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UNITED STATES
ATOMIC ENERGY COMM
WASHINGTON, D.C. 205

MAR 19 1974

L. Rogers, Director, Directorate of Regulatory Standards

SRI-1 ORNL V-5 INTERMEDIATE VESSEL TEST RESULT

This memo is the first of a series of memos to transmit safety research information (SRI) to you for assistance it may provide in regulatory use.

The importance of this first transmittal is that it presents experimental evidence that a "safe" failure-mode (leak-before-break) for reactor pressure vessels may exist. The existence of this mode has been a subject for speculation in the past, but this experimental evidence is the first.

The enclosed ORNL test result of V-5 intermediate vessel demonstrated that a leak occurred instead of a fracture break when the vessel was heated to 190°F and pressurized to 26,600 psi. Further analytical study to generalize this result is underway.

Herbert J. C. Kouts, Director
Division of Reactor Safety Research

Enclosure:
ORNL test result of
V-5 intermediate vessel

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March 5, 1974

Dr. H. J. C. Kouts, Director
Division of Reactor Safety Research
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Dr. Kouts:

Subject: Preliminary Test Results for Heavy Section Steel Technology Intermediate Test Vessel V-5

The sixth in a series of ten 6-in.-thick vessels, designated intermediate test vessel V-5, was tested under pressure overload on February 13, 1974. This vessel had a radial nozzle located at the midplane of the cylindrical barrel thereby providing a geometry typical of a heavy-section reactor vessel-nozzle junction.

The vessel was fabricated from ASTM A508 class 2 forging material in accordance with the requirements of Section III of the ASME Pressure Vessel Code. The cylindrical barrel of the vessel had a design pressure rating of 9700 psi. A fatigue sharpened flaw, 1.20 in. deep and 3.75 in. long at the base, was placed on the interior surface of the nozzle-cylinder intersection in the longitudinal plane. The size of this flaw was monitored during sharpening by ultrasonic techniques which were proven by post-test measurements to be very accurate in describing the actual flaw configuration. The attached composite photograph shows the vessel prior to test along with a section through the vessel giving the principal dimensions and the flaw location.

In the test the vessel was heated to 190°F and pressurized with water to a maximum pressure of 26,600 psi. At this pressure a leak occurred at the exterior of the nozzle cylinder intersection opposite the flaw. Data from a crack opening displacement gage and an ultrasonic pulse-echo system show that the flaw did not begin to grow significantly until the pressure reached 18,000 psi, and thereafter it extended in a stable fashion. At the peak pressure the flaw had opened approximately 1 in. at the inside surface as measured by the crack opening displacement gage.

A "leak-before-break" condition was achieved at the maximum pressure. Although the sharpened flaw extended through 8 in. of steel at the nozzle-cylinder intersection at the point of leakage, an unstable rapidly growing crack configuration did not occur. The leakage occurred in an innocuous manner, and it was initially detected by a slow pressure decay under continued pumping. The exact point of leakage was finally determined by visual observation of a small discharge of water that was emitted under 1,000 psi pressure. No obvious structural damage was apparent on the outside of the vessel. A post-test photograph will be supplied as soon as it is available; however, the appearance is unchanged except for superficial surface marks.

The test data are being analyzed in more detail and this must be considered as a preliminary evaluation of the experiment. However, the results of this test again demonstrate the capability of heavy-section light-water reactor pressure vessel steels to endure very large flaws without failure. The predictions of behavior using fracture mechanics methods were conservative relative to the pressure at the final overload leakage condition, and a comparison of energy density values between a similar region in a previously conducted model test and the intermediate test vessel using the equivalent energy method agreed within 7%.

It is obvious from the results of this test, as in the case of three of the five previous ones, when tests are performed under conditions such that upper shelf levels of toughness exist, crack growth occurs initially in a stable fashion and energy must be put into the system to extend the flaw. The flaw must become very large relative to the vessel dimensions before failure occurs and, in the case of vessel V-5, the decreasing stress-strain gradient in the nozzle corner provided a condition wherein critical flaw size for unstable growth could not be achieved before leakage occurred.

Sincerely,

DB Trauger

D. B. Trauger
Associate Director

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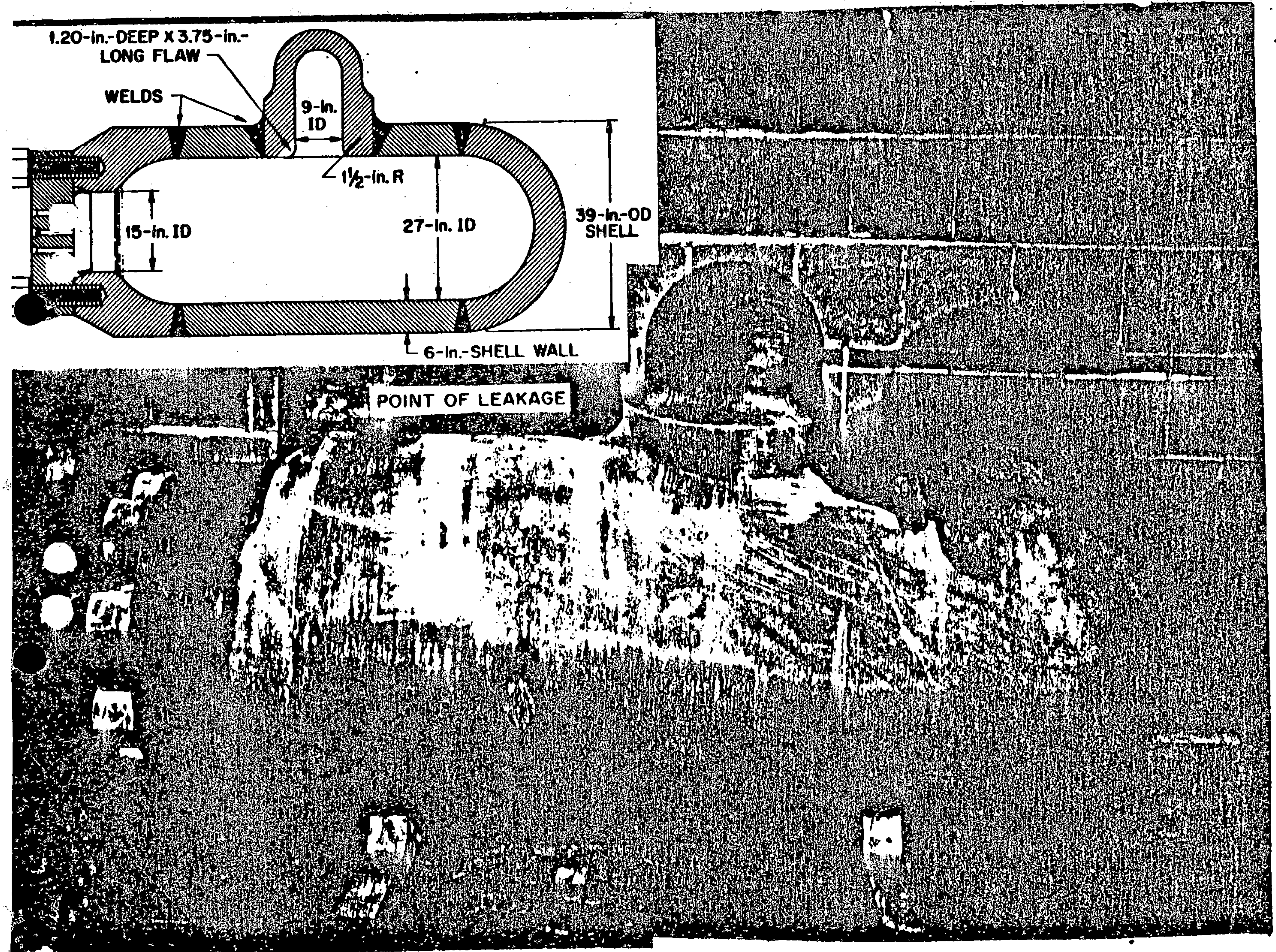

1.20-in.-DEEP X 3.75-in.-LONG FLAW
WELDS
9-in. ID
1½-in. R
15-in. ID
27-in. ID
39-in.-OD SHELL
6-in.-SHELL WALL
POINT OF LEAKAGE