# IP-2 Steam Generator Lower Assembly Packaging, Transport and Disposal - 16510

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## ABSTRACT
WMG, Inc. led a team of industry experts in the first of its kind packaging, transportation and disposal of four (4) Steam Generator Lower Assemblies (SGLAs). The project had a number of significant challenges including qualifying the SGLAs as IP-2 packages, implementing roadway improvements and orchestrating the use of three different modes of transportation. In the end, these SGLAs would be the first large components disposed at the WCS Disposal facility in Andrews Texas.

The client was repurposing the SGLA storage mausoleum for 'Fukushima equipment' preparedness so it became necessary to dispose of the assemblies.

The WMG team needed to:

- Dismantle the mausoleum to allow removal of the SGLAs,
- Design, fabricate, deliver and install IP-2 SGLA packaging, and
- Transport the packaged SGLAs from the client to the WCS facility for disposal.

After qualifying the packaging as IP-2 containers, the SGLAs were loaded onto special equipment for over-the-road transport to the harbor in Kewaunee, WI. Following transload, the SGLAs were barged down Lake Michigan through the Mississippi River to the Port of Houston for another transload. The SGLAs arrived by rail at WCS' Andrews TX facility. Each transport segment required coordination for transport clearances, proper marking, labeling and placarding for that particular mode of transport as well as coordination with the team involved in moving the large packages from one conveyance to another.

The project was completed with zero safety issues, significantly below dose goals, ahead of schedule, and within budget.

## INTRODUCTION
Frequently, Steam Generators are classified as SCO-II material with more than an A2 quantity of radioactive material. The proper packaging for such a quantity of SCO-II material is an IP-2 package in accordance with 49CFR173.427(b)(1) Reference [1]. However, IP-2, Type A and Type B packages of sufficient capacity for a 200 tonne SGLA nearly 2.4 meters (14 ft) in diameter and 12.2 meters (40 ft). long do not exist. Accordingly SGLAs have been shipped as their own packaging after demonstrating equivalent safety by the US DOT via the 49CFR107 special permit process. WMG began preparing a special permit application for the SGLAs but learned that the review and approval schedule could be extended well beyond that necessary to satisfy the customer.

## CONSTRAINTS

All radioactive material shipments necessarily begin with characterization. As an industry leader, having previously performed the characterization of the steam generators that became the basis for NRC Generic Letter 96-07 '*Interim Guidance on Transportation of Steam Generators*, Reference [2] WMG's experienced engineers commenced characterization and classification of the steam generators to determine the total quantity of radioactive material contained in the individual SGLAs as well as the extent of heterogeneous contamination deposition in the different SGLA regions. As is frequently the case, two of the four SGLAs represented more than an A2 quantity of SCO-II material. In order to meet the schedule, WMG would need to design, fabricate and install unprecedented IP-2 packaging for two of the SGLAs.

The two decade old closure plates were installed with the nothing more than a seal weld (Figure 1).

Figure 1 – SGLA Welds

Finite Element Analysis (FEA) of the SGLA in the as-stored configuration during the free drop test [49CFR173.465(c)] indicated the weld would fail (Figure 3). Even though the closure plate is on the steam/secondary side of the SGLA, WMG deemed weld failure unacceptable, reasoning it could result in loss or dispersal of radioactive contents [49CFR173.411(b)(2)(i)] that may be present on the secondary side due to tube failure and limited primary to secondary side leakage. As can be inferred from Figure 2, the initial impact is not necessarily limiting. In the case of large components, the secondary slap following rotation to horizontal is frequently most limiting and is commonly granted regulatory relief during the special permit process via rigging and transport plan constraints that provide an equivalent level of safety.

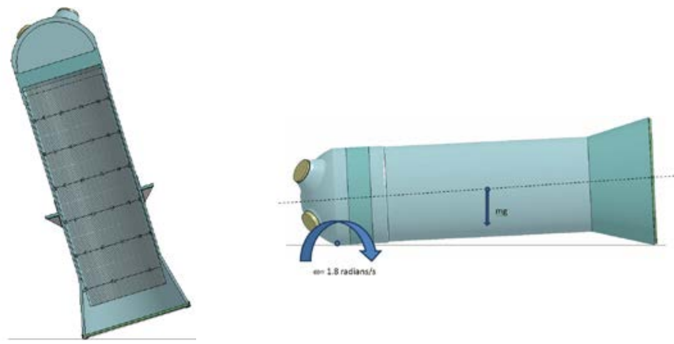

Figure 2 A/B – Free Drop

Figure 3 – Unprotected SGLA Closure Plate Weld Failure

A common method to protect radioactive material packages is the use of sacrificial impact limiters that surround the areas of interest (Figure 4). However, rail clearance would only permit an additional 2.5 centimeters (1 in) radially for the impact limiter. As with the protection of all transportation containers, it is preferable to avoid additional volume and weight to minimize transport costs.


Figure 4 – RH-72B Cask and Impact Limiters

Packaging work around the SGLAs would need to be performed in a radiation area. Furthermore, the efficient storage facility dimensions were such that packaging work would need to be performed in very close proximity to the large radioactive source(s).

## ALTERNATIVES

One possible alternative was to increase the size of the closure plate welds. This alternative was not attractive for reasons principally associated with dose. The adjacent weld surfaces in the as-stored configuration would need to be dressed to facilitate additional welding, and would require time and tooling. The closure plates were of such size that the as-built seam would require gouging, dressing and welding to increase the weld from the AISC minimum. Remotely operated and semi-automated grinding and welding tools could be used to reduce, but not avoid, additional dose to the workers, but such tooling would be expensive and would require additional unforeseen schedule time.

WMG also investigated filling and sealing the secondary side of the SGLA but determined that the filler could not be reliably place in an ALARA efficient

Large sacrificial impact limiters would not be acceptable due to rail clearances that were only 2.5 centimeters (1 in) radially larger than the SGLA. In fact, direct rail transport from the client to WCS was even more dimensionally constrained, hence WMG's selection of a barge route.

Extended over-the-road transport was also dismissed as a viable alternative due to the long distances between the storage facility and the disposal site and the consequential pricing risk to move low-hanging utility lines and the slow pace of transport by a highly specialized transporter.

## IP-2 DESIGN

Thorough FEA modeling and innovative approaches to the problem yielded a design that provided IP-2 protection and could be prefabricated and installed with minimum dose. Prefabricated collars were engineered to interface with the SGLA while accommodating the rail clearance restrictions. The bolt on configurations reduced dose during installation and facilitated standard dimension truck transport from the fabricator to the storage location. The team persevered through more than twenty iterations of collar shapes, locations Figure 5 A/B/C, and sizes before arriving at an optimal design Figure 6. Protection of the inlet and outlet nozzle cover plate welds is even more important than the closure plate weld because of direct access to the more contaminated channel head surfaces. Failure of the manway seals would also be unacceptable. A cylindrical ring and strategically placed blocks around the SGLA shell were used to protect vulnerable portions of the channel head. In addition to keeping the client well-informed of the design status and schedule, WMG provided concept and status reports to the USDOT for this unprecedented package design. Periodic discussions with the regulator avoided schedule delays associated with formal questions and responses.

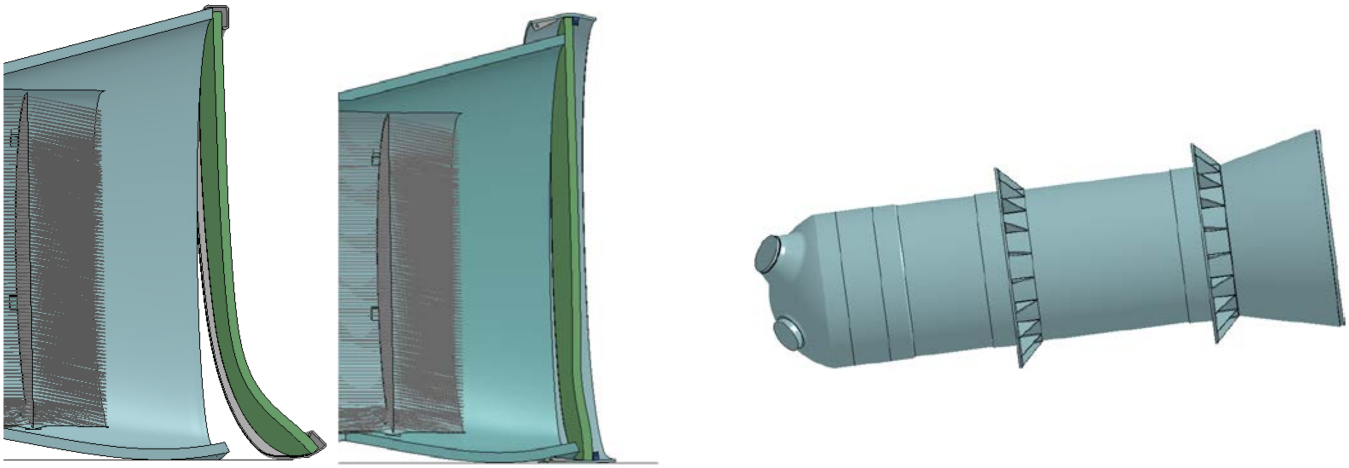

Figure 5 A/B/C – Design Iteration Examples

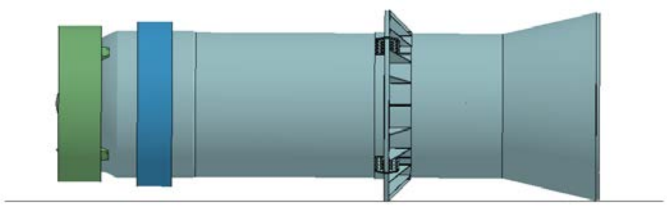

Figure 6 – Final Design Configuration

## IP-2 FABRICATION AND INSTALLATION

As is frequently the case, as-built drawings of components replaced decades ago may not be available, however important design decisions are based on available drawings. In this case it was important to verify drawing dimensions because of the necessarily tight fit up and the impossibility of field changes to thick, welded steel configurations. “Old-school” measurement techniques using simple twine wrapped around the steam generator shell within the radiation area to precision laser measurement of bolt holes from outside the radiation are were performed to ensure proper fit-up of the prefabricated collars.

Figure 7 A/B – Impact Limiter Rigging

Installation of the collars also required innovative rigging techniques that precisely aligned portions of the collars with the bolt locations. As can be seen in Figure 8 clearances were tight. In one case the outer corner of a nozzle cover plate required about a half inch chamfer over a 45 degree arc to facilitate ring installation.


Figure 8 – Tight Fit Up

## TRANSPORTATION

As mentioned previously WMG's IP-2 package design was constrained by schedule, dose and transportation clearance factors. Transport of these SGLA included three different modes which is rather unusual for projects involving domestic disposal.

Transport timing was also important. Frost depth and thaw was a factor for road transport. Barge transport needed to occur after Lake Michigan was free of ice, and after the spring surge on the Mississippi river but before the summer river lows.

### Over the Road Transport

Seventeen miles of transport over public roads was necessary between the client's site and the port for barge embarkation. The client worked closely with local utilities to ensure low-hanging lines would remain clear of the SGLAs over the transport route. Even though a portion of the route had been used a few years previously for a different large component transport evolution, roadway improvements were deemed necessary by the state DOT. WMG's innovative teammates developed a method where the ramps necessary for barge loading were repurposed to span a culvert in disrepair (Figure 9). The ramps were positioned over the culvert only during periods of SGLA transport and were removed from the roadway during all other times to avoid a deleterious effect on local traffic. The SGLAs loaded on a Self-Propelled Modular Transporter (SPMT) moved at the rate of one per day.


Figure 9 – Culvert Span

**Barge Transport**

The SGLAs were temporarily staged at the port of Kewaunee while the barge was prepared. Local law enforcement provided round-the-clock security of the SGLAs, while work continued to be performed under the client's radiation protection and monitoring program. Barge loading was also accomplished using the SPMT, load ramps, specially designed blocking and bracing and ballasting equipment. Following loading, the barge departed for Chicago on Lake Michigan bound for the Mississippi river via the Illinois river. Barge departure did no mark the end of the team's efforts at Kewaunee, as we paid particular attention to staging area restoration for a local festival, only days away.

Figure 10 – Barge Loadout

**Rail Transport**

Barge progress along the Mississippi was quicker than expected, and the team mobilized to Houston, TX prior to Independence day. Transload of the SGLAs from the barge to waiting railcars was accomplished by waterborne crane (Figure 11) after a survey confirmed no loss of contamination control. Barge blocking and bracing and the barge itself were surveyed and released. Despite a myriad of potential placement variations during the transload, the SGLAs were precisely placed on the railcars to meet the clearance requirements as verified by on-site railroad representatives. Following welding of blocking and bracing the railcars were received at WCS within a week (Figure 12).

Figure 11 – Barge-Rail Transload


Figure 12 – Receipt at WCS

## CONCLUSION

Full IP-2 packaging safety was achieved for the SGLAs using WMG's precedent setting design. The project was completed with zero safety issues, significantly below dose goals, ahead of schedule, and within budget. WMG's commitment to Safety, ALARA and Schedule is identified in the Project Scorecard below:

| | |
|---|---|
| **SAFETY** | |
| First Aids | None |
| OSHA Reportables | None |
| OSHA Recordables | None |
| **ALARA** | |
| Goal | 65 mSv |
| Revised | 28 mSv |
| Actual | 19 mSv |
| **SCHEDULE** | |
| Original Completion | 8/13/14 |
| Actual Completion | 7/26/14 |

## REFERENCES


1. 49CFR173 Subpart I Class 7 (Radioactive Materials), USDOT, Washington DC, 12/1/2014
2. Generic Letter 96-07 “Interim Guidance on Transportation of Steam Generators” USNRC, Washington, DC, 12/5/1996


## ACKNOWLEDGEMENTS

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