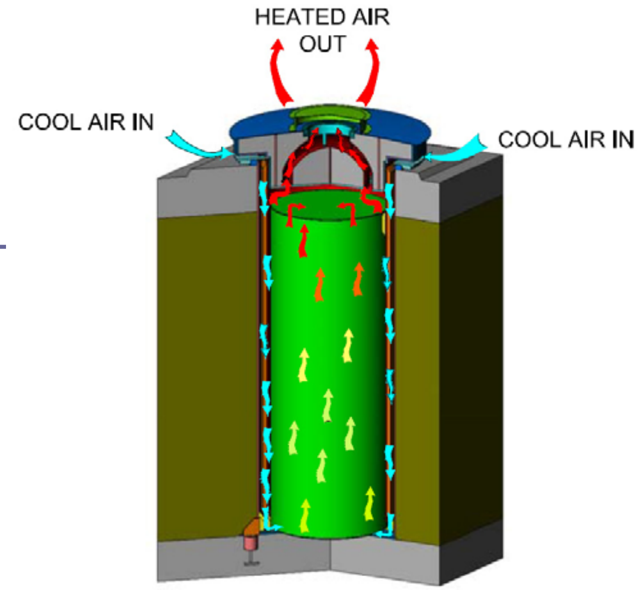
California's Nuclear Waste
Problems and Solutions

Donna Gilmore, SanOnofreSafety.org
California Energy Commission 2015 IEPR
Nuclear Power Workshop
April 27, 2015

Game changer
Indefinite on-site storage

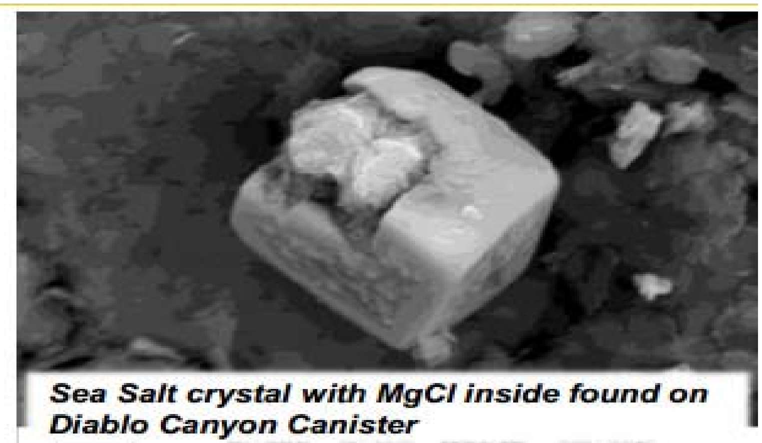


- **2014 NRC continued storage decision***
  - **100 years (short term)** on-site storage
  - **200 years (long term)** on-site storage
  - **Indefinite** on-site storage
  - **Reload** canisters every 100 years
- **No other storage sites on horizon**
- **U.S. thin steel canisters may start failing in 20 to 30 years**
  - Some may already have stress corrosion cracks
- **Cannot inspect for or repair corrosion and cracks**
  - No warning until after radiation leaks into the environment
- **Diablo Canyon Holtec thin canister has *conditions* for cracking after only two years**!
- Edison plans to spend about **$1.3 billion** to install another thin canister system for San Onofre spent fuel with no replacement plan for failure.

*GEIS analyzed the environmental impact of storing spent fuel beyond the licensed operating life of reactors over three timeframes: 60 years (short-term), 100 years after the short-term scenario (long-term) and indefinitely, August 26, 2014. [assumes 40 year license: 60+40 = 100 (short term), 100 + 100 = 200 (long term)]

Two-year old Diablo Canyon Holtec canister has conditions for cracking

- **Temperature low enough to initiate cracks in 2 years <85°C (185°F)**
- **Moisture dissolves sea salt – trigger for corrosion and cracking**
- **Only small surface area of two canisters sampled Jan 2014**
  - Sampled temperature and part of surface for salt and other surface contaminants, due to limited access via concrete air vents
- **Canisters not repairable & millions of curies of radiation would be released from even a microscopic crack**
  - Holtec CEO Dr. Singh,10/14/2014 http://youtu.be/euaFZt0YPi4
- **No plan in place to replace cracked canisters**



Condition of existing canisters unknown

- **No technology exists to inspect canisters for cracks**
  - Most thin canisters in use less than 20 years
- **Won't know until AFTER leaks radiation**
- Similar steel components at nuclear plants **failed in 11 to 33 years** at ambient temperatures ~20°C (68°F)
- **Crack growth rate about four times faster** at higher temperatures
  - 80ºC (176°F) in "wicking" tests compared with 50°C (122°F)
- **Crack initiation unpredictable**
  - Cracks more likely to occur at higher end of temperature range up to 80°C (176°F) instead of ambient temperatures
  - Canister temperatures above 85°C will not crack from marine air – chloride salts won't stay and dissolve on canister
- **Many corrosion factors not addressed**. NRC focus is chloride-induced stress corrosion cracking (CISCC).

Koeberg steel tank failed in 17 years

- **California coastal plant environment similar to Koeberg nuclear plant in Cape Town, South Africa**
  - **Salt and high moisture from on shore winds, surf and fog**
  - **EPRI excluded these factors in their crack analysis**
- **Koeberg refueling water storage tank failed with 0.6" deep crack**
  - **EPRI excluded this fact in their crack analysis**
- **California thin canisters only 0.5" to 0.625" thick**
  - **Diablo Canyon 0.5"** steel canister, stored in vented concrete cask
  - **Humboldt Bay 0.5"** steel canister, stored in thick bolted lid steel cask
    - Stored in uninspectable underground concrete system
  - **Rancho Seco 0.5"** steel canister, stored in vented concrete overpack
    - **Marine salt air and fog a risk factor**, even though not a coastal plant
  - **San Onofre 0.625"** steel canister, loaded in vented concrete overpack
- **San Onofre proposed experimental Holtec vented underground HI-STORM UMAX system (0.625" canisters) never used anywhere in the world and not NRC approved**
- **Koeberg cracks could only be found using dye penetrant testing** (PT)
  - **Test cannot be used with canisters filled with spent nuclear fuel**

Do we wait for the leak?
California canisters year of first loading

- **2001 Rancho Seco** **20 years = 2021**
  - NUHOMS 24PT
- **2003 San Onofre** **20 years = 2023**
  - NUHOMS 24PT1
- **2008 Humboldt Bay** **20 years = 2028**
  - Holtec HI-STAR Ver. HB & MPC HB
- **2009 Diablo Canyon** **20 years = 2029**
  - Holtec HI-STORM MPC-32
- **Most U.S. thin canisters in use less than 20 years**
  - Earliest: 1989 (Robinson, H.B., SC), 1990 (Oconee, SC), 1993 (Calvert Cliffs, MD)

Failure Modes and Effects Analysis (FMEA) of Welded Stainless Steel Canisters for Dry Cask Storage Systems, EPRI, Final Report, December 2013, Table 2-2

Can’t repair canisters and no plan to replace them

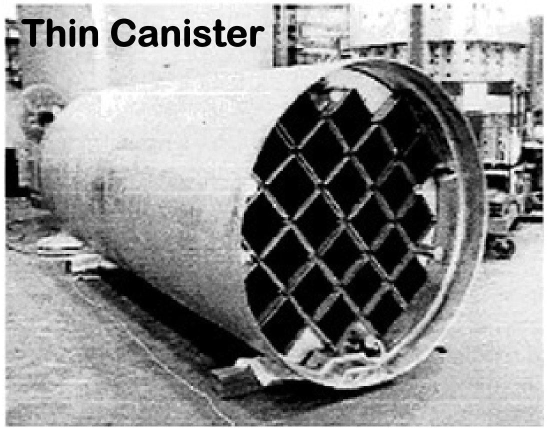
- **No solution to repair canisters filled with spent nuclear fuel**
- “It is not practical to repair a canister if it were damaged…if that canister were to develop a leak, let’s be realistic; you have to find it, that crack, where it might be, and then find the means to repair it. You will have, in the face of millions of curies of radioactivity coming out of canister; we think it’s not a path forward.”
  − Dr. Kris Singh, Holtec CEO & President **http://youtu.be/euaFZt0YPi4**
- **No realistic plan to replace casks or cracked canisters**
  - **NRC allows pools to be destroyed,** removing the only available method to replace canisters and casks
  - **Dry transfer systems don’t exist** for this and are extremely expensive to build and maintain
  - **Transporting cracked canisters is unsafe** & not NRC approved
  - **Storing a cracked canister in a thick transport cask provides no path forward**, is expensive & not NRC approved
  - **No seismic rating for a cracked canister**
  - **Funds are not allocated** to replace pools or procure new systems

No warning before radiation leaks from thin canisters

- **No early warning monitoring**
  - Remote temperature monitoring not early warning
  - No pressure or helium monitoring
  - Thick casks have continuous remote pressure monitoring – alerts to early helium leak
- **No remote or continuous canister radiation monitoring**
  - Workers walk around canisters with a "radiation monitor on a stick" once every 3 months
  - Thick casks have continuous remote radiation monitoring
- **After pools emptied, NRC allows**
  - **Removal of all radiation monitors**
  - **Elimination of emergency planning to communities** – no radiation alerts
  - **Removal of fuel pools** (assumes nothing will go wrong with canisters)
    - **Humboldt Bay & Rancho Seco pools destroyed**

Thin Canisters vs. Thick Casks

Safety Features	Thin canisters	Thick casks
Thick walls	1/2" to 5/8"	Up to 20"
Won't crack		√
Ability to repair		√
Ability to inspect		√
Early warning monitor		√
ASME **container** certification		√
Defense in depth (redundancy)		√
Stored in concrete building		√
Gamma & neutron protection	With concrete overpack	√
Transportable w/o add'l cask		√
Market leader	**U.S.**	**World**



CASTOR® - Type V/19 cask

Thick casks designed for longer storage

- **Market leader internationally**
- **No stress corrosion cracking**
- **Maintainable**
  - **Can inspect**
  - **Replaceable parts (metal seals, lids, bolts)**
  - **Double bolted thick steel lids allow reloading without destroying cask**
  - **40 years in service with insignificant material aging.**
  - **Option for permanent storage with added welded lid.**
- **Thick cask body** – forged steel or thicker ductile cast iron up to 20"
- **Early warning before radiation leak** (remote lid pressure monitoring)
- **Cask protects from all radiation**, unlike thin steel canisters.
  - **No concrete overpack required (reduced cost and handling)**
  - **No transfer or transport overpack required (reduced cost and handling)**
  - **Stored in concrete building for additional protection**
  - **Used for both storage and transportation (with transport shock absorbers)**
- **ASME & international cask certifications for storage and transport**
- **Damage fuel sealed (in ductile cast iron casks)**
- **Not currently licensed in U.S. (18 to 30 month process)**
- **Vendors won't request NRC license unless they have customer**

Thin canisters not designed to be replaced

- Welded lid not designed to be removed
- Lid must be unwelded under water
- Fuel transfer from damaged canister to new canister must be done under water
- **No spent fuel has ever been reloaded into another thin canister**
- Thick casks are designed to remove and reload fuel
- Potential problem unloading fuel from a dry storage canister or cask into a pool with existing fuel

No defense in depth in thin canisters

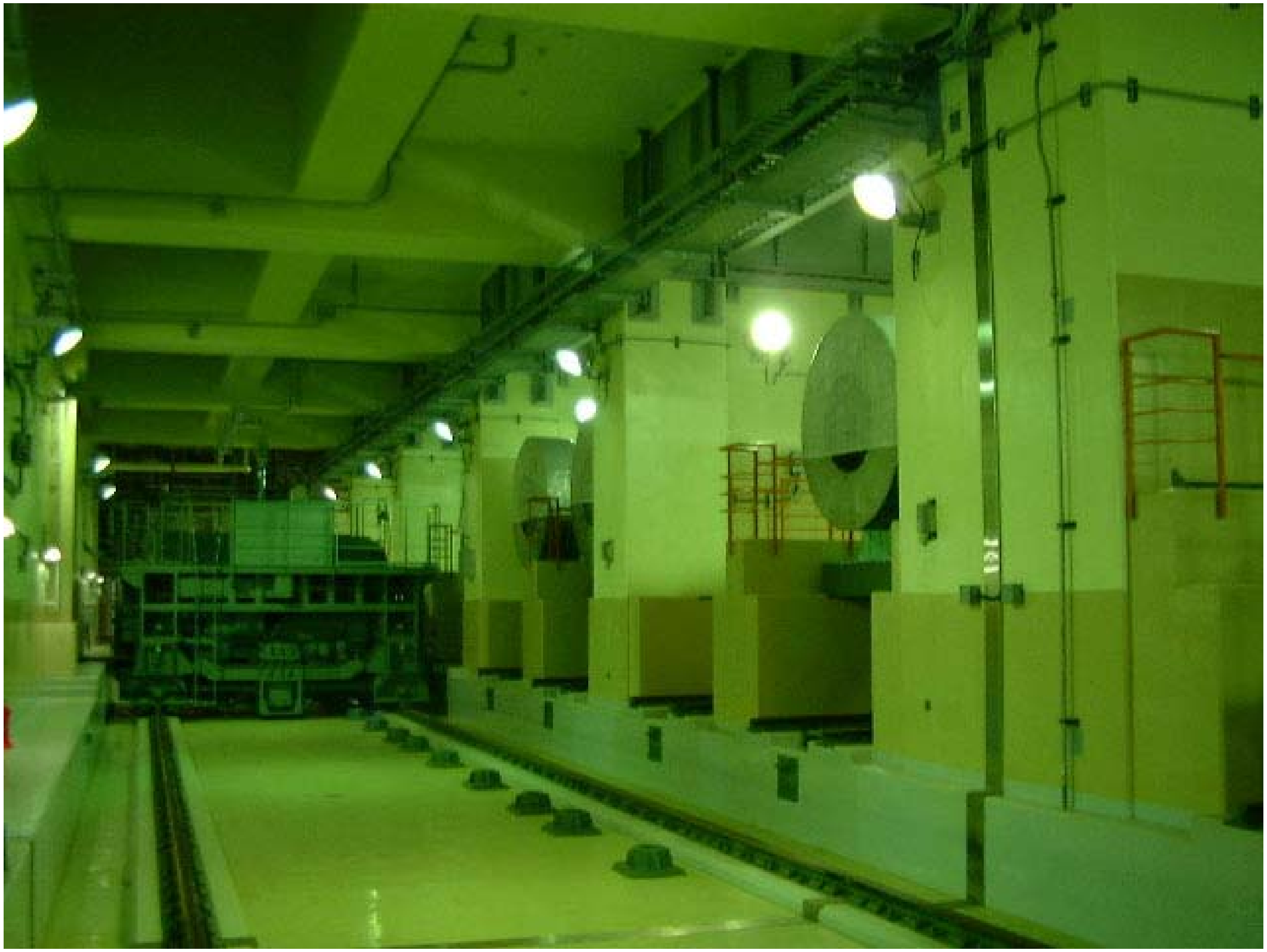
- **No protection** from gamma or neutron radiation in thin canister
  - **Unsealed** concrete overpack/cask required for gamma & neutrons
  - **No other type of radiation protection if thin canister leaks**
  - Thick steel overpack transfer cask required to transfer from pool
  - Thick steel overpack transport cask required for transport
- **High burnup fuel (HBF)** (>45 GWd/MTU)
  - Burns longer in the reactor, making utilities more money
  - Over twice as radioactive and over twice as hot
  - Damages protective Zirconium fuel cladding even after dry storage
  - Unstable and unpredictable in storage and transport
- **Limited technology** to examine fuel assemblies for damage
- **Damaged fuel cans** vented so no radiation protection
  - Allows retrievability of fuel assembly into another container

Thin canisters not ASME certified

- Canisters do not have independent quality certification from American Society of Mechanical Engineers (ASME)
- NRC allows exemptions to some ASME standards
- No independent quality inspections
- ASME has not developed standards for spent fuel stainless steel canisters
- Quality control has been an issue with thin canisters

Germany interim storage

Fukushima thick casks in building



Fukushima thick casks

Specification of Dry Casks

	Large type	Medium type	
Weight (t)	115	96	
Length (m)	5.6	5.6	
Diameter (m)	2.4	2.2	
Assemblies in a cask	52	37	
Number of casks	5	2	2
Fuel type	8 x 8	8 x 8	New 8 x 8
Cooling-off period (years)	> 7	> 7	> 5
Average burn-up (MWD/T)	<24,000	<24,000	<29,000

Additional 11casks are being prepared for installation.

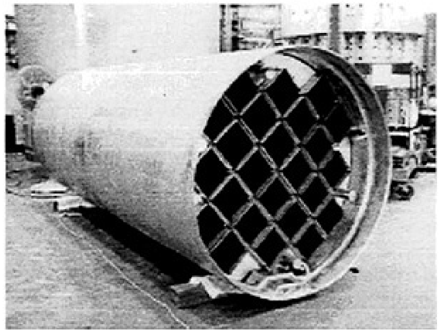
TOKYO ELECTRIC POWER COMPANY

13

Sandia Labs: Ductile cast iron performs in an exemplary manner

- **Safe from brittle fracture in transport**
  - …studies cited show DI [ductile iron] has sufficient fracture toughness to produce a containment boundary for radioactive material transport packagings that will be safe from brittle fracture.
- **Exceeds drop test standards**
  - …studies indicate that even with drop tests exceeding the severity of those specified in 1 OCFR7 1 the DI packagings perform in an exemplary manner**.**
- **Exceeds low temperature requirements**
  - Low temperature brittle fracture not an issue. The DCI casks were tested at **-29°C and -49°C** exceeding NRC requirements.
- **Conclusions shared by ASTM, ASME, and IAEA**
  - *Fracture Mechanics Based Design for Radioactive Material Transport Packagings Historical Review*, Sandia Labs, SAND98-0764 UC-804, April 1998 http://www.osti.gov/scitech/servlets/purl/654001

Problems with thin stainless steel canisters



- **Not maintainable**
  - Cannot inspect exterior or interior for cracks
  - Cannot repair cracks
  - Not reusable (welded lid)
- **No warning BEFORE radiation leaks**
- **Canisters not ASME certified**
- **NRC allows exemptions from ASME standards**
- **No defense in depth**
  - Concrete overpack vented
  - Unsealed damaged fuel cans
  - No adequate plan for failed canisters
- **Early stress corrosion cracking risk**
- **Inadequate aging management plan**

NRC license excludes aging issues

- **Ignores issues that may occur after initial 20 year license, such as cracking and other aging issues**
- **Refuses to evaluate thick casks unless vendor applies**
- **Requires first canister inspection after 25 years**
  - Allowing **5 years** to develop inspection technology
- **Requires inspection of only one canister per plant**
  - That same canister to be inspected **once every 5 years**
- **Allows up to a 75% through-wall crack**
  - **No seismic rating** for cracked canisters
- **No replacement plan for cracked canisters**
  - Approves destroying fuel pools after emptied
    - **No fuel pools at Humboldt Bay and Rancho Seco**
  - No money allocated for replacement canisters
- **NRC standards revision (NUREG-1927) scheduled for 2015**

Recommendations

We cannot kick this can down the road

CASTOR® - Type V/19 cask

- **STOP thin canister procurement**
- **Develop minimum dry storage requirements to ensure adequate funding for new 100+ year storage requirements**
  - **Maintainable** – We don't want to buy these more than once
  - **Early warning** prior to failure and prior to radiation leaks
  - **Inspectable, repairable** and **doesn't crack**
  - **Cost-effective, transportable solution**
  - **Ability to reload fuel without destroying container**
- **Don't allow purchase of vendor promises – it's not state policy to purchase non-existent features (e.g., vaporware)**
- **Require bids from leading international vendors**
- **Replace existing thin canisters before they fail**
- **Store in hardened concrete buildings**
- **Require mitigation plan**
  - **Don't destroy empty pools until waste removed from site**
  - **Install continuous radiation monitors with on-line public access**
  - **Continue emergency planning until waste is off-site**


Donna Gilmore
SanOnofreSafety.org
dgilmore@cox.net
SOS

Additional Slides

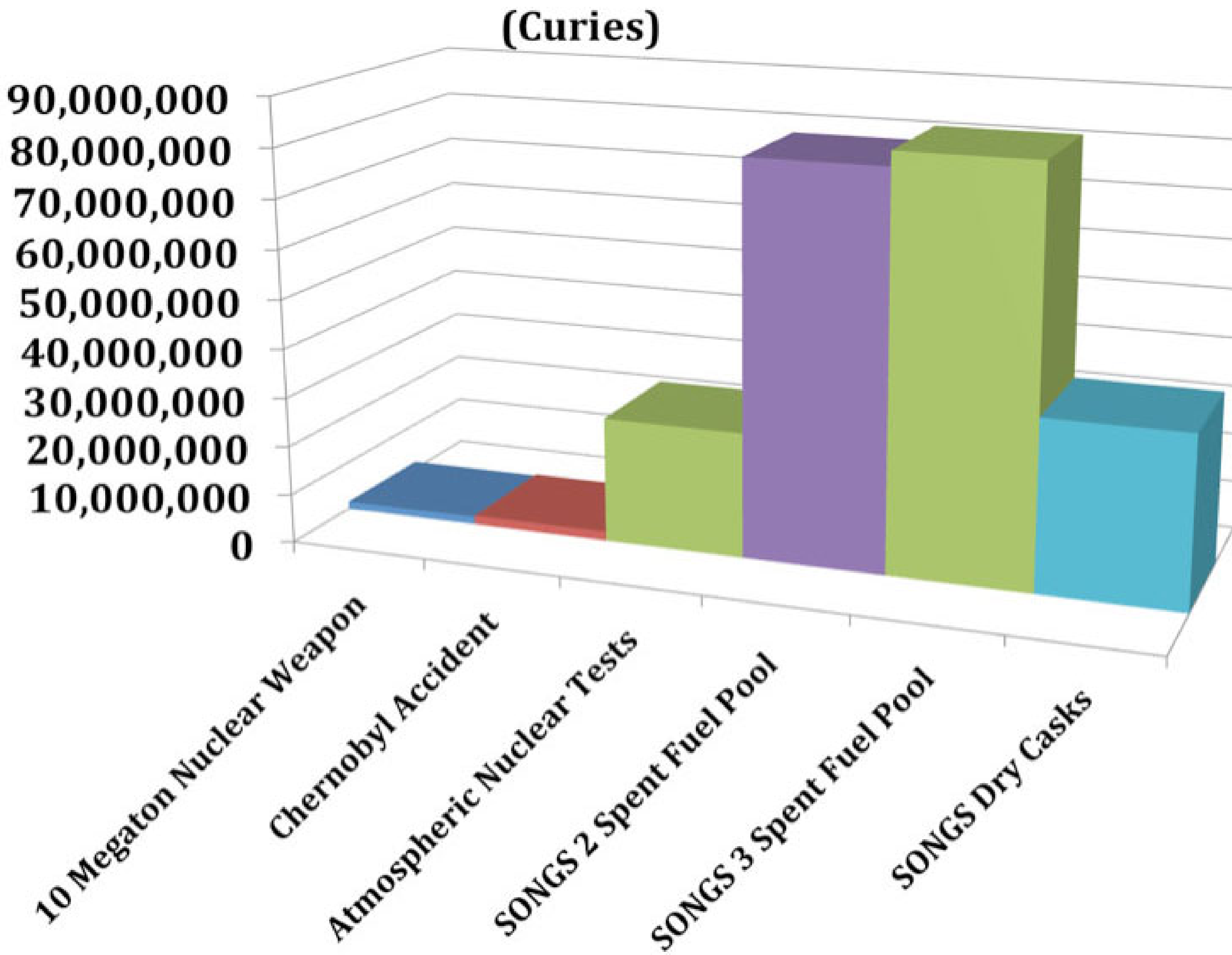
References

- Diablo Canyon: conditions for stress corrosion cracking in two years, D. Gilmore, October 23, 2014
  https://sanonofresafety.files.wordpress.com/2011/11/diablocanyonscc-2014-10-23.pdf
- Reasons to buy thick nuclear waste dry storage casks and myths about nuclear waste storage, April 16, 2015, D. Gilmore
  https://sanonofresafety.files.wordpress.com/2011/11/reasonstobuythickcasks2015-04-16.pdf
- Donna Gilmore's CPUC Pre-Hearing Conference Statement (A1412007), March 20, 2015
  http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M148/K824/148824935.PDF
- Additional references: **SanOnofreSafety.org**

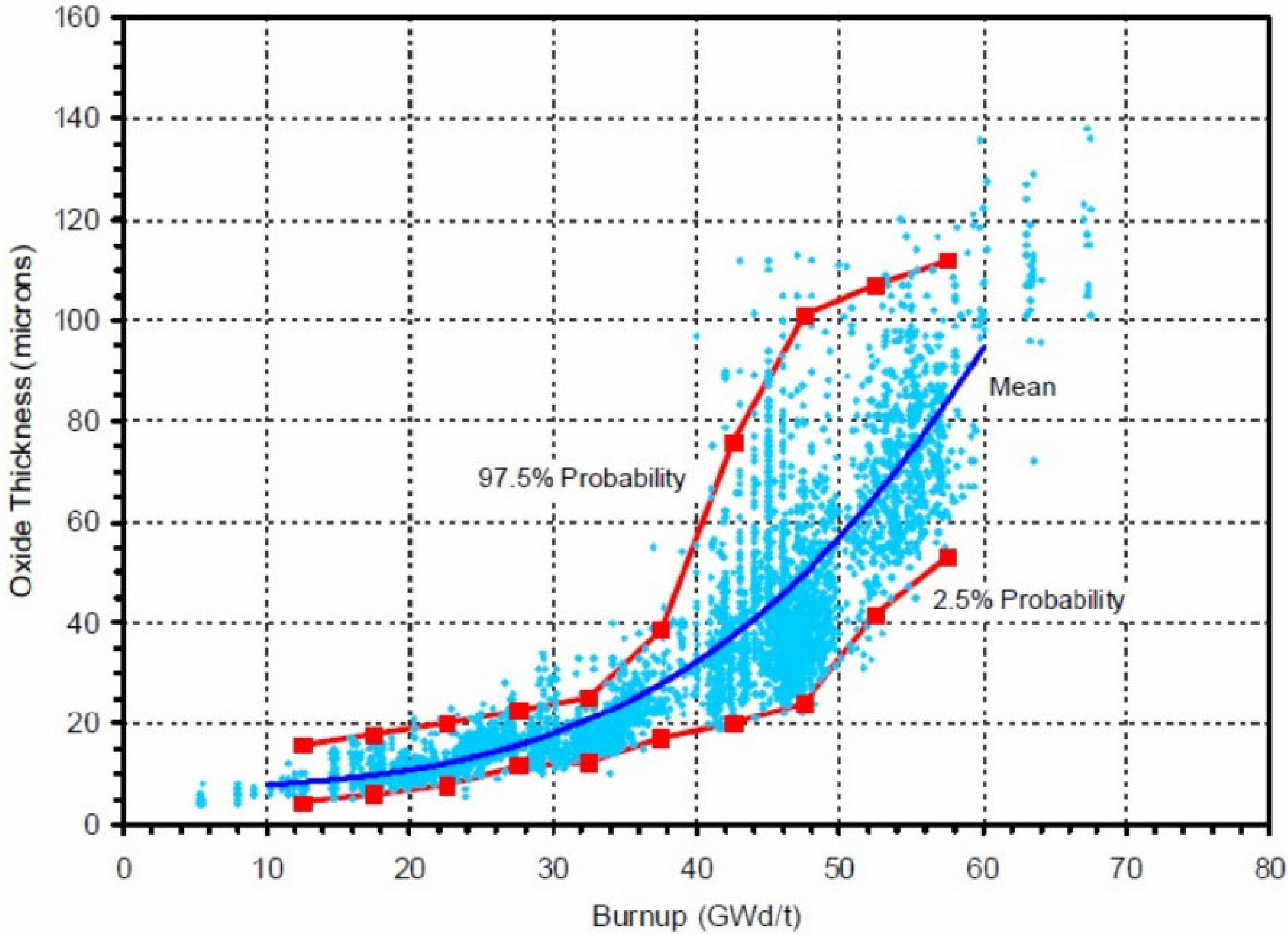
Roadblocks to moving waste

- **Yucca Mountain geological repository issues unresolved**
  - **DOE plan: Solve water intrusion issue 100 years AFTER loading nuclear waste**
  - **Inadequate capacity for all waste**
  - **Not designed for high burnup fuel**
  - **Numerous technical, legal and political issues unresolved**
  - **Congress limited DOE to consider only Yucca Mountain**
  - **Funding of storage sites unresolved**
  - **Communities do not want the waste**
- **Poor track record for finding safe waste solutions**
  - **WIPP repository leaked within 15 years – broken promises to New Mexico**
  - **Hanford, Savannah River and others sites leak – more broken promises**
  - **No state authority over problems**
- **Transport infrastructure issues, accident risks, cracking canisters**
- **High burnup fuel over twice as radioactive, hotter, and unstable**
  - **Zirconium cladding more likely to become brittle and crack -- eliminates key defense in depth. Radiation protection limited to the thin stainless steel canister. Concrete overpack/cask only protects from gamma and neutrons**.
- **Fuel assemblies damaged after storage may not be retrievable**
- **Inspection of damaged fuel assemblies is imperfect**

San Onofre Cesium-137

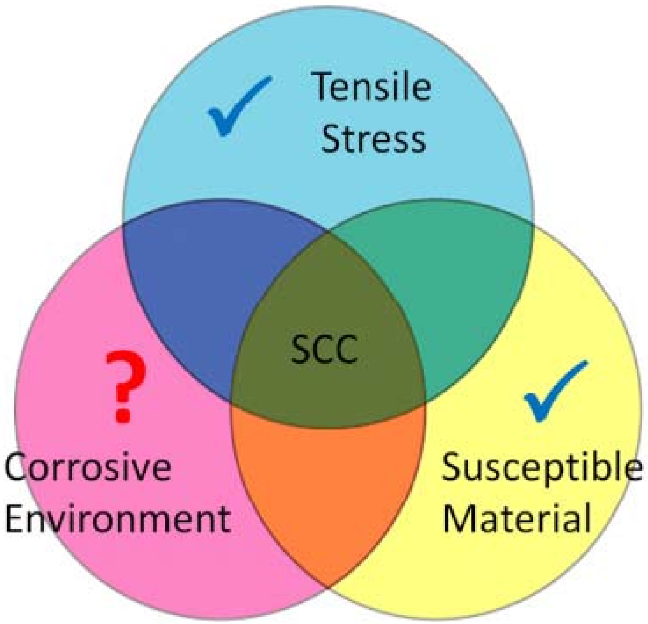


Higher Burnup = Higher Cladding Failure



Higher oxide thickness results in higher cladding failure. Argonne scientists reported high burn-up fuels may result in fuel rods becoming more brittle over time. "… insufficient information is available on high burnup fuels to allow reliable predictions of degradation processes during extended dry storage." U.S. Nuclear Waste Technical Review Board *Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel,* December 2010, Burnup Chart Page 56

Stress Corrosion Cracking Background Information



2/3 of the requirements for SCC are present in welded stainless steel canisters

- 304 and 316 Stainless steels are susceptible to chloride stress corrosion cracking (SCC)
  - Sensitization from welding increases susceptibility
  - Crevice and pitting corrosion can be precursors to SCC
  - SCC possible with low surface chloride concentrations
- Welded stainless steel canisters have sufficient through wall tensile residual stresses for SCC
- Atmospheric SCC of welded stainless steels has been observed
  - Component failures in 11-33 years
  - Estimated crack growth rates of 0.11 to 0.91 mm/yr

Power Plant Operating Experience with SCC of Stainless Steels

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Plant	Distance to water, m	Body of water	Material/ Component	Thickness, or crack depth, mm	Time in Service, years	Est. Crack growth rate, m/s	Est. Crack growth rate, mm/yr
Koeberg	100	South Atlantic	304L/RWST	5.0 to 15.5	17	9.3×10^{-12} to 2.9×10^{-11}	0.29 to 0.91
Ohi	200	Wakasa Bay, Sea of Japan	304L/RWST	1.5 to 7.5	30	5.5×10^{-12} to 7.9×10^{-12}	0.17 to 0.25
St Lucie	800	Atlantic	304/RWST pipe	6.2	16	1.2×10^{-11}	0.39
Turkey Point	400	Biscayne Bay, Atlantic	304/pipe	3.7	33	3.6×10^{-12}	0.11
San Onofre	150	Pacific Ocean	304/pipe	3.4 to 6.2	25	4.3×10^{-12} to 7.8×10^{-12}	0.14 to 0.25

- CISCC growth rates of 0.11 to 0.91 mm/yr for components in service
  - Median rate of 9.6×10^{-12} m/s (0.30 mm/yr) reported by Kosaki (2008)
- Activation energy for CISCC propagation needs to be considered
  - 5.6 to 9.4 kcal/mol (23 to 39 kJ/mol) reported by Hayashibara et al. (2008)

Data Gap Summarization

Gap	Priority	Gap	Priority
Thermal Profiles	1	Neutron poisons – Thermal aging	7
Stress Profiles	1	Moderator Exclusion	8
Monitoring – External	2	Cladding – Delayed Hydride Cracking	9
Welded canister – Atmospheric corrosion	2	Examination of the fuel at the INL	10
Fuel Transfer Options	3	Cladding – Creep	11
Monitoring – Internal	4	Fuel Assembly Hardware – SCC	11
Welded canister – Aqueous corrosion	5	Neutron poisons – Embrittlement	11
Bolted casks – Fatigue of seals & bolts	5	Cladding – Annealing of radiation damage	12
Bolted casks – Atmospheric corrosion	5	Cladding – Oxidation	13
Bolted casks – Aqueous corrosion	5	Neutron poisons – Creep	13
Drying Issues	6	Neutron poisons – Corrosion	13
Burnup Credit	7	Overpack – Freeze-thaw	14
Cladding – Hydride reorientation	7	Overpack – Corrosion of embedded steel	14

Imminent need
Immediate to facilitate demonstration early start
Near-term High or Very High
Long-term High
Near-term Medium or Medium High
Long-term Medium

Safety Complaints from On-Site Employees & Contractors

U.S. Nuclear Power Plants

2007 to 2012 (6 years)

The **Nuclear Regulatory Commission** (NRC) refers to these complaints as "**Allegations from On-Site Sources**" (current/former power plant employees/contractors and anonymous allegers). These are reports of impropriety or inadequacy of NRC-related safety or regulatory concerns. One allegation report may contain multiple allegations; however, the NRC counts it as one allegation in these statistics (Note: A concern about a safety-conscious work environment (SCWE) problem at a facility is an important allegation. However, a Notice of Violation cannot be issued, because there is no applicable NRC regulation.) There are 64 U.S. nuclear power plants & 104 reactors. Plants with multiple reactors are noted.

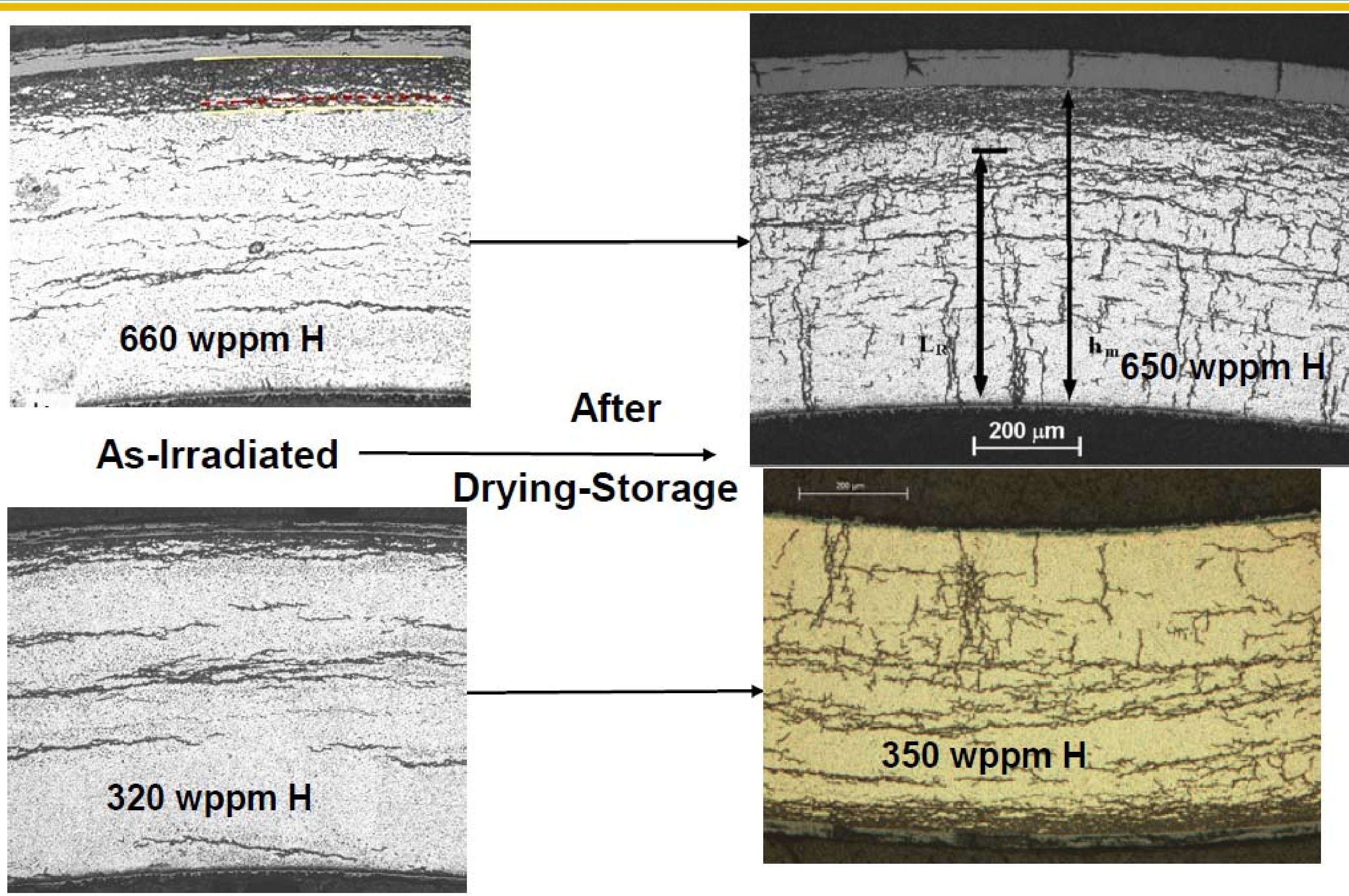
Source: www.nrc.gov/about-nrc/regulatory/allegations/statistics.htm

SanOnofreSafety.org

U.S. DEPARTMENT OF ENERGY

Nuclear Energy

Introduction: Circumferential and Radial Hydrides in HBU Cladding



Summary of Results

■ Susceptibility to Radial-Hydride Precipitation

- **Low for HBU Zry-4 cladding**
- **Moderate for HBU ZIRLO™**
- **High for HBU M5®**

■ Susceptibility to Radial-Hydride-Induced Embrittlement

- **Low for HBU Zry-4**
- **Moderate for HBU M5®**
- **High for HBU ZIRLO™**

■ DBTT Values for HBU Cladding Alloys

- Peak drying-storage hoop stress at 400°C: 140 MPa→110 MPa→90 MPa→0 MPa
- DBTT for **HBU M5®** after slow cooling: 80°C → 70°C → <20°C → <20°C
- DBTT for **HBU ZIRLO™** after slow cooling: 185°C → 125°C → 20°C → <20°C
- DBTT for **HBU Zry-4** after slow cooling: 55°C → <20°C → → >90°C
  - Embrittled by circumferential hydrides: 615±82 wppm 520±90 wppm 640±140 wppm
  - HBU Zry-4 with 300±15 wppm was highly ductile at 20°C

Background information

- CoCs/licenses for high burn-up fuel storage to be renewed over next few years
  - 2012 Prairie Island-TN-40HT, Calvert Cliffs-NUHOMS[1]
  - 2015 Transnuclear-NUHOMS 1004
  - 2020 NAC-UMS; Holtec-Hi-STORM
- Storage of high burn-up fuel is relatively recent
  - 9 years – Maine Yankee[2] (since 2003) up to 49.5 GWd/MTU
  - 7 years – Robinson (since 2005) up to 56.9 GWd/MTU
  - 6 years – Oconee (since 2006) up to 55 GWd/MTU
  - <4 years for most – up to 53.8 GWd/MTU
- ~ 200 loaded-casks contain high burn-up fuel
- Most fuel in pools for future loading is high burn-up

NEI

1) Since 1992, allowable burn-up to 47 GWd/MTU, since 2010, up to 52 GWd/MTU
2) All high burn-up fuel is in damaged fuel cans

High Burnup Fuel Approval

June 1992

Up to 60 GWd/MTU

(60 MWD/kg)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

June 22, 1992

Mr. A. E. Scherer, Director
Nuclear Licensing
Combustion Engineering, Inc.
P. O. Box 500
Windsor, Connecticut 06095

Dear Mr. Scherer:

SUBJECT: GENERIC APPROVAL OF C-E TOPICAL REPORT CEN-386-P, "VERIFICATION OF THE ACCEPTABILITY OF A 1-PIN BURNUP LIMIT OF 60 MWD/kg FOR COMBUSTION ENGINEERING 16X16 PWR FUEL (TAC NO. M82192)

On November 14, 1991, you requested NRC review and generic approval of the C-E topical report CEN-386-P, entitled "Verification of The Acceptability of A 1-Pin Burnup Limit of 60 MWD/kg for Combustion Engineering 16X16 PWR Fuel." The methodology described in the topical report CEN-386-P was approved for licensing applications for ANO-2 and St. Lucie 2 in NRC safety evaluations dated November 27, 1990, and October 18, 1991, respectively. Based on your submittal and review of the previously approved SERs, we conclude that CEN-386-P is not necessarily plant-specific for ANO-2 or St. Lucie 2, and therefore CEN-386-P can be applied generically to other C-E 16x16 plants. The NRC staff was supported in this review by our consultant, the Pacific Northwest Laboratory, who previously provided input to the approval for applications to ANO-2 and St. Lucie 2. In summary, the NRC staff approves the generic applicability of CEN-386-P for licensing applications. Our evaluation applies only to matters described in the topical report.

In accordance with procedures established in NUREG-0390, "Topical Report Review Status," we request that C-E publish accepted versions of this topical report, proprietary and non-proprietary, within 3 months of receiving this letter. The accepted versions shall include an "A" (designating accepted) following the report identification symbol, and shall include this letter and the ANO-2 SER dated November 27, 1990.

If our criteria or regulations change such that we can no longer accept this report, applicants referencing this topical report will be expected to revise and resubmit their respective documentation, or submit justification that the topical report continues to apply without revision of their respective documentation.

Sincerely,

Ashok C. Thadani, Director
Division of Systems Technology
Office of Nuclear Reactor Regulation

Enclosure:
ANO-2 Safety Evaluation

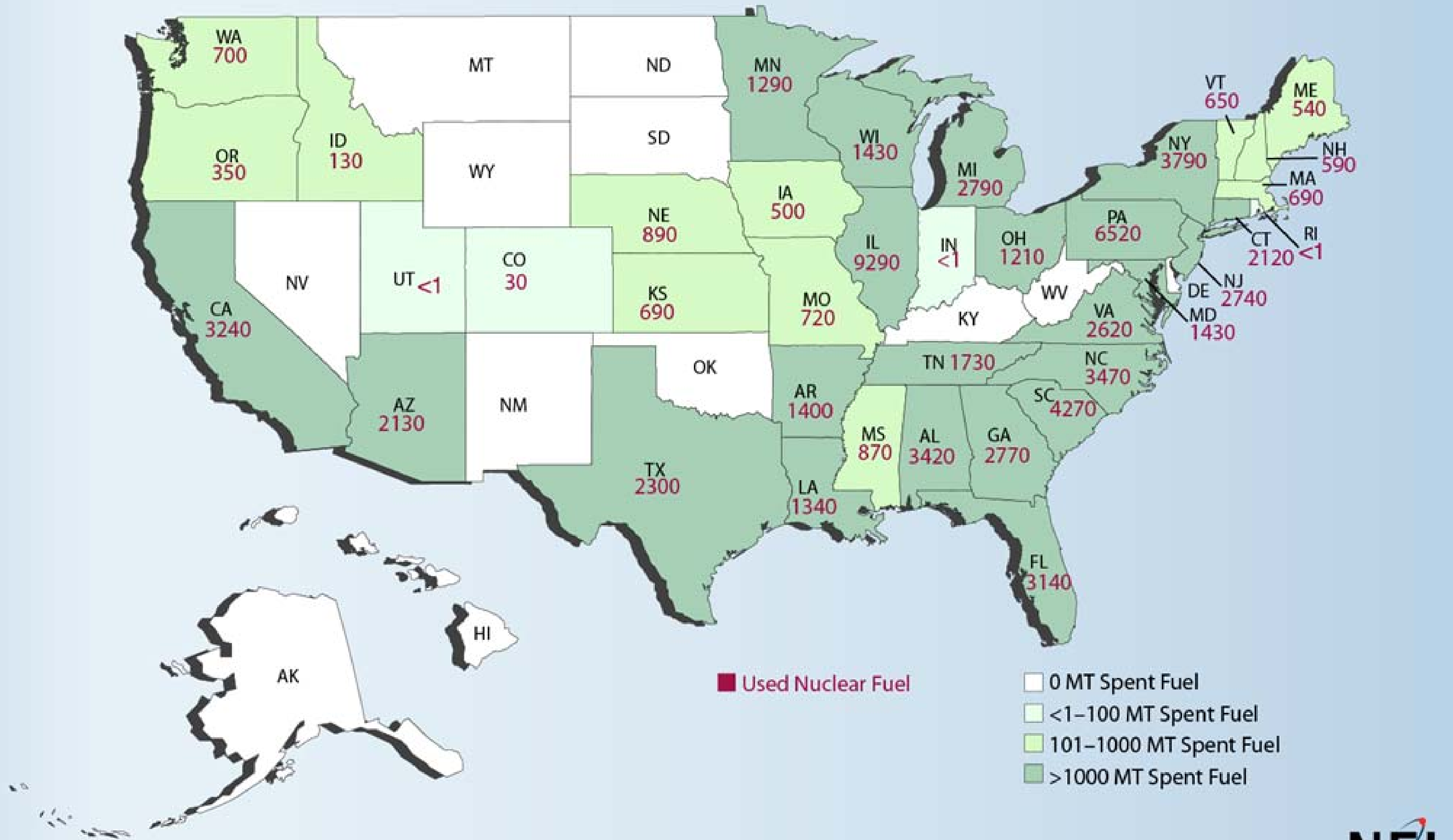
4

Thin canisters cannot be inspected

- No technology to detect surface cracks, crevice and pitting corrosion in thin canisters filled with nuclear waste
  - Canister must stay inside concrete overpack/cask due to radiation risk, so future inspection technology may be limited
  - Thin canisters do not protect from gamma and neutrons
  - Microscopic crevices can result in cracks
- Thick casks can be inspected
  - Provide full radiation barrier without concrete
  - Surfaces can be inspected
  - Not subject to stress corrosion cracking

Used Nuclear Fuel in Storage

(Metric Tons, End of 2013)



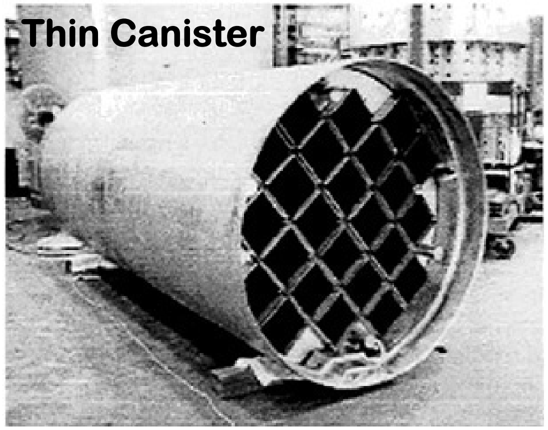
Recommendations to NRC


CASTOR® - Type V/19 cask

- Require best technology used internationally
- Base standards on longer term storage needs
  - Not on limitations of thin canister technology
  - Not on vendor promises of future solutions
- Store in hardened concrete buildings
- Don't destroy defueled pools until waste stored off-site
- Install continuous radiation monitors with on-line public access
- Continue emergency plans until waste is off-site
- Certify safety of dry storage systems for 100 years, but require 20-year license renewals

Thin Canisters vs. Thick Casks

Safety Features	Thin canisters	Thick casks
Thick walls	1/2" to 5/8"	**Up to 20"**
Won't crack		√
Ability to repair		√
Ability to inspect		√
Early warning monitor		√
ASME **container** certification		√
Defense in depth (redundancy)		√
Stored in concrete building		√
Gamma & neutron protection	With concrete overpack	√
Transportable w/o add'l cask		√
Market leader	**U.S.**	**World**



CASTOR® - Type V/19 cask

Recommendations

We cannot kick this can down the road

CASTOR® - Type V/19 cask

- STOP thin canister procurement
- Develop minimum dry storage requirements to ensure adequate funding for new 100+ year storage requirements
  - **Maintainable** – We don't want to buy these more than once
  - **Early warning** prior to failure and prior to radiation leaks
  - **Inspectable, repairable** and **doesn't crack**
  - **Cost-effective, transportable solution**
  - **Ability to reload fuel without destroying container**
- Don't allow purchase of vendor promises – it's not state policy to purchase non-existent features (e.g., vaporware)
- Require bids from leading international vendors
- Replace existing thin canisters before they fail
- Store in hardened concrete buildings
- Require mitigation plan
  - **Don't destroy empty pools until waste removed from site**
  - **Install continuous radiation monitors with on-line public access**
  - **Continue emergency planning until waste is off-site**

Donna Gilmore
SanOnofreSafety.org
dgilmore@cox.net