# U.S. Lessons Learned Initiative for Locked High Radiation Areas

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**Threshold of Concern in U.S. Nuclear Industry – The Regulatory Context**

The regulatory framework for oversight of the U.S. nuclear industry[1] is a tiered approach to ensuring plant safety based upon relative risk (see Appendix 1). Three key strategic performance areas support the U.S. Nuclear Regulatory Commission's (NRC) overall safety mission: reactor safety, radiation safety and safeguards. Within each strategic performance area are cornerstones the NRC has determined central to plant safety. Satisfactory licensee performance in the each of the three strategic performance areas is essential to satisfying the NRC's overall safety mission.

Within the Occupational Radiation Safety Cornerstone, U.S. federal regulations place a limit on radiation doses permitted by radiation workers, and the cornerstone monitors the effectiveness of the licensee's program to control and minimize those doses. An important aspect of monitoring licensee performance in terms of occupational radiation safety via this "reactor oversight process" (ROP) is keyed on compliance with regulations for controlling access to high radiation areas and unplanned radiation exposures to workers more than 2 percent of the stochastic regulatory limit, which equates to 100 mrem (1 mSv) TEDE[2,3].

The ROP contains two elements, a licensee self-reporting aspect referred to as "Performance Indicators," and a NRC inspection-based aspect referred to as the "significance determination process." The intent of this approach to regulatory oversight is to provide a risk-informed basis "so that NRC and licensee resources are focused on those aspects of performance having the greatest impact on safe plant operation." The goal of ROP was to develop an oversight process that provides adequate margin to ensure appropriate licensee and NRC actions are taken before significant violations occur. In terms of occupational radiation protection, a major emphasis of the NRC oversight is therefore cast upon licensee control of high radiation areas.

Short of violations of regulatory exposure limits, a highly visible aspect of a U.S. nuclear power plant's radiation protection program has become the number and frequency of non-compliance events with 10 CFR 20[4] or license technical specification[5] requirements for high radiation areas (HRAs)

The Hierarchy of Regulatory Controls

The NRC regulates all commercial power reactor radiation protection programs through the Code of Federal Regulations (CFR), in specific Title 10, Part 20 Standards for Protection Against Radiation, where they establish the minimum requirements to protect both workers and the public from harm as a result of operation of a nuclear power plant. Since the ROP keys on these "technical specification" high radiation areas, frequently referred to as "Locked High Radiation Areas (LHRAs)," it's

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[1] SECY-99-07, "RECOMMENDATIONS FOR REACTOR OVERSIGHT PROCESS IMPROVEMENTS, William D. Travers to NRC Commissioners, 8 January, 1999

[2] U.S. Nuclear Regulatory Commission Inspection Manual, Chapter 0308, "Reactor Oversight Process (ROP) Basis Document," Attachment 3, Significance Determination Process Basis Document, 28 July, 2005.

[3] NEI 99-02 Revision 3, "Regulatory Assessment Performance Indicator Guideline," Nuclear Energy Institute, April 2005

[4] Code of Federal Regulations, Title 10 (Energy), Part 20 (Standards for Protection Against Radiation), Subpart G (Control of Exposure from External Sources in Restricted Areas), section 1601 (Control of Access to High Radiation Areas), as amended 21 May, 1991.

[5] NUREG-1432, Volume 1, Rev. 3.0, "Standard Technical Specifications-Combustion Engineering Plants," Division of Regulatory Improvement Programs, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, June 2004. NOTE: One of several different STS volumes prurient to specific reactor designs.

important to understand federal requirements affecting those areas. 10 CFR 20.1601 states the following with respect to LHRAs:

*(a) The licensee shall ensure that each entrance or access point to a high radiation area has one or more of the following features— . . .*

(3) *Entryways that are locked, except during periods when access to the areas is required, with positive control over each individual entry. . . .*

*(c) A licensee may apply to the Commission for approval of alternative methods for controlling access to high radiation areas.* (Emphasis added)

Readers will no doubt notice that it appears that licensees are required to lock all High Radiation Areas (HRAs) because of statement (a)(3), above. In the CFR, NRC defines a HRA as "an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv) in 1 hour at 30 centimeters from the radiation source or 30 centimeters from any surface that the radiation penetrates." The NRC recognizes that the requirement to lock all HRAs is unduly burdensome, and statement (c), above, allows the licensee to apply for "alternative means" for controlling HRAs. Most U.S. power reactor licensees have incorporated this provision via their technical specifications, a lengthy licensing document describing required conditions for operation, administrative controls and surveillance requirements.

Technical Specifications in the U.S. generally do not require locking of HRAs that are less than 10 mSv/hr, and institute requirements for locking at a general exposure rate exceeding 1.0 rem/hour (10 mSv/hr). Areas exceeding 10 mSv/hr are referred to as either "technical specification" HRAs or LHRAs, connoting the requirement for locking. Characteristic wording of U.S. nuclear plant technical specifications regarding the locking of high radiation areas may be seen in Appendix 2.

Additional Guidance

Many locations where LHRA conditions (i.e., exposure rates exceed 10 mSv/hr) are not located in portions of the facility that lend themselves to easy locking. The NRC, to assist licensees with implementation of regulations, provides a series of documents called "regulatory guides," which describe means the Commission finds acceptable to comply with codified rules. While these regulatory guides carry no specific regulatory requirements, they do provide licensees with the insight to interpret means to demonstrate compliance at their own facilities.

Regulatory Guide 8.38[6] provides clarification to most licensees' questions regarding the adequacy of barriers and barricades to prevent inadvertent access. Over the past few years, there has been apparent inconsistency between the NRC and licensee expectations of what constitutes an adequate barrier or barricade, and that has led to the issuance of a draft revision to Regulatory Guide 8.38[7] intended to clarify those nuances of interpretation.

**Acceptable Barriers for Locked High Radiation Areas – *A Learning Process***

The wording of the initial issue (in 1993) of Regulatory Guide 8.38 appeared to offer licensees some latitude with respect to the design of barriers used to lock LHRAs:

> *Physical barriers (such as chain-link fencing or fabricated walls) may be used to prevent unauthorized personnel access to high and very high radiation areas. Physical barriers surrounding high radiation areas should be sufficient to prevent inadvertent entry (e.g., a 2-meter* [6-foot] *fence, with worker training and signs or procedures to deter climbing, may be adequate for controlling access to a high radiation area). Physical barriers should, to the extent practicable, completely enclose very high radiation areas sufficient to thwart* undetected circumvention of the barrier (i.e., fencing around very high radiation areas* [areas

[6] U.S. Nuclear Regulatory Commission Regulatory Guide 8.38, "Control of Access to High and Very High Radiation Areas in Nuclear Power Plants," June 1993.

[7] U.S. Nuclear Regulatory Commission Draft Regulatory Guide 8.38, "Control of Access to High and Very High Radiation Areas in Nuclear Power Plants (Proposed Revision 1 of Regulatory Guide 8.38)," September 2005.

with dose rates greater than 500 rad/hr or 5 Gy/hr] *should extend to the overhead and preclude anyone from climbing over the fencing) . . . . Openings in physical barriers around a high radiation area are not required to be controlled as entrances if exceptional measures are needed to access them.* (Emphasis added)
** Determined circumvention of a physical barrier, with wire cutters or other tools, cannot be prevented absolutely. Such instances should be addressed with appropriate disciplinary action.*

Substantial Barriers

In the U.S., NRC conducts oversight of licensees from four different regional Inspection and Enforcement (I&E) offices. In February of 2003, the first indication of divergence between licensee understanding of acceptable barriers for LHRAs and that of the NRC surfaced. During an inspection at Davis-Besse in NRC Region III[8], inspectors examined temporary barriers in use to cocoon the transfer tube:

***Description,*** *On February 25, 2003, the inspectors toured the Containment Building and observed openings/gaps accessible to workers that allowed alternate access into posted LHRAs which were barricaded with orange colored netting commonly used as snow fencing along roadways. The licensee used the netting material during outages as a barricade to prevent personnel from entering LHRAs through pathways that were not intended for access. The netting was secured with tie-wraps and/or tape to cover openings and gaps under and adjacent to LHRA gates, or to barricade openings around cable trays that led into LHRAs. The gaps/openings were accessible to workers and physically large enough to permit entry into the areas. . . .*
*Regulatory Guide 8.38, "Control of Access to High and Very High Radiation Areas in Nuclear Plants," provides acceptable methods of excluding personnel from such areas by constructing a substantial (robust) physical barrier that completely encloses the area and has no openings or portals. This type of control is commonly called cocooning. When properly cocooned, an area would not be accessible and the access control and posting requirements in 10 CFR Part 20 and licensee Technical Specifications would not apply. The licensee erroneously believed that the netting was sufficiently "robust" and made access into the LHRAs via the openings/gaps "inaccessible." . . .*
*While some "snow fence" material provides an adequate barrier and is acceptable for cocooning purposes, the orange netting used by the licensee was determined to be inadequate because it did not require specialized tools (e.g., wire cutters) to breach. Specifically, the inspectors determined that the material in question could be easily breached with a pocket knife and thus did not meet NRC guidelines as a "substantial barrier."*

Intentional Circumvention – How Robust does the Barrier Need to Be?

In October of 2003, NRC Region IV (western U.S.) inspectors conducted an inspection at a power plant, the results of which further signaled a difference between NRC interpretation of barrier adequacy and that of licensees. Up until this time, licensees generally believed that a barrier would be adequate if the barrier prevented inadvertent or accidental entry. The October 2003 inspection at Ft. Calhoun Nuclear Generating Station[9] contained two findings that indicated barrier adequacy must also be judged by whether it is able to prevent intentional circumvention:

***Description.*** *On October 28, 2003, while touring the reactor containment building, the inspectors observed that the ladder leading to Steam Generator Bay A from the steam generator platform was barricaded and posted as a restricted high radiation area* [LHRA]. *Licensee survey records confirmed that dose rates beyond the barricade were as high as 4000 millirems per hour* [40 mSv/hr] *at 30 centimeters from the source of radiation. The inspectors*

[8] Correspondence, First Energy Nuclear Operating Company, Davis-Besse Nuclear Power Station, dated 30 May, 2003, Subject: "Davis-Besse Nuclear Power Station - NRC Supplemental Inspection and Radiation Protection Program Effectiveness Review Report 50-346/03-08(DRS)."
[9] Correspondence, Omaha Public Power District, dated 4 February, 2004, Subject: "Fort Calhoun Station - NRC Integrated Inspection Report 05000285/2003006."

*noted that the ladder into the area was controlled with a locked sheet metal gate. However, the gate was flanked on the side by rails which were approximately 3 feet* [91 cm] *high. This would have allowed an individual to bypass the gate by simply stepping over the railing on either side. Therefore, the inspectors concluded that the licensee's control of the restricted high radiation area was inadequate to prevent unauthorized entry.*

***Description.*** *On October 28, 2003, the inspectors observed that the reactor cavity was posted as a restricted high radiation area. Licensee survey records confirmed that dose rates within the reactor cavity were as high as 5000 millirems per hour* [50 mSv/hr] *at 30 centimeters from the source of radiation. The inspectors noted that a permanent ladder leading into the reactor cavity from the south side of the cavity was controlled by locking the ladder climbing rails at the top of the ladder. Additionally, on the north side of the cavity, scaffolding was erected to house a set of temporary stairs into the cavity. A locked door was installed, in the horizontal plane, over the temporary stairs to prevent unauthorized use of the stairs. The inspectors concluded that the licensee's control of the restricted high radiation area within the reactor cavity was inadequate to prevent unauthorized access. On the south side an individual could either step around the ladder barrier or go underneath it and enter the reactor cavity. On the north side an individual could bypass the locked door by climbing on the outside of the scaffolding and down into the reactor cavity using a ladder-like structure which was part of the scaffolding.*

In both of these situations, if anyone chose to intentionally circumvent the barriers in place, they risked a thirty-five foot (~ eleven meter) fall to do so.

Gap Sizes

Issues have continued to develop in NRC inspections further amplifying the distinction between licensee interpretation of adequate LHRA boundaries and the NRC staff position. A recent example:

*. . . the inspectors identified that the physical barrier (a fence with a locked gate) that was provided to control entry to the Unit 1 reactor coolant drain tank area was not adequate to prevent personnel entry into the area. Specifically, unauthorized entry into the Unit 1 reactor coolant drain tank area (located in the annulus of lower containment) was physically controlled by a lattice-style metal fence and locked gate. However, the fence did not extend the full length of the annulus region and an approximate 19-inch* [48 cm] *wide by 7-foot* [2.1 m] *high opening existed between the outer annulus wall and the fence that allowed physical passage by an individual around the barrier. Other openings/gaps of approximately 12-inches* [30 cm] *wide existed between other structures (a vertical pipe, lateral cable tray, and a vertical support beam) that were interior to the 19-inch* [48 cm] *wide opening that would allow unauthorized personnel entry into the reactor coolant drain tank area and, therefore access into areas with radiation levels that represented a locked high radiation area (LHRA) condition. . . . Based upon the inspector's assessment, the openings were sufficiently large to allow personnel passage around the barrier and into the LHRA with only low to moderate physical effort.*[10]

The forgoing suggested NRC interpretation that if a barrier can be easily circumvented, then it is not sufficient.

Decreased Effective Height

In August 2004, a NRC Region II inspection demonstrated licensee vulnerability to an additional aspect of LHRA barrier effectiveness also related to the ability to circumvent the barrier. In this case, while NRC Regulatory Guide 8.38 alludes to a height of six feet (~ 1.8 m) as sufficient height for an HRA barrier, proximity of items that could aid someone to climb over the barrier reduced the effective height[11]:

[10] Correspondence, Indiana Michigan Power Company, dated 4 August, 2005, Subject: "D. C. Cook Units 1 and 2, NRC Integrated Inspection Report 05000315/2005004; 05000316/2005004"

[11] Correspondence, Florida Power and Light Company, dated 25 October, 2004, Subject: "St. Lucie Nuclear Plant - NRC Integrated Inspection Report 05000335/200405 and 05000389/200405."

***Description***. *Licensee procedure HPP-3, High Radiation Areas, Rev. 15, Section 6.6 requires that each LHRA be locked to physically prevent access and that enclosure walls be a minimum of six feet in height, labeled (posted) properly, and no ladders are to be stored or used in a manner to allow access over the walled enclosure. During the week of August 16, 2004, the inspectors observed examples of postings and signs that did not meet the established LHRA guidance. In addition, although the procedure addressed the use/storage of ladders around LHRAs, the inspectors noted that the procedure did not address the use/maintenance of other equipment which was observed near or placed against established physical barriers which potentially could facilitate unauthorized access to LHRAs. Specific observations included the following:*

*U2 Volume Control Tank (VCT) cubicle - The inspectors noted an unattended/unsecured step-stool, approximately two and one-half to three feet* [76 – 91 cm] *in height, within the corridor associated with the U2 VCT cubicle. The step stool was easily moved adjacent to the VCT LHRA entrance which consisted of a locked gate approximately six feet in height with an open area between the top of the gate and the ceiling . . . .*

*U1 Drumming Room LHRA Radioactive Waste Storage Facility The inspectors observed several empty 55 gallon* [208 l] *drums approximately 34 inches in height placed against the 85 inch* [2.2 m] *high gate and 92 inch* [2.3 m] *high wall comprising the eastern barrier of the U1 drumming room LHRA radioactive waste storage facility. The area above the established barrier was open and the distance between the top of the drums to the gate and wall was 51inches* [130 cm] *and 58 inches* [147 cm], *respectively. From the top of the barrier wall, a ladder attached to the inside of the wall was available to allow access to the floor of the established LHRA facility . . . .*

***Analysis.*** *The inspectors determined that the licensee's failure to follow and to have adequate radiation protection procedural controls for established LHRAs was a performance deficiency because the licensee is expected to meet TS required procedural administrative and physical controls for high radiation areas. Although, the licensee had established barrier heights of six feet* [two meters] *and designated posting and sign specifications to meet the reasonable assurance criteria for preventing access to LHRA, the failure to follow procedures and inadequate procedural guidance could compromise the licensee program for controlling access to high radiation areas. The finding is more than minor because it was associated with the Occupational Radiation Safety Cornerstone access control program and process attribute and affected the associated cornerstone objective to ensure adequate protection of worker health and safety from exposure to radioactive materials as a result of routine civilian nuclear reactor operations.*

**Licensee Networking and Working with Regulators– Getting the Message Out**

U.S. licensees network to share operating experience via several mechanisms. Two industry organizations, the Nuclear Energy Institute (NEI) and the Institute for Nuclear Power Operations (INPO) both communicated developing issues to radiation protection staff and management at member utilities. The first issue communicated was the question of what constituted a substantial barrier following the Davis-Besse Inspection. This issue was communicated in early 2004 via the NEI, and later by INPO. Subsequent developments were communicated in a similar manner via working Radiation Protection Manager (RPM) meetings with the NRC to discuss developing issues as well as via the two industry organizations.

During the 22-23 January 2004, Region IV RPM meeting in Dallas, Texas, the NRC offered clarification of their guidance contained in Regulatory Guide 8.38. In essence, the NRC staff explained that a barrier is required to be sufficient to prevent intentional unauthorized access to a LHRA. Discussion at this same meeting led to further exploration of issues. "Exceptional measures," despite the above clarification of "determined circumvention" from Regulatory Guide 8.38 and example use of "wire cutters or other tools," did not extend to the use of more common hand tools

such as a pocketknife to cut through plastic netting ("snow fence") in use at that time in some plants to cocoon or barricade LHRAs.

In September 2005, the NRC issued for comment a draft proposed revision to Regulatory Guide 8.38 that would address most distinctions between NRC staff and licensee interpretation of barrier adequacy. In this proposed revision, the following distinction is added:

> *Barriers used to control access to high radiation areas should provide reasonable assurance that they secure the area against unauthorized access and cannot be easily circumvented. (That is, an individual who incorrectly assumes, for whatever reason, that he or she is authorized to enter the area, would be unlikely to disregard and/or circumvent the barrier.)* (Emphasis added)

**Main Issues for Licensees to Address**

The result of U.S. licensee sharing of information and cooperation with the regulator has resulted in de facto clarification of the considerations affecting LHRA barrier effectiveness. They are:

- Is the barrier *substantial*, fabricated of *substantial material*? Acceptable barriers may be made of chain link fencing fabric, boards, walls, etc. and may not be readily removable with *commonly available hand tools*. A pocketknife, a personal tool that many radiation workers carry daily is considered a *commonly available hand tool*. Wire cutters, pliers, handsaws, and alike are not considered *commonly available hand tools*.
- Does the barrier have any *gaps* greater than six inches wide? Six inches (15 cm) has generally been taken to be sufficiently narrow to prevent anyone from circumventing a barrier, and is readily demonstrated by the diameter of the dome of a typical hardhat.
- If an LHRA is cocooned (e.g., surrounded) to prevent access to LHRA conditions, is the material that it is fabricated of *substantial material* and secured with *substantial fastener*s, thus requiring more than *commonly available hand tools* to defeat it? Cocooned areas do not require HRA postings since they are not accessible, but must have clearly visible warning signs alerting workers to the dangers and restrictions on removal of the cocoon.
- Are there any materials, devices or natural features that *decrease* the *effective height* of the LHRA barrier? Examples of this consideration are stepstools, ladders and wall brackets that could aid climbing and alike. Similarly, are there approaches to an area, albeit dangerous, that could permit a determined individual to possibly gain access to the LHRA condition?

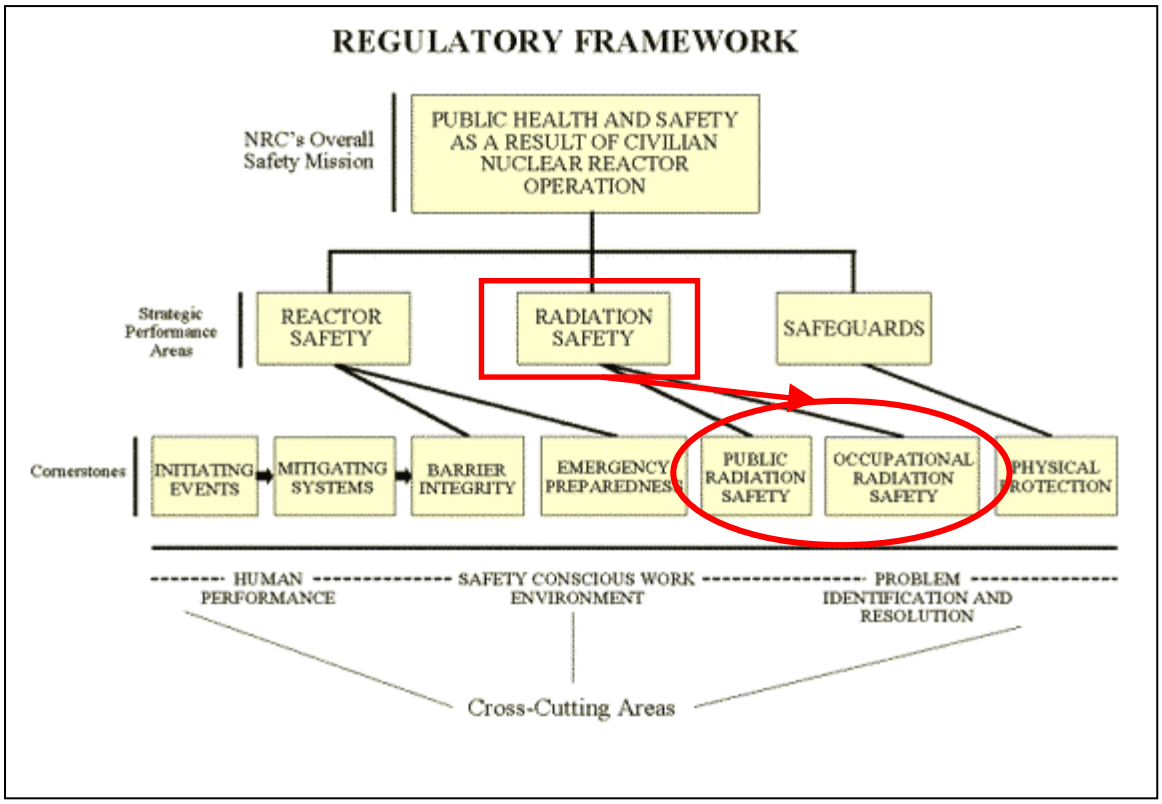
Many licensees have also found it beneficial to require a supervisory inspection of each new LHRA area to ensure that the forgoing considerations are satisfactorily incorporated into the barrier.

**Harmonization Efforts**

The U.S. NRC Region III Radiation Protection Manager's Committee, a regional RP Manager's meeting started in 1989 to exchange best practices and lessons learned, undertook an effort to harmonize the LHRA posting and barricading practices to the extent practical among the 22 operating reactor units. While each plant has somewhat different technical specifications, the essential requirements for LHRA controls are generally similar enough to permit standardization. This task group has also recently spread efforts to promote standardization through the auspices of national Radiation Protection industry organizations.

The proposed revision to Regulatory Guide 8.38 has recently completed its comment period, and is back with NRC staff to resolve comments. While this regulatory guide does clarify many of the issues discovered in NRC inspections, the harmonization effort across the industry is seen as the best opportunity for licensees to establish consistency of practice in cooperation with their regulator.

Appendix 1 – Figure, U.S. Regulatory Oversight Process (ROP)[12]




[12] U.S. Nuclear Regulatory Commission, "Detailed ROP Description," http://www.nrc.gov/reactors/operating/oversight/rop-description.html, 17 November 2004

Appendix 2 - **Standard Technical Specifications, Administrative Controls, "Alternative Methods"[13]**

*As provided in paragraph 20.1601(c) of 10 CFR Part 20, the following controls shall be applied to high radiation areas in place of the controls required by paragraph 20.1601(a) and (b) of 10 CFR Part 20:*

*5.7.1 High Radiation Areas with Dose Rates Not Exceeding 1.0 rem/hour [10 mSv/hr] at 30 Centimeters from the Radiation Source or from any Surface Penetrated by the Radiation*

*a. Each entryway to such an area shall be barricaded and conspicuously posted as a high radiation area. Such barricades may be opened as necessary to permit entry or exit of personnel or equipment.*

*5.7.2 High Radiation Areas with Dose Rates Greater than 1.0 rem/hour [10 mSv/hr] at 30 Centimeters from the Radiation Source or from any Surface Penetrated by the Radiation, but less than 500 rads/hour [5 Gy/hr] at 1 Meter from the Radiation Source or from any Surface Penetrated by the Radiation*

*a. Each entryway to such an area shall be conspicuously posted as a high radiation area and shall be provided with a locked or continuously guarded door or gate that prevents unauthorized entry, and, in addition:*

*1. All such door and gate keys shall be maintained under the administrative control of the shift supervisor, radiation protection manager, or his or her designee.*

*2. Doors and gates shall remain locked except during periods of personnel or equipment entry or exit.*

*b. Access to, and activities in, each such area shall be controlled by means of an RWP or equivalent that includes specification of radiation dose rates in the immediate work area(s) and other appropriate radiation protection equipment and measures.*

. . .

*f. Such individual areas that are within a larger area where no enclosure exists for the purpose of locking and where no enclosure can reasonably be constructed around the individual area need not be controlled by a locked door or gate, nor continuously guarded, but shall be barricaded, conspicuously posted, and a clearly visible flashing light shall be activated at the area as a warning device.*

**NOTE**: U.S. Technical Specifications were not required to follow a precise standard format, making provision for some degree of tailored approach for each reactor unit. Individual licensee administrative controls for high radiation areas may be significantly different from the "standard" wording shown herein. This has resulted in some degree of variation in acceptable controls from one site to another.

[13] NUREG-1432, Volume 1, Rev. 3.0, "Standard Technical Specifications-Combustion Engineering Plants," Division of Regulatory Improvement Programs, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, June 2004.