

# Technology Overview



*Innovative Flow Solutions*





# Company Overview

Master Flo Valve Inc. is the technological leader and world-class manufacturer of surface and subsea chokes, specialty control valves, and supporting actuation.

Privately owned, proudly independent, and upholding a vision of excellence, our company structure offers the flexibility to adapt to ever-evolving market needs and developments, quickly and efficiently, providing you with the level of commitment you expect from a critical component supplier.

Since 1979, our goal has been to design and produce the highest quality chokes and control valves available in the industry, only equalled by our innovative engineering, creative R&D and outstanding quality assurance programs supporting the complete Master Flo product offering.

From our Edmonton facility of over 80,000 square feet located on eight acres of land, we house in a single location our engineering, manufacturing and research and development teams, aftermarket support group, and facilities.

Our world-class facility embodies our commitment to product development and manufacturing excellence, playing a key role in our ability to maintain our position as the industry leader in choke technology.

Complemented by a global network of sales locations and service centres, Master Flo is positioned better than ever to support your local operations, wherever you are.

The leading designs and material technologies utilized in the conception of our chokes are available to resolve your most demanding choke applications.

Master Flo Valve Inc. designs and manufactures choke valves, control valves and actuators for the world's leading oil and gas companies. Our field-proven products are engineered for surface and subsea environments where reliability and exceptional performance are basic requirements. Master Flo valves are installed on some of the most demanding production sites around the world, punctuating our ability to meet the most difficult requirements end users face.

**When uptime is your main concern, you can turn to Master Flo—the leader in choke technology—for optimum performance and lower cost of ownership.**

Master Flo provides flow solutions for a range of applications, including: high erosion, high pressure, high temperature, and enhanced oil recovery projects such as gas and steam injection. We collaborate with customers

to ensure our chokes deliver optimal field performance and productivity. Our products are designed and manufactured to ISO and API requirements.

**Master Flo E-Series Valves are engineered to deliver improved flow control, longer life, and lower life cycle cost.**

- Ported cage with an external sliding sleeve design provides greater control and reduction of wear in high pressure and severe service applications.
- Proprietary 5CB Tungsten Carbide trim material provides outstanding strength as well as erosion and corrosion resistance.
- Multi-stage and labyrinth trim reduces the potential for cavitation and its accompanying erosion and noise.
- Trim achieves exceptional shutoff throughout its life.





MASTER FLO

4611 - 74 Ave.



# E-Series Valve Range

Master Flo's standard range of E-Series valves includes choke valves (right-angle bodies) and control valves (inline bodies) that share the same internals for a given nominal size, thus they also share the same design features and benefits.

In addition to the standard configurations below, project-specific and special configurations are also available. Detailed brochures for each valve are available to provide additional information on the various options.

## E-Series Choke Valve and Trim-Selection Guide

Nominal Valve Size	Standard End Connection Sizes	Maximum Pressure Rating		E Series Trim Cv		Dual Cage Multi-Stage Trim	LabFlo Trim
		PSI	kPa	Max Cv	Bean Size		
P1E	1", 2"	6 000	41 000	14	58	9	N/A
		15 000	103 000	14	58	*	N/A
P2E	2", 2 1/2", 3"	10 000	69 000	27	81	15	9
P25E	2", 2 1/2", 3", 4"	6 000	41 000	45	103	26	11.5
		15 000	103 000	45	103	*	11.5
	2", 3"	20 000	138 000	57	117	*	11.5
P3E	3", 4"	6 000	41 000	83	137	43	13
		10 000	69 000	83	137	43	13
P35E	3", 4", 5", 6"	6 000	41 000	129	179	*	*
		15 000	103 000	129	179	*	*
P4E	4", 5", 6"	6 000	41 000	205	216	100	30
		10 000	69 000	205	216	100	30
	4", 5"	20 000	138 000	115	160	*	30
P5E	5", 6"	6 000	41 000	300	265	143	57
		10 000	69 000	300	265	143	57
		15 000	103 000	300	265	*	57
P6E	6", 8"	6 000	41 000	400	304	188	75
		10 000	69 000	400	304	188	75
	7", 9"	20 000	138 000	360	285	*	75
P8	8", 10"	6 000	41 000	700	450	423	190
		20 000	138 000	600	366	*	*
P10	9", 11", 12"	6 650	46 000	1200	494	*	*
P12	12", 14"	5 000	35 000	1700	540	*	*

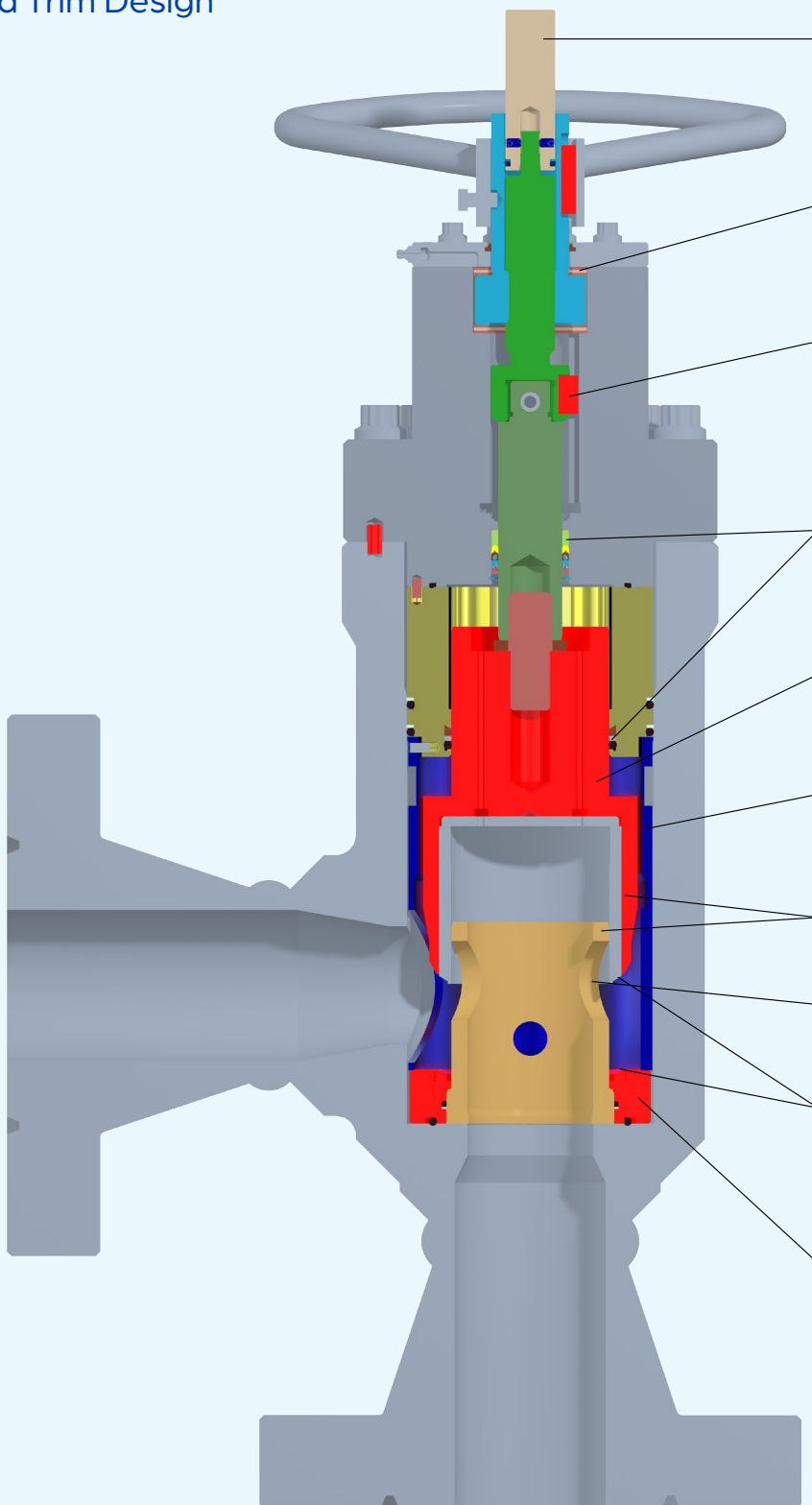
\* Available, consult engineering

## E-Series Control Valve and Trim-Selection Guide

Nominal Valve Size	Standard End Connection Sizes	Maximum Pressure Rating		E Series Trim Cv		Dual Cage Multi-Stage Trim	LabFlo Trim
		PSI	kPa	Max Cv	Bean Size		
C1E	1", 2"	3 600	25 000	14	58	9	N/A
C2E	2", 3"	6 000	41 000	27	81	15	9
C25E	2", 3"	3 600	25 000	45	103	26	11.5
C3E	3", 4"	3 600	25 000	83	137	43	13
C4E	4", 6"	3 600	25 000	205	216	100	30

# Valve Features

## Balanced Trim Design



*Micrometer calibration head for repeatable trim positioning.*

*Heavy-duty thrust bearings minimize operating torque.*

*Keyed stem provides non-rotating rising motion.*

*Bushings guide and support valve stem and trim.*

*Pressure-balanced trim minimizes stem load.*

*Retaining sleeve protects valve body, controls annular flow, and retains the seat/nozzle assembly.*

*Cage with external sleeve provides long service life.*

*4-Port equal-percentage flow trim provides superior control.*

*Upstream independent shutoff for long sealing integrity.*

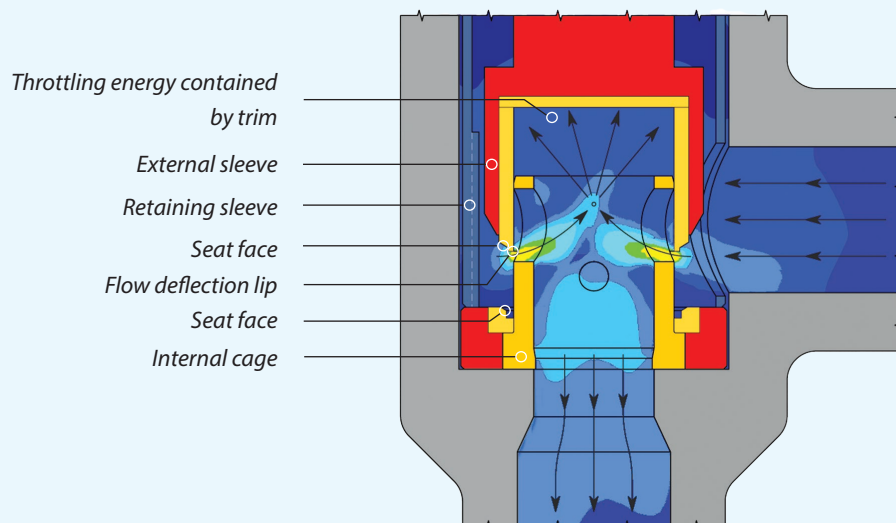
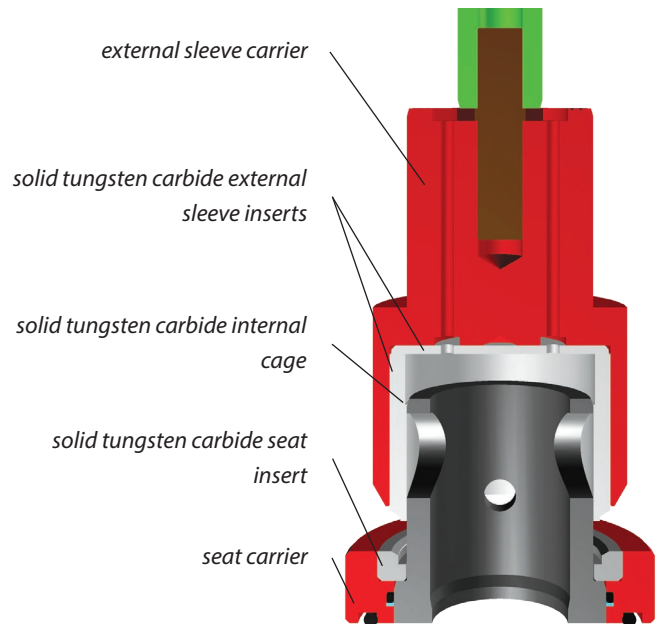
*Non-threaded trim allows for easy servicing and tight fit between trim and components.*

# Features and Benefits

Master Flo's E-Series trim has been designed for improved flow control, reduced wear and longer life. The product line showcases advanced design and technology leading to greater flow performance and productivity.

## Cage with external sleeve

The E-Series trim consists of a ported cage with an external sliding sleeve, which results in flow that impinges in the center of the cage thereby dissipating the throttling energy within the process media. The external sleeve directs the impinging flow upward into the trim away from the outlet; this further reduces the throttling energy and contains the residual throttling wear within the hardened trim components. The valve body outlet is protected from wear because the throttling energy is dissipated before the flow enters the outlet bore. The retaining sleeve isolates the main body bore from the incoming flow, further protecting the body from potential wear. Flow control and containment of wear make the Master Flo choke valve ideal for high-pressure, large-pressure-drop, and severe-service applications for both liquids and gases.

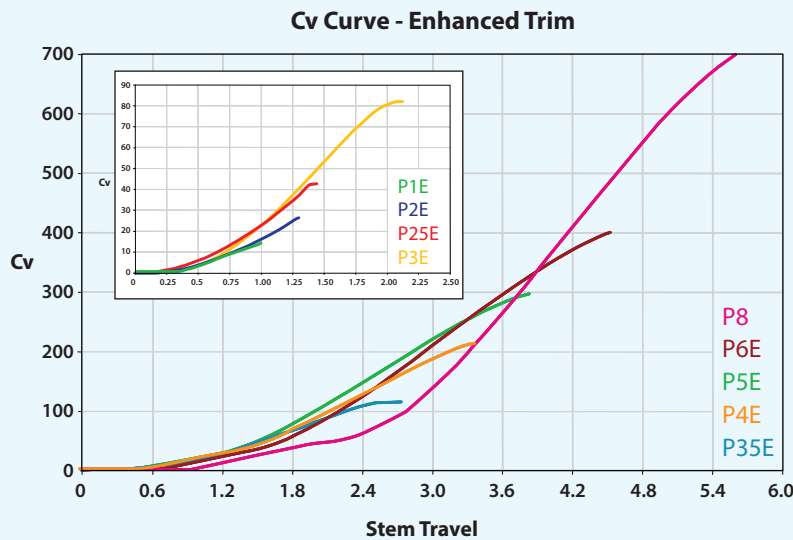


# Flow Characteristics

## 4-Port Flow Control

The Master Flo standard trim achieves accurate long-life control by using two pairs of ports in the nozzle. The smaller lower ports provide the initial 15% control range while the larger upper ports provide the overall capacity. This produces an equal-percentage flow char-

acteristic that offers maximum control throughout the operating range. The port configuration incorporates an exceptionally high turndown ratio, which provides a wide control range and excellent versatility.



*As shown in the Cv curves, the trim for each valve size provides an equal-percentage flow characteristic.*

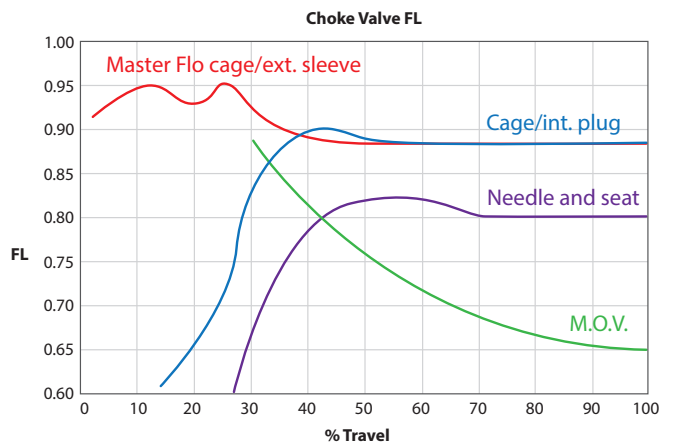
## Cv-Curve

A gradual response in the lower portion allows for controllability near the closed position, and the upper portion shows the overall capacity of the trim. This results

in an exceptionally high turndown ratio and maximum controllability.

## FL Pressure Recovery

The tendency for the pressure of a fluid to dip below its final pressure while being throttled is called the vena contracta effect. The magnitude of this dip compared to the inlet and outlet pressures is described by the liquid pressure recovery factor (FL). A high FL value means a less drastic vena contracta effect, which results in a decreased cavitation potential, lower noise generation and longer trim life. The Master Flo trim has high FL values throughout its control range.

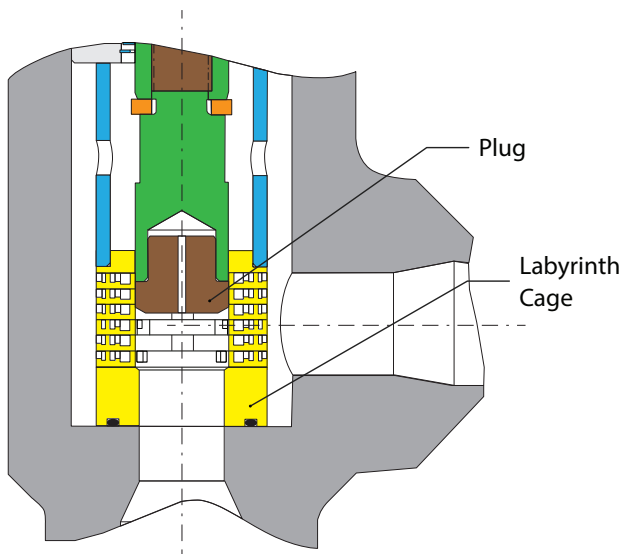
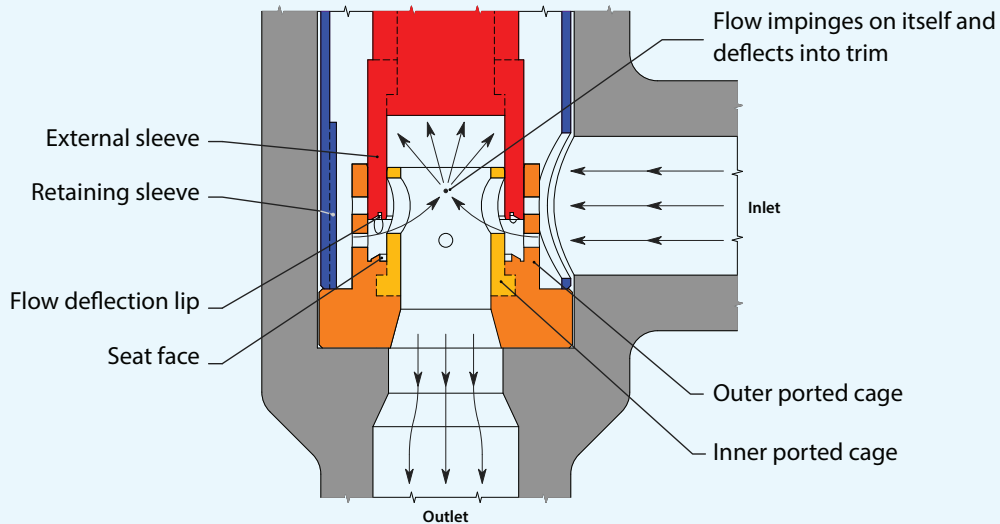


# Features and Benefits

## Multi-stage Trim

For applications with large pressure drops, Master Flo has multi stage trims available that throttle the pressure in multiple separate stages. These trims consist of two concentric ported cages with an intermediate sliding sleeve. As in the standard trim, seating integrity is maintained throughout the life of the trim. By splitting the overall pressure drop into a number of separate segments, the pressures at the vena contracta are

prevented from dipping as low as in a single stage trim. The potential for cavitation and its associated erosion and noise are also reduced. These trims were designed through the combination of empirical data, CFD, and validated through high pressure flow loop testing. Standard material for the multi stage trim is UNS 17400 nitrided.



## LabFlo Trim

Master Flo's LabFlo trim features an internal plug with a labyrinth cage designed to allow smooth transition between cage ports as well as control velocity throughout the labyrinth. This premium tungsten carbide trim is excellent for high pressure drop applications, noise control, and cavitation control. The compression-loaded trim allows for ease of service and features a robust cage for durability.

Custom port designs are available to optimize performance depending on fluid type and Gas-Oil Ratio (GOR). This design is not recommended for sandy service or service where scale may cause plugging.



# Features and Benefits

## SizeFlo Sizing Software Application

Master Flo’s engineering tool, SizeFlo, allows users to calculate flow rates, valve sizing, etc. It is a free program that can be accessed from our website masterflo.com. This user-friendly flow sizing software calculates valve

capacity, flow rate, pressure drop and valve settings. It uses ISA S75.01 formulae to guide users through a series of step-by-step entries.



## Calibration Head

Manually-operated valves are supplied with a linear position indicator called a calibration head. This indicator has a square cross section, so it can have a different scale on each of its four faces. This ensures that the valve position can be monitored in the desired units including Cv, bean size, mm or number of turns (micrometer scale).

The standard scale is the “micrometer” scale, which indicates valve position by the number of turns of the handwheel with a resolution of 1/10 of a turn. This provides exceptional repeatability in valve positioning.



# Features and Benefits

## Balanced Trim Design

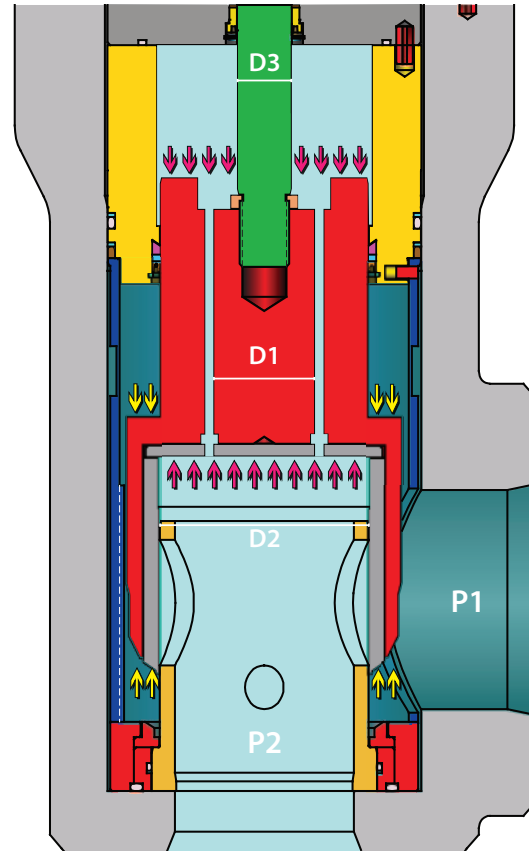
For applications where minimum thrust is needed, Master Flo uses a balanced trim design that effectively reduces valve thrust requirements. By communicating downstream pressure behind the external sleeve, this trim design balances the forces exerted on the internal components of the choke.

## 5CB Trim Model

Master Flo has developed a proprietary 5CB Tungsten Carbide with a micrograin composite binder. Extensive erosion testing has confirmed that 5CB offers a marked improvement in erosion resistance. This material also has exceptional corrosion resistance and superior toughness.

5CB Tungsten Carbide is a premium material suitable for all service conditions and especially for high-velocity or erosive applications. All 5CB trim components are manufactured from solid (rather than coated) parts, which further enhances the trim life.

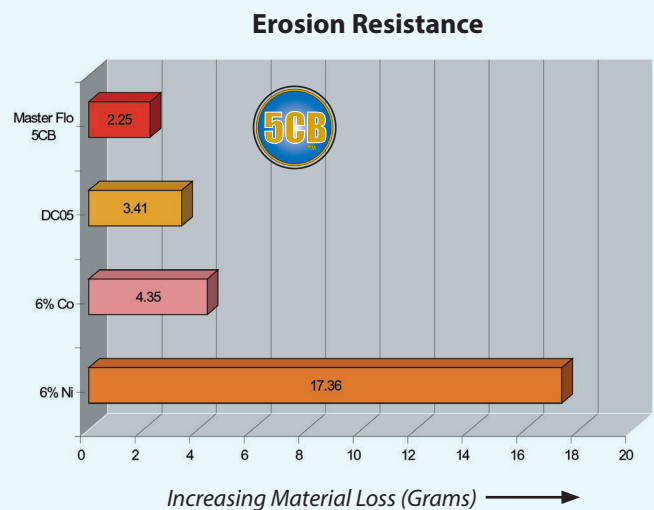
Together with the E-Series design features, 5CB trim materials set the standard for choke performance.



# E-Series

## Erosion Resistance

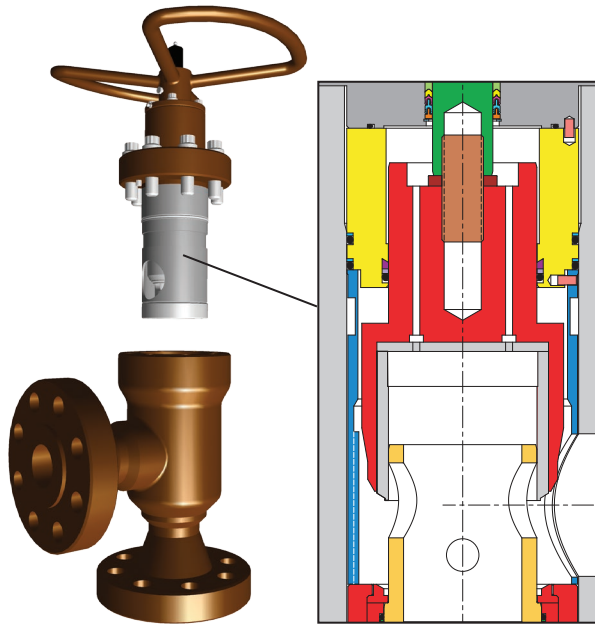
To control erosion, the carbide must prevent loss of the binder element. 5CB's structure and composition optimize erosion performance. The results show Master Flo's 5CB as having the least amount of material loss compared to other Tungsten Carbides. Testing in the Master Flo erosion loop evaluated various Tungsten Carbide grades based on mass loss under controlled conditions of velocity and sand concentration. It provided evidence that our 5CB material will control erosion 7.7 times better than 6% nickel carbide. Of the 5 cemented carbide grades tested, the nearest challenger suffered material loss at a rate 51% greater than 5CB.





### Trim Retention

The stationary trim components are held in place by a retaining sleeve that allows these parts to be easily aligned with the external sleeve during valve assembly. With the trim mechanically retained rather than threaded into the valve body, all of the valve's internal components can be removed from the body without the need for special tools. This ensures ease of service and inspection and the tightest tolerance between trim components.



Once the bonnet has been released from the valve body, the entire "choke cylinder" (including all internal components as well as the actuator, if applicable) is free to be removed.

The retaining sleeve also functions to control the flow of the process media in the annular volume around the trim. It isolates the valve-body bore from the flow and directs the flow to the nozzle ports. Through extensive erosion testing, the design of the retaining sleeve has been optimized to extend valve life.

the stationary seat and the nozzle ports ensures that flow is minimal during seating, which further protects the seat faces from wear.

### Independent Upstream Shutoff

The Master Flo trim is designed to achieve exceptional shutoff throughout its life. The tapered seat faces are positioned upstream from the throttling components to reduce throttling wear. Incoming flow is diverted away from the sliding seat face by a flow-deflection lip on the leading edge of the flow ring. A "dead band" between

the stationary seat and the nozzle ports ensures that flow is minimal during seating, which further protects the seat faces from wear.

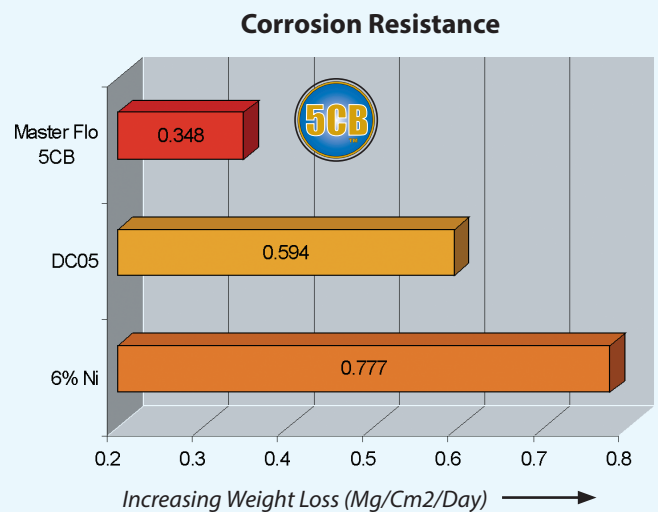
*The trim achieves Class V shutoff per FCI 70-2 - 1998. Class VI shutoff is also available with suitable actuation.*

### Corrosion Resistance

To control corrosion, the micrograin composite binder in the Tungsten Carbide trim is key.

Master Flo's proprietary 5CB provides exceptional corrosion resistance necessary for oilfield applications. Testing was conducted at a third-party facility where three Tungsten Carbide grades were tested in a solution comprised of HCl acid saturated with H<sub>2</sub>S and CO<sub>2</sub> at a temperature of 50°C for 168 hours. The results show 5CB with a 220% improvement in corrosion resistance over a 6% nickel carbide binder.

= Optimal Performance



# Other Valve Options

## High-Pressure Service

Valves suitable for pressures up to 10,000 or 20,000 PSIG with temperatures limited to 350°F (177°C) are available in a variety of sizes.

## High-Temperature Service

Valves designed for high-temperature service are available in a variety of sizes. Temperature ratings up to 850°F (454°C) and pressures to 6,000 PSI and 350°F (177°C) for 15,000 PSI can be accommodated in either manual or automated operation. These valves are used in a variety of high-temperature applications including steam injection and SAGO.

## Low-Temperature Service

Valves suitable for service temperatures as low as -150°F (-101°C) are available. The use of appropriate materials is critical in such applications.

## Fugitive Emission Testing

Valves undergo customer-specific or Fugitive Emission testing to meet ISA, ISO or ANSI/FCI industry standards.

## Fire Safe

Most of the Master Flo choke valve product line has been tested to meet API 6FA fire safe standards.

## High-Corrosion Applications

For applications that are highly corrosive and require superior materials, valves are available in API-6A material class HH.

## Stem-Lock Mechanism

For manually-operated valves, an optional stem-lock mechanism is available to lock the trim in any position.



Stem-lock



# Actuation and Control

Master Flo manufactures a range of actuators to complement our choke and control valve product lines. Master Flo actuators are designed to meet the needs of the industry including compact design, robust, high performance, high control, and versatile configurations. Manually-operated valves may be field converted to automated actuation.

Master Flo can supply the following actuators in various sizes and configurations:

- Linear Hydraulic
- Spring Close Hydraulic
- Pneumatic Piston
- Pneumatic Diaphragm
- Rotary Hydraulic and Pneumatic
- Rotary Electric

Our actuators have the following features:

- Compact
- Robust
- High Performance
- Controllability

## Other Actuators

Various commercial actuators may also be mounted on Master Flo valves. These include:

- Single and three-phase AC electric
- Low-voltage DC electric
- Pneumatic diaphragm
- Electro-hydraulic actuators

## Control Options

Actuator controls are available with the following features:

- Input Signal 3-15 psig, 6-30 psig, 4-20 mA, HART, fieldbus\*
- Output Signal 4-20 mA, HART, fieldbus
- Supply Pressure 80 - 150 psig
- Accuracy  $\pm 1$  to 3% full scale\*
- Certification CSA/FM/UL explosion proof or ATEX intrinsically safe or flameproof\*
- Operating Medium instrument air, sweet instrument gas also available
- Temperature Range -20 to +150° F (-29 to +66°C)
- Fail Action spring-assist fail close - standard, fail lock also available



*Master Flo Pneumatic Piston Actuators are suitable for use with a variety of positioners.*

*\*positioner dependent*



# Master Flo Subsea Choke Systems

Master Flo’s excellence in flow solutions for severe service applications continues with our subsea systems. With more than 30 years of subsea experience, Master Flo subsea chokes and supporting actuation are your first choice for reliable performance.

**Bolted Bonnet:** The choke internals are held in place by a bolted bonnet and are suitable for modular retrieval systems.

**Diver Insert Retrievable:** A diver-operated clamp mechanism allows for the retrieval of choke internals and actuator. Tapered metal bonnet seals provide reliable and durable closure.

**Insert Retrievable (HRV):** Chokes are qualified for depths to 11,000 ft (3350 m) and pressures up to 15,000 PSIG (103,000 kPa). The choke internals and actuator are contained in a module that can be installed by a cable-deployed tool and the assistance of a remote operated vehicle (ROV). An ROV-operated bonnet clamp fastens the insert to the choke body and metal-to-metal seals are used at all critical sealing areas.

**Subsea Actuation:** Master Flo, SL Hydraulic Stepping Actuator is a compact, lightweight and durable unit qualified to depths of 11,000 feet (3,350 m). It is a modular unit that adapts to a variety of orientation and interface options.







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