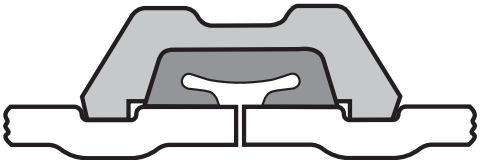
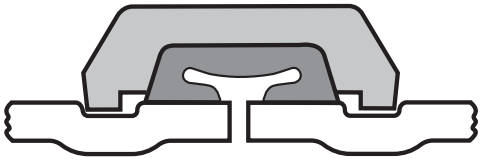
Grinnell Mechanical Products Design Data System Design

Rigid Joints



Grinnell Rigid Couplings provide rigid gripping of the pipe. They are designed to bring the pipe ends closely together and the coupling clamps firmly onto the pipe OD and also into the bottom of the grooves. Because rigid couplings clamp around the entire pipe surface, they provide resistance to flexural and torsional loads and therefore permit longer spacing to ASME/ ANSI B31.1 (Power Piping) and ASME/ANSI B31.9 (Building Services) requirements.

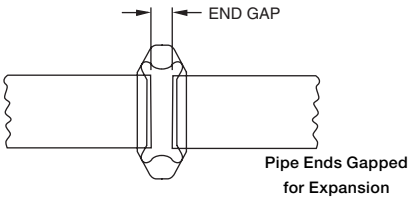
Flexible Joints



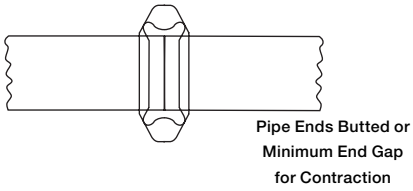
Grinnell Flexible Couplings act as an expansion joint, allowing linear and angular movement of the pipe. They are designed with the coupling keys engaging the pipe without gripping on the bottom of the grooves, while still providing for a restrained mechanical joint. This is particularly useful to allow for pipe expansion/contraction and piping misalignment.

Linear Movement (Flexible Couplings)

For thermal expansion with flexible couplings, the pipe ends at each joint should be fully gapped to the maximum end gap. This can be accomplished by pressurizing the system and then anchoring the system.



For thermal contraction with flexible couplings, the pipe ends at each joint should be at the minimum end gap. The system can then be anchored in place to prevent the pipe ends from opening up to the maximum end gap when pressurized.



For design purposes, the maximum pipe end gap should be reduced to account for field practices as follows:

End Gap Reduction	
Pipe Size ANSI Inches DN	**Maximum Pipe End Gap Reduction**
1 - 3 (DN25 - DN80)	50%
4 - 24 (DN100 - DN600)	25%

Therefore the following values should be used as available pipe end movements for Grinnell Figure 405, 705, and 707 flexible couplings:

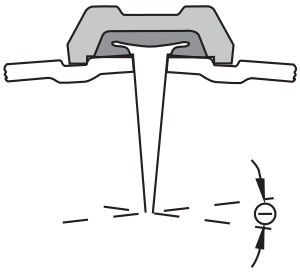
Pipe End Movements		
Pipe Size ANSI Inches DN	**Cut Grooved Inches / (mm)**	**Roll Grooved* Inches / (mm)**
1 - 3 (DN25 - DN80)	0 - 0.063 (0 - 1,6)	0 - 0.031 (0 - 0,8)
4 - 24 (DN100 - DN600)	0 - 0.188 (0 - 2,4)	0 - 0.094 (0 - 2,4)

* Roll grooved joints provide 1/2 the available movement of cut grooved joints.

IMPORTANT
Refer to Technical Data Sheet G1100 for warnings pertaining to regulatory and health information.

Angular Deflection

Grinnell Flexible Couplings are capable of accommodating angular deflection

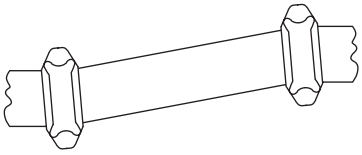


The deflection published is a maximum value. For design purposes the maximum deflection should be reduced to account for field practices as shown:

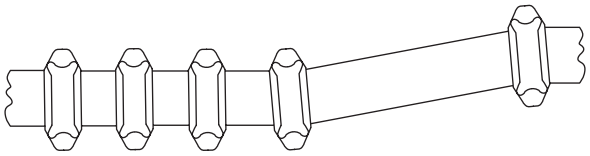
Deflection	
Pipe Size Inches DN	**Maximum Pipe Deflection Reduction**
1 - 3 DN25 - DN80	50%
4 - 24 DN100 - DN600	25%

Expansion/Contraction

Grinnell Flexible Couplings are capable of accommodating pipe thermal movements provided they are properly gapped, anchored, and a sufficient quantity of flexible couplings are used. Note that flexible couplings will not accommodate both full maximum linear movement and the maximum available angular deflection concurrently at the same joint.



If it is desired to have both deflection and linear movement available, then the system should have sufficient flexible joints to accommodate the requirement.



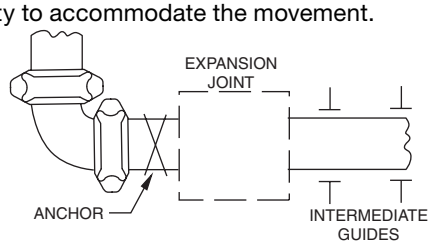
Thermal Movement

The following guidelines are similar to any expansion joint:
It is recommended that anchors be installed at changes of direction on the pipe lines to control the pipe movement. The thermal expansion/contraction in the piping system can be accommodated utilizing Grinnell Flexible Couplings. In designing anchoring systems, it is suggested that the following be taken into consideration as a minimum:

- Pressure thrusts
- Frictional resistance of any guides or supports
- Centrifugal thrust due to fluid velocity at changes of direction
- Activation force required to compress or expand a flexible coupling

Three methods are available as examples to accommodate thermal expansion/contraction:

1) Design the system with rigid couplings and place expansion joints at the proper locations. Expansion joints may be a series of flexible grooved couplings of a sufficient quantity to accommodate the movement.



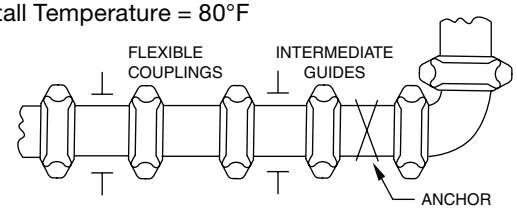
2) Design the system with flexible and/or rigid couplings and allow the pipe to move in directions desired, with the use of anchors and guides if so required. With this method, it is important to ensure that movement at branch connections, changes of direction, equipment hookup, etc., will not cause damage or harmful stresses.

Activation Force				
Pipe Size ANSI Inches DN	**Activation Force Lb/(N)**		**Pipe Size ANSI Inches DN**	**Activation Force Lb/(N)**
1 DN25	30 (134)		4 DN100	240 (1068)
1¼ DN32	35 (156)		5 DN125	375 (1668)
1½ DN40	45 (200)		– DN150	500 (2224)
2 DN50	70 (311)		6 DN150	520 (2313)
2½ DN65	100 (645)		8 DN200	880 (3914)
– DN65	110 (489)		10 DN250	1365 (6072)
3 DN80	145 (645)		12 DN300	1915 (8519)

3) Design the system with flexible couplings utilizing the expansion/contraction capabilities of these products.

The following example illustrates this method:

- 6 in. Schedule 40 Steel Pipe, Roll Grooved, 150 ft long, anchored at each end.
- Maximum Temperature = 200°F
- Minimum Temperature = 40°F
- Install Temperature = 80°F



Thermal Movement -continued

To calculate the number of couplings required in this example to compensate for the Thermal Expansion and Contraction of the pipe:

1. **Thermal Contraction:** Utilize the Thermal Expansion Table. Allowance for installation temperature to the minimum temperature, in this case 80°F to 40°F is calculated as:
   80°F = 0.61" per 100'

   40°F = 0.30" per 100'

   Difference = 0.31" per 100'

   For 150' of pipe = 0.31" x 1.5 = 0.47" per 150'
2. **Thermal Expansion:** Utilize the Thermal Expansion Table. Allowance for installation temperature to the minimum temperature, in this case 80°F to 200°F is calculated as:
   200°F = 1.52" per 100'

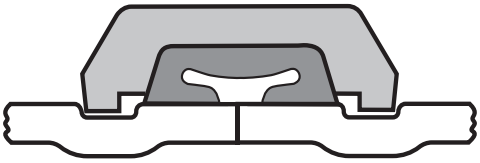
   80°F = 0.61" per 100'

   Difference = 0.91" per 100'

   For 150' of pipe = 0.91" x 1.5 = 1.36" per 150'
3. **Couplings Required:** Available linear movement for a 6" Figure 707 Flexible Couplings on roll grooved pipe = 0.094" per coupling.
   a) **Fully Butted Together for Contraction Only**
   Therefore the number of flexible Figure 707 Couplings required is:

   0.47" / 0.094" per coupling = 5.0

   Use 5 Figure 707 Couplings for pipe contraction



Thermal Expansion of Carbon Steel in Inches/100 Feet (Millimeters/30.5Meters) Between 0°F (-18°C) and Indicated Temperature			
Temperature °F (°C)	**Inches/100 Feet (mm/30,5m)**	**Temperature °F (°C)**	**Inches/100 Feet (mm/30,5m)**
-40 (-40)	-0.30 (-7,62)	100 (37,8)	0.76 (19,30)
-30 (-34,4)	-0.23 (-5,84)	110 (43,3)	0.84 (21,34)
-20 (-28,9)	-0.15 (-3,81)	120 (48,9)	0.91 (23,11)
-10 (-23,3)	-0.08 (-2,03)	130 (54,4)	0.99 (25,15)
0 (-17,8)	0.00 (0,00)	140 (60,0)	1.06 (26,92)
10 (-12,2)	0.08 (2,03)	150 (65,6)	1.14 (28,96)
20 (-6,7)	0.15 (3,81)	160 (71,1)	1.22 (30,99)
30 (-1,1)	0.23 (5,84)	170 (76,7)	1.29 (32,77)
40 (4,4)	0.30 (7,62)	180 (82,2)	1.37 (34,80)
50 (10,0)	0.38 (9,65)	190 (87,8)	1.44 (36,58)
60 (15,6)	0.46 (11,68)	200 (93,3)	1.52 (38,61)
70 (21,1)	0.53 (13,46)	210 (98,9)	1.60 (40,64)
80 (26,7)	0.61 (15,50)	220 (104,4)	1.67 (42,42)
90 (32,2)	0.68 (17,27)	230 (110,0)	1.75 (44,45)

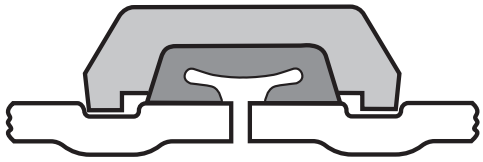
Mean Coef. of thermal expansion = 0.00000633 in/in/°F
Source: ASME B31.9

b) **Fully Gapped Apart for Expansion Only**

Therefore the number of flexible Figure 707 Couplings required is:

1.36" / 0.094" per coupling = 14.47

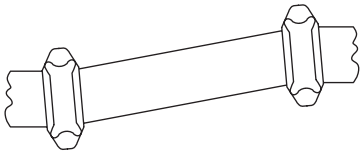
Use 15 Figure 707 Couplings for pipe expansion



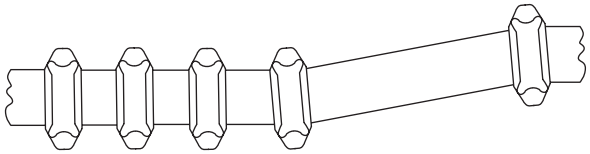
Misalignment and Deflection

Grinnell Flexible Couplings provide for restrained joints and allow for deflection to aid where the pipe or equipment is misaligned.

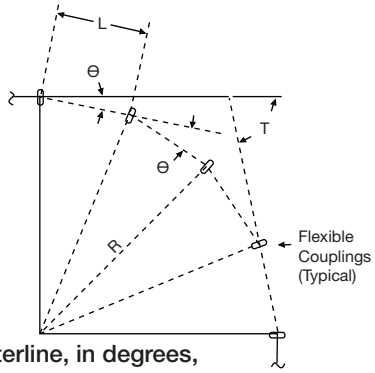
Note that flexible couplings will not accommodate both full maximum linear movement and the maximum available angular deflection concurrently at the same joint.



If it is desired to have both deflection and linear movement available, then the system should have sufficient flexible joints to accommodate the requirement.



Flexible couplings are also useful in laying out curved piping systems.



$R = \frac{L}{(2)\ (\sin\frac{\Theta}{2})}$

$L = (2)\ (R)\ (\sin\frac{\Theta}{2})$

$N = \frac{T}{\Theta}$

R = Radius of curve
L = Pipe length
Θ = Deflection from centerline, in degrees, for each coupling (see table)
N = Number of flexible couplings needed
T = Total deflection, in degrees, required

Design Deflection for Roll Grooved Pipe					
Pipe Size ANSI Inches DN	**Figures 405, 705 & 707**	**Pipe Size ANSI Inches DN**	**Figures 405, 705 & 707**	**Pipe Size ANSI Inches DN**	**Figures 405, 705 & 707**
1 DN25	1.38°	– DN65	0.60°	6 DN150	0.81°
1¼ DN32	1.08°	3 DN80	0.50°	8 DN200	0.63°
1½ DN40	0.94°	4 DN100	1.19°	10 DN250	0.50°
2 DN50	0.75°	5 DN125	0.97°	12 DN300	0.42°
2½ DN65	0.62°	– DN150	0.83°		

Pipe Support

All piping systems require that the support system accommodate the weight of the pipe, joint connections, fluid and other system components. In addition, consideration may be necessary in reducing stresses, accommodating thermal expansion or contraction, building settlement, seismic movement, etc. The following tables provide guidelines for grooved steel piping products without concentrated loads between supports.

Flexible Joints

For pipe runs when linear movement is accommodated by the flexible coupling:

Number of Hangers Per Pipe Length								
Pipe Size ANSI Inches DN	Pipe Length in Feet (m)							
	10 (3,3)	12 (3,7)	15 (4,6)	22 (6,7)	25 (7,6)	30 (9,1)	35 (10,7)	40 (12,2)
	Avg. Hangers Per Pipe Length							
1 - 2 DN25 - DN50	2	2	2	3	4	4	5	6
2½ - 4 DN65 - DN100	1	2	2	2	2	3	4	4
5 - 24 DN125 - DN600	1	1	2	2	2	3	3	3

For pipe when linear movement is not required:

Distance Between Supports	
Nominal Size ANSI Inches DN	Maximum Distance Between Supports Feet (m)
1- 1½ DN25 - DN40	12 (3,7)
2 - 8 DN50 - DN200	15 (4,6)
10 - 12 DN250 - DN300	16 (4,9)
14 - 16 DN350 - DN400	18 (5,5)
18 - 24 DN450 - DN600	20 (6,1)

Note: *The requirements of ANSI, ASME or other code groups may require additional supports.*

Rigid Joints

For pipe runs with rigid couplings:

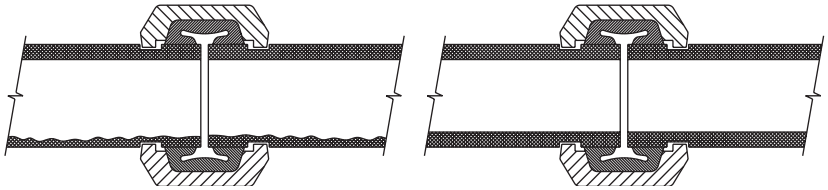
Pipe Size ANSI Inches DN	Suggested Maximum Span Between Supports Feet / (m)			
	Water Service I	Water Service II	Air Service I	Air Service II
1 DN25	7 (2,1)	9 (2,7)	9 (2,7)	10 (3,0)
1¼ DN32	7 (2,1)	11 (3,4)	9 (2,7)	11 (3,4)
1½ DN40	7 (2,1)	12 (3,7)	9 (2,7)	13 (4,0)
2 DN50	10 (3,0)	13 (4,0)	13 (4,0)	15 (4,6)
2½ DN65	11 (3,4)	14 (4,3)	14 (4,3)	16 (4,9)
– DN65	11 (3,4)	14 (4,3)	14 (4,3)	16 (4,9)
3 DN80	12 (3,7)	15 (4,6)	15 (4,6)	17 (5,2)
4 DN100	14 (4,3)	17 (5,2)	17 (5,2)	21 (6,4)
5 DN125	16 (4,9)	19 (5,8)	20 (6,1)	24 (7,3)
– DN125	17 (5,2)	20 (6,1)	21 (6,4)	25 (7,6)
6 150	17 (5,2)	20 (6,1)	21 (6,4)	25 (7,6)
8 DN200	19 (5,8)	21 (6,4)	24 (7,3)	28 (8,5)
10 DN250	19 (5,8)	21 (6,4)	24 (7,3)	31 (9,4)
12 DN300	23 (7,0)	21 (6,4)	30 (9,1)	33 (10,1)
14 DN350	23 (7,0)	21 (6,4)	30 (9,1)	33 (10,1)
14 DN400	27 (8,2)	21 (6,4)	35 (10,7)	33 (10,1)
18 DN450	27 (8,2)	21 (6,4)	35 (10,7)	33 (10,1)
20 DN500	30 (9,1)	21 (6,4)	39 (11,9)	33 (10,1)
24 DN600	32 (9,8)	21 (6,4)	42 (12,8)	33 (10,1)

I - Spacing by ANSI B31.1 Power Piping Code
II - Spacing by ANSI B31.9 Building Piping Code

Rotational Movement

Grinnell Flexible Couplings are suitable for use in seismic as well as mining applications. The inherent capability of the flexible coupling to allow for linear movement, angular deflection, and rotational movement, make it an excellent choice for reducing stresses in a piping system and to increase pipe life in slurry applications.

For mining applications where the pipe needs to be rotated, the system should be depressurized and drained. The pipe couplings bolts/nuts can be loosened, pipe rotated and the bolts/nuts re-tightened and the system be put back in service.

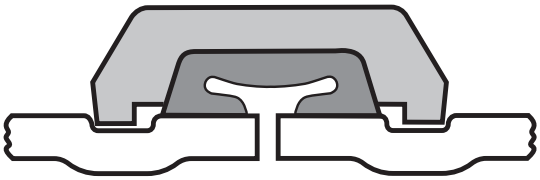


Even distribution of pipe wear can be achieved with this method on the inner service of the pipe.

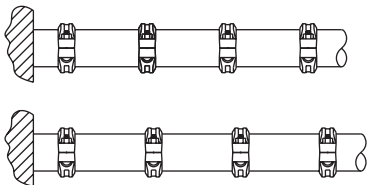
Note: Precautions are necessary to monitor pipe wall thickness to evaluate pressure capability of the pipe with reduced wall.

Linear Movement

Flexible couplings are designed with the coupling keys engaging the pipe without gripping on the bottom of the groove while still providing for a restrained mechanical joint.



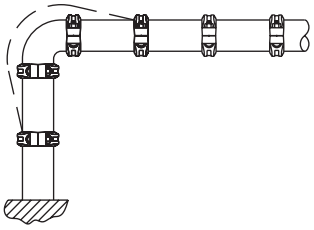
The inherent flexibility of the coupling must be considered when deciding on support arrangements for the piping system as movement can occur in more than one plane (linear movement, angular deflection and rotational movement).



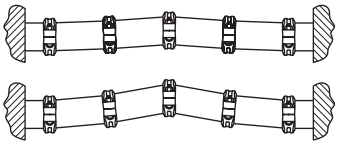
Upon system pressurization, each pipe end within the flexible couplings will expand to the maximum published value. The coupling keys make contact with the face of the groove and restrain the joint. In piping systems, this movement will be accumulative.

Angular Movement

System movement can be accommodated by providing for sufficient offset lengths. Temperature increases/decreases can further increase this movement.



When systems are anchored with partially deflected joints, the system can move to the fully deflected condition upon pressurization resulting in the “snaking” of the piping system. Light weight hangers may not be suitable to prevent the lateral motion.

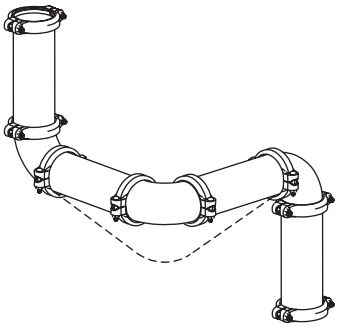


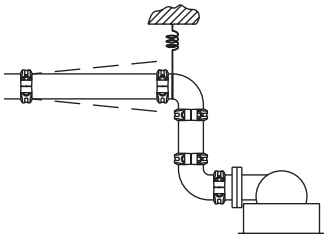
Pipe Support

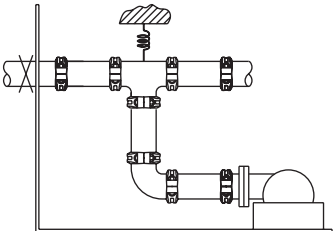
Pipe hanger positioning is important when considering pipe "sagging" due to the flexible nature of the piping system. Proper positioning of hangers near the elbow, for example, should be considered.

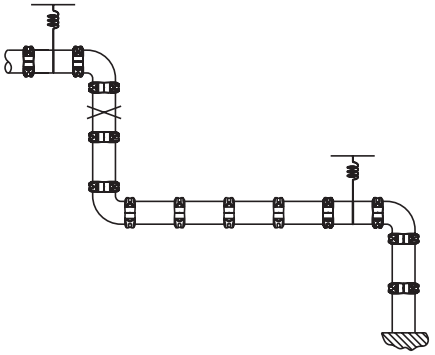
The use of spring hangers or other methods can be considered to accommodate vibrations. Base supports, pressure thrust anchors and pipe offsets can be used to direct pipe movement.

The use of rigid couplings can be considered to reduce the movement available with flexible couplings. Consideration to other methods of accommodation pipe movements may be required.









Vertical Piping

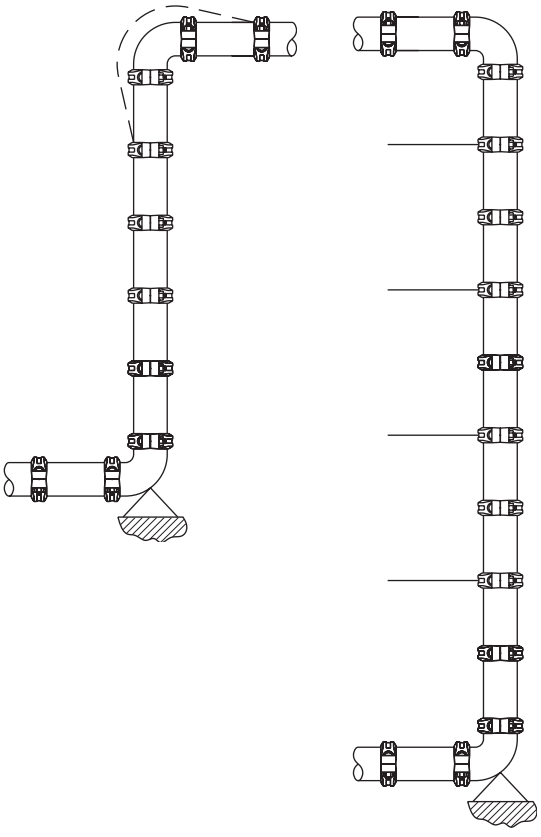
Risers comprised of rigid couplings can be considered similar to welded or flanged systems. Where thermal movement exists, expansion joints and/or flexible couplings with offsets may be required.

When using flexible couplings, the movement that occurs in long lengths of piping needs to be considered. Each joint can move up to the maximum pipe end separation published. This movement can accumulate and result in the growth of the piping system, for example, at the top. Offsets may be necessary.

Should the riser contain branch connections, the movement that occurs at these locations with flexible couplings, will also need to be considered.

One solution would be to anchor the vertical piping at appropriate locations to prevent movement that can cause stresses at the branches or equipment. The use of rigid couplings can be an advantage.

As always, good piping practice should prevail. It is the Designer's responsibility to select products suitable for the intended service and to ensure that pressure ratings and performance data is not exceeded. Never remove any piping component nor correct or modify any piping deficiencies without first depressurizing and draining the system. Material and gasket selection should be verified to be compatible for the specific application.



1400 Pennbrook Parkway, Lansdale, PA 19446 | Telephone +1-215-362-0700

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