Three Mile Island, Chernobyl, and the Fukushima Daiichi Nuclear Crises: An Argument for Normal Accident Theory

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By

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Abstract

This paper will study three particular accidents in the nuclear industry: Three Mile Island, Chernobyl, and the Fukushima Daiichi plant. These crises will be evaluated through a crisis management framework, using two main accident theories: Normal Accident Theory, and High Reliability Theory. The examination of the crises and the organizations involved will show that no matter how reliable the complex systems are, accidents are inevitable in the nuclear industry. High reliability theory expresses an ideal for complex organizations. While following the theory's suggestions can limit some problems from occurring, acting as a mindful and reliable organization cannot prevent all disasters. The three cases presented in this paper will show that Normal Accident Theory must be accepted by the nuclear industry. Thus, governments and nuclear power plant operators must be prepared with crisis management plans in order to successfully handle emergency situations and limit damages.

The first part of this paper will introduce Normal Accident Theory and High Reliability Theory. Then, after a brief overview of the basics of nuclear power, Three Mile Island, Chernobyl, and Fukushima Daiichi will be examined in the theoretical framework, including a discussion of each event's crisis management techniques.

Chapter One: Theoretical Framework

I. Normal Accident Theory

Charles Perrow introduced the Normal Accident Theory in his book Normal Accidents in 1984. He proposes that no matter how complex a system may be, accidents are inevitable because it is impossible to predict and prevent every negative event from occurring. Perrow (1984) defines an accident as "an unintended and untoward event" (p. 63). The event "involves damage to a defined system that disrupts the ongoing or future output of that system" (Perrow, 1984, p.64). His theory is particularly aimed at "high risk" systems such as nuclear power and weapons, aircraft and air traffic control, and space missions. Perrow (1984) concluded, "no matter how effective conventional safety devices are, there is a form of accident that is inevitable (p. 3). Although safety technologies are advancing exponentially, Normal Accident Theorists claim that risk can never be eliminated because parts of systems can fail or behave in an unforeseen manner.

Perrow also outlines the characteristics of such "high-risk systems". Along with an involvement with explosive and toxic materials, the system has "interactive complexity" and is "tightly coupled". Interactive complexity refers to the many parts of the system that can react unexpectedly. Not only is it impossible to predict the behavior of the many parts of the system, the system is "tightly coupled" because reactions occur extremely quickly making it hard to isolate a failure and stop the system from operating. Although systems may incorporate emergency procedures and early warning signals, these adjustments only increase the complexity and coupling of the system. Despite his pessimistic perspective on highly advanced technologies, Perrow (1984) admits, “system accidents are uncommon, even rare; yet this is not all that reassuring, if they can produce catastrophes” (p. 5). Accidents are “normal” in these systems because of their complexity, not because of frequency.

Often times, human error is also one of the causes of an accident. Operators of high-risk systems are in control of highly destructive materials. Because these systems are tightly coupled, an operator must follow specific steps and take the necessary precautions. Operators and the organization as a whole must not ignore warnings given by the system or take any unnecessary risks. Nonetheless, history has shown that members of high-risk organizations have lied or disregarded procedures and warning signs. Mankind is not perfect by any means but this sloppy behavior can have disastrous and unexpected consequences.

Nuclear power plants fit all of the characteristics of Perrow’s high-risk system. They combine dangerous materials to create enormous amounts of energy, include many parts and work continuously and rapidly. In addition, Perrow (1984) notes that nuclear power systems are relatively new and scientists have little operating experience. Because of the complexity, very few people deeply understand nuclear power systems. In addition, adverse weather can affect the plants, such as earthquakes and tornadoes. These are unpredictable events that are difficult to prepare for.

Although these systems are highly susceptible to accidents, nuclear power plants are constructed with built-in safety mechanisms. One of these is a containment building.

This concrete shell “covers the reactor vessel and other key pieces of equipment, and is maintained at negative pressures…so that if a leak occurs, clean air will flow in rather than radioactive air flowing out” (Perrow, 1984, p. 40). Another safety mechanism is the Emergency Core Cooling System designed to cool the reactor core if it overheats and starts to melt. In addition, plants are usually built in areas with lighter populations concentrations, placing a smaller number of people at risk to radiation exposure.

Perrow’s analysis of normal accidents focuses particularly on Three Mile Island (TMI), the most prominent nuclear crisis at that time. For Perrow (1984), this event clearly illustrated a normal accident because of “the interaction of multiple failures that are not in a direct operational sequence” (p. 23). His theory preceded the accidents at the Chernobyl and Fukushima Daiichi plants but is very applicable to both situations.

II. High Reliability Organizations and High Reliability Theory

Perrow's theory is directly challenged by the ideas of Karl Weick and Kathleen Sutcliffe. In the book *Managing the Unexpected: Assuring High Performance in an Age of Complexity,* Weick and Sutcliffe (2001) discuss how high reliability organizations (HROs) can in fact avoid disasters despite their high-risk systems. Weick and Sutcliffe (2001) analyzed the same organizations as Perrow and realized that they all have "no choice but to function reliably" (p. xiii). If they do not function in a reliable manner, severe harm and destruction can occur. For this theory, reliability is defined as "the ability to maintain and execute error-free operations" (Shrivastava et al., 2009, p. 1363).

Despite facing numerous unexpected events, HROs rarely fail. HROs fall victim to unexpected events more than other organizations because "their technologies are complex and their constituencies are varied in their demands" (Weick et al., 2001, p. 3). According to Weick and Sutcliffe (2011), HROs are successful in preventing disasters because they act "mindfully". In other words, these systems achieve a state of mindfulness through

> The combination of ongoing scrutiny of existing expectations based on newer experiences, willingness and capability to invent new expectations that make sense of unprecedented events, a more nuanced appreciation of context and ways to deal with it, and identification of new dimensions of context that improve foresight and current functioning. (Weick et al., 2001, p. 42)

HROs generally do not ignore any warning signals, weak or strong, and address them with strong responses in order to avoid crises.

In particular, Weick and Sutcliffe (2001) identify five characteristics of HROs that lead them to act “mindfully”. The characteristics are “preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, [and] deference to expertise” (Weick et al., 2001, p.10). HROs are preoccupied with failure by analyzing and responding to any error, while also encouraging the reporting of errors. In addition, HROs are reluctant to simplify issues because the systems they run are “complex, unstable, unknowable, and unpredictable” (Weick et al., 2001, p. 11).

Along with not simplifying the systems, HROs are sensitive to the operations on the front line, rather than focusing on an obscure “big picture”. In their commitment to resilience, these organizations have the “capabilities to detect, contain and bounce back from those inevitable errors that are part of an indeterminate world” (Weick et al., 2001, p. 14). Lastly, HROs are characterized by deference to expertise. HROs promote diversity and give authority to members with the most expertise. Typically, ordinary organizations are structured as a hierarchy where only the top ranking members hold the power to make decisions.

Given these five characteristics, HROs must promote a particular culture. James Reason, a human factors researcher, named this a “safety culture”. Reason adopted this term’s definition from the UK’s Health and Safety Commission of 1993. The commission defines the “safety culture” of an organization as:

> The product of individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety programmes. Organizations with a positive safety culture are characterized by communciations founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measure. (Reason, 1997, p. 194)

This ideal culture for HROs is rarely attained, but should be strived for, according to Reason (1997).

A safety culture is made up of five subcultures: informed, reporting, just, flexible, and learning. A HRO has an informed culture if the operators and managers "have current knowledge about the human, technical, organizational and environmental factors that determine the safety of the system as a whole" (Reason, 1997, p. 195). The second component of a safety culture is a reporting culture, where staff and officials have the ability to report errors and potential issues. A reporting culture relies on a just culture, "an atmosphere of trust in which people are encouraged, even rewarded, for providing essential safety-related information" (Reason, 1997, p. 195). The fourth subculture identified by Reason (1997) is a flexible culture, where traditional business hierarchies are adjusted to a flat structure and "control passes to task experts on the spot, and then reverts back to the traditional bureaucratic mode once the emergency has passed" (p. 196). Reason identifies this adaptability as a key to successful crisis communication. Lastly, a safety culture stems from a learning culture. HROs have a successful learning culture if they show "the willingness and the competence to draw the right conclusions from its safety information system, and the will to implement major reforms when their need is indicated" (Reason, 1997, p. 196). Very few organizations can create such a culture and behave consistently as a HRO. This paper will explore whether the organizations involved in the Three Mile Island, Chernobyl, and Fukushima Daiichi nuclear accidents behaved reliably and mindfully, while fostering a safety culture.

III. Theory Discussion

There are many clear differences between Normal Accident Theory (NAT) and High Reliability Theory (HRT). The theories focus on varying aspects of accident avoidance for high-risk systems. NAT focuses primarily on the complex physical structure of the systems while HRT studies an organization's behavior and processes. According to NAT proponents, if an accident does not occur, it is due to "the system in question being not complicated enough" (Shrivastava et al., 2009, p. 1358). On the other hand, if an accident occurs in a HRO, HRT advocates would argue that the organization stopped being reliable and acting mindfully. Because of these contradictions, "the two theories cannot be tested as they can rationalize any outcome and almost always explain away their failure to make a prediction" (Shrivastava et al., 2009, p. 1358).

While the nuclear industry should be highly reliable, is acting mindfully and creating a "safety culture" an unreachable ideal? The crises at Three Mile Island and Chernobyl were a result of operator and hardware malfunctions. At the time, nuclear power technology was still new, increasing the probability of an accident. The organizations did not act in a reliable and mindful manner in their treatment of the nuclear plants and their crisis management afterwards.

Twenty-five years after Chernobyl, it was assumed that the nuclear industry had improved its technology and safety systems to prevent another accident. While the Tokyo Electric Power Company (TEPCO) may have been a high reliability organization prior to March 11, 2011, the natural disasters that shutdown its nuclear disasters supports

Perrow's (1984) idea that accidents are inevitable, no matter what precautions are taken. Similar to Three Mile Island and Chernobyl, TEPCO failed to act as a HRO following the accident in its crisis management efforts. Instead of showing concern for the safety of citizens, the organizations and countries involved focused on salvaging their reputations and protecting the nuclear industry.

Chapter Two: The Basics of Nuclear Energy

Since nuclear energy was first used to generate electricity in the United States in the early 1970s, the amount of power generated by nuclear plants has increased twenty-fold. Nuclear energy is created when atoms separate, a process called fission. On the United States Nuclear Regulatory Commission's (NRC) website, the agency provides background on the process. The purpose of a nuclear power plant is to transform heat into electricity using steam. Heat is created during the fission process and this heat creates the steam necessary for the conversion. As the website explains,

> "In a nuclear power plant, uranium is the material used in the fission process. The heat from fission boils water and creates steam to turn a turbine. As the turbine spins, the generator turns and its magnetic field produces electricity." (United States Nuclear Regulatory Commission [NRC], 2011b)

Radioactive particles are created during the fission process. Although the term "radioactivity" carries a negative connotation, radiation is everywhere and is naturally emitted by the environment. According to the NRC (2011a), a person's exposure to radiation in his lifetime is split evenly between natural and manmade sources.

Because the radioactive emissions produced in nuclear power plants can be very dangerous, plants have many complicated safety systems to keep radioactive materials contained. Many plants have automatic systems that can shut down the reaction and stop the fission process. In addition, plants can have mechanisms that "cool the reactor and carry heat away from it" and concrete "barriers" that keep the dangerous particles out of the environment (NRC, 2011b). Specifically in nuclear reactors, "radiation is contained inside small ceramic pellets about the size of an adult's finger. They are placed in long metal rods inside a reactor vessel, which is enclosed in a concrete and steel containment building" with walls that are several feet thick (NRC, 2011b). As mentioned by Perrow (1984), Emergency Cooling Systems are also in place to automatically turn in if the reactor reaches a higher, dangerous temperature.

Many studies have been done to test the biological effects of radiation. Scientists disagree on the "dangerous" level of radiation exposure and exactly what the consequences are of such exposure. In the time of TMI and Chernobyl, the majority of the public believed that radiation was harmful only if a person was exposed to a large dose of it.

> Decades ago, there was the notion of a 'threshold dose' of radiation, below which there was no harm. That's because when nuclear technology began and people were exposed to radioactivity, they didn't promptly fall down dead. But as the years went by, it was realized that lower levels of radioactivity take time to result in cancer and other illnesses- that there is a five-to-40-year 'incubation' period. (Grossman, 2011, p. 9)

Today, this belief in a "threshold dose" has shifted following studies of victims of Chernobyl. The NRC's website explains, "the radiation protection community conservatively assumes that any amount of radiation may pose some risk for causing cancer and hereditary effect, and that the risk is higher for higher radiation exposures" (NRC, 2011a). The main issue with establishing causation between cancer and radiation exposure is that sometimes the cancers do not develop until many years after the exposure. At this point, it is practically impossible to determine if radiation caused the harm or if it developed from exposure to another carcinogen. Other problems with studying the affects of radiation come up when pro-nuclear agencies alter or falsify information about the dangers of radioactive emissions. This was common following the accident at Chernobyl and will be discussed later in the paper. Although scientists may disagree on the exact effects of radiation exposure, there is no controversy over the fact that the materials used in nuclear plants are extremely dangerous to humans if they are exposed to high doses of radiation. While nuclear energy is a convenient and efficient way to provide power to millions of citizens, it is crucial that these highly complex systems be treated with care.

Chapter Three: Three Mile Island

I. Three Mile Island: Background Information

The Three Mile Island (TMI) nuclear power plant is located in Pennsylvania, south of the capital Harrisburg. It is the site of the first nuclear crisis that will be examined in this piece. The accident at TMI occurred on the morning of March 28, 1979 when "the pressurized water reactor in Metropolitan Edison's Unit-2 came very close to a core meltdown" (Casamayou, 1993, p. 101). The accident was attributed to both a hardware failure and wrongful behavior on the part of the plant operators.

In order to fully understand the development of the accident in Pennsylvania, it is crucial to study the legislative, social, and cultural constructs surrounding the nuclear energy industry in the United States during the second half of the 20^{th} century. The global desire to invest in nuclear energy was born after the end of World War II, with the dropping of the atomic bombs on Hiroshima and Nagasaki. The Atomic Energy Act of 1946 established the United States Atomic Energy Commission, which was "firmly committed to commercializing civilian nuclear power…[and] overseeing military applications of nuclear development programs" (Casamayou, 1993, p. 134). The Act identified the purpose of the United States' nuclear energy policy as follows:

> Accordingly, it is hereby declared to be the policy of the people of the United States that, subject at all times to the paramount objective of assuring the common defense and security, the development and utilization of atomic energy shall, so

far as practicable, be directed toward improving the public welfare, increasing the standard of living, strengthening free competition in private enterprise, and promoting world peace. (United States Atomic Energy Commission, 1964).

Interest in nuclear energy increased rapidly along with the reactor size and orders for new plants. While there were only eight orders in 1965, that number jumped to twenty-one in 1966, and twenty-seven in 1967. The Atomic Energy Commission was not prepared to handle the increased orders for licenses while keeping up to date on safety concerns and regulations. Nuclear energy involves extremely complicated technology and procedures and it was still in the experimental stages at this time. Thus, the agency was tainted with a negative image due to its "lack of focus on safety aspects during these years of rapid nuclear commercialization" and the public shared its concerns through "mandatory public hearings at the construction permit and the operating license stage" (Casamayou, 1993, p. 135). These hearings were cancelled in 1962 and were essentially just for show. The public hearings were bypassed to accelerate the licensing process for new plants. Generally, the public was uninformed about the technology behind nuclear energy and their concerns went unheard.

Negativity towards the Atomic Energy Commission came to a head in the 1970s. "Public skepticism about the agency's commitment and competence in safeguarding the public against radiation" led Congress to pass the Energy Reorganization Act of 1974 (Casamayou, 1993, p. 136). This act separated nuclear regulation into two organizations: "The Energy Research and Development Administration was responsible for promoting nuclear energy, and the Nuclear Regulatory Commission was given the regulatory task of the old AEC" (Casamayou, 1993, p. 136). Despite the government's efforts, the Nuclear Regulatory Commission (NRC) inherited the distrust of the public from the AEC.

The NRC was under increased pressure by Congress to revaluate its safety criteria. Congress held many hearings on topics such as cracks in pipes at certain reactors, the placement of plants relative to seismic and earthquake activity, and the licensing process for new plants. Congress urged "the NRC to attend to safety concerns, even if these were costly, before the nation became too dependent upon nuclear energy" (Casamayou, 1993, p. 139).

Nonetheless, it seemed that Congress was expressing a contradictory message. While investigating safety regulations of the industry, the Chairman of the House Subcommittee on Appropriates "continually railed at the NRC commissioners for failing to speed up the licensing process and threatened to cut the agency's budget" (Casamayou, 1993, p. 144). Thus, the NRC was dealing with increasing pressure to investigate the safety of the United States' nuclear plants while being urged to accelerate the process by which they are built. The new safety criteria developed under Congress' watchful eye only made the licensing process longer for new plants.

It is important to note that the safety concerns brought forth and examined by the government at this time were focused on the technology and hardware of nuclear power plants, not operator errors and guidelines. It was thought that if safety and hardware criteria were met, an accident would not occur. "Automatic failsafe redundant safety systems were the answer to serious threats to reactor safety…the operator was virtually an onlooker" (Casamayou, 1993, p. 115). In addition, regulators were comforted by the fact that no accident had occurred. Until the accident at TMI, focus was solely on the technological aspects of nuclear power plants.

Even though Congress was much more involved in the nuclear industry in the 1970s, the NRC's attitude did not seem to change. This was partially due to the fact that the majority of the government agency's staff was a veteran of the industry and a strong advocate for the advancement of nuclear power in the United States. A study in 1976 found,

> 307 of the 429 senior official at the NRC were hired from private industries with heavy involvement in the energy field. Ninety percent of these came from private enterprises holding license, permits, or contracts with the NRC. Seventy of these came from the five largest reactor manufacturers.(Casamayou, 1993, p. 147)

The strong connection between the NRC and the industry created a very pro-nuclear atmosphere that could not be deterred by the concerns of Congress and anti-nuclear groups such as the New England Coalition on Nuclear Pollution and Ralph Nader's organization, the Public Interest Research Groups. Labor groups, on the other hand, supported the growth of the nuclear power industry and seemed to be "more worried at the prospect of massive job losses than the radiological hazards of their work environment" (Casamayou, 1993, p. 143). Given the rapid development of nuclear energy and general ignorance of the public, it was only a matter of time before an accident occurred.

II. Three Mile Island: The Accident

On March 28, 1979, the pressurized water reactors in the second unit of Metropolitan Edison's Three Mile Island power plant stopped operating automatically due to a leak in a seal. As heat started to gather in the reactor, alarms went off in the control room and emergency cooling systems and water pumps turned on. This was also an automatic system, "designed to pull water from an emergency storage tank and run it through the secondary cooling system to compensate for the water that boils off once it is not circulating" (Reason, 1997, p. 53). Although the operators were following established guidelines, the procedure instructed them to slow the emergency cooling system. The operators' main error during the crisis was to slow down the amount of water flowing into the system to cool it. It was this action that was mainly responsible for the damage to the unit.

With the cooling system not working at full capacity and a small leak in the reactor core, there was significant fuel damage to the reactor and the release of radioactive steam. It took operators and engineers an additional sixteen hours to make the plant safe again. Nonetheless, no lives were lost in the accident and the materials released from the plant proved not to be a health concern. The incident at TMI proved to the government and the public that the nuclear industry was much more dangerous than initially anticipated.

The accident at TMI on March 28, 1979 cannot be blamed on only one party or technical mishap. The technology was still in the early, experimental changes and the dangers of radioactive materials had not yet been determined. Manufacturers were rushing to build the largest, most efficient plants. Congress was torn between passing stringent safety regulations and allowing faster licensing processes. The public was both scared of the new technology, but excited for cheaper energy after the oil price surges in the first half of the 1970s. No one, not even the engineers, understood the potential for disaster with this new energy source.

Fortunately, no lives were taken in the accident at TMI. The incident served as a wake up call for the global nuclear industry and the United States government. Following the crisis, the human factor was recognized as a potential source of accidents and emergency procedures were rewritten to reflect this. From the nuclear industry, the NRC "demanded a general upgrade in the technical expertise of the operators and supervisors and the adoption by the industry of higher standards in both its recruitment and training programs" (Casamayou, 1993, p. 158). In addition, the commission increased the breadth and depth of its safety regulation and inspection programs, leading to "a significant increase in both the number and the dollar amount of fines levied against the industry" (Casamayou, 1993, p. 158).

Importantly, the NRC was forced to confront the reality that accidents can happen, despite automatic safety cooling systems and the technological enhancements made to the system. This was portrayed clearly in the new regulation that required "states and localities establish emergency evacuation plans for the geographic area within a ten-mile radius of nuclear plants" (Casamayou, 1993, p. 159). This plan had to be developed and approved before any nuclear plant could be operated. In addition, there were efforts to consolidate the energy agencies and improve communication between the government, the industry, and the public. To address the operator error that occurred at TMI, regulators required operators to not "cut back on the high-pressure injection during the recovery stages of an off-normal event" (Reason, 1997, p. 53).

Not surprisingly, anti-nuclear power groups used the accident at TMI to support the shutdown of all nuclear plants. To combat the negativity, President Carter, Congress, and the Secretary of Energy discussed how the United States needs nuclear power especially to decrease the nation's dependency on oil. Thus, the NRC was given the financial resources to continue operating the existing plants and the licensing process for future plants. Since there have been no accidents in the United States since, it appears that the efforts after the crisis at TMI were successful. High reliability theorists would argue that engineers have learned from the initial mistakes and developed such advanced technology that another accident will not occur. Normal accident theorists would counter that an accident is bound to happen, because such a complex system combined with the imperfect behavior of an operator will lead to an unpredictable, and dangerous, outcome.

III. Crisis Communication After the Accident at Three Mile Island

Following the accident, the government commissioned a study from the Public's Right to Information Task Force to study the crisis communication efforts. The report produced by the task force included "an assessment of the performance of public information officials and an assessment of the performance of the news media" (United States President's Commission on the Accident at Three Mile Island Public's Right to Information Task Force [Public's Right to Information Task Force], 1979, p.1). The report begins with this dramatic statement:

> For every group even remotely connected to the nuclear power industry, the accident at Three Mile Island (TMI) was a time of truth. The training of plant personnel, the durability of equipment, the planning of civil defense officials, the responsiveness of public health officers – all were tested under harrowing conditions in the glare of national publicity. (Public's Right to Information Task Force, 1979, p. 1)

In the study's review of the performance of the news media, the task force reported that the needs of the public had not been met. The report held journalists and public officials to high standard, claiming that they must provide "timely, accurate, and understandable information to the public" (Public's Right to Information Task Force, 1979, p. 3).

Some of the communication problems originated from the NRC and Metropolitan Edison (Met Ed), the owners of the plant. The report found that the issues stemmed from a lack of planning, especially since neither organization had a plan for disseminating information to the public in the event of a disaster. There was only a short mention of crisis communication in Met Ed's emergency plan for TMI. The document stated, "the personnel at the utility's headquarters in Reading, Pa., 'will provide technical support' to Public Relations and Information Services, and that 'all information given to the press or radio stations, regardless of what category of emergency exists, shall be issued through Met Ed Communication Services Department'" (Public's Right to Information Task Force, 1979, p. 66).

In addition, Met Ed did not have a designated spokesperson and the responsibility of crisis communication was not well defined between the NRC and the utility. The report found that the most prominent failure of the pre-accident stage was that "neither the utility nor the NRC made provision for getting information from people who had it (in the control room and at the site) to people who needed it" (Public's Right to Information Task Force, 1979, p. 4).

Along with a lack of crisis communication planning before the accident on the part of the NRC and Met Ed, journalists were also ill prepared to cover the nuclear industry. The majority of reporters had little or no knowledge of nuclear power and could not understand the vocabulary utilized by the industry. The task force found, "neither Met Ed nor the NRC provided enough technical briefers in the first 5 days of the accident to help journalists interpret what they were being told" (Public's Right to Information Task Force, 1979, p. 5).

Furthermore, Met Ed and the NRC did not coordinate communication efforts after the accident, resulting in contradicting information. News from Met Ed tended to be more optimistic, acknowledging, "they were unwilling to release 'pessimistic' information to the public until it was confirmed to their satisfaction" (Public's Right to Information Task Force, 1979, p. 7). The task force found no evidence of a cover-up on the part of Met Ed, yet some of the press releases issued by the company suggest that they were not truthful about the reality of the situation the day of the accident. Specifically, one release published the day of the accident explained that the cooling system was working correctly and no radioactive emissions were expected from the reactor. It was later discovered that at this time, "utility officials knew that high radiation levels were already present in the containment vessel, that a valve was stuck open, and that cooling pumps could not be made to work" (Rubin, 1987, p. 49).

On the contrary, news coming from the NRC had a more pessimistic tone. From the start of the accident, the government agency distanced itself from the utility by not participating in joint press conferences and releases. The task force also analyzed statements made to the press and the NRC "was a chief source of 'alarming' statements about such subjects as the possibility of meltdown and the explosiveness of a hydrogen bubble in the reactor" (Public's Right to Information Task Force, 1979, p. 7-8).

Although the media was accused of publishing incomplete stories, a study by the task force found that "the media offered more reassuring statements than alarming statements about the accident" (Public's Right to Information Task Force, 1979, p. 12). A subsequent content analysis of the first week of news reporting by New York University professor Mitchell Stephens (1982) also came to the same conclusion: Overall, the media did not represent an alarming view of the accident at TMI. Stephens (1982) found that only one topic had completely unbalanced coverage. When discussing the quality of the information on the accident provided to the public, 99% of statements issued by the media were negative (Stephens & Edison, 1982, p. 201).

A close look at the individual public relations policies of Met Ed and the NRC prior to the accident gives some explanation as to why the combined efforts after the accident were so disgraceful and unsuccessful. Met Ed had an under-staffed communications services department that was generally ignored by management. Top executives, who had no prior experience or knowledge in the field, made public relations decisions. The task force found that public relations activities were limited to press releases about TMI and community relations. Starting in 1973, Met Ed provided weekly statements about the status of TMI. On the surface, this seems to be a proactive and helpful policy. Yet, these releases were written by engineers, included neither a date nor a contact person, and always contained positive information to support the company's reputation. The technical jargon used in the releases made them incomprehensible to an ordinary reader or journalist.

Nonetheless, the releases did provide some warning that Unit 2 at TMI was operating with difficulties. The task force studied releases from the year before the accident and found that the unit was "out of operation 71 percent of the time…[and] had suffered at least 11 reactor shutdowns and numerous turbine trips" (Public's Right to Information Task Force, 1979, p. 38). Why did this information not attract more attention? These crucial issues were hidden within “a plethora of obscure detail” in order to protect Met Ed’s reputation (Public’s Right to Information Task Force, 1979, p. 39). Reporters interviewed by the task force admitted that they did not understand Met Ed’s weekly releases and felt that they were misled about the seriousness of the events taking place at the plant.

The lack of action on the part of Met Ed when it found out that the reactor was having issues illustrates the lack of safety culture and mindfulness. Met Ed was not acting as a high reliability organization because it did not address the warning signs and issues before the accident.

On May 10, 1979, Met Ed published its own report to the community that included a letter from the president of the utility and transcripts of testimonies before the Subcommittee On Nuclear Regulation of the Senate Committee on Environment and Public Works. The testimony by Herman Dieckamp, President of General Public Utilities Corporation (of which Met Ed is a subsidiary) addressed the causes of the accident, the company’s response, and plans for the future. Dieckamp named “a complex combination of equipment malfunctions and human factors” as the cause of the accident (Metropolitan Edison Company, 1979, p. 1). He also defended the operators of the plant, calling them “a qualified and competent. They performed their functions professionally in a period of extreme stress” (Metropolitan Edison Company, 1979, p. 3). It was the pre-established guidelines that misdirected the plant operators.

The NRC also had its own public relations issues prior to the accident. The task force summarized the agency’s incompetence:

> At the NRC the problem was a technical staff unable to communicate with the public, an atmosphere of secrecy left over from the NRC's predecessor agency, the AEC, as well as a commitment to promoting nuclear power, and a fuzzy definition of what a public affairs program for a regulatory agency should be. (Public's Right to Information Task Force, 1979, pg. 48)

As mentioned earlier, the public generally held a negative view of the NRC, encouraging the agency to maintain a low public profile. In addition, the agency office was not located at the same address as the communications office, hindering daily contact. A physically disjointed communications effort continued during the first week of the accident, with ten different locations providing information from the NRC and Met Ed.

It is clear that Met Ed was not behaving as a high reliability organization, making an accident inevitable. The company and the NRC overlooked safety problems with the plant and failed to keep the public informed after the accident that occurred. The crisis at TMI resulted from operator and technical errors. Since the technology was still new, the nuclear plant could not have been a high reliability organization and should have accepted Normal Accident Theory. Coming to terms with the idea that accidents will occur, especially in high-risk, complex systems, would have forced the NRC and Met Ed to have emergency plans in place. This would have avoided the communications debacle.

Chapter Four: Chernobyl

I. Chernobyl: Background

The Chernobyl nuclear power station is located in the Ukraine. At the time of the disaster, this land was part of the Soviet Union. Chernobyl is located a little over 100 kilometers north of Kiev, the capital of Ukraine, and three kilometers from the larger town of Prypyat, with 45,000 residents. In 1986, the year of the accident, the town of Chernobyl had 12,500 residents and the nuclear power station was located fifteen kilometers to the northwest of the small town (Marpels, 1988, p. 3).

The Soviet Union's nuclear power program began with the country's research into nuclear weapons. The Cold War pushed both the United States and the USSR into a frenzy of scientific discoveries, as each wanted to be the country with the most powerful weapons. The technology aimed towards the creation of nuclear weapons lent itself well to nuclear power plants. The Chernobyl power plant included a graphite-moderated reactor that was "originally part of the military economy – that is geared to the production of plutonium and tritium for the nuclear weapons program" (Medvedev, 1993, p. 7). By 1986, Chernobyl was home to four "modern" Soviet RBMK reactors. RBMK, a Russian acronym, can be roughly translated to "reactor cooled by water and moderated by graphite" and was used for electric power production (Marpels, 1988, p. 3).

In addition to the Cold War, the USSR turned to nuclear power because of its problems with oil and gas. Mining had become increasingly difficult and "the Soviet coal industry experienced the highest accident rate in the world" in the 1970s (Medvedev, 1993, p. 9). Production of oil had peaked early in the decade and oil prices were falling. The Soviet Union needed a source of power that "could provide a guaranteed supply of electricity in the heavily industrialized and most populated regions of the country" (Medvedev, 1993, p. 9).

The four units at Chernobyl were completed by December 1983, with units 3 and 4 constructed as "twin reactors", sharing a common building. At the time, it appeared to the outside world that the plant was running well and efficiently. Yet in 2003, documents were released by the KGB (the Russian Committee for State Security), which discussed deficiencies in the plants and problems with the equipment in 1984. Up until the disaster there were no public reports of problems at the plant, except for one piece written by a young, female Ukranian journalist. She explained several issues with the construction of the plant and described it as "an accident waiting to happen" (Medvedev, 1993, p. 15).

The industry and the government blatantly ignored her warning. This was not surprising given the Soviet Union's strict control over the media. In fact, one year before the accident at Chernobyl, the Minister of Energy of the Soviet Union "decreed that information on any adverse effects caused by the functioning of the energy industry on employees, inhabitants and environment, were not suitable for publication by newspapers, radio or television" (Laka Foundation, 2011). He reinforced this rule following this accident, and prohibited his civil servants from giving the media any truthful information about what occurred at the plant.

II. The Accident at Chernobyl

On April 26, 1986, the fourth reactor at the Chernobyl nuclear planted exploded during a safety and maintenance test. The plant operators decided to test whether or not the cooling system would continue to work in the event of a loss of power in the time that it took the back up power supply to be turned on. The Soviets wanted to ensure that their reactor could withstand an accident and “cope simultaneously with a loss of electric power” (Marpels, 1988, p. 12).

The test removed the majority of the control rods from the reactor and slowed down the reactor. The operators wanted to observe how long the “spinning turbine would provide electric power to certain systems in the plant” (Marpels, 1988, p. 12). This would not have been a problem except for the entrance of warmer feed water and the lack of rods caused water to start boiling within the reactor.

At this point, the operators should have stopped the experiment from continuing. Because the power had been turned off, the plant was operating at only seven percent of full power. Operators violated plant regulations by continuing to test the generator. James Reason (1997), the safety culture theorist, remarks on the operators’ error:

> The station operating procedures strictly prohibited any operations below 20 percent full power (the initial intention was to run the experiment at 25 percent full power). Subsequently, operators successively switched off various engineered safety systems in order to complete the experiment, and in so doing made the subsequent explosions inevitable. (p. 76-77)

The boiling water and extra heat immediately increased the power being created by the reactor. Steam was forming in the reactor and fuel cells began to erupt. The damaging of the fuel channels and the steam increased the pressure within the reactor. The increased pressure, failure of the cooling systems, and misplacement of the fuel rods along with the incompetence of the operators led to the worst nuclear disaster the world had yet seen.

The World Nuclear Association explains,

> Two explosions were reported, the first being the initial steam explosion, followed two or three seconds later by a second explosion, possibly from the build-up of hydrogen due to zirconium-steam reactions. Fuel, moderator, and structural materials were ejected, starting a number of fires, and the destroyed core was exposed to the atmosphere. (2009)

The explosions fed radioactive debris and fumes into the air. Scientists claim that the radioactive emissions from the reactor "exceeded a hundredfold the radioactive contamination of the bombs dropped on Hiroshima and Nagasaki" (Yablokov et al., 2009, p. 1). A lot of discussion and controversy surrounds the exact amount of radioactive emissions that erupted from the reactor. Researchers today and at the time disagreed on what the threshold was for dangerous exposure to radioactivity and the direct link between cancers and radioactive exposure.

A report from the Annals of the New York Academy of Sciences concluded, "9,000 victims died or developed radiogenic cancers…some 4,000 children were operated on for thyroid cancer [and] in the contaminated areas, cataracts were increasingly seen in liquidators and children" (Yablokov et al., 2007, p. 2). Unfortunately, the destruction of Chernobyl was not contained to the Ukraine and the Soviet Union. Research has shown that "more than 50% of the surface of 13 European countries and 30% of eight other countries have been contaminated by Chernobyl fallout" (Yablokov et al., 2007, p.2).

In addition, it was not just humans that were negatively affected by the radioactive emissions. Toxic materials poisoned water, animals, plants and other food sources that were not immediately destroyed or purified after the accident. This increased the negative consequences of the nuclear disaster for mankind in the region. "Chernobyl contamination traveled across the Northern Hemisphere for hours, days, and weeks after the catastrophe, was deposited via rain and snow, and soon ended up in bodies of water" spreading the consequences of the disaster across the globe (Yablokov et al., 2007 p. 226). In fact, researchers found,

> Mutation rates in plants, animals, and microogranisms in the Chernobyl-contaminated territories are much higher than elsewhere…[and] has resulted in transgenerational accumulation of genomic instability, manifested by abnormal cellular and systemic effects (Yablokov et al., 2007, p. 285).

Some scientists believe that the ground is still contaminated with radiation. It has not been determined what the final ecological impact of the disaster will be.

Statistics calculated by research groups are rarely consistent and results of studies contradict one another often. It is very difficult to develop a complete picture of the impacts of the Chernobyl disaster. This is mainly due to the behavior of the USSR and "the official secrecy that the USSR imposed on Chernobyl's heath data in the first days after the meltdown, which continued for more than three years" (Yablokov et al., 2007, p. 33). This secrecy was a trademark of the USSR and the country later admitted to "official irreversible and international falsification of medical statistics" (Yablokov et al., 2007, p. 33). There is a serious lack of trustworthy medical statistics so it is impossible to determine exactly how many people were affected by the disaster. The USSR was not the only country to try to cover up the crisis. Many nations and international organizations tried to downplay the consequences of the nuclear accident at Chernobyl in order to support the developing nuclear programs across the globe.

III. Soviet Crisis Communication After the Accident at Chernobyl

At the time of the disaster, the Telegraph Agency of the Soviet Union (TASS) was the central source and distributor of news in the USSR and its newspapers, radio stations, and television programs. The agency first reported the events at Chernobyl

> In a terse two-line statement on April 28, and on the following day this statement was published on the back of page of two Kiev newspapers – one of the few occasions on which these newspapers released a major news item before their Moscow counterparts." (Medvedev, 1993, p. 16)

Because of the scant news coverage by the Soviet media, rumors were the main source of information for citizens.

Ten days after the accident, Ukraine's minister of health instructed citizens to "keep your windows shut and wipe your shoes well on a wet rag before entering home. Wash the floors and wipe the furniture with a damp cloth" in order to be safe from radiation (Yaroshinskaya, 2011, p. xvi). Naturally, this advice only served to panic the citizens more and did nothing to protect them from radiation.

Mikhail Gorbachev, who served as General Secretary of the Communist Party of the Soviet Union at the time, finally addressed the situation on May 14 in a speech to Soviet citizens. He explained that the accident at Chernobyl claimed nine lives and injured 299 others and applauded the workers and volunteers for their bravery. Despite his appreciation for the American doctors helping at the scene, Gorbachev accused the Western press and governments for "a vast accumulation of lies, unscrupulous and malicious to the extreme" ("Gorbachev speaks out about Chernobyl", 1986). Not only did the nuclear power accident at Chernobyl affect the Soviet people, Gorbachev stated that the disaster "disturbed world opinion" on nuclear power and suggested meeting with President Reagan and European leaders to discuss a ban on nuclear testing ("Gorbachev speaks out about Chernobyl", 1986).

In order to shed light on the disaster, the Soviet Union took the perspective that "Chernobyl, while a terrible accident, [would] not be quite as bad as originally suspected" (Marpels, 1988, p. 56). Rather than report on the medical illnesses arising from exposure to radiation, the Soviet government and press created "radiophobia", loosely defined as a condition characterized by "the fear of the biological influence of radiation" (Marpels, 1988, p. 49). Thus, no citizen was really ill, just afraid of falling ill. Those suffering from "radiophobia" connected every ailment with exposure to radioactive substances and were ignorant of the truth about radiation.

The Soviet government classified all documents that would shed a negative light on the country and its nuclear power industry. For example, a memo issued by the USSR Health Ministry two months after the accident instructed officials to do the following:

> (4) Classify as secret all information about the accident. (8) Classify as secret all information about the results of medical treatment. (9) Classify as secret all information about the degree of radioactive injuries to the personnel taking part in the liquidation of the consequences of the accident at the Chernobyl Nuclear Power Plant. (Yaroshinskaya, 2011, p. 46)

These instructions make it clear that the government was hiding the true seriousness of the accident both from its own people and from the global community. It is no surprise that researchers and doctors can only estimate the effects of radiation exposure from Chernobyl with the secrecy surrounding the documents.

The USSR also provided media outlets with a "List of Data on Issues of the Chernobyl Accident Not to be Circulated by the Press, Radio, and Television". Similar to the prior memo, this list classified certain information as secret:

> (1) Information about radioactive contamination levels in separate localities in excess of the maximum permissible concentrations. (2) Information about the indices of physical deterioration in work capacity and loss of professional skills by the operative personnel working in special conditions at the Chernobyl nuclear power plant, or by persons employed in eliminating the consequences of the accident. (Yaroshinskaya, 2011, p. 46)

In the government's efforts to maintain its image and hide the truth about the accident, it was simultaneously putting millions of its citizens in harms way. They had no access to honest information and continued to live in radioactive areas. Many deaths that occurred in the first few years after the accident went unregistered or death certificates were left undated and without a cause of death.

IV. Western Media and the Accident at Chernobyl

Because of the Soviet's secrecy, the American media had relatively little information to report to the public. In a research study on the coverage of Chernobyl on major television networks during the first week following the accident, it was calculated that reporting of Chernobyl on ABC, NBC, and CBS "exceeded that of TMI by 10.5%", even though it did not occur in the United States (Gorney, 1992, p. 460). Although there was increased coverage, a review of the transcripts from the evening news held "frequent indications that the networks were resorting to repetition of background information and the use of marginal continent to fill the time" (Gorney, 1992, p. 460).

While the Soviet press was reluctant to publish information, the Western media immediately began reporting on the accident. They published incorrect reports of initial casualties, ranging from 2,000 to 15,000. The American news channels ignored the Soviet announcement that their had only been two casualties and appeared to charge "implicitly, or explicitly, that the Soviets were trying to cover up the true death toll" (Dorman & Hirsch, 2006, p. 26). According to the study of network evening news broadcasts, every report in the first week following the accident included sensational words such as "meltdown", "catastrophe", "disaster", and "tragedy" (Gorney, 1992, p. 461). Specifically, the review of transcripts found,

> CBS warned viewers that 'the horror is just beginning' and ABC talked about the accident 'spewing radioactivity into the air'. CBS seemed to enjoy its description

> of 'an atomic reactor gone wild'…The networks consistently depicted Chernobyl as being the worst nuclear accident in history. (Gorney, 1992, p. 462)

In response, the Soviet Union accused the Western press of lies, sensationalist reporting, and scaremongering tactics.

The United States media was determined to distance the American nuclear industry from the Soviet one. The message to the American public was clear: "Americans had little to fear from a Chernobyl-like disaster" (Dorman &Hirsch, 2006, p. 27). The press tried to convince the public that the reactors at Chernobyl were dated and did not have the security systems and advanced technology that were employed at American reactors. In addition, the media accentuated the differences in government in the two countries, taking a clear pro-democracy stance. Although government structure is unrelated to operator error and technological malfunctions, the media linked the accident "to the nature of Soviet society, the absence of debate, and state control of the press" (Dorman & Hirsch, 2006, p. 28).

Chapter Five: The Fukushima Daiichi Power Plant

I. The Accident at the Fukushima Daiichi Reactors

With the rapid advancements in technology since Chernobyl, high reliability theorists would argue that our systems are reliable and accidents can be avoided with the proper planning and hardware. The disaster in March 2011 would prove them wrong. Like the normal accident theorists stated, accidents are inevitable, no matter how many safety systems are put into place.

On March 11, 2011, an earthquake occurred off the coast of Japan. This natural disaster only fueled more damage, with a tsunami hitting the coast of the Japanese islands. Subsequent flooding swept away homes and resulted in over 15,000 casualties. The most dangerous victim of this natural disaster was the Fukushima Daiichi Nuclear Power Station, operated by Tokyo Electric Power Company (TEPCO).

In addition to nuclear energy, TEPCO is also involved in information technology, telecommunications, power facility construction, materials shipping, real estate, capital investment, and consulting services. Despite their multiple business endeavors, the company's electric power business alone generated 88.9% of operating revenues for the 2010 fiscal year (Tokyo Electric Company [TEPCO], 2011a, p. 1). Prior to the earthquake and tsunami, TEPCO served 35% of the Japanese population, providing electricity to almost 45 million citizens (TEPCO, 2011a, p. 1). Because of their large and financially significant consumer base, the events of March 11 affected the company, Japanese citizens, the Japanese government, and the global nuclear industry.

At 2:46pm on Friday, March 11, 2011, a magnitude 9.0 earthquake hit off of the east coast of Japan. In response to the earthquake, the operating units at TEPCO's Fukushima Daiichi nuclear plant were automatically shutdown by the reactors' safety systems. The tremors of the earthquake created a 13-meter tsunami, which came crashing into the plant, flooding it under several meters of water. The combined effect of the earthquake and tsunami caused the entire plant to lose power. In the TEPCO's 2011 Annual Report, it states that the nuclear power station was inundated with 11.5 – 15.5 meters of water (p. 4). According to a company presentation for investors, civil engineers had estimated in 2002 that the highest level of water that could possibly reach the plant from a tsunami would be no higher than 5.7 meters (TEPCO, 2011d, slide 3).

The loss of power shut down the cooling systems, "brought on emissions of radioactive material into the air, collapse of the reactor buildings caused by hydrogen explosion and leakage of highly radioactive contaminated water into some of the turbine buildings" (TEPCO, 2011a, p. 4). In order to cool the reactors, fresh water as well as seawater was injected into the units. Of the six reactor units that make up the Fukushima Daiichi plant, only unit 6 had emergency power available during the disaster while all the others lost their emergency power supply due to flooding.

II. Crisis Communication After the Accident in Japan

TEPCO issued its first press release at 4:30pm the day of the disaster to alert the public of the consequences of the earthquake and tsunami to its facilities. In addition to listing which reactors and utilities were out of service, the release announced that over four million homes had lost power. Right from the beginning, the company admitted that its units and customers would be negatively affected by the natural disaster.

> Due to the earthquake, our power facilities have huge damages, so we are afraid that power supply tonight would run short. We strongly ask our customers to conserve electricity. If you find any disconnected transmission lines, please do not touch them. (TEPCO, 2011c).

Despite leaving millions of citizens without power, TEPCO did not issue an apology in its first press release, only advice to conserve electricity and stay away from fallen power lines. To the company's credit, its press releases included detailed information about the status of every unit and reactor at the Fukushima Daiichi power station and listed injuries and casualties. In a release at 12:00am on March 12, 2011, the company stated that there was no difference in radioactivity in the plant or in the area outside the station (TEPCO, 2011e). Thirteen hours later, another release from TEPCO indicated that one employee "working in the Unit 1 was irradiated" and "confirmed that radioactive materials level [was] higher than ordinary level" (TEPCO, 2011f).

Rumors about radiation levels in and around the reactors began spreading through the global media before the company had publicly addressed it. An article in

Financial Times claimed, "radiation levels in the control room at the affected reactor were reported to have surged to 1,000 times normal levels" at the Fukushima Daiichi plant and seventy times normal levels at the gates of the plant (Soble et al., 2011). This is particularly worrisome because "radiation levels are not supposed to rise in a control room, which is designed to allow operators to continue working during emergencies" (Iwata & Monahan, 2011). On the day of the accident, many news sources reported the possibility of a leak and the release of radioactive emissions, but none could state for certain that this had happened.

The following day, *Agence France Presse* picked up on a discrepancy in the information being provided to the public by TEPCO and the Japanese government. "Japan's nuclear authorities warned Saturday that quake-hit atomic plant Fukushima No. 1… 'may be experiencing a nuclear meltdown'" read the first line of the article (Suzuki, 2011). Then, the article quoted a statement from a TEPCO spokesman, "we believe the reactor is not melting down or cracking" (Suzuki, 2011). In a second article published by the same source almost seven hours later, Japan's chief cabinet secretary claimed that the small explosion that occurred at the plant decreased radiation levels ("Tepco says no damage to reactor", 2011). At the same time, the article told the public that the government was now evacuating all citizens living within twenty kilometers of the plant, "widening the evacuation zone from ten kilometers" ("Tepco says no damage to reactor", 2011).

It was clear from the articles published in the twenty-four hours after the accident that contradictory and unclear information was coming from Japan. Supposedly there was an explosion at the plant, which reduced the radiation levels around it. Simultaneously, more and more citizens were being evacuated from the surrounding areas.

There was a clear discrepancy between the actions taken by the Japanese government and TEPCO and the statements they were publishing. Like the organizations before them, TEPCO was trying to reassure the public. The Japanese chief cabinet secretary held an "urgent" press conference and "urged people to stay clam and said the radiation level has been monitored" (BBC Monitoring Asia Pacific, 2011). It is doubtful that the lack of clear information and the widening evacuation zones helped to reassure a scared and anxious public. It also did not help TEPCO and Japanese officials that many news sources were reporting that the plants "may" be melting down and that Japan was working to "avert a meltdown".

A possible reason for the confusing information coming out of Japan was revealed several months after the accident. *The New York Times* reported in June 2011 that the Prime Minister of Japan, Naoto Kan, had strained relations with the nuclear industry and did not have confidence in the country's chief nuclear regulator. Kan was wary of TEPCO, "compliant bureaucrats and sympathetic politicians" so during the crisis, he turned to a few close advisers who had a little knowledge of nuclear power (Onishi & Fackler, 2011, A1).

Although there were emergency and crisis communication systems in place, Kan ignored them since he only trusted his close circle of aides. He was even hesitant to accept help from the United States, "which offered pump trucks, unmanned drones and the advice of American nuclear crisis experts" (Onishi & Fackler, 2011, A1). The United States felt it had a right to get involved, since it was worried for the well being of the 50,000 military personnel that were present in the country at the time of disaster.

Due to the mutual distrust and miscommunication between Japanese officials and plant operators, along with inexperienced advisors, Kan did not know of "the existence of a nationwide system of radiation detectors known as the System for Prediction of Environmental Dose Information…until March 16, five days into the crisis" (Onishi & Fackler, 2011, A1). There was controversy over whether to use fresh water or salt water from the ocean to cool the reactors. According to the article, the plant manager disobeyed orders from the government and continued to use seawater. In hindsight, his misbehavior prevented further disaster. Although the plant operator may have had little knowledge in the area of crisis communication, he is an expert in nuclear energy, unlike the Japanese government officials.

Despite the turmoil within the country and the contradictory information coming out of it, TEPCO made a more significant effort to educate the public about the status of the plants than its predecessors. The company issued numerous press releases every day following the accident. Nonetheless, it was not until March 16, 2011 that an apology was included in a release. The release first addressed "an abnormal noise" that came from one of the reactors and stated that some of the workers at the plant would be removed from the scene (TEPCO, 2011g). TEPCO attempted to show remorse in the last sentence of the short, six sentence press release: "We are aware of and sincerely apologize for the great distress and inconvenience this incident has caused to not just those inhabitants residing in the immediate vicinity but also society at large" (TEPCO, 2011g). This statement was unsigned and was placed as an afterthought at the end of the release.

On March 18, 2011, TEPCO issued a press release featuring a letter from the President of the company, Masataka Shimizu. In this brief message, Shimizu reported the International Nuclear and Radiological Event Scale assessment on the accident and addressed the public in a second apology. He addressed his apology to the citizens living in the area surrounding the plant, "as well as to the people of society for causing such great concern and nuisance" (TEPCO, 2011b). The last half of Shimizu's statement explained the cause of the crisis and iterated the company's efforts to contain the damage:

> We are taking this reality as an extreme regret, although it was caused by the marvels of nature such as tsunami due to large-scale earthquake that we have never experienced before. While receiving support and cooperation from the Japanese government and related department and local authority, we will continue our maximum effort to converge current situation. (TEPCO, 2011b)

This extremely broad statement does not address the public's concern for health and safety. The President does not give any specific information on the actions his company is taking to prevent radioactive emissions. He places all blame on "Mother Nature". Although this is a fair claim since the natural disaster could not have been predicted, citizens want the company to take responsibility for some of the consequences. Considering the advanced safety tests and technologies available, why did the company not test these rare and extremely dangerous conditions? If flooding can shutdown the "emergency" power supply, what purpose does it really serve in an emergency?

In addition, Shimizu does not provide any words of reassurance and does not give any insight into what the public can expect next. Although speculation can often backfire, the public was completely left in the dark about what the company's and the reactors' next actions could possibly be. Could there be an explosion? When will electricity be returned to homes? On the surface, Shimizu's apology was a necessary public relations move, but it came late and provided no concrete support or reassurance for the victims of the disaster and Japanese citizens. He appeared to be avoiding the seriousness of the damage.

On March 29, 2011, the United States Congress held a hearing to get more information on the accident in Japan and ensure that something similar could not occur on American soil. The executive director for operations of the NRC, R. William Borchardt, tried to reassure Congress that American nuclear power stations were safer than those in Japan. In his statement, he explained that the United States has

> Since the beginning of the regulatory program…used the philosophy of defense-in-depth, which recognizes that nuclear reactors require the highest standards of design, construction, oversight, and operation, and safety does not rely on any single level in order to protect the public health and safety. There are multiple physical barriers to fission product release at every reactor design. Beyond that, there are both diverse and redundant systems that are required to be maintained and in operable condition. They are frequently tested to ensure that the plant is in

> a high condition of readiness to respond to any scenario. (United States Committee on Energy and Natural Resources, 2011, p. 5)

Borchardt's words directly tie into the High Reliability Theory's idea that advanced technologies with enough safety systems can perform without any accidents. Like with TMI, he addressed only the hardware issues and did not mention the chance of operator error causing a nuclear accident. Despite the executive director's supposed confidence in American nuclear power stations, the NRC established "a Senior Level Agency Task Force to conduct a methodical and systemic review" of nuclear power regulations in the United States and suggest any adjustments in light of crisis in Japan (United States Committee on Energy and Natural Resources, 2011, p. 6).

Along with addressing the technical aspects of nuclear energy in the United States and the crisis in Japan, the hearing discretely discussed both the information coming out of Japan and the importance of crisis communication during a nuclear accident. Senator Udall of Colorado mentioned that those at the hearing were "frustrated with the various kinds of information, that's often contradictory, coming out of Japan" (United States Committee on Energy and Natural Resources, 2011, p. 14). This feeling was shared by many media sources, which were not sure if they could trust the information coming out of Japan. TEPCO and the Japanese government were not particularly forthcoming with detailed information, despite the multitude of press releases issued by the company.

Later in the briefing, Senator Coats of Indiana mentioned the issue of crisis communication in the nuclear industry. He admitted he is not an expert on nuclear power, but neither is the majority of the public. Senator Coats suggested that the alarming news reports could harm the image of the industry as a whole. The chaos overseas as a result of the nuclear crisis has the potential to "undermine any kind of consensus building for the place of nuclear energy in addressing energy needs in the future whether it's here in the United States or elsewhere in the world" (United States Committee on Energy and Natural Resources, 2011, p. 19). Senator Coats was concerned an anti-nuclear opinion would gain traction among American citizens after the dangerous situation that played out in Japan, especially now that Americans are slightly more informed about the harmful effects of radiation. Although this concern is warranted, investments in nuclear power continued after both TMI and Chernobyl.

In early April 2011, the media reported that radioactive water had been leaking through the bottom of the reactor. The global community had been suspicious of the actions of the Japanese government and TEPCO from the beginning and they came under increased pressure because of their failure to plug the leaks. In their efforts to reassure the public right after the disaster, the company was accused of "understating the scale of the crisis it faced early on, and failing to call in outside help that might have avoided this leakage" (Coghlan, 2011, p. 10). TEPCO announced that the radiation in the water spewing from the leaks were "7.5 million times the legal limit", after stating the day before that the levels were only "1.1 million times the legal limit" (Coghlan, 2011, p. 10). Radioactive water can spread to other countries and affect living organisms in the water, creating more problems for Japan and surrounding countries. The confusing reports of radiation levels echoed the reporting following the accident at Chernobyl.

As of November 2011, the Japanese company was still trying to completely shutdown the reactors at the Fukushima Daiichi nuclear power plant. Although both the government and TEPCO believe that it can be shut down by the end of the year, "it remains uncertain whether the two sides will be able to guarantee the safety of the site" ("Tepco Still Fumbling Response to Fukushima crisis, 2011).

TEPCO opened its facilities up to a select group of journalists in mid-November to take a tour of the disaster area and speak with members of the company. *The Japan Times* reported on this tour, noting the destruction of buildings along with the fact that "the melted fuel will continue to emit decay heat for years to come" (Yoshida, 2011). If this were not worrisome enough, a cabinet minister involved with the crisis suggested, "it would take another 30 years to complete the work of fully dismantling the reactors" ("A Look Inside Fukushima Daiichi", 2011). Even the plant manager is not sure if fuel leaked from the pressure vessel, "where the fuel is, what state it's in [or] what is really going on inside the reactors" ("A Look Inside Fukushima Daiichi", 2011). It is clear that there is still a lot of clean up to do at the Fukushima Daiichi plant, within the company TEPCO, and throughout all of Japan.

III. Theoretical Analysis of the Accident at Fukushima Daiichi

Was TEPCO acting as a high reliability organization? At this point, it may be too early to tell. Nonetheless, the technology and safety systems have greatly improved since Chernobyl and TMI. TEPCO had run tests to determine the highest level of flooding from a tsunami that could occur, but the tsunami on March 11 proved the tests wrong. TEPCO also had emergency power supplies set up, but what good were they if they were destroyed during an emergency?

Did TEPCO foster a safety culture? Following a scandal in 2002 where the company admitted to "falsifying 29 cases of safety repair records" and failing to "accurately report cracks at its nuclear reactors in the late 1980s and 1990s", the company completely revamped its corporate values ("Heavy Fallout from Japan Nuclear Scandal", 2002). According to TEPCO's website, the company's goal is to create "a corporate system and climate of individual responsibility and initiative" by taking the following four actions:

> (1) Promoting disclosure of information and ensuring transparency of nuclear operations. (2) Creating a work environment where proper operations can be carried out. (3) Strengthening internal surveillance and reforming our corporate culture. (4) Promoting observance of corporate ethics. (TEPCO, n.d.)

Whether or not the company achieved these goals before the accident is irrelevant because a safety culture could not prevent an earthquake and tsunami. In addition, the company did not hold to these initiatives after the accident. There was little "transparency of nuclear operations" because TEPCO and the Japanese government did not coordinate their communication and relief efforts. While TEPCO published releases that radiation levels were still normal, the government was evacuating citizens from the surrounding areas.

Again, the situation in Japan supports the Normal Accident Theory. If it is assumed that TEPCO was a high reliability organization with a safety culture prior to the accident, there was still nothing the company could do to prevent a massive earthquake and tsunami from hitting their reactors. Perhaps in the future, tests will be able to predict where and when natural disasters will occur. Even then, nuclear reactors cannot be transported to a new location. Those built in dangerous places would have to be completely and safely dismantled. If new, more advanced reactors are built in earthquake, tsunami free zones, there is no proof that Mother Nature will not attack with another disaster.

III. Global Reactions to the Japanese Accident

Following the disaster in Japan, The Institute of Nuclear Power Operations prepared a detailed report on the chronology of the accidents to help the United States adjust its own nuclear policies. The United States is taking a proactive approach and learning from the disaster and subsequent chaos that occurred in the Japan.

Other countries are planning on slowing or shutting down their nuclear efforts after seeing the harm that occurred in Japan. In Germany, for example, "public opinion is generally opposed to nuclear power" despite the country having seventeen reactors (Vogel, 2011). Just three days after the earthquake and tsunami destroyed the Fukushima Daiichi power plant, German Chancellor Angela Merkel "suspended for 3 months a newly enacted law covering the country's nuclear power industry" (Vogel, 2011). In April, over 100,000 people protested nuclear power in Germany, "demanding an end to the use of nuclear power and increasing pressure on Chancellor Angela Merkel's government to speed up the closing of the country's 17 nuclear plants" (Dempsey & Ewing, 2011). Their demands were met on May 30, 2011 when the German government stated they would "shut down all nuclear power plants in the country by 2022", despite the fact that this would increase energy costs for citizens (Dempsey & Ewing, 2011).

Germany was not the only country to put their nuclear program on halt. Switzerland announced on March 14, 2011 that it was putting on hold its search for locations for three new nuclear plants (Vogel, 2011). In addition, the United Kingdom retracted funding for new power plants. In 2010, the government had promised to ease the process of construction and licensing for plants, but now this will have to occur without federal funding. Similar to the United States, the United Kingdom also announced they would be conducting a "new nuclear safety review in light of the events in Japan" (Vogel, 2011). Italy had shut down its power plants in 1987, following the Chernobyl disaster, but the Prime Minister said it would renew its nuclear power industry in 2009. After watching the events in Japan unfold along with anti-nuclear rallies erupt at home, "the government decided on a one-year moratorium on its plants to revive nuclear power" (Martin, 2011).

In contrast to the hesitation shown by these countries, Poland did not change its plans to build a nuclear power plant, the country's first. The Prime Minister argued that the Poland is not at risk for earthquakes so the construction could proceed (Vogel, 2011). Despite anti-nuclear protests in India, the country will continue expanding its nuclear power network. The rapidly developing country needs additional sources of energy. In fact, India plans to "build the world's largest nuclear plant in Jaitapur" in order to meet their citizens' needs (Martin, 2011). Currently, India has twenty operating nuclear power plants that provide "three percent of the nation's energy, but plans are in motion to supply 25 percent of its electricity from nuclear power by 2050" (Martin, 2011). Similarly, China will continue its investment in nuclear power in order to decrease its dependence on coal. In 2011, China was operating 14 nuclear plants and there were 25 plants under construction.

Chapter Six: Analysis and Comparison of Cases

I. Theoretical Analysis and Comparison

When organizations control high-risk, complex, tightly coupled systems, they must embody the ideas of the High Reliability Theory. This includes reporting errors, relying on experts, and ensuring the safety of operators and the public. Met Ed did not act as a high reliability organization (HRO). The company ignored early signs of problems within the plant and did not coordinate well the NRC. In addition, plant guidelines incorrectly directed operators to slow the emergency cooling system. The organization did not foster flexibility and the expert operators had no choice but to follow procedures.

Considering how new nuclear energy technology was at the time, it is unacceptable that the company did not have any crisis management systems in place. Following the accident, the company did not incorporate Reason's (1997) ideas of a safety culture. A HRO must keep the safety of the public in mind at all times, since its systems are handling potentially deadly materials. Met Ed and the NRC did not provide the appropriate information and resources to educate the public on what was going on at the plant. This lead to confusing reports from journalists, who were not familiar with the technical jargon and could not reach any spokespeople for updated information.

It is clear that Met Ed was not acting mindfully or reliably, thus an accident should have been expected. As Perrow (1984) argues, it is impossible for operators and organizations to behave perfectly and control the systems flawlessly, so accidents are unavoidable. The organizations in control of Three Mile Island should not have been so confident and ignorant about nuclear energy. They should have focused on the "what if" situations in order to prevent as much damage and chaos as possible.

Unfortunately, Chernobyl experienced very similar problems to TMI. Both were not acting as high reliability organizations. In a report by the International Nuclear Safety Advisory Group given to the International Atomic Energy Agency in Vienna, the lack of safety culture at Chernobyl is directly addressed.

> Safety culture had not been properly instilled in nuclear power plants in the USSR prior to the Chernobyl accident. Many of its requirements seem to have existed in regulations, but these were not enforced. Many other necessary features did not exist at all. Local practices at nuclear plants, of which it may be assumed that practices at Chernobyl were typical, did not reflect a safety culture...Factors leading to the accident are to be found in the safety features of the design, the actions of the operators, and the general safety and regulatory framework. (1992, p. 22)

Three Mile Island also failed to create a safety culture. No one acted upon the initial failures of the system. None of the operators noticed the broken seal. There were no emergency plans or crisis communication systems in place.

Twenty years after the accident at Chernobyl, the Commission on Security and Cooperation in Europe held a hearing on the disaster's legacy before the United States Congress. A member of the commission identified the main problem with how the USSR dealt with the accident at Chernobyl:

> Transparency in governance…silence and obfuscation in the immediate aftermath of the accident perhaps manifested itself most starkly in the failure of the authorities to provide the population of surrounding areas with timely warnings regarding the dangers posed by the massive fallout of radiation" (Commission, 2007, p. 36).

Lack of transparency characterized the Soviet Union's crisis communications approach to Chernobyl. Unlike at TMI, the communications debacle at Chernobyl was directly linked to the Soviet government's refusal to be honest about the situation. Officials involved with TMI wanted to provide information to the public but did not have the organizational structure or communications plans to do so. Nonetheless, in both situations "the press and public were unable to learn that was happening within the damaged reactors [because] systems for communication under disaster conditions were not in place" (Rubin, 1987, p. 44).

Another similarity in the crisis communication methods after the accidents is the organizations efforts to soften the severity of the situation and avoid reporting bad news. This reaction is understandable because the nuclear industry did not want to lose support from the public, which had been led to believe that nuclear accidents were extremely rare and therefore unlikely to happen.

Following these two accidents, it appeared that an organization could not be consistently reliable. Both events support the Normal Accident Theory: Despite multiple safety systems, mankind will make mistakes when operating dangerous technologies and advanced, complex systems can break down without warning. Thus, organizations need to be aware of the possibility of disasters and develop crisis communication plans to address this in order to avoid the chaos that followed the accidents at TMI and Chernobyl.

In the 25 years between Chernobyl and the disaster in Japan, nuclear power technology greatly advanced. In addition, safety tests became more reliable and emergency procedures were re-evaluated to ensure the well being of the plant, the operators, and the general public. Following a scandal over falsified safety reports, TEPCO revamped its corporate ethics and compliance standards to embody many of the characteristics discussed in Reason's (1997) safety culture. The company clearly sought to transform itself into a high reliability organization. Even if these changes happened successfully, acting mindfully and reliably could not stop an earthquake and tsunami from hitting the Fukushima Daiichi nuclear power plant.

Although TEPCO did perform tests to see what the highest level of flooding could be at the plant, these results were incorrect. In addition, the company had emergency power supplies set up in case the plant lost power, but these supplies were destroyed in an emergency, so served no purpose at all. This disaster clearly illustrates that Perrow's (1984) Normal Accident Theory is correct. As previously stated, "no matter how effective conventional safety deices are, there is a form of accident that is inevitable" because humans, nature, and highly complex systems will interact in unpredictable ways (Perrow, 1984, p. 3).

II. Conclusion

It appears that the disaster at the Fukushima Daiichi power plants have had a profound affect on the opinions and actions of governments, the nuclear power industry, and the public. No countries renounced their nuclear power programs following the accidents at Chernobyl and TMI. Those accidents were caused by operator error and technology malfunctions – all factors which could be improved in order to avoid problems in the future. The global community assumed that all issues had been taken care of. The events in Japan show that the Normal Accident Theorists are correct: no organization can avoid natural disasters, no matter how highly reliable they are or whether they create a safety culture. As Perrow (1984) mentioned, crises may rarely occur in these highly complex systems, but when they do occur, an inconceivable amount of damage can be done to the environment, the facilities, and the public. Thus, all organizations, especially those involved in dangerous, highly complex industries, need to have the crisis management plans and expertise necessary to deal with accidents. As Japan continues to recover from the natural disasters and nuclear damage, hopefully other nuclear power organizations will evaluate their safety and communication plans in order to be ready for when another accident occurs.

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