International Foundation for Protection Officers

APPLYING THE PRINCIPLES OF RISK MANAGEMENT TO NUCLEAR POWER PLANT SAFETY

Sontino Trigilio

July 2006

In a world of terrorism, violence, crime, and corruption, safety should be the main priority. Instead, there exist cover-ups, breaches, deception, and negligence. The time has come to take the proper measures to save the environment and its population. Nuclear power plant safety has been one of the leading areas of concern, especially since the terrorist attacks of September 11th, 2001.

To help understand more about nuclear power plants, their purposes must be known. Reactors are classified by function. Most reactors today are classified as **research reactors** and are used primarily to release neutrons for various physical experiments for educational and training purposes in the areas of power production. **Test reactors** are used to determine the effects of radiation on materials and systems, such as the test reactor in Arco, Idaho. **Production reactors** are used to produce fissionable material from fertile material. Harford, Washington and Savannah River, South Carolina are examples of production reactors. **Power reactors** are used for producing heat and/or electrical energy. Peach Bottom and Three Mile Island are prime examples of power reactors (Smith).

A nuclear reactor is a device designed to produce and sustain a long-term controlled fission chain reaction. This energy causes the nucleus to split and release neutrons, gamma photons, and about 200 million electron volts of energy per fission. As these particles slow down on collision with atoms in the material, the energy appears in the form of heat (Smith).

In essence, to build a reactor, what is needed is some mildly enriched uranium. Uranium is formed into pellets, which are arranged into long rods formed into bundles. These bundles are submerged in water inside a pressure vessel with the water acting as a coolant. However, left to its own device, the uranium would eventually overheat and melt. To prevent this, control rods are mechanically inserted and controlled by operators. When more heat is needed, the rods are raised out of the uranium bundle. When less heat is needed, the rods are lowered. In case of an accident, the rods are completely lowered in to the uranium bundle to shut the reactor down (Brain).

The uranium bundle acts as an extremely high-energy source of heat. It heats the water and turns it to steam. The steam drives a steam turbine, which spins a generator to produce power. Pipes are used to carry steam to power the generator.

The reactor’s pressure vessel is typically housed inside a concrete liner that acts as a radiation shield. That liner is housed within a much larger steel containment vessel. This vessel contains the reactor core as well as the equipment used. These containment structures are necessary to prevent the escape of radiation/radioactive steam in the event of an accident, such as the one at Three Mile Island (Brain). Some natural radiation is exposed to people each day from the sun, radioactive elements in the soil and rocks and household appliances (like television sets and microwave ovens), as well as medical and dental x-rays. Even the human body itself emits radiation. These levels of radiation are normal. The average American receives 360 millirems of radiation each year. However, radioactive materials or radiation accidentally released into the environment can be dangerous because of the harmful effects of certain types of radiation on the body (Allbaugh).

On a typical reactor plant, between 3000 and 7000 digital systems signals measure temperature, pressure, flow, neutron power levels, voltage, and current. There are an additional 10,000 to 20,000 state signals, which are used to provide information on switchgears, valves, and alarms. The computer systems read these signals within one second and keep recording the plant condition. The human factor is needed to read and understand all this information. However, as the cost of computers continues to decrease and reliability increases, computers are being used extensively. Technology is rapidly changing, so in order to keep computers up to date, new software is needed. To keep performance at its peak, training for the staff, specialists and maintenance is also needed. Again, the human factor is a must for maintaining the performance of a power plant (Lewins & Becker).

On March 28, 1979, a power failure of two water pumps caused an alarm to sound at Three Mile Island. Without continuous water to cool the reactors, they rapidly began to heat. An emergency backup water flow is usually built into the plant to take over in case of this kind of failure. However, at Three Mile Island, not only did the water pumps fail, a valve became stuck in the open position. Radioactive steam and water spilled into one of the reactor's tanks. Shortly thereafter, the emergency backup water system failed because of human negligence. The maintenance crew that had gone off duty earlier had forgotten to open three other valves. No water was able to reach the fuel rod because of the emergency water flow being blocked by the closed valves. These rods are to be covered in water at all times. Since no one realized the fuel rods were uncovered, everyone was racing around trying to figure out what the problem was and what they should do to fix it. According to the Uranium Information Centre Ltd, "the emergency core cooling system would have prevented the accident but for the intervention of the operators" (UIC 2). Between human error and equipment malfunctions, Three Mile Island was turning into the worst nuclear crisis the United States had ever seen.

Another major problem at TMI was a procedural factor. The power company (Metropolitan Edison) didn't warn state or federal officials. Radiation started leaking out of the reactors and eventually Met Ed was forced into contacting state and federal authorities. However, once again, procedures were not followed and the danger of the incident was minimized. Met Ed issued statements to the public that the situation was stable. The NRC stepped in and issued a meltdown warning. According to studies in 1975, a meltdown could kill over 3,000 people immediately and cause 45,000 cases of radiation sickness. Within a few years, an extra 45,000 people would die from cancer and there would be 5,000 cases of genetic birth defects (Hampton). "Fifteen states the size of Maryland might be contaminated; agriculture restricted or forbidden; water supplies contaminated; not to mention that other power plants could become contaminated" (Gofman & Tamplin 354). Fortunately, after several days of pumping water into the reactors, the threat of a meltdown had diminished.

Since the TMI event, many diagnostic aids have been implemented, such as critical parameter displays, saturation and sub cooling margins, and symptom-based emergency operating procedures. These have all been very helpful in assisting humans in making their decisions. Studies are performed all the time on human and machine operations. This information is used to help reduce errors, improve productivity, and reduce risk to plant and personnel. Most training programs, while informative, lack the human factor issue. It is imperative to have full participation in training instructions and drill. This way, any actual problem that may arise can be controlled and handled using this “hands on approach” (Lewins & Becker 164).

There are several risks and safety issues concerning nuclear power plants. To help control these safety issues, in January of 1975, the Nuclear Regulatory Commission was formed. It was a spin-off from the Atomic Energy Commission, which had been created 29 years earlier. The NRC performs licensing and rulemaking functions and is the final arbiter of regulatory issues. Shortly after its creation, one of the main issues before it was the safeguarding of nuclear materials. This applies to the prevention of theft, loss or diversion of nuclear fuel or other materials or the sabotage of nuclear plants. The NRC tries to prevent **human**, **mechanical**, **environmental**, and **procedural** factors from threatening the safety of Nuclear Power Plants (Adato, et al).

TMI has come to the attention of the public more since the September 11th incident. The terrorists behind the attacks selected some of the most recognized targets in the U.S. Since TMI is known worldwide as the site of the worst nuclear accident in America, it would make it a viable target. The willingness of terrorists to commit suicide via airplanes to achieve their evil makes the nuclear terrorism threat far more likely than it was before Sept. 11 (Tagliabue 1-2). On September 21, 2001, the Nuclear Regulatory Commission issued a news release addressing this concern. “Nuclear power plants…are among the most hardened structures in the country and are designed to withstand extreme events, such as hurricanes, tornadoes and earthquakes,” the statement reads. “ . . . However, the NRC did not specifically contemplate attacks by aircraft such as Boeing 757s or 767s, and nuclear power plants were not designed to withstand such crashes. Detailed engineering analyses of a large airliner crash have not yet been performed” (Lynch 4a). However, in government-run tests, concrete structures used in reactor domes have withstood battering by heavy steel rods traveling at several hundred miles an hour and, in one instance, a deliberate crash by a military jet fighter, said Robert Henry, senior vice president of Fauske & Associates, a research group in Burr Ridge, Ill (Behr). According to the Uranium Information Centre Ltd, “it should be emphasized that a commercial-type power reactor simply cannot under any circumstances explode like a nuclear bomb” (UIC 3). Without the tests to prove this theory, the best defense against nuclear terrorism is to end civilian commerce in plutonium and bomb-grade uranium and to draw down military stocks of these materials as soon as possible (Paul Leventhal & Yonah Alexander).

Babcock and Wilcox were the builders of this reactor and were also the builders of the Davis Besse plant, which in 1977 also had a relief valve stick open. Fortunately, that plant was operating at a low power and no major damage was done. This important piece of information was not relayed by Babcock and Wilcox to any other of their plants. It took officials at TMI two hours and 22 minutes to realize the valve was stuck open. Had this prior incident at Davis Besse been shared, this whole situation could have been avoided (Lewins & Becker 26-27).

While nuclear disasters have come alarmingly close, the need for nuclear energy is still viable. For one thing, no one has found a successful and affordable alternative source of energy to replace our reliance on coal and other fossil fuels. There is a distinct possibility that the world’s supply of oil could run out sometime before the end of this century. Not only is the supply of oil limited, it is also harmful to the environment (Hampton). Coal has become too hazardous between the mining and the huge amount that must be obtained in order to produce a small amount of energy. The following chart shows the comparison of accident statistics in the primary energy producers (UIC 5).

Fuel	Immediate fatalities 1970-1992	Who?	Normalized to deaths per TWy* electricity
Coal	6400	Workers	342
Natural gas	1200	Workers & The Public	85
Hydro	4000	The Public	883
Nuclear	31	Workers	8

Source: Ball, Roberts & Simpson, Research Report #20, Centre for Environmental & Risk Management, University of East Anglia

Several safety measures are used to meet the requirements of the NRC. Most use a “defense-in-depth approach, with multiple safety systems” (UIC 2). These include a series of physical barriers between the reactor and the environment and multiple safety systems, each with backup and designed to accommodate human error. There are vehicle barrier systems, electronic detection systems, concrete barriers and chain-link fences around the plant, closed circuit television systems monitoring the perimeter. Periodic testing is required for all security equipment to make sure it is operating correctly. Security guards are deployed all over the plant and are in constant contact. Each person goes through background checks, psychological assessments, behavioral observation, and drug testing before being allowed unescorted access to the plant. In order for any individual to gain entry into the protected area of the power plant, he or she must first clear a metal detector, an explosive detector, empty his/her pockets and any carried objects must go through an x-ray machine. Once the individual is found to be clear, he/she must obtain a security badge from the security building. Depending on the plant being accessed, eye identification, finger print identification or even both are needed. Before leaving the plant, as a personal safety measure, every individual must pass through a radioactive scanner to make sure they have not been contaminated (Dennis Trigilio Personal Interview, 11/22/01).

The NRC performs safety inspections at the power plants. Under the safety significance determination process, NRC officials classify certain conditions at nuclear power plants as being one of four colors which delineate increasing levels of safety significance, beginning with green and progressing to white, yellow or red (Strasma & Alloway-Mueller).

Since the first reactor went into service in 1957 (Shippingport), no property damage or injury to the public has ever been caused by radiation from a US commercial nuclear power plant. Currently there are more than 100 operable nuclear plants in the country. From the beginning until now, “the US nuclear power industry’s primary concern has been to protect the health and safety of the public” (University of Missouri-Rolla American Nuclear Society 1). Independent organizations such as the American medical Association, World Health Organization, and National Academy of Sciences have concluded that nuclear power is one of the safest methods available to us to make electricity (University of Missouri-Rolla American Nuclear Society).

Starting in 1980, "each utility that owned a commercial nuclear power plant in the United States has been required to have both an onsite and offsite emergency response plan as a condition of obtaining and maintaining a license to operate that plant. Onsite emergency response plans are approved by the Nuclear Regulatory Commission (NRC). Offsite plans are evaluated by the Federal Emergency Management Agency (FEMA) and provided to the NRC, who must consider the FEMA findings when issuing or maintaining a license" (Allbaugh 1).

A self-policing program by the nuclear power industry was schedule to begin during fall, 2003. Operators themselves would test their plants for anti-terrorist readiness, with the NRC official reviewing results. The NRC approved this one-year pilot of the Safeguards Performance Assessment Program. The testing will occur every three years and federal regulators will review results (Schoch).

Since 1985, the NRC's policy statement "encouraged but did not require licensed power plant operators to meet certain safety standards" (Thompson & Lippman). Safety standard were originally organized by the INPO (Institute of Nuclear Power Operations), which is owned by the nuclear utilities. The federal appeals court did not feel the INPO was being responsible enough in enforcing these regulations. Therefore, on April 17, 1990, the federal appeals court ordered the Nuclear Regulatory Commission to establish and enforce training standards for workers at nuclear power plants. According to the Court of Appeals for the District of Columbia Circuit, "Congress directed the NRC to create mandatory requirements for civilian nuclear power plant licensee personnel but the commission has failed to do so" (Thompson & Lippman). This all came about from a suit filed by Ralph Nader's Public Citizen group and six other organizations. However, the NRC feels that a set of federal regulations would make nuclear power plants less safe by "choking off the industry's attempts to regulate itself."

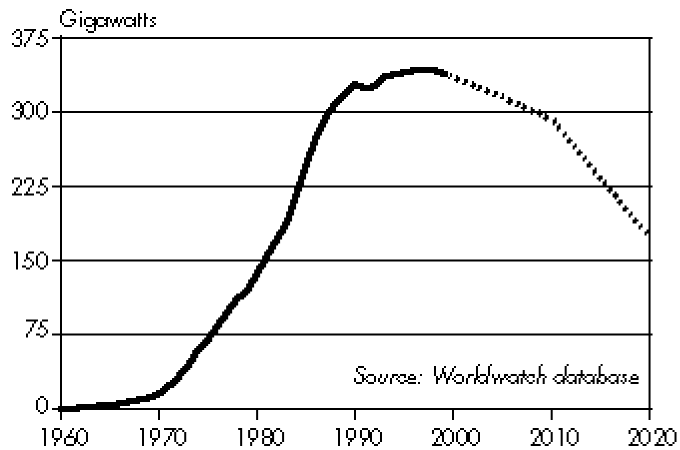
The main safety issues include:

- Mining and purifying uranium has not, historically, been a very clean process
- Improperly functioning nuclear power plants can create serious problems.
- Spent fuel from nuclear power plants is toxic for centuries and, as yet, there is no safe permanent storage facility for it.
- Transporting nuclear fuel to and from plants poses some risk, although to date, the safety record in the US has been good (Brain 8).

In order to monitor effects on the environment, utilities set up a monitoring program, which takes samples and compares effects during the life of the plant. This may include monitoring of a nearby lake, milk from cows, broad leafy vegetables, and fish. In many areas, independent laboratories analyze the sample and report to the utility, regulatory agencies, and public document rooms. These records are public information (University of Missouri-Rolla American Nuclear Society).

With new technological equipment, training, drills, upgrades and new software, the safety of powers plants should be under control (Lewins & Becker). Between all the safety measures installed at the power plants, the Nuclear Regulatory Commission and future safeguarding programs, the risk factor is very slight and apparently controlled.

However, since 1990, nuclear generating capacity has only increased less than 5 percent, which is a major drop from the 700 percent growth of 1970. The following graph shows the generating capacity of nuclear power plants from 1960 and projected to 2020.



Nuclear power plants biggest problems are economic; it is no longer competitive with other, newer forms of power generation. The most recent reactors had a price tag of $3 to $4 billion to build (Flavin & Lenssen). The Worldwatch Institute projects that nuclear capacity will begin a sustained decline by 2002 and the U.S. Dept. of Energy projects that it will fall by half in the next two decades. Wall Street analysts and the Washington International Energy Group project that as many as one-third of US reactors are in danger of being shut down in the next five years. The main reason once again is cost. Nuclear energy cannot compete in increasingly competitive power markets. Most nuclear power plants were built by monopoly utilities, and the costs were passed through to consumers. With governments opening electric power markets, nuclear power plants are taking a blow. CBS decided to sell what was once the world's largest nuclear company, Westinghouse Nuclear. The company sold for just $1.2 billion. By contrast, Exxon is valued at $172 billion and Microsoft at $278 billion.

With their marketability going down, costs going up and supply and demand going down, how safe will these plants continue to be? Training of personnel, new software, and new computers cost money and with no profitable income, how will they be able to afford their safety measures?

Safety and protection measures are what risk analysis and management seek to provide. " Risk cannot be eliminated, but it can be managed. Risk can be reduced to a manageable level through the proper risk analysis research and assimilation of data. Then with a thorough implementation of measures designed to avoid, reduce, or eliminate remaining factors associated with that risk" (Neal 1). The risk management process starts with a comprehensive understanding of the factors that greatly enhance the chances of risk occurring. The process follows a definitive sequence of 10 steps:

1) Define the problem
2) Define the objective(s)
3) Evaluate current measures and resources
4) Risk identification
   - Personal
   - Property
   - Physical
   - Speculative
   - Static
   - Dynamic
   - Fundamental
5) Risk evaluation
   - Probability
   - Severity
   - Predictability
6) Select risk reduction measures
   - Risk avoidance
   - Risk reduction
   - Risk acceptance
   - Risk transference
   - Risk spreading
7) Develop risk reduction measures
8) Implement risk reduction methods
9) Evaluate risk reduction measures
10) Redefine risk identification and restart risk analysis process (Neal, 4-5).

The first step (defining problem) lists the source of the problem. The two main purposes of this step are that it provides evidence that will identify exactly what the elements are and how they relate to certain types of risk. It will also help you to learn about your opponent (Neal 13). Since nuclear power plants have many safety and security risks, many procedures and regulations are often designed and implemented to prevent or lessen various types of risk. Examples include such things as contamination, storage hazards, and physical attacks.

The second step (defining objective) is in conjunction with and builds off of the first step. The two main functions of this step are to establish an effective security/protection plan and to redefine any existing security/protection plan and implement necessary changes (Neal 18). Basically, this step is designed to develop mission directions and organize network coordination. Examples include the installation of radiation shields, alarms, and fail-safe emergency systems.

The third step (evaluate current measures and resources) serves as a safety check for existing security/protection plans. Evaluating specific or critical areas will show where vulnerabilities are and how they can be linked to other weaknesses that contribute to risk. The two main categories to be concerned with are those that are internal and external to the plant. Internal usually refers to personnel and equipment, while external deals with the environment, public, media, consultants, government agencies, and private security. Both categories go hand in hand and must meet necessary requirements and procedures for the plant and/or its key personnel. Examples include following and upgrading new software, policies, maintenance operations, skills training, communications, and crisis management (Neal 23).

The fourth step (risk identification) is crucial and isolates the types of risks that pose the greatest threat to the security/protection plan. There are seven major types of risks that are analyzed in this step. They are: personal, property, physical, speculative, static, dynamic, and fundamental (Neal 28). Examples of personal risk are the errors in which the plant personnel can cause or create, in turn possibly injuring, infecting, or killing other personnel or innocent people. Examples of property risk include the total or value loss of equipment and operations. Liability, negligence, and fault are also a part of this step, which may lead to lawsuits and/or total shutdown of the plant. Examples of physical risk include damage to the plant and/or its environment, such as a meltdown or radioactive leak. An example of static/dynamic risk would be the fact that consumers are gearing more towards saving the environment with safer forms of energy or power, such as with solar forms. Examples of fundamental risk include the possibility of terrorist infiltration to steal materials that are needed to create an atomic bomb.

The fifth step (risk evaluation) is separated into three categories: probability, severity, and predictability. Probability is the possibility or likelihood of an event. Examples of high probability factors that nuclear power plants are likely to face are accidents, mechanical malfunctions, and radiation exposure. Examples of low probability factors (not likely to occur) are things such as hostage situations and vandalism. Severity deals with the impact that an event would have on the plant and/or its personnel, as well as any losses that would occur. Losses are equated in two ways, monetarily and productivity wise. Loss of life and/or property and interruption of plant activity are main concerns. Predictability allows risk to be possibly foreseen and combated based on probability and severity factors. The “what if” game strategy is often the ideal tool used in the risk evaluation process review (Neal).

The sixth step (selecting risk reduction measures) is another crucial step that seeks to re-align risk possibilities. It involves five major categories: risk avoidance, risk loss reduction, risk acceptance, risk transference, and risk spreading. Risk avoidance seeks to eliminate or avoid risk-causing activities. Ways of incorporating risk avoidance would be to have a good safety and security plan, which would consist of properly maintained alarms, equipment, and access control. Risk loss reduction and spreading aim at reducing the maximum amount of probable loss, which would be combated effectively by using the fourth and fifth steps (risk identification and reduction measures) of the risk analysis and management process. Risk acceptance is just how it sounds; the risk is accepted and dealt with because it cannot be cost effectively reduced. An example of that would be the small amounts of radioactivity that are emitted into the air on a daily basis of operation. Risk transference attempts to aim liability and loss to other parties (Neal 37). Risk transfer is really not an option considering this, a typical set of nuclear exclusion clauses from a Homeowner’s policy issued by Hartford Insurance Group:

> *2. Nuclear Clause-Section1: The word “fire” in this policy or endorsements attached hereto is not intended to and does not embrace nuclear reaction or nuclear radiation or radioactive contamination, all whether controlled or uncontrolled, band loss by nuclear reaction or nuclear radiation or radioactive contamination is not intended to be and is not insured against by this policy or said endorsements, whether such loss be direct or indirect, proximate or remote, or be in whole or in part caused by, contributed to, or aggravated by “fire” or any other perils insured against by this policy or said*

endorsements; however, subject to the foregoing and all provisions of this policy, direct loss by "fire" resulting from nuclear reaction or nuclear radiation or radioactive contamination is insured against by this policy.

3. Nuclear Exclusion-Section I: This policy does not insure against loss by nuclear reaction or nuclear radiation or radioactive contamination, all whether controlled or uncontrolled, or due to any act or condition incident to any of the foregoing, whether such loss be direct or indirect, proximate or remote, or be in part caused by, contributed to, or aggravated by any of the perils insured against by this policy; and nuclear reaction or nuclear radiation or radioactive contamination, all whether controlled or uncontrolled, is not "explosion" or "smoke." This clause applies to all perils insured against hereunder except the perils of fire and lightning, which are otherwise provided for in the nuclear clause contained above (Gofman & Tamplin 175).

The seventh step (developing risk reduction methods) takes into account the time, costs, personnel, materials, and equipment necessary to complete risk reduction phases. Any acquisitions to be made, equipment to be installed, and personnel to train must be done very diligently and efficiently, especially in the case of power plants because most often they are not allotted much of a "break-in" period (Neal).

Steps eight, nine, and ten are a tandem that involve the implementation, evaluation, and redefining of risk reduction measures. Issues involving concerns, dislikes, suggestions, and unexpected factors from implementation are addressed and reconsidered (Neal). We cannot achieve zero risk; we can reduce the likelihood of serious accidents by the effective use of relevant technical and managerial skills (Farmer). Risk is a part of life as long as we continue to make discoveries, inventions and advances. As industry has advanced so has pollution. As atomic energy has advanced, so has hazardous radioactive waste. No human activity is without risk and nuclear power is no exception to the general rule (Farmer).

Since the risk for nuclear power accidents is a potential threat, the need for safeguarding power plants is a most crucial and important factor. This is where the NRC and OSHA need to stay one step ahead. There needs to be deadlines set for unresolved safety issues. Prompt installation of improvements should supercede the cost factors. Safety should always remain the top priority. Thorough investigations into future power plants should precede any issuing of licenses. Practice drills, computer and software upgrades, training, investigations, committees to keep track of power plants and top notch security is the very basic forms to help keep safety a priority. These should only be a starting point and should only get better with time. As long as the NRC and nuclear power plants keep safety in their operations, the environment and the personal safety of life forms should be within acceptable limits.

ABOUT THE AUTHOR

Sontino Trigilio is a graduate of York College of Pennsylvania with a bachelor's in Criminal Justice. This article was completed as a course requirement in CJA102 Introduction to Asset Protection. It was subsequently selected as the top paper in the ASIS International Annual Student Paper Competition in 2003.

BIBLIOGRAPHY

Adato, Michelle, MacKenzie, James, Pollard, Robert, & Ellyn Weiss. (1987). *Safety second: The NRC and America's nuclear power plants.* Indianapolis: Indiana University Press.

Allbaugh, Joe M. (February 27, 1997). *Fact sheet: Nuclear power plant emergency*. Available: http://www.fema.gov/library/radiolo.htm. (November 22, 2001).

Archibold, Randal C. (October 18, 2001, Thursday). A nation challenged: Indian Point; Concerns rise over safety of a-plants. *The New York Times, Section: Metropolitan Desk*.

Behr, Peter. (September 26, 2001). Security of nuclear power plants under review. *The Washington Post,* A08.

Brain, Marshall. (2001). *How nuclear stuff works.* Available: http://www.howstuffworks.com/nuclear-power.htm/printable. (November 6, 2001).

Farmer, F. R. (1977). *Nuclear reactor safety*. New York: Academic Press.

Flavin, Christopher & Nicholas Lenssen. (March 1999). *Nuclear power nears peak.* Available: http://www.worldwatch.org/alerts/990304.html. (November 20, 2001).

Gofman, John W. & Arthur R. Tamplin. (1971). *Poisoned power: The case against nuclear power plants.* Emmaus: Rodale Press Inc.

Hampton, Wilborn. (2001) *Meltdown: A race against nuclear disaster at Three Mile Island.* Cambridge: Candlewick Press.

Heaberlin, Scott. (August 2000). *Nuclear safety and technology applications projects and research.* Available: http://www.pnl.gov/etd/product/nstproj.htm. (October 18, 2001).

Jones, Edwin. (August 1996). *Risk assessments: From reactor safety to health care.* Available: http://www.llnl.gov/str/Risk.html. (October 18, 2001).

Lewins, Jeffery & Martin Becker. (1997). *Advances in nuclear science and technology (vol.25).* New York: Plenum Press.

Lewins, Jeffery & Martin Becker. (1997). *Advances in nuclear science and technology (vol.24).* New York: Plenum Press.

Neal, Murray. (1996). *Risk assessment & management: A definitive method for proactive risk manipulation.* United States of America: Targeted Security Consultants Ltd.

NRC. (2001). *United States Nuclear Regulatory Commission.* Available: http://www.nrc.gov/. (October 18, 2001).

Nuclear Control Institute. (2000). *Nuclear terrorism: How to prevent it.* Available: http://www.nci.org/nci-nt.htm. (November 20, 2001).

Schoch, Deborah. (September 22, 2001). *Federal regulators reviewing security at nuclear power plants.* Available: http://www.latimes.com/news/nationworld/nation/la-092201nuke.story. (November 18, 2001).

Smith, Charles O. (1967). *Nuclear reactor materials.* Reading: Addison-Wesley Publishing Company.

Tagliabue, John. (November 2, 2001). *A warning from an official about an increased possibility of nuclear terror.* Available: http://www.nytimes.com/2001/11/02/in…/02NUCL.html?searchpv=past7days&pagewanted=prin. (November 5, 2001).

Thompson, Tracy & Thomas W. Lippman. (April 18, 1990). Court orders NRC to set training standards; Nuclear industry says regulations will make power plants less safe. *The Washington Post,* a25.

Trigilio, Dennis. (November 10, 2001). Personal Interview.

University of Missouri-Rolla American Nuclear Society. (2001). *Answers to questions.* Available: www.nuc.umr.edu/~ans/pages21-30.html. (September 25, 2001).

Uranium & Nuclear Information Centre. (Updated weekly). *Safety of nuclear power reactors.* Available: http://www.uic.com.au/nip14.htm. (November 6, 2001).

Walter, Katie. (March 1998). *Nuclear safety: Reliable software for protection systems.* Available: http://www.llnl.gov/str/GJohnson.html. (October 18, 2001).