Regulatory Roulette: The NRC's Inconsistent Oversight of Radioactive Releases from Nuclear Power Plants

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Executive Summary

Protecting People and the Environment is the tagline used by the Nuclear Regulatory Commission (NRC). This report shows that the NRC is not living up to its self-stated mission when it comes to accidental releases of radioactive liquids and gases from nuclear power plants.

While it is not possible to eliminate the risks of radioactive releases, the NRC has regulations in place to reduce this risk. All releases must be monitored, controlled and not exceed specific limits. For each reactor, these regulatory requirements constitute three-way contracts between the NRC, plant owners, and the public. The contracts protect plant owners from the NRC imposing more rigorous, and costly, safety measures without first revising its regulations or amending the operating licenses through formal processes. The contracts also protect the public from the NRC accepting lower safety levels than those established by the regulatory requirements.

There have been more than 400 accidental leaks, some involving millions of gallons of contaminated water. Some of the leaks remained undetected for years. Nearly every nuclear plant in the country has experienced at least one accidental leak.

The NRC has breached its contract with the public by repeatedly tolerating unmonitored and uncontrolled leaks of radioactively contaminated water into the ground and nearby waterways. For years, the NRC sporadically sanctioned plant owners for violations of regulations. There was little correlation between the severity of the violation and whether a sanction was issued. But in all 27 cases in which plants accidentally released radioactive materials over the past four years, the NRC has allowed plant owners to violate these regulations with impunity.

While no fatalities have yet been linked to these recurring violations, people and the environment have already been harmed. For example, in 2005 is was reported that over six million gallons of tritium-laden water leaked from the Braidwood nuclear plant in Illinois, and the specter of radioactive contamination depressed the home prices of innocent families in the plume’s path.

The NRC must become the regulator the public deserves. The NRC cannot set the safety bar at acceptable levels and then meekly watch as plant owners limbo beneath it. The NRC must consistently and aggressively enforce its regulations to protect the public and environment from radioactive contamination.

Routine Releases of Radioactive Materials

Radioactively contaminated gases, liquids, and solids are routine byproducts of nuclear power plant operation. Radioactive waste management systems, commonly called radwaste systems, collect, process, and either recycle or dispose of these radioactive materials. The design and operation of the radwaste systems are governed by Nuclear Regulatory Commission (NRC) regulations. In some cases, radioactive material is intentionally discharged to the environment. Such discharges are also regulated by the NRC. Plant owners are required to submit annual reports to the NRC detailing the amounts and compositions[1] of radwaste discharged—intentionally or accidentally—from their facilities.

In pressurized water reactors,[2] gaseous radwaste comes largely from the high pressure water continuously removed from the primary loop that circulates water between the reactor vessel and the steam generators. The removed water is cooled so it can be purified and chemically treated as necessary, and the associated reduction in pressure allows gas bubbles to form. This gas is collected in large tanks, and once they are full, workers take a sample and measure its radioactivity level. If that level is below specified limits, the contents of the tank can be discharged through a vent pipe to the atmosphere. If not, the gas is allowed to sit to give the short-lived radionuclides some time to decay, and workers take another sample to determine if the radioactivity level has dropped enough to permit the gas to be released.

In boiling water reactors,[2] gaseous radwaste comes largely from the steam produced in the reactor vessel and routed to the turbine-generator to make electricity. This steam carries along with it radionuclides in gaseous form. The "offgas" system removes the radioactive gas from the condensers located directly beneath the turbines. The offgas system removes small radioactive particles from the flow and delays the release of radionuclides like the noble gases krypton and xenon to allow their decay. The treated flow, which is now significantly less radioactive, is discharged from a chimney that is hundreds of feet tall to promote mixing and dilution with the non-radioactive air.

In both types of reactors, liquid radwaste comes from floor drains that capture in-plant spills, equipment drains that collect controlled releases from valve gaskets and relief valves, and water rejected from other systems due to chemistry problems (e.g., high or low pH levels, conductivity that is not within specifications, etc.). The liquid radwaste system has many tanks that store water from its initial receipt through various processing stages. Most of the water can be re-used in the plant after one or more cycles through the liquid radwaste system.

However, there are times when the capacity of the liquid radwaste system to process incoming water is reduced. For example, the liquid radwaste system is taxed during refueling outages if several systems are drained for maintenance and/or flushed to remove internal contamination. The radwaste system many not be able to repetitively process such large amounts of incoming water until it is clean enough to be recycled. In this case, the radioactive water may be discharged instead.

When workers plan to release the contents of a liquid radwaste system tank to the environment, they mix the contents of the tank to obtain a homogeneous mixture for sampling. After analysis of a representative sample confirms that the radioactivity levels are below specified limits, the tank's contents can be discharged into the nearby lake, river, or ocean that

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[1] For example, the report would indicate how many curies of tritium in gaseous form and how many curies of cesium in liquid form were discharged.

[2] For the location of pressurized water reactors and boiling water reactors in the United States, visit UCS's Nuclear Power Information Tracker www.ucsusa.org/nuclear_power/reactor-map/embedded-flash-map.html.

provides the cooling water for the reactor. Typically, the discharged cooling water is used to dilute the releases from liquid radwaste system tanks and promote mixing in the lake, river, or ocean water.

Solid radwaste includes the resin beads used to purify the radioactive water circulating through the reactor vessel, the steam generators, and the spent fuel pools. The resin beads remove dissolved impurities by ion exchange and particles by filtration. Periodically, workers replace the resin beads, and the used resin is dried and shipped offsite for burial in a licensed low-level radwaste dump.[3]

Regulations Governing Releases of Radioactive Materials

There are several NRC regulations that govern the release of gaseous and liquid radwaste, and the disposal of solid radwaste. Such regulations were first set out in 1971 by the NRC's predecessor, the Atomic Energy Commission, as part of the general design criteria (GDC) for nuclear reactors. The GDC include almost six dozen safety criteria; criterion 60 and 64 address the controlled release of radioactive materials to the environment, and monitoring of such releases, respectively.

Criterion 60 requires that nuclear plants be designed to provide positive control of all radioactively contaminated gases and liquids discharged to the environment during all modes of normal reactor operation. For example, the radwaste system tanks must have sufficient volume to handle and process the large amounts of radioactively contaminated water that often accumulate prior to each start-up of a reactor. The system must also be able to store radioactive liquids and gases if local environmental conditions can be expected to prevent the release of this material (e.g., when the river flow is low in the summer, or temperatures are too low in the winter).

Criterion 64 requires that radiation monitors inside and outside the plant measure the radioactivity of materials released both during normal operations and during accidents. Thus, all pipes used to discharge radioactive liquids and ducts used to discharge radioactive gases must be equipped with radiation monitors.

The NRC spent over five years developing the general design criteria, and provided two separate formal comment periods when the public and the industry could provide feedback on the existing draft. The NRC staff also met separately with representatives of the industry trade group, the Atomic Industrial Forum, to secure their input. The history shows that the industry interacted extensively with the NRC during this period and that it played an active role in crafting the final wording of these regulatory requirements. (See Appendix A for a more detailed review of this history.) Thus, the industry cannot honestly argue that these regulatory requirements are either too onerous or too vague for them to meet.

In addition to these two criteria, NRC regulations limit the total amount of radioactive materials released from nuclear power plants during non-accident conditions.[4] The cap is set so that no member of the public would receive a radiation dose greater than 0.1 rem annually from the radioactivity released to the environment from all pathways..

Thus, the nuclear plant owner must monitor all potential pathways by which radioactivity could leave the power plant, determine the amount of radioactive emissions on an ongoing basis, and control those emissions so that a member of the public would not receive an annual dose

[3] The GDC are contained in Appendix A to 10 CFR Part 50 (AEC 1971b).

[4] The limits are contained in Appendix I to 10 CFR Part 50, which the NRC adopted in May 1975, and in 10 CFR 20.1301, which it adopted in 1991.

greater than the cap. These three elements of the radwaste system—monitor, control, and cap—complement each other and together ensure that radioactive releases are handled in a responsible manner that protects the public.

The Environmental Protection Agency (EPA) has a separate regulation that limits the radioactivity of drinking water. This regulation sets a maximum allowed concentration for each radionuclide. For example, it limits the concentration of tritium, a radioactive form of hydrogen produced by power plants, to that which results in a radioactivity of 20,000 picocuries per liter. Over the past ten years, the nuclear industry and the NRC have repeatedly dismissed leaks and spills at nuclear power plants by arguing that the amount of radioactivity that ended up in people's drinking wells or in groundwater was less than that allowed by the EPA standards. While the known leaks have not violated the EPA standards, this does not excuse violations of NRC standards. The NRC standards are necessary to ensure that reactor operators protect the public by consistently monitoring and limiting leaks of radioactivity. The NRC must ensure reactors comply with all, not merely some small subset of, the applicable federal safety regulations.

Operating Licenses for Releases of Radioactive Materials

Before the NRC issues an initial operating license or amends an existing operating license for a nuclear power plant, it must reach two conclusions: (1) that the facility conforms to all applicable regulations and regulatory requirements, and (2) that reasonable assurance exists that the facility will continue to conform to all applicable regulations and requirements. As in rulemaking, the NRC follows a two-stage process when issuing and revising operating licenses. First, the nuclear plant's owner applies to the NRC for an operating license or submits a request to amend an existing license. Except under limited special circumstances, the NRC provides a formal comment period that provides individuals an opportunity to comment on or intervene against the proceeding. To resolve concerns raised by public comments or, more frequently, to answer questions raised by its internal reviews, the NRC will request additional information from the owner. When the NRC's independent assessments reach the two required conclusions and any intervener issues have been resolved, the NRC issues or amends the operating license.

Applications for operating licenses for existing reactors were accompanied by multi-volume Final Safety Analysis Reports describing how the plant was designed and constructed and how it would be operated and maintained. For example, Chapter 11 in most of these reports describes how the design, construction, operation, and maintenance of liquid, gaseous, and solid radwaste systems conforms with NRC's regulatory requirements. The NRC reviewed this material in order to reach the two conclusions regarding conformance with applicable regulations.

The language in the Final Safety Analysis Reports varies from plant to plant, but has the same overall theme and content. Verbatim excerpts from some reports are provided in Appendix 2; these excerpts are representative of the report language for all operating nuclear plants. The monitor, control, and cap elements are readily apparent in all cases. The reports describe the equipment installed to continuously monitor releases, and to stop releases if radiation levels rise too high. They describe the process of returning radioactive water to the lake, river, or ocean and mixing it with the clean lake, river or ocean water to reduce concentration levels below the NRC's limits.

Regulations, Operating Licenses, and Three-Way Contracts

The relationship between NRC regulations and operating licenses has best been explained by an Atomic Safety and Licensing Appeal Board (Farrar, 1973):

> *As a general rule, the Commission's regulations preclude a challenge to applicable regulations in an individual licensing proceeding. This rule has frequently been applied in such proceedings to preclude challenges to intervenors to Commission regulations. Generally, then, an intervenor cannot validly argue on safety grounds that a reactor which meets applicable standards should not be licensed. By the same token, neither the applicant nor the [NRC] staff should be permitted to challenge applicable regulations, either directly or indirectly. Those parties should not generally be permitted to seek or justify the licensing of a reactor which does not comply with applicable standards. Nor can they avoid compliance by arguing that, although an applicable regulation is not met, the public health and safety will still be protected. For, once a regulation is adopted, the standards it embodies represent the Commission's definition of what is required to protect the public health and safety.*

In other words, the NRC's two-stage rulemaking process leads to final regulations that define the height of the safety bar. Members of the public intervening in an initial licensing or a license amendment proceeding cannot argue that the safety bar is set too low—their opportunity for that argument came during the rulemaking process. Likewise, owners of nuclear plants cannot limbo beneath the safety bar arguing their reactors are safe anyway—their opportunity for arguing that the bar was set higher than safety warranted also came during the rulemaking process.

Final regulations and operating licenses for each reactor represent three-way contracts between the NRC, plant owners, and the public. The contracts protect plant owners from the NRC requiring more precautions than specified in the regulations and operating licenses, which defined the acceptable levels of safety. If the NRC felt an existing regulation or operating license insufficiently protected public health and safety, it can raise the safety bar through its two-stage rulemaking and operating license processes. The contracts also protect the public from the NRC tolerating lower performance than that formally defined in the regulations and operating licenses. If the NRC felt an existing regulation or a plant owner felt an FSAR requirement caused needless burden, the two-stage processes can be used to lower the bar.

Case Studies

Literally hundreds of leaks and spills—releases that were unmonitored, uncontrolled and/or uncapped—of radioactively contaminated liquids have occurred at U.S. nuclear power plants. A list summarizing more than 400 leaks and spills reported for individual plants is available online at http://www.ucsusa.org/nuclear_power/nuclear_power_risk/safety/.

We have selected a sample of these events, including those in which the NRC enforced its regulatory requirements, and those in which it didn't. For both cases, we included examples of violations of each of the three NRC requirements: that all releases be monitored, that release pathways be controlled, and that release amounts be capped. The cases also include some in which there were comparable violations of the requirements to monitor and control releases, but the NRC enforced the requirements in one case and not in another. Table 1 summarizes these selected events, which we discuss in more detail below.

Cases in which the NRC enforced the monitor, control or cap requirements

Depending on the severity of the violation, the NRC can sanction the owner of the reactor. A sanction generally results in negative publicity and potential investors use this information in their decision making. The NRC's reactor oversight program features five levels of sanctions: non-cited violations for minor offenses, and green, white, yellow, and red for progressively more significant violations. In the case of a significant violation, the NRC can also assess a monetary fine. The NRC modified its reactor oversight program in April 2000 and significantly reduced the number of sanctions involving fines. However, this did not alter the NRC's ability to sanction plant owners for violations of regulatory requirements, even if fewer of those sanctions involve monetary fines.

- Braidwood plant, Illinois, 2005

  The owner of the Braidwood nuclear plant in Illinois notified the NRC in December 2005 that tritium had been detected in a homeowner's drinking well near the site. Further investigation revealed several occasions over the prior ten years when more than six million gallons of radioactively contaminated water leaked into the ground from the line intended to discharge that water into the river. About 250,000 gallons leaked in November 1996. About 3,000,000 gallons leaked in December 1998. Another 3,000,000 gallons leaked in November 2000. In June 2006, the NRC sanctioned the plant's owner with a white finding for the failure to evaluate the potential radiation dose to members of the public from the large amount of radioactively contaminated water that went into their lands and drinking wells instead of into the river (NRC, 2006b).

  The Braidwood spills caused significant financial harm to people. A representative of the State of Illinois stated during the NRC's groundwater protection workshop on April 20, 2010, that some residents were approaching retirement age and had plans to sell their properties and use the proceeds to finance relocation to the retirement communities of their lifelong dreams (Buscher, 2010). These plans were dashed when the specter of radioactive contamination from the millions of gallons leaked from Braidwood sent real estate prices spiraling downward. The NRC's white finding was probably not much solace to those who had their golden years tarnished by repeated leaks spanning a decade.

- Comanche Peak plant, Texas, 1999

  In June 2000, the NRC reported that two violations had occurred at the Comanche Peak nuclear plant in Texas during 1999. On March 23, 1999, workers released radioactive gas from the Unit 2 volume control tank without first verifying that the radiation monitor in the discharge ducts was functioning properly, which it wasn't. On September 28, 1999, workers repeated the mistake by releasing radioactive gas from the Unit 1 volume control tank without first checking its radiation monitor, which was also not working. The NRC inspectors estimated that the amount of radioactivity released during these two unmonitored discharges was less than one percent of the federal limits. Although no member of the public was exposed to unlawful amounts of radioactivity by these mistakes, the NRC sanctioned the company with a green finding because:

> *The failure to perform the source check could have resulted in a radioactive gaseous effluent release to the environment through a release pathway which was not monitored by an operable radiation monitor* (NRC, 2000).

- Oyster Creek plant, New Jersey, 1998

  In April 1998, the NRC cited the owner of the Oyster Creek nuclear plant in New Jersey for unmonitored releases of radioactively contaminated gas (NRC, 1998). Oyster Creek uses two isolation condensers to remove decay heat produced by the reactor core when the normal heat removal systems are unavailable. Oyster Creek's Final Safety Analysis Report stated that the isolation condensers would be filled with clean, non-radioactive water. But for nearly 30 years, workers had been filling the condensers with radioactively contaminated water. As that water evaporated, it was vented directly to the atmosphere. No radiation monitors were installed in the vent pathways since the water should have been clean, so the radioactively contaminated vapor left the plant without being monitored. Although the NRC projected that members of the public had received, at most, very small fractions of the federal radiation limits, the agency sanctioned the company for the unmonitored releases of radioactivity.

- Oyster Creek plant, New Jersey, 1996

  In December 1996, the NRC cited the owner of the Oyster Creek nuclear plant in New Jersey for the accidental release of 133,000 gallons of radioactively contaminated water into Barnegat Bay (NRC, 1996). The plant was shut down for refueling at the time. Multiple failures by workers to follow procedures resulted in the fire protection system being cross-connected to the condensate transfer and storage system. This errant valve line-up allowed contaminated water to drain from the condensate storage tank into the discharge canal and then the bay. Another worker performing the daily water inventory balance check noted that the water level inside the condensate storage tank was about half of what it had been, but attributed the discrepancy to a typographical error and simply ignored this large loss of radioactively contaminated water. The liquid in the condensate storage tank was only contaminated to a low level, and this liquid was then further diluted by the millions of gallons of water in Barnegat Bay. Thus, this accidental release did not cause any person to receive radiation exposures approaching, yet alone above, federal limits. Nevertheless, the NRC cited the company for failing to control the release of radioactive material.

- FitzPatrick plant, New York, 1991

  In July 1991, the NRC levied a $137,500 fine on the owner of the FiztPatrick nuclear plant in New York for releasing unmonitored radioactivity in amounts up to 65 times the federal limit (NRC, 1991). In March 1991, workers at FitzPatrick discovered that radioactively contaminated gas had been vented from the auxiliary boiler, which burns fossil fuel to boil water and make steam for in-plant use when the reactor is shut down. The auxiliary boiler was designed to use clean, non-radioactively contaminated water when making steam; consequently, its vent to the atmosphere was not equipped with a radiation monitor. But an unexpected connection between the auxiliary boiler and the radwaste concentrators allowed radioactivity to enter the auxiliary boiler and escape to the atmosphere via its unmonitored vent.

- St. Lucie plant, Florida, 1982

  In November 1982, the NRC cited the owner of the St. Lucie nuclear plant in Florida for unmonitored disposal of radioactively contaminated sewage sludge (NRC, 1982). St. Lucie had an onsite sanitary treatment facility. On January 8 and June 22, 1982, sewage sludge containing radioactive material, primarily Cobalt-60, was sent offsite without being surveyed or monitored. The sanitary treatment facility was designed to handle only non-radioactive materials and, by definition, its sludge had been considered to be free of radioactive contamination. By mistake, a drain line from a sample sink inside the plant had been routed to the sewage facility instead of to the liquid radwaste system.

In the 1996 Oyster Creek case, the owner accidentally released 133,000 gallons of contaminated water, and the NRC sanctioned the owner for failing to control radioactive releases. The remaining cases all involved a failure to monitor radioactive releases. In each case, the NRC cited violations of monitoring requirements even though no case caused the radioactive contamination of drinking water in excess of EPA limits. In the 1991 FitzPatrick case, the unmonitored and uncontrolled release also violated the NRC's regulatory cap.

Cases in which the NRC Did Not Enforce Monitor, Control or Cap Requirements

The following cases involve leaks of radioactively contaminated water. In each case, the regulatory requirements that all releases be monitored and controlled were violated, yet the NRC imposed no sanctions.

- Haddam Neck plant, Connecticut, 2005

  The owner of the Haddam Neck nuclear plant notified the NRC in October 2005 that several gallons per day of radioactively contaminated water from the spent fuel pool had been leaking into the ground for an unspecified duration. The NRC found no violations and imposed no sanctions for this uncontrolled, unmonitored release of radioactively contaminated water (NRC, 2006a).

- Indian Point plant, New York, 2005

  The owner notified the NRC in September 2005 that workers excavating ground adjacent to the Unit 2 spent fuel pool found water weeping through cracks in the concrete (UCS, 2006a). Ensuing investigations also determined that radioactively contaminated water was leaking from the Unit 1 spent fuel pool. The NRC found no violations and imposed no sanctions for this uncontrolled, unmonitored release of radioactively contaminated water.

- Dresden plant, Illinois, 2004

  In August 2004, elevated tritium levels in monitoring wells at the Dresden nuclear plant in Illinois triggered an investigation that led to the discovery of a leak in a buried pipe connecting equipment in the plant with a large storage tank (UCS, 2006a). The plant's owner estimated that about 267,000 gallons of radioactively contaminated water leaked into the ground. The Illinois Environmental Protection Agency reported that the leak contaminated the local soil to more than 500 times the EPA limit for drinking water. The NRC found no violations and imposed no sanctions for this uncontrolled, unmonitored release of radioactively contaminated water.

- Salem plant, New Jersey, 2002

  In September 2002, workers about to leave the auxiliary building for the Salem Unit 1 reactor in New Jersey detected radioactivity on their shoes. The ensuing investigation found a puddle of water on the floor of a room in the auxiliary building. Chemical analysis of this water determined it had leaked from the spent fuel pool (UCS, 2006a). A consultant retained by the plant's owner concluded that radioactively contaminated water had been leaking from the spent fuel pool into the adjacent ground for at least five years. In response to pressure from the State of New Jersey, the plant's owner undertook a remediation plan. By December 31, 2008, more than 23 million gallons of water had been recovered from the ground around and under the plant and processed as liquid radwaste (Arcadis, 2009). Yet, the NRC found no violations and imposed no sanctions for this uncontrolled, unmonitored release of radioactive contaminated water.

For unannounced and unexplained reasons, the NRC stopped enforcing regulatory requirements for releases of radioactively contaminated liquid after the massive Braidwood spills in 2005. The NRC has imposed no sanctions in response to the 27 accidental releases that have occurred over the past four years:

- Pilgrim plant, Massachusetts, July 2010: Workers detected tritium concentrations of over 11,000 picocuries per liter in a monitoring well.
- LaSalle plant, Illinois, July 2010: Workers detected tritium concentrations of up to 700,000 picocuries per liter on the ground around the condensate storage tank.
- Browns Ferry plant, Alabama, April 2010: Radioactively containment water overflowed condensate storage tank #5 through an open valve.
- Salem plant, New Jersey, April 2010: Workers detected tritium concentrations exceeding 1,000,000 picocuries per liter in the north storm drain system.
- Vermont Yankee plant, Vermont, January 2010: The company informed the NRC about tritium concentrations of up to 2,500,000 picocuries per liter in monitoring wells; workers later discovered holes in two underground pipes.
- Brunswick plant, North Carolina, January 2010: Workers discovered radioactively contaminated water leaking into the ground from an outdoor pipe.
- Shearon Harris plant, North Carolina, January 2010: Workers discovered radioactively contaminated water leaking into the ground from an 8-inch diameter pipe.
- Monticello plant, Minnesota, September 2009: Workers detected tritium concentrations of over 21,000 picocuries per liter in a monitoring well.
- Oyster Creek plant, New Jersey, August 2009: Workers discovered radioactively contaminated water leaking into the ground from where a condensate transfer pipe passed through the turbine building wall.

- Peach Bottom plant, Pennsylvania, July 2009: Workers detected tritium concentrations exceeding 127,000 picocuries per liter in soil sampled near the Unit 3 turbine building.
- Dresden plant, Illinois, June 2009: Workers detected tritium concentrations exceeded 3,000,000 picocuries per liter in a monitoring well near the condensate storage tank, and tritium concentrations of 500,000 picocuries per liter in a nearby storm drain line.
- Oyster Creek plant, New Jersey, April 2009: Workers detected tritium concentrations of over 100,000 picocuries per liter in water collecting in an underground cable vault; workers later identified the source of this contaminated water to be leaks in two separate buried pipes to and from the condensate storage tank.
- Shearon Harris plant, North Carolina, April 2009: An independent consultant concluded that radioactively contaminated water was leaking from the underground pipe that ran from the cooling tower basin to Lake Harris.
- Davis-Besse plant, Ohio, October 2008: Workers detected tritium concentrations exceeding 37,000 picocuries per liter in soil excavated during a search for a leaking fire protection system pipe.
- Brunswick plant, North Carolina, March 2008: Workers detected tritium in 14 of 15 monitoring wells around the storm drain storage pond; samples from some monitoring wells had tritium concentrations exceeding 30,000 picocuries per liter.
- McGuire plant, North Carolina, February 2008: Approximately 100,000 gallons of radioactively contaminated water leaked into the groundwater from a holdup pond.
- River Bend plant, Louisiana, January 2008: Workers detected tritium concentrations of over 129,000 picocuries per liter in water leaking from a cooling tower pipe into a nearby creek that empties into the Mississippi River.
- Browns Ferry plant, Alabama, January 2008: Radioactively contaminated water overfilled a condensate storage tank and permeated through a concrete pipe tunnel into the ground.
- Palisades plant, Michigan, December 2007: Workers detected tritium concentrations of over 20,000 picocuries per liter in a monitoring well.
- Surry plant, Virginia, October 2007: Workers detected tritium concentrations of over 31,000 picocuries per liter in water leaking from an underground storm drain.
- Catawba plant, South Carolina, October 2007: Workers detected tritium concentrations of over 42,000 picocuries per liter in monitoring wells.
- Brunswick plant, North Carolina, June 2007: Workers detected tritium concentrations of 30,000 picocuries per liter in monitoring wells.
- Salem plant, New Jersey, May 2007: Approximately 20,000 gallons of radioactively contaminated water spilled onto the ground.
- Fort Calhoun plant, Nebraska, May 2007: Workers detected tritium concentrations of up to 173,000 picocuries per liter in water leaking into the basement through an exterior wall.
- Brunswick plant, North Carolina, May 2007: Workers detected tritium in water samples drained from electrical manholes on the plant grounds.
- Kewaunne plant, Wisconsin, August 2006: Workers detected tritium in groundwater sampled from beneath the auxiliary and turbine buildings.

- San Onofre plant, California, August 2006: Workers detected tritium concentrations ranging between 50,000 and 330,000 picocuries per liter in soil around the Unit 1 reactor.

Some of the leaks listed above remained undetected for years. Some were finally detected by chance. None of these cases was less egregious or significant than the 1999 events at Comanche Peak that triggered NRC sanctions. But the NRC imposed no sanctions at all.

By failing to enforce applicable regulatory requirements, the NRC has become an enabler of sustained poor behavior patterns by nuclear plant owners. It is also failing to protect the public.

Regulatory Roulette

The case studies above clearly show that the NRC has sporadically enforced its regulatory requirements with respect to radioactive releases. Moreover, its decision about whether to enforce these regulations in a given case appears to be independent of the quantity of radioactive liquids released and of their level of radioactivity.

The 2008 event at the River Bend plant in Louisiana and the 2010 event at Vermont Yankee offer a compelling contrast between the NRC invoking its regulatory requirements and ignoring those same requirements. The NRC prevented Entergy from resuming operation of the River Bend plant even though there was no reason to believe that any radioactive release would occur. Two years later, the NRC allowed Entergy to continue operating Vermont Yankee even though an unknown quantity of radioactively contaminated liquid had been and continued to be released from unknown sources and was contaminating unknown locations.

- River Bend plant, Louisiana, 2008

  In September 2008, Hurricane Gustav damaged the River Bend nuclear plant. High winds peeled virtually all of the sheet metal siding from three sides of the turbine building (see Figures 1 and 2). Entergy prepared to restart River Bend with plans to repair the turbine building after the plant was back online. However, the NRC intervened and reminded Entergy of the regulations and operating license requirements that radioactive materials be released only via controlled and monitored pathways. If piping or components inside the turbine building leaked radioactive gas after the plant restarted, it would escape through the wide-open walls. As described in its Final Safety Analysis Report and accepted by the NRC as part of the basis for issuance of the operating license, the intact turbine building was designed to force all airborne contents through ventilation ducts that would allow monitoring. The ducts were equipped with isolation dampers that would allow any releases to the atmosphere to be controlled. No one had detected radioactivity offsite. No known leakage of radioactivity existed from piping and components inside the turbine building. Nevertheless, the NRC strongly suggested to Entergy that the plant not resume operations until the turbine building was repaired and compliance with regulatory requirements restored. Entergy repaired the turbine building and then restarted the reactor about a week later.

Figure 1

Figure 2

- Vermont Yankee plant, Vermont, 2010

  In January 2010, Entergy informed the NRC that radioactively contaminated liquid was leaking from one or more unknown sources at its Vermont Yankee nuclear plant. Despite this ongoing unmonitored and uncontrolled release of contaminated liquid, the NRC permitted Entergy to continue operating the plant for several weeks until its next scheduled refueling outage. NRC inspectors assessed the event and reported (NRC 2010b):

> *The NRC determined Entergy-Vermont Yankee (ENVY) appropriately evaluated the contaminated ground water with respect to off-site effluent release limits and the resulting radiological impact to public health and safety; and that ENVY complied with all applicable regulatory requirements and standards pertaining to radiological effluent monitoring, dose assessment, and radiological evaluation. No violations of NRC requirements or finding of significance were identified.*

The NRC considered the *potential* for uncontrolled, unmonitored releases of radioactivity from Entergy's River Bend plant to be significant enough to preclude the plant from operating until that potential was eliminated. The piping and components inside the turbine building were intact. Their radioactive contents would be monitored and controlled prior to release. But the potential for a leak to develop from a pipe or component such that it created an unmonitored, uncontrolled pathway to the atmosphere through the missing turbine building walls was sufficient for the NRC to step in. The NRC took the appropriate action to protect the people living around River Bend from a missing safety barrier, even though that barrier was not being relied on or challenged at that time.

The NRC considered the *actual* uncontrolled, unmonitored release of radioactivity from Entergy's Vermont Yankee plant to be insignificant enough to allow the plant to continue operating. The underground piping was not intact, and radioactively contaminated liquid was leaking into the ground, with some making it into the nearby Connecticut River. Yet the NRC did nothing to protect the people living around Vermont Yankee from a safety barrier known to have failed.

NRC cheated someone. They either cheated the people living around Vermont Yankee by depriving them of the protection they extended to the communities around the River Bend, Comanche Peak, Oyster Creek, and St. Lucie plants, or they cheated the River Bend ratepayers, and Entergy stockholders and bondholders by depriving them of a week's revenue. We believe the NRC cheated the people living near Vermont Yankee and owes them both an apology and a promise to serve them better in the future.

The NRC Must Become the Regulator the Public Deserves

The NRC's rulemaking and licensing processes establish the minimum height of the nuclear safety bar. It would be unfair to the plant owners for the NRC to require them to implement safety measures over and above that level. It is equally unfair to the public for the NRC to accept measures below that level. To be an effective regulator, the NRC must establish appropriate safety levels and consistently enforce them.

The case studies clearly reveal that the NRC has not consistently enforced its regulations governing releases of radioactive materials from nuclear power plants. More specifically, the case studies show that the NRC has never required higher safety levels than those defined by the monitor, control and cap regulatory requirements but has often accepted lower safety levels. Hence, the NRC is neither an effective regulator nor an acceptable guardian of public health and safety.

The US Congress oversees the NRC, and must compel the agency to consistently and aggressively enforce its regulatory requirements to monitor, control, and cap all releases of radioactive materials from nuclear power plants. Congress must pressure the NRC to stop breaching its contract with the public. It must compel the NRC to implement the reforms necessary to become the effective regulator. Congress should impose a deadline—say six months—for the NRC to report back with the steps it will take to transform itself into the consistent, aggressive regulator of nuclear safety that the public deserves.

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Table 1: NRC Responses to Leaks

Plant	Date	Leak Summary	Monitor	Control	Cap	NRC Response	UCS Comment
Vermont Yankee (VT)	01/2010	Radioactively contaminated water leaking into the ground from an unknown location from an unknown period of time	Failure	Failure	Perhaps Okay	No violations identified	Highly inappropriate NRC response: ignored violations and allowed ongoing leak of unknown scale
River Bend (LA)	08/2008	Hurricane Gustav blew siding off turbine building; no leaks occurring from equipment inside building but NRC resisted restart until siding was replaced	Potential failure without siding; okay with siding	Potential failure without siding; okay with siding	Okay	NRC reminded owner that restarting the plant without first replacing the siding meant that monitor and control functions were absent should a leak later develop	Appropriate NRC response
Braidwood (IL)	12/2005	More than 6 million gallons leaked from the discharge line to the river; some tritium detected in nearby drinking wells	Failure	Failure	Okay	White finding issued 6/2006	Marginal NRC response: issued the lightest possible sanction
Haddam Neck (CT)	10/2005	Several gallons per day of radioactively contaminated water from the spent fuel pool was discovered to have been leaking into the ground for an unknown period of time	Failure	Failure	Perhaps Okay	No violation identified	Inappropriate NRC response: ignored violations and allowed ongoing leak of unknown duration

Plant	Date	Leak Summary	Monitor	Control	Cap	NRC Response	UCS Comment
Indian Point (NY)	09/2005	Radioactively contaminated water from the spent fuel pool was discovered to have been leaking into the ground for an unknown period of time	Failure	Failure	Perhaps Okay	No violation identified	Inappropriate NRC response: ignored violations and allowed ongoing leak of unknown duration
Dresden (IL)	08/2004	An estimated 267,000 gallons of radioactively contaminated water leaked from an underground pipe	Failure	Failure	Perhaps Okay	No violations identified	Inappropriate NRC response: ignored violations
Salem (NJ)	09/2002	Radioactively contaminated water from the spent fuel pool was discovered to have been leaking into the ground for at least five years	Failure	Failure	Perhaps Okay	No violations identified Over 23 million gallons of water remediated to satisfy State of New Jersey	Highly inappropriate NRC response: ignored violations and accepted leak lasting many years
Comanche Peak (TX)	03/1999 09/1999	Radioactive gas released without adequate radiation monitoring	Failure	Okay	Okay	Violation issued 6/2000	Appropriate NRC response: issued a sanction commensurate with the circumstances

Plant	Date	Leak Summary	Monitor	Control	Cap	NRC Response	UCS Comment
Oyster Creek (NJ)	04/1998	Workers filled isolation condenser with radioactively contaminated water but did not monitor vent line for radiation	Failure	Okay	Okay	Violation issued 4/1998	Appropriate NRC response: issued a sanction commensurate with the violation
Oyster Creek (NJ)	12/1996	133,000 gallons of radioactively contaminated water accidentally discharged into Barnegat Bay	Okay	Failure	Okay	Violation issued 12/1996	Marginal NRC response: issued the lightest possible sanction
FitzPatrick (NY)	03/1991	Radioactively contaminated water filled auxiliary boiler and vapor released to the atmosphere	Failure	Failure	Failure	$137,500 fine issued 7/1991	Appropriate NRC response: issued a sanction commensurate with the violation
St. Lucie (FL)	01/1982	Radioactively contaminated sewage sludge was trucked offsite without being surveyed	Failure	Failure	Failure	Violation issued 11/1982	Marginal NRC response: issued the lightest possible sanction

Appendix 1
NRC's Process for Establishing Regulations

The process used by the NRC to adopt new and revise existing regulations is governed by Section 533 of the Administrative Procedures Act.[5] Except in limited special situations, it's a two-stage process. In the first stage, a proposed new or revised regulation is published in the *Federal Register* for a public comment period of typically 75 to 90 days. The NRC develops the proposed language in response to internal needs, laws passed by Congress, or petitions for rulemaking submitted by external stakeholders. The public comment period provides an opportunity for stakeholders, usually the nuclear industry and the public but sometimes federal and state agencies, to formally comment on the need for and contents of the proposed regulatory requirements.

In the second stage, the NRC reviews the comments and makes any needed revisions to the text. The NRC submits the draft final regulation to its Chairman and Commissioners. If approved by a simple majority of the Commission, the final regulation is published in the *Federal Register* along with the date upon which the new or revised regulations become effective (NRC 2010a).

The NRC's regulations do not provide absolute protection of the public and the environment. Instead, the regulations seek to lower the risk of nuclear plant operation to an acceptably low level. Like beauty, "acceptably low level" is in the eyes of the beholder. However, the NRC's two-stage rulemaking process eliminates subjectivity by defining what constitutes the minimally acceptable level of safety. The process affords those viewing the proposed level as being too high as well as those viewing the proposed level as being too low an equal opportunity to contest the height. The NRC's final rule developed through this formal process becomes the acceptable level in everyone's eyes.

The NRC's regulations are the "answer keys" for questions posed by its reviewers and inspectors. In determining whether an application for a license or a condition observed at an operating plant is acceptable, the answer is "yes" when applicable regulations are satisfied and "no" otherwise. Thus, the "answer keys" embodied in the regulations protect plant owners from NRC staff members who believe that additional safety measures are necessary. Similarly, the "answer keys" protect the public when NRC staff members are comfortable with fewer safety measures. The regulations set the safety bar at the height where no more is required and no less is tolerated.

With regard to regulations governing releases of radioactive materials from nuclear power plants, the Atomic Energy Commission (AEC)—NRC's predecessor—adopted in February 1971 nearly six dozen safety criteria for reactor designs, called general design criteria (GDC), as Appendix A to 10 CFR Part 50 (AEC 1971b). Section 50.34 of Part 50 already required applicants for licenses to operate nuclear power reactors to describe the reactors' principal design criteria and the bases for those criteria. The GDC were codified to "*establish the minimum requirements for the principal design criteria*." The formal GDC communicated the AEC's expectations to reactor manufacturers and applicants for reactor operating licenses. The formal GDC also aided AEC staff in their reviews of applications against regulatory requirements.

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[5] The Administrative Procedures Act was enacted by Public Law 89-554 in September 1966 and amended by Public Law 95-251 in March 1978.

The final GDC were developed via an expanded two-stage rulemaking process spanning many years and including two separate formal comment periods. The AEC issued 27 draft GDC for public comment in November 1965 (AEC, 1965). Criteria 24, 26, and 27 covered releases of radioactivity to the environment:

> *Criterion 24 – All fuel storage and waste handling systems must be contained if necessary to prevent the accidental release of radioactivity in amounts which could affect the health and safety of the public.*
>
> *Criterion 26 – Where unfavorable environmental conditions can be expected to require limitation upon the release of operational radioactive effluents to the environment, appropriate hold-up capacity must be provided for retention of gaseous, liquid, or solid effluents.*
>
> *Criterion 27 – The plant must be provided with systems capable of monitoring the release of radioactivity under accident conditions.*

The proposed GDC, revised in response to comments received during the first comment period, were re-issued by the AEC for public comment in July 1967 (AEC 1967). Representatives from Westinghouse, General Electric, Babcock & Wilcox, Combustion Engineering, Yankee Atomic, Wisconsin Electric, Duke Power, and the Atomic Industrial Forum—the nuclear industry's trade group and a forerunner to today's Nuclear Energy Institute—were among the 21 persons commenting on the proposed GDC (AEC 1971a). In the revised draft GDC, Criteria 69 and 70 covered releases of radioactive materials to the environment:

> *Criterion 69 – Containment of fuel and waste storage shall be provided if accident could lead to release of undue amounts of radioactivity to the public environs.*
>
> *Criterion 70 – The facility design shall include those means necessary to maintain control over the plant radioactive effluents, whether gaseous, liquid, or solid. Appropriate holdup capacity shall be provided for retention of gaseous, liquid, or solid effluents, particularly where unfavorable environmental conditions can be expected to require operational limitations upon the release of radioactive effluents to the environment. In all cases, the design for radioactivity control shall be justified (a) on the basis of 10 CFR 20 requirements for normal operations and for any transient situation that might reasonably be anticipated to occur and (b) on the basis of 10 CFR 100 damage level guidelines for potential reactor accidents of exceedingly low probability of occurrence except that reduction of the recommended dosage levels may be required where high population densities or very large cities can be affected by the radioactive effluents.*

In their comments, the AIF recommended that the exception on condition (b) be deleted because it "*could be subject to misinterpretation by the uninformed public.*" (Wiggin, 1967)

Long after the second formal public comment period ended, the AEC sat down with AIF representatives:

> *… to discuss the revised General Design Criteria. The comments of this group were reflected in a June 4, 1970 draft of the revised General Design Criteria that was forwarded to the AIF for comment. The AIF forwarded comments and stated it believed the criteria should be published as an effective rule after reflecting its comments. These comments have been reflected in the General Design Criteria in Appendix A.* (AEC, 1971a)

After much reflection, the AEC in January 1971 recommended that its Commission approve the GDC in a final rule. Final GDC 60 and 64 covered releases of radioactive materials to the environment:

> *Criterion 60 – The nuclear power plant unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal reactor operation, including anticipated operational occurrences. Sufficient holdup capacity shall be provided for retention of gaseous and liquid effluents containment radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment.*

> *Criterion 64 – Means shall be provided for monitoring the reactor containment atmosphere, spaces containing components for recirculation of loss-of-coolant accident fluids, effluent discharge paths, and the plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.*

Appendix 2
Typical Final Safety Analysis Report Information

The following information is extracted verbatim from the Final Safety Analysis Reports (FSARs) for several nuclear power reactors. It is representative and typical of information contained in the FSARs of every US nuclear power reactor. These FSAR sections describe how the nuclear power reactors will be designed and operated. The NRC staff reviewed this information in order to reach a determination that the operating licenses could be issued based on reasonable assurance that applicable regulations—in these cases, General Design Criteria 60 and 64—would be met.

Diablo Canyon (CA):

Following treatment, effluents from the LRS [liquid radwaste system] are released to the environment at either of the units' circulating water system discharge structures via the auxiliary saltwater system. The waste liquid releases are diluted in the auxiliary saltwater system and main circulating water system flows. Releases require positive operator action, are continuously monitored, and are automatically isolated in the event of a high radiation alarm or a power failure.

Dresden Units 2&3 (IL):

Before any batch of liquid waste is discharged to the environment from the liquid waste treatment facility, the tank is isolated so that no additional water can be added to it. The batch of liquid waste is mixed by recirculation to assure that the sample obtained is representative. After mixing, the batch of liquid waste is sampled and analyzed for gamma isotopic activity. Factors for H-3, Fe-55, Sr-89 and Sr-90 which are based on previous discharges are calculated periodically. The factors may then be used to estimate H-3, Fe-55, Sr-89 and Sr-90 concentrations if the actual value is not known. Based upon these analyses, a discharge rate for the batch is determined so that when the batch is discharged and diluted by the plant circulating water discharge, the radioactivity level in the circulating water leaving the plant site will be less than the applicable effluent concentration limit (ECL), as stated in 10 CFR 20, Appendix B, Table 2. This ensures that the level of activity at the outlet of the discharge canal will be within the NRC limit for non-occupational use.

Hatch Units 1&2 (GA):

The liquid radwaste system is designed to process and recycle the liquid waste collected to the extent practicable. During normal plant operation, the annual radiation doses to individuals from each reactor on the site, resulting from these routine liquid waste discharges, are below the guidelines set forth in 10 CFR 50, Appendix I. The design further ensures that releases from the plant are within the applicable 10 CFR 20 limits. Liquid effluents are continuously monitored and discharges are terminated if the effluents exceed preset radioactivity levels.

North Anna Units 1&2 (VA):

The liquid waste disposal system was designed to satisfy the applicable sections of the general design criteria of Section 3.1. In addition, this system was designed to meet the criteria of 10 CFR 20, 10 CFR 50, and 10 CFR 100 so as not to endanger the health of station operating personnel or the general public.

Quad Cities Units 1&2 (IL):

The liquid radioactive waste system collects, treats, stores, and disposes as necessary all radioactive liquid wastes. Liquid wastes are collected in sumps and drain tanks in the various buildings, then transferred to the appropriate tanks in the radwaste building for further treatment or temporary storage, and discharge. If the waste meets the requirements for re-use, it is recycled back into the contaminated condensate storage tanks. If it does not meet recycling requirements, the contents are either returned for reprocessing or discharged from the plant. Batches with radioactivity concentrations low enough to allow discharge to the river are released to the south diffuser, or discharge flume weir. Wastes to be discharged from the system are handled on a batch basis with each one being analyzed and handled appropriately. These batches are diluted with condenser circulating water effluent in order to achieve a discharge concentration, at the point of entry into the river, below the limits set by 10 CFR 20, and Illinois and Iowa state regulations.

Seabrook (NH):

The concept of radioactive waste management involves the examination of all potential pathways of radioactive release to the environment and the provision of appropriate processing and treatment equipment to ensure that release of radioactivity to the environment is kept as low as is reasonably achievable (ALARA) in compliance with Section 50.34a of 10 CFR Part 50. Appendix I to 10 CFR Part 50 provides numerical guides for those design objectives to meet the criterion ALARA. The plant operates within the limits of radiation levels set forth in 10 CFR Part 20.

Turkey Point Units 3&4 (FL):

Liquid wastes will be collected in tanks and processed by the waste disposal demineralizers. The waste process provided can reduce activity well below established limits and represents a design for reducing activity to the lowest practicable value. Analyses of liquid prepared for release will be made to determine that activity levels have been minimized before release is permitted. The resulting activity after mixing with the circulating water will be near to or equal to natural background.