

## Water-Hammer Valve

This tool incorporates a cycling valve that momentarily interrupts the flow to create water-hammer pressure pulses inside the coil and suction pressure pulses in the wellbore. The water hammer generates traction forces of up to 2000 lbf on the end of the coil at a rate of 10 pulses per second. These periodic pulses also vibrate the coil, which reduces friction drag and extends the lateral range of the coil by delaying the onset of helical buckling and lockup.

The valve generates suction pressure pulses in the wellbore that pull in formation fluids and clean perforations and screens. When the valve opens, the trapped pressure is released as an intense jet pulse through the jetting head.

### Coiled Tubing Applications:

- Formation stimulation
- Chemical placement
- Screen and perforation cleaning
- Extended reach milling
- Scale removal
- Acidizing
- Drilling damage removal
- Deployment of logging tools

### Flow Rate Effect

The traction force is linearly proportional to flow rate in the coil. The low impact configuration is recommended for jobs with motors and tricone bits. The high-impact configuration of the tool is recommended for maximum reach or when an upstream bypass (separator) is run.

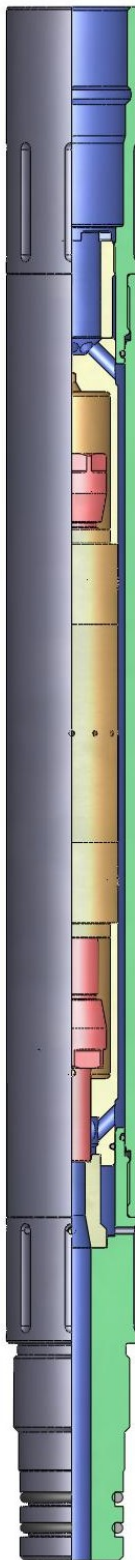
### Through-Tubing Motors

The tool is designed to run above a thru-tubing motor for milling applications. The pressure pulsations improve weight transfer in long horizontal wells for more effective milling. ***The need for friction reducing beads or chemicals is eliminated.***

### Nozzles and Jetting Tools

A bullhead nozzle equipped with forward and rear firing jets is available for well cleanout and stimulation. The jet pulsation is effective in clearing bridged fill. This configuration provides the highest flow rate and traction force.

The pressure pulsation produced by the tool increases the effectiveness of high-pressure jetting tools. High-flow nozzles should be specified to maximize pulse amplitude and extended reach. Low flow nozzles should be specified for hard scale milling.



U.S. Patents  
6,237,701 and  
7,139,219

## Two-Phase Flow

The HydroPull™ tool is designed to operate on two-phase flow. The presence of nitrogen dampens the impulse amplitude. If a Tempress motor gas separator (MGS™) is run, it should be located downstream of the HydroPull™ tool to ensure maximum effectiveness of the tool. The HydroPull™ should not be operated on straight gas while on surface.

## Logging Tool Deployment

A crossover sub is available for logging tool deployment. The crossover ports the flow to the side of the tool.

## Coiled Tubing Connection

A high-quality coiled tubing connection is required to prevent leakage and failure when the HydroPull™ tool is operated at the high end of its flow rate range. The connection should be pressure-tested at twice the maximum impulse pressure or pull-tested at twice the maximum impulse load.

## Last Chance Screen

A last chance screen is included with each tool to prevent gravel and other debris from blocking the tool. The screen openings are 1/16-inch (1600 microns).

## Specifications

Diameter	1.69 inch (43 mm)	2.88 inch (73 mm)	
Connected length (including last chance screen)	40.01 inch (890 mm)	58.7 inch (1490 mm)	
Flow Rate Range	1.0 - 1.5 bpm (160 - 250 lpm)	2.5 - 3.5 bpm (400 - 550 lpm)	
Average Pressure differential	360 - 720 psid (2.5 - 5.0 MPa)	300 - 500 psid (2.2 - 3.5 MPa)	
Pulse Cycle Rate	8 - 12 Hz	6 - 12 Hz	
Pulse Amplitude	850 - 1300 psid (6 - 9 MPa)	<u>Low Impact</u> 700-1100 psid (5 - 7 MPa)	<u>High Impact</u> 1200 - 1600 psid (8 - 11 MPa)
Traction Force Proportional to flow rate	1300 - 2000 lbf (600 - 900 daN)	1600 - 2500 lbf (700 - 1100 daN)	2800 - 3900 lbf (1250-1700 daN)
Sour Gas	All H <sub>2</sub> S compatible materials		
Max. Temperature	400°F (200°C)		
Fluid compatibility	Clear fluids: water, 1% acid, 3% KCl, scale dissolvers, frac oil <i>28% acid capable tools are available in the 1.69 size</i>		
Gas compatibility	Multiphase with fluid: air, carbon dioxide, nitrogen		

## Case Histories

- 1. Heavy Oil Well Stimulation (2 well program):** The HydroPull™ was operated on 1-1/2-in coil to enter a 7-in slotted liner heavy oil horizontal completion. Prior attempts to enter this well were prevented because of obstructions at 3100 to 3800 ft. A bullnose nozzle was run. The tool was operated at a flow rate of 1.3 bpm of produced water plus 15% AS-1 solvent (kerosene+xylene). The tool slowed at the obstruction but moved though at 8 ft/min feed resuming a feed rate of 20 ft/min. TD was reached at 4592 ft and the tool run out of hole at 33 ft/min. 280 bbl of fluid was pumped. **Well production increased from 44 to 605 bbl per day with low water cut.**

On the second well, a 1.69-in HydroPull™ was used to place 315 bbl water with 3% KCl and 2% MudSol. A bullnose with 3 x .188-in forward facing jet nozzles was run. Flow rate was 0.9 to 1.3 bpm with surface pump pressure of 1740 psi. The tool was run at 10 to 20 ft/min though the 5-1/2-in horizontal slotted liner to TD at 4920 ft MD, 1970 ft TVD. The tool was pulled back every 300 ft to sweep sand fill. Well production increased from 25 to 44 bbl per day with low water cut.

- 2. Extended Reach CO2 Injection Well:** This job required re-entry into a 6.1-in diameter horizontal openhole from 4760 to 8070-ft MD to place solvent. The horizontal section was 3313-ft. Prior attempts to enter this well with 1-in continuous rod failed at 6230-ft MD. The casing was 2.44-in ID so a 1.69-in HydroPull with a 4-jet nozzle pattern was run on 1.5-in coiled tubing. The tool was operated at 1.3 bpm and at feed rates of 30 to 65 ft/min. The final 1000-ft to TD was entered at 10-ft/min with snubbing forces well below the coil limits. The solvent was placed at the toe of the well and allowed to soak for 24 hours. The well was re-entered with the HydroPull tool the following day. Commingled fluid (0.7 bpm water and 525 scf nitrogen) was pumped to lift the solvent from the well. **The HydroPull extended the lateral reach of the coil by 20% or 690 ft in this well.**

- 3. Milling Bridge Plugs in 5.5-in casing (4-Well Program):** A 2.88-in HydroPull was run with a motor and mill to mill bridge plugs inside 5.5-in casing from 7500 to 13,000 ft MD on a horizontal gas well completion (5500 ft horizontal). For the first job, a Tempress gas separator bypass tool was run below the HydroPull and above the motor. The tools were operated at 3.25 bpm with 0.5 bpm fluid, or gas equivalent, bypassed by the separator. Eight bridge plugs were milled in an average time of 8 minutes each. At TD the coil shaking on surface was strong. In offset jobs running a competitive vibrating tool instead of the HydroPull, the average milling time was 40 minutes per plug.

For the second two wells, the Tempress gas separator was run above the HydroPull and motor to reduce pulse amplitude. Each job involved milling 8 bridge plugs with fluid. The average milling time per plug was 15 minutes.

On the last well, nitrogen was run to maintain circulation while drilling the last two bridge plugs. **Nitrogen dampened the pulse amplitude but did not reduce the milling speed.**

- 4. Bridge Plug Milling in the Marcellus Shale (5-Well Program):** These jobs required milling bridge plugs in 5000 to 6000-ft horizontal 5.5-in casing to a measured depth of 11,700 to 12,000 feet. Prior to this work, the operator had been specifying friction reducing beads and chemicals. The wells are inclined up to 95° with some heavy sand accumulations. Thirty-one composite bridge plugs were milled using the HydroPull™ and thirty-seven were milled without the HydroPull™ using beads and chemicals. The 2.88-in HydroPull was operated on 2-in tapered coil with a motor and mill using produced water at 2.5 bpm. In the toe of the well *the average plug milling time was reduced from 147- to 36-minutes*, a factor of four. In the heel the plug milling time was cut in half.
- 5. Bridge Plug Milling:** This job involved milling 14 bridge plugs over 4000 ft of horizontal 5.5-in casing. The tool was operated on water with friction reducer at 2.5 bpm. The pump pressure while milling with 2-inch coil was 4900 psi with 1750 psi wellhead pressure. The total job duration was 36 hours. The average plug milling time was 26 minutes, with times improving as the coil operator became familiar with the new tool. This job illustrates the ability to mill bridge plugs in a pressurized well because of the low-pressure differential through the tool.