Independent Spent Fuel Storage Installation Aging Management Concerns

Dave Lochbaum
February 15, 2023

Manna Jo Greene asked the following questions during the December 7, 2022, public meeting of the Indian Point Closure Task Force and Indian Point Decommissioning Oversight Board:

Question 1:

If the canisters are welded shut, how are the fuel assemblies retrievable if a problem occurs? [Transcript, page 208, lines 20-23]

Question 2:

How is scratching to be prevented? These are indeed thin-walled canisters; they're a half inch to five-eighths an inch. They're essentially a big tin can made of steel, of stainless steel. But how will Holtec prevent scratching when loading, because scratching can ultimately lead to through-wall leak. [Transcript, page 209, lines 6-15]

Both questions involve the storage of spent fuel assemblies within dry casks an Independent Spent Fuel Storage Installation (ISFSI) at Indian Point licensed per Part 72 to Title 10 of the Code of Federal Regulations.

Background: Dry Storage

Holtec Decommissioning International, “IPEC Decommissioning Update, February 2, 2023, slide 5.

ISFSI Dry Cask Totals:

Unit 1:	5 Casks	160 Fuel Assemblies	100% Complete	(9/19/2008)
Unit 2:	63 Casks	2016 Fuel Assemblies	100% Complete	(2/1/2023)
Unit 3:	18 Casks	576 Fuel Assemblies	30.5% Complete	(4/14/2021)

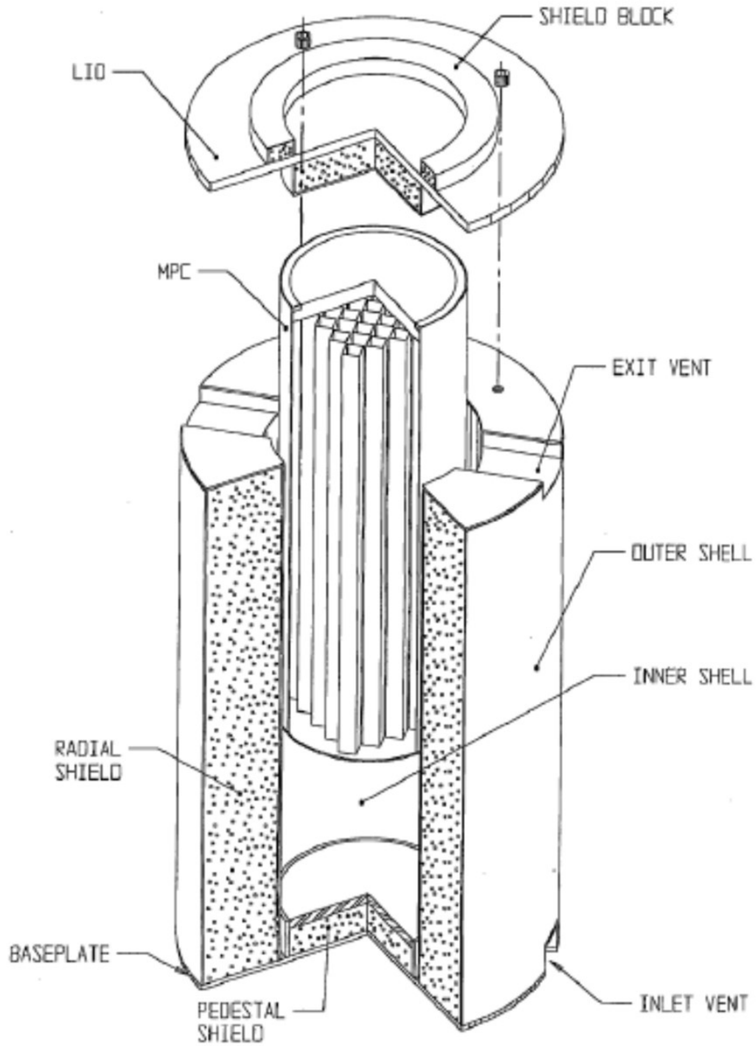
NYS Oversight Updates, February 2, 2023, slide 5.

ISFSI Pad

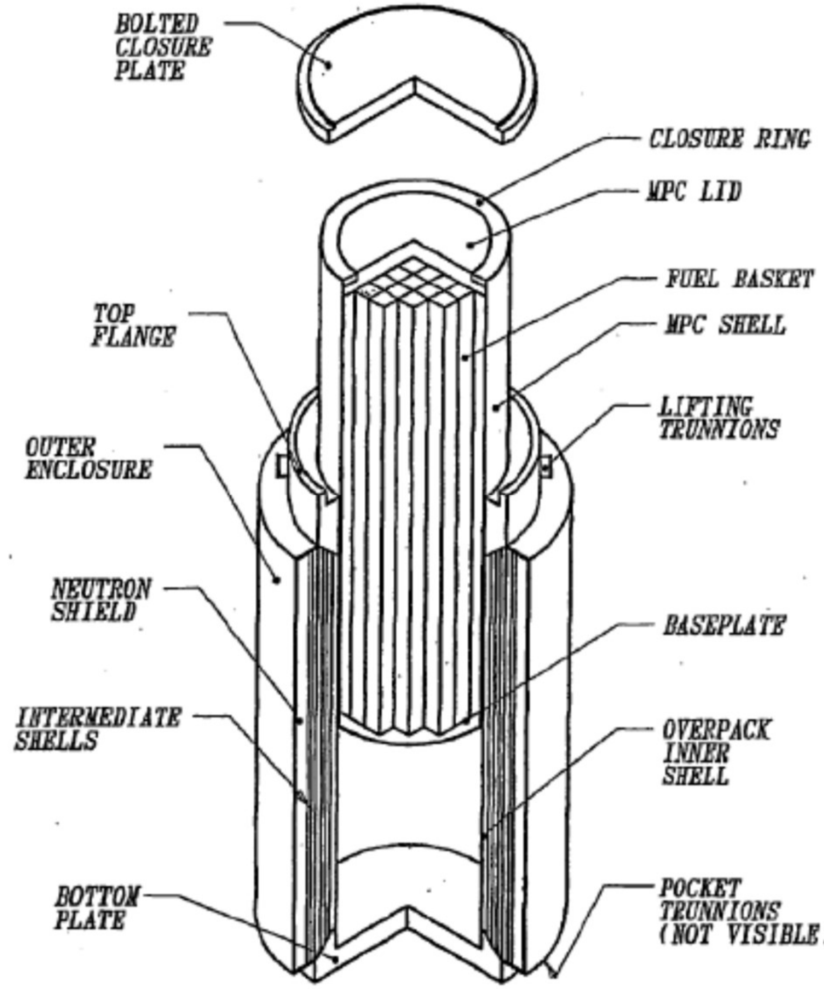
As previously noted, an additional ISFSI pad had to be constructed to accommodate all the Holtec HI-Storm 100S casks. 127 casks are needed to secure all the fuel from both the Unit 2 and Unit 3 Spent Fuel Pools. The original pad will hold 75 casks and the new pad will hold 52 casks. As reported in a previous DOB meeting, fencing and monitoring equipment have been installed such that both pads are now part of the Site Protected Area.

Holtec Decommissioning International, "IPEC Decommissioning Update, February 2, 2023, slide 4.

Indian Point had 86 dry casks loaded with spent fuel as of February 1, 2023, with plans for a total dry cask inventory of 126 casks. The casks are located on two concrete pads north of the plant enclosed within a security fence.



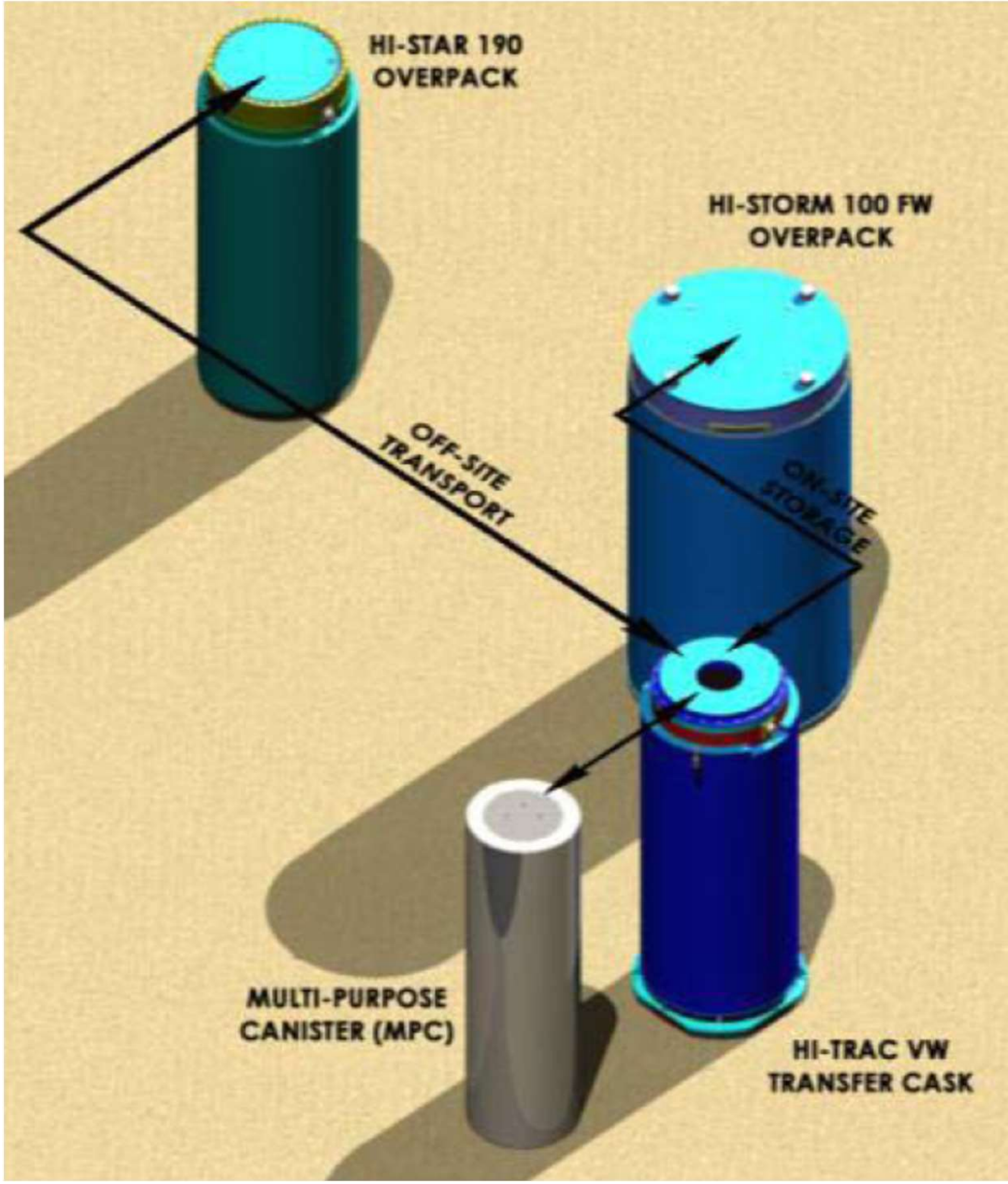
HI-STORM 100



HI-STAR 100

Indian Point uses Holtec's vertical dry casks.

U.S. Nuclear Regulatory Commission, "Managing Aging Processes In Storage (MAPS) Report," NUREG-2214, July 2019 (ML19214A111).



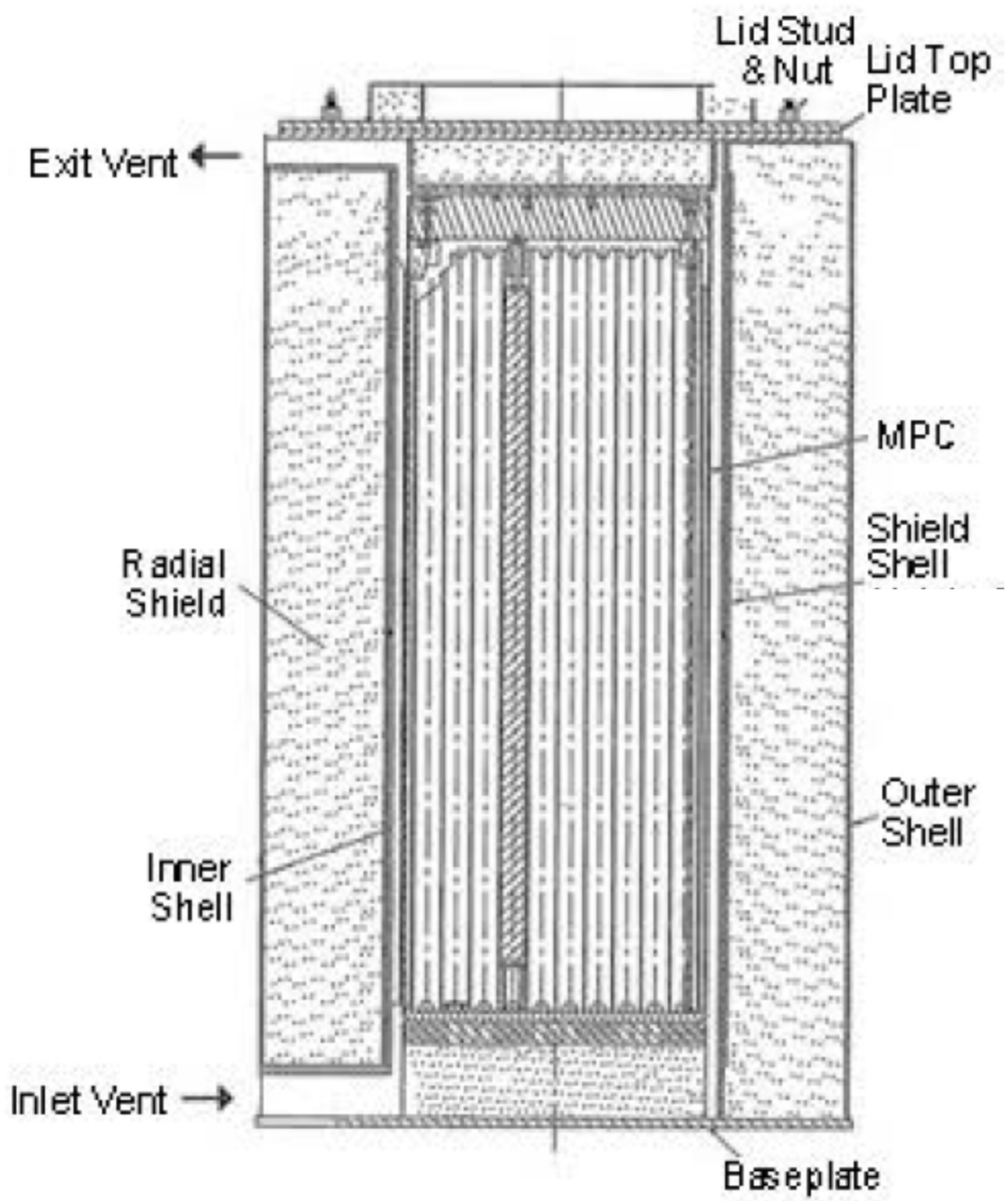
An empty multi-purpose canister is lowered into the spent fuel pool and loaded with up to 32 spent fuel assemblies.

The MPC's lid is put on. It is lifted from the spent fuel pool and drained of water. Helium gas is inserted to protect against degradation due to moisture.

The loaded MPC is placed in a HI-TRAC cask for transfer to a HI-STORM 100 dry cask.

Someday, perhaps, the MPC will be transported offsite in a HI-STAR 100 overpack.

Darrell Dunn, U.S. Nuclear Regulatory Commission, "Aging Management During Spent Fuel Storage," October 4, 2015 (ML15310A435).



A stainless steel Multi-Purpose Canister (MPC) resides within a concrete overpack or cask.

Via the chimney effect, air flowing in the Inlet Vent and through the space between the MPC and the cask removes the decay heat emanating from the spent fuel assemblies.

There are no moving parts.

U.S. Nuclear Regulatory Commission, "Managing Aging Processes In Storage (MAPS) Report," NUREG-2214, July 2019 (ML19214A111).

Question 1: Fuel Retrievability

Federal Register / Vol. 53, No. 161 / Friday, August 19, 1988 / Rules and Regulations 31651

NUCLEAR REGULATORY COMMISSION

10 CFR Parts 2, 19, 20, 21, 51, 70, 72, 73, 75 and 150

Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Waste Policy Act of 1982, as amended (NWPA) requires that monitored retrievable storage facilities (MRS) for spent nuclear fuel and high-level radioactive waste (HLW) be subject to licensing by the Nuclear Regulatory Commission (NRC). The NRC is adding language to its regulations in 10 CFR Part 72 to provide for licensing the storage of spent nuclear fuel and HLW in an MRS. The Commission intends to have the appropriate regulation to fulfill the requirements of the NWPA in place in a timely manner. The rule would also clarify certain issues that have arisen since Part 72 was made effective on November 28, 1980 and incorporate other changes resulting from public comments received.

EFFECTIVE DATE: September 19, 1988.

10 CFR Part 72 was issued on August 19, 1988, establishing licensing requirements for the independent storage of spent fuel.

§72.122 **Overall requirements.**

(l) *Retrievability.* Storage systems must be designed to allow ready retrieval of spent fuel or high-level radioactive waste for further processing or disposal.

Section 72.122 paragraph L required that spent fuel storage systems be designed to allow ready retrieval of spent fuel.

10 CFR Part 72 was revised by the NRC on June 22, 1999, and October 11, 2001.

§72.122 paragraph (l) was not altered, supplemented, or superseded by either of these changes to the original regulation. In other words, the requirements imposed on August 19, 1988, remain unaffected today:

> (l) *Retrievability.* Storage systems must be designed to allow ready retrieval of spent fuel or high-level radioactive waste for further processing or disposal.

The NRC issued ISG-2, "Fuel Retrievability," in October 1998. It is referenced in other documents issued by the NRC as having ADAMS Accession No. ML092800367. A search of ADAMS on February 13, 2023, failed to find this document publicly available.

Revision 1 to ISG-2, "Fuel Retrievability," was issued on February 22, 2010 (ML100550861). ISG-2 Rev. 1 stated:

> *This Interim Staff Guidance (ISG) provides guidance to the staff for determining if storage systems to be licensed under 10 CFR Part 72 allow ready retrieval of spent fuel.*
>
> *The staff considers a fuel assembly to be "ready retrievable" if it remains structurally sound (i.e., no gross degradation) and could be handled by normal means (i.e., does not pose operational safety problems during removal) or, in the case of a structurally unsound assembly or an assembly that has rods with breaches greater than a pinhole or a hairline crack that could release fuel particulate, if the assembly is placed inside a secondary container (described in ISG-1 as a "can for damaged fuel") that confines the fuel particulate to a known volume and, that container can be handled by normal means.*

Revision 1 to ISG-2, "Fuel Retrievability," was issued on February 22, 2010 (ML100550861). ISG-2 Rev. 1 stated (continued):

> ***For removal of spent fuel from storage prior to transport, spent fuel should be retrievable on an assembly basis, in addition to a canister basis.***
>
> ***Thus, this guidance defines ready retrieval of spent fuel as the ability to both move the canister containing the fuel to either a transportation package or a location where the fuel can be removed, as well as maintaining the ability to handle individual fuel assemblies or canned fuel assemblies by normal means.***

Revision 2 to ISG-2, “Fuel Retrievabiliy,” was issued April 26, 2016 (ML16117A070). ISG-2 Rev. 2 stated:

> *ISG-2, Rev. 2 defines ready retrieval as "the ability to safely remove the spent fuel from storage for further processing or disposal." In order to demonstrate the ability for ready retrieval, a licensee should demonstrate it has the ability to perform any of the three options below.* ***These options may be utilized individually or in any combination or sequence, as appropriate****.*
>
> A. *remove individual or canned spent fuel assemblies from wet or dry storage,*
> B. ***remove a canister loaded with spent fuel assemblies from a storage cask/overpack****,*
> C. *remove a cask loaded with spent fuel assemblies from the storage location.*
>
> ***By redefining guidance on the ability to remove the individual spent fuel assemblies or canned assemblies by normal means and providing alternatives, the spent fuel would still be retrieved safely*** *and be readied for transportation consistent with the law and regulations.*

“Ready retrieval of spent fuel” is not defined in 10 CFR Part 72 even though Section 72.3 contains over 40 definitions of terms used in the regulation.

ISG-2 Rev. 1 specified that “*spent fuel should be retrievable on an assembly basis.*”

ISG-2 Rev. 2 removed the requirement for retrievability of an individual assembly.

It’s not a question of whether the definition in ISG-2 Rev. 1 or that in ISG-2 Rev. 2 is correct. Both were apparently issued unlawfully.

10 CFR 72 is explicit on how interpretations of the meanings of this regulation are to be handled. 10 CFR 72 requires either specific authorization by the Commission or written decision by the NRC’s General Counsel for interpretations. No authorizations or decisions have been found. Hence, there is reasonable doubt of the applicability of both since it seems neither was legally issued.

The only signature on ISG-2 Rev. 1 was by the NRC's Director of the Division of Spent Fuel Storage and Transportation.

The only signature on ISG-2 Rev. 2 was by the NRC's Director of the Division of Spent Fuel Management. A cover memo stated that ISG-2 Rev. 2 had been reviewed by "*the Division of Spent Fuel Management staff and branch chiefs, and Advisory Committee on Reactor Safeguards*."

Section 72.5 of 10 CFR Part 72 states:

> ***Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of the Commission, other than a written interpretation by the General Counsel, will be recognized to be binding upon the Commission.***

SECY-01-0076, "Retrievability of Spent Fuel From Dry Storage Casks," dated April 27, 2001 (ML011020520) informed the Commission of the staff's plans. ISG-1, "Damaged Fuel," was mentioned, but there was no mention of ISG-2 or a plan to develop an interim staff guidance memo on fuel retrievability. No Staff Requirements Memorandum from the Commission in response to this SECY was found.

Answer 1: Fuel Retrievability

10 CFR 72.122 requires that "*Storage systems must be designed to allow ready retrieval of spent fuel or high-level radioactive waste for further processing or disposal*." Although 10 CFR Part 72 defines more than 40 terms used in the regulation, "ready retrieval" is not defined.

NRC has issued guidance over the years that defined "ready retrieval" to be on an individual fuel assembly basis and later on a loaded canister basis. However, it appears that none of this guidance was issued legally.

The NRC should legally define what constitutes "ready retrieval" of spent fuel in dry storage and then ensure all dry storage systems comply with that definition.

Question 2: Canister Scratching

Origin and Prevalence of Scratches

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- Scratches in plates and shells in the manufacture of any weldment are present everywhere. From the time a stack of plates arrives at the factory, the rubbing between the plate layers causes scratches to develop. Most plates come from the mill bearing scratches. Rolling, bending, forming, shearing, machining, etc., necessary to fabricate are all potential scratch-making operations. Surface scratches are commonplace and expected in MPCs.
- Quality manufacturing plants, such as ours, place a limit on admissible depth and population density of scratches, primarily to address workmanship considerations. Holtec's procedure HSP-320 has been used to screen scratches in thousands of hardware supplied by the company to nuclear plants.

Holtec International, "HI-STORM UMAX Canister Storage System Incidence and Consequences of Surfaces Scratches on the MPC Shell," April 10, 2019 ML20254A065).

Closing Remarks

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- Localized scratches are an inevitable factor in MPC manufacture, transport and operation.
- Localized scratches in the MPC are not of concern from the standpoint of compliance with ASME Section III, Subsection NB stress intensity limits, nor do they violate any design or licensing requirements per the HI-STORM UMAX FSAR.
- Localized scratches in the MPC are not a safety concern nor do they affect its functionality.
- The discussion of scratches in FSAR Section 9.5 represents non-safety significant information.
- Using 10CFR72.48, Holtec has clarified the FSAR language describing wear and scratches on the MPC external surface.

~~Holtec copyrighted material~~

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Holtec International, "HI-STORM UMAX Canister Storage System Incidence and Consequences of Surfaces Scratches on the MPC Shell," April 10, 2019 ML20254A065).

The Many Incarnations of Scratches

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> Two materials rubbing against each other produce scratches through abrasive wear.

> Materials that have close metallurgical affinity (such as austenitic stainless against austenitic stainless) are also susceptible to adhesive wear (galling) which can cause the scratch to be exacerbated.

> The depth and width of a scratch depends on the contact force and the state of the armor on the stainless steel surface (which varies from plate to plate). However, *the greater the contact force, the deeper the scratch.*

> Predicting the size of the scratch, therefore, is not an exact science.

Holtec International, "HI-STORM UMAX Canister Storage System Incidence and Consequences of Surfaces Scratches on the MPC Shell," April 10, 2019 ML20254A065).

Dry cask storage systems (DCSSs) are used to store used nuclear fuel prior to final geologic storage or reprocessing. A large portion of the DCSS systems used throughout the world employ a ventilated concrete overpack with a welded stainless steel canister that confines the used nuclear fuel.

For DCSSs using welded stainless steel canisters, a potential degradation mechanism that has been proactively identified by industry and regulatory assessments is stress corrosion cracking (SCC) caused by deposition of chloride salts on the canister surface.

Operating experience and laboratory testing has shown that CISCC in atmospheric marine environments rarely occurs without being accompanied (and preceded) by rust staining of the surface and by localized corrosion, such as pitting. Visual inspection of the surface for these accompanying forms of corrosion is a viable way to screen for the potential presence of CISCC degradation.

Based on the literature review, a failure modes and effects analysis (FMEA) was performed, and it concluded that a tight through-wall crack growing by CISCC was the most likely way in which the canister could be penetrated.

Electric Power Research Institute, "Aging Management Guidance to Address Potential Chloride-Induced Stress Corrosion Cracking of Welded Stainless Steel Canisters," March 2017.

CISCC Main Questions

- Will it happen?
  - Probably yes (CISCC criteria are or will eventually be met)
- When?
  - *Many* decades from now?
    - Likely for the majority of welded SS canisters
  - Within the current or next license/CoC periods?
    - Can’t rule it out for a subset of canisters

Chloride-induced stress corrosion cracking takes time but is likely to appear.

John Kessler, “Prioritizing Aging Management Activities for Dry Cask Storage,” October 4, 2016.

Table 4-1
Most Likely Locations for CISCC Degradation (Adapted from Reference [21])

Factor for CISCC Susceptibility	Locations on Horizontal Canister	Locations on Vertical Canister
Tensile Stresses on OD	Regions in the vicinity of welds (e.g. within about 2 thicknesses)	Regions in the vicinity of welds (e.g. within about 2 thicknesses)
Low Surface Temperature(1)	Lids; shell along canister underside and along ends	Lower region of canister OD
Elevated Chloride Deposition	Upward-facing surfaces of canister shell	Top lid; possibly the areas in the vicinity of the overpack inlets
Crevice-like Geometry	Support rail contact region	Areas where canister contacts the overpack channels/standoffs(2)
Material Condition	Areas of heavy grinding or mechanical damage (e.g. gouges)	Areas of heavy grinding or mechanical damage (e.g. gouges)
Most Susceptible Location(s)	Shell welds at canister ends (top surface); support rail interface near welds	Canister sides near welds at the bottom of the canister

Electric Power Research Institute, "Susceptibility Assessment Criteria for Chloride-Induced Stress Corrosion Cracking (CISCC) of Welded Stainless Steel Canisters for Dry Cask Storage Systems," 3002005371, September 2015.

The HI-STORM 100 dry storage system, US NRC Certificate of Compliance (CoC) 1014, has a life that is broken down into three classifications. The first classification, the license life of the system, is the amount of time that the system has been licensed by the NRC for use in dry storage. The second classification, a design life of 60 years is the length of time for which the storage system has been engineered to perform all of its design functions. The final classification is the minimum service life of 100 years, which is contingent upon at least two license renewals beyond the original license life.

Because the HI-STORM 100 dry storage system is nearing the end of its initial 20 year license life and the US NRC requires an aging management program be put in place in order to complete the license renewal for the next 40 year license life*, this chapter presents the Aging Management Review (AMR) for the HI-STORM 100 system. The purpose of the AMR is to assess the aging effects and mechanisms that could adversely affect the ability of the system, structures, or components (SSC), determined to be within the scope of the license renewal, to perform their intended functions during the period of extended storage.*

Casks and canisters need not be inspected for the first 20 years of storage. Periodic inspections begin after two decades.

Holtec International, "Certificate of Compliance Renewal Application for the HI-STORM 100 Dry Cask Storage System," April 23, 2021 (ML21113A203).

A visual inspection of the MPC surface shall be performed using a boroscope (or equivalent). The boroscope (or equivalent) inspection shall look at the accessible areas of the MPC surface, while the MPC remains in the overpack with the overpack lid installed.

The inspection shall be site-specific and performed on a minimum of one canister at each site that uses the HI-STORM 100 System. *Note that if a site has more than one type of canister (for example, MPC-68 and MPC-68Ms), the population should be treated as a whole.* ***The selection criteria for choosing the canisters to inspect and the determination of population size of canisters to inspect should consider the following:***

- *EPRI Susceptibility Criteria (Technical Report 3002005371)*
- *ASME Code Case N-860 Population Size Criteria*
- *Canister Age*
- *Canister with Lowest Heat Load*
- ***Canister with specific previously identified manufacturing deviation***

Holtec International, "Certificate of Compliance Renewal Application for the HI-STORM 100 Dry Cask Storage System," April 23, 2021 (ML21113A203).

The inspection shall be performed by a qualified individual on one canister at a site at a frequency of 5 years *(+/- 1.25 years). The first inspection shall occur prior to entering the period of extended operation or no later* [than] *365 days of the issuance of the renewed license, whichever is later.* ***It is recommended that the same canister be used for each inspection to allow for the best continued monitoring and trending.***

Canister inspections begin after 20 years and then every five years or so afterwards.

At least one canister gets inspected with a recommendation that it get inspected over and over and over again (not other canisters.)

So, how reliable is the selection of the canister to be inspected and inspected and the non-selection of the 100+ canisters not inspected?

Holtec International, "Certificate of Compliance Renewal Application for the HI-STORM 100 Dry Cask Storage System," April 23, 2021 (ML21113A203).

Can We Rely on Predictive Models to Tell Us When?

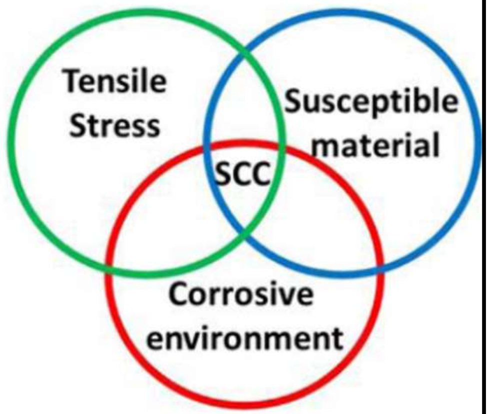
Primary parameters governing CISCC:

Somewhat known:

- Surface temperature;
- Cold work and surface condition (grinding, polishing, etc.)

Poorly known:

- Deposited chlorides on the canister surface (type and amount);
- Composition of other surface deposits (e.g., presence of free iron, dust, etc.);
- Presence of water leading to deliquescence of some of the deposited salts (surface humidity high enough to cause deliquescence);
- Residual or applied stress;
- Material condition (microstructure, sensitization, and fabrication defects);
- Presence of crevices



Chloride-induced stress corrosion cracking is not well understood and is therefore challenging to predict.

John Kessler, "Prioritizing Aging Management Activities for Dry Cask Storage," October 4, 2016.

Some dry cask storage component aging mechanisms are well-known and characterized by a great deal of information available from power plant experience (e.g., concrete and bolted connections exposed to the environment). ***These postulated aging mechanisms are well understood from a scientific standpoint. However, there is currently insufficient operating data to predict whether or not they might occur at Independent Spent Fuel Storage Installations (ISFSIs) or, if they do, to determine the timeframe during the period of extended operation (PEO) for such mechanisms to produce aging-related degradation.***

Furthermore, there may be some dry cask storage component aging mechanisms that are not yet known due to the relatively short time periods the storage systems have been in service (less than 30 years nationwide as of this writing). These factors make it difficult to perform, at the time of the renewal application submittal, Aging Management Reviews (AMRs) for all in-scope SSCs that address the maintenance of intended safety functions through the end of the PEO. *Two items of particular interest in this regard are High Burnup (HBU) fuel performance and stainless steel dry storage system (DSS) canister integrity,* ***especially with respect to potential Chloride-Induced Stress Corrosion Cracking (CISCC).***

Nuclear Energy Institute, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management," NEI 14-03 Rev. 2, December 2016 (ML16356A210)

Operating experience should be submitted in a timely manner to the ISFSI Aging Management INPO Database (ISFSI AMID) maintained by Certificate of Compliance (CoC) holders per NEI and INPO guidance. … *EPRI recommends that licensees should report the outcome of all inspections—both positive and negative. The availability of this information assists other licensees in assessing the relevance of that operating experience to their population of canisters.*

Does Holtec have access to the ISFSI Aging Management INPO Database?

If not, how will Holtec collect the operating experience needed to confirm the efficacy of its ISFSI aging management program or to make the adjustments necessary for effectiveness?

Electric Power Research Institute, "Aging Management Guidance to Address Potential Chloride-Induced Stress Corrosion Cracking of Welded Stainless Steel Canisters," March 2017.

ISFSI Inspection Program Enhancement Initiative Overview

Jeremy Tapp
Office of Nuclear Materials Safety and Safeguards
Division of Fuel Management
March 9, 2020

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

ISFSI Enhancement Scope

- Oversight of ISFSI operations:
  - Onsite component construction
  - Dry runs
  - Loading
  - Monitoring

- Not in scope of review:
  - Transportation
  - Vendor Inspections
  - Aging Management
  - Security

?

??? ISFSI aging mechanisms are poorly understood and modeled. So why did NRC exclude this area from an effort to enhance its ISFSI inspection program???

ML20066L232

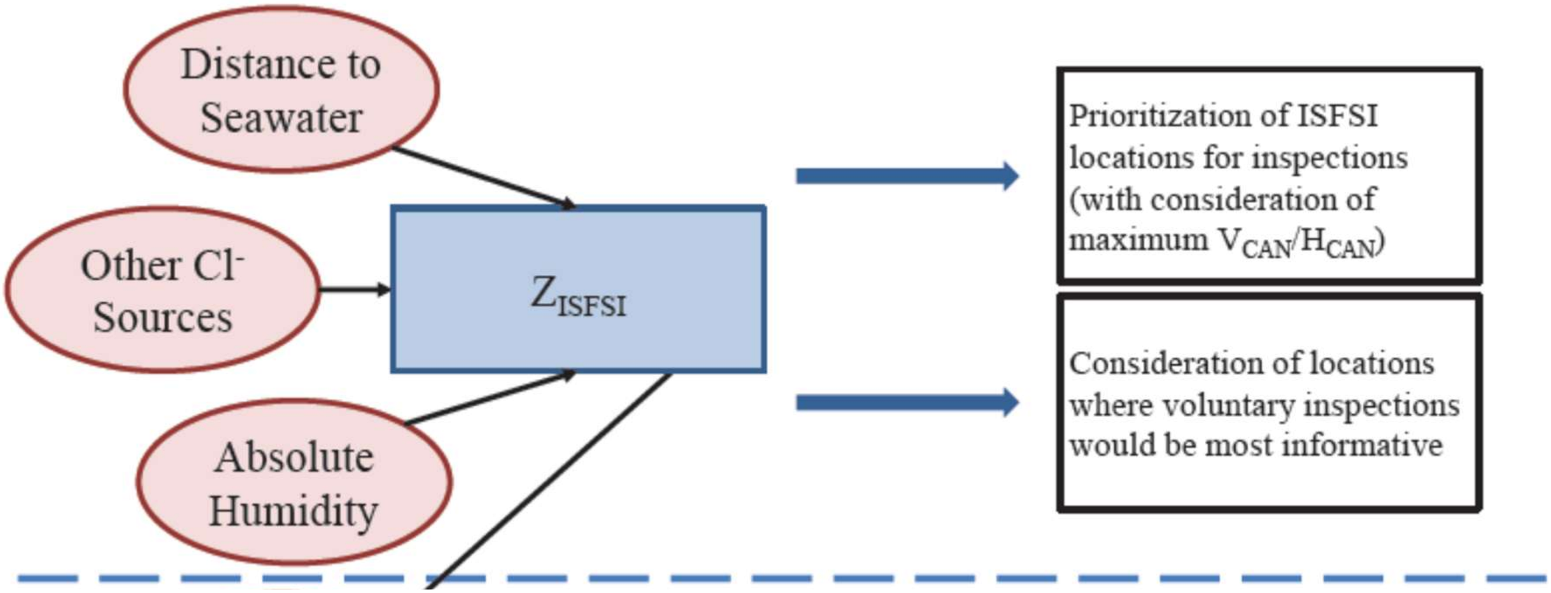
Examples of fabrication anomalies that would justify the prioritization of a canister include:

- *Poor surface condition*
  - ***Poor surface condition can be indicative of high surface cold work and surface flaws can act as microcrevices that can concentrate solutions***

What is the difference between a microcrevice and a scratch?

If as Holtec says, "*Surface scratches are commonplace and expected in MPCs*" and most if not all canisters have surface scratches, how is the single one to be inspected selected?

Electric Power Research Institute, "Aging Management Guidance to Address Potential Chloride-Induced Stress Corrosion Cracking of Welded Stainless Steel Canisters," March 2017.

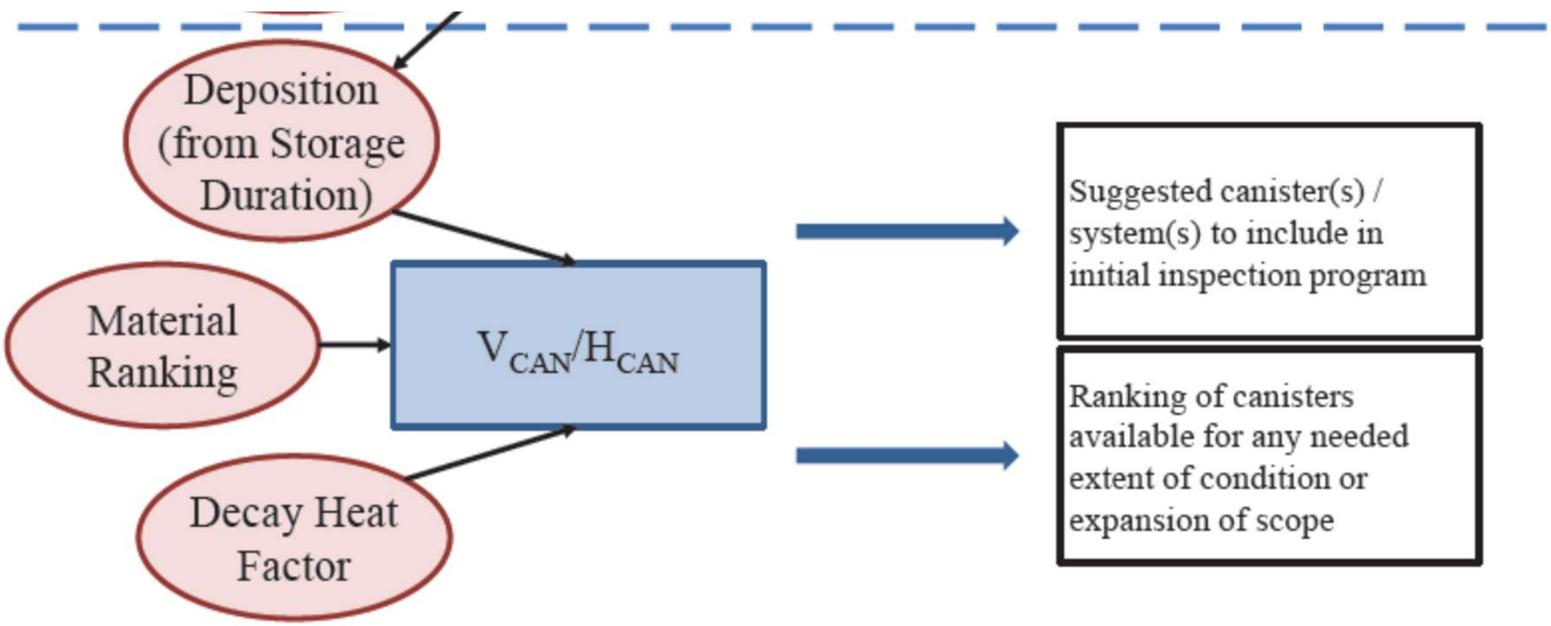


These factors are essentially identical for all casks and canisters at a single location like Indian Point. These factors vary site to site (i.e., the Pilgrim nuclear plant in Massachusetts is closer to seawater than the Indian Point nuclear plant in New York.

Figure 6-1
Summary of Susceptibility Assessment Criteria

Electric Power Research Institute, "Susceptibility Assessment Criteria for Chloride-Induced Stress Corrosion Cracking (CISCC) of Welded Stainless Steel Canisters for Dry Cask Storage Systems," 3002005371, September 2015.

These factors vary for each and every cask and canister at a single site like Indian Point.



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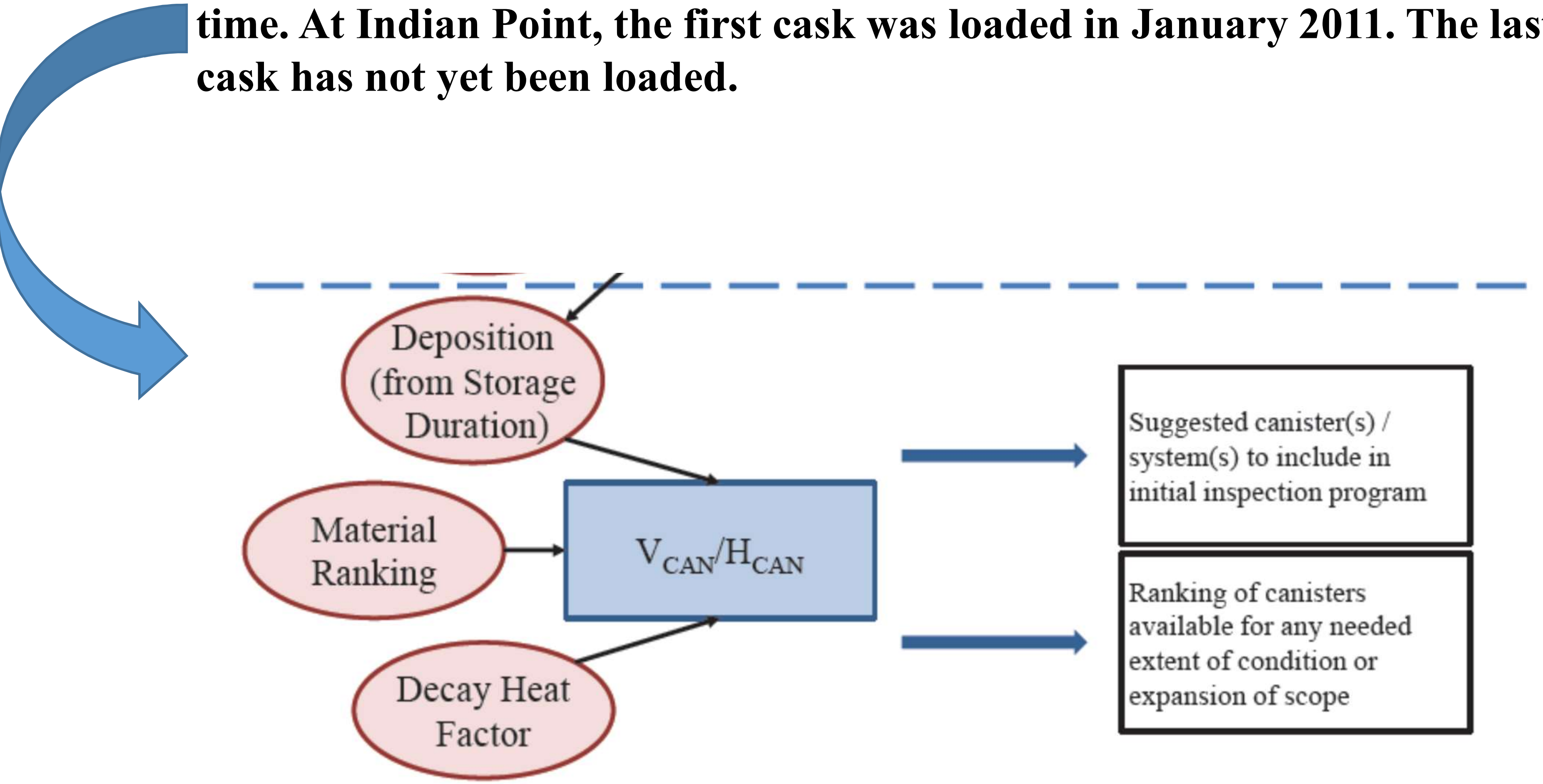
Electric Power Research Institute, "Susceptibility Assessment Criteria for Chloride-Induced Stress Corrosion Cracking (CISCC) of Welded Stainless Steel Canisters for Dry Cask Storage Systems," 3002005371, September 2015.

Storage duration is different for each cask since they are loaded one at a time. At Indian Point, the first cask was loaded in January 2011. The last cask has not yet been loaded.



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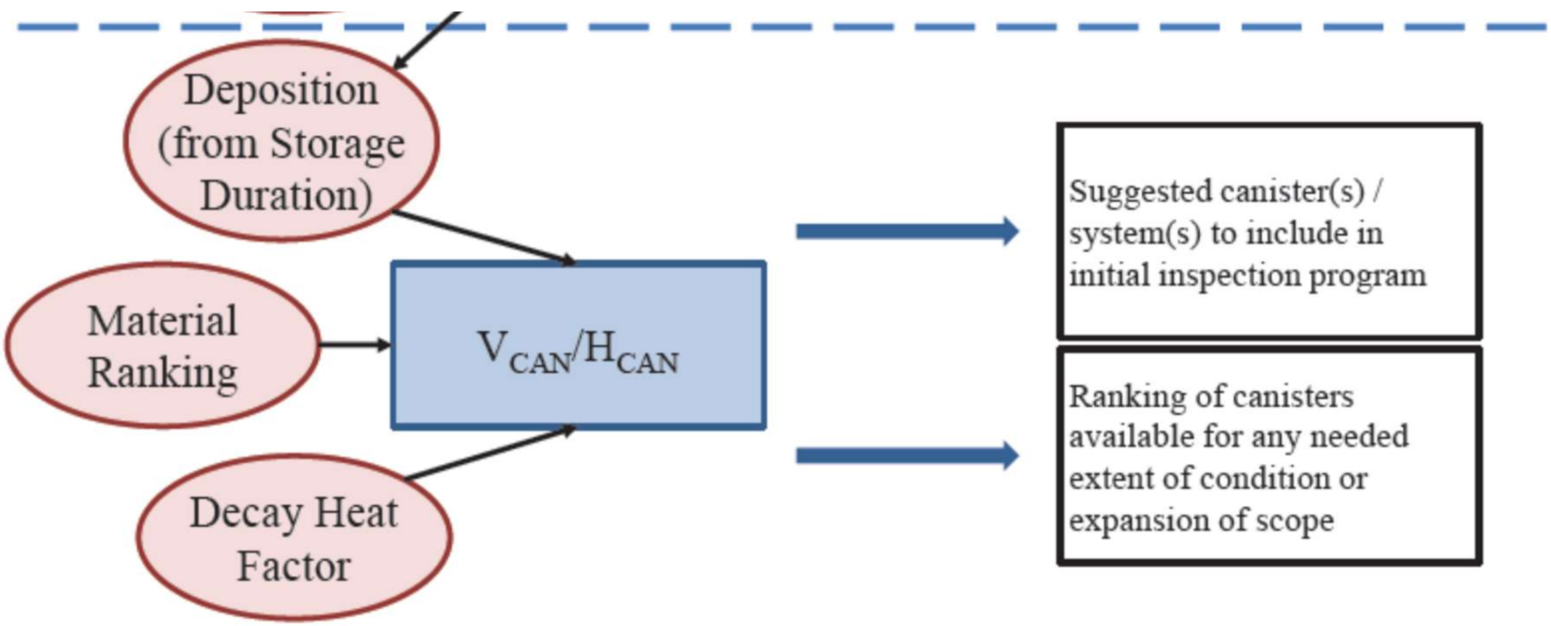
Electric Power Research Institute, "Susceptibility Assessment Criteria for Chloride-Induced Stress Corrosion Cracking (CISCC) of Welded Stainless Steel Canisters for Dry Cask Storage Systems," 3002005371, September 2015.

Decay heat levels are different for each canister although several canisters may have decay heat levels close to the maximum allowed by the certificate of compliance and associated Updated Final Safety Analysis Report.



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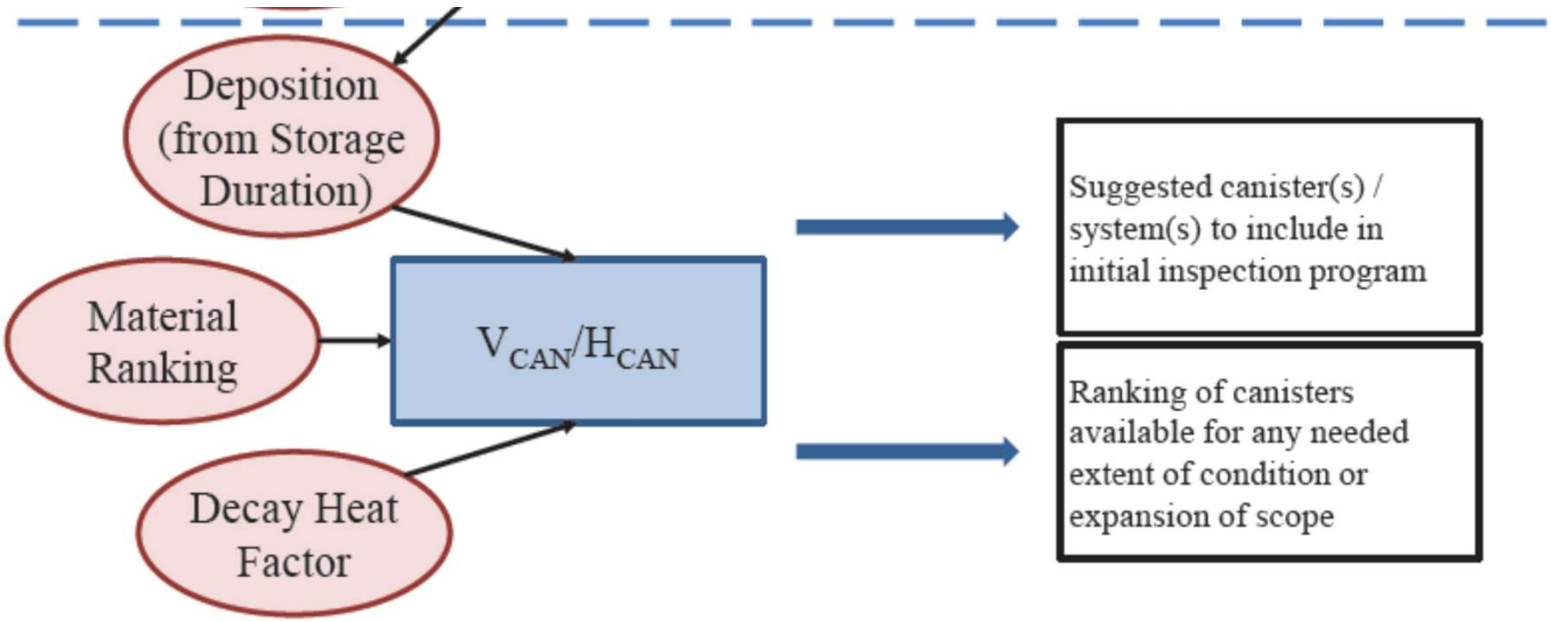
How are canisters ranked by material? If as Holtec says "*Surface scratches are commonplace and expected in MPCs*," are all canisters ranked equally or is there a scratchiness hierarchy?



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*The documented inspection results shall provide the ability to monitor and trend the appearance of the canister, **it is recommended that the inspection video/photos be retained for comparison in subsequent examinations.** Changes to the size and location of any areas of discoloration, localized corrosion, and/or stress corrosion cracking should be identified and documented for subsequent inspections.*

Holtec's aging management program recommends photographic records of canister inspections be maintained.

Are all canisters inspected after initial loading with photographic records retained for that follow-up inspection 240 months later?

If not, how can discoloration, etc. found then be compared to the as-loaded condition of the canister?

If not, how can selection of the most susceptible canister ever be verified?

Holtec International, "Certificate of Compliance Renewal Application for the HI-STORM 100 Dry Cask Storage System," April 23, 2021 (ML21113A203).

Inspection Results Requiring Additional Evaluation

Indications of interest *in locations on the MPC susceptible to SCC-which include areas adjacent to fabrication welds, closure welds, locations where temporary attachments may have been welded to and subsequently removed from the MPC, and the weld affected zones that are* ***subject to additional examination and disposition through the corrective action program include:***

- *Localized corrosion pits, stress corrosion cracking, and* ***etching****; deposits or corrosion products*
- *Discrete red-orange colored corrosion products especially those adjacent to fabrication welds, closure welds, locations where temporary attachments may have been welded to and subsequently removed from the MPC and the weld heat affected zones of these areas*
- *Linear appearance of any color of corrosion products of any size parallel to or traversing fabrication welds, closure welds, and the weld heat affected zones of these areas.*
- *Red-orange colored corrosion products greater than 1 mm in diameter combined with deposit accumulations in any location of the stainless steel canister*
- *Red-orange colored corrosion tubercles of any size.*

Holtec International, "Certificate of Compliance Renewal Application for the HI-STORM 100 Dry Cask Storage System," April 23, 2021 (ML21113A203).

What is the difference between an etching and a scratch?

If as Holtec says, "*Surface scratches are commonplace and expected in MPCs*" and most if not all canisters have surface scratches, would identification of a scratch-like etching or etching-like scratch require further evaluation?

If photographic records of as-loaded canister surface conditions are unavailable, how can one determine if an indication of an etching reflects an existing condition or an emerging condition?

Are the individuals conducting and evaluating the canister inspections tested for their ability distinguishing between microcrevices, etchings, and scratches? If so, is the minimum passing grade higher than 50%?

Failure Modes and Effects Analysis (FMEA)
Failure Modes

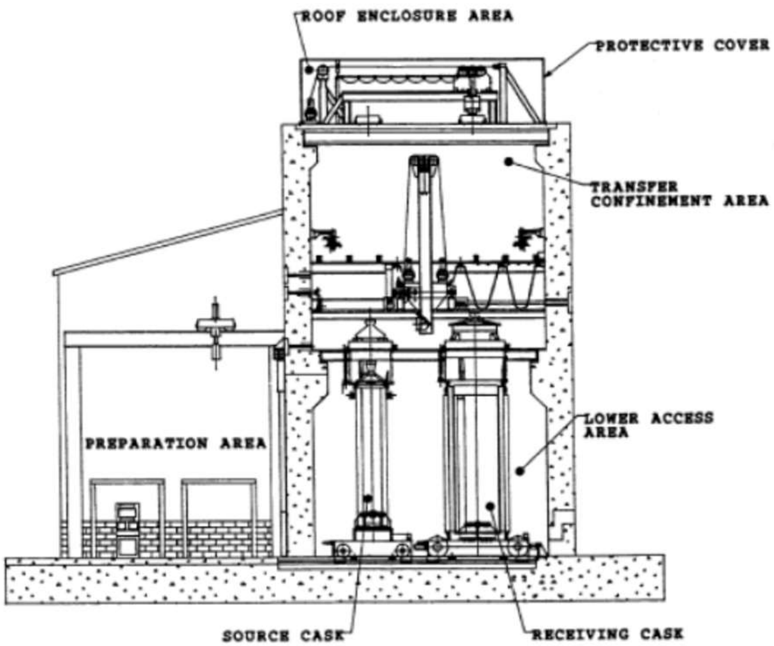
- Tight through-wall crack is most likely mode of canister penetration (CISCC/crevice)
  - Would release helium overpressure, then allow air ingress over time; likely to not release particulates
  - Reliable detection of degradation prior to release of helium backfill likely requires non-visual NDE
  - Time for growth of an initiated CISCC crack to TW depth is expected to take a number of years
- Growth of a flaw to critical flaw size would have higher consequences; this is very unlikely or not credible
  - Even under accident pressure and lifting loads, the critical flaw length is multiple feet long

Potential silver lining – while cracking is the most like mode for loss of canister integrity, it may take a very large crack to cause harm. But this answer was provided without any of the work being shown.

Electric Power Research Institute, "EPRI Literature Review and Failure Modes and Effects Analysis (FMEA) for Welded Stainless Steel Canisters in Dry Cask Storage Systems," January 24, 2013 (ML14052A422).

Mitigation: Use of a Cask-to-Cask Transfer Facility

- Missing technology: cask-to-cask transfer facility
- Uses:
  - Repackage at sites without a pool
  - Inspection of full-scale experimental casks ("Demo")



If canister inspections identify a need to unload a canister, there's no current means of doing so.

It may be possible to refurbish or repair a degraded canister before unloading becomes necessary (if the right canister gets inspected.)

John Kessler, "Prioritizing Aging Management Activities for Dry Cask Storage," October 4, 2016.

Answer 2: Canister Scratching

Scratching cannot be prevented. Holtec conceded that "*Surface scratches are commonplace and expected in MPCs.*"

Scratches, whether from fabrication or loading, can contribute to through-wall cracking.

Cask and canister aging mechanisms are not well understood and are poorly modeled.

Loaded canisters need not be inspected during the first 20 years. Thereafter, at least one canister from among the 126 to be loaded must be inspected about every 60 months. If the most vulnerable canister happens to be selected or a canister at another site fails, problems at Indian Point may be averted.