Keywords:
Pipe welding
Socket weld
Leak repair

EPRI TR-108132
Final Report
January 1998

On-Line Welding Repair for Leaking Pipe Components

(continued on back cover)

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On-Line Welding Repair for Leaking Pipe Components

Process leakage from cracked socket welds and leaking threaded connections during plant operation can lead to unscheduled shutdowns and loss of revenue to power plant owners. On-line repair methods have been developed to provide permanent repairs without taking the system off-line or isolating the leaking component. A temporary repair method to seal leaking threaded end caps has been developed that can be used to stop the leakage until the next scheduled shutdown when a permanent repair can be made. This report provides well-documented and demonstrated welding methods and procedures to repair cracked socket welds and leaking threaded connections on-line and under pressure.

INTEREST CATEGORIES

Piping, reactor vessel, and internals
Component repair
On-line repair
Welding

KEYWORDS

Pipe welding
Socket weld
Leak repair

BACKGROUND Conventional repair methods for the repair of cracked socket welds and leaking threaded connections require isolating or shutting down the system in order to stop the process flow through the leaking joint so that a sound weld repair can be made. The cost of unscheduled shutdowns required to make such repairs can be great. As an alternative, the EPRI Repair and Replacement Applications Center (RRAC) has developed repair procedures that can be used to seal leaking carbon steel and stainless steel socket welds and threaded connections with the system under pressure.

OBJECTIVE To evaluate and demonstrate methods that provide acceptable repairs to cracked socket welds and leaking threaded connections on-line and under pressure.

APPROACH Carbon steel and stainless steel mockups were fabricated from 1" Schedule 80 pipe with socket welded end caps and threaded end caps. Flaws were induced in the weld coupons to permit water leakage around the fittings when internal water pressure was applied. Fatigue cracks and EDM flaws were placed in the socket welded coupons. Flaws were placed in the threaded end cap coupons by machining or grinding a small groove in the pipe threads. The coupons were placed on a test stand, filled with water, and pressurized to 150 psi. Different repair sequences of peening and welding under pressure were tested to determine the best repair methods for each combination of materials and end cap types. Two new methods of leak sealing, a split-collar technique for stainless steel threaded end caps and a temporary mechanical coupling for stainless and carbon threaded end caps, were also developed. The repaired test coupons were hydrostatically tested to determine if all leaks had been successfully sealed. Metallographic examination of the repair area cross-sections was performed to determine subsurface weld quality.

RESULTS The program established sound repair practices and welding procedure guidelines to perform on-line seal welding of cracked socket welds and leaking threaded fittings. Although end caps were evaluated for ease of testing, the repair processes developed can be applied to unions, elbows, valves, and so on. Detailed mockup fabrication drawings, test results, repair procedures, and welding parameters are provided in this report to guide utility personnel or their contractor through a successful training effort and field application.

EPRI PERSPECTIVE The on-line seal welding methods described in this report offer effective, permanent repair methods as an alternative to shutting down a unit due to leakage from cracked socket welds or damaged threaded fittings. These cost-effective methods can be implemented quickly with no requirement for special tools or equipment. All welding is performed in accordance with the requirements of ASME Section IX and as directed by ASME Section XI for repairs and modifications.

PROJECT

TR-108132

WO 5887 under WO 3887

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ACKNOWLEDGMENTS

The authors gratefully acknowledge the time, consultation, and direction provided by Mike Sullivan of Pacific Gas and Electric in assembly of this project and report. We would also like to thank Mike Newman of EPRI-RRAC for his efforts in performing welding evaluations for this project.

Finally, the authors would like to acknowledge the members of the EPRI Repair and Replacement Applications Program who funded and directed this effort. Members of this committee include:

Mike Schwartzwalder	American Electric Power Service
Rick Rogoski	Cleveland Electric Illuminating Company
Michel Carre	Electricité de France-UTO
Richard Corbit	GPU Nuclear Corporation
Neal Chapman	New York Power Authority
Mike Sullivan	Pacific Gas & Electric
James Hallenbeck and Erach Patel	PECO Energy
Ed Gerlach	Pennsylvania Power & Light Company
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Evan Dalasta and Jagdish Gupta	TU Electric
Bruce Newton	Union Electric
Steve Sprague	Wolf Creek Nuclear Operating Corporation
Eric C. Biemiller and Ken Willens	Yankee Atomic Electric Company / Maine Yankee

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1 BACKGROUND/BASIS

Process leakage caused by through-wall cracks, pin holes, damaged threads, and cut or eroded gaskets often leads to unplanned shutdowns if the leakage cannot be stopped in a safe and timely manner. In many cases, temporary mechanical methods are successfully applied to pipes and pipe fittings, flanged connections, socket-weld fittings, and valve body-to-bonnet connections just to name a few examples. More permanent welded repairs have been applied with varying success because of the pressure and process flow extinguishing the arc at the point of closure.

Previous RRAC programs have addressed the problem of making permanent weld repairs on-line and under pressure. These programs successfully demonstrated that pressurized leaks can be stopped by mechanical peening of the base material and then seal welding. This practice permits the subsequent application of a structural repair, such as a weld overlay in accordance with Section XI of the ASME Boiler and Pressure Vessel Code. The challenge is to stop the leak and provide a completely dry surface prior to applying the structural repair.

2

PROJECT PURPOSE AND APPROACH

The purpose of the task was to develop repair techniques that can be used to perform permanent repairs of threaded end caps and cracked socket welds on-line and under pressure. Although end caps were evaluated for ease of testing, the repair processes described also pertain to threaded and socket-type unions, elbows, valves, and so on. The ability to perform such repairs will provide substantial cost savings because it will not be necessary to take the plant off-line or otherwise isolate the repair location while a permanent weld repair is made.

Several test coupons were fabricated from 1" diameter carbon steel and stainless steel pipe. One end of the coupons was threaded for the attachment of a hydraulic pump to provide operating pressures up to 150 psi. Some of the coupons were threaded on the opposite end as well for the attachment of a threaded end cap. Socket end caps were welded to the remainder of the test coupons using the gas tungsten arc welding (GTAW) process. To induce water leakage, a flaw was placed in the capped end of the pipes to allow water flow around the annulus of the pipe. Welding repair of the leaking threaded and socket end caps was performed to determine the optimum conditions of welding process, welding technique, electrode type, and bead placement in order to seal the leaking joint. A mechanical coupling that is used to temporarily seal leaking threaded end caps was also obtained. Detailed directions for the use of the mechanical coupling are provided. Specifically, practices and parameters to perform permanent and temporary repairs of leaking pipe components on-line and under pressure were developed and demonstrated.

3

TEST METHODS

3.1 Test Fixture

A pressurized test fixture was fabricated for weld parameter development. The fixture was designed to hold the test coupons at a comfortable height for welding. Provisions were made to attach a hydraulic pump to the test coupons in order to maintain a positive internal pressure and water level during the repair sequence. The mockup is shown in Figure 3-1. The SC Hydraulic power unit pump used during testing is pictured in Figure 3-2. The mockup assembly is described in Appendix A.

Figure 3-1
Assembled Mockup

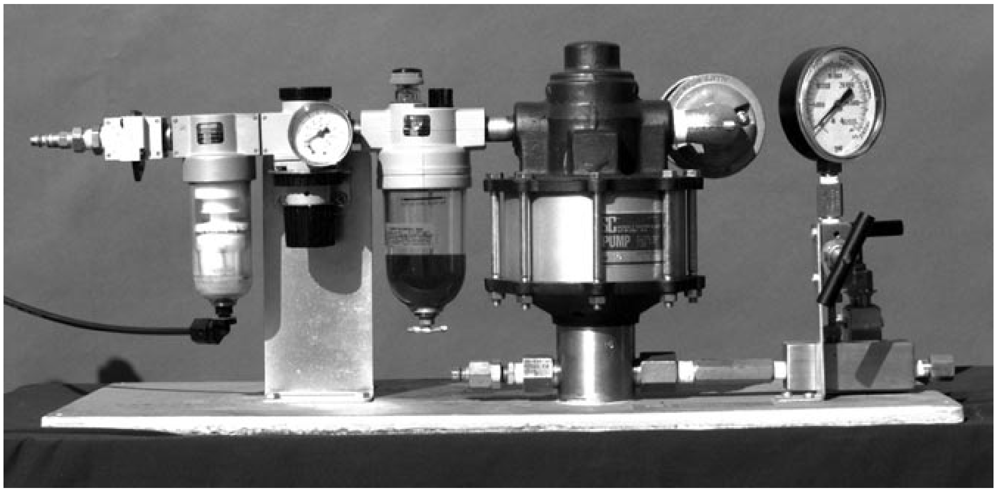

Figure 3-2
SC Hydraulic Power Unit Pump

3.2 Evaluation Coupons

The weld coupons were made using one-inch Schedule 80 A106 carbon steel and A312 304 stainless steel pipe. Threaded pipe caps and socket end caps of carbon steel and stainless steel material were used (see Figure 3-3). The pipes were cut to a length of 18 inches and threaded on one end to accept the pressure fitting for connection to the hydraulic pump. The pipes to be used with the threaded end caps were also threaded on the opposite end to accept the threaded pipe caps. For the pipes used with the socket end caps, the sockets were attached to the pipes by welding using the GTAW process.

Figure 3-3
Carbon Steel Threaded and Socket End Caps

3.3 Welding Materials Evaluated

The following filler materials and piping components were used during the evaluation and development effort:

- Covered Electrodes (Shielded Metal Arc Welding—SMAW)
  Lincoln 3/32" AWS A5.1; E7018
  Sandvik 3/32" AWS A5.4; E6011, E309L-16
  Avesta 3/32" AWS A5.4; E316L-PW

- Flux-Cored Filler Wire (Flux-Cored Arc Welding—FCAW)
  Cor-Met 0.045" 308LF-FC-UW

- Filler Rods (Gas Tungsten Arc Welding—GTAW)
  Sandvik 3/32" AWS A5.9; E308, E309

- 1" Schedule 80 Stainless Steel Pipe, A312 TP304

- 1" Schedule 80 Carbon Steel Pipe, A106 Grade B

- Class 3000 Stainless Steel Socket and Threaded End Caps, A182 TP304L/304

- Class 3000 Carbon Steel Socket and Threaded End Caps, A105 Grade B

3.4 Equipment

The following equipment was used during the evaluation and development effort:

- Hobart Cyber-Tig II, 300 series, constant current, 3 phase, 300 Amp (max.), 60 Hz, 460V power source

- SC Hydraulic Power Unit Pump, Model 40-500-16
  SC Hydraulic Engineering Corporation, Los Angeles, CA

- Peening Gun, Superior Pneumatic Model 240000 with Modified tips; Chisels used:
  Flat Chisel and Peening Tool (see Appendix B)
  Superior Pneumatic, P.O. Box 40420, Cleveland, OH 44140

3.5 Test Matrix

A test matrix was established to develop on-line welding techniques for end cap configurations that would provide quality weldments on carbon and stainless steel substrates. The overall test matrix was divided into four separate matrices covering the different combinations of base materials and end cap types (see Tables 3-1, 3-2, 3-3, and 3-4). The internal hydrostatic pressure of most of the pipe coupons was held at 150 psi during welding to simulate on-line conditions. In some cases, the pressure was reduced below 150 psi because of excessive water flow from the flawed weld coupons.

Mechanical peening of the leaking pipe coupons was used in nearly all of the weld tests because of the success of using this method in previous RRAC programs dealing with on-line seal welding [1,2]. In conjunction with the peening operation, different welding materials, processes, and techniques were used to determine the best repair process for each combination of base material and end cap type. The actual repair sequence for each test shown in the following tables varies. Detailed descriptions of the sequence of peening and welding used in each test are given in Section 4.

Table 3-1
Test Matrix for Carbon Steel Socket Welded End Caps

Test No.	Base Metal	Weld Metal	Weld Process	Type of End Cap Used	Mockup Pressure (psi)	Peening Used?
CSS-1	A106 Grade B	E7018	SMAW	Socket	150	Yes
CSS-2	A106 Grade B	E309L-16	SMAW	Socket	150	Yes

Table 3-2
Test Matrix for Carbon Steel Threaded End Caps

Test No.	Base Metal	Weld Metal	Weld Process	Type of End Cap Used	Mockup Pressure (psi)	Peening Used?
CST-1	A106 Grade B	E309L-16	SMAW	Threaded	150	No
CST-2	A106 Grade B	308LF-FCUW	FCAW	Threaded	150	Yes
CST-3	A106 Grade B	308LF-FCUW	FCAW	Threaded	80	Yes
CST-4	A106 Grade B	ER309	GTAW	Threaded	50	No
CST-5	A106 Grade B	E6011	SMAW	Threaded	100	Yes

Table 3-3
Test Matrix for Stainless Steel Socket Welded End Caps

Test No.	Base Metal	Weld Metal	Weld Process	Type of End Cap Used	Mockup Pressure (psi)	Peening Used?
SSS-1	A312 TP304	E309-16	SMAW	Socket	150	Yes
SSS-2	A312 TP304L	E316L-PW	SMAW	Socket	150	Yes

Table 3-4
Test Matrix for Stainless Steel Threaded End Cap

Test No.	Base Metal	Weld Metal	Weld Process	Type of End Cap Used	Mockup Pressure (psi)	Peening Used?
SST-1	A312 TP304	E309L-16	SMAW	Threaded	150	Yes
SST-2	A312 TP304L	308LF-FCUW	FCAW	Threaded	150	Yes
SST-3	A312 TP304L	ER309	GTAW	Threaded	80	Yes
SST-4	A312 TP304L	E6011	SMAW	Threaded	100	Yes

3.6 Flaw Fabrication

In order to permit water leakage from the socket and threaded end caps, it was necessary to induce flaws in the pipe and end cap assemblies. These flaws were fabricated in two different ways on the socket end caps: by introducing a fatigue crack in the weld and by burning an EDM notch in the pipe at the toe of the weld. For threaded end cap evaluation, flaws were introduced by machining or grinding a groove in the threads on the pipe where the end cap was placed.

The fatigue crack in the socket welds was created by welding a small portion of the socket weld (approximately 1/2"). The socket end of the weld coupon was then clamped in a vice, and the weld was cracked by flexing the pipe back and forth (see Figure 3-4). Then, the remainder of the root was welded so that the capped pipe could be filled with water and pressurized.

Figure 3-4
Fatigue-Induced Crack in Socket Weld

Another method used to place flaws in the socket weld coupons was electrical discharge machining (EDM). The placement of the flaw is shown in Figure 3-5. The size of the notch was 0.010" wide by 0.250" long through the pipe wall at the toe of the socket weld.

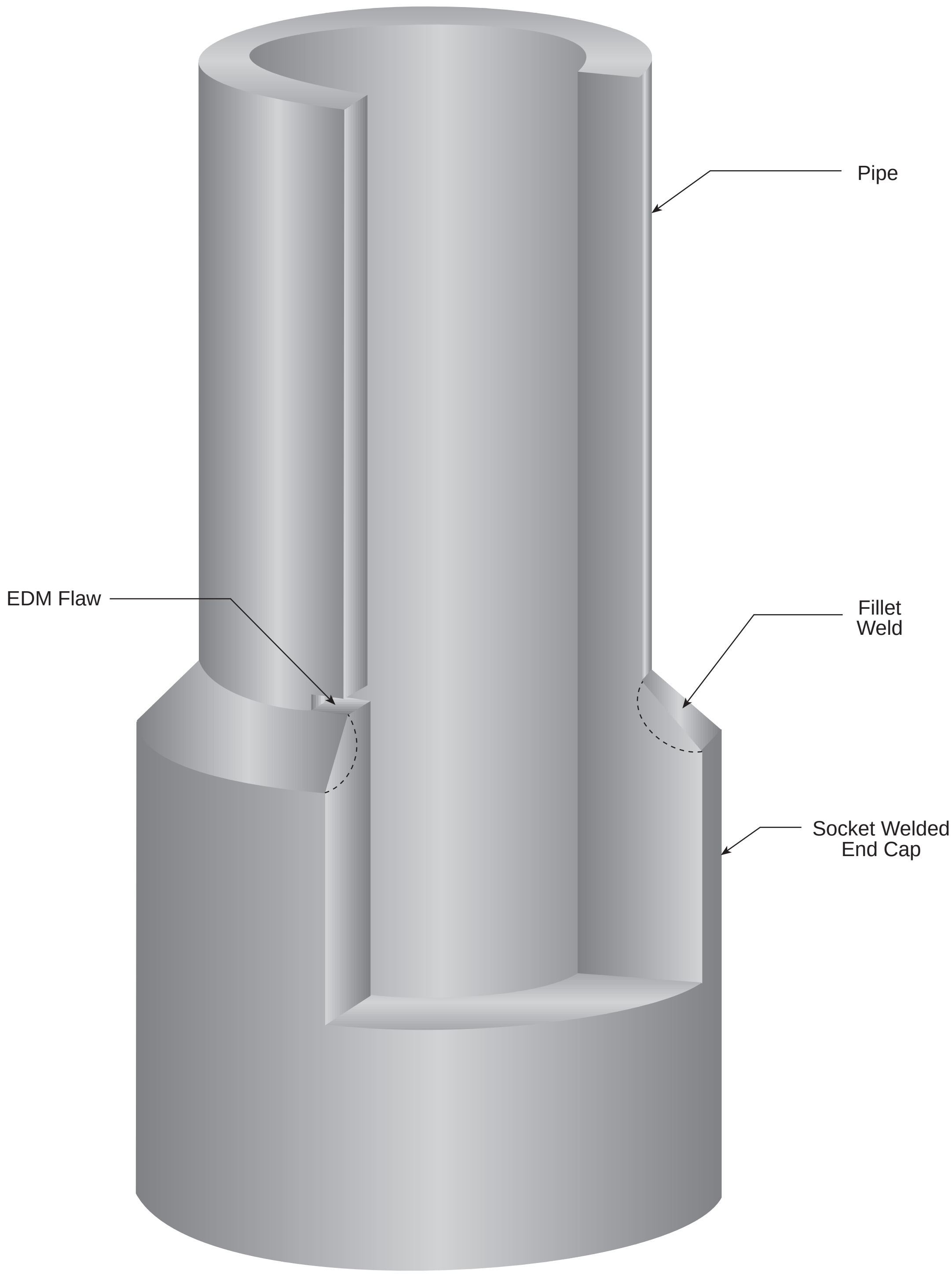

Figure 3-5
Placement of EDM Notch in Socket Weld Coupons
(Flaw Size Is Exaggerated)

On the threaded end cap coupons, water leakage was induced by placing a groove in the pipe threads. Initially, the grooves were machined to exact dimensions of 0.014" wide by 0.062" deep extending nearly the length of the threads. For later tests, the grooves were made using a pneumatic wheel grinder with a wheel thickness of 1/16" (see Figure 3-6). Use of the grinder made it possible to place the flaw in the threads more quickly and more easily than by machining.

Figure 3-6
Groove Cut in Threads to Induce Water Leakage

4

TEST PROCESSES AND RESULTS

4.1 Carbon Steel Socket Welded End Cap Mockup Repair Tests CSS-1 and CSS-2

The goal of this portion of the project was to repair leaking carbon steel socket welded end caps by welding under pressure with water flowing out of the flaw. The socket end caps were welded to the 1" diameter pipe using the GTAW process, and either an EDM flaw or a fatigue crack was placed in the welds (as described in Section 3.6) to facilitate water leakage. The mockup for each test was assembled according to the steps given in Appendix A. Different combinations of intermittent peening and welding were used in an effort to seal the leaking welds. The following sections describe the tests that were performed and the results of the tests.

4.1.1 Test CSS-1

The weld test coupon was flawed by placing an EDM notch through the pipe wall at the fillet weld joining the end cap to the pipe (see Figure 3-5). The mockup was pressurized to 150 psi. At this pressure, the water leakage from the EDM flaw was visible as a spraying stream (see Figure 4-1).

Figure 4-1
Water Leakage from Socket Weld Coupon under Pressure

Welding on the leaking socket end cap was done using the SMAW process, AC polarity, and a Lincoln E7018 electrode. Based on results from previous RRAC programs, welding over flowing water would not be successful; thus, mechanical peening was performed on the flaw to plastically deform the metal around the flaw and stop the leak (see Figure 4-2) [1,2].

Figure 4-2
Mechanical Peening of Socket Weld

After mechanical peening, a weld bead was placed slightly below the flaw location. The shrinkage caused by welding re-opened the leak and peening was again used to stop the water flow. A second weld bead was placed directly over the flaw, and no water leakage was observed. A third weld bead was placed above the second bead, and again, no water leakage was observed (see Figure 4-3). Figure 4-4 shows a cross-section of the repair weld at a magnification of 6.3x.

Figure 4-3
Test Coupon CSS-1 after Welding

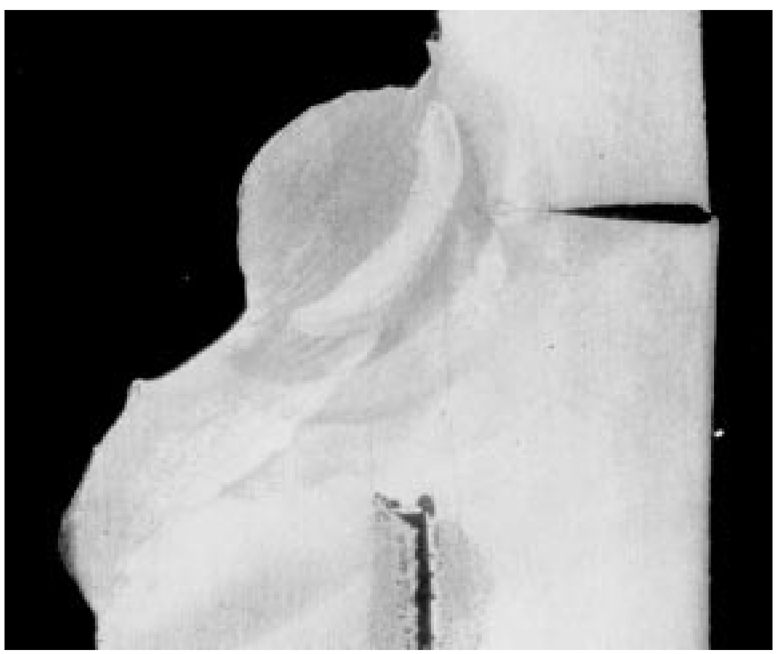

Figure 4-4
Cross-Section of Coupon CSS-1 Showing EDM Flaw Sealed by Welding (Magnified 6.3x)

4.1.1.1 Results/Observations

Welding with AC polarity allowed a slower travel speed and less heat input to the base metal. If too much heat is applied to the weld coupon the water inside vaporizes, and the steam could potentially blow through the molten metal. The lower heat input allowed the welder more time to make a proper weld without being concerned about blow-holes in the weld. After peening and welding, no water leakage was observed at a pressure of 1,000 psi.

4.1.2 Test CSS-2

This test was done on a carbon steel socket welded coupon with a fatigue-induced flaw in the weld (see Figure 3-4). The pipe was pressurized to 150 psi and water began leaking from the flaw. The metal above and below the crack was peened toward the crack, and peening was done directly on the crack location in order to thoroughly seal the water leakage. Repair welding was performed using the SMAW process, reverse polarity, and a Sandvik E309L-16 electrode. One weld bead was placed directly over the peened crack, and a second bead was placed above the first pass. Figure 4-5 shows an overall cross-section of the weld coupon with the weld repair. Figure 4-6 shows a cross-section of the fatigue crack sealed by welding.

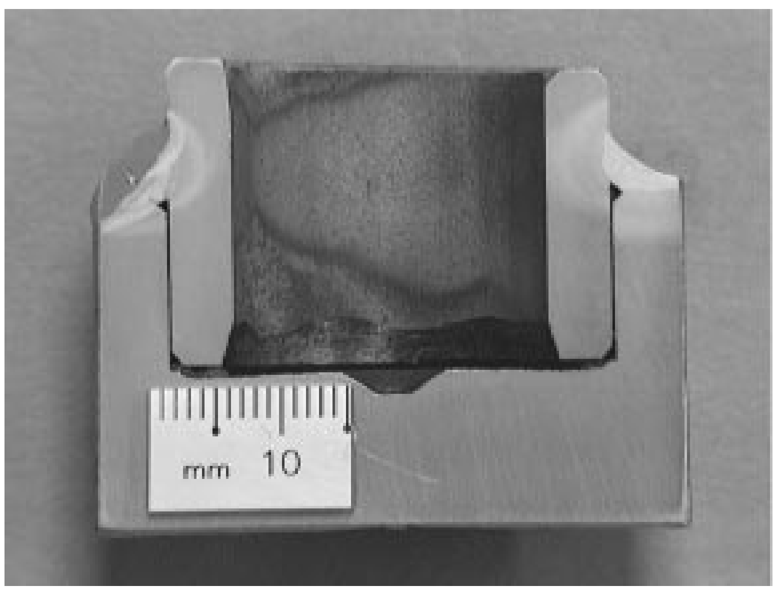

Figure 4-5
Cross-Section of Coupon CSS-2

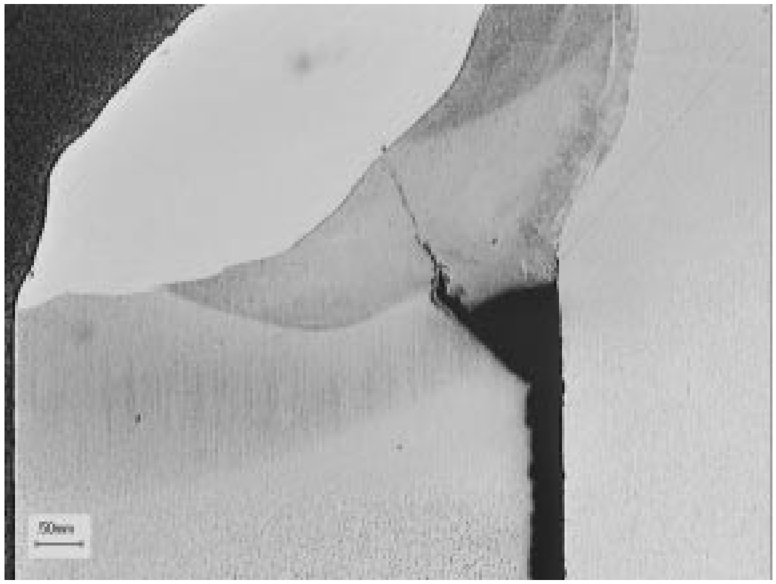

Figure 4-6
Cross-Section of Coupon CSS-2 Showing Fatigue Flaw Sealed by Welding (Magnified 10x)

4.1.2.1 Results/Observations

Thorough peening of the crack allowed placement of the first weld bead directly over the crack location without the negative effects of welding in direct contact with water. Welding directly over the peened crack sealed the leak instead of re-opening it as in Test CSS-1 where the first weld was placed slightly below the crack location. The repair was completed using this repair method and no water leakage was observed at a pressure of 1,000 psi after welding.

4.2 Carbon Steel Threaded End Cap Mockup Repair Tests CST-1 through CST-5

The objective of the following tests was to repair leaking carbon steel threaded end caps by welding under pressure with water leaking. A flaw was placed in the pipe threads either by machining or grinding (see Section 3.6), and the end caps were threaded tightly onto the pipes. The mockup for each test was assembled according to the steps presented in Appendix A. Various combinations of intermittent peening and welding were evaluated in an effort to seal the leaking end caps. In Test CST-3 the pipe cap was slightly modified to make the peening operation more effective. The following sections describe the tests that were done and the results of the tests.

4.2.1 Test CST-1

The weld coupon for this test was flawed by cutting a groove in the threads by machining as described in Section 3.6. With the end cap in place, the pipe was pressurized to

150 psi and water began to flow around the annulus between the pipe and the cap. Welding was attempted using the SMAW process, AC polarity, and a Sandvik E309-16 electrode. The weld bead was placed directly over the point where the water was leaking, which resulted in a poor weld repair that did not stop the water flow (see Figures 4-7 and 4-8).

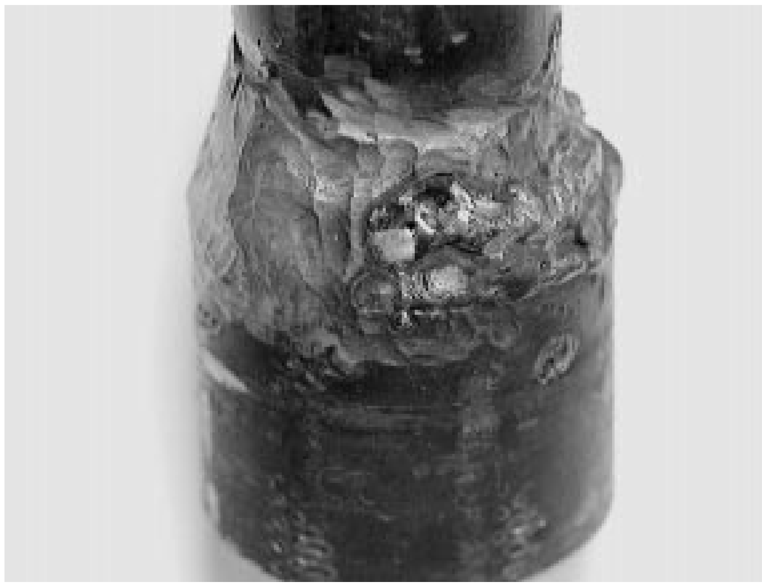

Figure 4-7
Test Coupon CST-1 after Welding

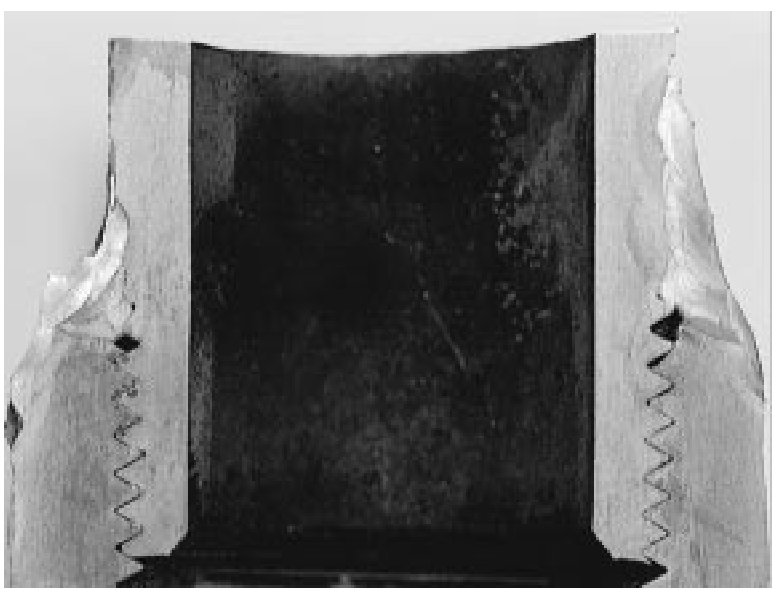

Figure 4-8
Cross-Section of Test Coupon CST-1 after Welding

4.2.1.1 Results/Observations

Welding in direct contact with the water flow causes porosity in the weld that results in an unacceptable repair. The water leakage around the end cap did not stop using this repair method. All future tests will utilize peening to stop the water flow so that the flaw can be sealed by welding without contact with the water flow.

4.2.2 Test CST-2

Test CST-2 was performed on a carbon steel pipe with a threaded pipe cap. The flaw was placed in the pipe threads using a pneumatic grinder as described in Section 3.6. The weld coupon was pressurized to 150 psi, and welding was performed using the FCAW process, reverse polarity, and a 308L wire developed in the RRAC's underwater welding program. Welding was initiated adjacent to the leak location and continued around the annulus of the pipe and ended on the opposite side of the leak. Another weld bead was initiated just below the leaking hole, continued around the pipe, and stopped at the same point below the leak. A third bead was started just above the leaking hole, continued around the pipe, and terminated at the same point above the leak. The weld metal was then peened in toward the hole to stop the water leakage. A fourth weld bead was placed directly over the leak location causing the leak to re-open. The leakage was stopped by peening and another weld bead was placed over the hole. This process of welding and peening was continued until no water leakage was observed (see Figure 4-9). A total of eight weld beads was placed on this particular weld coupon. Figure 4-10 shows a cross-section of the repair weld at a magnification of 6.3x.

Figure 4-9
Test Coupon CST-2 after Welding

Figure 4-10
Cross-Section of Weld Repair on Coupon CST-2
(Magnified 6.3x)

4.2.2.1 Results

No water leakage was observed at a pressure of 1,000 psi after welding.

4.2.3 Test CST-3

The flaw was placed in the weld coupon for this test using a pneumatic grinder. The threaded pipe cap used in this test was modified in an effort to make the process of mechanical peening more effective. A small lip was machined into the pipe cap in order to reduce the thickness of the cap making it easier to deform the metal by peening, and thereby, close the water leak (see Figure 4-11).

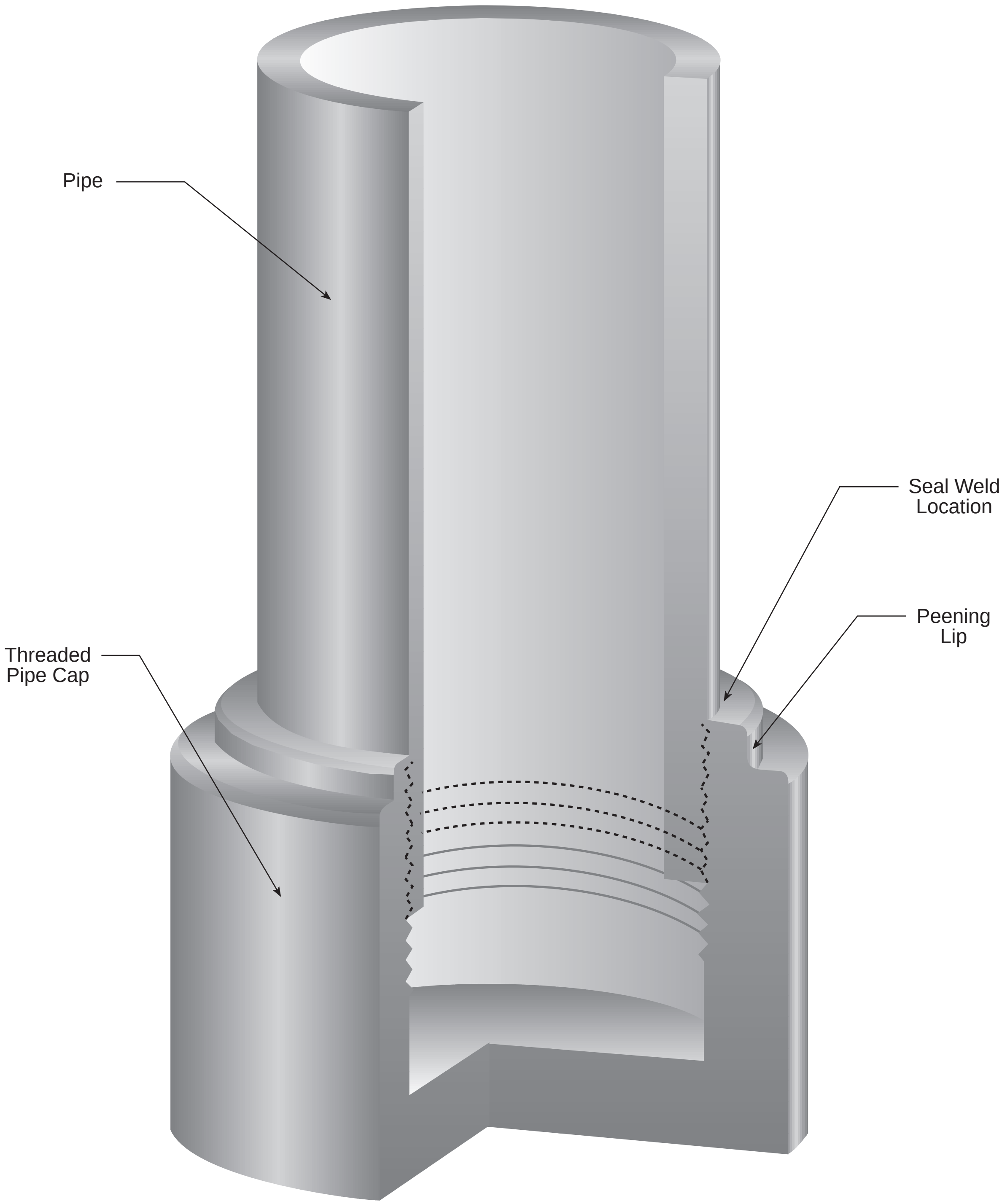

Figure 4-11
Threaded Pipe Cap with Machined Peening Lip

The mockup was fitted with the modified pipe cap and pressurized to 80 psi. Welding was done using the FCAW process, reverse polarity, and a 308L wire developed in the RRAC's underwater welding program. First, peening was done on the 1/8" lip on the pipe cap to deform the peening lip into the pipe threads, thereby stopping the water flow. Then, a continuous weld bead was placed on the machined lip around the entire circumference of the pipe, and no leakage was observed. Placement of the first weld bead was such that the metal lip was consumed, and the weld bead fused slightly into the pipe wall. A second bead was placed on and just above the first bead to tie the repair weld more fully into the pipe wall (see Figures 4-12 and 4-13).

Figure 4-12
Test Coupon CST-3 after Welding

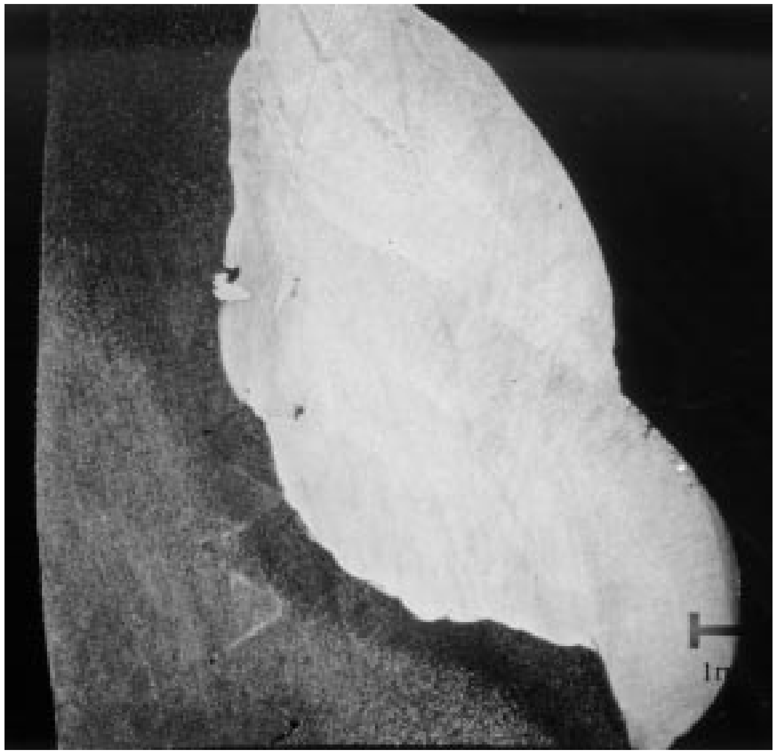

Figure 4-13
Cross-Section of Weld Repair on Coupon CST-3
(Magnified 6.3x)

4.2.3.1 Results

No water leakage was observed at a pressure of 1,000 psi after welding.

4.2.4 Test CST-4

The weld coupon for test CST-4 was prepared identically to the one for test CST-2. The water pressure on the pipe was reduced from 150 psi to 50 psi because the water flow from the flawed threads was too large. Welding was performed using the GTAW process with argon flow of 40 CFH and a Sandvik ER309 filler material. No mechanical peening of the weld joint was done prior to welding. Welding was initiated adjacent to the water leak and continued away from the leak around the pipe. During welding the water was pushed away by the argon flow and the heat of the welding plasma. Welding was stopped after traveling a distance of 1" because heat and pressure were building in the pipe causing steam to escape from the leaking flaw. Porosity was found at the end of the weld. The porosity was ground out and welding was resumed. Almost immediately after the welding arc was established, the pressure in the pipe blew a hole through the molten weld metal and welding was stopped.

4.2.4.1 Results/Observations

The water leakage was not stopped using this repair method. Because of the poor results obtained by welding of the threaded end cap with the GTAW process, this method of sealing the leaking pipe cap was abandoned.

4.2.5 Test CST-5

This test was performed on a pipe coupon with a threaded end cap with the flaw placed in the threads by grinding. The weld coupon was pressurized to 100 psi, rather than 150 psi to slightly reduce the water flow from the flaw. Welding was performed using the SMAW process, reverse polarity, and a E6011 electrode. A "whip" or "long-arcing" technique was used when welding to control heat input to the pipe. When welding with this technique, a "nugget" of weld metal is deposited on the base metal, and then the electrode is pulled away from the base metal just far enough to keep the electrode from melting while still maintaining the welding arc. The electrode is held off the base metal for approximately 1 second and then returned to deposit a nugget of molten weld metal. This in and out motion is continued for the duration of the weld. By repetitively pulling away from the base metal, the heat input to the pipe is less than when the welding electrode is kept in constant contact with the base metal.

Welding was initiated on the pipe coupon adjacent to the leaking flaw and continued away from the flaw, around the pipe, and terminated on the opposite side of the leak. After the welding of the first pass, the leaking hole was peened shut. A second weld bead was placed on top of the first pass to completely seal the leak. After welding with the E6011 rod, a E7018 electrode was used to place 3 cover passes over the seal welds (see Figure 4-14). Figure 4-15 shows a cross-section of the completed weld repair at a magnification of 6.3x.

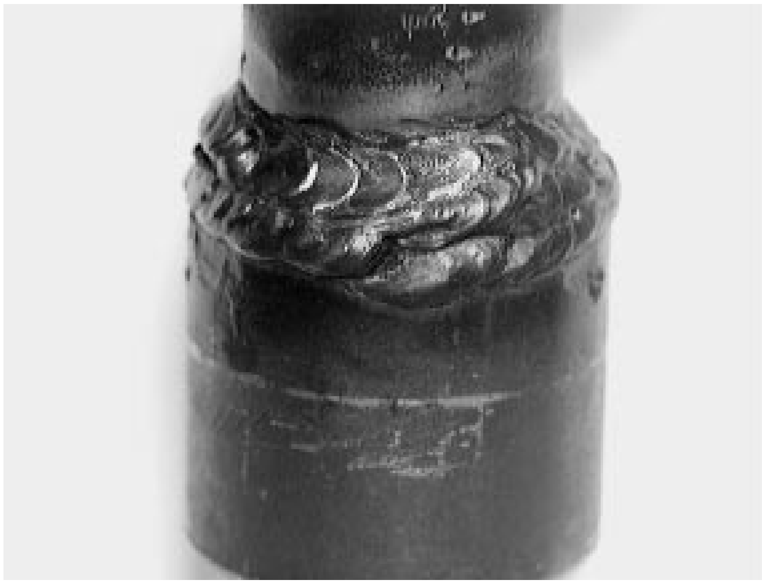

Figure 4-14
Test Coupon CST-5 after Welding

Figure 4-15
Cross-Section of Weld Repair on Coupon CST-5
(Magnified 6.3x)

4.2.5.1 Results/Observations

The whip technique used with the E6011 electrode helped to minimize the heat input to the pipe, thereby preventing excessive steam buildup and potential blow holes in the weld. No water leakage was observed at a pressure of 1,000 psi after welding.

4.3 Stainless Steel Socket Welded End Cap Mockup Repair Tests SSS-1 and SSS-2

The goal of this series of evaluations was to repair leaking stainless steel socket welded end caps by welding under pressure with water flowing. The socket end caps were welded to the 1" diameter pipe using the GTAW process, and either an EDM flaw or a fatigue crack was placed in the welds (see Section 3.6) to facilitate water leakage. The mockup for each test was assembled according to the steps given in Appendix A. Different combinations of intermittent peening and welding were used in an effort to seal the leaking welds. The following sections describe the tests that were done and the results of the tests.

4.3.1 Test SSS-1

The weld coupon for Test SSS-1 was flawed by placing an EDM notch through the pipe wall at the fillet weld joining the end cap to the pipe (see Figure 3-5). The weld coupon was pressurized to 150 psi. Welding on the leaking socket end cap was done using the SMAW process, AC polarity, and a Sandvik ER309L-16 electrode. Before any welding was done, the peening gun was used to mechanically deform the metal around the leaking flaw and close the leak. Then, a weld bead was placed slightly below the flaw location. The shrinkage caused by welding re-opened the leak and peening was again used to stop the water flow. A second weld bead was placed directly over the flaw, and no water leakage was observed. A third weld bead was placed slightly below the second bead to cover the peening marks, and no water leakage was observed. Figure 4-16 shows the EDM flaw sealed by welding (magnified 10x).

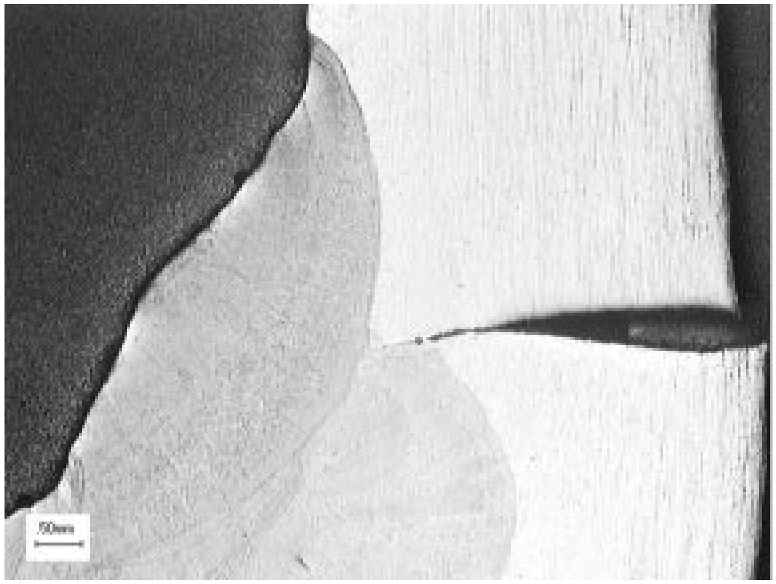

Figure 4-16
Cross-Section of Coupon SSS-1 Showing EDM Notch Sealed by Welding (Magnified 10x)

4.3.1.1 Results

No water leakage was observed at a pressure of 1,000 psi after welding.

4.3.2 Test SSS-2

Test SSS-2 was performed on a stainless steel socket welded coupon with a fatigue flaw placed in the weld (see Figure 3-4). The pipe was pressurized to 150 psi and water began leaking from the flaw. The cracked area was peened until the water flow was completely stopped. Welding on the socket was done using the SMAW process, reverse polarity, and an Avesta E316L-PW electrode. One weld bead was placed directly over the peened crack, and a second bead was placed above the first pass (see Figures 4-17 and 4-18).

4.3.1.2 Results

No water leakage was observed at a pressure of 1,000 psi after welding.

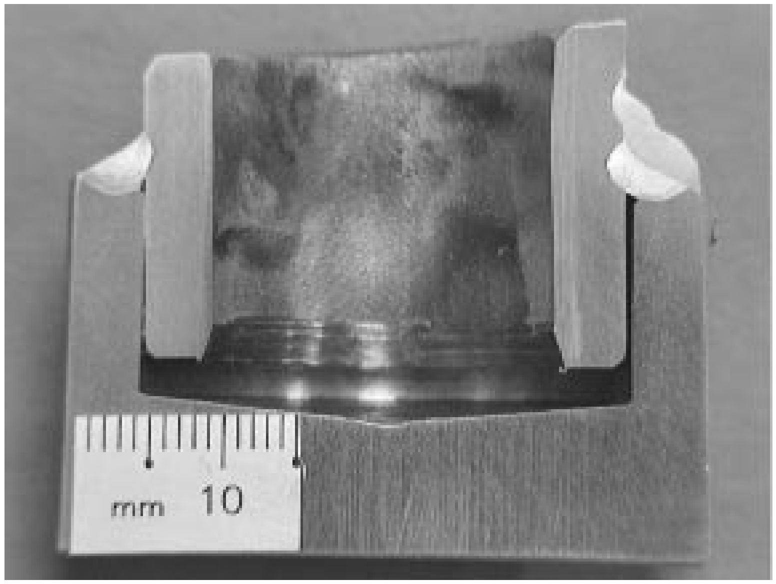

Figure 4-17
Cross-Section of Coupon SSS-2 with Weld Repair (Repair Weld on Right Side of Coupon)

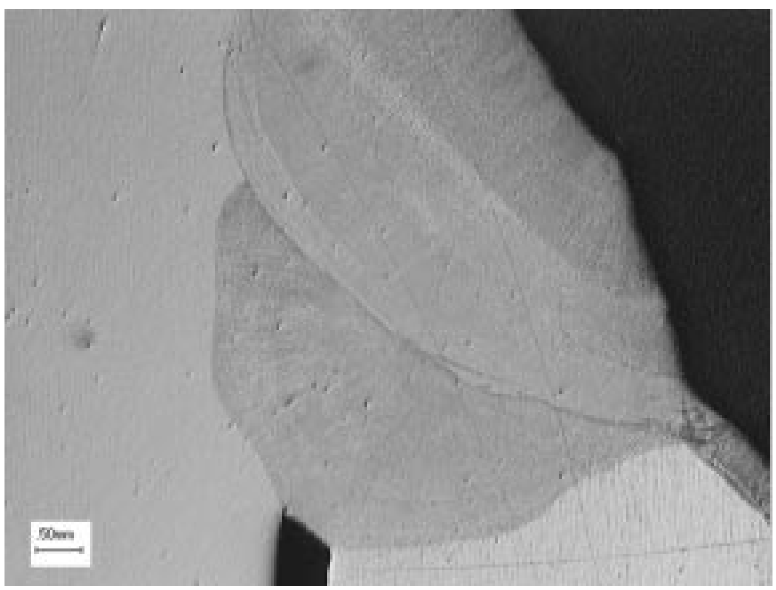

Figure 4-18
Cross-Section of Coupon SSS-2 Showing Repair Weld
(Magnified 10x)

4.4 Stainless Steel Threaded End Cap Mockup Repair Tests SST-1 through SST-4

The goal of the following evaluations was to repair leaking stainless steel threaded end caps by welding under pressure with water flowing. A flaw was placed in the pipe threads either by machining or grinding as described in Section 3.6, and the end caps were threaded tightly onto the pipes. The mockup for each test was assembled according to the steps given in Appendix A. Different combinations of intermittent peening and welding were used in an effort to seal the leaking end caps. The following sections describe the tests that were performed and their results.

4.4.1 Test SST-1

A flaw was placed in the pipe threads of the test coupon by machining (see Section 3.6). The pipe coupon was pressurized to 150 psi. Welding was done using the SMAW process, straight polarity, and a Sandvik E309L-16 electrode. Welding was initiated adjacent to the leak location and continued around the annulus of the pipe, then terminated on the other side of the leak. Another weld bead was started just below the leaking hole, continued around the pipe, and stopped at the same point below the leak. A third bead was started just above the leaking hole, continued around the pipe, and stopped at the same point above the leak. The weld metal was then peened in toward the hole to stop the water leakage. Then, three more beads were welded around the pipe to completely seal the leak (see Figure 4-19).

Figure 4-19
Test Coupon SST-1 after Welding

A cross-section of the weld repair was taken at the point where the water was leaking from the pipe cap (see Figure 4-20). This picture shows small cracks and porosity in the weld repair.

Figure 4-20
Cross-Section of Weld Repair on Coupon SST-1
(Magnified 6.3x)

4.4.1.1 Results/Observations

The water leakage from the threaded pipe cap was stopped, but with much difficulty. Porosity was present in the first three weld beads.

4.4.2 Test SST-2

The weld coupon for this test was prepared by cutting a groove in the pipe threads using a pneumatic grinder (see Section 3.6). The pipe was pressurized to 150 psi, and welding was performed using the FCAW process, reverse polarity, and a 308L wire developed in the RRAC's underwater welding program. Before welding, peening of the leaking threads was attempted, but water continued leaking around the pipe cap. Welding was started adjacent to the leak and continued around the pipe to the opposite side of leak. The resulting weld had a very poor appearance and was full of porosity (see Figure 4-21).

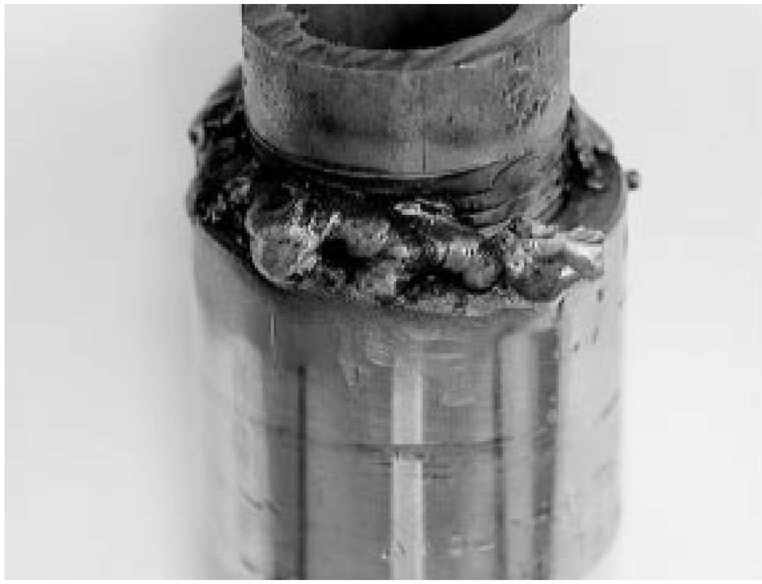

Figure 4-21
Test Coupon SST-2 after Welding

4.4.2.1 Results

Water continued to flow freely from the leaking joint even after welding. The FCAW method of welding the leaking pipe cap was abandoned because the welder had very little control of wire feed speed and penetration.

4.4.3 Test SST-3

The flaw was placed in the pipe threads of this test coupon using a pneumatic grinder as described in Section 3.6. The pipe was pressurized to 80 psi and welding was performed using the GTAW process, straight polarity, and a 3/32" Sandvik 309 filler material. The water pressure was only 50 psi because the water flow from the flawed threads was excessive. Welding was initiated adjacent to the leak location and continued around the annulus of the pipe and ended on the opposite side of the leak. Another weld bead was placed around the pipe just below the leaking hole. A third bead was placed around the pipe just above the leaking hole. The weld metal was then peened in toward the hole to stop the water leakage. Three more weld beads were placed over the previous welds to close the leaking hole.

4.4.3.1 Results/Observations

This welding process was very difficult to implement because of the control needed to weld very closely above and below the leaking hole. It was necessary to stop often and let the pipe cool in order to avoid pressure buildup in the pipe. Even though time was allowed for the pipe to cool, some blow holes and porosity were present in the welds caused by escaping steam. Use of the GTAW process is not recommended for repairing leaking threaded connections because of the difficulty encountered in this test.

4.4.4 Test SST-4

Test SST-4 was performed on a threaded pipe cap coupon with a flaw induced by grinding a groove in the pipe threads. The pipe was pressurized to 100 psi and welding was done using the SMAW process in reverse polarity with a Sandvik E6011 electrode. The objective of this test was to try the E6011 electrode with the "whip" technique, which was successful on carbon steel, to determine the usefulness of this repair method on the stainless steel coupon. Welding was attempted by starting next to the leak and continuing around the pipe. It was immediately determined that the E6011 rod was not compatible with the stainless steel material because of porosity in the weld and the poor appearance of the weld (see Figure 4-22).

Figure 4-22
Cross-Section of Coupon SST-4 after Welding

4.4.4.1 Results

The water leakage was not stopped using this method. This repair method was abandoned because of the poor results obtained and the fact that no stainless steel electrode was available with similar flux-coating characteristics to the E6011 electrode.

4.5 Split-Collar Technique for Sealing Leaking Threaded Pipe Caps

A new technique for sealing the leaking stainless steel threaded pipe caps was developed at the RRAC as an alternative to the peening and welding methods that were attempted. Although this method was developed for the stainless steel coupons, it would work equally well for carbon steel threaded pipe caps. This technique consists of fabricating a split collar (see Figure 4-23) from 304 stainless steel, placing it around the pipe above the leaking threads, and welding the collar to the pipe and pipe cap to make a permanent weld repair.

Figure 4-23
Split Collar

The split collar is made with a threaded hole in one half to allow pressure and steam created by welding temperatures to escape; thereby, preventing blow holes in the weld repair. After welding the collar to the pipe, a pipe plug can be threaded into the leak-off hole and welded to permanently seal the water leakage. A schematic drawing of the split collar placed on a pipe and threaded pipe-cap assembly is shown in Figure 4-24.

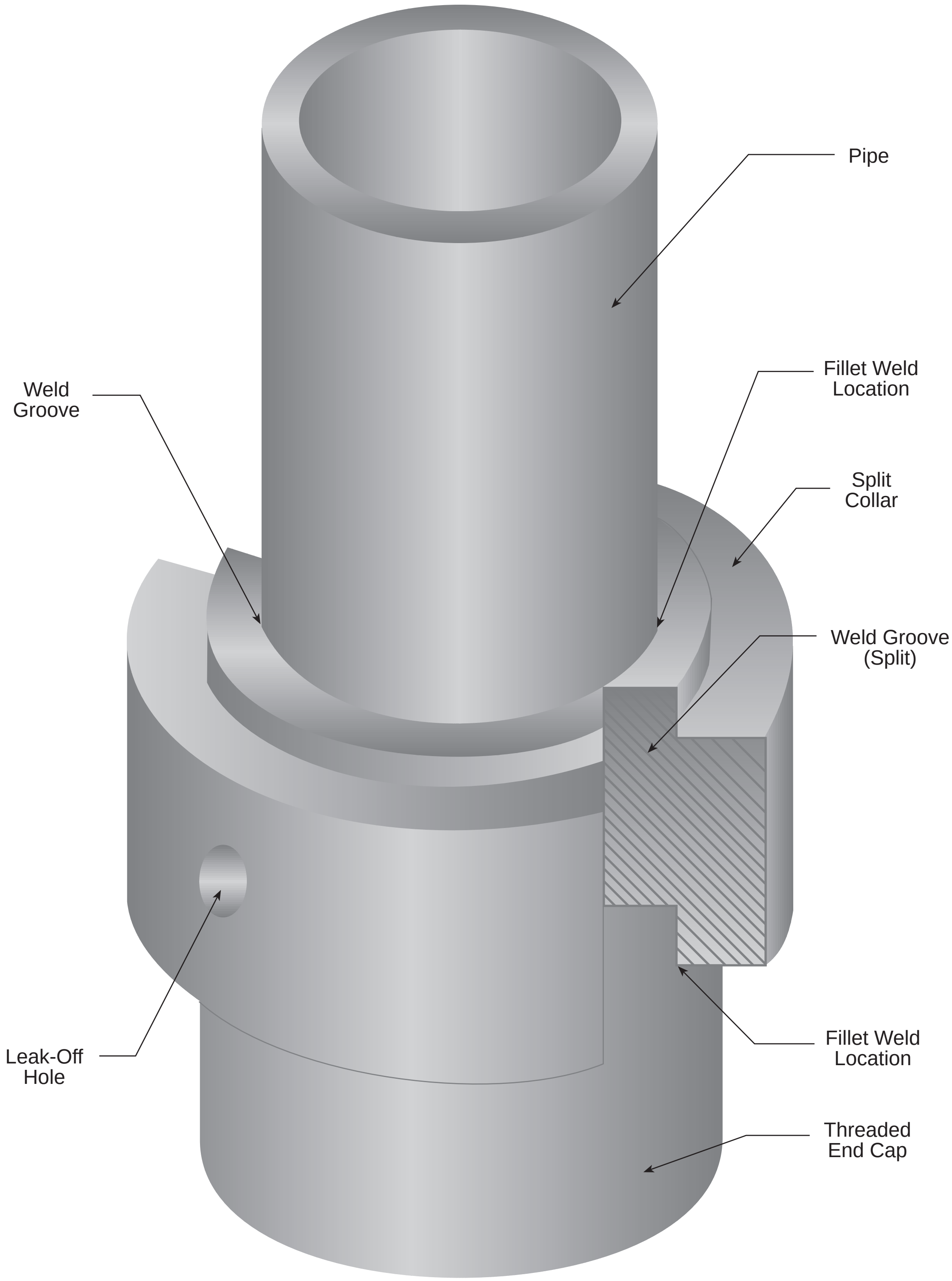

Figure 4-24
Split Collar on Pipe and Pipe-Cap Assembly

Stainless steel threaded pipe cap weld coupons used in testing of the split collar repair method were flawed by grinding a groove in the pipe threads. The weld coupons were pressurized to 150 psi. Welding was performed using both the GTAW process with a Sandvik ER309 filler material and the SMAW process with a Sandvik 309L-16 electrode. The two halves of the split collar (see Figure 4-23) were placed on the pipe as shown in Figure 4-24 and held in place by hand while they were tack welded to the pipe and pipe cap.

The two V-shaped weld grooves on either side of the pipe were welded first. Welding was continued around the lower circumference of the split collar to seal the collar to the pipe cap. Then, the upper circumference of the collar was welded to seal the collar to the pipe. During the weld repair, excess water and steam was allowed to escape through the leak-off hole, thereby preventing porosity and blow holes in the weld. After completing the weld sequence, a pipe plug is threaded into the leak-off hole and welded to provide a permanent repair to the leaking pipe cap. Figures 4-25 and 4-26 show a cross-section and exterior view, respectively, of a stainless steel threaded pipe cap coupon that was repaired using the split-collar technique. Appendix E provides a detailed weld sequence for repairs made using the split-collar technique.

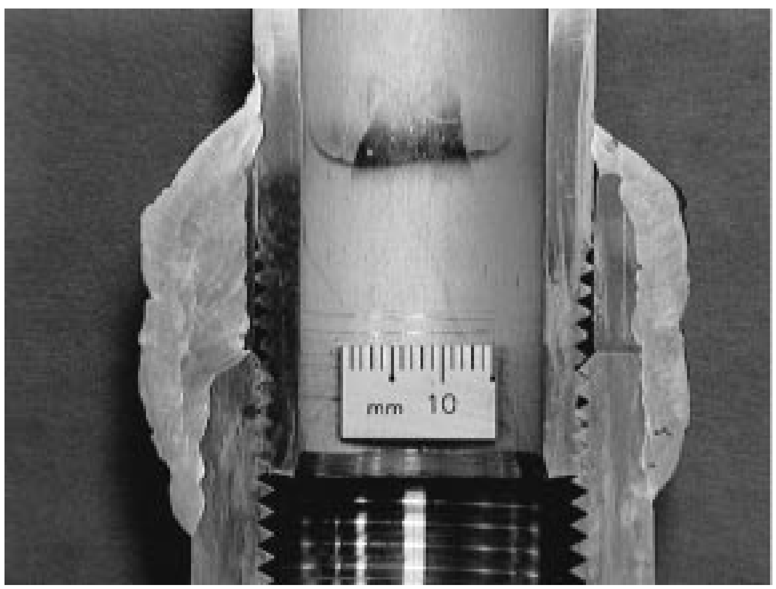

Figure 4-25
Cross-Section of Stainless Steel Threaded Pipe Cap Coupon Repaired Using Split Collar

Figure 4-26
Exterior of Stainless Steel Threaded Pipe Cap Coupon Repaired Using Split Collar

4.6 Mechanical Coupling for Temporary Repairs of Leaking Threaded Pipe Caps

A temporary method for repairing leaking end caps was developed and utilized by Pacific Gas and Electric. This mechanical coupling is applied by placing a graphite packing ring around the annulus of the pipe cap and attaching the temporary coupling to force the graphite into the leaking threads. The coupling is left on the pipe until the next scheduled outage when a permanent repair can be made.

The coupling consists of three separate components, a split flange, an I-flange (referred to as I-flange because of its shape) and a bottom flange. The hole in the center of the split flange is of the same diameter of the pipe being repaired. The hole in the center of the I-flange is of the same diameter of the pipe cap being repaired. Before attaching the coupling, a graphite packing ring is placed around the pipe at the point of the leak (see Figure 4-27).

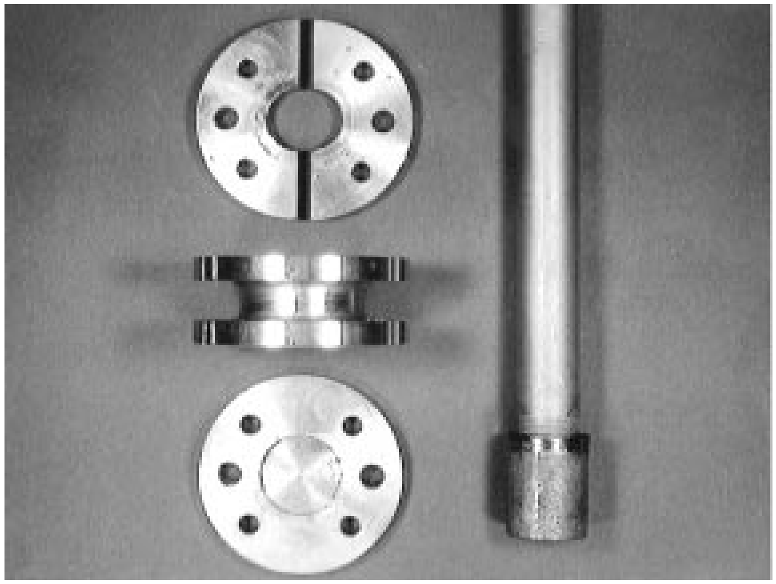

Figure 4-27
Unassembled Mechanical Coupling and Pipe with Threaded End Cap and Graphite Packing Ring

Next, the I-flange is slipped over the pipe cap and packing ring. The split flange is then placed around the pipe and bolted securely to the I-flange. The final step in the repair is to bolt the bottom flange to the I-flange. The four bolts in the bottom flange are first threaded in by hand and then progressively tightened to pull the split flange against the packing ring. This presses the graphite packing into the leaking threads, thereby stopping the leak. The assembled coupling is shown in Figure 4-28. Appendix F gives detailed instructions for assembly and use of this temporary mechanical coupling for stopping leaks in threaded pipe caps.

Figure 4-28
Assembled Coupling Attached to Pipe with Threaded End Cap

5

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this program was to develop and demonstrate socket weld and threaded connection repair techniques that could be used to stop system leaks on-line and under pressure. Although end caps were evaluated for ease of testing, the results obtained apply to unions, elbows, valves, and so on. The ability to perform such repairs while the plant is in operating or start-up mode can provide substantial cost benefits, as plant operators otherwise face the shutdown of a unit because of excess leakage.

Full-scale socket weld and threaded end cap mockups were fabricated from carbon and stainless steel. The socket weld coupons were flawed either by placing a fatigue crack in the weld or by burning an EDM notch through the pipe wall at the toe of the weld. The threaded end cap coupons were flawed by machining or grinding a groove in the pipe threads. The mockups were filled with water and held at constant internal pressure using a hydraulic pump to simulate leakage under service pressure. Mechanical peening was used in almost every test in combination with different welding techniques to seal the leaking end caps. In addition, two new methods of leak sealing were developed: the split-collar technique and a temporary coupling. Successful repairs were hydrostatically tested, then cross-sectioned, polished, etched, and photographed to determine subsurface weld quality.

No single method of leak sealing was found to be adequate for all of the combinations of base materials and end cap types. For the carbon steel and stainless steel socket welded end caps, the leaks were peened shut and then welded using the SMAW process. Both ac and reverse polarities were used and neither polarity seemed to provide any advantage over the other. Placement of the first weld bead was tried slightly below and directly over the flaw location. When the first bead was placed below the flaw, the shrinkage caused by welding re-opened the leak. When the first bead was placed directly on the flaw, the welding arc fused the metal around the flaw and sealed the leak. Based on these results for cracked carbon steel and stainless steel socket welds, it is recommended that the crack be closed by peening and then sealed by welding directly over the crack. Additional passes should be welded over the seal weld to reinforce the repair.

For leaking carbon steel threaded end caps, the recommended welding method is SMAW in reverse polarity with a E6011 electrode using a “whip” technique. This welding technique helped to minimize heat input to the base metal; thereby, preventing steam buildup inside the pipe coupon. Other welding processes that were used overheated the base metal and generated steam within the pipe resulting in porosity in the weld repair.

Because of the configuration of threaded end caps, it is difficult to deform the metal around the leak enough by peening to stop the water flow. For this reason a fillet weld was started beside the leak, continued around the annulus of the pipe, and stopped on the opposite side of the leak. This placed enough metal around the flaw location so that the leak subsequently could be closed by peening and sealed by welding. Additional passes were welded over the seal weld to reinforce the repair.

For leaking stainless steel threaded end caps, several different welding techniques were tried with little success. As with the carbon steel mockups, steam buildup within the stainless pipes caused porosity in the weld repair. The SMAW process using the “whip” technique was tried on the stainless threaded end caps to reduce the heat input to the base metal. It was found that the E6011 electrode used with this technique was not compatible with the stainless material, and no other electrode with similar flux coating characteristics was available. As an alternative to sealing the leak by fillet welding, a split collar was fabricated from stainless steel. The split collar has a threaded hole in one half that allows excess water and steam to escape during welding. After the collar is welded to the pipe and pipe cap, a pipe plug is threaded into the leak-off hole and welded to give a permanent repair. This method of leak sealing was used successfully to seal leaking stainless steel threaded end caps.

A temporary mechanical coupling was obtained from Pacific Gas and Electric that is used to seal leaking carbon steel or stainless steel threaded end caps. This method utilizes a graphite packing ring placed around the pipe above the end cap that is pressed into the leaking threads by the temporary coupling. The coupling is left on the threaded end cap until the next scheduled shutdown when a permanent repair can be made.

Detailed repair procedures are provided in the appendices of this report for making permanent weld repairs on leaking carbon steel and stainless steel socket welds and threaded connections. Procedures are provided for the split-collar repair technique and for the use of the temporary mechanical coupling. Information is also provided for the fabrication of a mockup test stand.

6

REFERENCES

1. *On-Line Seal Welding of Pipe Cracks*. EPRI RRAC. TR-108133.

2. *Valve Body-to-Bonnet Seal Welding Development*. EPRI RRAC. TR-108140.

APPENDIX A
MOCKUP ASSEMBLY

The following steps outline the mockup assembly procedure. Figure A-1 shows the completed mockup. A list of materials is provided in Table A-1.

1. Attach air and water lines to the air-hydraulic pump assembly.

2. Place the weld coupon in the retaining ring on the test stand with the flawed end cap downward.

3. Tighten the set screws in the retaining ring to secure the weld coupon in place.

4. Fill the weld coupon with water.

5. Thread the pipe cap fitted with the high pressure adapter onto the top of the weld coupon.

6. Attach the high pressure hose to the pump and the mockup.

7. Pressurize mockup to approximately 150 psi. Wait for any air trapped in the mockup to be purged through the leaking flaw before beginning the repair sequence.

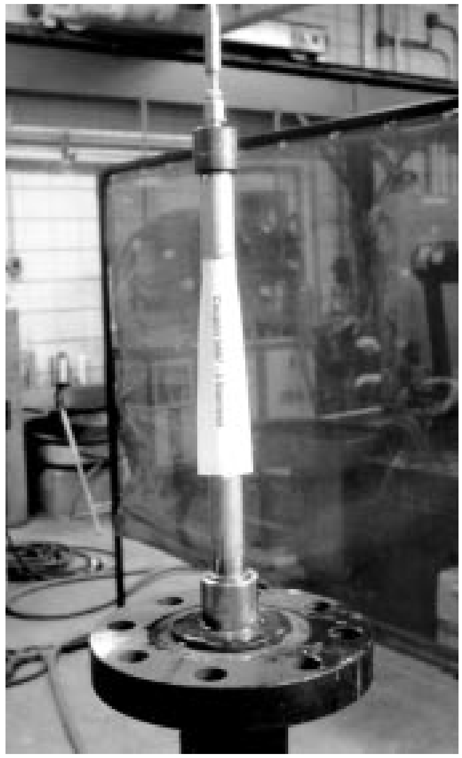

Figure A-1
Completed Setup

Table A-1
List of Materials

Part No.	No. Required	Description	Material
1	1	1/4" NPT x 3/8" High Pressure Adapter, 10,000 psi, AE Part #6M46N6	316 SS
2	1	1" Schedule 80 Carbon Steel Pipe Coupon	A106 Gr B
	1	1" Schedule 80 Stainless Steel Pipe Coupon	A312 Type 304 or 316
3	1	1" Class 3000 Carbon Steel Socket Weld End Cap	A105
	2	1" NPT Class 3000 Carbon Steel Threaded Pipe Cap	A105
	1	1" Class 3000 Stainless Steel Socket Weld End Cap	304L SS
	1	1" NPT Class 3000 Stainless Steel Threaded Pipe Cap	304L SS
4	1	2" Schedule 80 Carbon Steel Retaining Ring	A105
5	2	1C 1/4-20 Cap Screws	A105
6	2	4" Class 900 Blind Flange	A105
7	1	4" Schedule 80 Carbon Steel Pipe, 48" Long	A106, Gr B
8	1	Medium Pressure Hose, Tested to 31,500 psi (min.), with 3/8" Male AE End Fittings, Type SM375CX	316 SS
9	2	Medium Pressure Gland Nut, 20,000 psi AE Part #CGLX 60	316 SS
10	2	Medium Pressure Collar, 20,000 psi AE Part #CCLX 60	316 SS

Note: AE—Autoclave Engineering, 814/838-5700

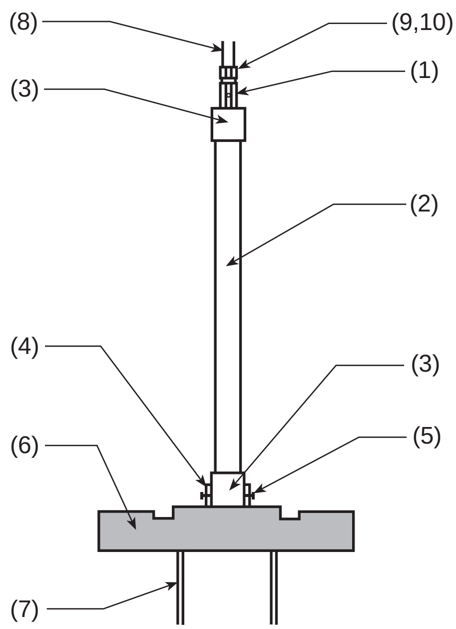

Figure A-2
Mockup Assembly

APPENDIX B
SUPERIOR PNEUMATIC BROCHURE FOR PEENING GUN AND ACCESSORIES

CHISEL DESCRIPTION FOR ALL SUPERIOR HAMMERS

CHISEL NAME	ILLUSTRATION	BANTAM BULLY SERIES 90000	BIG BULLY SERIES 120000	HEAVY DUTY SERIES 60000	HEAVY DUTY SERIES 40000, 70000, 80000, 150000, 240000	TYPICAL USE
Scaling Tool		10100	20100			Rust Scaling, Weld Scaling
Routing Chisel		10300*	20300	30300		Grooving Bearings, Oil Grooving
Flat Chisel		10400, 10500 10700, 12000	20500, 20700 20701*	30500, 30700 30701	40500, 43000 40501	Weld Scaling, Paint Scraping, Removing Brick Mortar, Busting Rivets
Offset Flat Chisel		11700* 11701	21700	30702 31700	42900	Weld Scaling, Paint Scraping, Cutting Motor Windings
Peening Tool		10600 10601	20600	30600		Peening Welds—Sheet Metal
Forming Tool		10800	20800	30800	40800	Forming Sheet Metal
Star Drill		10900* SERIES	20900* SERIES	30900* SERIES	40900* SERIES	Drilling holes in masonry for anchors
Sheet Metal Cutter		11000	21000	31000	41000	Rough cutting sheet metal
Panel Cutter					41001	Smooth cutting of sheet metal, Edging sheet metal
Blank		11100 11200	21100 21200	31100	41100	Forming or machining to desired use by customer
Spoon Face Chisel		11400	21400	31400		Cleaning welds
Gouge		11600	21600	31600		Weld scaling grooves Grooving metal
Paint Scraper		12500 12501	22500 22501	32500	42500	Paint scraping Rust removal
Routing Chisel		12600	22600			Oil grooving Key way cutting
Rivet Buster					42900	Removing and cutting rivets Cutting Bolts
Rivet Sets				34800 34900	44800 44900	Setting rivets—Special sizes available other than listed
Punch					40600	Punching holes in sheet metal
Lockseam Adapter			26000	36000		Bending metal edge, Peening Pittsburgh lock seam on sheet metal ducts, etc.
Coil Cutting					41800*	Cutting winding in electric motors
OSHA Blanks		13500	23400	33300		Blank for OSHA tools for customers alteration

Product of U.S.A.

NOTE: Refer to Price List 100A for chisel length, blade width, shank size and price. If no chisel number is shown under Hammer Model Number, chisel is not available from stock for that particular hammer. Special order chisels, however, can be made for all Superior Hammers. Prices and delivery on request.

*Available while supply lasts

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Recommendations For Safe Use of Percussion Tools

Chippers, Riveters and Scalers

Safety is a primary consideration when operating percussion tools. The following information outlines procedures which should be followed to help ensure the safety of the operators.

When operating percussion tools, always wear:

- Impact–resistant eye protection
- Hearing protection
- Gloves

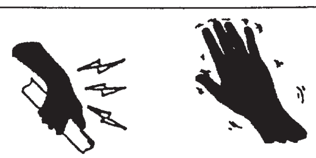
Do not operate a percussion tool unless the chisel, scaling tool, rivet set or other implement is in the tool and in contact with the workpiece or work surface.

The tool should be disconnected from the air supply when it is not in operation to protect from accidental operation. If a quick-disconnect air coupling is used, separate the coupling from the tool with a whip hose. Use a whip hose with fittings of hardened steel or other material which is at least comparably resistant to shock.

Retainers are recommended and furnished as standard equipment. Periodic inspection of the retainer and occasional replacement is recommended since these devices can receive heavy abuse.

Retainers are not required when proper barriers have been erected to protect persons in surrounding or lower areas. When the workpiece itself provides the necessary protection against ejected chisels, rivet sets, scaling tool or other implements, retainers are not required. It is a good safety practice, therefore, to erect suitable safety barriers to protect adjacent work areas and to use chisel retainers when questionable situations exist.

When operating percussion tools in explosive or flammable environments, use only non-sparking chisels or implements.



WARNING: EXPOSURE TO HIGHLY REPETITIVE MOTIONS AND/OR VIBRATION MAY BE HARMFUL.

Some individuals are susceptible to disorders of the hands and arms when exposed to high intensity vibration and/or tasks which involve highly repetitive motions. Those individuals predisposed to vascular or circulatory problems may be particularly susceptible. Cumulative trauma disorders such as carpal tunnel syndrome and tendinitis can be caused or aggravated by repetitious, forceful exertions of the hands and arms. These disorders develop gradually over periods of weeks, months and years. Tasks should be performed in such a manner that the wrists are maintained in a neutral position — not flexed, hyperextended or turned side to side. Stressful postures should be avoided and can be controlled through tool selection and work location. Any person who experiences prolonged symptoms of tingling, numbness, blanching of fingers, clumsiness or weakened grip, inability to hold objects, nocturnal pain in the hand, or who is known to be susceptible to vibration disorders is advised to consult a physician prior to operating any power tool. Tool abuse or poor operating procedures can amplify and contribute to the vibration produced by any percussion tool. Running the tool off the workpiece will not only damage the barrel, but will expose the operator to severe vibration. Worn tool noses and barrels which allow the chisel to cock, or the piston to rock in the bore reduce the power and lengthen the job, exposing the operator to unnecessary vibration. Dull or improperly sharpened chisels act as a spring which also exposes the operator to unnecessary vibration.

The proper selection of the correct type of tool is an important ergonomic consideration. Each application should be carefully considered and the tool chosen that will minimize the stresses on the operator, thus diminishing the onset of cumulative trauma disorders. Some tasks require more than one type of tool to obtain the optimum operator/tool/task relationship.

The following recommendations will help reduce or moderate the effects of extended vibration exposure. The operator of any portable tool is advised to:

- Use a minimum hand grip force consistent with proper control and safe operation.
- Keep body and hands warm and dry.
- Avoid anything that inhibits blood circulation (smoking tobacco, cold temperatures, certain drugs).
- Avoid continuous vibration exposure (exposure to vibration should be interrupted with rest intervals free from vibration)
- Keep wrists as straight as possible.
- Avoid highly repetitive movements of hands and wrists.

Work Gloves

Special work gloves with vibration reducing liners and wrist supports are available from many manufacturers of industrial work gloves. These gloves are designed to reduce and moderate the effects of extended vibration exposure and repetitive wrist trauma. Since they vary widely in design, material, vibration reduction and wrist support qualities, it is recommended that you consult your glove manufacturer for gloves designed for your specific application. Proper fit of gloves is important. Improperly fitted gloves may restrict blood flow to the fingers and can substantially reduce grip strength.

Additional Safety Information

- Refer to other side of this sheet, under *Additional Safety Information*, for publications of Safety Information.
- We **RECOMMEND USER WEAR EYE AND HEARING PROTECTION** when using any power tool.

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APPENDIX C
SUGGESTED PROCEDURE FOR ON-LINE REPAIR OF CARBON STEEL OR STAINLESS STEEL SOCKET WELDED FITTINGS

1.0 Purpose

To provide guidance for on-line application of a repair weld to a leaking carbon steel or stainless steel socket weld.

2.0 Reference

2.1 ASME Boiler and Pressure Vessel Code, Section IX, Current Edition.

2.2 ASME Boiler and Pressure Vessel Code, Section XI, Current Edition.

2.3 Appropriate ASME or B.31.1 Design Section, Current Edition.

3.0 Repair Prerequisites

3.1 Obtain system drawings and material specifications.

3.2 Obtain and review maintenance repair history to see if there have been any changes to the original design.

3.3 Prepare a work instruction to outline the repair sequence.

3.4 Qualify welding procedures and personnel in accordance with Section IX of the ASME B&PV Code.

3.5 Verify that welders are knowledgeable of the repair process and have successfully demonstrated the repair techniques on a mockup.

4.0 Repair Procedure

The socket weld repair should be performed with the SMAW process. The on-line socket seal weld should be applied using the following method:

4.1 Reduce the line pressure to 150 psi maximum.

4.2 Thoroughly clean the area to be welded.

4.3 Close the leaking crack by peening.

4.4 Dry the area with a torch.

4.5 Seal the crack using the SMAW process by welding directly over the peened area.

4.6 Peen closed any new or remaining leaks in the weld, dry with a torch, and re-weld.

4.7 Weld three additional passes over the seal weld to reinforce the repair.

4.8 Examine the completed weld by visual (VT) and liquid penetrant (PT) in accordance with specified requirements.

5.0 Welding Recommendations

5.1 SMAW

- Recommended covered electrode material specifications for stainless steel applications include: ASME SFA-5.4; E308L, E316L, or E309L.
- Recommended covered electrode material specifications for carbon steel applications include: ASME SFA-5.1; E7018, E6010, E6011, or E6013 covered electrodes.
- Avoid long arcing.

6.0 Peening Recommendations

- Peening should be performed on the metal immediately around the crack to deform the metal in towards the crack. Then, peen directly on the crack's center line until the water flow is stopped.
- Custom grinding of the peening chisel may be necessary where access is limited. Do not use sharp-cutting chisels. (Additional chisel tool configurations are shown in Appendix B.)

APPENDIX D
SUGGESTED PROCEDURE FOR ON-LINE REPAIR OF CARBON STEEL THREADED FITTINGS

1.0 Purpose

To provide guidance for on-line application of a repair weld to a leaking carbon steel threaded fitting.

2.0 Reference

2.1 ASME Boiler and Pressure Vessel Code, Section IX, Current Edition.

2.2 ASME Boiler and Pressure Vessel Code, Section XI, Current Edition.

2.3 Appropriate ASME or B.31.1 Design Section, Current Edition.

3.0 Repair Prerequisites

3.1 Obtain system drawings and material specifications.

3.2 Obtain and review maintenance repair history to see if there have been any changes to the original design.

3.3 Prepare a work instruction to outline the repair sequence.

3.4 Qualify welding procedures and personnel in accordance with Section IX of the ASME B&PV Code.

3.5 Verify that welders are knowledgeable of the repair process and have successfully demonstrated the repair techniques on a mockup.

4.0 Repair Procedure

The threaded fitting repair should be performed with the SMAW process. The on-line threaded fitting repair weld should be applied using the following method:

4.1 Reduce the line pressure to 150 psi maximum.

4.2 Grind off all exposed threads to eliminate stress risers and crack initiation points.

4.3 Thoroughly clean the area to be welded.

4.4 Weld using the SMAW process with a whip technique (described in Section 4.2.5) starting at a point adjacent to the leak location. Continue the weld around the circumference of the pipe and stop on the opposite side of the leak (see Figure D-1).

4.5 Peen the deposited weld metal towards the leak until all leakage is stopped.

4.6 Seal the crack by welding directly over the peened area.

4.7 Peen closed any new or remaining leaks in the weld, dry with a torch, and re-weld.

4.8 Weld three additional passes over the seal weld to reinforce the repair.

4.9 Examine the completed weld by visual (VT) and liquid penetrant (PT) in accordance with specified requirements.

5.0 Welding Recommendations

5.1 SMAW

- Recommended covered electrode material specifications for initial seal welding of carbon steel threaded fittings are ASME SFA-5.1 E6010 and E6011.
- Recommended covered electrode material specifications for cover pass welding of carbon steel threaded fittings include: ASME SFA-5.1; E7018, E6010, E6011, or E6013 covered electrodes.
- Use “whip” technique to minimize heat input to base material.

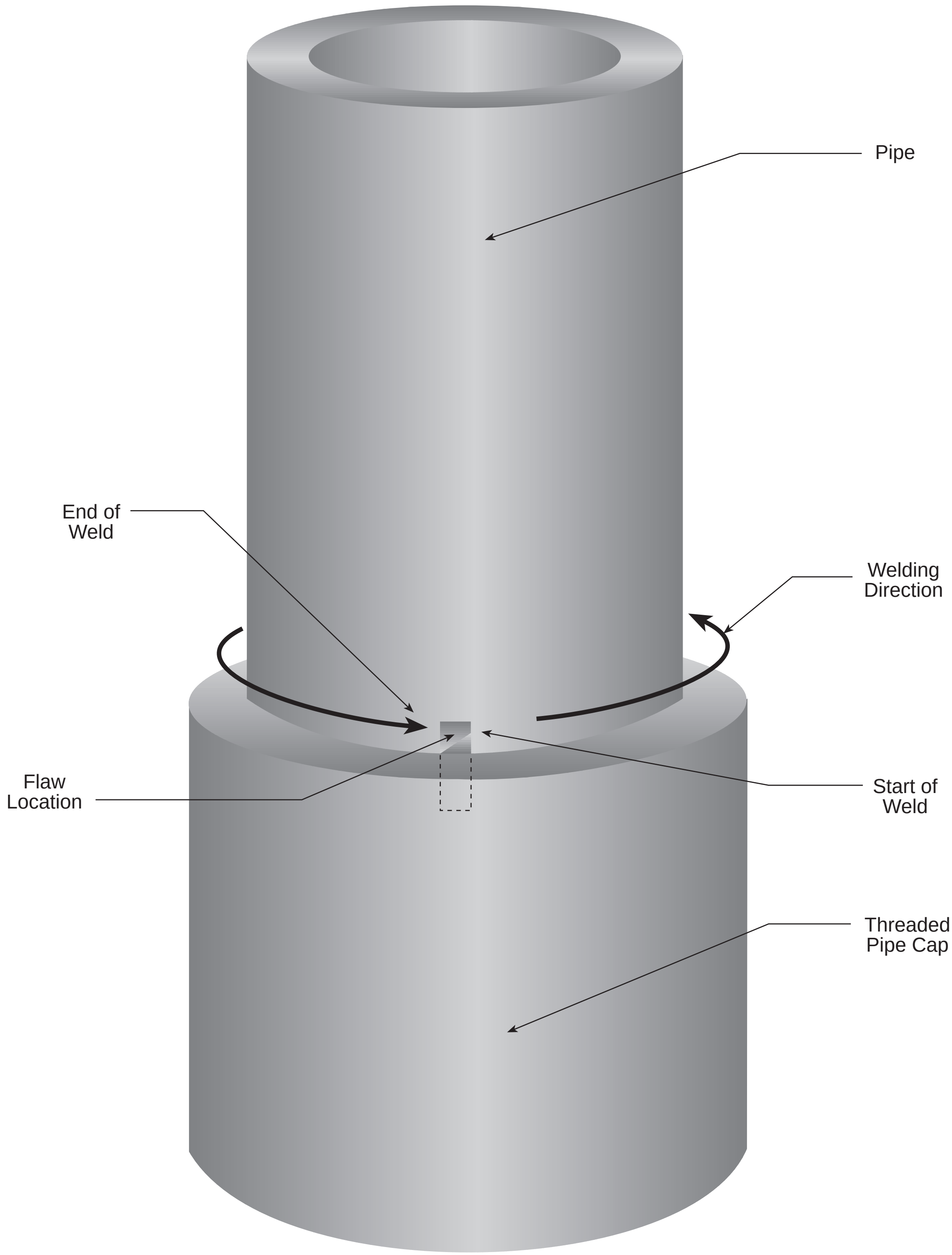

Figure D-1
Weld Placement for Threaded Fitting Repair

APPENDIX E
WELDING PROCEDURE FOR SPLIT COLLAR LEAK SEALING METHOD

1.0 Purpose

To provide guidance for on-line application of a repair weld to leaking stainless steel threaded fittings using a stainless steel split collar. (This method can also be applied to carbon steel fittings.)

2.0 Reference

2.1 ASME Boiler and Pressure Vessel Code, Section IX, Current Edition.

2.2 ASME Boiler and Pressure Vessel Code, Section XI, Current Edition.

2.3 Appropriate ASME or B.31.1 Design Section, Current Edition.

3.0 Repair Prerequisites

3.1 Obtain system drawings and material specifications.

3.2 Obtain and review maintenance repair history to see if there have been any changes to the original design.

3.3 Procure or fabricate split collar.

3.4 Prepare a work instruction sheet to outline the repair sequence.

3.5 Qualify welding procedures and personnel in accordance with Section IX of the ASME B&PV Code.

3.6 Verify that welders are knowledgeable of the repair process and have successfully demonstrated the repair technique on a mockup.

4.0 Repair Procedure

The threaded fitting repair can be performed with the SMAW or GTAW process. (SMAW is recommended.) The on-line threaded fitting repair weld should be applied using the following method:

4.1 Reduce the line pressure to 150 psi maximum.

4.2 Grind off any threads that might come in contact with the welding operation.

4.3 Thoroughly clean the area to be welded.

4.4 Place the split collar over the pipe and threaded fitting as shown in Figure 4-24 and either clamp in place or hold in place by hand. Extreme care should be taken to ensure that the leak-off hole is directed away from equipment and personnel during welding to prevent damage or injury from spraying steam.

4.5 Tack weld the two halves of the collar to the pipe and pipe cap.

4.6 Weld the V-grooves on either side of the collar, alternating grooves for each pass in order to balance shrinkage.

4.7 Weld root pass around the lower circumference of the collar.

4.8 Weld root pass around the upper circumference of the collar.

4.9 Complete welding on the upper and lower circumferences alternating from one to the other for each pass.

4.10 Thread a pipe plug into the leak-off hole and weld to permanently seal the split collar repair.

4.11 Examine the completed weld by visual (VT) and liquid penetrant (PT) in accordance with specified requirements.

5.0 Welding Recommendations

5.1 SMAW

- Recommended covered electrode material specifications for stainless steel applications include: ASME SFA-5.4; E308L, E316L, or E309L.
- Avoid long arcing.

5.2 GTAW

- Recommended filler material specifications for stainless steel applications include: ASME SFA-5.9; ER308L, ER316L, or ER309L.

APPENDIX F
INSTALLATION PROCEDURE FOR TEMPORARY THREADED END CAP COUPLING

1.0 Purpose

To provide guidance for on-line application of a temporary coupling to repair leaking carbon steel and stainless steel threaded end caps.

2.0 Reference

2.1 ASME Boiler and Pressure Vessel Code, Section XI, Current Edition.

2.2 Appropriate ASME or B.31.1 Design Section, Current Edition.

3.0 Repair Prerequisites

3.1 Obtain system drawings and material specifications.

3.2 Obtain and review maintenance repair history to see if there have been any changes to the original design.

3.3 Procure or fabricate temporary coupling.

3.4 Prepare a work instruction to outline the repair sequence.

3.5 Verify that personnel are knowledgeable of the repair process and have successfully demonstrated the coupling application on a repair mockup.

4.0 Repair Procedure

The on-line threaded end cap repair temporary coupling should be applied using the following method (Refer to Figure F-1 for steps 4.4 through 4.6):

4.1 Reduce the line pressure to 150 psi maximum.

4.2 Thoroughly clean the area to be repaired.

4.3 Place a graphite packing ring around the pipe against the threaded fitting.

4.4 Slide the I-flange over the end cap.

4.5 Place the two halves of the split flange around the pipe and bolt securely to the I-flange.

4.6 Place the bottom flange beneath the I-flange in contact with the bottom of the end cap. Place the bolts through the bottom flange and thread the bolts into the I-flange by hand. The space between the bottom flange and the middle flange should be equal around the circumference of the coupling.

4.7 Using a wrench, each bolt should be tightened one full turn following the pattern shown in Figure F-2. Care should be taken to tighten each bolt the same amount in order to keep the faces of the middle and bottom flanges parallel.

4.8 Continue tightening each bolt one full turn following the given pattern until the leakage from the pipe threads is completely stopped.

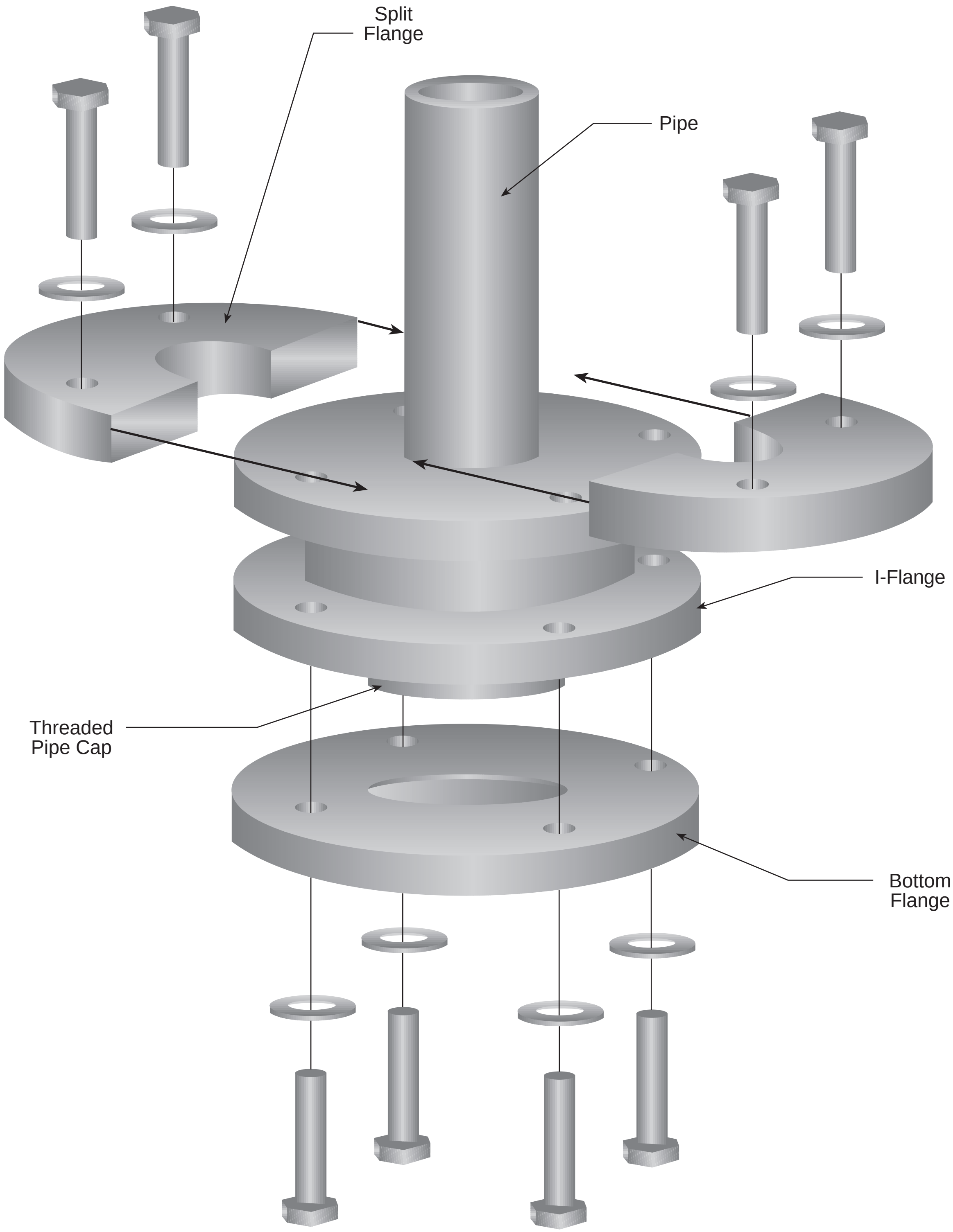

Figure F-1
Assembly Drawing for Temporary Coupling

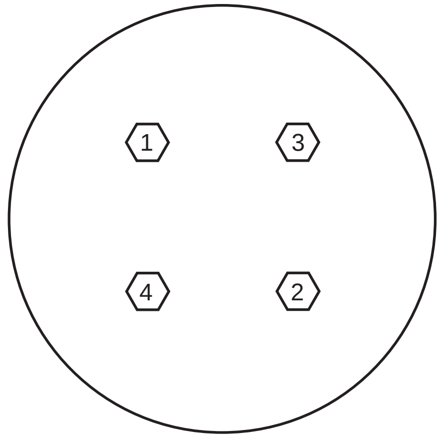

Figure F-2
Sequence for Tightening Bottom Flange Bolts

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