San Onofre Dry Cask Storage Issues

Are San Onofre's aging nuclear waste canisters starting to crack?
Has salt erosion from the sea damaged them?
Are they about to leak radiation?
How would we know and what can be done about it?

According to the Nuclear Regulatory Commission (NRC)

- **The thin (1/2" to 5/8") stainless steel canisters may crack within 30 years.**
- **No current technology exists to inspect, repair or replace cracked canisters.**
- **With limited monitoring, we will only know after they leak radiation.**

Summary: Southern California Edison plans to select another dry cask storage system, possibly this month. Both the Areva NUHOMS 32PTH2 and Holtec UMAX/MPC-37 systems being considered have these and other problems. The California Public Utilities Commission (CPUC) should not approve use of ratepayer decommissioning funds until Edison resolves these and other nuclear waste storage and transport issues. $400 million is currently estimated for the storage system.

No current solutions: The NRC has no current solutions to these problems, yet approved these steel/concrete dry storage systems. They have *unsubstantiated hope* that the nuclear industry will develop solutions before there is a radiation leak, even though they do not know what those solutions might be. We cannot rely on government or nuclear industry promises that they will have a solution in time. We do not want to be the next leaking nuclear waste dump like Hanford in Washington,[1] the "flagship" Waste Isolation Pilot Project (WIPP)[2] in New Mexico, the West Valley Demonstration Project in New York,[3] or Maxy Flats in Kentucky,[4] to name a few.

Alternatives: Edison should compare these welded steel/concrete storage systems with the thick, bolted-lid cask storage systems used internationally. The steel/concrete storage systems have many short and long term unresolved issues,[5,6] so Edison's statement that "this is what everyone else in the U.S. is doing" is not a good reason to procure inferior systems, now that we know the waste may be stored on our coastline for 60 to 100 years or more – longer than the intended life of these canisters.

Technology Gaps: The steel/concrete systems were designed for temporary storage, yet the NRC decided they can stay near our coast for 60 or 100 years – or indefinitely, even though they have not finished their research and analysis on how to do that and do not even know if it is possible. The NRC, the Electric Power Research Institute (EPRI), the Department of Energy (DOE) and numerous other government and scientific sources have identified 94 technical data gaps for spent fuel storage and transportation.

Recommendations: No dry storage system is as good as it should be for extended storage. However, Edison can do better for Southern California. And as CPUC Commissioner Michel Florio recently commented, *ratepayers should not have to buy this dry storage system more than once*. The CPUC should not release decommission funds to Edison until these nuclear waste storage issues are resolved. See *San Onofre Dry Cask Storage Issues* detailed report for recommendations, licensing issues, background information and references. An electronic copy is available at *SanOnofreSafety.org*.

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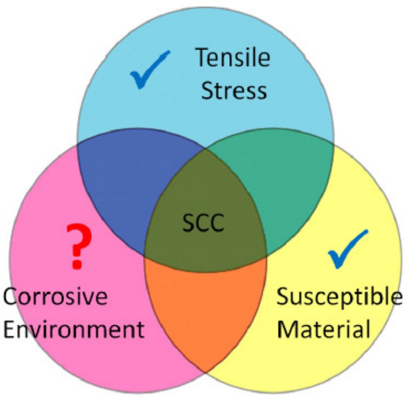
Stress Corrosion Cracking Background Information

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



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

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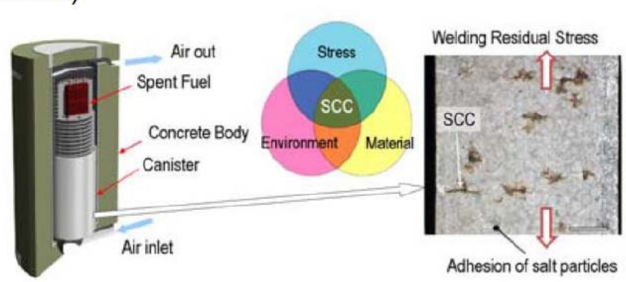
Stress-Corrosion Cracking (SCC) of SS Welded Canisters

For SCC you need:

- Austenitic stainless steels (e.g. 304, 316)
- Tensile stress (residual weld stress)
- Corrosive environment
  - Salts in the air
  - Deliquescence
    - Surface temperature
    - Humidity



SCC can occur *under conservative lab conditions*

What we don't know …
What are the conditions on actual canisters?

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Recommendations

The CPUC should not approve the $400 million for a dry cask storage system and should not release other decommissioning funds until the following issues are addressed.

1. **Cost/Benefit:** Edison should provide a long-term storage and transport Cost/Benefit Analysis to both the CPUC and Edison's Community Engagement Panel (CEP).
2. **Other casks:** Edison should be required by the CPUC to fully evaluate other dry cask storage and transport solutions used internationally. *The German CASTOR ductile cast iron casks, with about 20" thick walls (e.g., CASTOR V/19), are currently the most widely used transportation and storage containers for spent fuel rods in the world. Another common system used internationally is the French Areva thick forged steel cask (e.g., TN-24).*
3. **Buildings:** The casks should be stored in reinforced concrete buildings for additional protection against environmental and other external hazards. *This what Germany, Japan (at Fukushima) and other countries do.*[7,8] *Premature cask degradation caused by moisture at Peach Bottom and Three Mile Island would have been prevented if they were in buildings .*[9]
4. **Mitigation:** Edison should provide documentation to the public about how the dry storage system will be monitored, inspected, repaired and how fuel assemblies can be retrieved,[10] transferred to another canister or cask, and prepared for transport.[11, 12] A system should be in place for all this.
5. **Cracked canisters:** Seismic and other integrity evaluations are needed for cracked canisters. *The NRC plan to allow canisters to have up to a 75% crack before they must be removed from service. However, there are no ASME standards for cracked nuclear waste canisters.*
6. **Fewer assemblies:** Edison should store no more than 24 fuel assemblies per cask, preferably less. *Edison plans to increase their current 24 assemblies per canister to 32 (Areva) or 37 (Holtec). Germany stores about 19 to 24 fuel assemblies per* cask. *Canisters designed for permanent storage have even fewer assemblies per canister. Fewer assemblies per cask are safer. Fewer assemblies reduce heat load and required cooling time for storage and transport, especially for high burnup fuel (HBF).*[13] *HBF burns longer in the reactor, resulting in waste over twice as radioactive, thermally hotter, and far more unpredictable in storage. Higher temperatures increase risk for fuel cladding failure.*
7. **Fuel pools:** Edison should keep the spent fuel pools until they have another system in place to replace canisters or casks.[14] Once the fuel assemblies are emptied from the pools, they may be able to use the pools to repackage the fuel under water. *The NRC allowed California's Humboldt Bay and Rancho Seco to destroy their pools and they plan to do the same at San Onofre, even though they have no adequate system in place to transfer fuel to other canisters.*
8. **Damaged fuel:** Damaged fuel should be stored in containers (cans) prior to loading in canisters/casks in order to meet fuel retrievability requirements.[15] *The Holtec system stores damaged fuel in unsealed containers (cans). The Areva NUHOMS 32PTH2 system doesn't even use damaged fuel containers. The German cast iron casks use sealed containers.*[16]
9. **High burnup fuel:** Questions about how high burnup and damaged fuel are handled should be clearly addressed by Edison. Storage, retrievability and transport of high burnup fuel assemblies that may develop cladding embrittlement and failure after storage should also be addressed. *Defense-in-depth protection is lost once cladding fails. Maine Yankee and Zion nuclear plants both can their high burnup fuel, due to the unknowns about high burnup fuel in storage and transport. However, the cans are not sealed.*

10. **Monitoring:** Monitoring for helium leak should be required. *The DOE considers this a high priority issue. However, neither the Areva nor Holtec welded canisters have this capability. Only bolted lid casks, such as the Castor and Areva TN-24 have this capability.*
11. **Technology gaps:** Dry storage and transport technology gaps should be evaluated against the current dry storage and transport technologies used in the U.S. and internationally to determine if the major issues can be eliminated or at least adequately managed and mitigated prior to any radiation leak. *The DOE, the NRC and the nuclear industry identified 94 technology gaps[17] in storage and transport of nuclear waste.*

Licensing

The cast iron and forged steel casks are not currently licensed by the NRC even though they are licensed for both storage and transportation internationally. A license certificate for a new or amended dry cask system takes 18 to 30 months, including for a ductile cast iron cask like the CASTOR, stated Mark Lombard, NRC Director of Spent Fuel Storage and Transportation Division. The time variance is based on how complete the vendor package is when it's submitted to the NRC. The NRC will not evaluate a dry storage technology unless a vendor requests a license and no vendor will request a license unless they have a customer, such as Edison.

Given the amount of cooling time needed for the spent fuel, particularly the high burnup fuel, there is plenty of time to consider another dry storage vendor. This decision has long term impacts and should not be based on Edison's artificial June 2016 dry storage loading deadline. California Energy Commission (CEC) policy is to expedite the fuel into dry storage after adequate cooling. However, CEC Chairman Robert B. Weisenmiller said he was never informed there may be aging issues with the canisters, such as stress corrosion cracking.

Siempelkamp manufactures the CASTOR casks and other ductile cast iron casks, such as the TUK-141 and TUK-153.[18] These casks meet international certifications, ASME standards and have "N3" stamp certification, which ensures independent quality inspections.[19] The canisters Edison is considering do NOT meet ASME standards and do NOT have "N3" stamp certification. The NRC allows exceptions to the ASME standards. The NUHOMS 24PT1 and 24PTH2 canisters currently loaded at San Onofre have the N3 stamp. The new canisters they plan to purchase do not.

Areva sells both steel/concrete and forged steel dry cask systems. It is unclear if they are interested in competing with themselves by bidding both the steel/concrete NUHOMS system and the forged steel dry cask system.

Background

On August 26, 2014, the NRC decided thousands of tons of nuclear waste can be stored at nuclear plants for 60 years (short-term), 100 years (long-term) and indefinitely, [20] even though they only have *unsubstantiated hope* of solving current technology issues.

The NRC currently only certifies dry cask storage systems for 20 years (for high burnup spent fuel)[21] and has not completed their evaluation for long term storage, so we cannot depend on the NRC for assurances these cask systems will last long term. NRC Director Mark Lombard said the NRC is not evaluating other systems and technology used internationally. They are limiting their research and analysis to currently approved systems.

The NRC, the Electric Power Research Institute (EPRI), the DOE[22] and numerous other government and scientific sources identified numerous problems with the current steel/concrete dry storage systems. Some of these are detailed below.

Cracks within 30 years

The thin 1/2" to 5/8" welded stainless steel canisters may have premature stress corrosion cracking within 30 years, due to our marine environment. This could result in major radiation releases to Southern California and beyond. Cracks in similar materials at nuclear power plants caused component failures in 11 to 33 years, including at San Onofre (25 years).[23, 24] *Other cask systems, such as the German CASTOR V/19 (~20" thick) ductile cast iron casks, do not have this problem.* A January 2014 limited inspection for salt and temperature on two Diablo Canyon canisters found sea salt crystals on a canister that was loaded for less than 3.5 years.[25] Salts (chlorides) are a precursor to stress corrosion cracking. The canister surface temperature range was low enough (well below 85°C) to provide temperature conditions for crack initiation. Measured temperatures ranged from 49°C (120°F) to 118°C (245°F). Calculated temperatures ranged from 60°C (140°F) to 105°C (221°F).[26]

The NRC said once a crack occurs, it may go through-wall within 16 years and then must be taken out of service after 12 years (e.g., when 75% through-wall). The hotter the canister, the quicker the crack will go through-wall after the crack initiates.[27] The NRC proposed guideline of allowing cracks in canisters is based on ASME standards for other steel components; there is no such ASME standard for nuclear waste canisters.

> *The [ASME] determination of acceptable flaw size is based on the procedure to evaluate flaw stability provided by American Petroleum Institute (API) 579 Fitness-for-Service (Second Edition). The material mechanical and fracture properties for base and weld metals and the stress analysis results are obtained from the open literature such as NUREG-1864.* ***Subcritical crack growth from stress corrosion cracking (SCC), and its impact on inspection intervals and acceptance criteria, is not addressed****.* [28]

NUREG-1864, *A Pilot Probabilistic Risk Assessment Of a Dry Cask Storage System At a Nuclear Power Plant,* limited the assessment to a 20 year life-span of canisters, did not evaluate stress corrosion cracking, and used the German CASTOR V/21 ductile cast iron cask as a basis for cask integrity.[29] Also, cracks in canisters are excluded from seismic evaluations.[30]

> **Recommendation:** The NRC standard for acceptable through-wall crack percentage needs to be reevaluated for seismic and other integrity impacts. The NRC proposed guideline is based on ASME standards for other steel components – not spent fuel canisters. There are no ASME standards for cracked nuclear waste canisters.

No inspections – internal or external

There is no technology to inspect even the exterior of stainless steel canisters for cracks once they are loaded with fuel.[31] [32] In fact, no U.S. steel canisters have been opened or removed from their concrete overpacks or even inspected on the exterior of the canisters. The conditions on and in actual canisters are unknown (EPRI).[33]

Due to concerns of gamma radiation and neutrons (which the steel containers don't block) and the possibility of damaging the canister, the NRC does not require the utilities to remove the stainless steel canisters from the concrete overpacks. *Canister inspections present a number of* *challenges including lack of physical accessibility, dose considerations, lack of qualified and benchmarked techniques, and interpreting the significance of finding.*[34]

The NRC is allowing the nuclear industry five years to develop technology to adequately inspect the exterior of the steel canisters.[35]

The NRC's proposed Aging Management Plan requires only one canister at each plant be inspected and only on the exterior surface. The first inspection would be at 25 years (allowing 5 years for inspection technology to be developed), then once every 5 years after that for the same canister.[36] After the inspection technology is implemented, future new licenses would require an initial inspection within 20 years.

The nuclear industry proposed an alternative "Toll-Gate Aging Management Plant (AMP)" requiring inspection of only one canister in the U.S. instead of one at each plant. And they propose licenses be renewed *before* inspecting any canisters.[37]

Cask systems, such as the German CASTOR, can be inspected, since, unlike steel canister systems, they do not need concrete overpacks for gamma ray and neutron protection.

No repairs

There is no technology to repair cracks in these canisters. Technology used for other stainless steel components cannot be used to repair canisters containing nuclear fuel waste.[38] The NRC is *optimistic* there will be a solution before it is needed, but they do not know what that might be.[39] The original assumption was these canisters would not be here long enough to need repairs.

No replacement — no pool or dry handling (hot cell) transfer facility

There is currently no method to replace failing canisters . Empty spent fuel pools might be useful for this. However, Edison plans to destroy the pools. Pools have already been eliminated at California's Humboldt Bay and Rancho Seco nuclear waste storage facilities. *The only fuel-handling method currently available to the commercial nuclear generating industry is to bring a cask [or canister] back into a spent fuel pool for reopening. However, dry handling of the cask and fuel is important to avoid disturbing the properties of the cask, cladding, fuel, and related hardware that would occur if the materials were rewetted and rapidly cooled. However, there is no dry handling facility available in the nation that is large enough to handle these canisters…and removal of a welded storage cask lid is problematic.*[40]

A dry handling (hot cell) facility would be very expensive to build. A recent DOE report estimated $500 million to build a hot cell facility and $300 million for a spent fuel pool.[41] These estimates exclude costs to manage those facilities. And, according to NRC's Mark Lombard, hot cells are difficult to build, operate and maintain. He also stated "*When you think about the realities of utilizing that, one thing that we try to avoid is cutting of canister systems and because there is dose and difficulty associated with that, too. That would require some sort of a cutting of one end of the canister to push or pull the fuel assembly through. But it is certainly feasible…*"[42]

Also, there are no dry handling (hot cell) mobile facilities.[43] Areva has a few smaller mobile hot cells in France, but they do not exist here and are not designed for transferring larger canisters. There are numerous issues to evaluate to determine if that option is even feasible.[44]

Note: Rancho Seco has six damaged fuel assemblies loaded in a canister not approved for damaged fuel. However, the NRC gave them a license exemption so they could keep them in the canister.[45]

> **Recommendation**: Edison should keep the spent fuel pools until they have another system in place.[46] Costs for this should be included in the decommissioning plan submitted to the CPUC. *The CASTOR type casks have bolted lids, designed for easier removal of fuel compared to welded canisters.*[47] *However, there still needs to be a pool at the site to replace the casks.*

Transport casks are not an acceptable solution for a failed canister

An option suggested by the nuclear industry is to store a defective canister inside a transport cask, such as the NUHOMS-MP197[48,49] and deal with the problem later. However, transport casks are approved by the NRC for transport and not for interim storage. And they are not approved for use with cracked canisters. In addition, once a crack starts, it will continue. Putting a cracked canister in a cask is kicking the "can" down a dangerous road. The MP197 is designed to be reusable. The cost to use this in lieu of a better cask means we will be paying over twice as much for storage and then be left without a transport solution. Putting a failed canister in a transport cask should not be considered an acceptable solution.

Concrete buildings

Germany, Japan (Fukushima) and other countries house their casks in reinforced concrete buildings for additional environmental and other external hazards.[50,51]

> **Recommendation:** Edison should store casks in reinforced concrete buildings, similar to those used internationally.

Monitoring

Edison monitors casks for radiation. However, radiation monitoring only notifies us AFTER the canister leaks radiation. Edison also has temperature monitoring, but without a remediation plan in place, that is not sufficient.

There is no monitoring for helium leaks in welded canisters. This would provide a warning prior to a radiation leak. The DOE said it is a high priority to have helium monitoring in welded canisters and considers this a deficiency of the welded technology.[52] Bolted, pressurized lid casks, such as the CASTOR, indirectly monitor for helium leaks.[53]

> **Recommendation:** Require helium leak monitoring.

Concrete overpack and cask aging

The unsealed concrete overpacks and concrete casks may develop structural degradation that could affect seismic rating.[54] The ductile cast iron and forged steel casks do not require concrete overpacks.

Damaged fuel

Damaged fuel assemblies in steel canisters are not stored in sealed containers. There is no replacement for the "defense in depth" protective fuel cladding lost from damaged fuel assemblies.[55] San Onofre has a record 95 damaged (failed) fuel assemblies in dry storage and an additional 31 in the spent fuel pools**.** The Holtec canister[56] uses retrievable damaged fuel assembly containers (cans), but they are not sealed. The Areva NUHOMS 32PTH2[57] does not even have retrievable damaged fuel assembly containers (cans). The German cask technology encloses damaged fuel in retrievable sealed containers (quivers)[58] prior to loading into the casks.

In addition, high burnup fuel may damage the fuel cladding while in dry storage. This issue has not been addressed.[59]

> **Recommendation:** Questions about how damaged fuel is handled should be addressed by Edison. And the issue of storage, retrievability and transport of high burnup fuel assemblies that may develop cladding embrittlement and failure after storage need to be addressed. Requirements for defense in depth, redundancy and fuel assembly retrievability need to be addressed.

Technology Gaps

The Department of Energy (DOE), the NRC and the nuclear industry identified 94 technology gaps[60] in storage and transport of nuclear waste.

> **Recommendations:** Technology gaps should be evaluated against the current dry storage and transport technologies used in the U.S. and internationally to determine if the major issues can be eliminated or at least adequately managed and mitigated prior to any radiation leak. Edison should compare existing technologies used in the U.S. and internationally to ensure Southern California communities are provided the best solution available. The steel/concrete canister technology has many short and long term unresolved issues,[61,62] so Edison's statement that "this is what everyone else in the U.S. is doing" is doing it" is not a good reason to procure inferior technology, now that we know the waste may be stored on our coastline for 60 to 100 or more years -- longer than the intended life of these canisters.
>
> Any decisions about dry cask storage and transport for San Onofre must include requirements for short term storage (60+ years) and long term storage (100+ years). Storage and transport requirements, including aging management, mitigation, and related costs should be included in a Cost/Benefit analysis submitted to the CPUC and Edison's CEP.
>
> There should be documentation available to the public about how the dry storage system will be monitored, inspected, repaired and how fuel can be transferred to another canister, overpack or cask (if and when needed), and prepared for transport. A system should be in place for all this and the costs included in the decommissioning plan.

Canister or cask assembly capacity

Fewer fuel assemblies in a canister or cask is a safer and more flexible solution for short and long term storage, transportation and final disposal. Current San Onofre canisters hold 24 fuel assemblies. Edison plan to increase this to 32 (Areva) or 37 (Holtec) fuel assemblies. The

CASTOR V/19 cask holds 19 PWR fuel assemblies. The Areva TN-24 forged steel casks hold 24 fuel assemblies. Fewer assemblies reduce heat load and required cooling time for storage and transport, especially for high burnup fuel (HBF). HBF burns longer in the reactor, resulting in waste over twice as radioactive, thermally hotter, and unpredictable in storage. Higher temperatures increase risk for fuel cladding failure. Maximum exterior of canister is 400° C for storage, but must be a maximum of 185° C for transport. This means the ability to transport fuel must be delayed for decades.[63]

Transport

All canisters and casks are designed for both storage and transport. However, the NRC has rarely approved transportation for high burnup fuel. The German and French casks are approved for storage and transport internationally. Independent testing has been done on the CASTOR and other cask systems by BAM. [64] This information may be useful to compare with other vendors' product testing and analysis. The NRC approved the NUHOMS MP-197 overpack transport cask for high burnup fuel and for mitigation of a failed cask. However, the **entire** justification for that approve is labeled proprietary, so the public does not have access to the information. It is unclear how this canister can possibly meet the NRC's own regulatory guidance (ISG-11) for transport of high burnup fuel.[65] The public was not allowed an opportunity to comment on this approval. The MP-197 approval was released May 1st, 2014,[66] just in time for Areva to make a presentation at the May 5th CEP meeting and claim they have NRC approval for storage *and* transport of high burnup fuel. However, neither the NRC nor Areva mention it was a new approval and didn't mention why they were given this approval, in spite of the NRC's ISG-11 regulatory guidance to the contrary.

Ductile cast iron and forged steel casks

The German ductile cast iron casks are the most widely used for both storage and transportation internationally. Many of the limitations of the steel/concrete technology are eliminated with the ductile cast iron technology, although there is no proven safe long term storage solution. That is why the ability to monitor, inspect, and mitigate problems is critical.

> **Recommendation:** Edison should meet with the ductile cast iron (DCI) vendor technical staff to learn the facts about this technology and the company. Edison should allow vendors of the German ductile cast iron technology and other cask technology to bid and provide the technical information needed to compare their cask technology with the current U.S. steel/concrete technology. Any potential issues with these technologies, such as bolt and seal aging, should also be identified and documented in the Cost/Benefit analysis.

The information Edison has shared about the Castor technology is missing critical information needed to make an informed decision. And Edison appears to have misinformation about the ductile cast iron technology.[67] For example, Edison's concerns about embrittlement are unfounded, per this Sandia Labs report:[68]

> *Sandia Abstract*
>
> *The use of a fracture mechanics based design for the radioactive material transport (RAM) packagings has been the subject of extensive research for more than a decade. Sandia National Laboratories (SNL) has played an important role in the research and development of the application of this technology. Ductile iron has been internationally accepted as an exemplary material for the demonstration of a fracture mechanics*

based method of RAM packaging design and therefore is the subject of a large portion of the research discussed in this report. SNL's extensive research and development program, funded primarily by the U. S. Department of Energy's Office of Transportation, Energy Management & Analytical Services (EM-76) and in an auxiliary capacity, the office of Civilian Radioactive Waste Management, is summarized in this document along with a summary of the research conducted at other institutions throughout the world. In addition to the research and development work, code and standards development and regulatory positions are also discussed.

Sandia Page viii

The proposed use of ferritic materials for packaging containment has not been without controversy and critics. Ferritic materials, unlike austenitics, such as stainless steel, may exhibit a failure mode transition with decreasing temperatures and/or increasing loading rates from a ductile, high-energy failure mode to a brittle, low-energy fracture mode at below-yield stress levels. Regulators have thus been justifiably cautious regarding the use of ferritics for RAM package applications and have indicated that certification of such packages would require extensive confirmatory research and supporting data (although ferritic RAM packages for storage applications have been certified by the NRC). However, the general conclusion of the research reported herein is that appropriate engineering design methodologies exist which, when rigorously applied to RAM transport packaging conditions and environments, warrant the use of suitable ferritic materials for packaging containment. This report summarizes the Sandia work in support of that conclusion. The report also cites and references parallel research and conclusions of other institutions.

Sandia Page 53

The numerous studies cited show that DI [ductile iron] is a well characterized material that does have sufficient fracture toughness to produce a containment boundary for RAM packagings that will be safe from brittle fracture. All the drop tests discussed in this report were conducted using DI packagings and the 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.

Dry Storage Technology Options

The two major types of interim dry storage are the Steel/Concrete dry storage system and the ductile cast iron or forged steel cask system.

Steel/Concrete: Thin (1/2" to 5/8") welded stainless steel canisters with thick unsealed reinforced concrete casks or overpacks is the main type of dry storage system used in the U.S. Transport approval of this technology has been extremely limited due to insufficient data on potential fuel cladding failures from high burnup fuel (>45 GWd/MTU), even after dry storage.[69] High burnup fuel is fuel that is allowed to burn longer in the reactor, resulting in spent fuel that is over twice as radioactive, unstable in storage and transport and thermally hotter. This fuel normally requires longer cooling times before it can be placed in dry storage. [70]

Ironically, the research done to "prove" it is safe to use the steel/concrete cask technology was based on an examination of a CASTOR V/21 bolted cask, storing lower burnup fuel.[71,72] No such exam has been done for high burnup fuel on any cask; and none has been done for high or low burnup fuel with the steel/concrete welded casks.[73] *Note: the TAN dry fuel handling facility* *used to open this cask has since been destroyed and no new one is available.*[74] *The EPRI Demonstration Project*[75] *to do a confirmatory evaluation of high burnup fuel in a cask does not have a plan as to how they will open the cask. Also, the cask they are choosing to do their evaluation for high burnup fuel is a bolted cask – not any of the current canister designs currently approved to store or transport high burnup fuel.*

The U.S. chose the steel/concrete system because it was less expensive than the cask systems, such as the CASTOR V/21. The canisters were supposed to be moved to the proposed Yucca Mountain geological repository within a short time, so these canisters were not designed for long term storage and do not have adequate aging management systems. The cost difference between the steel/concrete systems and the ductile cast iron and forged steel systems needs to be reevaluated. Material costs have changed and there may be other cost variables. However, unless Edison allows vendors of the other technology to bid, they will not be able to do a cost/benefit analysis.

The steel/concrete cask technology has many short and long term unresolved issues,[76,77] so Edison's statement that "this is what everyone else in the U.S. is doing" is not a good reason to procure inferior technology, now that we know the waste will be here longer than the original intended life of these canisters.

The U.S. steel/concrete system has been used since 1993, starting with Calvert Cliffs.[78] The Calvert Cliffs dry storage license (similar to what Edison plans to procure) has not been renewed by the NRC due to aging concerns. Prairie Island's dry storage license has also not been renewed. Both licenses are expired. The NRC currently only certifies dry cask systems that store high burnup fuel for an initial 20 years. Before renewing these and other licenses, the NRC plans to require an aging management plan, due to numerous unresolved aging issues. They intend to issue a proposed revision to NUREG-1927 *Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance*, in 2015.[79]

Thick casks: Thick (14" to 20") monolithic ductile cast iron (DCI) casks with sealed and double bolted lids are the main long term interim storage and transport technology used internationally. The DCI casks do not require concrete overpacks. They are frequently housed in buildings for better environmental and external hazards.[80] Other thick casks used international are the Areva thick forged steel casks, such as those used at Fukushima, Japan. The Fukushima casks currently store only low burnup fuel (14 casks <24 GWd/MTU and 5 casks <29 GWd/MTU). The Fukushima casks are also housed in a building.[81]

Germany no longer reprocesses their waste and has numerous interim dry storage sites. The German DCI casks have been in use since 1983 – over 30 years.[82] *…A key advantage for the CASTOR as a system as a whole is the monolithic structure of the cask body, which under the principle of "all from a single cast" meets the requirements for completely safe and reliable enclosure and the shielding function without any additional seams. The suitability of the material must be proved in a series of highly involved tests and the specifications for the design include the transportation accident conditions set out by the IAEA (e.g. a drop from 9 m onto an inflexible ground surface, a 1 m drop onto a spike and a subsequent heating test).* The CASTOR technology is currently the most widely used transportation and storage container for spent fuel rods in the world.[83] Over 1100 CASTOR casks are now in interim storage worldwide.[84] This is not a recommendation for a particular cask product, but the DCI technology appears to be more suited to longer term storage.

Financial Analysis

Multi-year annual reports and financial analysis of all vendors considered should be evaluated to determine any potential financial concerns about vendor viability. Even if vendors have sold a large number of products in the U.S. does not mean they will continue to be viable vendors in the future, especially since dry cask storage requirements have changed.

Conclusion

It is of critical importance Southern California communities have assurance that the best dry storage technology is being procured for Southern California, given these cask systems may be here for 60 to 100 years or longer and given the NRC and many others identified possible short-term failure of the thin stainless steel canisters, such as stress corrosion cracking from marine environments and with no adequate remediation.[85,86,87] The CPUC should not approve decommissioning funds until these issues are adequately addressed. We cannot rely on the federal government to decide this for us. The future of California may depend on this decision.

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