Joint Design
O-ring rubber gasket joints, including Northwest Pipe’s O-Tite® brand gasket, provide an economical, non-welded method for joining steel water pipe. Rubber O-ring gasket joints are suitable for a variety of buried pipeline applications with a rated working pressure equal to the class of pipe for most typical water transmission applications. Over four decades of field-proven performance backs Northwest Pipe’s O-ring gasket joints, as well as an extensive program of in-plant testing. Literally millions of lineal feet of rubber O-ring gasket joint steel water pipe are now in active service.

Benefits

• Economical, non-welded method of joining buried steel water pipe
• Ease of installation, ensuring cost-effective pipeline installation
• Suitable for diameters up to 78 inches
• Flexibility in joint allows angular deflection for long-radius curves and minor field alignment changes. Non-rigid joints accommodate differential ground settlement after pipeline is installed.
• Formed integrally into the pipe cylinder, the joint has strength equal to that of the pipe itself.

Basis of Design

An O-ring gasket joint consists of a bell and spigot formed directly into the ends of the cylinder by expanding the steel beyond its elastic limit. The joint does not require attachments such as backing bars or other formed shapes welded to the pipe end.

Basis of Design (cont.)

The spigot end includes a formed groove that retains an O-ring gasket. When the spigot is inserted into the bell, which is flared to facilitate insertion of the spigot, the O-ring gasket compresses against the steel surfaces to form a watertight seal.

The O-ring gasket joint is designed to be self-centering upon assembly. The design of the groove is such that the O-ring gasket is confined to an annular space. Watertightness of the joint relies solely on the compressive force of the O-ring gasket, not on water pressure within the pipe cylinder.

Close circumferential tolerances between the inside diameter (ID) of the bell and the outside diameter (OD) of the spigot shoulder are critical to the function of the joint and is closely monitored during joint formation.

O-ring Joint

The O-ring gasket consists of a 50% synthetic rubber or synthetic rubber blend. Sizing of the O-ring gasket is dependent upon the configuration of the spigot, and is of sufficient volume to fill the recess of the groove when compressed. Sizing of the O-ring gasket is per the pipe manufacturer’s recommendation.

Design and manufacture of bell-and-spigot O-ring gasket joints are in accordance with AWWA C200, paragraphs 3.6.6 - 3.6.6.3 and AWWA Manual M11, paragraph 8.1.
O-ring Rubber Gasket Joints for Steel Water Pipe

History and Background

The use of O-ring gaskets in pipe joining systems dates to the 1930s. By the 1950s, a number of steel water-pipe manufacturers in the eastern United States, including U.S. Steel Company and Bethlehem Steel Company, began to offer versions of O-ring gasket joint pipe in which the pipe ends were cold formed. These early O-ring gasket joint versions comprised a formed bell; however, the spigot generally relied, in part, on a backing bar welded to the pipe to retain the O-ring gasket (in lieu of today’s formed groove).

In 1956, the Beall Pipe & Tank Corporation, a predecessor of Northwest Pipe Company, began to offer a true formed groove O-ring gasket joint pipe. Armco Steel Corporation introduced a similar version in 1958. Northwest Pipe Company has manufactured its rolled groove O-ring gasket joint since 1963.

Throughout the history of O-ring gasket joints—a history that now spans over four decades—a number of controlled tests have been undertaken by Northwest Pipe Company and its affiliated companies. Testing programs have demonstrated the joint’s ability to operate at more than double the recommended angular deflection, with repeated pressure cycling, and with damaged gaskets. O-ring gasket joints also have been tested to failure in excess of 760 psi. In many cases, the steel in the pipe cylinder went into a yield condition before actual joint failure occurred.

Method of Manufacture

The bell is generally formed by the swedge method in which the end of the pipe is sized over a plug die, usually during standard pipe hydrotesting operations. The use of a die ensures a smooth radius.

The spigot end, which includes the groove to retain the O-ring gasket, is formed by rotating the pipe end between a set of matched rolling dies.

All affected spiral-weld seams within the joint configuration are ground flush prior to end formation and are nondestructively tested upon completion by use of either dye-penetrant or magnetic-particle methods.

Available Diameters

Typical O-ring joints for steel water pipe are available in sizes up to 78-inch nominal diameters. Consult Northwest Pipe for larger diameters.

Rated Working Pressure

Because the O-ring gasket joint is formed integrally into the pipe cylinder itself, the joint has a rated working pressure equal to the class of pipe, plus a standard allowance for surge or transient conditions equal to the pipe pressure class.

Angular Deflection

O-ring gasket joints can be offset or "pulled" a maximum 1.00 inch. This allows for long–radius curves in pipeline alignment as well as minor offsets during pipeline construction.

Maximum allowable angular deflection per joint is limited to

\[
\text{Tangent} \leq \frac{\text{Allowable Pull}}{	ext{Pipe OD}}
\]

A summary of angular deflections based on a 1-inch pull is provided below:

### Angular Deflections

<table>
<thead>
<tr>
<th>Nominal Diameter (Inches)</th>
<th>Angular Deflection (Degrees)</th>
<th>Nominal Diameter (Inches)</th>
<th>Angular Deflection (Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤10</td>
<td>5.00</td>
<td>36</td>
<td>1.59</td>
</tr>
<tr>
<td>12</td>
<td>4.76</td>
<td>42</td>
<td>1.36</td>
</tr>
<tr>
<td>14</td>
<td>4.09</td>
<td>48</td>
<td>1.19</td>
</tr>
<tr>
<td>16</td>
<td>3.58</td>
<td>54</td>
<td>1.06</td>
</tr>
<tr>
<td>18</td>
<td>3.18</td>
<td>60</td>
<td>0.95</td>
</tr>
<tr>
<td>20</td>
<td>2.86</td>
<td>66</td>
<td>0.87</td>
</tr>
<tr>
<td>24</td>
<td>2.39</td>
<td>72</td>
<td>0.80</td>
</tr>
<tr>
<td>30</td>
<td>1.91</td>
<td>78</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Two Variations of O-ring Gasket Joints

![Two Variations of O-ring Gasket Joints](image-url)
O-ring Rubber Gasket Joints for Steel Water Pipe

**Installation Guidelines**

- Joint ends should be thoroughly cleaned and inspected prior to assembly. The bell and spigot ends should have a smooth radius and be free of indentations, burrs, or other projections that could interfere with the gasket’s ability to properly seal the joint.
- The gasket should be thoroughly lubricated with a lubricant supplied and/or approved by the pipe manufacturer. Immediately after lubrication, the gasket should be stretched over the spigot and inserted into the groove.
- Tension on the gasket should be equalized by inserting a dull instrument such as a dowel or screwdriver shaft) under the gasket and completing at least two revolutions around the joint circumference.
- The bell and spigot of the pipe can be lubricated. After lubrication and gasket insertion, the pipe ends should be kept clean and as dirt free as possible.
- The spigot should be initially inserted into the bell end in a straight alignment. Any angular deflection should be taken after insertion, but in no case should the angular deflection exceed the recommended maximum allowance.
- After alignment, the spigot should be driven into the bell a distance at least equal to the minimum recommended joint lap, as shown in the Pipe Manufacturer’s shop drawings.
- Before the pipe is released from its holding slings, the entire placement of the O-ring gasket should be checked by use of a feeler gauge. The feeler gauge should be inserted under the flare of the bell, making contact with the gasket at a constant, predetermined depth, until the full circumference of the joint has been inspected.
- If it is determined that the gasket has disengaged or rolled during joint assembly, the O-ring joint should be immediately pulled apart, the gasket discarded, and the joint area and gasket inspected. The joint should be reassembled with a new gasket and rechecked with a feeler gauge.
- Upon successful completion of the joint, the pipe should be unslung and, if practical, a small amount of embedment material placed over the mid-point of the completed pipe length to minimize any incidental movement of the pipe in the trench until joint wrapping and backfill is completed.
- Bonding clips or bonding straps need to be attached for electrical continuity of the pipeline system.
WELDED JOINTS

Bell-and-Spigot Lap-welded Joints

Bell-and-spigot lap-welded joints are available for all pipe diameters. This joint is an economical means of joint restraint for buried joints with working pressures up to 400 psi. The bell-and-spigot ends allow for some angular deflection at the joint and provide easy assembly and fit-up in the field. Where additional angular deflection is required, the weld bell will be miter cut before forming, thus allowing up to 5 degrees of deflection per joint.

Lap-welded joints are configured for application of a single fillet weld either on the outside or inside of the pipe. The bells are formed either by swedging or by expansion. Either method of forming weld bells will maintain the minimum radius of curvature and dimensional requirements as outlined in AWWA C200 and C206.

Where inside fillet welds are preferred, “weld-after-backfill” joint preparation can be used. This preparation allows the Contractor to complete the exterior joint preparation and backfill the pipe completely prior to welding. Use of this method of welding can significantly increase productivity during the installation phase of a pipeline.

Installation Guidelines for Lap-welded Joints

- Joint ends should be inspected prior to assembly and be free of burrs or indentations that may interfere with the engagement of the joint. A wire brush should be used to clean all exposed ends of joint surfaces.
- In most installation conditions, the joint can be assembled bell over spigot. A pull of 1 inch is allowed. The annular space between the bell and the spigot should be equalized as necessary to avoid excessive gap.
- The plain end of the pipe should extend into the bell for a nominal overlap of 21/4-inches, but in no case should the overlap be less than 1 inch at any location around the joint circumference.

Installation Guidelines for Lap-welded Joints (cont.)

- Only certified welders qualified under AWS D1.1 or ASME should be used, following a pre-approved field weld procedure. Both shielded metal arc and flux core arc techniques are generally acceptable.
- A single full-fillet weld is typically specified for most installations.
- It is desirable to nondestructively test the joint field weld upon completion using the magnetic particle or other approved method.

Outside Lap-welded Joint

Inside Lap-welded Joint

Butt-strap Joints

Butt-strap joints are used for closure or to assist with field alignment. The straps are furnished loose in one or two sections, requiring one or two longitudinal welds in addition to the circumferential fillet welds. Butt-straps can also be furnished attached to the pipe, thus modeling a lap-weld bell-type end. Butt-strap joints are used for joints with working pressures up to 400 psi. Similar to weld-bell joints, butt-strap joints can be welded from the inside, from the outside, or both.

Butt-strap Joint

Butt-welded Joints

Butt-weld joints are used for working pressures in excess of 400 psi or other special applications. Butt-weld joints do not allow for angular deflection at the joint except by the use of miter-cut ends. Deflections of up to 5 degrees can be taken by miter cutting one end of a pipe, provided that the major axis of the ellipse formed by the miter cut does not exceed the diameter of the pipe by more than 1/8 inch. Deflections of up to 10 degrees can be taken mitering two adjacent pipe ends up to 5 degrees each. A full penetration weld is required for this type of joint. The pipe ends will be prepared in accordance with the requirements of AWWA C200 and C206. To aid in the installation of butt-weld joints, an internal or external backup bar can be used. The backup bar serves several purposes: to act as a guide for placement of the adjacent pipe; to help maintain alignment of the two pipe ends during welding; and to help ensure a quality butt weld by providing a backup plate for the root pass of the butt weld. External backup bars do not need to be removed after welding is complete.

Butt-welded Joint
Mitered Bell Ends

For lap-welded joints, the bell can be mitered up to 5 degrees. This allows for angular deflection without the use of a fabricated elbow and is useful in accommodating minor alignment changes or long-radius curves.

Split-sleeve Mechanical Coupling

A split-sleeve coupling is another type of coupling similar to the mechanical coupling. This coupling consists of three basic components that include a one- or two-piece housing, gaskets, and bolts and nuts. The materials, quality, and performance of the split-sleeve coupling shall conform to the requirements of AWWA C219. If no thrust restraint is required, plain-end pipe is used. If thrust restraint is required, it is accomplished by welding end rings to the ends of the pipe. The end rings and their attachments welds shall be designed for the maximum internal pressure of the pipe.

OTHER JOINTS

Mechanical Couplings

Mechanical couplings are used for connection of plain-end pipe. Mechanical couplings provide joint flexibility and are commonly used for interior pipe applications as well as at wall penetrations or other locations where pipe intersects permanent structures. Mechanical-coupled joints can be mechanically restrained with the use of tie rods that thread through gussets or lugs attached to the pipe. In cases where the coupling is buried, a dielectric coating, such as liquid-applied epoxy, petrolatum coating, or fusion-bonded epoxy, is recommended. Mechanical couplings shall conform to AWWA C219.

Flanged Joints

Flanged joints are commonly used at connections to valves or other areas where disassembly of the joint may be required for service or access. Ring flanges, which are fabricated from steel plate, are the most common type and are suitable for most water transmission applications. Gaskets are generally cloth-inserted rubber. Bolts and nuts can be carbon steel, where the flanged connection is inside buildings or structures including vaults. For direct burial or outdoor applications, stainless steel bolts and nuts are preferable. Flange design, pressure rating, and drilling shall conform to AWWA C207.
Carnegie O-ring Gasket Joint for Concrete Cylinder and Steel Water Pipe

Carnegie-bell-and-spigot gasketed joints provide an economical, non-welded method for joining bar-wrapped concrete pressure pipe and steel water pipe. Carnegie-bell-and-spigot joints are suitable for a variety of buried pipeline applications and can be welded for joint restraints. Over five decades of use has proven the Carnegie joint to be reliable in performance and economical for field installation.

**Benefits**
- Economical, non-welded method of joining buried steel water pipe
- Ease of installation
- Permanent watertight seal
- Suitable for diameters from 12 to 84 inch
- Flexibility in joint allows angular deflection for long-radius curves and minor field alignment changes.
- Flexibility of the joint accommodates differential settlement after pipeline is installed.
- To achieve greater angular deflection, the joint can accommodate a 5-degree bevel.
- Consistent quality is achieved by the preformed Carnegie shape.

**Basis of Design**

A bell-and-spigot Carnegie joint consists of steel joint rings welded to the cylinder to form a self-centering joint sealed by a compressed rubber gasket. The spigot ring shall have a preformed groove in its exterior for retaining the rubber gasket. The gasket shall seal the joint under all conditions of service including expansion, contraction, and earth settlement. Gaskets shall be of sufficient volume to substantially fill the space provided when the joint is assembled. The design thickness of the bell ring shall be in accordance with Section 4.5.3.2 of AWWA C303. The total cross-sectional steel area of the bell plus the cross-sectional area of the bar reinforcement around the bell shall be equal to that required in the body of the pipe. The rings are sized by expanding over a press or expander beyond their elastic limit. On the finished pipe, the circumference of the inside bell ring contact surface shall not exceed the circumference of the outside spigot-ring contact surface by more than 3/16 inch. Close circumferential tolerance between the inside diameter (ID) of the bell and outside diameter (OD) of the spigot shoulder is critical to the function of the joint and is closely monitored during joint formation. The O-ring gasket consists of a 50% synthetic rubber or synthetic rubber blend. Sizing of the O-ring gasket is dependent upon the configuration of the spigot and is of sufficient volume to fill the recess of the groove when compressed. Design and manufacture of bell-and-spigot O-ring gasket joints is in accordance with AWWA C303 and AWWA M9.

Carnegie Bell-and-Spigot Gasketed Joint
Carnegie O-ring Gasket Joint for Concrete Cylinder and Steel Water Pipe

History and Background

The use of O-ring gaskets in pipe-joining systems dates to the 1930s with the development of Carnegie-shaped joints. Their use continued with the development of concrete cylinder pipe in the early 1940s, which uses the Carnegie-shaped joint exclusively. Since that time, tens of millions of feet of concrete cylinder pipe have been installed using the Carnegie-shaped joint. Carnegie joints have been successfully used for more than five decades. Controlled tests have demonstrated the joint’s ability to operate even under excessive angular deflection and repeated pressure cycling.

Rated Working Pressure

Because the O-ring gasket joint is a preformed spigot ring with a fully enclosed gasket groove, the joint has a rated working pressure equal to that of the class of pipe plus a standard allowance for surge or transient conditions equal to that of the cylinder.

Angular Deflection

Carnegie-shaped gasket joints can be offset or "pulled" a maximum 0.75 inches for 12-inch through 21-inch diameters and 1-inch for 24-inch and larger diameter pipe. This allows for long-radius curves in pipeline alignment as well as minor offsets during pipeline construction. Maximum allowable angular deflection per joint is limited to

\[
\text{Tangent} \leq \frac{\text{Allowable Pull}}{\text{Pipe OD}}
\]

Thrust Restraint

Carnegie-shaped gasket joints are considered unrestrained. Carnegie shaped gasket joints should not be used in areas where unbalanced thrust develops at changes in diameter and direction of the pipeline without the use of thrust blocks or other suitable methods of developing frictional force between the pipe and surrounding soil.

Installing Guidelines

- Joint ends should be thoroughly cleaned and inspected prior to assembly. The bell-and-spigot ends should have a smooth radius and be free of indentations, burrs, or other projections that could interfere with the gasket’s ability to properly seal the joint.
- The gasket should be thoroughly lubricated with a lubricant supplied and/or approved by the pipe manufacturer. After lubrication, the gasket should be immediately stretched over the spigot and inserted into the groove.
- Tension on the gasket should be equalized by the insertion of dull instrument (such as a dowel or screwdriver shaft) under the gasket and the completing of at least two revolutions around the joint circumference.
- To facilitate insertion, the bell and spigot of the pipe can be lubricated as well. However, after lubrication and gasket insertion, the pipe ends should be kept clean and as dirt free as possible.
- To facilitate joint assembly, the pipe can be marked on the outside spigot end showing the full engagement of the joint (provided on the joint detail drawing) plus an additional 1 inch.
- After joint assembly, the gasket position must be checked with a feeler gauge. If it is determined that the gasket has disengaged or rolled during joint assembly, the O-ring joint should be immediately pulled apart, the gasket discarded, and the joint area and gasket inspected. The joint should be reassembled with a new gasket and rechecked with a feeler gauge.
- Upon successful completion of the joint, the pipe should be unslung and, if practical, a small amount of embedment material placed over the midpoint of the completed pipe length. This is to minimize any incidental movement of the pipe in the trench until joint coating and backfill is completed.