Overview of Crane Design Standards for Research Reactors

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1. Introduction

Research reactors have several cranes of various types installed to operate the facility. Cranes are used to handle nuclear fuel, radioisotopes and test equipment, and transfer heavy loads such as casks. Different design criteria are required depending on the applications and types of the crane.

In 2021, U.S. Nuclear Regulatory Commission (NRC) issued Regulatory Guide (RG) 1.244, "Control of Heavy Loads at Nuclear Facilities." [1] RG 1.244 updated the existing guidance in technical reports NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" [2] and NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants." [3] Both NUREG reports were published before 1980 and do not reflect current information. The updated guidance endorsed three consensus standards, American Society of Mechanical Engineers (ASME) Standard (Std.) NML-1, "Rules for the Movement of Loads Using Overhead Handling Equipment in Nuclear Facilities," 2019 [4], ASME Std. NOG-1, "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)," 2020 [5], and ASME Std. BTH-1, "Design of Below-the-Hook Lifting Devices," 2017 [6].

This study provides a brief overview of the nuclear crane standards from a research reactor crane design perspective.

2. Nuclear Crane Standards

2.1 NML-1

ASME NML-1 specifies requirements for safe and effective load handling within nuclear facilities. This standard is a replacement of NUREG-0612. It reflects the current qualitative risk-informed approach and extends the scope for wider use in nuclear facilities. It covers various aspects related to crane operations, ensuring compliance with safety guidelines and minimizing risks.

This standard separates lifts into three classifications: standard, special, and critical, based on probability and consequence. The lifting requirements and safer load paths are defined by the lift classification. Within the critical lift class, nuclear safety critical safety lifts require more stringent safety measures. It also provides requirements for crane design, inspection, maintenance and testing and for operating personnel. Cranes used for critical lifts shall be designed to meet the requirements of ASME NOG-1 or ASME NUM-1[7], Type I. For special lifts, NOG-1 or NUM-1, Type II or III shall be met. Non-nuclear crane standards, Crane Manufacturers Association of America (CMAA) specification No. 70[8] or No. 74[9] shall be met for standard lifts.

Fuel handling in pools of the research reactor can be categorized as the nuclear critical lift under the NML-1 criteria. Lifting over special structure, system, or component (SSSC) can be classified as the special lift.

2.2 NOG-1

ASME NOG-1 specifically addresses the design, manufacture, testing, inspection, shipment, storage, and erection requirements for electric overhead and gantry multiple girder cranes with top running bridge and trolley used at nuclear facilities. This standard includes requirements for the single-failure-proof features as an update to NUREG-0554. The single-failure-proof requirements apply to Type I crane used to handle a critical load. Type II crane does not handle critical load and does not require the single-failure-proof features. Type II crane shall be designed to remain in place during a seismic event. Type III crane does not need the single-failure-proof and seismic design requirements. The Type III crane is similar to the CMAA 70 crane in design features. Korea Electric Power Industry Code (KEPIC) MCN, "Cranes for Nuclear Facilities," [10] adopted the NOG-1 as its main reference standard and KEPIC MCF, "Fossil Power Plant Cranes," [11] adopted the CMAA 70.

The fuel handing crane for research reactor can be designed as NOG-1 (MCN) Type I with the single-failure-proof requirements. Overhead cranes located above reactor core, spent fuels, hot cells and radwaste storage can be designed as NOG-1 Type II with the seismic design. Non-seismic overhead cranes can be designed to NOG-1 Type III or CMAA 70 (MCF).

2.3 NUM-1

ASME NUM-1, titled "Rules for Construction of Cranes, Monorails and Hoists (with Bridge or Trolley or Hoist of the Underhung Type)," is not endorsed in RG 1.244, but is called in ASME NML-1.

Whereas NOG-1 applies to double-girder top-running bridge and gantry cranes, NUM-1 covers various types of cranes, monorails, and hoists with under-running type bridge or trolley or hoist including single-girder crane. NUM-1, like NOG-1, classifies equipment into Type I, II, and III. One difference is that Type I is subdivided into Type IA and IB. Type IA is essentially the same as Type I in NOG-1. Type IB requires enhanced safety features instead of single-failure-proof features. The choice of Type IA or IB is the responsibility of the owner. Type II requirements include seismic design and Type III requirements are similar to CMAA 74. NUM-1 is not adopted in KEPIC.

Single-girder cranes have advantages in hook approach and compact design while double-girder cranes offer higher load capacity. If a double-girder crane of Type I or II is replaced by a single-girder crane, NUM-1 can be used instead of NOG-1.

2.4 BTH-1

ASME BTH-1, in part, Chapters 1 to 3 for mechanical devices is endorsed in RG 1.244. BTH-1 provides essential criteria for the structural, mechanical, and electrical design of lifting devices used below the hook. BTH-1 specifies calculations for different types of loading, including tension, compression, flexure, shear, and combined loading of beams.

3. Summary

In this study, the nuclear crane standards are briefly discussed. The applicability of these crane standards to various cranes used in research reactor is examined. The ASME NOG-1 and NUM-1 are compared based on the application of single-failure-proof features and seismic design. In future research reactors, the application of the NUM-1 may be considered for various cranes such as single-girder cranes, jib cranes, and monorails when applying single-failure-proof features or seismic design.

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[5] ASME NOG-1, Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder), American Society of Mechanical Engineers.
[6] ASME BTH-1, Design of Below-the-Hook Lifting Devices, American Society of Mechanical Engineers.
[7] ASME NUM-1, Rules for Construction of Cranes, Monorails, and Hoists (With Bridge or Trolley or Hoist of the Underhung Type), American Society of Mechanical Engineers.
[8] CMAA Specification No. 70, Multiple Girder Cranes, Crane Manufacturers Association of America, Inc.
[9] CMAA Specification No. 74, Single Girder Cranes, Crane Manufacturers Association of America, Inc.
[10] KEPIC MCN, Cranes for Nuclear Facilities, Korea Electric Association.
[11] KEPIC MCF, Fossil Power Plant Cranes, Korea Electric Association.

Table I: Summary of ASME NOG-1 and NUM-1

Standard	Scope	Type	Single-failure-proof	Seismic Design	Relevant Standard
ASME NOG-1 (KEPIC MCN)	Overhead and gantry multiple girder cranes with top running bridge and trolley	I	O	O	NUREG-0554
		II	X	O	
		III	X	X	CMAA 70 (KEPIC MCF)
ASME NUM-1	Underhung cranes Top-running bridge and gantry cranes with underhung trolley Traveling wall crane Jib cranes Monorail systems Overhead hoists Hoists with integral trolleys	IA	O	O	NUREG-0554
		IB	X (Enhanced safety features)	O	
		II	X	O	
		III	X	X	CMAA 74 (single girder crane)