

RIL #3

AUG 7 1974

L. Rogers, Director
Directorate of Regulatory Standards

SRI-3 ORNL V-7 INTERMEDIATE VESSEL TEST RESULT

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

The information transmitted in the enclosed letter from ORNL titled "Preliminary Test Results for Heavy Section Steel Technology Intermediate Test Vessel V-7," is of high value because it demonstrates additional experimental evidence that a "safe" failure mode for reactor vessels may exist, namely "leak-before-break." You will recall that earlier this year the HSST program showed leak behavior rather than fracture from a flaw in a nozzle corner in another vessel.

The present test result is of additional importance because the flaw was 18-inches long and five inches deep in the six inch thick pressure vessel wall. Despite the enormity of this flaw, the vessel still was able to sustain twice the design load prior to penetration of the flaw through the remaining thin ligament of vessel material. It is not likely that such a flaw could be undetected in a reactor vessel, but even if it were, this test shows that the reactor would require an overpressure of more than 100% of its design operating pressure before leakage would occur. Pretest predictions made of the failure pressure for this vessel and test conditions proved to be quite accurate even though linear elastic fracture mechanics were no longer strictly applicable to the material and testing conditions. The results of this test are under continuing analysis to further generalize the results for application to operational reactors.

Distribution:

Subject

~~EMER~~

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CHRON

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Sincerely,

Signed, H. J. C. Kouts

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

Enclosure:

ORNL test result of
V-7 intermediate vessel

cc: see next page

OAK RIDGE NATIONAL LABORATORY

01324

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July 24, 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-7

The seventh of the series of ten six-inch-thick pressure vessels was tested under pressure overload on June 19, 1974. The purpose of this test was to determine the performance of a thick-walled pressure vessel containing a long surface crack that extended nearly through the wall. The vessel had a longitudinally oriented external flaw located in the cylindrical portion of the vessel that was 18.6 inches long by 5.3 inches deep which had been sharpened by an electron beam welding and hydrogen charging technique. A copy of ORNL Dwg. 74-7166 is attached which shows a cross section of the defect in the vessel wall.

The pressure overload test was conducted with water at 196°F. A maximum pressure of 21,360 psi was achieved at which level leakage occurred through stable crack extension of the flaw through the vessel wall. The pressure fell to 18,600 psi and held as the flaw resealed itself. It was then necessary to vent through a relief valve to reduce the system pressure to atmospheric. The maximum pressure obtained was a factor of 2.2 over the design pressure of 9,700 psi for the cylindrical barrel of the vessel. The attached photograph which was taken after the vessel was removed from the test cell shows the flaw and the crack extension at the base of the machined notch which is visible as a contrasting line under the scale.

The fracture analysis procedure used by ORNL to predict the performance of this vessel was very accurate since the pretest prediction of failure was 20,800 psi which is within three percent of the failure pressure. This prediction was developed with the aid of test data from three 1/7-scale models of vessel V-7. It was found that linear elastic fracture mechanics calculations agreed with the model data when the fracture toughness of the steel was considered to be a function of the size of the unbroken ligament beneath the flaw.

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It is of interest to predict the behavior of a full thickness vessel using this method. Considering a vessel twice the thickness of intermediate test vessel V-7 - i.e., with a wall thickness of 12 inches - similar calculations indicate that a flaw of the same shape would have to exceed 10 inches in depth in order to result in crack extension at the maximum stress reached in vessel V-7. Therefore, comparable pressure overloads could be achieved before failure or leakage occurred.

This test demonstrates, as have the six previous ones on intermediate test vessels, the remarkable capability of these reactor pressure vessel steels to tolerate large defects. In the case of the test just completed, it has been shown that very large flaws which extend nearly through the wall do not result in failure at design pressure level. Further, with over pressure, an innocuous leak-before-break condition has occurred when the materials are operated in the ductile regime.

Sincerely yours,

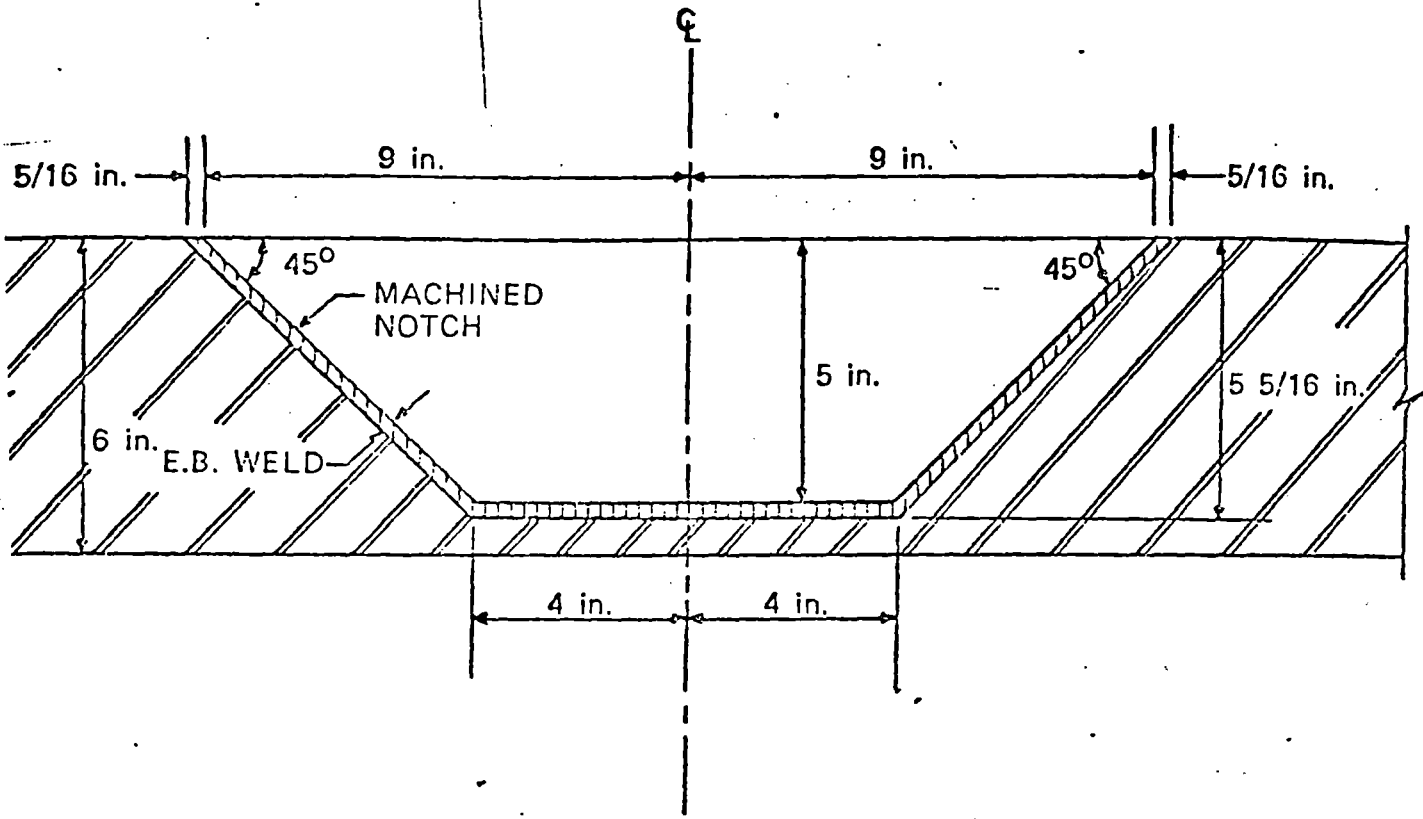


D. B. Trauger
Associate Director for
Reactor and Engineering Sciences

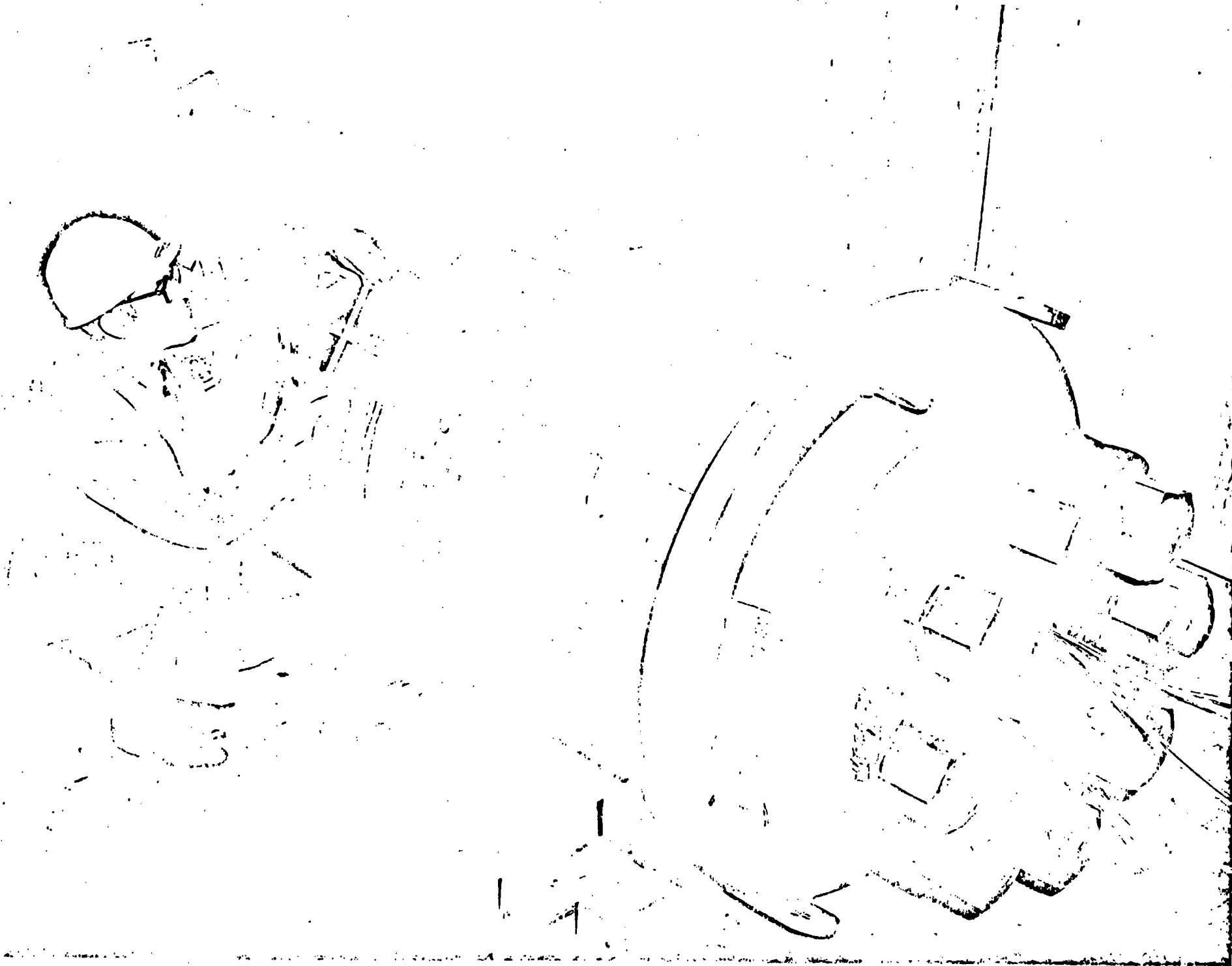
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Attachments



FLAW DESIGN FOR HSST PROGRAM INTERMEDIATE TEST VESSEL V-7



Intermediate Test Vessel V-7 After Completion of Test