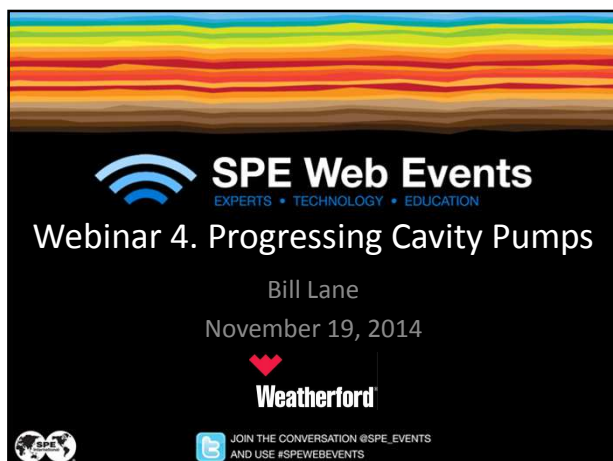








Presentation Outline

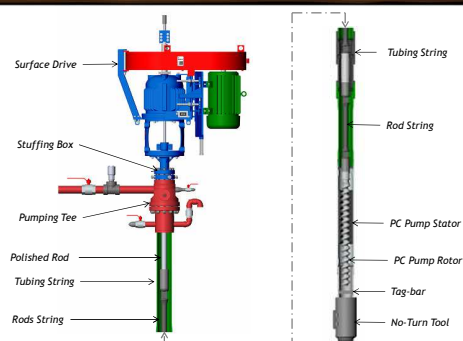
- Progressing Cavity Pump Systems
- Operating Envelope
- Special configurations
 - Insertable pumps
 - Charge pumps
 - Horizontal gas separator
 - Bottom drive pumps (ESPCP)
 - Elastomerless pumps (metal-to-metal)



SPE Web Events

#SPEWEBEVENTS

PC Pump System Configuration



SPE Web Events

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Weatherford®

Progressing Cavity Pumping System

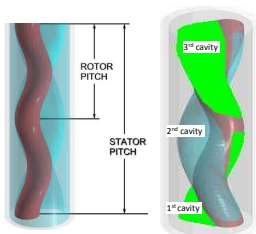


SPE Web Events

#SPEWEBEVENTS

Stator Pitch & Cavity Formation

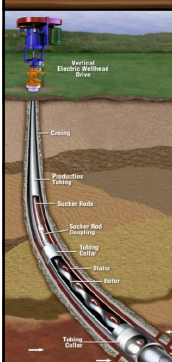
- Cavities are one stator pitch length (lobe to lobe)
 - Two cavities 180° apart in a 1:2 geometry pump
- One cavity starts where the other ends
- As one cavity closes another opens
- Constant cross-sectional area that results in a non-pulsating flow.



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PCP Current Ranges of Application



	Typical Range	Maximum*
Operating Depth	2,000' – 6,000' TVD	8,600' TVD
Volume	5 – 2,500 BPD	>5,000 BPD
Temperature	75 – 150 °F	300 °F
Well Deviation	15°/100 feet (30m)	
Corrosion	Excellent (regarding pump)	
Gas Handling	Good	
Solids Handling	Excellent	
Fluid Gravity	Below 45 °API (depends on aromatics)	
Svc and Repair	Workover or Pulling Rig	
Prime Mover	Electric Motor or Gas Engine	
Offshore	Limited	
Total Efficiency	50% to 75% (up to 90%)	



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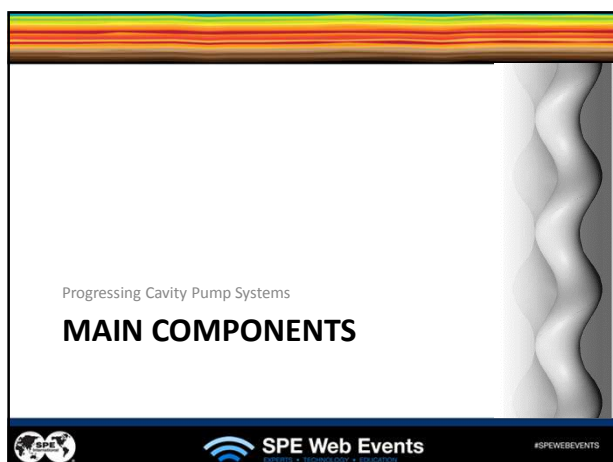
Typical PC Pump Applications

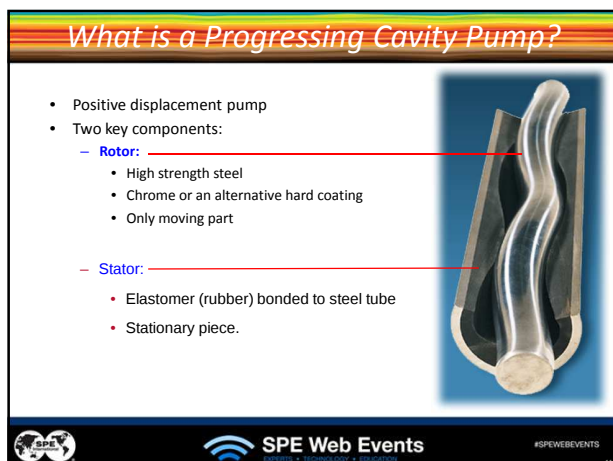
- Land Applications (and limited offshore)
- Heavy, medium, light oil with low CO₂, H₂S, BTX
- Sand and particulate matter
- Lifting from low pressure reservoirs
- Temperature ≤ 300°F
- Depth ≤ 8600 ft
- In markets with skilled service resources
- Offshore above deep-set SSSV

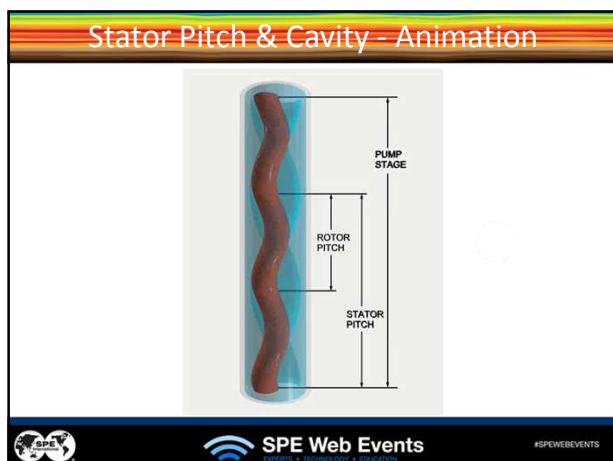


SPE Web Events

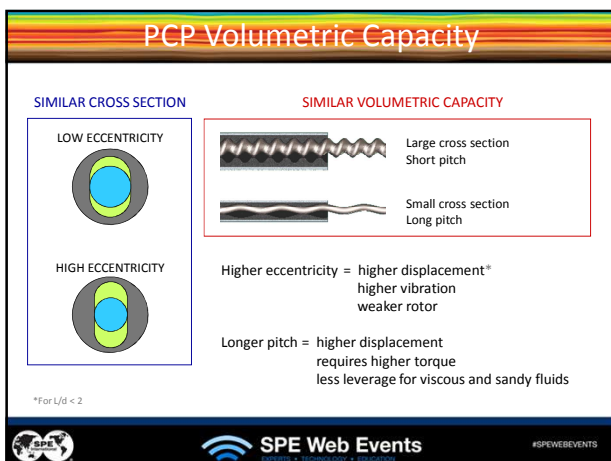
#SPEWEBEVENTS

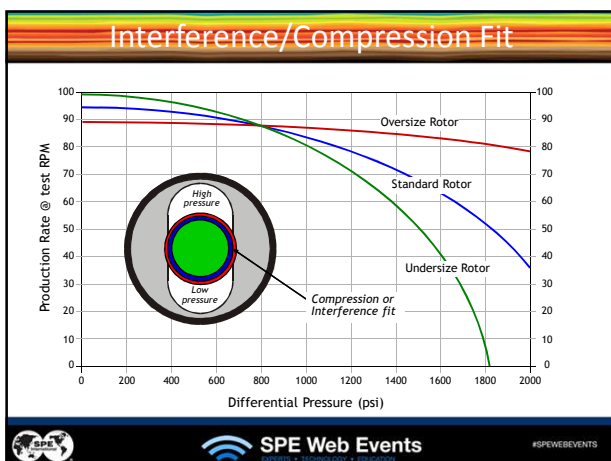


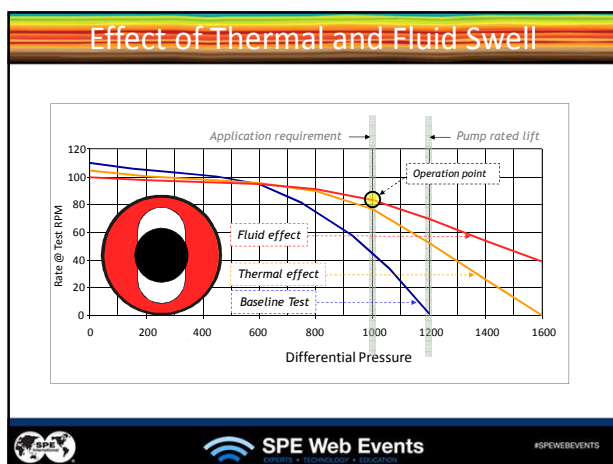


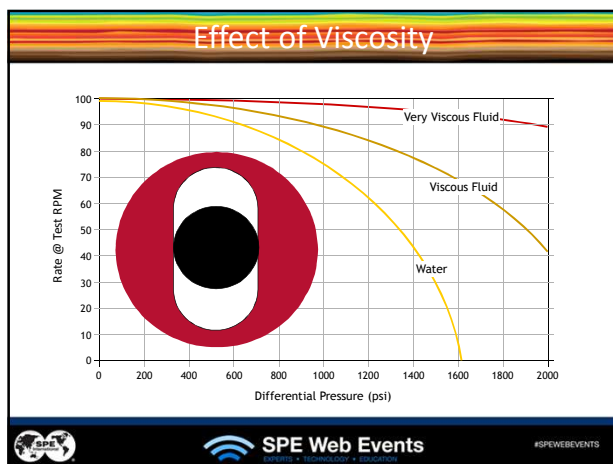












Not all PC pumps are equal...

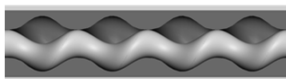
What can we do to increase pump run life?

SPE Web Events
#SPEWEBEVENTS

Not all PC pumps are equal...

What can we do to increase pump run life?

1. Longer pump, more pump cavities
2. Longer pump with fewer cavities
3. Larger diameter pump turning slower
4. Smaller diameter pump turning faster
5. Allow more fluid "slippage"
6. Allow less fluid "slippage"



SPE Web Events

#SPEWEBEVENTS

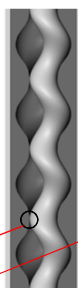
Not all PC pumps are equal

To increase run life:

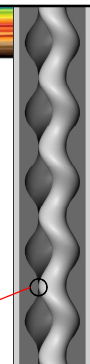
- Add pump cavities (adjust pitch and/or length)
- Increase displacement and reduce speed
- Decrease interference fit

0.010" interference fit

0.005" interference fit



200 BPD/100 rpm
@ 4100 ft rating



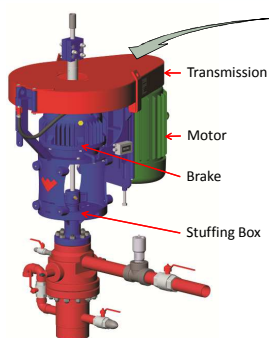
200 BPD/100 rpm
@ 5200 ft rating



SPE Web Events

#SPEWEBEVENTS

Surface PC Drive



Basic configurations:

- Direct Drives (belted)
- Geared Drives
- Hydraulic Drives

Typical operating speeds

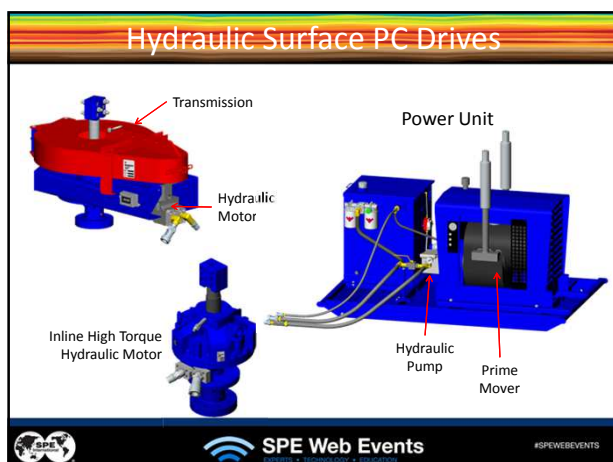
Heavy Oil: 100 to 200 rpm

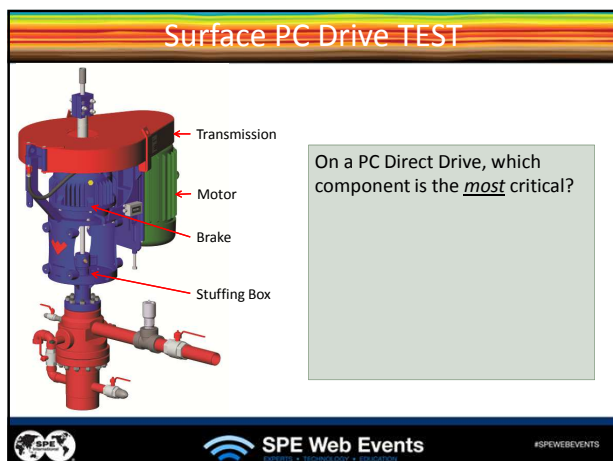
Water: 250 to 400 rpm

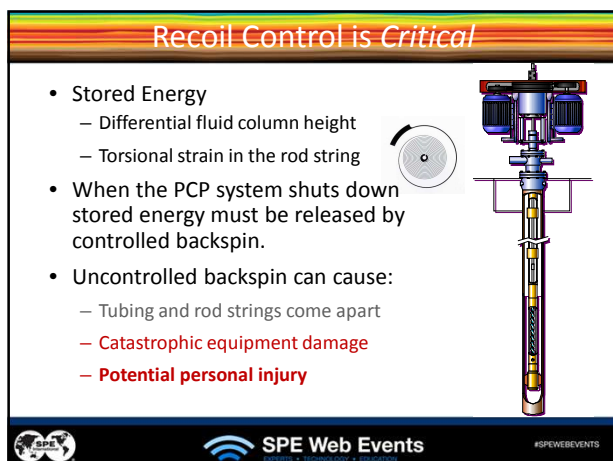


SPE Web Events

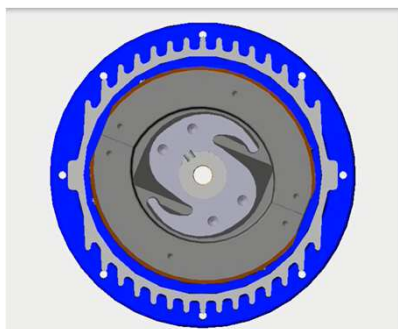
#SPEWEBEVENTS







Surface PC Drive *Centrifugal Brake*



SPE Web Events

#SPEWEBEVENTS

Progressing Cavity Pump System

OPTIMIZATION



SPE Web Events

#SPEWEBEVENTS

Motor Controller



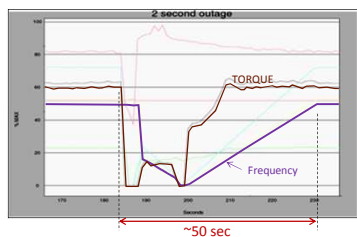
- Fixed Speed Controller
 - Motor-load or torque shut down
 - Some capable of auto-restart
 - Low cost alternative
- Variable Speed Controller
 - Full automation and control
 - External inputs (P, T, flow, etc.)
 - Remote communication/control
 - Typically a high cost solution



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Automatic Restart Systems



- Decelerate backspin speed
- Resume forward rotation
- Controlled acceleration to preset speed
- Reduced stress on mechanical components



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#SPEWEBEVENTS

PCP Systems Advantages

- Effective for *high* viscosity fluids (up to 100,000 cp)

Viscosities of Common Liquids

Liquid	Viscosity [cP=mPa.s] @ 20°C
Water	1
Motor Oil SAE 40	200
Glycerin	1,400
Honey	10,000

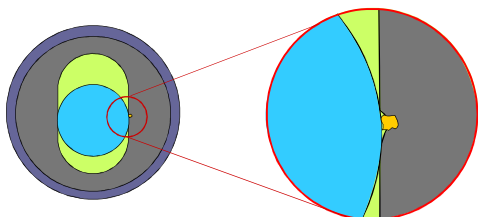


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#SPEWEBEVENTS

PCP Systems Advantages

- Excellent abrasion resistance (sand cuts up to 60% v/v)
 - Abrasion-resistant coating on the rotor
 - Soft elastomer surface in the stator



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PCP Systems Advantages

- Positive displacement, rotary motion
 - High efficiency
 - Low operating cost
 - Low system cost
 - Simple, few moving parts
 - Reliable
 - Low maintenance
 - Strong drawdown



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PCP Systems Advantages (Cont.)

- No valves or reciprocate parts so ***no gas locking***



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#SPEWEBEVENTS

PCP Systems Advantages (Cont.)

- Low fluid velocity + low turbulence = ***low emulsions***



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PCP Systems Advantages (Cont.)

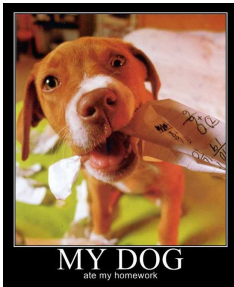
- **Green** technology
 - Constant energy demand
 - Low profile
 - Low noise



  #SPEWEBEVENTS

There is one “but” for PCP systems...

If you don't do your homework...



  #SPEWEBEVENTS

There is one “but” for PCP systems...



It is the least forgiving artificial lift method!

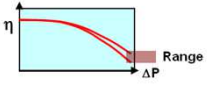
  #SPEWEBEVENTS

What is the "homework"?

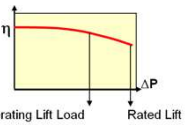
1 Elastomer compatibility test



3 Determine target test bench efficiency = $f\{\text{swelling and thermal expansion}\}$



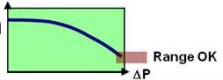
2 Establish target efficiency and load (% of rated lift) for downhole conditions



4 Calculate rotor size to produce desired fit and efficiency



5 Bench test verification



#SPEWEBEVENTS

PCP Limitations

- Limitations of elastomers and bonding systems
 - Aromatic gases (benzene, xylene, toluene)
 - CO₂ and H₂S
 - Hot water (corrosion at the elastomer-tubing interface)
 - High temperatures (elastomer overcure)
- Limitation of rods
 - Depth < 8700 ft (axial + torsional forces overstress rods)
 - Rod-tubing wear in deviated well bores
 - Use offshore (rods inhibit operation of subsurface safety valves)



#SPEWEBEVENTS

Progressing Cavity Pump Systems

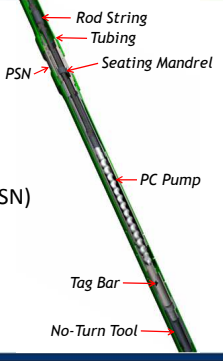
SPECIAL CONFIGURATIONS



#SPEWEBEVENTS

Insert PC Pumping System

- Run and retrieved on rod string
 - Seating mandrel
 - PC pump
 - Tag bar
 - No-turn tool
- Lands in pump seating nipple (PSN)

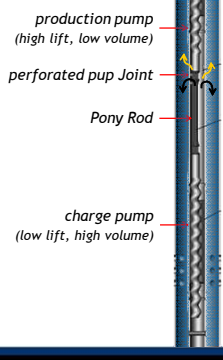


Labels in diagram: Rod String, Tubing, PSN, Seating Mandrel, PC Pump, Tag Bar, No-Turn Tool

SPE Web Events #SPEWEBEVENTS

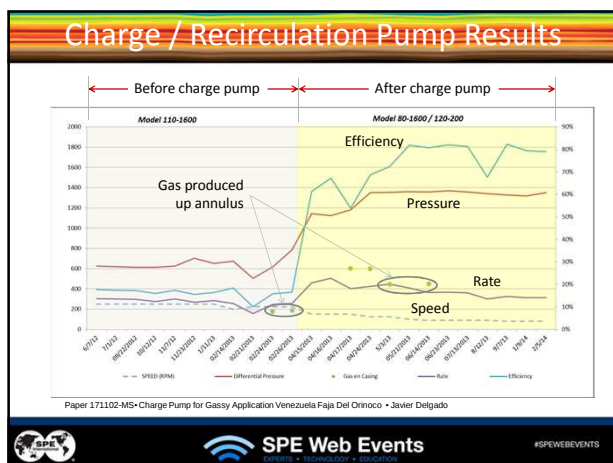
Charge / Recirculation Pump

- Tandem PC pump configuration
- Excess fluid from lower pump **recirculates** through a perforated pup joint
 - Sand stays in solution
 - Gas in excess fluid gravity separates in annulus
- Lift efficiency increases

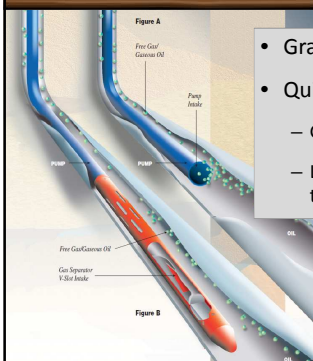


Labels in diagram: production pump (high lift, low volume), perforated pup joint, Pony Rod, charge pump (low lift, high volume)

SPE Web Events #SPEWEBEVENTS



Gravity Orienting Horizontal Gas Separator



- Gravity oriented bottom intake
- Quiet volume in separator
 - Gas rises and exits slots
 - Liquid falls and enters a channel to the pump intake



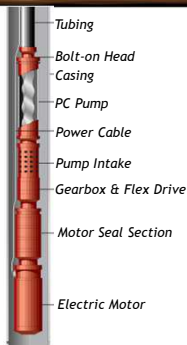
SPE Web Events

#SPEWEBEVENTS

Bottom Drive PCP System

(ESPCP or Downhole Driven PCP)

- Eliminates rod string problems
 - Tubing and rod string wear
 - Flow restrictions
- A **gearbox** reduces motor speed and increases torque
- A **flex-shaft** between the pump and gearbox absorbs the eccentric motion of the PC rotor
- Much higher cost than conventional PC pump systems



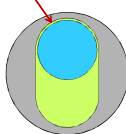
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Elastomerless PC Pump

(Metal-to-Metal)

- Metallic stator profile
- Hydrodynamic seal between rotor and stator
- Applications
 - High temperature (SAGD)
 - Severe aromatic gasses
- Challenges:
 - Solids handling capability
 - Sensitive to changes in viscosity
 - Cost is much higher than conventional PC Pumps



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