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Safe and Secure Transport of Subcritical Experiment Assemblies

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ABSTRACT

In support of the National Nuclear Security Administration's (NNSA) Stockpile Stewardship Program (SSP), the Los Alamos National Laboratory has developed, manufactured, and transported a series of Subcritical Experiment (SCE) assemblies for stockpile reliability assessments. The latest SCE, named POLLUX, was successfully tested at the underground U1a complex located on the Nevada National Security Site (NNSS) in late 2012. The SCE examines the behavior of plutonium as it is shocked by forces produced by high explosives. The scientific data and technical information produced from the execution of the experiment will be used to support the safety and effectiveness of the nuclear weapons stockpile. POLLUX was the 27th SCE to date. In addition to high-powered x-ray radiographs from a device called Cygnus, data was also acquired from a new diagnostic technology developed called the Multiplexed Photonic Doppler Velocimeter.

The PATRM paper will discuss the unclassified aspect of the SCE, the intricate transportation fixture, and the various analyses supporting the transportation certification and approval. The transport fixture utilized a complex metal structure for supporting and maintaining the SCE's high fidelity tolerances and positional relationships. The design of the transportation fixture was challenging as the fixture was required to sufficiently support the SCE components, but also be flexible enough to preclude damage such as crushing, bending, or breakage. In addition, the SCE contained diagnostic components which were isolated to preclude damage to the SCE or the diagnostic component themselves. Various other elements of the fixture included inert gas compartments, leakage test connections, and shock mitigation devices.

A full scale model of the SCE, fixture, and transport package was fabricated and assembled for testing certain aspects of the expected transport environment. The most significant concern of the transportation environment was vibration and shock during the loading/unloading cycle and during over-

the-road transport. The design of the shock mitigation and clamping interface is very unique and could be applied to other contents where similar care is required.

INTRODUCTION

The SCE is a subscale test of a nuclear weapon's plutonium core called a "pit". The pit initiates the weapon's nuclear chain reaction when imploded into a supercritical mass. The SCE, being a subscale version, does not contain a mass of plutonium necessary to achieve supercritical mass, hence the term "subcritical". The experiment allows the design physicists and engineers to examine the pit's implosion mechanics when explosively compressed. The results are paramount to ensure the reliability of the nation's nuclear deterrent.

The focus of this paper is the fixturing and packaging of the SCE to ensure the safe and secure transport from the Los Alamos National Laboratory to the Nevada National Security Site. The SCE was transported in a packaging (transport container) named the DDP-2. The DPP-2 package is used to transport government-owned special nuclear materials and components in highly modified secure tractor-trailers operated by the NNSA Office of Secure Transportation.

DPP-2 with SCE

Note: For purposes of this paper, the pit and diagnostic assembly's configuration has been purposely altered to allow for discussion is an unclassified manner.

Figure 1 illustrates the Containment Vessel (CV) of the DPP-2 packaging with the SCE configured for transport. The transparent CV body provides an overall view of the intricate transport fixture supporting the SCE which is depicted as the "red cylindrical object".

The transport fixture performs many functions that are vital to the safe and secure transport of the SCE. The transport fixture is primarily designed to protect the SCE from normal conditions of transport (NCT). However, because the SCE is shipped within a NNSA certified Type B packaging (DPP-2), both NCT and hypothetical accident conditions (HAC) were addressed prior to regulatory approval. For purposes of this paper, the discussion will focus only on the NCT.

A primary concern for the SCE is the over-the-road shock and vibration encountered during the transport. Although the transport trailers have excellent suspensions, and the technicians are extremely careful during loading/unloading operations, the SCE fixture must provide mitigation when the DPP-2 encounters extended shock or vibration during transport. As an example, the SCE fixture incorporates eight wire rope vibration isolators between the lower base plate and the upper support plate also shown in Figure 1. The location and quantity of the isolators were determined by subjecting a prototype fixture with a mock SCE to shock and vibration profile measured for the SGT tractor/trailer.

Once the SCE fixture was properly isolated from the transport environment, the next challenge was to affix a support structure too firmly, but gently, hold the SCE in its proper position. To accommodate this challenge, a flexure spring and elastomeric cushion were incorporated into two vertical support assemblies, referred to as "ear muffs" as shown in Figure 2 and Figure 3. The ear muffs incorporate a unique spring assembly which provided a controlled clamping force on the SCE component while still providing a means to flex as needed. To further protect the SCE, an elastomeric cushion was incorporated to provide a protection interface with the SCE by preventing metal-to-metal contact.

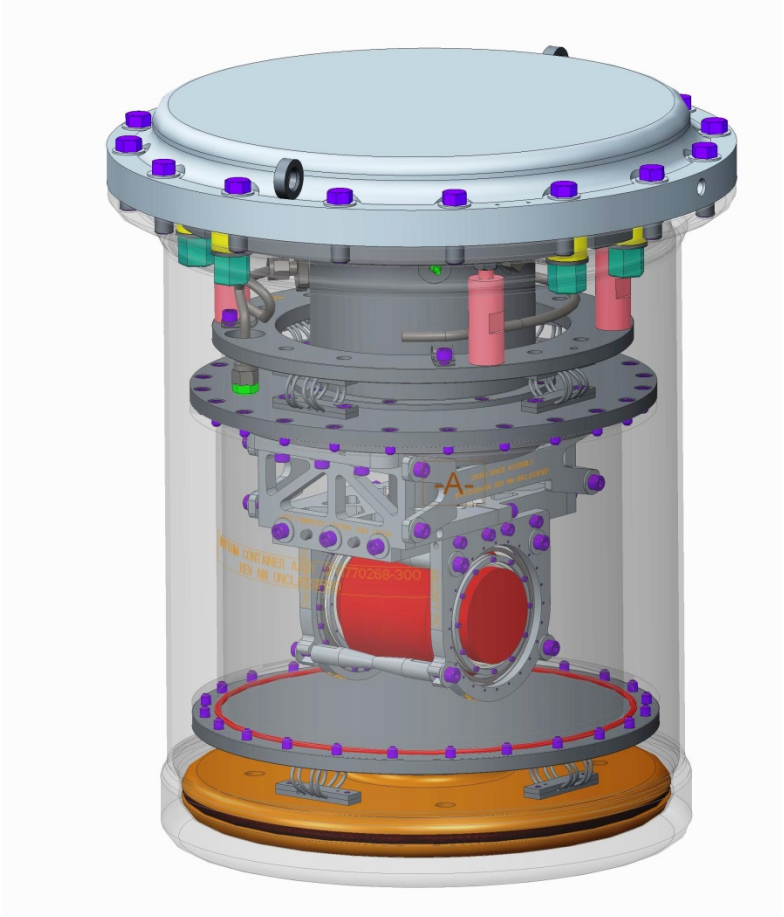

Figure 1

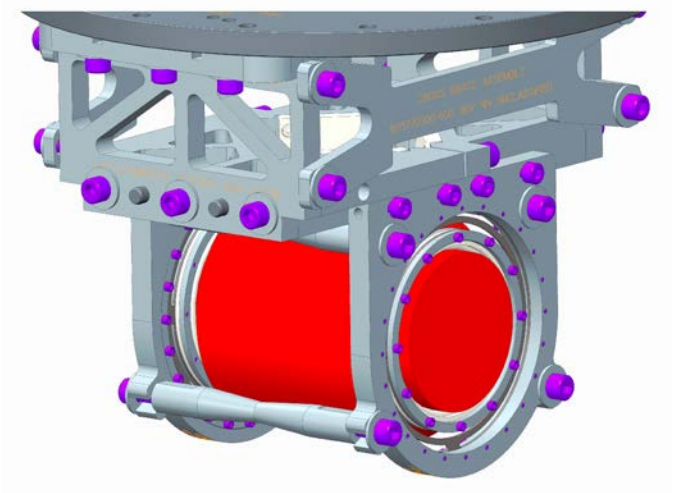

Figure 2

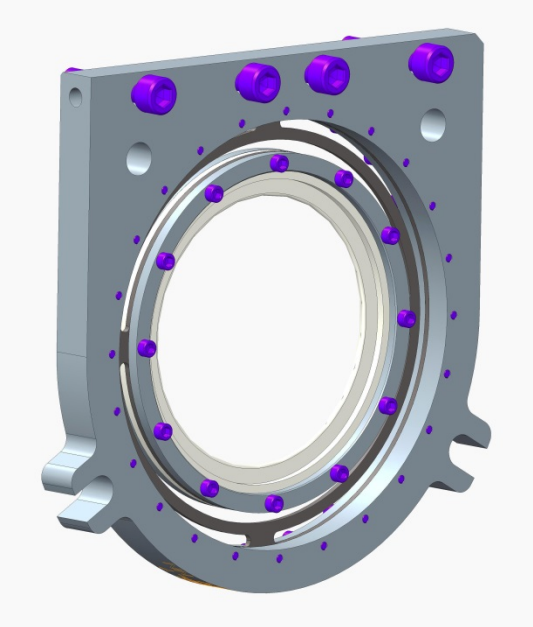

Figure 3

To protect the fixtured SCE from contamination and surface degradation, a sealed convenience canister was incorporated to provide a vacuum tight atmosphere where an inert gas could be maintained during transport. The convenience can assembly is shown in Figure 4. Once sealed, a valve port was used to evacuate the cavity and subsequently backfilled with either nitrogen or argon.

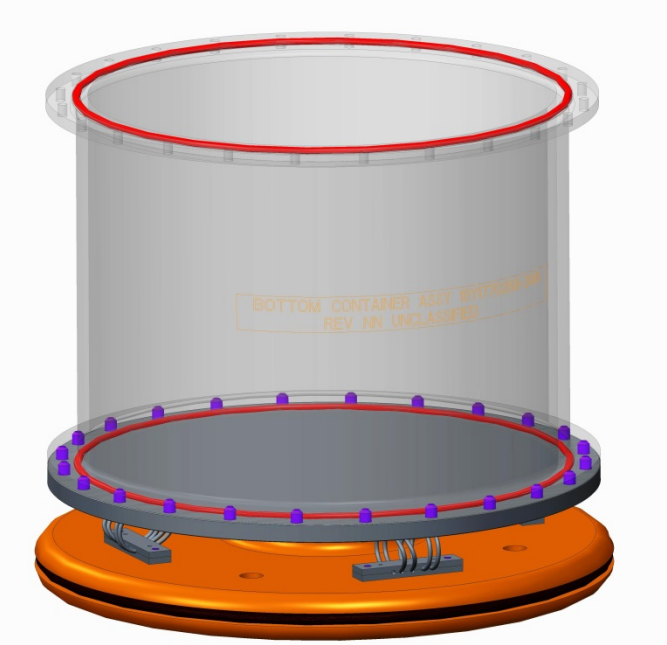

Figure 4

Finally, the diagnostic devices installed in the SCE during final assembly required the fiber optic cable assembly to be isolated and secured for transport. An isolation assembly was implemented to secure the cable assembly as shown in Figure 5. The challenge was to provide a method where pressure and leak tightness could be measured prior to disassembly. Typical through-the-wall penetration components were incorporated which provided connectivity to external test equipment.

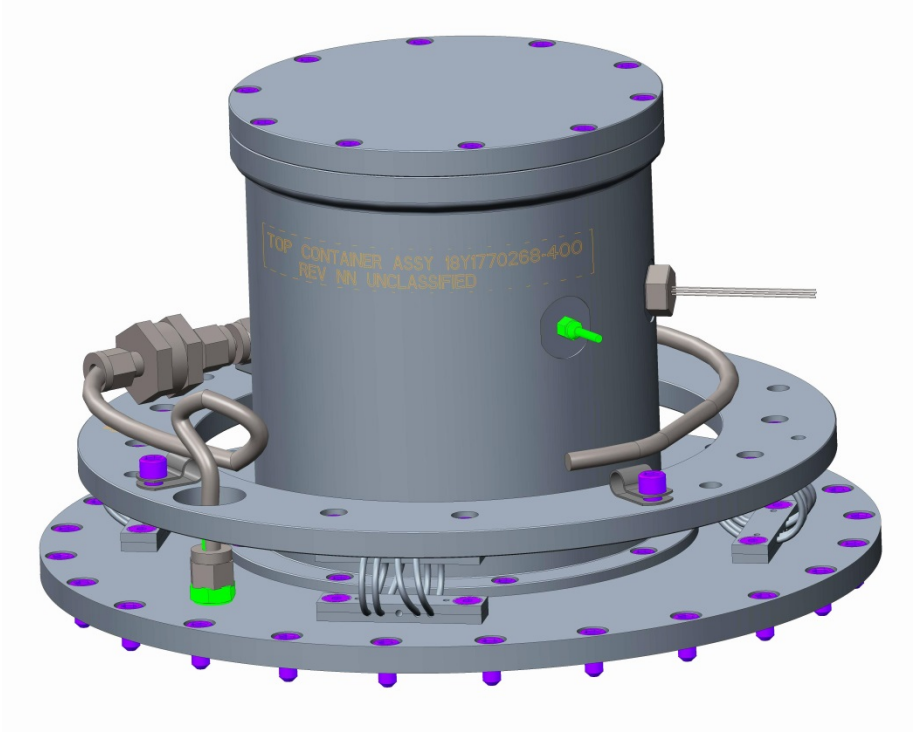

Figure 5

CONCLUSIONS

Subcritical Experiment Assemblies require extraordinary measures to ensure the safe and secure transport to the test facility. Transport packagings and fixtures must be designed to protect the SCE from transport insults while maintaining the SCE's high fidelity in terms of form, fit, and function. The unique design of the POLLUX SCE fixturing resulted in the successful delivery to the test facility. All post-transport inspections, testing, and measurements confirmed the SCE arrived in pristine condition. The SCE was subsequently prepared for implosion testing at the NNSA U1a complex in the test apparatus shown in Figure 6.

The following is a quote from NNSA Administrator Thomas D'Agostino: "*Challenging subcritical experiments maintain our capabilities to ensure that we can support a safe, secure and effective stockpile without having to conduct underground testing. I applaud the work done by the men and women who worked to make this experiment successful. Experiments such as this help deliver President Obama's nuclear security agenda.*"

Figure 6

ACKNOWLEDGMENTS

1. NNSA Los Alamos Field Office
2. Los Alamos National Laboratory
3. Nevada National Security Site
4. NNSA Office of Packaging and Transportation
5. NNSA Office of Secure Transportation
6. National Security Technologies, LLC

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