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DESIGN REVIEW OF THE DAYTON BAR-GRIP REINFORCING BAR SPLICE SYSTEM

TECHNICAL EVALUATION REPORT

Prepared By:

Science Applications, Inc.
1710 Goodridge Drive
McLean, VA 22102

Prepared For:

U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

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EXECUTIVE SUMMARY

This Technical Evaluation Report (TER) has been prepared by Science Applications, Inc. (SAI), under contract from the U. S. Nuclear Regulatory Commission (NRC) staff, to document an engineering evaluation of the Dayton Bar-Grip Reinforcing Bar Splice System. Neither the NRC nor its staff has, as yet, approved this TER for use in any licensing action. This splice system is used to positively connect steel reinforcing bars (i.e., rebars) in such a manner as to develop the minimum ultimate tensile strength of the concrete reinforcing steel on which they are used. The coupler design concept consists of using an hydraulic press to cold-press a steel sleeve around the ends of the deformed reinforcing bars.

Steel for tension elements in reinforced concrete requires direct, positive coupling of adjoining elements in conformance with standards defined by the American Concrete Institute (ACI) and the American Society of Mechanical Engineers (ASME). Currently, the only splice system approved by the NRC for general use in nuclear power plant construction applications is the CADWELD System. The Public Service Company of New Hampshire has proposed the use of the Dayton Bar-Grip System, which is manufactured by Dayton Barsplice, Inc. (DBI), of Miamisburg, Ohio, in constructing their Seabrook Nuclear Power Plant. This TER has been prepared to support an NRC staff evaluation of the Dayton Bar-Grip splice system.

The information presented in this TER is based on a review of data obtained from DBI, a number of users of the couplers, and applicable codes and regulations. The report includes a description of coupler design features, the process used to manufacture the couplers, installation procedures and quality assurance/inspection procedures. An engineering analysis discussion and a summary of performance tests performed by DBI to substantiate their coupler design are also included in this TER.

The Dayton Bar-Grip coupler is furnished in two types (i.e., the plain Coupler and the threaded Coupler) and several sizes to accommodate No. 5 through No. 18 rebars. Only the plain coupler is evaluated in this TER.

The couplers have been successfully used on a wide variety of construction projects both in the United States and in several foreign countries. The couplers used on most of these projects had to be designed to satisfy requirements that were similar to those imposed on projects regulated by the NRC.

Performance tests have been run on all of the coupler sizes that are manufactured by DBI. Although these tests generally conform to the requirements of the applicable codes and standards, several apparent nonconformances were noted. These nonconformances included strains in excess of 0.3 percent, lack of total elongation at failure data and reduction in strength after some cyclic tests. It is recommended that DBI be asked to either justify such apparent nonconformances or to run appropriate additional tests before the NRC accepts the Bar-Grip plain coupler for general use in nuclear plant construction.

It is suggested that DBI be encouraged to develop a generic Quality Assurance Manual and related Quality Control Procedures rather than relying on each customer to develop his own such documentation for each specific project.

Although it has been recommended that DBI be asked to provide certain additional data/documentation prior to the granting of NRC approval for the general use of the Dayton Bar-Grip Splice System on nuclear power plant projects, it is concluded that this system can be used in specific applications provided that such applications are reviewed and approved on a case-by-case basis. Consequently, the pending application for the use of this splice system at the Seabrook Nuclear Power Plant should not be delayed pending the gathering of additional data according to recommendations contained in this TER. None of the recommendations presented should preclude the use of the Dayton Bar-Grip Splice System at the Seabrook Nuclear Power Plant.

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1.0 INTRODUCTION

Steel for tension elements in reinforced concrete requires direct, positive coupling of adjoining elements in conformance with a variety of standards defined by the American Concrete Institute (ACI), the American Society of Mechanical Engineers (ASME) and the Nuclear Regulatory Commission (NRC). Currently, the only splice system approved by the NRC for general use in nuclear power plant construction applications is the CADWELD system. The Public Service Company of New Hampshire has proposed the use of the Dayton Bar-Grip Reinforcing Bar Splice System for work at its Seabrook Nuclear Power Plant [1][1]. This Technical Evaluation Report (TER) has been prepared by Science Applications, Inc. (SAI), under contract from the NRC staff, to document an engineering evaluation of the Bar-Grip splice system.

The objective of this work assignment was to review and evaluate conformance of the Bar-Grip splice system with the requirements of ACI Standard 349-80 [2], the ASME Code Section III, Division 2 [3,4], including Code Case N-185 [5], and NRC Regulatory Guide 1.136 [6] and to make an independent assessment of the acceptability of the splice system for use in nuclear power plant construction applications.

The information presented in this TER is based on a review of documents and literature obtained from Dayton Barsplice, Inc. (DBI), who is the manufacturer of the couplers used in the splice system and applicable codes and regulations.

A background discussion describing the events which led up to the need for this report is presented in Section 2.0 together with a list of applicable codes, regulations and specifications. Section 3.0 contains a description of the splice system. Included is a description of significant design features as well as descriptions of the process used to manufacture the couplers, quality assurance procedures and installation procedures.

A discussion is presented in Section 4.0 in which the behavior of the splice system is described from an engineering analysis point of view. Section 5.0 contains a summary of some of the more significant test results which were obtained by DBI to substantiate their coupler design.

Section 6.0 contains data resulting from SAI's review of the Bar-Grip splice system design. Included is a general discussion regarding the adequacy of the coupler design, a summary of current users of the splice system, and a number of conclusions and/or recommendations regarding the acceptability of the system for use in nuclear plant construction.

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[1]References are denoted by "[1]" throughout this TER. A complete list of references is given on Page 7-1.

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2.0 GENERAL DISCUSSION

This section contains a general background discussion to establish the need for the evaluation documented in this report. Also included are summaries of codes, regulations, specifications and correspondence that relate to the Dayton Bar-Grip Splice System design and the request to the NRC for the approval of its use in nuclear power plant construction.

2.1 BACKGROUND

Steel for tension elements in reinforced concrete requires, in certain situations, direct, positive coupling of adjoining elements in conformance with standards such as those defined in ACI Standard 349-80 [2], the ASME Code Section III--Division 2 [3,4], ASME Code Case N-185 [5], NRC Regulatory Guide 1.136 [6], the Uniform Building Code [7] and ACI 318-77 [8]. Currently, the only splice system approved by the NRC for general use in nuclear power plant construction applications is the CADWELD system.

The Public Service Company of New Hampshire has proposed the use of the Dayton Bar-Grip Reinforcing Bar Splice System manufactured by Dayton Barsplice, Inc. (DBI) of Miamisburg, Ohio in performing work on their Seabrook Nuclear Power Plant. This request, which has been initiated through appropriate NRC channels with the assistance of United Engineers and Constructors, who are the Architect/Engineers for the Seabrook project, is officially documented in [1].

DBI was formed in 1979 as a joint venture of the Dayton Sure-Grip and Shore Company of Dayton, Ohio and CCL Systems Ltd. (CCL) of London and Leeds, England. Dayton Sure-Grip has been making accessories and chemicals for concrete construction for over 57 years. CCL Systems has been making engineered systems for prestressing and placing concrete for over 47 years.

DBI has provided considerable product description and performance test data [9,10] to support the evaluation documented in this report and the request for approval to use the Bar-Grip splice system in nuclear plant construction. These data, which are summarized in Sections 2.3 and 2.4, includes DBI brochures and procedure manuals [11,12], reports on tests performed both directly for DBI or CCL [13-18] and for potential users of the system [19-21] and documents approving the use of the splice system in particular applications [22,23].

2.2 APPLICABLE CODES AND REGULATIONS

This section contains a brief description of the various codes and regulations which are referenced in this TER. Included is a short summary of the sections of each document that pertain to the use of a swaged mechanical splice like the Dayton Bar-Grip splice evaluated herein. Also included as Table 2.1 is a comparative listing of significant splice system code requirements between the latest revision of the principal codes referenced on nuclear power plant construction projects.

Table 2.1. Comparative Splice System Code Requirements.

Item	Summary of Code Requirement		
	ACI 318-77	ACI 349-80	ACI 359-80 (with 80 Summer Addenda)
Design Requirements	Must develop 125% of bar yield strength	Must develop 125% of bar yield strength	See applicable performance test requirements.
Performance Test Requirements:			
Static Tensile Test Required	No	Yes, 6 specimens.	Yes, 6 specimens.
Cyclic Test Required	No	Yes, 100 cycles of 5-90% of minimum yield, 3 specimens.	Yes, 100 cycles of 5-90% of minimum yield, 3[1] specimens.
Test Acceptance Criteria	N/A	125% of specified yield, no loss of strength after cyclic test.	125% of specified yield, 100% of specified ultimate, and 90% of actual ultimate.
Strain Criteria	None	Connections staggered if strain at 0.9 f_y exceeds 0.3% and design load exceeds 50% of yield.	Load-strain curve required up to 2% strain, Total elongation at failure must be recorded.
Unspliced Rebar Test Requirements	None	None	Average strength not less than 90% of actual strength of any bar.

Note: 1. For swaged splices - 3 of each pattern in each size.

1. "Code Requirements for Nuclear Safety Related Concrete Structures," ACI 349-80, American Concrete Institute, Detroit, Michigan, April 1981 [2].

   This code covers the proper design and construction of concrete structures which form part of a nuclear power plant and which have safety related functions, but does not cover concrete reactor vessels and concrete containment structures as defined in [3,4]. The code is an extension of [8] and, as such, permits the use of mechanical reinforcing bar connections. The additional requirements specified in this code include either the need for static tensile strength and cyclic performance tests or an extremely conservative design; visual inspection by a qualified inspector; and, in some cases, a requirement to stagger connections between adjacent bars.

   Qualification tests must be performed under this code to verify that the splice system develops 125 percent of the specified yield strength of the bar during both the static tensile and low cycle (i.e., 100 cycle) tensile tests. If the splice system does not satisfy these qualification test requirements, this code then requires that adjacent splices be staggered at least 24 inches so as to develop at least twice the calculated tensile force at each cross-section. The code also requires that the splices be staggered if the unit strain of the splice at 90 percent yield exceeds 0.003 in. per in. and if the maximum computed design stress of the splice equals or exceeds 50 percent of the yield strength of the bar.

2. ASME Boiler and Pressure Vessel Code, Section III--Division 2, "Code for Concrete Reactor Vessels and Containments," the American Society of Mechanical Engineers, 1980 Edition [3].

   The only mechanical splice system permitted by this edition of the ASME code, which is also identified as ACI 359-80, is a filler metal splice system (i.e., the CADWELD splice system). This code specifies that the splicer must be subjected to initial qualification tests prior to splicing, continuing splice performance tests to insure that production splices meet the tensile requirements, and certain quality assurance and inspection criteria.

3. ASME Boiler and Pressure Vessel Code, Section III--Division 2, "Code for Concrete Reactor Vessels and Containments," the American Society of Mechanical Engineers, 1980 Edition with Summer 1980 Addenda [4].

   This addition of the code, which is also identified as ACI Standard 359-80 (with Summer Addenda), permits, for the first time, the use of several different types of mechanical splice systems for splicing of reinforcing bars (e.g., sleeve with ferrous filler metal splices, taper threaded splices, swaged splices and threaded splices in thread deformed reinforcing bars). Earlier editions of the code only permitted the use of

mechanical splices made using a ferrous filler metal concept.

This code specifies that all splice systems must be subjected to splice performance tests, splicer qualification tests, and continuing splice performance tests as well as well documented quality assurance and inspection criteria.

4. "ASME Code Case N-185, Requirements for Materials, and Qualification and Performance Testing of Swaged Reinforcing Bar Splices Splices", Section III, Division 2, Concrete Reactor Vessels and Containment. Approved by Council, 8/29/77, Approved by ACI, 10/17/77 [5].

   The approval of this Code Case by the ACI and ASME resulted in the acceptance of a swaged mechanical splice system for use in Category I nuclear plant construction as stated in [4].

5. "Regulatory Guide 1.136, Material for Concrete Containments," U. S. Nuclear Regulatory Commission, Revision 2, June 1981 [6].

   This guide describes some bases acceptable to the NRC staff for implementing certain Quality Standards and Quality Assurance Criteria specified in 10 CFR Part 50 with regard to material for concrete containments. This revision of the guide endorses those articles of Part CC of the 1980 Edition of the ASME Code [3] which relate to the use of mechanical splicing of reinforcing bars. This edition of the guide did not permit the use of any mechanical splice system except for those using a ferrous filler metal and, consequently, does not permit the use of a swaged splice system such as is described in this TER.

6. Uniform Building Code, 1979 Edition, International Conference of Building Officials, Whittier, California, 1979 [7].

   This code, in Section 2607 (f) 2, permits the use of either welded splices or other positive connections in reinforced concrete building construction. This code further states that full positive connections shall develop in tension or compression, as required, at least 125 percent of the specified yield strength of the bar.

7. "Building Code Requirements for Reinforced Concrete," ACI 318-77, American Concrete Institute, Detroit, Michigan, 1977 [8].

   This code, in Section 12.15.3, permits the use of mechanical connections provided that the connection develops in tension or compression, as required, at least 125 percent of the specified yield strength of the bar.

2.3 APPLICABLE SPECIFICATIONS AND PROCEDURES

The following documents contain specifications for the Bar-Grip Reinforcing Bar Splice System. Also included in this list of documents are documents that

contain quality assurance and inspection procedures.

1. "Brochure - Bar-Grip Systems," Dayton Barsplice, Inc., Miamisburg, Ohio, 7/81 [11].

   This brochure contains a summary of the design and performance characteristics of the Bar-Grip splice system. This brochure has been included as Appendix A of this TER.

2. "Operating Manual - Bar-Grip Mechanical Splicing Systems for Reinforcing Bars with Hydraulic Press Equipment," Dayton Barsplice, Inc., Miamisburg, Ohio, 12/80 [12].

   This manual contains detailed operating instructions for the use of the three types of presses which can be used to install Bar-Grip splices. The Bar-Grip Draw Press described in this manual is no longer in use per information received from DBI [9]. The Bar-Grip Side Press and the Bar-Grip Bench Press continue to be used.

3. "Report on Performance Testing of No. 5 through No. 18 Bar-Grip Sleeves for Dayton Barsplice, Inc.," WJE No. 820300Q, Wiss, Janney, Elstner and Associates, Inc., Northbrook, Illinois, 5/7/82 [13].

   Appendix 2 to this test report contains a procedures manual for the performance testing of spliced reinforcing bars as manufactured by DBI.

2.4 BIBLIOGRAPHY

The documents summarized below support the request from the Public Service Company of New Hampshire for NRC approval of the use of the Bar-Grip splice system in nuclear power plant construction.

1. Letter from J. DeVincentis, Project Manager, Yankee Atomic Electric Company/Public Service Company of New Hampshire, to Mr. George W. Knighton, Chief, Licensing Branch No. 3, Division of Licensing, NRC, Subject: "Request for Authorization to Utilize the Dayton Bar Grip System at Seabrook Station," 12/28/82 [1].

   This letter was the initial request for NRC approval for the use of the Dayton Bar-Grip System at the Seabrook Nuclear Power Plant.

2. "Report on Mechanical Splicing and Non-Destructive Examination of Reinforcing Bars Spliced by Swage Method for NRC Approval," Prepared for Public Service Company of New Hampshire - Seabrook Station by United Engineers and Constructors, Inc., Philadelphia, Pennsylvania, November, 1982 [24].

   This report was submitted as an attachment to [1] and contained several documents which supported the request for permission to

use the Dayton Bar-Grip System at the Seabrook Nuclear Power Plant.

3.0 SYSTEM DESCRIPTION

This section contains a description of the Dayton Bar-Grip Reinforcing Bar Splice System. Included is a description of significant design features, the process used to manufacture the couplers, quality assurance procedures and installation procedures.

The Dayton Bar-Grip Splice System was designed to connect steel reinforcing bars in such a manner as to develop the minimum ultimate tensile strength of bars of the specification and grade of reinforcing steel on which it is used. The coupler design concept adopts a portable hydraulic press to cold-press the sleeve to the ends of deformed reinforcing bars [11].

The Bar-Grip splice system is furnished in two types, the Bar-Grip plain coupler and the Bar-Grip threaded coupler. The Bar-Grip plain coupler, as shown in Fig. 3.1, is used in straight line applications to join two reinforcing bars. The Bar-Grip threaded coupler is used for special situations like those calling for the elimination of starter bars, slip forming, diaphragm walls, access openings and potential or planned additions [11]. Only the Bar-Grip plain coupler will be evaluated in this report since this is the only design for which NRC approval has been requested.

3.1 DESIGN FEATURES

Dayton Barsplice, Inc. (DBI) states in [11] that their Bar-Grip coupler was designed to provide the construction industry with a compact, easy-to-install, and fast system for use in splicing rebars. DBI further states [12] that most Bar-Grip coupler configurations can be installed in less than three minutes by operators with simple training.

DBI has sought to achieve their design requirements by a swaging process to mechanically splice two reinforcing bars together. DBI states in [11] that their Bar-Grip couplers are capable of mechanically splicing high yield, ribbed reinforcing bars, sizes No. 5 through No. 18, without special end preparation. The design concept of the Bar-Grip plain coupler system, as described in a report published by the International Conference of Building Officials (publishers of the Uniform Building Code) [19], basically employs a steel sleeve which has an inner diameter slightly larger than the reinforcing bars which are to be spliced. The ends of the reinforcing bars are inserted an equal distance into the sleeve. The sleeve is then spliced onto the bars, by a swaging procedure, using a hydraulic side or bench press and swaging the sleeves onto the bar by a series of overlapping pressings.

Enough room must be left on the job site to insert the Bar-Grip press between adjacent rows of reinforcing bars. The minimum "setting out" dimensions required for this purpose are given in [11] and shown in Fig. 3.2. If such is not the case, then Bar-Grip Couplers can be "half-spliced" in the fabricating shop. For this latter case, the second half of the splice is completed on the job site. Threaded couplers can also be used, if necessary.

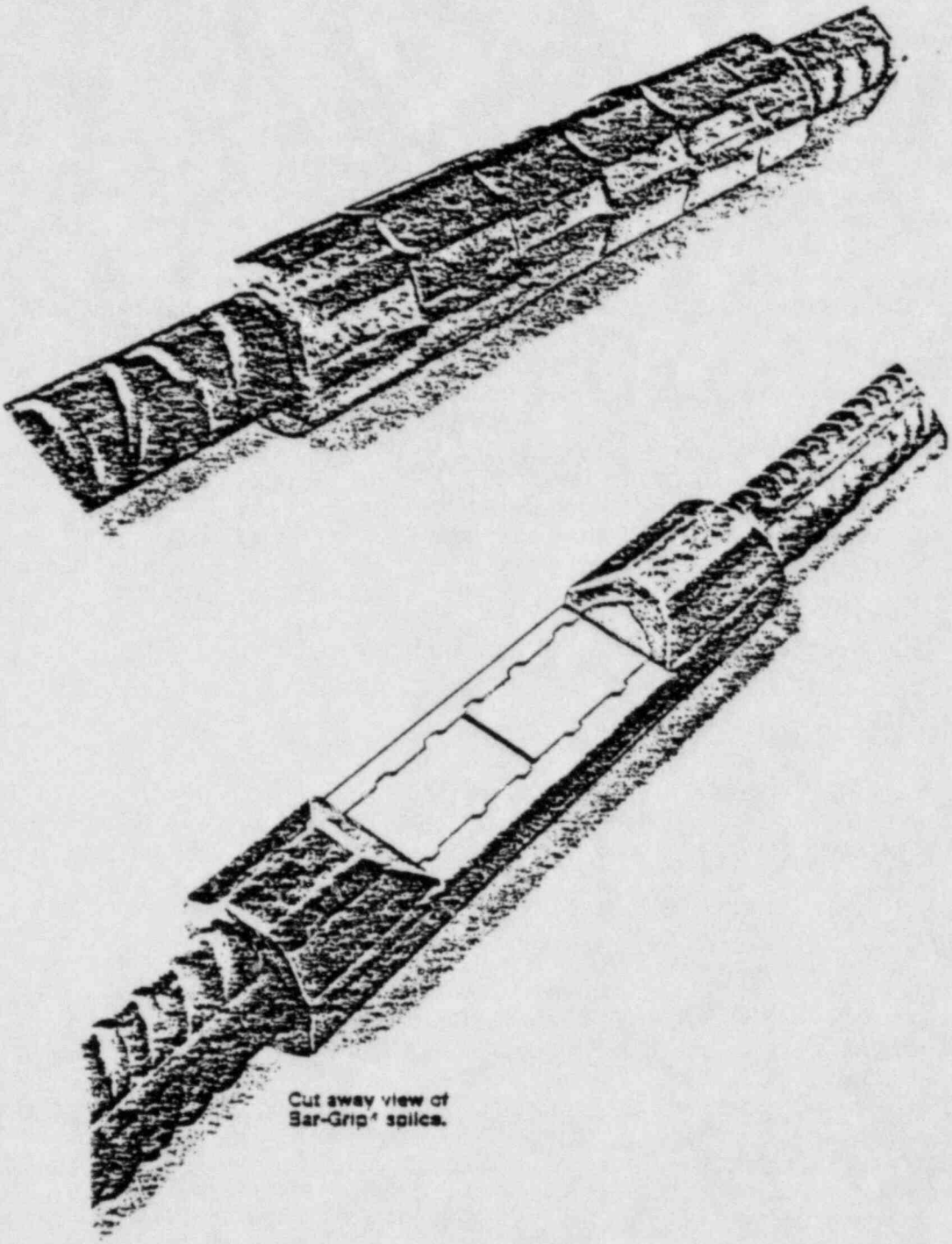
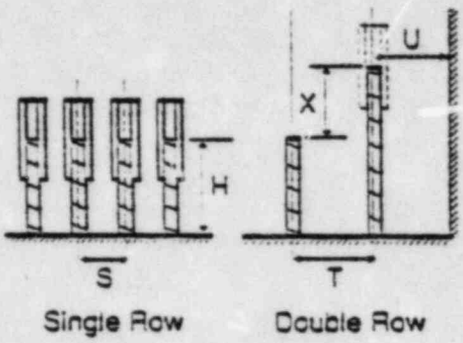


Figure 3.1. Dayton Bar-Grip Plain Coupler Configuration.

Minimum Setting Out Dimensions
(accompanying tables for Bar-Grip Couplers)



H = height for bar above concrete
S = centers of bars
T = center of rows of bars
X = height of one row above another
U = distance of row from structure

Note: These measurements assume the outer die is removed clear of the coupler. Rear bars are completely spliced first.

Weights and Access Measurements for Bar-Grip® Couplers

Rebar Size	Bar-Grip Press To Be Used	Coupler Lengths Nominal Average Initial in. (mm)	Coupler Lengths Nominal Average Final in. (mm)	Coupler Weight lb. (kg)	Minimum Setting Out Dimensions H in. (min)	S in. (mm)	T in. (mm)	X in. (mm)	U in. (mm)
5	Side Press BG750	3⅛ (80)	3⅜ (86)	0.46 (0.21)	4¾ (120)	2¾ (70)	4½ (115)	6½ (165)	6¼ (160)
6	Side Press BG750	3¾ (95)	4 (102)	0.35 (0.39)	5 (125)	3 (75)	4¾ (120)	7 (180)	6¼ (160)
7	Side Press BG750	4 3/16 (110)	4⅝ (117)	1.24 (0.56)	5½ (135)	3 (75)	5 (125)	8 (200)	6½ (165)
8	Side Press BG750	5 (127)	5⅜ (136)	1.81 (0.82)	6 (150)	3¼ (80)	5⅛ (130)	8¾ (220)	6½ (165)
8	Side Press BG1140	5 (127)	5⅜ (136)	1.81 (0.82)	6½ (165)	4¼ (105)	6 (155)	9½ (240)	8½ (215)
9	Side Press BG1140	5½ (140)	6 (152)	2.43 (1.10)	7 (175)	4¼ (105)	6⅛ (160)	10¼ (260)	8½ (215)
10	Side Press BG1140	6 3/16 (160)	6¾ (172)	3.48 (1.58)	7½ (190)	4½ (110)	6½ (165)	11 (275)	8¾ (220)
11	Side Press BG1140	6⅞ (175)	7⅞ (198)	4.42 (2.01)	8¼ (205)	4¾ (120)	6¾ (170)	12 (300)	8¾ (220)
14	Side Press BG1140	8 11/16 (220)	9⅜ (239)	8.33 (3.78)	9¼ (230)	4¾ (120)	7 (175)	14 (355)	9 (225)
18	Side Press BG1157	11¾ (298)	12¾ (324)	19.60 (8.89)	12 (300)	5½ (135)	9 (225)	18¼ (465)	11 (280)

Figure 3.2. Minimum Setting Out Dimensions for Bar-Grip Couplers.

3.2 MANUFACTURING PROCESS

The Bar-Grip sleeves are manufactured from seamless steel tubing that conforms to the requirements specified in ASTM A-519. The sleeves are available in sizes compatible with No. 5 through No. 18 reinforcing bars.

As discussed in [11] and Appendix A, DBI supplies a series of Bar-Grip Side and Bench Presses for use in the installation of the Bar-Grip splice system. The Side Press is available in three models and can be used to install splices for all sizes of rebars. Two Bench Press models are available. One of these models is used to install No. 14 splices and the other is used to install No. 18 splices.

The special dies used in the various presses described above are supplied by DBI to suit a particular size of sleeve and are stamped with a number corresponding to the rebar size and press.

In addition to providing the coupler sleeves and presses, DBI will supply all necessary hydraulic pumps and auxiliary equipment, including spring load balancers to provide fingertip control of the positioning of the press over the sleeves and around the bars on the construction site. These balancers can be suspended from the rebar to be spliced or from suitable scaffold equipment which may be in use for other functions on the job site.

3.3 QUALITY ASSURANCE

DBI states that their Bar-Grip System has met the following industry specifications [11]: ASME Section III, Division 2 (ACI 359-80 with Summer 1980 Addenda) [4]; ACI 349-80 Nuclear Design Code [2]; U.S. Army Corps of Engineers Typical Specification; ACI 318-77 Building Code [8]; Canadian Standards Association Nuclear Code, CSA N287.3.

No specific quality control manual or set of quality control procedures on either the manufacturing or installation of the splice system has been provided for use in preparing this report. DBI has indicated that they do not normally write such manuals/procedures although they would if they were asked to. Such a manual would be a useful tool for providing a uniformly installed and verifiable product. Rather than write such manuals, DBI identifies the guidelines to be followed when installing their splice system in design brochures [11] and operating manuals [12] and subsequently expect the construction project manager to develop specific documentation.

Quality assurance of the connection involves:

1. Confirming that a minimum pressure of 10,000 psi has been reached by the hydraulic press during installation,

2. Measuring the initial and final nominal average coupler lengths,

3. Determining the number of bites indented on the sleeve, and

4. Determining the insertion length of the rebar into the coupler sleeve.

The Bar-Grip sleeves are identified by a stamp on the sleeve indicating the size of bar for which the coupling is intended, the heat lot number, and a Bar-Grip identification code. The sleeves are packaged in containers that are labeled with company name and address, product name, item, quantity, bar size and identification mark.

An operating manual for the Bar-Grip hydraulic press has been written by DBI [12] to govern the use of the various hydraulic presses and to specify procedures for installing the splice system. Dies are supplied in different sizes to suit different sizes of sleeve. Each die is stamped with a number for identification so as to ensure that the correct die has been used for a particular size of sleeve.

DBI has specified that the minimum design pressure exerted by the hydraulic press to make a good connection in the coupler is 9,700 psi. They recommend that the pressure be set to 10,000 psi and to have a 300 psi permissible fluctuation during pressing. DBI describes that an oval shape, rather than an octagon shape, would be formed on the coupler if the swaging pressure was inadequate. Conformance to specified pressure requirements can, therefore, easily be assured by visual inspection.

DBI further states that, if inadequate pressing is found, the coupler can be re-pressed to acquire the desired 10,000 psi swaging pressure. This will avoid the need for cutting the rebar due to incorrect pressing pressure.

DBI recommends that a trial run be performed using off-cuts of rebar. During the trial, the pressure gauge on the hydraulic pump should be checked to assure that it registers up to 10,000 psi at full load. The frequency of performing this test has not been stated.

Finally, DBI states that no special requirements must be adhered to when installing the Dayton Bar-Grip Splice System under adverse environmental conditions (e.g., moisture, temperature, dirt, etc.) beyond those which would normally be maintained on a construction site. For example, although there would be no requirement to wire brush the coupler to remove rust before installation, there might be a requirement to wipe the coupler off with a cloth or brush to remove loose material as a matter of good "housekeeping" practice.

3.4 INSTALLATION PROCEDURES

Ease of installation is one of the principal advantages claimed for the Bar-Grip plain coupler. DBI states in their brochure [11] that a worker could be trained to install these couplers in less than one hour. DBI also states that the installation of their plain coupler requires no heat and no bar end preparation, and that it can be applied in any weather condition, even under water.

Although DBI supplies two types of coupler, the Bar-Grip plain coupler and the Bar-Grip Threaded Coupler, only the plain coupler is evaluated in this report. The Bar-Grip plain coupler is used to join two high yield, ribbed reinforcing bars. Since the coupler utilizes a swaging process rather than a thread or other positive interlock mechanism, the two bars to be connected can be

completely free to rotate, if required, immediately prior to installation.

The Bar-Grip sleeve installation process uses an hydraulic press which is calibrated to the force required to swage the sleeve onto the two bars to be joined. Each bar size has a particular sleeve that varies in inside diameter and length in accordance with the size of the bar to be joined. End preparation of the bars is generally not necessary beyond cursory hand wiping or brushing as noted above.

There are currently two types of Bar-Grip press available (A third type of press, the Bar-Grip Draw Press, was formerly used, but is no longer, due to a recent redesign of the Bar-Grip press.) [9]:

1. The Bar-Grip Side Press, which is designed for bars up to size #18, swages the coupler sleeve to the end of the bar in a series of side-action squeezes; and

2. The Bar-Grip Bench Press, which can handle rebars in sizes #5 to #18, is used primarily in the fabrication shop to half splice couplers so bars are ready for final coupling when they reach the job site.

Following installation, outside inspection personnel can visually examine the coupler by measuring the length of rebars being pressed, the number of indentation marks on the coupler and the shape of the coupler after pressing.

When pressing the sleeve on-site, the press should be supported by a chain fall or cable, which can be suspended from scaffolding or other convenient support. This supports the weight of the press, leaving the hands free to locate the die accurately.

The following steps are performed when properly installing the coupler:

1. <u>Fitting Splice or Coupler Off Site</u>

   (a) Place a chalk mark or wire tie on the bar at a location equal to half of the length of the sleeve as shown in Fig. 3.3 (a). (Note - This is most important!)

   (b) Coat the inner and outer pressing dies with Release Agent to prevent the sleeve sticking to the die after the splicing operation.

   (c) With the press supported on a bench or by a chain fall, the bar is inserted between the dies and a sleeve is placed over the end of the bar to the mark or wire. The sleeve should be positioned in the press so that the right end of the die jaws will make the first swage at or slightly to the left of the center of the sleeve as shown in Fig. 3.3 (b). This swage is shown in Fig. 3.3 (c). The remaining swages on the first rebar can be completed on the site when the second rebar is coupled. Measure accurately for the first rebar swage. The sleeve should not be swaged beyond the end of the bar in the sleeve, since this will prevent the second

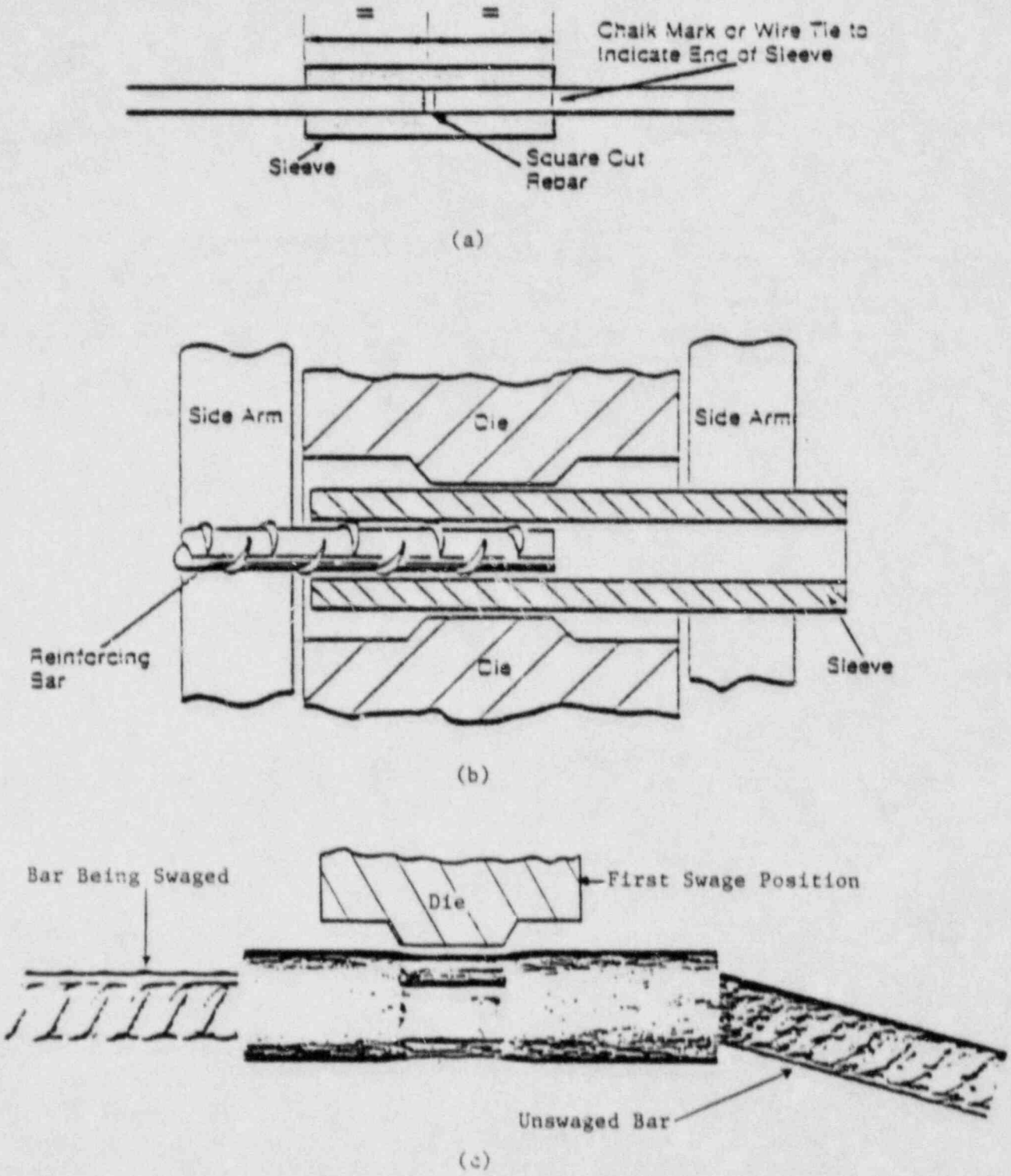
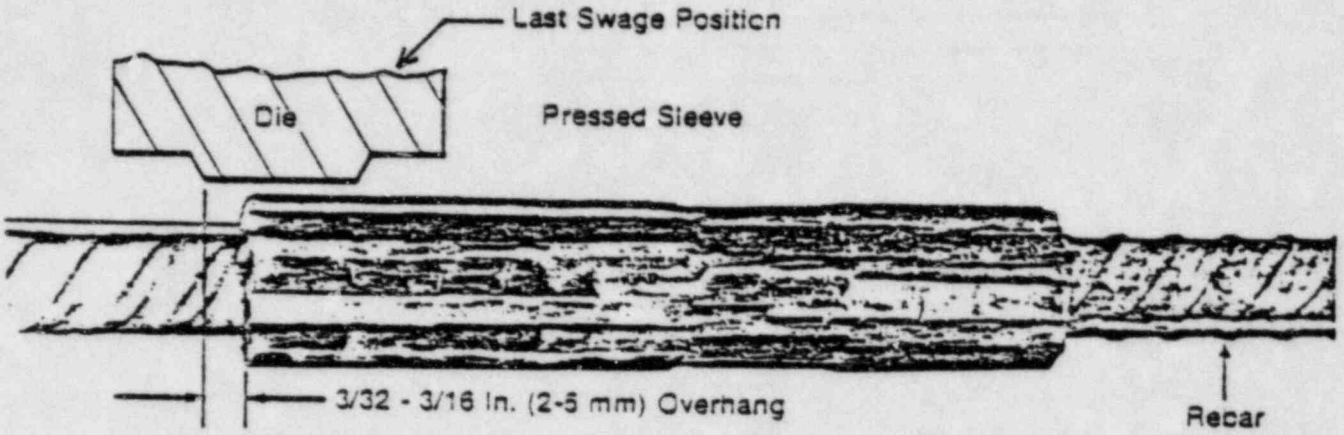
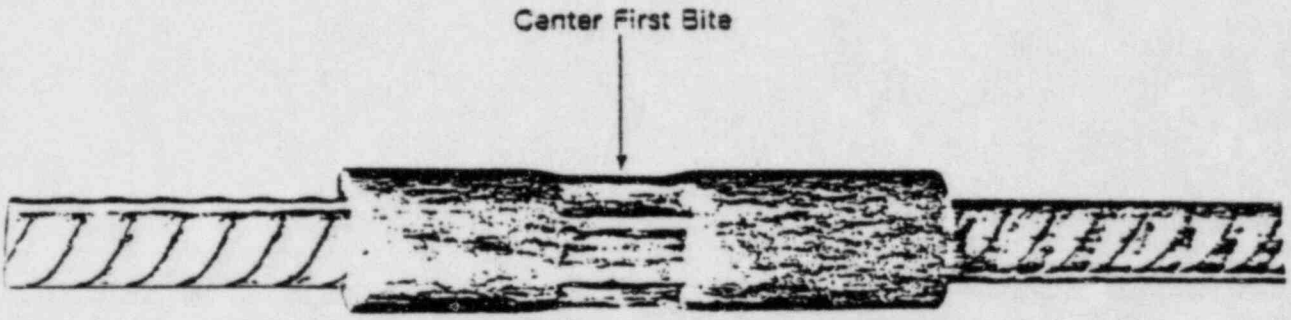


Figure 3.3. Installation of Dayton Bar-Grip Couplers.



(d)



(e)

Figure 3.3. Installation of Dayton Bar-Grip Couplers (Cont'd).

rebar from butting to the first; and, the second rebar will have a shorter swage length.

(d) Activate the pump. Activate the press with the hand or foot switch. The inner die is pushed forward by the hydraulic ram until it reaches the sleeve. The dies then compress the sleeve until the maximum operating pressure of 10,000 psi (700 bars) is reached. The hydraulic pump will automatically release at 10,000 psi. The pump switch should then be released. If, at any time before full pressure is reached, the operator sees that the bar or sleeve have slipped out of alignment; or, if anything becomes trapped in the press, the switch should be released and the ram will react immediately.

2. Completion of Half Splice On Site

(a) Coat the inner and outer pressing dies with Release Agent to prevent the sleeve sticking to the die after the splicing operation.

(b) If the reinforcement is vertical, the bar with the half swaged sleeve is located above it and lowered until the fixed reinforcing bar butts up to the bar inside the sleeve. The weight of the new bar will ensure that the ends of the bars will remain in contact until the swaging is started.

(c) If the reinforcement is horizontal, there is a possibility that the ends of the bars may not be in contact when pressing is started. As a guide, place a chalk mark on the second rebar the same distance as on the first bar (equal to one half sleeve length).

(d) The first bite should be made in the center of the sleeve. Bites should then be made progressively out to both ends of the sleeve with 3/32 to 3/16 in. (2 to 5 mm) die overhang beyond the end of the sleeve as shown in Fig. 3.3 (d). All bites must overlap.

3. Splicing Both Bars At One Time

(a) Coat the inner and outer pressing dies with Release Agent to prevent the sleeve sticking to the die after the splicing operation.

(b) On-site splicing of both bars at one time can be done if desired. Wire tie the lower bar for vertical splicing to hold the sleeve as previously explained. Chalk marks can be used on the bars for horizontal splicing. Start in the middle of the sleeve and work out to one end. Then come back and work from the middle toward the other end as shown in Fig. 3.3 (e).

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4.0 ENGINEERING ANALYSIS

This section includes a discussion of the process through which loads are transferred between the spliced reinforcing bars through the Bar-Grip splice system.

Since no specific engineering analysis was provided by DBI for use in performing this evaluation, the following discussion reflects SAI's understanding of the behavior of the Bar-Grip splice system. It should be noted that such an analysis is not required by any of the reinforced concrete design codes discussed in this TER.

As previously discussed, the Bar-Grip splice system uses a concept in which a steel sleeve is swaged around the rebars to be spliced. This swaging process forces the sleeve around the deformations in the rebar thus locking the sleeve to the rebars. Because of this, the loads to be transferred between the rebars are transferred primarily as normal loads between the deformations in one of the rebars and the splice sleeve, through the splice sleeve, and finally as normal loads between the deformations in the other rebar and the splice sleeve. These loads are shown schematically in Figs. 4.1 and 4.2 as the force notation F. Figure 4.1 illustrates the transfer of tensile loads and Fig. 4.2 illustrates the transfer of compressive loads.

An alternate load path would be for the loads to transfer between the rebars and splice sleeve through friction along their contact surface. This load path, which is also shown schematically in Fig. 4.1 by the forces P and F_f, would only be effective if the residual radial pressing forces, P, were large enough to develop a significant friction force, F_f. Since the magnitude of this residual pressing force would probably be difficult to predict with any degree of accuracy, it would probably be best not to assume that this load path exists when determining the load carrying capability of the splice.

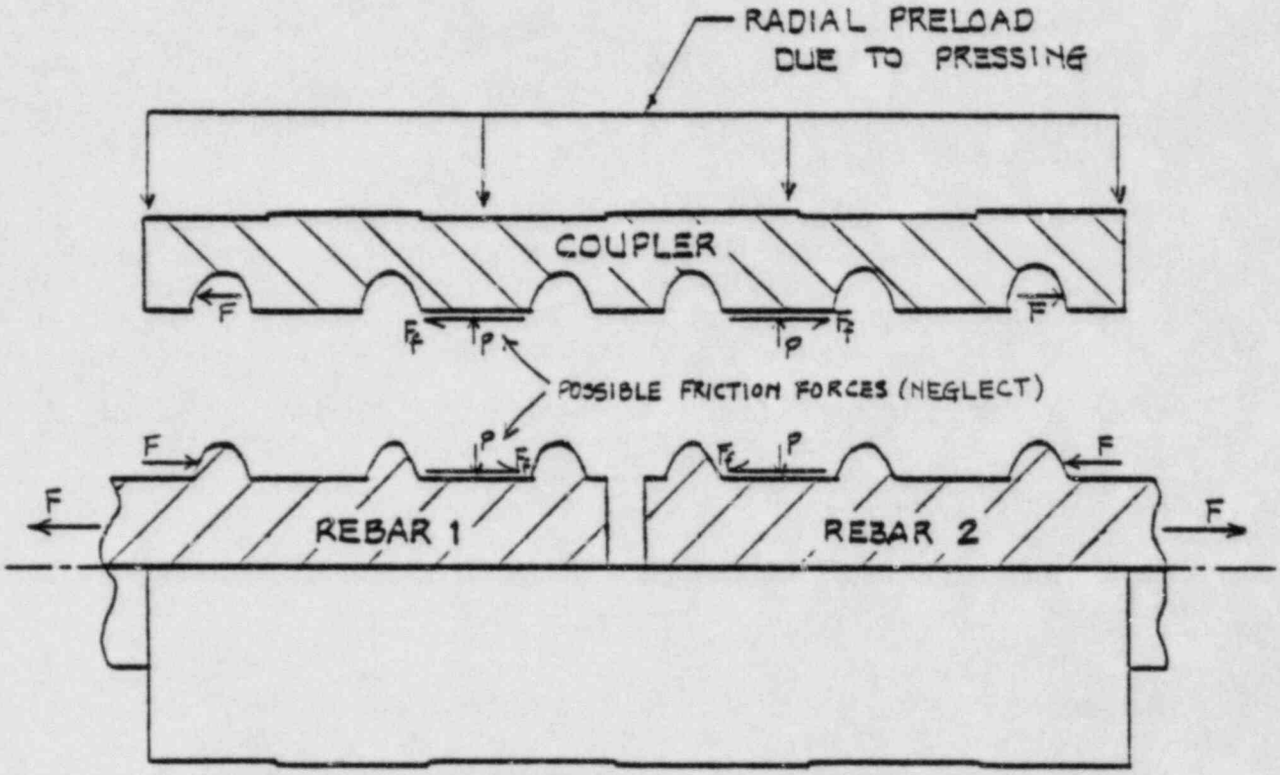

Figure 4.1. Schematic Representation of Tensile Load Transfer.

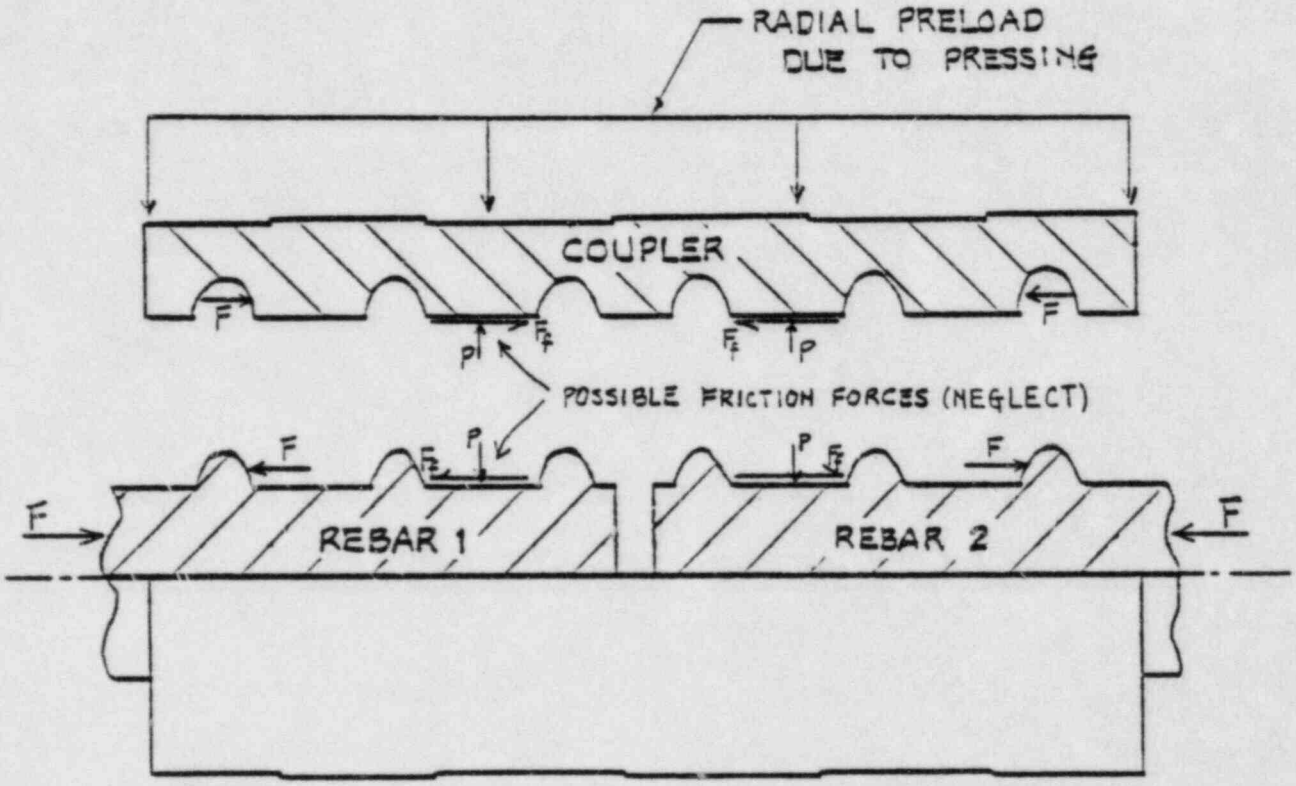

Figure 4.2. Schematic Representation of Compressive Load Transfer.

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5.0 TEST RESULTS

Engineering structures are rarely loaded to levels that cause material failures. For this reason, the fact that a particular new material or product is being used in such a structure is not necessarily a good measure of a system or material's capability. Testing of full-size specimens or simulations of actual components has, therefore, become a generally accepted method of evaluating new materials and products. The Dayton Bar-Grip splice system has been evaluated using such an approach.

These evaluation tests have been performed both directly for Dayton Barsplice, Inc. (DBI) or their parent company, CCL [13-18], and under the auspices of potential users of the splice system [20-22]. Many of these tests have been performed for DBI by the independent testing laboratory of Wiss, Janney, Elstner and Associates, Inc. (WJE) of Northbrook, Illinois. A portion of the tests performed by WJE to demonstrate conformance of the splice system to applicable codes are summarized in this section together with a description of a series of installation tests performed to simulate the preparation of splices under adverse conditions that might occur at a construction site.

It should be noted that each of the tests described in this section were witnessed by representatives of United Engineers and Constructors (UE&C), who are responsible for the design and construction of the Seabrook Nuclear Power Plant.

5.1 INSTALLATION TESTS

Each of the tests performed by WJE used bars which were spliced, under adverse conditions, by DBI. These adverse conditions were selected to simulate conditions which might occur at a typical construction site. It should be noted that these conditions would, generally, not occur under a vigorous inspection and quality assurance program.

The following procedures were carried out during the preparation of test bar splices to simulate adverse conditions:

1. The bar ends were immersed in water prior to being inserted into the sleeve.

2. Bars No. 5 through No. 14 were deliberately mis-inserted by one-half bar diameter each.

3. No. 18 bars were deliberately mis-inserted by one inch.

4. Pressing was done at the lowest permissible hydraulic pressure specified by DBI in their installation procedures (i.e., 9,700 psi).

5.2 PERFORMANCE TESTS

As previously mentioned, DBI has conducted a series of performance tests of tensile splices at WJE [13-15]. These tests were performed to evaluate the Bar-Grip plain coupler for conformance with the ASME Section III, Division 2 (ACI 359-80 with Summer 1980 Addenda), ACI 318-77 and ACI 349-80 Codes as well as typical splice requirements of the U.S. Army Corps of Engineers. These tests, which are summarized in the following subsections, were performed on splices that had been installed under adverse conditions as described in the previous section to simulate conditions that might occur at a typical construction site. It should be noted that, although all WJE test data provided to SAI by DBI has been reviewed, only the data from the most recent WJE test report [13] has been summarized in the various tables included with this Section of the TER.

It was concluded that, unless specifically noted otherwise, the performance tests described in this section are sufficiently complete so as to be an acceptable demonstration of the quality of the Dayton Bar-Grip plain coupler for use on the Seabrook Nuclear Power Plant. This conclusion is discussed more completely in Section 6.3.

5.2.1 Code Requirements

As previously discussed, tests have been performed on the Bar-Grip splice system to evaluate its conformance to several codes. Two of these codes, the ASME Section III, Division 2 (ACI 359-80 with Summer Addenda) [4] and the ACI 349-80 [2] codes, relate directly to nuclear power plant construction. The discussion in the remainder of this section will be restricted to an evaluation of the conformance of the Bar-Grip system to these latter two codes.

The ACI 349-80 Code [2] specifies that the splices must develop in tension or compression, as required, at least 125 percent of the specified yield strength of the bar. This code further specifies that mechanical connections shall be qualified for use on the basis of a series of performance tests. These tests must include a minimum of six static tensile tests and three cyclic tensile tests. During the cyclic tests, the bar-to-bar connection specimens for each reinforcing bar size and grade being evaluated must be subjected to 100 cycles of tensile stress variations from 5 percent to 90 percent of the specified minimum yield strength of the reinforcing bar. Furthermore, the specimen shall be tested statically to failure following the cyclic tests to demonstrate that no loss of static tensile strength occurs when compared with like specimens from static tensile strength tests.

As discussed in Section 2.2, the ACI 349-80 Code also requires that mechanical connections must be staggered relative to connections of adjacent bars if both the unit strain over the full length of the splice at 90 percent of the yield strength of the bar exceeds 0.003 in. per in. (i.e., 0.3 percent) and the maximum computed design load stress at the connection equals or exceeds 50 percent of the yield strength of the bar.

The 1980 Summer Addenda to the ASME Code [4] contains a number of performance test requirements that must be satisfied to qualify mechanical splice systems

for use in the construction of nuclear power plant components. These performance test requirements include both static tensile tests and cyclic tensile tests. This edition of the ASME Code is the first edition of this code that permits the use of mechanical reinforcing bar splices of the type evaluated in this report. This permission was granted through the incorporating of Code Case N-185 [5] into the code.

The ASME Code specifies that each of these tensile and cyclic tests must be performed on specimens of each bar size and splice type to be used in construction. Six splice specimens for each bar size and splice type must be tensile tested to failure and three specimens for each bar size and splice type must be subjected to the low cycle tensile test. For swaged splices, the ASME Code further specifies that three different deformation patterns shall be used for each bar size tested. Table 5.1 lists the reinforcing bar manufacturers and their respective deformation patterns for each size of splice used to run the performance tests described in this report.

The ASME Code also specifies that the average tensile strength of all of the splices tested shall not be less than 90% of the actual tensile strength of the reinforcing bar being tested nor less than 100% of the specified minimum tensile strength of the bar, and that the tensile strength of an individual splice specimen shall not be less than 125% of the specified minimum yield strength of the spliced bar.

The specified minimum strength values for the ASTM 615, Grade 60 reinforcing bar material which was used for all of the performance tests is:

Minimum Yield Strength, f_y = 60 ksi

125% of Minimum Yield Strength, $1.25f_y$ = 75 ksi

Minimum Tensile (i.e., Ultimate) Strength = 90 ksi

The ASME Code further states that each individual test report on the spliced and unspliced specimens shall include, as a minimum, information on the tensile strength of the material, the total elongation at failure, and a load-strain curve up to a minimum of 2% strain. Implicit in this statement is a requirement that the total elongation at failure be measured and recorded to be at least 2%.

5.2.2 Unspliced Rebar Tests

A series of tensile tests were run on samples of unspliced rebar to determine tensile strength, elongation, and load versus strain data for bars that would subsequently be used for coupler performance tests. This data was required to support the performance tests since the ASME Code [4] and Code Case N-185 [5] require that the average tensile strength of splice specimens shall not be less than 90% of the actual tensile strength of the reinforcing bar being tested. The data resulting from this series of tests is summarized in Table 5.2.

Table 5.1. Rebar Manufacturers and Deformation Patterns.

Rebar Size	Rebar Manufacturer	Deformation Pattern
5,6,7,10,11	Armco Bethlehem North Star	Crescent Diagonal Slant
8	Armco Bethlehem North Star	Cross Hatch Diagonal Slant
14	Armco Bethlehem Marathon	Cross Hatch Diagonal Horizontal
18	Armco Bethlehem Marathon	Cross Hatch Diagonal Slant

Table 5.2. Summary of Unspliced Rebar Tensile Tests.

Bar Size	Number of Tests Performed	Deformation Pattern	Ultimate Stress (ksi)	90% of Ultimate Stress (ksi)	Strain at 0.9 f_y (Percent)	Elongation at Failure (Percent)
5	1	Diagonal	105.8	95.2	0.238	13.9
	1	Crescent	103.2	92.9	0.236	12.7
	1	Slant	105.5	95.0	0.215	14.6
6	1	Diagonal	113.4	102.1	0.186	14.2
	1	Crescent	112.5	101.3	0.165	14.1
	1	Slant	108.0	97.2	0.184	15.8
7	1	Diagonal	110.3	99.3	0.205	14.3
	1	Crescent	105.7	95.1	0.205	15.8
	1	Slant	113.0	101.7	0.197	13.9
8	1	Diagonal	105.7	95.1	0.201	12.6
	1	Cross Hatch	105.9	95.3	0.194	14.9
	1	Slant	101.1	91.0	0.203	16.0
9	1	Diagonal	109.3	98.4	0.191	13.3
	1	Crescent	106.5	95.9	0.196	15.8
	1	Slant	103.8	93.4	0.199	12.6
10	1	Diagonal	105.1	94.6	0.190	11.6
	1	Crescent	106.9	96.2	0.185	15.7
	1	Slant	110.5	99.5	0.197	13.8
11	1	Diagonal	103.7	93.3	0.204	11.3
	1	Crescent	105.4	94.9	0.193	15.0
	1	Slant	111.4	100.3	0.197	13.0
14	1	Diagonal	105.3	94.8	0.173	15.6
	1	Crescent	108.9	98.0	0.201	11.0
	1	Horizontal	99.8	89.8	0.197	11.9
18	1	Diagonal	105.8	95.2	0.190	12.2
	1	Crescent	102.5	92.3	0.181	11.9
	1	Slant	110.4	99.4	0.180	11.9

5.2.3 Static Tensile Tests

As seen from Table 5.3, static tensile tests have been performed using No. 5 through No. 18 rebar and for a variety of deformation patterns. Most of the results obtained during these tests demonstrate the conformance of the coupler design to code requirements. However, several apparent abnormal tests were observed.

Two relatively low ultimate strength values were documented in these test results. One occurred with a No. 10 rebar which had a diagonal deformation pattern. This rebar pulled out of the coupler at an ultimate strength of 87 ksi. The other low ultimate strength value involved a No. 14 rebar which had a horizontal deformation pattern. This rebar pulled out of the coupler at an ultimate strength of 86 ksi. Although both of these low strength values indicated that the specimen ultimate strength was less than 90% of the actual tensile strength of the unspliced rebar being tested, the average ultimate strength of both of the specimens being tested for each particular size and type of reinforcing bar being tested did exceed appropriate code requirements and thus these low values did not constitute a code nonconformance. Furthermore, both of these low strength values exceeded 75 ksi and, consequently, were more than 125 percent of the specified minimum yield strength of the spliced bar.

Several strain-related nonconformances were documented in these test results. Six of the specimens exhibited a total strain at 90 percent of the specified yield strength of the unspliced bar that was greater than 0.3 percent. These six specimens involved No. 5, 7, 9 and 14 splices. Only one of these nonconformances exceed requirements by more than 10%. This latter case involved the same No. 14 test specimen with horizontal deformations and failed in pull-out mode discussed above that had a low ultimate stress.

The ASME Code specifies that the individual test report for each splice specimen test must contain the total elongation at failure. This data has not been provided for more than 25% of the specimens (15 specimens out of a total of 54 specimens). The apparent reason for the failure of WJE to provide this data is that the specimens in question failed in bar pull-out mode. It would be difficult, if not impossible, to accurately determine total elongation for such a failure since it might not be possible to put the failed specimen "back together" temporarily for purposes of measuring total change in length in such a case. However, it is suggested that an estimate of total elongation could be made for such pull-out cases and, as such, it is recommended that DBI be asked to provide further data regarding total elongation for the specimens in question. One way to make such an estimate would be to saw cut the splice longitudinally after failure and measure the elongated length of the reconstructed sample between previously established marks.

Another nonconformance was that the load-extension curve for approximately one-half of the samples tested had not been carried out to a minimum of 2% strain as required by the ASME Code [4]. WJE states in [13] that this was done to avoid possible damage to the extensometer that was used to record the load-strain data. Again, this could be estimated by other means. It is recommended that DBI be asked to furnish data confirming that the 2% strain requirement specified by the code has been satisfied prior to permitting the use of the Dayton Bar-Grip Splice System in nuclear power plant construction.

Table 5.3. Summary of Plain Coupler Static Tensile Tests.

Bar Size	Number of Tests	Deformation Pattern	Splice Ultimate Stress (ksi)	Strain at 0.9 f_y (Percent)	Elongation at Failure (Percent)	Failure Mode
5	2	Diagonal	Min 109.4 Max 109.7 Avg 109.6	0.156 0.187	4.6 4.3	Bar Break Bar Break
	2	Crescent	Min 102.9 Max 105.5 Avg 104.2	0.332[2] 0.270	7.3 5.0	Bar Break Bar Break
	2	Slant	Min 105.8 Max 106.1 Avg 106.0	0.228 0.273	6.7 5.6	Bar Break Bar Break
6	2	Diagonal	Min 110.9 Max 112.5 Avg 111.7	0.151 0.168	4.1 (4)	Bar Break Pull Out
	2	Crescent	Min 104.5 Max 113.2 Avg 109.0	0.164 0.153	(5) 5.6	Bar Break Bar Break
	2	Slant	Min 107.7 Max 108.4 Avg 108.1	0.196 0.176	5.3 5.0	Bar Break Bar Break
7	2	Diagonal	Min 109.8 Max 110.7 Avg 110.3	0.155 0.192	4.1 3.7	Bar Break Bar Break
	2	Crescent	Min 101.7 Max 106.3 Avg 104.0	0.330[2] 0.302[2]	(4) 5.3	Pull Out Bar Break
	2	Slant	Min 106.3 Max 110.2 Avg 108.3	0.209 0.240	(4) (4)	Pull Out Pull Out

Table 5.3. Summary of Plain Coupler Static Tensile Tests (Cont'd).

Bar Size	Number of Tests	Deformation Pattern	Splice Ultimate Stress (ksi)	Strain at 0.9 f_y (Percent)	Elongation at Failure (Percent)	Failure Mode
8	2	Diagonal	Min 105.9 Max 106.3 Avg 106.1	0.170 0.141	4.3 3.8	Bar Break Bar Break
	2	Cross Hatch	Min 104.6 Max 105.7 Avg 105.2	0.202 0.170	(4) 5.0	Pull Out Bar Break
	2	Slant	Min 100.8 Max 102.5 Avg 101.7	0.236 0.214	4.5 4.7	Bar Break Bar Break
9	2	Diagonal	Min 106.0 Max 108.0 Avg 107.0	0.158 0.189	3.9 4.7	Bar Break Bar Break
	2	Crescent	Min 105.5 Max 106.0 Avg 105.8	0.214 0.305[2]	(4) (4)	Pull Out Pull Out
	2	Slant	Min 104.0 Max 104.5 Avg 104.3	0.214 0.229	(4) (4)	Pull Out Pull Out
10	2	Diagonal	Min 86.6[1] Max 106.7 Avg 96.7	0.298 0.197	(4) 2.6	Pull Out Bar Break
	2	Crescent	Min 106.7 Max 107.3 Avg 107.0	0.187 0.187	4.8 5.3	Bar Break Bar Break
	2	Slant	Min 105.7 Max 109.1 Avg 107.4	0.208 0.211	3.5 10.1	Bar Break Coupler Break

Table 5.3. Summary of Plain Coupler Static Tensile Tests (Cont'd).

Bar Size	Number of Tests	Deformation Pattern	Splice Ultimate Stress (ksi)	Strain at 0.9 f_y (Percent)	Elongation at Failure (Percent)	Failure Mode
11	2	Diagonal	Min 104.7 Max 104.7 Avg 104.7	0.187 0.213	5.3 4.9	Bar Break Bar Break
	2	Crescent	Min 97.4 Max 102.9 Avg 100.2	0.253 0.268	(4) (4)	Pull Out Pull Out
	2	Slant	Min 102.4 Max 106.3 Avg 104.4	0.231 0.263	3.9 (4)	Coupler Break Pull Out
14	2	Diagonal	Min 104.4 Max 104.4 Avg 104.4	0.199 0.202	6.0 5.9	Coupler Break Coupler Break
	2	Crescent	Min 105.3 Max 107.8 Avg 106.6	0.255 0.220	6.1 6.8	Coupler Break Coupler Break
	2	Horizontal	Min 85.6[1] Max 97.1 Avg 91.4	0.426[2] 0.320[2]	(4) (4)	Pull Out Pull Out
18[3]	2	Diagonal	Min 102.6 Max 104.4 Avg 103.5	0.180 0.170	2.8 5.5	Bar Break Coupler Break
	2	Crescent	Min 103.0 Max 104.9 Avg 104.0	0.166 0.210	4.2 3.6	Bar Break Coupler Break
	2	Slant	Min 107.1 Max 107.4 Avg 107.3	0.155 0.150	5.2 4.8	Coupler Break Coupler Break

Table 5.3. Summary of Plain Coupler Static Tensile Tests (Cont'd).

Bar Size	Number of Tests	Deformation Pattern	Splice Ultimate Stress (ksi)	Strain at 0.9 f_y (Percent)	Elongation at Failure (Percent)	Failure Mode

Notes:
1. Splice tensile strength less than 90% of actual tensile strength of rebar being tested.
2. Strain is greater than 0.3 percent.
3. The No. 18 splices were made with a special 14 inch long sleeve that was designed specifically for nuclear applications.
4. Elongation not measured due to bar pull-out.
5. Reason not given for not measuring elongation.

5.2.4 Cyclic Load Tests

Three cyclic tests were run on bar-to-bar splices in order to satisfy the code requirements discussed in Section 5.2.1. Results from these tests are summarized in Table 5.4.

The ASME Code [4] requires that three specimens of the bar-to-bar splice for each reinforcing bar size and grade splice type to be used in construction be subjected to a low cycle tensile test. For swaged splices, the code also requires that three different deformation patterns be used for each bar size tested. Each specimen must withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load and return. The only failure criteria specified in this code is that the specimen must "withstand" the applied cyclic load.

The ACI 349-80 Code [2] is similar to the ASME Code. However, the ACI 349-80 Code is more specific in its requirements in that it specifies that the specimen must be tested statically to failure after completion of the cyclic tests and that each specimen should show no loss of static tensile strength capacity when compared with like specimens used in the static tensile strength tests.

As seen from Table 5.4, each specimen withstood 100 cycles of stress variation and, therefore, satisfied the applicable ASME Code [4] cyclic load test requirements. However, almost half of the specimens failed to satisfy the ACI 349-80 Code [2] in that the specimen static tensile strength capacities after cyclic tests were shown to be lower than the values for like specimens in static tensile strength tests as previously given in Table 5.3. Considering only those specimens showing strength reduction after cyclic tests, it is found that the strength reduction was an average of 1.9 ksi (minimum 0.1 ksi, maximum 7.3 ksi). Since these strength reductions were quite small and since none of these strength reductions resulted in ultimate strengths below those permitted by the applicable codes for static tensile tests, it is recommended that this code nonconformance should not be used as a basis for rejecting the use of the Dayton Bar-Grip coupler on nuclear plant construction projects.

Table 5.4. Summary of Plain Coupler Cyclic Tensile Tests.

Bar Size	Deformation Pattern	Number of Tests	Ultimate Stress (ksi)	Stress[1] Variation (ksi)	Failure Modes
5	Diagonal	1	108.1[2]	-1.5	Bar Break
	Crescent	1	106.1	1.9	Bar Break
	Slant	1	105.8[2]	-0.2	Bar Break
6	Diagonal	1	110.0[2]	-1.7	Bar Break
	Crescent	1	113.2	4.2	Bar Break
	Slant	1	108.6	0.5	Bar Break
7	Diagonal	1	110.0[2]	-0.3	Bar Break
	Crescent	1	104.5	0.5	Bar Break
	Slant	1	113.2	4.7	Bar Break
8	Diagonal	1	106.2	0.1	Bar Break
	Cross Hatch	1	105.6	0.4	Pull Out
	Slant	1	101.4[2]	-0.3	Bar Break
9	Diagonal	1	106.5[2]	-0.5	Bar Break
	Crescent	1	101.0[2]	-4.8	Pull out
	Slant	1	105.3	1.0	Bar Break
10	Diagonal	1	107.5	10.8	Bar Break
	Crescent	1	108.3	1.3	Bar Break
	Slant	1	103.5[2]	-3.9	Pull Out
11	Diagonal	1	105.8	1.1	Bar Break
	Crescent	1	99.0[2]	-1.2	Pull Out
	Slant	1	107.1	2.7	Coupler Break
14	Diagonal	1	104.4	0.0	Coupler Break
	Crescent	1	99.3[2]	-7.3	Pull Out
	Horizontal	1	97.3	5.9	Pull Out
18	Diagonal	1	104.8	1.3	Coupler Break
	Crescent	1	103.7[2]	-0.3	Bar Break
	Slant	1	106.2[2]	-1.1	Coupler Break

Notes: 1. Stress variation values were obtained by subtracting the average ultimate stress of like specimens in static tensile tests from the ultimate stress in cyclic tensile tests.

2. These ultimate stresses were lower than the ultimate stresses measured in like specimens in static tensile tests.

6.0 DESIGN REVIEW

This section summarizes data obtained during SAI's review and evaluation of the Dayton Bar-Grip Rebar Splice System design. Included is a general discussion regarding the adequacy of the coupler design, a summary list of current users of the splice system together with comments obtained from some of the users, and a number of conclusions and recommendations regarding the acceptability of the design for use in nuclear power plant construction applications.

6.1 GENERAL DISCUSSION

This design review was conducted by SAI at the request of the NRC. As background information, SAI was provided with a number of documents by the NRC staff for use in this review. It was further suggested by the NRC staff that SAI contact DBI with a request for additional, more recent data. This request was made and Mr. Steven Holdsworth of DBI sent SAI a number of documents [9] which were used extensively during the review.

Another valuable source of information used during this review was a presentation made by Mr. Anthony Cave, President, DBI and Mr. Steven Holdsworth, Operations Manager, DBI [10]. This presentation included a general discussion regarding the design and use of the Bar-Grip splice system as well as the actual preparation of a splice. DBI had made a similar presentation to members of the NRC staff in 1981 [25].

Several advantages and disadvantages of the Bar-Grip coupler design which were identified during this design review and which directly concern the safe use of the couplers are summarized in the following paragraphs.

A primary advantage claimed for the Bar-Grip splice system is the speed by which the couplers can be installed in the field by relatively unskilled labor. DBI claims that any construction worker can be trained to install a Bar-Grip splice in less than one hour. The speed of installation claimed by the manufacturer of the coupler appears to be valid. The claim that the coupler installation procedure can be taught quickly to any construction worker is also probably valid provided that appropriate inspection procedures are followed after installation.

Another advantage claimed for the Bar-Grip splice system is that the couplers can be installed under a variety of adverse conditions including bad weather (e.g., rain, snow, etc.), low hydraulic pressure, and non-square bar end cuts. This advantage also appears to be valid as based on the splice installations witnessed by SAI.

One potential disadvantage of the Bar-Grip splice system is that a relatively bulky hydraulic press must be used to install the splice. The press used to install large splices (e.g., No. 14 and No. 18 splices) is particularly large. This disadvantage would be most pronounced during the installation of splices at construction locations which are far above ground or which involve the

installation of splices in close proximity to adjacent rebars.

The Dayton Bar-Grip splice system has been reviewed by several potential users for use on construction projects. Data generated under the direction of some of these potential users is included in [20-22]. A Research Report written by the International Conference of Building Officials [19], who are the publishers of the Uniform Building Code, states that the Dayton Barsplice Bar-Grip Systems for joining reinforcing steel bars are an alternate method of construction to that specified in the 1979 Uniform Building Code [7] provided that several conditions are satisfied concerning location, cover and inspection. In [23] the City of Los Angeles has given its approval to the use of the Bar-Grip system subject to conditions similar to those proposed by the International Conference of Building Officials.

6.2 CURRENT USERS OF SPLICE SYSTEM

Bar-Grip couplers have been used for several years on a large number of construction projects, including several power plant projects both in the United States and in other countries. DBI provided the representative list of such projects given in Table 6.1.

DBI also provided the list of references given in Table 6.2 of persons who have used the Dayton Bar-Grip Splice System. These persons have been involved with the evaluation, testing, quality assurance, and/or installation of Bar-Grip couplers and can be contacted for further information concerning the use of this splice system.

6.3 CONCLUSIONS AND RECOMMENDATIONS

It is concluded by SAI that the Dayton Bar-Grip Rebar Splice System is a suitable system for use in the construction of critical facilities such as nuclear power plants. Furthermore, it is our opinion that the Bar-Grip splice system is at least as good as the other coupler design which is currently accepted for use on nuclear plant construction projects.

Although the coupler design is considered to be acceptable, it is recommended that the manufacturer be asked for further substantiating data to resolve several apparent code nonconformances that were observed during an evaluation of performance test data before it is approved for general use in nuclear plant construction. These apparent nonconformances include:

1. Certain No. 7, 9 and 14 splices exhibited strains in excess of 0.3 percent when loaded to 90 percent of the yield strength of the bar. Since the ACI 349-80 Code [2] states that splices which exhibit this level of strain at 90 percent of the yield strength of the bar must be staggered relative to connections of adjacent bars, it is recommended that such staggering be required until such time as DBI provides an acceptable resolution of this nonconformance for these bar sizes.

2. The total elongation at failure was not provided for several of the static tensile test specimens as required by the ASME Code

Table 6.1. Power Plant Projects that have used Bar-Grip Couplers.

Location	Project
Foreign Countries:	
United Kingdom	Torness Nuclear Power Station Heysham Nuclear Power Station Windscale Nuclear Power Station
France	Flamanville Nuclear Power Station Gravelines Nuclear Power Station Cattenom Nuclear Power Station Chinon Nuclear Power Station Belleville Nuclear Power Station La Hague Nuclear Power Station
Canada	Bruce Power Station Nuclear Plant, Ontario Hydro
Brazil	Angra 11 Nuclear Power Station Foz de Areia Power Station
South Korea	Canatom Nuclear Power Station
Australia	Tarong Power Station Erasing Power Station
United States:	
New Hampshire	Seabrook Station Nuclear Plant, Outlet Tunnels
California	Diablo Canyon Nuclear Plant, Retaining Walls
Idaho	Idaho Falls Nuclear Waste Disposal Plant
Louisiana	Cajun Electric Coal Power Plant
South Carolina	Santee-Cooper Coal Power Plant
Kentucky	J. K. Smith Power Plant D. B. Wilson Power Plant
Kansas	Sunflower Power Plant

Table 6.2. References Supplied by Dayton Barsplice, Inc.

1.	Hans Hasen Harza Engineers 150 S. Wacker Drive Chicago, Illinois	Phone: (312) 855-7000
2.	Fred Milsovic Project Manager Kiewit-Raymond-Tidewater Ft. McHenry Tunnel Baltimore, Maryland	Phone: (301) 539-7950
3.	Mr. H. B. McCoy Massman Construction Cajun Electric Power Plant New Roads, Louisiana	Phone: (816) 523-1000
4.	Mr. Richard Jarrett Greiner Engineering 5601 Mariner Street Tampa, Florida	Phone: (813) 879-1711
5.	Mr. John Arrington Arrington Construction Department of Energy Idaho Falls, Idaho	Phone: (208) 523-1000

[4]. DBI explained that this data was not available since the specimens in question failed by bar pull-out and, consequently, that an accurate measurement of total change in length could not be made since the failed bars could not be reinserted into the splice. Since the code only requires that the total elongation be given at failure and since it does not give any specific requirement as to the magnitude of such elongation, it is felt that DBI could easily have made an approximate measurement of such elongation to a degree of accuracy which would satisfy the intent of the code. It is recommended that DBI be asked to either provide additional data to satisfy this code requirement or to provide an acceptable explanation regarding the absence of such data.

3. Several of the cyclic test specimens exhibited an ultimate stress that was lower than the ultimate stress measured during static tensile tests of like specimens. The ACI 349-80 Code [2] specifies that there shall be no such reduction in strength after cyclic tests. It is recommended that this code nonconformance should not be used as a basis for rejecting the use of the Dayton Bar-Grip coupler on nuclear plant construction projects since the reductions in strength, as presented in the cyclic test results, did not result in ultimate stresses below those permitted by any of the applicable codes for static tensile tests.

In addition to resolving the apparent code nonconformances described above, it is suggested that DBI be encouraged to develop a generic Quality Assurance Manual, together with related Quality Control Procedures, which could be used by splice system users as a basis for writing appropriate manuals for their specific construction project. DBI has stated that they would write such a manual if asked to by the users of their splice system but that there has been no need to do this up to the present time since each specific construction project manager writes his own such documents anyway.

None of the recommendations presented should preclude the use of the Dayton Bar-Grip Splice System at the Seabrook Nuclear Power Plant as requested by the Public Service Company of New Hampshire provided that each specific usage be reviewed and approved on a case-by-case basis. For example, if the specified usage is for No. 7, 9 or 14 splice, it may be necessary to require that the splices be staggered relative to adjacent connections. As another example, it may be necessary to make an especially thorough review of the construction managers Quality Assurance program regarding the use of this splice system pending the receipt of generic quality assurance documentation from DBI.

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REFERENCES

1. Letter from J. DeVincentis, Project Manager, Yankee Atomic Electric Company/Public Service Company of New Hampshire, to Mr. George W. Knighton, Chief, Licensing Branch No. 3, Division of Licensing, NRC, Subject: "Request for Authorization to Utilize the Dayton Bar-Grip System at Seabrook Station," 12/28/82.

2. "Code Requirements for Nuclear Safety Related Concrete Structures," ACI 349-80, American Concrete Institute, Detroit, Michigan, April, 1981.

3. ASME Boiler and Pressure Vessel Code, Section III - Division 2, "Code for Concrete Reactor Vessels and Containments," the American Society of Mechanical Engineers, 1980 Edition.

4. ASME Boiler and Pressure Vessel Code, Section III - Division 2, "Code for Concrete Reactor Vessels and Containments," the American Society of Mechanical Engineers, 1980 Edition with Summer 1980 Addenda.

5. "ASME Code Case N-185, Requirements for Materials, and Qualification and Performance Testing of Swaged Reinforcing Bar Splices", Section III, Division 2, Concrete Reactor Vessels and Containment. Approved by Council, 8/29/77, Approved by ACI, 10/17/77.

6. "Regulatory Guide 1.136, Material for Concrete Containments," U. S. Nuclear Regulatory Commission, October, 1978 (Revision 1).

7. Uniform Building Code, 1979 Edition, International Conference of Building Officials, Whittier, California, 1979.

8. "Building Code Requirements for Reinforced Concrete," ACI 318-77, American Concrete Institute, Detroit, Michigan, 1977.

9. Letter from Steve Holdsworth, Operations Manager, Dayton Barsplice, Inc., Miamisburg, Ohio, to Neil E. Johnson, Science Applications, Inc., Oak Ridge, Tennessee, Subject: "Transmittal of Information on Dayton Bar-Grip Splice Systems," 7/13/82.

10. Letter from Neil E. Johnson, Science Applications, Inc., to Owen Rothberg, NRC Division of Engineering, Subject: "Dayton Bar-Grip Splice System Presentation to the NRC on 10/1/82," 2/28/83.

11. "Brochure - Bar-Grip Systems," Dayton Barsplice, Inc., Miamisburg, Ohio, 7/81.

12. "Operating Manual - Bar-Grip Mechanical Splicing Systems for Reinforcing Bars with Hydraulic Press Equipment," Dayton Barsplice, Inc., Miamisburg, Ohio, 12/80.

13. "Report on Performance Testing of No. 5 through No. 18 Bar-Grip Sleeves for Dayton Barsplice, Inc.," WJE No. 820300Q, Wiss, Janney, Elstner and

Associates, Inc., Northbrook, Illinois, 5/7/82.

14. "Interim Report - Camtak and Bar-Grip Sleeve Testing for Dayton Barsplice, Inc.," WJE No. 78649Q, Wiss, Janney, Elstner and Associates, Inc., Northbrook, Illinois, 9/18/79.

15. "Bar-Grip Systems Test Report - Summary of Test Results for Bar-Grip Plain Couplers," Dayton Barsplice, Inc., Undated (Note - This is a reissued version of "Report on Bar-Grip Plain Coupler Testing for Dayton Barsplice, Inc.," WJE Nos. 78649Q and 81530Q, Wiss, Janney, Elstner and Associates, Inc., Northbrook, Illinois, Undated.

16. Roger G. Slutter, "Tests of Grade 60 Reinforcing Bars Spliced Using CCL Camtak System," Report No. 200.79.674.1., Prepared by Fritz Engineering Laboratory, Department of Civil Engineering, Lehigh University, Bethlehem, Pennsylvania for the Dayton Sure-Grip and Shore Company, June, 1979.

17. E. W. Bennett, "Tests of CCL Standard Splices on 32 mm Grade 380 Deformed Bar," Report No. CCL 8, Prepared by University of Leeds, Department of Civil Engineering for CCL Systems Ltd, Surrey, England, January 1980.

18. E. W. Bennett, "Fatigue Tests of Spliced Reinforcement in Concrete Beams," Paper presented at the American Concrete Institute Convention, Puerto Rico, September 1980.

19. "Research Report - Bar-Grip Systems for Splicing of Reinforcing Steel Bars," Report No. 3848, International Conference of Building Officials, Whittier, California, October, 1981.

20. "Report of Tests of Mechanical Butt Splices on Reinforcing Steel Bar," Arkansas State Highway and Transportation Department, Division of Materials and Tests, Little Rock, Arkansas, 10/23-24/79.

21. "Report on Reinforcing Steel Mechanical Splice Tests," Pacific Testing Laboratories, 11/29/79.

22. "Report on Tests of #7 CCL Bar-Grip Side Action Press Splice and #14 CCl Camtak Extrusion Type Press Splice," State of Ohio, Department of Transportation, Division of Highways Testing Laboratory, Columbus, Ohio, 1/25/80.

23. "General Approval - Dayton Barsplice, Inc. Bar-Grip Systems for Splicing Reinforcing Bars," Research Report No. RR 24374, Department of Building and Safety, City of Los Angeles, California, 1/1/82.

24. "Report on Mechanical Splicing and Non-Destructive Examination of Reinforcing Bars Spliced by Swage Method for NRC Approval," Prepared for Public Service Company of New Hampshire - Seabrook Station by United Engineers and Constructors, Inc., Philadelphia, Pennsylvania, November, 1982.

25. Memorandum from H. L. Graves, Mechanical/Structural Engineering Branch, NRC Division of Engineering Technology to Distribution, Subject: "Meeting with Representatives of Dayton Barsplice, Inc.," 4/22/81.

APPENDIX

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BROCHURE DESCRIBING THE DAYTON BAR-GRIP SPLICE SYSTEM

This appendix contains a brochure published by Dayton Barsplice, Inc. which describes the characteristics of the Dayton Bar-Grip Rebar Splice System.

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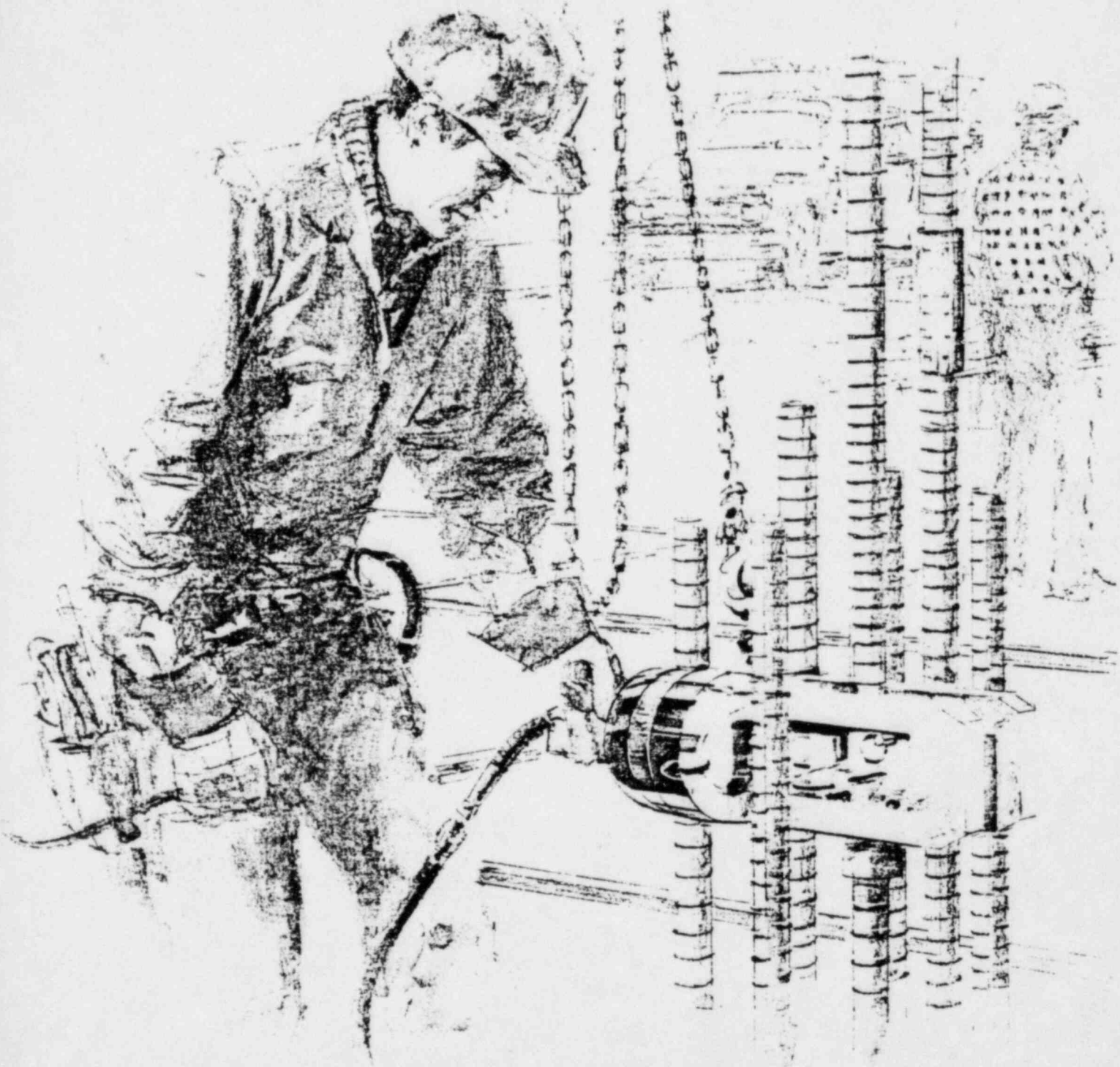
Bar-Grip® Systems

3.7/Day



DAYTON BARSPLICE, INC.

Bar-Grip® Systems—Rebar

Get to know Bar-Grip Systems for mechanical rebar coupling, and you'll say goodbye forever to messy, slow-setting mortars and complex, temperamental ignition and hot-splicing methods. With mechanical couplers to fit all diameters of ribbed reinforcing bars, Bar-Grip Systems provide absolutely rigid joints for complete structural stability. What's more, when you use Bar-Grip Systems, you can save three ways

Save space—because Bar-Grip Systems, unlike traditional methods, require no overlapping of bars. As a result, you can design slimmer structural members because you need 20% less space to complete your splicing operations.

Save steel—again because there no overlapping of the rebars to make the splices. Often that's a saving in steel of up to 10% of each rebar.

Save time—because our mechanical cold splices are made more quickly than hot and mortar splices.

Naturally, then, you can save money—because splicing the Bar-Grip way requires less designing and less installation time, less access space, and—since bars do not overlap—less steel.

Like so many great inventions, Bar-Grip Systems are surprisingly simple, providing maximum productivity with a minimum of fuss.

They consist of couplers which are cold-pressed to ribbed rebars by means of a portable hydraulic press and, in certain applications, by turning a threaded stud into pre-threaded couplers.

Using Bar-Grip® Couplers

To join bars, a side-action press with a removable die is used. The press fits around the coupler and bar and hydraulically pushes the inner die toward the outer die in order to deform a segment of the coupler onto the rebar. This process is repeated down the length of the coupler so that it is completely pressed down and around the ribs and core of the bar.

No special preparation of the bar-ends is required, so ends can be shear cut or flame cut. Plus—bars can be spliced in any direction and in any weather. Even under water.

Cut away view of Bar-Grip® splice.

© 1981 Dayton Barsplice, Inc.

splicing the faster, easier way

Using Bar-Grip® Threaded-Couplers

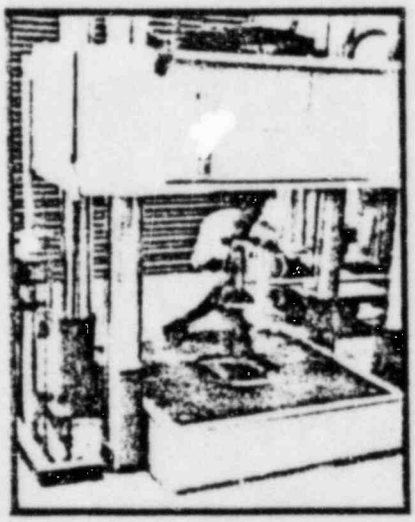
The pressing on of our supplied pre-threaded couplers can take place at the fabrication shop or adjacent to the jobsite. The rebars are coupled by turning our pre-threaded steel stud into the threaded couplers.

Consider these advantages

- **Easy-to-install.** The Bar-Grip System of mechanical rebar splicing requires very little specialized labor. Your own workers can be trained in less than an hour.
- **Require no heat, powders, or mortars.** Applied cold to the bars, couplers are pressed into rigid, permanent splices. In effect, they form one continuous bar.
- **Can be applied in any weather conditions.** There are no powders to ignite, no hot metals to protect from the rain, mist, or dampness, and no pre-heating of bars or splices.
- **Require no bar-end preparation,** so ends can be shear-cut or flame-cut. No threading of rebar or purchase of specially ribbed bars is necessary.
- **Join standard lengths of steel** to provide extra long bars; join cut-offs to provide required lengths of steel. Can be done in the fabricating shop or on-site.
- **Behave like continuous bars.** Practical tests on concrete beams reinforced by continuous bars and by bars spliced the Bar-Grip way show that the spliced bars perform equivalent to the continuous bars at service, yield, and ultimate loads.
- **Require less transverse reinforcement** because the bursting forces produced by the counter-action of lapped bars has been eliminated by elimination of the overlap itself.
- **Eliminate the need for bent steel** at the overlap splice because there are no overlap splices with Bar-Grip couplings.
- **Can cut on-site labor costs in half** because they can be applied half in the fabrication shop and then supplied to the construction site for final installation.

Bar-Grip® Systems pass every test

All Bar-Grip Systems meet the following industry specifications: ACI-359-ASME Nuclear; ACI-349 Nuclear Design Code; U.S. Army Corps of Engineers Typical Specification; ACI-318 Building Code; Canadian Standards Association Nuclear Code, CSA N287.3.



The results of tensile tests and compression tests carried out by independent laboratories in the U.S. and abroad repeatedly show that reinforcement bars joined the Bar-Grip way meet all specifications of the appropriate agencies. Time and again, test results confirm that Bar-Grip splices achieve both 125% of the yield and 100% of the ultimate specified minimum tensile strength of the bar.

Our systems have been satisfactorily tested for normal and seismic conditions by various local, state, and national agencies throughout the world, including the Public Works Commission in New Zealand, the Department of Transport, United Kingdom; the Building Commission in Hong Kong; the CSIR in South Africa; the Technical Institute in Sao Paolo, Brazil; and in accordance with design codes used in Australia, Holland, France, Spain, the Middle East, and Central and South America.

In the past few years, our systems have met or exceeded standards in tests by the University of Illinois, Lehigh University, Pittsburgh Testing Laboratories, New York City Board of Appeals, the Corps of Engineers, various federal, state, and local authorities. They are recognized by the CRSI in the current handbook.

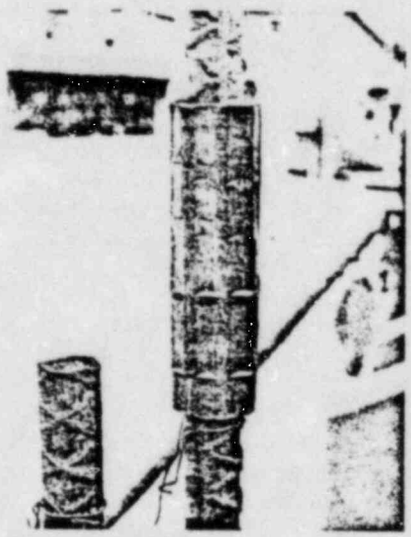
Bar-Grip Systems have been used successfully by many contractors, including Massman Construction, Turner Construction, George Hyman Construction, Bellows Construction, Southern States Steel, Texas Cold Finished Steel, F. M. Russell Construction, Haywood Construction, and J. A. Jones Construction.

Bar-Grip® Couplers—strong,

Bar-Grip® Couplers

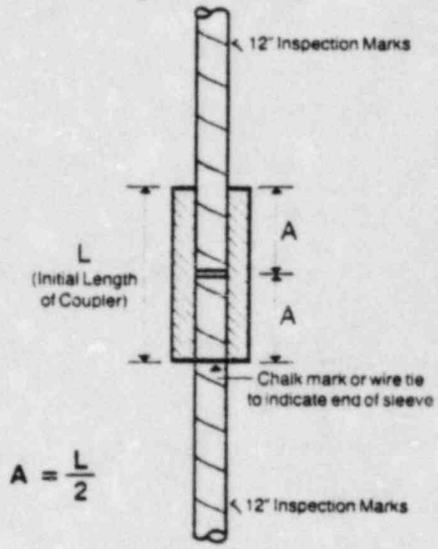
For mechanically joining high yield ribbed reinforcing bars, sizes 5 through 18, without overlapping or special end preparation, you want Bar-Grip Couplers—seamless steel sleeves applied over rebars on-site with a hand controlled hydraulic press—or "half-spliced" in the fabricating shop. Once complete, this Bar-Grip splice achieves the specified ultimate tensile strength as well as the yield strength of the bars themselves, as required by various design codes in the United States, as well as throughout the world.

Bar-Grip Couplers eliminate the need for bent steel in such applications as beams, slabs, columns, and retaining walls. As a result, they cut down significantly on the time required for design detailing. Special octagonal dies increase pressing speed by allowing single line pressing. Better-swaging steel formulations improve strength and rigidity. The result: easy-to-install, reliable splices at very reasonable cost.

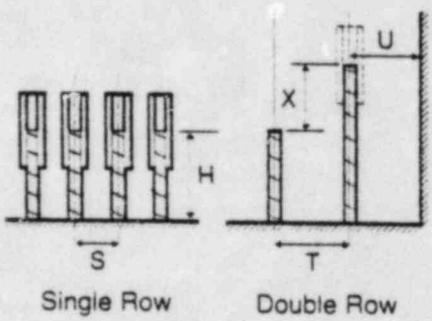


Bar-Grip® Coupler

Positioning Bars in Coupler



Minimum Setting Out Dimensions
(accompanying tables for Bar-Grip Couplers)



H = height for bar above concrete
S = centers of bars
T = center of rows of bars
X = height of one row above another
U = distance of row from structure

Note: These measurements assume the outer die is removed clear of the coupler. Rear bars are completely spliced first.

Weights and Access Measurements for Bar-Grip® Couplers

Rebar Size	Bar-Grip Press To Be Used	Coupler Lengths Nominal Average Initial in. (mm)	Final in. (mm)	Coupler Weight lb. (kg)	Minimum Setting Out Dimensions H in. (mm)	S in. (mm)	T in. (mm)	X in. (mm)	U in. (mm)
5	Side Press BG750	3⅛ (80)	3⅜ (86)	0.46 (0.21)	4¾ (120)	2¾ (70)	4½ (115)	6½ (165)	6¼ (160)
6	Side Press BG750	3¾ (95)	4 (102)	0.85 (0.39)	5 (125)	3 (75)	4¾ (120)	7 (180)	6¼ (160)
7	Side Press BG750	4 5/16 (110)	4⅝ (117)	1.24 (0.56)	5½ (135)	3 (75)	5 (125)	8 (200)	6½ (165)
8	Side Press BG750	5 (127)	5⅜ (136)	1.81 (0.82)	6 (150)	3¼ (80)	5¼ (130)	8¾ (220)	6½ (165)
8	Side Press BG1140	5 (127)	5⅜ (136)	1.81 (0.82)	6½ (165)	4¼ (105)	6 (155)	9½ (240)	8½ (215)
9	Side Press BG1140	5½ (140)	6 (152)	2.43 (1.10)	7 (175)	4¼ (105)	6¼ (160)	10¼ (260)	8½ (215)
10	Side Press BG1140	6 5/16 (160)	6¾ (172)	3.48 (1.58)	7½ (190)	4½ (110)	6½ (165)	11 (275)	8¾ (220)
11	Side Press BG1140	6⅞ (175)	7⅜ (188)	4.42 (2.01)	8¼ (205)	4¾ (120)	6¾ (170)	12 (300)	8¾ (220)
14	Side Press BG1140	8 11/16 (220)	9⅜ (239)	8.33 (3.78)	9¼ (230)	4¾ (120)	7 (175)	14 (355)	9 (225)
18	Side Press BG1157	11¾ (298)	12¾ (324)	19.60 (8.89)	12 (300)	5½ (135)	9 (225)	18⅜ (465)	11 (280)

Bar-Grip® Systems Presses speed

All Bar-Grip Presses are compact, easy-to-operate, and designed to speed up the jointing process, whether they're used on-site or in the fabricating plant.

Dayton Barsplice can supply all necessary hydraulic pumps and auxiliary equipment, including spring load balancers to provide fingertip control of the positioning of the press over the sleeves and around the bars.

These balancers can be suspended from the rebar to be spliced or from suitable scaffold equipment which may be in use for other functions on the jobsite.

Either electric or gasoline hydraulic power sources are available—220 volt single phase or 220-440 volt three phase—or regular gasoline, whichever is best suited to site conditions.

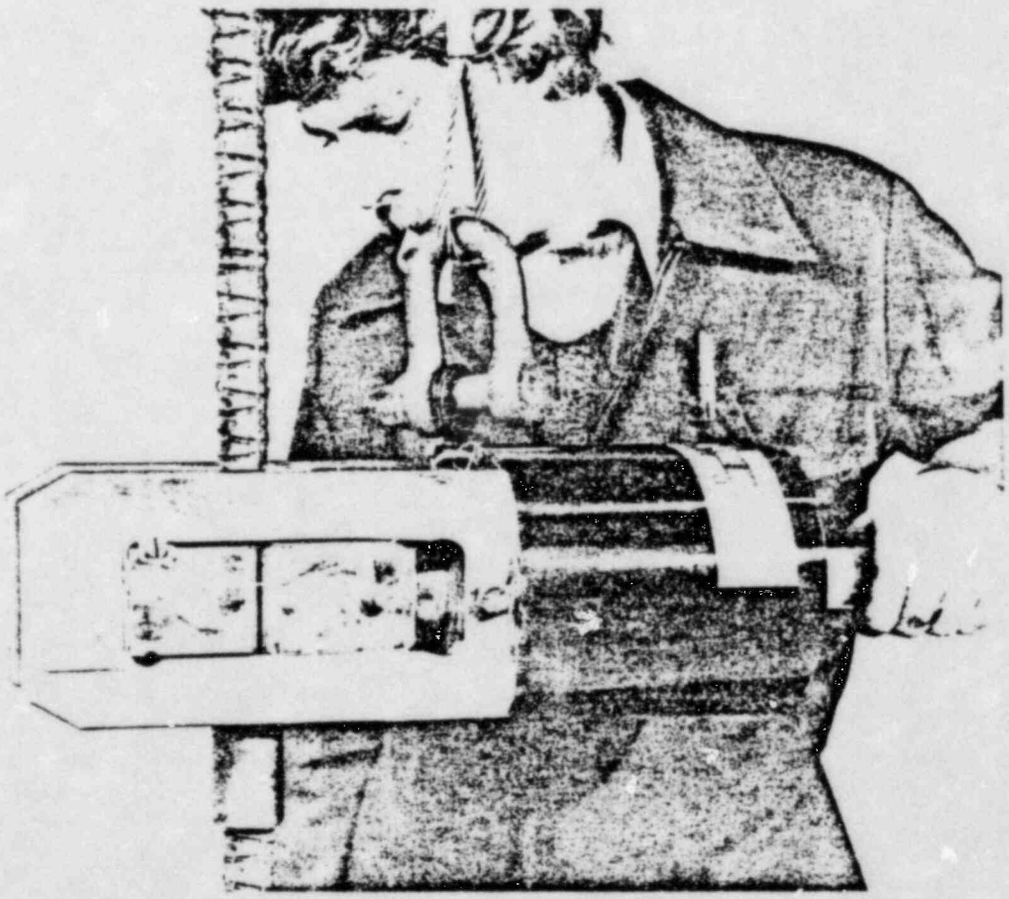
Bar-Grip® Side Press

This press is used to attach all bar-Grip splices. Compact, easy-to-operate, and fast, it can apply a coupler or threaded coupler in approximately 3 minutes.

The Bar-Grip Side Press swages the coupler to the end of the reinforcing bar by means of a series of side-action "bites." Application speed increases as bar diameters decrease, because smaller diameters require shorter sleeves, hence fewer squeezes. Naturally, then, the smaller bar sizes require the smaller, lighter hydraulic press. The Bar-Grip Side Press requires a load balancer or block-and-tackle.

Rebar Sizes # (mm)	Type of Coupler	Press Model	Weight lb. (kg.)	Dimensions Length in. (mm)	Dia. in. (mm)
8,7,6,5 (25-16)	Coupler and Threaded Coupler	BG750	115 (52)	24 (600)	8 (205)
14,11,10,9,8 (43-25)	Coupler and Threaded Coupler	BG1140	207(94)	29(735)	9(222)
18 (57)	Coupler	BG1157	230 (105)	34 (825)	9 (225)

Bar-Grip® Side Press



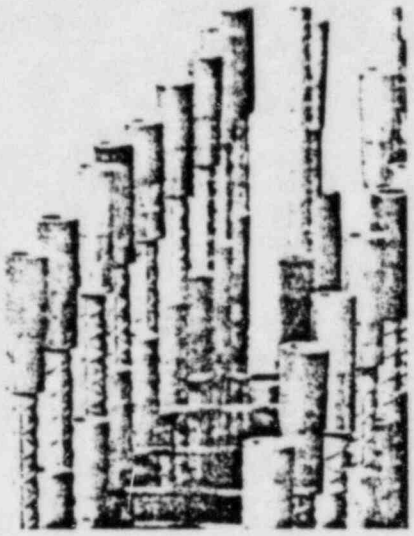
up pre-fab, on-site swaging

Bar-Grip® Bench Press

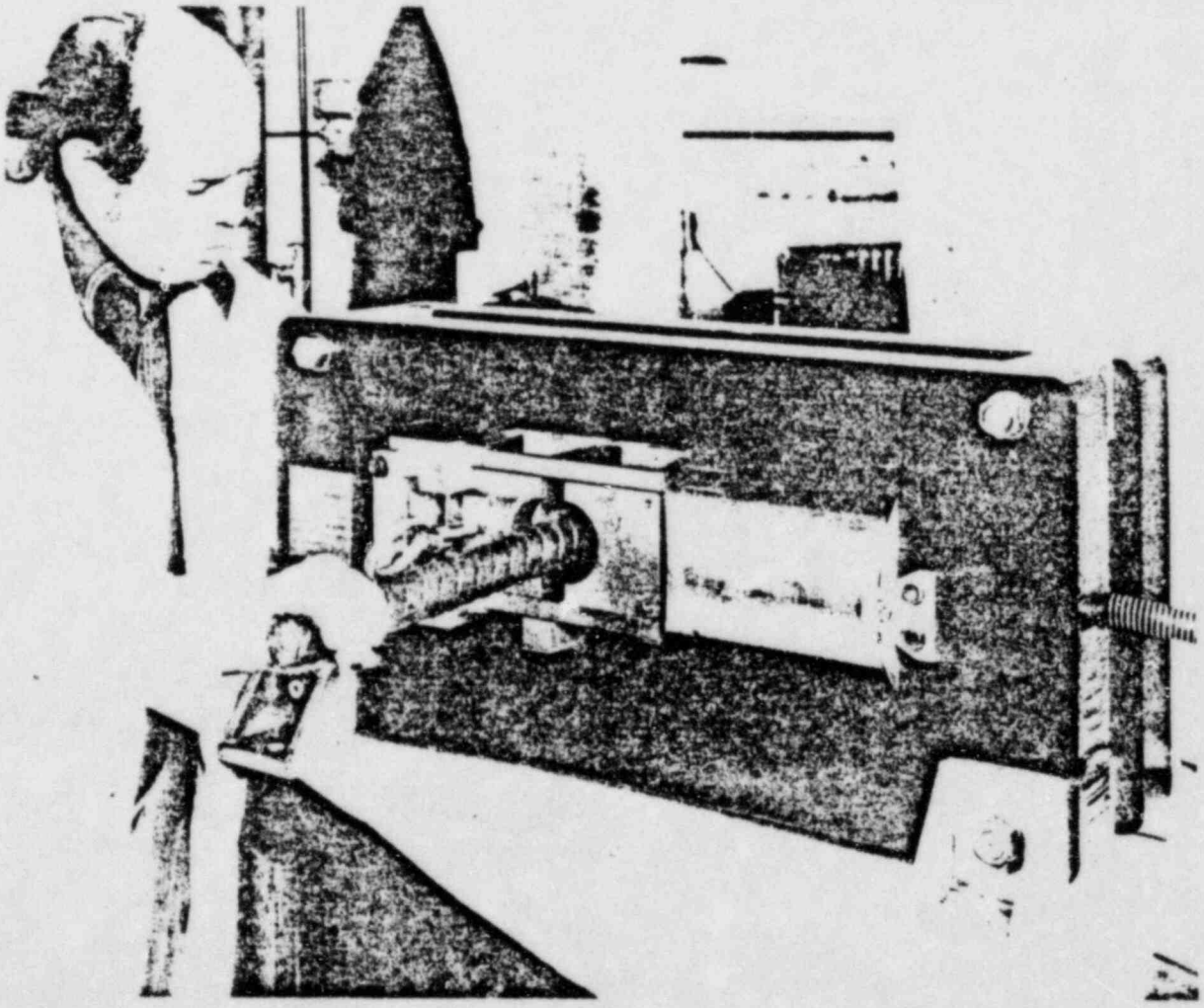
Generally, the Bar-Grip Bench Press is used in the fabrication shop to swage on threaded couplers and to half-splice Bar-Grip Couplers so that bars are ready for final coupling when they reach the job-site.

The Bar-Grip Bench Press can also be used on-site—where fabricating shop conditions can be provided—to speed up the jointing process. Either way, this press helps you install steel more quickly and to pour concrete sooner.

Rebar Sizes # (mm)	Type of Coupler	Press Model	Weight lb. (kg)	Dimensions Length in. (mm)	Height in. (mm)	Width in. (mm)
14 (43)	Coupler and Threaded Coupler	BP1400	745 (343)	31 (785)	15 (380)	8 (210)
18 (57)	Coupler and Threaded Coupler	BP3800	3300 (1500)	52 (1315)	77 (1960)	43 (1080)
			(includes pump in base of press)			



Bar-Grip® Bench Press



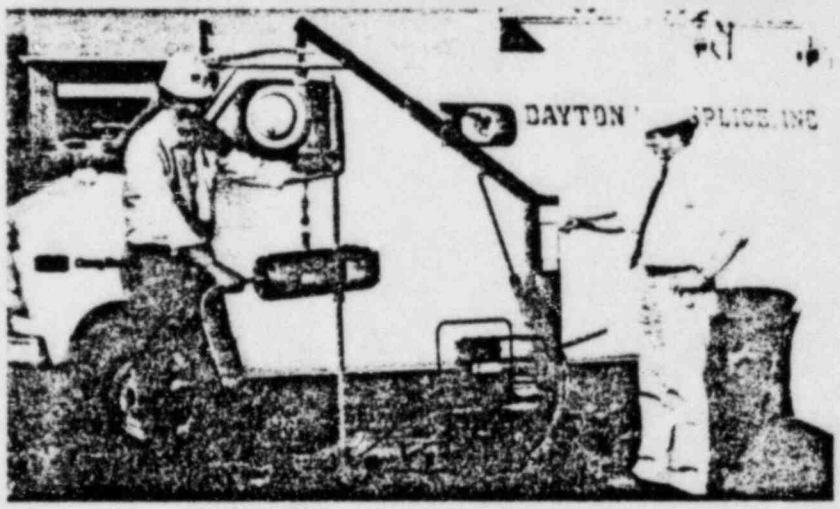
We're Dayton Barsplice, Inc. — ready to put generations of concrete construction experience to work for you

We have the best of two worlds. As a new company founded in 1979, we have the forward-looking exuberance of youth. At the same time, however, we enjoy the know-how that comes from the generations of experience shared by the companies who pooled their resources and expertise to form us—The Dayton Sure-Grip and Shore Company of Dayton, Ohio, U.S.A., and CCL Systems Ltd. of London and Leeds, England.

Dayton Sure-Grip has been making accessories and chemicals for concrete construction for over 57 years. CCL Systems has been making engineered systems for prestressing and placing concrete for 47 years.

We've got everything you'll need to put Bar-Grip Systems to work on your next contract—the engineering and technical staff to help and advise during the design stage, and the couplers, presses, and auxiliary equipment for installation.

Best of all, with Bar-Grip Systems you get everything you need for one low price. There are no hidden costs of any kind. For further information or a quote on your next job, call our Engineering Sales Department, collect, at 1-513-859-1263 Telex: 288 249



DAYTON BARSPLICE, INC.

Engineered systems for concrete reinforcing steel
P.O. Box 366 Miamisburg, Ohio 45342 (513) 859-1263

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The Bar-Grip splicing equipment outlined here is protected by patents around the world.

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