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Status of Fukushima Dai-ichi Lessons Learned

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November 17, 2015

Topics

- Walkdowns
- Flooding Reevaluations
- Seismic Reevaluations
- Hardened Vents and Filtration
- Mitigation Strategies
- Regulatory Framework

Walkdowns

Arkansas Nuclear One:

"There were some observed conditions of features that did not meet the NEI 12-07 acceptance criteria. … The operability determinations for these conditions concluded that the feature could perform its intended flood protection function when subject to its design basis flooding hazard."

"There were no observations that required actions to address a deficiency."

Source: Licensee 50.54(f) response letter dated 11/17/2012 (ML123340008)

Walkdowns

Arkansas Nuclear One timeline:

03/12/2012 – NRC 50.54(f) flooding walkdown letter (ML12053A340)

11/17/2012 – Licensee 50.54(f) letter response (ML123340008)

03/31/2013 – Fatal accident resulting in flooding (ML13158A242)

04/01/2013 – Beginning this day, previously invisible flood protection deficiencies became visible to workers and NRC inspectors

Walkdowns

Arkansas Nuclear One:

"...there were more than 100 unknown ingress pathways for a flooding event..."

"The unexpected rate of flooding would likely be beyond the licensee's capability to prevent or mitigate as equipment and connections associated with alternative mitigating strategies could be submerged."

"...the licensee did not design, construct, and/or maintain over 100 barriers to ensure design margins were sustained."

Source: NRC letter dated 09/09/2014 (ML14253A122)

Walkdowns

St. Lucie:

"The flooding walkdowns verified that permanent structures, systems, components (SSCs), portable flood mitigation equipment, and the procedures to install and/or operate them during a flood are acceptable and capable of performing their design function as credited in the current licensing basis (CLB) with one exception:

- **Missing and degraded conduit seals were determined in RAB-connected electrical manholes in Unit 1 and Unit 2."**

Source: Licensee 50.54(f) response letter dated 11/27/2012 (ML123350128)

Walkdowns

St. Lucie timeline:

03/12/2012 – NRC 50.50(f) flooding walkdown letter (ML12053A340)

11/27/2012 – Licensee response (ML123350128)

01/09/2013 – It rained in Florida and flooded the RAB at St. Lucie (ML13158A242)

01/10/2013 – Beginning this day, previously invisible flood protection deficiencies became visible to workers

Walkdowns

St. Lucie:

- **"Approximately 50,000 gallons of water entered the -0.5 foot elevation of the RAB through two degraded conduits in the ECCS pipe tunnel which were severely corroded and lacked internal flood barriers."**

- **"After the [January 9, 2014] event, the licensee identified four additional conduits in the ECCS pipe tunnel without internal flood barriers…".**

Source: NRC letter dated 09/24/2014 (ML1426A337)

Walkdowns

St. Lucie:

- **"The licensee evaluated the missing flood barriers and concluded that a design basis external flood event would have allowed water to enter the Unit 1 RAB and potentially impact both trains of high head and low head ECCS pumps."**
- **"The licensee also concluded that modifications implemented in 1978 and 1982 had installed the six conduits below the design basis flood elevation without internal flood barriers."**

Walkdowns

NRC required walkdowns to examine flooding protection measures after Fukushima. After the walkdown "verifications," events revealed deficiencies and violations previously and repeatedly overlooked.

Flood protection deficiencies are likely easier to find than still-hiding seismic protection deficiencies.

Value of the walkdowns: 0-ish

Flooding Reevaluations

GIGO

Because the flooding walkdowns failed to accurately determine the adequacy of existing flood protection measures, the results from the ensuing re-evaluations are garbage, too.

Seismic Reevaluations

Three Mile Island Unit 1 (TMI-1) operated for four decades in configurations where an earthquake could disable the emergency core cooling system. The owner reported:

> ***"TMI-1 staff interpreted the original plant licensing basis as a pre-GDC plant … to not include an ECCS performance requirement concurrent with a seismic event."***

Source: Licensee event report dated October 15, 2015 (ML15278A507)

Hardened Vents and Filtration

Site Name	10-Mile Population	Delta ILCF	Expected Latent Cancer Deaths if Entire Population Exposed	Evacuation Success to Save Enough Lives: $64M filter and $3M per life	Evacuation Success to Save Enough Lives: $64M filter and $8M per life	Evacuation Success to Save Enough Lives: $11M filter and $3M per life	Evacuation Success to Save Enough Lives: $11M filter and $8M per life
Limerick Units 1 & 2	216,988	9.50E-05	20.6	-3.49%	61.19%	82.21%	93.33%
Duane Arnold	160,790	9.20E-05	14.8	-44.22%	45.92%	75.21%	90.70%
Oyster Creek	140,318	9.20E-05	12.9	-65.26%	38.03%	71.60%	89.35%
Fermi Unit 2	104,850	9.20E-05	9.6	-121.16%	17.07%	61.99%	85.75%
Pilgrim Unit 1	94,595	9.20E-05	8.7	-145.13%	8.07%	57.87%	84.20%
Susquehanna Units 1 & 2	74,924	9.50E-05	7.1	-199.72%	-12.39%	48.49%	80.68%
Nine Mile Point Unit 2	73,841	9.50E-05	7.0	-204.11%	-14.04%	47.73%	80.40%
James A. FitzPatrick	73,841	9.20E-05	6.8	-214.03%	-17.76%	46.03%	79.76%
Nine Mile Point Unit 1	73,841	9.20E-05	6.8	-214.03%	-17.76%	46.03%	79.76%
Hope Creek Unit 1	71,595	9.20E-05	6.6	-223.88%	-21.46%	44.33%	79.12%
Peach Bottom Units 2 & 3	68,588	9.20E-05	6.3	-238.08%	-26.78%	41.89%	78.21%
Dresden Units 2 & 3	67,379	9.20E-05	6.2	-244.15%	-29.06%	40.85%	77.82%
Monticello	67,351	9.20E-05	6.2	-244.29%	-29.11%	40.82%	77.81%
Quad Cities Units 1 & 2	50,408	9.20E-05	4.6	-360.01%	-72.51%	20.94%	70.35%
Brunswick Units 1 & 2	38,123	9.20E-05	3.5	-508.25%	-128.09%	-4.54%	60.80%
Browns Ferry Units 1, 2 & 3	34,794	9.20E-05	3.2	-566.45%	-149.92%	-14.55%	57.05%
LaSalle County Units 1 & 2	23,350	9.50E-05	2.2	-861.72%	-260.64%	-65.30%	38.01%
Edwin I. Hatch Units 1 & 2	22,397	9.20E-05	2.1	-935.34%	-288.25%	-77.95%	33.27%
Cooper	10,965	9.20E-05	1.0	-2014.77%	-693.04%	-263.48%	-36.30%
Columbia Generating Station	6,403	9.50E-05	0.6	-3407.13%	-1215.17%	-502.79%	-126.05%

NOTES:

1) Populations from June 2005 FEMA Fact Sheet

2) Blue shaded reactors have Mark I containment designs

3) Pink shaded reactors have Mark II containment designs

4) Delta ILCFs calculated from average Individual Latent Cancer Fatality (ILCF) risks within 10 miles from Tables 4-23 and 4-24 in the NRC Draft Regulatory Basis, May 2015 (ML15022A214)
The delta ILCF is the average SAWA/SAWM + External Filter value minus the average SAWA/SAWM value for each containment type.

5) Filter costing $64 million is justified if it saves 21.3 lives when value of a life is $3 million

6) Filter costing $64 million is justified if it saves 8.0 lives when value of a life is $8 million

7) Filter costing $11 million is justified if it saves 3.7 lives when value of a life is $3 million

8) Filter costing $64 million is justified if it saves 1.4 lives when value of a life is $8 million

9) Negative (green-shaded) evacuation success values indicate that a population larger than living within 10 miles must be exposed to yield the number of deaths needed to justifiy the filter's cost.

10) Positive (yellow-shared) evacuation success values indicate the percentage of the 10-mile population that must NOT be exposed in order to maintain the number of deaths below that needed to justify the filter's cost.

With few exceptions, external filters are cost-beneficial safety upgrades.

Mitigation Strategies

The mitigation strategies rely in large part on equipment fetched from onsite and regional storage and manually installed and operated.

What are the chances these mitigation strategies will be successfully deployed?

Mitigation Strategies

Table 4: Comparison Between Industry and NRC Risk Estimates				
Event	**Licensee ΔCDF**	**NRC ΔCDF**	**Risk Difference**	**Sources**
ANO flood protection yellow finding	1.44E-05	1.00E-04	594%	ML14329B209
ANO Stator Drop on Unit 1 yellow finding	4.8E-06	6.0E-05	1,150%	ML14174A832
ANO Stator Drop on Unit 2 yellow finding	1.8E-06	2.8E-05	1,456%	ML14174A832
Browns Ferry Unit 1 RHR Valve red findings	1.0E-06	1.0E-04	9,900%	ML111290482 ML111930432
Fort Calhoun flood protection yellow finding	8.4E-07	3.2E-05	3,710%	ML102800342
Fort Calhoun trip relay contactor white finding	1.0E-06	2.6E-05	2,500%	ML111660027 ML112000064
Indian Point 2 steam generator tube leak red finding	6.6E-06	2.85E-05	332%	ML003770186
Monticello flood protection yellow finding	8.92E-07	3.6E-05	3,936%	ML13233A068 ML13162A776
Oconee safe shutdown facility yellow finding	8.0E-06	1.6E-05	100%	ML102240588
Palo Verde voided ECCS suction line yellow finding	7.0E-06	4.6E-05	557%	ML051010009
Watts Bar flood protection yellow finding	8.15E-09	6.35E-06	77,814%	ML13115A020 ML13071A289

Source: UCS letter dated March 4, 2015 (ML15063A536)

Mitigation Strategies

In May 2015, Indian Point Unit 3 experienced a transformer failure that involved flooding of the 480-volt switchgear room and the potential for a station blackout.

The NRC's SPAR model and SDP Notebook assume workers have an 80% chance of mitigating a SBO.

The owner assumes workers have a 96% chance of success.

Source: NRC worksheet dated May 15, 2015 (ML15138A307)

Regulatory Framework

M4P and UCS petitioned the NRC to resolve a safety/security gap that was closed by the 10 CFR 73.58. (See also Regulatory Guide 5.74, Rev. 1.)

Because the regulatory framework recommendation by the NTTF remains open, NRC opened a gap between design basis and beyond design basis measures.

Source: UCS letter on behalf of M4P and UCS dated April 28, 2003 (ML031681105)

Regulatory Framework

Examples of the new gap created:

- **Installing a valve between a FLEX connection and the reactor vessel or spent fuel pool.**
- **Lowering a relief valve setpoint below the point where FLEX pump discharge pressure would keep it open.**
- **Erecting a security fence or flood wall that would prevent or impede deployment of FLEX equipment.**

Regulatory Framework

Examples of the new gap created:

- **Removing a valve that creates a pathway for FLEX flow to be diverted from the reactor vessel or spent fuel pool.**
- **Filling the FLEX building with transient combustibles, since App. R/NFPA 805 don't apply to it.**
- **Replacing the FLEX pump with one having higher discharge pressure such that existing relief valves will open and transform makeup water into internal flood water.**

Regulatory Framework

NRC should close the gap created by its post-Fukushima fixes, or prepare for a recycled UCS petition for rulemaking seeking to close it.

Regulatory Framework

The regulatory footprint for design bases requirements has identified hundreds of mis-steps:

- **Over 100 50.59 violations listed in a 2013 NRC compilation (ML13094A257)**
- **NRC issued Confirmatory Order 08/26/2015 to Millstone Unit 2 for 50.59 violations**

Licensees are changing design bases requirements without prior NRC review and approval.

Regulatory Framework

The regulatory footprint for beyond design bases "requirements" is microscopic by comparison.

NRC has no control over, and therefore no assurance that, beyond design bases mitigating measures "promised" today will remain in place and in effect tomorrow.

Fukushima Litmus Test

If all the Fukushima lessons learned that involve actions had been fully implemented at Fukushima on March 10, 2011, would disaster have been averted the following day?

Industry: <173% chance of yes
NRC: >50% chance of yes

The American public deserves better than "well, maybe."

List of Acronyms (LoA)

CLB – current licensing basis
ECCS – emergency core cooling systems
FEMA – Federal Emergency Management Agency
GDC – general design criteria (Appendix A to 10 CFR 50)
GPA – grade point average
GIGO – garbage in, garbage out
ILCF – individual latent cancer fatality
M4P – Mothers for Peace of San Luis Obispo
MBDBE – mitigating beyond design basis events
NRC – Nuclear Regulatory Commission
NNTF – NRC's Near Term Task Force
RAB – reactor auxiliary building
SDP – significance determination process
SSC – structures, systems, and components
SPAR – standardized plant accident response
UCS – Union of Concerned Scientists