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Released 1994

Prepared for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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SUBJECT Building 105-Conference on Welding Design and Technique

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FROM H. T. Daniels

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PROJECT 9536 - H.E.W. - BUILDING 105 - CONFERENCE ON WELDING DESIGN AND TECHNIQUE

We are transmitting herewith a copy of the minutes of the conference held February 7 in F. W. Pardee's office on the subject of Welding Design and Technique.

DESIGN DIVISION

H. T. Daniels

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February 15, 1944

TO: H. T. DANIELS
FROM: J. A. BURNS

PROJECT 5536 - H.E.W. - BUILDING 105 - CONFERENCE ON WELDING DESIGN AND TECHNIQUE

On February 4 at a conference in T. C. Gary's office attended by Messrs. Wood, Gary, H. T. Daniels, Burns and C. R. Johnson, the design of the strap plates on the front and rear shields of the pile was discussed from the standpoint of welding technique in the field. Discussion of the design centered around the plug welding of the plates to the laminated blocks and the ability of the field to perform this work properly. It was decided that welding specialists should be consulted prior to the beginning of the actual field erection in order that the best technique could be employed to guarantee good workmanship. It was agreed that a conference with such specialists should embrace both the features of the design as well as the practical phases of welding itself.

It had been proposed to obtain the services of A. J. Moses, Vice President of the Combustion Engineering Corporation at Chattanooga, Tenn. To complete the staff of specialists for consultation, it was decided to canvass the American Bridge Co., Bethlehem Steel Co., Lukens Steel Co., The Maritime Commission and the Morrison, Knudsen Co. By February 5 three welding specialists had consented to come to Wilmington for a conference to be held on February 7. These were Mr. A. J. Moses, Combustion Engineering Corporation; Dr. W. G. Theisinger, Lukens Steel Co.; and Mr. H. W. Pierce, New York Shipbuilding Corporation. These were deemed to be equally, if not the most competent, and the most readily available of those considered.

The welding specialists were cleared in order that a comprehensive outline of the problem might be presented without withholding information pertinent to the structural features of the pile shield. At a preliminary discussion in J. F. Martel's office on February 7 with the three specialists, T. C. Gary, J. F. Martel, C. R. Johnson and J. A. Burns present, T. C. Gary outlined the broad features of the problem and disclosed information relative to it to the extent necessary to acquaint the specialists with the difficulties involved.

The conference in J. F. Martel's office was adjourned to F. W. Pardee's office for further discussion with the following people present:

| E. C. Ackart | H. T. Daniels | J. A. Collins |
| G. M. Read  | N. F. Wood    | T. A. Betty   |
| T. C. Gary  | H. S. Stanton | D. B. Vesstrom|
| J. P. Martel | C. R. Johnson | J. A. Burns   |
A. J. Moses, Combustion Engineering Corporation
Dr. W. G. Thiesinger, Lukens Steel Company
H. W. Pierce, New York Shipbuilding Corporation

Three main problems were submitted for discussion: representing the three critical points at which good workmanship is necessary to obtain both structural strength and a tight shield against gas leakage.

1. The problem of design of the welds and erection of the tie strap plates on both sides of the two end walls of the pile shield.

2. The problem of fillet welding 2000 centering flanges on the face of these strap plates to obtain a tight gas seal.

3. The problem of properly welding the tee sections which form the frames of the side walls in order to obtain satisfactory structural strength.

A brief description of the structure was given in order to acquaint the outside consultants with the magnitude of the problem and with the pertinent features connected directly with the design of the walls as now prepared.

It was pointed out that each side wall, when assembled, weighs approximately 1000 tons. Each end wall weighs approximately 1300 tons with a weight of approximately 1300 tons in the roof supported in part by the two side walls. It was explained that there were temperature gradients across the faces of the structure and that due to the irregular effect of this temperature that some zones in each wall were hotter than others giving non-uniform stress effects due to expansion. It was explained that the inner face of the side walls would expand relative to the outer face resulting in a bow inward to the extent of 3/32 of an inch. It was further explained that due to the operation of the unit that the end walls, of necessity, were designed in horizontal rows of laminated blocks tied together to form "beams", the flanges of which were steel strap plates and the webs of which were the laminated blocks themselves. The irregular expansion of these "beams" was described in order that some background could be provided for the design of the plug welds forming the attachment of the strap plates to the blocks. The following comments were expressed by the welding specialists, who in general were in agreement on the individual technical phases of welding.

1. Plug welds are in general difficult to make unless precautions are taken to assure uniformly good workmanship.

2. Welds of any sort, and in particular, plug welds are impractical in the field when the plate thickness exceeds 1-1/4" unless stress relieved. The range of thickness was discussed from 3/4" to 1-1/4" and it was generally agreed that the welds as designed should be practical if sufficient precautions are taken.
3. It was unanimously agreed that the outside surface of each plate in a plug weld must be thoroughly cleaned of all mill scale either by grinding, sand blasting or machining so that a fresh surface is presented to the weld metal as it is deposited. In this case this applies to the outside surface of the blocks and the outside surface of the first laminated plate. In view of the difficulties in removing sand particles after sand blasting, it was agreed that if used at all, sand blasting should be done on those parts which could be thoroughly cleaned prior to assembly in Building 105.

4. Considerable doubt was expressed about the ability to obtain good penetration and good fusion at the bottom of the plug weld. In this particular case it was pointed out that the chilling effect of the 3-3/4" plate on one face of the laminated block would prevent good fusion unless preheating of this plate to a temperature of at least 150°F. was obtained. Various methods of applying heat were considered and it was generally agreed that heating with a torch or by electrical resistance should be adequate for the moderate temperatures required.

5. The volume of weld metal being deposited was also considered in view of the possibility of cracks developing either in the weld or adjacent to the weld as a result of stresses being built up. It was unanimously recommended that each layer of weld metal be thoroughly peened in order to relieve these stresses and that precaution should be taken to over-peen rather than under-peen in order to guarantee some flow of the metal. This peening should be done as soon as the electrode is removed from the weld when the metal is black hot.

6. The most difficult part of the plug weld is the small crescent at the top of the hole where it is most difficult to obtain good penetration. In order to provide access for the welder at this point it was agreed that all holes in the 1-1/4" plates should be chipped out at the top at an angle of approximately 30 to 40 degrees in order to form a more open corner for deposition of the weld metal.

7. From the standpoint of welding technique, it was considered more difficult to build the plug welds on the rear wall where both strap plates are 1-1/4" thick, than on the front walls where the plates are 1-1/4" and 1/2" respectively. It was agreed that in no case should a plug weld be made through two plates at the same time. It was pointed out in this connection that the presence of the 1/2" plate greatly facilitated the plug welding of this plate to the block and also reduced the chilling effect when making.
the plug weld which attaches the 1-1/4" plate to the 1/2" plate.

6. Considerable attention was paid to the vertical butt welds which join the two end sections of each strap to the center section. These strap plates were originally designed in three sections to facilitate the cutting of the holes and machining prior to shipment. It was agreed that this was desirable but that a better job of butt welding these sections could be done on the ground than could be expected if the welding was done in a vertical position on the wall. On this basis it was decided that the three sections of each lamination should be clamped to a rigid frame on the ground and welded in the flat position using the U-shaped welding groove which was provided. The plate should then be turned over, the metal chipped out from the back and the bead laid in to complete the joint, grinding off any excess weld metal which might be present. In this connection attention was focused on the quality of the weld at the extreme edges of the plate. Because of the concentration of stresses along the edges of these strap plates it was recommended that temporary extensions be provided in order that the weld metal could be carried beyond the edge of the plate and then cut back to provide a smooth finished section. Peening of this weld was also recommended in order to relieve the stresses and prevent distortion of the plates.

9. It was pointed out that it was extremely important to clamp the inner plate tightly against the face of the block and that care should be taken to pull these plates up as tightly as possible in order to get the best possible plug welds between the first plate and the face of the block. This principle also applies to the plug welding of the second strap plate to the first plate. It was agreed that clamping through the holes in the block such that both plates were held in position at the same time should give ample support during welding. It was pointed out that some special clamping device would have to be provided at either end of each strap where no holes exist in the end block and where clamping is extremely important.

10. The present design calls for horizontal interrupted welds across a 4'-2" span between successive tie straps at the center line. This was done to obtain a column effect and to tie the straps firmly at the center to prevent progressive movement during expansion. This interrupted welding was considered bad practice and it was generally agreed that such welds would not hold during operation. It was recommended that the same amount of weld be laid continuously and that the weld be tapered off at the
ends at a ratio of about 2 to 1. It was recommended that this weld be laid in several passes with peening between each pass.

11. The question of porosity of the welds was discussed with reference to their function as a gas seal. It was pointed out that thorough peening together with good welding technique should provide a gas-tight weld. Leakage would indicate poor fusion or cracking of the metal core which would be in turn caused by inadequate peening or poor welding technique. It was not believed that this should present any serious problem.

12. The type of flexible seal being considered to close the 1/4" joint between successive straps was described for comment by the committee. It was generally agreed that if the Omega type flexible seal joint were employed, that the thin metal plate should be welded to the 1/4" welding strap in the shop and carefully tested prior to assembly. It was generally agreed that the additional longitudinal welding of this strap to the face of the pile would further accentuate distortion of the tie plate plates and possibly result in the development of transverse cracks across the welds during operation. A definite preference was shown for the mechanical type of clamped neoprene strip which it is now planned to use on all joints except the lower joint between the bottom strap plate and the first row of blocks.

13. Considerable attention was given to the problem of fillet welding the centering flanges to the face of the wall. This was considered to be one of the most difficult welding problems encountered in the assembly of the end walls. It was pointed out that the continuous bead around the periphery of the flange plate would result in a hoop stress set-up in the strap plates, and that there would be some doubt as to its gas tightness unless special precautions were taken. It was recommended that two beads be laid to form this fillet weld with peening after each layer to relieve stresses as far as possible. It was suggested also that consideration be given to silver soldering this joint to obtain a gas tight seal. This method was not rejected but it was agreed that some development work would be necessary to establish proper technique. Preference was expressed for welding, if possible, because of the greater ease of repairing a leaky joint. It was definitely recommended that the center flange be beveled at an angle of 22-1/2 degrees in order that an obtuse angle could be obtained which would give better results in sealing.
14. It was recommended that the seal weld between the top ring of the bellows and the "gun barrel" be made with a torch in order to obtain a satisfactory seal and to avoid the necessity of caulking. It was recommended that this ring be turned back to present a narrow surface at the welded joint and that a single pass gas weld would be adequate. It was not expected that any bulging or distortion of the tube would result from this procedure.

It was agreed that this is a difficult weld to make because of the possibility of weakening the silver soldered joint at the top of the bellows. There is an alternate opinion that a small arc welded joint at this point is superior to a flame weld which would introduce more heat into the top ring of the bellows.

15. Some attention was given to the welding of the tee sections making up the side wall structure. It was agreed that no serious difficulty should be encountered in welding the stem plate to the base plate, but that where intermittent welding was employed the bead should be tapered off gradually in order to relieve the stress. It was pointed out that little strength could be expected from the welds in the vertical joint between the 2-1/2" flange plates which were designed as 3" beads on 3" centers. It was agreed that these welds would be adequate to hold the members in position during erection but that no permanent strength should be expected from such a joint.

16. The outer seal weld which attaches the outermost plate of the side walls to the stem plate was discussed in detail. It was finally agreed that a 1/2" fillet weld along this joint would be sufficient provided the side thrust or eccentricity was not sufficient to require any greater strength. This force has been investigated and found to be of a low magnitude.

17. The weld joint between the 2-1/2" flanged plates and the base plate was considered adequate as a fillet weld, in view of the fact that the main thrust is taken by the stem plates.

At the end of the discussion it was generally agreed that the structure could be built provided the above precautions were followed and good workmanship provided throughout. It was recommended that the welders who were assigned to this work be made to qualify as welders in all positions, and further that sample plug welds be provided by them to show their ability in following the instructions that will be supplied for this work.
Mr. Moses supplied two films showing photographs of plug welds which he had prepared in his shop prior to his visit to Wilmington. These photographs showed the practicability of plug welding provided the proper precautions were taken.

The outside welding specialists expressed their extreme interest in this unusual problem and expressed their willingness to cooperate further in developing information or in consultation regarding any phases of the work as it progressed.

Mr. Moses, prior to his return to Chattanooga, agreed to make available his shop facilities for development work, which is planned, in order to develop the exact technique of welding in all of the details which will be required in the field. Steps will be taken to provide suitable plates and blocks to the Combustion Engineering Corporation's plant at Chattanooga where this development work will be carried on during the next three weeks. The program for this development work will be outlined in a separate memorandum.