1 of 1

HW-44473

Cover Sheet for a Hanford Historical Document Released for Public Availability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

Battelle

DECLASSIFIED

[redacted]
(CLASSIFICATION)

DNM-RC

GENERAL ELECTRIC

HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

CIRCULATING COPY
RECEIVED 700 AREA
AUG 8 1956
RETURN TO
TECHNICAL INFORMATION FILES

DOCUMENT NO.
HW-44473

DATE July 9, 1956

COPY NO. AND [redacted]

1 [redacted]

FILE DESIGNATION

[x] RESTRICTED DATA
THIS DOCUMENT CONTAINS RESTRICTED DATA AS DEFINED IN THE ATOMIC ENERGY ACT OF 1954. ITS TRANSMITTAL OR THE DISCLOSURE OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED.

[ ] 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.

TITLE

VENTURI THROAT DIAMETER AND PROCESS TUBE CONNECTOR CAVITATION ANALYSIS
CG-654

AUTHOR

W. J. Morris

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 IN 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	SIGNATURE	DATE
C. E. Bonham	11128	762 Bldg	C E Bonham	8-12-56

MASTER

[redacted]

C-3195-MS (11-54) AEC-GE RICHLAND, WASH.

[redacted]
(CLASSIFICATION)

DECLASSIFIED

[redacted]

This document consists of 13 pages. Copy No. 1 of 17 copies.

[redacted]

VENTURI THROAT DIAMETER AND PROCESS TUBE CONNECTOR CAVITATION ANALYSIS
CG-654

W. J. Morris
Reactor Design and Development
Design Section
ENGINEERING DEPARTMENT

July 9, 1956

[redacted]

[redacted]

VENTURI THROAT DIAMETER AND PROCESS TUBE CONNECTOR CAVITATION ANALYSIS, CG-654

DISTRIBUTION

1. C. E. Bonham
2. J. R. Carrell
3. A. B. Carson
4. L. G. Henke
5. D. S. Lewis
6. G. L. Locke
7. D. Marinos
8. W. W. McIntosh
9. W. J. Morris
10. H. L. Pringle
11. W. A. Richards
12. E. R. Rudock
13. M. H. Russ
14. H. F. Zuhr
15. 300 Files
16. File Copy
17. Extra

[redacted]

[redacted]

A. B. Carson, Head
Reactor Design & Development
Design Section
ENGINEERING DEPARTMENT

VENTURI THROAT DIAMETER AND PROCESS TUBE CONNECTOR CAVITATION ANALYSIS CG-654

INTRODUCTION

When a "K" type process tube is operated without a slug column, damage may take place in the connector because of the cavitation that originates in the venturi. Reported here is a study of this cavitation problem as related to CG-654 operating conditions. A series of curves were developed to present the effect of the venturi diameter on the venturi ΔP for instrument operation and on the cavitation problem at the higher flows which are experienced when the tube is operated without a slug column.

SUMMARY

From the curves presented, it can be seen that to prevent cavitation in a tube with no slug column with CG-654 conditions, a minimum venturi throat diameter of about .41 inches is needed for the aluminum case and .39 inches for the zirconium case. With these throat diameters the pressure drop in the venturi for instrument operation becomes 35 psi and 28 psi respectively. These instrument ΔP's are considerably smaller than those of "K" pile since the normal operating flows are less and the unloaded larger I.D. tube flow is higher. Thus, the cavitation is more severe than that of "K" pile. If, for instrument operation or for a different sensitivity, a larger ΔP is selected, then the venturi throat could be reduced to say a .30 inch throat diameter giving an instrument ΔP of 130 psi which would indicate that at no time a tube would be allowed to operate without a slug column in order to prevent the cavitation. Actual venturi throat diameter selection should consider unrecoverable pressure drop since this pressure drop is equal to approximately 20% of the pressure drop through the throat, and it can be shown that pumping costs are equal to about $.008/gpm/psi/year, the larger unrecoverable pressure drop through the .30 inch throat diameter ventur means that when based on a ten-year life, $44.50* more can be spent on the .41 inch throat diameter venturi instrument.

It is concluded that the ΔP's are so low for a venturi that will not cavitate when the tube is operated without a slug column that the venturi throat diameter should probably be based on instrument requirements. This

----

*See Appendix

[redacted]

DECLASSIFIED

[redacted]

cavitation problem of an unloaded tube will exist in all piles upon the completion of CG-558.

Figure 1 is a series of curves for various venturi throat diameters showing the instrument ΔP or pressure drop in the venturi throat for various flows. From these curves, figure 2 was developed which presents a plot of the pressure drop in the venturi throat for various venturi throat diameters at CG-654 flows. Also from figure 1, the curves of figure 3 are obtained. Figure 3 gives the flow at which cavitation will occur in the venturi for various venturi throat diameters at inlet pressures for the zirconium and aluminum cases of CG-654. Indicated on figure 3 are the CG-654 tube flows with no slug column which are obtained from figure 4.

Figures 5 and 6 are added to provide a quick check of the changes in velocity head with various tube diameters, flows and temperatures.

USE OF THE CURVES

Example 1. Given a desired ΔP of 100 psi for instrument operation. To find the venturi throat diameter, enter figure 2 at 100 psi instrument ΔP for CG-654 flows and for the aluminum case, read the venturi throat diameter of .32 inches. Check for cavitation on figure 3 by entering at venturi diameter of .32 inches and for the aluminum case, read the cavitation flow of 56 gpm. Thus, since the unloaded tube would have a theoretical flow of some 90 gpm, this venturi diameter will cavitate.

Example 2. Given a desired flow of 90 gpm at which no cavitation will occur. To find the venturi throat diameter and the instrument ΔP, enter figure 3 at 90 gpm and read the venturi throat diameter of .40 inches for the aluminum case. Enter figure 2 at .40 venturi throat diameter and read instrument ΔP of 40 psi.

It must be noted that because of the assumptions necessary to arrive at these curves, they are not highly accurate nor are they meant to be - rather, they are meant to be a useful aid in understanding the cavitation problem and selection of the venturi throat diameter. The ultimate selection must be based on experimental flow data.

In the following discussion, the methods used to obtain the curves are given in detail.

DISCUSSION

To obtain the curves in figure 1, first reference was made to HW-31992 which gives experimental curves for the pressure drop vs. flow of a "K" tube and the pressure drop vs. flow for the .37 inch "K" venturi[1].

---

(1) HW-31992, " 'K' Pile Tube Pressure Drop - Flow Characteristics", June 1, 1954, H. H. Greenfield

[redacted] DECLASSIFIED

[redacted]

Substituting this known data into the discharge equation for a venturi meter:[2]

$$Q = c \frac{a}{\sqrt{1-\left(\frac{D_2}{D_1}\right)^4}} \sqrt{2gh}$$

The coefficients of discharge which varies with Reynolds number, were established where:

Q	=	flow
D_2	=	venturi throat diameter
D_1	=	pipe diameter
a	=	area of the throat
h	=	difference in piezometric head between a section just before the reducing taper and the throat

Thus, with the coefficients of discharge established for a "K" type venturi the curves for figure 1 were obtained.

The design criteria for CG-654 establishes the process tube flow for aluminum process tubes as 29.8 gpm and 23.8 gpm for the zircalloy-2 process tubes[3]. The curves for figure 2 then are taken from figure 1, (the vertical dotted lines), at the designated flow rates giving the pressure drop of the venturi for instrumentation vs. the venturi throat diameters.

Figure 3 shows the flows at which cavitation will take place vs. the venturi diameters. These curves are derived by figure 1, (the horizontal dashed lines), since when the pressure drop through the venturi drops below the vapor pressure of the water, cavitation takes place. The design criteria places the inlet pressure for the aluminum case at 340 psi and for the zirconium case at 600 psi. With the inlet temperature at about 110° F., the vapor pressure of the water is about 1.3 psig. Thus, cavitation takes place roughly when the pressure drop through the venturi equals the inlet pressure.

Figure 4 is simply curves of pressure drop vs flow for the "K" process tube which is taken from experimental data and a "J" process tube loaded and unloaded based on theoretical calculations. Figures 5 and 6 are self-

---

(2) Engineering Hydraulics, Rouse
(3) HW-42116 RD, "Design Criteria for 105-J Reactors Fundamental Design Bases - J Reactor", May 18, 1956, E. R. Astley, R. J. Shields

[redacted]

[redacted]

explanatory and are included for ready reference.

W. J. Morris

Reactor Design & Development
Design Section
ENGINEERING DEPARTMENT

WJ Morris/cg

[redacted]

[redacted]

APPENDIX

Pumping Cost Calculations

$$1 \text{ gpm} = \frac{8.345 \ \#/\text{min.}}{60 \ \text{sec/min.}} = .139 \ \#/\text{sec.}$$

$$1 \text{ psi} = 2.3 \text{ ft.} \times .139 \ \#/\text{sec.} = .3197 \text{ Ft-}\#/\text{sec.}$$

$$\frac{.3197 \text{ ft} - \#/\text{sec.}}{737.7 \text{ ft} - \#/\text{sec./KW}} = .000433 \text{ KW}$$

$22.50 per EPA-KW Year x .000433 KW x 80% efficiency = $0.0078

26 psi - 7 psi = 19 psi

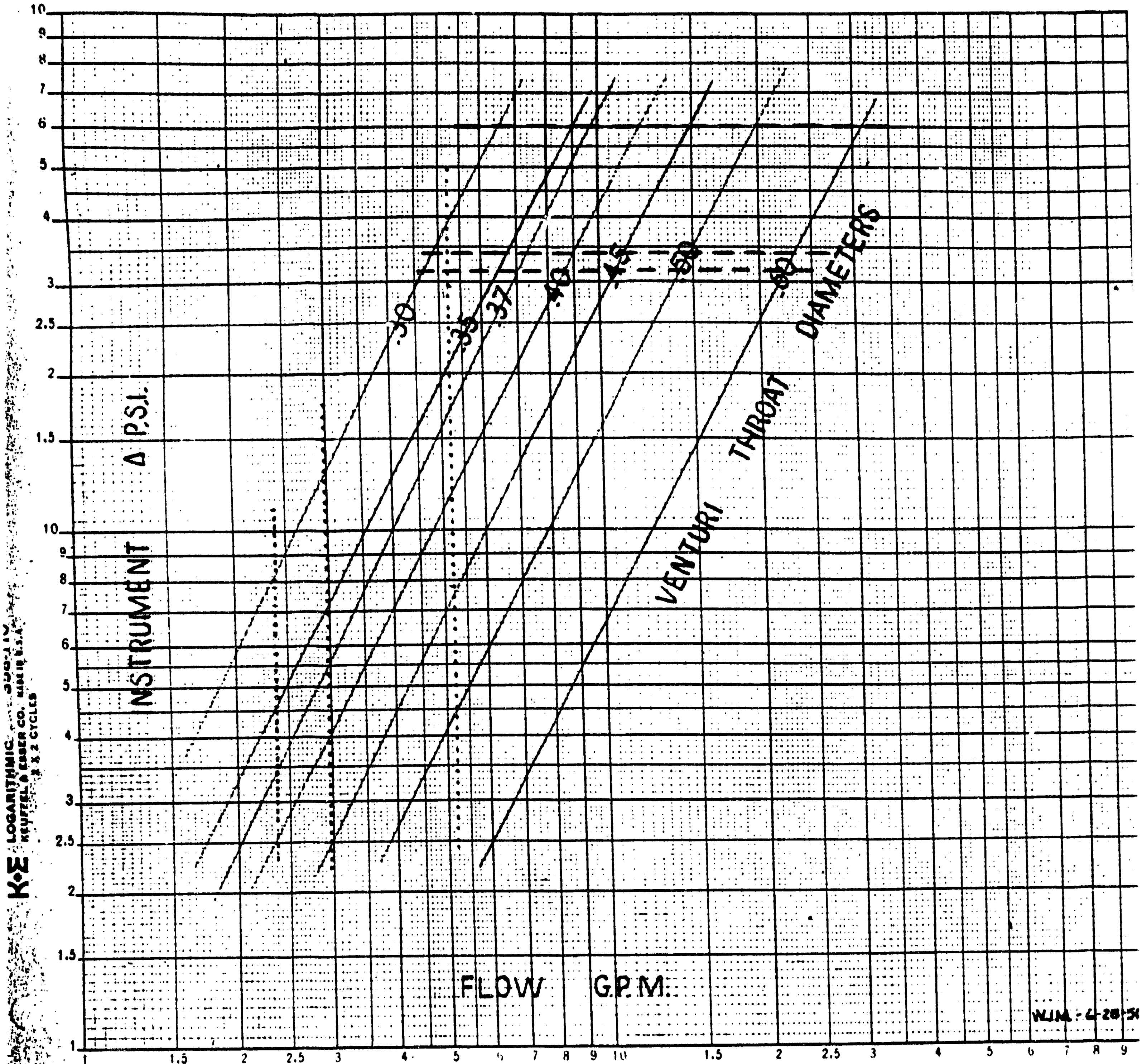
19 psi x 30 gpm x $0.0078 = $4.45

[redacted]

DECLASSIFIED

[redacted]

HW 44473
Page 8



DECLASSIFIED

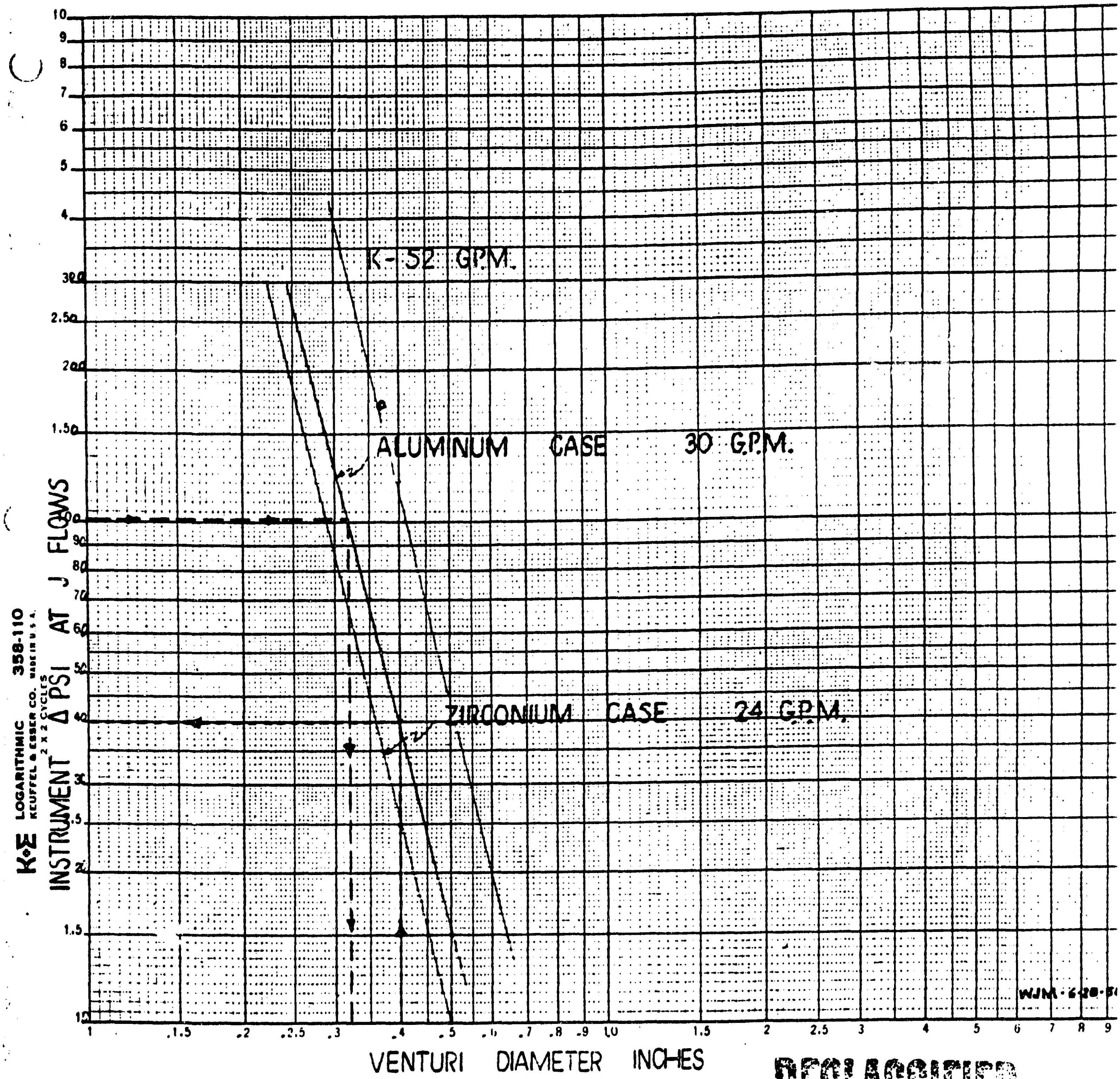
FIGURE 1

[redacted]

DECLASSIFIED

HW 44473
Page 9

[redacted]



DECLASSIFIED

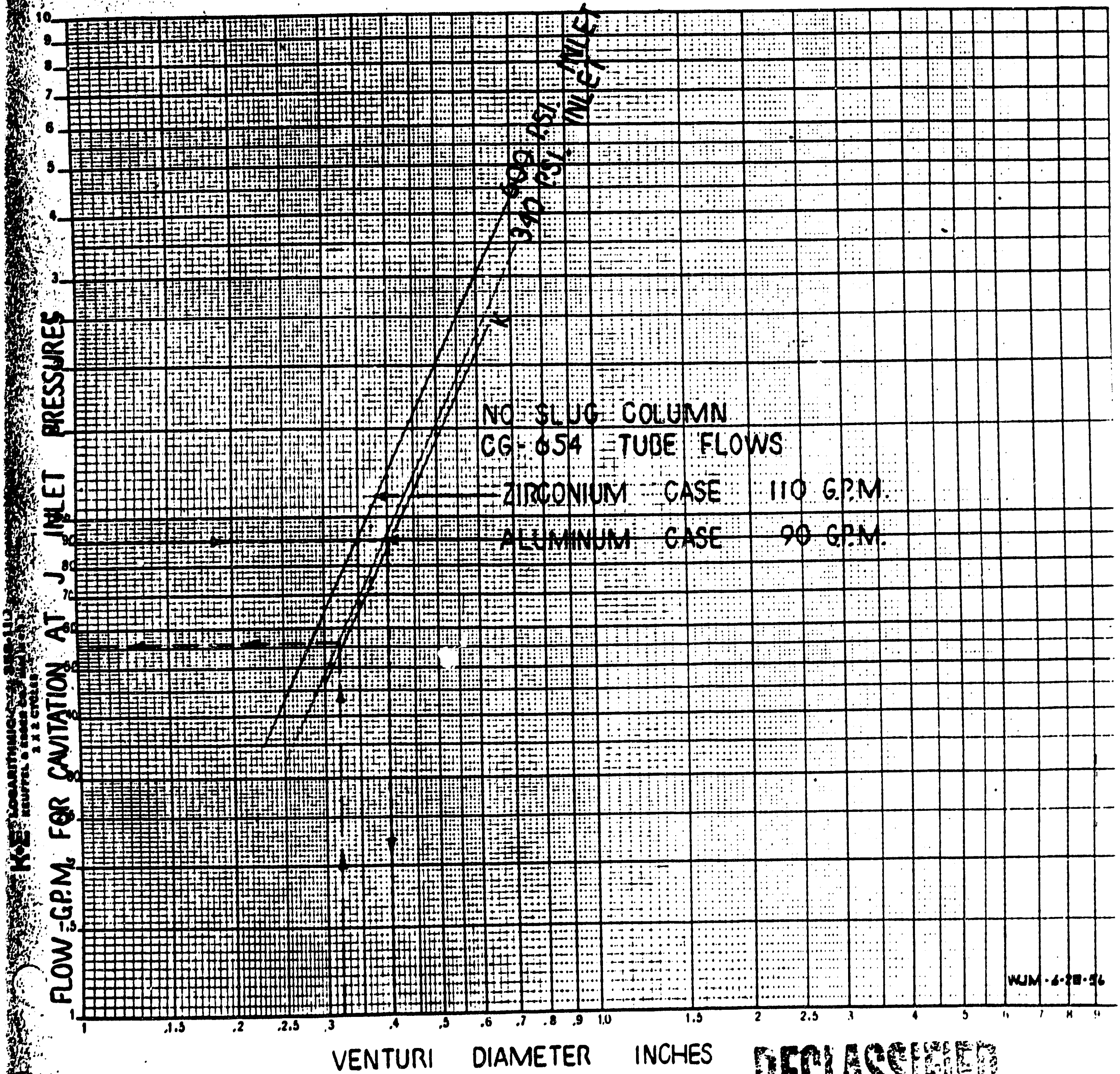
FIGURE 2

[redacted]

DECLASSIFIED

HW 44473
Page 10

[redacted]



DECLASSIFIED

FIGURE 3

[redacted]

DECLASSIFIED

HW 44473
Page 11

[redacted]

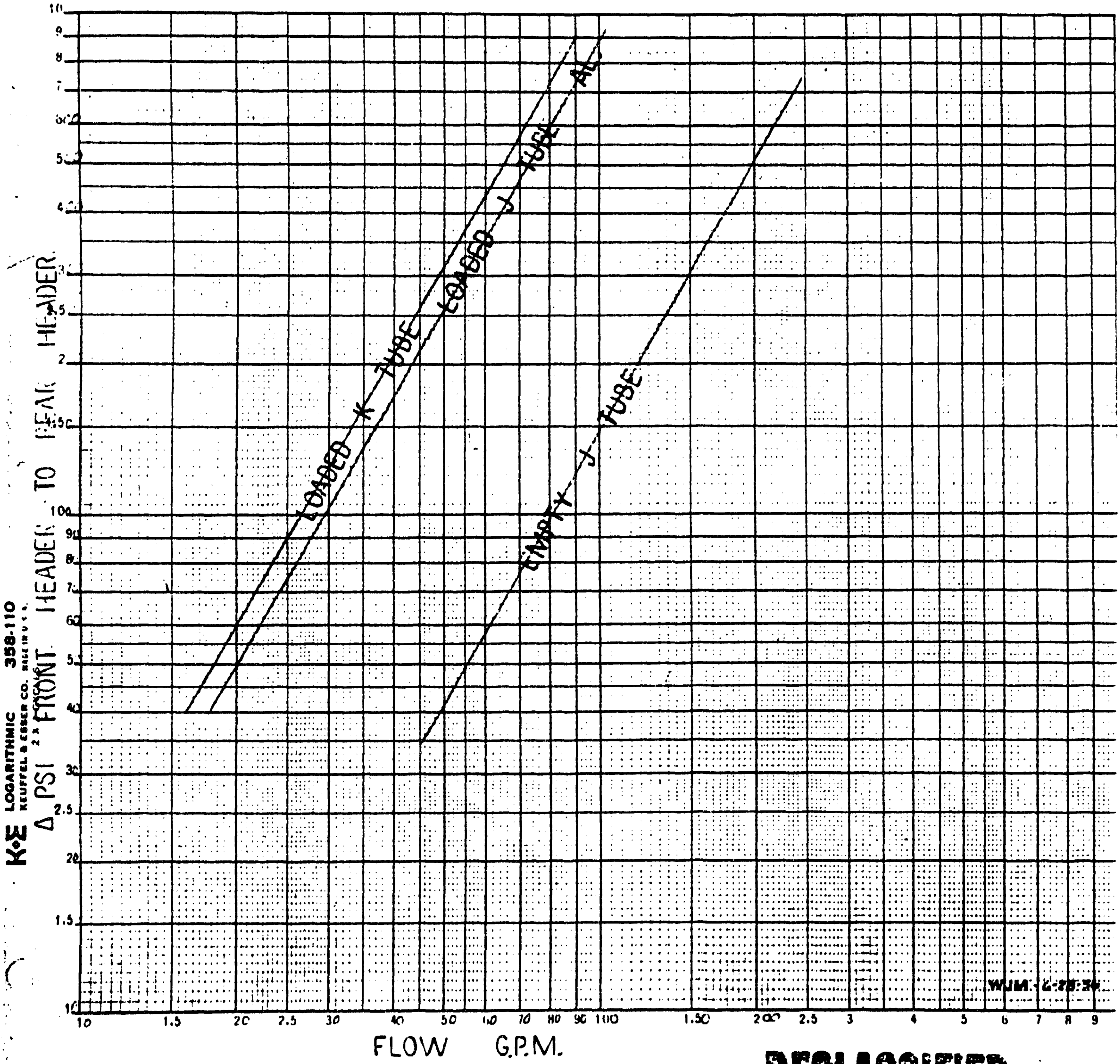


FIGURE 4

DECLASSIFIED

[redacted]

[redacted]

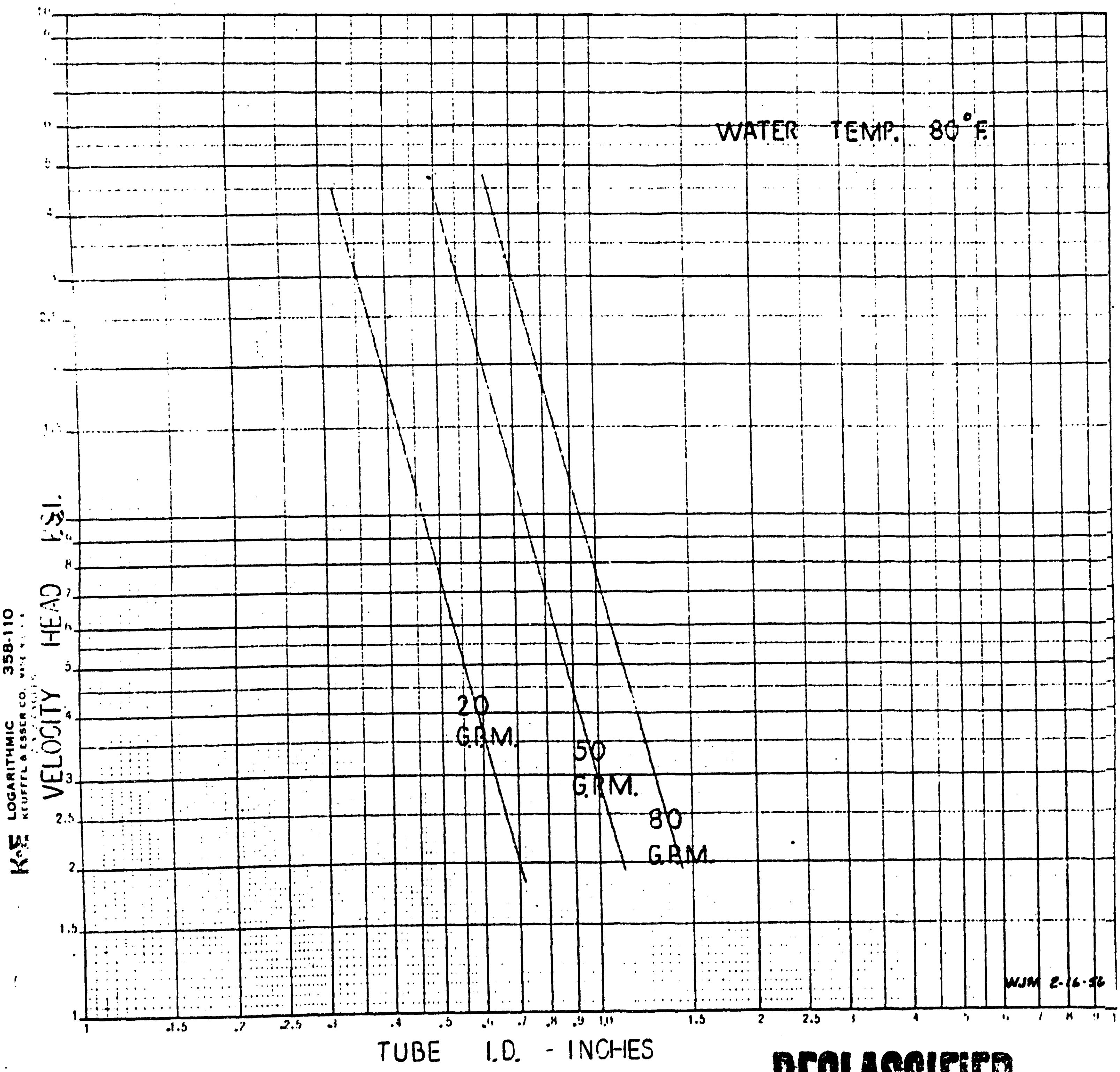


FIGURE 5

[redacted]

DATE
FILMED
9/30/94

END