International Shipment of Plutonium by Air

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INTERNATIONAL SHIPMENT OF PLUTONIUM BY AIR

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1.0 BACKGROUND

In support of the United States (U.S.) Government's decision to place excess plutonium oxide at the U.S. Department of Energy's (DOE) Hanford Site under International Atomic Energy Agency (IAEA) safeguards, the Department of State notified the Congress that a plutonium storage vault at the Plutonium Finishing Plant at the Hanford Site would be added to the eligible facilities list. As part of the preparations to transfer the plutonium oxide under IAEA safeguards, samples of the powder were taken from the inventory to be shipped to the IAEA headquarters in Vienna, Austria, for laboratory analysis. The analysis of these samples was of high priority, and the IAEA requested that the material be shipped by aircraft, the most expeditious method.

The preparation and execution of this shipment presented a challenge to Westinghouse Hanford Company (WHC), IAEA, and DOE personnel. Because of the potential health risks resulting from a transportation accident, the shipment of plutonium by air is strictly regulated. In addition to the U.S. Department of Transportation (DOT) requirements (49 CFR 173) and the U. S. Nuclear Regulatory Commission (NRC) requirements (10 CFR 71) that apply to all shipments of radioactive material, there are special requirements specifically governing the shipment of plutonium by air. Furthermore, because the shipment was international, International Air Transport Association (IATA) requirements (IATA 1995) and International Civil Aeronautics Organization (ICAO) requirements (ICAO 1995) were applicable. This type of shipment is not a routine transportation operation.

2.0 PACKAGING

The packaging selected was the Plutonium Air-Transportable Model 2 (PAT-2) container. This packaging is the only system approved in the U.S. for plutonium transportation by air.

The successful preparation of the packaging for shipment was ensured by assigning a cognizant engineer responsible for thorough knowledge of the
applicable requirements. The engineer coordinated the inspection and leak testing of the shipping containers, reviewed the packaging procedures prepared by the loading facility, and performed the mass and activity calculations required for the shipping papers.

2.1 Description of PAT-2

The PAT-2 packaging system is designed for the safe transport of gram quantities of solid plutonium and uranium, specifically by air transport. The packaging system design was developed to withstand severe accident environments such as those resulting from a high-speed jet aircraft crash.

The packaging design, test and analysis results, and operating procedures are documented in the Safety Analysis Report for Packaging (SARP [Andersen et al. 1981]). The use of the packaging in the U.S. is authorized by the NRC Certificate of Compliance USA/9150/B(U).

The PAT-2 packaging system is a stainless-steel drum 38 cm in diameter, 36 cm high, weighing 33 kg. The system is comprised of three assemblies: (1) the AQ-2 overpack; (2) the iron-base superalloy containment vessel, the TB-2; and (3) the stainless steel C-1 capsule, which is contained within the TB-2 vessel. The contents are limited to 15 grams of fissile isotopes. Figure 1 shows the PAT-2 packaging system.

The packaging is designed to be assembled and disassembled with hand tools.

The AQ-2 overpack consists of a double-walled outer drum of 1.4-mm 304 stainless steel sheet metal with an overlapping and rounded top and bottom joint design, riveted at the bottom and bolted at the top. Inside this stainless steel container are 91 mm of redwood, 6.35 mm of titanium, and 40 mm of maple wood. These materials were selected and designed to protect the contents in extreme accident conditions.

The TB-2 is a spherical containment vessel fabricated of A-286 iron-base superalloy. The outside diameter is 88 mm. The flanges are bolted together over a copper gasket. This sealed containment vessel will not vent in an accident environment.

The C-1 capsule is fabricated from Nitronic 60 stainless steel. The capsule is sealed with a torqued screw thread joint. This capsule provides secondary containment for plutonium contents greater than 20 Ci, as required by 10 CFR 71.

Several canisters designs are available for use inside the C-1 capsule as sample holders. The BC-5 canisters, selected for use in this shipment, are brass canisters which may be equipped with a quartz liner for nuclear processing. The C-1 capsule can hold up to 6 BC-5 canisters. The BC-5 lid screws onto the canister body to seal against a polyvinylchloride (PVC) gasket which is furnished as part of the lid.
2.2 PAT-2 Leak Testing

In order to ensure containment, the SARP requires that the TB-2 be leak tested after the contents are loaded, prior to shipment. The required sensitivity for the leak test method is $10^{-4}$ cm$^3$/s. The SARP suggests a test in which the TB-2 is placed in a closely fitting chamber, a vacuum drawn rapidly, and chamber pressure rise correlated with leak rate. WHC Nondestructive Examination (NDE) and Packaging Engineering personnel were concerned that this method would yield erroneous results in the event of a gross leak due to the extremely limited volume present between the TB-2 vessel and the C-1 capsule. A more reliable method was developed employing a helium mass spectrometer leak detector (MSLD). The TB-2 vessel was assembled and the bolts hand tightened inside a helium-filled enclosure. The TB-2 vessel was then removed from the helium enclosure and the bolts torqued to their specified value. The TB-2 was placed in a leak test chamber designed with the smallest possible void volume. This minimum volume permitted the MSLD to achieve the test mode as quickly as possible (approximately 5 seconds). This quick on-line time is critical when testing for gross leakage. In development testing conducted by NDE, it was determined that gross leakages of $10^{-1}$ atm-cc/sec were detectable with this leak test assembly. This leak rate equates to the TB-2 vessel assembled with one finger-tight bolt.
Because no leak test reports were available for the C-1 capsules, these components were also tested to verify the containment. Test results showed that the capsules met the acceptance criteria.

2.3 PAT-2 Packaging Operations

The packaging of the plutonium oxide powder in three PAT-2 containers presented several challenges. Preparation of the payload was performed in a glovebox. The IAEA required that the material be weighed precisely and placed in BC-5 canisters with quartz liners. The capsules were then bagged in PVC film before being placed in the C-1 capsule.

The bagging of the sample bottles proved to be an unanticipated obstacle in completing the operation. The PAT-2 SARP requires that the quantity of organic material in the packaging be strictly limited. Other than a specified mass of polytetrafluoroethylene (PTFE) tape used to seal the C-1 capsule threads, and the gaskets in the BC-5 canisters, less than 9 grams of PVC film is permitted. Deviation from the SARP or Certificate of Compliance is prohibited. The standard plastic film used for glovebox operations at the Hanford Site is polyethylene. The PVC film available was too thick to meet the SARP mass limit. A special order was placed to obtain 4 mil PVC film for the operation.

Other concerns encountered in the course of preparing the BC-5 canisters for shipment involved radiological controls. Because the loading of the canisters occurred in the contaminated environment of the glovebox, the exterior surfaces of the canisters were potentially contaminated and, therefore, the interior surfaces of the PVC bagout sleeve. Facility procedures dictated the use of adhesive tape to seal the cut edge of the heat sealed bag. Because the SARP prohibited the addition of tape to the payload, an alternate means of ensuring an uncontaminated surface was developed using a double seal.

After the bagged canisters were loaded in the C-1 capsule, the loading of the TB-2 containment vessel was performed in a helium atmosphere to permit leak testing. Several unsuccessful attempts to assemble the TB-2 resulted in the discarding of three copper gaskets. These deformable metallic seals cannot be reused. All three TB-2 vessels were successfully assembled and leak tested.

The remaining steps in the PAT-2 assembly were straightforward.

2.4 Packaging Contents

Each PAT-2 container was shipped with 5 BC-5 canisters containing less than 1 gram of plutonium oxide. The radioisotopes present were $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{242}$Pu, and $^{241}$Am. In order to document that all shipping requirements were met, the mass and activity of the fissile isotopes ($^{238}$Pu, $^{239}$Pu, $^{241}$Pu) were determined from the isotopic distribution data provided by the Plutonium Finishing Plant. Further calculations were performed to determine the total activity. Activity was calculated in curies and becquerels.
2.5 Certification Documentation for the PAT-2

As previously discussed, the SARP is the controlling document for the preparation of the package for shipment. In order to ship the package in commerce in the U.S., a valid Certificate of Compliance is required. NRC Certificate Number USA/9150/B(U) was available at the time of shipment, but the DOT Certificate of Competent Authority required for international shipment had expired. The IAEA requested and obtained a new Certificate of Competent Authority from the DOT. This certificate was used as the basis for requesting the required Certificates of Competent Authority from Austria and Germany. These certificates expire in July 1996.

3.0 TRANSPORTATION

The successful completion of the PAT-2 shipments was heavily dependent on thorough preparations and constant communication throughout the planning and execution phases. Table 1 lists the steps involved in the shipment, illustrating the complexity of the preparations required.

<table>
<thead>
<tr>
<th>Date</th>
<th>Preparation steps</th>
</tr>
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<tbody>
<tr>
<td>10/17/94</td>
<td>IAEA representatives met with key DOE and WHC personnel at Hanford</td>
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<tr>
<td>11/04/94</td>
<td>U.S. Competent Authority Certificate issued for PAT-2</td>
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<tr>
<td>11/07/94</td>
<td>PAT-2s arrived at WHC from New Brunswick National Laboratory, Argonne, Illinois</td>
</tr>
<tr>
<td>11/14/94</td>
<td>Notified broker (Transnuclear, Inc.) of intention to ship</td>
</tr>
<tr>
<td>11/21/94</td>
<td>IAEA applied for Austrian Certificate of Competent Authority for PAT-2</td>
</tr>
<tr>
<td>11/28/94</td>
<td>RL requested authorization from the DOE Office of Arms Control &amp; Non-Proliferation to ship</td>
</tr>
<tr>
<td>11/29/94</td>
<td>National Cargo Service (NCS) applied for German Transportation Plan and Certificate of Competent Authority for the PAT-2</td>
</tr>
<tr>
<td>11/30/94</td>
<td>WHC submitted Categorical Exclusion request to RL</td>
</tr>
<tr>
<td>12/01/94</td>
<td>WHC requested RL approval to ship Type B quantities of plutonium by air</td>
</tr>
<tr>
<td>12/07/94</td>
<td>RL granted approval to ship Type B quantities of plutonium by air</td>
</tr>
<tr>
<td>12/09/94</td>
<td>Austrian Competent Authority Certificate issued for PAT-2</td>
</tr>
<tr>
<td>12/09/94</td>
<td>Categorical Exclusion approved by RL</td>
</tr>
<tr>
<td>12/12/94</td>
<td>Plutonium oxide samples prepared at Plutonium Finishing Plant</td>
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<tr>
<td>12/12/94</td>
<td>Foreign Contract # assigned by DOE Nuclear Materials Management &amp; Safeguards Program Control</td>
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<td>12/12/94</td>
<td>Approval to ship granted by RL to WHC</td>
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<tr>
<td>12/15/94</td>
<td>German Competent Authority Certificate issued for PAT-2, as requested by NCS</td>
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<tr>
<td>12/16/94</td>
<td>German Transportation Plan approved</td>
</tr>
<tr>
<td>01/04/95</td>
<td>Samples loaded into PAT-2 containers</td>
</tr>
<tr>
<td>01/09/95</td>
<td>Shipment left WHC for Spokane, Washington, via Federal Express truck</td>
</tr>
<tr>
<td>01/09/95</td>
<td>U.S. DOT granted approval as required by Variation 4 in the IATA regulations</td>
</tr>
<tr>
<td>01/10/95</td>
<td>Shipment transported by Federal Express air to New York City, John F. Kennedy Airport (JFK)</td>
</tr>
<tr>
<td>01/10/95</td>
<td>Lufthansa received original copies of German and Austrian Certificates of Competent Authority and the German Transportation Plan</td>
</tr>
<tr>
<td>01/11/95</td>
<td>Shipment transported by Lufthansa to Frankfort, Germany</td>
</tr>
<tr>
<td>01/12/95</td>
<td>Shipment arrived (via Lufthansa) in Vienna (Customs)</td>
</tr>
<tr>
<td>01/17/95</td>
<td>IAEA received samples in Vienna</td>
</tr>
<tr>
<td>02/05/95</td>
<td>IAEA shipped empty PAT-2s from Vienna back to WHC</td>
</tr>
<tr>
<td>02/13/95</td>
<td>Empty PAT-2 containers arrive from Vienna</td>
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While domestic regulations prohibit the transport of plutonium in passenger aircraft, these restrictions do not apply in Europe. Operational controls imposed on the PAT-2 required that the packages be stowed in the aft-most lower compartment of the aircraft. The packages were also required to be restrained. These requirements were included in the documentation that accompanied the shipment.

The shipping papers required to carry out the shipment included the Offsite Radioactive Shipment Record; the domestic air bill; DOT Emergency Response Guide 63; the Shipper's Declaration for Dangerous Goods; the Shipper's Letter of Instruction and Pro Forma Invoice; the Customs Declaration for Austria; the U.S Certificate of Competent Authority for the PAT-2; original German and Austrian Certificates of Competent Authority; and the original German Transportation Plan.

Although the payload was fissile-excepted by U.S. (10 CFR 71, 49 CFR 173) and IAEA regulations (IAEA 1990) with a Proper Shipping Name "Radioactive material, n.o.s." and Identification Number UN2982, the payload did contain fissile isotopes. This distinction led to extensive discussions with Lufthansa about why the material was not shipped as "Radioactive material, fissile, n.o.s.," UN2918.

Another issue that arose immediately prior to the shipment concerned the requirements of U.S. Variation 10 (c)(4) of the ICAO Technical Instructions (ICAO 1995), which requires DOT Research and Special Programs Administration (RSPA) approval to ship plutonium by air. In response to Lufthansa's concern, RSPA advised that the NRC Certificate of Compliance, which specifically authorizes the use of the packaging for shipment of plutonium by air, satisfies this requirement, which is the basis for the USG 10 (c)(4) variation in the IATA Dangerous Goods Regulations (IATA 1995).

German regulations require that the applicant for a Certificate of Competent Authority for a foreign packaging be a German company. This application was filed by National Cargo Service (NCS), a German broker.

Three PAT-2 packages containing plutonium oxide were shipped by truck from Richland to Spokane, Washington and then transported by cargo aircraft from Spokane to John F. Kennedy Airport (JFK) in New York by Federal Express. At JFK the export agent, Transnuclear, Inc., assumed control of the shipment, which was transferred by Fritz Air Services to Lufthansa Flight 8161, cargo-only aircraft, which departed New York for Frankfurt on January 11, 1995. The shipment was then transferred to Lufthansa passenger/cargo aircraft Flight 3436, which arrived in Vienna on January 12, 1995. Upon release of the shipment from WHC, the export agent and the IAEA Transportation Unit were notified. The progress of the air carrier was tracked daily.

The successful execution of a complex shipment such as the international transportation of plutonium by air is highly dependent on effective planning and communications. Preparations for the shipments described involved legal counsel, procurement services, environmental compliance issues, laboratory services, and training staff. As other DOE sites prepare to make similar shipments, they may find the Hanford Site experiences described in this paper useful.
4.0 ACKNOWLEDGEMENTS

The authors wish to acknowledge the contributions of the following individuals in carrying out the successful preparation and shipment of the PAT-2 packages:

- John Keve, WHC Nondestructive Examination
- Bill Purdy, WHC Nondestructive Examination
- Dean Bartlett, WHC Plutonium Finishing Plant Special Projects
- Robert Cimoch, WHC Plutonium Finishing Plant Process Engineering
- Matthew George, Transnuclear, Inc.

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