

Branch Technical Position HICB-10

Guidance on Application of Regulatory Guide 1.97

A. Background

This branch technical position (BTP) provides additional guidelines for reviewing an applicant/licensee's post-accident monitoring system. These guidelines are based on reviews of applicant/licensee design submittals that contained approved interpretations and alternatives for the guidance identified in Reg. Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident."

1. Regulatory Basis

10 CFR 50.34(f)(2)(xvii), "Accident Monitoring Instrumentation," requires in part that instrumentation be provided to measure, record, and read out in the control room: containment pressure, containment water level, containment hydrogen concentration, containment radiation intensity (high-level), and noble gas effluents.

10 CFR 50 Appendix A, General Design Criterion (GDC) 13, "Instrumentation and Control," requires in part that instrumentation be provided to monitor variables and systems over their anticipated ranges for accident conditions, as appropriate, to ensure adequate safety.

10 CFR 50 Appendix A, GDC 19, "Control Room," requires in part that a control room be provided from which actions can be taken to maintain the nuclear power unit in a safe condition under accident conditions, including loss-of-coolant accidents. It also requires that equipment, including the necessary instrumentation, be provided at appropriate locations outside the control room; such equipment must have a design capability for prompt, hot shutdown of the reactor.

10 CFR 50, Appendix A, GDC 64, "Monitoring Radioactivity Releases," requires in part that means be provided to monitor (1) the reactor containment atmosphere, (2) spaces containing components for recirculation of loss-of-coolant accident fluid, (3) effluent discharge paths, and (4) the plant environs for radioactivity that may be released from postulated accidents.

2. Relevant Guidance

Reg. Guide 1.97 describes a method acceptable to the NRC staff for complying with the NRC's regulations to provide instrumentation to monitor plant variables and systems during and following an accident in a light-water-cooled nuclear power plant.

Applicant/licensees may base design submittals upon Reg. Guide 1.97, Revision 2 or Revision 3.

3. Purpose

The purpose of this BTP is to provide additional guidance for NRC reviewers to verify that the previously cited regulatory bases are met by an applicant/licensee's submittal. This BTP has one objective:

- Provide supplemental guidance that clarifies the Staff position and identifies alternatives acceptable to the Staff for satisfying the guidelines identified in Reg. Guide 1.97.

B. Branch Technical Position

1. Introduction

Applicant/licensees have provided design submittals to the Staff containing interpretations of guidelines identified in Reg. Guide 1.97. In some cases, applicant/licensees have requested relief from selected guidelines. Where the applicant/licensee provided adequate justification, the Staff has accepted alternatives to implementing specific provisions of Reg. Guide 1.97. The Staff documented the basis for this acceptance in various safety evaluation reports. Staff positions and clarifications applicable to various classes of plant designs emerged from these applicant/licensee-specific safety evaluations. These positions included identification of specific designs acceptable to the Staff for instrumentation to assess plant and environs conditions during and following an accident.

2. Information to be Reviewed

The information to be reviewed for post-accident monitoring systems is in the SRP Section 7.5.

3. Acceptance Criteria

The design and qualification criteria identified in Reg. Guide 1.97 should be supplemented by the considerations outlined below:

Environmental Qualification of Category 1 and 2 Instrumentation

10 CFR 50.49(b)(3) has been interpreted by the Staff to require that all post-accident monitoring equipment that falls within the scope of Category 1 or 2 equipment (as defined in Revision 2 of Reg. Guide 1.97) be environmentally qualified as required by 10 CFR 50.49, or the applicant/licensee should provide an acceptable alternative for complying with 10 CFR 50.49(b)(3).

10 CFR 50.49 provides an acceptable basis for environmental qualification of Category 1 and Category 2 instrumentation as defined in Reg. Guide 1.97 Revision 2 or Revision 3. In addition, the use of Reg. Guide 1.97 Revision 3 in lieu of Revision 2 in itself does not exempt the applicant/licensee from addressing environmental qualification of Category 1 and 2 equipment.

Seismic Qualification of Category 1 Instrumentation

If a reactor licensing basis does not include commitment to Reg. Guide 1.100, "Seismic Qualification of Electric Equipment for Nuclear Power Plants," and credit is taken for original equipment in meeting the guidelines identified in Reg. Guide 1.97, then installation of the original equipment in conformance with the licensing basis for seismic qualification is acceptable, provided the other guidelines identified in Reg. Guide 1.97 and this BTP are satisfied. However, for all reactors, new instrumentation that is installed for the purpose of satisfying Reg. Guide 1.97, or new instrumentation that is installed to replace original equipment for which credit was taken in satisfying Reg. Guide 1.97, should satisfy the seismic qualification guidelines identified in Reg. Guide 1.97.

Independence of Redundant Category 1 Instrumentation

If a reactor licensing basis does not include a commitment to Reg. Guide 1.75, "Physical Independence of Electric Systems," and credit is taken for original equipment in meeting the guidelines identified in Reg. Guide 1.97, then installation of the original equipment in conformance with the licensing basis requirements for separation and independence is acceptable, provided the other guidelines identified in Reg. Guide 1.97 and this BTP are satisfied. However, for all reactors, new instrumentation that is installed for the purpose of satisfying Reg. Guide 1.97, or new instrumentation that is installed to replace original equipment for which credit was taken in satisfying Reg. Guide 1.97, should satisfy the separation and isolation guidelines identified in Reg. Guide 1.97.

Display and Recording

Reg. Guide 1.97 states in part that if direct or immediate trend or transient information is essential for operator information or action, the recording should be continuously available on dedicated recorders. Otherwise, the information may be continuously updated, stored in computer memory, and displayed on demand. For the latter non-essential applications, the use of Category 2 computers or dedicated Category 2 recorders is acceptable for recording Category 1 information, provided the Category 1 instrumentation is isolated from the Category 2 instrumentation using qualified isolation devices.

Range

Deviations from the range values identified by Reg. Guide 1.97 may be acceptable if supported by analyses demonstrating that the indication would remain on scale with appropriate margins for any design basis event or accident for which the instrumentation might be required for operator information. An appropriate margin should include allowance for analytical uncertainties and instrumentation uncertainties. However, Reg. Guide 1.97 identifies that, for a limited number of functionally significant variables (e.g., containment pressure or primary system pressure), instrument ranges should extend beyond those values that the selected variables can attain under limiting conditions.

Alternate Instrumentation

The use of alternate instrumentation to monitor variables different than those identified in Reg. Guide 1.97 is acceptable, provided that:

- a. The alternate instrumentation fulfills the purpose of the variables identified in Reg. Guide 1.97;
- b. The alternate instrumentation conforms to the design and qualification criteria for the variables identified in Reg. Guide 1.97; and
- c. No credit is taken by the applicant/licensee in post-accident procedures, emergency operating procedures, or functional recovery guidelines for indication of the variables identified in Reg. Guide 1.97 for which the alternative instrumentation is proposed.

Guidance for Boiling Water Reactor (BWR) and Pressurized Water Reactor (PWR) Variables

Table 1 ("BWR Variables") and Table 2 ("PWR Variables") of Reg. Guide 1.97, Revision 2, and Table 2 ("BWR Variables") and Table 3 ("PWR Variables") of Reg. Guide 1.97, Revision 3, identify guidelines for the range, the design/qualification category, and the purpose for specific BWR and PWR variables. Acceptable deviations from or clarifications to Reg. Guide 1.97 for selected BWR and PWR variables

identified in those tables are identified on Table 1 and Table 2 (respectively) of this BTP. Presented in Tables 1 and 2 are identification of the Reg. Guide 1.97 variable, the type of deviation from Reg. Guide 1.97 guidelines (e.g., deviation with respect to category, redundancy, range, direct measurement), and a summary of the acceptance guidelines or clarification associated with the deviation.

4. Review Procedures

The review procedure for post-accident monitoring systems is described in part III of SRP Section 7.5.

Table 1. Acceptable Deviations and Clarifications to Reg. Guide 1.97 for BWRs

Variable	Deviation	Acceptance Guidelines/Clarification
Neutron flux	Category, Equipment qualification, Redundancy, Power source, Quality assurance, Range	Except for applications submitted after January 13, 1993 (which should satisfy the guidelines identified in Reg. Guide 1.97), the design criteria identified in NEDO-31558, "Position on NRC Regulatory Guide 1.97, Revision 3, Requirement for Post-Accident Neutron Monitoring System," are an acceptable alternative to Category 1 criteria. Pursuant to these alternate criteria, the applicant/licensee should perform a plant-specific evaluation of the electrical power distribution to the neutron monitoring system (including the recorders) to verify that the instrument power is not lost during design basis events.
Coolant level in reactor vessel	Range, Redundancy	If redundant channels of Category 1 instrumentation cover the fuel zone and the wide range (i.e., all manual and automatic trip functions), then a single channel of Category 3 upset range instrumentation (from the upper end of the wide range to the top of the vessel or centerline of the main steamline) is acceptable for detection of water carryover.
Core temperature	N/A	This variable is not necessary for satisfying the guidelines identified in Reg. Guide 1.97, per NUREG 0737 Supplement 1, "Clarification of TMI Action Plan Requirements-Requirements for Emergency Response Capability."

Table 1. Acceptable Deviations and Clarifications to Reg. Guide 1.97 for BWRs, cont.

Variable	Deviation	Acceptance Guidelines/Clarification
Drywell sump and drywell drain sumps level	Category, Direct measurement	<p>Category 3 instrumentation (e.g., flow instrumentation) is an acceptable alternative to Category 1 instrumentation for this variable if it can be shown that:</p> <ul style="list-style-type: none"> a. For small leaks, the alternate instrumentation will not experience a harsh environment; and b. For larger leaks, the sumps fill promptly and the sump drain lines isolate due to the increase in drywell pressure, negating the need for the measurement; and c. Drywell pressure and temperature indication can be used to detect leakage into the drywell; and d. The instrumentation neither automatically initiates nor alerts the operator to initiate operation of a safety system in a post-accident situation.
Primary containment isolation valve position	Redundancy	Redundant position indication for each active containment isolation valve is not necessary, because the valves are redundant. Likewise, position indication is not necessary for valves within the operator's cognizance that are normally closed and remain closed after an accident, and that are administratively controlled.
Radioactivity concentration or radiation level in circulating primary coolant	N/A	A continuous post-accident monitor is not necessary.
Containment & drywell hydrogen concentration	Range	For plants where credit is taken for Class 1E hydrogen ignitors, the range recommendations may be relaxed if analysis shows that the instrumentation will remain on scale through all design basis events with adequate margin for uncertainties.
Containment & drywell oxygen Concentration (inerted containment)	Range	As an alternative to total conformance to Category 1 criteria, qualified instrumentation up to 5 volume percent (v/o) and redundancy up to 10 v/o is acceptable if it can be shown that the instrumentation will perform adequately during all accident and post-accident conditions.

Table 1. Acceptable Deviations and Clarifications to Reg. Guide 1.97 for BWRs, cont.

Variable	Deviation	Acceptance Guidelines/Clarification
Suppression chamber & drywell spray flows	Direct measurement	The use of RHR flow, suppression chamber temperature and pressure, and drywell temperature and pressure are acceptable alternatives if it can be shown that (1) use of these variables can accurately and reliably measure the effectiveness of the drywell and suppression chamber spray in a timely manner, and (2) that the position of the spray throttling valves can be monitored and the sprays adequately controlled from the control room using the alternate variables.
SLCS flow	Direct measurement	Measurement of SLCS pump discharge pressure and SLCS storage tank level may be acceptable as an alternate indication that the SLCS pump is operating and that SLCS flow is occurring.
Reactor building or secondary containment area radiation	Category	Area radiation monitors located in Mark III containments and in primary containments of other BWRs may be Category 2 as an alternative to Category 1 monitors. Area radiation monitors located in reactor building secondary containments for Mark I and Mark II plants and in other plant areas may be Category 3 in lieu of Category 2.
Radiation exposure rate/variables used to monitor airborne radioactive materials released from plant	Category	If the instrument is located in a mild environment and is not part of a safety system, Category 3 instrumentation is acceptable in place of Category 2 instrumentation.

Table 2. Acceptable Deviations and Clarifications to Reg. Guide 1.97 for PWRs

Variable	Deviation	Acceptance Guidelines/Clarification
Neutron flux	Environmental qualification	A non-environmentally qualified instrument is acceptable if qualified core exit thermocouples and RCS hot and cold leg temperature indications are provided in conjunction with directions in emergency procedures for operator action to ensure that boric acid injection is occurring.
RCS pressure (CE reactors)	Range	A range of 0-3,000 psig is an adequate alternative to 0-4,000 psig if analysis is presented or referenced in the FSAR that shows that pressure will remain on scale for all design basis transients and accidents. However, if ATWS analysis indicates that pressures exceeding FSAR values are possible, an expanded range of the Category 1 instrumentation should be provided.
Containment sump level	Range	Separate narrow-range instrumentation is not required if the wide-range instrumentation satisfies the guidelines of Reg. Guide 1.97 and is of sufficient range and accuracy to monitor the sump operation for all design basis conditions.
Containment isolation valve position	Redundancy	Redundant position indication for each active containment isolation valve is not necessary, because the valves are redundant. Likewise, position indication is not necessary for valves within the operator's cognizance that are normally closed and remain closed after an accident, and that are administratively controlled.
Radioactivity concentration or radiation level in circulating primary coolant	N/A	A continuous post-accident monitor is not necessary.
Containment hydrogen concentration	Range	For plants where credit is taken for Class 1E hydrogen ignitors, the range recommendations may be relaxed if analysis shows the instrumentation will remain on scale through all design basis events with adequate margin for uncertainties.
Accumulator tank level and pressure	Category	The safety function of the accumulator is performed passively by opening the discharge check valve when RCS pressure is lower than the tank pressure. Therefore, Category 3 instrumentation is an acceptable alternative to Category 2 if there are no operator actions that depend on use of this instrumentation for accident mitigation.
Accumulator isolation valve position	Category	Category 3 position indication is acceptable if the accumulator isolation valves are locked open motor operated valves (i.e., power to the motor operators is disabled during normal operation) and cannot change position during an accident.
Pressurizer heater status	Indication	At a minimum, status indication should be provided for pressurizer heaters governed by the technical specification (i.e., those heaters required to be served by emergency power).

Table 2. Acceptable Deviations and Clarifications to Reg. Guide 1.97 for PWRs, cont.

Variable	Deviation	Acceptance Guidelines/Clarification
Quench tank temperature and pressure	Range	Pressure relief of the tank via rupture disk limits the temperature of the tank contents to saturated steam conditions (less than 750°F). Therefore, it is acceptable if the upper-range value includes (with adequate margin) the saturation temperature corresponding to the tank rupture disk relief pressure (e.g., a rupture disk relief pressure of 100 psig corresponds to 328°F saturation temperature). Likewise, an upper-range value less than the design pressure of the tank is acceptable if the upper range value covers (with adequate margin) the rupture disk relief pressure.
Steam generator level (wide-range)	Redundancy	For the wide-range level, two-loop plants should have two channels of instrumentation per loop, but three- and four-loop plants may have one channel of instrumentation per loop
Steam generator pressure	Redundancy	If steam generator pressure is identified as a Type A variable, two-loop plants should have two channels of instrumentation per loop, but three- and four-loop plants may have one channel of instrumentation per loop.
Containment atmosphere temperature	Category, Direct measurement	Category 3 instrumentation is an acceptable alternative to Category 1 if it is shown that this instrumentation is considered to be backup instrumentation, i.e., if containment atmosphere temperature is not used in any post-accident procedures, emergency procedures, or functional recovery guidelines, and Category 1 containment pressure instrumentation is available as primary instrumentation.
Containment sump water temperature	Direct measurement	<p>As an alternative to Category 2 containment sump water temperature instrumentation, either Category 2 residual heat removal heat exchanger inlet or outlet temperature instrumentation is an acceptable alternative for determining containment cooling status.</p> <p>In plants where the containment cooling function is provided by the recirculation spray system, either Category 2 recirculation spray system heat exchanger inlet or outlet temperature instrumentation is an acceptable alternative.</p>
Makeup flow/letdown flow/VCT level	Category, Direct measurement	Category 3 instrumentation is an acceptable alternative to Category 2 instrumentation if the charging and letdown lines are isolated with an accident signal and no credit is taken for indication of these variables in post-accident procedures, emergency procedures, or functional recovery guidelines.
Radiation exposure rate & variables used to monitor airborne radioactive materials released from plant	Category	If the instrument is located in a mild environment and is not part of a safety system, Category 3 instrumentation is an acceptable alternative to Category 2 instrumentation.

C. References

- General Electric Report NEDO-31558-A. "Position on NRC Regulatory Guide 1.97, Revision 3, Requirement for Post-Accident Neutron Monitoring System." March 1993.
- NUREG 0737 Supplement 1. "Clarification of TMI Action Plan Requirements-Requirements for Emergency Response Capability." January 1983.
- Regulatory Guide 1.100. "Seismic Qualification of Electric Equipment for Nuclear Power Plants." Revision 2, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, June 1988
- Regulatory Guide 1.75. "Physical Independence of Electric Systems," Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, 1978.
- Regulatory Guide 1.97. "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident." Revision 3, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, May 1983.
- Regulatory Guide 1.97. "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions During and Following an Accident." Revision 2, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, December 1980.
- Safety Evaluation by the Office of Nuclear Reactor Regulation. "Boiling Water Reactors, Regulatory Guide 1.97, Post-Accident Neutron Flux Monitoring Instrumentation." January 13, 1993.
- Safety Evaluation by the Office of Nuclear Reactor Regulation. "Pressurized Water Reactors Accumulator Pressure and Volume Instrumentation-Relaxation of Regulatory Guide 1.97 Environmental Qualification Requirements." January 21, 1992.
- Safety Evaluation by the Office of Nuclear Reactor Regulation. "Pressurized Water Reactors Containment Sump Water Temperature Instrumentation Regulatory Guide 1.97." November 22, 1993.

