NEI 12-02 [Revision 1]

# Industry Guidance for Compliance with NRC Order EA-12-051, "To Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation"

August 2012

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A team of highly qualified individuals drawn from the Task Force devoted countless hours to writing and re-writing NEI 12-02. We are grateful for the efforts of the following individuals:

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With the deepest appreciation,
Steven P. Kraft
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# NOTICE

# EXECUTIVE SUMMARY

In studying the sequence of events that took place at Fukushima Daiichi during the accident that occurred due to the March 11, 2011, earthquake and resulting tsunami, the U.S. Nuclear Regulatory Commission (NRC) determined that several near-term actions were needed at U.S. commercial nuclear power plants. Among them was to provide Spent Fuel Pools (SFP) with reliable level instrumentation to significantly enhance the knowledge of key decision makers such that resources are allocated effectively in the event of a very low probability beyond design basis event. Consequently, the NRC issued Order EA-12-051 " *Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation*" (ML12054A679) on March 12, 2012, for all US nuclear plants with an operating license, construction permit or combined construction and operating license.

> "*All licensees … shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred."*

All licensees subject to the technical scope of the NRC Order EA-12-051 shall:

- provide a primary and back-up level instrument that will monitor water level from the normal level to the top of the used fuel rack in the pool;
- provide a display in an area accessible following a severe event; and
- provide independent electrical power to each instrument channel and provide an alternate remote power connection capability.

This guidance document provides additional details on an acceptable approach for complying with NRC Order EA-12-051. In addition, as suggested in section two of NRC EA-12-051:

> *"Additional details on an acceptable approach for complying with this Order will be contained in final interim staff guidance (ISG) scheduled to be issued by the NRC in August 2012."*

The guide provides the industry suggested method for compliance with NRC Order EA-12-051.

AP1000 licensees shall refer to Appendix A-4 of this document for guidance to address the technical scope of the NRC Order for Reliable Spent Fuel Pool Level Instrumentation; the guidance in Appendix A-4 applies *only* to AP1000 plants.

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# 1. Introduction

On March 11, 2011, an earthquake occurred off the coast of Japan that resulted in a tsunami causing considerable damage to several commercial nuclear power plant facilities. The U.S. Nuclear Regulatory Commission (NRC) assembled a response task force to investigate and review the event. The task force recommended a series of actions to be taken by each licensee, and provided a series of orders, a request for information, and rulemaking. These actions were grouped into three tiers to address those items requiring an immediate response as well as items that will require significant time for implementation due to resource limitations or required additional, detailed study. The items to be performed without undue delay were the Tier 1 actions. These Tier 1 actions were approved by the Commission on the one-year anniversary of the accident, and issued to each licensee. One of these Tier 1 actions was to provide reliable spent fuel pool level instrumentation.

The NRC found that providing spent fuel pools with reliable level instrumentation would significantly enhance the knowledge of key decision makers such that resources are allocated effectively in the event of a very low probability beyond design basis accident. The NRC issued Order EA-12-051 " *Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation,*" ML12054A679, on March 12, 2012 (Reference 1) for all US nuclear plants with an operating license, COL (Combined Operating License) or CP (Construction Permit). Each licensee shall, unless granted relief by the NRC, comply with Order EA-12-051 within two fuel cycles following the submittal of the overall integrated plan required by Order EA-12-051 or not later than December 31, 2016, whichever comes first.

The requirement to provide reliable SFP water level instrumentation is independent of other requirements, and the guidance in this document presents an acceptable method for implementing Order EA-12-051. This guidance is complementary to the guidance for implementing Order EA-12-049 (Reference 2), NEI 12-06, *Diverse and Flexible Coping Strategies (FLEX) Implementation Guide*, (Reference 3).

All holders of COLs issued under Part 52, notwithstanding the provisions of any Commission regulation or license to the contrary, comply with the requirements described in Attachment 3 of the Order except to the extent that a more stringent requirement is set forth in the license. These licensees shall promptly start implementation of the requirements in Attachment 3 to the Order and shall complete full implementation prior to fuel load.

The AP1000 standard plant guidance for Attachment 3 is in Appendix A-4.

# 2. Levels of Required Monitoring

## 2.1. Introduction

The NRC issued Order EA-12-051 for Modification of Licenses with Regard to Reliable Spent Fuel Pool Instrumentation on March 12, 2012 (Reference 1). The requirements for the new instrumentation state, in part:

> *All licensees identified in Attachment 1 to this Order shall have a reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.*

## 2.2. Rationale

During the events at Fukushima Daiichi, responders were without reliable instrumentation to determine water level in the spent fuel pool. This led to NRC concerns that the Fukushima Daiichi Unit 4 pool might have boiled dry, resulting in significant fuel damage. The events at Fukushima Daiichi demonstrated the confusion and misapplication of resources that may result from beyond-design-basis external events when reliable spent fuel pool level instrumentation is not available.

## 2.3. Wide Range Pool Level Instrumentation

The requirement from this order is for instrumentation that covers a wide level range within the spent fuel pool. For implementation of this order and guideline a spent fuel pool has the following distinct characteristic:

- is a water-filled structure housing storage racks that contain irradiated fuel discharged from the reactor vessel that has been used for power generation within the last five years, and
- is considered a single spent fuel pool when two or more spent fuel pools are connected by normally open gates designed for under-water transfer of irradiated fuel (refer to Appendix A-3 for further details and examples).

Conversely, for purposes of implementation of this order and guideline, pools that have the following distinct characteristics are not spent fuel pools:

- Spent fuel pools that contain no fuel used in a reactor vessel for power generation within the past five years, or
- Water-filled structures within primary containments that contain temporary fuel storage locations at some Boiling Water Reactors (BWR) and Pressurized Water Reactors (PWR).

The three critical levels that must be monitored in a spent fuel pool are discussed below. It should be noted that continuous indication from a single instrument over the entire span from level 1 to level 3 is not required but could be used. If more than one instrument is used to monitor the entire span, that set of instruments constitutes a single channel satisfying either the primary or backup instrument channel requirement (refer to Figure 1 below).

A visual representation of monitoring levels 1, 2 and 3 and the associated requirements for monitoring between the points are presented in Figure 1. The minimum requirements apply to the separation distance between level indications and support development of appropriate response procedures. These requirements are separate from the instrument channel design accuracy discussed in section 3, which apply to either discrete or to continuous instruments.

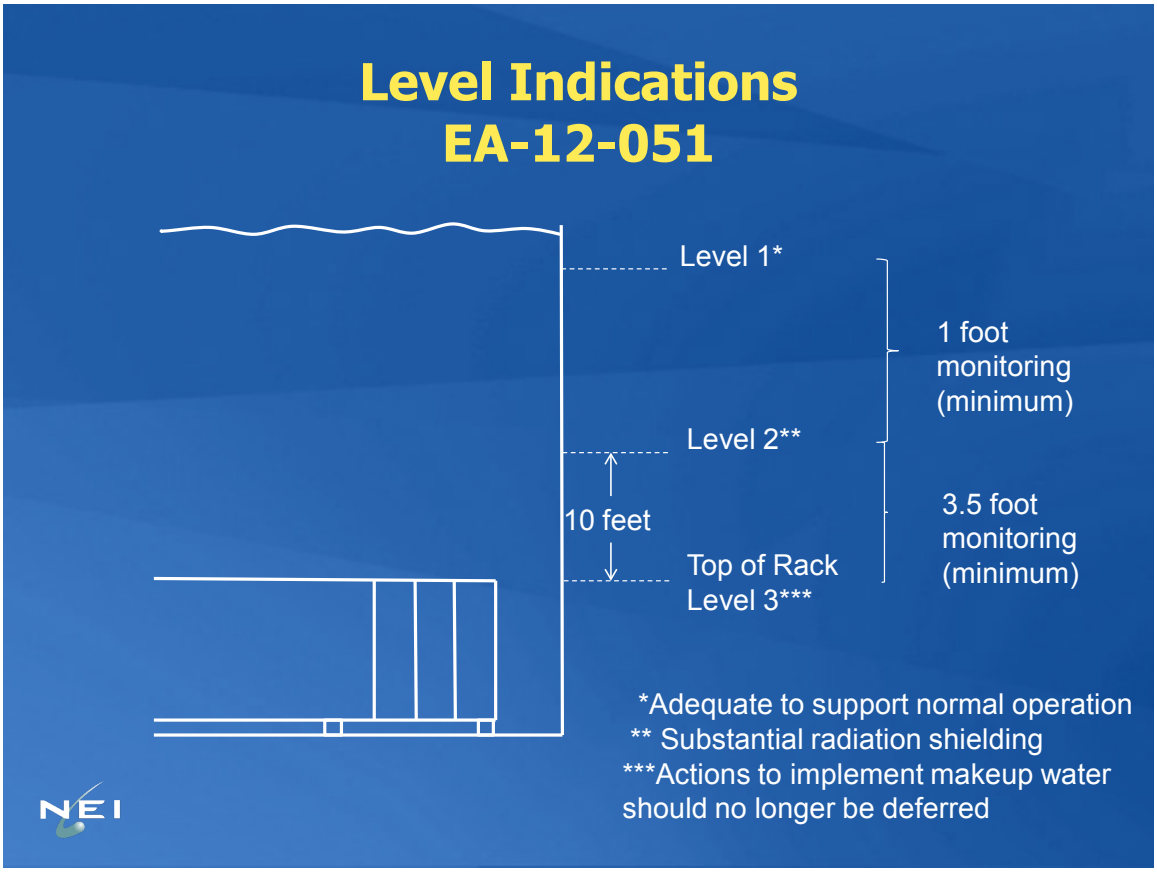


Figure 1

### 2.3.1. Level 1 – level that is adequate to support operation of the normal fuel pool cooling system

A typical fuel pool cooling system design includes a combination of weirs and/or vacuum breakers that prevent siphoning of the pool water level, below a minimum level, in the event of a piping rupture that can affect the SFP level. Level 1 represents the HIGHER of the following two points:

- The level at which reliable suction loss occurs due to uncovering of the coolant inlet pipe, weir or vacuum breaker (depending on the design), or
- The level at which the water height, assuming saturated conditions, above the centerline of the cooling pump suction provides the required net positive suction head specified by the pump manufacturer or engineering analysis.

This level will vary from plant to plant and the instrument designer will need to consult plant-specific design information to determine the actual point that supports adequate cooling system performance.

### 2.3.2. Level 2 – level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck

Level 2 represents the range of water level where any necessary operations in the vicinity of the spent fuel pool can be completed without significant dose consequences from direct gamma radiation from the stored spent fuel. Level 2 is based on either of the following:

- 10 feet (+/- 1 foot) above the highest point of any fuel rack seated in the spent fuel pools, or
- a designated level that provides adequate radiation shielding to maintain personnel radiological dose levels within acceptable limits while performing local operations in the vicinity of the pool. This level shall be based on either plant-specific or appropriate generic shielding calculations, considering the emergency conditions that may apply at the time and the scope of necessary local operations, including installation of portable SFP instrument channel components. Additional guidance can be found in EPA-400 (Reference 4), USNRC Regulatory Guide 1.13 (Reference 5) and ANSI/ANS-57.2-1983 (Reference 6).

Designation of this level should not be interpreted to imply that actions to initiate water make-up must be delayed until SFP water levels have reached or are lower than this point.

### 2.3.3. Level 3 – level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.

Level 3 corresponds nominally (i.e., +/- 1 foot) to the highest point of any fuel rack seated in the spent fuel pool. Level 3 is defined in this manner to provide the maximum range of information to operators, decision makers and emergency response personnel. Designation of this level should not be interpreted to imply that actions to initiate water make-up must or should be delayed until this level is reached.

# 3. Instrumentation Design Features

## 3.1. Instruments

Order Requirement:

*The instrumentation shall consist of a permanent, fixed primary instrument channel and a backup instrument channel. The backup instrument channel may be fixed or portable. Portable instruments shall have capabilities that enhance the ability of trained personnel to monitor spent fuel pool water level under conditions that restrict direct personnel access to the pool, such as partial structural damage, high radiation levels, or heat and humidity from a boiling pool.*

Guidance:

Reliable level indication shall be provided for each spent fuel pool that can be used in responding to beyond design basis external events as described in Order EA-12-051. This instrumentation shall consist of at least one primary and one backup instrument channel. The backup instrument channel may be fixed, portable, or a combination of fixed and portable components. A spent fuel pool level instrument channel is considered reliable when the instrument channel satisfies the design elements listed in Section 3 of this guidance and the plant operator has fully implemented the programmatic features listed in Section 4. Appropriate quality assurance measures are listed in Appendix A-1 (these are similar to those imposed by Regulatory Guide 1.155, "Station Blackout").

Reliable level indication shall be functional (for fixed channels) or functional when installed (for portable channels or combination of fixed and portable component channels) during all modes of operation consistent with paragraph 4.3, Testing and Calibration, below.

Primary and backup instruments that are permanently mounted should meet the criteria below. If portable components are used as part of a backup instrument channel then, to limit personnel resources required for deployment, it shall be designed such that it can easily be deployed by a maximum of two trained personnel within 30 minutes at the spent fuel pool (*i.e.*, no more than 1 person-hour).

Portable instrument components must be placed in service in predetermined accessible locations. However, in anticipation that such predetermined locations may be inaccessible at the time of the event, guidance must be provided to the trained personnel as to how to determine and use alternate locations.

Portable instrument components must be stored in predetermined accessible locations that will not hinder the ability of trained personnel to install the portable components when needed. Portable components of the backup instrument channel must be in protected the manner prescribed in NEI 12-06 for on-site portable FLEX equipment, but no spare components are required.

Wireless and other advanced technologies may be used provided that an evaluation is performed to address their interaction with other plant systems, failure modes, and impact on plant cyber security controls. The use of such wireless technology must be evaluated for any possible adverse impact it may have on other plant equipment likely to be in use at the same time as the wireless SFP instrumentation is functioning. Licensees should

also consider the ability of a wireless communication link to perform in the environment (e.g., high humidity, radiation) in which it may be called upon to function. Wireless technologies must meet the same requirements as wired technologies as specified in this guidance document. Wireless technologies that might be used in either the permanent or backup water level instrument channels are not Critical Digital Assets as defined in NEI 08-09, *Cyber Security Plan for Nuclear Power Reactors* (Reference 7); however, licensees should be cognizant of the logical connections that the wireless system may enable and adhere to the controls in their plant-specific cyber security plans with respect to its implementation.

The time duration for which SFP level instrumentation shall be required to be functional is until additional off-site resources can be obtained, deployed and SFP conditions stabilized as described in NEI 12-06. In determining if the alternate sources of power for the two channels of level instrumentation meet that requirement, reasonable assumptions about intermittent (as opposed to continuous) level monitoring may be made, provided the channels have the capability for intermittent monitoring. If intermittent monitoring is credited, the assumptions shall be consistent with the emergency operating instructions for the equipment and the capability of plant staff to place the level instrumentation into and out of service.

## 3.2. Arrangement

Order Requirement:

*The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the primary instrument channel and fixed portions of the backup instrument channel, if applicable, to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.*

Guidance:

The intent of the arrangement requirement is to specify reasonable separation and missile protection requirements for permanently installed instrumentation used to meet this order. Although additional missile barriers are not required to be installed, separation and shielding can help minimize the probability that damage due to an explosion or extreme natural phenomena (e.g., falling or wind-driven missiles) will render fixed channels of SFP instrumentation unavailable. Installation of the SFP instrument channels shall be consistent with the plant-specific SFP design requirements and should not impair normal SFP function.

Channel separation should be maintained by locating the installed sensors in different places in the SFP area. If practical, examples of sensor location arrangements are

- on opposite sides or corners of the pool area,
- separated by a distance comparable to the shortest length of a side of the pool,
- in recesses of the pool to maximize the inherent missile protection provided by the pool walls,
- cask decontamination pits and fuel transfer tube areas, or

- next to or connected to structures that are securely connected to the side of the pool (e.g., a new fuel elevator), which may provide some protection from falling debris or missiles.

Provisions for portable instruments should also consider the need for physical separation. Plans for portable instrument use should allow inserting and operating the sensors and associated equipment in a different part of the SFP from the permanent channel. Ideally the portable channel will be able to use multiple (or all) SFP locations.

Similarly, cabling for power supplies and indications for each channel should be routed separately from cabling for the other channels.

To the extent not otherwise covered in this guidance, the reasonable protection guidance outlined in NEI 12-06 to meet Order EA-12-049 should be used to provide protection for installed and portable channels from external hazards. At a minimum, cables routed outside structures should be protected in buried conduit and designed to commercial standards for submergence.

## 3.3. Mounting

Order Requirement:

*Installed instrument channel equipment within the spent fuel pool shall be mounted to retain its design configuration during and following the maximum seismic ground motion considered in the design of the spent fuel pool structure.*

Guidance:

These order requirements apply to any SFP level instrument channel equipment that is permanently installed in the SFP. Consideration shall be given to the maximum seismic ground motion to the design basis of the SFP structure.

The mounting shall be designed consistent with the highest seismic or safety classification of the SFP. An evaluation of other hardware stored in the SFP shall be conducted to ensure it will not create adverse interaction with the fixed instrument location(s).

The basis for the seismic design for mountings in the SFP shall be the plant seismic design basis at the time of submittal of the Integrated Plan for implementing NRC Order EA-12-051 (See Appendix A-2-2). Should the plant seismic design basis change, changes to the seismic design for mountings in the SFP will be processed in accordance with the procedures for such changes at the plant.

## 3.4. Qualification

Order Requirement:

*The level instrument channels shall be reliable at temperature, humidity and radiation levels consistent with the spent fuel pool water at saturation conditions for an extended period. This reliability shall be established through the use of an augmented quality assurance process (e.g. a process similar to that applied to the site fire protection program).*

Guidance:

The instrument channel reliability shall be demonstrated via an appropriate combination of design, analyses, operating experience, and/or testing of channel components for the following sets of parameters, as described in the paragraphs below:

- conditions in the area of instrument channel component use for all instrument components,
- effects of shock and vibration on instrument channel components used during any applicable event for only installed components, and
- seismic effects on instrument channel components used during and following a potential seismic event for only installed components.

Selection of instrument channel components should consider ease and simplicity of design and replacement after the event. Readily available commercial components shall be considered. See section 4.2, Procedures, for guidance on instrument channel component replacement at the time of an event or thereafter until the unit is returned to normal service.

**Conditions**

The temperature, humidity and radiation levels consistent with conditions in the vicinity of the SPF and the area of use considering normal operational, event and post-event conditions for no fewer than seven days post-event or until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049 should be considered. Examples of post-event (beyond-design-basis) conditions to be considered are:

- radiological conditions for a normal refueling quantity of freshly discharged (100 hours) fuel with the SFP water level 3 as described in this order,
- temperatures of 212 degrees F and 100% relative humidity environment,
- boiling water and/or steam environment,
- a concentrated borated water environment, and
- the impact of FLEX mitigating strategies.

**Shock and Vibration**

For the effects of shock and vibration in the area of instrument channel component use after an event for applicable components (with the exception of battery chargers and replaceable batteries), the following measures are acceptable to verify that the design and installation is adequate. This qualification does not apply to the mounting of components, which is discussed in section 3.3.

Applicable components of the instrument channels are rated by the manufacturer (or otherwise tested) for shock and vibration at levels commensurate with those of postulated design basis event conditions in the area of instrument channel component use using one or more of the following methods:

- instrument channel components use known operating principles, are supplied by manufacturers with commercial quality programs (such as ISO9001) with shock and vibration requirements included in the purchase specification and/or instrument design, and commercial design and testing for operation in environments where significant shock and vibration loadings are common, such as for portable hand-held devices or transportation applications;
- substantial history of operational reliability in environments with significant shock and vibration loading, such as transportation applications; or
- use of components inherently resistant to shock and vibration loadings or are seismically reliable such as cables.

**Seismic**

For seismic effects on instrument channel components used after a potential seismic event for only installed components (with the exception of battery chargers and replaceable batteries), the following measures are acceptable to verify that the design and installation is adequate. This qualification does not apply to mounting of components, which is discussed in section 3.3.

Applicable components of the instrument channels are rated by the manufacturer (or otherwise tested) for seismic effects at levels commensurate with those of postulated design basis event conditions in the area of instrument channel component use using one or more of the following methods:

- instrument channel components use known operating principles, are supplied by manufacturers with commercial quality programs (such as ISO9001) with seismic requirements included in the purchase specification and/or instrument design, and commercial design and testing for operation in environments where significant seismic effects are common;
- substantial history of operational reliability in environments with significant vibration, such as for portable hand-held devices or transportation applications;
- demonstration of seismic reliability using methods that predict the equipment's performance by
    - analysis,
    - testing of the equipment under simulated seismic conditions,
    - using a combination of test and analysis, or
    - the use of experience data.
- demonstration that proposed devices are substantially similar in design to models that have been previously tested for seismic effects in excess of the plant design basis at the location where the instrument is to be installed (g-levels and frequency ranges); or
- seismic qualification using seismic motion consistent with that of existing design basis loading at the installation location.

**General**

The basis for the seismic qualification for instrument channel components shall be the plant seismic design basis at the time of submittal of the Integrated Plan for implementing NRC Order EA-12-051 (See Appendix A-2-2). Should the plant seismic design basis change, changes to the instrument channel component qualifications will be processed in accordance with the procedures for such changes at the plant.

The instrument channel components do not have to be qualified for missile impact. Meeting the arrangement requirements in Section 3.2 will satisfy the missile protection requirements of Order EA-12-051.

The quality assurance process to be applied is provided in Appendix A-1.

These qualifications do not apply to any plant systems, components or structures that are not part of the SFP instrumentation channel, even if such plant systems, components, or structures are connected, attached or otherwise relied upon for the SPF instrumentation channel to remain functional.

## 3.5. Independence

Order Requirement:

*The primary instrument channel shall be independent of the backup instrument channel.*

Guidance:

Independence of permanently installed instrumentation, and primary and backup channels, is obtained by physical and power separation commensurate with the hazard and electrical isolation needs. If plant AC or DC power sources are used then the power sources shall be from different buses and preferably different divisions/channels depending on available sources of power. Use of stand-alone battery powered channels is acceptable. For two (2) permanently mounted (fixed) instruments in the pool, they should be separated to the extent practicable considering existing spent fuel pool construction (reference Section 3.2). Instrument technologies of the two (2) channels may be the same. Use of diverse technologies is not required, but may lessen the potential failure of all instrument channels

## 3.6. Power Supplies

Order Requirement:

*Permanently installed instrumentation channels shall each be powered by a separate power supply. Permanently installed and portable instrumentation channels shall provide for power connections from sources independent of the plant ac and dc power distribution systems, such as portable generators or replaceable batteries. Onsite generators used as an alternate power source and replaceable batteries used for instrument channel power shall have sufficient capacity to maintain the level indication function until offsite resource availability is reasonably assured.*

Guidance:

The normal electrical power supply for each channel shall be provided by different sources such that the loss of one of the channels primary power supply will not result in a loss of power supply function to both channels of SFP level instrumentation.

All channels of SFP level instrumentation shall provide the capability of connecting the channel to a source of power (e.g., portable generators or replaceable batteries) independent of the normal plant AC and DC power systems. For fixed channels this alternate capability shall include the ability to isolate the installed channel from its normal power supply or supplies. The portable power sources for the portable and installed channels shall be stored at separate locations, consistent with the reasonable protection requirements associated with NEI 12-06 (Order EA-12-049). The portable generator or replaceable batteries should be accessible and have sufficient capacity to support reliable instrument channel operation until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049

If adequate power supply for either an installed or portable level instrument credits intermittent operation, then the provisions shall be made for quickly and reliably taking the channel out of service and restoring it to service. For example, a switch on the power supply to the channel is adequate provided the power can be periodically interrupted without significantly affecting the accuracy and reliability of the instrument reading. Continuous indication of SFP level is acceptable only if the power for such indication is demonstrably adequate for the time duration specified in section 3.1

## 3.7. Accuracy

Order Requirement:

*The instrument channels shall maintain their designed accuracy following a power interruption or change in power source without recalibration.*

Guidance:

The instrument channels shall maintain their designed accuracy following a power interruption or change in power source without recalibration. Accuracy should consider SFP conditions, *e.g.*, saturated water, steam environment, or concentrated borated water. Additionally, instrument accuracy should be sufficient to allow trained personnel to determine when the actual level exceeds the specified lower level of each indicating range (levels 1, 2 and 3) without conflicting or ambiguous indication.

## 3.8. Testing

Order Requirement:

*The instrument channel design shall provide for routine testing and calibration.*

Guidance:

Static or non-active installed (fixed) sensors can be used and should be designed such that testing and /or calibration can be performed in-situ. For microprocessor based channels the instrument channel design shall be capable of testing while mounted in the pool.

Back-up portable channels shall be designed such that calibration does not require the use of any additional test or reference equipment at the time of deployment, i.e., plug-and-play type technology.

Other testing and calibration requirements are located in Section 4.3. Existing work control processes may be used to control maintenance and testing. (*e.g.*, PM Program, Surveillance Program, Vendor Contracts, or work orders).

## 3.9. Display

Order Requirement:

*Trained personnel shall be able to monitor the spent fuel pool water level from the control room, alternate shutdown panel, or other appropriate and accessible location. The display shall provide on-demand or continuous indication of spent fuel pool water level.*

Guidance:

The intent of this guidance is to ensure that information on SFP level is promptly available to the plant staff and decision makers. Ideally there will be an indication from at least one channel of instrumentation in the control room. While it is generally recognized (as demonstrated by the events at Fukushima Daiichi) that SFP level will not change rapidly during a loss of spent fuel pool cooling scenario more rapid SFP drain down cannot be entirely discounted. Therefore, the fact that plant personnel are able to determine the SFP level will satisfy this requirement, provided the personnel are available and trained in the use of the SFP level instrumentation (see Section 4.1) and that they can accomplish the task when required without unreasonable delay.

SFP level indication from the installed channel shall be displayed in the control room, at the alternate shutdown panel, or another appropriate and accessible location (reference NEI 12-06). An appropriate and accessible location shall include the following characteristics:

- occupied or promptly accessible to the appropriate plant staff giving appropriate consideration to various drain down scenarios,
- outside of the area surrounding the SFP floor, e.g., an appropriate distance from the radiological sources resulting from an event impacting the SFP,
- inside a structure providing protection against adverse weather, and
- outside of any very high radiation areas or LOCKED HIGH RAD AREA during normal operation.

If multiple display locations beyond the required “appropriate and accessible location” are desired, then the instrument channel shall be designed with the capability to drive the multiple display locations without impacting the primary “appropriate and accessible” display.

SFP level indication from a portable channel shall be displayed in an accessible location.

# 4. Program Features

## 4.1. Training

Order Requirement:

*Personnel shall be trained in the use and the provision of alternate power to the primary and backup instrument channels.*

Guidance:

The personnel performing functions associated with these SFP level instrumentation channels shall be trained to perform the job specific functions necessary for their assigned tasks (maintenance, calibration, surveillance, etc.). SFP instrumentation should be installed via the normal modification processes. In some cases, utilities may choose to utilize portable instrumentation as a portion of their SFP instrumentation response. In either case utilities should use the Systematic Approach to Training (SAT) to identify the population to be trained. The SAT process should also determine both the initial and continuing elements of the required training.

## 4.2. Procedures

Order Requirement:

*Procedures shall be established and maintained for the testing, calibration, and use of the primary and backup spent fuel pool instrument channels.*

Guidance:

Procedures will be developed using guidelines and vendor instructions to address the maintenance, operation and abnormal response issues associated with the new SFP instrumentation. For portable instruments, the procedures will also specify storage location and installation activities.

If, at the time of an event or thereafter until the unit is returned to normal service, an instrument channel ceases to function, its function must be recovered within a period of time consistent with the emergency conditions that may apply at the time.

If, at the time of an event or thereafter until the unit is returned to normal service, an instrument channel component must be replaced, it is acceptable to use commercially available components that may or may not meet all of the qualifications (Section 3.4) to maintain the instrument channel functionality.

All licensees shall have a strategy to ensure SFP water level addition is initiated at an appropriate time consistent with the implementation of NEI 12-06.

## 4.3. Testing and Calibration

Order Requirement:

*Processes shall be established and maintained for scheduling and implementing necessary testing and calibration of the primary and backup spent fuel pool level instrument channels to maintain the instrument channels at the design accuracy.*

Guidance:

Processes shall be established and maintained for scheduling and implementing necessary testing and calibration of the primary and backup SFP level instrument channels to maintain the instrument channels at the design accuracy. The testing and calibration of the instrumentation shall be consistent with vendor recommendations or other documented basis. Calibration shall be specific to the mounted instrument and the monitor.

Surveillances or testing to validate functionality of an installed instrument channel shall be performed within 60 days of a planned refueling outage considering normal testing scheduling allowances (e.g., 25%). This is not required to be performed more than once per 12 months.

The primary or back-up instrument channel can be out of service for testing, maintenance and/or calibration for up to 90 days provided the other channel is functional. Additionally, compensatory actions must be taken if the instrumentation channel is not expected to be restored or is not restored within 90 days. If both channels become non-functioning then initiate actions within 24 hours to restore one of the channels of instrumentation and implement compensatory actions (e.g., use of alternate suitable equipment or supplemental personnel) within 72 hours.

If a single SFP for the purposes of this order is divided by the closure of a normally open gate(s) such that a portion of the SFP containing fuel used for power production within the last five years is no longer able to be monitored by a required SFP instrumentation channel, then the actions described above must be taken for the impacted instrumentation channel.

# 5. References

1. USNRC, Letter EA-12-051, "Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation," March 12, 2012.

2. USNRC, Letter EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis external Events," March 12, 2012.

3. NEI 12-06, *Diverse and Flexible Coping Strategies (FLEX) Implementation Guide,* version endorsed by the NRC.

4. US Environmental Protection Agency, "Manual of Protection Action Guides and Protective Actions for Nuclear Incidents," EPA-400-R-92-001, May 1992.

5. USNRC, Regulatory Guide 1.13, Revision 2, "Spent Fuel Storage Facility Design Basis," March 2007.

6. ANSI/ANS 57.2 – 1983, "Requirements for Light Water Reactor Spent Fuel Storage Facilities," W1993.

7. NEI 08-09, *Cyber Security Plan for Nuclear Power Reactors,* April 2010.

# Appendices

## *A-1. Quality Assurance*

The QA guidance provided here is applicable to non-safety systems and equipment used to meet the requirements of this document that is not already explicitly covered by existing QA requirements. Additionally, non-safety equipment installed to meet this document must be implemented so that it does not degrade the existing safety-related systems. Activities should be implemented from this section as appropriate, depending on whether the equipment is being added (new) or is existing.

### A-1-1. Design Control and Procurement Document Control

Measures should be established to ensure that all design related guidelines used in complying with this document are included in design and procurement documents, and that deviations there from are controlled.

### A-1-2. Instructions, Procedures and Drawings

Inspections, tests, administrative controls, and training necessary for compliance with this document should be prescribed by documented instructions, procedures, and drawings and should be accomplished in accordance with these documents.

### A-1-3. Control of Purchased Material, Equipment and Services

Measures should be established to ensure that purchased material, equipment, and services conform to the procurement documents.

### A-1-4. Inspection

A program for independent inspection of activities required to comply with this document should be established and executed by or for the organization performing the activity to verify conformance with documented installation drawings and test procedures for accomplishing the activities.

### A-1-5. Testing and Test Control

A test program should be established and implemented to ensure that testing is performed and verified by inspection and audit to demonstrate conformance with design and system readiness requirements. The tests should be performed in accordance with written test procedures; test results should be properly evaluated and acted on.

### A-1-6. Inspection, Test, and Operating Status

Measures should be established to identify items that have satisfactorily passed required tests and inspections.

### A-1-7. Nonconforming Items

Measures should be established to control items that do not conform to specified requirements to prevent inadvertent use or installation.

### A-1-8. Corrective Action

Measures should be established to ensure that failures, malfunctions, deficiencies, deviations, defective components, and non-conformances are promptly identified, reported, and corrected.

### A-1-9. Records

Records should be prepared and maintained to furnish evidence that the criteria enumerated above are being met for activities required to comply with this document.

### A-1-10. Audits

Audits should be conducted and documented to verify compliance with design and procurement documents, instructions, procedures, drawings, and inspection and test activities developed to comply with this document.

## *A-2. Order Response Template*

Order Requirement:

*All holders of operating licenses issued under Part 50 shall by February 28, 2013, submit to the Commission for review an overall integrated plan, including a description of how compliance with the requirements described in Attachment 2 will be achieved.*

*All Licensees and CP holders shall provide an initial status report sixty (60) days after the issuance of the final ISG, and at six (6) month intervals following submittal of the overall integrated plan, as required in Condition C.1, which, delineates progress made in implementing the requirements of this Order.*

Guidance:

The following content is suggested for the reports required by the order

### A-2-1. 60-Day Progress Report

- Acknowledgement of availability of guidance
- Plan to submit Integration Plan

### A-2-2. Overall Integrated Plan

- See next page

### A-2-3. Six-Month Progress Reports

- Any changes in compliance method
- Schedule
- Need for relief and basis, if any

## Overall Integrated Plan Guidance

[Words in *italics* are meant as examples for how to present information based on individual plans.]

**Applicability:**

This integrated plan applies to [*Unit*] [*and Uni*t].

**Schedule:**

[Single Unit Spent Fuel Pool - The installation of reliable spent fuel pool level instrumentation for the spent fuel pool associated with [*Unit*] is scheduled for completion prior to [*November 30, 2015*] [*based on the end of the second refueling outage following the submittal of this integrated plan*.]]

[Multiple Unit Spent Fuel Pool - The installation of reliable spent fuel pool level instrumentation for the spent fuel pool associated with [*Unit*] [*and Unit*] is scheduled for completion prior to [*November 30, 2015*] [based on the end of the second refueling outage for [*Unit*] following the submittal of this integrated plan.] *[This is the [earlier/later] outage sequence of the units discharging to the pool.] [The schedule is based on the later outage sequence because…]]*

[Associated Spent Fuel Pool Configuration:

[*Unit*] [*and Unit*] discharge irradiated fuel to a [*single*][*shared*][*set of {2} interconnected*] spent fuel storage pool[s]. [*With the exception of limited time periods for maintenance or non-refueling operations, administrative controls maintain gates between the following pools open: [spent fuel pool {A}], [spent fuel pool {B}], [fuel transfer canal to [Unit]], and [cask loading pit]. Thus, these pools are normally inter-connected and at the same water level when the water level in the spent fuel pool is greater than [1 foot] above the top of stored fuel seated in the storage racks.*]

**Identification of Spent Fuel Pool Water Levels:**

Key spent fuel pool water levels will be identified as follows:

- Level adequate to support operation of the normal fuel pool cooling system – Indicated level on either the primary or backup instrument channel of greater than [*x feet*] above the top of stored fuel seated in the storage racks based on the design accuracy of the instrument channel [*of+/- y feet for both the primary and backup instrument channels*] and [*a calculation demonstrating a water level of x-y feet is adequate for normal fuel pool cooling system operation.*]

- Level adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck - Indicated level on either the primary or backup

instrument channel of greater than [*10 feet*] above the top of stored fuel seated in the storage racks based on [describe the reason the selected level provides adequate shielding for necessary operations] *[specification of this level as adequate in NRC JLD ISG 2012-03 and NEI 12-02, the design accuracy of the instrument channel, and the relatively low sensitivity of dose rate to changes in water depth at this level*]. This monitoring level ensures there is an adequate water level to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck.

- Level where fuel remains covered - Indicated level on either the primary or backup instrument channel of greater than [*x foot*] above the top of stored fuel seated in the storage racks based upon design accuracy of the instrument channel [*of+/-y feet*] for both the primary and backup instrument channels *[and location of the primary and backup instrument channel sensing components in areas separated from the fuel storage area by weirs or gates no more than x-y feet above the top of stored fuel*]. This monitoring level assures that there is adequate water level above the stored fuel seated in the rack *[and adequate communication between the instrument location and the pool]*.

**Instruments:**

The design of the instruments will be consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02[, *with the exceptions and clarifications noted below*.] Specifically, the channels will be designed as discussed below.

**Primary (fixed) instrument channel**: The primary instrument channel level sensing component[*s*] will be located in [*the cask loading pit*]. [For locations outside of the spent fuel pool, a description of the how the location provides the appropriate water level coupling to the spent fuel pool should be provided.] The primary instrument channel will provide [describe technology of instrument, the instrument range, and how the instrument provides indication of the required levels] *[continuous level indication over a range from [x feet] to [x feet]][and ][discrete level indications at [x feet and x feet]] above the top of stored fuel seated in the storage racks. [The continuous level indication will be provided by a [pressure transmitter]. The discrete level indication will be provided by [level switches]]*.

**Backup instrument channel**: The backup instrument channel level sensing component[*s*] consist of [*[both portable and] [fixed] components. [The portable components will be deployed in [spent fuel pool A], and] the fixed components are located in [the transfer canal adjacent to spent fuel pool A]*]. The backup instrument channel will provide [*continuous level indication over a range from [x feet] to [x feet] [and] discrete level indications at [x feet and x feet]*] above the top of stored fuel seated in the storage racks. [*The continuous level indication will be provided by a [portable ultrasonic level detector] and the discrete level indication will be provided by [level switches]*.]

**Reliability:**

Reliability of the primary and backup instrument channels will be assured by conformance with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02[, *with the exceptions and clarifications noted below:*]

[*Plant-specific response*]

**Instrument Channel Design Criteria:**

Consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02[, *with the exceptions and clarifications noted below*:]

**Arrangement:** [*Plant-specific response*]

**Mounting:** [*Plant-specific response*]

**Qualification:** [*Plant-specific response*]

**Independence:** [*Plant-specific response*]

**Power Supplies:** [*Plan- specific response*]

The power supplies for the instrument channels are arranged as follows:

- *[The primary instrument channel normally receives power from plant direct current power, and this power supply can be separated from the channel with a disconnect switch and replaced by battery power for intermittent monitoring.]*
- *[The backup instrument channel components are all powered by batteries maintained in a charged state by commercial-grade uninterruptible power supplies. The battery for power supply supporting intermittent monitoring is sized to be capable of supporting the channel operations for a minimum of X days of operation, before being replaced with a fresh battery, until off-site resources can be deployed by the mitigating strategies resulting from Order EA-12-049.]*

**Accuracy:**

The accuracy will be consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02[, *with the exceptions and clarifications noted below:*]

[The plan shall describe how conflicting and/or ambiguous indications will be avoided through the overall design of both the primary and backup instrument channels. This shall include specific design accuracies for both normal and design-basis accident conditions. The instrument design accuracy shall include the display accuracy.]

[*Plant-specific response*]

**Testing:**

Testing will be consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02[*, with the exceptions and clarifications noted below:*]

[*Plant-specific response*]

**Display:**

The primary instrument display will be located in (at) the [*control room, auxiliary shutdown panel, or described accessible location*. *The backup instrument channel display will use wireless data transmission to a portable, battery-powered display.*] The display will be consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02[, *with the exceptions and clarifications noted below:*]

[P*lant-specific response*]

**Instrument Channel Program Criteria:**

The program criteria will be consistent with the guidelines of NRC JLD-ISG-2012-03 and NEI 12-02[*, with the exceptions and clarifications noted below:*]

[*Plant-specific response*]

**Need for relief and basis, if any.**

## *A-3. Implementation Considerations*

For plant sites (units) with shared SFPs (two or more SFPs connected by normally open gates designed for under-water transfer of irradiated fuel) the shared pool(s) may be treated as a single SFP and the latest of the unit's 2nd refueling outage post Feb. 28, 2013, or Dec. 31, 2016, whichever is earlier, will determine the implementation deadline for the actions from this order for that plant site. However, this clarification needs to be stated in the Integrated Plan Submittal and an appropriate justification on the need for invoking this clarification should be included with the plan.

An example of justifications for use of this clarification is a plant with physical constraints that dictate the instrument channel components need to be routed during a refueling outage associated with the later unit (as defined above). This constraint could be breach of containment boundaries for penetrations or mountings, location of connected buses during one refueling outage versus another.

# *A-4. AP1000 Spent Fuel Pool Instrumentation Guidance*

[This Appendix applies *only* to AP1000 plants.]

## A-4-1 Introduction (2.1)

AP1000 is required to provide reliable indication of the water level in associated spent fuel storage pools capable of supporting identification of the following pool water level conditions by trained personnel: (1) level that is adequate to support operation of the normal fuel pool cooling system, (2) level that is adequate to provide substantial radiation shielding for a person standing on the spent fuel pool operating deck, and (3) level where fuel remains covered and actions to implement make-up water addition should no longer be deferred.

## A-4-2 Background (2.2)

The design bases of AP1000 address many of these attributes of spent fuel pool level instrumentation. The NRC staff reviewed these design features prior to issuance of the combined licenses for these facilities and certification of the AP1000 design referenced therein. The AP1000 certified design largely addresses the above requirements by providing two safety-related spent fuel pool level instrument channels. The instruments measure level from the top of the spent fuel pool to the top of the fuel racks to address the range requirements listed above. The safety-related classification provides for the following additional design features:

- Seismic and environmental qualification of the instruments
- Independent power supplies
- Electrical isolation and physical separation between instrument channels
- Display in the control room as part of the post-accident monitoring instrumentation
- Routine calibration and testing

## A-4-3 Requirements

AP1000 is required to address the following requirements that were not specified in the certified design.

## A-4-4 Arrangement (3.2)

Order Requirement:

*The spent fuel pool level instrument channels shall be arranged in a manner that provides reasonable protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. This protection may be provided by locating the safety-related instruments to maintain instrument channel*

*separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.*

*Guidance*

Protection against missiles should be described, noting the protection that may be provided by location of the safety-related instruments and their associated connections below the operating deck. Describe the arrangement and basis for why the operating deck provides protection of the level indication function against missiles that may result from damage to the structure over the spent fuel pool. Alternatively, provide description of the features for additional protection that may be provided by the location the safety-related instruments to maintain instrument channel separation within the spent fuel pool area, and to utilize inherent shielding from missiles provided by existing recesses and corners in the spent fuel pool structure.

## A-4-5 Qualification (3.4)

Order Requirement:

*The level instrument channels shall be reliable at temperature, humidity, and radiation levels consistent with the spent fuel pool water at saturation conditions for an extended period.*

*Guidance*

Provide a description of the instrumentation sensors and their capability to operate in the environmental conditions that they will experience during design basis events, noting that for the AP1000 design basis conditions include a SBO with steaming in the SFP. The environmental conditions to be addressed should include appropriate consideration for temperature, humidity, steaming, radiation, and seismic activity (SSE) levels where the sensors are located. Provide information to demonstrate the reliability of the instrument under these conditions.

Appropriate evaluations should also be provided to demonstrate the operability of these sensors for indefinite SBO durations.

## A-4-6 Power Supplies (3.6)

Order Requirement:

*Instrumentation channels shall provide for power connections from sources independent of the plant alternating current (ac) and direct current (dc) power distribution systems, such as portable generators or replaceable batteries. Power supply designs should provide for quick and accessible connection of sources independent of the plant ac and dc power distribution systems. Onsite generators used as an alternate power source and replaceable batteries used for instrument channel power shall have sufficient capacity to*

*maintain the level indication function until offsite resource availability is reasonably assured.*

*Guidance*

Provide a description of the design features provided to ensure continuous power supply to the instrumentation for extended loss of power conditions. The AP1000 design provides extended SFP monitoring capability with two trains of dedicated class 1E DC power supply for at least 72 hours of post accident monitoring. Beyond the initial 72 hours, the response shall detail how the instrument power supply can be met by the use of offsite portable generators with quick and accessible connection points and sufficient capacity to maintain level indication indefinitely. The capability to use both onsite and offsite equipment should be discussed as well as the availability of clear guidance for the operator as part of the AP1000 post-72 hours procedures per AP1000 DCD Section 1.9.5.4.

## A-4-7 Accuracy (3.7)

Order Requirement:

*The instrument shall maintain its designed accuracy following a power interruption or change in power source without recalibration.*

*Guidance*

As discussed under Section A-4-3.3the AP1000 design provides means for continued power supply to the spent fuel pool level instrumentation, relying for the first 72 hours only on class 1E batteries. The power supply can then be extended indefinitely by various means as described in Section A-4-3.3

Additionally, the potential impact on temporary loss of power to the level instrument shall be discussed and evaluated in this section including confirmation that the instruments would not need to be re-calibrated following a loss of power.

The instrument should be discussed to address sufficient accuracy during SBO conditions which includes boiling of the SFP water.

## A-4-8 Display (3.9)

Order Requirement:

*The display shall provide on-demand or continuous indication of spent fuel pool water level.*

*Guidance*

For the first 72 hours, provide details regarding the continuous display provided in the Main Control Room with power provided by the class 1E batteries. For Post 72 hours, describe the features of the Main Control Room display and use of power supplies described in Section A-4-3.3. Describe the SFP water level display features. Provide a description of appropriate alarms for low water level. The display requirement may be described by reference to appropriate instrumentation datasheets, specifications, and other relevant documentation.

## A-4-9 Programmatic Controls (4)

Order Requirement:

*The spent fuel pool instrumentation shall be maintained available and reliable through appropriate development and implementation of a training program. Personnel shall be trained in the use and the provision of alternate power to the safety-related level instrument channels.*

*Guidance*

As noted in the background, the safety-related classification of the AP1000 spent fuel level instrumentation ensures routine calibration and testing of the instrumentation, which maintains the equipment as available and reliable. The training program shall be described to provide training to personnel in the use and the provision of alternate power supplies to the existing ac or dc power distribution system to power the instrument channels consistent with the post-72 hours procedures detailed in DCD Section 1.9.5.4. Implemented procedures consistent with the training program shall be summarized and clarified as part of the response.