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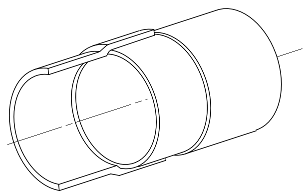
FIBERGLASS PIPE GROUP



Installation of Buried Bondstrand Pipe

Introduction

To ensure long life and trouble-free service from a Bondstrand piping system, the principles of excavation, joint make-up, bedding, backfilling and field testing must be properly applied. These principles must be reflected in the phrasing of contract documents and must be enforced through inspection. **Be sure that contractor personnel have been thoroughly trained in Bondstrand assembly procedures by a certified Ameron field representative.**

These recommendations for installing buried Bondstrand pipe are based on two principles:

- Follow Ameron's recommendations for assembling pipe sections and curing the joints carefully.
- Provide evenly distributed support for each section of pipe rather than concentrating the support at points or short stretches of the pipe bottom. Evenly distributed support is achieved through proper bedding.

1 Receiving, storing and handling fiberglass pipe

Bondstrand pipe is manufactured from fiberglass reinforced epoxy or vinyl ester resins. When properly handled and installed, fiberglass pipe and fittings will provide a maintenance-free, high-performance piping system. Fiberglass reinforced pipe and fittings are impact sensitive and **must** be handled with a reasonable amount of care. Refer to the Ameron publication SHIPPING, HANDLING, STORAGE AND INSPECTION OF BONDSTRAND FIBERGLASS PIPE, FP167 for pertinent guidelines and a table of pipe weights.

2 Trench design and excavation

1) The excavation must allow the pipe to be laid to the grades and alignments shown on the plans.

2) Provide the narrowest practical trench width that will allow proper compaction of the pipe zone backfill. The trench must have vertical sidewalls from the foundation to at least the top of the pipe. Maintain a minimum trench width equal to the inside diameter of the pipe plus 12 inches (300 mm). The maximum trench width from the foundation to the top of the pipe must not exceed the inside diameter of the pipe plus 24 inches (600 mm).

3) Beneath vehicular traffic, the height of earth cover over the top of the installed pipe must be no less than 3 feet (.91 m) unless suitable methods are used to protect the pipe. See ROADWAY CROSSINGS below.

4) Provide firm, but not hard foundations consisting of sound earth[1] or granular soil[2], and free from stones or lumps exceeding one inch (25 mm) in greatest dimension that might bear against the pipe. Prepare suitable foundations by overexcavating the trench for not less than 4 inches (100 mm) and backfilling

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2 Trench design and excavation

2 inches (50 mm) to subgrade with loose bank run material, graded uniformly in one plane for the full length of the pipe. Overexcavate at each bell so that the pipe barrel rests on the bottom of the trench. Foundations must provide uniform support under the haunches of the pipe along the full length of each pipe section.

5) When the excavation is in soft or wet, unstable soils that will not provide sufficient support for the pipe, overexcavated the trench at least 6 inches (150 mm) and backfill to 2 inches (50 mm) below subgrade with solid granular soil compacted to at least 85-95% Proctor (40-70% relative density). Then complete the subgrade as described in section 5. The method described in NFPA No. 24 section 8-4.3 under "Exception" is not acceptable for fiberglass pipe.

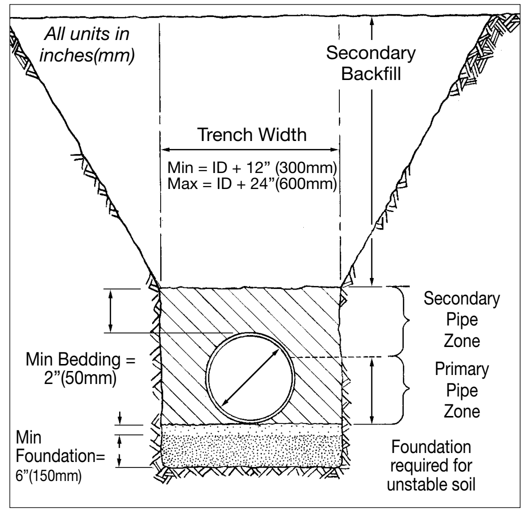


Fig.2. Pipe zone backfill should consist of sound earth or granular material free of stones or lumps exceeding 1 inch (25 mm) in diameter. The material should not contain vegetation or debris that could leave voids upon decomposition. Granular materials such as sand, gravel or crushed rock yield high densities with a minimum of compaction effort and have proven ideal for the pipe zone backfill. Granular materials should pass a ⅜-inch screen and no more than 15% should pass a No. 200 sieve.

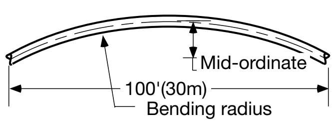
6) When solid rock, hardpan or other hard foundation is encountered during excavation, overexcavate the trench at least 6 inches (150 mm) and backfill to 2 inches (50 mm) below subgrade with solid granular soil compacted to at least 85-95% Proctor (40-70% relative density). Then complete the subgrade as described in section 5.

1) Most native soils, with the exception of highly organic, spongy soils and fat, highly plastic expansive clays.
2) Sand with a maximum particle size of ¼ inch (6 mm) or gravel with a minimum grain size of ¼ inch (6 mm), or pea gravel or crushed rock mixed with sand.

3 Assembling pipe and fittings

1) Prepare and assemble Bondstrand Quick-Lock joints in accordance with the recommendations contained in Ameron publication, FP170. For taper/taper joints to 6 inches (150 mm), consult Ameron publication FP104.

2) Position pipe on 4 x 4 timbers across the trench. Block pipe to hold alignment and prevent lateral movement during cure. For larger diameters, use of come-alongs for joint assembly.



Pipe Diameter		Mid-Ordinate to 100-ft Chord				Bending Radius			
		2000 Series		3000 Series		2000 Series		3000 Series	
(in)	(mm)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)
2	50	16.5	5.0	19.1	6.0	85	25	75	23
3	80	10.5	3.2	13.4	4.7	125	38	100	30
4	100	8.1	2.5	8.6	2.7	160	48	150	46
6	150	5.3	1.6	6.4	2.0	235	71	200	60
8	200	4.1	1.2	4.0	1.3	305	93	320	98
10	250	3.2	0.9	3.3	1.0	380	116	375	114
12	300	2.7	0.8	2.8	0.9	450	138	450	138
14	350	2.5	0.8	2.2	0.7	495	150	560	170
16	400	2.2	0.7	1.7	0.5	565	172	750	230

1) Curvature may be vertical, horizontal, or a combination. Restraints, if required for alignment control, shall each bear along at least 4 inches (100 mm) of pipe surface.

4 Placing pipe in trench

1) Cure the joints fully before lowering the pipe into the trench. Any vibration or movement of partially cured joints will increase the risk of joint failure.

2) When the joints have cured, raise the pipe slightly to remove the timber supports, using rope or webbed sling to lift the pipe. **Do not use chains.** Lower the pipe into the trench gradually. **Do not drop the pipe.** When working manually, use at least two men for 6-inch (150 mm) pipe and four men for 8 and 10-inch (200 and 250 mm) pipe. Install larger pipe with lifting equipment. Do not lift pipe over 10 inches (250 mm) in diameter or 30 feet (9 m) in length at a single point: use a spreader bar.

4 Placing pipe in trench

3) Should the depth of the trench measured from the top of the supports upon which the pipe is assembled to the trench bottom exceed 5 feet (1.5 m), do not lower the pipe by the method outlined in section 4 as it may overstress the pipe. It is the customer's responsibility to submit specific laying conditions (trench depth, handling equipment, pipe diameter, etc.) to Ameron for recommendations for trench depths in excess of 5 feet (1.5 m).

4) Pipe may be installed in curved trenches provided the curvature is uniform and does not exceed the tabulated values.

5 Bedding and backfill

Fill the pipeline with water or use other appropriate means to prevent buried pipe from floating during compaction with water in cohesionless soils.

1) Grade the trench bottom accurately and bed with sand to provide uniform bearing and support along the entire length of each pipe section. Provide a shallow depression for bells and couplings. The grade should not exhibit abrupt changes in direction or slope except at fittings.

2) Do not cover pipe joints until all pressure tests have been performed.

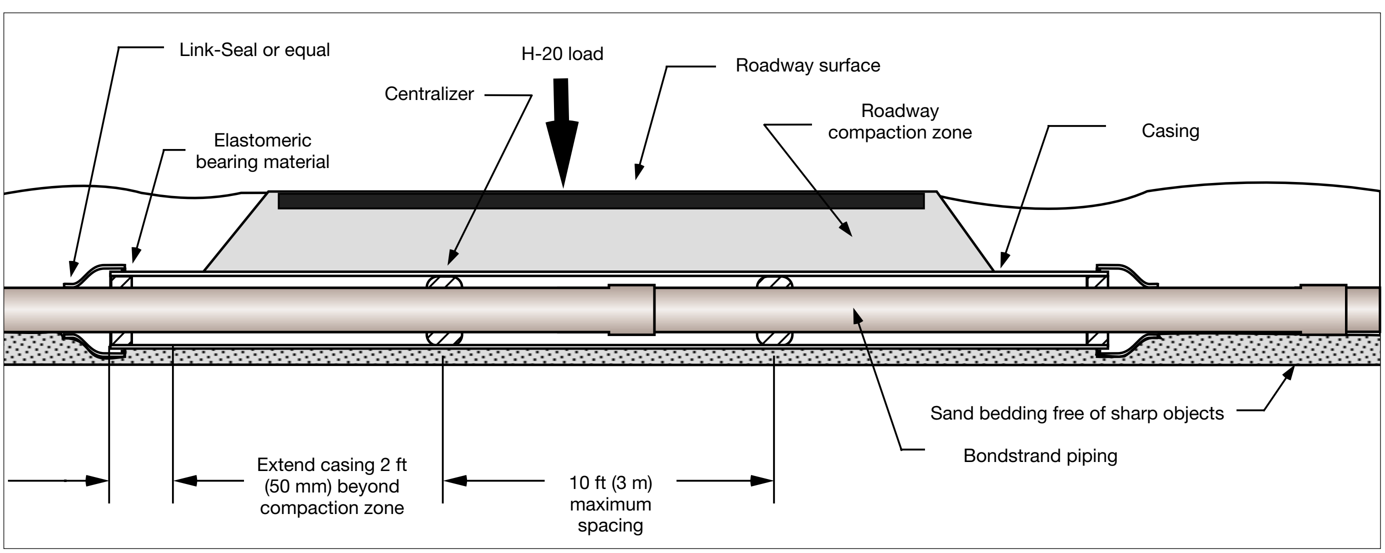
3) Compact the backfill uniformly around the pipe giving particular care to the bedding beneath the haunches of the pipe. Compaction may be done with water if the native soil is free draining. If the native soil is not free draining, bedding with damp sand will facilitate compaction. Extend backfill at least 6 inches (150 mm) above the pipe.

4) Place backfill in 6-inch (150 mm) maximum lifts to a point at least 2 feet (.6 m) above the top of the pipe. Do not use mechanical compactors directly over the pipe until at least 12 inches (300 mm) of fill have been placed over the pipe, or at least 24 inches (600 mm) if heavy compaction equipment is used. Compact each lift to 85% of maximum density as determined in accordance with ASTM D1557 for cohesive soils, or to 70% relative density in accordance with ASTM D2049 for cohesionless soils which fail to produce a well-defined, moisture-density relationship when tested in accordance with ASTM D1557. Avoid damage to pipe wall during compaction. Place the remaining backfill as directed by the engineer. Make in-place tests of soil density in accordance with ASTM D1556 or ASTM D2167. Contact Ameron Applications Engineering for specific information on ASTM specifications.

Mechanical compactors may be used provided harmful shock loads are not transmitted to the pipe. Maintain at least 12 inches (300 mm) between tamping feet and pipe wall to avoid damage to the pipe.

6 Roadway crossings

Where live loads are less than the conventional H20-S16 loading, the burial depth measured from the top of pipe should be at least 3 feet (.91 m) for all diameters. At road crossings where the loading exceeds H20-S16, bury the pipe deeper or use casing pipe and collars or sleeves to protect the pipe. Ameron will make recommendations on increased depth of burial upon request provided complete loading and soil conditions are submitted for an engineering analysis.



7 Hydrostatic thrust

1) It is the responsibility of the engineer to evaluate the need for thrust blocks. A complete evaluation must consider singly and in combination the effects of temperature changes, internal pressure surges and pipeline geometry.

2) Temperature changes produce stress in buried pipe that is restrained by (1) friction of the surrounding bedding, (2) passive soil pressure at fittings, or (3) thrust blocks. Forces developed at fittings in fully restrained pipe are tabulated in Section 8 below.

3) Hydrostatic thrust at fittings is a function of the degree of restraint of the adjacent pipe. *The magnitude of the hydrostatic thrust experienced by a Bondstrand piping system is also a function of the method of construction of the pipe: different values must be used for systems employing reciprocally wound pipe (Series 2000, 2400, 3400, 4000, 5000, 5100 and 7000) and pipe made by the continuous winding process (Series 3000, 3000A, 3200, 3300 and adhesive-bonded oilfield line pipe such as Bondstrand 200, 300, etc). In a fully restrained reciprocally wound Bondstrand fiberglass pipe (i.e., blocked against movement at both ends) with all joints bonded, the Poisson effect produces considerable tension in the pipe wall: as the internal pressure increases, the pipe expands circumferentially and at the same time tries to contract longitudinally. The resulting tensile force in the pipe wall acts to reduce the axial hydrostatic thrust on the fitting by about 50% compared to the thrust experienced in a system using continuously wound Bondstrand pipe.*

The thrust forces acting on a bend are defined as follows:

$T = 2PA \sin\frac{\theta}{2}$ where

- T = Thrust at fitting (lb_f)
- P = Hydrostatic pressure (psi)
- A = Flow area of pipe (in^2)
- θ = Angle of bend (deg)

Use this formula for determining thrust in systems employing Series 3000 and related continuously-wound products. To determine hydrostatic thrust in pipe using Series 2000 and related reciprocally-wound piping, use one half the value given by the above formula. Hydrostatic thrusts at fittings in fully restrained systems at 100 psi (7 bar) are tabulated in Appendix A. Thrusts at other pressure may be determined by ratio.

4) Valves should normally be blocked as indicated in section 9.8 (fig. 9.2) to support their own weight, resist thrust and to prevent excessive torque loads on the pipe connections.

5) Thrust blocks are required at hydrants and at 6-inch (150 mm) or larger diameter tees and elbows for firewater mains regulated by Factory Mutual Research Corporation.

8 Thrust due to thermal expansion

Thrust forces arising from thermal expansion of the pipe wall in Series 2000 and related products are tabulated below. The effects of thermal expansion will generally be less in systems employing Series 3000 and related piping since the pipe wall thickness of these latter systems is less than for Series 2000 products.

Thrust at Fittings for a 140° ΔT in 2000 Series Piping

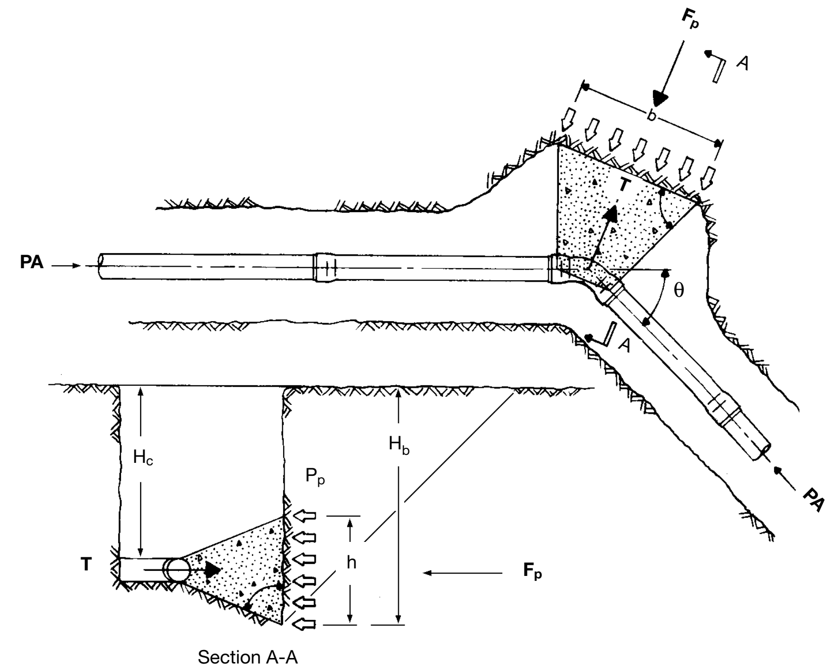
Pipe Dia		Tees or Ends		90° Elbows		45° Elbows	
(in)	(mm)	(lb_f)	(kN)	(lb_f)	(kN)	(lb_f)	(kN)
2	50	1,880	8.4	2,660	11.9	1,440	6.4
3	80	2,830	12.6	4,000	17.8	2,170	9.7
4	100	4,550	20.3	6,430	28.7	3,480	15.5
6	150	6,760	30.2	9,560	42.6	5,170	23.1
8	200	9,710	43.3	13,700	61.1	7,430	33.1
10	250	12,200	54.4	17,300	77.2	9,340	28.3
12	300	14,500	64.7	20,500	91.4	11,100	49.5
14	350	17,400	77.6	24,200	108.0	13,200	58.9
16	400	22,000	98.1	27,800	123.6	15,100	67.4

1) Initial temperature = 60°F (15°C)
Operating temperature = 200°F(93°C)

9 Thrust block design and construction

1) Once the anticipated thrusts have been determined, thrust block design must consider soil strength, soil stability and location of the water table. Blocks must (a) have adequate bearing area to resist the soil thrust, (b) bear against undisturbed soil and (c) be so designed that the resultant thrust vector passes perpendicularly through the center of the bearing surface (except for valves as in section 9.8). Should the soil be unstable or the installation below the water table, the engineer must make provisions to ensure stability such as driving piles to anchor to deeper layers of soil. Note that any connecting metallic pipe must be anchored at the point of connection to the fiberglass pipe to prevent transfer of excessive stress.

Fig. 9-1 Thrust blocks should be cast with the bearing area against undisturbed native soil.



A	=	Cross sectional area of pipe (in^2)
A_b	=	Block bearing area (ft^2)
b	=	Width of block bearing area (ft)
C_s	=	Soil cohesion factor
D	=	Pipe OD (ft)
f_s	=	Safety factor
F_p	=	Soil thrust (lb_f)
h	=	Height of block bearing area (ft)
H	=	Depth of cover (ft)
H_c	=	Burial depth of pipe (ft)
H_b	=	Depth of block base (ft)
P	=	Operating plus surge pressure (psi)
P_p	=	Passive soil pressure (lb_f/ft^2)
R	=	Soil weight reduction factor
T	=	Thrust force on bend (lb_f)
w	=	Unit soil weight (lb_f/ft^3)
W	=	Soil weight/ft of pipe (lb_f/ft)
θ	=	Pipe bend (deg)
ϕ	=	Soil friction angle (deg)

Formulas:

$$T = 2PA \sin\frac{\theta}{2} \ (lb_f)$$

Existing Condition	Reduction Factor, R
General construction backfill soils compacted to critical void ratio	⅔
Well-compacted backfill and select backfill to critical void ratio	¾

2) Safe bearing pressures for common soil type are tabulated below.

	Allowable Soil Bearing Pressure P_p	
Soil Description	(lb_f/ft^2)	MPa
Rock, hard thick layers	400,000	19.2
Rock, ≈ good masonry	50,000	2.39
Rock, ≈ best brick	30,000	1.44
Rock, ≈ poor brick	10,000	0.48
Clay, always dry	8,000	0.38
Clay, fairly dry	4,000	0.19
Clay, soft	2,000	0.10
Gravel, coarse sand, firm	16,000	0.77
Sand, compact, firm	8,000	0.38
Sand, clean, dry	4,000	0.19
Quicksand, alluvial soil[1]	-	-

1) Piles or tie rods may be required in loose or soft soils, particularly when below the water table.

3) The required bearing area is computed using the formula:

$$A_b = \frac{T}{P_p} \quad \text{where}$$

A_b = Bearing area of thrust block (ft^2)

T = Thrust (lb_f)

P_p = Allowable soil bearing pressure (lb_f/ft^2)

9 Thrust block design and construction

4) Thrust blocks for Bondstrand pipe systems should be poured after hydrostatic testing to allow for clear visual inspection of all fitting joints during the test. To retain pipe in proper alignment while testing, placement of sand bedding and backfill per section 5 may be required. Joints should be left exposed for observation during testing.

5) Thrust blocks should be shaped with the "designed bearing area" against native soil of the trench wall. Smaller blocks using a dry mix may be shaped by hand but larger blocks (2 ft^2 or greater) require formwork.

Soil Description	Friction Angle, ϕ (deg)	Cohesion, C_s (lb_f/ft^2)
Well-graded sand		
dry	44.5	0
saturated	39.0	0
Silt (passing 200 sieve)		
dry	40	0
saturated	32	0
Cohesive granular soil		
wet to moist	13-22	385-920
Clay		
wet to moist at max compaction	11.5-16.5	460-1175

6) Unless otherwise specified by the engineer, use a concrete mix consisting of 1 part Portland cement, 2 parts washed sand and 3 parts washed gravel with enough water for a relatively a dry mix. A dry mix is stronger and is easier to shape.

7) Work the concrete thoroughly around the fittings to maximize surface contact. The entire area between the fittings and the freshly cut trench wall must be filled with concrete and be void free. Maintain at least a 2-inch (50 mm) space between concrete vibrators and pipe or fittings as even indirect contact through the concrete aggregate may produce excessive impact loads on the fiberglass pipe.

8) Valve blocks should incorporate the steel necessary to support the weight of the valve and resist any torque loads caused by opening and closing the valve.

9) Thrust blocks should encapsulate crossovers with at least six inches (150 mm) of concrete between fittings and native soil.

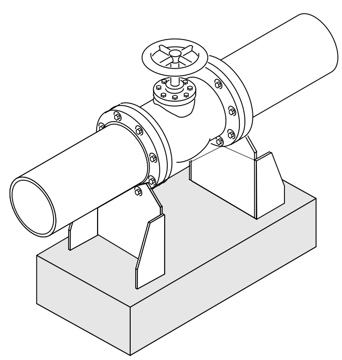


Fig. 9-2. Valves must be independently supported to prevent transfer of torque loads to the fiberglass piping.

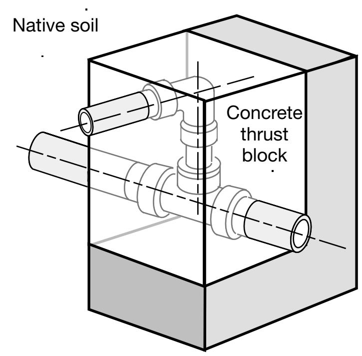


Figure 9-3. Provide encapsulating thrust blocks for crossovers.

10 Manhole penetrations and connections

1) When making penetrations through concrete walls, run Bondstrand pipe through metal pipe sleeves at least two sizes larger in diameter than the pipe. Caulk the space between the sleeve and the pipe with a waterproof compound that dries to a firm but pliable mass.

2) Assemble flanged connections in accordance with the recommendations in ASSEMBLY INSTRUCTIONS FOR BONDSTRAND FIBERGLASS FLANGES, FP196.

3) When connecting fiberglass piping to metallic piping, anchor the metallic line to avoid stress transfer to the fiberglass.

4) Support valves independently of fiberglass piping.

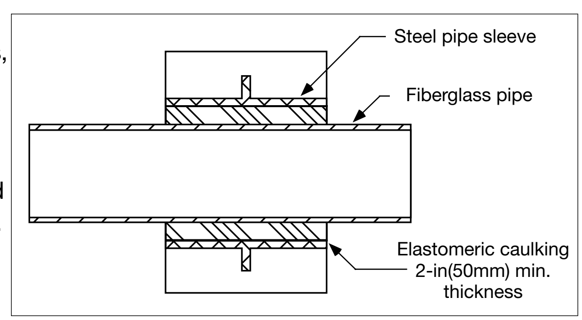


Fig. 10. Typical wall penetration. The fiberglass pipe passes though a metal sleeve two pipe sizes larger than the pipe diameter. The space between pipe and sleeve is sealed with an elastomeric caulking compound.

11 Field testing

1) Pneumatic testing is not recommended for reasons of safety.

2) Use weights on pipe and wood blocking at bends to restrain pipe during test.

3) Displace all free air in the Bondstrand piping system with the test fluid. Provide taps for air and vapor release at all high points in the system.

4) Increase pressure in increments of no more than 50 psi/minute (3 bar/min.).

A Appendix

Hydrostatic Thrust at Reducers at 100 psi[1] in 2000 Series Piping Systems[2]

Reducer Size		Thrust		Reducer Size		Thrust	
(in x in)	(mm x mm)	(lb_f)	(kN)	(in x in)	(mm x mm)	(lb_f)	(kN)
3 x 1½	80 x 40	___	___	10 x 6	250 x 150	2,650	11.8
3 x 2	80 x 50	240	1.0	10 x 8	250 x 200	1,550	6.9
4 x 2	100 x 50	510	2.3	12 x 8	300 x 200	3,350	15.0
4 x 3	100 x 80	270	1.2	12 x 10	300 x 250	1,800	8.0
6 x 3	150 x 80	1,150	5.1	14 x 10	350 x 250	6,000	26.8
6 x 4	150 x 100	880	3.9	14 x 12	350 x 300	2,500	11.2
8 x 4	200 x 100	1,980	8.8	16 x 12	400 x 300	7,000	31.2
8 x 6	200 x 150	1,100	4.9	16 x 14	400 x 350	4,500	20.1

1) In a fully restrained system.
2) Includes Series 2000, 2400, 3400, 4000, 5000, 5100 and 7000.

Hydrostatic Thrust at Reducers at 100 psi[1] in 3000 Series Piping Systems[2]

Reducer Size		Thrust		Reducer Size		Thrust	
(in x in)	(mm x mm)	(lb_f)	(N)	(in x in)	(mm x mm)	(lb_f)	(N)
3 x 1½	80 x 40	___	___	10 x 6	250 x 150	5,300	23.6
3 x 2	80 x 50	470	2.1	10 x 8	250 x 200	3,100	13.8
4 x 2	100 x 50	1,010	4.5	12 x 8	300 x 200	6,700	29.9
4 x 3	100 x 80	540	2.4	12 x 10	300 x 250	3,600	16.1
6 x 3	150 x 80	2,300	10.3	14 x 10	350 x 250	12,000	53.5
6 x 4	150 x 100	1,750	7.8	14 x 12	350 x 300	5,000	22.3
8 x 4	200 x 100	3,950	17.6	16 x 12	400 x 300	14,000	62.4
8 x 6	200 x 150	2,200	9.8	16 x 14	400 x 350	9,000	40.1

1) In a fully restrained system.
2) Includes Series 3000, 3000A, 3200, 3300, Bondstrand 150, 200, 300, 450 and 800.

Thrust at Fittings at 100 psi[1] in 2000 Series Piping Systems[2]

Pipe Dia		Tees or 45° Laterals		90° Elbows		45° Elbows	
(in)	(mm)	(lb_f)	(kN)	(lb_f)	(kN)	(lb_f)	(kN)
2	50	170	.8	245	1.1	130	.6
3	80	405	1.8	575	2.6	310	1.4
4	100	675	3.0	950	4.3	515	2.3
6	150	1,550	6.9	2,200	9.8	1,200	5.4
8	200	2,650	11.8	3,750	16.7	2,050	9.1
10	250	4,200	18.7	5,950	26.5	3,300	37.0
12	300	6,000	26.8	8,450	37.7	4,600	20.5
14	350	7,300	32.6	10,200	45.5	5,500	24.5
16	400	9,500	42.4	13,300	59.3	7,200	32.1

1) In a fully restrained system.
2) Includes Series 2000, 2400, 3400, 4000, 5000, 5100 and 7000.

Thrust at Fittings at 100 psi[1] in 3000 Series Piping Systems[2]

Pipe Dia		Tees or 45° Laterals		90° Elbows		45° Elbows	
(in)	(mm)	(lb_f)	(kN)	(lb_f)	(kN)	(lb_f)	(kN)
2	50	340	1.5	490	2.2	260	1.2
3	80	810	3.6	1,150	5.1	620	2.8
4	100	1,350	6.0	1,900	8.5	1,030	4.6
6	150	3,100	13.8	4,400	19.6	2,400	10.7
8	200	5,300	23.6	7,500	33.5	4,100	18.3
10	250	8,400	37.5	11,900	53.1	6,600	29.4
12	300	12,000	53.5	16,900	75.4	9,200	41.0
14	350	14,600	65.1	20,400	91.0	11,000	49.1
16	400	19,000	84.7	26,600	118.6	14,400	64.2

1) In a fully restrained system.
2) Includes Series 3000, 3000A, 3200, 3300, Bondstrand 150, 200, 300, 450 and 800.

Important notice

This literature and the information and recommendations it contains are based on data reasonably believed to be reliable. However, such factors as variations in environment, application or installation, changes in operating procedures, or extrapolation of data may cause different results. Ameron makes no representation or warranty, expressed or implied, including warranties of merchantability or fitness for purpose, as to the accuracy, adequacy or completeness of the recommendations or information contained herein. Ameron assumes no liability whatsoever in connection with this literature or the information or recommendations it contains.

AMERON INTERNATIONAL

FIBERGLASS PIPE GROUP

Group Headquarters
P.O. Box 801148
Houston TX 77280
Tel: (713) 690-7777
Fax: (713) 690-2842

Fiberglass Pipe Division-Asia
No. 7A, Tuas Avenue 3
Singapore 2263
Tel: 65 862 1301
Fax: 65 862-1302

Fiberglass Pipe Division-Europe
J.F. Kennedylaan 7
4191 MZ Geldermalsen
The Netherlands
Tel: +31 345 573-341
Fax: +31 345 575 254
Telex: 40257 bonds nl

Fiberglass Pipe Division-U.S.A.
P.O. Box 878
Burkburnett, Texas 76354
Tel: (817) 569-1471
Fax: (817) 569-4012