Bondstrand™ 2000M/7000M, 2400 and 2400-C

Pipe Installation Handbook

Marine Products

Fiber Glass Systems
NOV Completion & Production Solutions
nov.com/fgs

Bondstrand pipe for Marine Market

This installation manual is to provide installers a comprehensive overview for installation of NOV fiberglass pipe systems, on marine projects, such as, ships, FPSO's, Drilling Units, Etc.

Characteristics for marine installations are, piping is arranged in confined space; and the installation work is significantly affected by hull structure design, fabrication and erection. Therefore it is necessary to take special precaution and follow the included recommendations for installation.

This manual contains material on receiving and handling, piping layout and support principles. The manual also covers various types of joint assembly, followed by hydro test and conductivity test procedures.

In case any site modification is required, or any damage on fiberglass piping system occurs, modification and repair recommendation are provided.

General health and safety recommendations are given in the last chapter of the manual.

Reference

AME/INS-004	Hydro-testing procedure for Bondstrand GRE/GRV pipe
AME/INS-003	Procedure for conductivity and grounding of GRE pip
MOD01, 02, 03	Modification and repair recommendation

Table of Contents

Table of Contents

Tables

Figures

Section 1

Pipe Arrangement

Pipe Arrangement

Layout

- Fiberglass piping shall be routed in such a way that:
- It is in accordance with specification and piping diagram;
- The number of direction changes are minimized to reduce the surge effect on the piping system;
- It allows sufficient expansion joints in appropriate locations for ship sagging and hogging effect, and also be able to accommodate minimal fabrication, erection and installation deviation of hull structure and piping work;
- It allows sufficient expansion joints in appropriate locations for ship sagging and hogging effect, and also be able to accommodate minimal fabrication, erection and installation deviation of hull structure and piping work;
- It provides for ease of installation;
- Ease of supporting. Supports can be easily located and fabricated;
- Certain flexibility is provided in the system to enable joint assembled to the correct dimensions without the need to pull/push a spool into position.

Spool Breaking

The use of prefabricated spools shall be maximized to minimize the amount of site adhesive jointing work. Fiberglass piping shall be broken for spooling in such a way:

- To avoid /minimize site adhesive bonding joint;
- To not exceed handling capacity of installation and transportation equipment or facilities;
- To make if feasible to bring the spool into position after hull-block erection;
- That no spool will protrude through the hull-block after installation in the block;
- That the breaking point shall be located at accessible location.

Conductivity and Grounding

(Applicable on Conductive System Only)

NOV Fiber Glass Systems conductive fiberglass pipe, fittings and flanges incorporate high strength conductive filaments to prevent accumulation of potentially dangerous levels of static electrical charges by the flow of liquids or other environmental causes.

Accumulated charges are harmlessly drained from the fiberglass pipe system into the metallic hull structure by means of:

- Flange connection to metallic flange of metallic piping, equipment, tanks, bulkhead penetration, etc.;
- Flange frame support at fiberglass flange. The flange frame is bolted at the back of fiberglass flange, and the base of flange frame will be connected to steel structure;
- Grounding saddle with embedded stainless steel cable, one end is bonded onto pipe surface, and the other end is bolted to steel structure.

Sufficient electrical drainage points shall be installed to enable a completely conductive system.

Grounding saddles shall be mounted on the pipe section that is isolated from other means of electrical drainage. Mechanical coupling joints and double o-ring joints are considered as isolating points or conductivity breaking points.

In general, the grounding saddle shall be positioned near a support, so that the extension cable of the grounding saddle can be fixed on the support structure, avoiding disruption to the primary hull structure.

Section 2

Supports

Introduction

Piping supports shall be arranged in such a way that:

- Supports shall be arranged to avoid sag and/or excessive vibration;
- Valves and other heavy in line items shall be independently supported;
- Hose connections, utility or loading stations shall be supported to avoid excessive bending stress;
- Fiberglass pipe shall not be used to support other piping;
- Enough space is provided between support and fittings to ensure that pipe movement is not obstructed either axially or laterally;
- Supports shall be located at convenient and accessible location;
- Supports shall be preferably located on plain-pipe sections rather than at fittings or joints;
- A fixed support must be located along the length of the straight pipe/spool if its both ends are connected with unrestrained mechanical joints;
- An anchor support shall be installed between an unrestrained mechanical joint and an elbow, a tee or a reducer.

Support Span

Maximum Support Span

Recommended **maximum support spans** for NOV Fiber Glass Systems pipe at operating temperatures of 66°C and below are listed in Table 1. These spans are intended for normal horizontal piping arrangements. The tabular values are for partial span that represent a compromise between continuous and simple spans.

NOTE:

Consult NOV Fiber Glass Systems for product series other than 2000M and 7000M.

Table 1

Maximum Support Spacing

in	mm	Span
1	25	3.0
1½	40	3.5
2	50	3.8
3	80	4.3
4	100	4.9
5	125	5.2
6	150	5.5
8	200	6.0
10	250	6.0

in	mm	Span
12	300	6.0
14	350	6.0
16	400	6.0
18	450	6.0
20	500	6.0
22	550	6.0
24	600	6.0
26	650	6.0
28	700	6.0

in	mm	Span
30	750	6.0
32	800	6.0
36	900	6.0
40	1000	6.0
48	1200	6.0
52	1300	6.0
60	1500	6.0

Support Span at Double O-ring Expansion Joint

Supports shall be arranged at both sides of Double O-Ring Expansion Joint. The support shall be positioned in such a way that it will not cause obstruction to dismantling/assembly of the joint, and it provides good support for the weight effect of the joint assembly.

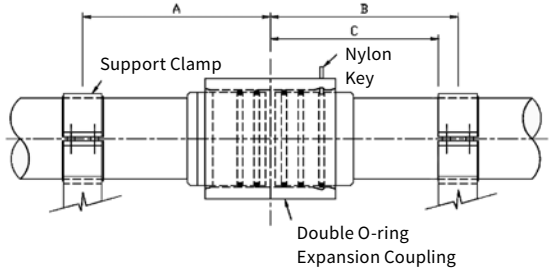


Figure 2.1
Support Span at Double O-ring Expansion Joint

Table 2

2000M & 7000M Double O-ring Expansion Chart (only applicable for up to 40")

in	mm	A Min. (m)	A&B Max. (m)	C Min. (m)
2	50	0.23	1.0	0.30
3	80	0.23	1.0	0.30
4	100	0.23	1.0	0.30
5	125	0.25	1.0	0.36
6	150	0.25	1.5	0.36
8	125	0.30	1.5	0.44
10	250	0.33	1.5	0.46
12	300	0.38	1.5	0.53
14	350	0.40	1.5	0.55
16	400	0.43	1.5	0.58
18	450	0.45	2.0	0.54
20	500	0.49	2.0	0.56
22	550	0.53	2.0	0.62
24	600	0.55	2.0	0.62
26	650	0.60	2.0	0.70
28	700	0.63	2.0	0.72
30	750	0.63	2.0	0.73
32	800	0.68	2.0	0.82
36	900	0.68	2.0	0.95
40	1000	1.00	2.0	0.95

NOTE:

A Min. denotes the recommended minimum distance for double O-ring male (DOM) end to avoid interference between clamp and fiberglass component.

A&B Max. denotes the recommended maximum distance of the support.

C Min. denotes the minimum clearance for assembly/dismantling of double O-ring expansion coupling.

Support Span at Mechanical Expansion Joint

Supports shall be arranged at both sides of Mechanical Expansion Joint. The support shall be positioned in such a way that it will not cause obstruction to dismantling/assembly of the mechanical expansion coupling, and it provides good support for the weight effect of the joint assembly.

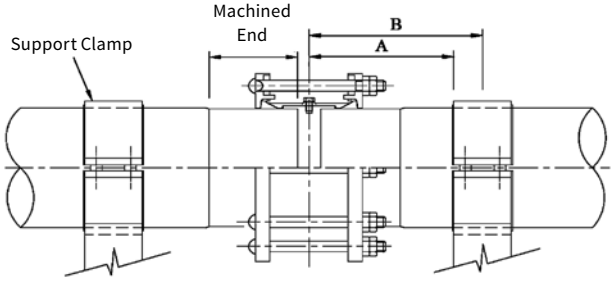


Figure 2.2
Support Span at Mechanical Expansion Joint

Table 3

2000M & 7000M Mechanical Expansion Joint Support (only applicable for up to 40")

in	mm	A Min. (m)	B Max. (m)
2	50	0.35	1.0
3	80	0.35	1.0
4	100	0.35	1.0
5	125	0.36	1.0
6	150	0.36	1.0
8	200	0.37	1.5
10	250	0.38	1.5
12	300	0.38	1.5
14	350	0.38	1.5
16	400	0.38	1.5

in	mm	A Min. (m)	B Max. (m)
18	450	0.39	2.0
20	500	0.42	2.0
22	550	0.42	2.0
24	600	0.42	2.0
26	650	0.42	2.0
28	700	0.42	2.0
30	750	0.42	2.0
32	800	-	2.0
36	900	-	2.0
40	1000	-	2.0

Axial Load on Anchor Support

When a mechanical joint and/or double o-ring joint is in place together with a bend, the strength of the steel structure of axial stop type support is the essential to the reliability of the piping system. The steel support shall be designed, fabricated and installed to withstand the full axial force (thrust) with minimal deflection.

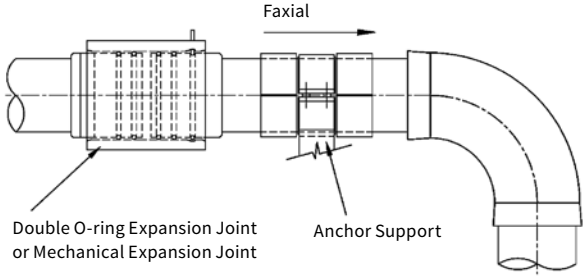


Figure 2.3
Axial Load on Anchor Support

Table 4
Axial Load on Anchor and Blank Saddle

in	mm	Axial Force (N) @ 5 Bar Pressure	Axial Force (N) @ 7.5 Bar Hydro test Pressure	Max. Allowable Load (N) on 360° Blank Saddle	Remarks
2	50	2168	3252	29480	4" length saddle blank
3	80	4186	6280	45269	4" length saddle blank
4	100	6550	9825	58188	4" length saddle blank
5	125	9909	14864	72928	4" length saddle blank
6	150	13230	19845	87889	4" length saddle blank
8	125	24750	37125	115382	4" length saddle blank
10	250	42934	64400	145279	4" length saddle blank
12	300	55651	83477	173294	4" length saddle blank
14	350	58450	87675	186488	4" length saddle blank
16	400	73916	110874	213098	4" length saddle blank

Table 4 - Cont.

Axial Load on Anchor and Blank Saddle

in	mm	Axial Force (N) @ 5 Bar Pressure	Axial Force (N) @ 7.5 Bar Hydro test Pressure	Max. Allowable Load (N) on 360° Blank Saddle	Remarks
18	450	90372	135558	360487	6" length saddle blank
20	500	110455	165682	396536	6" length saddle blank
22	550	142671	214006	436518	6" length saddle blank
24	600	156779	235168	476172	6" length saddle blank
26	650	192423	288634	534994	6" length saddle blank
28	700	222693	334040	576046	6" length saddle blank
30	750	251296	376944	617181	6" length saddle blank
32	800	288653	432980	658315	6" length saddle blank
36	900	363534	545302	738034	6" length saddle blank
40	1000	443988	665982	822935	6" length saddle blank

NOTE:
For other pressure ratings, the estimated axial force can be computed linearly to the pressure. System hydro test pressure (1.5 times of system design pressure) shall be considered for support design.

Support Type and Detail

The following support types are most commonly used for fiberglass piping system on the shipboard and offshore projects:

Guide Supports

Guide supports permit longitudinal movement of the pipe but restrain lateral movement. A guide support on horizontal pipe shall hold the pipe against moving up and down. Guide supports shall be designed; fabricated and installed that:

- No direct contact between fiberglass pipe and steel support base/clamp occurs. Protective material such as polyethylene, or PVC, or fiberglass blank saddles shall be installed permanently;
- A gap 0~5mm shall be maintained between pipe clamp and fiberglass pipe.
- Nut locking device (extra nut, locking washer) is recommended.

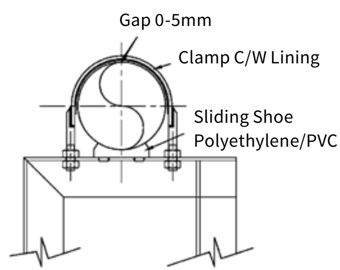


Figure 2.4a
Guide Supports - Front View

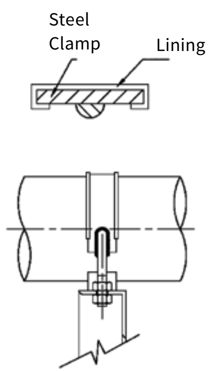


Figure 2.4b
Guide Supports - Side View

NOTE:

Where the support is exposed to strong lateral force, the U-Bolt/Clamp type guide support will NOT be recommended. In such circumstance, the two-half clamps shall be installed.

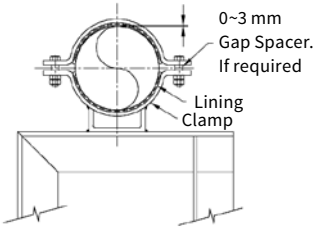


Figure 2.5a
Guide Supports - Half Clam, Front View

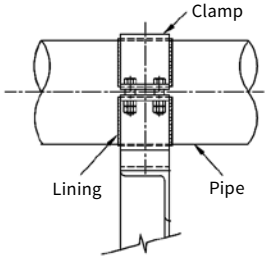


Figure 2.5b
Guide Supports - Half Clam, Side View

Fixed Support (Light Anchor)

Generally, fixed supports are installed on **straight fiberglass pipe** where both ends are connected to mechanical expansion joint such as Mechanical Expansion Coupling, Mechanical Flange Adapter, Double O-Ring Expansion Coupling, Double O-Ring Flange Adapter, etc. The fixed support provides restrain to both lateral movement and axial movement. Fiberglass saddles are fixed onto fiberglass pipe as a stopper collar. The fixed support shall be designed, fabricated and installed that:

- No direct contact between fiberglass pipe and steel support clamp occurs. Protective material such as rubber, or polyethylene, or PVC, or fiberglass blank saddles shall be installed permanently;
- Double nuts shall be installed for clamp bots to prevent excessive clamping force on pipe;
- Axial gap between blank saddle and steel clamp shall not be greater than 3mm.

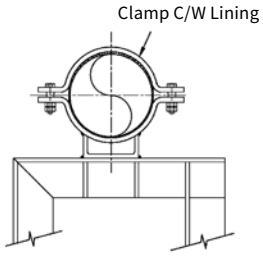


Figure 2.6a
Fixed Supports - Half Clam, Front View

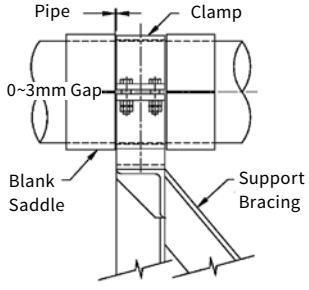


Figure 2.6b
Fixed Supports - Half Clam, Side View

Anchor Supports

Generally, anchor supports are installed to provide restrain to both lateral movement and axial movement. Fiberglass saddles are fixed onto fiberglass pipe as stopper collars. Strong force is expected on an anchor support. The anchor support shall be designed, fabricated and installed in such a way that:

- No direct contact between fiberglass pipe and steel support clamp, protection material such as rubber, or polyethylene, or PVC, or fiberglass blank saddles shall be installed permanently;
- Double nuts shall be installed for clamp bolts to prevent excessive clamping force on pipe;
- Axial gap between blank saddle and steel clamp shall not be greater than 3mm;
- Support structure shall be strong enough to stand force caused by internal pressure, separation force generated by free joint such as Double O-Ring Joint and Mechanical Expansion Joint, calculated surge and so on.

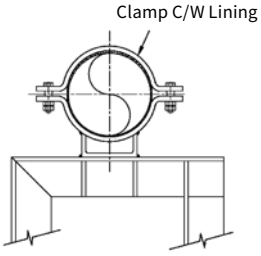


Figure 2.7a
Anchor Supports - Half Clam, Front View

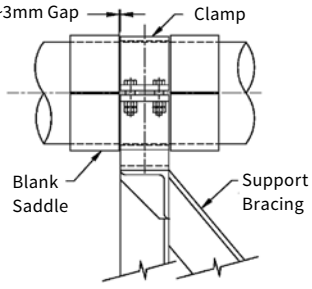


Figure 2.7b
Anchor Supports - Half Clam, Side View

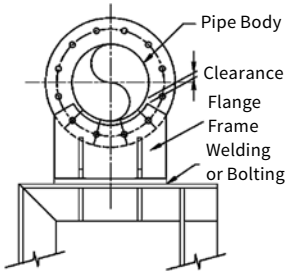


Figure 2.8
Flange Frame - Front View

Flange Frame

Flange frames are used for supporting flanged valves and flanged heavy inline items independently. Flange frames can also be installed to pipe flange for other supporting purpose. The flange frame can be fully welded to structure, thus being a fixed type or anchor type support; also the flange frame can sit loose on a support base with guide bars, thus being a guide type support.

The flange frame is connected to piping with bolts, and it might be exposed to high axial force, thus it shall be designed, fabricated and installed that:

- It must provide clearance with pipe body;
- It is of the correct size and covers appropriate number of bolt holes;
- The plate shall not be too high, thus to minimize bending stress on steel;
- It is installed with reinforcement wedge plate if necessary;
- It shall be bolted to flange prior to being fully secured to structure.

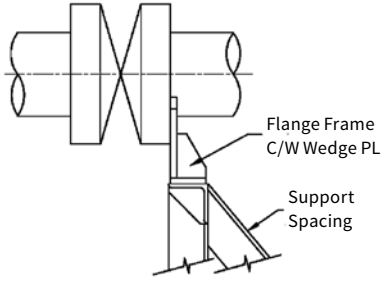


Figure 2.9
Flange Frame - Side View

Section 3

Receiving, Handling, Storage

Receiving
Handling
Transportation
Lifting
Storage

Receiving, Handling, Storage

Receiving

Inspect all shipments of fiberglass materials and accessories and do the following:

- Verify packing list and material
- Check material for any damage

Fiberglass pipe, fittings, fabricated spools, tools, accessories shall be inspected immediately upon receiving and shipping agent is to be informed of any deficiency. In the event of damage or missing items, relevant parties shall be informed immediately.

Handling

The following recommendations are made to protect the fiberglass pipe, fittings and fabricated spools against damage:

- End protection shall remain in place during handling and transportation. End protection can be removed for receiving inspection, but is shall be put back immediately.
- Fiberglass components shall be handled with care and protected from impact. Throwing, dropping, bumping or hitting the fiberglass component is prohibited. Fiberglass component shall not be dragged or pushed over sharp objects.

The use of a forklift truck is tolerated, provided that the forks are padded with carpeting or some other suitable soft material.

Transportation

It is recommended to transport fiberglass materials in their original container and original packing. In case the contents of the containers would be altered, attention shall be paid to the following:

- Do not let the fiberglass pipe and spools rest on the floor of the container where nails, studs or other sharp objects might damage them;

- The fiberglass pipe and spools shall be securely fastened directly over the timbers with tie-downs such as nylon straps or ropes. Do not use steel wire ropes or other sharp material, which might cause damage;
- No other materials shall be loaded on top of the fiberglass components;
- Do not drop the fiberglass products, walk or stand on them;
- When stacking 12m lengths, a minimum of 4 wooden supports must be used to separate each length;
- Do not allow the fiberglass pipe to extend more than 2 meters beyond the truck or trailer bed to prevent excessive bowing.

Lifting

When the pipe and spool have to be lifted, the following has to be taken in to account:

- When mechanical lifting is required, canvas or nylon slings are to be used. No steel chains, wire ropes or clamps shall be used for lifting fiberglass pipe components;
- Pipe/spools up to 3m in length may be lifted with a crane using at least one sling. Longer sections, up to 6m in length, may be lifted with a 3m spreader bar and two slings. Twelve-meter long sections may be lifted with a 6m spreader bar and two slings;
- Cartons can be lifted by hand or, in case of pallet cartons, by using a forklift truck. Do not throw or drop the cartons.

Storage

Storage of piping components may be required prior to installation. Special precautions shall be taken to avoid damage.

Pipe

Fiberglass pipe may be safely stored outside for extended periods provided the following recommended storage procedures be observed.

- Supports shall be spaced at 3-meter intervals and approximately not more than 1½ meter from each end. The supports should have a minimum 100mm (4-inches) wide bearing surface. The supports (timbers) used in the NOV-FGS containers can be used for this purpose at the storage area.
- The pipe stack should not exceed 3m in height and should have side supports or blocks to prevent rolling or slipping in the stack.
- It is not recommended to stack pipes directly on the ground.
- Protective end coverings must be left intact until the time of installation.

Fittings

Fittings shall be kept in cartons, stored on shelves, preferably inside a warehouse.

Fabricated Spools

Pipe spools are packed by NOV Fiber Glass Systems to avoid damage during transportation. Spools shall be stored with temporary protection in place. If possible, spools shall be stored in the original packing and shipping skid. When spools are stacked after receiving inspection, sufficient wood spacers shall be placed in between layers

Adhesives

Adhesives shall be stored indoors at temperatures between 5°C and 35°C (40°F and 95°F) . Extended storage at higher temperatures will degrade the catalyst and the resin, and reduce adhesive strength. Avoid storage of the adhesive in direct sunlight.

Adhesive shall be kept in original packing; it shall not be stored upside down. Each adhesive kit is stamped with an expiration date. FIFO (First In, First Out) is recommended for adhesive usage.

Accessories

Accessories such O-rings and nylon keys shall be stored away from direct sunlight and rain. The minimum storage temperature for O-ring and nylon key is 10°C (50°F).

Tools

Pipe shavers, arbors and power drive shall be kept in original toolbox after use. These tools shall be kept in dry location.

Heating blankets shall be rolled up when not in used. Heating blankets shall be kept in box or on a rack to avoid damage from any heavy objects. The storage shall be away from direct sunlight and rain.

Section 4

Installation of Fiberglass Pipe

Adhesive Bonding Joint
Flange Assembly
Double O-ring Joint Assembly
Mechanical Coupling Joint Assembly
Connection to Other Materials
Testing of Fiberglass Pipe System

Installation of Fiberglass Pipe

Adhesive Bonding Joint (only applicable for up to 40")

Site adhesive bonding joint shall be minimized so that to facilitate an efficient installation. In the situation that adhesive bonding joint is inevitable, the adhesive bonding joint shall be carried out by well-trained and qualified bonder in accordance with NOV Fiber Glass Systems adhesive bonding joint procedure.

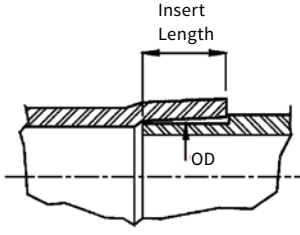


Figure 4.1a
QL Joint

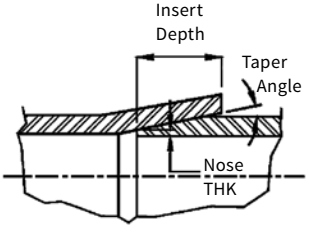


Figure 4.1b
Taper Joint

Special Tools for Adhesive Bonding Joint

Pipe shavers – to machined pipe end to required dimensions:

- B1F for 1" ~ 6" Quick-Lock Male (QLM);
- M74 for 2"~16" Quick-Lock Male (QLM) & Machined End (ME);
- M86 for 2"~6" Taper Male (TM);
- M87 for 6"~16" QLM, TM & ME;
- M87XL for 16"~24" QLM, TM & ME;
- M88 for 26"~40" QLM, TM & ME

Power Drive – is the power unit to drive M74, M86, M87, M87XL & M88 shavers;

Pipe Arbor – is required to fix shaver (M74, M86, M87, M87XL & M88) onto pipe;

Heating Blanket – to heat cured adhesive bonding joint.

NOTE:

Refer to relevant product literature for safety and proper use of tools.

Bonding Procedure

Brief adhesive bonding joint procedure is as follows:

- Cut the pipe to required length;
- Shave the pipe end to required dimensions (Diameter and length for QLM; Nose thickness, Taper angle and length for TM)
- Bonding surface preparation to ensure all bonding surfaces are clean, non-glossy, fresh finish without oil and water contamination;
- Dry fit and mark alignment and reference;
- Select and mix adhesive;
- Apply adhesive to all bonding surfaces;
- Assemble the joint and remove excessive adhesive;
- Heat cure with heating blanket;
- Complete necessary documentation

Adhesive joints shall be bonded by qualified bonders only. For bonder Qualification - please refers to Project Specification.

NOTE:

Refer to relevant bonding procedure, or adhesive product literature for detail guidance for adhesive bonding process and concerns, measures and precautions for making quality bonding joint.

References:

PF-01-Assembly procedure of Quick lock joints-1-16inch, 18-40 inch

PF-02A Assembly procedure of Taper joints 8-40 inch-S2000M-7000M series

Lamination procedure for LD pipes (48" , 52" and 60")

Brief bonding procedure is as below:

- surface preparation for lamination as per required laminated length
- prepare the materials and tools
- make sure the safe working place (if staging is required, to be prepared)
- prepare the Putty, Hand lay up lamination resin and UV Top Coating resin as per formulation

- Mix the resin with correct ratios
- Apply layers of Chopped Strand Mat (CSM) and Woven Roving (WR) externally and internally.
- Ambient cure for one day
- Must protect the curing of lamination joint from rain

References:

LAM-52IN- Lamination procedure(B&W) with vinylester resin

Photo 4.1
Lamination procedure

Photo 4.2
Lamination procedure

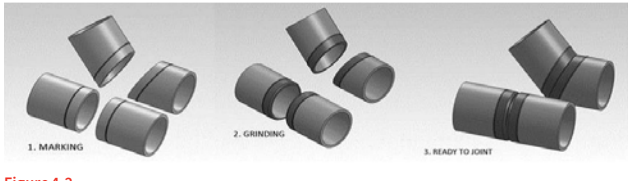


Figure 4.2
Marking, Grinding, Ready to Joint

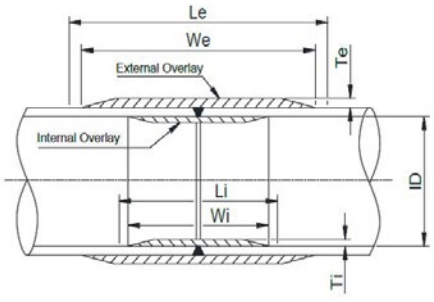


Figure 4.3
Internal/External Overlay

Flange Assembly

Gaskets

Use full-face gaskets of an elastomeric (Shore A Hardness 55-65) or other compatible material, suitable for the service pressure, temperature and fluids in the system. Gaskets shall be at least 3 mm thick.

Bolts

Well-lubricated new bolts shall be used. Bolt material and treatment shall be in accordance with project technical specification. Plain washers shall be installed on all fiberglass flanges to prevent damage. Spring washer shall not have direct contact with fiberglass flange.

In general, stud bolts shall be used. Bolts shall be placed only when they are ready to tighten the flange joint. In the situation where it is difficult to place bolt after spool/flange placement, the bolts shall be preset in the flange.

Assembly

Mount lubricated washers under both nuts and bolt heads to avoid damage of the flange back-face. Tighten all nuts following the sequences given in "Tightening sequence".

Do not exceed the torque increments given in "Recommended Bolt Torques".

After all bolts have been tightened to the recommended torque, recheck the torque on each bolt in the same sequence, since previously tightened bolts may have relaxed

Excess torque can damage the flange.

Flange Mounting Misalignment Tolerances

The alignment of the flanges is very important. Forcing the bolts to align a mismatch flange pair will result in damage on fiberglass components and/or leaking at the bonded joint. When a flange joint is assembled, the maximum misalignment shall not exceed the recommendation shown below. Otherwise, the pipe work must be rectified to correct the alignment.

Table 5

Maximum Misalignment Allowance

Size	A		B	
Up to 16"	1/16"	1.6 mm	1/8"	3.2 mm
18" - 40"	3/32"	2.4 mm	3/16"	4.8 mm
42" - 60"	3/32"	2.4 mm	3/16"	4.8 mm

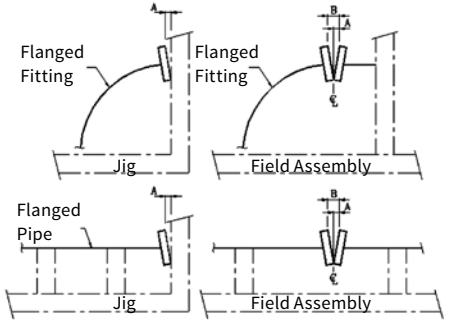


Figure 4.4
Maximum Misalignment Allowance

Flange pair offset results in difficulty of bolt installation. The maximum offsets are given in Table 6.

Figure 4.5
Flange pair offset

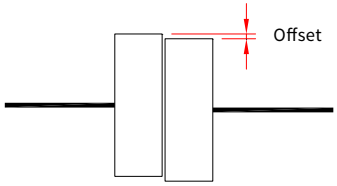


Table 6

Maximum Offset Allowance (mm)

Size	JIS5K	JIS10K	DIN10	CL150
2" - 22"	3.0	3.0	2.0	3.0
24" - 40"	3.0	3.0	3.0	3.0
42" - 60"	4.0	4.0	4.0	4.0

Recommended Bolt Torque

To achieve full pressure seal, bolt tightening shall achieve "Recommended Torque" as minimum. To prevent damage, the bolt torque for Heavy Duty type flange shall not be more than maximum torque shown in the Table 7.

Table 7

Recommended Bolt Torque

Heavy Duty Flanges

Flange Size		Torque Increments	Recommended Torque	Maximum Torque
in	mm	Nm	Nm	Nm
1 - 4	25 - 100	7	27	56
6 - 8	150 - 200	14	41	82
10 - 14	250 - 350	14	68	150
16	400	14	68	250
18 - 20	450 - 500	27	81	400
22 - 30	550 - 750	34	102	500
32 - 40	800 - 1000	45	210	500
42 - 60	1200 - 1500	45	400	875

Tightening Sequence

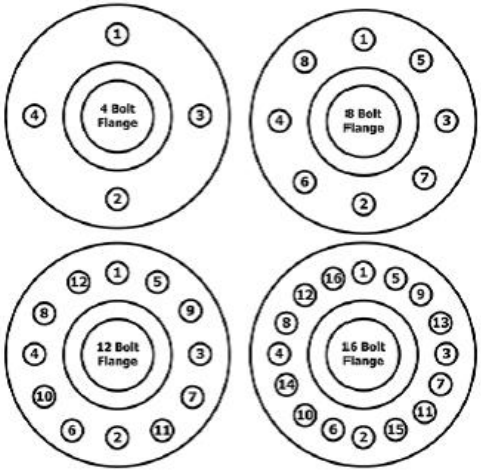


Figure 4.6
Torque Sequence

Remark: Tightening sequence for other no. of holes to be followed as same bolting method mentioned above

Double O-ring Joint Assembly (only applicable for up to 40")

Preparation and Pre-Set

Inspect all connecting surfaces of fiberglass double O-ring to ensure there are no scratches and damage on double O-ring Male (DOM) end, double O-ring male key (DOMK) end, and inner surface of double O-ring female (DOF). Clean all connecting surfaces so that there are free of oil, dirt, loose scale, and so on.

The double O-ring expansion coupling shall be preset onto DOMK end. The preset work shall be done during block installation stage and/or prior to placement of connection spools.

The double O-ring expansion coupling shall be preset in right direction, i.e. the key-hole side of the double O-ring expansion coupling shall be at the far side of the joint.

The double O-ring expansion coupling shall be secured onto pipe and it wrapped together with DOM end to prevent to prevent weld slag and sparks from torches.

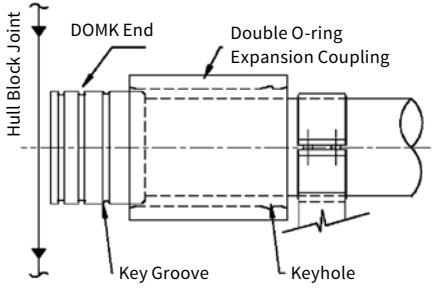


Figure 4.7
Double O-ring Expansion Coupling

Insertion Depth and Accessories

Refer to Table 8 for standard insertion depth, O-ring size and Nylon-Key size.

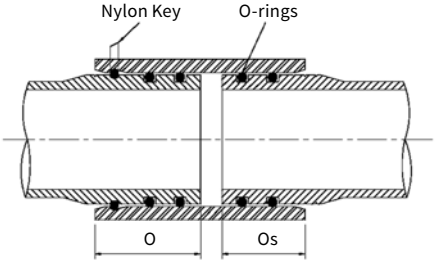


Figure 4.8
Double O-ring Expansion Coupling - Nylon Key and O-rings

Table 8

Insertion Depth/O-ring Size

Size		DOM Insertion (Os) mm	DOMK Insertion (Os) mm	O-ring	Nylon Key
in	mm				
2	50	81	91	7 x 59.7	6 x 305
3	80	81	91	7 x 88.3	6 x 400
4	100	81	91	7 x 113.7	6 x 483
5	125	102	112	9 x 135	8 x 580
6	150	105	115	10 x 161.3	8 x 660
8	200	138	149	10 x 225	10 x 840
10	250	148	158	12.5 x 302	12 x 1270
12	300	175	185	12.5 x 342.3	15 x 1270
14	350	185	195	12.5 x 342.3	15 x 1360
16	400	195	205	12.5 x 393.1	18 x 1585
18	450	178	188	15 x 445	15 x 1750
20	500	186	197	15 x 490	15 x 1930
22	550	210	220	18 x 556	18 x 2100
24	600	210	220	18 x 580	18 x 2240
26	650	247	257	18 x 622.3	18 x 2510
28	700	250	260	20 x 685	20 x 2700
30	750	257	267	20 x 740	20 x 2700
32	800	292	302	20 x 790	20 x 3065
36	900	347	357	20 x 890	25 x 3175
40	1000	340	350	20 x 987	25 x 3500

Inspection Prior to Assembly

To ease installation, to obtain proper assembly, and to avoid unnecessary stress to double O-ring joint and its components, the following dimensional criteria shall be inspected prior to final assembly:

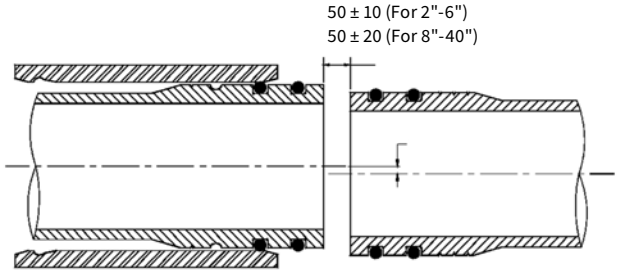


Figure 4.8
Double O-ring Joint Coupling

Before Installation

- Gap between connecting pipes (For Double O-ring Coupling joint), the gap shall be 50mm for standard design, the tolerance is ±10 mm for pipe size 6" (150 mm) and below, and ±20 mm for pipe size 8" (200 mm) and above;
- Offset between connecting pipes shall be within allowable tolerance specified in table below;
- All connecting surfaces are in good condition without scratches and/or structural damage.

Table 9

DOR Joint-Allowable Offset

Pipe Size Range		Offset	
in	mm	in	mm
2-5	50-125	3.0	0.12
6-8	150-200	4.0	0.16
10-12	250-300	5.0	0.20
14-16	350-400	4.0	0.16
18-20	450-500	6.0	0.24
22-40	550-1000	5.0	0.20

Assembly Integral DOF – DOM Joint

When ready to join the pipe, remove the dirt and debris from o-ring grooves using compressed air, a clean rag or a paintbrush;

Brush or rub a layer of vynoleo grease into o-ring grooves, pipe end, and male end surface, and all inside surfaces of the female end. (Apply lubricant only when you are ready to assemble the joint) Keep lubricated surfaces clean and free of sand and dirt.

Lubricate entire surface of o-ring and slip them into both grooves on the male end, distribute each o-ring evenly in the groove by slipping a screwdriver under them and sliding the screwdriver around the joint;

Mount band clamps (with D-rings) a convenient distance on each side of the joint, hook up band clamps with come-a-longs or lever hoists;

Tighten the come-a-longs or lever hoists to pull mating pipe to join together until the center scribe line is aligned with the leading edge of the female end.

After Installation

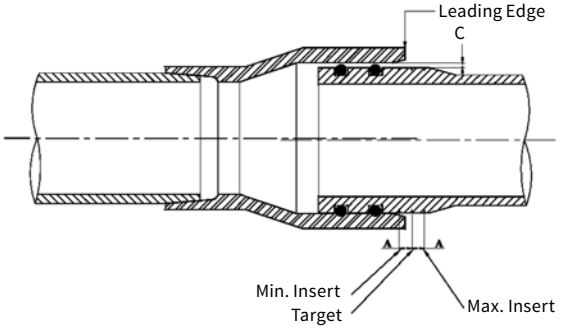


Figure 4.9
DOF-DOM Joint

Assembly Double O-ring Expansion Coupling

Brush or rub a layer of vynoleo grease into o-ring grooves, key groove, pipe end, and male ends surface, and inner surface of the Double o-ring expansion coupling. (Apply lubricant only when you are ready to assemble the joint) Keep lubricated surfaces clean and free of sand and dirt.

Lubricate entire surface of o-ring and slip them into grooves on the male ends. Distribute each o-ring evenly in the groove by slipping a screwdriver under them and sliding the screwdriver around the joint;

Using band-clamps (with D-rings) and come-a-longs/lever hoists to pull Double O-ring Expansion Coupling to the DOM end till the leading edge of Double O-ring Expansion Coupling is aligned with scribe line on the DOMK end;

Lubricate the nylon-key and insert it into keyhole till the leading end of nylon-key can be seen from keyhole. (Note: Over insertion will result in difficulty of key extraction);

After installation, inspect the insertion depth; the edge of Double O-Ring Expansion Coupling shall fall in between maximum and minimum insertion scribe lines. Check angular deflection to ensure alignment is within tolerance.

Angular Deflection

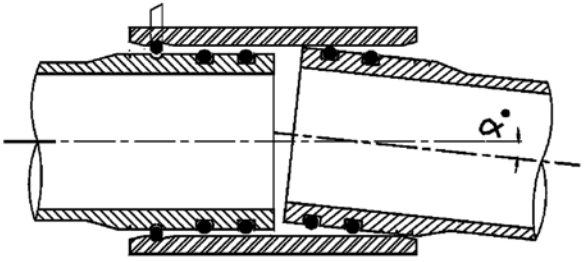


Figure 4.10
Angular Deflection

Table 10

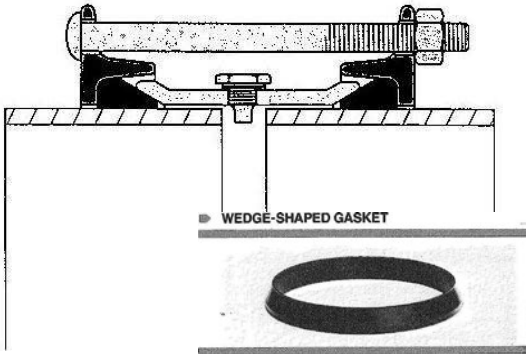
DOR Joint Allowable Angular Deflection

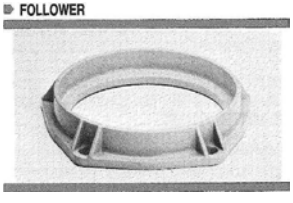
in	mm	a
2-16	50-400	0.5°
18-28	450-700	0.7°
30-36	750-900	0.5°
40	1000	0.7°

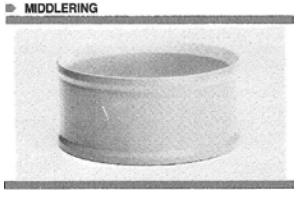
All O-rings and nylon keys for the GRE expansion couplings are to be kept in a cool dry place, away from heat or direct sunlight to prevent deterioration of the materials.

Mechanical Coupling Joint Assembly (only applicable for up to 40")

Mechanical coupling can be used to join fiberglass pipe to fiberglass pipe, and also fiberglass pipe to metallic pipe. For mechanical expansion coupling installation and joint assembly, and its requirement on pipe outside diameter, insertion length, alignment tolerance and so on, refer to specification and recommendation from product manufacturer.







Preparation and Pre-Set

Inspect machined fiberglass pipe ends to ensure there are no scratches or damage. Clean pipe-ends so that pipe ends are free of oil, dirt, loose scale and rust.

The preset work shall be carried out during block installation stage, and/or prior to placement of connection spools.

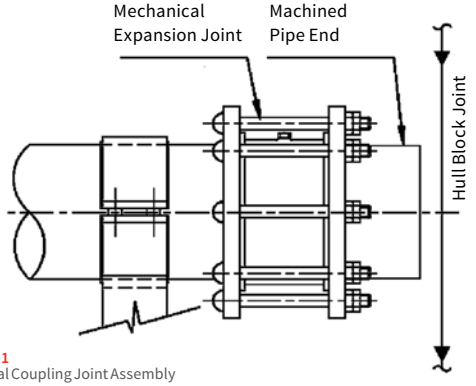


Figure 4.11
Mechanical Coupling Joint Assembly

Detailed steps are as follows:

- Slip one follower ring over pipe end;
- Wipe one gasket clean and immerse in soapy water (Glycerine may be added in freezing weather) and slide the rubber gasket over the pipe end;
- Loosen (screw out) the stop bolt of middle ring;
- Clean coupling middle ring, paying attention to flares on ends where gaskets will seat, then slip the middle ring over one pipe-end;
- Wipe the other gasket clean and immerse in soapy water, and slide it over the pipe end;
- Slip the other follower ring over pipe end;
- If final joint assembly is not carried out immediately, slide gaskets and followers together with middle ring; insert bolts and temporary assemble the expansion coupling.

Inspection

When connecting pipes are placed. The following shall be inspected prior to final joint assembly:

- Gap between connecting pipes, the gap shall be 70±30 mm for "Long" type expansion joint;
- Angular deflection and offset between connecting pipes shall be within allowable tolerance specified by manufacturer.
- Connecting pipe ends are in good condition without scratches and/or structural damage.

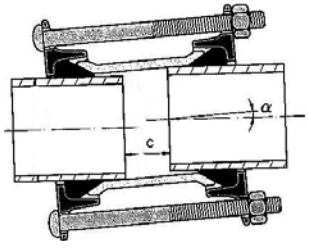


Figure 4.12
Mechanical Coupling Joint Inspection

Assembly

- Dismantle all bolts of preset mechanical coupling;
- Clean pipe-ends so that pipe ends are free of oil, dirt, loose scale and rust;
- Slip one follower ring over the other pipe end;
- Wipe one gasket clean and immerse in soapy water again if necessary, and slide the rubber gasket over the other pipe end;
- Slip the middle ring over the joint and center it;
- Slip rubber gaskets and followers into place, making sure gaskets are pushed under middle ring flare all the way round;
- Insert bolts and tighten bolts to uniform bolt torque specified by manufacturer. Tightening sequence shall follow flange-tightening sequence.
- Screw in the stop bolt of middle ring.

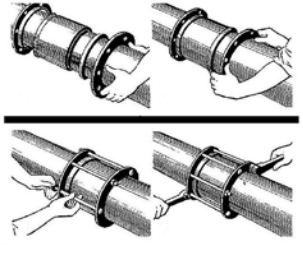


Figure 4.13
Mechanical Coupling Assembly

Connection to Other Materials

Where possible, connect fiberglass piping to either metallic or thermoplastic piping using flanges. Fiberglass flanges may be bolted directly against raised-face steel flanges. Fiberglass flanges also seal well against lined steel configurations.

Flanged valves and other equipment are frequently supplied with different flange facings. The configuration of these facings may vary widely. Unless it has been demonstrated that these facings are compatible with the face of fiberglass flanges, consult NOV Fiber Glass Systems Engineering.

Where fiberglass piping is connected to metallic pipe, securely anchor the metallic pipe at the point of connection so that expansion and contraction or weight of the metal line is not transferred to the fiberglass line.

All welding work on metallic piping that is adjacent to fiberglass piping shall be completed prior to joining to fiberglass piping; otherwise, cooling devices shall be in place to prevent heat transfer.

When instrumentation and metallic piping is threaded on fiberglass component, the fiberglass component must be properly held with spanner to prevent damage caused by torque force.

Connections to Equipment, Tanks, Pressure Vessels

Bondstrand pipe will safely absorb vibration from pumping or other conditions if stresses are controlled within reasonable limits. In general, pipeline vibration is severe only when the generating frequency is at, or near, the natural resonance frequency of the pipeline. This frequency is a function of the support system, layout geometry, temperature, mass, and pipe stiffness, and is often difficult to predict.

To control stress caused by vibration, it is typical to observe the stability of the system during initial operation and add restraints or supports as required to reduce effects of equipment vibration. In special cases where source vibration is excessive, an elastomeric expansion joint or other vibration absorber should be considered.

The wall flexure of a tank/pressure vessel, as it is filled and emptied, produces movements at nozzles that must be accommodated in the design. These movements can be absorbed by a loop or turn, or by an expansion joint. Avoid direct, straight-line connections between tanks.

Maximum Allowable Misalignment Tolerances

Force fitting misaligned fiberglass piping will result in damage on fiberglass components and/or leaking at bonding joint. When fiberglass pipe is joined, the misalignment shall not exceed maximum allowable tolerances shown below.

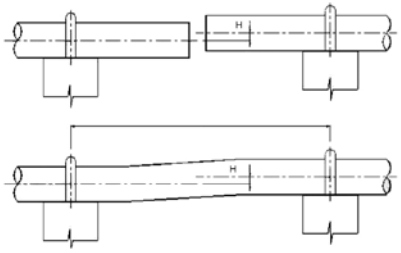


Figure 4.14
Misalignment Tolerances

Table 11

Maximum Allowable Misalignment Tolerances

Pipe Size Range		**Maximum Tolerance h_{6m} (C=6m)**	
in	**mm**	**in**	**mm**
up to 4	100	1.00	25.0
6-12	150-300	0.75	19.0
14-20	350-500	0.50	12.5
24-40	600-1000	0.40	10.0
42-60	1200-1500	0.25	6.5

Maximum tolerance for support spacing (C) can be computed in the following formula:

$h = h_{6m} \times C^2 / 36$

Where:

h = maximum allowable misalignment

C = support span in meter

h_{6m} = maximum allowable misalignment in support span of 6m

Installation in Hull Block

Fiberglass fabricated spools shall be placed into hull blocks in block stage. The fiberglass spools shall be installed into hull blocks after block painting and blasting. If fiberglass spools have to be installed into hull blocks prior to blasting and painting, the fiberglass spools shall be wrapped with protection canvas or equivalent protection materials.

When the fiberglass piping is exposed to the possibility of damage by falling objects, the fiberglass piping shall be protected by wooden planks on top. The protection wooden plank shall be secured.

During installation in hull block, fiberglass pipe/spool shall be handled with care, surrounding hazards shall be observed all the time, thus to prevent:

- Impact damage due to dropping to hull structure or collision with hull structure;
- Scratch damage when pipe/spool passing through a manhole and/or opening on non-watertight bulkhead.

During block installation stage, it is recommended to:

- Not fully weld the bulkhead penetration piece so that adjustment at steel can be done at later stage to accommodate minor piping misalignment;
- Not fully weld the support structure so that piping alignment can be easily adjusted after block joint;
- Install Mechanical Expansion Coupling on the pipe end in accordance with predetermined location shown on layout, or,

  Install Double O-Ring Expansion Coupling at pipe end with Key-Groove,

  The Mechanical Expansion Coupling or Double O-Ring Expansion Coupling shall be secured on the pipe during block transportation;
- All pipe/spools installed shall be secured during block transportation.

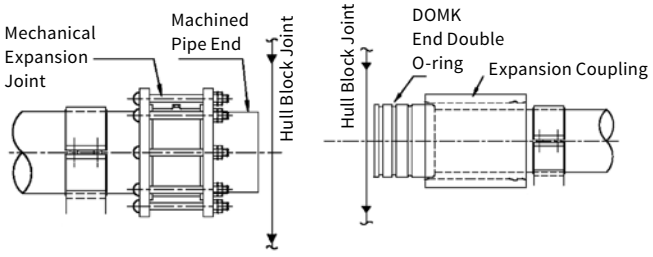


Figure 4.15
Installation in Hull Block

Testing of Fiberglass Pipe System

Hydro Test

The hydro test is considered to provide the best assurance of a GRP pipe system's integrity' (ISO14692:4, Annex-E). Installed fiberglass piping shall be hydro tested to ensure successful installation. Refer to AME/INS-004, '*Hydro-Testing Procedure for Bondstrand GRE/GRV Pipe*' for comprehensive recommendations and guides.

Test General Recommendations

Every part that has to be tested shall be vented until free of air. Be aware that there is always a possibility of the presence of entrapped air in a system.

Before testing, all lines or systems shall be inspected to ensure that all connected parts to be excluded from the test are removed and/or isolated.

The piping system must be completed with support installation.

During pressure testing the fiberglass pipe system shall be continuously monitored in order to prevent damages, especially at branches and elbows, due to snaking and expansion of the fiberglass pipe.

Pressure gauges and instrument must be calibrated and within 6 months period. Appropriate pressure gauge shall be used, the test pressure shall be between 30% to 75% of the reading range. If possible, pressure recorder shall be used.

Test Medium and Test Pressure

The system shall be hydrostatically tested with fresh industrial water; water used for testing shall be clean and free from filth or un-dissolved solids of any description.

The test pressure shall be 1.5 times of the system design pressure, the test pressure shall be held for one hour minimum or sufficient time to carry out line check, whichever is longer.

The test pressure shall be brought up slowly and gradually to allow for equalizing for strain during the test, and in stages to allow checking for leaks and inspection of the system. In doing so, no fast closing valves and booster pumps shall be used. In any case, the test pressure shall be raised over a period of 30 minutes or longer.

Inspection, Acceptance Criteria, and Approval

Inspection shall be carried out by means of instrument reading and visual line check to ensure the system is:

- No sign of leaking or weeping;
- No sign of significant pressure lost. The pressure lost during hydro-testing must be accountable;
- No deflection / damage due to hydro-test pressure on any support structure.

The hydro-test report shall be endorsed by all relevant parties after successful completion of hydro-test.

Effect of Temperature

The test pressure gauge/recorder has to be kept under observation so that any change in pressure can be controlled and compensated immediately. An increase of pressure could cause damage to the fiberglass system.

It should be noted that variation of water-temperature in the system, could affect the pressure significantly.

When ambient temperature falls below 0°C (32°F), glycol antifreeze shall be added into test medium.

Reinstatement

After system hydro testing, all items that were removed before hydro testing shall be reinstated.

Safety

As in any system, where pressure is employed, adequate safety precautions shall be exercised. The following safety precautions are recommended as minimum, but not limited to:

- The piping system is free from air;
- Safety devices are installed in test system;
- Qualified and experienced personnel shall operate pressurizing equipment. Untrained and unauthorized personnel shall not be near the test equipment and test area.
- Necessary signs, notice boards and barricade shall be in place.

Conductivity Test (For Conductive System Only)

For installed piping, conductivity test shall be carried out to verify the conductivity between fiberglass piping and earth points.

Ohmmeter (0~20 M-Ohm) shall be used for conductivity test. The end of probe of Ohmmeter shall be wrapped with wet sponge. This increases the "footprint" of the probe and gives better indication of suitability.

Test Methods

When conductivity of installed piping is checked, apply one probe with wetted sponge to the pipe surface as indicated on sketch below. The pipe surface must be sanded to expose the carbon fiber prior to checking. The sanded surface shall be painted after testing.

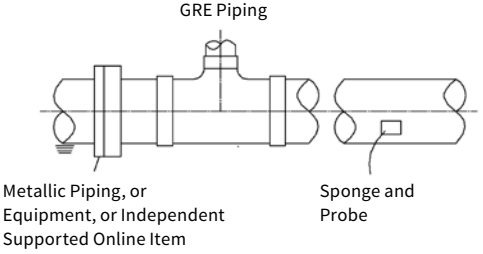


Figure 4.16
Test Methods

To avoid additional work on sanding and painting the pipe surface, alternatively, the back of a fiberglass flange or adhesive fillet between pipe and fitting could be used as a testing point.

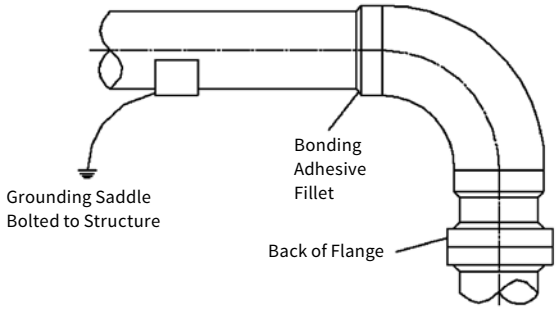


Figure 4.17
Testing Points

Apply the other probe directly onto metallic structure that is near to earth point, and record the reading.

Acceptance Criteria

For installed piping, the resistance reading must not exceed 1.0 Mega Ohm between two sides of site bonding joints, and also between piping and earth point.

Section 5

Field Modification and Repair

Field Modification and Repair

Recommendations are based on the philosophy that the modification/repair should be permanent. It is recommended that all damaged, impacted or sheared areas be cut out and replaced with new pipe/fitting.

Modification and Repair Procedure

When field modification is required, or when damage, impact and leaking are observed and necessary site repair is required, it is recommended to carry out following processes:

- Site inspection, collecting necessary information/document (such as drawings, reports, safety requirement, etc);
- If applicable, study the cause of defect/failure and work out corrective action plan to prevent re-occurrence;
- Prepare modification/repair proposal and submit to relevant parties for approval, the proposal shall contain, but not limited to:
  - Modification/Repair method;
  - Work description;
  - Material requirement;
  - Tools/Equipment requirement;
- Carry out modification/repair work in accordance with relevant procedures;
- Report and/or Record modification/repair work.

Modification and Repair General Concerns

The modification/Repair work shall be carried out by qualified fiberglass pipe bonder/fitter;

The modification/repair piping must be depressurized and emptied prior to modification/repair work;

It is recommended to preheat existing pipe if the piping has been filled with water;

After modification or repair, the piping section containing the modification and repair shall be re-certified by performing a pressure test.

Common Modification and Repair Methods

Partial Replacement

Partial replacement is to replace pipe and fitting (Including flange) which has problem on the body and/or at the bonding joint. The new pipe and fitting shall be jointed with existing piping in accordance with appropriate jointing procedure. It is recommended to assemble the existing pipe and new pipe with coupling. Alternatively, "Lamination (Butt & Wrap)" is commonly used jointing method for pipe-to-pipe joint.

When partial replacement is applicable:

- Careful inspection should be made to ensure that all imperfections/leaks etc. are identified;
- Cut out damaged section with consideration of extension of the damage, sufficient left-over pipe length for shaving or lamination, sufficient length to accommodate new pipe and fitting;
- Assemble new pipe, and/or new fitting, and/or new spool with existing piping in accordance with appropriate joint assembly procedures.

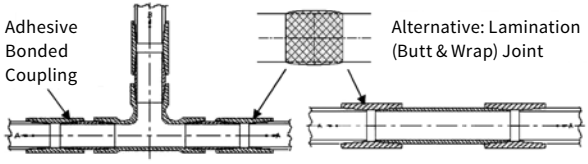


Figure 5.1
Partial Replacement

Overwrap

Over-wrap can be applied to minor damage pipe and fitting, and minor leaking adhesive bonding joint. The Over-wrap is good to use in places where it is not practical to partial renew due to space constraint, insufficient time schedule, lack of replacement pipe/fittings, and so on.

When overwrap is applicable:

- The sharp corner of bell of pipe or bell of fitting shall be chamfered to obtain a smooth transition area;
- All loose fiber must be removed, and the damage part must be coated with adhesive or resin prior to lamination;
- Following over-wrapping procedure for surface preparation, building structural laminates, curing, and post work finishing, and so on.
- Lamination length and number of layers depends on system design pressure.

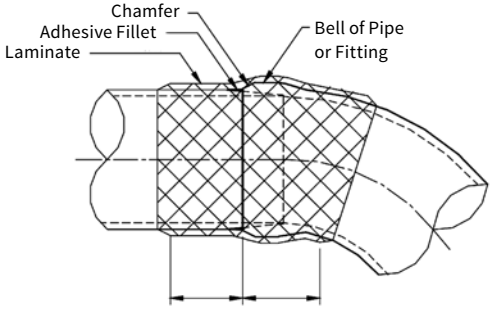


Figure 5.2
Overwrap

Surface Repair

The method can be used minor defects that pipe/fitting structure is not damaged and there is no sign of leaking, such as minor scratch; surface crack; adhesive fillet crack; minor surface burning; and so on.

The repair work shall be carried out in following sequence:

- Lightly sand down the affected area (Such as minor scratch, surface crack);
- Apply a thin coat of adhesive, or spray paint, the adhesive and paint shall be compatible with product material;
- Leave the coating for self-curing at ambient temperature.

Temporary Repair

A temporary repair should only be utilized when it is unfeasible to shut down the pipe system to install a permanent repair. Temporary repair may be carried out as agreed by owner, repair kit manufacturer and NOV Fiber Glass Systems.

A range of techniques are available which include, but are not limited to, overwrap with water activated resin-glass tape, self-sealing clamps.

It must be recognized that NOV Fiber Glass Systems does not endorse the long-term performance of the temporary repair, and it is recommended to install a permanent repair as soon as circumstances permit.

Other Methods and Solutions

When above methods are not appropriate for the defect and failure, when it is difficulty and limitation to adopt above methods, consult NOV Fiber Glass Systems engineering for other modification/repair method and case-to-case solution.

Section 6

Safety Recommendations

Dust Hazards
Chemical Hazards
Spill and Disposal

Safety Recommendations

Always refer to the Safety Data Sheet (SDS) prior to working with unfamiliar materials or if there are questions concerning the contents of the fiberglass product and materials.

Dust Hazards

When machining fiberglass pipe, worker may be exposed to dust. This dust is considered as non-hazardous, however, in high concentrations it may cause a temporary irritation of the skin. This exposure can be minimized by following the guidelines. Keep the dust concentration below the MAC value (10 mg/m^3).

- Keep working area properly ventilated to maintain low dust concentration;
- Wear long-sleeved shirts along with long trousers;
- Wear safety glasses, goggles or a face shield to protect eyes from dust. A disposable dust mask shall be used when grinding or sanding the material;
- Shower in cool water with mild soap to reduce irritation;
- Do not rub or scratch irritated skin;
- Wash work clothes separately;
- Follow below mentioned procedures if irritation is caused by contact with glass fibers:
  - Skin - Wash with cool water.
  - Eyes - Flush with running water for at least 15 minutes and seek medical attention if irritation does not stop at the completion of the flushing.

Chemical Hazards

The adhesive is compound of resin and hardener. The hardener is irritating to skin, eyes and respiratory tract. It is toxic orally and may cause sensitization. The resin may be mildly irritating to skin, eyes and respiratory tract. Avoid contact with eyes, skin or clothing, and avoid breathing vapor.

Disposable polyethylene gloves or equivalent shall be used to avoid contact of adhesive with the skin. Wear safety glass to avoid contact of adhesive with eyes.

In case of contact:

- Eyes: Immediately flush eyes with plenty of water for at least 15 minutes, then call a physician;
- Skin: Wash skin with soap and water;
- Clothing: Remove contaminated clothing and wash before reuse;
- Inhalation: Remove to fresh air. Give oxygen or artificial respiration if necessary.

Spill and Disposal

When handling resin and/or adhesive, the surrounding area shall be covered with paper carton to avoid spill.

For small spills, apply sand or other absorbent material onto the resin and shovel the mixture into a container. Large spills should be contained with a dike and the excess resin collected in container. Any residue resin should be removed from the floor with hot, soapy water.

CAUTION:

The use of solvents in the final cleanup can pose unnecessary hazards from breathing vapors and possible ignition.

Disposal practice shall be in compliance with local laws and regulations, and other regulations applicable. The preferred waste management option for unused, uncontaminated, unformulated, unaltered resins is to send them to a licensed or permitted recycler, reclaimer, or incinerator. The same waste management options are recommended for used or contaminated materials.

Fiber Glass Systems
17115 San Pedro Avenue, Ste 200
San Antonio, Texas 78232 USA
Phone: 210 477 7500 | Fax: 210 477 7560

INS2011ENG November 2016