JCM Industries, Inc.

General Pipe Repair Information
&
Repair Fitting Selection Guidelines

JCM Industries, Inc.
P. O. Box 1220
Nash, TX 75569-1220
800-527-8482 or 903-832-2581
www.jcmindustries.com

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JCM Industries, Inc.
Marketing Services Dept.
P. O. Box 1220
Nash, TX 75569-1220
903-832-2581

General Pipe Repair Information and Guidelines

Repairing in-service pipelines is the common, industry accepted form of maintaining critical service to hospitals, fire protection, businesses, industrial consumers, public and private end users. While a shutdown and replacement process provides a repair, a comparison of "shutdown/replace" vs. "repair in place" overwhelmingly is in favor of repairing a pipeline while in place, under pressure if the situation allows.

By incorporating the shutdown/replace method, responsible authorities encounter several factors that increase costs, lengthen time frames and expose the system to contaminants. Several factors determine whether a line may be repaired in-service or is better served by being replaced. The concept of "less disturbance = less problems" should be considered when dealing with pipeline excavation.

The shutdown/replace method includes, but is not limited to:

1. Locate the damaged area
2. Excavate the pipeline and assess the required repair materials
3. Determine the least used or "low flow" period for the line
4. Backfill the excavated area until the low flow time frame (most authorities will not allow an open ditch overnight)
5. Obtain the repair/replacement materials
6. Return to jobsite at low flow time (usually early hours of morning, incurring overtime rates for crews)
7. Excavate pipe to expose damaged area. Additional excavation may be required to accommodate multiple crew personnel and equipment.
8. Shut the line down (if valves are available and operational)
9. Drain line contents (for potable systems this wastes billable gallons of processed water)
10. Proceed with removal of damaged area by dismantling pipe system or cutting the pipeline (many districts require special clothing and processes)
11. Replace damaged pipe with new materials.
12. Test repair connection
13. Purge and decontaminate
14. Backfill site and finish as required

Time and cost consuming steps can be avoided by making an in-place repair:

1. Locate the damaged area
2. Excavate the pipeline and assess the required repair materials
3. Maintain, reduce or shutdown pressure on the line
4. Obtain the repair materials
5. Proceed with installation of repair fitting
6. Resume water pressure and confirm successful installation of repair fitting
7. Backfill site and finish as required

Positive aspects of repairing in place include:

- Less downtime – flow remains intact to critical services (hospital, fire, etc.)
- Less soil disturbance – excavation is limited
- Less expense – repair fittings less expensive than full replacement
- Reduce personnel number and time
- Less hazardous to system – limited internal or line content exposure, limited pressure in line prevents infiltration of debris into pipe system
- Less decontamination processes after repair is complete

The practice of pipe replacement for repairing pipelines has definite positive aspects; however, it should be reserved for severely damaged pipe applications.

A Universal Clamp Coupling is frequently used as a temporary repair fitting to seal pipeline leaks. Engineers, distributors, pipeline owners and end users need to be aware that such emergency repairs may be inadequate for long-term use without consideration of additional actions to assess the pipeline's sufficient structural strength. Such failures of applications have the potential to cause serious damage and personal injury.

Aging infrastructures and piping systems can experience decomposition of the pipe wall at the location of an installed repair clamp. This can result in structural failure of the pipe, leading to the pipe being ejected or pulled from the clamp. The failure is a direct result of insufficient wall thickness to resist the normal axial load due to pressure and other forces (e.g. thermal expansion). Repair clamps are designed to seal and repair the leak but they do not provide sufficient axial (lateral) strengthening of the pipe.

Failure to fully assess and consider the conditions of the pipe and the expected performance of a clamp to be installed, can lead to failure of the application. To successfully install and obtain maximum performance of the fitting, the following procedures should be performed for each application:

1. A thorough assessment of the type, size and location of the damage to be repaired
2. Accurately determine the operating conditions to which the clamp will be subjected Include line content, pressure, temperature, pipe diameter and the size and type of damage to repair
3. For installation as a temporary repair, determine the time frame to remove the repair clamp and proceed with a permanent repair
4. Consider the geometry of the pipeline being repaired (i.e. flat spots, ovality, etc.) which can affect the performance of the repair clamp

For the greatest safety factor in repairing critical piping systems, the repair philosophy should include:

1. Replace with products of similar material and pressure rated capabilities.
2. Temporary repair until replacement can be carried out.
3. Permanent repair only where replacement is not practical.

The use of Universal Clamp Couplings should be managed by implementing proper procedures. Users of repair clamps should carry out the following steps prior to the use of such a clamp:

1. An appraisal of the nature and extent of the damage considered for repair.
2. A full evaluation of the operating conditions to which the clamp will be subjected, include line contents, pressure, temperature, pipe size and any additional environmental issues.
3. An estimated time frame for which the clamp is required to be in operation.

If a Universal Clamp Coupling is considered suitable following these reviews then this same detailed information should be communicated to the clamp supplier.

End users should make certain that all pipelines subject to separation or pull out, repaired with universal clamps, include additional lateral restraint of the pipe. Additionally, it is especially important to consider the ability of the remaining pipe wall thickness to accommodate the forced axial loadings/stresses. In applications where the continuation of internal pipeline material loss cannot be prevented it is necessary to consider the suitability of the repair fitting and its ability to accommodate the forces should the material loss affect the pipeline's ability to carry these loading/stresses.

Users of existing repair clamps which have not been provided with full structural restraint should carry out a suitable and sufficient risk assessment of the conditions in which the clamp has been installed. Note this may result in it being necessary to reinforce fittings with additional restrainers or remove some existing clamps from service.

Factors of Pipe Repair

Severely damaged pipe that can not be repaired with a fitting or fabrication will be clearly apparent when fully excavated. Knowledge of fittings available in the industry for pipe repair, their design features and benefits, capabilities and availability is an invaluable tool that should be exercised and shared with others.

There are several factors in determining how a damaged area should be repaired. Most important are the basic following:

- Type of Pipe
- Diameter of the Pipe
- Size and Type of Damage
- Line Pressure
- Line Content
- Accessibility

Let's review each of these and its importance to a successful repair.

Type of Pipe
There are a variety of piping materials used throughout the U.S., Canada and Mexico. Each piping material has its own characteristics for which it was selected when installed. For example, ductile iron is a rigid, strong pipe that has good corrosion resistance and withstands a wide variety of environments. Polyvinylchloride (PVC), is lightweight, has excellent corrosion resistance and is easy to install.

Whatever the reasoning the piping materials were chosen, their characteristics to stress, pressure and environment must be taken into consideration when selecting a repair fitting. For example, if the soil is acidic or "hot" and PVC pipe was installed for this reason, then the materials used to construct the repair fitting should withstand the same soil conditions and have a life expectancy equal to the pipeline.

Size/Diameter of the Pipe
The waterworks industry recognizes that during the manufacturing of certain types of pipe, the finished outside diameter of the pipe may have a +/- tolerance (i.e. ductile iron pipe +/-6/100th of inch from the standard diameter). Varying diameters especially true of older pipe such as pit cast pipe, cast iron pipe and asbestos cement pipe. Newer piping materials such as PVC, HDPE and steel are manufactured to an exact outside diameter (O.D.) with little variation. Determining the diameter of the pipe is critical. Guessing at the O.D. can cost time, labor and effort along with water loss and downtime.

Determining Outside Diameters
To determine the outside diameter of the pipe, clean and scrape pipe in area to be measured. Remove large debris deposits that will interfere with surface area to be measured.

Simple measurement of the pipe can be accomplished with a "pipe O.D. tape" similar to the JCM Model 920. If an O.D. Tape is unavailable, measure pipe with a standard narrow, flat metal measuring tape. A narrow tape will lie flat against the pipe for a true circumferential measurement. Determine the diameter of the pipe by using the formula shown at the right.

If a narrow tape is not available, select a strip of material that can be wrapped around the pipe that will lie flat against the pipe. Use materials such as cable, chain, wire, etc. Do not use a material that will stretch or has elasticity. Mark the strip where it meets around the pipe. Lay the strip out flat, measure the strip of material with a standard measuring tape to determine the inches length (circumference). Determine the diameter of the pipe by using the formula: **Circumference ÷ 3.1416 = Outside Diameter**
This is the information to be used in selecting and ordering the correct size repair fitting.

A question was put to the PM Engineer (PME) staff (one of SUPPLY HOUSE TIME'S sister magazines) asking how nominal pipe size came to be. Here is the answer provided by PME Editorial Director Julius Ballanco.

> The person directly responsible for the nominal pipe size was a gentleman by the name of Robert Briggs. Briggs was the superintendent of the Pascal Iron Works in Philadelphia. In 1862, he wrote a set of pipe specifications for iron pipe, and passed them around to all of the mills in the area.
>
> Realize that in 1862, this country was engaged in the Civil War. Each pipe mill made its own pipe and fittings to its own specifications. Briggs tried to standardize the sizing, which would also help the war effort. The pipe and fittings would be interchangeable between mills. This was rather novel in 1862.
>
> The pipe standards went on to become known as the "Briggs Standards." They eventually became the American Standards, and finally the standards used for modern day pipe.
>
> The current ASTM A53 Steel Pipe Standard uses basically the Briggs Standard for pipe sizes 1/2 inch through 4 inch. You will notice that after 4 inches, pipe starts to get closer to the actual dimension used to identify the pipe.

So, you are probably asking, where did the sizes come from? Well, they were the sizes of the dies used in Pascal Iron Works. Briggs made everyone adjust to him. Hence, the name "nominal" pipe size came about, meaning "close to" or "somewhere in the proximity of" the actual dimension.

Size and Type of Damage

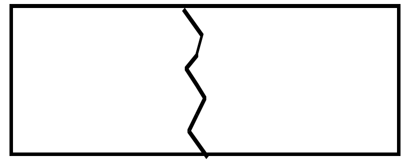
A knowledgeable assessment of the damaged area must be performed. Damage identification and description examples include:

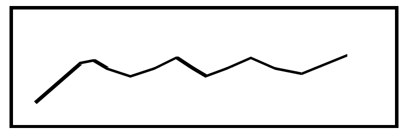
Type of Damage	**Required Information for Successful Repair**
Hole/Puncture/Gouge	Measure the diameter of the damaged area or the longest and widest measurements.
Full or Partial Beam Break	Circumferential Break Inspect and measure any gaps between pipe ends. Observe for pipe deflection or offset that may have occurred.
Split or Crack	Longitudinal Break Inspect and measure the length of the crack and the range of any circumferential travel of the break along the pipe. Note gaping areas in the split.
Pitted or Corrosion Leak	Measure the diameter of the damaged area or the longest and widest measurement.

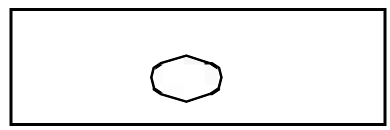
Other Types of Pipe Leaks Include:

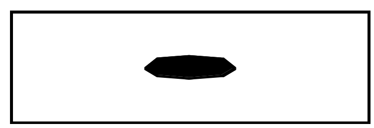
Leaking Bell/Spigot Joint	Type of pipe, size of pipe; if possible, length of bell, diameter of bell
Leaking Threaded Joint	Type of pipe, size of pipe; if possible, length of collar/joint
Leaking Asbestos Cement Coupling	O.D. of pipe, O.D. of Coupling, Length of Coupling
Leaking Mechanical Joint, Cracked Bell	O.D. of pipe, O.D. of Bell, Length of Bell

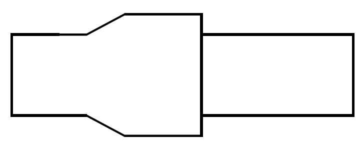
The following examples briefly describe each of these types of damage and are provided for an educational outline. Other types of damage exist and can present unique challenges to the field technician.

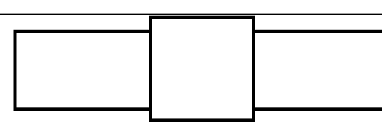
Type of Damage	**Full or Partial Beam Break (Circumferential Break)**	
Type of Pipe	Cast Iron Ductile Iron PVC Asbestos Cement Steel	

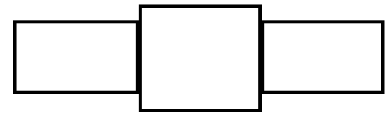
Type of Damage	**Split or Crack (Longitudinal Break)**	
Type of Pipe	Cast Iron Ductile Iron PVC Asbestos Cement Steel	

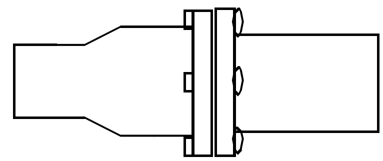
Type of Damage	**Pitted or Corrosion Leak**	
Type of Pipe	Cast IronDuctile Iron Steel	

Type of Damage	**Holes or Punctures**	
Type of Pipe	Cast IronClay Ductile IronConcrete PVC Polyethylene Steel	

Type of Damage	**Leaking Bell/Spigot Connection**	
Type of Pipe	Cast Iron Ductile Iron PVC	

Type of Damage	**Leaking Threaded Joints, PVC Solvent Weld**	
Type of Pipe	PVC Steel	

Type of Damage	**Leaking Asbestos Cement Coupling**	
Type of Pipe	Asbestos Cement	

Type of Damage	**Leaking Mechanical Joint, Cracked Bell**	
Type of Pipe	Cast Iron Ductile Iron	

Line Pressure

A critical factor in a successful repair is determining the working pressure and any fluctuations in the flow of the pipeline. The accepted, standard working pressure in the waterworks industry (and the rating for most distribution products) is 150 PSI. Of course in various areas, working pressures can run much higher, and those superintendents and field technicians know their systems.

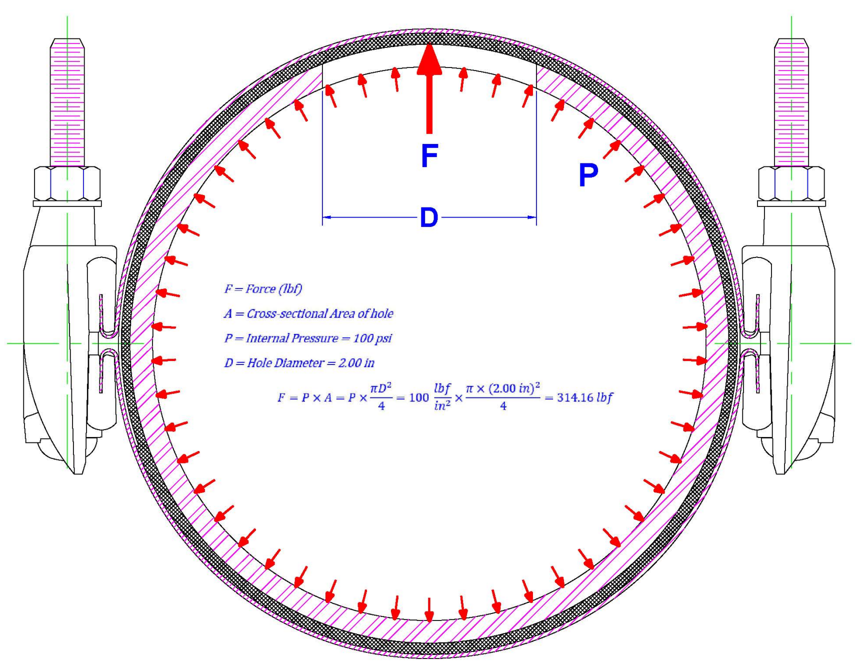
When a pipeline expriences damage, keeping a minimum amount of pressure on the line during the repair process can assist in preventing infiltration of debris and contamination into the line. While this is a helpful practice, it may not alway be practical.

Line pressures in excess of 150 PSI working pressure and any extreme fluctuations must be divulged to a distributor/manufacturer so that a proper repair fitting will be recommended and provided. For higher working pressures and large diameter, see "Large Diameter Pipe Repair" later in this presentation.

Once the type of damage has been identified, the amount of working pressure on the line will influence the type of repair fitting. The larger the damaged area, the more internal pressure is allowed to escape. This puts a variety of mechanical forces on a repair fitting. Superintendents, distribution managers and field technicians should have a current knowledge of what operating line pressure is on a damaged line.

An additional thought is, "What pressure will be expected of that line in the future?" Is the line in an older part of town that has little room for growth or expansion, or is it in a new, devloping area that may put additional demands on the line in the future. The repair fitting should be rated equal to that of the pipeline it is installed on. For example, currently the highest pressure a line may have experienced is 80 PSI, but with municipal, housing and industrial growth, the line may be expected to serve at 125 PSI in the future.

The graphic to the left represents mathematical formula of determining the type of force that is put on a full circumferential gasket repair clamp – with a 2" hole/puncture/gouge operating at 100PSI. Actual force at the damaged area is <u>over 300PSI</u>. Clamp design, material and construction must be prepared to meet this force and provide safety factor for a permanent repair. The mechanical strength of the repair fitting is critical in these types of applications and an assessment of the application should be performed.



Line Content
Potable water, wastewater, reclaimed water, sewage, chemicals, process water, etc. Knowing the line content is critical so that the distributor/manufacturer can provide the proper gasket material and coatings that will withstand the content. Temperature is also a factor with industrial applications (higher than 180^{o} F).

Accessability
Many times the location of the repair site presents obstacles that first appear insurmountable. Crowded underground utilities and piping galleries, rockbound soil conditions, concrete footings and thrust blocks, weak trench and soil conditions and other environments add considerations to selection and availability of repair fittings. In these situations, the knowledge of the repair fittings available in the industry is a must. Distributors, salespersonnel and manufacturers are unlimited resources for product submittals and application solutions.

Types of Repair Products

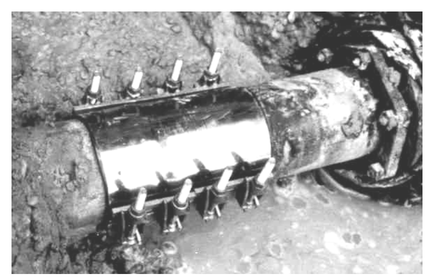
There are a variety of repair products in the pipeline industry. The type of fitting selected is all dependent upon those 5 basic pipe items – type, size, damage, pressure, content.

One of the most common items, immediately available are **UNIVERSAL CLAMP COUPLINGS**. They are constructed to open and wrap around the pipe and seal the damaged area. Some designs are gasketed around the full circumference of the clamp; others provide a limited gasketed area similar to a "band-aid."

Clamps are constructed with a stainless steel band, a gasket and a bolted lug system. These are available in a variety of materials, configurations and sizes.

These fittings are used on the straight run of pipe and can conform to pipe irregularities and deflections (within a limited range).

Clamps are generally recommended for use in repairing:



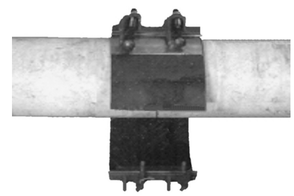
Hole/Puncture/Gouge
Full or Partial Beam Break
Split or Crack
Pitted or Corrosion Leak

Benefits of using a Repair Clamp include:
- Less down time for water service
- Repairs are made with a minimum of crew
- Repair can be made with out cutting the pipe and opening the system to possible contamination.
- Less excavation, laber, equipment, traffic hazards
- Disturb less backfill around the system – minimizing potential of future damage caused by general ground settlement
- Small inventory covers a wide range of pipe sizes

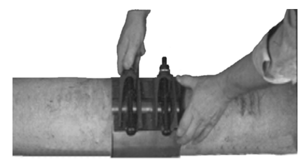
Use of the wrap around repair clamp is simple and in most cases a permanent repair. Installation is fast and easy. The basic steps include:

1. Clean and scrape pipe. Remove any dirt or debris that would interfere with the complete sealing of the gasket around the pipe. Lubricate the pipe with soapy water. **Do not use oil base pipe lubricant.** *Trick of the Trade: Place a mark on the pipe to each side of the damaged area equal to the width of the clamp. This presents a visual mark to center the repair clamp over the damage area (1/2 of this distance is center).*

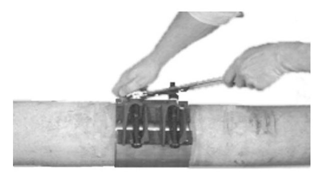
2. Inspect pipe for integrity, size and outside diameter. Confirm the proper size and range of repair clamp. Place clamp on pipe and center over damaged area.



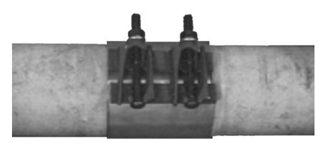
3. Tuck tapered gasket in place, mesh finger lugs and rotate clamp in direction of arrow to smooth tapered gasket flap. Engage bolts and tighten finger tight to hold in place.



4. Tighten all bolts evenly to the recommended torque values.



5. Complete installation of fitting and confirm minimum bolt torque levels have been maintained.



Universal Clamp Coupling Installation "Tricks of the Trade"

From JCM Industries Product Installation Instructions

Years of field experience, special applications and product testing have revealed many subtleties regarding application and installation of repair clamps. For maximum performance under adverse conditions take advantage of the JCM "Tricks of the Trade."

- Always clean and lubricate pipe with water or soapy water. This will help overcome friction when rotating the clamp to smooth the gasket. Do not use oil base pipe lubricant.
- Place a reference mark on the pipe back from the damaged area to help in centering clamp over break. Clamps provide maximum performance when centered over damage area. Inspect full diameter of the pipe. Use of a mirror will allow an easy inspection of backside and underside of pipe.
- Breaks involving deflected pipe require a wider clamp. JCM lug sections will articulate, permitting clamp to better conform to pipe.
- Damage involving large holes or massive pitted areas – use of a stainless steel or galvanized metal plate over large holes (under repair clamp) provides the gasket something to seal against.
- Drill holes in the ends of splits or cracks to relieve forces which could cause splits to continue.
- Clamp performance drops when gap between pipe ends is larger than 1/2". Use a stainless steel spacer to fill or to place over gap.
- Leave sufficient pressure on a broken line to prevent intrusion of foreign matter to prevent excessive line contamination.
- With pressure reduced, spraying water will cease as soon as water level rises above break.
- Lubricating clamp bolts will ease clamp installation and assure proper torque of bolts.
- When repairing holes, gouges or centralized damage, position the bolting lug over the damaged area to provide additional gasket compression at the location.
- Confirm bolt torques with torque wrench prior to backfilling. Proper bolt toque is crucial to the success of repair clamp performance.
- Universal Clamp Couplings do not provide restraint of pipe ends. For applications in which pipe may pull out of clamp, external restraint must be provided.

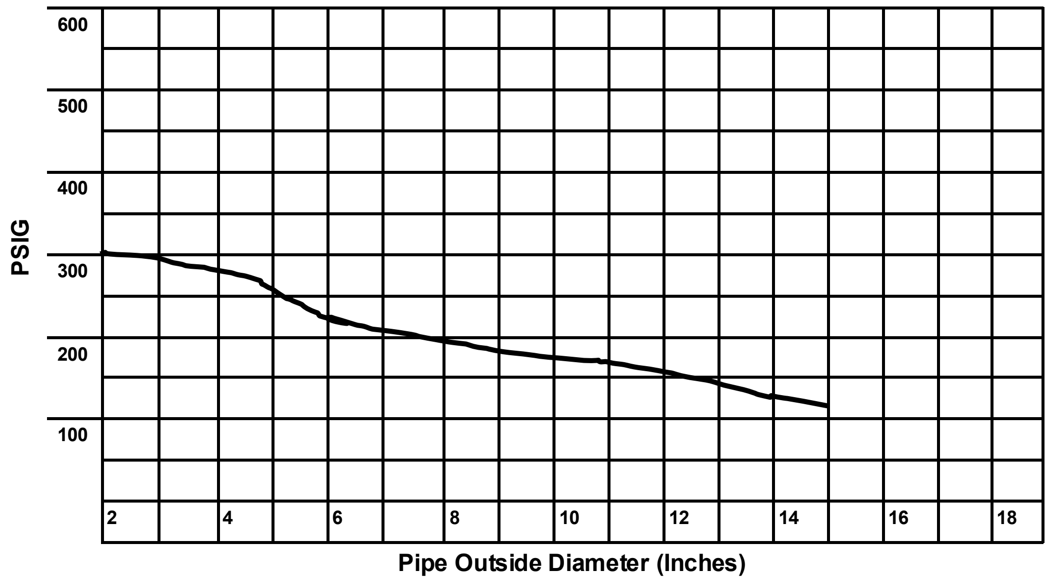
Repairs of Pipelines Nominal Size up through 12”

Commonly, pipelines up through 12” in diameter are repaired by using full circumferential clamp couplings in applications involving breaks, splits, cracks, corrosion and small holes in working pressures up through 150 PSI. However, the amount of pressure that a Universal Clamp Coupling will contain is proportionate to the diameter of the clamp and the amount of the torque applied to the bolts. Small diameter clamps will have a higher pressure rating than larger diameter clamps. On any given installation, the pressure capability of a clamp is heavily influenced by the type and extent of the damage, service conditions, site conditions and installation workmanship.

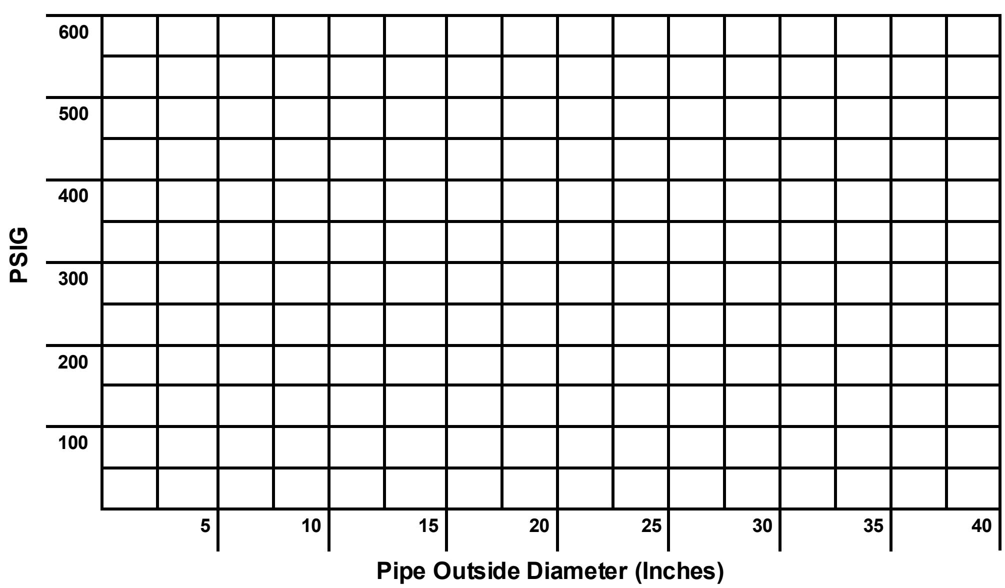
The following charts provide a general guideline to universal clamp couplings and their pressure holding capabilities as nominal pipe size increases. The feature charts represent both single and multi-band clamps and are offered as examples of product expectations, not hard and fast rules.

Comparing small diameter clamps (12” and under) to larger diameter clamps really relates to materials used and design. Forces involved in repairing pipelines 14” and larger are vastly different than lines 12” and under. For example, a subcompact car has a set of brakes. They are designed to help reduce speed and stop the car. When designing the brakes, engineers consider factors such as speed capablities, weight, distance and driving conditions. While those brakes would function on other cars of similar weight and design, they would not function on a 1-ton truck. There would be greater **forces** involved in slowing and stopping the 1-ton truck (weight, size, load, etc.). This is true with repair fittings and pipelines. Larger diameters, greater pressure ratings, service requirements, etc. all play a part in the successful selection of repair fittings.

JCM SINGLE BAND UNIVERSAL CLAMP COUPLING
PRESSURE RATING FOR WATER SERVICE



JCM MULTI-BAND UNIVERSAL CLAMP COUPLING
PRESSURE RATING FOR WATER SERVICE



NOTES:

1. Pressures based on test performed on a 1/8" full circumferential break.
2. The amount of pressure that a Universal Clamp Coupling will contain is proportionate to the diameter of the clamp and the amount of the torque applied to the bolts. Small diameter clamps will have a higher pressure rating than larger diameter clamps. On any given installation, the pressure capability of a clamp is heavily influenced by the type and extent of the damage, service conditions, site conditions and installation workmanship.

Multi Band UCC	**Pressure Rating Chart**
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The above charts are graphic representation of pressure holding dynamics of full circumferential repair clamps in relation to nominal pipe size. This representation is not for definiatived use for fitting performance. As noted, on any given installation, the pressure capability of a clamp is heavily influenced by the type and extent of the damage, service conditions, site conditions and installation workmanship

JCM Large Diameter Repair Clamps
Selection and Application

In the repair applications to large diameter pipe, there are several factors to be considered to maintain pipe integrity and return to 100% service capacity. These factors, which are critical to the application, include: size and type of pipe, severity of damage, working pressure or service requirements, location of repair and time factor.

Line pressure forces encountered in repair applications will determine the success or failure of a repair fitting. The forces of large pipe reduce the working capability and safety factor of large repair clamps. Performance of these fittings is determined by the relationship of bolting power to gasket area, fastener attachment, bolt efficiency and thickness of metal. Therefore, a repair clamp may not be the proper repair fitting for certain applications. JCM offers various repair fittings which are suitable for repairs to large pipe operating at higher working pressures. To understand the forces involved in the application, see the comparison values listed below relating size of pipe to the internal forces involved.

Nominal Pipe Size (In.)	Outside Diameter	Area of 1/4" Break	Force at 100 PSI
12	13.20	10.37 sq in	1,037 lbs
16	17.40	13.67 sq in	1,367 lbs
20	21.60	16.96 sq in	1,696 lbs
24	25.80	20.26 sq in	2,026 lbs
30	32.00	25.13 sq in	2,513 lbs

On a repair clamp the mechanical seal is made by tightening bolts to create a greater force on the gasket (PSI) than is in the pipeline. **Safety factor** is that amount of sealing capability the clamp has above the operating pressure of the pipeline.

Clamps are limited in performance by the relationship of bolting power to gasket area. Also entering into the picture are the fastener attachment, bolt efficiency and the thickness of the metal.

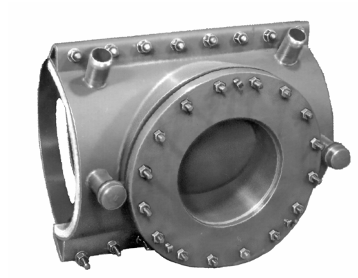
JCM clamps have been designed to limit traditional clamp weaknesses, thereby giving a higher working capability and safety factor. Even so, they do have a limited capability. Therefore other types of repair fittings should be taken into consideration. Fabricated repair sleeves are designed to overcome the forces involved with large diameter pipe and its characteristics.

For larger diameter pipe and higher working pressures and forces, there are fittings that are made of cast iron, fabricated carbon steel and stainless steel that will provide the repair, safety factor and return to 100 % service capacity of the line. A common example of these fittings is a mechanical joint repair sleeve.

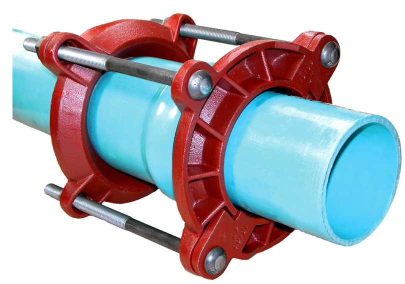
This type of fitting bolts on around the pipe and provides a gasketed end and side bar seal. Encompassing the entire damaged area. These are also commonly used over leaking cast iron, ductile iron and asbestos cement joints.

Fabricated repair sleeves can be designed and built to accommodate gaping holes on pipelines operating at high pressures. These sleeves can also be provided to repair damaged areas up to 12” in diameter for municipalities or distributors who are stocking repair fittings for their most common sized pipelines.

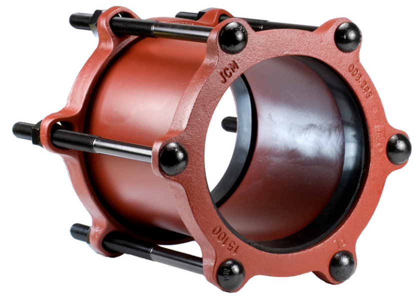
Other types of pipe such as Concrete Steel Cylinder Pipe and High Density Polyethylene Pipe require repair fittings that will accommodate the unique characterisitcs of the pipe and maintain a successful repair for the life of the pipeline.



Leaking Bell/Spigot Joint problems are solved with Bell Joint Leak Clamps. With the advance design of pipe, problems with joints have been reduced over the years, however, a number of systems with older pipe face this problem daily. Usually a quick cure to the old, leaking lead joint cast iron or older gasketed joint ductile iron is this fitting that bolts on round the pipe and “packs” a gasket into the leaking joint area, sealing off the leak.

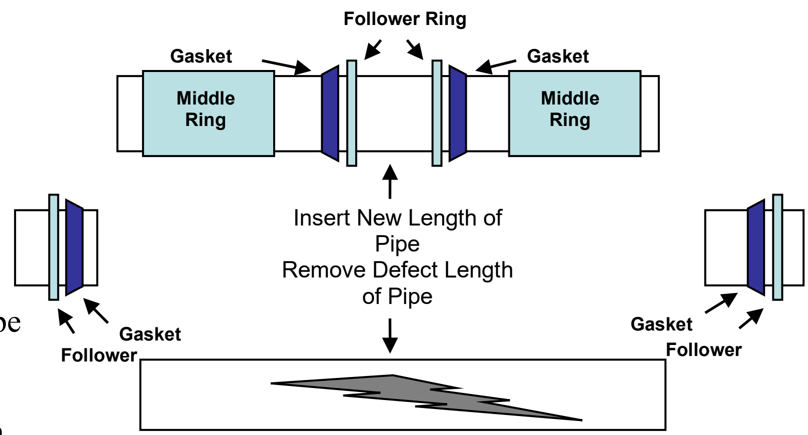


Pipe Repair with Bolted Couplings



Extensive pipe damage that is beyond repairing with a Repair Clamp or other repair fittings should be removed and replaced. This application exposes the line to other outside elements, but with prior knowledge and planning, a superintendent can use the repair to an advantage.

This type of repair requires a line shutdown (or a line bypass system). It entails cutting the pipe on each side of the damaged area and replacing that section of pipe with a new length of pipe and two bolted couplings to join the section back into the line.



The benefits of using bolted couplings:

- Relieves stress – accommodates ground movement or shifting
- Eliminates precise curring of pipe ends
- Provides deflection capabilities
- Allows 3/8" expansion/contraction
- Absorbs shock and vibration
- Provides a quick, easy means of disassembling system maintenance

By planning ahead for the possibility of this type of repair situation, a superintendent can stock two flanged coupling adapters and a valve. Should an opportunity arise, using the flanged adapters (FCA's) and the valve in place of the pipe section, the repair installation can become a "zone isolation" allowing another shut off location in the system.

Installation of bolted couplings:

1. Clean pipe surface of all dirt, rust, mud or loose scale from pipe ends. Inspect the pipe ends where gaskets will contact the pipe for any gouges, grooves, irregularities or imperfections that will interfere with the gasket seal. Measure the cleaned pipe diameter to confirm proper size of coupling for application. Inspection of the pipe's integrity for product application is the responsibility of the end user. ***TIP*** *Difficult to reach or cramped areas on the backside or underside of the pipe can be visually checked by using a mirror.*

2. *Measure back on each pipe end one-half of the middle ring length plus two inches and place a reference mark. These marks will be a visual reference point for centering the middle ring over the joint.* ***TIP*** *Couplings perform at optimal effectiveness when centered over joint area.*

3. *Install follower rings, then gasket onto the pipe ends.* **NOTE:** Flat side of the gasket face meets the follower ring, the tapered side inserts into the middle ring. ***TIP*** *To ease installation of the gaskets, pipe should be lubricated with water or soapy-water mixture. Alcohol may be added to water in freezing weather.* **DO NOT** use pipe lubricant or grease based products to lubricate.

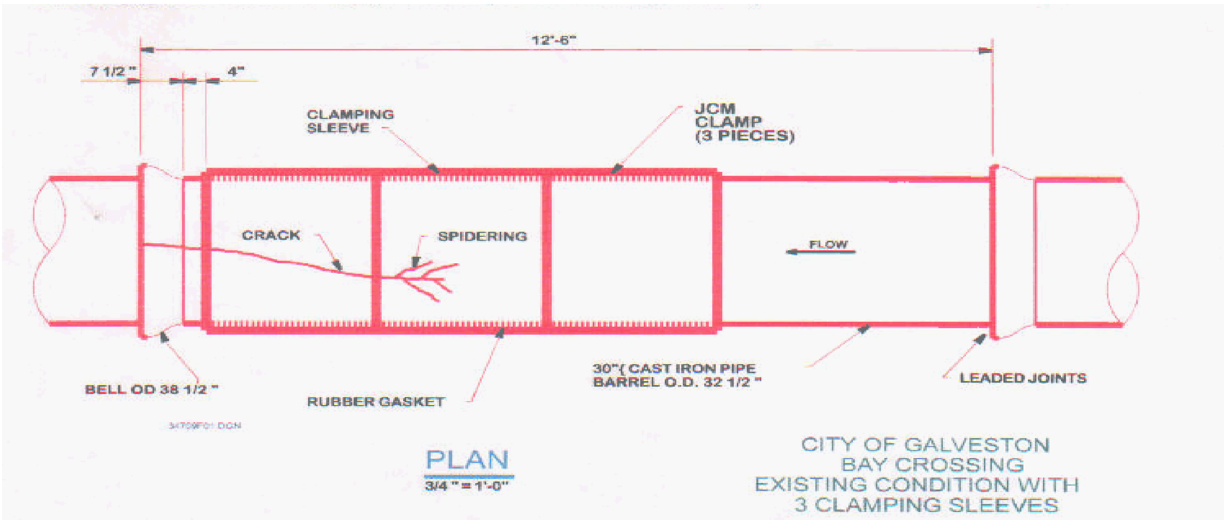
4. Install middle ring on one pipe end. Insert other pipe end into middle ring and center the middle ring over the joint, between the reference marks. Lift the center ring when installing gaskets to center gasket evenly on top and bottom. Otherwise the heavy ring tends to have smaller cavity on the top and large opening on the bottom, preventing the gasket from seating into the cavity equally.

5. Torque coupling bolts on opposite sides, using a star rotation pattern, drawing up the followers evenly until all bolts have been tightened to a minimum of 75 foot pounds of torque.

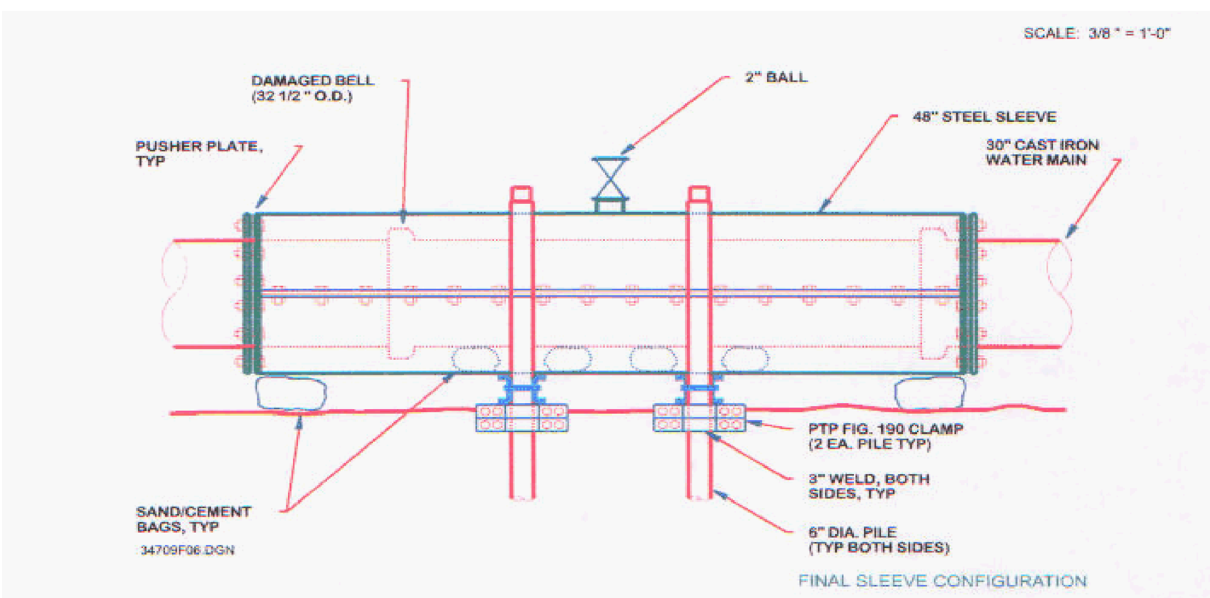
   NOTES: On joints that do not permit centering of the coupling, the pipe ends must be inserted past the end of the gasket a minimum of one and one-half (1-1/2") inch. For applications with deflection or offset pipe ends, the pipe end must be inserted a minimum of one and one-half (1-1/2") inch past the end of the gasket after the deflection/offset has occurred. Do not exceed a recommended 4° of pipe deflection with the coupling without inspecting the centering and sealing of the gasket in the middle ring and follower ring. Excessive deflection will cause the gasket to improperly seal. Lift the middle ring to insure that the gasket is evenly centered in the ends.

Unique Applications of Repair Fittings on In-Service Pipelines

PROBLEM: Underwater 30" Cast Iron Pipe about 100 years old. Galveston Island water supply from City of Houston. Numerous leaks and breaks, old valves and growing demands put enormous stress on the older line. *Note the temporary JCM Universal Clamp Couplings.*



SOLUTION: 114 MJ Bell Repair Sleeve
JCM submitted a custom fabricated 114 MJ Repair Sleeve to isolate the entire section of pipeline and permanently seal the damaged areas.



Pipe Joints

A joint is the connection between elements in a piping system. Five common types of joints used are:

Bell and Spigot/Mechanical Joint/Push-On Joint
Welded
Fusion (HDPE)
Screwed
Flanged

Bell and Spigot joints are used for connecting lengths of water pipe. The enlarged section at one end of the pipe is the bell; the plain end is the spigot. For cast iron, ductile iron, PVC, concrete (reinforced and CSCP), clay, etc. The bell spigot was developed in 1785 and was used extensively for new installation until the 1950's. This joint is assembled by caulking yarn or braided hemp into the base of the annular bell cavity, then pouring molten lead into the remaining space inside the bell. Upon solidification, the lead is compacted by caulking creating a water-tight seal.

The **Mechanical Joint** was developed for gas industry use in the late 1920's, but has since been used extensively in the water industry. This joint utilizes the basic principle of the stuffing box.

Push-on Joint was developed in 1956 and represented an extremely important advance in the water distribution field. This joint consists of a single rubber gasket placed in a groove inside the bell end of the pipe. By pushing the plain end of the pipe through the lubricated rubber gasket, the gasket is compressed and the joint become pressure tight.

Welded is the process of heating materials to such a high temperature that the sections to be joined melt and blend together. Welded joints are often chosen for applications involving high pressure and temperatures.

Fusion joints are similar to the welded joints; the material is actually heated to a high temperature and melted together.

Screwed Joints are threaded joints are commonly used to join sections of smaller diameter pipe which carries fluids at low pressure and normal temperatures.

Flanged Joints are connected to pipe ends by threading then faced off. Not for used underground because joint is so rigid.

PIPE

Sizes of Pipe

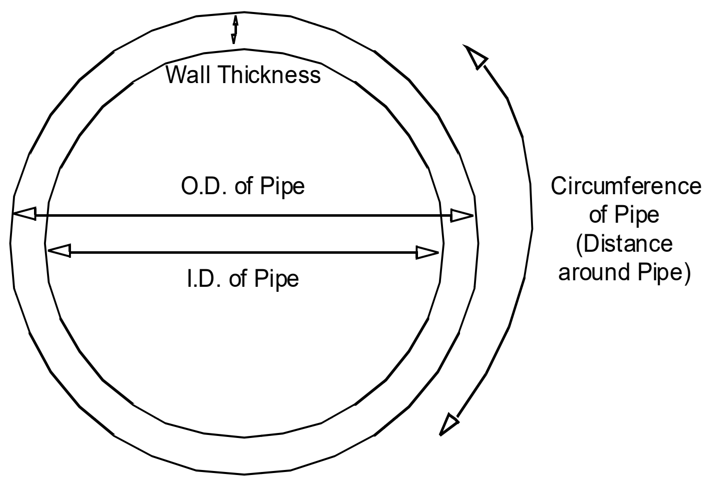
Pipe sizes are referred to by the "Nominal" pipe size. This size is based on the Inside Diameter (I.D.) of the pipe. For example, a Nominal 6" pipe has a 6" I.D. (within a tolerance).

Fittings and fabrications for repair, connection and branching are sized by and identified with the Outside Diameter (O.D.) of the pipe. In a few instances, we are concerned with the I.D. of the pipe (line stops, tapping HDPE). In general, familiarity with nominal sizes and the related O.D.'s is a must for superior customer service.

Another pipe dimension utilized in some applications is the Wall Thickness Formulas

Determine the O.D. By: Circumference ÷ ∏ (3.1416) = Outside Diameter

Determine the O.D. By: Wall Thickness x 2 + I.D. of pipe = Outside Diameter



Determine the Circumference By: Outside Diameter x ∏ (3.1416) = Circumference

Pipe diameters are affected by:

Tolerances - allowed by manufacturing standards for that specific type of pipe.
Manufacturing - historic methods of manufacturing pipe were unable regulate the outside diameter of the pipe.

Occasionally pipe dimensions will be provided in fraction measurements. To facilitate conversion of these figures this decimal equivalent chart is provided.

Decimal Equivalent Chart									
1/32	.03	1/4	.25	7/16	.44	5/8	.63	13/16	.81
1/16	.06	9/32	.28	15/32	.47	21/32	.66	27/32	.84
3/32	.09	5/16	.31	1/2	.50	11/16	.69	7/8	.88
1/8	.13	11/32	.34	17/32	.53	23/32	.72	29/32	.91
5/32	.16	3/8	.38	9/16	.56	3/4	.75	15/16	.94
3/16	.19	13/32	.41	19/32	.59	25/32	.78	31/32	.97

Common Pipe Types and Diameters

Nominal Pipe Size (In Inches)	IPS/PVC Steel IPS/HDPE	C-900/905 Ductile Iron Cast Iron DI/HDPE	Asbestos Cement Class 150	PIP	SDR35 Sewer
2”	02.38	02.50			
3’	03.50	03.96	04.13		
4”	04.50	04.80	05.10	04.13	04.22
5”	05.56				
6”	06.63	06.96	07.20	06.14	06.28
8”	08.63	09.05	09.40	08.16	08.40
10”	10.75	11.10	12.00	10.20	10.50
12”	12.75	13.20	14.20	12.24	12.50
14”	14.00	15.30	16.50	15.30	15.30
16”	16.00	17.40	18.75	18.70	18.70
18”	18.00	19.50	21.30		
20”	20.00	21.60	23.64		
24”	24.00	25.80	28.32		24.80
30”	30.00	32.00	35.42		
36”	36.00	38.30			

Types of Pipe that Require O.D. Verification
Cast Iron, Pit Cast Iron
Asbestos Cement (Class 100, 150, 200)
Soil Pipe
Clay Pipe
Steel Pipe (O.D., West Coast)
Fiberglass
Reinforced Concrete

PIPE
Basic Types of Pipes

1. Usages
    - Service Connection Pipe
    - Distribution System
    - Transmission System
    - Sewer Collection - Gravity
    - Sewer Main - Gravity and Force Main)
    - Irrigation
    - Industrial

2. Common Types of Pipe

Rigid Pipe	**Non-Rigid Pipe**
Cast Iron	IPS PVC (Polyvinylchloride)
Ductile Iron	C-900/C-905 PVC
Asbestos Cement	HDPE (High Density Polyethylene)
Steel	Fiberglass (Permastrand)
Reinforced Concrete Pipe	Irrigation Pipe
Concrete Steel Cylinder Pipe	Sewer Pipe
Soil Pipe (Cast Iron)	
Clay, Vitrified Clay	
Copper (soft pipe)	
Aluminum	

3. General Pipe Description / Characteristics

Cast Iron - (no longer manufactured, miles and mile of it in the ground) is widely used for water transmission and distribution, gravity sewers and force mains, water and sewage treatment plants and industrial piping. Its characteristics made it an ideal piping material for underground, underwater and above ground installations. Cast Iron (Gray Iron) is an alloy of iron and carbon containing appropriate amounts of silicon, manganese, phosphorus and sulfur. In gray cast iron, a major part of the carbon content occurs as free carbon or graphite in the form of flakes interspersed throughout the metal. Cast iron has excellent corrosion resistance and is more easily machined that most other metal because the graphite flake break up the chips and lubricate the cutting tool. This "flaky" matrix creates a disadvantage in that flakes will "break" thus making this pipe brittle and less malleable. Because of early manufacturing processes and the lack of industry standards, old Pit Cast Pipe and a large percentage of Cast Iron Pipe have unique pipe diameters and they should be verified prior to manufacturing fittings.

Ductile Iron - (replaced cast iron) is usually defined as cast iron with primary graphite in the nodular of spheroidal form. The chemical composition of ductile iron is similar to gray cast iron except for an inoculant, (usually magnesium) that changes the graphite form to the nodular shape. This nodular or spheroidal form provides a malleable characteristic or gives “ductility” to the pipe. Ductile iron, as compared to gray cast iron, will have about twice the strength as determined by various tests. The pipe is strong, rugged and is corrosion resistant. This pipe was developed in 1948 and is generally manufactured to industry standard pipe tolerances.

Asbestos Cement - (no longer manufactured in U.S., miles in the ground, still manufactured in Mexico) made of Asbestos, Pulverized Sand, Portland Cement and silica (A/C) is highly resistant to attack by corrosion. One of the first uses was for piping salt water. This pipe was easy to install, it weighs approximately one-half as much as cast-iron pipe of equal size and class. The pipe is immune to electrolysis, reduced flow losses, eliminated tuberculate problems, is easy to cut and machine in the field. However, it is a brittle pipe that is subject to breaking under stress situations, carries irregular diameters and has been determined harmful when cutting or drilling.

Steel Pipe - is most common in industrial applications due to its resistance to chemicals and harsh line contents. Steel pipe can be fabricated to any O.D. which makes specific inquiry about the pipe crucial. Generally Steel pipe is manufactured to “Schedule” sizes. The most common schedule numbers used are 40, 80, 120, and 160. The Schedule number range from 10 to 160, the difference being the wall thickness. As the number gets greater, the wall thickness increases towards the I.D. of the pipe, keeping the O.D. Constant. Thus, 6” Schedule 10 steel pipe has the 6.63 O.D. and the 6” Schedule 80 steel pipe has a ticker wall, but the O.D. is still 6.63. Codes devised by engineering societies and standard groups determine the minimum pipe size and will thickness to use in given applications. Underground steel pipe is commonly Cement Coated to prevent corrosion. This should not be confused with Concrete Steel Cylinder Pipe.

Soil Pipe - is cast iron sewer pipe manufactured to different O.D.’s for gravity flow sewer applications. Thin wall and different O.D.’s make this pipe unique, yet commonly used. Double check dimensions given by customers. Be aware that some Soil Pipe was manufactured to IPS/Steel Pipe diameters for industrial use.

Vitrified Clay Pipe (Sewer) - is corrosion and abrasion resistant. Manufactured from clay and shale, the manufacturers developed the inherent strength and load bearing capacities. Clay pipe has a long life expectancy, is chemically inert, low friction flow characteristic, structural integrity, abrasion resistance, is easy to handle and is economical. Vitrified clay pipe is the most corrosion-proof product available for industrial and sewage wastes. 4” - 36”

IPS (Iron Pipe Size, steel pipe O.D.) PVC (Polyvinylchloride) - provides the desirable combination of chemical resistance, good long-term strength and high stiffness that accounts for PVC having become a popular pipe material for many pressure and non-pressure applications. PVC has become a strongly used pipe material for major markets including pressure and non-pressure sanitary sewer and pressure water distribution market. New technology has allowed larger pipe diameters and efficient use of materials, resulting in the PVC being introduced to buried pipe market including gravity storm sewers, highway drainage, agricultural drainage and the larger diameter pressure transmission pipe market. PVC is a thermoplastic and is manufactured using an extrusion process. The ability to be reheated and reformed also enables PVC pipes to be manufactured with a post-extrusion, heat formed bell end for joining.

However, this material is plastic and does have the disadvantage of limited pipe load, limited hoop stress and point loading, earth load, egg shaping etc. factors that affect pipe fitting applications and must be allowed for.

C-900/C-905 PVC - PVC pipe with Ductile Iron Diameters, developed to compete with the ductile iron market (pressure and size). Higher pressure capabilities than IPS PVC and utilizing common industry fittings (MJ, Valves, etc.). Corrosion resistance, durability, availability, installation and economically is more preferred in some areas of the country than Ductile Iron Pipe. The C-900 Standard is for sizes 4" - 12" and the C-905 Standard is for sizes 14" - 36".

Fiberglass (Permastrand) - is a thermosetting plastic and remains hardened once it has been formed; it cannot be softened and rehardened as a thermoplastic (PVC). This pipe is a thin wall, glassy type surface that will not stand up to point loading. Not commonly used.

Irrigation Pipe - (Plastic Irrigation Pipe PIP) - available for both high pressure and low pressure applications. The pipe diameters are smaller than IPS or C900/905 pipe. Larger sizes generally used for agricultural irrigation. Sizes 4" - 15"

Plastic Sewer Pipe (SDR 35) - Non-pressure pipe for gravity flow sewer applications. Smaller pipe diameters. Sizes 4" - 36".

Reinforced Concrete Pipe

Concrete Steel Cylinder has unique characteristics. JCM manufactures the 116 Reparand often the pipe manufacturer should be contacted for repair guidance.

What is SDR?

Standard dimension ratio (SDR) is a method of rating a pipe's durability against pressure. The standard dimension ratio describes the correlation between the pipe dimension and the thickness of the pipe wall. Common nominations are SDR11, SDR17 and SDR35. Pipes with a lower SDR can withstand higher pressures.

From JM Eagle Pipe Website: What is the difference between DR and SDR?

The terms "dimension ratio" and "standard dimension ratio" are widely used in the PVC pipe industry. Both terms refer to the same ratio, which is a dimensionless term that is obtained by dividing the average outside diameter of the pipe by the minimum pipe wall thickness.

Dimension ratios and standard dimension ratios were developed out of convenience rather than out of necessity. They have been established to simplify standardization in the specification of plastic pipe on an international basis. Since these define a constant ratio between outer diameter and wall thickness, they provide a simple means of specifying product dimensions to maintain constant mechanical properties regardless of pipe size. In other words, for a given DR or SDR, pressure capacity and pipe stiffness remain constant regardless of pipe size.

Even though the terms DR and SDR are synonymous, one minor difference between them is that SDR refers only to a particular series of numbers, i.e., 51, 41, 32.5, 26, 21, etc. This series of "preferred numbers" is based on a geometric progression, and was developed by a French engineer named Charles Renard. These numbers are often called "Renard's Numbers."

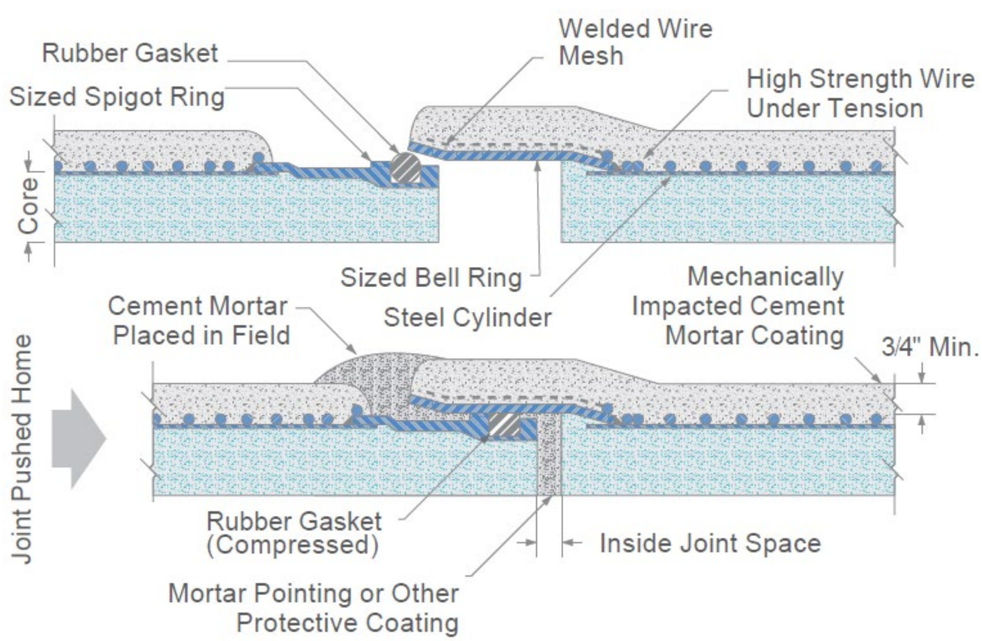
The term DR became widely used, in 1975, with the publication of AWWA C900, which governs production of small diameter PVC pressure pipe. AWWA allowed the desired pressure capacity to dictate wall thickness. Since the OD/t values generated did not happen to fall on any of Renard's Numbers, AWWA removed the "standard" designation from the SDR term.

It is interesting to note that the most widely used product for small diameter sanitary sewer in the U.S., ASTM D3034, SDR 35, provides an apparent contradiction in terms. While 35 is not a Renard Number, it is still referred to as a standard dimension ratio. In fact, all OD/t ratios in D3034 are listed as SDRs whether they are included in Renard's "preferred numbers" or not. This was probably for convenience's sake. D3034 was written in 1972, prior to the popularization of the DR term. Accordingly, ASTM may have allowed all OD/t ratios to be called SDRs.

The bottom line is simple: the two terms are interchangeable. SDR=DR=OD/t.

Plastic Pipe Institute: Certain DRs that meet an ASTM International specified number series (32.5, 26, 21, 17, 13.5, 11, 9 and 7.3) are referred to as Standard Dimension Ratios, SDR.

From Thompson Pipe Group:
Prestressed Concrete Cylinder Pipe – PCCP C301L (Lined Cylinder Pipe)
In Prestressed Concrete Lined Cylinder Pipe (L-301), prestressing is achieved by helically wrapping, under measured tension and at uniform spacing, a high tensile strength wire around the concrete-lined steel cylinder. This wire wrap places the steel cylinder and concrete core in compression, developing the pipe's ability to withstand specified hydrostatic pressures and external loads with a safety factor comparable to other waterworks piping materials.



Embedded Presstressed Concrete Cylinder pipe (C301)

In Prestressed Concrete Embedded Cylinder Pipe (E-301), prestressing is achieved by helically wrapping, under measured tension and at uniform spacing, a high tensile strength wire around the concrete core. This wire wrap places the concrete core and the embedded cylinder in compression, developing the pipe's ability to withstand specified hydrostatic pressures and external loads with a safety factor comparable to other waterworks piping materials.