Accident Monitoring Instrumentation

NEI Advanced Reactor DI&C Task Force
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Overview

- History of IEEE 497 and RG 1.97
- Current Joint Standards Activities by IEEE and IEC
- Advanced Reactor Applications
- Path Forward
- Review / Discussion

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History of IEEE 497 and RG 1.97

- RG 1.97, Rev. 3 issued December 1983 and endorsed ANSI/ANS-4.5-1980 – and referenced but did not endorse IEEE 497-1977
  - Provides prescriptive listing of Type A - E variables and variable categories for both BWRs and PWRs
- RG 1.97, Rev. 4 issued June 2006 and endorsed IEEE 497-2002, subject to regulatory positions
  - States that Rev. 3 had become outdated, did not provide criteria for advanced instrumentation system designs based on modern digital technology and did not address the need for technology-neutral guidance for new plant licensing
  - Instead of prescribing instrument variables to be monitored, provides flexible, performance-based criteria for the selection, performance, design, qualification, display and quality assurance of variables per IEEE 497-2002

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History of IEEE 497 and RG 1.97

- RG 1.97, Rev. 5 issued April 2019 to endorse IEEE 497-2016, subject to regulatory positions
  - IEEE 497-2016 incorporates some of the NRC staff's regulatory positions in Rev. 4 and to revise some definitions and terminology
  - Based on insights from the Fukushima Dai-ichi accident in March 2011, the US nuclear industry recognized the need for instrumentation to monitor plant conditions associated with fuel damage events
  - IEEE 497-2016 expanded the scope of the standard to include consideration of instrumentation potentially required for coping with severe accidents as Type F variables

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IEEE and IEC Joint Standards Activities

- IEEE and IEC first proposed consideration of a joint-logo standard in ~2012, and in 2014, the first full draft of IEEE 497 was shared with IEC for consideration and expert review
- In 2016, IEC received the proposal of IEEE to endorse IEEE 497-2016 as a dual-logo standard
- In 2017, IEEE 497-2016 adoption as IEC 63147 was approved, and IEC TR 63123, Guidance for the application of IEC 63147:2017/IEEE Std 497™-2016 in the IAEA / IEC framework, was issued
- IEEE standard life cycle requirements mandate that a new revision of IEEE 497 be published before the end of 2026; a draft is being developed to produce a true joint-logo standard incorporating:
  - Points raised in IEC TR 63123
  - Main points of IAEA NP-T-3.16, “Accident Monitoring Systems for Nuclear Power Plants”

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IEEE and IEC Joint Standards Activities

- Joint-logo scope and principles of revision:
  - A revision of IEC 63147 scope is not envisioned
  - Addition of IEC terms and definitions; existing terms will be reviewed to ensure conflicts are avoided
  - The functional types A - F from IEEE 497 and functional categories A - C from IEC 61226 will be correlated to demonstrate that the two category sets represent analogous requirements
  - Comments provided by NRC during development of the current RG 1.97, Rev. 5 will be considered for inclusion in the standard

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Advanced Reactor Applications

Advanced Reactors:

- Characterized by intrinsically safe attributes and passive design features
- Capable of preventing fuel damage and meeting regulatory dose limit criteria without relying on active safety systems or operator actions during or after licensing basis events (LBEs)
- Do not require active monitoring of critical plant safety functions by operators in the same manner as conventional reactor designs for implementation of emergency operating procedures (EOPs)

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Advanced Reactor Applications

- Implementation of RIPB methodologies such as NEI 18-04, as endorsed by RG 1.233, uses PRA to select licensing basis events (LBEs), identify PRA safety functions (PSFs), and define performance requirements within the LBEs
- The PSFs provided by monitoring instrumentation are based on plant design, the risk-significance of the functions, and the role of the functions in defense-in-depth (DID) adequacy
- Implementation of NEI 18-04 can result in Non-Safety-Related with No Special Treatment (NST) classification of monitoring systems
- Disconnect between requirements derived from SSC classification per NEI 18-04 and design, qualification, and quality requirements per IEEE 497 / IEC 63147

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Advanced Reactor Applications

- IEEE 497 / IEC 63147:
  - Defines six monitoring variable types (Type A - F)
  - Assigns monitoring instrumentation types according to functions performed but does not provide any functional categorization or system/component classification schemes
  - Safety classification of monitoring instrumentation per the standard is subject to interpretation, prompting issuance of IEC TR 63123
  - Type A - C monitoring channel requirements align with requirements conventionally applied to SR equipment
  - Type D - F monitoring channel requirements align with requirements conventionally applied to NSR equipment
    - Exception: Type D monitoring channels require qualification

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Advanced Reactor Applications

Table 4-1. Summary of Special Treatments for SR and NSRST SSCs

Special Treatment Category	Applicability[1] SR SSC	NSRST SSC	NST SSC	Available Guidance[4]
Basic Requirements for all Safety-Significant SSCs				
Design Requirements for SSC capability to mitigate challenges reflected in LBEs	√	√		Guidance in this guidance document, MHTGR Preliminary Safety Information Document
10 CFR 50 Appendix B Quality Assurance Program	√			QA requirements consistent with 10 CFR 50 Appendix B should be risk-informed and performance-based and not compliance-based; guidance in SRP 17.5 Quality Assurance for safety-related SSCs, 10 CFR 50.69, SRP 1.201
User provided Quality Assurance (QA) Program for non-safety SSCs		√		QA requirements consistent with SRP 17.4 (Reliability Assurance Program) for non-safety-related, safety significant SSCs should be risk-informed and performance-based and not compliance based; guidance in SRP 17.5 Quality Assurance for non-safety-related SSCs, 10 CFR 50.69, SRP 1.201
Additional Special Treatment Requirements				
Seismic qualification testing	√			Essentially the same as for existing reactors for SR SSCs, 10 CFR 100 Appendix A, Regulatory Guide 1.100
Equipment qualification testing	√			Essentially the same as for existing reactors for SR SSCs, 10 CFR 50.49

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Path Forward

- IEEE and IEC working groups are developing a true joint-logo standard, incorporating risk-informed techniques
- Revision is in progress per the IEEE 10-year life cycle before standard expiration, and intends to:
  - Incorporate operational lessons learned and address other industry concerns
  - Reconcile differences in definitions and applications between IEEE and IEC as indicated in IEC 63147 and IEC TR 63123 related to IEEE 497-2016
  - Consider functional categorization and system classification as defined in IEC 61226

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Review / Discussion

- A risk-informed revision of IEEE 497 / IEC 63147 is not expected to be published prior to 2026 and will therefore not be available for near-term license applicants
- Disconnect between requirements derived from SSC classification per NEI 18-04 and design, qualification, and quality requirements per IEEE 497 / IEC 63147
- Advanced reactor developers anticipate deviating from the currently endorsed standard

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