field operator is available, sometimes the controls are shared. One of the motivations is to keep track of process variables.
• Estimating the rate of a variable and foresee a time to take action while in divided attention: Sometimes instead of following a variable, the operator forecasts how long it would take to reach determined value.

5.2 Commission interview
The interview indicated the major points, as bellow:
• It is difficult to schedule meetings due to the unavailability of all members of the Commission;
• Corporative procedures and alarm management corporate standard (based in ANSI/ISA 18.2 Standard) are the main source of information; and
• The Commission is due to pressure / availability / priority - as there are no people exclusively dedicated to the commission, these activities should fit in without compromise of regular daily duties.

6. Discussion and conclusion
The strategies developed only mitigate the problem. Some operators, mostly the ones that never uses before other supervisory system, at first said that the system support was good enough. As indicated by the literature at the investigation of some major accidents, alarm system bad design was an important factor, not to mention government regulations that require alarm systems. It shows that there is a need to impose some improvements, even if not characterized unanimously.
Rates are still considered high enough to opt for not using the alarms. The frequency oscillates from likely over-demanding to unacceptable, based on EEMUA benchmark, showing an inconsistency.
The commission seems to overburden its members, which need to fit these activities to their normal agenda, as we heard from them. Hence, makes more difficult to schedule meetings.
Furthermore, the alarms solved/removed by the maintenance were only those did not fit into the definition as proposed by the corporative standard (based on ISA 18.2). This would be evidence that the operation knowledge is not reaching the commission at the proper manner.
Against the expectation based on some authors (ASM, 2009; Rothenberg, 2009), the alarm removed (on/off gangway movement) did not result in a better average alarm rate. Moreover, at June, it reduced to a value never reached before. As there were no significant events as a maintenance shutdown, it indicates that some operational contexts contribute for heterogeneous behavior of the alarms composition.
These results indicate that more studies regarding metric levels and organization of the commissions could be made, regarding mainly composition of the commission and assessment of operational needs.

References
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