**Cover Sheet for a Hanford
Historical Document
Released for Public Availability**

Released 1994

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DEC 13 1994

OSTI

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

(CLASSIFICATION)

DECLASSIFIED
WITH DELETIONS

HW-76794-DEL
UNDOCUMENTED

SERIES AND COPY NO.

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

DATE
February 1, 1960

RESTRICTED DATA

THIS DOCUMENT CONTAINS REFINANCING INFORMATION AS
DEFINED IN THE NATIONAL DEFENSE FINANCE AND CREDIT ACT OF 1954.
ITS TRANSFER TO ANY OTHER PERSON OR THE DISCLOSURE OF ITS
CONTENT IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED.

TITLE

SINGLE TUBE MELTDOWN INCIDENT

OTHER OFFICIAL CLASSIFIED INFORMATION

THIS MATERIAL CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U. S. C., SECS. 793 AND 794, THE TRANSMISSION OR REVELATION OF WHICH IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

AUTHOR

R. E. Trumble

ISSUING FILE

THIS DOCUMENT IS TO BE LEFT UNATTENDED OR WHERE AN UNAUTHORIZED PERSON MAY HAVE ACCESS TO IT. WHEN IN USE, IT MUST BE STORED IN AN APPROVED LOCKED REPOSITORY OR IN AN APPROVED GUARDED AREA, WHILE IT IS IN YOUR POSSESSION AND UNTIL YOU HAVE OBTAINED A SIGNED RECEIPT FOR CLASSIFIED FILES, IT IS YOUR RESPONSIBILITY TO KEEP IT AND ITS CONTENTS WITHIN THE LIMITS OF THIS PROJECT AND FROM AN UNAUTHORIZED PERSON. ITS TRANSPORT TO, AND STORAGE AT YOUR PLACE OF RESIDENCE IS PROHIBITED. IT IS NOT TO BE DISCLOSED. IF ADDITIONAL COPIES ARE REQUIRED, OBTAIN THEM FROM THE RELATED ISSUING FILE. PERSONS READING THIS DOCUMENT ARE REQUESTED TO SIGN IN THE SPACE PROVIDED BELOW.

[illegible]

ON 5/7/81
BY [Signature]
CLASSIFICATION/UNCHANGED

54-3000-052 (7-59) A.E.C.-G.E.-RICHLAND, WASH.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

(CLASSIFICATION)

DECLASSIFIED

Classification (Declassify) Authority

DECLASSIFIED

WITH DELETIONS

By Authority of DS Lewis
CG-NMP-1, 8-5-94
By J E Savely 8-5-94
Verified By PM Eck 8-5-94

HW-76 794-DEL

UNDOCUMENTED

February 1, 1960

DISTRIBUTION

1. JH Brown
2. PA Carlson
3. WD Gilbert
4. OH Greager
5. RE Trumble
- 6-7 ~~RE Trumble~~
7. *300 File*

~~This document contains restricted information as defined in the Atomic Energy Act of 1954. It is not to be disclosed or its contents made known to an unauthorized person is prohibited.~~

This document classified by:

RE Trumble

J. H. Brown, Manager
Process & Reactor Development
RESEARCH & ENGINEERING SECTION

SINGLE TUBE MELTDOWN INCIDENT

1. INTRODUCTION

In connection with design of rear face fittings for the plant-expansion study currently being conducted we have been asked to determine if rear face pressurization is required for safety reasons and if so, how much. Pressurization of the rear face piping would be used to provide sufficient reverse flow to prevent process tube burnout in the event of complete loss of coolant supply to a single tube by virtue of a front connector failure.

Consideration of the effectiveness of rear face pressurization, however, requires a more general look at the problem of single tube meltdown than that provided by considering front fitting failure alone.

2. SUMMARY AND CONCLUSIONS

A reactor can recover from a single tube meltdown incident and, upon completion of Project CG-791 (Reactor Confinement), significant contamination outside the project boundaries can be avoided. Thus the single tube meltdown falls in a class of incidents for which the protection to be provided can be evaluated by statistical means. (For an intolerable accident, protection must be provided at all costs, or the reactor shut down.)

Some degree of protection can be provided against tube burnout upon loss of a front pigtail by providing additional pressure at the outlet fittings. However, this pressurization cannot protect against a progressive failure of the fitting, or against tube parting, or tube plugging events which could also lead to meltdown.

DECLASSIFIED

MASTER

Her-76 794
February 1, 1960

DEL

UNDOCUMENTED

If it is assumed that one process tube will meltdown as a result of a pigtail failure during the life of the plant (200 reactor years), the cost of providing protection is one order of magnitude greater than the worth of protection. It is therefore recommended that rear face pressurization not be provided for the sole purpose of protecting against front fitting failure.

Recognition that protection, which is technically feasible, is not being provided for a relatively high probability accident carries responsibility for preparations for living with the event. An engineering study should provide general procedures for restoring a reactor to operation, proto-typical tools should be developed, and the economic incentive for providing aids to decontamination (such as coating the work area concrete with strippable plastic, and providing suitable drainage from the elevator pit to waste storage) should be evaluated.

3. DISCUSSION

3.1 Potential for Meltdown on Pigtail Failure

Process tubes having a rear header pressure of approximately 35 psig or greater at K's (approximately 32 psig at all others) are protected against burnout if the front connector (pigtail) discharges to the atmosphere. About 0.8 of the K tubes and 0.5 of the process tubes of each of the remaining reactors are subject to burnout on loss of a front pigtail. However, only about half of the tubes subject to burnout are also subject to tube and fuel meltdown. Thus about four-tenths of the tubes at the K-Reactors and three-tenths of the tubes at the other reactors are subject to meltdown on complete and instantaneous loss of a front pigtail. These conclusions are based upon tests performed in the Thermal Hydraulics Laboratories of HLO and obtain at present power levels.

As power levels are increased the required pressurization will increase and a larger fraction of the tubes will be subject to meltdown.

It should be emphasized that pressurizing the rear face will not provide protection against all types of front pigtail failure. A partial rupture could provide front header pressure equal to the rear header pressure. This would result in no flow through the process tube and lead to most rapid burnout and melting.

3.2 Alternate Sources of Protection

Other methods for protecting against process tube burnout resulting from front pigtail failure include:

DECLASSIFIED

New 76794
February 1, 1960

UNDOCUMENTED

- 1) Maintenance inspection and replacement schedules as currently in effect.
- 2) New design of front face fittings to reduce potential for failure.⁽¹⁾

In reference (1) a "captive" pigtail is proposed which appears to have greatly reduced potential for failure.

3.3 Other Sources of Meltdown

Providing rear header pressurization will not provide protection against tube plugging events or tube parting events such as might be caused by sticking gunbarrels.

Thus, providing pressurization of the rear crossheaders will provide only partial protection against front pigtail failures and no protection against tube plugging or tube rupture caused losses of coolant flow.

meltdown
A third alternate source of single tube meltdown would be loss of a front nozzle cap from equilibrium conditions. Protection against this type of failure would probably be provided by pressurization of the rear crossheaders although this event may result in expulsion of fuel elements into the front work area if tube powers are high enough that steam is rapidly formed within the active zone.

3.4 Consequences of Meltdown

In the event of establishing burnout conditions in a process tube due to loss of a front pigtail radioactive steam would issue from the broken front face fitting. After fuel jacket melting this steam would contain oxidized uranium and particulate fission products. The gaseous fission products (noble gases and halogens) would also issue with the steam. We would expect, therefore, to find gross contamination of the front face of the reactor and immediately adjacent work area spaces and general contamination along the ventilation air flow stream from the point of release of fission products into the filter building and filters.

The filtration to be provided by CG-791 will be adequate to prevent any release of particulate or halogen fission products from the stack which would be significant beyond the project boundaries.

(1) HW-63343, "Expansion Study - Header to Header Fittings", P.B. McCarthy, January 5, 1960 (Unclassified)

DECLASSIFIED

February 1, 1960

Rev-76 794 DEL

UNDOCUMENTED

3.5 Worth of Providing Rear Face Pressurization

We can approach an idea of the worth of providing protection against front fitting failure by estimating the number of incidents and their cost, and expressing this as an annual rate.

So far aggressive inspection and maintenance has prevented all but one front pigtail failure. This occurred at C-Reactor on ~~7-1957~~ 3/27/56. No fuel burnout occurred. Thus in over 100 reactor years of operation one front pigtail has failed. Combining this with the approximation that one half the process tubes are subject to burnout in the event of pigtail loss would yield an expectation of burnout due to pigtail loss of one in two hundred reactor years, or once in the life of the plant (8 reactors at 25 years each).

The K-Reactor meltdown incident cost about $\$0.5 \times 10^6$ and one month's downtime. This was a startup incident and involved very low exposure elements. It has been estimated (private communication, J.F. Music) that meltdown of a maximum exposure tube today would result in a direct cost of $\$5.0$ to 10.0×10^6 and six months downtime.

DECLASSIFIED
WITH DELETIONS

3.6 Cost of Protection

If the required pressurization is provided at the expense of flow reduction about 3-1/2% flow decrease will result.

Thus the cost of protection is one order of magnitude greater than the worth of the protection.

Feb 76 794 DEL
February 1, 1960

UNDOCUMENTED

As the power levels are raised the back pressures required to provide protection will increase, using current fittings. Specially designed fittings may well limit the increases in the cost of protection. However the ratio between cost and worth of protection is expected to increase as power levels increase.

3.7 Philosophical Considerations

The basic problem to be resolved is: "Is a single-tube meltdown tolerable from the point of view of off-site contamination and from the point of view of damage to a reactor." If so, the virtue of providing some degree of protection can be weighed against the cost and a decision reached on an economic basis using statistical, or "risk" calculations. However, if the meltdown incident is "intolerable", an acceptable degree of protection must be provided at any cost, or the reactor must be shut down.

Since the noble gas cloud (which is essentially all that would issue from the exhaust stack in the event of a single tube incident) would be dispersed and would yield only a one-shot gamma dose/ which would probably not be significant outside the project boundaries, and since there appears to be no doubt that it would be technically feasible to restore a reactor to normal operation after a single tube meltdown, it appears appropriate to "live with the possibility" without providing the partial protection against single tube burnout afforded by rear face pressurization.

However, if we agree to "live with" the single tube incident in spite of a reasonable expectation of its occurrence (say one chance in two that a tube will meltdown during the life of the plant) we must then evaluate what action should be taken to recover from such an event, and what methods of easing the recovery process can be economically taken in advance.

3.8 Action to Ease Recovery

Recovery from a single-tube meltdown incident could be greatly speeded up and the overall costs reduced if the following steps are taken in advance of the incident:

- 1) Make an engineering study to determine the general methods of procedure to restore a reactor to normal operation, and the tools required.
- 2) Provide and test prototype tools.
- 3) Determine the economic incentive for aids to decontamination such as:

DECLASSIFIED

J. H. Brown

-6-

Rev-76794 **DEL**
February 1, 1960

UNDOCUMENTED

- a) Coating areas of concrete with either an impervious material, or with a strippable plastic coat, and
- b) Provide appropriate drains from the elevator pit to a suitable contaminated waste storage facility;
- 4) Provide such aids to decontamination as may be justified.

ORIGINAL SIGNED BY
R. E. TRUMBLE

**R. E. Trumble, Supervisor
Reactor Engineering Unit**

RET:vb

DECLASSIFIED