UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SEP 30 1988

Docket Nos. 50-445
and 50-446

APPLICANT: Texas Utilities Electric Company (TU Electric)

FACILITY: Comanche Peak Steam Electric Station (CPSES), Units 1 and 2

SUBJECT: SUMMARY OF MEETING ON MARCH 21, 1988 - DEVELOPMENT AND ATTENUATION OF JETS FROM HIGH-ENERGY LINE BREAKS

The staff and applicant met previously on February 5, 1988 to discuss staff comments on Ebasco calculation CPE-SI-CA-000-645 Revision 0 for evaluating the attenuation of jets from high-energy line breaks at the CPSES.* The subject was reviewed by the staff during inspection of the systems interaction portion of the CPSES Corrective Action Program and as documented in NRC Inspection Report 50-445/87-37,50-446/87-28 dated February 8, 1988, the staff raised several technical concerns regarding misinterpretation of terms and limitations in the theory being used to calculate jet attenuation. During the February 5, 1988 meeting, the applicant committed to provide the staff with justification for the attenuation factors employed in the analysis of single-phase steam jets and two-phase flashing water jets. The applicant subsequently informed the staff by letter from W. G. Counsil to NRC dated February 18, 1988 (TXX-88227), that it was performing analyses to demonstrate the conservatism of the attenuation factors being used for the CPSES.

On March 21, 1988, NRC staff and its contractor met with representatives of TU Electric in Rockville, Maryland to continue discussions on this matter. The meeting notice and list of attendees are provided as Enclosures 1 and 2, respectively, to this meeting summary.

TU Electric and its contractor for systems interaction, Ebasco, wanted to get the staff's impression as to whether the analyses (to demonstrate that the jet attenuation factors being used at the CPSES are conservative) are headed in the right direction. Ebasco explained that its analyses are using an approximate method, based on NUREG/CR-2913, "Two-Phase Jet Loads" (1983), which extends beyond the physical and thermodynamic region of NUREG/CR-2913. (Enclosure 3 provides the applicant's handouts used during this discussion.) The staff and applicant discussed the fact that Working Draft 7 (1987) of ANS-58.2, "Design Basis for Protection of Light Water Nuclear Power Plants Against Effects of Pipe Rupture," endorsed the NUREG/CR-2913 method for steam and flashing water jets where initial fluid conditions are between 870-2466 psia and with subcooling no more than 126°F. Although some minor changes to the draft standard are expected before it is finalized, the staff indicated that it would review a methodology based on the draft.

*See "Summary of Meeting on February 5, 1988 - Development and Attenuation of Jets From High-Energy Line Breaks," dated March 17, 1988.

DF01
1/1

The applicant agreed to revise its jet modeling methodology using Draft 7 of ANS 58.2, submit corresponding FSAR changes to NRC for review, and reverify its analyses of all CPSES jets using the revised methodology. In the interim, the applicant agreed to provide the staff a description of the methodology to be used to validate all previously calculated jet loads and how any differences will be resolved.

original signed by:

Melinda Malloy, Project Manager
Comanche Peak Project Division
Office of Special Projects

Enclosures:
1. Meeting Notice
2. List of Attendees
3. TU Electric Handouts on Jet Impingement Loadings

cc: See next page

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DATE	:9/29/88	:9/30/88	:	:	:	:	:

OFFICIAL RECORD COPY

SEP 30 1988

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Enclosure 3

COMANCHE PEAK PROJECT

JET IMPINGEMENT

LOADINGS

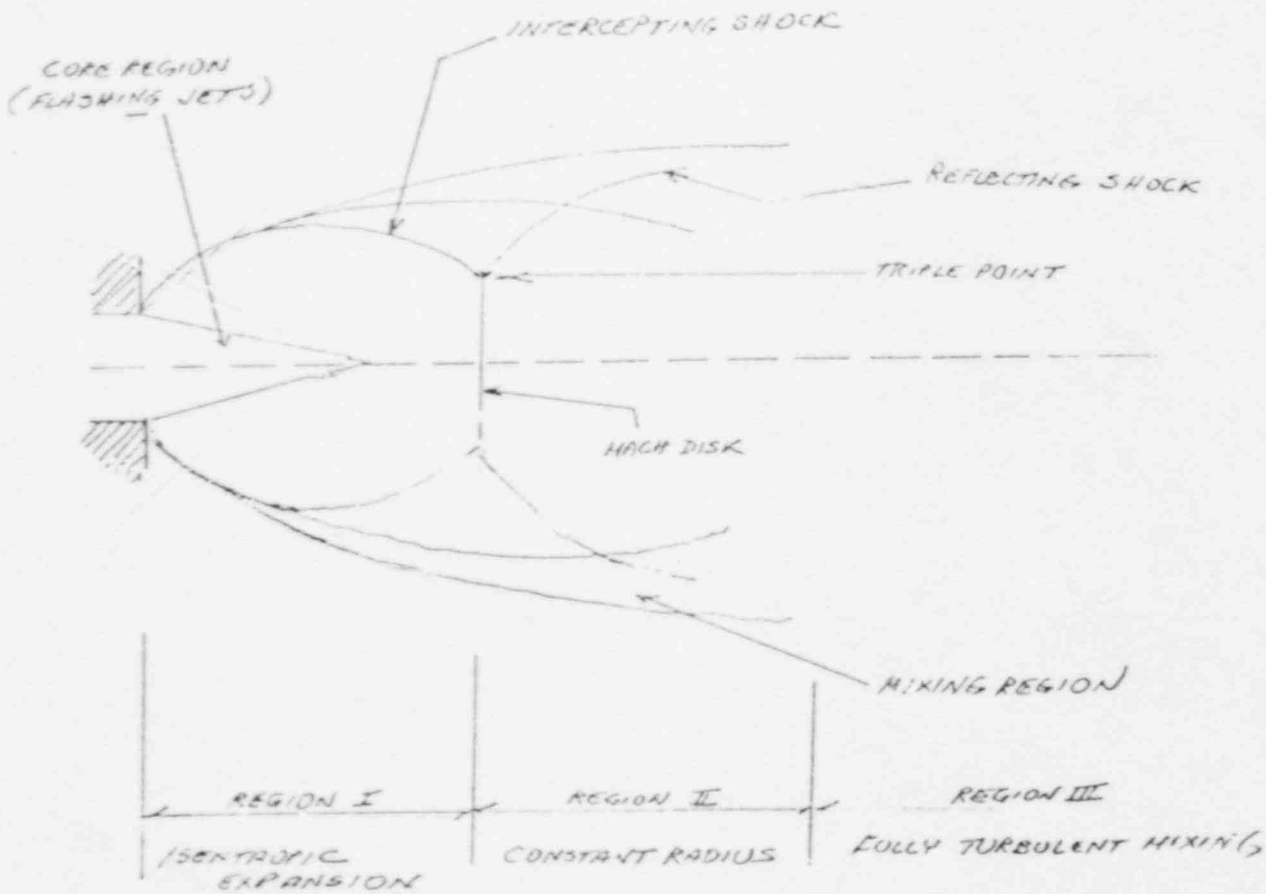
METHODOLOGY

- 0 USES APPROXIMATE METHOD BASED ON NUREG 2913

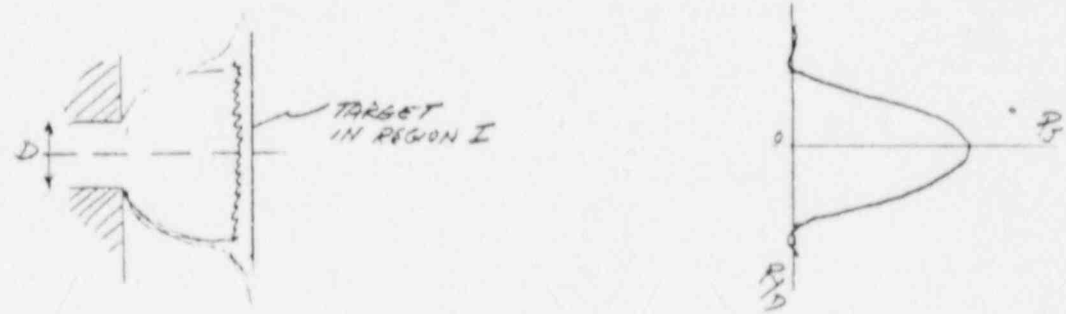
- 0 METHOD EXTENDS BEYOND PHYSICAL & THERMODYNAMIC REGION OF NUREG 2913

- 0 METHOD IS APPLIED TO BOTH SUBCOOLED (FLASHING TWO-PHASE) AND STEAM (APPROX. SINGLE PHASE) JETS

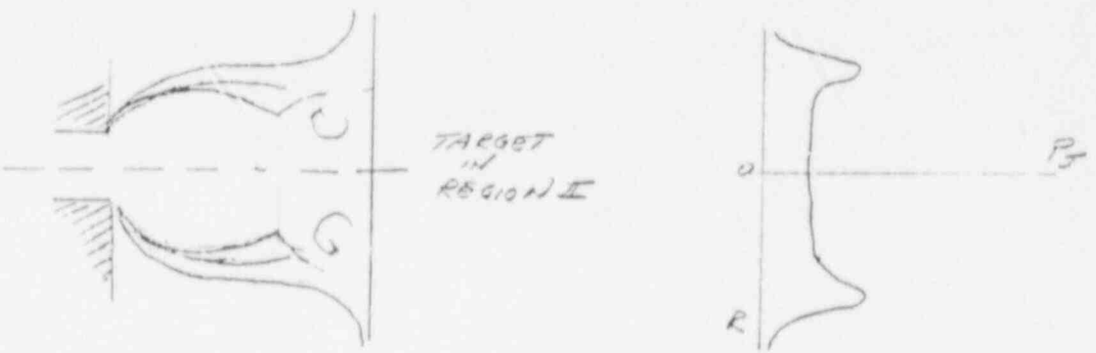
NATURE OF A FREE JET



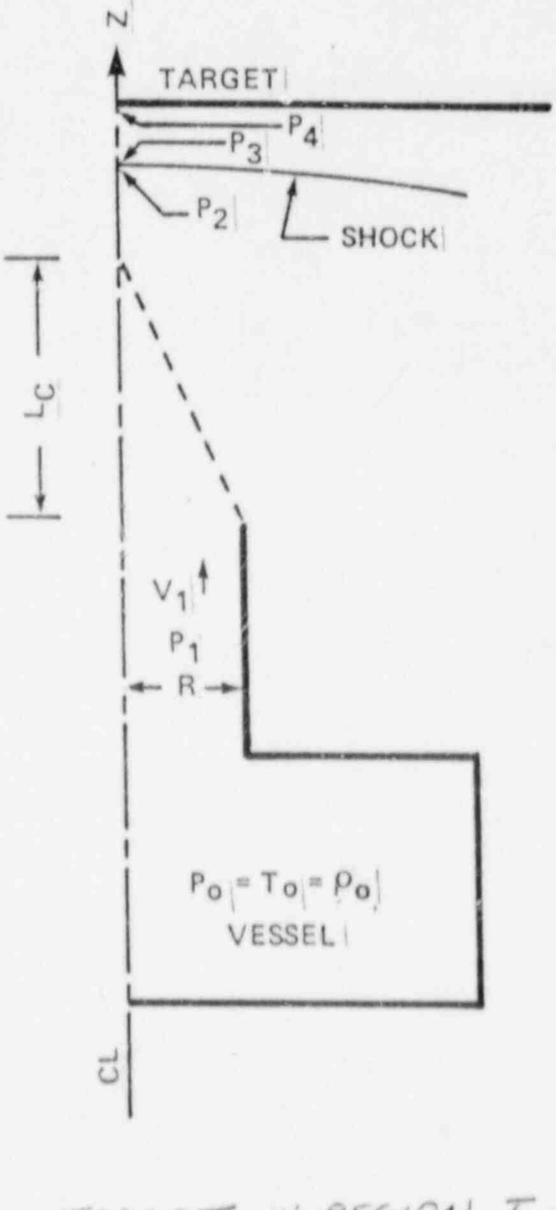
PATTERNS OF IMPINGEMENT



REGION PRIMARILY ADDRESSED
BY NUREG 2913



NUREG/CR-2913 APPROXIMATE MODEL



TARGET IN REGION I

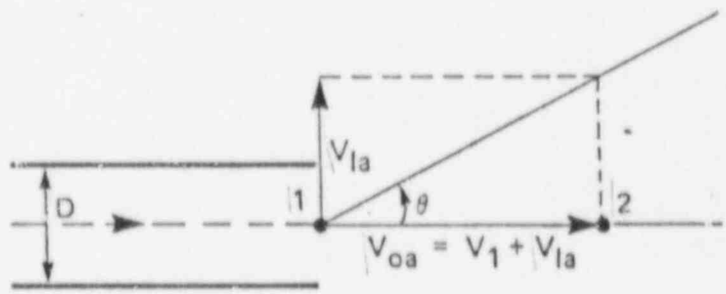
PROCEDURE

(1) HEM CRITICAL FLOW MODEL TO CALCULATE EXIT CONDITIONS: P_1, V_1, H_1, S_1

(2) ISENTROPIC EXPANSION FROM P_1 TO P_2

(3) $V_{oa} = V_1 + V_{la}$, V_{la} = RADIAL VELOCITY ISENTROPIC EXPANSION (1)

(4) $\tan\theta = \frac{V_{la}}{V_1 + V_{la}}$, θ = EXPANSION ANGLE (2)



PROCEDURE (CONT'D)

(5a). SATURATED WATER:

$$(\rho V)_2 = (\rho V)_1 \left(\frac{D}{2Z}\right)^2, \quad Z \geq \frac{1}{2} D \qquad (3a)^*$$

ρ = 2-ϕ MIXTURE DENSITY

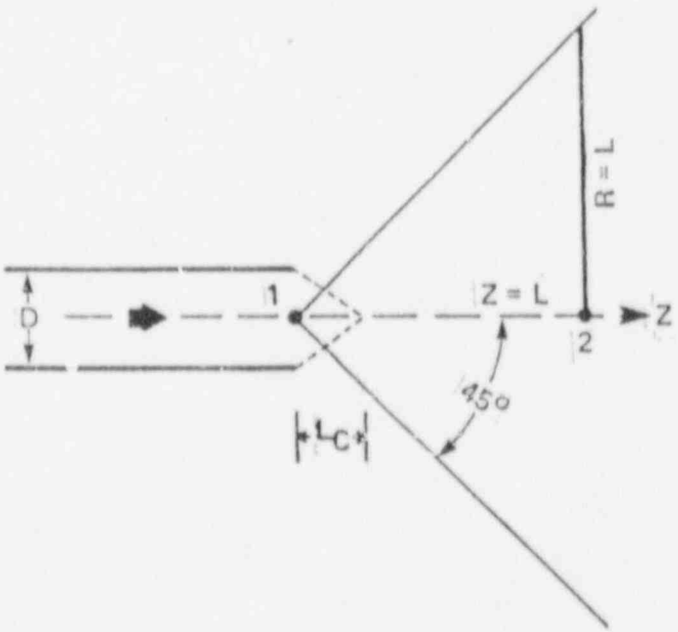
V = AXIAL VELOCITY

Z = AXIAL DISTANCE TO POINT 2

$$(\rho VA)_2 = (\rho VA)_1 \qquad (4)$$

$$A_1 = \frac{1}{4}\pi D^2 \qquad (5)$$

$$A_2 = \pi Z^2 \qquad (6)$$



* $\theta \approx 40^\circ \sim 45^\circ$, FORM EQ. (2)

PROCEDURE (CONT'D)

(5b). WATER WITH SUBCOOLED STAGNATION CONDITIONS:

$$(\rho V)_2 = (\rho V)_1 \left\{ \frac{\left(\frac{D}{2Z}\right)^2}{1 - \left(\frac{L_C}{Z}\right)^{\beta} \left[1 - \left(\frac{D}{2L_C}\right)^2\right]} \right\} \quad \frac{D}{2} \leq L_C \leq Z \qquad (3b)$$

WHERE $\beta \approx 14$

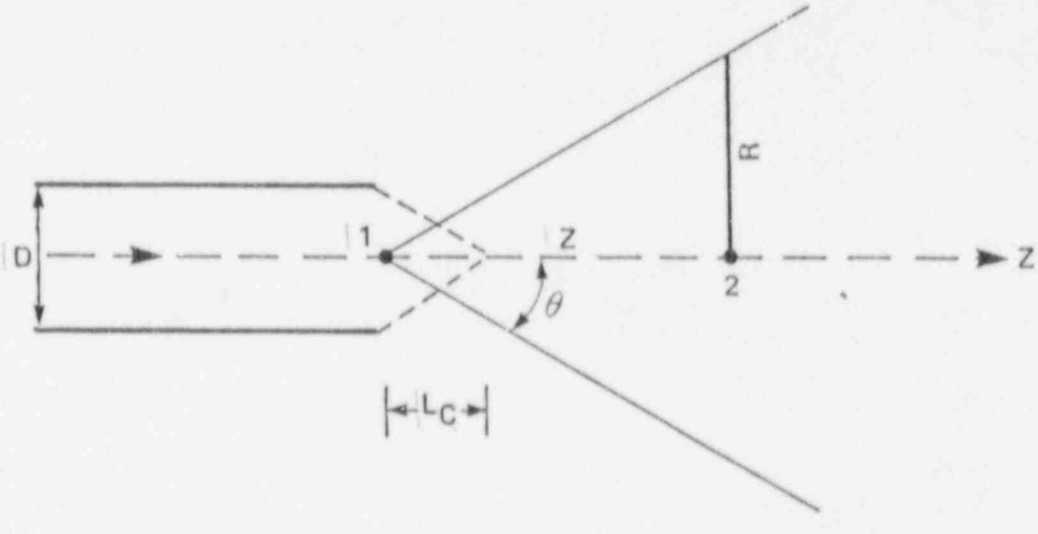
$$\frac{L_C}{D} = \frac{V_1}{2C_S}, \quad C_S = \text{SONIC SPEED}$$

FOR $D \leq Z \leq L_C$, FOLLOW HEM CHOKE FLOW CONDITION

PROCEDURE (CONT'D)

(5c). STEAM WITH SATURATED STAGNATION CONDITIONS

$$(\rho V)_2 = (\rho V)_1 \quad \left(\frac{D}{2\,Z\,TAN\,\theta}\right)^2 \quad Z \geq \frac{1}{2}\,D \qquad (3c)$$



FOR P_o = 4.02 MPa , $\theta \sim 35^o$, FROM EQ. (2)

PROCEDURE (CONT'D)

(6). ISENTROPIC EXPANSION IN FREE FIELD

$$H_o = H_2 + \frac{1}{2} V_2^2 \qquad (7)$$

$$S_o = S_2 \qquad (8)$$

(7). SOLVE EQS (3a) OR (3b) OR (3c) AND (7) AND (8) WITH THE EQ OF STATE FOR WATER (USE STEAM TABLE): $P_2, V_2, H_2, S_2,$

(8). CONDITIONS AFTER SHOCK (AT POINT 3), SOLVE

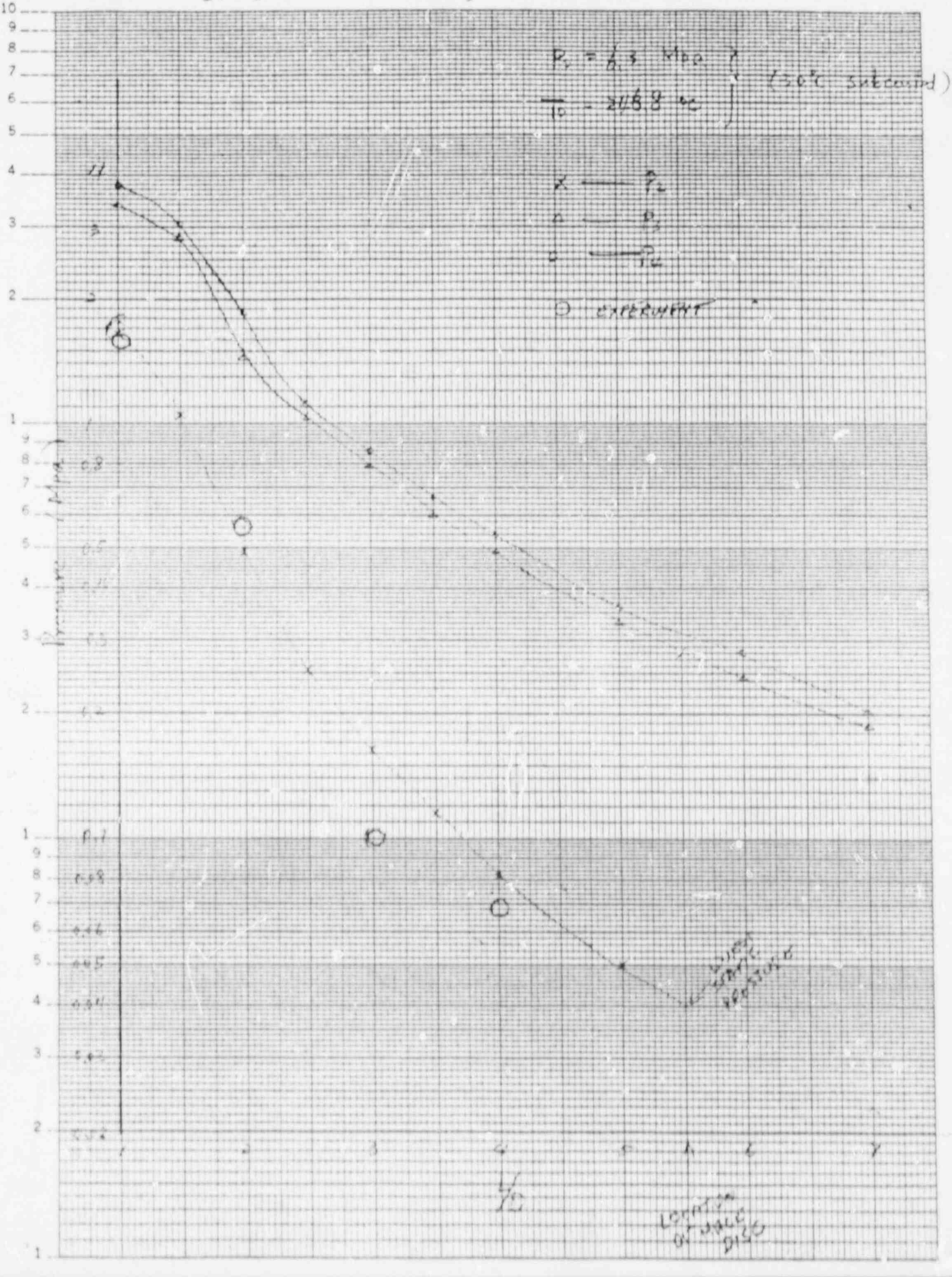
$$\rho_2 V_2 = \rho_3 V_3 \qquad (9)$$

$$P_2 + \rho_2 V_2^2 = P_3 + \rho_3 V_3^2 \qquad (10)$$

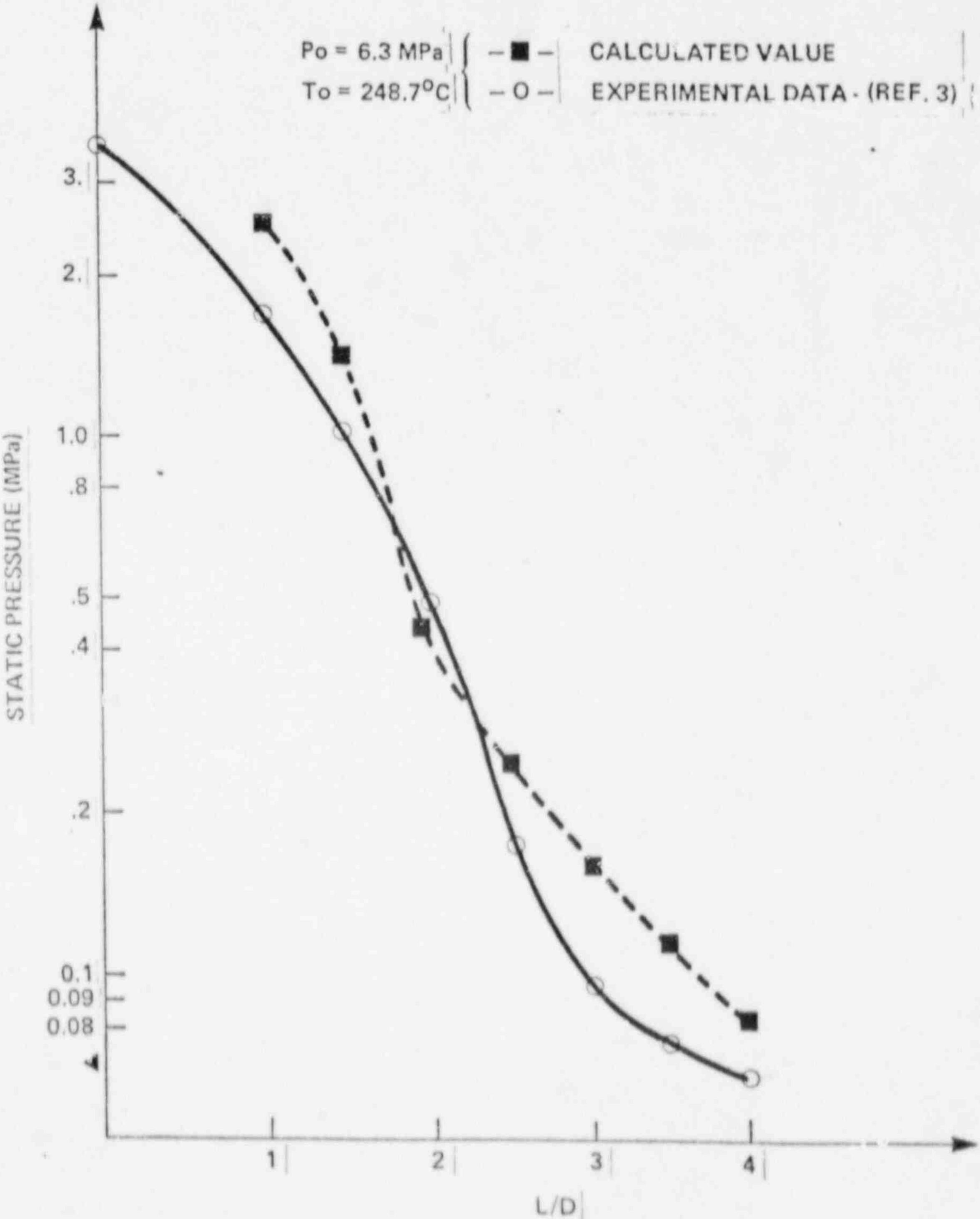
$$E_3 - E_2 = \frac{1}{2}(P_3 + P_2)\left(\frac{1}{\rho_2} - \frac{1}{\rho_3}\right) \qquad (11)$$

(9). STAGNATION PRESSURE ON TARGET: P_4 (DETERMINED FROM P_3 & V_3)

Center line Pressure for Subcooled Jet.



CENTERLINE STATIC PRESSURE



Centerline Pressure Distribution for subcooled Jet

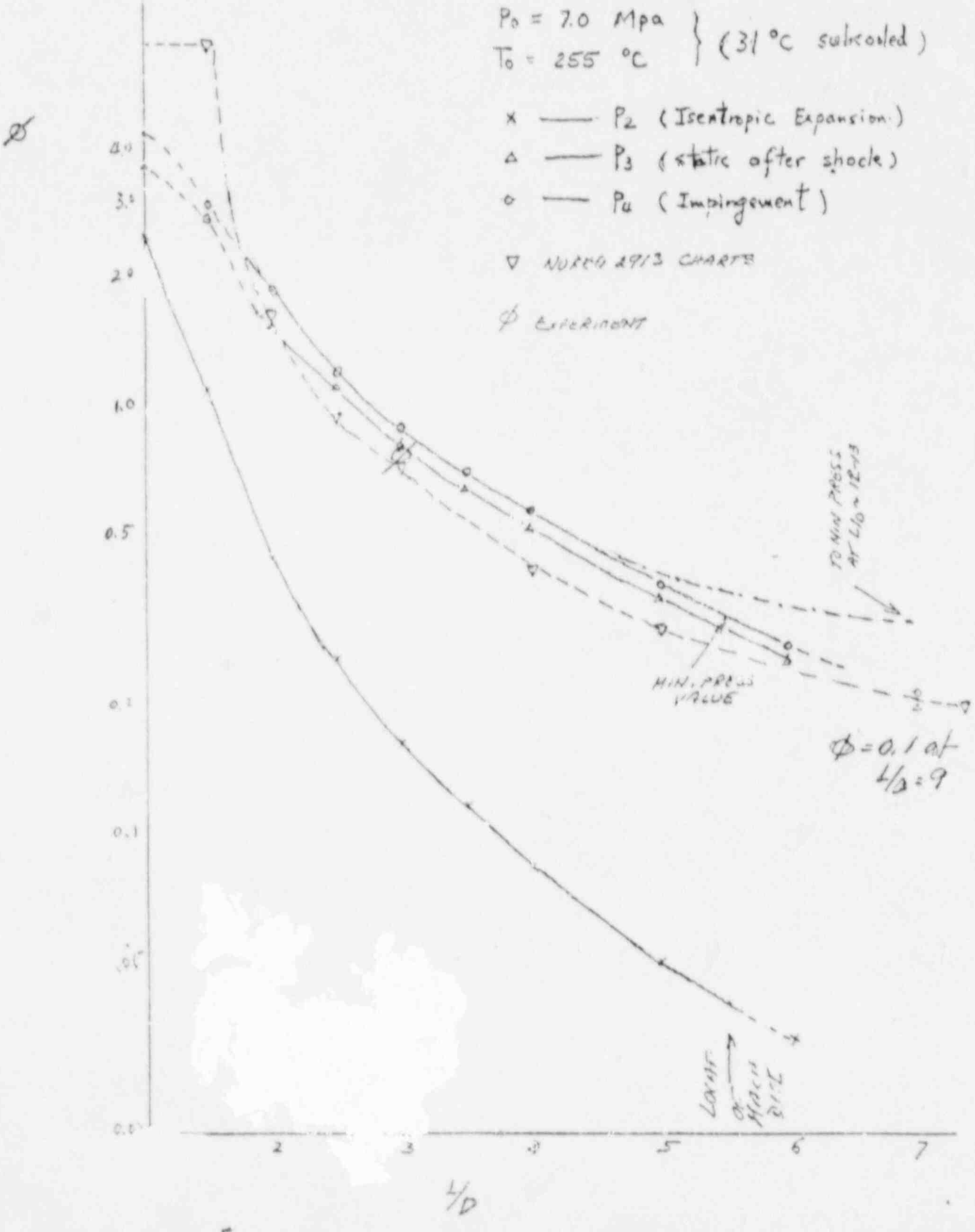
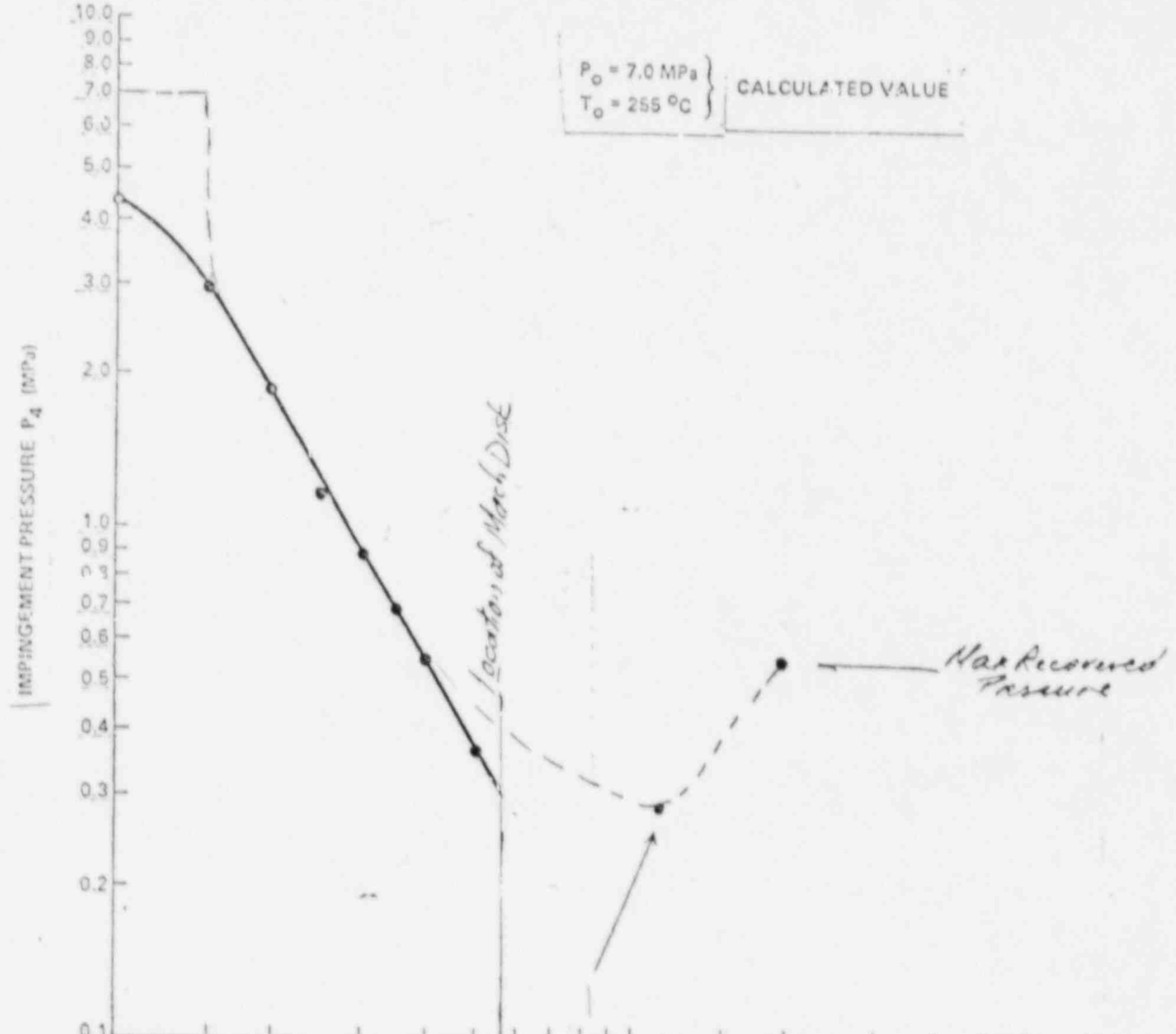
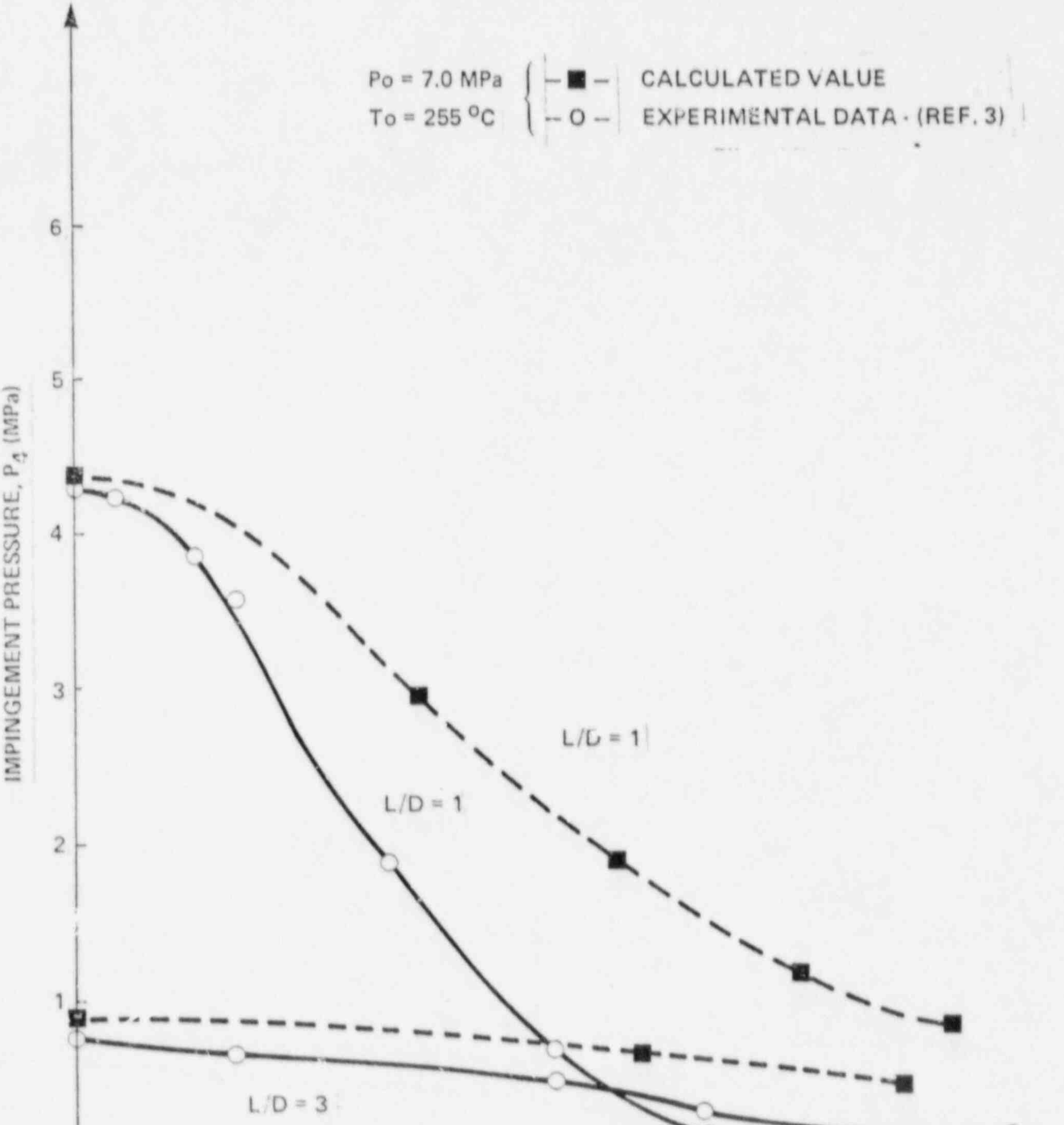


Fig. 4

CENTERLINE IMPINGEMENT (STAGNATION) PRESSURE FOR SUBCOOLED JET

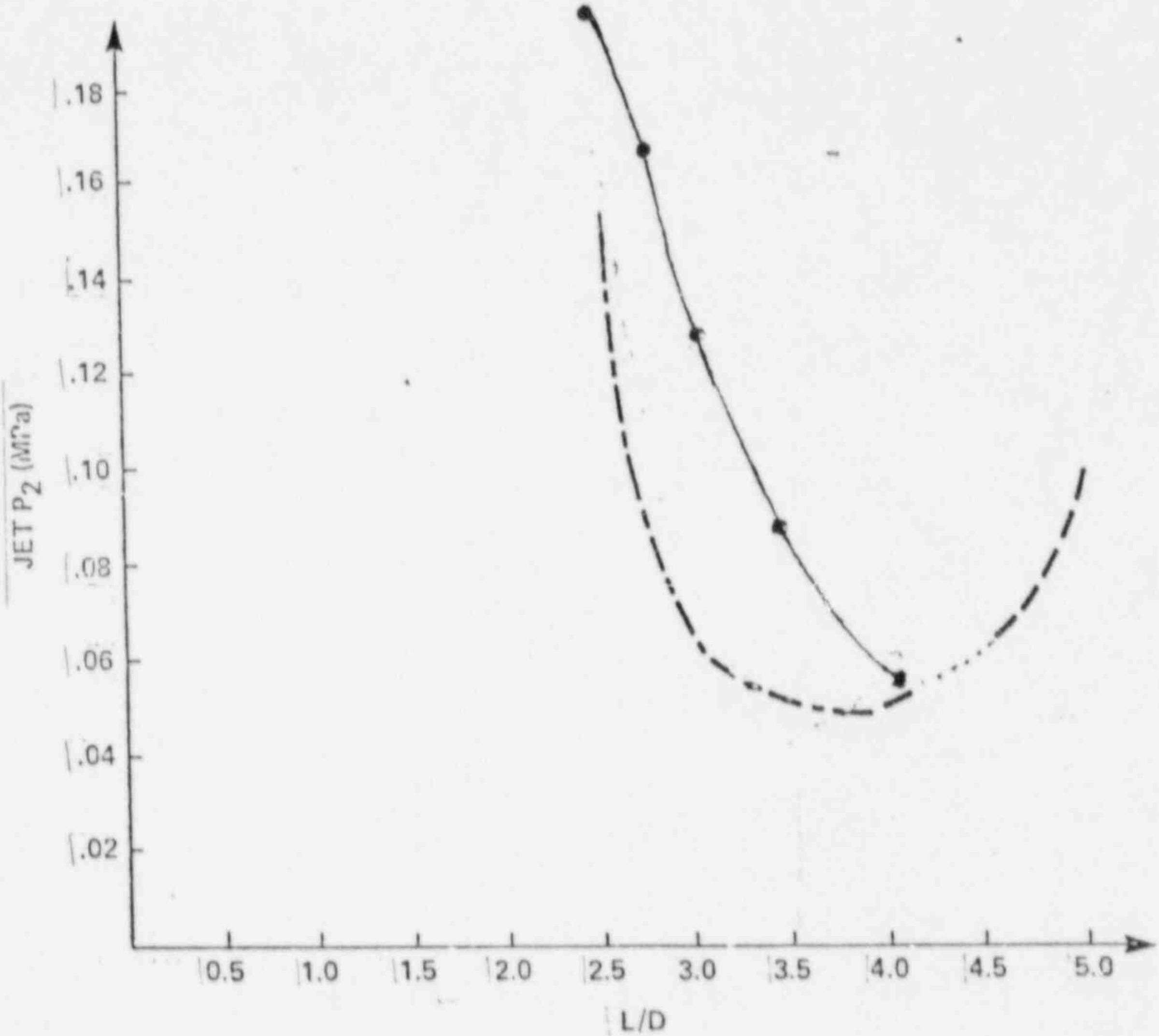


IMPINGEMENT PLATE PRESSURE DISTRIBUTION



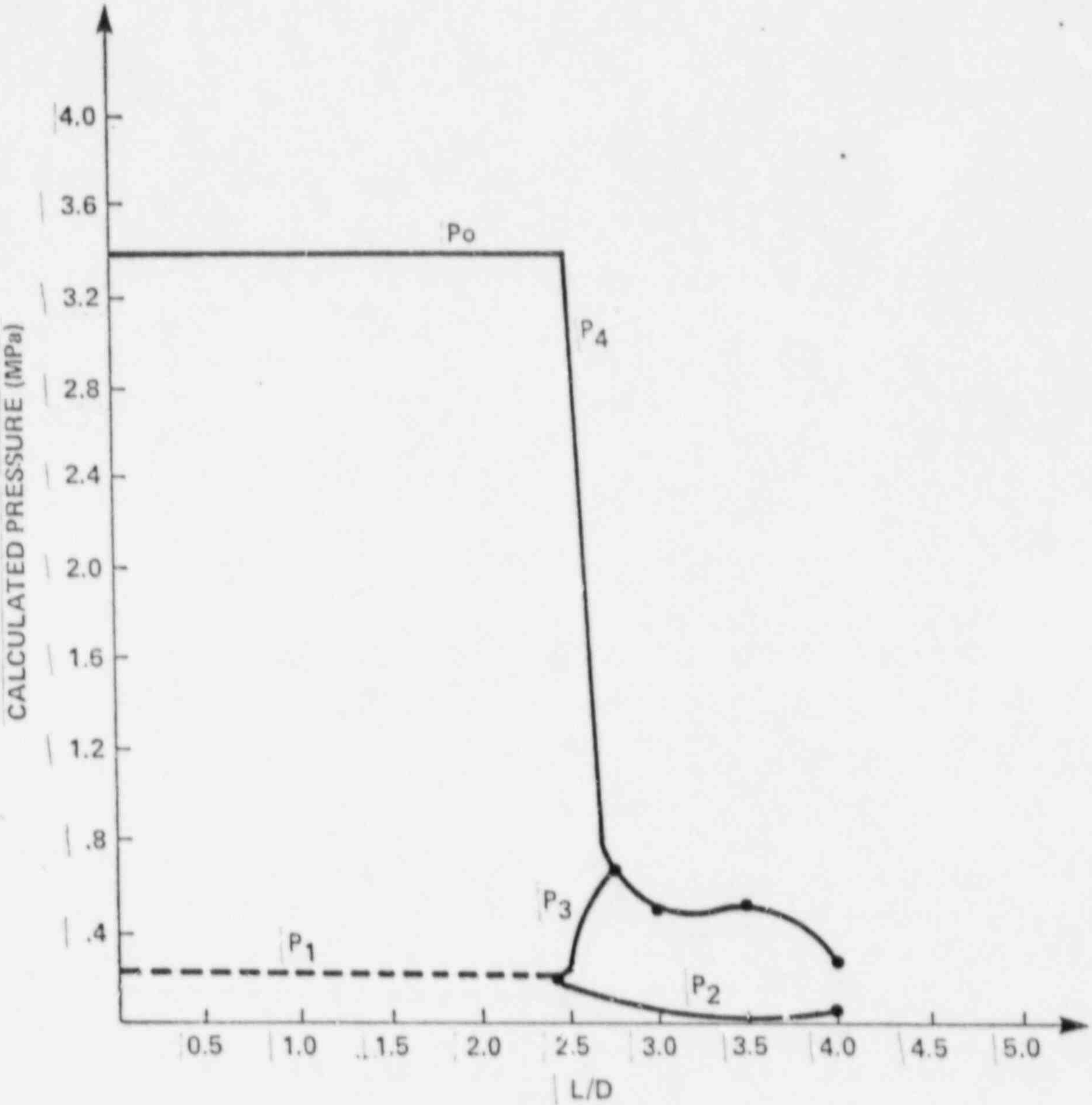
$P_o = 3.4\ MPa$

$\Delta T_{s.c.} = 30\ °K$



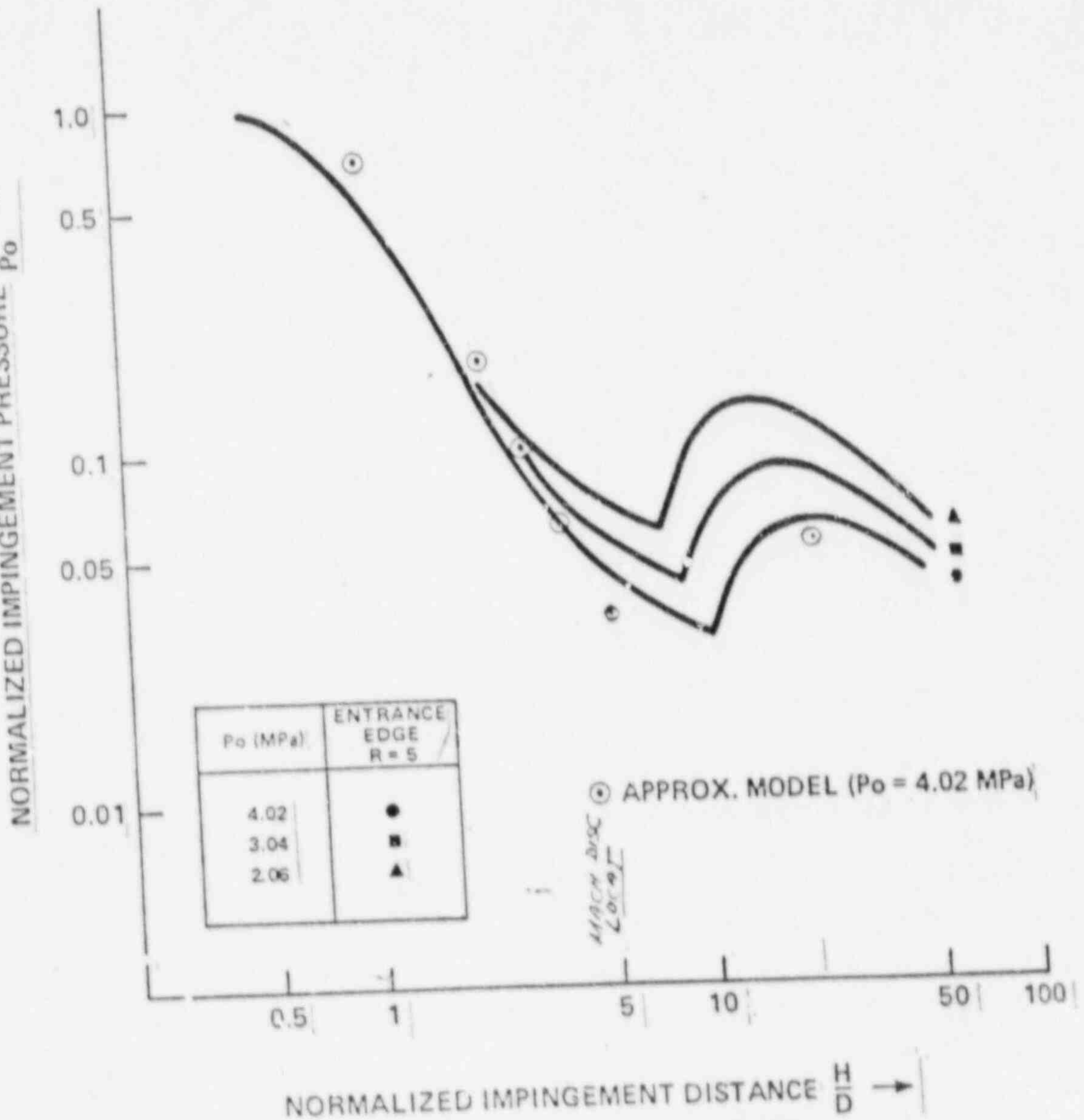
—— CALCULATED PER NUREG/CR-2913 CHAPTER 6

– - – MEASURED PER C. FOREST, K.S. SHIN ET AL.

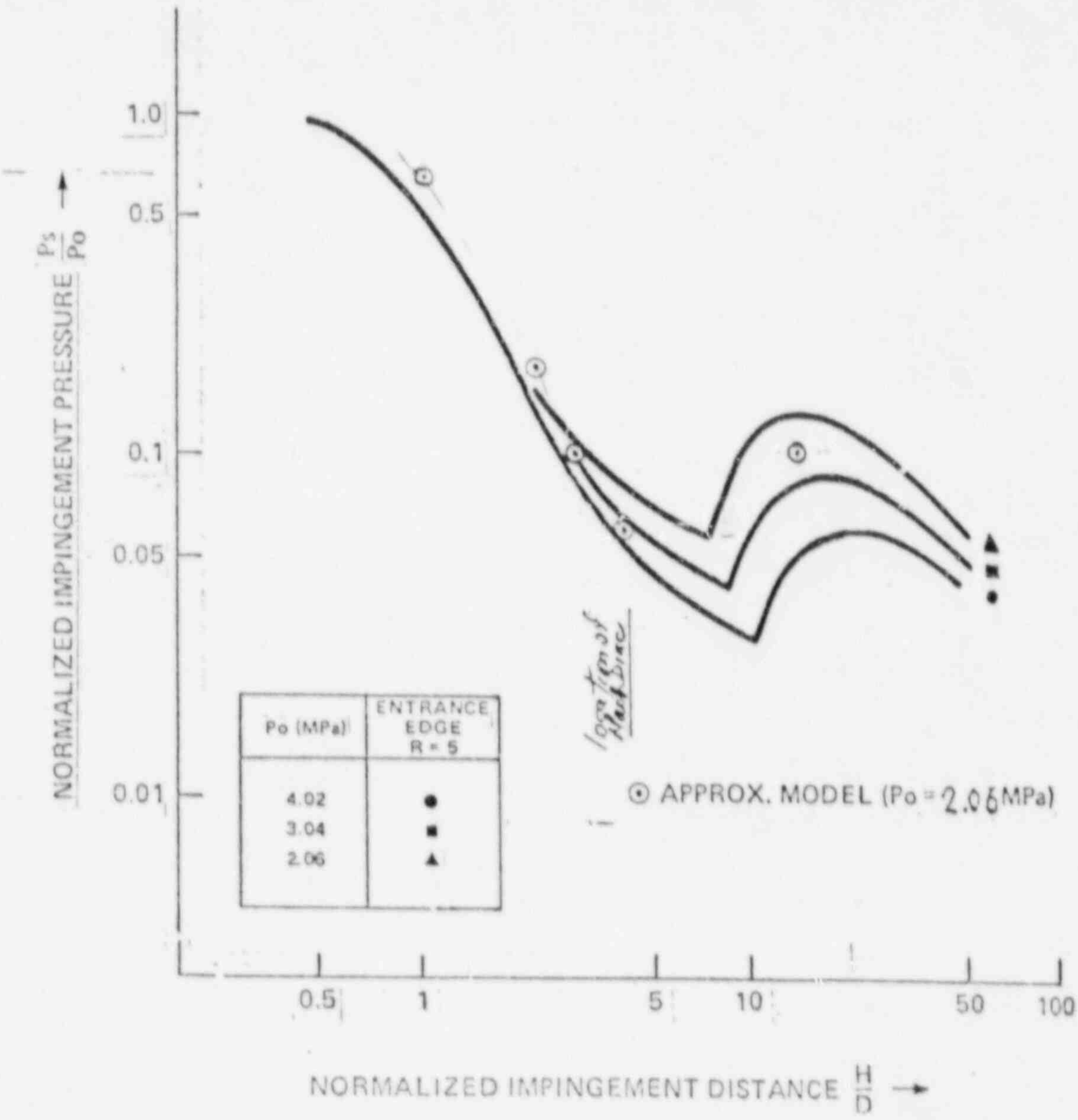


PRESSURE VARIATION ALONG THE CENTER LINE OF A TWO PHASE JET
(P_o = 3.4 MPa, $\Delta T_{SUBCOOL}$ = 30° K)

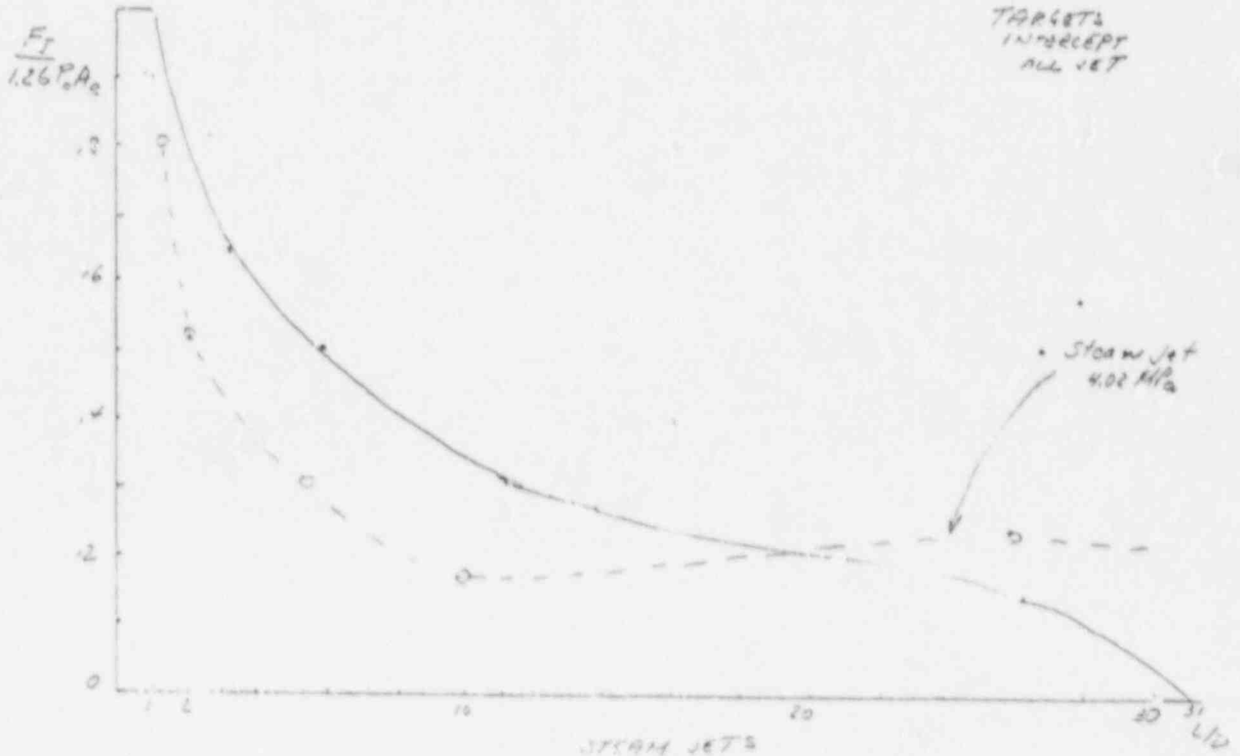
VARIATION OF CENTRAL IMPINGEMENT PRESSURE FOR STEAM JET



VARIATION OF CENTRAL IMPINGEMENT PRESSURE FOR STEAM JET



JET ATTENUATION USED AT CPSES



STEAM JETS

FLASHING WATER JETS

STATIC JET FORCES (KIPS)

CASES		1 T [2913+58.2(O)]	2 T [ANS 58.2(O)]	3 T [2913+58.2(N)]	4 T [ANS 58.2(N)]	Calculated by Site Personnel
TARGETS	L/D					
A1	2.6087	209.5	477.7	209.5	477.7	222.877
A2	4.7896	44.4	142.0	44.4	142.0	80.193
A3	11.144	34.4	130.3	6.2	22.6	39.555

P_o = 2235 PSIG $\Delta T_{sc} = 0$

KS/af/3/18/88

$P_o = 2285$ PSIG , $\Delta T_{s.c.} = 96\ ^\circ F$, $D_i = 8.75''$

	KIPS 2913 + 58.2 (0)	KIPS Site, 10° ~
$L/D = 11.3$ Target = Wall $\alpha = 22^\circ$	263	321
$L/D = 9.5$ Target = 2 ft^2 $\alpha = 0^\circ$	13.6	86
$L/D = 3.3$ Target = 0.38 ft^2 $\alpha = 45^\circ$	3.8	38
$L/D = 13.7$ Target = < 5 ft^2 $\alpha = 60^\circ$	89	155

α : Angle between Jet Center Line & Normal to The Target

REFERENCES

1. NUREG / CR - 2913, REV. 0

2. ANS/ANSI 58.2- 1980.

3. "MEASUREMENTS OF IMPACT LOADS AND EXPANSION OF FLASHING WATER JETS", NUCLEAR ENGINEERING AND DESIGN 99(1987)53-61, BY FORREST, AND SHIN, ET.AL.

4. "EXPERIMENTAL STUDY ON AN IMPINGEMENT HIGH-PRESURE STEAM JET", F. MASUDA, ET.AL., NUCLEAR ENGINEERING AND DESIGN 67(1981), 273-286.

5. "EXPERIMENTAL STUDY OF PIPE REACTION FORCE AND JET IMPINGEMENT LOAD AT THE PIPE BREAK", K. KITADE, ET.AL., INTERNATIONAL CONF. ON STRUCTURAL MECHANICS IN REACTOR TECHOLOGY, BERLIN, GERMANY, AUG 1979.

6. ANS/ANSI 58.2, WORKING DRAFT REV7, AUG 1987.

7. E. LOVE ET AL., EXPERIMENTAL AND THEORETICAL STUDIES OF AXISYMMETRIC FREE JETS; NACA TECH. REPORT R-6 1959

Enclosure 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

March 16, 1988

Docket Nos. 50-445
and 50-446

MEMORANDUM FOR: Christopher I. Grimes, Director
Comanche Peak Project Division
Office of Special Projects

THRU: James H. Wilson, Assistant Director
for Projects
Comanche Peak Project Division
Office of Special Projects

FROM: Melinda Malloy, Project Manager
Comanche Peak Project Division
Office of Special Projects

SUBJECT: FORTHCOMING MEETING WITH TU ELECTRIC

Date & Time: Monday, March 21, 1988
11:30 am

Location: One White Flint North
11555 Rockville Pike
Room 10B 13
Rockville, MD 20855

Purpose: For Applicant and Staff to continue discussions on development and attenuation of jets from high-energy line breaks

Participants*:

NRC	Applicant
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J. Lyons	R. Walker, et al.
M. Malloy	
S. Hou	
K. K. Niyogi (consultant)	

Melinda Malloy, Project Manager
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* Meetings between NRC technical staff and applicants for licenses are open for interested members of the public, petitioners, intervenors, or other parties to attend as observers pursuant to "Open Meetings and Statement of NRC Staff Policy," 43 Federal Register 28058, 6/28/78.

~~8803210417~~ 4pp

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Enclosure 2

NRC/TU ELECTRIC MEETING ON DEVELOPMENT
AND ATTENUATION OF JETS
March 21, 1988

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David A. West	TU Electric
DAVID A LAWRIE	TU ELECTRIC
ROBERT G. LEO	EBASCO - SIP
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