APPENDIX 5C

MECHANICAL SPLICING OF REINFORCING BAR USING THE CADWELD PROCESS

29 PART I - The procedures for mechanical splicing of reinforcing bar described on the following pages 5C-1 through 5C-4 are applicable to all splicing work done prior to June, 1973. For splicing work done after this date see page 5C-4a.

SCOPE

This procedure specification is to be used for mechanical splicing of deformed concrete reinforcing bar for tensile loading. The minimum tensile strength of the splices shall equal or exceed 125 percent of the minimum yield strength for each grade of reinforcing steel as specified in the appropriate ASTM standard.

PROCESS

Splicing of concrete reinforcing bar under this procedure specification shall be done by the CADWELD Process (ERICO Products, Inc.) using "T" series and "B" series full tension splice materials only. "C" series and "C-16" series splice materials shall not be used. Any "special" splice kits used should also meet the minimum tensile strength requirements as stated in "Scope" above unless specifically permitted otherwise.

5 Connection of reinforcing bars to reactor building embedded plates shall be made with "B" series splices except that the sleeves will be supplied by the liner plate fabricator, as shown on attached Fig 5C-1.

MATERIALS

REBAR MATERIAL

This procedure specification shall be used only for splicing the concrete reinforcing bars shown in Table 5C-1.

SPLICE MATERIAL

The "T" series splice material shall be shown in Table 5C-2.

SPLICING

GENERAL

All splices shall be made in strict accordance with the manufacturer's instructions as presented in ERICO Products Bulletin RB10M-169, CADWELD Rebar Splicing.

A manufacturer's representative, experienced in CADWELD splicing of reinforcing bar, shall be present at jobsite at the outset of the work to demonstrate the equipment and techniques used for making quality splices. He shall also be present for at least the first fifty (50) production splices to observe and verify that the equipment is being used correctly and that quality splices are being obtained.

CARE AND HANDLING OF SPLICE KITS AND EQUIPMENT

The splice sleeves, cartridges, asbestos wicking, ceramic inserts and graphite parts shall be stored in a clean, dry, temperature-controlled area with adequate protection from the elements to prevent absorption of moisture.

Splice sleeves are wrapped in a special rust-inhibiting paper. Sleeves shall not be unwrapped until they are to be used in the joining procedure.

Each splice sleeve shall be visually examined immediately prior to use to insure the absence of rust and other foreign material on the inside surface.

The graphite pouring basins and crucibles shall be preheated to 300 F minimum with an oxyacetylene torch to drive off moisture immediately prior to initial use each day. If continued operation is interrupted, preheating of both basins and crucibles will again be required.

All graphite parts (except crucible covers) must be cleaned before reusing. Clean with whisk broom, rag, coarse brush or rolled up newspaper. DO NOT use wire brush on graphite parts.

REBAR END PREPARATION

The bar ends to be spliced shall be in good condition with full size, undamaged deformations.

Bar ends which have been badly deformed by shearing shall require cutting to assure proper fit of the splice sleeve. Bar end shear drag may be flame-cut or ground off.

The reinforcing bar deformations, except longitudinal ribs, which become engaged in the CADWELD splice shall not be ground, flame-cut or altered in any way. Oversize longitudinal ribs may be ground down to match the diameter of the bar deformations, but shall not be ground to a diameter less than the bar deformations.

The bar ends for a minimum distance of two inches beyond where the end of the sleeve will be located shall be heated with an oxyacetylene "rosebud" torch to 300 F minimum to remove all moisture and burn off any organic foreign material.

After the heating operation, the bar ends shall be thoroughly cleaned by power brushing or sandblasting to remove all loose mill scale, concrete, dirt and other foreign material not removed by burning.

If there is any delay between the initial preheating and placing of the splicing sleeve in its final position, the previously cleaned bar ends shall again be preheated to 300 F minimum with an oxyacetylene "rosebud" torch to insure complete removal of moisture.

A permanent line shall be marked by painting, keel or draw file 12 in. back from the end of each bar for a reference point to confirm that the bar ends are properly centered in the splice sleeve. The use of a prick punch for this purpose will not be allowed.

INSPECTION AND TESTING

VISUAL INSPECTION

All completed splices shall be visually inspected at both ends of the splice sleeve and at the tap hole in the center of the splice sleeve.

Filler metal shall be visible at both ends of the splice sleeve and at the tap hole in the center of the splice sleeve. Filler metal is usually recessed approximately 1/4 inch from the end of the sleeve due to the packing material and this amount of recess is not considered a poor fill.

Splices which contain slag or generally porous metal in the riser, tap hole or at the ends of the sleeves shall be rejected. A single shrinkage bubble present below the riser is not detrimental and should be distinguished from general porosity as described above.

CADWELD splices may contain voids at either or both ends of the CADWELD splice sleeve. Alowable limits for end voids shall be as shown in Table 5C-3.

TENSILE TESTING

For purposes of quality control, production splices representing the work of each splicing crew shall be tensile tested for each position, bar size and grade of bar. The number and frequency of tests shall be in accordance with the schedule for testing rebar splices included in the job specifications, but if such schedule is not included with the job specifications, the number and frequency of tests for each splicing crew shall be as follows:

a. One out of the first lot of ten splices for each position, bar size and grade of bar.

b. Three out of the next and subsequent lots of one hundred splices for each position, bar size and grade of bar.

The first five tensile test specimens shall be made by cutting out randomly selected production splices. Thereafter, at least one of every four tensile tests shall be made from production splices. At least one tensile test specimen shall be cut out from an actual production splice for each position, bar size and grade of bar. The remainder of the required tensile tests may be made from 3-ft long test bars spliced in sequence with and in an otherwise identical manner as the production splices.

Testing of "B" series connections of reinforcing bars to embedded plates shall be made on samples prepared by the reactor building liner plate fabricator.

Number of samples shall conform to requirements described in Paragraph "a" above.

STRENGTH REQUIREMENTS

The minimum tensile strength of the CADWELD splices shall be equal to or greater than 125 percent of the ASTM specified minimum yield strength of the bar as shown in Table 5C-1.

If any of the tensile test specimens fail to meet the strength requirements in paragraph above, two production splices from the same lot represented by the test which failed shall be cut out and tensile tested. If both of the retests pass the strength requirements, all of the splices in that lot shall be accepted. If one or both of the retests fail to meet the strength requirements, all of the splices in that lot shall be subject to rejection.

QUALIFICATION OF OPERATORS

Prior to the production splicing of reinforcing bars, each operator or crew, including the foreman or supervisor for that crew, shall prepare and test a joint for each of the positions to be used in production work. These splices shall be made and tested in strict accordance with this specification using the same ASTM grade, size and deformation pattern of bar to be spliced in the production work. To qualify, the completed splices shall meet the acceptance standards in "Inspection and Testing" for visual inspection and minimum tensile strength. A list containing the names of qualified operators and their qualification test results shall be maintained at the jobsite.

PART II - The procedures for mechanical splicing of reinforcing bar described on the following pages 5C-4a through 5C-4d are applicable to all splicing work done after June, 1973.

SCOPE

This procedure specification is to be used for mechanical splicing of deformed concrete reinforcing bar for tensile loading. The minimum tensile strength of a single splice shall be equal to or greater than 125 percent of the minimum yield strength for the grade of reinforcing bar used. The average tensile strength of each group of 15 consecutive splices tested shall be equal to or greater than the minimum ultimate tensile strength for the specified grade of reinforcing bar used.

PROCESS

Tensile splicing by the exothermic process shall be done by the Cadweld process (ERICO Products, Inc.) using T series and B series full tension splice materials only. Any "Special" splice kits used shall also meet the minimum tensile strength requirements as stated above unless specifically permitted otherwise.

MATERIALS

REBAR MATERIAL - This procedure specification shall apply only to concrete reinforcing bars of ASTM designation A615, Grades 40 and 60. (See Table 5C-1).

SPLICE MATERIAL - The "T" series splice material shall be as shown in Table 5C-2, except the catalog numbers for bar sizes no. 8 are RBT-8101 (Vertical) and RBT-8101-H (Horizontal).

SPLICING

GENERAL - All splices shall be made in strict accordance with the manufacturer's instructions as presented in ERICO Products Bulletin RB20M173, CADWELD Rebar
29 Splicing.

A manufacturer's representative experienced in exothermic splicing of reinforcing bar, shall be present at jobsite at the outset of the work to demonstrate the equipment and techniques used for making quality splices. The representative shall also be present for at least the first 50 production splices to observe and verify that the equipment is being used correctly and that quality splices are being obtained.

CARE AND HANDLING OF SPLICE KITS AND EQUIPMENT - The splice sleeves, cartridges, asbestos wicking, ceramic inserts and graphite parts shall be stored in a clean, dry temperature-controlled area with adequate protection from the elements to prevent absorption of moisture.

Splice sleeves are wrapped in a special rust inhibiting paper. Sleeves shall not be unwrapped until they are to be used in the joining procedure.

Each splice sleeve shall be visually examined immediately prior to use to insure proper machining and the absence of rust and other foreign material on the inside surface.

B series sleeves which have been installed in the shop on prefabricated structural steel assemblies and which contain no "Cadwelded" rebars will be covered and sealed to protect inside of sleeve from moisture, rust or other foreign material.

The graphite pouring basins and crucibles shall be preheated with an oxyacetylene torch to drive off moisture immediately prior to initial use each day. If continued operation is interrupted, both basins and crucibles shall be preheated again.

All graphite parts (except crucible covers) shall be cleaned before re-using with whisk broom, rag, coarse brush or rolled up newspaper. Wire brushes shall not be used on graphite parts.

PREPARATION FOR SPLICING - Reinforcing bars will be furnished whose ends to be spliced have been either sawcut, flamecut, or shearcut. On flamecut ends slag will have been removed by chipping, brushing, or grinding. Plane of cut shall not deviate from the "square" more than 1/8 inch. Bar deformations shall be full size, undamaged, and uninterrupted by trademark or any other identification mark, for the portion of the reinforcing bar that is inside the cadweld sleeve.

The reinforcing bar deformations, except longitudinal ribs, which become engaged in the exothermic splice shall not be ground, flamecut or altered in any way. Oversize longitudinal ribs may be ground down to match the diameter of the bar deformations, but shall not be ground to a diameter less than the bar deformations.

The bar ends for a minimum distance of two inches beyond where the end of
29 the sleeve will be located shall be heated with an oxyacetylene "rosebud" torch to remove all moisture and burn off any organic foreign material.

After the heating operation, the bar ends shall be thoroughly cleaned by power brushing or sandblasting to remove all loose mill scale, concrete, dirt and other foreign material not removed by burning.

If there is any delay between the initial preheating and placing of the splicing sleeve in its final position, the previously cleaned bar ends shall be preheated with an oxyacetylene "rosebud" torch to insure complete removal of moisture.

B series sleeves shall be protected with sealed coverings to insure that insides of sleeves are maintained in a moisture free, rust free, dirt free condition. Prior to making splices the sleeves shall be inspected, all rust and foreign material removed as required and the sleeves heated with an oxyacetylene "rosebud" torch to insure complete removal of moisture.

Prior to splicing a permanent line shall be marked by painting, keel or draw file 12 inches back from the end of each bar for a reference point to confirm that the bar ends are properly centered in the splice sleeve. The use of a prick punch for this purpose will not be allowed.

Special attention shall be given to maintaining the alignment of sleeve and guide tube to ensure a proper fill.

When the temperature is below freezing or the relative humidity is above 65 percent, the splice sleeve shall be externally preheated with an oxyacetylene or propane torch after all materials and equipment are in position.

INSPECTION AND TESTING

Inspection and testing of mechanical splices in reinforcing bars shall be in accordance with AEC Regulatory Guide 1.10, Revision 1, 1/2/73, as interpreted by the AEC in their May 15, 1973, MEMO TO ATTENDEES, SUMMARY OF MEETING WITH ERICO PRODUCTS, INC. on May 8, 1973, with the following exceptions:

1. Regulatory Position C-3, Tensile Testing, sixth paragraph requires that the locations of all reinforcing bar splices, including replacements for production test samples....should be shown on the as-built drawings;...

   For the Midland plant, the location information will be available on other field records prepared in controlling the cadweld work, but will not be transferred to the as-built drawings.

2. Regulatory Position C-4, Tensile Testing Frequency, first paragraph specifies that separate test cycles should be established for.... each splicing crew.....

   For the Midland plant, the testing frequency follows the interpretation in the above referenced AEC memo, items 15 and 17, by deleting the words "for each splicing crew." The tensile test frequency is based upon the total output of all splices. 29

3. Regulatory Position C-5, Procedure for Substandard Tensile Test Results, third paragraph requires that if two or more splices from any of these six additional splice samples fail to meet the tensile test specification.... the balance of the 100 production splices under investigation should be rejected and replaced.

   For the Midland plant in the above situation, the acceptability of the reduced average tensile strength with respect to the required strength at the location from which the samples were taken will be evaluated and assessed by Project Engineering. Thus, this procedure permits accepting the reduced average tensile strength in areas of low stress, yet does not preclude the rejection of the remaining splices if this is evaluated as necessary.

QUALIFICATION OF OPERATORS

The qualification of splicing crew members shall be in accordance with AEC Regulatory Guide 1.10, Revision 1, 1/2/73, as interpreted by the May 15, 1973, AEC MEMO TO ATTENDEES referenced above, with the following exceptions:

1. Regulatory Position C-1, Crew Qualification, first paragraph as clarified by the referenced AEC memo, item no. 2: "It is acceptable to prepare the qualification splices for each of the splice positions using the largest bar size to be used in that position."

   For the Midland plant, the operators are qualified using the largest bar size to be used for each applicable position.

2. Regulatory Position C-1, Crew Qualification, second paragraph specifies that each member of the splicing crew (or each crew if the members work as a unit) is subject to requalification if....(2) completed splices fail to pass the visual inspection test....or fail to pass the tensile tests... The requalification procedure should be identical to the original qualification procedure...

   For the Midland plant, the splicing work shall be reviewed and evaluated to determine required corrective action if the tensile test failures accumulated from all splicing crews exceed the rate of one for each 15 consecutive test samples, or if splices are consistantly failing to pass visual inspection, or if there is a question of a crew's ability. Thus, this procedure precludes the requirement for requalification for each instance of failing visual and/or tensile test requirements, while still satisfying the intent of the regulatory position.

Table 5C-1

Deformed Concrete Reinforcing Bar Materials

ASTM Designation	Tensile Strength, psi Min	Yield Strength, psi Min	125% of Min Yield Strength, psi	Type of Material	Splice Code Number(1)
A615 Grade 40	70,000	40,000	50,000	Billet Steel	1
A615 Grade 60	90,000	60,000	75,000	Billet Steel	2
A615 Grade 75	100,000	75,000	93,750	Billet Steel	3
A616 Grade 50	80,000	50,000	62,500	Rail Steel	2
A616 Grade 60	90,000	60,000	75,000	Rail Steel	2
A617 Grade 40	70,000	40,000	50,000	Axle Steel	1
A617 Grade 60	90,000	60,000	75,000	Axle Steel	2

Note

(1) See Table 5C-2 for splice materials.

Table 5C-2

"T" Series Splice Materials

Bar Size No.	Splice Code No.(1)	Splice Kit Catalog Number(2)(3)
6	1	RBT-6101 (Vertical) and RBT-6101-H (Horizontal)
6	2	RBT-6101 (Vertical) and RBT-6101-H (Horizontal)
6	3	See Note 4
7	1	RBT-7101 (Vertical) and RBT-7101-H (Horizontal)
7	2	RBT-7101 (Vertical) and RBT-7101-H (Horizontal)
7	3	See Note 4
8	1	RBT-891 (Vertical) and RBT-891-H (Horizontal)
8	2	RBT-891 (Vertical) and RBT-891-H (Horizontal)
8	3	See Note 4
9	1	RBT-9101 (Vertical) and RBT-9101-H (Horizontal)
9	2	RBT-9101 (Vertical) and RBT-9101-H (Horizontal)
9	3	See Note 4
10	1	RBT-1091 (Vertical) and RBT-1091-H (Horizontal)
10	2	RBT-1091 (Vertical) and RBT-1091-H (Horizontal)
10	3	See Note 4
11	1	RBT-11101 (Vertical) and RBT-11101-H (Horizontal)
11	2	RBT-11101 (Vertical) and RBT-11101-H (Horizontal)
11	3	RBT-11101 (Vertical) and RBT-11101-H (Horizontal)
14	1	RBT-1476 (Vertical) and RBT-1476-H (Horizontal)
14	2	RBT-14101 (Vertical) and RBT-14101-H (Horizontal)
14	3	RBT-14101 (Vertical) and RBT-14101-H (Horizontal)
18	1	RBT-1876 (Vertical) and RBT-1876-H (Horizontal)
18	2	RBT-1891 (Vertical) and RBT-1891-H (Horizontal)
18	3	RBT-18101 (Vertical) and RBT-18101-H (Horizontal)

Notes

(1) See Table 5C-1 for selection of proper splice code number.

(2) Expendable items only are provided with the splice kits. Contact the manufacturer, ERICO Products, Inc, for required nonexpendable tools and equipment.

(3) & (4) For splice kits not listed, size transitions, rebar to structural steel connections and positions other than vertical and horizontal, contact the manufacturer, ERICO Products, Inc.

Table 5C-3

Allowable Void Limits

Bar Size No.	Splice Catalog No.	Maximum Allowable Void Limits(1)(2) Void Area Standard Splices(3)(4), sq in.	Vertical - Full Circumference Low(5), in.
6-6	RBT-6101 (-H)	1.05-1.05	5/8 - 5/8
6-7	RBT6-7101 (-H)	1.05-1.03	5/8 - 9/16
7-7	RBT-7101 (-H)	1.03-1.03	9/16 - 9/16
7-8	RBT7-8101 (-H)	1.03-1.02	9/16 - 1/2
8-8	RBT-891 (-H)	1.02-1.02	1/2 - 1/2
8-9	RBT-8-9101 (-H)	1.02-1.02	1/2 - 1/2
9-9	RBT-9101 (-H)	1.02-1.02	1/2 - 1/2
9-10	RBT9-10101 (-H)	1.02-1.03	1/2 - 7/16
10-10	RBT-1091 (-H)	1.03-1.03	7/16 - 7/16
10-11	RBT10-11101 (-H)	1.03-1.53	7/16 - 9/16
11-11	RBT-11101 (-H)	1.53-1.53	9/16 - 9/16
11-14	RBT-11-14101 (-H)	1.53-1.52	9/16 - 5/8
11-18	RBT11-18101 (-H)	1.53-1.99	9/16 - 1/2
14-14	RBT-1476 (-H)	2.15-2.15	5/8 - 5/8
14-14	RBT-14101 (-H)	2.15-2.15	5/8 - 5/8
14-18	RBT14-18101 (-H)	2.15-1.99	5/8 - 1/2
18-18	RBT-1876 (-H)	2.64-2.64	9/16 - 9/16
18-18	RBT-1891 (-H)	3.00-3.00	5/8 - 5/8
18-18	RBT-18101 (-H)	3.00-3.00	5/8 - 5/8

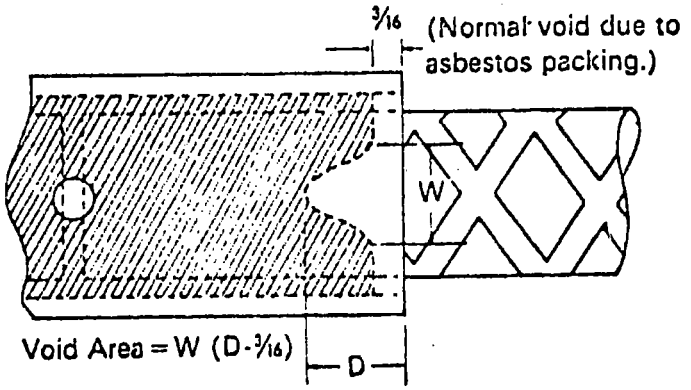


Table 5C-3 (Contd)

Notes

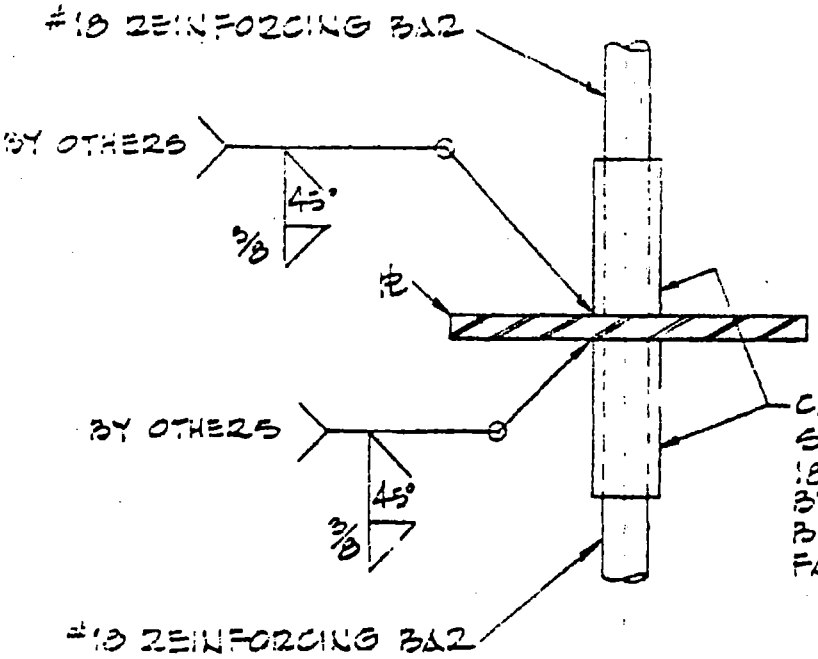
(1) Void dimensions shall be measured by use of a tie wire probe.

(2) Splices with filler metal voids in excess of the maximum allowable shall be rejected.

(3) The maximum allowable void area shall be computed separately for each end of the splice sleeve as shown in the sketch.

(4) This column to be used for all standard splices, including vertical, horizontal, horizontal side fill, angled splices and "B" series structure splices.

(5) This column to be used for vertical splices only with low filler metal around entire circumference. For spot voids in vertical splices, use standard splices column.



CADWELD SERIES B CONNECTION

NOTE:

COMPONENTS FOR B-SERIES SPLICES TO BE IN ACCORDANCE WITH ERICO PRODUCTS BULLETIN EB 10M 169

FIG. No 5-C-1

No.	DATE	REVISIONS	BY	CH'K	APPR
		ISSUED FOR REVIEW			

ORIGIN

CONSUMERS POWER COMPANY
MIDLAND, MICHIGAN

JOB No. 7220
DRAWING NO SK-C-213
REV 0

SHEET ____ OF ____