Burkhardt, Janet

From: RidsNrrDorl Resource
Sent: Thursday, August 18, 2016 1:46 PM
To: Singal, Balwant
Subject: FW: Two e-mails re: Diablo Canyon June 22 Town Hall Meeting
Attachments: FW: Re: Question from Diablo Canyon June 22 Town Hall Meeting - nuclear waste storage; FW: Re: Question from Diablo Canyon June 22 Town Hall Meeting - nuclear waste storage

From: RidsNrrMailCenter Resource
Sent: Wednesday, August 17, 2016 11:31 AM
To: RidsNrrDorl Resource <RidsNrrDorl.Resource@nrc.gov>
Subject: FW: Two e-mails re: Diablo Canyon June 22 Town Hall Meeting

FYI

From: Jones, Latoya
Sent: Wednesday, August 17, 2016 9:22 AM
To: RidsNrrMailCenter Resource <RidsNrrMailCenter.Resource@nrc.gov>
Cc: Walker, Sandra <Sandra.WalkerNRR@nrc.gov>; Clark, Theresa <Theresa.Clark@nrc.gov>
Subject: Two e-mails re: Diablo Canyon June 22 Town Hall Meeting

Assigned to NRR – no action required. Please add to ADAMS and have declared an OAR.

Thank you,
LaToya

Burkhardt, Janet

From: CHAIRMAN Resource
Sent: Monday, August 15, 2016 9:29 AM
To: Lewis, Antoinette; Remsburg, Kristy; Craver, Patti
Subject: FW: Re: Question from Diablo Canyon June 22 Town Hall Meeting - nuclear waste storage
Attachments: [External_Sender] Re: Question from Diablo Canyon June 22 Town Hall Meeting - nuclear waste storage

Burkhardt, Janet

From:	PER PETERSON <perfpeterson@me.com>
Sent:	Friday, August 12, 2016 12:36 PM
To:	Donna Gilmore
Cc:	Groom, Jeremy; Robert Budnitz; Peter Lam; Ferman Wardell; Rick McWhorter; Rob Wellington; Jane Swanson - MFP; Linda Seeley; Robert Alvarez; Marvin Resnikoff; Kevin Barker - CEC; Ken Alex; CHAIRMAN Resource; Shane, Raeann; Peter Bradford; Andrew R. Griffith; John Kotek - DOE; Rita Conn; Toni Iseman; Damon Moglen; Joseph Street; Arnie Gundersen
Subject:	[External_Sender] Re: Question from Diablo Canyon June 22 Town Hall Meeting - nuclear waste storage

Dear Donna,

Thank you for providing this additional information. The DCISC will follow up with another Fact Finding to review it.

Best regards,

Per

> On Aug 12, 2016, at 9:29 AM, Donna Gilmore <dgilmore@cox.net> wrote:
>
> Thanks for your quick response, Per. Apparently, you are not aware of updated information on Diablo Canyon. EPRI took temperatures of two Diablo Canyon canisters and found the temperatures were low enough on the canisters for salt to dissolve on the canisters. One of these canisters had only been loaded with spent fuel for **two years**. Unfortunately, the previous assumption that canisters would be too hot for about 30 years has been proved false. Therefore, all the conditions of cracking exist on those Diablo Canyon canisters. Since EPRI has delayed producing a report on these inspection results, I developed this document using EPRI data from other sources.
> https://sanonofresafety.files.wordpress.com/2011/11/diablocanyonscc-2014-10-23.pdf
>
> The Sandia Lab report referenced in my initial email below also has this information.
>
> Regarding having operators adjust the vents to increase the temperature of the canister, that is an idea that Holtec President Dr. Singh suggested when I met with him. However, I am not aware of any license amendment or any other documentation that has been submitted to the NRC regarding the feasibility of that option nor that it has been implemented.
>
> Regarding the impact of a through wall crack, according to Dr. Singh, even a microscopic through wall crack will release millions of curies of radiation into the environment. https://youtu.be/euaFZt0YPi4
>
> Also, this letter from the ACRS Chairman raises concerns that if air reaches high burnup spent fuel it could result in an explosion at any temperature. This letter was regarding the spent fuel pools. However, when I asked Mark Lombard at the NRC November 2015 Annual Nuclear Waste Management Conference if there were any studies that indicated if this would also apply to fuel in dry storage, he said he wasn't qualified to answer that question and that no one at that technical conference was qualified to answer that question.
> http://pbadupws.nrc.gov/docs/ML0037/ML003704532.pdf

A number of additional reports indicate this could also be a problem in dry storage. For example,

> A 2010 Nuclear Waste Technical Review Board report discusses the dramatic increase of hydrogen in burnups as low as 35 GWd/MTU
>
> Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel, Nuclear Waste Technical Review Board (NWTRB), Douglas Rigby, December 2010, Page 55 and 56 http://www.nwtrb.gov/reports/eds_rpt.pdf
>
> A 2005 INL report addresses the pyrophoric nature of these materials.
>
> *The generation of high surface area uranium metal SNF fragments and uranium hydride necessitates additional measures during SNF drying, dry storage, and transportation because* ***of the pyrophoric nature of these materials when exposed to air.*** *As a result, degraded uranium metal fuels are stored and transported in inerted canisters after removal from the basin and drying. Radiolysis of water within the SNF-water corrosion products must also be addressed for long-term storage because of the ability of the resultant gases to overpressurize containers, embrittle welds on containers, and reach flammable concentrations.*
>
> Damaged Spent Nuclear Fuel at U.S. DOE Facilities, Experience and Lessons Learned, by INL, Nov 2005 INL/EXT-05-00760, Page 4 and 5 https://inldigitallibrary.inl.gov/sti/3396549.pdf

Regarding your suggestion of moving these canisters away from the coast into consolidated interim storage, there are a number of problems with that. There are many other factors that can cause these thin-walled (1/2") stainless steel canisters to crack. Mark Lombard and EPRI stated at the November 2015 meeting that they do not plan to study these other factors. Al Csontos, an NRC manager who works for Mark Lombard, had told me previously that the NRC was going to study these in the future. Apparently, that is not the case.

Also, the transport risks of moving these canisters are numerous. High burnup fuel has not been proven safe in transport or storage. As you know from our previous email correspondence, high burnup fuel cladding can become brittle in dry storage. It could then shatter like glass in an accident, according to nuclear physicist Marvin Resnikoff and others. The NRC and other are still studying this issue to see if it can be safely transported even without an accident. They are studying train vibration impact on high burnup fuel cladding.

There are also unresolved issues regarding transporting these canisters on our poor rail infrastructure. In addition, the Holtec transport cask for high burnup fuel has not yet been approved by the NRC. It is also much heavier than any previous commercial transport cask.

And, of course, no one will want to take these canisters, especially if they knew the safety issues. The New Mexico Governor expressed interest to Secretary Moniz, but in her letter she assumed there were no safety risks once the fuel is in these canisters. Obviously, she is misinformed on that issue.

Also, were you aware Japan has discontinued using aluminum baskets (that hold the fuel assemblies inside the canister)? They found after a Fukushima inspection of casks they won't last 60 years. Since the majority of U.S. baskets are also aluminum (including at Diablo and San Onofre), I asked Mark Lombard how this is being addressed. So far, I have not received an answer. The Japanese made this decision a number of years ago. Given that the U.S. thin-walled canisters are welded shut, the baskets cannot be inspected without destroying the canisters. And for those sites with no pools, such as Humboldt and Rancho Seco, this wouldn't even be possible at the site.

I hope you will now recognize that these thin-walled canisters are unacceptable for store for more than 20 years. Given there is no permanent repository on the horizon, it's critical the U.S. standard be raised to thick-walled casks that can be inspected, maintained, repaired, don't crack, and can be adequately monitored to avoid radiation releases. The thin-walled canisters we currently use do not meet any of those requirements. I also hope you support keeping empty spent fuel pools at San Onofre and Diablo Canyon, so we have a way to transfer the fuel assemblies to safer casks.

Donna

On 8/11/2016 8:15 PM, PER PETERSON wrote:

Dear Donna,

Thank you for copying me on this email. The Diablo Canyon Independent Safety Committee has also been studying this question of salt deposition on canisters in the DCPP Independent Spent Fuel Storage Facility and the potential for deliquescence and stress corrosion cracking to occur. I have appended material from the Fact Finding we performed in July, 2015 on this topic.

The basic conclusion was that stress corrosion cracking is not an immediate concern because heat generation by spent fuel in the canisters is currently maintaining the canister temperatures above the temperatures at which deliquescence of moisture, and thus stress corrosion cracking, could occur, even under conditions where the relative humidity is 100% (e.g., fog is present). This is a different situation from the Koeberg refueling water storage tank cited below which did not have internal heat generation and thus remained at ambient temperature where deliquesce can occur.

However, heat generation rates will drop in these canisters in coming decades, so salt deposition and potential for stress corrosion cracking will be an issue that must continue to be studied and monitored. It would be possible in the longer-term to partially close vents on the overpack to restrict air flow and maintain sufficiently high canister temperatures, but of course the correct solution is for the nation to develop consolidated interim storage facilities and remove spent fuel from coastal locations where salt deposition will remain an ongoing issue.

The other key question, which I will ask our DCISC to investigate, involves the consequences if a through-wall stress corrosion crack were to occur in a storage canister. The canisters are purged with helium at atmospheric pressure, so the pressure differential across the crack would be small and the driving force for flow through the crack would involve daily changes in barometric pressure, which are also small. With the low pressure difference, the crack will remain closed and will have significant resistance for flow. It is an important question whether any significant amount of radioactive material inside the canister might be mobilized under these conditions.

Best regards,

Per Peterson
Member, DCISC

3.3 <u>Potential for Corrosion of Spent Fuel Multi-Purpose Canisters (MPCs)</u>

The DCISC Fact-finding Team met with Larry Pulley, Used Fuel Storage Manager, to discuss the potential for Chloride-Induced Stress Corrosion Cracking (CSCC) of Multipurpose Canisters in DCPP's Independent Spent Fuel Storage Installation (ISFSI). The DCISC last reviewed this topic in May 2015 (Reference 6.3) when it concluded:

> *DCPP is participating in an industry initiative to determine the impact of atmospheric chlorides on the corrosion rate of ISFSI Multipurpose Canisters (MPCs). It is expected that these corrosion rates will be individually dependent upon the material properties of the individual MPCs and the atmospheric conditions at each ISFSI. DCPP's initial 16 MPCs that were used for transfer of used nuclear fuel to the ISFSI are made of 304 austenitic stainless steel, which tends to be somewhat more susceptible to chloride induced stress corrosion cracking than other types of stainless steel that are used for this purpose. Deliquescence that can cause stress corrosion cracking can be made impossible if the canister surface temperatures are maintained sufficiently above outside ambient temperatures, so periodic monitoring of canister temperatures is valuable. Because PG&E and the state of California are examining the possibility of installing salt-water cooling towers as an option to once through cooling at DCPP, it would be advisable, to the extent possible, to examine the potential impact of such cooling towers on the rate of salt aerosol deposition at the ISFSI.*

The next two paragraphs provide a brief summary of the spent fuel storage situation at DCPP. After each nuclear fuel cycle, the operating unit is shut down, and a portion of the nuclear fuel is removed from that reactor and replaced with new nuclear fuel. The spent nuclear fuel assemblies are then temporarily stored (for a number of years) in the Unit's Spent Fuel Pool (SFP). However, each SFP, one for each operating Unit, has a capacity that is limited. Therefore, DCPP has constructed an Independent Spent Fuel Storage Installation (ISFSI) pad above the plant on a hill to the east of the plant, on which the spent nuclear fuel is stored outside after undergoing a highly controlled transfer process. The following is a summary of this process. Spent fuel assemblies (32 in each movement) are inserted into a stainless steel Multi-purpose Canister (MPC-32) which has been lowered into the SFP for this transfer process. A lid is placed on the MPC which is then removed from the SFP, and the lid is then seal welded onto the MPC. The interior of the MPC, containing the fuel assemblies, is then completely drained, dried, and blanketed with helium. Through a detailed process the MPC is then transported to the ISFSI and is eventually transferred into a thick concrete and steel High Integrity Storage Module (HI-STORM), which is then bolted to a reinforced concrete pad at the ISFSI.

The HI-STORM, which contains the sealed MPC, has vents in its bottom and top to allow natural convection air flow upward around the outside of the stainless steel MPC to carry away decay heat being produced by the nuclear fuel. Stainless steel can undergo corrosion influenced by chlorides, which are in the salt aerosol particles formed from sea-spray and carried inland by winds at the DCPP site. Some types of stainless steel are more susceptible to chloride stress-induced corrosion cracking than others. DCPP has a program to monitor salt deposition rates in various locations around the plant. The issue is whether the MPCs could undergo chloride stress-induced corrosion cracking to an extent that could expose the nuclear fuel to the outside atmosphere and permit the release of radionuclides to the outside atmosphere. This issue is discussed in the remaining paragraphs of this topic.

The U. S. nuclear industry is pursuing this issue, and Mr. Pulley is a member of the Electric Power Research Institute's (EPRI's) Technical Advisory Committee on Stress Corrosion Cracking. DCPP is part of an EPRI pilot program where some sample swabs have been taken from the surfaces of some MPCs, from the circumferential weld at the midpoint as well as from an axial weld. The samples were analyzed, and found to contain chlorides. Mr. Pulley has noted that different types of stainless steel have differing degrees of susceptibility to chloride stress-induced corrosion cracking, and lower carbon content in stainless steel tends to reduce its susceptibility to this type of corrosion. Four types of stainless steel in particular have this susceptibility: 304 (austenitic), 304L (L means lower carbon), 316, and 316L. The 304 stainless were determined to be the most susceptible to this corrosion, and the first two sets of DCPP's casks (16 casks in total) transferred to the ISFSI in 2009 and 2010 contain MPCs made of 304 stainless.

On November 14, 2012, the Nuclear Regulatory Commission issued NRC Information Notice (IN 2012-20) to all holders and applicants for an independent spent fuel storage installation (ISFSI) license. The reason for this notice was "to inform addressees of recent issues and technical information concerning the potential for chloride-induced stress corrosion cracking (SCC) of austenitic stainless steel dry cask storage system canisters. Significant SCC could affect the ability of the spent fuel storage canisters to perform their confinement function during the initial license or license renewal storage period(s). The NRC expects that recipients will review this information to determine how it applies to their designs and facilities and consider actions, as appropriate, to avoid these potential problems. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required."

The NRC's Information Notice further provides background information, as follows:

> "SCC is induced from the combination of tensile stress and a specific corrosive environment. Austenitic stainless steels under tensile stress are known to be susceptible to SCC when exposed to chlorides in the environment. A literature survey has revealed failures attributed to chloride-induced SCC in the types of austenitic stainless steels typically used in dry cask storage system canisters when these materials are exposed to atmospheric conditions near salt-water bodies. This phenomenon is of concern at temperature and relative humidity combinations that allow the chloride compounds to deliquesce *(i.e. to become soft or liquid with age)*. It is thought that airborne salts could deposit on the material surface, then form chloride-rich deliquescent brines in conditions of high relative humidity. Laboratory data suggests that chloride-induced SCC is of particular concern as the canister surface temperature decreases to the level where salt will deliquesce."
>
> "Researchers do not yet fully understand the relationship between the proximity to a salt-water body and the potential for chloride deposition on a dry cask storage system canister. However, it should be noted that many ISFSIs are located near salt-water bodies or other sources of chlorides, such as salted roads or condensed cooling tower water. These canisters may have high tensile residual stresses from welding or other fabrication processes."

NRC Information Notice 2012-20 further states:

> "The NRC is currently evaluating data to determine the level of susceptibility and potential safety significance for existing licenses and certificates. The NRC has engaged the Nuclear Energy Institute (NEI) to describe information related to structures, systems, and components important and to understand industry plans for generically addressing this issue. The NRC also has communicated concerns and technical information regarding this topic at several stakeholder meetings. At this point, no immediate safety concern has been identified with currently approved licenses that would warrant a backfit analysis under 10CFR 72.62, 'Backfitting.' However, maintenance and surveillance programs during initial license periods and aging management programs (AMPs) during license renewal periods are required to address aging effects, such as chloride-induced SCC, as appropriate for the relevant canister design(s), operating conditions, specific site environmental conditions, and proposed license renewal periods."

As stated above, NEI has been engaged in supporting the industry on this issue. In an October 29, 2014 letter to the NRC, NEI concluded, and informed the NRC and the industry, that this issue "has not reached a level of urgency of safety significance to qualify it for the NRC's generic safety issue process because testing is inconclusive (laboratory conditions do not accurately represent in-situ conditions at ISFSI sites), actual conditions (atmospheric and cask) vary from site to site and from model to model and cask to cask; and actual field data is insufficient. Since there is not an immediate safety concern, use of this protocol permits a deliberate yet timely approach to understanding the issue and creating the necessary tools for licensing and implementing prevention and mitigation strategies, as necessary." NEI's stated goal at that time was to finalize and send to the NRC by June 2015 "Industry Susceptibility Criteria that can be used by ISFSI licensees to evaluate the potential for Chloride Induced Stress Corrosion Cracking to occur on canisters at their site."

Measurement of the surface temperature of the canisters in the DCPP ISFSI, along with the outside ambient temperature, provides a way to verify that the canister surface temperatures are sufficiently high to make deliquescence impossible, even if the air relative humidity is 100%. The rate of decay heat generation in the canisters currently in storage is sufficiently high that this condition exists and deliquescence is therefore impossible. One concern is that in coming decades, decay heat generation will drop and ISFSI canisters may then become vulnerable to deliquescence and SCC. Given the age of the spent fuel in storage in the ISFSI, the dominant heat generation comes from decay of Cs-137 and Sr-90, which have 30-year half-lives, so heat generation can be expected to drop by about half every 30 years. However, if the canister temperatures are monitored, it will be possible to block air vent holes in the over pack containers to reduce air flow, and thus to maintain appropriate canister temperatures over extended periods of time if required.

During this July 2015 Fact-finding Visit, the DCISC Fact-finding Team learned that DCPP is part of an EPRI pilot program that involves two other commercial nuclear plants, both of which have been operating longer than DCPP. Thus far, this has involved EPRI taking sample swipes of the sides and upward facing surfaces of MPCs and analyzing the swipes for chlorides. These initial samples tended to reveal a higher chloride content on the upward facing surfaces of the MPCs than on the sides. Consideration is also being given to sampling the surfaces of the welds of the MPCs. Also, an EPRI report is to be published by the end of 2015 regarding the susceptibility of MPCs of various designs and materials to chloride stress-induced corrosion cracking based on factors including spent fuel heat generation, locations of the spent fuel storage facilities, and characteristics of the surfaces and environmental conditions to which the canisters could be exposed. Mr. Pulley noted that the report on DCPP is expected to be issued before year-end 2015. The DCISC should review this report during the first quarter of 2016.

As mentioned in DCPP's May 2015 Fact-finding Report, PG&E and the State of California are also examining the possibility of installing salt-water cooling towers as an option to replace once through cooling. The DCISC continues to believe that, to the extent possible it would be advisable to examine the potential impact of such cooling towers on salt deposition rates at the ISFSI, and the accompanying impact on the possible deliquescence and SCC phenomena for DCPP's ISFSI Multipurpose Canisters.

Subsequent to this Fact-finding Visit, the DCISC obtained a copy of an August 31, 2015 report by the U.S. Nuclear Waste Technical Review Board which has been engaged in reviewing the transportation of Spent Nuclear Fuel. This Review Board has also been engaged in reviewing the storage of spent nuclear fuel. Portions of the above August 2015 report that are relevant to DCISC's examination of the potential for CISCC of spent nuclear fuel canisters are in the following nine bullets:

- CISCC requires three things for crack initiation and growth: a susceptible material, high tensile stress in the material, and the presence of wet chlorides in contact with the material.
- Welding can create a heat-affected zone in the steel that is susceptible to various forms of corrosion including CISCC, if the residual tensile stresses are sufficiently high and the local environment is sufficiently aggressive.
- Although CISCC has not yet been found on any dry-storage canisters, it has been found in steel structures in similar atmospheric conditions.
- A crack growing at 0.5 millimeter per year, which is possible under aggressive conditions, would penetrate the wall of a susceptible stainless steel canister in 25 to 30 years.
- The local environment on the canister surface is critical, but is variable and not well understood under atmospheric conditions.
- Chemical analyses have been performed on samples taken from the surfaces at three sites located in brackish or marine atmospheric environments, and the chloride concentrations were either very low or much lower than expected.
- The chloride ions deposited from aerosols on the surface of a canister may be depleted when dry or they may be depleted after they have deliquesced in the presence of humidity to form hot brine. These chloride ions in the hot brine may be converted to volatile hydrogen chloride, which could then degas from the surface of the MPC to leave a much less aggressive environment. However, this mechanism has not been proven, and even very small concentrations (e.g. parts per billion) of dissolved hydrogen chloride (hydrochloric acid) can be very corrosive. Therefore, the local environment on canisters, including chloride concentration, temperature, and local humidity, must be understood in order to develop meaningful models. Some models have been developed, but were based on limited data.
- The state of stress at the welds and the resultant stress intensity at defects or corrosion pits are also critical for assessing the susceptibility to CISCC. It is not uncommon for residual stresses to vary through the thickness of a component such that a tensile stress at the surface becomes a compressive stress at the interior, thus stifling crack growth and penetration of the wall. In this vein,

experiments are being conducted on a mock-up canister to assess the three-dimensional stress state.

- The final important aspect of this issue is inspection. However, dry storage ISFSIs were not designed to allow for inspection. The size and position of vents in the overpacks as well as the high radiation fields and temperatures make inspection extremely difficult. Fully automated inspection systems are not yet available and the high radiation field and temperature make current inspections by hand extremely difficult. Participation of several universities is being pursued in this regard.

Conclusions: DCPP is continuing its participation, as one of three pilot independent spent fuel storage facilities, in an industry initiative being led by the Nuclear Energy Institute (NEI) and supported by the Electric Power Research Institute (EPRI) to examine the potential impact of chloride-induced stress corrosion cracking on Multipurpose Canisters (MPCs) of Independent Spent Fuel Storage Installations (ISFSIs). Deliquescence of salts from the atmosphere is known to be a significant factor in the likelihood and rate of such corrosion. However, the higher temperatures of the MPC surfaces in their earlier years due to the heat generated by radioactive decay are known to greatly diminish, and even eliminate, the likelihood of deliquescence. The US Nuclear Waste Technical Review Board is also actively involved in studying this topic. The DCISC should obtain a copy of NEI's planned document: "Industry Susceptibility Criteria that can be used by ISFSI Licensees to Evaluate the Potential for Chloride Induced Stress Corrosion Cracking to occur on Canisters at their Site." The DCISC notes again that PG&E and the State of California are examining the possibility of installing salt-water cooling towers as an option to replace once through cooling. The DCISC continues to believe that, to the extent possible, it would be advisable to examine the potential impact of such cooling towers on salt deposition rates at the ISFSI, and the accompanying impact on possible deliquescence and stress corrosion cracking phenomena for DCPP's ISFSI Multipurpose Canisters.

On Aug 11, 2016, at 4:55 PM, Donna Gilmore <dgilmore@cox.net> wrote:

Hi Jeremy,

Who and what is the source of your information regarding conditions for cracking of Diablo Canyon spent nuclear fuel storage canisters?

The below Sandia Lab report clearly states there are abundant salts on the Diablo spent nuclear fuel canisters (from breaking surf) and that there is frequent fog that resulted in salt deliquensce (dissolved salts) on the canister. As you know, these are one of the conditions that can cause these thin-walled canisters to crack and leak.

The investigation of two thin-walled stainless steel Diablo Canyon canisters was very limited, only examining a small part of the outside of the canisters for corrosive dust particles, yet they found all the conditions for stress corrosion cracking in a 2-year old Diablo Canyon canister.

California climate zone data shows both Diablo Canyon (Zone 5) and San Onofre (Zone 7) are located in high moisture zones (with on-shore winds, surf, and frequent fog); enough moisture to dissolve salts on the canisters and start the pitting and cracking of the canisters. http://www.pge.com/includes/docs/pdfs/about/edusafety/training/pec/toolbox/arch/climate/california_climate_zones_01-16.pdf

The NRC Spent Fuel Management Division was provided this information, but has apparently chosen to ignore it. I live 5 miles from San Onofre and see frequent morning and evening fog at the coastline. When the NRC in a technical meeting suggested there was not enough humidity at San Onofre I knew they had some misinformation about conditions along the Pacific Coast. Unfortunately, it appears this information and my discussion during the meeting with Darrell Dunn and Mark Lombard has been ignored. The Sandia Lab report recognizes the frequent fog. What will it take for the NRC to acknowledge this?

Also, the NRC states the Koeberg nuclear plant in South Africa is located in a similar environment to Diablo and San Onofre and had a similar container (a 304L stainless steel refueling water storage tank (RWST)) **leak within 17 years**. The container develop multiple cracks up to 0.61 inch deep, which is deeper than the thickness of most U.S. canisters including the Diablo Holtec canisters, which are only 0.50 inch thick. The Koeberg tank required dye penetrant testing to reveal the cracks. This cannot be done with canisters filled with spent fuel.

And even if you could find cracks, then what? Holtec's President, Dr. Singh, says it's not practical to repair them, even if you could find the cracks. https://youtu.be/euaFZt0YPi4

The NRC should stop approving these thin-walled canisters and raise their minimum dry storage standards. Most of the rest of the world is using thick-walled metal casks up to almost 20" thick that can be inspected (inside and out), can be maintained, monitored, repaired, have defense in depth and don't have the cracking risks of the U.S. thin canisters.

We don't have a lot of time to improve standards and procure safer casks. Canisters at San Onofre have been loaded since 2003 and California nuclear utilities (Southern California Edison, PG&E, SMUD) and other utilities have no plans in place to deal with leaking canisters.

The NRC continues to avoid answering the question of what can specifically be done if one or more of these canisters starts leaking. They also have not provided evidence of what might happen with leaking canisters filled with high burnup spent fuel, including the possibility of an explosion from gasses building up in the canisters.

These are urgent issues that need to be address now rather than wasting talented engineering time and millions and millions of dollars looking for inspection solutions which will never be adequate and don't solve this urgent problem.

California utilities and most other utilities will not buy higher quality dry storage systems unless the NRC requires this. Therefore, it's very unlikely vendors could sell higher quality casks unless the NRC does this.

The DOE should refuse to accept these thin-wall canisters, since they do not meet current Nuclear Waste Policy Act requirements for monitored retrievable storage.

State regulators are claiming they don't have jurisdiction to require higher standards, even though ratepayers and residents will have the financial burden (directly or indirectly) of replacing these multi-million dollar canisters. Cost is about $4 million per thin-wall canister system (including labor). This doesn't cover the replacement costs or other major impacts that would result from failed canisters.

I've had numerous discussions about these issues with Mark Lombard (NRC Director of Spent Fuel Management Division), so am not hopeful this can be resolved at his level.

Please review the below Sandia Lab report and let me know where we differ in our understanding of the facts.

There has been a lot of "misinformation" about the problems with these thin-walled canisters. It's in all of our best interests to have an understanding of the facts on these critical and time sensitive issues.

We're all entitled to our own opinions, but not our own facts.

Donna Gilmore
SanOnofreSafety.org
949-204-7794

Results of Stainless Steel Canister Corrosion Studies and Environmental Sample Investigations, Charles Bryan and David Enos, Sandia National Laboratories, September 25, 2014, SAND2014-20347

http://www.energy.gov/sites/prod/files/2015/05/f22/FCRDUFD2014000055CanisterCorrosionnStud.pdf

Selected paragraphs from the above Sandia report:

> ***Since Na, Cl, Mg, and S O_4 are the most abundant ionic species in seawater, these are certainly sea-salt aggregates.*** *The hollow spheres formed when droplets of seawater, suspended in the air by breaking waves, evaporated from the outside inwards. They commonly*

have an aperture, apparently where the last fluid escaped. ***As morning fogs are common at Diablo Canyon, it is likely that this evaporation occurred, in at least some cases, within the overpack as the deliquesced sea-salt droplets were drawn in and moved upwards through the heated annulus. Figure 19 illustrates the abundance of salts in the dust, and Figure 20 is a close-up of three salt aggregates, showing the size and morphology.***

At lower temperatures, deliquescence of the mixed salts occurred and both HCl and HNO3 degassed; however, chloride was replenished in the deliquesced brine by dissolution of the underlying chloride mineral. Replenishment of nitrate did not occur, so the nitrate was eventually depleted. This also explains the corroded surface of many of the NaCl crystals on the canister surfaces.

MPC-170 (canister): ***The dust is almost entirely sea salt particles***

From: "Groom, Jeremy" <Jeremy.Groom@nrc.gov>

Date: July 28, 2016 at 1:33:05 PM PDT
To: "Lindaseeley <lindaseeley@gmail.com> (lindaseeley@gmail.com)" <lindaseeley@gmail.com>
Cc: "Dricks, Victor" <Victor.Dricks@nrc.gov>
Subject: Question from Diablo Canyon June 22 Town Hall Meeting

Ms. Seeley,

At the Diablo Canyon open house held in San Luis Obispo, CA on June 22, 2016, you asked a question about the discovery of magnesium salt on an independent spent fuel installation (ISFSI) canister at Diablo Canyon. At the meeting, I committed to providing an overview of the NRC's assessment of this issue after speaking with the appropriate NRC staff who were not in attendance at the open house. To answer your question, I coordinated with our technical experts in the NRC Region IV Division of Nuclear Material Safety and the NRC's Office of Nuclear Material Safety and Safeguards who implement the inspection and assessment programs for ISFSIs.

In January 2014, the Electric Power Research Institute (EPRI), as part of a research study, collected dust samples from an in-service ISFSI canister at Diablo Canyon. When analyzed, researchers at Sandia National Laboratories found traces of sodium chloride and magnesium sulfate crystals in the dust samples. Donna Gilmore of San Onofre Safety.org posted a report on her website stating that the presence of magnesium chloride salts found on a two-year old ISFSI canister at Diablo Canyon, at a temperature and relative humidity that would dissolve the salts, established conditions that could accelerate stress corrosion cracking of the ISFSI.

The NRC staff reviewed Ms. Gilmore's statements and disagree with her conclusions. NRC found that the humidity around the ISFSI's at Diablo Canyon is not high enough to cause the salts to dissolve and cause accelerated stress corrosion cracking. Using site-specific data from the National Oceanic and Atmospheric Administration, the fastest crack growth rates would not result in a through-wall flaw of an ISFSI for at least thirty years. As such, the NRC staff continues to conclude that the Diablo Canyon ISFSI canisters are safe to store spent nuclear fuel.

Additionally, methods to apply existing non non-destructive examination techniques to welded stainless steel canisters are under development and currently being tested by both EPRI and dry storage system manufacturers. Testing and demonstration of inspection technology has been conducted at three ISFSI sites and NRC staff has observed these demonstrations. These inspections include the use of a camera with fiber optic probe capable of performing inspections that meet the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel code. The entire height of the canister was accessible and the fabrication and closure welds were readily visible. The NRC staff continues to monitor industry initiatives to develop inspections for dry storage systems to ensure the appropriate examinations are performed at ISFSI locations including Diablo Canyon.

If you have any questions, please feel free to contact me.

Sincerely,

Jeremy R. Groom
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Division of Reactor Projects
U.S. NRC Region IV
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E: jeremy.groom@nrc.gov

****

Burkhardt, Janet

From:	CHAIRMAN Resource
Sent:	Monday, August 15, 2016 9:29 AM
To:	Lewis, Antoinette; Remsburg, Kristy; Craver, Patti
Subject:	FW: Re: Question from Diablo Canyon June 22 Town Hall Meeting - nuclear waste storage
Attachments:	[External_Sender] Re: Question from Diablo Canyon June 22 Town Hall Meeting - nuclear waste storage

Burkhardt, Janet

From:	Donna Gilmore <dgilmore@cox.net>
Sent:	Friday, August 12, 2016 12:29 PM
To:	PER PETERSON; Groom, Jeremy
Cc:	Robert Budnitz; Peter Lam; Ferman Wardell; Rick McWhorter; Bob Rathie; Jane Swanson - MFP; Linda Seeley; Robert Alvarez; Marvin Resnikoff; Kevin Barker - CEC; Ken Alex; CHAIRMAN Resource; Shane, Raeann; Peter Bradford; Andrew R. Griffith; John Kotek - DOE; Rita Conn; Toni Iseman; Damon Moglen; Joseph Street; Arnie Gundersen
Subject:	[External_Sender] Re: Question from Diablo Canyon June 22 Town Hall Meeting - nuclear waste storage

Thanks for your quick response, Per. Apparently, you are not aware of updated information on Diablo Canyon. EPRI took temperatures of two Diablo Canyon canisters and found the temperatures were low enough on the canisters for salt to dissolve on the canisters. One of these canisters had only been loaded with spent fuel for **two years**. Unfortunately, the previous assumption that canisters would be too hot for about 30 years has been proved false. Therefore, all the conditions of cracking exist on those Diablo Canyon canisters. Since EPRI has delayed producing a report on these inspection results, I developed this document using EPRI data from other sources.
https://sanonofresafety.files.wordpress.com/2011/11/diablocanyonscc-2014-10-23.pdf

The Sandia Lab report referenced in my initial email below also has this information.

Regarding having operators adjust the vents to increase the temperature of the canister, that is an idea that Holtec President Dr. Singh suggested when I met with him. However, I am not aware of any license amendment or any other documentation that has been submitted to the NRC regarding the feasibility of that option nor that it has been implemented.

Regarding the impact of a through wall crack, according to Dr. Singh, even a microscopic through wall crack will release millions of curies of radiation into the environment. https://youtu.be/euaFZt0YPi4

Also, this letter from the ACRS Chairman raises concerns that if air reaches high burnup spent fuel it could result in an explosion at any temperature. This letter was regarding the spent fuel pools. However, when I asked Mark Lombard at the NRC November 2015 Annual Nuclear Waste Management Conference if there were any studies that indicated if this would also apply to fuel in dry storage, he said he wasn't qualified to answer that question and that no one at that technical conference was qualified to answer that question.
http://pbadupws.nrc.gov/docs/ML0037/ML003704532.pdf

A number of additional reports indicate this could also be a problem in dry storage. For example,

> A 2010 Nuclear Waste Technical Review Board report discusses the dramatic increase of hydrogen in burnups as low as 35 GWd/MTU
> Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel, Nuclear Waste Technical Review Board (NWTRB), Douglas Rigby, December 2010, Page 55 and 56
> http://www.nwtrb.gov/reports/eds_rpt.pdf
>
> A 2005 INL report addresses the pyrophoric nature of these materials.
>
> *The generation of high surface area uranium metal SNF fragments and uranium hydride necessitates additional measures during SNF drying, dry storage, and transportation because **of the pyrophoric nature of these materials when exposed to air.** As a result, degraded uranium metal fuels are stored and transported in inerted canisters after removal from the basin and drying. Radiolysis of water within the SNF-water corrosion products must also be addressed for long-term storage because of the ability of*

the resultant gases to overpressurize containers, embrittle welds on containers, and reach flammable concentrations.

Damaged Spent Nuclear Fuel at U.S. DOE Facilities, Experience and Lessons Learned, by INL, Nov 2005 INL/EXT-05-00760, Page 4 and 5 https://inldigitallibrary.inl.gov/sti/3396549.pdf

Regarding your suggestion of moving these canisters away from the coast into consolidated interim storage, there are a number of problems with that. There are many other factors that can cause these thin-walled (1/2") stainless steel canisters to crack. Mark Lombard and EPRI stated at the November 2015 meeting that they do not plan to study these other factors. Al Csontos, an NRC manager who works for Mark Lombard, had told me previously that the NRC was going to study these in the future. Apparently, that is not the case.

Also, the transport risks of moving these canisters are numerous. High burnup fuel has not been proven safe in transport or storage. As you know from our previous email correspondence, high burnup fuel cladding can become brittle in dry storage. It could then shatter like glass in an accident, according to nuclear physicist Marvin Resnikoff and others. The NRC and other are still studying this issue to see if it can be safely transported even without an accident. They are studying train vibration impact on high burnup fuel cladding.

There are also unresolved issues regarding transporting these canisters on our poor rail infrastructure. In addition, the Holtec transport cask for high burnup fuel has not yet been approved by the NRC. It is also much heavier than any previous commercial transport cask.

And, of course, no one will want to take these canisters, especially if they knew the safety issues. The New Mexico Governor expressed interest to Secretary Moniz, but in her letter she assumed there were no safety risks once the fuel is in these canisters. Obviously, she is misinformed on that issue.

Also, were you aware Japan has discontinued using aluminum baskets (that hold the fuel assemblies inside the canister)? They found after a Fukushima inspection of casks they won't last 60 years. Since the majority of U.S. baskets are also aluminum (including at Diablo and San Onofre), I asked Mark Lombard how this is being addressed. So far, I have not received an answer. The Japanese made this decision a number of years ago. Given that the U.S. thin-walled canisters are welded shut, the baskets cannot be inspected without destroying the canisters. And for those sites with no pools, such as Humboldt and Rancho Seco, this wouldn't even be possible at the site.

I hope you will now recognize that these thin-walled canisters are unacceptable for store for more than 20 years. Given there is no permanent repository on the horizon, it's critical the U.S. standard be raised to thick-walled casks that can be inspected, maintained, repaired, don't crack, and can be adequately monitored to avoid radiation releases. The thin-walled canisters we currently use do not meet any of those requirements. I also hope you support keeping empty spent fuel pools at San Onofre and Diablo Canyon, so we have a way to transfer the fuel assemblies to safer casks.

Donna

On 8/11/2016 8:15 PM, PER PETERSON wrote:

Dear Donna,

Thank you for copying me on this email. The Diablo Canyon Independent Safety Committee has also been studying this question of salt deposition on canisters in the DCPP Independent Spent Fuel Storage Facility and the potential for deliquescence and stress corrosion cracking to occur. I have appended material from the Fact Finding we performed in July, 2015 on this topic.

The basic conclusion was that stress corrosion cracking is not an immediate concern because heat generation by spent fuel in the canisters is currently maintaining the canister temperatures above the temperatures at which deliquescence of moisture, and thus stress corrosion cracking, could occur, even under conditions where the relative humidity is 100% (e.g., fog is present). This is a different situation from the Koeberg refueling water storage tank cited below which did not have internal heat generation and thus remained at ambient temperature where deliquesce can occur.

However, heat generation rates will drop in these canisters in coming decades, so salt deposition and potential for stress corrosion cracking will be an issue that must continue to be studied and monitored. It would be possible in the longer-term to partially close vents on the overpack to restrict air flow and maintain sufficiently high canister temperatures, but of course the correct solution is for the nation to develop consolidated interim storage facilities and remove spent fuel from coastal locations where salt deposition will remain an ongoing issue.

The other key question, which I will ask our DCISC to investigate, involves the consequences if a through-wall stress corrosion crack were to occur in a storage canister. The canisters are purged with helium at atmospheric pressure, so the pressure differential across the crack would be small and the driving force for flow through the crack would involve daily changes in barometric pressure, which are also small. With the low pressure difference, the crack will remain closed and will have significant resistance for flow. It is an important question whether any significant amount of radioactive material inside the canister might be mobilized under these conditions.

Best regards,

Per Peterson
Member, DCISC

3.3 Potential for Corrosion of Spent Fuel Multi-Purpose Canisters (MPCs)

The DCISC Fact-finding Team met with Larry Pulley, Used Fuel Storage Manager, to discuss the potential for Chloride-Induced Stress Corrosion Cracking (CSCC) of Multipurpose Canisters in DCPP's Independent Spent Fuel Storage Installation (ISFSI). The DCISC last reviewed this topic in May 2015 (Reference 6.3) when it concluded:

> *DCPP is participating in an industry initiative to determine the impact of atmospheric chlorides on the corrosion rate of ISFSI Multipurpose Canisters (MPCs). It is expected that these corrosion rates will be individually dependent upon the material properties of the individual MPCs and the atmospheric conditions at each ISFSI. DCPP's initial 16 MPCs that were used for transfer of used nuclear fuel to the ISFSI are made of 304 austenitic stainless steel, which tends to be somewhat more susceptible to chloride induced stress corrosion cracking than other types of stainless steel that are used for this purpose. Deliquescence that can cause stress corrosion cracking can be made impossible if the canister surface temperatures are maintained sufficiently above outside ambient temperatures, so periodic monitoring of canister temperatures is valuable. Because PG&E and the state of California are examining the possibility of installing salt-water cooling towers as an option to once through cooling at DCPP, it would be advisable, to the extent possible, to examine the potential impact of such cooling towers on the rate of salt aerosol deposition at the ISFSI.*

The next two paragraphs provide a brief summary of the spent fuel storage situation at DCPP. After each nuclear fuel cycle, the operating unit is shut down, and a portion of the nuclear fuel is removed from that reactor and replaced with new nuclear fuel. The spent nuclear fuel assemblies are then temporarily stored (for a number of years) in the Unit's Spent Fuel Pool (SFP). However, each SFP, one for each operating Unit, has a capacity that is limited. Therefore, DCPP has constructed an Independent Spent Fuel Storage Installation (ISFSI) pad above the plant on a hill to the east of the plant, on which the spent nuclear fuel is stored outside after undergoing a highly controlled transfer process. The following is a summary of this process. Spent fuel assemblies (32 in each movement) are inserted into a stainless steel Multi-purpose Canister (MPC-32) which has been lowered into the SFP for this transfer process. A lid is placed on the MPC which is then removed from the SFP, and the lid is then seal welded onto the MPC. The interior of the MPC, containing the fuel assemblies, is then completely drained, dried, and blanketed with helium. Through a detailed process the MPC is then transported to the ISFSI and is eventually transferred into a thick concrete and steel High Integrity Storage Module (HI-STORM), which is then bolted to a reinforced concrete pad at the ISFSI.

The HI-STORM, which contains the sealed MPC, has vents in its bottom and top to allow natural convection air flow upward around the outside of the stainless steel MPC to carry away decay heat being produced by the nuclear fuel. Stainless steel can undergo corrosion influenced by chlorides, which are in the salt aerosol particles formed from sea-spray and carried inland by winds at the DCPP site. Some types of stainless steel are more susceptible to chloride stress-induced corrosion cracking than others. DCPP has a program to monitor salt deposition rates in various locations around the plant. The issue is whether the MPCs could undergo chloride stress-induced corrosion cracking to an extent that could expose the nuclear fuel to the outside atmosphere and permit the release of radionuclides to the outside atmosphere. This issue is discussed in the remaining paragraphs of this topic.

The U. S. nuclear industry is pursuing this issue, and Mr. Pulley is a member of the Electric Power Research Institute's (EPRI's) Technical Advisory Committee on Stress Corrosion Cracking. DCPP is part of an EPRI pilot program where some sample swabs have been taken from the surfaces of some MPCs, from the circumferential weld at the midpoint as well as from an axial weld. The samples were analyzed, and found to contain chlorides. Mr. Pulley has noted that different types of stainless steel have differing degrees of susceptibility to chloride stress-induced corrosion cracking, and lower carbon content in stainless steel tends to reduce its susceptibility to this type of corrosion. Four types of stainless steel in particular have this susceptibility: 304 (austenitic), 304L (L means lower carbon), 316, and 316L. The 304 stainless were determined to be the most susceptible to this corrosion, and the first two sets of DCPP's casks (16 casks in total) transferred to the ISFSI in 2009 and 2010 contain MPCs made of 304 stainless.

On November 14, 2012, the Nuclear Regulatory Commission issued NRC Information Notice (IN 2012-20) to all holders and applicants for an independent spent fuel storage installation (ISFSI) license. The reason for this notice was "to inform addressees of recent issues and technical information concerning the potential for chloride-induced stress corrosion cracking (SCC) of austenitic stainless steel dry cask storage system canisters. Significant SCC could affect the ability of the spent fuel storage canisters to perform their confinement function during the initial license or license renewal storage period(s). The NRC expects that recipients will review this information to determine how it applies to their designs and facilities and consider actions, as appropriate, to avoid these potential problems. However, suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required."

The NRC's Information Notice further provides background information, as follows:

> "SCC is induced from the combination of tensile stress and a specific corrosive environment. Austenitic stainless steels under tensile stress are known to be susceptible to SCC when exposed

> to chlorides in the environment. A literature survey has revealed failures attributed to chloride-induced SCC in the types of austenitic stainless steels typically used in dry cask storage system canisters when these materials are exposed to atmospheric conditions near salt-water bodies. This phenomenon is of concern at temperature and relative humidity combinations that allow the chloride compounds to deliquesce *(i.e. to become soft or liquid with age)*. It is thought that airborne salts could deposit on the material surface, then form chloride-rich deliquescent brines in conditions of high relative humidity. Laboratory data suggests that chloride-induced SCC is of particular concern as the canister surface temperature decreases to the level where salt will deliquesce."
>
> "Researchers do not yet fully understand the relationship between the proximity to a salt-water body and the potential for chloride deposition on a dry cask storage system canister. However, it should be noted that many ISFSIs are located near salt-water bodies or other sources of chlorides, such as salted roads or condensed cooling tower water. These canisters may have high tensile residual stresses from welding or other fabrication processes."

NRC Information Notice 2012-20 further states:

> "The NRC is currently evaluating data to determine the level of susceptibility and potential safety significance for existing licenses and certificates. The NRC has engaged the Nuclear Energy Institute (NEI) to describe information related to structures, systems, and components important and to understand industry plans for generically addressing this issue. The NRC also has communicated concerns and technical information regarding this topic at several stakeholder meetings. At this point, no immediate safety concern has been identified with currently approved licenses that would warrant a backfit analysis under 10CFR 72.62, 'Backfitting.' However, maintenance and surveillance programs during initial license periods and aging management programs (AMPs) during license renewal periods are required to address aging effects, such as chloride-induced SCC, as appropriate for the relevant canister design(s), operating conditions, specific site environmental conditions, and proposed license renewal periods."

As stated above, NEI has been engaged in supporting the industry on this issue. In an October 29, 2014 letter to the NRC, NEI concluded, and informed the NRC and the industry, that this issue "has not reached a level of urgency of safety significance to qualify it for the NRC's generic safety issue process because testing is inconclusive (laboratory conditions do not accurately represent in-situ conditions at ISFSI sites), actual conditions (atmospheric and cask) vary from site to site and from model to model and cask to cask; and actual field data is insufficient. Since there is not an immediate safety concern, use of this protocol permits a deliberate yet timely approach to understanding the issue and creating the necessary tools for licensing and implementing prevention and mitigation strategies, as necessary." NEI's stated goal at that time was to finalize and send to the NRC by June 2015 "Industry Susceptibility Criteria that can be used by ISFSI licensees to evaluate the potential for Chloride Induced Stress Corrosion Cracking to occur on canisters at their site."

Measurement of the surface temperature of the canisters in the DCPP ISFSI, along with the outside ambient temperature, provides a way to verify that the canister surface temperatures are sufficiently high to make deliquescence impossible, even if the air relative humidity is 100%. The rate of decay heat generation in the canisters currently in storage is sufficiently high that this condition exists and deliquescence is therefore impossible. One concern is that in coming decades, decay heat generation will drop and ISFSI canisters may then become vulnerable to deliquescence and SCC. Given the age of the spent fuel in storage in the ISFSI, the dominant heat generation comes from decay of Cs-137 and Sr-90, which have 30-year half-lives, so heat generation can be expected to drop by about half every 30 years. However, if the canister temperatures are monitored, it will be possible to block air vent holes in the over pack containers to reduce air flow, and thus to maintain appropriate canister temperatures over extended periods of time if required.

During this July 2015 Fact-finding Visit, the DCISC Fact-finding Team learned that DCPP is part of an EPRI pilot program that involves two other commercial nuclear plants, both of which have been operating longer than DCPP. Thus far, this has involved EPRI taking sample swipes of the sides and upward facing surfaces of MPCs and analyzing the swipes for chlorides. These initial samples tended to reveal a higher chloride content on the upward facing surfaces of the MPCs than on the sides. Consideration is also being given to sampling the surfaces of the welds of the MPCs. Also, an EPRI report is to be published by the end of 2015 regarding the susceptibility of MPCs of various designs and materials to chloride stress-induced corrosion cracking based on factors including spent fuel heat generation, locations of the spent fuel storage facilities, and characteristics of the surfaces and environmental conditions to which the canisters could be exposed. Mr. Pulley noted that the report on DCPP is expected to be issued before year-end 2015. The DCISC should review this report during the first quarter of 2016.

As mentioned in DCPP's May 2015 Fact-finding Report, PG&E and the State of California are also examining the possibility of installing salt-water cooling towers as an option to replace once through cooling. The DCISC continues to believe that, to the extent possible it would be advisable to examine the potential impact of such cooling towers on salt deposition rates at the ISFSI, and the accompanying impact on the possible deliquescence and SCC phenomena for DCPP's ISFSI Multipurpose Canisters.

Subsequent to this Fact-finding Visit, the DCISC obtained a copy of an August 31, 2015 report by the U.S. Nuclear Waste Technical Review Board which has been engaged in reviewing the transportation of Spent Nuclear Fuel. This Review Board has also been engaged in reviewing the storage of spent nuclear fuel. Portions of the above August 2015 report that are relevant to DCISC's examination of the potential for CISCC of spent nuclear fuel canisters are in the following nine bullets:

- CISCC requires three things for crack initiation and growth: a susceptible material, high tensile stress in the material, and the presence of wet chlorides in contact with the material.
- Welding can create a heat-affected zone in the steel that is susceptible to various forms of corrosion including CISCC, if the residual tensile stresses are sufficiently high and the local environment is sufficiently aggressive.
- Although CISCC has not yet been found on any dry-storage canisters, it has been found in steel structures in similar atmospheric conditions.
- A crack growing at 0.5 millimeter per year, which is possible under aggressive conditions, would penetrate the wall of a susceptible stainless steel canister in 25 to 30 years.
- The local environment on the canister surface is critical, but is variable and not well understood under atmospheric conditions.
- Chemical analyses have been performed on samples taken from the surfaces at three sites located in brackish or marine atmospheric environments, and the chloride concentrations were either very low or much lower than expected.
- The chloride ions deposited from aerosols on the surface of a canister may be depleted when dry or they may be depleted after they have deliquesced in the presence of humidity to form hot brine. These chloride ions in the hot brine may be converted to volatile hydrogen chloride, which could then degas from the surface of the MPC to leave a much less aggressive environment. However, this mechanism has not been proven, and even very small concentrations (e.g. parts per billion) of dissolved hydrogen chloride (hydrochloric acid) can be very corrosive. Therefore, the local environment on canisters, including chloride concentration, temperature, and local humidity, must be understood in order to develop meaningful models. Some models have been developed, but were based on limited data.
- The state of stress at the welds and the resultant stress intensity at defects or corrosion pits are also critical for assessing the susceptibility to CISCC. It is not uncommon for residual stresses to

vary through the thickness of a component such that a tensile stress at the surface becomes a compressive stress at the interior, thus stifling crack growth and penetration of the wall. In this vein, experiments are being conducted on a mock-up canister to assess the three-dimensional stress state.

- The final important aspect of this issue is inspection. However, dry storage ISFSIs were not designed to allow for inspection. The size and position of vents in the overpacks as well as the high radiation fields and temperatures make inspection extremely difficult. Fully automated inspection systems are not yet available and the high radiation field and temperature make current inspections by hand extremely difficult. Participation of several universities is being pursued in this regard.

Conclusions: DCPP is continuing its participation, as one of three pilot independent spent fuel storage facilities, in an industry initiative being led by the Nuclear Energy Institute (NEI) and supported by the Electric Power Research Institute (EPRI) to examine the potential impact of chloride-induced stress corrosion cracking on Multipurpose Canisters (MPCs) of Independent Spent Fuel Storage Installations (ISFSIs). Deliquescence of salts from the atmosphere is known to be a significant factor in the likelihood and rate of such corrosion. However, the higher temperatures of the MPC surfaces in their earlier years due to the heat generated by radioactive decay are known to greatly diminish, and even eliminate, the likelihood of deliquescence. The US Nuclear Waste Technical Review Board is also actively involved in studying this topic. The DCISC should obtain a copy of NEI's planned document: "Industry Susceptibility Criteria that can be used by ISFSI Licensees to Evaluate the Potential for Chloride Induced Stress Corrosion Cracking to occur on Canisters at their Site." The DCISC notes again that PG&E and the State of California are examining the possibility of installing salt-water cooling towers as an option to replace once through cooling. The DCISC continues to believe that, to the extent possible, it would be advisable to examine the potential impact of such cooling towers on salt deposition rates at the ISFSI, and the accompanying impact on possible deliquescence and stress corrosion cracking phenomena for DCPP's ISFSI Multipurpose Canisters.

On Aug 11, 2016, at 4:55 PM, Donna Gilmore <dgilmore@cox.net> wrote:

Hi Jeremy,

Who and what is the source of your information regarding conditions for cracking of Diablo Canyon spent nuclear fuel storage canisters?

The below Sandia Lab report clearly states there are abundant salts on the Diablo spent nuclear fuel canisters (from breaking surf) and that there is frequent fog that resulted in salt deliquensce (dissolved salts) on the canister. As you know, these are one of the conditions that can cause these thin-walled canisters to crack and leak.

The investigation of two thin-walled stainless steel Diablo Canyon canisters was very limited, only examining a small part of the outside of the canisters for corrosive dust particles, yet they found all the conditions for stress corrosion cracking in a 2-year old Diablo Canyon canister.

California climate zone data shows both Diablo Canyon (Zone 5) and San Onofre (Zone 7) are located in high moisture zones (with on-shore winds, surf, and frequent fog); enough moisture to dissolve salts on the canisters and start the pitting and cracking of the canisters.

http://www.pge.com/includes/docs/pdfs/about/edusafety/training/pec/toolbox/arch/climate/california_climate_zones_01-16.pdf

The NRC Spent Fuel Management Division was provided this information, but has apparently chosen to ignore it. I live 5 miles from San Onofre and see frequent morning and evening fog at the coastline. When the NRC in a technical meeting suggested there was not enough humidity at San Onofre I knew they had some misinformation about conditions along the Pacific Coast. Unfortunately, it appears this information and my discussion during the meeting with Darrell Dunn and Mark Lombard has been ignored. The Sandia Lab report recognizes the frequent fog. What will it take for the NRC to acknowledge this?

Also, the NRC states the Koeberg nuclear plant in South Africa is located in a similar environment to Diablo and San Onofre and had a similar container (a 304L stainless steel refueling water storage tank (RWST)) **leak within 17 years**. The container develop multiple cracks up to 0.61 inch deep, which is deeper than the thickness of most U.S. canisters including the Diablo Holtec canisters, which are only 0.50 inch thick. The Koeberg tank required dye penetrant testing to reveal the cracks. This cannot be done with canisters filled with spent fuel.

And even if you could find cracks, then what? Holtec's President, Dr. Singh, says it's not practical to repair them, even if you could find the cracks. https://youtu.be/euaFZt0YPi4

The NRC should stop approving these thin-walled canisters and raise their minimum dry storage standards. Most of the rest of the world is using thick-walled metal casks up to almost 20" thick that can be inspected (inside and out), can be maintained, monitored, repaired, have defense in depth and don't have the cracking risks of the U.S. thin canisters.

We don't have a lot of time to improve standards and procure safer casks. Canisters at San Onofre have been loaded since 2003 and California nuclear utilities (Southern California Edison, PG&E, SMUD) and other utilities have no plans in place to deal with leaking canisters.

The NRC continues to avoid answering the question of what can specifically be done if one or more of these canisters starts leaking. They also have not provided evidence of what might happen with leaking canisters filled with high burnup spent fuel, including the possibility of an explosion from gasses building up in the canisters.

These are urgent issues that need to be address now rather than wasting talented engineering time and millions and millions of dollars looking for inspection solutions which will never be adequate and don't solve this urgent problem.

California utilities and most other utilities will not buy higher quality dry storage systems unless the NRC requires this. Therefore, it's very unlikely vendors could sell higher quality casks unless the NRC does this.

The DOE should refuse to accept these thin-wall canisters, since they do not meet current Nuclear Waste Policy Act requirements for monitored retrievable storage.

State regulators are claiming they don't have jurisdiction to require higher standards, even though ratepayers and residents will have the financial burden (directly or indirectly) of replacing these multi-million dollar canisters. Cost is about $4 million per thin-wall canister system (including labor). This doesn't cover the replacement costs or other major impacts that would result from failed canisters.

I've had numerous discussions about these issues with Mark Lombard (NRC Director of Spent Fuel Management Division), so am not hopeful this can be resolved at his level.

Please review the below Sandia Lab report and let me know where we differ in our understanding of the facts.

There has been a lot of "misinformation" about the problems with these thin-walled canisters. It's in all of our best interests to have an understanding of the facts on these critical and time sensitive issues.

We're all entitled to our own opinions, but not our own facts.

Donna Gilmore
SanOnofreSafety.org
949-204-7794

Results of Stainless Steel Canister Corrosion Studies and Environmental Sample Investigations, Charles Bryan and David Enos, Sandia National Laboratories, September 25, 2014, SAND2014-20347

http://www.energy.gov/sites/prod/files/2015/05/f22/FCRDUFD2014000055CanisterCorrosionnStud.pdf

Selected paragraphs from the above Sandia report:

> ***Since Na, Cl, Mg, and S O_4 are the most abundant ionic species in seawater, these are certainly sea-salt aggregates.*** *The hollow spheres formed when droplets of seawater, suspended in the air by breaking waves, evaporated from the outside inwards. They commonly have an aperture, apparently where the last fluid escaped.* ***As morning fogs are common at Diablo Canyon, it is likely that this evaporation occurred, in at least some cases, within the overpack as the deliquesced sea-salt droplets were drawn in and moved upwards through the heated annulus. Figure 19 illustrates the abundance of salts in the dust, and Figure 20 is a close-up of three salt aggregates, showing the size and morphology.***
>
> ***At lower temperatures, deliquescence of the mixed salts occurred and both HCl and HNO3 degassed; however, chloride was replenished in the deliquesced brine by dissolution of the underlying chloride mineral. Replenishment of nitrate did not occur, so the nitrate was eventually depleted. This also explains the corroded surface of many of the NaCl crystals on the canister surfaces.***
>
> *MPC-170 (canister):* ***The dust is almost entirely sea salt particles***

From: "Groom, Jeremy" <Jeremy.Groom@nrc.gov>

Date: July 28, 2016 at 1:33:05 PM PDT
To: "Lindaseeley <lindaseeley@gmail.com> (lindaseeley@gmail.com)" <lindaseeley@gmail.com>
Cc: "Dricks, Victor" <Victor.Dricks@nrc.gov>
Subject: Question from Diablo Canyon June 22 Town Hall Meeting

Ms. Seeley,

At the Diablo Canyon open house held in San Luis Obispo, CA on June 22, 2016, you asked a question about the discovery of magnesium salt on an independent spent fuel installation (ISFSI) canister at Diablo Canyon. At the meeting, I committed to providing an overview of the NRC's assessment of this issue after speaking with the appropriate NRC staff who were not in attendance at the open house. To answer your question, I coordinated with our technical experts in the NRC Region IV Division of Nuclear Material Safety and the NRC's Office of Nuclear Material Safety and Safeguards who implement the inspection and assessment programs for ISFSIs.

In January 2014, the Electric Power Research Institute (EPRI), as part of a research study, collected dust samples from an in-service ISFSI canister at Diablo Canyon. When analyzed, researchers at Sandia National Laboratories found traces of sodium chloride and magnesium sulfate crystals in the dust samples. Donna Gilmore of San Onofre Safety.org posted a report on her website stating that the presence of magnesium chloride salts found on a two-year old ISFSI canister at Diablo Canyon, at a temperature and relative humidity that would dissolve the salts, established conditions that could accelerate stress corrosion cracking of the ISFSI.

The NRC staff reviewed Ms. Gilmore's statements and disagree with her conclusions. NRC found that the humidity around the ISFSI's at Diablo Canyon is not high enough to cause the salts to dissolve and cause accelerated stress corrosion cracking. Using site-specific data from the National Oceanic and Atmospheric Administration, the fastest crack growth rates would not result in a through-wall flaw of an ISFSI for at least thirty years. As such, the NRC staff continues to conclude that the Diablo Canyon ISFSI canisters are safe to store spent nuclear fuel.

Additionally, methods to apply existing non non-destructive examination techniques to welded stainless steel canisters are under development and currently being tested by both EPRI and dry storage system manufacturers. Testing and demonstration of inspection technology has been conducted at three ISFSI sites and NRC staff has observed these demonstrations. These inspections include the use of a camera with fiber optic probe capable of performing inspections that meet the requirements of the American Society of Mechanical Engineers Boiler and Pressure Vessel code. The entire height of the canister was accessible and the fabrication and closure welds were readily visible. The NRC staff continues to monitor industry initiatives to develop inspections for dry storage systems to ensure the appropriate examinations are performed at ISFSI locations including Diablo Canyon.

If you have any questions, please feel free to contact me.

Sincerely,

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