

## Leak Rate Tests of Full Scale Elements of Prestressed Concrete Secondary Containments

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### Abstract

An experimental program is being performed to provide the utility industry with a test-verified analytical method for making realistic estimates of actual capacities and leak rates of reinforced and prestressed concrete containments under internal overpressurization from postulated degraded core accidents. Selected areas of the cylinder wall of prestressed concrete secondary containments have been identified as potential areas of distress and subsequent leakage during overpressurization. Three full-scale test specimens have been designed to examine the behavior and leakage characteristics of selected areas of secondary containment walls under biaxial deformation and internal pressure.

### 1. Introduction

Since the Three Mile Island (TMI) incident, scenarios with a potential for loss of coolant accident (LOCA) combined with hydrogen deflagration have become priority items. As a result, the need to evaluate behavior of nuclear containments under high internal pressures became apparent.

To investigate the behavior of containments subjected to overpressurization, the Electric Power Research Institute (EPRI) has undertaken a research program at Construction Technology Laboratories (CTL).

The overall objective of the EPRI program is to provide the utility industry with a test-verified analytical method for making realistic estimates of actual capacities and leak rates of reinforced and prestressed concrete containments under internal overpressurization from postulated degraded core accidents. These estimates are needed to perform plant-specific probabilistic risk assessments. Results from the overall test program are being used to confirm analytical models for predicting strength and deformations of containment walls in a separate parallel investigation sponsored by EPRI.

The overall test program being performed at CTL is described in Reference 1. Testing was initiated in 1981 and is currently scheduled for completion in 1985. Results of tests performed through mid-1984 are presented in detail in Reference 2.

## 2. Objective

Selected areas of the cylinder wall of prestressed concrete secondary containments have been identified as potential areas of distress and subsequent leakage during overpressurization. To examine the behavior of these areas under biaxial deformation and internal pressure, three specimens have been designed and will be tested as part of the program at CTL. The objective of these tests is to determine strength, deformation, and air leak-rate characteristics of full-scale wall elements from a prestressed concrete secondary containment.

## 3. Specimen Design

Each of the three wall element specimens represent a square piece of the cylindrical containment wall, as shown in Fig. 1. Two of the test specimens were 7 ft (2.1 m) sq and 3-1/2 ft (1.1 m) thick and one of the specimens was 11 ft (3.4 m) sq and 3-1/2 ft (1.1 m) thick. Reinforcement, liner plate, and tendon duct details were typical of current industry practice. Selected typical liner plate details were incorporated into each of the specimens. These details include liner plate welds, interrupted angle anchorages, and a large size penetration. The specimen with the 36 in. (914 mm) diameter penetration had typical details for interruption of the main reinforcement at the penetration. Tendon ducts were displaced to pass around the penetration. Welded studs were used for anchorage of the pipe penetration. A photograph of a test specimen is shown in Fig. 2.

## 4. Experimental Apparatus and Procedures

Biaxial load is applied on each specimen to both the reinforcement and the liner plate using the specially built test frame, as shown in Figs. 3 and 4. Loading is adjusted to ensure uniform strain across each face of the specimen as would occur on hoop or meridional planes in the containment. This is accomplished by varying the ratio of applied reinforcement load to applied liner plate load during the test. The ratio of total load in the hoop and meridional directions is adjusted continually during the test to follow a predetermined changing ratio of strains. The predetermined ratio of strains is intended to simulate conditions in the containment wall for increasing internal pressure.

A cross-section of a specimen with a penetration being tested is shown in Fig. 5. The dark-shaded specimen is in the center of the test frame. Biaxial loading rods are connected to reinforcement and to the liner plate that is on the bottom surface of the specimen. Loading rods are also connected to the penetration for application of outward force. The air pressure cavity below the specimen is sealed against the liner plate by two O-rings. The outer O-ring provides a buffer zone maintained at an air pressure equal to the pressure in the control cavity for security against O-ring leakage.

Air leak-rate tests are conducted while the test specimen is subjected to biaxial load. Air leak rate is measured by imposing a pressure on the surface of the liner plate and measuring the amount of air leakage, if any, through the liner plate. At successive stages of biaxial loading, air pressure is increased and a standard leak-rate monitor is used to determine if a leak has occurred. When a leak is detected, the leak-rate monitor is used to determine the rate of leakage at that biaxial load and at that pressure. A schematic of the

complete loading, leak rate, and instrumentation system for a typical specimen is shown in Fig. 6. The instrumentation records measurements of all loads, displacements, strains, air pressures, and air leak rates.

#### 5. Acknowledgment

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#### 6. References

1. Schultz, D.M., and Hanson, M.W., "Full Scale Leak-Rate Tests on Concrete Containment Wall Elements," Proceedings Second Workshop on Containment Integrity, Washington, D.C., June 12-15, 1984.
2. Julien, J.T., Schultz, D.M., and Weinmann, T.L., Concrete Containment Structural Element Tests, Volume 1: "Half-Thickness Element Tests - Description and Results," Volume 2: "Half-Thickness Element Tests - Detailed Test Data," Volume 3: "Liner-Plate Tests," report to the Electric Power Research Institute, Palo Alto, California, submitted by Construction Technology Laboratories, a division of the Portland Cement Association, Skokie, Illinois, November 1984, 104 pp. Available through Research Reports Center, P.O. Box 50490, Palo Alto, California 94303, Document EPRI NP-3774.

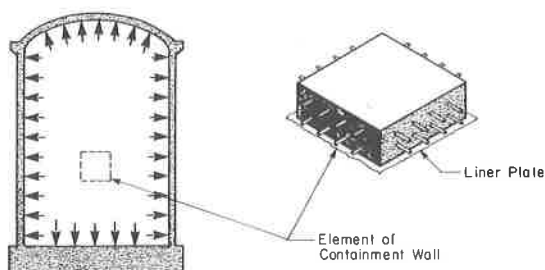


Fig. 1 Element of Secondary Containment Building

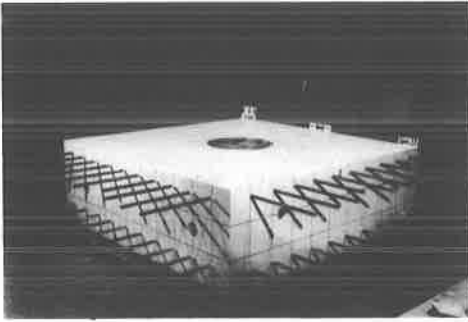


Fig. 2 Test Specimen

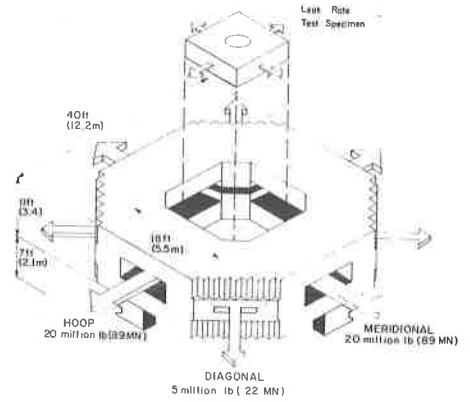


Fig. 3 Multi-Axial Test Frame

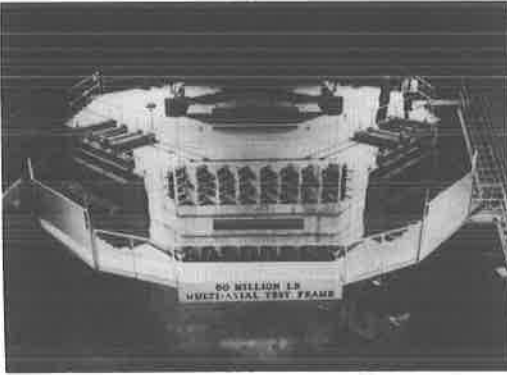


Fig. 4 Photograph of Multi-Axial Test Frame

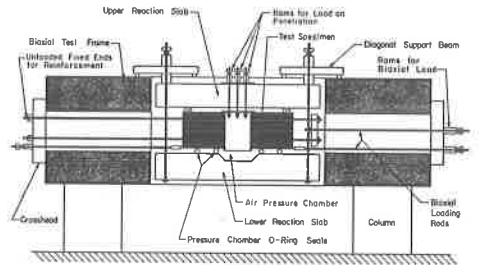


Fig. 5 Cross-Section of Specimen being Tested

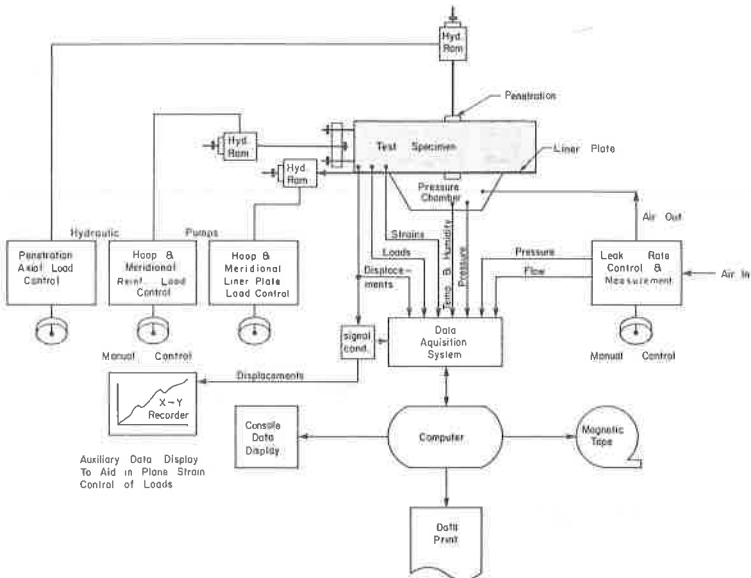


Fig. 6 Schematic of Testing Apparatus