

## **GENERIC LICENSING TOPICAL REPORT EDR-1, REVISION 7**

### **“Westinghouse eXtra Safety and Monitoring (X-SAM®) Single Failure Proof”**

**ORIGINATING ORGANIZATION: Westinghouse Electric Company  
(previously Ederer, Inc.)**

**PROJECT NO. NRR: MF2938 (NRO: RQ3600)**

#### **1.0 INTRODUCTION AND BACKGROUND**

Generic Licensing Topical Report (TR) EDR-1, “eXtra Safety and Monitoring (X-SAM®) Single Failure Proof Cranes” provides generic descriptions of the safety features and components of the “single failure proof” X-SAM cranes and compact hoists and is used to show the method of compliance with (originally issued) Regulatory Guide (RG) 1.104, “Overhead Crane Handling Systems for Nuclear Power Plants,” and the more recent guidelines of NUREG-0554, “Single-Failure-Proof Cranes for Nuclear Power Plants.” The U.S. Nuclear Regulatory Commission (NRC) withdrew RG 1.104 in 1979. After issuance of the guide, the NRC staff revised its guidance on the single-failure-proof option for handling heavy loads over or near the spent fuel pool, and the staff decided to withdraw the guide and publish the information it contained in a technical report (NUREG-0554). This TR has been approved as an acceptable means for meeting NUREG-0554, as indicated below. These cranes are designed for a wide range of single-failure-proof overhead handling equipment applications in nuclear power plants.

By letter dated September 26, 2013, (Reference 1), as supplemented by letters dated July 16, and December 17, 2014, and May 15, and June 11, 2015 (References 2–5, respectively), Westinghouse Electric Company, LLC (Westinghouse), the current owner of the X-SAM crane technology, requested the NRC review and approval of Revision 7 to the EDR-1 TR. The NRC approved Revisions 1 and 3 to this TR (initially prepared by Ederer, Inc.), in the 1980’s. As indicated in the Westinghouse submittal letters, Revision 4 and 6 of the EDR-1 TR were interim revisions and will not be used or referenced. Since the interim revisions were not submitted to the NRC, the staff has not reviewed or approved Revision 4 and 6 of the EDR-1 TR.

The objective of this revision is to retain the protective functionality and features of the previously accepted X-SAM technology, while updating nondestructive examination (NDE) acceptance criteria and providing closer alignment with current industry technology and standards. Also, this report will establish the term “critical items” in lieu of the prior terminology designation “nuclear safety related.”

#### **2.0 REGULATORY EVALUATION**

By letter dated August 22, 1978 (Reference 6), Ederer, Inc., requested approval of Generic Licensing TR EDR-1 (P), “eXtra-Safety and Monitoring (X-SAM®) Cranes,” Revision 1 (proprietary). Ederer later provided a nonproprietary version, dated June 25, 1979 (Reference 7). By letter dated January 2, 1980, NRC issued its evaluation (Reference 8) of TR EDR-1, Revision 1, which approved the X-SAM principle and associated engineering concept. By letter dated March 28, 1980 (Reference 9), Ederer forwarded proprietary and nonproprietary versions of Revision 2 to TR EDR-1, dated February 15, 1980, which incorporated the NRC evaluation into Revision 1.

Enclosure

By letter dated October 8, 1982, as supplemented by letters dated January 24, and May 27, 1983 (References 10–12, respectively), Ederer requested NRC staff review of Revision 3 to the EDR-1 TR. Revision 3 of the EDR-1 TR was submitted to extend applicability to compact hoist designs. In a letter dated August 26, 1983 (Reference 13), the NRC staff approved Ederer's generic licensing TR EDR-1, Revision 3, as an acceptable method of meeting the guidelines of RG 1.104 which was superseded by NUREG-0554.

Westinghouse has indicated that the EDR-1 TR is meant to be a "generic" TR and will be used to satisfy the guidance of NUREG-0554. The main body of the report provides information related to design and quality assurance applicable to all X-SAM crane installations. Appendices B and C of the EDR-1 TR identify the plant-specific information needed to verify an X-SAM crane's conformance with NUREG-0554 guidelines. Appendix B summarizes the plant-specific crane data to be supplied by the hoist vendor, and Appendix C summarizes the plant-specific crane data supplied by the licensee. Revision 7 to EDR-1 proposed changes to the report that do not change the principal design elements of an X-SAM crane. Instead, the revision proposed changes to the designation of components subject to quality assurance requirements, acceptable NDE methods for these components, and technology changes since the previous revision.

In accordance with the guidance of Revision 1 to Section 9.1.5 of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," the use of a single-failure-proof handling system is one acceptable method of protecting safety-related equipment from the effects of handling system component failures. The likelihood of a load drop as a result of a crane component failure is minimized by use of single-failure-proof handling system designed to the criteria of NUREG-0554. Accordingly, these TR changes are reviewed for compliance with the applicable sections of NUREG-0554. Section 2 contains acceptance criteria applicable to the crane structure, including references to material testing, welding standards, and NDE of all weld joints whose failure could result in a drop of a critical load. Section 6 addresses acceptance criteria applicable to the hoist drive controller. Finally, Section 10 of NUREG-0554 contains acceptance criteria for quality assurance programs applied to the procurement and design of single-failure-proof cranes.

### **3.0 TECHNICAL EVALUATION**

This EDR-1 TR provides generic descriptions of the safety systems and components of X-SAM cranes and compact hoists that are used to meet the guidance originally issued in RG 1.104, which was superseded by NUREG-0554. No design changes or additional appendices are included in Revision 7, but items have been updated to provide closer alignment with current industry technology and standards. Also, this report establishes the term "critical items" in lieu of the prior terminology designation "nuclear safety related."

The EDR-1 TR included a single-failure-analysis of the reference design X-SAM trolley for installation on an existing crane bridge. However, as indicated in the TR, the generic information regarding the X-SAM hoisting system is equally applicable to complete new cranes and hoists. Additional actions necessary to incorporate a complete X-SAM crane or compact X-SAM hoist in a new facility design are developing a detailed girder or monorail design to support the trolley or hoist and performing the requisite structural and seismic analyses of the girder or monorail design. These items are outside the scope of this report and should be later developed for the site-specific application by the licensee incorporating this crane design.

This report uses typical design data for cranes and hoists of the reference design ranging in capacity from 10 tons to 250 tons. As indicated in response to Request for Additional Information (RAI) EDR1-003, dated July 16, 2014, the capacity ranges listed in EDR-1 are meant to denote typical crane capacities in differing crane types. Should requirements for a single failure proof crane design exist where the critical crane load is in excess of 250 tons, the effect on some of the crane's safety system components will need to be scaled using the same methodology, formulas, and design allowables that were originally used for the 10 to 250 ton crane types.

Specific changes to Revision 7 of the TR mainly update information to reflect current technology and nondestructive examination standards and criteria and address modern technology or terminology. It also revises the phrase "nuclear safety related" (NSR). These updates align EDR-1 more closely with accepted industry standards that remain compliant with NUREG-0554. The guide also includes compliance with the applicable regulatory guidance and the provisions for operational testing of the hoist safety systems.

### Changes in Crane Technology

Table III.F.1 of EDR-1 revises the characteristics of controller and control braking to provide the appropriate correlation to modern technology and the corresponding industry terminology and classification for these components. It identifies a variable frequency flux vector drive as the modern state-of-the art technology that could be used as hoist drive controllers on X-SAM cranes. The table also includes the designation of dynamic lowering as an additional alternative for control braking. While this reference design represents current technology commonly used for cranes, the type of controller and method of control braking will be specified by the licensee. In addition, changes were made to the rope classification to reflect modern industrial naming conventions. This is reflected in the revised notation for the 6 x 36 independent wire rope core (IWRC) classification of wire rope, which includes the previously identified 6 x 37 IWRC type of wire rope in this classification.

NUREG-0554, Section 6, contains criteria for driver and controls that should be applied to the flux vector drive. Changes to the EDR-1 TR summary specify the incorporation of variable frequency flux vector drives to represent the modern state-of-the art controls that can be used on X-SAM cranes. An important safety aspect is the separation of the safety circuits (e.g., hoist integrated protective system (HIPS), overspeed, etc.) from the flux vector drive control circuits. It is essential for the crane to include a means to engage the holding brakes independent of the control system; so a control system failure without a loss of power would not interfere with the ability for the crane to hold the load.

As indicated in Section E of the EDR-1 TR, the safety circuits and the emergency drum brake provide an independent means of stopping a load in the event that a control system failure prevents the conventional holding brake from setting while the control system's regenerative braking is operating. In addition, Item C.2.a of the TR section, "Summary of Compliance with Regulatory Positions of RG 1.104," specifies that "an emergency stop button is included at all control stations. This button removes power from the crane and sets the Emergency Drum Brake if the load starts to lower." The staff issued RAI EDR-1-006, dated November 24, 2014, requesting Westinghouse to describe how the use of an emergency stop button removes complete power from a crane and to discuss how potential damage to crane hoist motor controls is avoided when safety circuits remove hoist motor power. The RAI response clarifies how the emergency stop button de-energizes (opens) the main power contactor, removing all

power from the crane motion motors and stopping/holding brakes. By design, when power is removed from the stopping/holding brakes, this automatically sets the brakes, which then begins deceleration and holds the crane motions to a standstill. Crane control damage (opening of the main contactor) does not occur because the crane electrical controls are designed to handle a sudden loss of power event, whether that occurs with relay logic control designs or modern alternating current and direct current variable flux vector drive controls. The staff finds this design feature reliably provides protection against uncontrolled lowering with removal of power through either actuation of safety circuits or the use of an emergency stop button.

By letter dated May 15, 2015, (Reference 4), Westinghouse informed staff that they were in the process of developing the critical characteristics for the equalizer cylinder on the AP1000 polar crane main hoist and that their engineering study targeted the internals of the hydraulic cylinder in order to address the failure modes analysis that was conducted. While Westinghouse concluded no issues were identified within the content of EDR-1 TR as it corresponds to the provisions described in NUREG-0554, they determined that a further clarification of the Equalizer Arrangements in Figure III.D.5 would be useful to convey more comprehensive configurations of the equalizer cylinder applications. Therefore, Westinghouse modified Figure III.D.5 to provide additional details of the typical hydraulic equalization arrangements.

Based on the above, the staff finds that technology changes have been acceptably incorporated into the X-SAM crane design, as described in Revision 7 to the EDR-1 TR.

#### Changes in Nondestructive Examination

Appendix A contains a table titled "Sample Critical Items List for Ederer's X-SAM Cranes," which includes supplemental notes regarding necessary material test reports, NDE, and additional tests. The report terminology has been updated to reflect modern terminology designations, standards, and allowances for alternative NDE techniques and practices. For instances in which alternative NDE methodology has been established to qualify components, these alternative NDE testing methods, at a minimum, will offer the same level of quality assurance and component integrity validation as the original NDE requirement in previous revisions.

NUREG-0554 recommends specific design requirements for welding and component testing and inspections. NUREG-0554 further recommends all weld joints whose failure could result in the drop of a critical load should be nondestructively examined. The revised critical items list in the TR appeared to remove the requirement of stress relief from some components, such as trolley truck structure (inside plates) (T.2), hoist truck structure (side plates) (H.2.1), hoist trunnion (H.2.4), hoist drum hubs (H.4.5), and hoist gear case structural shell (H.5.1). As a result, the staff issued RAI EDR1-007, dated November 24, 2014, requesting clarification on why the stress relief requirement was removed. In response, Westinghouse indicated that EDR-1 invokes American Welding Society (AWS) D1.1 welding for the structural items throughout the TR. Westinghouse refers to this overarching specification to provide the guidance and requirements for any post-weld and stress relief applications, as it had done previously. This is consistent with NUREG-0554, Section 2.8, and consistent with the position in Section C.1.f, the TR, which again focuses on the design parameters to determine when post-weld heat treatment or stress relief is needed.

Other NDE notes were revised to better align with industry standards (NOG-1, Section 7000). The staff finds the alignment of NDE criteria with NOG-1 and AWS D1.1 standards, while retaining test commitments from previous versions of the EDR-1 TR report, to be acceptable.

## Changes in Quality Assurance

The TR indicates there had been confusion about the phrase “nuclear safety related”(NSR) when used as the similarly expressed safety-related component or system (basic component) in the nuclear application environment, as defined in Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.2, “Definitions.” The original use and identification of components within the EDR-1 TR as NSR was never meant to designate a component as a safety-related item in terms of a system, structure, component, or control that is relied upon to remain functional during and following design basis events. For this reason, the term “nuclear safety related” has been removed from the EDR-1 TR to avoid future misinterpretation of these components or system classifications. The TR clarifies that items, components, and systems within Appendix A are identified as “critical items” and subject to the specified augmented quality requirements, tests, and certifications established in the generic licensing TR. The TR specifies that application of these augmented quality requirements will fall under an approved quality program under 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” when used at a nuclear facility.

As indicated in the TR, the licensee is responsible for the quality assurance program for site assembly, installation, and testing of the crane. While the TR references an “Ederer” quality assurance (QA) manual and an “Ederer” QA program, the current owner of the technology is Westinghouse. The NRC issued RAI EDR1-005, dated November 24, 2014, to clarify whether the Westinghouse QA program is applicable. The RAI response confirmed that Westinghouse is the current owner of this technology and committed to replace the applicable references to Ederer programs, documents, and personnel with the corresponding Westinghouse equivalent. As stated in the TR, the QA manual implements the relevant provisions of 10 CFR Part 50, Appendix B, for design and manufacture of X-SAM cranes.

Appendix A of the TR identifies items, components, and systems as “critical items” subject to the specified augmented quality requirements, tests, and certifications established in the generic licensing TR. The control of these “critical items” will be managed by a QA program that satisfies both the QA provisions of Section 10 of NUREG-0554 and the requirements of 10 CFR Part 50, Appendix B.

In evaluating the EDR-1 TR for reference in plant-specific licensing actions, the NRC staff noted that the acceptance applies only to the features described in the TR, and does not constitute acceptance of the total overhead crane handling system or the requirements that may be necessary to ensure the safe application of the crane system within the nuclear power plant. The plant specific information required, as identified in Appendices B and C of the report will be provided by the licensee. The NRC staff can then review the plant-specific information and compare it to the guidelines of NUREG-0554, as well as any exceptions to those guidelines approved in the safety evaluation of the EDR-1 TR.

The staff finds that Revision 7 of the EDR-1 TR, with changes noted in the supplemental information provided by letter dated December 17, 2014, provides the same level of protection as the previously approved Revision 3. In addition, the staff finds it reasonable that changes included in this revision have no impact on compliance with NUREG-0554.

#### 4.0 **LIMITATIONS AND CONDITIONS**

The generic information regarding the X-SAM hoisting system is equally applicable to new cranes and hoists. The following are additional actions necessary to incorporate a complete X-SAM crane or compact X-SAM hoist in a new facility design:

- Develop the detailed girder or monorail design to support the trolley or hoist.
- Perform the requisite structural and seismic analyses of the girder or monorail design.

Appendices B and C of the TR identify the plant specific information needed to verify a specific crane's conformance with (originally issued) RG 1.104 and superseded by NUREG-0554 guidelines. Licensees that incorporate the use of these hoists and trolleys into a crane design are expected to complete Appendices B and C to address how the plant specific application of the EDR-1 hoist system satisfies the guidelines of NUREG-0554.

#### 5.0 **CONCLUSION**

The staff noted that the acceptance applies only to the features described in the TR, and do not constitute acceptance of the total crane handling system or the requirements that may be necessary to ensure the safe application of the crane system within the nuclear power plant. Licensees that incorporate the use of EDR-1 guidance for hoists and trolleys into their designs should complete Appendices B and C to address how plant specific application of the system satisfies the guidelines of NUREG-0554.

Based on its review, the staff concludes that the design provisions found in section III of Revision 7 to EDR-1 TR are equivalent to, or more conservative than, the design provisions of the previously approved Revision 3 (as amended).

#### 6.0 **REFERENCES**

1. EDR-1, "eXtra Safety and Monitoring (X-SAM) Single Failure Proof Cranes," Revision 5, dated September 26, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13276A053).
2. DCP-NRC-003273, "Response to RAI's for Topical Report EDR-I Single Failure Proof Cranes," dated July 16, 2014 (ADAMS Accession No. ML14198A374).
3. DCP-NRC-003282, "Response to RAI's for Topical Report EDR-1 Single Failure Proof Cranes," dated December 17, 2014 (ADAMS Accession No. ML14356A276).
4. DCP-NRC-003293, "Submittal of Proposed Clarifications to EDR-1, eXtra Safety and Monitoring (X-SAM) Single Failure Proof Cranes, Revision 6," dated May 15, 2015 (ADAMS Accession No. ML15139A019)
5. EDR-1, "eXtra Safety and Monitoring (X-SAM) Single Failure Proof Cranes," Revision 7, dated June 11, 2015 (ADAMS Accession No. ML15167A048).
6. Forwards for approval EDR-1, "Ederer's Nuclear Safety-related Extra-Safety & Monitoring (X-SAM) Cranes," dated August 22, 1978 (ADAMS Legacy Accession No. 7908300666).

7. Topical Report, "Ederer's Nuclear Safety-related Extra Safety & Monitoring (X-SAM) Cranes," dated June 25, 1979 (ADAMS Legacy Accession No. 7908300672).
8. Correspondence, Notices of EDR-1, Revision 1, "Ederer's Nuclear Safety Related, Extra-Safety & Monitoring Cranes," dated January 2, 1980 (ADAMS Legacy Accession No. 8001100389).
9. Correspondence, Forwards (proprietary and nonproprietary versions) of EDR-1-A, Revision 2, "Nuclear Safety-Related Extra-Safety & Monitoring (X-SAM) Cranes," dated March 28, 1980 (ADAMS Legacy Accession No. 8004020267).
10. Correspondence, Forwards proposed (proprietary), Revision 3, to Topical Report EDR-1 (P)-A, "Ederer's Nuclear Safety-Related Extra-Safety & Monitoring (X-SAM) Cranes," dated October 8, 1982 (ADAMS Legacy Accession No. 8210210329).
11. Correspondence, Forwards (proprietary version) of Revision 3 to Topical Report EDR-1 (P)-A, "Ederer Nuclear Safety-Related Extra-Safety & Monitoring (X-SAM) Cranes," dated January 24, 1983 (ADAMS Legacy Accession No. 8302020277).
12. Forwards Amendment 2 to Revision 3 to "Ederer Nuclear Safety-Related Extra-Safety & Monitoring (X-SAM) Cranes," dated May 27, 1983 (ADAMS Legacy Accession No. 8306020364).
13. Completed review regarding acceptance for referencing of licensing topical report EDR-1 (P), Revision 3, "Ederer Nuclear Safety Related Extra-Safety & Monitoring (X-SAM) Cranes," dated August 26, 1983 (ADAMS Legacy Accession No. 9909200011).