



# World Oil<sup>®</sup> **HPHT**

**DRILLING, COMPLETIONS & PRODUCTION CONFERENCE**

**September 26–27, 2017**

Norris Conference Centers – CityCentre, Houston, Texas

[HPHTConference.com](http://HPHTConference.com)

# Annulus Monitoring in HPHT Subsea Environments

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# Agenda

1. Background on Subsea Monitoring
2. Subsea Annular Monitoring Study
3. Well Integrity & Annular Monitoring
4. Past Industry Performance
5. Closing Comments

# Regulatory

***Evaluate the possibility of monitoring the B-annulus based on your proposed casing program and associated annuli clearances on HPHT wells. The technology now exists to do this without a penetration in the high pressure housing. Provide how you plan to monitor the B-annulus or justify why it is not feasible for your well design. (BSEE Guidance, August, 2017)***

# Annular Monitoring Study

Supplier	Power Source		Annuli Accessible		Est. Deliv. of Comm. "B" Ann. Product (Years)	Est. Deliv. of Comm. "C" Ann. Product (Years)
	Batteries	Continuous	"B" Annulus	"C" Annulus		
Vendor A		✓	Yes	Possibly	0	1.5
Vendor B		✓	Yes	No	0	N/A
Vendor C		✓	Possibly	Possibly	1 - 2	3
Vendor D		✓	Possibly	Possibly	1.5	3
Vendor E		✓	Yes	No	1	N/A
Vendor F*	✓		Possibly	Yes	0.5	0
Vendor G*	✓		Possibly	Yes	0.5	0
Vendor H*	✓		Possibly	Yes	0.5	0

\* These systems require porting through the intermediate casing from the "C" annulus to access the "B" annulus.

**Note: Annulus access rankings based on applicability to Lower Tertiary well designs**

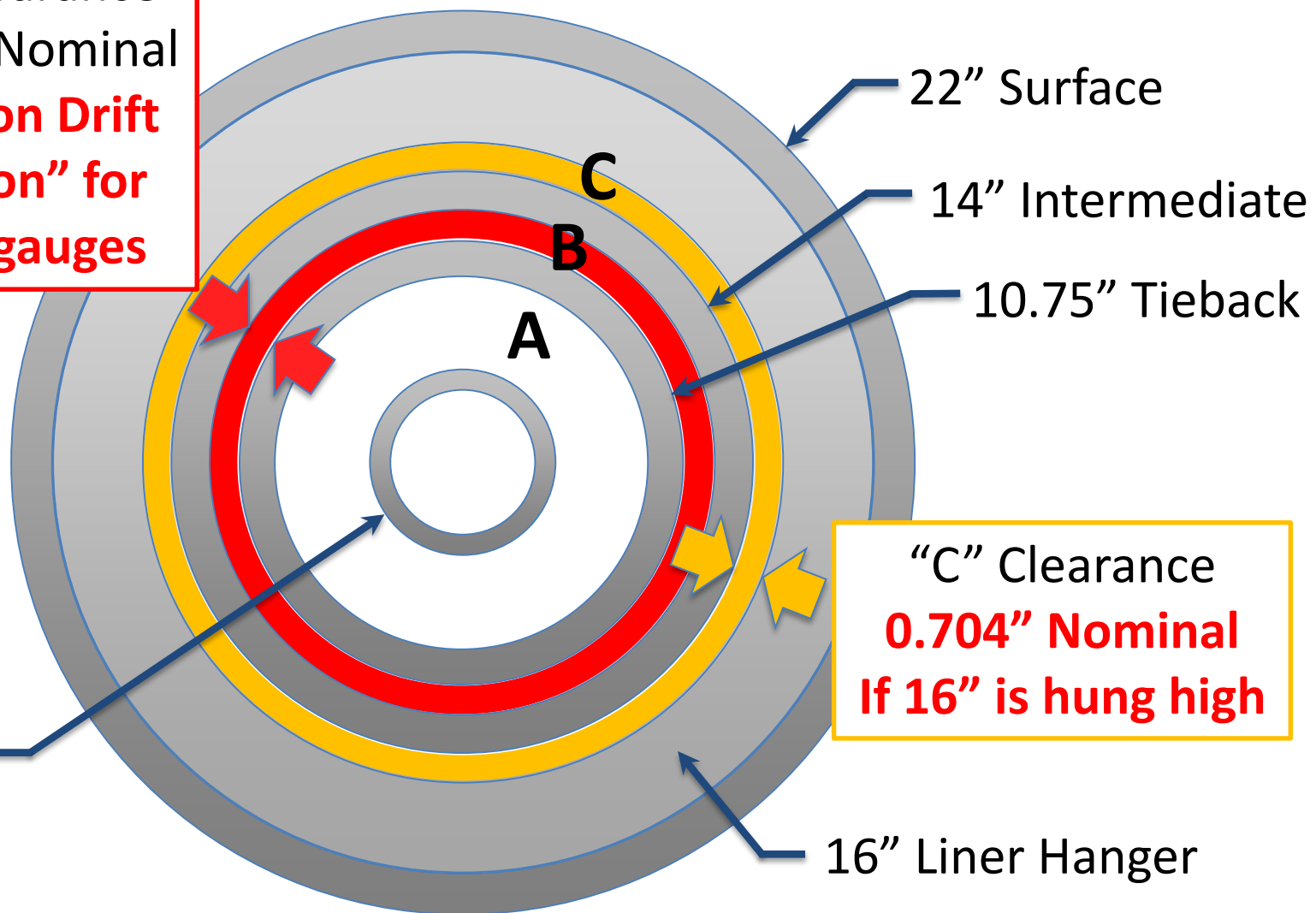
# Annular Monitoring Study (Cont'd.)

Supplier	Technical Readiness Level (TRL)*	Mode of Transmission		Ability to Retrofit Existing Wells	Number of Systems Installed To-Date	Location
		Sonic	Electro-magnetic			
Vendor A	7		✓	No	2	North Sea
Vendor B	7		✓	No	23	North Sea
Vendor C	2	✓		No	0	N/A
Vendor D	3		✓	No	0	N/A
Vendor E	4	✓		No	0	N/A
Vendor F	7	✓	✓	No	14 (12/2)	North Sea/GOM
Vendor G	6		✓	No	1	Malaysia
Vendor H	4		✓	No	0	N/A

\* Technical Readiness Levels per API 17N (see attachment in Appendix "B" for details).

# Casing Cross Section

“B” Clearance  
0.806” Nominal  
**0.75” on Drift**  
**“Size on” for**  
**most gauges**



22” Surface  
14” Intermediate  
10.75” Tieback

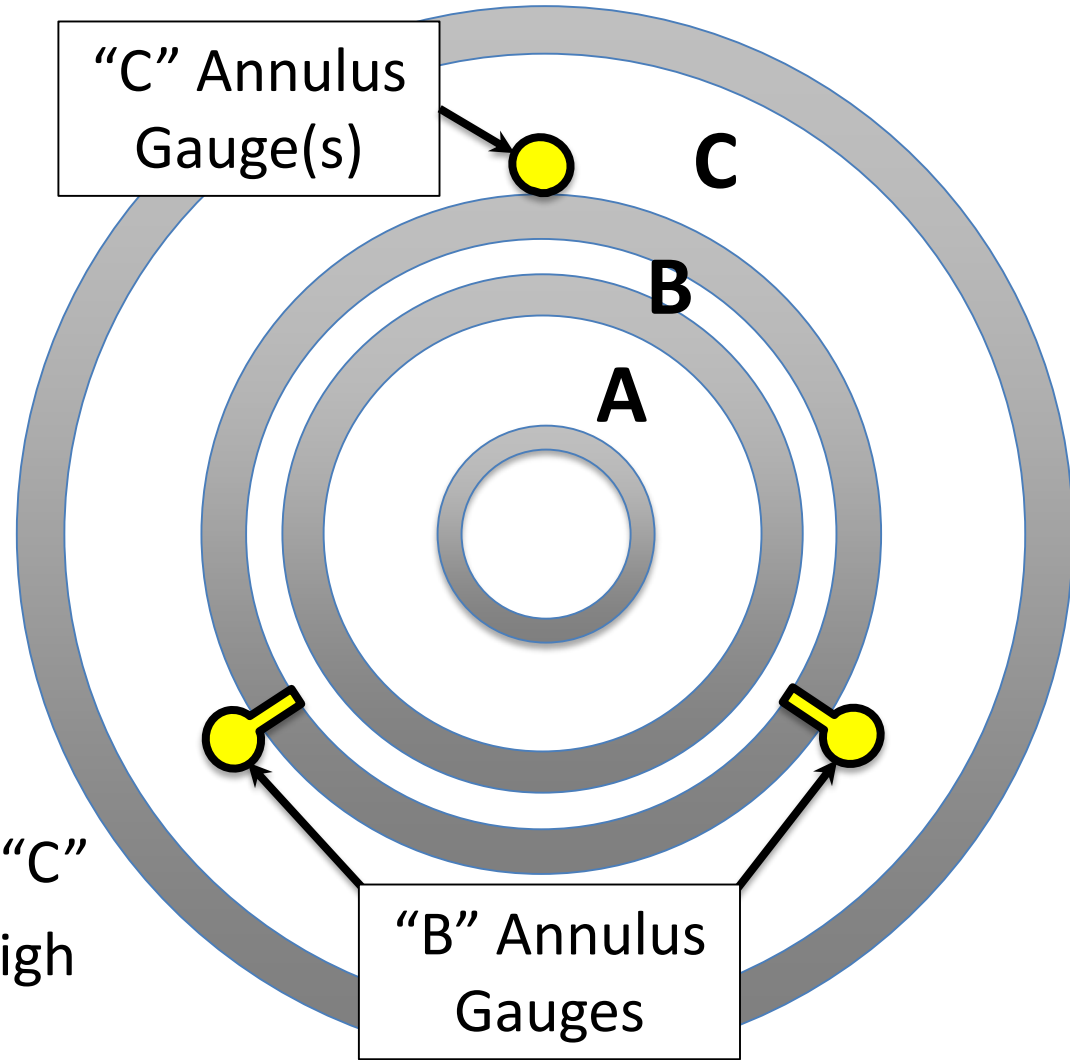
“C” Clearance  
**0.704” Nominal**  
**If 16” is hung high**

4.5” Tubing

16” Liner Hanger

# Battery Powered Systems

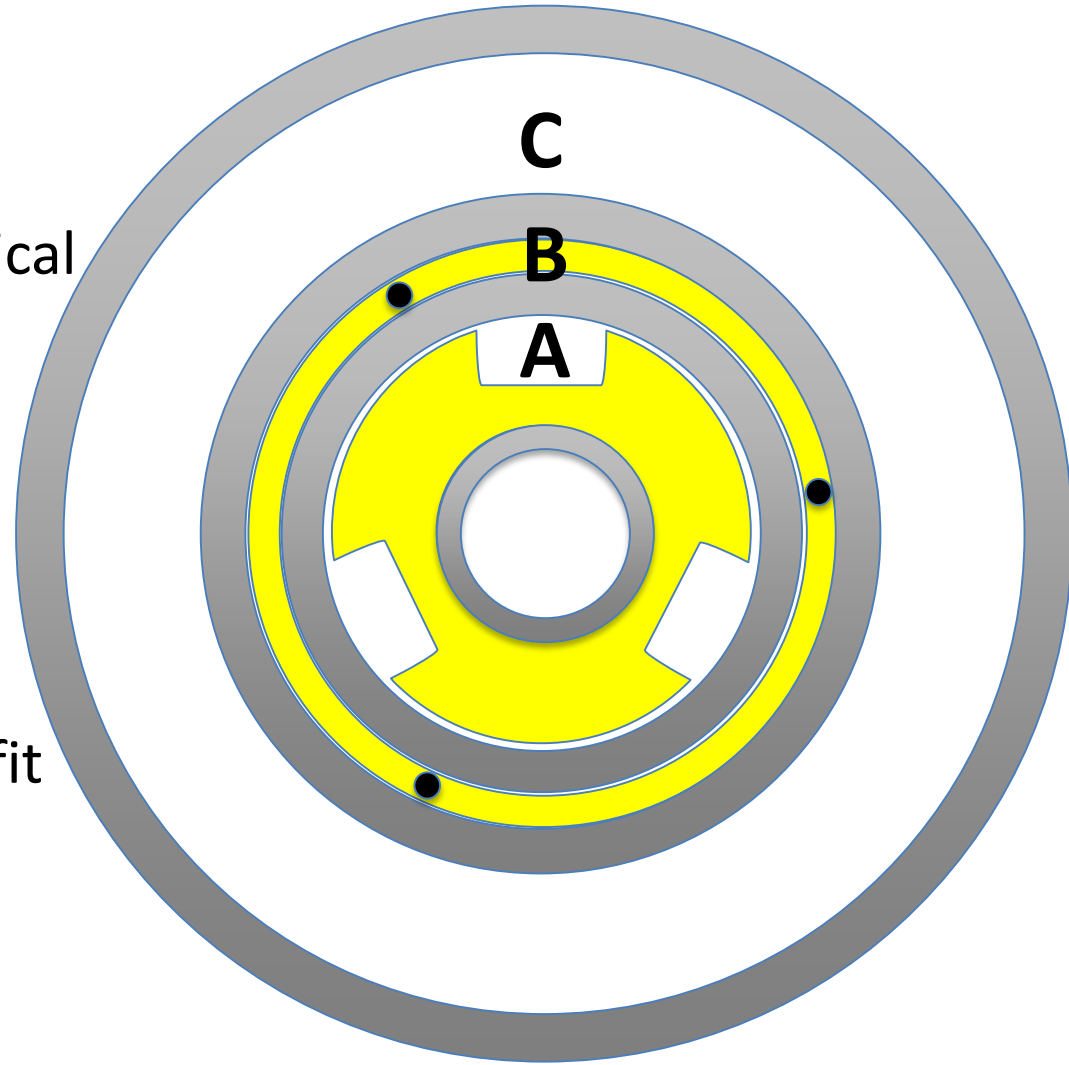
- Installation in “C” annulus
- Penetration to “B” introduces potential leak path
- “C” annulus gauges can monitor both temperature and pressure
- “B” annulus pressure only, temperature influenced by “C”
- Not an option if 16” hung high





# Continuous Power Systems

- Equipment in “A” and “B”
- Angular alignment not critical
- Relative depth space-out very important
- Life of well monitoring potential
- Current designs require further vetting to confirm fit with this geometry



# Well Integrity & Annular Monitoring

## Annular Pressure Buildup (APB)

*Pressure generated by thermal expansion of wellbore fluids within a closed annulus.*

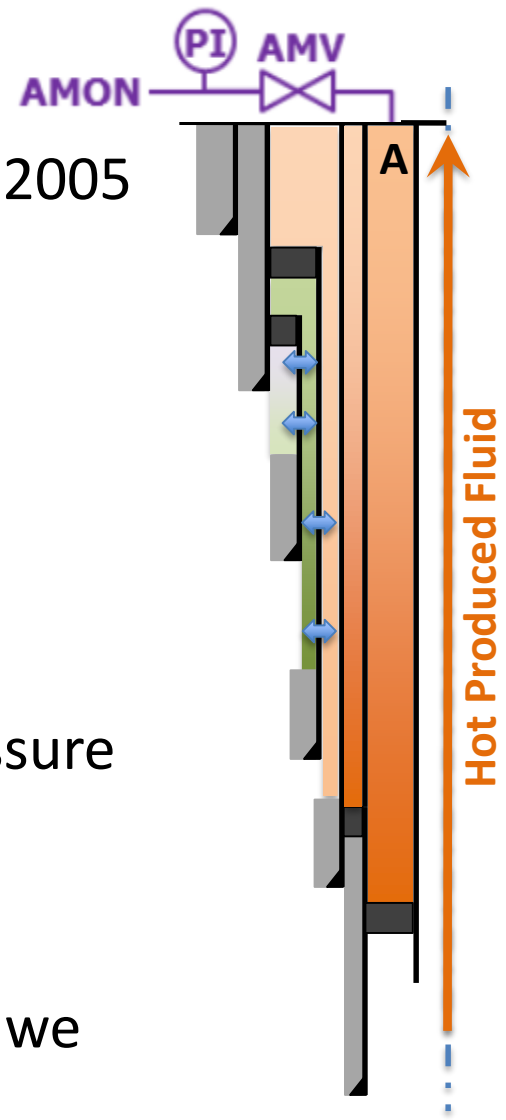
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## Sustained Casing Pressure (SCP)

*Any measurable casing pressure that rebuilds after being bled down, attributable to cause(s) other than artificially applied pressures or temperature fluctuations in the well.*

# Annular Pressure Buildup

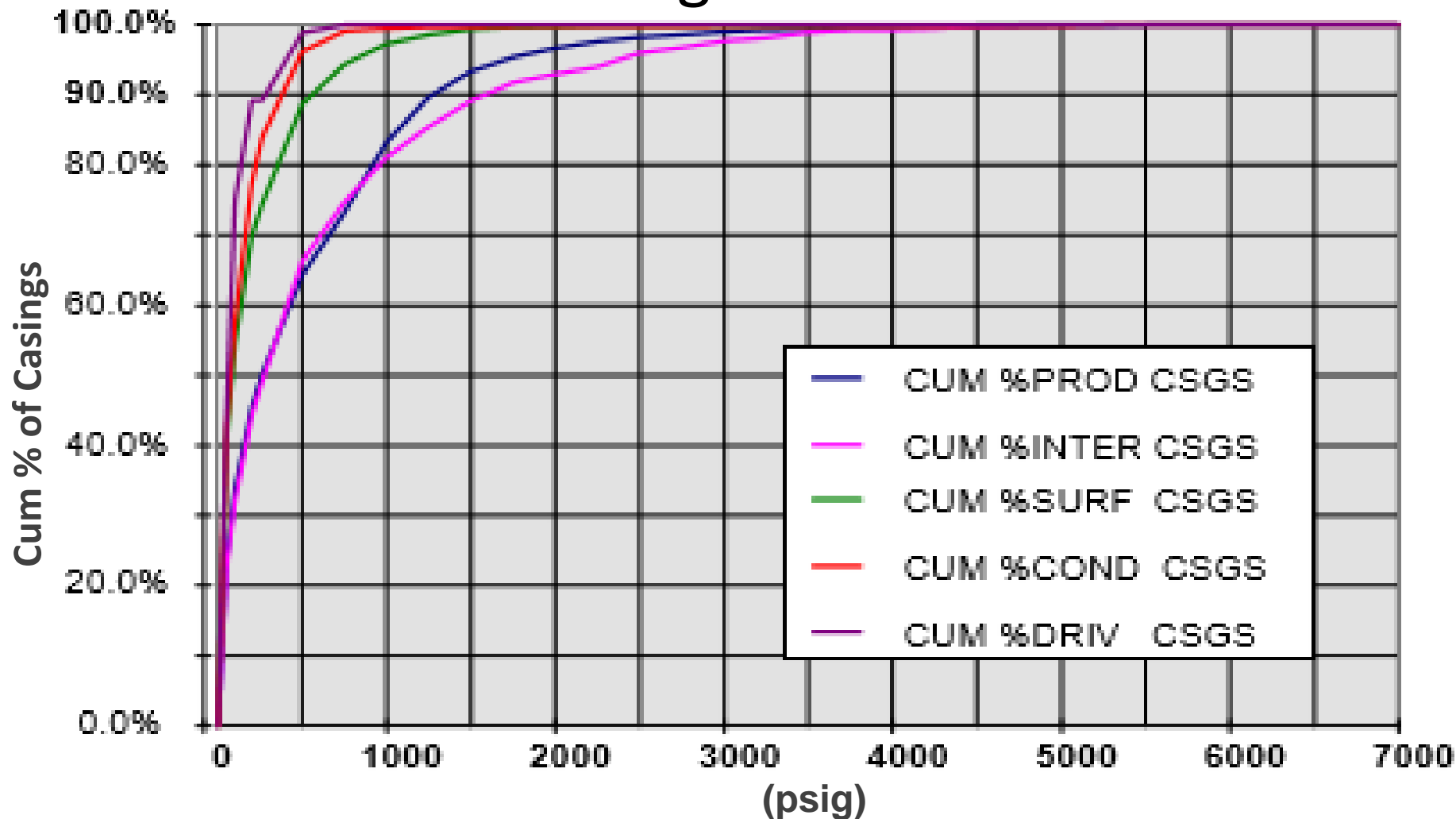
- Last published APB production related failure in 2005
- Current casing designs proven reliable using:
  - Robust tubulars
  - Rupture disks
  - Vacuum Insulated Tubing
  - Viscous completion fluids
  - Syntactic foam
  - “A” annulus access - monitor and adjust pressure
- Benefits to monitoring “B” and “C” annuli:
  - Confirm current models are conservative
- If industry has designed adequately for APB, do we need to monitor the “B” and “C” annuli?



# Sustained Casing Pressure (SCP)

- SCP studies to-date are limited to shelf wells
- Causes of SCP :
  - Tubing and casing leaks
  - Channeling through primary cement jobs
  - Compromised cement bond - thermal stresses
- Consider differences between old shelf well designs and current subsea well designs

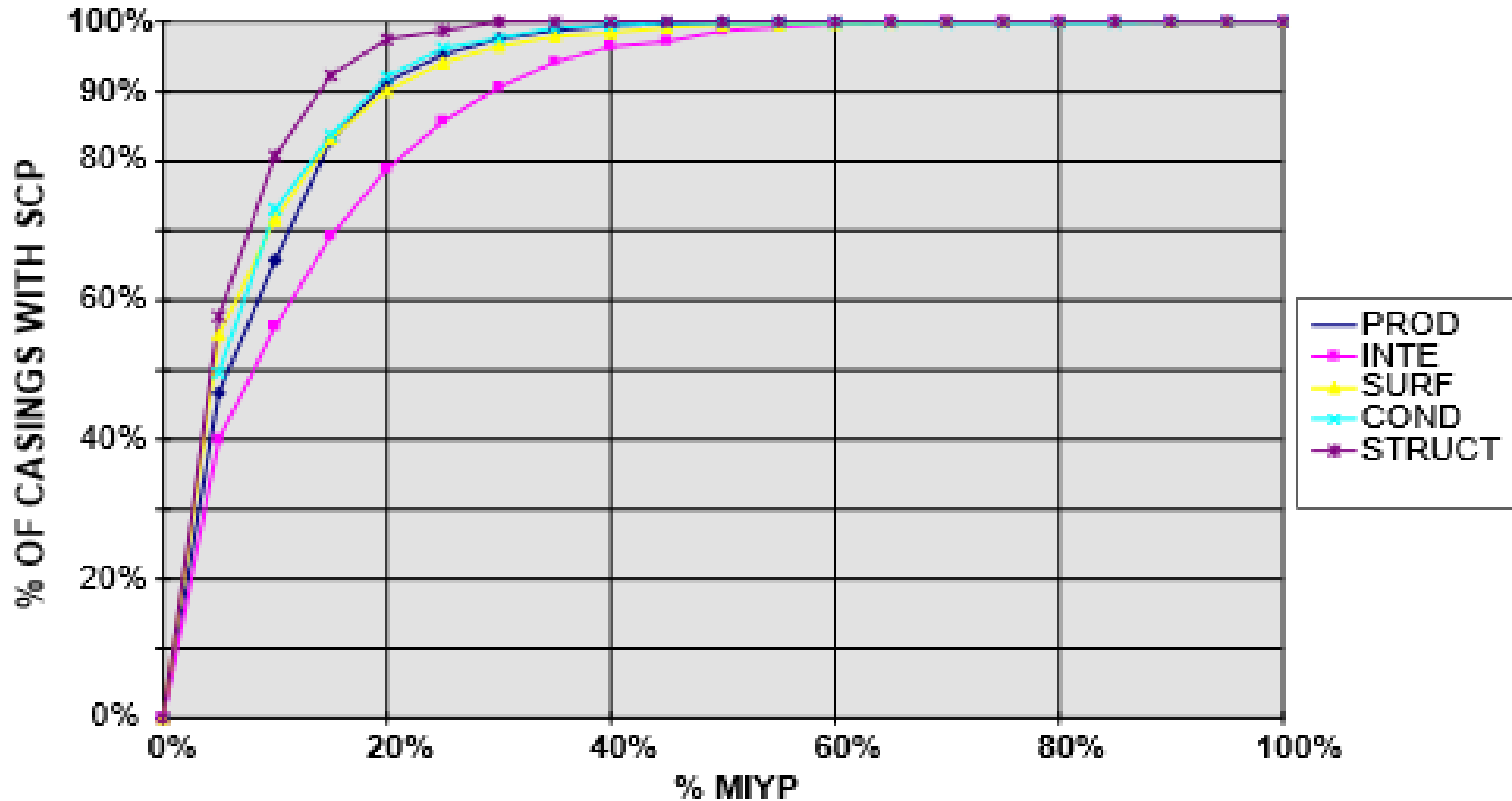
# Sustained Casing Pressure – Shelf Wells



Burgoyne et al 2000<sup>(1)</sup>

**Pressure Distribution by Occurrence in Each Casing.**

# Sustained Casing Pressure – Shelf Wells



SCP distribution as a percentage of Minimum Internal Yield Pressure.

Burgoyne et al 2000<sup>(1)</sup>

# Closing Comments

- “A” annulus monitoring in subsea wells is already being performed
- Idle Iron P&A operations have had no SCP issues to-date 63 wells
- A collective industry position on well design practices to address risk of SCP would be beneficial
- Industry collaboration with BSEE in advance of regulations essential