HOLTEC INTERNATIONAL

HI-STORM UMAX Canister Storage System
Docket # 72-1040

Incidence and Consequences of Surface Scratches on the MPC Shell

a generation ahead by design

A Public Presentation to the NRC

By: Charles Bullard & Dr. Stefan Anton

Holtec International (*Holtecinternational.com*)

April 10, 2019, White Flint, MD

Presentation Agenda

HOLTEC INTERNATIONAL

a generation ahead by design

Areas of presentation:

- Consideration of Scratches in the ASME Code, regulatory and licensing space
- Information in the UMAX FSAR related to MPC scratches and the basis for change

Principal Meeting Objective

HOLTEC INTERNATIONAL

a generation ahead by design

- To present Holtec's regulation-informed and ASME Code-based position on MPC surface scratches for NRC's consideration.
- To provide a definitive case why the statement in the Operations chapter (Section 9.5) of the "UMAX" FSAR on the plausible absence of scratches during Canister loading is **NOT** safety-significant information and does **NOT** affect functional performance under the Certificate-of-Compliance granted by the NRC.

Origin and Prevalence of Scratches

HOLTEC INTERNATIONAL

a generation ahead by design

- 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.

The Many Incarnations of Scratches

HOLTEC INTERNATIONAL

a generation ahead by design

- 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.

Minimizing the Extent of Scratching

HOLTEC INTERNATIONAL

a generation ahead by design

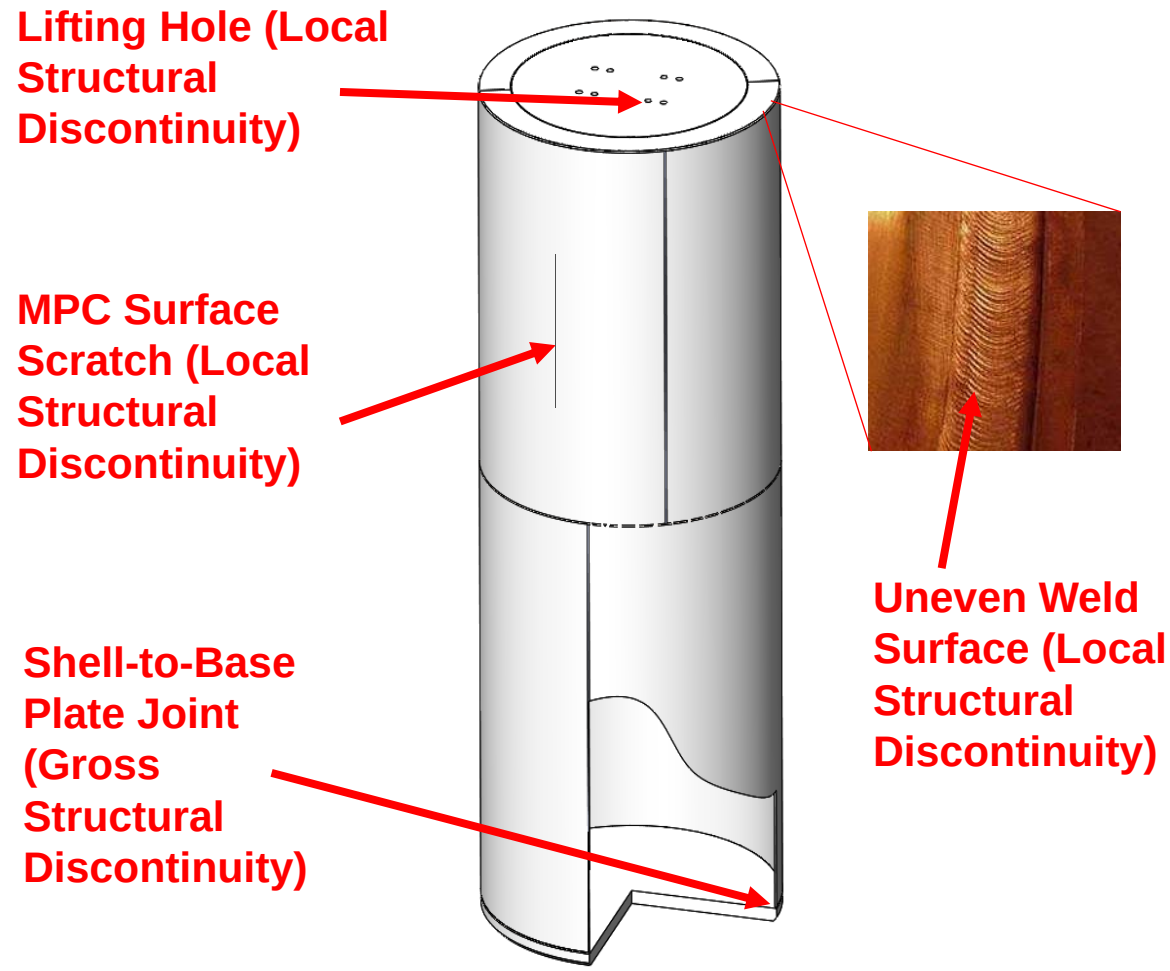
- Minimizing the extent of scratching on the Canister's surface must occur in conjunction with other considerations.
- For example, the ID of the Shield Ring opening in "UMAX" is 1/2 inch larger than the Canister OD to minimize the crew dose; the MPC Seismic Restraints are likewise closely positioned.
- The result: UMAX has a very high seismic tolerance capability, and the dose sustained by the crew is negligible.
- Scratches, which are purely cosmetic, are tolerated for the sake of the far more important benefits mentioned above.

The MPC is replete with local discontinuities such as scratches

HOLTEC INTERNATIONAL

a generation ahead by design

- As the figure shows, the Local Discontinuities are everywhere in a manufactured MPC.
- Every ridge and valley in an as-welded seam is a Local Discontinuity.



Vertical Canister Insertion in "UMAX" minimizes scratches and their severity

HOLTEC INTERNATIONAL

a generation ahead by design

- Compared to horizontal insertion, where scratching occurs by the full weight of the Canister, the maximum contact load in UMAX, under the most limiting condition tolerance stack up, is merely ~ 2500 lbs. (2.5% of the Canister's weight).
- As a result, the scratches, if any, are inevitably shallow.
- Numerical analyses by Holtec showed the maximum depth of the scratch, due to abrasive wear, to be roughly 1.2 mils (0.0012") per 1000 lbs. of force.
- Tests in the shop to simulate the MPC shell contact showed a deeper scratch (but still quite shallow) because the scratching was accompanied by adhesive wear (i.e., galling of the plate surface).

Existing surface scratches do not impact the safety and functionality of the MPC.

Quantifying the Maximum Scratch Depth

HOLTEC INTERNATIONAL

a generation ahead by design

- Shop tests and finite element analyses showed that the maximum average scratch depth (due to abrasive wear) is bounded by 2.4 mils (0.0024”).
- Minimum wall thickness required to meet the design internal pressure for the Canister is only 0.216” (per NB-3324 of the ASME Code); leaving a substantial thickness reserve (> 0.25”) for imperfections such as scratches.
- Extensive examination of the loaded Canisters has showed most loading related scratches to be invisibly small; the average depth across the width the scratch mark was near zero, and the deepest valley at any measured scratch location was 26 mils (0.026”) deep.

The scratches introduced during insertion remain a fraction of the required limit in the ASME Code.

How does the ASME Code classify surface scratches in an MPC?

HOLTEC INTERNATIONAL

a generation ahead by design

- The MPCs are designed to meet the highest pedigree of the ASME Code, Section III Subsection NB, to the maximum extent practicable. The MPCs are manufactured to the same rigorous requirements as the Reactor Vessel and the Pressurizer in nuclear reactors.
- Several types of stresses are produced in a pressure vessel; they are classified by their degree of significance to the equipment's safety:
  - Primary Stress (NB-3213.8): Controlling, it is most significant to equipment's safe operation.
  - Secondary Stress (NB-3213.9): Somewhat significant, produced at locations of ***gross structural discontinuity.***
  - Peak Stress (NB-3213.11): Non-significant in quiescent equipment such as an MPC; develops at locations of ***local structural discontinuity***.

Import of Local Discontinuities in a Canister

HOLTEC INTERNATIONAL

a generation ahead by design

- Examples of local discontinuities are: unevenness in the welded mass, scratches on the surface, vent and drain port holes, non-linear component of thru-thickness stress distribution from pressure & other loadings.
- Every MPC has local discontinuities whether there are scratches or no scratches.
- Because the local discontinuities produce only peak stresses which are inconsequential to safety, they are not considered in the FSARs.
  - Table 3.1.10 of the HI-STORM UMAX FSAR describes Peak Stress (F) as follows:

    "Increment added to primary or secondary stress by a concentration (notch), or, certain thermal stresses that may cause fatigue but not distortion. Because fatigue is not a credible source of failure in a passive system with gradual temperature changes, the cumulative damage factor from fatigue is not computed for HI-STORM UMAX components."

Local Discontinuity produces peak stress which is immaterial to the safety margin in an MPC

Code places no limit on peak stresses

HOLTEC INTERNATIONAL

a generation ahead by design

- Local discontinuities and hence peak stresses are ubiquitous in every MPC. The Code places no limit on their number or size because they are irrelevant to the vessel's safe operation.
- That is why Chapter 2- Principal Design Criteria in the UMAX FSAR has no limits on peak stresses.
- That is why the NRC's Safety Evaluation Report (SER) makes no mention of the Commission having considered the peak stresses.
- That is why the Certificate-of-Compliance makes no mention of any type of local discontinuity (such as scratch) or peak stresses in the MPCs.

Classifying Contents of a FSAR

HOLTEC INTERNATIONAL

a generation ahead by design

> The FSAR's content can be divided in three categories:

1. Safety critical: This material is placed and locked down in the CoC. It can only be altered by a License amendment.

2. Safety significant (SS): Not locked down in the CoC but subject to a highly controlled change process under 10CFR72.48.

3. Non-safety significant (NSS): Supplemental information that is not relied on to fulfill a safety function and is not included in the NRC SER.

Regulatory Perspective on Scratches on Canisters

HOLTEC INTERNATIONAL

a generation ahead by design

- The scratches are not mentioned or relied on in the NRC's SER for "UMAX".
- Indeed, our research shows, scratches have never been considered a safety issue in any SER written by the NRC for any Holtec storage system.
- The NRC treated scratches in Canisters as non-germane to safety going back to the 1980s.

Regulatory and Licensing Perspectives

HOLTEC INTERNATIONAL

a generation ahead by design

- From a regulatory perspective, the presence of surface scratches on the MPC are not relevant to the safety determination.
- Any discussion of scratches in the FSAR represents non-safety significant information, along with numerous other non-safety items in the MPC.
- Given that information in the FSAR on surface scratches is non-safety significant, clarifying the associated FSAR discussion cannot, by definition, imply a change of any safety consequence.
- The statement in the FSAR regarding no risk of scratching during insertion can be deleted or amended without affecting the safety analyses and conclusions in the FSAR.

Licensing Perspectives

HOLTEC INTERNATIONAL

a generation ahead by design

> Filing a License Amendment Request (LAR) that does not pertain to a safety consideration would be a *non sequitur*.

> We have accordingly changed the following statement in Section 9.5:

"Because the MPC insertion (and withdrawal) occurs in the vertical configuration with ample lateral clearances, there is no risk of scratching or gouging of the MPC's external surface (Confinement Boundary). Thus the ASME Section III Class 1 prohibition against damage to the pressure retaining boundary is maintained."

to (through the 72.48 process):

"MPC insertion and withdrawal occurs in a tightly controlled vertical configuration with minimal lateral clearances. The MPC may come in contact with the shield ring and upper and lower seismic restraints (when present). The confined vertical configuration during MPC insertion limits the lateral loads placed on the MPC and precludes significant wear or scratches on the MPC's external surface (Confinement Boundary). Because scratches produce only localized stress raisers known as "peak stresses" in Section III of the ASME Code which (as noted in Table 3.1.10 of this FSAR) are germane only to cyclic fatigue considerations, the applicable stress intensity limits of ASME Section III Class 1 (primary and secondary) for the pressure retaining boundary will remain unaffected by the presence of scratches."

Licensing Perspectives (cont.)

HOLTEC INTERNATIONAL

a generation ahead by design

- FSAR Section 9.5 was only meant to summarize (using several high level narrative examples) why Safety and ALARA is achieved through the operational steps outlined in Sections 9.1 - 9.4, as well as through the HI-STORM UMAX design itself.
- Thus, Section 9.5 simply makes a conclusion based on the preceding sections. It does not, nor was it intended to, articulate new or additional safety or operational requirements. This fact is supported by the omission of Section 9.5 from all other Holtec ISFSI FSARs.

Licensing Perspectives (cont.)

HOLTEC INTERNATIONAL

a generation ahead by design

- The CoC/TS references the FSAR in various locations, for example in Table 3-1 with respect to ASME Code.
- When statements in the FSAR are incorporated into the CoC/TS in the sense that they become a legal part of it, they are identified clearly to avoid any misunderstanding. Examples can be found in the HI-STORM 100 FSAR, Section 9.1.5.3, and HI-STAR 180 SAR, Section 1.2.2.1, UMAX CoC Appendix B, Section 5.3.9. A general reference to the FSAR in the CoC is therefore not considered an inclusion by reference. Hence independent of the discussion about the relevance of Section 9.5 above, the statement about “no risk of scratching” can not be considered as being included by reference in the CoC.

Closing Remarks

HOLTEC INTERNATIONAL

a generation ahead by design

- 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.

End of Presentation