

# NRC INSPECTION MANUAL

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## INSPECTION PROCEDURE 71111 ATTACHMENT 20

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### REFUELING AND OTHER OUTAGE ACTIVITIES

Effective Date: January 1, 2019

PROGRAM APPLICABILITY: **IMC 2515 A**

CORNERSTONE:        Initiating Events  
                          Mitigating Systems  
                          Barrier Integrity

INSPECTION BASES:    **See Inspection Manual Chapter (IMC) 0308, "Reactor Oversight Process Basis Document," Attachment 2, "Technical Basis for Inspection Program"**

#### SAMPLE REQUIREMENTS:

Sample Requirements		Minimum Baseline Sample Completion Requirements		Budgeted Range	
Sample Type	Section	Frequency	Sample Size	Samples	Hours per Unit Refueling Outage
Refueling/Other Outage	03.01	One Each Outage*			1 unit: 71+/-15 2 units: 77+/-15 3 units: 81+/-15

\* An outage is a shutdown with a plant cooldown or a shutdown for containment entry, or both.

#### 71111.20-01 INSPECTION OBJECTIVES

- 01.01 To verify that outage activities important to safety are appropriately managed.
- 01.02 To verify that safety-related and risk-significant structures, systems, and components in inaccessible areas during power operations are appropriately maintained to support required safety functions.
- 01.03 To verify that risk is appropriately managed during outage-related activities such as during reduced-inventory and midloop conditions.

#### 71111.20-02 GENERAL GUIDANCE

Use Inspection Procedure (IP) 71153, "Follow-Up of Events and Notices of Enforcement Discretion," for non-complicated reactor trips where a startup is performed without entering the containment. Use IP 71111.19, "Post-Maintenance Testing," and IP 71111.22, "Surveillance

Testing,” to address testing activities that normally occur during refueling outages, such as physics testing, emergency diesel generator time response testing, reactor coolant system (RCS) hydrostatic testing, control rod scram time testing, rod drop time testing, reactor trip breaker testing, and containment sump valve testing. However, IP 71111.20 should take precedence for outage planning and configuration management reviews in areas where it overlaps with other areas that require inspections, such as maintenance risk assessments and emergent work control, equipment alignment, and inservice inspection activities.

IMC 0609, “Significance Determination Process,” Appendix G, “Shutdown Operations Significance Determination Process,” contains checklists for various plant configurations that can be used to assess mitigating capability. Higher risk configurations have more checklist guidelines for each safety function. The following examples are high-risk configurations:

- pressurized-water reactors (PWRs)
  - breached RCS boundary with steam generators that cannot be used for decay heat removal (DHR)
  - midloop conditions under which it is more likely that DHR can be lost because of poor RCS-level control or poor DHR flow control
- boiling-water reactors (BWRs)
  - cold shutdown conditions (i.e., technical specifications (TS) allow more equipment to be inoperable during cold shutdown conditions than they do during hot shutdown conditions)
  - inoperable safety relief valves under conditions in which such valves would be needed to provide an alternate DHR path and pressure control during a loss of the primary DHR system

For each sample, conduct a routine review of problem identification and resolution activities using IP 71152, “Problem Identification and Resolution.”

Sample Considerations	
Risk Priority	Examples
Equipment or actions that could cause a loss of DHR	Inadvertent lowering of the reactor vessel level in midloop as a result of operator inattention
Actions that could <b>adversely</b> affect reactor vessel level	<b>Actions that could cause the reactor vessel level indication to be non-conservative.</b>
Activities that <b>could</b> contribute to loss of offsite power or station blackout	Activities that affect the electrical power sources designated in the <b>licensee’s outage/shutdown risk control plan</b>

Risk Priority	Examples
Equipment used to mitigate a loss of DHR	Activities that affect the ability of pumps designated in the licensee's outage/shutdown risk control plan as necessary to add water to the reactor vessel
Equipment used to mitigate a loss of reactor vessel level	Activities that affect the water source for any of the pumps designated in the licensee's outage/shutdown risk control plan
	Improper hanging or restoration of clearance tags that could affect reactor vessel level, DHR, or electrical power availability
	Failure to verify refueling interlocks
Actions that could affect the integrity of the fuel cladding barrier, reactor vessel/RCS, or containment	Exceedance of heatup or cooldown rate limits
	Failure to establish containment integrity during fuel movement

71111.20-03 INSPECTION SAMPLE

03.01 Refueling/Other Outage Sample

- a. Outage Plan. **Before a planned outage, verify that the outage/shutdown risk control plan appropriately considers risk, industry experience, and previous site-specific problems.**

Specific Guidance

Review the licensee's outage/shutdown risk control plan, related industry experience, and previous site-specific problems. Confirm that the licensee has mitigation/response strategies for losses of key safety functions.

- b. Shutdown. **Verify that plant shutdown activities are appropriately conducted.**
1. Cooldown. **Observe portions of the cooldown process to verify that TS cooldown restrictions are followed.**
  2. Containment Opening. **If the containment is opened, conduct a walkdown of the containment promptly after it is opened.**

Specific Guidance

If containment entry is available, conduct a thorough containment walkdown as soon as reasonably possible after shutdown to inspect plant areas that are inaccessible during power operations.

- (a) Consider the following:

- (1) "as low as is reasonably achievable" controls
  - (2) industrial/personnel safety (heat stress)
  - (3) outage duration
  - (4) unidentified RCS leakage before shutdown
- (b) During the initial containment walkdown, note areas exhibiting boric acid leakage and verify that the licensee has subsequently identified these areas during the licensee's walkdown of containment.
  - (c) Verify that the containment sump is undamaged and debris free.
  - (d) Verify that supports, braces, and snubbers have no damage or deformation. Verify that hydraulic snubbers have no hydraulic fluid leaks and that the hydraulic fluid reservoirs are adequately filled.
  - (e) Check for items that may be indicative of a larger problem. These problems may include, but are not limited to, the following:
    - (1) blistered paint and rust on containment liners
    - (2) leakage from containment ventilation and cooling systems
    - (3) cracks in concrete support structures
    - (4) damaged cable insulation
    - (5) presence of loose foreign material
    - (6) presence of temporary plant equipment left or stored in containment that the licensee's design-basis analyses may not have considered

c. **Outage. Verify that outage-related activities are appropriately conducted.**

Specific Guidance

Verify that the license maintains defense-in-depth when equipment is taken out of service. Verify that the licensee controls configuration changes in accordance with the outage/shutdown risk control plan and applicable TSs. Consider the effect of concurrent and overlapping work. Confirm that appropriate considerations have been given to scheduling activities and risk mitigating strategies. Such activities may include but are not limited to activities that:

- involve heavy load lifts
- could adversely affect the other unit
- can result in a loss of offsite power, compressed air, or cooling water

- involve the erection of scaffolding
- increase the potential for a fire or internal flooding
- impact fuel transfer or the integrity of radiological barriers

1. **Isolation and Clearance/Cleanliness Activities. Verify that tags are properly hung and removed and that associated equipment is appropriately configured to support the function during clearance restoration.**

Specific Guidance

Examples of risk-significant clearance activities include the opening of water system boundaries for maintenance near risk-important equipment and power restorations that could adversely affect safety systems, such as the improper repositioning of a motor-operated valve upon restoration of power. Pay particular attention to maintenance activities that could affect RCS, DHR, or spent fuel pool cooling.

2. **Foreign Material Exclusion. Verify that foreign material exclusion practices are appropriately implemented.**

Specific Guidance

- (a) Review foreign material exclusion logs and records.
- (b) Review the controls used to limit and assess debris found inside the containment. When appropriate, consider the guidance in Operating Experience Smart Sample (OpESS) 2007-01, "PWR Containment Sump Recirculation Pipe Foreign Material Blockage."

3. **Reactor Coolant System Instrumentation. Verify that RCS pressure, level, and temperature instruments have been installed, calibrated, and configured to provide accurate indications.**

Specific Guidance

For level instruments, verify that the tubing runs do not have elevation changes that could trap either liquid or vapor/gas in the instrument lines (i.e., loop seals). If the plant uses normal operating level instrumentation, verify that the operators have considered the effects of changes in water density (resulting from lower temperature). Verify that the operators are aware of the effect of loss of DHR on the plant's level instrumentation resulting from heatup and pressurization.

For temperature instruments, verify that the operators are aware of the effect of loss of DHR on the plant's temperature indication and the potential for discrepancies between the temperature indications and the actual plant state. Temperature may be measured in the DHR loop; in this case interruption, bypass, or partial bypass of DHR flow could lead to incorrect and nonconservative temperature indications.

4. **Electrical Power. Verify that the status and configurations of electrical systems meet TS requirements and the licensee's outage/shutdown risk control plan.**

Specific Guidance

Verify that switchyard activities are controlled commensurate with safety and are consistent with the licensee's outage/shutdown risk control plan assumptions.

5. **Containment. Verify that the plant has the proper containment configuration during risk-significant evolutions (e.g., PWR midloop operations, BWR cavity drain down), including provisions for achieving prompt containment closure during periods when containment is permitted to be open.**

Specific Guidance

For BWRs, verify that secondary containment meets the TS requirements. Verify that the containment closure procedures are available and that the licensee uses them when applicable.

For PWRs, verify that containment penetrations meet TS requirements and that containment closure<sup>1</sup> can be achieved at all times.

6. **Decay Heat Removal. Observe DHR parameters to verify proper system operation.**

Specific Guidance

For BWRs, verify that training and procedures are in place for alternate DHR systems.

For PWRs, when the licensee is relying on the steam generators to provide a backup means of DHR by single-phase natural circulation, verify that the licensee has confirmed the viability of this cooling method.

When the licensee is relying on the steam generators to provide a backup means of DHR by single-phase natural circulation, verify the following:

- (a) Procedures for these methods are derived from analyses, and the required equipment is available.

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<sup>1</sup> Licensees of PWRs meet containment closure if all containment penetrations (including temporary penetrations, the equipment hatch, and the personnel hatch) have a differential capability equal to the ultimate pressure or would be expected to remain intact following an accident. Leakage requirements, as described in Appendix J, are not a concern. Results from the shutdown probabilistic risk analysis that the Office of Nuclear Regulatory Research conducted at Surry Power Station shows that containment pressure (in a subatmospheric containment) can be high at shutdown after a core damage event.

- (b) The RCS pressure boundary is closed.
- (c) Steam generator tubes are full.
- (d) Pressure control capability in the RCS is maintained to ensure the subcooling margin.
- (e) The plant has the capability to feed the steam generators.
- (f) The plant has the capability to remove steam from the steam generators (e.g., atmospheric relief valves, condenser with steam dump capability).

7. **Inventory Control. Verify that the flowpaths, configurations, and alternative means for inventory addition are consistent with the outage/shutdown risk control plan.**

Specific Guidance

For activities that have the potential to cause a loss of inventory, verify that adequate controls are in place to prevent inventory loss. RCS pressure boundary problems can pose significant shutdown risk.

- (a) Examples of loss of inventory paths include the following:
  - (1) on BWRs—DHR to the suppression pool
  - (2) on BWRs—main steamline paths, including safety relief valve removal, automatic depressurization system testing, and main steam isolation valve maintenance
  - (3) on PWRs—DHR system crosstie valves, thimble tube seals, and steam generator nozzle dams
  - (4) maintenance activities on connected piping or components that are at an elevation lower than the vessel flange on all plants
  - (5) paths for an intersystem loss-of-coolant accident, such as maintenance and testing on the nonoperating loop low-pressure injection (LPI) train or LPI testing on return back to the refueling water storage tank
- (b) For BWRs, verify the following:
  - (1) The automatic isolation on low level is aligned in accordance with TS requirements that apply to the mode.
  - (2) The main steamline plugs are installed, and the systems required for proper operation of the reactor cavity seal (e.g., instrument air) are maintained to prevent seal failure.
  - (3) The plant has adequate vents to accomplish gravity feed and

low-pressure makeup when relied upon.

8. Reduced Inventory. **Verify that plant conditions during reduced inventory and midloop operations are appropriately controlled.**

Specific Guidance

Review the unit/outage-specific time-to-boil curves. The time-to-boil period can be less than 30 minutes when DHR is lost under midloop or reduced inventory conditions. During midloop operations, the operator provides the only prevention/mitigating function for a loss of reactor vessel level before the loss of DHR. The plant does not generally have alarms that indicate a loss of level under midloop or reduced inventory conditions. The operator's attention to plant conditions is the key preventative aspect for a loss of DHR event. Closely observe the operator's performance during drain down, and frequently observe control room activities while the plant is under reduced inventory or midloop conditions. Observe how potential control distractions, such as unexpected conditions and emergent work, affect the operator's focus.

For BWR licensees that have adopted reactor pressure vessel water inventory control, review the licensees' drain time calculation and calculation assumptions. Verify that the plant water inventory levels and limiting drain rate are consistent with plant conditions. Verify that TS-required equipment and instrumentation is in the required configuration.

For BWR licensees that have not adopted reactor pressure vessel water inventory control, verify that operations with a potential for draining down the reactor vessel are appropriately managed and comply with TS.

For PWRs, review their commitments from [Generic Letter 88-17](#), "Loss of Decay Heat Removal," dated October 17, 1988, and confirm by sampling that they are still in place and adequate. During midloop operations, observe the effect of distractions from unexpected conditions or emergent activities on the operator's ability to maintain the required reactor vessel level. In addition to reduced inventory and midloop conditions, assess planned outage activities occurring during other periods when there is a short time-to-boil. Verify the following:

- (a) The licensee has reviewed its controls and administrative procedures governing midloop operation and has conducted training for midloop operations.
- (b) The licensee uses procedures for the following:
  - (1) identifying unexpected RCS inventory changes and verifying that an RCS vent path is adequate during RCS draining to midloop
  - (2) emergency/abnormal operation during reduced inventory
- (c) Indications of core exit temperature are operable and periodically monitored (typically at least two independent and continuous indications).



- (d) Indications of RCS water level are operable and periodically monitored (typically at least two independent and continuous indications).
- (e) RCS perturbations are avoided.
- (f) Means of adding inventory to the RCS are available (typically at least two means in addition to residual heat removal pumps).
- (g) Reasonable assurance is obtained that not all hot legs are simultaneously blocked by nozzle dams unless the upper plenum is vented.
- (h) Contingency plans exist to repower vital electrical busses from an alternate source if the primary source is lost.

9. Spent Fuel Pool Cooling. **Verify that outage work is not affecting the ability of the operations staff to operate the spent fuel pool cooling system during and after core offload consistent with the outage/shutdown risk control plan.**

Specific Guidance

Verify the following:

- (a) Spent fuel pool cooling recovery procedures exist for situations that involve loss of spent fuel pool cooling and are based on current/bounding heat loads.
- (b) Operators are trained on backup equipment, **power sources**, and procedures for loss of spent fuel cooling.
- (c) Equipment designated in the recovery procedures is readily available, is dedicated, is unobstructed by outage activities, and has compatible equipment connections.
- (d) Instrumentation, alarms, equipment, instructions, and training are provided to alert operators of the need, and to enable them, to add water to the spent fuel pool when necessary.

10. Heavy Lifts. **Verify that heavy load lifts are appropriately conducted.**

Specific Guidance

See OESS 2007-03, "Crane and Heavy Lift Inspection, Supplemental Guidance to IP 71111.20" for detailed and specific guidance.

11. Refueling. **Verify that reactor core refueling activities are appropriately conducted.**

Specific Guidance

Verify the following:

- (a) Fuel handling operations (removal, inspection, sipping, reconstitution, and insertion) and other ongoing activities are being performed in accordance with TS requirements and approved procedures.
- (b) Refueling seals have been properly installed and tested, and foreign material exclusion is being maintained in the refueling, spent fuel, and suppression pool areas.
- (c) Fuel assembly locations are being tracked, including new fuel, from core offload through core reload. Verify that coupling between the reactivity monitoring instruments and fuel loading location within the core is maintained.
- (d) Fuel assemblies are loaded in the reactor core locations as specified by the design. Verify fuel assembly loading by reviewing video recording, other core loading records, or physics testing results with as-predicted core operating limit parameters.
- (e) Discharged fuel assemblies are placed in allowable locations in the spent fuel pool.

12. Reactivity Control. **Verify that reactivity is being controlled in accordance with the TS. Verify that the outage/shutdown risk control plan identifies activities or structures, systems, and components that could cause unexpected reactivity changes are being appropriately controlled.**

Specific Guidance

Verify that the licensee has established adequate controls during refueling to preclude improper sequencing of control rods or fuel assemblies to prevent any approach to criticality in any core region without early source range monitor detection.

For PWRs, verify that the licensee has implemented appropriate administrative controls on potential boron dilution paths.

d. Startup. **Verify that plant startup activities are appropriately controlled.**

1. Heatup and Startup. **Verify that the licensee has met TS; license conditions; and other requirements, commitments, and administrative procedure prerequisites for mode changes before it changes modes or plant configurations.**

Specific Guidance

- (a) Review the reactor physics testing results. Verify that core operating limit parameters are consistent with the design.
- (b) Review the RCS boundary leakage calculations. Verify that the licensee

has met the TS leakage requirements before making the applicable mode changes.

- (c) Review the status of containment penetrations and containment isolation valves. Verify that the licensee has established containment integrity before entering the applicable TS mode.
- (d) Verify that the licensee is appropriately considering and managing plant risk.

2. **Containment Closure. If containment is opened, conduct a walkdown of containment just before closure.**

Specific Guidance

During required containment walkdowns, verify the following:

- (a) There is no evidence of leakage, and pay attention to areas recently worked.
- (b) There is no debris left adrift that might contribute to emergency core cooling system sump blockage.
- (c) All items brought into the containment during the outage have either been removed or appropriately evaluated to remain inside the containment.
- (d) Maintenance tags have been appropriately cleared.
- (e) Passive systems have no obvious indications of damage (e.g., BWR torus suppression pool strainers).

e. **Fatigue Management. Verify that the licensee appropriately managed worker fatigue during the outage.**

Specific Guidance

Verify licensee has complied with Title 10 of the *Code of Federal Regulations* (10 CFR) 26.205(d)(4) and (5) during the outage.

Consider the following:

- 1. **Outage Work Schedules.** During or after the outage, review actual worked hours by operations, maintenance, and fire brigade personnel during the outage. Verify that
  - (a) Personnel working on outage activities were provided with the minimum days off.
  - (b) The transition from the operating work schedule into the outage work schedule is managed to ensure all work hour control requirements were met.

- (c) Reactor Operators and Senior Reactor Operators on the operating unit, if applicable, are under operating hours control and are not allowed the less restrictive minimum days off requirements for outage activities. Refer to IP 93002, "Managing Fatigue," for additional guidance on work hour control requirements.
2. Waiver Requests, Self-Declarations, and Assessments. Once during or after the outage, review three to five waiver requests (10 CFR 26.207, "Waivers and Exceptions"); self-declarations (10 CFR 26.209, "Self-Declarations"); and fatigue assessments (10 CFR 26.211, "Fatigue Assessments"), when they are available. Verify that the licensee is managing operator fatigue appropriately. IP 93002 provides additional guidance.

## 71111.20-04 REFERENCES

Cross Reference of Generic Communications to IP 71111.20 and Inspection Resources:  
<http://drupal.nrc.gov/nrr/ope/34016> (nonpublic)

Operating Experience:  
<http://drupal.nrc.gov/nrr/ope> (nonpublic)

Operating Experience Smart Sample Directory:  
<http://fusion.nrc.gov/nrr/team/dirs/ioeb/opess/default.aspx> (nonpublic)

IHS Codes and Standards:  
<http://www.internal.nrc.gov/TICS/library/standards/ihs.html> (nonpublic)

NRC Technical Library:  
<http://www.internal.nrc.gov/TICS/library/index.html> (nonpublic)

END

Attachment 1 – Revision History for IP 71111.20

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment Resolution and Closed Feedback Form Accession Number (Pre-Decisional, Non-Public Information)
N/A	04/03/00 CN-00-003	Initial Issuance. Revision history reviewed for the last four years	None	
N/A	ML010820156 03/06/01 CN-01-006	Revised to clarify resource estimates for refueling, non-refueling, and forced outages. The IP was also revised to show the interaction between the shutdown operations SDP and IP 71111.13, "Maintenance Risk Assessments and Emergent Work Evaluation," in performing risk assessments in accordance with 10 CFR 50.65(a)(4).	None	
N/A	ML020400005 01/17/02 CN-02-001	Revised to integrate with IMC 0609, Appendix G, "Shutdown Operations Significance Determination Process," regarding risk insights and how to evaluate inspection findings. It also addresses refueling controls, improper sequencing of control rods or fuel assemblies, reactivity control, and methods to ensure fuel assemblies are loaded in correct positions.	None	
N/A	<a href="#">ML033230221</a> 11/05/03 CN-03-036	Revised to address licensee procedures for foreign material exclusion, instruments tracking plant condition changes, training procedures for BWR alternate decay heat removal. It also cross references IMC 2515, Appendix D, "Plant Status" regarding plant status tours of areas accessible only during outages.	None	
N/A	<a href="#">ML041280023</a> 05/06/04 CN-04-011	Revised to add guidance for containment inspections, when possible, and to add a completion status section.	None	

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment Resolution and Closed Feedback Form Accession Number (Pre-Decisional, Non-Public Information)
N/A	<a href="#">ML052580099</a> 09/02/05 CN-05-024	Revised to add the objective of evaluating licensee activities during reduced inventory and mid-loop conditions to ensure that they appropriately manage risk using commitments made in response to GL 88-17 (Loss of Decay Heat Removal). The IP was also revised to recognize that the need for containment walkdown should factor in containment type with regard to ALARA and heat stress.	None	
NA	<a href="#">ML080300064</a> 01/31/08 CN-08-005	Revised as part of the 2007 ROP realignment to: (1) clarifies when outages should be addressed via IP 71111.20 vs IP 71153, and (2) clarifies annual inspection resources for non-refueling and forced outages.  Incorporated guidance regarding: (1) managing fatigue (IP 93002), (2) containment walkthroughs, and (3) inspection resources in accordance with the 2009 ROP realignment. The revised inspection procedure will take effect on January 1, 2010.	None	<a href="#">ML080250276</a>
NA	<a href="#">ML092090694</a> 11/09/09 CN 09-026	Guidance regarding (1) managing fatigue (IP 93002), (2) containment walkthroughs, and (3) inspection resources in accordance with the 2009 ROP realignment.  Revised to group existing fatigue assessment guidance into a new, separate section, and to add IP 71111.11 as acceptable guidance to observe start-up activities in the control room, based on the 2014 ROP Enhancement Project feedback.	None	<a href="#">ML092780024</a>

Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment Resolution and Closed Feedback Form Accession Number (Pre-Decisional, Non-Public Information)
NA	<a href="#">ML15016A138</a> 01/27/15 CN 15-001	(1) Grouped existing fatigue assessment guidance into new, separate section; and (2) added IP 71111.11 as acceptable guidance to observe start-up activities in the control room (2014 ROP Enhancement Project feedback)	None	71111.20-2046 <a href="#">ML15026A551</a> 71111.20-2047 <a href="#">ML15026A552</a> 71111.20-2048 <a href="#">ML15026A569</a>
	<a href="#">ML17179A651</a> 11/28/17 CN 17-027	Added guidance to review calculations for reactor pressure vessel water inventory control. Eliminated redundancy and improved plain language. Relocated optional requirements to the guidance section to better align with the sample completion requirements in IMC 2515, Section 08.04.	None	<a href="#">ML17184A001</a> 71111.20-2274 <a href="#">ML17205A326</a>
	ML18130A265 12/20/18 CN 18-044	Added heavy load lift review. Revise fatigue monitoring section to allow post outage reviews. Added guidance to assess foreign material controls in the containment.	None	<a href="#">ML18169A319</a> 71111.20-2041 <a href="#">ML16161A014</a> 71111.20-2042 <a href="#">ML16161A018</a> 71111.20-2149 <a href="#">ML16188A081</a> 71111.20-2188 <a href="#">ML16188A093</a>