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ALARMS RATIONALIZATION IN MEXICO POWER UNITS

by

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SUMMARY

The Comisión Federal de Electricidad (CFE) is a Mexican utility company, which is the manager of offering the electrical service in the whole country that generates, transmits, distributes and sells electricity in Mexico, in conjunction with the Instituto de Investigaciones Electricas (México' Electrical Research Institute, right hand as R&D institution of the CFE http://vmwl1.iie.org.mx/sitioIIE/site/indice.php,) have been proposed to implement the intelligent management of alarms to prepare control centers and operators of the power units in a new operating philosophy with the introduction of smart grids. Digital control systems installed in control centers to operate power plants are of various suppliers, among which we can mention: SIEMENS in its various versions, Ovation and Delta V by Emerson, Telvent, Mark V from GE; Conductor NT, Advant and 800xA by ABB, Mitsubishi and Metso.
The project consists of the following stages: Diagnostic performance of alarm systems, alarm rationalization, rationalized alarm implementation, monitoring, and performance evaluation system with rationalized alarms operating, and study to define the power units and control systems to apply advanced management alarm systems. During the project's actions were performed diagnostic performance of alarm systems hydroelectric power plants, combined cycle, conventional steam, internal combustion (diesel), coal and geothermal plants. This will take into account the criteria in the standards: ANSI/ISA 18.02_2009 and EEMUA 191.

Alarm rationalization and implementation of rationalized alarms in the digital control system were performed using methodologies developed by the IIE-CFE in project activities. In the control centers it has been modified and, in some cases, it has included new alarm system interfaces. Once finished the implementation of rationalized alarms are defined power units that are candidates to apply advanced methods alarm depending on the amount of alarms set in the databases after rationalizing alarms, rate alarms during normal operation, the rate of alarms during major disturbances and hardware and software capabilities of the digital control system. The paper presents the process of diagnosis and alarm rationalization methodology and the implementation in the control centers of power plants operated by the CFE.

KEYWORDS

Alarm, alarm rationalization, control room, power plant, safety.

Introduction

With the purpose making them more efficient the processes of transmission and distribution of electricity in Mexico have been initiated projects for the development of smart grids, which will require greater flexibility in the operation of electric power generating units, generating more at the peak hours and reducing the generation in peak hours. With this profile operation, digital control systems generate a greater amount of alarms due to operational changes in the units. For the efficient and effective management of the alarms in the smart grid environment, it is necessary to implement advanced alarm systems that provide to the operator with alarms "aware of the unit's operating mode" which promptly notify that is happening one anomaly in the process and the operator to take corrective action effectively.

To improve the performance of alarm systems in accordance with the new operating profiles, the EEMUA 191 "Alarm Systems: A Guide to Design, Management and Procurement" recommends the following stages: 1) analysis of the alarm system, 2) basic rationalization of alarms and 3) application of advanced solutions in the alarm management.

Analysis of the alarms systems. Through surveys, review of documentation, review of database, and review alarm historical file, to locate problem areas, and opportunities for improvement, and thus determine the level of performance with which it is currently operating the alarm system.

Basic Rationalization of alarms. Alarm Rationalization is a process in which, derived from studies of safety, reliability, vendor recommendations, operating experience, analysis of hazardous operations and techniques such as: What happens if ...? alarms are proposed to call the operator's attention to the process section where it is presented an abnormal situation which would cause accidents to equipment, people, process fluids or the environment, so that to avoid the consequences if the trend abnormal of process continues, it requires the operator to take an action to change the trend of the process and avoid the consequences of the disturbance in the process. For operator action is effective on the process, is required to be notified with enough time, considering the inertia of the process, the time it takes the operator to acknowledge the alarm and take action, and the time it takes order to get to the process area. Each proposals alarm is justified and prioritizes are described: operator actions, the causes and the consequences of that operator actions are not sufficient to change the trend of the variable. During alarm rationalization process it highlights two aspects: a) the formation of the group responsible for alarms management, defining the specific roles of each participant, and b) the document structure with adequate control of changes, which should include diagrams, drawings, design documents, vendor documents, considerations made during the rationalization, file of alarms historical, original databases and databases after rationalization.

Application of advanced solutions in alarm management. Alarm systems applied to processes whose modus operandi is variable, changing the normal operating area, such as: down load, the unit out operation, bring it to peak load, synchronize the unit, take it to base load, and so on; generating too many alarms that are not useful to the operator and, in some cases, not generated alarms necessary for safe operation of the power generation unit.

To generate alarms "aware of the operating mode of the plant" and predictive alarms in various modes of operation of the power generation units, are required to apply alarms logic processing techniques that aid the operator in the various maneuvers during changes in operating mode.

Background

The power plants construction began in Mexico for over one hundred years, and over exploitation are making improvements to equipment and modernization of instrumentation and control systems to extend its life, in this way, the control boards are replaced by digital control systems with intelligent field instrumentation which drastically changes the alarm management in the following areas, among others:

a) The number of alarms configured in the database passed the order of hundreds to the order of thousands.

b) The alarm configuration: from to be on a panel at sight of the operator to be in the database hidden from the operator.

c) The display of alarms in a list that eventually saturates the screen due to the large number of alarms that occur in the process for a larger disturbance or a change of operational mode of the plant.

d) The rate of alarms that are presented to the operator increased due to the number of alarms configured in the database.

e) Previously only had alarms in the process, now in addition to these, there are also diagnostic alarms for control systems themselves.

f) Previously only had absolute alarms, now there are various types of alarms.

Additionally, digital control systems for operation of the power units are of various providers among which we can mention: Siemens, ABB, Emerson, General Electric and Mitsubishi. So the presentation of alarms to the operator and its management is different.

In this situation, each individual power plant developed his philosophy for configuration and alarm management, based on the experience of the personnel operating and maintaining the plant itself.

Against this background, the Federal Electricity Commission (CFE), which is the company responsible for generation, transmission, distribution and marketing of electricity in Mexico asked the Electrical Research Institute (IIE) to do a study to diagnose and determine the operational status performance level alarm systems in plants equipped with digital control systems and, derived from the result of the diagnosis and performance level alarm systems, to develop a project to bring the level of performance of alarm systems to stable according to the criteria established in EEMUA 191.
This article discusses the alarm rationalization work done in Mexico in 28 hydroelectric plants and 27 thermal power plants with different technologies, such as combined cycle, internal combustion, geo-thermal, coal, gas turbine and conventional steam.

Issues and challenges

To perform alarm rationalization is required conform a working group expert in the operation and maintenance, specialist in instrumentation and control, security, electrical and mechanical of power generation units as well as personal with knowledge of ANSI / ISA 18.2-2009 "Management of alarm systems for the Process Industries" and the mentioned EEMUA 191, and engineering expert staff and alarm systems design embedded in digital control systems. The working group for the implementation of this project was formed for ten researchers IIE and by the CFE, a specialist in instrumentation and control, and other specialist operation, additionally, for local work was integrated operation and maintenance staff of each plant.
The generating plants are located throughout the country, representing long journeys from the workplace researchers to generating stations to work in conjunction with the central staff for the rationalization of alarms in each of power generation units.
For diversity in technologies of digital control systems, as well as different versions of the same, methods for extracting information from digital control systems are varied and in some cases unknown to the user, making it difficult to extract databases and alarm history files for quantitative evaluation of the performance of alarm systems. Similarly, by the lack of procedures to modify the attributes of the alarms configure in digital control systems has impeded implementation of rationalized alarms. So it was necessary to involve on project to staff of various suppliers of digital control systems.
In most cases, the implementation of rationalized alarms in the digital control system had to be performed with the units outside operating, taking advantage of scheduled shutdowns for major maintenance in order to avoid making a mistake in programming and cause unit trip or some other similar accident. In some cases was implanted the rationalized alarms with the unit operating, taking all possible safety measures to avoid accidents that affect the operation of the unit.
Due to incremental upgrades on the power plants, documentation was not updated, so it was necessary to locate information in various sources such as the engineering station and computers of the operating and maintenance staff. Considering this situation it was necessary to make cross reviews between different documents in order to be certain documentation compatibility with currently installed on the alarms module.

Alarm systems suppliers philosophy

The review 2009 of the norm ANSI/ISA-18.2 [1], establishes the requisite of preparing a document known as *alarms philosophy*, in which there are established the basic definitions, the principles and the processes to design, implement and maintain an adequate alarms system.

These principles must be defined previous to the activities of the management of the alarms systems [2], since there is realized an evaluation of the entity to be analyzed, what allows to know the main problems that influence the deficient functioning of the alarm systems, this way to obtain a clear vision of the current state of the power plant and it is the starting point for making the alarm philosophy.

The alarm philosophy must join to international acceptance standards and like product of all this, a substantive reduction of the shots of the units and operative costs will be obtained.

On global terms, technology providers exist and each one has their own methodology as well as its own philosophy for the design and rationalization of alarms, such is the provider’s case as ABB from Switzerland, GE from USA, Mitsubishi of Japan, Siemens of Germany, among others. Why technicians alarm philosophies define two alarm priority levels, while another define up to sixteen?

Before the review of the reference norm, some of the modern distributed control system (DCS) were previous installed, and providers as mentioned before, applied their own criteria of AP that impacted on both: alarms rationalization and in its database implantation and hence in the operative results.

With the modernization of the power plants, and the new SCD implanted, the international norms had not been created with such universal criteria to assist to the operator, simply it was intended of instrumenting the most possible the generation process and providing to the operator with information field and to control and maintain the biggest efficiency of the process in normal operation conditions but, rather than that, such modernization created a great deal of alarms and complicated the operation of the power plants and the problems to solve it grow up. The problems were understood once the creation and reviewed the reference norms.

Diagnostics

For the purpose of applying adapted and normalized criteria to rationalize the most efficient possible the priority of the alarms, there was considered as an initial stage a diagnosis that there should determine the state of the units of the power plant which alarms system should be improved. For such intention the following activities were realized.

a) Qualitative evaluation, consisting of an interview with specific questions concerning the state and appreciation of the alarm systems that from eight to ten operators' point of view are perceived.

b) Quantitative evaluation, the analysis initiates from the review of the historical files accumulated in a particular period of approximately one month. The alarms were identified, in accordance with its priority established by design, this means, critical, warning, and tolerance. The quantity of acceptable occurrences of alarms limit per day according to the reference norm, and the alarms with major regularity (bad actors) are also counted.

The result of diagnostics determines the performance of generation units at the power plants.

Reference standards

The framework for this project is: EEMUA 191-2007 Ed 2, ANSI/ISA-18.2-2009 and NAMUR NA 102 Version 2008. In Mexico have not yet published guidelines concerning to alarm management. Origins of these standards are the labor results of the Abnormal Situation Management Consortium. The purpose of these standards is to improve the effectiveness of alarm systems in both normal operation and during major disturbances. This last emphasized the alarm management throughout the life cycle from conception, development, procurement, installation, testing, commissioning, operation, maintenance and removal of alarms.

EEMUA 191-2007 clearly defines five levels of performance of alarm systems starting with the overloaded (which is inefficient) to the predictive; also proposed qualitative and quantitative methods to assess the current performance of alarm systems in operation. It also proposes roadmap for, from the current performance level, reach the target level in terms of investment and the costs and risks of not having an effective alarm system.
To implement alarm management CFE generating units adopt the life cycle diagrammed in ANSI/ISA 18.2-2009.

Rules are aimed at improving the safety of personnel, materials and process equipment and the environment. Taking into account the capacity of the operator to timely respond to each alarm, for which, makes recommendations on the presentation of the alarms and the amount and rate of alarms, promotes continuous improvement and maintaining control of changes during entire life cycle alarms.

Implementation

After the reference norms arose, a methodology was applied to each one of the power plants with modern DCS, no matter what type of technology it has, finally this methodology will impact directly to the most important human factor of every processing plant: *the operator*. This methodology will survive during the life cycle of the alarm management, which consisted of several phases: the first one corresponds to the making of the philosophy of the power plant, this means, the current situation of the alarms system and the definition of the premises, commitments and all those definitions that establish clearly how there will be carried out the alarm system management; the second part is the administration of changes, to register and approve any modification that applies inside the steps of the cycle; in the third part it is considered to be the monitoring and evaluation of the changes realized and implanted in the DCS; and the fourth part refers to the audit, which until now it has not yet established like obligatory, the world tendency tries to turn it into an essential practice as parts from the alarm life cycle management, closing this way the entire loop. See Fig. 1.

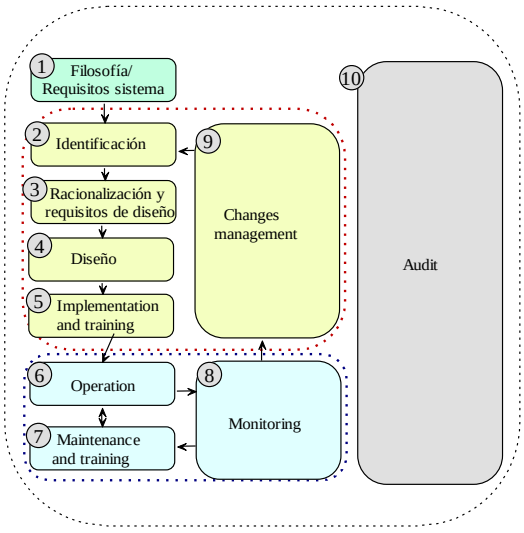

Fig. 1 Alarm life cycle during its administration period

Results

During alarm life cycle management improvement, the participant personnel identified signals and unknown alarms that until now did not appeared, nevertheless they exist in the database. This needed a detailed review to separate those signals that are not right of appearing to the operator and to leave only those who need some action by the operator, additionally to distributing alarms on priority levels following the nearest possible to the criteria of the reference norm. ANSI establishes 5, 15, and 80% for critical, warning, ant tolerance alarms respectively. Of course, it was not the same to apply such criteria to thermoelectric power plants than to hydroelectric power plants, for mentioning some. A substantial reduction was obtained in the alarms quantity by generation unit in every power plant. Obtained results of some power plants attended are shown in table 1.

Table 1 Results of alarm rationalization at power plants

DCS	Power plant	Unit number	Generation MW	Alarms

GE MARK V	CTG TIJUANA	1, 2, 3	30 (1-2) 150 (3)	225
	CCC SAMALAYUCA	1, 2, 3, 4, 5, 6	114 (TG) 59 (TV)	568/PAQ
ABB CONDUCTOR NT	CCI LA PAZ BCS	2	40	612
	CCC EL SAUZ	7	158	1970
ABB ADVANT	CCC PRESIDENTE JUAREZ	8, 9	248	4673
	CCC HUINALÁ	7	225	347 (TG)
MITSUBISHI	CGT CERRO PRIETO	10, 11, 12, 13	25 per unit	5091 per unit
EMERSON OVATION	CCC HERMOSILLO	1, 2	134 (1) 93 (2)	909
	CCC TULA	1, 2, 3	69 (TG) 100 (TV)	483
	CCC FELIPE CARRILLO PUERTO	3, 4, 5	70 (TG) 80 (TV)	1105
SIEMENS TXP	CCC GÓMEZ PALACIO	1, 2, 3	73.4 (TG) 93 (TV)	960
	CT VILLA DE REYES	1, 2	350	2156
SIEMENS S7 300	CH MAZATEPEC	1, 2, 3, 4	55	244
	CH CHILAPAN	1, 2, 3, 4	4 (1-2) 9 (3-4)	780
	EL SALTO	1, 2	18	110
	MINAS	1, 2, 3	5	92
SIEMENS PCS7	CH VILLITA	1, 2, 3, 4	180	1060
	CH AGUAMILPA SOLIDARIDAD	1, 2, 3	320	2425
	CH EL CAJÓN	1, 2	375	3616
	CH AGUAPRIETA	1, 2	120	728
	CH CHICOASEN	1, 2, 3, 4, 5, 6, 7	300	5315
	CH MALPASO	1, 2, 3, 4, 5	180	3269
	CH ANGOSTURA	1, 2, 3, 4, 5	180	550
	CH EL FUERTE	1, 2, 3	22	922
	CH OVIACHIC	1, 2	12	1256
	CH EL NOVILLO	1, 2, 3	50	1990
	CH COMEDERO	1, 2	58	3558
	CH BACURATO	1, 2	45	4268
	CH HUMAYA	1, 2	45	4279
	CH SANALONA	1, 2	8.75	2464
	CH EL CARACOL	1, 2, 3	200	1082
	CH ZIMAPÁN	1, 2	146	4957
SIEMENS PCS5	CH HUITES	1, 2	230	1182
SIEMENS SPPA T3000	CT LERDO	1, 2	160	6289
	CT TUXPAN	1, 2	350	5375
SIEMENS Westinghouse	CCC HUINALÁ	6	150	312
SIEMENS TELEPERM	CT PETACALCO	1, 6	350 (1) 350 (6)	2125
BAILEY INFI 90	CT CARBÓN II	3, 4	350	2761
TELVENT SUPCANT 866	CH PEÑITAS	1, 2, 3, 4	105	864
	CH TEMASCAL	1, 2, 3, 4, 5, 6	55 (1-4) 100 (5-6)	482
	CT RIO BRAVO	1, 2, 4	33 (1-2) 145 (4)	777
Note: CT=thermoelectric, CH=hydroelectric, CCC=combined cycle, CGT=geothermal, TG=Gas Turbine, TV=Steam Turbine				

After implanting changes of rationalization activities, a new analysis was realized to determine the performance level of the power plants. The main goal was done: *to move performance of power plants from overloaded to stable level*.

In some cases progress was realized to the interface of the operator, because there were developed interfaces dedicated for monitoring alarms, preserving previously established deployment formats.

Conclusions

Alarms rationalization in generating units is necessary because the alarms systems were implemented before the norms were applied in a massive way into the electrical industry. With implanted alarm rationalization in digital control systems of generating units the following benefits are obtained:
Alarms systems work in the STABLE performance level in accordance with the criteria of EEMUA 191; so when a shot proceeding from the exterior appears, the operator can take the unit to a safety shutdown.
The main purpose of alarm systems has recovered: to alert and conduct the operator through the actions to minimize the problem and, to avoid damages to the personnel, equipment, and environment.
Alarm rationalization process is a way to obtain operators knowledge, known as al*arm book*. It is also a learning process for future generations. It assists to identify problematic alarms, to optimize configuration parameters and to organize alarm priorities.

Future works

Once the alarms systems got STABLE performance level it is necessary to keep the information updated applying control changes as much as possible. There is necessary to monitor the performance of the alarms system in order to identify noisy alarms that are generated in an unnecessary way, and to find improvement areas.

Where the process and operation require the benefit cost study will realize to identify opportunities to apply advanced alarms systems and to get ROBUST or PREDICTIVE performance level in accordance to process type and operation mode.

It is necessary to improve the operation interfaces so that the operator has a complete vision of the present alarms, which have been recognized and those that were restored so that it improves the situational awareness and its tendency.

Alarms rationalization and continuous improvement of operation interfaces need to apply into oil industry, refineries and petro-chemistries, for providing to operator with the necessary alerts to take the opportune actions and to avoid accidents in the future.

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