EVALUATION OF FLAWS FOUND ON RHR LINE 337

Calculation No. 97222-C-34
Revision 0
Volume 1 of 1

Prepared for:

Consolidated Edison Company of New York
Indian Point Unit 2

July, 1998

9808120309 980803
PDR ADOCK 05000247
P PDR

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Report Record

Document No.: 97222-C-34 Rev. No.: 0 Sheet No.: 2

Nuclear Safety Related: Yes ☒ No ☐ Total No. of Sheets: 21

TITLE: Evaluation of Flaw Found on RHR Line 337

CLIENT: Consolidated Edison Company of New York FACILITY: Indian Point Unit 2

REV. DESCRIPTION: Revision 0: Original Issue

COMPUTER RUNS: (Identified on Computer File Index): Yes ☐ N/A ☐

Error reports evaluated by: Date:

Impacted by error reports: No ☐ Yes ☐ (if Yes, attach explanation)

Originator(s)	Date	Checker(s)	Date
S. Yim	7/31/98	S. Blodgett	7/31/98
M. Zwolle	7/31/98	S. Yim	7/31/98

DESIGN VERIFICATION: / (EOP 3.4) Required ☒ Not Required ☐[e]

[e] Justification:

Performed by: W. McBrine Date: 7/31/98

Method of design verification:

☒ Design Review ☐ Alternate Calculations (Attached) ☐ Qualification Test (Data/Results Attd.)

Comments resolved by: Date:

Design verifier concurrence: Date: 7/31/98

APPROVED FOR RELEASE

PROJECT MANAGER: P. Brach Date: 7/31/98

ENGINEERING MANAGER: Dr. Johnsen Eissa Date: 7/31/98

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Introduction/Objective

This calculation is performed to determine – from an operability perspective – if the pin hole size flaws in the 1 - ½" RHR pump recirculation line is stable and thus acceptable for short term continued operation. This calculation will also determine the size hole that will result in a leakage rate of 50,000 cc/min, based on 52 psig pressure.

Input/Assumptions

see Section 2.0

Methodology/Criteria

see Section 3.0

Results/Conclusions

The pinhole size flaws on line 337 of the RHR system are stable. The maximum calculated stress intensity, K was determined to be 19.3 ksi$\cdot\sqrt{\text{in}}$, which is less than the 135 ksi$\cdot\sqrt{\text{in}}$ as permitted by GL 90-05 for stainless steel material (see attachment A). As such from an operability perspective the line is stable and acceptable for continued operation for the short term. The maximum permissible hole size which will meet the stress intensity of 135 ksi$\cdot\sqrt{\text{in}}$ as established in GL 90-05 was determined to be 0.35 inch. If the hole size is 0.35 inch then, the two flaws closest to the weld (locations #1 and #2 on UT report – Attachment B), should be considered as one flaw, due to their proximity.

A hole diameter that would result in a flow rate of 50,000 cc/min was determined to be 0.181 inch (see Attachment C for evaluation). The hole diameter of 0.181 inch is based on three holes of equivalent size.

References

See Section 4.0

1.0 INTRODUCTION/OBJECTIVE

Line 337 on the RHR recirculation line was found to have several (three) "through wall" flaws each about the size of a pin hole downstream of valve VA-1819. This calculation will determine whether the pipe is stable and thus acceptable - from an operability perspective - for short term continued operation. This calculation will also determine the size hole that will result in a leakage rate of 50,000 cc/min, based on 52 psig pressure.

2.0 INPUT/ASSUMPTIONS

The following inputs were used in this calculation.

a) The line analyzed is 1-½" diameter line 337, (1-½"-AC-601R per flow diagram) and from pipe specifications, the material is A312, Type 304 stainless steel, schedule 40.

b) Design Pressure and Temperature, per pipe spec. are
   P = 600 psig
   T = 600 °F

c) Per the UFSAR, stress limits for piping in Section 1.11, are based on those specified in USAS B31.1 - 55 Code.

d) The flow rate of 50,000 cc/min used for the hole determination was provided by Con Edison [8]

e) The pressure of 52 psig used for the hole determination was provided by Con Edison [8]

The following assumptions were used in this calculation.

1. The flaws are characterized by Con-Edison as pinholes and are not cracks.
2. Stress levels are considered to be at the maximum permitted under B31.1 and UFSAR criteria and are calculated within Attachment A. This assumption is considered to be conservative.

3.0 METHODOLOGY/CRITERIA

A through wall hole, categorized as a pin hole by Con Edison on a 1-½" stainless steel pipe will be evaluated using guidance provided by the NRC in GL 90-05 to asses the flaw stability. GL90-05 provides guidelines for the assessment of Class 3 piping only. Since the portion of piping in question would be equivalent to Class 2 piping (i.e. IP2 is

a B31.1 plant), this evaluation is performed for this Class 2 system only in support of an operability assessment.

3.1. Structural Evaluation

Evaluation guidelines provided in Enclosure 1 of GL 90-05 for "through wall" flaws is based

> *"... on linear elastic fracture mechanics and assuming a pipe thickness of 't_{min}', the stress intensity factor 'K' resulting from the flaw under the applied load is given as*

$$K = 1.4\, s\, F (\pi a)^{0.5} \qquad \text{Eq. 1}$$

where the geometry factor, 'F' is

$$F = 1 + A(c)^{1.5} + B(c)^{2.5} + C(c)^{3.5} \qquad \text{Eq. 2}$$

All other terms are defined in [2]

The acceptance criteria, based on GL 90-05, for austenitic stainless steel is the stress intensity, K as determined in Equation 1 above, should be less than 135 ksi$\cdot\sqrt{\text{in}}$. Which as it states in GL 90-05 is

> *"... consistent with the lower-bound fracture toughness property used in Article IWB-3640 of Section XI of the ASME Code."* [2, p. 5].

Two flaws that are close in proximity to each other shall be treated as one, if the spacing between the two flaws is less than two times the depth of the deeper flaw.

3.2. Hole Size

A hole size that would result in a flow rate of 50,000 cc/min was determined by modeling the hole as an orifice. The equation for flow through an orifices is:

$$q = AC\sqrt{\frac{2g\Delta P}{\rho}} \qquad \text{[7, Eq. 3-21]}$$

All terms are defined in [7]

Using the above equation, the orifice area was back-calculated using all known parameters (see Attachment C for evaluation).

4.0 REFERENCES

1. Con-Edison CITRS OIR No. 98-E06574
2. USNRC GL 90-05, *Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping,* dated 6/15/90
3. Con-Edison Drwg. A251783, *Flow Diagram Auxiliary Coolant System Residual Heat Removal Pumps.*
4. Con Edison Piping Spec. 9321-01-248-18
5. USAS B31.1, *Power Piping Code,* 1955 & 1973 w/ Addenda through 1976
6. NAVCO Piping Datalog.
7. Crane Technical Paper No. 410, *Flow of Fluids Through Valves, Fittings, and Pipe,* Crane Engineering Department 1988
8. Telephone Conversation, Mike Cheskis (Con Edison) to William McBrine and Sontra Yim (Altran Corporation), *Provided flow rate of 50,000 cc/min and 52 psig pressure for hole size determination*, 4:15 PM 7/31/98

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Calculation Sheet

Calc. No. 97222-C-34 By: S. Yim Date: 7/31/98 Sheet A-1

Rev. No. 0 Chk: S. Blodgett Date: 7/31/98

Attachment A

Evaluation

Attachment A

Calculation Sheet

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Calculation No. 97222-C-34 By: S. Yim Date: 7/31/98 Sheet: A-2

Rev. No. 0 Chk: S. Blodgett Date: 7/31/98

RHR Line 337 Flaw Evaluation

This evaluation will determine the stress intensity, K in the flaw and compare it to the acceptance criteria provided in Enclosure 1 of USNRC Generic Letter (GL) 90-05. The guidelines provided in GL 90-05 for the evaluation of "through thickness flaw" is for Class 3 piping only. Since the portion of piping in question would be equivalent to a Class 2 piping (i.e. IP2 is a B31.1 plant), this evaluation is performed only in support of an operability assessment.

Input

System

RHR Line 337

Pipe Size and Spec.

1.5" SCH 40

SA312 TP304 [4]

Material Allowable(s):

$S_h := 15900 \cdot psi$ @ 600 F

$S_c := 18700 \cdot psi$ @ 70 F

Design Conditions:

Design Pressure $P_D := 600 \cdot psi$

Design Temperature = 600 F

Pipe Properties: [6]

$OD := 1.9 \cdot in$ Outside Diameter

$t_{nom} := 0.145 \cdot in$ Nominal Thickness

$t_{act} := 0.136 \cdot in$ min. thickness of flaw location #3
see - UT Measurement Record (Attachment B - Item 1)

Code Minimum Wall:

$$t_{min} := \frac{P_D \cdot OD}{2 \cdot (S_h + 0.4 \cdot P_D)}$$ Code required minimum wall thickness

$t_{min} = 0.035 \cdot in$

Attachment A

Calculation Sheet

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Calculation No. 97222-C-34 By: S. Yim Date: 7/31/98 Sheet: A-3

Rev. No. 0 Chk: S. Blodgett Date: 7/31/98

RHR Line 337 Flaw Evaluation

Determine Maximum Stress

Conservatively consider stresses are at the maximum as permitted by the UFSAR & B31.1

For DW + Pressure, limit is Sh.
(Conservatively let Sh = Sc)

For D.W. + Pressure + Thermal, limit is (Sh + Sa)

Where

Sa = f (1.25Sc + 0.25Sh)
Conservatively let Sh = Sc ; f = 1)

then

Sa = 1.5Sc

For Seismic (SSE)

D.W. + Pressure + SSE, limit is 1.8Sh
(Conservatively let Sh = Sc)

Since exact relationship of D.W., Thermal and SSE is unknown. Maximize each and combine, which will be very conservative.

DW + Pressure + Thermal	= 1.5 Sc
Seismic (Alone)	= 1.8 Sc
Max. Stress	= 3.3 Sc

$\sigma_{max} := 3.3 \cdot S_c$

$\sigma_{max} = 6.171 \cdot 10^4 \cdot psi$

Attachment A

Calculation Sheet

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Calculation No. 97222-C-34 By: S. Yim Date: 7/31/98 Sheet: A-4

Rev. No. 0 Chk: S. Biodgett Date: 7/31/98

RHR Line 337 Flaw Evaluation

Determine Stress Intensity Factor: K

[1, p. 5]

$R := \frac{OD - t_{act}}{2}$ Mean Pipe Radius

$i := 0..6$ Variable Hole Size

$c_i := \frac{a_i}{\pi \cdot R}$

$r := \frac{R}{t_{min}}$

$a_i :=$

$\frac{1}{64} \cdot in$
$\frac{1}{32} \cdot in$
$\frac{1}{16} \cdot in$
$\frac{1}{8} \cdot in$
$\frac{1}{4} \cdot in$
$0.35 \cdot in$
$0.45 \cdot in$

$R = 0.882 \cdot in$

$r = 24.975$

$A = 14.489$

$B = -34.11$

$C = 41.516$

$A := -3.26543 + 1.52784 \cdot r - 0.072698 \cdot r^2 + 0.0016011 \cdot r^3$

$B := 11.36322 - 3.91412 \cdot r + 0.18619 \cdot r^2 - 0.004099 \cdot r^3$

$C := -3.18609 + 3.84763 \cdot r - 0.18304 \cdot r^2 + 0.00403 \cdot r^3$

Geometry Factor

$F_i := 1 + A \cdot (c_i)^{1.5} + B \cdot (c_i)^{2.5} + C \cdot (c_i)^{3.5}$

$K_i := 1.4 \cdot \sigma_{max} \cdot F_i \cdot (\pi \cdot a_i)^{0.5}$

Conclusion:

Therefore assuming a hole diameter of 1/64" the stress intensity, K was determined to be 19.3 ksi (in)^0.5 which is considerably less than 135 ksi (in)^0.5. Flaws in Line 337 are acceptable from an operability perspective. As presented below, if a single hole diameter were greater than 0.35 inch, it would not meet the acceptance criteria of 135 ksi (in)^0.5

$$K = \begin{bmatrix} 1.926 \cdot 10^4 \\ 2.753 \cdot 10^4 \\ 4.006 \cdot 10^4 \\ 6.09 \cdot 10^4 \\ 1.009 \cdot 10^5 \\ 1.347 \cdot 10^5 \\ 1.702 \cdot 10^5 \end{bmatrix} \cdot psi \cdot (in)^{0.5}$$

Attachment A

Calculation Sheet

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Calculation No. 97222-C-34 By: S. Yim Date: 7/31/98 Sheet: A-5

Rev. No. 0 Chk: S. Blodgett Date: 7/31/98

Reference(s): RHR Line 337 Flaw Evaluation

1. USNRC Generic Letter (GL) 90-05, *Guidance for Performing Temporary Non-Code Repair of ASME Code Class 1, 2, and 3 Piping*, June 15, 1990.
2. ASME B&PV Section XI, *Rules for Inservice Inspection*, 1989
3. Con Edison Drwg. A251783, *Flow Diagram Auxiliary Coolant System Residual Heat Removal Pumps.*
4. Con Edison Piping Spec. 9321-01-248-18
5. USAS B31.1, *Power Piping Code, 1955 & 1973 w/ Addenda thru 1976*
6. NAVCO Piping Datalog.

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Calculation Sheet

Calc. No. 97222-C-34 By: S. Yim Date: 7/31/98 Sheet B-1

Rev. No. 0 Chk: S. Blodgett Date: 7/31/98

Attachment B

Input

INDIAN POINT STATION
CON EDISON
QUALITY ASSURANCE

ULTRASONIC THICKNESS MEASUREMENT RECORD

DATE: 7-30-98 WORK ORDER: 98-02880

COMPONENT: 1½" LINE AT VA-1819 SYSTEM: RHR LINE 33

LOCATION: PIPE PEN MATERIAL: S/S

INSTRUMENT: PANA. 26 DL PLUS SN 9206 4205 DUE 1-21-99 PROCEDURE: QA 9001

TYPE/SIZE TRANSDUCER: D795 / .200 5 MHZ 39416 VELOCITY: 2270

CALIBRATION BLOCK: MINIMUM 0.050 MAXIMUM 0.750

TYPE COUPLANT: EXOSEN 30

LEAK #1

140	140	140	140	141	142
140	140	140	140	141	142
143	142	139	138	140	142
143	142	142	138	140	142
142	142	145	138	140	142
142	142	147	142	140	142

FLOW

LEAK #2

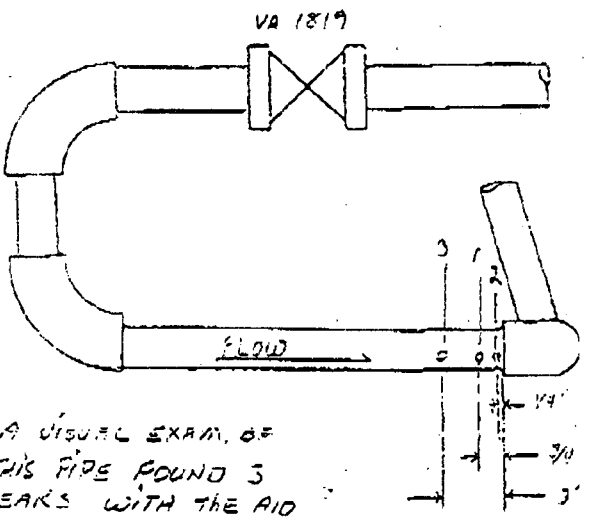
142	142	142	143		
140	140	140	143		
139	139	142	143		
139	139	142	143		
140	138	140	142		
140	138	140	142		

FLOW

LEAK #3

139	140	140	141	141	141
139	140	140	141	141	141
140	139	139	139	139	141
140	139	139	139	139	141
141	139	140	141	141	141
141	139	140	142	141	142

FLOW



VIEW LOOKING DOWN STREAM

NOTE: A VISUAL EXAM. OF THIS PIPE FOUND 3 LEAKS WITH THE AID OF PENETRANT DEVELOPER.

PERFORMED BY: [signature] LEVEL: II C

ASSISTED BY: [signature] II C

ITEM 1

Altran Report 97222-C-34 Rev. 0
Att./Appx. B Sh. B-2

10

UNITED ENGINEERS & CONSTRUCTORS INC.
Philadelphia, Pennsylvania 19105

Specification
for
Fabrication of Piping Systems

Westinghouse Electric Corporation
Indian Point Generating Station-Unit No. 2
Consolidated Edison Company of New York

Revision 6A Sept. 1, 1990

Prepared By: Albert White; Senior Engineer

Approved By: Lawrence J. Burbige, Process & Equipment Engineer

Date: October 14, 1966
Rev. 1: January 30, 1967
Rev. 2: February 17, 1967
Rev. 3: June 28, 1974 (by C.E.)*
Rev. 3A: May 3, 1978
Rev. 3B April 1, 1980
Rev. 4A May 21, 1984
Rev. 5A August 20, 1985
Specification No. 9321-01-243-13

* Includes U.E. & C. Addenda No.'s 1 thru 15 and updating of Technical Society data.

ITEM 2
Altran Report
97222-C-34 Rev. 0
Att./Appx. B Sh. 33

EQUIPMENT SPECIFICATION

PIPE SPECIFICATION
ASS 601

Design Conditions

Pressure	600 psig	700 psig	875 psig	500 psig
Maximum Temperature	600°F	400°F	200°F	400°F (See Note below)

Material: Stainless Steel of ASTM Specification listed below for each item.

Pipe (R-3B)

Size	1/2" to 10"	12" only	14"&16"
Construction	Seamless or welded	Seamless or welded	
ASTM Spec	A 312 Type 304	A 376 or A 358 Class 1 Gr 304	
Schedule	40S	3/8" Std. Wall	Sch 40

Fittings (R-3B)

Size	2" and smaller	2-1/2" to 10"	12" only	14"&16"
Type	Forged	Seamless or welded	Seamless or welded	
Joint	Socket weld	Butt weld	Butt weld	Buttweld
ASTM Spec	A 182 F 304	A 403 WP 304	A 403 WP 304	A403 WP304
(R-3) Rating	3000#	Schedule 40S	3/8" Std. Wall	Sch 40

Flanges (R-3B)

Size	2" and smaller	2-1/2" to 10"	12" only	14"&16"
Type	Forged	Forged	Forged	Forged
Joint	Socket weld	Welding neck	Welding neck	Welding neck
ASTM Spec	A 182 F 304	A 182 F 304	A 182 F 304	A182 F304
Rating	600# RF	600# RF	600# RF	600#RF
Bored to	Schedule 40S	Schedule 40S	3/8" Std. Wall	Sch 40

Note: A 300# RF Flange of Grade F 316 may be substituted for the 600# RF flange of Grade F 304 specified above, but only for the 500 psig/400°F design condition.

Altran Report
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Att./Appx. B Sh B4

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Calculation Sheet

Calc. No. 97222-C-34 By: S. Yim Date: 7/31/98 Sheet C-1

Rev. No. 0 Chk: S. Blodgett Date: 7/31/98

Attachment C

Hole Size Evalution

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Attachment C

Calc. No. 97222 - C-34 By: M.W. Zweigle Date: 7/31/98 Sheet: C2

Rev. No. 0 Chk: SY Date: 31-Jul-98

Objective:
Calculate flow rate at different hole sizes.

Inputs:

$n := 3$ Number of holes

$P := 52 \cdot \frac{lb}{in^2}$ Internal pressure

Method/Assumptions:
Treat as orifices.
Boron concentration of water has negligible affect on results.
Water is at saturation temperature for 52 psig to determine the density. This is conservative since a higher flow rate will result for a given hole size. Also, if the fluid were at 300F then it would flash when exiting the hole and the flow rate would be less than modeled with single phase.

$q(A, C, \rho, \Delta P) := A \cdot C \cdot \sqrt{\frac{2 \cdot g \cdot \Delta P}{\rho}}$ Equation to be used from Crane 410 Eq. 3-21

Where
q= flow rate
A = orifice flow area
C = flow coefficient
g = gravitational acceleration
ΔP = pressure drop
row = fluid density

Attachment C

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Calc. No. 97222 - C-34 By: M.W. Zweigle Date: 7/31/98 Sheet: C3

Rev. No. 0 Chk: SJ Date: 31 Jul 98

Analysis:

$Tsat := 300 \cdot F$ Saturation temp at 52 psig (67psia) from Crane 410

$\rho := 57.3 \cdot \frac{lb}{ft^3}$ Density of water at Tsat.

The holes are very small so the Beta ratio shown on P. A-20 of Crane 410 is zero.
The Flow coefficient is then:

$C := 0.6$ Crane 410 p. A-20

The hole diameters being considered are:

$i := 0 .. 5$

$d_i :=$

0.075·in
0.1·in
0.125·in
0.15·in
0.175·in
0.2·in

The areas then being considered is:

$A_i := n \cdot \frac{\pi}{4} \cdot (d_i)^2$

$$A = \begin{bmatrix} 0.086 \\ 0.152 \\ 0.238 \\ 0.342 \\ 0.466 \\ 0.608 \end{bmatrix} \cdot cm^2$$

$Flow_i := q(A_i, C, \rho, P)$

$$Flow = \begin{bmatrix} 8.604 \cdot 10^3 \\ 1.53 \cdot 10^4 \\ 2.39 \cdot 10^4 \\ 3.442 \cdot 10^4 \\ 4.684 \cdot 10^4 \\ 6.118 \cdot 10^4 \end{bmatrix} \cdot \frac{cm^3}{min}$$

specifically at 50,000 cc/min:

$$Area := \frac{50000 \cdot \frac{cm^3}{min}}{C \cdot \sqrt{\frac{2 \cdot g \cdot P}{\rho}}}$$

$Area = 0.497 \cdot cm^2$

$$diam := \sqrt{\frac{Area}{3} \cdot \frac{4}{\pi}}$$

$diam = 0.181 \cdot in$ **with 3 holes**

note: $50000 \cdot \frac{cm^3}{min} = 13.209 \cdot \frac{gal}{min}$

Attachment C

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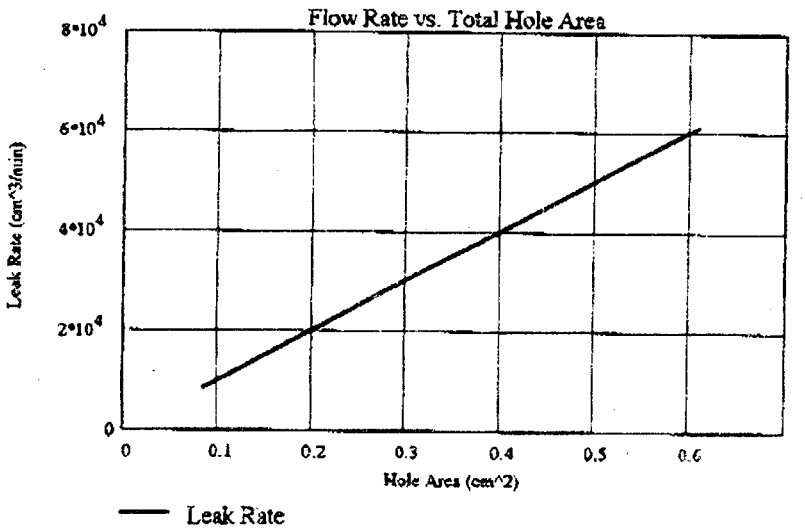
Calc. No. 97222 - C-34 By: M.W. Zweigle Date: 7/31/98 Sheet: C4

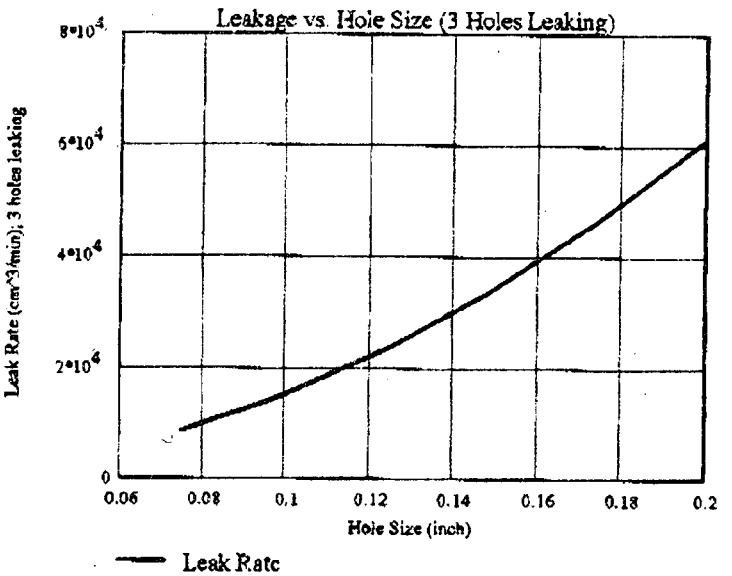
Rev. No. 0 Chk: SJ Date: 31 Jul-98

Results At 50,000 CC/min, with flow through 3 equivalent holes, the hole size would be:

diam = 0.181 in

For other flow rates:





ATTACHMENT 4

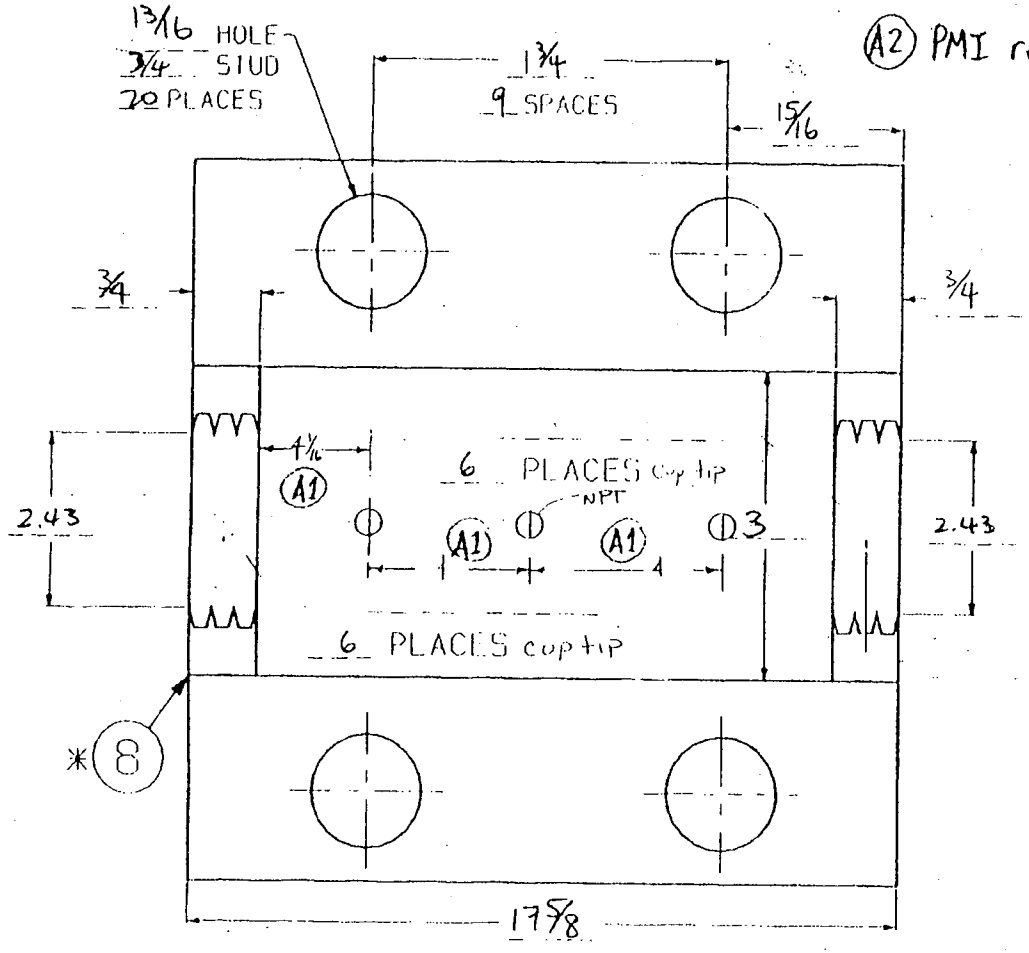
CLAMP

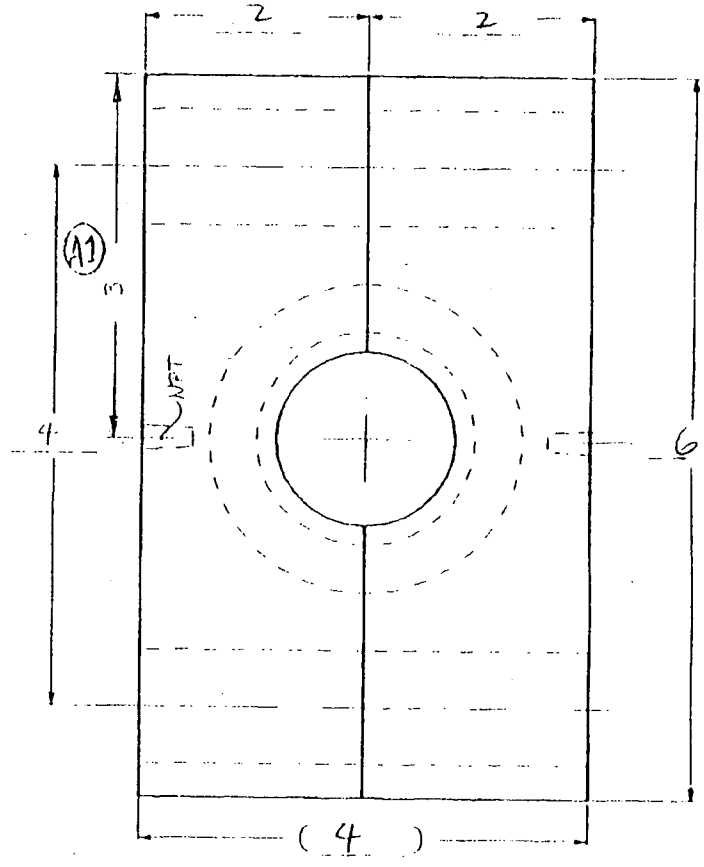
Consolidated Edison Company of New York, Inc.
Indian Point Unit No. 2
Docket No. 50-247
August 1998

ECO# 7224
A 7/31/98

ALL DIMENSIONS TYPICAL UNLESS OTHERWISE NOTED

(A2) PMI required for all materials





"CONFIDENTIAL"
PROPRIETARY INFORMATION

NUCLEAR
DO NOT PAINT

* WELDED ENDPLATES OPTIONAL

0.110 CRUNCH

D&T 6 - 1/8 NPT (CAVITY)

TERM INC. ALVIN, TEXAS	JOB NO. P37-079832N	MATERIAL SEE MS SHEET	WEIGHT 112.4 lb / VOID 68.5 in³ BC
	CLAMP NO. 74298	UNLESS NOTED OTHERWISE	CON-ED IPZ
	EST. NO.	MACHINED SURFACES 250	
	WELDING SPEC. NO. SEE WELD MAP	Break Sharp Corners .005 / .020	
DRAWN BY: CYL	7/30/98	TOLERANCES: 3 Place Decimal ± .005; 2 Place Decimal ± .01; 1 Place Decimal ± .1; ANGLES ± 1/2°; FRACTIONS ± 1/32	DWG. NO. sb_cr_2w_ss2
CHECKED: JBM	7/31/98	ALL DIMENSIONS IN INCHES	SCALE NTS / Sheet 1 of 3
APPROVED:			REV