

		REPAIR OF STEEL PIPELINE DEFECTS	A-65
Department: Gas System Technical Support	Section: Gas System Standards Management		
Approved by: D. W. Anderson	Approved by: S. Y. Chwistek	Date: 06-04-98	
Rev. #01: This document replaces Revision #00. For a description of the changes, see Page 10.			

Purpose and Scope

This gas standard specifies the requirements for repairing steel pipelines.

General

1. The following criteria are established.
 - A. Maximum hoop stress permitted during welding.
 - B. Allowable methods of repair for welded steel pipelines.
 - C. Work procedures and design requirements for allowable repair methods.
 - D. Welding procedure on pipelines under pressure.
 - E. Cathodic protection requirements for leak repairs.
 - F. It is not the intent of this gas standard to preclude the use of repair methods other than welding (e.g., mechanical clamps) when these other methods are more appropriate (such as anticipated early retirement of the main). However, alternate action must comply with 49 CFR, Part 192.
 - G. This gas standard specifies repairs based on the maximum allowable operating pressure (MAOP) and the percent of specified minimum yield strength (SMYS). The pipeline's ability to operate at pressures above the MAOP may be limited by some repairs. Accordingly, use a repair method qualified for the future design pressure (FDP) when the FDP is greater than the MAOP (making future upgrades or uprating possible) and removal of the repaired section will not be practical or likely.

Maximum Hoop Stress Permitted During Welding

2. Before welding a pipeline under pressure, make an evaluation to determine if the operating pressure needs to be lowered so that the hoop stress will be at or below the level specified by this gas standard. The maximum operating pressure permitted during welding is the least pressure provided in Paragraphs 2.A., 2.B., 2.C., and 2.D.

The maximum pressures are also shown on the pipeline survey sheets. Where the condition of the pipe is found to be poor, or where other conditions exist which could cause problems while welding, it may be necessary to lower the operating pressure. This lower pressure should be determined based on an evaluation of the observed condition of the pipe and good engineering judgement.

- A. For seamless and double-submerged arc welded pipe, the maximum pressure permitted during welding shall be determined using the formula given below, the MAOP, or a pressure which will produce a hoop stress of 50% of the SMYS, whichever is lowest:

$$P = \frac{2S(t - 0.094 \text{ in.})(0.72)}{D}$$

P = Internal Pressure, psig
 S = Specified Minimum Yield Strength, psi
 t = Nominal Pipe Wall Thickness, inches

Repair of Steel Pipeline Defects

D = Outside Pipe Diameter, inches

For all other pipe, the maximum pressure permitted during welding shall be determined by the formula given above or the MAOP, or a pressure which will produce a hoop stress of 40% of the SMYS, whichever is lowest.

- B. The maximum hoop stress permitted during welding shall not exceed 20% of the SMYS when:
1. Welding within 3" of the longitudinal seam, the circumferential, and any branch weld on any type of pipe (except the longitudinal seam of double-submerged arc welded pipe).
 2. Welding within 3" of any defect (gouges, corrosion, laminations, etc.) in the pipe which exceeds 1/3 of the nominal wall thickness in depth and/or 1/4 of the nominal pipe diameter in length. Any number of closely spaced adjacent defects shall be treated as one defect of a size and depth encompassing all the defects.
 3. More than one weld repair is required in any length equal to five pipe diameters or 5', whichever is less.
- C. When preheating to temperatures less than 450°F, the maximum hoop stress permitted shall not exceed 50% of the SMYS for seamless and double-submerged arc welded pipe, or 40% of the SMYS for all other types of pipe.
- D. Preheating above 450°F, or high temperature stress relieving, is not permitted on pipelines under pressure. The yield point and fracture sensitivity of non-expanded high strength pipe are adversely affected when it is heated above 600°F unless it is heated and cooled under controlled conditions. The yield point of expanded pipe is permanently lowered by approximately 20% when it is heated above this temperature.

Extent of Defects and Methods of Repair

3. Repairs are required when the extent of defect exceeds that allowed by the appropriate repair selection table (Table 1, Table 2 or Table 3) shown on Pages 4 through 10. For corrosion, a qualified engineer may determine the MAOP of the pipe and the allowable extent of defects using ASME B31G guidelines or other fitness for purpose methods approved by the Gas System Maintenance (GSM) Pipeline Engineering section.
4. Only those methods of repair recommended in this gas standard are approved as permanent repairs to welded steel mains. When a repair cannot be made in conformance with the conditions of this gas standard, the section of defective pipe shall be replaced with a good piece of pipe. The most appropriate method of repair permitted shall be selected from the proper appropriate Repair Selection Table and the repair completed in conformance with the work procedures established in Paragraph 2. as well as in Paragraphs 5. through 16.

Work Procedures and Design Requirements

5. Grinding

When grinding to eliminate a defect, take care to remove the entire defect. Ensure that the pipe is smoothly contoured after grinding. This helps to eliminate all possible points of stress concentration.

6. Grinding and Fill Welding

When grinding and fill welding, the repair area must be ground clean. The fill weld metal shall penetrate the base material. The surface of the finished repair weld shall be ground smooth to the contour of the pipe on all lines operating over 100 psig.

7. Patching

Patches shall be designed, installed and tested according to Gas Standard A-64.

8. Sleeving

Sleeving shall be designed and tested according to either Gas Standard A-60 or Gas Standard A-61.

9. Mueller Save-A-Valve Nipple

The Mueller Save-A-Valve nipple may be used to repair an individual corrosion pit (either leaking or nonleaking) where the diameter of the pit at the surface of the pipe is less than the inside diameter of the nipple. The weld shall be visually inspected. See the Repair Selection Tables for pressure-stress level limitations when using the Mueller Save-A-Valve nipple.

Repair of Steel Pipeline Defects

10. Canning

Gas main repair cans may be used for repairs on pipelines with a design pressure which produces a hoop stress of less than 20% SMYS and not exceeding 400 psi. Cans shall be designed and tested according to Gas Standard A-63.

11. Replace Segment of Pipe

Take the segment to be replaced out of service. Remove the damaged portion of pipe by cutting out a cylindrical piece of pipe. Replace it with pipe of equal or greater design strength and equal or greater wall thickness. Testing shall be performed as described in Gas Standards A-34 and D-33.

12. Dents (Pipe Distortion)

A. Distortion or denting may be defined as a depression which produces a gross disturbance in the curvature of the pipe wall (as opposed to a scratch or gouge which reduces the pipe wall thickness). The depth of a dent shall be measured as the gap between the lowest point of the dent and prolongation of the original contour of the pipe in any direction.

1. All dents which affect the curvature of the pipe at the longitudinal or any circumferential weld shall be removed on mains operating at greater than 100 psi. Dents at welds in mains operating below 100 psi shall be treated the same as a dent which does not affect a weld.
2. The percent of distortion shall be defined as the ratio of the depth of the dent to the actual diameter of the pipe times 100. Distortion exceeding the limitations in the repair selection tables shall be removed.

Welding Procedure on Pipelines Under Pressure

13. Procedures for arc welding and preheating pipes while under pressure shall be performed as specified in Gas Standard D-22. Arc welding is the preferred method of repair. For small, lower-pressure lines where arc welding is not convenient or the equipment is not readily available, oxyacetylene welding may be used wherever it is allowed under Gas Standard D-20.

A. When the surface temperature of the pipe is less than 50°F, the pipeline flow should be made static and the pipe preheated and welded as described in Gas Standard D-22.

1. When the surface temperature of the pipe is less than 50°F, and the pipeline flow cannot be made static, welders shall use low hydrogen electrode equipment as specified in Gas Standard D-22.
2. Before welding, workers shall ensure that there are no liquids in the segment of the pipeline to be welded. Install drains as described in Gas Standard A-32 or Gas Standard A-32.1, and check existing drains for liquids.

14. All welding shall be performed according to an approved PG&E welding procedure. Low hydrogen electrodes or gas metal arc welding shall be used if the line flow cannot be made static. If line flow can be made static and welding is to be done using cellulose electrodes, the pipe at the weld location must be preheated according to Gas Standard D-22.

15. Instructions for Field Application

It is recommended that each local area tabulate the maximum operating pressure permitted during the various welding operations for each transmission line or principal distribution main within the local area. The tabulations should include a description of the extent of the defect, permissible methods of repair, and actual dimensions or other limitations on the method of repair. The tabulation should be designed to facilitate routine application of this gas standard under emergency field conditions by repair personnel.

Cathodic Protection Requirements for Leak Repairs

16. Install one 9 pound magnesium anode or one 5 pound zinc anode on each corrosion leak repair unless adequate pipe-to-soil potential is measured at the leak location.

Repair of Steel Pipeline Defects

Table 1 Repair Selection Table for Mains with a MAOP of 100 psig or Less ¹

Mechanical Damage: Notches, Scratches, Gouges, Grooves and Dents		
Extent of Defect	Permissible Methods of Repair	Limitations on Methods
Dent - less than 10% distortion (1/2" for 4-1/2" OD and smaller).	No Repair Required	No notches, scratches, gouges or grooves in dent.
Dent - more than 10% distortion (1/2" for 4-1/2" OD or smaller).	Sleeving or Canning	Dent must not prevent proper fit up.
	Replace Segment of Pipe	Entire affected section must be removed.
Notch, scratch, gouge, groove - less than 50% of pipe wall thickness.	Grinding	Less than 10% distortion or dent (1/2" for 4-1/2" OD and smaller). Pipe wall not to be reduced to less than 50% of original nominal wall thickness.
Notch, scratch, gouge, groove - more than 50% of pipe wall thickness.	Grinding & Welding	Less than 10% distortion or dent (1/2" for 4-1/2" OD and smaller). Repair not to exceed 1/4 circumference of pipe nor 5" square. Not more than one repair per foot of pipe length.
	Patching	Less than 10% distortion or dent (1/2" for 4-1/2" OD or smaller). Patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Sleeving or Canning	Dent must not prevent proper fit up.
	Replace Segment of Pipe	Entire affected section must be removed.
Corrosion Damage		
Depth less than 50% of pipe wall thickness.	No Repair Required	Limitations on Methods
Depth over 50% of pipe wall thickness but less than 80% - no leakage (or as determined by a qualified engineer per Paragraph 3. on Page 2).	Grinding and Welding	Repair not to exceed 1/4 circumference of pipe nor 5" square. Not more than one repair per foot of pipe length.
	Patching	Patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Sleeving or Canning	No limitations.
	Mueller Save-A-Valve Nipple	2" maximum size.
	Leak Clamps	See Gas Standards B-53 and B-53.1.
Depth 80% of pipe wall thickness or more including leaking corrosion pits.	Patching	Patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Sleeving or Canning	No limitations.
	Mueller Save-A-Valve Nipple	2" maximum size.
	Leak Clamps	See Gas Standards B-53 and B-53.1.
	Leak Repair Tapes	Limited to low-pressure (<14" W.C.) application, where other repairs are not feasible and subject to the conditions in Gas Standard A-68.
	Replace Segment of Pipe	Entire affected section must be removed.

¹ See Footnote 1 on Page 5 for repair procedures. Also, FDP may be limited. See Note 1.G. on Page 1.

Repair of Steel Pipeline Defects

Table 1 Repair Selection Table for Mains with a MAOP of 100 psig or Less¹ (continued)

Leaks in Weld		
Extent of Defect	Permissible Methods of Repair	Limitations on Methods
All	Patching	Existing facilities only – patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Sleeving or Canning	Existing facilities only.
	Mueller Save-A-Valve Nipple	2" maximum size – existing facilities only.
	Clamp	See Gas Standards B-53 and B-53.1.
	Leak Repair Tape	Limited to low-pressure (<14" W.C.) application, where other repairs are not feasible and subject to the conditions in Gas Standard A-68.
Nonleaking Cracks or Defects in Welds		
Any longitudinal weld crack greater than 2" long, a branch or circumferential weld crack that is more than 8% of weld length, or a crack that penetrates either the root or second bead.	Replace Segment of Pipe	Entire section affected must be removed. If not feasible to take main out of service, install sleeve.
Any longitudinal weld crack less than or equal to 2" long, a branch or circumferential weld crack less than or equal to 8% of weld length, or other defects.	Grinding or Fill Welding	If crack penetrates either the root or second bead, replace pipe segment.
	Patching, Sleeving or Canning	Limitations for patches – patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Replace Segment of Pipe	Entire affected section must be removed.
Leaks in Body of Fitting or in Clamps		
All	Canning	Existing Facilities Only
	Replace Fitting or Clamp	No Limitations

¹ For repair procedures, see Paragraphs 5. through 12. of this gas standard and the following applicable Gas Standards:
 A-60, A-61 Sleeving
 A-62 Mueller Nipple, Leak Patch
 A-63 Canning
 A-64 Patching
 A-68 Leak Repair Tapes
 B-53, B-53.1 Leak Repair Clamps
 D-22 Arc Welding
 Also, FDP may be limited. See Note 1.G. on Page 1.

Repair of Steel Pipeline Defects

Table 2 Repair Selection Table for Mains with a MAOP Greater than 100 psig but Less than 20% of the SMYS and 500 psig ¹

Mechanical Damage: Notches, Scratches, Gouges, Grooves and Dents		
Extent of Defect	Permissible Methods of Repair	Limitations on Methods
Dent – less than 5% distortion (3/8" for 6-5/8" OD and smaller).	No Repair Required	No notches, scratches, gouges or grooves in dent. No welds affected.
Dent – more than 5% distortion (3/8" for 6-5/8" OD or smaller).	Sleeving or Canning	Dent must not prevent proper fit up. Cans not to be used on main with MAOP over 400 psig.
	Replace Segment of Pipe	Entire affected section must be removed.
Notch, scratch, gouge, groove – depth less than 10% of pipe wall thickness.	Grinding	Pipe wall not to be reduced to less than 90% of nominal pipe wall thickness. Dent or distortion less than 5% of OD.
Notch, scratch, gouge, groove – depth between 10% and 30% of pipe wall thickness.	Grinding and Welding	Dent or distortion less than 5% of OD (3/8" for 6-5/8" OD and smaller). Repair not to exceed 1/4 of pipe circumference nor 4" square. Not more than one repair per 5 pipe diameters of length.
	Patching	Dent or distortion less than 5% of OD (3/8" for 6-5/8" OD and smaller). Repair not to exceed 1/2 of pipe circumference. Length not over 10 pipe diameters on pipe over 8-5/8" OD. A minimum of 3" clearance between patches.
	Sleeving or Canning	Dent must not prevent proper fit up. Cans not to be used on mains with MAOP over 400 psig.
Notch, scratch, gouge, groove – depth less than 30% of pipe wall thickness.	Patching	Patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Sleeving or Canning	Dent must not prevent proper fit up. Cans not to be used on main with MAOP over 400 psig.
	Replace Segment of Pipe	Entire affected section must be removed.

¹ See Footnote 1 on Page 8 for repair procedures. Also, FDP may be limited, see Note 1.G. on Page 1.

Repair of Steel Pipeline Defects

Table 2 Repair Selection Table for Mains with a MAOP Greater than 100 psig but Less than 20% of the SMYS and 500 psig (continued) ¹

Corrosion Damage		
Extent of Defect	Permissible Methods of Repair	Limitations on Methods
Depth less than 20% of pipe wall thickness.	No Repair Required	Limitations on Methods
Depth between 20% and 30% of pipe wall thickness (or as determined by a qualified engineer per Paragraph 2.A.).	Grinding and Welding	Repair not to exceed 1/4 circumference of pipe nor 4 square inches. Not more than one repair per 5 pipe diameters of length.
	Patching	Patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Sleeving	No limitations.
Depth over 30% of pipe wall thickness but less than 80% - no leakage (or as determined by a qualified engineer per Paragraph 2.A.).	Patching	Patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
Depth over 30% of pipe wall thickness but less than 80% - no leakage. (or as determined by a qualified engineer per Paragraph 2.A.).	Sleeving	No limitations.
	Mueller Save-A-Valve Nipple	2" maximum size.
Depth 80% of pipe wall thickness or more (including leaking corrosion pits).	Patching	Patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Sleeving	No limitations.
	Mueller Save-A-Valve Nipple	2" maximum size.
	Replace Segment of Pipe	Entire affected section must be removed.
Leaks in Weld		
All	Patching	Existing facilities only – patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches.
	Sleeving or Canning	Existing facilities only. Cans not to be used on mains with MAOP over 400 psig.
	Mueller Save-A-Valve Nipple	2" maximum size – existing facilities only.

¹ See Footnote 1 on Page 8 for repair procedures. Also, FDP may be limited. See Note 1.G. on Page 1.

Repair of Steel Pipeline Defects

Table 2 Repair Selection Table for Mains with a MAOP Greater than 100 psig but Less than 20% of the SMYS and 500 psig (continued) ¹

Nonleaking Cracks or Defects in Welds		
Extent of Defect	Permissible Methods of Repair	Limitations on Methods
Any longitudinal weld crack greater than 2" long, a branch or circumferential weld crack that is more than 8% of weld length, or a crack that penetrates either the root or second bead.	Replace Segment of Pipe	Entire affected section must be removed. If not feasible to take main out of service, install sleeve.
Any longitudinal weld crack less than or equal to 2" long, a branch or circumferential weld crack less than or equal to 8% of weld length, or other defects.	Grinding and Fill Welding	If crack penetrates either the root or second bead, replace pipe segment.
	Patching, Sleeving or Canning	Patch not to exceed 1/2 pipe circumference. On pipe over 8-5/8" OD, length not over 10 pipe diameters. A minimum of 3" clearance between patches. Cans not to be used on mains with MAOP over 400 psig.
	Replace Segment of Pipe	Entire affected section must be removed.
Leaks in Body of Fittings or in Clamps		
All	Canning	Existing facilities only. Not to be used on mains with MAOP over 400 psig.
	Replace Fitting or Clamp	No limitations.

¹ For repair procedures see Paragraphs 5. through 12. of this gas standard and the following applicable Gas Standards:
 A-60, A-61 Sleeving
 A-62 Mueller Nipple, Leak Patch
 A-63 Canning
 A-64 Patching
 Also, FDP may be limited. See Note 1.G., Page 1.

Repair of Steel Pipeline Defects

Table 3 Repair Selection Table for Lines with a MAOP of 20% or More of the SMYS, or 500 psi or Greater ¹

Mechanical Damage; Notches, Scratches, Gouges, Grooves and Dents		
Extent of Defect	Permissible Methods of Repair	Limitations on Methods
Dent – less than 2% distortion (1/4" for OD less than 12.750").	No Repair Required	No notches, scratches, gouges or grooves in dent. No welds affected by dent.
Dent – more than 2% distortion (1/4" for OD less than 12.750").	Sleeving	Dent must not prevent proper fit up. If dent affects a weld, entire affected section must be removed.
	Replace Segment of Pipe	Entire affected section must be removed.
Notch, scratch, gouge, groove – depth less than 10% of pipe wall thickness and less than 8% of pipe wall thickness for welded pipe 20" OD or larger.	Grinding	Pipe wall not to be reduced to less than 90% of nominal wall thickness (92% on welded pipe 20" OD or larger). Dent or distortion less than 2% of OD (1/4" for OD less than 12.750").
Notch, scratch, gouge, groove – depth 10% or more of pipe wall thickness. Design pressure less than 40% SMYS.	Sleeving	Dent or distortion must not prevent proper fit up.
Notch, scratch, gouge, groove – depth 10% or more of pipe wall thickness. Design pressure 40% SMYS or more (8% or more for welded pipe 20" or larger).	Replace Segment of Pipe	Entire affected section must be removed. If not feasible to take main out of service, repair with sleeve. Dent must not prevent proper fit up. If dent affects a weld, entire affected section must be removed.
Corrosion Damage		
Depth 10% or less of pipe wall thickness. ²	No Repair Required	Limitations on Methods
Depth over 10% of pipe wall thickness but less than 80% - no leakage (or as determined by a qualified engineer per Paragraph 3.A).	Patching	Pipe of not more than 40,000 psi SMYS. Length or width of patch not to exceed 1/2 pipe circumference. A minimum of 3" clearance between patches.
	Sleeving	No limitations.
	Replace Segment of Pipe	Entire affected section must be removed.
Depth 80% of pipe wall thickness or more including leaking corrosion pits.	Patching	Pipe of not more than 40,000 psi SMYS. Length or width of patch not to exceed 1/2 pipe circumference. A minimum of 3" clearance between patches.
	Sleeving	No limitations.
	Replace Segment of Pipe	Entire section affected must be removed.

¹ See Footnote 1 on Page 10 for repair procedures. Also, FDP may be limited. See Note 1.G., Page 1.

² The allowable depth is less for ASTM A-381 material. Contact the Pipeline Engineering section in the Gas System Maintenance Department.

Repair of Steel Pipeline Defects

Table 3 Repair Selection Table for Lines with a MAOP of 20% or More of the SMYS, or 500 psi or Greater (continued) ¹

Leaks in Weld		
Extent of Defect	Permissible Methods of Repair	Limitations on Methods
All	Replace Segment of Pipe	Entire affected section must be removed. If not feasible to take main out of service, repair with sleeve. Dent must not prevent proper fit up. If dent affects a weld, entire affected section must be removed.
Non-Leaking Cracks or Defects in Welds		
<p>Any longitudinal weld crack greater than 2" long, a branch or circumferential weld crack that is more than 8% of weld length, or a crack that penetrates either the root or second bead.</p> <p>Any longitudinal weld crack less than or equal to 2" long, a branch or circumferential weld crack less than or equal to 8% of weld length, or other defects.</p>	Replace if Feasible to Remove From Service or Sleeve	Entire affected section must be removed. If not feasible to take main out of service, repair with sleeve. Dent must not prevent proper fit up. If dent affects a weld, entire affected section must be removed.
	Grinding or Fill Welding	At least 1/8" wall thickness remaining. For maximum hoop stress permitted during welding, see Paragraph 2 of this gas standard. Inspect repair. If defect remains, entire affected section must be removed. If not feasible to take main out of service, repair with sleeve. Dent must not prevent proper fit up. If dent affects a weld, entire section affected must be removed.
	Sleeving	No limitations.
	Replace Segment of Pipe	Entire section affected must be removed.
Leaks in Body of Fittings or in Clamps		
All	Canning	Existing facilities only.
	Replace Fitting or Clamp	X-ray tie-in welds of replaced fittings.

¹ For repair procedures, see Paragraphs 5. through 12. of this gas standard and the following applicable Gas Standards:
 A-60 Sleeving
 A-62 Mueller Nipple, Leak Patch
 A-63 Canning
 A-64 Patching
 D-22 Arc Welding
 Also, FDP may be limited. See Note 1.G., Page 1.

Revision Notes

Revision 01 has the following changes:

1. Changed paragraph numbering to conform to standard numbering format.
2. Minor editorial changes throughout document to meet new document format.
3. Corrected paragraph references.
4. Added leak clamps and leak repair tapes to Table 1.
5. This document is part of Change 43.