IBP1287_09

ALARM MANAGEMENT IN A GAS PIPELINE PLANT: A CASE STUDY

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Abstract

In order to improve the requirements of industrial processes, many decision support systems have been introduced in recent years. In this context, the alarm management systems have great relevance. On the other hand, the informatics revolution allowed a great increase of information concerning the operation of the industrial processes. Currently, process operators handle an excessive number of about 1.500 alarms per day. Thus, this overdose of information implies in the discredit of alarms. Then, in order to improve the operation activities of industrial processes, it is mandatory to incorporate procedures to evaluate and rationalize alarms. Since the EMMUA191 Standard is the reference guide to alarm management, but it does not specify how to execute an alarm management procedure, in this paper, a systematic procedure to evaluate alarms configurations in industrial processes is proposed. This procedure is in line with EMMUA191 and is composed by the following steps: i) to use statistics analyses to identify problematic alarms, such as occurrence, intermittency, correlation, and flooding calculation; ii) to indicate problematic alarm group; and iii) to propose a set of actions to be implemented. To validate our proposal, we present a case study in a gas pipeline plant using the BR-AlarmExpert software.

1. Introduction

The need to incorporate more stringent standards for emission of pollutants into the environment, waste of raw material, energy consumption and public health risks, as well as challenges in the global economy, and the development of new technologies, made the use of automation at all stages of the exploitation and transportation of flammable fuel fundamental (SIRKKA and JAMSA, 2007).

Due to the great complexity of industrial processes, the identification of all the contained states of execution becomes very difficult. It is, therefore, necessary to conduct the monitoring through a set of devices, sensors, and alarms, to be responsible, mainly, for the notification of unwanted occurrences of states in the plant (KLETZ, 2004).

Moreover, technological development experienced in the field of digital electronics has made possible the purchase of sophisticated electronic instrumentation at low cost. So, now it is common that there are hundreds of sensors installed on a single plant. In general, the deployment of these devices is based solely on intuition and prior knowledge of the employees involved in these processes and, consequently, the lack of a clearly defined procedure for the installation of sensors generates a large quantity of equipment in the long process that, by its turn, is a potential generator of alarms. The use of excessive quantity of sensing devices often has as a consequence the occurrence of events that trigger the generation of multiple simultaneous alarms which, in turn, lead to incidents that impact in a negative way in the safe operation of the plant, bringing up the costs of operation and may lead to loss of equipment and

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damage to the environment. With that comes a new challenge in the area of industrial automation which is to convert the great mass of data generated by such equipment into useful information for decision making. Thus, the rational use of devices for generating alarms became an activity of great importance both for operation and for the design of industrial processes (LEITÃO, 2008).

This challenge is best viewed when comparing the evolution of alarm systems and analyzing the problems arising from such developments. Initially, the alarm systems were composed of panels with a small number of light devices, arranged in an order that facilitated the identification of failure and possible corrective action. With the adoption of programmable electronic systems, the addition of new alarms has become a simple and low cost task, bringing a number of problems that negatively impact the performance of operators and, consequently, the operation of the plant. It is estimated today that a process operator handles an average of about 3500 alarms and/or events usually organized in tables which are not always visible or easily accessible (see Figure 1 for the evolution of the number of alarms monitored by an operator) (HABIBI, EDDIE and BILL HOLLIFIELD, 2006; LEITÃO at all, 2008).

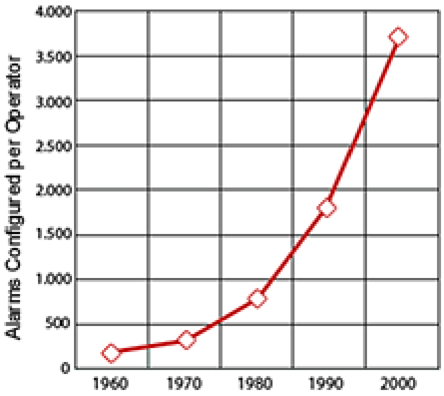

Figure 1. The increase of alarms monitored by an operator.

Consequently, many problems can be generated by the large number of alarms to which the operator is subjected, such as: flood of alarms, intermittent alarms, irrelevant alarms, and alarms with the same functionality. To demonstrate the complexity in operating some plants, an investigation in Scanraff showed that during normal operation of a plant, the average number of operator actions per hour is 3.1 via the management system (in a random week). During a disturbance in the process, the average number of actions increases to 52.8 per hour. This is almost an action per minute. The actions of the system are still held together with discussions and instructions passed via radio and telephone. This further affects the quality and performance of the operator (MATTIASSON, 1999).

Thus, to use in a rational manner the alarm management system, it is necessary to implement a formal philosophy for the joint management of alarms. In this context, this work has as main objective to present a case study of a procedure carried in TBG (*Transportadora Brasileira Gasoduto Bolívia-Brasil S.A.*) for rationalization of the alarm system, which heavily used the BR-AlarmExpert tool as support to this process.

The reminder of this article is organized as follows: in Section 2 are described the definitions, characteristics, and the cycle of an alarm management system, as well as a computational system for the management of alarms BR-AlarmExpert; in Section 3 the plant used for the case study is presented and the procedures used for the rationalization of alarms are described; in Section 4 the results obtained with the process of rationalization of the alarm system are presented; finally, in Section 5 are presented the main contributions obtained with the rationalization work and future works are identified.

2. Alarm management system

The alarm systems are an important mean for automatic monitoring of the plant, attracting the attention of the operator to significant changes in process that need evaluation or action (EEMUA, 1999). Keeping the plant within a safe range of operation, recognizing and acting to avoid dangerous situations, identifying deviations from operating conditions that could lead to financial losses, environmental pollution, and risks to the health of the population, and understanding the complex conditions of the process are the main functions of a good alarm system.

However, incidents like Three Mile Island, the explosion of the Texaco refinery in Milford Haven, and the fire in the Eurotunnel indicate that alarm systems are inefficient when subjected to a large amount of data received during a period of abnormality of the process. These facts stimulated the development of various projects related to alarm system.

2.1. EEMUA

In 1999, a good practice guide was published by EEMUA (Engineering Equipment & Materials Users' Association) for the management of alarms, which is a set of practices to develop, design, document, operate, monitor, and maintain an alarm system. This standard was based on four basic principles for an alarm system. First the handling, stating that the alarm system shall provide the relevant information clearly and with enough time for the user to act. The second principle is safety, which establishes the need to protect the population, equipment, and environment. The third is the performance monitoring, where it is determined that the performance of an alarm system should be tracked continuously. And finally, the investments which report that every new alarm to be added to the current or a new system to be adopted must have in principle a high degree of quality in the mechanisms of choice, management, and maintenance (EEMUA, 1999).

2.2. SP18

Another important work, carried out by the Committee on Practice and Standardization, created the standard SP18. Its proposal is to define terminology, models, and processes to effectively implement the management of alarms in computer systems. The sensors, final control equipment, safety instrumental systems (except alarms), and processes and events data were excluded from the scope of this standard. The SP18 uses the life cycle model for the management of alarm systems. This model extends from the initial planning to performance management and can be very useful for identifying the requirements and rules to implement the alarm management system (DUNN and SANDS, 2005). This management cycle can be simplified into five steps (Figure 2):

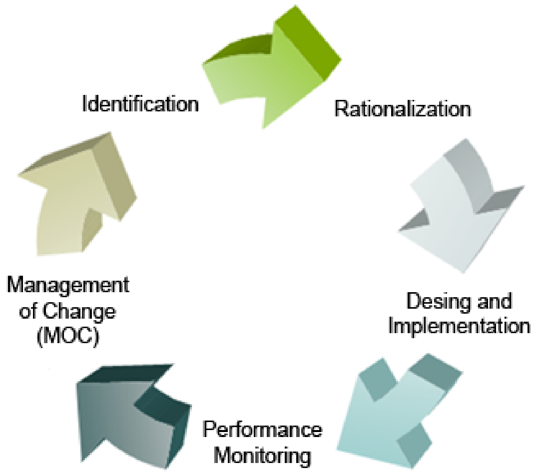

Figure 2. Alarm management cycle

- Identification: Step where the problematic alarms must be found. The SP18 specifies only the method of tracking routines for the identification of these alarms; however, it mentions that this identification can be performed by various methods, such as the analysis of “bad actors” which identifies the alarms that were more active in a given range of time.
- Rationalization: In this step, the alarms identified during the previous step are reassessed and documented. Information such as the actions of the operator, time of response, and consequences of failures must be documented, because with this information you can determine the priority of alarms.
- Design and Implementation: In this stage, the basic settings of the alarms, the design of the HMI (human machine interface) for alarms, and advanced methods of alarm management are defined and implemented. Many troublesome alarms can be eliminated with a good setup practice.
- Performance Monitoring: Stage of the cycle in which it is analyzed whether the changes made to the settings of the alarms were beneficial to the alarm system. Without this monitoring, it is virtually impossible to effectively manage the system alarms.
- Management of Change: Finally, management of change, dealing with the additions, changes and removals of the process alarms. In this stage, all procedures should be formalized and documented to ensure that all changes are in line with the philosophy of alarms adopted.

2.3. The BR-AlarmExpert system

To assist the process of alarm management, it is of fundamental importance a computer system capable of analyzing the historical data of alarms and events to provide users with information that facilitate the identification of possible problems in the configurations of alarms.

From this context, the BR-AlarmExpert system emerged, which was developed by UFRN and CENPES/PETROBRAS within the research project called SIGA (*Sistema Inteligente de Gereciamento de Alarmes*) (SIGA, 2006). This system, in addition to having several analyses that help identifying problems, also has a module for documentation of alarms which will help in the complete documentation of the alarms and will store the history of all changes made to alarms.

2.3.1. Analyses of historical data

The BR-AlarmExpert (Figure 3) has several statistics of frequency that allow the recognition of "bad actors", the identification of priority distribution, the detection of periods of instability of the plant, and the inspection of the range settings and points of operation of the alarm.

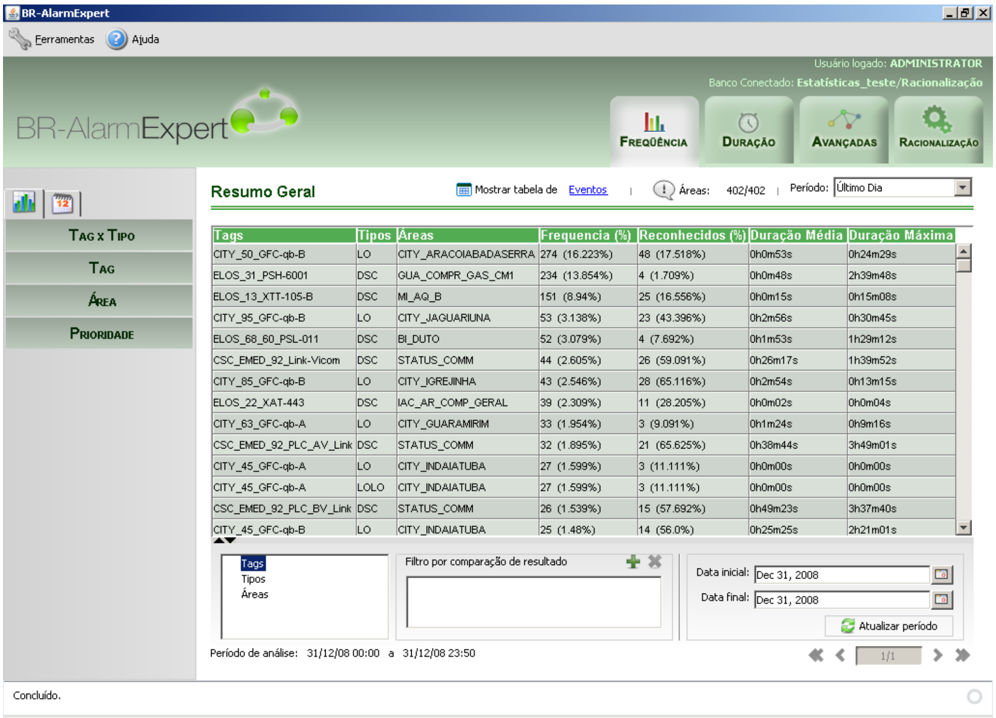

Figure 3. BR-AlarmExpert interface.

In addition to statistics of frequency, the system allows the analysis of active and acknowledgement time, and indicates alarms that have not been recognized. This set of analyses enables the identification of alarms that have a very short or very long cycle of duration and, consequently, become troublesome for operators.

The BR-AlarmExpert also has analyses that aim to gather a set of qualitative information, providing, for example, the dynamics of activation and transition between levels for a particular alarm, the behavior of recurrence of an alarm (intermittent alarms), and percentage of relationship between alarms, making possible a greater understanding of the dynamics of the process for use in change management

2.3.2. Rationalization Aid

In order to aggregate all of the existing information about the cycle of rationalization of alarms in one single system, the BR-AlarmExpert, as mentioned above, has a history of alarms module where it is possible to see the entire life cycle of a given alarm.

This module allows operators and engineers to analyze and submit proposed changes to the system, and state: possible causes, injuries, and procedures for treating the alarm.

3. The TBG plant situation and adopted methodology

In this section, the methodology adopted by TBG S.A. is presented to manage its process of alarm management that includes tasks such as: monitoring, identification of critical points, rationalization, and management of changes.

TBG operates the Brazilian side of GASBOL, a 3,150 km long pipeline that transports natural gas from production fields in Bolivia to five states in Brazil. The CSC, located at TBG's headquarters in Rio de Janeiro, fully operates the pipeline, 24/7.

It includes, on the Brazilian side of GASBOL, 15 compressor stations installed each one with two or more compressors, where daily volumes demanded by the shippers determine the number (and location) of compressors that must be operated. The transported gas feeds the turbines and the backup energy generators. There are also more than 40 city gates, serving as interfaces between the pipeline and consumers (gas distributors, thermo electrical plants, etc), 41 Rectifiers, installed under the gas pipeline, protecting it against electrochemical corrosion caused by the soil, and 2 measurement stations, the first one at the Bolivian border and the other one located at an interconnection with other pipelines, in São Paulo.

The supervisory system is composed by SCADA real time and historical servers that run Wonderware applications over Windows, acquiring data from the field and storing it in Historical Databases and files. Because of the increase of plant operation complexity, over time it has been included more alarms in SCADA. Then, currently operators of the system are subject to an excessive amount of alarms. TBG`s reality has forced them to start an alarm management process.

After detecting the need for deployment of a process for management of alarms by various areas of the company, a meeting was held with officials from various sectors such as engineering, environment and safety, operation, maintenance, and IT. From this meeting, a group was created for alarm management called the Committee of Alarm Management consisting of representatives of different areas. This group was responsible for defining a philosophy for alarm management, i.e., to set a methodology to be adopted, the definitions and principles to be used, detailing the practices and procedures necessary in each step of the alarm management cycle described by SP18.

The first task handed to the Committee was to meet once a month and generate a minute in order to formalize the process. The way to achieve this formalization was through registry of all the analyses, actions, deadlines, and responsibilities, together with the development of internal procedures and dissemination of the activities.

The first actions taken by the Committee were:

- Prioritization of the deployment of formal methodology for alarm management;
- Dissemination of the alarm management actions;
- Choosing a computer system to aid the management process.

After analyzing some computer systems, BR-AlarmExpert was chosen because:

- It supports the monitoring, anomaly identification, rationalization, and management of change;
- Provides a simples and friendly interface;
- Holds essential analyses with "bad actors" and active time statistics, as well as advanced analyses, like intermittence, flood, and interrelation between alarms;
- Allows the reconfiguring of analyses;
- Has a very flexible and robust driver for the capture of data.

The area responsible for the deployment of the BR-AlarmExpert software in TBG was the Coordination of Automation (CAUT), subordinate to the Engineering, Environment, and Safety Management (GEMS), whose main internal client is the Operations Management (GOPE), both subordinate to the Directory of Maintenance and Operation (DMO).

The first stage of the alarm management implementation consisted of a presentation of the software to the potential stakeholders and key people involved in its deployment, use, maintenance, and possible suggestion making to its improvement. In addition to all employees of DMO, employees from TI were also invited, which is responsible for providing that the operational data from the SCADA network is available in the corporative network with privacy and security. Therefore, it was decided to start the alarm management already with a support software. Thus it was possible to implement the following cycle: automatic monitoring of alarms, identification of recurring alarms, analysis of rationalization, and documentation of management of change.

In the periodic Committee meetings, the reports generated by BR-AlarmExpert for identification of recurring alarms are analyzed (graphs and spreadsheet). Initially, the strategy of prioritizing the efforts over "bad actors", which are considered the top ten most frequent alarms, was adopted. From the analyses, the Committee first examines its relevance. The alarms considered not relevant are inserted in the rationalization stage. Those considered relevant are analyzed to discover the reasons which lead to bad behavior and then actions to be taken are suggested, such as change of set point and priority. Deadlines are designated, as well as people, to evaluate the changes made in the next Committee meeting.

In order to quantify the progress of management exercised by the Committee, describing the relation between the current scenario and the goals to be achieved by the group, it was decided that it would be generated a monthly report of the alarm management and a model was proposed to be followed.

This report aims to standardize the form of communication with users and the ones interested in the progress made with the system, distributing the monthly top ten bad-actors of the system, the top ten “chattering alarms”, the number of floods that have occurred, the percentage of instability of the system, among other performance indicators (KPIs). The proposed report model also includes a section of rationalization, in which all alarms that have suffered some kind of change are cited.

The data that consolidates all information in the report is the record of the "Alarm System’s Status", to which is assigned a qualitative scale to classify the system as overloaded, unstable, manageable, robust, or ideal, according to the integration between statistical and instability data, with the goals of the standards previously cited as a reference.

It is worth mentioning that, besides the events raised by the monthly meetings, the alarms rationalization also receives inputs from the CSC (Control and Supervision Center), which passes crucial information to the optimization of the system.

4. Results

Since the deployment of the system and the first meeting of the Committee in July 2008, it is possible to see the evolution of the alarm management system.

Besides the formalization through the record and continuity of processes, one of the main results noticed with the alarm management process was the attainment of a greater stability of the system as a whole. This fact can be observed in Figure 4. Before the deployment of the system, changes made would not have the expected effects and the number of alarms would vary without following any quantitative or qualitative pattern.

Since the establishment of the Committee, the amount of alarms that affect the CSC started to decline and, even when a new fact or sporadic event increases this quantity, right after the detection of the problem, analysis, and responsive action, the system returns to present even better results, as noted specifically in the month of September 2008, when a compression station returned to operation, however, with new set points. After the reconfiguration of the set points of the alarms of this station, in October, the system has shown improved levels from those of August.

The first focus of the analyses and actions taken at the beginning of the work was in alarms of stations that were out of operation but had tags with alarms configured in SCADA. Every time the SCADA was restarted in the CSC, the alarms would appear back on the screens of the HMIs, without any action that could be taken by the operator. All of these tags had their alarms removed and the changes were recorded.

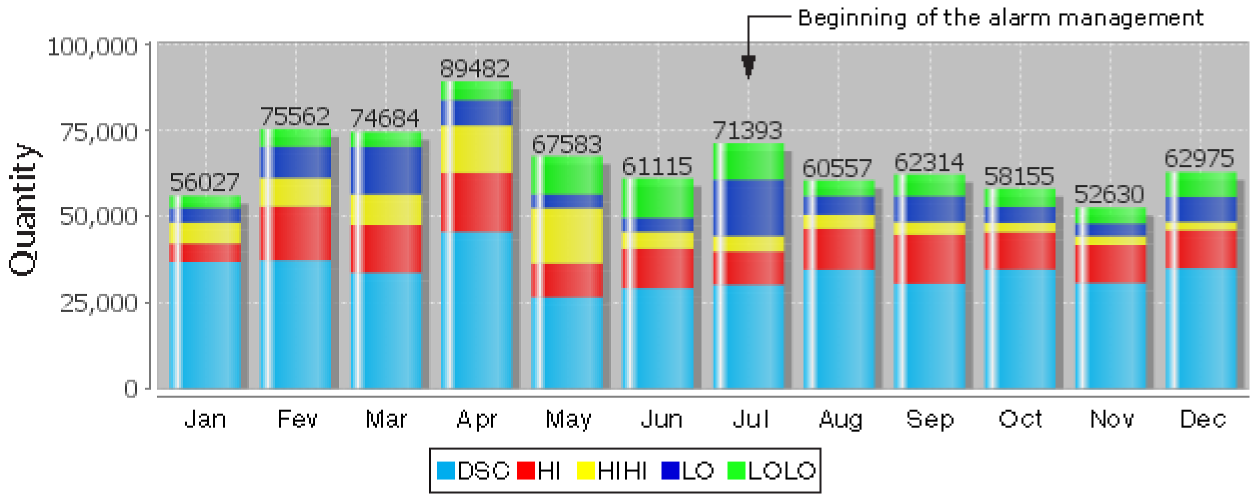

Figure 4. Distribution of alarm types by month in 2008.

Another important event that can be illustrated occurred with temperature alarms of the "LO" and "LOLO" type of the gas fuel system in city gates, located in cities near the south of the country, in July of 2008 (see Figure 5). In the first analysis of the alarm management, these tags held four of the twenty positions of biggest "bad actors" of the system. In this case, such alarms only flagged low temperatures on the CSC early in the morning in these locations, which, for being close to 0 °C, intermingled with the set points of Lolo alarms configured near the lower limit of the instrument, with the aim to signal the failure of the instrument and the consequent need for opening a maintenance note by the controller.

The first action of the Committee, after analyzing the value history graphs of these variables in the previous months, was to propose a reduction of the set points of alarms (from 5°C to 1°C) and arrange its resetting in SCADA. Done that, on the next week, it was observed that the temperature of the south region of the country had also decreased and the new set points configuration was still close to the operation band. Therefore, the changes had not had the expected effect and the many low-temperature alarms were still arriving at the CSC without any action that could be taken by the operator. Then, a new analysis was made and a new configuration proposed. This time, the operating ranges were reset and alarm set points adjusted to negative bottom ranges, from 0 °C to -20 °C, avoiding temperatures close to 0 °C to be confused with failure of the instrument when operating near the bottom range.

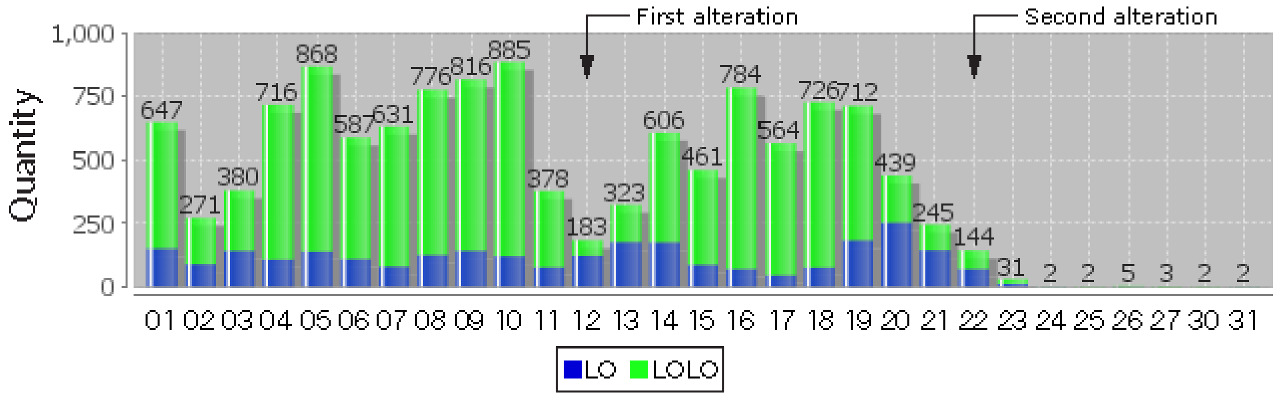

Figure 5. Occurrence of “LO” and “LOLO” alarms in July, 2008.

The analysis and actions performed in the following months had the premise that the top 10 “bad actors” from the previous month should not appear in the next month, after the management of these alarms.

Another example which features a maintenance problem was diagnosed in a control loop of a Compression Station`s fuel gas control, in which a control valve, that operated in split range with another, had its actuator damaged, making the control of this control loop inefficient, resulting in oscillations of large amplitude around the set point of the process variable. This event was diagnosed by identifying the pressure alarms of the fuel gas of three motor compressors that were downstream of the control loop. In Figure 6, you can notice the high incidence of these three alarms (three major blocks) in January and, after repairing the valve at the end of January, there is again a scenario within the normality.

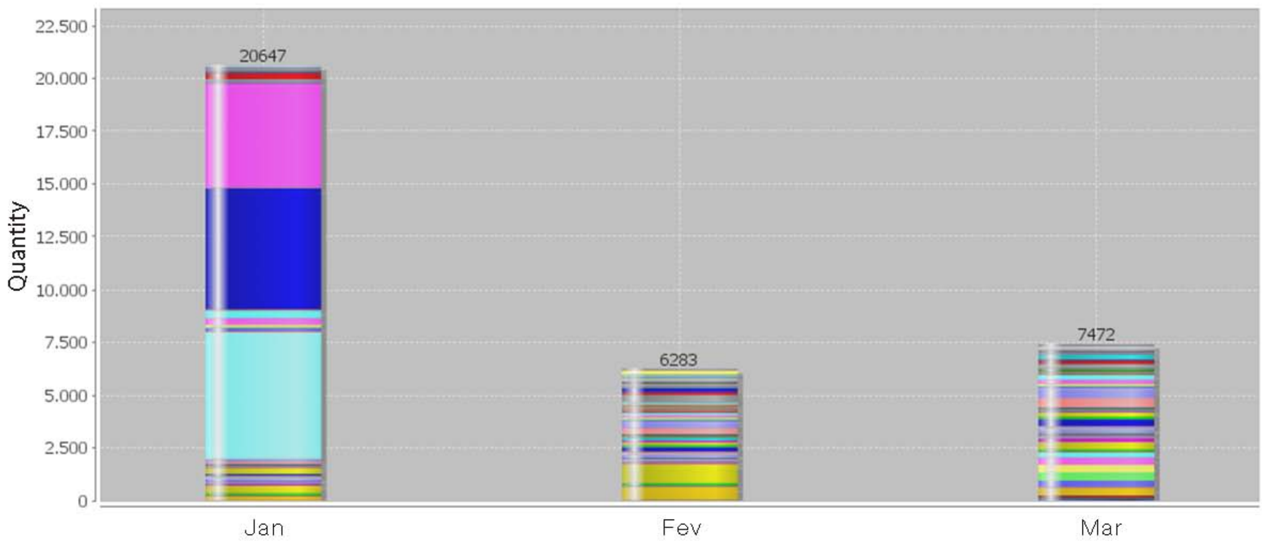

Figure 6. Distribution of a compression station’s alarms in 2009.

5. Conclusion

Since the beginning of the alarm management system implementation, it was observed that the process is very dynamic and constantly needs to be the target of analyses, reviews, and updates.

It is essential that the critical analysis of recurring alarms, such as “bad actors”, is continuously made, preferably daily, or as soon as an anomaly is detected through an alarm that bothers the controllers and affects their routine, making them "mere alarms recognizers", until the real question or problem is finally resolved.

Another important lesson learned is that, before each change is implemented, it must be thoroughly examined and approved by experts from all areas involved. The rationalization of an alarm that, for some, may appear to be resolved by simply changing the tag in the SCADA system, may involve changes in design and, therefore, changes in various documents, technical drawings, cause and effect matrices, requiring a long SCADA downtime or even the technical unavailability in the field which may or may not be economically advantageous to the company.

Finally, a different relevant aspect to be emphasized is that the formalization of the processes through records in minutes, actions and results dissemination, and preparation of internal procedures, promotes the continuity of alarm management, increasing the involvement and commitment of the ones most interested that the stipulated goals are achieved: the members of the rationalization of alarms Committee and controllers.

6. Acknowledgements

The authors thank Finep (Financiadora de Estudos e Projetos), UFRN (Universidade Federal do Rio Grande do Norte), Cenpes/Petrobras and TBG for the incentive given during the development of this work.

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