An Experimental Investigation of the Correlation between Lid Displacement and Leakage Rate of Transport Cask

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Previous studies show that the release rate of radionuclides contained in a submerged transport cask is significantly affected by the area of flow path generated at the breached containment boundary. In this study, tests and analyses are performed to determine the equivalent flow path gap considering the influence of O-rings. A small flange assembly is fabricated and the release rate and release area are evaluated when sliding displacement is imposed to the lid. Pressure drop tests were performed at atmospheric pressure, and helium leak tests were performed under vacuum. The release rate and release area of flange assembly for sea water was then evaluated by converting the test data obtained for gas.

1. Research Objectives and Overview

1.1 Research Objectives

- The Research Objectives is to experimentally evaluate the containment performance of a transport cask when sliding displacement is applied to its lid equipped with an O-ring.

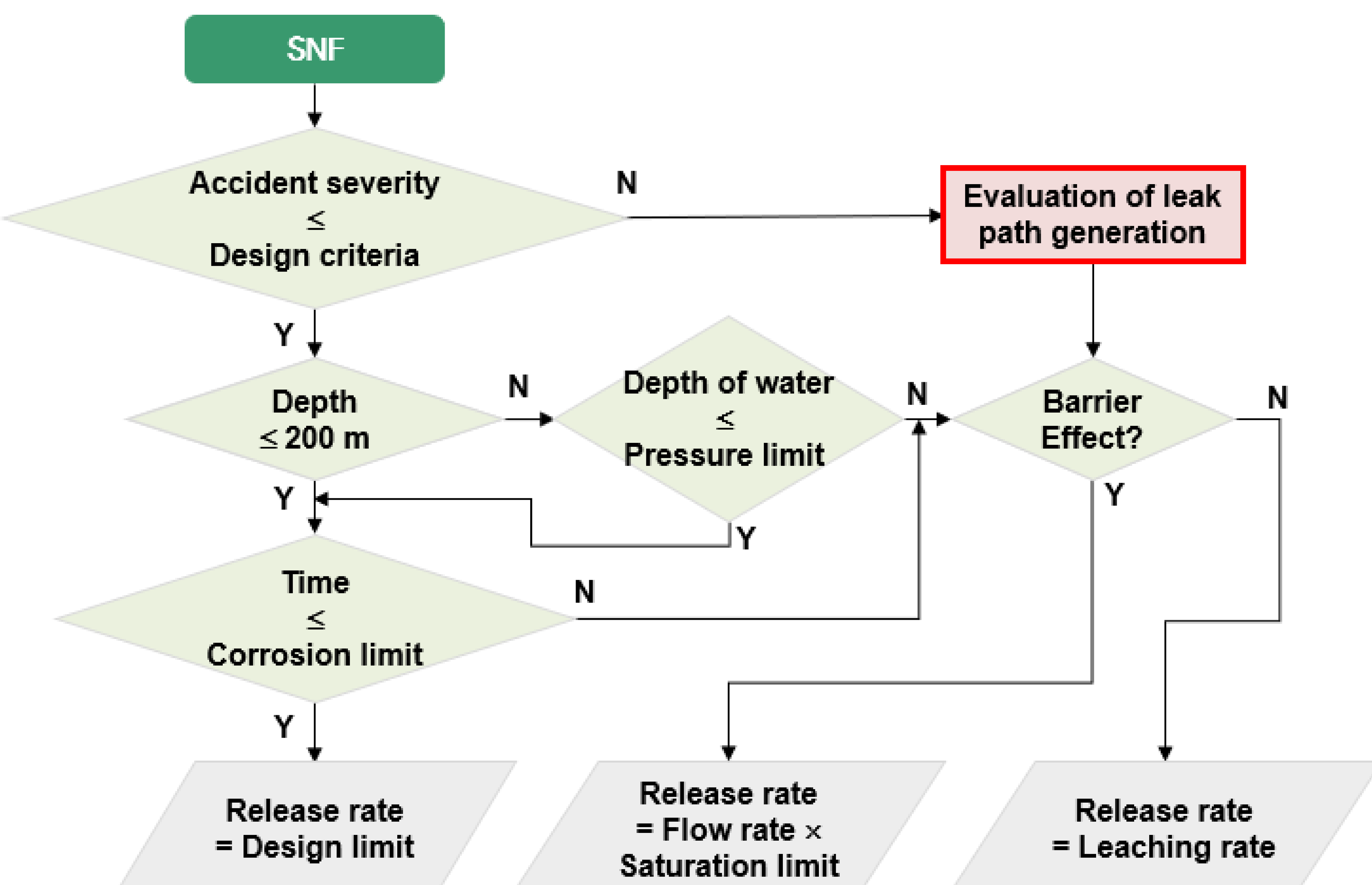


Fig. 1 The radioactive material ocean release scenario

1.2 Research Overview

- The radioactive material ocean release scenario is shown in Fig. 1. This study is conducted to evaluate of leak path generation.

2. Test Method and Process

2.1 Fabrication of lid to Apply Sliding Displacement

- An equipment was designed to apply sliding displacement to small flange lid. And the method of applying displacement to the lid is as shown in Fig. 2.

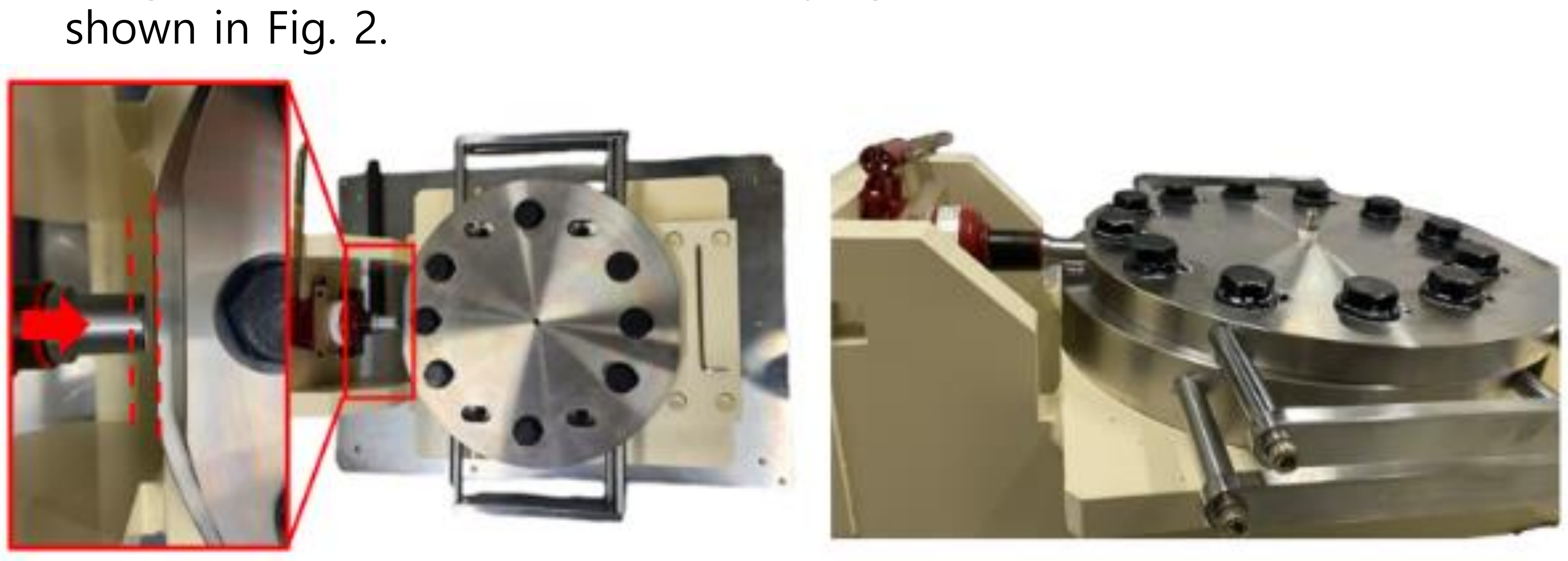


Fig. 2 Small containment container and method of applying displacement to container

2.2 The Differential Pressure Method

- The test is conducted using the differential pressure method. Case. 1 is performed under atmospheric pressure with air, and case. 2 is performed under vacuum with helium.

(case. 1) (case. 2)

Fig. 3 (case. 1) Pressure drop test of atmospheric pressure, (case. 2) helium leak test of vacuum pressure

3. Test Results and Analysis

3.1 Result of Pressure Drop Test

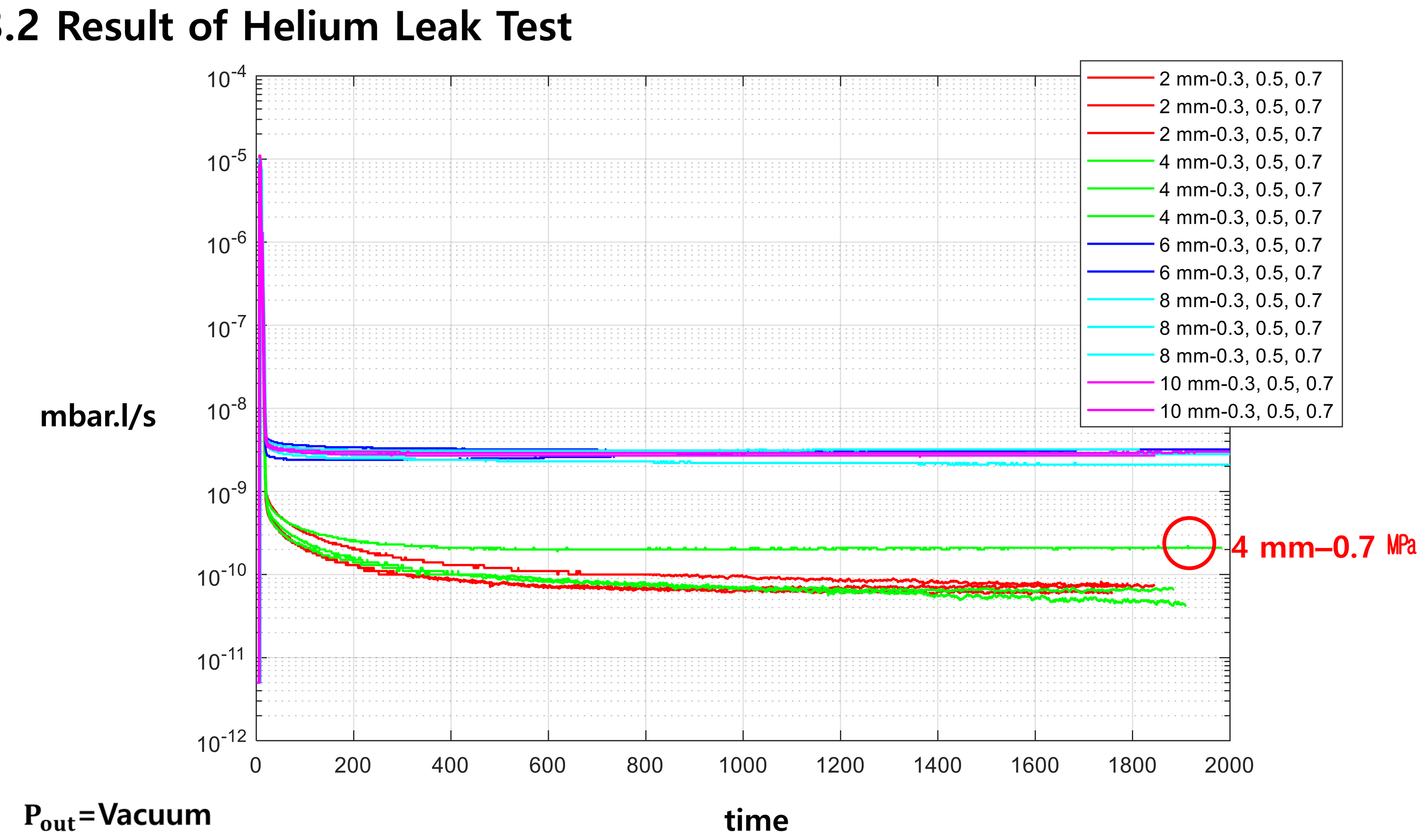
Displacement / Pressure	2 mm	4 mm	6 mm	8 mm	10 mm
0.4 MPa = 3000 Torr	-	-	0.39 MPa 32.7 lusec	0.29 MPa 359.8 lusec	0.2 MPa 654.1 lusec
0.6 MPa 4500 Torr	-	-	0.58 MPa 65.4 lusec	0.44 MPa 523.3 lusec	0.21 MPa 1275.6 lusec
0.7 MPa 5250 Torr	-	-	0.67 MPa 98.1 lusec	0.48 MPa 719.5 lusec	0.31 MPa 1275.6 lusec

P_{out}=1 atm

Table. 1 Result of Pressure Drop Test at atmospheric pressure

- There is no change in leak rate up to sliding displacement to 4 mm, and a change occurs from 6 mm.
- As displacement increases, release rate increases resulting in low residual pressure.

3.2 Result of Helium Leak Test



P_{out}=Vacuum

Fig. 4 Vacuum Pressure Test with Injected Helium Result

- There is no change up to 0.5 MPa for a sliding displacement of 4 mm, and the release rate changes from 0.7 MPa.

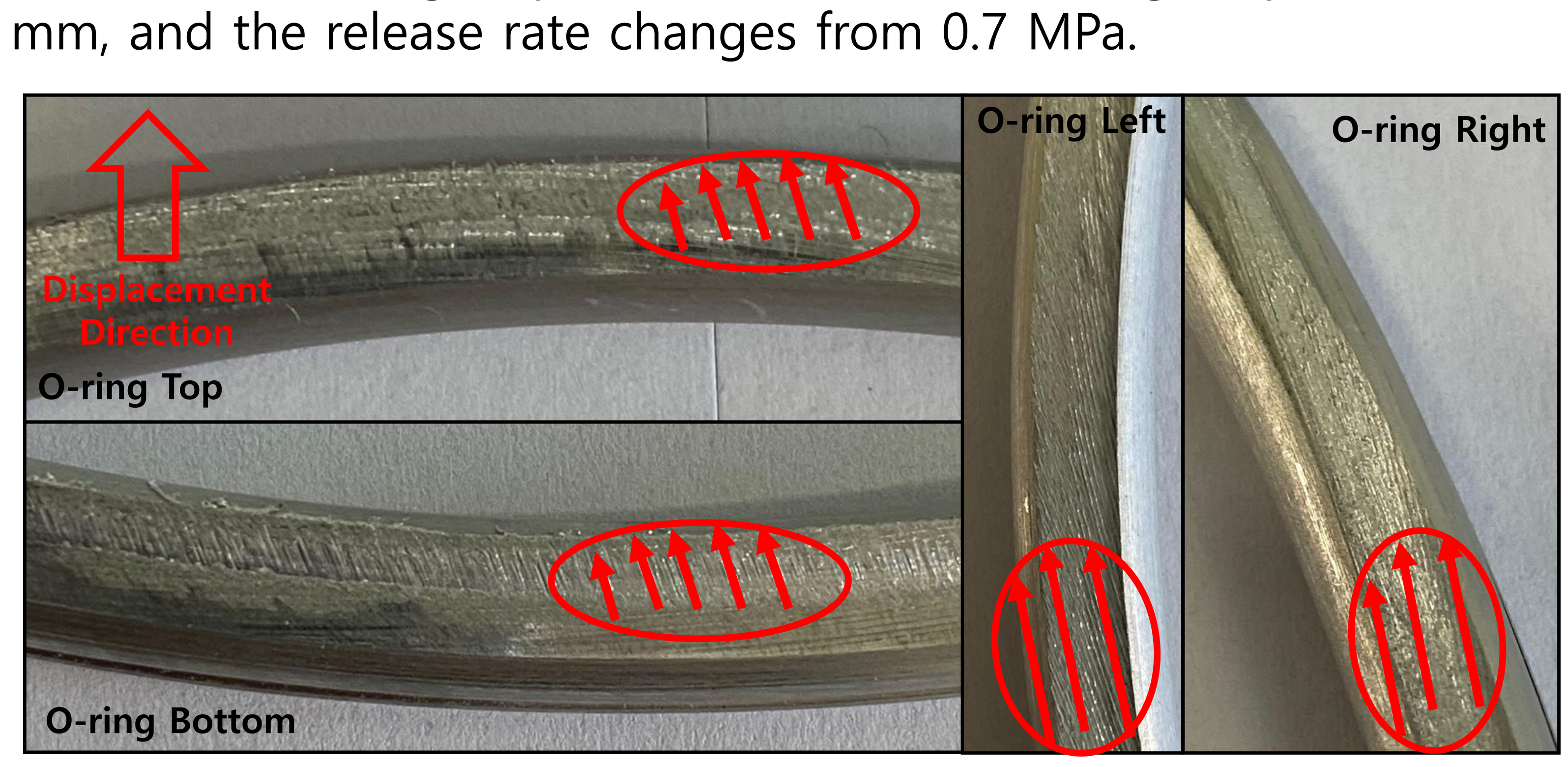


Fig. 5 O-ring after differential pressure test by applying displacement

4. Conclusion

- When a gas differential pressure test is performed at three different pressures, the release rate and release diameter for liquid medium can be calculated through the following equations.

$$Q_L = 9.5\frac{\eta_g}{\eta_L}\Delta P_L \frac{(P_B-P_A)(Q_{gC}-Q_{gB})-(P_C-P_B)(Q_{gB}-Q_{gA})}{(P_C-P_A)(P_C-P_B)(P_B-P_A)}$$

$$D = 31\sqrt{\frac{T}{M}\left\{\frac{P_B\left(Q_{gC}-Q_{gA}\right)-P_A\left(Q_{gC}-Q_{gB}\right)-P_C\left(Q_{gB}-Q_{gA}\right)}{P_A^2\left(Q_{gC}-Q_{gB}\right)-P_B^2\left(Q_{gC}-Q_{gA}\right)+P_C^2\left(Q_{gB}-Q_{gA}\right)}\right\}}\,\mu$$