Schlumberger

ResFlow

Inflow control device

APPLICATIONS

- Production wells requiring flow control
- Vertical, deviated, and horizontal completions
- Openhole stand-alone completions
- Homogenous and heterogeneous sandstone and carbonate reservoirs
- Long and extreme-reservoir-contact wells

ADVANTAGES

- Ensures balanced flow profile
- Balances inflow from the outset, providing more efficient well cleanup from heel to toe
- Delays water and gas breakthrough
- Significantly reduces water cut and gas/oil ratio
- Provides simple production management of multiple zones in openhole completions
- Ensures safer and more efficient installation of the lower completion because of mechanically robust assembly
- Has removable housing for wellsite nozzle optimization based on LWD data

FEATURES

- Designed pressure drop achieved through combination of ceramic nozzles
- Pressure drop across nozzles independent of fluid viscosity (Bernoulli's principle)
- Ability to exert higher backpressure in high-rate sections so low-flow-rate zones are stimulated to produce more
- Optimal inflow control device (ICD) completion design modeled using Schlumberger best-in-class steady-state and dynamic simulators
- Risk of plugging eliminated due to nozzles at least 10 times larger than screen slot openings
- ICD validated through extensive flow, erosion, and mechanical integrity testing

The ResFlow* inflow control device (ICD) is designed to optimize production in openhole completions by balancing the inflow along the entire length of the wellbore. In high-permeability or high-pressure zones, the ResFlow ICD exerts higher backpressure than in less productive zones because of the higher fluid velocity (ΔP is proportional to linear velocity squared). Consequently, low-productivity zones are stimulated to produce more than in normal screen completions; therefore, hydrocarbon recovery increases.

Integrated system

The ResFlow ICD, combined with the strength and accuracy of a Schlumberger sand screen, becomes a production management system in which sand control and inflow control are intelligently integrated in a simple, robust, and reliable solution. This integration is achieved without the need for downhole telemetry; the system is self-regulating by design.

ICD construction

Each joint includes a sand screen on unperforated basepipe with a ResFlow ICD housing located at the end of the screen. The produced fluid flows from the annulus through the screen, between the screen medium and basepipe into the housing, and then through the nozzles into the production tubing. For carbonate reservoirs, the screen section is shortened, providing a cost-efficient debris barrier to avoid plugging of the nozzles.

Benefits

An important benefit of the ResFlow ICD is its ability to minimize risk of bypassing reserves, thereby increasing recovery. The ICD provides a significant reduction in water and gas rates, or both, when these breakthrough phases have higher mobility than the oil in the reservoir. Because of its robustness and simplicity, the device also contributes to reduced development and well intervention costs and to prolonged completion life.

Combined inflow and injection control

When multiple wells across a field are being managed, reservoir modeling and optimization of producer and injector interaction using both the ResFlow ICD and the ResInject* injection control device offer additional reservoir management benefits. The Schlumberger in-house ICD Advisor* inflow control device planning software allows engineers to design the optimal solution for each set of reservoir conditions.

ResFlow inflow control device.

ResFlow CV

Check-valve ICD

APPLICATIONS

- Extended-reach completions
- Mid-to-high tier completions
- Stand-alone screen completions in oil-producing reservoirs
- Multizone openhole completions with hydraulic-set packers
- Openhole horizontal to highly deviated wells
- Carbonate and sandstone reservoirs

BENEFITS

- Saves rig time, especially beneficial for offshore operations
- Eliminates washpipe rental costs
- Enables longer BHAs and increased reservoir access through reduced string weight
- Streamlines operational logistics
- Simplifies operations due to elimination of requirement for a fluid loss control device

FEATURES

- Drop-in replacement for standard ResFlow ICD nozzle
- Preservation of washdown capability without a washpipe
- Ability to function through multiple pressure cycles before production starts
- Ability to use openhole, hydraulically set packers
- Proven ball check-valve technology
- No protrusion into basepipe ID
- Ball options:
  - aluminum ball dissolved before production with acid-base breaker system
  - ceramic ball produced out with hydrocarbons

The ResFlow CV* check-valve ICD is an inflow control device that eliminates the need to deploy washpipe for well cleanup (fluid displacement) and for setting openhole hydraulically set packers. The check-valve assembly, which includes a ceramic nozzle, a ceramic or aluminum ball, and an aluminum plate, is used instead of the standard ResFlow ICD nozzle assembly within the ICD housing. The check-valve assembly prevents fluid loss through the nozzles during washdown and then controls the flow of hydrocarbons during production in the same way as a conventional ResFlow ICD.

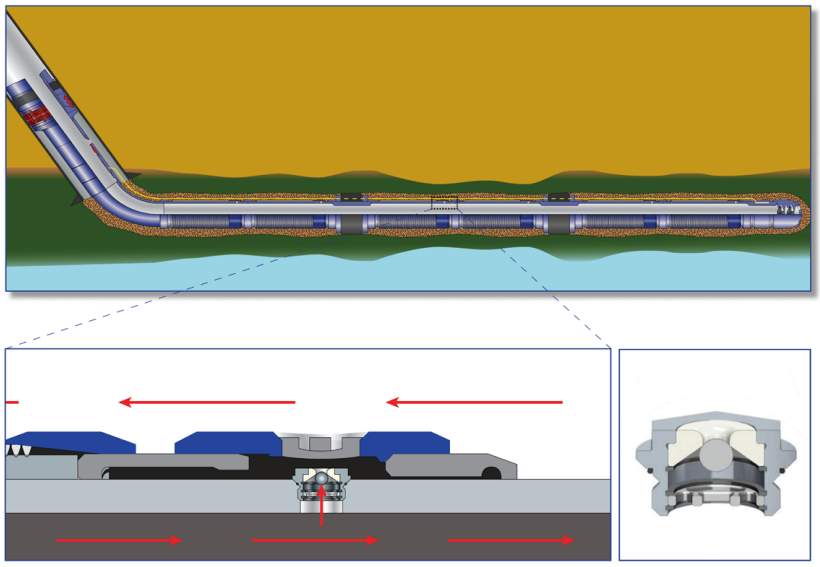
The ResFlow CV ICD is designed for use in openhole completions with certain procedures to help ensure completion string hydraulic integrity, including circulation of fluid to the toe of the well (for example, while the completion string is being run inhole or during fluid displacement) and application of pressure to wellbore fluids. In extended-reach wells, eliminating washpipe deployment—and consequently, washpipe weight and rental costs—helps reduce costs and increase operational efficiency, safety, and logistics. It also enables the use of longer BHAs, thereby increasing reservoir access.

ICDs deployed without washpipe with no fluid lost through nozzles

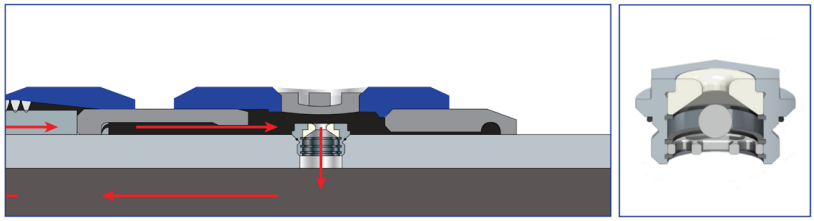
During the running in hole of the screen completion, the ResFlow CV ICD ball closes the check valve as pumping pressure is applied, preventing the fluid from leaking into the annulus through the nozzle. The fluid must instead travel the length of the completion string to the toe before returning up the annulus. This design feature also enables the setting of openhole hydraulically set packers.

Fluid path through nozzle reinstated before start of production

The aluminum ball and plate are removed from the wellbore by a standard fluid displacement technique with a breaker system. The ceramic ball can be used to control fluid loss while the upper completion is being run or if packers need to be set. When the pressure is released or pumping stops, this ceramic ball drops back onto the plate, enabling fluid to flow into the string again. It eventually flows back to surface with produced hydrocarbons, and the seat erodes. Afterward, the check-valve ICD behaves like a conventional ResFlow ICD nozzle.



When fluid is being pumped downhole, fluid pressure causes the ball to seal the ResFlow CV check-valve ICD assembly, preventing fluid loss through the nozzle. The ball dissolves or flows back before production starts, opening the valve to flow.



When the ball is removed, hydrocarbons can flow from outside the annulus through the screen filter into the ICD housing and then into the basepipe through the nozzle.

ResFlow SP & ResFlow MP

Single-position sleeve ICD and multiposition sleeve ICD

APPLICATIONS FOR RESFLOW SP

- Wells with direct vertical access
- Multizone openhole completions with hydraulic-set packers

BENEFITS OF RESFLOW SP

- Cost-effective solution to optimize recovery during well life cycle
- Enhanced reservoir management
- Decreased produced water handling costs
- Optimized production facility capabilities
- Ability to deploy in open or closed position and to mechanically cycle open and close
- Preservation of washdown capability without washpipe
- Ability to shut off unwanted water/gas breakthrough
- Compatibility with nozzles (including check-valves) that are field replaceable
- Integration into basepipe of the screen joint
- Actuated with commercially available third-party shifting tools
- Intervention available with:
  - ACTive* family of live downhole coiled tubing services with real-time depth correlation
  - ReSOLVE* instrumented wireline intervention service with universal shifting tool for real-time depth correlation
- Ability to include commercially available water tracer to identify water influx interval

APPLICATIONS FOR RESFLOW MP

- Stimulation
- Steam distribution

ADVANTAGES OF RESFLOW MP

- Two or three ports used as as openings or configured for injection or inflow control
- Short sleeve and shorter valve travel for easy activation
- No risk of false positives
- Patented volume diversion seals
- Improved resistance to sticking
- Ability to be configured with a variety of nozzle styles (CrossFlow, SecureFlow, StandardFlow)

Single-position ICD

ResFlow SP* single-position sliding sleeve ICD is used with the ResFlow ICD for openhole completions to shut off unwanted water/gas breakthrough. It can also be run in closed position to provide the completion string with the hydraulic integrity required for various operational procedures, eliminating the need for washpipe. These procedures include circulation to the toe of the well and operations requiring application of pressure to wellbore fluids.

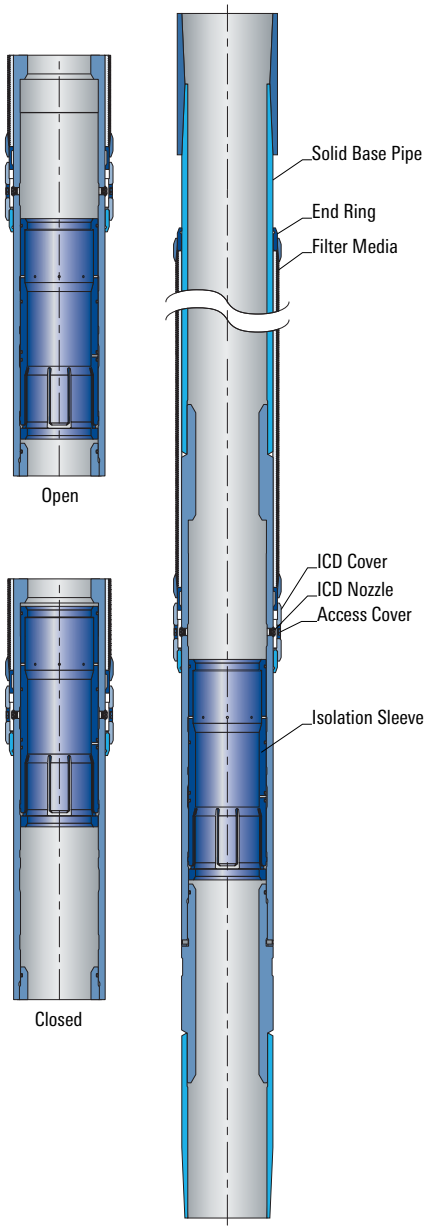
The ResFlow SP ICD houses an integrated isolation assembly, which consists of a sliding sleeve that closes the ports in the basepipe, entirely shutting off flow through the screen joint. This sliding sleeve is actuated by deploying a shifting tool designed to match profile and size of the isolation sleeve, which in turn is dependent on the basepipe size.

The recommended shifting tools for the ResFlow SP ICD's isolation sleeves are flow-activated shifting tools for coiled tubing intervention or universal shifting tools for wireline intervention. These tools can be run in completions with multiple sleeves to selectively open some sleeves without disturbing the others.

Multiposition ICD

ResFlow MP* multiposition sliding sleeve ICD allows operators to dynamically manage the pressure profile along horizontal wells and drive optimum well performance from complex reservoir intervals. The unique valve and port system can be actuated for a variety of production and injection operations over the life of the well.

The ResFlow MP ICD consists of a multiposition valve integrated with either two or three ports, which can be left as simple openings or configured with nozzles suitable for either injection or inflow control. A Harrier™ shifting tool, run on coiled tubing, is used to shift the position of the valve to expose different port configurations.



ResFlow

ResFlow ICD Specifications

Basepipe Size, in [mm]	Basepipe Weight, lbm/ft [kg/m]	Min. Basepipe ID, in [mm]	Additional Assembly Weight,† lbm/ft [kg/m]	Max. Screen OD, in [mm]	Max. Tensile Rating,‡ lbf [N]	Max. Torque Rating,‡,§ ft.lbf [N.m]	Max. Collapse Rating,‡ psi [kPa]	Max. Burst Rating,‡ psi [kPa]
4.000 [101.6]	9.5 [14.1]	3.55 [90.2]	5.2 [7.7]	5.00 [127]	180,100 [801,124]	12,400 [16,812]	5,500 [37,921]	2,700 [18,615]
4.000 [101.6]	11.0 [16.4]	3.48 [88.4]	5.2 [7.7]	5.00 [127]	206,500 [918,557]	11,000 [14,914]	5,500 [37,921]	2,700 [18,615]
4.500 [114.3]	11.6 [17.3]	4.00 [101.6]	5.5 [8.2]	5.50 [139.7]	229,200 [1,019,532]	15,800 [21,422]	5,500 [37,921]	2,400 [16,547]
4.500 [114.3]	12.6 [18.8]	3.96 [100.6]	5.5 [8.2]	5.50 [139.7]	247,100 [1,099,155]	17,200 [23,320]	5,500 [37,921]	2,400 [16,547]
5.000 [127]	15.0 [22.3]	4.41 [112.0]	6.0 [8.9]	6.00 [152.4]	305,200 [1,357,597]	22,400 [30,370]	5,500 [37,921]	2,200 [15,168]
5.000 [127]	18.0 [26.8]	4.28 [108.7]	6.0 [8.9]	6.00 [152.4]	367,200 [1,633,386]	26,200 [35,522]	5,500 [37,921]	2,200 [15,168]
5.500 [139.7]	17.0 [25.3]	4.89 [124.2]	6.6 [9.8]	6.50 [165.1]	350,900 [1,560,880]	26,600 [36,065]	5,500 [37,921]	2,100 [14,478]
5.500 [139.7]	20 [29.8]	4.78 [121.4]	6.6 [9.8]	6.50 [165.1]	411,700 [1,831,333]	34,100 [46,233]	5,500 [37,921]	2,100 [14,478]
6.625 [168.3]	20 [29.8]	6.05 [153.7]	7.8 [11.6]	7.62 [193.5]	415,200 [1,846,902]	41,000 [55,588]	3,400 [23,442]	1,700 [11,721]
6.625 [168.3]	24.0 [35.7]	5.92 [150.4]	7.8 [11.6]	7.62 [193.5]	501,900 [2,232,562]	48,600 [65,893]	5,500 [37,921]	1,700 [11,721]
6.625 [168.3]	28.0 [4.7]	5.79 [147.1]	7.8 [11.6]	7.62 [193.5]	587,700 [2,614,220]	55,894 [75,782]	5,500 [37,921]	1,700 [11,721]
7.000 [177.8]	23.0 [34.2]	6.37 [161.8]	8.2 [12.2]	8.00 [203.2]	484,500 [2,155,163]	49,200 [66,706]	3,800 [26,200]	2,000 [13,789]

†Data based on 32-ft filter.
‡ Data based on 12 GA, 316L, direct-wire-wrapped screen, 80,000-psi basepipe, R3, SLHT.
§ Torque value based on 80,000-psi, SLHT coupling.
Note: ISO certifications are available on request.

ResFlow MP ICD Specifications

Casing Size, in [mm]	OD, in [mm]	ID, in [mm]	Liner Weight, lbm/ft [kg/m]	Liner Drift, in [mm]	Max. Tensile Load,† lbf [N]	Max. Burst Pressure, psi [MPa]	Max. Collapse Pressure, psi [MPa]	Open Port Flow Area, in^2 [mm^2]	Material	Upper Thread	Lower Thread
3.5 [88.9]	4.60 [116.8]	2.89 [73.4]	9.2 [13.7]	2.870 [72.90]	159,000 [707,267]	10,000 [68.95]	10,000 [68.95]	2.8 [1,806.4]	L-80	3.5 NUE	3.5 NUE
4 [101.6]	5.10 [129.5]	3.37 [85.6]	11.0 [16.4]	3.350 [85.09]	144,000 [640,544]	8,000 [55.16]	8,000 [55.16]	4.2 [2,709.7]	L-80	4.0 NUE	4.0 NUE
4.5 [114.3]	5.50 [139.7]	3.90 [99.1]	11.6 [17.3]	3.880 [98.55]	211,000 [938,574]	8,000 [55.16]	8,000 [55.16]	2.6 [1,677.4]	L-80	4.5 LTC	4.5 LTC
5 [127.0]	6.00 [152.4]	4.30 [109.2]	15.0 [22.3]	4.280 [108.71]	294,000 [1,307,777]	8,000 [55.16]	8,000 [55.16]	2.1 [1,354.8]	L-80	5.0 LTC	5.0 LTC
5.5 [139.7]	6.63 [168.4]	4.82 [122.4]	17.0 [25.3]	4.800 [121.92]	337,000 [1,499,050]	8,000 [55.16]	8,000 [55.16]	2.6 [1,677.4]	L-80	5.5 LTC	5.5 LTC
5.6.625 [168.3]	7.80 [198.1]	5.82 [147.8]	24.0 [35.7]	5.800 [147.32]	337,000 [1,499,050]	8,000 [55.16]	8,000 [55.16]	2.6 [1,677.4]	L-80	6.625 LTC	6.625 LTC

†Tensile strengths states are designed to match or exceed standard liner tensile strengths.

ResFlow SP ICD Specifications

Max. temperature, degF [degC]	300 [149]					
Sliding sleeve pressure rating, psi [kPa]	5,000 [34,473]					
Sliding sleeve material	4130/4140 L80, 13 Cr L80					
Seals material	Viton® or customer request					
Screen size, in [mm]	4.5 [114.3]	4.5 [114.3]	4.5 [114.3]	5.5 [139.7]	5.5 [139.7]	6.625 [168.3]
ID, in [mm]	2.813 [71.45]	3.125 [79.38]	3.313 [84.15]	3.813 [96.85]	3.813 [96.85]	4.562 [115.87]
Basepipe weight, lbm/ft [kg/m]	11.6 [17.3]	11.6 [17.3]	11.6 [17.3]	17 [25.3]	20 [29.8]	24 [35.7]
Upper completion						
Min. tubing OD, in [mm]	3.5 [88.9]	4 [101.6]	4 [101.6]	4.5 [114.3]	4.5 [114.3]	5.5 [139.7]
Tubing weight, lbm/ft [kg/m]	9.2 [13.7]	11.6 [17.3]	11.6 [17.3]	13.5 [20.1]	13.5 [20.1]	17.0 [25.3]
Min. tubing drift, in [mm]	2.867 [72.8]	3.303 [83.9]	3.303 [83.9]	3.795 [96.4]	3.795 [96.4]	4.767 [121.1]
Intervention						
ReSOLVE service max. OD, in [mm]	3.2 [81.3]	3.2 [81.3]	3.2 [81.3]	3.2 [81.3]	3.2 [81.3]	4.3 [109.2]
Max. CT OD, in [mm]	2.72 [69.1]	3.06 [77.7]	3.25 [82.6]	3.75 [95.25]	3.75 [95.25]	4.52 [114.8]
Option	CT only	CT only	CT/WL	CT/WL	CT/WL	CT/WL

ResFlow CV ICD Specifications

Nozzle size,† in [mm]	0.06, 0.1, and 0.15 [1.6, 2.5, and 4.0]
Construction material	
Housing	316L stainless steel
Nozzle	Ceramic
Ball	Aluminum or ceramic
Plate	Aluminum
Snap ring	Elgiloy®
O-ring	Viton®
Max. temperature, degF [degC]	300 [149]
Max. differential pressure, psi [MPa]	5,000 [34]

†To provide a higher inflow area, an extended ICD housing with more nozzles can be provided in the available sizes.

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