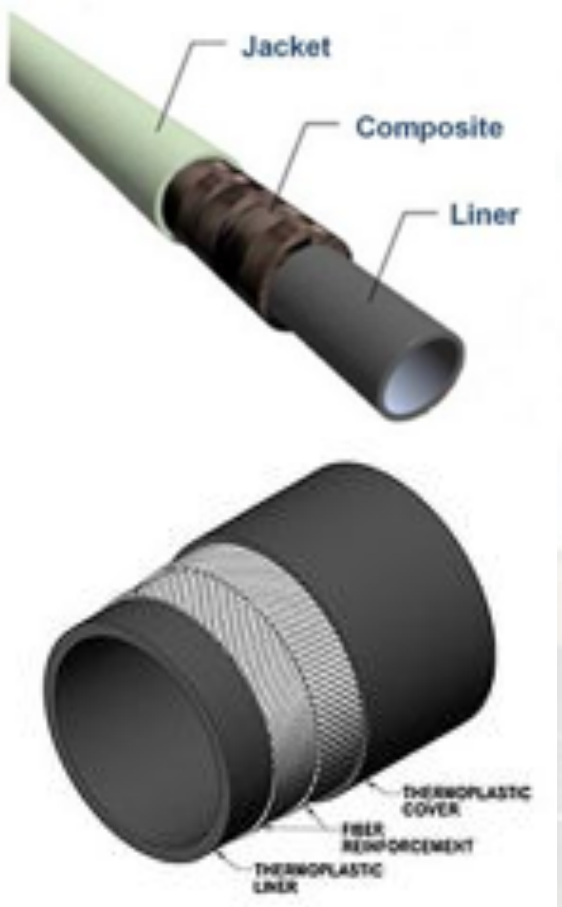
COMPOSITE PIPE APPLICATIONS AND DESIGN FACTORS TO EXTEND SYSTEM LIFE

PRESENTATION AGENDA

- Composite Pipe Design
- Composite Pipe Benefits & Limitations
- Design Factors to Extend Life
- Questions

What Is Composite Pipe?

- Plastic inner liner for corrosion resistance
- Reinforcement layer made of high strength materials examples: fiberglass, aramid fiber, steel
- Might include an epoxy layer
- External Jacket made of similar material to inner liner to protect and contain reinforcement layer
- Referred to as RTP Reinforced Thermoplastic Pipe or SCP Spoolable Composite Pipe
- Can be supplied on reels, in coils or stick lengths

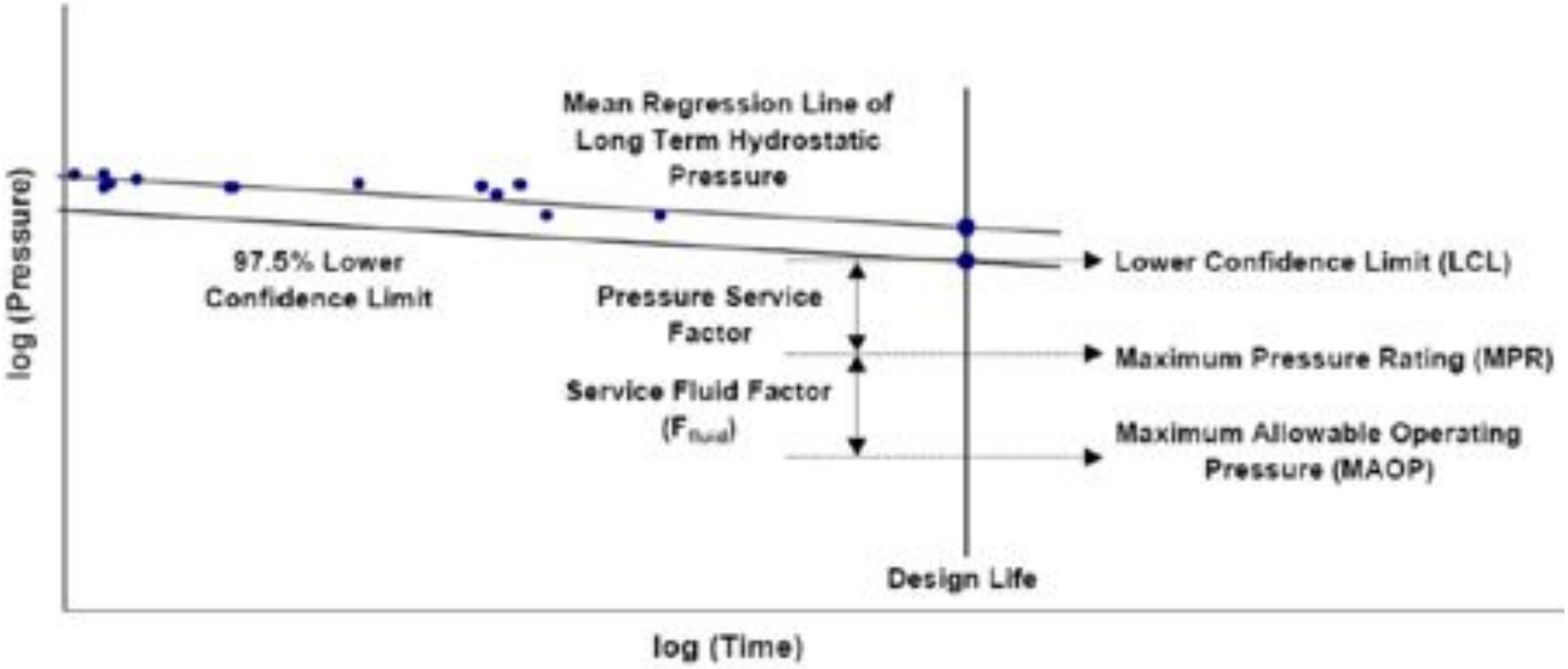


Composite Pipe Industry Standards

- API RP 15S
- ASME B31
- ASME Composite pipe standard in development
- International regulations include local codes
  - CSA Z662 – Canada pipeline construction standard includes composite pipes
  - NTC 3728 – Colombia
  - NOCs have developed internal standards including Saudi Aramco, KOC, YPF Argentina

Composite Pipe Pressure Ratings

- Steel reinforced pipe is rated on wall thickness and short term burst tests
- Fiber reinforced pipe is rated on regression testing per ASTM D2992



PSF = 0.67 as per API 15S
SFF = 0.67 as per CSA Z662

COMPOSITE PIPE BENEFITS

1. Corrosion Resistance
2. Erosion Resistance
3. Installation Time and Cost
4. Installation Safety

CORROSION RESISTANCE

- Based on historical data corrosion accounts for over 65% of buried pipeline failures in Alberta
- Suitable for corrosive applications
  - H2S
  - CO2
  - Produced Water
  - Reinforcement material must be considered
- Liner material resistant to chemical depositions

EROSION RESISTANCE

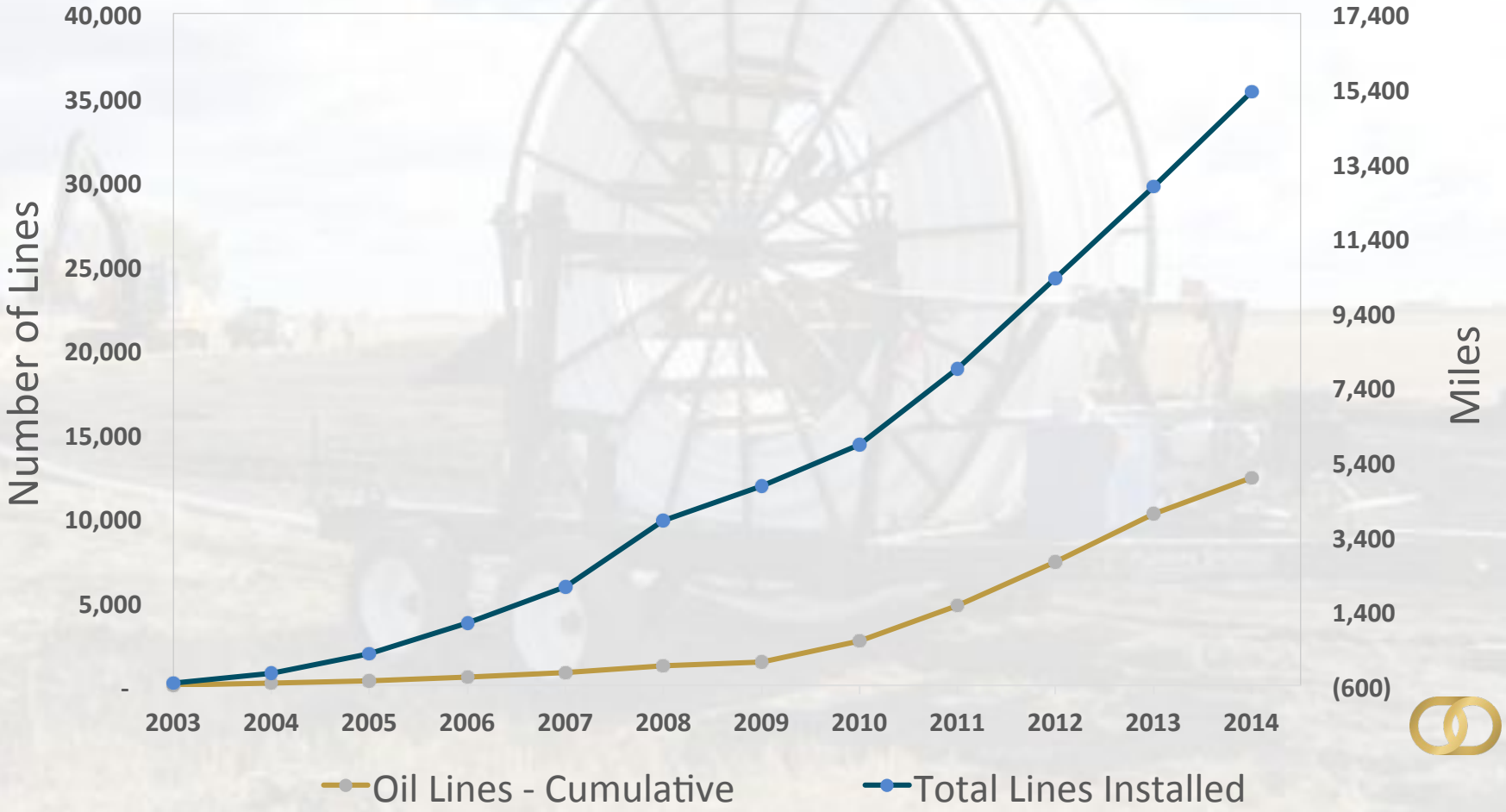
- Suitable for high solids content
- Plastic materials have increased wear resistance in erosive flow regimes
- Wear of liner material will not impact strength of reinforcement layer

TABLE 1. Wear Rates Of Plastics And Metals Under Abrasive Slurries

	Wear Rates (mm)			
	Coarse Sand		Fine Sand	
Material	**7 fps**	**15 fps**	**7 fps**	**15 fps**
Steel	0.65	1.81	0.04	0.02
Aluminum	1.81	7.48	0.14	0.86
Polyethylene	0.06	0.46	nil	0.06
ABS	0.36	2.07	0.07	0.51
Acrylic	0.99	4.10	0.17	1.42

Flexpipe Experience with Corrosive / Erosive Oil & Emulsion Applications

- Number of lines assumes 2300 ft per line



INSTALLATION BENEFITS

- Smaller crew size: 2-4 people versus 10-12 for steel
- Less equipment & Lighter equipment
- Welding and weld inspection costs are eliminated
- Smaller Right Of Way requirement
- Spooled lengths up to and above 3500 ft
- Installation in ½ the time of steel

INSTALLATION BENEFITS

Comparing installation costs of identical 6,500 ft flow lines

	6,500 ft FlexPipe Linepipe Flow Line	6,500 ft Steel Flow Line
Mobilization:	2 Trucks: -1 x Track Hoe -1 x Pipe Reels	6 Loads: -1 x Warehouse -2 x Track Hoe's -1 x Grader -1 x Pipe
Equipment:	1 x 200D series track hoe for stripping top soil, digging, lowering and backfill	2 x 250 series track hoe's and 1 x grader for top soiling 20 m ROW
Manpower:	-1 Supervisor -1 Equipment Operator -2 Laborers	-1 Supervisor -2 Equipment Operators -2 Welders (bead & hot pass/cap) -2 Welder's Helpers -3 Laborers
Testing:	-1 digital deadweight -2 recorders	-1 digital deadweight -2 recorders
X-Ray:	Not Needed	Required, 100%
Risers:	Cathodic protection as required	Coating costs for risers
Demobilization:	2 Trucks: -1x Track Hoe -1x Pipe Reels	4 Loads: -2x Track Hoe's -1x Grader -1x Misc. equipment and materials

Composite Pipe Limitations

- Does not fit all applications
  - Pipe diameters
  - Operating pressures
  - Operating temperatures
- Relatively new to industry
  - Composite Pipe has been in use for 15 years versus steel pipe in use for 150+ years
  - Industry knowledge and understanding of Steel Pipe is very well developed
  - Education is needed on composite pipe and composite failure modes
- Not all composite pipe products perform the same
- Regulatory acceptance is not yet universal

Design and Construction Factors to Optimize Composite Pipe Life

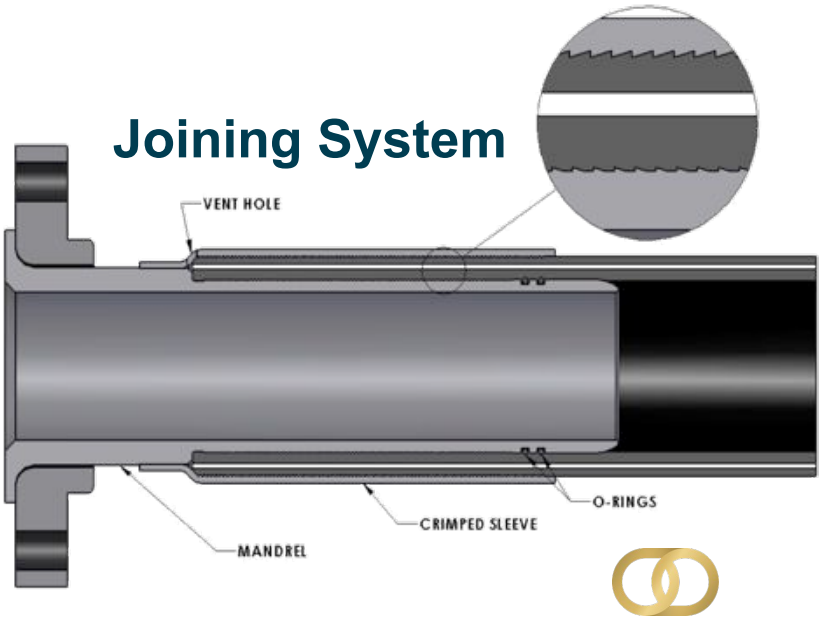
Fitting and Riser System

- How repeatable is the fitting installation process? What opportunities are there for human error?
- When over-pressured, does the pipe or fitting fail first?
- As ground settles, how are shear loads next to fittings accounted for?
- What is the available temperature installation window?
- How is wall thickness variation accounted for to ensure distribution fitting clamping force around pipe?

Design and Construction Factors to Optimize Composite Pipe Life

Operating Factors

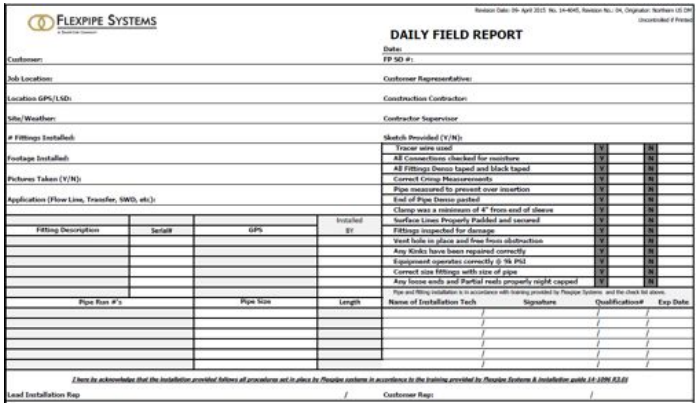
- Will the pipe grow axially or radially when pressurized? What must be done to compensate for the resulting movement?
- How are permeated gases accounted for?
  - Will service fluids lead to corrosion in composites reinforced with steel?
  - How are annulus spaces vented?
  - For fully bonded composites, how are voids where pressure can build prevented?
- Will pipe for surface lines survive ground fires?
- Will the pipe be used in an area that floods and is additional anchoring needed?
- Will the pipe survive cyclic fatigue due to water hammer?
- Does the supplier offer an application review to identify failure modes and ensure fit?



Design and Construction Factors to Optimize Composite Pipe Life

Installation Quality Control

- How much handling and impact damage can the product resist? Is sand bedding required?
- What is the available pipe installation temperature window?
- Can a third party be trained or does the vendor require that they install the fittings?
- Is detailed documentation of technical, installation, and training procedures provided?
- Is a process for tracking and documenting proper installation procedures provided? Recommend including a QC package in scope of work for third party contractors.



FLEXPIPE SYSTEMS

DAILY FIELD REPORT

Date:

Customer: | FP SO #:

Job Location: | Customer Representative:

Location GPS/LSD: | Construction Contractor:

Site/Weather: | Contractor Supervisor

Fittings Installed: | Sketch Provided (Y/N):

Footage Installed: | Tracer wire sized Y N

Pictures Taken (Y/N): | All Connections checked for moisture Y N

Application (Flow Line, Transfer, SWD, etc): | All Fittings Denso taped and black taped Y N

Correct Crimp Measurements Y N

Pipe measured to prevent over insertion Y N

End of Pipe Denso packed Y N

Clamp was a minimum of 4" from end of sleeve Y N

Surface Lines Properly Padded and secured Y N

Fitting Description	Serial#	GPS	Installed BY

Fittings inspected for damage Y N

Vent hole in place and free from obstruction Y N

Any Kinks have been repaired correctly Y N

Equipment operates correctly @ 96 PSI Y N

Correct size fittings with size of pipe Y N

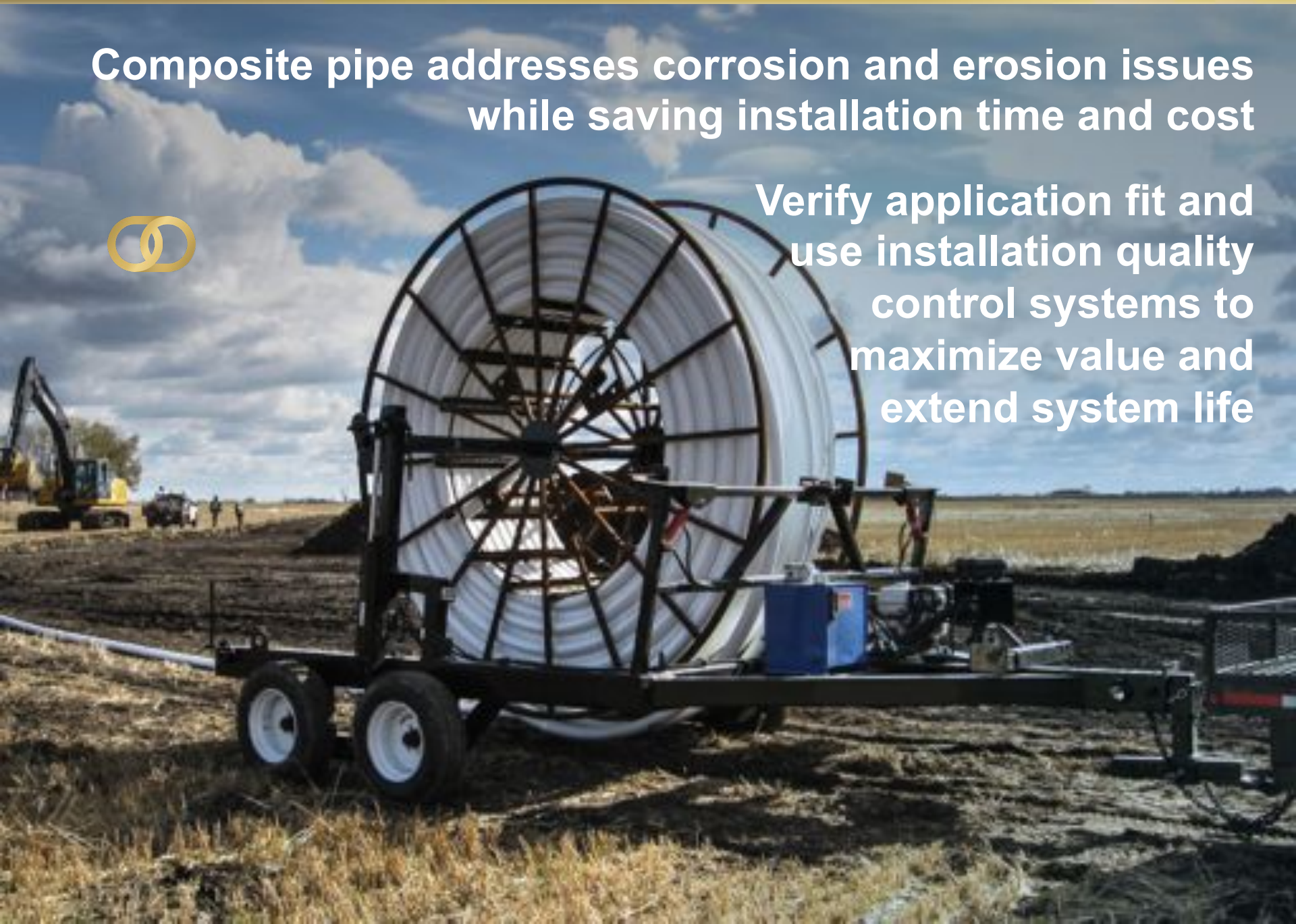
Any loose ends and Partial reels properly night capped Y N

Pipe and fitting installation is in accordance with training provided by Flexpipe Systems and the check list above.

Pipe Run #'s	Pipe Size	Length	Name of Installation Tech / Signature	Qualification#	Exp Date
			/	/	/
			/	/	/
			/	/	/
			/	/	/
			/	/	/

I here by acknowledge that the installation provided follows all procedures set in place by Flexpipe systems in accordance to the training provided by Flexpipe Systems & installation guide 14-1096 R2.01

Lead Installation Rep / Customer Rep: /



Composite pipe addresses corrosion and erosion issues while saving installation time and cost

Verify application fit and use installation quality control systems to maximize value and extend system life

FLEXPIPE OFFERS THE COMPLETE SOLUTION

Provide end-to-end solution for your individual needs