Background and Technical Basis for Development of NEI 07-01, Revision 1

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NRC Public Meeting
January 31, 2014 • White Flint, MD
Background

• Development of NEI 07-01 R0 began in 2006 and was finalized July 2009

• An NRC letter, dated August 2009, found NEI 07-01 R0 to be technically sufficient to pursue formal endorsement via Reg Guide 1.101*
  - NRC stated that license applicants may review NEI 07-01 R0 as a reference in the development of their applications
  - NRC noted that the formal endorsement process may require a revision to the Revision 0 document

* NRC ADAMS ML092190035
Background

- The NRC has not yet issued a revision of Reg Guide 1.101 that formally endorses NEI 07-01 R0
- NEI 07-01 R0 was based on NEI 99-01 R5
- NEI 07-01 R0 was based on early revisions of Design Control Document (DCD) for the AP1000
  - The current AP1000 DCD is R19++ (FSAR Rev. 0)
- The NEI 07-01 Revision 0 design approach was, by design, prescriptive in EAL threshold setpoint values, instrumentation and equipment
Condition of License

• Per NRC letter*, 2 options were provided for new reactor applicants to develop EALs
  - Option 1 was to submit an entire scheme containing all site-specific information including setpoints
  - Option 2 was to provide an overview of its EAL scheme, commit to implementing specific NRC endorsed guidance (NEI 07-01) with few or no deviations, propose a license condition committing to develop the scheme and incorporate the scheme into a document controlled by 10CFR50.54(q)

• AP1000 license applicants that have opted for Option 2 have a condition of license that specifies that they SHALL implement an EAL scheme consistent with NEI 07-01 Revision 0 with NO deviations

* NRC ADAMS ML083220276
IC/EAL Deviations

- Per RIS 2003-18 Supplements 1 & 2, deviations are:
  - An EAL change where the basis scheme guidance differs in wording and is altered in meaning or intent, such that classification of the event could be different between the basis scheme guidance and the site-specific proposed EAL.
  - Any change to an IC and/or EAL, and/or basis or wording stated in NEI 99-01 [NEI 07-01] that alters the intent of the IC and/or EAL:
    - Does not classify at the classification level consistent with NEI 99-01 [NEI 07-01]
    - Is not logically integrated with other EALs in the scheme
    - Results in an incomplete EAL scheme (i.e., does not classify all potential emergency conditions)
NEI 07-01 Rev. 0 Implementation Issues

- Technical
- Human Factor/Usability
- Fukushima informed classification thresholds
- Alignment with current industry best practice approach to emergency classification guidance (NEI 99-01 R6)
Example Required Corrections

• Technical
• Human Factors/Usability
Technical

• There is no “Stable Shutdown” mode (ESBWR). Per ESBWR T. S. Table 1-1 the mode title is “Safe Shutdown.”

• CA2 IC is a loss of all on-site and offsite AC power to vital buses for > 60 min. The example EALs specify 120 min. with RCS intact. The EAL is comprised of not only the site specific EAL wording but also the IC, operating mode and notes. The IC and EAL are not in agreement.
Technical

- IC CU1 AP1000 EAL #1 threshold specifies the inability to maintain or restore pressurizer level above the Pressurizer level Low-2 setpoint for > 15 min. IC CA1 AP1000 EAL #1.a specifies Pressurizer level at 12% and lowering on RCS-LT-200. The CA1 bases states that “The pressurizer level setpoint is 12%, which is the Pressurizer level Low-2 setpoint.” The AP1000 CU1 EAL #1 and CA1 EAL #1.a are the exact same threshold setpoint. Due to the 15 min. timing criteria in CU1 EAL #1 (CA1 has no timing criteria), CA1 EAL #1.a would always be exceeded before CU1 EAL #1.
IC CU2 AP1000 EAL #1 specifies 2 bulleted threshold conditions applicable in the Refueling mode. The first is RCS water level drop below the RPV flange for > 15 min. The second is RCS water level drop below the level band being maintained if RCS level was intentionally being maintained below the RPV flange. In the first threshold the indications for water level being below the RPV flange is either by visual observation (someone looking in the reactor cavity) or RCS Hot Leg level at the Low-3 setpoint and lowering. The lowest maintained RCS level band would be when at mid-loop operation. The minimum level allowed when in mid-loop operation is 10.5” above the bottom of the hot leg (critical vortex limit with 1 RNS pump running). However, the hot leg Low-3 setpoint is at 16.1% instrument span or ~5” above the bottom of the hot leg, well below the minimum allowed mid-loop level band. Additionally, the Low-3 setpoint is only 2” above the Low-4 setpoint of ~3” above the bottom of the hot leg that escalates to CA1. The Low-3 setpoint is ~75” below the RPV flange.
IC CU2 AP1000 EAL #1 and CA1 EAL #2 prescribe, under conditions where RPV level cannot be monitored: “Unexplained rise in Containment sump level on WLS-LICR-034, WLS-LICR-035, OR WLS-LICR-036.” IC CS1 AP1000 EAL #1 specifies: ‘Unexplained containment sump level rise on [Site specific]”. However the intended threshold conditions are the same. No developer guidance is provided as to why or if these are intended to be different.

IC CA1 AP1000 EAL #1 specifies a Pressurizer level threshold of 12%. The bases states that this corresponds to the Pressurizer level Low-2 setpoint. The setpoint is now 10%.
Technical

• IC CS1 AP1000 EAL #1 & 2. The AP1000 cannot directly measure RCS level below the bottom of the RCS Hot Leg. Neither level cited, RCS hot leg Low-4 setpoint nor 0.5% on RCS LT-160A/B can be considered to be indicative of the intent of the IC which states: “affecting decay heat removal capability.” There is still ~42” of water above TAF when RCS level is at the bottom of the hot leg. RCS hot leg Low-4 used in this EAL is the same threshold value used in IC CA1 EAL 1.b.

• IC CS1 AP1000 EAL #1 bases states that the specified RCS Hot Leg Low-4 setpoint is the lowest observable level. The lowest observable level is 0.5%.
Technical

• IC CS1 AP1000 EAL #3 specifies conditions indicative of inventory loss for when RPV level cannot be determined for > 60 minutes. One of those conditions includes [site-specific] containment radiation monitor readings on [site-specific] radiation monitors. There is a developer note that states the containment radiation value corresponds to 5% clad damage. There is no bases given nor developer notes provided on the assumptions to be made for this calculation or how it is indicative of RCS inventory loss. The NEI 99-01 equivalent EAL is based on indications of core uncovery and a corresponding containment radiation level due to shine from a loss of core shielding. The NEI 07-01 bases also states that passive cooling systems will continue to function and provide sufficient cooling, so the 60 minute duration allows sufficient time to restore cooling systems. Therefore no clad damage would be expected within this 60 minute time period.
Technical

- IC CG1 AP1000 EAL #1 specifies containment radiation High-2 alarm as indication of core uncovering. This alarm setpoint, contrary to the bases statement, has no relationship to an indication corresponding to uncovering of the core or a specific % of core damage. It would also appear that the radiation level associated with 5% clad failure specified in CS1 would be significantly higher than the containment radiation monitor High-2 alarm of 100 R/hr specified in CG1.
Technical

- IC CA7 (loss of monitoring and control) excludes Defueled mode. For AP1000, PCCWST is required for Spent Fuel Pool Makeup when SFP heat load is greater than 7.2MWt (Tech Spec 3.7.9). TRM 3.6.1 also requires functionality of PCCWST in MODE 6. Defueled mode needs to be included.
Technical

• Wrong system actuation signal specified in AP1000 FPB RCS Loss 4.A. Ruptured SG results in Safeguards actuation. Safeguards actuation results in CMT actuation, which in turn, initiates PRHR actuation.

• AP1000 FPB Fuel Clad Potential Loss 3.A threshold specifies a hard value of 700 deg. F. This value is not correct for the AP1000 and is not consistent with Core Cooling Orange Path entry upon which it is based.
Technical

- AP1000 FPB threshold Fuel Clad Loss 6.A is based on containment radiation level > the High-1 alarm setpoint as indicated on PXS-JE-RE-160 thru 163.
  - Bases states the High-1 alarm setpoint is based on release of reactor coolant with elevated activity indicative of 5% fuel clad damage. The High-1 alarm has no bases related to a specific % of fuel damage, rather the alarm is an indication to operators that there is increasing radiation in containment and actuates VFS isolation.
  - The Containment Radiation High-1 alarm setpoint is 2 R/hr
Technical

- RCS Loss 6.A is based on containment radiation level > [site-specific] alarm which indicates release of coolant into containment with no fuel damage.
  - There is no alarm on these instruments that corresponds to this condition
  - PXS-JE-RE-160 thru 163 have a range of 1E0 – 1E7 R/hr
  - If the High-1 alarm of 2 R/hr represents 5% clad damage, the indication for normal coolant activity (0.25% clad defect) would not be within the measurable range (< 1 R/hr) on the detectors.
Technical

• AP1000 FPB threshold Containment Potential Loss 6.A is based on containment radiation level > the High-2 alarm setpoint as indicated on PXS-JE-RE-160 thru 163.
  - Bases states the High-2 alarm setpoint is based on release of reactor coolant with elevated activity indicative of 20% fuel clad damage. The High-2 alarm setpoint has no bases related to a specific % of fuel damage, rather the alarm is an indication to operators that there is increasing radiation in containment and actuates RNS and CVS makeup isolation.
  - The Containment Radiation High-2 alarm setpoint is 100 R/hr.
  - If the Containment Radiation High-1 alarm represents 5% clad failure, then a radiation monitor reading of ~8 R/hr would be indicative of 20% clad failure (linear function).
Technical

• IC HU1 EAL #2 specifies high wind gusts > 145 mph on “JE-MES [site specific].” The bases states that 145 mph is the design wind speed and is within the range of the wind speed instrument. The AP1000 wind speed instrument has an upper range of 144 mph. Further, 145 mph is only applicable for Category C siting exposures. The EAL and associated bases do not allow for site-specific exposures that would reduce the plant design wind speed (e.g., exposure category D = 130 mph).
Technical

- IC HU2 EAL #1 AP1000 structure list does not include the Diesel Generator Building in the list of applicable buildings. The bases states: “The list is limited and applies to buildings and areas in actual contact with or immediately adjacent to VITAL AREAS or other significant buildings or areas” Even though the EDGs are not safety related, the Emergency Diesel Building clearly meets the significant building criteria.

- IC HA1 EAL #3 based on internal flooding does not specify a list of applicable areas. However the bases states: “Threshold #s 2, 3, and 4 specifies site-specific safety structure, system, or component and functions required for safe shutdown of the plant.”
ICs CU3, SU1 and SA1 are based on the loss of power to the buses that charge the Class 1E batteries as opposed to the intent of the IC which is a failure of the ability to charge the Class 1E batteries.

IC SS1 credits the 72-hour Class 1E batteries. However, it is the 24-hour Class 1E DC power that compromises the ability to monitor and control plant safety functions. AP1000 includes four IDS 24-hr 1E batteries and battery chargers (one battery and charger for each division). Division B and C include an additional IDS 72-hr battery and battery charger. The four 24-hr battery IDS divisions supports control of components for at least 24 hrs. The two (B and C) 72-hr battery IDS portions support monitoring but not control.
IC SS2 AP1000 EAL #1 developers note specifies a calculated site-specific Intermediate Range Nuclear Instrumentation power level to define reactor shutdown for ATWS events. However, no guidance is provided as to the method or bases for that calculated value. By limiting the shutdown power level indication to that of the Intermediate Range NIs, it is implied that the calculated value is a value below the lower range of the Power Range NIs. The bases states that “under these conditions, the reactor is not shutdown and producing more heat than safety system design capability” This has typically been taken to be, for PWR plants implementing CSFSTs, the CSF Subcriticality Red Path entry condition, typically 5% RTP. The current prescribed threshold would result in classification at low post trip power levels that do not threaten FPB integrity as described in the bases. In comparison, the ESBWR threshold specifies a shutdown criteria of power > APRM ATWS Permissive which is > APRM downscale (5% RTP).
Human Factors/Usability

- Numerous instances of EALs specifying instrumentation elements and transmitters that cannot be directly read in the control room. It is the displayed indication derived from these elements or transmitters that are available to the control room. Examples:
  - AP1000 ICs AU1, AA1, AS1 & AG1 specify monitors BDS-RE-010 and -011, TDS-JE-RE 001. These are radiation elements and cannot be read in the Control Room (BDS-RY010, TDS-RY001A etc.).
  - AP1000 IC AU2 specifies VAS-RE 001. This is a radiation element that cannot be read in the Control Room (VAS-RY001).
  - AP1000 CS1 EAL #1 specifies the use of Hot Leg level transmitters RCS LT-160 A & B. These transmitters cannot be read in the Control Room (RCS-LICA160A/B).
Human Factors/Usability

• Numerous EAL thresholds limiting classification to specific instrumentation. This excludes classification based on other available direct or indirect indications and instrumentation. Example, IC CU4 AP1000 EAL #1 limits classification for a loss of decay heat removal to two channels of one instrument; RCS-TI-135A/B. However, design documentation states that in addition to these indicators at least two in-core thermocouple channels are available to measure core exit temperatures during mid-loop RNS operation.
Human Factors/Usability

- IC CS1 AP1000 EALs #1 and #2 specify thresholds based on RCS hot leg levels depending on Containment Closure status. With Containment Closure not established the threshold is RCS level < Hot Leg Level Low-4 setpoint. This setpoint is 3” above the bottom of the hot leg. With Containment Closure established the threshold is RCS level < 0.5” (lowest readable level) on the hot leg level instrument. This is only a 2.5” difference. Additionally, since 0.5” is the lowest readable RCS hot leg level, level < 0.5” (the classification threshold) cannot be determined. (this issue also applies to IC CG1 AP1000 EAL #1.b)
Human Factors/Usability

- The AP1000 emergency classification escalation path due to loss of RCS inventory and hot leg level indication, IC CU2 EAL #1 to CA1 EAL #1.b to CS1 EAL #2 spans a total RCS hot leg level drop of 4.5”. If Containment Closure is not establish while in Refueling mode, a direct escalation from IC CU2 EAL #1 to CS1 EAL #1 occurs based on a 2” RCS hot leg level drop.
Human Factors/Usability

• For the ESBWR, Containment Closure (defined term) is defined as action taken to secure Primary Containment OR the Reactor Building per T.S. 3.6. Reactor Building Isolation (defined term) is defined as “See Containment Closure.” IC CS1 ESBWR EALs #3 and #2 and CG1 EAL #1 use the term Reactor Building Isolation in lieu of the term Containment Closure. However, there are separate and distinct operability requirements for both the Primary Containment and Reactor Building. This implies only the Reactor Building is credited for containment closure.
Fukushima Informed Thresholds

• NRC Order EA-12-051, Issuance of Order to Modify Licenses with Regard to Reliable Spent Fuel Pool Instrumentation, requires licensees to provide each spent fuel pool with reliable level instrumentation to significantly enhance the ability of key decision-makers to allocate resources effectively following a beyond design basis event.
  - This order is applicable to plants with an operating license, construction permit, or combined construction and operating license.

• NEI 07-01, Revision 1, includes three EALs that reflect the availability of the enhanced spent fuel pool level instrumentation associated with NRC Order EA-12-051.
  - These EALs are included within existing IC AA2, and new ICs AS2 and AG2. Associated EAL notes, bases and developer notes are also provided.
Alignment with current industry best practice (NEI 99-01 Rev. 6)

- NEI 07-01 Revision 1 is based on the material contained in NEI 99-01, Development of Emergency Action Levels for Non-Passive Reactors, Revision 6.
- NEI 99-01, Revision 6 represents a significant improvement in emergency classification scheme development guidance (including incorporation of NEI 99-01 Revision 5 based FAQs), much of which is applicable to the advanced passive reactor designs.
- NEI 07-01, Revision 1, also accommodates the more evolved design information currently available for the advanced passive reactor designs (e.g., the Westinghouse AP1000 Design Control Document (DCD).
- NEI 07-01 Revision 1 has been formatted to accommodate future design changes.