# Extreme Occupancy Challenges From a Nuclear Perspective

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As building envelope consultants, we typically deal with design challenges relating to the occupancy of the buildings we work on. Challenges directly related to the occupancy of the building include scheduling conflicts, safety concerns, and continuing functionality of the facility. These challenges commonly arise in schools, hospitals, high-security data centers, correctional facilities, and public service buildings. This article will focus on these concerns at nuclear power generating facilities (*Figure 1*).

Currently, there are 99 licensed operating nuclear reactors in the Unites States producing about 20% of the electricity in the country,[1] and 22 reactors in Canada, accounting for about 15% of the electricity consumed in that country.[2] It is common for utilities to operate multiple reactors on a single site. In the U.S., reactor licensure is governed by the Nuclear Regulatory Commission (NRC). The Canadian Nuclear Safety Commission handles its licensures.

*Figure 1 – Typical nuclear power generating facility. Calvert Cliffs Nuclear Power Plant, Units 1 and 2. ("Operating Nuclear Reactors," Nuclear Regulatory Commission, Nov. 15, 2007. Accessed Oct. 9, 2015.)*

Each reactor operator or utility has a license agreement with the federal government that includes a set of well-defined operating procedures that the utility must follow to ensure the safe and continued operation of the reactor(s). These procedures have direct control over our project management decisions as designers, and relate to security, design, and document review policies.

## SECURITY

Not just anyone can walk onto a nuclear power site. These are secure facilities similar to military bases and prisons. Security personnel at these facilities carry real weapons and are authorized to protect the facility at any cost (*Figure 2*). For the consultant, access to a nuclear facility typically involves extensive training (approximately 40 to 80 hours) with testing, personality, credit, background, and criminal record checks. It is an arduous process that can take up to a month to complete.

The training process is designed to instill in all nuclear workers the best industry work practices that incorporate the nuclear safety culture and prepare them for working within radiation-exposure areas. This includes hands-on exercises in dressing out in protective clothing, using fall protection equipment, and emergency response drills.

Each day, as personnel enter the plant,

*Figure 2 – Security officer on post at nuclear facility. ("Security," Nuclear Regulatory Commission, Sept. 10, 2004. Accessed Oct. 9, 2015.)*

*Figure 3 – Access control security gates provide another layer of protection. ("Nuclear Plant Security," Nuclear Regulatory Commission, July 2013. Accessed Oct. 30, 2015.)*

they are searched similarly to security at airports, and must pass through metal detectors and past explosives monitors and have their personal items run through X-ray machines (*Figure 3*). When exiting, workers also follow a process that scans them for radioactive contamination. The equipment used for this can be so sensitive that naturally occurring isotopes such as those found during summertime thunderstorms have caused a few roofers to lose various articles of clothing at the end of the day.

## DESIGN

Buildings that are essential to the operation and safety of the reactor are typically subjected to design standards that go beyond local building codes. These design standards are known as the plant's licensing basis and include site-specific values for wind speed, rainfall, seismic intensities, etc. (*Figure 4*).

Temperature extremes are commonplace at nuclear facilities. Some plants use borated ice to cool the reactor during an emergency shutdown. Designs of the cladding systems for the storage and production areas have challenges similar to that of refrigerated warehouses, where dew point and insulation considerations are essential priorities. Counter to the frigid conditions found in the production of ice and cold storage, other buildings—such as the turbine and service buildings—often exhibit extremely high temperatures, where 90˚ to 120˚F (32˚ to 49˚C) at the roof deck is not uncommon. This temperature is typically constant, and, therefore, should be considered in selecting materials that can handle those consistently high temperatures.

Movement challenges are abundant in the nuclear world. The designer must take into consideration the extremes in thermal movement and the mechanically induced

*Figure 4 – NRC Commissioner Ostendorff tours Tennessee nuclear plant. ("Inspectors," Nuclear Regulatory Commission, 15 Jan., 2014. Accessed 9 Oct., 2015.)*

movement of operating plant machinery. When a plant is on-line, some of the steam-related piping can reach surface temperatures of 800˚F (427˚C). Temperatures inside some buildings exceed 120˚F (49˚C) year-round, while others are kept at sub-freezing conditions. This provides the designer not only with the obvious challenge of selecting materials compatible with the extreme surface temperatures, but when the reactor is taken offline for maintenance, there can be six inches or more of thermal movement as the pipe cools down that the design must accommodate. Harmonic vibrations can cause differential movement between the buildings and roof penetrations. This can prove difficult in designing flashings around low or oddly shaped penetrations (*Figures 5-8*).

Plant processes affect material selections. Each material brought onto a nuclear site must be preapproved through a multidisciplinary evaluation process. The chemical components of all products are checked to ensure compatibility with the plant systems they may come into contact with. As designers, we are often asked to use materials that have already been approved rather than introducing any new materials that would serve an equivalent purpose. This often affects the selection of sealants, mastics, and epoxies typically used in construction projects.

## DOCUMENT REVIEW POLICIES

As designers or consultants, we typically work closely with the client to ensure the proposed designs meet the intent of the plant's licensing basis. This is known as the modification of design process or commonly referred to as a "MOD." The operating utility's engineering group usually handles this process.

It is a regimented procedure with many rigorous checks and balances to help ensure that the potential consequences of any proposed changes to the station are understood prior to implementation. The MOD process also documents and provides detailed instructions and procedures to the various work groups assigned to implement the changes. This can be a methodical and often slow process, taking months or even years to complete. This makes scheduling considerations extremely important, ensuring that building envelope repairs are executed in a timely manner.

The applicability of the MOD process varies at each facility with respect to the building envelope components. For example, at some stations, the MOD process may not be considered applicable to replacing the roof on a turbine building, whereas modifying, repairing, or replacing the metal siding on the vertical walls and parapets is. Certain stations may consider all cladding components to be governed by the process, while at other stations, the building envelope may not be governed by the MOD. Regardless of whether or not the design is controlled by a formal MOD process, the design must still meet all licensing basis parameters.

## SAFETY

No discussion concerning the nuclear industry is complete without mentioning safety. Safety is a part of all aspects of the nuclear power generation culture.

In 2010, a nuclear power plant in southern Maryland was shut down for 10 days due to roof leaks. After water infiltrated key electrical equipment, the plant's safety features performed as designed and safely shut down both reactors.[3]

Nuclear designs often embrace safety through scheduling, radiation exposure strategies, and personal air quality.

Schedules often impact many design decisions. Due to safety concerns, some

*Figure 5 – Typical as-found roof penetration configuration.*

*Figure 6 – Typical low-roof penetration configuration.*

*Figure 8 – Difficult flashing detail around an equipment exhaust penetration.*

*Figure 7 – Low flashing around a high-heat steam relief penetration.*

*Figure 10 – Roof drain located inside an equipment curb.*

*Figure 9 – Roof drain located inside elevation wall.*

buildings are only accessible when a reactor is off-line for scheduled maintenance; this, in turn, causes the contractor's window of opportunity to be limited to a few days or weeks of project duration. This can sometimes drive the decision to select systems with quicker turnaround times or those that can be phased with long periods (usually 18 to 24 months) between phases.

Radiation exposure is of the utmost concern at these facilities. Management and regulators take extreme measures to protect the public and the workers from exposure to radiation. Some buildings house radioactive materials, and the energy they emit may penetrate the building's envelope. Exposure is controlled by time, distance, and shielding. In many building envelope projects, distance cannot be changed, and shielding with lead blankets may not be an option, so the easiest way to reduce exposure is to reduce the amount of time workers are exposed. This time-vs.-exposure consideration often impacts system selection. Out of the list of appropriate available cladding systems, the one with the lowest number of labor hours may be the most desirable from a radiological point of view.

Personal air quality requirements can also greatly impact the design process at a nuclear power generating facility. Some areas, such as the control rooms and security posts, are continuously occupied and are exceptionally sensitive to sound, dust, and odors. These areas are required to be operational 24/7 and cannot be evacuated due to volatile compounds entering the ventilation system.

Communication among the occupants is another vital requirement for operation and cannot be interrupted by a noisy tear-off or the unrelenting racket of noisy screw guns or hammer drills boring into the decking above. Control rooms house all the electrical equipment that actually monitors and controls the operation of the entire plant. Dust, debris, and water infiltration are taboo in this environment. Due to their potential to adversely impact the safe operation of the plant, care must be taken in selecting and specifying robust, resilient roof systems that have inherent redundancy to mitigate infiltration of potentially harmful contaminants over these areas.

In conclusion, nuclear power generating facilities provide building envelope design professionals a rare opportunity to address multiple extreme design challenges within the same project. Success can be found in the timely, careful selection and specification of materials and systems that meet the needs of the demanding nuclear environment.

## REFERENCES


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