

GHG SRP Current and Completed Projects MATR-3-15A/B

MATR-3-15A: Assessment of Nonwelded Repair Methods to Reduce Pipeline Blowdowns
and
MATR-3-15B: Industry Best Practices for Making Nonwelded Repairs Permanent

Melissa Gould, DNV

15 October 2024

MATR-3-15, Methods to Reduce Pipeline Blowdowns for Repairs and Inspections

- White paper study in 2021 by Blade Energy Partners
- Objectives:
 - To compile and describe the methods currently in use for minimizing GHG emissions during pipeline repairs.
 - To identify any technologies in development, including technologies that have become commercially available in the near past.
 - To develop suggestions as to future studies or investigations in this area.
- PRCI Strategic Research Priority (SRP) for GHG Emissions Reduction



LEADING PIPELINE RESEARCH

Catalog No. PR328-214501-R01

PR328-214501-R01 Methods to Reduce Pipeline Blowdowns for Repair and Inspections

Project ID MATR-3-15

Contract PR328-214501

Contractor Project Number: PRC-21-035

Prepared for the

Design, Materials and Construction Technical Committee

Of

Pipeline Research Council International, Inc.

Prepared by:

Blade Energy Partners, Ltd.

Authors:

Ravi Krishnamurthy, Ryan Milligan, Nigel Alvares, Ismail Ceyhan

Release Date:

January 7, 2022

MATR-3-15, Methods to Reduce Pipeline Blowdowns for Repairs and Inspections

PRCI research into overall pipeline detection, characterization, and assessment of all pipeline integrity threats will continue to contribute to reducing emissions. **As this research continues mitigation with repairs will continue to increase and reduce the need for cut outs.** Pipeline repair with the use of steel sleeves is the industry accepted, has a long successful case history, and can continue to mitigate pipeline threats. However, composites may provide some increased efficiency or in some cases reduction in costs. A significant amount of research in composites has been completed and is on-going. Composite wraps and sleeves have the potential to be used in situations where the use of steel sleeves is impeded. Conversely, steel sleeves can be used in situations where the use of composite wraps and sleeves are not appropriate. **It is recommended that the reader refers to the latest version of the Pipeline Repair Manual for further details.**



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MATR-3-15A: Assessment of ~~Temporary~~ *Nonwelded* Repair Methods to Reduce Pipeline Blowdowns

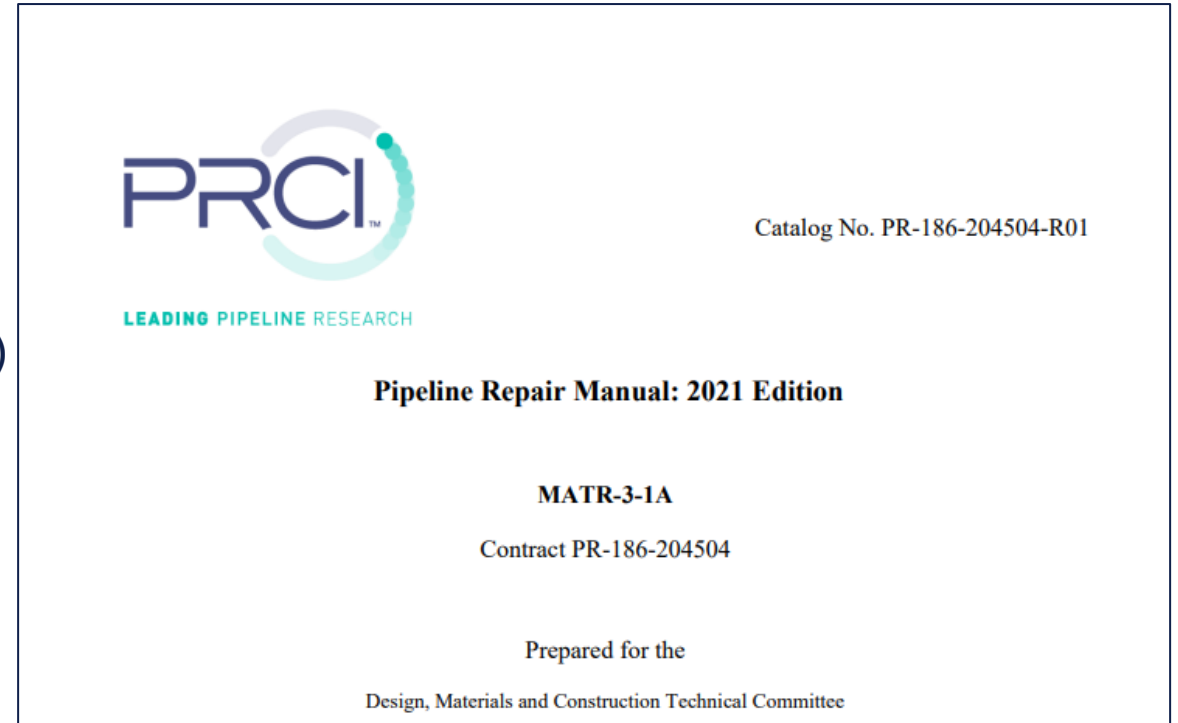
- Nonwelded repairs (composite systems, clamps with elastomer seals, etc.) may degrade over the life of the pipeline
- If a repair is not expected to last as long as the pipe under normal conditions, US Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) does not consider the repair to be permanent

The standard we proposed was that the repair method be able to “*permanently restore the serviceability of the pipe,*” a result comparable to that expected from replacing damaged pipe or installing a full-encirclement split sleeve. We explained that such restoration would be permanent if the repair were expected to last as long as the pipe under **normal operating and maintenance conditions.**

- Pipeline Safety: Gas and Hazardous Liquid Pipeline Repair, Final Rule

Background (MATR-3-1A)

- Aligns with “temporary” and “permanent” definition changes in MATR-3-1A, *Update of PRCI Pipeline Repair Manual*. (based on ASME PCC-2 approach)



Throughout this manual, we limit references to *permanent* and *temporary* repairs. Many of the repair techniques included in this manual are considered to be *permanent*, intended to remain in place for the life of the pipeline. Others may only be suitable for short-term service and should be replaced with a more *permanent* repair at an appropriate opportunity. For our purposes, a *temporary* repair is a repair that will be re-evaluated within a period specified by the pipeline operator’s written procedures. The anticipated life of a repair depends on many circumstances and could include consideration of risk. Therefore, the determination of *permanent* and *temporary* is left to the user.

MATR-3-15A Objectives

- Assess nonwelded pipeline repair methods to determine their expected life, which will:
- Facilitate a reduction in GHG emissions from a potential leak of a temporary repair, allowing operators to either plan for their replacement with a permanent in-service repair or justify their continued use without arbitrary replacement
- This aligns with the current PRCI Research objectives to:
 - *“Develop, demonstrate, and validate repair systems, including those that can be deployed on in-service facilities. Determine the useful life and safe operating envelopes of such repair systems.”*
 - *“Reduce all product leaks and equipment emissions from all parts of the hydrocarbon transport and storage infrastructure by developing, demonstrating, and validating processes and technologies to detect, quantify, and mitigate such releases.”*



MATR-3-15A Work Performed

- Milestone 1 – Year 1 (from April 2022)
 - M1-T1 – Project Kick-Off Meeting
 - M1-T2 – Operator Survey
 - M1-T3 – Literature Review
 - M1-T4 – Identification of Existing Repairs for Experimental Tasks
 - M1-T5 – Experimental Plan and Setup
- Milestone 2 – Year 2 (from January 2023)
 - M2-T1 – Burst Tests
 - M2-T2 – Integrity Analyses
 - M2-T3 – Analysis of Results
 - M2-T4 – Draft Final Report
 - M2-T5 – Final Report based upon Technical Committee Feedback (April 2024)
 - M2-T6 – Year 2 Project Management and Reporting
- SME support: Chris Alexander (ADV Integrity) and Mike Rosenfeld (RSI Pipeline Solutions)



MATR-3-15A M1-T2: Operator and Vendor Surveys

- Summary of the operator and vendor survey results
- Incorporated into the final report
- Vendor results (and provided documents) were included in M1-T3: Literature Review

PRCI MATR-3-15A
Assessment of Temporary Repair Methods to Reduce Pipeline Blowdowns

Melissa Gould
William A. Bruce, P.E., IWE
DNV GL USA, Inc.

September 21, 2022

**Milestone Deliverable M1-T2 –
Operator and Vendor Surveys**

The objective of this work is to assess temporary pipeline repair methods to determine their expected life. This will facilitate a reduction in pipeline blowdowns by allowing operators to plan for replacement with a permanent in-service repair, prior to failure of the temporary repair through degradation. It may also facilitate a reduction in pipeline blowdowns by justifying the continued use of a temporary repair that would otherwise be replaced at an arbitrarily assumed service life limit. This milestone deliverable is a summary of the operator and vendor surveys, which were developed and distributed to gain insights on the current use of temporary repairs.



MATR-3-15A M1-T3: Literature Review

- Review focuses on the life expectancy of non-welded pipeline repairs
- Incorporated into the final report
- Co-authored by DNV, RSI Pipeline Solutions, and ADV Integrity
- Additional references/context added by Dr. Paul Hill (TEAM)

PRCI MATR-3-15A
Assessment of Temporary Repair Methods to Reduce Pipeline Blowdowns

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ADV Integrity, Inc.

November 30, 2022

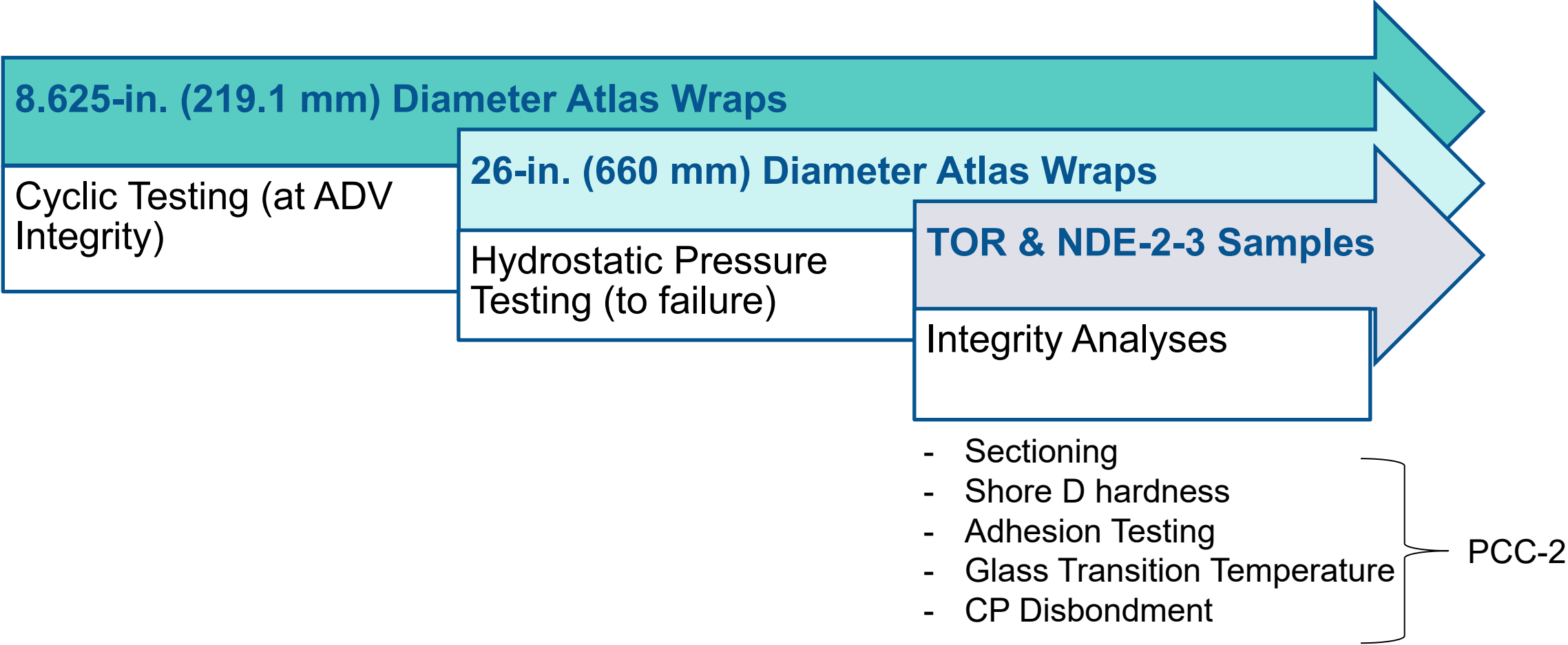
**Milestone Deliverable M1-T3 –
Literature Review**

The objective of this work is to assess temporary pipeline repair methods to determine their expected life. This will facilitate a reduction in pipeline blowdowns by allowing operators to plan for replacement with a permanent in-service repair, prior to failure or leakage of the temporary repair through degradation. It may also facilitate a reduction in pipeline blowdowns by justifying the continued use of a temporary repair that would otherwise be replaced at an arbitrarily assumed service life limit. This milestone deliverable is a literature review, summarizing documentation pertinent to the life expectancy of non-metallic pipeline repairs, including various types of mechanical repair clamps and fiber-reinforced composite repair systems.

There is a multitude of technical information on the long term performance and degradation mechanisms of both elastomer seals and composite materials themselves, but the scope of this review focused only on the use of these materials for pipeline repair applications. If additional resources are identified through the course of this project, this literature review can be updated for the final report.



MATR-3-15A M1-T5: Experimental Plan





MATR-3-15A M2-T3: Analysis of Results



- The assessed repairs exhibited no apparent time-dependent degradation
- Donated repairs had limited in-ground service lives
 - In Ground: 26-in. (660 mm) Atlas wraps = 16 months; 8.625-in. (219.1 mm) Atlas wraps = 1 month
 - Above Ground: Armor Plate® repair was in above-ground service for approximately 15 years
 - No Service: Remaining repairs were in storage at PRCI's TDC warehouse for approximately 20 years
- Of the 5 composite pipe sections that were in service, one (1) 8.625-in. (219.1 mm) diameter Atlas™ wrap showed significant installation issues
 - The use of duct tape for repair area marking became part of the repair system
 - It is important to remember that service lives can be extended, and any “temporary” repair should be installed as if its service life may become extended in the future



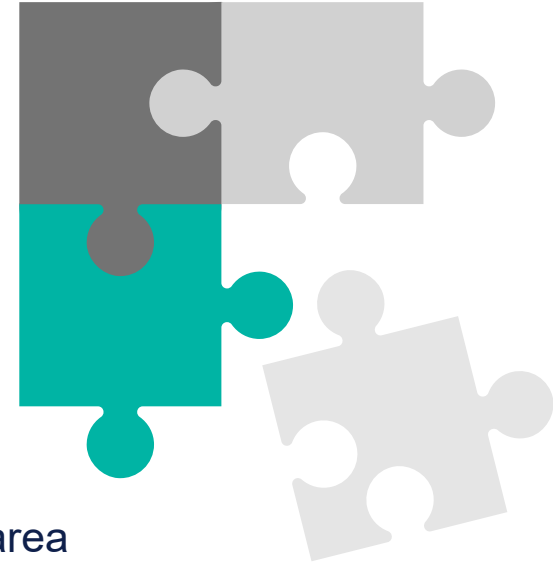
MATR-3-15A M2-T3: Analysis of Results (con.)



- Three (3) of the composite repair systems exhibited indications of potential undercuring (not considered a significant finding)
 - All external surface hardness data aligned with expectations.
- Four (4) ERW seam defects were identified as hook cracks
 - Even the 2 unreinforced defects didn't grow by fatigue during 100,000 cycles from 5 – 72% SMYS
 - The ability of the composite system to adequately repair cracks was not demonstrated in this scenario, as even unreinforced cracks did not have sufficient driving force to grow during testing



MATR-3-15A Conclusions



- The assessed repairs exhibited no apparent time-dependent degradation
 - Donated repairs had limited in-ground service lives (maximum of 16 months)
 - Previous PRCI-sponsored research showed that not all composite materials perform equally
 - One vendor (Armor Plate) who completed the 10-year study had all samples fail in the repair area beginning in year 5
- One (1) 8.625-in. (219.1 mm) diameter Atlas™ wrap showed significant installation issues
 - One of the main considerations for a lasting and quality non-welded repair is robust installation practices
- **The type of repair matters, including all repair components and assumed design conditions**
 - Literature review identified failure due to improper filler under a composite repair
 - The inclusion of duct tape under the 8.625-in. (219.1 mm) diameter Atlas™ repair led to disbondment



MATR-3-15A Project Recommendations

- Develop Robust Installation Training, Practices, and Oversight
 - The main consideration for a lasting and quality non-welded repair is robust installation practices
 - The failure rate for mechanical clamps appears to follow a bathtub curve, with the highest failure rate in a short time
 - Failures of composites have been attributed to poor installation practices, deficient design, inadequate specification, degradation of properties over time, and use in unsuitable applications

A review of in-service composite failures found the vast majority occurred within weeks of installation

Top 2 critical installation steps: surface preparation & curing





MATR-3-15A Project Recommendations (con.)

Keep Detailed Repair Records

- Necessary for any life assessment or extension activities
- As more repair systems age and more information is obtained, detailed records can help operators perform engineering or risk assessments, or prioritize reinspection of existing repairs





MATR-3-15A Project Recommendations (con.)

- Reassess at Specific Intervals and Near End-of-Life
 - Develop and inspection plan, which may include ILI review of defect and/or repair edges
 - When excavations are possible, inspect visually and via tap testing
- Repair as Required
 - See MATR-3-15B





WHEN TRUST MATTERS

MATR-3-15B

Industry Best Practices for Making *Temporary Nonwelded* Pipeline Repairs Permanent

15 October 2024



LEADING PIPELINE RESEARCH

MATR-3-15B Introduction / Objectives

- **Non-metallic repairs (composite systems, clamps with elastomer seals, etc.) may degrade over the life of the pipeline**
- **MATR-3-15B will explore best practices for making temporary repairs permanent**
 - A revision of the Pipeline Repair Manual will link the users to the findings of this project

Objective 1:

- Answer the “what now” question with industry best practice guidance if a temporary repair is assessed to not have a life as long as the asset (per MATR-3-15A)

Objective 2:

- Facilitate a reduction in GHG emissions from a potential leak of a temporary repair, allowing operators to either plan for their replacement or remediation.

MATR-3-15B Project Team



Melissa Gould

DNV
Principal Investigator

- M.Sc. (Welding Engineering)
- 15 years at DNV
- API 1104 Secretary
- Co-PI of MATR-3-1A and MATR-3-15A



Dr. Paul Hill

TEAM
Subject Matter Expert

- PhD (Modelling Long-term Performance of Composite Mtls), CEng
- Over 25 years exp.
- ASME PCC-2 and ISO 24817 committee



David Futch

ADV Integrity
Testing Lead

- M.Sc. (Materials Science and Engineering), P.E.
- 12 years experience
- API 1104 committee

MATR-3-15B Proposed Work

- Milestone 1 – Year 1 (from July 2023)
 - M1-T1 – Project Kick-Off Meeting
 - M1-T2 – Literature Review
 - M1-T3 – Experimental Plan and Setup
 - M1-T4 – Year 1 Project Management and Reporting
- Milestone 2 – Year 2 (from July 2024)
 - **M2-T1 – Experimental Program**
 - M2-T2 – Analysis of Results
 - M2-T3 – Development of Industry Best Practice Guidance
 - M2-T4 – Draft Final Report
 - M2-T5 – Final Report based upon Technical Committee Feedback
 - M2-T6 – Revision of PRCI Pipeline Repair Manual (PR-186-204504-R01)
 - M2-T7 – Year 2 Project Management and Reporting

MATR-3-15B Schedule

Milestone	M1 (2023)					M2 (2024-2025)																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
M1-T1 – Project Kick Off Meeting and Minutes																								
M1-T2 – Literature Review																								
M1-T3 – Experimental Plan and Setup																								
M2-T1 – Experimental Program																								
M2-T2 – Analysis of Results																								
M2-T3 – Development of Guidance																								
M2-T4 – Draft Report																								
M2-T5 – Final Report based upon Technical Committee Feedback																								
M2-T6 – Revision of Pipeline Repair Manual																								

MATR-3-15B M1-T2 – Literature Review



- M1-T2: Literature Review
 - Identify documentation on the repair or life extension of non-metallic components
 - Laboratory tests, failure analysis reports, international codes and standards, reassessment considerations, replacements, etc.
 - Current practices employed
 - Other relevant literature such as the high temperature degradation of components via fire/radiation (welding)



Adjacent tight-fitting sleeves installed



Backing strip behind longitudinal seam of over-sleeve



MATR-3-15B M1-T3 – Experimental Plan and Setup



- M1-T3: Experimental Plan and Setup
 - Developed with input from Paul Hill (TEAM) and David Futch/Chris Alexander (ADV)
 - Uploaded to project website on December 1, 2023
- Four (4) repair options:
 - Welding of a mechanical bolt-on clamp, including the side bars and bolts
 - Welding of a leak clamp and removal of the band
 - Encapsulation of a composite in a steel sleeve
 - Repair of a composite with a different composite

PRCI MATR-3-15B
Industry Best Practices for Making Temporary Pipeline Repairs Permanent

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Dr. Chris Alexander, P.E.
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December 1, 2023

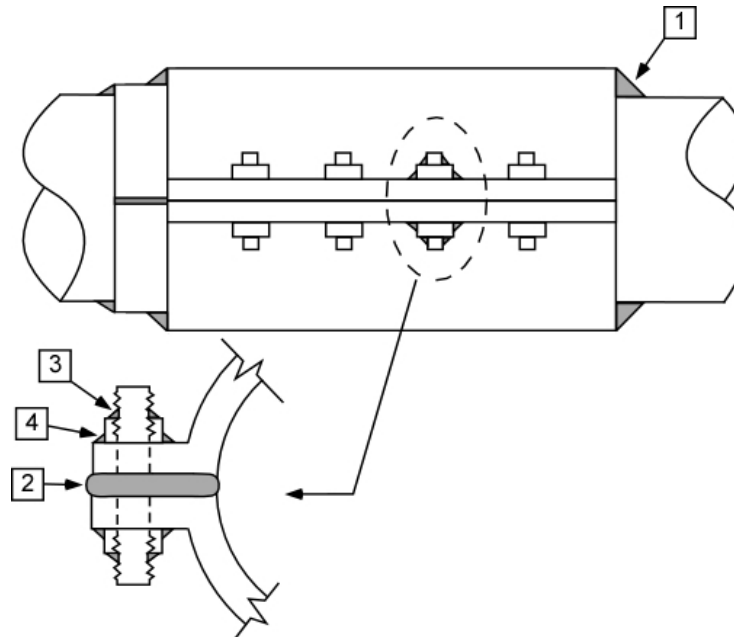
**Milestone Deliverable M1-T3
Experimental Plan**

The objective of this work is to answer the “what now” question with industry best practice guidance if a temporary or existing repair is assessed to have a shorter life than the asset. This milestone deliverable outlines the experimental plan.

MATR-3-15B Welding of a Mechanical Bolt-On Clamp



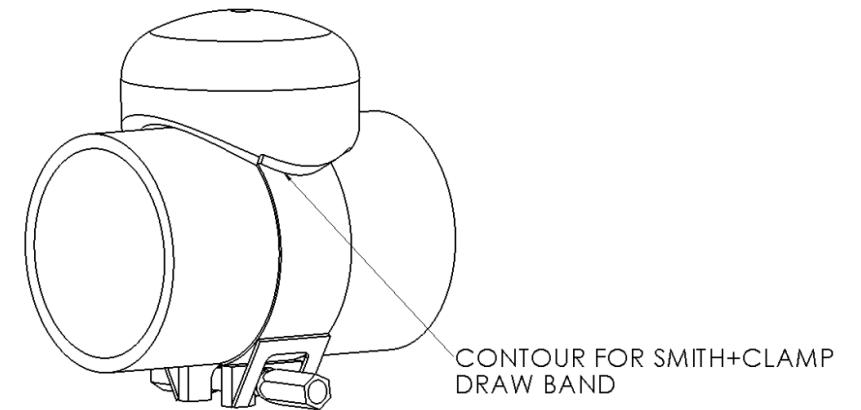
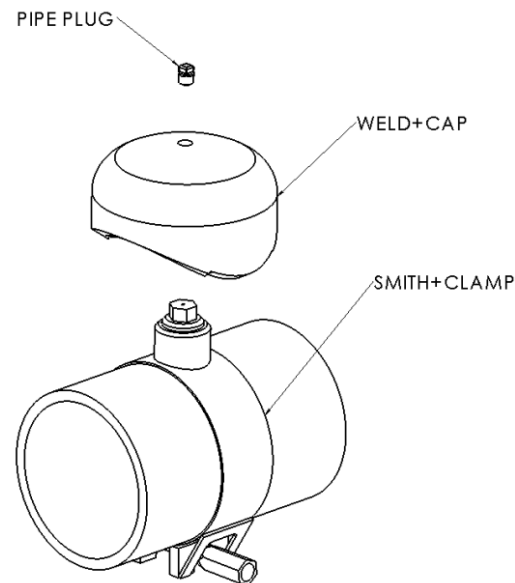
- Split+Sleeve fittings will be donated to the project by PLIDCO
 - Fittings will be welded to a pressurized pipe to validate the life extension concept and develop industry best practices
 - Investigate thermal severity (water vs. air), accommodate end gap/gross thickness change, and preheat the stud-to-nut and nut-to-fitting welds
 - Vessel will remain pressurized overnight after welding, inspection performed (after suitable delay), and sectioning/analysis of the welds and seals will be undertaken



MATR-3-15B Welding of a Leak Clamp



- Smith+Clamp and Weld+Caps will be donated to the project by PLIDCO
 - Weld a Weld+Cap over the force screw and sealing core, removing the draw band, to develop industry best practices
 - Vessel will remain pressurized overnight after welding, inspection performed (after suitable delay), and sectioning/analysis of the welds and seals will be undertaken

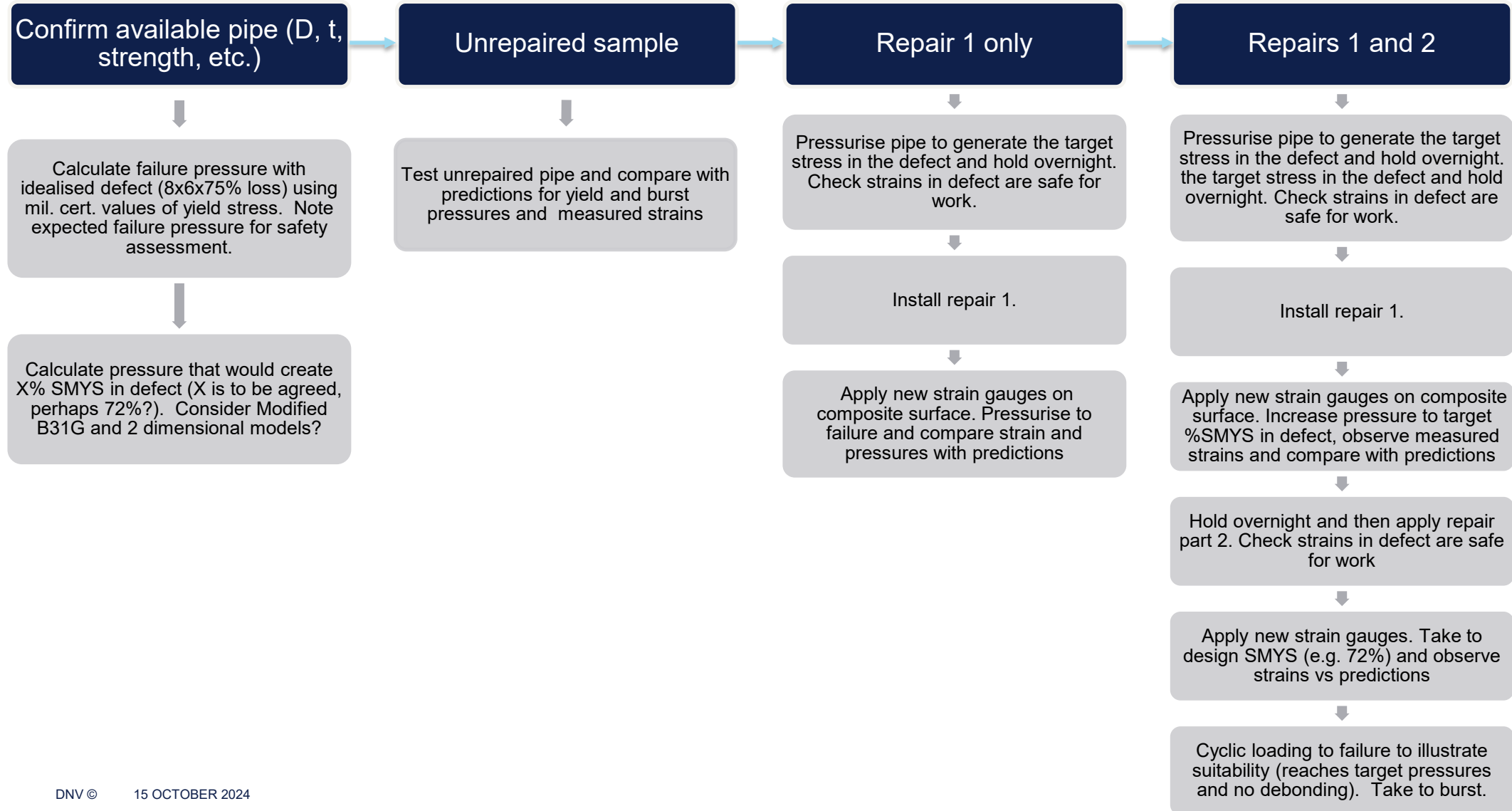


MATR-3-15B Repair of a Composite with a Composite



- Composite materials donated to the project by vendors
 - Aggressive, but realistic metal loss will be intentionally created
 - The planned wall loss feature will be 2 ¼ in by 4 3/8 in and 70% wall thickness (0.225in) for a severe but repairable wall loss feature
 - Control samples will be tested wherein modelling predicts failure at defect area under initial under-designed composite (rigid coil and wrap) repairs
 - Strain gauges will be placed on the initial repair and the subsequent repair to determine if load transfer occurs
 - Samples will be cycled (dents) and hydrostatically pressure tested to failure (dents and metal loss)
 - Installation pressure will be investigated
 - Dents will be Phase 2, following metal loss

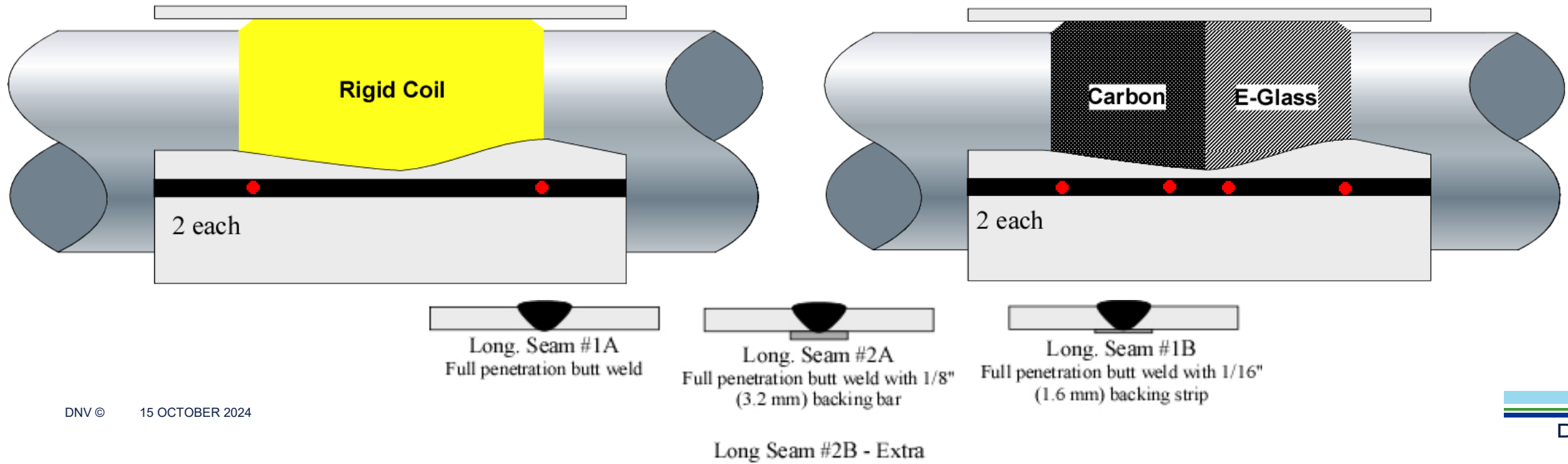
Repair of a Composite with a Composite



MATR-3-15B Encapsulation of a Composite in a Sleeve

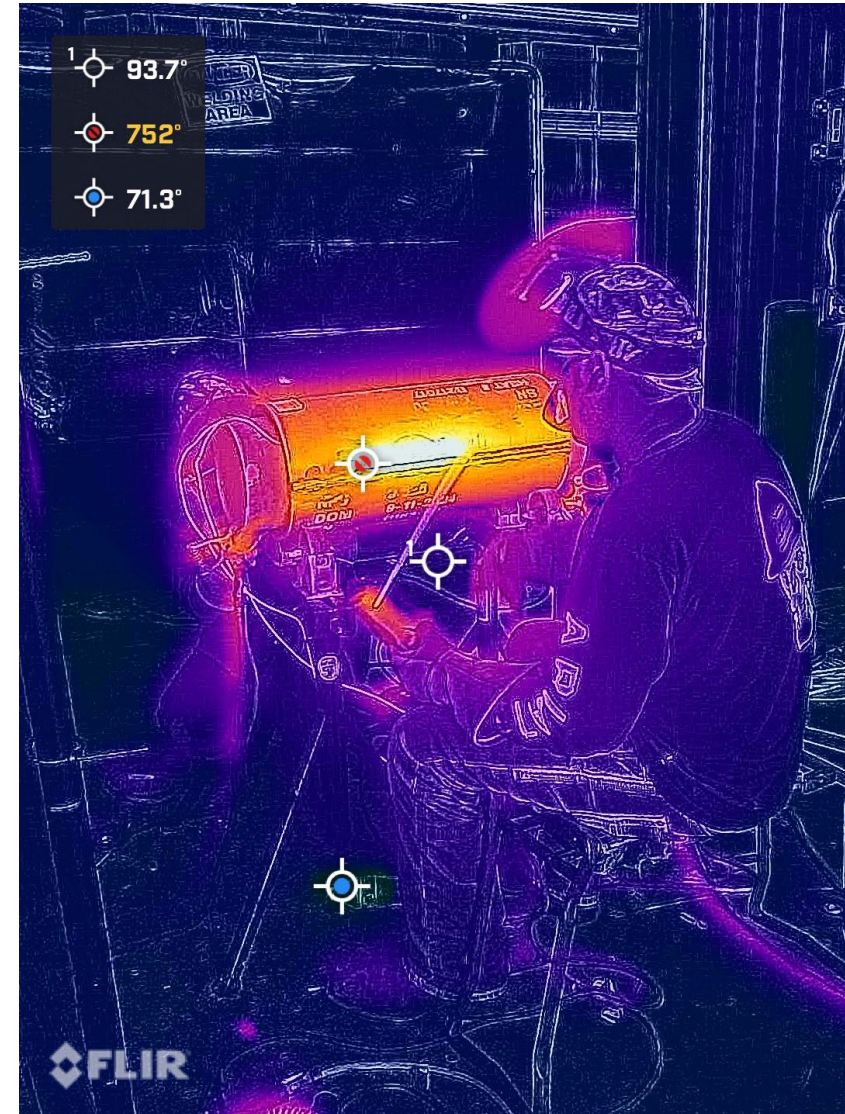


- Composite materials donated to the project by vendors
 - Main concern is potential degradation of the repair due to heat/gases which could reduce the quality of the sleeve welds, particularly at the longitudinal seam
 - Composite repairs were welded over with three (3) options: no backing strip, 1/16 in. (1.6 mm) backing strip, and 1/8 in. (3.2 mm) backing bar
 - Thermocouples (●) under weld measured temperatures experienced by the composites
 - Assessment via radiography, tensile testing, metallography, and hardness mapping (pending)



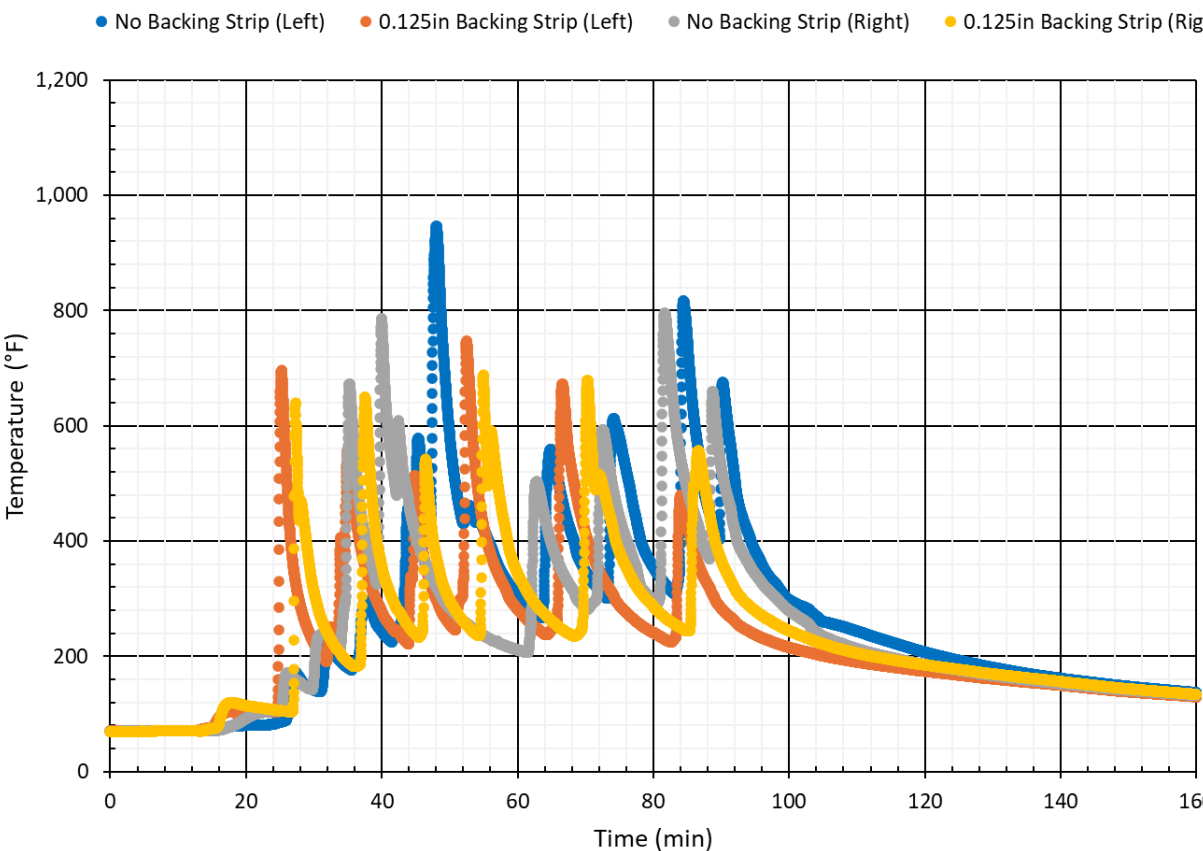
MATR-3-15B Encapsulation – Initial Thoughts/Results

- Design:
 - Sleeves should be ordered slightly larger
 - Composites were just larger than designed, making fit up with a backing strip difficult due to precise sleeve size ordered
- Welding:
 - A robust WPS with a practical range of longitudinal seam root gap should be selected
 - WPS allowed root gap up to 3/8 in., which was necessary on one pipe
 - Welder questioned quality of weld with no backing strip
 - Felt that he was fighting porosity, including through multiple passes when the root gap was large

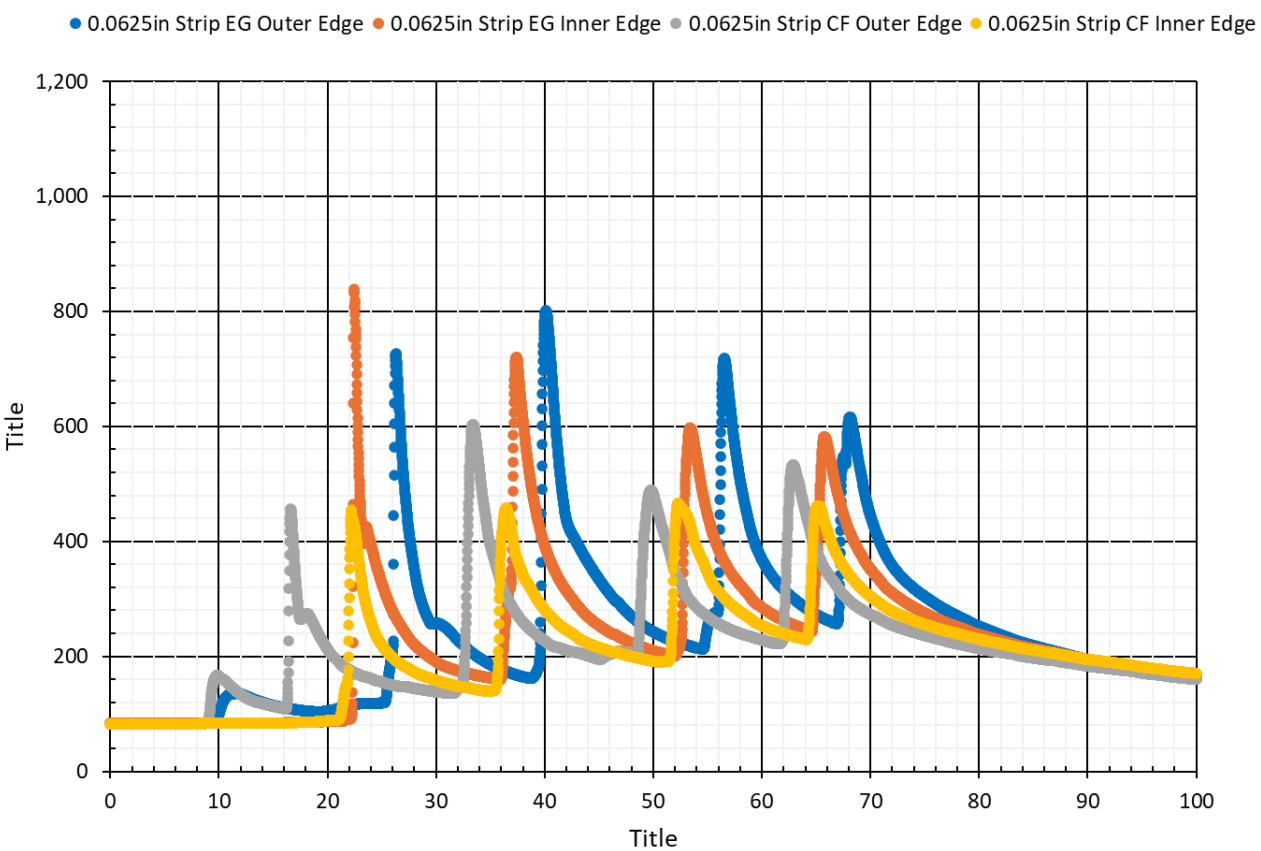


MATR-3-15B Encapsulation – Temperature Data Examples

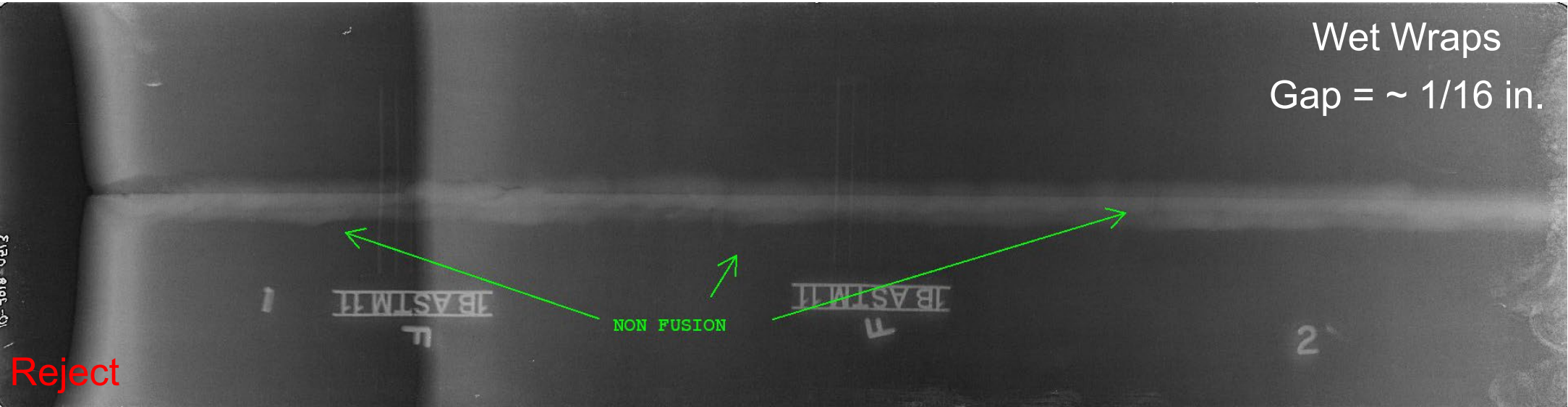
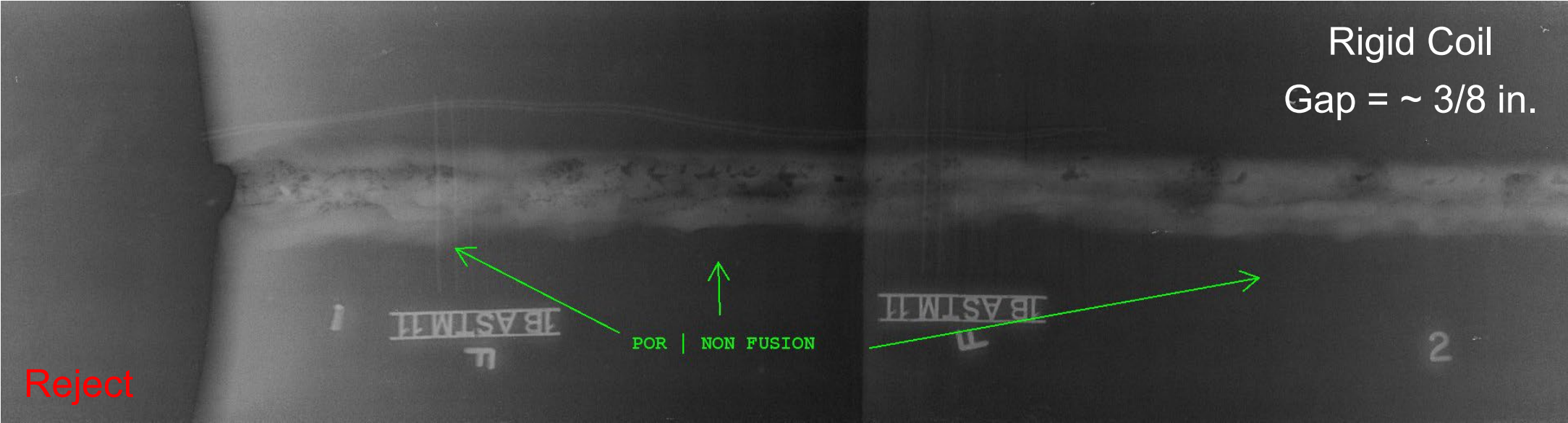
Rigid Coil – none and 1/8 in.



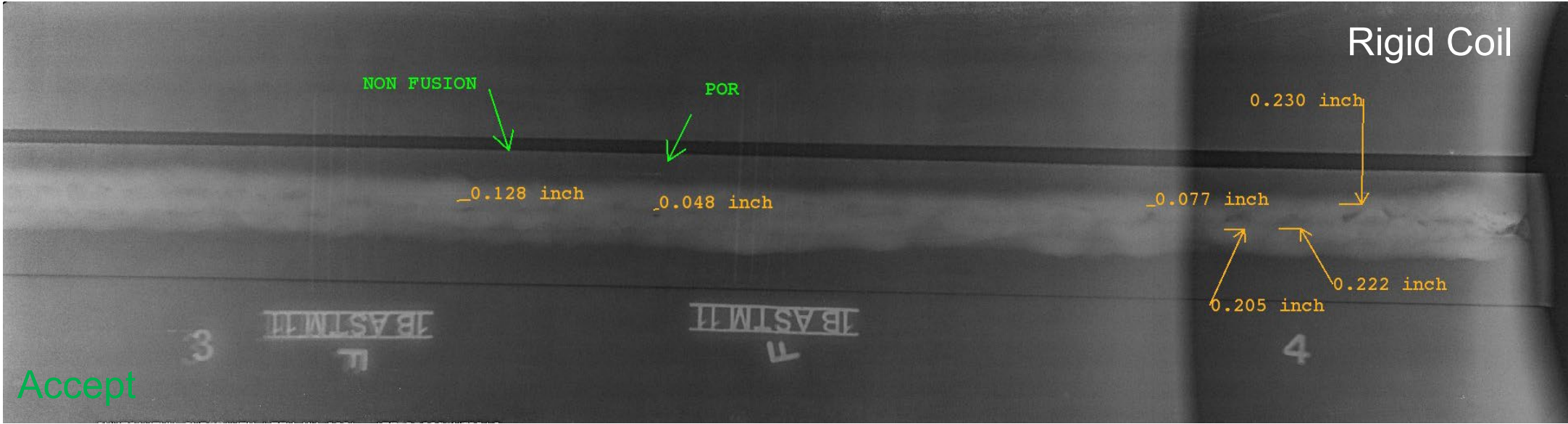
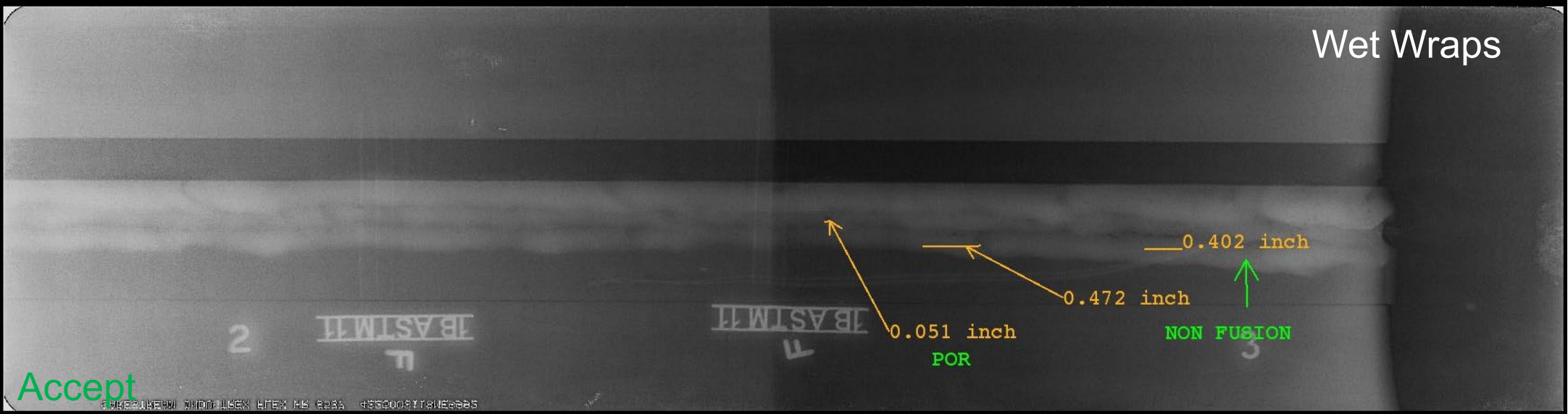
Wet Wraps – 1/16 in.



MATR-3-15B Radiography Results – No Backing Strip



MATR-3-15B Radiography Results – 1/8” Backing Strip



Next Steps

- Complete analysis of encapsulation welds (mechanical testing) – **Nov. 2024**
 - Perform repair of composites with additional composites, and analysis
 - Perform mechanical bolt-on clamp welding and analysis
 - Perform leak clamp welding and analysis
 - Develop industry best practice guidance
 - Reporting (draft, final, and final webinar) – **by end of 2025**
 - Insert new information into the PRCI Pipeline Repair Manual
-
- Monthly project updates held the first Thursday of the month at 10 am Central

Questions?

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