Workshop On

(Edward D. Throm - WITH NOTES)

Risk Related to Spent Fuel Pool Accidents at Decommissioned Plants

Heavy Loads Discussion Session

George T. Hubbard
Section Chief, SPLB

Edward Throm
DSSA/SPSB

Division of Systems Safety and Analysis
NRR — USNRC

Frequency of Load Drops

Technical working group considered only cask handling. ***[NUREG-0612 - heavy load: weights more than the combined weight of a single spent fuel assembly plus its associated handling tool]***

NUREG-0612: "Control of Heavy Loads at Nuclear Power Plants" ***[INCLUDE .1 to .2 for hot fuel]***

Based on Navy crane data (1974 -1977):

1.5×10^{-4} to 1.0×10^{-5} drops per lift	(non-single-failure proof system)	
1.5×10^{-3} to 1.0×10^{-4} drops per lift	(with common mode failures)	***[Figure B-2]***
1.0×10^{-4} to 4.0×10^{-7} /R-yr	(failure of handling system, single-failure proof system)	***[Figure B-3]***

[Non-single failure, exceed guidelines 3×10^{-5} to 2×10^{-8}] ***[single failure 1×10^{-5} to 3×10^{-9}]***

1.0×10^{-4} comes from 8.0×10^{-5} crane ("two-blocking", over load, limit switch failure, backup components)
3.0×10^{-5} failure from rigging and redundant rigging

NUREG-1353: Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design Basis Accidents in Spent Fuel Pools"
1.0×10^{-3} to 1.0×10^{-4} drops per lift ***[Based on 6×10^{-4}, 3×10^{-7} wall damage]***

"Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities," Westinghouse Savannah River Co., WSRC-TR-93-581, February 28, 1994. 1.5×10^{-3} to 1.5×10^{-5} drops per operation
[200 drops in 2,000 crane years and additional data from nuclear power plants - drops/operating-hour]
[Operation, lift, move and set down, if takes 1 hour, then could look at it like drop/lift]

[SUMMARY]

[construction loads	**1 / 852**	**or 1.0×10^{-3} drops per lift]**
["small loads' low level waste	**2 / 39,000**	**or 5.0×10^{-5} drops per lift]**
[drums	**1 / 6,884**	**or 1.5×10^{-4} drops per lift]**
[composite	**4 / 68,486**	**or 6.0×10^{-5} drops per lift]**

Mechanical/Electrical crane failure rates: 3×10^{-6} per operating hour ***[10% or less compared to human errors]***
[sometimes hardware/electrical failure rates are in the 10^{-4} to 10^{-5} per demand]]

Human Errors Are The Major Concern

NUREG-0612

OSHA data: Rigging 34% Operator errors 42%

Navy data('74-'77): Rigging 7% Operator errors 70% ***[Table 4-2 - 23% design, maintenance, crane failures]***

Technical Study

Department of Interior(DI): Major contributor "employee negligence" 44% poor maintenance, overloading

[Mineral Management Services] ***[50 accidents, 1/71 to 6/83]***

Crane Accident Workgroup (DI): 35% human error ***[34 incidents, 1995 to 1998]***

[looking at Mineral Management Services and US Coast Guard regulatory requirement]

DOE Study: Human error (68%) is major cause of incidents ***[491 incidents, 10/93 to 3/96]***

[Management and Personnel errors] ***[131 evaluated]***

Work planning (18%) a significant factor

Training-related deficiencies not a significant problem (9% inadequate procedures)

(http://tis-hq.eh.doe.gov/oversight/reviews/hoist_rig.html)*

Root Cause	Crane	Forklift	Other
Inattention to Detail	20%	23%	8%
Work Organization and Planning	18%	3%	27%
Procedure Not Used or Used Incorrectly	9%	15%	0%
Policy Not Adequately Defined, Disseminated, or Enforced	9%	10%	4%
Inadequate or Defective Design	5%	5%	19%
Defective or Inadequate Procedure	9%	5%	0%
Inadequate Administrative Control	9%	0%	4%
Defective or Failed Part	5%	5%	8%
Other Management Problem	3%	3%	12%
Other Human Error	3%	3%	0%
Inadequate Work Environment	0%	10%	0%
Lack of Procedure	2%	3%	4%
Insufficient Refresher Training	3%	3%	0%
Insufficient Practice or Hands-On Experience	5%	0%	0%
Communication Problem	2%	3%	4%
Inadequate Supervision	0%	3%	4%
Error in Equipment or Material Selection	0%	3%	4%
Weather	0%	3%	0%
No Training Provided	0%	0%	4%

*Rounded to the nearest whole number.

Technical Study Summary

Since the human error contribution appears to have remained constant and human errors are the major concern, the technical study used the NUREG-0612 evaluation to estimate the frequency of damage to the spent fuel pool at a decommissioned plant.

System	Drop over or near spent fuel pool (per R-yr)	Result in pool wall damage (per R-yr)	Result in pool floor damage (per R-yr)
Non-single failure proof system	$1.5x10^{-3}$ - $1.0x10^{-4}$ handling system failure (per lift) times $1.0x10^{-1}$ to $2.0x10^{-3}$ over fuel (per R-yr) $1.5x10^{-4}$ - $2.0x10^{-7}$ *median (mean) $7.5x10^{-5}$*	(1/100 - 10% of path and 10% conditional) $1.5x10^{-6}$ - $<10^{-8}$ *$7.5x10^{-7}$*	(1/10 - 10% of path) $1.5x10^{-5}$ - $2.0x10^{-8}$ *$7.5x10^{-6}$*
Single failure proof system	$1.0x10^{-4}$ to $4.0x10^{-7}$ handling system failure (per R-yr) time $2.5x10^{-1}$ to $5.0x10^{-2}$ over fuel(per event) $2.5x10^{-5}$ - $2.0x10^{-8}$ *median (mean) $1.3x10^{-5}$*	$2.5x10^{-7}$ - $<10^{-8}$ *$1.3x10^{-7}$*	$2.5x10^{-6}$ - $<10^{-8}$ *$1.3x10^{-6}$*

Other Factors Which Influence Risk

Risk of loss of inventory is reduced with:

- segregated cask loading area (limit draindown)
- cask crush pad (prevent pool floor failure)
- specific cask drop analyses (adequate structural design)

Potential areas to refine risk estimates:

- data specific to nuclear power plant cranes (75 to 125 ton)
- cask handling plans
  - frequency (estimates based on ~200 lifts per year)
  - time after last fuel removed from reactor
- human factor considerations
- other heavy loads handled near or over spent fuel pool

Definitions

Single failure proof system:

A lifting system (hoisting system and braking system for the trolley and bridge) designed so that a single failure will not result in the loss of capability of the system to safely retain a critical load or setting the load down while repairs or adjustments are made.

Common mode failure (as used in NUREG-0612):

Prescribed load path not followed and electrical interlocks have failed. For example, poorly trained or unqualified operator fails to follow load path, fails to check operability of interlocks and proceeds to operate load handling system, leading to a load drop.