NUCLEAR ENERGY INSTITUTE

Frequently Asked Questions: Japanese Nuclear Energy Situation

1. *What is the nuclear industry doing in the short-term to respond to the accident at the Fukushima nuclear power plant?*

   The nuclear energy industry's top priority remains providing Japan with the support necessary to achieve safe shutdown of the Fukushima reactors.

   The accident at Fukushima Daiichi was caused, in part, by extraordinary natural forces that were outside the plant's required design parameters. Even though the full extent of damage to these reactors still is unknown, the combination of the earthquake and the tsunami challenged the structural integrity and safety of the plant. As more is learned about the Japanese events, more long-term corrective actions will be developed.

   The U.S. nuclear energy industry has already started an assessment of the events in Japan and is taking steps to ensure that U.S. reactors could respond to events that may challenge safe operation of the facilities. These actions include:

   - Verify each plant's capability to manage major challenges, such as aircraft impacts and losses of large areas of the plant due to natural events, fires or explosions. Specific actions include testing and inspecting equipment required to mitigate these events, and verifying that qualifications of operators and support staff required to implement them are current.
   - Verify each plant's capability to manage a total loss of off-site power. This will require verification that all required materials are adequate and properly staged and that procedures are in place, and focusing operator training on these extreme events.
   - Verify the capability to mitigate flooding and the impact of floods on systems inside and outside the plant. Specific actions include verifying required materials and equipment are properly located to protect them from flood.
   - Perform walk-downs and inspection of important equipment needed to respond successfully to extreme events like fires and floods. This work will include analysis to identify any potential that equipment functions could be lost during seismic events appropriate for the site, and development of strategies to mitigate any potential vulnerabilities.

2. *Could an accident like the one at Japan's Fukushima Daiichi nuclear plant happen in the United States?*

   It is difficult to answer this question until we have a better understanding of the precise problems and conditions that faced the operators at Fukushima Daiichi. We do know, however, that Fukushima Daiichi Units 1-3 lost all offsite power and emergency diesel generators. This situation is called "station blackout." U.S. nuclear power plants are designed to cope with a station blackout event that involves a loss of offsite power *and* onsite emergency power. The Nuclear Regulatory Commission's detailed regulations address this scenario. U.S. nuclear plants are required to conduct a "coping" assessment and develop a strategy to demonstrate to the NRC that they could maintain the plant in a

safe condition during a station blackout scenario. These assessments, proposed modifications and operating procedures were reviewed and approved by the NRC. Several plants added additional AC power sources to comply with this regulation.

In addition, U.S. nuclear plant designs and operating practices since the terrorist events of September 11, 2001, are designed to mitigate severe accident scenarios such as aircraft impact, which include the complete loss of offsite power and all on-site emergency power sources *and* loss of large areas of the plant. U.S. nuclear plants are equipped to deal with these extreme events ("beyond-design-basis events") and nuclear plant operations staff are trained to manage them.

U.S. nuclear plant designs include consideration of seismic events and tsunamis. It is important not to extrapolate earthquake and tsunami data from one location of the world to another when evaluating these natural hazards. These catastrophic natural events are very region- and location-specific, based on tectonic and geological fault line locations.

3. *How will the U.S. nuclear industry assess the impact of the Fukushima Daiichi accident?*

Until we understand clearly what has occurred at the Fukushima Daiichi nuclear power plants, and any consequences, it is difficult to speculate about the long-term impact on the U.S. nuclear energy program. The U.S. nuclear industry, the U.S. Nuclear Regulatory Commission, the Institute of Nuclear Power Operations, the World Association of Nuclear Operators and other expert organizations in the United States and around the world will conduct detailed reviews of the accident, identify lessons learned (both in terms of plant operation and design), and we will incorporate those lessons learned into the design and operation of U.S. nuclear power plants. When we fully understand the facts surrounding the event in Japan, we will use those insights to make nuclear energy even safer.

In the long-term, we believe that the U.S. nuclear energy enterprise is built on a strong foundation:

- reactor designs and operating practices that incorporate a defense-in-depth approach and multiple levels of redundant systems
- a strong, independent regulatory infrastructure
- a transparent regulatory process that provides for public participation in licensing decisions, and
- a continuing and systematic process to identify lessons learned from operating experience and to incorporate those lessons.

4. *How serious are the releases of radiation from Fukushima Daiichi? Do they represent a threat to human health? Will we see an increase in cancer rates in future years?*

As a result of fuel damage in at least four of the Fukushima reactors, significant releases of radioactive materials have been detected at the site. The implications of these releases on the health and safety of the public are not yet fully understood. The Japanese government implemented emergency planning procedures and evacuated residents within a 12.5-mile radius of the plant before the radiation releases were detected. Authorities are also distributing potassium iodide tablets to specifically protect against exposure from radioactive iodine that may be present in the releases and are monitoring the evacuees for potential exposure. Any speculation about possible health effects would be premature until more accurate and complete data becomes available.

5. *How many U.S. reactors use the Mark I containment design used at Fukushima Daiichi Unit 1?*

   Six U.S. nuclear reactors (Monticello in Minnesota, Pilgrim in Massachusetts, Dresden 2 and 3 and Quad Cities 1 and 2 in Illinois) are the same base design as the Fukushima Daiichi Unit 1 design (BWR-3 design with Mark I containment). Twenty-three U.S. nuclear plants are boiling water reactors (either BWR-2, BWR-3 or BWR-4) *and* use the Mark I containment: Browns Ferry 1, 2 and 3; Brunswick 1 and 2; Cooper; Dresden 2 and 3; Duane Arnold; Hatch 1 and 2; Fermi; Hope Creek; Fitzpatrick; Monticello; Nine Mile Point 1; Oyster Creek; Peach Bottom 2 and 3; Pilgrim; Quad Cities 1 and 2; Vermont Yankee. Although these are the same basic reactor design, specific elements of the safety systems will vary based on the requirements of the U.S. NRC.

6. *There have been questions raised in the past about the BWR Mark I containment like that at Fukushima Daiichi. Some critics have pointed to a comment by an NRC official in the early 1980s: "Mark I containment, especially being smaller with lower design pressure, in spite of the suppression pool, if you look at the WASH 1400 safety study, you'll find something like a 90% probability of that containment failing."*

   The Mark I containment meets all Nuclear Regulatory Commission design and safety requirements necessary to protect public health and safety. The WASH-1400 safety study referenced was performed in 1975. The Nuclear Regulatory Commission has analyzed the Mark I containment design in great detail since then. The NRC analysis found that the BWR Mark I risk was dominated by two scenarios: station blackout and anticipated transient without scram. The NRC subsequently promulgated regulations for both of these sequences as well as other actions to reduce the probability of containment failure.

   GE has made a number of design changes to the Mark I containment to address concerns raised in the past, including modifications to dissipate energy released to the suppression pool and supports to accommodate loads that could be generated. These retrofits were approved by the Nuclear Regulatory Commission and made to all U.S. plants with the Mark I containment.

7. *What happens when you have a complete loss of electrical power to operate pumps in a BWR-3 reactor with Mark I containment like the one at Fukushima Daiichi Unit 1?*

   If plant operators cannot move water through the reactor core, the water in the reactor vessel begins to boil and turn to steam, increasing pressure inside the reactor vessel. In order to keep the reactor vessel pressure below design limits, this steam is then piped into what is called a "suppression pool" of water or "torus" – a large doughnut-shaped tank that sits beneath the reactor vessel.

   Eventually, the water in the suppression pool reaches "saturation" – i.e., it cannot absorb any additional heat and it, too begins to boil, increasing pressure in containment. In order to stay within design limits for the primary containment, operators reduce pressure by venting steam through filters (to scrub out any radioactive particles) to the atmosphere through the vent stack.

   If operators cannot pump additional water into the reactor vessel, the water level will begin to drop, uncovering the fuel rods. If the fuel remains uncovered for an extended period of time, fuel damage, possibly including melting of fuel, may occur. If there is fuel damage, and steam is being vented to the suppression pool, then to primary containment, then to secondary containment (in order to relieve pressure build-up on plant systems), small quantities of radioactive materials will escape to the environment.

8. *Are U.S. emergency planning requirements and practices adequate to deal with a situation like that faced at Fukushima Daiichi?*

   Yes. Federal law requires that energy companies develop and perform graded exercises of sophisticated emergency response plans to protect the public in the event of an accident at a nuclear power plant. The U.S. Nuclear Regulatory Commission reviews and approves these plans. In addition, the NRC coordinates approval of these plans with the Federal Emergency Management Agency (FEMA), which has the lead federal role in emergency planning beyond the nuclear plant site. An approved emergency plan is required for the plant to maintain its federal operating license. A nuclear plant's emergency response plan must provide protective measures, such as sheltering and evacuation of communities within a 10-mile radius of the facility. In 2001, the NRC issued new requirements and guidance that focus in part on emergency preparedness at plant sites in response to security threats. The industry has implemented these measures, which address such issues as on-site sheltering and evacuation, public communications, and emergency staffing in the specific context of a security breach. Several communities have used the structure of nuclear plant emergency plans to respond to other types of emergencies. For example, during the 2007 wildfires in California, county emergency officials drew on relationships and communications links they had established during their years of planning for nuclear-related events.

   In addition, as part of the emergency plan, nuclear plant operators would also staff Emergency Centers within one hour to provide support to the plant staff during the event. This support would be in the form of:

   - Technical expertise (engineering, operations, maintenance and radiological controls)
   - Offsite communications and interfaces, (state, local and NRC)
   - Security and logistics

9. *Should U.S. nuclear facilities be required to withstand earthquakes and tsunamis of the kind just experienced in Japan? If not, why not?*

   U.S. nuclear reactors are designed to withstand an earthquake equal to the most significant historical event or the maximum projected seismic event and associated tsunami without any breach of safety systems.

   The lessons learned from events at Fukushima must be reviewed carefully to see whether they apply to U.S. nuclear power plants. It is important not to extrapolate earthquake and tsunami data from one location of the world to another when evaluating these natural hazards, however. These catastrophic natural events are very region- and location-specific, based on tectonic and geological fault line locations.

   The U.S. Geological Survey (USGS) conducts continuous research of earthquake history and geology, and publishes updated seismic hazard curves for various regions in the continental US. These curves are updated approximately every six years. NRC identified a generic issue (GI-199) that is currently undergoing an evaluation to assess implications of this new information to nuclear plant sites located in the central and eastern United States. The industry is working with the NRC to develop a methodology for addressing this issue.

10. *Is this accident likely to result in changes to regulatory requirements for U.S. nuclear plants in seismically active areas? Will those regulatory requirements be revisited and made more robust?*

    The nuclear energy industry believes that existing seismic design criteria are adequate. Every U.S. nuclear power plant has an in-depth seismic analysis and is designed and constructed to withstand the maximum projected earthquake that could occur in its area without any breach of safety systems. Each reactor is built to withstand the maximum site-specific earthquake by utilizing reinforced concrete and other specialized materials. Each reactor would retain the ability to safely shut down the plant without a release of radiation. Given the seismic history in California, for example, plants in that state are built to withstand an even higher level of seismic activity than plants in many other parts of the country.

    Engineers and scientists calculate the potential for earthquake-induced ground motion for a site using a wide range of data and review the impacts of historical earthquakes up to 200 miles away. Those earthquakes within 25 miles are studied in great detail. They use this research to determine the maximum potential earthquake that could affect the site. Each reactor is built to withstand the respective strongest earthquake. Experts identify the potential ground motion for a given site by studying various soil characteristics directly under the plant. For example, a site that features clay over bedrock will respond differently during an earthquake than a hard-rock site. Taking all of these factors into account, experts determine the maximum ground motion the plant must be designed to withstand. As a result, the design requirements for resisting ground motion are greater than indicated by historical records for that site.

    It is also important not to extrapolate earthquake and tsunami data from one location of the world to another when evaluating these natural hazards. These catastrophic natural events are very region- and location-specific, based on tectonic and geological fault line locations.

11. *What would happen to the used fuel in the storage pools if cooling was lost?*

    We do not know the precise condition of the used fuel storage pools at Fukushima Units 1, 2, 3 and 4.

    Used nuclear fuel at the Fukushima Daiichi plant is stored in seven pools (one at each of the six reactors, plus a shared pool) and in a dry container storage facility (containing nine casks). Sixty percent of the used fuel on site is stored in the shared pool, in a building separated from the reactor buildings; 34 percent of the used fuel is distributed between the six reactor fuel storage pools, and the remaining six percent is stored in the nine dry storage containers. The used fuel pools at the Fukushima Daiichi reactors are located at the top of the reactor buildings for ease of handling during refueling operations. There are no safety concerns regarding the used fuel in dry storage at Fukushima Daiichi.

    Used fuel pools are robust concrete and steel structures. Pools are designed with systems to maintain the temperature and water levels sufficient to provide cooling and radiation shielding. The water level in a used fuel pool typically is 16 feet or more above the top of the fuel assemblies. The used fuel pools are designed so that the water in the pool cannot drain down as a result of damage to the piping or cooling systems. The only way to rapidly drain down the pool is if there is structural damage to the walls or the floor.

    If the cooling systems are unable to function, the heat generated by the used fuel would result in a slow increase in the temperature of the spent fuel pool water. The operating temperature of the pools is typically around 40 degrees C or 100 degrees F (the boiling point for water is 100 C or 212 F).

This slow increase in temperature would result in an increased evaporation rate. Rapid evaporation of the water will not occur.

Exact evaporation rates would depend on the amount of used fuel in the pool and how long it has cooled. The rate at which the pool water level would decrease (due to evaporation or mild boiling) in the absence of cooling system function would not be expected to lower water levels by more than a few percent per day. Given that there is approximately 16 feet or more of water above the used fuel assemblies, operators would have time to find another way to add water to the pools before the fuel would become exposed.

At the surface of the used fuel pool, the dose rate from gamma radiation emanating off the used fuel assemblies is typically less than 2 millirem per hour. If the water level decreases, gamma radiation levels would increase substantially. This increase would be noticed at the radiation monitors near the reactor buildings.

12. *Given that Fukushima Daiichi Unit 1 is a 1970s-vintage plant, do you anticipate increased regulatory requirements and scrutiny on U.S. plants of similar vintage? Do you think the accident will have an impact on license renewal of the older U.S. nuclear power plants?*

    The U.S. nuclear energy industry and the Nuclear Regulatory Commission will analyze the events at Fukushima Daiichi, identify lessons learned and incorporate those lessons, as appropriate, into the design and operation of U.S. nuclear power plants.

    The U.S. industry routinely incorporates lessons learned from operating experience into its reactor designs and operations. For example, as a result of the 1979 accident at Three Mile Island, the industry learned valuable lessons about hydrogen accumulation inside containment. As an example, after Three Mile Island, many boiling water reactors implemented a modification referred to as a hardened vent or direct vent. This allows the plant to vent primary containment via high pressure piping. This precludes over-pressurization of containment.

13. *Do the events indicate that iodine tablets should be made widely available during an emergency?*

    The thyroid gland preferentially absorbs iodine. In doing so it does not differentiate between radioactive and nonradioactive forms of iodine. The ingestion of nonradioactive potassium iodide (KI), if taken within several hours of likely exposure to radioactive iodine, can protect the thyroid gland by blocking further uptake of radioactive forms of iodine. KI does not protect any other part of the body, nor does it protect against any other radioactive element.

    The NRC has made available KI tablets to states that have requested it for the population within the 10-mile emergency planning zone (EPZ) of a nuclear reactor. If necessary, KI is to be used to supplement other measures, such as evacuation, sheltering in place, and control of the food supply, not to take the place of these actions. The Environmental Protection Agency and the Food and Drug Administration have published guidance for state emergency responders on the dosage and effectiveness of KI on different segments of the population. According to the EPA guidance, "KI provides optimal protection when administered immediately prior to or in conjunction with passage of a radioactive cloud."

    Populations within the 10-mile emergency planning zone of a nuclear plant are at greatest risk of exposure to radiation and radioactive materials including radioactive iodine. Beyond 10 miles, the major risk of radioiodine exposure is from ingestion of contaminated foodstuffs, particularly milk

products. Both the EPA and the FDA have published guidance to protect consumers from contaminated foods within a 50 mile radius.

14. *What caused the explosions at Fukushima Daiichi Units 1-3?*

The explosions at Units 1, 2 and 3 appear to have been caused by a build-up of hydrogen.

The uranium fuel pellets are enclosed in metal tubes made of a zirconium alloy. When exposed to very high temperatures, the zirconium reacts with water to form zirconium oxide and hydrogen.

This appears to have happened at Fukushima Daiichi Units 1 and 3, when a portion of the uranium fuel was uncovered. It is assumed that the hydrogen found its way into the reactor building, accumulated there, and ignited. Although significant events, the explosions did not appear to compromise the integrity of the primary containments or the reactor vessels at these units.

The explosion in Unit 2 appears to have happened as a result of a similar phenomenon. The hydrogen appears to have ignited inside the reactor causing a breach of the primary containment. We do not have complete information yet, but indications of pressure level inside the reactor and increased radiation releases suggest a breach.

15. *Did the reactor cores melt at any of the Fukushima Daiichi reactors? Was there any fuel damage?*

Fukushima Daiichi Units 1, 2, and 3 have experienced some fuel damage, since the fuel rods or portions of the fuel rods were uncovered (not covered with water) for some period of time. There is no evidence of a complete core meltdown at any unit, however. The information we have suggests that the basic core configuration so far remains intact, so some water or steam cooling through the core is occurring.

16. *Are there any additional concerns associated with the mixed oxide fuel in Unit 3?*

Unit 3 installed some mixed oxide (MOx) fuel assemblies during its last refueling outage in September, 2010. Mixed oxide fuel is a combination of uranium oxide and plutonium oxide, and is not used in the U.S. reactors, except for limited experimental testing. Failure to keep MOx fuel assemblies covered with water – and the resulting overheating and damage to the MOx fuel assemblies, and release of fission products – does not pose an additional threat when compared with the traditional uranium oxide fuel assemblies. The melting point of the MOx fuel assemblies is also similar to uranium oxide fuel assemblies, so the risk of damage due to overheating does not increase with the use of MOX fuel.

17. *Do the events indicate that evacuation zones around plants should be extended?*

The 10-mile emergency planning zone around nuclear power plants as determined in 1978 by a multi-agency federal task force is appropriate and should not change due to the accident at Fukushima Daiichi. In the United States, a nuclear plant's emergency response plan must provide protective measures, such as sheltering and evacuation of communities within a 10-mile radius of the facility. Japan used a similar plan. During the accident there, the Japanese government has issued evacuation orders for a 20-kilometre (12.5-mile) radius around Fukushima Daiichi, and a 3-kilometre radius around Fukushima Daini.

18. *What will be the impact of the Fukushima Daiichi accident on new nuclear plant construction in the United States?*

New plants in the U.S. have not yet started safety-related construction. There is ample time to incorporate lessons learned from these events during the construction period.

Nuclear energy has been and will continue to be a key element in meeting America's energy needs. The nuclear industry sets the highest standards for safety and, through our focus on continuous learning, we will incorporate lessons learned from the events in Japan into the ongoing process of designing, licensing and building new nuclear power plants.

New nuclear power plant construction in the United States is in the early stages and proceeding in a deliberate fashion. Two companies have started site preparation and other construction activities for new nuclear power plants in Georgia and South Carolina, with the expectation that they will receive their combined construction-operating licenses from the Nuclear Regulatory Commission in late 2011 or early 2012. We expect those new reactor projects to proceed. Both projects use a light water reactor design with advanced safety features – i.e., the reactors rely on natural forces like gravity (rather than engineered safety features like pumps) to deliver cooling water to the reactor core.

In addition, a number of companies are moving forward with design, licensing and – at the appropriate time – construction of small modular reactors (SMRs), which also incorporate design features that provide additional safety margin.

Although America's 104 nuclear power plants are safe and meet all requirements necessary to protect public health and safety, these new designs are even safer.

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Russia
Vladivostok
Chongjin
Kimchaek
China
West Asia
South Korea
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Hakodate
Hirosaki
Akita
Onagawa
Kashiwazaki Kariwa
Nagaoka
Fukushima Daiichi
Fukushima Daini
Shika
Kanazawa
Tsuruga
Fugen
Fukui
Mihama
Matsumoto
Tokai
Tokyo
Kofu
Ulchin
Wolsong
Taegu
Shimane
Matsue
Kori
Takahama
Gifu
Monju
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Numazu
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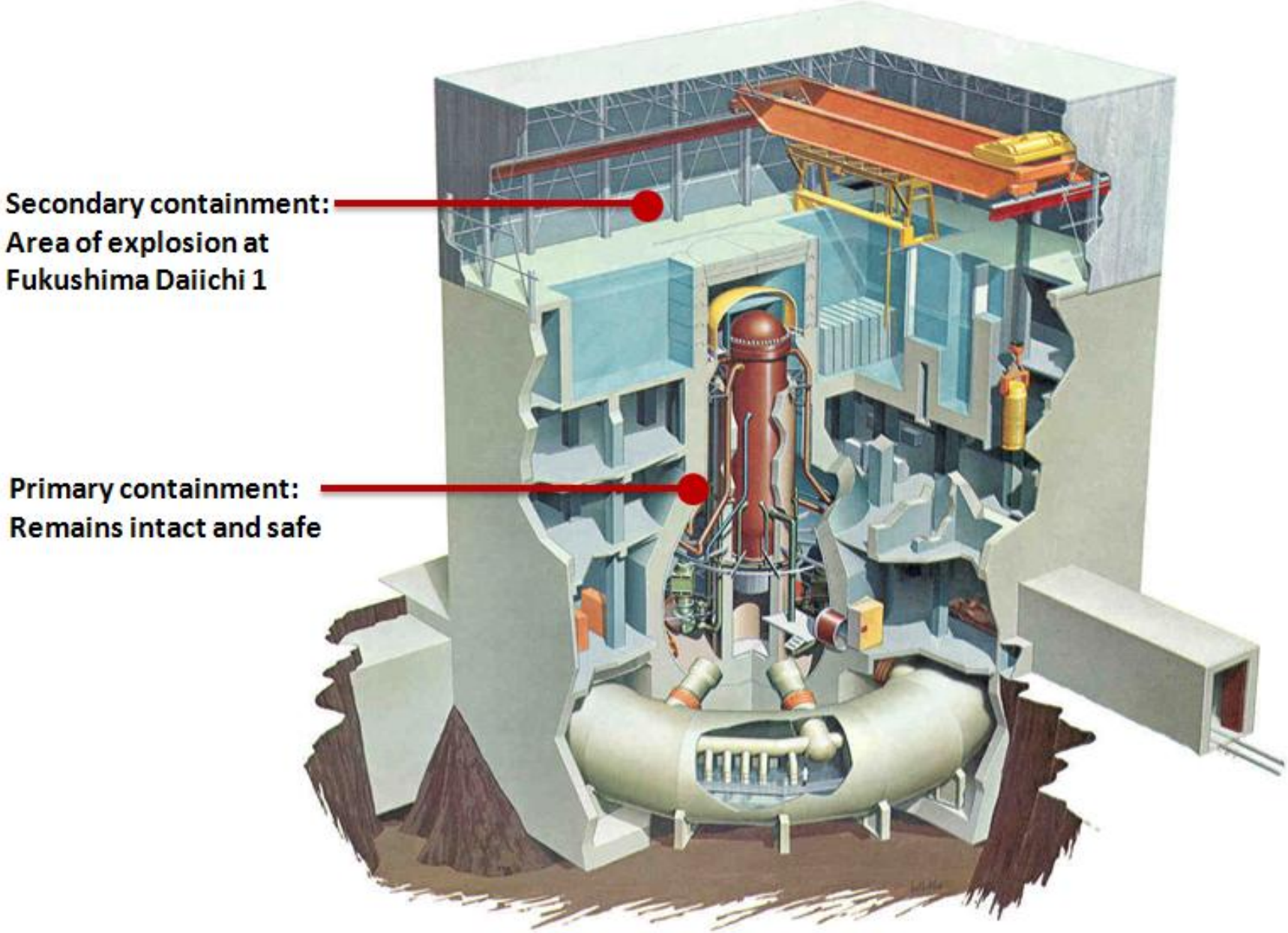

Boiling Water Reactor Design

Boiling Water Reactor

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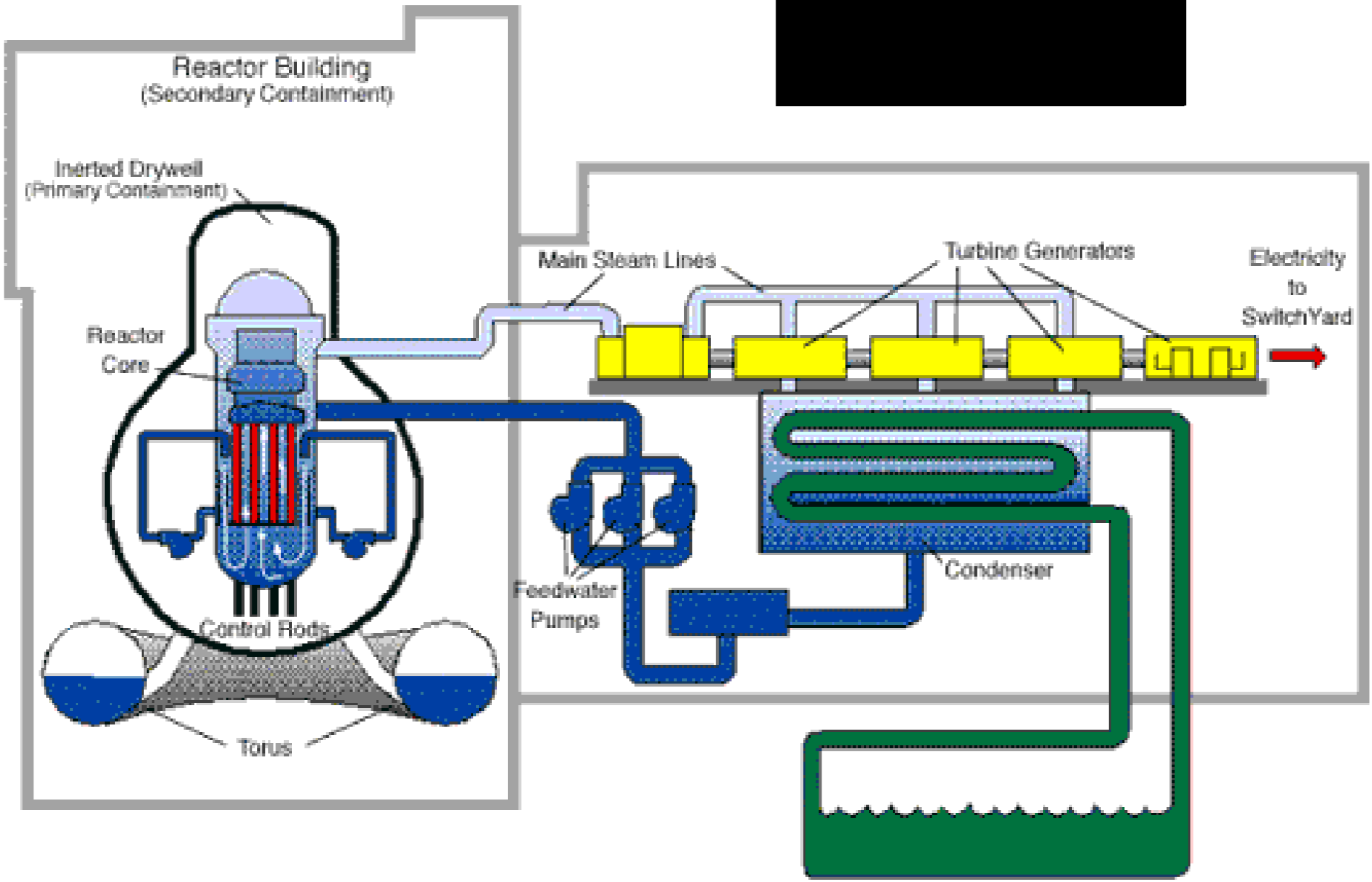

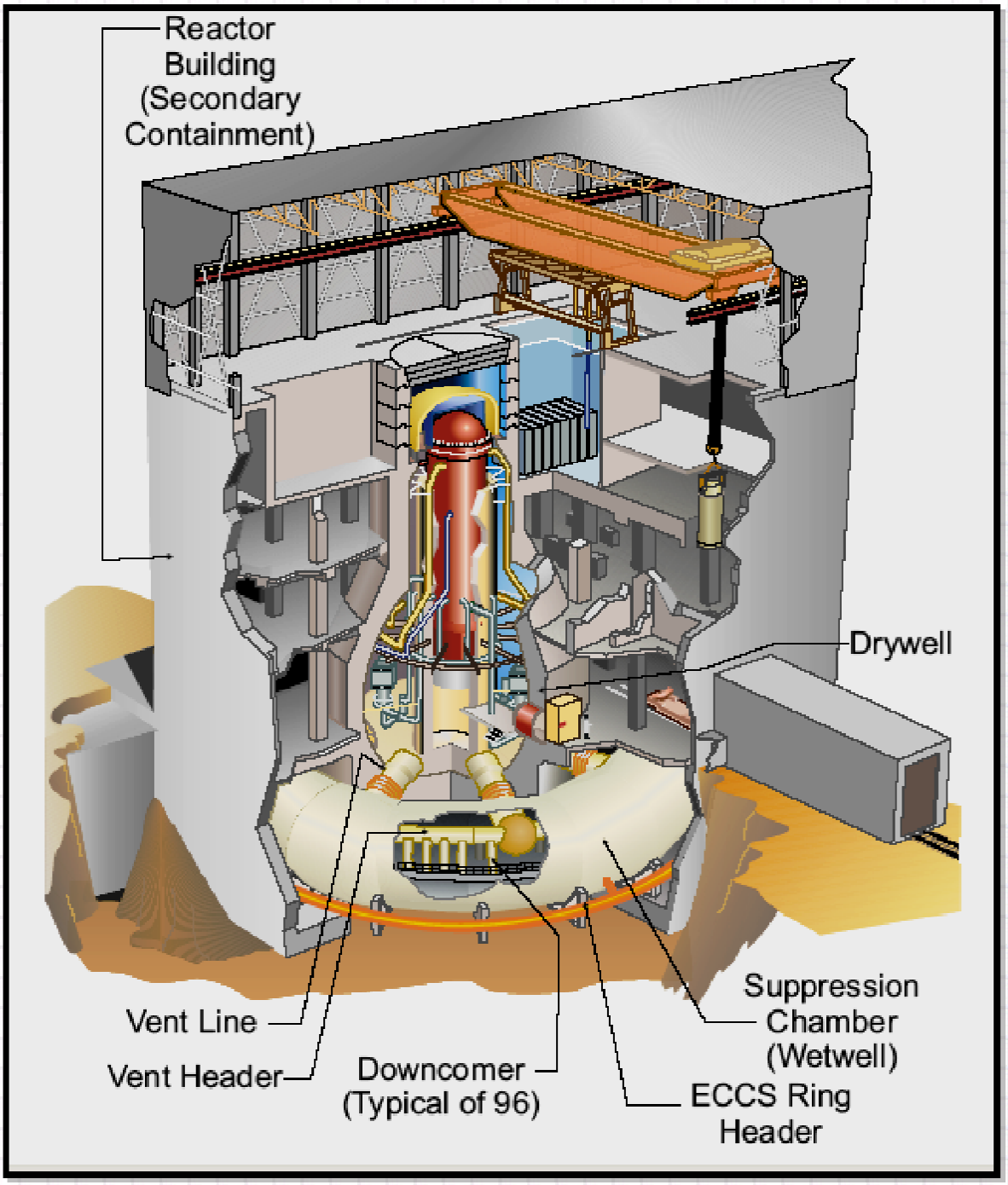
Reactor Building (Secondary Containment)
Drywell
Suppression Chamber (Wetwell)
Vent Line
Vent Header
Downcomer (Typical of 96)
ECCS Ring Header