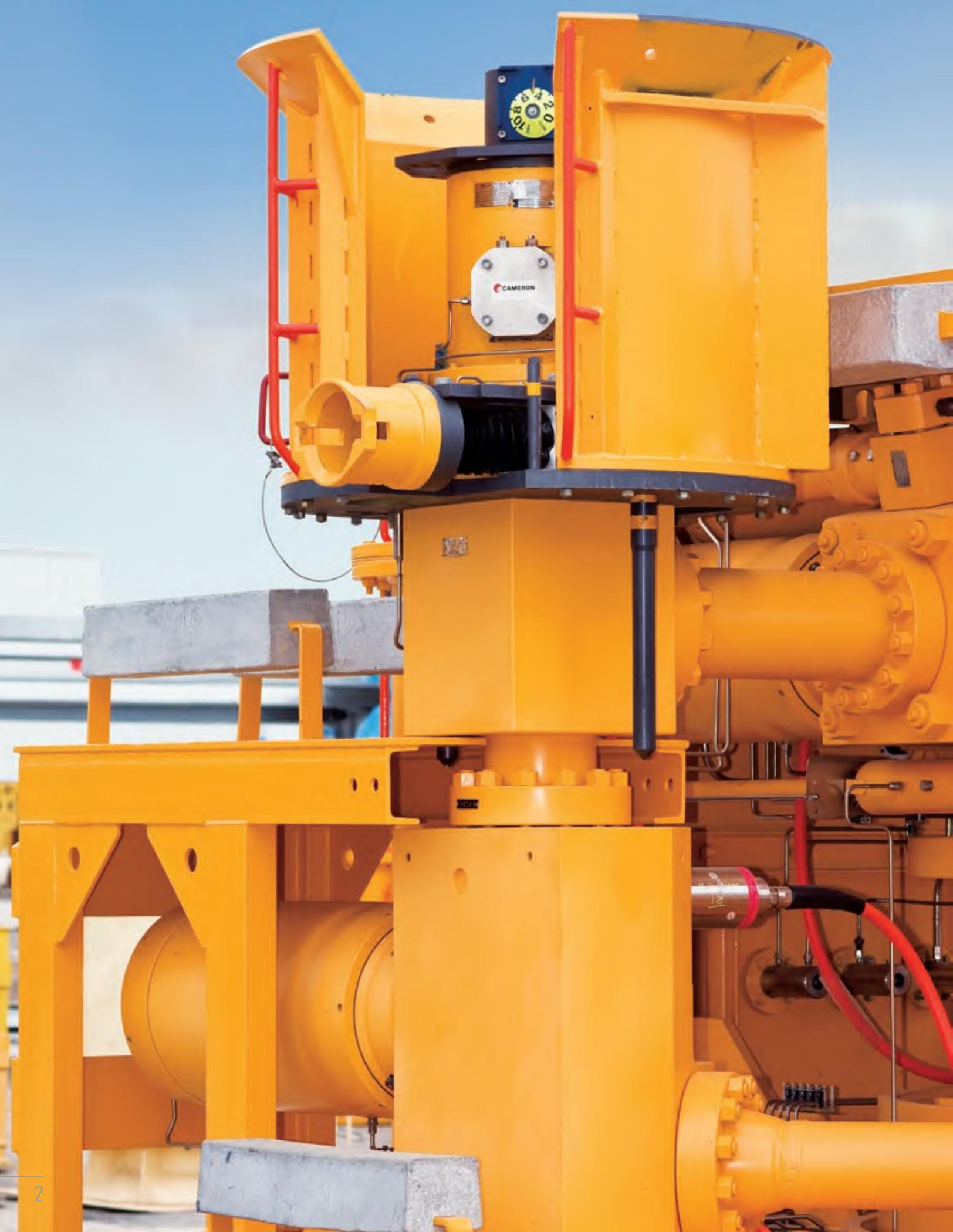




Subsea Chokes

Setting the industry standard,
decade after decade



The World's Most Advanced Subsea Chokes

Cameron provides surface and subsea choke and actuation solutions, project management, system engineering, operability and training.

Cameron WILLIS* subsea chokes are designed for use in production, water injection, gas injection, gas lift and reverse flow applications with chokes ranging from 2 in through 8 in nominal sizes and C_v from less than 1 up to 1,000.

Subsea chokes are typically used to:

- Start up and shut in subsea wells
- Balance pressures from different wells to a common manifold
- Reduce flowline pressures and costs
- Protect against reservoir collapse during startup
- Control flowrates to minimize sand and water production extending production life
- Protect subsea gate valves from high-pressure drops during startup and shutdown

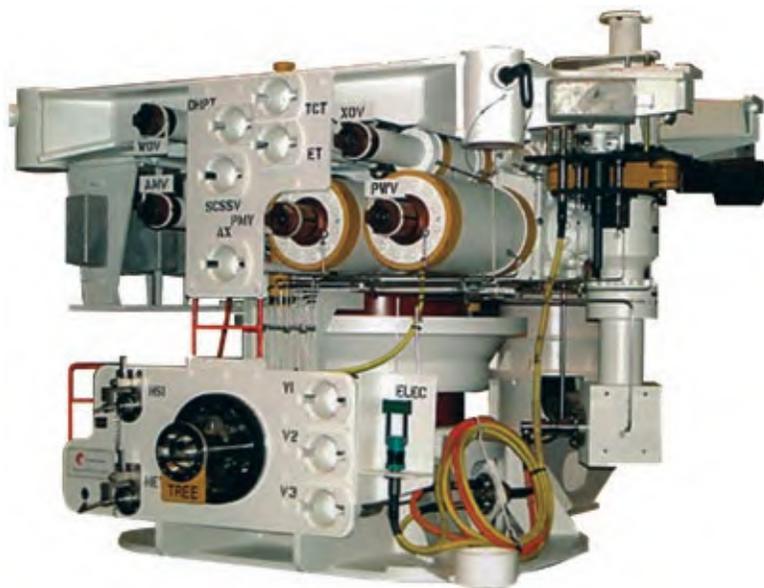
Cameron offers both non-retrievable and insert-retrievable chokes. Non-retrievable chokes remain permanently attached to subsea structures, while insert-retrievable chokes are designed so that the trim, actuator and retention mechanism can be retrieved to the surface.

Cameron subsea choke trim options are easily interchangeable to accommodate changing field parameters.

- Plug & cage, external sleeve or multistage
- Bi-directional flow, gas injection, gas lift, water injection (typically multistage) or water alternating gas (WAG)



Deepwater SpoolTree system with DLRT insert-retrievable choke



SpoolTree system with insert-retrievable choke*

A History of Innovation

In 1975, Cameron manufactured the world's first subsea choke for the Mobil West Delta project in the Gulf of Mexico based on the design of manual surface chokes and Multi-Orifice Valve (MOV*) trim technology. The MOV controlled flow via two rotating discs with circular orifices.

Today, Cameron subsea chokes have been used in more than 3,500 installations around the globe and feature leading-edge technology:

- Plug & cage, external sleeve and multistage trim styles
- High-pressure, high-temperature designs of 15,000 psi, 400 degF [204 degC], with 20,000 psi choke under development
- Insert-retrievable and fixed non-retrievable designs
- Hydraulic stepping and stand-alone DC electric actuation



Early WILLIS subsea choke*

Two Basic Designs Meet a Variety of Requirements

In shallow or deepwater, for subsea Christmas trees or manifolds, Cameron has the subsea choke for the job. The non-retrievable choke is the ideal choice in subsea tree designs with a retrievable flow control module or choke bridge. For other applications, the insert-retrievable choke offers additional advantages.

Non-retrievable chokes

The first non-retrievable subsea choke was installed in 1975 and today, with almost 1,000 of these rugged chokes installed, they are a proven, reliable choice.

Permanently mounted to a subsea structure such as a Christmas tree or manifold, the choke body may also be incorporated into a retrievable flow control module or choke bridge, which can also house flow meters and instrumentation. To maintain or replace the choke or trim, the flow control module or choke bridge is retrieved. These chokes are usually fitted with a hydraulic stepping or stand-alone DC electric actuator, but can also be adjusted by an ROV or diver.



CC40HP non-retrievable choke 15,000 psi MWP with SLCA actuator



CC80 non-retrievable choke 10,000 psi MWP with SLCA actuator $C_v = 1,000$

Subsea Non-Retrievable Choke Summary

Choke	Description	Application	Nom. size [†] , in	MWP, psi	Max C_v [‡]	Flow curve type
CC30FNR	Non-retrievable choke	Gas lift	3	5,000	13.6	P&C EQ%
					38	P&C linear
CC30FNR	Non-retrievable choke	Production	3	10,000	86	P&C linear
					64	P&C EQ%
CC40FNR	Non-retrievable choke	Production	4	5,000	256	P&C linear
					206	P&C EQ%
CC40FNR 10k	Non-retrievable choke	Production	4	10,000	256	P&C linear
					206	P&C EQ%
CC40FNR HP	Non-retrievable choke	Production	4	15,000	130	ES EQ%
CC40FNR	Non-retrievable choke	Water injection	4	5,000	76	MS33
					345	P&C EQ%
CC50FNR 10k	Non-retrievable choke	Production	5	10,000	428	P&C linear
CC60FNR	Non-retrievable choke	Production	6	5,000	544	P&C EQ%
CC80FNR	Non-retrievable choke	Production	8	10,000	1,000	P&C linear
					433	P&C EQ%

[†] Nom. size refers to the seat nominal diameter, not the inlet or outlet end connection size.

[‡] Reduced capacity and custom trims available.

P&C—Plug & cage

EQ%—Equal percentage

ES—External sleeve

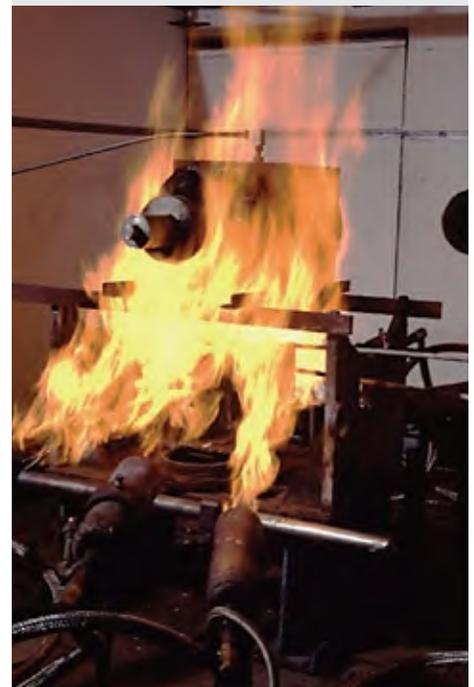
MS33—3 in, three-stage, multistage

Subsea HP/HT chokes

With more than 30 years of experience with high-pressure, high-temperature (HPHT) technology for surface choke applications to bank on, Cameron brings proven performance to the subsea domain with its evolutionary 15,000 psi subsea chokes.

In fact, Cameron HPHT chokes have already seen successful service in several land and platform applications with working pressures of 20,000 psi and temperatures of 650 degF [343 degC].

As a result, our R&D team is developing the world's first 20,000 psi subsea choke technology.



API 6FA choke fire testing

Subsea Insert-Retrieveable Choke Summary

Choke	Description	Application	Nom. size [†] , in	MWP, psi	Max C _v [‡]	Flow curve type
CC20SR	Clamp insert choke	Gas lift/MEG injection	2	10,000	6	PNT
CC20SR	Clamp insert choke	Gas lift	2	10,000	14	P&C EQ%
					8	P&C EQ%
CC30SR	Clamp insert choke	Gas lift/production	3	10,000	46	ES linear
					33	P&C EQ%
CC40SR	Clamp insert choke	Production	4	10,000	288	P&C linear
					210	P&C EQ%
CC40SR	Clamp insert choke	Production	4	15,000	200	P&C EQ%
					206	Single stage
					130	Two stage
CC40SR	Clamp insert choke	Reverse flow water injection (DBA multistage anti-cavitation trim)	4	10,000	94	Three stage
					84	P&C linear
CC30SRC	Compact insert choke	Gas lift	3	10,000	33	P&C EQ%
					224	P&C EQ%
CC40SRC	Compact insert choke	Production	4	10,000	288	P&C linear
CC40SRC	Compact insert choke	Reverse flow water injection	4	10,000	216	MS32 EQ%
CC50SR	Clamp insert choke	Production	5	10,000	500	P&C linear
					345	P&C EQ%
CC80SR	CVC insert choke	Gas production	8	7,500	1,000	P&C Linear
					757	P&C EQ%



CC80SR 8-in nominal insert retrieveable choke with CVC collet connector

[†] Nom. size refers to the seat nominal diameter, not the inlet or outlet end connection size.

[‡] Reduced capacity and custom trims available.

PNT—Profiled needle trim

P&C—Plug & cage

EQ%—Equal percentage

ES—External sleeve MS33—3 in, three-stage, multistage

Non-retrieveable choke design highlights

- Pressure ratings up to 15,000 psi
- Temperature ranges from -50 to 400 degF [-46 to 204 degC]
- Trim sizes from 2 through 8 in with controllable C_v from less than 1 up to 1,000
- 25-year design life, excluding wearing trim elements
- Meet or exceed API 6A /17D, ISO 10423/13628-4, NACE MR-01-75/ISO 15156 and NORSOK requirements

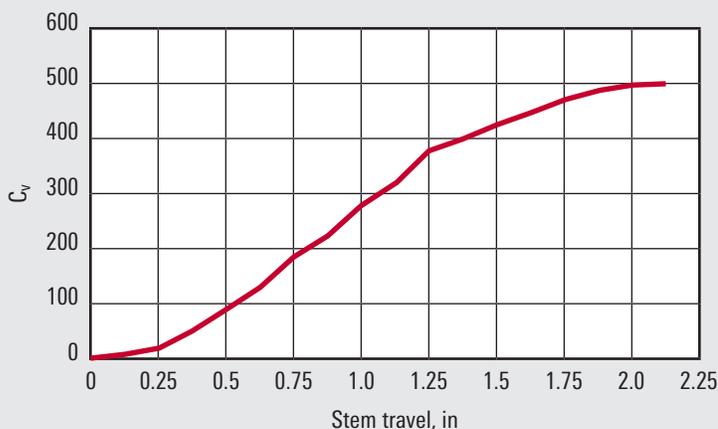
Insert-retrieveable chokes

Cameron supplied the first insert-retrieveable choke in 1991. Since then, these highly successful chokes have been installed on subsea systems in varying water depths around the world. A number of insert-retention designs are available, including the totally vertically retrieveable lightweight compact choke, with its dog-in-window connector, and the more traditional three-segment clamp CLRT-style choke with the latest edition to the family of insert irretrieveable chokes being the 8-in nominal CC80SR insert retrieveable large bore gas choke.

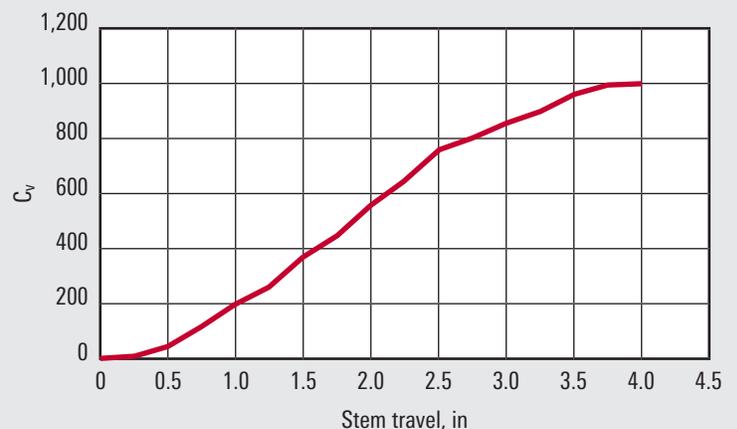
Insert-retrieveable choke design highlights

- Pressure ratings up to 15,000 psi
- Temperature ranges from -50 to 350 degF [-46 to 177 degC]
- Trim sizes from 2 through 8 in with C_v up to 1,000
- Designed for 25 years of service life, excluding wearing trim elements
- Meet or exceed all API 6A/17D, ISO 10423/13628-4, NACE MR-01-75/ISO 15156 and NORSOK requirements

Flow curves



Flow curve for CC50SR linear plug & cage C_v=500



Flow curve for CC80FNR linear plug & cage C_v=1,000

Exceptional Options Put You in Control

Insert-retrievable control chokes are available with a number of retention mechanisms, including the lightweight vertically retrievable dog-in-window and the three-segment clamp style.

With either design, the lockdown mechanism is released from the choke body so the trim, actuator, seals and lockdown mechanism are retrieved to the surface as a self-contained package for easy maintenance and trim replacement.

Compact insert-retrievable chokes

Our latest innovation to our revolutionary compact choke is a dog-in-window connector that offers tremendous advantages: It's 35% smaller, 45% lighter and 100% proven. It also provides total vertical access — with absolutely no compromise in performance.

Total vertical access is achieved via push/pull rods, which engage/disengage dogs for insert installation and retrieval, with the option of hydraulic override for disconnect. And, because it requires no horizontal access, the choke can be more centrally placed, potentially reducing the size and weight of the Christmas tree and manifold significantly. Installation is simple enough for smaller, more readily accessible vessels to handle.



Dedicated compact choke running tool



CC40SRC compact choke



Dog-in-window connector

Complete choke resources

Beginning with complete design services, Cameron covers the realm of subsea choke equipment and support to save you time, money and headaches. Whatever your requirements and however complex the application, count on Cameron to provide all the products you need to get the job done:

- Running tools
- Intervention skids
- Marine growth/debris caps
- Guide funnels
- Spare inserts
- Commissioning seal kits
- Trim change kits
- Running tool spares kits



Choke insert ship and workover skid

The compact choke features an increased trim cavity and annular area for reduced flow velocity and a more uniform fluid presentation to trim. Several cage-style trims are available, including plug & cage for reverse and forward flow and maximum C_v , and water injection multi-stage, the choice for long-term operation in cavitation-sensitive conditions and reverse flow applications.

Our reliable Subsea Stepping Linear Choke Actuator (SLCA*), comprehensively tested and qualified to 10,000-foot water depths, powers the new compact choke. The number of actuation pulses can be halved on the open or closed cycles independently, for either greater control or faster operation.



Subsea manifold with compact chokes

Clamp-style insert-retrievable chokes

The simple clamp mechanism for latching the insert to the choke body is a robust, ROV/diver-friendly system. A remotely operated tool lowers the insert with its clamp assembly into the choke body. Guide pins align the insert, and hydraulic and electrical connectors automatically mate as the insert is soft landed. Finally, the ROV operates a single threaded shaft to close the clamp segments.

Cameron has developed configurations to allow retrieval by the Cameron dedicated Clamp Running Tool (CLRT) or a third-party Deepwater Lifeline Running Tool (DLRT) or Multi-Purpose Running Tool (MPRT).



Retrievable subsea choke with clamp connector



CC40SR clamp choke with CLRT running tool funnel

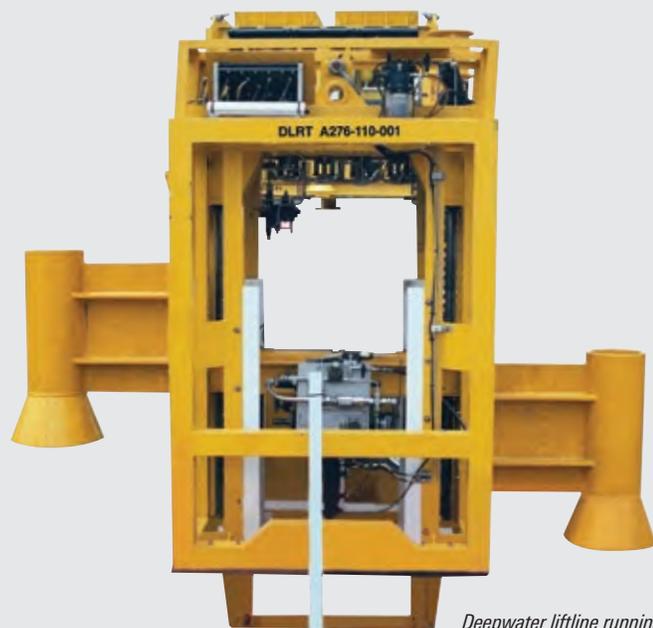


CC40SR clamp choke with DLRT land out interface

Intervention tooling

For deepwater subsea choke applications requiring specialized intervention techniques, Cameron supplies intervention tooling, test skids and shipping skids designed and manufactured to meet customer and project requirements.

In addition, Cameron insert-retrievable chokes are compatible with the intervention tooling currently supplied with the CAMTROL* subsea production control system, which means the same intervention tooling used to install and retrieve subsea control modules can also be used with Cameron chokes.



Deepwater lifeline running tool

High-performance actuators for every purpose

Cameron provides a variety of subsea choke actuators, including hydraulic “fail fixed” actuators in operating pressures of 3,000 and 5,000 psi, which are compatible with water or mineral-oil-based control fluids, as well as optional stand-alone DC electric actuators.

RD250 ROV gearbox

For use with Cameron non-retrievable chokes with either diver or ROV operation, this actuator is oil-filled and pressure-compensated, and has an external marine-growth-resistant local-position indicator, which allows the choke setting to be easily read.

Subsea stepping linear choke actuator (SLCA)

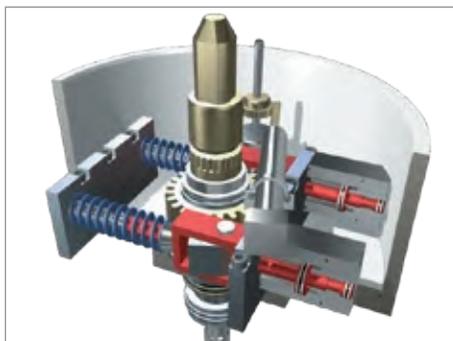
Developed for use on non-retrievable chokes and now also used on the new compact choke, the SLCA has two single-acting piston-pawl assemblies — one for open and one for closed. It is oil-filled and pressure-compensated with a remote-position feedback via an LVDT, a marine-growth-resistant local-position indicator and an ROV override.

Aqua-Torq actuator

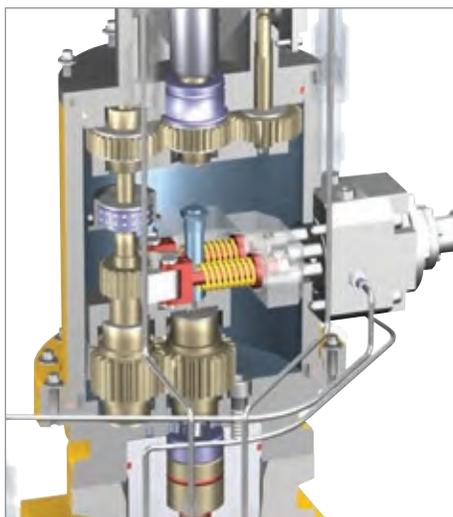
The Aqua-Torq* hydraulic stepping choke actuator is designed to provide precise incremental steps from open to closed. Oil-filled and pressure-compensated, it incorporates a marine-growth-resistant local-position indicator and is available with an internal LVDT. The actuator is fitted with flushing ports, and the customer hydraulic interface is usually by the weld tails on the stab mate hydraulic couplers.

Linear variable differential transformer

An accurate Linear Variable Differential Transformer (LVDT) electronic remote-position feedback sensor is available for both Aqua-Torq and SLCA actuators. These non-contacting position sensors are seal welded, digitally calibrated and available in analog (4–20mA) and digital (CANBus) output designs. Reliable, field-proven and individually hyperbarically tested to 11,400-ft [3,475-m] water depths.



SLCA actuator



Aqua-Torq actuator



Digitally calibrateable LVDT

Trim principle

Cameron subsea chokes feature a control choke trim that uses hydrodynamic energy dissipation to reduce erosion problems and ensure positive flow. The flow enters the inlet and circulates in the annulus between the body and cage. The even distribution of ports around the cage determines maximum flow capacity. High-velocity jets produced by the flow collide in the cage center, dissipating the most erosive energy away from the downstream components.



The Cameron WILLIS* control choke cage-style trim design incorporates “hydrodynamic energy dissipation” to reduce erosion problems while ensuring positive flow.

Electrically Actuated Omni-Choke

The Cameron Omni-Choke* provides the benefits and functionality of all-electric actuation to both greenfield and brownfield applications by virtually any traditional multiplexed controls system through a simple changeout of the choke. The SIIS compliant interface allows the Omni-Choke to be treated as a standard instrument, compatible with traditional subsea control modules. Functioning successfully since September 2008 in the K5F Field in the North Sea, the Omni-Choke makes all-electric performance a reality.

Cameron actuator performance

- Operating depths to 10,000 ft [3,000 m]
- Designed for 25 years of service life
- Footprint identical to common clamp-style chokes



The Cameron electrically actuated Omni-Choke

Control choke trim minimizes erosion, maximizes control

Cameron subsea chokes are available in plug & cage (forward and reverse flow), external sleeve and anti-cavitation multi-stage trims.

In these cage-style trim designs, the production fluid is directed through the cage port so that it impinges upon itself. The energy of the fluid is dissipated within the tungsten carbide trim, reducing the wear on the choke and downstream components.

Design features

- Availability of both plug & cage and external sleeve trims provides interchangeability, maximum flexibility and lower costs over the life of the field
- Thick cross-sections of tungsten carbide material provide extensive erosion resistance and reduced wear
- Robust metal outer cage protects internal components from slugged flow or impact from entrained solids during well clean up
- Trim ports and geometry design reduces wear and noise, maximizes flow and controls pressure throughout the choke's operating range
- Pressure-balanced stem and thrust bearings reduce torque, allowing minimized stem loads and actuation requirements



Cameron provides a wide variety of control choke trims

Premier manufacturing



Longford, Ireland

The Cameron choke manufacturing facility in Longford, Ireland, has global responsibility for the design and manufacturing of all subsea chokes and intervention tooling, as well as subsea chemical-injection metering valves (CIMV) and gate valve actuators.

This plant is equipped with sophisticated tools and flow control technology, including CNC machining centers; fabrication and weld-cladding stations; hydrotest bays; TV-monitored hydrostatic and gas test facilities rated to 30,000 psi; advanced NDE capabilities such as X-ray, UT and PMI; and a semi-automated blast-and-paint facility.

Our in-house R&D group works hand in hand with sales and manufacturing teams in 21 countries worldwide, with further support provided by 65 Cameron Services locations. Wherever you need us, we're already there.

Plug & cage trim

Our plug & cage trim uses a plug that throttles the flow on the inside diameter of the ported cage. The tungsten carbide plug assembly in conjunction with the cage provides optimum wear resistance in erosive conditions. In addition, an outer cage provides protection from impact damage during well cleanup or from failed downhole completions.

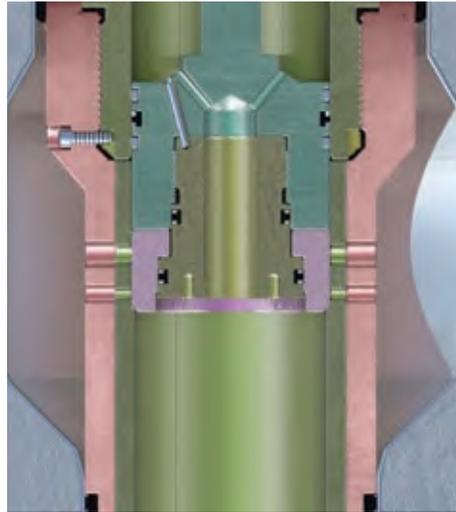
The cage construction enables tungsten carbide components to withstand the tensile forces generated during reverse flow. This allows the trim to be used during production (forward flow) and injection (reverse flow) applications.

This versatile trim offers excellent erosion resistance and precise control, making it ideally suited to deepwater oil or gas production. Because of its high capacity, the plug & cage trim design is perfect for flow optimization near the end of the life of a well.

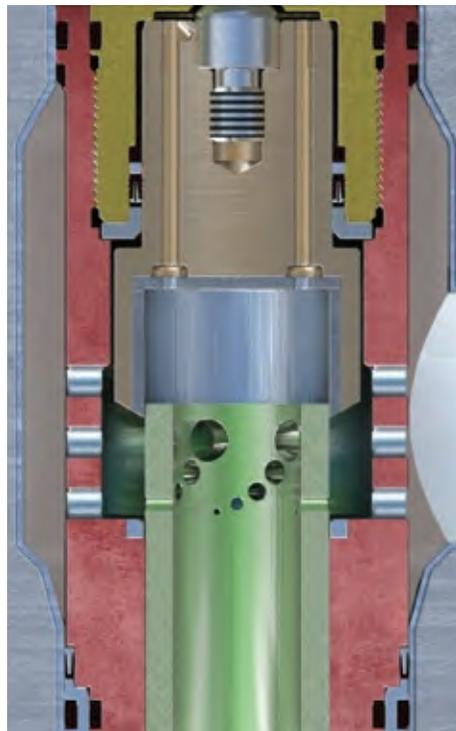
External sleeve trim

This design incorporates an outer sleeve that throttles the flow on the outside diameter of the ported cage. A tungsten carbide flow sleeve and seat provide optimum wear resistance in erosive conditions. In addition, a reverse-angle flow sleeve extends the life of the trim by reducing annular flow-by.

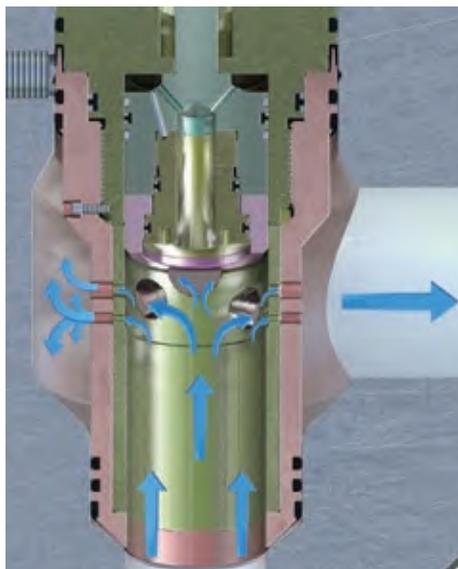
Field applications have shown this trim to be the industry leader in erosion performance. In two separate joint industry projects, Cameron external sleeve chokes were rated the most wear-resistant to sand-laden gas or liquified production service. As a result, this trim is the preferred solution for severe sand service.



Plug & cage trim



External sleeve trim



Reverse flow-in plug & cage

Choke sizing program

Because choosing the right trim size is vital to your success in the field, Cameron has developed a comprehensive choke sizing program.

Based on the flow and pressure requirements of the application, the software analyzes and specifies the optimum choke size and trim configuration for an array of flow conditions.

The Cameron choke sizing program was developed according to ANSI/ISA S75.01/02 (IEC 60534-2-1 Mod) requirements in a specially designed CV test flow loop.



Choke sizing flow loop



The Cameron choke sizing program

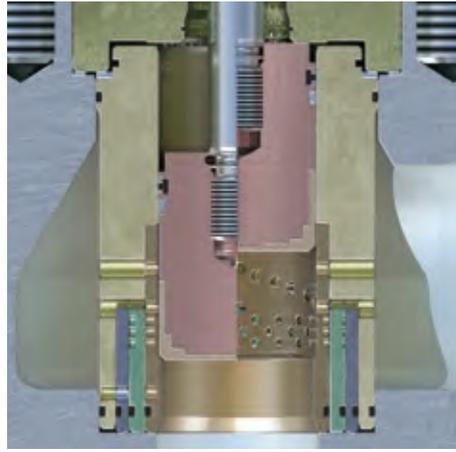
Water injection (anti-cavitation) trim

Cameron offers two- and three-stage DBA and multistage (MS) trims for water injection service. These custom engineered anti-cavitation trims can be interchanged with production trims as required.

The cavitation problem

Cavitation is a serious enemy to efficient flow control. Cavitation's destructive effects include high noise levels, vibration and damage to valve and trim materials. Cavitation is the formation and sudden collapse of vapor bubbles in a flowing liquid. During the liquid's passage through a valve, the pressure drops from the inlet pressure (P_1) to a minimum pressure (P_{vc}) in the vena contracta just past the restriction. If the P_{vc} falls below the liquid's vapor pressure (P_v), vaporization occurs and vapor bubbles form. As the liquid moves downstream from the vena contracta, the pressure recovers to P_2 .

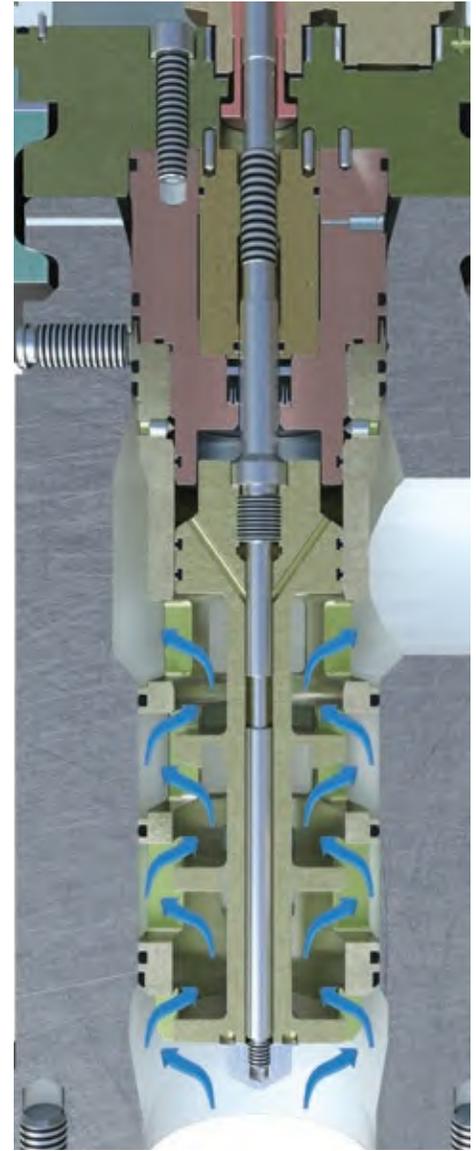
If this outlet pressure, P_2 , is above the vapor pressure, the vapor bubbles collapse. This causes high pressure shock waves, which can cause damage to nearby metal surfaces.



MS three-stage anti-cavitation trim

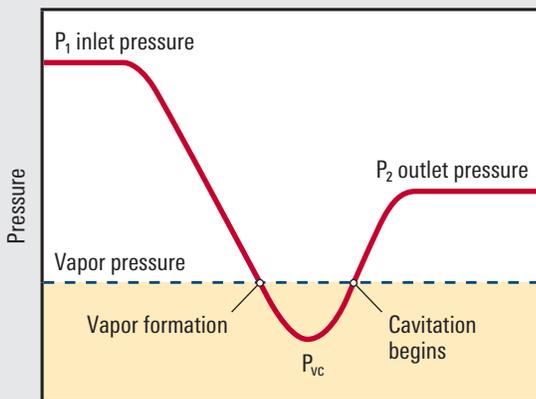
The Cameron solution

Cameron DBA and MS trims were developed specifically to combat cavitation in water injection applications. Their multiple pressure drop design divides the normally large pressure drop into a series of smaller pressure drops. Cavitation is eliminated by keeping the pressure at the vena contracta, P_{vc} , above the vapor pressure, P_v , of the liquid. The result is a trim that eliminates the threat of cavitation, reduces noise and vibration in downstream pipes and joints, improves control and performance, and increases production life.



DBA two-stage anti-cavitation trim

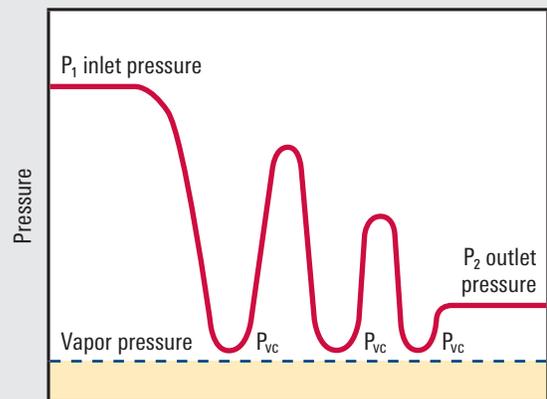
Multistage anti-cavitation trims



Pressure drop profile through one stage.



Single-stage pressure letdown



DBA flow characteristics. Minimum pressure (P_{vc}) stays above vapor pressure.



Three-stage multistage pressure letdown

Subsea Chokes



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