2025 GAS LIFT WORKSHOP

GAS LIFT VALVE WITH REDUNDANT SEALING MECHANISMS SUITABLE FOR HARSH ENVIRONMENTS

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2025 GAS LIFT WORKSHOP

Agenda

- Review industry standard injection pressure operated (IPO) gas lift valve
- Detail primary goals of a gas lift system
- Explore the various factors that contribute to challenges experienced with standard IPO valves
- Examine components of a traditional IPO valve and current safeguards in place
- Compare and contrast sealing components and mating sequence of traditional IPO valve versus the improved gas lift valve with redundant seals
- Study the impact of unintended pressure variation within a gas lift system
- Review third-party testing results for the alternate gas lift valve
- Identify pressure void area improvements and capture in the improved valve
- Analyze Eagle Ford operator feedback and real-world results

Historical Use of Traditional Injection Pressure Operated (IPO) Valves

- The gas lift valve depicted to the left has been the standard go to for decades across all operating basins.
- Often, no issues are encountered with their use.
- However, in certain circumstances and under certain conditions, these valves simply cannot endure the demands that are placed on them.
- Several factors play into this.

What Are The Current Issues With Standard IPO Valves?

- Standard injection pressure operated (IPO) valves simply cannot always withstand harsh conditions characteristic of some operating areas or conditions.

- The Eagle Ford, Bakken and other areas often prove to be very challenging for successful, long-term operation of gas lift valves due to numerous factors.

- Efficiency of the installation is often compromised.

- Production and life expectancy of the well may be reduced by failed equipment or subpar operation without subsequent intervention to mitigate issues.

What Are The Primary Goals of a Gas Lift System?

1) Operate as deep as possible
2) Achieve a single point of injection
3) Utilize as little gas as possible
4) Maintain integrity of all valves in the system

Often, these may all be achieved. However, more challenging environments may cause premature issues.

What Factors Contribute to Issues Seen With Standard IPO Valves?

- Heat
- Well bore fluids and gases
- Well bore contaminants and debris
- Offset fracturing activity (particularly in open ended wells)
- Valves installed earlier in the lifecycle of the well (i.e.: hybrid systems; wells still flowing above critical rate when valves are installed
- Natural formation pressure
- Introduced, non-naturally occurring pressure (i.e.: injection pressure)

How Do These Factors Play a Role in Issues Seen?

Wellbore heat, fluids, and gases

- May act to degrade sealing components by causing expansion, contraction, or other deformities

Wellbore contaminants and debris

- Often find their way into the dome bore of the valve along with pressure

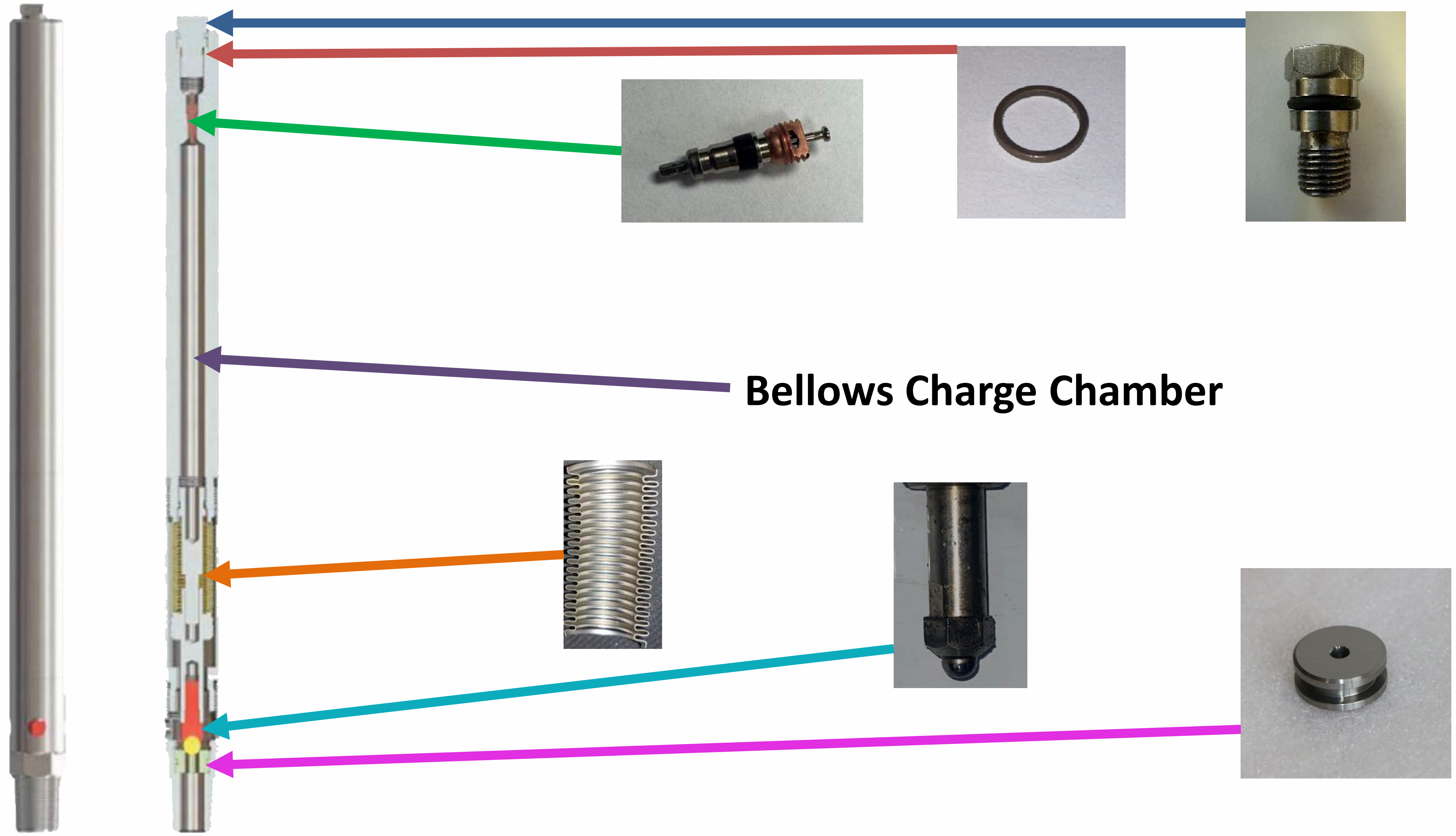
Offset fracturing activity

- Can damage elastomers or can increase the set pressure in the bellows reducing integrity of the valve

Valves installed earlier in the life of the well

- Valves may be exposed to static fluids for extended periods or may be in direct path of flow in hybrid setups

Components of a Traditional IPO Valve



What Currently Safeguards Against These Issues to Prevent Pressure Loss or Gain?

Valve Core (Shrader Core)

- Functions as a one-way check valve
- Pressure can enter from above but is not supposed to exit once introduced to the valve bellows through the core
- Contains two elastomers—one seal on exterior and one seal on underside of spring-loaded stem
- Does not protect against pressure intrusion (if barriers fail, differential pressure can enter)

Copper Crush Gasket

- Meant to act as a secondary method of pressure containment to the valve core and intermediate seal between valve core and tail plug elastomer

Tail Plug with Elastomeric O-Ring

- Serves as the final barrier against pressure loss from the charged valve bellows
- First line of defense against differential pressure gain from outside
- Bottom face of the tail plug seats and torques against the copper crush gasket —in turn crushing the gasket and creating an intended, dual-purpose seal.

Safeguard Components Explained

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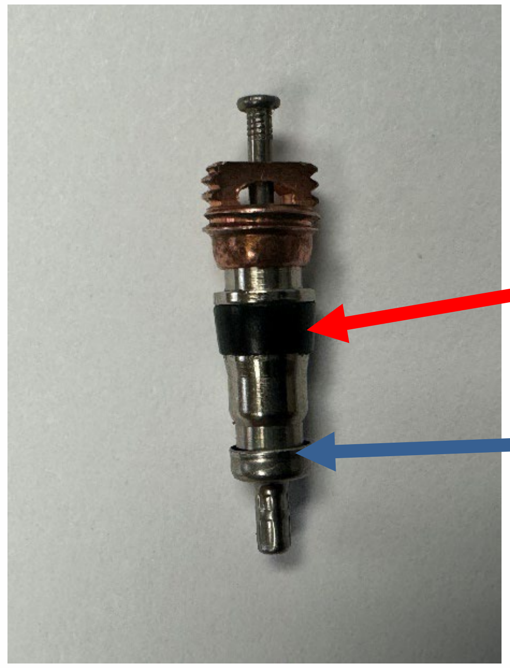

External Sealing Elastomer

Sealing Elastomer Inside Dish-Like Structure

Safeguard Components Explained

Copper Crush Gasket

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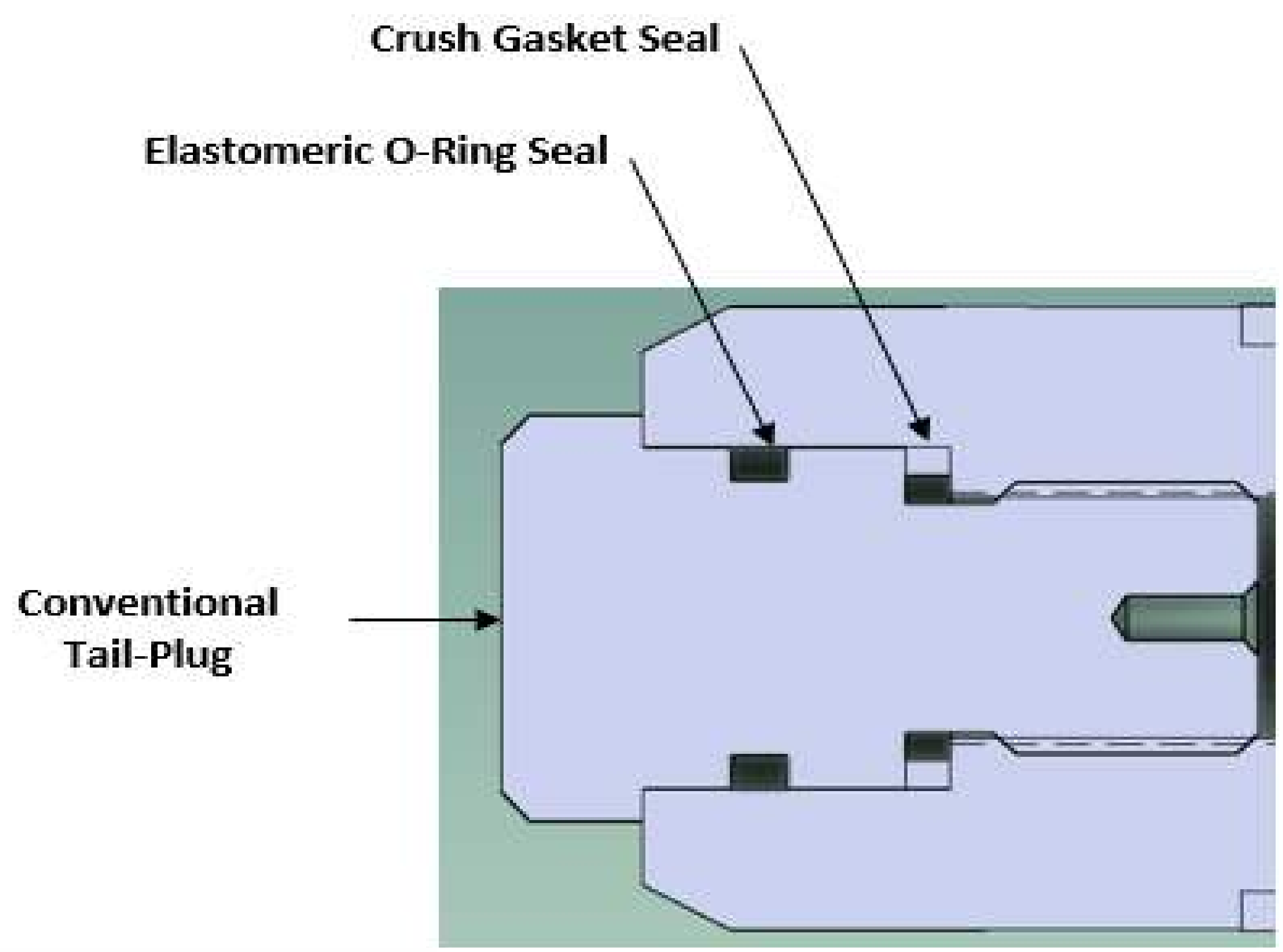
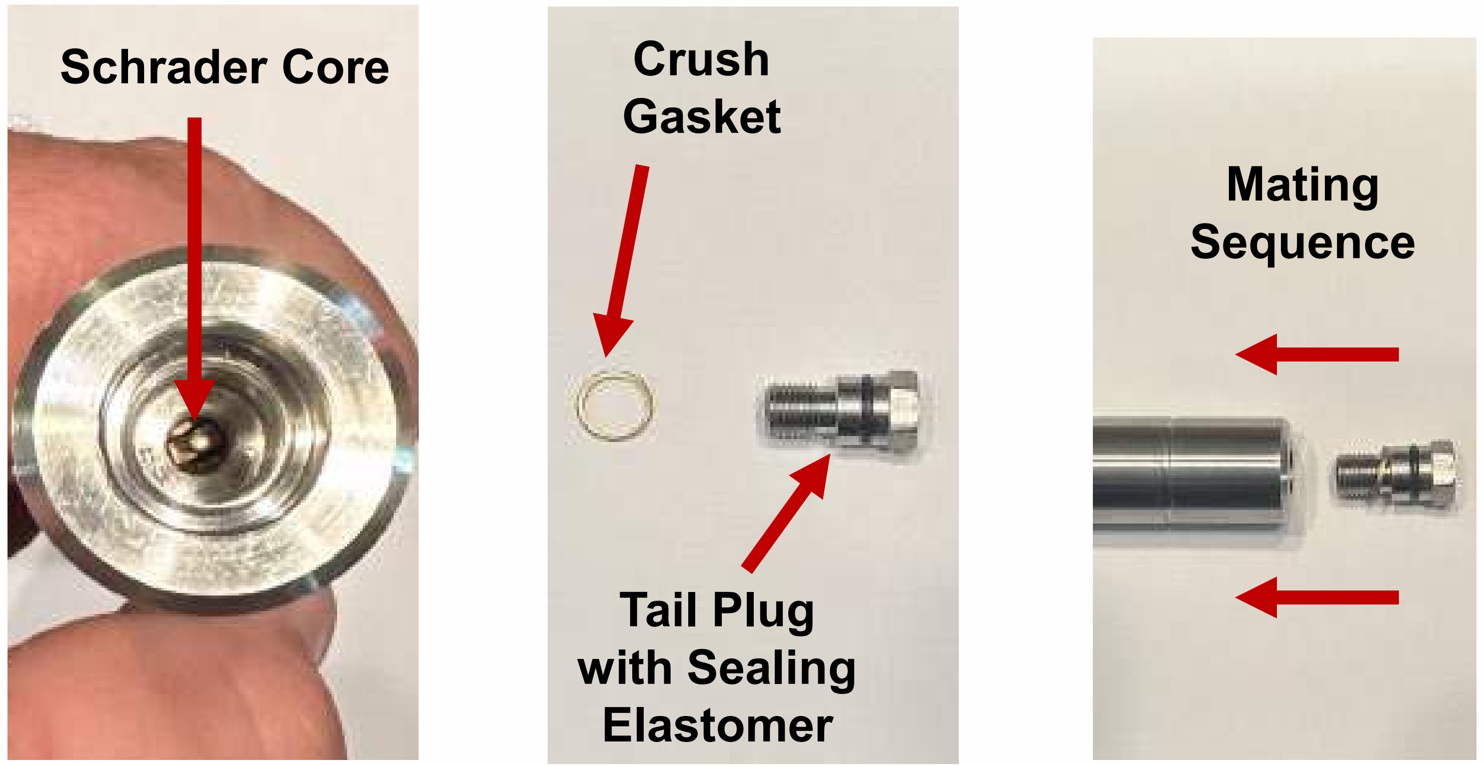
External Sealing Elastomer

Conventional IPO Valve Sealing Components and Mating Sequence

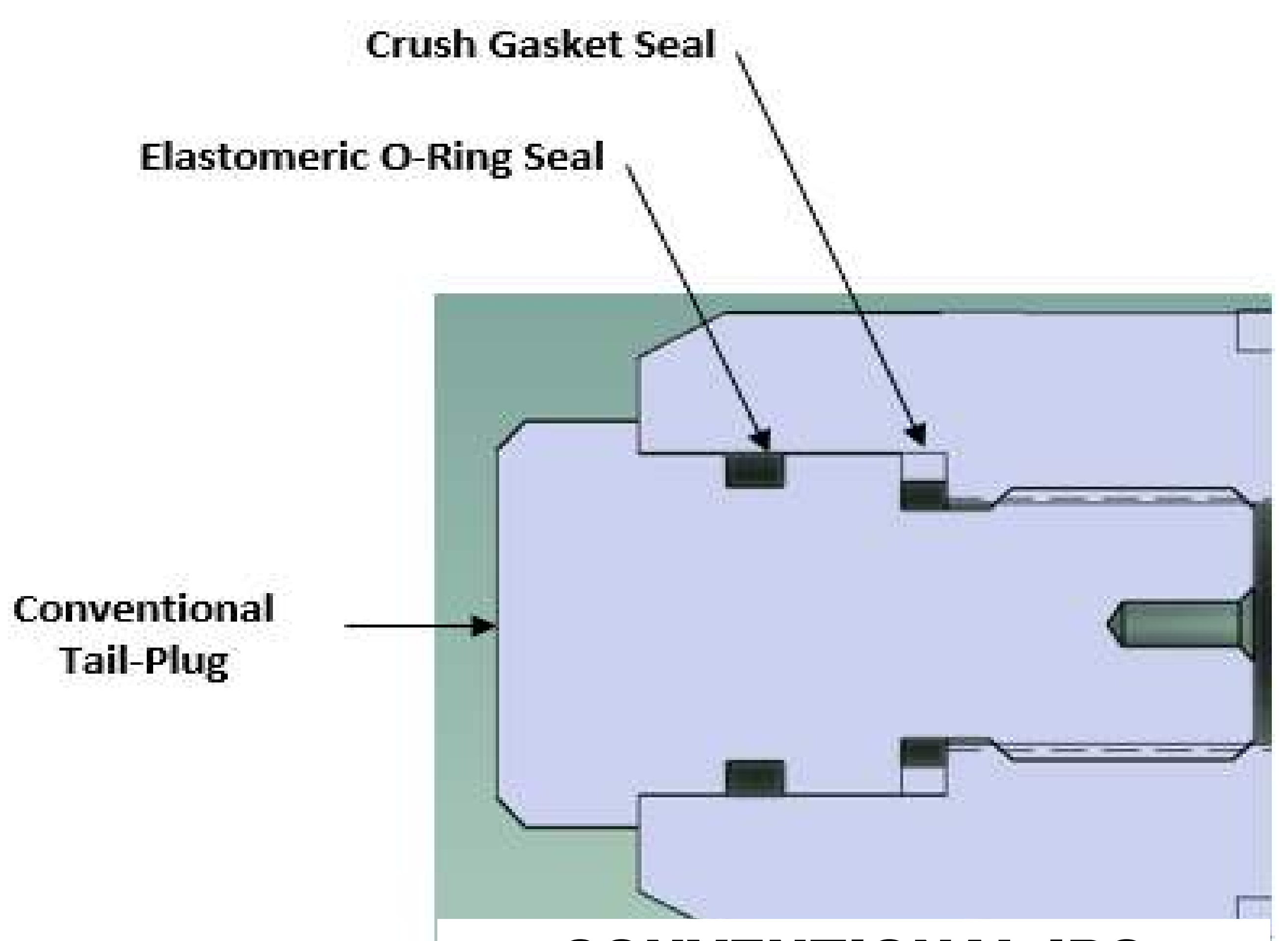


CONVENTIONAL IPO VALVE SEALING COMPONENTS (ASSEMBLED DEPICTION)



CONVENTIONAL IPO VALVE SEALING COMPONENTS (DISASSEMBLED, EXPLODED VIEW)

Conventional IPO Valve Tail Plug Elastomer Exposure



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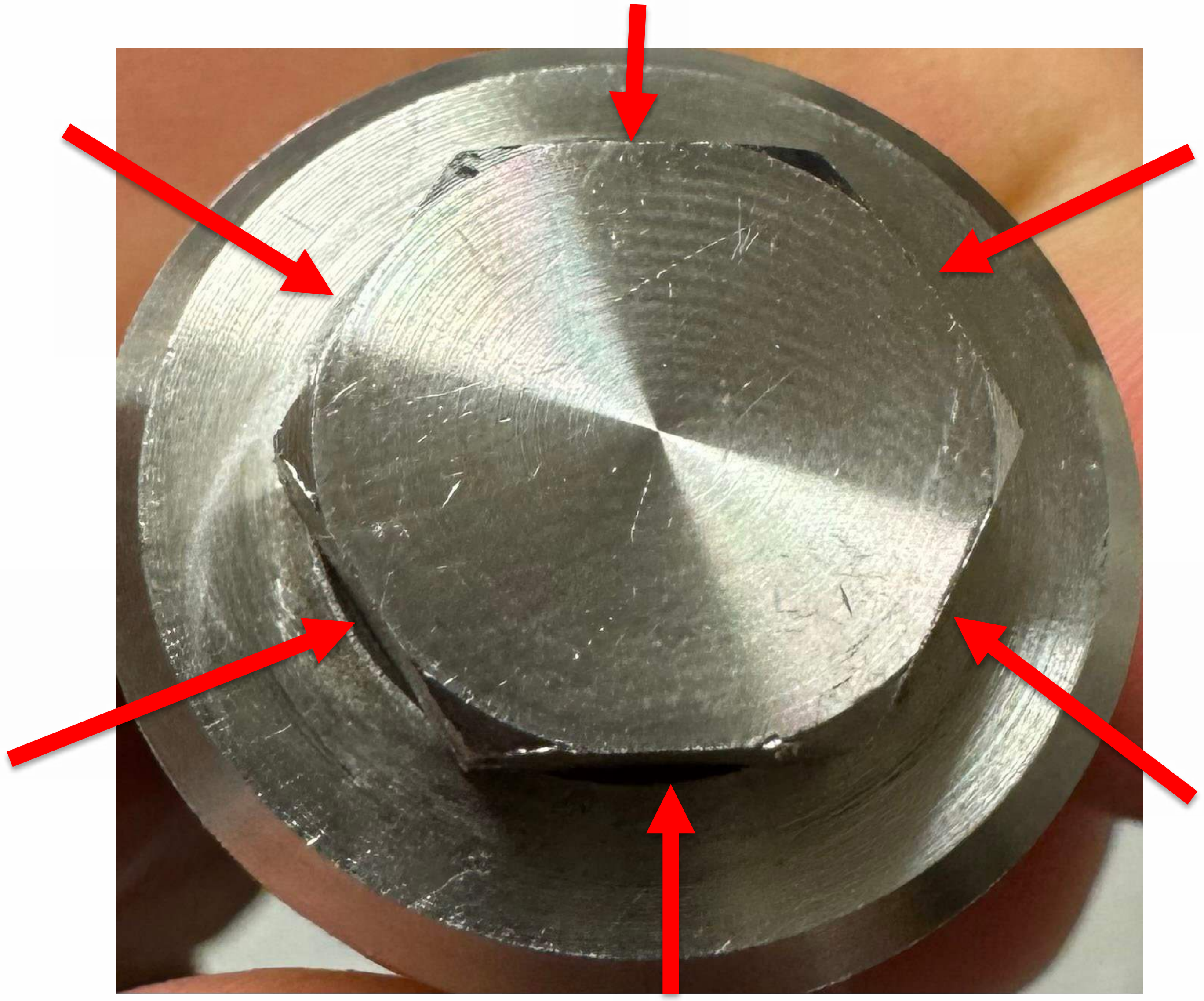

Six void areas exist surrounding the tail plug shank. These serve as exposure points for pressure, debris, chemicals, gases, etc.

Actual Examples of Issues Seen


Valve core elastomer degradation/deformity


Tail plug elastomer degradation/failure


Tail plug elastomer degradation/failure


Tail plug elastomer degradation/failure


Tail plug elastomer failure/intrusion of well solids


Tail plug elastomer extrusion


Intrusion of well solids into dome cap bore

Intended Function of a Gas Lift Valve

- An IPO valve acts as a backpressure regulator, achieved through use of a bellows, which expands or contracts, based on applied forces (tubing and casing pressure).
- Designed to pass high pressure injection gas into the tubing string or annulus, dependent on lift configuration
- Injection gas aerates the produced fluid, thus reducing its flowing density to surface
- Flowing bottom hole pressure of the wellbore is reduced, which allows greater feed in from the reservoir
- Drawdown is achieved.

#	Valve Desc.	Depth TVD ft	Depth MD ft	TV F	TCF	Port Size 64th	R	PT psi	DPC psi	PSC psi	PVC psi	OP psi	PSO psi	PD @60 psi	PTRO psi
10	L-CIPO-2	2000	2029	126	0.8721	12	0.038	297	52	924	976	1003	951	851	885
9	L-CIPO-2	3650	3704	157	0.8227	12	0.038	315	96	898	994	1021	925	818	850
8	L-CIPO-2	5300	5380	187	0.7799	12	0.038	414	139	872	1011	1035	896	789	820
7	L-CIPO-2	6750	6853	213	0.7463	12	0.038	488	177	848	1025	1046	869	765	795
6	L-CIPO-2	8050	8173	237	0.7177	12	0.038	578	211	821	1032	1050	839	741	770
5	L-CIPO-2	9150	9290	257	0.6956	12	0.038	643	239	798	1037	1053	814	722	750
4	L-CIPO-2	10100	10255	274	0.6778	12	0.038	704	264	772	1036	1049	785	702	730
3	L-CIPO-2	10900	11067	288	0.6638	12	0.038	761	285	751	1036	1047	762	688	715
2	L-CIPO-2	11550	11727	299	0.6532	12	0.038	773	302	722	1024	1034	732	669	695
1	L-CIPO-2	12150	12336	307	0.6457	12	0.038	764	318	695	1013	1023	705	654	680

TV: Temperature of Valve
TCF: Temperature Correction Factor
R: Ap/Ab
DPC: Gas Weight = Casing Pres at Depth - CP at Surface
PT: Tubing Pressure
PSC: Closing Pressure at Surface

PVC: Closing Pressure at Depth
OP: Opening Pressure at Depth
PSO: Surface Opening Pressure
PD at 60F: Bellows Press at Base Temperature = TCF x PVC
PTRO: Test Rack Opening Pressure

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What Impact Can Pressure Loss or Gain Have on an IPO Valve?

#	Valve Desc.	Depth TVD ft	Depth MD ft	TV F	TCF	Port Size 64th	R	PT psi	DPC psi	PSC psi	PVC psi	OP psi	PSO psi	PD @60 psi	PTRO psi
7	L-CIPO-2	2200	2203	113	0.8969	12	0.038	270	76	1013	1089	1121	1045	976	1015
6	L-CIPO-2	4200	4204	149	0.8383	12	0.038	356	145	985	1130	1161	1016	948	985
5	L-CIPO-2	6100	6105	183	0.7899	12	0.038	522	211	958	1169	1195	984	924	960
4	L-CIPO-2	7700	7705	212	0.7531	12	0.038	594	267	927	1194	1218	951	899	935
3	L-CIPO-2	9200	9205	238	0.7232	12	0.038	692	319	898	1217	1238	919	880	915
2	L-CIPO-2	10530	10535	262	0.6980	12	0.038	572	365	869	1234	1260	895	861	895
1	Orifice	12200	12211	292	0.6693	12	OV								

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On this design, a 985 PSI TRO corresponds to a surface closing pressure (PSC) OF 985 PSI

- Hypothetically, valve six loses sixty PSI of charge pressure.
- The new pressure surface closing value for valve six becomes 916 PSI.
- Gas circulates in at valve six, and the system is then stuck. The system operating pressure has been reduced.
- Subsequent transfers cannot be achieved due to the reduction in pressure. The effectiveness of the system has been compromised.

What Has Been Done to Mitigate These Risks?

- **Root cause analysis processes have become more intensive.**
- **Vendors have placed greater focus on developing solutions and adapting equipment to meet stringent demands associated with some areas.**

What Makes the Alternative Gas Lift Valve with Redundant Sealing Mechanisms Superior and Different?

VALVE CORE (SCHRADER CORE)

- Same functionality as that in a conventional IPO valve

MORE UNIFORM CRUSH GASKET IN A CENTRALIZED BORE SEAT

- Gasket on the robust valve maintains a more uniform fitment
- Area remaining between the plug end and valve core within the dome bore is considerably less (gasket has through bore hole to sit directly above the valve core)

THREADED PRIMARY DOME PLUG

- O-Ring seal is housed on the lower portion of a primary threaded plug and crush gasket abuts to blunt end of primary dome plug and is sandwiched between plug and dome bore internal
- Machined so that the underside is cut with a semi-hollowed underside that butts up right above the valve core stem and crush gasket
- Even in the event pressure escapes through the valve core, the void area is reduced, and subsequent backups are there to protect against greater loss

What Makes the Alternative Gas Lift Valve with Redundant Sealing Mechanisms Superior and Different?

AFLAS PLUG ELASTOMER

- Aflas elastomer is contained on the lower section of the primary plug and seals just above valve core
- Meant to contain pressure lost through a failed valve core and/or crush gasket

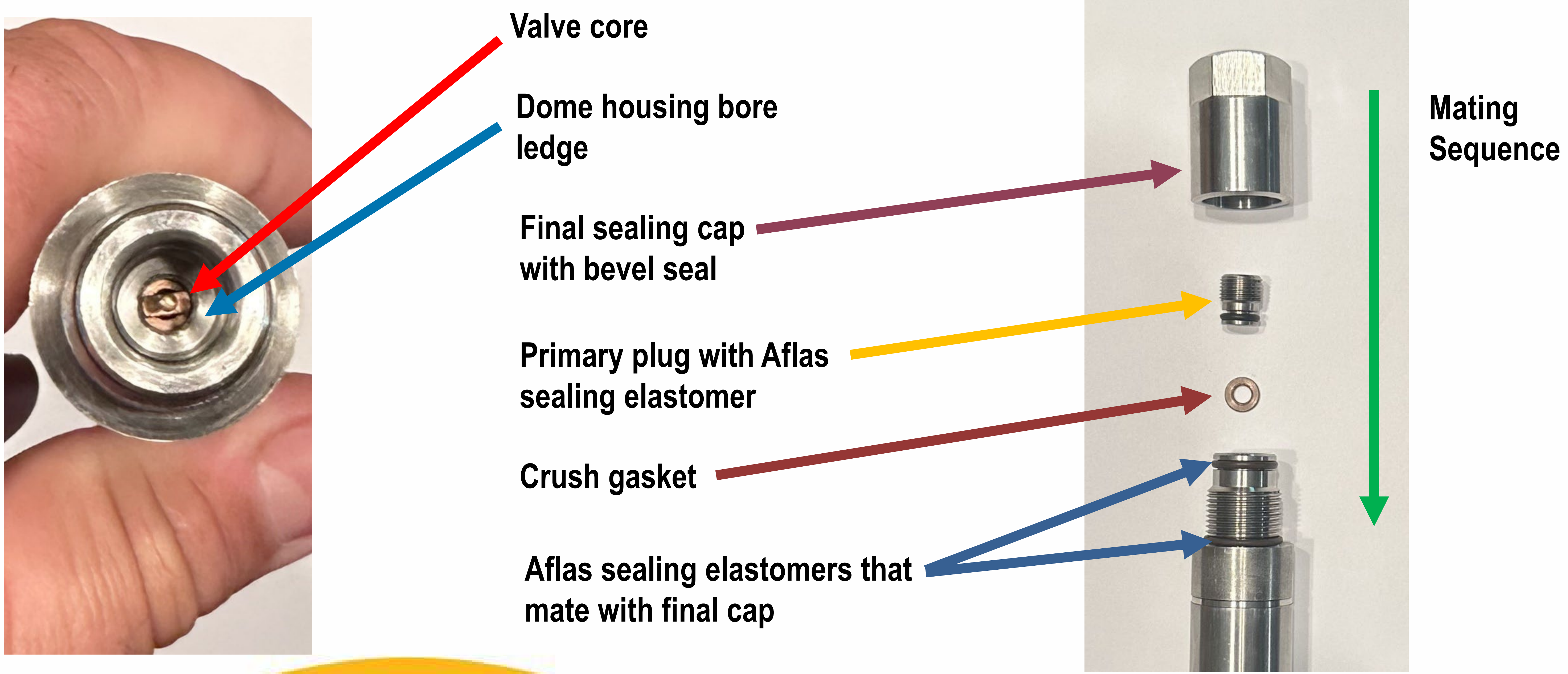
ENCAPSULATION FIXTURE WITH OPPOSING METAL-TO-METAL SEAL

- Dome post which accepts the Schrader core, copper gasket and sealing plug is externally male threaded
- Male dome post accepts an engineered cap that is female threaded
- Opposing beveled chamfer face of this metal-to-metal cap seal protects against pressure loss and/or outside differential pressure intrusion.

AFLAS ELASTOMER SET USED IN CONJUNCTION WITH SEALING CAP

- Male threaded external dome post contains another set of Aflas elastomers
- First elastomer mates against the uppermost internal bore of the cap and acts as barrier for internal pressure loss and outward pressure intrusion
- Secondary elastomer is at the mating base where the sealing cap mates to the charge chamber body adapter and redundantly protects against pressure loss or intrusion.

Improved Valve Sealing Components and Mating Sequence



How Was the Improved Valve Tested?

A third-party was employed to test the effectiveness of the gas lift valve with redundant sealing mechanisms.

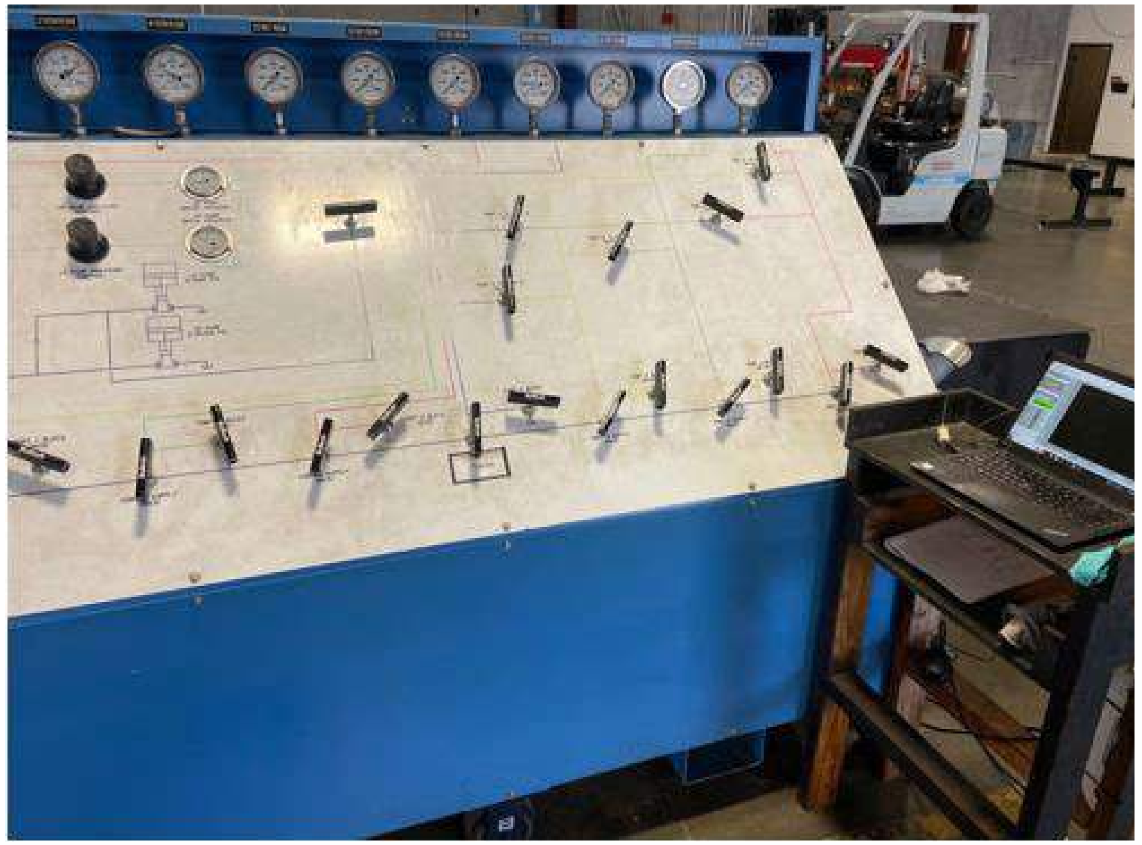
Test Conditions

- Test Temperature: 325 degrees Fahrenheit
- Test Vessel Pressure: 5,000 psig
- Test Fluid: Hydraulic oil
- Test Duration at Controlled Conditions: 10 hours (once pressure and temp reached desired values)

Testing Facility Photographs

VALVES BEING LOADED INTO TESTING CHAMBERS AND PRESSURE BUNKER WITH HEAT COILS AFFIXED

Testing Facility Photographs



TESTING MANIFOLD
CONTROL CENTER

VALVES PULLED FROM CHAMBERS
AT CONCLUSION OF TESTING PHASE

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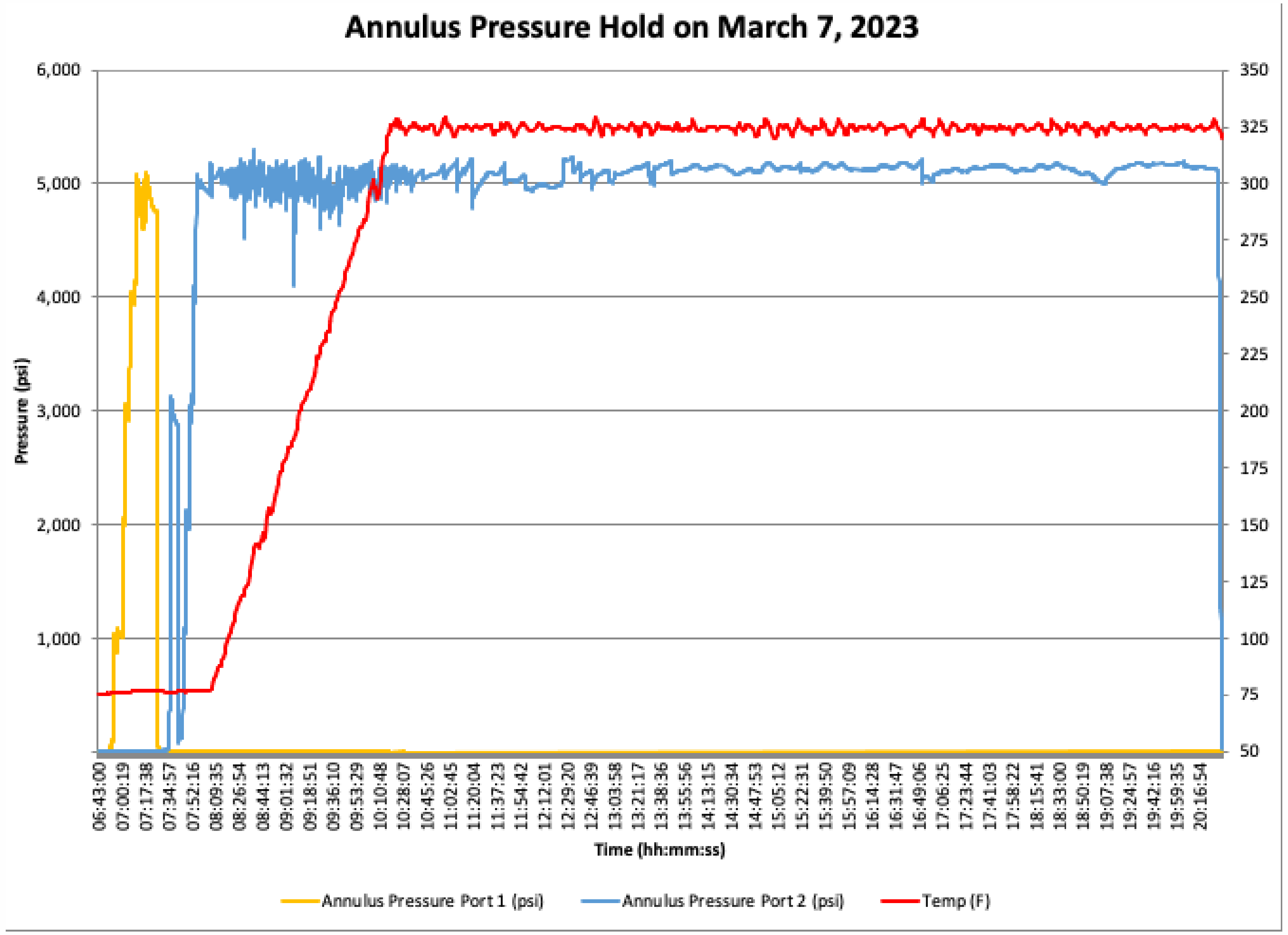
Testing Pressure and Temperature Chart



GRAPH DEPICTS THE RISE TO AND STABILIZATION OF TEST CHAMBER PRESSURE AND TEMPERATURE

- Temperature at 325 degrees Fahrenheit
- Chamber pressure at 5,000 PSIG
- These pressure and temperature conditions were created to align with actual down hole scenarios.

Results: Standard Versus Improved Valves

Test Chamber Number	Description	TRO Ambient	TRO Shelf @ 60 Degrees F	TRO After First Age	TRO After Second Age	TRO After Third Age	Final TRO Before Third-Party Testing	TRO After Third-Party Testing	Notes
1	1" Valve	1273	1233	1223	1227	1221	1221	1260	Robust Valve
2	1" Valve	1244	1245	1238	1236	1236	1236	1270	Robust Valve
1	1" Valve	1211	1202	1193	1202	1203	1205	1218	Robust Valve
2	1" Valve	1270	1220	1210	1210	1210	1210	1253	Standard IPO Valve
2	1.5" Valve	1186	1176	1173	1172	1160	1155	NO PRESSURE	Robust Valve
2	1.5" Valve	1237	1118	1117	1117	1117	1117	1075	Robust Valve
1	1.5" Valve	1211	1159	1157	1157	1157	1157	1113	Robust Valve
1	1.5" Valve	1293	1264	1268	1266	1263	1258	265	Standard IPO Valve

***NOTE: 1.5" valve with no pressure was the result of a failed bellows solder joint, not a seal failure

AS DEPICTED IN THE ABOVE DATA, THE ROBUST VALVE WITH MULTIPLE SEALS ESTABLISHED OVERALL RESILIENCY COMPARED TO THE CONVENTIONAL IPO VALVES UTILIZED AS THE CONTROL GROUP.

Third-Party Testing Conclusions

- The robust valve with multiple seals was resilient to a test pressure of 5,000 PSIG and a temperature of 325 degrees Fahrenheit.
- Elastomers in the robust valve with multiple seals faired very well throughout the test.
- No intrusion of outside pressure or fluid into the bellows charge chamber of the robust valve with multiple seals was identified.
- No identifiable trapped pressure existed within any of the sealing voids other than between the valve core and primary plug of the robust valve with multiple seals.

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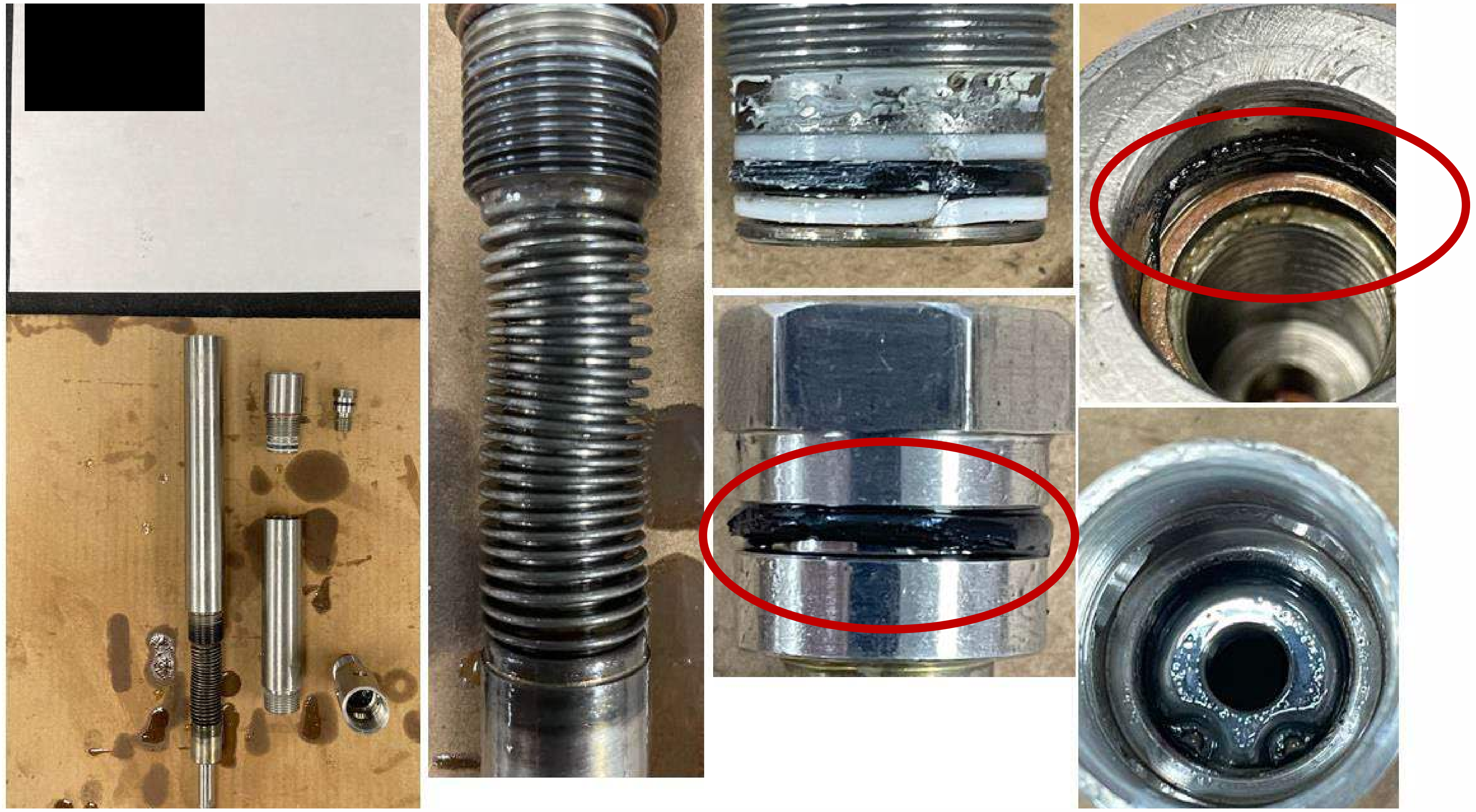
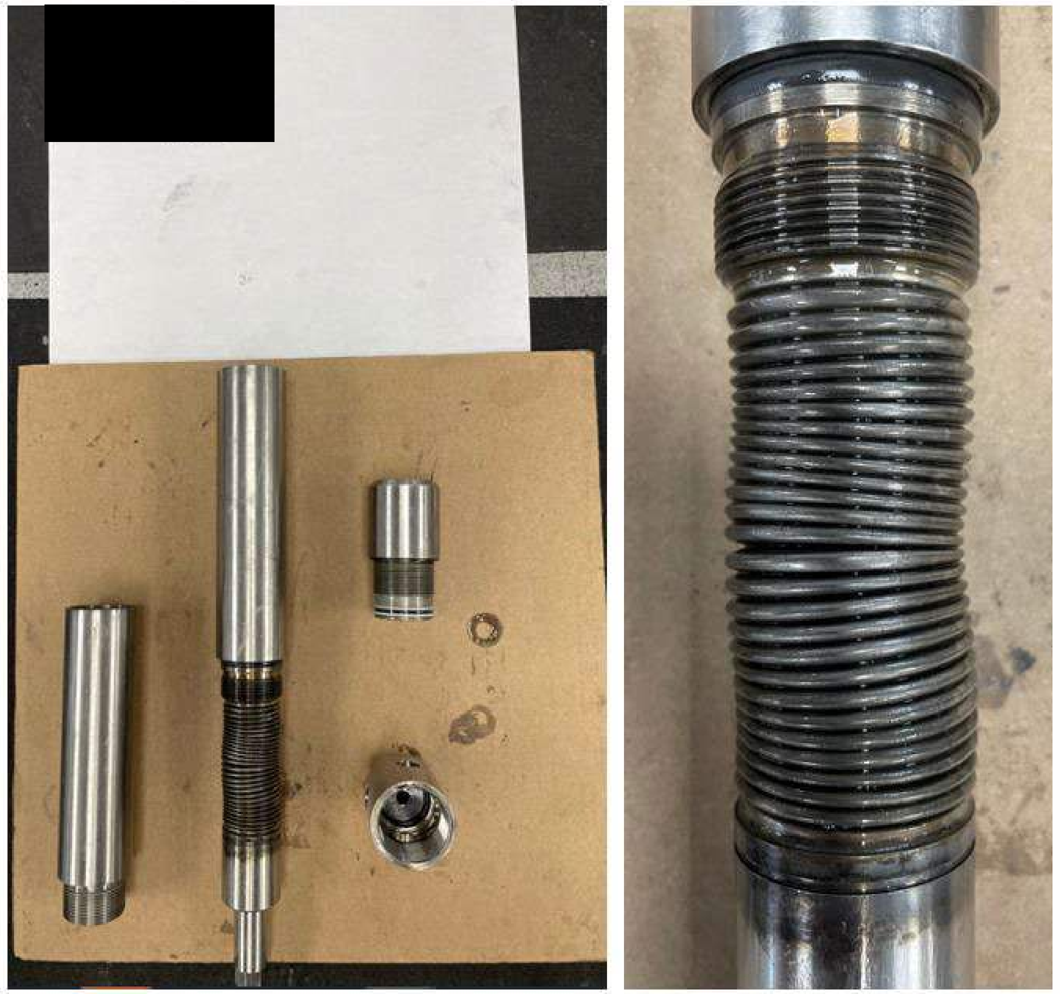
Post Testing Photographs: Conventional IPO Valve (1.00”)



View of Internal Sealing Elements of Conventional IPO Valve Post Testing

OBVIOUS SIGNS OF ELASTOMER DEGRADATION PREVALENT

Post Testing Photographs: Conventional IPO Valve (1.50”)



View of Internal Sealing Elements of Conventional IPO Valve Post Testing

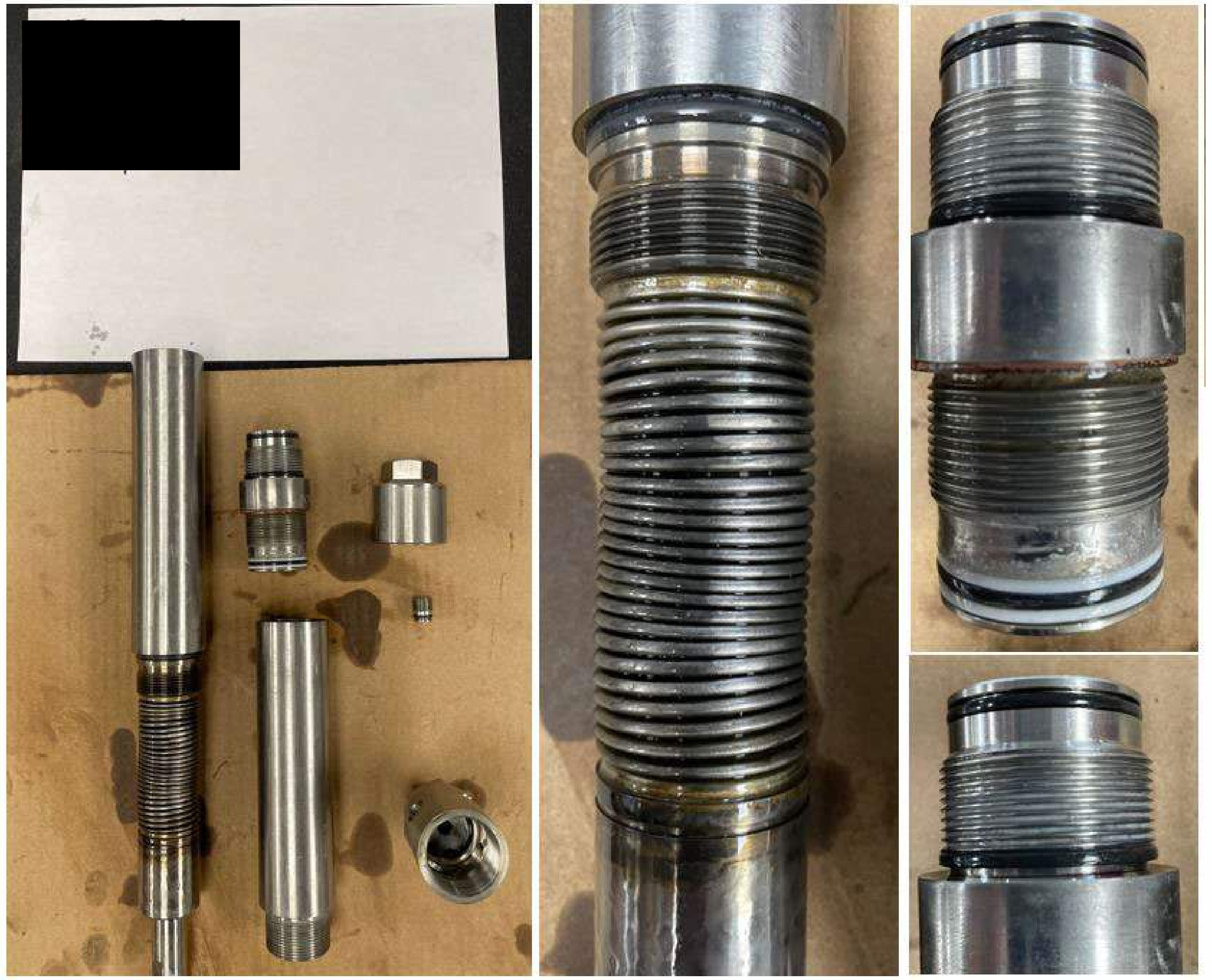
OBVIOUS SIGNS OF ELASTOMER DEGRADATION PREVALENT

Post Testing Photographs: Improved Valve with Sealing Redundancies (1.00")

View of Internal Sealing Elements of Robust Valve with Multiple Seals Post Testing

NO SIGNS OF ELASTOMER DEGRADATION PREVALENT

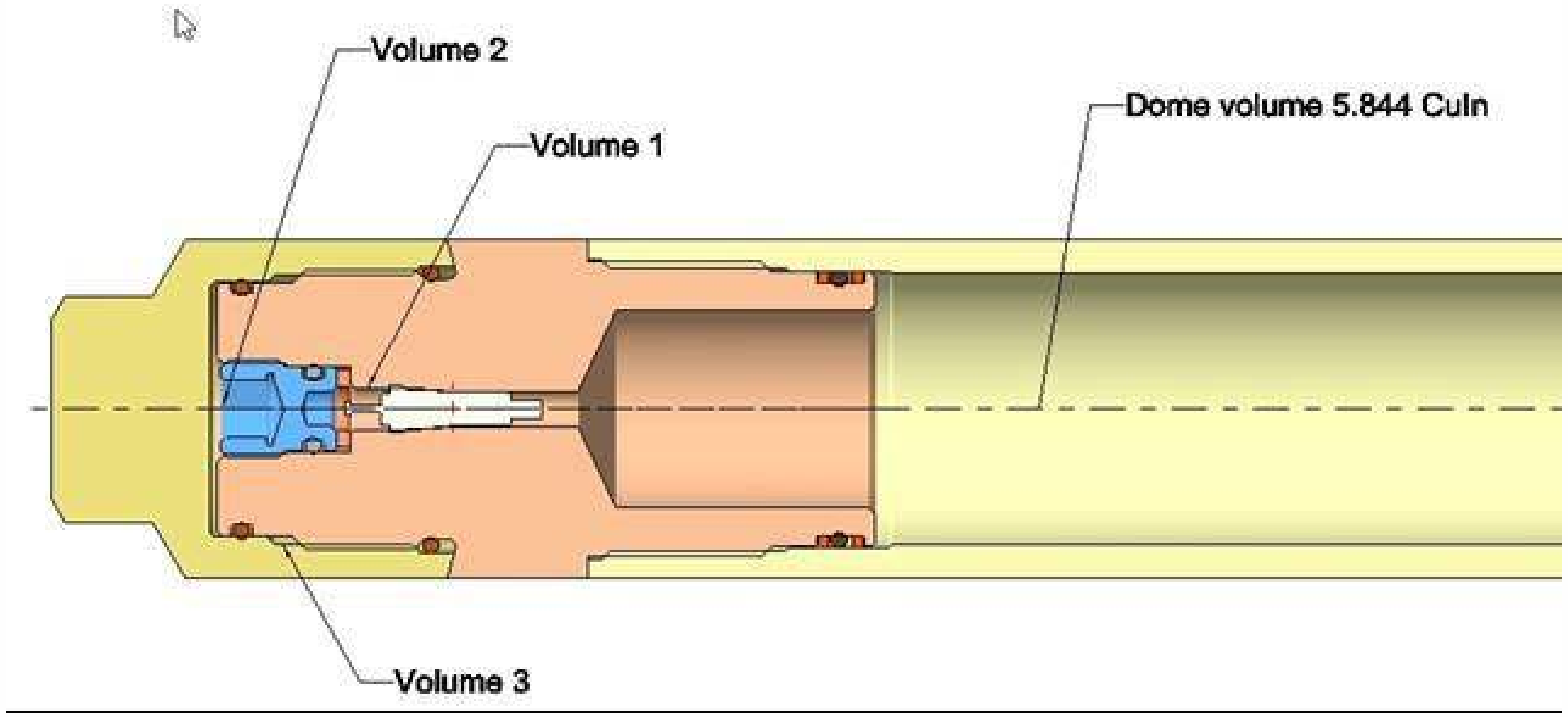
Post Testing Photographs: Improved Valve with Sealing Redundancies (1.50”)



View of Internal Sealing Elements of Robust Valve with Multiple Seals Post Testing

NO SIGNS OF ELASTOMER DEGRADATION PREVALENT

Alternative Valve Pressure Loss Calculations

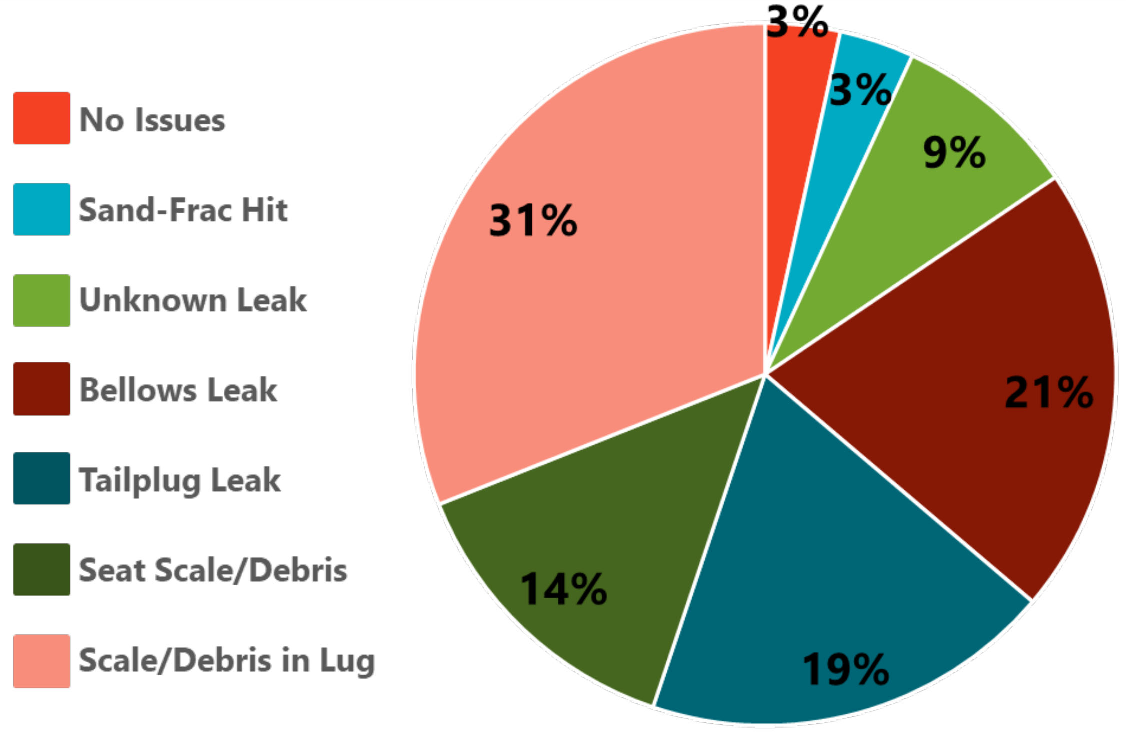


PRESSURE VOID AREAS IDENTIFIED
(VALVE WITH REDUNDANT SEALS)

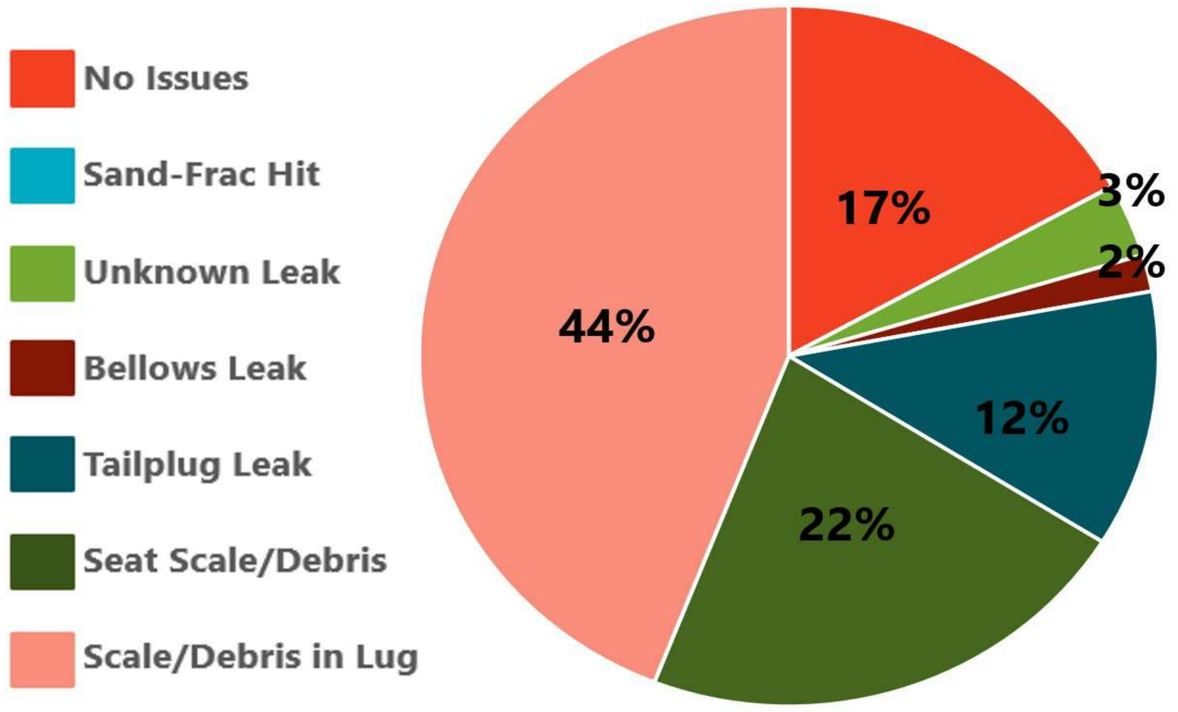
- **If just the Schrader core leaks, the bellows pressure variation would be a two PSI loss at 1000 PSI dome pressure (at 60 degrees Fahrenheit API control)**
- **If the Schrader core, crush gasket and first O-Ring leaks, the pressure variation would be a ~7 PSI loss, assuming a 1000 PSI dome pressure.**
- **If the Schrader core, crush gasket, and all O-Rings except the last leaks, the pressure variation will be a ~9 PSI loss, again assuming a 1000 PSI dome pressure.**

Eagle Ford Operator Feedback

"Transition to re-design has shifted mechanism, reducing pulls that are leak prone."



GAS LIFT FAILURE MECHANISM: Q1 2022 - Q1 2023



GAS LIFT FAILURE MECHANISM: Q1 2023 - Q1 2024

- Identified bellows leaks reduced from 21% to 2%
- Tail plug leaks have been reduced from 19% to 12%

Success of the Valve with Multiple Sealing Redundancies

6,517 VALVE UNITS IN THE GROUND AS OF MAY 26, 2025

- **Eagle Ford: 5,582**
- **Permian: 242**
- **Bakken: 475**
- **Powder River Basin: 218**

AS OF MAY 26, 2025, THERE HAVE BEEN NO REPORTED OPERATOR PULLS DUE TO A FAILED ROBUST VALVE WITH MULTIPLE SEALS.

Question Time

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