Lessons Learned
from Natural Gas STAR Partners

Composite Wrap for Non-Leaking Pipeline Defects

Executive Summary

Composite wrap is a permanent, cost-effective pipeline repair technology, suitable for non-leaking defects such as pits, dents, gouges, and external corrosion. Composite wrap can be performed on an operating pipeline without taking it out of service. This repair technique is quick and generally less costly than other repair options, and it permanently restores the pressure-containing capability of the pipe when properly installed.

Composite wrap can serve as an alternative to the traditional pipeline repair practices such as pipeline replacement or the installation of full-encirclement steel split sleeves. Compared to these traditional practices, composite wrap repairs are generally less expensive, time consuming, and labor intensive. In the case of pipeline replacement, composite wrap repair has additional advantages of avoiding customer service interruptions and eliminating methane emissions associated with the venting of the damaged pipeline.

Using composite wrap as an alternative to pipeline replacement often saves enough gas to pay back repair costs immediately. One Natural Gas STAR partner reported completing 2 to 65 composite wrap repairs per year on pipelines 10" and larger, saving 526 thousand cubic feet (Mcf) to 27,500 Mcf of natural gas per repair. Between 1993 and 1999, this partner saved 106,133 Mcf by choosing composite wrap over pipeline replacement.

Technology Background

Non-leaking pipeline defects such as corrosion, dents, gouges, pits, and cracks can cause pipelines to rupture. According to the U.S. Department of Transportation (DOT), there are three primary methods of repair for non-leaking defects on steel pipelines:

- ★ Cut out damaged segment and replace with new pipe.
- ★ Install a full-encirclement steel split sleeve over the damaged area.
- ★ Install a composite sleeve over the damaged area.

Both the pipeline replacement and steel sleeve installation procedures are expensive, time-consuming, and labor-intensive. Pipeline replacement requires that the affected portion of the line be shutdown, often resulting in service interruption. The gas in the line is then purged, the affected segment is cutout, and a new segment of pipeline is welded into place. Steel sleeves are typically used to repair leaking or weakened pipe without shutdowns. The damaged pipeline is excavated, the pipe exterior is cleaned, and the stainless steel split sleeve is bolted or welded into place.

Use of composite wrap as an alternative to pipeline replacement can reduce safety risks, decrease pipeline downtime, save gas for sale, and decrease methane emissions to the atmosphere. Composite wrap systems

Economic and Environmental Benefits

Method for Reducing Natural Gas Losses	Volume of Natural Gas Savings (Mcf/yr)	Value of Natural Gas Savings ($/yr)			Implementation Cost ($)[b]	Payback (Months)		
		$3 per Mcf	$5 per Mcf	$7 per Mcf		$3 per Mcf	$5 per Mcf	$7 per Mcf
Composite Wrap Repair[a]	3,960	$11,880	$19,800	$27,720	$5,648	6	4	3

General Assumptions:
[a] Repair of a 6" defect on a 24" diameter pipeline operated at 350 psig with 10 miles between shut-off valves.
[b] Includes labor, equipment and materials, and indirect costs. Note that cost of pipeline replacement for this example is $39,534, including cost of purge gas (nitrogen at $8/Mcf). See Exhibit 5 for more details.

allow pipeline repair without shutting down gas flow, purging the pipeline, or cutting into the pipe. Composite wrap systems operate by transferring the hoop stress from the defect through a high compressive strength filler to a composite sleeve, which is wrapped around and bonded to the pipe. Composite wrap sleeves are considered Type A full-encirclement repairs (see the Text Box).

> **Two Classes of Full-Encirclement Sleeves**
>
> **Type A:** Steel Sleeves are not welded around the circumference to parent pipe.
>
> **Type B:** Steel sleeves are welded around the circumference.

Composite Wrap Variations

Many variations of composite wrap systems are available. Composite wrap systems use different materials for wraps and adhesives, and some systems use epoxy polymers and curing agents. Examples include Clock Spring®, StrongBack, Armor Plate®, and PermaWrapTM. Each has certain advantages:

- ★ Clock Spring® is a three-part system in which the sleeve itself is composed of glass fibers and polyester resin.
- ★ The StrongBack system is water activated, and can be applied to wet surfaces.
- ★ Armor Plate® produces varieties of wrap systems that can be used in a wide range of conditions including high or low pressure, high or sub freezing temperature, and under water.
- ★ PermaWrapTM (manufactured by WrapMaster, Inc.) has a feature to allow detection of a previous wrap by a smart pig, so operators will not have to uncover pipeline segments that have already been repaired.

Most manufacturers offer installation videos, training assistance, and pipe defect analysis software. Composite wrap technologies are advancing rapidly, and partners are encouraged to look for the best system for their needs once they decide to repair a non-leaking pipeline using composite wrap. For a partial list of manufacturers, see the References section at the end of this study.

Clock Spring® Repair

As noted above, there are several variations of composite wrap repair systems. One that has been used for many years by several Natural Gas STAR partners is the Clock Spring® system.[1] This section will expand on the materials, installation technique, and special considerations of this system.

The composite structure. The composite wrap laminate layers are nominally 0.062" thick and have a glass fiber content ranging from 60 to 70 percent by weight. One wrap will cover a one-foot length of pipe. The composite wrap is wound 8 times around the pipe creating a ½" thickness of reinforcing material. The length of the spiral strip varies for each pipe diameter. Clock Spring® composite wrap is available for pipelines between 4" and 56" in diameter.

Adhesive. The two-part adhesive is an epoxy methyl methacrylate, which is used to hold the repair in place.

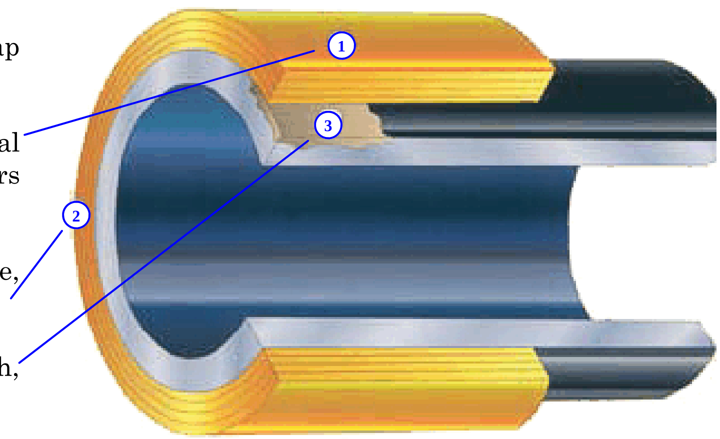
Exhibit 1: Clock Spring® Composite Wrap

A Clock Spring® composite wrap consists of three parts:

1. A high-strength, unidirectional composite structure of glass fibers and a polymer base;

2. A fast curing, high-performance, two-part adhesive system; and

3. A high compressive-strength, load-transferring filler compound.



Clock Spring® Company L.P.

Load transfer (filler). In pipeline repair, the composite wrap works by sharing the hoop load carried by the pipe wall. This load is efficiently transferred to the composite by the filler. The external defect is filled with the high-compressive strength filler material to prevent the weakened pipe wall from further yield. The filler material is a methacrylate with a compressive strength exceeding 800 psi.

Installation. Training is required to ensure proper installation of a composite wrap system. For the Clock Spring® composite wrap system, the pipeline rehabilitation process includes the following steps:

1. Filling the external defect with the filler material.

2. Winding eight layers of composite sleeve around the pipe with adhesive applied between the layers.

3. Tightening the composite wrap sleeve onto the pipe with a tension strap.

4. Allowing the adhesive to cure for about two hours.

5. Coating the repaired pipe to prevent corrosion or ultraviolet radiation damage (depending on whether the pipe is buried or not).

6. Reburying the pipeline (if applicable).

Once installed, the filler, adhesive, and composite bond together to form a permanent repair that the manufacturer estimates will last at least 50 years. In some situations, the entire project, from excavation to reburial, can be completed in as little as 4 hours. A trained two-person crew can complete an installation in as little as 30 minutes, excluding curing time.

There are several important points to keep in mind when installing a Clock Spring® system:

★ The maximum operating temperature for the standard Clock Spring® system is 130oF under worst -case conditions of fully saturated soil.

★ Internal gas temperatures up to 180^{o}F can be accommodated in a modified version of the Clock Spring® system.

★ If the Clock Spring® system is used above ground, a protective coating is required due to the UV sensitivity of the material.

★ While the Clock Spring® repair can be made at full line pressure, manufacturers recommend that line pressure be reduced during repair. Reducing the pressure reduces the stress on the defect during repair. As the repaired area expands during repressuring, the hoop strain transfers from the steel to the composite wrap, resulting in a greater load transfer.

★ At least 2" of wrap must extend beyond the damage on either side of the defect for the Clock Spring® system to adhere to the parent pipe. Therefore, a single 12" sleeve can be used to repair a defect up to 8" long. For damage longer than 8", multiple composite wrap sleeves are butted adjacent to each other to cover the length of the damage (a ½" gap can remain between butt joints). In the U.S., up to 15 Clock Spring® sleeves have been butted side-by-side to repair defects on pipelines between 16" and 30" diameter at 800 to 900 psi.

Economic and Environmental Benefits

Using composite wrap as an alternative to pipeline replacement can yield significant economic and environmental benefits:

★ Avoidance of costs associated with ensuring uninterrupted service during a repair, such as installing bypasses or temporary service lines.

★ No methane is vented to the atmosphere. Using composite wraps eliminates the income lost through natural gas losses.

★ Easier and faster installation without the need for special equipment or highly skilled labor, such as welders. A single composite wrap can be installed by a trained two-person crew within 30 minutes. Curing time is approximately 2 hours.

★ Ability to perform repairs at full line pressure, although vendors recommend reducing line pressure for repair.

Decision Process

Using the five steps discussed below, partners can determine the methane savings and economics of choosing composite wrap over pipeline replacement. The cost analysis for composite wrap in Step 2 is also useful for comparison with steel sleeve repairs, if sleeving is your corporate practice.

Step 1: Determine suitable application.

Typical non-leaking defects suitable for composite wrap repair include dents, gouges, and external corrosion. Defects of up to 80 percent loss of wall thickness can be repaired with composite wrap. There are no pressure limits on the use of composite wrap. Composite wrap can also be used to repair internal corrosion on a temporary basis. If the source of corrosion is eliminated, the repair can be deemed permanent.

When considering the use of composite wrap, important decision factors include the depth and length of wall loss or deformation, yield strength, defect depth, defect axial length, pipeline diameter, wall thickness, and pipeline operating pressure. While detailed field measurements are needed to make a final decision as to whether composite wraps will restore the pipe to American Society of Mechanical Engineers (ASME) standards, software programs such as GRIWrap® can be useful in determining the suitability of composite wrap for a given repair job. Composite wrap may be an ideal choice for non-leaking defects when repair is urgently required, must be completed quickly, and no backup gas supply is available.

If it is determined that composite wrap repairs are not applicable and that cut-and-replace pipeline repair will be performed, partners should consider other techniques recommended by the Natural Gas STAR Program to reduce the methane emissions from a pipeline undergoing repairs. See Lessons Learned Study "Using Pipeline Pump -Down Techniques to Lower Gas Line Pressure Before Maintenance."

Step 2: Calculate cost for composite wrap repair

The cost of composite wrap repair can range greatly depending on the length of the defect and the pipeline diameter. The primary costs for installing a composite wrap sleeve are labor costs, equipment and materials, and indirect costs such as permits and inspection services. According to vendors contacted for this study, a two-person crew can install a single Clock Spring® composite wrap in hour. As a rough estimate, assume 2½ hours per person per composite wrap (½ hour per installation plus 2 hours curing time). For a more comprehensive estimate of the duration of repair, include the time required for excavation, installation of composite wrap, adhesive curing time, drying time for coatings, and pipeline reburial. One partner reports using an estimate of 16 hours from excavation to reburial for repairs requiring up to 4 composite wraps. Estimates should also include direct costs for consumable repair materials (e.g., composite wrap kit and coatings) and indirect costs such as inspection services and permits.

Five Steps for Evaluating Composite Wrap Repair

1. Determine suitable application;
2. Calculate cost for composite wrap repair;
3. Estimate natural gas savings;
4. Calculate cost of pipeline replacement; and
5. Evaluate the economics

Methane Content of Natural Gas

The average methane content of natural gas varies by natural gas industry sector. The Natural Gas STAR Program assumes the following methane content of natural gas when estimating methane savings for Partner Reported Opportunities.

Production	79 %
Processing	87 %
Transmission and Distribution	94 %

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Clock Spring® composite wrap kits contain many of the items needed to conduct the repairs, including the sleeve, the adhesive, the filler, a roller applicator, and application brushes. Cost may range from $535 for a 4" pipeline kit to nearly $2,477 for a 56" pipeline kit. Some additional equipment, such as a cinch bar and strap, and a spool feeder, will also have to be purchased. This equipment, however, can be used for multiple repairs and the costs can be spread over the lifetime of the equipment. For more information on composite wrap kits, please refer to the Appendix.

Kits from other manufacturers will contain different equipment. Although this study does not compare the economics of all of the available composite wrap systems, the marketplace is quite competitive. The following economic analysis incorporates cost information provided by Clock Spring®. Partners are encouraged to search for the composite wrap system that best meets their needs, and to use the methodology described in this Lessons Learned study to perform their own economic analysis.

Exhibit 2 shows the most common labor and equipment costs used in estimating the cost of a composite wrap repair. One-time costs for training and purchasing reusable equipment are excluded as they are assumed to be similar or less than their equivalent costs for a pipeline replacement project.

Exhibit 2: Calculating the Cost for Installing a Composite Wrap

Given: To repair a 6" non-leaking defect on a 24" pipeline, operating at 350 psig, assume 16 hours to complete project[1] using the following labor categories[2]. Assume costs for engineering management and planning to be 25% of field labor.

C_{labor} = cost of labor
Hourly rate of field labor category
Operator = $46/hr
Pipeliner = $42/hr
Apprentice = $28/hr

C_{equip} = cost of equipment
Cost of individual equipment
Composite Wrap Kit = $1,087 for 1 kit
Backhoe = $45/hr
Sandblasting Equipment = $12/hr
Pipeline coatings (5% composite kit) = $54

$C_{indirect}$ = indirect costs such as field inspection crew, permits, etc. (Assume 50% of total equipment and labor cost[3])

(1) Calculate Cost of Labor

C_{labor} = Engineering management cost + Field labor cost
Field Labor Cost = hourly rate * time required to complete work
= ($46 + $42 + $28) * 16
= $1,856
Engineering management cost = 0.25 * $1,856 = $464
C_{labor} = $464 + $1,856 = $2,320

(2) Calculate Cost of Equipment

C_{equip} = Cost of consumable materials (Composite wrap kit and coatings) + Cost of renting/using equipment on-site
= $1,087 + $54 + ($45 * 16) + ($12 * 16)
= $2,053

(3) Calculate Indirect Costs

$C_{indirect}$ = Cost of permits, inspection services, right-of-way related expenses
= 0.5 * (C_{labor} + C_{equip}) = 0.5 * ($2,320 + $2,053)
= $2,186

(4) Calculate Total Cost of Repair

Total Cost of Repair = C_{labor} + C_{equip} + $C_{indirect}$
= $2,320 + $2,053 + $2,186
= $6,559

[1] Partner supplied information.
[2] Quick, P. "Economics of Pipeline Repair," The Southern Gas Association Transmission Operating Conference, New Orleans, LA, July 2001.
[3] Derived from Boreman, David. J. et.al. "Repair Technologies for Gas Transmission Pipelines," Pipeline and Gas Journal, March 2000.

Please note that these labor rates may not be applicable to all types of composite wrap repair. Partners should consult the composite wrap manufacturers before finalizing cost estimates.

Step 3: Calculate natural gas savings.

Composite wrap repair is not used to address active natural gas leaks. The amount of gas saved is the amount of gas that would have been vented had a pipeline replacement strategy been implemented. Replacement requires the shutdown of pipeline and isolation of the damaged portion of pipe with the use of shut-off valves. The distance between shut-off valves is prescribed by DOT regulations and can be up to 10 miles in remote locations. Natural gas in the isolated pipeline segment is generally vented to the atmosphere.

As shown in Exhibit 3, the volume of gas that would be saved by using composite wrap instead of pipeline replacement can be calculated through the use of a simple formula that takes into account the pipeline pressure, length of the isolated section, and the cross sectional area.

Step 4: Calculate cost of pipeline replacement.

Calculate cost of pipeline replacement. Costs associated with pipeline replacement can be grouped into three categories:

- ★ Purge procedures.
- ★ Labor and equipment costs.

Nelson Price Indexes

In order to account for inflation in equipment and operating & maintenance costs, Nelson-Farrar Quarterly Cost Indexes (available in the first issue of each quarter in the *Oil and Gas Journal*) are used to update costs in the Lessons Learned documents.

The "Refinery Operation Index" is used to revise operating costs while the "Machinery: Oilfield Itemized Refining Cost Index" is used to update equipment costs.

To use these indexes in the future, simply look up the most current Nelson-Farrar index number, divide by the February 2006 Nelson-Farrar index number, and, finally multiply by the appropriate costs in the Lessons Learned.

Exhibit 3: Calculating Natural Gas Savings with Composite Wrap Repair

Given: A pipeline company performs a composite wrap repair on a 24" pipeline, operating at 350 psig, with 10 miles between shut-off valves.

D = Inside diameter of pipeline (inches)

L = Length of pipeline between shut-off valves (feet)

P = Pipeline pressure (psia for low pressure[1], psig for high pressure)

$P_{natural\ gas}$ = Current natural gas market price ($7/Mcf)

$V_{natural\ gas}$ = Volume of natural gas emissions

(1) Calculate Volume of Natural Gas Emissions
Natural Gas Savings with Composite wrap = Natural Gas Emissions avoided from Pipe Replacement

$V_{natural\ gas}$ = Volume of natural gas savings with composite wrap for line under pressure

$$V_{natural\ gas} = \frac{0.372\ D^2 P \frac{L}{1{,}000}}{1{,}000}$$

$$= \frac{0.372 \times 24^2 \times 350 \times \frac{52{,}800}{1{,}000}}{1{,}000}$$

= 3,690 Mcf

(2) Calculate Value of Natural Gas Savings

Value of Natural Gas Savings with Composite wrap = $V_{natural\ gas} * P_{natural\ gas}$

= 3,960 Mcf * $7/Mcf

= $27,720

Source: Pipeline Rules of Thumb Handbook, 5th Edition, 2002.

[1] Pipeline pressure of 50 psi or less is considered low pressure.

- ★ Additional indirect expenses associated with pipeline replacement, such as the cost of advertising if gas service is to be shutdown, relighting customer pilots, inspection services, and permits.

After pipeline replacement, there is a need to purge a repaired segment before bringing it back on-line, requiring the purchase and use of inert gases, such as nitrogen. Exhibit 4 shows how to calculate costs from purge procedures, by multiplying the volume of required purge gas by the gas price.

Exhibit 5 shows how to calculate the labor and equipment costs of a pipe replacement project. In general, the costs associated with pipeline replacement are usually higher than those associated with composite wrap repair.

Exhibit 4: Calculating Purge Procedure Cost for Pipeline Replacement

Given: Assume a 24" pipeline case operating at 350 psig, with shut-off valves 10 miles apart.

D = Inside diameter of pipeline (inches)

L = Length of pipeline between shut-off valves (feet)

V_p = Volume of the pipeline segment

P_{pgas} = Current purge gas market price ($/Mcf)

V_{pgas} = Volume of purge gas

(1) Calculate Volume of Purge Gas

V_{pgas} = Volume of purge gas[1] used during pipeline replacement procedure

= V_p * 1.2 (restoring line + 20% wasted)

$$= \frac{PD^2L}{4\times144\times1{,}000}\times1.2 = \frac{3.14\times24^2\times52{,}800}{4\times144\times1{,}000}\times1.2$$

= 199 Mcf

(2) Calculate Cost of Purge Gas

Purge Gas Cost = V_{pgas} * P_{pgas}

= 199 Mcf * $8/Mcf

= $1,5921

[1] Inert gas assumed to be nitrogen at $8/Mcf.

Exhibit 5: Calculating Labor, Equipment, and Indirect Costs for Pipeline Replacement

Given: A pipeline company has detected a 6" non-leaking defect on a 24" diameter pipeline operating at 350 psig. The shut-off valves are 10 miles apart. Replace 72" of pipeline[1].

Assume a 40-hour job[2] and the following labor and equipment classes and hourly rates[3]. Assume costs for engineering management and planning to be 25% of field labor.

Hourly Rate of each Labor Category	*Cost of Equipment*
Welder = $47/hr	Crane/Boom Truck = $45/hr
Operator = $46/hr	Welding Rig = $25/hr
Pipeliner = $42/hr	Backhoe = $45/hr
Apprentice = $28/hr	Steel Pipe[4] = $62/ft
	Coatings[5] = $375

(1) Calculate Cost of Labor

Cost of Field Labor = ($47 + $46 + $42 + $28)/hr * 40 hr
= $6,520

Engineering Management Cost = 0.25 * $6,520 = $1,630

Total Labor Cost, C_{labor} = $6,520 + $1,630 = $8,150

(2) Calculate Cost of Equipment

Total Equipment and Material Cost, C_{equip}
= ($45 + $25 + $45)/hr * 40 hr + $62/ft * 6ft + $375
= $5,303

(3) Calculate Indirect Cost

Indirect Cost = cost of permits, inspection services, right-of-way related expenses[6]

$C_{indirect}$ = (Assume 40% of total equipment and labor cost)
= 0.4 * (C_{labor} + C_{equip}) = $5,381

(4) Calculate Total Cost

Total Cost = C_{labor} + C_{equip} + $C_{Indirect}$ = $18,835

[1]Replace at least three times the pipe diameter. Information based on partner reported information.
[2]Time required to replace pipeline from excavation to reburial. Based on partner reported information. Assumes 1 work-week (5 days, 8 hours/day). Excludes overtime.
[3]Quick, P. "Economics of Pipeline Repair," The Southern Gas Association Transmission Operating Conference, New Orleans, LA, July 2001.
[4]Assumes $62/foot. Partner reported information.
[5]Basis: Oil and Gas Journal, "Composite Wrap Approved for U.S. Gas-Pipeline Repairs", Oct 9, 1995. Used three times the cost listed for a 2-foot split sleeve.
[6]Derived from Boreman, David. J. et.al. "Repair Technologies for Gas Transmission Pipelines," Pipeline and Gas Journal, March 2000.

Step 5: Evaluate the Economics.

The comparison shown in Exhibit 6 examines the cost of replacing a segment of damaged pipeline and the cost of repairing the defect with composite wrap for two scenarios. In both cases, the defect has been found on a 24" pipeline at 350 psig. The only difference is the length of the defect; in the first case, it is 6" long, and in the second, 234" long.

Site excavation and reburying the pipeline are activities common to both repair options. To simplify the analysis, the costs for such common activities are assumed equal and are excluded.

The remaining costs for labor and materials are unique to each repair option. Exhibit 6 lists major costs for each repair. A crane or boom truck is unique to pipeline replacement and is included in the basic analysis.

Once the replacement segment is aligned and welded in place, there is typically a 24-hour wait before it can be tested to ensure the welds are secure. The analysis in Exhibit 6 assumes that the testing is completed within the specified period.

This analysis shows that composite wrap repair results in significant natural gas, nitrogen, and labor savings. The cost of the composite wrap kits is low for the first scenario, as only one repair kit is needed for the 6" defect. In the 6" defect case, natural gas savings alone cover the cost of composite wrap repair, and the payback is immediate.

For the 234" defect case, 20 composite wrap kits are butted together and equipment costs increase approximately 20-fold over the short defect case, while they increase by a factor of 2 for pipeline replacement. Natural gas savings and lower labor costs in the composite repair are offset by high materials costs—this results in more comparable costs for both repair options.

It is important to note that in some circumstances (i.e., certain long defects), pipeline replacement is the most cost-effective repair option, despite the gas losses. Some Natural Gas STAR partners, however, have chosen composite wrap over pipeline replacement in these circumstances, underscoring that cost is not the only factor that influences the selected repair option. As the following case study from a Natural Gas STAR partner illustrates, urgency of repair, availability of a back-up gas supply, and speed of repair influence the final decision.

Exhibit 6: Comparison of Pipeline Replacement and Composite Wrap Economics

Given: 24" diameter pipeline at 350 psig[1] with 10 miles between shut-off valves.

	6" Defect		234" Defect	
	Composite Wrap Repair	Pipeline Replacement	Composite Wrap Repair	Pipeline Replacement
Natural Gas Lost (Mcf)	0	3,960	0	3960
Purge Gas (Mcf)	0	199	0	199
Number of Composite Wrap Kits	1	0	20[2]	0
Cost of Natural Gas Lost	$0	$27,720	$0	$27,720
Cost of Purge Gas[4]	$0	$1,592	$0	$1,592
Labor [4]	$2,320	$5,850	$4,640	$8,775
Equipment and Materials	$1,142	$3,520	$22,833	$6,950
Indirect Costs	$2,186	$3,748	$13,736	$6,290
Total Cost of Repair	$5,648	$42,430	$41,209	$51,327
Most Economical Option	X		X	

1. Equivalent to the reduced pressure at which composite wrap repair would be performed.

2. Based on the number of composite wraps side-by-side less 2" needed on each end of the first and last sleeve to adhere the composite wrap to the parent pipe.

3. Assume natural gas at $7/Mcf.

4. Assume nitrogen at $8/Mcf.

5. Pipeline Replacement: Assume 40 hours (no overtime) to complete 6" project, 60 hours (no overtime) for 234" project. Composite Wrap Repair: Assume 16 hour to complete 6" project and 32 hour to complete 234" project. Labor rates as shown in Exhibits 1 and 4. Labor for the pipeline replacement excludes operator, as assumption made that operator's primary role would be related to excavation and reburial. No similar adjustments made for labor categories for composite wrap.

6. Excludes cost of backhoe and sandblasting equipment shown in Exhibits 1 and 4. For 234" defect, assume 39 ft of replacement pipeline (double the length of defect).

Partner Experience

One Natural Gas STAR partner reported completing more than 300 composite wrap repairs of non-leaking defects on transmission lines larger than 10" since 1995. In one situation, the partner repaired a 20" defect on a pipe by butting together two composite wrap sleeves. Since the damaged pipe was near a creek bed, not having to open the pipeline (as would have been the case with a segment replacement), prevented any water exposure to the pipeline interior and avoided all the attendant complications. Two trained personnel installed the composite wrap and reburied the pipeline in four hours. The entire repair, from excavation to reburial, was completed in two days, and the line was never out of service.

For this partner, cost is often a secondary consideration in selecting composite wrap over pipeline replacement. Primary considerations include:

- ★ Can the repair be completed without taking the pipeline out of service? This is important in areas where there is no back-up gas source.
- ★ How quickly can the repair be completed? Composite wrap repair usually requires two days, while five to seven days are common for pipeline replacement.
- ★ Can the repair be completed safely? Operators are always concerned when repairs such as composite wrap or steel sleeves are performed on a "live" pipeline. Composite wrap presents no additional safety concerns compared to steel sleeve repair.

Lessons Learned

Composite wrap repair can cost-effectively eliminate methane emissions associated with repairing certain non-leaking defects on pipelines. Partners offer the following lessons learned:

- ★ Composite wrap repair can be used for permanent repair of non-leaking defects on pipelines and temporary repair of defects caused by internal corrosion.
- ★ Composite wrap repair results in methane emissions reductions as it eliminates the need to shutdown damaged pipeline and vent natural gas to the atmosphere prior to repair.
- ★ Natural gas savings may be sufficient to cover the costs of composite wrap repair and result in immediate payback.
- ★ Composite wrap may be an ideal choice for non-leaking defects when repair is urgently required, must be completed quickly, and no back-up gas supply is available.
- ★ During repair, the pipeline can usually operate at pressures at least half of full pressure, which avoids potential service interruptions, revenue losses, and vented gas costs.
- ★ The light weight of the composite wrap material makes it relatively easy to install. Two lower-skilled technicians can complete a repair in a few hours without welding, cutting, or special handling equipment.
- ★ Composite wrap eliminates costly delays for specifying and procuring metal sleeves or pipe segments to repair the pipeline.
- ★ Composite wrap restores the pipe's original pressure capabilities and improves its resistance to further structural deterioration.
- ★ Tests of segments repaired with composite wrap indicate continuous cathodic protection.
- ★ Many companies now supply composite wrap systems, each with its own advantages, so it is important to shop around.
- ★ Record methane emissions reductions achieved through this approach and include reductions in Natural Gas STAR Program reports if your company's prior policy was to replace sections of damaged pipeline.

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