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NUCLEAR ENERGY SAFETY - NEW CHALLENGES

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ABSTRACT

Fukushima's accident in March this year, the second most serious nuclear accident in the world, put in evidence a discussion that in recent years with the advent of the "nuclear renaissance" has been relegated in the background: what factors influence the use safe nuclear energy?
Organizational precursor, latent errors, reduction in specific areas of competence and maintenance of nuclear programs is a scenario where the guarantee of a sustainable development of nuclear energy becomes a major challenge for society. A deep discussion of factors that influenced the major accidents despite the nuclear industry use of the so-called "lessons learned" is needed. Major accidents continue to happen if a radical change is not implemented in the focus of safety culture.

1. INTRODUCTION

The scenario of "nuclear renaissance" has been seriously shaken by the recent accident in Fukushima in Japan. Programs of building new plants have been suspended, safety reviews in the current Nuclear Power Plants are running in almost all countries, reviews the safety rules are being made in countries like China, Germany, France, Japan, South Korea, Switzerland, England, USA and UAE (United Arab Emirates).

The nuclear energy power generation has again been questioned by the public and environmental groups to strengthen back even taking radical decisions such as Germany which decided to close all plants.

The costs for the complete recovery of the Fukushima Daiichi nuclear power plant in northeastern Japan are expected to reach $ 250 billion over the next ten years [1].

The objective of this study is to analyze the organizational precursors, which may have proven their presence in several accidents that are part of the history of the evolution of the chemical plants, petrochemical, nuclear etc. This paper presents a brief analysis from the perspective of organizational precursors, the following accidents: Seveso, Bhopal, Three Mile Island and Fukushima.

2. ORGANIZATIONALS PRECURSORS

The precursors are defined as events or facts, advertising and much of the prior industrial accidents [2]. The precursors are linked to unfavorable conditions, moreover, are repetitive and potentially dangerous, can manifest not only in the plant itself, as in similar plants, serving as a warning [2].

Perception of the precursors through its signals is not enough, it is necessary that the "decision makers of the organization" to develop preventive or corrective actions in a timely manner to prevent accidents occur [2]. The perception is linked to identification, i.e., only perceives what is identified therefore, correct identification is important [2].

The precursors in a more comprehensive manner, are events, facts, changed circumstances, incidents of any kind, anomalies in the process, defects, failures or issues such as deterioration of the socio-technical environment, excessive staff turnover, especially managers and operators, problems in organization of work and financial problems [2].

The warning signs are the precursors, are alerts that precede the possible accidents, these signals are generated from the technological, organizational and economic systems [2].

2.1 Major Accidents and their Precursors

2.1.1 The Seveso Accident.

The Seveso accident ocurred around 12:37 pm of a Saturday, on July 10 1976, with an explosion in a reactor with TCP (2,4,5-trichlorophenol), in the Industrial plant Industrie Chimiche Meda Società Azione (ICMESA) situated on the outskirts of the city of Meda, Italy, that belonged to the multinational pharmaceutical company Roche [3].

A toxic cloud containing TCDD (2,3,7,8-Tetrachlorodibenzo-p-dioxin), one of the most toxic chemicals produced by man, was accidentally released into the environment, seriously contaminating a densely populated area six miles beyond the point of the accident according to the wind direction and the width of a mile [3]. This incident became known internationally as the Seveso disaster and contributed dramatically to the growth of public concern about industrial hazards and accelerated the response regulator about the safety of chemical plants [3].

2.1.1.1 Precursors of the Seveso Accident

As evidenced by the Parliamentary Commission of Inquiry, the accident was directly related to the lack of investment in the safety of the plant [4]. The lack of investment in safety was a decision ICMESA, this decision can be considered a organizational precursor.

The ICMESA was during 30 years, as the Mayor reported, only a source of occasional complaints by nearby residents concerned about unpleasant smells [3]. One can assume that the unpleasant smells over the 30 years were likely to consequences of leaks.
The condescension of ICMESA can be considered an organizational precursor. The lack of action on the part technique for solving the problem can be considered a technological precursor. The technical part was prevented from acting because they had no support in the company. This impediment can be considered an organizational precursor.

In Seveso, changes in the industrial process were carried out compromising safety, but were not reported to the authorities responsible for public health and safety [3]. Such changes in the safety process of the plant can be considered a technological precursor.

The ICMESA's failure to communicate the changes can be considered an organizational precursor.

2.1.2 The Bhopal Accident

This accident occurred in Bhopal, India. It´s considered the worst ever occurred in the chemical industry [5].
A leak of 25 tons of methyl isocyanate (MIC) occurred in a plant of Union Carbide Company (UCC) for 90 minutes at dawn on day 2 to 3 December 1984 and affected thousands of people [5]. The consequences are estimated from 3,000 up to 8,000 deaths and about 200,000 rescued people, when the toxic cloud has spread to beyond the factory's borders [5].

2.1.2.1 Precursors of the Bhopal Accident

The UCC has deployed his unit in 1969, whose initial goal was to formulate a series of pesticides. In 1979, after ten years, UCC has built a unit of MIC, existing facilities, which were located near a densely populated neighborhood and near a railway station [5]. Thus, the UCC has violated the "Development Plan of Bhopal," because the dangerous plants, such as the UCC, should have its location northeast of the city in the area of low population density [5]. Violation of the Bhopal Development Plan by the UCC can be considered an "organizational precursor."

Given the location of the unit technicians UCC plant in India wanted a small unit, but were defeated by U.S. executives, who chose a large drive, given the low costs and economies of scale, even though the high risk that the community would be submitted [5]. The decision by executives of the UCC in the United States, against the opinion of the technicians from India can be considered an "organizational precursor."

The cooling system of reservoirs in the MIC was not working for saving measure [6]. The failure of the cooling system by saving measure can be considered an "organizational precursor".

The safety valve of the MIC tank opened but the gas cleaning system, which should absorb the vapors exhaled, was under-estimated [6]. One can assume that this context was known to the executives of UCC, at least in India, and then the "under-estimated" gas cleaning system is considered a technological precursor and should be also an organizational precursor.

The system of gas flaring in the flare tower, which should have burned any residual steam to pass through the washing system was defective and out of service for three months [6]. One can assume that this context was known to the executives of UCC, at least in India, then disabling the system of gas flaring in the flare tower is considered a technological precursor and should be also an organizational precursor.

The water spray curtains system that would serve to mitigate the toxic gases did not reach a height of 33 meters, where the safety valve was installed [6]. One can assume that this context was known to the executives of UCC, at least in India, then the problem of the curtain system is considered a technological precursor and should be also an organizational precursor.

2.1.3 The Three Mile Island Accident

This accident it happened on March 28 1979, affected the unit 2 of TMI Nuclear Power Plant. The event was provisionally determined to be Level 5 of INES Scale (International Nuclear Event Scale). The great importance of this accident is due to the fact that the same have happened from a relatively common event, the stopped from the main pumps in the secondary circuit, however, this event could have been easily controlled in spite of this, degenerated into a major accident proportions, with severe damage to the reactor core, with consequent deactivation of the plant. The amount of radioactive material released into the environment was considered by the NRC (Nuclear Regulatory Commission) as relatively small.

2.1.3.1 Precursors of the Three Mile Island Accident

Right after the TMI accident there was a change in the organizational vision of nuclear power plants, so that the Working Group "Lessons Learned", which analyzed deeply the TMI accident, had a total of 23 specific recommendations in 12 general areas (nine being in the design area and three in the operation area) [7].

A new fact at that time, resulting from studies of this group,was the recommendation that all the suggested modifications were implemented: in nuclear power plants who were requesting the licenses application for construction, in the plants were under construction (partly already licensed) and the plants which were in operation, a procedure known today as "backfitting" (adaptation to new requirements) [7].

The change in the organizational vision can be characterized by three important aspects:

- The limit condition for operation of the nuclear power plant should be revised so that it meets a complete shutdown the plant in case of a total loss of function of safety systems because of human error or an operational error [7].
- It was created the post of shift technical advisor on each plant. The position should be occupied by a qualified person with a college degree in engineering or equivalent and have specific training in the behavior of the nuclear power plant in case of abnormal events or accidents [7].
- Due to investigation of the causes and consequences of the TMI accident, the Kemeny Commission carefully assessed the behavior of the parties involved: the NRC, the utility and the manufacturer [7]. The main target of criticism , according to the recommendations in the final report of the Kemeny Commission, was the NRC, which with its organization, personnel and attitudes, was not able to fulfill its responsibility to ensure an acceptable level of safety for nuclear power plants and should, therefore, be completely re-structured [7]. It was recommended the creation of a new regulatory agency, headed by a single administrator directly linked to the President [7].

The recast of the entire organizational structure of the nuclear area, both the regulatory agency, as well as the utilities and manufacturers, was initially realized through of the 23 specific recommendations. Important is all that modifications also boosted the area of Human Factors Engineering. One can assume that this context of the organizational structure nuclear pre TMI, can be seen as an organizational precursor of the accident.

2.1.4 The Fukushima Accident.

On 11 March 2011, an earthquake generated a series of large tsunami waves that struck the east cost of Japan. Several nuclear power facilities were affected by severe ground motions and large multiple waves including TEPCO´s Fukushima Dai-ichi and Dai-ni.

The tsunami overwhelmed the defenses of the nuclear power plant, which were only designed to withstand tsunami waves of a maximum of 5.7 m high. One month later, after the earthquake, the Japanese Agency for Nuclear Safety determined Level 7 of INES Scale (International Nuclear Event Scale). The same level it was classified the Tchernobyl accident.

The tsunami resulted in extensive damage to site facilities and a complete loss of ac electrical power at Units 1 through 5, a condition known as station blackout (SBO). Unit 6 retained the function of one of the diesel generators.

In the sequence of events following the loss of cooling followed by an increase in core temperature, the discovery of the core and hydrogen explosions. "The operators were faced with a catastrophic, unprecedented emergency scenario with no Power, reactor control or instrumentation, and in addition, severely affected communications systems both within and external to the site. They had to work in darkness with almost no instrumentation and control systems to secure the safety of six reactors, six nuclear fuel pool and dry cash storage facilities" [8]. The explosions caused further destruction at the site and radiological contamination spread into the environment.

2.1.4.1 Precursors of the Fukushima Accident

The IAEA mission Report about Fukushima´s accident issued in June 2011 [8] pointed out some important issues**.**

Despite warnings about the location (near known fault line) and even after 2002, when additional protective measures should have been taken as result of an technical evaluation conducted, the design and construction followed without major investments in safety that would ensure defense-in-depth, i.e. with the complacency of the regulator [9].

Mechanisms of communication failed during the accident, plant operators Station Black Out (SBO) scenarios in the failed reactor control systems and instrumentation systems by adding the failure of internal and external communication. The communication systems of with the population were the target of criticism during and after the accident.

Additional protective measures were not reviewed and approved by the regulatory authority [8].

The performance of the regulatory body has been questioned in several situations: in the updating of regulatory requirements and guidelines, complicated structures and organizations can result in delays in urgent decision making and "nuclear regulatory systems should ensure that regulatory independence and clarity of roles are preserved in all circumstances" [8].

The use of tools such as Probabilistic Safety Analysis that complement the Deterministic Analysis should be used to performing the assessment of external events [8].

All the issues above mentioned by the IAEA can be considered "organizational precursors", because the actions on issues that should have been taken by the organization, i.e. managers and directors.

2.2 Safety Culture

The term safety culture was introduced by the International Atomic Energy Agency - IAEA - as a result of their first analysis into the nuclear reactor accident at Tchernobyl [10]. The implementation of safety culture must be taking in account by the utilities s and the regulatory bodies.

A good definition of safety culture includes "aspects of organizational culture that will impact on attitudes and behaviors related to increased or decreased risk" [11]. These attitudes and behaviors are closely linked to organizational precursors to some extent, are the factors that generate such precursors.

There is a close relationship between major accidents, incidents and "near misses" followed by unsafe actions suggested in a study [12] with the result of deficiencies in safety management. The research emphasizes the link between "good safety, good business."

What can be considered good attributes of safety culture? The Professor Andrew C. Kadak in his lecture at Massachusetts Institute of Technology says people have to trust in: operate conservatively, make the right technical decisions, perform preventive maintenance, make design and operational improvements not because someone ordered you to do it, but because it was the right thing to do [13].

Investigation of near miss occurrences is a very useful measure of health and safety Performance as well as enabling organizations to learn from such errors [14].

Good performance in the nuclear business must be driven by excellence in nuclear operations and uncompromising safety. If this does not occur the ability of a nuclear organization to manage nuclear technology safely can be jeopardized. Despite increased awareness worldwide of the major role played by safety management and safety culture in the safety performance of nuclear installations, many nuclear organizations have, in recent years, experienced serious declines in these aspects. This has, in turn, led to extensive and costly improvement programmes and intensified regulatory supervision. The magnitude and difficulty of the effort required to recover performance are such that the continued viability of the organization comes into question [15].

One of the major challenges for the future is for both the nuclear industry and regulators is to achieve a more proactive approach to safety management and safety culture so that problems are detected and acted upon at an early stage, in order to prevent a significant degradation of safety. So, the concept of “safety culture” should not be considered only during the operation of nuclear power plants but should be extended during the design and construction.

2.3 Economic Considerations

In 2002, Sajarroff, Lederman, Lekpecki et all [16] identified a challenge to nuclear industry and regulatory authorities face to reduce costs and improve efficiency resulting from deregulation of electric markets, combined with changes to the organizational structure of nuclear power plant companies or in the privatization of this companies.

Considering only the accident of the Fukushima the headline in Nuclear Net News says that “the accident could cost for tax-payer $ trillions”. The industry, says Nei Magazine [17] “… the Japan Atomic Industrial Forum reported that at a Board of Directors meeting on May 20, TEPCO officially decided to decommission Units 1 to 4 at Fukushima Daiichi, and to abandon a plan to build Units 7 and 8, ABWRs, in addition”.

TEPCO will pay more $591MI in compensation for nuclear crisis. This compensation will offered for about 50 thousand families around 30 kilometers the nuclear power plants. This is the statement of Exame Magazine [18].

TEPCO reported on August 9, a $7.35 billion net loss for its fiscal first quarter, but the utility said "the company is unlikely to be crushed by swelling liabilities after the government recently passed a bill creating a state-backed entity to help the company meet mammoth compensation claims".[19]

An MIT study on the future of Nuclear Fuel Cycle [20] says in a postscript after Fukushima that "costs are likely to go up for currently operating and future nuclear power plants", "requirements for on-site spent full management may increase and design basis threats may be elevated and the importance of events beyond design basis accidents may increase".

The industry, the nuclear market will pay for "lessons not learned" or for the "cost-saving culture". Worse, the consequences of accidents are often paid by taxpayers or impossible to measure when socio-cultural factors are affected.

3. CONCLUSIONS

The standard formulation of risk is that it is a function of probability of an event occurring and the magnitude of the hazard. From the viewpoint of technological optimism and managerialism, the seductiveness of a very low probability often leads people to discount the magnitude of the hazard.

This distortion is amplified even further by the fact that the profits of success remain privatized, whereas the responsibility for large-scale hazards is often socialized, with governments and taxpayers picking up the tab.

It must be take in account "lessons learned" from the major accidents, good balance in the design and operation of Nuclear Power Plants between utilities and regulatory bodies' principles. This is including transparency to the whole society of the acts of the organizations involved (industry and regulatory bodies) and regulatory independence. As discussed above, we also include the "lessons learned" all so-called precursors discussed above. The sustainability of the nuclear industry in the short and medium term should be based on these principles: lessons learned and safety culture not only in operation phase but during the design and construction of Nuclear Power Plants.

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