Spoolable Pipe Joint Industry Program

CLASPS-01 JIP

(Combined Loading Assessment of Spoolable Pipe Systems)

IDT EXPO Winter Meeting

Thursday, December 5th, 2019

Prepared by Chantz Denowh, PhD, PE

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Presentation Overview

- JIP background
- JIP participants (operators & manufacturers)
- Test matrix
- Current progress
- Path Forward

Spoolable Pipe Background

- Pipe flexible enough to be spooled into a coil or reel
  - Reinforced thermoplastic (RTP)
  - Steel reinforced
  - Glass reinforced epoxy
- Advantages
  - Fast installation
  - Corrosive fluids

The CLASPS-01 JIP History

- Basic framework organized in a *Prospectus* based on survey results and knowledge gaps (September 2018)
- Assessment involves full-scale testing with tension, bending, and pressure (static & cyclic)
- Cost driven by test matrix, systems to be tested, and number of participants
- Participants: six (6) operators and six (6) manufacturers

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JIP Participants

OPERATORS (6)	MANUFACTURERS (6)
BP	BHGE (Polyflow)
Chevron	FlexSteel
ExxonMobil	NOV
OXY	Pipelife (Soluforce)
PG&E	Primus Line
TransCanada	Shawcor

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Main Testing Themes

- Develop an understanding on **end connector** bending capacity
- Quantify pipe-end connector **stiffness** based on load-deflection data
- **Low cycle / high strain** loading being integrated into the program
- Apply **cyclic pressures** combined with bending loads
- Integrating **inspection technology** into program (Sonomatic's DRS and CT)

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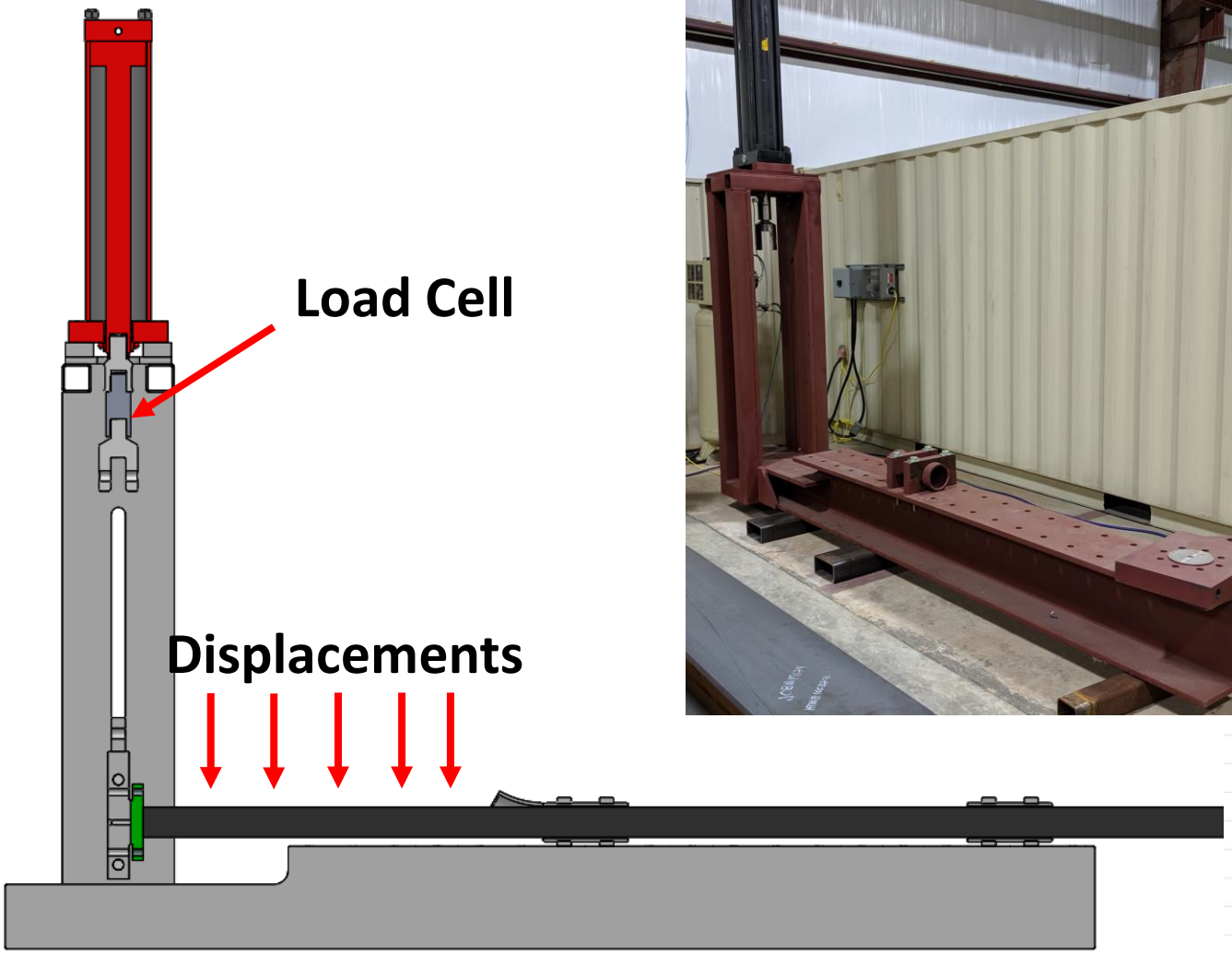
Test Matrix

- Static pressure with combined loading
  - Axial loading (load-deflection data)
  - Bending deflection at end connection
    - Bending cycles and failure
- Cyclic pressure with combined loading
  - Bending cycles at end connection
  - 1,000-hour hold
  - 100,000 pressure cycles
  - Burst test samples that survive
- Numerical modeling
  - Global model for pipe stress analysis

Test Samples

1. Static pressure with axial tension and bending loads
2. Cyclic pressure with constant bending (1)
3. Cyclic pressure with constant bending (2)
4. Cyclic pressure with constant bending (3)
5. Extra “contingency” pipe sample

CLASPS Test Fixture



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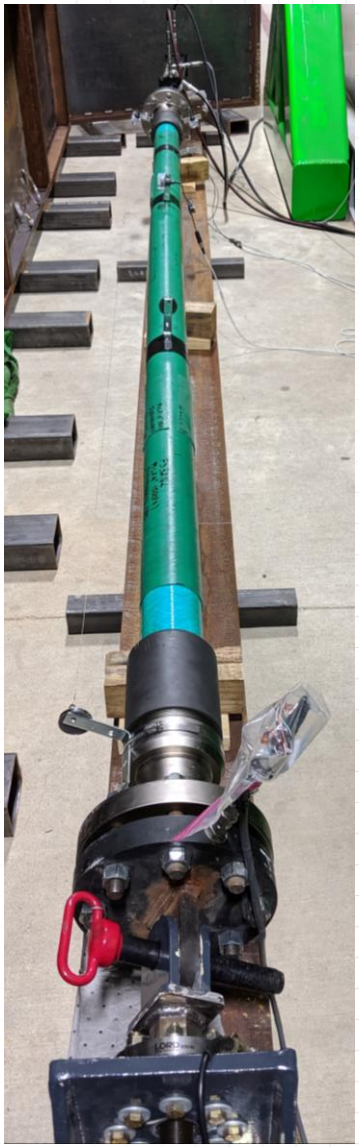
Current Progress

- All contracts in place and received all samples
- Axial tension tests are currently underway
- Followed by the initial end fitting bend tests



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Project Schedule

Phases of Work	Schedule
Contracts and Confirm Participation	January – February 2019
Project Kickoff for JIP Participants	April 2019
Complete Contracts	September 2019
Sample Delivery	November 2019
Test Configuration 1	December 2019 – January 2020
Test Configuration 2	January 2020 – May 2020
Data Analysis and Reporting	(late) May 2020
Final Results –Meeting in Houston*	June 2020

* NOTE: It is possible to align “report out” meetings with API 15S or SPUG meetings.

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Proposed Matrix (1/2)

Testing Configuration Number	No. of Samples	Test Sample Details

1	1[1]	**Static Pressure Testing with Combined Loading**
		• *Pre-testing activities* to include installation of measurement equipment to permit measurement of deflection and strain.
		• *Axial Loading:*
		  ○ Axial tension design load without internal pressure, then remove load. Record load-deflection data.
		  ○ Apply MAOP, then ramp to design axial tension load. Record load-deflection data (internal pressure to be maintained).
		• *Bending Deflection at End Connection:*
		  ○ Apply design deflection/bending loads as defined by manufacturer without internal pressure, then remove the load. Record load-deflection data.
		  ○ Apply MAOP, then ramp up to design deflection/bending load. Hold for a given period of time (e.g., 10 minutes), then deflect to achieve gross plastic failure. Record load-deflection data.
		  ○ If failure does not occur even after gross plastic failure has been reached, hold applied bending moment constant and pressurize to failure.

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Proposed Matrix (2/2)

Testing Configuration Number	No. of Samples	Test Sample Details
2	3	**Cyclic Pressure Testing with Combined Loading** • *Pre-testing activities* to include installation of measurement equipment to permit measurement of deflection and strain. Also, conduct a baseline inspection using an appropriate NDE technique. • *Cyclic pressure loading with constant bending moment[1]:* ○ Choose a target deflection (bending) load based on results for Pipe Spool #1. This will require a discussion with each company, possibly imposing a design factor of 0.5 from any observed inflection point in the load-deflection curves (i.e., can provide a baseline starting point for the discussion). ○ Apply internal pressure to pipe NPR or MAOP. ○ Deflection load cycle 10 times to target deflection load. ○ Remove loads and pressure, allow inspection companies access. ○ Slowly ramp to target pressure and design deflection load. Hold samples at 1,000 hours at MAOP + target deflection load. ○ Remove loads and pressure, allow inspection companies access. ○ Apply cyclic pressure loading until failure or runout (e.g., 100,000 cycles). "R" to be determined. ○ For samples that reach runout condition, conduct a burst test.
3	1	Contingency sample. Several options exist for this sample, but one option could be to duplicate the Pipe Spool #2 test, but replace the deflection load and deflection cycling with an axial tension load and axial tension cycling.
Analytical Modeling Phase		Set aside $30,000 to fund a piping engineer to conduct a stress analysis of a case study buried spoolable line, highlighting expected loads at end connections and relating to experimental data. Help provide guidance for future design efforts.

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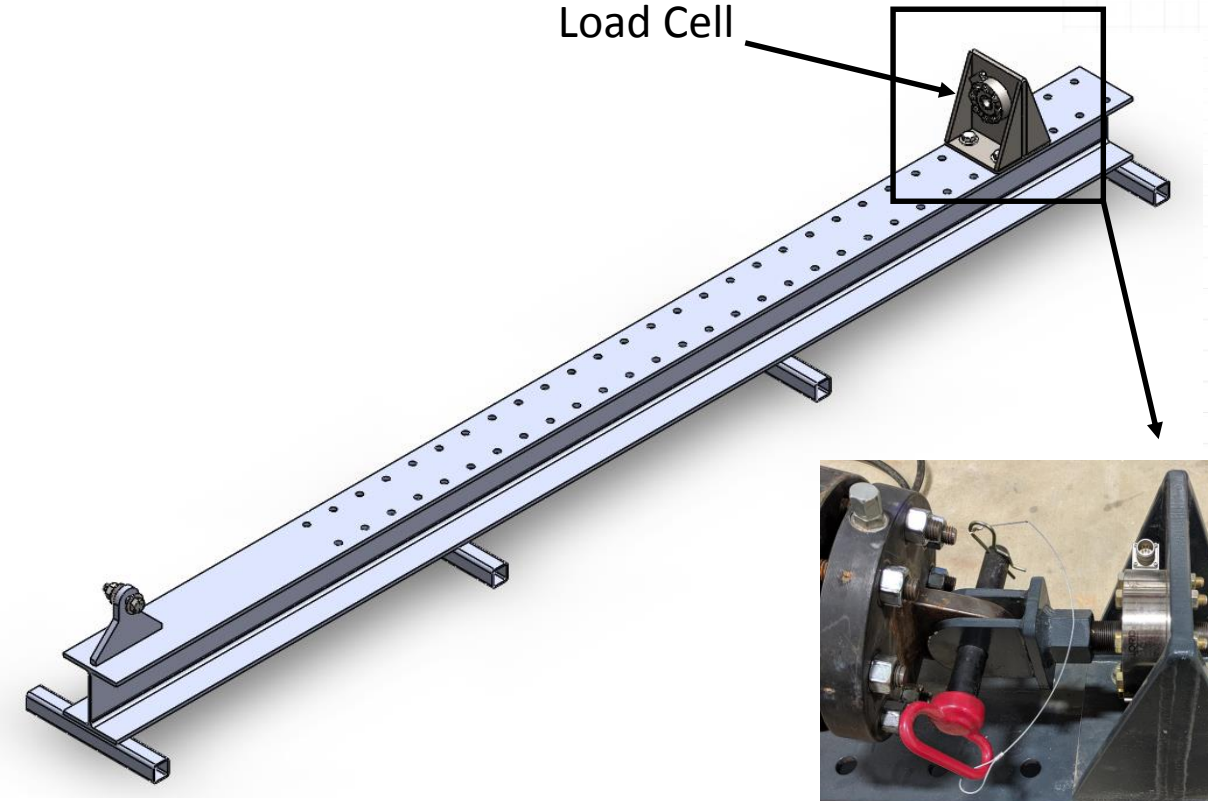
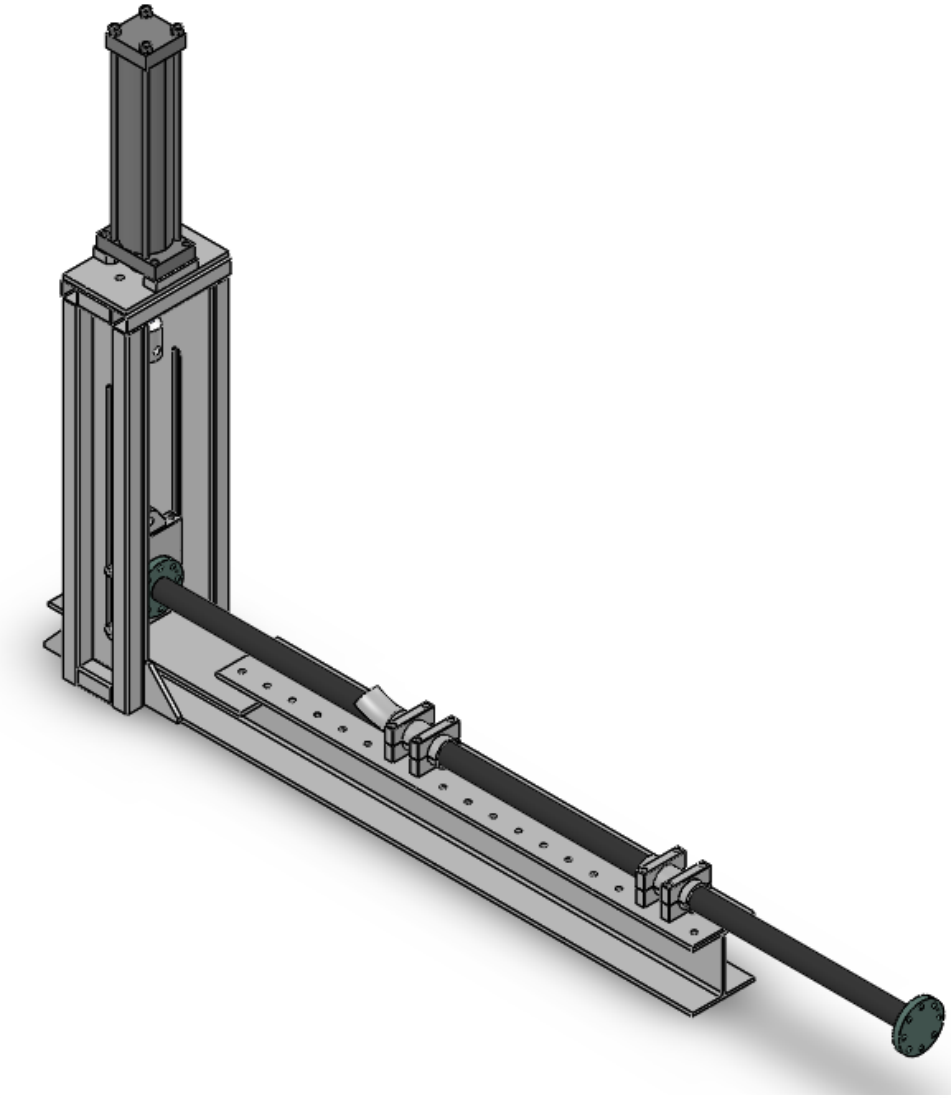
Axial Tension Frame

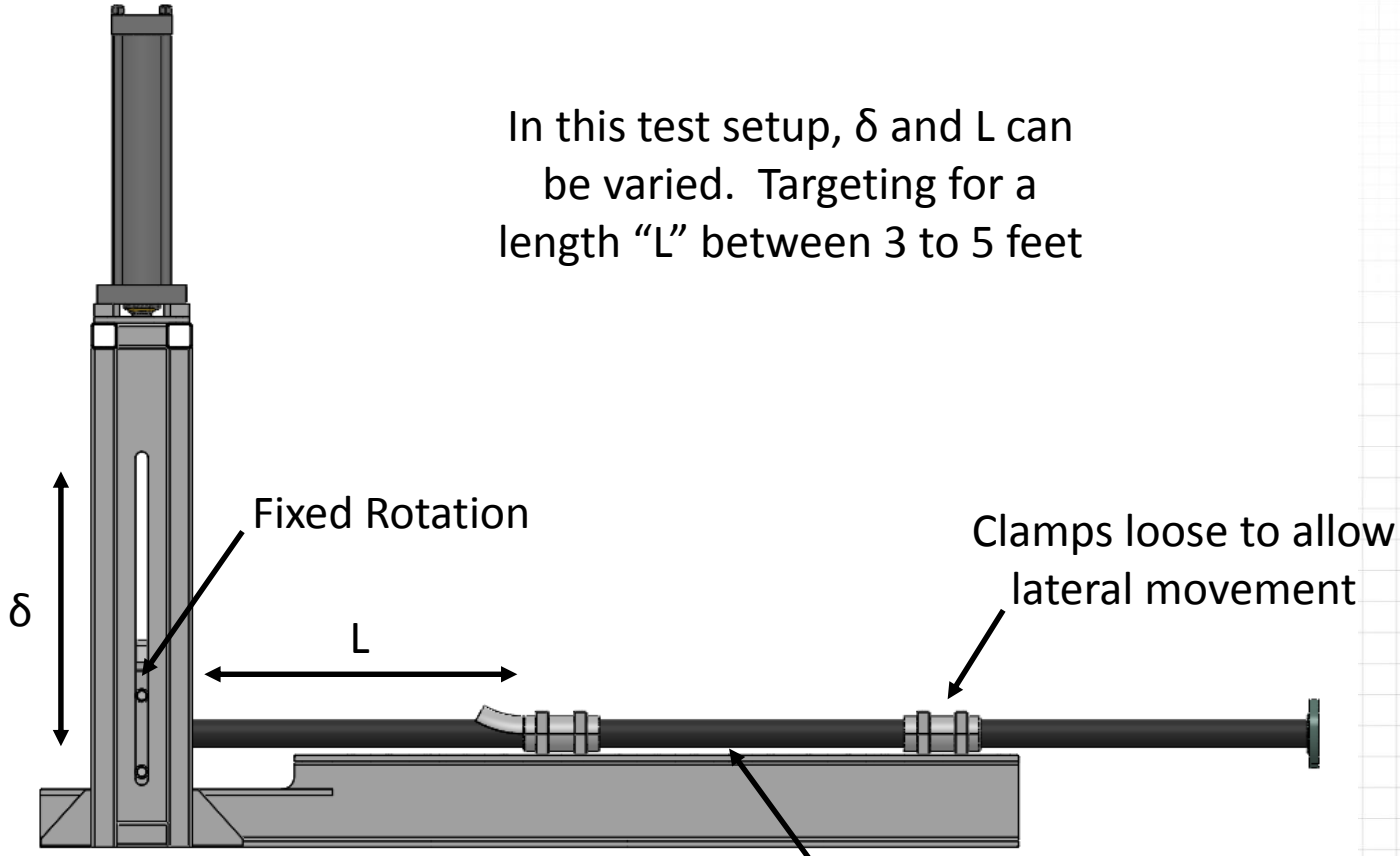


CLASPS Test Fixture (1/3)

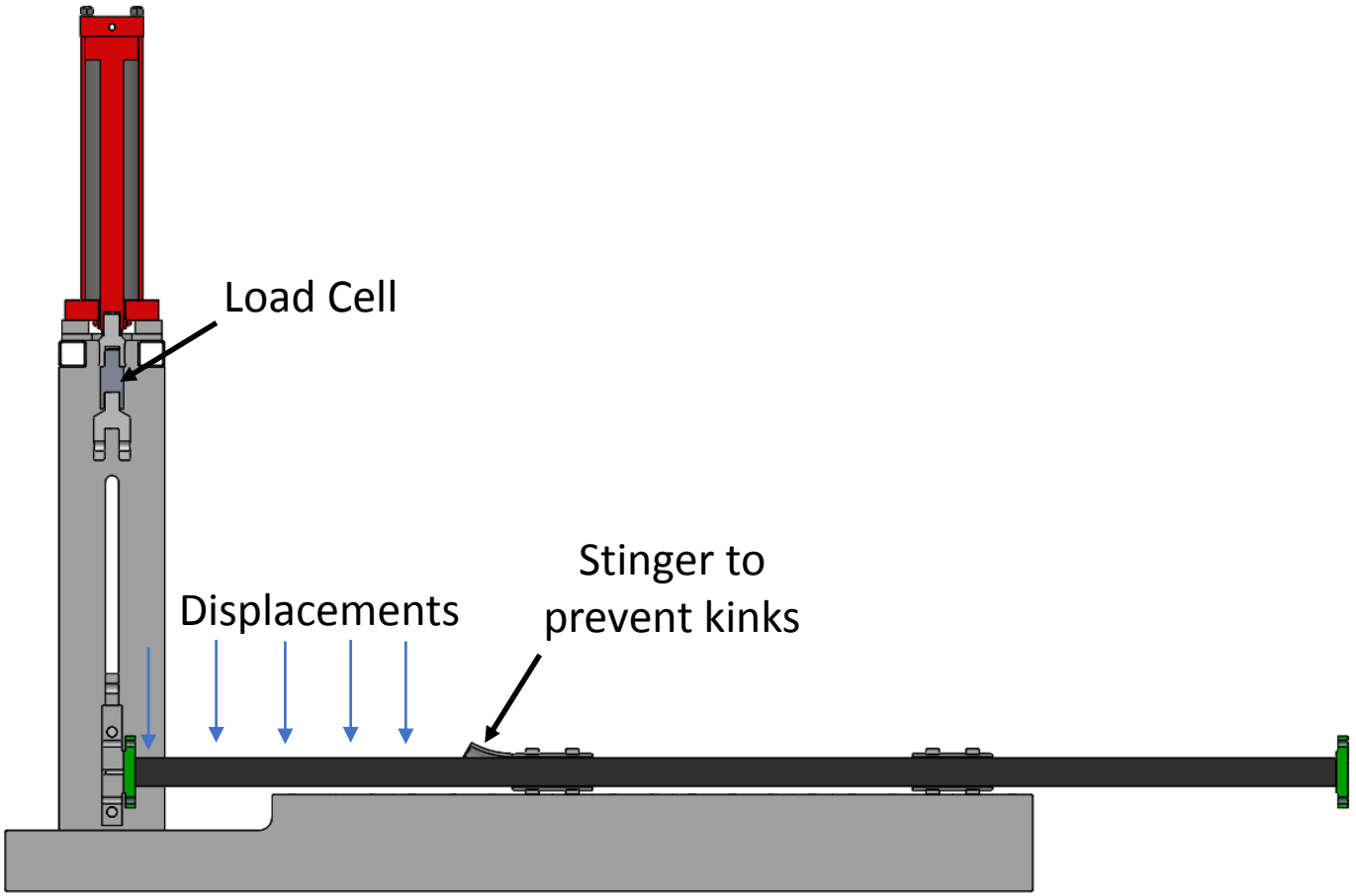


CLASPS Test Fixture (2/3)

In this test setup, δ and L can be varied. Targeting for a length "L" between 3 to 5 feet



CLASPS Test Fixture (3/3)



Path Forward
(Required Roles & Responsibilities)

- Complete axial tension tests (12/9)
  - Axial loads varied between products
- Start end fitting bend tests early January
  - Target displacements (manufacturers)
  - Work with ADV on target displacements, including lateral deflection (δ) over length (L)
  - Test includes initial bend cycle followed by bend to failure
- Complete all end fitting bend tests prior to the 1,000-hr hold at chosen offset