EPRI Hoisting, Rigging and Crane User Group Presentation: Control of Heavy Loads

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Purpose

• Communicate background information regarding existing licensing basis for control of heavy loads
• Communicate operating experience important to NRC regulation and interface with industry initiative activities
• Discuss relationship with ASME Cranes for Nuclear Facilities Committee
Heavy Load Issue Timeline

1978
NUREG 0612

1980
GL 80-113

1985
GL 85-11

1999
GSI-186 Opened

2005
RIS 2005-25

2015
Closure of GSI-186

2018
Two Yellow Violations for Stator Drop

1978
NUREG 0554

1980
NUREG-0554

1985
NUREG-1774 (Operating Experience)

1999
Reactor Vessel Head Lift Issues

2005
Industry Initiative

2015
Stator Drop and Temp Rig Collapse

2018
ASME Issues NOG-1 Comparison Matrix

2018
ASME Issues Crane O&M Standard?

1978
Task A-36

1980
First Dry Fuel Storage Installation Licensed
Analysis of Issue

• Task A-36:
  – Analyze current licensing criteria
  – Analyze measures that ensure safe handling of heavy loads.
  – Recommend changes

• NUREG-0612 (July 1980)
  – Overview of potential consequences of a load drop
  – Summary of current licensee programs
  – Review of Historical Data
  – Guidelines and Recommendations
    • Procedures and safe load paths
    • Consistency with industry standards
    • Assurance that critical SSCs adequately protected
Heavy Load Handling Program

• Licensees review heavy load programs against NUREG-0612 guidelines
• Requested responses in two phases to determine how NUREG-0612 guidelines would be met
Phase I and II Guidelines:

• Phase I [prevention] :
  – Safe load paths
  – Load handling procedures
  – Periodic inspection and testing
  – Operator qualification
  – Lifting device standard
  – Sling standard
  – Crane design standard
  – Interim Technical Specifications

• Phase II [protection or consequence analysis] :
  – Stops or interlocks prevent movement of load over critical SSCs, OR;
  – Overhead crane and lifting devices designed to be single failure proof, OR;
  – Load drop analyses demonstrate acceptable consequences.
Review of Phase I and II

- All licensees submitted Phase I and II information
- Resource intensive reviews confirmed conformance with Phase I guidelines
- Phase II responses sampled
- Phase II responses generally enhanced Phase I implementation through limited load drop analyses and administrative controls (where single-failure-proof cranes were not installed)
Resolution of Phase II (GL 85-11)

- Greatest risk - heavy loads over irradiated fuel
- Risk to safe-shutdown systems considered small
- Full implementation of Phase II unjustified
- Phase II responses did not identify additional concerns; no need for further generic action
- However, Phase II responses captured in licensing basis
Bulletin 96-02

- Handling of dry storage casks began after establishment of heavy load programs
- Bulletin initiated because of proposed movement of dry storage casks at power in a BWR
- Potential for cask drop to initiate transient and damage key equipment
- Reinforced requirement to evaluate changes in operations through safety analysis report change process (10 CFR 50.59)
Heavy Load Generic Issue

- Generic Issue 186 was opened in 1999 to determine the need for more regulatory action
- Operating experience review published as NUREG-1774
- RIS 2005-025 in October 2005 and Supplement in May 2007 reemphasized expectations regarding heavy load handling
- Identified focus areas based on operating experience
Operating Experience Findings

• Most heavy lift accidents due to “below the hook” issues (human errors, rigging failures, etc.) vice crane deficiencies
• Industry standard provides clear single failure proof criteria for cranes
• Consequence and load drop analysis methodologies vary between licensees
• Three >30 ton load drops between 1980 and 2002, all due to rigging failures (not crane failures)
Key Insights

• Three recurring causes of load drops at nuclear power plants:
  – Two-blocking
  – Intermediate hoists
  – Inadequate sling protection

• Human performance important to prevention

• Additional measures can reduce risk
  – Limit height of lift
  – Redundant equipment available
  – Use specially designed lift rigs
“Two Blocking”

• Three drops due to cutting of wire rope
  – 1970-Palisades (Polar Crane Aux Hoist; Prior to Operation; Limit Switch Bypassed)
  – 1985-Browns Ferry (Unloaded Turbine Aux Hoist)
  – 1993-Calvert Cliffs (Unloaded Turbine Aux Hoist)

• Relationship to nuclear safety
  – Aux hoist faster than main hoist; less time for operator action
  – Main hoists carry heaviest loads
  – “Two Blocking” is a credible cause of load drops
Intermediate Hoists

- **Hoist failure - Comanche Peak - 1999**
  - 20 foot drop of 45 ton motor
  - Snag avoided RCS impact
  - Plant was defueled

- **Chain failure - Peach Bottom - 2002**
  - 10 inch drop of 24 ton motor
  - No damage to RCS; fuel in vessel

- **Load path issue - South Texas - 2003**
  - 50 ton motor moved over operating RHR heat exchanger (in containment)
  - Double-capacity lift rig specified in heavy load program not used
Intermediate Hoists (Continued)

• Relationship to nuclear safety
  – Intermediate hoist increases failure probability
  – Failures could threaten decay heat removal

• Regulatory Insights
  – Not addressed in heavy load guidelines
  – Redundant capabilities unaffected by potential load drop should be available to manage risk pursuant to 10 CFR 50.65(a)(4)
Slings

• Three drops of very heavy loads
  – 2001 at San Onofre (mobile crane dropped from turbine bldg crane)
  – 2001 at Turkey Point (mobile crane dropped form turbine bldg crane)
  – 2005 at Browns Ferry (old trolley dropped from reactor building crane temp hoist)

• All outside scope of heavy load program
Slings (Continued)

- Nuclear safety insights
  - Failed slings used in basket configuration
  - Slings used as part of cask lifting device with special fittings
  - Operating experience suggests synthetics more susceptible to cutting than steel
  - Training and procedures may improve identification of incorrect sling usage
  - Steel slings may allow more time to correct inadequate corner softening
Continued Heavy Load Issues

- Mid-2000s: refueling delays
- Regulatory Issue: unclear licensing bases (particularly reactor head lifts)
- Safety Issue: potential damage that precludes adequate cooling of irradiated fuel
- Desired Resolution: improved practices aligned with licensing basis
Industry Initiative

• NEI proposed industry initiative related to heavy load handling:
  – Safety basis for key heavy lifts
  – Safety basis incorporated in FSAR
  – Develop industry guidance for reactor head lifts (load drop analyses and single-failure-proof crane equivalence)

• Enforcement discretion during implementation

• NRC held public meetings with NEI to speed guideline development
Industry Guidelines (NEI 08-05)

• Realistic reactor head drop analysis methodology
• Single-failure-proof handling system equivalence for head lifts
• Maintenance rule risk management
• NRC staff endorsed the NEI guidelines, with some exceptions
Safety Significance

• PWR Head Lifts
  – Significant portion of lift at height/location where drop could severely damage vessel
  – High lift – increased potential for “two-blocking,” an important cause of drops
  – Crane inspection/maintenance on or near critical path
  – Vulnerable to single failures/operator error

• BWR Cask Movements
  – Potential for drops from high elevations over sensitive structures (e.g., spent fuel pool floor and torus)
  – Often performed with reactor operating at power
Load Drop Probabilities

- NUREG-0612, 1980 (Navy Data):
  6.3 E-05 Drops/Lift
- NUREG-1774, 2003 (>30 Ton Lifts):
  5.6 E-05 Drops/Lift
- DOE WIPP Study
  - Crane Failure (Navy Data):
    2.5 E-06 Failures/Lift
  - Human Error Probability (Failure of Lifting Device):
    8 E-07 Failures/Lift
- Estimates uncertain due to limited data
ANO Stator Drop

• Collapse due to buckling of unstable column assembly
  – New configuration
  – Not load tested

• Adverse impacts
  – Loss of electric power
  – Trip of adjacent unit
  – Flooding

• Safety Significance
  – Mechanical damage and flooding impacted all sources of AC power except EDGs
  – Unit 1 EDG work not coordinated with stator move
Ongoing Activities

• Policy is to endorse consensus standards where appropriate
• Participation with ASME for standards development
  – ASME NOG-1, 2010 and later include matrix to NUREG-0554 guidelines for single failure proof cranes
  – ASME HRT-1 addressed heavy component replacement activities following ANO stator drop
  – ASME developing operation and maintenance standard addressing scope of NUREG-0612
• Inspection and licensing
  – Consolidated interim fuel storage license application
  – At-reactor independent fuel storage facilities
  – Reactor refueling activities