FORMAL DOCKET

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON 25, D. C.

Docket No. 50-22

SEP 7 1960

Mr. E. T. Morris, General Manager
Westinghouse Testing Reactor
Westinghouse Electric Corporation
P. O. Box 1075
Pittsburgh 30, Pennsylvania

Dear Mr. Morris:

Enclosed herewith is an authorization to start-up and operate the Westinghouse Testing Reactor (WTR) in accordance with the provisions of License No. TR.-2 and certain additional conditions. The first of the conditions sets forth a table of minimum coolant flow rates to the core which must be observed by Westinghouse during operation of the WTR. The purpose of the minimum coolant flow rates designated in the enclosed authorization is to preclude any significant amount of boiling in the WTR core. It is our understanding that in accordance with your letter of July 11, 1960, you will not permit the boiling pattern set forth on the boiling detector noise level to be more severe than the pattern set forth in Figure 13, WTR-49, with a coolant flow of 8,000 gpm.

I am also enclosing an authorization to fuel and operate the modified high-pressure experimental tube in accordance with WTR-40.

Sincerely yours,

Harold Price, Director
Division of Licensing and Regulation

Enclosures:
As stated above

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UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

In the Matter of WESTINGHOUSE TESTING REACTOR	)	Facility License No. TR-2

Docket No. 50-22

Following an investigation of the incident which occurred at the Westinghouse Testing Reactor (WTR) on April 3, 1960, involving the partial destruction of a fuel element through overheating and subsequent melting, an Order was issued on June 30, 1960, to the Westinghouse Electric Corporation (hereinafter referred to as "Westinghouse") requiring Westinghouse to file certain information with the Atomic Energy Commission and prohibiting further operation of the WTR without the prior written approval of the Commission.

Westinghouse, has filed WTR-49, "Report on WTR Fuel Element Failure, April 3, 1960," dated July 7, 1960, and letters dated July 8, 11, 18 and 25, 1960, and August 15, 1960 in compliance with the aforementioned Order. The report and letters describe the incident and results of a metallurgical examination of the melted fuel element, corrective measures taken to prevent recurrence of the incident, inspection of fuel elements proposed to be loaded into the reactor, and changes made in the venting system for the process water head tank and the process water surge tank to protect against releases of fission products to the atmosphere.

Based upon a review and analysis of the aforementioned submittals, as reflected by the attached hazards analysis, prepared by the Hazards Evaluation Branch of the Division of Licensing and Regulation, there is reasonable assurance that the operation of the WTR in accordance with License No. TR-2, and the additional conditions set forth below, will not endanger the public health and safety and will not be inimical to the common defense and security.

In view of the foregoing, and in accordance with the aforementioned Order of June 30, 1960, approval of the modification of the venting system for the process water head tank and the process water surge tank proposed in the Westinghouse letter dated July 8, 1960, is hereby granted. Westinghouse is hereby authorized to load, start-up and operate the WTR with the modified venting system in accordance with License TR-2 and subject to the following additional conditions:

1. Westinghouse shall observe the following power-level minimum coolant flow conditions:

Thermal Power	Inlet Temperature °F	Minimum Core Flow GPM	(Approximate Total Coolant Flow GPM)
60 mw	140	11 200	16 800
60 mw	115	9 260	13 900
50 mw	140	8 200	12 300
50 mw	115	7 530	11 300
40 mw & below	140	6 530	9 800
40 mw & below	115	5 930	8 900

For operations at thermal power levels not specified above, temperature and flow conditions shall be determined by linear interpolation.

2. No fuel element shall be inserted into the facility unless it has been subjected to, and has passed, the fuel element inspection procedures set forth in WTR-[illegible], dated July 7, 1960.

FOR THE ATOMIC ENERGY COMMISSION

Harold L. Price, Director
Division of Licensing and Regulation

Dated At Germantown, Maryland
September 7th, 1960

HAZARDS ANALYSIS

by the

HAZARDS EVALUATION BRANCH

DIVISION OF LICENSING AND REGULATION

in the matter of

WESTINGHOUSE TESTING REACTOR

Introduction

On April 3, 1960 at approximately 8:40 p.m. a fuel element failure occurred in the Westinghouse Testing Reactor, resulting in a release of fission products to the primary coolant system and a discharge of some gaseous fission products to the atmosphere. The reactor was shutdown and the reactor core, including the damaged fuel, removed. Decontamination of the primary coolant system and the facility is now nearing completion.

On June 30, 1960, the Commission issued an order to the Westinghouse Electric Corporation requiring that Westinghouse: 1) not re-load or re-start the WTR without prior written approval of the Commission; 2) file a report of the April 3, 1960 incident with the Commission stating the corrective measures taken or to be taken to prevent a recurrence of the incident and including an analysis of the incident, the findings resulting from the metallurgical examination of the melted fuel element and the proposed inspection of fuel elements to be reloaded into the reactor; and, 3) submit plans for proposed changes in the venting system for the process water head tank and surge tank designed to protect against releases of fission products to the atmosphere.

In response to the Commission's Order, Westinghouse has subsequently filed WTR-49, "Report on WTR Fuel Element Failure April 3, 1960," dated July 7, 1960 and letters dated July 11 and 18, and August 15, 1960 which discuss the incident and certain corrective measures taken, and letters dated July 8 and 25, 1960 which discuss the proposed changes in the venting system.

We have reviewed the foregoing documents, the report of the incident by the AEC investigating committee, have visited the facility and held several discussions with WTR personnel on revised plans for operation. Following is a discussion of items of significance to the safety of the WTR operation which were disclosed by the incident of April 3, 1960.

Cause of the Incident

The incident was initiated by the partial destruction of one reactor fuel element through overheating and subsequent melting. The technical origin of the incident is not known with certainty, but it is likely that either or both of two factors played a major role: 1) defective metallurgical bonding of the fuel element; and, 2) inadequate coolant flow to the fuel element.

At the time of the incident an experiment was in progress in which the coolant flow through the reactor core had been reduced to promote substantial boiling in the core. Subsequent analysis of the thermal conditions which probably existed at the time of the incident indicate that a burnout of a sound fuel element due to excessive heat flux probably would not have occurred. The calculated minimum burnout ratio using Mirshak's correlation (DP-355) is approximately 2 in accord with the WTR license requirement for minimum burnout ratio.

There is good reason to believe that the element which did fail was defective. Subsequent ultrasonic examination of clean WTR fuel elements of the same batch as the failed element revealed that in 133 out of 235 fuel tubes there were areas of poor bonding larger than ½ inch in diameter, with several areas larger than 1 inch in diameter. If the failed fuel element contained a defective metallurgical bond as large as 1 inch in diameter, calculations indicate that it could have burned out at that local spot due to excessive heat flux. Burnout in this local spot could have caused mechanical distortion of the element, leakage of coolant flow, further overheating and melting of a substantial part of the element such as did occur.

It is not certain, however, that the incident was initiated by local boiling burnout due to a local bonding defect. One would suspect from the massive failure of the element and the conditions in WTR at the time of failure (low flow in the downward direction through the core and substantial local boiling) that the entire element could have progressively voided due to a hydraulic instability commonly known as "boiling disease" even in the absence of a local defect.

A satisfactory analysis of the hydraulic conditions existing in the core at the time of the incident cannot be made due to the lack of relevant experimental data in the range of WTR conditions. Calculations using Reynolds' data for local boiling pressure drop (ANL-5178) indicate that a parallel channel flow instability did not occur in the WTR at the time of the burnout. However, the conditions of Reynolds' experiments did not include conditions of coolant channel dimensions, coolant flow rates, flow direction, heat flux, or probably void fraction which existed in the WTR at the time. It has not been established either that Reynolds' correlation does or does not apply, but the differences between Reynolds' experiments and WTR conditions probably causes substantial limitations in the applicability of the method to the WTR. In a recent paper (L. Bernath, A Theory Of Local Boiling Burnout and Its Application To Existing Data, presented at the Third National Heat Transfer Conference, August 1959) Bernath points out that at low pressures and subcoolings the lifetime of bubbles both on the surface and in the stream become appreciable, and under these conditions, an appreciable bubble void fraction can be attained in narrow coolant passages at high heat fluxes. Such conditions have been observed in experiments at Argonne and Savannah River with coolant channels larger than those of WTR. It appears likely, therefore, that although local subcooled boiling existed in WTR at the time of the incident, the void fraction of the coolant in the element was larger than might have been suspected and this together with the unstabling effect of low flow velocities in downflow could have resulted in a flow instability, progressive voiding of the coolant channels, and overheating of the element even in the absence of a local defect.

Operating Modifications Proposed

If, as now appears possible, a parallel channel flow instability initiated the fuel element failure at WTR, we believe it prudent to restrict the future operation of WTR to substantial coolant flows through and insignificant amounts of boiling in the core until more information is available on flow instability in local subcooled boiling in narrow channels.

In their letter to the Commission dated July 18, 1960, Westinghouse has proposed in tabular form, a set of minimum coolant flow rates to the core for various reactor power levels and inlet coolant temperatures. These values were calculated on the basis that the surface temperature of the hotest fuel element in the core would not exceed the surface temperature required to initiate local boiling. The surface temperature in local boiling was calculated using the Jens and Lottes correlation (ANL 4627). We believe that the specified ratios between coolant flow and power level are conservative, and if followed during reactor operation should not result in any significant amount of boiling in the WTR core. This table of minimum coolant flow rates for various reactor power levels and inlet coolant temperature should be incorporated in the WTR license, with the notation that the values given for 40 Mw apply for power levels of 40 Mw and below.

Since there is good reason to believe that a defective metallurgical bond may have initiated the incident or contributed to the severity of the overheating of the element, Westinghouse has initiated more stringent fuel element inspection procedures for elements to be reloaded into the reactor. Details are contained in Report WTR-49 dated July 7, 1960 filed by Westinghouse. The Report indicates that the presence of any defects in the bonding between cladding and fuel to be reloaded in the reactor will be determined by ultrasonic means or by any better means which may become available, and fuel with defects larger than an equivalent diameter of approximately 1/8 inch will be rejected. The effect of defects smaller than 1/8" has been taken into account by a 10% hot channel factor which was used in the calculations to determine acceptable reactor power and coolant flow ratios discussed above. From a safety standpoint, we believe that these new procedures are adequate to assure that the fuel proposed to be reloaded in the WTR will be suitable for the modified operating conditions and procedures proposed.

Westinghouse has indicated in their letter dated August 15, 1960 that they intend to modify the WTR administrative procedures to provide for review of all reactor operating and experimental procedures by either the WTR Technical Support Group or the WTR Safeguards Committee. We believe that this change will serve to strengthen the administrative procedures for the facility in that it will provide an independent technical review of all WTR procedures significant to safe operation of the reactor and its experimental facilities.

Head Tank Vent

The fuel element failure of April 3, 1960 disclosed a design deficiency of the facility in that gaseous activity was released to the atmosphere from the process water head tank vent which was not provided with an isolation valve. Westinghouse has proposed, in their letters to the Commission dated July 8 and 25, 1960, to install a motor operated valve in the head tank vent line. Closure of this valve will be actuated automatically by signal from the head tank radioactivity monitor or manually by the reactor operator. The alarm setting on the head tank monitor will be 1.33×10^{-2} $\mu c/cc$, set on the basis of standard calculations for atmospheric diffusion and measured diversity of wind direction, such that the concentration of airborne activity at the point of maximum ground concentration would not be expected to exceed 1×10^{-9} $\mu c/ml$ averaged over one year, as permitted by 10 CFR Part 20. Operating procedures for the WTR will require that if the head tank monitor should alarm, the operator will actuate closure of the head tank vent valve and shutdown the reactor. Automatic closure of the vent valve will be actuated at a measured concentration level approximately two orders of magnitude higher than the alarm setting. Thus, the valve would be closed automatically in the event of a sudden large increase in effluent activity level.

Since the normal activity level, primarily Argon 41, expected at the head tank vent during operation is approximately one order of magnitude below the specified alarm point, and the vent valve will be closed manually if the activity level should reach the monitor alarm point, with backup automatic closure to occur for higher levels, we conclude that the design and operating procedures proposed for the head tank vent system are satisfactory and that it is highly unlikely that persons in surrounding areas will be exposed to concentrations of airborne radiation in excess of permissible levels.

Conclusions

Based on our analysis of the course and consequences of the April 3, 1960 incident of the WTR, and the corrective measures in design, inspection and procedures taken or proposed to be taken by Westinghouse to prevent its recurrence, we have concluded that operation of the WTR under the proposed modified operating conditions will not result in undue hazard to the health and safety of the public.