ASIA TURBOMACHINERY & PUMP SYMPOSIUM

Development of Perforated Wear Component Design for Centrifugal Pumps

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The Perforated Design

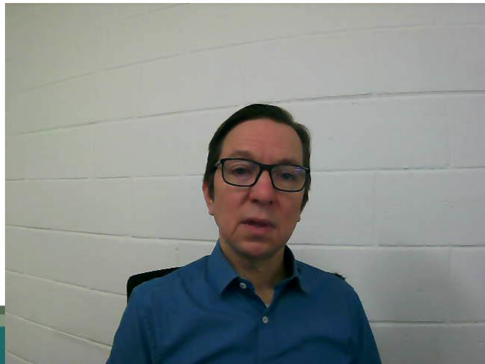
API610 Recommendations for Composite Materials

Table H.3 — Non-metallic wear part materials

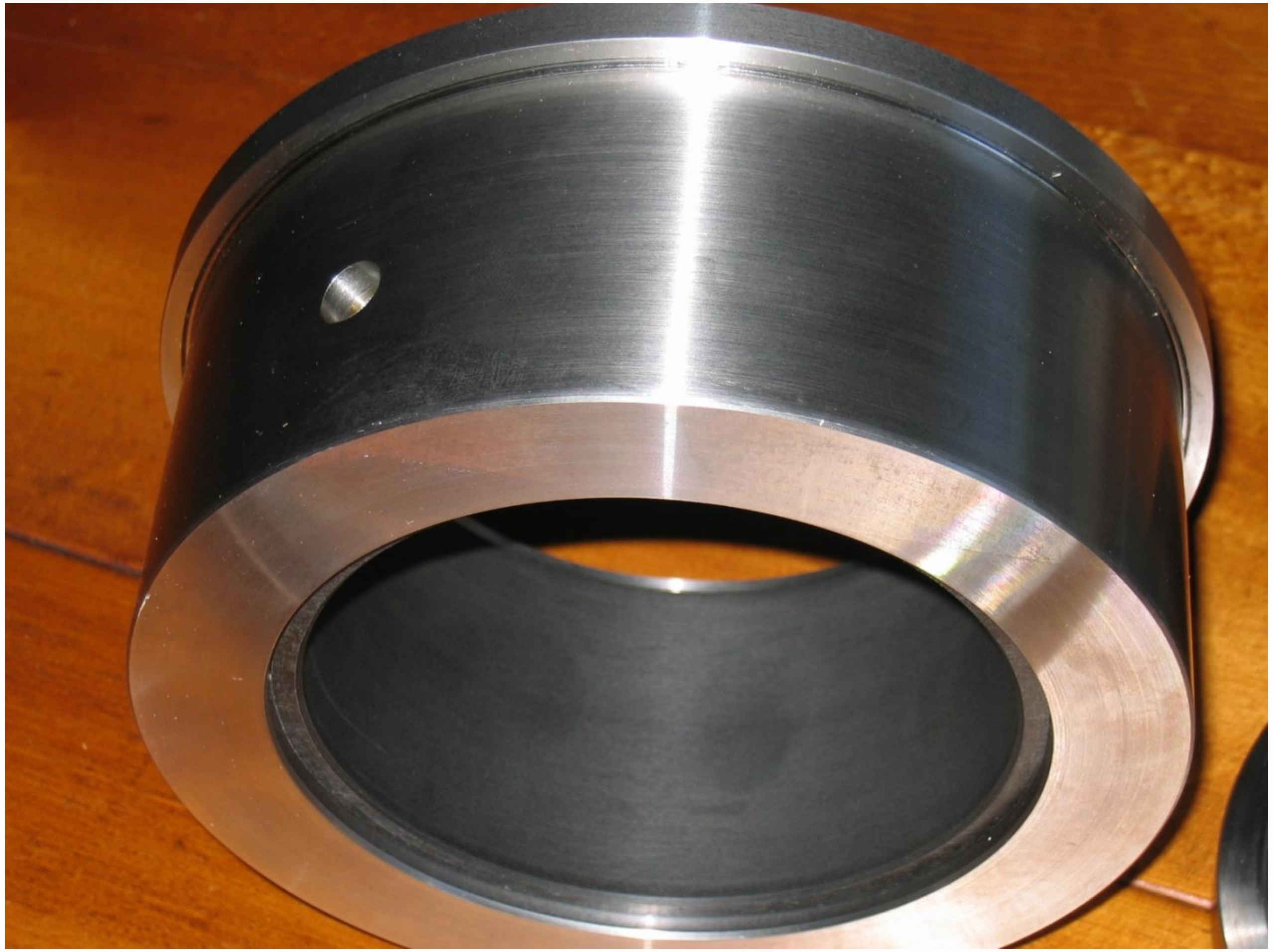
Material	Temperature limits °C (°F) min.	Temperature limits °C (°F) max.	Limiting pressure differential per wear part linear measure of 25 mm (1,0 in) kPa (bar; psi)	Application
Polyether ether ketone (PEEK) Chopped-carbon-fibre filled	–30 (–20)	135 (275)	2 000 (20; 300)	Stationary parts
Polyether ether ketone (PEEK) Continuous-carbon-fibre wound	–30 (–20)	230 (450)	3 500 (35; 500), or 14 000 (140; 2 000) if suitably supported	Stationary or rotating
PFA/CF reinforced composite 20 % mass fraction random X-Y oriented carbon-fibre	–46 (–50)	230 (450)	2 000 (20; 300)	Stationary parts
Carbon graphite				Stationary parts
Resin-impregnated	–50 (–55)	285 (550)	2 000 (20; 300)	
Babbitt-impregnated	–100 (–150)	150 (300)	2 750 (27,5; 400)	
Nickel-impregnated	–195 (–320)	400 (750)	3 500 (35; 500)	
Copper-impregnated	–100 (–150)			

Non-metallic wear part materials that are proven compatible with the specified process liquid may be proposed within the above limits. See 6.7.4 c).

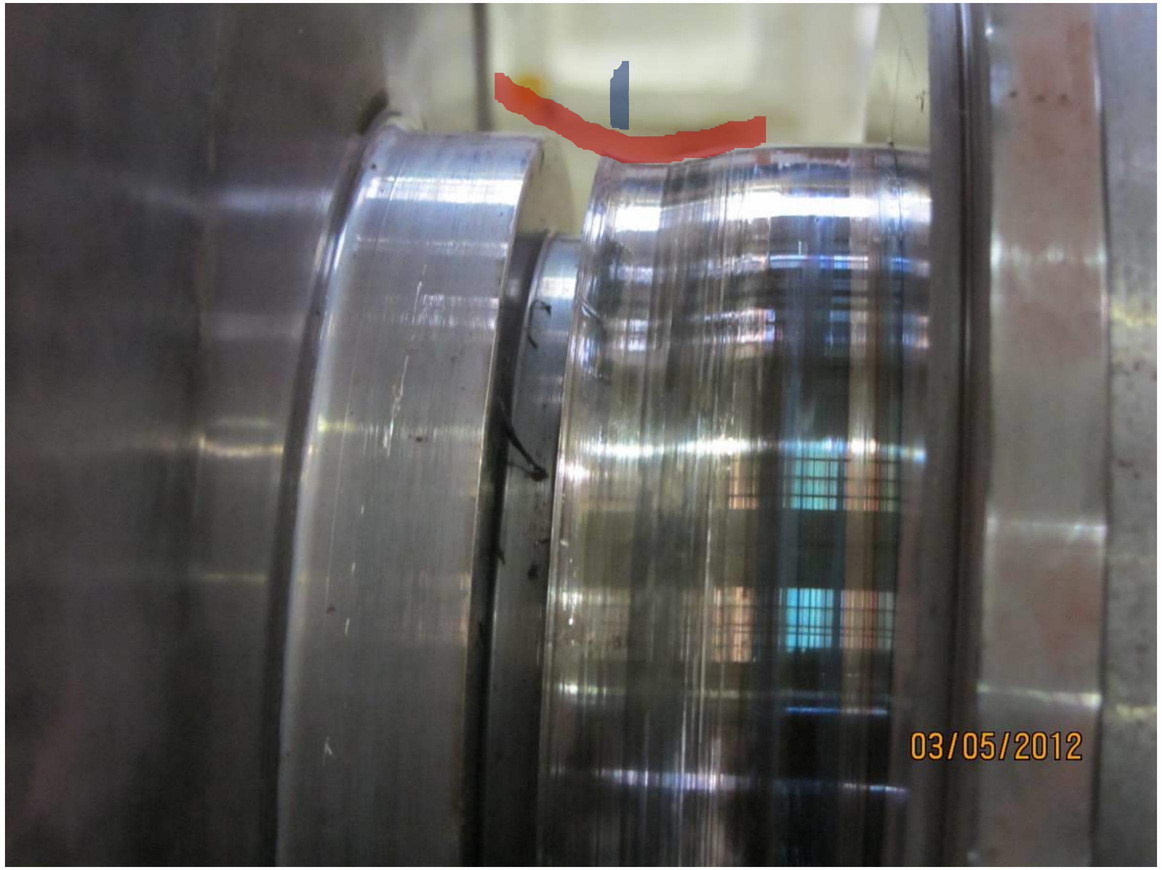
Such materials may be selected as wear components for mating against a suitably selected metallic component such as hardened 12 % Cr steel or hard-faced austenitic stainless steel. Materials may be used beyond these limits if proven application experience can be provided, and if approved by the purchaser.



What sets differential pressure limit?

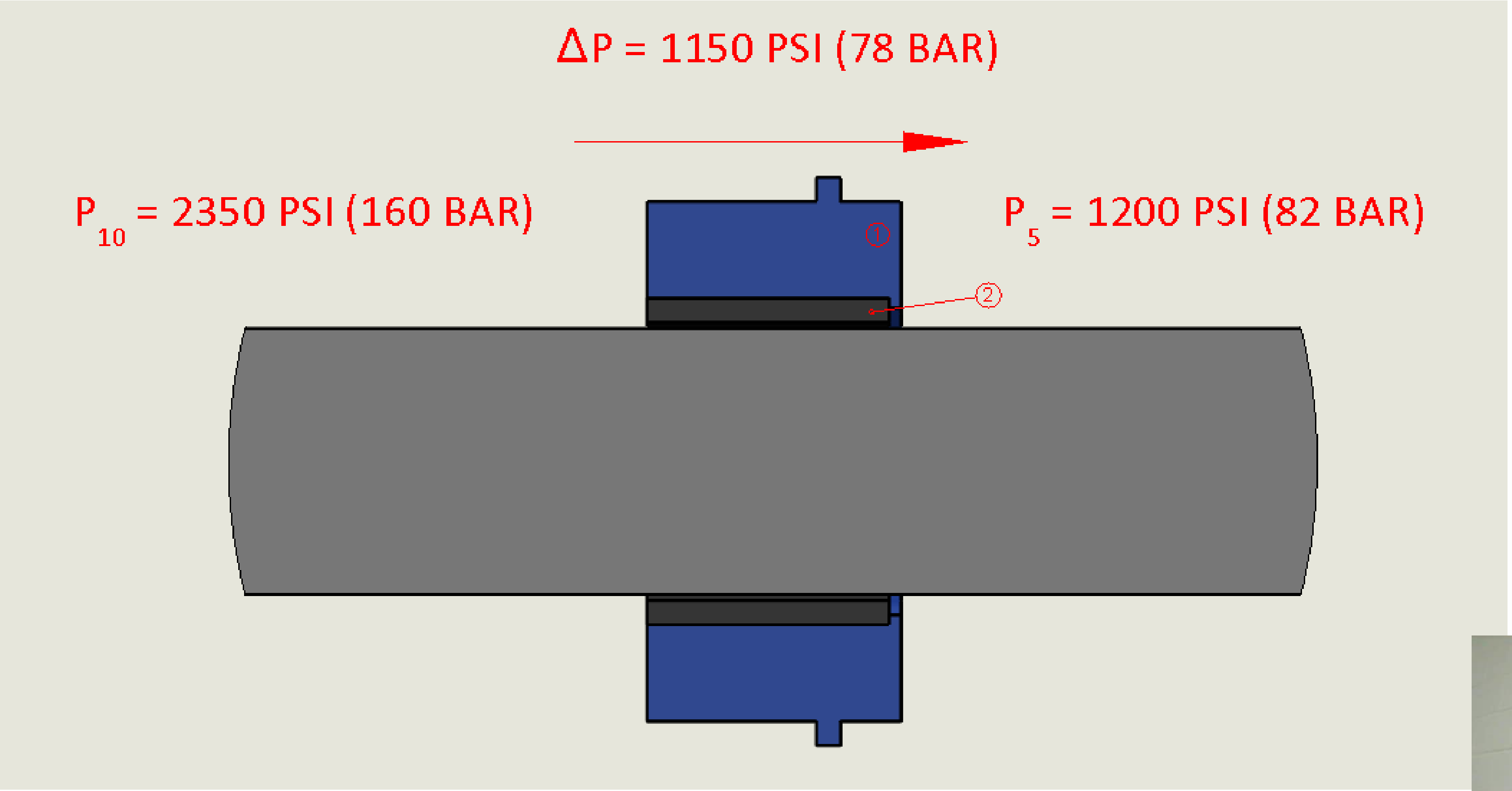


Sleeve of a center bushing operating within limits…

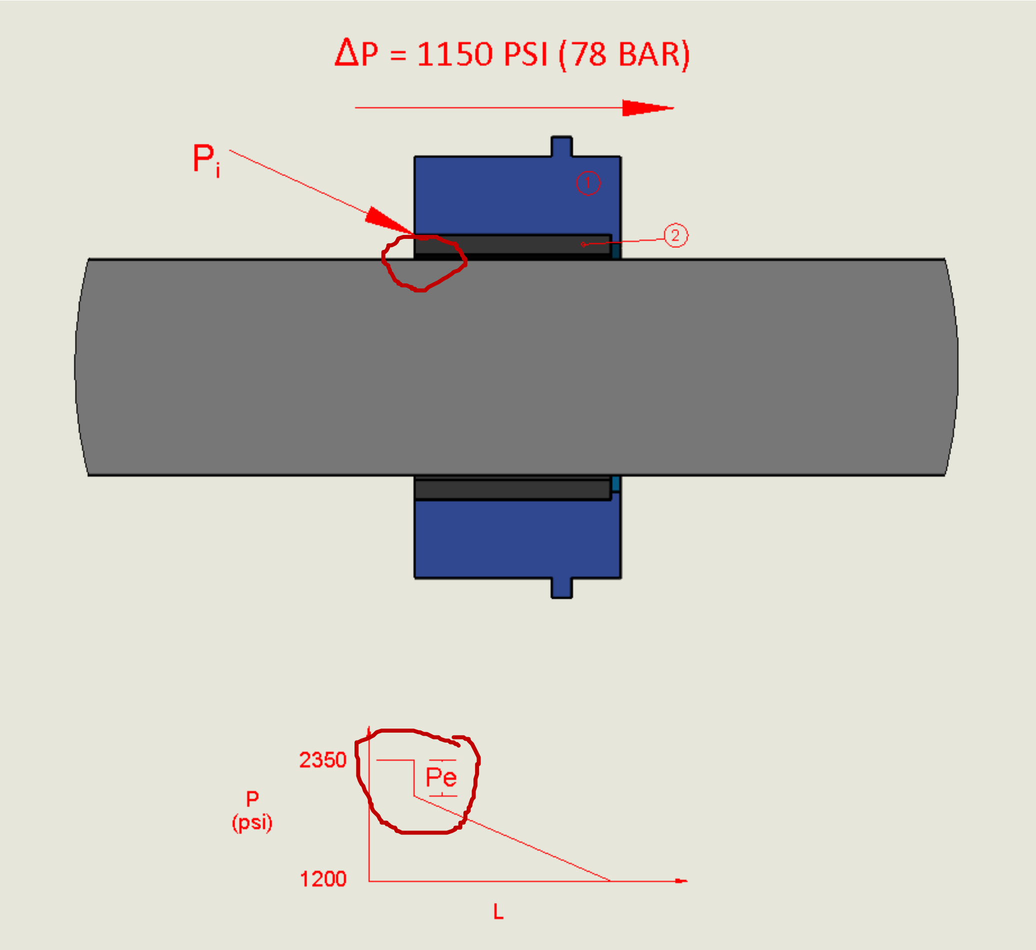


Why?

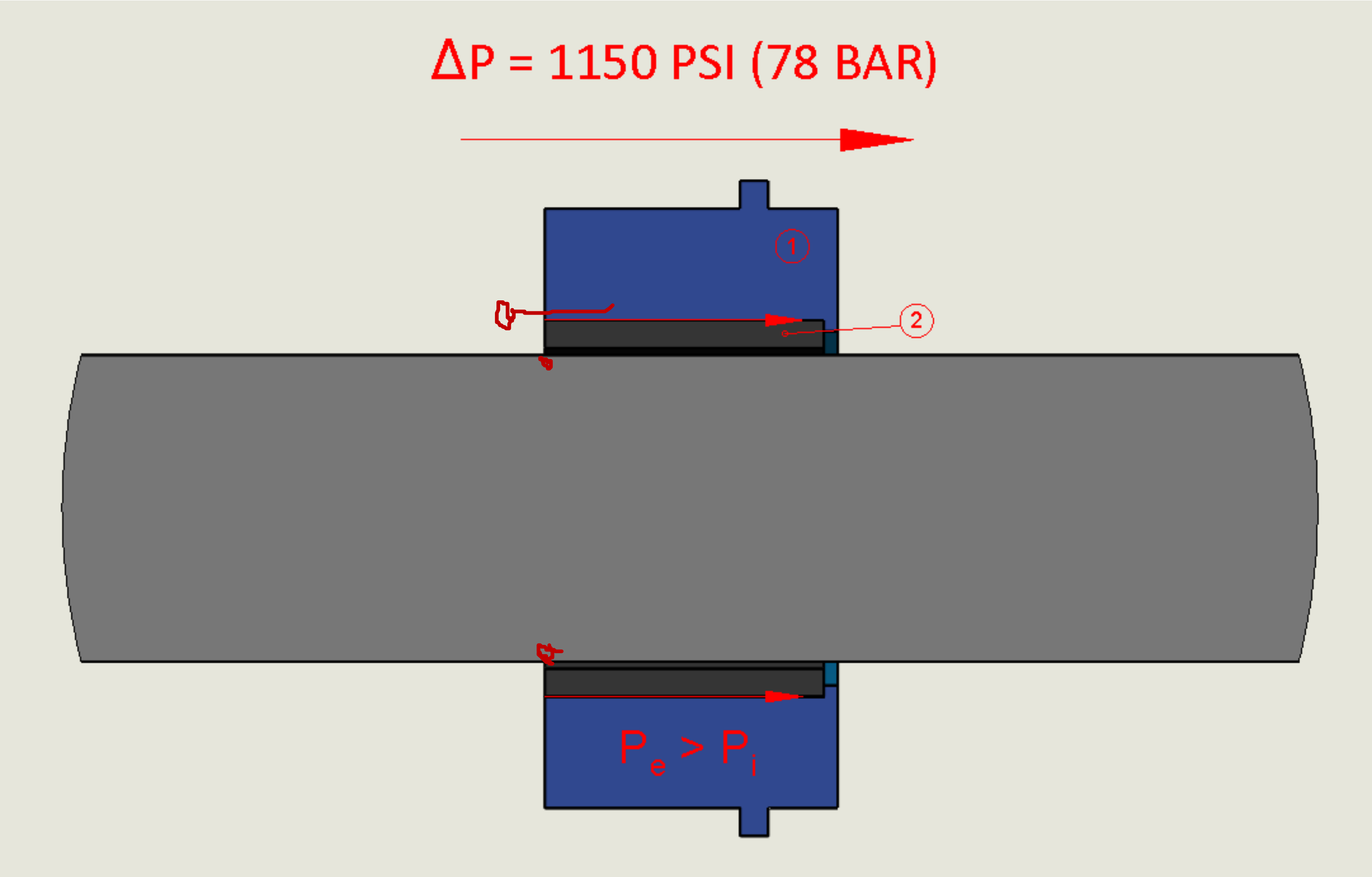
Understand how the pressure changes across the bushing



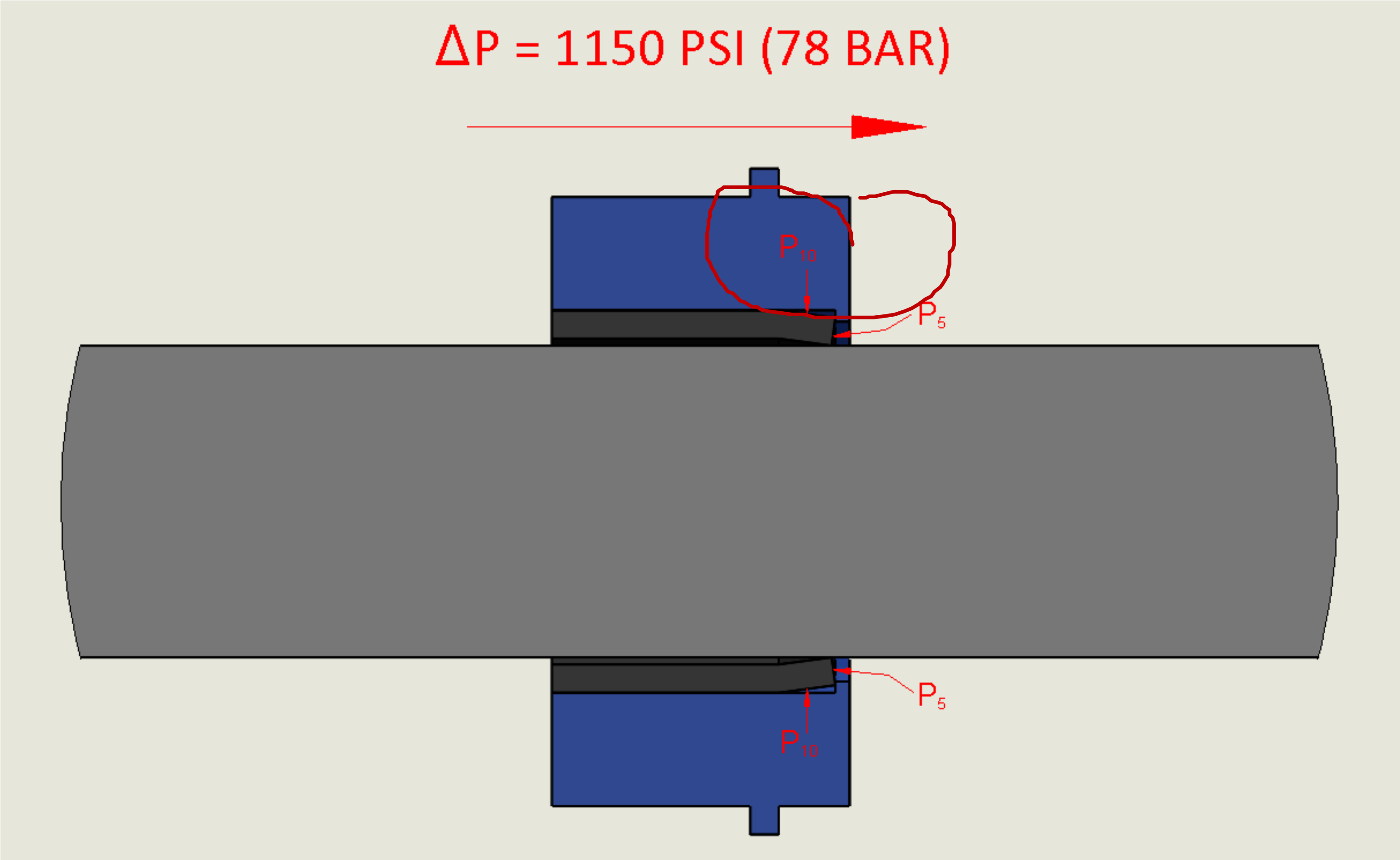
Press fit creates pressure (Pi) at O.D.
Entry pressure drop (Pe) offsets at I.D.



If Pe > Pi, liquid can enter the press fit interface

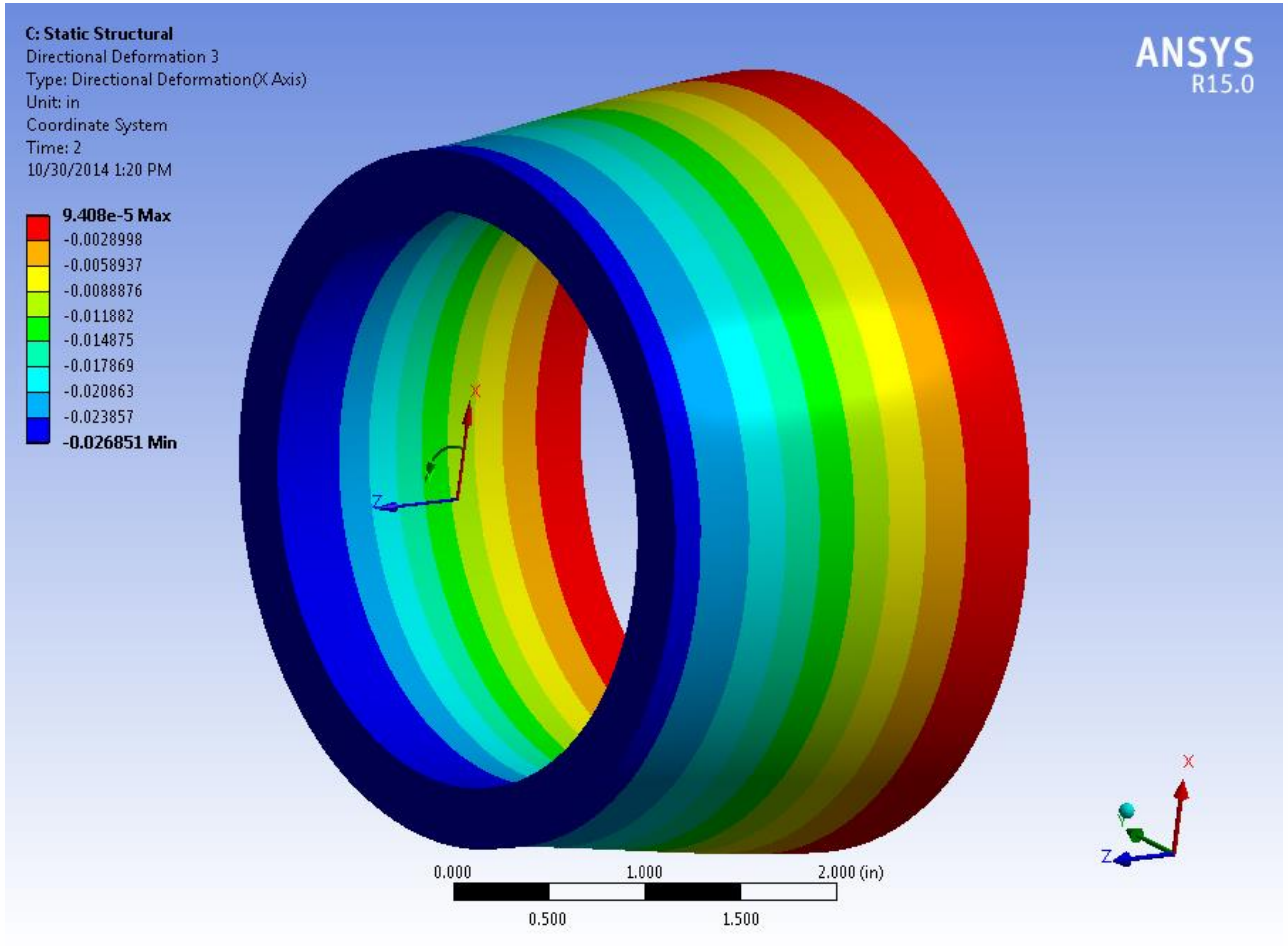


If this happens, a radial differential pressure develops and can deform the composite insert

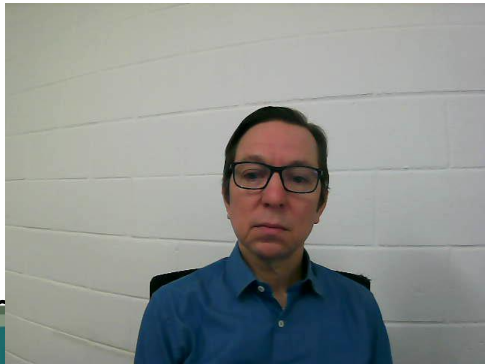


FEA Analysis

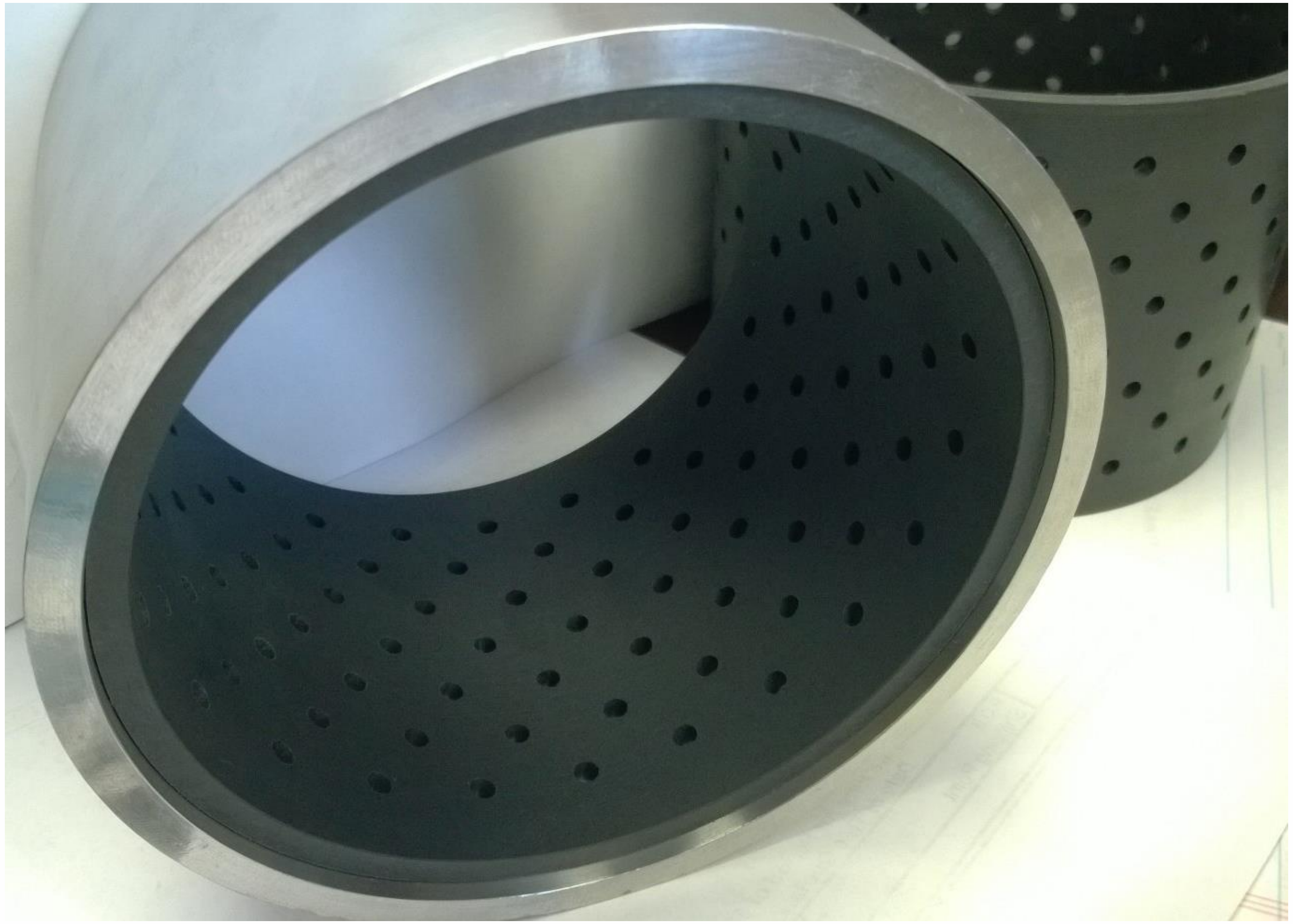
If Pressure Migrates Down the Press Fit Interface, the Model Deforms

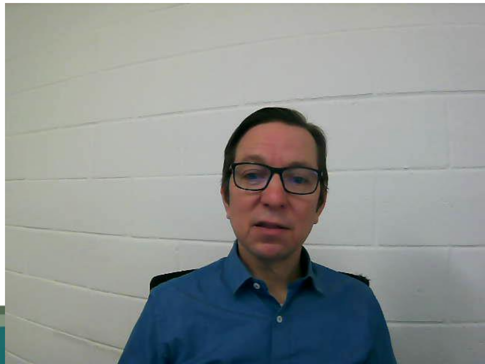


But what is the solution and will it wor

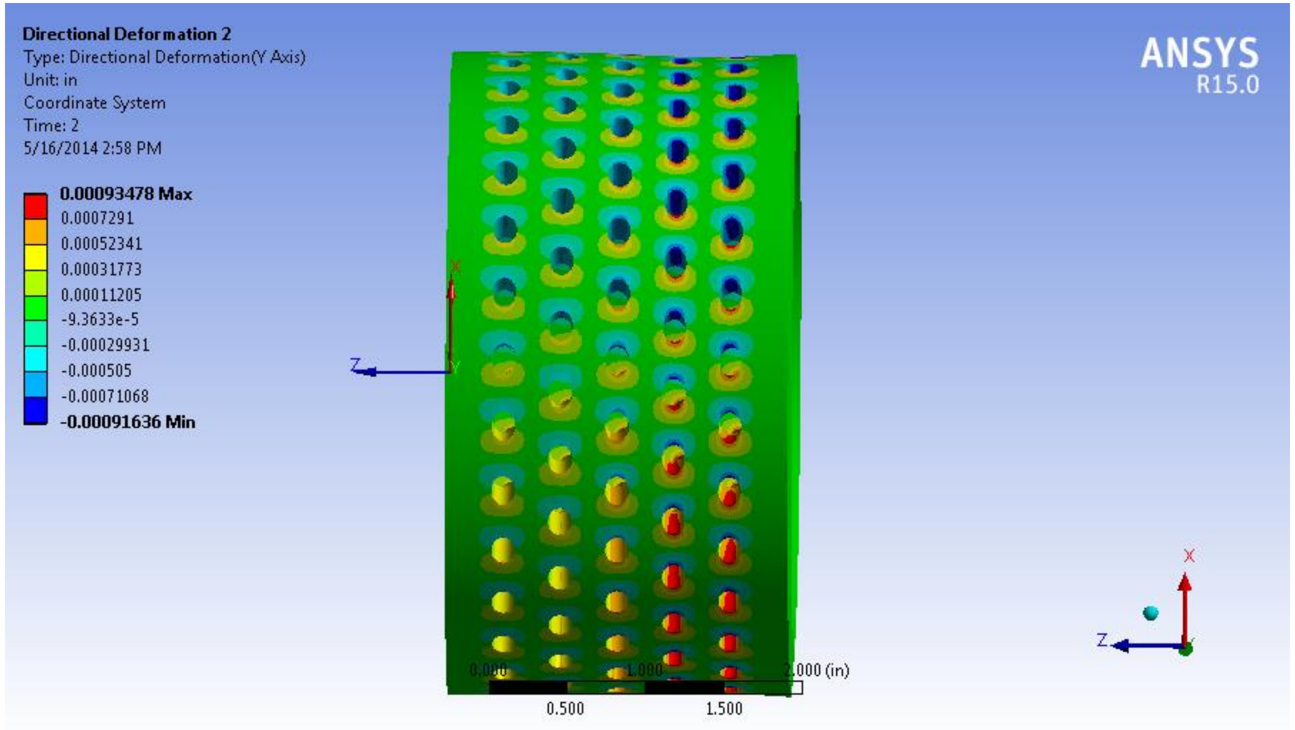


The Solution: Perforated Design

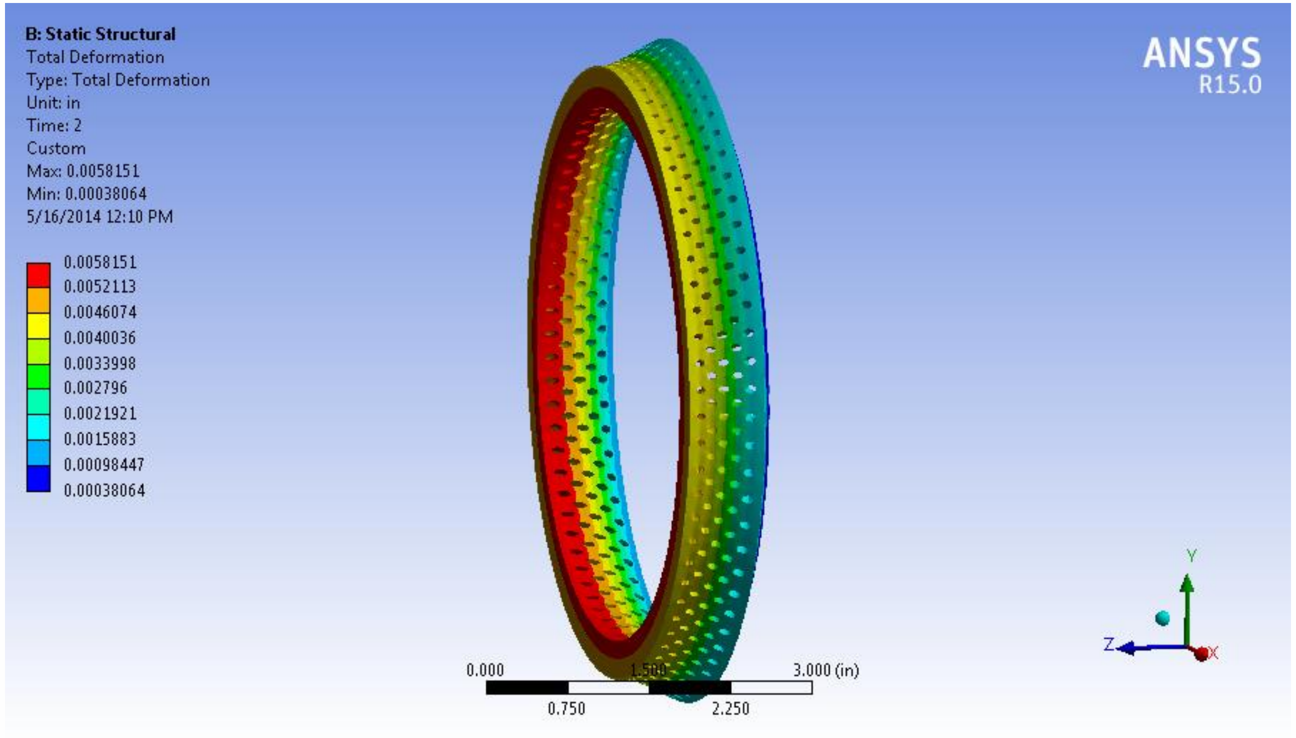




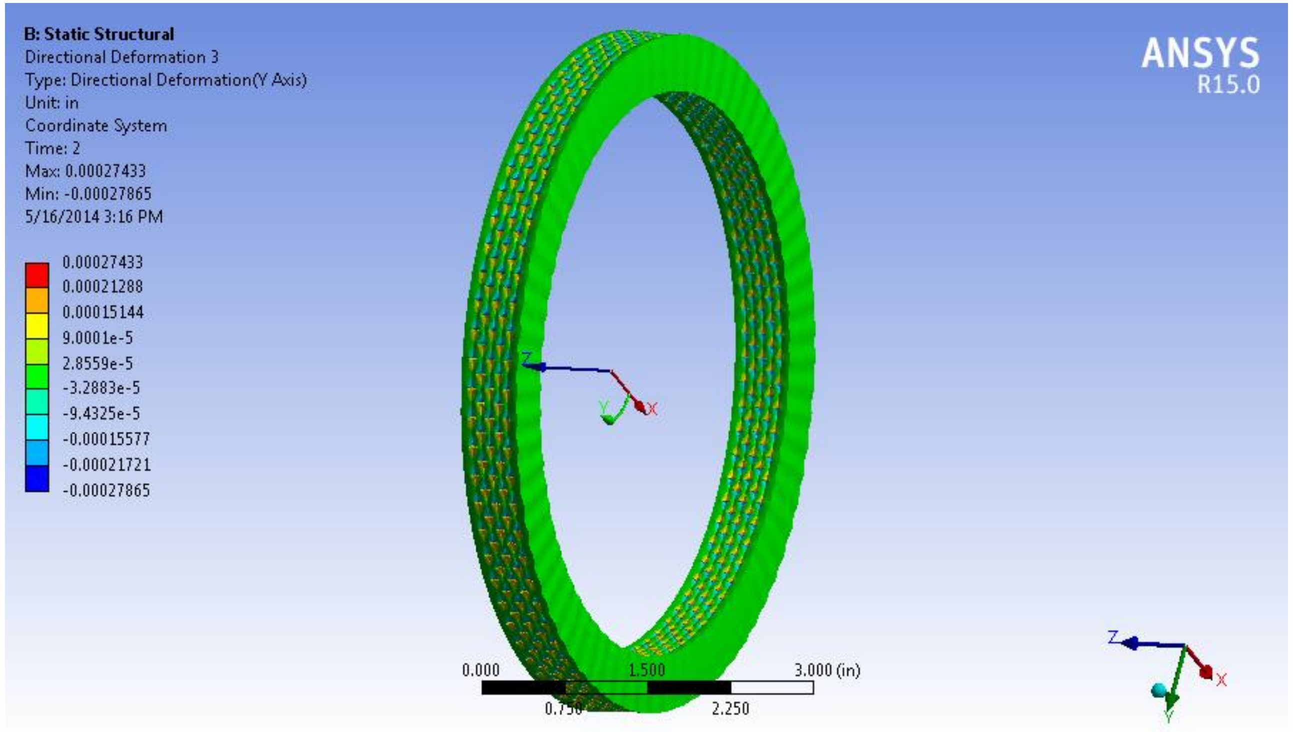
With Perforations,
Minimal Deformation



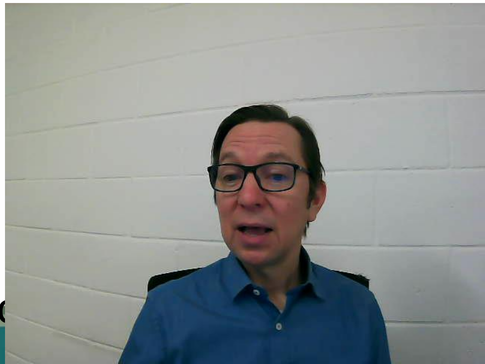
The Same Applies to Wear Rings



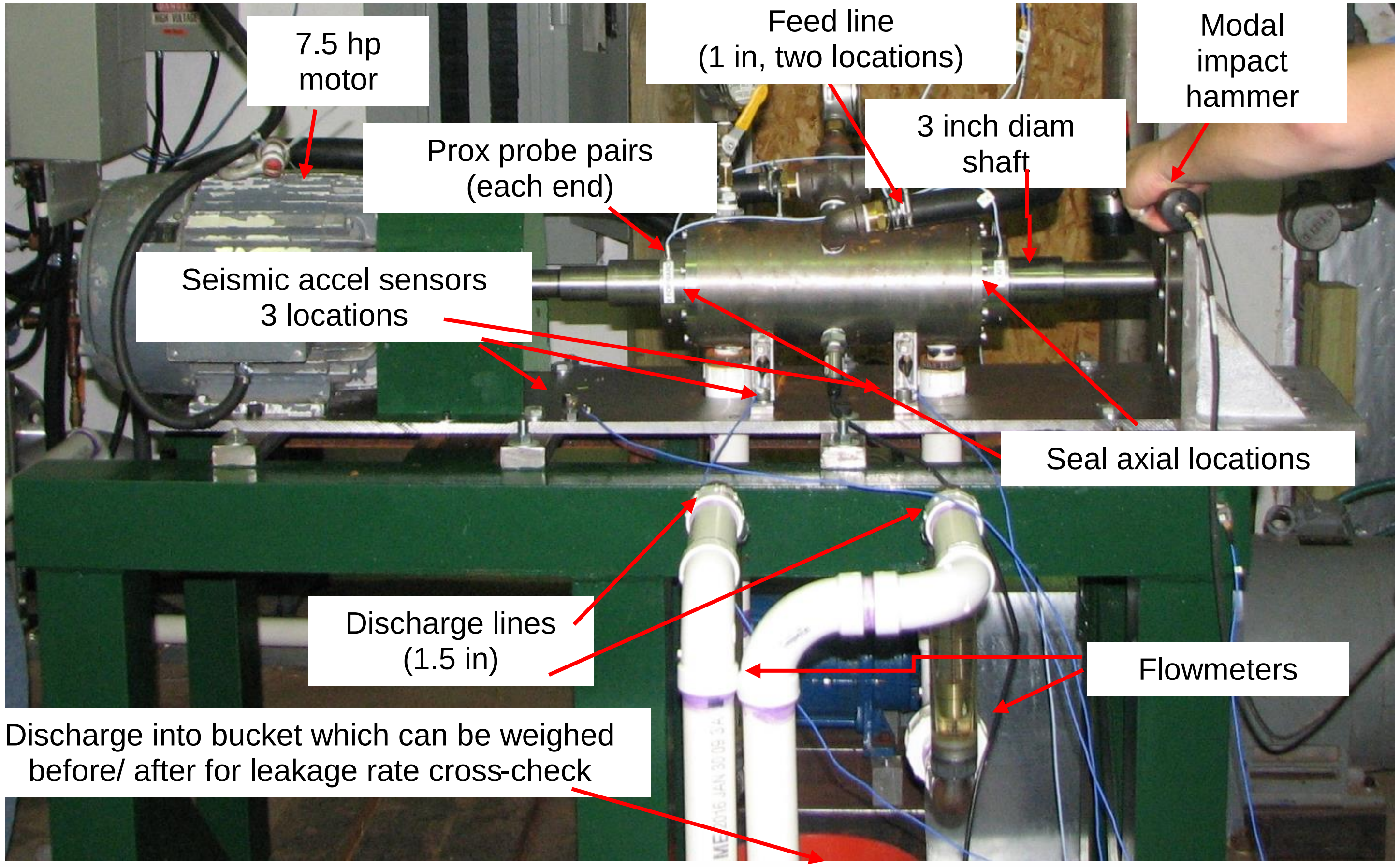
Deformation is Minimized with Perforations



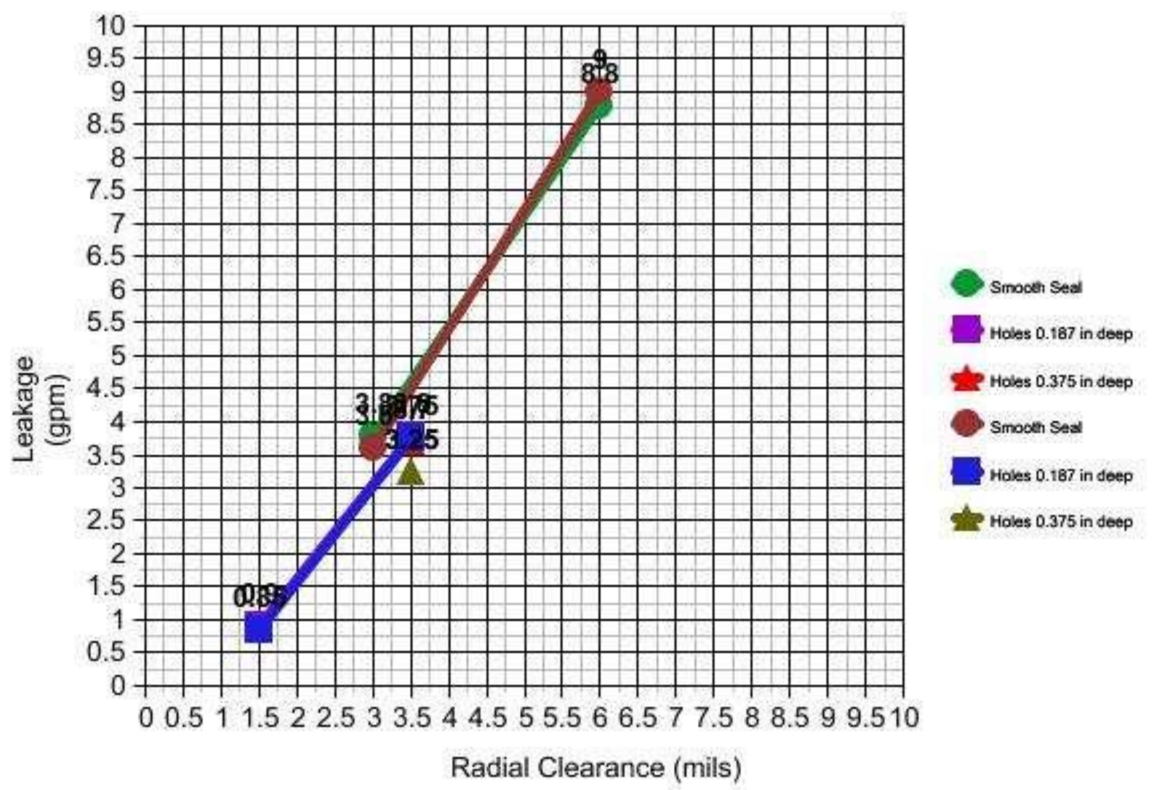
But does the design affect pump performanc



Custom Test Rig for Leakage and Rotordynamic Response



Leakage Across Bushing Decreases with Clearance and Perforations



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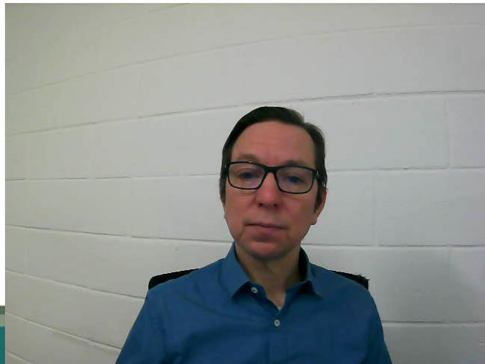
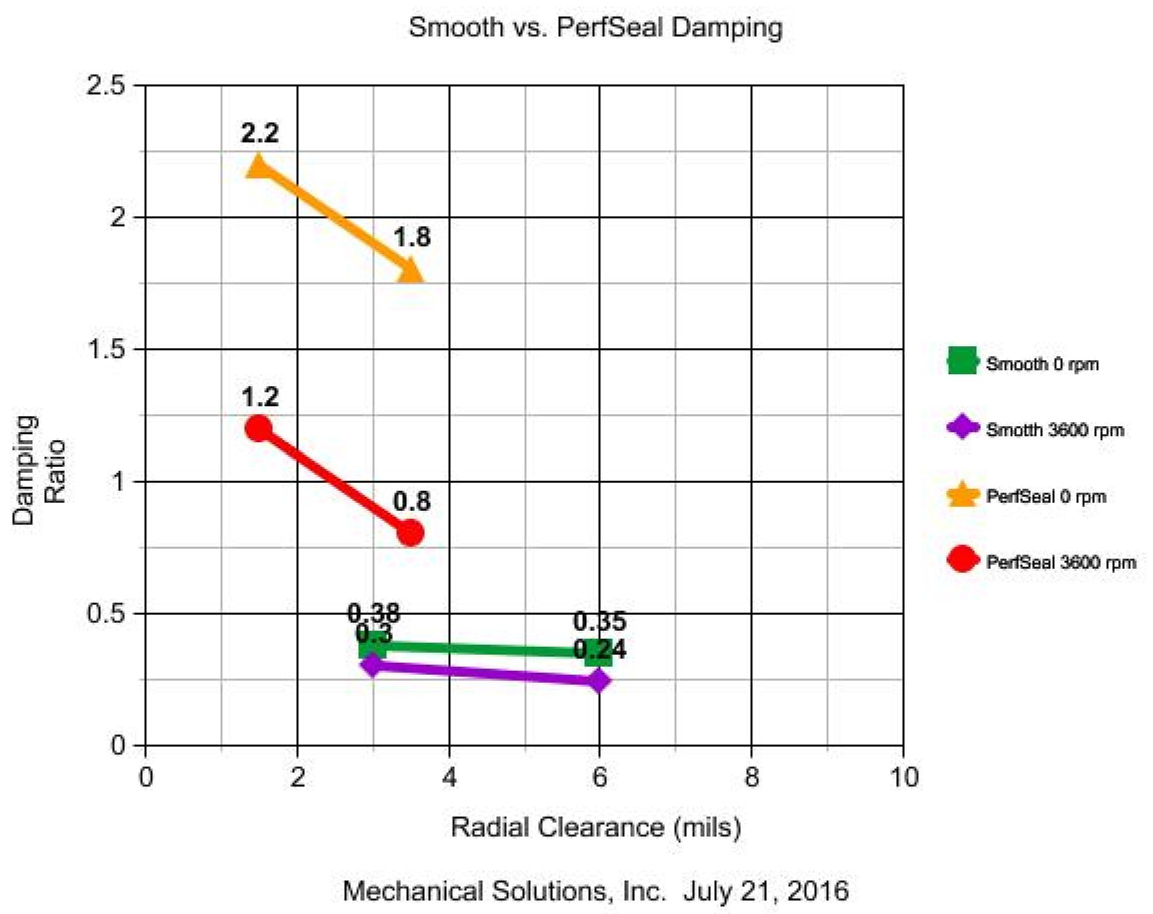
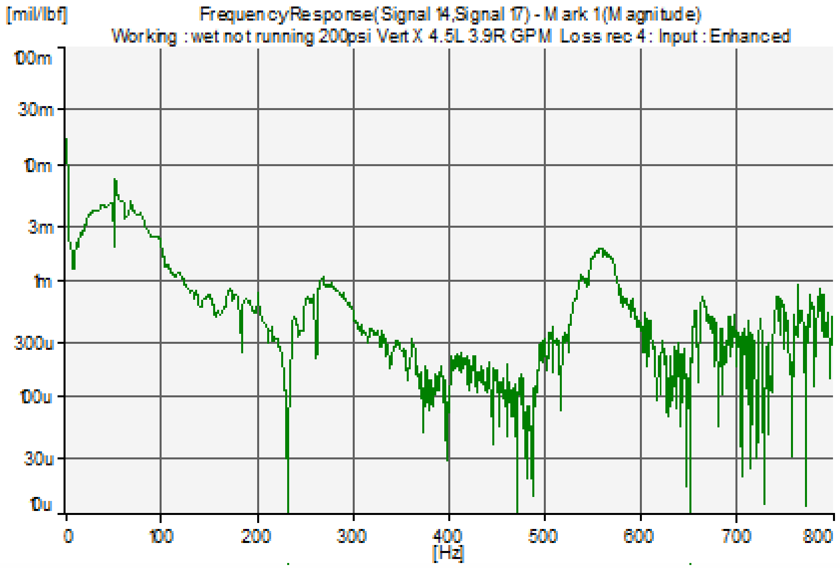


Damping Ratio Much Higher with Perforated Design

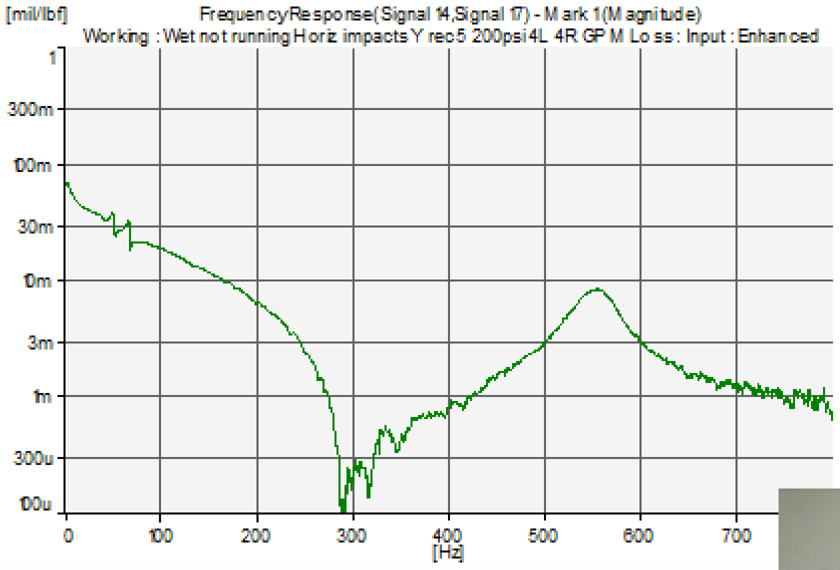


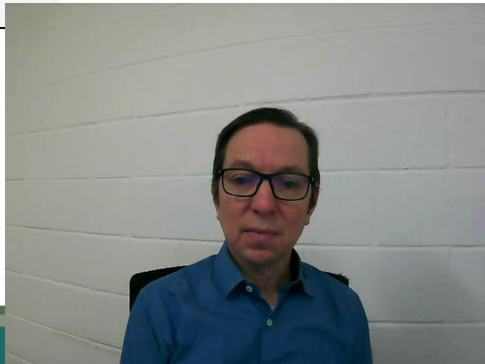
Frequency Response: Not Running

Smooth Bore



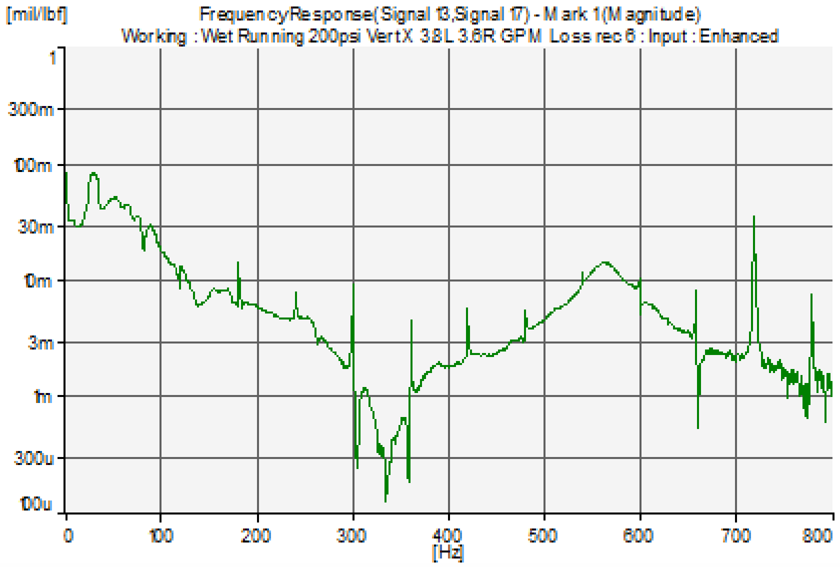
Perforated Design



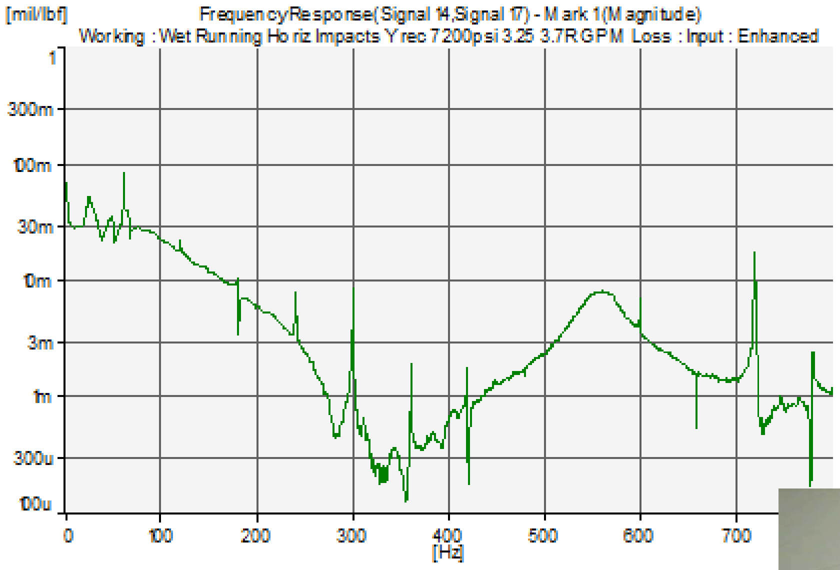


Frequency Response Running

Smooth Bore

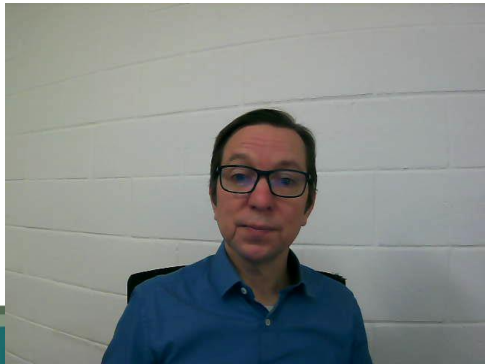


Perforated Design

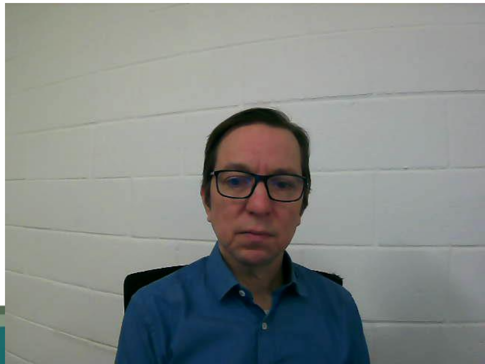


Summary of Rotordynamic Response

Damping ratio much higher with perforated design
No Significant loss of Lomakin stiffness with perforated design compared to smooth-bore components.
Low cross-coupled stiffness with perforated design.

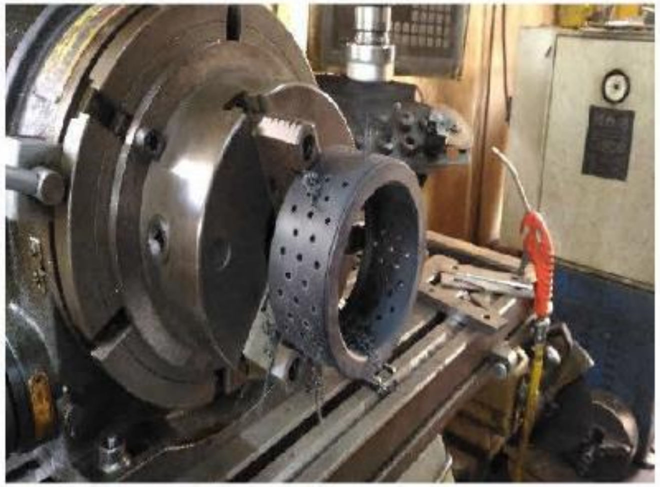


Case Study: Amine Stripping Pump

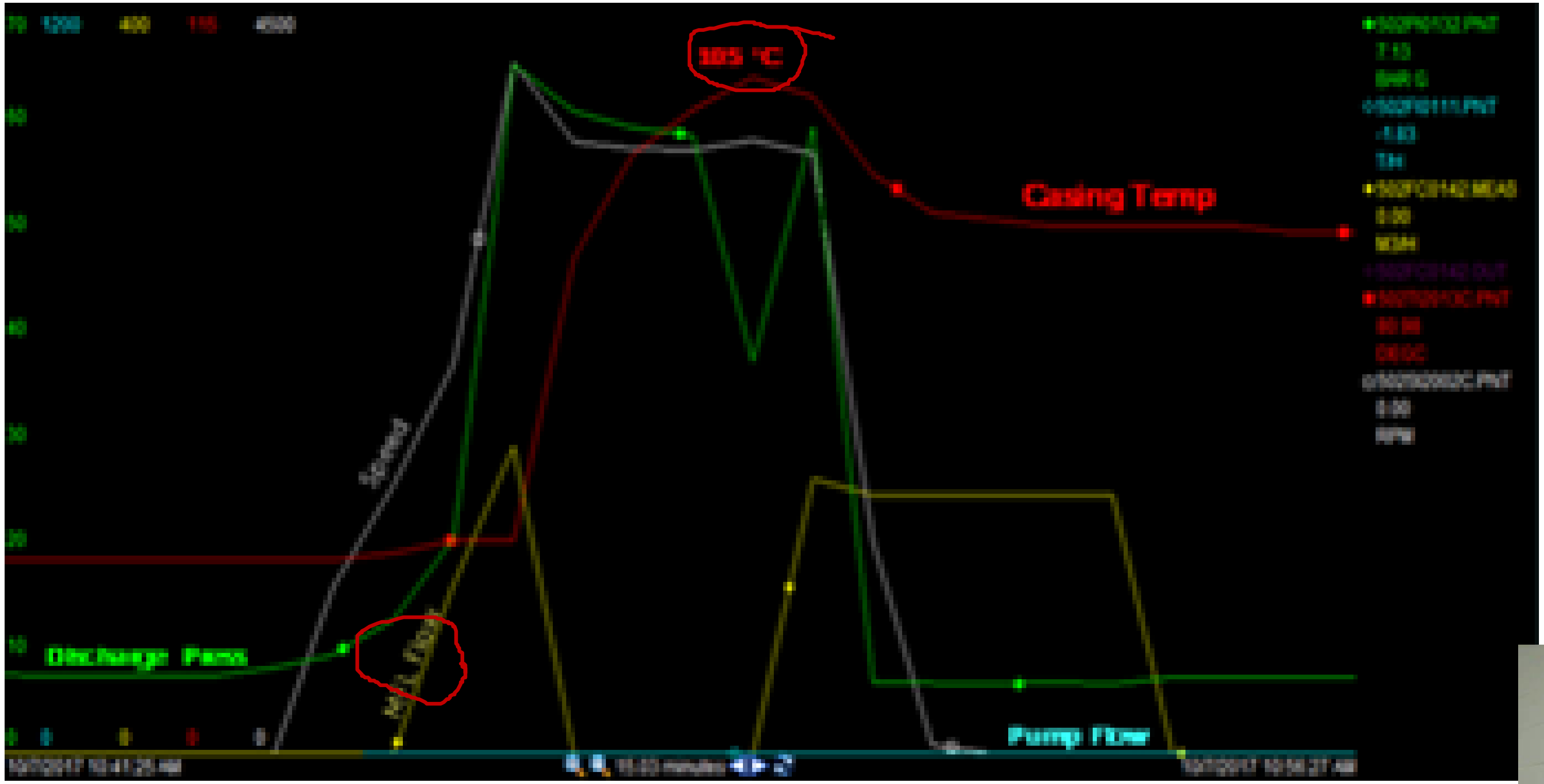


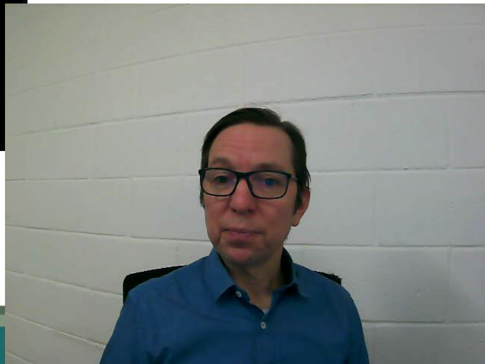
Metal Parts Seized

Upgraded Key Components to Perforated Design

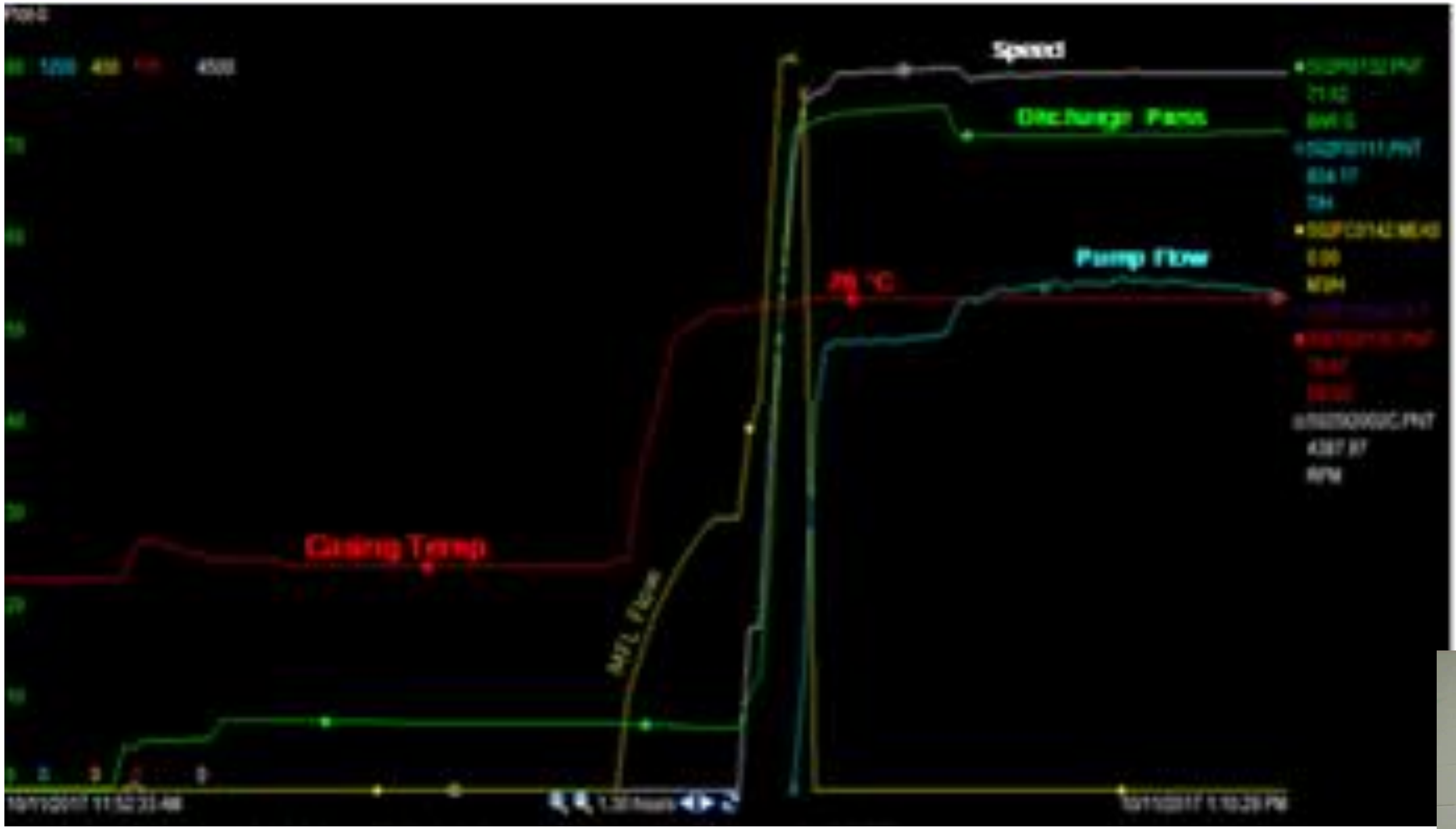


Initial Run After Upgrade

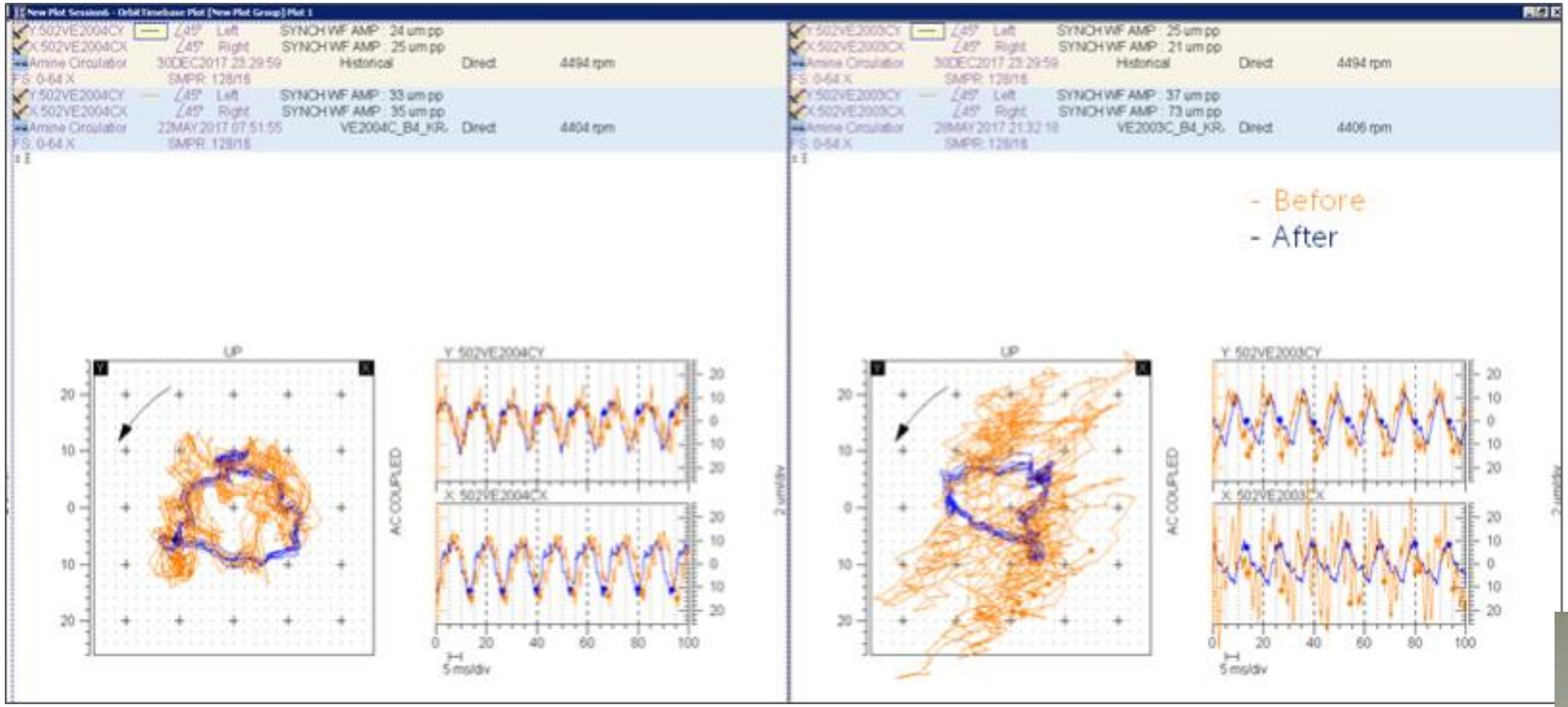


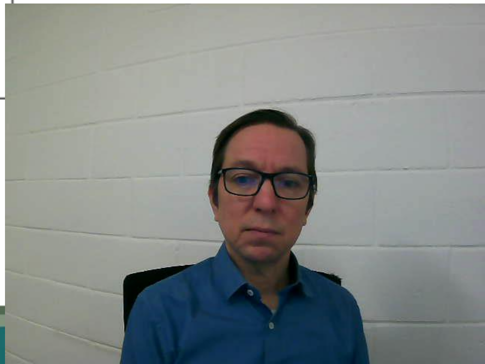


Second Attempt Successful

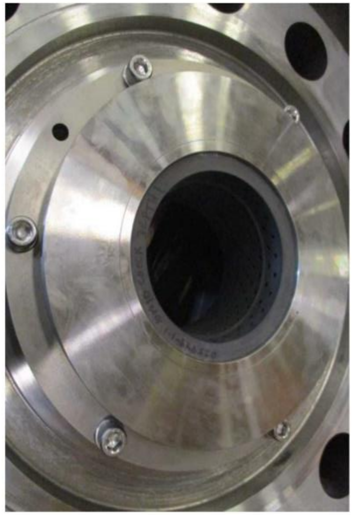


Vibration Significantly Reduced





Highest Pressure: 2600 psig (175 bar)
(557 psi/inch of length)







Conclusions

- Perforated design components can operate at higher differential pressures than plain components—and beyond limits set in API610 Table H.3.
- Response to differential pressure with the perforated design is more predictable and reliable
- Leakage across the components is reduced compared to smooth bore components
- The perforated design imparts significant rotordynamic benefits compared to smooth bore components

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QUESTIONS