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NAVY DEPARTMENT
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Report on

The Gamma Ray Radiography of Pipe Welds.

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APPENDIX

SUMMARY

Welded pipes with inside diameters of 2, 4, 6 and 8 inches were radiographed using the standard gamma ray technique. The film-to-source distances employed were those obtained by placing the radium on the axes of the pipes with the films on the outside. Several additional exposures were made with the film on the inside of the pipe and the radium at a distance of 18 inches.

It was found that gamma ray radiographs prepared on welded pipe 8 inches in diameter or less with wall thicknesses of 0.45 inch or less are lacking in contrast, definition and sensitivity. Thus only large defects can be located and porosity cannot be detected.

AUTHORIZATION

1. The studies on the radiography of pipe welds were authorized by the Bureau of Engineering letter S48/L5(9-24-Ds) of 2 October 1937.

STATEMENT OF PROBLEM

2. The problem consisted of determining the practicability of radium radiography as applied to welds in thick walled pipes and tubes.

KNOWN FACTS BEARING ON THE PROBLEM

3. The New York Navy Yard fabricated the welded pipe from seamless drawn tubing and elbows in stock at the Navy Yard of the following dimensions:

Tubing	Elbows	Specifications
2.375" O.D. x 0.145" wall	Bent from tubing	44-T-13
4.500" O.D. x 0.215" wall	0.26" wall elbow - 2 seams	Equal to
6.625" O.D. x 0.427" wall	0.46" wall elbow - 2 seams	44-T-13
8.75" O.D. x 0.325" wall	0.35" wall elbow - 2 seams	ditto

4. The following conditions were imposed on the welding:

(a) One assembly was required in each of the sizes listed in the table of dimensions.
(b) Joints numbers 1 and 2 were to be made with the pipe rotating, welding in the flat position. (The joints being numbered consecutively from the welding neck flange. See Fig.1.)
(c) Joints numbers 3 and 4 were to be welded with the pipe fixed, namely, No. 3 with the pipe axis horizontal and No. 4 with the pipe axis vertical.
(d) Chill rings were to be left in place after welding.
(e) All welds were to be in at least two layers.
(f) Electrodes used were to be in accordance with Grade EA, Class 1, of Navy Department Specifications 22W7.

5. The welded pipe arrived at the Laboratory with the weld beads in place.

TEST METHODS

6. The four welded pipes were radiographed as received, then the weld bead was ground flush with the outside diameter of the pipe and the chill ring at the welding neck flange end was machined out and the welds were re-radiographed. The pipes were radiographed under the following conditions:

(a) With 25 mg of radium at the axis of the pipe.
(b) With 100 mg of radium at the axis of the pipe.
(c) With 100 mg of radium outside the pipe. An 18-inch film to source distance was used.
(d) With 25 mg of radium at the axis of the pipe and calcium tungstate intensifying screens.

Only the condition of (a) was applied to all the welds.

7. The standard Navy step type penetrameter was used in radiographing every welded joint. These steps were of the following thicknesses: .005, .010, .020, .030, and .040 inches.

8. The normal gamma ray technique was employed.

RESULTS OBTAINED

9. Radiographs from the pipe in the as-received state with the weld bead in place did not show the weld to good advantage. All defects present, unless they were very large ones, were made obscure by the irregularity of the weld bead. It was thought that the 25 mg quantity would give the best results so that most of the radiographs were taken with this amount as the source. There was, however, very little difference between the films taken with 100 mg and 25 mg quantities when the weld bead was in place. On the 8-inch pipe a sensitivity of only 6% was recorded with the 100 mg quantity and only slightly better results could be obtained with the 25 mg quantity. See envelopes 1 to 5 inclusive for radiographs obtained with the weld bead in place.

10. In studying the radiographs exhibited in this report, it will be noted that practically all films will show lines traversing them that indicate definite breaks in density. Reference is made to those markings other than those normally made by overlapping films whose position can easily be ascertained by the location of the number. These odd markings or changes in density result from the fact that the film is not in close contact with the lead intensifying screens. It is very difficult to maintain this close relationship in flexible type cassettes made up of light-tight paper envelopes. If a considerable amount of radiographing is to be done on curved surfaces, it would be infinitely better to have the holders made out of a light metal or heavy cardboard so that a close packed arrangement could be maintained between the intensifying screens and the film. The reader of the films presented is asked to disregard the peculiar markings shown.

11. After the weld bead was ground flush with the pipe, another set of radiographs were taken similar to the first set. See envelopes 6 to 10 inclusive. Under these conditions the defects present in the welds are more pronounced but definitely lack sufficient contrast to make for ease in reading.

12. By comparing the films obtained from the 100 mg source (Envelope 6) with those of the 25 mg source (Envelope 7) on the 8-inch pipe, it will be seen that there is no difference in grain characteristics of the film but

there is a great difference in the definition in favor of the 25 mg source and the sensitivity of the latter was slightly better. Both sets exhibited about the same degree of contrast, which was poor.

13. A study of the four sizes of pipe with the 25 mg source at the axis of the pipe showed some interesting results.

TABLE I.

Radium: 25 mg at axis of pipe.

Pipe Size Inches	Film to Source Distance Inches	Thickness Inches	Per Cent Sensitivity
6	3.3	.45	2.5
8	4.4	.33	6.0
2	1.3	.22	9.0
4	2.3	.11	18.0

From the above table it may be seen that the most important single item to effect the sensitivity is the thickness of the metal. Neither the film to source distance nor the amount of radium (25 mg to 100 mg) is as important as is the thickness of the metal in obtaining the desired sensitivity. It also becomes apparent from these results that those defects which show up in the welds of the 2, 4 and 8-inch pipe must be quite large. Also, again it is pointed out that the definition and the contrast of these films are poor when it is known that the penetrameter was placed in the most advantageous place, that is, between the metal and the film.

14. The above information points to the fact that very little, if anything, would be gained in sensitivity with the moving of the radium from the axis to the pipe wall and radiographing the opposite wall.

15. A series of radiographs were taken with the radium outside the pipe at a film to source distance of 18 inches. A comparison of Table II with the results of Table I will indicate the degree of sensitivity obtained. (See Envelopes 11, 12, 13 and 14.)

TABLE II

Radium: 100 mg at 18", outside the pipe.

Pipe Size Inches	Film to Source Distance Inches	Thickness Inches	Per Cent Sensitivity
6	18	.45	2.5
8	18	.33	3.3
2*	18	.22	5.0
4	18	.11	18.0

* 25 mg of radium used on 2" pipe.

16. It may be noted that the sensitivity is a little better in the case of the 8 and 2 inch pipes. The real thin wall pipe, however, still exhibits the same poor sensitivity of 18 per cent. This means that metal of corresponding thickness can not be radiographed with radium with any degree of success.

17. If films resulting from 100 mg of radium exposure at 18 inches are compared with those of 100 mg at 4.4 inches on the 8 inch pipe, it may be noted that there is no difference in the grain of the film but that the longer distance gives better definition, contrast and sensitivity.

18. If the radiographs from the 8 inch pipe with 100 mg at 18 inches are compared to those obtained with 25 mg at 4.4 inches, it will be observed that the 100 mg - 18 inch combination gave much better sensitivity, contrast and definition than obtained by the 25 mg - 4.4 set-up. This is true even though the penetrameter was in the most unfavorable position in the 18 inch distance while it was next to the film in the 4.4 inch distance.

19. On two pipes (8 inch and 6 inch) the Eastman Industrial double-backed intensifying screens were used in radiography. By the use of intensifying screens it is possible to cut the exposure time to about 1/8 of the exposure time used with the standard technique. It may be noticed, upon comparing these films (Envelopes 15 and 16) with those exhibiting the standard technique (Envelopes 7 and 8) that there is very little loss in sensitivity but that the definition and contrast are much poorer. Also the use of the intensifying screens causes a much larger distortion of the defect than is obtained by the use of the standard technique. The large grain of the films is a distinct disadvantage.

20. The per cent sensitivity in this work is based on the penetrameter as devised by the Bureau of Engineering. It is felt that this tell-tale does not, however, present the true conditions that exist.

21. In the first place, it is relatively easy for the eye to travel down a step construction and see a step beyond that which you actually could see if the penetrameter were made up in separate individual plates. Thus a mistaken measurement of sensitivity is obtained.

22. Also the holes in the penetrameter are 3/16 inch in diameter. This means that defects should be 3/16 inch in diameter (regardless of the thickness of the metal) in order to obtain the sensitivity recorded. Since porosity in wells is seldom as large as this, the sensitivity recorded is again in error.

23. It also should be mentioned that the hole outlines are sharp and easily seen by the eye, thus tending for good definition whereas defects seldom have sharp discontinuities, being in general more of a blending type. This condition detracts from the sensitivity as well as from the definition. Since the penetrameter was in the most advantageous place and considering the above points, it may be said that gamma ray radiography of welded pipe will not be very successful. This, of course, was to be somewhat expected considering the information that has already been presented in Report No. N8-12 "Comparison of X-Ray and Gamma Ray Examination of Welds". Two tables are included from this report to show the nature of the results.

24. It was concluded in the N8-12 report that nothing less than 1/4 of an inch of steel should be radiographed by gamma rays and from the work accomplished in this report it is suggested that in pipes, nothing less than 1/2 inch of steel be radiographed by gamma rays.

CONCLUSIONS

25. Gamma ray radiographs prepared on welded pipe of sections up to 0.45 inch and 8 inches in diameter are lacking in contrast, definition and sensitivity, and that weld porosity can not be ascertained and only large defects can be located.

Tables taken from Report N8-12 "Comparison of X-Ray and Gamma Ray Examination of Welds" by R.A. Gezelius and C.W. Briggs, issued to Bureau of Engineering on 20 July 1933.

TABLE II

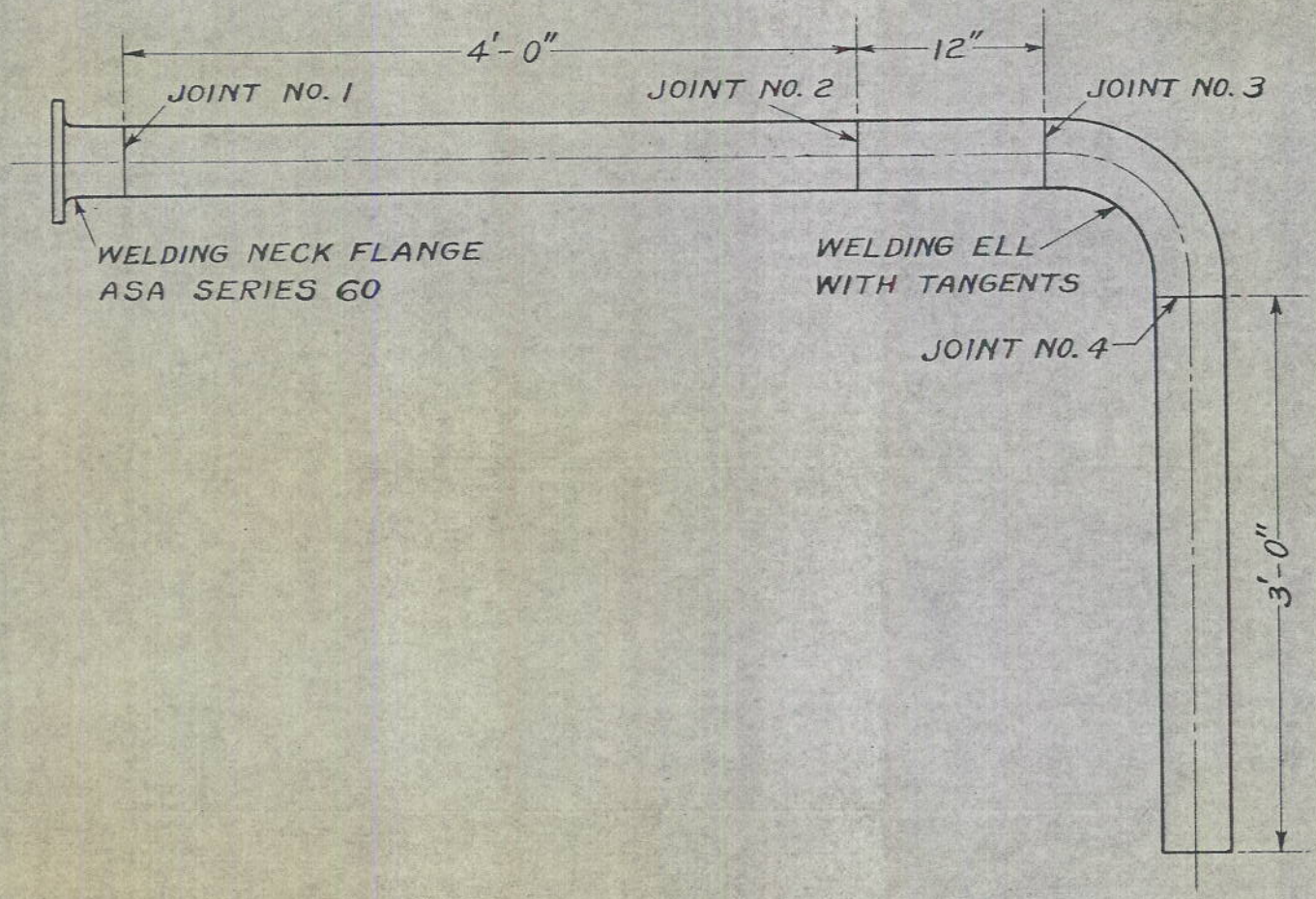
DATA ON X-RAY EXPOSURES

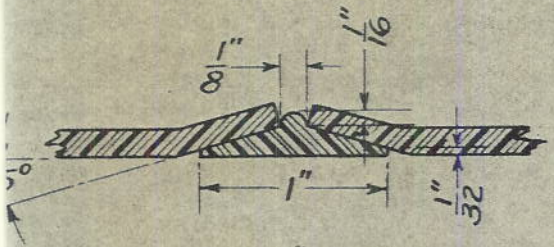
	Thickness in Inches	K.V.	M.A.	Exposure Time	Distance in Inches	Notes - Percent Visible
Plate 1	3.0626	238	4.5	90'	11	One slot only 4%
2	2.094	215	5.5	12'	19	All very pronounced 2%
3	1.437	200	6.0	3'30"	22	All three 2%
4	1.000	185	6.5	1'30"	28	All three 2%
5	0.469	125	7.0	1'15"	32	All three - 3rd barely on film 2%
6	0.25	125	7.5	10"	32	All three 2%
7	0.077	95	7.5	3"	32	All three 2%

TABLE III

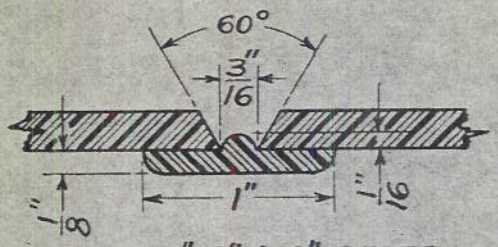
DATA ON GAMMA RAY EXPOSURES

	Thickness in Inches	Exposure time in hours	Mg Radium	Distance in Inches	Notes - Percent Visible
Plate 1	3.0626	3.75	278	18	All 3 slots 2%
2	2.094	2.6	278	18	All 3 slots 2%
3	1.437	1.6	278	18	All 3 slots 2%
4	1.000	1.2	278	18	All 3 slots 2%
5	0.469	0.85	278	18	All 3 slots 2%
6	0.25	0.68	278	18	All 3 slots 2%
7	0.077	0.60	278	18	One slot only 8%
8	4.2625	18.0	278	18	All 3 slots 2%





FOR 2" SIZE



FOR 4", 6" & 8" SIZES

DETAIL OF JOINTS

PLATE 1