Gas lift valve bellow crimping and protection from high dome and injection pressure

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The purpose of bellow crimping is to increase overall mechanical toughness and increase external/internal pressure rating.

Bellows used in gas lift valves are rated to approximately 200-250 PSI.

In gas lift valves bellows are exposed up to 2000 PSI or even higher pressures.

Bellow is delivered in free length LF, must be compressed to LC in order to produce as crimped length L.

Determining optimal as crimped length L is lengthy process that includes EDM cutting for inspection, cycle testing etc. Bellow partially springs back during crimping, like spring.
Bellow reference dimensions
Existing bellow crimping method

- Most manufacturers crimp bellows after soldering to mating parts.
- After crimping valve is aged, to “stabilize” bellow which further deforms it. Ageing is usually performed with 1000 PSI dome pressure and 5000 PSI external pressure.
- This method completely deforms bellow convolutions during crimping because of built in mechanical stop and over-pressurizing. See picture below:
Bellow crimping with ext./int. pressure per pending patent # 41262340

- Bellow is crimped before soldering to mating parts in custom designed device.
- Int/ext. pressure applied following very specific sequences.
- Bellows is crimped-compressed to perfect Ω shape, see picture.
- Bellow plys-layers are pressure supported internally and don’t separate.
- Maintaining Ω shape is essential for proper bellow functioning.
- Bellow crimping pressure exceeds valve working pressure.
Picture of 1” and 1.5” nominal bellow sizes crimped mechanically
Mechanical bellow crimping

- Bellows can be mechanically crimped, better than simple pressure crimping.
- However, plys-bellow layers are not supported internally and this may result in ply separation.
- Result is much better but inferior to internal/external pressure crimping.
- Mechanically crimped bellow does not have perfect $\Omega$ shape.
GLV bellow hydraulic protection from high injection pressure

- Most GLV feature internal seal that traps “non compressible” silicone oil and protects bellow from high injection pressure. This is actually wrong assumption. See picture below:
Permanent gas effect

- In GLV dome charged Nitrogen is in direct contact with silicone oil and dissolves/penetrates into oil.
- Nitrogen is permanent gas and never liquifies no matter how high pressure is.
- This creates mixture of silicone oil and Nitrogen bubbles rendering it compressible.
- Complete theory of GLV “hydraulic bellow protection” is based on wrong assumption.
- Bad bellow crimping, wrong theory of hydraulic bellow protection, chatter, overtravel and over-pressurizing are main reasons for valve/bellow failures.
- Bellows mostly fail due to material fatigue.
Solution for absolute bellow protection

- First step is proper bellow crimping.
- Second is application of patent based “FORTRESS™”-external stem seal”
- “FORTRESS™”- seal is placed outside bellow and engages when valve is in fully open position.
- This prevents high injection pressure ever reaching bellow.
- The “FORTRESS™”- doors are closed and enemy-high injection pressure kept outside fortress, bellow.
Solution for absolute bellow protection

- Conventional valve with “FORTRESS™ “seal” engaged and valve in fully open position. Path of injection pressure to bellow is closed.
- No impact on valve performance
- Silicone oil is used only to prevent valve chatter
Internal/external crimped bellows

- Picture below shows Monel 400-26 and Inc 625-17 bellows crimped mechanically before soldering and aged at 1000/6000 PSI.
Dual fortress seal gas lift valve approved patent # 17349318

- This design features dome and stem fortress seal. Dome seal protects bellow from high dome pressure, stem seal protects bellow from high injection pressure and ageing pressure.
- Valve is using pre-crimped Inc 625 or Monel 400 bellow.
- Valve is using telescoping stem because two mechanical stops at a same time are impossible. Dome fortress seal is mechanical stop.
High pressure DEWB gas lift valve pending patent # 17072846

- Valve features sealed DEWB-dual edge welded bellows subassembly filled with non-compressible de-gassed silicone oil.
- Both bellows go to full compression either by dome or injection pressure, bellows are fully protected.
- Lower bellow surface area is larger than upper-dome bellow area for the area of orifice. This provides close to zero differential pressure across bellows for complete pressure range.
- Valve max dome pressure is 10KSI.
DEWB subassembly

- DEWB subassembly is sealed, filled with de-gassed silicone oil.
- Oil volume is minimized to minimize effect of thermal expansion.
Introducing game changer - TSMS valve patent application # 17746060

- TSMS - Two simultaneous mechanical stop chemical injection and gas lift valve
- First mechanical stop fully compressed SEWB or DEWB bellow that fully protects bellow from high dome pressure.
- Second adjustable mechanical stop TC ball/orifice or conical sealing surface with compressible seal.
TSMS chemical injection and gas lift valve

- Valves feature “Fortress ™” seal that engages when valve is fully open and completely protects bellow from high injection pressure.
Slide 3 Acknowledgements, Thank You & Questions

1. Existing valve design work, why do we need change?
2. Why is aging performed and is it necessary?
3. When is differential pressure against bellow at maximum?

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