Master Flo

Master Flo

Product Overview

Haynesville Choke

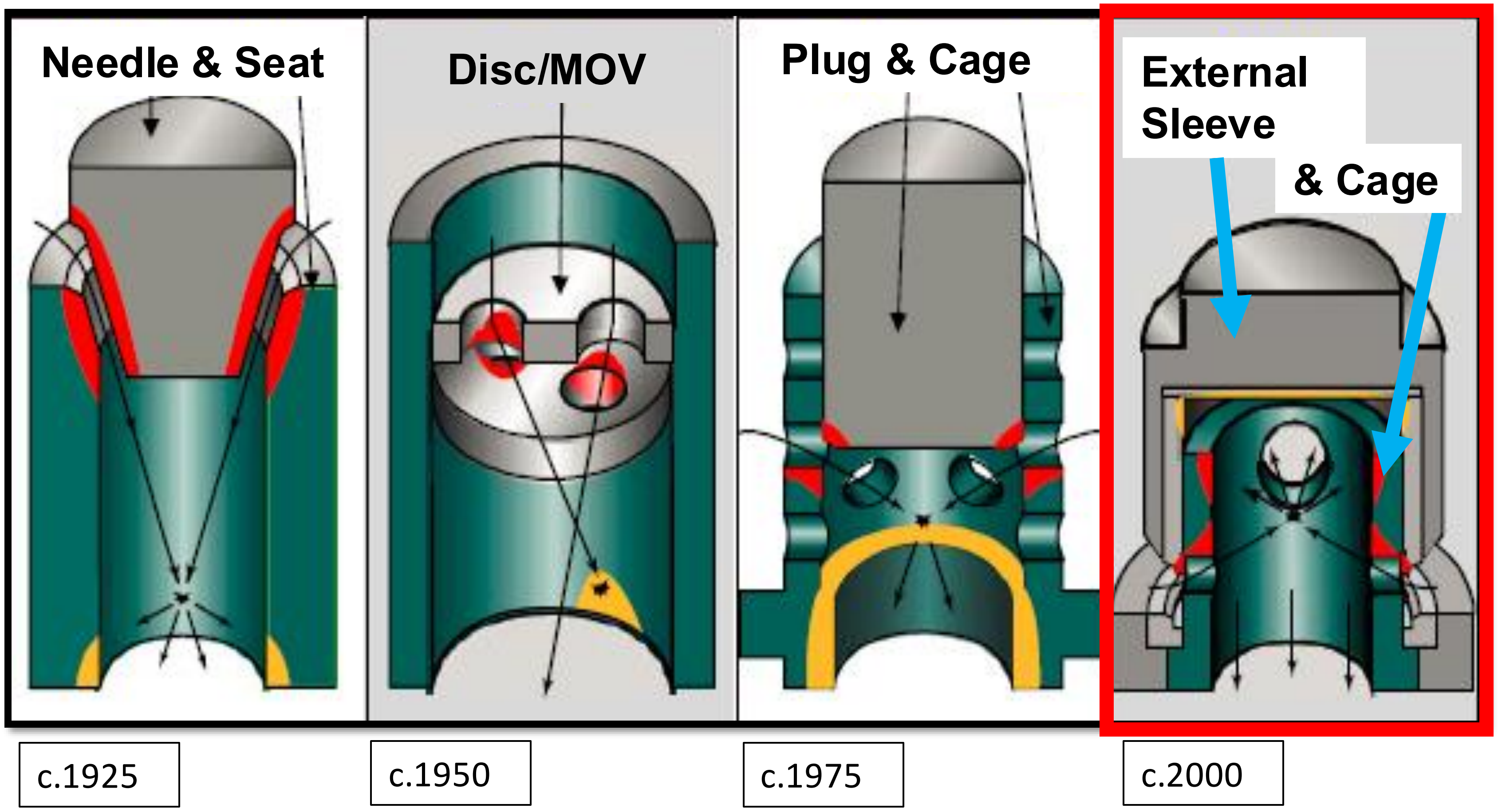
Manual Chokes vs Auto Chokes

Back Pressure H Pump CV Produced Water

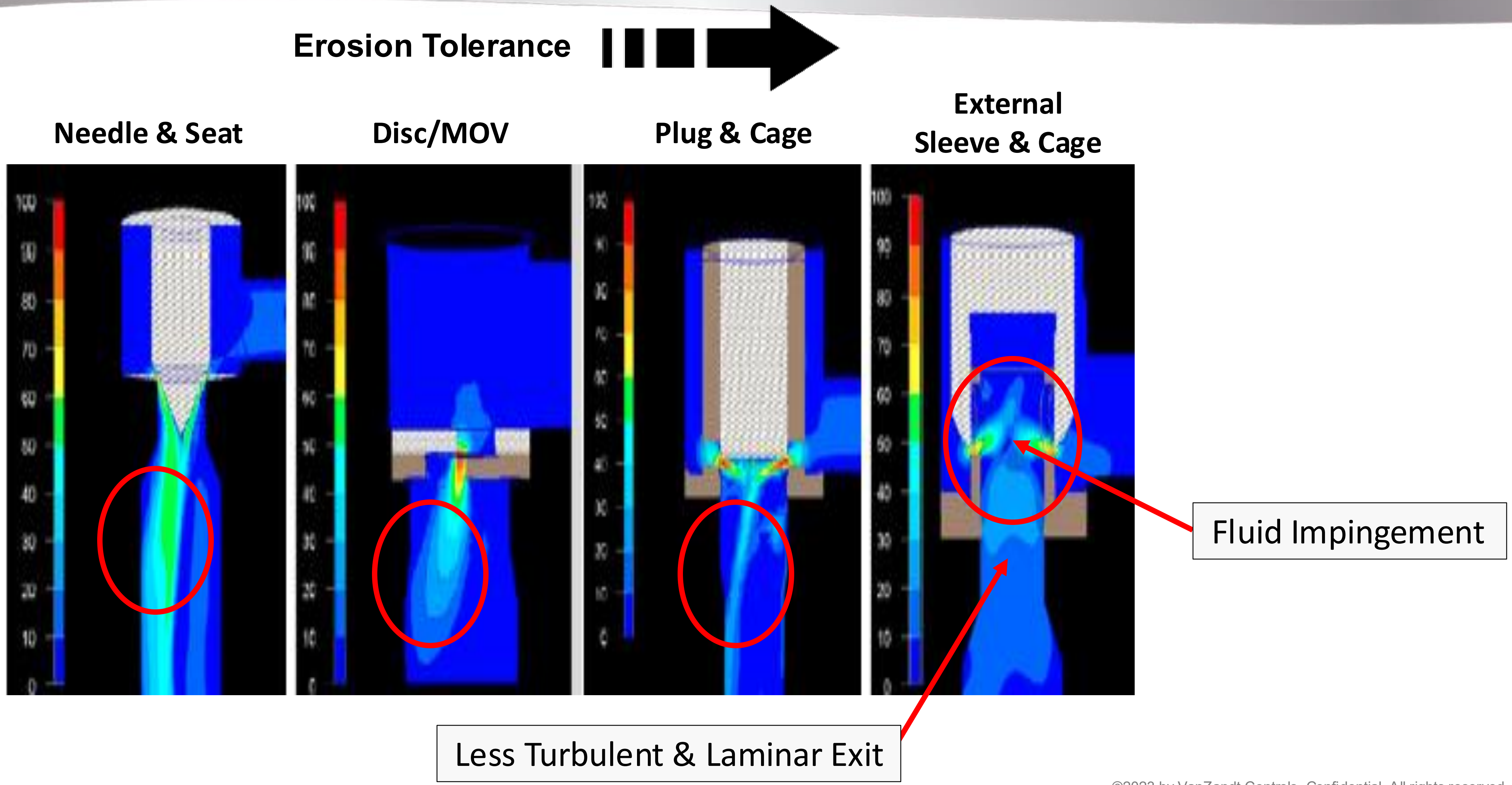
Extreme Erosion Solution

PRODUCTION CHOKES FUNDAMENTALS

Four Primary Trim Designs



Fluid Jetting Comparison



NEEDLE & SEAT CHOKES
Low Cost, Significant Challenges

VANZANDT CONTROLS, LLC
Eagle AUTOMATION

Not Pressure Balanced
Unbalanced Trim requires much **more Torque** to Operate

Extreme Torque Requirements
Directly proportional to Inlet Pressure
Can become Extreme in applications where:
- High DP
- High Inlet Pressure

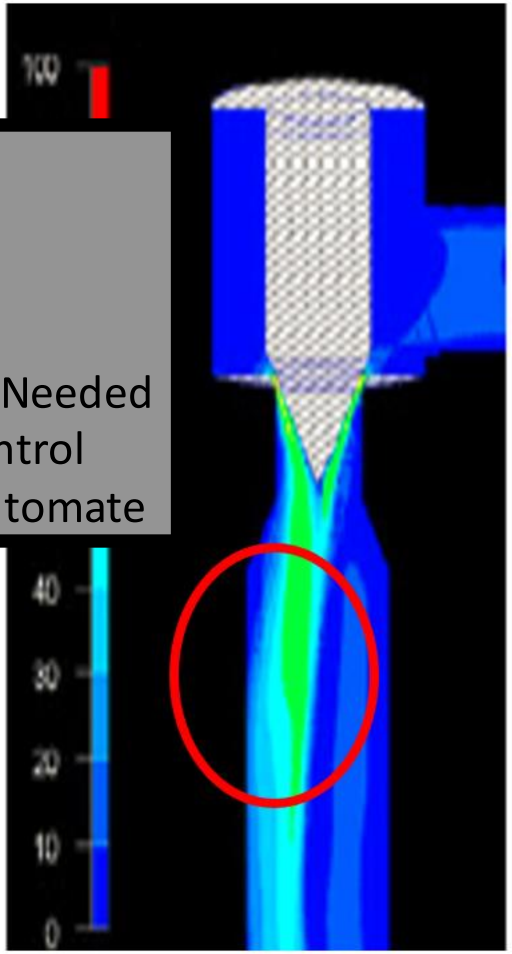
Shearing Valve Stems is Common
In Automated Applications
After adding Safety Factor, might exceed MAST Value
- Maximum Allowable Stem Torque

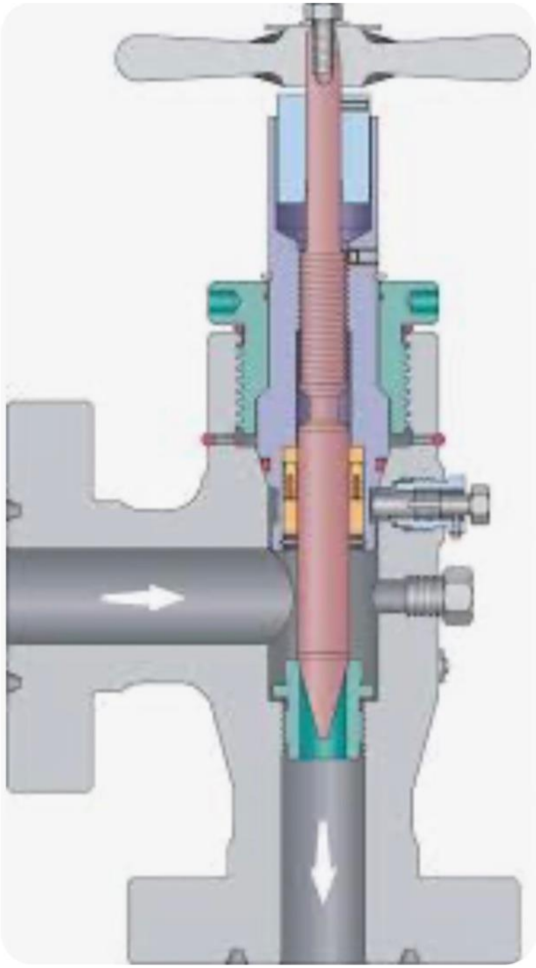
Serious Safety Concern
If the **Stem Shears below the Stem Packing/Sealing area**
- Process media **might be released at high velocity**
- Towards surrounding equipment or personnel

Highest Market Share
Needle & Seat
60-70% Market Share
Low Cost
High Maintenance Effort Needed
Damaged Seat = Poor Control
Not Recommended to Automate

Can't Automate
Too Difficult to Control

Not Robust
Easy Erosion





MASTER FLO CHOKES
Erosion Challenges Have Increased

Erosion Defined
Gradual Reduction & weakening of valve bodies or trim
Due to severe process conditions including
dirty process, flashing, cavitation and outgassing

Longer Lateral Reach of Wells
In the last 10 years

Fracking Proppant Challenges
Getting Finer and More Erosive
Finer Sand = Deeper into Fractures

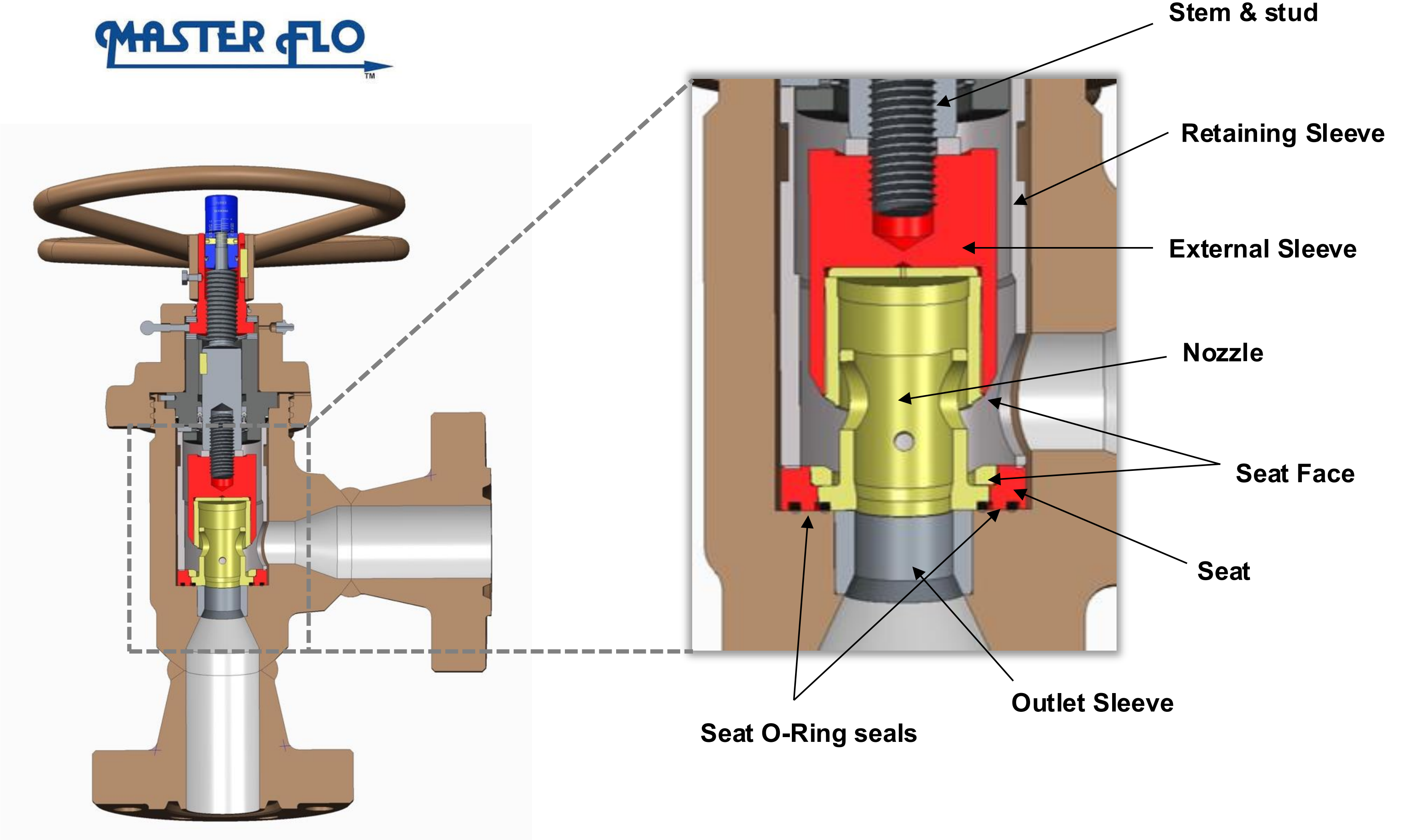
Downtime for Valve Maintenance is Never Good
Due to Trim and/or Valve Replacements
Reduces Well Output
Causes Deferred Revenue

SIDE-BY-SIDE COMPARISON
Clear Cut Differences

VANZANDT CONTROLS, LLC Eagle AUTOMATION

	Cage and Sleeve	Needle and Seat
Unit Cost	Higher	**Lower**
Cost of Ownership	**Lower**	Higher, due to more frequent maintenance and production downtime
Torque Requirement	Higher (unbalanced), Lower (balanced)	Much Higher [unbalanced]
Stem Seal	Better due to **non-rotating linear motion stem design**	Bad for stem seal due to rotary movement of stem and seat sealing
Seat	**Class V shut off**, choke is able to seat even after trim washout/broken due to patented design "deadband" to divert flow primary wear areas away from the seat.	Primary wear areas = needle & seat, can never achieve Class V shut off after slight indications of wear.
Fluid Annular Velocity	**Low annular velocity** due to patented design of "deadband" to allow larger flowing volume in choke body bore	Lower due to large body cavity
Body Protection	Retaining sleeve, **replaceable body protection sleeve**	None
Trim Alignment	Easy due to **floating seat design** that will align itself during assembly controlled by tight tolerance external sleeve and compression of retaining sleeve without rotational movement	Seat is threaded on which might cause alignment issue if it is not precisely machined. Needle must be precisely machined to alignment with seat.
Fluid Exit Velocity	Lower due to **opposing jet impingement design** and **upward deflected fluid diverter design** to dissipate most of fluid kinetic energy (erosion) onto each other before any hard surface. This also results in much **lower erosion rates.**	High velocity fluid jet delivers flow straight onto body and outlet
Cv	**More restrictive and backpressre**, result in lower Cv for the same BS.	Less restrictive therefore less choking
Plugging	More prone to plugging due to multiple smaller ports	**Less prone to plugging** due to one large single port
Cavitation and Hydrate Formation	**More backpressure** therefore **high FL pressure recovery factor**, result in less prone to cavitation and hydrate formation	Lower FL (pressure recovery) value therefore higher initial pressure drop at Vena Contracta, result in more likely to cause cavitation and hydrate formation

MASTER FLO
External Cage & Sleeve Design



MASTER FLO EXTERNAL SLEEVE & CAGE CHOKES

You Get What You Pay For!!

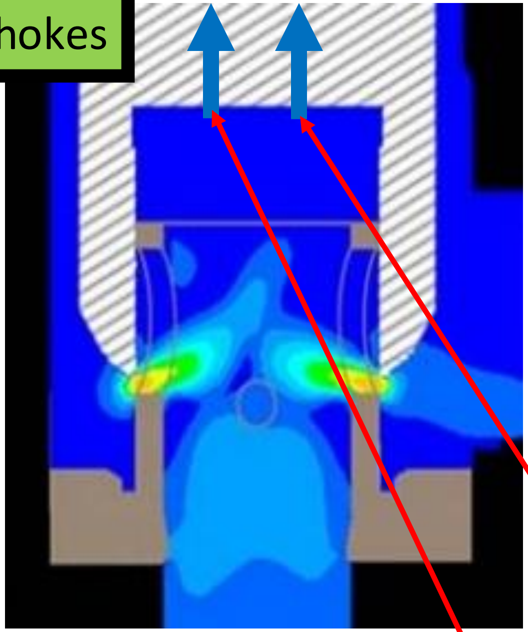
Balanced Trim Available
Recommended for Actuated Packages

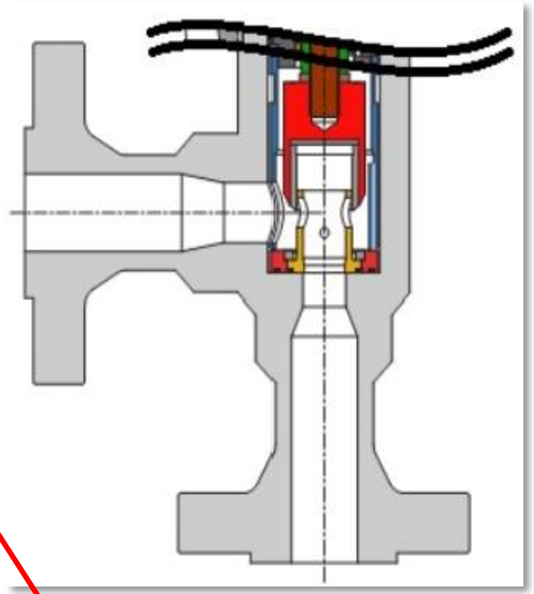
Lower Torque Requirements
Pressure Balanced Trim
Much Less Torque to Operate

Shearing Valve Stems is Unlikely
With Safety Factor, very unlikely to exceed MAST
Shearing Valve Stems is greatly minimized

Minimized Safety Concerns
Lower Force Needed = Lower Actuator Requirement
Lower Actuator Requirement
    Less Power Consumption
    Lower Cost Actuation too!!

Highest ROI Solution
10x Longer Life
Balanced Trim
Lower Cost Actuation
Much Safer
Best Choice for Auto Chokes

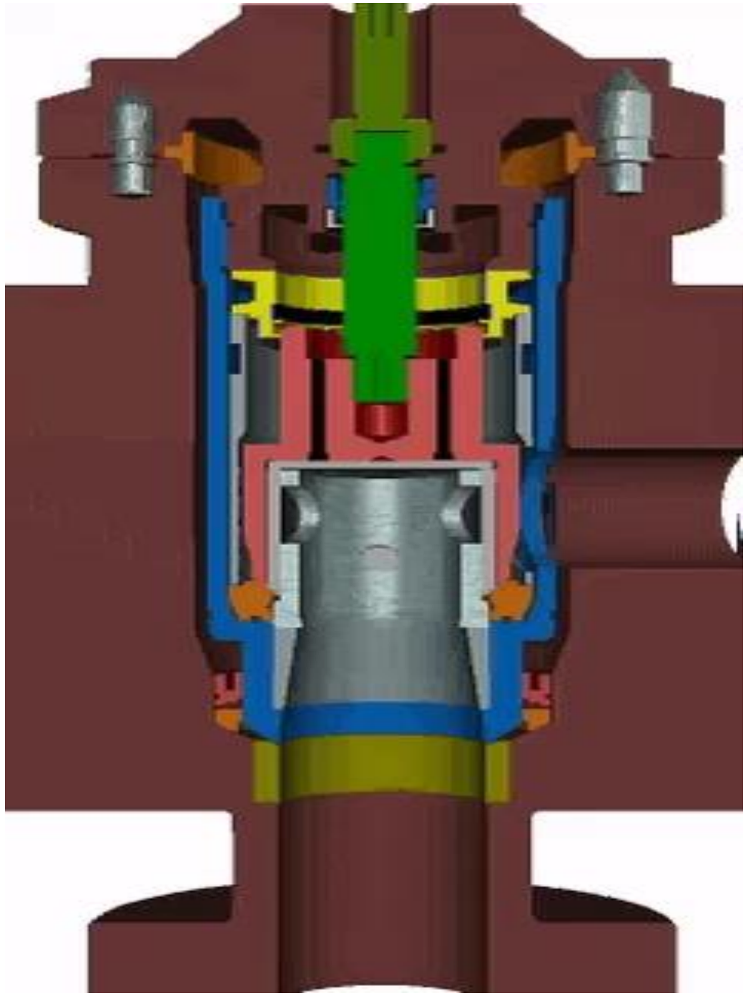




Pressure Balancing Channels

UNDERSTANDING WHAT HAPPENS WITHIN THE VALVE

Sequence of Events



1 **Process Flows FROM Inlet Bore INTO Body Annular Space**

2 **Valve "Breaks Seat" & Begins to Rise**
Stems rises thru the Deadband
15-30% of Travel

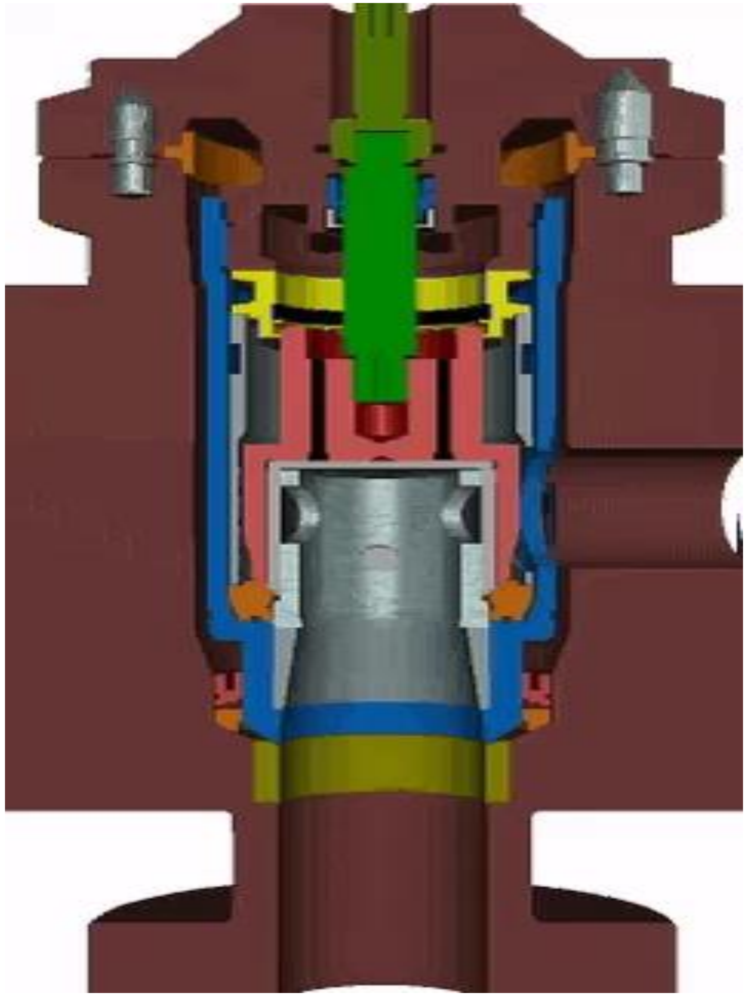
3 **Small Control Ports are Slowly Uncovered**
Lower end of Cv is now accessible

4 **Larger Control Ports are Uncovered**
Remaining Cv is available

5 **Valve Closes**
Shut Off Valve & Seat Face are Protected From Upstream Increased Velocities

6 **Valve Returns to Class 5 Shutoff Position**

UNDERSTANDING WHAT HAPPENS WITHIN THE VALVE
Key Attributes



Valve is Balanced
Via Red External Sleeve & Yellow Balancing Sleeve
- Communication Ports at Top

Reduces Actuation Demands
Unbalanced Option for Smaller Sizes

Retaining Sleeve Protection
Blue Barrier
Holds Trim in place
Protects Body from Process

Fluid Energy Reduction
Impingement: Process is Used Against Itself
Fluid is Directed Up into Hardened Sleeve
Happens during Steps 3 & 4

UNDERSTANDING CV VERSUS BEAN SIZE
Actual Versus Max Positive Equivalent

MF has higher Cv
Per Same Size v other ES&C Chokes

MAX Positive Equivalence
Industry Standard
Based on Positive Fixed Bean Choke

ACTUAL Positive Equivalence
MF Bean
It's Different!!

Valve Size	MAX Positive Equivalence Bean Size	ACTUAL Positive Equivalence Bean Size	MAX Cv
P1	50	58	14
P2	68	81	27
P25	88	103	45
P3	120	137	83
P35	150	179	129
P4	189	216	205
P5	228	265	300
P6	264	304	400
P8	349	450	700
P10	417	490	1000

UNDERSTANDING VALVE SIZING

Cv Versus Bean Size

Cv

“How much can get through”

Cv
Valve “FLOW” Coefficient
Universal Measurement of **Volume**
1 Cv = 1 USGPM with a Pressure Drop of 1 psi @ 68 deg F

Bean

“The size of the port”

Bean Size [BS]
“Orifice Diameter” in 64th of an Inch
Measurement of **Size**
An Orifice of a 2” inch diameter = Bean Size of 128/64th

WHY CHOOSE MASTERFLO CHOKES
Competitor ES&C Chokes Pro's & Con's

NOV/CORTEC

Pro's
External Sleeve & Cage Design
Good Control & Erosion Resistance
Pressure Balanced, like Master Flo
- Reduces Operating Torque

Built-In Wear Sleeve
Similar Construction to Needle & Seat
Price Point

Con's

Less Robust Design & Construction
Thinner/Less Durable Trim Material
Increased Lateral Movement & Vibration

Limited Configurations
Lower Max Cv
- Eg, ~78.1 on 2" Max

Threaded Cage/Bean
Loose Tolerances
Excess Clearance Flow & Side Load
Less Alignment
Requires Special "Seat Wrench" Tool
Recommend Seal Change on each inspection
- Metal Seals vs Elastomers

No Balancing Chamber [Cortec]
Requires More Torque to Actuate

WHY CHOOSE MASTER FLO CHOKES

Master Flo Pro‘s & Con‘s Versus Other ES&C Chokes

Pro’s

“Floating” Cage & Seat
No Special Tools Needed
Low Maintenance
Tighter Tolerances
    0.2 Cv Clearance Flow
Centered & Self Aligning
Less Lateral Movement & Vibration

Class 5 Shut-Off [Industry Best]

Highest Cv on Market

Tougher MFV 5CB Tungsten Carbide
Versatile Body & Trim Configs

Pressure Balanced Design
    Reduces Operating Torque

Master Flo

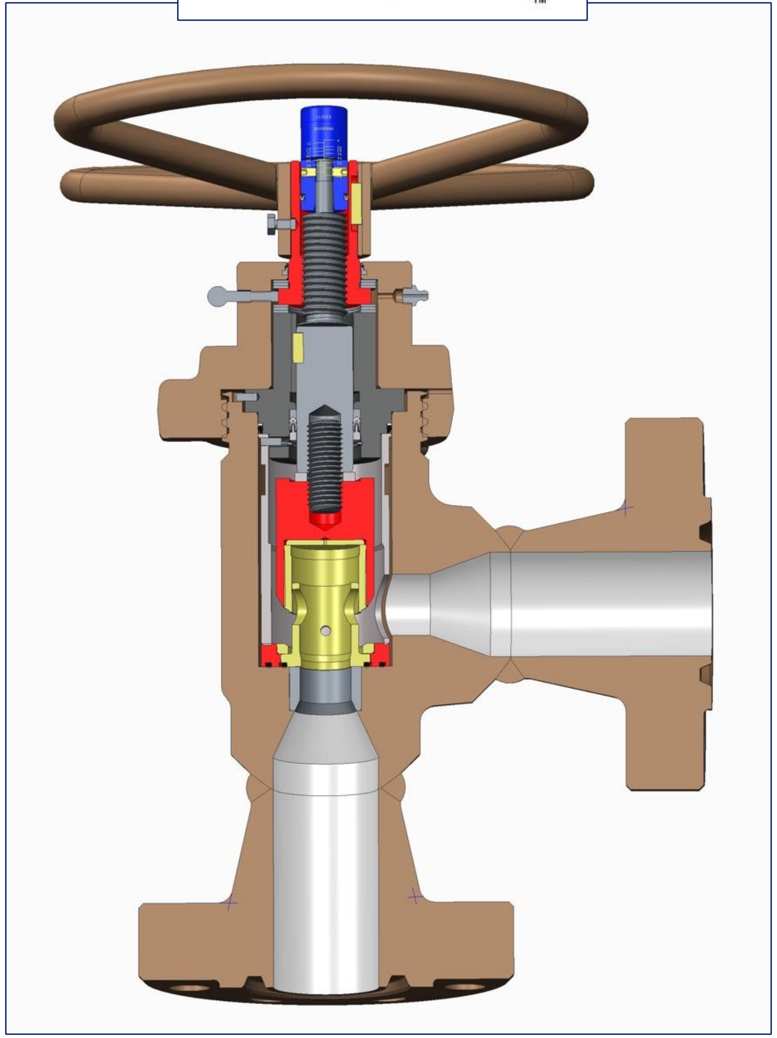
Con’s

“Over-Engineered” Reputation
Value Perception/Price Point
High Grade TC isn’t cheap

Unique Design = Customer Learning Curve
Dissimilar to Needle & Seat

WHY CHOOSE MASTER FLO CHOKES

Master Flo's Superior Design



Superior SERVICEABILITY

No threaded, wetted parts
Retention Sleeve [Floating Alignment]
Three Piece Trim
   External sleeve, Cage, and Seat
No special tools required

Superior CONTROLLABILITY

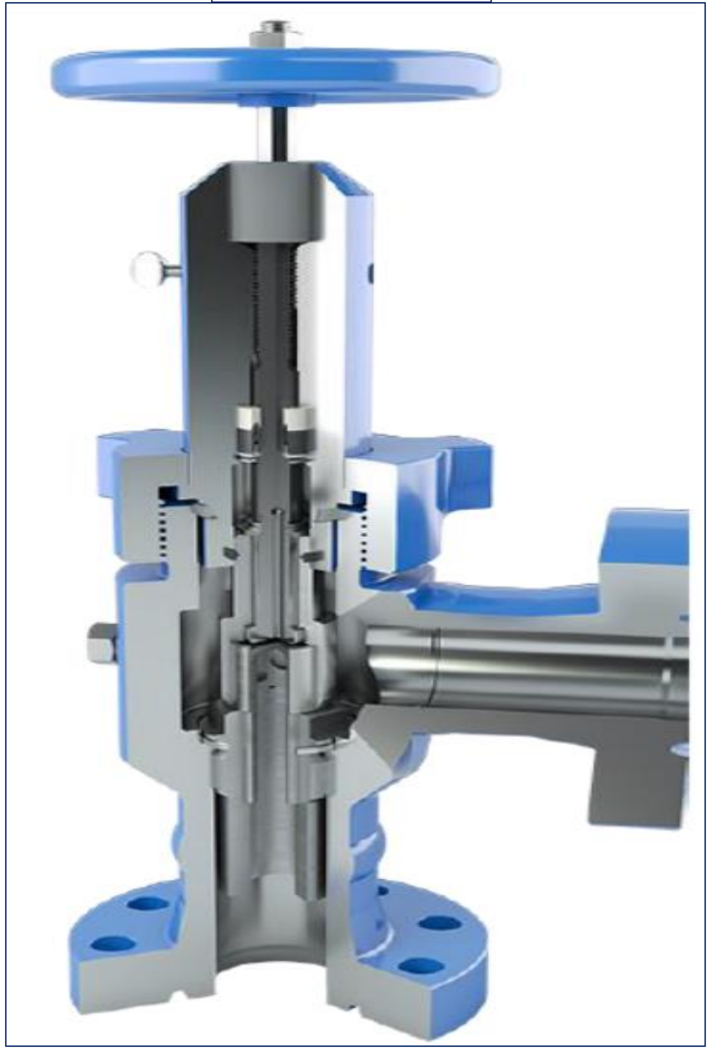
Two row, four port nozzle for highest resolution
Patented Equal % trim [Cv tables, Accuracy]
Dead band first 30% of total travel
Minimized clearance & tolerances
Easily balanced

Superior PERFORMANCE

Patented Equal % trim design
Reduced velocities
   Hydrostatic restriction
Class 5 shutoff
Superior Tungsten Carbide
Superior body and outlet protection

WHY CHOOSE MASTER FLO CHOKES

Competition's Inferior Design



Inferior SERVICEABILITY

Threaded, wetted parts, Seat & Nozzle
Fixed alignment, Threaded Seat
Two Piece Trim
Specialized tools required [Seat Wrench]

Inferior CONTROLLABILITY

Multiport nozzle: Low resolution + Port Migration
Equal % trim: Theoretical Cv Tables, Inaccurate
Minimal Dead Band
Excessive clearance
Unbalanced or difficult to achieve

Inferior PERFORMANCE

Poor Velocity & Kinetic Energy reduction
    Capped Nozzle
Standard Tungsten Carbide
No Body Protection
Class 4 shut-off [at factory only]
No dedicated Seat Face
Vibration concerns due to internal clearances

WHY CHOOSE MASTER FLO CHOKES
Velocities Within a Master Flo Choke

VANZANDT CONTROLS, LLC
Eagle AUTOMATION

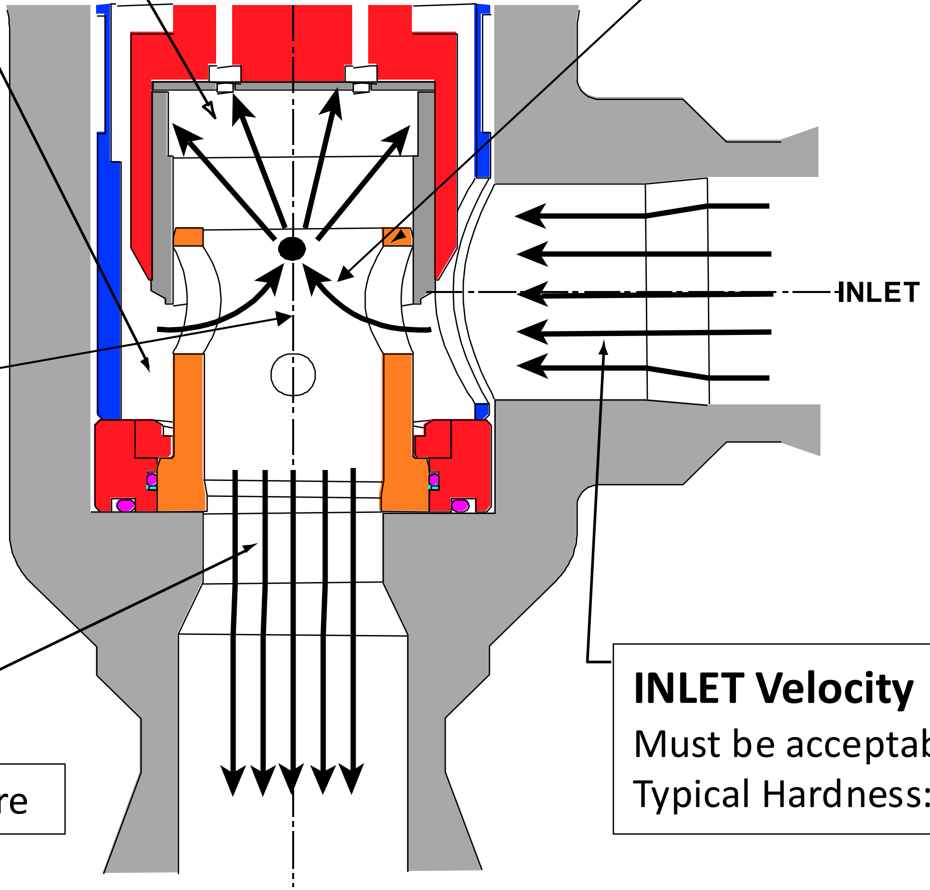
ORIFICE Velocity
Tungsten Carbide Trim
Allows high acceptable velocity
Typical Hardness: RA 94

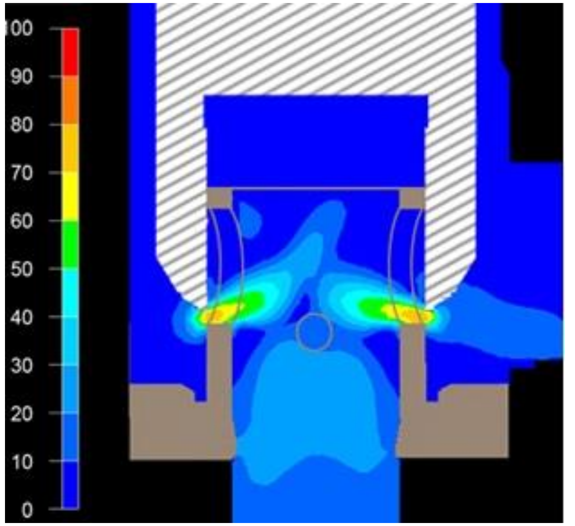
Velocity increases
Pressure decreases
Temperature decreases

BODY Velocity
Must be acceptable for alloy or SSt material
Typical Hardness: Rc 22

Fluid Energy Absorbed

Fluid Impingement
Hydrostatic Restriction
Pressure Stabilizes
Flow Stabilizes





TRIM EXIT Velocity
Must be acceptable for alloy or SSt material
Typical Hardness: Rc 22

Downstream Pressure

INLET Velocity
Must be acceptable for alloy or SSt material
Typical Hardness: Rc 22

Upstream Pressure

WHY CHOOSE MASTER FLO CHOKES
Deadband & Class 5 Shutoff

VANZANDT CONTROLS, LLC
Eagle AUTOMATION

Fine Flow Control
During full range of travel

Restrict Liquid Flow
And particulate flow
During 1st 30% of travel

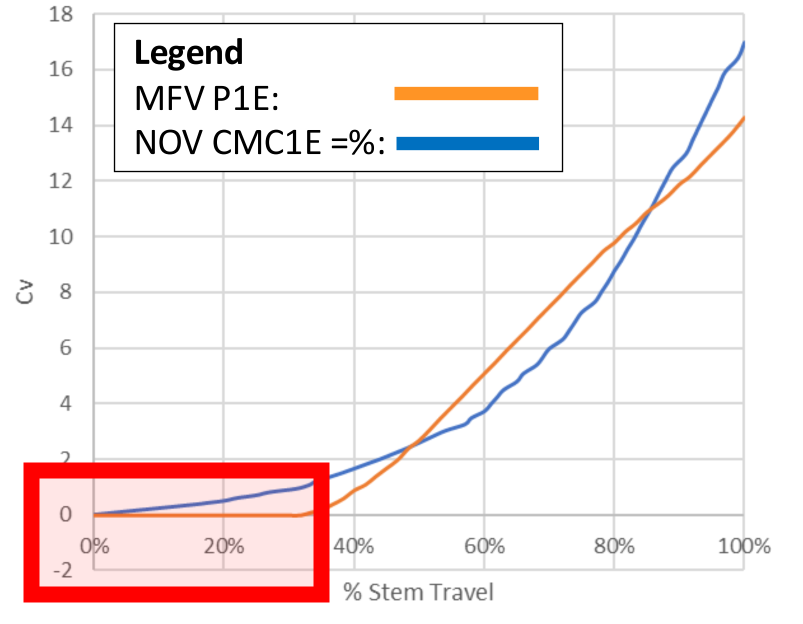
Minimize Flow
During seating & unseating of the valve

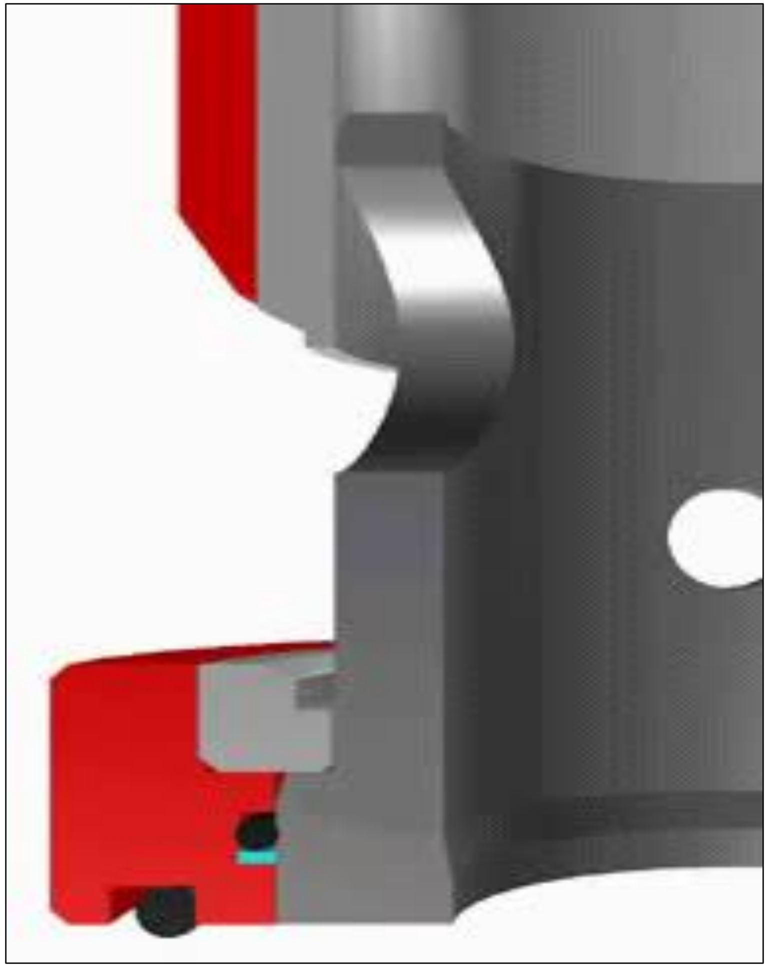
Minimal Bypass
Due to right tolerances
With "floating trim" design

Keep Seat Faces Away
From higher velocities at VC

Minimize Erosion to Seat Face
To maintain Class 5 shut off

Variety of Materials for Seat Face
Tungsten Carbide, SSt, Elastomers





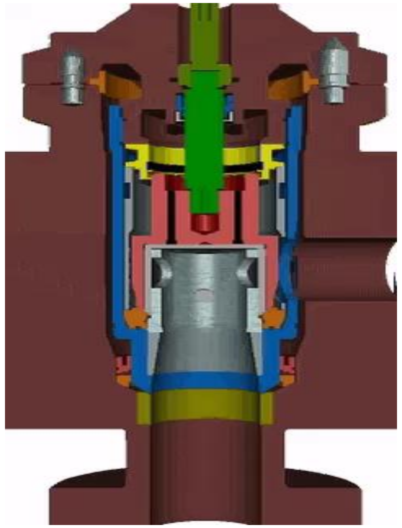
MASTER FLO CHOKES
Value Summary

Better Design
Master Flo pioneered the ES&C design
Hold the original patent
Much more knowledge over all other competitors
Only Independent Subsea Valve Manufacturer
~50% more Carbide thickness

Precision Control
Trim design handles fluid better
Dead set control and very tight

Higher CV [More Thruput]
For equivalent Trim ID
83 CV is standard [P3]

Lower Torque Actuation Needed
Balanced Trim Design [Channels]
Equalizes Pressure across the Sleeve
Requires ~50% less Torque, less Power Draw
Thinner Stem, Less Friction



Video

Better Erosion Resistance
Fluid Impingement

Shutoff
Class 5 Shut Off
Throttling surface is separate from Shutoff surface
Protects All Other Wellhead Equipment

Mechanical Deadband
- First small part of travel [~20%] = Bypass Flow only
  - Can Open super slow and still have control
- Super tight Tolerance between Cage & Sleeve
  - Leads to much longer Seal Life
- Regular Grade Tungsten Trim doesn't hold up as well
  - Less Impact Resistant
  - Master Flo has proprietary blend for Trim

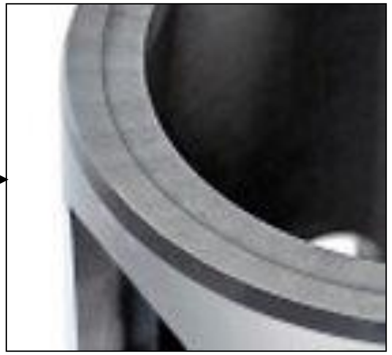
Less Time to Repair
30-60 Minutes v 4-8 hours
Trim comes out by hand!!
Free Floating Trim Design
"Complete Insert" Format

MASTER FLO CHOKES
Available Trims

Multiport

Labyrinth

Impact Resistant



Multistage

2 Row, 4 Port

Well Cleanup

ACTUATOR OPTIONS
Several Choices

VZLifter
w Valvcon

Rotork

Diaphragm

FOUR CORE APPLICATIONS
Key Applications

Production/Wellhead
Auto & Manual Chokes

Pain Point
Control & Erosion Resistance

Case Study
Manual = Much Longer Lasting
Auto = 85% Flaring Reduction

Competition
NOV, Cameron, Cortec
Needle & Seat

SWD H-Pump
Back Pressure Control

Pain Point
Cavitation/Washing

Case Study
Proven to Eliminate, Mitigate, or Last Several Times Longer than Disc Chokes

Competition
Cyclonic, Taylor, Fisher HPD

Flowback
Choke Manifold

Pain Point:
Downtime

Case Study:
Reduce Flowback Time by ~50%
Minimize Sand Production
Increase I/P & Reach it Faster

Competition
Typically Needle & Seats
Manifolds [2]

Sand Dump
Production & Flowback

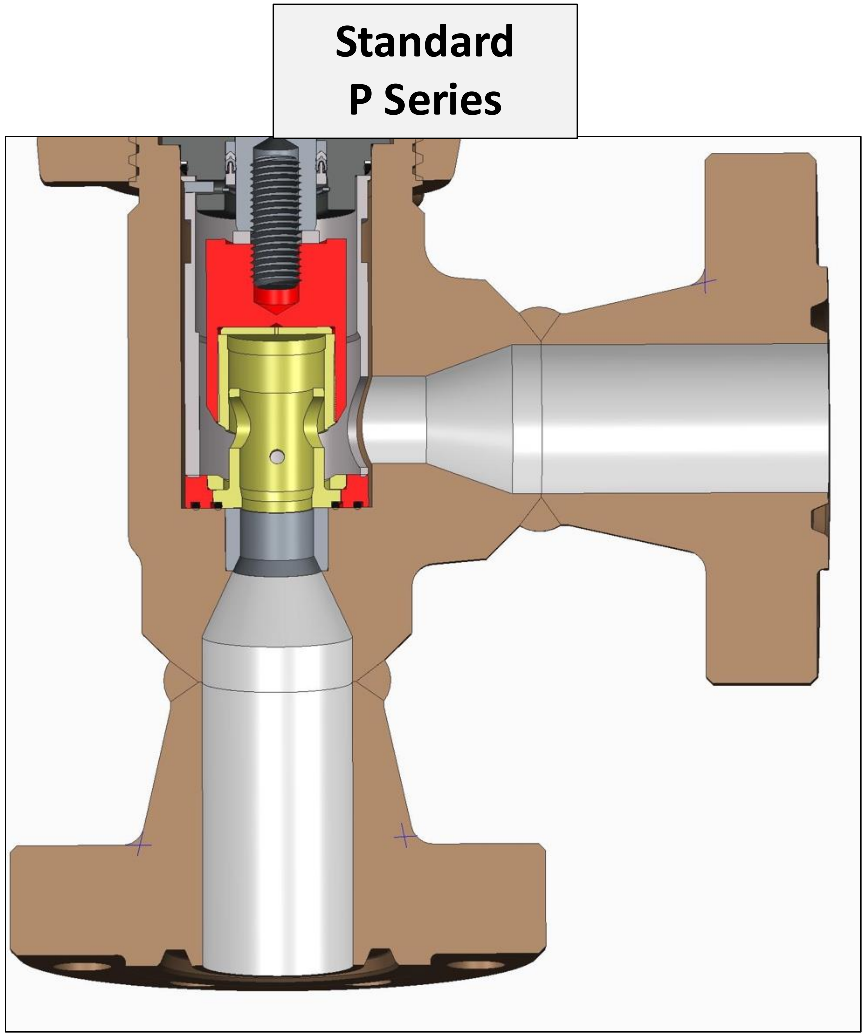
Pain Point:
Erosion Resistance

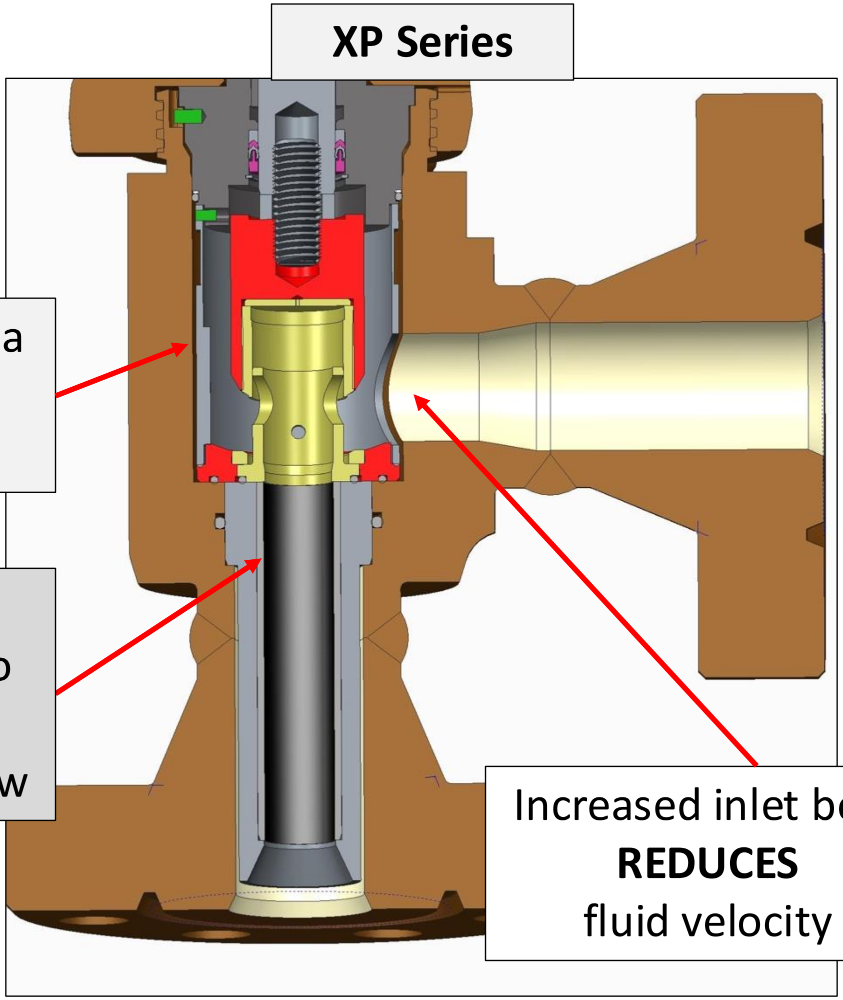
Case Study
Decrease Downtime
Reduce Repair Intervals
Extend Replacement Intervals

Competition
Typically Needle & Seats
Manifolds [2]

MASTER FLO CHOKES

Increased Annulus, Longer Wear Sleeve, Increased Inlet Bore





Increased annulus area
REDUCES
fluid velocity

Removable
Longer wear sleeve to
PROTECT
outlet & normalize flow

Increased inlet bore
REDUCES
fluid velocity

MASTER FLO CHOKES
XP for Extreme Erosion Situations

Increased Annular Space in Choke
To Slow Velocities

Extended TC-lined Outlet Wear Sleeve
Addresses Erosion Migration potential
Field Replaceable

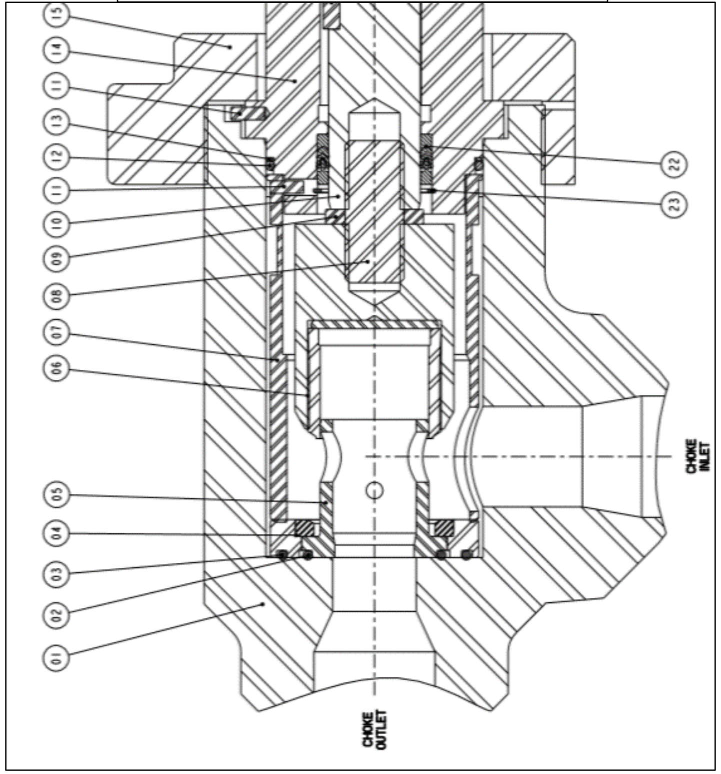
Reduced Max Orifice Size
For Optimal Fluid Impingement

Target Applications
Flowback
High Sand
Sand Dump
Problem Child Wells

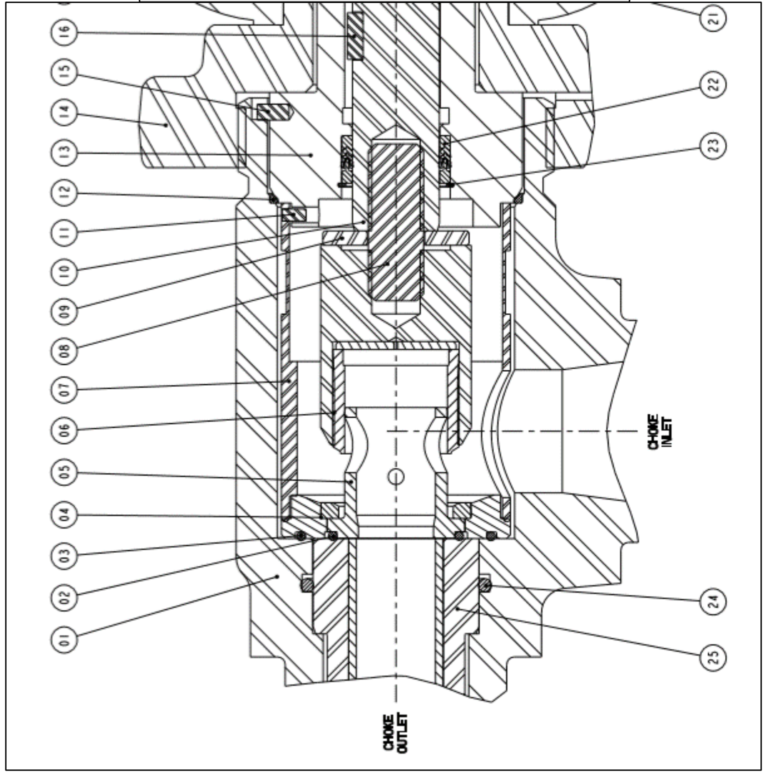
Circa 2021

XP2, XP25, XP3

E Series
Wear Sleeves Optional



XP Series
Larger Inlet & Annulus
Extended Wear Sleeve (6”)
Interchangeable Trim

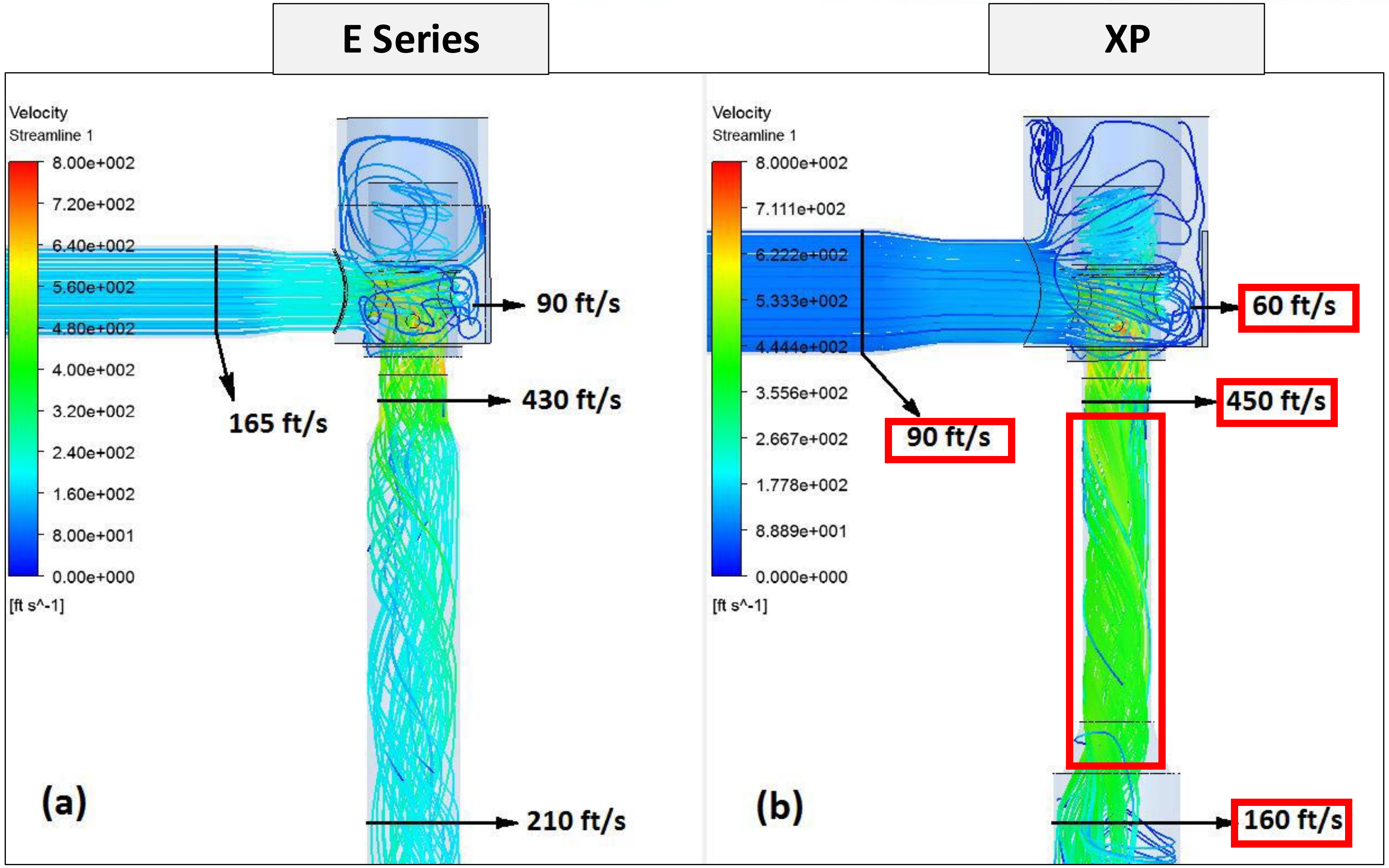


MASTER FLO CHOKES
Lower Velocities = Longer Life

Lower Velocities
On the Inlet, Annulus and Exit

Less Turbulent Exit
Less Erosion Potential
On the Pipe & Outlet Valve Body

Slightly Higher Immediate Exit Velocity
Only on TC Harden Wear Sleeve
However has Laminar Exit
  Not bouncing back & forth off pipe wall
When exits Hardened Wear Sleeve
  Velocities are Lower



MASTER FLO CHOKES
Well Clean Up Trim

For Flowback & Well Clean-up Chokes
For high-impact situations
Absorbs impact energy in its SSt outer cage
Protecting against catastrophic failure
Leverages proprietary 5CB tungsten carbide
    For enhanced durability

MASTER FLO CHOKES
XP: Customer Reference

Ovintiv

E Series Investment
$723k, 100 chokes purchased
$289k, Loss with 40 Washouts

40% Washout
Due to Extreme Application

XP Series Investment
$1800k, 185 chokes purchased
$20k Loss with 2 Washouts

1% Washout
Even with Extreme Application

Less Downtime
38 Less Washout Replacements

More Production
38 Lost Production Events!!

Why Auto Choke versus Manual Chokes?

WHY AUTO CHOKES?
Key Benefits Relative to Manual Chokes

Reduced Flaring
Based on Midstream Events
Number 1 solution
Eliminate Royalty Penalties

Improved Safety
Reduces Site visits
Leverage Existing Automation

More Production Quicker
Manage dynamic Process Conditions
Operate closer to Process Constraints
FROM infrequent MANUAL Adjustments
TO frequent CONTINUOUS Adjustments

Why Choke?
High Flowline Pressure
High Tubing Pressure
High Separator Pressure
Separator High Level
Loss of CTB or Wellhead Comm
Automated choke

WHY AUTO CHOKES?

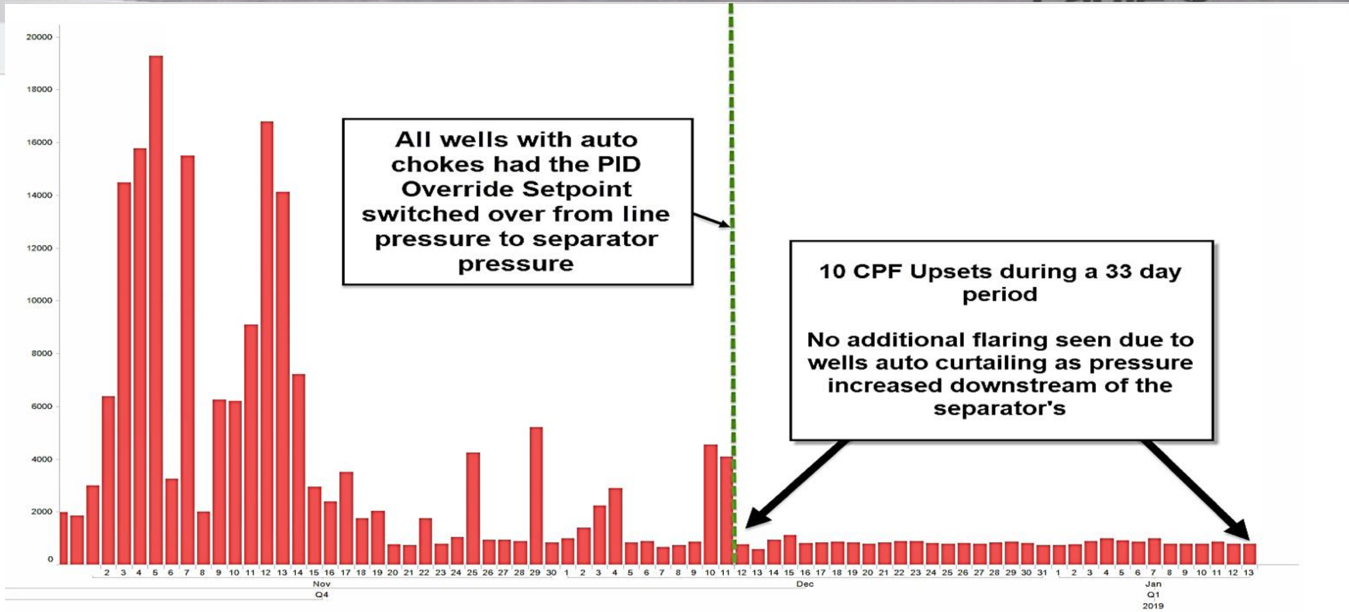
Key Benefits Relative to Manual Chokes

Primary Choke Strategy
Positive Choke Size [x/64th's]
Slow Ramp Up Time to Eliminate Well Surging

Secondary Choke Strategy
Pressure Override based Separator Pressure
Eg, Ramp to 140 PSI then Choke to Maintain
At or below 140 PSI

Eliminate Flaring During Midstream Upset
25% Royalty Reduction on Flared volumes!!

Reduced Manpower Requirements
For Curtailing & Bringing Wells Back Online
Automation takes over!!
966% Improvement Returning to Full Production
Compared to Human Intervention



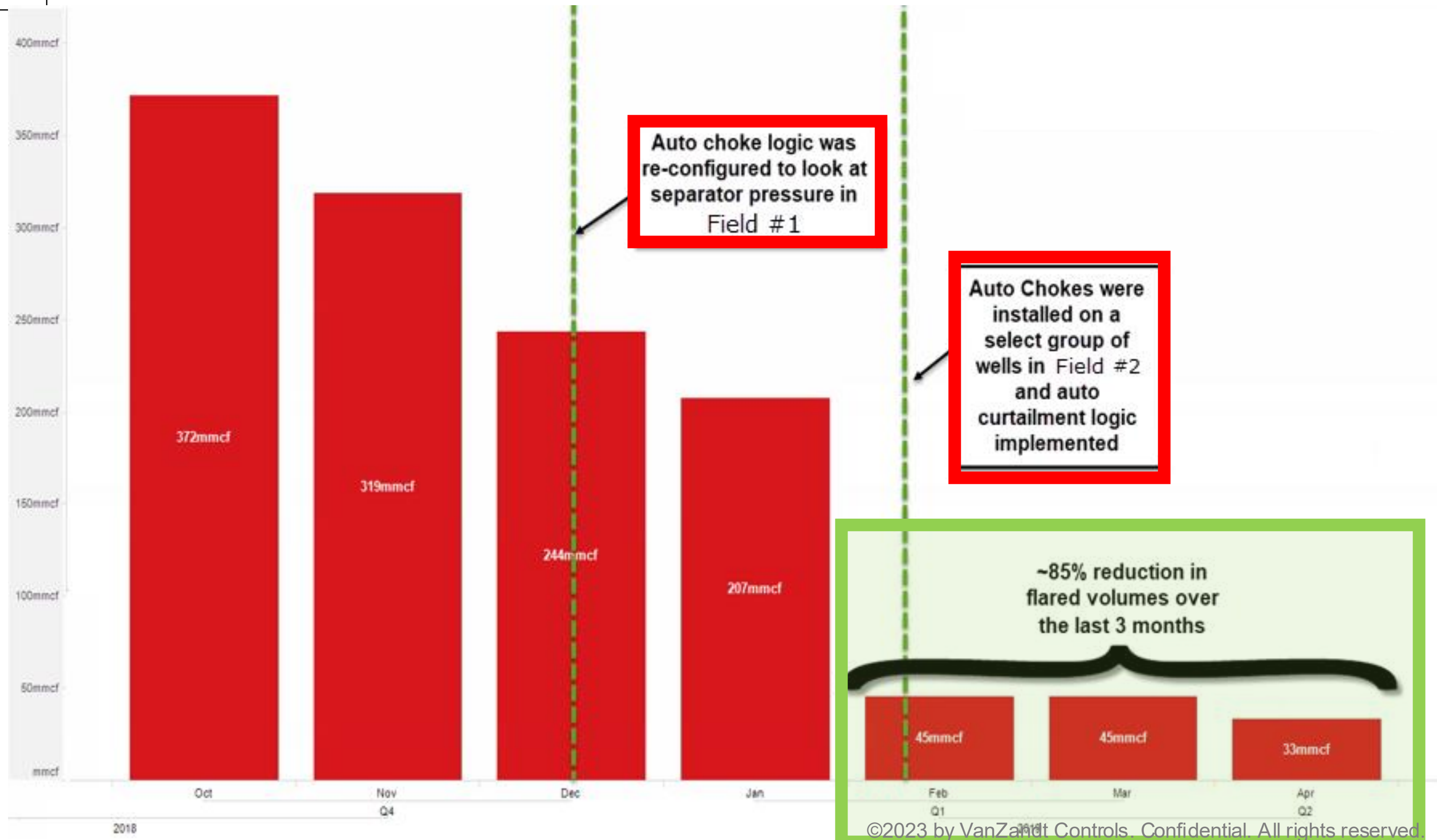
WHY AUTO CHOKES?
Permian Customer Reference

Field 1
Automated to Curtail based on Separator Pressure
12.15.18
Reduced Flare Volumes by 60%

Field 2
Operating Philosophy Change
Automated Chokes Installed February 2019
Reduced Flare Volumes by 90%
Compared to prior Four Months

Fields 1 & 2
Combined Flare Reduction: 85%!!

Permian Flared Volumes
[Fields 1 & 2]



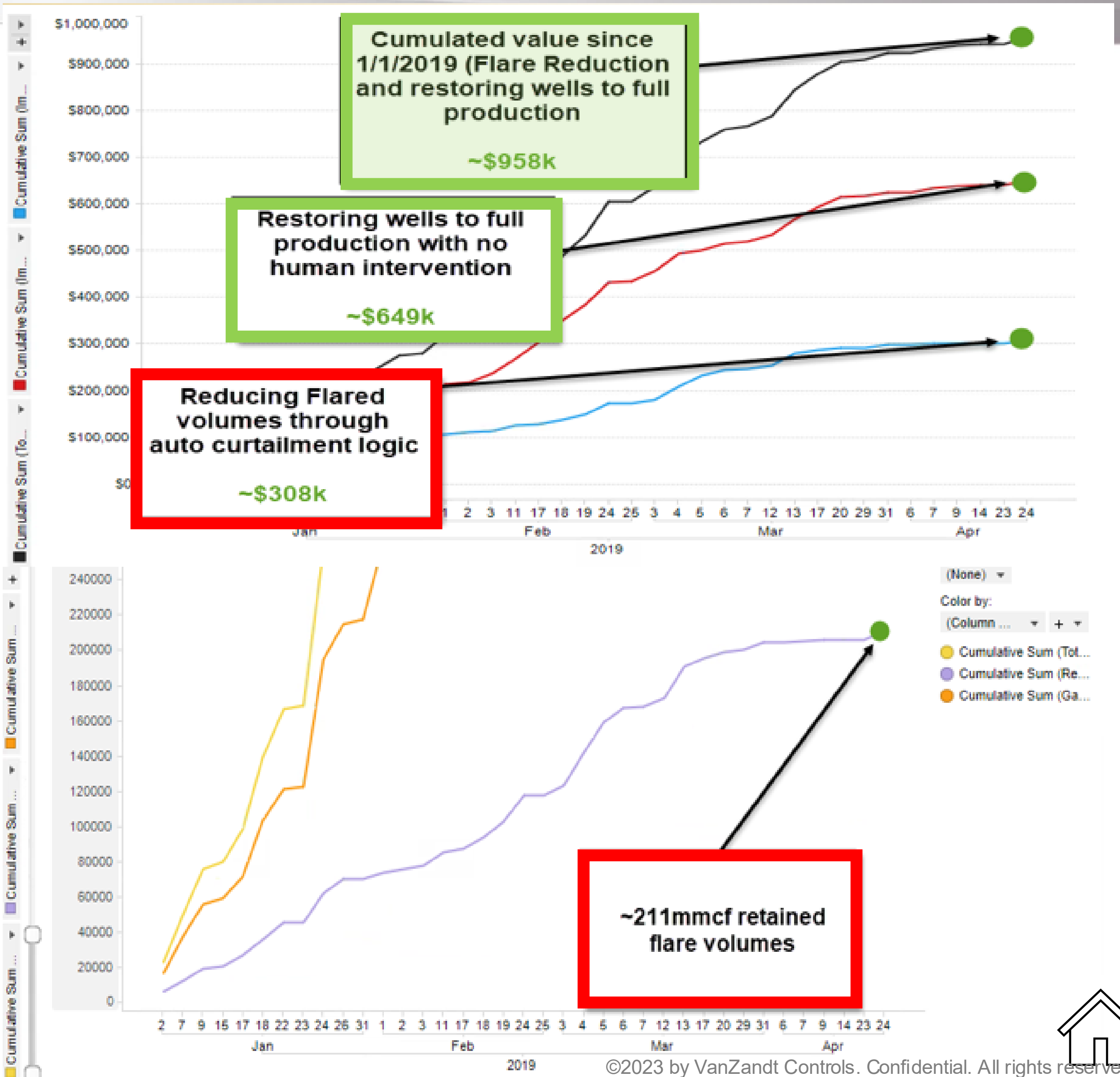
WHY AUTO CHOKES?

Permian Customer Reference: Total Value Captured

Value Captured
From 01.01.19 thru 04.30.19

Multiple Midstream Upsets
Causing Curtailment Events
Eliminated 211MMCF in Flared Volumes

Value Created
By Eliminating Flaring
By Bringing Wells on Faster
$958k over 118 days
Less than 1 Month Payback!!
Over $4M extrapolated over 1 year!!



Haynesville Choke

HAYNESVILLE CHOKE
Most Challenging Environments

VANZANDT CONTROLS, LLC
Eagle AUTOMATION

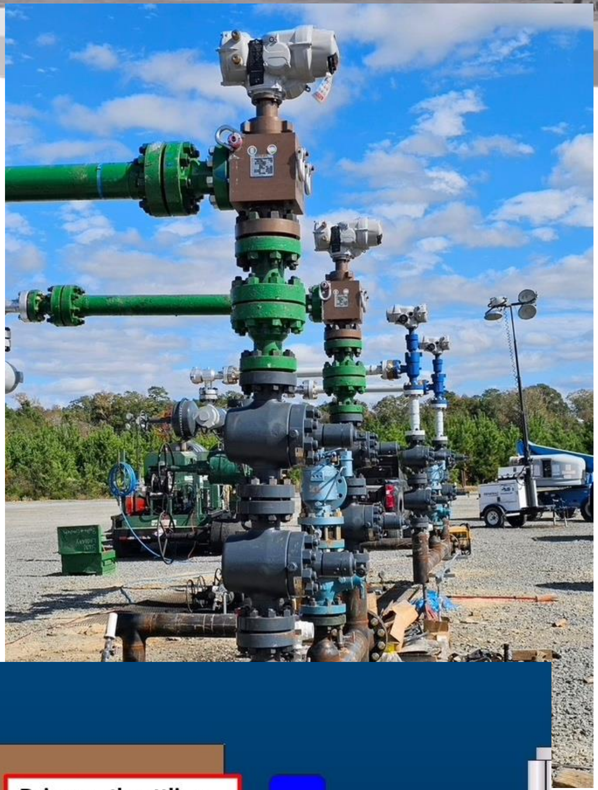
15K Pressure
XP Series to 15K
Accommodates P1 thru P3 Trims

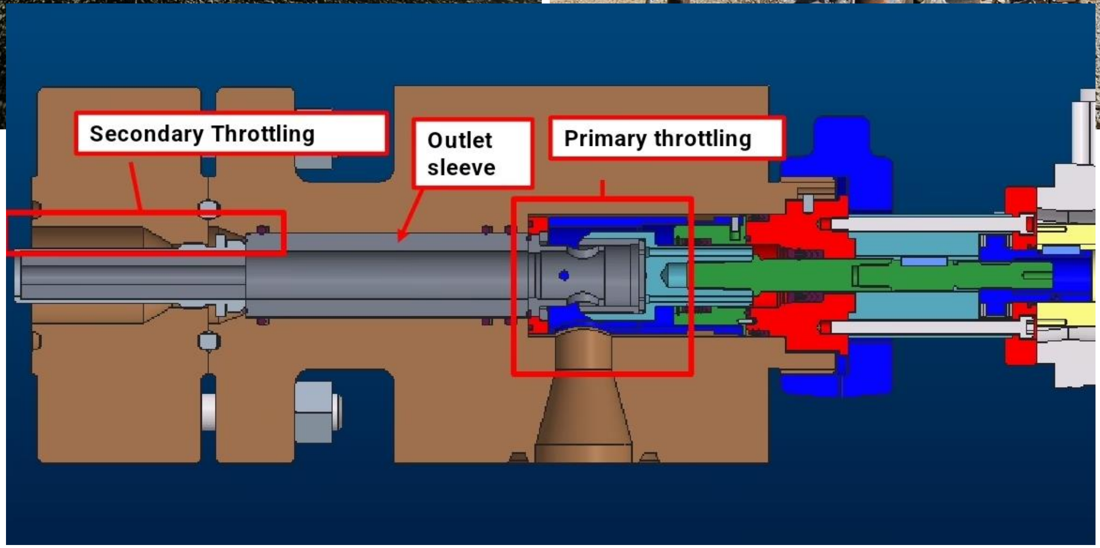
Field Repairable Wear Sleeve
Runs along Outlet Bore

Additional Inline Positive Choke
Optional Adapter
Inlet or Outlet mounting
For additional velocity reduction
Could go to 20k if needed

High Temperature
FFNL: SSt No Limit H2S

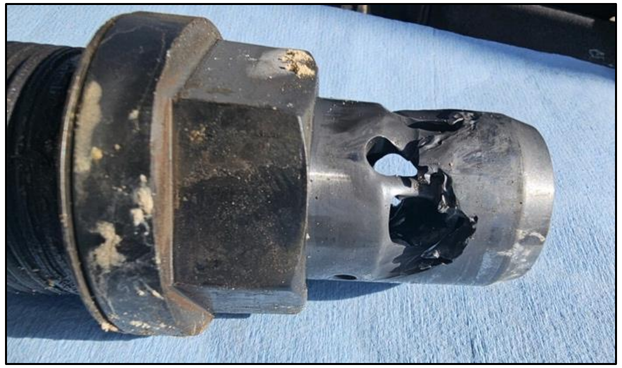
Extended Wear Sleeve
Blast Joint No Longer Required
Saves at least $1500





HAYNESVILLE CHOKE
Longer Service Intervals

NOV Trim
After Three Weeks



Master Flo Trim
After Three Weeks

With Much Higher Water Cut!!