INTRODUCTION

San Onofre Nuclear Generating Station (SONGS) performed a visual assessment of three multi-purpose canisters (MPCs) from March 21 - 23, 2019. This report includes the following:

- Scope of visual assessments
- Visual assessment techniques utilized
- Visual assessment results
- Conclusion

SONGS QA program requirements were applied to visual assessment activities, see Appendix C.

VISUAL ASSESSMENT SCOPE

The scope of the visual assessment is the accessible surfaces of the MPC shell and baseplate. The three MPCs included in the visual assessment were selected for the following reasons: 1) MPC serial number (S/N) 067 which was involved in the August 3, 2018 event where it was suspended by the divider shell shield ring, 2) MPC S/N 064 which was documented as having made contact with the divider shell on July 22, 2018 during downloading operations, and 3) MPC S/N 072, an MPC loaded at an earlier portion of the fuel transfer campaign, is on a different row than the previous two MPCs. A different row was selected to account for the minimal drainage slope on the HOLTEC ISFSI pad and its potential effect on MPC vertical alignment during downloading operations.

VISUAL ASSESSMENT TECHNIQUES

A robotic crawler with cameras and a borescope with interchangeable tips (general area tip and measurement tip) were deployed in two stages to perform the visual assessment. During the first stage, the robotic crawler and borescope with the general area tip was used to provide general locations of surface irregularities. These surface irregularities were compared to post-fabrication photos and areas of interest were selected for characterization in the second stage. During the second stage, the robotic crawler and borescope with the measurement tip was used to characterize the surface irregularities (width and depth measurements as applicable).

The software used in conjunction with the borescope with measurement tip is able to detect a minimum width and depth of 0.001 inches (1 mil). See Appendix C for details regarding use of the borescopes and software.

Note: This is NOT a formal "inspection" or an activity qualified to ASME Sections III, V, XI or otherwise.

VISUAL ASSESSMENT RESULTS

The information below summarizes the results of the visual assessment.

The following surface irregularities were not found:

- Cracking
- Pitting

The following surface irregularities were found:

- Wear marks
- Water staining
- Carbon steel contamination – exhibited by iron oxide staining
- Fabrication artifacts

All surface irregularities were compared to post-fabrication photos taken at Holtec Manufacturing Division prior to being shipped to SONGS. This comparison was used to assist in determining whether the surface irregularity was a result of downloading operations.

Surface irregularities that were not consistent with post-fabrication photos were documented in completed visual assessment procedures (Ref. 1-3). Of those surface irregularities, areas of interest were identified to undergo characterization (width and depth measurements as applicable). Some identified areas of interest reside within the weld and heat affected zones (HAZs) of the circumferential weld and HAZ. Table 1 below provides characterization measurements for areas of interest associated with downloading operations.

The majority of wear marks identified are correlated with contact with the divider shell shield ring. The first MPC (S/N 064) had no areas of interest with a measurable depth (< 0.001 inches). A small number of the wear marks related to contact with the divider shell shield ring, in the other two MPCs, had measured depths ranging from 0.003 to 0.012 inches as noted in Table 1 below. Additional wear marks identified were correlated with contact with the MPC inner seismic restraints (SR), also referred to as upper seismic restraints. See Appendix A for figures of the cavity enclosure container and divider shell layout.

Wear profiles for divider shell shield ring and MPC inner seismic restraints are different. The divider shell shield ring wear marks are shallower in comparison. The maximum depth of a MPC inner seismic restraint is a localized narrow depth and does not apply over the entire width of the wear mark. See Appendix B for characterization images.

TABLE 1 – DOWNLOADING OPERATIONS AREA OF INTEREST CHARACTERIZATION

MPC S/N	Description	Circumferential Location[3]	Length[1] (inches)	Width[2] (inches)	Depth[2] (inches)
067	No areas of interest from downloading operations provided a measurable depth (< 0.001 inches)				
064	Carbon Steel Contamination	Between SR5 – SR6	30	2	0.012
064	Wear Mark	Between SR5 – SR6	6	1	0.009
064	Wear Mark	Between SR5 – SR6	6	1	0.009
064	Wear Mark	Between SR5 – SR6	8	1	0.009
064	Wear Mark[4]	Between SR5 – SR6	1	4	0.009
064	Wear Mark	Between SR6 – SR7	15	5	0.011
064	Wear Mark	Between SR7 – SR8	30	2	0.003
072	Carbon Steel Contamination[4]	Between SR1 – SR2	4	8	< 0.001
072	Wear Mark	Between SR1 – SR2	0.002 square inches[6]		0.007
072	Wear Mark[4]	Below SR1	> 120	~ SR4 wear mark	~ SR4 wear mark
072	Wear Mark[4]	Below SR4	> 120	0.107 to 0.192	0.016[5]
072	Wear Mark	Below SR4	12-24	< 0.192	0.026
072	Wear Mark	Below SR5	24-36	~ SR4 wear mark	~ SR4 wear mark

Notes: 1) Length measurements are approximate values based on the general area visual assessment.
2) Width and depth measurements characterized during the area of interest visual assessment.
3) See Appendix A for cavity enclosure container and divider shell reference information.
4) Area of interest resides within the weld and/or HAZ.
5) Maximum recorded depth of ten measurements taken over the total length.
6) A direct surface area measurement was recorded.

The results of the visual assessment have been entered in the corrective action program and will be considered in the aging management program.

CONCLUSION

Three MPCs underwent visual assessments where various types of surface irregularities were identified. The deepest surface irregularity identified as a result of downloading operations was a wear mark due to contact with an MPC inner seismic restraint and had a maximum depth of up to 0.026 inches. Holtec Report HI-2188437 (Ref. 7) describes that the SONGS HI-STORM MPC has 0.175 inches of available margin for localized losses of shell thickness to remain in compliance with all applicable ASME Boiler & Pressure Vessel Code requirements. Based on the available margin, there is still 0.149 inches available for the worst-case observed surface irregularity. Additionally, with worst-case wear mark having a margin of almost 7 times compared to the allowable limit, the scope of the visual assessment is considered adequate. Therefore, even with incidental contact during downloading operations, the SONGS HI-STORM MPCs remain in compliance with all applicable ASME Boiler & Pressure Vessel Code requirements.

REFERENCES

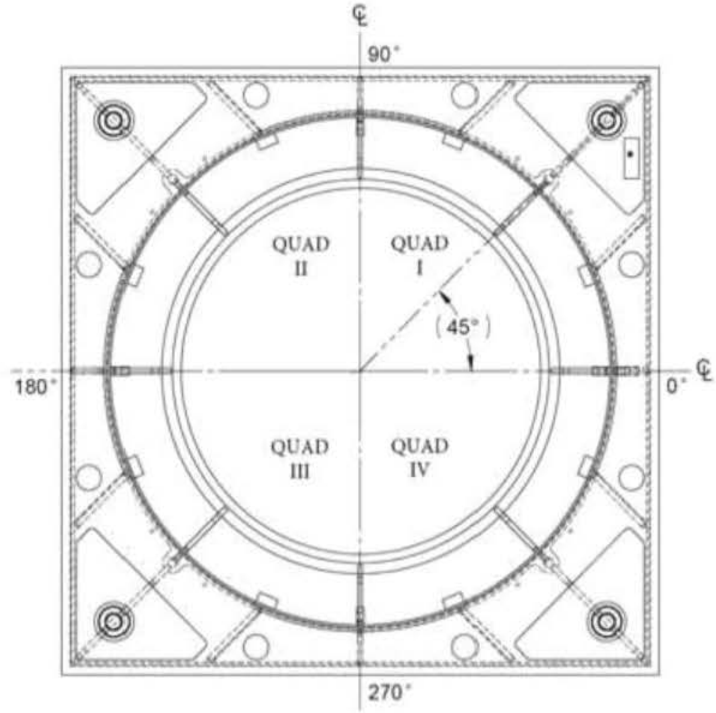
1) SO23-X-9.1, *Robotic Inspection of Multi-Purpose Canisters,* completed 3/21/2019 (MPC S/N 067)
2) SO23-X-9.1, *Robotic Inspection of Multi-Purpose Canisters,* completed 3/22/2019 (MPC S/N 064)
3) SO23-X-9.1, *Robotic Inspection of Multi-Purpose Canisters,* completed 3/23/2019 (MPC S/N 072)
4) *GE Inspection Technologies Remote Visual Inspection San Onofre Nuclear Generating Station Inspection Report, Inspection: MPC 1593-9986100-67*
5) *GE Inspection Technologies Remote Visual Inspection San Onofre Nuclear Generating Station Inspection Report, Inspection: MPC 1593-9986100-64*
6) *GE Inspection Technologies Remote Visual Inspection San Onofre Nuclear Generating Station Inspection Report, Inspection: MPC 1593-9986100-72*
7) Holtec Report HI-2188437, *Incidence and Consequence of Canister Shell Wear Scars from Misaligned Insertion of a Loaded MPC at SONGS*

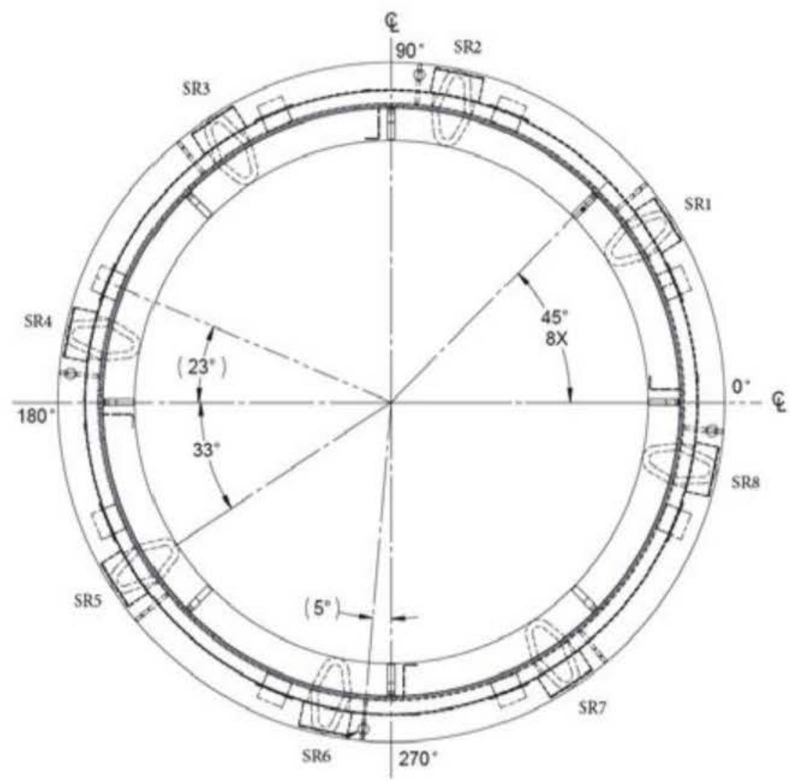
LIST OF APPENDICES

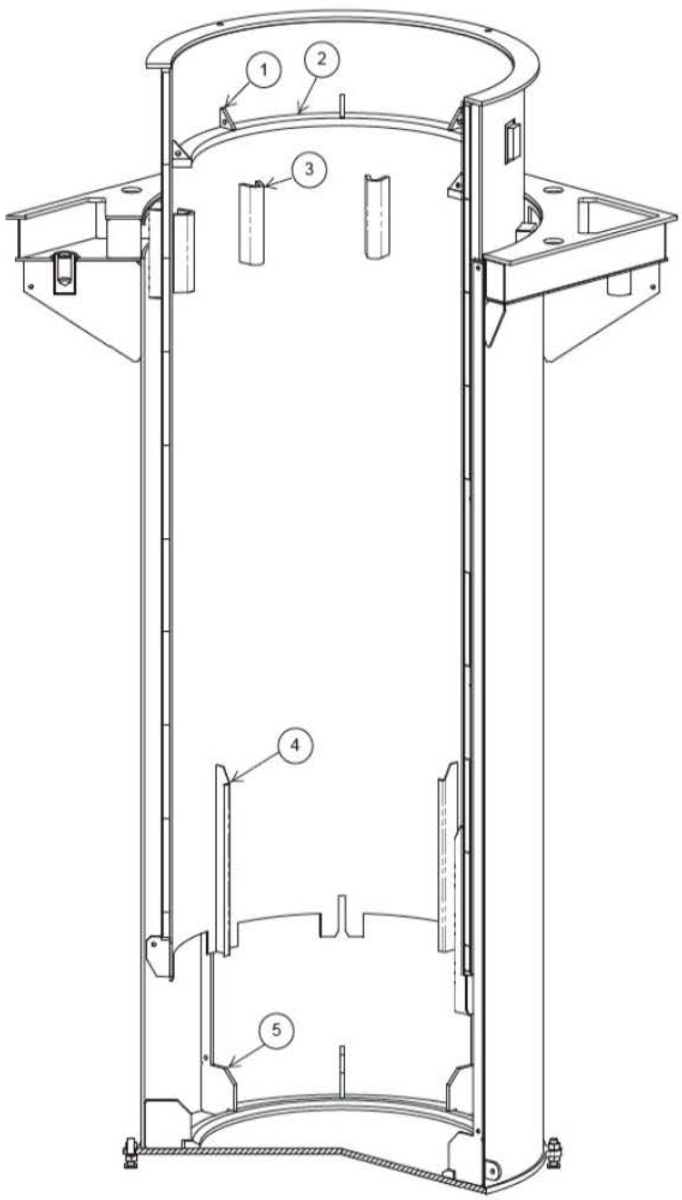
A. Cavity Enclosure Container and Divider Shell Reference Information
B. GE Inspection Technologies General Location Photographs and Characterization
C. Description of GE Inspection Technologies Utilized

Appendix A

Cavity Enclosure Container and Divider Shell Reference Information


℄
90°
QUAD II
QUAD I
45°
180°
0°
℄
QUAD III
QUAD IV
270°


℄
90°
SR2
SR3
SR1
SR4
45°
8X
23°
0°
℄
180°
33°
SR8
SR5
5°
SR7
SR6
270°



List of Potential Contact Points

1 Divider Shell Shield Ring Guide
2 Divider Shell Shield Ring
3 MPC Inner Seismic Restraint (also referred to as upper seismic restraint)
4 Divider Shell MPC Guide Cover
5 Lower MPC Guide / CEC Baffle (also referred to as lower seismic restraint)

Appendix B

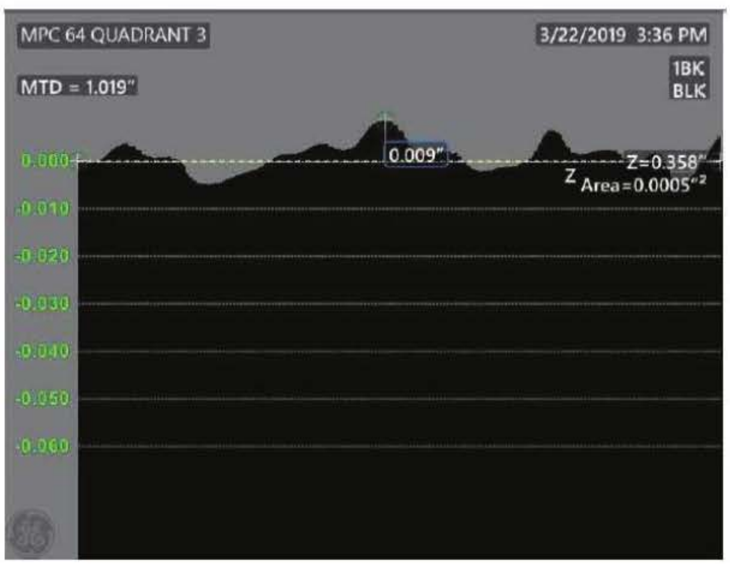
GE Inspection Technologies General Location Photographs and Characterization

MPC S/N 064

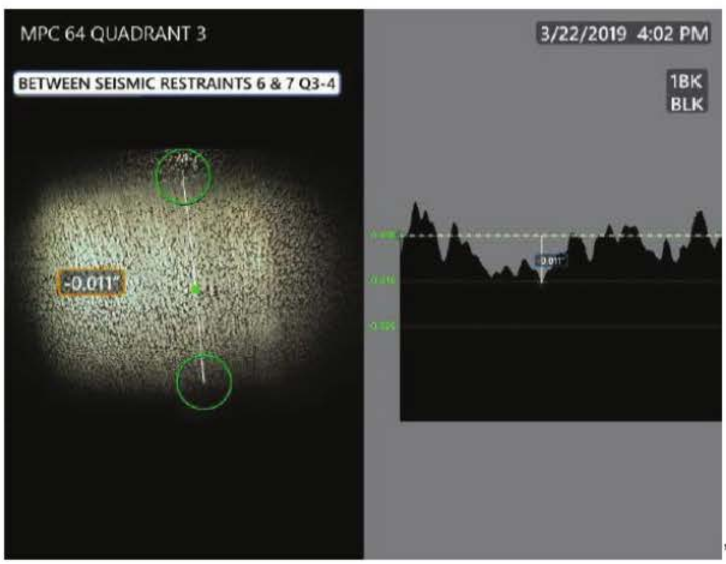
The figures above correspond to the carbon steel conamination in the shield ring induced wear mark between MPC Inner Seismic Restraints 5 and 6 as documented in Table 1 in the body of the report.

The figures above correspond to the shield ring induced wear marks identified between MPC Inner Seismic Restraints 5 and 6 as documented in Table 1 in the body of the report.

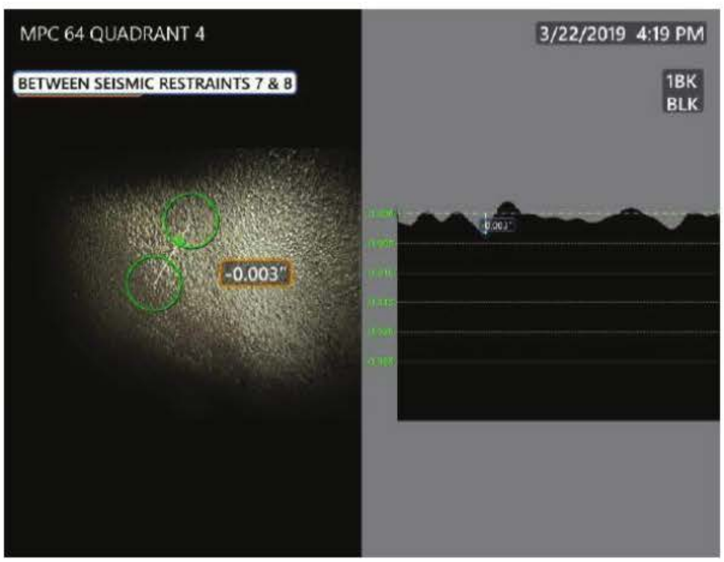
Wear mark is located within the MPC circumferential weld.



The figures above correspond to the shield ring induced wear marks identified between MPC Inner Seismic Restraints 5 and 6 as documented in Table 1 in the body of the report.



The figures above correspond to the shield ring induced wear marks identified between MPC Inner Seismic Restraints 6 and 7 as documented in Table 1 in the body of the report.

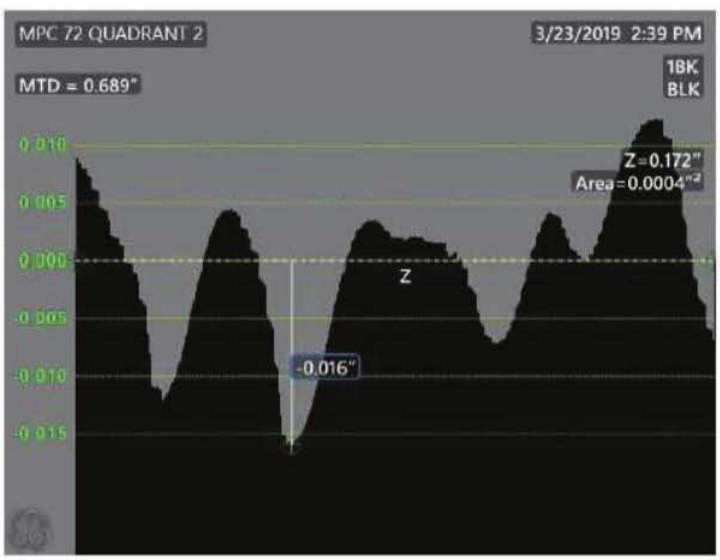


The figures above correspond to the shield ring induced wear marks identified between MPC Inner Seismic Restraints 7 and 8 as documented in Table 1 in the body of the report.

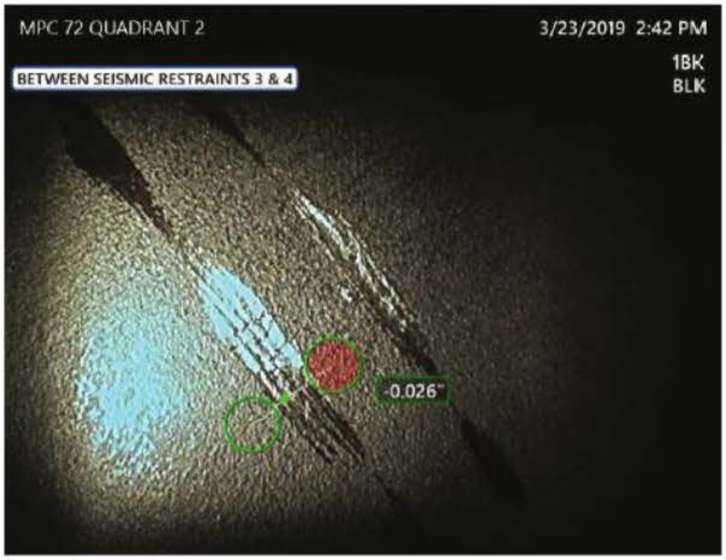
MPC S/N 072

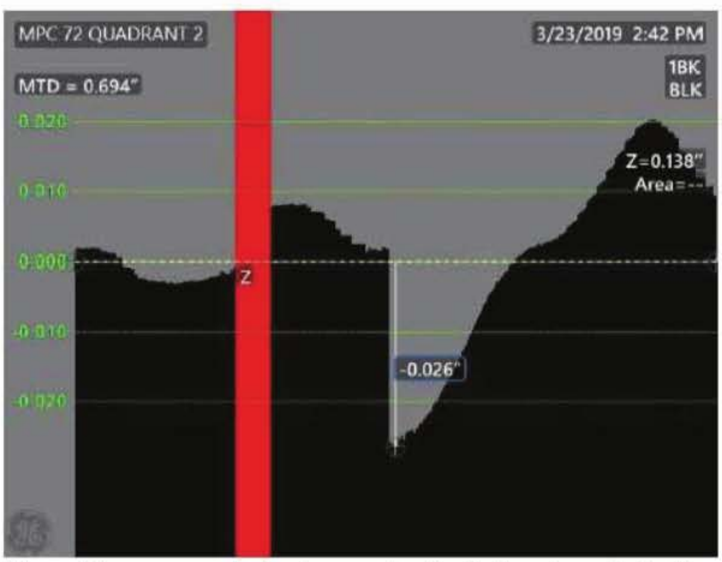
Carbon Steel Contamination within the HAZ of the MPC circumferential weld

The figure above corresponds to the shield ring induced carbon steel contamination identified between MPC Inner Seismic Restraints 1 and 2 as documented in Table 1 in the body of the report. There was no measurable depth for this location.



The figures above correspond to the greather than 120 inch long SR induced wear mark identified below MPC Inner Seismic Restraint 4 as documented in Table 1 in the body of the report.





The red bar represents background noise in the characterization

The figures above correspond to the 12 to 24 inch long SR induced wear mark identified below MPC Inner Seismic Restraint 4 as documented in Table 1 in the body of the report.

Appendix C

Description of GE Inspection Technologies Utilized

The GE borescope (i.e., VideoProbe™), along with the RTT robot, were adopted by EPRI's Extended Storage Collaboration Program (ESCP) NDE subcommittee, which was tasked with developing technology to support inspecting dry storage canisters. The robot and borescope have been deployed at multiple U.S. sites, most recently at Vermont Yankee and Maine Yankee. The NRC has been present during many of these inspections. The Maine Yankee inspection was performed to support renewal of NAC CoCs 72-1015 (NAC-UMS) and 72-1025 (NAC-MPC).

GE Inspection Technologies' VideoProbe, with Real3D™ point cloud surface scanning and analysis, is used widely for aviation, military, and oil & gas applications. On a daily basis, there are hundreds of technicians globally using the technology to ensure airplanes are safe to fly, and turbines are safe to operate.

GE Inspection Technologies' VideoProbe manufacturing facility is in Skaneateles, NY; this is an ISO 9001:2015 certified facility. All calibrations for all measurement-capable VideoProbes, and the related measurement accessories, are calibrated to NIST-traceable standards under GE's ISO 9001:2015 procedures.

SCE confirmed the GE inspectors' Level II visual inspection certification, and that their certification was current. A corresponding "encode" was created in SONGS training program, which was used to confirm the GE inspectors were qualified to perform the borescope inspections (procedure requirement).

SONGS QA program requirements were applied to inspection activities, including developing and issuing the inspection procedure, calibration verification, and documentation of results.

To verify a VideoProbe is in calibration for all measurement types, an NIST-traceable Verification Block ships with all measurement probes and the tips calibrated to that probe:

- A Certificate of Calibration is created for each probe(s) and the tip(s) calibrated to a given probe, as well as for all Verification Blocks.
- The Verification Block is an NIST-traceable standard with precise targets.
- The A target has two (2) distance targets with a separation of 0.1000 in. +/- .0002 in.
- The B target has a distance separation of 1.000mm +/- .005mm.
- The standard's characteristics were optimized for length measurements (x, y), and is not intended to be used as a depth (z) standard.
- With Real3D, it is the plurality of the x, y, z data that is used to generate a point cloud of data on which measurements are made.
- Thus, the Verification Blocks' targets also verify a system is in calibration for use in measuring Depths, Lengths, and Areas.

To provide additional assurance of depth measurement capabilities, SCE procured NIST-traceable gauge blocks. Two gauge blocks were placed parallel to each other, upon a NIST-traceable flat surface plate, with a small gap between the two blocks. The VideoProbe correctly measured the height of the gauge blocks (space between the two blocks).

As documented in SCE procedure SO23-X-9.1, *Robotic Inspection of Multi-Purpose Canisters,* the depth measurement function was verified prior to use on the first canister, using the GE-supplied targets and SCE-supplied gauge blocks. This verification was performed again after completing inspection of the final canister.