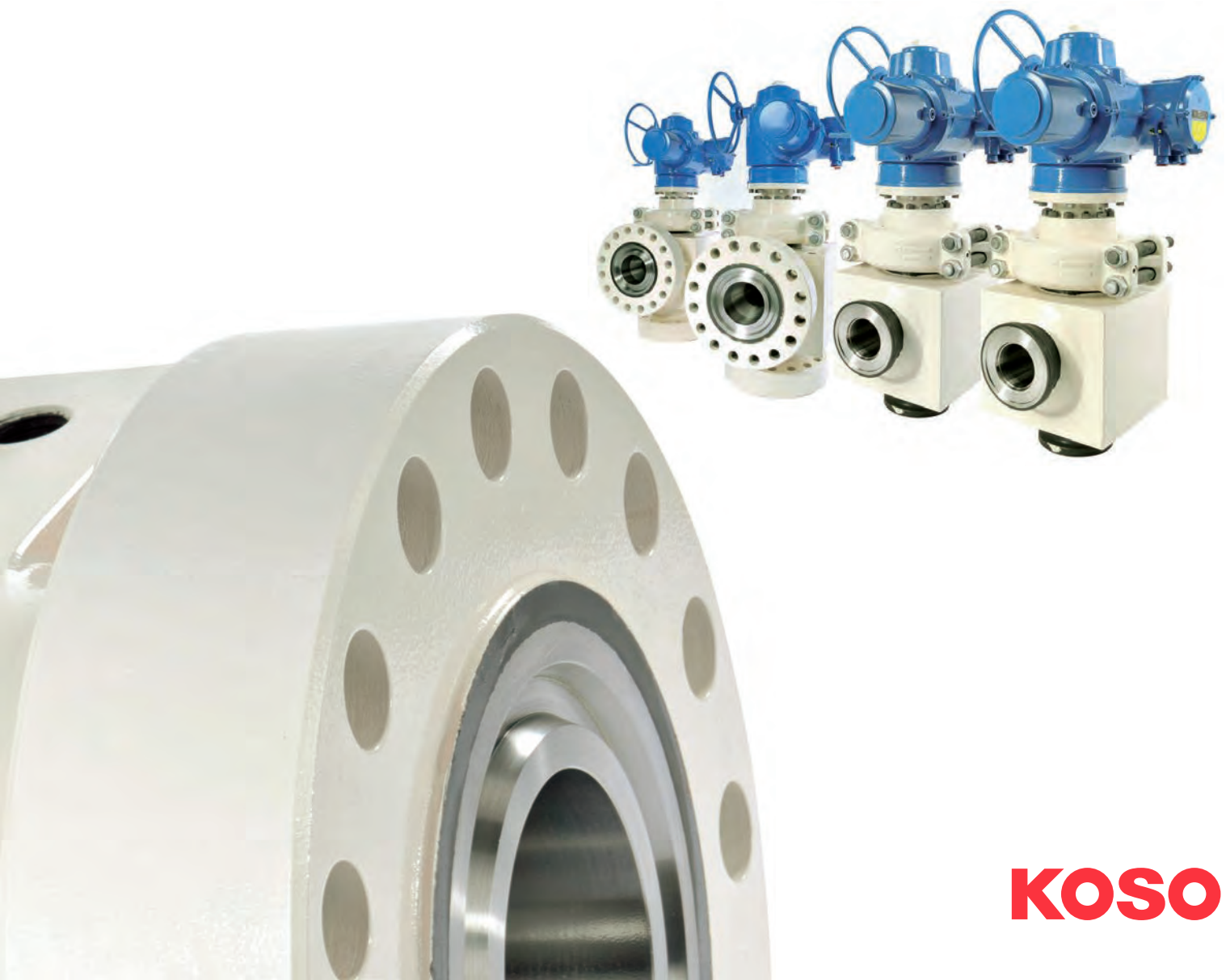
PRODUCT SERIES
73

kentintrol

TECHNICALLY ADVANCED SURFACE CHOKES FOR SEVERE SERVICE APPLICATIONS



KOSO

KOSO KENT INTROL SUPPLIES A DIVERSE RANGE OF PRECISION -MANUFACTURED CHOKE, CONTROL AND ROTARY VALVES FOR OIL AND GAS, PETROCHEMICAL AND POWER INDUSTRIES – WORLDWIDE

TABLE OF CONTENTS

PRODUCT RANGE

TOP & BOTTOM-GUIDED CONTROL VALVES

Our range of high-performance top and bottom-guided control valves includes single and double-seated valves suitable for low and high-capacity applications, as well as three-way valves for mixing or splitting flows. Our control valves are designed to facilitate pressure drops at all stages of transportation in the oil, gas and power industries. All valves are refined by our engineers to suit the needs of each application and all service conditions.

CAGE-GUIDED CONTROL VALVES

The Series 1200/7200 range of cage-guided control valves is KKI's core product. The exceptional valves in this range combine high-integrity features, such as ASME VIII body/bonnet bolting design, a high flow capacity and a wide range of trim designs, from low-noise anti-cavitation to multi-stage trims. These valves are ideally suited to the critical service process control requirements of a wide range of industry applications.

SURFACE CHOKE VALVES

The KKI Series 73 surface choke valve offers a unique solution for the majority of choke applications in the oil and gas industry. The flexible valve design can incorporate many different trim and body material options to suit differing flow rates and in-service conditions. Thousands of KKI Series 73 surface chokes are installed around the world on projects for some of the world's leading oil and gas production companies.

ROTARY CONTROL VALVES

The Rotrol range of high-capacity butterfly valves has been developed to overcome the problems associated with control, cavitation and noise in conventional butterfly valve designs. Lighter in weight and more compact than globe valve alternatives, this innovative valve performs especially well in severe-service applications, where pressure drops tend to be high in the controlling position but where high-capacity throughputs at low pressure drops are also required.

SEVERE SERVICE SOLUTIONS

For more than 50 years, KKI has built up a reputation for delivering valve solutions for the most arduous service conditions. We have developed a range of advanced, high-quality severe service valve solutions for every type of problematic application, from high-pressure, high-temperature environments to sub-zero temperatures. Our valves are designed to combat the effects of cavitation, flashing, erosion, contaminated fluids, corrosion, high velocity, vibration, noise and energy dissipation.

INSTRUMENTS

KKI offers a wide selection of sophisticated instrumentation to support our comprehensive range of high-performance valves and actuators. The instruments we supply include pneumatic and electro-magnetic positioners, airsets, volume boosters and airlocks. All instruments are specified to deliver optimum performance for the service conditions and specific needs of each application. We also supply proprietary instruments to suit individual customer preferences.

ACTUATORS

Our range of robust, versatile and reliable pneumatic actuators includes the 'G', 'C' and 'D' Series models. These have been developed to meet the needs of all control valve applications, offering proven design and high reliability. They are used extensively for on-shore, offshore and power installations. In addition, we supply various proprietary actuators – such as electric, electro-hydraulic, pneumatic stepping and hydraulic stepping actuators – to meet customer requirements. All actuators can be supplied with hand-wheels and limit stop features.

TOP & BOTTOM-GUIDED CONTROL VALVES

SINGLE SEATED SERIES 10/71

DOUBLE SEATED SERIES 20

3-WAY MIXING AND DIVERTING SERIES 30

CAGE-GUIDED CONTROL VALVES

SERIES 1200/7200

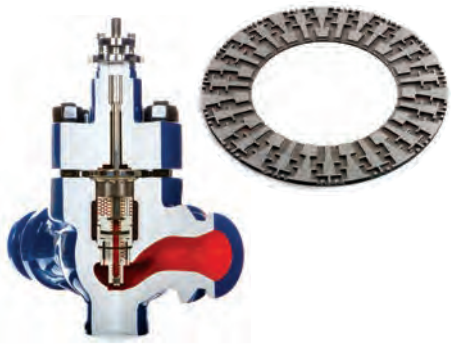
SURFACE CHOKE VALVES

SERIES 73

ROTARY CONTROL VALVES

SERIES 60

SEVERE SERVICE SOLUTIONS



INSTRUMENTS

ACTUATORS

SERIES G

SERIES C

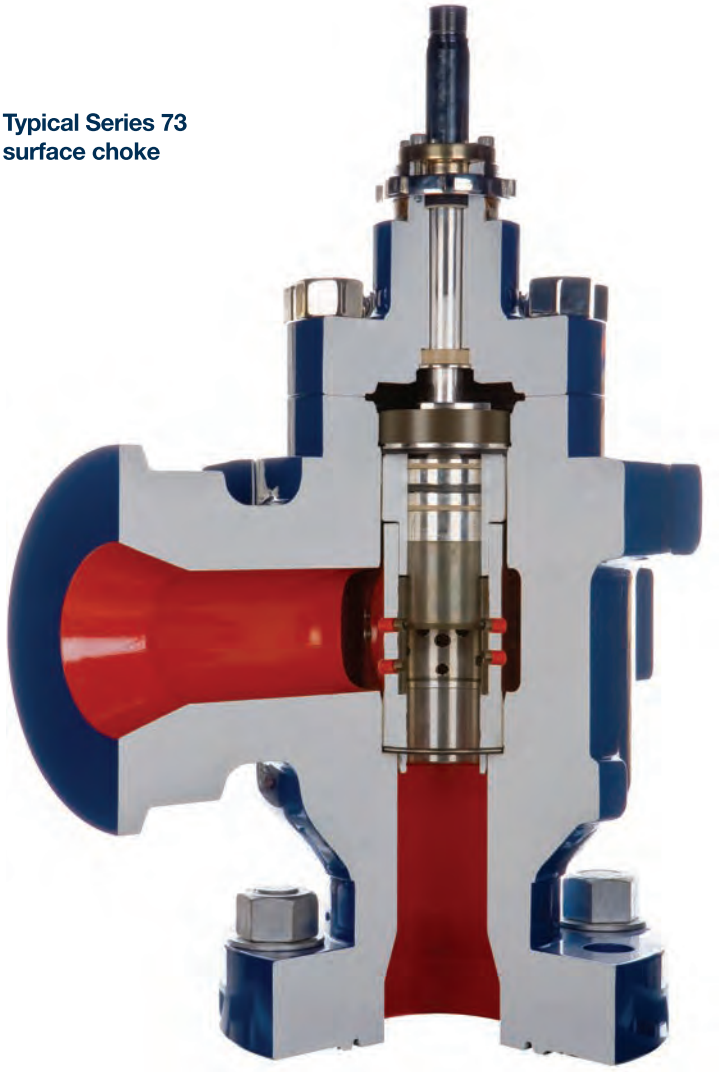
SERIES D

INTRODUCTION TO KOSO KENT INTROL'S SURFACE CHOKES

At Koso Kent Introl an unrivalled blend of proven expertise, innovative design technology and skilled engineering is the motivating force behind the development of the Introl range of high quality choke valves

Thousands of Introl Series 73 surface chokes are installed around the world on projects for some of the worlds leading oil and gas production companies.

Koso Kent Introl manufactures from it's plant in the UK, with global sales and application support from specialist sales people and carefully selected channel partners throughout the world.



Typical Series 73 surface choke

QUALITY MANUFACTURING

Maintaining the highest standards of quality throughout design, production and customer service is the cornerstone of Koso Kent Introl's philosophy. Our plant is accredited in accordance with Quality Management System ISO 9001 and Environmental Management System ISO 14001. In addition all products, where applicable, conform to ATEX, PED and all other applicable EU Directives and are CE marked accordingly.

The company's standard manufacturing experience includes NACE MR01.75, NORSOK, API 6A specifications and individual customer specifications. Our in-house inspection and testing facilities include hardness testing, NDE, PMI, gas and flow testing. Safety is the key element in everything we do, with all employees undergoing both general and specific Health and Safety training.

Surface choke complete with electro-hydraulic actuator

OHSAS 18001 · ISO 14001 · ISO 9001 · ISO/TS 29001 · 6A-1275 · 17D-0088

SERIES 73 SURFACE CHOKE

The Koso Kent Introl Series 73 surface choke valve offers a unique solution to the majority of choke applications within the oil and gas industry. The flexibility of this design facilitates many different trim and body material options.

FEATURES OF THE SERIES 73 SURFACE CHOKE

- Choke body materials can be of forged, HIPped or cast construction.
- Numerous trim designs from single stage high capacity to multi stage low noise/anti cavitation.
- Patented sand resistant LCV trim design.
- Premium grade (solid) tungsten carbide control elements (dependant on application).
- Non-Collapsable trim design option.
- Various trim sizes can be used, in different choke body sizes, to ideally suit the process parameters.
- Specially characterised trims can be provided.
- The choke design has an inherently high capacity and rangeability.
- All seals are resilient and do not suffer from explosive decompression
- A wide range of actuator options are available, including manual, pneumatic spring opposed diaphragm, pneumatic piston, pneumatic stepping, hydraulic stepping, electric, electro-hydraulic + Koso America REXA 'Electraulic™' actuator.

API 6A 15K RATED CHOKE
– Clamped bonnet
– Electric actuator

Choke complete with Koso America REXA 'Electraulic™' actuator

PERFORMANCE TESTING OF CHOKE ASSEMBLIES

- API 6A PR2 testing – of various choke sizes and ratings.
- API 17D testing – of various choke sizes and ratings.
- Flow testing – verification of flow capacity and trim characteristic.
- Bend testing – to validate design integrity of pressure envelope.
- Low temperature testing – to verify suitability of the chokes at sub zero temperatures.
- Erosion qualification and CFD reports – to verify the expected life of the choke under erosive service conditions.
- Choke trim impact testing – to verify that the choke trim does not collapse when hit by solid components at high velocity.

REXA
ELECTRAULIC™ ACTUATION

HIGH TECHNOLOGY CHOKES

FEATURES OF THE SERIES 73 SURFACE CHOKE

SIZES
1” to 16” (25mm to 400mm)

RATINGS
ANSI 600 to 4,500/API 3,000 to 15,000

END CONNECTION STYLES
ISO 10423 – API 6A, API 17D, ANSI Flanges and Clamp/Hub type connections. Other end connections available on request.

DESIGN STANDARDS
ISO 10423 – API 6A/API 17D/ANSI B16.34/ASME VIII/PED/ATEX /NACE MR-01-75/NORSOK

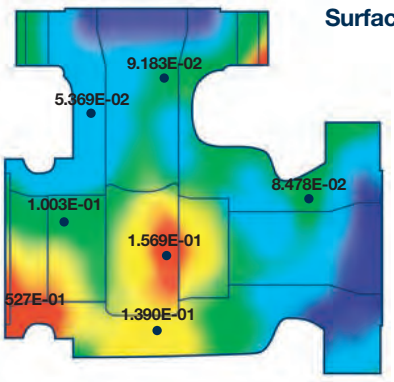
BODY FORM
Castings, HIPpings or Forgings, dependant on application.

BONNET DESIGN
Bolted or Clamped design in accordance with ASME VIII.

TRIM DESIGN
HF, LCV, Microspline, Multi-spline and various Multi-stage trim options. Other special trim configurations available on request.

PLUG DESIGN
Solid or Balanced.
Metallic and resilient sealing ring options are available for balanced plug designs. Plug scraper rings are available as an option for high duty applications.

INHERENT CHARACTERISTIC
Modified Eq%, Linear or Equal Percentage.



Surface choke body under going finite element analysis

Solid alloy 625 choke body and bonnet for a design temperature of –120 degrees centigrade

MATERIALS OF CONSTRUCTION

The procedure for selecting the materials of construction for chokes necessitates the considerations of a number of factors. In addition to the application, type of fluid, corrosion/erosion effects, fluid temperature, process pressure and contamination level, other factors also need to be considered.

Typical materials of construction are:
- ASTM A216 WCB/ASTM A352 LCB and LCC
- AISI 4130/8630 and ASTM A182 F22 (Including partial or full alloy 625 overlay)
- UNS S31803, UNS S32550 and solid alloy 625
- Titanium

NOTE: Various material options available, depending on actual process fluid

SURFACE CHOKE TRIM TECHNOLOGY

All Koso Kent Introl Series 73 choke valves utilise the low-pressure recovery High Friction (HF) design of trim. First introduced in 1967, the HF trim philosophy is that the high energy, velocity and turbulence are dissipated and controlled within the confines of the trim, avoiding erosion damage to the pressure containing boundaries.

Depending on the specific application and service conditions, single stage or a multiple of stages can be used. On multi-stage trims, the holes are specifically aligned from one sleeve to the next, so the individual jets must change direction repeatedly in the recovery chambers between each sleeve. This arrangement provides controlled staged pressure reduction without the onset of incipient cavitation and its associated problems of erosion, vibration and noise.

FEATURES OF THE HF CARTRIDGE TRIM DESIGN

- Divides the main flow into a large number of small streams, increasing the turbulence/noise peak frequency and maximising the pipe wall transmission loss.
- High energy levels, pressure, velocity and turbulence intensity are dissipated within the confines of the trim, avoiding erosion damage to the pressure containing boundaries.
- Design of last stage ensures low velocity non-interacting jets, avoiding unnecessary generation of noise in the choke outlet.
- Various trim sizes can be used in different choke body sizes, to ideally suit the process parameters.
- Specially characterised trims can be provided.
- The inner tungsten carbide control elements are protected from impact damage by the outer cartridge sleeve (verified by testing).
- The HF trim design has an inherently high capacity and rangeability.
- All seals are resilient and do not suffer from explosive decompression.

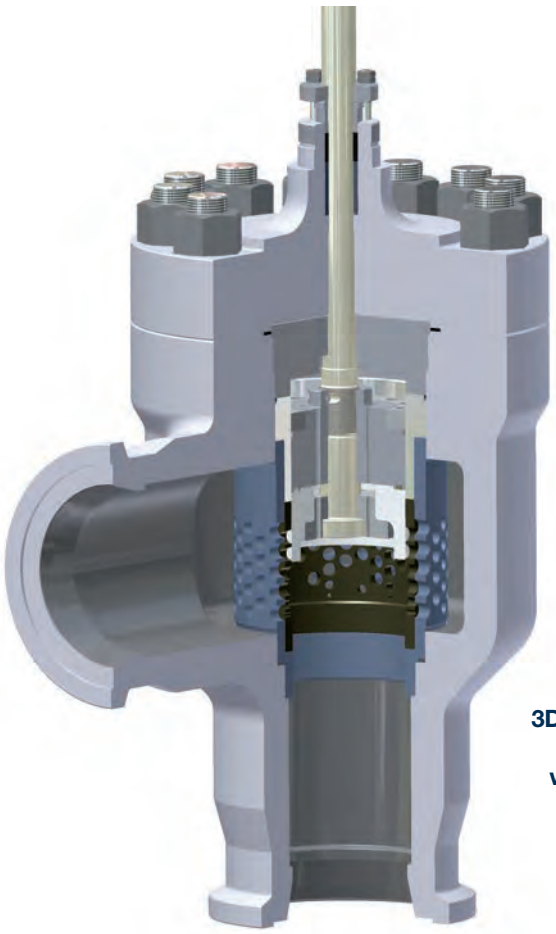
Cartridge trim design which incorporates a metallic ‘Brick Stopper’

PROTECTION AGAINST SAND EROSION

On applications, where there is a potential for high sand contamination within the medium, the HF-LCV design of trim would be offered. This design of trim has been independently tested and proved very successful on some of the most erosive services.

THE MAIN FEATURES OF THE HF-LCV TRIM DESIGN

- Premium grade solid tungsten carbide critical control elements.
- Solid tungsten carbide sacrificial plug nose.
- Shrouded plug seat – seating area is protected from the high erosive flow path.
- Hole development dead band – seating area is moved away from the main flow area.
- Stem scrapers – prevents migration of sand into the stem seal area.
- Resilient plug seals with scraper rings.
- Metallic ‘Brick stopper’.
- prevents solid particles impacting directly on to the tungsten carbide.
- Optional tungsten carbide wear sleeve.



3D illustration of choke with HF trim design

DEALING WITH EROSION FROM SOLID CONTAMINANTS

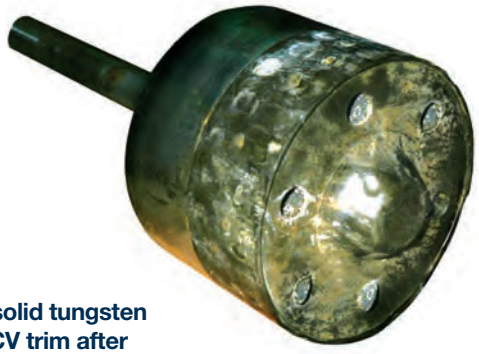
Some severe service applications do not just have to handle high-pressure drop scenarios; there is also the potential problem of erosion due to solid contaminants entrained in the process medium.

EXAMPLE APPLICATION

Koso Kent Introl developed the LCV trim over 20 years ago to handle these particular severe service applications. With the aid of Finite Element Analysis, Computational Fluid Dynamics, Extensive Erosion testing and the use of the latest erosion resistant materials, the design has been further enhanced to maximise the expected life of the trim components.

The initial choke was supplied in 1974 on a Level Control Valve (LCV) first stage separator application. The trim was of a HFD st 316L standard cage guided design. In the early 1980's the client introduced water injection, the additional water cut also produced sand. Within 2 weeks of operation of the valve, the trim was being severely eroded away due to excessive sand contamination.

Fully stellited cage guided trim after two weeks operation



Patented solid tungsten carbide LCV trim after two years operation

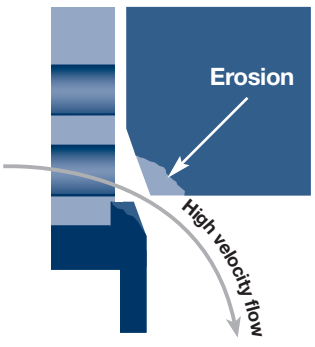
THE LCV SOLUTION

Koso Kent Introl introduced a number of design enhancements to ensure that the choke trim would withstand the erosive nature of the medium. These enhancements included the introduction of a dead band, a sacrificial plug nose, a shrouded seat face arrangement and solid tungsten carbide main trim control elements.

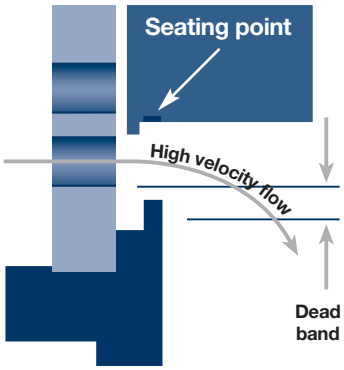
INTRODUCTION OF THE DEAD BAND

The dead band is designed so that the valve stem will travel between 5 and 10% prior to any significant flow being passed through the valve. This moves the seating faces away from the main flow path of the medium as the flow is directed onto specially designed hard wearing sacrificial areas.

Conventional seat arrangement



LCV design (patented)



CUSTOM DESIGNED VALVES

Koso Kent Introl has built its reputation on providing ingenious solutions to what is envisaged by the customer, as a problematic application. Whether it be for problems relating to high pressure high temperature, cavitation, erosion, corrosion, velocity, noise or energy dissipation, Koso Kent Introl has proved it has the solutions.

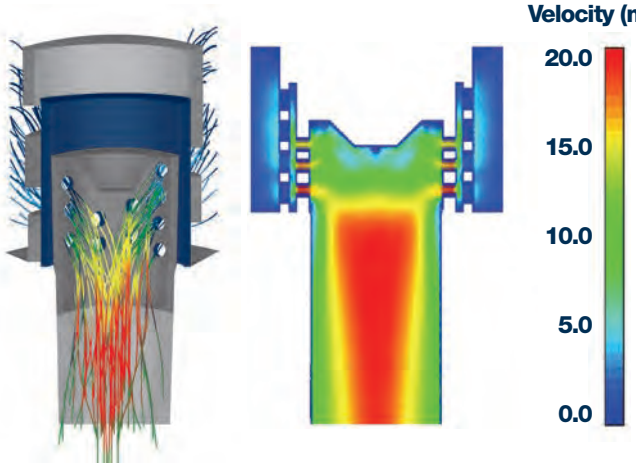
EXAMPLE TECHNICAL SOLUTION

Following vibration surveys of the wellhead and associated flow line piping it was found that broadband excitation was the primary source of the induced fatigue failures, with the dominant vibration source between 100-1500 Hertz. The survey revealed that the primary source of the excitation in the system was the existing competitors choke valve. Vibration measurements of 33 mm/sec were recorded in the downstream pipe.

Koso Kent Introl initially provided a 6” trial carbon steel choke with a 4” multistage high duty trim. The main trim control elements were tungsten carbide. The vibration in the down stream pipe was significantly reduced to 3.5 mm/sec. Due to the success of the trial choke, Koso Kent Introl subsequently received an order for an additional 26 duplex chokes of the same design. The choke valves were provided with special end connections to ensure that they fit into the existing pipe-work.

Specially designed valve for the Australian market

CFD Analysis showing velocity vectors



ENGINEERING TOOLS

Koso Kent Introl is committed to providing fully analysed and tested choke products. Our expert engineering staff continually designs, develops, and tests products to meet the ever-changing needs of the industry while supporting products that are already installed and operating throughout the world.

Our engineering staff utilises modern engineering tools, such as CAD, Finite Element Analysis, 3D Modelling and CFD analysis, to ensure that the products are designed to the highest level of integrity and reliability.

NON-COLLAPSABLE CHOKE VALVE TRIM CONSIDERATIONS

Kent Introl has previously carried out choke valve trim impact testing on numerous projects. The first testing of its' kind was carried out on a subsea choke valve back in May 2001.

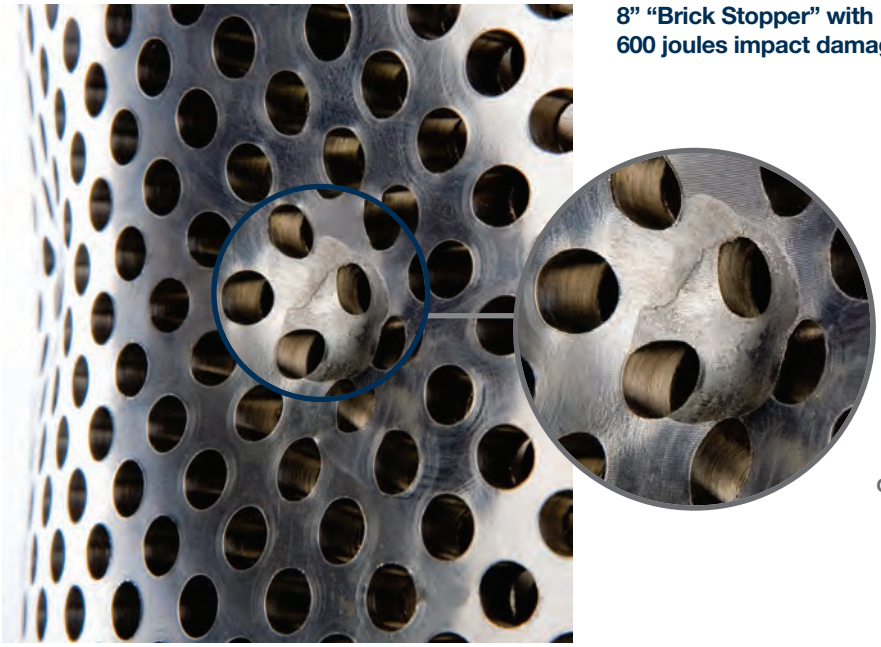
Kent Introl choke valves have a specially designed trim to combat the effects of impact damage which, could if not other wise protected, result in catastrophic failure destroying the tungsten carbide trim. The "Brick Stopper" is designed to undertake a number of tasks: -

- Reduce impact damage to the solid tungsten carbide trim components, therefore protecting over pressurization and or damage to down stream equipment; helping to prevent serious potential safety issues.
- Contain the cartridge assembly in single housing putting the tungsten carbide guide in compression.
- To proportion the flow stream around the main tungsten carbide throttling element/cage.
- Specifically designed to take minimal pressure differential therefore the "Brick Stopper" does not erode under normal operation.

Previous testing has shown that unprotected tungsten carbide components can fail with impact values less than 10 Joules. Kent Introl, as standard, generally supplies all it's Series 73 Production Choke Valves with the "Brick Stopper" feature.

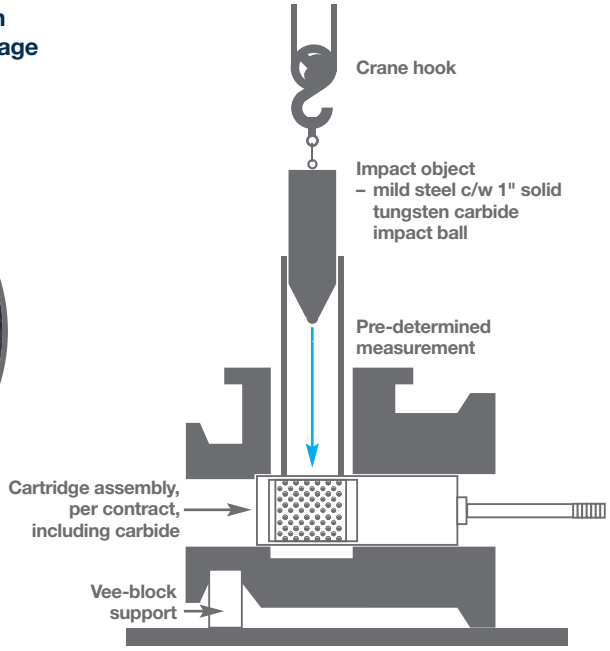
Recent testing has seen more stringent requirements. On a contract for a major Norwegian operator, we have tested three different choke valve trim sizes (6", 8" and 10"). The test required 3 off impacts, on each trim, with impact acceptance criteria of 660 Joules. After the test, the tungsten carbide components were checked visually and had Dye Penetrent Examination. All the testing was witnessed and approved by the customer and the customer's independent representative.

The next stage of the testing was to take the testing up to destruction. Circa 1300 Joules impacts have now been achieved using a 65.5kg impact object dropped from a height of 2.02 metres.



8" "Brick Stopper" with 600 joules impact damage

Typical testing configuration

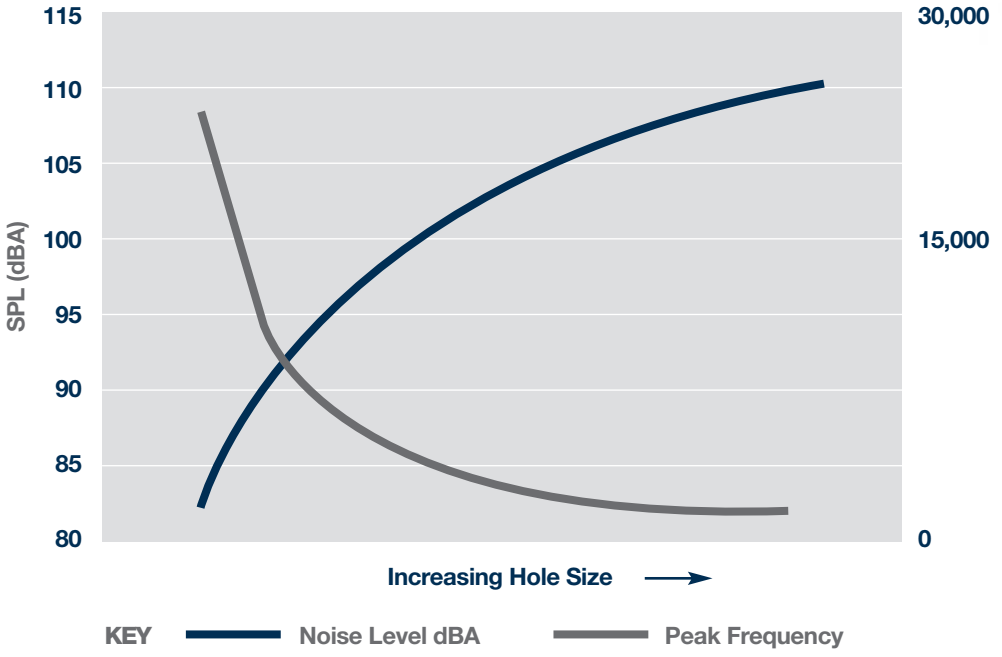


Solid tungsten carbide ball impact object dropped from a height of 2.02 metres

TRIM SELECTION

WHY USE SMALL HOLES?

- Smaller jets increase noise frequency and this will in turn reduce the noise level
- Larger jets create low frequency noise that can create resonance within choke components

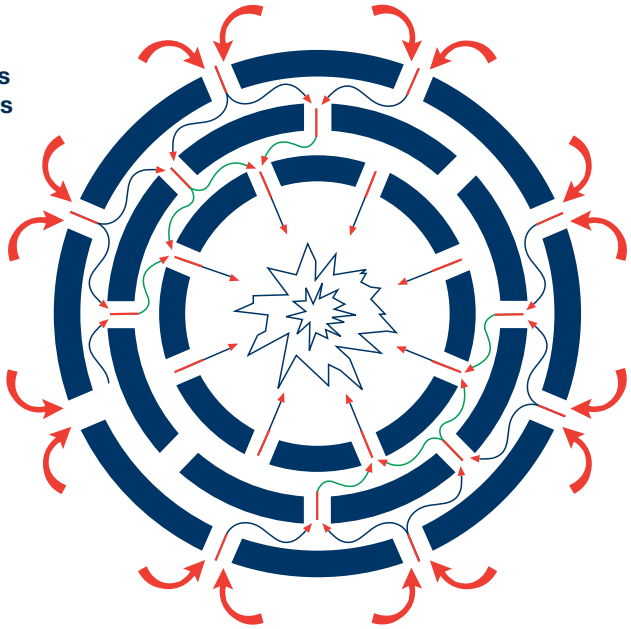


HIGH PERFORMANCE LOW NOISE TRIMS

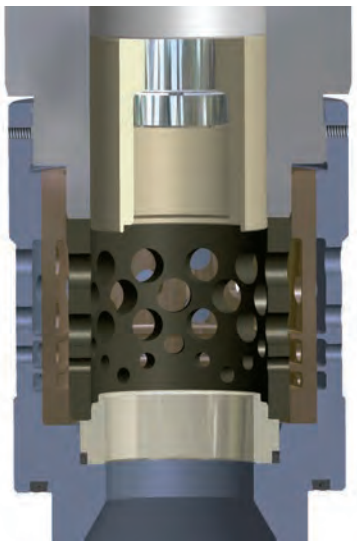
Koso Kent Introl were one of the first valve companies to introduce a noise reducing control valve in 1969. Development has advanced considerably with the aid of new design techniques like Solid Modelling, Finite Element Analysis, and Computational Fluid Dynamics.

The Koso Kent Introl High Friction (HF) design of trims can reduce noise significantly (42dBA and higher are possible) whilst avoiding problems of erosion and cavitation.

Flow path through the HFT trim design. The main impingement takes place within the confines of the trim



HFT trim design



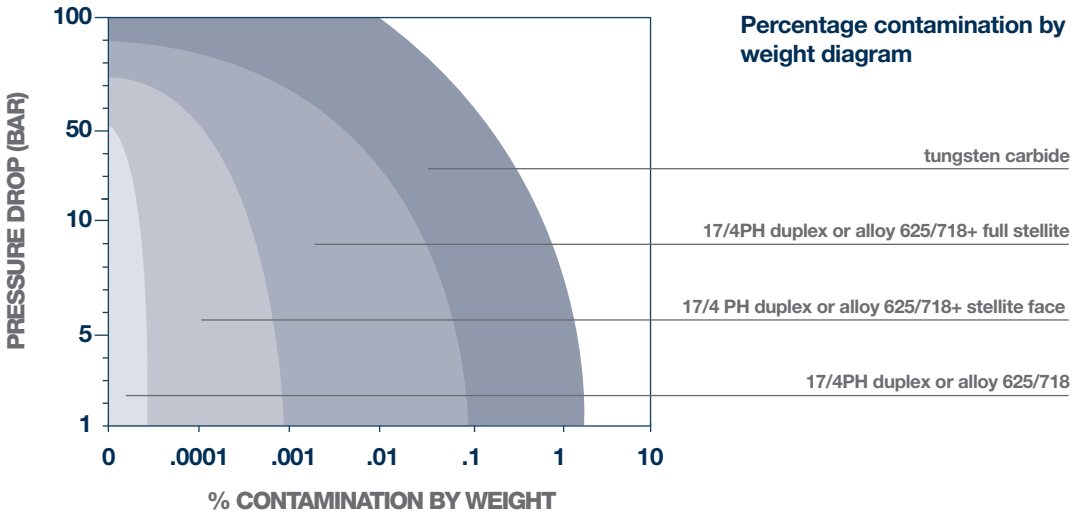
SELECTION OF TRIM MATERIALS ON CONTAMINATED SERVICES

The following graph provides an indication of the materials that Koso Kent Introl would select dependant on the operating pressure drop and the level of solid contamination within the process medium.

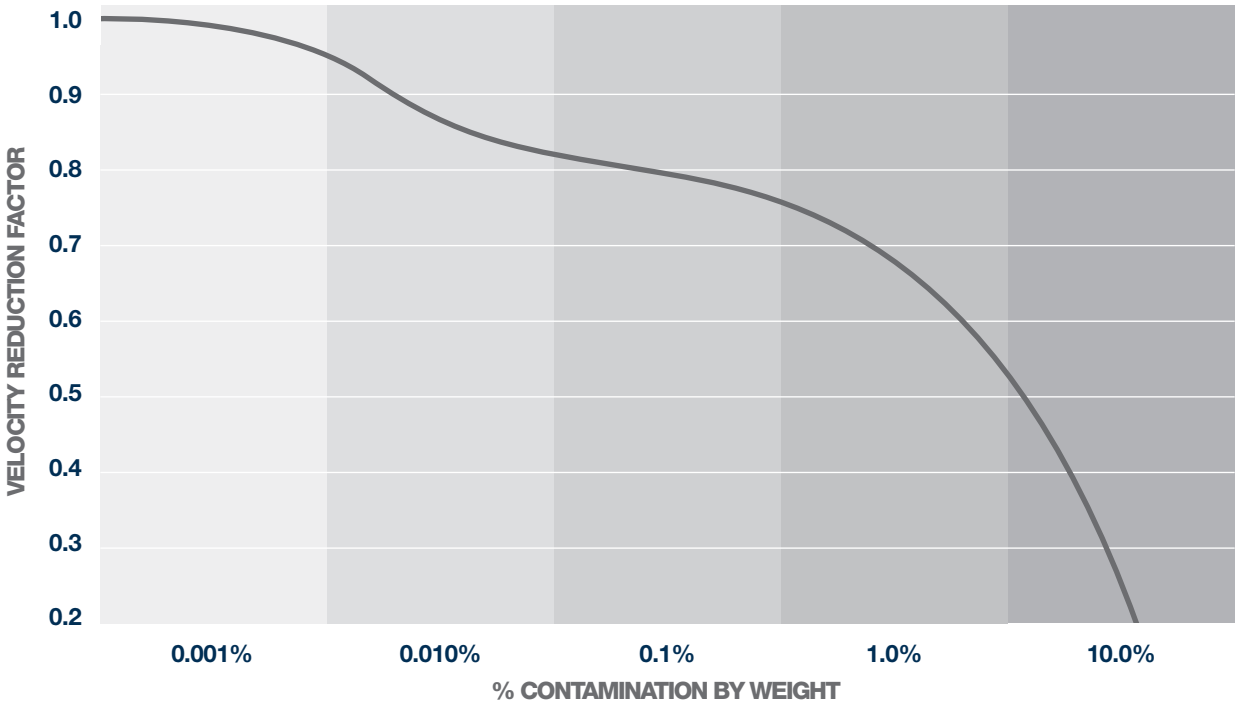
Other factors that will influence the correct material selection are flashing and the level of entrained gas that will come out of solution as the process pressure reduces.

When the choke engineer sizes and selects a choke for a contaminated service application, he will also refer to the following graph. This graph provides an indication of the velocity limit reduction factor versus the percentage contamination.

The recommended limiting velocity for each choke size and material will be multiplied by the appropriate factor below. If the calculated velocity falls outside the revised limiting velocity, then an alternative solution would be offered.



Percentage contamination by weight diagram



Velocity limit reduction factor versus % contamination

APPLICATION SOLUTIONS AND SELECTION GUIDELINES

During the selection of the appropriate trim for each specific application, many issues and potential problems are reviewed by the choke engineer. Energy dissipation, noise, vibration, velocity control, cavitation, erosion and corrosion are all elements that can adversely affect the reliability of the choke in the field. Below are just a few of the items reviewed during the selection of a choke for a particular application.

HIGH PRESSURE PRODUCTION / GAS / CONDENSATE FLUIDS

POTENTIAL ISSUES	SOLUTION
Droplet erosion	Use Premium grade tungsten carbide.
Debris production / erosive service	Use “Brick Stopper” to protect carbide from impact damage. Incorporate stem and seal scrapers. Incorporate sacrificial wear area to protect critical trim components.
Vibration	Use trim with guiding throughout travel, such as plug and cage design. Consider the use of multi-stage trim.
Corrosive medium	Use corrosion resistant material for body, trim and corrosion resistant binder tungsten carbide.
Hydrate formation	Use methanol injection. Use low pressure recovery trim to reduce temperature drop across the choke.
Explosive decompression of elastomeric seals	Use resilient seals that are resistant to explosive decompression.
Low temperature Gas cap at start up	Low temperature material selection. Low temperature actuator capability.

HF-LCV Trim for Erosive Applications

WATER INJECTION APPLICATIONS

POTENTIAL ISSUES	SOLUTION
Cavitation	Use Low-Pressure Recovery trim design. Use multi-stage trim with small holes.
Possible reverse flow / bi-directional capability	Consider the use of stellite trim material to protect from debris impact in reverse flow mode. Check velocity in choke body annulus. Incorporate reverse flow sealing system.
Vibration	Use trim with guiding throughout travel such as plug and cage design. Consider use of multi-stage trim. Verify natural frequency of trim compared to fluid flowing frequency.
Potentially corrosive	Use corrosion resistant material for body and trim.

HFT-LCV Trim for Anti Cavitation Applications

METHANOL/MEG INJECTION

POTENTIAL ISSUES	SOLUTION
Cavitation	Use low pressure recovery trim design, or multi-stage micro-spline trim.
Blockage by debris	Self cleaning trim required.
Very low flow control required	Micro-spline trim required.
High pressure drops	Use trim with guiding through out travel such as plug and cage design. Consider the use of multi-stage trim.

GAS LIFT

POTENTIAL ISSUES	SOLUTION
Very low flow control required	Small cage or micro-spline trim required.
Erosive/non erosive	If dry gas then consider non erosive and stellite trim can be used. If wet gas then consider erosive and use tungsten carbide trim control elements.
Potentially Corrosive	Use corrosion resistant material for body and trim.

Microspline Trim for Low Flow Applications

INFORMATION TO SIZE AND SELECT A CHOKE VALVE

APPLICATION: PRODUCTION CHOKE VALVES

PROCESS FLUID

CONTAMINATES

		*UNITS	MAXIMUM	NORMAL	MINIMUM	†START UP
FLOW RATE	*Liquid *Oil					
	*Water					
	Gas/Vapour					
PRESSURE	*Inlet					
	*Outlet					
	Delta P					
TEMPERATURE	Inlet					
OIL	*Specific Gravity					
	Vapour Pressure					
	Critical Pressure					
	Viscosity					
LIQUID	*Specific Gravity					
	Vapour Pressure					
	Critical Pressure					
	Viscosity					
GAS/VAPOUR	*Molecular Weight					
	Compressibility (z)					
	Specific Heat Ratio (σ)					

APPLICATION: WATER INJECTION/LIQUID SERVICE CHOKE VALVES

PROCESS FLUID

CONTAMINATES

		*UNITS	MAXIMUM	NORMAL	MINIMUM	†START UP
FLOW RATE	*Liquid					
PRESSURE	*Inlet					
	*Outlet					
	Delta P					
TEMPERATURE	Inlet					
LIQUID	*Specific Gravity					
	Vapour Pressure					
	Critical Pressure					
	Viscosity					

APPLICATION: GAS LIFT CHOKE VALVES

PROCESS FLUID

CONTAMINATES

		*UNITS	MAXIMUM	NORMAL	MINIMUM	†START UP
FLOW RATE	*Gas/Vapour					
PRESSURE	*Inlet					
	*Outlet					
	Delta P					
TEMPERATURE	Inlet					
LIQUID	*Molecular Weight					
	Compressibility (z)					
	Specific Heat Ratio (σ)					

VALVE SPECIFICATION DETAILS

*End Connection size and style
*Temperature Ratings (min / max)
*Choke Pressure Rating
Material or API Class Rating
Quality or API PSL Requirement
Line Size and Schedule

*** Mandatory Requirements**

† Please specify the frequency of the start up conditions

Pressure and Temperature Units to be specified by the customer

Full information allows detailed application review and correct trim/choke selection

PREVIOUS SERIES 73 EXPERIENCE

Choke with SMART Positioner

14",12" & 10" ANSI 2500 Duplex valves for an FPSO

Choke c/w electro-hydraulic actuator and sunshade

API 10K PSL4 chokes for sour gas re-injection

12" ANSI 1500 choke C/W electro-hydraulic actuator

ANSI 600/900 rated chokes for Nigeria

10"x 8"x 10" ANSI 1500 gas chokes for Qatar

Various chokes with electric and manual operators for the Southern North Sea

CUSTOMER	DATE SUPPLIED	QTY	CM SIZE	FLANGE SIZE	FLANGE RATING	PRESSURE IN BAR	PRESSURE OUT BAR	DESIGN PRESS. BAR	DESIGN TEMP °C	DUTY	LINE FLUID	DESTINATION
Shell	1976	11	6”	6”	ANSI 2500	245	Various	402	93	Water	Liquid	North Sea
Shell	1976	17	6”	4 1/16”	API 10000	415	215	670	90	Production	Hydrocarbon Gas	North Sea
A.D.N.O.C	1982	21	6”	6”	API 5000	219	103	345	99	Production	Hydrocarbon Gas	Abu Dhabi
Kent Process Control Inc.	1985	10	2”	2”	ANSI 2500	311	25	311	165	Injection	Hydrocarbon Gas	Alaska
McDermott Engineering Ltd.	1987	44	4”	4”	ANSI 1500	192	8	242	47	Production	Hydrocarbon Gas	North Sea
BP Pet. Development	1988	25	4”	4 1/16”	API 3000	207	70	207	70	Production	Multi-phase	UK
Qatar General Petroleum Corp	1988	9	4”	4”	ANSI 900	121	23	128	93	Water Injection	Liquid	Qatar
Artificial Lift Consortium	1989	23 19	8” 6”	8” 6”	ANSI 1500	36	8	232	93	Production	Multi-phase	North Sea
Earl & Wright	1992	12	8”	10” x 8”	ANSI 900	89.2	43.7	120	20	HC Liquid	Multi-phase	UK
Marathon Oil UK Ltd	1992/ 94/95	6	4”	4”	API 10000	593	103	690	200	Gas and Condensate	Multi-phase	North Sea
McDermott Engineering Ltd.	1994	33	6”	6”	ANSI 1500	179	90	243	-29/90	HC Gas	Hydrocarbon Gas	North Sea
Arco China Inc.	1994	27	Up to2”	Up to2”	ANSI 1500	Various	Various	Various	Various	Various	Multi-phase	China
Bechtel	1995	119	Up to4”	Various	Up to API 10000	Various	Various	Various	Various	Various	Various	Abu Dhabi
Brown and Root Ltd.	1995	1	10”	10”	ANSI 2500	81	41	311	-20/+85	HC Gas/Liquid	Gas/Liquid	North Sea
ABB Offshore Technology	1995	34	8”	8”	ANSI 900	139	96	142	75	Natural Gas	Multi-phase	Norway
Shell	1995	16	3”	3”	ANSI 900	40.3	6	120	80	Production	Multi-phase	Gabon
ABB Offshore Technology	1996	18	6”	8”	API 5000	70	29	130	130	Production	Multi-phase	Norway
ABB Control Valves Inc.	1995	10	4”	4 1/16”	API 10000	615.5	Various	689	118	Gas Lift	Hydrocarbon Gas	Venezuela
Kvaerner H&G Offshore	1996	21	6”	8”	API 10000	515.5	190	550	150	Hydrocarbon Vapour	Hydrocarbon Gas	North Sea
Kvaerner H&G Offshore	1996	6	4”	4 1/16”	API 15000	Various	Various	800	175	Hydrocarbon Vapour	Gas Condensate/ Water/Sand	North Sea
ABB Kent Taylor PTE Ltd.	1996	26	6”	7 1/16” x 6”	ANSI 1500	170	117	344	90	Production	Gas Liquid	Australia
ABB Offshore Technology	1997	19	6”	6”	ANSI 1500	100	Various	222	54	Water Injection	Water	Norway
Brown and Root Ltd.	1997	5	4”	6”	ANSI 2500	218.2	81.74	280	90	Production	Hydrocarbons	Bangladesh
ABB Industrial Systems	1998	12	4”	6”	ANSI 2500	31	28	345	100	Production	Hydrocarbons	Denmark
NPCC	2000/01	27	4”	8”	ANSI 2500	258.6	89.8	299	100	Production	Multi-phase	Iran
Stolt Offshore SA	2001	36	2”	4”	ANSI 600	85	21	114	60	Production	Oil/Water	Nigeria
Score (Europe) Ltd.	2001	6	4”	6”	API 10000	414	Various	448	100	Gas Production	Hydrocarbon Gas	North Sea
Sakhalin Energy Investment Co	2003	7	8”	9” x 14”	API 5000	Various	Various	200	121	Production	Wellstream	Russia
Sakhalin Energy Investment Co	2004	5 6	6” 4”	5 1/8” x 8” 8” x 5 1/8”	ANSI 1500	83.7 149	12.5 Various	258 234	75 90	Production Water Injection	Wellstream Water	Russia
PFD (UK) Ltd	2003/05	16	3”	3 1/16”	API 10000	Various	Various	690	120	Multi-phase	Multi-phase	Kazakhstan
ABU ADEL Engineering Services	2003	8	8”	10” x 10”	ANSI 1500	Various	Various	240	100	Production	Production Fluids	Qatar
Vetco Aibel	2005	1 2	8” 10”	10” x 10” 12” x 12”	ANSI 1500	160	Various	180	90	Production	Multi-phase	Norway
Single Buoy Moorings Inc.	2005	2 7 1	2” 8” 10”	2” 8” 10”	ANSI 1500	200	Various	230	100	Production	Multi-phase	Brazil
Origin Energy Resources Ltd.	2006	3	4”	7 1/16”	API 5000	257	70	309	110/-46	Production Fluid	Well Fluids	New Zealand
Single Buoy Moorings Inc.	2007	1 1 2	14” 12” 10”	12” 12” 8”	ANSI 2500	25	24.5	345	123/-10	Well Fluids	Multi-phase	Angola
Woodside Energy Ltd.	2006	3	10”	11” x 10	API 5000	92.5	90.5	345	121/-20	Hydrocarbon Gas	Gas	Australia
BP	2007	2	6”	6”	API 11000	624	153	759	100/-50	Well Fluids	Multi-phase	Azerbaijan
BP	2007	2	6”	7 1/16”	API 15000	640	153	759	100/-50	Well Fluids	Multi-phase	Azerbaijan

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