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AEC RESEARCH AND DEVELOPMENT REPORT

METALLURGY AND CERAMICS

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JOINT DESIGN FOR MAKING ROOT PASS WELDS WITHOUT FILLER MATERIAL

BY

L. C. LEMON AND W. R. SMITH

PILE TECHNOLOGY SECTION

ENGINEERING DEPARTMENT

JULY 9, 1956

HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

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L. C. Lemon and W. R. Smith*

Corrosion and Welding Unit
Metallurgy Research Sub-Section

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JOINT DESIGN FOR MAKING ROOT PASS WELDS WITHOUT FILLER METAL

INTRODUCTION

The fabricating industry has been searching for several years for an economical, dependable, and practical joint design and welding technique for making pipe butt joints in steel and stainless steel piping without the use of backing rings. The fabrication of equipment and piping systems for atomic energy applications where highly corrosive radioactive solutions must be contained has increased the need for such a joint.

Requirements for a root pass are:

1. That it have complete penetration and uniform weld reinforcement on the far side of the joint in all positions of welding, with no danger of burn-through or fall-out.
2. That a visual inspection of the near side of the root pass will indicate the completeness and uniformity of penetration.
3. That the joint be made economically with minimum skills required in all positions of welding.

An investigation was initiated to evaluate some of the designs, techniques, and methods which have been employed with some degree of success and to develop new methods if necessary.

Recent investigators[1-5] have all concluded that the inert-gas, tungsten arc welding process is the best process to be employed for making root passes without backing rings. These investigators have also demonstrated that an inert gas backup or purge is required for making root passes in stainless steel with the inert-gas, tungsten-arc welding process if a smooth, uniform and unoxidized surface is to be obtained on the far side of the weld. Dry nitrogen, helium, and argon appear to be effective gas purges for stainless steel.

Since the present work appeared to confirm most of these conclusions, emphasis was placed on the evaluation of joint preparations and welding techniques.

A joint with special preparations of the root edges, which had seen limited use within the General Electric Company, appeared to have great potential in the initial comparison. Efforts were therefore directed toward development and evaluation of this joint for several materials and applications. For convenience of identification, this joint will be identified as the "G. E." joint.

SUMMARY AND CONCLUSIONS

Several joints were evaluated and both the consumable insert joint and the newly developed "G. E." joint appeared to fulfill the requirements. Both joints provide a weld whose quality can be determined by visual inspection of the near side of the weld, and both can be made with the minimum of weldor skills and training. The consumable insert joint is the more costly because of the longer time required for machining, fitting, and welding, and because of the high cost for the individual insert.

The "G. E." joint is easier to make, fitup tolerances and welding conditions are less critical. There may be some applications where filler metal is required which is of a different chemical composition than the base material, and in these instances the "G. E." joint would not fulfill the requirements. However, the tendency for the "G. E." joint to crack is minimized by the joint geometry. The "G. E." joint preparation on one side of the joint can be joined to a standard 37-1/2 degree bevel joint if a small 45 degree bevel is made on the far side of the beveled joint. This preparation will allow one to take advantage of the benefits of the "G. E." joint even when one-half of the joint must be prepared in place in the field by filing and grinding.

DETAILS

The "G. E." joint preparation consists of machining the root edges to the general configuration shown in Figure 1. The raised edges on the near side of the joint provide the metal required to replace the metal which was removed in forming the small bevels on the far side. This joint geometry provides for a weld bead in which the surface tension forces are sufficient to overcome the gravitational forces in all positions of welding. As a result of these conditions, complete and uniform penetration is consistently obtained in all positions of welding of steel and stainless steels, with no tendency for burning through or falling out within a wide range of welding conditions. Figure 2 is a drawing of a cutting tool suitable for preparing joints on pipes with wall thicknesses from 1/8 in. to 3/4 in.

The dimensions of the joint are not critical and a large tolerance is permissible in the actual dimensions of the joint configuration. Figures 3 through 7 show the cross-sections of a variety of sizes, materials, and joint dimensions. Figure 8 demonstrates the offset which can be tolerated and Figure 9 shows a "G. E." joint prepared on the end of one pipe joined to a pipe which was prepared with a standard bevel and a small root bevel on the far side. The size and shape of the weld bead on the near side of the weld indicates the completeness and uniformity of the weld reinforcement on the far side. The root pass can be inspected before subsequent weld passes are made by any other acceptable welding process.

A comparison of the times required to prepare and weld joints of different design is illustrated in Table I. These comparisons are based on the preparation and welding of only three joints of each type so the data are only indicative of the time to be expected for actual applications.

Some of the low carbon steel welds were made without a gas backup and they appeared to be as sound and as easily welded as those welds made with argon or helium backup. More experimental work must be performed to actually determine if a backup gas is required on low carbon steel and what grades of steel can be welded by the inert-gas, tungsten-arc process.

The preparation of a few samples indicates that the "G. E." joint is also satisfactory for joining aluminum pipe, and it is expected that it can be employed for other metals and alloys.

BIBLIOGRAPHY

1. Mueller, R. A. and Root, W. B., "Inert-Arc Welding Technique for Eliminating Backing Rings in Piping", Welding Journal, Vol. 32, p. 205, (March 1953).

2. Pilia, F. J., "Inert-Tungsten Arc Welding of Stainless Steel Piping", Welding Journal, Vol. 32, p. 1167, (December 1953).

3. Pursell, R. T., "Inert-Arc Field Welding of Pressure Piping", Welding Journal, Vol. 33, P. 41, (January 1954).

4. Pursell, R. T., "Joint Detail in Inert Arc Welding of Pressure Piping", Welding Journal, Vol. 34, p. 747, (August 1955)

5. Risch, T. A. and Dohna, A. E., "Consumable Insert Method of Root Pass Welding", Welding Journal, Vol. 33, p. 670, (July 1954).

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TABLE I

PREPARATION AND WELDING TIME FOR "G. E.", INSERT, AND BEVEL JOINTS ON PIPE

Type of Joint	Size Pipe*	Material	Joint Preparation Time	Fit-Up and Task Time	Welding Time for Root Passes	Number of Additional Passes	Welding Time for Additional Passes	Total Welding Time	Total Time Preparation and Welding
"G.E."	3"	304L SS	2.5	0.6	6.5	2	10.5	17.6	20.1
Insert	3"	304L SS	1.2	7.2	7.0	2	9.5	23.7	24.9
Bevel	3"	304L SS	1.2	0.7	6.2	2	9.5	16.4	17.6
"G.E."	3"	A53	2.0	0.6	6.5	2	11.5	18.6	20.6
Insert	3"	A53	1.0	7.5	6.5	2	11.5	25.5	26.5
Bevel	3"	A53	1.0	0.7	5.0	2	10.0	15.7	16.7
"G.E."	2"	304L SS	2.0	0.6	4.5	1	4.0	9.1	11.1
Insert	2"	304L SS	0.7	7.0	4.5	1	4.0	15.5	16.2
Bevel	2"	304L SS	0.7	0.6	4.0	1	5.0	9.6	10.3
"G.E."	2"	A53	1.2	0.6	4.5	1	4.0	9.1	10.3
Insert	2"	A53	0.7	7.0	5.0	1	4.0	16.0	16.7
Bevel	2"	A53	0.7	0.7	3.0	1	5.0	8.7	9.4
"G.E."	1"	304L SS	1.3	0.6	2.0	1	3.0	5.6	6.9
Bevel	1"	304L SS	0.7	0.6	2.2	1	3.0	5.8	6.5
"G.E."	1"	A53	1.3	0.6	2.0	1	3.0	5.6	6.9
Bevel	1"	A53	0.7	0.6	2.0	1	3.0	5.6	6.3

*All pipe is Schedule 40

NOTE:
1. All times expressed in minutes.
2. All times are the average for three joints.
3. All welds made in horizontal fixed position by inert-gas tungsten-arc process.
4. All joints prepared in a turret lathe.

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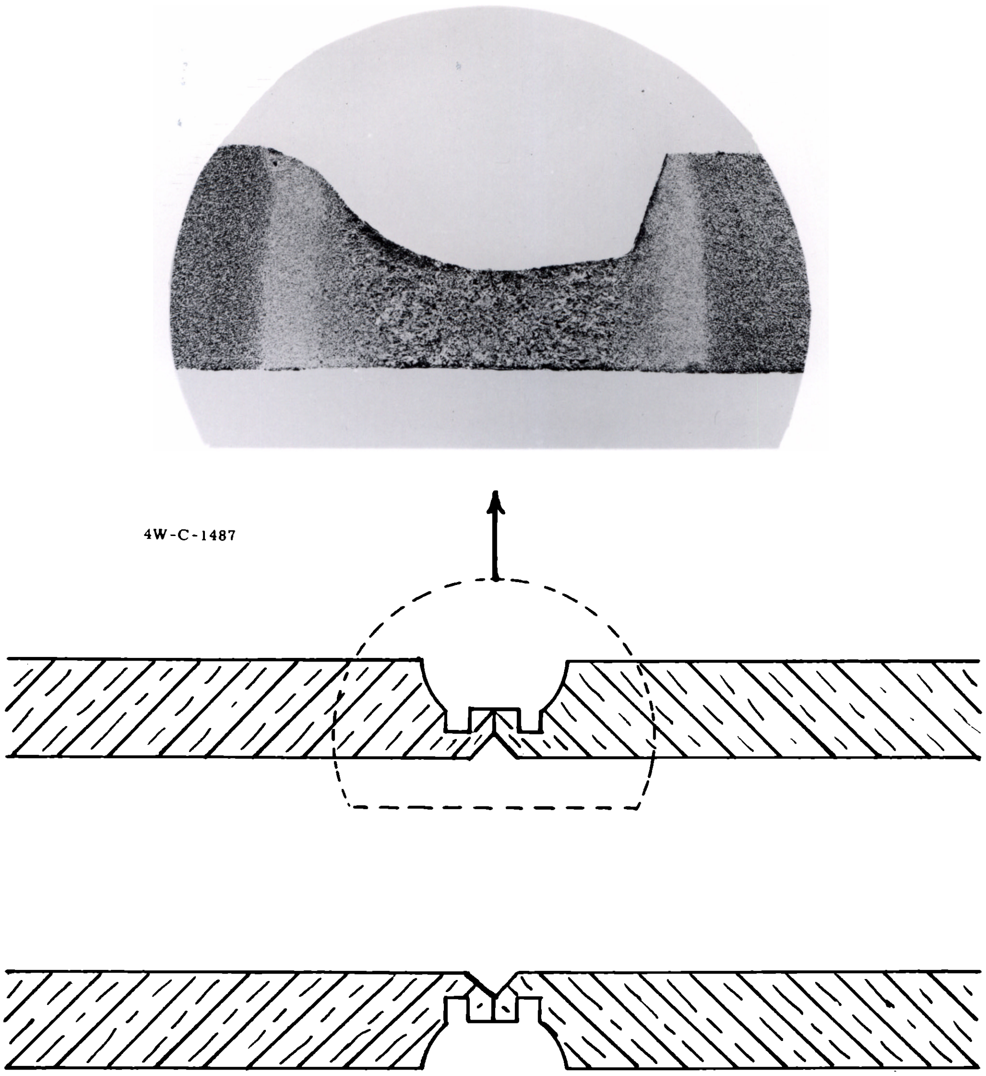
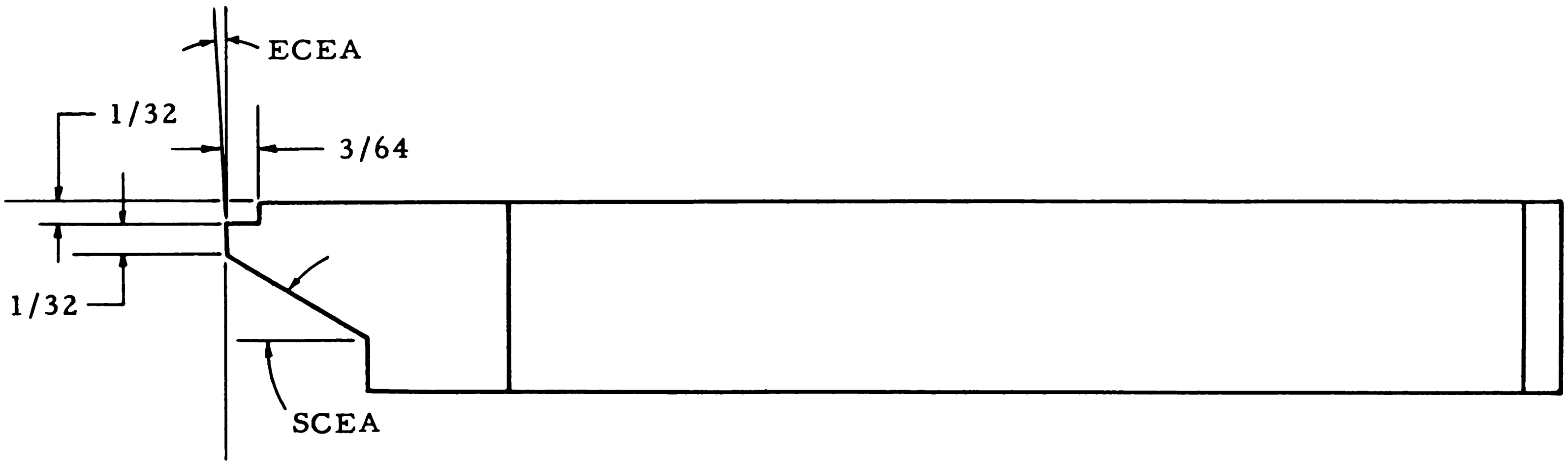


FIGURE 1

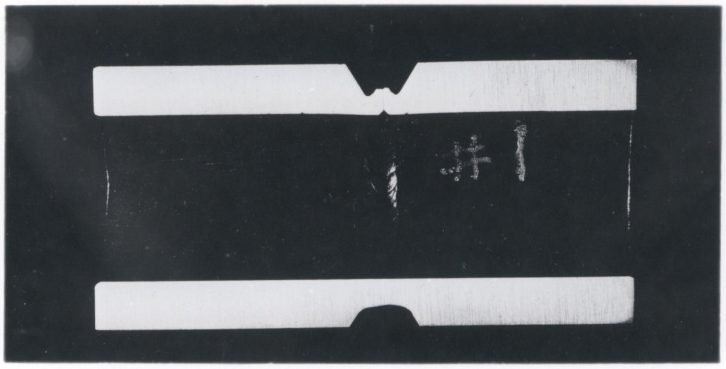
IDEALIZED DRAWING OF THE "G. E." JOINT WITH A PHOTOMACROGRAPH SHOWING PENETRATION AND QUALITY OF THE ROOT PASS IN CARBON STEEL PIPE AFTER WELDING.



SCEA - 20°
ECEA - 3°

FIGURE 2

CUTTING TOOL FOR FABRICATION OF "G. E." JOINTS ON PIPE AND TUBING WITH WALL THICKNESSES FROM 1/8 IN. TO 3/4 IN.



5W-C-998

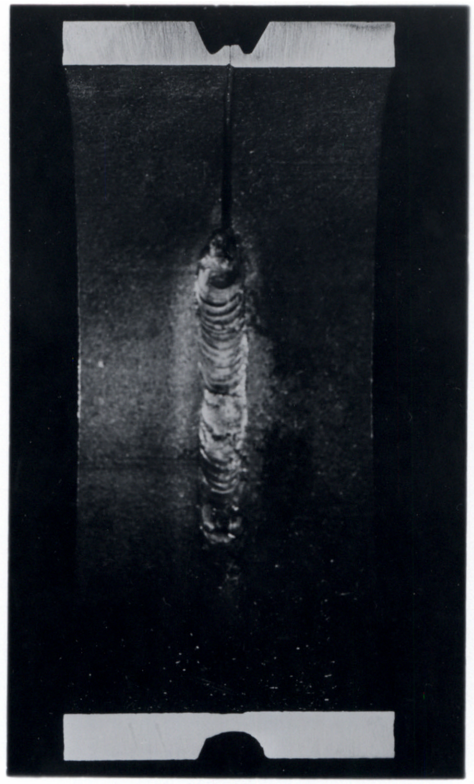
FIGURE 3

ONE INCH SCHEDULE 160, TYPE 304 STAINLESS STEEL PIPE SHOWING THE "G. E." JOINT PREPARATION AND ROOT-PASS WELD. THE BOTTOM OF THE SPECIMEN WAS IN THE OVERHEAD POSITION WHEN IT WAS WELDED. 1X

5W-C-999

FIGURE 4

CROSS-SECTION OF A THREE INCH SCHEDULE 40, TYPE 304 STAINLESS STEEL PIPE. OTHERWISE SAME AS FIGURE 1. NOTE DIFFERENCE IN DETAIL OF JOINT.

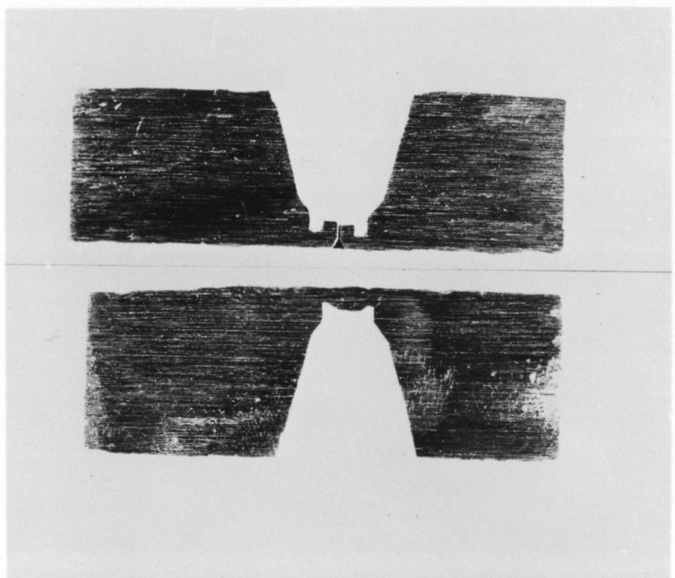


5W-C-1002 FIGURE 5

CROSS SECTION OF A THREE INCH SCHEDULE 40 LOW CARBON STEEL PIPE.

5W-C-1003 FIGURE 6

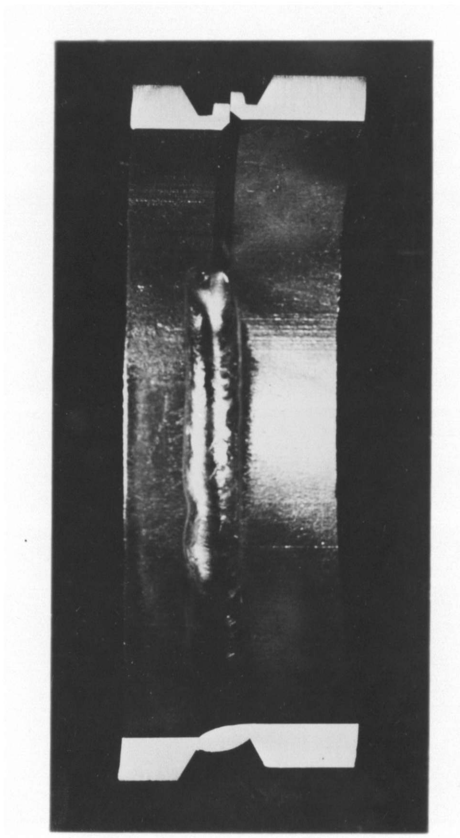
CROSS SECTION OF TWO INCH SCHEDULE 160 LOW CARBON STEEL PIPE.



4W-C-1192A
4W-C-1193B

FIGURE 7

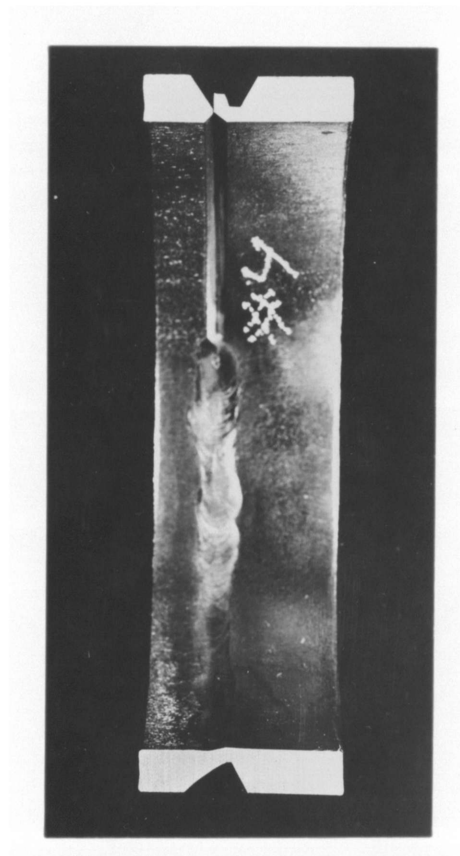
CROSS SECTIONS OF EIGHT INCH, SCHEDULE 160 LOW CARBON STEEL PIPE.



5W-C-1000

FIGURE 8

CROSS SECTION OF THREE-INCH, SCHEDULE 40, TYPE 304 STAINLESS STEEL PIPE DEMONSTRATING THE OFFSET WHICH IS TOLERABLE WITH THE "G. E." JOINT.



5W-C-1001

FIGURE 9

CROSS SECTION OF THREE-INCH, SCHEDULE 40, TYPE 304 STAINLESS STEEL PIPE DEMONSTRATING THE JOINING OF A 37 1/2 DEGREE BEVEL JOINT TO A "G. E." JOINT.

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