The most trusted severe service technology company.

Valve Design Considerations for Abrasive Services

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MOGAS Industries, Inc.

Valve Engineering History

13 years API 6A & API 6D Trunnion Ball Valve engineering

- Specialized in
- Elastomers and thermoplastics
- Codes and Standards

17 years "General Purpose" valve engineering

- Floating ball valves; end and top entry styles
- Butterfly valves
- Forged Steel gate, globes and check valves
- Electric and Pneumatic Quarter-Turn Actuators

13 years Severe Service Metal Seated Ball Valve engineering

Valve Failure Drivers

It's never just one factor that results in valves underperforming:

- Accelerated Corrosion
- Accumulation of Solids
- Temperature excursions
- Other upsets in operating conditions
- Undersized operators

We're going to try and focus on just one factor: abrasion

Abrasion vs Erosion

High cycles w/ abrasive media

Abrasive wear is the loss of material by friction through the passage of hard particles over a softer surface.

Erosive wear only requires energy. The impact energy is derived from the local velocity of the flowing media. Adding abrasives only accelerates erosion.

High pressure, fast moving, erosive media

The sequence of events is Important

Failures that start as abrasion may quickly transition to erosion in high pressure fluid flow systems when the initial damage creates a focused high-velocity flow path.

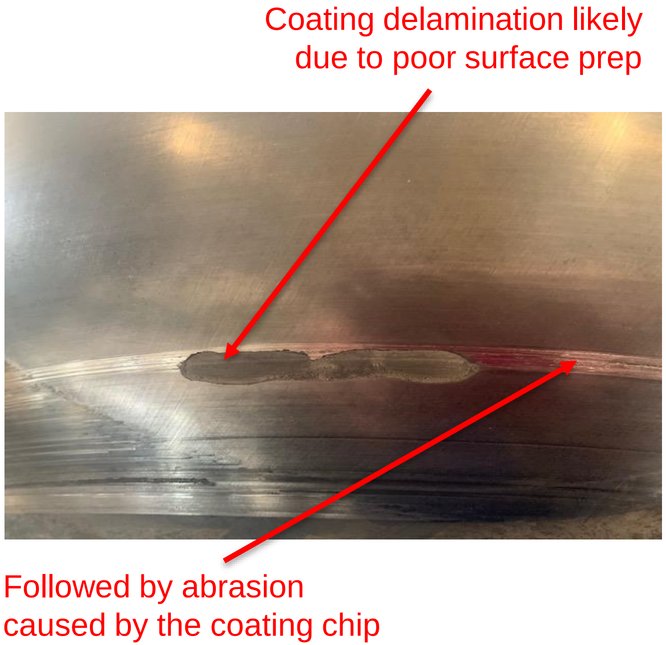
Thus, hiding the true root cause.

Note: This valve featured a locked-in seat design, not the preferred tracking-seat design.

Likely started as abrasion – a small scratch across the sealing area

The media:
Iron ore fines

Abrasion Characteristics



Key attributes that contribute to abrasive wear:

- Nature of the Abrasive:
  - It's implied that the abrasive is harder than the surface that's being worn
  - Shape or profile of the abrasive itself
- Friction Factors
- Lubricity of the process
- Third-body involvement

Is there one valve type better than all others?

Valve Design Type	Closure moves within its volume (+)	Sealing Surfaces Exposed to Flow (-)	Closed Body Cavity (-)	Self-Cleaning Sealing Areas (+)	Ease of Automation (+)
Ball Valve	Yes	No	Yes	Yes*	Yes
Butterfly Valve	No	Yes	No	No	Yes
Check Valve	No	Yes	No	No	Auto
Gate Valve	No*	Yes*	Yes	No	Yes
Globe Valve	No	Yes	No	No	Yes
Plug Valve	Yes	No	Yes	No	No

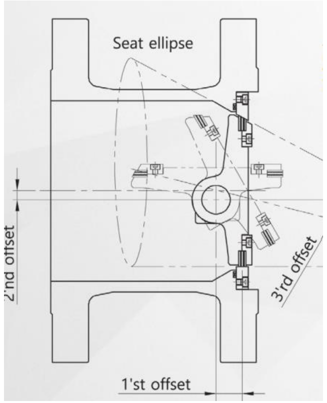
Battling Abrasion

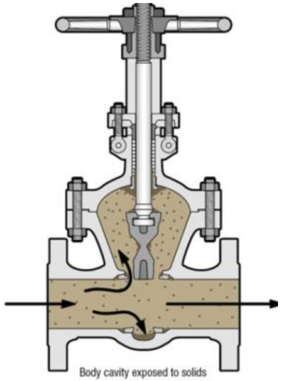
Design:

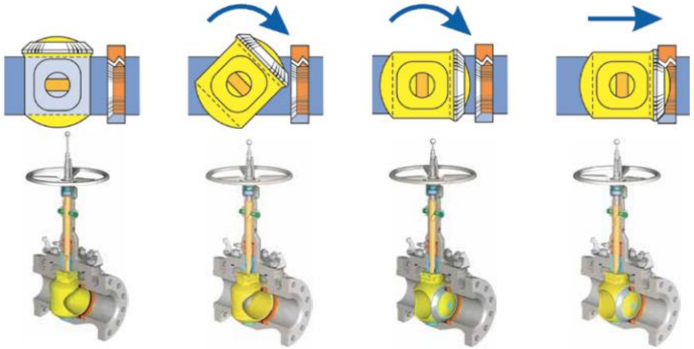
Sealing surfaces should not be exposed to flow.

Body cavity should either be open or resistant to packing-in.

Ideally, the valve’s closure member needs to move within its own volume.





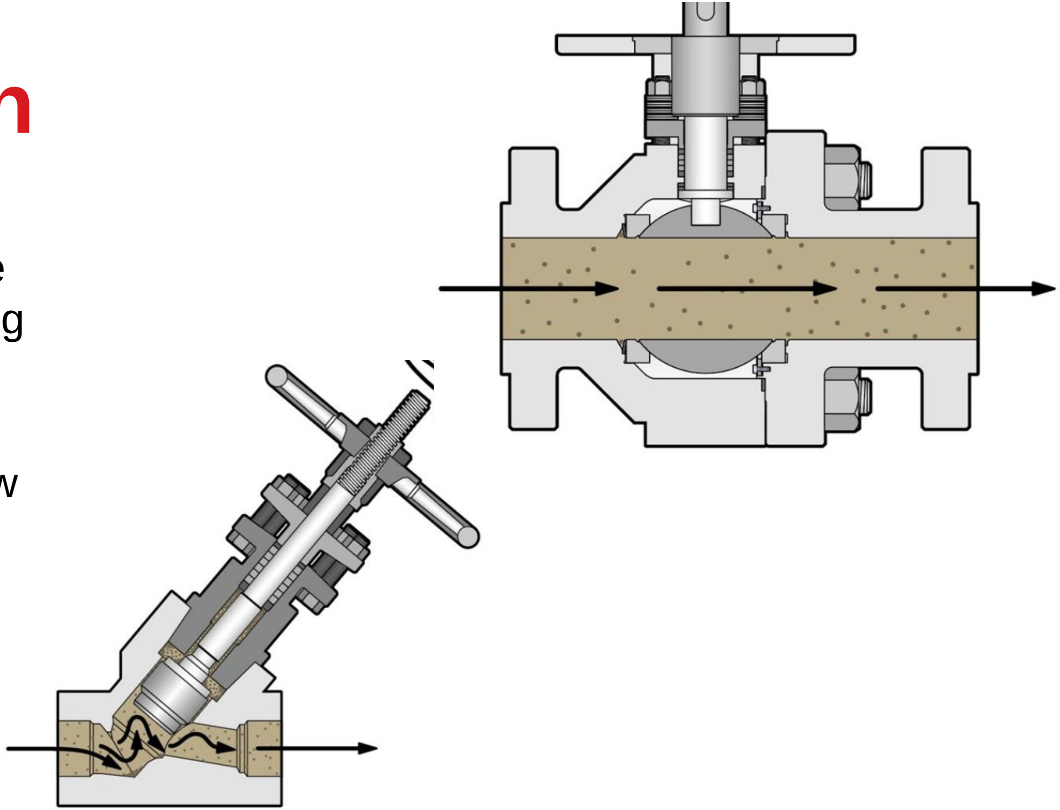


Battling Abrasion

Design:

To avoid third-body involvement, the sealing areas should be self-cleaning and in constant intimate contact.

Straight as opposed to torturous flow path is also desirable.



No design type is ideal in all aspects.

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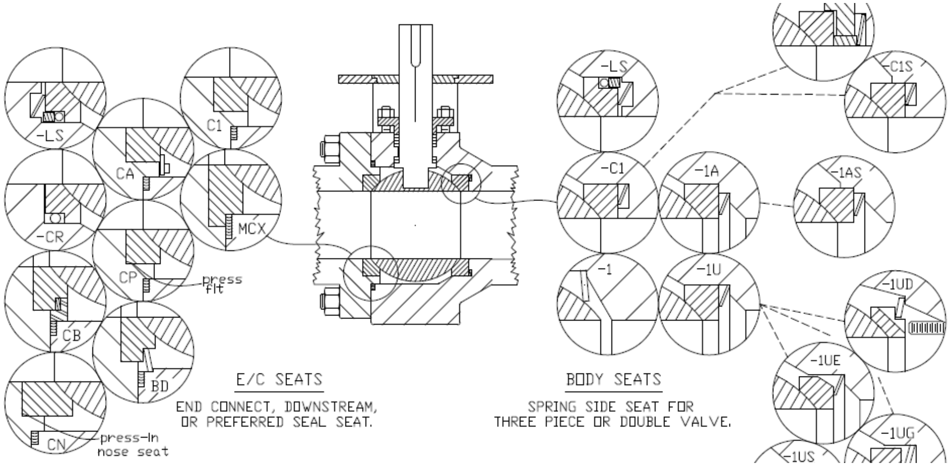
Tools Against Abrasion

Design:

“Design” is made up of geometry plus materials.

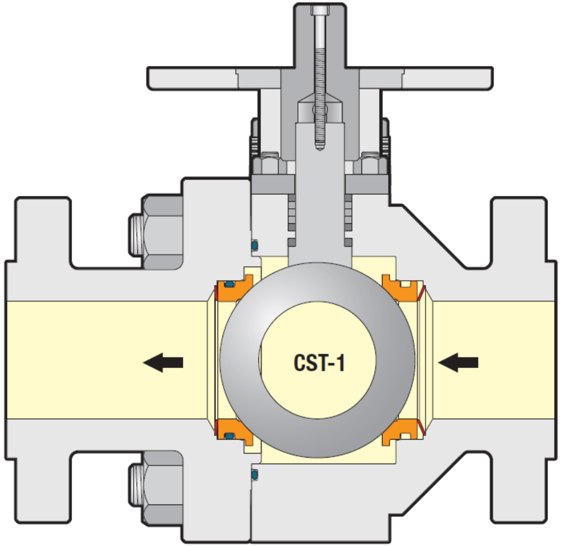
No one set of geometries can address every application.

MOGAS has at least 14 different seat designs. Each with features tuned to address the specific challenges of a particular installation.

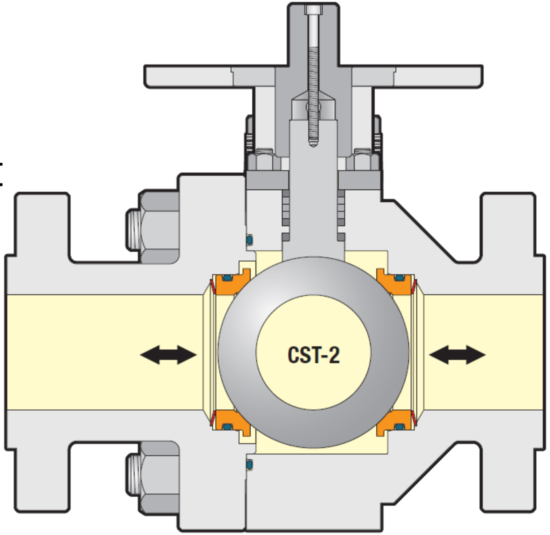


Tracking Seat design for Slurry Transport

To avoid third-body abrasion, solids need to be excluded from the ball and seat sealing surfaces.

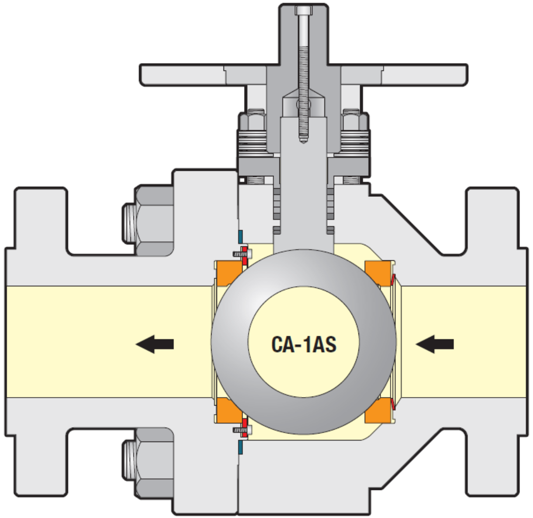


Design (continued):
Maintaining constant intimate contact between the seats and ball are essential to long, trouble-free service life in slurry transport applications.



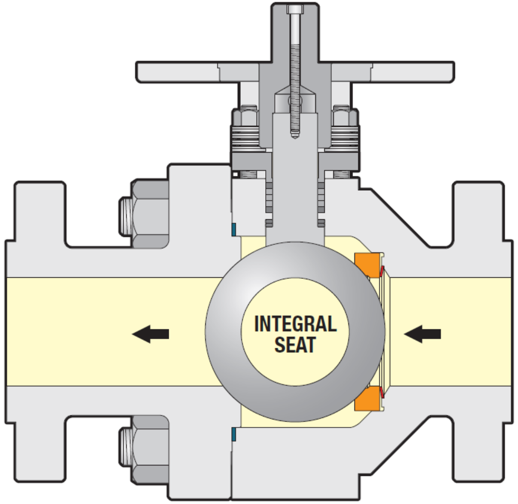
Tracking Seat design for Slurry Transport

Fixed or Locked-in Primary Seat – Primary Direction



Design (continued):
One EPC specifies the use of valves where the primary seat is integral or locked-in to the valve body. In the primary isolation direction, this approach is acceptable.

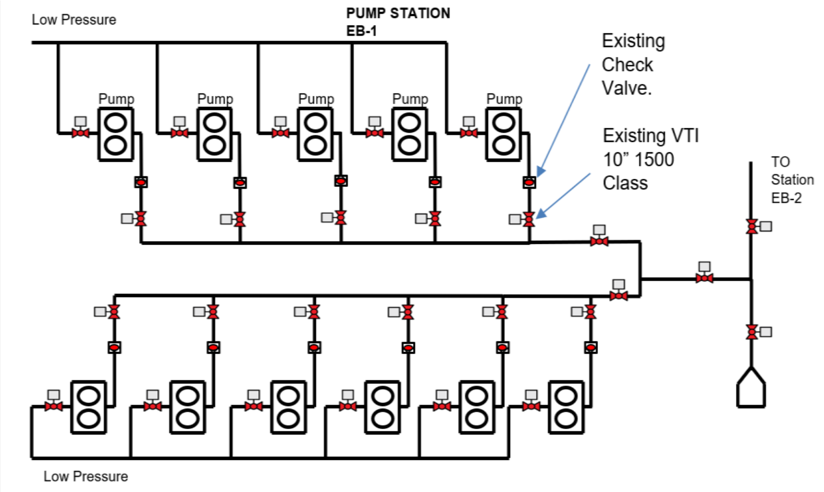
Note: For pump isolation, that same EPC requires the addition of a check valve in line with the Isolation valve for reliable bi-directional shut-off.

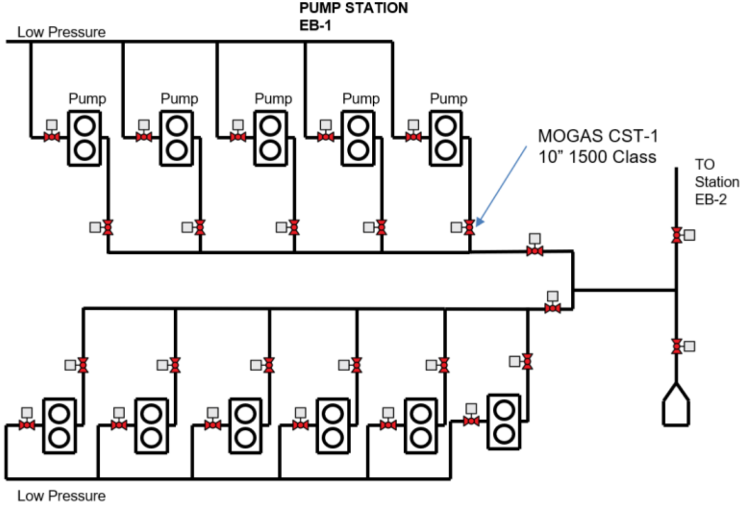


Existing "Spec" Pump Station VS. MOGAS style Pump Station

Check valves were considered sacrificial.

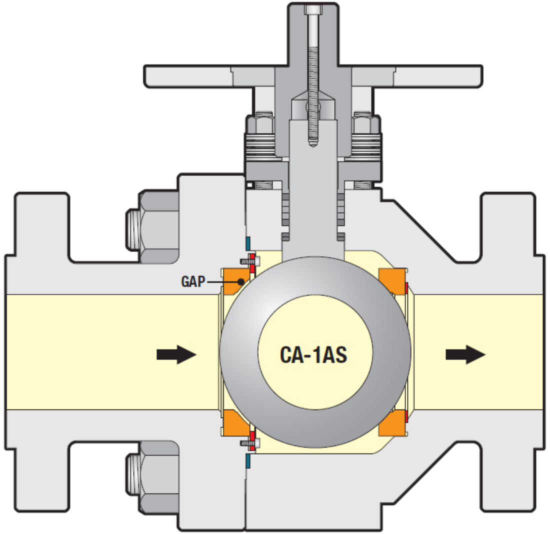
MOGAS considers them a waste of money,



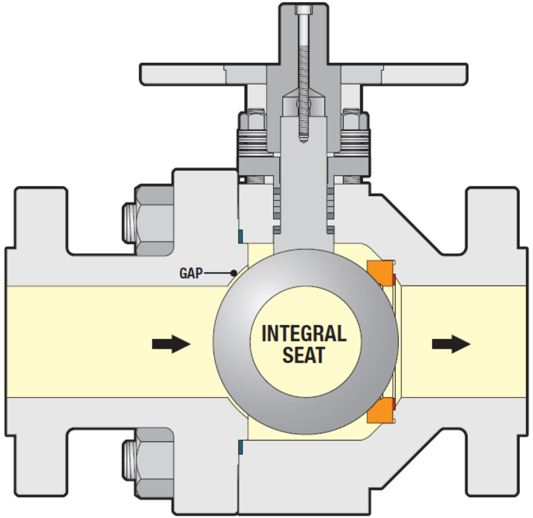


Tracking Seat design for Slurry Transport

Fixed or Lock-in Seat – Reverse Isolation

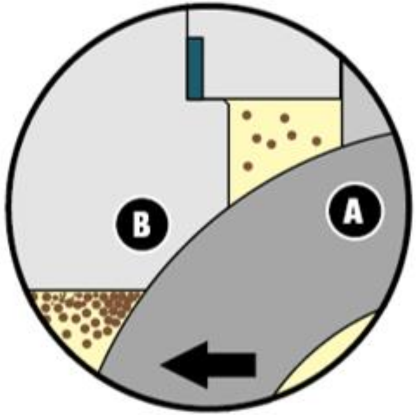


Design (continued):
But in the case of reverse pressure (or flow) the ball shifts off the primary seat toward the alternate seat resulting in a gap between the seat and ball's sealing surfaces.



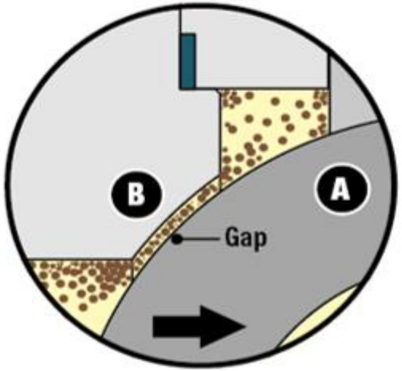
Tracking Seat design for Slurry Transport

Fixed or Lock-in Seat – Reverse Isolation



Normal Pressure

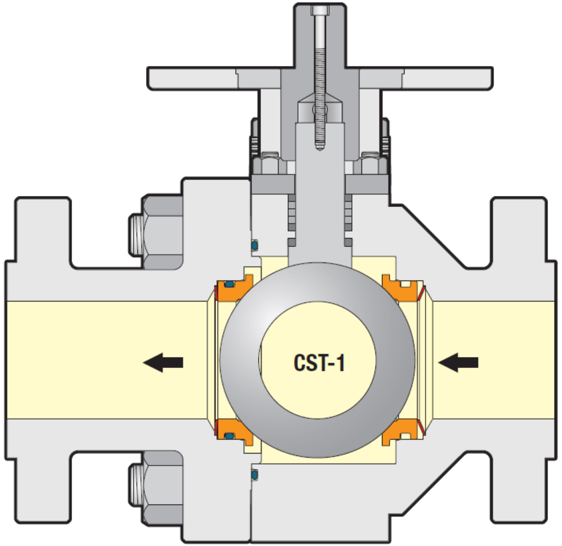
Design (continued):
When flow returns to normal, solids get compressed between the ball and primary seat resulting in leak paths.



Reverse Pressure

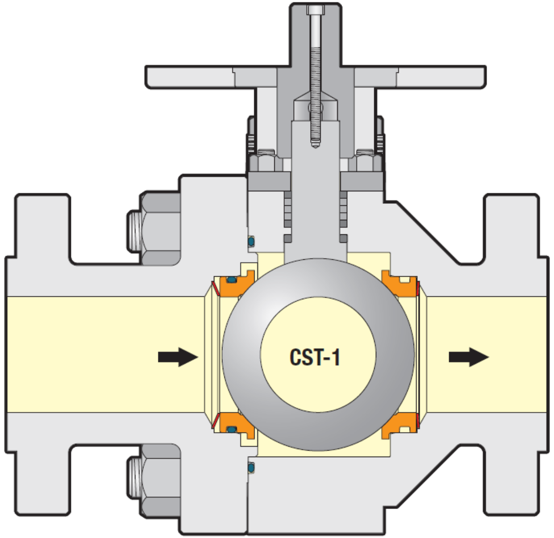
Tracking Seat design for Slurry Transport

MOGAS' CST-1



Design (continued):
MOGAS' recommended design for slurry transport is our CST Model.

These valves feature "tracking seats". Both seats are spring loaded to remain in constant contact with the ball regardless of flow direction, preventing third-body particles from being trapped between the ball and seat's sealing surfaces.

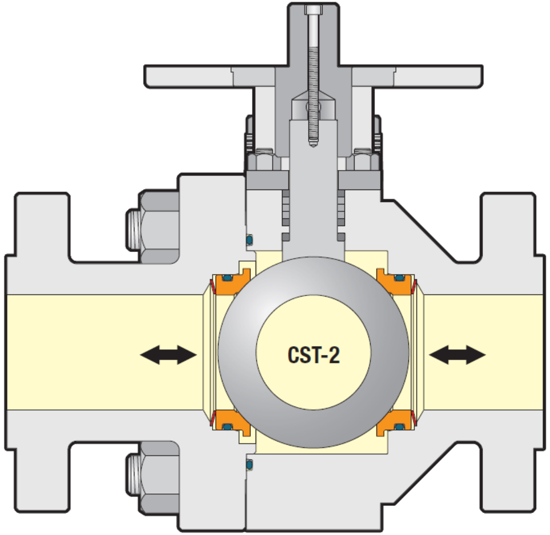


Tracking Seat design for Slurry Transport

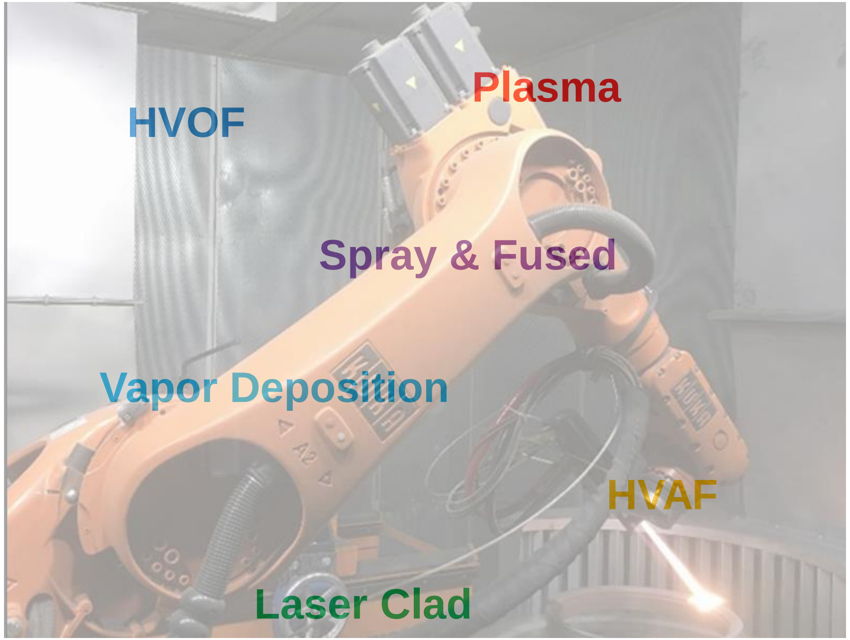
MOGAS' CST-2

Design (continued):
For fully bi-directional performance, MOGAS offers the CST-2. (This comes with an increase in operating torques.)

- Regardless of whether the choice is CST-1 or CST-2 an auxiliary in-line check valve isn't needed for reliable bi-directional isolation with MOGAS.
- Seat and ball sealing surfaces remain in constant contact avoiding introduction of third-body erosion opportunities.



Tools Against Abrasion



Design (continued):

Besides physical design features, the next most powerful weapon is coating technology; balancing hardness, ductility, abrasion resistance, chemical resistance, thermal characteristics and cost.

Tools Against Abrasion

Design (continued):

- MOGAS offers 7 standard HVOF coatings ranging from Chrome Carbides to Tungsten Carbides and including Metal Oxides (ceramics).
- Another 13 standard coatings are offered based on other application technologies; HVAF, Spray and Fuse, Nano, Plasma, etc.
- There are at least another dozen optional coating selections.

MOGAS COATING #	MAX. COATING TEMP.	NOTES
MH-831 HVOF CC w/ Ni Cr Binder ***700 HV min.***	1650°F	**MOGAS Standard HVOF Chrome Carbide. Nickel based coatings should not be used in Sulfide applications at temperatures greater than 600ºF** Limit to 800°F on 300 series SS Limit to 1100°F cont./ 1200°F Short Term on 400 series SS Limit to 1000°F for 660 SS Limit 500°F cont./ 650°F Short Term for 17-4PH Limit to 1400°F for Incoloy 800H Limit to 1200°F for Inconel 625 and 1300°F for Inc 718.
MH-817 HVOF WC w/ Co Binder ***950 HV min.*** (Tungsten Carbide – No Chrome)	950°F (Note 1)	**MOGAS Standard HVOF Tungsten Carbide.** Limit to 500°F cont./ 650°F Short Term for 300 series SS* Limit to 800°F cont./ 950°F Short Term for 400 series SS Limit to 800°F cont./850°F Short Term for 660 SS. Limit to 500°F cont./ 650°F Short Term for Incoloy 800H* Limit to 650°F for 17-4PH and Monel K500 Base Metals Limit to 900°F for INC. 718, INC. 625, Hastelloy, Monel 400 Limit to 600ºF for Super Duplex* (Use MH-273 for higher Temps) Limit to 800ºF for Ti Gr 5. *MH-273 Coating preferred on these Base Metals especially at higher temps. This coating is the same composition as MH-273, but more brittle and susceptible to cracking at elevated high temperature.
MS-216 S&F Ni Base ***58 HRC min.***	1300°F (Note 2) (1500°F short term excursion)	**MOGAS Standard Nickel Based Spray and Fuse. Nickel based coatings should not be used in Sulfide applications at temperatures greater than 600ºF. More Corrosion Resistant than MS-238, so more suitable for Process Applications. For valves 20" and larger consult SME prior to use.** Base Material Temperature Limits given in Table 2 Apply. S&F coating cannot be applied on 17-4PH,410SS or Monel K500 (Coating cracks on cool down after fusing). Consult Engineering when specifying for Super Duplex Base Metals as special fusing processes and testing are required. x[a]: Not offered as Standard but can be offered as an alternate
MS-238 S&F Ni Base ***59 HRC min.***	1300°F (Note 2) (1500°F short term excursion)	**MOGAS Standard Nickel Based Spray and Fuse. Nickel based coatings should not be used in Sulfide applications at temperatures greater than 600ºF. Tougher and more wear resistant than MS-216, so more suitable for Power Applications. For valves 20" and larger consult SME prior to use.** Base Material Temperature Limits given in Table 2 Apply. This coating cannot be applied on 17-4PH, 410SS or Monel K500 (Coating cracks on cool down after the fusing). Consult Engineering when specifying for Super Duplex Base Metals as special fusing processes and testing are required. x[a]: Not offered as Standard but can be offered as an alternate

Market Challenges

Each market has its own unique hurdles, and each has a multitude of individual applications with special demands. There are no universal solutions . . .

at least that are affordable.

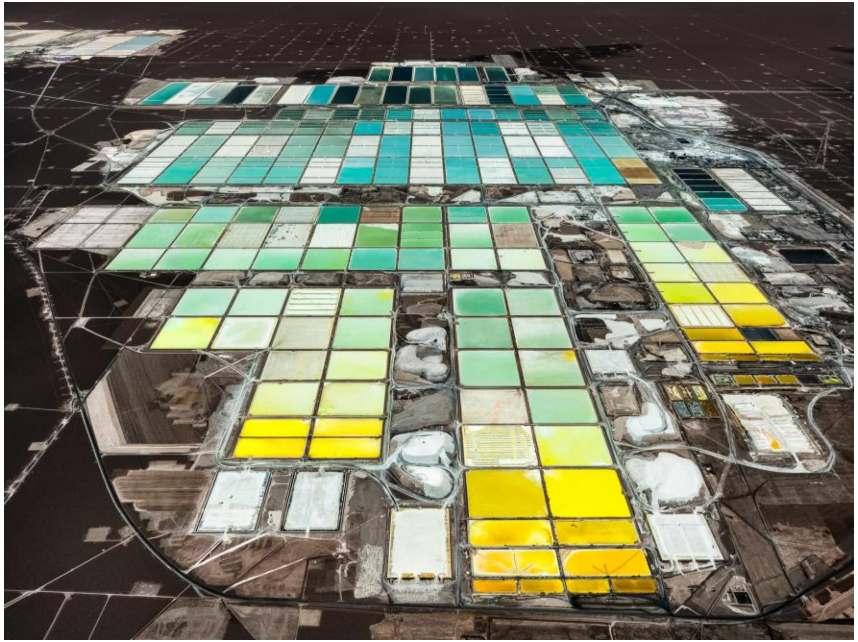
- Chemical/Petro-Chemical
- Metals Refining
- Mining/Slurry Transport
- Oil and Gas production
- Power
- Recycling*
- Refining

Mining/Slurry Transport

Materials:

Slurry transport system operate at medium pressures and ambient temperature, with the ore body ground and mixed with water* to about the consistency of toothpaste.

Abrasion is a concern, but the actions are slow.



Worldwide Experience

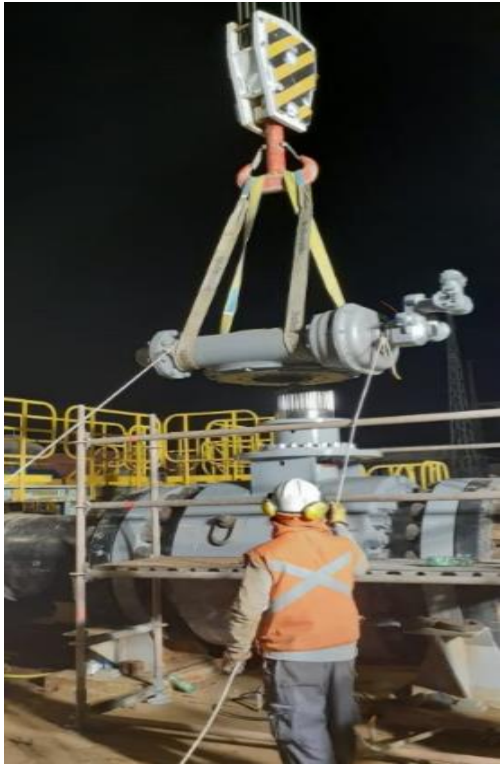
Year	Customer	Location	Application	Size, in	Pressure Class, psig
2016	Eti Bakir	Turkey	Copper, Cobalt, Gold	1 to 8	300, 600
2012	BHP Billiton (Esperanza Mine)	Chile	Copper Slurry	2, 3, 6, 8, 10	150, 600, 900, 1500
2007	Falconbridge Kidd Creek	Canada	Mine Dewatering	4, 6	1500
2000	Falconbridge Research Plant	Canada	POx (Various Metals)	3/4, 1	300, 600
1998	Gold Ridge	Solomon Islands	Gold Slurry	3, 12	300, 600
2005	Fosfertil	Brazil	Phosphate Ore Slurry	10	900
2003	Freeport-McMoran (Bagdad)	Arizona, USA	POx (Copper)	1 to 8	300
2006	Freeport-McMoran (Morenci)	Arizona, USA	POx (Copper)	1 to 8	300
2013	Huayou Cobalt Company	China	Cobalt	3/4 to 4	300, 600
2011	Impala Platinum	South Africa	Nickel	3	300, 600
1999	J.R. Simplot	Idaho and Wyoming, USA	Phosphate Ore Slurry	2, 6, 8	600, 900, 1500
2001	Kahama Mining Corporation	Tanzania, Africa	Mine Dewatering	1/2, 4, 6	900
2008	Kansanshi	Zambia, Africa	POx (Copper and Gold)	1-1/2 to 6	300, 600
2003	Kensington Gold Mine	Alaska, USA	Mine Backfill Plant	8	300
2007	Kittila / Agnico-Eagle	Finland	POx (Gold)	1/2 to 8	300, 600
2004	Lane Xang / Sepon	Laos	POx (Copper)	1 to 6	300, 600
1998	Lihir	Papua New Guinea	POx (Gold)	1/2 to 10	300, 600
2020	Ma'aden Gold and Base Metal Co.	Saudi Arabia	Gold	2 to 6	300, 600
1999	Macraes	New Zealand	POx (Gold)	1 to 6	900
2016	Mantos	Chile	Copper	4, 6, 8	900, 1500

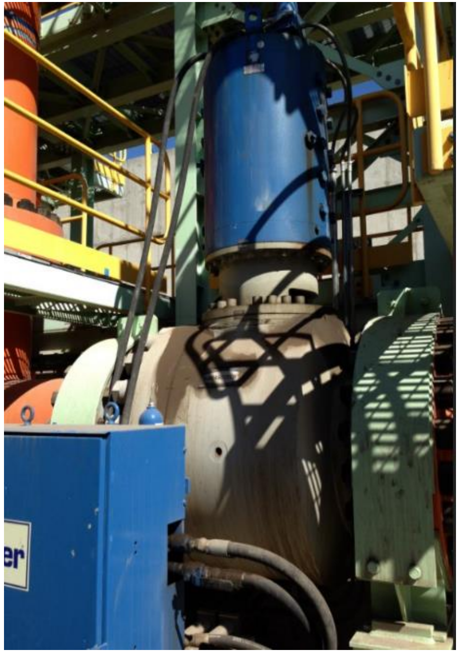
Year	Customer	Location	Application	Size, in	Pressure Class, psig
2009, 2012	Amursk	Eastern Russia	POx (Gold)	2 to 6	300, 600
1990–1993	Anglo American (Compania Minera Disputada)	Chile	Copper Slurry	2, 4, 6, 8, 12, 14, 16, 18, 20, 24	150, 600, 900, 1500
2021	Anglo American Plc Rustenburg	South Africa	Platinum	1 to 4	300, 600
2014	AngloGold Ashanti	Brazil	Gold	3	300, 600
2016	Anagold Madencilik	Turkey	Gold	1 to 10	300, 600
1996	Aur Louvicourt	Canada	Mine Dewatering	4, 6, 8	600
2002	Australian Bulk Minerals – Savage River	Tasmania, Australia	Magnetite Slurry	10	1500
1992	Barrick – Goldstrike	Nevada, USA	POx (Gold)	1 to 10	300
1992–2005	BHP Minerals – Samarco	Brazil	Iron Ore Slurry	4, 8, 12	600, 900
2013	CAP (Cerro Negro Norte)	Chile	Iron Ore Slurry	1, 2, 3, 4, 6, 8, 10	150, 300, 600, 900
2007	CAP (Hierro Atacama)	Chile	Iron Ore Slurry	1, 2, 3, 6, 8, 10	150, 900, 1500
1999	Cawse	Western Australia	HPAL (Nickel)	3 to 10	300, 600
2007	Chelopech	Bulgaria	POx (Gold)	1/2 to 8	300, 600
2006	Da Hong Shan Mining	China	Iron Ore Slurry	1-1/2, 2, 3, 4, 6, 8, 10	150, 1500
2006	Dominion Reefs / Uranium One	South Africa	POx (Uranium)	2 to 8	300, 600
2007	Dynatec / Ambatovy	Madagascar	HPAL (Nickel)	1 to 14	300, 600

(continued)

Automation

Just a reminder, Hydraulic actuators are common in slurry transport, but so are electric actuators and some locals dictate something othe rthan hydraulics.





Summary

- MOGAS has 50 years of experience in severe service and critical applications
- Custom designs for application specific requirements across many industries
- Lowest overall cost of ownership due to extended valve life / less maintenance
- Performance Guarantee
- Worldwide service & support
- Predictable Opex; lower cost of operation.

Qualifications, Certifications, Standards, or Tests will not guarantee the performance of your valve.

SIL FCI epa
ANSI ASTM B16.34 TUV
GOST-R NBBI API 6A
API 598 IEC MSS SP-82
MSS SP-61 CRN
BS 6755 ATEX NACE
API 6FA ISO 9001:2008
API 607 zero leakage TA-Luft
ISA PED
V-stamp DIN GOST-K ASME

WE DO.

Application-Specific

PERFORMANCE GUARANTEE

PLUS lifetime warranty on materials and workmanship

MOGAS will repair or replace valves at no charge should inspection indicate the valves have had external leakage or did not perform to its intended purpose because of internal leakage during the application specific, pre-determined time period.

Only from MOGAS

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QUESTIONS?

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