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CERTIFICATION OF THE EQUIPMENT INSPECTION SPECIFIC SERVICE: A CASE STUDY IN A CONTINUOUS PRODUCTION ENTERPRISE

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Abstract:
The job and employment ministry, through the Brazilian Regulatory Law number 13 (NR13) establishes the requirements of insurance for the installation, inspection and maintenance of equipments of the type of pressure vessels and boilers. This rule allows significant benefits for the enterprises that have their own equipment inspection service (the Brazilian SPIE), certified by INMETRO - the Institute of Metrology of Brazil. This paper has as a goal to identify the contribution of the SPIE certification in a continuous production enterprise, in relation to costs reduction, accidents prevention, reliability increase of the installations system, and environmental protection. After the data analysis it was possible to perceive that the quantitative and qualitative benefits in economic, insurance, environment, and quality aspects of the enterprise, which are consequence of the SPIE certification are considerably favorable. A theoretical support will also be presented in this paper, concerning the certification process, the characteristics of continuous production enterprises and the results for a business unit of the petroleum and gas unit.

Keywords: Certification, Equipment inspection, Continuous production.

1 Introduction

The market open economics scenery in highly competitive levels, never experimented before, demands a new positioning in the entrepreneurial management. This scenery requires that the enterprises do their best. The permanent search for the operational efficiency improvement, as well as for the excellence in security of people and installations, is not anymore a differentiation factor. It has turned to mean the enterprise's own survival conditions. Within this context, the enterprise studied here through its reliability policy, sees the certification process as a certain return investment in terms of the improvement of the production and services quality, thus positively affecting its products, the environmental protection, the financial results, customers benefit, the society, the stakeholders and the employees.

The certification process for the own equipment inspection service of an enterprise, registered by the Brazilian Regulatory Law for the installation, inspection and maintenance of pressure vessels and boilers - NR 13, is nowadays in expansion, due to the observed benefits in big enterprises of the petroleum and petrochemical sectors.

Moschine (2003), in na oral presentation at the 7th COTEC - Conference on Equipments Technology, highlights the SPIE (Brazilian enterprises´ own equipment inspection service) actions:

a) An increase in the equipment inspection deadlines, causing a greater impact on bigger operations campaigns;
b) Increase of the reliability of the equipments and installations, due to a greater control and following of the maintenance and inspection teams activities;
c) Reduction of the operation and maintenance costs, with the increase of the operational campaigns times;
d) Reduction of the environmental pollution risks, for a lower exposition of the man to the environmental risks and of the minimization of the generated residuals;
e) Improvement in the image of the enterprise in relation to the society and to the market, for obtaining a certificate in a highly market positioned institute.

According to GPBI - Gas and Petroleum Brazilian Institute (IBP, in Portuguese), which is the certification organism authorized by Brazilian Metrology Institute (INMETRO) for SPIE certification, there are 27 certificated enterprises by the end of 2004. The SPIE certification has started in 1997 as a pilot project and it has turned to be an official

program in 2001 by the INMETRO resolution number 16. This resolution establishes the process and the requirements that a SPIE has to fulfill to be certified.

The enterprise in question is a business unit of a great group (holding) of the petroleum sector. It is located in Fortaleza-CE and it is considered the smallest capacity unit of production of the holding. The benefits presented in this paper are identified quantitatively and qualitatively. Thus, the importance of the certification process for the enterprise, for its clients and for the society are shown.

2. Theoretical Background

2.1. The NR-13 and the SPIE

The Regulatory Rules elaborated by the Job and Work Ministry (The Brazilian MTE) are public resolutions, and so they are obligatory. There are twenty-nine urban Rules and 5 field Rules nowadays. In this sense, in the industrial sector the NR-12 (Machines and Equipments), NR-13 (Pressure Vessels and Boilers), NR-14 (Batches), and NR-20 (Fuels and Fire prone liquids) are highlighted.

The Regulatory Rule NR-13 for pressure vessels and boilers was first published in 1978. The technical security report establishes the parameters and responsibilities related to installation, operation, maintenance and inspection of pressure vessels and boilers. This obligatory Rule was first revised in 1994. The review was performed by a tri-part group, composed by enterprises, government, and workers. Components of the parts were indicated by the Brazilian MTE and it was observe a great participation of the society and of technicians that deal with this kind of activity. In this revision, important and new advances were included in the text. Among the changes, there was a higher flexibility in the maximum periods for pressure vessels and boilers, as shown in Figure 1. These advances allow some types of enterprises to extend their operational campaigns, consequently increasing productivity. In order to allow the extending of the periods without causing damages to the installations, people and environmental protection, it was inserted, in the NR-13, Appendix II, the SPIE certification.

INSPECTION PERIODS (years)			
Categories NR 13 without SPIE			
CAT.	EXT.	INT.	TH
I	1	3	6
II	2	4	8
III	3	6	12
IV	4	8	16
V	5	10	20
Categories NR 13 with SPIE			
CAT.	EXT.	INT.	TH
I	3	6	12
II	4	8	16
III	5	10	according to the criteria
IV	6	12	according to the criteria
V	7	according to the criteria	according to the criteria

CAT. - Pressure Vessels Category
EXT. - External Inspection
INT. - Internal Inspection
TH - Hydrostatic Test

Figure 1 - Maximum security inspection periods of pressure vessels (MTE, 1994)

The SPIE can be adapted to the conditions of the enterprise's organization in terms of their sectors, sections, divisions or groups. The most important thing in this case is that the periods and the facilities contained in the NR-13 are evaluated and certified before being adopted. The SPIE evaluation and certification are performed by a previously authorized entity institution, certified by INMETRO. The SPIE certification, as well as its authorization, follows specific regulations and procedures.

The SPIE certification is a voluntary decision of the enterprise managers and it can be applied in the most varied kinds of industries, which may have pressure vessels and boilers.

The extension of the periods between security inspections (either internal or external) is possible, since the enterprise has a SPIE, as cited in the Appendix II of the NR-13. Besides, it has to fulfill the certification requirements, determined by INMETRO resolution number 016, and dated January 20th, 2001. The resolution establishes the process and the requirements that a SPIE has to fulfill to be certified and gives structural details as follows:

1) Objective
2) Definitions
3) Reference Documents
4) Managerial Structure of the SPIE
5) SPIE Functions
6) SPIE Activities

7) Documentation and Registration System
8) Inspection Services Acquisition
9) Inspection Equipments Control
10) Internal Inspections
11) Non-conformities Identification
12) Critical Analysis
13) Minimum Effective Personnel Determination
14) Instruction and Attributions of Equipments Inspectors

This structure allows the identification of the SPIE with the Integrated Management Systems (IMS), which, in turn, are based on international regulations such as ISO 9001: 2000 and ISO 14001: 2004 and BS 8800 and OHSAS 18001: 1999. This way, the documental structure of the IMS can be used, in a way to control the equipments inspection activities.

The SPIE products are equipments in safe operation conditions, documented in inspection reports, recommendations, records and other documents that may provide the diffusion and consolidation of the acquired knowledge.

The criteria for the certification allowance are based in a list of 76 required items, according to the INMETRO Resolution number 016. These requirements are divided into three categories:

a) Category A: thirty-three obligatory requirements, whose fulfillment has to be complete;
b) Category B: thirty-four important requirements, whose fulfillment has may not be under 70 per cent;
c) Category C: nine complimentary requirements, whose lack of fulfillment does not exclude the enterprise SPIE certification.

2.2. Continuous Production System

Gaither and Frazier (2004) classify the production organizations by focusing the product, the process and the cellular group/manufacturing technology. However, they highlight that, in the product centralized production there is the continuous production, for it is characterized by materials that tend to move linearly along the production set, without much interruption.

Russomano (2000) presents three classic kinds of industrial production, which depend on specific operational characteristics: continuous or linear production, interrupted

production and projects assembly. The author characterizes as a continuous production the one which presents a fast production flow and the one that has specialized and aligned machines according to the product.

A wider discussion is performed by Tubino (2000), who presents the classification of the production systems in three ways:

a) By the standardizing degree - it can be through productive standardized product systems and through systems that produce product under specific orders.

b) By the type of operation - classified in two groups: continuous processes that involve the goods and services production which may not be identified individually and processes that involve the production of goods and services that may not be insulated in batches or units, and that cannot be identified among the others.

c) By the product nature - they can be related to the goods and services production.

The continuous processes, for Tubino, are identified by to the lack of uniformity in the production and request for goods and services, as well as by the non-existence of flexibility in the system. There is also the characteristic of favorable automation conditions of the productive process.

The concept presented by Slack *at al* (2002) for continuous processes considers that the products cannot be separated. They are also produced in a continuous flow. Besides, the authors contend that these products are normally associated to relatively non-flexible technologies, of intense capital investment and a highly predictable flow. As an example of this, there are the petrochemical oil refinery companies, and paper and iron transformation industries.

2.3. Fail Control in the processing industry

Equipments such as pressure vessels and boilers are considered the most important and of higher cost part in petrochemical oil refinery companies and in other sites of the petrochemical oil refinery sector in general (TELLES, 1991). One of the characteristics of these equipments is the fact that they are not common products. Instead, they are almost always projected and built under order. The severe working conditions imposed to the equipments of the industry processing and the high accumulated power level are a potential risk for the people, the installations and the environment, thus demanding a strong physical and mechanical conditions control, in a way to avoid and minimize eventual risks and losses. Still, many fails have occurred in the processing industry. Some of them have serious accidents as consequences. According to a report, among

the 170 main types of damage in the processing industry along 30 years, more than half of them have been caused by mechanical equipment failure (LAFRAIA, 2001). Figure 2 shows the about 40% of losses in a process industry due to mechanical failure, and the significance of the control of the causes of these failures.

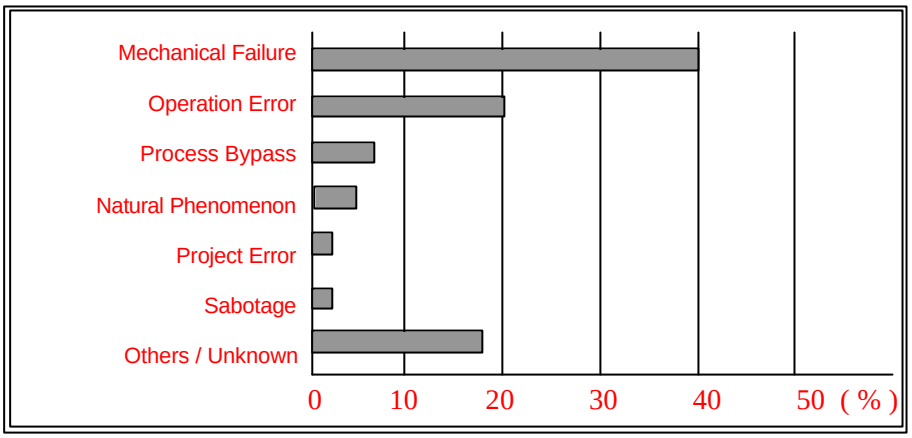


Figure 2 - Failure in the Processing Industry (LAFRAIA, 2001)

Doyle and Barry (2001) contend that maintenance interventions introduce the new equipment failure, thus influencing the failure taxes, reintroducing the ´early death´ in the failure "bathtub" curve, as shown in Figure 3.

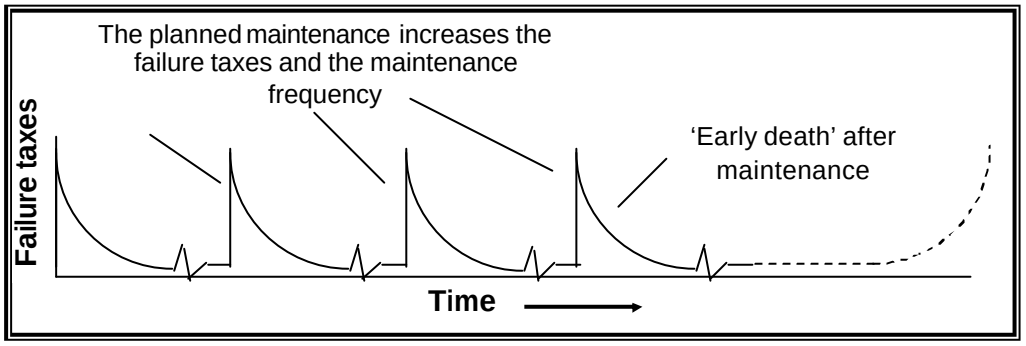


Figure 3 - Effect of the maintenance interferences in the failure curve (DOYLE e BARRY, 2001)

3. Case Study

The next sections present the main points of the case study performed, through the characterization of the enterprise, of the information identified as benefits for the enterprise and the cost-benefit analysis of the SPIE process.

3.1. Characteristics of the enterprise

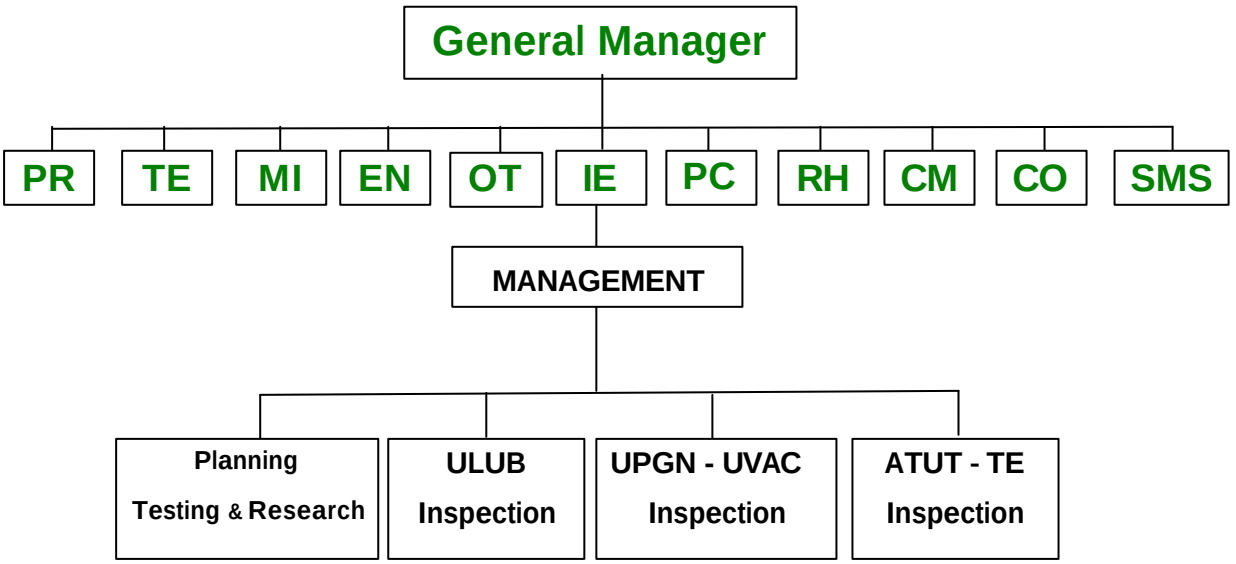
The research was performed in an enterprise located in Fortaleza-CE. The oil derivates enterprise has started its operation with 450m^3/day of petroleum. Along the years, its installations have been turned bigger and new units were installed, going up to a 1.100m^3/day petroleum processing and an expressive diversification of products of a higher related value.

The main enterprise products are: asphalts, basic lubrication oils, Liquid Petroleum Gas, and Marine Fuel. The enterprise also has, as an end-of-line function, imports activities. It works mainly as an oil refinery, constituted by distillation and production of basic lubricant oils and natural gas.

The working force of the company is consisted of 338 people. Among them, 195 belong to the enterprise (58%), working basically in the main activities, and 143 externally hired people (42%), working in complimentary activities.

The commitment of the enterprise with quality, environmental, life and well-being protection, related to its processes and products damages is detailed in its integrated management policy through the certification obtained through Rules NBR ISO 9001: 2000, NBR ISO 14001:2004, OHSAS 18001 and SA 8000.

In order to fulfill its mission and answer the demands and goals, the managerial structure of the enterprise was designed as shown below in Figure 4.



Legend:

PR: Production Management	**TE**: Transference and Storage Management
MI: Maintenance Management	**EN**: Engineering Management
OT: Optimization Management	**IE**: Equipment Inspection Management
PC: Planning and Control Management	**RH**: Human Resources Management
CM: Commerce Management	**CO**: Communication Management
SMS: Environment, Health and Security Management	
ULUB: Lubricant Oil Production Unit	**UPGN**: Natural Gas Processing Unit
UVAC: Vacuum Distillation Unit	**ATUT**: Utility Activity
TE: Transference and Storage Unit	

Figure 4 - Graphic Representation of the Equipment Inspection Management

The SPIE of this enterprise is characterized by the Equipment Inspection Management in its organizational structure.

The enterprise has reached, in 26.07.2005, the goal of 1.355 days without accidents with employee work interruption, which was the highest *benchmark* of the *holding* units in number of days without employee working interruption.

The main enterprise SPIE functions are:

a) Implementing an inspection program, in conformity with the legal and rules demands, with the aim of guaranteeing equipments´ safe operation physical conditions;

b) Defining the methods and the evaluation frequency of the equipments residual life, thus providing basic elements for the planning of their inspection, operation and maintenance. Identificar as causas e fatores de deterioração e falhas de equipamentos com o objetivo de evitar sua ocorrência ou repetição;

c) Registering and maintaining, in updated and easily accessible records, the inspections results (observed physical conditions, measurement results, tests reports, corrosion taxes calculations, residual life, among others);

d) Informing, when necessary, who are the responsible for the Project of the equipments about their service performs;

e) Making sure that the repair and modification quality performed by the equipments is satisfactory, in terms of security.

Figure 5 presents the kinds and amounts of the enterprise's SPIE - controlled equipments.

STATIC EQUIPMENT

EQUIPMENT	ULUB	UPGN	UVAC	ATUT	TE	TOTAL
Heater	3	1	1	-	-	5
Pressure Vessels	66	75	25	28	6	200
Process towers / refrigeration	4	7	2	3	-	16
Heat Exchanger	29	40	25	3	-	97
Storage Spheres	-	-	-	-	3	3
Reactors	4	-	-	-	-	4
Boilers	-	-	-	2	-	2
Storage tanks	-	-	-	5	41	46
Flares	1	1	-	-	-	2
Piping systems	91	33	22	2	33	181
Ducts	-	-	-	-	15	15
Security valves (PSV's)	78	61	67	35	74	315
TOTAL	276	218	142	78	172	886

Categorized equipments NR-13	CAT I	CAT II	CAT III	CAT IV	CAT V	TOTAL
	23	67	161	50	19	320

Figure 5 - Enterprise's SPIE - Controlled Equipments

3.2. Data Collection and Results

The data collected for this study were drawn form a management and control SPIE documental source, as well as the cost estimation reports for the maintenance area. Such sources have allowed to verify quantitatively the SPIE certification benefits.

Initially, interviews, documents and records were used to identify the various contributions of SPIE certification that had a direct impact on the enterprise management.

Some items are listed as follows, from which the benefits for the enterprise results were perceived:

a) Valuation of security aspects, environment and health in the enterprise, through:
   - Services reduction in limited space, such as pressure vessels inside, according to NBR 14787: 2001, thus minimizing the workers health risks;
   - Escape reduction in units starting and stopping processes;
   - Equipments cleaning residuals and effluents reduction;
   - Potential working risk exposure employees' reduction.

b) Increase in the reliability of the installations with more effective monitoring and control actions, through modern non-destructive testing experiments and residual life evaluation.
c) A bigger integration to the certification processes (ISO, OHSAS, SA), through adequate and updated registering processes.
d) Possibility of security prizes reduction paid to the security enterprise with the valuation of the SPIE, through the implementation of the Inspection Management Sector.
e) Increase in the enterprise productivity with the programmed stops reduction and consequent increase in the operational campaign.
f) More motivation of the SPIE group, due to the increments in inspection professionals qualification and certification, as recommended for the certification requirements.
g) Reduction in the stops and maintenance costs and in the stopped profits due to operational maintenance stops.

A cost-benefit analysis is presented as follows. A significative relevance aspect in terms of SPIE certification personnel security is also shown, which justifies quantitatively the real benefits of the SPIE certification in the enterprise in question.

3.2.1. Average number of yearly maintenance stops:

a) Situation without SPIE certification:

- UVAC = 25 days/3years = 8,3 days/year
- ULUB = 25 days/3 years = 8,3 days/year
- UPGN = 20 days/3 years = 6,7 days/year

b) Situation with SPIE certification:

- UVAC = 30 days/5years = 6,0 days/year
- ULUB = 30 days/5 years = 6,0 days/year
- UPGN = 25 days/5 years = 4,2 days/year

Notes:

The increase in maintenance stops periods after certification is due to the following factors:

- The equipments will be able to present more damages after longer campaigns;
- In longer campaigns, the stops need more planning, but they do not increase significantly the maintenance stopping periods;
- New criteria of services scope in a way to reduce services in operational campaigns.

3.2.2. Reduction of the maintenance stopping days per year:

- UVAC = 8,3 - 6,0 = 2,3 days/year
- ULUB = 8,3 - 6,0 = 2,3 days/year
- UPGN = 6,7 - 4,2 = 2,5 days/year

3.2.3. Average reduction of the profits (approximated values)**:**

- UVAC= 2,3 days/year x US$ 48.000,00 /day = US$ 110.400 /year
  = R$ 276.000,00 /year
- ULUB = 2,3 days/ year x US$ 52.000,00 /day = US$ 119.600 /year
  = R$ 299.000,00 /year
- UPGN = 2,5 days/year x US$ 22.000,00 /day = US$ 55.000 /year
  = R$ 137.500,00 / year
  TOTAL = US$ 285.00,00 /year = R$ 712.500,00 /year
  Note: (US$ 1,00 = R$ 2,50)

3.2.4. Unit maintenance stopping costs reduction (approximated values):

- UVAC = R$ 3.000.000,00 /3 years - R$ 3.500.000,00 /5 years
  = R$ 300.000,00 /year
- ULUB = R$ 3.000.000,00 /3 years - R$ 3.500.000,00 /5 years
  = R$ 300.000,00 /year
- UPGN = R$ 2.000.000,00 /3 years - R$ 3.000.000,00 /6 years
  = R$ 166.666,00 /year
  TOTAL = R$ 766.666,00 /year

3.2.5. SPIE certification process costs:

- Initial certification Auditing = R$ 30.000,00
- Yearly certification Auditing = R$ 30.000,00

3.2.6. During the normal units operation period, the personnel involved in the routine operation and maintenance, does not per pass the amount of 10 (ten) people per unit / day in normal working hours (8 hours). When there is a stopping maintenance, there is a considerable increase in the externally hired personnel and in the own enterprise's employees. This number, in this situation, goes up to more than 100 people in a 10 working hours per day, divided into two working teams. In this case, there is a big amount of people to risk conditions. As the units inspection and maintenance periods, there is a considerable personal security risk exposure reduction.

4. Conclusions

This paper has examined the SPIE certification contribution for the results of an enterprise in the petroleum sector. After the data analysis, the real and significant qualitative and quantitative benefits were noted, in terms of economy, security, environment and quality for the enterprise.

It could also be perceived that the SPIE integrated to the management system allows a broader view of the equipments operational condition and the real risks and economy conditions provided by the system.

As a result, the recommendation is that other studies related to the theme should be performed in other units with a bigger number of employees and higher production batches, in a way to measure the results and to confirm the importance of the SPIE certification in this sector, considered of great importance for the economy of our country (Brazil).

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