Security and Risk Mitigation –Practical and Cost-Effective Solutions by the U.S. Nuclear Industry

Gary Hayner
Manager, Safety and Reliability
Jensen Hughes
2015 S. Bascom Ave, Suite 350
Campbell, CA 95008 USA
(408)559-4514 ghayner@jensenhughes.com

Introduction

The highly regulated United States nuclear industry must balance safety, performance, and cost. Safety to the public, competition with other energy producing industries, and the large capital and O&M costs of nuclear are exaggerated compared to other industries. Among these clashing constraints is the intersection of plant safety and security. Many view security as taking away from the bottom line of a plant's performance; however, the current global climate dictates the need to examine critical infrastructure security in a dynamic and effective manner while minimizing the cost and operational impacts to highly complex systems.

The nuclear industry has successfully navigated this challenge in the last 15 years. While the almost 100 operating nuclear plants in the U.S have been spent collectively billions on security, emergency response, and beyond design basis events, the process to determine the requirements and the results can be labeled as success. There have also been residual benefits that the industry is now realizing.

A combination of several factors, such as early industry involvement, engaged stakeholders, and regulatory negotiation, have allowed the nuclear plant operators and U.S. nuclear regulator to conclude in a mutually-agreeable, reasonable, and effective response to the need for safety and security change.

While the petrochemical industry is notably less regulated in this area than the nuclear industry, the lessons learned by the nuclear industry throughout this process may benefit the petrochemical industry in establishing more consistency and effectiveness in the safety and security area in a cost-effective manner. The massive number of petrochemical facilities in the U.S. and across the globe dwarfs the number of nuclear plants in the same locations, and face similar threats.

This paper will examine and discuss the challenges faced by the U.S. nuclear industry after 9/11 and the Fukushima accident, the process to determine the appropriate path to success, and the solutions themselves.

Background

Two major events have occurred in the last 20 years which have profoundly affected the U.S. nuclear industry – the terrorist attacks of 9/11/2001 and the nuclear disaster at Fukushima, Japan in 2011. These events have caused waves within the industry that are still felt today through regulatory, operational, and design changes. The uncertainty surrounding the events, particularly in the periods just after the events, led to a variety of responses across the spectrum. Some believed nothing needed to be done. Others believed that a massive overhaul of the regulatory process and physical plants were required. Between these extremes were most opinions which desired a balance between effectiveness, usefulness, and near and far term costs.

The Nuclear Regulatory Commission (NRC) is the federal regulator of the U.S. nuclear industry. It consists of five Commissioners appointed by the President and confirmed by the U.S. Senate for five year terms. The primary decision making tool is written correspondence from the NRC staff to the Commission. This includes policy, security, rulemaking, and adjudicatory matters. The Staff will typically engage the industry in some degree during this process, if only to get feedback on issues and potential recommendations. The independence between regulatory and industry may be categorized as high, but with a respectful consideration of one another.

The NRC develops the regulations with which the nuclear licensees must comply. They also develop some guidance documents and standards, provide oversight, identify and resolve generic issues, and perform support activities for decisions (e.g., research, risk assessment). They typically perform a regulatory analysis of cost and benefit for regulatory positions.

Discussion

Challenges

There are approximately 100 nuclear operating plants in the U.S. The energy generation industry is extremely competitive, operating in both regulated and deregulated environments. Nuclear plants have a very low profit margin compared to other power producers, such as many fossil plants. Nuclear plants have very high initial construction costs capital, often amortized over the life of the plant, as well as high operation and maintenance costs. Plant modification costs are consequently also high, particularly when considering the stringent design and construction controls and reviews for safety-related systems. Plant owners and utility shareholders desire to avoid additional costs as much as possible if they do not add to increased output or reduced cost. The types of regulations imposed by Fukushima and 9/11 are generally “overhead” costs which detract from the bottom line.

Both Fukushima and 9/11 made international headlines and echoes of those events are present in everyday life to this day. The public and political response, often knee-jerk, demanded a quick response, especially for critical infrastructure. It is no secret that the general perception of nuclear power is “scary” with high consequences. Nuclear plants are considered a high value target to terrorists and with each unit averaging almost 1500 MWe, they are considered critical infrastructure. A quick response must be balance with a reasonable, effective, and useful solution to avoid losing time, cost, or stakeholder confidence.

As 9/11 and Fukushima were examined in further detail with respect to the nuclear industry, it was found that the potential threats, either man made (i.e., terrorism/sabotage) or natural (i.e., tsunami, earthquake) have a very large set of possible circumstances and definition of specific threats is not realistic. The “what if’s” for defining initial conditions or causes of events becomes endless. In order to solve the issue, a reasonable box must be drawn around the problem.

The NRC is a regulator independent of the industry, but still evaluates the cost effectiveness, benefit, and necessity of regulatory policies. The NRC must follow its own rules when developing new requirements.

Process

The NRC and the Nuclear Energy Institute (NEI), representatives of the nuclear utilities, perform independent research on issues. This includes threats, technical solutions, bounding conditions, and impacts to the population of affected plants. There are often both formal and informal discussions between NRC and NEI during this period, with both groups normally sharing research to reach a realistic basis for decisions. NEI may provide feedback on impact to the licensees, yet ultimately the NRC will decide on its approach independent of the industry. NRC may provide some guidance for implementation of orders, or may rely on NEI to write such guidance and then endorse that guidance.

Whatever the NRC's position may be, an implementation timeframe accompanies any orders. Plants may have 30 days or 24 months to implement requirements. During this period, plans may be submitted to NRC for verification. Subsequent to implementation, NRC may perform inspections or audits. The NRC may accept exceptions to any requirements but normally requires extensive technical supporting information.

Solutions

Through extensive research, technical studies, and discussions, the industry and the regulatory body came to consensus on an approach. The use of realistic, best-estimate calculations, unlike the conservative, specific design-basis calculations typically performed in the past, resulted in a reasonable picture of consequences and expected actions. A measure of relative risk and risk improvement for such changes can also be quantified and compared.

The defense-in-depth concept was appealing and ultimately implemented. This approach minimized the impact to existing plant configuration. Flexibility was also desired to avoid limiting the assessments to specific scenarios. It was desired to have the solutions be as independent from the initiating event as possible to maximize its usefulness.

From 9/11 the industry response evolved into what was called "B.5.b." A quick response was needed due to the sudden new threat vectors and public and political pressure. There were many revisions to physical security regulations with commensurate spending, but there was also a need for operational and emergency response revisions to meet these new threat scenarios. It couldn't be said that a security event would not occur, and the plant had to have an integrated response plan. B.5.b was the operational and emergency preparedness response and had a "broader" application than just a security-related incident. Initially, it was defined as a loss of large area of the plant due to fire or explosion (i.e., aircraft crash). This later evolved into an undefined, nonspecific threat. The industry responded to the short and general orders with sets of 10 to 15 plant procedures and limited new equipment (portable pumps, hoses) along with minor modifications (connection points to existing systems). Diversity and mitigating strategy entry points are not specific.

From Fukushima the industry response was called FLEX (Flexible and Diverse). A task force was established in response to Commission direction to conduct a systematic and methodical review of U.S. Nuclear Regulatory Commission processes and regulations to determine whether the agency should make additional improvements to its regulatory system and to make recommendations to the Commission for its policy direction, in light of the accident at Fukushima. This task force concluded that, among other things, the sequence of events like the Fukushima accident is unlikely to occur in the United States and some appropriate measures have been implemented. The task force then concluded that that a more balanced application of the Commission's defense-in-depth philosophy using risk insights would provide an enhanced regulatory framework that is logical, systematic, coherent, and better understood. The NRC recognized that there must be a balance between voluntary industry initiatives and regulatory actions. Some key actions included re-examination of the seismic and flooding studies for all plants, as well as developing revised strategies for extended losses of AC power to prevent or mitigate the consequences of such events. The industry pushed back on some recommendations, such as installing filtered containment vents. These were viewed as minimally effective with a high cost. Eventually, the NRC concurred on this issue. Nonetheless, the industry has recognized the importance of such advanced planning for such low likelihood, high consequence events. The use of procedural revisions, portable equipment, and relatively minor plant modifications resulted in a diverse, flexible mitigation strategy that extended well beyond the intended scenarios.

<u>Results, Effects, and Benefits</u>

Nuclear plants rely on risk assessments and risk can be greatly impacted by defense in depth. Daily plant operations rely on risk insights to support safe maintenance planning. NRC performs risk-informed decision making and risk-informed enforcement. A benefit of the FLEX and B.5.b initiatives has been reduced risk profiles for plants. The results in more flexible operation, more confidence in operating principles, and cost reduction due to improved risk margins for systems and components.

While the B.5.b and FLEX initiatives were directed at specific scenarios, additional benefit to the plants was later realized. For example, it was found that the B.5.b pumps and equipment provided a means to add water to cool the reactor core or spent fuel pool in events other than security-related events. This additional defense in depth extended beyond the intended scenario, and the benefit of having an additional plant system to provide makeup water to such vital plant components reduced the overall risk of the primary systems as well as the cumulative risk of the plant based on detailed probabilistic risk analyses. The FLEX equipment provided similar benefits. This additional risk margin is beneficial to the plant for providing margin for maintenance windows, outage times, inspection and surveillance frequencies, and system management.

The application of these new capabilities was further realized during emergency preparedness drills. These drills often simulate loss of many primary systems, and exercise the operator and support personnel response. It was found that these beyond design basis procedures provided additional resources and methods to perform key safety functions. Classroom training on these procedures is required, but they are not normally used during live simulator exercises or full scale drills. They have been incorporated more into such training elements because of the realized benefits.

Full scale drills, including offsite responders such as local law enforcement, FBI, DHS, and others, are now required for all plants. The command and control enhancements included in the B.5.b efforts allow effective management of numerous organizations during such emergency events.

<u>Comparison with Petrochemical Industry</u>

The petroleum and petrochemical industry is less regulated in the security and risk area than the nuclear industry. For most petroleum facilities, the risk and security assessment is developed and implemented by the respective facility owner. Although API has issued several guidance documents with best practices for the industry for performing such assessments, there is still variability within the industry.

Additional regulation upon the petroleum industry in this area would not be well received, and is an impractical approach. The threat matrix for such facilities, given the diverse locations across the globe, require a more flexible and realistic approach where a wide variation of capabilities can be applied. This minimizes cost and still provides reasonable assurances of risk mitigation and public safety. Sabotage or attack on a single facility does not have the degree of consequence of the same on a nuclear plant. Also, the public perception of such an event is much less extreme for a petroleum facility. A consistent approach to risk mitigation within the petroleum may also provide a solid contingency plan for the industry in response to any future events to manage public, media, and political responses. The image that the industry is united and in control during and after such events is a powerful message. This is a cornerstone of NEI for the nuclear industry.

Conclusion

The defense in depth philosophy of the NRC and the nuclear industry is a beneficial approach to risk and security management and can be applied to the petroleum industry. The nuclear industry solutions were effective, useful, and cost-effective. It is possible the petroleum and petrochemical industry may glean valuable lessons from the experience of the nuclear industry regarding security and risk mitigation.

References

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