Atlas Installer Manual for Transmission Pipelines

MILLIKEN INFRASTRUCTURE
A Milliken COMPANY

pipe wrap®

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Scope

The scope of this Installer Manual is to provide a thorough installation guide for the Atlas™ repair system, for application on D.O.T. regulated transmission pipelines or equivalent piping systems. This manual is **NOT** intended for use on any leaking repairs or process piping – a separate manual covering these conditions is available upon request. This document provides a detailed guide for general repair scenarios including external corrosion and certain types of mechanical damage. For repairs that are outside of this scope, please contact a Milliken Infrastructure Solutions (MIS) representative to determine if this document can still be used as a general procedure.

Repair System Overview

The Atlas™ Repair System is a pliable, super-high strength, carbon epoxy wet layup composite system used to permanently repair external defects associated with general corrosion up to 80% wall loss, blunt dents and gouges of pipelines and other piping systems. The repair system is comprised of several distinct components including a high compressive strength Filler material, an Epoxy Coating, ILI magnetically detectable markers (optional) and the load carrying Carbon Fiber composite wrap. The Atlas™ composite consists of two primary components. First is a single layer of bi-directional fiberglass fabric, which serves to insulate the pipe from the conductive Carbon Fiber. This ensures that the Carbon Fiber does not interfere with cathodic protection systems. The primary strength member is comprised of a high strength bi-directional Carbon Fiber fabric. A 2-part epoxy resin system is used to saturate the fabric in the field. When used in conjunction with each other, and properly installed, these components work together to form an exceptionally strong composite pipeline repair capable of restoring the pipe to at least its original design conditions.

The Atlas™ repair system has been thoroughly tested to ensure that prudent engineering methods of evaluation have been met by an independent testing laboratory. This testing includes, but is not limited to, constituent material testing as well as system level hydrostatic burst, cyclic fatigue, cathodic disbondment and dent testing. Additionally, the Atlas™ system meets or exceeds all required and relevant testing presented in the ASME PCC-2 and ISO 24817 standards. The approval for use of composite repair systems is in the January 2000 release of the Federal Registry. This system can be used on D.O.T. regulated pipelines.

The Atlas™ repair system, in general, is designed on a per-defect basis. For transmission pipelines, this means that as long as there is a minimum of 20% remaining wall thickness, the Atlas™ repair system can be designed for any pressure rating (within the composite's temperature range).

At its core, the material science used for the Atlas™ system is similar to other wet-layup composite wrap systems. Additionally, when coupled with the patented ILI Marker™ system, this repair option boasts "smart ILI detectability" without any of the pit-falls associated with creating potential cathodic reactions. The Atlas™ system is very conformable allowing it to be used in situations where more rigid repair options are not advisable.

Repair Limitations

Non-concentric pipe profile

- The Atlas™ may be applied to a pipe with non-concentric profiles as established by API Specifications.
    - 12.5% for gas pipelines
    - 10% for liquid pipelines
- The primary concerns for installations are:
    - Removal of stress risers
    - Surface preparation
    - Insulation of the steel pipeline, using a layer of fiberglass fabric. No CP (cathodic protection) interference.
    - The assurance of intimate contact with the Atlas™ via the load transfer filler. The objective is to ensure a "load transfer" path to the composite sleeve from the defective area of the pipe.

External Corrosion / Erosion

- On regulated lines following the ASME B31.4 standard, any external corrosion exceeding 80% wall loss cannot be considered a permanent repair. An emergency temporary repair can be installed until a permanent repair option can be implemented.
- On non-regulated lines, please discuss repair scenario with an MIS representative on any external corrosion defects above 80% wall loss.
- All sharp edges must be removed.

Internal Corrosion / Erosion

- A temporary repair can be installed until the end-of-life design wall loss is obtained (not to exceed 80% on regulated lines).
- An external repair will not slow down or prevent any internal wall loss; the sole purpose is to provide structural reinforcement until a permanent solution can be implemented.

Gouges

- No existing cracks at time of repair; must be inspected to ensure there are no cracks.

- Clean gouges not exceeding 80% wall loss can be repaired.
- Gouge must be rounded off – no sharp edges allowed.

Cracks

- Cracks in the main body of the pipe can be repaired if the entire crack is removed (typically via grinding).
- After removing crack, the defect area shall not exceed 80% wall loss.

Dents

- Dents with a dent depth less than 6% of the pipe's diameter can be repaired
- For dents exceeding 6%, please contact an MIS representative.
- Dent must be crack free (requires on-site inspection – typically dye penetration).

Defects near a weld

- Defects located in the proximity of a weld may be more complicated and will need to be assessed as such by an MIS representative.
- In general, a repair is not recommended if the defect exceeds 50% wall loss and it exceeds 30% of the circumference (in the weld).

Defects within a Weld

- Cracks, gouges or dents in the longitudinal or girth weld seam will be reviewed on a case-by-case basis.
- In general, a repair is not recommended if the defect exceeds 50% wall loss and it exceeds 30% of the circumference (in the weld).
- In general, a repair is not recommended for mechanical damage to longitudinal welds.

Other Defects

- Wrinkle bends, seam weld anomalies, and other defect types can also be considered for repairs with Atlas™.
- These are all considered on a case-by-case basis and will require communication with a Milliken Pipe Wrap Engineer to help make such determinations.

Storage and Application Conditions

The following storage conditions should be observed when the material is not being primed for immediate use. Additionally, following these conditions in the field prior to application will result in an easier install and eliminate potential issues. All perishable materials will be marked with appropriate expiration dates.

All materials

- Always store material at temperatures less than 80°F.
- Keep away from open flames – materials may be flammable.
- Thoroughly review materials' Safety Data Sheet (SDS) documents before handling material.

Atlas™ Carbon Fiber Fabric

Storage Conditions

- Maintain temperature between 45°F and 80°F.
- Store away from water, alcohols, strong bases, metal compounds or surface active materials.
- Do not handle fabric with bare hands, always wear gloves to avoid transferring oils into fabric.
- Keep out of direct sunlight, as Carbon Fiber is thermally conductive and will get very hot, speeding up the chemical reaction of the epoxy that is impregnated into it, reducing working time.
- Refer to SDS for additional handling and storage information and accidental release measures.

Shelf Life

- Carbon Fiber fabric has no expiration date
- Refer to the above storage conditions so to preserve the fabric for as long as is required.

CS-105: Epoxy Resin Kit (A&B)

Storage Conditions

- Between 40°F and 80°F.
- Avoid prolonged storage above 90°F.
- Maintain in a dry environment with good ventilation.
- Store away from water, alcohols, strong bases, metal compounds or surface active materials.
- Keep out of direct sunlight.

- Refer to SDS for additional handling and storage information and accidental release measures.

Shelf Life

- 1 year shelf life from date of manufacturing.

Atlas™ System (Fiberglass, Carbon Fiber, and Epoxy Resin)

Application Conditions

- Ideal ambient application temperature is above 45°F and up to 120°F.
- Ideal pipe temperature for application is above 45°F and up to 120°F.
- Atlas™ can be applied at ambient temperatures below 40°F.
    - Site should be tented and heated to expedite cure time.
    - Please contact a MIS representative for additional detailed directions.
- Atlas™ cannot be applied in adverse weather conditions.
    - Unless installation area can be well protected from elements (tented).

EP-420: Load Transfer Filler Paste

Storage Conditions

- Between 40°F and 80°F.
- Avoid prolonged storage above 90°F.
- Maintain in a dry environment with good ventilation.
- Store away from water, alcohols, strong bases, metal compounds or surface active materials.
- Keep out of direct sunlight.
- Refer to SDS for additional handling and storage information and accidental release measures.

Shelf Life

- 1 year shelf life from date of manufacturing.

Application Conditions

- Ideal ambient application temperature is above 50°F and up to 120°F.
- Ideal pipe temperature for application is above 60°F and up to 150°F.
- EP-420 can be applied at ambient temperatures below 40°F.
    - Site should be tented and heated to expedite cure time.
- EP-420 can be applied on pipes up to 150°F.
- EP-420 requires application on a dry surface.

PPR: Adhesive Primer

Storage Conditions

- Between 40°F and 80°F.
- PPR can be frozen and used after being thawed.
- Avoid prolonged storage above 90°F.
- Maintain in a dry environment with good ventilation.
- Store away from water, alcohols, strong bases, metal compounds or surface active materials.
- Keep out of direct sunlight.
- Keep containers tightly closed when not in use or empty.
    - Used or empty containers may still contain hazardous residue.
- Refer to SDS for additional handling and storage information and accidental release measures.

Shelf Life

- 1 year shelf life from date of manufacturing.

Application Conditions

- Ideal ambient application temperature is above 50°F and up to 110°F.
- Ideal pipe temperature for application is above 60°F and up to 115°F.
- PPR can be applied at ambient temperatures below 40°F.
    - Site should be tented and heated to expedite cure time.
- PPR can harden and cure in wet environments but should be applied on dried pipe. Only use where there is adequate ventilation.

Installation Overview

The following is a quick reference guide for the simplified installation steps for the Atlas™ repair system. This list does not contain all detailed steps and should only be used as a quick refresher or reference material for an on-site observer.

1) Prepare materials and ensure that a sufficient “repair area” and “staging area” are established.
2) Ensure that proper surface preparations have been reached.
3) Confirm defect dimensions match design conditions.
4) Inspect pipe for any sharp edges and solvent wipe the area to remove any contaminates. Allow 1-2 minutes for solvent to flash.
5) Mark the repair zone. A minimum of 2” on either side of the defect is required. An additional minimum of 2” is required if ILI Marker™ set is to be installed.
6) Wearing proper PPE, begin mixing load transfer filler material until uniform in color.
7) Apply load transfer filler to all defect and tented areas; smooth to pipe contour.
8) Mix primer until uniform in color. Allow material to sit for 10-15 minutes to thicken.
9) Apply adhesive primer over entire repair zone plus an additional 4” on either side. Ideally, the adhesive primer is applied with no more than 30 mil thickness.
10) Allow primer to gel until it reaches the consistency of peanut butter (10-15 minutes).
11) Apply a single layer of fiberglass fabric over the Primer 2” on either side of the repair zone, to insulate the substrate from the carbon fiber, if required.
    a. Mix a premeasured Epoxy Resin kit (A&B) and apply it into the fiberglass.
    b. Wrap fiberglass around the pipe
    c. Install ILI Marker™ system if applicable.
12) Begin application of the Atlas™ carbon fiber material.
    a. Mix a premeasured Epoxy Resin kit (A&B) and apply it into the carbon fiber, ensure that the fabric has no dry spots.
13) Continue wrapping per installation method within the repair zone. Once two layers have been achieved, ensure that constant, uniform tension is applied to the roll.
    a. Pull tight! Every layer needs to be in tension.
14) Immediately upon completing the installation (or at a hold point), wrap 4-6 layers of constrictor wrap.
15) Immediately perforate the constrictor wrap to allow for de-bulking and excess resin to extrude out.
16) Allow to cure for a minimum 2 hours (temperature dependent).
17) Remove constrictor wrap and inspect the repair.
18) Top-coat if required (it is recommended that a top-coat be applied).

Pictorial Overview of Basic Installation Steps

1. Ensure that proper surface preparations have been made (NACE #3 MINIMUM).

2. Inspect defect and remove any sharp edges. Then solvent wipe with Acetone, MEK, or Toluene.

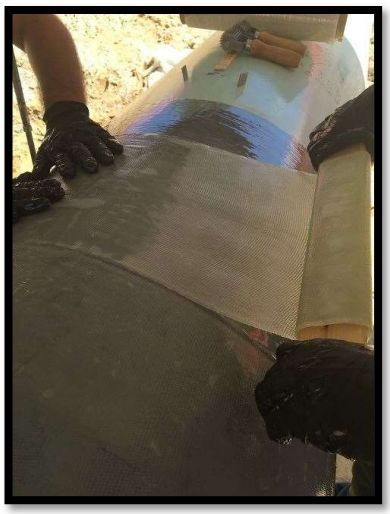
3. Mark the repair zone as per what is indicated by design calculation.

Repair Design			
Number of Layers	24 layers	Repair Thickness	0.528 inches
Wall Loss Percentage	60.00 %	Repair Zone	12.0 inches
Pressure Capabilities			

4. Mix and apply specified Load Transfer Filler materials over all defect and tented areas (i.e. welds), trying to return the pipe to a near-net profile. Smooth to pipe as needed.

5. Mix specified Epoxy Primer and apply a coating that is no more than 30 mils thick to entire repair zone. Once applied, allow approximately 10-15 minutes for the consistency to thicken, before moving to the next step.

6. Mix an Epoxy Resin kit (Parts A&B) for approximately 1 minute and apply the resin to the fiberglass fabric until it is saturated. Excess resin can be scraped off using the blue squeegee. Apply a fiberglass layer to the repair zone. Install ILI Marker™ system if applicable.




7. Begin application of the Atlas™ material. Mix Epoxy Resin kits (A&B) and impregnate necessary lengths of carbon fabric.


8. Continue wrapping per installation method. Once two layers have been achieved, ensure that constant, uniform tension is applied to the roll.
    a. Pull tight! Every layer needs to be in tension.

9. Immediately upon completing the installation (or at a hold point), wrap 4-6 layers of constrictor wrap.

10. Immediately perforate the constrictor wrap to allow for de-bulking.

11. Allow the repair to cure for a minimum of 2 hours, before removing constrictor wrap.

12. Top coat the repair if required (a top coat is always recommended over our repair systems).

General Installation Tips

Following is a check list of installation tips that should be followed when possible:

- Ensure that Epoxy Resin is impregnated throughout entire Carbon fabric, leaving NO dry spots.
- Do not mix the Epoxy Resin kits until ready for immediate application into Atlas™ fabric followed by immediate application to repair zone. Doing so may cause the roll to set-up before it is ready for use and can significantly reduce expected working time. **This is a very common installation error.**
- Working time is temperature dependent. At 70°F, expect a working time of 30 minutes for the Atlas™ fabric.
- Effects of temperature – general rule of thumb is as follows:
    - Starting at 77°F as the default "working time" temperature, a 10°F **increase** in temperature results in half the working time. Every subsequent 10°F increase further halves the working time.
        - Set-time and cure-time follow the same rule.
    - Starting at 77°F as the default "working time" temperature, a 10°F **decrease** in temperature doubles the working time. Every subsequent 10°F decrease further doubles the working time.
        - Set-time and cure-time follow the same rule.
- The Atlas™ system provides axial stiffness to a repair area, however the system was not specifically designed to resist axial bending moments. The pipeline operator is to secure the pipe to their satisfaction with respect to the repair area.

Detailed Installation Manual

The following sections provide a detailed procedure for the installation of the Atlas™ repair system. For additional information on any section, please contact an MIS representative. These guidelines should be followed on all repairs unless overwritten by a repair-specific procedure provided by an MIS representative.

1) Repair Material Preparation

Before starting an Atlas™ repair installation, ensure that all material is accounted for and staged appropriately. When possible, it is recommended that two distinct locations are tented and shaded; the repair area on the pipe and the staging area. In cold ambient conditions, it is recommended that the working areas are heated. In hot weather conditions, both sites should be shaded and cold water readily available for personal hydration.

Typical material provided for an Atlas™ repair on a transmission pipeline:

- Atlas™ Carbon Fiber fabric rolls (lengths and widths may vary depending on the repair).
- Fiberglass fabric rolls, used for isolating the Carbon Fiber from the steel substrate.
- Load transfer filler material (EP-400 inside plastic tube OR EP-420 in A and B containers)
- Adhesive primer material (either in paint cans or 1-pint plastic pouches)
- ILI Markers™ (optional)
- Application Kit
    - Cardboard mixing pallets
    - Stir sticks
    - Mix buckets
    - Plastic putty knives
    - Applicators for adhesive primer
    - Squeegee
    - Nitrile Gloves
    - Trash Bag
    - Can Opener
    - Razor blade
    - Scissors
    - Plastic sheeting (for covering table)
- Constrictor Wrap
- Perforator

Additional material that is typically required and provided by the installer:

- PPE
- Surface prep tools (sand blasting, grinding etc.)
- Tables (for staging materials and wetting out fabrics)
- Rags and Solvent (Acetone, MEK or Toluene)
- Tenting / Tarp
- Sandpaper (24-80 grit)
- Measuring tape
- Pipe marker

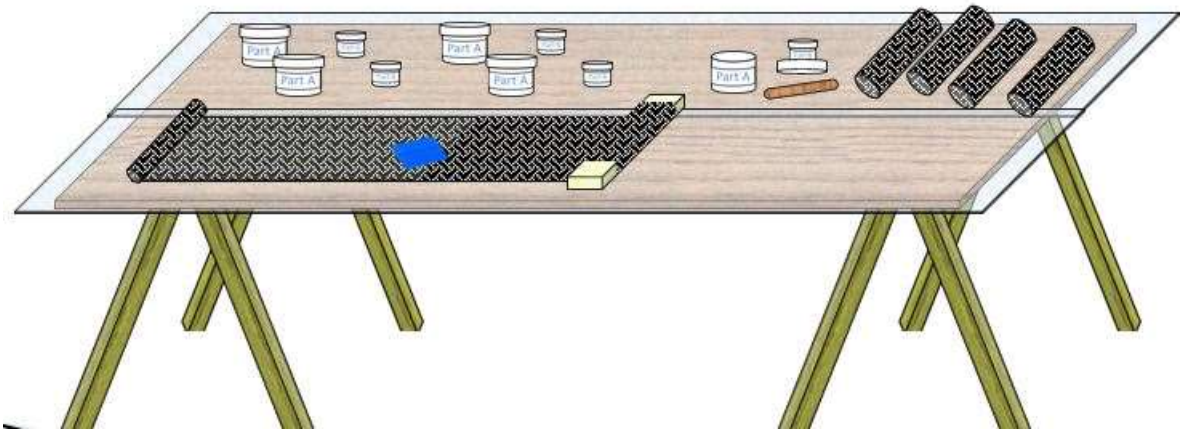
Repair area

The repair area should be tented to provide protection from harsh elements (heavy rain, dust, wind, etc.…). If direct tenting is not available, a plan of action is required should the repair need to be stopped due to outside influences. If possible, it is recommended that a plastic sheet or tarp is laid under the pipe to prevent contamination of fabric should anything touch the ground. In addition to Governmental and Company Regulations, the ditch preparation for installations should be an inverted “bell-shaped” with approximately 48” of working area on both sides of the pipe and deep enough provide “belt-buckle” working height (if possible – provide approximately 24” of clearance beneath pipe). Additionally, during the Atlas™ installation, scissors and gloves should be available for use as needed.

Staging area

The staging area should be tented to provide adequate conditions for personnel and material storage. If the ambient temperature is above 80°F, all inventory not currently in use should be stored in the staging area or nearby (air conditioned) vehicle for easy access. The provided AK-25 Application Kit should provide most (if not all) of the tools required to apply the filler material and the adhesive primer. It is recommended to mix at the staging area and bring the mixed product down to the repair area for installation. Once completed, dispose of trash properly to avoid contaminating other products.

It is recommended that a portable table is set up under the tent and covered with plastic. Repair materials can be organized and laid out on the table. This is where all the fiberglass and carbon fiber fabric will be impregnated with the Epoxy Resin, during the repair process using the AK-30 Application Kit.



Material Clean-up and Disposal

Throughout the repair installation, proper disposal of used materials should be followed. Along with good common sense, the following list is a general guideline for proper disposal methods:

- Unmixed or uncured materials may be removed by wiping or scraping excess material, then followed by a solvent wipe.
    - Unmixed materials must be disposed of as hazardous waste according to local, state, provincial and governmental regulations when applicable.
- For cured materials that need to be removed, Acetone, MEK and Toluene will “soften” cured materials and assist in clean-up.
- Unmixed materials should be mixed appropriately and allowed to cure. For large volumes, pour onto a plastic sheet to allow the material to cure into a thin sheet.
    - Large volumes of reacting materials can overheat and reach temperatures exceeding 300°F and set nearby material on fire.
- Unused materials should be sealed in their original packaging containers and stored in a covered area until further use or properly disposed of. If any material is contaminated, mix proper materials together, allow to cure then discard appropriately.

2) Surface Preparation

For a long-term, “permanent” repair, surface preparation is extremely important. All coating, loose debris and any sharp edges must be completely removed via media-blasting (such as sandblasting) or with an angled grinder. The following surface preparation requirements shall be met for any composite repairs on a transmission pipeline.

For media blasting –

- A minimum surface prep of NACE #3 Commercial Blast Cleaning shall be achieved
- NACE #1 White Metal Blast cleaning is preferred
- A minimum of 4 inches beyond the anticipated repair zone shall be prepped.

For side-grinding –

- 24-80 grit sanding disks or equivalent shall be used to provide an appropriate anchor pattern
- A minimum of 4 inches beyond the anticipated repair zone shall be prepped.

Other methods –

- Wire brushing the surface or other, light preparation techniques are **not recommended for final surface preparation**. If an alternate method is required for surface preparation, contact a Milliken Infrastructure Solutions representative for guidance.

All coating must be removed, including soft coatings and paint

- Elastomeric materials (rubber based, mastic, urethane, etc.) interfere with proper load transfer to the composite wrap.
- EXCEPTION – Fusion Bonded Epoxy (FBE) coatings; Modified procedure for FBE - Abrade the entire "work area" using 24-80 grit sandpaper removing all high spots and the "sheen" from the fusion bonded coating. The entire surface must be "etched" with a minimum of a 1 mil Anchor Pattern.
- All "coal tar" and zinc residue must be removed from the repair area. These materials can inhibit the cure time and affect the bonding properties of the primer coat. A visual indication for the presence of "coal tar" is that the material will leach into the primer turning the primer and Atlas™ system color to a "murky" brown color.

Defect Inspection

Verify that final defect is within the initial design parameters. If the defect has worsened or is worse than anticipated, contact an MIS representative for a new design before continuing.

Cracks must be completely removed (typically done by grinding).

All sharp edges, corrosion residue and weld splatter **MUST** be removed – defects must be "blunt".

Repair zone must be solvent wiped with **ONLY** Acetone, MEK or Toluene to remove all loose debris and liquid residue (such as oil or grease). Be sure to review appropriate SDS before use of solvent.

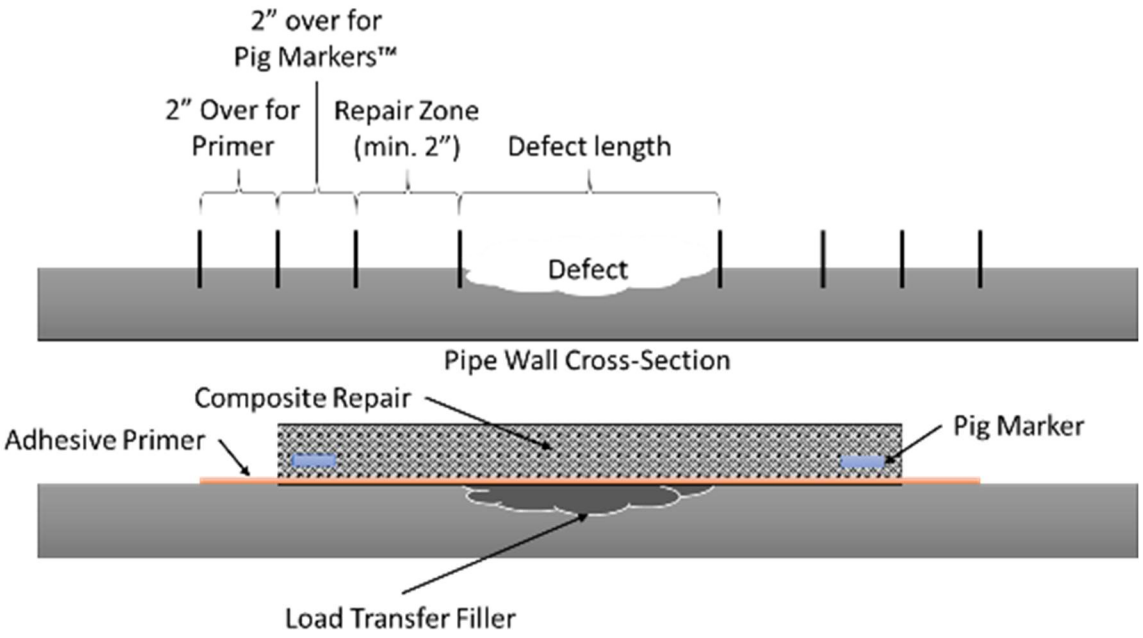
3) Marking the Repair Zone

Determine the required repair zone from the design documentation. If the design documents provided do not match what is expected for the actual installation, please contact a Milliken Infrastructure representative to confirm procedure.

Unless specified otherwise, the repair zone shall be centered over the center of the defect. Mark the repair zone on the pipe. Ensure that a minimum of 2 inches beyond the defect is achieved. The calculated repair zone will typically ensure that this value will be greater than 2 when following the minimum repair length equations in the ASME PCC-2 and ISO 24817 standards.

If a ILI Marker™ magnetic detection system is used, an **additional** 2 inches will need to be added to the minimum 2 inches beyond the defect in either direction; this equates to a minimum of 4 inches beyond the defect. When following design documentation, the additional length due to the ILI markers is already included in the displayed repair zone.

In preparation for the adhesive primer, mark an additional 2 inches on either side of the repair zone. Using a pipe marker, removable tape or constrictor wrap, circumferentially “mark” the repair zone for reference during the actual repair process. These outer identification “marks” indicate the surface area to be coated with the adhesive primer. When installing the repair, the composite material should stay 2 inches inside the coated area; in other words, when finished, 2 inches of coating should be visible on either side of the repair. This will ensure that the composite is fully engaged within the adhesive primer and provides a transition zone for the final coating to ensure that no gap under the composite wrap is present.



4) Installation of the Load Transfer Filler

Milliken Infrastructure Solutions offers many choices for a load transfer filler material. The default material for the Atlas system is EP-420. The directions that follow apply specifically to the EP-420 material. For a detailed installation procedure utilizing a different load transfer filler, see appendix 1. When working with any epoxy or liquid polymeric material, proper PPE should always be worn. From this point forward, PPE should be worn at all stages of installation.

The load transfer filler material serves two primary purposes:

1) The filler material will reshape the pipe to near-original contour.
    a. This will ensure that the composite being utilized does not experience any odd deformities which may negatively impact the structural integrity of the repair.
2) The high compressive nature of the filler material will prevent the defect region from expanding by distributing the load to the composite material.
    a. This process of load distribution is referred to as creating a “load transfer path”.

The EP-420 load transfer filler product will come packaged in 2 plastic jars as either a ½ pint kit or a 1-pint kit. Remove all material, Parts A and B, and place on a mixing service. Mix together with a putty knife until uniform in color. Below 50°F or above 85°F it is recommended to keep the material stored in a vehicle or other climate controlled environment until ready for use. In warmer temperatures, the EP-420 material should be kept out of direct sunlight to avoid prolonged heating which may affect working time.

Apply the epoxy paste to all voids and “tented” areas associated with the defect areas. Additionally, any large welds need to be smoothed out using the filler material to create a smooth transition zone for the composite material. Press firmly into any voids to ensure no air-gaps are located underneath the filler. Smooth the filler material to match the pipe contour as best as possible. Avoid creating any sharp edges. Wait for material to harden (approx. 15-30 minutes) and use sand paper or a grinding tool to reshape and remove any sharp edges.

Application Tips:

- For condensing or “sweaty” pipes – solvent wipe the pipe surface and immediately apply the filler material once the solvent flashes off (the condensate should no longer be visible as well).
    - If the EP-420 begins to harden too soon, reduce the temperature.
- For ambient temperatures near freezing – keep the filler material (as well as the composite and adhesive primer) warm. This can be accomplished by storing the material inside a vehicle or inside a coat pocket. The cold temperatures may cause the pipe to sweat; solvent wipe as necessary.

5) Installation of the Adhesive Primer

Milliken Infrastructure Solutions offers many choices for an adhesive primer material. The default material for the Atlas system is PPR. The directions that follow apply specifically to the PPR material. For a detailed installation procedure utilizing a different adhesive primer, see appendix 1.

The adhesive primer material serves two primary purposes:

1) The adhesive primer will bond to the pipe and prevent disbondment.
2) The adhesive primer acts as a coating underneath the repair, thus preventing moisture ingress.

The PPR adhesive primer product comes in multiple packaging types; either in a plastic blister pouch (1-pint kits) or in a set of two equal sized paint cans (2-pint kit, 2-quart kit or 2-gallon kit). The mix ratio of this product is 1:1 by volume. Based on the required amount, this product can be mixed by hand on a cardboard tray using a putty knife, in a mixing cup using stir sticks or in a larger bucket using a mixing paddle. Mix until uniform in color. Mixing time is typically 3-5 minutes depending on the process used. In cold weather (<40°F), mixing time should increase to 8-10 minutes due to material thickening (becoming more viscous).

Once thoroughly mixed, allow 5-15 minutes to achieve an optimum viscosity for application. This time may adjust due to ambient temperatures and quantity mixed. Below 50°F or above 85°F it is recommended to keep the material stored in a vehicle or other climate controlled environment until ready for use. In warmer temperatures, the PPR material should be kept out of direct sunlight to avoid prolonged heating which may affect working time.

Once ready, trowel the adhesive primer over the repair surface. This is typically done with the hand applicator, however, other tools or equipment may be used as well. A general guideline for thickness is to apply approximately 30 mils of coverage. Enough primer needs to be applied to coat the entire pipe; it needs to be thin enough to not interfere with load transfer. Depending on the installation technique, different amounts of the adhesive primer may be applied in one go. The adhesive primer should extend 4” beyond the end of the repair zone to act as a tie-in location for future top-coating.

Application Tips:

- For condensing or “sweaty” pipes – solvent wipe the pipe surface and immediately apply the adhesive primer material once the solvent flashes off (the condensate should no longer be visible as well). Material may need to be applied is small, concentrated patches.
- If the PPR begins to thicken up too quickly:
    - Mix less material at one time
    - Reduce the temperature (store in air conditioning)
- For ambient temperatures near freezing – keep the adhesive primer material (as well as the composite and load transfer filler) warm. This can be accomplished by storing the material inside a vehicle or inside a coat pocket. The cold temperatures may cause the pipe to sweat; solvent wipe as necessary.
- For extensive corrosion around the entire pipe, it is critical that a smooth profile is obtained that mimics the natural pipe geometry. The following steps may be taken to help achieve this:
    - Apply the adhesive primer to the entire repair zone, apply extra material to defect areas as needed to supply sufficient material for reshaping.
    - Use constrictor wrap or 60mil thick polyethylene sheeting to encapsulate the adhesive primer and ensure the correct shape.
    - Allow material to harden; remove plastic and file down any high spots or sharp edges.
    - Lightly abrade the hardened adhesive primer with 24-80 grit sandpaper and solvent wipe.
    - Mix another batch of adhesive primer and apply using a standard procedure.

6) Application of the Atlas™ System

Application of the Atlas™ wrap requires a few particular tools to assist in impregnating the fabric and applying it to the pipe. Proper evaluation of the corrosion anomaly or dent assures an accurate calculable hoop strength enhancement. The material's inherent physical characteristics offer high adhesive strength, a complete fit-up integrity and conformity between the reinforcing wrap and pipe.

Atlas™ System Preparation

Before starting the application of the Atlas™ repair system, it is very important that any design documents are reviewed, and the final design and installation procedure are understood. Once the Atlas™ has the Epoxy Resin impregnated into it, the curing process cannot be stopped. This is why it is imperative to ensure that all preceding steps are taken care of before any Epoxy Resin kits are mixed and applied to the fabric.

Once the PPR has been applied and is thick (close to the consistency of peanut butter), the initial layer of fiberglass is ready to be utilized. Wearing proper PPE, open a Part A and Part B for an appropriate Epoxy Resin kit. Pour B into A and mix thoroughly for approximately 1 minute. After mixing, use the blue squeegees to apply the resin into the fiberglass fabric until saturated and then scrape any excess resin off to the side to be used on the next roll. This procedure should be followed every time a new roll or Epoxy Resin kit is required.

Review of Installation Techniques

Installation of the Atlas™ system can be performed using many different techniques. The best technique to be used in any situation varies based on several conditions. Before wrapping any pipe, it is necessary to review the design document to determine the recommended installation technique. If questions arise or it makes more practical sense to change the installation technique, contact a MIS representative to ensure that best practices are followed; do not make a change to the installation method without prior consultation. The three basic techniques are listed below in extensive detail; for more complicated repair scenarios, a MIS representative may provide a procedural guide for the specific repair. This procedural guide should be followed in place of the basic installation techniques discussed here. The following table is provided as a general guideline for which installation technique should be used (only straight pipe sections are considered in detail).

Layer over Layer

This technique is used when the minimum required repair zone is shorter than the composite width. With regards to the adhesive primer, it is required to apply the primer over the entire repair zone. More details on this method will be presented in the following section.

Spiral Wrap Method

This technique is generally used when a large linear length is to be repaired on a small diameter pipe and typically only on small diameter pipes (OD less than 16”). With regards to the adhesive primer, it is recommended that if the entire repair zone will be done in one segment, apply primer to the entire repair zone. If the pipe will be repaired in multiple segments, apply primer to only one segment at a time. In general, it is recommended that repair zones be broken into segments if the total repair zone exceeds 4 feet. Further details on this method will be presented in the following section.

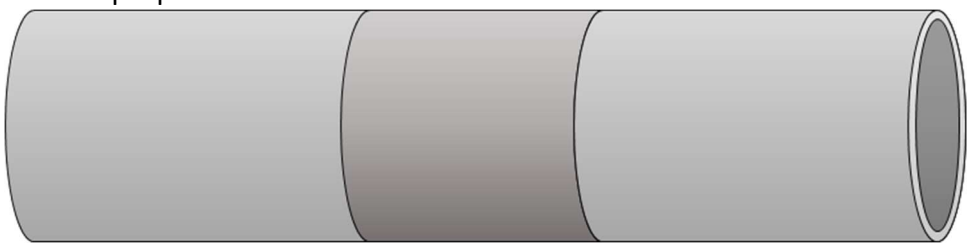
Offset Method

This technique is generally used when a large linear length is to be repaired on a larger diameter pipe or when a spiral wrap method is not practical. With regards to the adhesive primer, it is recommended that if the repair zone is less than 3 feet, the adhesive primer should be applied to the entire repair zone at one time. If the repair zone exceeds 3 feet, the adhesive primer should only be applied over 3 feet at a time. Further details on this method will be presented in the following section.

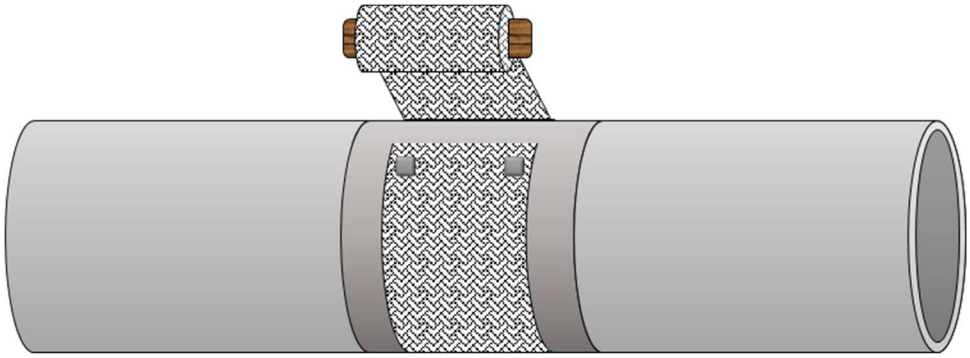
Layer over Layer

The simplest installation technique is “Layer over Layer”. This technique is used when the minimum required repair zone is shorter than the composite width. The design package will state a repair zone width equivalent to the width of the fabric. With this technique, after the load transfer filler is applied, the adhesive primer should extend two inches beyond the width of the fabric on either side. The following directions should be followed for the “layer over layer” installation technique:

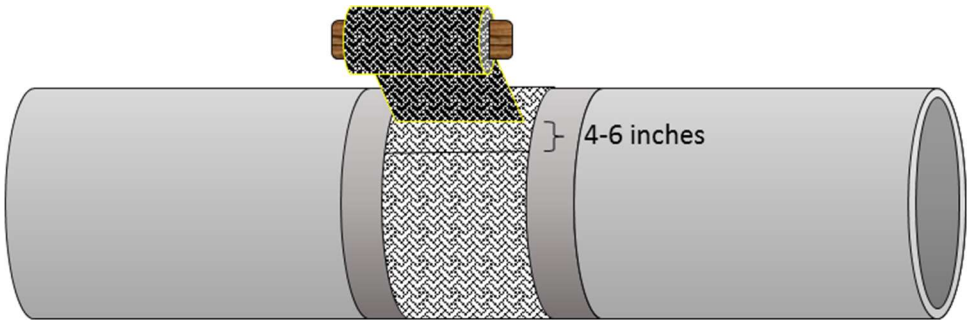
1) Apply the load transfer filler and the adhesive primer. Wait for the adhesive primer to achieve proper tackiness.



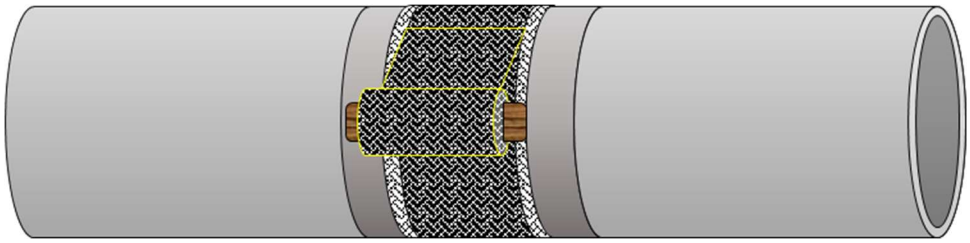
2) After preparing the roll of fiberglass, unroll a few feet and place in the center of the repair zone. There should still be two inches on either side with exposed adhesive primer.
3) Staying in the center of the repair zone, continue unrolling the fiberglass around the pipe until the initial starting point is about to overlapped.



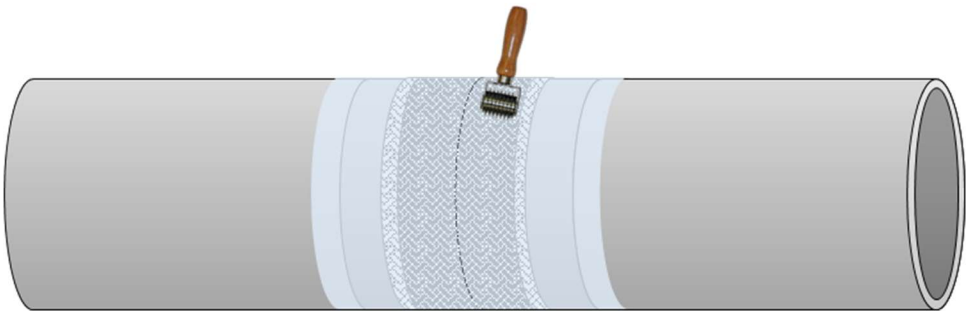
4) Apply the ILI Marker™ system at each end of the repair zone, if applicable. Continue wrapping the fiberglass until a complete 2 layers has been achieved.
5) Once the fiberglass layer is installed, begin applying Epoxy Resin to the Carbon Fiber fabric for immediate application to the pipe.
6) After preparing the first roll of Carbon Fiber, unroll a few feet and place in the center of the repair zone. Overlap 4-6 inches from the end of the fiberglass fabric. There should still be at least 2 inches on either side with exposed fiberglass.



7) After the second layer has been applied, begin to pull the wrap tightly at a minimum once per side of pipe. This is to ensure a tight fit application and minimizes the possibility of voids, massage fabric as needed. For large pipe (24" OD or greater), it is recommended that an effort is taken to pull the wrap tightly twice per side of pipe; once when receiving the roll and again before the roll is passed on to the other side.
8) Continue applying the Atlas™ product until the desired layer count is achieved or the end of the roll is reached.



9) If the end of a roll is reached and more Atlas™ is required, wet-out an additional roll with epoxy and follow the same application steps. Overlap the end of the previous roll by 4-6 inches with the new roll before continuing to wrap.
10) Continue to pull tightly and apply the Atlas™ Carbon Fiber rolls until proper layer count is achieved.
11) Immediately constrictor wrap (4-6 layers) and immediately perforate to allow Atlas™ to de-bulk and for excess resin to escape (see page 47 for details on this step).



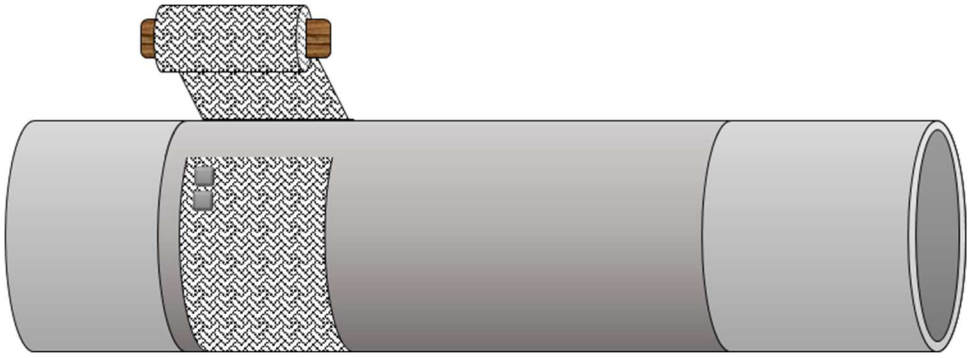
Spiral Wrap Method

The spiral wrap technique is best utilized on smaller pipes that cover a large repair zone (larger than two times the wrap width) and is often recommended for weld or dent repairs. This technique is also limited to repair thickness – if more than 20 layers are to be installed, the spiral wrap method is not recommended. The design package will state a repair zone width larger than the width of the fabric. The design package will also state that is to be wrapped with the using the spiral wrap method and indicate what the calculated overlap will be.

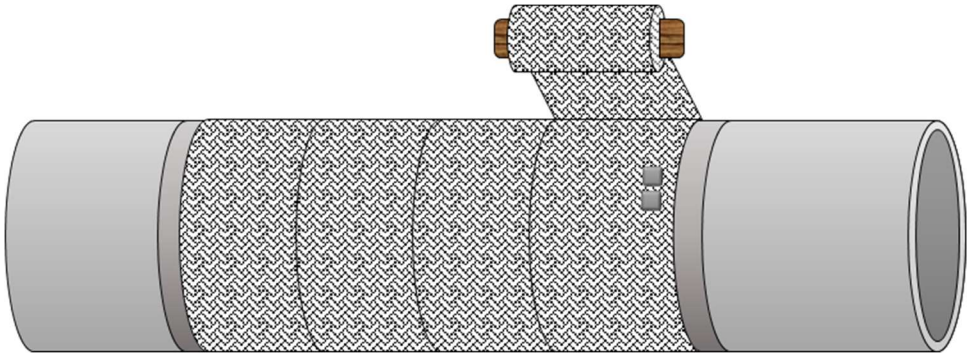
Before beginning this technique, it is crucial to determine if the entire repair zone will be repaired in one pass or if the repair zone should be divided into multiple sections. As a general guide, if the repair zone exceeds 4 feet, it should be divided into multiple sections. The directions that immediately follow are for repairs where the entire repair zone is to be wrapped in one pass. With this technique, after the load transfer filler is applied, the adhesive primer should extend two inches beyond the indicated repair zone on the design package. The following directions should be followed for the “spiral wrap” installation technique:

1) Apply the load transfer filler and the adhesive primer. Wait for the primer to become tacky.

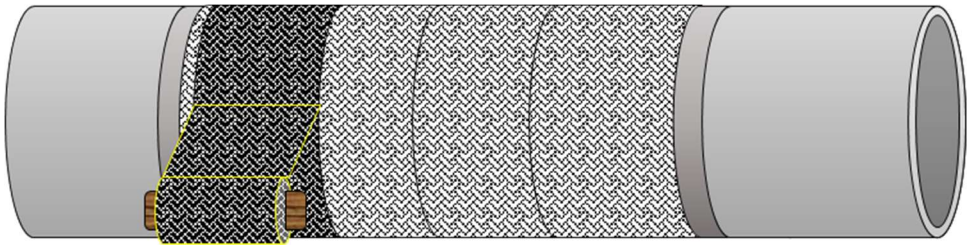
2) Prepare the first roll of fiberglass by impregnating with epoxy resin, unroll a few feet and place at one end of the repair zone. There should still be two inches between the edge of the fiberglass and end of the adhesive primer.
3) After the first layer, if applicable, follow the directions in the following section to install the ILI Marker™ system at each end of the repair zone.



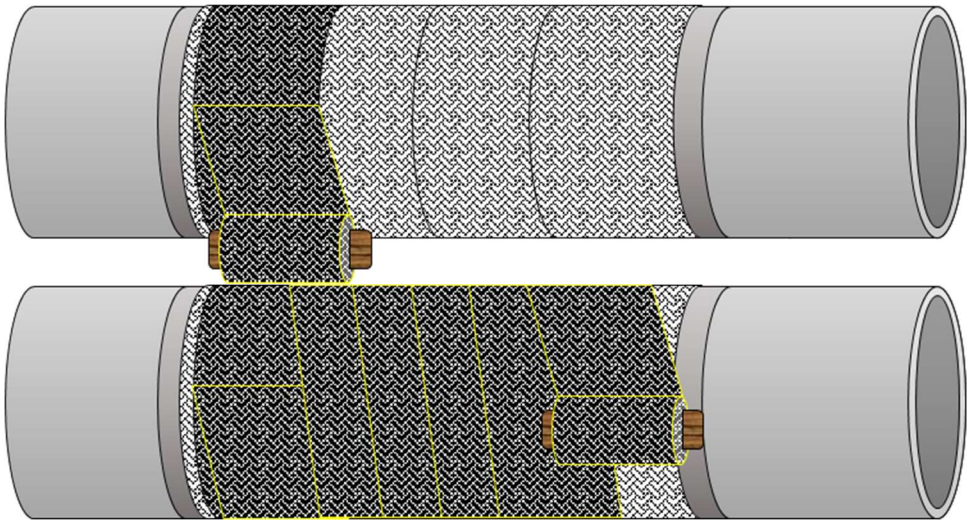
4) Wrap the entire repair zone (or segments as necessary) with a single layer of fiberglass. When the other end of the repair zone has been reached, install ILI markers between the first and second layer. Finish with the second layer.



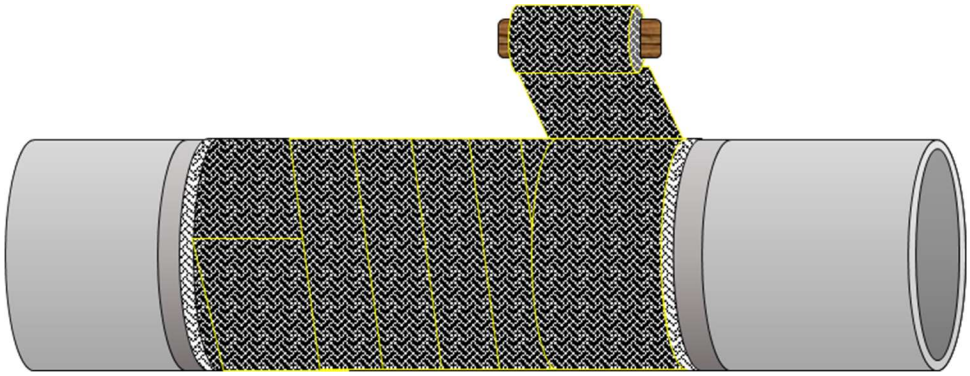
5) Prepare the first roll of Atlas™ Carbon Fiber by mixing and applying Epoxy Resin into the fabric. Unroll a few feet and place at one end of the repair zone. Be sure to leave a minimum of 2" of fiberglass showing at the edges of the repair zone.
6) Continue unrolling the Atlas™ around the pipe, overlapping itself, until two complete layers are achieved.
    a. If the pipe is sloped or vertical, always begin the spiral wrap method from the lowest point and wrap upward.



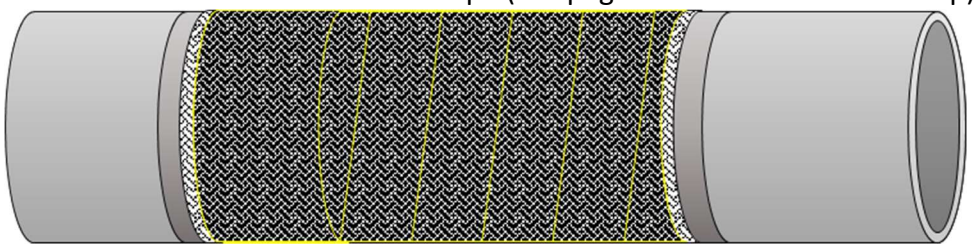
7) After the second layer has been applied, begin to pull the wrap tightly at a minimum once per side of pipe, massage fabric as needed. This is to ensure a tight fit application and minimizes the possibility of voids. For large pipe (24" OD or greater), it is recommended that an effort is taken to pull the wrap tightly twice per side of pipe; once when receiving the roll and again before the roll is passed on to the other side.
8) Begin angling the wrap and working down the remaining repair zone overlapping the previous wrap by the indicated amount (Unless noted otherwise, a 50% overlap is required).



9) If the end of a roll is reached and more Atlas™ is required, wet-out an additional roll and follow the same application steps. Overlap the end of the previous roll by 4-6 inches with the new roll before continuing to wrap.
10) Continue wrapping at an angle until the end of the repair zone is reached (leaving 2” of adhesive primer and at least 2” of fiberglass). Each pass counts as two layers when a 50% overlap is being utilized.
11) Wrap two complete layers at the end and reverse direction.



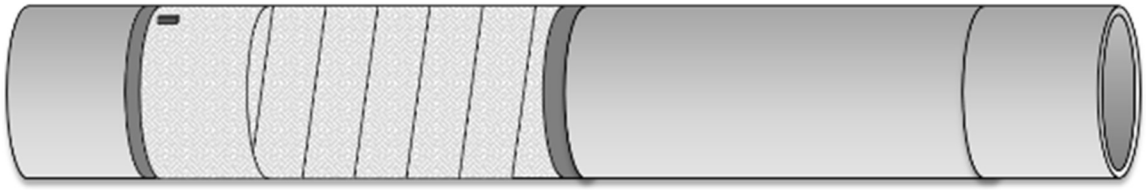
12) Continue wrapping and repeating until all designated rolls are used or the appropriate layer count is achieved.
13) Immediately constrictor wrap (4-6 layers) and immediately perforate to allow Atlas™ to de-bulk and for excess resin to escape (see page 47 for details on this step).



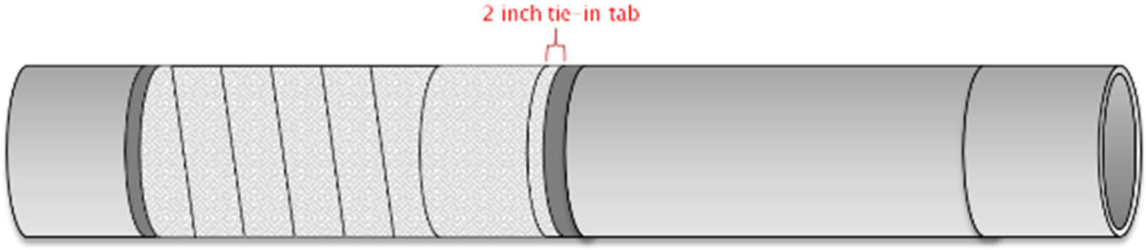
If multiple segments are to be utilized in a spiral wrap repair, the following steps are a general guide for any composite system that need to be implemented. The individual spiral wrap process should follow the guides discussed prior.

1) First, determine what the length that each segment will be.
2) The adhesive Primer needs to be applied only over the segment to be wrapped; an additional 2 inches are to be added at the end of the repair zone and an additional 4 inches need to extend beyond the end of the first segment where a tie-in is to occur.

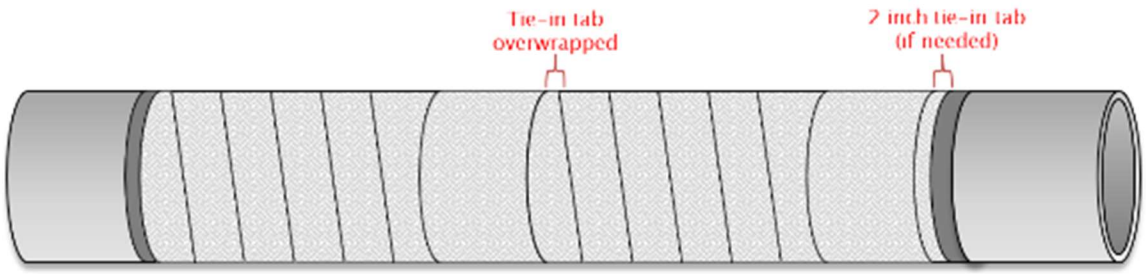
3) Begin wrapping at the tie-in location. After wrapping the first two layers, begin spiral wrapping.
4) Upon reaching the edge of the repair zone, wrap once, install ILI Markers™, if required. Achieve a 2nd layer and then continue spiral wrapping.



5) Upon reaching the tie-in location, the end of the 2nd pass should leave 2 inches of the 1st pass exposed (tie-in tab).
6) Continue wrapping until the required layer count is achieved.
7) Immediately constrictor wrap (4-6 layers) and immediately perforate.



8) When starting the next segment, leave another 2 inch tie-in tab, if required. This segment will wrap over the initial tie-in tab.



9) Continue wrapping in this manner until the entire repair zone is completed.
10) Immediately constrictor wrap (4-6 layers) and immediately perforate.

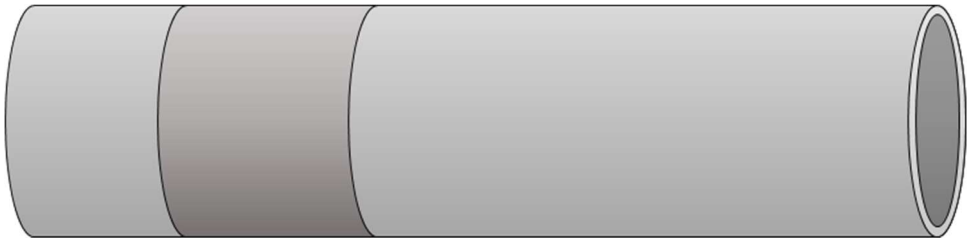
Offset Method

The offset method is used when the minimum required repair zone is larger than the composite width and the layer count exceeds 20 or the Atlas™ is being applied on large pipe. The design package will state a repair zone in increments of the width of the fabric. Before beginning this technique, it is crucial to determine if the entire repair zone will be primed at once or if the adhesive primer needs to be applied in segments. As a general guide, if the repair zone exceeds 4 feet, the adhesive primer should be applied in segments.

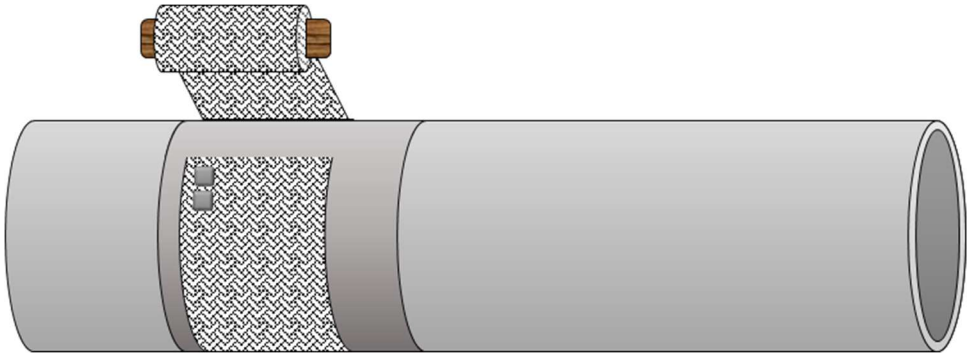
One concern often brought up is with regards to the space between two sections. A proper installation will leave no visible gap, however there may be a reduced thickness in between the section. While minimum direct strength is provided in this transition area, the Atlas™ system, when installed using the offset method, relies on the "Edge Effect". The "Edge Effect" is a strength of materials phenomena, not exclusive to composite repairs, where residual reinforcement extends beyond the physical limits of the actual reinforcing material. The use of the "Edge Effect" phenomena enables the systems to have a misalignment of approximately ½" from one section to another without affecting the structural integrity of the repair. Although the structural integrity is not in question, an additional concern involves the potential for moisture ingress though this "gap". To ensure that this does not become an issue, the offset method offsets the first two layers by 2 inches to prevent a direct water ingress path.

With this technique, after the load transfer filler is applied, the adhesive primer should extend four inches beyond the starting end of the repair zone and two inches beyond the first segment (or four inches beyond the end of the repair zone, if applicable). The following directions should be followed for the "offset method" installation technique demonstrating the adhesive primer being applied in multiple segments:

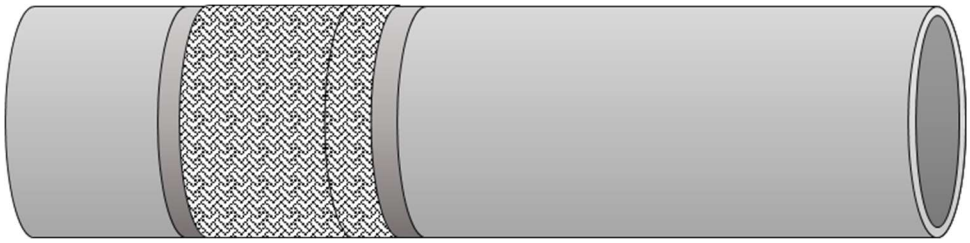
1) Apply the load transfer filler over the entire repair zone and the adhesive primer in the first segment. The primer should extend an additional four inches at the edge of the repair zone. Wait for the adhesive primer to achieve proper tackiness.



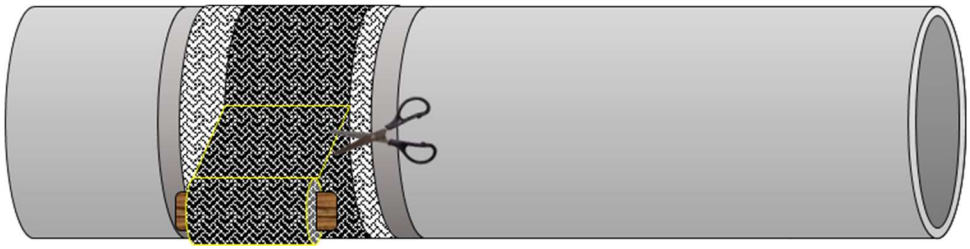
2) Apply your initial layer of fiberglass over the primer. There should still be two inches of exposed adhesive primer at the end of the repair zone. Insert ILI Markers™ near edge of the repair zone, if required.



Note: It may be necessary to use a smaller width roll to ensure adequate space is available to install the Atlas™ Carbon Fiber on. When applying fiberglass overlap the two layers with a minimum of one inch.

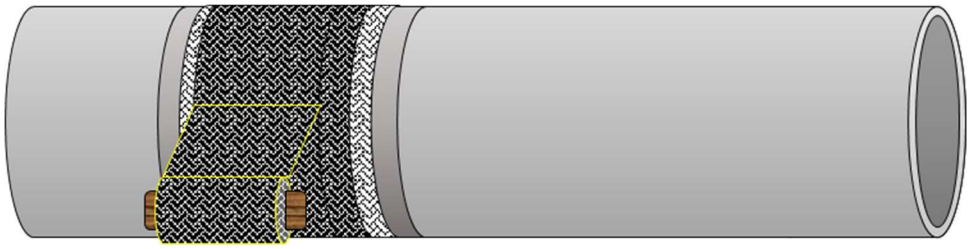


3) After wetting out the first roll, unroll a few feet and place 6 inches in from the end of the adhesive primer, at the edge of the repair zone.
4) Continue unrolling the Atlas™ around the pipe until two layers are installed.
5) Using scissors, cut the fabric cleanly.

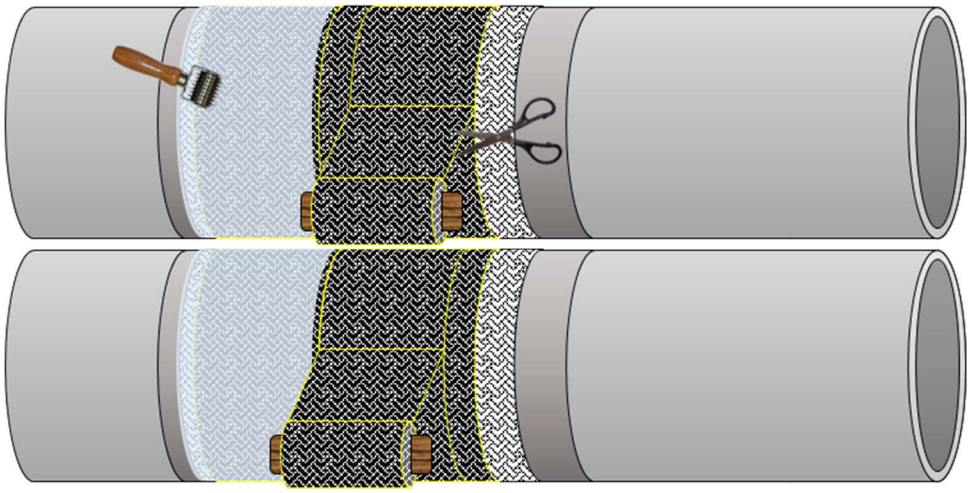


6) Restart the installation two inches from the end of the adhesive primer. There should now be a 2 inch tie-in tab as well as an additional 2 inches of fiberglass at the start of the repair.

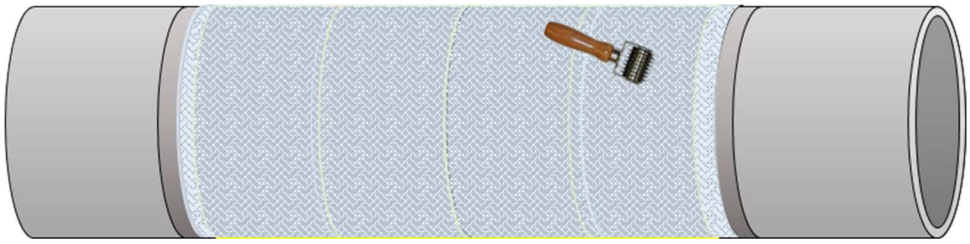
7) Continue unrolling the Atlas™ around the pipe keeping the repair centered.



8) After the second layer has been applied, begin to pull the wrap tightly at a minimum once per side of pipe. This is to ensure a tight fit application and minimizes the possibility of voids. For large pipe (24" OD or greater), it is recommended that an effort is taken to pull the wrap tightly twice per side of pipe; once when receiving the roll and again before the roll is passed on to the other side.
9) Continue applying the Atlas™ product until the desired layer count is achieved or the end of the roll. For pipes over 18" OD, it is recommended that an installation "break" is taken near every 20th layer (whenever a roll ends naturally). An installation "break" consists of:
    a. Immediately apply constrictor wrap in the same direction as the wrap installation and immediately perforate.
    b. Allow 15-20 minutes for compression and initial de-bulking.
    c. Remove the constrictor wrap gently – make sure to not peel off the Atlas™.
    d. Continue applying for another approximate 20 layers if required before repeating.
10) If the end of a roll is reached and more Atlas™ is required, wet out an additional roll and follow the same roll preparation procedure. Overlap the end of the previous roll by 4-6 inches with the new roll before continuing to wrap.
11) Continue to pull tightly throughout the installation.
12) Once the first segment is completed, immediately constrictor wrap and immediately perforate, then adhesive primer needs to be installed for the next segment. A secondary crew can be utilized to keep applying adhesive primer and fiberglass ahead of the wrapping crew to speed up the installation process.
13) Begin wrapping with an offset (the first two layers will be indented an extra two inches; they will not overwrap the tie-in tab).
14) After applying two layers, cut the fabric and apply the remaining layers overwrapping the initial tie-in tab.
15) When practical, be sure to use constrictor wrap and perforate any completed wraps before they begin to set-up.



16) Continue this process until the entire repair zone has been wrapped. The last segment does not require a tie-in tab to be generated – rather, all layers should be lined up at the edge of the repair (allowing 2 inches of exposed adhesive primer to remain visible). Be sure to include ILI Markers™, if applicable, in the last segment on the first layer of fiberglass.
17) After final layer count is achieved, immediately apply 4-6 layers of constrictor wrap and immediately perforate repair zone to allow de-bulking.



Installation of ILI Markers™ (optional)

In most transmission pipeline installations, ILI Markers™ are installed at each end of the repair zone. The intent of these markers is to indicate the location of the repair on any future inspections. An ILI Marker™ set contains four magnets, typically in a plastic container. The magnets are high powered and should not be stored near any sensitive equipment. In order to ensure effectiveness and prevent any issues, it is critical that the following directions are followed whenever installing an ILI Marker™.

Before installing the ILI marker system, consider the two recommended installation layouts for ILI Markers™. If a flow direction is consistent and it is desired to mark this direction with ILI markers, one marker can be installed on the downstream side (12:00 o'clock position) and the remaining three are to be installed on the upstream side to form a triangle indicating flow direction (9:00, 12:00 and 3:00 o'clock). If flow direction is not a concern, it is recommended to place two magnets on either end of the repair (10:00 and 2:00). For large pipes (24" OD or greater), it is recommended that the amount of markers installed at each location is doubled to increase visibility when viewing the inspection data.


Upon reaching the optional step for installing ILI Markers™ in the previous installation techniques section, the following steps are to be followed:

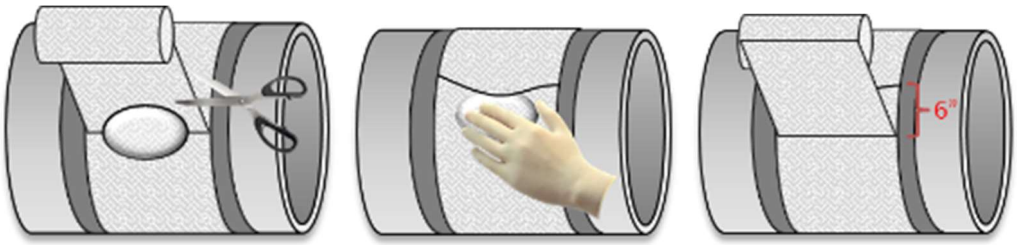
1) Ensure that one or two layers of fiberglass are installed at the end of the repair system.
2) Apply a small batch of the adhesive primer at each location where an ILI Marker™ is to be installed – approximately 1" from the outside edge of where the Carbon Fiber will lay and 2" apart from each other. This will put the ILI Markers™ approximately 3-4" inside the edge of the fiberglass layer.
3) Firmly place the ILI Marker™ into the adhesive primer; avoid entrapping air.
4) Apply more adhesive primer around and over the ILI Marker™. This is to reduce any chance of entrapped air.

5) Overwrap the ILI Marker™ with the remainder of the fiberglass layer, prior to installing the Atlas™ Carbon Fiber.

Troubleshooting

The following list contains issues that may be encountered during installation and tips for avoiding or correcting these issues:

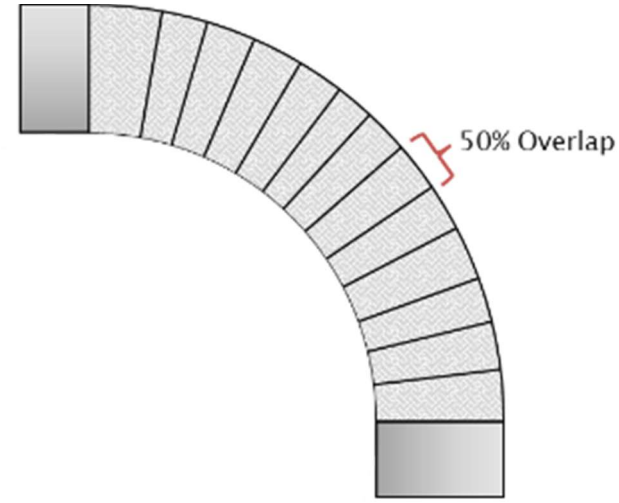
- Atlas™ material is beginning to get very hot and may set-up before repair is finished
  - This can occur on warm pipe or in hot ambient conditions
  - Finish the remaining material on the roll if possible or cut and discard remainder
  - Immediately constrictor wrap the Atlas™ material, immediately perforate and wait for 30 minutes
  - Remove constrictor wrap and continue applying additional layers
- One edge of the Atlas™ fabric is in tension while the other side develops slack
  - This can occur if installation is occurring over irregularities such as girth welds, dents or if excessive overlapping is occurring.
  - This issue can also occur is if uneven tension is applied
  - Immediately stop and cut the fabric
  - Completely eliminate slack by massaging fabric in the same direction as the wrap
  - Flip over the roll to reverse built in tension
  - Reapply with a 4-6” overlap
  - Avoid unevenly pulling on the Atlas™ using only the edges
  - Alternatively, cur far enough into the fabric to relieve the tension
  - Massage the fabric and pull tightly to remove voids (if present)



- Additional defect or unexpected obstacle in the repair zone
    - Contact a MIS representative and discuss the situation – the currently proposed design may not be adequate and will require a redesign and possibly more material
    - A designed repair can only be performed based on the information given – if something seems wrong with design package as compared to the on-site information, please verify with a MIS representative before proceeding with repair.

Geometric Considerations

For repairs on elbows or bends, a smaller width fabric may be recommended. In general, the fabric width should not exceed half of the pipe diameter (i.e. a 6” wide wrap would be better to use on a 12” pipe bend than a 12” wide wrap). For most bends and elbows, the spiral wrap method will be the most practical installation method. With this method, it is very crucial to ensure that the required 50% overlap occurs on the extrados (outside) of the bend. The intrados (inside) of the bend will have excess overlap and be thicker by design. In general, all defects that can be repaired on a straight segment of pipe can also be repaired on an elbow or bend.

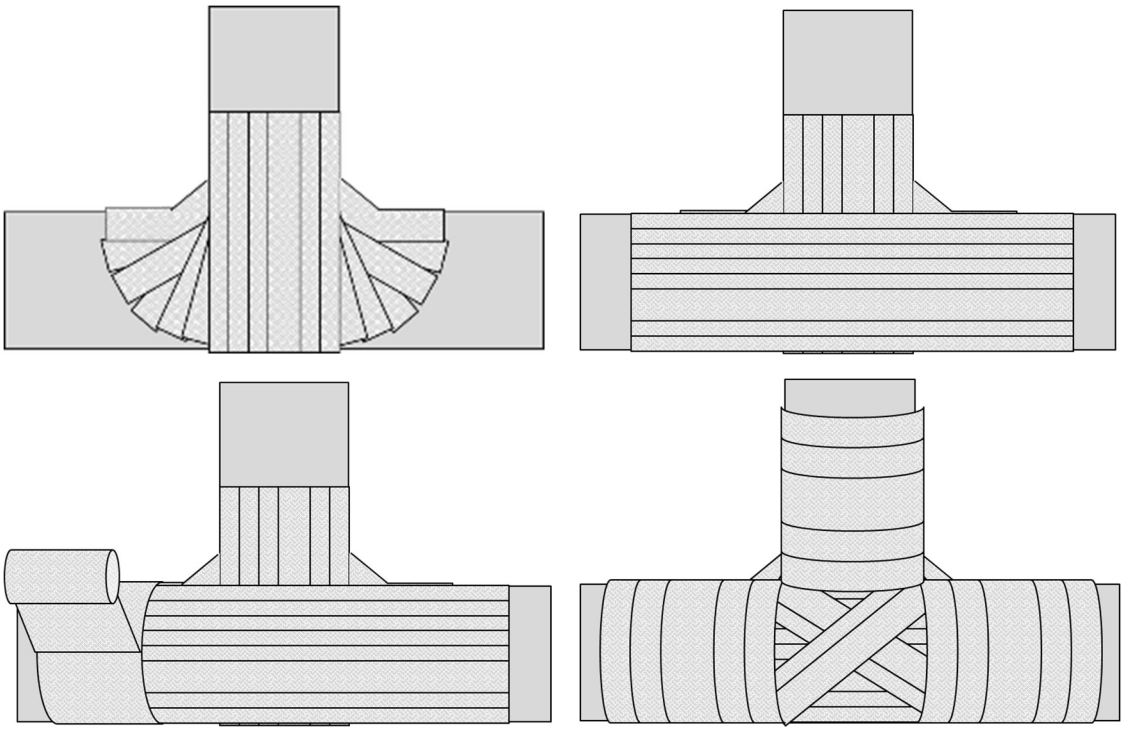


Tee Repair

For repairs on a Tee, the installation method can vary greatly based on the specific geometric conditions. In MIS documentation, the “Base Pipe” refers to the main line of the pipe and it is assumed to be one continuous size and runs in a linear direction. The “Branch Pipe” can be the same diameter as the base pipe but is often a smaller size; the branch pipe also, typically, juts out at a 90° angle from the base pipe. For pipe systems that have a significant difference in the branch pipe and base pipe diameter, two separate size materials may be recommended. The design package will typically call out a “base pipe repair zone” and a “branch pipe repair zone”. The base pipe repair zone is the total linear length on the base pipe centered in the middle of the Tee. The branch pipe repair zone is the length to be repaired on the branch pipe (extending from the intersection). Not all defects can be repaired on a Tee; please contact a MIS representative for specific repair scenarios.

The standard installation technique for a Tee is as follows:

1) Apply filler material and adhesives primer; build a smooth transition zone
2) Prepare composite by cutting as necessary to create wrap at the intersection
3) Apply half the layers spreading from the branch pipe down onto the base pipe
4) Apply axial layers across the base pipe repair zone
5) Encapsulate all three ends using the spiral wrap technique
    a. Create several crossovers to tie in the bottom of the Tee



7) Constrictor Wrap and Perforating

After the final repair thickness or layer count has been achieved (or as an intermediate step if required), the constrictor wrap shall immediately be applied tightly, typically, using a spiral wrap technique extending a minimum 2 inches past the repair zone. A minimum layer count of 4 layers is required for the constrictor wrap, although 6 is preferred; when applying with a spiral wrap method, remember that a 50% overlap yields two layers per pass. Constrictor wrapping ensures that the composite repair is compact, reduces possibility of underlying voids and protects the composite during the curing process.

After applying 4-6 layers of constrictor wrap, immediately use the perforating tool to perforate. Minimal pressure should be applied – the objective is to create holes in the plastic, not in the fabric underneath. Perforating achieves two primary goals: in the case of the Atlas™, it allows the system to shed excess resin through the constrictor wrap ensuring a stronger repair.

Additionally, some resin should be squeezed out of the perforations (resin dots); if very minimal resin is coming through, it may indicate that the perforations did not go through the plastic. Alternatively, it could indicate that the Atlas™ has already begun to harden which indicates that the constrictor wrap was not applied soon enough. Once the resin dots begin to harden and can be flaked off (allow minimum 2 hours) the constrictor wrap is ready to be removed. The constrictor wrap should peel off with no issues. If a razor blade is utilized to assist, ensure that the composite fabric is not cut into as this may cause damage to the repair.

8) Repair Inspection Guide

At the conclusion of a repair procedure, before the area is to be recoated and (most likely) buried, it is good practice to inspect the repair. It is very important to have accurate records kept during the repair procedure; this will help eliminate issues during the repair installation as well as assist in troubleshooting any defects or anomalies in the repair at the conclusion of an installation. Milliken Infrastructure Solutions provides copies of the 'Quality Verification Form for Atlas' with each order. It is **strongly recommended** that these forms are kept on hand and filled out properly as the repair procedure is carried out. These forms should be taken seriously in order to decrease the potential for errors. The process for inspection incorporates just a couple of simple nondestructive techniques.

Visual Inspection

This is the primary inspection method for in-service inspections. This method can detect the following discrepancies:

- Resin starvation
- Resin richness
- Wrinkles
- Ply bridging
- Discoloration (due to overheating, lightning strike, etc.)
- Impact damage
- Foreign matter
- Blisters
- Disbonding
- And more

Most types of damage are visible on the composite's surface (i.e. scorch, dent, chips, etc.). If visible damage is observed, the affected area should be more closely examined. Utilization of tools such as a magnifying glasses, mirrors, or flashlights is recommended to get a closer look at the damage. Visual inspection CANNOT detect internal flaws in the composite; more sophisticated NDI (Non-Destructive Inspection) techniques are needed for this and recommended when possible.

Audible Sonic Testing (Tap Test)

This technique makes use of frequencies in the audible range of 10 Hz to 20 Hz and can be extremely accurate if conducted by experienced personnel. This is the most common technique used for the detection of delamination and/ disbondment. The method is accomplished by tapping the inspection area with a solid round disk or lightweight hammer-like device, listening to the response of the structure to the hammer.

- A clear, sharp, ringing sound is indicative of a well-bonded solid structure
- A dull or 'thud-like' sound would indicate a discrepant area

The tapping rate should be rapid enough to produce adequate sound for any difference in sound tone to be discernable to the ear. Inherent in the method is the possibility that changes within the internal elements of the structure might produce pitch changes that are interpreted as defects when they may in fact be present by design. The inspection area should be kept as quiet as possible and should be carried out by experienced personnel.

Automated Tap test

Very similar test procedure to the Audible Sonic Testing, but instead of using a hammer, a solenoid is used. The solenoid produces multiple impacts in a single area. The tip of the impactor has a transducer that records the force versus time signal of the impactor. The magnitude of the force depends on the impactor, the impact energy, and the mechanical properties of the structure. The impact duration (period) is not sensitive to the magnitude of the impact force, however, this duration changes as the stiffness of the structure is altered. The signal from an unflawed region is used for calibration, any deviation from the unflawed signal would indicate the existence of damage.

Post Installation Maintenance

The ASME PCC-2 and ISO 24817 repair standards list several post-installation inspection techniques. Section 9.5 of ISO 24817 (2017) standard suggests the following for dealing with the maintenance of a repair system post-installation (paraphrased).

The maintenance and replacement strategy for repair systems is a function of original defect in the substrate. A risk assessment shall be completed to determine the appropriate strategy and shall consider the guidance given in the subclause. Annex L provides informative guidance on how to manage the overall integrity of repair system applications.

Condition of the repair- visual inspection

Visual inspection of the repair laminate for defects in accordance with Table 16 and Table 17 is recommended as part of the maintenance strategy. If defects are located, then further assessment shall be made in conjunction with the repair system supplier. The frequency of inspection should be determined in accordance with the risk assessment.

External Defects

For external defects it is assumed that further deterioration of the defect is stopped on application of the repair laminate. Therefore, the maintenance strategy should be to ensure that the repair laminate remains intact, i.e. the repair laminate is not damaged or partially delaminated from the substrate.

Internal or Through Wall Defects

For internal corrosion or through wall defects further deterioration or growth of the defect may continue despite application of the repair laminate. Therefore, in addition to the requirements set out in 9.5.3.1 the maintenance strategy should ensure that the internal defect does not grow to a size greater than assumed in the design or that the repair laminate does not delaminate from the substrate.

The frequency of inspection should be determined in accordance with the risk assessment.

Remedial Options

If assessment determines that replacement is required replacement options include:

- *Removal of the repair (e.g. through ultra-high pressure, water jetting or grit blasting) and replacement*
- *Repair of the repair laminate. In this case the damaged repair laminate should be considered as the defect for design purposes and a new repair designed*
- *Localized repair of the damaged area*

9) Top-coating the Repair

The Atlas™ has UV inhibitors in the resin, however, in most cases, a top-coat should be applied to the repair. The top-coat should be opaque on above ground pipes to minimize heat build-up to the composite. The top-coat on a composite repair serves two primary purposes:

1) Protection from UV and other harsh environmental factors.
2) Additional coating to prevent water ingress.

The provided adhesive primer may be used as a top-coat; most conventional pipe coatings are will work as well, if there are any concerns, please contact a MIS representative to determine compatibility. Additionally, it is recommended that at a minimum, the edges of the composite are sealed to help prevent any potential from moisture ingress through the sides.

It is Milliken Infrastructure Solutions stance that the initial layer of adhesive primer, when applied correctly, acts as a coating. The additional top-coat on the repair is to protect the composite from external elements and acts as a secondary backup to the internal coating.

Training and Installer Certification Requirements

Proper training is an essential aspect to any type of repair (or pipeline) procedure in general. Milliken Infrastructure Solutions considers proper training and certification maintenance to be of the upmost importance. Any individual utilizing the Atlas™ repair system must be certified to do so. Training is required to install the MIS products including, but not limited to, the A+ Wrap™, Atlas™, and FormaShield™ repair systems.

A recommended training log is attached as an appendix to this installer manual. It is highly encouraged that this, or a similar, log be filled out after every repair for tracking installations. In order to obtain re-certification, proof of recent installations must be provided. There are 2 levels of certification that personnel can obtain through Pipe Wrap via different types of training courses.

Installer

An **Installer** is someone who takes part in a full day course that includes both a classroom and hands-on portion, followed by a written exam. An **Installer** is certified to install their qualified system onto a pipeline following the relevant installer manual or any overriding, relevant procedures. At a minimum, one **Installer** is required on site to supervise and lead a repair. No additional supervisory levels are required. It is highly recommended that for the first 2 jobs, a **Trainer** is present to ensure proper procedure is followed. An **Installer** is the most common certification for trained installers.

Installer requirements:

- Classroom and hands-on training
- Full day course covering
    - Introduction to the products and company
    - Safety orientation
    - Detailed applications pertaining to specific products
- A written test with a passing score of at least 80%

Installer responsibilities:

- Assist or lead in repair installation
- Ensure quality control documentation is properly filled out
- Ensure procedures are followed precisely
- Determine if on-site defect condition matches repair documentation
    - If not – verify before proceeding with installation
- Make determination if a repair should be stopped (Call an MIS representative if needed)
- Ensure proper safety protocols are followed

- Maintain installation log / history
- Minimum of 2 recorded repairs in the past 6 months to retain installer qualification
- Submit for recertification by certified installer prior to 1 year certification expiration

Trainer level installer

A **Trainer** is someone who participates in the 3 day course at the MIS facility. This level of training provides application techniques for all scenarios, thorough product knowledge, use of engineering analysis software, etc. The individual will be fully qualified to train others to install the Atlas™ repair system. In the field, a **Trainer** has authority over **Installers**. A company based **Trainer** is responsible for maintaining documentation and records for all trained installers and ensuring that certifications are maintained and current.

Trainer level requirements:

- 3 day training course
    - Covers all **Installer** requirements
    - Additional, situational dependent courses
    - Advanced trouble shooting techniques
    - Detailed composite theory and functionality
    - Teach a classroom course to MIS representatives
- Written installer test with a passing score of at least 100%
- Written **trainer** level test with a passing score of 100%

Trainer level responsibilities:

- Lead training course for **Installers**
    - Lead in-class and hands-on training for all participants
    - Must maintain records of attendance for all individuals involved in a training class
    - Proctor exams at the conclusion of a training course
    - Classroom training will be provided to all individuals seeking installer certification
        - Minimum in classroom training requirement is ½ day
        - Classroom session will include presentation and video that include:
            - Introduction to the products
            - Safety orientation
            - Applications where Pipe Wrap products can be utilized
    - Hand-on training will be provided to all individuals seeking installer certification
        - Minimum hands-on training requirement is ½ day
        - Trainees will practice proper installation techniques under supervision

- Document Control Specialist
    - Maintain a list of ALL certified individuals
    - Maintain tests and revision history for all such documentation
    - Follow up with individuals for re-certifications purposes, as applicable
- Minimum of 1 recorded training in the past 6 months to retain **Trainer** qualification
    - Refresher courses for trained installers are valid in this category
- It is highly recommended, although not required, that each trainer participate in a minimum of 2 on-site repairs a year to observe and provide feedback for training courses if required.

General Information on Installer Certifications

- Certifications will be valid for a period of 1 year from the date of training
- Upon passing the test, a certificate will be issued, and a copy maintained on file
- Re-certification will be required within that 1 year timeframe
    - Re-certification requires providing installation logs from the previous year to ensure up to date familiarity with the installation process
    - Installer level classes will take an online or written test. It is required that a passing score of 80% is earned as a minimum.
    - Trainer level classes will take an online or written test as well. A minimum passing score of 95% is required for re-certification.
    - Re-certification is the responsibility of the installer and / or trainer
- Training can occur at a MIS location or at a customer's location. A classroom session can be connected to a live training (actual repair) for **Installer** certification
- If relevant training can be demonstrated, a shortened class may be applicable for training purposes. This is up to an MIS trainer qualified representative. A test is still required.
- If certification has lapsed, a three month grace period is available for re-certification following standard re-certification procedures.
    - If more than three months lapse, training is required for re-certification.

APPENDIX 1

Alternate Load Transfer Fillers and Adhesive Primers

Appendix 1. Alternate Load Transfer Fillers and Adhesive Primers

EP-400: Load Transfer Filler

The EP-400 load transfer filler is a high compressive strength, 2-part epoxy stick that can be applied to smaller defect areas to reshape the original pipe contour.

Storage Conditions

- Between 40°F and 80°F.
- Avoid prolonged storage above 90°F.
- Maintain in a dry environment with good ventilation.
- Store away from water, alcohols, strong bases, metal compounds or surface active materials.
- Keep out of direct sunlight.
- Refer to SDS for additional handling and storage information and accidental release measures.

Shelf Life

- Minimum 1 year from shipping date.
- 3 year shelf life from date of manufacturing.

Application Conditions

- Ideal ambient application temperature is above 50°F and up to 120°F.
- Ideal pipe temperature for application is above 60°F and up to 150°F.
- EP-400 can be applied at ambient temperatures below 40°F.
    - Site should be tented and heated to expedite cure time.
- EP-400 can be applied on pipes up to 200°F.
- EP-400 can harden and cure in wet environments but should be applied on dry pipe.

Installation of the Load Transfer Filler

The EP-400 load transfer filler product will come packaged in a plastic tube with a cap; remove the epoxy putty from the tube. Remove the plastic wrapping as well. It is then recommended to tear the stick in half or into thirds for easier mixing. Knead one piece for 2-3 minutes using a gloved hand. Continue mixing until uniform in color. Below 50°F or above 85°F it is recommended to keep the material stored in a vehicle or other climate controlled environment until ready for use. In warmer temperatures, the EP-400 material should be kept out of direct sunlight to avoid prolonged heating which may affect working time.

Apply the epoxy putty to all voids and “tented” areas associated with the defect areas. Additionally, any large welds need to be smoothed out using the filler material to create a smooth transition zone for the composite material. Press firmly into any voids to ensure no air-gaps are located underneath the filler. Smooth the filler material to match the pipe contour as best as possible. Avoid creating any sharp edges. Wait for material to harden (approx. 5 minutes). If required, use sand paper or a grinding tool to reshape and remove any sharp edges.

Application Tips:

- For condensing or “sweaty” pipes – solvent wipe the pipe surface and immediately apply the filler material once the solvent flashes off (the condensate should no longer be visible as well).
    - If the EP-400 begins to harden too soon, mix smaller pieces, and reduce the temperature (store in air conditioning)
- For ambient temperatures near freezing – keep the filler material (as well as the composite and adhesive primer) warm. This can be accomplished by storing the material inside a vehicle or inside a coat pocket. The cold temperatures may cause the pipe to sweat; solvent wipe as necessary.

EP-913: Load Transfer Filler and Adhesive Primer

The EP-913 load transfer filler system is utilized for large area, yet minor, external corrosion / pitting defects. The system can be utilized as the load transfer filler and as the primer adhesive.

Storage and Application Conditions

The following storage conditions should be observed when the material is not being primed for immediate use. Additionally, following these conditions in the field prior to application will result in an easier install and eliminate potential issues. All perishable materials will be marked with appropriate expiration dates.

Storage Conditions

- Between 40°F and 80°F.
- Avoid prolonged storage above 90°F.
- Maintain in a dry environment with good ventilation.
- Store away from water, alcohols, strong bases, metal compounds or surface active materials.
- Keep out of direct sunlight.
- Refer to SDS for additional handling and storage information and accidental release measures.

Shelf Life

- 1 year shelf life from date of manufacturing.

Application Conditions

- Ideal ambient application temperature is above 50°F and up to 120°F.
- Ideal pipe temperature for application is above 60°F and up to 150°F.
- EP-913 can be applied at ambient temperatures below 40°F.
    - Site should be tented and heated to expedite cure time.
- EP-913 can be applied on pipes up to 150°F.
- EP-913 requires application on a dry surface.

Installation of the Load Transfer Filler

When working with any epoxy or liquid polymeric material, proper PPE should always be worn. From this point forward, PPE should be worn at all stages of installation.

The load transfer filler material serves two primary purposes:

1) The filler material will reshape the pipe to near-original contour.
    a. This will ensure that the composite being utilized does not experience any odd deformities which may negatively impact the structural integrity of the repair.

2) The high compressive nature of the filler material will prevent the defect region from expanding by distributing the load to the composite material.
    a. This process of load distribution is referred to as creating a “load transfer path”.

Milliken Infrastructure Solutions offers many choices for a load transfer filler material. The default material for the Atlas system is EP-400. The directions that follow apply specifically to the EP-913 material.

EP-913 comes in multiple packaging types as a set of two equal sized paint cans (2-pint kit, 2-quart kit or 2-gallon kit). The mix ratio of this product is 1:1 by volume. Based on the required amount, this product can be mixed by hand on a cardboard tray using a putty knife, in a mixing cup using stir sticks or in a larger bucket using a mixing drill bit. Mix until uniform in color. Mixing time is typically 3-5 minutes depending on the process used. In cold weather (<40°F), mixing time should increase to 8-10 minutes due to material thickening (becoming more viscous).

Once thoroughly mixed, allow 5-15 minutes to achieve an optimum viscosity for application. This time may adjust due to ambient temperatures and quantity mixed. Below 50°F or above 85°F it is recommended to keep the material stored in a vehicle or other climate controlled environment until ready for use. In warmer temperatures, the EP-913 material should be kept out of direct sunlight to avoid prolonged heating which may affect working time.

Once ready, trowel the adhesive primer over the repair surface. Apply the epoxy paste to all voids and “tented” areas associated with the defect areas. Additionally, any large welds need to be smoothed out using the filler material to create a smooth transition zone for the composite material. Press firmly into any voids to ensure no air-gaps are located underneath the filler. Smooth the filler material to match the pipe contour as best as possible. Avoid creating any sharp edges. Wait for material to harden (approx. 5 minutes). If required, use sand paper or a grinding tool to reshape and remove any sharp edges.

Application Tips:

- For condensing or “sweaty” pipes – solvent wipe the pipe surface and immediately apply the filler material once the solvent flashes off (the condensate should no longer be visible as well).
- If the EP-913 begins to harden too soon:
    - Reduce the wait time after mixing
    - Mix in smaller quantities
    - Reduce the temperature (store in air conditioning)
- For ambient temperatures near freezing – keep the filler material (as well as the composite and adhesive primer) warm. This can be accomplished by storing the material

inside a vehicle or inside a coat pocket. Cold temperatures may cause the pipe to sweat; solvent wipe as necessary.

Installation of the Adhesive Primer

Milliken Infrastructure Solutions offers many choices for an adhesive primer material. The default material for the Atlas system is PPR. The directions that follow apply specifically for EP-913.

The adhesive primer material serves two primary purposes:

1) The adhesive primer will bond to the pipe and prevent disbondment.
2) The adhesive primer acts as a coating underneath the repair, thus preventing moisture ingress.

As an adhesive primer, the EP-913 has the same mixing procedure as discussed earlier. Once ready, trowel the adhesive primer over the repair surface. This is typically done with the hand applicator, however, other tools or equipment may be used as well. A general guideline for thickness is to apply approximately 30mils of coverage. Enough primer needs to be applied to coat the entire pipe; it needs to be thin enough to not interfere with load transfer. Depending on the installation technique, different amounts of the adhesive primer may be applied in one go. The adhesive primer should extend 2” beyond the end of the repair zone to act as a tie-in location for future top-coating.

Application Tips:

- For condensing or “sweaty” pipes – solvent wipe the pipe surface and immediately apply the adhesive primer material once the solvent flashes off (the condensate should no longer be visible as well). Material may need to be applied is small, concentrated patches.
- If the EP-913 begins to thicken up too quickly:
    - Reduce the wait time after mixing
    - Mix less material at one time
    - Reduce the temperature (store in air conditioning)
- For ambient temperatures near freezing – keep the adhesive primer material (as well as the composite and load transfer filler) warm. This can be accomplished by storing the material inside a vehicle or inside a coat pocket. The cold temperatures may cause the pipe to sweat; solvent wipe as necessary.
- For smaller corrosion around the entire pipe, it is critical that a smooth profile is obtained that mimics the natural pipe geometry. The following steps may be taken to help achieve this:

- Apply the adhesive primer to the entire repair zone, apply extra material to defect areas as needed to supply sufficient material for reshaping.
- Use constrictor wrap or 60mil thick polyethylene sheeting to encapsulate the adhesive primer and ensure the correct shape.
- Allow material to harden; remove plastic and file down any high spots or sharp edges.
- Lightly abrade the hardened adhesive primer with 80 grit sandpaper and solvent wipe.
- Mix another batch of adhesive primer and apply using a standard procedure.

EP-920: Load Transfer Filler and Adhesive Primer (SplashBond™)

The EP-920 load transfer filler system is utilized for large area, yet minor, external corrosion / pitting defects. The system can be utilized as the load transfer filler and as the primer adhesive. Additionally, when utilized as part of the SplashGuard™ system, the SplashBond™ material can be utilized in wet zone repairs as well as underwater repairs. The procedures listed here are solely for above ground repairs.

Storage and Application Conditions

The following storage conditions should be observed when the material is not being primed for immediate use. Additionally, following these conditions in the field prior to application will result in an easier install and eliminate potential issues. All perishable materials will be marked with appropriate expiration dates.

Storage Conditions

- Between 40°F and 80°F.
- Avoid prolonged storage above 90°F.
- Maintain in a dry environment with good ventilation.
- Store away from water, alcohols, strong bases, metal compounds or surface active materials.
- Keep out of direct sunlight.
- Refer to SDS for additional handling and storage information and accidental release measures.

Shelf Life

- Minimum 1 year from shipping date.
- 1 year shelf life from date of manufacturing.

Application Conditions

- Ideal ambient application temperature is above 50°F and up to 120°F.
- Ideal pipe temperature for application is above 60°F and up to 150°F.
- EP-920 can be applied at ambient temperatures below 40°F.
    - Site should be tented and heated to expedite cure time.
- EP-920 can be applied on pipes up to 150°F.
- EP-920 can be applied on a wet surface.

Installation of the Load Transfer Filler

When working with any epoxy or liquid polymeric material, proper PPE should always be worn. From this point forward, PPE should be worn at all stages of installation.

The load transfer filler material serves two primary purposes:

1) The filler material will reshape the pipe to near-original contour.
    a. This will ensure that the composite being utilized does not experience any odd deformities which may negatively impact the structural integrity of the repair.
2) The high compressive nature of the filler material will prevent the defect region from expanding by distributing the load to the composite material.
    a. This process of load distribution is referred to as creating a “load transfer path”.

Milliken Infrastructure Solutions offers many choices for a load transfer filler material. The default material for the Atlas system is EP-400. The directions that follow apply specifically for EP-920.

EP-920 comes in multiple packaging types as a set of two equal sized paint cans (2-pint kit, 2-quart kit or 2-gallon kit). The mix ratio of this product is 1:1 by volume. Based on the required amount, this product can be mixed by hand on a cardboard tray using a putty knife, in a mixing cup using stir sticks or in a larger bucket using a mixing drill bit. Mix until uniform in color. Mixing time is typically 3-5 minutes depending on the process used. In cold weather (<40°F), mixing time should increase to 8-10 minutes due to material thickening (becoming more viscous).

Once thoroughly mixed, allow 5-15 minutes to achieve an optimum viscosity for application. This time may adjust due to ambient temperatures and quantity mixed. Below 50°F or above 85°F it is recommended to keep the material stored in a vehicle or other climate controlled environment until ready for use. In warmer temperatures, the EP-920 material should be kept out of direct sunlight to avoid prolonged heating which may affect working time.

Once ready, trowel the adhesive primer over the repair surface. Apply the epoxy paste to all voids and “tented” areas associated with the defect areas. Additionally, any large welds need to be smoothed out using the filler material to create a smooth transition zone for the composite material. Press firmly into any voids to ensure no air-gaps are located underneath the filler. Smooth the filler material to match the pipe contour as best as possible. Avoid creating any sharp edges. Wait for material to harden (approx. 5 minutes). If required, use sand paper or a grinding tool to reshape and remove any sharp edges.

Application Tips:

- For condensing or “sweaty” pipes – solvent wipe the pipe surface and immediately apply the filler material once the solvent flashes off (the condensate should no longer be visible as well).
- If the EP-920 begins to harden too soon:
    - Reduce the wait time after mixing

  - Mix in smaller quantities
  - Reduce the temperature (store in air conditioning)
- For ambient temperatures near freezing – keep the filler material (as well as the composite and adhesive primer) warm. This can be accomplished by storing the material inside a vehicle or inside a coat pocket. Cold temperatures may cause the pipe to sweat; solvent wipe as necessary.

Installation of the Adhesive Primer

Milliken Infrastructure Solutions offers many choices for an adhesive primer material. The default material for the Atlas system is PPR. The directions that follow apply specifically for EP-920.

The adhesive primer material serves two primary purposes:

1) The adhesive primer will bond to the pipe and prevent disbondment.
2) The adhesive primer acts as a coating underneath the repair, thus preventing moisture ingress.

As an adhesive primer, the EP-920 has the same mixing procedure as discussed earlier. Once ready, trowel the adhesive primer over the repair surface. This is typically done with the hand applicator, however, other tools or equipment may be used as well. A general guideline for thickness is to apply approximately 30mils of coverage. Enough primer needs to be applied to coat the entire pipe; it needs to be thin enough to not interfere with load transfer. Depending on the installation technique, different amounts of the adhesive primer may be applied in one go. The adhesive primer should extend 2” beyond the end of the repair zone to act as a tie-in location for future top-coating.

Application Tips:

- For condensing or “sweaty” pipes – solvent wipe the pipe surface and immediately apply the adhesive primer material once the solvent flashes off (the condensate should no longer be visible as well). Material may need to be applied is small, concentrated patches.
- If the EP-920 begins to thicken up too quickly:
  - Reduce the wait time after mixing
  - Mix less material at one time
  - Reduce the temperature (store in air conditioning)
- For ambient temperatures near freezing – keep the adhesive primer material (as well as the composite and load transfer filler) warm. This can be accomplished by storing the material inside a vehicle or inside a coat pocket. The cold temperatures may cause the pipe to sweat; solvent wipe as necessary.

- For smaller corrosion around the entire pipe, it is critical that a smooth profile is obtained that mimics the natural pipe geometry. The following steps may be taken to help achieve this:
    - Apply the adhesive primer to the entire repair zone, apply extra material to defect areas as needed to supply sufficient material for reshaping.
    - Use constrictor wrap or 60mil thick polyethylene sheeting to encapsulate the adhesive primer and ensure the correct shape.
    - Allow material to harden; remove plastic and file down any high spots or sharp edges.
    - Lightly abrade the hardened adhesive primer with 80 grit sandpaper and solvent wipe.
    - Mix another batch of adhesive primer and apply using a standard procedure.

APPENDIX 2

Unique Applications and Considerations

Appendix 2. Unique Applications and Considerations

2A: Installation on Large Diameter Pipes under Hot Weather Conditions

On large diameter pipes in hot ambient weather, the working time of the Atlas™ can be significantly shortened leading to possible issues during installation. The following is a summarized installation procedure with special focus on methods to increase the working time of the Atlas™ system, thereby reducing the possibility for mistakes.

Repair Material Preparation:

- The repair area shall be sheltered (tented) to reduce the temperature and prevent materials from being heated by direct sunlight.
- All repair material should be stored between 50 to 80°F and out of direct sunlight.
- For installations performed at temperatures > 90 °F (32 °C), the Atlas™ fabric rolls and epoxies are to be stored in an ice chest prior to installation.

Overview of Installation

1) Prepare materials and ensure that a sufficient “repair area” and “staging area” are established.
    a. Atlas™ material shall be submerged in an ice chest until used.
2) Ensure that proper surface preparations have been reached.
3) Confirm defect dimensions match design conditions.
4) Inspect pipe for any sharp edges and solvent wipe the area to remove any contaminates. Allow 1-2 minutes for solvent to flash.
5) Mark the repair zone. A minimum of 2” on either side of the defect is required. An additional minimum of 2” is required if ILI Marker™ set is to be installed.
6) Wearing proper PPE, begin mixing load transfer filler material until uniform in color.
7) Apply load transfer filler to all defect and tented areas; smooth to pipe contour.
8) Mix adhesive primer until uniform in color. Allow material to sit for 10-15 minutes to thicken.
9) Apply adhesive primer over entire repair zone plus an additional 2” on either side. Ideally, the adhesive primer is applied with approximately 30-mil thickness.
10) Allow adhesive primer to gel until it reaches the consistency of peanut butter (10-15 minutes)
11) Mix an Epoxy Resin kit (A&B), impregnate the resin into the fiberglass base layer and apply the layer of fiberglass within the repair zone. Install ILI Marker™ system if applicable.
12) Begin application of the Atlas™ material. Install ILI Marker™ system if applicable.
13) Continue wrapping per installation method. Once two layers have been achieved, ensure that constant, uniform tension is applied to the roll.
    a. Thoroughly saturate each layer of fabric with water.

b. Pull tight! Every layer needs to be in tension.
c. Manually remove all air pockets that develop between each layer if present.
d. If excessive “slack” develops during the application, cut the fabric and “flip the roll over” before continuing installation to “reset” the slack.

14) In hot weather repairs, hold points may be required. At a hold point, immediately apply constrictor wrap, immediately perforate and allow the Atlas™ material to set for 30 minutes. Remove the constrictor wrap and continue applying the Atlas™ material until complete or another hold point is required. Contact a MIS Representative to determine proper hold points, based on up to date field conditions.
15) Immediately upon completing the installation (or at a hold point), wrap 4-6 layers of constrictor wrap.
16) Immediately perforate the constrictor wrap to allow for excess resin to escape and de-bulking.
17) Allow to cure for a minimum 2 hours (temperature dependent).
18) Remove constrictor wrapping and inspect the repair.
19) Top-coat if required (it is recommended that a top-coat be applied)

Although all steps and procedures of the Atlas™ installation are important, the following items are of key concern and are therefore required to be provided by the Installer. Please verify that all necessary items are available prior to the installation Atlas™ System.

Personnel Required

- 2ea Installers - one on each side of the pipe applying the Atlas™ roll
- 1ea installer underneath the pipe passing the roll (for very large pipe diameters)
- 2ea installer mixing the chemicals, replenishing materials & assisting in the application

Additional Material Required by Installer

- Tenting / Tarp (ex: 2-3ea Canopy Pop-Up, 12ft x 12ft)
- Thermometer
- 2ea 6’ Folding Tables
- Paint Marker
- Shore D Hardness Tester
- Rags
- Solvent (Acetone, MEK, or Toluene ONLY)

Recommended items available for purchase

- 2ea Perforating Tool

2B: Cold Weather Installations

Repair Material Preparation:

- The repair area should be sheltered to protect the repair area from the elements.
- If possible, heaters can be used to heat the pipe and general repair area.
- All repair material should be stored between 50 to 80°F prior to use, so they will be easier to work with.
    - Materials can be kept in a heated truck to protect them from the cold ambient temperatures.
- **If temperatures are below 40°F, contact a **Milliken Pipe Wrap representative** prior to carrying out any installations.

Additional Materials required by installer:

- Tents/tarps for sheltering repair area
- Heaters
- Thermometer

2C: Bad Weather Installations

The Atlas™ system cannot be utilized in bad weather conditions unless the repair area can be adequately protected from the elements. *Contact a **Milliken Pipe Wrap rep** prior to installing in poor weather conditions.

2D: Dent Repairs

Dent repairs can be completed using the Atlas™ system. Refer back to page 3 for limitations used for dent repairs. If a dent is inspected and it is determined to have no cracks present, then it can be considered for repair with Atlas™. There are a couple of steps that need to be taken prior to wrapping the dent, which will help ensure a successful repair.

Repair Material Preparation:

- Extra Load Transfer Filler materials will need to be utilized in order to bring the pipe's surface back to a near net profile.
    - The EP-420 paste will be the go to filler materials for reshaping dents.
- A 'mold' will need to be made of a thin piece of polyethylene sheeting, or a similar material that can be secured in the same contour of the pipe, holding its proper shape and allowing the filler to cure.

Special steps to be taken:

1. Ensure that the proper level of pipe preparations have been met (minimum of NACE #3)
2. Inspect dent and ensure that no cracks are present.
3. Solvent wipe repair area with Acetone, MEK, or Toluene and allow to flash for 1-2 minutes.

4. Mix appropriate quantity of load transfer filler paste (i.e. EP-420) as previously determined by repair design calculations and discussions with Milliken Pipe Wrap personnel.
5. Apply filler within entire dent area, trying to reshape and achieve a near-net profile with the original pipe OD.
6. Once filler is adequately applied, use a 'mold' to tightly hold the filler paste in the dent and to keep the pipe profile. A 'mold' can be made using a thin polyethylene sheet and secured to itself using duct tape.
7. Allow approximately 1 hour (temperature dependent) for the filler to cure.
8. Once the filler has cured, remove the mold and check the profile of the filler material.
9. Remove any high spots or stress risers by using sand paper, a file, or a disk grinder.
10. If there are still low spots in the dent area, repeat steps 3-9 as necessary.
11. Once dent is sufficiently filled and cured, refer back to page 7 for the remainder of the Atlas™ installation steps.

2E: Wrinkle Bends

Wrinkle bends are a type of defect which get assessed and considered on a case-by-case basis, before determining if the Atlas™ system should be utilized for the repair. If it is determined that Atlas™ is a viable repair option, then there are certain steps that should be taken to ensure an adequate repair will be made.

Repair Material Preparation:

- Extra Load Transfer Filler materials will need to be utilized in order to transition the wrinkles so that they can be wrapped over smoothly.
    - EP-420 will be the go-to filler materials for such applications, unless designated otherwise in the design calculations.

Special steps to be taken:

1. Ensure that the proper level of pipe preparations have been met (minimum of a NACE #3)
2. Inspect repair zone and ensure that no cracks are present.
3. Solvent wipe repair area with Acetone, MEK, or Toluene and allow to flash for 1-2 minutes.
4. Mix appropriate quantity of load transfer filler paste (i.e. EP-420) as previously determined by repair design calculations and discussions with Milliken Pipe Wrap personnel.
5. Apply load transfer filler on each side of the wrinkles, creating a more smooth transition area to wrap over.

6. Allow filler to set up for approximately 1 hour (temperature dependent).
7. Remove any high spots or stress risers by using sand paper, a file, or a disk grinder.
8. Once wrinkles are sufficiently transitioned and the filler has cured, refer back to page 7 for the remainder of the Atlas™ installation steps.

2F: Girth Weld Repairs

In general, a repair is not recommended if the defect exceeds 50% wall loss and it exceeds 30% of the circumference (in the weld). If the defect falls within these parameters, then Atlas™ can be utilized as a repair option.

Special steps to be taken:

1. Ensure that the proper level of pipe preparations have been met (minimum of NACE #3)
2. Inspect repair zone and ensure that no cracks are present.
3. Solvent wipe repair area with Acetone, MEK, or Toluene and allow to flash for 1-2 minutes.
4. Mix appropriate quantity of load transfer filler paste (i.e. EP-420) as previously determined by repair design calculations and discussions with Milliken Pipe Wrap personnel.
5. Fill the defects and tent the entire weld area for a smooth wrap transition.
6. Refer back to page 7 for the remainder of the Atlas™ installation steps.

APPENDIX 3:

Supporting Documentation

Appendix 3A. Technical Data

September 2016

Milliken Infrastructure

Atlas™

Carbon Fiber Composite Repair System

OIL, GAS + INDUSTRIAL

Atlas™ is a high strength, high stiffness carbon fiber solution for on-site repair of piping structures. Atlas™ is designed for repairs requiring strain reduction due to dynamic loading conditions

MECHANICAL PROPERTIES	UNITS	ASTM TEST METHOD	VALUES
Tensile Strength	PSI, MPa	D3039-00	151,000 (1,041)
Tensile Modulus	PSI, MPa	D3039-00	9.7 x 10^6, (66,879)
Flexural Strength	PSI, MPa	D790-00	113,000 (779)
Flexural Modulus	PSI, MPa	D790-00	9.1 x 10^6, (62,742)
Shear Modulus	PSI, MPa	D5279-01	9.64 x 10^5 (6,647)
Interlaminar Shear Strength	PSI, MPa	D3165-07	8,200 (56.5)
Barcol Hardness		D-2583	53
Glass Transition		ISO 11357-2	350°F (177°C)
Thermal Expansion		E831-6	.116 um/m/°F (.208 um/m/°C)
Poisson's Ratio		D3039-00	.150

PHYSICAL PROPERTIES (ACFE)	
Stocked Width	12" (30.5 cm)
% Resin content by weight	36 ± 3
Fabric Orientation	Bi-Axial 0° and 90°
Cure Ply Thickness	0.019 IN (19 mils) (0.48 mm)

GENERAL PROPERTIES	
Maximum Operating Temperature	314°F (157°C)
Working Time (Dependent on Temperature)	40 Minutes @ Ambient
Set Time	1 Hour
Chemical Resistance	Gasoline, MEK, Acetone, Toluene, Ethyl alcohol and other hydrocarbons
Shelf Life	One year from ship date
Application Conditions	Above 45°F (7°C) up to 120°F (49°C)

Typical Uses

The Atlas™ system is most commonly used for pipelines and piping systems that have suffered from corrosion or third party damages. Possible defects that can be repaired include:

- External corrosion and pitting
- Dents, gouges and scratches
- Welds and other manufacturing flaws
- Wrinkle Bends
- Crack Reinforcement (conditional cases)

Benefits

- Site impregnated
- Resin part A and part B come to the field pre-measured
- Structural fabric is impregnated in the field with conventional equipment
- Restores pipe to original strength
- Ideal application temperature up to 120 °F (49 °C)
- Independently certified to ASME-PCC-2 and ISO 24817 standards

Complete Kit Includes

- Carbon Fabric
- Primer Kit
- Constrictor Wrap

pipe wrap®

infrastructure.milliken.com
855-655-6750

MILLIKEN INFRASTRUCTURE
A Milliken COMPANY

PW1102 - 0916

Appendix 3B. Repair Questionnaire

Milliken | Milliken Infrastructure Solutions, LLC — pipe wrap — **Repair Questionnaire** www.piperepair.net			
15832 West Hardy Road, Suite 600 Houston, TX 77060		Phone : (281) 999-7100 Fax : (281) 999-7110	
If repair zone contains more than one component, please provide separate Repair Questionnaires. Where applicable, please use dropdown selections to input information. Units are also dropdown. **For further clarification on any question, please select the question text (ex: "Pipe Material").**			
Contact Name		Company Name	
Contact Number		Shipping Address	
Contact E-mail			
Repair Type			
Requested Design Life	years	Component Type	
Project Name / Info			
Pipe Information and Operating Conditions			
Pipe Material		Component Shape	
Pipe Diameter	inches		
Nom. Wall Thickness	inches		
Pipe Grade (SMYS)		Product in Pipe	
Surface Prep Available			
Class Location (Factor)		Location of Pipe	
Operating Pressure	psi	Operating Temperature	°F
Installation Pressure	psi	Installation Temperature	°F
Design Pressure	psi	Design Temperature (max)	°F
Unique Conditions		Design Temperature (min)	°F
Defect Information			
Defect Type			
Defect Length	inches		
Defect Width	inches		
Amount of Wall Loss	inches		
Remaining Wall	inches		
Location of Defect			
Other Considerations			
Additional Information (optional)			
Fabric (Roll) Width		Maximum Repair Length	inches
Application Method		Requested Repair Length	inches
Include Pig Markers		Can external heating be applied	
Include Top Coat		Can line be depressurized	
Include Training		Include Job Supervision	
Inspector's Name		Date	
Upon completion of Repair Questionnaire, please submit form to your Sale's Representative or e-mail to pipewrap@milliken.com			

Appendix 3C. Project Repair Notes

Milliken | Milliken Infrastructure Solutions, LLC

pipe wrap

Project Repair Notes

PROJECT NO:	**DATE:**	
Customer Name:		
Address:		
City:	State:	ZIP Code:
Repair number:	Sales Representative:	
INSTALLATION CONDITIONS		
Defect observed (detailed description):		
Installation Pressure:	Inspector:	
Ambient Temperature:	Inspection Results:	
Pipe Skin Surface Temperature:		
Location of Installation:		
REPAIR NOTES		
Material Storage Conditions:		
Repair Material:		
Repair Length:	Installation Method:	
Target Thickness:	Measured Repair Thickness:	
Start of Installation (time):	End of Installation (time):	Repair time:
Repair Notes:		
POST INSTALLATION INSPECTIONS		
Time to Set:	Hardness:	
Tap Test Result:	Visual Inspection Results:	
CUSTOMER FEEDBACK		
Remarks:		
Name :	Designation:	Phone/Fax:
Email:		
Signature:	Date:	Place:

Appendix 3D. Atlas™ Installation Log

Date	Customer	Contact Name	Contact phone / e-mail	Location of Repair	Project Name	Pipe Diameter	Defect Type / Dimensions	Qty. Units Installed