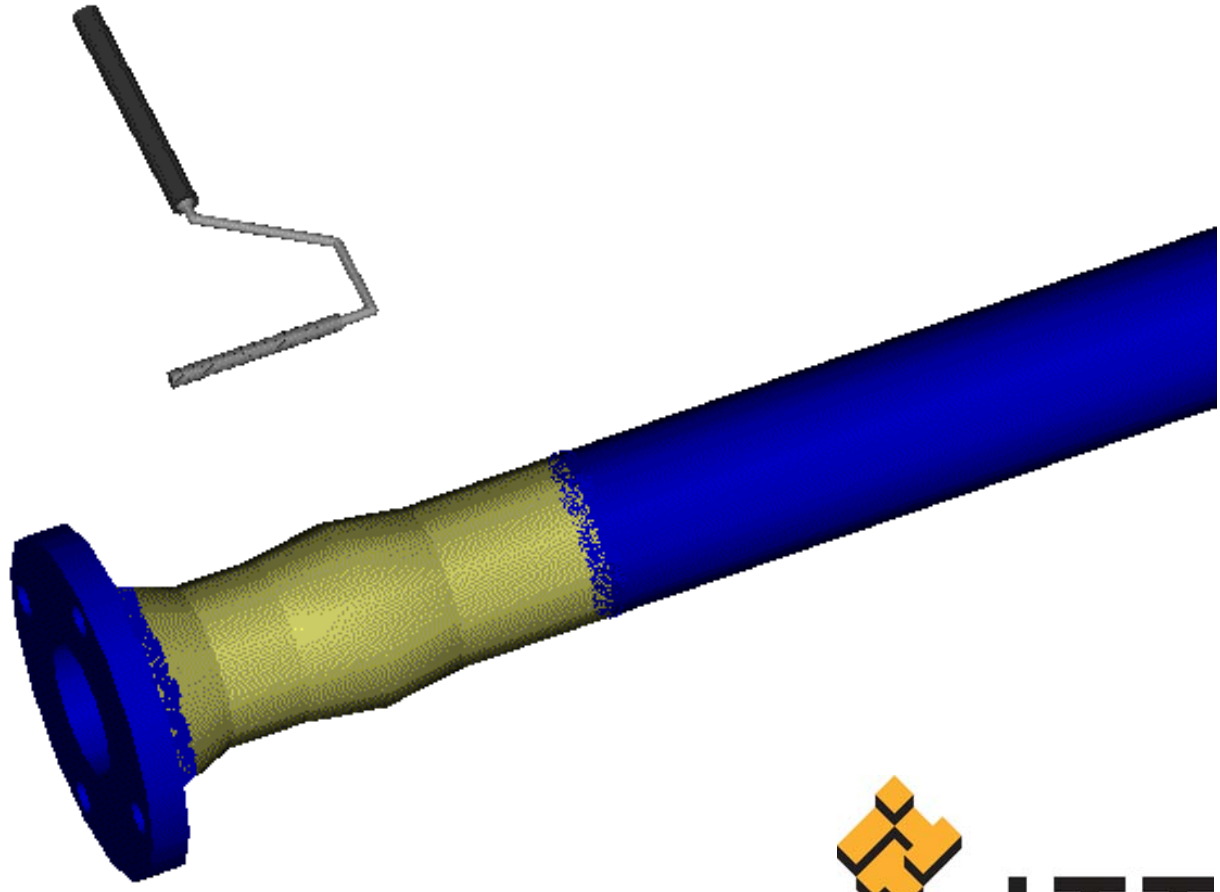
FIBERBOND®

FIBERGLASS AND ADVANCED COMPOSITE PIPING SYSTEMS

Bonding Procedures

For FIBERBOND® Fiberglass Piping Systems



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INTRODUCTION

The intent of this document is to provide reference information to those individuals involved in field bonding FIBERBOND® Fiberglass and Advanced Composite Piping Systems. It is not the intention of this document to provide the reader with full details for performing fiberglass bonding. In no way should this information be used as a substitute for training. Personnel not properly trained to work with fiberglass composites should not rely on the information contained in this manual for specific instructions. Furthermore, any personnel working with fiberglass composites should be properly supervised.

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Revision Log:
March 2011: Updated PPE recommendations.

January 2011: Updated contact information. Updated catalyzation table for putty. Added notes to catalyzation table for resin.

October 2010: Added information on resins, promoters, catalysts, topcoats and solvents. Added additional details throughout the document.

June 2009: Corrected CoNap ratios in Table 3. Updated contact info.

April 2008: Added photos of raw materials to assist in identification. Added section on Assembly. Added details on promotion, other additives, accelerators, and catalyzation in the bonding section.

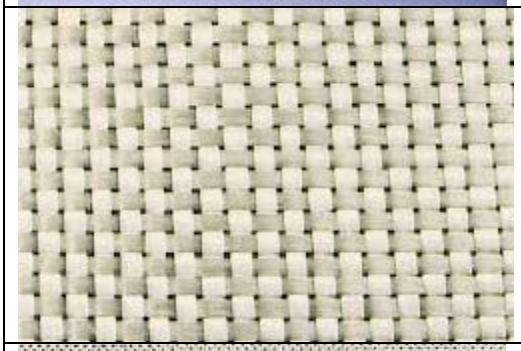
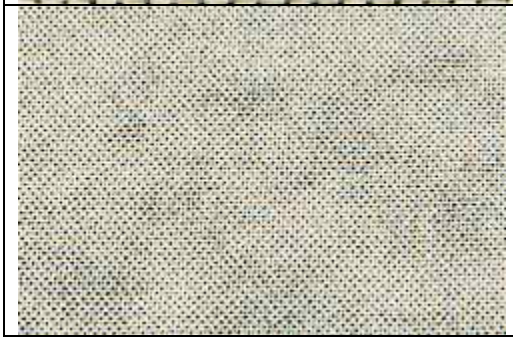
October 2002: This is the first release of this document.

MATERIALS

The following is a general list of materials used for field bonding fiberglass-reinforced plastic. This list in not necessarily a complete list nor is it typical for all FRP field bonding. Note: FRP and GRP are used interchangeably in this document. The terms bonding and welding are also used interchangeably in this document.

Glass Reinforcements

Glass fiber products should be carefully stored to prevent absorption of water and dirt. Use of dirty or wet fibers can result in poor laminate quality, and therefore, should not be used.

Glass Reinforcements	
	**Chopped Strand Mat** – 1.5 oz/ft^2 (450g/m^2) or 0.75 oz/ft^2 (225g/m^2) chopped strand mat is matrix of short, randomly oriented chopped E-glass fibers. Chopped strand mat is used in combination with woven roving to make up the structural cage of FRP welds.
	**Woven Roving** – 24 oz/yd^2 (800g/m^2) woven roving is a matrix of bi-directional woven E-glass fibers used in the structural cage of FRP welds.
	**Veil** – a synthetic veil, such as Nexus manufactured by Burlington Industries, is a surfacing material used in the external corrosion barrier of FRP welds.

Glass Reinforcements	
	**Milled Fiber** – a milled fiber can be added to putty for better tacking properties.
	Continuous Rovings – Continuous rovings (individual strands of filaments) are used as part of the fitup and bonding process for certain product lines.
	"Hoop" Unidirectional Fabrics – E-glass and carbon-fiber "hoop" unidirectional fabrics are used as part of the bonding process in certain sizes and certain product lines.

Resins and Additives

Resins provide the corrosion resistance and act as the matrix material for the glass fibers in FRP welds. Most resins for FIBERBOND® products are vinyl ester or polyester and thus do not require external heat for proper curing. Instead, the promoter and catalyst react in the resin to generate the heat necessary to cure the laminate. Other additives may be used depending upon the FIBERBOND® product and application. The solvent for cleaning is also listed in this section.

Resins and Additives
Resins – The resin used in FRP welds varies according to the FIBERBOND® product and application. Typically, for field weld kits, there is only one resin used, however, some products such as Series 20JF and 20JF-C, may use a "dual" laminate composed of two different resins. Resins are Class 3 flammables.
Promoters – The promoter for the resins and adhesives is Cobalt Napthenate, or CoNap, a 6% solution of active cobalt in solvent. CoNap is a Class 3 flammable. The promoter for the putty is N,N-Dimethylaniline (DMA). DMA, instead of CoNap, may be used as a promoter for the adhesive and/or resin. DMA is a Class 6.1 toxic. NOTE: Resin shipped to the jobsite for use in field weld kits can be requested as pre-promoted (and does not require additional promotion). However, the shelf-life of the resin is reduced to 30 days or less once it is promoted. If not specified, the resin is shipped unpromoted (and requires additional promotion). The container of resin shall denote whether or not the resin is pre-promoted. Putty may also be shipped as pre-promoted or un-promoted. Adhesive is normally always shipped as pre-promoted.

Resins and Additives

Catalysts – When promoted with CoNap, the catalyst for the resins and adhesives is Methyl Ethyl Ketone Peroxide (MEKP), a 9% active-oxygen solution of MEKP and a plasiticizer. When promoted with DMA, the catalyst for the putty is Benzoyl Peroxide (BPO). BPO may also be used as a catalyst for the adhesive and/or resin when they have been promoted with DMA. Note that a DMA/BPO cure typically provides for much shorter working times than CoNap/MEKP, which is sometimes advantageous when working with putty or adhesive. BPO is sometimes referred to as BZQ. MEKP and BPO are Class 5.2 organic peroxides.

Accelerators – The accelerator is typically N, N-Dimethylaniline (DMA), an amine used to accelerate MEKP, BPO, and CHP cures. With MEKP as the catalyst, DMA is normally only required in cool climates. At temperatures of 70F (21c) or higher, DMA is rarely needed with an MEKP catalyst.

Top Coat – All FRP welds are finished with an external corrosion barrier. One part of the external corrosion barrier is the "top coat", sometimes referred to as a "gelcoat". The topcoat is an epoxy that contains a wax solution and UV absorbers. It is catalyzed with resin and brushed onto the exterior surfaces of the weld to seal all exposed glass. Topcoats are Class 3 flammables.
NOTE: In products with electrically conductive exteriors, such as 20FR-EC and 20JF-C, the topcoat is a conductive topcoat that is black in color. It is a two-part mix (Parts A and B). Part A is a Class 3 flammable.

Thixotropies – A thixotropic material, such as Silica Whacker (manufactured by Wacker-Chemie GmbH) is a thickener used in the putty and/or adhesive for tacking welds. Tween® 20, also known as Polysorbate 20, a non-ionic surfactant manufactured by Croda Inc, is another additive for making putty and/or adhesive.

UV Absorbers – Tinuvin 326 (manufactured by Geigy Chemical) is used in the external corrosion barrier of FRP welds. The UV absorber is normally included in the topcoat.

Fire Retardant Additives – Certain FIBERBOND® products, such as 20FR-E, 20FR16, 20FR20, 20JF and 20JF16, require an additive for fire retardancy. Antimony pentoxide is a common additive that is used. Series 20JF and 20JF-C use two different additives. The antimony pentoxide is used with the 510C-350 resin and the alumina trihydrate (ATH) is used with the 441-400 resin. Note: some resins may be premixed with these additives.

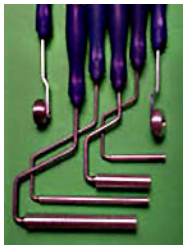
Gel Time Retardants – In some cases, when the temperature is above 90F (32c), a gel time retardant is necessary. 2,4-Pentanedione (by Union Carbide) is typically used.
NOTE: 2,4-P will not affect gel time when used with a BPO/DMA cure system.

Cleaning Solvents - Acetone is typically used to wash brushes, rollers, and other equipment that has become coated with resin or semi-gelled resin. Acetone is a Class 3 flammable.

TOOLS & PPE

The following is a general list of the tools & PPE used for field bonding fiberglass-reinforced plastic. This list is not necessarily a complete list nor is it typical for all FRP field bonding.

Assembly and Bonding Tools

Assembly and Bonding Tools	
	**Brushes –** Typically 2” or 3” natural-hair brushes used to wet-out the chopped strand mat and woven roven with resin.
	**Serrated Rollers –** Typically 1/2” x 3” metal serrated aluminum rollers used to rollout the trapped air pockets in the lamina.
	**Paint Rollers –** Blue felt sleeved rollers are typically used on large diameter welds for placement and applying resin. Paint rollers are not to be used for rollout purposes.
	**Buckets –** One or two quart plastic buckets are used for mixing putty and resin. Paper cups can be used for small mixtures.
	**Putty Sticks –**Tongue depressors are used to mix putty and resin. Wooden or plastic sticks are acceptable.

Assembly and Bonding Tools

	**Catalyst Bottle –** A "squeeze" measure beaker used to accurately measure the proper amount of catalyst. Typically a 16oz (473mL=473cc) or 8oz (237mL=273cc) bottle is used for resin. Also referred to as a Squeeze Bottle or Measuring Dispenser.
	**Wash Bottle –** A "squeeze" beaker used to dispense very small amounts (a few cc's) of catalyst or accelerator. A wash bottle is used when the amount to be dispensed is too little for a catalyst bottle. Wash bottles are typically used to catalyze putty and adhesive and to add DMA as an accelerator to certain mixtures.
	**Grinder –**Typically a 4 1/2" right angle grinder used in surface preparation of field welds. The grinding discs are usually 24-grit.
	**Sawzall (shown) or Circular saw –** Used for trimming ends of pipe to the proper length for field bonding. Carbide-tipped or Diamond-tipped blades are required for cutting fiberglass pipe. Standard steel blades are not suitable for cutting fiberglass.
	**Cardboard –** Typically used as a disposable material for protection when wetting out plies of mat and woven roven prior to lay-up. It is also used for mixing putty with catalyst.
	**Level –** A carpenter's level is required for fit-up of joints.
	**Tape Measure –** Used for measuring field trim to be removed for fit-up of joints.

Assembly and Bonding Tools	
	**Pipe Stands –** Used when spools are fabricated in the field. Pipe stands are when piping needs additional support.
	**Electric Drill w/ Jiffy Mixer –** Required to mix chemicals, if a large number of welds need to be made. A 3/8" drill is suitable for mixing.
	**Pencil Grinder w/ burr bits –** Used for touch up work and hard to reach areas. Burr bits can be straight or tapered.
	**Acetone –** Typically, acetone is used to clean tools that have been coated with resin. Acetone replacement solvents, such as Diacetone Alcohol (DAA), can be used as substitutes.

Personal Protective Equipment

Personal Protective Equipment (PPE)	
	**Gloves** – Neoprene (or other suitable material) gloves may be required by fiberglass welders to prevent irritation. When used as a disposable glove, natural latex gloves offer good short-term protection along with maximum dexterity.

Personal Protective Equipment (PPE)	
	**Filtering Facepiece** – An N95 filtering facepiece (sometimes referred to as a dust mask) may be required during grinding procedures to prevent irritation.
	**Eye protection glasses** – Safety glasses with side shields should be worn at all times for impact protection. If splashing or spraying from chemicals is a concern, goggles should be used instead. If protection of the entire facial area is needed, a faceshield should be used as well.

FIELD BONDING

NOTE: The steps in the assembly and bonding sections are for reference purposes only. It is not the intention of this document to provide the reader with full details for performing fiberglass bonding. In no way should this information be used as a substitute for training. Personnel not properly trained in working with fiberglass composites should not rely on this information or this manual alone for specific instructions. Furthermore, any personnel working with fiberglass composites should be properly supervised.

Surface Preparation

All contamination must be removed from the surfaces to be joined. This includes dirt, dust, moisture, and all other foreign materials.

The surface to be welded must be completely sanded and roughened (there should be no glossy resin finish). The roughened surface should extend at least 1inch (25mm) beyond the area where the glass/resin will be applied.

The bonding should be performed as soon as possible following grinding. Under no circumstances shall the bonding be performed if the area has been contaminated or the grinded surface is older than 12 hours.

Putty / Adhesive Mixing

A typical mixture of putty consists of 4.5 gallons of Silica Whacker, 2.5 gallons of resin, 25-35 cc of Tween® 20, and 0.5 gallons of milled fiber. Note: the milled fiber is optional in the putty mix. This mixture will produce approximately 5 gallons of "unpromoted" putty. An electric drill with a jiffy mixer is suitable for mixing. The amount of Silica Whacker can be adjusted to produce the desired thickness. The Silica Whacker only acts as a thickener, it does not affect the mechanical properties of the putty.

1. Putty mixture (unpromoted)

4. BPO (Luperox AFR40)

2. Putty mixture (promoted)

For puttying a field weld, measure the needed portion of the putty mixture and place onto a small strip of cardboard (approximately 4in x 4in) with a putty stick. Mix the appropriate amount of catalyst thoroughly into the putty (see Table 1). The working time will vary according to resin used, amount of catalyst, and temperature. Typically, BPO-

3. DMA

promoted putty is catalyzed with 1cc of DMA per pound of putty. CoNap-promoted putty is catalyzed with 8.0cc of MEKP per pound of putty.

Adhesive is similar to putty except that it uses an elastomer-modified epoxy vinyl ester resin for the resin and requires the use of milled fiber. Adhesive is typically promoted with CoNap and catalyzed with MEKP.

After the putty is mixed with the catalyst, it is applied to the joint will a putty stick. Be sure to cover all crevasses evenly with putty. When the putty has hardened, the excess putty needs to be removed with a grinder. Before bonding continues the joint must be inspected for removal of glossy surfaces and regions with excess putty.

Table 1. Recommended Catalyzation - Putty

Temperature	Working Time		
	5 minutes	**10 - 20 minutes**	**20 - 30 minutes**
Cool 50s to Hot 90s (10 to 35c)	Use BPO-putty. Catalyze with 1cc of DMA per pound (454 grams) of putty.	Use MEKP-putty. Catalyze with 8cc of MEKP per pound (454 grams) of putty.	N/A

Assembly

All cut pipe lengths must be square and butted together as close as possible. All surfaces must be dry. Do not contaminate the grinding area with your hands. Wear cloth gloves, if needed, when handling.

Series 20HV, 20FR-E, 20FR-EC, 20JF, 20JF-C, 20C, 110FW:

Roughen all cut edges, then coat with resin. Butt together the pieces of pipe/fittings/flanges to be joined. Apply putty to the joint from the exterior to fill any gaps and irregularities in the joint. After the putty hardens, it must be ground for a good anchor pattern prior to any bonding work. All putty, except that required to fill any cracks or crevices, must be removed.

It is not necessary, however, it is acceptable to bevel the edges of the two pieces to be joined to allow more putty to be applied and thus hold the joint better prior to layup. However, the putty (after grinding) shall not be wider than 1/4" (6mm) nor thicker than 1/4" (6mm) to fill the gaps.

Series 20FR16, 20FR16-C, 20FR20, 20FR20-C:

These products have a slight modification to the assembly procedure:

A 1:1 bevel is required at the center of the joint where the two parts are butted together. After beveling, butt together the pieces of pipe/fittings/flanges to be joined. Apply catalyzed resin to the beveled area. Hoop wrap 10 strands of filaments to fill the 1:1 bevel. Do not use putty, however, a very light application of putty may be used to tack the pieces together. The strands of

filament should be "wetted out" with catalyzed resin prior to hoop wrapping. Once filaments have cured, re-grind the entire area with a grinder and then with 36grit sandpaper. Any "hump" from the filaments that extends beyond the bevel may be ground evenly with the pipe, but it is not required.

Resin Mixing

Promotion: Before use, the resin must first be promoted. This is normally done in 55-gallon drums (approximately 450 lbs) prior to shipment to the field, however, some resins may be shipped unpromoted to extend their shelf life (promoted resins normally have a shelf life of one month; unpromoted resins have a shelf life of 3 months or more). A drum mixer should be used to thoroughly mix the appropriate amount of promoter in to the resin. Smaller portions of resin can be promoted with a jiffy mixer. Any additives or accelerators, if needed, should be added after the promoter is completely mixed into the resin.

5. 510C-350 Resin (unpromoted)

7. CoNap (purple)

6. 510C-350 Resin (promoted)

Under no circumstances should the promoter (CoNap) be mixed directly with a peroxide catalyst (MEKP, BPO, and CHP). This could cause a fire or explosion.

Other Additives: Series 20FR-E, 20FR-EC, 20FR16, 20FR16-C, 20FR20, and 20FR20-C require an antimony pentoxide additive that is normally mixed after promotion. The antimony pentoxide, typically labeled as Nyacol APE-1540, is added at a rate of 3.75% by resin weight (e.g., for each 10lbs of resin, add 0.375lbs of Nyacol APE-1540).

8. Nyacol APE-1540

Series 20JF and 20JF-C use two different resins and each resin has its own additive. The 1st resin, which is typically labeled as 510C or 510C-350, requires the antimony pentoxide additive to be added at a rate of 3.75% by resin weight. The 2nd resin, which is typically labeled as 441 or 441-400, requires an alumina trihydrate (ATH) additive. The ATH additive is typically labeled as Solem SB-336 or Solem SB-432 in 50lb (23kg) bags. Note: the labeling of the resin and additives may vary depending on the material supplied. Materials supplied by Specialty Plastics, Inc. or one of its licensees are in accordance with the internal quality assurance requirements of the product line. Please contact Specialty Plastics, Inc. or the licensee from which the materials were purchased for assistance.

Accelerators: In colder temperatures, it can become necessary to add dimethylaniline (DMA) as an accelerator to help assist with the cure of the resin. DMA is a liquid, clear to somewhat yellowish in color that has a very strong, pungent odor. You will not see a color change when

DMA is added as an accelerator. Typically, if DMA is being added to a drum of resin, it should be mixed for 45 minutes.

Catalyzation: When you are ready to begin field bonding, use a one-pound cup (about 1 pint or 473mL) to measure the amount of resin you wish to catalyze. Then add the appropriate amount of catalyst using a catalyst bottle. Thoroughly mix the catalyst with the resin and scrape the sides and bottom while mixing. It is important to never use a brush to mix catalyst with the resin, because it will absorb the uncatalyzed resin changing the ratio of catalyst to resin.

Once the resin has been catalyzed the working time will be reduced to 10-40 minutes (see Table 3). Be sure to catalyze only the amount of resin needed within the given time. Because conditions vary greatly from day to night, it can be very difficult to catalyze resin at night. It is strongly recommending that bonding be carried out during the day.

9. MEKP (Luperox DDM-9)

Important Note: It is not the intention of this manual to provide specific formulating information for proper curing of fiberglass laminates. Characteristics of resins vary from manufacturer to manufacturer, working conditions fluctuate during the day, weather conditions vary from jobsite to jobsite, and desired gel times vary from one fabricator to another. It is not uncommon for actual catalyzation levels to vary from 50 to 150% of the values in these tables. The resin manufacturer's literature can be referenced for general information; however, personnel not properly trained in working with fiberglass composites should not rely on this information or this manual alone for specific instructions. Furthermore, any personnel working with fiberglass composites should be properly supervised.

Table 3. Recommended Promotion & Catalyzation - Resin

Temp.			
< 50F (10c)	At temperatures below 50F (10c), for optimum performance, it may be necessary to provide some source of heat to the resin and the surfaces being bonded in order to ensure a satisfactory degree of cure. Changes in promotion and catalyzation are at the discretion of the bonder.		
Cold - 50s (10-15c)	0.40% CoNap 2.5% MEKP 0.05 to 0.10% DMA	16.4cc per gallon 11.4cc per pound 0.2 to 0.5cc per pound	4.3cc per liter 25.0cc per kg 0.5 to 1.0cc per kg
Cool - 60s (15-20c)	0.30% CoNap 2.5% MEKP 0.0 to 0.10% DMA 0.40% CoNap 2.0 to 2.5% MEKP 0.0 to 0.05% DMA	12.3cc per gallon 11.4cc per pound 0.0 to 0.5cc per pound 16.4cc per gallon 9.1 to 11.4cc per pound 0.0 to 0.2cc per pound	3.2cc per liter 25.0cc per kg 0.0 to 1.0cc per kg 4.3cc per liter 20.0 to 22.5cc per kg 0.0 to 0.5cc per kg
Mild - 70s (20-25c)	0.20% CoNap 1.0 to 1.75% MEKP 0.05% DMA 0.30% CoNap 1.75% MEKP 0.40% CoNap 2.25% MEKP	8.2cc per gallon 4.5 to 7.9cc per pound 0.2cc per pound 12.3cc per gallon 7.9cc per pound 16.4cc per gallon 10.2cc per pound	2.2cc per liter 10.0 to 17.5cc per kg 0.5cc per kg 3.2cc per liter 17.5cc per kg 4.3cc per liter 22.5cc per kg
Warm - 80s (25-30c)	0.20% CoNap 1.25% MEKP 0.0 to 0.035% 2,4-P 0.30% CoNap 1.5 to 1.75% MEKP 0.40% CoNap 2.0 to 2.25% MEKP	8.2cc per gallon 5.7cc per pound 0 to 0.16cc per pound 12.3cc per gallon 6.8 to 7.9cc per pound 16.4cc per gallon 9.1 to 10.2cc per pound	2.2cc per liter 12.5cc per kg 0 to 0.35cc per kg 3.2cc per liter 15.0 to 17.5cc per kg 4.3cc per liter 20.0 to 22.5cc per kg
Hot - 90s (30-35c)	0.20% CoNap 1.0 to 1.5% MEKP 0.0 to 0.05% 2,4-P 0.30% CoNap 1.25 to 1.75% MEKP 0.40% CoNap 1.75 to 2.25% MEKP	8.2cc per gallon 4.5 to 6.8cc per pound 0 to 0.2cc per pound 12.3cc per gallon 5.0 to 7.0cc per pound 16.4cc per gallon 7.0 to 9.0cc per pound	2.2cc per liter 10.0 to 15.0cc per kg 0 to 0.5cc per kg 3.2cc per liter 11 to 15.4cc per kg 4.3cc per liter 15.4 to 19.8cc per kg

See Important Note preceding this table.

Table 2. Recommended Catalyzation - Gelcoats (Promoted)

Temperature	Working Time		
	10 - 20 minutes	20 - 30 minutes	30 - 40 minutes
< 50F (10c)	At temperatures below 50F (10c), for optimum performance, it may be necessary to provide some source of heat to the resin and the surfaces being bonded in order to ensure a satisfactory degree of cure. Changes in promotion and catalyzation are at the discretion of the bonder.		
55 - 65F (12-18c)	4.4% MEKP (20.0cc per pound) (44.2cc per kg)	3.6% MEKP (16.4cc per pound) (36.1cc per kg)	2.2% MEKP (10.0cc per pound) (22.1cc per kg)
65 - 75F (18-24c)	3.6% MEKP (16.4cc per pound) (36.1cc per kg)	3.0% MEKP (13.7cc per pound) (30.1cc per kg)	1.8% MEKP (8.2cc per pound) (18.1cc per kg)
75 - 85F (24-29c)	3.0% MEKP (13.7cc per pound) (30.1cc per kg)	2.2% MEKP (10.0cc per pound) (22.1cc per kg)	

See Important Note preceding this table. This table does not apply to conductive topcoats.

Batch Conversion Factors

Weight %	cc per pound	cc per kilogram	cc per gallon	cc per liter	fluiz oz per drum	cc per drum (452lb, 50gal, 190L)
0.10%	0.5	1.0	4.1	1.1	7.7	204
0.20%	0.9	2.0	8.2	2.2	15.5	409
0.30%	1.4	3.0	12.3	3.2	23.2	613
0.40%	1.8	4.0	16.4	4.3	31.0	818
0.50%	2.3	5.0	20.4	5.4	38.7	1022
0.60%	2.7	6.0	24.5	6.5	46.4	1226
0.70%	3.2	7.0	28.6	7.6	54.2	1431
0.80%	3.6	8.0	32.7	8.7	61.9	1635
0.90%	4.1	9.0	36.8	9.7	69.7	1840
1.00%	4.5	10.0	40.9	10.8	77.4	2044
1.25%	5.7	12.5	51.1	13.5	96.8	2555
1.50%	6.8	15.0	61.3	16.2	116.1	3066
1.75%	7.9	17.5	71.5	18.9	135.5	3577
2.00%	9.1	20.0	81.8	21.6	154.8	4088
2.25%	10.2	22.5	92.0	24.3	174.2	4599
2.50%	11.4	25.0	102.2	27.0	193.5	5110

(1) gallon = (4) quarts = (3.8) liters; (1) quart = (2) pints; (1) pint = (2) cups; (1) cup = (8) ounces; (1) ounce = 29.57cc

Based on cured resin weight (cured resin S.G. of 1.08, liquid resin S.G. of 1.15, liquid additive density of 1.00).

Bonding (also called Welding)

Refer to the field weld kit packages for the laminate sequence. The glass reinforcement materials are already cut to the proper length and width for field bonding.

1. On a piece of thick paper or cardboard apply a layer of catalyzed resin with a 2in. or 3in. natural hair brush. The cardboard should be completely saturated with resin (no dry spots). Apply the widest ply of the weld sequence to this layer of resin and add more resin to this ply of glass.

Note:

- The widest ply of the weld sequence is not necessarily the widest ply of the weld kit. The weld kit may have to be divided into more than one "sequence" because of thickness. A typical sequence consists of 5 plies of material. Therefore, a weld kit with 8 plies of material will normally be divided into 2 sequences. You should separate the weld sequences in the kit when wetting out the glass. The last and first ply of each sequence should always be a chopped strand mat.

- Be sure the mat is wet out thoroughly. There should be no white strands showing.

2. Continue adding the following plies to the sequence one at a time. Completely saturate each with resin.

Note:

- When adding the glass plies to the sequence, stagger each about 1/2in. from the previous ply.

3. Lift the mat from the cardboard and place one end over the puttied joint (The narrowest ply should be placed to the inside.). The weld should be centered on the joint. While holding one end of the wetted sequence, start rolling (circumferentially around the pipe) the sequence on the joint. Continue rolling until 180degrees of the joint is covered.

Note:

- When you first begin rolling, it is important to hold the other end of the sequence in your hand to prevent stretching.

4. Form the remainder of the weld around the joint and continue rolling in the direction of the wrap until all the air is removed.

Note:

- Keep the roller going in one direction. If all the air has not been removed, continue rolling in the same direction for another pass around the joint. It is important that all visible air pockets are completely removed before proceeding with the next step.

- If the roller is picking up strands of mat or causing more air bubbles, clean the roller. Shake all the cleaner off of the roller and dip the roller in catalyzed resin and continue rolling.

- Direct sunlight may cause burns and should not make contact with the weld. Shade the joint with cardboard or other suitable protection.

5. Once rolling is completed, the first sequence needs to harden and cool down (part of its curing process). During curing, do not let the joint be moved, impacted, or contaminated with water, dirt, etc.

   For the second and remaining sequences, repeat steps 1 through 4. Note that in the remaining sequences, there are normally more than 3 plies, depending upon the resin. Also note that normally there are woven plies in these sequences.

Note:

- After the first sequence has hardened and cooled down, it should be lightly sanded to smooth any glass that may be sticking up that can cause air entrapment in the second sequence.

- If the first sequence cures for more than 12 hours, it must be reground with a 24-grit disc on an electric sander before applying the second sequence.

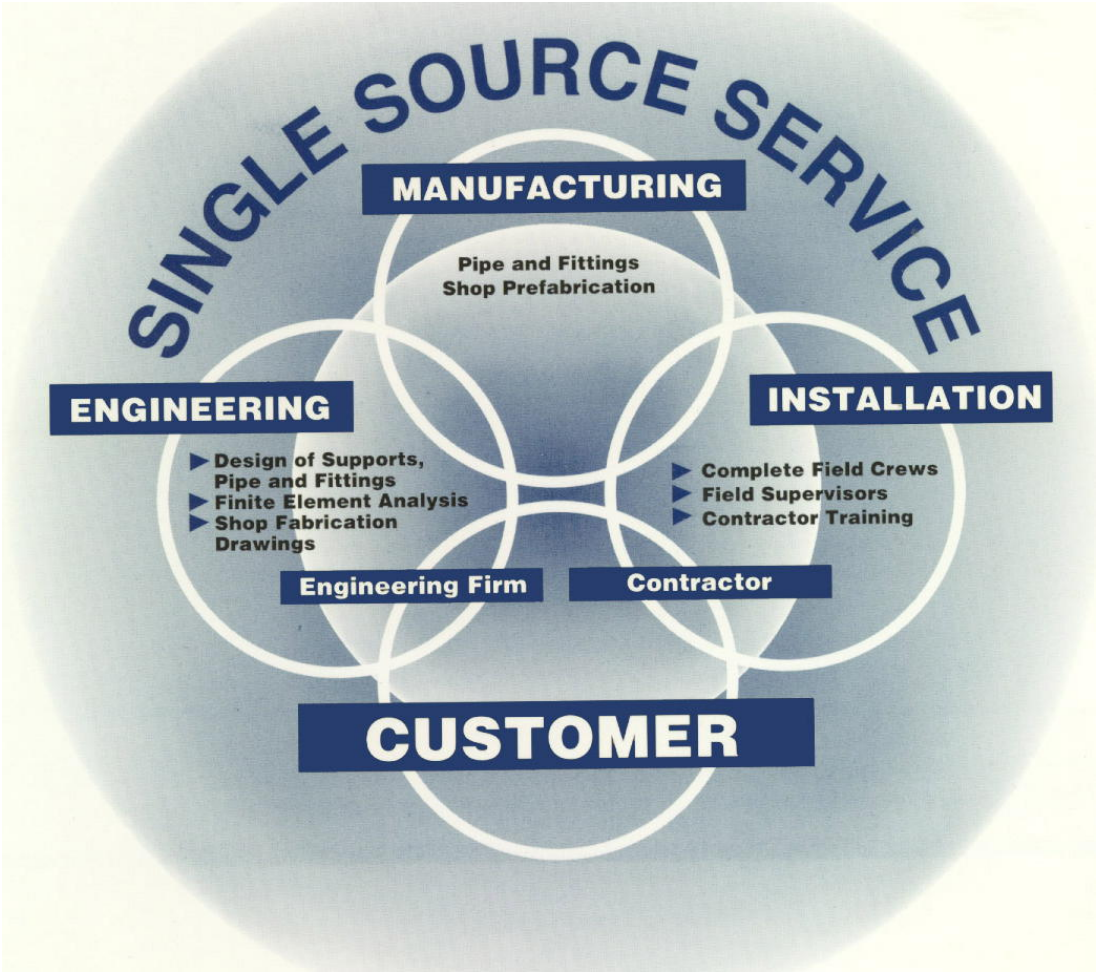
6. Once the final structural sequence has cured, visual inspection should be performed. Visually look for air entrapment, burns, drains, and contamination. Also ensure that the weld is properly positioned over the joint.

	7. Once the final sequence is applied, a veil layer is applied. Please note that the veil layer is applied before the final sequence has hardened. It is usually necessary to brush a thin layer of resin onto the final sequence before applying the veil. Continue applying the veil until the entire joint is covered. The veil should be applied tightly to the joint to help remove excess air and resin.

	8. Once the veil is applied, it should be brushed with resin. It is important to cover the entire veil layer with resin until saturated. Before applying the external coat (which may be a natural color waxcoat, pigmented topcoat, or conductive topcoat), the veil layer (which has now hardened and cooled) needs to be ground lightly. Once the surfacing veil has hardened and cooled down, the external coat is applied (not shown). Apply the external coat to the exterior surface with a brush being sure to cover the entire surface.

Note:

- At temperatures below 50F (10c), for optimum performance, it may be necessary to provide some source of heat to the resin and the surfaces being bonded in order to ensure a satisfactory degree of cure. The use of an enclosure, such as tenting, may provide assistance in maintaining satisfactory temperatures. An external heat source may be in the form of electric heater blankets, space heater units with the hot air ducted to the work area or other suitable method.



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