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Intelligent Completions



Introduction

Halliburton is the world's leading provider of intelligent completion technology to the upstream oil industry. Introduced in 1997, SmartWell® system technology was the industry's first intelligent well completion system and was designed specifically to remotely control and monitor specific reservoir zones.

Today, Halliburton offers a broad range of intelligent completion technologies from reservoir engineering studies to advanced completion design, zonal isolation and flow control, reservoir monitoring, and surface digital infrastructure solutions.

SmartWell systems provide an advanced reservoir management approach to optimizing well production through remote monitoring of wellbore parameters in real time. This technology also enables remote control of the reservoir without the need for mechanical intervention. In conjunction with reservoir models and prudent reservoir management processes, a SmartWell completion helps operators accelerate production and increase ultimate recovery to maximize return on investment (ROI).

SmartWell® Systems

A SmartWell® completion system optimizes production by collecting, transmitting, and analyzing completion, production, and reservoir data; allowing remote selective zonal control and ultimately maximizing reservoir efficiency by:

- » Helping increase production: Commingling of production from different reservoir zones increases and accelerates production and shortens field life.
- » Helping increase ultimate recovery: Selective zonal control enables effective management of water injection, gas and water breakthrough, and individual zone productivity.
- » Helping reduce capital expenditure: The ability to produce from multiple reservoirs through a single wellbore reduces the number of wells required for field development, thereby lowering drilling and completion costs. Size and complexity of surface handling facilities are reduced by managing water through remote zonal control.
- » Helping reduce operating expenditure: Remote configuration of wells optimizes production without costly well intervention. Additionally, commingling of production from different reservoir zones shortens field life, thereby reducing operating expenditures.

SmartWell systems are designed to meet the demands of intelligent completions, worldwide, and in the most challenging environments.

A SmartWell system completion consists of some combination of zonal isolation devices, interval control devices, downhole control systems, permanent monitoring systems, surface control and monitoring systems, distributed temperature sensing systems, data acquisition and management software, and system accessories.

Reliability

Reliability is essential for intelligent completion systems, and Halliburton engineers reliability into all of its equipment. The company is ISO 9001 application certified and has developed processes to guide, monitor, and optimize system delivery and performance.

Halliburton maintains a detailed database to track the field performance of each SmartWell system installation. The knowledge gleaned from this data is used to calibrate design predictions and optimize the design and production process.

Flow Control Valves

Halliburton offers interval control valves (ICVs) with and without shrouds and deflectors:

- » HS-ICV: ICV for high-pressure/high-temperature (HP/HT) applications
- » MCC-ICV: Cost-effective valve with choking capability

HS-ICV Valve

The Halliburton HS-ICV is debris-tolerant and designed for high-pressure, deepwater environments characterized as severe operating conditions. Building on the Halliburton record as the leading provider of intelligent completion technology, the HS-ICV enables deployment of SmartWell systems in more extreme environments.

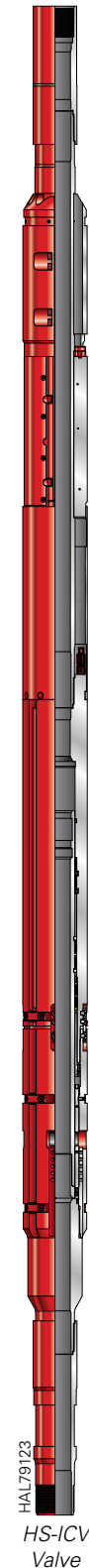
The HS-ICV's eight-position customizable gas or liquid flow trims can be characterized to provide optimum production or injection at various positions. Optional onboard sensors track the movement of the flow trim. These position sensors provide the operator with real-time feedback to confirm valve movements on surface.

Features

- » Proprietary, debris-tolerant, metal-to-metal seal
- » Customizable gas or liquid flow trim
- » Can be used in simple on/off intervention avoidance applications or in more versatile advanced reservoir management choking applications with a control module

Benefits

- » Can be run in conjunction with the eMotion® unit to suit remote open close applications
- » Remotely control flow into or out of the reservoir in challenging environments, such as deepwater and HP/HT
- » Eliminate the potential for wellbore debris to be trapped inside the tool and consequently prevent valve movement or affect sealing integrity
- » Obtain real-time confirmation of remotely actuated valve movements using optional position sensors
- » Unload at a maximum differential pressure of 5,000 psi without the threat of any valve damage — the highest unloading capacity in the industry



Operation

Hydraulically actuated, the HS-ICV is operated remotely from surface using the Halliburton Direct Hydraulics, Digital Hydraulics™, or the SmartPlex® downhole control system. The premium thermoplastic hydraulic chamber seals are designed to operate under high actuation pressures and temperatures. The valve has also been subjected to a stringent qualification program, including temperature, pressure, debris, and erosion tests.

The HS-ICV body has slots to accommodate two 1/4-in. dedicated instrument wires for position sensors and allows bypass of up to six 1/4-in. bare hydraulic control lines or instrument wires — all without compromising the valve body rating or working envelope.

Debris-Tolerant Design

The HS-ICV is designed and tested such that the flow trim helps ensure complete metal-to-metal (MTM) seal integrity, even when exposed to heavy wellbore debris. A one-moving-piece valve mandrel design eliminates the potential for wellbore debris to be trapped inside the tool and consequently prevent valve movement.

Proprietary MTM Seal

The HS-ICV houses a proprietary MTM interference fit seal that enables the valve to unload at a maximum differential pressure of 5,000 psi without the threat of any valve damage. Any additional tubing or annulus pressure acts on the MTM seal to help further ensure seal integrity, which has been rigorously tested and qualified at low- and high-pressure differentials.

Pressure-Balanced Valve Mandrel

A pressure-balanced valve mandrel design eliminates the need for a latch mechanism to hold trim closed or the need to maintain hydraulic pressure on the close chamber to keep the flow trim shut. This balanced sleeve design also prevents drifting of the sleeve in the incrementally open position.

Mandrel design also includes a shifting profile that allows for mechanical shifting of the sleeve in the event hydraulic control is compromised or if sleeve momentum is not achievable due to scale buildup inside the ICV.

Available in Three Variants

- » HSP premium choking ICV designed for more advanced reservoir management when used in conjunction with a downhole control system
- » HSB base choking ICV designed for more versatile choking applications when used in conjunction with a control module for incremental positioning
- » HSO ICV designed for simple on/off applications

The flow trims on the HSB and HSP ICV can be customized to suit a particular well injection or production philosophy. Tungsten carbide is the material of choice for these flow trims to combat the threat of erosion caused by high flow rates.

Shrouded Versions

A shrouded HS-ICV configuration is available primarily for a two-zone stacked gravel pack application. The shrouds can also be shrink-fitted with a carbide insert when the valve is used in a stacked gravel pack injection application. Shrouds can also be fitted with screens for gas lift applications, depending on the OD/ID and pressure limitations.

Deflector Version

This HS-ICV configuration is available primarily for high-rate gas or water injection applications. The deflectors are lined with tungsten carbide inserts to prevent erosional effects caused by impingement from high flow velocity exiting the valve flow trim.

HS Interval Control Valves

Size	Maximum Working Pressure Available	Maximum Hydraulic Chamber Rating	Maximum Temperature Rating Available	Maximum OD Available	Minimum ID Available	Minimum Internal Flow Area	Piston Area	Total Stroke	Hydraulic Chamber Displacement	Version Available	Maximum Differential Unloading Pressure	Shroud Size/Weight		Shroud OD Available	Flow Area, Shroud ID, ICV OD	Deflector Available	Deflector OD Available	Flow Area, HS OD, Deflector ID
in.	psi	psi	°F	in.	in.	in. ²	in. ²	in.	in. ³		psi	in.	lb	in.	in. ²		in.	in. ²
2 7/8	7,500	10,000	275	4.660	2.313	4.20	1.716	6.00	10.29	Choke	5,000	5 1/2	20	5.800	5.030	Yes	5.995	2.58
3 1/2	7,500 10,000	10,000	40 to 275 and 70 to 330	5.850 or 5.660	2.750	5.62	1.990	6.00	11.94	Choke	5,000	7	29	7.070	7.980	Yes	7.685	6.38
			40 to 235					3.28	6.53	On/Off								
	15,000	15,000	40 to 235															
4 1/2	10,000	10,000	40 to 275	7.125	3.750	11.04	2.780	6.00	16.68	Choke	5,000	7 5/8	39	8.535	9.300	Yes	8.315	5.32
								3.28	9.11	On/Off								
5 1/2	7,500	10,000	40 to 275	8.279	4.562	16.38	4.240	6.00	25.44	Choke	5,000	No	No	N/A	N/A	Yes	9.330	12.49
								3.28	13.90	On/Off								

Notes:

HS-series valves are available in various metallurgy to suit well conditions.

HS-series valves provide incremental positioning only in conjunction with a control module.

HS-series choke trims can be customized to suit operator needs.

Some versions of the HS-series 2 7/8-in. size choking valve are eccentric in design.

Please consult the ICV data sheet for exact specifications.

Please contact Halliburton for more details.

MC-Series Interval Control Valves

Halliburton MC interval control valves (MC-ICVs) are multi-position valves that provide incremental flow control over individual reservoir zones, allowing optimization of reservoir architecture downhole and maximizing recovery.

MC-ICVs offer a cost-effective solution that allows operators to employ the benefits of SmartWell® technology while working with moderate or marginal assets. MC-ICVs are available in a range of sizes and thread configurations and can be coupled with either an automatic or manual control system to accommodate specific operational requirements.

Features

- » Simple cost-effective design
- » Bonded/nitrile/HNBR/Viton™ seals
- » Multi-position functionality with tungsten carbide flow trim
- » Manual override

Benefits

- » Cost-effectively control reservoir intervals remotely without well intervention
- » Apply SmartWell technology capabilities in moderate or marginal assets

Operation

Halliburton surface control systems provide accurate incremental control over the MC-ICV choke trim. These systems can be tailored to fit the operator's specific needs.

The MC-ICV is fitted with a tungsten carbide flow trim to control erosion from aggressive downhole conditions. It is available in a range of sizes and can be coupled with either an automatic or manual control system to accommodate specific operational requirements.

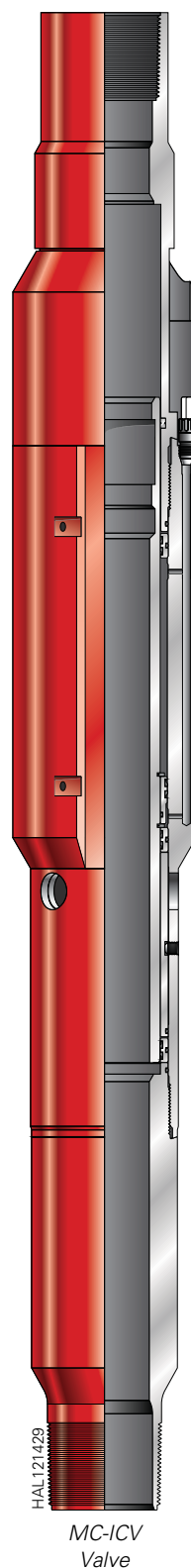
MC0-ICV

The MC0-ICV is an open/close ICV capable of isolating individual reservoir zones. The main valve element is based on robust bonded nitrile seals, designed for longevity and resistance to corrosion.

MC-ICV

The MC-ICV is a multi-position ICV that provides incremental flow control over individual reservoir zones, thereby allowing optimization of reservoir architecture downhole and maximizing recovery. Accurate incremental control over the MC-ICV choke trim is achieved with Halliburton surface control systems, which can be tailored to fit specific needs. The MC-ICV is fitted with a tungsten carbide flow trim to control erosion from aggressive downhole conditions.

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MC-Series Interval Control Valves

Size	On/Off Version	Choking Version	Maximum OD Available	Minimum OD Available	Minimum Internal Flow Area	Hydraulic Chamber Displacement	Piston Area	Total Stroke	Maximum Working Pressure Available	Maximum Temperature Rating Available		Maximum Hydraulic Chamber Rating	Maximum Differential Unloading Pressure	Shroud
in.			in.	in.	in. ²	in. ³	in. ²	in.	psi	°F	°C	psi	psi	
2 7/8	Available	Available	4.660	2.250	3.98	11.22	1.870	6.00	5,000	275	135	5,000	1,000	Available
3 1/2	Available	Available	5.66	2.750	6.023	15.232	2.56	6.00	5,000	275	135	5,000	1,000	Available

Note: Special ID valves are made to order.

HS Circulating Valve

The HS circulating valve is designed for use in SmartWell® and conventional completion systems. Based on the proven HS interval control valve (ICV) design technology, the HS circulating valve is designed for safe and efficient circulation of completion fluids after landing the completion and setting the HF-1 and completion packer.

The HS circulating valve is a bi-directional hydraulically operated balanced piston valve with a gas-tight redundant sealing mechanism. The sealing mechanism consists of a debris-tolerant metal-to-metal (MTM) primary seal and a secondary thermoplastic seal array. The valve mandrel incorporates a carbide nose to prevent erosion of the sealing surface areas.

Features

- » Proprietary, debris-tolerant MTM seal
- » Redundant thermoplastic seal helps ensure gas-tight seal integrity
- » Erosion-resistant carbide nose seal
- » High circulation rates
- » Remotely activated without intervention
- » Manual override shift profile
- » Bypass slots for 12 1/4-in. control lines

Benefits

- » Can be run in conjunction with an eMotion® unit to suit remote open close applications
- » Run above the production packer, operated after packer is set, providing improved well control
- » Helps eliminate need to circulate across packer element, reducing risk of damage to the element
- » Prevents circulation pressures from impacting reservoir
- » Faster circulation rates, reducing rig time
- » Allows for circulating well kill fluid during workover operations without the need for perforating tubing

Operation

The HS circulating valve is placed above the production packer in the completion string and is run into the well. During a SmartWell completion, once on depth, the HF-1

production packer is set via pressure down the production tubing. Element packoff integrity is then determined by applying pressure down the annulus. The open line of the valve is pressured up via the surface control unit to open the sleeve. Circulation down the annulus or tubing begins. Higher circulation rates can be attained because fluid is not circulated past the packer element. Once the desired volumes are circulated, the close line of the valve is pressured up to move the sleeve into the closed position. The tubing is then pressured up to a maximum 7,500 psi to test the sleeve integrity. A zero leak rate should be observed. Upon completion of a successful pressure test, the completion program can progress to the next step.

Field-Proven MTM Seal

The HS circulating valve houses a proprietary MTM seal from the proven HS-ICV design. Any additional tubing or annulus pressure acts on the seal to help further ensure its integrity. The seal has been rigorously tested and qualified at low- and high-pressure (up to 10,000 psi) differentials.

Redundant Thermoplastic Seal

The MTM seal is backed up by a redundant thermoplastic seal to achieve gas-tight sealing integrity. These field-proven thermoplastic metal energized (MSE) seals are designed for redundancy during low- and high-pressure applications. The MTM, along with the redundant thermoplastic seal, are qualified to provide gas-tight (zero leak) seal integrity.

Pressure-Balanced Valve Mandrel

A pressure-balanced valve mandrel design eliminates the need for a latch mechanism to hold the trim closed or the need to maintain hydraulic pressure on the close chamber to keep the flow trim shut. This balanced sleeve design prevents drifting of the sleeve in the open position. The valve mandrel design also includes a shifting profile that allows the sleeve to be mechanically shifted in the event hydraulic control is compromised, or if sleeve movement is not achievable because of scale buildup inside the ICV.

HS Circulating Valve

Tubing Size	Valve OD	Valve ID	Minimum Internal Flow Area	Hydraulic Chamber Displacement	Piston Area	Piston Stroke	Maximum Working Pressure	Maximum Actuation Pressure	Temperature Range	Maximum Unloading Differential
in.	in.	in.	in. ²	in. ³	in. ³	in.	psi	psi	°F	psi
5.5	8.279	4.562	16.346	23.438	4.246	5.52	7,500	10,000	40 to 330	5,000

Zonal Isolation Packers

HF-1 Packer

The HF-1 packer is a single-string, retrievable, cased-hole packer that features a facility for bypass of multiple electrical and/or hydraulic control lines. Available for use as both the top production packer or as one of many lower packers that isolate adjacent zones, the HF-1 packer includes a specialized slip configuration and additional body lock ring. This allows operation under higher loads and greater pressures than standard production packers.

Features

- » Hydraulically activated interlock mechanism prevents premature setting
- » No body movement during setting
- » Premium thread connections
- » NBR and HNBR element with anti-extrusion system
- » Tailpipe can be left in tension or compression

Benefits

- » Less damage to casing using a multi-cone, full-coverage slip system
- » Fully retrievable after installation
- » Can be deployed with SmartWell® systems
- » Can be used as both top production packer and lower isolation packer
- » Avoid damage to control line during setting

Setting Mechanisms

The HF-1 packer has two setting and three release mechanisms.

- » Setting mechanisms
 - Tubing-pressure set
 - Control-line set
- » Release mechanisms
 - Punch and pressure release
 - Shift and pressure release
 - Mechanical shift release

The release mechanism is recessed and selective, allowing for passage of other toolstrings. Axial loads are supported in both directions so tool cannot be released by tubing forces.

Connections

The packer is made up directly to the tubing string via integral premium thread connections. The internal mandrel also uses premium thread connections for continuity.

- » Anti-preset mechanisms: Incorporate a hydraulically activated interlock system and can be adjusted before run in hole. This system allows packer to be run in highly deviated or horizontal wells, thus eliminating presetting risks caused by casing drag.
- » Tandem setting: Designed for tandem setting with tailpipe in tension, compression, or neutral. Setting mechanism is independent of tubing movement or pressure-induced tubing forces. Setting action will not impart loads on or damage any penetrations or lines.

Penetrations

Provision is made for the passage of multiple hydraulic and/or electrical control lines. All connections are sealed using Halliburton proprietary FMJ connectors.

Elastomeric Seals

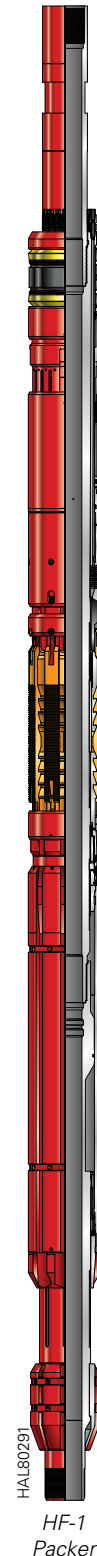
Material for setting chamber seals and tubing to the lower annulus is selected based on application conditions.

Integral Element Anti-Extrusion System

The packing element is multi-piece with NBR sealing elements. It incorporates an anti-extrusion system that provides high resistance to swab off, which permits increased running speeds and high annular circulation rates (up to 8 bbl/min) before setting. The system was qualified through multiple thermal cycles using both water and nitrogen as test media.

Load and Functional Performance

All HF-series packers are API 11D1 V0 or V3 rated.



Retrievable Feed-Through HF Packers

Type	Casing		Mandrel Size	Maximum OD	Bore ID	Maximum Feed-Through	Maximum Differential Across Element	Working Pressure	Working Temperature	Required Setting Pressure	Element Type	ISO 14310 Rating				
	OD	Weight														
	in.	lb/ft	in.	in.	in.		psi	psi	°F	psi						
HF1 Series (722HF1) Production/Isolation	7	23	2 7/8	6.180	2.315	4	5,000	5,000	75 to 275	4,500 for tubing set; 6,500 for control line set	Nitrile	V3				
			3 1/2		2.750	5	7,500	7,500			Nitrile	V3				
		26	3 1/2	6.090	2.750	5	7,500	7,500			Nitrile	V3				
		29	2 7/8	5.995	2.315	5	7,500	7,500	75 to 275		Nitrile	V3				
			3 1/2		2.750						Nitrile	V0				
		32	3 1/2	5.905	2.750	5	7,500	7,500	75 to 275		Nitrile	V3				
			7 5/8	33.7	3 1/2	6.570	2.750	5	7,500		7,500	75 to 275	4,500 for tubing set; 6,500 for control line set	Nitrile	V3	
		39		6.430		10,000			10,000		Nitrile	V0				
	45.3	6.240		7,500		7,500			140 to 260	Nitrile	V0					
	47	6.180		10,000		10,000			75 to 275	Nitrile	V0					
	8 5/8	61.4	3 1/2	6.980	2.750	6	10,000	10,000	75 to 275	4,500 for tubing set; 6,500 for control line set	Nitrile	V0				
	9 5/8	43.5	3 1/2	8.440	2.750	6	7,500	7,500	75 to 275	4,500 for tubing set; 6,500 for control line set	Nitrile	V3				
			5 1/2	8.515	4.562	5	7,500	7,500	75 to 275		Nitrile	V3				
		47	3 1/2	8.440	2.750	6	7,500	7,500	75 to 275		Nitrile	V3				
			4 1/2		3.525	5	7,500	7,500	75 to 275		Nitrile	V0				
					3.788		10,000	10,000	75 to 275		Nitrile	V0				
					3.813	6	7,500	7,500	75 to 275		Nitrile	V0				
							7,500	7,500	75 to 275		Nitrile	V3				
			10,000		10,000	75 to 275	Nitrile	V3								
				5 1/2	4.560	5	7,500	7,500	75 to 275		Nitrile	V0				
			53.5	3 1/2	8.300	2.750	6	7,500	7,500		75 to 275	Nitrile	V3			
				4 1/2		3.525	5	7,500	7,500		75 to 275	Nitrile	V0			
						3.783	7	10,000	10,000		40 to 200	Nitrile	V3			
		3.788				5	7,500	7,500	75 to 275		Nitrile	V3				
						6	7,500	7,500	40 to 275		Nitrile	V0				
		3.813				5	7,500	7,500	75 to 275		Nitrile	V3				
						7	7,500	7,500	40 to 275		Nitrile	V0				
		5 1/2				4.560	7	7,500	7,500		75 to 275	Nitrile	V0			
							5	10,000	10,000		40 to 275	Nitrile	V0			
							7	7,500	7,500		40 to 275	Nitrile	V0			
							5	10,000	10,000		40 to 275	Nitrile	V3			
		71.8		4 1/2		7.890	3.525	5	7,500		7,500	75 to 275	Nitrile	V0		
		9 7/8		62.8		4 1/2	8.440	3.788	5		10,000	10,000	80 to 275	5,000	Nitrile	V3
							3.813	12,500			12,500	55 to 235	5,500	Nitrile	V3	
		10 3/4		60.7	3 1/2	9.430	2.949	5	7,500		7,500	45 to 275	4,100	Nitrile	V0	
					5 1/2	9.430	4.562	6	7,500		7,500	45 to 275		Nitrile	V0	
			65.7	5 1/2	9.330	4.562			6		7,500	7,500		80 to 275	Nitrile	V0
					73.2		9.175	5			8,000	8,000		140 to 260	5,000	Nitrile
		11 7/8	71.8	4 1/2	10.550	3.688	5	5,000	5,000		80 to 275	4,400	Nitrile	V3		

Retrievable Feed-Through HF Packers

Type	Casing		Mandrel Size	Maximum OD	Bore ID	Maximum Feed-Through	Maximum Differential Across Element	Working Pressure	Working Temperature	Required Setting Pressure	Element Type	ISO 14310 Rating
	OD	Weight										
	in.	lb/ft	in.	in.	in.		psi	psi	°F	psi		
HFP Series (722HFP) Production/Isolation	9 7/8	62.8	3 1/2	8.440	2.755	5	10,000	10,000	100 to 240	6,000	AFLAS®	V3
			4 1/2		3.788							
		65.1	4 1/2		3.562	6	15,000	15,000	68 to 300	5,800	HNBR	V0

Notes:

a) Available in two setting options: tubing set or control line set.

b) Available in three releasing options: straight shift-and-pull method, knock-out plug-and-pump method, punch-and-pump method.

c) Available in various metallurgy, elastomers, and thread connections to suit well conditions.

d) Refer to individual specification sheets for additional details.

Contact Halliburton for additional information.

AFLAS® is a registered trademark of the Asahi Glass Co., Ltd.

MC Packers

MC packers, available for both production (MC-1) and isolation (MC-0) applications (no slips), are single-string, cased-hole, retrievable packers primarily designed for use in SmartWell® completions in marginal or mature assets.

Both MC production and isolation packers have the facility to feed through up to eight hydraulic or electrical control lines. This allows for communication with other SmartWell equipment without compromising the integrity of the isolated zones. In some cases, the MC production packer can be used as an isolation packer below the primary HF-1 production packer.

Features

- » Simple, cost-effective design
- » Feed through for up to eight control lines
- » Tubing set
- » Nitrile, HNBR, and Viton™ packing element

Benefits

- » Apply SmartWell technology in marginal or mature assets
- » Maintain zonal integrity
- » Perform high-pressure/tubing-pressure testing
- » Achieve communication with laser tools

Setting Mechanism

Both MC production and isolation packers are tubing-pressure set. Incorporating a hydraulically activated interlock system, the MC packers can be adjusted externally before running in the hole. The interlock system allows the packers to be run in highly deviated wells, helping eliminate the risk of presetting caused by casing.

Retrieval Mechanism

The MC-1 production packer is released by the “shift-and-pull” method. Once the primary packer is released, the MC-0 isolation packer can be retrieved simply by overpull; there is no release feature.

Packing Element

The MC packer is fitted with state-of-the-art nitrile, HNBR, or Viton packing elements similar to those used in the high-performance HF-1 packer. These elements offer robustness and excellent sealing properties.

Nominal Conditions

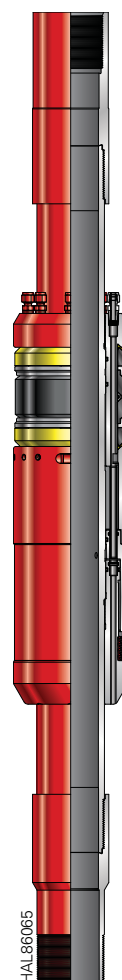
The MC production and MC isolation packers are designed for use in wells with the following normal conditions:

- » Bottomhole pressure <5,000 psi
- » Negligible H₂S and CO₂ bottomhole temperature <275°F
- » ΔP 5,000 psi

Reliability

The MC production and isolation packers are qualified to an ISO 14310 V3 rating.

Viton™ is a trademark of The Chemours Company.



MC
Packer

Retrieable Feed-Through MC Packers

Type	Casing		Mandrel Size	Maximum OD	Bore ID	Maximum Feed-Through	Maximum Differential Across Element	Working Pressure	Working Temperature	Required Setting Pressure	Element Type	ISO 14310 Rating
	OD	Weight										
	in.	lb/ft	in.	in.	in.		psi	psi	°F	psi		
722MC Production Packer	7	23	3 1/2	6.180	2.817	8	5,000	5,000	75 to 275	4,000	HNBR	V3
		26 to 29	3 1/2	5.992						2,400	Nitrile	V3
		26	3 1/2	5.992							Viton™	V3
		29	3 1/2	5.992							Viton	V3
		2,500	HNBR	V3								
	9 5/8	40	5 1/2	8.614	4.580	8	5,000	5,000	75 to 275	4,000	HNBR	V3
		43	4 1/2	8.515	3.820					4,000	Nitrile	V3
		47	3 1/2	8.440	2.750					4,000	HNBR	V3
			4 1/2	8.460	3.810					3,500	Nitrile	V3
			5 1/2*	8.455	4.590					4,000	Nitrile	V3
		53.5*	3 1/2	8.297	2.825		5,000	5,000		4,000	Nitrile	V3
			4 1/2		3.820						Nitrile	V3
			5 1/2		4.590						Nitrile	V3
Isolation Packer	5 1/2	13 to 17	2 7/8	4.700	2.373	8	2,500	5,000	75 to 275	2,400	Nitrile	V3
	7	26 to 29	3 1/2	5.980	2.885	8	2,500	5,000	75 to 275	2,400	Nitrile	V3

Notes:

Packer is set only via the tubing.

Packer is released via straight shift and pull method

Thread connections: VAM TOP® (VAM TOP® is a registered trademark of Vallourec Oil and Gas France.)

Refer to individual specification sheets for additional details.

*Pending qualification testing

Contact Halliburton for additional information.

Viton™ is a trademark of The Chemours Company.

Feed-Through Seal Assembly

In SmartWell® intelligent completion systems, the feed-through seal assembly isolates individual zones during applications where it is not possible or desirable to use packers for isolation.

The feed-through seal assembly enables bypass of control lines to communicate with equipment installed lower in the completion string.

Typical applications are gravel pack or expandable sand screen completions in which the seal stack assembly stabs into a polished bore to provide isolation between different reservoir intervals in the sandface completion. This ability is based on the use of a stack of robust bonded seal rings arranged along the assembly length.

The seal assembly allows up to six independent control lines to bypass, thus enabling control and monitoring of the equipment below, such as interval control valves (ICVs) and permanent downhole gauges (PDGs).

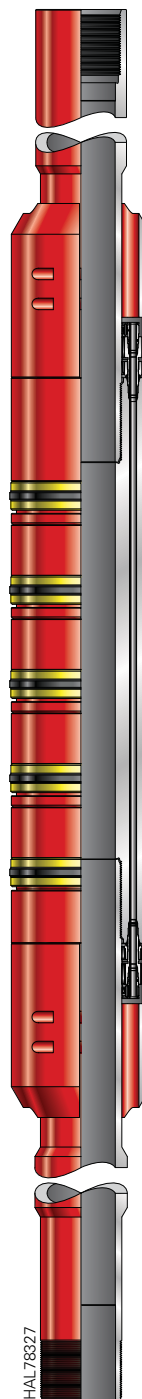
The device is capable of isolating zones with differential pressures of up to 7,500 psi but, unlike the HF-1 packer range, has no load-bearing capability.

Features

- » Simple, effective design
- » Multiple sets of bonded seals
- » Bypass for up to six control lines
- » Field proven

Benefits

- » Installs above ICVs and PDGs
- » Isolates reservoir intervals without requiring a packer
- » Helps eliminate the need for a setting/release system



*Feed-Through
Seal Assembly*

Feed-Through Seal Assembly

Size	Maximum Body OD	Seal OD	Minimum ID	Length	Maximum Temperature	Maximum Pressure (Burst and Collapse)	Maximum Differential Pressure	Hydraulic Port Pressure Rating	Thread Size and Type (Box x Pin)
in.	in.	in.	in.	in.	°F	psi	psi	psi	
4.75 (ECC)	4.695	4.826	2.382	83.640	275	10,000	7,500	10,000	2 7/8 in. 6.4 lb VAM TOP®
4.80 (ECC)	4.740	4.870	2.340	92.420	275	10,000	7,500	10,000	2 7/8 in. 6.4 lb New VAM®
5.00	5.076	4.945	2.313	80.000	275	10,000	7,500	10,000	2 7/8 in. 6.4 lb New VAM
5.80	5.770	5.876	2.945	88.923	275	10,000	7,500	10,000	3 1/2 in. 9.2 lb New VAM
6.10	6.050	6.176	2.945	72.220	275	10,000	7,500	10,000	3 1/2 in. 9.2 lb VAM TOP
7.125	7.075	7.201	2.945	72.210	275	10,000	7,500	10,000	3 1/2 in. 9.2 lb VAM TOP
7.20	7.150	7.276	3.813	107.210	275	10,000	7,500	10,000	4 1/2 in. 12.6 lb VAM TOP

Control lines are normally hydraulically spliced above and below the seal stack assembly. Control-line feed throughs are also available.

Number of feed throughs, hydraulic splices, or both depends on the mandrel size.

Seals are nitrile-bonded 90 duro.

Contact Halliburton for additional information.

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Downhole Control Systems

Downhole control systems provide a method of integrating the surface control system (either manual or automated) with downhole SmartWell® equipment.

The following table lists the basic specifications for the Halliburton Direct Hydraulics, SmartPlex®, and Digital Hydraulic™ systems.

Downhole Control Systems

Downhole Control System	Operational Method	Zonal Isolation Packer	Interval Control Valve (ICV) Integration			Control Line Fluid Compatibility	Environment
			ICV	Control Modules			
				On/Off	Choke		
Direct Hydraulics Downhole Control System	Hydraulic	HF-1, MC, or MFT	HS, HVC	N/A	Accu-Pulse™ module	Water/oil based	Subsea, platform, or land
			MC	N/A	Surface positioning	Water/oil based	Platform or land
SmartPlex® Downhole Control System	Electro-hydraulic	HF-1, MC, or MFT	HS, HVC, or MC	SmartPlex on/off decoder	SmartPlex choke decoder	Oil based	Platform or land
Digital Hydraulics™ Downhole Control System	Hydraulic	HF-1, MC, or MFT	HS or HVC	Digital Hydraulics on/off decoder	Digital Hydraulics choke decoder + Accu-Pulse module	Water/oil based	Platform or land

Direct Hydraulics Downhole Control System

The Direct Hydraulics downhole control system uses direct hydraulic control lines from the surface to remotely actuate downhole flow control devices, such as interval control valves (ICVs). ROC™ permanent downhole gauges and Venturi flowmeters and densitometers can also be used in conjunction with the Direct Hydraulics system for measuring downhole pressure, temperature, and flow rate. The system provides on/off or variable control of flow into or out of reservoir intervals and can be used in onshore, platform, or subsea applications.

Features

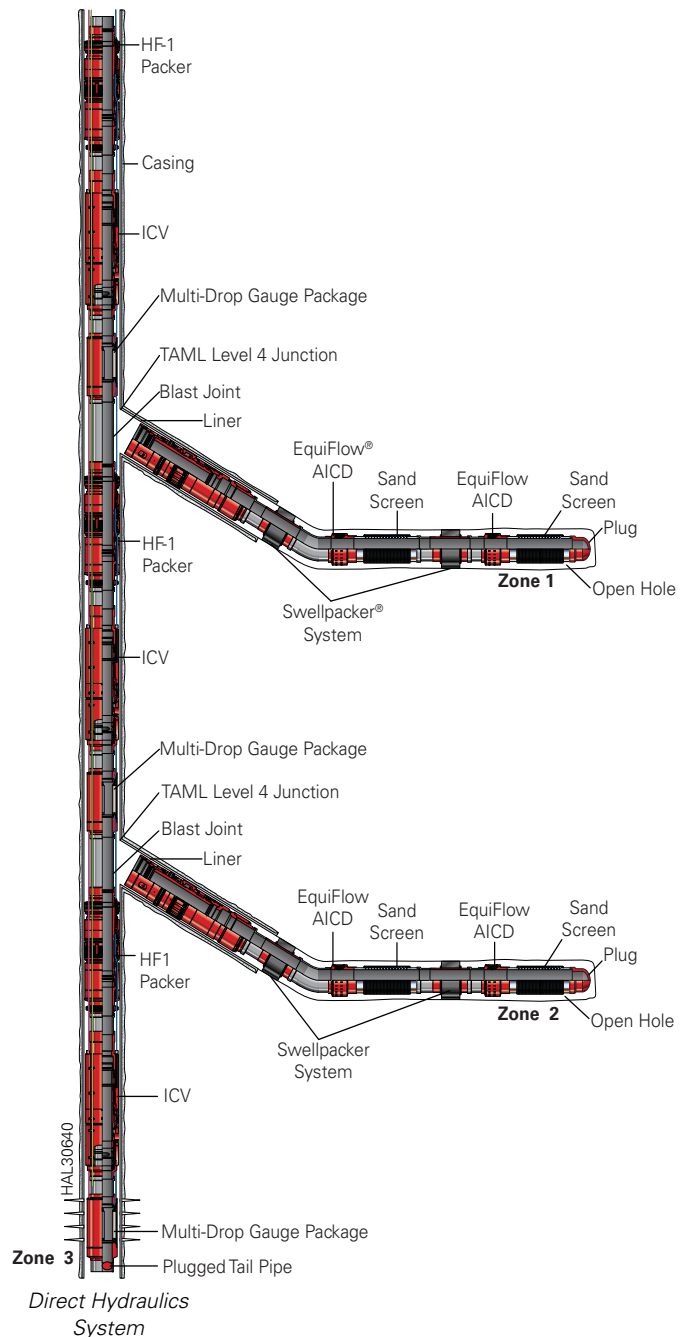
- » Can be used to control Halliburton hydraulic flow control equipment
- » Provides all-hydraulic control
- » Networking option reduces the number of control lines required
- » Operates as a closed-loop system
- » Requires no setting depth

Benefits

- » Control reservoir intervals without costly intervention
- » Helps eliminate dependence on mechanical or pneumatic spring return mechanism to open and close ICV
- » Can be used in onshore, platform, or subsea applications

Operation

All Halliburton intelligent hydraulic flow control equipment can be controlled by the Direct Hydraulics system, bringing simple and reliable zonal control to even the most complex intelligent well. A typical Direct Hydraulics system includes an ICV, Accu-Pulse™ hydraulic positioning module, and a zonal isolation packer, such as the HF-1 packer. For control of a single ICV, two control lines are run from surface with one attached to the open side of the piston and the other attached to the close side. Pressure applied to one line, rather than the other, drives the piston to the corresponding position. Because the piston is rigidly attached to the ICV opening mechanism, piston movement operates the valve. This feature can dramatically improve the ability to shift a sleeve that is stuck due to scale buildup.



SmartPlex® Downhole Control System

The SmartPlex® downhole control system is an electro-hydraulic multi-drop system that provides simple and reliable zonal control of multiple valves in a single wellbore with a minimum number of control lines. The SmartPlex downhole control system uses two hydraulic and one electric line from the surface to remotely and selectively actuate multiple downhole flow control devices, such as interval control valves (ICVs). This makes a significant number of tubing hanger penetrations unnecessary and reduces operational complexity and risks.

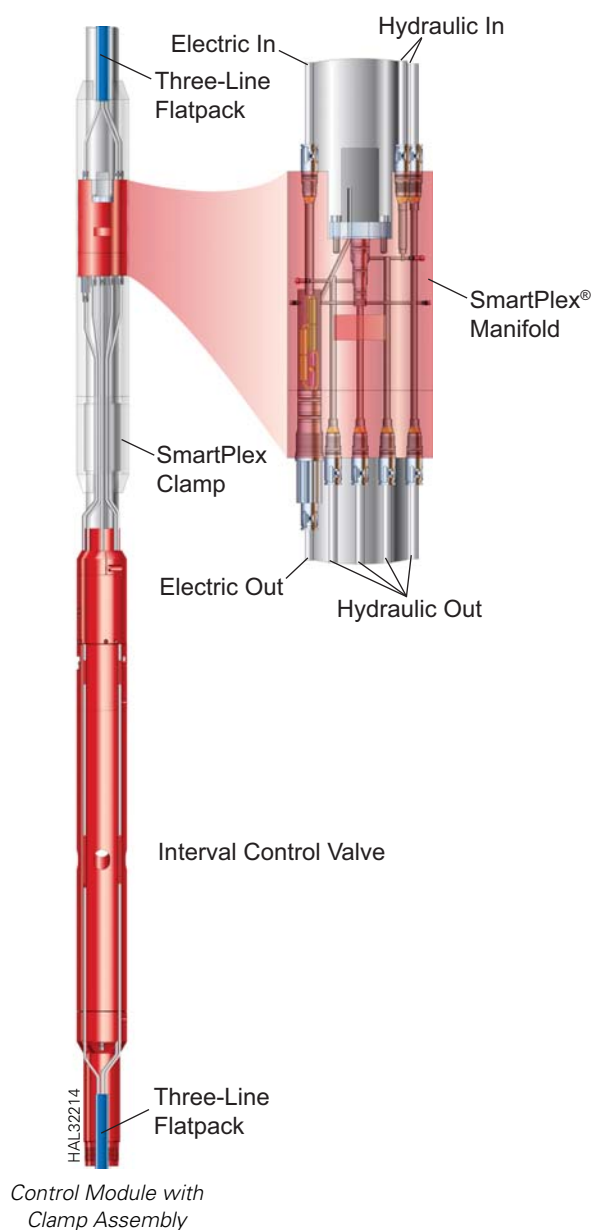
The SmartPlex system can control any flow control tool in the field-proven Halliburton portfolio.

Features

- » Three control lines for up to 12 downhole devices or four control lines for up to 24 downhole devices
- » Minimal use of only passive and no active electrical components
- » Can remain pressured when operating any of the ICVs in the same direction, thus significantly decreasing ICV actuation times
- » Can be deployed with non-integrated systems and fiber optics
- » Supports “fail-as-is” device types
- » Independent of tubing or annulus pressure
- » Can be used to position ICVs in choking applications

Benefits

- » Helps reduce multi-valve completions costs
- » Faster activation time for valves
- » Reduces rig time through greater facilitation of completion installation and retrieval
- » Electro-hydraulic system provides high level of motive power to operate ICVs
- » Allows the ICV to be closed in a single step
- » Provides the ability to move the ICV from the closed to any choking position in a single step



Application

The SmartPlex® downhole control system is applicable for any dry-tree multizone completion that requires more than two valves. When compared to the Direct Hydraulics system, the SmartPlex system not only helps reduce the overall costs of an intelligent completion, it also reduces the complexity involved by minimizing the number of control lines required.

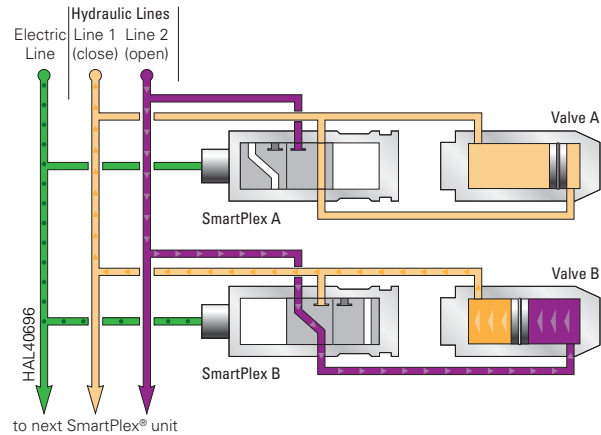
The SmartPlex system is ideally suited for long horizontal, compartmentalized completions, in both cased or open hole, in which selective control of each interval is desired. Typically, this can be advantageous for selective stimulation control in tight-gas applications or in combination with a choking ICV for drawdown optimization in production applications.

Operation

The SmartPlex system uses a simple passive electrical switching method. Each valve is coupled with a SmartPlex actuator module, which allows selective and remote control of each valve. Control lines consisting of one electrical and two hydraulic lines run from surface and are networked to each SmartPlex module. A signal down the electrical line switches a solenoid at the desired module, allowing hydraulic communication between the surface control unit and valve. By regulating the fluid volume in combination with a time-domain control method, valves can be incrementally positioned (choking) to allow for advanced reservoir management.

Qualification Testing

The SmartPlex control system successfully passed extensive in-house deep well simulation testing. The tool was cycled more than 10,000 times at high temperatures and pressures. A nine-valve system integration test with 15,000-ft control line was also successfully conducted.



Electrically selecting SmartPlex® System B creates the hydraulic circuit to operate Valve B while all the other valves remain balanced.

Digital Hydraulics™ Downhole Control System

The Digital Hydraulics™ system is an all-hydraulic, multi-drop intelligent completion system that can direct any flow control tool in the Halliburton portfolio, providing simple and reliable zonal control for even the most complex reservoirs. The Digital Hydraulics system allows up to six flow control devices to be controlled from only three hydraulic control lines, making a significant number of tubing hanger penetrations unnecessary.

Features

- » High activation forces for flow control devices in both directions
- » Three control lines for up to six downhole devices
- » Four control lines for up to 12 downhole valves
- » Can be deployed with non-integrated systems and fiber optics
- » No setting depth limitations
- » All-hydraulic system
- » Supports “fail-as-is” devices
- » Field-proven
- » Independent of tubing or annular pressure
- » Can be used in conjunction with the Accu-Pulse™ module for choking applications

Benefits

- » Helps reduce control line costs
- » Helps reduce rig time through greater facilitation of completion installation and retrieval
- » Fewer connections through tubing hanger

Operation

The Digital Hydraulics system design uses the logical absence or presence of pressure (hydraulic code) to communicate between a surface controller and the downhole tools.

Existing pressure greater than 2,000 psi is represented by “1,” and pressure less than 500 psi is represented by “0.” Depending on the pressure in the wellbore, a sequence of 1s and/or 0s is communicated to the flow control devices within the Digital Hydraulics system.

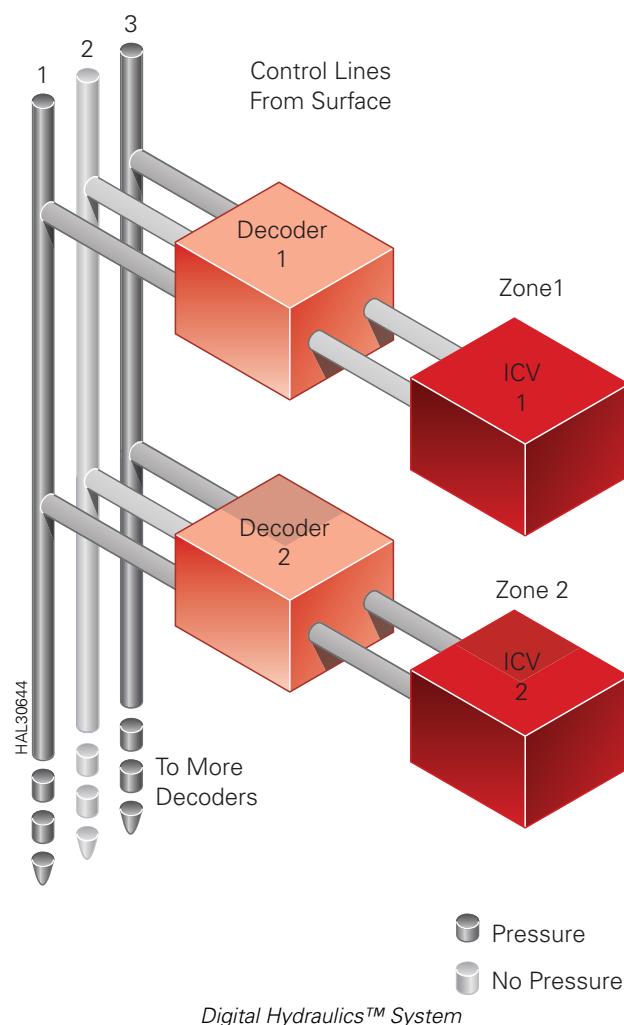
Each flow control device is paired with a decoder that is designed to respond to its own unique code and rejects all other codes or sequences. Using this method, the communication between the surface controller and the downhole tools maintains its integrity — even when conditions, such as temperature changes, long control lines, fluids, and leaks, can cause other hydraulic communication methods to fail.

The Digital Hydraulics system controls simple open/close interval control valves (ICVs) and lubricator valves (LVs) to provide on/off flow control from each zone.

Surface Control

The surface equipment for the Digital Hydraulics system, the Halliburton SmartWell® Master supervisory application, is designed as part of the Digital Infrastructure system. A fully automated surface hydraulic system (SHS) controlled from a central location allows control of the Digital Hydraulics system from a local or remote control station.

The SmartWell Master application translates Digital Hydraulics system logic into standard central control room operations. This translation allows the operator to easily monitor and control multiple Digital Hydraulics completion systems as well as an individual zone within an intelligent well completion.



Accu-Pulse™ Incremental Positioning Module

The Accu-Pulse™ incremental positioning module is a complementary control module that provides incremental opening of a multi-position interval control valve (ICV). The Accu-Pulse control module allows the operator to control produced or injected fluid rates to the desired quantity, thus significantly enhancing reservoir management capabilities.

The Accu-Pulse module works in tandem with either the Halliburton Digital Hydraulics™ or Direct Hydraulics downhole control systems and with the HS-ICV multi-position valve.

Applications

The Accu-Pulse module provides effective incremental control of an ICV in a range of applications, such as:

- » Auto-gas lift
- » Waterflood
- » Gas injection
- » Commingled production
- » Dump flood

Features

- » Hydraulic, incremental control
- » Ability to close a valve from any position in one pressure cycle
- » Provides up to 11 discrete positions with the appropriate ICV

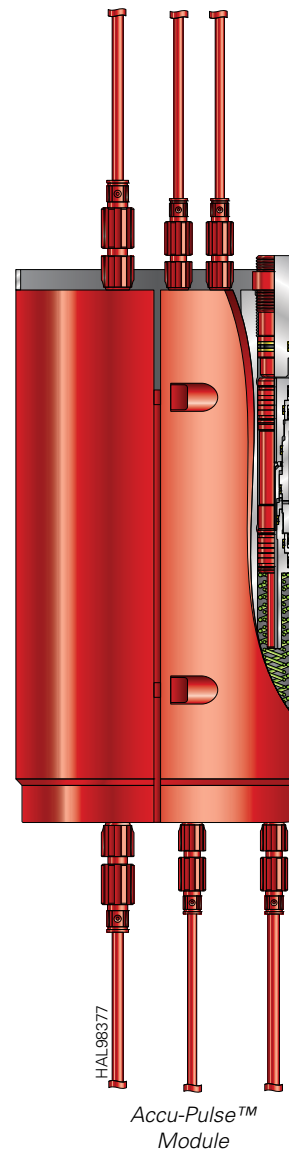
Benefits

- » Enhanced reservoir management through control of produced or injected fluids
- » Helps provide accurate flow estimation and allocation
- » Avoidance of reservoir drawdown
- » High level of well control for auto-gas lift, waterflood, dump flood, and commingled flow

Operation

The Accu-Pulse module provides incremental movement of a suitable ICV flow trim by exhausting a predetermined amount of control fluid from the ICV piston. The capability to recharge and exhaust the same amount of fluid repeatedly allows the ICV flow trim to be accurately moved through up to 11 predetermined positions.

The Accu-Pulse module can communicate with either side of the ICV piston. It can drive the ICV open or closed. This ability provides incremental positioning in one direction with the ICV being driven to a fully open or closed position when pressure is applied from the other direction.



Reliability Testing

Extensive reliability and integration testing is performed on the Accu-Pulse module to help ensure accuracy and long-term performance.

Long-Term Testing

The Accu-Pulse module has been long-term tested for:

- » High temperature
- » High pressure
- » Flow-induced vibration

Auxiliary Components

Control-Line Cut Sub

The Halliburton control-line cut sub (CLCS) incorporates reliable and field-proven methods for effective removal of the tubing string and control lines in contingency situations. The CLCS helps ensure proper retrieval of complex upper completions, thus ensuring a clean tubing stub for subsequent fishing operations.

The CLCS is used in SmartWell® completions in which hydraulic line and electric line flatpacks are used and removal of the complex upper completion is necessary.

Features

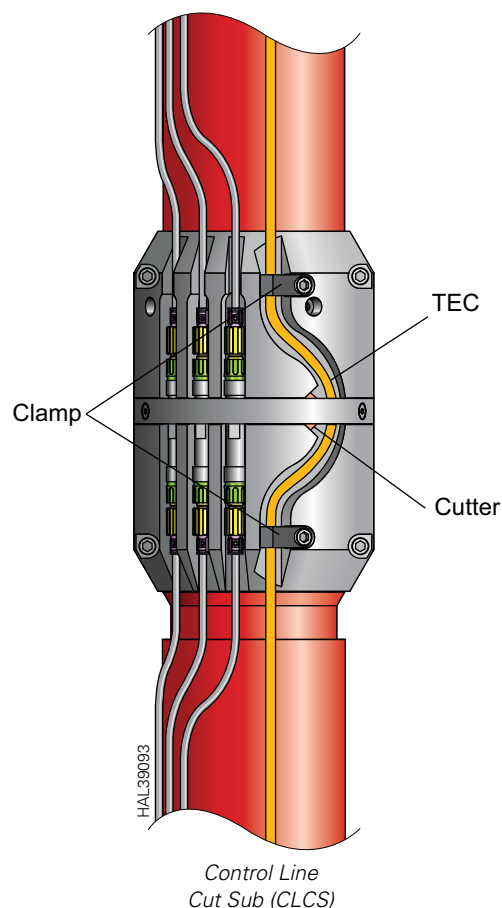
- » Fully compatible with standard Halliburton FMJ metal-to-metal sealing fittings
- » FMJ connectors fitted to the splice sub are fully testable using a standard FMJ connector test kit
- » All splice connections are set within the body of the sub for protection
- » Easily disconnects the hydraulic FMJs by over pulling
- » Easily severs the electrical line for successful removal of a complex upper completion

Benefits

- » Splice multiple hydraulic lines with a single splice sub connector
- » Freely bypass one bare electrical line
- » Easily assemble in the field
- » Minimize workover operations

Operation

The CLCS provides the possibility to chemically or physically cut the tubing string above a tubing packer. A nipple profile below the CLCS will straddle the targeted cut zone. Hydraulic lines are successfully disconnected by pulling on the tubing string and overcoming the ratings of the FMJ fittings. In addition, the electrical line is severed during the pulling motion of the string. Tension on the electrical line drives it against a cutting blade that swiftly severs the line.



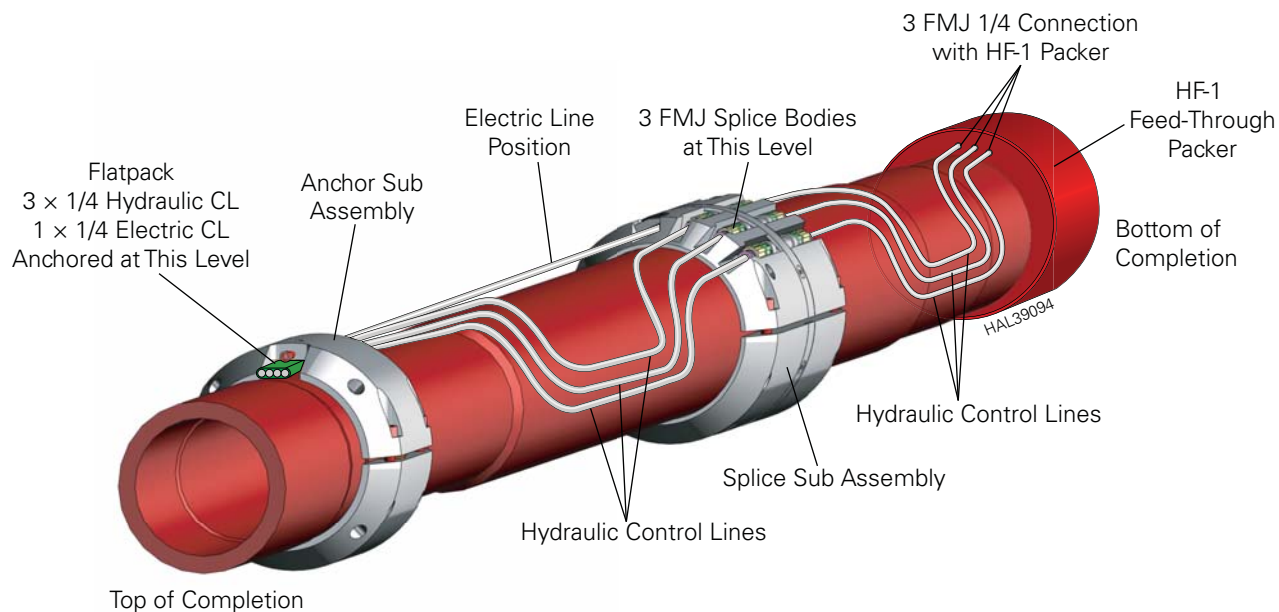
Connections

FMJ connectors are used to make the splice connection and are retained within the body of the clamp to protect the splices, flatpack, and control lines from damage.

Using the metal-to-metal FMJ connectors, completed connections can be pressure tested to help ensure integrity.

The device also includes a provision for bypassing at least one bare 1/4-in electrical line. This line is retained in a special section of the body clamp that contains a line-severing blade for electrical connections.

The splice sub connector is available in 4 1/2-in. and 5-in. configurations.



Splice Clamp/Sub

The Halliburton splice clamp/sub is a reliable and field-proven method of splicing two ends of the flatpack or tubing encased conductor (TEC). The splice clamp/sub also helps protect the flatpack by securing it to the tubing.

The splice sub connector incorporates a two-piece robust splice clamp with a profile that locates into a groove machined in a custom-designed Halliburton crossover sub. This arrangement helps ensure that no vertical or rotational slippage of the clamp occurs during installations or tubing string retrieval. The crossover sub is made up directly to the tubing string.

Applications

The splice sub connector is used in most SmartWell® completions in which flatpack or TEC is deployed, including wells with permanent monitoring, chemical injection, fiber optics, and surface-controlled subsurface safety valve (SCSSSV) control lines.

Features

- » Fully compatible with Halliburton standard FMJ metal-to-metal (MTM) sealing fittings.
- » FMJ connectors fitted to the splice sub are fully testable using a standard FMJ connector test kit.
- » All splice connections are set within the body of the sub for protection.

Benefits

- » Splice multiple lines within a single splice sub connector, depending on size
- » Freely bypass control line/TEC that does not require splicing
- » Clamps can be designed to accommodate TEC splice
- » Easily assembled in the field

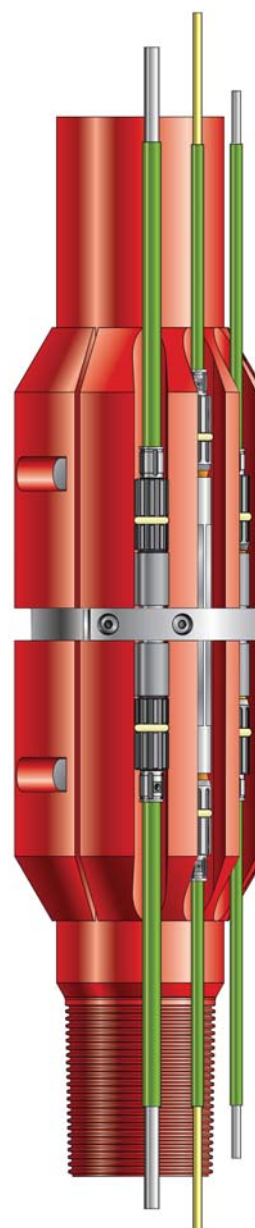
Connections

FMJ connectors are used to make the splice connection and are retained within the body of the clamp to protect the splices, flatpack, and control lines from damage.

Using the MTM FMJ connectors, completed connections can be pressure tested to help ensure integrity.

The device also includes a provision for bypassing control lines for operation of permanent monitoring, a chemical injection valve, or SCSSSV.

The splice sub connector is available in a range of sizes to suit different tubing specifications and splice applications.



*Splice/Clamp
Sub*

Splice Sub

The Halliburton splice sub is a reliable and field-proven method of splicing two ends of the flatpack or tubing encased conductor (TEC). The splice sub also helps protect the flatpack by securing it to the tubing.

The splice sub assembly incorporates a single-piece robust mandrel with multiple machined grooves on outer ends for control lines or TECs. A recess in the center houses all of the splices, which are then secured by two cover plates. This arrangement allows multiple configurations of splices to be installed using a standard splice sub. The mandrel is made up directly to the tubing string allowing safe installations or retrieval.

Applications

The splice sub connector is used in most SmartWell® completions in which flatpack or TEC is deployed, including wells with permanent monitoring, chemical injection, fiber optics, and surface-controlled subsurface safety valve (SCSSSV) control lines.

Features

- » Fully compatible with Halliburton standard FMJ metal-to-metal (MTM) sealing fittings
- » FMJ connectors fitted to the splice sub are fully testable using a standard FMJ connector test kit
- » All splice connections housed within the body of the mandrel and secured by cover plates

Benefits

- » Splice multiple lines within a single splice sub connector, depending on size
- » Freely bypass control line/TEC that does not require splicing
- » Compatible with various splice configurations (splices must be ordered separately)
- » Easily assembled in the field

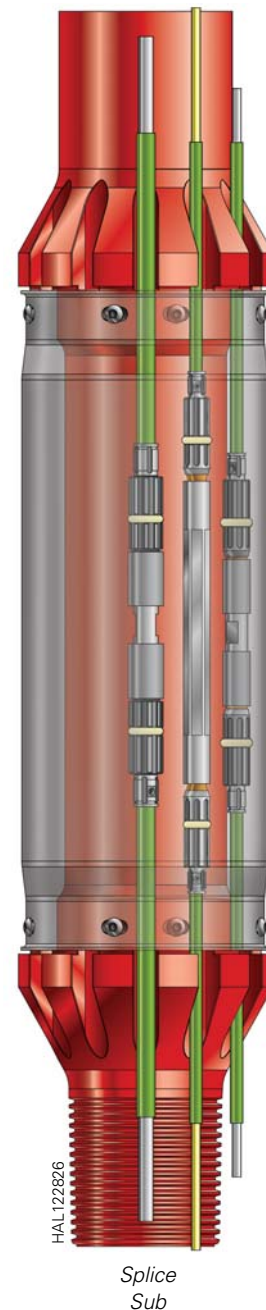
Connections

FMJ connectors are used to make the splice connection and are retained within the body of the clamp to protect the splices, flatpack, and control lines from damage.

Using the MTM FMJ connectors, completed connections can be pressure tested to help ensure integrity.

The device also includes a provision for bypassing control lines for operation of permanent monitoring, a chemical injection valve, or SCSSSV.

The splice sub connector is available in a range of sizes to suit different tubing specifications and splice applications.



SmartWell® Hydraulic Disconnect Tool

The SmartWell® hydraulic disconnect tool facilitates the removal of the upper completion from the lower completion, without any destructive or mechanical intervention, leaving the intelligent completion lower assemblies, such as packers and interval control valves (ICVs), in place.

Compact in design, the hydraulic disconnect tool enables reconnection and isolation of the tubing and hydraulic umbilicals to the lower completion when the upper completion is redeployed.

Applications

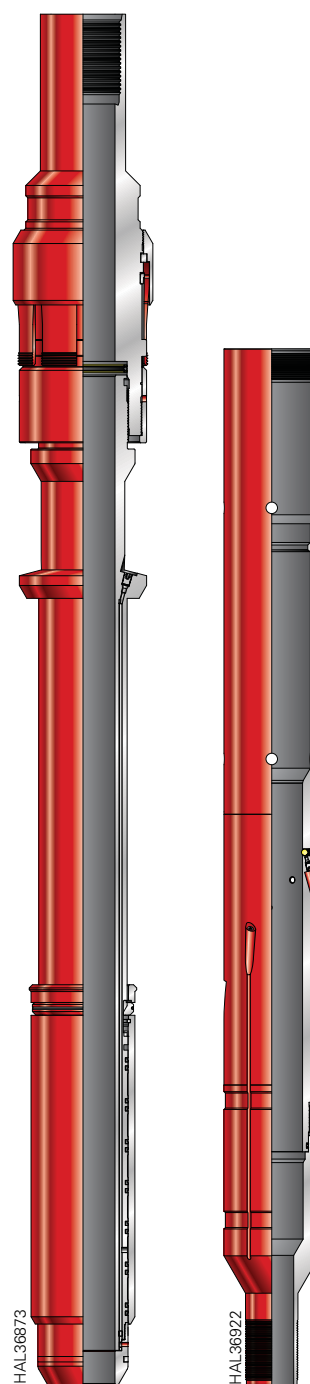
- » Electric submersible pump applications
- » Safety valve replacement
- » Deepwater plug and abandonment
- » Two-trip completions

Features

- » Compact, concentric design
- » Up to six hydraulic control line channels
- » Proven bonded seal technology
- » Protective sleeve over seal assembly
- » Spring-loaded poppets in receptacle control line channels
- » Adjustable shear-to-release, straight stab-in to reconnect (typical)

Benefits

- » Minimize risks and costs associated with workovers: Pull upper string, leaving lower completion undisturbed
- » No orienting mechanism or special alignment necessary: Concentric design allows for straight stab installation
- » Re-establish hydraulic integrity: Durable high-performance seals maintain isolation between hydraulic control lines and the tubing and annulus
- » Verify control line integrity during workover: Protective sleeve allows for low-pressure testing
- » Prevent control line contamination while disconnected: Poppets prevent well ingress into the hydraulic system



Hydraulic
Disconnect Tool

HALLIBURTON

Completion Tools

Operation

The hydraulic disconnect tool features six hydraulic control line channels that provide communication in a SmartWell® completion.

All six channels are independent of each other, using concentric seal channels that eliminate the need for special orientation.

While running the upper assembly, a protective sleeve covers the seals, preventing damage and providing a means to verify hydraulic control line integrity. The sleeve is engaged during stab-in, sliding up the seal assembly to safely present the seals in the receptacle.

While disconnected, spring-loaded poppets provide a debris barrier for the control line channels. The poppets are lifted off seat by the seal mandrel during stab-in, establishing hydraulic communication from the surface.

The secure latching mechanism can be configured on location to complement the customer well plan. Three modes of operation are available:

- » Snap latch: Snap in/snap out
- » Anchor: Snap in/rotate out to release
- » Shear anchor: Snap in/shear to release

SmartWell® Hydraulic Disconnect Tool

Tubing Size	4 1/2 in.
Maximum OD	8.300 in.
Minimum ID	3.788 in.
Sealbore Diameter	5.35 in.
Connection	4 1/2-in, 15.1 lb/ft, VAM TOP® box x pin
Working Temperature	135°C
Body Working Pressure	5,000 psi
Control Line Pressure	7,500 psi
Maximum Differential Unloading Pressure	500 psi
Snap-In Force	10,000 lb
Compression Rating	353,000 lb
Running Tool Tensile Rating	178,000 lb
Snap Latch Rating	40,000 to 50,000 lb
Shear Rating	70,000 up to 120,000 lb
Seals	Bonded HNBR
Hydraulic Connections	6 x 1/4-in. FMJ
Control Line Fluids	Oil-based (Red Oil)

Other sizes and metallurgy can be made available.

VAM TOP® is a registered trademark of Vallourec Oil and Gas France.

SmartWell® Electro-Hydraulic Disconnect Tool

The SmartWell® electro-hydraulic disconnect tool facilitates removal of the upper completion from the lower completion, without any destructive or mechanical intervention, leaving the intelligent completion lower assemblies, such as packers, interval control valves (ICVs), and gauges, in place.

Compact in design, the electro-hydraulic disconnect tool enables reconnection and isolation of the tubing, electrical, and hydraulic lines to the lower completion when the upper completion is redeployed.

Applications

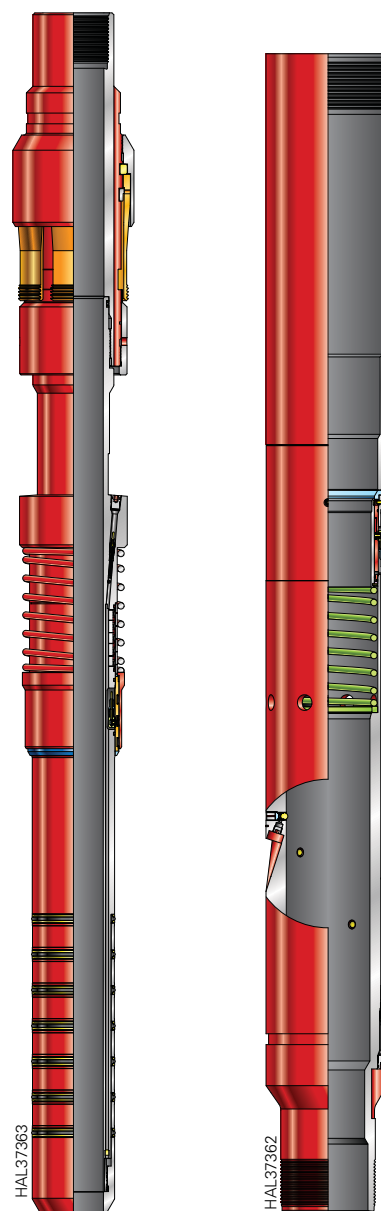
- » Multi-trip completions
- » Electric submersible pump applications
- » Safety valve replacement
- » Deepwater plug and abandonment

Features

- » Compact, concentric design
- » One electrical channel for use with up to eight permanent gauges
- » Connection for six hydraulic channels for use with up to five valves using Direct Hydraulics™ downhole architecture
- » Pressure-compensated electrical system allows for reliable mating and de-mating
- » Proven FFKM replaceable “T” seal technology
- » Protective sleeve over electrical assembly
- » Spring-loaded poppets in receptacle control line channels
- » Multiple disconnect sub/receptacle latching configurations

Benefits

- » Minimizes risks and costs associated with workovers: Pull upper string, leaving lower intelligent completion undisturbed
- » No orienting mechanism or special alignment required: Concentric design allows for straight stab installation
- » Re-establishes electrical integrity: Qualified proprietary connector allows wet mates by reliably isolating completion fluid from electrical contacts during reconnection or after disconnection
- » Re-establishes hydraulic integrity: Durable high-performance seals maintain isolation between hydraulic control lines and the tubing and annulus
- » Oil or water-based control line fluid compatibility
- » Prevents control line contamination in receptacle while disconnected: Poppets prevent well ingress into the hydraulic system



SmartWell® Electro-Hydraulic Disconnect Tool

Operation

The electro-hydraulic disconnect tool features six hydraulic control line channels that provide hydraulic communication, and one electrical channel that provides gauge communication in a SmartWell® system completion. All six hydraulic channels are independent of each other, using concentric FFKM “T” seal channels that help ensure compatibility across most wellbore and control-line fluids and eliminate the need for special orientation.

The disconnect sub is run to depth, remaining centralized as it enters the disconnect receptacle. The stabbing sequence results in the protective electrical sleeves moving out of the way. The sub shoulders out against the receptacle. In this state, the electrical contacts are completely mated with each other. The electrical contact on the sub uses a canted spring to help ensure reliable mating, regardless of radial tolerances. Elastomeric pillow seals isolate wellbore fluids from the electrical connector. The electrical connector is pressure compensated to the annulus. Upon pulling out of the hole, the sub disengages from the receptacle, and the sleeves retract to their original position via springs, thus isolating the connectors from the environment.

In the disconnect receptacle, spring-loaded balls maintain a debris barrier to help prevent contamination of the lower completion hydraulic channels. As the disconnect sub enters the receptacle, it safely lifts the poppets off seat. The poppet springs are designed for an optimum force that prevents any damage to the seals. The sub continues into the disconnect receptacle until the latching mechanism is engaged and the sub shoulders out on the receptacle. In this mated state, the hydraulic seals reliably isolate annulus-to-tubing and hydraulic channels.

The secure latching mechanism can be configured in the region to complement the customer well plan. Three modes of operation are available:

- » Snap latch: Snap in/snap out
- » Anchor: Snap in/rotate out to release
- » Shear: Snap in/shear to release

SmartWell® Electro-Hydraulic Disconnect Tool

Tubing Size	3 1/2 in.
Maximum OD	5.950 in.
Minimum ID	2.890 in.
Connection	3 1/2-in. 10.2 lb/ft VAM TOP® box × pin
Working Temperature	257°F (125°C)
Working Pressure	5,000 psi
Control Line Pressure	7,500 psi
Maximum Differential Unloading Pressure	500 psi (Hydraulic channel to tubing or annulus)
Snap-In Force	7,500 lb
Maximum Compression Rating	233,000 lb
Maximum Tensile Rating	114,000 lb
Shear Rating	70,000 lb (standard); Other sizes available on request
Seals	Open Gland “T” Seal (FFKM) - field replaceable
Electrical Connection	1 × 1/4-in. E-FMJ
Hydraulic Connections	6 × 1/8-in. NPT
Control Line Fluids	Oil- or water-based fluids

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Permanent Monitoring

The DataSphere® permanent monitoring suite encompasses the full line of permanent monitoring systems available from Halliburton. The modularity and compatibility of these tools enables customized monitoring solutions to provide enhanced reservoir monitoring capabilities. The suite helps deliver real-time pressure, temperature, flow, and density feedback from the wellbore, while helping optimize production and validating reservoir models.

DataSphere® ROC™ Permanent Downhole Gauges

ROC™ permanent downhole gauges help increase productivity through the life of the well or reservoir by providing reliable, real-time permanent monitoring of downhole conditions. Based on an industry-standard, field-proven resonating quartz crystal sensor, ROC gauges can be used for single or multizone monitoring applications. In multizone applications, variations of the standard gauge are available, along with dual-, triple-, and quad-splitter block assemblies for multi-drop capabilities.

Halliburton has installed thousands of ROC gauge systems — both as standalone systems and integrated components of a SmartWell® completion system — worldwide.

Applications

- » Life of well production monitoring
- » Life of field reservoir monitoring
- » SmartWell completion system optimization
- » Artificial lift optimization

Features

- » Incorporates the most advanced high-temperature electronics available
- » Accurate quartz pressure/temperature (P/T) sensor
- » Designed for harsh environments up to 30,000 psi
- » Dual-pressure testable metal-to-metal sealing arrangement on both the gauge and cable termination
- » Reduced OD gauge design
- » Multi-drop capability on single tubing-encased conductor
- » Flow measurements for specific applications
- » Hermetically sealed electron beam-welded design

Benefits

- » Obtains continuous P/T data without the need for well intervention
- » Enhances reservoir management
- » Helps increase system reliability using stable P/T measurements obtained from state-of-the-art testing



DataSphere® ROC™ Gauge and Cablehead Connection

DataSphere® ROC™ Gauge Single Sensor

HALLIBURTON

Completion Tools

ROC™ Gauge Designs

- » Quartz transducer
- » Hybrid technology
- » Maximum 200°C operating temperature
- » Multi-drop capability — up to eight gauges at 30,000 ft downhole cable
- » Dual sensor feed-through capability
- » Improved shock and vibration performance
- » 0.75-in. OD slimline design available

Mechanical Arrangement

The DataSphere® ROC™ gauge mechanical arrangement comprises all “wetted” parts manufactured from high-performance, NACE-compliant corrosion-resistant alloys.

Cable Termination

The FMJ cable termination has a pressure-testable, dual metal-to-metal ferrule seal arrangement that isolates the downhole cable outer metal sheath from the well fluid.

Testing

The complete DataSphere ROC gauge (sensor and electronic boards) is independently calibration-checked at the manufacturing facility. A calibration certificate is included with each gauge and provided before each installation.

New gauge designs are subjected to a highly accelerated lifetime test (HALT) program. This program is a series of controlled environmental stresses designed to help ensure stringent criteria are met for thermal shock, mechanical shock, vibration, and thermal aging.

During manufacture, all ROC gauges are also subjected to environmental stress screening to highlight any defect in functionality before installation at the wellsite. This screening method has proven far more effective than “burn-in” techniques. All gauges are further subjected to pressure tests at elevated temperatures during factory acceptance testing. Reliability testing demonstrated 13.55 years at 150°C, which exceeded the target reliability of 10 years at 150°C.

For more information on any of the details featured here, please email us at completions@halliburton.com.







DataSphere® ROC™ Gauge Family: Temperature Performance

Accuracy	0.5°C
Typical Accuracy	0.15°C
Achievable Resolution	<0.005°C/second
Repeatability	<0.01°C
Drift at 177°C	<0.1°C/year

DataSphere® ROC™ Gauge Family: Pressure Performance

Pressure Range		Accuracy	Typical Accuracy	Achievable Resolution	Repeatability	Response Time to FS Step (for 99.5% FS)	Acceleration Sensitivity (any axis)	Drift at 14 psi and 25°C	Drift at Maximum Pressure and Temperature
psi	bar	% FS	% FS	psi/sec	% FS		psi/g	% FS/year	% FS/year
0 to 10,000	0 to 690	0.015	0.012	<0.006	<0.01	<1 second	<0.02	Negligible	0.02
0 to 16,000	0 to 1100	0.02	0.015	<0.008	<0.01	<1 second	<0.02	Negligible	0.02
0 to 20,000	0 to 1380	0.02	0.015	<0.008	<0.01	<1 second	<0.02	Negligible	0.02
0 to 25,000	0 to 1725	0.02	0.015	<0.0010	<0.01	<1 second	<0.02	Negligible	0.02
0 to 30,000	0 to 2070	0.025	0.02	<0.010	<0.01	<1 second	<0.02	Negligible	0.025

DataSphere® ROC™ Gauges

Configurations	ROC-150	ROC-175				ROC-200		
	10K	16K	20K	25K	30K	20K	25K	30K
Single Pressure/ Temperature (P/T) Sensor	 HAL32155							
	✓	✓	✓	✓		✓	✓	
Single P/T Sensor + Feed Through	 HAL32156							
	✓	✓	✓	✓		✓	✓	
Dual P/T Sensor	 HAL32157							
	✓	✓	✓	✓		✓	✓	
Dual P/T Sensor + Feed Through	 HAL32158							
	✓	✓	✓	✓		✓	✓	
Dual P/T Sensor Fully Redundant	 HAL32159							
	✓	✓	✓	✓	✓	✓	✓	✓
Dual P/T Sensor Fully Redundant + Feed Through	 HAL32160							
	✓	✓	✓	✓		✓	✓	

DataSphere® ROC™ Gauge Mandrel

The DataSphere® ROC™ gauge mandrel is used to deploy the ROC electronic permanent downhole gauge. Its robust design helps ensure that ROC gauges are securely and safely transported into the wellbore. The ROC gauge mandrel is available in various sizes to match the completion tubulars as well as the ROC gauge variant being deployed. The ROC gauge mandrel is machined from a solid billet to provide the required completion string structural integrity.

Applications

Halliburton has an extensive portfolio of ROC gauges and ROC gauge mandrels to suit different market segments and applications.

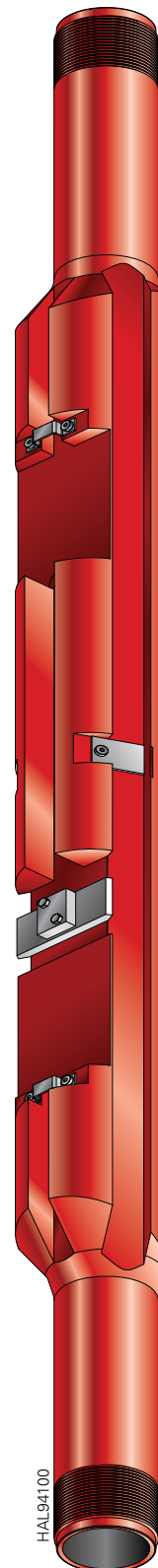
- » Standalone or intelligent completion monitoring
- » Cased or openhole completions
- » Vertical or horizontal completions

Features

- » Optimized OD
- » Standardized pin × pin end connection
- » Optimized mandrel design for maximum gauge protection and ease of gauge installation
- » Dual recessed bypass slot for control line flatpack protection
- » Dual metal-to-metal seal on gauge mount-sub
- » Porting for annulus or tubing measurement
- » Full bore ID — no restriction on production ID nor interference with intervention
- » Rugged billet-style mandrel design
- » Compatible with most common wellbore fluids

Benefits

- » Ability to deploy multiple pressure/temperature sensors as part of the completion string
- » Versatile design to suit many applications



DataSphere® ROC™
Gauge Mandrel

DataSphere® FloStream™ Venturi Flowmeter

The DataSphere® FloStream™ flowmeter incorporates a Venturi profile and two high-accuracy DataSphere ROC™ quartz pressure/temperature gauges to measure pressure at the Venturi inlet and throat. An optional third DataSphere ROC gauge can be added to enable continuous calculation of downhole fluid density.

Benefits

- » Accurate downhole flow rate measurement
- » No moving parts mean high reliability
- » Based on proven ROC permanent gauge technology
- » Wireline-retrievable Venturi section option enables changing flow rate measurement without a workover
- » Absolute pressure measurement allows redundancy in pressure measurement and a wide flow rate measurement window
- » Minimum pressure loss throughout the entire system

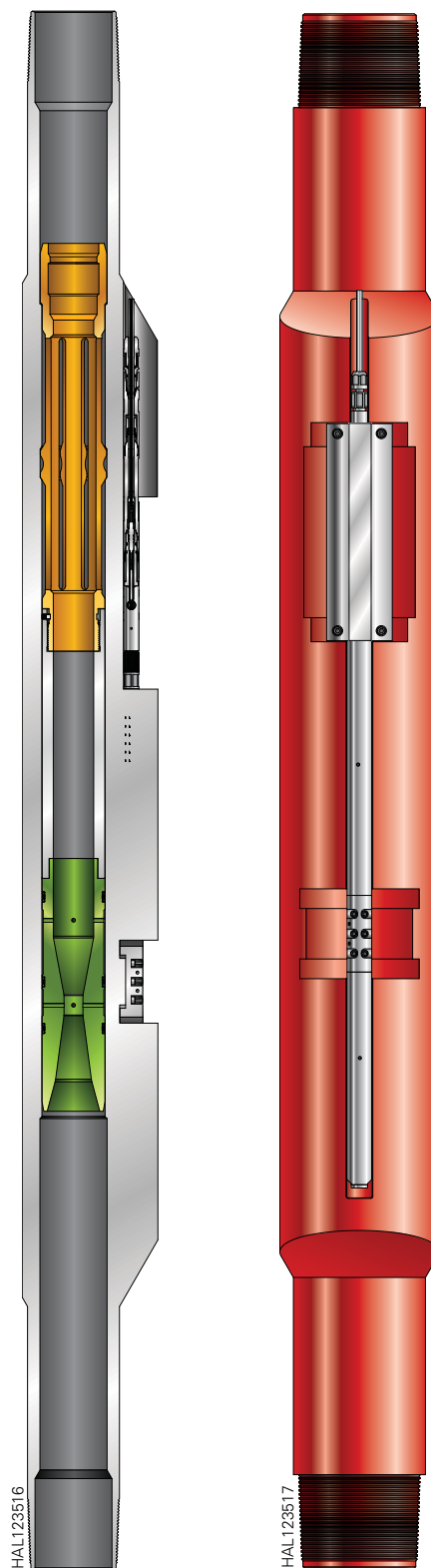
Accuracy and Resolution

- » Accuracy of +5% can be achieved, provided the limits of the Venturi flowmeter principle are not exceeded
- » Resolution of <0.1% of full scale

Operational Parameters

The Venturi flowmeter mandrel can be machined to a specific profile or can incorporate a wireline-retrievable Venturi flowmeter section, which can allow for:

- » Changing of the Venturi flowmeter should the flow rate change significantly
- » Replacement should the Venturi profile become worn
- » Removal of the restriction imposed should it become necessary to perform some well maintenance operation below the flowmeter



DataSphere® FloStream™
Venturi Flowmeter

HALLIBURTON

Completion Tools

DataSphere® Array System

The DataSphere® Array system is the next step in the evolution of Halliburton Permanent Monitoring solutions. The technology is built upon the reliability of ROC™ gauge hybrid technology and provides greater system customization by deploying multiple discrete sensors across challenging wellbore regions.

A system comprising conventional gauges can communicate with multiple Array sensor systems distributed across different wellbore intervals. Each Array system provides discrete real-time annular downhole distributed multi-point temperature and pressure monitoring data. The Array system incorporates no cable terminations, which reduces installation time and eliminates risks associated with multiple terminations. Furthermore, the Array system uses internal short circuit protection circuitry that minimizes system line takedowns.

Based on an industry-standard, field-proven resonating quartz crystal sensor, the Array system can be used for distributed, single zone, or multizone monitoring applications. During distributed monitoring, the use of Halliburton conventional downhole gauges can be enhanced by the Array system, allowing operators greater visibility into their operations efficiency in a cost-effective manner.

Applications

- » Inflow control device (ICD) efficiency monitoring
- » Production monitoring
- » Injection monitoring
- » Field reservoir monitoring
- » SmartWell® completion system optimization
- » Artificial lift/gas lift optimization

Features

- » Can be deployed standalone
- » Up to 50 sensors per array
- » ROC-Modbus® communication protocol

- » Designed for harsh environments up to 10,000 psi and 150°C
- » AWES qualified
- » Reduced OD design
- » Multi-drop capability on single core tubing encased conductor (TEC)
- » Available as temperature only or both pressure and temperature
- » Hermetically sealed electron beam-welded design
- » Application Specific Integrated Chip (ASIC) technology
- » Increased capabilities, such as fault protection per sensor
- » Designed for a 20-year life

Benefits

- » Quartz sensors provide high accuracy and resolution and low drift
- » Can be deployed across the sandface for greater reservoir inflow/outflow understanding
- » Reduces rig time through faster installation times (up to 8 hours saved per gauge)
- » Reduces need for cable terminations
- » Eliminates requirement for gauge mandrels in annular sensing applications
- » Validates/disproves reservoir models
- » Tool head voltage and gauge current measurement for diagnostics
- » Reduces potential leak points by minimizing system connections

FMJ Cable Termination

When connected to a conventional gauge, the DataSphere Array system uses a high-performance cable termination that uses a sealing arrangement based on the highly reliable, field-proven, intelligent completion FMJ connector. This cable termination incorporates a pressure-testable dual metal-to-metal ferrule seal arrangement for isolating the downhole cable outer metal sheath from the well fluid.



Testing

The individual sensor design has gone through the Design for Reliability process, which includes a Highly Accelerated Lifetime Test (HALT) program. This program is a series of controlled environmental stresses designed to ensure that stringent criteria are met for thermal shock, mechanical shock, vibration, and thermal aging. During manufacture, all gauges are also subjected to Environmental Stress Screening (ESS) to highlight any defect in functionality before installation at the well site. This screening method has proven to be far more effective than “burn-in” techniques.

All of the individual sensors that compose the DataSphere® Array system are independently calibration checked in our manufacturing facility. During Factory Acceptance Testing (FAT), the DataSphere Array sensor welds are pressure tested for integrity as the array is being built and spooled onto the final drum.

DataSphere Array System Designs

- » Quartz transducer and hybrid technology
- » ASIC technology
- » Maximum 150°C operating temperature
- » Multi-drop capability to 10,000-ft maximum depth
- » Can be used in conjunction with existing gauges
- » Improved shock and vibration performance
- » 0.625-in. OD ultra-slim design
- » Less than 7-in. length per sensor
- » Does not need a gauge mandrel to be deployed
- » Short-circuit protection per sensor, prevents line takedowns

DataSphere® Array System: Temperature Performance

Accuracy	0.5°C
Typical Accuracy	0.15°C
Achievable Resolution	<0.005°C/second
Repeatability	<0.01°C
Drift at 177°C	<0.1°C/year

DataSphere® Array System: Pressure Performance

Pressure Range		Accuracy	Typical Accuracy	Achievable Resolution	Repeatability	Response Time to FS Step (for 99.5% FS)	Acceleration Sensitivity (any axis)	Drift at 14 psi and 25°C	Drift at Maximum Pressure and Temperature
psi	bar	% FS	% FS	psi/sec	% FS		psi/g	% FS/year	% FS/year
0 to 10,000	0 to 690	0.015	0.012	<0.006	<0.01	<1 second	<0.02	Negligible	0.02

For additional pressure- and temperature-rated systems, please contact your Halliburton representative.

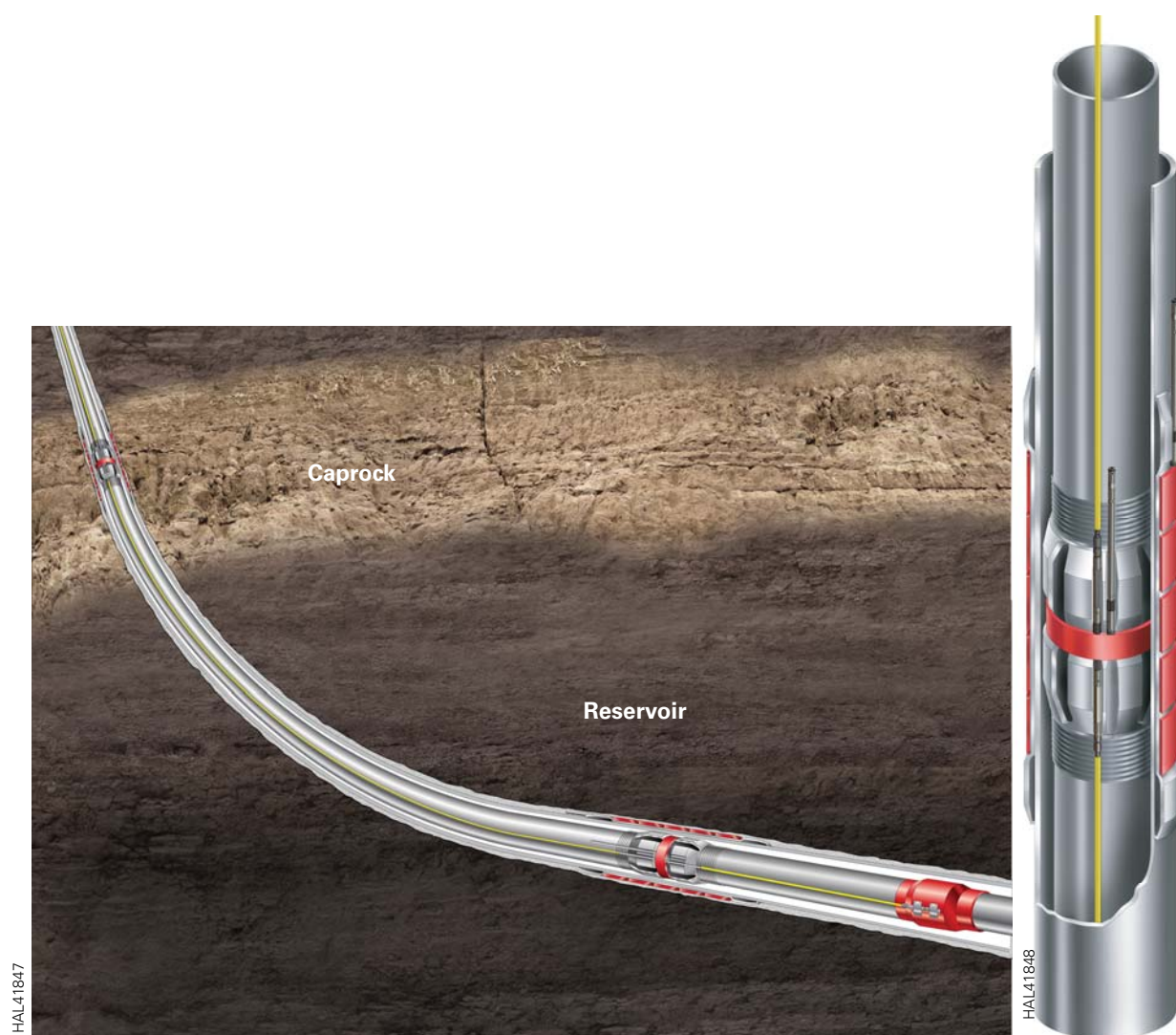
DataSphere® LinX® Monitoring System

Methods to monitor reservoir performance without shutting in the well and optimized reservoir performance are more important than ever before. Continuous reservoir pressure/temperature (P/T) monitoring behind casing would be ideal, but pore pressure only measures during the drilling phase. Injection profiles have costly safety factors, and unmonitored pressure regimes in the overburden results in costly and risky drilling operations.

The DataSphere® LinX® monitoring system is a step change in reservoir monitoring enabled by wireless through-casing power and communication. With the LinX system, sensors are permanently placed behind the well barriers to monitor without compromising well integrity or

changing the well design and without significant revisions to the drilling program.

The LinX monitoring system is a wireless through-wellbore technology that enables placement of a permanent P/T gauge behind the casing or liner in the cement. It uses electromagnetic power and communication to drive and communicate with the sensors without batteries or extra barrier penetrations. Power and communication with the surface is provided by industry-standard cable and an IWIS interface card. This enables the system to be combined with traditional downhole monitoring on a single cable.



DataSphere® LinX® Monitoring System

Behind Casing Reservoir Monitoring

The DataSphere® LinX® system senses any pressure/temperature (P/T) fluctuations in the formation. This enables the operator to detect pressure changes, while producing or injecting in:

- » Overburden
- » Caprock
- » Reservoir
- » Cement

This newly obtained knowledge yields significant benefits. Production increases, reduced drilling costs lower capital expenditure, and fewer integrity verification programs lower operating expenditure, all while helping ensure safe well operation and reducing risks of costly non-productive time.

Operation

LinX system monitoring is a three-step process powered by electromagnetic currents that power quartz P/T gauge sensors.

1. One sensor and coil are fitted on the casing or liner using a custom casing pup.
2. Another sensor and coil are fitted on the tubing using a custom tubing joint. The tubing-conveyed sensor is then connected to surface by means of a traditional downhole cable.
3. Using the two coils, electromagnetism powers and communicates with the casing-conveyed sensor. The electromagnetic transfer of power does not have the limitations of batteries. This helps enable unlimited data transfer throughout the life of the well as necessary for permanent monitoring.

Benefits

- » No periodic integrity tests necessary, which saves testing costs, reduces risks, and helps eliminate deferred production costs
- » Real-time barrier and in-situ reservoir status monitoring
- » Reservoir and integrity monitoring by continuously providing P/T from caprock and cement
- » Less need to compensate for insecurity with costly drilling programs
- » Customizable to any well design — single, multizone, intelligent, standard, subsea, dry tree, etc.
- » Compatible with the DataSphere ROC™ permanent downhole gauges because both can be run on the same interface card and downhole cable

Permanent Gauge

Pressure Range	0 to 10,000 psia
Temperature Range	32 to 302°F (0 to 150°C)
Accuracy	±5 psi/±0.1°C
Resolution	<0.02 psi/<0.01°C
Drift at Maximum Pressure and Temperature (per year)	<2 psi <0.2°C
Cable Type	1/4-in. OD monoconductor/ tubing encapsulated conductor
Gauge Diameter	3/4 in. (19.05 mm)
Gauge Material	Inconel® 718 per NACE MR-0175
Electrical Wellhead Requirements	1-pin conductor: 0.75 mm ² feed through
Downhole Network Capacity per Cable	12 single/6 A/B-annulus nodes or combination
Seals	All primary seals are metal-to-metal

DataSphere® LinX® B-Annulus Pressure/Temperature Monitoring

The DataSphere® LinX® monitoring system provides real-time reservoir and well integrity monitoring in subsea wells without the need to halt production.

The DataSphere LinX monitoring system monitors well integrity using wireless through-casing power and communication. With the LinX system, sensors are continuously communicating from behind the well barriers without compromising well integrity or changing the well design and without major revisions to the drilling program.

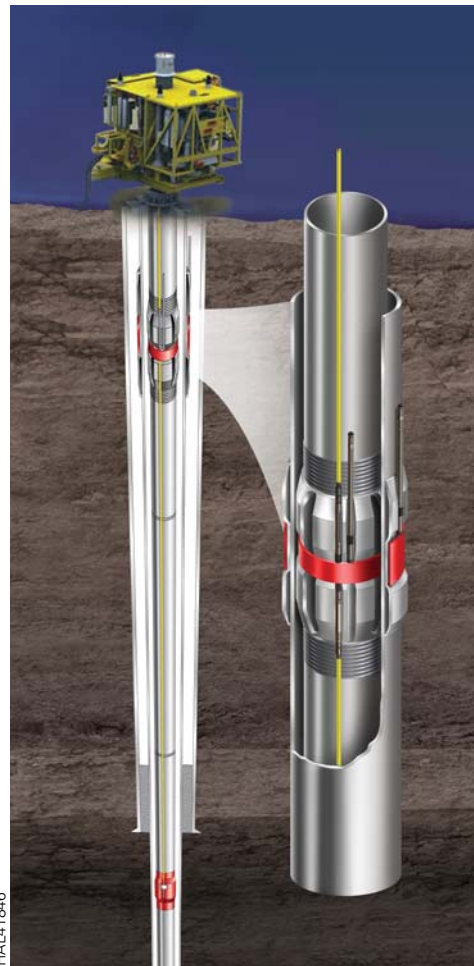
The LinX B-annulus pressure/temperature (P/T) monitoring system is a wireless through-wellbore technology that enables placement of a permanent P/T gauge behind the production casing in the B-annulus. The system uses electromagnetic power and communication to drive and communicate with sensors, without the need for batteries or extra barrier penetrations. Power downhole and communication with the surface is provided by industry-standard cable and an IWIS interface card. This enables the LinX system to be combined with traditional downhole monitoring on a single cable.

Why B-Annulus Monitoring

Subsea wells have enclosed volume in the B-annulus, which is prone to operator-induced pressure buildup. Many current subsea wells make use of the A-annulus for gas injection, moving the barrier from the A- to the B-annulus. This makes managing the pressure integrity of the wellhead more complex because the B-annulus on subsea wells is sealed off at the wellhead. The system picks up any P/T fluctuations, which enables the operator to detect pressure buildups during production. This new knowledge drives revenue up, while less costly casing programs drive capital expenditure down, thus helping ensure safe well operation and reducing the risks of costly interventions and non-productive time.

Benefits

- » No periodic integrity tests necessary, which saves testing costs, reduces risks, and helps eliminate deferred production costs
- » Real-time barrier status monitoring
- » Identification of potentially more low-cost remediation options before progressing to workover intervention
- » Less need to compensate insecurity with costly casing programs
- » Customizable to any well design — single, multizone, intelligent, standard, subsea, dry tree, etc.
- » Compatible with the DataSphere ROC™ permanent downhole gauges because both can be run on the same interface card and downhole cable



HAL41846

DataSphere® LinX® B-Annulus Pressure/Temperature (P/T) Monitoring System

Chemical Injection System

The Halliburton chemical injection system provides operators with precise wellbore chemical management that is designed to optimize flow assurance and production performance and reduce costly intervention.

Applications

- » Scale
- » Asphaltines
- » Emulsions
- » Hydrates
- » Foaming
- » Paraffin
- » Scavengers
- » Corrosion

Benefits

- » Maintains flow assurance
- » Optimizes production performance
- » Helps reduce costly intervention

Chemical Injection Mandrels

Two types of chemical injection mandrels are available.

- » The non-welded mandrel features a robust one-piece machined design for use in all applications, including deep water. This mandrel uses the same design criteria as the permanent downhole gauge mandrel.
- » The welded pup joint mandrel is designed for use in lower risk environments, such as shallow set, non-deviated wells, or land applications.

Dual Check Valves

Typical deepwater and higher risk applications use check valves with dual metal checks and dual metal-to-metal seals that are externally pressure testable in the valve-to-line connection. These valves come in various cracking pressures as well as specific flow ranges and have undergone extensive qualification testing. Metallurgy is typically Inconel® or MP35N.

Lower risk environments typically use a simpler valve with fewer special features, and metallurgy is often stainless steel or comparable.

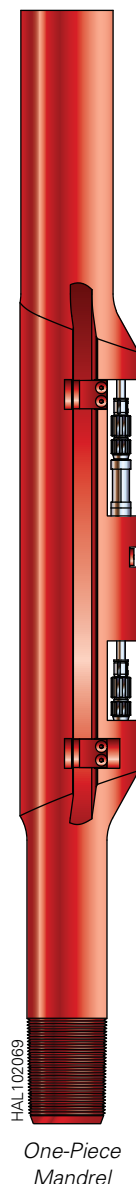
Both applications can use a burst disk to allow continual verification of control line pressure integrity during installation.

Injection Lines and Cable Protectors

Chemical injection lines are available in 316 stainless steel and Inconel 825 alloy as standard, with tubing sizes and wall thicknesses to suit all applications.

Inconel® is a registered trademark of Huntington Alloys.

The chemical injection lines are typically encapsulated or in a bundled configuration. Lines are supplied fluid-filled, flushed, and filtered to the client's cleanliness standard. Standard cast or pressed steel cable protectors secure the control lines while running in the hole.



One-Piece
Mandrel

Installation Services

Multiline spooling can be provided, including all necessary spooler units, hydraulic slip rings, pumps, filters, and sheave wheels. Full pump capability for operations is provided during running in hole and for commissioning the well. A fluid particle counting service, which is conducted by certified offshore technicians, is also supplied as necessary.

CheckStream® Chemical Injection System

The CheckStream® downhole chemical injection system features a dual-redundant check valve installed and protected by an industry-standard mandrel.

The CheckStream system provides precise wellbore chemical management, maintaining flow assurance and continuing production without costly intervention. The dual-redundant check valve allows delivery of chemical fluids to the wellbore while simultaneously preventing wellbore fluids and gas from entering the control line and migrating to the surface.

Features

- » Dual-redundant checks (hard and soft seats)
- » Field-installable burst disk with selectable ranges
- » Cracking pressures up to 1,000 psi
- » Range of flow rates up to 8 gal/min
- » Industry-proven testable, dual metal-to-metal (MTM) FMJ seal connectors
- » High-pressure, high-temperature ratings of 15,000 psi differential and 392°F (220°C)
- » Configurable for multi-point, single control-line injection applications
- » Extensive qualification testing performed to achieve the highest reliability

Benefits

- » Maintains flow assurance
- » Optimizes production performance
- » Helps reduce costly intervention

CheckStream Mandrel

The CheckStream mandrel features a one-piece machined design for all applications, including deep water. The one-piece mandrel uses the same design criteria as the permanent downhole gauge mandrel.

CheckStream Check Valve

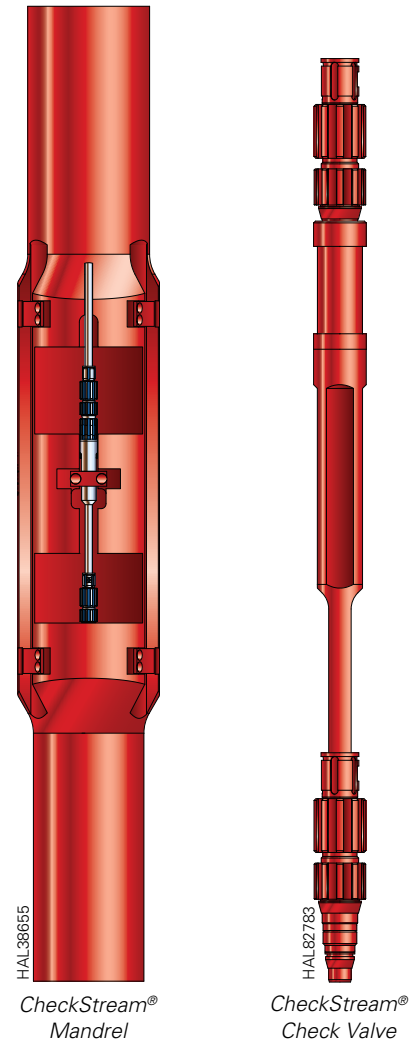
CheckStream dual-redundant check valve configurations include a range of flow, variable cracking pressures, and different connection sizes that provide a variety of options to best suit well conditions. The 3/8- and 1/2-in. variants enable burst disk installation in the field. The 1/4-in. variant comes with burst already installed.

Connections to the check valve are pressure testable, dual MTM seal FMJ connectors that deliver added protection compared to standard single MTM seal connections.

CheckStream System Qualification

Extensive qualification testing has been performed on CheckStream system mandrels, valves, and connectors to achieve the highest reliability in the industry.

The system valves endured thousands of pressure/temperature cycles using liquid and gas test mediums. Long-term endurance testing was also performed to help ensure optimal valve performance throughout the life of the well.



CheckStream® Check Valve

Size	Flow Rate	Cracking Pressure
in.	gal/min	psi
1/4	0.02 to 0.2	500
1/4	0.02 to 0.2	1,000
1/4	0.2 to 3.0	50
3/8	0.02 to 0.2	500
3/8	0.02 to 0.2	1,000
3/8	0.2 to 3.0	50
3/8	2.0 to 8.0	50
1/2	0.2 to 3.0	50
1/2	2.0 to 8.0	50

HALLIBURTON

Completion Tools

CS1 Chemical Injection Sub

The CS1 chemical injection sub is used to introduce chemicals that are pumped from surface via dedicated injection lines in the annulus into the tubing. The injection sub incorporates inline check valves that prevent tubing pressure from escaping back up the injection lines. A shear-out plug allows the injection line to be run under pressure.

Applications

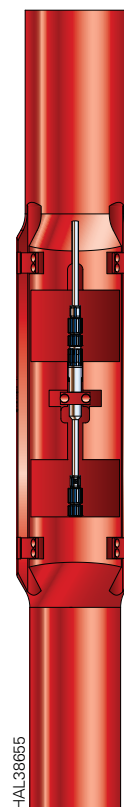
The CS1 chemical injection sub is used during chemical injection applications in which it is not possible or desirable to run side-pocket injection mandrels.

Features

- » One-piece injection sub body
- » Dual chemical injection
- » Nitrogen-tested check valves
- » Metal-to-metal seals
- » Emergency shear-out
- » Control-line pressure test

Benefits

- » Reliable chemical injection without the complexity of a chemical injection side-pocket mandrel
- » Allows the introduction of non-compatible chemicals



CS1 Chemical Injection Sub

CS1 Chemical Injection Sub

Casing Size		Tubing Size		Weight		Maximum OD		Minimum ID		Pressure Rating			
										Above		Below	
in.	mm	in.	mm	lb/ft	kg/m	in.	mm	in.	mm	psi	bar	psi	bar
5 1/2	139.70	2 7/8	71.75	7.9	11.76	4.450	113.03	2.229	56.62	7,500	516.75	7,500	516.75
7	177.80	3 1/2	88.90	9.2	13.69	5.800	147.32	2.949	74.90	7,500	516.75	7,500	516.75
9 5/8	244.48	4 1/2	114.30	12.6	18.75	8.000	203.20	3.880	98.55	7,500	516.75	7,500	516.75
						6.050	153.67	3.860	98.04	5,000	344.50	5,000	344.50
		5	127.00	15.0	22.32	7.515	190.88	4.339	110.21	5,000	344.50	5,000	344.50
						8.275	210.19	4.848	123.14	7,000	482.30	7,000	482.30
						8.265	209.93	4.892	124.26	5,000	344.50	5,000	344.50
						8.265	209.93	4.756	120.80	5,000	344.50	5,000	344.50
10 3/4	273.05	7	177.80	26.0	38.69	9.250	234.95	6.125	155.58	5,000	344.50	5,000	344.50
				29.0	43.15	9.250	234.95	6.098	154.89	5,000	344.50	5,000	344.50

Part Number Prefix: P.220CS1

Multiline Spooling Services

Halliburton multiline spooling services provide the physical link, both hydraulic and electrical, between surface control systems and downhole completion equipment during completion deployment.

This service comprises a variety of spooling units, sheave assemblies, clamping kits, hydraulic pressure units, and both electrical and hydraulic data acquisition units. The service also provides the skilled personnel necessary to operate the equipment.

Halliburton monitors real-time downhole pressure/temperature (P/T) data and maintains full functionality of all hydraulic tools during completion installation.

Features

- » Hydraulic slip rings on the spooling units handle up to six control lines to maintain full functionality of downhole tools while running in hole.
- » Electrical slip rings on the spooling units allow uninterrupted real-time data streaming while running in hole.
- » Data acquisition units rated to 30,000 psi provide real-time digital P/T readouts.

- » Heavy- and light-duty spooling units meet rig space and all Gulf of Mexico lifting requirements.
- » Heavy-duty sheave and spreader bar assemblies are rated up to 35 tons.
- » Engineered clamp boxes are designed to be lifted to the rig floor, eliminating the handling of wooden crates.
- » Multi-function pressure testing allows for simultaneous testing of up to five tubing hanger connections.
- » Custom specialty equipment includes electric submersible pump cable spooling units, dual-drum spooling systems inclusive of level winds, and small fluid-specific hydraulic power units.
- » Control cabins are certified to DNV 2.7-1, suitable for use in Class 1, Division 1 locations, and are A-60 fire rated.

Benefits

- » Fully functioning downhole tools offline help eliminate costly rig downtime.
- » Slip ring design helps eliminate the need for a technician to get inside the spooling unit.
- » Sheave assemblies are rated to withstand the breaking strength of multiple control line combinations.



Multiline Spooling Service

Digital Infrastructure

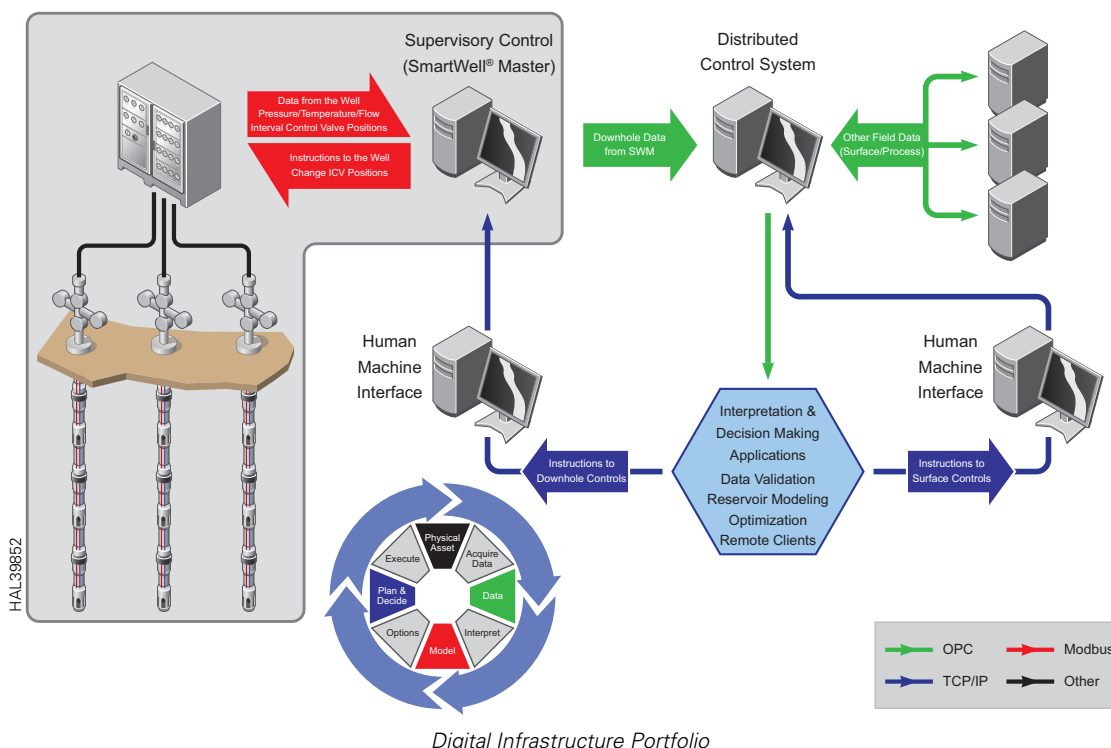
The Halliburton Digital Infrastructure surface control and monitoring system allows operators to monitor permanent downhole gauges (PDGs) and control downhole interval control valves (ICVs) from surface. Consisting of both electrical and hydraulic systems, Digital Infrastructure also provides the means for operators to remotely configure ICVs, expand deployed systems, and interpret and model data acquired by the system.

Benefits

- » Monitor and control PDGs
- » Remotely control and configure downhole ICVs
- » Connect to distributed control systems (DCS) and other third-party systems for monitoring and control
- » Provide remote power and communications for SmartWell® systems and DataSphere® permanent monitoring systems when infrastructure is not available

The Digital Infrastructure portfolio consists of the following electrical and hydraulic subsystems and applications:

- » SmartWell Master supervisory application — provides a central point of control and monitoring for SmartWell and DataSphere permanent monitoring systems.
- » XPIO data acquisition and control unit — allows operators to monitor and control downhole gauges and topside instrumentation.
- » UACU+ system — a larger variant of the XPIO system that enables monitoring of up to 10 wells/20 gauges.
- » Surface hydraulic system (SHS) — designed to supply pressurized hydraulic fluid to downhole SmartWell systems and provide automatic and manual control of downhole ICVs.
- » Subsea interface cards — allow users to monitor PDGs and control the reservoir management system completions in subsea applications. The cards reside in pods provided by subsea control system vendors.
- » Remote power systems — designed to support the Digital Infrastructure control systems and DataSphere permanent monitoring systems in areas where conventional power and, in some cases, where communications are unavailable, unreliable, or cost-prohibitive.



SmartWell® Master Supervisory Application

The SmartWell® Master supervisory application for the Digital Infrastructure system provides a central point of control and monitoring for SmartWell and DataSphere® permanent monitoring systems.

The SmartWell Master application is based on the ICONICS GENESIS32™ web-enabled human machine interface (HMI)/supervisory control and data acquisition (SCADA) software that runs on the Microsoft® Windows® operating system.

Features

- » Web-based HMI/SCADA visualization
- » Modular tool suite for visualization, HMI, and SCADA
- » GENESIS32 OPC-To-The-Core Technology™ system
- » Visual OPC alarming and event notification
- » OPC connectivity
- » Extensive diagnostics and analysis capabilities
- » Powerful data-mining technology
- » Custom configuration utility
- » International language switching and global aliasing
- » Visual control replay traceability playback

Benefits

- » Control SmartWell downhole equipment from a central location
- » Interface with external systems, including third-party computers and distributed control systems (DCS)

External System Connectivity

A custom external control module allows the SmartWell Master application to connect to an external system, such as a third-party computer or DCS for control and data handoff. Resource locking is utilized to help ensure control is available from either the SmartWell Master application or the external system. Both OPC and Modbus® versions are available.

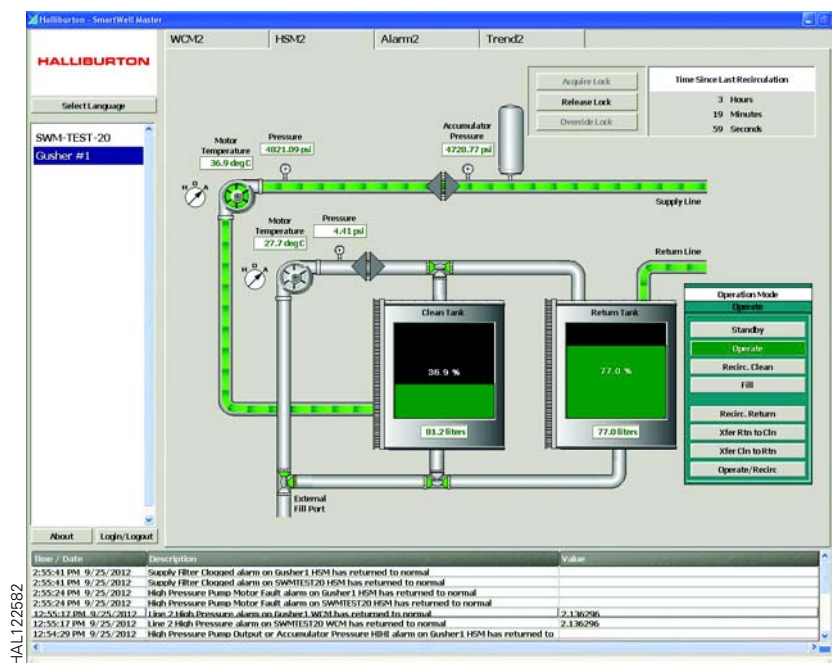
Displays

The SmartWell Master application features standard displays specifically designed for:

- » Hydraulic control modules (HCMs)
- » Well control modules (WCMs)
- » DataSphere permanent downhole monitoring
- » Alarming
- » Trending

A well configuration panel, which is a standard feature on the left-hand side of the screen, shows which wells are configured for the project. A standard alarm banner, located at the bottom of the screen, displays the most recent real-time alarms that have been raised.

Tabs at the top of the screen allow for easy switching between displays. Various hardware configurations are available, including standalone PC and rack-mount server with retractable VDU/keyboard/mouse unit.



Hydraulic Supply Module (HSM) Screen

Modbus® is a registered trademark of Schneider Automation, Inc.
Microsoft® Windows® is a registered trademark of Microsoft Corporation.

Modules

The SmartWell® Master application features several modules that can be enabled according to the operator's specific needs, including:

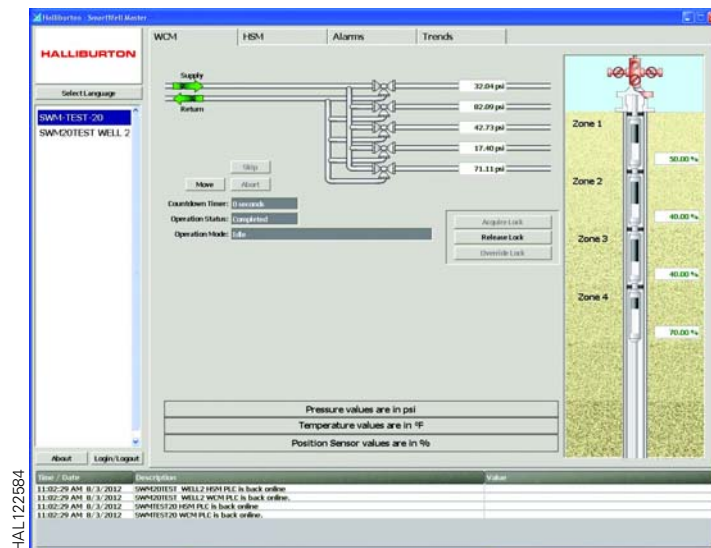
- » Human machine interface (HMI)
- » Historical data
- » External OPC interface
- » Remote client
- » Alarms and events
- » Microsoft .NET helper programs, such as calculation engines and external Modbus® data link modules

SmartWell® System Configuration

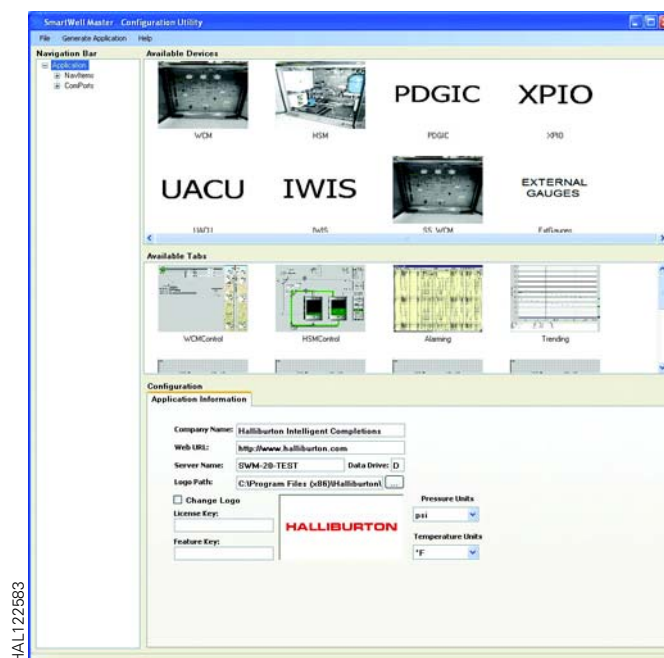
A custom configuration utility allows project-specific SmartWell systems to be built up in the SmartWell Master application by dragging and dropping standard functional modules.

Trending

Trending can be performed in real time or configured from historical data.



Well Control Module (VCM) Screen



SmartWell® Configuration Utility Screen

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Remote Power Systems

For circumstances in which conventional power is unavailable, unreliable, or cost-prohibitive, Halliburton offers a wide variety of remote power systems. Each system is designed to support the Digital Infrastructure control systems and DataSphere® permanent monitoring systems including:

- » XPIO data acquisition and control units
- » Surface hydraulic system (SHS)

Depending on site conditions and available resources, operators can choose from solar, wind, thermoelectric generator (TEG), solar-powered air compressors, engine generator-set (gen-set), or DC-UPS systems, either individually or in combination. Systems use existing local resources and enable wireless communication to remote locations. Offshore systems use solar power with wind power backup.

The remote power systems used by Halliburton are completely self-contained, pre-assembled, and tested before shipment and are specifically tailored for the electrical load and climatic conditions of each particular site.

Reliability

Health and safety margins are built into each remote power system to help ensure high reliability and continuous operation. Like all Halliburton equipment and electronics, remote power systems are pre-wired inside custom enclosures and fully factory-acceptance tested (FAT) before shipment.

Selecting the Appropriate Remote Power System

Among the most crucial considerations related to selecting an appropriate remote power system is the year-round availability of sunlight. Every remote power system must be able to perform reliably during even the most inclement weather. Accurate load information is also important, particularly if communications equipment is included.

Generally, solar photo voltaic (SPV) cells are the preferred method for providing remote power because of their simplicity, reliability, and cost-effectiveness. The solar panel/battery combination is determined by accurately calculating the total power consumption of the data acquisition and control equipment and then sizing the system based on the worst weather conditions. A safety margin is included.

SPV Systems

SPV systems convert sunlight to DC electricity and are the preferred choice in most circumstances. Solar power can be used in conjunction with wind, TEG, or gen-set systems.

Wind Generators

Modern electrical windmills harness wind power that can complement solar power in conditions with intermittent sunlight. Regular maintenance and repair are required.

Thermoelectric Generators

TEGs burn natural gas and are extremely reliable when natural gas is readily available. They can also be a good supplement to solar power. A separator is normally required if the gas is "wet."

DC-UPS Systems

DC-UPS systems are recommended during situations in which power is dirty, intermittent, or unreliable. Additional filtering and surge suppression are offered in addition to backup.

Gen-Set Systems

Gen-set systems use conventional fuel to charge a large battery bank. They can be used to supplant solar power and charge batteries in temporary applications or during circumstances in which weather extremes make other options unattractive.



XPIO Data Acquisition and Control Unit

The Halliburton XPIO data acquisition and control system allows operators to monitor and control downhole gauges and topside instrumentation. Acquiring data at a rate of 0.5 seconds per gauge, the XPIO system is available in a range of capacities, from one well/four gauges to four wells/eight gauges. A larger variant within the XPIO range is the UACU+, which extends capacity up to 10 wells/20 gauges for a single unit. The UACU+ is fitted with a permanent downhole gauge interface card (PDGIC) module for each downhole channel.

Downhole cable inputs are independent and fully isolated.

Features

- » Up to four permanent downhole gauge (PDG) communications channels (up to 10 for UACU+)
- » Five channels of 4-20 mA analog inputs (12 bit)
- » Four channels of 4-20 mA analog outputs (16 bit)
- » 8-MB onboard flash memory plus 4 GB of CompactFlash memory
- » Modbus® RTU protocol support via the RS-485 or RS-232 port or via the TCP/IP port
- » Modem communications support via the RS-232 port
- » Two relay contacts
- » Communications programs that allow full configuration of the unit

Benefits

- » Control PDGs, including the DataSphere® ROC™ and SmartLog™ gauges and surface instruments
- » Store and display data from Halliburton PDGs and surface sensors
- » Interface with external systems, including third-party computers and distributed control systems (DCS)

Analog Inputs

The XPIO system features five channels of 4-20 mA inputs (12 bit) that are fully configurable using the XPIO 2K PC program. Users can set the offset, span, and units of measure and then can choose to monitor them on the display or log them into memory.

Analog Outputs

The XPIO system features four channels of 4-20 mA outputs (16 bit). Users can select the pressure, temperature, span, and offset of a PDG, and the XPIO system will drive the translated value onto an output as it is decoded from downhole.

Memory Logging

The XPIO system includes 8 MB of onboard flash memory. A CompactFlash card extends the memory by 4 GB as standard.

The standard 4-GB CompactFlash provides memory capacity to hold pressure and temperature data from two gauges at 1-second updates for more than 1 year.

The data are retrieved via an RS-232 port using the supplied PC program or by file transfer protocol (FTP) over the TCP/IP link and can easily be imported to other applications, such as a spreadsheet. Data are logged to memory at a maximum rate of once per second.

Both the standard XPIO and UACU+ are available in NEMA 4X enclosure and 19-in. rack-mount versions. The 19-in. rack-mount UACU+ has a capacity of 10 wells/20 gauges.

Serial Communications

The XPIO system supports Modbus RTU protocol via its RS-485 or RS-232 port or via its TCP/IP port. These interfaces are fully configurable in terms of parity, baud rate, etc. As a slave device, the XPIO system provides gauge data (i.e., pressure and temperature) that can be polled as well as data from any of the 4-20 mA inputs. Time and date are also available.

Modem Support

The XPIO system supports modem communications via the RS-232 port. Users can dial into the unit using the supplied XPIO 2K PC program or use the port to talk to Modbus over a radio modem, cellular modem, or regular modem.

Pressure-Controlled Relay Contacts

The XPIO system includes two relay contacts (1/2 A at 115 VAC), which are controlled by software. When a selected gauge's pressure rises above or falls below a set pressure, the contact is closed. This feature is ideal for alarms and/or pump control.

Web-Installed PC Application

The XPIO system includes a web-installed application that provides for full configuration of the unit as well as data memory retrieval, real-time logging of data to the computer hard drive, and real-time data trending.

The application communicates with the XPIO system via a standard RS-232 port and runs under Microsoft® Windows® 2000/XP/Vista/Win10.

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Microsoft® Windows® is a registered trademark of Microsoft Corporation.

Operating Information

- » 110/250-VAC or 10-36-VDC power input
- » 14-W power consumption plus 1 W per gauge for XPIO
- » 10-W power consumption plus 2 W per PDGIC plus 1 W per gauge for UACU+
- » -10 to 65°C operation

Gauges Supported

- » DataSphere® ROC™ permanent downhole gauges
- » DataSphere SmartLog™ gauges

Communication Ports

- » 2 x RS-232
- » 1 x RS-485
- » Ethernet

Port Usage Options

- » One RS-232 dedicated to the XPIO 2K PC program
- » Modbus® RTU
- » Modem support (radio/cell)
- » TCP/IP via ethernet (optional)

Inputs

- » Five 4-20 mA inputs (12 bit)
- » One 16-bit A/D (tool current)

Outputs

- » Four 4-20 mA outputs (16 bit)
- » Two pressure-controlled relays

Memory

- » 8-MB onboard flash memory
- » 4-GB CompactFlash memory

Enclosure

- » NEMA 4 type water resistant
- » Anodized aluminum
- » 19-in. rack-mount option
- » ATEX explosion proof

Variants

- » XPIO one well/eight gauges
- » XPIO-QT+ four wells/eight gauges
- » UACU+ 10 wells/20 gauges
- » UACU+ 19-in. rack five or 10 wells/20 gauges



*XPIO Data Acquisition
and Control Unit*

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Hydraulic Systems

The Halliburton surface hydraulic system (SHS) supplies pressurized hydraulic fluid to the downhole SmartWell® systems and provides automatic and manual control of downhole interval control valves (ICVs).

A standalone self-contained unit, the SHS consists of an electro-hydraulic or pneumatic supply capable of delivering pressurized fluid up to 10,000 psi. It is housed in a single stainless steel enclosure that includes one main hydraulic supply module (HSM) and up to six well control modules (WCMs) with expansion capabilities.

Part of the Digital Infrastructure system, SHS units are available in a range of designs for every environment.

- » The integrated system consists of the SmartWell Master supervisory application and an SHS consisting of an HSM and WCM per well. Data acquisition and control is managed either locally at the SmartWell Master server or remotely.
- » The automated system is an SHS, which includes an HSM and WCM per well. If the SmartWell Master application is not used for control, the SHS can be controlled via a distributed control system (DCS) through direct Modbus® interface to the programmable logic controllers (PLCs).
- » The manual system consists of the same basic hardware as the automated or remote control. Manually operated valves are used throughout.

In subsea applications, SmartWell system control is provided by hydraulic functionality from the third-party subsea controls company.

Features

- » A variety of physical configurations for well type, number of zones, and completion details
- » Modules that allow for remote control and monitoring by the SmartWell Master supervisory application

Benefits

- » Remote operation of well and automated tool moves
- » Logging and monitoring of well conditions
- » Modular system allows costs to be distributed among multiple wells

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Surface Hydraulic System (SHS)

Enclosure Features

The surface hydraulic system features several modules that can be enabled according to the operator's specific needs, including:

- » 316 stainless steel, built to NEMA 4X
- » Removable latching doors
- » Sloped drip pan
- » 4X lifting eyes
- » Flame arrestor
- » Ergonomic design
- » Lexan® door windows
- » Durability for harsh environments

Modules

The basic SHS contains the following modules:

- » HSM
- » WCM

Lexan® is a registered trademark of SABIC Global Technologies B.V.

The SHS is designed for hazardous area applications, including IEC/Cenelec Zone 1 (ATEX 2), NEC Class 1 Division 1, NORSOK. Automated systems can be controlled and monitored remotely by the SmartWell® Master supervisory application or from a third-party computer by the Modbus® system over TCP/IP communications to the programmable logic controller (PLC) in the hydraulic and well control units.

In single-well cabinets, the hydraulic supply module (HSM) and well control modules (WCMs) are combined into a single unit. For automated systems, hydraulic control and well control functionality is also combined in a single PLC.

The hydraulic control/well control unit firmware, developed in IEC 61131-3 standard language, automates the sequences and levels of pressure necessary to operate the SmartWell system completion and receives feedback from the interval control valve (ICV) movement from surface sensors.

Hydraulic Supply Module

The HSM provides control fluid to the WCM at the required pressure and cleanliness. Material selection for some HSM components can change according to the type of pressure and control fluid used.

The HSM contains the tanks necessary to store and filter control fluid. For optimal performance of downhole equipment, all HSM designs are provided with a recirculation capability for managing control fluid cleanliness. Although the standard product contains two tanks and two pumps, several variations — including one tank and one pump — are available, depending on the number of wells and operational philosophy.

The HSM provides all the electrical/hydraulic connections for connection to the WCMs. The HSM controls and manages system operation manually (switches) or automatically (pressure transmitters and PLCs). In automated systems, the hydraulic control unit houses the PLC and its accessories. The unit can also be housed in a remote electronics cabinet with cable connecting between the two.

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Hydraulic Supply Module (HSM)

The HSM consists of:

- » Clean supply reservoir (typically 220 L)
- » Return reservoir (typically 95 L)
- » Main hydraulic supply pump
- » Recirculation pump
- » Accumulator (up to 10,000 psi)
- » Filters (1 micron)
- » Relief valves
- » Tubing/fittings (up to 10,000-psi rated)
- » Hydraulic control unit junction box

Well Control Module

A well control module (WCM) provides a means of applying pressure sequences to hydraulic control lines and therefore a manner of manipulating the downhole tools. Pressurization and venting of the control lines is achieved using manual or automatic control by positioning the valves into supply/block/vent modes as required.

Designed for both reliable performance in the target environment and quick installation for future expansion, WCMs are interchangeable modules that can be combined with the same cabinet for multi-well applications, thus providing a flexible base for future expansion.

In automated systems, each WCM is controlled by a dedicated well control unit programmable logic controller (PLC).

The number of hydraulic lines required to operate a particular SmartWell® completion system depends on the selected control system (Digital Hydraulics™ or Direct Hydraulics systems) and the number of downhole valves in the well.

A WCM contains the following components:

- » Solenoid directional control valves
- » Pressure transmitters (24 VDC, 4-20 mA, 1-5 VDC for low power)
- » Hydraulic pressure gauges (up to 10,000 psi)
- » Three-way manual control valves
- » Relief valves and bleed valves
- » External connection bulkhead
- » WCM junction box



Well Control Module (WCM)

Physical Configurations

The surface hydraulic system (SHS) comes in various physical configurations, depending on well type, number of zones, and completion details. For example:

- » Eight-well expansion cabinet
- » Six-well cabinet
- » Two-well cabinet
- » Four-well expansion cabinet
- » One-well cabinet

Both automated and manual versions of the SHS are available.

Subsea Interface Cards

Halliburton offers a range of subsea interface cards to enable monitoring of permanent downhole gauges and control intelligent completion systems. Each subsea interface card resides in the pod provided by the respective subsea controls vendor. The Halliburton IWIS gauge interface card is the standard interface card used for any subsea supplier that conforms to the IWIS standard. Other variants are available upon request.

Features

- » Supports up to 20 gauge slots
- » Operating temperature range: -20 to +70°C
- » Supply voltage: +20 to +28 VDC
- » Maximum power consumption: 24 W
- » Actual power consumption: 4 W + 1 W per single-sensor DataSphere® ROC™ gauge
- » Heat dissipation <6.0 W
- » Gauge supply voltage: +48 VDC
- » Maximum gauge supply current: 250 mA
- » Conforms to ISO 13628-6



