NOTICE

CERTAIN DATA CONTAINED IN THIS DOCUMENT MAY BE DIFFICULT TO READ IN MICROFICHE PRODUCTS.

1/20-64415

DECLASSIFIED

[redacted]
(CLASSIFICATION)

DOCUMENT NO.

HW--64415

DE93 003943

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

[redacted]

TITLE

FLOW PROTECTION TRIP LIMITS OPERATIONAL CHARGE-DISCHARGE FACILITY - C REACTOR

☐ 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

F. W. Van Werner

ISSUING FILE

Received by OSTI

NOV 30 1992

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

ROUTE TO:	PAYROLL NO.	LOCATION	FILES ROUTE DATE	SIGNATURE AND DATE
300 File				

~~Classification Cancelled And Changed To~~

DECLASSIFIED

By Authority of CG-PR-2

D. L. Lewis 10-27-92

By J.D. Wells 11-3-92

Verified By P.M. Eick 11-4-92

REFERENCE COPY
RECEIVED 300 AREA
MAR 21 1960
RETURN TO
TECHNICAL INFORMATION FILES

MASTER

HW-3000-MD (3-57)

[redacted]
(CLASSIFICATION)

DISTRIBUTION RESTRICTED TO U.S. ONLY

DECLASSIFIED

[redacted]

DECLASSIFIED

No. 644
C. 1
9-19-58

[redacted]

FLOW PROTECTION TRIP LIMIT
OPERATIONAL CHARGE-DISCHARGE FACILITY - C REACTOR

A. INTRODUCTION

Because of wide variations in the venturi throat pressure, well beyond the panellit gage trip range, that occur during the sequence of operational charge-discharge, the panellit gage cannot be included in the scram safety circuit during the period of time that charge-discharge operations are being performed. In its stead, the function of the panellit gage is replaced, in an overlapping manner, by a tube inlet pressure monitor that is equipped with high and low pressure trip mechanisms that may be included in the scram safety circuit during the time that the panellit gage must be by-passed. The tube inlet pressure monitor is then used to provide the protection from unstable flow that is normally obtained with the panellit gage. This memorandum describes the manner in which the tube inlet pressure monitor trip points are to be determined and used. A more detailed document under preparation will describe the analytical methods used to arrive at these trip settings, the effect of the several variables, and the safety provided by the trips when called upon by flow reductions or other accidents.

B. DESCRIPTION OF THE CHARGE-DISCHARGE CYCLE

To understand some of the items to be discussed, a brief description of the steps involved in the operational charge-discharge of a process tube seems in order. These are as follows:

1. The charging machine is coupled to the front ball valve of the tube to be operated upon.
2. By means of an auxiliary high pressure (500 psig min.) water source, the interior of the charging machine magazine is pressurized to the pressure of the tube inlet pressure on the other side of the closed ball valve.

[redacted]

[redacted]

. The ball valve is then opened.

. The flow control of the auxiliary water addition system is operated to increase the tube inlet pressure to a value referred to as the Nominal Adjusted Tube Inlet Pressure (NATIP). As this pressure value is reached, the flow control valve of the auxiliary water system is locked and the hydraulic characteristic of the auxiliary water system then remains fixed throughout the remainder of the cycle. Because the Nominal Adjusted Tube Inlet Pressure is equal to or above the normal tube inlet pressure, the tube flow rate has been increased even though the flow that the tube receives from the normal process inlet connector has been decreased.

. The rear ball valve is then opened, flushing the fuel charge. At this time, the tube flow rate increases markedly and the portion of the flow that is supplied by the inlet connector increases until critical flow occurs in the flow meter (venturi). The remainder of the flow is supplied by the auxiliary water system. When the flow through the inlet venturi is at the critical value, the throat pressure is below atmospheric pressure. Because of the wide variations in this pressure, which is the same as manellit pressure, the manellit gage cannot be used during the charge-discharge operation.

. After the charge has been flushed from the tube the rear ball valve is closed. At this time, the tube inlet pressure rises to approximately 100 psi.

7. The downstream dummy pattern is then loaded from the charging machine, each dummy being singly flushed down the tube seating against the rear ball valve. Another increase in tube inlet pressure results because of the added hydraulic resistance.

DECLASSIFIED

[redacted]

DECLASSIFIED

3. The fuel slugs are then singly loaded from the charging machine, each flushing down the tube and seating against the dummy pattern or the preceding slug. The hydraulic resistance of the charge increases rapidly as the slugs are added and the tube inlet pressure rises rapidly at first then approaches the Nominal Adjusted Tube Inlet Pressure (NATIP) asymptotically. If the charge being loaded has identically the same hydraulic resistance of its predecessor, the inlet pressure after the final slug is charged will exactly equal the NATIP. Actually, this pressure will be slightly different than the NATIP because of differences in film and slug dimensional variations.

4. The front ball valve is then closed and the auxiliary water system is depressurized.

5. The tube inlet pressure of the new charge is compared with that of the pre-existing charge when both are being supplied with water only through the inlet connector, and if only a nominal variation exists the charging machine is uncoupled from the inlet ball valve nozzle -- and the operation is complete.

The feature making the system different from other process tubes is the addition of the auxiliary water. The tube can, and is, now supplied by two water sources; the normal inlet connector and the auxiliary system. If an event occurs in the tube, such as a plugging or boiling of the coolant flow, both these flow sources are affected. Because of its higher pressure the auxiliary system is least affected and under these circumstances the flow is decreased in the inlet connector, and may be even stopped or reversed if the plugging event is sufficiently severe. The presence of the inlet connector then acts to "mush" the inlet pressure increase accompanying a downstream plugging event and flow reduction. Because of the flow pressure loss relation-

in the inlet connector, in the region of small flow through the connector rather large changes in flow can occur with little change in the pressure loss of the connector or with little change in inlet pressure.

C. SUMMARY OF LIMITS

1. Tube outlet temperature limit, during charge-discharge operations, is the normal instability outlet temperature limit.

2. Low Tube Inlet Pressure Trip

The low tube inlet pressure trip shall be 10[illegible] psi below the instantaneous tube inlet pressure.

3. High Tube Inlet Pressure Trip

High Trip = 1/2(HP + NATIP), where HP is the associated front crossheader pressure.

a. When initial charge and its replacement are of the same composition and length; or

b. When the auxiliary water flow is readjusted prior to recharging so that the NATIP is reached at the end of the charging cycle; or

c. When, in the case of discharging and recharging dissimilar fuel charge compositions, the tube inlet pressure is adjusted before discharging to a value above or below the NATIP so that the NATIP is reached at the end of the charging cycle.

4. Pressure Ranges of Trip Validity

a. Front Crossheader Pressure: 300-41[illegible] psig

b. Auxiliary Water Supply: [illegible] psig minimum.

c. NATIP [illegible] HP minus [illegible] psi.

DECLASSIFIED

[redacted]

Rev 6/4/75

DECLASSIFIED

. DISCUSSION

1. Outlet Temperature Limit

The bases for the trip pressures, described here, are the same as those for the more conventional panellit gages -- that is, the trip will occur at a point when the flow reduction, due to either upstream or downstream flow blockage or loss, will still permit adequate cooling of the charge following a prompt reactor shutdown. The "tolerable" flow reduction used here is thirty percent of the normal tube flow rate, as it is in the more conventional instability limits. Hence, there is no reason to prescribe any tube outlet temperature limit other than the normal instability limit tube outlet temperature. This, of course, applies from the standpoint of flow stability and continuity, and the presence of lower limits (TOA corrosion, etc.) should be recognized.

2. Nominal Adjusted Tube Inlet Pressure (NATIP)

~~Through~~ With the use of auxiliary water addition, through the inlet ball valve, the nozzle or inlet pressure can be adjusted to predetermined values. This feature facilitates the specification of a single high pressure trip point for all process tubes regardless of charge or type of normal flow meter (orifice or venturi).

The Nominal Adjusted Tube Inlet Pressure, for routine operational charge-discharge operations, will be equal to, or higher than, the maximum normal tube inlet pressure of those tubes to be charge-discharged.

The normal tube inlet pressure may be found from the equations describing the inlet fitting pressure drops.

$$\text{Normal Tube Inlet Pressure} = H_1 - \left(\frac{F}{K_c}\right)^{\frac{1}{n}}$$

Where H_1 is the front crossheader pressure - psig
F is the tube flow rate - gpm
K_c and n are calibration constants for the ticular inlet fittings.

For the tubes now fitted with charge-discharge equipment, K_c = [illegible] and n = 0.512.

It will be seen from the equation, that the maximum normal tube inlet pressure will be obtained in the lowest flow tube, if all crossheader pressures are approximately the same.

To assure that a sufficient increase in the tube inlet pressure will occur, in the event of flow blockage at a downstream location, a minimum pressure change per percent inlet connector flow change is specified as [illegible] psi per percent change in flow. This acts as a restriction upon the maximum Nominal Adjusted Tube Inlet Pressure. Without this restriction, it would be possible to operate the facility in such a manner that large changes (decreases) in tube flow rate could occur with little change in inlet pressure and little high pressure trip protection.

The pressure change with flow rate change may be found in the following manner:

$$\frac{d(\text{[illegible]})}{\%\ \text{flow change}} = \frac{F^{1/n}}{100.n.K_c^{1/n}}$$

F is the inlet connector flow at trip in gpm.

It can be shown that, to meet the requirements above, the NATID must be not less than [illegible] psi below the front crossheader pressure. This restriction

DECLASSIFIED

DECLASSIFIED

[redacted]

Hr 64/413

is arbitrary, but is based upon assuring trip response by the high tube inlet pressure mercoid. Laboratory tests, now being scheduled, will define more precisely the proper degree of compensation for the "mushy" pressure response as the tube inlet pressure approaches front crossheader pressure.

Trip Settings

a. Low Inlet Pressure Trip

Through the use of a unique hydraulic memory feature, included in the charging machine apparatus, a following low pressure trip is provided that is based upon the instantaneous inlet pressure. With this feature, the low trip gradually increases as the inlet pressure rises due to the addition of fuel elements to the tube.

The following low inlet pressure trip should be set not more than 100 psi below the instantaneous tube inlet pressure. This trip setting assures a scram trip upon a flow reduction of thirty percent or less.

b. High Inlet Pressure Trip

As stated above, the addition of auxiliary water pressure makes possible the specification of a single high inlet trip pressure for all tubes to be operated upon. The high inlet trip pressure shall be set midway between the Nominal Adjusted Tube Inlet Pressure and the front crossheader pressure.

High Pressure Trip = 1/2(NA + NATIP)

The high pressure trip is valid for all operational charge-discharge operations provided that either:

1. The charge to be loaded has a hydraulic characteristic (same charge length and type of slugs) to that of the outgoing charge; or

2. The auxiliary water addition flow rate is first adjusted to cause the tube inlet pressure to equal the NATIP for the discharge

[redacted]

Hr-64415

and then is readjusted after discharge, but prior to charging a hydraulically dissimilar charge, so that the final tube inlet pressure at the end of the charging cycle will equal or exceed the MATI ; or

c. The auxiliary water addition flow rate is adjusted before charging to cause the tube inlet pressure to reach a pressure above or below the MATI, depending upon the types of charges being discharged and charged, so that at the conclusion of the charging sequence the tube inlet pressure equals or exceeds the MATI .

It is expected that options 1 and 2 above will ultimately become the routine procedures. However, to perform charge-discharge operations under the provisions of option 2 requires thorough calibration of the auxiliary water flow control equipment. To permit early operation of the equipment and to provide a means for the calibration to be performed the third method has been formulated. A more detailed discussion of the procedures involved is found in the following section.

Auxiliary Water Adjustment for the Discharge and Charging of Dissimilar Loadings

a. Replacing a Charge with one having lower hydraulic resistance

Under these circumstances (for example, replacing a solid slug charge with an lex slug charge or replacing a normal charge with one that is significantly shorter) the initial adjusted tube inlet pressure should be increased above the MATI, so that when the new charge is inserted into the tube the tube inlet pressure returns approximately to the MATI and the High Inlet Pressure Trip will be valid for the new charge.

If the expected flow of the tube with the new charge is less than 10 percent of the normal tube flow with its initial charge, the ...

DECLASSIFIED

[redacted]

DECLASSIFIED

discharge tube inlet pressure should exceed the normal NATI by the amount of 1 psi. Because of limitations upon the proximity of the inlet pressure to the high trip pressure, pressure increases above the NATI of greater than 1 psi are not practical.

b. Replacing a Charge with one having higher hydraulic resistance

To replace a charge with one of higher resistance (replacing IAF charge with a solid slug charge, or a short charge with a full length charge) the problem is to begin with an initial adjusted tube inlet pressure sufficiently below the Nominal Adjusted Tube Inlet Pressure that the new charge will cause the inlet pressure to return to the NATI. The attached figure describes the difference in pressure between the initial adjusted inlet pressure and the NATI in terms of the ratio of the expected flow with the new charge to that with the initial charge, that may be expected to cause the final tube inlet pressure to equal or slightly exceed the NATI.

c. Ranges of Pressure for which limits are valid

All limits above are valid over the range of crossheader pressures analyzed to date, that is over the range [illegible] to 41 psig.

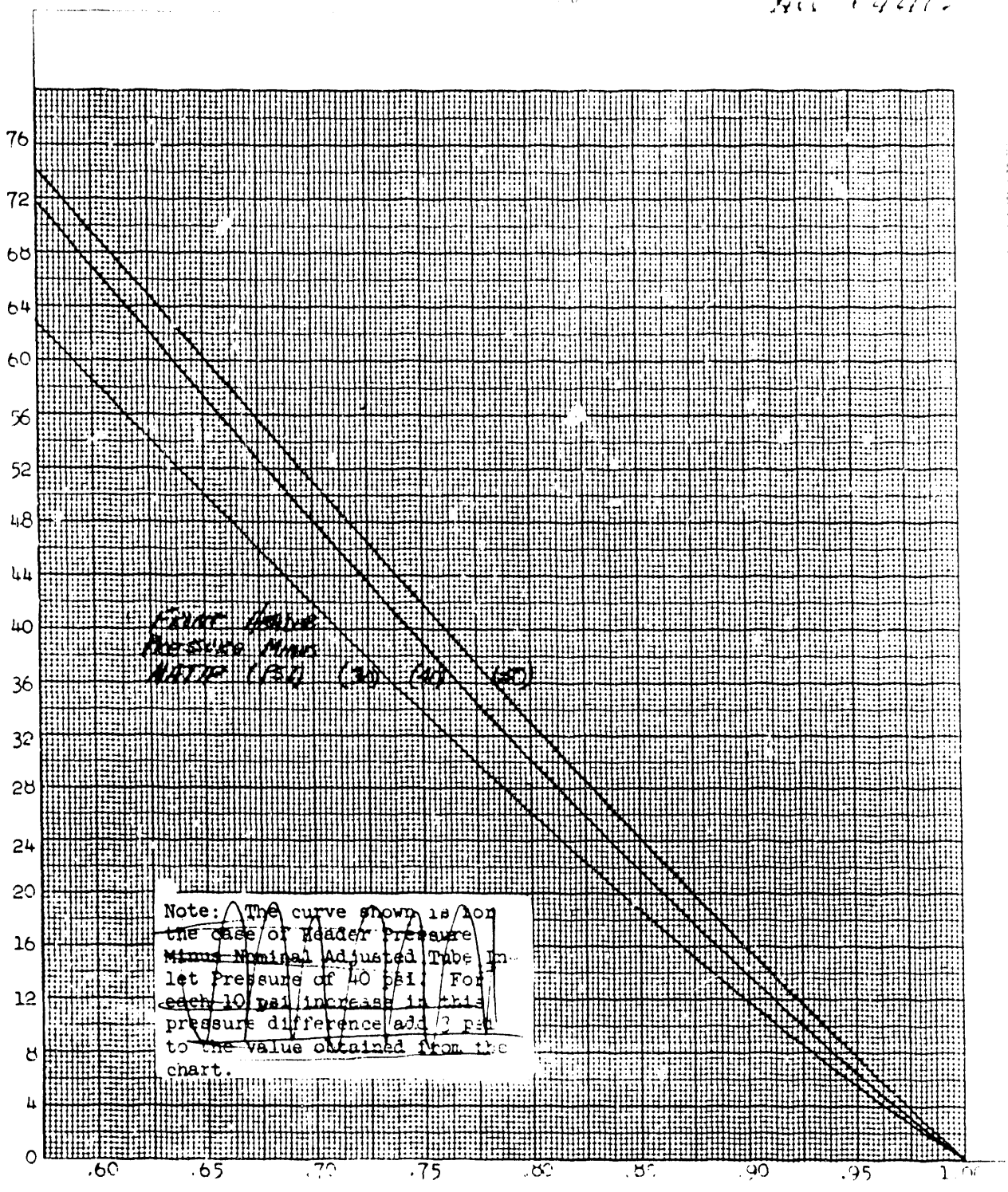
The limits are further valid for auxiliary water addition source pressure of 525 psig or higher. Although the limits should be relatively insensitive to pressures moderately lower than this value, these cases have not as yet been analyzed.

rw Van Wormer/cn

Distribution
[redacted]
Wm Marty
CO Lewis-JR Pierce
MP Moon-J Thompson
JF Music
RW Reidel-KT Leitz
[illegible] Trumble
RW Van Wormer
RC Wood

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, makes 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.



Ratio of expected [illegible] to normal flow with original charge.

DECLASSIFIED

END

DATE
FILMED
02/19/93