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SCHWENCER,A. Licensing Branch 2

SEE ALSO

SUBJECT: Forwards info on Apps G & H per agreement at 810401 meeting.Responses to Questions 121.011 through 121.019 also encl.Responses will be included in amend to FSAR.

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	NRR/DE/EQB	13	3	3	NRR/DE/GB	28	2	2
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December 18, 1981
G02-81-532
SS-L-02-CDT-81-107

Docket No. 50-397

Mr. A. Schwencer, Director
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission

Dear Mr. Schwencer:

Subject: NUCLEAR PROJECT NO. 2
APPENDIX G AND H INFORMATION RESPONSES TO MATERIALS ENGINEERING BRANCH - COMPONENT INTEGRITY SECTION

Reference: Letter, R. Auluck to R.L. Ferguson, "WNP-2 FSAR - Request for Additional Information", dated September 8, 1981

Enclosed are sixty copies of the information on Appendix G and H as agreed with NRC as proposed by the LRG during a meeting April 1, 1981.

Also, enclosed are sixty copies of the responses to Questions 121.011 through 121.019, which were transmitted to the Supply System via the referenced letter. These questions will be incorporated into an amendment to the WNP-2 FSAR.

Very truly yours,

G. D. Bouchey
Deputy Director, Safety and Security

CDT/jca
Enclosures

cc: R Auluck - NRC
WS Chin - BPA
R Feil - NRC Site

B001
S1/60

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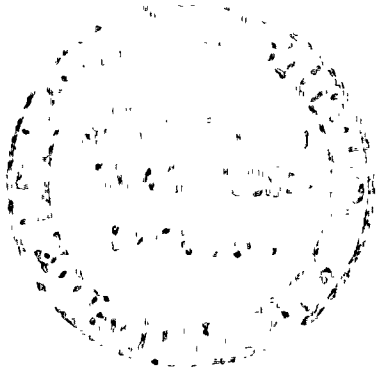

Q. 121.011

Provide data to justify that the value of -50°F used to estimate the nil ductility temperature for the beltline welds was obtained from test samples that represent the beltline welds in the WNP-2 reactor pressure vessel. This information should include a comparison of the significant weld parameters (e.g., weld tire, flux, thermal treatment) and mechanical properties from both the sample and beltline welds.

Response:

This question was responded to in the Appendix G and H submittal to the NRC. (See Reference 1)

8201070186

REFERENCE:

1. Letter G02-81- , G. D. Bouchey to A. Schwencer, "Appendix G and H Information, Responses to Materials Engineering Branch - Component Integrity Section", dated

Q. 121.012

In order to demonstrate that all reactor coolant pressure boundary (RCPB) materials comply with the requirements of Paragraph IV.A.2.a, The applicant must report the RT_{NDT} for all ferritic (RCPB) plates, pipes, forgings and welds outside the reactor vessel beltline region which will be limiting for operation of the reactor vessel. If the method for determining RT_{NDT} for these materials is different than that required by Paragraph IV.A.2.a, the applicant must identify the method and provide technical justification for its use.

Response:

This question was responded to in the Appendix G and H submittal to the NRC. (See Question 121.011, Reference 1)

Q. 121.013

Provide CVN impact data to demonstrate that all the reactor beltline materials except Girthweld AB/E8018NM/492L4871/Lot A422B27AF1, Girthweld AB/RAC01NM/5P6756/Lot 0342, and Girthweld AB/E8018/04T931/Lot A423B27AG have a minimum CVN impact test upper shelf energy of 75 ft-lb as required by Paragraph IV.B of Appendix G. The applicant must provide additional data, information from the literature, and/or analyses to demonstrate that the materials' upper-shelf will be assured for normal operation. The additional data should be from tests of plates having similar steelmaking practices and thermo-mechanical history. For the welds, the additional data should be from similar welds, i.e., those having the same weld wire, flux, and thermal treatments as the beltline welds and prepared by the same fabricator as the original beltline welds.

Response:

This question was responded to in the Appendix G and H submittal to the NRC. (See Question 121.017, Reference 1)

Q. 121.014

To demonstrate compliance with Appendix H, 10 CFR Part 50, provide a table that includes the following information for each surveillance material specimen:

1. Actual material specification;
2. Origin of each surveillance specimen (base metal; heat number, plate identification number; weld metal: weld wire, heat of filler material, production welding process, and plate material used to make weld speciments);
3. Test specimen, and type;
4. Heat treatment of each test specimen;
5. Chemical composition of each test specimen.

Provide the asmuthal location, lead factor and withdrawal time for each specimen capsule.

Response:

The information in response to the above questions, with the exception of the lead factor and withdrawal time for each specimen capsule, is given in the Appendix G and H package "RPV Surveillance Samples."

The withdrawal time for each specimen capsule is given in Section 5.3.1.6 of the FSAR.

The lead factor response is as follows:

Calculated lead factors have been prepared for the Hanford 2 reactor. The lead factor is the ratio of the fluence at the surveillance sample to the fluence at the peak location in the vessel. The lead factors are located at asymmetrical positions with respect to the core. Because of asymmetry each surveillance sample is expected to have the same lead factor.

1/4T lead factor = 1.2
Vessel ID lead factor = 0.86

Q. 121.015

Provide the following data to demonstrate the main steam isolation valve (MSIV) RCPB materials will meet the fracture toughness requirements of NB-2332 of the Summer 1972 Addenda to the 1971 ASME Code.

a. Indicate the diameter and nominal wall thickness of the connecting pipes.

b. Indicate the material specification, material type, material supplier, heat treatment received by the material, minimum design wall thickness and CVN impact test results for all ferritic RCPB materials used in the MSIV bodies, covers, discs, stems and bolting.

c. If CVN impact data can not be provided from each of these materials, provide CVN impact data from other materials which were fabricated from the same material specification and type, by same material supplier and heat treated to an equivalent metallographic condition as the MSIV materials.

Response:

a. Piping connecting the MISV;
Outside diameter = 26";
Nominal wall thickness = 1.103" plus 0.125".

b.

ITEM	MATERIAL SPEC	MATERIAL TYPE	MIN. DES. WALL THICK.
Body:	ASTM A-216	GR WCG	1.58" Min.
Cover:	ASME SA-105	GR II	7.66" Min.
Disc (Piston)	ASTM A-216	GR WCB	1.04" Min.
Stem:	ASTM A-276	Type 410	1.70" Min. at the throat
Bolting	ASME SA-540	GR 23 Class 4	1-5/8" actual diamete
No. of Bolts:	ASME SA-540	GR 23 Class 4	24

C. The response to this part of the question is included in the Appendix G and H submittal. (See Question 121.011, Reference 1.)

Q. 121.016

There are six weld heats in response to Questions 121.001 and 121.002 whose composition cannot be found in the list of weld metal compositions. They are (Location/Type/Heat/Lot):

a. Ring 21BA/RAC01NMM or 3P4966/1214

b. Ring 21BB/E8018NM/C3L46C/J020827A

c. Ring 21BC/E8018NM/19L853/A111A27A

d. Ring 21BC/E8018NM/C3L46C/J020A27A

e. Ring 21BD/E8018NM/C3L46C/J020A17A

f. Ring 21BD/E8018NM or 04P046/D217A27A

Indicate the chemical composition (particularly the copper, phosphorus and sulfur content) of these weld metals.

Response:

This question was responded to in the Appendix G and H submittal to the NRC. (See Question 121.017, Reference 1)

Q. 121.017

Indicate which reactor vessel beltline weld metals were utilized for root passes and are within the first quarter of the weld thickness.

Response:

This question was responded to in the Appendix G and H submittal to the NRC. (See Question 121.017, Reference 1)

Q. 121.018

If the chemical composition of the weld metals in Question 251.006 are not known and the weld metals are not located with the first quarter of weld thickness, utilize the upper limit curves in Regulatory Guide 1.99 to determine the predicted adjusted reference temperature (ΔRT_{NDT}). Indicate the end of life ΔRT_{NDT} for these materials and recalculate the pressure temperature limit curves if these weld metals become limiting during reactor vessel life.

Response:

This question was responded to in the Appendix G and H submittal to the NRC. (See Question 121.017, Reference 1)

Q. 121.019

Indicate the inside diameter and minimum wall thickness of the reactor vessel beltline.

Response:

The inside diameter with clad = 251" (minimum).

Wall thickness with clad = 6.625%.

Clad thickness = 0.1875" (nominal).
= 0.125" (minimum)

Refer to VFP No. 3133-31, which is included in the Appendix G and H submittal.

VFP 3133-31 is being sent from GE and will be included in the Appendix G & H submittal.

~~Hanford 2~~ WNP-2 Reactor Vessel Beltline Plate and Weld Information

1. Available Charpy V-notch and drop-weight/NDT toughness data are presented in Tables 1, 3 and 4 for ~~Hanford 2~~ WNP-2 beltline plates and welds. Table 2 shows a typical test certificate for a ~~Hanford 2~~ WNP-2 beltline plate. Table 4 gives supplementary Charpy V-notch results at +40°F for the surveillance program weld materials.

   These surveillance weld materials were also drop-weight tested to show 2 "no-break" results at -10°F; thus, assuring an NDT temperature of -20°F or lower. The actual NDT value was not determined, and, based on representative data, is assumed as -50°F.

2. The beltline layout is shown in Figure 1. This gives plate heat numbers and locations, as well as weld seam locations and identifications.

3. Copper and phosphorous values, to estimate the effects of radiation on toughness, are presented in Table 5.

4. Estimated starting (unirradiated) RT_{NDT} values are given in Table 5. They are estimated by using the data in Tables 1 and 3 in accordance with GE procedure Y1006A006 which meets the intent of ASME Code Paragraph NB-2300. This procedure is explained in Paragraph 5.3.1.5.2.2 (Attachment A) of the ~~Hanford 2~~ FSAR, Amendment 5. The procedure and data base are further clarified in response to Plant A Q121.11 and Q121.17. WNP-2

   For the ~~Hanford 2~~ WNP-2 beltline plates, longitudinal Charpy V-notch data are availble for the test temperature of +10°F (Table 1). For a given plate, if all Charpy values at +10°F are at least 50 ft-lb, then the 50 ft-lb transition temperature is conservatively assumed to be +10°F. For cases where any value is less than 50 ft-lb, the 50 ft-lb temperature is estimated from the lowest value at +10°F by adding a temperature increase correction factor of 2°F/ft-lb (Y1006A006). An additional increase of 30°F is added to these results to correct for orientation effects. These Charpy transition temperatures can then be used with the corresponding NDT data (Table 1) to determine RT_{NDT} in accordance with ASME NB-2300.

   For the beltline welds, the same procedure as for plates was used to estimate the Charpy 50 ft-lb transition temperatures. No orientation correction factor for the Charpy Transition Temperature is necessary for welds. Where NDT data are not available, an assumption of -50°F for NDT was made. Justification for this assumption is given in Item 7 of this submittal. The actual (when available) and assumed NDT values were used with the Charpy Transition Temperatures to determine RT_{NDT} in accordance with ASME NB-2300.

5. Estimated end-of-life (EOL) RT_{NDT} values (for ¼ thickness location from the vessel inside diameter) are given in Table 5, for the most

recent fluence estimate of $1.1 \times 10^{18} n/cm^2$. The EOL RT_{NDT} estimations are in accordance with NRC Regulatory Guide 1.99 Rev. 1.

6. Charpy V-notch upper shelf toughness testing was not a requirement when the ~~Hanford-2~~ WNP-2 vessel was manufactured. Thus, such data are not available for the ~~Hanford-2~~ WNP-2 beltline plates and welds. However, several weld materials exceed 75 ft-lb, even when tested at the lower test temperatures of +10 and -20°F.

Upper shelf toughness values for four of the ~~Hanford-2~~ WNP-2 beltline weld materials are shown in Table 3a and are in excess of 75 ft-lb. Further data, from representative materials, are supplied in Table 6 for vessel plates. All plate materials shown in Table 6 were produced by Lukens Steel Co. A typical test certificate (for ~~Hanford-2~~ WNP-2) from Lukens is shown in Table 2 to illustrate the requirements for the plate materials in Table 6 and for ~~Hanford-2~~ WNP-2. Table 6 shows that even though as little as 25 ft-lb (Heat C5978-1) is obtained at +10°F in some cases, that further testing at upper shelf temperatures can result in longitudinal specimen toughness on the order of 100 ft-lb or greater. To consider this in more detail, a conservative assumption of 65% reduction in upper shelf to estimate transverse results from longitudinal tests can be made (MTEB-5.2). A further reduction of upper shelf toughness to account for irradiation can be made from Regulatory Guide 1.99, Rev. 1, and is a maximum reduction of 15% for the highest Cu content of 0.15 wt% (Table 5). Using these conservative assumptions, with a goal of achieving at least 50 ft-lb toughness (transverse) at end-of-life, the longitudinal toughness requirements (L) for ~~Hanford-2~~ WNP-2 plates can be predicted as 91 ft-lb from the following equation:

$$50 = 0.65\ (L) - (0.15)\ [0.65\ (L)]$$

(Where L is the longitudinal upper shelf value at start of life)

It can be seen from the data in Table 6 that toughness in excess of 91 ft-lb is to be expected for longitudinal upper shelf testing of this material. Furthermore, supplemental transverse tests for such materials are also shown in Table 6 and exceed 75 ft-lb for upper shelf toughness.

Further upper shelf toughness data for representative welds, made by the same vendor as ~~Hanford-2~~ WNP-2, are given in Tables 7, 8, 9 and 10. Tables 7 and 8 present the weld procedures typical for the data base in Table 10. Table 9 shows the ~~Hanford-2~~ WNP-2 beltline surveillance weld procedure, which is, in fact, just another revision of the same procedure as in Tables 7 and 8. These tables represent surveillance program procedures and baseline data, as well as other vessel material data, which are considered representative of ~~Hanford-2~~ WNP-2 beltline welds. These data are in excess of 75 ft-lb. Furthermore, ~~for the Hanford-2~~ WNP-2 beltline weld materials, only relatively small decreases in upper shelf due to irradiation are predicted (Regulatory Guide 1.99, Rev. 1) because of the controlled Cu contents as shown in Table 5.

7. Drop-weight NDT values for weld materials are also shown in Table 9. It can be seen that the assumption of -50°F for these materials is reasonable. All NDT values are -50°F or lower, except for one case. This case (1P6484/0156 for PLant C) is considered to be non-representative because of the relatively low Charpy test value (17 ft-lb) at +10°F and 0°F for this material. The ~~Hanford-2~~ WNP-2 weld materials in Table 3 for which NDT values were determined, have values of -50°F for both shielded metal arc and submerged arc welds.

WNP-2
~~Hanford 2~~ Reactor Vessel
Non-Beltline Information

1. Limiting RT_{NDT} values which affect vessel testing and operation are shown in the FSAR (paragraphs shown on Attachment A). A sentence has been added in Paragraph 5.3.1.5.2.2 of Attachment A to further clarify that these are the RT_{NDT} values for the limiting vessel locations and materials that affect testing and operating limits. The other materials in the vessel which meet specified toughness requirements do not affect the pressure-temperature curves.

2. The estimation procedures for these RT_{NDT} values are in accordance with GE procedure Y1006A006, and are also explained in Paragraph 5.3.1.5.2.2 of the FSAR (Attachment A) and the responses to Plant A Q121.11 and Q121.17. Some further details follow:

   a. The limiting plate material for the vessel is in the beltline (Table 5, Heat C1272-1, RT_{NDT} = +28°F) in terms of initial RT_{NDT}. Plate Heat C1307-2 in the upper shell ring attaches to the closure flange and limits the bolt-up temperature with RT_{NDT} = +20°F (lowest longitudinal Charpy V of 30 ft-lb, at +10°F, and NDT = +10°F).

   b. The limiting closure flange toughness is for the shell closure flange Heat No. 2V2243 with RT_{NDT} = +10°F (lowest longitudinal Charpy V of 90 ft-lb at +10°F, and NDT = +10°F).

      Feedwater nozzle forgings all had NDT at least as low as -20°F. The lowest Charpy V toughness was 26 ft-lb at -20°F for Heat No. Q2Q55W, Forging No. 786S-3, resulting in RT_{NDT} = -2°F.

   c. The limiting closure stud toughnesses are for Heat #81741, Bar #124 with 45 ft-lb (and 50 mils) at +10°F, and Heat #81[illegible], Bars #135 and #137 with 26 mils (and 47 ft-lb) at +10°F, resulting in a lowest service temperature of +10°F.

   d. Charpy V-notch impact testing was done at +10°F or -20°F for vessel weld materials. An RT_{NDT} value of 0°F is conservatively assumed as limiting for non-beltline welds, based on the specified minimum single-value requirement of 25 ft-lb at +10°F and a Quality Assurance check that there were no deviations from this requirement. Although NDT testing was not done, data presented in support of the beltline welds (Table [illegible]) indicate NDT values much below 0°F. Thus, the limiting weld RT_{NDT} for the non-beltline region is taken as 0°F.

NSS:ggt:csc/150D
11/16/81

WNP-2 ~~Hanford-2~~ Main Steam Piping and NSSS Ferritic Valves

1. WNP-2 The ~~Hanford-2~~ main steam piping is in compliance with 10CFR50 Appendix G, since toughness testing was required at +70°F, or lower, in compliance with the 1971 ASME Code, Summer 1972 Addenda, Paragraph NB-2300.

2. WNP-2 ~~Hanford-2~~ Safety Relief Valves (SRV) are in compliance with 10CFR50 Appendix G, since they are exempted by the ASME Code from toughness testing because of their 6-inch size.

3. WNP-2 ~~Hanford-2~~ HPCS Injection Gate valve materials (ASME SA-216 Grade WCB, from Quaker Alloy Casting Co.) were toughness tested at -20°F as a requirement to meet the ASME Code, Section III, 1971 Edition, Summer 1971 Addenda. This indicates that these materials would meet 10CFR50 Appendix G requirements.

4. WNP-2 The ~~Hanford-2~~ main steam flued head is in compliance with 10CFR50 Appendix G, since toughness testing was required at +70°F, or lower, in compliance with the 1971 ASME Code, Summer 1972 Addenda, Paragraph NB-2300.

5. WNP-2 ~~Hanford-2~~ Main Steam Isolation Valves (MSIV) were exempt from toughness testing at the time of purchase. This is based on the system temperature being in excess of 250°F when system pressure is at the 20 percent of design limit, and the temperature increasing as the pressure increases. The MSIV's were procured in compliance with the ASME Code, Section III, 1971 Edition, Winter 1971 Addenda.

   The MSIV body and bonnet materials are characterized in Table 11. Note that the HPCS Injection Gate valve castings for ~~Hanford-2~~, WNP-2 which met Charpy requirements at -20°F, are the same specification as the MSIV bodies.

   Toughness data on similar materials for MSIV's on other projects, where toughness testing was done, is attached in Table 12. In some cases, the materials and valve vendors are the same as for ~~Hanford-2~~. WNP-2. These data demonstrate the capability of the ~~Hanford-2~~ MSIV materials to meet current toughness requirements. WNP-2

   Further evidence of toughness for SA-105 forgings (MSIV bonnet, or cover, material) can be found in the July 1978 issue of Metal Progress, Pages 35-39. This article shows Charpy V-notch toughness in excess of 25 mils at +40°F and NDT values no greater than -10°F for SA-105 material normalized at 1565°F for 4 hours and air cooled after forging.

WNP-2
~~Hanford-2~~
RPV Surveillance Specimens

1. Surveillance specimen materials are identified, with properties, in Tables 1 through 5 and are actual beltline materials. It can be seen in Table 5 that the surveillance specimen plate material, although not having the highest predicted EOL RT_{NDT}, does have the greatest predicted shift in RT_{NDT} (which is the current basis in ASTM E185-79 Table 1 for surveillance program design). All beltline weld materials in Table 5 are relatively resistent to neutron radiation damage, as shown by the small predicted shifts in RT_{NDT}. The surveillance program weld material has among the highest predicted EOL RT_{NDT} values for the beltline welds. Absolute compliance to ASTM E185 material selection methods is not considered significant because of the relatively low predicted shifts in RT_{NDT} for the WNP-2 - ~~Hanford-2~~ beltline materials (Table 5). Heat Affected Zone (HAZ) specimens were taken from the HAZ of the weldment fabricated from the materials indicated in Table 5.

2. The CBIN weld procedure used to prepare the surveillance specimen weldment is shown as Table 9. Both single and tandem wire submerged arc processes, with the same wire heat and flux lot, are documented as being used to perform the weld. As seen in Tables 3, 4 and 5, the properties and composition of the deposited weld metal by single and tandem wire processes are quite similar in this case. The weld joint design and specimen placement in the weld are shown in Figure 2, and it can be seen that the weld specimens are not in the vicinity of the weld root.

3. Base metal Charpy and tensile specimens are taken from the plate ¼ thickness location and their axis is parallel (longitudinal) to the plate principal rolling direction. The longitudinal surveillance specimens are consistent with the specimen orientation used to qualify the actual beltline material (Table 1), and the effect of specimen orientation on radiation damage has been shown to be insignificant (see response to Plant A Q121.16). The HAZ specimen axis is also parallel to the plate principal rolling direction, representing a vertical weld seam in the vessel.

4. Surveillance capsule contents and locations are the following:

Capsule No.	Azimuth	Charpy V-Notch Longitudinal			Tensile		
		Base	HAZ	Weld	Base	HAZ	Weld
1	300°	8	8	8	2	2	2
2	120°	8	8	8	3	3	2
3	30°	12	12	12	3	4	3

Two flux wires each of Fe and Cu are contained in each capsule. In addition, a separate neutron dosimeter is at the 30° Azimuth by Capsule No. 3 and contains 3 Fe and 3 Cu flux wires.

Because of the low fluence, and the relatively small predicted effects of radiation on the surveillance (and beltline) materials, the use of only 8 Charpy specimens (of each material) in two of the capsules is considered adequate.

5. Further details of the surveillance program are included in Paragraph 5.3.1.6 of the ~~Hanford-2~~ WNP-2 FSAR.

CROSS-REFERENCE OF SECTIONS AND PARAGRAPHS TO ~~HANFORD 2~~ WNP-2 QUESTIONS

~~HANFORD 2~~ WNP-2 QUESTION	THIS SUBMITTAL SECTION	PARAGRAPH(S)
121.11	RPV Beltline	6,7
121.12	RPV Non-beltline RPV Beltline	1,2 4
121.13	RPV Beltline	1,6
121.14	RPV Surveillance	1 through 5
121.15	Ferritic Valves, etc.	5
121.16	RPV Beltline	3
121.17	RPV Surveillance (Weld joint is Double-V and root pass is not in the first quarter thickness. Root passes would be back-gouged out, and general practice is for weld to be Submerged Arc except for repairs, which are E8018-G).	2
121.18	RPV Beltline	3,5

NS:rf/150T1
11/20/81

WNP-2
~~Hanford-2~~

Table 1

Beltline Plate Toughness Data

(SA-533 Grade B, Class 1 Plate - Lukens Steel Co.)

Plate	Heat#-Slab#	Dropweight NDT (Top/Bottom) °F	CHARPY V-NOTCH TOUGHNESS (TOP/BOTTOM)				
			Orientation (L or T)	Charpy Test Temp. °F	Energy Ft-Lb	Lat. Expansion Mils	% Shear
Lower Shell, Ring #1	C1272-1	-10	L	+10	34,26,30/31,34,30	30,34,24/27,26,32	10,10,10/40,40,40
	C1272-2	-30	L	+10	40,42,44/51,55,50	32,36,38/41,44,42	40,40,40/50,50,50
	C1273-1	-20	L	+10	33,33,30/30,34,35	30,31,27/26,34,32	10,10,10/10,10,10
	C1273-2	-30	L	+10	38,48,55/66,61,71	44,39,34/53,52,56	40,40,40/60,60,60
Lower Intermediate Shell, Ring #2	B5301-1*	-30	L	+10	64,62,66/52,52,55	56,56,56/45,44,44	60,60,60/40,40,40
	C1336-1	-30	L	+10	70,72,71/60,44,66	59,60,62/56,41,51	60,60,60/50,50,50
	C1337-1	-30	L	+10	71,76,74/70,72,55	61,60,60/63,61,52	60,60,60/60,60,60
	C1337-2	-50	L	+10	62,72,82/73,67,73	51,61,66/52,59,61	60,60,60/60,60,60

*This material is also in the reactor vessel surveillance program.

NSS:ggt:csc/15911
11/16/83

PURCHASER: TABLE 2 - WNP-2 Hanford 2 Surveillance Plate.

12 CBI Nuclear Co.
P.O. Box 13308
Presidents Island
Memphis, Tenn. 38101

LUKENS STEEL COMPANY
COATESVILLE, PA. 19320

TEST CERTIFICATE

MILL ORDER NO.	CUSTOMER P.O.	
16446-1	M72-2647-3 Pt. 1	DP 102372 DD

DATE: 10/27/72

CONSIGNED: Chicago Bridge & Iron Co.
Boyles, Ala. 35202

SPECIFICATIONS: CBIN MS-51.1 2647 Rev. 3 DTD 8/14/72 Except Para. 6.0 QAS-51 Rev. 1 SA-533 Gr. B Class 1 Sect. II & III Incl. Summer 1971 Addenda

BEND TEST: O.K. HOMOGENEITY TEST:

Sheet # 1 of 2

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B	Grain Size	
B5301	20	1.34	017	014	14	23	50		52	00				7-8	V.I.P. Steel

PHYSICAL PROPERTIES

MELT NO.	BAR NO.	YIELD PSI X1000	TENSILE PSI X1000	% ELONG. IN 2"	% R.A.	MIN	Long. IMPACTS V-Notch +10°F.			Fracture Appearance % Shear	DESCRIPTION
B5301	1	629	840	27			64	62	66	60-60-60	1- 6-7/16" x 177 x 258
		571	800	29			52	52	55	40-40-40	
					Lateral Expansion in Inches						
							.056	.056	.056		
							.045	.044	.044		

Rec. 11-30-72

TOP DROP WEIGHT TRANS. CURVE

TEMP.	RESULTS
+10°F.	No Break
0°F.	No Break
-20°F.	2 No Break
-30°F.	Break
-40°F.	Break

N.D.T. is -30 F.

BOTTOM DROP WEIGHT TRANS. CURVE

TEMP.	RESULTS
0°F.	No Break
-10°F.	No Break
-30°F.	2 No Break
-40°F.	Break
-50°F.	Break

N.D.T. is -40°F.

Pc MK 22-1-1

We hereby certify the above data are correct as contained in the records of the company.

SUPERINTENDENT

PURCHASER: TABLE 2 - (Continued)

12 CBI Nuclear Co.
Memphis, Tenn.

COATESVILLE, PA. 19320
TEST CERTIFICATE

MILL ORDER NO.	CUSTOMER P.O.	
16446-1	N72-2647-3 Pt. 1	

DATE: 10/27/72
CONSIGNED: Chicago Bridge & Iron Co.
Boyles, Ala.

(94)

SPECIFICATIONS:
SAME

Sheet # 2 of 2

BEND TEST | HOMOGENEITY TEST

CHEMICAL ANALYSIS

MELT NO.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	B		

PHYSICAL PROPERTIES

MELT NO.	SLAB NO.	YIELD PSI X100	TENSILE PSI X100	% ELONG. IN	% R.A.	BHN	IMPACTS			DESCRIPTION.

Plate and tests heated to 1650°F.±25°F., held 1/2 hr. per inch min. and water quenched to below 400°F., (Time in quench tank - 26 minutes) then tempered 1280°F., held 1/2 hr. per inch min. and water quenched. (Time in quench tank - 26 minutes)

Plate and tests stress relieved by heating to 1175°F., held 1 hr. and air cooled.

Tests stress relieved by heating within a rate of 100°F. per hr. to 1150°F.±25°F.-50°F., Hold 50 hrs. and furnace cooled within a rate of 100°F. per hr. to 600°F., then air cooled.

"Above material has not been U.T. Tested at LUKENS STEEL CO.

We hereby certify that the above material has been manufactured according to CBIN MS-51.1 2647 Rev. 3 DTD 8/14/72, Except Para. 6.0 QAS-51 Rev. 1 SA-533 Gr. B Class 1 Sect. II & III Incl. Summer 1971 Addenda, and that we have complied with all the requirements of these specifications.
U.T. Procedure - LS-102 Rev. 10, DTD 6/2/72.

We hereby certify the above figures are correct as contained in the records of the company.

SUPERVISOR-TESTING: L. H. Kline

-10-

WNP-2
~~Hanford-2~~

Table 3

Beltline Weld Toughness Data, Post Weld
1150°F for 50 hr. Typical; Submerged Arc Welding -
Raco 1NMM Wire With Linde 124 Flux; Shielded Metal Arc
Welding with E8018-G (E8018NM) Electrodes

Weld Seam	Type	Heat #	Lot # or Flux #	Drop-Weight NDT, °F	CHARPY TOUGHNESS Charpy Temp., °F	Charpy Energy, Ft-lbs.	Lat. Expansion, Mils	% Shear
AB	E8018-G	492L4871	A422B27AF	-50	-20	78,82,105,93,81	55,60,72,64,60	50,45,40,25,20
	E8018-G	04T931	A423B27AG	NA	-20	86,84,102,63,61	69,58,60,57,70	50,45,40,25,20
	Raco 1NMM	5P6756**	0342	-60	+10	76,79,77,80,72	64,72,55,69,60	30,55,40,65,50
	Raco 1NMM	3P4955***	0342	-20	+10	49,63,47,49,64	39,48,36,43,57	20,25,25,15,20
	Raco INMM	3P4955**	0342	-40	+10	52,37,45,55,33	44,30,43,50,32	15,15,15,20,15
	Race INMM	5P6756***	0342	-50	+10	76,79,77,80,72	64,72,55,69,60	30,55,40,65,50
	(Additional Charpy data for 5P6756/0342 and 3P4955/0342, single and tandem, are in Table 3a)							
BA	E8018-G	04P046	D217A27A	NA	-20	34,36,37,39,40	23,28,24,20,24	20,20,30,30,30
	E8018-G	07L669	K004A27A	NA	+10	50,50,54	44,44,46	50,60,40
	Raco 1NMM	3P4966**	1214	≥-20*	+10	39,38,38,82,84	68,64,63,81,72	70,60,70,80,70
	Raco 1NMM	3P4966***	1214	≥-20*	+10	28,84,63,75,78	18,62,57,51,57	30,40,40,40,40
BB	E8018-G	04P046	D217A27A	(See Preceding Results)				
	E8018-G	07L669	K004A27A	(See Preceding Results)				
	E8018-G	C3L46C	J020A27A	NA	+10	35,39,40	34,39,39	60,60,60
	E8018-G	08M365	G128A27A	NA	+10	49,50,51	38,40,43	60,50,60
	Raco 1NMM	3P4966	1214	(See Preceding Results)				
BC	E8018-G	09L853	A111A27A	NA	+10	78,78,79	60,62,62	70,80,60
	E8018-G	C3L46C	J020A27A	(See Preceding Results)				
	Raco 1NMM	3P4966	1214	(See Preceding Results)				

NA = Not Available.
* = Drop-weight test "no-break" at -10°F (Actual NDT not determined).
** = Single Wire Process.
*** = Tandem Wire Process.

NSS:ggt:rf/150112
11/20/81

Table 3 - (Continued)

Weld Seam	Type	Heat #	Lot # or Flux #	Drop-Weight NDT °F	CHARPY TOUGHNESS Charpy Temp. °F	Charpy Energy Ft-lbs.	Lat. Expansion Mils	% Shear
BD	E8018-G	C3L46C	J020A27A	(See Preceding Results)				
	E8018-G	04P046	D127A27A	(See Preceding Results)				
	Raco 1NMM	3P4966	1214	(See Preceding Results)				
BE	Raco 1NMM	3P4966	1214	(See Preceding Results)				
BF	E8018-G	05P018	D211A27A	NA	-20	29,30,31,36,38	26,26,31,33,35	30,30,30,40,40
	E8018-G	04P046	D217A27A	(See Preceding Results)				
	Raco 1NMM	3P4966	1214	(See Preceding Results)				
BG	E8018-G	624063	C228A27A	NA	-20	37,40,51,57,70	33,34,41,47,55	30,40,40,50,60
	E8018-G	624039	D224A27A	NA	-20	28,33,34,36,42	29,32,33,34,42	30,40,40,40,40
	Raco 1NMM	3P4966	1214	(See Preceding Results)				
BH	E8018-G	624039	D205A27A	NA	-20	41,44,49,54,58	32,36,40,41,45	20,30,30,35,40
	E8018-G	04P046	D217A27A	(See Preceding Results)				
	Raco 1NMM	3P4966	1214	(See Preceding Results)				

NA = Not Available.

NSS:ggt:cs:/150H3
11/16/81

Table 3a - Additional Toughness Data for ~~Hamboldt~~ WNP-2 Beltline Weld Materials, 5P6756/0342 and 3P4955/0342 (Single and Tandem Wire).

DROP WEIGHT TESTS

Type of Material Raco 1NMM (Single Wire) Size 3/16"ø Heat 5P6756

Linde 124 Lot 0342

Specimen Type P-2 Specimen Size 3/4" x 2" x 5"

Testing Conditions: Anvil 3/4" Weight 60# Drop Height 5"

Specimen	Location	Test Temp °F	Results
Weld Metal 1	1/4t	-50	No Break
" " 2	"	-50	No Break
" " 3	"	-70	Break
" " 4	"	-60	Break

WM_{NDT} Temp. -60°F

IMPACTS TESTS - CHARPY VEE NOTCH - FULL SIZE

Specimen	Location	Test Temp. °F	Energy Ft. Lbs.	Lateral Expansion	% Shear
Weld Metal 1	1/4t	-60	33	34	5
" " 2	"	-60	21	25	5
" " 3	"	-60	34	32	5
" " 4	"	0	55	54	20
" " 5	"	0	66	51	20
" " 6	"	0	63	57	25
" " 7	"	+10	69	62	30
" " 8	"	+10	59	58	25
" " 9	"	+10	60	59	25
" " 10	"	+10	58	55	20
" " 11	"	+10	54	53	20
" " 12	"	+40	70	61	50
" " 13	"	+40	73	59	55
" " 14	"	+70	75	61	75
" " 15	"	+70	78	75	80
" " 16	"	+70	72	62	65
" " 17	"	+212	89	75	100
" " 18	"	+212	94	70	100
" " 19	"	+212	91	64	100

WM T_{CV} Temp. 0°F

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy Vee Notch)	RT_{NDT} (Reference Temperature)
Weld Metal	-60°F	0°F	-60°F

Table 3a - (Continued)

DROP WEIGHT TESTS

Type of Material Raco 1NMM (Tandem Wire) Size 3/16"ø Heat 5P6756
Linde 124 Lot 0342
Specimen Type P-2 Specimen Size 3/4" x 2" x 5"
Testing Conditions: Anvil 3/4" Weight 60# Drop Height 5'

Specimen	Location	Test Temp. °F	Results
Weld Metal 1	1/4t	-40	No Break
" " 2	"	-50	Break
" " 3	"	-40	No Break
WM_{NDT} Temp. -50°F			

IMPACTS TESTS - CHARPY VEE NOTCH - FULL SIZE

Specimen	Location	Test Temp. °F	Energy Ft. Lbs.	Lateral Expansion	% Shear
Weld Metal 1	1/4t	-80	24	23	5
" " 2	"	-80	46	41	5
" " 3	"	-50	52	45	10
" " 4	"	-50	39	37	20
" " 5	"	-50	40	36	15
" " 6	"	+10	64	35	35
" " 7	"	+10	79	72	45
" " 8	"	+10	77	55	55
" " 9	"	+10	80	69	50
" " 10	"	+10	72	60	65
" " 11	"	+40	80	69	75
" " 12	"	+40	85	74	75
" " 13	"	+70	94	57	95
" " 14	"	+70	87	61	90
" " 15	"	+70	95	58	90
" " 16	"	+212	95	57	100
" " 17	"	+212	99	67	100
" " 18	"	+212	96	68	100
WMT_{CV} Temp. +10°F					

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy Vee Notch)	RT_{NDT} (Reference Temperature)
Weld Metal	-50°F	+10°F	-50°F

Table 3a - (continued)

DROP WEIGHT TESTS

Type of Material Raco lNMM (Single Wire) Size 3/16"ø Heat 3P4955

Linde 124 flux Lot 0342

Specimen Type P-2 Specimen Size 3/4" x 2" x 5"

Testing Conditions: Anvil 3/4 Weight 60# Drop Height 5'

Specimen	Location	Test Temp. °F	Results
Weld Metal 1	1/4t	-60	Break
" " 2	"	-50	Break
" " 3	"	-40	Break
" " 4	"	-30	No Break
" " 5	"	-30	No Break
" " 6			
WM T_{NDT} Temp. -40°F			

IMPACTS TESTS - CHARPY VEE NOTCH - FULL SIZE

Specimen	Location	Test Temp. °F	Energy Ft. Lbs.	Lateral Expansion	% Shear
Weld Metal 1	1/4t	-40	7	6	5
" " 2	"	-40	14	14	5
" " 3	"	-40	8	7	5
" " 4	"	+10	37	30	15
" " 5	"	+10	45	43	15
" " 6	"	+10	55	50	20
" " 7	"	+10	33	32	15
" " 8	"	+10	52	44	15
" " 9	"	+20	35	34	10
" " 10	"	+20	43	34	15
" " 11	"	+20	46	43	15
" " 12	"	+30	58	50	15
" " 13	"	+30	46	38	15
" " 14	"	+30	52	42	20
" " 15	"	+40	51	50	25
" " 16	"	+40	52	50	30
" " 17	"	+40	56	48	25
" " 18	"	+212	85	72	100
" " 19	"	+212	91	66	100
" " 20	"	+212	94	87	100
WM T_{CV} Temp. +40°F					

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy Vee Notch)	RT (Reference Temperature)
Weld Metal	-40°F	+40°F	-20°F

Table 3a - (Continued)

DROP WEIGHT TESTS

Type of Material Raco 1NM1 (Tandem Wire) Size 3/16"ø Heat 3P4955
Linde 124 flux Lot 0342
Specimen Type P-2 Specimen Size 3/4" x 2" x 5"
Testing Conditions: Anvil 3/4 Weight 60# Drop Height 5'

Specimen	Location	Test Temp. °F	Results
Weld Metal 1	1/4t	-60	Break
" " 2	"	-40	Break
" " 3	"	-30	Break
" " 4	"	-20	Break
" " 5	"	-10	No Break
" " 6	"	-10	No Break
WM RT_{NDT} Temp. -20°F			

IMPACTS TESTS - CHARPY VEE NOTCH - FULL SIZE

Specimen	Location	Test Temp. °F	Energy Ft. Lbs.	Lateral Expansion	% Shear
Weld Metal 1	1/4t	-40	25	24	5
" " 2	"	-40	32	23	5
" " 3	"	-20	12	15	10
" " 4	"	-20	43	34	5
" " 5	"	-20	51	46	10
" " 6	"	+10	49	39	20
" " 7	"	+10	63	48	25
" " 8	"	+10	47	36	25
" " 9	"	+10	49	43	15
" " 10	"	+10	64	57	20
" " 11	"	+30	60	57	30
" " 12	"	+30	65	47	35
" " 13	"	+30	52	50	25
" " 14	"	+40	74	68	55
" " 15	"	+40	73	65	60
" " 16	"	+40	78	63	55
" " 17	"	+212	95	76	100
" " 18	"	+212	94	74	100
" " 19	"	+212	97	66	100
" " 20					
WM T_{CV} Temp. +30°F					

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy Vee Notch)	RT_{NDT} (Reference Temperature)
Weld Metal	-20°F	+40°F	-20°F

TABLE 4 - Supplementary Results for ~~Hamtack 2~~ WNPP surveillance - Weld Metal (Heat 3P4966/Lot 1214)

CB IMPACT TEST DATA

TYPE OF NOTCH VEE

CN-40
INMM & LINDE 124

SPEC. NO.	SPEC. ORIENT	SPEC. SIZE	NOTCH LOCATION	TEST TEMP DEG F.	ENERGY FT-LB	LATERAL EXPANSION MILS	PER CENT SHEAR
S-1	SIDE 1	Full	WM	+40	88	72	75
S-2	1/4T	"	"	+40	88	68	85
S-3	"	"	"	+40	82	67	65
(Single Wire)							
T-1	SIDE 1	Full	WM	+40	65	52	55
T-2	1/4T	"	"	+40	69	55	65
T-3	"	"	"	+40	70	59	45
(Tandem Wire)							

REMARKS:

SIGNED: BY C. R Dunn 12/3/73

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WNP 2
~~Hanford 2~~

Table 5

Beltline Radiation

ΔRT_{NDT} & EOL (End-of-Life) RT_{NDT}

Peak EOL Fluence = 1.1 x 10^{18}n/cm^2 (>1MeV) at ¼T wall.

A. Plates - Beltline

Heat No.	Wt.% Cu	Wt.% P	Y1006A006 Start RT_{NDT} (°F)	Reg. Guide 1.99 Extrap ΔRT_{NDT} (°F)	Predicted EOL RT_{NDT} (°F)	
C1272-1	.15	.013	+28	45	+73	Limiting Plate
C1272-2	.15	.013	0	45	+45	
C1273-1	.14	.014	+20	43	+63	
C1273-2	.14	.014	+4	43	+47	
B5301-1*	.14	.017	-20	48	+28	
C1336-1	.13	.017	-8	45	+37	
C1337-1	.15	.018	-20	53	+33	
C1337-2	.15	.018	-20	53	+33	

B. Welds - Beltline

Heat No./Lot No.	Wt.% Cu	Wt.% P	Y1006A006 Start RT_{NDT} (°F)	Reg. Guide 1.99 Extrap ΔRT_{NDT} (°F)	Predicted EOL RT_{NDT} (°F)
492L4871/A422B27AF	.03	.020	-50	33	-17
04T931/A423B27AG	.03	.020	-50	33	-17
04P046/D217A27A	.06	.009	-48	15	-33
07L669/K004A27A	.03	.014	-50	23	-27
C3L46C/J020A27A	.02	.019	-20	32	+12
08M365/G128A27A	.02	.020	-48	33	-15
09L853/A111A27A	.03	.018	-50	30	-20
05P018/D211A27A	.09	.008	-38	17	-21
624063/C228A27A	.03	.009	-50	15	-35
624039/D224A27A	.07	.015	-36	25	-11
624039/D205A27A	.10	.010	-50	23	-27
5P6756/0342	.08	.010	-50	17	-33
3P4955/0342	.025	.016	-44	27	-17
**3P4966/1214*	.03	.011	-26	18	-8
***3P4966/1214*	.03	.010	-6	17	+11

* These materials are also in the reactor vessel surveillance program.
** Single Wire Process.
*** Tandem Wire Process.

NSS:ggt/150I1
11/13/81

Table 6

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

(Plant A Combustion Engineering)

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient. (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C5978-1	+10	-40	L	7.0, 7.0, 11.0	5, 3, 7	0, 0, 0
		+10		25.0, 33.0, 30.0	23, 25, 23	10, 10, 10
		+40		53,0, 48.0, 48.0	40, 35, 36	20, 20, 20
		+110		118.0, 116.0, 109.0	79, 76, 74	80, 80, 80
		+160		123.0, 136.0, 136.0	82, 84, 84	90, 95, 95
C5978-2	-10	-40	L	22.0, 24.0, 24.0	17, 18, 19	0, 0, 0
		+10		49.0, 46.0, 42.0	38, 36, 33	25, 25, 25
		+40		62.0, 60.0, 41.0	46, 44, 34	35, 35, 25
		+110		98.0, 90.0, 100	73, 67, 75	80, 70, 80
		+160		119.0, 120.0, 118.0	88, 86, 82	99, 100, 100
C5979-1	-10	-40	L	9.0, 11.0, 19.0	5, 7, 13	0, 0, 0
		+10		61.0, 57.0, 43.0	45, 41, 32	30, 30, 20
		+40		73.0, 92.0, 65.0	51, 63, 43	35, 45, 35
		+110		117.0, 116.0, 100.0	78, 76, 68	80, 80, 70
		+116		134.0, 136.0, 134.0	87, 86, 85	99, 99, 100
C6345-1	-40	-80	L	8, 6	4, 4	0, 0
		-40		29, 15, 23	21, 13, 16	5, 0, 1
		+10		109, 88, 77	76, 58, 56	50, 35, 35
		+40		103, 96, 122	68, 65, 77	45, 40, 60
		+110		147, 147	84, 82	100, 100
		+160		151, 165	87, 94	100, 100
C6318-1	-20	-40	L	25, 17, 14	18, 11, 9	1, 0, 0
		+10		80, 66, 72	57, 47, 50	35, 30, 30
		+40		85, 95, 112	64, 68, 75	40, 40, 50
		+110		126, 145, 117	81, 89, 76	90, 100, 90
		+160		140, 140, 139	86, 89, 88	100, 100, 100
C6345-2	-40	-80	L	10, 12	7, 9	0, 0
		-40		32, 16, 49	20, 11, 33	10, 0, 20
		+10		93, 94, 67	69, 66, 48	40, 40, 25
		+40		109, 125, 128	70, 72, 82	50, 60, 70
		+110		127, 165	81, 82	85, 100
		+160		153, 161	86, 88	100, 100

Table 6 (Cont.)

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

(Plant A - Combustion Engineering)

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C5979-2	-10	-80	L	8.0, 11.0	5, 9	0, 0
		-40		28.0, 17.0, 18.0	20, 16, 14	15, 10, 10
		+10		64.0, 63.0, 49.0	44, 44, 34	30, 30, 20
		+40		72.0, 76.0, 79.0	47, 49, 50	35, 35, 35
		+110		107.0, 102.0	77, 74	85, 80
		+160		134.0, 141.0	79, 83	100, 100
C5996-1	-10	-40	L	12.0, 53.0, 12.0	10, 20, 11	0, 15, 0
		+10		65.0, 60.0, 77.0	46, 42, 54	30, 30, 40
		+40		88.0, 113.0, 78.0	56, 70, 54	40, 60, 40
		+110		111.0, 126.0, 134.0	74, 85, 83	80, 90, 90
		+160		146.0, 148.0, 143.0	86, 89, 86	100, 100, 100
C6318-1		-40	T	7.5	5.0	1
		-10		32.5, 31.0	27.0, 28.5	5, 5
		+10		41.5, 42.0	36.0, 37.0	25, 25
		+40		31.5, 60, 49, 63	26.0, 44.0 34.0, 49.0	35, 30, 40, 40
		+61		70, 71.0	57.2, 57.5	50, 50
		+120		95	70.5	99
		+200		100.0, 91.0, 90.0	75.0, 63.5, 69.5	99, 100, 100

Table 6 (Cont)

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO)

(Plant A Combustion Engineering) (Continued)

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient. (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
A5333-1	-10	-40	L	21, 13, 11	17, 11, 9	5, 0, 0
		+10		56, 67, 53	41, 47, 40	20, 30, 20
		+40		82, 100, 84	56, 70, 60	40, 50, 40
		+110		126, 120, 133	87, 81, 84	80, 80, 80
		+160		155, 155, 145	92, 90, 89	100, 100, 100
B-0078-1	-10	-40	L	10, 14, 25	10, 13, 21	0, 0, 5
		+10		73, 49, 70	54, 39, 53	40, 30, 40
		+40		94, 100, 100	65, 68, 70	60, 60, 60
		+110		118, 128, 140	82, 86, 89	90, 90, 100
		+160		151, 136, 143	90, 84, 88	100, 100, 100
C6123-2	-10	-80	L	11, 8	9, 7	0, 0
		-40		28, 38, 10	22, 28, 9	10, 10, 0
		+10		77, 60, 73	56, 45, 53	40, 35, 40
		+40		113, 108, 122	73, 71, 75	65, 60, 75
		+110		120, 149	89, 91	90, 100
		+160		149, 151	91, 93	100, 100
C5987-1	-10	-40	L	19, 13, 14	14, 10, 13	0, 0, 0
		+10		63, 55, 35	47, 41, 26	35, 35, 30
		+40		80, 99, 87	59, 68, 61	50, 70, 55
		+110		122, 134, 122	84, 86, 84	100, 100, 100
		+160		122, 134, 127	86, 86, 84	100, 100, 100
C5987-2	-10	-40	L	15.0, 8.0, 10.0	7, 7, 7	0, 0, 0
		+10		76.0, 79.0, 51.0	54, 59, 57	35, 35, 30
		+40		57.0, 76.0, 75.0	42, 57, 54	30, 35, 35
		+110		106.0, 102.0, 113.0	72, 68, 76	80, 80, 80
		+160		140.0, 133.0, 138.0	87, 81, 84	100, 100, 100
C6003-2	-10	-40	L	10, 7.0, 8.0	7, 4, 3,	0, 0, 0
		+10		37.0, 31.0, 51.0	28, 22, 37	20, 20, 30
		+40		65.0, 49.0, 50.0	44, 34, 36	35, 30, 30
		+110		81.0, 95.0, 82.0	60, 67, 61	60, 70, 60
		+160		121.0, 107.0, 120.0	82, 78, 87	100, 99, 100
C5996-2	-10	-80	L	7.0, 10.0	5, 8	0, 0
		-40		18.0, 25.0, 25.0	14, 20, 19	10, 10, 10
		+10		62.0, 71.0, 66.0	45, 50, 47	20, 30, 25
		+40		81.0, 100.0, 91.0	52, 71, 64	35, 50, 40
		+110		124.0, 130.0	83, 88	90, 90
		+160		149.0, 151.0	89, 91	100, 100

Table 6 (Cont)

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

Plant D (Combustion Engineering)

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C4882-1	-60	-80	L	16.0, 14.0	15, 11	0, 0
		-40		41.0, 32.0, 54.0	28, 22, 38	20, 20, 25
		+10		75.0, 68.0, 48.0	52, 49, 35	30, 30, 25
		+40		83.0, 95.0, 100.0	59, 65, 70	45, 50, 60
		+110		104.0, 116.0	75, 82	85, 90
		+160		130.0, 131.0	86, 84	100, 100
C4882-2	-40	-80	L	10.0, 7.0	10, 8	0, 0
		-40		46.0, 43.0, 30.0	36, 35, 26	10, 10, 10
		+10		75.0, 50.0, 66.0	58, 44, 52	30, 20, 20
		+40		90.0, 80.0, 88.0	71, 62, 63	40, 35, 40
		+110		120.0, 107.0	84, 82	85, 80
		+160		137.0, 129.0	94, 90	100, 100
C4882-2		-80	T	19.0	15.5	1
		-50		41.0, 25.0, 37.5	29.0, 16.5, 26.0	20, 10, 20
		-30		41.0, 40.0	30.0, 29.5	20, 20
		+10		61.0, 68.0	45.0, 49.5	30, 30
		+39		77.0, 71.0	54.0, 54.5	50, 30
		+70		91.0, 71.0	62.0, 53.0	75, 40
		+121		113.0	79.0	95
		+200		115.5, 113.5	82.5, 74.0	95, 95

Table 6 (Cont)

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

(Plant B CBIN)

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C9481-1	-30	+40	L	74, 74, 81	61, 58, 60	50, 50, 50
		+40		103, 61, 85	48, 66, 72	40, 50, 50
C9481-1		-40	T	17.0	15.0	5
		+10		23.5, 22.0	21.0, 20.5	10, 10
		+25		36.0	31.0	20-25
		+40		45.0, 35.0, 42.0	42.0, 34.2 38.0	30-35, 30, 30-35
		+51		40.5	35.0	30
		+70		51.0, 50.0	44.5, 42.5	40, 40
		+93		71.0	58.5	70
		+120		93.0	69.5	90-95
		+200		93.5, 100.0, 93.0	74.0, 72.0 69.0	95, 95, 95

Table 6 (Cont)

SA-533 GRADE B, CLASS 1 PLATE
TOUGHNESS DATA BASE, INCLUDING UPPER SHELF
(VENDOR - LUKENS STEEL CO.)

Plant E (Combustion Engineering)

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C4574-2	-30	-80	L	8.0, 16.0	6, 13	0, 0
		-40		34.0, 32.0, 27.0	25, 24, 20	10, 10, 5
		+10		48.0, 49.0, 60.0	36, 37, 43	15, 15, 20
		+40		76.0, 63.0, 69.0	56, 47, 51	30, 20, 25
		+110		98.0, 103.0	72, 76	95, 95
		+160		121.0, 119.0	85, 82	100, 100
C4574-2		-20	T	22.0	17.5	1
		+10		32.0, 35.0	22.5, 27.5	5, 5
		+40		50.0, 52.5	35.5, 41.5	10, 10
		+65		64.0, 55.0	47.0, 42.5	30, 30
		+102		75.0	60.5	50
		+119		108.0, 88	75.0, 66.0	100, 85
		+201		112.5	83.5	100
		+202		108.5	79.0	100

TABLE 6 (cont)
SA-533 Grade B, Class 1 Plate
Toughness Data Base, Including Upper Shelf
(Vendor - Lukens Steel Co.)

Plant F (CBIN)

Heat No.	NDT (°F)	Charpy Temp (°F)	Orient (L or T)	(Top/Bottom) Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
C9533-2	0 / 10	-50	L	7-12	7-4	1-1
		-30		9-7	7-4	1-1
		-20		9-14/19-40	11-7/5-30	10-10/20-20
		+10		34-26/45-47	28-23/36-35	20-20/30-30
		+70		48-64/70-76	48-40/57-60	40-40/40-40
		+100		82-62/82-71	53-65/63-61	60-60/60-60
		+130		72-68/92-86	60-57/72-69	60-60/80-80
		+212		88-81/110-99	75-73/87-81	99-99/99-99
C9570-2 (Top)	-40	-70	L	6-4	5-4	1-1
		-50		10-13	20-20	10-10
		-20		14-27	23-14	20-20
		+10		30-42	29-39	30-30
		+70		70-64	56-54	40-40
		+100		76-79	64-63	60-60
		+212		106-108	66-81	90-90
C9570-2 (Bottom)	-50	-70	L	5-7	3-5	1-1
		-40		12-12	16-18	10-10
		-20		36-45	30-36	20-20
		+10		35-46	29-34	30-30
		+40		48-56	47-49	50-50
		+70		79-81	74-75	70-70
		+100		90-110	70-82	80-80
		+130		114-112	86-85	99-99
C9570-1	-20/ -10	-20	L	11-8/13-12	8-10/12-12	1-1/10-10
		-10		20-21/15-14	20-20/15-14	10-10/10-10
		+10		19-19/43-43	18-18/34-33	10-10/30-30
		+40		36-44	37-41	30-30
		+72		60-62/69-70	52-50/56-56	40-40/40-40
		+100		72-75/79-80	65-62/64-65	50-50/60-60
		+130		84-83/94-88	69-71/74-71	70-70/80-80
		+212		96-110/105-103	82-78/81-80	90-90/90-90

NSS:ggt/224C2
9/8/81

TABLE 7 - DETAIL WELD PROCEDURE FOR PLANT C SURVEILLANCE PROGRAM

CBI NUCLEAR COMPANY

CHICAGO BRIDGE & IRON CO.

WELD PROCEDURE SPECIFICATION

Low Alloy SMA & SA Grooves & Buildup

Customer General Electric Company
Product Nuclear Vessels (Class 1)
Description Shielded Metal Arc and Submerged Arc Welding of ASME P110 Subgroup 1 Material

Procedure Number WPS 322-SMAS
Page No. 1 of 3
Date 2-17-69
Revision No. 3 (7-23-74) MJC

REFERENCE SPECIFICATIONS
General WPS 300 Latest Revision
General WPS 320 Latest Revision

PROCEDURE QUALIFICATION

NO.	POSITION	THICKNESS RANGE
1890 (SMA)	V	3/16" to 8"
1891 (SMA)	H	3/16" to 8"
1892 (SMA)	OH, F	3/16" to 8"
1893 (SA-1)	F	3/16" to 8"
2200 (SA-2)	F	3/16" to 8"

POST HEAT TREATMENT -
Procedure qualified with 50 hrs. at 1150°F +25°/-50°F.
Postweld heat treatment of the weldment shall be in accordance with a CBI approved procedure.

BASE METAL -
ASME SA-533 Gr B Class 1 or SA-508 Class 2
ASME Group No. P129 Subgroup 1

FILLER METAL - ASME:
Shielded Metal Arc
Specification - SFA-5.5
Classification - E9018-G
Analysis - AI (except Ni 0.50 to 1.25)
Usability - F4
Trade Name - Alloy Rods Z9018M
Submerged Arc
See Adjacent Column.

ELECTRICAL CHARACTERISTICS -
See Adjacent Column.

SHIELDING GAS - None

BACKUP GAS - None

FLUX - Linde 124

CUSTOMER APPROVAL

PREHEAT REQUIREMENTS:
Minimum preheat of 300°F shall be applied uniformly to the full thickness of the weld joint and adjacent base material for a minimum distance of "T" or "6", whichever is least, where "T" is the material thickness.

Maintain 300°F min. preheat temp. until start of postweld heat treatment except for longitudinal and circumferential shell and head seams, preheat may be dropped to 250°F min. 8 hours after completion of welding. All runoff tabs and flux dams must be removed prior to dropping preheat below 300°F.

INTERPASS TEMPERATURE REQUIREMENTS:
The interpass temperature shall not exceed 500°F maximum.

FILLER METAL:
Submerged Arc
Specification - N.A.
Classification - N.A.
Analysis - AI (except Ni 0.50 to 1.25)
Usability - F6
Trade Name - CBI 1NMM (1% Nickel) or equal

ELECTRICAL CHARACTERISTICS:
SMA - DCRP
Submerged Arc
Tandem Wire
Lead Wire - DCRP
Trail Wire - AC
Single Wire - DCRP

Table 3 B

DETAIL WELD PROCEDURE FOR PLANTS G&B SURVEILLANCE PROGRAM

(B1)

CONTRACT NO.	BY	DATE
69-552	PCT	10/5/71

SPECIFICATION
Low Alloy SMA & SA Grooves & Buildup

CUSTOMER General Electric Company
PRODUCT NUCLEAR VESSELS (Class A)
DESCRIPTION Shielded Metal Arc and Submerged Arc Welding of ASME P12B Subgroup 1 Material

PROCEDURE NUMBER WPS 323-2F4F6
PAGE NO 1 OF 3
DATE 2-17-69
REVISION NO 4(9-21-70)R1

REFERENCE SPECIFICATIONS
General WPS 800 Latest Revision
General WPS 820 Latest Revision

PROCEDURE QUALIFICATION

NO	POSITION	THICKNESS RANGE
963(SW)	F(Sub Arc) F,V,H(SMA)	4 1/2" to 9.9"
1261(SW)	F(Sub Arc) F,V(SMA)	2 3/4" to 8"

POST HEAT TREATMENT -
Procedure qualified with 50 hrs. at 1150°F +25°/-50°F.

Post weld heat treatment of the weldment shall be in accordance with a CE&I approved procedure.

BASE METAL -
ASME SA-533 Gr B Class 1 or SA-508 Class 2
ASME Group No. P12B Subgroup 1

FILLER METAL - ASME
See Adjacent Column

ELECTRICAL CHARACTERISTICS -
See Adjacent Column

SHIELDING GAS - None

BACKUP GAS - None

FLUX - Linde 124

YPF # 2812-93-2

PREHEAT REQUIREMENTS:

Minimum preheat of 300°F shall be applied uniformly to the full thickness of the weld joint and adjacent base material for a minimum distance of "T" or 6", whichever is least, where "T" is the material thickness.

Maintain preheat temperature until start of post weld heat treatment.

INTERPASS TEMPERATURE REQUIREMENTS:

The interpass temperature shall not exceed 500°F maximum.

FILLER METAL:

Submerged Arc
Specification - N.A.
Classification - N.A.
Analysis - A3 (except Ni 0.50 to 1.25)
Usability - F6
Trade Name - Adcom 1NMM (1% Nickel or equal

Shielded Metal Arc
Specification - SA-316
Classification - E9018-G
Analysis - A3 (except Ni 0.50 to 1.25)
Usability - F4
Trade Name - Alloy Rods E9018-[illegible]

ELECTRICAL CHARACTERISTICS:

SMA - DCRP

Submerged Arc
Tandem Wire
Lead Wire - DCRP
Trail Wire - AC
Single Wire - DCRP

TABLE 9 - Detail Weld Procedure for ~~Hanford~~ surveillance program. TMP-2

WELD PROCEDURE SPECIFICATION
Low Alloy SMA & SA Grooves & Buildup

CUSTOMER General Electric Company
PRODUCT NUCLEAR VESSELS (Class 1)
DESCRIPTION Shielded Metal Arc and Submerged Arc Welding of ASME P12B Subgroup 1 Material

PROCEDURE NUMBER WPS 323-2F4F6
PAGE NO. 1 OF 3
DATE 2-17-69
REVISION NO. 5 (7-28-72) PAD

REFERENCE SPECIFICATIONS
General WPS 800 Latest Revision
General WPS 820 Latest Revision

PROCEDURE QUALIFICATION

NO.	POSITION	THICKNESS RANGE
963 (SW)	F (Sub Arc) F,V,H (SMA)	4.5" to 9.9"
1261 (SW)	F (Sub Arc) F,V (SMA)	.3/16" to 8"

POST HEAT TREATMENT -
Procedure qualified with 50 hrs. at 1150°F +25°/-50°F.

Post weld heat treatment of the weldment shall be in accordance with a CB&I approved procedure.

BASE METAL -

ASME SA-533 Gr B Class 1 or
SA-508 Class 2
ASME Group No. P12B Subgroup 1

FILLER METAL - ASME ____

See Adjacent Column

ELECTRICAL CHARACTERISTICS -
See Adjacent Column

SHIELDING GAS - None

BACKUP GAS - None

FLUX - Linde 124 CUSTOMER APPROVED
VPF# 6080-011-1

CUSTOMER APPROVAL DATE 6-4-79
Lynn Gibson
INITIALS

PREHEAT REQUIREMENTS:

Minimum preheat of 300°F shall be applied uniformly to the full thickness of the weld joint and adjacent base material for a minimum distance of "T" or 6", whichever is least, where "T" is the material thickness.

Maintain preheat temperature until start of post weld heat treatment.

INTERPASS TEMPERATURE REQUIREMENTS:

The interpass temperature shall not exceed 500°F maximum.

FILLER METAL:

Submerged Arc
Specification - N.A.
Classification - N.A.
Analysis - A3 (except Ni 0.50 to 1.25)
Usability - F6
Trade Name - Raco 1NMM (1% Nickel or equal

Shielded Metal Arc
Specification - SFA-5.5
Classification - E8018-G
Analysis - A3 (except Ni 0.50 to 1.25)
Usability - F4
Trade Name - Alloy Rods E8018NM

ELECTRICAL CHARACTERISTICS:

SMA - DCRP

Submerged Arc
Tandem Wire
Lead Wire - DCRP
Trail Wire - AC
Single Wire - DCRP

CQA Stamp Page 4

VIEWED	CB&I DES	CB ENGS DES	CB ENGR S.S.	CB ENGR MATL	CB WELD	CB INSP TEST	CB QC	CB NU QC	CB NU OPN	REG MFG	REG MFG QC	REG CONST	REG CONST QC		BY	DATE
	DES		RW	A2B	ANR					IVM	CDP			Made	AEH	3/6/69
	DES													Checked	ANR	3/6/69

Table 10

INMM ELECTRODE (TRADE NAME - TECHALLOY)
LINDE 124 FLUX, SUBMERGED ARC
POST WELD 1150°F FOR 50 HRS TYPICAL

Plant G (RPV, CBIN)

Heat No./ Flux Lot	NDT (°F)	Charpy Temp (°F)	Single or Tandem Wire (S or T)	Energy (ft-lbs)	Expansion (mils)	% Shear
KN203/0171	-80	-130	S	7, 6	7, 7	5, 5
		-80		34, 18, 22	32, 16, 21	40, 35, 40
		-20		68, 70, 62	61, 57, 56	80, 70, 75
		+10		75, 72	64, 64	90, 90
		+40		94, 82	81, 71	100, 95
		+212		94, 92, 86	76, 80, 80	100, 100, 100
	-80	-130	T	7, 5	6, 5	5, 5
		-100		25, 16	24, 19	10, 10
		-80		24, 22, 25	21, 19, 25	25, 20, 30
		-20		48, 49, 54	44, 42, 46	45, 45, 60
		-10		59, 54, 54	48, 49, 46	60, 45, 60
		+10		78, 67	65, 56	95, 80
		+40		80, 79	68, 68	95, 95
		+212		86, 89, 87	87, 86, 85	100, 100, 100

Table 10 (Cont)

E8018-G WELD ELECTRODE, SHIELDED METAL ARC
(TRADE NAME - ATOM ARC 8018 NM)
POST WELD 1150°F FOR 50 HR TYPICAL

Plant G (RPV-CBIN)

Heat No./ Lot No.	NDT (°F)	Charpy Temp (°F)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
640967/ D502B27AF	-80	-105	13, 14	4, 4	5, 5
		-80	16, 22, 28	11, 13, 18	10, 12, 15
		-20	58, 76, 86	18, 42, 56	15, 50, 50
		+40	102, 106, 119	69, 74, 86	90, 80, 90
		+72	119, 127	86, 82	90, 90
		+130	130, 140, 150	90, 92, 80	100, 100, 100

Table 10 (Cont)

E8018-G WELD ELECTRODE, SHIELDED METAL ARC
(TRADE NAME - E8018 NM)
POST WELD 1150°F FOR 50 HR TYPICAL

(PLANT B RPV - CBIN)

Heat No./ Lot No.	NDT (°F)	Charpy Temp (°F)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
401P2871/	-50	-90	7, 10	7, 11	3, 5
H430B27AF		-70	15, 16, 16	14, 15, 16	8, 8, 10
		-20	66, 76, 64	58, 61, 58	15, 15, 15
		-20	63, 81	50, 61	15, 15
		-10	27, 39, 54	25, 35, 46	35, 35, 35
		0	27, 50, 56	25, 42, 46	40, 45, 45
		+10	75, 76, 107	60, 62, 74	60, 50, 80
		+40	90, 100	71, 76	70, 80
		+130	130, 140, 142	91, 94, 93	100, 100, 100
402P3162/	-70	-70	11, 7, 14	9, 6, 8	5, 5, 5
H426B27AE		-40	33, 52, 32	27, 42, 22	10, 15, 10
		-20	65, 62, 37	52, 48, 30	20, 10, 20
		-20	52, 55	36, 38	15, 15
		-10	60, 54, 53	44, 37, -	40, 30, 30
		+40	96, 99	57, 68	60, 60
		+212	119, 122, 124	93, 90, 68	100, 100, 100

Table 19 (Cont)

1MM ELECTRODE (TRADE NAME - RACO)
LINDE 124 FLUX, SUBMERGED ARC
POST WELD 1150°F FOR 50 HR TYPICAL

(Plant B RPV, CBIN)

	Heat No./ Flux Lot	NDT (°F)	Charpy Temp. (°F)	Single or Tandem Wire (S or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
#	5P7397/ 0342	-70	-70	T	22, 16, 36	22, 18, 28	5, 5, 5
			-10		58, 68, 61	54, 50, 47	25, 20, 20
			+10		76, 73, 75	60, 65 60	30, 45, 50
			+10		75, 69	58, 56	35, 35
			+40		91, 84	75, 63	80, 85
			+70		79, 75, 77	73, 63, 74	90, 95, 95
			+212		84, 81, 87	69, 67, 75	100, 100, 100
		-70	-70	S	20, 34, 27	16, 32, 22	5, 5, 5
			-10		54, 50, 59	47, 47, 53	25, 20, 20
			+10		65, 59, 69	60, 56, 65	50, 25, 75
			+10		70, 75	56 61	45, 55
			+40		71, 78	65, 68	75, 90
			+70		92, 101, 94	82, 65, 69	95, 95, 100
			+212		100, 95, 96	88, 58, 82	100, 100, 100

* This material is in the Plant B vessel surveillance program

Table 10 (Cont)

E8018 NM ELECTRODE (TRADE NAME - ATOM ARC E8018NM)
SHIELDED METAL ARC
POST WELD, 1150°F FOR 50 HR TYPICAL

Plant C (RPV - CBIN)

Heat No./ Lot No.	NDT (°F)	Charpy Temp (°F)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
492L4871/A421B27AE	-60	-108	10, 11	5, 4	4, 4
		-90	25, 30, 32	6, 6, 6	8, 10, 10
		-30	19, 28, 31	19, 23, 25	20, 25, 25
		-20	22, 26, 30	23, 21, 27	25, 25, 30
		-10	38, 41, 43	28, 32, 30	30, 30, 30
		0	50, 51, 57	36, 38, 40	30, 40, 45
		+40	135, 137	84, 80	90, 80
		+130	151, 160, 161	80, 82, 81	100, 100, 100
422K8511/G313A27AD	-80	-90	14, 17	15, 16	5, 5
		-80	14, 16, 20	15, 16, 20	10, 10, 10
		-40	26, 26, 40	26, 24, 33	30, 30, 30
		-20	65, 74, 127	44, 48, 76	40, 50, 60
		+25	107, 108	74, 80	80, 70
		+40	125, 125, 140	84, 89, 82	100, 100, 90
		+50	153, 143, 156	95, 81, 91	90, 80, 90
		+68	153, 143, 165	85, 96, 91	100, 100, 100
640892/J424B27AE	-60	-108	14, 16	3, 3	3, 3
		-70	15, 20, 27	8, 9, 15	5, 10, 10
		-10	38, 42, 45	26, 31, 31	30, 30, 30
		0	55, 62, 62	38, 44, 48	35, 40, 40
		+40	56, 75	42, 55	50, 60
		+130	118, 122, 130	87, 89, 82	100, 100, 100
40150371/B504B27AE	-60	-60	42, 45, 23	35, 36, 20	5, 5, 5
		-20	61, 84, 77	48, 66, 62	30, 25, 25
		-20	68, 67	51, 52	25, 25
		0	80, 85, 82	63, 62, 60	35, 50, 35
		+40	95, 97	71, 76	40, 75
		+70	111, 107, 109	87, 85, 77	80, 90, 80
		+212	122, 114, 130	92, 92, 69	100, 100, 100
402P3162/H426B27AE	-70	-70	11, 7	9, 6	5, 5
		-40	33, 52, 32	27, 42, 22	10, 15, 10
		-20	65, 62, 37	52, 48, 30	20, 10, 20
		-20	52, 55	36, 38	15, 15
		-10	60, 54, 68	44, 37, 53	40, 30, 30
		+40	96, 99	57, 68	60, 60
		+212	119, 122, 124	93, 90, 68	100, 100, 100

Table 10 (Cont)

E8018 NM ELECTRODE (TRADE NAME - ATOM ARC E8018NM)
SHIELDED METAL ARC
POST WELD, 1150°F FOR 50 HR TYPICAL

Plant C (RPV - CBIN) (Continued)

Heat No./ Lot No.	NDT (°F)	Charpy Temp (°F)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
401P2871/H430B27AE	-50	-90	7, 10	7, 11	3, 5
		-70	15, 16, 16	14, 15, 16	8, 8, 10
		-10	27, 39, 54	25, 35, 46	35, 35, 35
		0	27, 50, 56	25, 42, 46	40, 45, 45
		+10	75, 76, 107	60, 62, 74	60, 50, 80
		+40	90, 100	71, 76	70, 80
		+130	130, 140, 142	91, 94, 93	100, 100, 100
07R458/S403B27AG	-60	-70	9, 9	7, 7	5, 5
		-60	10, 11, 13	9, 9, 11	15, 10, 10
		0	59, 61, 70	51, 52, 58	50, 50, 60
		+40	99, 101	77, 78	80, 75
		+72	106, 110	85, 87	80, 80
		+130	129, 131, 132	81, 78, 81	100, 100, 100
03L048/B525B27AF	-60	-105	8, 9	2, 3	3, 3
		-80	10, 16, 19	7, 10, 11	10, 10, 10
		-20	31, 50, 65	22, 37, 50	30, 30, 30
		-10	36, 53, 58	34, 43, 45	40, 40, 40
		0	61, 75, 79	44, 58, 59	50, 60, 60
		+40	104, 108	75, 77	80, 80
		+130	122, 123, 126	89, 83, 91	100, 100, 100
02R486/J404B27AG	-70	-100	12, 13	3, 5	3, 5
		-90	16, 17, 19	6, 8, 7	8, 8, 10
		-30	17, 30, 31	15, 24, 23	15, 20, 20
		-20	41, 42, 44	33, 34, 35	30, 30, 30
		-10	52, 64, 66	39, 45, 46	40, 40, 40
		+40	84, 87	63, 68	60, 60
		+130	121, 124, 129	91, 96, 95	100, 100, 100
L83978/J414B27AD	-80	-100	10, 12	6, 7	4, 5
		-80	14, 15, 24	10, 12, 18	10, 10, 12
		-20	51, 52, 81	37, 40, 63	35, 50, 40
		-20	64, 63, 69	51, 47, 55	15, 15, 15
		-20	67, 56	53, 45	15, 10
		+40	120, 123	72, 73	80, 80
		+72	128, 140	78, 81	90, 90
		+130	148, 156, 168	90, 81, 87	100, 100, 100

Table 10 (Cont)

INCO ELECTRODE (TRADE NAME - RACO)
LINDE 124 FLUX, SUBMERGED ARC
POST WELD 1150°F for 50 HR TYPICAL

Plant C (RPV - CBIN)

Heat No./ Flux No.	NDT (°F)	Charpy Temp (°F)	Single or Tandem Wire (S or T)	Energy (ft-lbs)	Lateral Expansion (mils)	% Shear
5P7397/0156	-50	-70		25, 21	18, 15	5, 5
		-50		42, 27, 19	33, 25, 20	10, 15, 10
		+10		64, 67, 55	53, 53, 52	30, 35, 40
		+10		64, 70	53, 54	40, 45
		+40		91, 84, 85	78, 68, 79	85, 90, 95
		+212		103, 92, 94	59, 66, 59	100,100,100
3P4966/0342	-80	-80		51, 27, 9	45, 25, 12	5, 5, 5
		-20		71, 66, 54	57, 57, 45	30, 25, 20
		+10		85, 84, 71	68, 72, 61	70, 80, 65
		+10		83, 76	67, 64	65, 55
		+40		87, 91	71, 60.	75, 80
		+70		100,101, 97	82, 89, 71	90, 95, 90
		+212		108,111,108	66, 84, 86	100,100,100
4P7465/0751	-60	-80		27, 14	21, 12	5, 0
		-70		48, 43, 26	42, 36, 22	15, 15, 5
		0		63, 57, 68	54, 45, 63	30, 25, 35
		+10		56, 58, 90	62, 62, 86	30, 25, 45
		+10		87, 55	83, 42	40, 30
		+40		67, 97	71, 90	45, 50
		+212		118,102,112	88, 71, 72	100,100,100
1P6484/0156	-20	-80		5, 8	6, 11	5, 5
		-60		22, 16, 12	23, 13, 10	10, 10, 10
		0		17, 36, 30	20, 27, 28	25, 20, 25
		+10		30, 38, 17, 34, 38	25, 38, 12, 28, 30	15, 15, 15, 15, 20
		+30		34, 46, 42	29, 37, 45	25, 50, 35
		+40		72, 60, 72	54, 47, 49	50, 45, 50
		+212		93, 81, 83	65, 66, 69	100,100,100
5P5657/0931	-60	-80		39, 39	27, 37	5, 5
		-60		19, 20, 32	18, 22, 28	10, 10, 10
		0		51, 55, 58	50, 50, 63	30, 30, 55
		+10		69, 69, 66	61, 65, 59	50, 50, 40
		+10		62, 57	60, 63	60, 40
		+40		77, 66	73, 72	70, 80
		+212		88, 91, 85	86, 75, 83	100,100,100

TABLE 11

Project ~~Hanford-2~~ WNP-2

Valve MSIV

Component Body - Typical

Applicable Code ASME Section III, 1971, Winter 1971 Addenda

Valve Vendor Rockwell, Material Vendor Rockwell

Material Specification - SA-216, Grade WCB

Heat No. - 2720638

Chemical Composition (wt.%) -

C	Mn	Si	P	S	Al
.27	.74	.53	.017	.014	.043

Grain Size (ASTM No.) - NA

Heat Treatment - 1700°F (12 hr.) Air Cool + 1650°F Water Quench
+1225°F (12 hr.) Air Cool + 1100/1150°F (15 hr.)

Charpy V-Notch Impact Toughness

Test Temperature:
Ft-lb
Mils
% Shear
} NA

Note:

Weld materials AWS A5.20, Type E70T-1 tested at-20°F exceed 20 ft-lb average with any single value at least 15 ft-lb, and AWS 5.1, Type E7018 exceed 20 ft-lb at -20°F for Charpy V-notch tests.

NA = Not Available.

NSS:ggt/150I2
11/13/81

TABLE 11 Cont

Project ~~Hanford 2~~ WNP-2

Valve MSIV

Component Bonnet - Typical

Applicable Code ASME Section III, 1971, Winter 1971 Addenda

Valve Vendor Rockwell , Material Vendor Cann & Saul Steel Co.

Material Specification - SA-105, Grade II

Heat No. - 6068582

Chemical Composition (wt.%) -

C	Mn	Si	P	S	Al
.26	.84	.22	.015	.024	NA

Grain Size (ASTM No.) - NA

Heat Treatment - 1650°F (5 hr.) Air Cool
+1250°F (5 hr.) Furnace Cool
+1150°F (4½ hr.) Furnace Cool

Charpy V-Notch Impact Toughness

Test Temperature:
Ft-lb
Mils
% Shear } NA

Note:

Weld materials AWS A5.20, Type E70T-1 tested at-20°F exceed 20 ft-lb average with any single value at least 15 ft-lb, and AWS 5.1, Type E7018 exceed 20 ft-lb at -20°F for Charpy V-notch tests.

NA = Not Available.

NSS:ggt/150I3
11/13/81

Table 12

Project	Plant H
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1974
Valve Vendor	Atwood & Morrill Co.
Material Vendor	Quaker Alloy Casting Co.

Material Specification: ASME SA216 Grade WCB

Heat No.: F7516

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.25	0.78	0.53	0.018	0.013	NA

Grain Size (ASTM No.): NA

Heat Treatment: 1690/1710°F (6 hr. 5 min) Air Cool
+ Temper 1350/1360°F (6 hrs) Air Cool
+ Post Weld 1200°F (6 hr, 5 min) Air Cool

Charpy V - Notch Impact Toughness

Test Temperature: +60°F

Ft-lb.	30,24,34
Mils	37,27,33
% Shear	40,40,40

NA - Not Available

TABLE 12 (Cont)

Project	Plant H
Valve	MSIV
Component	Cover (Bonnet)
Applicable Code	ASME Sect. III, 1974
Valve Vendor Material Vendor	Atwood & Morrill Co., Cann & Saul Steel Co.

Material Specification	ASME SA105 QT
Heat No.	214934

	C	Mn	Si	P	S	Al
Chemical Composition (Wt %)	0.28	0.76	0.22	0.017	0.023	NA

Grain Size (ASTM No.)	N/A
Heat Treatment	1600°F (12 hr) Quench, Water + 1175°F (12 hr) Furnance Cool

Charpy V - Notch Impact Toughness

Test Temperature:	+ 60°F
Ft-lb.	62,60,55
Mils	48,45,50
% Shear	30,30,30

NA - Not Available

Table 12 (Cont)

Project	Plant J
Valve	MSIV
Component	Cover (Bonnet)
Applicable Code	ASME Sect. III, 1974
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Cann & Saul Steel Co.

Material Specification: ASME SA105 QT

Heat No.: 216149

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.30	0.88	0.16	0.006	0.014	NA

Grain Size (ASTM No.): NA

Heat Treatment: 1550°F (12 hr) Quench in water
+ 1225°F (12 hr) Furnance cool

Charpy V- Notch Impact Toughness

Test Temperature:	+60°F
Ft-lb.	62,64,60
Mils	56,54,52
% Shear	20,20,20

NA - Not Available

Table 12 (Cont)

Project	Plant J
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1974
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Atwood & Morrill, Ltd.

Material Specification: SA216 Grade WCB

Heat No.: 35

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.24	0.82	0.46	0.022	0.013	NA

Grain Size (ASTM No.): NA

Heat Treatment: 1650°F – 1800°F (8 hrs.) air cool to 400°F
+ temper 1150°/1250°F (8 hrs) air cool
+ post weld 1095°/1195°F (18 hrs) furnace cool to 800°F (100°F/hr) air cool

Charpy V – Notch Impact Toughness

Test Temperature: +60°F

Ft-lb.	31.5,37.5,39.5
Mils	33,41,40
% Shear	10,10,10

NA – Not Available

Table 12 (Cont)

Project: Plant K

Valve: MSIV

Component: Body

Applicable Code: ASME Sect. III, 1974 with Summer 1975 Addenda

Valve Vendor: Atwood & Morrill Co.,
Material Vendor: Quaker Alloy Casting Co.

Material Specification: ASME SA216 Grade WCB

Heat No.: F3547

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.23	0.88	0.38	0.016	0.015	NA

Grain Size (ASTM No.): NA

Heat Treatment: 1700°/1725°F (6 hr, 20 min) air cool
+ temper 1345°F (6 hr, 45 min) air cool
+ post weld 1200°/1225°F (6 hrs, 30 min) air cool

Charpy V - Notch Impact Toughness

Test Temperature:	+60°F
Ft-lb.	66,56,54
Mils	53,50,53
% Shear	40,40,40

NA - Not Available

Table 12 (Cont)

Project	Plant K
Valve	MSIV
Component	Cover (Bonnet)
Applicable Code	ASME Sect. III, 1974 with Summer 1975 Addenda
Valve Vendor	Atwood & Morrill Co.,
Material Vendor	Cann & Saul Steel Co.

Material Specification: ASME SA105

Heat No.: 217630

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.23	0.92	0.19	0.013	0.013	NA

Grain Size (ASTM No.): #9

Heat Treatment: 1650°F (6 hrs) air cool
+ 1550°F (6 hr, 30 min) water quench
+ Temper 1200°F (12 hr, 30 min)

Charpy V - Notch Impact Toughness

Test Temperature:	+60°F
Ft-lb.	90,89,77
Mils	71,67,59
% Shear	50,50,40

NA - Not Available

Table 12 (cont)

Project	Plant L
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1971 with Summer 1973 Addenda
Valve Vendor Material Vendor	Rockwell International
Material Specification	SA216 Grade WCC
Heat No.	1750262

Chemical Composition (Wt. %)	C	Mn	Si	P	S	Al
	0.21	1.19	0.43	0.011	0.009	0.043

Grain Size (ASTM No.)	NA
Heat Treatment	1700°F (10 hrs) normalize + 1225°F (7.5 hrs) Temp + 1100°F (6 hr) post weld

Charpy V - Notch Impact Toughness

Test Temperature:	+40°F
Ft-lb.	29.0,33.0,35.0
Mils	25.0,26.0,30.0
% Shear	15,15,15

NA - Not Available

Table 12 (Cont)

Project	Plant L
Valve	MSIV
Component	Bonnet
Applicable Code	ASME Sect. III, 1971 with Summer 1973 Addenda
Valve Vendor	Rockwell International
Material Vendor	Cann & Saul Steel Co.

Material Specification: SA105 Grade NUC

Heat No.: 211971

Chemical Composition (Wt. %)	C	Mn	Si	P	S	Al
	0.27	1.03	0.22	0.010	0.014	NA

Grain Size (ASTM No.): NA

Heat Treatment: 1550°F (10 hr) Quench in water + 1175°F (10 hr) Furnace cool

Charpy V - Notch Impact Toughness

Test Temperature:					
	+40°F				
Ft-lb.	35,45,34	31,34,35	45,38,48		
Mils	NA	NA	64,57,65		
% Shear	30,40,30	30,30,30	15,15,15		
Ft-lb	55,47,43	62,64,52	58,62,72	39,44,38	40,45,50
Mils	66,64,60	74,72,65	70,68,75	56,60,57	58,60,60
% Shear	20,15,15	20,20,20	20,20,20	15,15,15	20,20,20

NA - Not Available

Table 12 (Cont)

Project	Plant M
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1971 with S73 Addenda
Valve Vendor	Rockwell International,
Material Vendor	Rockwell International

Material Specification: SA216 Grade WCC

Heat No.: 3760171

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.17	1.09	0.50	0.008	0.011	0.060

Grain Size (ASTM No.): NA

Heat Treatment: 1700°F (8 hours) Normalize
1275°F (8 hours) Temper
1100°F (6 hours) Post Weld

Charpy V - Notch Impact Toughness

Test Temperature:	+40°F
Ft-lb.	35.0,38.0,29.0
Mils	32.0,36.0,29.0
% Shear	20,20,20

NA - Not Available

Table 12 (Cont)

Project: Plant M

Valve: MSIV

Component: Bonnet

Applicable Code: ASME Sect. III, 1971 with S73 Addenda

Valve Vendor / Material Vendor: Rockwell International, Cann & Saul Steel Co.

Material Specification: SA105

Heat No.: 214943

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.35	0.78	0.25	0.014	0.023	NA

Grain Size (ASTM No.): NA

Heat Treatment: 1550°F (10 hours) water quench
1175°F (10 hours) furnace cool
1100°F (10 hours) post weld

Charpy V - Notch Impact Toughness

Test Temperature:	+40°F	
Ft-lb.	25,25,29	28,30,34
Mils	36,34,34	36,37,35
% Shear	20,20,20	20,20,20

NA - Not Available

Table 11 (cont)

Project	Plant N
Valve	MSIV
Component	Body
Applicable Code	ASME Sect. III, 1974
Valve Vendor Material Vendor	Atwood & Morrill, Co., Quaker Alloy Casting Co.

Material Specification: ASME SA216 Grade WCB

Heat No.: F6406

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.23	0.89	0.53	0.019	0.012	NA

Grain Size (ASTM No.): NA

Heat Treatment: 1680/1710°F (5 hrs, 30 min) Air Cool
+ Temper 1350°F (5 hr, 30 min) Air Cool
+ Post Weld 1200°F (6 hr) Air Cool

Charpy V - Notch Impact Toughness

Test Temperature: +60°F	
Ft-lb.	32,31,34
Mils	33,32,31
% Shear	40,40,40

NA - Not Available

Table 11 (Cont)

Project: Plant N

Valve: MSIV

Component: Cover (Bonnet)

Applicable Code: ASME Sect. III, 1974

Valve Vendor: Atwood & Morrill Co.,
Material Vendor: Cann & Saul Steel Co.

Material Specification: SA-105 (QT)

Heat No.: 632202

	C	Mn	Si	P	S	Al
Chemical Composition (Wt. %)	0.26	0.94	0.20	0.023	0.015	NA

Grain Size (ASTM No.): NA

Heat Treatment: 1550°F (12 hr) quench in water
+ 1175°F (12 hr) furnace cool

Charpy V - Notch Impact Toughness:

Test Temperature: +60°F

Ft-lb.	66,74,65
Mils	58,64,54
% Shear	20,20,20

NA - Not Available

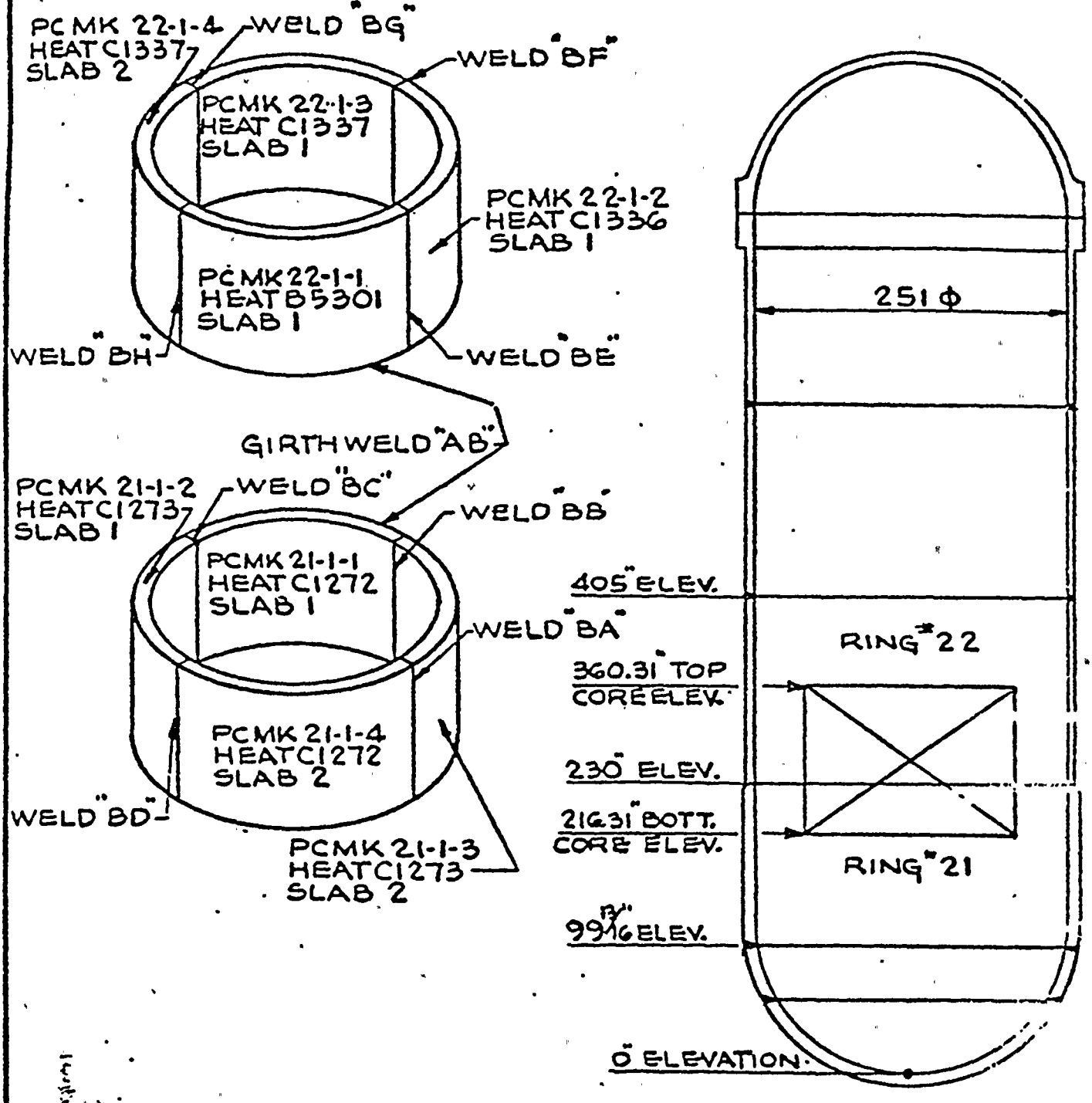
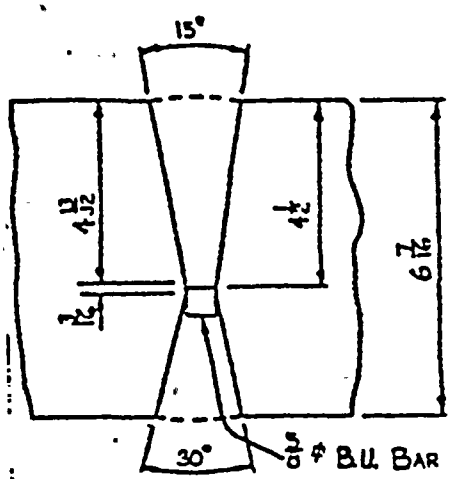
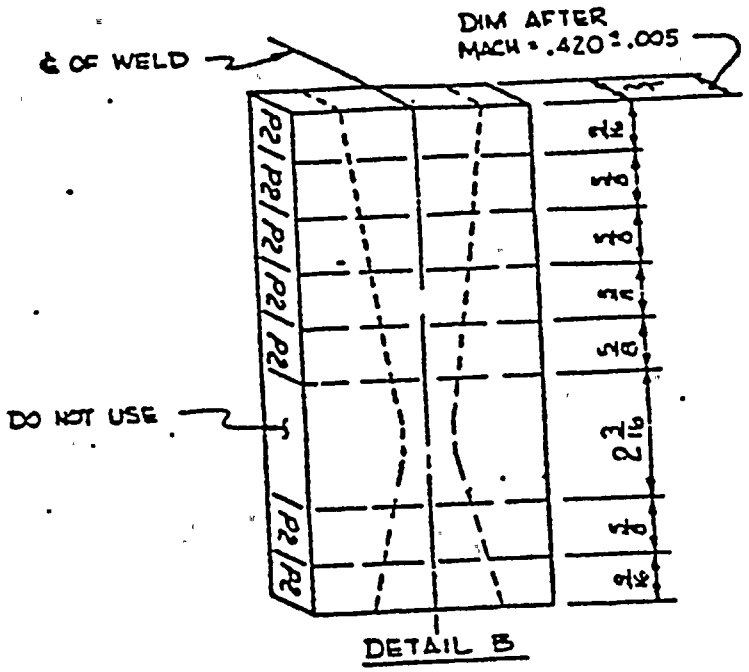


FIGURE 1

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	BELT LINE MATERIAL IDENTIFICATION	FIGURE 121.1-1



DETAIL E



DETAIL B

FIGURE 2 - Surveillance Specimen Weld Joint Detail and Weld Metal Charpy Specimen Locations for ~~Hamford 2~~ WNP-2.

5.3.1.5.2.1 Intent of Proposed Approach

The intent of the proposed special method of compliance with Appendix G for this vessel is to provide operating limitations on pressure and temperature based on fracture toughness. These operating limits assure that a margin of safety against a nonductile failure of this vessel is very nearly the same as that for a vessel built to the Summer 1972 Addenda.

The specific temperature limits for operation when the core is critical are based on a proposed modification to 10 CFR 50, Appendix G, Paragraph IV, A.2.C. The proposed modification and the justification for it is given in GE Licensing Topical Report NEDO-21778-A.

5.3.1.5.2.2 Operating Limits Based on Fracture Toughness

Operating limits which define minimum reactor vessel metal temperatures vs reactor pressure during normal heatup and cooldown and, during inservice hydrostatic testing, were established using the methods of Appendix G of Section III of the ASME Boiler and Pressure Vessel Code, 1971 Edition (Appendix G first appeared in the Summer 1972 Addenda). The results are shown in Figure 5.3-4.

Estimated RT_{NDT} values and temperature limits are given in this section for limiting locations in the reactor vessel.

All the vessel shell and head areas remote from discontinuities plus the feedwater nozzles were evaluated, and the operating limit curves are based on the limiting location. The boltup limits for the flange and adjacent shell region are based on a minimum metal temperature of RT_{NDT} + 60°F. The maximum through-wall temperature gradient from continuous heating or cooling at 100°F per hour was considered. The safety factors applied were as specified in ASME Code Appendix G and GE Licensing Topical Report NEDO-21778-A.

For the purpose of setting these operating limits the reference temperature, RT_{NDT}, is determined from the toughness test data taken in accordance with requirements of the Code to which this vessel is designed and manufactured. This toughness test data, Charpy V-notch (CVN) and/or dropweight nil ductility transition temperature (NDT) is analyzed to permit compliance with the intent of 10 CFR 50 Appendix G. Because all toughness testing needed for strict compliance with Appendix G was not required at the time of vessel procurement some toughness results are not available. For example, longitudinal CVN's, instead of transverse, were tested, usually at a single test temperature of +10°F or +40°F, for absorbed energy. Also, at the time neither CVN nor NDT testing was permitted; therefore, in many cases both tests were not performed as is currently required. To substitute for this absence of certain data, toughness property

correlations were derived for the vessel materials in order to operate upon the available data to give a conservative estimate of RT_{NDT}, compliant with the intent of Appendix G criteria.

These toughness correlations vary, depending upon the specific material analyzed, and were derived from the results of NRC Bulletin 217, "Properties of Heavy Section Nuclear Reactor Steels", and from toughness data from the WNP-2 vessel and other reactors. In the case of vessel plate material (SA-533 Grade B, Class 1), the predicted limiting toughness property is either NDT or transverse CVN 50 ft-lb temperature minus 60°F. NDT values are available for WNP-2 vessel shell plates. The transverse CVN 50 ft-lb transition temperature is estimated from longitudinal CVN data in the following manner. The lowest longitudinal CVN ft-lb value is adjusted to derive a longitudinal CVN 50 ft-lb transition temperature by adding 2°F per ft-lb to the test temperature. If the actual data equals or exceeds 50 ft-lb, the test temperature is used. Once the longitudinal 50 ft-lb temperature is derived, an additional 30°F is added to account for orientation effects and to estimate the transverse CVN 50 ft-lb temperature minus 60°F, estimated in the preceding manner.

Using the above general approach, an initial RT_{NDT} of 28°F was established for the core beltline region.

For forgings (SA-508 Class 2), the predicted limiting property is the same as for vessel plates. CVN and NDT values are available for the vessel flange, closure head flange, and feedwater nozzle materials for WNP-2. RT_{NDT} is estimated in the same way as for vessel plate.

For the vessel weld metal the predicted limiting property is the CVN 50 ft-lb transition temperature minus 60°F, as the NDT values are -50°F or lower for these materials. This temperature is derived in the same way as for the vessel plate material, except the 30°F addition for orientation effects is omitted since there is no principal working direction. When NDT values are available, they are also considered and the RT_{NDT} is taken as the higher of NDT or the 50 ft-lb temperature minus 60°F. When NDT is not available, the RT_{NDT} shall not be less than -50°F, since lower values are not supported by the correlation data.

For vessel weld heat affected zone (HAZ) material the RT_{NDT} is assumed the same as for the base material as ASME Code weld procedure qualification test requirements and post weld heat treatment indicates this assumption is valid.

Closure bolting material (SA-540 Grade B24) toughness test requirements for WNP-2 were for 30 ft-lb at 60°F below the bolt-up temperature. Current Code requirements are for 45 ft-lb and 25 mils lateral expansion (MLE) at the preload or lowest service temperature, including boltup. All WNP-2 closure stud materials meet current requirements at +10°F.

The effect of the main closure flange discontinuity was considered by adding 60°F to the RT_{NDT} to establish the minimum temperature for boltup and pressurization. The minimum boltup temperature of 80°F for Hanford Unit 2, which is shown on Figure 5.3-4, is based on an initial RT_{NDT} of +20°F for the closure flange forgings. shell plate connecting to the

The effect of the feedwater nozzle discontinuities were considered by adjusting the results of a BWR/6 reactor discontinuity analysis to the reactor. The adjustment was made by increasing the minimum temperatures required by the difference between the Hanford-2 and BWR/6 feedwater nozzle forging RT_{NDT}'s. The feedwater nozzle adjustment was based on an RT_{NDT} of -14°F. -2°F

The reactor vessel closure studs have a minimum Charpy impact energy of 48 ft-lbs and a 26-mil lateral expansion at 10°F. The lowest service temperature for the closure studs is 10°F.

5.3.1.5.2.3 Temperature Limits for Boltup

A minimum temperature of 10°F is required for the closure studs. A sufficient number of studs may be tensioned at 70°F to seal the closure flange O-rings for the purpose of raising reactor water level above the closure flanges in order to assist in warming them. The flanges and adjacent shell are required to be warmed to a minimum temperature of 80°F before they are stressed by the full intended bolt preload. The fully preloaded boltup limits are shown on Figure 5.3-4.

5.3.1.5.2.4 Temperature Limits for Preoperational System Hydrostatic Tests and ISI Hydrostatic or Leak Pressure Tests

Based on 10 CFR 50 Appendix G IV.A.2.d, which allows a reduced safety factor for tests prior to fuel loading, the preoperational system hydrostatic test at 1563 psig may be performed at a minimum temperature of 128°F which is established by core beltline plate material. The maximum hydrostatic test pressure is 1563 + 6% psig (1613 psig) with a minimum temperature of 131°F. The fracture toughness analysis for inservice inspection or leak tests resulted in the curves labeled A shown in Figure 5.3-4. The curves labeled "core beltline" are based on an initial RT_{NDT} of 28°F.

(note: the hydrostatic test temperature without fuel in the reactor vessel may be reduced to 88°F upon adoption of a new revision to 10CFR50 App. G now being finalized.)

5.3-5b

Not new P.

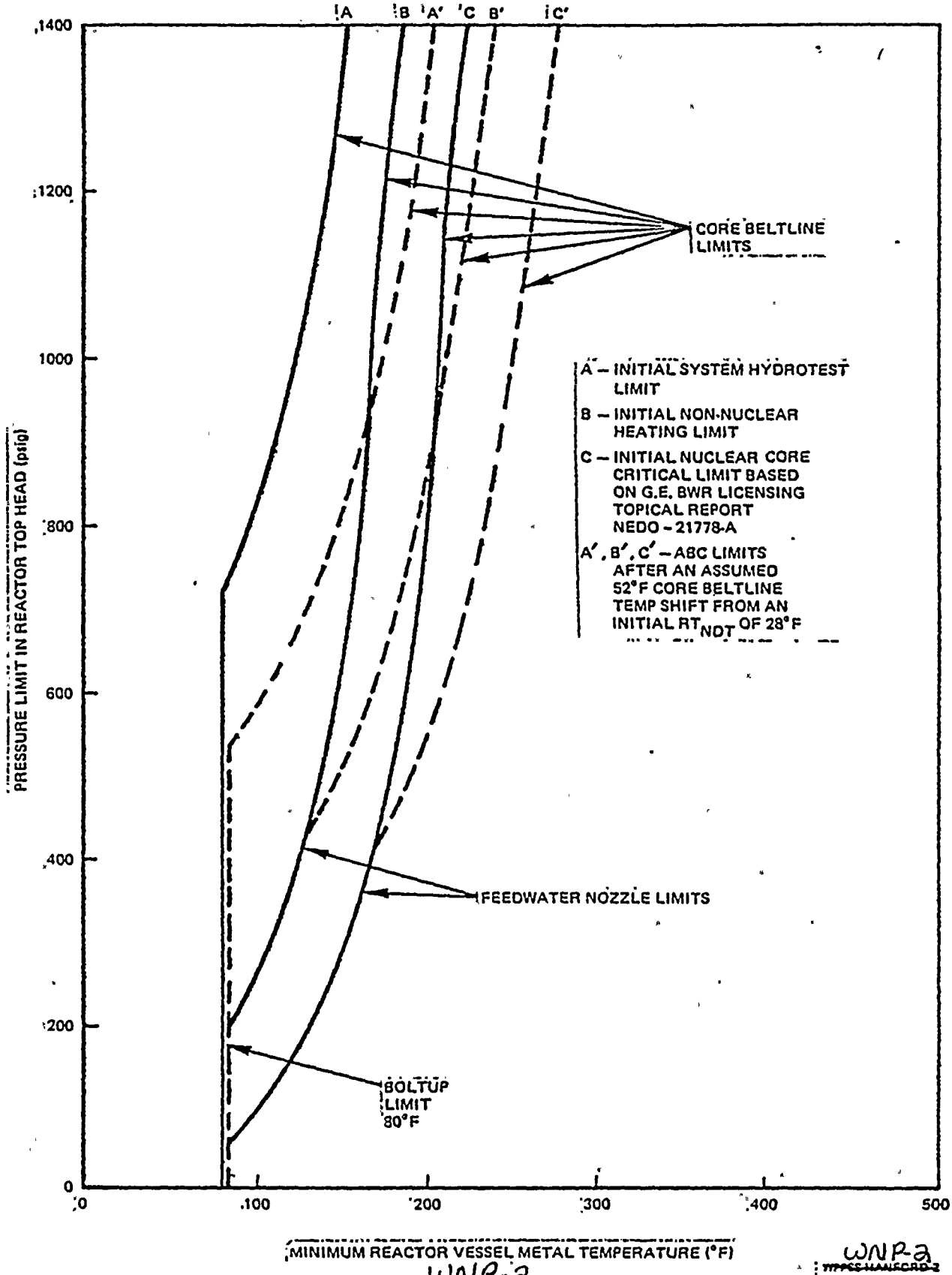
The predicted shift in the RT_{NDT} from Figure 5.3-5 (based on the neutron fluence at 1/4 of the vessel wall thickness) must be added to the beltline curve to account for the effect of fast neutrons, see Figure 5.3-4.

5.3.1.5.2.5 Operating Limits During Heatup, Cooldown and Core Operation

The fracture toughness analysis was done for the normal heatup or cooldown rate of 100°F/hour. The temperature gradients and thermal stress effects corresponding to this rate was included. The results of the analyses are a set of operating limits for non-nuclear heatup or cooldown shown as curves labeled B on Figure 5.3-4. Curves labeled C on these figures apply whenever the core is critical. The basis for Curves C is described in GE BWR Licensing Topical Report NEDO-21778.

5.3.1.5.2.6 Reactor Vessel Annealing

Inplace annealing of the reactor vessel because of radiation embrittlement is unnecessary because the predicted value in transition of adjusted reference temperature will not exceed 200°F (see 10 CFR 50, Appendix G, Paragraph IV.C).



WNP-2

Figure 5.3-4. ~~WPPSS Hanford Unit 2~~ WNP-2 Minimum Temperature Required vs. Reactor Pressure

(original attached)

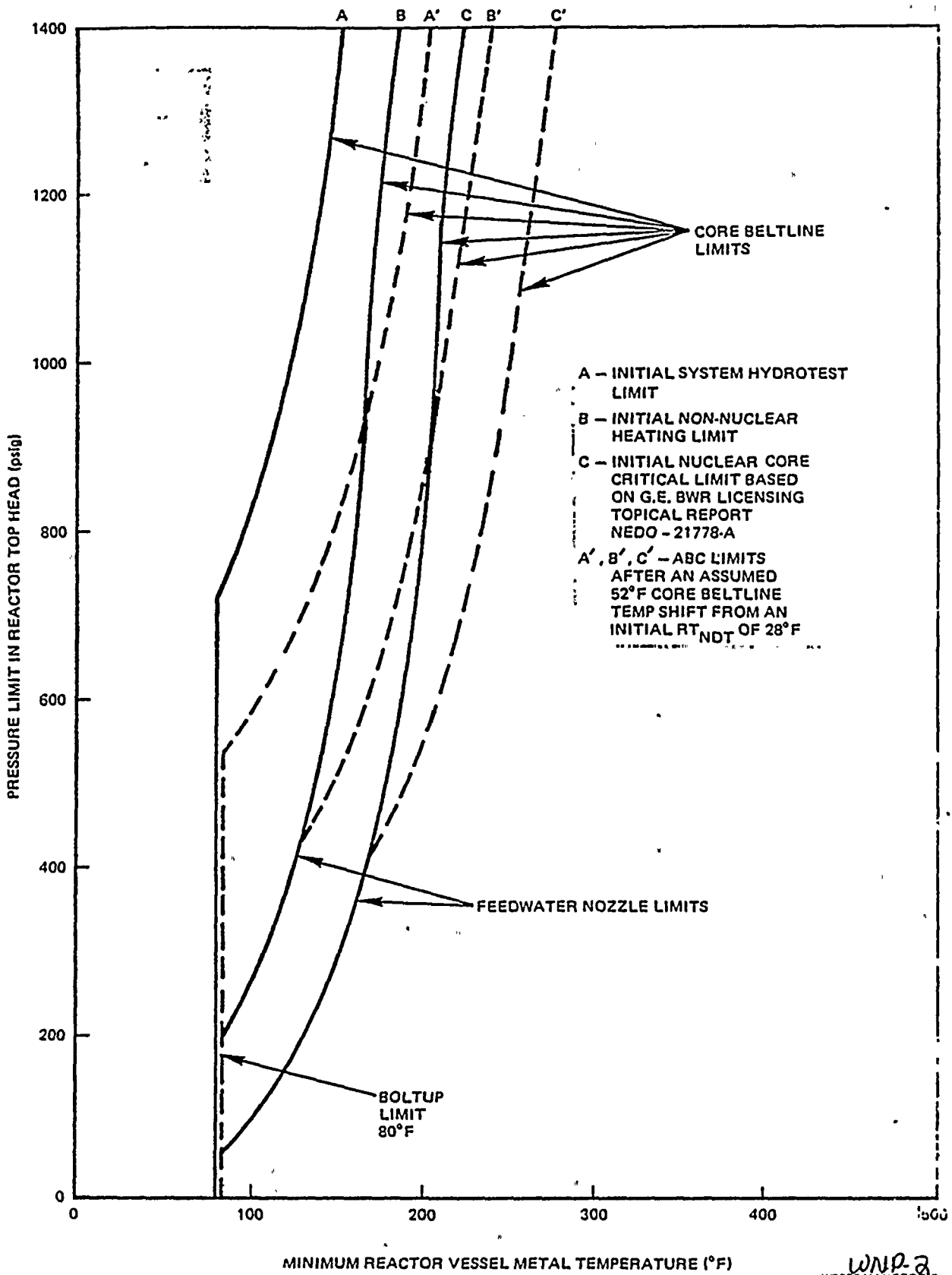


Figure 5.3-4. ~~WPPSS Hanford Unit 2~~ WNP-2 Minimum Temperature Required vs. Reactor Pressure

QUESTION 121.11

"In Section 5.2.3.3.1.4, of the FSAR, 'Operating Limits Based on Fracture Toughness,' a factor of 2° F per ft-lb is used to convert longitudinal Charpy V-notch impact data obtained at the 30 ft-lb level to estimates of the data at the 50 ft-lb level. It is stated that these estimates plus a 30° F adjustment for specimen orientation are based on information tabulated in WRC Bulletin 217, 'Properties of Heavy Section Nuclear Reactor Steel,' and other fracture toughness tests. Explicitly state the procedrues used to verify these factors, including a sample calculation and any data, other than that in WRC Bulletin 217, used as a basis for the estimates."

RESPONSE

Methods to estimte Charpy 50 ft-lb temperature. A factor of 2° F/ft-lb was used to adjust the longitudinal CVN energy curve (1/4T location) from Figure 1 of WRC Bulletin 217. Points taken from this curve, of 50 ft-lb at 15° F and 20 ft-lb at -35° F yield a slope reciprocal of 1.67° F/ft-lb. Therefore, 2° F/ft-lb was selected as a conservative value for use in estimating the 50 ft-lb temperature from lower temperature results. The data from Table Q121.11-1 verify this approach for vessel plate material, and the data in Table Q121.11-2 show it is also appropriate for vessel weld materials. The value of 30° F, added to the longitudinal 50 ft-lb temperature in order to estimate the transverse 50 ft-lb temperature, was derived from Figures 1 and 2 of WRC Bulletin 217 based upon a longitudinal 1/4T 50 ft-lb temperature of 15° F and a corresponding transverse temperature of 45° F. This assumed 30° F shift is conservative in comparison to the Branch Technical Position MTEB No. 5-2, paragraph (3)(b) recommendation of a 20° F shift.

For SA-508 CL 2 forgings, the transverse CVN data in WRC Bulletin 217 are too limited (one heat) to use in a judgement of estimated material behavior. However, the longitudinal 1/4T data curve in Figure 3 does show that the same assumed slope reciprocal as for plate (2° F/ft-lb) is conservative based upon forging values of 50 ft-lb at 10° F and 20 ft-lb at -45° F to yield a slope reciprocal of 1.83° F/ft-lb. However, based upon forging transverse CVN data on several vessels (Table Q121.11-3) it is concluded that the drop weight NDTT is generally the limiting property, not CVN results. Therefore, such CVN temperature estimations are rarely needed for forgings, but in the event that they are, then similar methods as for vessel plates appear adequate.

TABLE Q121.11-1

REACTOR VESSEL DATA FOR CHARPY CURVE SLOPE,
SA-533 GR. B, CL. 1 PLATES, LONGITUDINAL TESTS AT 1/4T

PLANT A HEAT NO.	VALUES FOR 50 ft-lb INTERPOLATION Min. ft-lb TEST TEMP., °F	CHARPY CURVE SLOPE (°F/ft-lb)
C5978-1	109 (110°F), 48 (40°F)	1.15
B0078-1	94 (40°F), 49 (10°F)	0.70
C6003-2	82 (110°F), 49 (40°F)	2.20
C5979-2	72 (40°F), 49 (10°F)	1.30
C6003-3	64 (110°F), 22 (40°F)	1.70
C5978-2	90 (110°F), 41 (40°F)	1.43
C5979-1	65 (40°F), 43 (10°F)	1.36
C6345-1	77 (10°F), 15 (-40°F)	0.81
C6318-1	66 (10°F), 14 (-40°F)	0.96
C6345-2	67 (10°F), 16 (-40°F)	0.98
A5333-1	53 (10°F), 11 (-40°F)	1.19
C6123-2	60 (10°F), 10 (-40°F)	1.00
C5987-1	80 (40°F), 35 (10°F)	0.67
C5987-2	51 (10°F), 10 (-40°F)	1.22
C5996-2	66 (10°F), 18 (-40°F)	1.04
C5996-1	60 (10°F), 12 (-40°F)	1.04
C5540-1	63 (10°F), 23 (-40°F)	1.25
C5328-1	83 (40°F), 47 (10°F)	0.83
C5505-2	63 (10°F), 31 (-40°F)	1.56
C5445-3	67 (10°F), 34 (-40°F)	1.16
C7434-1	65 (10°F), 37 (-40°F)	1.78
C7376-2	65 (10°F), 40 (-40°F)	2.00

TABLE Q121.11-2

REACTOR VESSEL DATA FOR CHARPY CURVE SLOPE, SMAW (E8018G) AND SAW (INMM/LINDE 124 FLUX)

HEAT/LOT	TYPE	VALUES FOR 50 ft-lb INTERPOLATION Min. ft-lb TEST TEMP., °F	CHARPY CURVE SLOPE (°F/ft-lb)
402P3162/HA26B27AE	E8018G	53 (-10°F), 37 (-20°F)	0.63
401P2871/HA30B27AF	E8018G	75 (10°F), 27 (0°F)	0.21
5P5657/--	INMM	51 (0°F), 19 (-60°F)	1.87
03L048/B525B7AF	E8018G	61 (0°F), 36 (-10°F)	0.40
02R486/J404B27AG	E8018G	52 (-10°F), 41 (-20°F)	0.91
L83978/J414B27AD	E8018G	51 (-20°F), 14 (-80°F)	1.62
5P7397/0156	INMM	55 (10°F), 19 (-50°F)	1.67
40150371/B504B27AE	E8018G	61 (-20°F), 23 (-60°F)	1.05
3P4966/0342	INMM	54 (-20°F), 9 (-80°F)	1.33
402P3162/H426B27AE	E8018G	54 (-10°F), 37 (-20°F)	0.59
1P6484/0156	INMM	60 (40°F), 34 (30°F)	0.38
4P7465/0751	INMM	57 (0°F), 26 (-70°F)	2.25
492L4871/A421B27AE	E8018G	50 (0°F), 38 (-10°F)	0.83
422K8511/G313A27AD	E8018G	65 (-20°F), 26 (-40°F)	0.51
640892/J424B27AE	E8018G	55 (0°F), 38 (-10°F)	0.59
07R458/5403B27AG	E8018G	59 (0°F), 10 (-60°F)	1.22

TABLE Q121.11-3

REACTOR VESSEL DROP-WEIGHT NDT AND TRANSVERSE CHARPY TOUGHNESS RESULTS FOR SA-508 CL. 2 FORGINGS

FORGING NO.	TEST LOCATION	NDTT (°F)	CVN Temp. (°F)	CVN ENERGY (ft-lb)	
315A-1, Q2QL2W	0°	-30	40	111, 113, 118	
	180°	-20	40	103, 103, 87	
315A-2, Q2QL2W	0°	-30	40	81, 90, 98	
	180°	-30	40	110, 119, 110	
315A-3, Q2QL2W	0°	-30	40	117, 116, 119	
	180°	-30	40	94, 77, 100	
315A-4, Q2QL2W	0°	-30	40	127, 109, 116	
	180°	-20	40	83, 119, 137	
315A-5, Q2QL2W	0°	-20	40	95, 72, 116	
	180°	-20	40	120, 112, 138	
315A-6, Q2QL2W	0°	-20	40	101, 79, 73	
	180°	-20	40	111, 109, 117	
CDS MHP, 2V6969, SER 802	0°	-30	20	64, 88, 77	
	180°	-50	10	81, 72, 82	
	0°	-30	10	125, 136, 138	Longi-tudinal
	180°	-50	10	120, 122, 104	

toughness favorably. Some feeling for the quantitative influence of the preceding parameters on toughness may be gained from examining regression equations for calculating transition temperatures based on composition and ferrite grain size. Particular equations which appear applicable to the PLANT A MSIV carbon steel materials are found on page 214 of Reference 1. The following equations were derived based upon 27 steels covering the ranges: 0.10 to 0.32% C, 0.30 to 1.31% Mn, 0.02 to 0.43% Si, and nil percent to 0.136% acid-soluble Al. Specimens represented were two conditions of heat treatment (including normalized material) and as-rolled. The equation for predicting drop weight NDT is:

$$\text{NDT, } ^\circ\text{F} = (210 \times \%\text{C}) - (15.9 \times \%\text{ Mn}) - (182 \times \%\text{ Xi}) +$$

$$(377 \times \%\text{ Si}^2) - (6.9 \times \%\text{ Si} \times \%\text{ Mn}) - (159 \times \%\text{ Al}) +$$

$$(321 \times \%\text{ Al}^2) - (258 \times \%\text{ Al} \times \%\text{ Si}) - (11.0 \times \text{grain size}) + 77.2.$$

The equation for predicting Charpy V-notch 25 ft-lb. transition temperature is:

$$CVN_{25} = (465 \times \%\text{ C}) - (61.3 \times \%\text{ Mn}) - (265 \times \%\text{ Si}) +$$

$$(216 \times \%\text{ Si}^2) + (111 \times \%\text{ Si} \times \%\text{ Mn}) - (583 \times \%\text{ Al}) +$$

$$(3228 \times \%\text{ Al}^2) + (360 \times \%\text{ Al} \times \%\text{ Si}) - (20.2 \times \text{grain size}) + 178.$$

The following composition, to conservatively represent the PLANT A materials, was input to the preceding equations: 0.30% C, 0.70% Mn, 0.15% Si, 0.030% Al, and ferrite grain size ASTM No. 7. The calculations produce an estimated NDT value of 27° F and an estimated CVN 25 ft-lb. transition temperature of 96° F. It is expected that the relatively low sulfur content of the PLANT A steels would also result in substantial CVN upper shelf toughness.

More recent SA-216 Gr WCB materials, procured to the requirements of the 1974 ASME Code, have verified the capability of meeting a minimum Charpy impact requirement of 25 mils lateral expansion at +60° F. Similarly, more recent SA-105 (quenched and tempered) materials have also demonstrated this capability of meeting the 25 mils minimum requirement at +60° F. These actual toughness results show that the preceding regression equations are conservative for the MSIV materials of interest. Furthermore, MSIV's are considered to have adequate material toughness since they see less than 20% of design pressure at temperatures below 250° F, and estimated toughness transition temperatures for PLANT A MSIV materials are considerably below 250° F.

References

1. Fracture, An Advanced Treatise (ed. by H. Liebowitz), Vol. VI, 1979.

QUESTION 121.16

"Section II.B of Appenidx H of 10 CFR Part 50 requires that materials from the reactor beltline region be monitored by a surveillance program complying with ASTM E 185-73, 'Recommended Practice for Surveillance Tests for Nuclear Reactor Vessels.' The FSAR indicates that the specimens selected for the surveillance program are from representative materials from orientation and location not in conformance to ASTM E 185-73. Provide the following information for the specimens in the surveillance program:

(1) Identify the surveillance specimens taken from the base and weld materials in the beltline region of the reactor vessel, including the plate and weld identification number, specimen orientation, and the location from which the specimens were taken. Also identify the base and weld metal surveillance specimens that were not taken from the actual base and weld materials in the reactor vessel beltline region. The identification should include:

(a) Materials specification, heat number and material identification number

(b) Weld wire

(c) Weld flux

(d) Weld process

(e) Heat treatment

(f) C_V impact energy test results

(g) RT_{NDT}

(h) Copper content

(2) Provide technical justification for deviation from the requirement of Section II.C.1 of Appendix H that the test specimens in the surveillance program be taken from alongside the fracture toughness test specimens which were required by Section III.A of Appendix G of 10 CFR Part 50. The information should demonstrate that the test specimens are fully representative of the materials and processes used for the fabrication of the beltline region of the reactor vessel.

(3) In response to Question 121.3, the statement is made that based on experience at the General Electric company the amount of shift measured on irradiated longitudinal test specimens will be essentially

the same as the shift in equivalent transverse specimens. Provide the Charpy impact test data to demonstrate that the RT_{NDT} shift and the decrease in the upper-shelf energy level due to neutron irradiation are equivalent regardless of the specimen orientation."

RESPONSE

Part A. PLANT A Reactor Pressure Vessel

(1) Identification of the surveillance specimen materials follows:

All base and weld metal specimens were manufactured from the actual baseplates and weld materials in the PLANT A vessel beltline. Base metal specimens (Charpy V-notch and tension test) were taken from the plate quarter-thickness location. All base metal surveillance and baseline specimens are longitudinal, with Charpy specimens from heat No. C6345-1 and tensile specimens from C6318-1. Additionally, transverse baseline Charpy specimens were made from C6318-1 and tested. Weld metal and heat affected zone (HAZ) Charpy and tensile specimens were taken at all locations in the weldment plate thickness, but not within 3/4 inch of the root of the weld. The weld direction is perpendicular to the rolling direction of the two base plates, CG345-1 and C6318-1, which were joined. Weld tensile specimens have their axis in the direction of the weld so as to contain all weld metal. HAZ Charpy and tensile specimens and weld metal Charpy specimens have their axis perpendicular to the weld direction. Weld metal Charpy specimens have their notch centered in the weld metal; HAZ Charpy and tensile specimens have their notch and reduced section, respectively, located at the edge of the weld in Heat No. C6345-1 in the HAZ.

(a) SA-533 Gr. B. Channel 1 plates heat No. C6345-1 (Code No. G-5604-1) and C6318-1 (Code No. G-5604-2) joined by welding to represent weld seam No. 4-308 in La Salle 1.

(b) Weld electrodes type 8018, Lot No. ABEA Shielded Metal Arc Weld. Weld wire type B-4 MOD, Heat No. 1P3571 Submerged Arc Weld.

(c) Weld flux type 1092, Lot No. 3958 for Submerged Arc Weld.

(d) Weld process SMAW for root passes and SAW (tandem-wire) for remainder.

(e) Post Weld Heat Treatment of weldment at 1150° F ± 25° F for 40 hours, 27 minutes.

(f) Charpy V-notch impact energy results are attached in Table Q121.16-1.

(g) RT_{NDT} values for CG345-1 and C6318-1 are determined as equal to the drop-weight NDT values of -40° F and -20° F (attached) because of the relatively high Charpy energy values. RT_{NDT} values for the weld metals are estimated as -50° F, as determined by attached Charpy values at ± 10° F, in the absence of NDT data.

(h) Copper content, based on preliminary information, is 0.15% for C6345-1, 0.12% for C6318-1, 0.04% for ABEA and 0.37% for 1P3571/3958. These values are tentative and are being verified.

(2) Surveillance test specimens were not necessarily taken from directly alongside the specimens used to qualify the materials in the reactor vessel. However, the surveillance specimens would meet all requirements in terms of orientation, processing and location, as the other specimens. Since these plates are vacuum degassed (VIP) and also pass all nondestructive examination requirements, it is likely that they possess a high degree of homogeneity, and the surveillance specimens are just as representative of the materials actually in the reactor vessel as the original qualification specimens. Furthermore, in the unlikely instance that there is a discrepancy between the two groups of specimens, it would be detected by comparing the qualification test results with those of the baseline (out-of-reactor) surveillance specimens. It be can be seen from the summary in Table Q121.16-2 that the transverse specimen test results from the surveillance plate are in line with expectations based upon the longitudinal material qualification test results and are representative.

(3) See the attached Figures Q121.16-1 and Q121.16-2 from GE report NEDO-20243 (Figures 3 and 4) as justification that transverse and longitudinal Charpy test specimens undergo essentially equivalent shifts in upper shelf and transition temperature, as caused by irradiation, especially at fluences less than 10^{19} n/cm^2. In Figure

Q121.16-1 there is considerable data scatter to predict decrease in upper shelf as a function of orientation, but longitudinal tests seem to give a conservative result. It is felt that this is a test data scatter effect, since other results have shown the opposite effect as a result of similar scatter.

Part 2. PLANT B Reactor Pressure Vessel

(1) Identification of the surveillance specimen materials for PLANT B follows:

All base metal specimens were taken from the beltline shell plate heat number C9481-1 at the 1/4 thickness (1/4 T) location. All base metal Charpy V-notch (CVN) and tensile specimens are longitudinal, except that additional transverse CVN's were made and tested to define baseline (unirradiated) toughness.

Two test block welds were made perpendicular to the principle rolling direction fo plate C9481-1 for weld metal and heat affected zone (HAZ) specimens. One weld was used for weld tensile specimens, and the other weld was used for the weld and HAZ CVN's and HAZ tensile specimens. Weld metal and HAZ specimens were taken at all locations in the weldment place thickness, but not within 3/4-inch of the root of the weld. Weld tensile specimens have their axis in the direction of the weld, so as to contain all weld metal. HAZ CVN and tensile specimens and weld metal CVN's have their axis perpendicular to the weld direction. Weld metal CVN's have their notch centered in the weld metal; HAZ CVN and tensile specimens have their notch and reduced section, respectively, located at the edge of the weld fusion line in the HAZ of the plate C9481-1.

The surveillance specimen weld is representative of the beltline circumferential weld seam AB, which adjoins plate C9481-1. The same submerged arc welding (SAW) process was used with the same flux log 0342 (Linde 124). However, the same heat number of weld filler wire used in the vessel fabrication was not available, and heat number 5P7397, rather than 5P6771, was used for the surveillance specimen weld. This is not considered significant since the copper contents of all beltline weld filler materials for PLANT B are very low (0.05 wt. % Cu or lower), and high resistance to radiation embrittlement is predicted. The surveillance weld has 0.03 wt. % Cu.

(a) SA-533 Gr.B, Cl. 1 plate heat number C9481-1.

(b) Weld electrode wire type 1NMM (Raco) for single and tandem wire submerged Arc Weld (SAW).

(c) Weld flux type Linde 124 lot number 0342.

(d) Weld process SAW single wire for root passes, tandem wire for remainder.

(e) Post weld heat treatment of weldment at 1150° F ± 25° F for 52 hr. 3 min.

(f) Charpy V-notch impact energy results are shown in Tables Q121.16-3 and -4 and Figure Q121.16-3.

(g) RT_{NDT} is 6° F (limited by transverse Charpy V-notch 50 ft-lb. temperature) for C9481-1. RT_{NDT} is -70° F for both tandem and single wire SAW heat 5P7397/lot 0342.

(h) Copper content, based on preliminary information, is 0.11 wt. % for C9481-1. (Final, recheck on actual surveillance base plate is 0.084 wt. %) Copper content for 5P7397/0342 SAW (both single and tandem wire) is documented as 0.03 wt. %.

(2) Surveillance test specimens were not necessarily taken from directly alongside the specimens used to qualify the materials in the reactor vessel. However, the surveillance specimens would meet all requirements in terms of orientation, processing and location, as the other specimens. Since these plates are vacuum degassed (VIP) and also pass all nondestructive examination requirements, it is likely that they possess a high degree of homogeneity, and the surveillance specimens are just as representative of the materials actually in the reactor vessel as the original qualification specimens. Furthermore, in the unlikely instance that there is a discrepancy between the two groups of specimens, it would be detected by comparing the qualification test results with those of the baseline (out-of-reactor) surveillance specimens. It can be seen from the summary table attached to this response that the transverse specimen test results from the surveillance plate are in line with expectations based upon the longitudinal material qualification test results, and are representative.

(3) See the attached Figures Q121.16-1 and Q121.16-2 from GE report NEDO-20243 as justification that transverse and longitudinal clarify specimens undergo essentially equivalent shifts in upper shelf and transition temperature, as caused by irradiation, especially at fluences

less than 10^{19} n/cm^2. In Figure Q121.16-1, there is considerable data scatter to predict decrease in upper shelf as a function of orientation, but longitudinal tests seem to give a conservative result. It is felt that this is a test data scatter effect, since other results have shown the opposite effect as a result of similar scatter.

TABLE Q121.16-1

C. E. St. Cln

COMBUSTION ENGINEERING, INC.
METALLURGICAL RESEARCH AND DEVELOPMENT DEPT
MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(c) CONTRACT NO. 2867
VENDOR Lukens Steel Company JOB NO. V-70766-001
HEAT NO. C6345-1 CODE NO. G-5604-1
MATERIAL DESCRIPTION 299-7/16" x 114-1/8" x 7-3/8" Lower Intermediate Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cu	
	.14	1.24	.011	.015	.20	.49		.46			

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
NRT-A	.505	RT	61.2	81.6	28.5	65.2
NRT-B	.505	RT	62.4	82.2	28.0	64.6

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES			TEMP. °F	VALUES			NDT
		Ft/Lbs.	% Shear	Mils Lat. Exp.		Ft/Lbs.	% Shear	Mils Lat. Exp.	
CVN Impacts	-80	8	0	4	+160	151	100	87	
	-80	6	0	4	+160	165	100	94	
	-40	29	5	21					
	-40	15	0	13		Drop Weights			
	-40	23	1	16	0	1 NF			-40°F
	+10	109	50	76	-20	1 NF			
	+10	88	35	58	-30	2 NF			
	+10	77	35	56	-40	1 F			
	+40	103	45	68					
	+40	96	40	65					
	+40	122	60	77					
	+110	147	100	84					
	+110	147	100	82					

ADDITIONAL DATA INCLUDING HEAT TREATMENT:
(a) 1550-1650°F 4 hrs. water quenched.
(b) 1225°F ±25°F 4 hrs.
(c) 1150°F ±25°F 40 hrs. furnace cooled to 600°F

The impacts were taken parallel to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface. The tensiles were taken in accordance with ASTM A-20-68.

Form E-2120

cc: Mrs. P. Webb (2)
Mr. J. Brasfield
Mr. S. R. Lewis
Mr. R. E. Lorentz, Jr.
Mr. T. B. Burton

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY Wm C. Riggs

DATE February 26 1970

TABLE Q121.16-1 (Cont'd)

C. E. St. Cln

BUSTION ENGINEERING, INC.

METALLURGICAL RESEARCH AND DEVELOPMENT DEPT

MATERIALS CERTIFICATION REPORT

MATERIAL SPECIFICATION P3F12(c) CONTRACT NO. 2867

VENDOR Lukens Steel Company JOB NO. V-70766-003

HEAT NO. C6318-1 CODE NO. G-5604-2

MATERIAL DESCRIPTION 299-7/16" x 114-1/8" x 7-3/8" Lower Intermediate Shell

MILL CHEMICAL ANALYSIS

TYPE	C	Mn	P	S	Si	Ni	Cr	Mo	Cb	Cv	
	.20	1.22	.012	.014	.18	.51		.46			

MECHANICAL TESTS

TEST NO.	GAUGE	TEST TEMPERATURE °F	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	ELONG. IN 2" %	REDUCTION OF AREA %
NDT-A	.505	RT	62.9	83.4	25.0	65.0
NDT-B	.505	RT	62.5	82.5	28.5	65.9

IMPACT AND/OR FRACTURE TESTS

TYPE	TEMP. °F	VALUES			TEMP. °F	VALUES			NDT
		Ft/Lbs.	% Shear	Mils Lat. Exp		Ft/Lbs.	% Shear	Mils Lat. Exp	
CVN Impacts	-40	25	1	18	+160	140	100	89	
	-40	17	0	11	+160	139	100	88	
	-40	14	0	9					
	+10	80	35	57					
	+10	66	30	47		Drop Weights			
	+10	72	30	50	0	1 NF			-20°F
	+40	85	40	64	-10	2 NF			
	+40	95	40	68	-20	1 F			
	+40	112	50	75					
	+110	126	90	81					
	+110	145	100	89					
	+110	117	90	76					
	+160	140	100	86					

ADDITIONAL DATA INCLUDING HEAT TREATMENT:

(a) 1550-1650°F 4 hrs. water quenched.

(b) 1225°F ±25°F 4 hrs.

(c) 1150°F ±25°F 40 hrs. furnace cooled to 600°F.

The impacts were taken parallel to the major rolling direction of the plate at the 1/4T level and notched perpendicular to the plate surface. The tensiles were taken in accordance with ASTM A-20-68.

Form C-2120

cc: Mrs. P. Webb (2)
Mr. J. Brasfield
Mr. S. R. Lewis
Mr. T. B. Burton
Mr. R. E. Lorentz, Jr.

We hereby certify that the foregoing data is a true copy of the data furnished us by the producing mill, or data resulting from tests performed in the Combustion Metallurgical Laboratory.

COMBUSTION ENGINEERING, INC.

BY Wm. C. Riggs

TABLE Q121.16-1 (Cont'd)

METALLURGY LABORATORY
CHARPY IMPACT TEST DATA

MATERIAL DESCRIPTION PLANT A Weld impact results - (WELD) Heat No. 7C6318-1

Specimen Identification	Bath Medium	Test Temperature	Energy Absorbed	Lateral Expansion	Remarks
4UA	AIR	61°	70	57.2 mils	50% shear
4UJ	Alcohol	+40	31.5	26.0 mils	35% shear
4U5	"	+40	60.	44.0 mils	30% shear
4UK	"	+10	41.5	36.0 mils	25% shear
4UE	"	+10	42.0	37.0 mils	25% shear
4UB	↓	-40	7.5	5.0 mils	10% shear
4UL	WATER	+180	75.0	70.5 mils	99% shear
4UC	"	+200	120.0	75.0 mils	99% shear
4U1	"	+200	91.0	63.5 mils	100% shear
4U3	↓	+200	90.0	69.5 mils	100% shear
4U7	AIR	61°	71.0	57.5 mils	50% shear
4U4	Alcohol	+40	49	34.0 mils	40% shear
4U2	"	+40	43	49.0 mils	40% shear
4U6	"	-10	37.5	37.0 mils	5% shear
4UD	"	-10	31.0	38.5 mils	5% shear

Test Procedure No. CM & S 2.1.7.2 Rev
S/N Tester 119073
Calibration File No. 509-1
S/N Lateral Expansion gage 16602
Performed by G E Olson

Specimen Size 10mm x 10mm
Specimen Orientation TRANSVERSE
level 3

TABLE Q121.16-1 (Cont'd)

COMBUSTION ENGINEERING, INC.

ADDRESSEE	SUBJECT	FROM — DATE
Mr. P. C. Kiefer	Welding Material Qualification to Requirements of ASME Section III A-32255 810560	Metallurgical Research Development Departmen Chattanooga
c: Mr. R. E. Lorentz, Jr.		
Mr. S. A. Lewis		
Mr. S. R. Lewis		June 9, 1970
Mr. Glenn Porter		

The following test data is for 3/16" diameter bare wire, type B-4 MOD., heat number 1P3571 (tandem), flux type 1092, lot number 3958.

A weld deposit was made using the above heat of wire and lot of flux. Welding was done in accordance with C. E. Welding Procedure Specification SMA-33-H3. The completed weldment was given a post weld heat treatment of 1150°F ±25°F for 40 hours and furnace cooled to 600°F.

Charpy V-Notch Impacts

Test Code	Ft/Lbs. @ + 10°F	Requirements
VZ	79, 68, 64	30 Ft./Lbs. @ +10°F

All Weld Metal .505 Tensile

Yield Strength KSI	Ultimate Tensile Strength KSI	Elongation in 2" %	Reduction of Area %
70.5	86.8	27.0	67.0

C. E. Bingham

C. E. Bingham

CEB:sl

COMBUSTION DIVISION

Mr. P. C. Kiefer

Mr. R. E. Lorentz, Jr.
Mr. S. A. Lewis
Mr. S. R. Lewis
Mr. L. Rose
Mr. D. Humble

Welding Material Qualification to Requirements of ASME Section III
B-32255
810556

Metallurgical Research and Development Department
Chattanooga

February 19, 1971

The following test data is for 3/16" diameter electrodes, type 8018, lot number ABEA.

A weld deposit was made using the above lot of electrodes. Welding was done in accordance with C-E Welding Procedure Specification MA-33 B4. The completed weldment was given a post weld heat treatment of 1150°F ±25°F for 40 hours and furnace cooled to 600°F.

Charpy V-Notch Impacts

Test Code	Ft/Lbs. @ +10°F	Requirements
IL	101, 117, 98	30 Ft/Lbs @ + 10°F

All Weld Metal .505 Tensile

Yield Strength KSI	Ultimate Tensile Strength, KSI	Elongation in 2", %	Reduction of Area, %
71.9	86.8	29.0	70.3

NUCLEAR QUALITY ENGR.
FEB 22 1971

J. M. Arnold

JMA:sl

P. C. K.

TABLE Q121.16-2

SUMMARY OF BASELINE TOUGHNESS VALUES FOR SA-533 GR. B, CL. 1 BASE MATERIAL IN PLANT A VESSEL SURVEILLANCE PROGRAM

	CE LONGITUDINAL TEST (C6345-1)	CE LONGITUDINAL TESTS (C6318-1)	GE TRANSVERSE TESTS (C6318-1)
30 ft-lb transition temperature (°F)	-30	-24	-14
50 ft-lb transition temperature (°F)	-12	-5	36
35 mils transition temperature (°F)	-16	-6	7
50% shear transition temperature (°F)	40	55	62
Drop-weight NDT (°F)	-40	-20	*
Upper shelf energy (ft-lb)	158	140	94

*Can be assumed same as longitudinal result.

Q121.16-9a

TABLE Q121.16-3

Purchaser.
Mr. Grant Wagner
Chicago Bridge & Iron Co.
P.O. Box 13308
Presidents Island
Memphis, Tenn. 38101

LUKENS STEEL COMPANY
Coatesville, Pa. 19320
TEST CERTIFICATE

Sales Order No.	Customer's	
49254-4	M2046-2	DF 91871 LK

Date 10-1-71 Invoice No. 1540-06-24

Consigned.
Chicago Bridge & Iron Co.
1500 N. 50th St.
Birmingham, Ala. 35202

Specifications.
We hereby certify that we have complied with all requirements of
MS-1 Rev. 11 DTD 3/31/71 ASME SA-533 Gr. B Cl. 1 Mod. and ASME Code 1968 Edit 1970 Winter Addenda

Grind Mill Q.F. Normalizing Mill

CHEMICAL ANALYSIS

Mill No.	C	Mn	P	S	Cu	Si	Ni	Cr	Mo	V	Ti	Al	Remarks	Grain Size
Q 11	.21	1.87	.008	.018		.23	.50		.50				V.I.P. Steel	7 - 8
				Grain Size after stress relieve 7 - 8										

PHYSICAL PROPERTIES

Mill No.	Bar No.	Tensile PSI	Yield PSI	% Elong. in 2"	R.A.	Hard.	Long. Impact V-Notch +10°F.			Fracture Appearance % Shear	Description
C9481	1	636	856	27			74	74	81	50-50-50	1-326 x 152-3/4 x 6-7/16"
		639	847	26			103	61	85	40-50-60	
					Lateral Expansion in Inches						
							.061	.058	.060		
							.048	.066	.072		

Drop Weight Transition Curve Top of Plate

Temp.	Results
+10°F.	No Break
-10°F.	No Break
-20°F.	No Break
-30°F.	Break
-40°F.	Break

N.D.T. is -30°F.

Drop Weight Transition Curve Bottom of Plate

Temp.	Results
+10°F.	No Break
-10°F.	No Break
-20°F.	No Break
-30°F.	Break
-40°F.	Break

N.D.T. is -30°F.

All heat treatments per specification 111A-71.

APR 7 1971 JEG

We hereby certify the above figures are correct as contained in the records of the company.

Authorized Signature H. P. McAfee

Purchaser:

Chicago Bridge & Iron Co.

LUKENS STEEL COMPANY
Coatesville, Pa. 19320
TEST CERTIFICATE

MILL ORDER NO.	CUSTOMER P.O.
49254-1,2,3, 4,5	M2046-2

File No. 1540-66

Specification Sheet No. 111A-71

Test Location:

Drop Weights-Top & Bottom - Longitudinal
Bend - Top Middle - Transverse
Tensions - Top & Bottom - Transverse
Impacts - Top & Bottom - Longitudinal
Tests 1/4T from rolled surface
No closer than "T" from quenched & tempered edge

APR 17 1972

Specification:

A.S.M.E. SA-533 Gr. B CL-1 Pressure Vessel Quality
C.B. & I. MS-1 Rev. 11 DTD 3/31/71 A.S.M.E. Sec. III Class A

Fine Grain Practice
V.I.P. Steel
Basic Process: Electric Furnace

Mechanical Property Requirements

Tensile:	80/100,000 PSI
Yield:	50 Min. .2% Offset
Elong:	18% in 2" Min.
Impacts:	30 ft.lbs.@ 40°F. Lateral Expansion & % Shear Fracture for information only.
Drop Weights:	NDT determination per E208. Type P-3 specimens.
Grain Size:	Final Plate Grain Size #5 or finer determined on a fully heat treated test coupon.

Heat Treatment:
Procedure LS-102 Rev. 7 DTD 4/16/71 Approved by C. B. & I. On 4/22/71.
Note - All temperatures shown below are actual.

Plates:
Austenitized at 1625 °F held 1/2 hr./inch min., & water quenched.
Tempered at 1260 °F held 1/2 hr./inch min., & air cooled.
Stress relieved at 1150 °F held 1 hr. min. & air cooled.
Test coupons then cut from plate.

Tests Only:
Stress relieved at 1150 °F held 50 hrs. & furnace cooled to below 600°F., then air cooled.

Max. Heating Rate	Max. Cooling Rate
Rate/hr. 100°F.	Rate/hr. 100°F.

Top end of plate as received by C. B. & I. is at least 1T from quenched & tempered edge.

We hereby certify the above figures are correct as contained in the records of the company.

Authorized Signature: W. A. Pisic

Q121.16-9b

TABLE Q121.16-3 (Cont'd)

TABLE Q121.16-3 (Cont'd)

LAB. NO. 05550

METALLURGY LABORATORY

CHARPY IMPACT TEST DATA

MATERIAL DESCRIPTION: HT. NO. C9481-1

SA-533 GR.B CL.1

Specimen Identification	Bath Medium	Test Temperature	Energy Absorbed	Lateral Expansion	% SHEAR Remarks
#1	AIR	70°F	51.0	44.5 mils	40%
#2	AIR	70°F	50.0	42.5 mils	40%
#3	H_2O	120°F	93.0	69.5 mils	90-95%
#4	"	200°F	93.5	74.0 mils	95%
#5	"	200°F	100.0	72.0	95%
#6	"	200°F	97.0	69.0	95%
#7	"	93°F	71.0	58.5	70%
#8	MeOH	-40°F	45.0	42.0 mils	30-35%
#9	"	-40°F	35.0	34.2 mils	30%
#10	"	-10°F	23.5	21.0 mils	10%
#11	"	-10°F	22.0	20.5 mils	10%
#12	"	-40°F	17.0	15.0	5%
#13	"	-40°F	42.0	38.0	30-35%
#14	"	-25°F	36.0	31.0	20-25%
#15	"	-51°F	40.5	35.0	30%

Test Procedure No. CM & S 2.1.7.2 Rev Ø Specimen Size 1cm x 1cm

S/N Tester -119073 Specimen Orientation TRANSVERSE

Calibration File No. 509-1

S/N Laterial Expansion Gage 16602

Performed by R G Denning level 3

TABLE Q121.16-3 (Cont'd)

DROP WEIGHT TESTS

Type of Material INMM (Tandem Wire) Size 3/16" Heat [illegible]
Linde 124 Flux Lot 0342
Specimen Type P-7 Specimen Size 3/4" x 2" x 5"
Testing Conditions: Anvil 3/4 Weight 60# Drop Height 5'

Specimen	Location	Test Temp. °F	Results
Weld Metal 1	1/4t	-40	No Break
" " 2	"	-80	Break
" " 3	"	-60	No Break
" " 4	"	-70	No Break
" " 5	"	-70	Break
" " 6	"	-60	No Break
WM T_{NDT} Temp. -70°F			

IMPACTS TESTS - CHARPY VEE NOTCH - FULL SIZE

Specimen	Location	Test Temp. °F	Energy Ft. Lbs.	Lateral Expansion	% Shear
Weld Metal 1	1/4 t	-70	22	22	5
" " 2	"	-70	16	18	5
" " 3	"	-70	36	28	5
" " 4	"	-10	58	54	25
" " 5	"	-10	68	50	20
" " 6	"	-10	61	47	20
" " 7	"	+10	76	60	30
" " 8	"	+10	73	65	45
" " 9	"	+10	75	60	50
" " 10	"	+10	75	58	35
" " 11	"	+10	69	56	35
" " 12	"	+40	91	75	80
" " 13	"	+40	84	63	85
" " 14	"	+70	79	73	90
" " 15	"	+70	75	63	95
" " 16	"	+70	77	74	95
" " 17	"	+212	84	69	100
" " 18	"	+212	81	67	100
" " 19	"	+212	87	75	100
" " 20					
WM T_{CV} Temp. -10°F					

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy Vee Notch)	RT_{NDT} (Reference Temperature)
Weld Metal	-70°F	-10°F	-70°F

TABLE Q121.16-3 (Cont'd)

DROP WEIGHT TESTS

Type of Material 1NMM (Single Wire) Size 3/16"Ø Heat ST"39"
Linde 124 Flux Lot 0342
Specimen Type P-2 Specimen Size 3/4" x 2" x 5"
Testing Conditions: Anvil 3/4 Weight 60# Drop Height 5'

Specimen	Location	Test Temp. °F	Results
Weld Metal 1	1/4 t	-40	No Break
" " 2	"	-80	Break
" " 3	"	-60	No Break
" " 4	"	-70	No Break
" " 5	"	-70	Break
" " 6	"	-60	No Break
WM RT_{NDT} Temp. -70°F			

IMPACTS TESTS - CHARPY VEE NOTCH - FULL SIZE

Specimen	Location	Test Temp. °F	Energy Ft. Lbs.	Lateral Expansion	% Shear
Weld Metal 1	1/4T	-70	20	16	5
" " 2	"	-70	34	32	5
" " 3	"	-70	27	22	5
" " 4	"	-10	54	47	25
" " 5	"	-10	50	47	20
" " 6	"	-10	59	53	20
" " 7	"	+10	65	60	50
" " 8	"	+10	59	56	25
" " 9	"	+10	69	65	75
" " 10	"	+10	70	56	45
" " 11	"	+10	75	61	55
" " 12	"	+40	71	65	75
" " 13	"	+40	78	68	90
" " 14	"	+70	92	82	95
" " 15	"	+70	101	65	95
" " 16	"	+70	94	69	100
" " 17	"	+212	100	88	100
" " 18	"	+212	95	58	100
" " 19	"	+212	96	82	100
" " 20					
WM T_{CV} Temp. -10°F					

REFERENCE TEMPERATURE

Material	T_{NDT} (Drop Weight)	T_{CV} (Charpy Vee Notch)	RT_{NDT} (Reference Temperature)
Weld Metal	-70°F	-10°F	-70°F

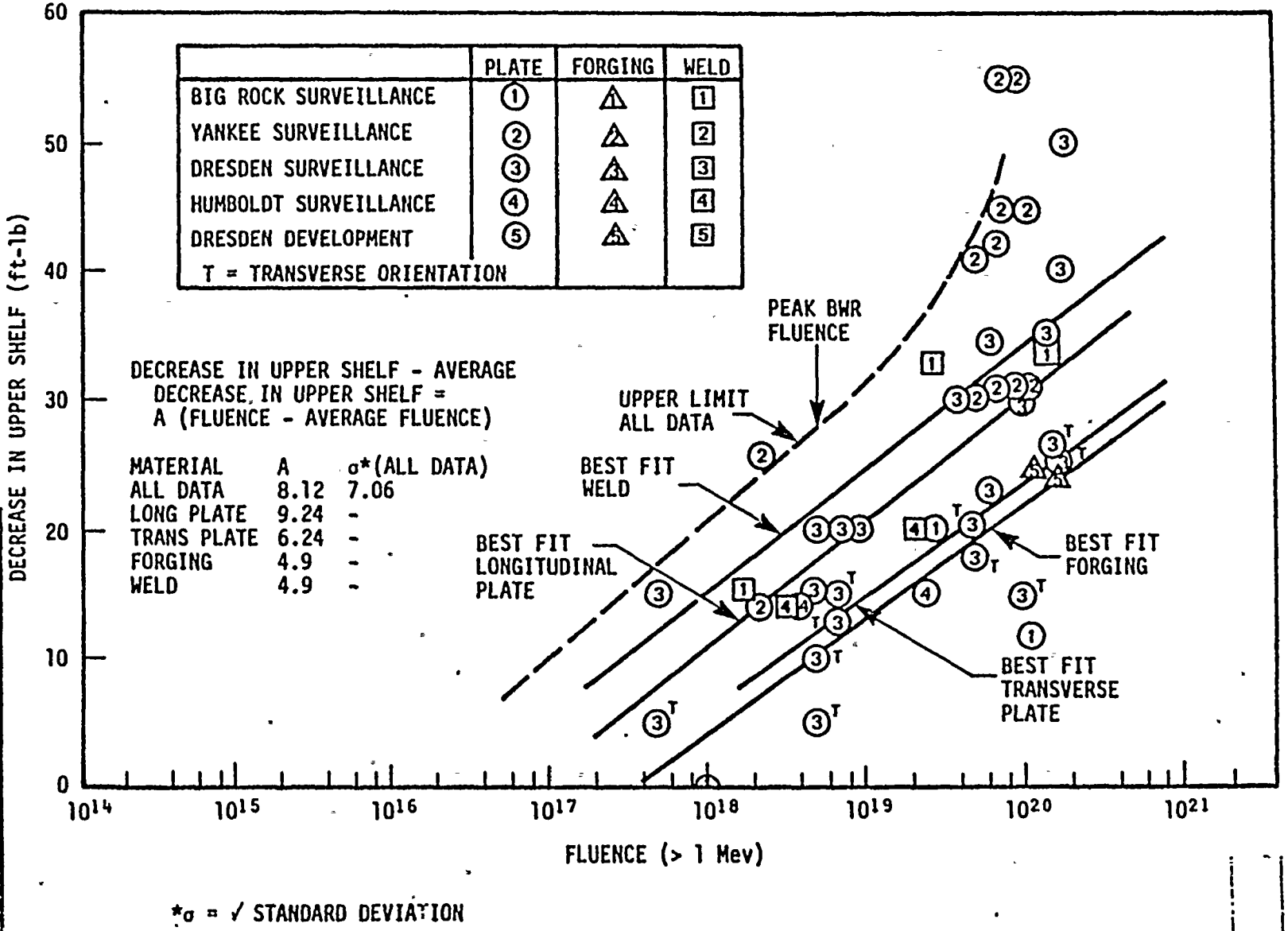
TABLE Q121.16-4

SUMMARY OF BASELINE TOUGHNESS VALUES FOR
SA-533 GR. B, CL. 1 BASE MATERIAL IN PLANT B
REACTOR VESSEL SURVEILLANCE PROGRAM (HEAT NO. C9481-1)

	CBIN LONGITUDINAL TESTS	GE TRANSVERSE TESTS
30 ft-lb Transition Temperature (°F)	NA	24
50 ft-lb Transition Temperature (°F)	< 40	66
35 mils Transition Temperature (°F)	< 40	40
50% Shear Transition Temperature (°F)	40	82
Drop-weight NDT (°F)	-30	-*
RT_{NDT} (°F)	Not Applicable	6*
Upper Shelf Energy (ft-lb)	NA	96

NA = Not available; can be determined by Company from their baseline (unirradiated) surveillance specimens.

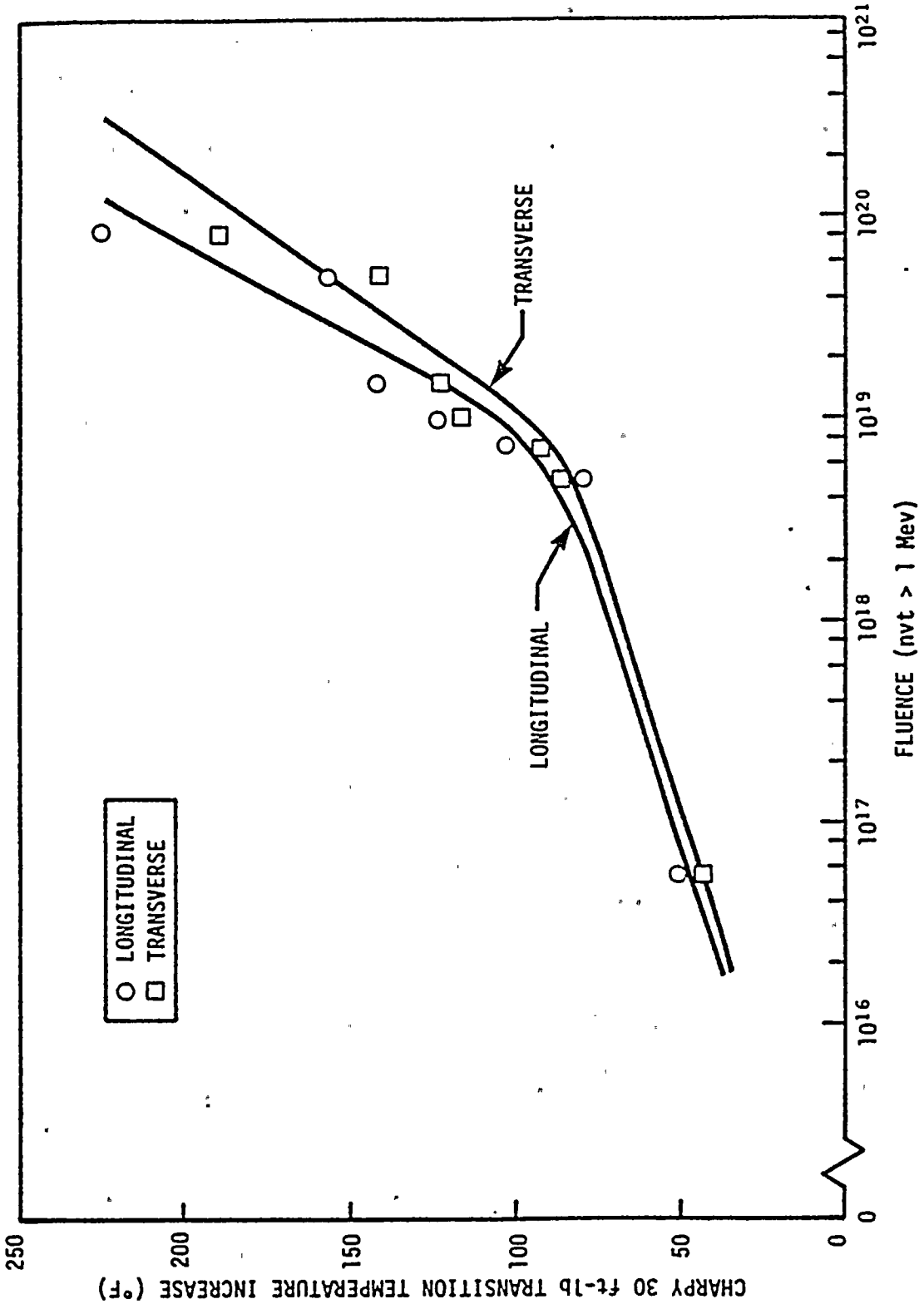
* = NDT can be assumed same as longitudinal result.



PLANT A
FINAL SAFETY ANALYSIS REPORT

FIGURE Q121.16-1

DECREASE IN UPPER SHELF ENERGY VS. NEUTRON FLUENCE FOR A302B AND A533B PLATE, WELD HEAT-AFFECTED ZONE, AND A508 FORGING

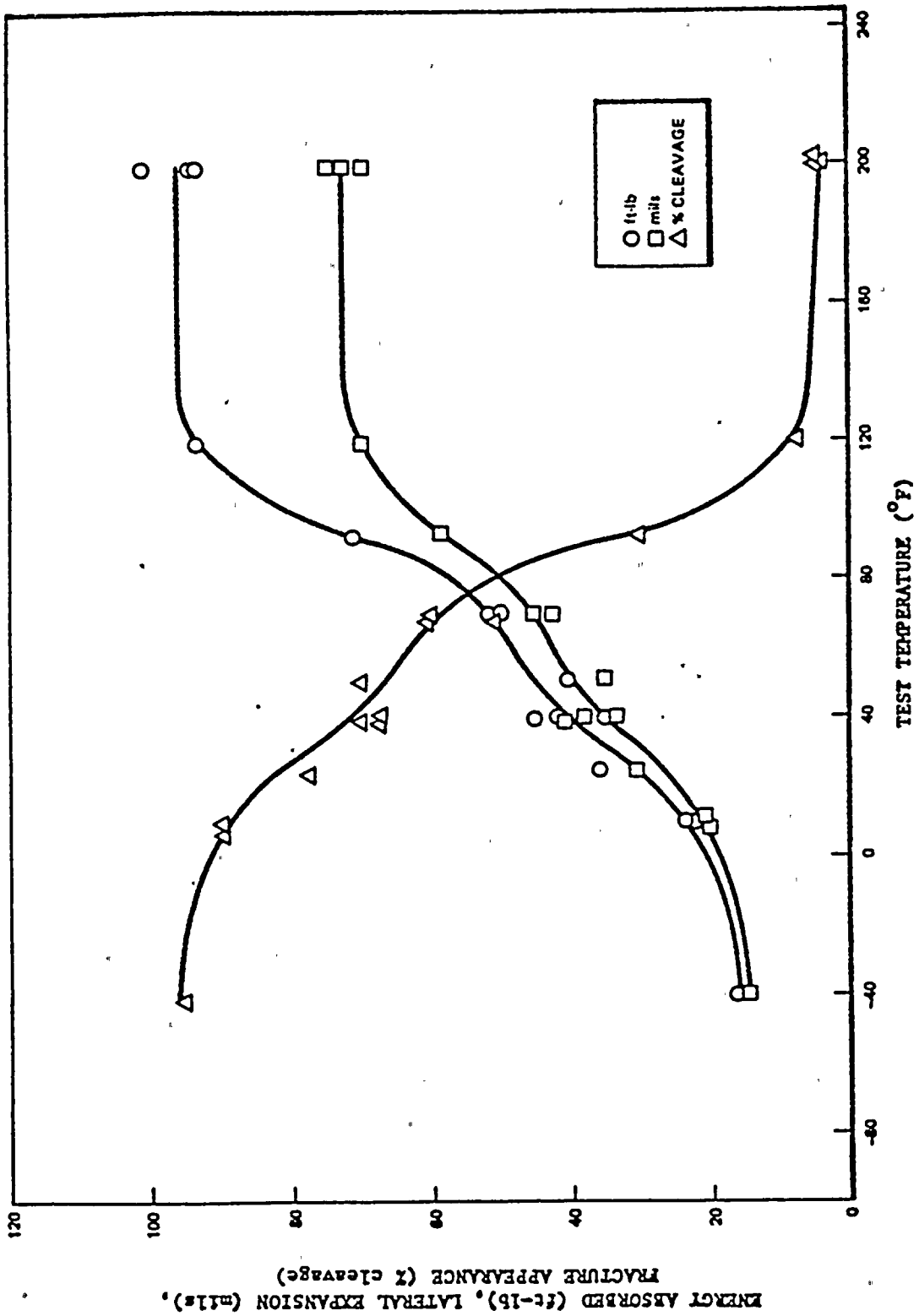


TEMPERATURE AT WHICH 30 ft-lb CHARPY ENERGY IS ABSORBED FOR REACTOR PRESSURE VESSEL A302B AND A533B PLATE-DNPS-1 DATA (REFERENCES 18-22)

PLANT A
FINAL SAFETY ANALYSIS REPORT

FIGURE Q121.16-2

EFFECT OF SPECIMEN ORIENTATION ON INCREASE IN TEMPERATURE



PLANT A
FINAL SAFETY ANALYSIS REPORT

FIGURE Q121.16-3

CHARPY V-NOTCH
IMPACT TESTS TRANSVERSE

QUESTION 121.17

"High values of Charpy V Notch energy can be achieved at the nil ductility temperature for reactor vessel forging material. You have stated that the RT_{NDT} for your reactor vessel forging material is assumed to be the nil ductility temperature as determined by the dropweight test. You did not supply any corroborative data or analyses to verify that this assumption would lead to conservative values of RT_{NDT} for vessel forging material. Consequently, before we can complete our evaluation of compliance of the forging material, RT_{NDT} to the requirements of Paragraph IV.A.2.a of Appendix G, provide additional data, information available in the literature, and/or analyses to verify the conservativeness of using nil ductility temperature alone to define the values of RT_{NDT} for the vessel forging material."

RESPONSE

In the case of PLANT A , both longitudinal (or unidentified orientation) Charpy V-notch and drop-weight NDT values are available for the SA-508 Class 2 vessel forgings analyzed. These toughness values are shown in Tables Q121.17-1 and Q121.17-2.

In all cases except one (PLANT B Feedwater Nozzle Forging Q2Q25W), the drop-weight NDT temperature limited the determination of RT_{NDT}.

RT_{NDT} was estimated in accordance with the estimation method described below. For forging Q2Q25W, the Charpy orientation was conservatively assumed as longitudianl (parallel to principle working direction). Then, following the estimation method (below), the RT_{NDT} evaluated Charpy tests is: -20° F + (50-28 x 2) + 30° F -60° F = 6° F. The drop-weight NDT is -10° F, and the difference of 4° F is within the ASTM E208 10° F testing interval for determining NDT.

The longitudinal Charpy results in Table Q121.17-1 show that the 2° F per ft-lb estimation is conservative. This is also in agreement with the longitudinal 1/4 T data curve in Figure 3 of NRC Bulletin 217.

Also, based upon forging transverse (perpendicular to principle working direction) Charpy data on several vessels (Table Q212.17-3) it is concluded that the drop-weight NDT is generally the limiting property, not Charpy results. This is consistent with the results, except for one very close case with the 4° F discrepancy.

RT_{NDT} ESTIMATION METHOD

1. Scope and Objectives

This procedure describes the method to be used for establishing the initial reference temperature (RT_{NDT}) for ferritic vessel steels for older plants where fracture toughness data may be incomplete. These methods represent a General Electric alternate position to the NRC Regulation 10 CFR 50 Appendix G for these plants.

2. Methods

a. Vessel Plate (SA-533 GR. B Cl.1):

Predicting limiting property - either NDT (nil-ductility transition temperature) or transverse CVN (Charpy V-notch) 50 ft.-lb. T.T. (transition temperature)

Usual data available - NDT and/or longitudinal CVN at + 10 or +40° F

RT_{NDT} prediction method -

Operate on lowest longitudinal CVN ft.-lb to get at least 50 ft-lb T.T. by adding 2° F per ft-lb or by plotting a curve (ft-lb vs. temperature), where possible. Add additional 30° F to convert from longitudinal to transverse 50 ft-lb T.T.

Derive NDT, where missing, as equal to longitudinal CVN 35 ft-lb T.T.

RT_{NDT} is higher of NDT or transverse CVN 50 ft-lb t.T. -60° F.

b. Forgings (SA-508 Cl.2):

Predicted limiting property - NDT or transverse CVN 50 ft-lb T.T.

Usual data available - NDT and/or CVN at single temperature.

RT_{NDT} prediction method -

Derive CVN 50 ft-lb T.T. as for plate. When only CVN values are available, estimate NDT, when missing, as the lower of +70° F or the CVN test temperature where at least 100 ft-lb or 50% shear is achieved. RT_{NDT} is higher of NDT or transverse CVN 50 ft-lb T.T. -60° F.

TABLE Q121.17-1

SUMMARY OF PLANT A SA-508 CLASS 2 FORGING TOUGHNESS

COMPONENT HEAT NO.	DROP* Wt. NDT	CHARPY ORIENT.	CHARPY TEMP.	ENERGY Ft-lbs	LAT. EXPANSION Mils	% SHEAR
Vessel Flange: 2V-659ATF-112	+20°F	L	-100°F	11,7,8	7,5,6	0,0,0
			- 70°F	29,6,25	26,3,21	20,0,10
			- 40°F	46,47,40	38,41,33	25,25,20
			+ 10°F	69.5,67.8,96.7/ 70.1,79.0,78.9	51,51,70/ 57,61,60	36,36,53/ 42,48,42
			+ 77°F	99,115,115	71,61,60	80,85,80
			+100°F	133,130,111	76,77,83	99,99,85
			+140°F	127,132,128	87,70,87	99,99,99
Closure Head Flange ACT-USS-4P 1997 SER 118	+20°F	L	-100°F	1,3,3	0,0,0	0,0,0
			- 70°F	20,22,47	20,19,41	0,0,0
			- 40°F	28.5,75,43	25,57,37	0,29,0
			+ 10°F	105,5,104,5, 92.5/92,110,91	57,51,51/ 45,65,48	81,74,72, 69,79,71
			+ 40°F	100,116,116	75,87,74	59,67,67
			-100°F	140,165,158	91,78,96	83,100,100
			+140°F	166,166,166	95,90,90	99,99,99
Feedwater Nozzles Q2Q14VW	+40°F	Not Available	+ 10°F	60,66,73/96,77,77	47,53,60/67,56/52	20,20,30/40,30,30
			+ 10°F	82,78,87/94,90,95	61,60,67/66,61,63	40,40,40/40,40,40
			+ 10°F	68,92,87/48,72,60	56,69,63/36,56,44	30,30,30/20,36,20
			+ 10°F	55,80,65/60,61,76	48,57,55/52,51,61	30,30,30/30,30,40
			+ 10°F	89,85,95/104,83,88	65,63,66/79,62,65	40,40,40/50,40,40
			+ 10°F	125,105,101/ 95,91,94	84,72,70/68,63,67	60,50,50/40,40,40

*It is suspected that this is not necessarily the lowest NDT, but is, in some cases, simply a materials qualification test to show 2 no-break NDT specimens at this temperature or 10°F above it.

TABLE Q121.17-2

SUMMARY OF PLANT B SA-508 CLASS 2 FORGING TOUGHNESS

COMPONENT HEAT NO.	DROP* Wt. NDT	CHARPY ORIENT	CHARPY TEMP.	ENERGY Ft-lbs.	LAT. EXPANSION Mils	% SHEAR
Vessel Flange:						
BRC424	+10°F	N/A	+10°F	122,116,107 (0° location)	83,81,75	58,57,53
			+10°F	70,122,142 (180° location)	53,89,88	33,35,69
Closure Head Flange						
BWR-446	+10°F	N/A	+10°F	103,110,104.5 (0° location)	71,77,71	60,57,63
			+10°F	105,117,125 (180° location)	74,81,80	60,63,72
Feedwater Nozzle						
Q2Q25W	-10°F	N/A	-20°F	38,35,28/ 33,40,39	28,27,22/ 26,31,30	20,30,30/ 30,40,40
Q2Q29W	-10°F	N/A	-20°F	52,64,52/ 54,50,54	41,48,41/ 43,38,42	50,60,50/ 50,50,50
	-10°F	N/A	-20°F	61,51,60/ 51,44,76	47,40,45/ 39,33,56	60,50,60/ 50,40,60
Q2Q33W	-10°F	N/A	-20°F	35,37,43 62,47,43	26,27,32/ 47,35,32	30,30,40/ 50,40,40

*It is suspected that this is not necessarily the lowest NDT, but is, in some cases, simply a materials qualification test to show 2 no-break NDT specimens at this temperature or 10°F above it.

TABLE Q121.17-3

REACTOR VESSEL DROP-WEIGHT NDT AND TRANSVERSE CHARPY TOUGHNESS RESULTS FOR SA-508 CL.2 FORGINGS

PLANT Y, Z

FORGING NO.	TEST LOCATION	NDTT (°F)	CVN TEMP (°F)	CNV ENERGY (Ft-lb)
315A-1, Q2QL2W	0°	-30	40	111,113,118
	180°	-20	40	103,103,87
315A-2, Q2QL2W	0°	-30	40	81,90,98
	180°	-30	40	110,119,110
315A-3, Q2QL2W	0°	-30	40	117,116,119
	180°	-30	40	94,77,100
315A-4, Q2QL2W	0°	-30	40	127,109,116
	180°	-20	40	83,119,137
315A-5, Q20L2W	0°	-20	40	95,72,116
	180°	-20	40	120,112,138
315A-6, Q2QL2W	0°	-20	40	101,79,73
	180°	-20	40	111,109,117
CDS MHP,2V6969, SER 802	0°	-30	20	64,88,77
	180°	-50	10	81,72,82
	0°	-30	10	125,136,138 (longitudinal)
	180°	-50	10	120,122,104 (longitudinal)

8112160113

BILL OF MATERIAL

DATE 12-10-73

WRITTEN R.G. CHKD. R.K.S.

		QUANT. 1 UNITS	QUANT. UNIT	PART NO.	MATERIAL	DESCRIPTION	ITEM NO.
			*	P.O.#		MOTOR, TYPE , V.H.S./V.S.S.	1
				DIRECT		HP., PH., CY., VOLTS, R.P.M.	2
				STOCK		FRAME ,B.D. ,C.D. ,CLUTCH	3
						AH , U , WITH(OUT) RING KEYWAY	4
						ENCLOSURE, WITH(OUT) N.R.R.	5
						HIGH THRUST, NORMAL THRUST, LOCK FOR UPTHRUST	6
							7
							8
							9
	△	1	*	P.O.# 45135		U.S./ ~~AMARIGO~~/ JOHNSON MODEL HF 200 RIGHT ANGLE	10
				DIRECT		GEAR DRIVE 1:1 INCREASING/DECREASING SPEED RATIO	11
				STOCK		PUMP R.P.M.- 1770 ROTATION- FIG. 1	12
						BASE DIA.- 20" CLUTCH BORE- 1"/16	13
						GEAR DRIVE TO BE IN ACCORDANCE W/CUSTOMERS SPEC.	14
					①	SECTION IS-A (COPY ATTACHED) ATTACH A METAL PLATE TO	15
					①	GEAR & STAMP "TAG. NO. FP-P-1"	16
	△	1		P.O.#		WATSON-SPICER MODEL WS 70 FLEXIBLE SHAFT 11 " LG.	17
	△	1		DIRECT		WATSON-SPICER MODEL W 70 FLANGE 2 3/4 " BORE	18
				STOCK		5/8 " x 5/16 " KEYWAY	19
	△	1				WATSON-SPICER MODEL W 70 FLANGE 2 3/4 " BORE	20
						3/4 " x 3/8 " KEYWAY	21
							22
							23
							24
							25
							26
							27
							28
							29
							30
					*	FURNISH BY RETURN MAIL: ATTN: PURCHASING DEPARTMENT	31
						DWGS & DATA REQ'D BY SECT. IS-A OF SPEC	32
							33
						AFTER APPROVAL FURNISH 20 COPIES OF MATERIAL REQ'D. FOR	34
						OPERATING & MAINTENANCE MANUALS	35

~~A PRELIMINARY — HOLD FOR APPROVAL~~

① RELEASE FOR PRODUCTION PER APPROVED AS NOTED DWG'S. & RESUBMIT FOR FINAL APPROVAL

① REV. R.G. 12-10-73

BUY-OUT

DRIVER GEAR DRIVE - FLEX. SHAFT

WASHINGTON PUBLIC POWER

ORDER NO. GE-2328

NO. UNITS 1

SHEET 1 OF 2 SHEETS

JP-465

Attachment I - Set 1 of 3

BILL OF MATERIAL

DATE

WRITTEN R.G. CHK. R.K.S.

Q.C. CODE
B = BARS
C = CERTS.
W = WELDING CERTS.

QUANTITY 1 UNIT	QUANTITY UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
① △ *	1	PO# 45319			CUMMINS MODEL NT-280IF DIESEL ENGINE	1
					U.L. LABELED FIRE PUMP ENGINE RATED @ 255	2
					B.H.P. AT OUTPUT SHAFT @ 1770 R.P.M	3
					ELEV. 491 FT. ABOVE SEA LEVEL	4
					WITH 2 3/4" DIA STUB SHAFT w/ 3/4 x 3/8 KEYWAY	5
					WITH FABRICATED STEEL BASE & COUPLING GUARD	6
					FOR WATSON WS-70 ELEX. SHAFT & ACCESSORIES	7
					ENGINE IS TO BE IN ACCORDANCE WITH CUSTOMERS	8
					SPEC. SECTION 15-A (COPY ATTACHED) INCLUDING	9
					DIESEL ENGINE FUEL SYSTEM WITH 280 GAL. TANK.	10
					& WIRED FOR AUTOMATIC OPERATION BY METRON CUSTOM BUILT	11
					FD-2 CONTROLLER PER CUMMINS QUOTE IND 72-052 REV. 1	12
					DATED 5-12-72	13
				①	ATTACH A METAL PLATE TO ENGINE AND STAMP	14
					"TAG. NO. EP-P-1"	15
						16
① △ *	1	PO# 45136			METRON ENGINE CONTROLLER MODEL FD-2 CUSTOM	17
					BUILT WITH AUTO & MANUAL START, 120 VOLT AC	18
					BATERY CHARGER 24 VOLT DC IN ACCORDANCE	19
					WITH CUST. SPEC SECTION 15-A (COPY ATTACHED)	20
				①	ATTACH A METAL PLATE TO CONTROLLER AND STAMP	21
					"TAG NO. EP-P-1"	22
△ ~~PRE-ORDER, HOLD FOR APPROVAL~~						23
① RELEASE FOR PRODUCTION PER APPROVED AS NOTED						24
DWG'S. & RESUBMIT DWGS FOR FINAL APPROVAL						25
					FURNISH BY RETURN MAIL. ATTN. PURCH. DEPT.	26
					DATA & DWGS REQ'D BY SECT. 15-A OF SPEC.	27
						28
					AFTER APPROVAL FURNISH 20 COPIES OF MATERIAL REQ'D	29
					FOR OPERATING & MAINTENANCE MANUALS	30
						31
						32
						33
						34

* BUY-OUT

DIESEL ENGINE - CONTROLLER

WASHINGTON PUBLIC POWER
ORDER NO. GE-2328
NO. UNITS 1
SHEET 2 OF 8 SHEETS

Form JP 331

Q.C. CODE
B = BARS
C = CERTS.
W = WELDING CERTS.

BILL OF MATERIAL

DATE 12-7-13

WRITTEN R.G. K.J.

QUANTITY 1 UNIT	QUANTITY UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
1		5314-1-C	C/B	C.I. A48 CL. 30	DISCHARGE HEAD HYDROTEST TO 360 P.S.I.	1
4				A307 GR. A STL.	CAP SCREWS 5/8-11 NC X 2 1/2" LG. (HEX. HD.) } DRIVER	2
4				A307 GR. A STL.	NUTS 5/8-11 NC (HEX.) }	3
1		6603-A		AA79-410 S.S.	NAMEPLATE W/DRIVE SCREWS (DATA AFTER TEST)	4
1				C.I.	PIPE PLUG 1 1/4" N.P.T. (SQ. HD.)	5
1		5410-A		AA79-410 S.S.	NAMEPLATE W/DRIVE SCREWS (SEE SNT. FOR INSTRUCTIONS)	6
1				BRASS	U.L. LABLE	7
1		5457-A	C	C.I. A48 CL. 30	SUB-BASE	8
4				A307 GR. A STL.	CAP SCREWS 3/4-10 NC X 1 3/4" LG. (HEX. HD.)	9
						10
1		3481-A	C/B	C.I. A48 CL. 30	PACKING BOX	11
1		4222-A	C	BRZ. B144-3D	PACKING BOX BEARING	12
1		3184-A		BRZ. B145-4A	LANTERN RING	13
1		3188-1-A		BRZ. B145-4A	PACKING GLAND - SPLIT	14
6				J.C. SS #3	PACKING RINGS 1 11/16 x 2 11/16 x 1/2	15
1				STL.	ALEMITE FITTING #1622 1/8 N.P.T. X 30°	16
2				BRASS	STUDS 3/8-16 NC X 2 1/2" LG. (T.F.L.)	17
2				BRASS	NUTS 3/8-16 NC (HEX.)	18
6				A307 GR. A STL.	CAP SCREWS 1/2-13 NC X 1 1/2" LG. (HEX. HD.)	19
1		1022-A		VELUMOID	GASKET	20
1		1075-A		RUBBER	DEFLECTOR	21
						22
1		2529-A	C	A582-416 S.S.	HEADSHAFT 1 11/16 x A = 7'-10 5/8" LG.	23
1		879-A		A108-1045 STL.	ADJUSTING NUT	24
2				A307 GR. A STL.	LOCKSCREWS 1/4-20 NC X 2 1/4" LG. (HEX. HD.)	25
1				A108-1045 STL.	KEY 3/8" SQ. X 1 3/8" LG. (UNDER HD.)	26
						27
						28
						29
						30
						31
						32
						33
1		4271-A			ENVELOPE: H-4651-D, H-4652-D, " AJ 1038	34

20" X 10" TYPE 'A' DISCH. HEAD - W.L.
10" FLGD. COL. - 1 11/16 SHAFT - MODEL EBA FIRE PUMP

WASHINGTON PUBLIC POWER
ORDER NO. GE-2328
NO. UNITS 1

Q.C. CODE
B = BASS.
C = CERTS.
W = WELDING CERTS.

BILL OF MATERIAL

DATE
WRITTEN R.G. CHKD. K.U.

QUANTITY 1 UNIT	QUANTITY UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
						1
						2
						3
						4
						5
						6
						7
						8
						9
						10
						11
						12
						13
						14
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						33
						34

SERIAL NUMBER GE-2328

R.P.M. 1770 B.H.P. 204

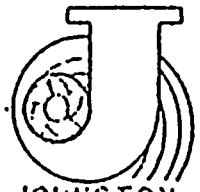
U.S.G.P.M. 2000 T.D.H. 298 FT.

SIZE & TYPE 16. CLC STAGES 3

FLUID WATER SP. GR. 1.0

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

HANFORD NO. 2 TAG. NO. FP-P-1



ROTATION

JOHNSTON PUMP CO.
GLENDORA, CALIF.

5410-A

NAMEPLATE STAMPING INSTRUCTIONS

WASHINGTON PUBLIC POWER
ORDER NO. GE-2328
NO. UNITS

BILL OF MATERIAL

DATE

WRITTEN R. G. K.H.

Q.C. CODE
B = BARS
C = CERTS.
W = WELDING CERTS.

QUANTITY 1 UNIT	QUANTITY UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
1		39872-A	C	FAB. STL.	TOP COL. PIPE 10" x A = 4'-2 5/8" LG.	1
1		39881-A	C	FAB. STL.	BOT. COL. PIPE 10" x A = 7'-11 5/8" LG.	2
1		569-A		HYDROIL	TOP COL. FLG. GASKET	3
12				A307 GR.A STL.	CAP SCREWS 3/4-10 NC x 2" LG. (HEX. HD.) (TOP COL.)	4
12				A307 GR.A STL.	CAP SCREWS 3/4-10 NC x 2 3/4" LG. (HEX. HD.) } (COL. TO	5
12				A307 GR.A STL.	NUTS 3/4-10 NC (HEX.) } COL.)	6
12				A307 GR.A STL.	CAP SCREWS 3/4-10 NC x 1 1/2" LG. (HEX. HD.) (COL. TO DISCH. CASE)	7
						8
1		21439-A	C	A108-1045 STL.	LINESHAFT 1 1/16 x A = 8'-0" LG.	9
1		7819-A	C	A582-416 S.S.	LINESHAFT COUPLING	10
1		21084-A	C/B	BRZ. B145-4A	BEARING RETAINER	11
1		21319-5-A		RUBBER	LINESHAFT BEARING	12
						13
						14
						15

COATING INSTRUCTIONS:

1.) SURFACES TO BE COATED WILL BE CLEANED BY SANDBLASTING PRIOR TO COATING

2.) DISCH. HEAD & SUB BASE PAINTED WITH J.P.CO. STD. PRIMER AND GREEN ENAMEL PAINT

3.) INSIDE & OUTSIDE OF COLUMN PIPE WILL BE COATED WITH COAL TAR EPOXY 16 MILS MIN. THICKNESS → 19 E.G. 5-3-74

NOTES:

1.) QUALITY ASSURANCE REQUIREMENTS, TESTS, CERTIFICATION OF MATL'S. & REPORTS ARE TO BE IN ACCORDANCE WITH WASHINGTON PUBLIC POWER SYSTEM SPEC. DIV. 15 SECTION 15A.

2.) PUMP IS SUBJECT TO SOURCE INSPECTION

3.) TESTS WILL BE WITNESSED

HYDROTEST COLUMN TO 360 P.S.I.

10" FLGD. COLUMN - 1 11/16 SHAFT - W.L.

MODEL EBA FIRE PUMP - COATING - NOTES.

WASHINGTON PUBLIC POWER

ORDER NO. GE-2328

NO. UNITS 1

Q.C. CODE
= BARS
= CERTS.
/ = WELDING CERTS.

BILL OF MATERIAL

DATE 12-7-15

WRITTEN R. G. K.H.

QUANTITY 1 UNIT	QUANTITY UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
1		33041-A	C/B	C.I. A48 CL. 30	DISCHARGE CASE	1
1		851-A	C	BRZ. B144-3D	DISCH. CASE BEARING	2
						3
3		19590-A	C/B	C.I. A48 CL. 30 YIT	INTER. BOWL	4
3		2356-A	C	BRZ. B144-3D	INTER. BOWL BEARING	5
3		4822-6-A		RUBBER	INTER. BOWL BEARING	6
						7
3		2357-A	C/B	BRZ. B145-4A	IMPELLER FULL 12" DIA. - 3/32 T.B.F. CL. B	8
3		4336-A	C	BRZ. B148-9C	IMPELLER SEAL RING	9
3		14046-A	C	A276-316 S.S.	LOCK COLLET	10
						11
1		19595-A	C/B	C.I. A48 CL. 30 YIT	SUCTION BELL	12
1		851-A	C	BRZ. B144-3D	SUCT. BELL BEARING	13
1				C.I.	PIPE PLUG 3/4" N.P.T. (SQ. HD.)	14
1		10253-A		A479-410 S.S.	BOWL SERIAL PLATE W/ DRIVE SCREWS	15
1		1638-A		NEOPRENE	SAND COLLAR	16
1		13609-A	C	A582-416 S.S.	PUMPSHAFT 2 3/16 x 1 "/16 x A = 62 1/16" LG.	17
1		7819-A		A582-416 S.S.	PUMPSHAFT COUPLING	18
						19
48				A307 GR. A STL.	CAP SCREWS 5/8-11 NC x 1 1/2" LG. (HEX. HD.)	20
						21
1		39871-A	C	316 S.S.	BASKET STRAINER	22
6		7640-A		316 S.S.	CLIPS	23
6				316 S.S.	CAP SCREWS 1/4-20 NC x 3/4" LG. (HEX. HD.)	24
6				316 S.S.	FLAT WASHERS 1/4" BOLT SIZE	25
						26
						27
						28
						29
						30
) DYNAMIC BALANCE					T.P.L. = 17-8 1/4" (BOT. OF SUB BASE TO BOT. OF STRAINER	31
HYDROTEST BOWLS TO 360	P.S.I.				SHAFT PROJ. ABOVE COL. SEAT = 10"	32
					" " " MOTOR SEAT = 37 1/4"	33
					MIN. ENDPLAY = 1"	34

3 STAGE 16 CLC BOWL ASSY - W.L. - DUAL BRG.
10" FLGD. COL. - 1 11/16 SHAFT - FIRE PUMP MODEL EBA

WASHINGTON PUBLIC POWER
ORDER NO. GE-2328
NO. UNITS 1

WRITTEN K.G. CHKD. K.N.

	QUANTITY 1 UNIT	QUANTITY UNITS	PART NO.	MATERIAL	DESCRIPTION
	1		H-1974-A	C.I.	REDUCING TEE - 10"x 10" x 6" -125# F.F. (6" OUTLET)
	2			GRANITE/EQ.	GASKET - 10" - 125# FULL FACE WITH HOLES
	24			STEEL	STUDS ⅞-9 N.C. x 4½ LG. (T.F.L.)
	48			STEEL	NUTS ⅞-9 N.C. (HEX.)
	1			C.I.	BLIND FLANGE 10"-125# F.F.
	1			C.I.	RELIEF TEE - 6" x 6" x 6" -125# F.F.
	4			GRANITE	GASKET 6 - 125# FULL FACE WITH HOLES
	32			STEEL	STUDS ¾-10 N.C. x 4½ LG. (T.F.L.)
	64			STEEL	NUTS ¾-10 N.C. (HEX.)
* Ⓢ	1			C.I.	RELIEF VALVE - 6 -125# INLET AND OUTLET-
					LONERGAN MODEL RU/OR EQUAL SET AT 150 P.S.I.
	1		28726-A	C.I.	RELIEF CONE 6"x10"
*	1			C.I.	AIR RELEASE VALVE - 2"NPT - CRISPIN AIR & VACUUM
	1			STEEL	NIPPLE - 2"NPT x 4"LG. (T.B.E.)
	1			C.I.	REDUCING FLANGE - 2"NPT x 11"O.D. 6" -125# F.F.
	1		7733-C	FAB.STL.	HOSE MANIFOLD FOR 6" 2-1/2" VALVES HYDRO TEST 360 P.S.I.
	6			STEEL	NIPPLES - 2-1/2"NPT x 4" LG. (T.B.E.)
* Ⓢ	6			BRONZE	HOSE VALVES - 2-1/2"NPT. WITH CAP AND CHAIN -300# STRAIGHTWAY GATE (HOSE THREAD PER ANS B26-1925) POMPATAN NO.281 OR APPROVED EQUAL
Ⓢ	1				PRESSURE GAUGE - 3-1/2"DIAL 0-250 LB. BRASS CASE UNITED STATES GAUGE NO.P-1590 (OR APPROVED EQUAL BY ACME OR HARSH.) (TAG. FP-P1-4)
	1			GALV.STL.	NIPPLE - 1/4"NPT x 6"LG. T.B.E.
	1			GALV.	ELBOW - 1/4"NPT x 90°
	1			BRASS	TEE HANDLE GAGE COCK MARSH MODEL 34MF OR EQUAL
			*FURNISH BY RETURN MAIL ATTN. PURCH. DEPT.		
Ⓢ MUST BE AS APPROVED AND LISTED BY U.L. AND F.M.			8 CERTIFIED DIM. PRINTS, REPAIR PARTS LISTS & INSTRUCTION MANUALS		

TEX OUT

FIRE PUMP DISCHARGE FITTINGS
2000 G.P.M. MODEL EBA FIRE PUMP (UL) (FM)

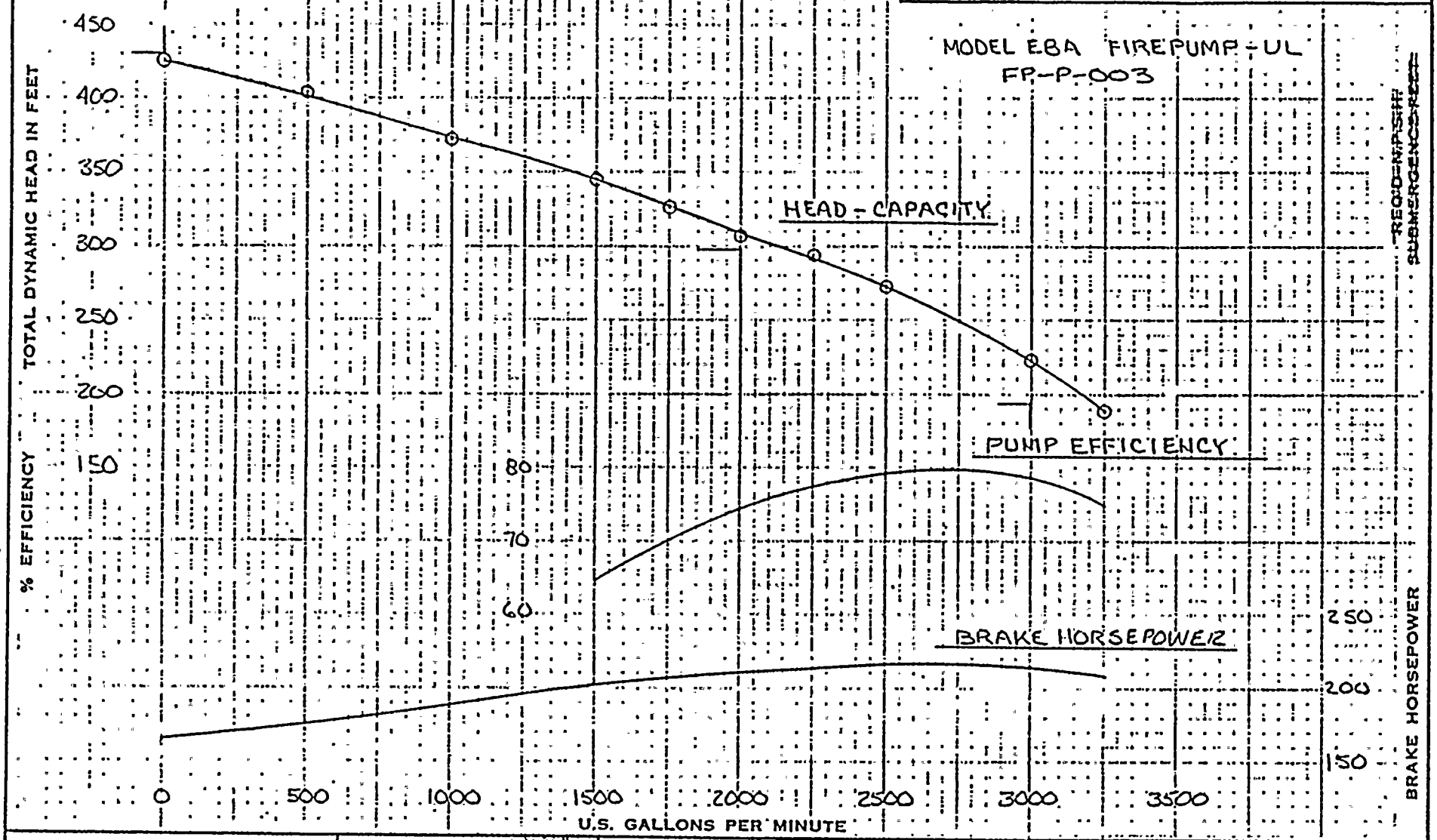
WASHINGTON PUBLIC POWER
ORDER NO. GE-2328

TC-02[illegible]5

CERTIFIED BY: J. C. Dennis DATE 9/5/74

CUSTOMER WASHINGTON PUBLIC POWER SUPPLY SYSTEM

PUMP SERIAL NUMBER GE-2328



THE CAPACITY, HEAD AND EFFICIENCY GUARANTEE IS FOR THE DESIGNATED POINT ONLY: IT IS BASED ON SHOP TESTS. WHEN HANDLING CLEAR, FRESH WATER AT A TEMPERATURE OF NOT OVER 85° F. AND UNDER SUCTION CONDITIONS AS SPECIFIED IN THE CONTRACT.

IMPELLER BRZ DIA (1) 11 7/16" (2) 11 3/8"

BOWLS C.I. - VIT

LIQUID WATER

SP. GR. 1.0

DATE 9-4-74 BY R. Hayes

JOHNSTON PUMP CO.

VERTICAL PUMPS

GLENDORA • CALIFORNIA • U.S.A.

TURBINE PUMP PERFORMANCE

3 STAGE 16CLC PUMP

1780 R.P.M.

CURVE NO. TC-02895

JP-157

DATE 8-20-13

WRITTEN R.G. , R.K.S.

QUAN. 2 PURCHASE ORDER NO. 45312 DIRECT/STOCK

REVISIONS
NO. 1 BY R.G. DATE 12-10-73

U.S. VERTICAL (~~SOLID~~) (HOLLOW) SHAFT, TYPE HV (~~NORMAL~~) (HIGH) 300% EXTRA THRUST

WITH (OUT) NON REVERSE RATCHET, DOWNTHRUST CAPACITY 14,000 LBS. ①5006PH

250 H.P. 3 PHASE 60 HERTZ 460 VOLTS 1800 RPM ~~1505PH~~ FRAME SIZE

BD 20 " NEMA (P) (~~E~~) BASE, AK 13½ AC 56~~44~~ CD 5~~8 13/32~~ CLUTCH BORE 1"/16

①55 13/16 ①49 25/32

ENCLOSURE - WEATHER PROTECTED NEMA I ~~(EXPLOSION-PROOF CLASS I. GROUP D)~~ ~~(TEFC)~~ ~~(SPLASH PROOF)~~ ~~(TENV.)~~

INSULATION TO BE CLASS 'B', S.F. 1.15, 60° C. RISE, 120 V. SPACE HEATERS

REMARKS:
ROUTINE TEST
15 YRS. MIN. LIFE BRGS.
MOTORS ARE TO BE IN ACCORDANCE WITH CUSTOMERS SPEC. SECTION 15-A (COPY ATTACHED)
① ATTACH A METAL PLATE TO MOTORS & STAMP WITH "TAG. NO. FP-P-2A" OR TAG. NO. FP-P-2B"
MOTORS TO BE IN ACCORDANCE WITH NEMA MG-1 STANDARD

SHAFT ROTATION TO BE COUNTERCLOCKWISE WHEN LOOKING DOWN ON TOP OF MOTOR
LOCK FOR 30% MOMENTARY UPTHRUST - MAXIMUM ENDPLAY - .010"

~~SOLID SHAFT~~ ONLY	MOTOR SHAFT DIMENSIONS. U _____, AH _____, NEMA STANDARD RING KEYWAY/~~KEYWAY~~ PER H-1394-A

MOTOR TO CONFORM TO FEDERAL SPEC. - CC-M-641 CLASS B AND MIL-P-13386 (CE)
PAINTING TO CONFORM TO MIL-T-704-C COLOR J.P. CO. GREEN
MOTOR SUBJECT TO INSPECTION BY (ARMY) (NAVY) (U.S.B.R.) INSPECTOR

PREORDER	PREORDER - SHIP TO _____ MAIL TO JOHNSTON PUMP CO. - ATTN. PURCHASING _____ CERTIFIED DIMENSION PRINTS FOR APPROVAL SEE SPEC FOR DATA TO BE SUBMITTED H-O-L-D F-O-R A-P-P-R-O-V-A-L

~~FURNISH BY RETURN MAIL ATTN:~~ AFTER APPROVAL JOHNSTON PUMP COMPANY PURCHASING DEPARTMENT - MARK - FOR - INSTALLATION

20 CERTIFIED DIMENSION PRINTS, REPAIR PARTS LIST AND INSTRUCTION MANUALS

①RELEASE FOR PRODUCTION PER APPROVED AS NOTED DWGS & RESUBMIT DWGS FOR FINAL APPROVAL

BUY OUT

JP-1011

FORCAST DATE _____

WASHINGTON PUBLIC POWER
ORDER NO. GE-2326-27
NO. OF UNITS 2
SHEET 1 OF 8 SHEETS

Attachment I - Set 2 of 3.

BILL OF MATERIAL

DATE [illegible] WRITTEN R.G. [illegible] R.K.S.

Q.C. CODE
B = BARS
C = CERTS.
W = WELDING CERTS.

QUANTITY 1 UNIT	QUANTITY 2 UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
①△	1	2	PO#45216		LEXINGTON FIRE PUMP CONTROLLER	1
					250 H.P. 3PH. 60 CYC. 460 VOLT 50,000 AMP	2
					INTERRUPTING CAPACITY, AUX. CONTACTS FOR MOTOR	3
					& CONTROLLER SPACE HEATERS, ALARM & SIGNAL	4
					DEVICES (LOCAL), SIGNAL DEVICES FOR REMOTE	5
					125 VOLT DC ANNUNCIATOR PER NEPA #20	6
					CONTROLLERS & SUBMITTAL DATA MUST BE IN	7
					ACCORDANCE WITH CUSTOMERS SPEC. SECTION	8
					15-A (COPY ATTACHED)	9
					① ATTACH A METAL PLATE TO CONTROLLER & STAMP WITH	10
					"TAG. NO. FP-P-2A" OR "TAG NO. FP-P-2B".	11
						12
					② FM-D40	13
①△	1	—	PO#		MERIAM MODEL ~~FM-40~~ FLOWMETER PACKAGE	14
					INCLUDING STEEL SLIPON FLANGES, ORIFICE PLATES AND	15
					MANOMETER FOR 1500 TO 4000 GPM OPERATING RANGE	16
					② TAG: ORIFICE PLATES & FLG'S WITH FE-1	17
					TAG: METER, VALVES & MANIFOLD W/ FI-1	18
						19
						20
						21
						22
						23
						24
						25
						26
						27
						28
					FURNISH BY RETURN MAIL: ATTN. PURCH. DEPT.	29
② CHANGED PER CO #3 M.G.L. 1/24-74					DATA & DWGS REQ'D BY SECT. 15-A OF SPEC.	30
~~△PRE-ORDER — HOLD FOR APPROVAL~~ ①						31
① RELEASE FOR PRODUCTION PER APPROVED AS NOTED					AFTER APPROVAL FURNISH 20 COPIES OF MATERIAL FOR	32
DRAWINGS & RESUBMIT DWGS FOR FINAL APPROVAL					OPERATING & MAINTENANCE MANUALS	33
						34

① REV. R.G. 12-10-73

LEXINGTON CONTROLLER - MERIAM FLOWMETER

WASHINGTON PUBLIC POWER
ORDER NO. GE-2326-27
NO. UNITS 2
SHEET 2 OF 2 SHEETS

Q.C. CODE
I = BARS
: = CERTS.
V = WELDING CERTS.

BILL OF MATERIAL

DATE 12-

WRITTEN R. G. K.L.

QUANTITY 1 UNIT	QUANTITY 2 UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
1	2	5314-1-C	C/B	C.I. A48 CL. 30	DISCHARGE HEAD HYDROTEST TO 360 P.S.I.	1
4	8			A307 GR. A STL.	CAP SCREWS 5/8-11 NC X 2 1/2" LG. (HEX. HD.) } DRIVER	2
4	8			A307 GR. A STL.	NUTS 5/8-11 NC (HEX.) }	3
1	2	6603-A		A479-410 S.S.	NAMEPLATE W/DRIVE SCREWS (DATA AFTER TEST)	4
1	2			C.I.	PIPE PLUG 1 1/4" N.P.T. (SQ. HD.)	5
1	2	5410-A		A479-410 S.S.	NAMEPLATE W/DRIVE SCREWS (SEE SHT. FOR INSTRUCTIONS)	6
1	2			BRASS	U.L. LABLE	7
1	2	5457-A	C	C.I. A48 CL. 30	SUB-BASE	8
4	8			A307 GR. A STL.	CAP SCREWS 3/4-10 NC X 1 3/4" LG. (HEX. HD.)	9
						10
1	2	3481-A	C/B	C.I. A48 CL. 30	PACKING BOX	11
1	2	4222-A	C	BRZ. B144-3D	PACKING BOX BEARING	12
1	2	3184-A		BRZ. B145-4A	LANTERN RING	13
1	2	3188-1-A		BRZ. B145-4A	PACKING GLAND - SPLIT	14
6	12			J.C. SS #3	PACKING RINGS 1 1/16 X 2 1/16 X 1/2	15
1	2			STL.	ALEMITE FITTING #1692 1/8 N.P.T. X 30°	16
2	4			BRASS	STUDS 3/8-16 NC X 2 1/2" LG. (T.F.L.)	17
2	4			BRASS	NUTS 3/8-16 NC (HEX.)	18
6	12			A307 GR. A STL.	CAP SCREWS 1/2-13 NC X 1 1/2" LG. (HEX. HD.)	19
1	2	1022-A		VELUMOID	GASKET	20
1	2	1075-A		RUBBER	DEFLECTOR	21
						22
1	2	2524-A	C	A582-416 S.S.	HEADSHAFT 1 1/16 X A = 9'-2 1/8" LG.	23
1	2	879-A		A108-1045 STL.	ADJUSTING NUT	24
2	4			A307 GR. A STL.	LOCKSCREWS 1/4-20 NC X 2 1/4" LG. (HEX. HD.)	25
1	2			A108-1045 STL.	KEY 3/8" SQ. X 1 7/8" LG. (UNDER HD.)	26
						27
1	2	708-3		S/M	MOTOR COOLING FITTINGS	28
						29
						30
						31
						32
						33
1	2	4271-A			ENVELOPE: H-4649-D, H-4650-D, 4J, 1038	34

20" X 10" TYPE 'A' DISCH. HEAD - W.L.
10" FLGD. COL. - 1 11/16 SHAFT - MODEL EBA FIRE PUMP

WASHINGTON PUBLIC POWER
ORDER NO. GE-2326-27
NO. UNITS 2
SHEET 1 OF 4 SHEETS

rm IP 331

Q.C. CODE
B = BARS
C = CERTS.
W = WELDING CERTS.

BILL OF MATERIAL

DATE 12-1-75

WRITTEN R.G. CHD. K.H.

QUANTITY 1 UNIT	QUANTITY UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
						1
						2
						3
						4
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						6
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SERIAL NUMBER GE-2326 OR GE-2327

R.P.M. 1770 B.H.P. 204

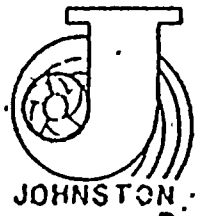
U.S.G.P.M. 2000 T.D.H. 298 FT.

SIZE & TYPE 16. CLC STAGES 3

FLUID WATER SP. GR. 1.0

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

HANFORD NO. 2 TAG. NO. FP-P-2A OR FP-P-2B



JOHNSTON PUMP CO.
GLENDORA, CALIF.

5410-A

NAMEPLATE STAMPING INSTRUCTIONS

WASHINGTON PUBLIC POWER
ORDER NO. GE-2326-27
NO. UNITS 2

Q.C. CODE
B = BARS
C = CERTS.
W = WELDING CERTS.

BILL OF MATERIAL

DATE 12-1-73

WRITTEN R. G. K.W.

QUANTITY 1 UNIT	QUANTITY 2 UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
1	2	39872-A	C	FAB. STL.	TOP COL. PIPE 10" x A= 4'-2 5/8" LG.	1
1	2	39881-A	C	FAB. STL.	BOT. COL. PIPE 10" x A= 7'-11 5/8" LG.	2
1	2	569-A		HYDROIL	TOP COL. FLG. GASKET	3
12	24			A307 GR.A STL.	CAP SCREWS 3/4-10 NC x 2" LG. (HEX. HD.) (TOP COL.)	4
12	24			A307 GR.A STL.	CAP SCREWS 3/4-10 NC x 2 3/4" LG. (HEX. HD.) (COL. TO COL.)	5
12	24			A307 GR.A STL.	NUTS 3/4-10 NC (HEX.) (COL. TO COL.)	6
12	24			A 307 GR.A STL.	CAP SCREWS 3/4-10 NC x 1 1/2" LG. (HEX. HD.) (COL. TO DISCH. CASE)	7
						8
X 1	2	21439-A	C	A108-1045 STL.	LINESHAFT 1 1/16 x A=8'-0" LG.	9
1	2	7819-A	C	A582-416 S.S.	LINESHAFT COUPLING	10
1	2	21084-A	C/B	BRZ. 8145-4A	BEARING RETAINER	11
1	2	21319-5-A		RUBBER	LINESHAFT BEARING	12
						13
1	—			A53 GR.B STL.	PIPE 10 3/4" O.D. x .279 WALL x 105" LG. (BEVEL ENDS FOR WELDING)	14
					(SHIP LOOSE FOR USE W/ FLOW TEST ASSY.)	15
COATING INSTRUCTIONS:						16
1.) SURFACES TO BE COATED WILL BE CLEANED BY SANDBLASTING PRIOR TO COATING						17
						18
2.) DISCH. HEAD & SUB BASE PAINTED WITH J.P.CO. STD. PRIMER AND GREEN ENAMEL PAINT						19
						20
3.) INSIDE & OUTSIDE OF COLUMN PIPE WILL BE COATED WITH COAL TAR EPOXY ~~16~~ MILS MIN. THICKNESS → 19 R.G. 5-3-74						21
						22
						23
						24
						25
NOTES:						26
1.) QUALITY ASSURANCE REQUIREMENTS, TESTS, CERTIFICATION OF MATL'S. & REPORTS ARE TO BE IN						27
ACCORDANCE WITH WASHINGTON PUBLIC POWER SYSTEM SPEC. DIV. 15 SECTION 15A.						28
2.) PUMP IS SUBJECT TO SOURCE INSPECTION						29
3.) TESTS WILL BE WITNESSED						30
						31
						32
HYDROTEST COLUMN TO 360 P.S.I.						33
						34

10" FLGD. COLUMN - 1 11/16 SHAFT - W.L.

MODEL EBA FIRE PUMP - COATING - NOTES

WASHINGTON PUBLIC POWER

ORDER NO. GE-2326-27

NO. UNITS 2

SHEET 5 OF 8 SHEETS

Q.C. CODE
B = BARS
C = CERTS.
W = WELDING CERTS.

BILL OF MATERIAL

DATE 12-7-10

WRITTEN R. G. K.W.

QUANTITY 1 UNIT	QUANTITY 2 UNITS	PART NO.	Q.C.	MATERIAL	DESCRIPTION	ITEM NO.
1	2	33041-A	C/B	C.I. A48 CL.30	DISCHARGE CASE	1
1	2	851-A	C	BRZ. B144-3D	DISCH. CASE BEARING	2
						3
3	6	19590-A	C/B	C.I. A48 CL.30 VIT	INTER. BOWL	4
3	6	2356-A	C	BRZ. B144-3D	INTER. BOWL BEARING	5
3	6	4822-6-A		RUBBER	INTER. BOWL BEARING	6
						7
3	6	2357-A	C/B	BRZ. B145-4A	IMPELLER FULL 12" DIA. - 3/32 T.B.F. CL. 'B'	8
3	6	4336-A	C	BRZ. B148-9C	IMPELLER SEAL RING	9
3	6	14046-A	C	A276-316 S.S.	LOCK COLLET	10
						11
1	2	19595-A	C/B	C.I. A48 CL.30 VIT	SUCTION BELL	12
1	2	851-A	C	BRZ. B144-3D	SUCT. BELL BEARING	13
1	2			C.I.	PIPE PLUG 3/4" N.P.T. (SQ. HD.)	14
1	2	10253-A		AA79-410 S.S.	BOWL SERIAL PLATE W/ DRIVE SCREWS	15
1	2	1638-A		NEOPRENE	SAND COLLAR	16
1	2	13609-A	C	A582-416 S.S.	PUMPSHAFT 2 3/16 x 1 "/16 x A = 62 1/16" LG.	17
1	2	7819-A		A582-416 S.S.	PUMPSHAFT. COUPLING	18
						19
48	96			A307 GR.A STL.	CAP SCREWS 5/8-11 NC x 1 1/2" LG. (HEX. HD.)	20
						21
1	2	39871-A	C	316 S.S.	BASKET STRAINER	22
6	12	7640-A		316 S.S.	CLIPS	23
6	12			316 S.S.	CAP SCREWS 1/4-20 NC x 3/4" LG. (HEX. HD.)	24
6	12			316 S.S.	FLAT WASHERS 1/4" BOLT SIZE	25
						26
1	—	T-134-A		STL.	LOCK COLLET HAMMER	27
						28
						29
						30
⊙ DYNAMIC BALANCE					T.P.L. = 17'-8 1/4" (BOTT. OF SUB BASE TO BOTT. OF STRAINER	31
HYDROTEST BOWLS TO 360 P.S.I.					SHAFT PROJ. ABOVE COL. SEAT = 10"	32
					" " " MOTOR SEAT = 53 3/8"	33
					MIN. ENDPLAY = 1"	34

3 STAGE 16CLC BOWL ASSY - W.L. - DUAL BRG.
10" FLGD. COL. - 1 11/16 SHAFT - FIRE PUMP MODEL EBA

WASHINGTON PUBLIC POWER
ORDER NO. GE-2326-27
NO. UNITS 2
SHEET 6 OF 8 SHEETS

WRITTEN R.G. CHKD. K.J.

QUANTITY 1 UNIT	QUANTITY 2 UNITS	PART NO.	MATERIAL	DESCRIPTION
1	2	H-1974-A	C.I.	REDUCING TEE - 10" x 10" x 6" -125# F.F. (6" OUTLET)
2	4		GRANITE/EQ.	GASKET - 10" - 125# FULL FACE WITH HOLES
24	48		STEEL	STUDS $\frac{7}{8}$"-9 N.C. x 4½ LG. (T.F.L.)
48	96		STEEL	NUTS $\frac{7}{8}$-9 N.C. (HEX.)
1	2		C.I.	BLIND FLANGE 10"-125# F.F.
1	2		C.I.	RELIEF TEE - 6" x 6" x 6" -125# F.F.
3	6		GRANITE	GASKET 6 - 125# FULL FACE WITH HOLES
24	48		STEEL	STUDS $\frac{3}{4}$-10 N.C. x 4½ LG. (T.F.L.)
48	96		STEEL	NUTS $\frac{3}{4}$-10 N.C. (HEX.)
1	2		C.I.	BLIND FLANGE 6"-125# F.F.
1	2		C.I.	AIR RELEASE VALVE - 2"NPT - CRISPIN AIR & VACUUM
1	2		STEEL	NIPPLE - 2"NPT x 4"LG. (T.B.E.)
1	2		C.I.	REDUCING FLANGE - 2"NPT x 11" O.D. 6" -125# F.F.
Ⓐ 1	2			PRESSURE GAUGE - 3-1/2"DIAL 0-250 LB. BRASS CASE
				UNITED STATES GAUGE NO.P-1590 (OR APPROVED EQUAL BY ACME OR MARSH) (TAG FP-PI-3)
1	2		GALV.STL.	NIPPLE - 1/4"NPT x 6"LG. T.B.E.
1	2		GALV.	ELBOW - 1/4"NPT x 90°
1	2		BRASS	TEE HANDLE GAGE COCK MARSH MODEL 3AMF OR EQUAL

Ⓐ MUST BE AS APPROVED AND LISTED BY U.L. AND F.M.

RM JP 911

BUY OUT

FIRE PUMP DISCHARGE FITTINGS

2000 G.P.M. MODEL EBA FIRE PUMP (UL) (FM)

WASHINGTON PUBLIC POWER

ORDER NO. GE-2326-27

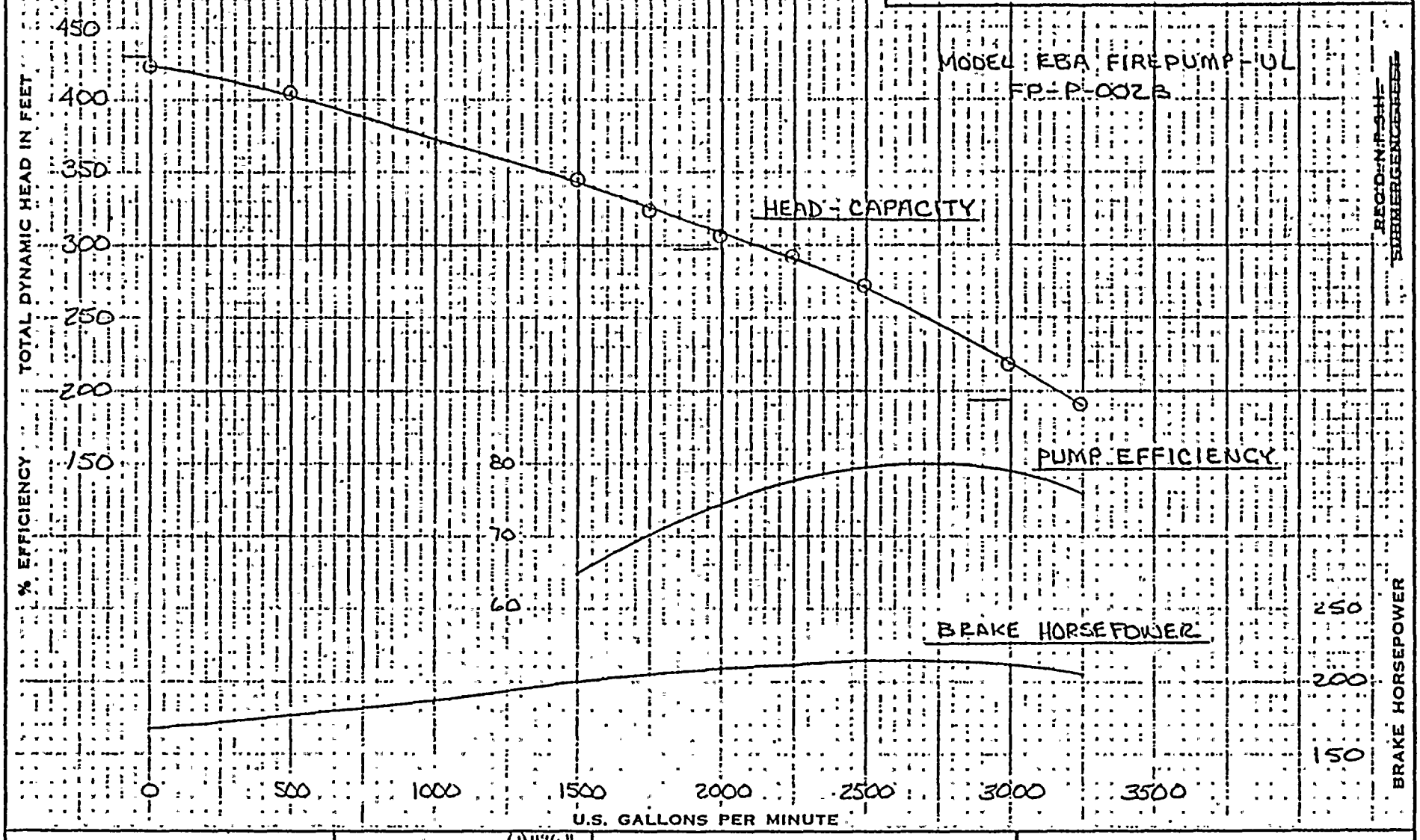
NO. UNITS 2

TC-02894

CERT. BY: J. C. Lemmon DATE 9/17/74

CUSTOMER WASHINGTON PUBLIC POWER SUPPLY SYSTEM

PUMP SERIAL NUMBER GE-2327



THE CAPACITY, HEAD AND EFFICIENCY GUARANTEE IS FOR THE DESIGNATED POINT ONLY; IT IS BASED ON SHOP TESTS, WHEN HANDLING CLEAR, FRESH WATER AT A TEMPERATURE OF NOT OVER 85° F. AND UNDER SUCTION CONDITIONS AS SPECIFIED IN THE CONTRACT.

IMPELLER BR.7 DIA (1) 11 15/16" (2) 11 7/8"

BOWLS CI-VIT

LIQUID WATER

SP. GR. 1.0

DATE 9-4-74 BY P. Mayer

JOHNSTON PUMP CO.

VERTICAL PUMPS

GLENDORA • CALIFORNIA • U. S. A.

TURBINE PUMP PERFORMANCE

3 STAGE 16CLC PUMP

1780 R.P.M.

CURVE NO. TC-02894

JP.137

QUALITY CLASS DOCUMENT

Document No. _____

"Approved As Noted For Fabrication" date: _____

Contractor may employ this APPROVED-AS-NOTED FOR FABRICATION document to control or describe work to be performed, provided he accepts the notations therein. If the Contractor does not accept the notation then this document has the status of NOT APPROVED and the Contractor shall notify Burns and Roe immediately to this effect. If the Contractor accepts the notation then the documents incorporating the notation must be resubmitted within 30 days of the date given and the "APPROVED" drawings must be distributed within 75 days of the date given above.

CARD NO	CVI NO	SHT	CVI	ISSUE	SHT	OF	DW'G SHT
02-29-00	CVI	58		1			

RECEIVED
APR 30 1975
WPPSS

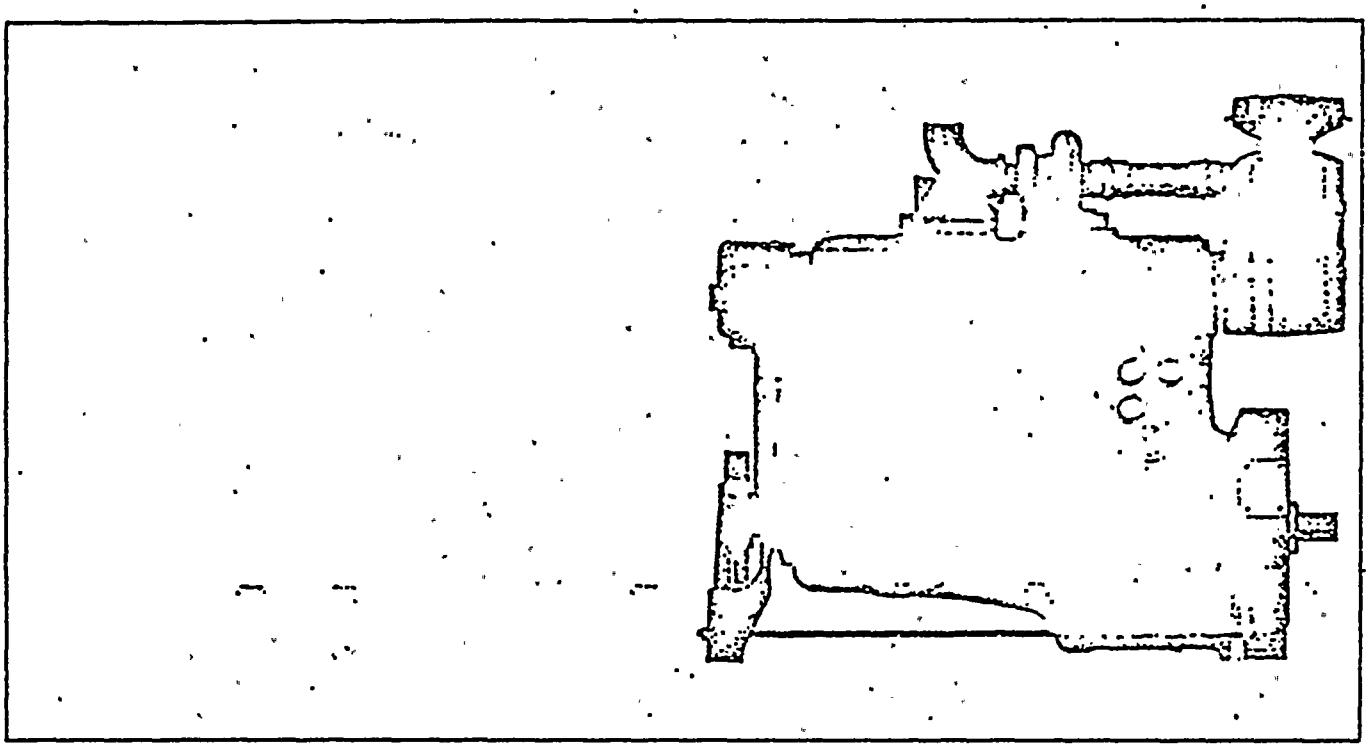
Rec = 29 00 0072
Nascip Cat. Cat

BF File 29 00 0072

CONTRACT
WASHINGTON PUBLIC POWER SUPPLY SYS. WPPSS NUCLEAR PROJECT NO. 2 W.O. 2808
BURNS AND ROE, INC. ORADELL, N.J.-HEMPSTEAD, N.Y.-LOS ANGELES, CAL.
REVIEWED AS CHECKED BELOW
☐ APPROVED FOR FABRICATION ---------- A
☐ NOT APPROVED ---------- NA
☐ APPROVED AS NOTED FOR FABRICATION ---------- AN
☒ FOR INFORMATION ONLY ---------- I
SUBJECT TO ALL CONTRACTUAL PROVISIONS THIS REVIEW DOES NOT IMPLY ACCEPTANCE OF ANY MATERIAL OR EQUIPMENT NOT FULFILLING ALL SPECIFICATION REQUIREMENTS
PROCESSED BY: BSS/EB — DATE: 4-23-75

Attachment I.
Set 3 of 3

Cummins Diesel NT-855-F1



Specifications

Number of Cylinders	6
Bore and Stroke—in. (mm)	5½ x 6 (140 x 152)
Piston Displacement—cu. in. (liters	855 (14.02)
Operating Cycles	4
Lube System Oil Cap.—U.S. gals (liters)	8 (30.3)
Engine Coolant Capacity—U.S. gals (liters)	9.5 (36)
Net Weight with Std. Accessories (lbs., dry)	3150 (1429 Kg.)

Specific ratings are shown on rear page.

Listed under Underwriters' Laboratories, Inc., reexamination service for fire protection applications.

Listed by Associated Factory Mutual Fire Insurance Companies for fire protection applications.

Listed under Underwriters' Laboratories of Canada label service for fire protection applications.

Design Features

Bearings: Precision type, steel backed inserts. 7 main bearings, 4½" (114mm) diameter. Connecting Rod — 3⅛" (83mm) diameter.

Camshaft: Single camshaft controls all valve and injector movement. Induction hardened alloy steel with gear drive.

Camshaft Followers: Roller type for long cam and follower life.

Connecting Rods: Drop forged, 12" (305mm) center to center length. Rifle drilled for pressure lubrication of piston pin. Taper piston pin end reduces unit pressures.

Cooler, Lubricating Oil: Tubular type, jacket water cooled.

Crankshaft: High tensile strength steel forging. Bearing journals are induction hardened. Fully counterweighted.

Cylinder Block: Alloy cast iron with removable, wet liners.

Cylinder Heads: Each head serves two cylinders. Drilled fuel supply and return lines. Corrosion resistant inserts on intake and exhaust valve seats.

Fuel System: Cummins PTR Fuel system with integral, flyball type, mechanical variable speed governor. Camshaft actuated injectors.

Gear Train: Heavy duty, located at front of cylinder block.

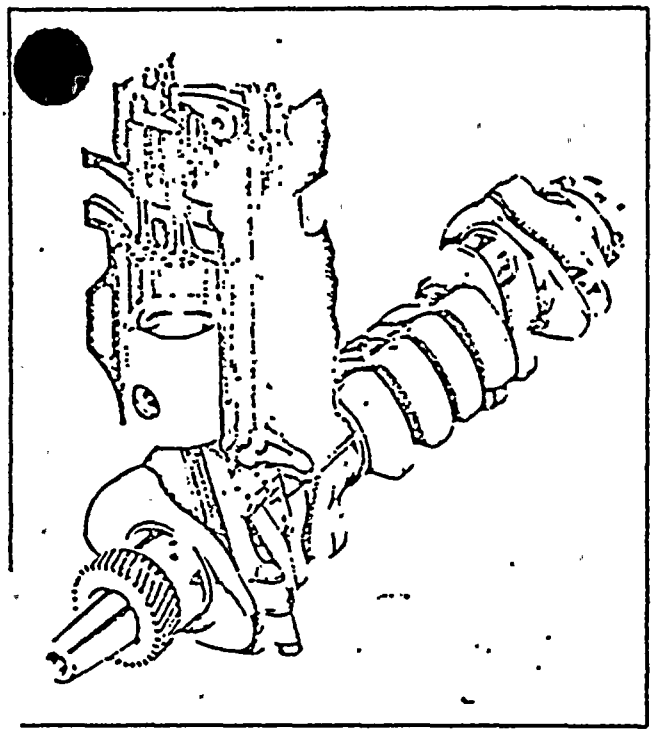
Lubrication: Force feed to all bearings, gear type pump. All lubrication lines are drilled passages except pan to pump suction line.

Pistons: Aluminum, cam ground. Oil cooled.

Piston Pins: 2" (51mm) diameter, full floating.

Turbocharger: Cummins, T-50, top mounted.

Valves: Dual intake and exhaust each cylinder. Each valve 1⅞" (47mm) diameter. Heat and corrosion resistant face on exhaust valve.



Big Displacement Design Features

1 Internal Fuel Lines: Drilled passages in cylinder h[illegible] eliminate threaded fuel line connectors and e[illegible]l lines.

2 Large Intake and Exhaust Passages: Minimize restriction of air and exhaust flow. Allows maximum air charge for clean burning, top economy.

3 Overhead Valves: Precision machined from high strength alloy steel. Intake valves are of silichrome steel. Exhaust valves of big displacement models are nitrogen steel for high temperature strength and faced with corrosion resistant material.

4 Open Type Combustion Chamber: Gives most efficient combustion . . . most power from each gallon of fuel.

5 Replaceable Wet-type Cylinder Liners: Dissipate heat faster. Liners are easily replaced without reboring block.

6 Conventional Push Rod and Rocker Lever Arrangement: Activates valves and injectors from a single camshaft. Roller type camshaft followers are used for long life.

7 Cam-ground Pistons: Assure perfect fit at operating temperatures.

8 Alloy Cast Iron Cylinder Block: Follows proven design and material specification to achieve maximum durability.

9 Large Volume Water Passages: Give even flow of coolant around cylinder liners, valves, and injectors to draw excess heat from combustion chamber. Centrifugal pump circulates large volumes of water.

10 [illegible]cting Rods: Forged from high tensile strength [illegible] steel. I-beam section gives maximum strength. Large diameter piston pins are full-floating. Tapered piston pin end used for superior load distribution and maximum crown material on piston.

11 Counterweighted Crankshafts: Precision machined from high tensile strength steel forgings. Bearing journals are induction hardened for long life.

LISTED AGENCY RATINGS

Underwriters' Laboratories:
255 HP @ 1750 RPM
255 HP @ 1900 RPM
255 HP @ 2100 RPM

Factory Mutual:
255 HP @ 1750 RPM
255 HP @ 1900 RPM
255 HP @ 2100 RPM

Underwriters' Laboratories of Canada:
255 HP @ 1750 RPM
255 HP @ 1900 RPM
255 HP @ 1900 RPM

The agency-approved horsepower ratings shown are already derated for fire pump service and available for driving the fire pump at sea level altitude (29.92 in. Hg and 60° F. intake air temperature. The only additional deration necessary is for higher ambient temperatures and elevations as follows: 3% for each 1000 feet above sea level and 1% for each 10 degrees above 60° F. in accordance with National Fire Protection Association Pamphlet No. 20.

Installation Considerations

Maximum raw water pressure must not exceed 65 PSI. Minimum acceptable raw water flow at 70° F. raw water temperature and 100° F. ambient air temperature should be at least 40 G.P.M. at the 2100 RPM listed rating.

Ventilation air required for engine combustion is 830 CFM at 2100 RPM rating. This is for engine air combustion only and does not take into consideration additional air required for normal room cooling.

CUMMINS SERVICE & SALES, INC.
1661 McGARRY STREET
LOS ANGELES, CA. 90021
(213) 746-3850

Cummins Engine Company, Inc., Columbus, Indiana 47201
Cummins Americas, Inc., Columbus, Indiana, U.S.A.
Cummins Diesel Australia, Ringwood, Australia
Cummins Diesel International Ltd.
Cummins Engine Company Ltd., London, England

Standard Equipment

Cleaner, Air: 16" (406mm) diameter, oil bath type, mounted.

Cooler, Lubricating Oil: Tubular type, jacket water cooled.

Corrosion Resister: Fleetguard, mounted, checks rust and corrosion, controls acidity, and removes impurities from coolant.

Damper, Vibration: Viscous type.

Electrical Equipment: 24 volt negative ground system. 24 volt starting motor; 24 volt, 20 ampere alternator; voltage regulator; manually operable contacters; junction box with enclosed terminal strip.

Exchanger, Heat: Tubular type, mounted.

Filters: Fleetguard. Lubricating oil, full flow replaceable paper element, mounted. Fuel, paper element throwaway type, mounted.

Flywheel: Machined for stub shaft mounting.

Governor: Mechanical flyball, mechanical variable speed type.

Guard, Belt and Damper Shield: Protection from alternator, accessory drive, and water pump belts and vibration damper.

Housing, Flywheel: SAE No. 1 with industrial supports.

Manifold, Exhaust: Water cooled.

Oil Pressure Switch: Provides signal to activate alarm (not included) for low oil pressure.

Outlet, Exhaust: 5" (127mm) diameter, 90° elbow.

Overspeed Switch: Mounted, overspeed shutdown with manual reset, stop crank contacts.

Pan, Oil: Cast aluminum, rear sump type, 7 U.S. gallon (26.5 liter) capacity. Provision for oil heater.

Panel, Instrument: Mounted. Includes ammeter, combination tachometer and hourmeter, water temperature gauge, lubricating oil pressure gauge.

Pump, Coolant: Belt driven, centrifugal type.

Stubshaft: Mounted on flywheel.

Support, Engine: Pedestal type, front and rear.

Throttle Control: Hydraulic type with vernier override.

Water Temperature Switch: Provides signal to activate alarm (not included) for high water temperature.

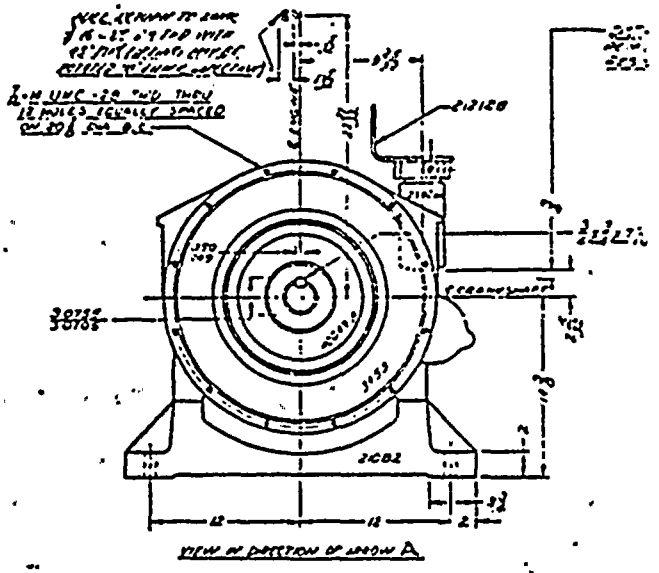
Optional Equipment

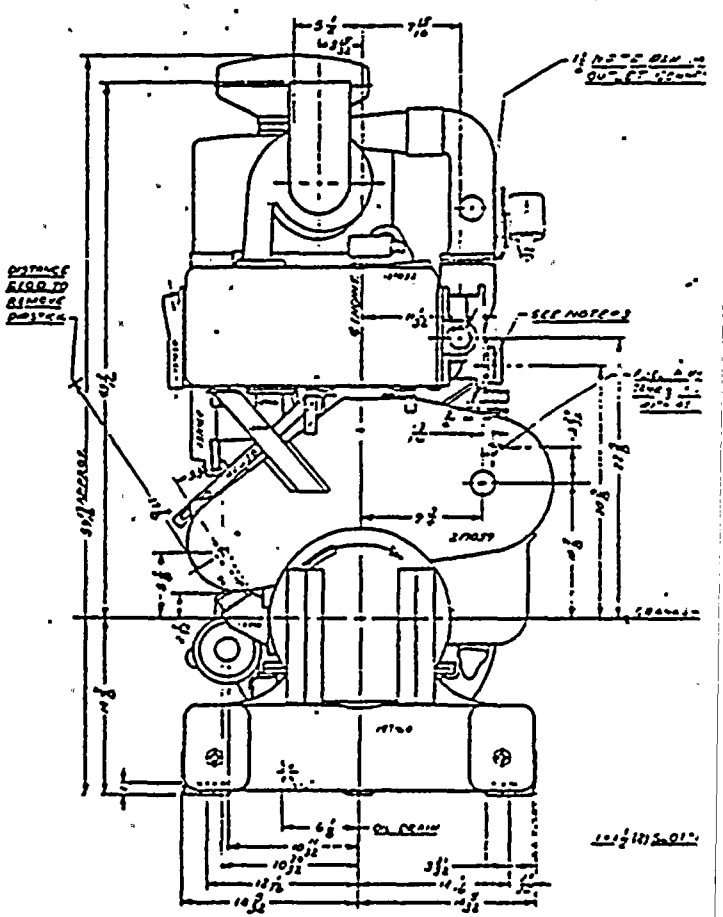
Heat Exchanger Tube Bundles: Element of copper nickel material.

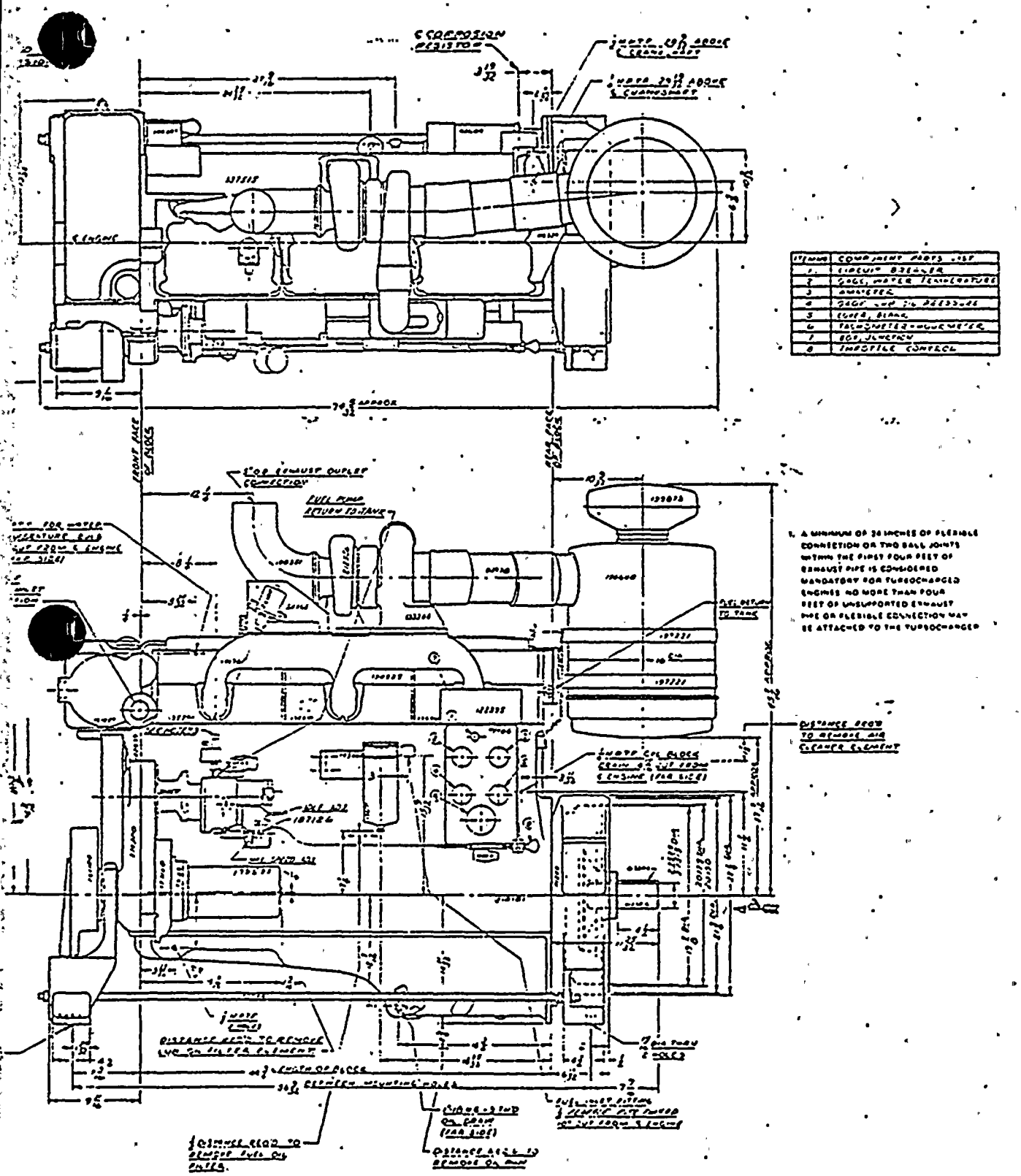
Left Hand Rotation: Counter clockwise rotation when viewing engine from front end.

Oil Heater: Mounted in side of oil pan.

Water Jacket Heater: Mounts on right side of engine (mandatory).







ITEM	COMPONENT PARTS LIST
1	CIRCUIT BREAKER
2	COOLANT WATER TEMPERATURE
3	AMMETER
4	GAGE, LUB OIL PRESSURE
5	LIGHT, PANEL
6	TACHOMETER-HOURMETER
7	BOX, JUNCTION
8	THROTTLE CONTROL

1. A MINIMUM OF 24 INCHES OF FLEXIBLE CONNECTION OR TWO BALL JOINTS WITHIN THE FIRST FOUR FEET OF EXHAUST PIPE IS CONSIDERED MANDATORY FOR TURBOCHARGED ENGINES. NO MORE THAN FOUR FEET OF UNSUPPORTED EXHAUST PIPE OR FLEXIBLE CONNECTION MAY BE ATTACHED TO THE TURBOCHARGER

NT-855-F1 Engine Installation Diagram 200359

Information about Silicone RTV Foam

DOW CORNING

DESCRIPTION

Dow Corning® 3-6548 silicone RTV foam is a medium-density, two-part product supplied as A and B liquid components. The A component is black and the B component is off-white for easy identification and inspection of mix. When the A and B components are thoroughly mixed in a 1:1 ratio by either weight or volume, the product will expand and cure to a foamed elastomer at room temperature in 1-3 mintues. Only a mild exotherm of 36 F (20 C) maximum internal temperature rise is exhibited during the curing reaction.

PATENT POSITION

A method of preparing foam by mixing Part A and Part B of Dow Corning® 3-6548 silicone RTV foam and the foams produced thereby are claimed in Dow Corning's U.S. Patent No. 3,923,705. Dow Corning intends to enforce that patent, but will offer licenses thereunder. If a license is needed, Dow Corning will ship the products in containers which bear a label license and the invoice will include a statement of the royalty due. Alternatively, upon written request Dow Corning will offer a license agreement at a comparable royalty rate under which the licensee may handle his own accounting of royalties due, regardless of the source of material.

USES

Dow Corning 3-6548 silicone RTV foam is specially formulated to have improved fire resistance properties. As a result, it is ideal for preparing fire resistant penetration seals. The suitability of Dow Corning 3-6548 silicone RTV foam for wall and floor penetration seals, is evidenced by the results of Fire Endurance Testing as defined in

DOW CORNING® 3-6548 SILICONE RTV FOAM

Type	Two-component silicone
Physical Form, as supplied	Thin liquid
as cured	Flexible foam
Special Properties	Cures at room temperature; reversion resistant; non-corrosive; improved fire resistance
Primary Uses	To prepare fire resistant penetration seals.

TYPICAL PROPERTIES

These values are not intended for use in preparing specifications.

As Supplied

Part A — Physical

CTM 0176	Appearance	Black, liquid
CTM 0097	Specific Gravity at 77 F (25 C)	1.05
CTM 0050	Viscosity, Brookfield Model HAF spindle No. 3 at 10 rpm, poises	45
CTM 0006	Flash Point, degrees	470 F (243 C)
CTM 0006	Fire Point, degrees	> 650 F (>344 C)
CTM 0787	Sulfur Content, ppm	<2
CTM 0787	Chlorine Content, ppm	<4
CTM 0787	Bromine Content, ppm	<5
CTM 0787	Iodine Content, ppm	<6

Part A — Electrical[1]

CTM 0149	Dielectric Strength, volts/mil	680
CTM 0210	Dielectric Constant, 100 Hz	3.08
CTM 0210	Dissipation Factor, 100 Hz	0.00103
CTM 0272	Volume Resistivity, 500 volts DC, ohm-cm	3.23×10^{12}

As Supplied

Part B — Physical

CTM 0176	Appearance	Off-white liquid
CTM 0097	Specific Gravity at 77 F (25 C)	1.05
CTM 0050	Viscosity, Brookfield Model HAF spindle No. 3 at 10 rpms, poises	60
CTM 0006	Flash Point, degrees	270 F (133 C)
CTM 0006	Fire Point, degrees	390 F (199 C)
CTM 0787	Sulfur Content, ppm	<2
CTM 0787	Chlorine Content, ppm	<4
CTM 0787	Bromine Content, ppm	<5
CTM 0787	Iodine Content, ppm	<6

Part B — Electrical[1]

CTM 0149	Dielectric Strength, volts/mil	900
CTM 0210	Dielectric Constant, 100 Hz	3.29
CTM 0210	Dissipation Factor, 100 Hz	0.0034
CTM 0272	Volume Resistivity, 500 volts DC, ohm-cm	$3.38 \times 1^{\prime}$

TYPICAL PROPERTIES — Continued

As Cured — Physical[2]

CTM 0176	Appearance	Dark grey — black elastomeric foam
CTM 092A	Snap Time[3], minutes	1.5
CTM 0812	Density[4], lbs/ft³	17
CTM 0826	Cell Structure[5], closed cell, percent	>50
CTM 0137A	Tensile Strength, psi	33.0
CTM 0243	Lap Shear (Cohesive) Tensile Strength, psi	35.0
CTM 0293	Peel Strength (180° Cohesive), ppi	2.0
CTM 0525	Compression Deflection, psi	
	at 20% compression	5.2
	at 40% compression	10.1
	at 60% compression	21.2
CTM 0544	Specific Heat, cal/gm °C	
	25°C	0.328
	50°C	0.336
	75°C	0.345
	100°C	0.353
	125°C	0.361
	150°C	0.370
CTM 0224	Thermal Conductivity[6], cal cm/sec sq cm °C	1.8×10^{-4}
CTM 0740	K Factor, 17 lb/cu ft foam, BTU—in/hr-ft²-°F	0.542
CTM 0585	Linear Coefficient of Thermal Expansion, (-25 to 150 C), cm/cm °C	3.2×10^{-4}
CTM 0585	Volume Coefficient of Thermal Expansion, (-25 to 150 C), cu cm/cu cm °C	9.6×10^{-4}

CTM 0316A Flammability[7], vertical burn:

Time In Flame, seconds	*Average Time To Flame-Glow Out, seconds*	*Average Weight Loss, percent*
15	7.2	1.3
60	15.6	13.5

CTM 0780	Limiting Oxygen Index, LOI rating	35

As Cured — Electrical[8]

CTM 0114	Dielectric Strength, volts/mil	165
CTM 0112	Dielectric Constant, 100 Hz	1.95
CTM 0112	Dissipation Factor, 100 Hz	0.00505
CTM 0249	Volume Resistivity, ohm-cm	2.24×10^{15}

CTM 0525 Radiation Resistance:

Exposure, megarads	*Modulus at 10% Compression, psi*
0	0.628
6	0.672
22	0.92
49	2.00
124	2.32
—	Still resilient

[1]50 mils liquid.
[2]One part A thoroughly mixed with one part B and cured at 77 F (25 C) for 24 hrs.
[3]Time to non-pour condition. Also time to begin foam rise.
[4]Power mixed for 30 seconds and cured in non-confined condition.
[5]Breathability method.
[6]Cenco fitch method.
[7]Tests, claims, representations, and descriptions regarding flammability are based on standard small scale laboratory tests. Such tests are not reliable for determining, evaluating, predicting, or describing the flammability or burning characteristics of the product under actual fire conditions, whether the product is used alone or in combination with other products.
[8]Cured foam sample thickness — 125 mils.

Specification Writers: Please contact Dow Corning Corporation, Midland, Michigan, before writing specifications on this product.

ASTM E 119-73 (standard for fire tests of building contruction and materials).The material successfully withstood three hours of fire exposure. The testing was conducted at the National Gypsum Company and witnessed by a representative of the Factory Mutual Research Corporation. A formal report is available by requesting Factory Mutual Report No. 26543 from Dow Corning Corporation.

Dow Corning 3-6548 silicone RTV foam is a UL classified material for use in fire rated penetration seals. It also has been assigned a Flame Spread Rating of 20 when tested in accordance with the provisions of ASTM Designation E-84-76a, "Standard Method of Test for Surface Burning Characteristics of Building Materials". Details of these tests are similarly available from Dow Corning Corporation.

It should be specifically noted that *not all* silicone foams have improved fire resistant properties. The use of the generic term "Silicone Foam" should be avoided when referencing this product or data. This test data is valid only to this product by its specific name and number designation, namely Dow Corning 3-6548 silicone RTV foam.

Dow Corning 3-6548 silicone RTV foam has demonstrated utility in a variety of other applications that require sealability, improved fire resistance, insulation against heat and cold, and relatively low toxicity.* It is particularly useful where stability at higher and lower temperatures is required. A list of application requirements, and the related pertinent properties for which data are or will be available on Dow Corning 3-6548 silicone RTV foam, is given in the table entitled "Typical Application and Property Requirements of Dow Corning Silicone RTV Foam."

*The hazardous decomposition products evolved from extreme heat or burning of this product are SiO_2, CO_2, and traces of incompletely burned carbon products.

TYPICAL APPLICATION AND PROPERTY REQUIREMENTS OF DOW CORNING SILICONE RTV FOAM

Application Requirement	*Related Property*
Sealability	Closed cell structure; Expansion ratio during cure
Insulation against hot and cold	Thermal conductivity; K factor
High-temperature stability	Thermal aging; Reversion resistance
Low-temperature stability	Stiffening temperature
Flame retardancy (cured foam)	Vertical burn; Limiting oxygen index
Flammability of liquid components	Flash point; Fire point
Toxicity	Toxicity of by-products; Toxicity of product
Nuclear applications	Radiation resistance; Halogen content

HOW TO USE†

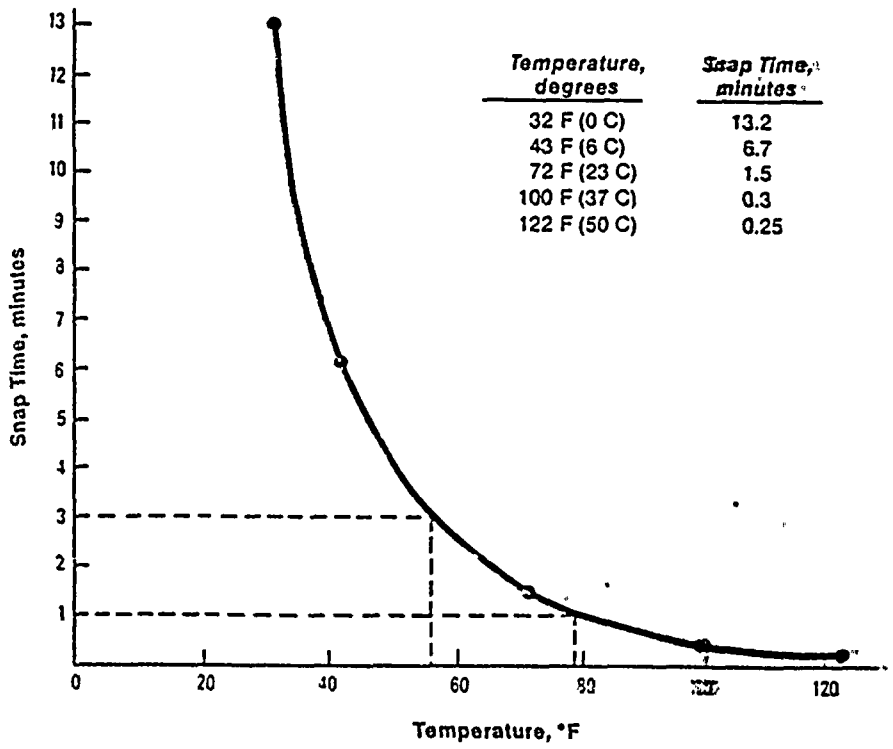
Mixing

Upon standing, some filler may settle to the bottom of the A and the B component containers. To insure a uniform product mix, the material in the A and B containers should be thoroughly mixed prior to use.

To properly catalyze Dow Corning [redacted] silicone RTV foam, add an equal quantity of Part A with an equal quantity of Part B by either weight or volume. For batch mixing, by hand or power mix, vigorous and thorough mixing should be maintained for 30 to 60 seconds. The mixed product should then be quickly transferred and poured into the desired application site. For larger volume applications, the use of suitable automatic mixing, metering, and dispensing equipment is recommended.

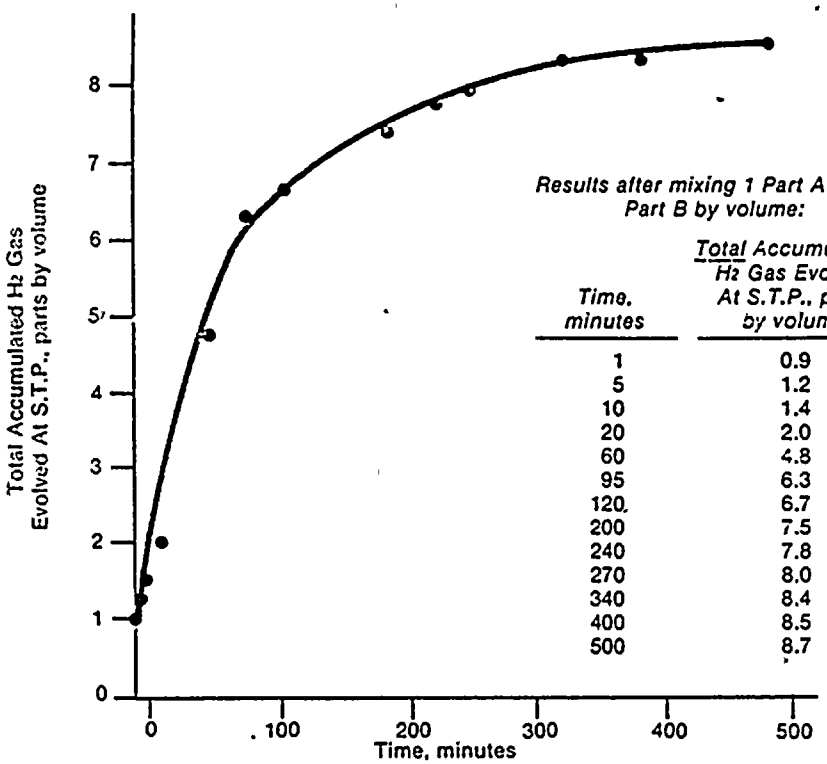
†Use of the components A and B and/or the methods disclosed in this data sheet may require a license from Dow Corning Corporation under U.S. Patent 3,923,705.

FIGURE I: SNAP TIME VS. TEMPERATURE AFTER MIXING



Temperature, degrees	*Snap Time, minutes*
32 F (0 C)	13.2
43 F (6 C)	6.7
72 F (23 C)	1.5
100 F (37 C)	0.3
122 F (50 C)	0.25

FIGURE II: HYDROGEN EVOLUTION



Results after mixing 1 Part A with 1 Part B by volume:

Time, minutes	*Total Accumulated H_2 Gas Evolved At S.T.P., parts by volume*
1	0.9
5	1.2
10	1.4
20	2.0
60	4.8
95	6.3
120	6.7
200	7.5
240	7.8
270	8.0
340	8.4
400	8.5
500	8.7

The type or degree of mixing can significantly affect the cell structure and density of the final foam product. The introduction of air during the mixing action is desirable to obtain a more uniform cell structure, maximum expansion ratio and volume efficiency. Typical batch hand mixing will generally result in a foam density of about 20 lbs/ft³. Batch power mixing will generally result in a density of about 17 lbs/ft³. Automatic mixing, metering and dispensing equipment, with introduction of auxiliary air into the mix, can result in foam densities as low as 15 lbs/ft³. Likewise, the expansion ratios of foam volume to liquid volume can vary from 2.5:1 to 4:1 depending on the type and degree of mixing. When cured under significant confinement and restriction, foam densities packed as high as 30 lbs/ft³ can result.

Cure Rate

As supplied and properly mixed, Dow Corning 3-6548 silicone RTV foam has a snap time, or working time, of 1-2 minutes at 77 F (25 C) and 50 percent relative humidity. A typical snap time would be about 1½ minutes. The cure rate or snap time is very dependent upon the temperature of the A and B components after they are mixed. As shown in Figure I, temperatures lower than 72 F (23 C) will result in significantly longer cure rates, while temperatures higher than 72 F (23 C) will result in significantly shorter cure rates. Snap times faster than 1 minute and longer than 3 minutes can result in a less uniform foam cell structure and a lower expansion ratio.

Repairability

Once cured in place, Dow Corning 3-6548 silicone RTV foam can be removed with relative ease, repairs or changes made, and the repaired area refoamed in place with additional product. Since this product develops good adhesion to itself, the repaired region will become an integral part of the original foam.

Adhesion

Upon curing, Dow Corning 3-6548 silicone RTV foam exhibits good adhesion to most common substrates. Substrates to which good adhesion is not normally obtained include Teflon,* polyethylene, polypropylene, and related materials. Adhesion to most substrates can be improved with the use of Dow Corning® 1200 RTV

*"Teflon" is a registered trademark of E.I. DuPont de Nemours.

prime coat. Good adhesion cannot be expected to substrates known to inhibit the cure of Dow Corning 3-6548 silicone RTV foam.

CAUTION

Dow Corning 1200 RTV prime coat is flammable. Keep away from heat and open flame. Use only with adequate ventilation.

Inhibition of Cure

Certain materials, chemicals, curing agents, and plasticizers can inhibit the cure of Dow Corning 3-6548 silicone RTV foam. The most notable include:

- Organo-tin and other organo-metallic compounds
- Silicone rubber containing organo-tin catalyst
- Sulfur, polysulfides, polysulfones and other sulfur-containing materials
- Amines, urethanes, and amine containing materials
- Unsaturated hydrocarbon plasticizers

If a substrate or material is questionable with respect to causing potential inhibition of cure, it is recommended that a small scale compatibility test be run to ascertain suitability in a given application. The presence of liquid or uncured product at the interface between the questionable substrate and the cured Dow Corning 3-6548 silicone RTV foam, would indicate incompatibility and inhibition of cure.

Gas Evolution

Immediately upon mixing the A and B components of Dow Corning 3-6548 silicone RTV foam, a cure reaction takes place that results in the evolution of hydrogen gas. The product then cures to an elastomer in the presence of the evolved gas resulting in a solid, flexible, elastomeric foam. Since the foam is greater than 50 percent closed cell, the gas is not immediately released to the surrounding atmosphere, but instead is released over a period of time by diffusion. The total volume of gas is essentially generated during the first three minutes after the A and B components are mixed together. Since the foam has a closed cell structure, the gas is initially retained and then released as shown in Figure II. Figure II shows that one part by volume of part A mixed with one part by volume of Part B will release 8.7 parts by volume of hydrogen gas at S.T.P. during the first 8 hours. More than one half of the total gas evolution is released from the foam during the first hour subsequent to mixing the A and B components. For estimation purposes, the following formula can be used to calculate the total volume of hydrogen gas released from a given weight of the liquid components: (0.066 (pounds of Part A + pounds of Part B) = cubic feet of hydrogen gas released at S.T.P.

On this basis the explosive limit of hydrogen gas in air (4 percent by volume) would be approached only if the total gas from one pound of the liquid mixture were totally confined within approximately two cubic feet of air. Wherever this degree of air volume restraint exists, adequate ventilation should be provided to prevent localized buildup of gas, and appropriate caution should be exercised.

CAUTION

Immediately upon mixing the A and B components of Dow Corning 3-6548 silicone RTV foam, a cure reaction takes place that results in the evolution of hydrogen gas. Appropriate caution should be exercised. Keep away from sparks and flame. Adequate ventilation should be provided to prevent localized buildup of gas.

TOXICOLOGICAL INFORMATION

Toxicological studies indicate Dow Corning 3-6548 silicone RTV foam has an acute oral ALD_{50} of 15 gm/kg body weight in albino rats. This value indicates no significant hazard pertaining to ingestion of amounts incidental to industrial handling.

Eye irritation studies suggest that this material does not cause significant

irritation. These results indicate hazard to the eyes is probably nil. Minimal eye protection should be adequate for industrial handling purposes.

Additionally, prolonged or repeated skin contact should not produce irritation. There is no evidence that Dow Corning 3-6548 silicone RTV foam is absorbed through the skin in acutely toxic amounts. No special handling precautions appear necessary to use this material safely.

Note: Comprehensive data concerning the nature of toxicity of gases from burning or smoldering Dow Corning 3-6548 silicone RTV foam is not available. However, it is known that the major decomposition byproducts are SiO_2, CO_2, CO, N_2 and some incompletely burned hydrocarbons.

SHIPPING LIMITATIONS

None.

STORAGE AND SHELF LIFE

Dow Corning 3-6548 silicone RTV foam should be stored in closed containers at or below 90 F (32 C). When stored in the original unopened containers at this temperature, the shelf life is 12 months from date of shipment. Storage at temperatures lower than 90 F (32 C) will lengthen the useful life.

Prior to use, after standing longer than one day, the liquid components (both Part A and Part B) should be thoroughly stirred to uniformly redisperse any fillers or pigments that may have settled.

PACKAGING

Dow Corning 3-6548 silicone RTV foam is packaged in 100- and 900-lb (45- and 409-kg) kits, net weight.

USERS PLEASE READ

The information and data contained herein are believed to be accurate and reliable; however, it is the user's responsibility to determine suitability of use. Since Dow Corning cannot know all of the uses to which its products may be put or the conditions of use, it makes no warranties concerning the fitness or suitability of its products for a particular use or purpose.

You should thoroughly test any proposed use of our products and independently conclude satisfactory performance in your application. Likewise, if the manner in which our products are used requires governmental approval or clearance, you must obtain it.

Dow Corning warrants only that its products will meet its specifications. There is no warranty of merchantability of fitness for use, nor any other express or implied warranties. The user's exclusive remedy and Dow Corning's sole liability is limited to refund of the purchase price or replacement of any product shown to be otherwise than as warranted. Dow Corning will not be liable for consequential damages of any kind.

Suggestions of uses should not be taken as inducements to infringe any patents.

The information and data contained herein are based on information we believe reliable. You should thoroughly test any application, and independently conclude satisfactory performance before commercialization. Suggestions of uses should not be taken as inducements to infringe any particular patent.

DOW CORNING CORPORATION, MIDLAND, MICHIGAN 48640

Atlanta Boston Brussels Chicago Cleveland Dallas Detroit Greensboro
Los Angeles New York San Francisco Sydney Tokyo Toronto

DOW CORNING

DOW CORNING

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Printed in U.S.A.

Form No. 61-3208-77

517-496-4664

Application Guide Specifications

DOW CORNING® 3-6548 SILICONE RTV FOAM PENETRATION SEAL SYSTEM

PATENT POSITION

A method of preparing foam by mixing Part A and Part B of Dow Corning® 3-6548 silicone RTV foam and the foams produced thereby are claimed in Dow Corning's U.S. Patent No. 3,923,705. Dow Corning intends to enforce that patent, but will offer licenses thereunder. If a license is needed, Dow Corning will ship the products in containers which bear a label license and the invoice will include a statement of the royalty due. Alternatively, upon written request Dow Corning will offer a license agreement at a comparable royalty rate under which the licensee may handle his own accounting of royalties due, regardless of the source of material.

GENERAL

The following application guide specification is provided for the convenience of the architect/specifier.

It is recommended that the detailed penetration seal system be specified with the penetration seal system installer under a separate document.

1.0 SCOPE

1.1 This specification guide covers the application of Dow Corning 3-6548 silicone RTV foam in penetration seal systems for new building constructions or in sealing and upgrading the capabilities of older existing building structures.

The key items in this guide shall be incorporated in the detailed specification covering application and quality control procedures of the selected penetration seal system installer. Any substantial deviations from this specification guide shall be referred to the manufacturer or its representative.

2.0 MATERIALS/PRODUCTS

2.1 Materials shall be manufactured and supplied by, or as supplied by Dow Corning Corporation, Midland, Michigan 48640, its authorized distributor, applicator, or other approved source, and shall include the following:

2.1.1 Dow Corning 3-6548 silicone RTV foam — Penetration fill material — comprising liquid component Part A (Black) and liquid component Part B (off-white).

2.1.2 Dow Corning® 96-081 RTV silicone adhesive sealant — caulking for small cracks and adhesive for flexible boot lap-seals.

2.1.3 Mineral fiber board, mineral fiber matting, and mineral fiber putty — forming and damming materials used to contain the liquid 3-6548 mixture prior to and during foam-filling penetrations — fire tested and functionally approved forming materials can be left in place to become an integral part of the foamed penetration seal.

2.1.4 Plywood sheet, particle board, or other combustible forming materials — forming and damming materials used for containment during foaming only and *must be removed* from the final completed penetration seal system.

3.0 DELIVERY AND STORAGE

3.1 Materials shall be delivered in their original, tightly sealed containers or unopened packages, all clearly labeled with the manufacturers name, product identification, and lot numbers where appropriate.

3.2 Dow Corning 3-6548 silicone RTV foam shall be delivered in two component kits containing a Part A and Part B component in each kit.

3.3 Materials shall be stored out of the weather, in their original, tightly sealed containers, or unopened packages, as recommended by the manufacturer.

4.0 CONTRACTOR

4.1 Foam and damming shall both be applied by a competent contractor or applicator.

4.2 Contractor or applicator shall be responsible for selecting and supplying all labor and supervision as well as furnishing all materials required to complete the job satisfactorily in accordance with the written specifications.

5.0 PREPARATION AND DAMMING

5.1 See Architectural Details Section for typical floor and wall penetration seal systems.

5.2 Penetration seal preparations shall include use of the procedures, techniques and quality control standards listed in the specification.

5.3 Preparation shall include but not be limited to:

5.3.1 Removing all incidental combustible materials and loose impediment from the penetration opening and involved surfaces.

5.3.2 Removal of free liquids or oil from all involved surfaces and penetration components.

5.3.3 Installation of the specified damming materials to accomadate and insure the proper thickness/fire rating requirements and provide containment during foaming.

5.3.4 Removal of all combustible damming materials or materials not intended for the final foam penetration seal system.

6.0 PRIMING

6.1 Priming of surfaces and penetrating components is usually not required since the 3-6548 foam develops considerable compression and forms a tight mechanical seal when properly installed.

7.0 FOAM MIXING AND DISPENSING EQUIPMENT USE

7.1 Material may be hand mixed so as to conform to the 4 step quality control procedure listed in Table I.

7.2 Specific equipment handling and operating procedures shall be as specified in the foam applicators quality control and operating procedures manual. These procedures shall include but not be limited to:

7.2.1 Dow Corning 3-6548 silicone RTV foam Part A and Part B shall be used as supplied by the manufacturer. Outside ingredients should not be added unless their specific mixture has been qualified with appropriate testing.

7.2.2 Prior to use, containers of Dow Corning 3-6548 silicone RTV foam Part A and Part B, shall be thoroughly agitated by stirring or recirculation in order to redisperse any solid filler or pigment that may have settled during storage or after standing longer than four hours.

7.2.3 The Part A and Part B liquid components of 3-6548 foam shall be thoroughly blended in a one to one ratio by either weight or volume.

7.2.4 Automatic mixing and dispensing equipment shall be checked a minimum of once daily (prior to start up) to ensure a proper ratio balance and thorough mixing.

7.2.5 A four step, in-line quality control check (see Table I) shall be made at least once daily, or upon changing to a new lot of material to ensure the performance of both dispensing equipment and foam product prior to installing penetration seals.

8.0 FOAM INSTALLATION

8.1 Properly mixed and dispensed Part A and B liquid mixture shall be added (injected) into a properly formed and dammed penetration opening producing a tight foamed-in-place penetration seal.

8.2 The 3-6548 liquid mixture shall not be continuously added for a time interval (shot) that exceeds its measured snap time (three minutes maximum).

8.3 Smaller penetration openings can often be completely foam sealed with one shot applications.

8.4 Larger penetration openings may require several separate shots. Each shot shall be given a minimum of fifteen minutes cure time before the next shot is added.

8.5 Sufficient liquid 3-6548 mixture shall be added to insure that the penetration opening is completely filled and tightly sealed with the cured foam elastomer.

8.6 After a foam penetration seal has been installed, a minimum of 24 hours shall be required before any damming forms are removed or the cured foam is trimmed.

8.7 After a minimum of 24 hours, the final penetration seal shall be inspected for tightness of seal of the cured foam. Should an area of non-tight seal exist, the affected area shall be injected with freshly applied 3-6548 liquid mixture and foamed to insure a tight seal.

9.0 RETROFIT AND MAINTANENCE

9.1 Changes, modification, repairs to damaged foam, removal of penetrating components, or addition of new penetrating component can be readily made to existing foam penetration seals. The cured elastomer foam can be easily removed or poked-thru and refoamed and sealed with the injection of freshly mixed 3-6548 liquid components.

10.0 CLEAN UP

10.1 A high-flash mineral spirit solvent is recommended for clean up of the 3-6548 Part A and B liquid components.

10.2 The cured foam can be cut and trimmed with a sharp knife or blade.

10.3 Application and mixing equipment shall be in good, clean operating condition. Daily cleaning of the mixing and dispensing gun assemblies is essential.

10.4 Upon completion of all work covered in the specification, the applicator/installer shall remove all equipment, material and debris leaving the area in an acceptable and undamaged condition.

11.0 SAFETY REQUIREMENTS

11.1 Dow Corning 3-6548 silicone RTV foam Part A and B liquid components do not contain

volatile solvents. Toxicological testing of the liquid components or their cured mixture does not suggest any significant hazard incidental to industrial handling.

Minimal eye protection should be adequate, however safety glasses with side shields are recommended for industrial environments. Masks or respirators should not be required for normal industrial handling purposes.

11.2 Spills of the liquid 3-6548 Part A and B components can become extremely slippery. Sawdust should be immediately applied to any liquid spill for temporary relief and the spill removed with high flash mineral spirits.

11.3 **CAUTION:** Due to the evolution of hydrogen gas during foaming and curing, appropriate caution should be exercised. Dow Corning 3-6548 silicone RTV foam should be mixed and applied away from sparks or open flame. Special forced air ventilation shall be provided if areas of installation have less than two cubic feet of free air space per pound of liquid mixture being foamed.

11.4 **CAUTION:** On direct contact, Dow Corning® 96-081 RTV silicone adhesive/sealant irritates eyes. In case of eye contact, flush immediately with plenty of water and consult a physician. Avoid prolonged or repeated skin contact.

11.5 Consult the manufacturer's safe handling procedures for the specific mineral fiber damming materials or other penetration forming materials used.

11.6 Coveralls, safety shoes and gloves are recommended for applicator/installers. Hard hats, safety belts and other auxiliarly safety equipment may often be required to satisfy specific area requirements.

11.7 Follow all label directions concerning flammability, ventilation, and any other safe handling procedures when using any cleaning solvents.

12.0 GUARANTEE AND LIMITATION

12.1 Dow Corning Corporation warrants that each quantity of Dow Corning 3-6548 silicone RTV foam product or Dow Corning 96-081 RTV silicone adhesive/sealant product delivered shall be the kind designated or specified by it, and no other warranty (except by title) shall be applied.

12.2 Certain chemical ingredients in some synthetic materials or substrates can inhibit or temporarily retard the cure of 3-6548 foam resulting in a tacky surface at the involved interface. Complete cure usually results after several days. A small scale compatibility test is recommended when suitability to a particular application is in question. More detailed information is contained in Dow Corning 3-6548 silicone RTV foam Information Sheet, Form Number 61-320B-77.

12.3 When the ambient temperature exceeds the range ideal for applying 3-6548 foam (55 to 80 F), the temperature of the Part A and B liquid components should be adjusted to obtain the specified snap time of one to three minutes.

12.4 Special openings or clearances less than ½ inch may be difficult to enter with typical 3-6548 dispensing equipment. Fire tested and approved elastomeric caulking materials, such as Dow Corning 96-081 RTV silicone adhesive/sealant should be used in lieu of the foam for small openings.

12.5 This specification guide does not cover all construction details for foam penetration seal systems. Shop drawings showing proposed damming materials, anchorage and fastenings will be required.

12.6 Openings to be sealed on traffic surfaces could be hazardous. If foam sealed penetrations require a traffic surface, suitable structural finishing plates with appropriate anchorage must be installed.

TABLE I: FOUR STEP QUALITY CONTROL REQUIREMENTS FOR CHECKING DOW CORNING 3-6548 SILICONE RTV FOAM AND DISPENSING EQUIPMENT

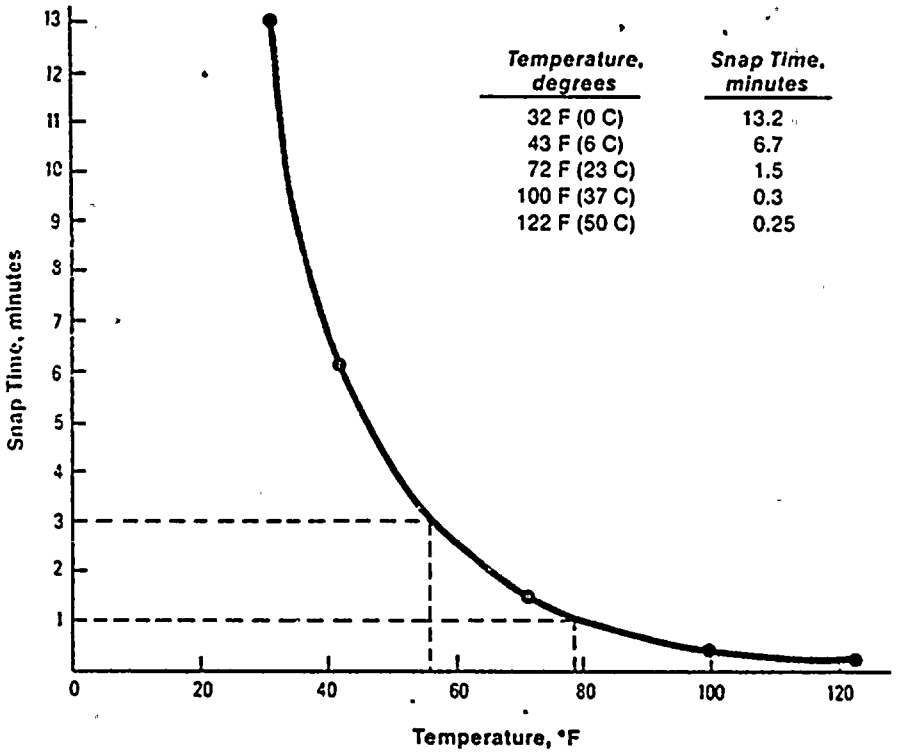
1. Snap Time, minutes	1-3
2. Free Foam Density, lbs/ft³	14-20
3. Color Chart Comparison, (Dow Corning Form No. 61-337)	Pass
4. Cell Structure Chart Comparison, (Dow Corning Form No. 61-339)	Pass

TABLE II: SUGGESTED GUIDE FOR DESIGNING MINIMUM PENETRATION THICKNESSES FOR DESIGNATED FIRE RATINGS

(Data extracted from results of several large scale E-119-76 fire tests of different Dow Corning 3-6548 silicone RTV foam penetration seal systems in both floor and wall test structures.)

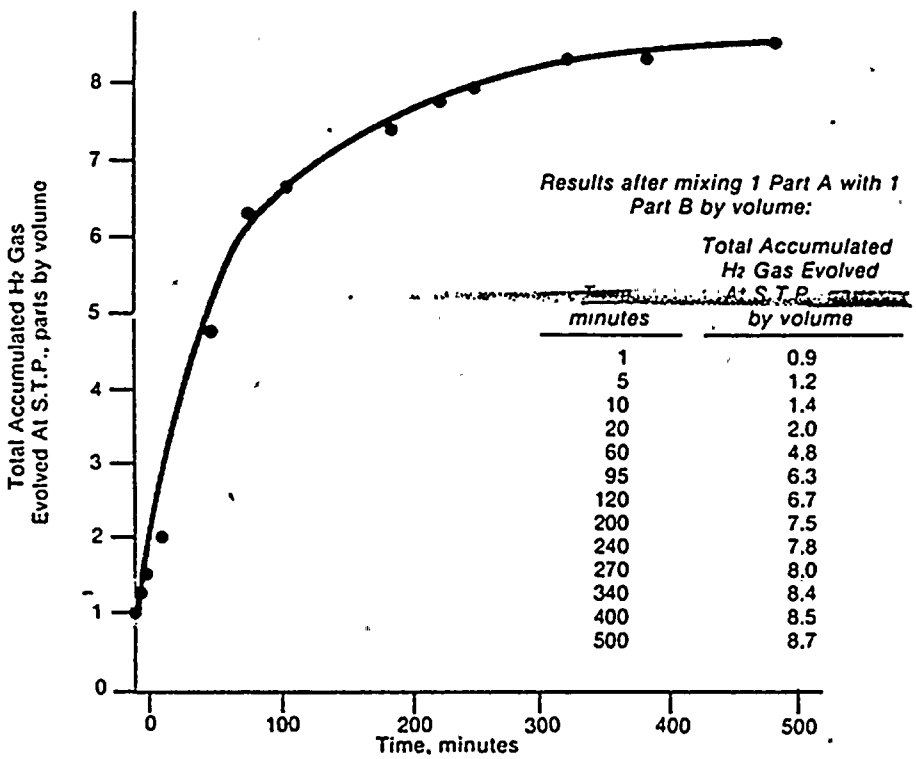
	Fire Rating		
	1 hour fire test	*2 hour fire test*	*3 hour fire test*
Thickness of Dow Corning 3-6548 silicone RTV foam alone	4 inches	8 inches	12 inches
Thickness of Dow Corning 3-6548 silicone RTV foam plus 1" of fire approved damming material	3 inches	4 inches	9 inches

FIGURE I: SNAP TIME VS. TEMPERATURE AFTER MIXING



Temperature, degrees	Snap Time, minutes
32 F (0 C)	13.2
43 F (6 C)	6.7
72 F (23 C)	1.5
100 F (37 C)	0.3
122 F (50 C)	0.25

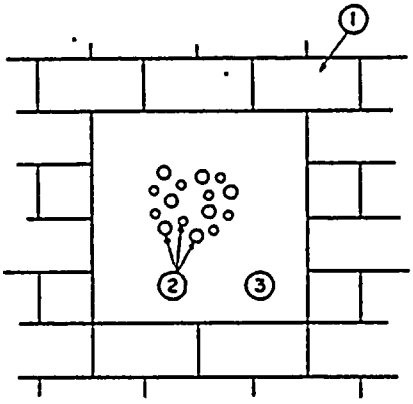
FIGURE II: HYDROGEN EVOLUTION



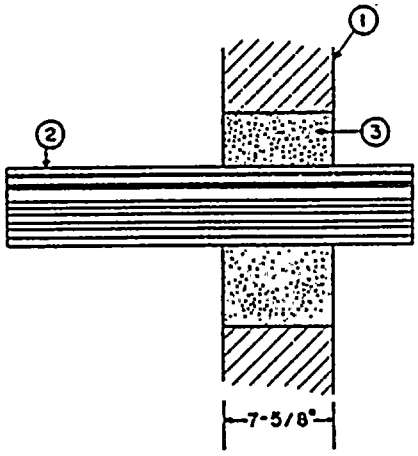
Results after mixing 1 Part A with 1 Part B by volume:

Time, minutes	Total Accumulated H_2 Gas Evolved At S.T.P., by volume
1	0.9
5	1.2
10	1.4
20	2.0
60	4.8
95	6.3
120	6.7
200	7.5
240	7.8
270	8.0
340	8.4
400	8.5
500	8.7

GUIDE ZCOR
WALL OPENING PROTECTIVE,
MULTIPLE-CABLE SYSTEMS

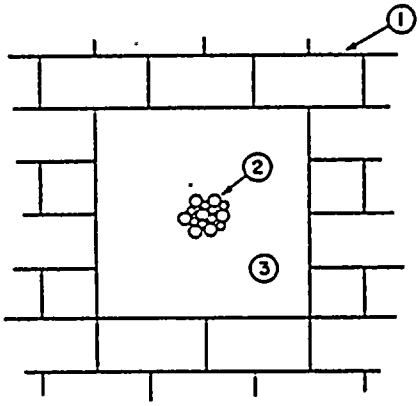


SYSTEM NO. 7
FIRE RATING — 2 HR.

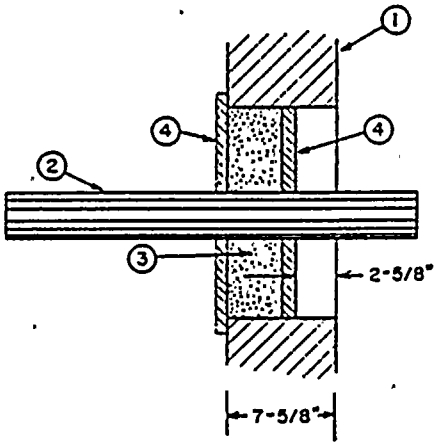


1. wall
2. cable
3. Dow Corning 3-6548 silicone RTV foam

GUIDE ZCOR
WALL OPENING PROTECTIVE,
MULTIPLE-CABLE SYSTEMS

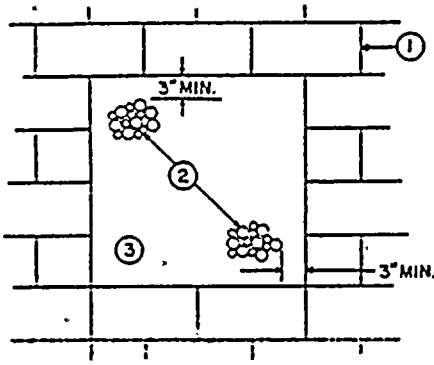


ALTERNATE CONSTRUCTION
SYSTEM NO. 7
FIRE RATING — 2 HR

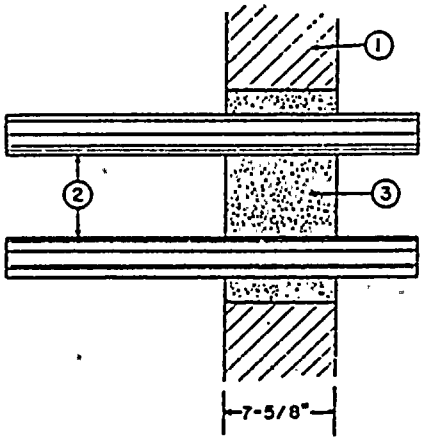


1. wall
2. cable
3. Dow Corning 3-6548 silicone RTV foam
4. mineral composition board

GUIDE ZCOR
WALL OPENING PROTECTIVE,
MULTIPLE-CABLE SYSTEMS

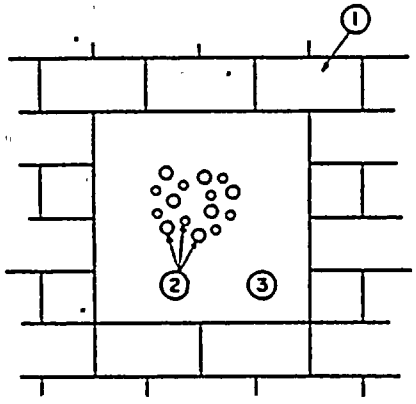


SYSTEM NO. 6
FIRE RATING — 2 HR.

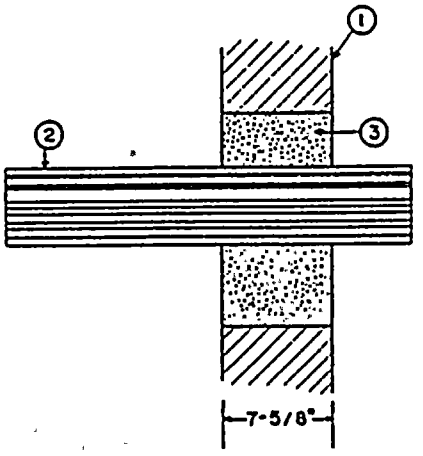


1. wall
2. cables
3. Dow Corning 3-6548 silicone RTV foam

GUIDE ZCOR
WALL OPENING PROTECTIVE,
MULTIPLE-CABLE SYSTEMS

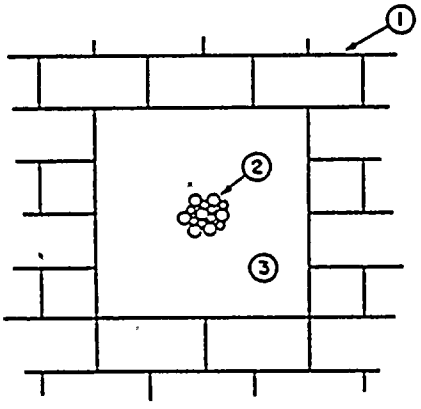


SYSTEM NO. 7
FIRE RATING — 2 HR.

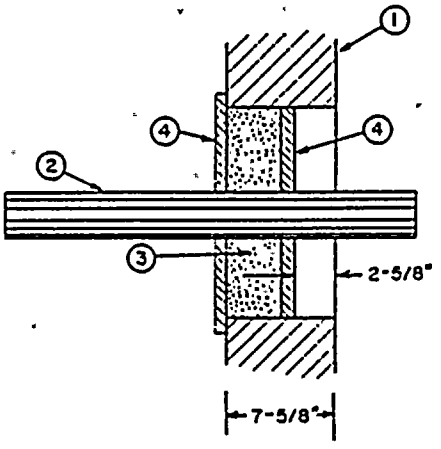


1. wall
2. cable
3. Dow Corning 3-6548 silicone RTV foam

GUIDE ZCOR
WALL OPENING PROTECTIVE,
MULTIPLE-CABLE SYSTEMS

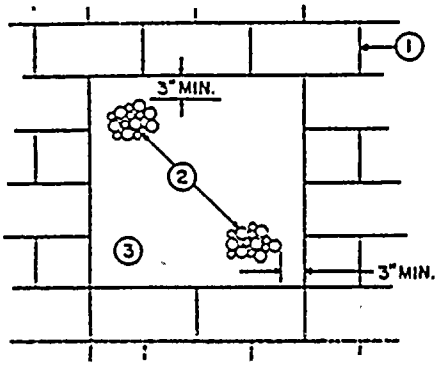


ALTERNATE CONSTRUCTION
SYSTEM NO. 7
FIRE RATING — 2 HR

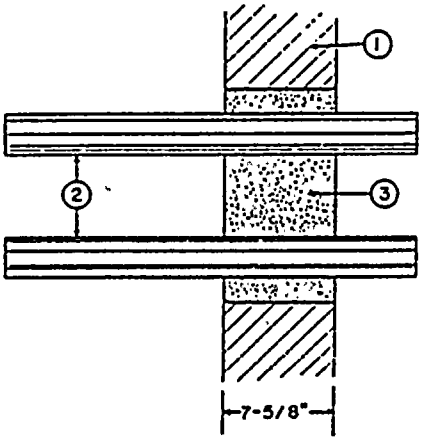


1. wall
2. cable
3. Dow Corning 3-6548 silicone RTV foam
4. mineral composition board

GUIDE ZCOR
WALL OPENING PROTECTIVE,
MULTIPLE-CABLE SYSTEMS



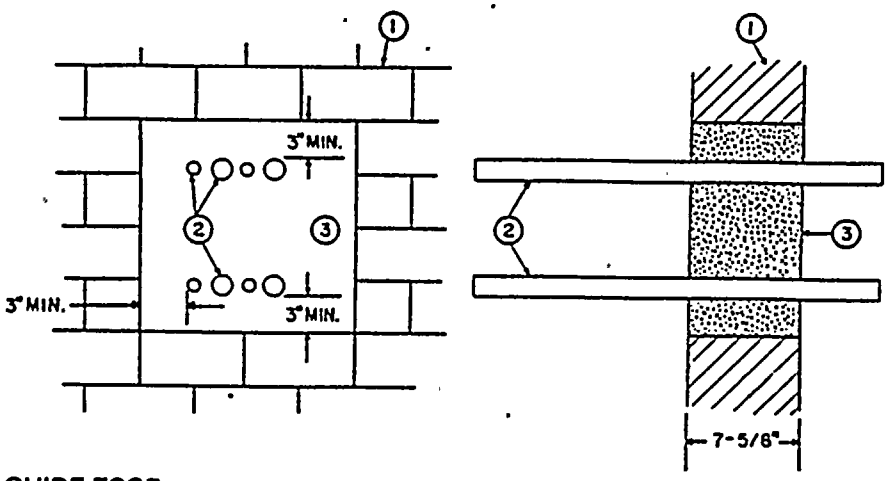
SYSTEM NO. 6
FIRE RATING — 2 HR.



1. wall
2. cables
3. Dow Corning 3-6548 silicone RTV foam

GUIDE ZCOR
WALL OPENING PROTECTIVE, MULTIPLE-CABLE SYSTEMS

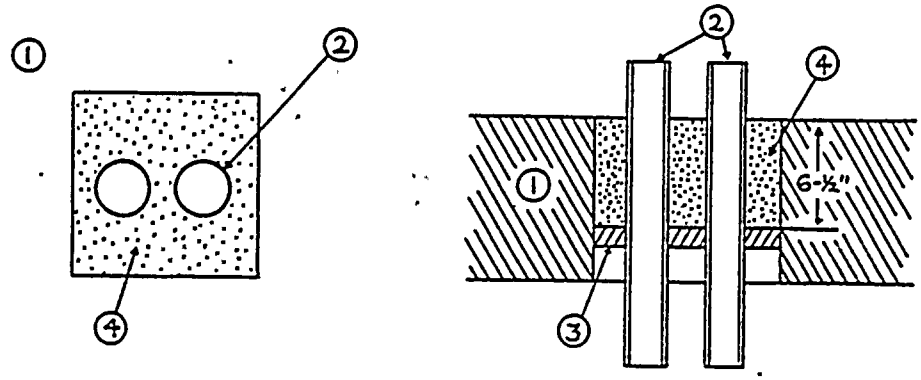
SYSTEM NO. 8
FIRE RATING — 2 HR.



1. wall
2. pipe (aluminum or steel)
3. Dow Corning 3-6548 silicone RTV foam

GUIDE ZCOR
WALL OR FLOOR OPENING PROTECTIVE, MULTIPLE-CABLE SYSTEMS

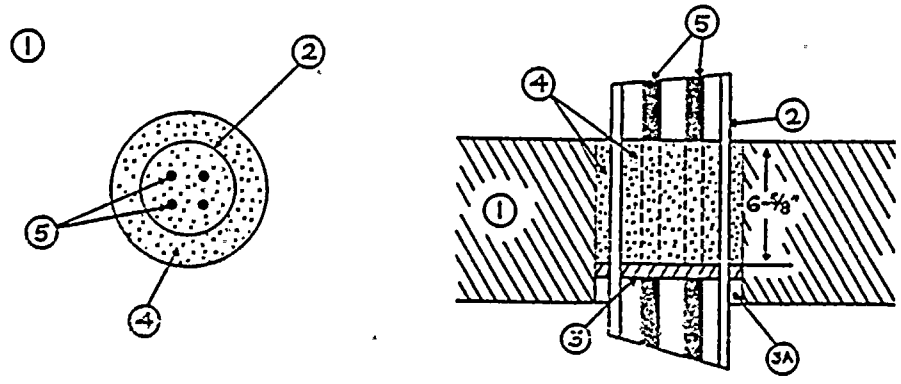
SYSTEM NO. 22
FIRE RATING - 2 HR.



1. floor
2. steel pipe
3. mineral composition board
4. Dow Corning 3-6548 silicone RTV foam

GUIDE ZCOR
WALL OR FLOOR OPENING PROTECTIVE, MULTIPLE-CABLE SYSTEMS

SYSTEM NO. 21
FIRE RATING — 2 HR.



1. floor
2. conduit
3. mineral composition board

3A. mineral fiber

4. Dow Corning 3-6548 silicone RTV foam
5. cables

The information and data contained herein are based on information we believe reliable. You should thoroughly test any application, and independently conclude satisfactory performance, before commercialization. Suggestions of uses should not be taken as inducements to infringe any particular patent.

DOW CORNING CORPORATION, MIDLAND, MICHIGAN 48640
Atlanta Boston Brussels Chicago Cleveland Dallas Detroit Greensboro
Los Angeles New York San Francisco Sydney Tokyo Toronto

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Printed in U.S.A.
Form No. 61-482A-79

3 hr Floor
ASTM - E-119

Attachment II
Set 2 of 3

FIRE ENDURANCE TEST

on

PENETRATION SEAL SYSTEMS IN PRECAST CONCRETE FLOOR

UTILIZING SILICONE ELASTOMERS

(CHEMTROL DESIGN FC 225)

for

DOW CORNING CORPORATION

MIDLAND, MICHIGAN 48640

and

CHEMTROL CORPORATION

10600 HEMPSTEAD RD.

HOUSTON, TEXAS 77018

SERIAL NO. 26543
(4610)

OCTOBER 28, 1975

Factory Mutual Research

1151 Boston-Providence Turnpike
Norwood, Massachusetts 02062

Factory Mutual System

Factory Mutual Research

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GENERAL

This report describes the construction, the test procedure and lists the results of a fire test conducted on twelve penetration seal systems installed in a 17 ft - 10 in. by 14 ft - 2 in. nominal 8 in. thick precast concrete floor assembly. The penetration seals included silicone elastomeric foam, silicone bonded lead radiation shields, flexible silicone impregnated fiberglass boots, silicone adhesive/sealant, and alumina silica damming material. The penetrations consisted of rectangular openings containing cable trays with conductors and various combinations of steel pipe sleeves containing electrical conductors and steel pipe conduits. The test assembly was constructed as shown on Illustration 1.

Chemtrol's specifications of the products employed in the construction of the penetration seal systems are attached as appendix sheets to this report. The raw materials or the in-place products of the seal systems are not manufactured or produced under Factory Mutual quality assurance follow-up in-plant inspection program.

The object of this test program was to investigate the fire endurance characteristics of the penetration seal systems as described herein. The test was performed following the procedures for evaluating floor-ceiling assemblies as defined under the Standard for Fire Tests of Building Construction and Materials ASTM E119-73, (NFPA 251).

The penetration seals were subjected to fire exposure for 3 hours. The performance of the twelve seal systems during fire exposure is detailed in this report.

DESCRIPTION

MATERIALS

The materials used in the construction of the floor assembly and the designated penetration seal components are described below:

Concrete Floor - Nominal 8 in. thick precast, prestressed hollow-core concrete planks manufactured by Spancrete Northeast Inc. Deck units were 40 in. wide by 13 ft 9 in. long.

Concrete - Laboratory mixed concrete consisting by volume of 1 part Portland cement, 2 parts sand and 2 parts pea gravel mixed with 6.0 gallons of water per 94 lb. bag of cement.

Foamed-In-Place Silicone Elastomer System - Dow Corning 03-6548 Silicone RTV Foam/Chemtrol Part No. CT-18 designed as a medium density penetration seal for liquids, gases and fire confinement. Dow Corning supplied certificate of compliance that the material furnished was within all applicable specification requirements. The average open-cup density of the silicone foam was 18.3 lbs. per cu ft. See Appendix E for cup specifications. Specification No. 3300 covering the foam is included in this report as Appendix A.

Foamed-In-Place Silicone Lead System - Chemtrol CT-300L gamma radiation shielding penetration sealing material. Material formulated utilizes a matrix including Dow Corning's Sylgard 170 silicone elastomer and powdered lead. Certificate of compliance for the Sylgard 170 was supplied by Dow Corning certifying the material as complying with applicable specifications. The nominal 150 and 250 lb. per cu ft density lead foam were 156.5 lb. per cu ft and 246.8 lb. per cu ft respectively Chemtrol. Specification No. 3400 for the radiation shielding foamed-in-place silicone lead is included in this report as Appendix B.

Penetration Boot Seal System - Chemtrol CT-15B silicone rubber fabric. Boot seal intended for use as a seal for pipe and duct penetrations where movement or vibration is present. The boot seal was installed with a fire stop. The boot fabric was fastened with Dow Corning 96-081 RTV Adhesive/Sealant or Chemtrol Part No. CT-4C. Certificate of Compliance for the adhesive was supplied by Dow Corning certifying the 96-081 RTV Adhesive/Sealant as complying with applicable specifications. Chemtrol Specification No. 3410 for the boot seal and specifications for the adhesive are included in this report as Appendix C.

Damming Materials - The following materials were used to contain the liquid silicone in a specific area while it reacts and expands into a solid mass. The damming materials were left in place and are an essential component of the seal.

a) Chemtrol Part No. CT-23F - Loose alumina-silica fiber for service temperatures of 2300°F.

b) Chemtrol Part No. CT-23B - Nominal 1 in. thick alumina-silica fiber blanket for service temperatures of 2300°F.

Specifications for the damming materials are given in Appendix D.

Cable Trays - 5 ft long solid bottom and ladder back ventilated cable trays were used in the construction. The sides of the open ladder trays were channel shaped, 4 in. deep with outward extending flanges 7/8 in. wide and a 3/8 in. wide return flange on the cable side, fabricated from 12 gage (0.107 in. thick) galvanized steel. The rungs were 1 in. diameter tubes of galvanized steel and located 12 in. O.C. The inside dimensions of the trays were nominally 3 in. deep by 18 in. wide.

The solid bottom cable trays were constructed with channel shaped sides 4 in. deep and fabricated from 17 gage (0.060 in. thick) galvanized steel. The cable side flange was formed into a 3/8 in. square closed box shape. The solid bottom was 23 gage (0.030 in. thick) corrugated galvanized steel with a pitch of 1 1/2 in. and 5/16 in. deep. The trays were nominally 3 5/8 in. deep by 18 in. wide.

The 34 in. wide cable trays were fabricated at the laboratory by joining two ladder back trays with the adjoining sides removed. The rungs were joined with pipe sleeves and welded to form a single unit. The 34 in. wide solid back trays were fabricated in the same manner with a 18 gage (0.052 in. thick) galvanized steel back welded to the ladder backed trays.

Electrical Conductors - The copper electrical wires used to fill the cable trays and conduits were as follows:

a) Anaconda W Type TW No. 14AWG. 600 volt oil resistant single conductors and having a thermoplastic coating.

b) Anaconda W Type THW 300MCM. 600 volt oil resistant single conductors and having a thermoplastic coating.

c) Anaconda M power and control tray cable, Type THHN or THWN CDRS, 7 conductor No. 12AWG 600 volt cable for installation in continuous rigid cable supports and having a thermo plastic coating.

Cable trays in one penetration were filled with the following copper conductors:

a) Raychem Flamtrol No. 4/0 AWG. 1000 volt, 90 C Type XLPE.

b) Raychem Flamtrol , 7 conductor No. 12 AWG. 2000 volt, 90 C Type XLPE.

c) Raychem Flamtrol , No. 12 AWG single conductor. 600 volt, Type XLPE.

Conduits and Sleeves - Standard weight steel pipe of nominal 6 in. dia. (6-5/8 in. O.D.) with a 0.280 in. wall thickness and nominal 10 in. dia. (10-3/4 in. O.D.) with a 0.365 in. wall thickness.

CONSTRUCTION OF TEST ASSEMBLY:

The floor assembly was installed in the test frame as shown in Illustration 1.

The 8 in. thick precast concrete floor slabs were placed directly on the top of 6 x 4 x 3/4 in. structural steel angles imbedded in the fireproofing concrete at the east and west sides of the test frame. The openings for the three rectangular penetration seals were formed in the floor using channel shaped structural steel headers supplied by the floor slab manufacturer. The floor slab joints and perimeter were filled with a non-shrink grout.

The 10 and 6 in. dia. pipe sleeves were fabricated into a single unit by welding the top edges of the sleeves to 4 x 3 x 1/4 in. thick structural steel angles. The sleeve assembly was then placed in position and supported by the 4 in. leg of the angles resting on the adjacent concrete floor slabs. The voids between the sleeves were then filled with laboratory mixed concrete. Illustrations 2 and 3 show the floor assembly during construction.

The cable trays and conduits were then filled with the electrical conducts before installation in the openings. The conducts were cut into 5 ft lengths and fastened to the 5 ft long trays with stainless steel band clamps. The trays and conduits were then placed in the openings and fastened by welding to structural steel angles and channels approximately 1 ft above the floor surface. None of the trays or conducts were supported by the precast concrete floor slabs. The cable trays, conduits, and conductors extended 12 in. below the exposed surface of the floor.

The damming materials were installed on the exposed side of the floor. The blanket type damming material was used to fill the larger spaces around the cable trays while the loose fibers were placed between the electrical conductors. The damming material was nominal 1 in. thick and installed flush with the exposed surface of the floor. Duct tape of 2 in. width was also used to provide additional support for the friction fit damming materials. Wood frames were constructed on the unexposed surface using nominal 2 x 4 in. lumber. The frame overlapped the floor 1 in. on all sides and by resting on the steel header beams positioned the top of the frame 4 in. above the floor surface. Illustrations 4 and 5 show typical cable tray preparation.

The silicone foam was then placed in the penetration by means of Chemtrol Series 106 proportioning and dispensing machine (Chemtrol Specification 3500-Appendix E). Before foam placement was started the material lot numbers were recorded and verified against the numbers contained on the certificate of compliance supplied by Dow Corning. Samples were then dispensed from the spray machine into a paper cup (Appendix F) for the determination of density and visual examination of cell structure. The damming materials were first coated with a thin layer of the silicone foam material with particular care between the electrical conducts. This provided a seal while leaks were filled with loose fiber damming material. The penetrations were then filled requiring from three to six passes, depending on the depth of the penetration. Sufficient time delay between passes was incorporated in order to allow the foam to expand and cure. The conductors were moved slightly during foaming

to allow material to flow into all voids. Some deflection of the damming materials were noted during application; however, no attempt was made to reinforce or restrain this movement. Several of the sleeve penetrations were filled with a hand held dispensing unit, designated as Chemtrol Series 101 (Specification 3500 , Appendix E), following the same application procedures. This unit is used generally for repair application. Illustrations 6 and 7 show the penetrations during silicone foam installation.

The radiation shielding penetrations were filled using similar procedures with a cartridge type dispensing unit designated as Chemtrol Series 101 (Specification 3500). Half of the lead powder was mixed by hand with each of the two components of the silicone elastomer and then placed in the cartridges. The densities were verified before dispensing the material in the penetrations. Due to the material having a greater density and requiring a longer cure time, leakage through the damming materials was greater and required repair to the loose fiber. The placement of the radiation shielding silicone was continuous except for stoppages in order to repair and reinforce the damming material. Illustration 8 shows the radiation shielding silicone penetration seal during construction.

A silicone rubber fabric boot was used to seal a 6 in. pipe conduit passing through a 10 in. dia. sleeve. The sleeve extended 4 in. above and below the concrete floor. The fire stop designated as Chemtrol Part No. CT-7C (Specification 3415) were fabricated by parting the blanket damming material (Chemetrol Part No. CT-23B) into approximately 1/2 in. thick batts measuring 10 in. wide x 48 in. long. One surface was coated with silicone foam and allowed to cure. The coated blanket was formed into a roll 48 in. long by approximately 1-5/8 in. in diameter positioned with the foam on the outside surface. One seal was wrapped around the 6 in. pipe at each side of the penetration and flush with the edges of the sleeve. See Chemtrol Dwg. A0015.

The silicone boot fabric was then fitted to the pipe and sleeve. The joint was cleaned with acetone and secured with Dow Corning 96081 RTV/Chemtrol Part No. CT-4C (Specification 3450) adhesive/sealant. The boot fabric was held smooth and tight to the pipe and sleeve with 1/2 in. wide by 0.025 in. thick stainless ~~steel adjustable clamps~~ (Chemtrol Part No. CT-6C) while the adhesive cured. Upon curing the clamps were removed, a 2 in. fold was formed in the boot and the boot sealed to the pipe and sleeve with the Dow Corning 96-081 RTV/Chemtrol Part No. CT-4C (Specification 3450) adhesive sealant.

The steel band clamps were replaced to complete the boot seal construction. An identical boot was installed on the opposite side of the floor. Illustrations 9 through 11 show the boot seals during construction. See Appendix C, Chemtrol Dwg. A0003.

The following descripts the penetrations as designated and shown on Illustration 1. All pipe conduits were closed on the exposed ends with steel

caps welded to the conduits. All cables were Anaconda Type TW, Type THW, Type THHN or THWN except as noted.

1. One 48 in. x 40 in. opening contained 4 - 18 in. x 4 in. ladder back trays in one row (east side) and 4 - 18 in. x 4 in. solid back trays in another row (west side). Each ladder back tray contained: 10 - 300 MCM conductors, 26 - 7 conductor No. 12 control cables, 425 - No. 14 single conductors. Each solid back tray contained: 8 - 300 MCM conductors, 23 - 7 conductor No. 12 control cables, 380 - No. 14 single conductors. All conductors had a thermoplastic coating. Penetration fire stop was constructed of 1 in. damming material and 11 in. silicone foam dispensed by Chemtrol CT-106 production unit.

2. One 40 in. x 20 in. opening contained 1 - 34 in ladder back tray and 1 - 34 in. solid back tray. Ladder back tray contained: 1 - 300 MCM conductors, 51 - 7 conductor No. 12 control cables, 840 - No. 14 single conductor. Solid back tray contained: 16 - 300 MCM conductors, 42 - conductor No. 12 control cables, 690 - No. 14 single conductors. All conductors had a thermoplastic coating. Penetration fire stop was constructed of 1 in. damming material and 11 in. silicone foam dispensed by Chemtrol CT-106 production unit.

3. One 6 in. diameter sleeve 8 in. long mounted flush with both sides of test assembly. Penetration contained: 4 - 300 MCM cables, 9 - 7 conductor No. 12 control cables, 100 - No. 14 single conductors. All conductors had a thermoplastic coating. Penetration fire stop was constructed of 1 in. damming material and 7 in. silicone foam dispensed by Chemtrol CT-106 production unit.

4. One 10 in. diameter sleeve 8 in. long mounted flush with test assembly. Penetration contained one 6 in. diameter pipe centered in opening. Penetration fire stop was constructed of 1 in. damming material and 7 in. silicone foam dispensed by Chemtrol CT-106 production unit.

5. Same as 4 except silicone foam dispensed by Chemtrol CT-101 repair unit.

6. One 10 in. diameter sleeve 16 in. long mounted flush with exposed surface extending 8 in. on unexposed surface. Top of unexposed surface was capped and mounted with valve for vacuum attachment. Penetration contained one 6 in. diameter pipe 28 in. long center in penetration protruding 1 ft. on exposed side and rigidly mounted to cap. Penetration fire stop was constructed of 1 in. dam and 7 in. silicone foam dispensed by Chemtrol CT-106 production unit. A 3 in. to 5 in. water vacuum was applied on unexposed side during test.

7. One 10 in. diameter sleeve 16 in. long protruded 4 in. on both sides of test assembly. Penetration contained one 6 in. diameter pipe mounted through center of opening. Penetration fire stop was constructed of silicone-ceramic laminate blanket wound around pipe and placed in opening between pipe and sleeve and two silicone rubber boots were installed on each side of test assembly.

8. One 10 in. diameter sleeve 8 in. long mounted flush with the test assembly. Penetration contained one 6 in. diameter pipe centered in opening. Penetration fire stop was constructed of 1 in. dam and silicone foam dispensed by Chemtrol CT-106 production unit. The silicone foam was placed to a below-design thickness of 4 in. to determine a measurement of time/thickness effectiveness.

9. Identical construction as No. 3.

10. One 10 in. diameter sleeve 8 in. long mounted flush with test assembly. Penetration contained one 6 in. diameter pipe centered in opening. Penetration fire stop was constructed of 1 in. dam and 7 in. of nominal 150 lb/ft.^{3} silicone lead.

11. One 10 in. diameter sleeve 8 in. long mounted flush with test assembly. Penetration contained one 6 in. diameter pipe centered in opening. Penetration fire stop was constructed of 1 in. dam and 7 in. of 250 lb./ft.^{3} silicone lead.

12. One 40 in. x 20 in. opening contained 1 - 34 in. ladder back tray and 1 - 34 in. solid back tray. Ladder back tray contained: 37 - 4/0 conductors, 32 - 7 conductor No. 12 control cables, 114 - No. 12 single conductors. Solid back tray contained: 34 - 4/0 conductors, 27 - 7 conductor No. 12 control cables, 93 - No. 12 single conductors. All conductors had Raychem-Flamtrol jackets. Penetration fire stop was constructed of 1 in. damming material and 11 in. silicone foam dispensed by Chemtrol CT-106 production unit.

Illustrations 12 through 18 show the exposed and unexposed surfaces before the fire endurance test. The exposed surfaces of the steel headers used to support the floor slabs adjacent to the penetrations were protected with mineral fiber board and gypsum plaster.

FIRE ENDURANCE TEST

The test was conducted subjecting one side of the floor assembly to fire exposure in accordance with the Standard for Fire Tests of Building Construction and Materials ASTM Designation E119-73, (NFPA No. 251). The standard test furnace of the National Gypsum Company for floor ceiling assemblies was used for the test.

SAMPLE:

The floor assembly containing the various penetration seal systems was constructed by Chemtrol's technicians at the National Gypsum Research Center as described in the preceding section of this report under Construction of Test Assembly and as shown on Illustrations 1 through 18.

METHOD:

The temperatures of the furnace chamber was measured with 16 thermocouples which were placed 12 in. below the underside of the concrete floor and located as shown in Illustration 19. The unexposed surfaces of the penetra-tion seals were measured by 16 thermocouples, each covered by a dry asbestos pad cut to fit between the cables or other penetration items and located as shown in Illustration 20. Ten thermocouples were also used to obtain representative temperature information of the cables, trays, conduits, sleeves and unexposed floor surface. The location of these thermocouples are shown on Illustration 21.

The furnace fire was started, exposing one side of the assembly to gas flames of controlled severity and extent in accordance with the Standard Time-Temperature Curve.

Throughout the test, observations were made to note the character of the fire and its control, the condition of the exposed and unexposed surfaces, and all developments pertinent to the performance of the assembly seal systems with reference to stability, passage of flame, and generation of smoke.

RESULTS:

Character and Distribution of Fire - The fire was luminous and well distributed throughout the test. The furnace temperatures were controlled in accordance with the Standard Time-Temperature Curve as shown on Illustration 19.

Observations of the Exposed Surface - At 1/2 minute the cable insulation was smoking and were burning at 3/4 minutes. After 1 minute of exposure heavy flames and smoke within the furnace made observations difficult. The smoke and flames from the cable insulation continued for the three hour duration of the test.

At 117 minutes white char could be seen developing on the copper cables. The smoke made observations of the sleeve penetrations at south end of the furnace impossible. The furnace fire was extinguished at 180 minutes.

Observations of the Unexposed Surface - At 38 minutes water marks were noted on the surface of the concrete floor slabs. At 39 minutes light steam was coming from the ends of the 300 MCM cables of the 40 x 48 in. penetration (No. 1) and by 61 minutes smoke began to issue. After 70 minutes spalling of the concrete floor adjacent to this penetration was noted. At 76 minutes smoke was issuing from the pipe penetration (No. 8) which was sealed with 4 in. of silicone foam and at 84 minutes flames penetrated this seal. The opening between the pipe and sleeve (No. 8) was then filled with mineral wool.

At 98 minutes the two 6 in. sleeve penetrations (Nos. 3 and 9) containing electrical cables of the thermoplastic insulation were smoking. Smoke continued from the 40 x 48 in. penetration (No. 1) as well as the 20 x 40 in. penetration (No. 2) with the thermoplastic wire insulation after 120 minutes. At 126 minutes the vacuum could no longer be maintained on the unexposed side of the penetration (No. 6) sealed with 7 in. of silicone foam. After 130 minutes the boot seal (No. 7), the lead foam seals (Nos. 10 and 11) and the two 6 in. conduits in the 10 in. sleeve penetrations (Nos. 4 and 5) showed no change in appearance.

At 141 minutes flame was noted at the 40 x 48 in. penetration (No. 1) on the thermoplastic insulated wires in the area of the solid back cable trays. This flaming was confined between the two Southern most trays. Heavy smoke continued from the two 6 in. sleeve penetrations (Nos. 3 and 9) and the 20 x 40 in. penetration (No. 2) containing the thermoplastic wire insulation after 150 minutes. Also, at this time light smoke was issuing from the 20 x 40 in. penetration (No. 12) containing Raychem Flamtrol wires. At 156 minutes liquid lead was noted adjacent to the center 6 in. pipe conduit of the 250 lb. density lead foam seal (No. 11). At 164 minutes the wire insulation above the two 6 in. sleeve penetrations (Nos. 3 and 9) appeared badly deteriorated. The two 10 in. sleeve penetrations (Nos. 4 and 5) containing 6 in. conduits as well as the boot seal (No. 7) appeared unchanged at 165 minutes. At 172 minutes light smoke appeared around the 150 lb. density lead seal (No. 10). The test was terminated at 180 minutes.

Observations After the Test - Within 1/2 minute after furnace shutdown, the unexposed surface of the 20 x 40 in. penetration (No. 2) containing the thermoplastic wire insulation was flaming heavily. Approximately 5 minutes after the test, as the assembly was being moved from the furnace for quenching with water, small flames were noted coming from the 20 x 40 in. penetration (No. 12) containing Raychem Flamtrol wires.

Examination of the silicone foam material after the test revealed that approximately 5 in. of the exposed side of the foam had formed a hard char while material above was resilient. All damming materials were in place. The unexposed side of the flexible boot seal (No. 7) was pliable and showed no effects from the fire exposure. The silicone foam material adjacent to the cables and tray was charred to within 2 in. of the unexposed surface. The flame which occurred at the 40 x 48 in. penetration (No. 1) was located on the wire insulation adjacent to the solid back cable tray. The lead foam seals (Nos. 10 and 11) were resilient for a depth of 4 in. on the unexposed surface except adjacent to the 6 in. conduits where the material was rigid.

Temperatures of the Unexposed Seal Surfaces - The temperatures that developed during the test and the thermocouple locations are shown on Illustration 20. The standard states that limiting end point temperatures are reached when heat transmission through the assembly is sufficient to raise the average temperature 250°F above ambient temperature or when the temperature of any individual point raises 30% in excess of the allowable 250°F rise. In this test the initial temperature was 67°F, therefore, based on the above conditions, the average limiting temperature was 317°F and the individual limiting temperatures was 392°F.

In this test the performance under fire exposure of discrete elements was evaluated, not a floor assembly. In the opinion of this testing laboratory, the determination of acceptable temperature limits is the responsibility of the authority having jurisdiction, based on the end use conditions of the penetration seals.

Analysis of the unexposed surface chart (Illustration 20) indicate that Thermocouple 11 placed on the foam surface of the 6 in. dia. sleeve penetration (No. 3) reached 392°F at 51 minutes. Thermocouple 14 on the foam surface of the second 6 in. diameter sleeve penetration (No. 9) reached 392°F at 57 minutes. Thermocouple 12 on the sleeve containing a 6 in. conduit and sealed with 4 in. of foam (No. 12) reached 392°F at 80 minutes. Thermocouple 13 on a sleeve containing a 6 in. conduit and sealed with 7 in. of foam (No. 5) reached 392°F at 96 minutes.

Thermocouple 16 on the 150 lb. density lead foam (No. 10) seal reached 392°F at 115 minutes and the 250 lb. density lead foam (No. 11) reached the limiting temperature at 129 minutes as recorded by Thermocouple 15. Thermocouple 10 located on a sleeve penetration containing a 6 in. conduit and sealed with 7 in. of silicone foam (No. 4) reached 392°F at 120 minutes. Thermocouple 4, located adjacent to the site where the flaming occurred at the unexposed surface of Penetration No. 1, failed to function after the flame appeared. All other foam surface temperatures were well below the limiting end-point temperatures at the time the test was terminated.

Steel Pipe and Cable Temperatures - The temperatures of the steel pipes, sleeves, electrical cables and trays were measured by 10 thermocouples as shown on Illustration 21.

Thermocouples 1 through 4 were placed on the concrete floor surface. At 155 minutes Thermocouple 1 was relocated to the silicone boot fabric (No. 7); all other remained as initially located. Thermocouple 5 was placed against the copper of a 300 MCM cable 1 in. above the foam (No. 1) while Thermocouple 6 was on the same wire 3 ft above the foam. Thermocouple 7 was placed at the interface of the foam and concrete floor at Penetration No. 12. Thermocouples 8 and 10 were on the ladder back steel cable tray. Thermocouple 8 was at the foam surface while Thermocouple 10 was located 6 in. above Thermocouple 8. Thermocouple 9 was located on a 6 in. conduit passing through a penetration (No. 5), 6 in. above the foam surface.

The temperatures are included for general fire performance information.

CONCLUSIONS

FIRE RESISTANCE PROPERTIES:

The penetration seals as described in this report were subjected to fire exposure for 3 hours in accordance with the ASTM E 119 Standard Time-Temperature Curve.

Penetration No. 8 consisted of a 10 in. diameter steel sleeve and containing a 6 in. diameter steel conduit. The void between the sleeve and conduit was filled with 1 in. thick damming material and 4 in. (below-design) depth of silicone foam. After 84 minutes of exposure, flame penetrated the unexposed surface of this seal system.

At 141 minutes of exposure, flame was observed at the unexposed surface of Penetration No. 1. The flaming was noted on the thermoplastic insulated wires in the area of the solid back cable trays and confined between the two southernmost trays. No flaming occurred at the location of the other solid back cable trays which contained identical electrical wires and sealed in the same manner.

The unexposed surfaces of the 20 by 40 in. penetration (No. 2) containing thermoplastic wire insulation, the two 6 in. diameter sleeve penetrations (Nos. 3 and 9) containing electrical conductors with thermoplastic insulation as well as the surface of Penetrations Nos. 1 and 8 resulted in the creation of considerable smoke during the test period. The remaining penetration seal surfaces did not produce excessive smoke during the test.

PRODUCT UNIFORMITY:

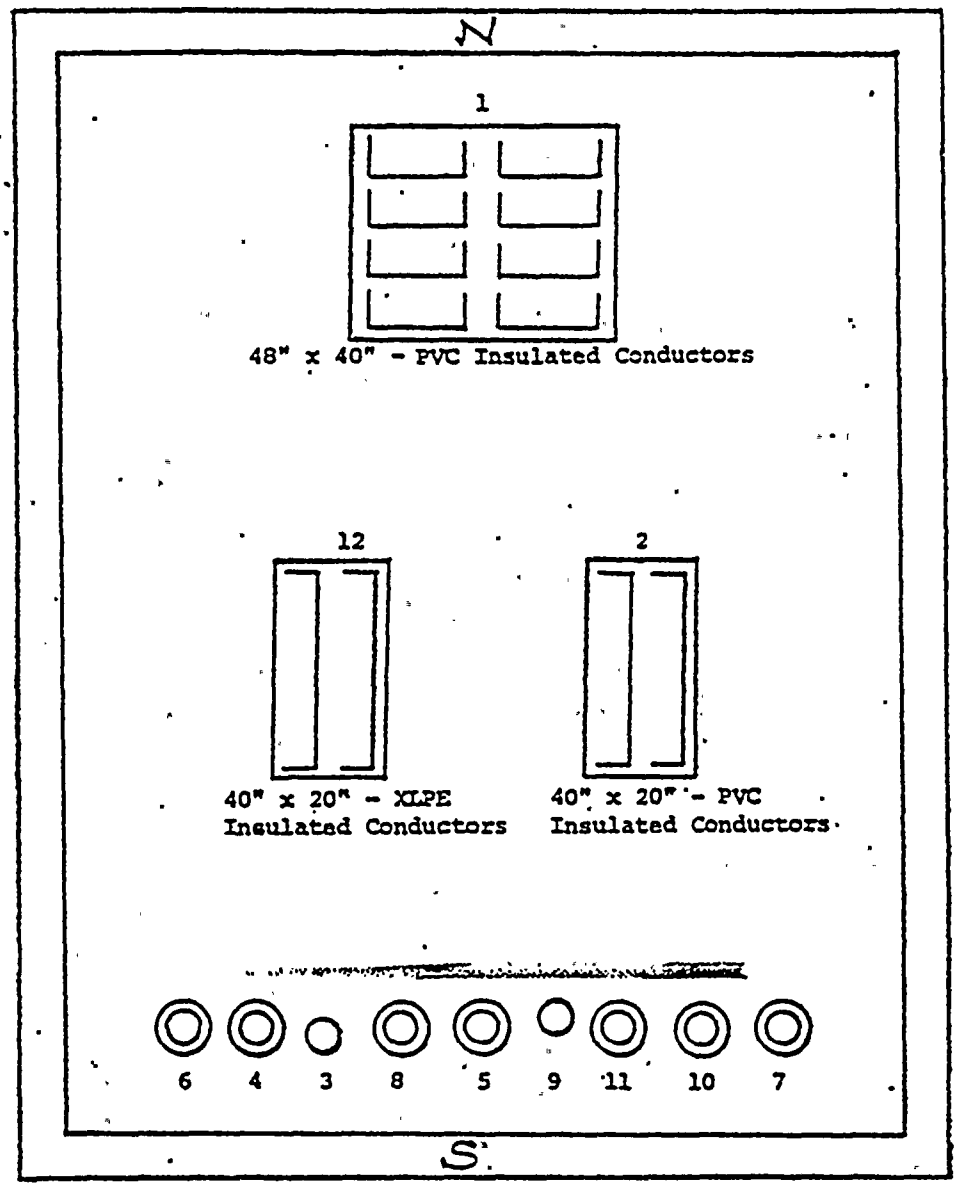
Factory Mutual Research Corporation makes no judgment of product uniformity solely as a result of this fire test. Product uniformity depends in part on manufacturing facilities and procedures which would be inspected under Factory Mutual quality assurance follow-up inspection program and on a written agreement put in force between the product manufacturer and Factory Mutual.

The components used in the construction of this assembly are not under this quality assurance inspection program.

LABORATORY RESPONSIBILITY:

Factory Mutual Research Corporation makes no judgment of product suitability for its intended end-use. Product acceptance of field installation are usually the prerogative of the authority having jurisdication.

ILLUSTRATION 1



Mechanical Penetrations - 6, 4, 8, 5, 11, 10, & 7

Electrical Penetrations, PVC Insulated Conductors - 1,2,3, and 9

CHEMTROL CORPORATION, HOUSTON, TEXAS	
DATE: 10/28/75	DRAWN BY: M.F.S.
SCALE: 3/8"=1'0	
FLOOR LAYOUT FOR ASTM-E-119-73 "STANDARD METHOD OF FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS, TESTS OF FLOORS AND ROOFS"	

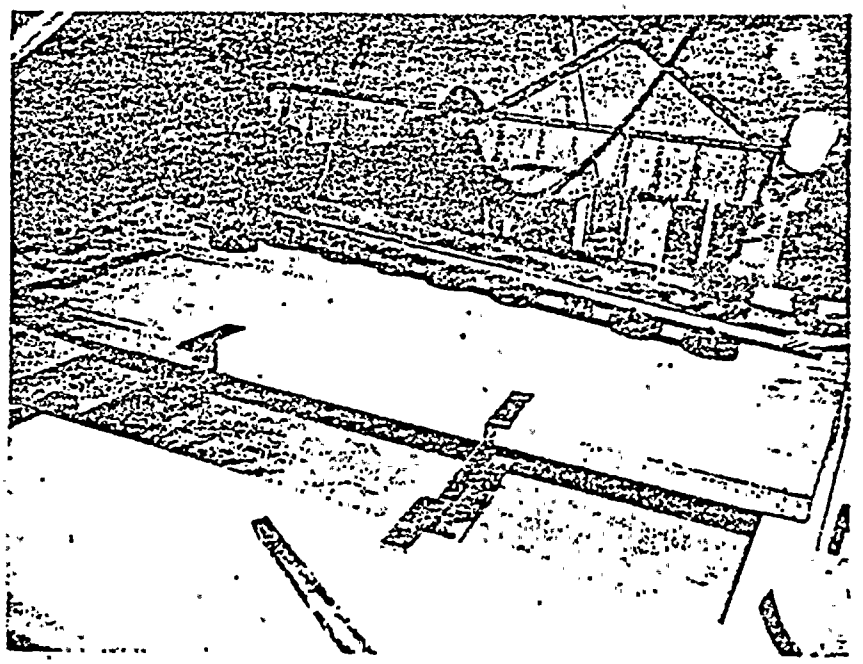


ILLUSTRATION 2

STEEL PIPE SLEEVES
DURING CONSTRUCTION

(3430-1)

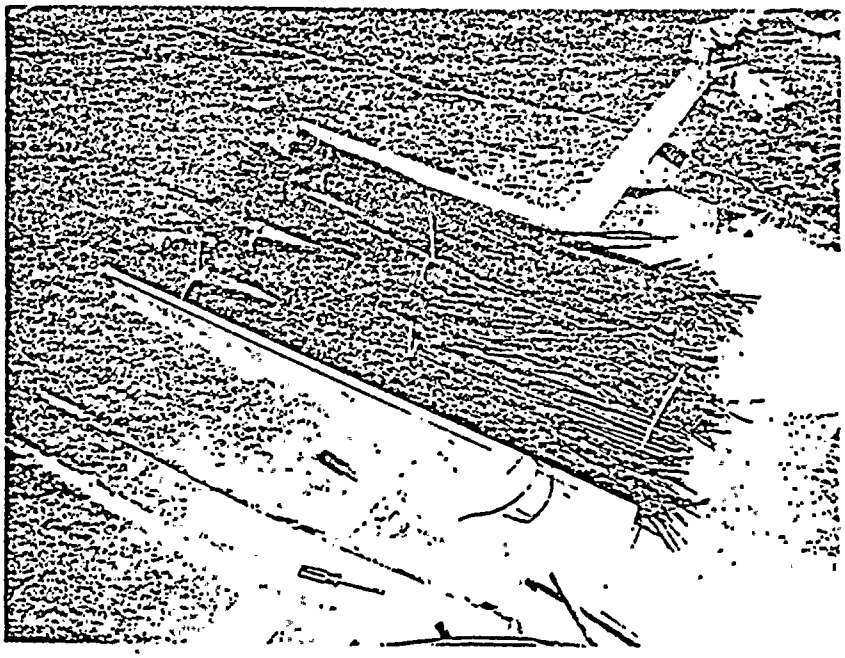
ILLUSTRATION 3

PENETRATION OPENINGS
DURING CONSTRUCTION

(3430-2)

ILLUSTRATION 4

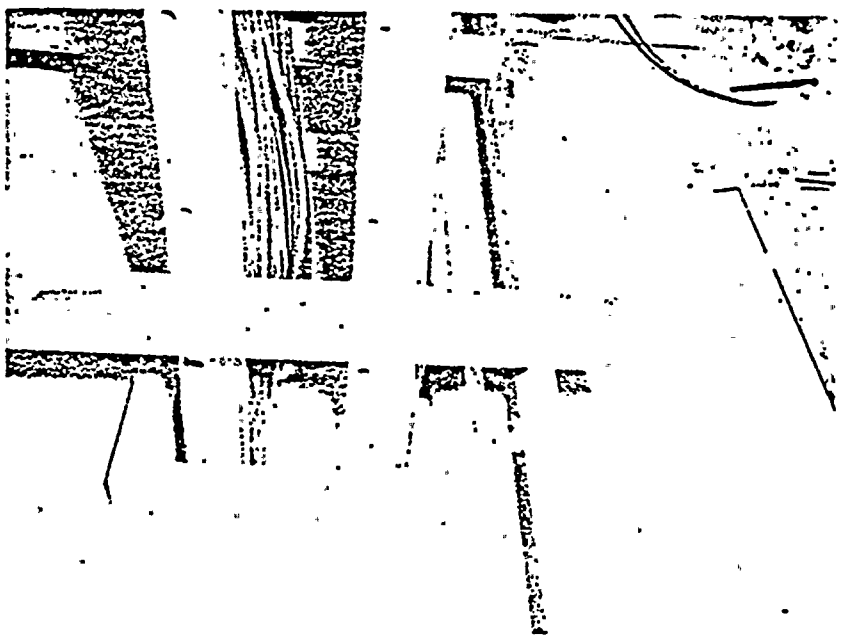
CABLE TRAYS DURING
WIRE INSTALLATION



(3430-3)

ILLUSTRATION 5

PENETRATION BEFORE
SILICONE FOAM INSTALLATION



(3430-4)

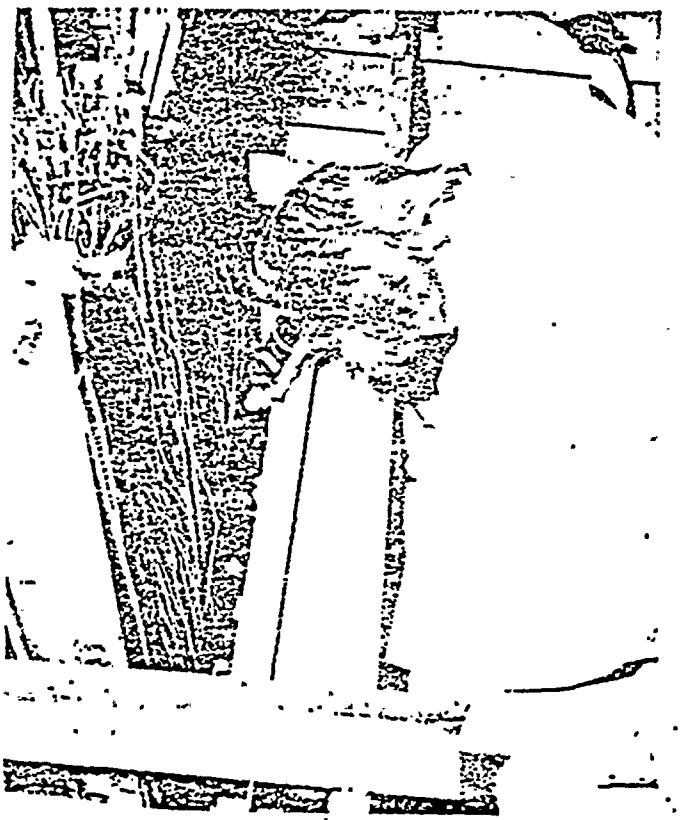


ILLUSTRATION 6

PENETRATION DURING
SILICONE FOAM INSTALLATION

(3430-5)

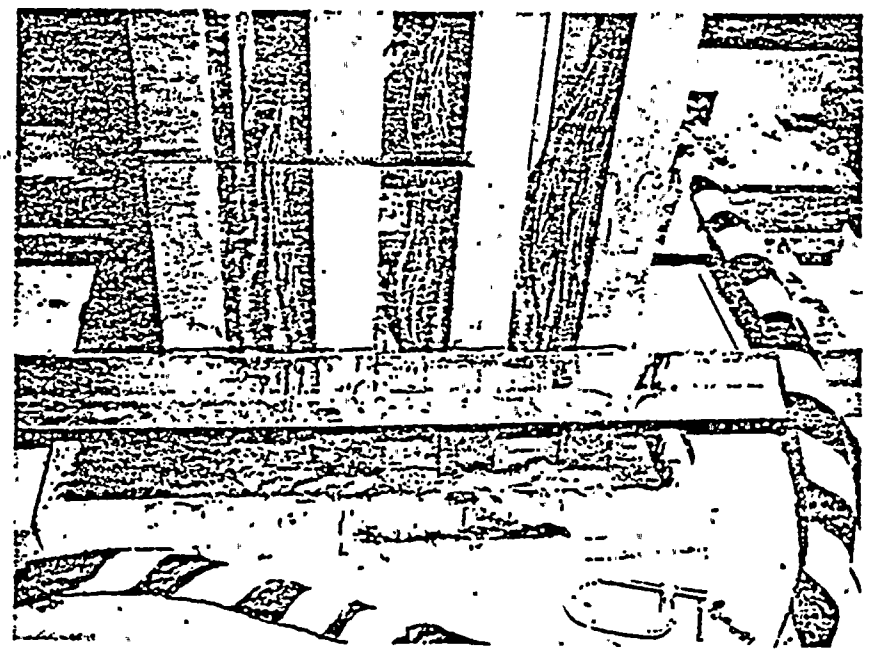


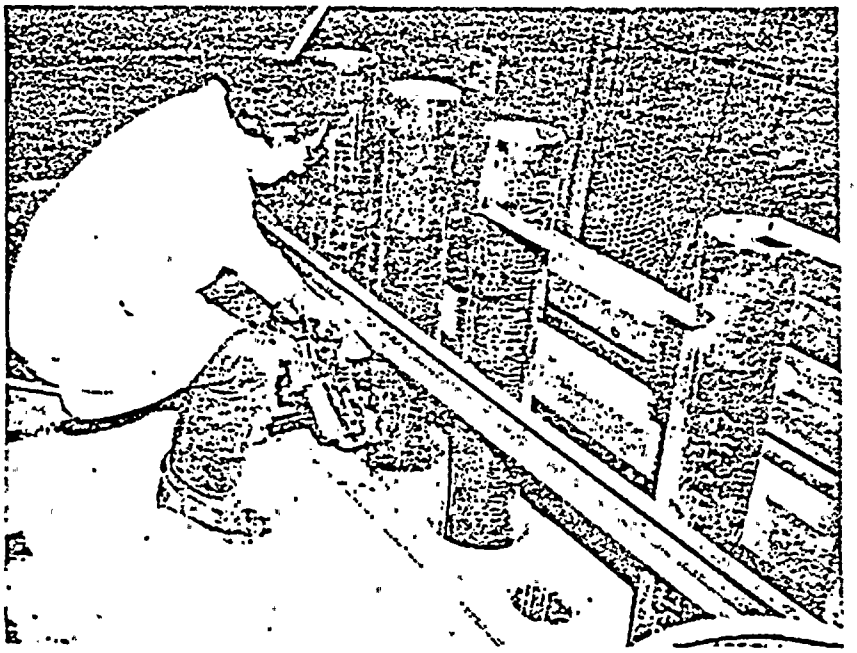
ILLUSTRATION 7

PENETRATION DURING
SILICONE FOAM INSTALLATION

(3430-6)

ILLUSTRATION 8

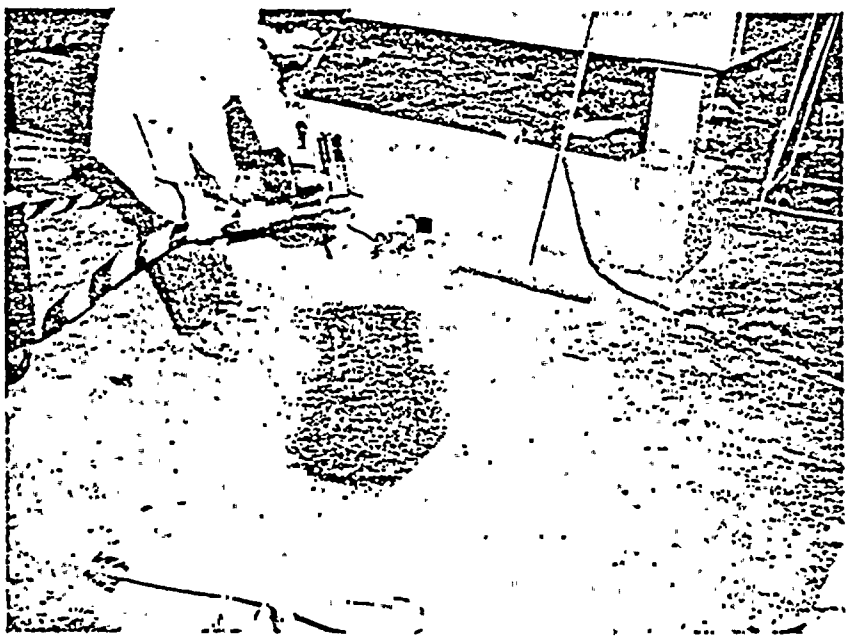
CONSTRUCTION OF LEAD FOAM PENETRATION SEAL



(3430-7)

ILLUSTRATION 9

CONSTRUCTION OF FIRE STOP FOR AIR PENETRATION BOOT SEAL



(3430-8)

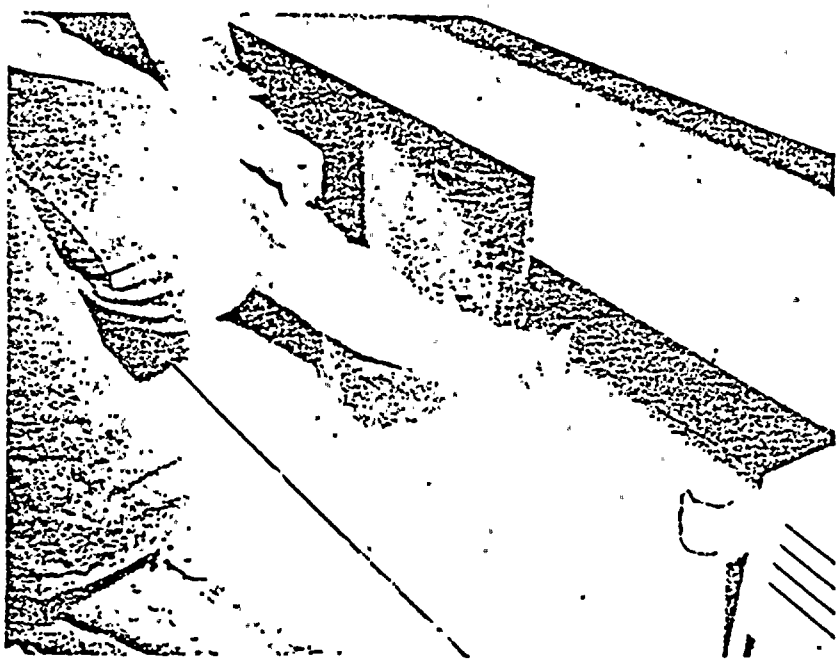


ILLUSTRATION 10

INSTALLATION OF FIRE STOP FOR AIR PENETRATION BOOT SEAL

(3430-9)

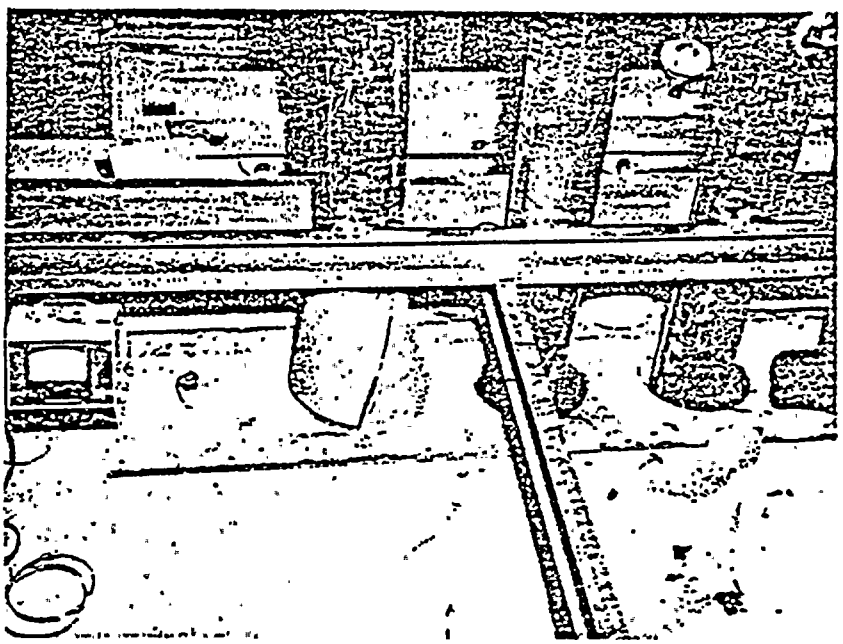


ILLUSTRATION 11

SILICONE FABRIC INSTALLATION FOR AIR PENETRATION BOOT SEAL

(3430-10).

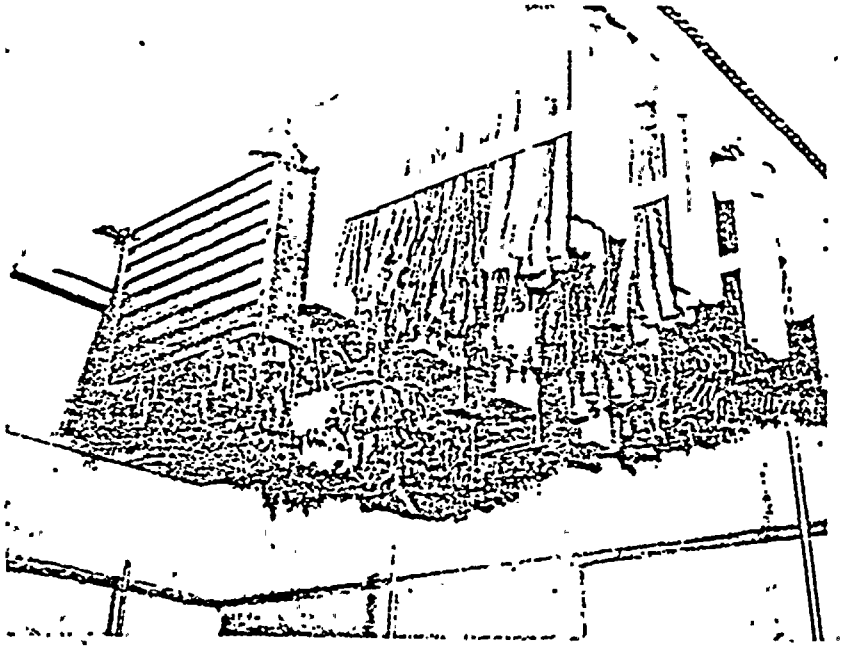


ILLUSTRATION 12

EXPOSED SURFACE OF LARGE PENETRATION BEFORE FIRE ENDURANCE TEST

(3430-11)

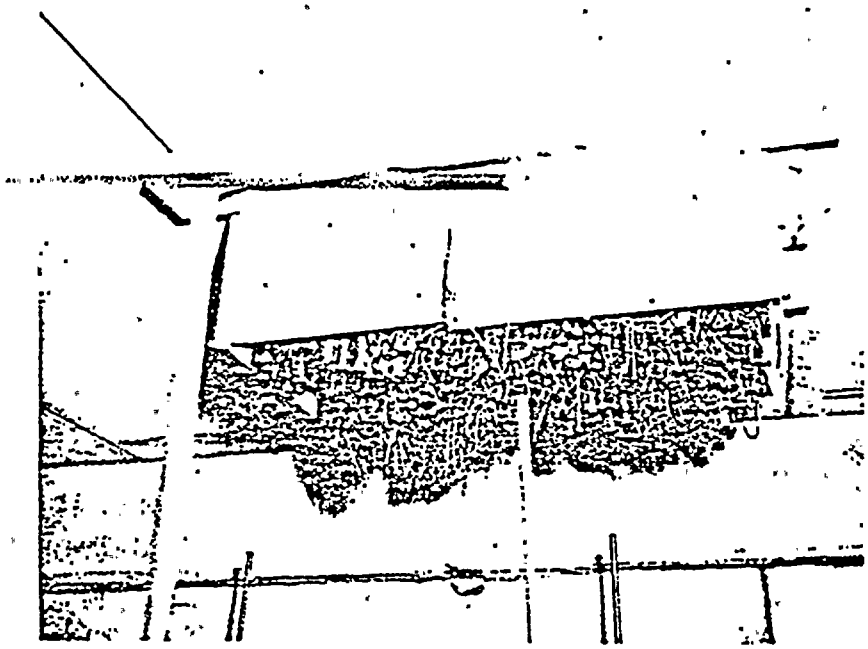


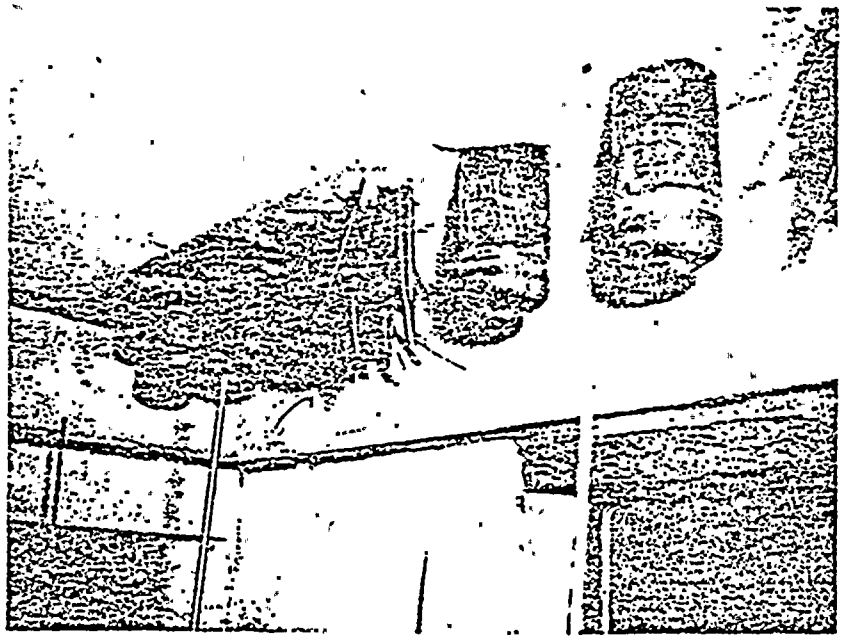
ILLUSTRATION 13

EXPOSED SURFACE OF SMALL PENETRATION BEFORE FIRE ENDURANCE TEST

(3430-12)

ILLUSTRATION 14

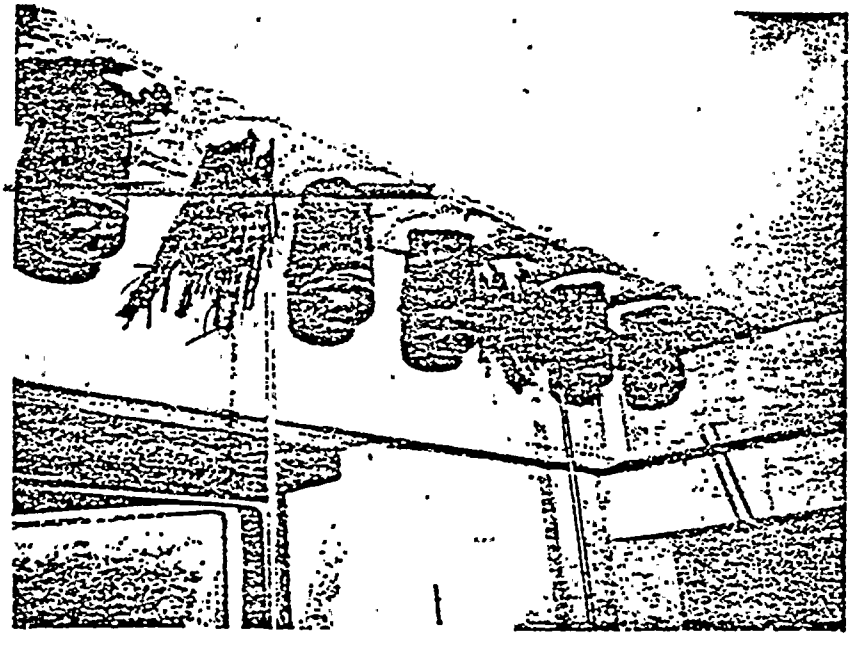
EXPOSED SURFACE OF STEEL PIPE PENETRATIONS BEFORE FIRE ENDURANCE TEST



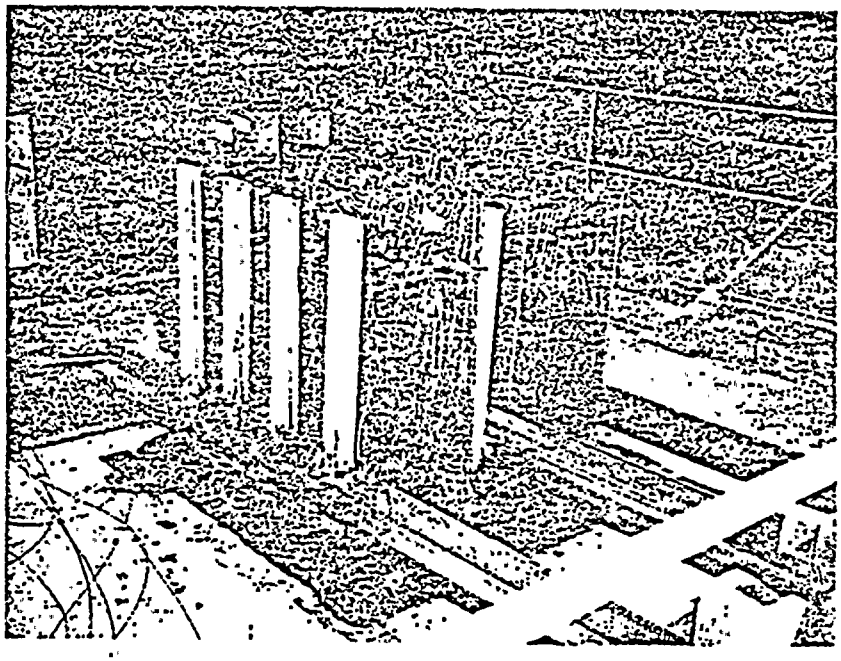
(3430-13)

ILLUSTRATION 15

EXPOSED SURFACE OF STEEL PIPE PENETRATIONS BEFORE FIRE ENDURANCE TEST



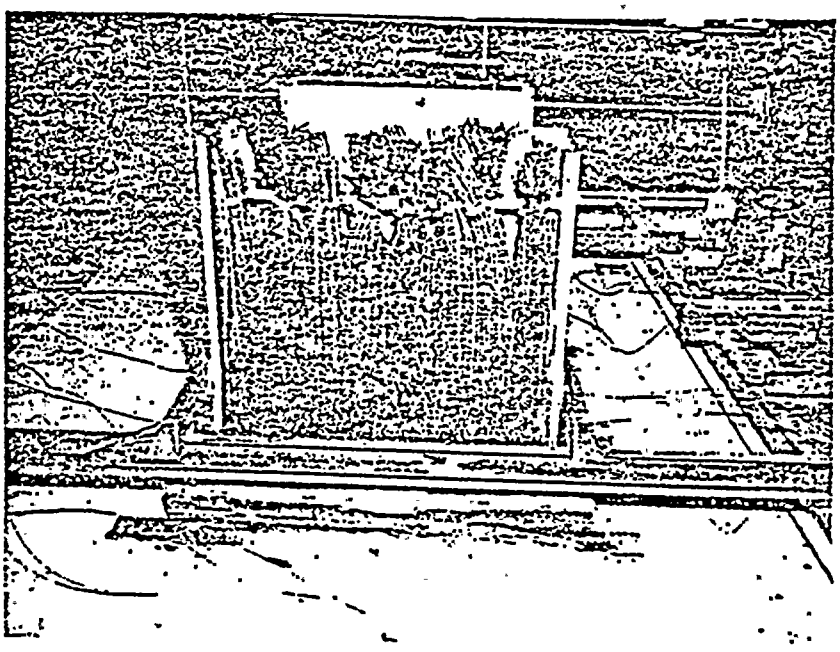
(3430-14)



(3430-15)

ILLUSTRATION 16

UNEXPOSED SURFACE OF LARGE PENETRATION BEFORE FIRE ENDURANCE TEST



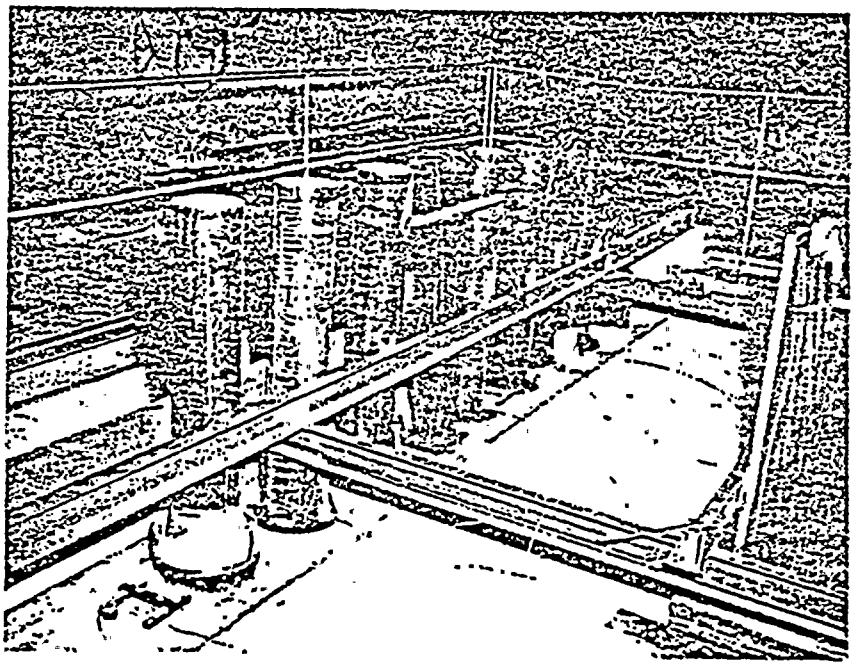
(3430-16)

ILLUSTRATION 17

UNEXPOSED SURFACE OF SMALL PENETRATION BEFORE FIRE ENDURANCE TEST

ILLUSTRATION 18

UNEXPOSED SURFACE OF STEEL PIPE PENETRATIONS BEFORE FIRE ENDURANCE TEST



(3430-17)

ILLUSTRATION 19

FURNACE TEMPERATURES
FIR. DURAIR EST
OCTOBER 28, 1975
DOW CORNING CORP. AND CHEMTROL CORP.

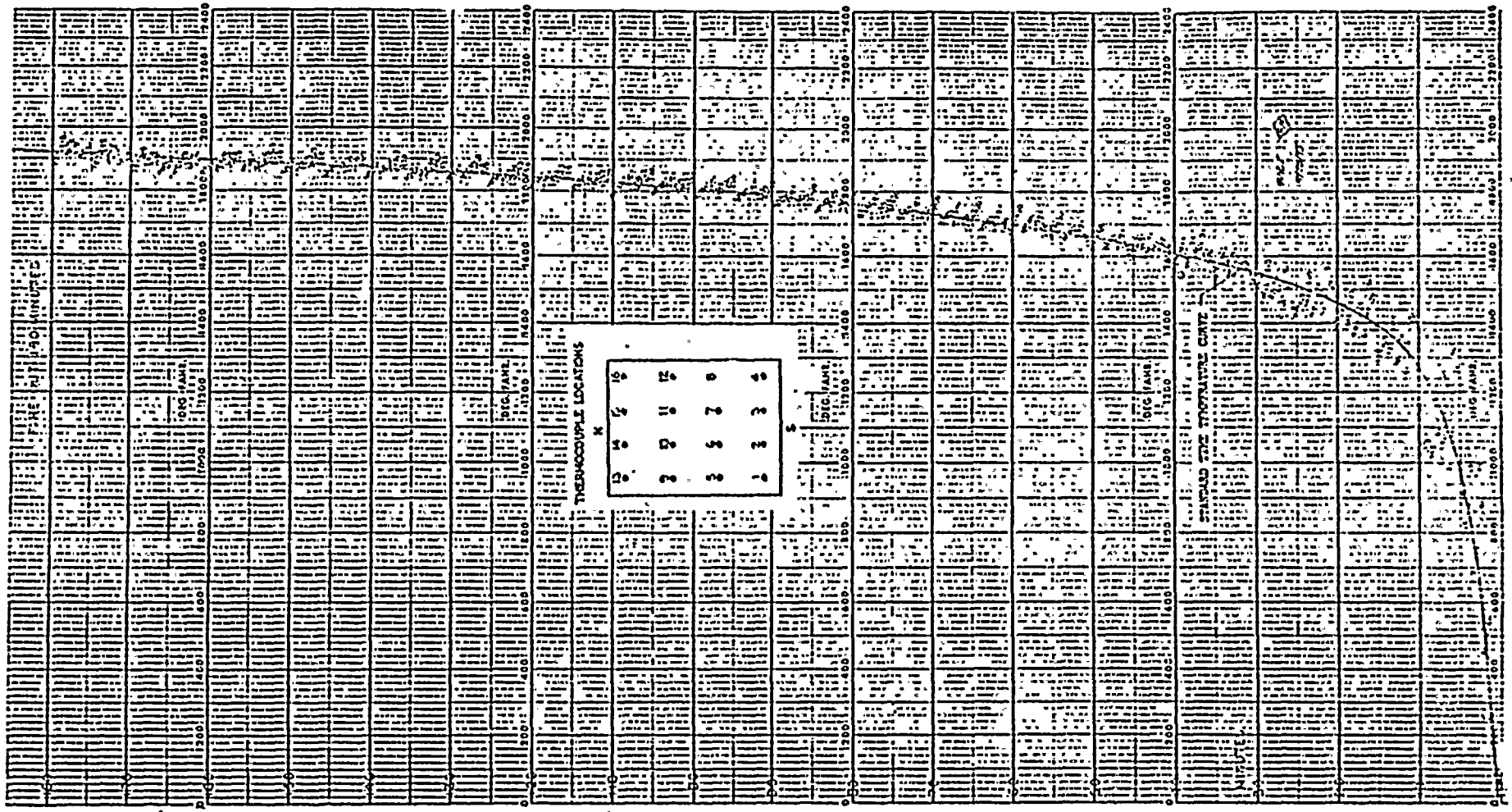


ILLUSTRATION 20

UNEXPOSED SURFACE TEMPERATURES
OF PENETRATION SEALS
3 HR FIRE ENDURANCE TEST
OCTOBER 28, 1975
DOW CORNING CORP. AND CHEMTROL CORP.

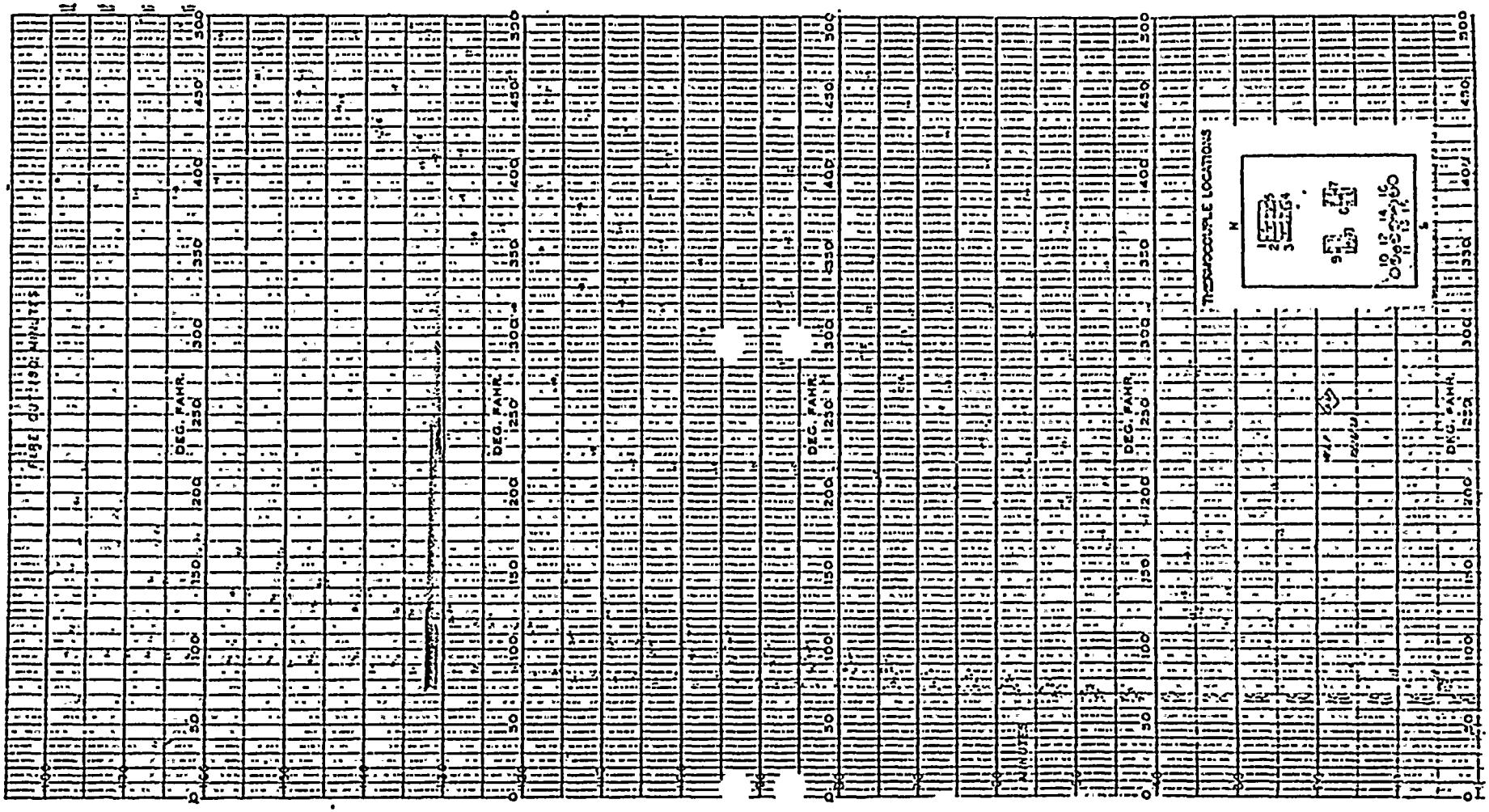
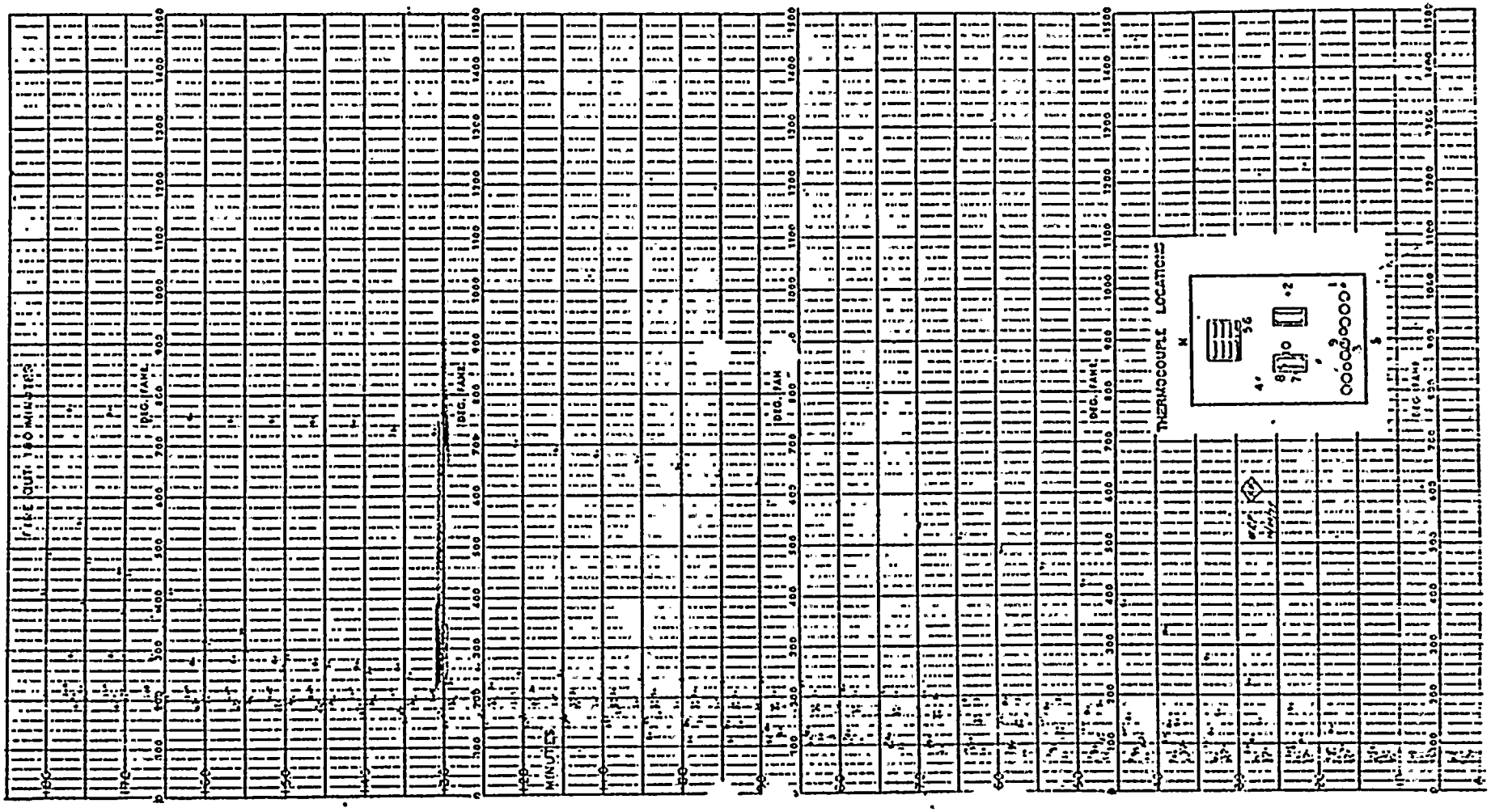


ILLUSTRATION 21

STEEL PIPE, TRA [redacted]ND CA. TEMPERATURES
FIRE ENDURANCE TEST
OCTOBER 28, 1975
DOW CORNING CORP. AND CHEMTROL CORP.



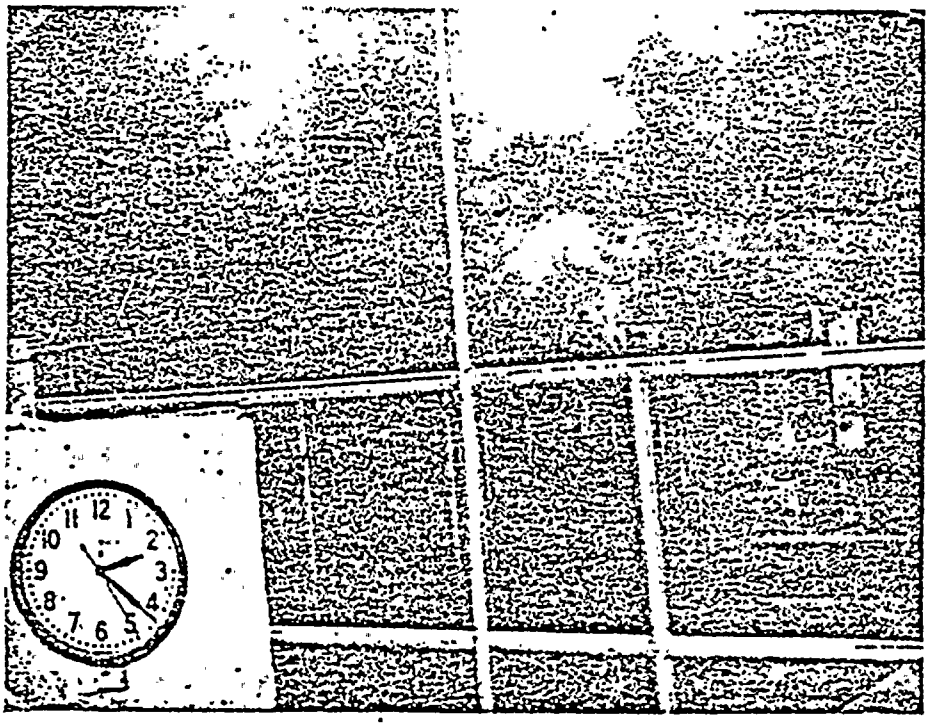


ILLUSTRATION 22

UNEXPOSED SURFACE
AT 142 MIN. OF EXPOSURE
FLAME AT PENT. 1.

(3430-18)

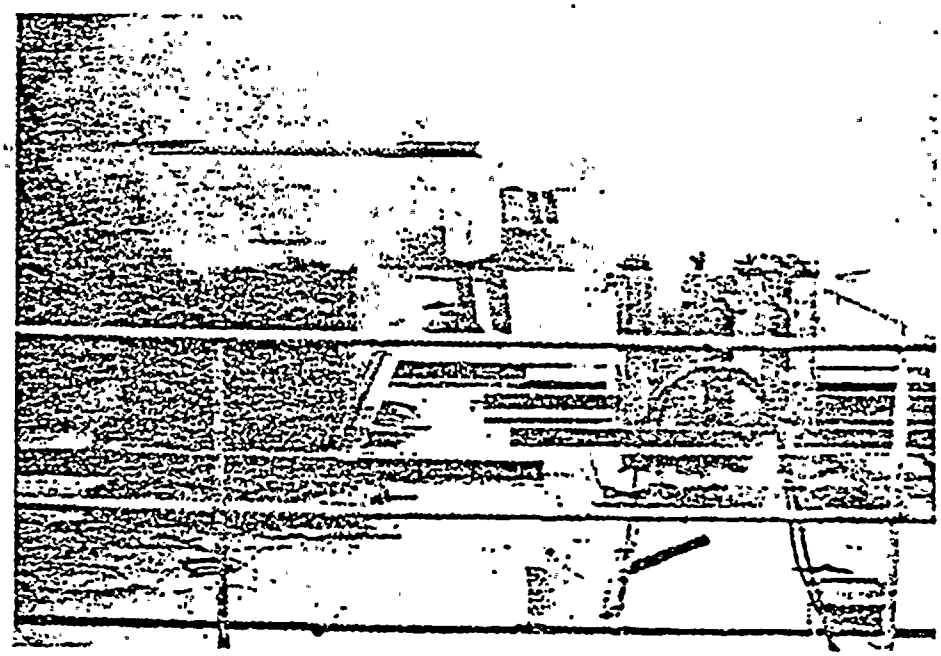


ILLUSTRATION 23

UNEXPOSED SURFACE
AT 3 HRS OF EXPOSURE

(3430-19)

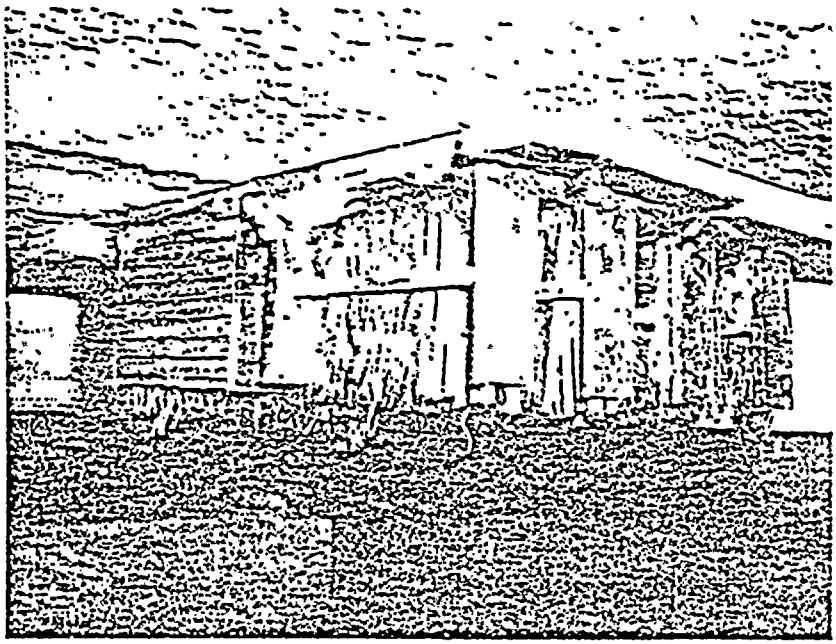


ILLUSTRATION 24

EXPOSED SURFACE OF LARGE PENETRATION AFTER FIRE ENDURANCE TEST

(3430-20)

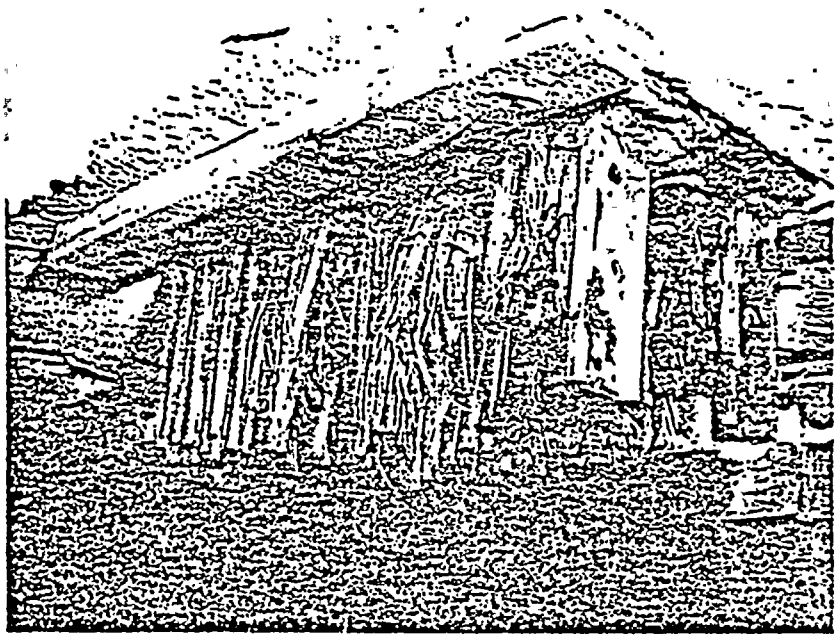


ILLUSTRATION 25

EXPOSED SURFACE OF SMALL PENETRATION AFTER FIRE ENDURANCE TEST

(3430-21)

ILLUSTRATION 26

EXPOSED SURFACE OF
STEEL PIPE PENETRATIONS
AFTER FIRE ENDURANCE TEST

(3430-22)

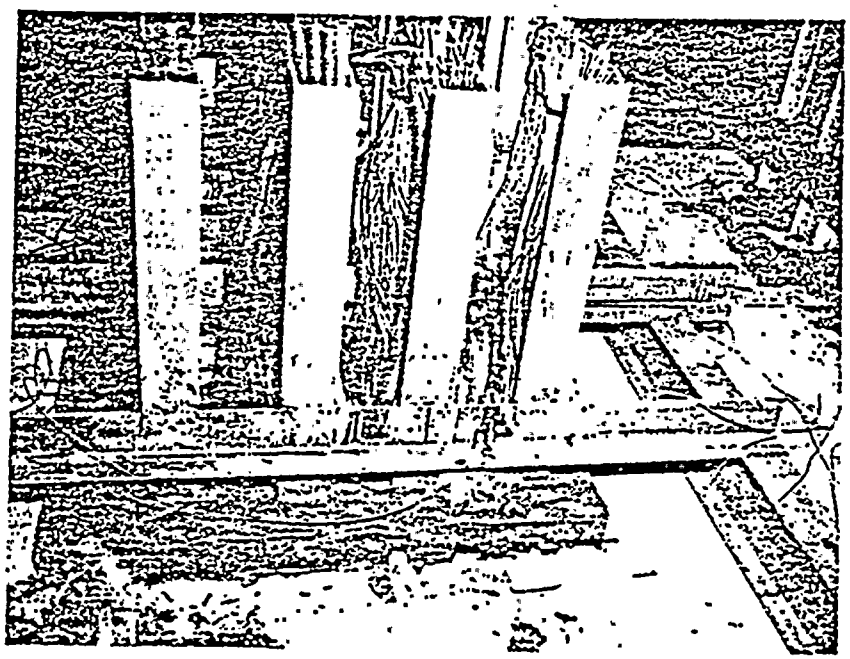


ILLUSTRATION 27

UNEXPOSED SURFACE OF
LARGE PENETRATION AFTER
FIRE ENDURANCE TEST

(3430-23)

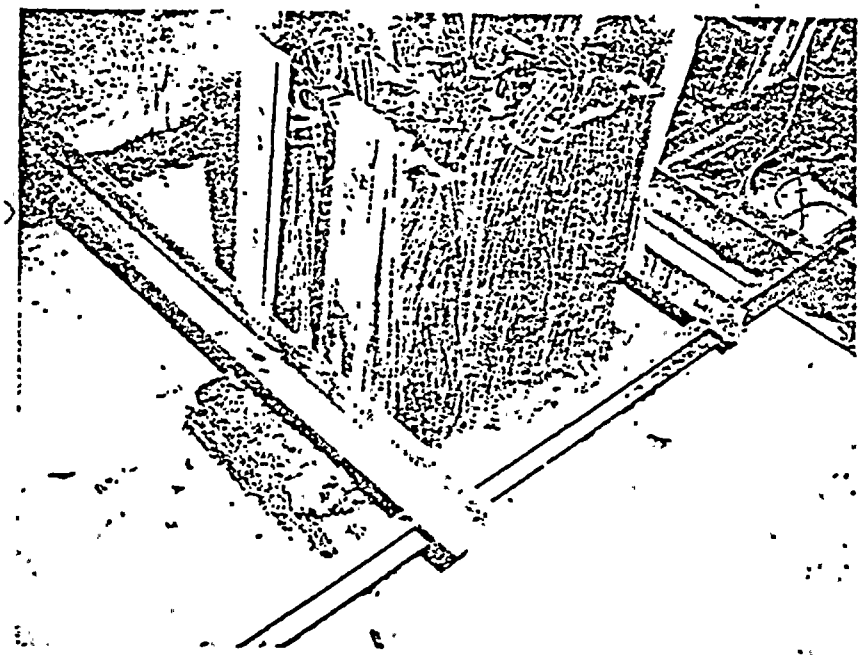


ILLUSTRATION 28

UNEXPOSED SURFACE OF SMALL PENETRATION AFTER FIRE ENDURANCE TEST

(3430-24)

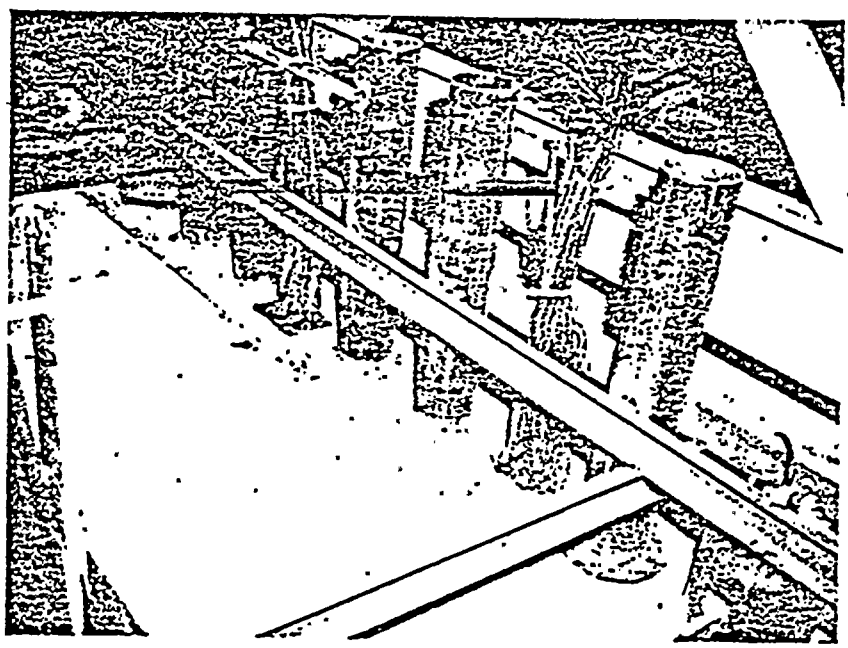


ILLUSTRATION 29

UNEXPOSED SURFACE OF STEEL PIPE PENETRATIONS AFTER FIRE ENDURANCE TEST

(3430-25)

Test by:

Fire Technology Group
National Gypsum Company
Chemtrol Design FC 225

Report, Technical Supervision of Construction and Fire Test by:

W. R. Price

W. R. Price
Factory Mutual Project Engineer

Reviewed by:

W. F. Shield

W. F. Shield
Assistant Chief Materials Engineer
Codes/Ratings
Factory Mutual Research Corporation

ATTACHMENT: Appendix Sheets A1-A12, B1-B3, C1-C12, D1-D2, E1 and F1

ance with the appropriate method described in the packaged installation instructions. Local authorities having jurisdiction should be consulted in all cases as to the particular requirements covering the installation and use of the Classified devices.

LOOK FOR CLASSIFICATION MARKING ON PRODUCT

The Classification Marking of Underwriters Laboratories Inc. (shown below) on the product is the only method provided by Underwriters Laboratories Inc. to identify Wall or Floor Opening Protective, Multiple-Cable Devices which have been produced under its Classification and Follow-Up Service.

WALL (WALL OR FLOOR) OPENING PROTECTIVE
MULTIPLE-CABLE DEVICE
CLASSIFIED BY
UNDERWRITERS LABORATORIES INC.*
FIRE RATING ——————HR

CROUSE-HINDS CO, SYRACUSE NY 13221 — R8819 (N)

*Types TWF6, -10 for use as wall or floor devices.

Hourly Classification	Mounting Position	Assembly Type	Maximum Opening Size (In.)
2 or 3	Vertical	Wall	13⅞ by 16
2 or 3	Horizontal	Floor	13⅞ by 16

LYCKEABORGS BRUK (AB), S-371 90 KARLSKRONA SWEDEN — R9341 (N)

Types RGB-2, -4, -6, -4x2 for use as wall or floor devices.

Hourly Classification	Mounting Position	Assembly Type	Maximum Opening Sizes (mm) Individual Units Height	Multiple Units Width
2 or 3	Vertical	Wall	120 by 218	160 by 250
2 or 3	Horizontal	Floor	120 by 218	160 by 250

NELSON ELECTRIC, UNIT OF GENERAL SIGNAL CORP, TULSA OK 74101 — R7269 (N)

Types RGB-2, -4, -4x2 and -6 for use as wall devices; Types RGB-2, -4, -4x2 and -6 for use as floor devices.

Hourly Classification	Mounting Position	Assembly Type	Maximum Opening Sizes (In.) Individual Units Height	Width	Multiple Units Height	Width
2 or 3	Vertical	Wall	9-11/32	5⅞	7⅞	10"/32
2 or 3	Horizontal	Floor	9"/32	5⅞	7⅞	10"/32

O Z/GEDNEY CO, TERRYVILLE CT 06786 — R8168 (N)

Types CAFSF, CAFSI, CFSF, CFSI for use as wall devices; Types CAFSF, CAFSI, CFSF, CFSI for use as floor devices.

Hourly Classification	Mounting Position	Assembly Type	Maximum Opening Size (Dia-In.)
1, 1½, 2 or 3	Vertical	Wall	8
1, 1½, 2 or 3	Horizontal	Floor	8

WALL OR FLOOR OPENING PROTECTIVE, MULTIPLE-CABLE SYSTEMS (ZCOR)

Wall opening protective multiple-cable systems are designed for the protection of openings in brick, concrete block masonry, or reinforced concrete walls against fire passage when electrical cables, raceways, and pipes penetrate through walls.

Floor opening protective multiple-cable systems are designed for the protection of openings in reinforced concrete floor slabs against fire passage when electrical cables, raceways, and pipes penetrate through floors.

A wall or floor opening protective, multiple-cable system includes specific construction details consisting of opening size; types and sizes of penetrations such as cables, cable trays, conduits, and pipes, together with their means of support through the opening; and the materials which seal the remaining opening.

The systems are subjected to the standard time-temperature fire exposure as described in UL 263 (ANSI A2.1) and hose stream test as described in UL 10B (ANSI A2.2). The hourly fire rating for the system indicates the duration of exposure to the standardized fire test. The unexposed surface temperature of the fill material and the temperatures of the cables, cable trays, and pipes on the unexposed side of the system are not used in determining Classifications.

Combustible materials which can ignite at relatively low temperatures, are not to be placed on or near the system.

The hourly fire resistance Classifications of walls and floors incorporating these systems are not indicated.

The specifications for the system materials and their assembly are important details in the development of fire ratings. Factory Follow-Up Service of Underwriters Laboratories Inc. is available for those materials provided with an (*) in the system description text. Information on such materials and names of manufacturers who have qualified to supply them under the Laboratories' Follow-Up Service are found under the specific product category.

In general, tests for Classification for system materials contemplate interior application only.

The form materials specified for a system are not to be removed after cure of the fill material unless their removal is specified in the itemized description of materials in the individual design.

Unless otherwise indicated in the system the fire rating applies when either face of the wall is exposed to fire. The fire rating for a floor applies when the underside or ceiling face is exposed to fire.

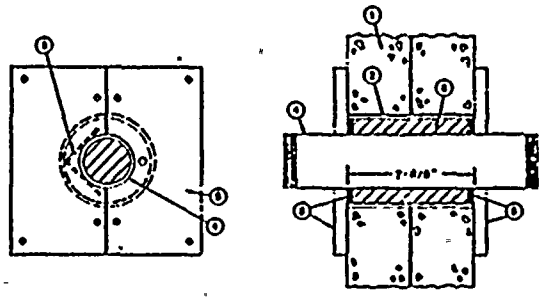
The systems Classified in this category are Classified with respect to (1) installation in a wall only, (2) installation in a floor only, or (3) installation in a wall or floor.

The wall or floor opening protective, multiple-cable systems are to be constructed as described below. Materials used in the systems are to be applied in accordance with any applicable application instructions.

Local authorities having jurisdiction should be consulted in all cases as to the particular requirements covering the installation and use of the Classified systems.

The National Electrical Code, NFPA No. 70, contains requirements for permissible percentage of conductor fill.

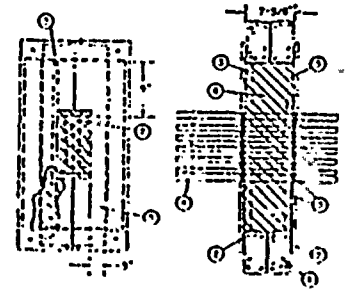
System No. 1
Fire Rating—2 Hr.



1. Wall—Nom 8 in. thick concrete block, or common brick laid up with mortar. Min 2 Hr fire rated wall.
2. Steel Framing—Nom 4 in. diam, 0.25 in. thick steel pipe rigidly attached to wall.
3. Support Angle—3 by 3 by ¼ in. thick steel angle welded to steel framing. For use when steel conduit is used.
4. Steel Conduit—Nom 3½ in. diam rigid steel conduit welded to support angle.
5. Forming Materials—Materials are used as a form and seal to prevent leakage of the foam sealant when in liquid state.
   A. *Form Boards**—½ in. thick units fastened to both sides of wall opening with 2 in. long masonry nails. Units are not removed after foam application.
      Johns-Manville Corp.—Marinite I.
   B. Packing Material—Loose alumina silica fiber packed about form boards, conduit, and cables sufficient to prevent liquid foam leakage.
6. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final thickness shown above. Density 17 pcf min, 20 pcf max.
      SEMCO, A Div. of Product Research & Chemical Corp.—Type PR-855.
7. Cables (Optional)—(Not Shown)—Placed inside of conduit, aluminum conductor, PVC jacket—10/C, No. 14 AWG. 40 percent max cable fill area.

*Bearing the UL Classification Marking

System No. 2
Fire Rating—2 Hr.



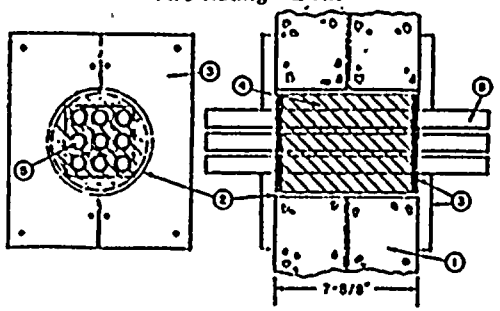
1. Wall—Nom 8 in. thick concrete block masonry, or common brick laid up with mortar. Min 2 Hr fire rated wall. Max size wall opening 12 in. high and 30 in. wide.
2. Steel Framing—3 by 3 by ¼ in. thick steel angles welded together forming a frame on both wall surfaces about the opening.
3. Support Angle—¼ in. legs channel welded to steel framing so outer leg is flush with wall surface.
4. Cable Tray—24 in. wide, 6 in. high ladder or solid min 16 MSG galv steel cable trays. Tack welded at each side to channel supports.

Attachment II
Set 3 of 3

6. Forming Materials—Materials are used as a form and seal to prevent leakage of the foam sealant when in liquid state.
   A. Form Boards*—½ in. thick units fastened to both sides of wall opening with 2 in. long masonry nails. Units are not removed after foam application.
      Johns-Manville Corp.—Marinite I.
   B. Packing Material—Loose alumina silica fiber packed about form boards and cables sufficient to prevent liquid foam leakage.
6. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final thickness shown above. Density 17 pcf min, 20 pcf max.
   SEMCO, A Div. of Product Research & Chemical Corp.—Type PR-855.
7. Cables—40 percent max cable fill area aluminum conductor of the following sizes and types:
   A. PVC jacket 10/C, No. 14 AWG.
   B. Neoprene jacket 10/C, No. 14 AWG.

*Bearing the UL Classification Marking

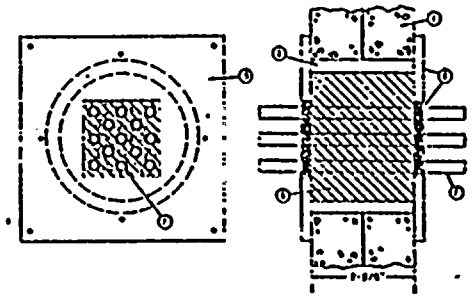
System No. 3
Fire Rating—2 Hr.



1. Wall—Nom 8 in. thick concrete block masonry, or common brick laid up with mortar. Min 2 Hr fire rated wall.
2. Steel Framing—Nom 6 in diam, 0.25 in. thick steel pipe rigidly attached to wall.
3. Forming Materials—Materials are used as a form and seal to prevent leakage of the foam sealant when in liquid state.
   A. Form Boards*—½ in. thick units fastened to both sides of wall opening with 2 in. long masonry nails. Units are not removed after foam application.
      Johns-Manville Corp.—Marinite I.
   B. Packing Material—Loose alumina silica fiber packed about form boards and conduit sufficient to prevent liquid foam leakage.
4. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final thickness shown above. Density 17 pcf min, 20 pcf max.
   SEMCO, A Div. of Product Research & Chemical Corp.—Type PR-855.
5. Cables—Aluminum conductor, PVC jacket 4/C, No. 14 AWG. 40 Percent max cable fill area.

*Bearing the UL Classification Marking

System No. 4
Fire Rating—2 Hr.

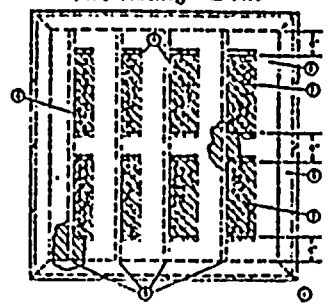


1. Wall—Nom 8 in. thick concrete block, or common brick laid up with mortar. Min 2 Hr fire rated wall.
2. Steel Framing—Nom 4 in. diam, 0.25 in. thick steel pipe rigidly attached to wall.
3. Steel Angle (Optional)—(Not Shown)—3 by 3 by ¼ in. thick steel angle welded to steel framing. For use when steel conduit is used.
4. Steel Conduit (Optional)—(Not Shown)—Nom 6 in. diam rigid steel conduit welded to support angle.
5. Forming Materials—Materials are used as a form and seal to prevent leakage of the foam sealant when in liquid state.

   A. Form Boards*—½ in. thick units fastened to both sides of wall opening with [illegible] long masonry nails. Units are not removed after foam application.
      Johns-Manville Corp.—Marinite I.
   B. Packing Material—Loose alumina silica fiber packed about form boards, conduit, and cables sufficient to prevent liquid foam leakage.
6. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final thickness shown above. Density 17 pcf min, 20 pcf max.
   SEMCO, A Div. of Product Research & Chemical Corp.—Type PR-855.
7. Cables—Placed inside of conduit or in lieu of conduit, aluminum conductor, PVC tele-communication cables. 40 percent max cable fill area.

*Bearing the UL Classification Marking

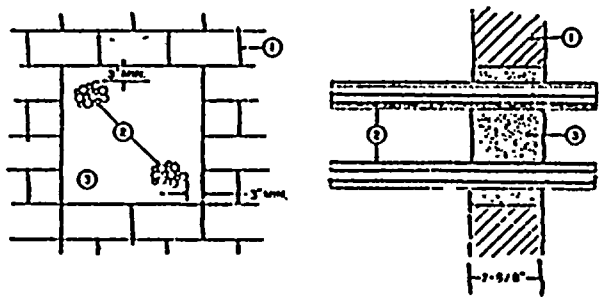
System No. 5
Fire Rating—2 Hr.



1. Wall—Nom 8 in. thick concrete block masonry, or common brick laid up with mortar. Min 2 Hr fire rated wall. Max size wall opening 48 in. high and 48 in. wide.
2. Steel Framing—3 by 3 by ¼ in. thick steel angles welded together forming a frame on both wall surfaces about the opening.
3. Support Angle—¼ in. legs channel welded to steel framing so outer leg is flush with wall surface.
4. Cable Tray—18 in. wide, 4 in. high solid 10 MSG min galv steel cable trays. Tack welded at each side to channel supports.
5. Forming Materials—Materials are used as a form and seal to prevent leakage of the foam sealant when in liquid state.
   A. Form Boards*—½ in. thick units fastened to both sides of wall opening with 2 in. long masonry nails. Units are not removed after foam application.
      Johns-Manville Corp.—Marinite I.
   B. Packing Material—Loose alumina silica fiber packed about form boards and cables sufficient to prevent liquid foam leakage.
6. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final 7⅞ in. thickness. Density 17 pcf min, 20 pcf max.
   SEMCO, A Div. of Product Research & Chemical Corp.—Type PR-855.
7. Cables—40 percent max cable tray fill area, aluminum conductor PVC jacket 4/C, No. 14 AWG.

*Bearing the UL Classification Marking

System No. 6
Fire Rating—2 Hr.



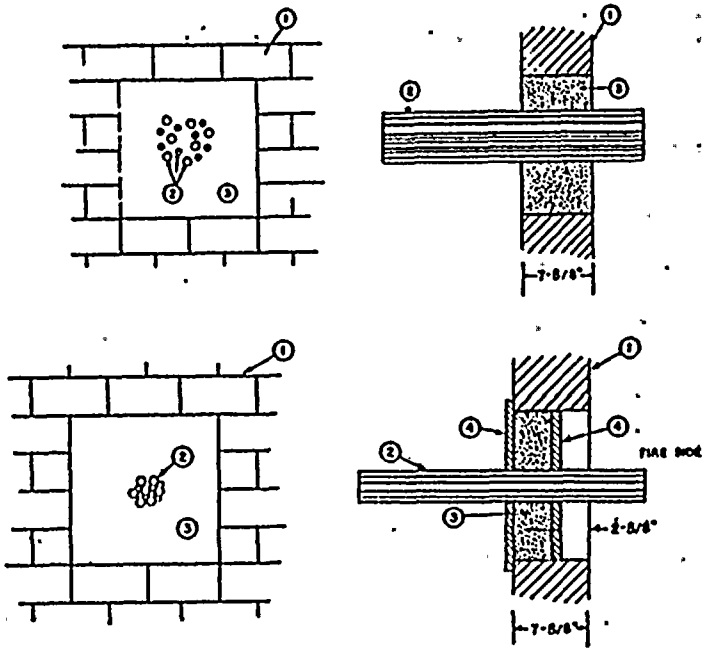
1. Wall—Nom 8 in. thick concrete block, or common brick laid up with mortar. Min 2 Hr Fire Rated wall. Max size wall opening 16 in. high and 16 in. wide.
2. Cables—10 percent max fill area per opening as shown. The following types and sizes of cables may be used:
   A) PVC jacket—600 v, 5 KCMIL (nom 1 in. or 1⅛ in. diam), aluminum and copper conductor.
   B) Hypalon jacket—9/C (nom 1 in. diam) and 4/C (nom ⅞ in. diam), copper conductor.
   C) PVC jacket, tele-communication 25 pair cable.

D) [illegible]one jacket, copper conductor, (nom ⅞ in. diam).

3. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final thickness shown above. Density 17 pcf min, 20 pcf max. Plywood boards ⅞ in. thick used as a form for the liquid foam material. Loose alumina silica fiber packed about cables and forms to prevent foam leakage when in the liquid state.
   Dow Corning Corp.—Type 3-6548.

*Bearing the UL Classification Marking

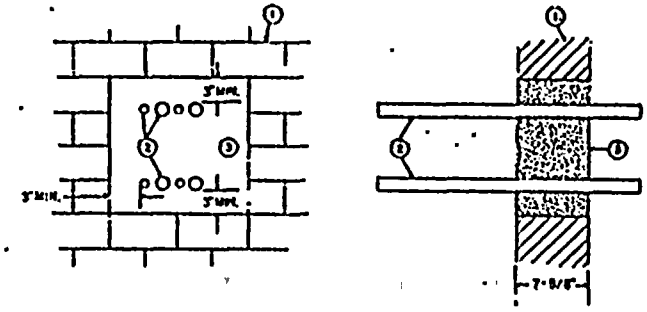
System No. 7
Fire Rating—2 Hr.



1. Wall—Nom 8 in. thick concrete block, or common brick laid up with mortar. Min 2 Hr Fire Rated wall. Max size wall opening 16 in. high and 16 in. wide.
2. Cables—5 percent max cable fill area per opening as shown. Cables may be grouped together or randomly scattered through the opening. Flamtrol Jacket (nom 1 in. diam) 1000 v, 12/C, No. 12 Awg, and Flamtrol Jacket (nom ⅞ in. diam) 11/C, No. 20 Awg, 600 v.
3. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final thickness shown above. When form boards are used min foam thickness is 4 in. Density 17 pcf min, 20 pcf max.
   Dow Corning Corp.—Type 3-6548.
4. Forming Materials—Materials are used as form and seal to prevent leakage of the fill material when in a liquid state.
   A. Plywood—⅞ in. thick sheets temporarily fastened to both wall surfaces. Sheets are removed after fill material has cured.
   B. Packing Material—Loose alumina silica fiber packed around plywood sheets or form boards, and between cables to prevent leakage of liquid fill material and to separate adjoining cables permitting full installation of fill material.
   C. Form Boards*—Optional—1 in. thick units located as shown. One unit is placed over opening and attached to wall surface with 2 in. long masonry nails. The other unit with dimensions approx equal to the wall opening size is placed inside the opening and positioned with its exposed face 2⅝ in. from the wall surface. Units are not removed after fill material installation.
   Johns-Manville Corp.—Marinite I.

*Bearing the UL Classification Marking

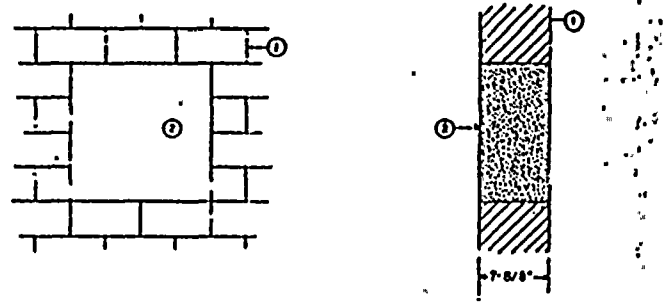
System No. 8
Fire Rating—2 Hr.



1. Wall—Nom 8 in. thick concrete block, or common brick laid up with mortar. Min 2 Hr Fire Rated wall. Max size wall opening 16 in. high and 16 in. wide.
2. Pipes—Aluminum, or steel nom 1 in. or ⅞ in. diam 0.125 in. thick pipes as shown.
3. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final thickness shown above. Foamed silicone also applied filling the interior of pipes. Min 30 in. length of pipe filled with foam material symmetrically located through wall. Density 17 pcf min, 20 pcf max.
   Plywood boards ⅞ in. thick used as a form for the liquid foam material. Loose alumina silica fiber packed about pipes and forms to prevent foam leakage when in the liquid state. Pipes may be removed during foam application, then placed into position after foam has cured.
   Dow Corning Corp.—Type 3-6548.

*Bearing the UL Classification Marking

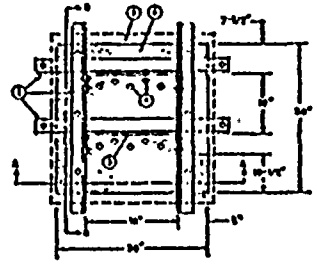
System No. 9
Fire Rating—2 Hr.

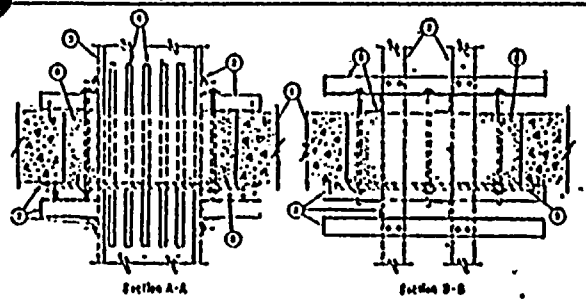


1. Wall—Nom 8 in. thick concrete block, or common brick laid up with mortar. Min 2 Hr Fire Rated wall. Max size wall opening 16 in. high and 16 in. wide.
2. Fill, Void or Cavity Materials*—Foamed silicone applied as described in application instructions to fill the remaining void in the wall opening to a final thickness shown above. Density 17 pcf min, 20 pcf max.
   Plywood boards ⅞ in. thick used as a form for the liquid foam material.
   Dow Corning Corp.—Type 3-6548.

*Bearing the UL Classification Marking

System No. 10
Fire Rating—3 Hr.



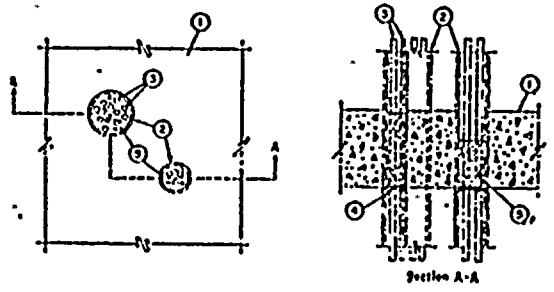


Section A-A Section B-B

1. Floor or Wall Assembly—Nominal 12 in. thick normal weight concrete. Max opening size 30 by 30 in.
2. Support Angles—3 by 3 by 3/16 in. thick steel angles welded together forming a frame on both surfaces of the opening. Angles secured to concrete surfaces with ⅜ in. diam masonry fasteners.
3. Cable Tray—18 in. wide, 4 in. deep, min No. 16 gauge galv steel cable trays with solid fluted steel backing or ventilated 3⅞ in. wide fluted steel backings spaced 12 in. O.C. At least one cable tray per opening. Cable trays attached to support angles with two ⅜ by 20 by 1 in. long steel bolts and nuts inserted through each cable tray side channel.
4. Cable—Various copper conductor cables with single or multiple conductors per cable. Max 7/C; min No. 16 Awg, max 300 MCM, min cable size 0.316 in. diam. PE insulation, PVC jacket material. 23 percent cable fill per cable tray area.
5. Forming Materials—Used as a form and sealant to prevent leakage of the fill materials when in a liquid state.
   A. Form Boards*—1 in. thick Marinite XL units located on the bottom surface of floor openings, and on both surfaces of wall openings. Units fastened to support angles with ⅜ in. diam threaded steel rods with steel washers and nuts located as shown. Units used with RTV800 or SCM4000 fill material are not removed after application of fill material. Units used with RTV6428 or SCM4200 fill material may be removed after the application of fill material.
      Johns-Manville Corp.—Marinite I.
   B. Plywood (Optional)—⅜ in. thick plywood located on the bottom surface of floor openings and on both surfaces of wall openings. Sheets coated with petroleum base grease and temporarily attached to support angles. Sheets used only with RTV6428 or SCM4200 fill material and are to be removed after application of fill material.
   C. Packing Material—Loose or blanket alumina silica fiber packed around the form boards or plywood sheets, and between cables to prevent leakage of liquid fill material and to separate adjoining cables permitting full penetration of the fill materials.
   D. Adhesive*—Bead of silicone adhesive used at joints and edges of form materials to prevent leakage of fill material while in liquid state.
6. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void in the opening. RTV800 or SCM4000 material applied to a final thickness of 12 in. Density 18 pcf min, 23 pcf max. RTV6428 or SCM4200 material applied to a final thickness of 6 in. Density 84 pcf min, 90 pcf max.
   General Electric Co., Silicone Products Dept.—Types RTV800, SCM4000, RTV6428 and SCM4200.

*Bearing the UL Classification Marking

System No. 11
Fire Rating—3 Hr.

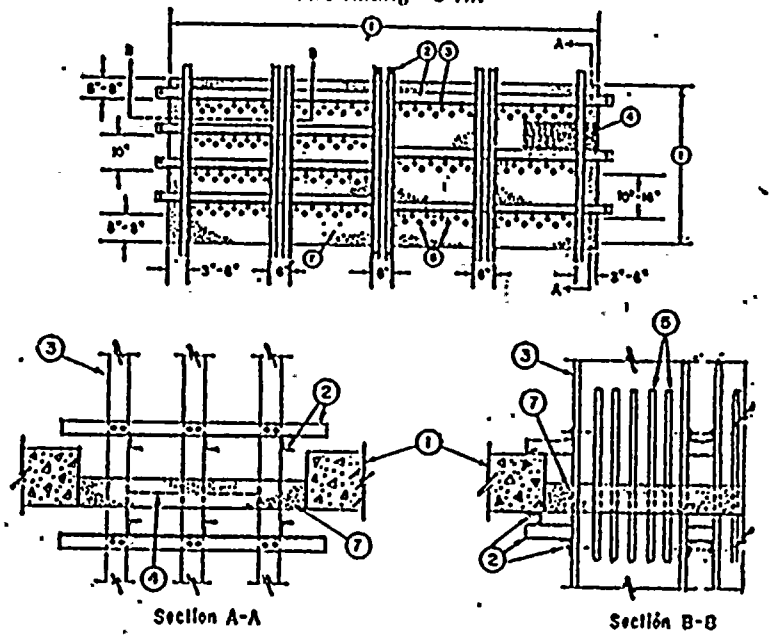


Section A-A

1. Floor or Wall Assembly—Nominal 12 in. thick normal weight concrete.
2. Steel Pipes—Schedule 40 steel pipe, 4 or 6 in. diam.
3. Cables—20 percent fill area per pipe as shown. The following cables to be used:
   A. 300 MCM uninsulated PVC jacket (0.819 in. diam) (max 8 percent fill area per pipe).
   B. 2/C, No. 16 Awg, (0.316 in. diam) PE/PVC.
   C. 9/C, No. 14 Awg, (0.692 in. diam) PE/PVC.
4. Packing Material—Loose alumina silica fiber packed around and between cables to prevent leakage of liquid fill material and to separate adjoining cables permitting full penetration of the fill materials.
5. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void in the opening. RTV800 or SCM4000 material applied to a final thickness of 7½ in. for 4 in. diam pipes and 11½ in. for 6 in. diam pipes. Density 18 pcf min, 23 pcf max. RTV6428 or SCM4200 material applied to a final thickness of 6⅛ in. for 4 in. diam pipes and 7 in. for 6 in. diam pipes. Density 84 pcf min, 90 pcf max.
   General Electric Co., Silicone Products Dept.—Types RTV800, SCM4000, RTV6428 and SCM4200.

*Bearing the UL Classification Marking

System No. 12
Fire Rating—3 Hr.



Section A-A Section B-B

1. Floor or Wall Assembly—Nominal 12 in. thick normal weight concrete. Max area of opening 44 sq ft. Min dimension 2 ft. Max dimension 11 ft.
2. Support Angles—3 by 3 by 3/16 in. thick steel angles welded together forming a frame on both surfaces of the opening. Angles secured to concrete surfaces with ⅜ in. diam masonry fasteners.
3. Cable Tray—Min No. 16 gauge galv steel cable trays with backings of solid fluted steel, solid flat steel, ventilated 3⅞ in. wide fluted steel spaced 12 in. O.C. or ventilated 2⅛ in. wide "hat" sections spaced 6 in. O.C. Min tray with 18 in., max tray width 36 in. Cable trays attached to support angles with two ⅜ by 20 by 1 in. long steel bolts and nuts inserted through each cable tray side channel.
4. Metal Lath—3.4 lb/sq yd expanded steel. Positioned between cable trays when tray spacing in rows ranges from 10 in. O.C. to 16 in. O.C. Lath located at mid depth of fill material.
5. Cables—Various copper conductor cables with single or multiple conductors. Percent of cable tray area filled with cables 11 min, 40 max. Any combination of the following types, and sizes of cables may be used:
   A. 300 MCM; uninsulated PVC jacket; or EP insulation, neoprene jacket. (max 20 percent fill per tray).
   B. 7/C, No. 12 Awg—PE insulation, PVC jacket; vulcanized rubber insulation, neoprene jacket; EPR insulation, neoprene jacket; EP insulation, hypalon jacket; silicone rubber insulation, silicone rubber jacket; or vulcanized rubber insulation, hypalon jacket.
   C. 7/C, No. 16 Awg—mineral filled nonchlorinated XLPE jacket and insulation.
   D. 7/C, No. 14 Awg—silicone insulation, rubber jacket.
   E. 2/C, No. 16 Awg—PE insulation, PVC jacket.
6. Forming Materials—Used as a form and sealant to prevent leakage of the fill materials when in a liquid state.
   A. Mineral Composition Units*—1 in. thick Marinite XL units located on the bottom surface of floor openings and on both surfaces of wall openings. Units fastened to support angles with ⅜ in. diam threaded steel rods with steel washers and nuts. Units are removed after application of fill material.
   B. Plywood—(Optional)—⅜ in. thick plywood located on the bottom surface of floor openings and on both surfaces of wall openings. Sheets coated with petroleum base grease and temporarily attached to support angles. Sheets are to be removed after application of fill material.
   C. Packing Material—Loose alumina silica fiber packed around the mineral composition units or plywood sheets and between cables to prevent leakage of liquid fill material and to separate adjoining cables permitting full penetration of the fill materials.

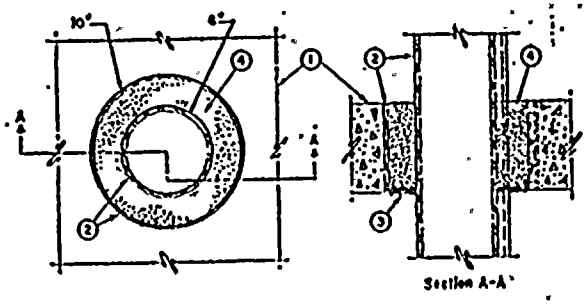
D. Adhesive*—Bead of silicone adhesive used at joints and edges of form materials to prevent leakage of fill material while in liquid state.

7. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void in the opening. Material applied to a final thickness of 6 in. Density 84 pcf min, 90 pcf max.

General Electric Co., Silicone Products Dept.—Types RTV6428 and SCM4200.

*Bearing the UL Classification Marking

System No. 13
Fire Rating—3 Hr.

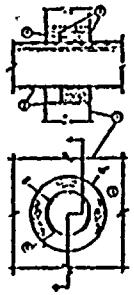


1. Floor or Wall Assembly—Nominal 12 in. thick normal weight concrete.
2. Steel Pipe—Schedule 40, 6 and 10 in. diam steel pipe.
3. Packing Material—Loose alumina silica fiber packed between openings and steel pipe to prevent leakage of liquid fill materials.
4. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void between 6 and 10 in. pipes. RTV800 or SCM4000 material applied to a final thickness of 12 in. Density 18 pcf min, 23 pcf max. RTV6428 or SCM4200 material applied to a final thickness of 6 in. Density 84 pcf min, 90 pcf max.

General Electric Co., Silicone Products Dept.—Types RTV800, SCM4000, RTV6428 and SCM4200.

*Bearing the UL Classification Marking

System No. 14
Fire Rating—2 Hr.

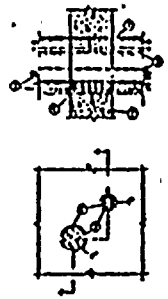


1. Wall Assembly—Nom 12 in. thick concrete block laid up with mortar. Min 4 Hr fire rated wall.
2. Steel Pipe—Schedule 40, 6 and 10 in. diam steel pipe.
3. Packing Material—Loose and blanket type alumina silica fiber packed between openings and steel pipe to prevent leakage of liquid fill materials.
4. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void between 6 and 10 in. pipes. RTV800 or SCM4000 material applied to a final thickness of 8 in. Density 18 pcf min, 23 pcf Max. RTV6428 or SCM4200 material applied to a final thickness of 5½ in. Density 84 pcf min, 90 pcf max.

General Electric Co., Silicone Products Dept.—Types RTV800, SMS4000, RTV6428, SCM4200.

*Bearing the UL Classification Marking

System No. 15
Fire Rating—2 Hr.

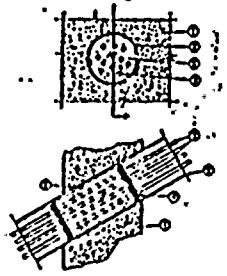


1. Wall Assembly—Nom 12 in. thick normal weight concrete.
2. Steel Pipes—Schedule 40 steel pipe, 4 or 6 in. diam.
3. Cables—18 and 21 percent fill area per 4 and 6 in. pipe as shown. The following cables to be used:
   A. 300 MCM uninsulated PVC jacket (0.835 in. diam) (max 8 percent fill area per pipe).
   B. 2/C, No. 16 Awg. (0.319 in. diam) PE/PVC.
   C. 7/C, No. 12 Awg. (0.702 in. diam) PE/PVC.
4. Packing Material—Loose alumina silica fiber packed around and between cables to prevent leakage of liquid fill material and to separate adjoining cables permitting full penetration of the fill material.
5. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void in the opening. RTV800 or SCM4000 material applied to a final thickness of 8¾ in. for 4 in. diam pipes and 8¾ in. for 6 in. diam pipes. Density 18 pcf min, 23 pcf max.

General Electric Co., Silicone Products Dept.—Types RTV800 or SCM4000.

*Bearing the UL Classification Marking

System No. 16
Fire Rating—3 Hr.

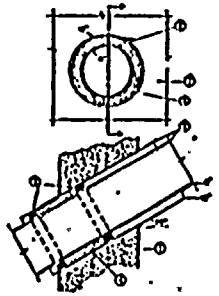


1. Wall Assembly—Nom 12 in. thick common brick laid up with mortar. Min 4 hr fire rated wall.
2. Steel Pipe—Schedule 40, 6 and 10 in. diam steel pipe installed at a 30 deg angle.
3. Packing Material—Loose and blanket type alumina silica fiber packed between steel pipes to prevent leakage of liquid fill materials.
4. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void between 6 and 10 in. pipes. RTV850 or SCM4300 material applied to a final thickness of 9 in. Density 24 pcf min, 27 pcf max. RTV6428 or SCM4200 material applied to a final thickness of 5 in. Density 84 pcf min, 90 pcf max.

General Electric Co., Silicone Products Dept.—Types RTV850, SCM4300, RTV6428, SCM4200.

*Bearing the UL Classification Marking

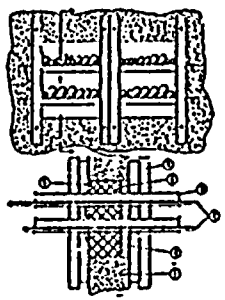
System No. 17
Fire Rating—3 Hr.



1. Wall Assembly—Nom 12 in. thick common brick laid up with mortar. Min 4 hr fire rated wall.
2. Steel Pipes—Schedule 40, 4 or 6 in. diam steel pipe installed at a 30 deg angle.
3. Cables—17.5 and 15.3 percent fill area per 4 and 6 in. pipe as shown. The following cables to be used:
   A. 7/C, No. 12 AWG, (0.753 in. diam) PE/Hyp.
   B. 2/C, No. 16 AWG, (0.319 in. diam) PE/PVC.
   C. 7/C, No. 12 AWG, (0.614 in. diam) VUL/NEO.
4. Packing Material—Loose alumina silica fiber packed around and between cables to prevent leakage of liquid fill material and to separate adjoining cables permitting full penetration of the fill material.
5. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void in the opening. RTV850 or SCM4300 material applied to a final thickness of 9 in. for 4 and 6 in. diam pipes. Density 24 pcf min, 27 pcf max. RTV6428 or SCM4200 material applied to a final thickness of 5 in. for 4 and 6 in. diam pipes. Density 84 pcf min, 90 pcf max.
   General Electric Co., Silicone Products Dept.—Types RTV850, SCM4300, RTV6428, SCM4200.

*Bearing the UL Classification Marking

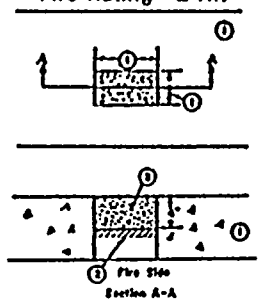
System No. 18
Fire Rating—3Hr.



1. Wall Assembly—Nom 12 in. thick concrete block laid up with mortar. Min 4 hr fire rated wall. Max opening size 24 by 48 in.
2. Support Angles—3 by 3 by ¼ in. thick steel angles welded together forming a frame on both surfaces of the opening. Angles secured through wall with ⅞ in. diam threaded steel rod, nuts and washers.
3. Cable Tray—18 in. wide, 4 in. deep, galv steel open ladder ventilated fluted rung cable trays. Side channels 0.002 in. thick min. Rungs 3¼ in. wide, 0.033 in. thick, and spaced 12 in. O.C. Max of four cable trays per opening. Distance between tray side channels 6⅛ in., distance between trays 4 in. and the distance between trays and edge of the opening min 3 in., max 6⅛ in. Cable trays attached to support angles with two ⅜ by 20 by 1 in. long bolts and nuts inserted through each cable tray side channel.
4. Cables—23 percent fill area per tray as shown. Any combination of the following types and sizes of copper conductor cables may be used.
   A. 1/C, 300 MCM, uninsulated PVC jacket (max 7 percent fill tray).
   B. 7/C, No. 12 AWG, (0.614 in. diam) VUL/NEO.
   C. 2/C, No. 16 AWG, (0.319 in. diam) PE/PVC.
5. Forming Materials—Used as a form and sealant to prevent leakage of the fill materials when in a liquid state.
   A. Form Boards*—Two layers of ½ in. thick units located on both surfaces of wall openings. Units fastened through wall with a min of twelve ⅜ in. diam threaded steel rods with steel washers and nuts. Units used with RTV850 or SCM4300 fill materials are not removed after application of fill material. Units used with RTV6428 or SCM4200 may be removed after application of fill material.
      Johns-Manville Corp.—Marinite I.
   B. Packing Material—Loose alumina silica fiber packed around the form board units and between cables to prevent leakage of liquid fill material and to separate adjoining cables permitting full penetration of the fill materials.
   C. Adhesive—Bead of silicone adhesive used at joints and edges of form materials to prevent leakage of fill material while in liquid state.
6. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void in the openings. RTV6428 or SCM4200 material applied to a final thickness of 5 in. Density 84 pcf min, 90 pcf max. RTV850 or SCM4300 material applied to a final thickness of 9 in. Density 24 pcf min, 27 pcf max.
   General Electric Co., Silicone Products Dept.—Type RTV6428, SCM4200, RTV850, SCM4300.

*Bearing the UL Classification Marking

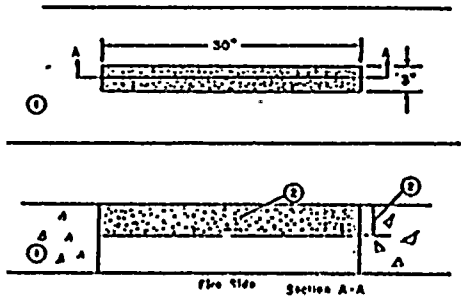
System No. 19
Fire Rating—2 Hr.



1. Floor or Wall Assembly—Nom 18 in. thick normal weight concrete. Max area of opening 32 sq in. Max dimension 8 in., min dimension 4 in.
2. Forming Materials—Used as a form and sealant to prevent leakage of the fill material when in a liquid state.
   A. Form Boards*—1 in. thick units located at the bottom surface of floor openings and at both surfaces of wall openings. Units tightly fitted into opening to prevent fill material leakage.
      Johns-Manville Corp.—Type Cera Form.
   B. Adhesive—Type 90-001 adhesive manufactured by the Dow Corning Corp. used at joints and edges of the form materials to prevent leakage of the fill material while in the liquid state.
3. Fill, Void or Cavity Materials*—Foamed silicone installed as described in the manufacturer's application instructions to fill the void in the opening to a thickness of 4 in. as shown in above illustration. Density 14.8 pcf min, 20 pcf max.
   Dow Corning Corp.—Type 3-6548.
   Semco, A Div. of Product Research & Chemical Corp.—Type PR-855.

*Bearing the UL Classification Marking

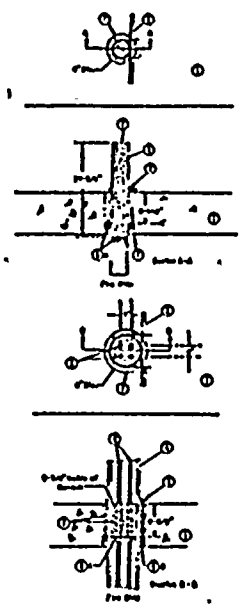
System No. 20
Fire Rating—2 Hr.



1. Floor or Wall Assembly—Nom 8 in. thick normal weight concrete. Opening size of 30 by 3 in.
2. Fill, Void or Cavity Materials*—Foamed silicone preformed and then installed into opening as shown. Fill material preformed using a suitable temporary form and poured in accordance with the manufacturer's application instructions. Fill material preformed to a size of 35 by 7⅛ by 3⅛ in. thick at a min density of 16.2 pcf and a max density of 20 pcf. After material has cured the material is compressed and placed into the opening.
   Dow Corning Corp.—Type 3-6548.
   Semco, A Div. of Product Research & Chemical Corp.—Type PR-855.

*Bearing the UL Classification Marking

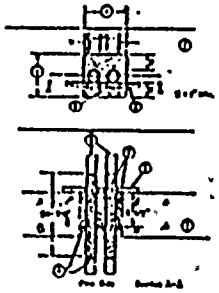
System No. 21
Fire Rating—2 Hr.



1. Floor or Wall Assembly—Nom 8 in. thick normal weight concrete. 6 in. diam opening for pipe penetration. 8 in. diam opening for conduit penetration.
2. Support Angles and Fasteners—⅞ by ⅞ by ⅞ in. thick angle bolted to concrete slab with ⅝ in. diam expansion bolts. Steel rods, 0.305 in. diam, bent to shape and placed about pipe or conduit as shown. Rod secured to angle with appropriate nuts and washers. Support located at top surface of a floor and on both sides of a wall.
3. Steel Pipe—Galv steel pipe, nom 3 in. diam with 0.190 in. thick wall.
4. Steel Conduit—Galv steel pipe, nom 6 in. diam with 0.300 in. thick wall.
5. Forming Materials—Used as a form and sealant to prevent leakage of the fill material when in a liquid state.
   A. Form Boards*—1 in. thick units located at the bottom surface of floor openings and at both surfaces of wall openings. Units tightly fitted into opening to prevent fill material leakage.
      Johns-Manville Corp.—Type Cera Form
   B. Packing Material—1 in. thickness of alumina silica blanket packed between conduit and edge of opening to form and prevent leakage of liquid fill material.
   C. Adhesive—Type 96-081 adhesive manufactured by the Dow Corning Corp. used at joints and edges of the form materials to prevent leakage of the fill material while in the liquid state.
6. Cables—Installed inside of 6 in. conduit, stranded copper 12 conductor, No. 14 AWG, PVC insulation and cable jacket. Max 4 percent fill. Cables installed separated 2 in. O.C. as shown.
7. Fill, Void or Cavity Materials*—Foamed silicone installed as described in manufacturer's application instructions to fill the remaining void between the opening and the pipe or conduit, and also inside of the pipe and conduit as shown above. Material applied to a final thickness as shown in above illustration. Density 14.8 pcf min, 20 pcf max.
      Dow Corning Corp.—Type 3-6548.
      Semco, A Div. of Product Research & Chemical Corp.—Type PR-855.

*Bearing the UL Classification Marking

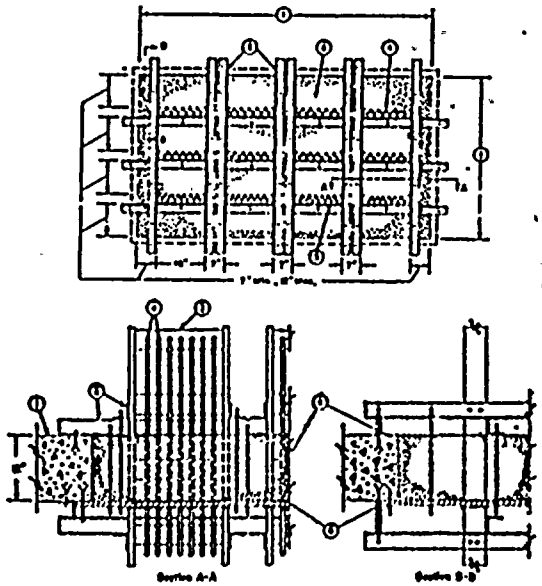
System No. 22
Fire Rating—2 Hr.



1. Floor or Wall Assembly—Nom 8 in. thick normal weight concrete. Max area of opening 64 in. square. Max dimension 8 in. Min dimension 4½ in.
2. Support Angles and Fasteners—⅞ by ⅞ by ⅞ in. thick angle bolted to concrete slab with ⅝ in. diam expansion bolts. Steel rods, 0.305 in. diam bent to shape and placed about pipe or conduit as shown. Rod secured to angle with appropriate nuts and washers. Support located at top surface of a floor and on both sides of a wall.
3. Steel Pipes—Nom 2 in. diam galv steel pipes with 0.136 in. thick wall.
4. Forming Materials—Used as a form and sealant to prevent leakage of the fill material when in a liquid state.
   A. Form Boards*—1 in. thick units located at the bottom surface of floor openings and at both surfaces of wall openings as shown. Units tightly fitted into opening to prevent fill material leakage.
      Johns-Manville Corp.—Type Cera Form.
   B. Adhesive—Type 96-081 adhesive manufactured by the Dow Corning Corp. used at joints and edges of the form materials to prevent leakage of the fill material while in the liquid state.
5. Fill, Void or Cavity Materials*—Foamed silicone installed as described in application instructions to fill the remaining void between the opening and the pipes, and also inside of the pipes. Material installed to a final thickness as shown in above illustration. Density 14.8 pcf min, 20 pcf max.
      Dow Corning Corp.—Type 3 6548.
      Semco, A Div. of Product Research & Chemical Corp.—Type PR-855.

*Bearing the UL Classification Marking

System No. 23
Fire Rating—3 Hr.



NOTE: Form to be placed on both surfaces for wall installation

1. Floor or Wall Assembly—Nom 12 in. thick normal weight concrete. Max area of opening 45 sq ft. Min dimension 5 ft. Max dimension 9 ft.

2. Support Angles—3 by 3 by 3/16 in. thick steel angles welded together forming a frame on both surfaces of the opening. Angles rigidly secured to concrete surfaces with ¼ in. diam masonry fasteners as shown.
3. Cable Tray—18 in. wide, 4 in. deep, galv steel open ladder ventilated fluted rung cable trays. Side channels 0.062 in. thick min, flange 3¼ in. wide, 0.033 in. thick, and spaced 12 in. O.C. Max of 12 cable trays per opening. Distance between tray side channels 7 in. Max 12 in. and min 7 in. between trays and between trays and edge of opening. Cable trays attached to support angles with two ⅜ by 20 by 1 in. long bolts and nuts inserted through each cable tray side channel.
4. Cables—Max 33 percent, min 26 percent fill area per tray. Any combination of the following types and sizes of copper conductor cables may be used:
   A. 7/C, No. 12 AWG, (0.702 in. diam) vulcanized rubber insulation, Hypalon jacket.
   B. 2/C, No. 16 AWG, (0.329 in. diam) polyethylene insulation, PVC jacket.
   C. 7/C, No. 12 AWG, (0.727 in. diam) ethylene propylene rubber insulation, neoprene jacket.
   D. 7/C, No. 12 AWG, (0.736 in. diam) silicone rubber insulation, silicone rubber jacket.
   E. 9/C, No. 14 AWG, (0.000 in. diam) polyethylene insulation, PVC jacket.
   F. 7/C, No. 12 AWG, (0.652 in. diam) polyethylene insulation, PVC jacket.
5. Forming Materials—Used as a form and sealant to prevent leakage of the fill materials when in a liquid state.
   A. Form Boards*—One layer of 1 in. thick units located on both surfaces of wall openings and at bottom surface of floor openings. Units fastened through angles with ⅜ in. diam threaded steel rods with steel washers and nuts located as shown.
      Johns-Manville Corp.—Marinite I
   B. Packing Material—Loose alumina silica fiber packed between cables to prevent leakage of liquid fill material and to separate adjoining cables permitting full penetration of the fill material.
   C. Adhesive*—Bead of silicone adhesive used at joints and edges of form materials to prevent leakage of fill material while in liquid state.
6. Fill, Void or Cavity Materials*—Silicone material applied as described in the application instructions to fill the remaining void in the openings. RTV850 or SCM4300 material applied to a final thickness of 12 in. Density 25 pcf min, 29 pcf max.
   General Electric Co., Silicone Products Dept.—Type RTV850, SCM4300.

*Bearing the UL Classification Marking

FILL, VOID OR CAVITY MATERIALS (ZCPY)

Fill, void, or cavity materials are Classified for use in specific systems described under Wall or Floor Opening Protective, Multiple-Cable Systems. These materials consist of proprietary products. They are intended to be applied as specified under the individual system details. The applicable system number or numbers in which the fill, void or cavity materials are used are shown under the individual manufacturer's Classifications.

Properties of the fill, void or cavity materials other than their capacity to provide a degree of fire resistance to multiple-cable openings in resistive walls have not been investigated.

Authorities having jurisdiction should be consulted before installation.

LOOK FOR CLASSIFICATION MARKING ON PRODUCT

The Classification Marking of Underwriters Laboratories Inc. (shown below) on the product is the only method provided by Underwriters Laboratories Inc. to identify Fill, Void or Cavity Materials which have been produced under its Classification and Follow-Up Service.

FILL, VOID OR CAVITY MATERIALS
CLASSIFIED BY
UNDERWRITERS LABORATORIES INC.
AS WALL (WALL OR FLOOR) OPENING PROTECTIVE, MULTIPLE CABLE SYSTEM MATERIAL FOR USE IN _____HR FIRE RATED SYSTEMS
FOR USE IN SYSTEM NOS. _____, _____, AND _____
SEE UL BUILDING MATERIALS DIRECTORY.

DOW CORNING CORP, MIDLAND MI 48640 R8196 (N)

Type 3-6548 RTV silicone foam, for use in System Nos. 6, 7, 8, 9, 19, 20, 21, or 22.

GENERAL ELECTRIC CO SILICONE PRODUCTS DEPT, WATERFORD NY 12188 R8325 (N)

Types RTV800 and SCM4000 silicone foam for use in System Nos. 10, 11, 13.
Types RTV850 and SCM4300 silicone foam for use in System Nos. 16, 17, 18, 23.
Types RTV8428 and SCM4200 silicone material for use in System Nos. 10, 11, 12, 13, 14, 15, 16, 17, 18.

SEMCO, DIV OF PRODUCT RESEARCH & CHEMICAL CORP, GLENDALE CA 91203 R8146 (N)

Type PR-855 RTV silicone foam, for use in System Nos. 1, 2, 3, 4, 5, 19, 20, 21, 22.

FORM BOARDS. (ZCRW)

Form boards are rigid sheet products manufactured from a proprietary mixture of predominantly inorganic materials. They are used as a form and seal to prevent leakage during the installation and curing of void or cavity fill materials. After the installation, the boards are left in place and together with the fill material provide a degree of fire resistance for the opening.

The form boards are Classified for use in specific systems described under Wall or Floor Opening Protective, Multiple-Cable Systems (ZCOR). They are intended to be installed as specified under the individual system details. The applicable system number or numbers in which the form boards are used are shown under the individual manufacturer's Classification.

Authorities having jurisdiction should be consulted before installation.

FORM BOARDS. (ZCRW)—*Continued*

LOOK FOR CLASSIFICATION MARKING ON PRODUCT

The Classification Marking of Underwriters Laboratories Inc. (shown below) on the product is the only method provided by Underwriters Laboratories Inc. to identify Form Boards which have been produced under its Classification and Follow Up Service.

FORM BOARDS
CLASSIFIED BY
UNDERWRITERS LABORATORIES INC.
AS WALL (WALL OR FLOOR) OPENING PROTECTIVE, MULTIPLE-CABLE MATERIAL FOR USE IN SYSTEM NOS._____
SEE UL BUILDING MATERIALS DIRECTORY

JOHNS-MANVILLE CORP, DENVER CO 80217 R8956 (N)

Marinite I for use in System Nos. 1, 2, 3, 4, 5, 7, 10, 18, 23.
Ceraform for use in System Nos. 19, 21, 22.