Southern California Edison Company

P. O. BOX 800

2244 WALNUT GROVE AVENUE

ROSEMEAD, CALIFORNIA 91770

JACK B. MOORE
VICE PRESIDENT

TELEPHONE
213-572-2292

May 30, 1979

Office of Inspection and Enforcement
Region V
U. S. Nuclear Regulatory Commission
Suite 202, Walnut Creek Plaza
1990 North California Boulevard
Walnut Creek, California 94596

Gentlemen:

Attention: Mr. R. H. Engelken, Director

Subject: Docket Nos. 50-361 and 50-362
San Onofre Nuclear Generating Station, Units 2 and 3

In a letter from your office dated April 27, 1979, we were requested to respond to a Notice of Violation resulting from the inspection of San Onofre Units 2 and 3 which took place during the period of February 1-28, 1979. Our response is provided as attachments I and II.

I trust that the attachments respond adequately to all aspects of the Notice of Violation. If you have any questions, or if we can provide additional information, please let me know.

Very truly yours,

J B Moore

Attachments
cc: R. J. Pate (NRC, San Onofre 2 and 3)

ATTACHMENT I

Notice of Violation

Based on the results of an NRC inspection conducted on February 1-28, 1979, it appears that certain of your activities were not conducted in full compliance with conditions of your NRC Construction Permit Nos. CPPR-97 and CPPR-98 as indicated below. These items are infractions.

A. 10 CFR Part 50, Appendix B, Criterion IX, states, in part, that "measures shall be established to assure that special processes, including...heat treating..are controlled and accomplished...using qualified procedures in accordance with applicable codes..."

Paragraph 9.1.1 of the SONGS Units 2 and 3 Quality Assurance Manual implementing the above criterion during design and construction of the facilities states, in part, that, "Special process procedures shall be qualified prior to use to demonstrate their ability to meet specified design requirements..."

Contrary to the above, as of February 5, 1979, the post weld heat treating procedure using the quartz lamp technique had not been qualified before use to demonstrate that the minimum heat treating temperature of 1100°F, a design requirement, was met during the post weld heat treatment of main steam piping and reactor coolant piping welds. This procedure had been used since mid-1977 for heat treating the aforementioned welds at Units 2 and 3.

1. Corrective Steps Which Have Been Taken and the Results Achieved

A testing and evaluation program was undertaken to demonstrate that the Post Weld Heat Treatment Procedure (PHT-501, Revision 5) utilized on San Onofre Units 2 and 3 produces acceptable post weld heat treatment in accordance with Section III of the ASME B&PV Code. The detailed description and results of this testing and evaluation program are included as Enclosure 1, Evaluation of Post-Weld Heat Treatment Processes, San Onofre Nuclear Generating Station, Units 2 and 3 (May 1979). In summary, Enclosure 1 demonstrates that while procedure PHT-501, Revision 5 did not procedurally ensure that the internal pipe temperature in the heat affected zone was maintained above 1100°F, acceptable post weld heat treatment operations have been performed at San Onofre Units 2 and 3. Acceptable post weld heat treatments, in accordance with Section III of the code, are demonstrated to have been obtained for all welds by test, review of appropriate post weld heat treatment records and evaluation.

In addition, the tests, data and evaluations described in Enclosure 1 are the bases for qualification of Post Weld Heat Treatment Procedure PHT-501, Revision 6. This revision procedurally ensures that internal pipe temperatures in the heat affected zone will be maintained above Section III of the code minimum allowables.

2. Corrective Steps Which Will Be Taken

Quality Control inspection and Quality Assurance surveillance of post weld heat treat operations will continue to be performed to assure that the process is controlled.

3. Date By Which Full Compliance Will be Achieved

Full compliance was achieved on May 25, 1979, the date when procedure PHT-501, Revision 6 was placed into use at San Onofre Units 2 and 3.

ATTACHMENT II

10 CFR Part 50, Appendix B, Criterion XII states, in part, that, "Measures shall be established to assure that tools... used in activities affecting quality are properly controlled, calibrated and adjusted at specified periods to maintain accuracy...."

Paragraph 12.1.1 of the SONGS Units 2 and 3 Quality Assurance Manual implementing the above criterion states, in part, that "The calibration of measuring and test equipment and devices will be controlled to comply with applicable...standards."

Contrary to the above, as of February 22, 1979, the relief valve pressure setting of the AMP hydraulic pump No. EC-206, a device used to establish the proper crimping of large electrical cable termination lugs, had not been calibrated monthly as specified in the device instruction manual. This device was used for crimping lugs on safety related cables at Unit 2.

1. <u>Corrective Steps Which Have Been Taken and Results Achieved</u>

The relief valve pressure setting for AMP hydraulic pump No. EC-206 was immediately checked and determined to be within the specified tolerance of the instruction manual. In addition, all other relief valves on AMP hydraulic crimping devices in use at San Onofre Units 2 and 3 were checked and the relief pressure settings verified to be within specified tolerances. Based on this confirmation of proper relief valve settings for these crimping devices, the lugs previously installed in safety related cables were accomplished in accordance with the vendor's instruction manual(s) regarding relief valve pressure settings.

Further, vendor manuals for related types of hydraulic crimping devices in use at San Onofre Units 2 and 3 were reviewed and determined not to contain periodic relief valve calibration requirements to ensure proper operation.

A procedure change was issued on April 11, 1979 which requires documented periodic calibration of pressure relief valves in accordance with vendor instruction manuals.

2. Corrective Step Which Will Be Taken

The calibration program for pressure relief valves as discussed above is now part of the Quality Assurance Program and will be appropriately monitored and audited.

3. Date When Full Compliance Will Be Achieved

Full compliance was achieved on April 11, 1979 with the issuance of the procedure change described above.

ENCLOSURE 1

EVALUATION

OF

POST-WELD HEAT TREATMENT PROCESSES

San Onofre Nuclear Generating Station

Units 2 and 3

May 1979

PROBLEM DEFINITION

The NRC has issued a citation regarding a lack of objective evidence that the Post-Weld Heat Treatment (PWHT) procedures in use on San Onofre 2&3 are properly qualified. Specifically there is a concern that the PWHT procedure in use does not ensure that the entire heat affected weld zone is maintained within the required temperature range for the required time period.

PWHT PROCEDURES IN USE ON SONGS 2&3

Two PWHT treatment methods are in use on San Onofre 2&3. These are the resistance blanket method and the quartz lamp method. Both methods have been used on previous nuclear projects.

The resistance blanket heat treatment method simultaneously used internal and external heaters to treat the heat affected zone. Externally, three different heat widths were used because of the geometry adjacent to the welds. These widths ranged from a minimum of 27 inches, 7.2T, to a maximum of 40 inches, 9.7T. The heaters on the pipe exterior were controlled in six zones by six thermocouples placed at the outside edge of the Code required heated band. The inside heaters were controlled in four zones by four external thermocouples on the edge of the Code required heated band. All controlling thermocouples were programmed to be within the required soak temperature range. Because the arrangement assured temperature uniformity, only the lower outside Code required heated band thermocouple was recorded.

The quartz lamp PWHTs utilized two parallel bands of heating modules placed around the pipes. In all cases thermocouples are recorded at the lower outside edge of the ASME Section III required heated band. For 5G welds, an additional thermocouple recorded the temperatures on the upper outside edge also.

QUALIFICATION OF PROCEDURES, EQUIPMENT, AND PERSONNEL

The critical parameters requiring control in post-weld heat treatment are temperature and time at temperature. Each post-weld heat treatment is recorded on a strip chart that plots reference thermocouple temperature versus time. Placement of the thermocouples and setup of the equipment is verified by Bechtel Quality Control personnel. The recorders are calibrated at least every 6 months as required by the welding procedures. The calibration records are located in the field welding office file per project procedure WPP/QCI209. Special qualification of personnel and equipment are not required. The strip chart record provides objective evidence that the equipment functioned correctly and that the operator properly supervised the PWHT procedure. NCR's are written when these permanent records indicate nonconforming conditions exist.

All previous PWHT welds were reviewed to verify that the code minimum allowable temperature was met or exceeded both inside and outside of the pipe in the heat affected zone. The heat affected zone is defined as an area 1/4 inch on either side of the weld per the letter from Combustion Engineering (Appendix A).

EXTENDED HEATING TIMES

The ASME Section III paragraph NB 4622.4 has long recognized that it may not always be possible to achieve the "specified minimum" temperatures. For the material of interest, if the "minimum temperature", 1100F, is not achieved, then lower temperatures are permitted provided the soak or holding time at temperature is increased. It is specified that if the minimum temperature was 1050F then the holding time shall be 2 hours per inch of thickness. Interpolations are allowed for intermediate temperatures.

Additionally the Winter 1975 Edition of the ASME Code paragraph NB-4622.4 (c)(1) exempts P-1 material from the requirement for remaking impact test specimens using the reduced holding temperatures and extended heating times. This exemption is being used on San Onofre 2&3.

TEST DATA

Since data was not collected to determine internal pipe temperatures, a series of tests were conducted using quartz lamp and resistance blanket methods to determine the maximum through-wall temperature gradient that could occur during PWHT. Knowing this gradient and knowing the reference thermocouple temperature that was maintained during PWHT, the minimum internal pipe temperature that existed during PWHT could be determined and verified to be above the code required minimum temperature.

A test was conducted at the Cooperheat facilities in Mountain View, California during March 1979 to determine the maximum through-wall temperature gradient using the resistance blanket method of PWHT. The test configuration was the same as that used on San Onofre production welds with the external heater width being less than the width used in production welds for conservatism. The internal heaters were 6-1/2 inches wide and were controlled from outside surface thermocouples as is done on production welds. The test showed essentially no temperature difference through the pipe wall with internal temperatures varying from 5F cooler inside the pipe to 25F warmer inside the pipe. Test data is provided in Appendix B. It can therefore be concluded that for resistance blanket method of PWHT, maintaining the reference thermocouple at 5F or greater above the code required temperature will ensure that the internal temperature in the heat affected zone meets code requirements.

Three tests were run on production weld quartz lamp heat treatments to demonstrate that the heat affected zone has been maintained above code minimums for all production welds. Test data and figures are in Appendix C.

The first test was run on a vertical reactor coolant system cold leg elbow to elbow weld with a 3-3/8 inch wall thickness (figure C-1). This test was selected since it would yield the largest negative through-wall differential temperatures since "chimney effect" (air velocity gradients in the pipe due to thermal heating) is maximized in vertical piping configurations. Reference thermocouples were placed on the outside diameter of the pipe at the crotch and outside of the elbow (location 1) 2-1/4 inches from the lower edge of the weld. These locations correspond to the standard thermocouple locations on production welds. Eight test thermocouples were then attached to the pipe. Two thermocouples were placed on the outside diameter of the elbow adjacent to the reference thermocouples described above. The remaining six thermocouples were placed on the inside diameter of the elbow at locations 2, 3, and 4 (figure C-1) on the crotch and outside of the elbow. The data recorded by one of the eight thermocouples, No. 4, located on the outside elbow was not accurate. Subsequent to the test, when the thermocouple was inspected, it was found to be held in place by the insulation and was not properly welded to the elbow wall which explains the inconsistent reading.

The thermocouple locations are shown in figure C-1 and the temperatures recorded are listed in table C-1. The through-wall differential temperature was 25F on the crotch of the elbow and 40F on the outside of the elbow one inch away from the weld centerline. This is well outside the heat affected zone.

The conclusion that can be drawn from this test is that for all pipe with 3-3/8 inch or less wall thickness, as long as the reference thermocouple is 40F or better above the code required minimum temperature, the inside diameter heat affected zone temperature will be acceptable. Since a vertical pipe configuration was tested and since this configuration maximizes the through-wall gradient, all horizontal pipes 3-3/8 inch or less in thickness will also have inside diameter heat affected zone temperatures that are acceptable as long as the reference thermocouple is 40F above the code required minimum temperature.

The second test was run on a horizontal reactor coolant cold leg pipe with 2-7/8 inch wall thickness on one side of the weld and 3-1/2 inch wall thickness elbow on the other side of the weld. The thicker walled elbow (3-1/2 inches) was selected for instrumenting since it would yield the largest through-wall temperature gradient. The thermocouple locations are shown in figure C-2, and the temperatures recorded are listed in table C-2. The through-wall differential temperature was plus 40F at the top and 0F at the bottom of the pipe with the weld centerline temperature being hotter than the reference thermocouple. With a horizontal configuration it is expected that the top of the pipe will be hotter than the bottom of the pipe.

The third test was run on a horizontal 2-inch wall thickness pipe to confirm the data from test number 2. The results of this test (figure C-3 and table C-3) show that one inch away from the weld centerline on the inside of the pipe the temperatures was 25F warmer than the reference thermocouple. This is expected since the internal thermocouple is located some 2 inches closer to the warmer centerline region.

The horizontal tests confirm that through-wall temperature gradients are much less than in the vertical piping configuration and may be even positive in some cases. In this test the through-wall gradient one inch from the weld centerline on the inside of the pipe (well outside the heat affected zone) was zero degrees. All quartz lamp production weld heat treatments on piping over 3-3/8 inches in thickness were done on horizontal piping runs with reference thermocouple temperatures of at least 1130F. The test data demonstrates that these welds would have inside diameter heat affected zone temperatures that meet code required temperatures.

FINITE ELEMENT MODEL OF PWHT TEMPERATURE GRADIENTS

A finite-element model was developed to predict post-weld heat treatment through-wall temperature gradients for reactor coolant piping. This mode would confirm the acceptability of post-weld heat treatments for pipes thicker than those field tested, quantify the effects of having pipe ends blocked during PWHT, and analyze the effect of various temperature gradients along the outside of the pipe on pipe inside diameter weld centerline temperatures.

Figures D-1 through D-4 and D-5 through D-8 are in Appendix 4D and show the predicted inside pipe diameter temperatures for outside pipe diameter temperature gradients of 40, 30, 20 and 10F per inch. Outside pipe temperature gradients of 20 and 30F per inch are usually encountered in production welds. The 10 and 40F per inch gradients were modeled to bound the analysis. The pipe modeled had a 3-inch wall thickness, was in a vertical configuration, and had ends both blocked and unblocked. In all cases, a 10F/inch outside gradient yielded the lowest internal temperature. This configuration would yield the largest through-wall temperature gradients. With a reference temperature 2 inches from the weld edge of 1165F, the lowest internal temperature, 1 inch from the weld centerline (outside heat affected zone), calculated was 1138F with pipe ends unblocked. This is a maximum through-wall temperature gradient of 37F and confirms that the 3-inch and smaller wall thickness pipes are acceptable since these pipes were all heat treated at reference temperatures at least 40F above the required temperature. The effect of not blocking the ends of the pipe is an increase in the through-wall temperature gradient of 6F for the 3-inch wall thickness vertical piping.

The computer model predicted a temperature difference of minus 27F between the control thermocouple on a 3-inch thick vertical axis pipe and the internal weld centerline. The installation test data from Appendix C showed this temperature difference on a 3-3/8 inch thick (compared to 3-inch thick) vertical axis pipe to be 35F. This shows good correlation considering the thicker wall pipe, the difference in thermocouple placement, and the accuracy of the recorders. The good correlation justifies use of the program to predict the internal temperatures on thicker pipe.

Figures D-9 through D-12 show the predicted inside pipe diameter temperatures for a horizontal 4-1/8 inch wall thickness pipe with ends unblocked. With a reference temperature 2 inches from the weld edge of 1165F, and a

10F/inch external axial temperature gradient the lowest weld heat affected zone temperature calculated was 1125F. This is a maximum through-wall gradient of 40F. Since all horizontal quartz lamp heat treatments were performed at temperatures 40F above code minimums, all 4-1/4 inch wall thickness and smaller piping will have inside diameter weld centerline temperatures that are acceptable.

ACCEPTABILITY OF PREVIOUS WELDS

Table 1 provides a representative list of welds heat treated and demonstrates the acceptability of each treatment. The table includes all welds thicker than three inch specified thickness. The last three welds listed in Table 1 are the welds shown in figures C-1 through C-3. In each case, heat affected zone temperatures were above 1100F even though the code would have allowed lower temperatures because of longer than required soak times.

REVISION OF EXISTING PROCEDURES

Since the existing Post-Weld Heat Treatment Procedure, PHT-501-Rev. 5, has not been written to ensure that internal temperatures in the heat affected zone are maintained above 1100F, it has been revised. The testing performed and discussed in this report qualifies revision 6 to PHT-501. This revised procedure ensures that internal temperatures in the heat affected zone will be maintained above code minimum allowables. Qualification of personnel and equipment have been previously discussed in this report.

Table 1

Weld Acceptance Data

Line & Weld	Position	PWHT Method	Thk. (In.)	Time Over 1100F (hours)	Soak Temp. 2 inch from OD Fusion Line	Min. Accept. Temp. Based on Time Above 1100° F	Predicted Internal Temperatures 1 inch from Weld Centerline (°F)	Margin (°F)	Hold Time Min. Req.	Hold Time Actual	Disposition
S2 1201 ML 001 A	5G	R	3-3/4	4	1130	1085	1125	40	2:27	3-1/2	Accept
S2 1201 ML 001 B	5G	QL	4-1/8	5	1150	1080	1110	30	2:32	4-1/2	Accept
S2 1201 ML 002 A	5G	QL	3-3/4	3-3/4	1130	1087	1090	3	2:27	3-1/2	Accept
Redone	5G	R	3-3/4	4-1/4	1160	1082	1155	73	2:27	3-1/4	Accept
S2 1201 ML 002 B	5G	QL	4-1/8	5-1/2	1140	1075	1100	25	2:32	3-1/4	Accept
S3 1201 ML 001 A	5G	R	3-3/4	4-1/2	1140	1080	1135	55	2:27	3	Accept
S3 1201 ML 001 B	5G	R	4-1/8	5	1130	1080	1125	45	2:32	3	Accept
S3 1201 ML 002 A	5G	R	3-3/4	3	1120	1095	1115	20	2:27	2-3/4	Accept
S3 1201 ML 002 B	5G	R	4-1/8	3-1/2	1130	1090	1125	35	2:32	3-1/4	Accept
S3 1301 ML 364 3	5G	QL	2	3	1145	1075	1105	30	2	2-1/2	Accept
S3 1201 ML 005 C	5G	QL	2-7/8 3-1/2	3-1/2	1140	1082	1100	18	2:13	3	Accept
S3 1201 ML 004 B	2G	QL	3-3/8	3-2/3	1155	1085	1115	30	2:21	3	Accept

APPENDIX A

LETTER FROM COMBUSTION ENGINEERING
REGARDING HEAT AFFECTED TIME
IN REACTOR COOLANT PIPE WELDS

C-E Power Systems
Combustion Engineering, Inc.
1000 Prospect Hill Road
Windsor, Connecticut 06095

Tel. 203/688-1911
Telex: 99297

JOB 10079
FILE 923
LOG CB 3698

AUG 25 '77

ROUT.		NOTED	COPIES TO	
	PROJ. MGR.			
	PROJ. ENG.			
	ASST. PROJ. ENG.			
	PROJ. ADMIN.			
	PROJ. ARCH.			
	PROJ. C. E.			
	PROJ. C. S. E.			
	PROJ. E. E.			
	PROJ. M. E.			
	PROJ. PLANT DES.			
	PROJ. N. E.			
	PROJ. Q. A.			
	PROJ. C. & ECH. E.			
	PROJ. COST E.			
	PROJ. ECH.			
	PROJ. T. E.			
	File			

Callahan
Rogers
Ryan
Limstrom

POWER SYSTEMS

August 19, 1977

S-CE-4126

Southern California Edison Company
San Onofre Units 2 and 3
SCE Order No. N1800003
Bechtel Job No. 1304-60
C-E Contracts 1370 and 1470

Mr. S. V. Tashjian
Project Management Engineer
San Onofre Units 2 and 3 Project
Room 353 - General Office
Southern California Edison Company
P. O. Box 800
Rosemead, CA 91770

Subject: Heat Affected Zone in Reactor Coolant Pipe Welds

Enclosure: (1) C-E Letter from J. W. Reed and George St. Cin, "Certification of Specific Welding Processes", dated August 19, 1977

Dear Mr. Tashjian:

Per your request we are forwarding for your use a statement from Messrs. Reed and St. Cin that the heat affected zone on typical welds of reactor coolant piping is less than 1/4 inch in width.

We also direct you to paragraphs NB-2546.2 and NB-5351(a) of the 1977 edition of the ASME Code both of which address to the question of indications at the interface between cladding and the base metal. These two paragraphs define such indications as not relevant. Paragraph NA-1140 of the ASME Code allows later editions of the Code to be used provided all concerned parties are in agreement. You may want to point out these paragraphs of the Code to your Authorized Inspector.

Please advise if we can be of further assistance in this matter.

Very truly yours,

R. W. DeVane, Jr.
Project Manager

RWD:AHS/agl
Enclosure

cc: J. D. Houchen (Bechtel) w/encl.
W. P. Hsiao (SDG&E) w/o encl.
W. L. MacDonald (C-E Orange) w/o encl.
S. W. Schock (C-E San Clemente) w/o encl.

C-E Power Systems
Combustion Engineering, Inc.
1000 Prospect Hill Road
Windsor, Connecticut 06095

Tel. 203/688-1911
Telex: 99297

POWER SYSTEMS

August 19, 1977

Southern Cal Edison
San Onofre Field Site
Certification of Specific
Welding Processes

TO WHOM IT MAY CONCERN:

This is to certify that the typical heat affected zone of shielded metal arc welding processes utilizing E-8018-XX or E-7018 type electrodes is approximately 1/8" wide in base material. This information is based on numerous samples made and examined at Combustion Engineering, Inc., Chattanooga Nuclear Operations, Chattanooga, TN over a several year period. Considering the possibility that slight differences in the widths of heat affected zones may exist due to the utilization of differences in welding parameters and techniques, we would consider that a 1/4" maximum width would be a safe and extremely conservative dimension for a heat affected zone utilizing the above mentioned materials.

Very truly yours,

COMBUSTION ENGINEERING, INC.

original signed by J. W. Reed

J. W. Reed, Section Manager
Nuclear Quality Engineering
Chattanooga Nuclear Operations

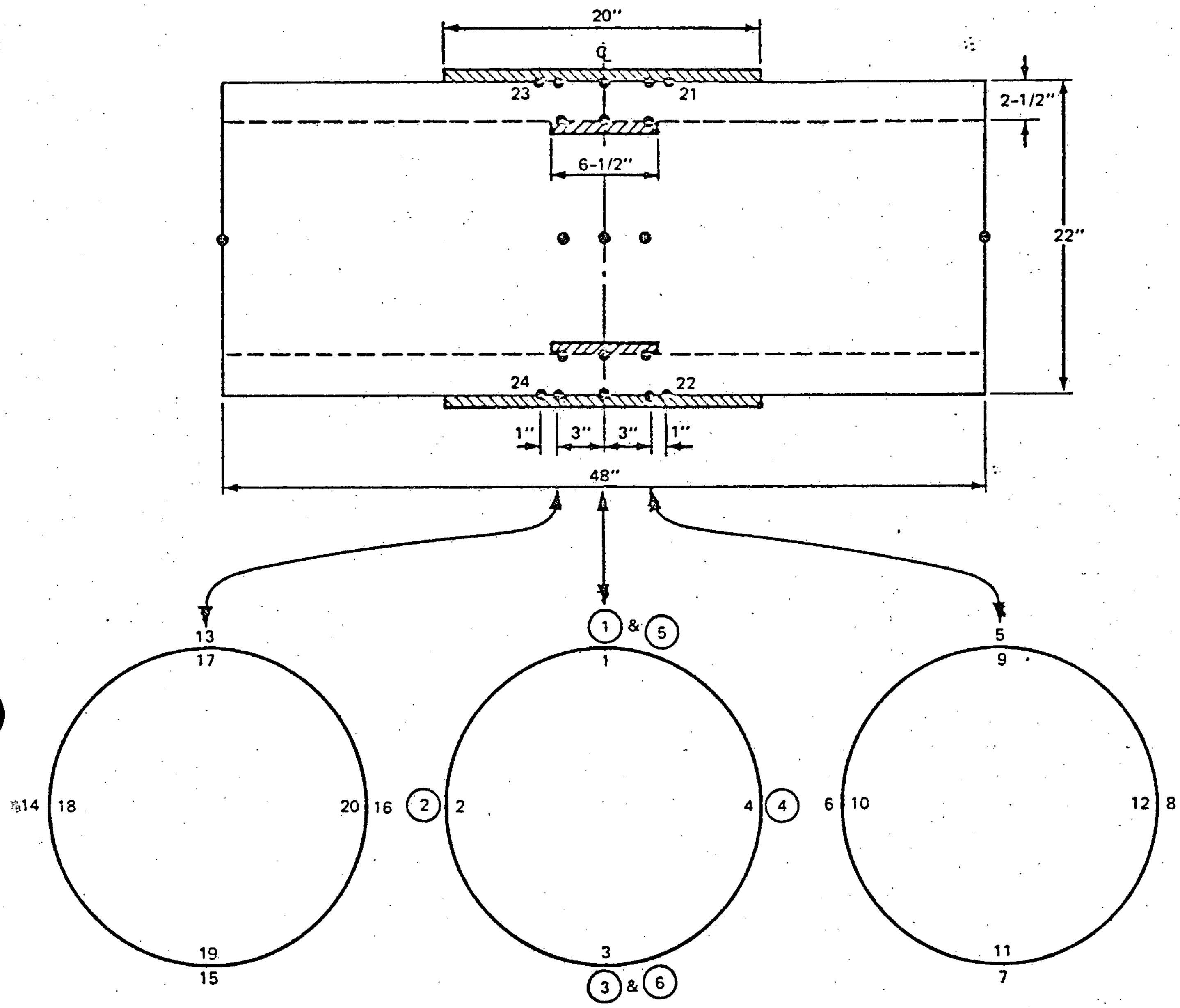
original signed by G. E. St. Cin

G. E. St. Cin, Section Manager
Miscellaneous Vessels
Component Engineering

JWR/GES;lt

APPENDIX B

RESISTANCE BLANKET HEAT METHOD

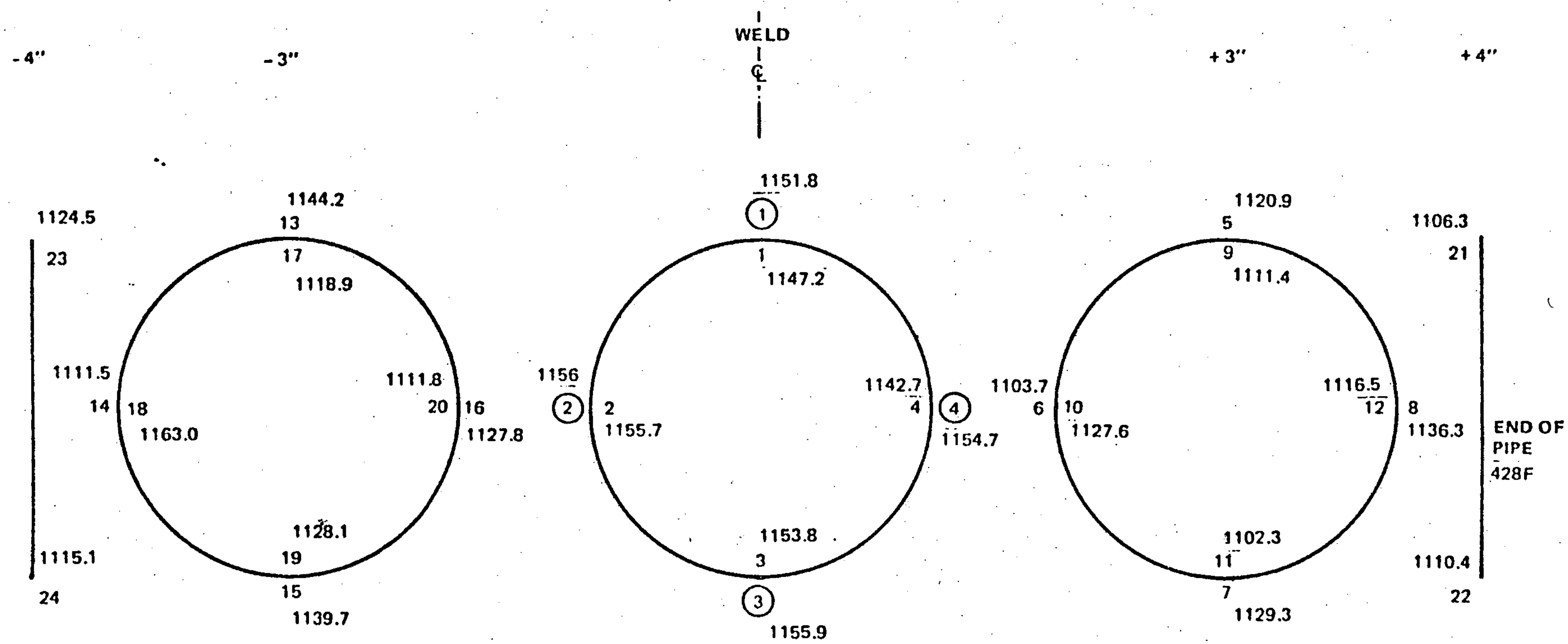


INTERNAL AND EXTERNAL HEATERS WERE CONTROLLED BY QUADRANTS BY EXTERNAL THERMOCOUPLES 3 INCHES FROM CENTERLINE, AT 5, 6, 7, AND 8.

● 5 = THERMOCOUPLE ON 24 PT RECORDER

● (6) = THERMOCOUPLE ON 6 PT RECORDER

Figure B-1. INTERNAL HEATER TEST ASSEMBLY



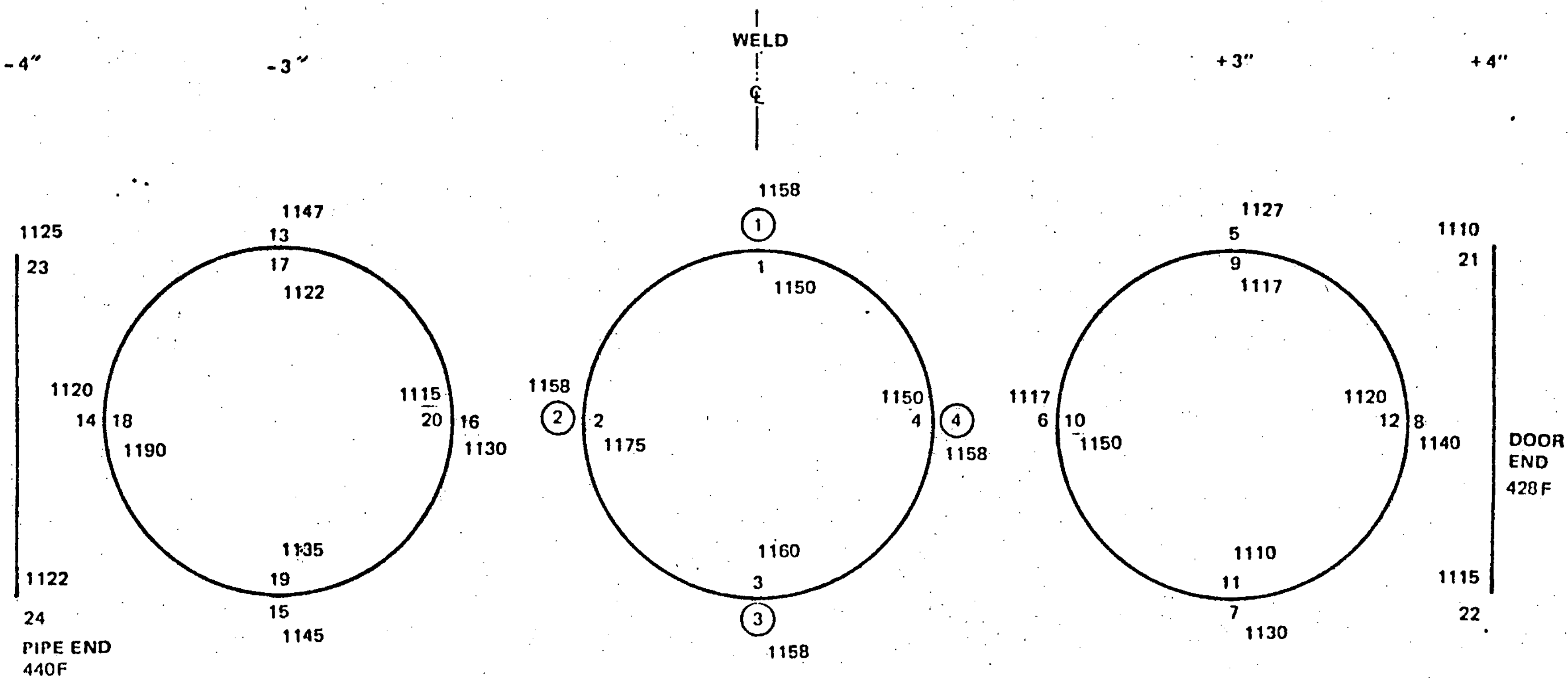
(1) DENOTES 6 PT. RECORDER

1 DENOTES 24 PT. RECORDER

PIPE: 22" DIA. 2-1/2" WT. 4 FT. LONG

OUTSIDE		INSIDE	
TOP	T/C 5	TOP	T/C 5
LT SD	T/C 6	LT SD	T/C 6
BOT	T/C 7	BOT	T/C 7
RT SD	T/C 8	RT SD	T/C 8

Figure B-2. TEMPERATURE DISTRIBUTION BLOCKED END PIPE
(Sheet 1 of 2)



① DENOTES 6 PT. RECORDER

1 DENOTES 24 PT. RECORDER

PIPE: 22" DIA. 2-1/2" WT. 4 FT. LONG

OUTSIDE		INSIDE	
TOP	T/C 5	TOP	T/C 5
LT SD	T/C 6	LT SD	T/C 6
BOT	T/C 7	BOT	T/C 7
RT T/C	T/C 8	RT SD	T/C 8

Figure B-2. TEMPERATURE DISTRIBUTION BLOCKED END PIPE
(Sheet 2 of 2)

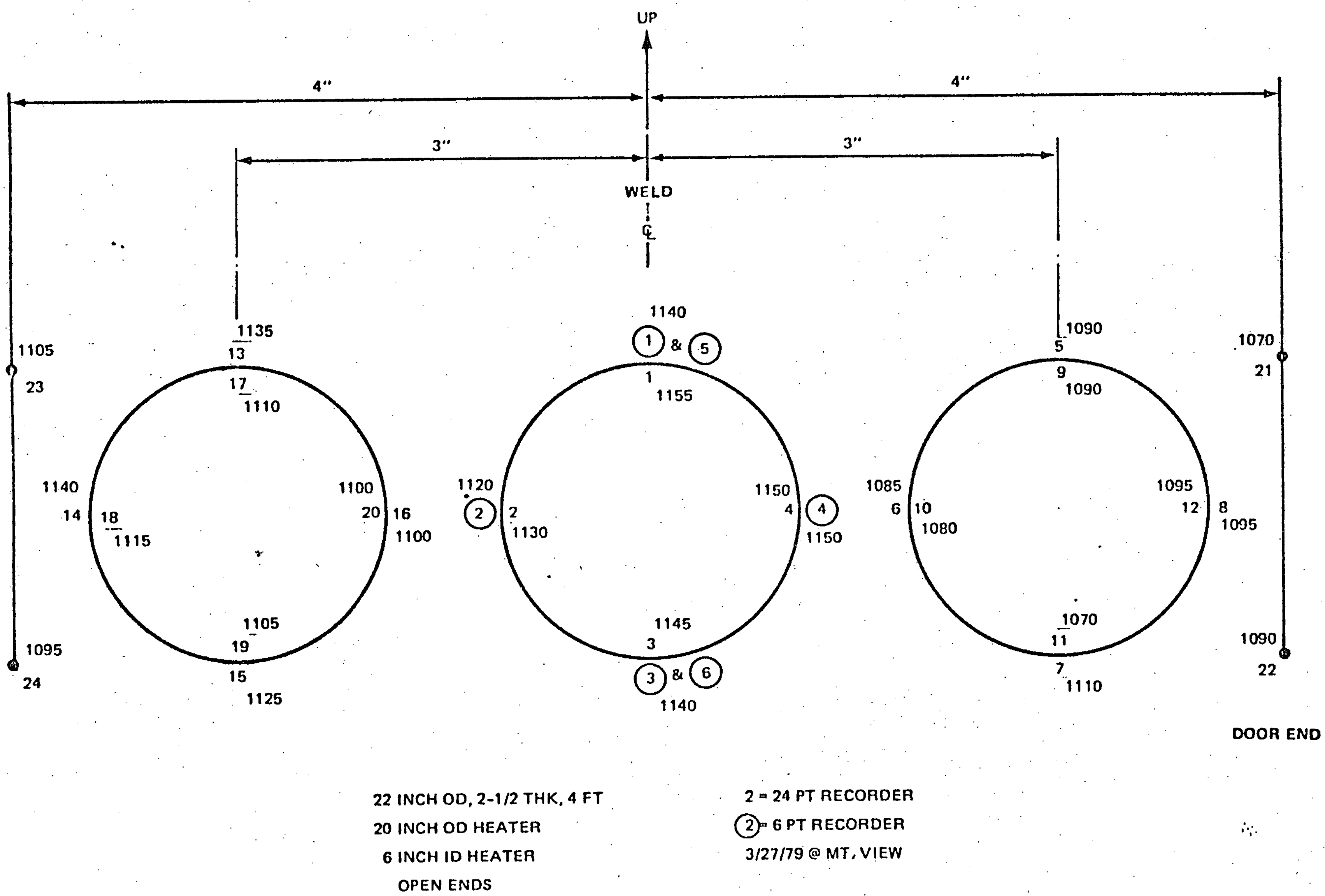


Figure B-3. TEMPERATURE DISTRIBUTION OPEN ENDS PIPE

APPENDIX C

San Onofre 2 & 3

Production Weld

PWHT Test Data

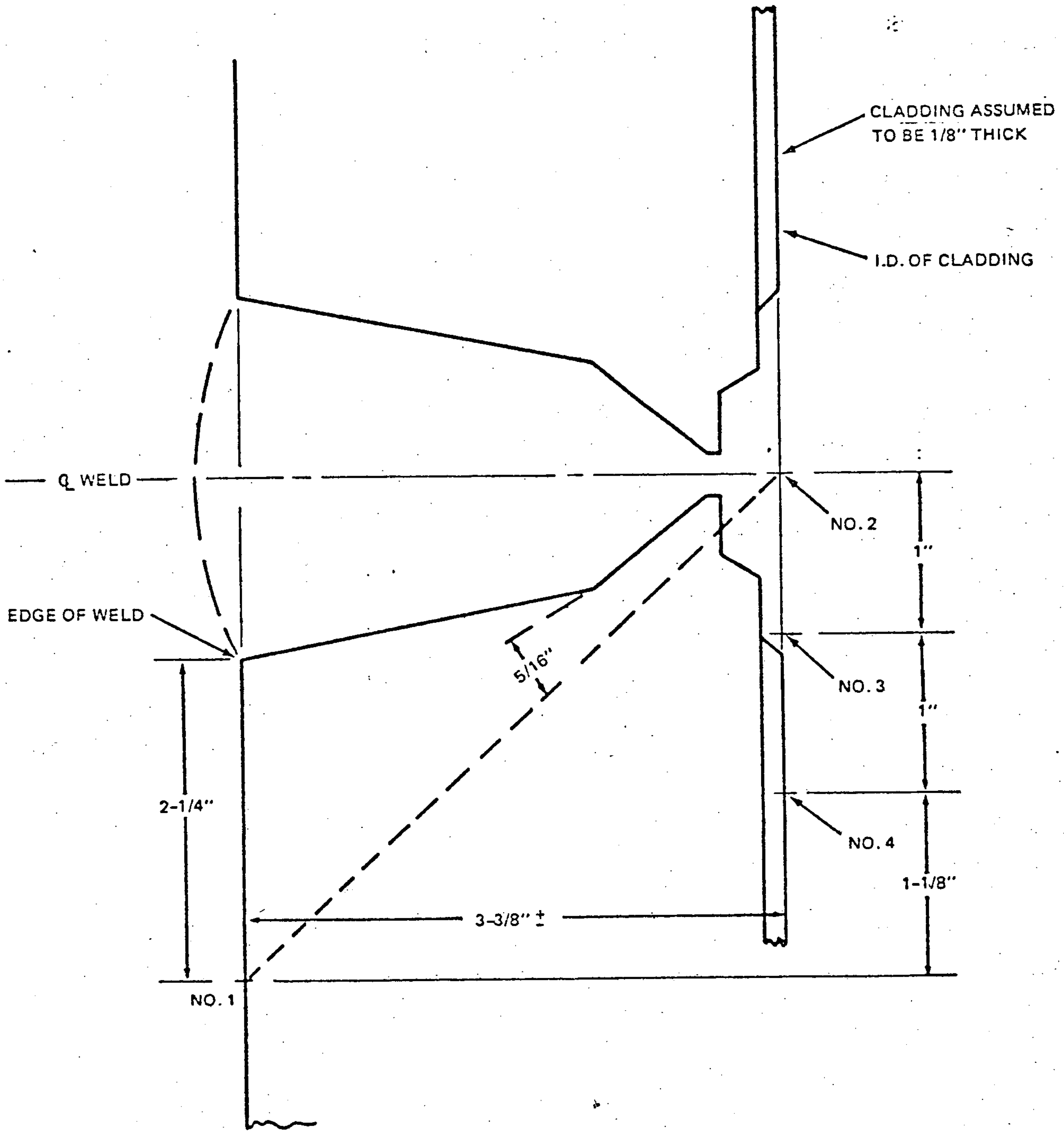


Figure C-1. POSTWELD HEAT TREATMENT VERTICAL CONFIGURATION TO DETERMINE ID TEMPERATURES - 3-3/8" THICK MATERIAL

Table C-1

SUMMARY OF TEMPERATURE RECORDINGS

Temperatures During Soak Period

Reference Thermocouple (Outside Radius of Elbow)	Reference Thermocouple (Inside Radius of Elbow)	Test Thermocouples (Inside Radius of Elbow)	Test Thermocouples (Outside Radius of Elbow)
1150F	1160F	#1 1175F	#1 1165F
		#2 1140F	#2 1130F
		#3 1150F	#3 1120F
		#4 1150F	#4 Faulty Thermocouple

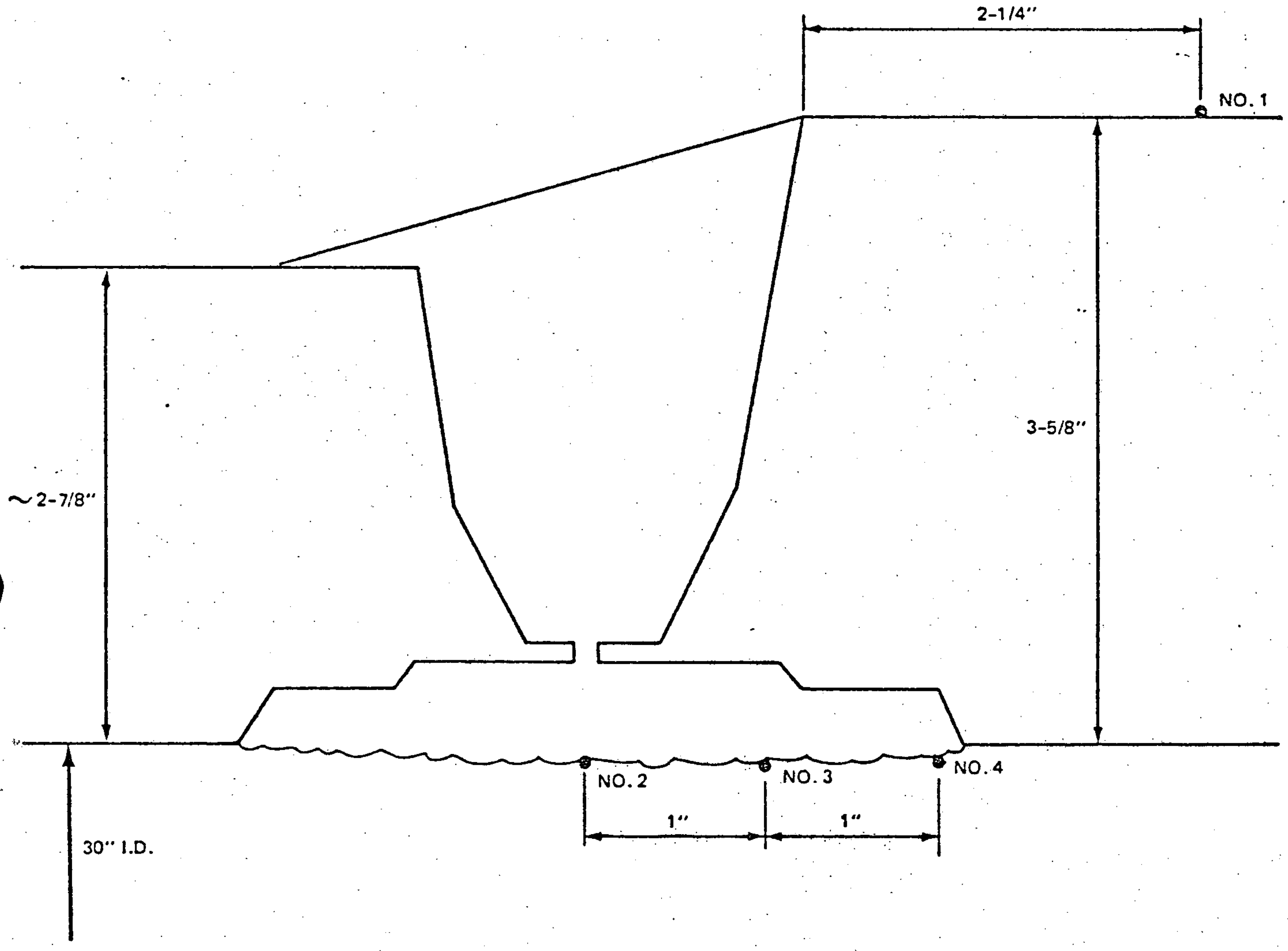


Figure C-2. POSTWELD HEAT TREATMENT HORIZONTAL CONFIGURATION TO DETERMINE ID TEMPERATURE - 3-5/8" THICK MATERIAL

Table C-2

SUMMARY OF TEMPERATURE RECORDINGS

Temperatures During Soak Period

Reference Thermocouple	Test Thermocouples Top	Reference Thermocouple	Test Thermocouples Bottom *
#1 1135 #3 1150	#1 1140 #2 1210 #3 1180 #4 1140	#7 1135 #9 1130	#1 1140 #2 1160 #3 1140 #4 1120

The Reference Thermocouples #1 and #7 were on the OD corresponding to the #1 Test thermocouples shown on the drawing. Reference thermocouples #3 and #9 were on the ID corresponding to the #3 thermocouple shown on the drawing.

* Calibration of recorder after test showed that strip chart readings for the bottom thermocouples read 20°F too high. Tabulated values have been corrected.

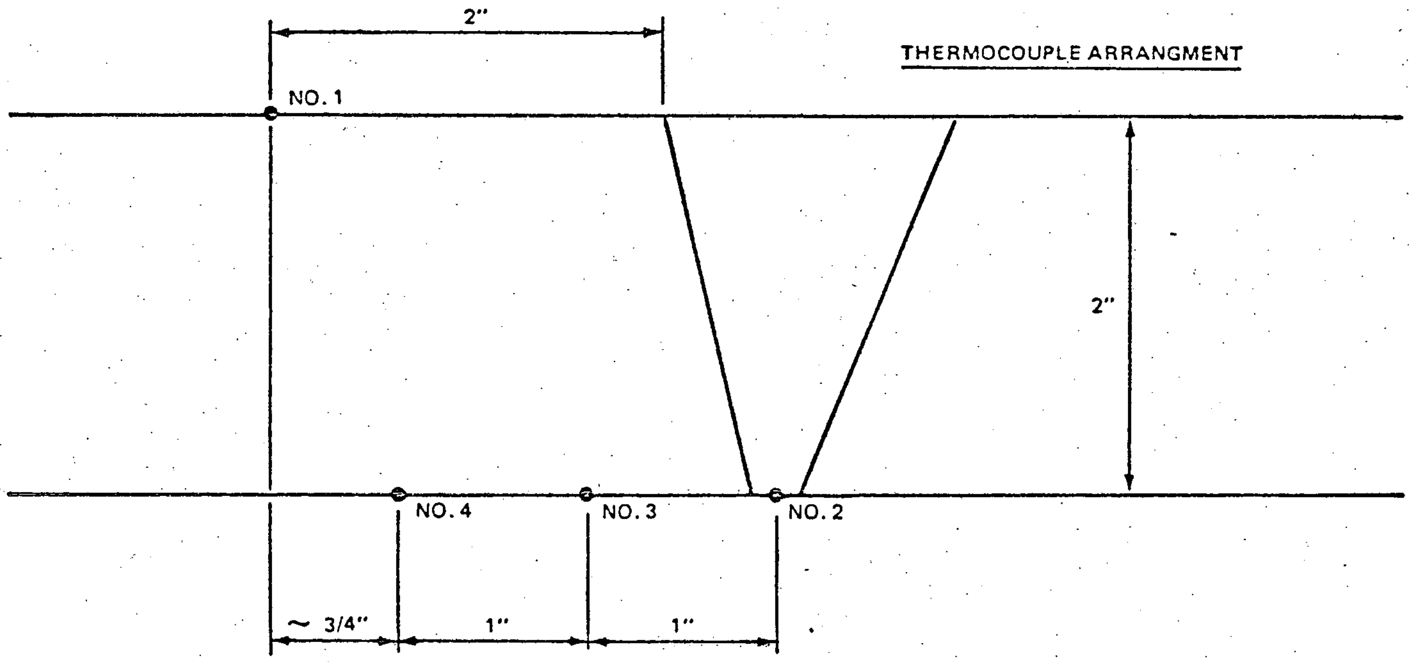


Figure C-3. POSTWELD HEAT TREATMENT HORIZONTAL CONFIGURATION TO DETERMINE ID TEMPERATURES - 2" THICK MATERIAL

Table C-3

SUMMARY OF TEMPERATURE RECORDINGS
DURING SOAK PERIOD

Thermocouple Number	Top (°F)	Bottom (°F)
1	1145	1145
2	1185	1180
3	1175	1170
4	1155	1160

APPENDIX D

San Onofre 2 & 3

Finite Element Thermal Analysis Results

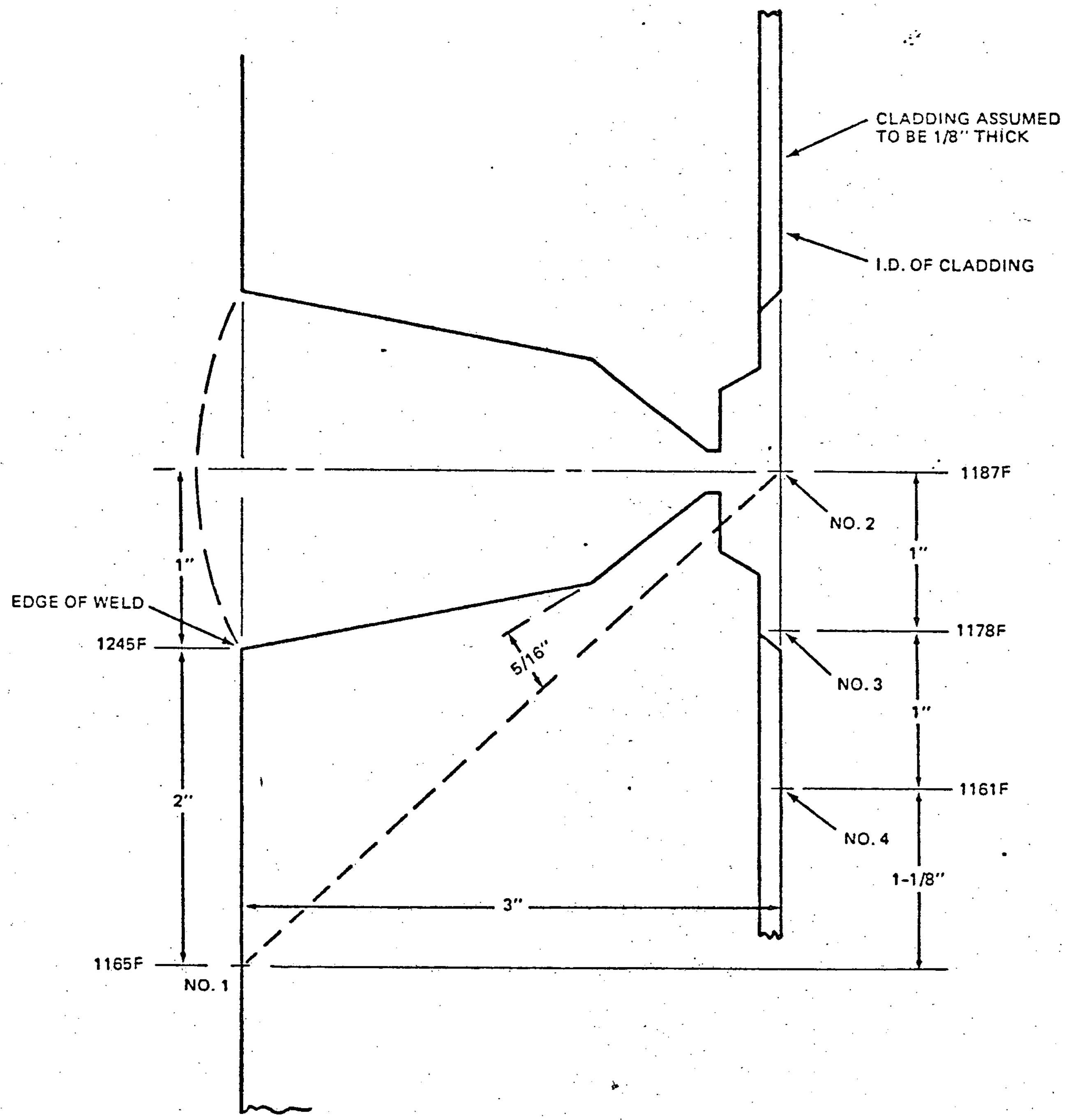


Figure D-1. VERTICAL PIPE ENDS BLOCKED 40F/INCH

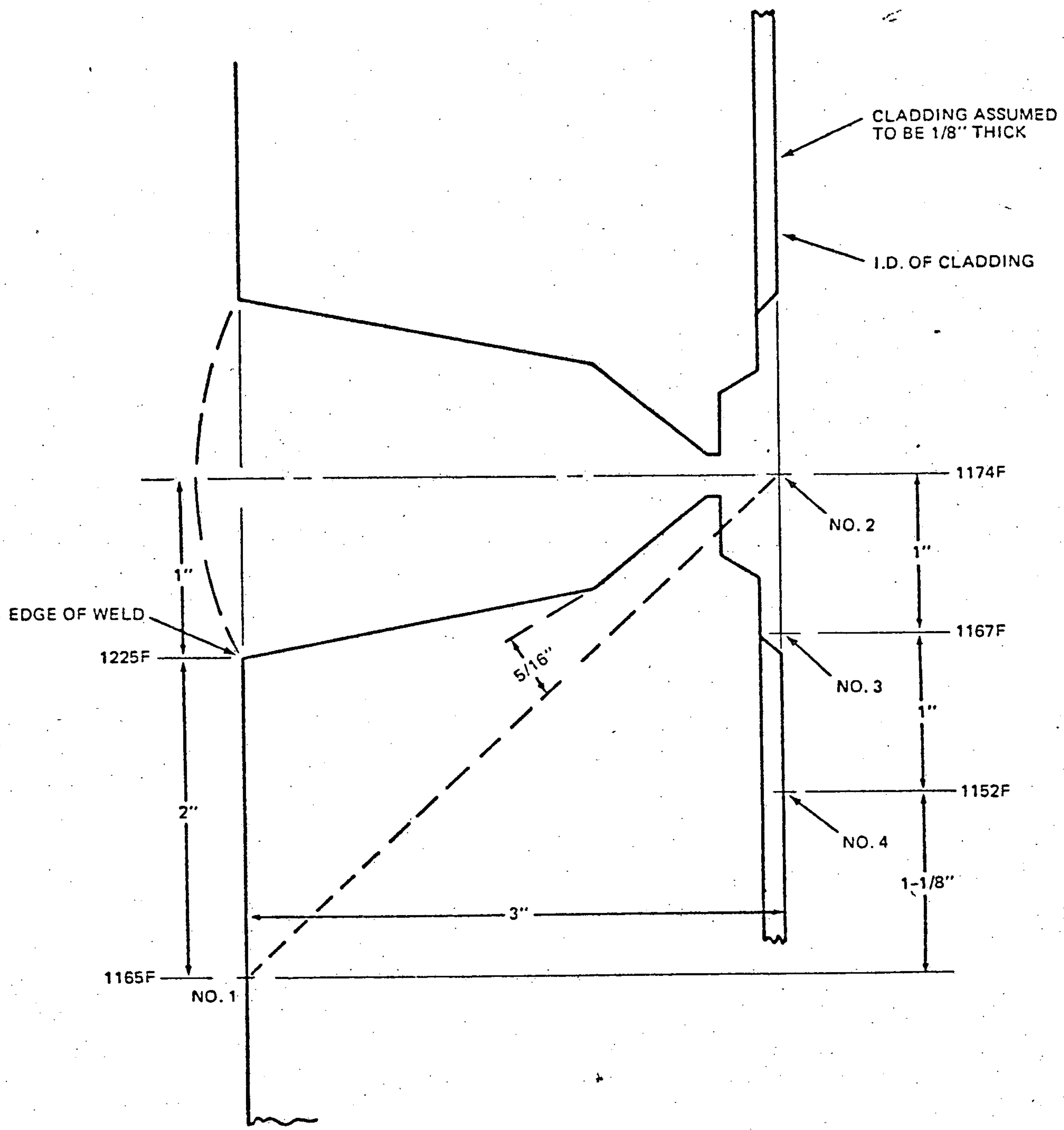


Figure D-2. VERTICAL PIPE ENDS BLOCKED 30F/INCH

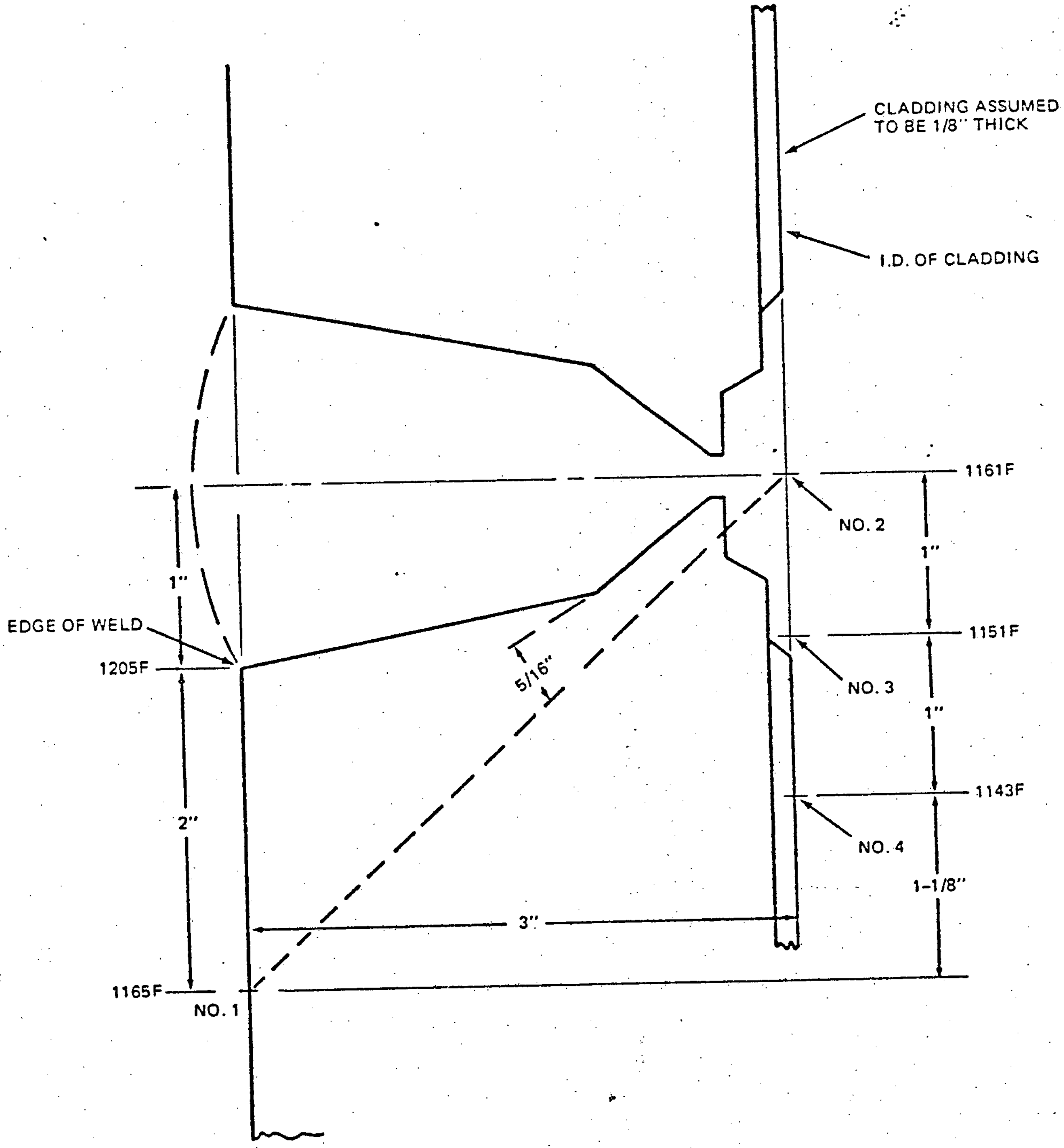


Figure D-3. VERTICAL PIPE ENDS BLOCKED 20F/INCH

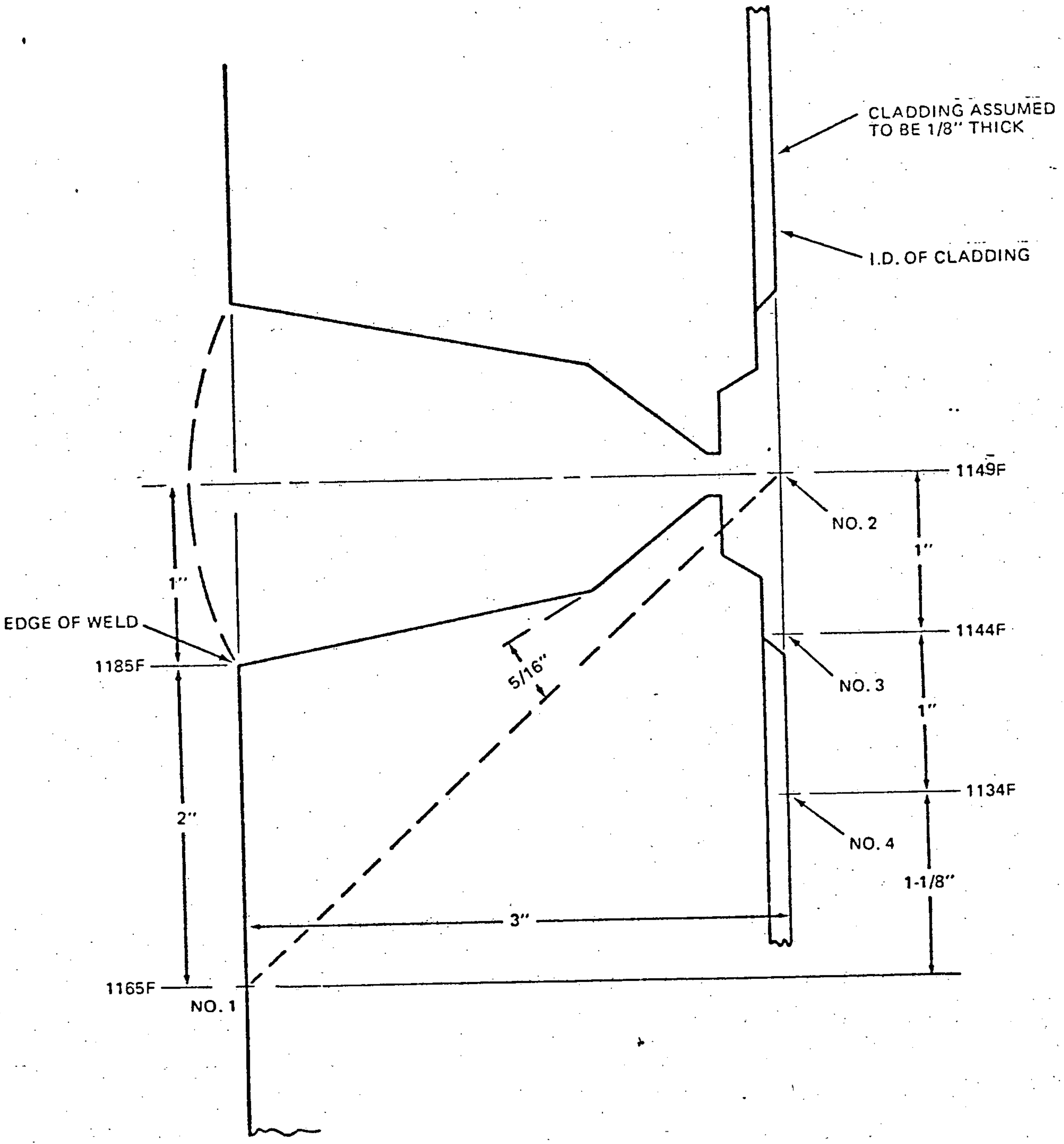


Figure D-4. VERTICAL PIPE ENDS BLOCKED 10F/INCH

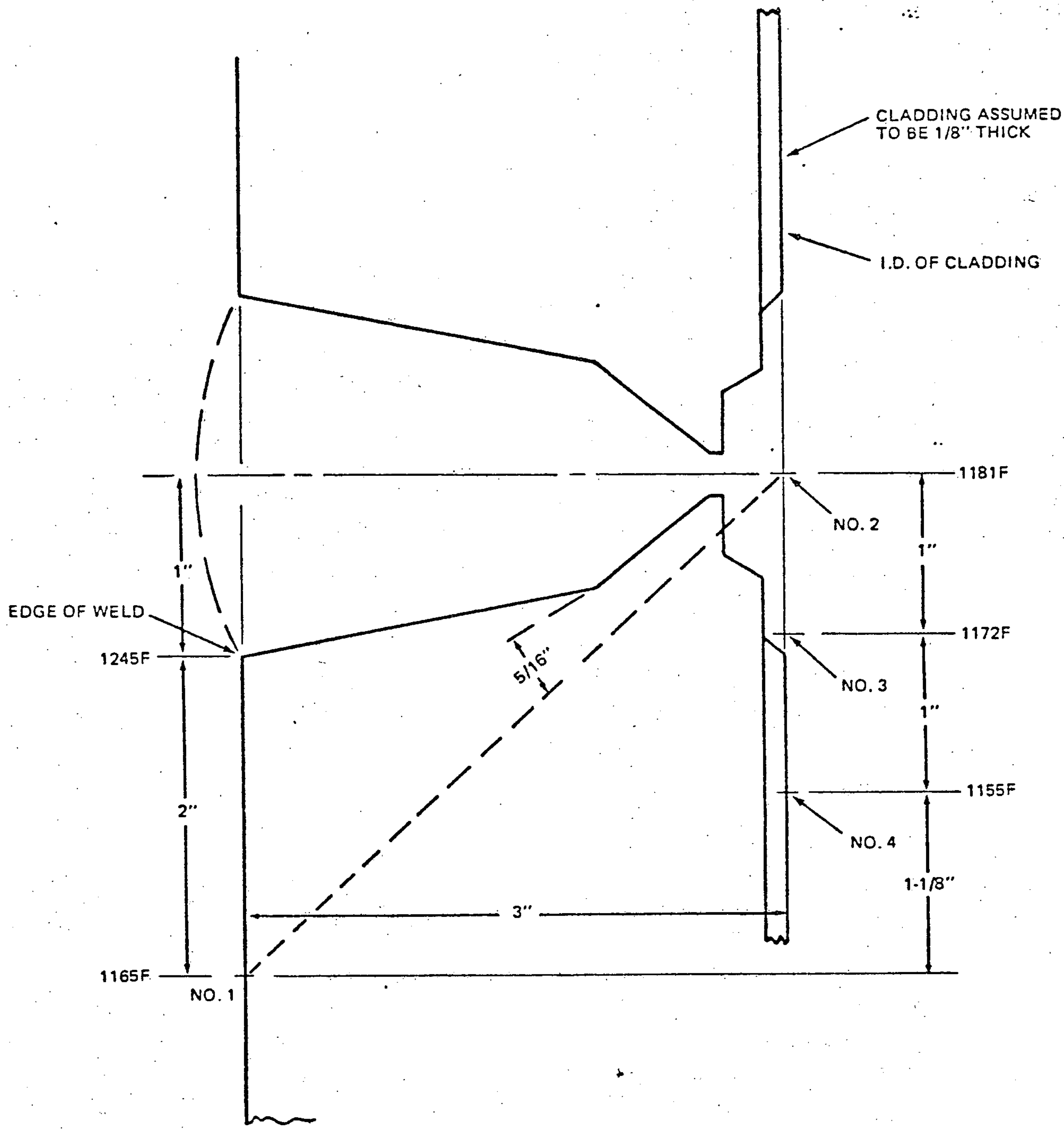


Figure D-5. VERTICAL PIPE ENDS NOT BLOCKED 40F/INCH

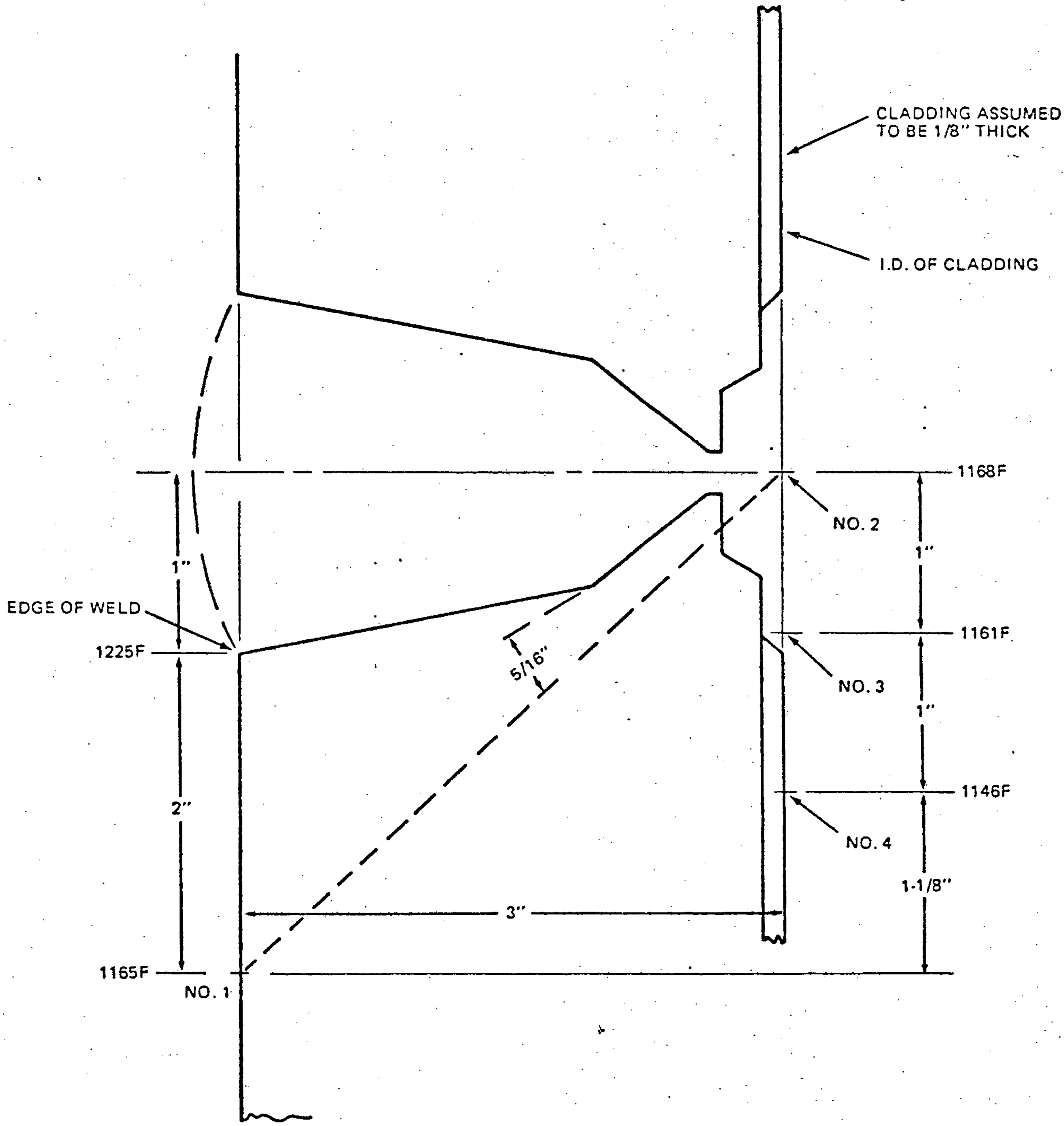


Figure D-6. VERTICAL PIPE ENDS NOT BLOCKED 30F/INCH

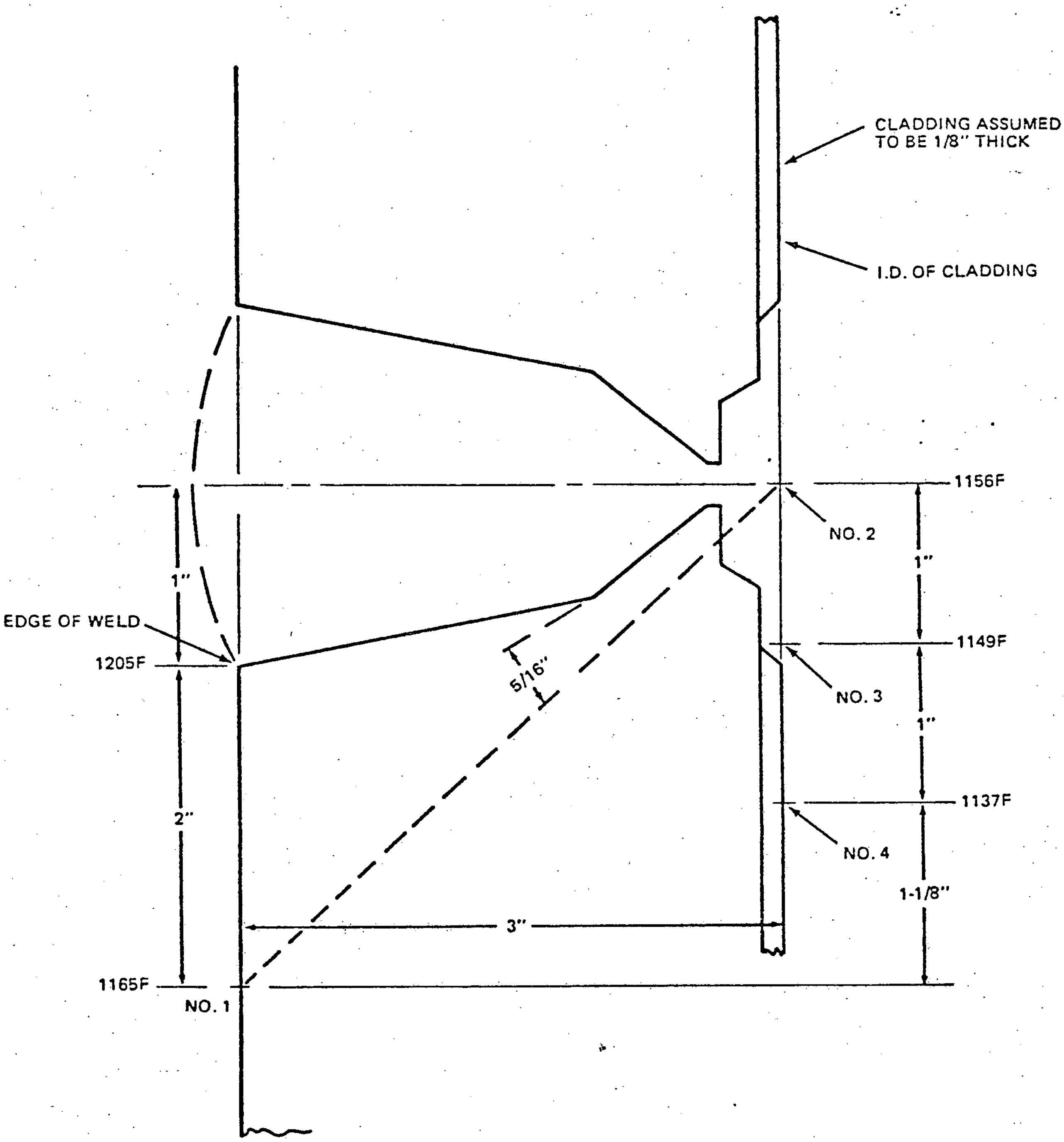


Figure D-7. VERTICAL PIPE ENDS NOT BLOCKED 20F/INCH

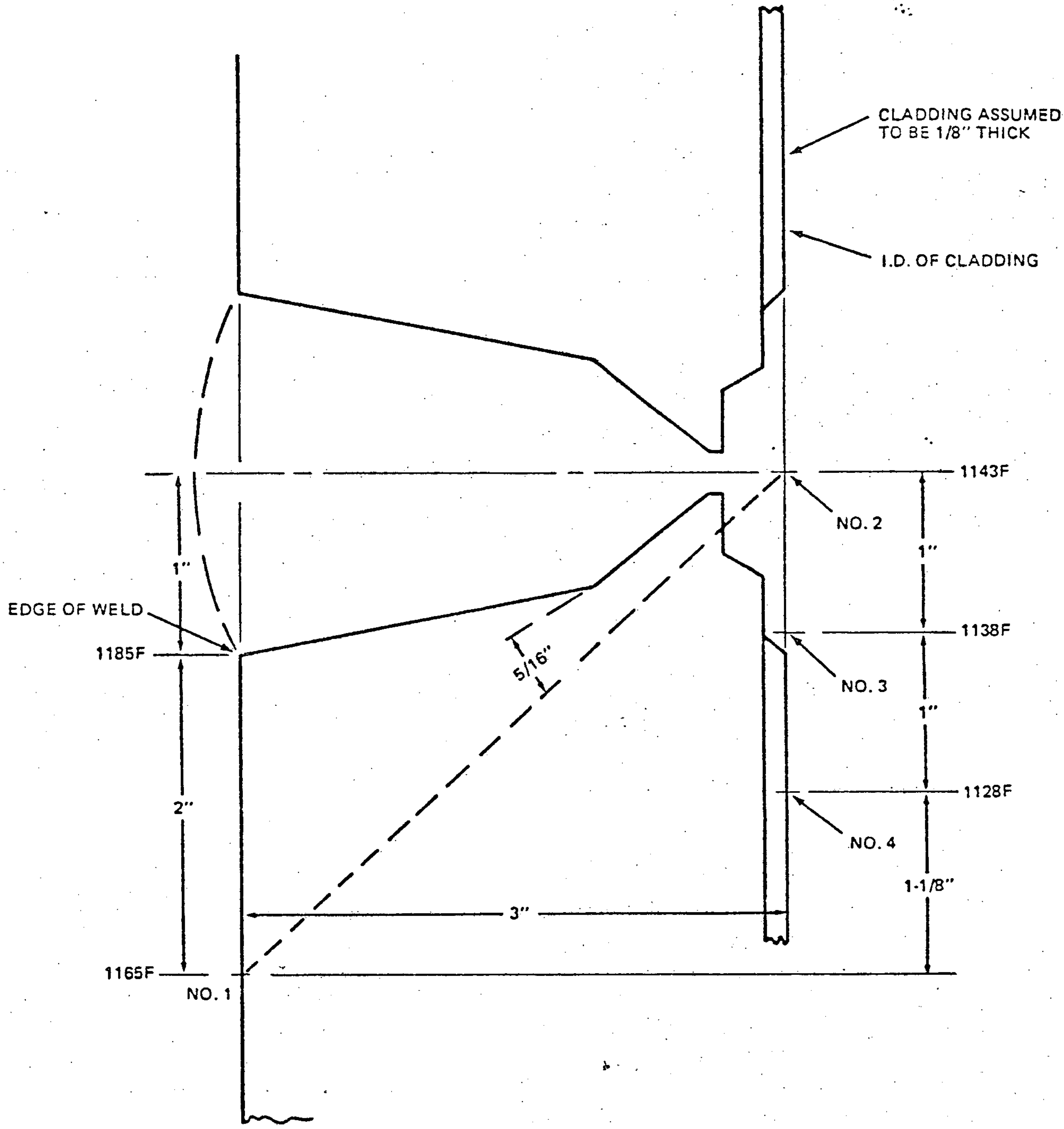


Figure D-8. VERTICAL PIPE ENDS NOT BLOCKED 10F/INCH

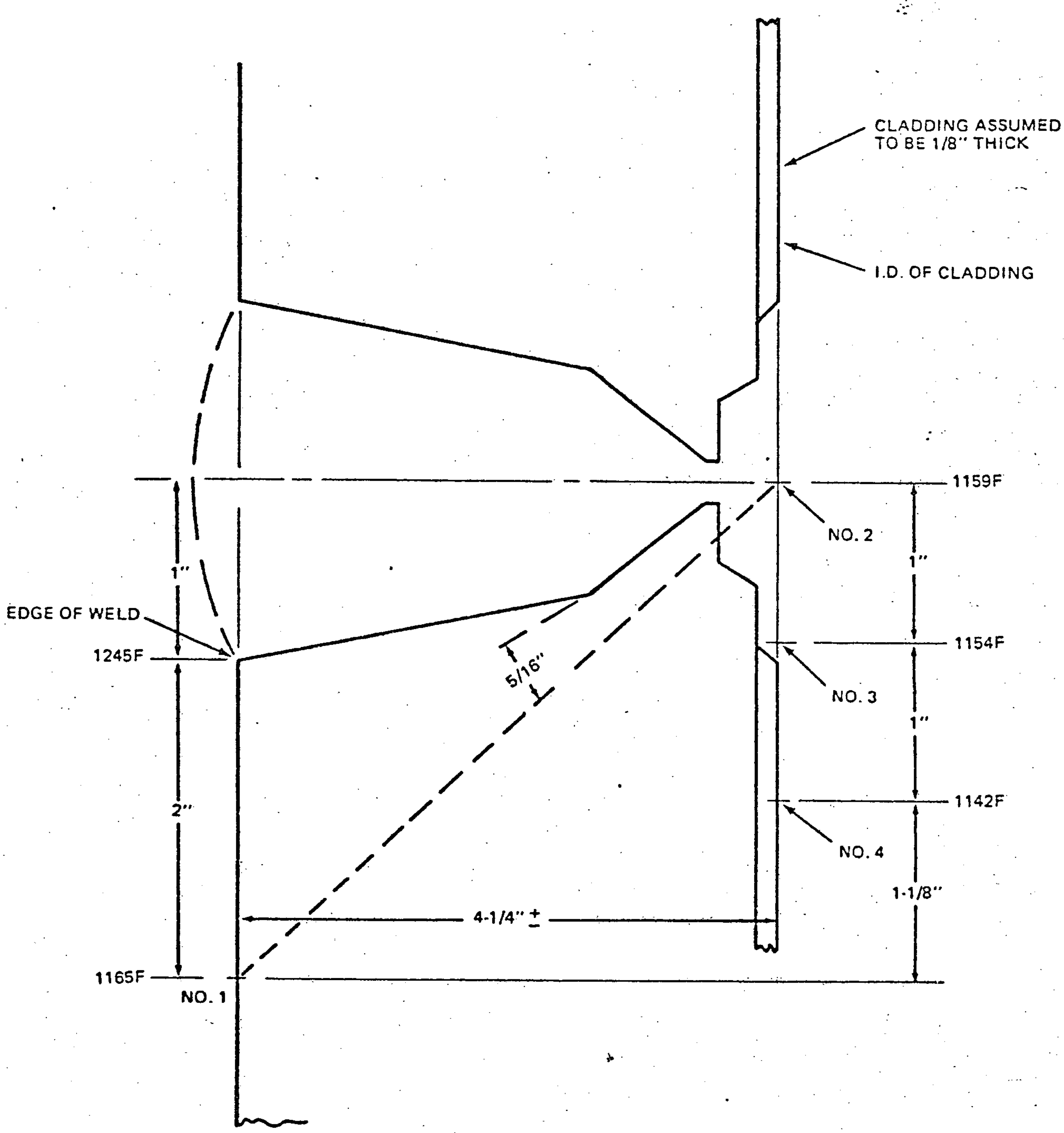


Figure D-9. HORIZONTAL PIPE ENDS NOT BLOCKED 40F/INCH

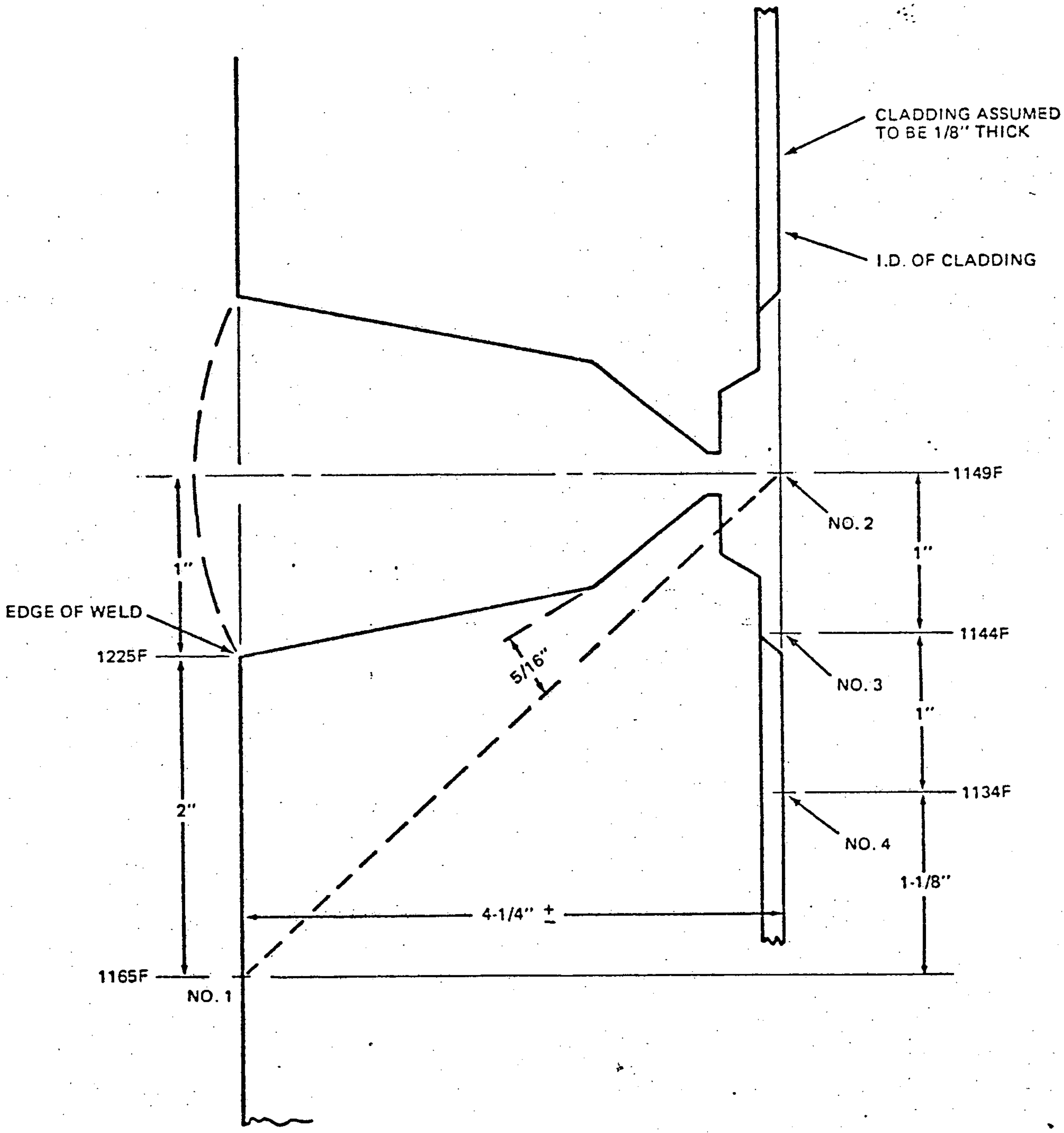


Figure D-10. HORIZONTAL PIPE ENDS NOT BLOCKED 30F/INCH

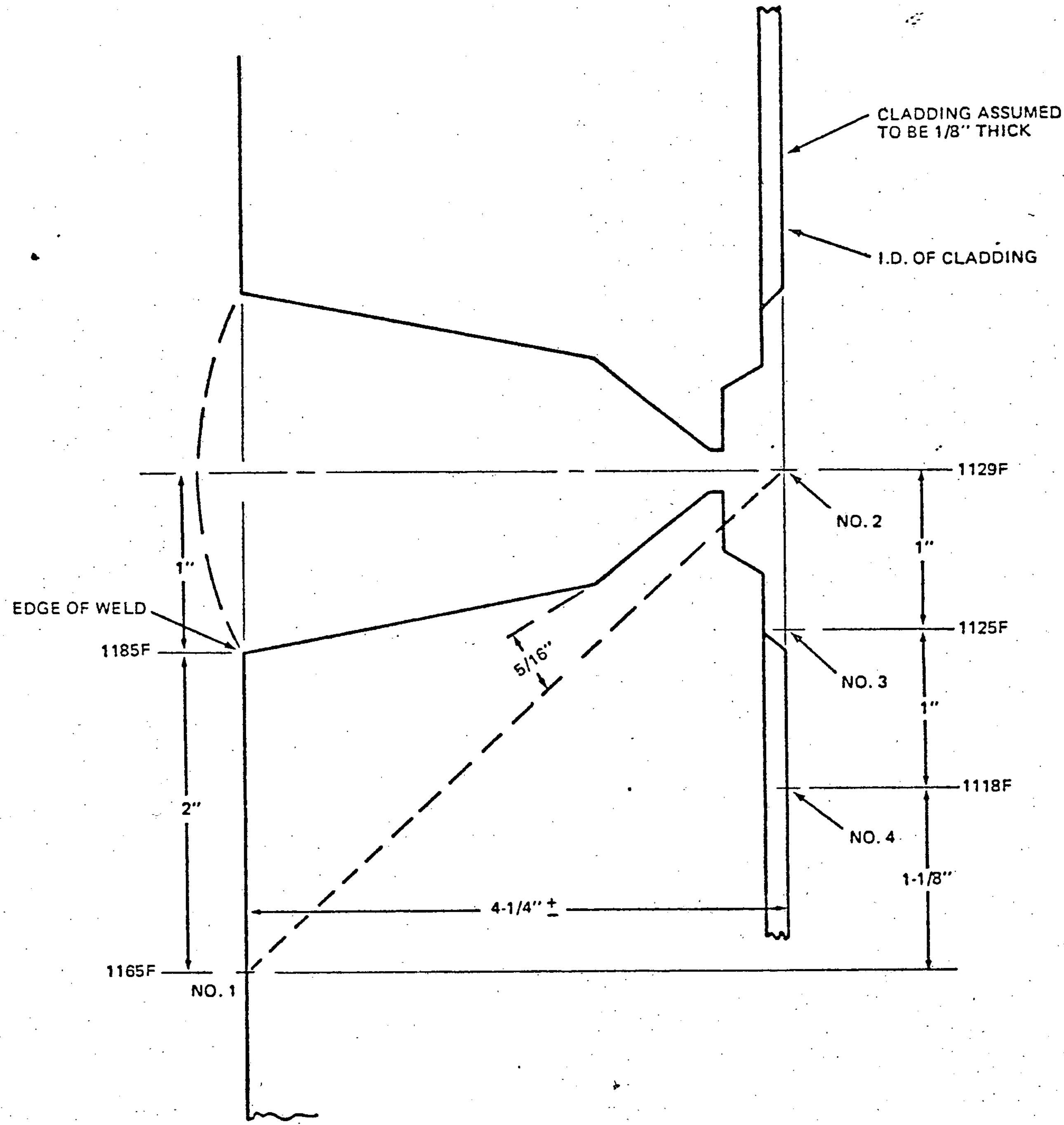


Figure D-12. HORIZONTAL PIPE ENDS NOT BLOCKED 10F/INCH

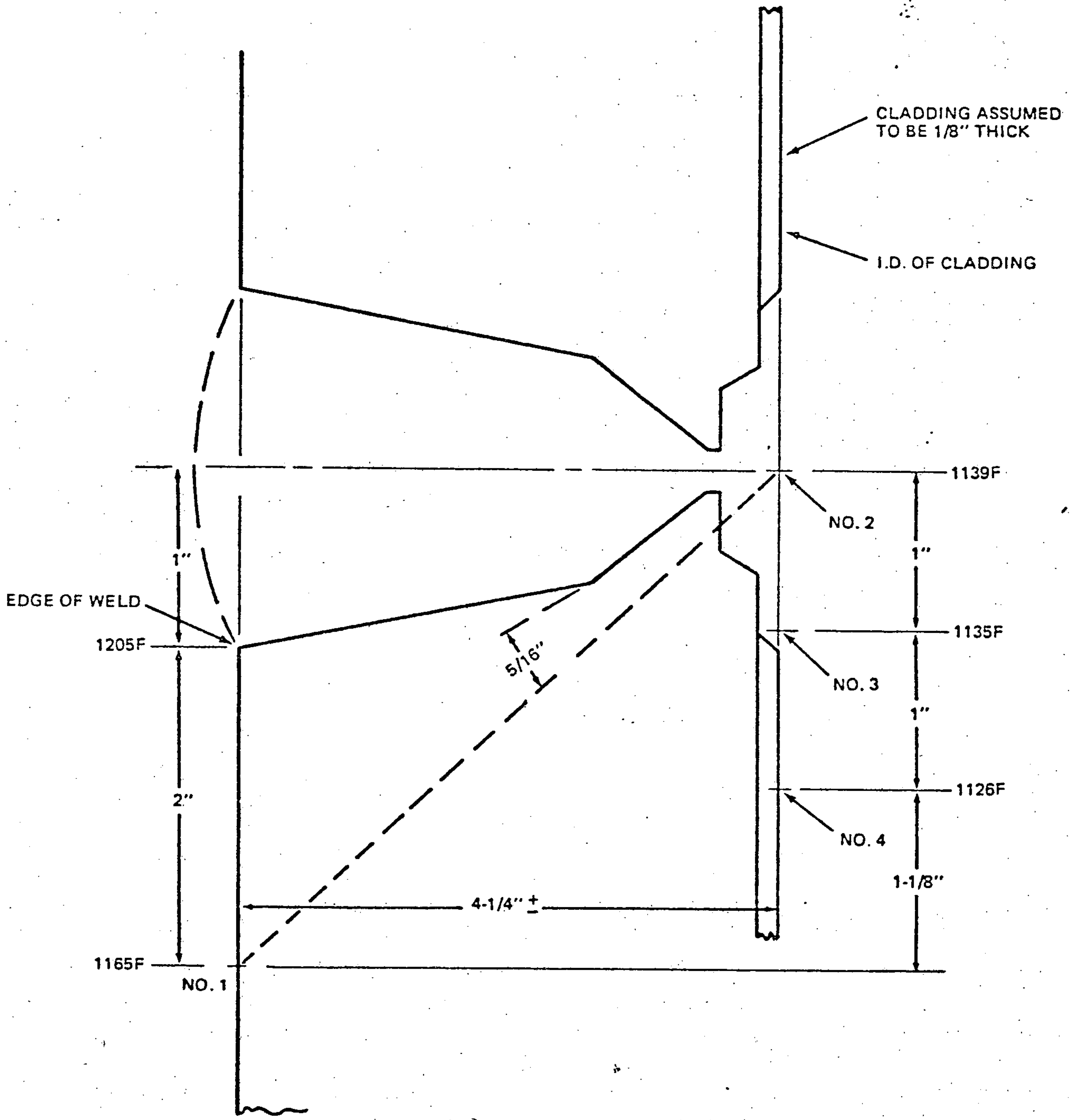


Figure D-11. HORIZONTAL PIPE ENDS NOT BLOCKED 20F/INCH