PowerSleeve® Installation Manual for Repairing Damaged Piping and Pipelines

Air Logistics Corporation
F.A.C.S.™ Group
925 North Todd Avenue
Azusa, CA 91702 USA
Phone 626-633-0294 • Fax 626-633-0791

INTRODUCTION

PowerSleeve® is a high strength, field-applied composite that is used for structural reinforcement of damaged piping. It is a wet layup, or field-pregged, fiber-reinforced polymer (FRP) system that consists of custom blended epoxy and unique fiber reinforcements tailored for piping repair.

There are several variations to the standard system that allow its use in high heat situations, harsh chemical environments, and cool installation temperatures.

PowerSleeve® with Standard Matrix –
This is our most common system used for applications in a mild environment. It is available with our high strength W-11 substrate, which is an E-glass premium fiberglass roving, alloyed with Kevlar®, in a stitched, tri-axial, non-crimped, fabric. This fabric is radically different than common fiberglass in a woven configuration. A custom woven E-glass tape fabric (G-03) is available for use on smaller applications. The Standard Matrix system has a cure time of approximately 30-60 minutes at 77°F. This system has a Heat Distortion Temperature of 300°F for the W-11 fabric and 275°F for the G-03 fabric. Ships DOT Non-Hazardous.

PowerSleeve® LT Matrix –
This system is a low temperature cure matrix that is suited for high humidity conditions, like those found in a marine environment. It can be used in temperatures as low as 50°F where its pot life is approximately two-hours. At 77°F, the pot life reduces to 10 minutes. This product ships DOT Hazardous (corrosive).

PowerSleeve® with 439 Matrix–
The 439 system is a medium temperature system that is available with either the W-11 or G-03 fabrics. This epoxy/novolac hybrid cures at room temperature, yet has a much higher HDT than the Standard Matrix. The addition of novolac gives it better chemical resistance in cases where contact, whether external or internal, may occur. The HDT for the W-11 fabric is 425°F and 300°F for the G-03 fabric. Ships DOT Hazardous (corrosive).

PowerSleeve® with 439S Matrix –
This system is nearly identical to the 439 system, but its slow cure allows for installation at higher temperatures. This system requires a minimum of 150°F to initiate the cure. It can be installed on temperatures up to 220°F, but special precautions need to be observed. Ships DOT Hazardous (corrosive).

PowerSleeve® with 70079 Matrix –
70079 Matrix is a premium two-component, epoxy/novolac hybrid system with excellent exposure resistance to most military and civilian fuels and a vast array of chemicals, including sulfuric acid. It is also resistant to moisture and humidity effects. It contains no solvents, is 100% solids, and contains zero VOC's. Ships DOT Non-Hazardous.

PowerSleeve® with X-TEMP-2 Matrix –
The X-TEMP-2 system is designed for use where high service temperatures will be encountered. To achieve its ultimate properties (HDT of 575°F), it must be exposed to 450°F during its curing stage. It cures in about 80 minutes at 150°F. Ships DOT Hazardous (corrosive).

PowerSleeve® has gone through numerous field trials, in-house testing, and third party testing. These tests have demonstrated that it possesses those performance qualities required for the repair of corrosion damage, both internal and external. The material can be applied both circumferentially and helically along the pipe. Its low profile enables use in tight locations, within an inch of an obstruction in some cases.

All of our PowerSleeve® products are available in a packaged kit format. This packaging format has many advantages. It eliminates field measuring of the epoxy components, and the possibility of calculation errors. It also greatly reduces the possibility of having too much or too little fiber to resin content, which can adversely affect the properties of the final composite layup. Special components and tools are provided in the kit to encourage proper installation techniques. The kit concept minimizes waste, both for application and disposal. The correct amount of material is provided in every kit to cover a pre-determined area, which assures the requisite amount of material is installed.

PowerSleeve® can be used to repair the following types of damage:

- External Corrosion (ASME PCC-2 Type A Repair)
- Internal Corrosion (ASME PCC-2 Type B Repair)
- External Mechanical Damage (dents, gouges, fretting, wear, etc.)
- Cracks
- External Coating Damage
- Internal Corrosion/Erosion
- Manufacturing or Fabrication Defects
- Leaks (if completely stopped prior to composite application)

TRAINING

As with any product, proper training is essential to ensure a quality installation. This installation manual is meant to be used as a guide and reference tool to backup hands-on training. All personnel using PowerSleeve® must attend a training course presented by a certified trainer. The course outlines safe handling of the product, product selection, surface preparation, and multiple installation techniques. Many more topics are covered in the training course than is practical to include in this manual.

It is not recommended for untrained personnel to attempt installation of any of the PowerSleeve® products until they are fully and properly trained. Doing so can create an unsafe situation for the installer, as well as an inadequate repair.

F.A.C.S.™ GROUP QUALITY OVERVIEW

Objective

To produce a high quality product having outstanding performance characteristics with consistent handling and mechanical properties coupled with excellent longevity. The program, from product design through field performance monitoring, is outlined below.

Design

The design activity entails not only that of the product but of the facility and equipment required to produce it.

Product Design: The product design activity required several years of resin development and testing coupled with evaluation of fabric weaves and construction alternates. The design activity has produced a number of product variants to suit specific customer applications.

Facility and Equipment: Consideration has been given to proper fabric and epoxy storage for all of the PowerSleeve® components. Measuring devices, fabric cutting tools, and assembly areas are designed for quality production and economical processing. Our production staff is trained on the safe handling and use of the product, as well as proper packaging techniques.

Development and Qualification Testing

Air Logistics has completed extensive strength and environmental testing as a part of the product development process utilizing our internal test facility. Outside test laboratories have confirmed the results of this internal testing. Having complete test capability is a key asset in the product formulation and the ongoing product improvement process.

Workmanship Practices

The development of, and rigorous adherence to, proper workmanship and processing practices is essential to achieve quality manufacturing. Air Logistics has developed a complete set of operational processes and procedures for the manufacture of its products. These processes include, but are not limited to, incoming material inspection, resin mixing, facility environment monitoring, equipment set-up, operational functions, and packaging integrity.

Incoming Material: Supplier certifications are required on all incoming production material used in the manufacturing process. The certifications are maintained as a part of the quality records. Where appropriate, physical measurements of testing are completed and recorded.

Material Traceability: Lot numbers of all materials used in production are recorded. Retains are also kept for future inspection if needed.

Packaging: Packaging quality is essential to the production process to protect all the components of the product. Proper packaging selection and sealing techniques are essential to ensure integrity during transportation of the product.

Product Testing: As part of our commitment to quality assurance, samples from different lots of product are periodically drawn from production, made into coupons, and tested.

Field Evaluation: Material quality data are collected and monitored as received from users. Should problems develop, they will be investigated to isolate the root cause and corrective actions will be taken as required.

Test Facilities

Air Logistics has a test facility capable of verifying most of the mechanical and life characteristics of our PowerSleeve® products. Each test complies with the appropriate ASTM standard and procedure. When a required test is beyond the scope of our facility, the material is sent to a reputable third-party test lab. The ability to test and verify new and existing products is an invaluable asset in the development process, as well as ongoing quality assessments.

HAZARDS ASSOCIATED WITH A PRESSURIZED SYSTEM

As with any repair on a pressurized system, certain precautions need to be observed when installing a composite system on a damaged pipeline or pipework. The level of damage should be considered and properly addressed. Has the structural integrity of the pipe been compromised? If the wall thickness has been degraded to a point where the pressure in the line presents an unsafe situation, the pressure may need to be reduced during the installation. This also applies to dents and other types of mechanical damage.

If the wall thickness is such that a leak may occur, but structural integrity of the system is still within safe limits, installation should be done with caution. It is good practice to apply a stiffener material, such as the high strength epoxy that is used as a load transfer compound. This will help keep the area intact and lessen the possibility of creating a through wall defect during the installation.

Proper surface preparation procedures should always be used, however, they need to be tailored to the type of defect being repaired. For instance, sandblasting would not be a wise choice of surface preparation if certain areas of the pipe are in danger of collapse. If a hole should occur on a pressurized system during the surface preparation, it could create a dangerous situation and may make the installation of a composite material impossible.

HEALTH, SAFETY, AND ENVIRONMENT

Always read and understand the MSDS and Product Data Sheet prior to attempting an installation.

Proper personnel protective equipment (PPE) should always be used. It must be appropriate for the conditions being encountered during the installation. Evaluating the risks of a possible line breach and release of the lines contents should also be considered. At minimum, latex gloves, long sleeves, and safety glasses must be worn.

Skin sensitivity to epoxy resins may occur in some people. Care should be taken to avoid contact with any of the composite components.

Cutting of glass fibers may release tiny particulates. If cutting large quantities of fiber while it is dry, wear minimum FP1 or preferably FP2 EEC approved dust masks. Type 3M 8710 or 3M 9900 respirators are approved according to American National Institute for Occupational Safety and Health (NIOSH). Masks should also be worn if cutting or sanding the material after it has been cured.

Dispose of all material according local and federal regulations. PowerSleeve® kits are designed to generate minimal waste. All jars or cans containing epoxy should be thoroughly emptied during use, and only remnants will be left. Generally these small amounts are acceptable to dispose of in waste containers, but check with local authorities for confirmation. Always refer to the MSDS sheet for the material you are working with. Specific hazards relating to handling, disposal, and transportation will be listed.

TEMPERATURE GUIDELINES

Temperature is a very important factor when considering the use of composites for structural reinforcement. Epoxies are very temperature sensitive. Too much heat and they will cure too quickly. If it is too cold, they may not cure at all.

Cure Time

A rule to remember for epoxy systems is that for every 18° F temperature change, either up or down, the working time (pot life) will half or double. For example, if you are working with a system that has a 30 minute working time at 77° F, and you use it on an application in 95° F weather, the working time now decreases to approximately 15 minutes. Conversely, if you are installing the same system in 59° F weather, the working time extends to nearly 60 minutes. One should be conservative in estimating installation time when dealing with elevated temperatures. When the epoxy begins to gel, or become unworkable, it can happen very quickly, and you may not have time to properly finish your installation.

Pot Life

The volume of material you are mixing will affect the pot life. Mixing large quantities generates a higher exothermic reaction, and can decrease the pot life significantly. One should never mix more than what can be used within the pot life of the material. When using large quantities of epoxy, mix thoroughly and spread it out onto the working surface or fabric immediately. Do not let large amounts remain in a container. Dangerous temperatures can be generated by the curing action of the mixed components. Temperatures exceeding 300° F have been observed.

Physical Properties

Temperature not only has an affect on the cure time, but also the physical properties. When exposed to warm temperatures, epoxies will begin to lose their viscosity. Cold temperatures will greatly increase their viscosity. Typical centipoise values for our mixed epoxy systems at 77° F range between 2,500 and 10,500 for mixed components. The resin, or part A side, usually is more viscous than the hardener, or part B side.

Cold epoxies are difficult to work with and warming them properly to an appropriate mixing temperature may take hours. It is best to keep these products as close to ambient temperature as possible, both when in storage and when mixing. Do not mix when the temperature of the materials are below 55° F. Improper blending of the two components may occur due to the increased viscosity. When temperatures are low, difficulty in wetting out the fabric may be observed. The thickened epoxy will not wet out the fabric as easily and this could lead to performance reductions for the completed application. The surface to be prepared should also be at least 55° F. Lower temperatures could inhibit the cure of the epoxy, even though the air temperature is warmer.

Epoxies are an excellent heat sink. Warmed epoxy components may take hours to cool to an appropriate mixing temperature. Mixing components while they are warmed above 77° F can significantly reduce the pot life and working time of the material. Air temperature can also decrease the working time. Never leave components in direct sunlight, or in an area where temperatures will exceed 90° F. When working in warm climates keep the materials in a portable cooler or air conditioned area to maintain a reasonable temperature. When applying epoxies to a warm surface, the material will thin and may become runny. In some cases, additives are combined with the resin to minimize this thinning effect. Be aware that at temperatures exceeding 180° F, the material can go from workable to unworkable in a matter of seconds. Plan your installation accordingly, accounting for all temperature

parameters for your given situation. Once the gel state of the material initiates, immediately stop working with the material and complete your installation. Trying to work with material or fix any problems after this point will only make matters worse.

Surface Temperature

Surface temperatures need to be carefully considered. Just because you have a system that is rated up to 300° F, does not mean it can be installed at that temperature. Read and understand the Technical Data Sheet for the system you are using prior to application. Installation temperature recommendations are listed and can be used as guidelines. Fast cure times can be detrimental in a few ways. First, it may have a negative effect on the properties of the material while it is going through its cure process. Also, the material needs time to bond with the surface. If it cures too quickly, it will not have time to wick into the surface to create the bond. Proper installation is another reason. When working on a surface that is hot, the installation time is reduced. This can lead to a hasty application that may not be done correctly.

SURFACE PREPARATION

Surface preparation is critical to success when high performance composites are applied in the field. Bad surface preparation can result in premature failure or weakened properties of the repair system. Please contact our office for information on preparation when encountering questionable conditions.

1. Major surface contamination buildup should be removed prior to any high quality cleaning. This is often done with water-based pressure washer machinery and high-alkalinity detergent wash.
2. Paint may or may not need to be removed, depending on the type of repair. Generally any paint or coating must be removed. All pipeline tape wraps, bitumen coatings, insulation, etc. must be removed.
3. Abrasive blast to a near white (NACE No.2/SSPC-SP 10) level all surfaces that the composite will contact. This is adequate for most work. Installations requiring structural adhesion, or for isolated patch applications where the patch is held to the work surface by its adhesion, must be white metal blasted (NACE No.1/SSPC-SP 5). Where abrasive blasting is dangerous or impossible, surfaces that the composite will contact should be abraded (scratched up) with the equivalent of an 80-grit abrasive and the metal surfaces should be brought to the equivalent of the appropriate NACE level mentioned above. If abrasive cleaning is not allowed, chemical cleaning of the affected are must be done. In addition, a high strength, high build epoxy should be applied over the worst areas and allowed to cure before the application of the composite reinforcement. (Fig.1 and Fig. 2)

Fig. 1

Fig. 1 – The sandblasting done on this line revealed more damage than was visible during the initial inspection. Proper cleaning is essential to a sound repair.

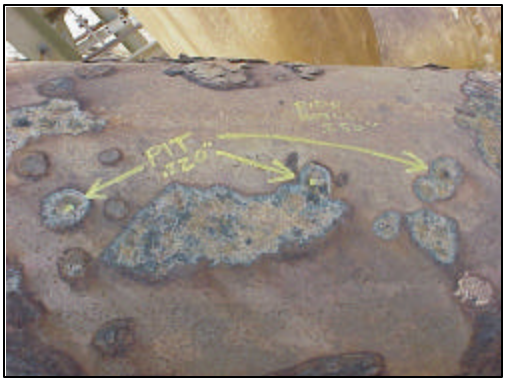


Fig. 2

Fig. 2 – Surface preparation as shown is generally unacceptable. In cases where the pipe cannot be properly cleaned, it should be noted that the final ultimate properties of the composite layup may be compromised (such as bonding to the steel surface).

4. Excess dust and residue from the abrading should be blown or wiped away with oil-free compressed air or new, clean solvent wipes. Special precautions should be observed when cleaning surfaces operating at high temperatures (above 100°F), or for applications where a low flash point solvent is inappropriate. For this type of cleaning, use of Bromothane S solvent is recommended. It is non-flammable and leaves no residue on the surface.
5. All sharp corners, corrosion pits, dents, leak repairing patches and wall/diameter offsets greater than 1/8th-inch (3mm) (1/16th-inch for fluid-tight installations) should be smoothed with a high compressive and high flexural strength filleting and filling compound. The recommended filler compound for structural applications is BIO-FIX 911 or BIO-DUR 563 (Fig. 3 and Fig. 4). Alternative fillers may be used only for non-structural applications. Most circumferential piping welds and the like require no special filleting or smoothing. Check with a straight edge to confirm the surface is level.

Fig. 3 – The defect must be completely filled in and the compound must be smoothed and leveled out. Remove high spots and fill any low spots

Fig. 4 – Use a straight edge to confirm evenness.

6. After filling and smoothing, wipe the surface again with a clean cloth and a solvent cleaner. Remove any dust or foreign matter from the surface of the pipe in the area of the repair.
7. Application of the primer and composite should begin within eight hours of the final cleaning, unless special preparations have been made. This time may be reduced in high humidity areas where flash rusting can occur.

MATERIAL PREPARATION

All of the PowerSleeve® components are best used when they are at ambient temperature (65°F-90°F). Using the materials within this temperature ranges allows for good mixing and fabric wet-out. Cooling or warming techniques should be implemented in an attempt to bring the materials into the optimum temperature range. If this is not possible, care should be taken to ensure that the components thoroughly interact with one another. In cooler temperatures, the resin and hardener of the epoxy system will become thicker, thus requiring a longer mixing time. Wet out of the fabric will also require more time, as the thicker epoxy will require a longer dwell time to impregnate into the fabric. When warmer temperatures are encountered, the epoxy resin may begin to react more quickly than anticipated. This lessens the working time of the material and may make installation difficult.

The fabric should be wetted out on a clean surface that is free from dust and foreign residue. Surfaces should be kept cool, or warm, depending on air temperatures. In warmer temperatures, a light colored material can be placed under plastic sheeting to reflect the warming rays of the sun. In cool temperatures, a darker colored material can make the surface warmer. The wet-out surface should be protected from wind gusts and rain. Contact with water will adversely affect the fabric and the resin and will render it useless.

Be sure all components are available prior to any mixing or application. Time management is important when working with epoxy materials. Once the process has started, you must finish, or get to a specific hold point before the material begins to gel (cured to a point where the epoxy does not flow freely).

Confirm that each section of fabric has its corresponding epoxy kit (parts A&B). Our kits are set up to have a one-to-one ratio. Each section of fabric will have its own epoxy kit that is pre-portioned and weighed to provide the correct epoxy/fabric fraction. It is important not to mix and match kits, as this will adversely affect the properties of the composite.

As part of the material preparation, the installer should check and verify the defect parameters. Current wall thickness, depth and length of defect, pressure, operating temperature, etc. The application temperature of the surface to be repaired should be checked with a calibrated temperature sensing device. Surface temperatures have a greater effect on the cure time than air temperature. All of this information should be confirmed against the application parameters obtained during the repair assessment. Verify the materials you have are correct before proceeding.

Remember the five P's… ***P**roper **P**reparation **P**revents **P**oor **P**erformance*

MATERIAL APPLICATION

The following instructions should be carefully read and understood prior to beginning the installation. Also read and understand the MSDS sheets for these materials. Proper factory training is required, as these instructions cover only the basic steps of proper installation. Any modification to these instructions should be approved by Air Logistics Corporation. If you have technical questions, please call Air Logistics Technical Support at 626-633-0294. Latex gloves, long sleeves, and safety glasses are mandatory, along with any other PPE specific to your application environment.

<u>Standard W-11 Fabric</u>

1. Follow the appropriate cleaning and preparation instructions listed above.

2. All sharp corners, dents, leak repairing patches and wall/diameter offsets greater than 1/8th-inch (1/16th-inch for fluid-tight installations) should be smoothed with a rapid-setting filleting and filling compound. Alternately, other non-structural F.A.C.S.™ products may be used to create smooth contours of the repair surfaces. Good consolidation between the layers of the composite and to the surface being repaired is essential to sound repair. Voids within the layup should be avoided.

3. For the Standard Matrix, 439 Matrix, and the 70079 Matrix, it is best that PowerSleeve® be applied between 60°F and 110°F (16°C - 44°C). If out of this range, special matrix systems should be used, such as the LT Matrix, 439S Matrix, or X-TEMP-2 Matrix. Also, all of the

PowerSleeve® Kit components should be maintained between 65°F and 90°F (18°C - 32°C) during the actual matrix mixing and wet-out procedure.

4. In most cases, the primer system will be the same material as the main matrix in the kit. However, in certain instances, it may be different. For this reason, always use the epoxy kit marked "Primer" for priming the surface of pipe. Mix the primer by pouring all of the contents of the Part B container into the Part A container. Mix thoroughly for at least 3 minutes. Mixing should be done slowly to avoid air bubble formation. Coat all surfaces that the PowerSleeve® will be applied to with a thorough application of primer, as furnished with the kit. Most primers should be over wrapped with at least the first layer of the main PowerSleeve® material while the primer is still wet. If applying to a flat surface, you may let the primer become slightly tacky, but not to a point where it becomes unmovable. If using a primer that is different than the main matrix system, you should allow the primer to cure before continuing.

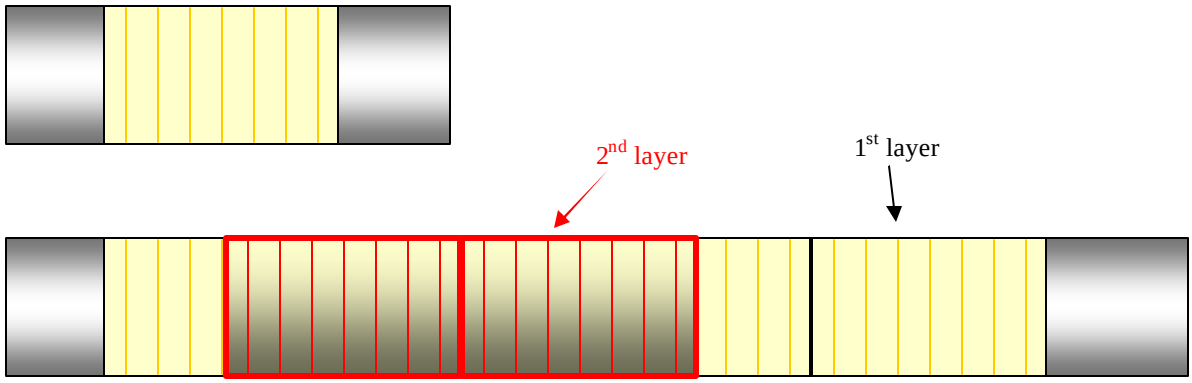
5. Unroll and lay out one segment of the PowerSleeve® substrate ("fabric") on the wet-out work surface, 45x45 side up, and the yellow striping side down.

6. Pour all of the contents of one of the Part B matrix containers into one of the Part A matrix containers. Mix thoroughly for at least 3 minutes. Mixing should be done slowly to avoid air bubble formation.

7. Pour about half of the mixed matrix onto the PowerSleeve® segment laid out on the wet-out work surface, and with the furnished squeegee, distribute the matrix evenly over the entire PowerSleeve® segment, using slow spreading strokes. Spreading speed and volume should be adjusted to matrix temperature. Flip the segment over. Repeat the wet-out spreading on this side using the balance of the mixed matrix. The total mix amount in a single module is appropriate for a single PowerSleeve® segment.

8. Roll up the resin-wetted PowerSleeve® segment and transport to the application site (45x45 side out).

9. Within 10 minutes of wetting-out, unroll the segment onto the surface to which the PowerSleeve® is being applied (45x45 side down). Press it into the application surface with the squeegee or your gloved fingers, working any trapped air bubbles to the edge and forcing the PowerSleeve® into tight contact with the surface below.



10. Repeat for all PowerSleeve® segment layers remaining in the kit. It is best to set the starting point of each layer at a different location around the vessel. For example, start the first layer at

the 12-o'clock position, the second layer at the 3-o'clock position, etc. If several kits are to be applied to a section of pipe, apply the first layer to the entire length of pipe to be sleeved, then start the second layer, offsetting the edges of the layers by at least 6 inches or half the width of a segment (as in laying courses of brick). Choose a segment of pipe short enough that you can install all four layers of material prior to any part of the installation entering its gel point. Overlap successive sections by at least two inches.

11. Once the PowerSleeve® segments are all installed, starting at one edge, begin spiral wrapping the Stricture Banding™, stretching it and pulling loosely at first, then tightly around the assembly, proceeding down to the other end, and back to the starting point. Do at least four complete layers, but more does not hurt and can actually improve the compression on the layup.
(NOTE: If the temperature and length of the installation causes the first layer of PowerSleeve® to begin hardening before installation of subsequent layer can be installed, stop and do the Stricture Banding™ procedure and allow the installed layers to compress and cure until they hold their shape dependably. Be certain to remove all Stricture Banding™ before adding additional layers of PowerSleeve®. Any time installation progress is delayed for more than 24 hours, all cured composite surfaces must be sanded to break the "glaze" of the surface, prior to application of subsequent PowerSleeve® layers. Under certain circumstances, this periodic Stricture Banding™ process may have to be done several times.)

12. Allow the PowerSleeve® to cure until it is dry to the touch and does not indent when pressed with a finger nail.

13. Completely remove the Stricture Banding™.

14. Paint the entire PowerSleeve® installation with PowerCoat™ paint, furnished in the kit, or factory approved UV & weather barrier coating. Two coats are recommended.

15. CAUTION: When cured only a few hours ("dry to the touch") the standard PowerSleeve® system is NOT fully cured and has NOT reached its full strength. Under circumstances where full structural strength is required prior to some action (such as re-pressurizing a leaking pipeline) a longer cure is required. Contact Air Logistics Technical Support for details.

<u>Standard G-03 Fabric</u>

1. Follow the appropriate cleaning and preparation instructions listed above.

2. All sharp corners, dents, leak repairing patches and wall/diameter offsets greater than 1/8th-inch (1/16th-inch for fluid-tight installations) should be smoothed with a rapid-setting filleting and filling compound. Alternately, other non-structural F.A.C.S.™ products may be used to create smooth contours of the repair surfaces. Good consolidation between the layers of the composite and to the surface being repaired is essential to sound repair. Voids within the layup should be avoided.

3. For the Standard Matrix, 439 Matrix, and the 70079 Matrix, it is best that PowerSleeve® be applied between 60°F and 110°F (16°C - 44°C). If out of this range, special matrix systems should be used, such as the LT Matrix, 439S Matrix, or X-TEMP-2 Matrix. Also, all of the PowerSleeve® Kit components should be maintained between 65°F and 90°F (18°C - 32°C) during the actual matrix mixing and wet-out procedure.

4. In most cases, the primer system will be the same material as the main matrix in the kit. However, in certain instances, it may be different. For this reason, always use the epoxy kit marked "Primer" for priming the surface of pipe. Mix the primer by pouring all of the contents of the Part B container into the Part A container. Mix thoroughly for at least 3 minutes. Mixing should be done slowly to avoid air bubble formation. Coat all surfaces that the PowerSleeve® will be applied to with a thorough application of primer, as furnished with the kit. Most primers should be over wrapped with at least the first layer of the main PowerSleeve® material while the primer is still wet. If applying to a flat surface, you may let the primer become slightly tacky, but not to a point where it becomes unmovable. If using a primer that is different than the main matrix system, you should allow the primer to cure before continuing.

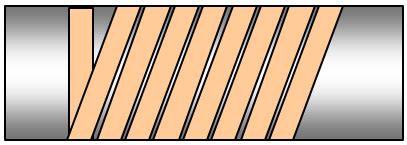
5. Unroll and lay out one segment of the PowerSleeve® G-03 substrate ("fabric") on the wet-out work surface.

6. Pour all of the contents of one of the Part B matrix containers into one of the Part A matrix containers. Mix thoroughly for at least 3 minutes. Mixing should be done slowly to avoid air bubble formation.

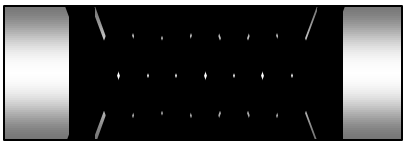
7. Pour about half of the mixed matrix onto the PowerSleeve® G-03 segment laid out on the wet-out work surface and distribute the matrix evenly over the entire PowerSleeve® G-03 segment, using slow spreading strokes. You may use light hand pressure or a soft spreading tool. Spreading speed and volume should be adjusted to matrix temperature. Flip the segment over. Repeat the wet-out spreading on this side using the balance of the mixed matrix. The total mix amount in a single module is appropriate for a single PowerSleeve® G-03 segment.

8. Roll up the resin-wetted PowerSleeve® G-03 segment and transport to the application site.

9. Within 10 minutes of wetting-out, unroll the segment onto the surface to which the PowerSleeve® G-03 is being applied. Press it into the application surface with your gloved fingers, working any trapped air bubbles to the edge and forcing the PowerSleeve® G-03 into tight contact with the surface below. This fabric is best applied using a spiral wrap technique.



First layer wrap direction → → →



Second layer wrap direction ← ← ←

Starting at one end of the repair area, spiral the material around the pipe, laying each subsequent wrap adjacent to the other, without overlapping. Upon reaching the other end of the repair, make one complete spiral around the pipe and continue back the other direction. Never exceed a 45° angle during installation.

10. Repeat for all PowerSleeve® G-03 segments required for your installation. When finished with one roll, begin the next roll by overlapping a minimum of 3" from the previous end point. Choose a segment of pipe short enough that you can install at least two layers of material prior to any part of the installation entering its gel point. Overlap successive sections of material by at least two inches.

11. Once the PowerSleeve® G-03 segments are all installed, starting at one edge, begin spiral wrapping the Stricture Banding™, stretching it and pulling loosely at first, then tightly around the assembly, proceeding down to the other end, and back to the starting point. Do at least 4 complete layers, but more does not hurt and can actually improve the compression on the layup. Always wrap the Stricture Banding™ in the same direction as the PowerSleeve® G-03 as wrapped.
    {NOTE: If the temperature and length of the installation causes the first layer of PowerSleeve® G-03 to begin hardening before installation of subsequent layer can be installed, stop and do the Stricture Banding™ procedure and allow the installed layers to compress and cure until they hold their shape dependably. Be certain to remove all Stricture Banding™ before adding additional layers of PowerSleeve® G-03. Any time installation progress is delayed for more than 24 hours, all cured composite surfaces must be sanded to break the "glaze" of the surface, prior to application of subsequent PowerSleeve® G-03 layers. Under certain circumstances, this periodic Stricture Banding™ process may have to be done several times.)

12. Allow the PowerSleeve® G-03 to cure until it is dry to the touch and does not indent when pressed with a finger nail.

13. Completely remove the Stricture Banding™.

14. Paint the entire PowerSleeve® G-03 installation with PowerCoat™ paint, furnished in the kit, or factory approved UV & weather barrier coating. Two coats are recommended. Other coatings may be used. Please contact Air Logistics if another type of coating is desired for use.

15. CAUTION: When cured only a few hours ("dry to the touch") the standard PowerSleeve® G-03 system is NOT fully cured and has NOT reached its full strength. Under circumstances where full structural strength is required prior to some action (such as re-pressurizing a leaking pipeline) a longer cure is required. Refer to the product technical data sheet for "full cure" properties.

External Coatings

Choosing the proper final coating is imperative to a successful long term repair. The composite should be coated if any of the following will be present during the lifetime of the repair:

- Ultraviolet Light (natural or man-made) – Use PowerCoat™ or equivalent
- Chemical fallout or mist – Use a coating resistant to chemical in question
- Submersion in water (ground water, tidal areas, saturating rain) – Use BP4 Primer/Coating
- Heavy abrasion (sand, rocks, other metal piping) – Depending on application, abrasive resistant coatings or other products should be used
- High heat from an external source (fire, exhaust) – Use an intumescing type of coating

Applications at High Temperatures

When using the 439-S or X-TEMP-2 Matrix, it is best to install them at temperatures between 140°F and 220°F (60°C – 104°C). At the upper limit of this range, using Stricture Banding™ may become difficult. As the temperature rises, the working time of the matrix is reduced. The matrix may even cure before you have completely installed your section of fabric, which is not preferred.

When encountering an application such as this, a laminating roller may be used.

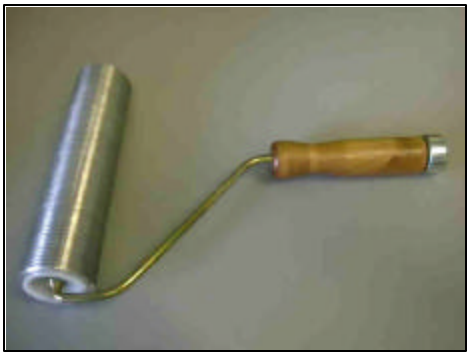
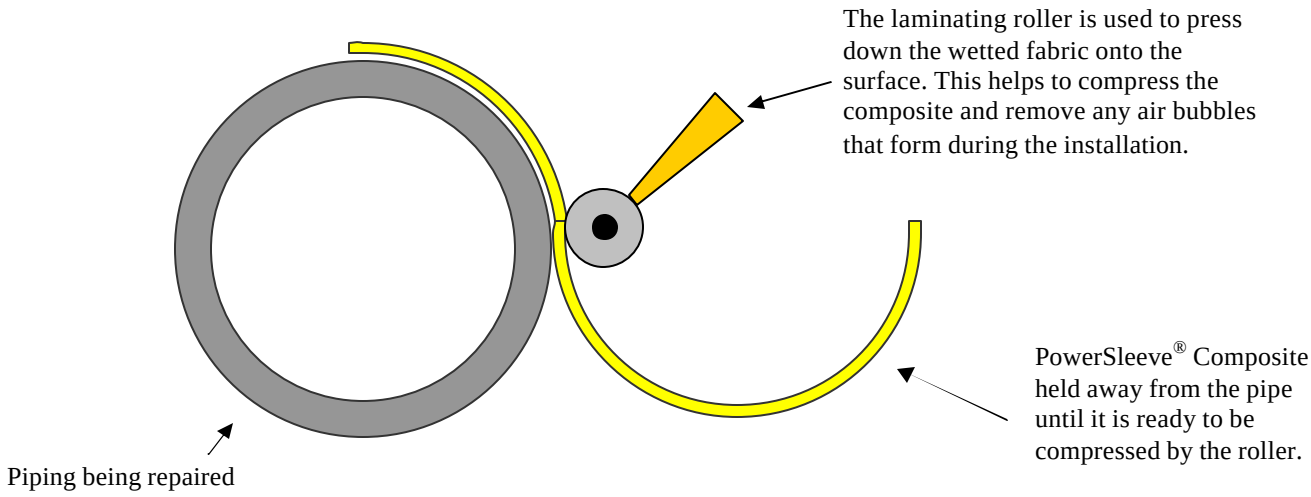


Fig. 5 – A laminating roller can make installations onto high temperature surfaces much easier. This tool can also be used on large flat surfaces where Stricture Banding™ cannot be effective.

This tool will allow the composite to be compressed and air bubbles to be forced out of the layup. When working at the higher temperatures, the layup method for either the W-11 fabric or the G-03 fabric can be modified as listed below:

9. Starting at the 12 o-clock position, place 4-6" of the fabric down onto the surface of the pipe. Do not allow the rest of the roll to come into contact with the pipe at this time. Using a laminating roller, apply pressure to this small section and allow it to cure (approximately 2-3 minutes, depending on temperature).
   Begin unrolling the fabric around the pipe. Using the roller, continuously apply pressure to all areas that are in contact with pipe. Only allow enough fabric to come into contact with the pipe that is able to be compressed with the roller in 1-2 minutes. Otherwise, sections that have touched the pipe may cure prior to them being compressed. Continue until the entire fabric section is laid up and cured.



DOCUMENTATION

It is good practice to record all data related to the repair. This documentation should be retained by the installer and/or the owner of the pipeline for at least the lifetime of the repair. A unique identifier should be generated for each repair application and location. At a minimum, records should be kept that include the following information:

Design Records

- Location of the repair
- Defect type and dimensions
- Design data and related calculations
- Level of surface preparation
- Cure procedure
- Number of layers required
- Axial length of repair
- Completed F.A.C.S.™ Pipe Repair Data Sheet

Material Records

- PowerSleeve® matrix and fabric used (include part number if available)
- Lot numbers and/or batch numbers from kit

Quality Control and Installation Records

- Repair reference number
- Report of visual inspection
- Number of layers actually installed
- Temperature at time of installation (air temperature and pipe surface temperature)
- Final repair dimensions
- Personnel completing the installation
- Re-inspection intervals

INSTALLATION CHECKLIST
PowerSleeve®

Instructions should be carefully read and understood prior to beginning the installation. Also read and understand the MSDS sheets for these materials prior to beginning the installation. Proper factory training is required, as the following checklist covers only the basic steps of proper installation. If you have technical questions, please call Air Logistics Technical Support at 626-633-0294. Chemical gloves and safety glasses are mandatory, along with any other PPE specific to your application environment.

- ð Measurements, Temperatures, and Product in line confirmed
- ð Proper repair materials confirmed
- ð Level work surface prepared for fabric wet-out
- ð Pipe surface preparation
- ð Filler material applied and smoothed
- ð Mix primer and apply
- ð **Hold** – primer should become slightly tacky before proceeding
- ð Wet-out fabric and install onto piping
- ð Apply Stricture Banding™
- ð **Hold –** composite should cure to "fingernail" hard before proceeding
- ð Remove Stricture Banding™ completely
- ð Check for voids and unacceptable imperfections
- ð Apply PowerCoat™ Paint or other environmentally suitable coating
- ð PowerSleeve® should be allowed to completely cure (up to 7 days at 77°F) before exposure to maximum design conditions.