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ROADRUNNER CONTAINMENT SEAL DAMAGE INVESTIGATION – OPERATING EXPERIENCE

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ABSTRACT

The Roadrunner Transportation Package is a Type B packaging used by Ontario Power Generation (OPG) to transport solid radioactive material. In 2005 a damaged containment seal was discovered during routine unloading operations. The packaging's double seal closure design ensured that the there was no radiological release during transport. The subsequent investigation examined the immediate causes of the incident and, also, assessed the adequacy of OPG's transportation program.

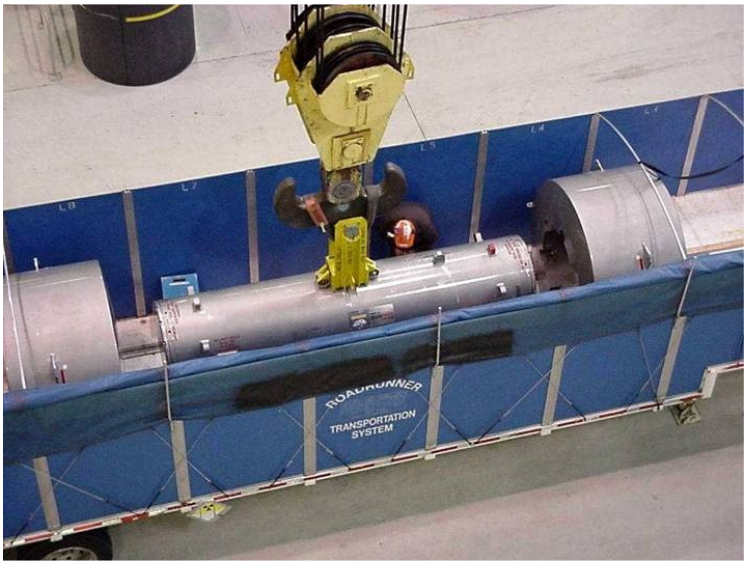

Figure 1: Roadrunner Transportation Package

An extensive improvement plan was undertaken based on the investigation findings. The actions were intended to correct identified deficiencies and to implement some longer term improvement initiatives for the transportation program.

The specified actions have been implemented by OPG with changes made to: procedures; personnel training and development requirements; package containment integrity checks; a defined approach to infrequently performed shipments; and management's coaching and oversight roles.

The lessons learned from the 2005 Roadrunner incident investigation were applied to many aspects of the OPG radioactive materials transportation program and have led to a stronger program with improved operating procedures, training, supervision and attention to procedural and regulatory compliance. The Roadrunner with the impact limiters retracted in preparation for unloading is shown in Figure 1.

INTRODUCTION

This paper describes OPG's response to a 2005 incident where it was discovered that a radioactive materials shipment had been made with significant containment closure seal damage to the transportation package. The relevant features of the transportation package design and the incident are explained. Although no radiological release occurred, the incident prompted OPG to perform a detailed investigation of its entire transportation program. The results of this investigation, with the follow-on actions to systematically improve the transportation program, are presented.

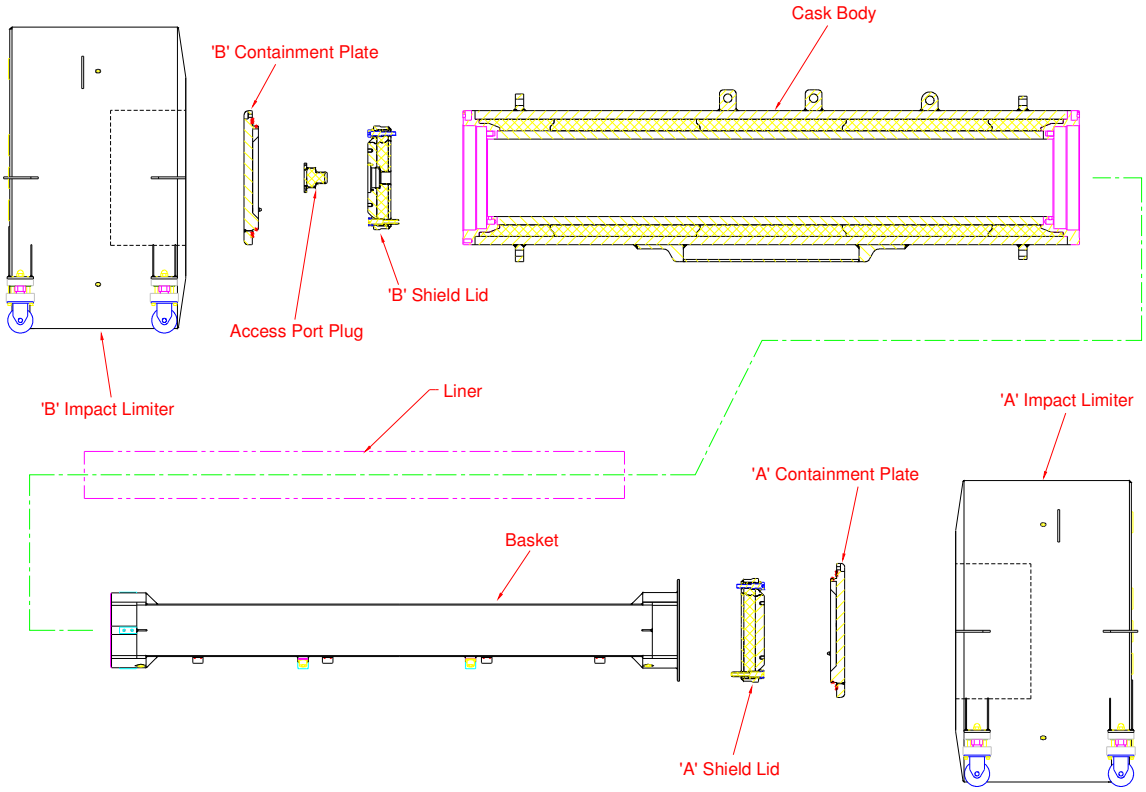

Figure 2: Roadrunner Transportation Package Components

PACKAGE DESCRIPTION

The Roadrunner is a large (23,000 kg), cylindrical package used to transport solid, activated reactor components (e.g.: pressure tubes, end-fittings, flux detectors). The package design is currently licensed as a Type B(U)-96 package under the Canadian regulations [1] which are derived from the 1996 Edition (Revised) of the IAEA Regulations [2]. The package configuration is shown in Figure 2 above. The main containment and shielding component of the package is the cylindrical cask body. Closures, consisting of a shield lid (without seals) and containment plate (with seals) on both ends of the package, provide full access to the cask body cavity. One end of the package is designated as "A" and the other is designated as "B". The significant difference between the package ends is that the "B" end shield lid incorporates an access port for unloading. Impact limiters are attached to the cask body for transport only and remain on the trailer during load and unload operations.

OPG owns, operates and maintains one Roadrunner Transportation Package. It has been in service for nine years and is used for approximately 10 shipments per year, usually on a campaign basis.

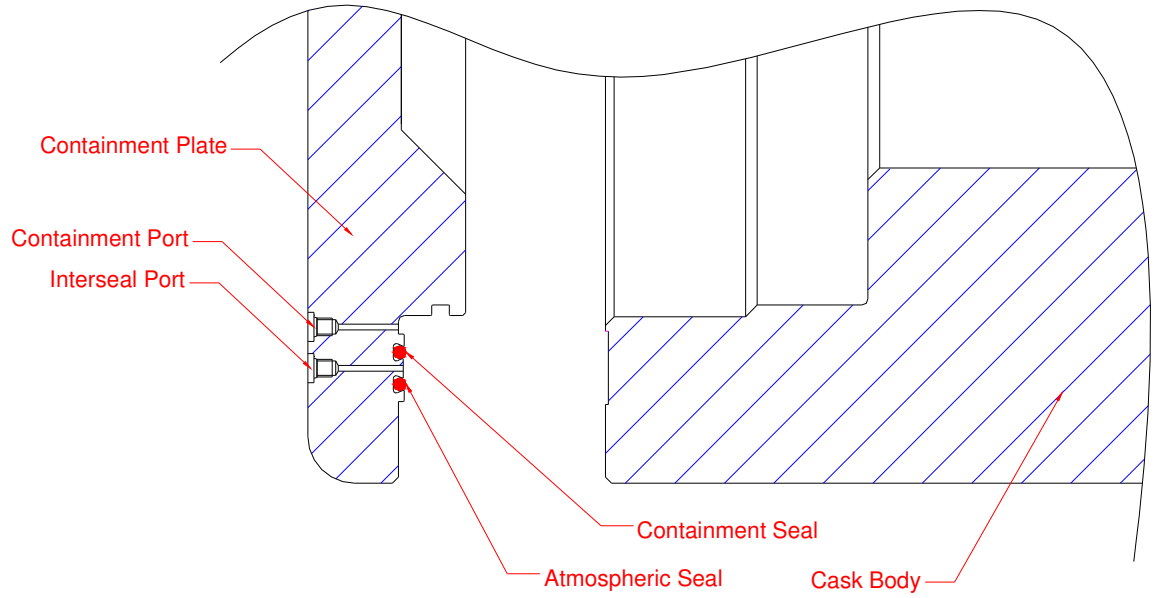

Figure 3: Roadrunner O-Ring Seal Detail

Description of Containment Closure Seal Design

The containment closure seal design, shown in Figure 3 incorporates two o-rings recessed into the containment plate. The o-rings are identical in all respects except for diameter. Only the inboard o-ring is credited with providing containment. The outboard o-ring, referred to as the "atmospheric seal", provides a boundary for leak testing. The o-ring grooves are dovetailed to retain the seals during handling. Each containment plate has two test ports, the "containment port" and "interseal port", which are used for leak testing and verification of containment closure seal integrity.

TYPICAL OPERATING CYCLE

Loading

The Roadrunner is loaded horizontally. Normally, only one end is opened (containment plate and shield lid removed) for loading. The package end selected for opening depends on the material to be shipped and the interfacing equipment. After loading, the shield lid and the containment plate are re-installed on the open end. A pre-shipment air pressure decay test, consistent with the ANSI N14.5 [3] standard, is then conducted on each closure to demonstrate containment integrity. Tests on each end are required (i.e., one for each closure) because the test procedure involves pressurizing the containment plate inter-seal volume (the annulus between the two o-rings) and not the cask body cavity itself. After successful verification of the containment closure integrity, the package is lifted onto the trailer, the impact limiters attached and the package is ready for shipment.

Unloading

After arrival at the receiving facility, the impact limiters are detached from the package and the package is removed from the trailer. The containment plates are then removed from both ends of the package. The shield lid from the "A" end and the access port plug from the "B" end are also

removed. For vertical unloading, a cable is attached to the payload via the "B" end access port, the package is rotated to the vertical orientation, mated with the in-ground storage container, and the payload is lowered out of the package into the storage location. A photo of a vertical unloading operation of the package is shown in Figure 4.

Figure 4: Unloading of the Roadrunner Transportation Package

INCIDENT DESCRIPTION

In 2005 a damaged containment o-ring was discovered when the "B" end containment plate was removed in preparation for unloading the Roadrunner. Details of the damage are shown in Figure 5 and Figure 6. No contamination was detected by surveys of the adjacent areas on the package, the corresponding impact limiter or on the transport trailer. The containment plate was re-installed on the package and an air pressure decay test was performed. The test was unsuccessful - the damaged containment seal could not retain pressure. It was concluded that the shipment had been made with a non-functional containment seal.

The incident was reported to the Canadian competent authority as required by the Canadian regulations [1].

Additional tests were conducted to assess the impairment. The containment plate was removed, a new containment o-ring was installed, the plate was re-installed and the air pressure decay test was repeated. The test was successful. This result proved that the atmospheric seal (which had not been disturbed during the tests) was functional and could retain pressure. Therefore, although the "B" end containment o-ring was not functional during the shipment, a barrier to release was provided by the atmospheric seal.

Figure 5: Damaged O-Ring in Groove

Figure 6: Damaged O-Ring Detail

INCIDENT INVESTIGATION

A team consisting of representatives from OPG's Nuclear Waste Engineering, Performance Assurance, and Operations departments was assembled to investigate the incident. The team employed the OPG Root Cause Investigation Methodology to identify the immediate and root cause of the incident and contributing factors. A summary of the investigation findings is provided below.

Investigation Findings

- **Safety.** No radiological release occurred during transport. The Roadrunner's double seal closure design ensured that, even with the designated containment seal impaired, a barrier to release of the contents existed.
- **Damage.** The probable cause of damage to the o-ring was mechanical. It is suspected that a portion of the o-ring was inadvertently dislodged from its groove after a previous shipment had been unloaded, and was sheared or cut by the containment plate during re-installation.
- **Design.** The closure design was found to be adequate and no improvements were proposed.
- **Operating Procedures.** Overall, the operating procedures lacked clarity in some critical steps and allowed for varying interpretations. They also did not ensure that integrity of packaging was verified prior to it being offered for use.
  The procedures for unloading the package did not clearly specify testing of each of the closures after reassembly of the empty packaging. Therefore the closure seal integrity was not verified prior to the next loading/transport/unloading cycle.
  The intent of procedures for loading the package had not been followed due to misinterpretation. The pre-shipment air pressure decay test had not been performed on the "B" end prior to the shipment, because the "B" end was not opened during the loading operations. The loading personnel assumed that the empty package was in proper condition when it had been delivered to them for use.
- **Oversight.** Supervisors did not provide effective oversight of this infrequently performed task evolution, previous operating experience was not adequately communicated, and personnel involved lacked familiarity with the package. Responsibilities and working relationships between the various departments involved with the shipment were not well defined, resulting in confusion and poor understanding of required tasks.
- **Training.** The training given to the crew loading and preparing the package for shipment did not provide them with sufficient understanding of the critical functions and features of the package.
- **Precursor Event.** In 2004 a Transportation Officer (a staff member whose role is to verify regulatory and procedural compliance of shipments) had reported a failure to conduct the air pressure decay test on the "B" end closure during a Roadrunner shipment. At the time, the event was treated as a one-off non-compliance problem and was not recognized as an indicator of more significant deficiencies.

Additional contributing factors identified by the investigation included: lack of standards to record and verify information on the pre-shipment check sheets; and misalignment of the package generic operating procedures with site-specific procedures and work plans.

CORRECTIVE ACTION PLAN

A comprehensive corrective action plan (CAP) was developed based on the incident investigation findings. The actions within the plan were aimed at preventing reoccurrence and similar incidents on any of OPG's transportation packages, not only the Roadrunner. A summary of the actions is presented below.

Governance and Regulatory Compliance

- Revise operating procedures to clearly and explicitly identify critical aspects (containment integrity, testing and safety) of package handling.
- Review and revise operating procedures for consistency and confirm that the specified tasks are compliant with the package safety analysis report and the Certificate for Transport Package Design.
- Review and revise maintenance and unloading procedures to require air pressure decay tests after re-assembly to verify package containment integrity prior to next use.

Supervision

- Review and assess staff training and provide additional or refresher training where required.
- Provide formal, structured pre-job and pre-campaign briefings.
- Coach Transportation Officers and package users regarding the need for procedural compliance.
- Mentor junior staff to ensure complete training and development.
- Instruct drivers to refuse carriage of Type B shipments unless the shipment has been released by a Transportation Officer.

Staff Training and Communications

- Develop training aids for each Type B package used by OPG. The aids are to include detailed information regarding key operational concerns, containment boundaries, critical checks, and special handling considerations and are to be used in pre-job or pre-campaign briefings. Consider providing the training to a wider audience to expand the knowledge base.
- Identify all infrequent shipments or conditions that could complicate a routine shipment and ensure that pre-job briefings and planning identify the need for increased vigilance.
- Assign accountability for communicating operating experience to a single point of contact.

Work Execution

- Provide guidance and standards for reviewing, confirming and completing procedures, user work plans and verification records.
- Require Transportation Officers be present for all pre-shipment air pressure decay tests on Type "B" packages, even if shipped empty as an excepted shipment.
- Require that Transportation Officers report on relevant operating experience at pre-job briefings.
- Periodically audit work processes and review, and revise where necessary, applicable documentation.

Incident Reporting

- Clarify the roles and accountabilities for regulatory incident reporting in an instruction document that also establishes a review circle of stakeholders.

CORRECTIVE ACTION PLAN IMPLEMENTATION

The actions specified by the Roadrunner incident CAP have been implemented over the past two years and have positively affected the entire OPG transportation program.

CONCLUSIONS

OPG responded to the discovery of a damaged containment o-ring on one of its transportation packages by seeking the root causes of the incident. The investigation led to the identification of several opportunities for improvement in OPG's radioactive materials transportation program. A plan of corrective actions was developed and has been implemented. As a result, OPG is ensuring that its transportation program sets and meets high standards of safety and regulatory compliance.

ACKNOWLEDGMENTS

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