Industrial Fiberglass Specialties, Inc.
521 Kiser Street
Dayton, OH 45404-1641
Tel: 937-222-9000
Fax: 937-222-9020

Thermal Expansion and Contraction

Industrial Fiberglass Specialties' pipe is filament wound and, therefore, has different thermal expansion in the hoop and axial direction. In the hoop direction, the thermal expansion is about the same as steel. However, in the axial direction, the thermal expansion is about twice that of steel.

The relatively low modulus of elasticity of the pipe is an advantage which should be considered in the design of a piping system. Since thermal forces are smaller, restraining equipment (guides, anchors, etc.) need not be as strong or heavy as for steel piping. There is some growth due to end load from pressure in the piping system. But experience has shown that his length change does not need to be considered in designing a piping system. FRP composite piping systems can handle thermal shocks between maximum rated operating temperatures and -40°F, unless the pipe joints are mechanical joint style.

To determine the effects of expansion and contraction within a piping system, it is necessary to know:

1. The design temperature conditions.

2. The type and size of pipe.

3. The layout of the system including dimensions and the thermal movements, if any, of the terminal points.

4. The limitations on end reactions at terminal points, as established by equipment manufacturers.

5. The temperature changes for expansion are calculated by subtracting the installation temperature (temperature at time of final tie in) from the maximum design temperature. Temperature changes for contraction are calculated by subtracting the minimum design temperature from the installation temperature.

Expansion and contractions of above ground fiberglass pipe may be handled by several different methods. Four methods are:

-- Direction Changes -- Anchors and Guides
-- Mechanical Expansion Joints -- Expansion Loops

Guides, Expansion Loops, and Mechanical Expansion Joints are installed in straight pipe lines which are anchored at both ends.

The experience of users of FRP composite piping systems has show that, if directional changes cannot be used to accommodate thermal expansion and contraction, then the guide spacing design approach is usually the most economical method.

Industrial Fiberglass Specialties, Inc.
521 Kiser Street
Dayton, OH 45404-1641
Tel: 937-222-9000
Fax: 937-222-9020

Operating experience with piping systems indicates that it is a good practice to anchor long straight pipe runs of above ground piping at approximately 300 foot intervals. These anchors prevent pipe movement due to vibration, water hammer, etc. Also an anchor is used wherever a pipe size change occurs. When joining FRP composite piping to other piping systems, the adjoining system **MUST** be securely anchored to prevent the transfer of thermal end loads.

A. LENGTH CHANGES

The total expansion/contraction per 100 feet (Δ L(in.)/100 ft.) for Industrial Fiberglass Specialties piping systems is give in Table 5.0 in 10°F increments. The total expansion/contraction (inches) is calculated by dividing the length of the line (ft.) by 100, and then multiplying by the expansion from Table 5.0. Interpolate to find the correct expansion when the temperature increments less than 10°F are not sufficient.

B. THERMAL END LOADS

The forces developed in FRP composite pipe by a temperature change are significantly less than the forces developed in steel pipe of the same diameter. For example: FRP composite pipe develops forces approximately 1/20 to 1/35 of those developed in Schedule 40 steel pipe of the same diameter, undergoing the same change in temperature.

The basic property of FRP composite pipe which produces these low thermal forces is the low axial modulus (approximately 1×10^6 psi) as compared with steel (approximately 30×10^6 psi). Table 5.1 is used to determine thermal end loads developed during temperature changes for each size and type of pipe.

C. EXPANSION JOINTS

Various types of expansion joints have been used successfully with FRP composite piping systems. Because the forces developed during a temperature change are relatively small as compared with metallic systems, it is <u>essential</u> to specify an expansion joint which is activated by low forces.

Industrial Fiberglass Specialties, Inc.
521 Kiser Street
Dayton, OH 45404-1641
Tel: 937-222-9000
Fax: 937-222-9020

TABLE 5.0
THERMAL EXPANSION/CONTRACTION
Inches per 100 Feet of Pipe

TEMP CHANGE °F	SERIES 5000 PIPE All Sizes
10	.13
20	.25
30	.33
40	.50
50	.63
60	.76
70	.88
80	1.01
90	1.13
100	1.26
110	1.39
120	1.51
130	1.64
140	1.76
150	1.89
160	2.02
170	2.14
180	2.27
190	2.39
200	2.52
210	2.65
220	2.77
230	2.90
240	3.02
250	3.15
260	3.28

The allowable activation force for expansion joints is dependent upon both the thermal forces developed, and the support spacing. Supports must be the type that prevent lateral movement. We suggest using 120° shoe-style supports. The maximum activation force allowable for pipe installed at standard support spacing is given in Table 5.2. Contact us for the equations used to calculate allowable activation force at other support spacings.

Industrial Fiberglass Specialties, Inc.
521 Kiser Street
Dayton, OH 45404-1641
Tel: 937-222-9000
Fax: 937-222-9020

Specification sheets are available from expansion joint manufacturers. Temperatures and pressure ratings should be checked to determine whether a particular expansion joint meets the design requirements for a particular system.

TABLE 5.1
THERMAL END LOADS FOR EXPANSION & CONTRACTION - FORCE (Pounds)
T(Δ F)

Type of Pipe	Size (in.)	20	40	60	80	100	120	140	160	180	200
Series 5000	2	150	300	450	600	750	900	1050	1200	1350	1500
	3	224	449	673	897	1121	1346	1570	1794	2019	2243
	4	291	582	873	1164	1455	1746	2037	2328	2619	2910
	6	573	1146	1718	2291	2864	3437	4009	4582	5155	5728
	8	904	1808	2711	3615	4519	5423	6326	7230	8134	9038
	10	1262	2524	3786	5048	6309	7571	8833	10095	11657	12619
	12	2072	4145	6217	8290	10362	12434	14507	16579	18652	20724
	14	3088	6176	9264	12353	15441	18529	21617	24705	27793	30881
	16	4006	8012	12019	16025	20031	24037	28043	32049	36056	40062

Three important design considerations which apply to systems containing expansion joints are:

1. The expansion join must be selected and installed so that it can accommodate any motion, in either direction, which can occur in the system. In most cases, this requires that a degree of preset be accomplished during installation. The amount of preset can be calculated using the following relationship:

$$\text{Length of Preset} = \frac{R(T_i - T_{min.})}{T_{max.} - T_{min.}}$$

Where:

R	=	Rated Movement of Expansion Joint (in.)
T_i	=	Temperature at Time of Installation (°F)
$T_{min.}$	=	Minimum Temperature (°F)
$T_{max.}$	=	Maximum Temperature (°F)

2. Suitable anchors must be provided to restrain the expansion joint.

3. Appropriate guides must be installed to assure that the pipe will move directly into the expansion joint.

Typical guides and supports require pads as shown when there is point contact. Supports can be snug or loose fitting around the pipe. Guides must be loose. In lines where thermal changes are frequent, pads should be as shown in Figure 5.0. Pads can be split sections of pipe bonded to pipe wall.

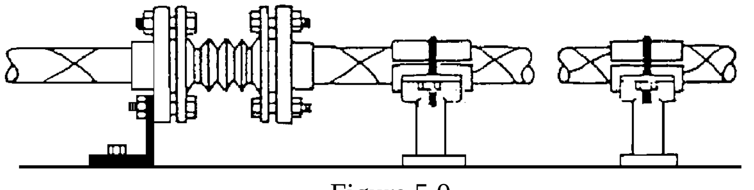

Figure 5.0
Expansion Joint

First guide, 4 diameters distance from expansion joint. Second guide, 14 diameters distance from expansion joint. Values give in Table 5.5

TABLE 5.2
ACTIVATION FORCES FOR EXPANSION JOINTS

(Maximum Allowable Compressive Activation Forces For Expansion Joints, Lbs. In any application, the activation force of the expansion joint must not exceed the thermal end loads developed by the pipe. Refer to Table 5.1 for thermal end loads.)[1]

NOMINAL PIPE SIZE (In.)	SERIES 5000 PIPE
1	--
1-1/2	--
2	171
3	457
4	857
6	2629
8	5647
10	10099
12	18285
14	28946
16	43010

[1] This table is based on using the support spacing for a pipeline full of water (specific gravity = 1) at 75°F. If the unsupported spans are greater, this table cannot be used.

Industrial Fiberglass Specialties, Inc.
521 Kiser Street
Dayton, OH 45404-1641
Tel: 937-222-9000
Fax: 937-222-9020

"Piping Handbook" by Crocker and King, published by McGraw-Hill, contains a very good section on design with expansion joints.

In some cases, the limited movement and the cost of expansion joints, make it economically impractical to use expansion joints. In these cases, the thermal expansion can be handled by expansion loops, guide spacing or installing a short length of flexible hose.