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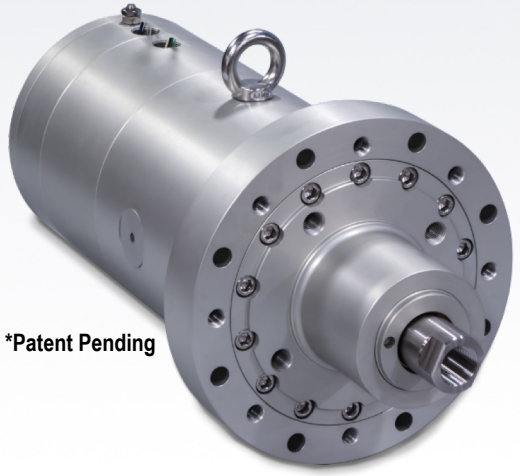
Enhanced Choke Valve Control with Integrated Automation Technologies

ServoChoke®



*Patent Pending

ServoChoke®

Agenda

- Meeting the challenges for MPD
- Comparing Available Technologies
- Design & Performance attributes
- Adding Value in MPD
- ServoChoke beyond MPD
- Industry Adoption
- Why Tolomatic
- Conclusions & considerations

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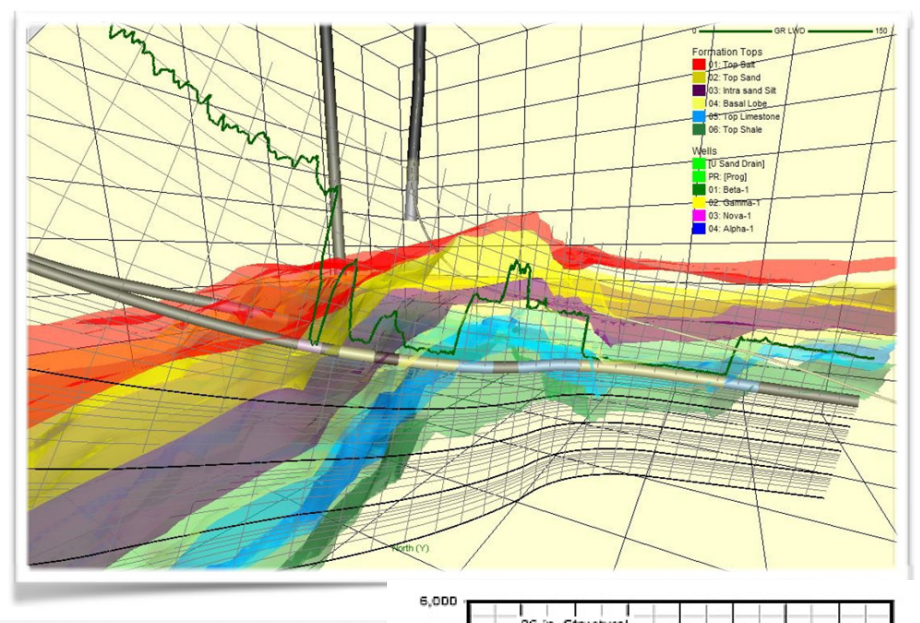
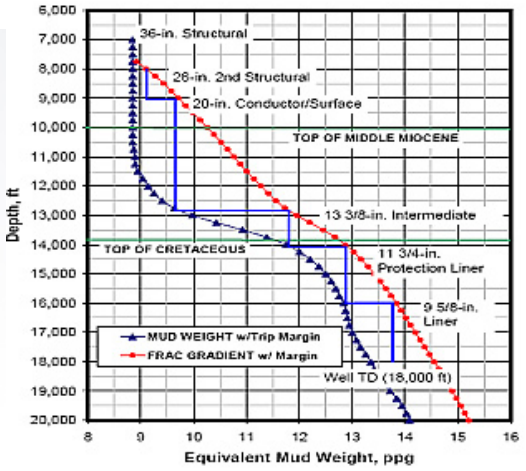
ServoChoke

Designed to Meet Challenging Pressure Control Requirements





High Reliability
No Maintenance & designed for long service life, reduces down time (NPT), No limitation on duty cycle

Rugged Integrated Design w/ Roller Screws

Superior Positioning
Low backlash, inline design, precise positioning

High System Rigidity

Speed – Open/Close, Adjustments
Quickly compensate for pressure changes, reduced settle time improves pressure control

Servo Controlled

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Comparing Available Technologies

- Comparison between commonly deployed MPD Choke Operators
- MPD requirements vary from operator to operator
- This chart has some of what would be minimum performance aspects for MPD equipment

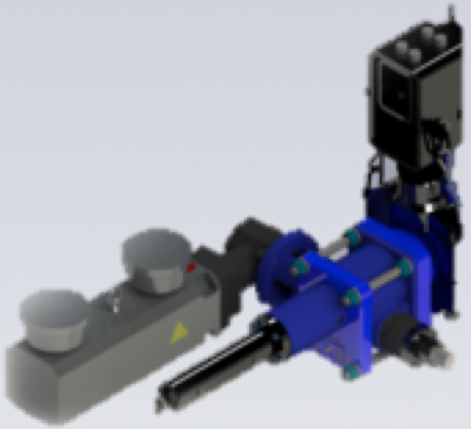
MPD Needs

	Hydraulic	Fully Integrated	Jack Screw
Tight pressure control	Good	Excellent	Very Good
Continuos operation	Fair	Excellent	Very Good
High reliability	Very Good	Excellent	Very Good
Minimal to no maintenance	Good	Very Good	Good
Long service life	Fair	Excellent	Very Good
Durable	Very Good	Very Good	Very Good
Safe	Excellent	Excellent	Excellent
Price	Excellent	Fair	Very Good

Excellent
Very Good
Good
Fair
Not Applicable

Available Technologies

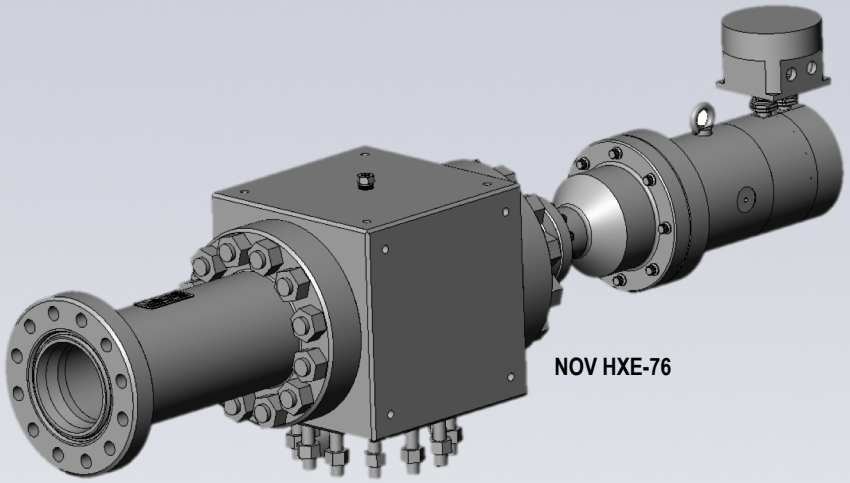
Fabricated Actuator



- Mechanics are not ideally suited for applications above 40% duty cycle
- Unpredictable service life
- Full open to full close times typically longer than 7 seconds (2” travel)
- Typically will use same or similar drive components from hydraulically actuated valves
- Allows use of brushless motor technology
- Motors may be subject to discontinuation
  - 2 commonly used motors have been discontinued or slated for discontinuation in the last 24 months
- Can be globally certified
  - Selection of manufacturers with ATEX, IECEx, and C1D1 on a single motor assembly is limited
  - May require stocking two separate part numbers
- Full range of operating temperatures available with the motor and mechanics
- Components separately sourced or manufactured
- Additional assembly and set-up when installing or replacing on the choke
- Repeatability is limited
  - Typically will not exceed +/- 0.002”
  - Continual maintenance will be required to maintain performance

Available Technologies

ServoChoke® SVC



- No mechanical adjustments needed to maintain repeatability
  - Reduced total cost of ownership
- Designed to achieve in excess of 7 million linear inches of travel at full load
  - Not limited to number of adjustments or start/stops per hour
  - Assuming an average adjustment of 3% - ServoChoke (15K) would exceed 50 million adjustments at full load
- Full open to full close in less than 3.5 seconds (2” travel)
- Utilizes highly reliable automation grade components
  - Brushless servo motor
  - Roller Screws
- Rated for 100% duty cycle
- Globally certified for ATEX, IECEx, and C1D1 (US & Canada)
  - Dual assemblies will not be required based on country of operation
- Single assembly contains the motor, mechanics, and feedback
  - No need install subassemblies on the valve
- Newly available to the market ensures reliable availability of new assemblies & parts
- Single source for entire assembly ensures consistency and performance of the “System”

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ServoChoke® INTEGRATED ELECTRIC CYLINDER

Tolomatic...MAXIMUM DURABILITY
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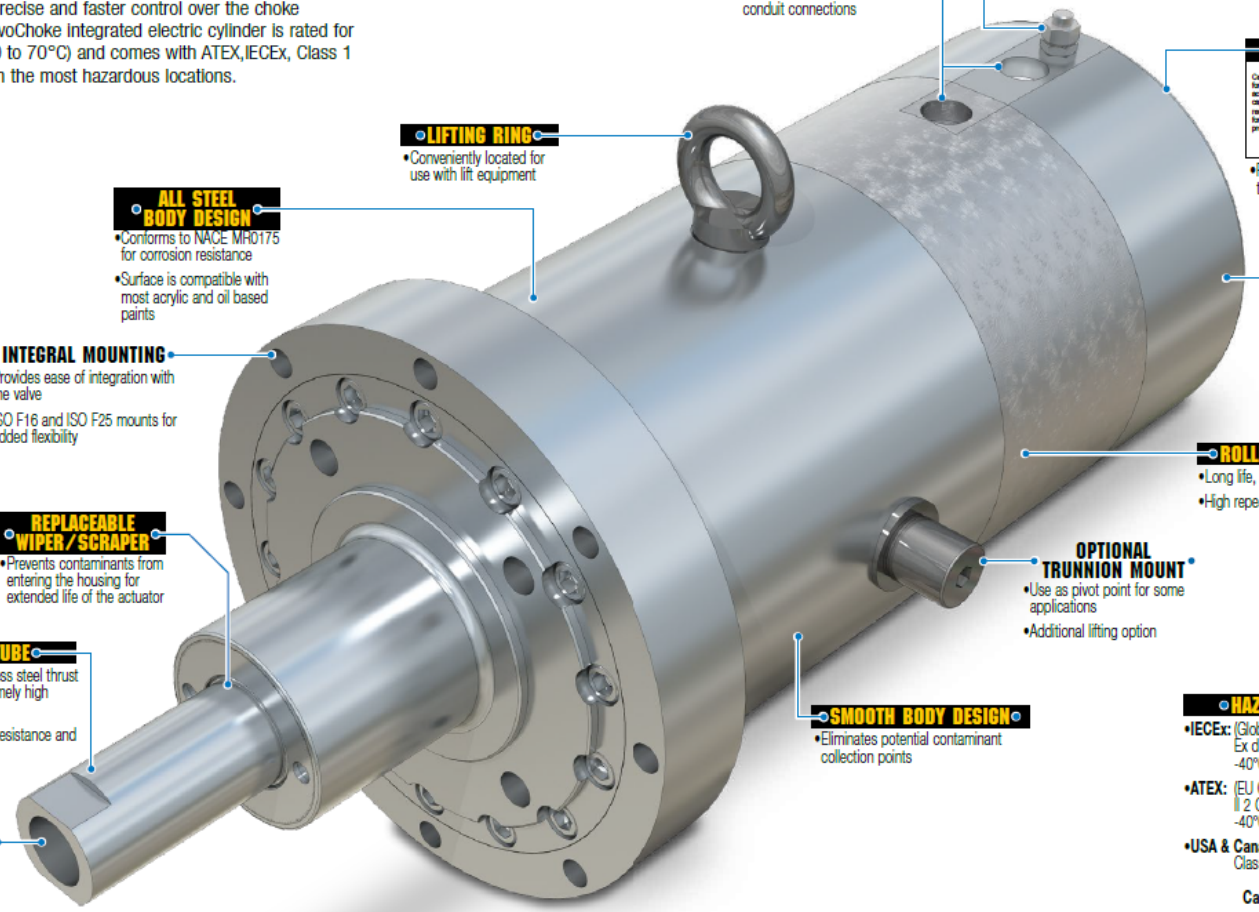
ENDURANCE TECHNOLOGY℠

Endurance Technology features are designed for maximum durability to provide extended service life.

ServoChoke is a high perfromance integrated electric cylinder designed specifically for controlling choke valves in MPD (Managed Pressure Drilling) and other well control installations. ServoChoke delivers more precise and faster control over the choke compared to hydraulic solutions. The ServoChoke integrated electric cylinder is rated for extreme temperatures (-40 to 158°F, -40 to 70°C) and comes with ATEX,IECEx, Class 1 Division 1 certification to operate safely in the most hazardous locations.



SIMPLE TO CONNECT
MOTOR & FEEDBACK
- 24" (0.6m) Flying leads with 3/4 NPT threads for conduit connections

GROUNDING LUG
- Conveniently located, stainless steel for corrosion resistance

MANUAL OVERRIDE
- Provides mechanical method to extend and retract the thrust rod in power off situations

LIFTING RING
- Conveniently located for use with lift equipment

ALL STEEL BODY DESIGN
- Conforms to NACE MR0175 for corrosion resistance
- Surface is compatible with most acrylic and oil based paints

HIGH POSITIONAL REPEATABILITY
± 0.00075" ± 0.0191mm

HIGH RESOLUTION FEEDBACK
- Multi-turn absolute encoder
- Hiperface protocol

INTEGRAL MOUNTING
- Provides ease of integration with the valve
- ISO F16 and ISO F25 mounts for added flexibility

ROLLER SCREW TECHNOLOGY
- Long life, high efficiency
- High repeatability, compact design

REPLACEABLE WIPER / SCRAPER
- Prevents contaminants from entering the housing for extended life of the actuator

OPTIONAL TRUNNION MOUNT
- Use as pivot point for some applications
- Additional lifting option

THRUST TUBE
- High strength stainless steel thrust tube supports extremely high force capabilities
- Excellent corrosion resistance and surface hardness

SMOOTH BODY DESIGN
- Eliminates potential contaminant collection points

THREADED ROD END
- Allows for custom rod connections for the valve stem

HAZARDOUS LOCATION RATED
- **IECEx:** (Global Certification) for Zone 1: Ex d IIB T4 Gb $-40°C < T_{AMB} < +70°C$, IP67
- **ATEX:** (EU Certification) for Zone 1: II 2 G EX d IIB T4 Gb $-40°C < T_{AMB} < +70°C$, IP67
- **USA & Canada:** Class 1 Division 1 Groups C and D, T4
  USA: Class 1, Zone 1 AEx d IIB T4 Gb
  Canada: Class 1, Zone 1 Ex d IIB T4 Gb $-40°C < T_{AMB} < +70°C$, IP67

Globally Certified

- Fit for purpose design for all choke valve applications, including MPD

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- Globally certified
  - Class I, Division 1, Groups C and D, T4 (UL1203/CSA C22.2)
  - Class 1, Zone1, AEx db IIB T4 Gb (IECEx U.S.)
  - Class 1, Zone1, Ex db IIB T4 Gb -40°C≥TAMB≤+60°C, Type 3R (IECEx Canada)
  - Ex db IIB T4 Gb -40°C≥TAMB≤+60°C (ATEX Zone 1)
  - CE Ex II 2 G Ex db IIB T4 Gb -40°C≥TAMB≤+60°C IP6X (IECEx Zone 1)

- Rugged, all steel, fully integrated design
  - Motor, linear actuator, and feedback
  - NACE MR0175 Compliant

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Performance Attributes

- Superior precision
  - Repeatable better than 0.001”
- Superior speed
  - Full open to full close in less than 3.2 sec (7K), 5.9 sec (15K)
  - Modulating moves 0.12” (6%) in less than 0.40 sec (7K) 0.61 sec (15K)
- Maintenance Free
- Continuous duty rated up to 15,000 lbf. (SVC15)
- Temp rated to -40C to +60C
- Self locking (fail in place)
- Manual override
- High efficiency
  - 208-460 VAC
  - 6 amp peak current draw

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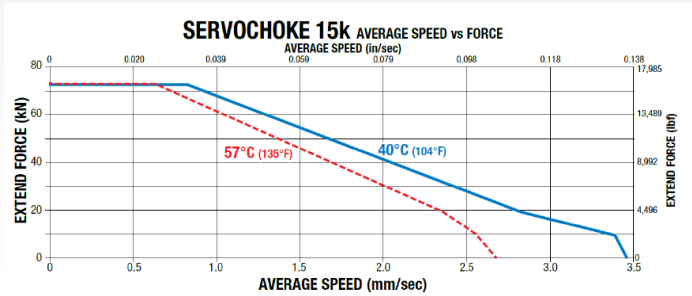
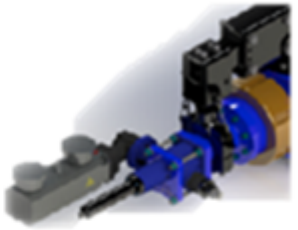


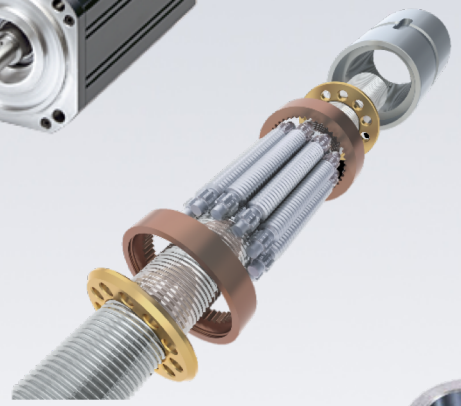
Comparing Similar Technologies

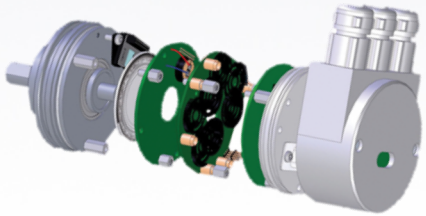
		SVC		Fabricated
				
Continuous Thrust	Lbf	15,000/7,000		Unknown
Peak Velocity	mm/sec	✓ 18.9 / 9.4		7.5 est
Programmable/Variable Speed	Yes/No	Yes		Yes
Reversting Time (Latency)	ms	5		5
Duty Cycle	%	✓ 100%		40%
Start/Stop per min		Unlimited		Unlimited
Repeatability (2" travel)	%	✓ 0.04		*0.50
Maintenance Free	Yes/No	✓ Yes		No
Real Time Data Collection	Yes/No	Yes		Yes
Certifications		✓ ATEX, IECEX, C1D1		ATEX, C1D1
Well Control Capable	Yes/No	Yes		Yes
MPD Capable	Yes/No	✓ Yes		Yes

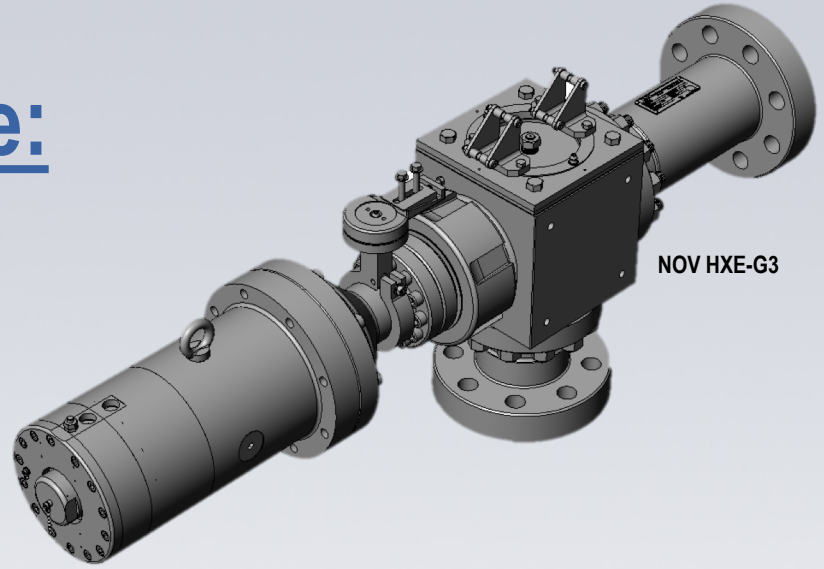
*Requires regular maintenance

Industrial automation components inside:

- Servo Motor
- Roller Screw
- Servo Class Gear Reduction
- Absolute multiturn encoder







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Why were these components chosen?

- This component combination is the primary choice for the automotive industry for resistant spot welding of body frames
  - 6-9 million welds per year with no preventative maintenance to the actuator
  - Average 2-3 years of service (15-20 million welds)

- Average cost of down time is $22,000 per minute
  - Some estimates indicate over $50,000 per minute
- These same components are what has been integrated into the ServoChoke® SVC actuator
  - Ensures maximum reliability, availability, and consistency in mission critical applications
- Over 30,000 ServoWeld® units from Tolomatic have been deployed globally

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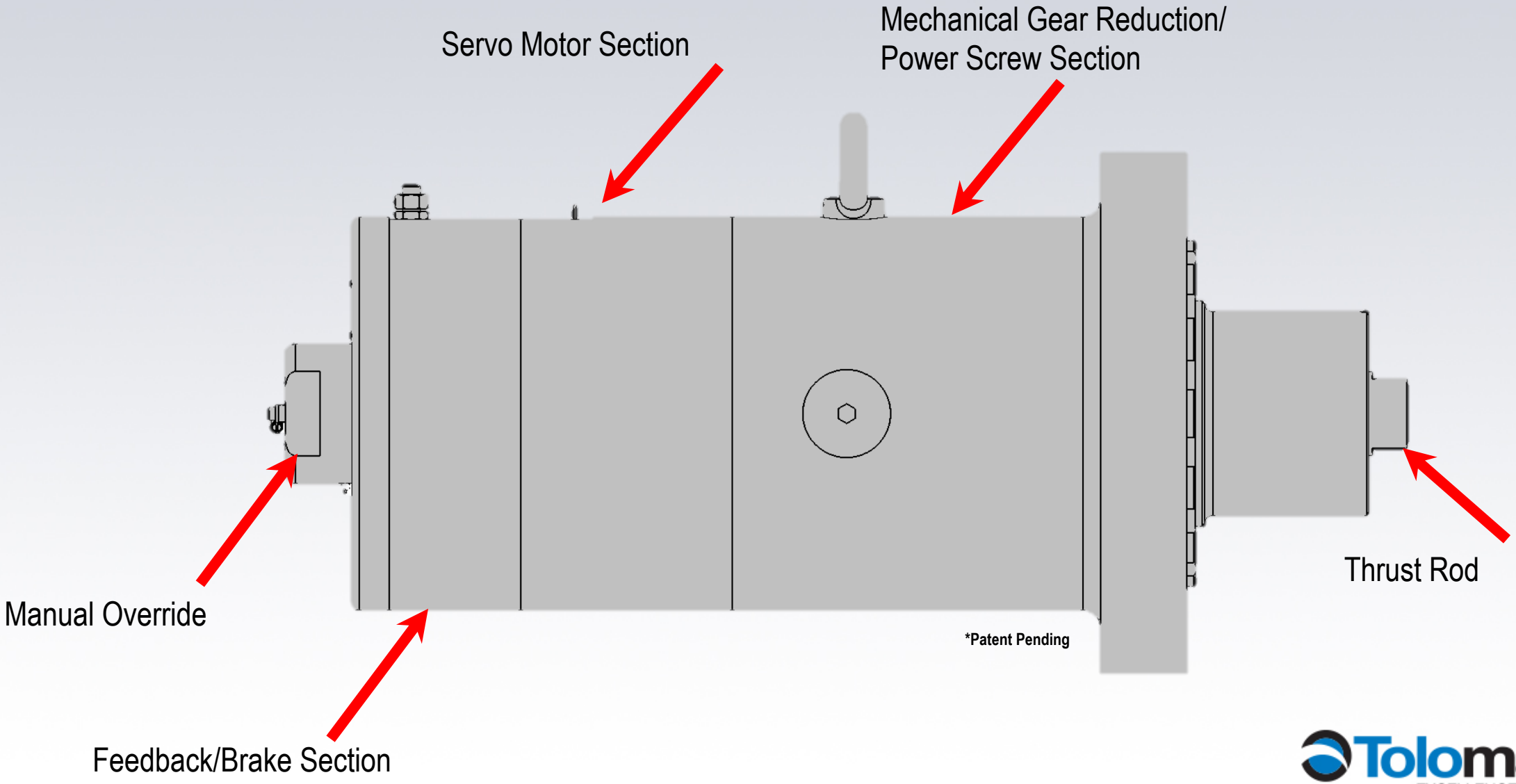
Fully integrated, all-in-one design



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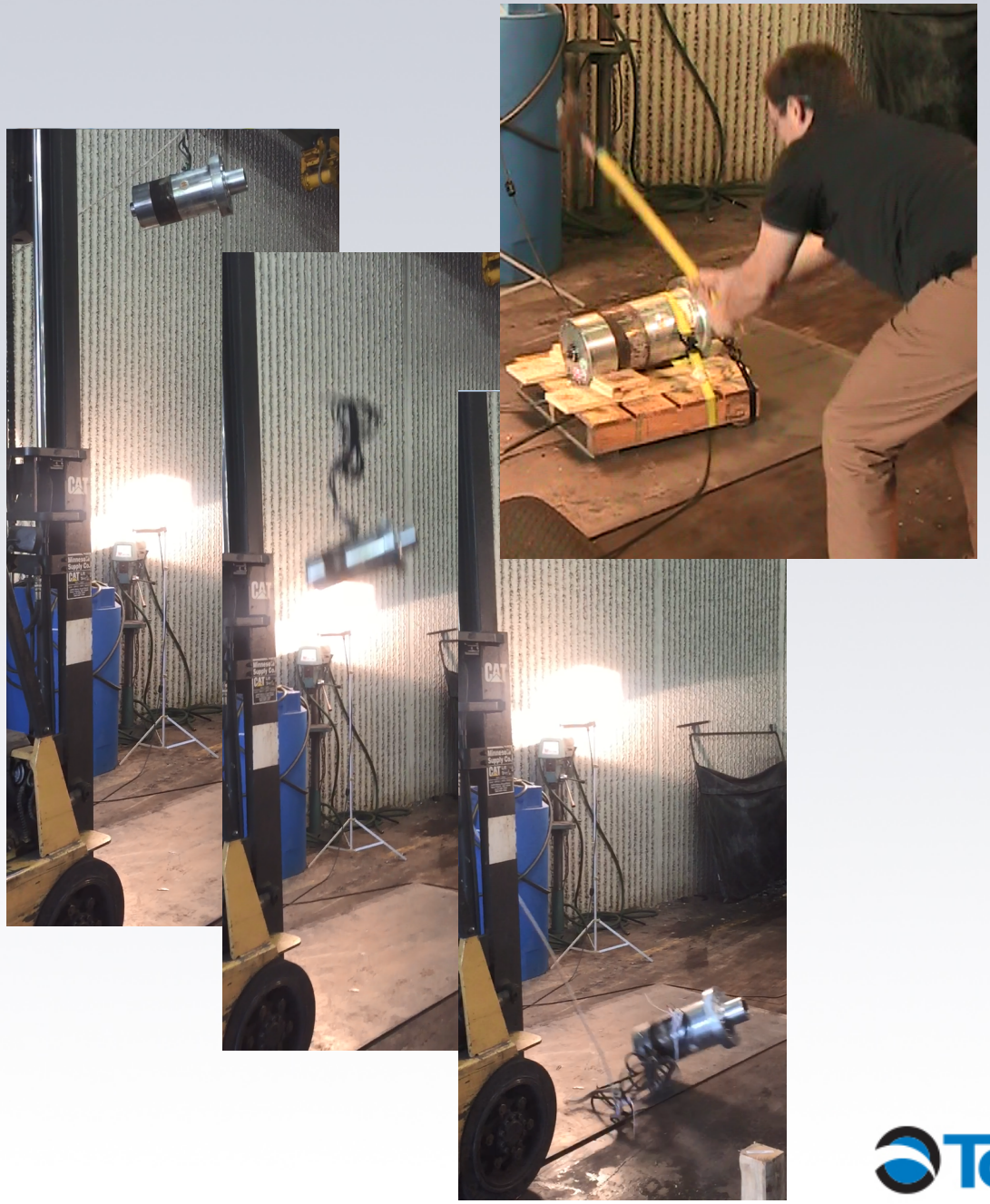
Ruggedized Design

- In-house impact testing



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Where does ServoChoke® add value

- Maximum reliability
- Designed for continuous duty
- Longest designed service life
- Zero maintenance
- Superior pressure control
- Full access to actuator performance parameters

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Robust Precision Solution for the Oilfield

- ServoChoke® can influence overall operational expenses
  - Cost of avoiding one influx can quickly exceed $12,000 to $15,000
  - The same can be said with stuck pipe with savings surpassing $1,000 to $2,000 per incident
- Higher overall repeatability and lack of maintenance can offer savings during start-up and while drilling
  - Calibration routines take time away from drilling
  - Additional time for initial set-up and calibration contributing to NPT
  - Saving >60 min/mo can net savings of >$5,000/mo
- Oilfield equipment is often mishandled leading to damaged components
  - One incident could cost the rig over $12,000
    - One replacement servo motor can cost over $4,000
    - NPT time and labor to replace this motor could exceed $8,000

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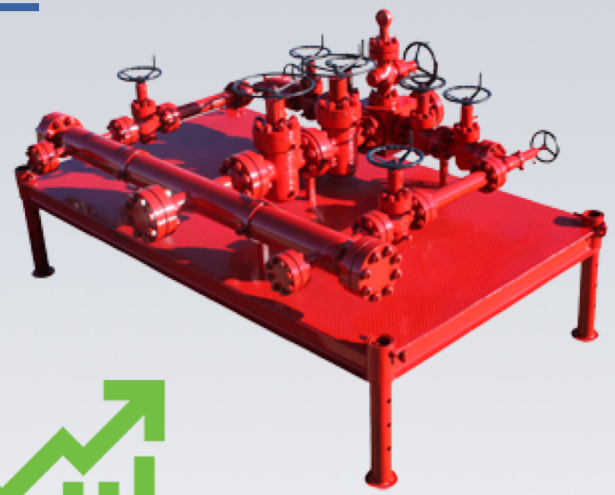
Help continue to optimize the drilling process?

- Peak reliability and availability ensure the equipment works where and when you need it

- Speed and precision can help enhance existing pressure control software
  - May enable software to calculate and execute more adjustments per minute or per second
  - Enhanced precision may help offset minor computational errors which could avoid an influx or stuck pipe
  - Some believe ServoChoke could eliminate the need to use a back pressure pump when making connections
- One actuator can be used across multiple chokes within the drilling process to reduce number of components and spares to track
  - MPD Chokes
  - Drillers Chokes
  - Choke & Kill
  - Block Style PRVs
- Better control, zero maintenance, and improved drilling operations all lead to reduced risk of NPT, damage to equipment and the safety of the rig crew



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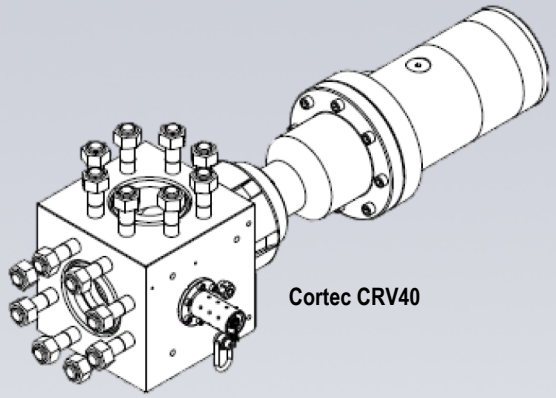
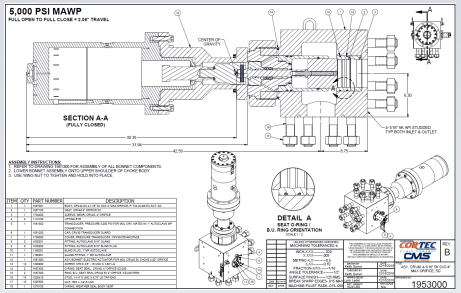
ServoChoke® beyond MPD Drilling Chokes





- We are seeing increased interest in other applications
  - Inquiries started in 2015
- ServoChoke® has also been evaluated & approved for use on:
  - 6” MPD choke systems
  - Set-point drilling chokes
  - Block style PRV
- Tolomatic has installed actuators on PRVs as part of an MPD manifold
- Common reasons driving inquiries for electric PRVs:
  - Adds ability for remote or condition based changes in pressure set point
  - Allows for “throttling” or slight bleed off of pressure rather than a conventional “pop off”
  - Can act as an additional means of controlling pressure
- ServoChoke® would also work on 5K & 10K C&K 1 ½” – 3” orifice sizes

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Industry Adoption

Tolomatic is working with the following choke manufacturers

CAMERON
A Schlumberger Company

CORTEC

EXPRO

NOV

VALVEWORKS USA
WHEN PRESSURE DEMANDS QUALITY®

ServoChoke® has been approved for use with the following MPD Drilling Software

ABSOLUTE CONTROL

KELDA
drilling controls

NOV

We have proven compatibility with

SafeKick
Empowered Solutions

Tolomatic is currently working with 6 different companies land and offshore MPD systems

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Why Tolomatic ServoChoke® for Choke Control?

- Global supplier of high performance automation grade actuators for over 60 years
- Specialists in linear mechanical motion control
- Designing fit for purpose actuators for the operation of linear choke valves
  - Choke & Kill
  - Managed Pressure Drilling
- Member of API-16C committee developing requirements for electric actuators for choke valves
- Performance tested under varying temperature and force conditions reflecting real world operating environments
- Single source for all choke valve actuators

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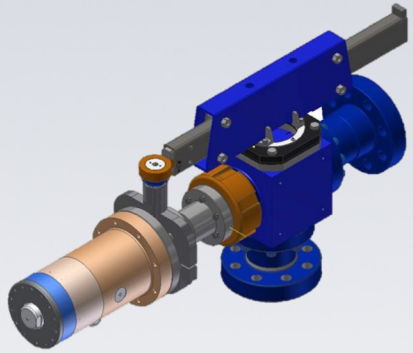
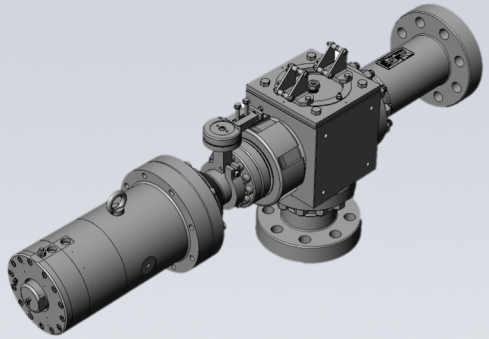
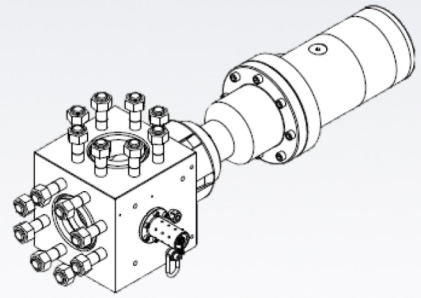
Considerations

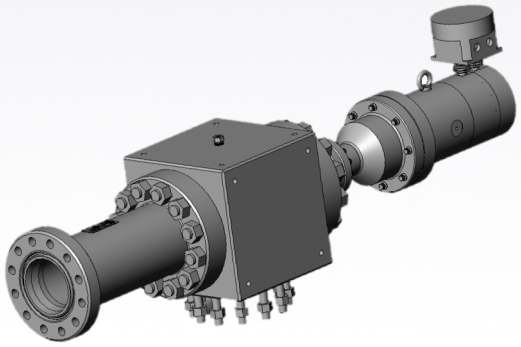
- Tolomatic ServoChoke® SVC actuators are ideally suited for continuous drilling or high performance valve operations
- Versatile for not only MPD chokes but, PRV operation, set-point, & C&K
  - Standardize on a single actuator for multiple uses
- Industrial Automation grade components with predictable service life ensure consistent and reliable performance for years with zero maintenance
- Expanding installed base, field deployments and industry acceptance
  - Currently being deployed on MPD chokes and electric PRVs
- Improved valve control allows for focus on other key components or systems that can further the increase in safety and provide additional cost reductions

Questions









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