Artificial Lift R&D Council

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

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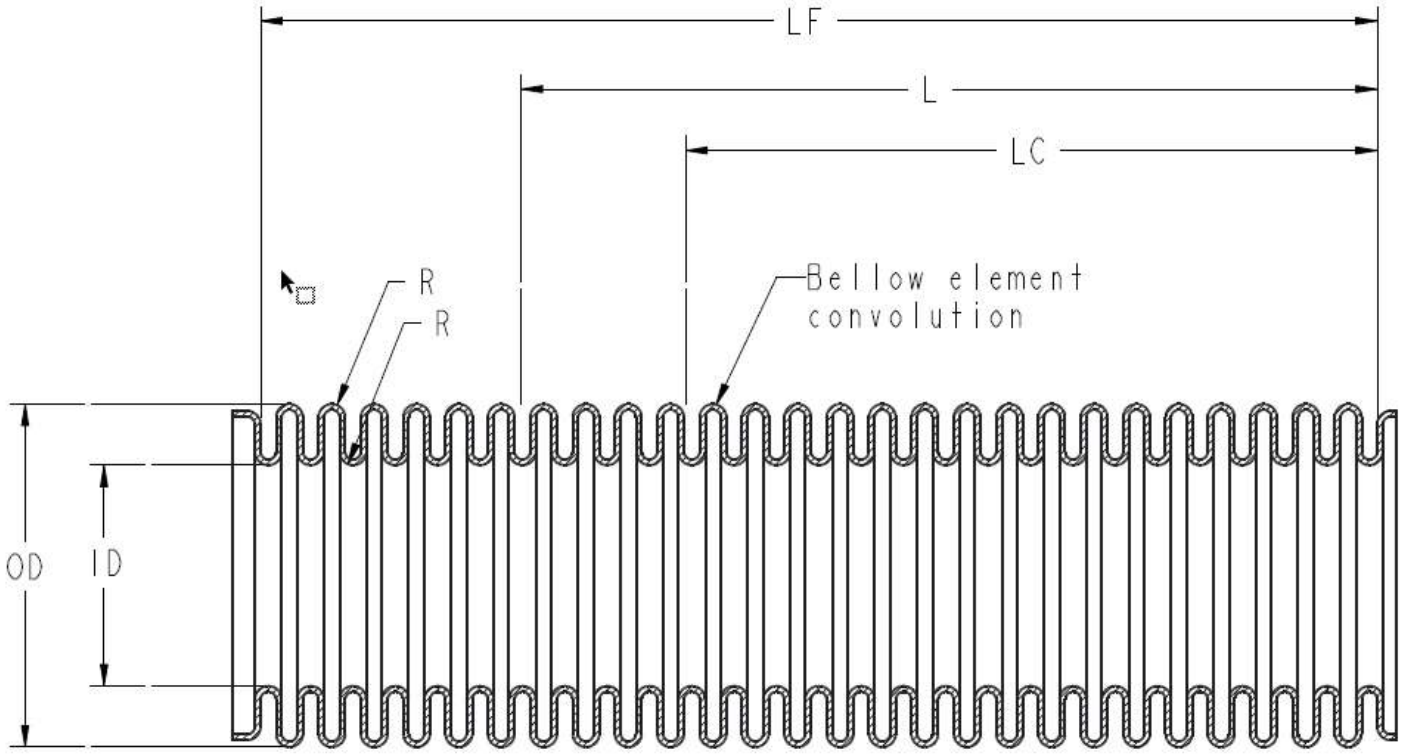
ALRDC Gas Lift Workshop

June 20-23-2022

Bellows crimping-compressing

- 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.

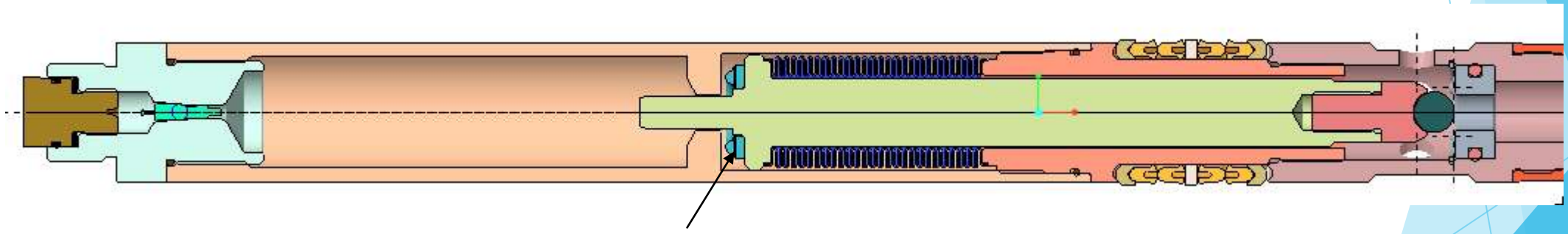
Picture of 1” and 1.5” nominal bellow sizes crimped mechanically

Mechanical bellow crimping

- Bellows can be mechanically crimped, better than simple pressure crimping.
- However, plys-bellow layers are not supported internaly 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 Ω 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:

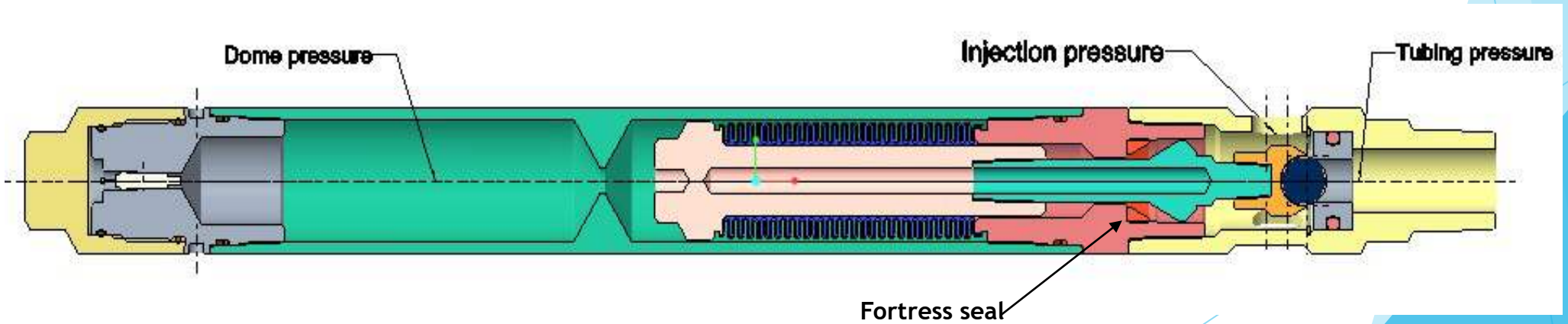


Permanent gas effect

- 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.

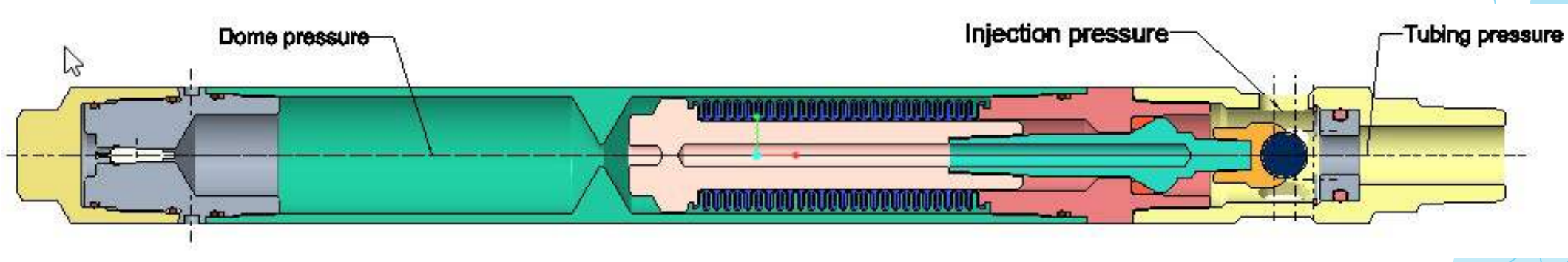
Solution for absolute bellow protection

- 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

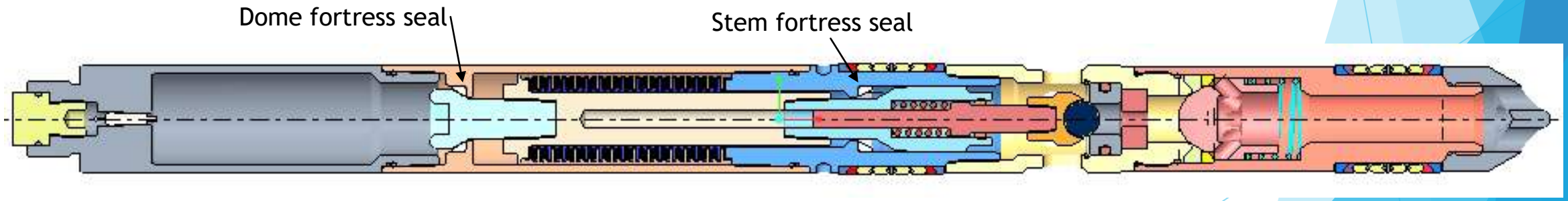


Internal/external crimped bellows

- Picture below shows Monel 400-26 and Inc 625-17 bellows crimped mechanically before soldering and aged at 1000/6000 PSI.

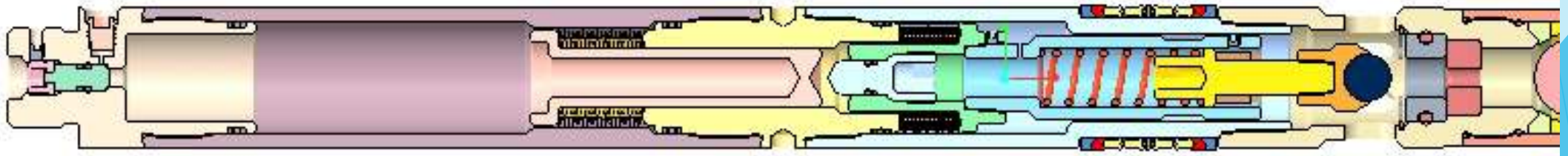
Dual fortress seal gas lift valve approved patent # 17349318

- 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.



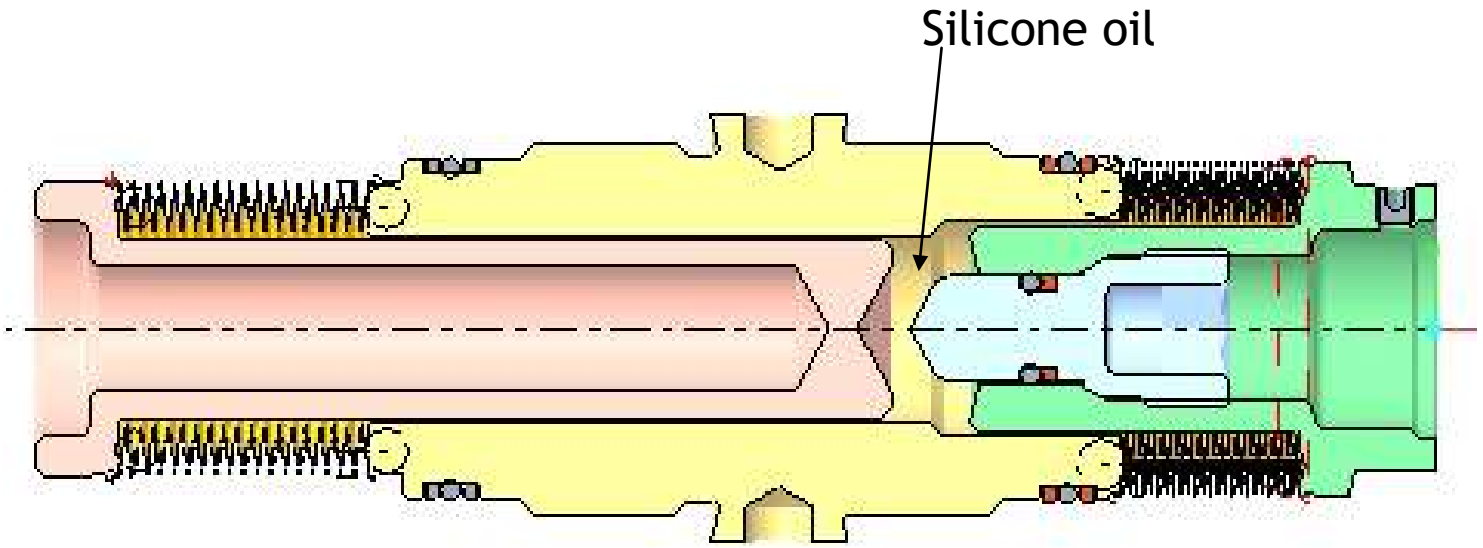
High pressure DEWB gas lift valve pending patent # 17072846

- 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.



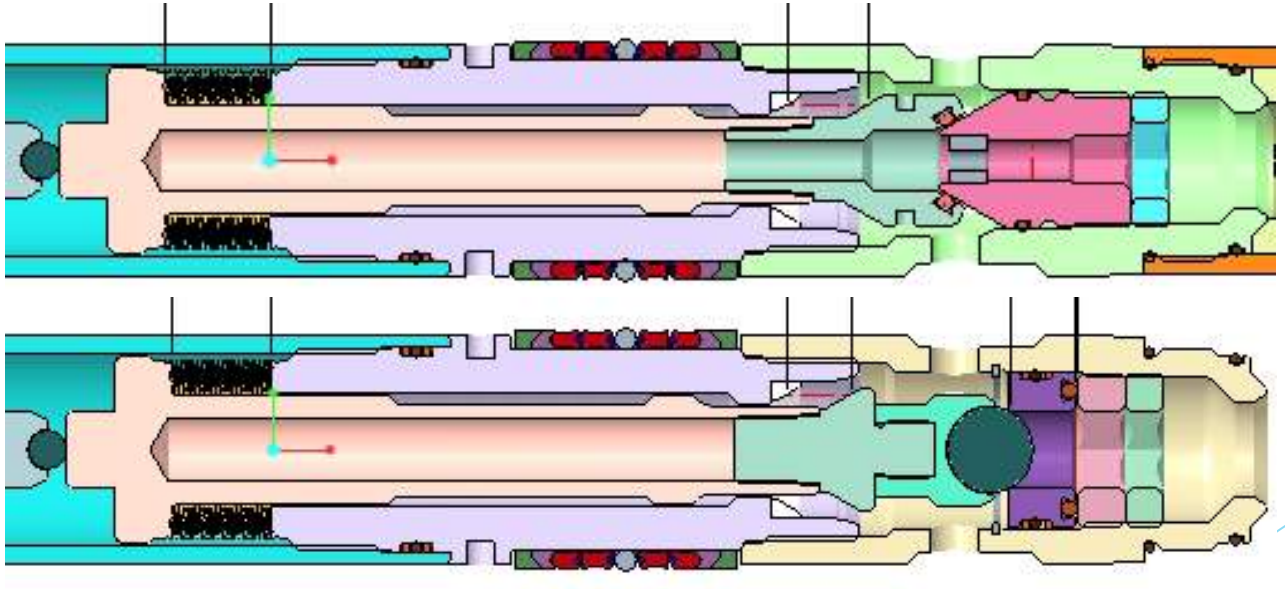
DEWB subassembly

- DEWB subassembly is sealed, filled with de-gassed silicone oil.
- Oil volume is minimized to minimize effect of thermal expansion.



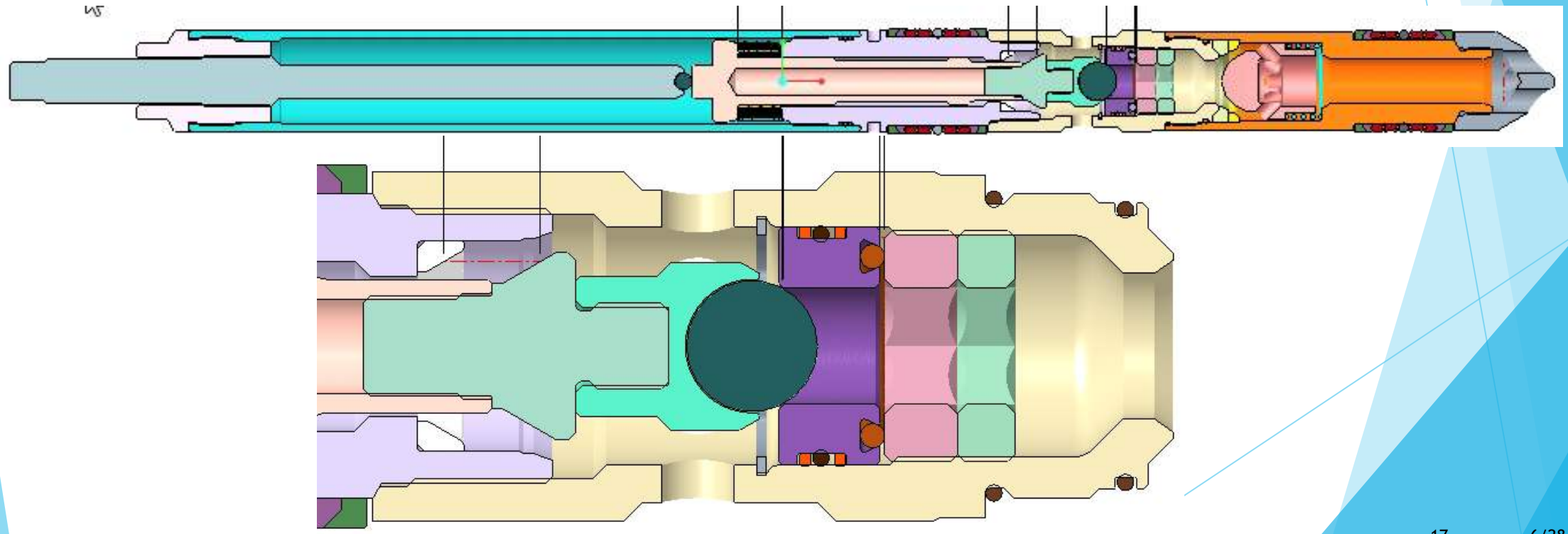
Introducing game changer- TSMS valve patent application # 17746060

- 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 features “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?

- Author would like to thanks Z-Tech Design New Iberia LA, ELC Energy Services Houston TX and Alloy Precision Technology OH for pictures and drawings used for this presentation.

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