August 25, 2014

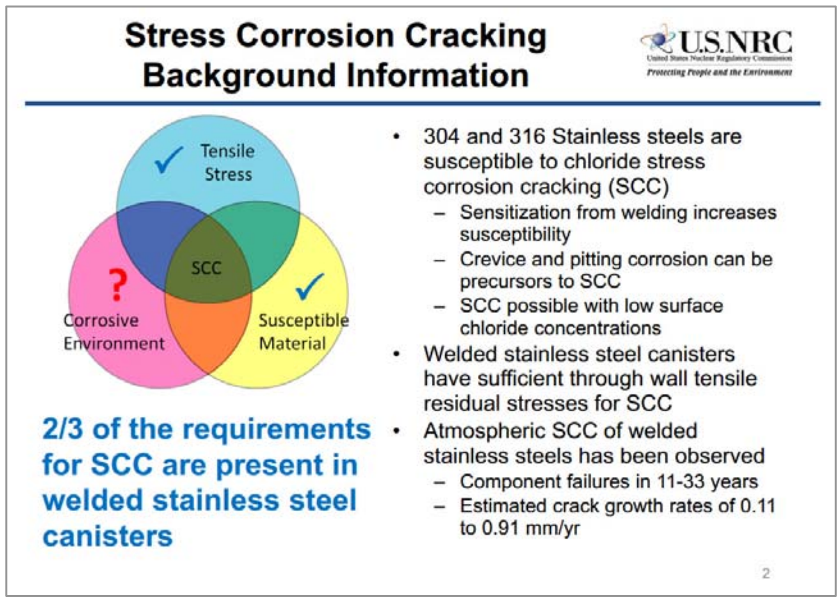
To: Tom Palmisano, VP and CNO, Southern California Edison
Chris Thompson, VP, Edison International

Re: Dry Cask Storage System Decision

Thanks for meeting with us today. Based on our meeting, this is my understanding of the issues, including both your concerns and ours.

I participated in the July 14th, 15th, and August 5th excellent Nuclear Regulatory Commission (NRC) technical presentations on some high priority unresolved aging issues with U.S. dry storage cask systems, which we discussed today.

Due to stress corrosion cracking, the thin stainless steel dry storage canisters may crack within 30 years, requiring them to be replaced. One of the NRC examples was a nuclear plant component that failed within 17 years and was thicker than current dry canisters. You appeared to agree that predicting how soon a crack will initiate is difficult. NRC's Darrell Dunn stated the crack would initiate once the temperature dropped below a certain level (under 80 or 60 degrees C). However, he said once the crack appeared, it would go through the wall faster in a hotter canister. You seemed to agree with this. NRC's Al Csantos said the ductile cast iron (DCI) casks do not have this issue.



No current method exists to mitigate (repair or replace) defective canisters. You agreed your current Decommissioning plan doesn't address this. It is extremely important to us that this be addressed with a solution that is in-place and not something delayed for the future. When Gene and I met with Senate offices, this was of great concern to them.

Mark Lombard, NRC Director of the Division of Spent Fuel Storage and Transportation, and his Branch Chief, Aladar Csontos, said there is no current mitigation method to repair or replace cracked stainless steel canisters. Aladar said, in some cases, you might be able to mitigate a cask failure, if there is a pool. However, pools are demolished for plants in decommissioning. You mentioned a hot cell as a possibility, but I don't understand how this would be feasible.

If you can address in detail your mitigation plan (as part of your decommission plan) and have a system in place before decommissioning, that would address our concerns. You also mentioned possibly putting the defective canister in the Areva MP-197 transport cask. That cask would not be able to be moved, since you can't put a defective canister in an MP-197 and transport it, per the specs. Also, I mentioned that it would be more important to us to spend money on having mitigation in place vs. spending money on demolishing the domes, if this becomes a money issue. The Marines won't have their land back as long as the canisters are there, anyway.

No technology to inspect or monitor the welded canisters BEFORE they leak. I think you agreed this is a problem that has not been address, but needs to be developed. Our position is to not count on technology that does not exist, when the need for it is eminent. I pointed out that the CASTOR and other similar casks designs already have this technology.
A Calvin Cliffs dry cask inspection report outlines all the obstacles and technology limitations in attempting to do adequate inspection of even the outside of a stainless steel canister. The NRC is giving the nuclear industry five years to try to develop the technology. However, the Calvin Cliffs report explains why this will be very challenging.

The EPRI High Burnup Demonstration Project is supposed to develop a lid for stainless steel welded canisters that have monitoring capability (e.g., detecting helium leaks based on changes in lid pressure). Tom, you said you are familiar with lid monitoring technology from your experience with Areva TN bolted casks. I understand San Onofre currently has some radiation and temperature monitoring capability, but the goal is to mitigate BEFORE a leak occurs.

Concrete overpacks/casks may have structural cracks. The DCI casks do not use concrete cask, so this problem is eliminated if we use a DCI cask. You pointed out that the bolted casks may have problems with seals, although it's easier to remove fuel from bolted lid casks. I agree seals may be an issue. We didn't discuss remediation if a seal failed. This would be a good discussion item with CASTOR or other cask type vendors. From my research on the CASTOR designs, this hasn't been a significant issue yet, but may be in the future. This is another reason to meet with a DCI vendor's technical staff. The key is to make sure we have a mitigation plan for this. And it should be a lot cheaper to replace a seal than an entire canister.

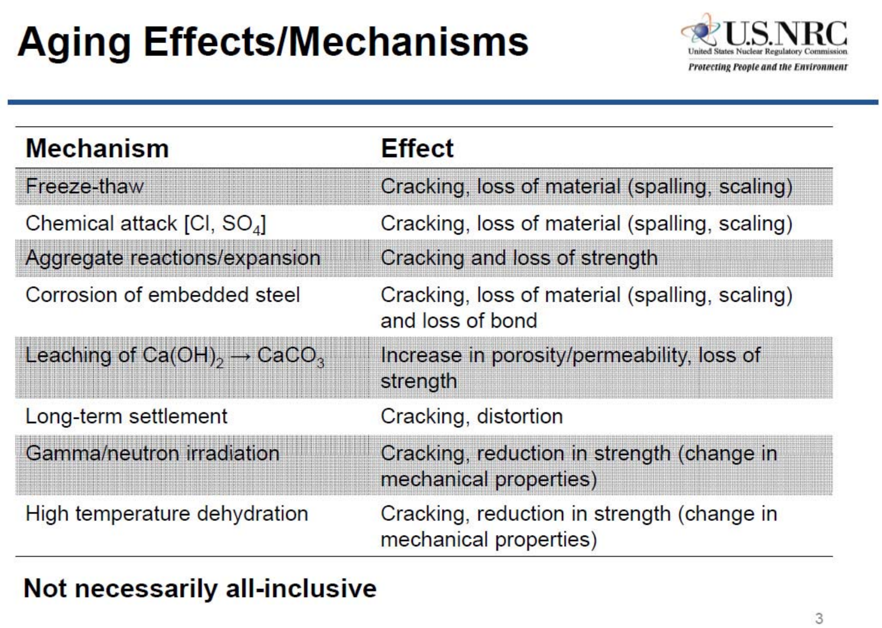
Stress Corrosion Cracking
NRC engineer Darrell Dunn provided excellent presentations on stress corrosion cracking on 7/14 and 8/5/2014. You agreed the welded canisters are only 1/2 to 5/8 of an inch thick, and subject to stress corrosion cracking (SCC) from our coastal environment, and technology doesn't exist to inspect them inside or out. See *Stress Corrosion Cracking (SCC) Background Information* slide on Page 1.

Since spent fuel stainless steel dry storage canisters have not been in use very long and because there are currently no inspections being done to even the outside of these canisters, Darrell referenced numerous SCC studies, and examples of similar stainless steel components at nuclear power plants in coastal environments in order to make his conclusions. None of these components hold hot fuel assemblies.

From this data Darrell estimated yearly crack growth rates as high as 0.91 mm (0.036 inch). This means once a crack has started, it would take 9 years for the crack to go 75% through-wall. Both Mark Lombard and Aladar Csontos stated they thought cracks would not start for 30 years, but they said no one can really predict when a crack will start. And the data presented by Darrell shows that this may happen sooner. Darrell said the hotter the canister, the quicker the crack would go through the wall of the canister.

The Koeberg Plant refueling water storage tank (RWST) failed within 17 years with a crack that was deeper (0.61 inch) than the thickness of most U.S. stainless steel canisters. The NRC staff stated canisters should be taken out of service after a 75% through-wall crack, which would be between 0.325 for 0.5 inch canisters and 0.469 inch for 0.625 inch canisters. See *Power Plant Operating Experience with SCC of Stainless Steel* slide.

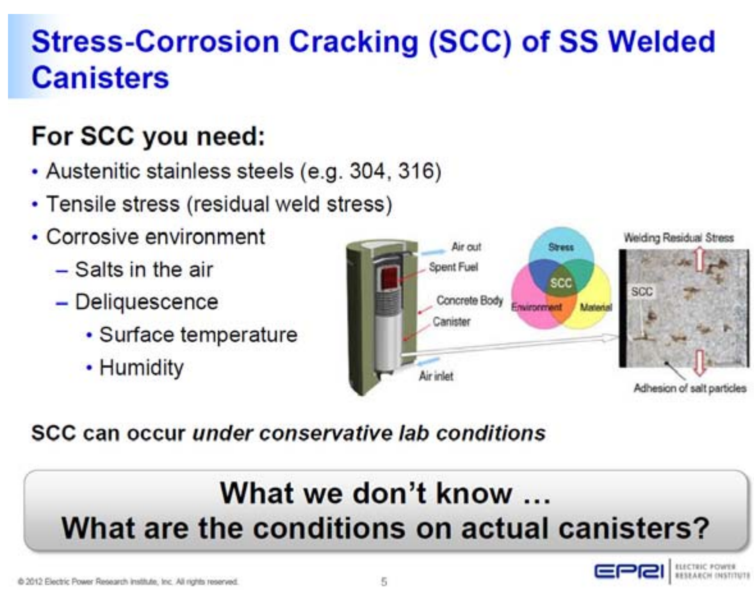
The concrete overpack/cask used with each canister is unsealed, and provides only gamma and neutron protection. They are also subject to structural cracks. See *Aging Effects/Mechanisms* slide. As you know, similar concrete/steel storage systems are used in most of the U.S. Al Csontos said one of the reasons for no current inspections of the stainless steel canister exterior is because of the radiation risk to workers to remove it from the overpack. This is not an issue with the DCI casks.



Mechanism	Effect
Freeze-thaw	Cracking, loss of material (spalling, scaling)
Chemical attack [Cl, SO_4]	Cracking, loss of material (spalling, scaling)
Aggregate reactions/expansion	Cracking and loss of strength
Corrosion of embedded steel	Cracking, loss of material (spalling, scaling) and loss of bond
Leaching of $Ca(OH)_2 \rightarrow CaCO_3$	Increase in porosity/permeability, loss of strength
Long-term settlement	Cracking, distortion
Gamma/neutron irradiation	Cracking, reduction in strength (change in mechanical properties)
High temperature dehydration	Cracking, reduction in strength (change in mechanical properties)

You said Edison plans to procure canisters in September. However, NRC staff aging management research will not be completed before Edison selects a cask system. The NRC told me they plan to have a draft aging management plan by the end of the year. However, they only plan to require inspection of one canister at each plant and they haven't addressed the mitigation issues with the stainless steel/concrete systems and have no idea what the solution could possibly be. You seem to already be aware of this. Also, the pending NUHOMS 32PTH2 canister approval at the NRC doesn't address any of the aging issues.

According to the NRC and EPRI, the current U.S. stored canisters have not been inspected, so it is unknown whether these stainless steel canisters currently have cracks. See *SCC of SS Welded Canisters* slide. I forgot to ask you how a cracked canister would affect its seismic rating. I did read an NRC document that said cracked canisters are excluded from seismic calculations.



The NRC dry storage licenses for Calvert Cliffs and Prairie Island have expired. The NRC staff said aging and mitigation issues need to be addressed before they will relicense them. You mentioned this will be an issue for you in the future with your existing NUHOMS canisters. I've included a link to one of the NRC Request for Information from Calvert Cliffs.

The NRC initially licensed canister before all of the above information was known and before the requirement to have extended storage at nuclear power plants. Now that you are aware of all these issues, it would be prudent to select a dry cask system that doesn't have all the above problems and has a better chance of lasting longer.

You expressed concern that the NRC may take 2 to 5 years to approve the DCI design for storage and transport. [**UPDATE**: On 8/25/2014 Mark Lombard said it would take 18 to 30 months for a new or amended license. The length depends on how complete the vendor package is and how quickly they respond to NRC requests for information. He also said the NRC has never denied a license.] The CASTOR and other DCI casks have international certifications and ASME certification with an N3 stamp, which you were not aware of, but seemed to appreciate. They are also approved for storage and transport internationally. We would need to check with the NRC to discuss timeline, but as you know, if a customer needs a new cask design this is higher priority than a vendor requesting a license for a cask when they don't have a customer. So to ask the vendor to start the licensing process without a customer doesn't seem reasonable, since they'd go to the bottom of the cue.

You mentioned someone at the NRC in the spent pool area said there may be issues with embrittlement with the DCI casks. I've included a link to a SANDIA Labs document that may put that issue to rest. I also told you BAM has done extensive testing on the DCI casks and it is more extensive than the tests in the U.S. (e.g., full size drop tests, fires, airplane crash test, etc.). We discussed how the existing NUHOMS canisters manufactured at San Onofre had the N3 stamp, but any new U.S. ones you order will not have it. In fact, U.S. canisters receive multiple exemptions to ASME standards.

You said you wanted to expedite the fuel out of the pools because that's what others want. However, I said the people pushing for that likely don't understand the issues with the current U.S. canisters. I am educating people around the country on the issues with these canisters. So far, it was news to every one of them. I still have more education to do on this. The community here locally is learning more about this issue and once educated agree that a better cask is important, even if it means a delay in the fuel unloading. The fuel still needs to cool a few years, so there may not be a delay. And we still have safety concerns about reducing the cooling time on the high burnup fuel and would like to see the final plans for cask loading.

We urge you to allow other vendors, such as the CASTOR manufacturer to meet with Edison, so you have an opportunity to evaluate this technology in comparison with the Holtec and NUHOMS steel/concrete technology. We don't want to buy canisters and then have to buy them again within 30 years or so. We've already wasted enough money on steam generators. If you take the step to procure a higher quality cask system, you could lead the nation in improved extended storage. This may be helpful to your company's reputation.

The NUHOMS does not have Failed Fuel Cans and you stated that is still an unresolved issue. How can Areva call this better technology when they've eliminated this capability? I mentioned the NUHOMS 32PTH2 even has a different definition for damaged fuel compared to the NUHOMS 24 series and the NUHOMS 32PTH1, even though it's supposed to be based on the NUHOMS 32PTH1 design. You said you weren't aware of this and plan to investigate. The Holtec has Failed Fuel Cans, but they are not sealed. The CASTOR and other DCI casks have sealed containers for failed/damaged fuel. Chris asked how they are able to dry the fuel if they are in sealed cans. I suggested this would be a great question to ask the vendor. Another reason to have a technical presentation from them.

Regarding canning high burnup – our concern is high burnup fuel cladding can degrade after the fuel is stored (see Billone link). The NRC and DOE require fuel be retrievable at the assembly level. We recommend all high burnup fuel be canned. If it's in sealed cans that's even better. This issue needs to be explored further. I recommended a technical discussion with the DCI iron vendor to see how they handle high burnup fuel issue.

You mentioned concerns that the DCI vendor may pull out of the process if it becomes too involved meeting the NRC's requirements. I mentioned the NRC has never denied a dry cask certification. You seemed to agree with that statement. I mentioned the vendor would be motivated by the $400 million budget for this project – the largest ever in the world for dry cask storage. Also, the opportunity for future business in the U.S. market is motivator that you mentioned. The cost difference in materials is now more competitive and our requirement for extended storage may make the DCI a more cost effective solution. You won't know unless you give them an opportunity to bid.

I realize you are concerned with the uncertainties of using a different vendor. However, the requirements for dry cask storage have changed, requiring a cask system for extended storage. None of the current U.S. vendors meet those needs. The international community seems to be ahead of us on this. The risks we have regarding the premature failure of the stainless steel canisters have much greater consequences than a couple of years delay (assuming there would even be a delay). Chris, you agreed the consequences would be greater if the canisters leaked. And if the U.S. canisters fail in 30 years or so, we're looking at a major expense for replacement canisters. Who pays for that and where is the money set aside for that? Commissioner Michel Florio told me he doesn't want to buy these canisters more than once.

Germany, Japan and other countries house their casks in buildings that provide protection from the environment and external forces. We recommend this option be seriously considered, especially with our coastal environment.

Page 6 contains references that may be useful to you. Page 7 has the slide we discussed regarding existing SCC experiences. It also has a list of DOE prioritized data gaps. It might be useful to see how the DCI compares to the steel/concrete design in terms of data gaps. Note that external monitoring and welded canister corrosion cracking are among the most critical issues to resolve. They don't exist with DCI casks.

Thank you,

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More references on http://sanonofresafety.org/nuclear-waste/

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)

Used Fuel Disposition

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