The Development of a Type B Sample Container*

R. E. Glass

Transportation Systems Technology Division, Sandia National Laboratories**
Albuquerque, New Mexico, United States of America

INTRODUCTION

Sandia National Laboratories is developing a Protective Sample Container to support chemical agent sampling requirements of the multilateral Chemical Weapons Convention. This work is sponsored by the U.S. Army Chemical Research, Development, and Engineering Center. The Protective Sample Container is designed to prevent the release of lethal chemical agents during international air transport of chemical agents by meeting International Atomic Energy Agency (IAEA) requirements for a Type B container and by incorporating features specific to the Chemical Weapons Convention such as tamper protection, interior sampling, and decontamination.

The current package design includes a removable insert that can be used to support the transport of a range of sample sizes from adsorption tubes to 2 l bulk samples. This package may be applicable to the analytical sampling needs of the U.S. Department of Energy Office of Environmental Restoration and Waste Management.

This paper discusses the design and engineering development tests performed for the Protective Sample Container.

DESIGN

The recommended design criteria (Glass and Gough, 1992) for the Protective Sample Container include the IAEA Type B packaging requirements (IAEA, 1985) and the American National Standards Institute (ANSI) N14.5 leak tight requirement (ANSI, 1987) during both normal transport and following the hypothetical accident sequence. The leak tight requirement eliminates the need for content-specific release rates similar to the A1 and A2 quantities of radioactive materials.

In addition to meeting the Type B design criteria, the Protective Sample Container includes a containment vessel designed to meet the requirements of the International Civil Aviation

---

*This work was performed at Sandia National Laboratories, Albuquerque, New Mexico, supported by the United States Department of Energy under Contract DE-AC04-76DP00789.

**A United States Department of Energy Facility.

Organization's (ICAO)Class 6, Division 6.1 Packaging Group I criteria (ICAO, 1992) for toxic materials. This will provide for operational flexibility in transporting toxic samples .

The Protective Sample Container is 40.6 cm in diameter and 40.8 cm long. The internal cavity is 15 cm in diameter and 14 cm long. An insert can be machined to accept multiple samples of any configuration up to 2 l in volume. The configuration of the packaging shown in Figure 1 includes the insert for 137 adsorption tubes.

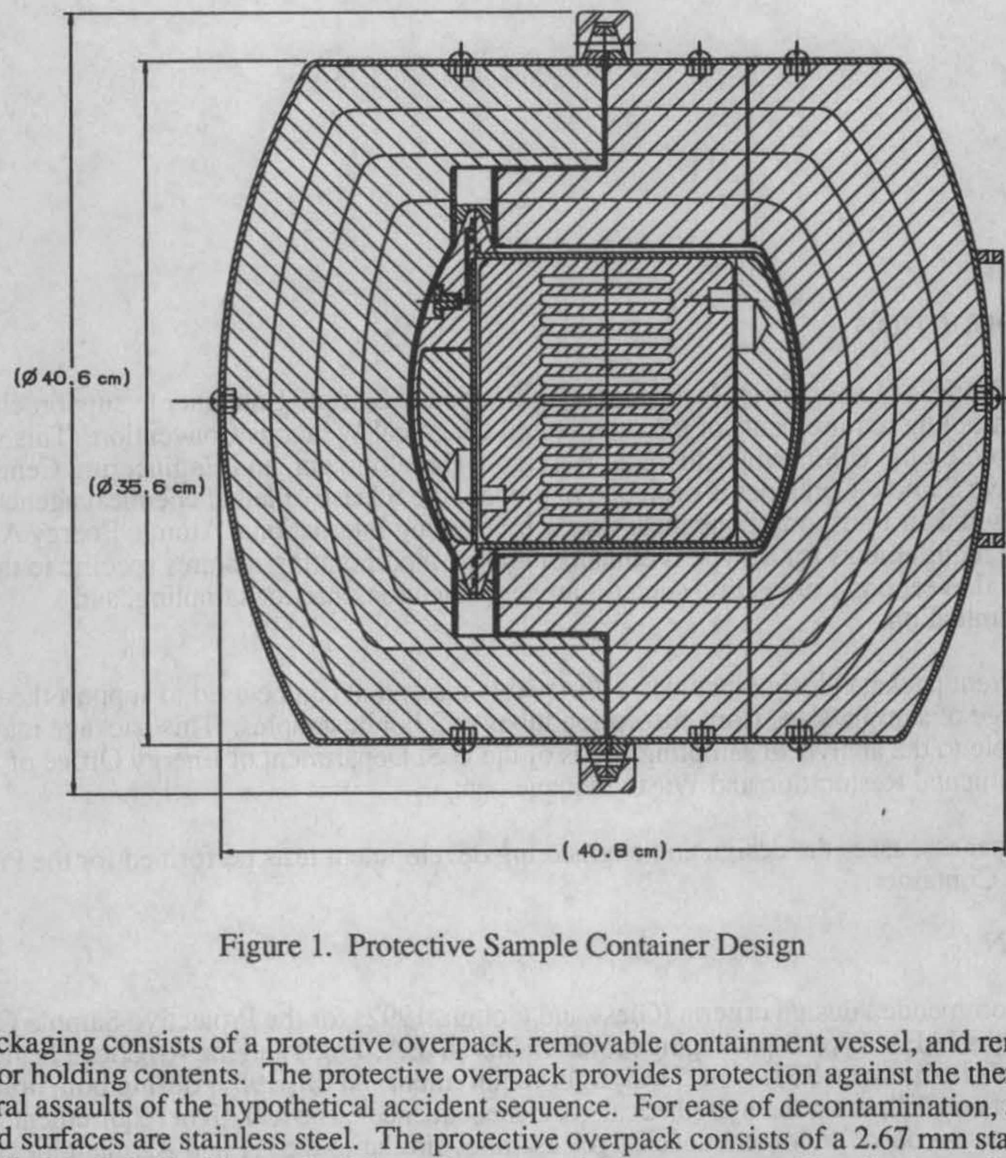

Figure 1. Protective Sample Container Design

The packaging consists of a protective overpack, removable containment vessel, and removable insert for holding contents. The protective overpack provides protection against the thermal and structural assaults of the hypothetical accident sequence. For ease of decontamination, all exposed surfaces are stainless steel. The protective overpack consists of a 2.67 mm stainless-steel cylindrical shell with standard flanged commercial pressure vessel heads, thermal insulation and an inner stainless-steel skin. The stainless-steel shell deforms to absorb most of the impact energy during the drop test and to provide protection from puncture. Internal to this shell is 10 cm of ceramic fiber insulation that limits the thermal input to the containment vessel. The ceramic fiber insulation is enveloped by a stainless-steel skin that can be readily decontaminated in the event of a leaking sample vial. The outer shell and inner skin are connected with a z-ring that limits heat conduction to the containment vessel. The protective overpack is closed with a stainless-steel v-clamp.

The containment vessel is designed to meet the vibration, drop, stacking, leakproof, and hydraulic tests specified for Class 6, Division 6.1 toxic substances by ICAO. The containment vessel is a 2.67-mm stainless-steel cylindrical shell with flanged pressure vessel heads at each end. The containment vessel from the engineering development model is shown in Figure 2 and is identical to the Protective Sample Container. The photograph shows the assembly with the protective overpack lid removed. This model did not include the z-ring between shells. The containment vessel closure is provided by a v-clamp. The containment vessel includes an o-ring test port, shown in upper left, to perform operational leak rate testing of the elastomeric double o-ring seal. The containment vessel also has a sample port that allows the interior of the package to be sampled without release of contents.

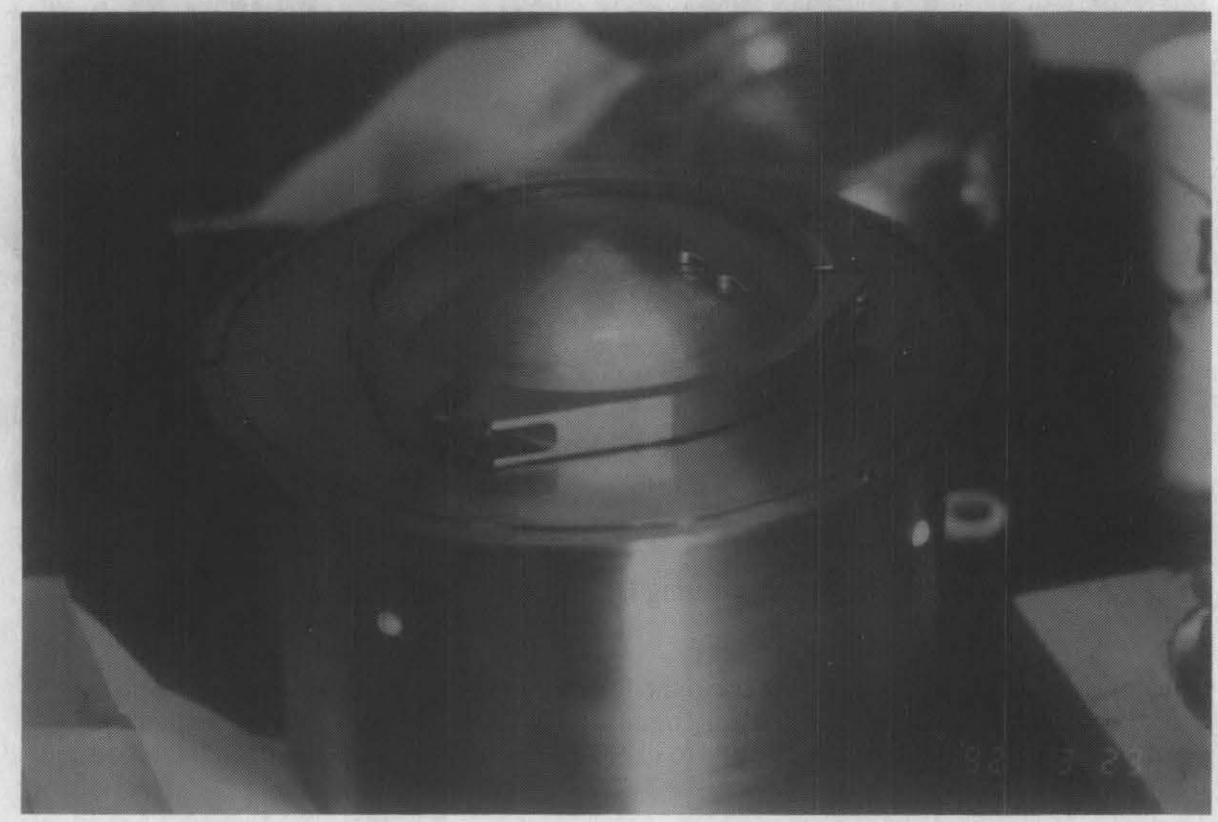

Figure 2. Engineering Development Model with Outer Lid Removed

A removable insert for 10 ml sample vials is shown in Figure 3. The insert consists of a teflon cylinder machined for specific sample vial sizes. The machined slots are lined with a low durometer butyl to attenuate shock. The vials are then placed in the insert slots and packed with an absorbent material.

ENGINEERING DEVELOPMENT MODEL TESTING

A series of drop, puncture and fire tests have been performed on an engineering development model for the Protective Sample Container. The model differed from the current design in that the fiber insulation was only 7.5 cm thick and the protective overpack outer shell and inner skin were connected with a straight ring instead of the current z-ring design. These changes were incorporated due to the response of the development model during the all-engulfing fire test.

Figure 3. Engineering Development Model Interior

The development model was subjected to the following sequence of tests: three 9-m free drops, one 1-m puncture test, and an all-engulfing JP-4 fuel fire test. This test sequence resulted in an unacceptable leak rate due to excessive temperatures experienced by the o-rings during the fire test.

The intended drop test orientations were flat side drop, center-of-gravity over corner drop, and flat top drop. The instrumentation for each of these drops consisted of two accelerometers. The x accelerometer was oriented to provide the acceleration through the center-of-gravity and the impact point. The y accelerometer measured the accelerations perpendicular to that line. The data presented in subsequent figures are from the flat top drop.

The flat top drop resulted in the lowest accelerations and the largest deformations. Conversely, the highest accelerations occurred during the flat side drop and were due to the impact on the relatively rigid v-clamp. The results of this flat top test are shown in Figure 4. The data show the vertical acceleration obtained using the Mobile Instrumentation Data Acquisition System (Uncapher, 1990). The data show the primary impact at time 0 and three subsequent impacts.

The primary impact had the highest accelerations. The wide band data for the primary impact are shown in Figure 5. These data indicate an impact duration of between 2 and 4 msec which

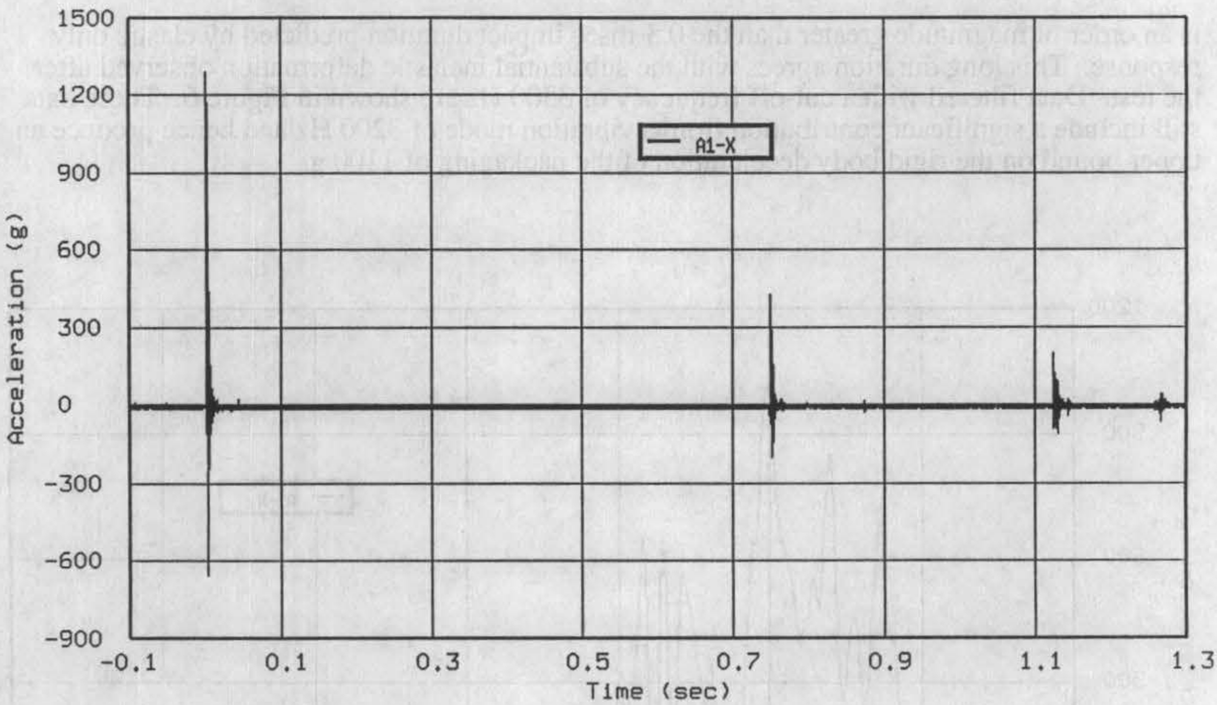

Figure 4. Flat Top Drop Vertical Acceleration Data

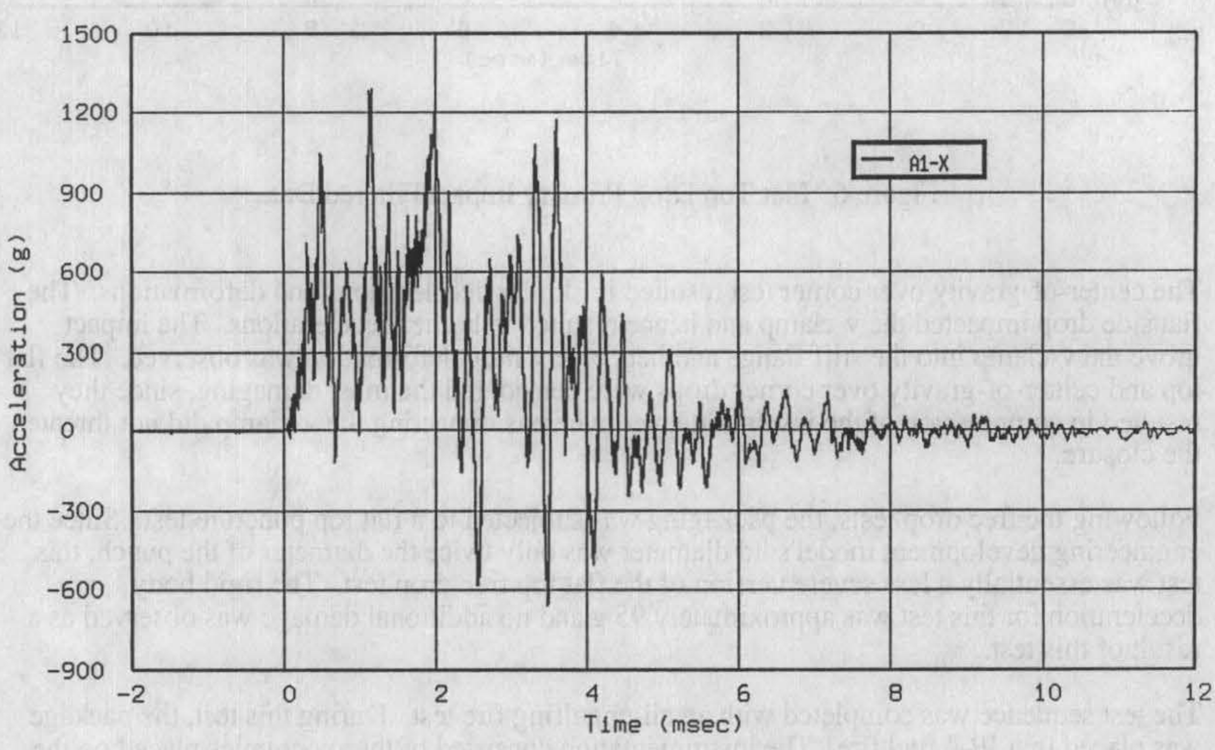

Figure 5. Flat Top Drop Primary Impact Acceleration Data

is an order of magnitude greater than the 0.3-msec impact duration predicted by elastic only response. This long duration agrees with the substantial inelastic deformation observed after the test. Data filtered with a cut-off frequency of 3300 Hz are shown in Figure 6. These data still include a significant contribution from a vibration mode of 3200 Hz and hence produce an upper bound on the rigid body deceleration of the packaging of 1100 g.

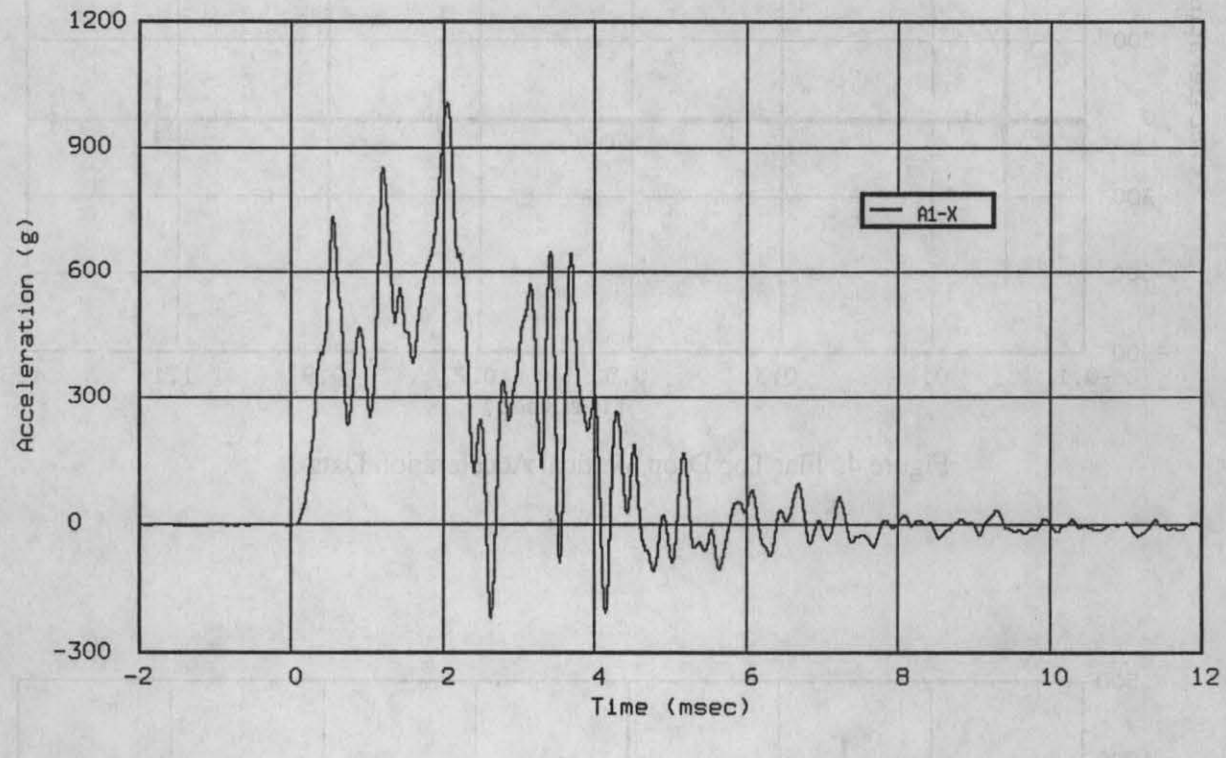

Figure 6. Flat Top Drop Primary Impact Filtered Data

The center-of-gravity over corner test resulted in similar decelerations and deformations. The flat side drop impacted the v-clamp and hence resulted in higher decelerations. The impact drove the v-clamp into the stiff flange and hence very little deformation was observed. The flat top and center-of-gravity over corner drops were considered the most damaging, since they resulted in compression of the insulation layer, whereas impacting the v-clamp did not threaten the closure.

Following the free drop tests, the packaging was subjected to a flat top puncture test. Since the engineering development model's lid diameter was only twice the diameter of the punch, this test was essentially a less severe version of the flat top free drop test. The rigid body deceleration for this test was approximately 95 g and no additional damage was observed as a result of this test.

The test sequence was completed with an all-engulfing fire test. During this test, the package was placed in a JP-4 fuel fire. The instrumentation consisted of thermocouples placed on the exterior of the package and passive thermal indicators placed inside the package. The exterior thermocouples were used to determine the external boundary condition in the event that additional thermal analyses needed to be performed following the test. The internal thermocouples monitored the packaging response. They were placed along the ring connecting the outer shell and inner skin, along the bottom of the inner skin, and on the exterior of the containment vessel. The actual exposure of the package exceeded the regulatory 30-min, all-engulfing fire. The regulatory test was followed by a 90-min exposure to a wall of flame. The additional exposure was the result of a failure in a mechanism used to shield the test article from the fire. Figure 7 shows the package while still exposed to the ongoing pool fire. The results from this test indicated that temperatures exceeded the maximum passive thermal indicator temperature of 400°C at the o-ring seal location. The bottom of the containment vessel reached temperatures of approximately 200°C.

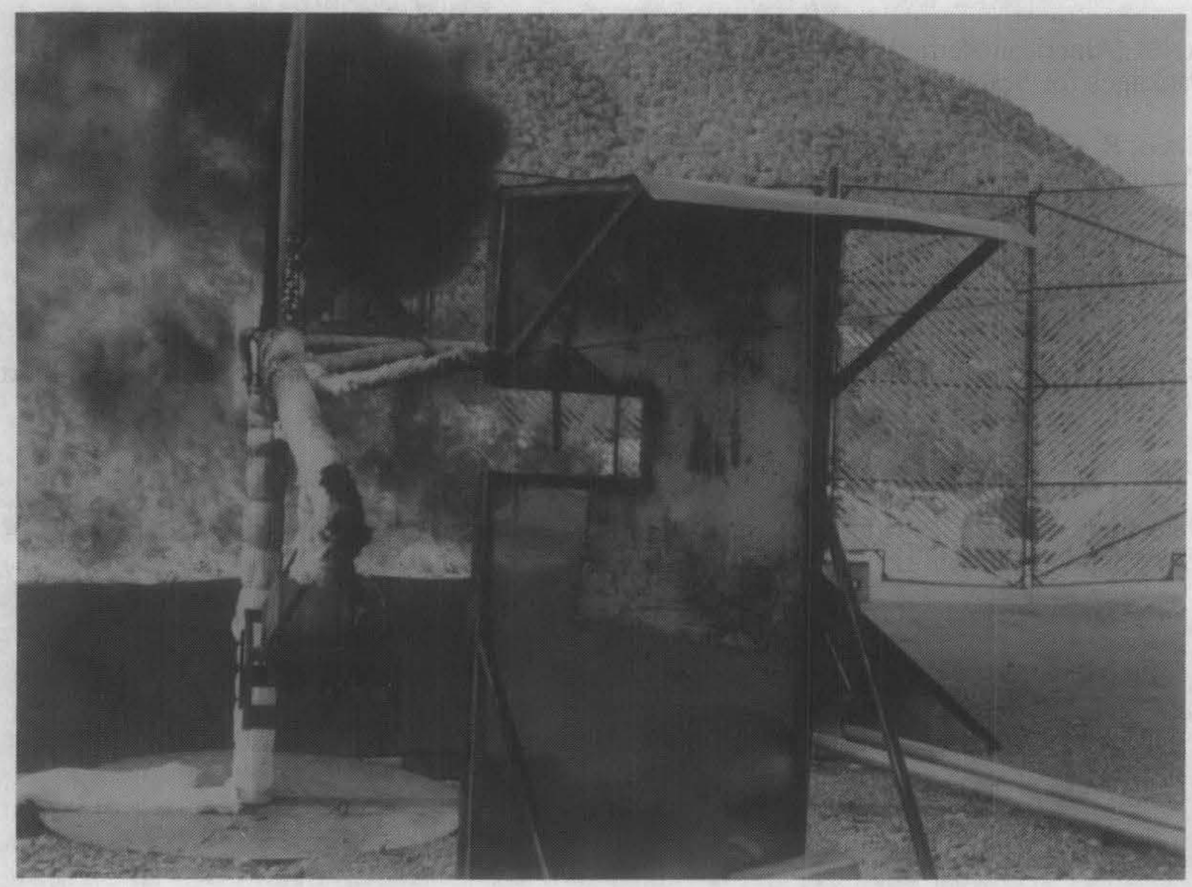

Figure 7. Protective Sample Container Exposed to Ongoing JP-4 Fuel Fire Test

Thermal analyses compared the actual thermal event with the regulatory 30-min all-engulfing fire. These analyses indicated that the peak temperatures at the o-ring surface would have been 480°C (Sisson, 1992) for the regulatory event and 760°C for the actual event. Since the predicted regulatory event o-ring temperature exceeds the manufacturer's continuous operating temperatures for standard materials such as viton and butyl, the package was redesigned as discussed in the DESIGN section.

CONCLUSIONS

The Protective Sample Container has been designed to remain leak tight following the hypothetical accident sequence of drop, puncture and fire specified in the IAEA regulations. The containment vessel has been designed to meet the requirements of the ICAO for Class 6, Division 6.1 toxic materials transport.

An engineering development model was tested to meet the IAEA requirements. These tests resulted in a redesign of the packaging to incorporate greater thermal resistance. A prototype is being fabricated and verification testing will be completed in October 1992.

REFERENCES

ANSI (American National Standards Institute), "Radioactive Materials - Leakage Tests on Packages for Shipment," ANSI N14.5, 1987.

Glass, R. E. and Gough, R. G., "Considerations for an Air-Transportable Protective Sample Container for the Chemical Weapons Convention," VST-030/TTC-1175, Sandia National Laboratories, Albuquerque, NM, January 1992.

IAEA (International Atomic Energy Agency), "Safety Series No. 6 Regulations for the Safe Transport of Radioactive Material," 1985 Edition.

ICAO (International Civil Aviation Organization), "Technical Instructions for the Safe Transport of Dangerous Goods by Air," Doc 9284-AN/905, 1991-1992 Edition.

Sisson, C. E., Private communication, April 1992.

Uncapher, W. L., "The Mobile Instrumentation Data Acquisition System (MIDAS)," SAND90-2916, Sandia National Laboratories, Albuquerque, NM, 1990.