

# PHMSA Public Underground Natural Gas Storage Safety Workshop

## Well Liner Integrity Overview

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# Outline

- **Introduction**
- **Well Construction Casing/Liner Integrity**
- **Well Remedial Casing / Liner Options**

# Well Construction Casing / Liner Integrity

Casing / Liner Design  
Open Hole Annulus Isolation  
Mid-String Isolation  
Liner Top Isolation

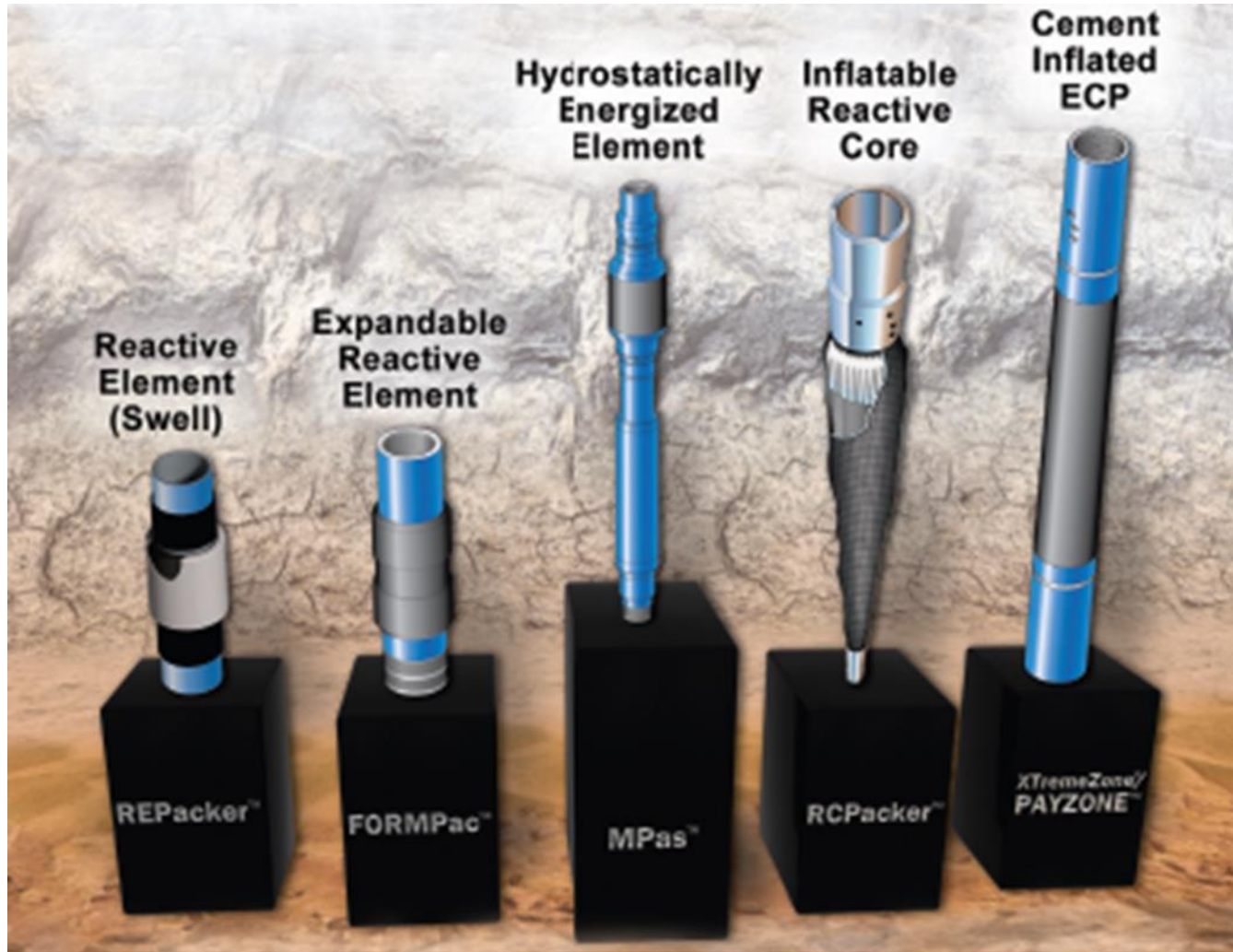
# Casing / Liner Design

- Main Objectives of Casing / Liner Design:
  - Ensure Well Mechanical Integrity
  - Exceed the well's expected loads
  - Cost efficiency
  
- Casing / Liner Performance
  - Burst
  - Collapse
  - Tensile
  
- Material Selection
  - API Spec 5CT
  - Mechanical Properties
  - Chemical Requirements
  - Connections

# Open Hole Annulus Isolation Systems

- Open Hole Isolation Systems are used in Primary Cementing and/or Zonal Isolation Applications to achieve a **positive seal between the Casing and/or Liner and the Wellbore.**
- Used for Annular Seal of the production and or injection interval, when:
  - There is a Risk of an ineffective Primary Cementing Job
  - Isolate Oil / Water Contacts
  - Isolate Gas Caps and or Gas Migration
  - Isolate Casing Shoe
  - Prevent Crossflow
  - Segment Production or Injection Intervals
- Available Open Hole Isolation Systems
  - Reactive Element Packers (Swell)
  - Expandable Reactive Element
  - Hydrostatically Energized Element
  - Inflatable Reactive Core
  - Cement Inflated ECP

# Open Hole Annulus Isolation Systems



# Mid-String Isolation Systems

- Hydraulic Double-Grip Mid-String Packers are full bore packers used to achieve a **positive seal between two strings of casing**
  - The packer can be run with Liners or long-string Casing
  - Optional Setting Methods for Cytadel Model:
    - Acoustic and/or Magnetic
  - May be used with in two-stage cementing programs
  - Specially useful when sealing off previous casing damage
  - Full casing ID through packer mandrel provides unrestricted access
  - Available in permanent and retrievable versions



# Liner Top Isolation Systems

- Liner Top Packers are used to achieve a **positive seal between casing and liner string**
  - Typically run as an integral component of the primary Liner Hookup.
  - Includes a large bore polished extension on the top to maintain liner ID if a Tieback is required.
  - It may also be run with a Tieback Seal Assembly to:
    - Remediate a leaking Liner Top
    - Tieback and Straddle a section of damaged Casing





# Well Remedial Casing / Liner Options

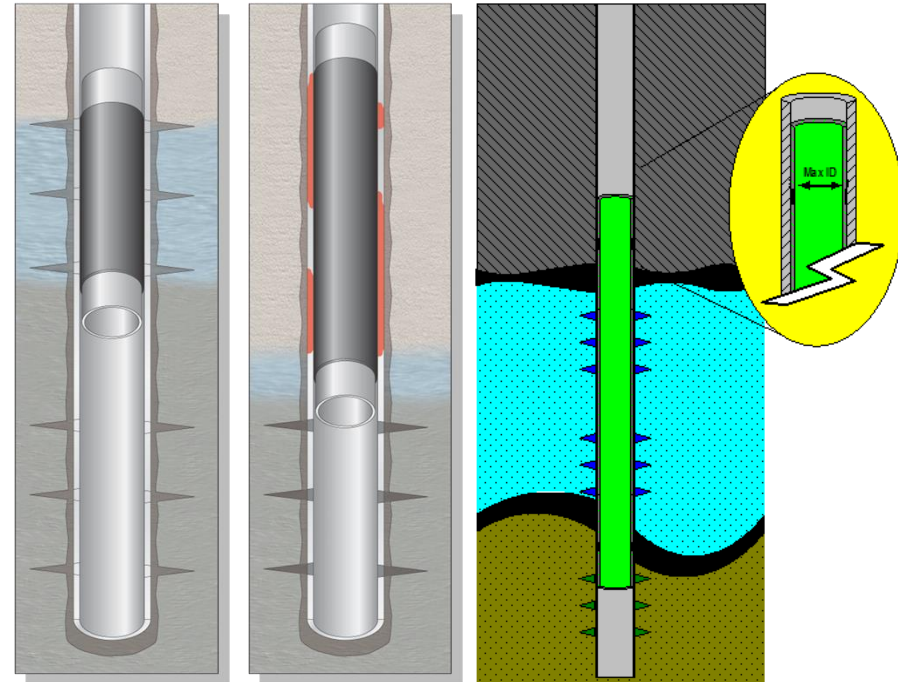
Internal Casing Expandable Cladding

Remedial Liner Hanger

Straddle Liner Assembly

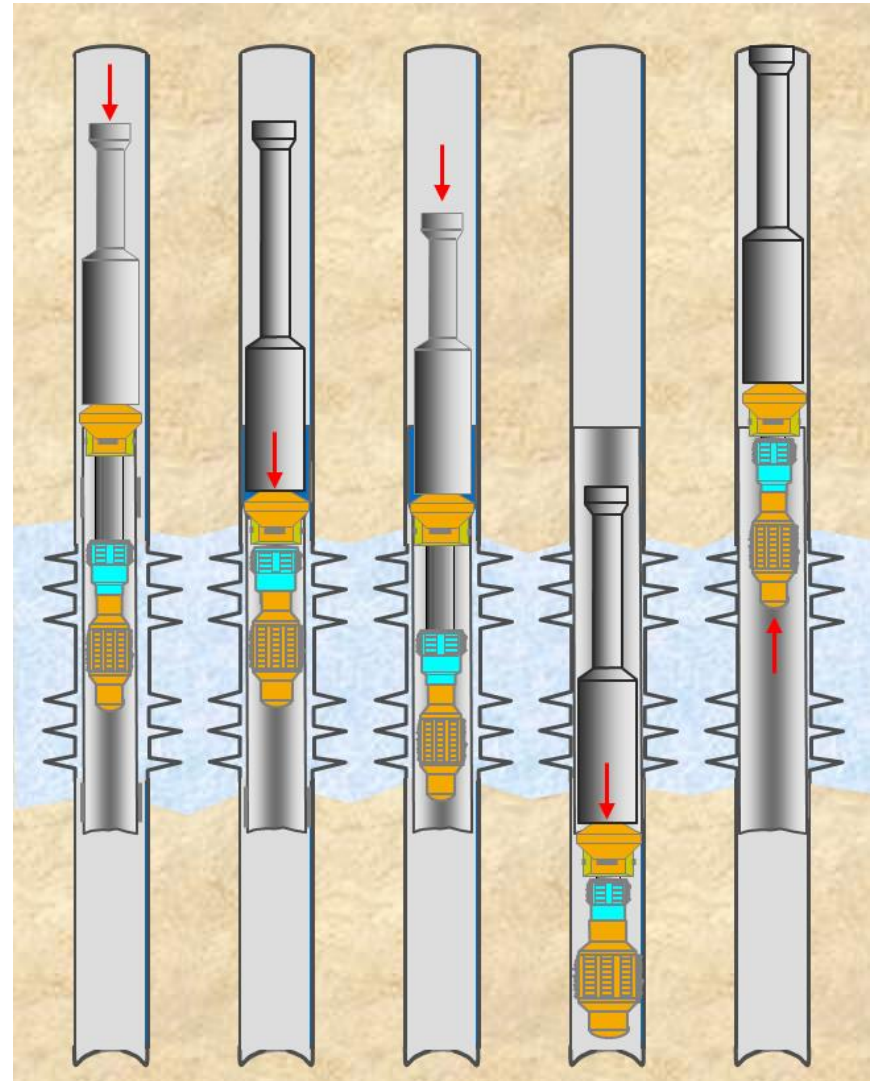
# Expandable Cladding

- Casing Repair
  - Expandable cladding can be used to repair corroded, damaged casing or parted casing or to shut off perforations
- Applications
  - Elastomer wrap on pipe (Seal Joint)
  - Corrosion Long Clad(s)
- Features
  - Variable Lengths
  - Post Expansion ID is typically ½ inch smaller than existing casing drift
  - **Retains the maximum ID in comparison to other methods**



# Expandable Cladding – Top to Bottom Deployment Sequence

- Run to desired depth
- At depth, hydraulic-activate system to anchor and expand clad
- Bleed-off pressure, move down to stroke system close
- Repeat hydraulic-activate anchor and expansion of total clad length
- After total expansion is complete, pull system from the well
- **No drill out is required**
- **Baker Hughes uses Top to Bottom Expansion**

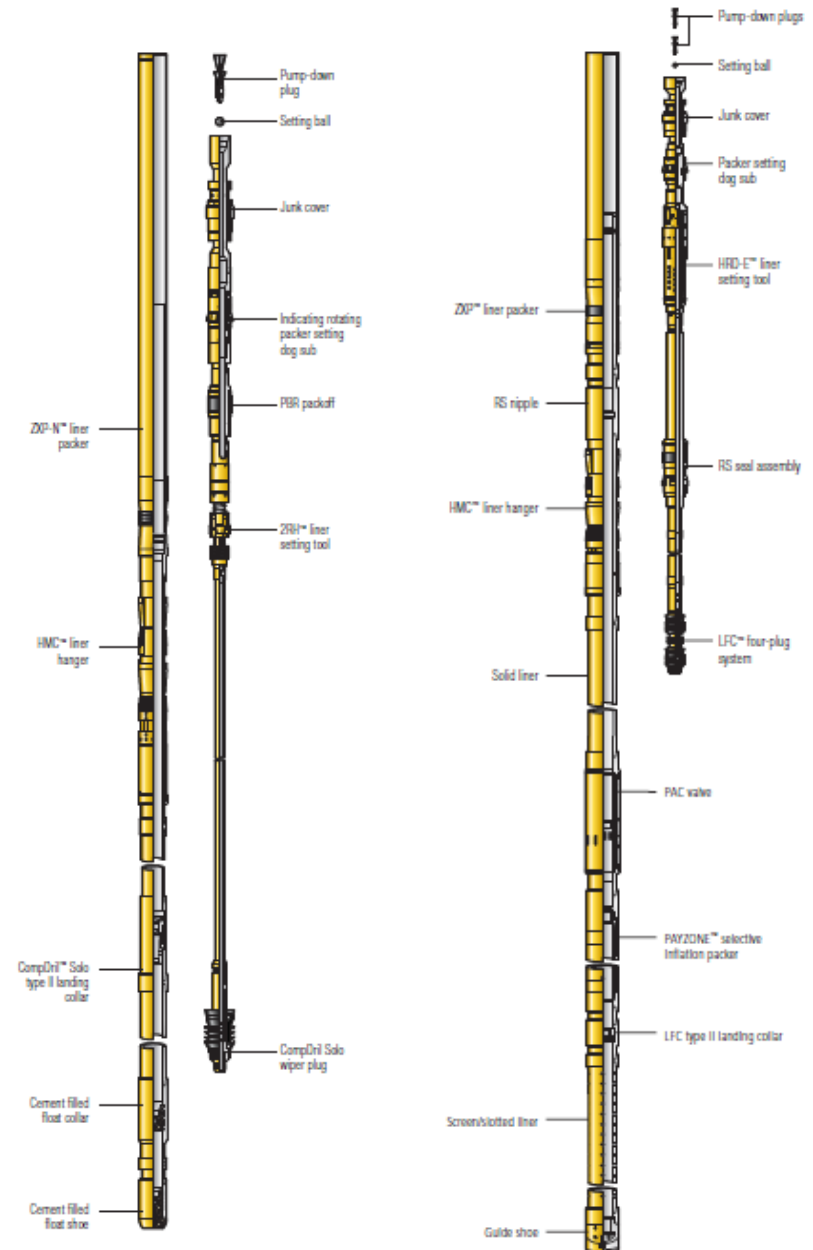


# Expandable Cladding – Typical System Specifications

Parent Casing				Expandable Clad					
				Pre-Expansion				Post-Expansion	
OD	Weight	Nominal ID	Drift	Max Hanger OD	Csg. Min. ID – Hanger OD	Clad OD	Clad ID	OD	ID
9-5/8	40.0	8.835	8.679	8.650	.079	7.625	6.969	8.658	8.002
9-5/8	43.5	8.755	8.599	8.570	.072	7.625	6.969	8.571	7.915
9-5/8	47.0	8.681	8.525	8.495	.067	7.625	6.969	8.491	7.835
9-5/8	53.5	8.535	8.379	8.350	.055	7.625	6.969	8.334	7.678
7.0	20.0	6.456	6.331	6.070	.311	6.000	5.500	6.381	5.881
7.0	23.0	6.366	6.241	6.070	.214	6.000	5.500	6.241	5.741
7.0	26.0	6.276	6.151	6.070	.117	6.000	5.500	6.151	5.651
7.0	29.0	6.184	6.059	5.763	.325	5.750	5.250	6.059	5.559
7.0	32.0	6.094	5.969	5.763	.227	5.750	5.250	5.969	5.469
5-1/2	14.0	5.012	4.887	4.773	.175	4.500	4.000	4.948	4.448
5-1/2	15.5	4.950	4.825	4.642	.239	4.500	4.000	4.881	4.381
5-1/2	17.0	4.892	4.767	4.642	.177	4.500	4.000	4.819	4.319
5-1/2	20.0	4.778	4.653	4.642	.054	4.500	4.000	4.696	4.196

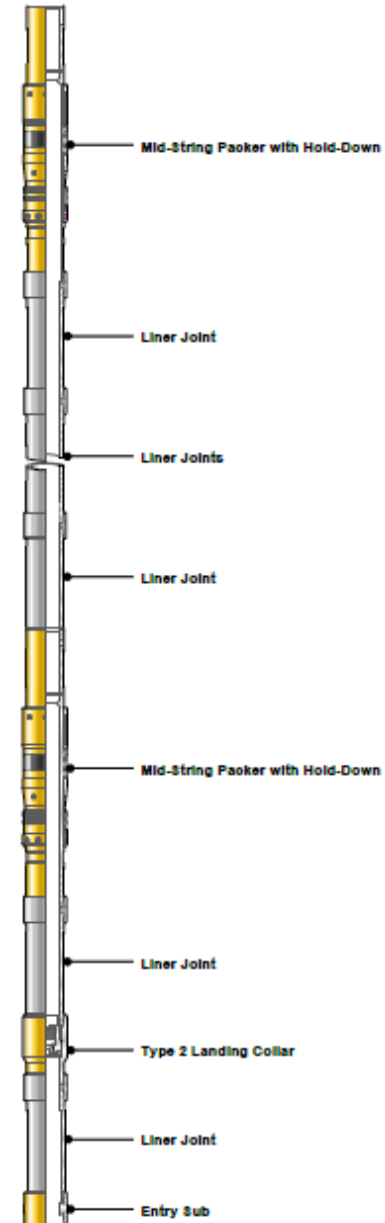
# Remedial Liner Hanger

- Liner Hanger run inside an existing casing to remediate large extensions of damaged casing.
  - Option when a casing string cannot be suspended from current wellhead.
  - Isolation can be obtained by complete or partial cementing, mid-string packers or combination.
  - Casing will require to be re-perforated.
  - Option to have perforated liner on bottom section with cement isolating upper section.
  - ID reduction for a typical scenario:
    - 7" 23# ID reduction from 6.366" ID to Equivalent of 5-1/2" 15.5# (4.950" ID)



# Straddle Liner Assembly

- A Straddle Liner Assembly can be achieved with 2 ZX Mid-String Packers to remediate large extensions of damaged casing.
  - Option when a casing damage requires isolation and string cannot be suspended from current wellhead.
  - Isolation obtained by Mid-String Packing Elements.
  - ID reduction for a typical scenario:
    - 7" 23# ID reduction from 6.366" ID to Equivalent of 5-1/2" 15.5# (4.950" ID)



Questions?

Thank you!

More information at <http://www.bakerhughes.com>