

# Testing Gas Lift Equipment for Offshore Applications Proves Synergistic to Land Based Applications Steve Long Weatherford International

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# Improvements from deepwater testing

- API 19G2 1<sup>st</sup> Edition 2010
- Bellows Testing
  - Life Cycle
  - Differential Submergence
- R value testing
  - At what dome pressures will the R values become distorted?
- Chatter Testing
  - Dampening system designs
  - Dampening Fluids
- Check Testing

– Pressure and temperature confirmation of specific seal designs







## What is a Bellows?

- Expansion joint made by forming convolutions into a metal tube
- Bellows exhibit a characteristic of flexible-rigidity.
- Pressure vessels that convert changes in internal/external pressure into an applied force.
- Bellows deflect in response to an applied force and exert a reactive force.
- Bellows compensate for motion and vibration and absorb stresses/deformations caused by thermal expansion.
- Two types mainly used in gas lift industry: Formed and Edge Welded
- Vast majority of gas lifted wells are utilizing formed bellows
- Used in a variety of industries and applications used for mechanical actuation in the gas lift industry.



### Formed



### **Edge Welded**





# **Bellows in a Gas Lift Valve**

- A nitrogen-charged dome pressure exerts a closing force on the valve's seat by axially extending the bellows.
- Combination of Injection pressure and tubing pressure opens the valve
- The bellows compresses which lifts stem off seat and allows the flow of injection gas.



### **Typical IPO Valve**





R	DPC	PT	PSC	PVC	OP	PSO	PD	PTRO
							@60F	
	(psi)							
.038	42	585	1080	1122	1143	1101	948	985
.038	66	722	1037	1103	1118	1052	914	950
.038	84	853	1017	1101	1111	1027	900	935
.066	95	844	994	1089	1107	1012	882	945
.066	106	835	975	1081	1099	992	868	930
.066	118	827	955	1073	1090	972	854	915
.066	129	819	935	1064	1082	952	840	900
.066	141	810	914	1055	1072	931	826	885
rifice		790			1049			



Bellows Facts Related To Operation of a Gas Lift Valve

- There is an optimum length and quantity of convolutions to achieve: ۲
  - Maximum inward and outward pressure rating Ο
  - **Optimum stem travel** Ο
  - **Reasonable load rate**  $\bigcirc$
  - Maximum cycle life Ο
- Typical stem travel for 1" gas lift valves is approximately .160" ٠
- Typical stem travel for 1.5" gas lift valves is approximately .250" •
- Cannot be over extended or over compressed or it will fail prematurely ۲
- Must be packaged in the gas lift value to allow enough stem travel for full open area equivalent of largest port size flow area ۲
- Bellows can fail in the open and closed position ٠
- Cycle testing measures the life cycle of a bellows ۲
- Aging testing qualifies the maximum submergence differential of a bellows without sacrificing significant cycle life •







Formed Bellows Forming Process

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- Material is 3 ply metal sheets which are 0.005" thick (0.015" total thickness)
- Bellows is then formed by hydroforming or mechanically forming
- The material used for most all formed bellows gas lift valves is 400 Monel with some special applications being 625 Inconel





## **Outward & Inward Formed** (Mechanically Formed)









Image courtesy of Alloy Precision Technologies

- Raw tube (~9")
- Formed Bellows (~3")
- Crimpled Bellows (~2")





Image courtesy of Alloy Precision Technologies





Bellow Adapter Assembly

## Formed Bellows are connected by induction welding

- Induction welding is a type of welding that fuses two or more metals together using resistive heat caused by changing electromagnetic fields – Corrosionpedia
- The changing magnetic field is typically induced through the use of an alternating current that runs through conductive coils -Corrosionpedia.
- The induced heat melts the solder ring and fuses the components together





**Top Bellow Assembly** 



## Weatherford Cycle Tester

### Gas Lift Valve cycle testing is a requirement per API 19G2













## **Bellows Life Cycle Testing**

- Bellows dome pressure 1000 psi
- Higher dome pressures can also be applied to confirm operational integrity
- One cycle applies ~1400 psi to valve and then bleeds to ~800 psi
- 3500 cycles is minimum requirement in API 19G2
- One cycle shall complete in 30 to 90 seconds
- Water with mineral oil is used









## Major Bellows Life Cycle Tests

<u>Test #</u>	Test Objective	<u>Result</u>	
1	API V1 validation	ОК	
2	failure investigation	Inferior	
3	API V1 validation	Great	
4	Qualification at max pressure rating	ОК	
5	API V1 validation	Good	
6	Special Applications Test	Good	
7	Special Applications Test	Good	
8	API test Alternate Material	ОК	
9	API test	Questionable	
10	Special Applications Test	Great	
11	Special Applications Test	Great	
12	API test	ОК	
13	Customer Specific Test	Questionable	
14	API test	Great	
15	Special Applications Test	Questionable	
16	Special Applications Test	Questionable	
17	API Validation Test	Great	









## **Gas Lift Valve Chatter**

- Chatter is when a valve cycles open and closed at very high frequencies,  $\bullet$ usually when the combination of upstream pressure downstream pressure and flow rate causes the valve to reach a resonant state. Causes of valve chatter •
  - Valve dampener system not functioning properly
  - High sustained operating differential pressure  $\geq$
  - **Too large port for injection gas rate applied**  $\succ$





## **Submergence Differential Pressure**





Natural Submergence Differential: (10,000')(.520 psi/ft) – 1000 psi = 4200 psi Test Submergence Differential: (10,000')(.520 psi/ft) - 1000 psi + 4000 psi = 8200 psi







## Conclusions

- Bellows life cycle testing is a good indication of the integrity of the bellows design arrangement and bellows quality
- Bellows designs must be tested and qualified
- Bellows suppliers must be tested and qualified
- Each specific sizes from each bellows supplier must be tested
- One size bellows from a specific supplier does not mean the other size will perform the best
- Chattering of a gas lift valve will often be the root cause of a bellows failure but is often overlooked
- Above a specific dome pressure, the R values will become distorted
- Exceeding a specific differential submergence pressure on a gas lift valve will cause immediate failure or ulletdrastically reduce cycle life





# Acknowledgements and Questions

• Acknowledgements to the Weatherford Engineering Team for extensive detailed testing





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