CHARACTERISTICS AND COMMON VULNERABILITIES INFRASTRUCTURE CATEGORY: NUCLEAR FUEL CYCLE SAFETY AND SECURITY

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Preventing terrorism and reducing the nation's vulnerability to terrorist acts require understanding the common vulnerabilities of critical infrastructures, identifying site-specific vulnerabilities, understanding the types of terrorist activities that likely would be successful in exploiting those vulnerabilities, and taking preemptive and protective actions to mitigate vulnerabilities so that terrorists are no longer able to exploit them. This report characterizes and discusses the common vulnerabilities of the nuclear fuel cycle used to support nuclear power plants, which are located in 31 states and produce more than 21% of the United States (U.S.) electricity requirements.

NUCLEAR FUEL CYCLE CHARACTERISTICS

Nuclear power plants in the U.S. use fuel rods that have been enriched in the uranium-235 (^{235}U) fissile isotope. At the time of their insertion to the reactor, typical commercial power plant fuel rods contain approximately 2% to 5% ^{235}U; the exact value depends on the details of the reactor design. This fuel remains in the reactor for up to three years or more, at which time fission product buildup necessitates its removal even though it still contains significant quantities of ^{235}U.

The entire nuclear fuel cycle contains several components as illustrated schematically in Figure 1. The Nuclear Regulatory Commission (NRC) has the overall regulatory responsibility for the safety and security of commercial nuclear power plants and the associated nuclear fuel cycle facilities in the U.S. This responsibility has included ensuring that licensed nuclear facilities provide safety and security against sabotage and theft of nuclear materials.

Uranium Mining and Milling

Until about ten years ago, uranium was typically mined in surface mines (open cut mines) and deep shaft mines. More recently, however, in-situ leaching in which chemical solutions are injected into underground uranium deposits to dissolve uranium has become more widely used.

Each technique concentrates the uranium into a product known as "yellowcake" (uranium oxide [U_3O_8]) because of its yellowish color.

The mined yellowcake is trucked to a milling facility where it is crushed and leached. In most cases, sulfuric acid is used as the leaching agent, but alkaline leaching can also be used. The leaching agent not only extracts uranium from the ore, but also several other constituents, including vanadium, selenium, iron, lead, and arsenic.

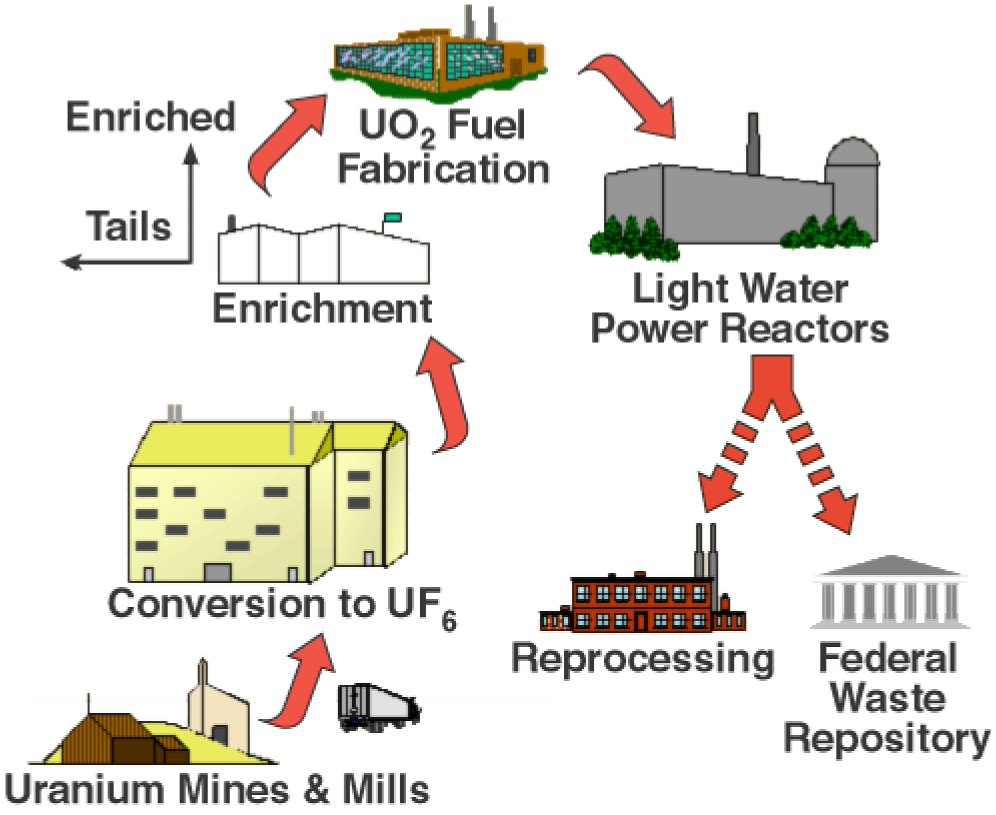

Figure 1 Schematic of the Nuclear Fuel Cycle (Source: NRC web site)

Conventional mills crush the ore and extract 90% to 95% of the uranium. Mills are typically located in areas of low population density, and they process ores from mines within about 50 kilometers (30 miles) of the mill. Approximately 21 uranium milling facilities are licensed by the NRC. However, as of September 2003, most of these mills are in decommissioning, three are in stand-by mode, and only one is in operation. This status reflects several market issues, including the inventory of mined and milled uranium, the flat demand curve for enriched uranium in the U.S., and the availability of enriched uranium from overseas suppliers.

NRC requirements for uranium mills cover the control of industrial hazards and address waste and decommissioning concerns. Because the uranium in the milling facilities is not enriched, no criticality hazard, and little fire or explosive hazard, exists for the uranium. However, the solvent extraction process does present a fire hazard. The primary hazards associated with milling operations are occupational hazards found in any metal milling operation that uses chemical extraction, plus the chemical toxicity of the uranium itself. Radiological hazards are low at these facilities, as uranium has little penetrating radiation and only moderate non-penetrating radiation. The primary radiological hazard is due to the presence of radium in the uranium decay chains and the production of radon gas from the decay of radium and radon progeny (short-lived radon decay products).

The solid waste from the milling process is called mill tailings. These tailings, which contain most of the progeny of uranium, are a significant source of radon and radon progeny releases to the environment. Human risks involve inhalation of radon progeny that may be deposited in the respiratory tract. Alpha radiation would be emitted into those tissues and could pose a cancer risk to anyone who inhales radon progeny.

Uranium Conversion

The next stage in the nuclear fuel cycle is conversion of the milled U_3O_8 into pure uranium hexafluoride (UF_6) gas for use in the enrichment stage. During the conversion stage, impurities are removed from the U_3O_8, and the uranium is combined with flourine to create the UF_6 gas that is then pressurized and cooled to a liquid. In its liquid state, it is drained into 14-ton cylinders where it solidifies after cooling for approximately five days. After cooling, the UF_6-containing cylinder is shipped to an enrichment plant.

The NRC has licensed the Honeywell International, Inc., Conversion Facility in Metropolis, Illinois. This is the only operating conversion facility in the U.S. Other countries having conversion plants are Canada, France, United Kingdom, China, and the Russian Federation.

As with mining and milling, the primary risks associated with the conversion process are chemical and radiological. Strong acids and alkalis are used in the conversion process, which involves converting the yellowcake (uranium oxide) powder to very soluble forms, leading to possible inhalation of uranium. In addition, conversion produces extremely corrosive chemicals that could cause fire and explosion hazards.

On December 21, 2001, the NRC notified Honeywell International, Inc., that interim security enhancements must be implemented “... to provide the Commission with reasonable assurance that the public health and safety and common defense and security continue to be adequately protected in the current threat environment.” On March 25, 2002, the NRC formalized these interim enhancements in the form of an NRC Order. Details of the enhanced security requirements at Honeywell International, Inc., are not publicly available.

Enrichment Process

When uranium is mined, it consists of heavy atoms (about 99.3% of the mass and generally referred to as ^{238}U), middleweight atoms (0.7% and ^{235}U), and lightweight atoms (<0.01% and ^{234}U). These are the different “isotopes” of uranium. The fuel for nuclear reactors has to have a higher concentration of ^{235}U than exists in natural uranium ore. This is because ^{235}U is the key ingredient that starts a nuclear reactor and keeps it going. Normally, the amount of the ^{235}U isotope is enriched from 0.7% of the uranium mass up to about 5%. The process, called “gaseous diffusion” is used in the U.S. Gas centrifuges can also be used to enrich uranium. Although this enrichment process is not now used in the U.S., the United States Enrichment Corporation (USEC) announced in late January 2004 their intention to construct and operate a centrifuge enrichment facility at their Portsmouth, Ohio, facility.

In the gaseous diffusion enrichment process, the solid uranium hexafluoride (UF_6) from the conversion facility is heated in its container until it begins to gasify. The UF_6 gas is slowly fed into the plant’s pipelines, where it is pumped through a series of several hundred special filters called barriers or porous membranes. The isotope enrichment occurs because the lighter UF_6 gas molecules (with the ^{234}U and ^{235}U atoms) tend to diffuse faster through the barriers than the heavier UF_6 gas molecules containing ^{238}U. After passing through several hundred barriers (the exact number being dependent on several design factors, including the desired final enrichment or ^{235}U concentration), the enriched UF_6 gas is withdrawn from the pipelines and condensed back into a liquid that is poured into containers. The UF_6 is then allowed to cool and solidify before it is transported to fuel fabrication facilities where it is turned into fuel assemblies for nuclear power reactors.

The waste from enrichment facilities consists principally of UF_6 that has been depleted in its ^{235}U content. This material is stored in thick-walled cylinders and has been stored at Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee (where an enrichment facility operated until 1985). A total of about 60,000 cylinders containing 700,000 metric tonnes of depleted UF_6 is currently stored in cylinder yards at these three sites. The U.S. Department of Energy (DOE) is currently (as of February 2004) in the process of preparing for the permanent disposal of this waste with a Congressional mandate to begin construction of a conversion facility by July 31, 2004. This facility will convert the depleted UF_6 to a waste form more suitable for long-term disposal in a repository.

The hazards in gaseous diffusion plants include the chemical and radiological hazard of a UF_6 release and the potential for mishandling the enriched uranium, which could create a criticality accident (inadvertent nuclear chain reaction).

The only gaseous diffusion plant in operation in the U.S. is in Paducah, Kentucky. Another similar plant is located near Portsmouth, Ohio, but it has been shut down since March 2001. Both plants are leased by USEC from DOE and have been regulated by the NRC since March 4, 1997.

Another process for enriching uranium is the gas centrifuge process, which uses a series of large rotating cylinders. These centrifuge machines, called trains, are interconnected to form cascades. In this process, UF_6 gas is placed in a rotating drum or cylinder and rotated at a high speed. This rotation creates a strong gravitational field so that the heavier gas molecules (containing ^{238}U) move toward the outside of the cylinder and the lighter gas molecules (containing ^{235}U) collect closer to the center. The stream that is slightly enriched in ^{235}U is withdrawn and fed into the next higher stage, while the slightly depleted stream is recycled back into the next lower stage. No gas centrifuge plants are now operating in the U.S. As noted above, however, USEC recently announced its intention to construct and operate such a facility.

As for the Honeywell Conversion Facility, on June 17, 2002, the NRC notified USEC that the temporary security enhancements ordered following the September 11, 2001, terrorist attacks were to be maintained until further notice. Details of these security enhancements are not publicly available.

Another source of enriched uranium for nuclear power plants has entered the marketplace in the recent past. In 1993, the U.S. and Russian Federation signed an agreement concerning the deposition of highly enriched uranium extracted from Russian nuclear weapons. Under this agreement, the U.S. will purchase approximately 15,000 metric tons of low-enriched uranium (at an enrichment level appropriate for commercial nuclear power plants) converted from 500 metric tons of highly enriched uranium from dismantled nuclear warheads. This agreement is to remain in effect through 2013.

The highly enriched uranium metal from the warheads is being converted to low-enrichment UF_6 at four facilities within Russia. The UF_6 is packaged in internationally approved shipping containers and sent to St. Petersburg, Russia, where it is loaded onto ocean vessels and transported to the U.S. Upon arrival in the U.S., this material is loaded onto trucks and sent to the USEC Enrichment Plant at Paducah, Kentucky. At this point, this fuel is indistinguishable from UF_6 of the same enrichment produced at Paducah. The fuel is sold to nuclear utilities and sent to a fuel fabrication facility for production of the fuel rods that go into the nuclear reactors. On an annual basis, the fuel imported under this agreement is sufficient to supply approximately 50% of the fuel needs of commercial nuclear power plants in the U.S. As of the end of 2002, 5,027 metric tons of low-enriched UF_6 had been delivered to the U.S. under this agreement.

The international standard container for storage and transport of UF_6 with a ^{235}U enrichment of 5% or less is the Type 30B cylinder. These cylinders are made from 0.5-inch-thick steel with a valve at one end and a plug at the other. Their nominal diameter is 30 inches (thus the name "30B"), and they are 81 inches long. The maximum capacity is 5,020 pounds. This cylinder has been the standard in the uranium enrichment and nuclear fuel industries for many years. For safety purposes, these cylinders are shipped inside protective, accident-resistant overpacks that have been designed and tested in accordance with both U.S. Department of Transportation and NRC requirements. On an annual basis, the agreement to accept this low-enriched UF_6 calls for approximately 600 30B cylinders to be shipped to the U.S. Approximately 15 ocean shipments per year are required to transport this fuel from Russia. The vast majority of these shipments arrive at the Port of Baltimore, Maryland, but some shipments have arrived at Hampton Roads, Virginia, and at the Port of Philadelphia and South New Jersey. The decision as to which port is used is partially at the discretion of the shipping company.

In support of national security, the U.S. Coast Guard (USCG) is responsible for protecting the public, the environment, and U.S. economic interests in the nation's ports and waterways. In this capacity, the USCG regulates marine safety in U.S. ports and considers enriched UF_6 to be "dangerous cargo" as defined in 33 CFR 126.07. Under this definition, the UF_6 may be loaded, handled, discharged, or stowed in a U.S. port only at a waterfront facility that meets the conditions specified in 33 CFR 126.05. Port operations consist of unloading the overpacks containing the 30B cylinders and putting them directly on a truck located dockside. The UF_6 is then temporarily stored in a holding area within the waterfront facility while awaiting inspection and clearance by U.S. Customs authorities.

Following clearance through U.S. Customs, the UF_6 is loaded onto trucks for shipment to the Paducah Enrichment Facility. Such shipments are made in accordance with radioactive materials packaging and highway routing regulations as required by the U.S. Department of Transportation (49 CFR 397 Subpart D). If necessary, to store this material while enroute (to facilitate efficient transportation operations), the storage facility must be fenced, secured, and patrolled, as per the requirements of 49 CFR 173.447.

Fuel Fabrication

The next stage in the nuclear fuel cycle is that of fuel fabrication. This stage represents the final step in what is referred to as the "front end" of the cycle. Fuel fabrication for light (regular) water power reactors typically begins with receipt of low-enriched uranium (LEU) hexafluoride UF_6 from an enrichment plant. The UF_6, in solid form within containers, is converted to gaseous form by heating, and the UF_6 gas is chemically processed to form LEU uranium dioxide (UO_2) powder. This powder is then pressed into pellets, sintered into ceramic form, loaded into Zircaloy tubes, and constructed into fuel assemblies. Depending on the type of light water reactor, a fuel assembly may contain up to 264 fuel rods and have dimensions of 5 to 9 inches square by about 12 feet.

Under its Surplus Plutonium Disposition Program, DOE is planning to convert approximately 34 metric tons of surplus plutonium from nuclear weapons into mixed uranium and plutonium oxide (MOX) fuel for use in commercial nuclear power plants. MOX differs from LEU fuel in that the dioxide powder from which the fuel pellets are pressed is a combination of UO_2 and plutonium oxide (PuO_2). Congress has directed the NRC to regulate DOE's fabrication of MOX fuel used for disposal of plutonium from international nuclear disarmament agreements. Before a licensee can use MOX fuel in a reactor, the NRC will issue a revised license to that plant.

The NRC anticipates licensing the MOX fuel fabrication facility under existing regulations. However, some changes to the regulations and guidance are expected before the NRC license application is received.

Chemical, radiological, and criticality hazards at fuel fabrication facilities are similar to hazards at enrichment plants. Most at risk from these hazards are the plant workers. These facilities generally pose a low risk to the public.

The NRC has licensed six fuel fabrication facilities in the U.S. These facilities were also ordered by the NRC to make permanent the enhanced security practices initiated following the terrorist attacks on September 11, 2001.

Nuclear Power Plants

This portion of the nuclear fuel cycle represents the irradiation of the fuel rods in a reactor to produce electric power. There are currently 104 nuclear-fueled electric power reactors in the U.S. As indicated in Figures 2 and 3, there are two general types of nuclear power plants in the U.S.: boiling water reactors (BWRs) and pressurized water reactors (PWRs). General descriptions of these power plants and their vulnerabilities have been presented in separate documentation and will thus not be repeated in this summary.

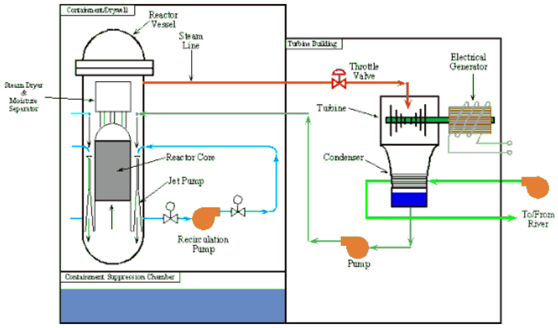

Figure 2 Boiling Water Reactor

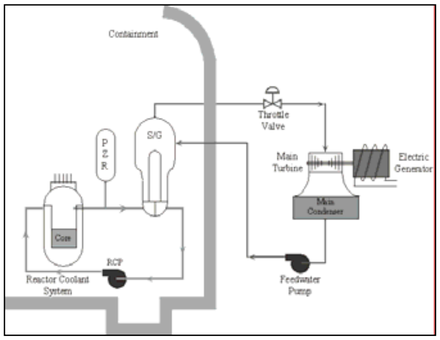

Figure 3 Pressurized Water Reactor

Spent Fuel Management

The final stage (or "back end") of the nuclear fuel cycle currently consists essentially of a waste management strategy as opposed to a definitive set of facilities. Once uranium has been used to generate electricity, it becomes spent fuel. (This term is to some extent a misnomer. While the fuel rods have been removed from the reactor due to the buildup of fission products that tend to shut down the reactor, the ^{235}U in the fuel has not all been spent or used up.) This is the major waste product of nuclear reactors, and as shown in Figure 1, can be dealt with in several ways. As this spent fuel is highly radioactive, it cannot be simply discarded. It is temporarily stored in special ponds at the nuclear power plant facility where it is allowed to cool and decrease its radioactivity. The storage ponds are steel-lined concrete tanks, up to about 30 feet deep and filled with water. The water cools the spent fuel rods and acts as a radiation shield. The heat and radioactivity decrease over time; after about 40 years, they are down to about 1/1000 of what they were when taken from the reactor. The longer they are stored, the easier they are to deal with.

Although the spent fuel can be stored in these storage ponds for fairly long periods of time, eventually the fuel will need to be either reprocessed or disposed of. Reprocessing involves separating the remaining uranium and the plutonium that has been produced in the reactor from the waste products in the spent fuel. This is done by cutting up the fuel rods and dissolving them in acid. The recovered uranium is then returned to the beginning of the nuclear fuel cycle, and the plutonium is mixed with this to produce more fuel. After reprocessing, the highly radioactive waste can be heated to produce a powder, a process called calcining. This powder is mixed with glass to encapsulate (or lock in) the waste, a process called vitrification. The liquid glass is then poured into stainless steel canisters for storage in a repository.

Public policy and economic factors have combined to preclude the reprocessing option in the U.S. for at least the near-term future. However, technical uncertainties, public policy, and environmental issues have combined to delay the opening of a permanent spent fuel repository until at least 2010. Thus, the spent fuel accumulates in the spent fuel storage ponds at the individual power plants. As of February 2004, the NRC has not licensed either a reprocessing facility or a Federal Waste Repository for spent fuel.

The Nuclear Waste Policy Act of 1982 as amended governs the permanent disposal of high-level radioactive waste. This act specifies that spent fuel and/or high-level radioactive waste will be disposed of underground, in a deep geologic repository, and that Yucca Mountain, Nevada, will be the single candidate site for characterization as a potential geologic repository.

The NRC is one of three federal agencies with a role in the disposal of spent nuclear fuel and other high-level radioactive waste. Briefly, these roles are as follows:

- DOE has the responsibility for developing permanent disposal capacity for spent fuel and other high-level radioactive waste.

- The Environmental Protection Agency (EPA) has the responsibility for developing environmental standards to evaluate the safety of a geologic repository.

- NRC has the responsibility for developing regulations to implement the EPA safety standards and for licensing the repository.

Additional information can be found in the Department of Homeland Security document entitled *Characteristics and Common Vulnerabilities — Infrastructure Category: Spent Fuel Storage Facilities*.

CONSEQUENCE OF EVENTS

Two basic types of consequences must be addressed in evaluating the nuclear fuel cycle. First, there are those consequences that could result from malevolent action causing damage to any of the facilities in the fuel cycle with a resultant radioactive and/or hazardous chemical release that could impact public health and safety. There are also those consequences resulting from malevolent action causing one or more fuel cycle components to shut down or significantly decrease its output.

As can be inferred from the above brief descriptions of the nuclear fuel cycle stages, the consequences of potential malevolent actions vary considerably. Table 1 indicates, in a very general sense, the level of each type of consequence within each stage of the fuel cycle. These consequences are intentionally very qualitative rather than quantitative because of the great range of potential damage and potential releases that could possibly occur. No consideration has been given to the probability of occurrence of any of these consequences.

Table 1 Potential Consequences of Malevolent Activities

Fuel Cycle Stage	**Potential Health & Safety Consequences**	**Potential Operational Consequences**
Mining and Milling	Release of chemical solvents to atmosphere	Impact limited by fuel stockpiles and availability of foreign supplies
Conversion	Release of chemical solvents to atmosphere Release of gaseous UF_6 to atmosphere Release of gaseous fluorine compounds to atmosphere	Near-term impacts because only one facility in operation but others could potentially be restarted; Impact limited by fuel stockpiles and availability of foreign supplies
Enrichment	Release of gaseous UF_6 to atmosphere Release of gaseous fluorine compounds to atmosphere Quantities of depleted UF_6 in storage of particular concern	Near-term impacts because only one facility in operation but others could potentially be restarted; Impact limited by fuel stockpiles and availability of foreign supplies
Fuel Fabrication	Release of gaseous UF6 to atmosphere	Impacts limited because of multiple facilities in U.S. and availability of foreign supplies
Power Plant	Discussed in document on nuclear power plants	Discussed in document on nuclear power plants
Spent Fuel Management	Direct exposure to highly radioactive spent fuel rods Melting of spent fuel rods with release of radioactive, gaseous fission products to atmosphere	Shutdown of plant(s) directly involved and possibly of all other nuclear power plants

COMMON VULNERABILITIES

The following are partial lists of common vulnerabilities found at, or associated with, facilities comprising the nuclear fuel cycle. Although all listed vulnerabilities might not be observed at a particular fuel cycle facility, the list is generally representative of vulnerability concerns related to the nuclear fuel cycle.

Exhibit 1 Economic and Institutional Vulnerabilities	
Economic and institutional vulnerabilities are those that would have extensive national, regional, industry-wide consequences if exploited by a terrorist attack.	
1	An attack on any facility related to the nuclear fuel cycle, whether successful or not, can precipitate a significant public reaction because of general concerns about nuclear safety.
2	Disruptions to any part of the nuclear fuel cycle, while not of immediate and direct impact, can cause a disruption to the generation of electricity by nuclear power plants, which make up a significant part of the national power production.

Exhibit 2 Site-Related Vulnerabilities	
Site-related vulnerabilities are conditions or situations existing at a particular site or facility that could be exploited by a terrorist or terrorist group to do economic, physical, or bodily harm or to disable or disrupt facility operations or other critical infrastructures.	
Access and Access Control:	
1	Public roads may be in close proximity to critical facilities, allowing easy access by a vehicle-borne explosive device.
2	Critical assets such as transformers and transportation facilities may be set close to the perimeter fence, allowing for a successful attack from outside the fence line.
3	Facilities heavily dependent on truck traffic entering facility to deliver raw materials and to take out product.
4	Facilities are vulnerable to an aircraft attack.
5	Facilities may use contract guard services, and guard turnover may be difficult to control.
6	Rules of engagement and use of force are narrowly defined for situations where a threat to the guard’s life is not imminent. Guards are subject to individual state criminal prosecution for actions taken during the performance of their official duties.
Operational Security:	
7	Information of transportation routes between facilities publicly available via environmental impact statements and other sources.
8	Critical assets not located inside buildings may be easily identifiable.
	Continued on following page.

9	Websites provide information on facility description, chemicals used, risks incurred, critical assets, and other data.
10	Lists of fuel cycle facility locations are readily available through several public sources.
Hazardous and Toxic Chemicals:	
11	Much of fuel cycle involves handling of hazardous, toxic, or radioactive materials.
Emergency Planning and Preparedness:	
12	Many facilities remotely located so that emergency response of offsite sources will be delayed.
13	Spare parts that are large and/or expensive are in short supply and have lead times potentially extending into years. Many facilities (e.g., the gaseous diffusion enrichment facilities) use one-of-a-kind equipment.

Table 3 Interdependent Vulnerabilities

Interdependency is the relationship between two or more infrastructures by which the condition or functionality of each infrastructure is affected by the condition or functionality of the other(s). Interdependencies can be physical, geographic, logical, or information-based.

Water:	
1	All facilities use water for environmental control, as part of chemical processes, for cooling, and/or for employee consumption. The quantities and qualities of water vary among the facilities. Remoteness of many facilities may limit the possible sources of water.
Transportation:	
2	Facilities heavily dependent on truck traffic to deliver raw materials and to transport product out of facility.
Electric Power:	
3	Facilities heavily dependent on electric power. Some onsite generation may be available but will be dependent on transportation infrastructure. Remoteness of facilities makes electric lines more vulnerable.
Telecommunications:	
4	Frequencies of handheld radios can be scanned by adversaries to determine operating conditions, location of employees, ongoing activities, etc.

OTHER INFORMATION

Although specifics are not available to the public, and the defense levels depend on the associated risks, elements of nuclear facility defense required by the NRC include:

- Fenced perimeters,
- Intrusion detection devices,
- Layers of access barriers,
- Armed and trained guard forces,
- Armored defensive positions, and
- A comprehensive defense strategy.

In addition, employees must undergo background checks and psychological testing. While on the job, employees are subject to random drug and alcohol testing.

Following the terrorist attacks of September 11, 2001, the NRC required enhanced security at licensed facilities. Although details are not publicly available, typical enhancements included:

- Increased patrols,
- Augmented security forces and capabilities,
- Additional security posts,
- Installation of additional physical barriers,
- Vehicle checks at greater stand-off distances,
- Enhanced coordination with law enforcement and military authorities,
- More restrictive site access controls for all personnel, and
- Expanded, expedited, and more thorough employee background checks.

Many of the regulatory responsibilities that the NRC has for nuclear facilities are spelled out in 10 CFR 73 (*Physical Protection of Plants and Materials*). Although this regulation set contains many requirements and defines several performance standards, two parts of 10 CFR 73 are reproduced below as illustrative examples of the rigor with which the NRC is authorized to regulate.

10 CFR 73.20 General Performance Objectives and Requirements

(a) In addition to any other requirements of this part, each licensee who is authorized to operate a fuel reprocessing plant pursuant to part 50 of this chapter; possesses or uses formula quantities of strategic special nuclear material at any site or contiguous sites subject to control by the licensee; is authorized to transport or deliver to a carrier for transportation pursuant to part 70 of this chapter formula quantities of strategic special nuclear material; takes delivery of formula quantities of strategic special nuclear material free on board (f.o.b.) the point at which it is delivered to a carrier for transportation; or imports or exports formula quantities of strategic special nuclear material, shall establish and maintain or make arrangements for a physical protection system which will have as its objective to provide high assurance that activities involving special nuclear material are not inimical to the common defense and security, and do not constitute an unreasonable risk to the public health and safety. The physical protection system shall be designed to protect against the design basis threats of theft or diversion of strategic special nuclear material and radiological sabotage as stated in §73.1(a).

(b) To achieve the general performance objective of paragraph (a) of this section, a licensee shall establish and maintain, or arrange for, a physical protection system that:

> (1) Provides the performance capabilities described in §73.25 for in-transit protection or in § 73.45 for fixed site protection unless otherwise authorized by the Commission;
>
> (2) Is designed with sufficient redundancy and diversity to ensure maintenance of the capabilities described in §§73.25 and 73.45;
>
> (3) Includes a safeguards contingency capability that can meet the criteria in appendix C to this part “Licensee Safeguards Contingency Plans;” and
>
> (4) Includes a testing and maintenance program to assure control over all activities and devices affecting the effectiveness, reliability, and availability of the physical protection system, including a demonstration that any defects of such activities and devices will be promptly detected and corrected for the total period of time they are required as a part of the physical protection system.

(c) Each licensee subject to the requirements of paragraphs (a) and (b) of this section shall establish, maintain, and follow NRC-approved safeguards physical protection and safeguards contingency plans that describe how the licensee will comply with the requirements of paragraphs (a) and (b) of this section.

10 CFR 73.45 Performance Capabilities for Fixed Site Physical Protection Systems

(a) To meet the general performance requirements of §73.20 a fixed site physical protection system shall include the performance capabilities described in paragraphs (b) through (g) of this section unless otherwise authorized by the Commission.

(b) Prevent unauthorized access of persons, vehicles and materials into material access areas and vital areas. To achieve this capability the physical protection system shall:

> (1) Detect attempts to gain unauthorized access or introduce unauthorized material across material access or vital area boundaries by stealth or force using the following subsystems and subfunctions:

(i) Barriers to channel persons and material to material access and vital area entry control points and to delay any unauthorized penetration attempts by persons or materials sufficient to assist detection and permit a response that will prevent the penetration; and

(ii) Access detection subsystems and procedures to detect, assess and communicate any unauthorized penetration attempts by persons or materials at the time of the attempt so that the response can prevent the unauthorized access or penetration.

(2) Detect attempts to gain unauthorized access or introduce unauthorized materials into material access areas or vital areas by deceit using the following subsystems and subfunctions:

(i) Access authorization controls and procedures to provide current authorization schedules and entry criteria for both persons and materials; and

(ii) Entry controls and procedures to verify the identity of persons and materials and assess such identity against current authorization schedules and entry criteria before permitting entry and to initiate response measures to deny unauthorized entries. (c) Permit only authorized activities and conditions within protected areas, material access areas, and vital areas. To achieve this capability the physical protection system shall:

(1) Detect unauthorized activities or conditions within protected areas, material access areas and vital areas using the following subsystems and subfunctions:

(i) Controls and procedures that establish current schedules of authorized activities and conditions in defined areas;

(ii) Boundaries to define areas within which the authorized activities and conditions are permitted; and

(iii) Detection and surveillance subsystems and procedures to discover and assess unauthorized activities and conditions and communicate them so that response can be such as to stop the activity or correct the conditions to satisfy the general performance objective and requirements of §73.20(a).

(d) Permit only authorized placement and movement of strategic special nuclear material within material access areas. To achieve this capability the physical protection system shall:

(1) Detect unauthorized placement and movement of strategic special nuclear material within the material access area using the following subsystems and subfunctions:

(i) Controls and procedures to delineate authorized placement and control for strategic special nuclear material;

(ii) Controls and procedures to establish current authorized placement and movement of all strategic special nuclear material within material access areas;

(iii) Controls and procedures to maintain knowledge of the identity, quantity, placement, and movement of all strategic special nuclear material within material access areas; and

(iv) Detection and monitoring subsystems and procedures to discover and assess unauthorized placement and movement of strategic special nuclear material and communicate them so that response can be such as to return the strategic special nuclear material to authorized placement or control.

(e) Permit removal of only authorized and confirmed forms and amounts of strategic special nuclear material from material access areas. To achieve this capability the physical protection system shall:

(1) Detect attempts at unauthorized removal of strategic special nuclear material from material access areas by stealth or force using the following subsystems and subfunctions:

(i) Barriers to channel persons and materials exiting a material access area to exit control points and to delay any unauthorized strategic special nuclear material removal attempts sufficient to assist detection and assessment and permit a response that will prevent the removal; and satisfy the general performance objective and requirements of §73.20(a); and

(ii) Detection subsystems and procedures to detect, assess and communicate any attempts at unauthorized removal of strategic special nuclear material so that response to the attempt can be such as to prevent the removal and satisfy the general performance objective and requirements of §73.20(a).

(2) Confirm the identity and quantity of strategic special nuclear material presented for removal from a material access area and detect attempts at unauthorized removal of strategic special nuclear material from material access areas by deceit using the following subsystems and subfunctions:

(i) Authorization controls and procedures to provide current schedules for authorized removal of strategic special nuclear material which specify the authorized properties and quantities of material to be removed, the persons authorized to remove the material, and the authorized time schedule;

(ii) Removal controls and procedures to identify and confirm the properties and quantities of material being removed and verify the identity of the persons making the removal and time of removal and assess these against the current authorized removal schedule before permitting removal; and

(iii) Communications subsystems and procedures to provide for notification of an attempted unauthorized or unconfirmed removal so that response can be such as to prevent the removal and satisfy the general performance objective and requirements of §73.20(a).

(f) Provide for authorized access and assure detection of and response to unauthorized penetrations of the protected area to satisfy the general performance objective and requirements of §73.20(a). To achieve this capability the physical protection system shall:

(1) Detect attempts to gain unauthorized access or introduce unauthorized persons, vehicles, or materials into the protected area by stealth or force using the following subsystems and subfunctions:

(i) Barriers to channel persons, vehicles, and materials to protected area entry control points; and to delay any unauthorized penetration attempts or the introduction of unauthorized vehicles or materials sufficient to assist detection and assessment and permit a response that will prevent the penetration or prevent such penetration and satisfy the general performance objective and requirements of §73.20(a); and

(ii) Access detection subsystems and procedures to detect, assess and communicate any unauthorized access or penetrations or such attempts by persons, vehicles, or materials at the time of the act or the attempt so that the response can be such as to prevent the unauthorized access or penetration, and satisfy the general performance objective and requirements of §73.20(a).

(2) Detect attempts to gain unauthorized access or introduce unauthorized persons, vehicles, or materials into the protected area by deceit using the following subsystems and subfunctions:

(i) Access authorization controls and procedures to provide current authorization schedules and entry criteria for persons, vehicles, and materials; and

(ii) Entry controls and procedures to verify the identity of persons, materials and vehicles and assess such identity against current authorization schedules before permitting entry and to initiate response measures to deny unauthorized access.

(g) Response. Each physical protection program shall provide a response capability to assure that the five capabilities described in paragraphs (b) through (f) of this section are achieved and that adversary forces will be engaged and impeded until offsite assistance forces arrive. To achieve this capability a licensee shall:

(1) Establish a security organization to:

(i) Provide trained and qualified personnel to carry out assigned duties and responsibilities; and

(ii) Provide for routine security operations and planned and predetermined response to emergencies and safeguards contingencies.

(2) Establish a predetermined plan to respond to safeguards contingency events.

(3) Provide equipment for the security organization and facility design features to:

  (i) Provide for rapid assessment of safeguards contingencies;

  (ii) Provide for response by assigned security organization personnel which is sufficiently rapid and effective to achieve the predetermined objective of the response; and

  (iii) Provide protection for the assessment and response personnel so that they can complete their assigned duties.

(4) Provide communications networks to:

  (i) Transmit rapid and accurate security information among onsite forces for routine security operation, assessment of a contingency, and response to a contingency; and

  (ii) Transmit rapid and accurate detection and assessment information to offsite assistance forces.

(5) Assure that a single adversary action cannot destroy the capability of the security organization to notify offsite response forces of the need for assistance.

USEFUL REFERENCE MATERIAL

1. Nuclear Regulatory Commission Website [http://www.nrc.gov/].
2. How Stuff Works Website [http://www.howstuffworks.com/].
3. Nuclear Tourist Website [http://www.nucleartourist.com/].
4. Nuclear Energy Institute Website [http://www.nei.org/].
5. Nuclear Control Institute Website [http://www.nci.org/].
6. Description of NRC Requirements in 10 CFR 73 [http://www.nrc.gov/reading-rm/doc-collections/cfr/part073/].
7. Department of Homeland Security document, *Characteristics and Common Vulnerabilities — Infrastructure Category: Spent Fuel Storage Facilities*.
8. Department of Homeland Security document, *Characteristics and Common Vulnerabilities — Infrastructure Category: Nuclear Power Plants.*