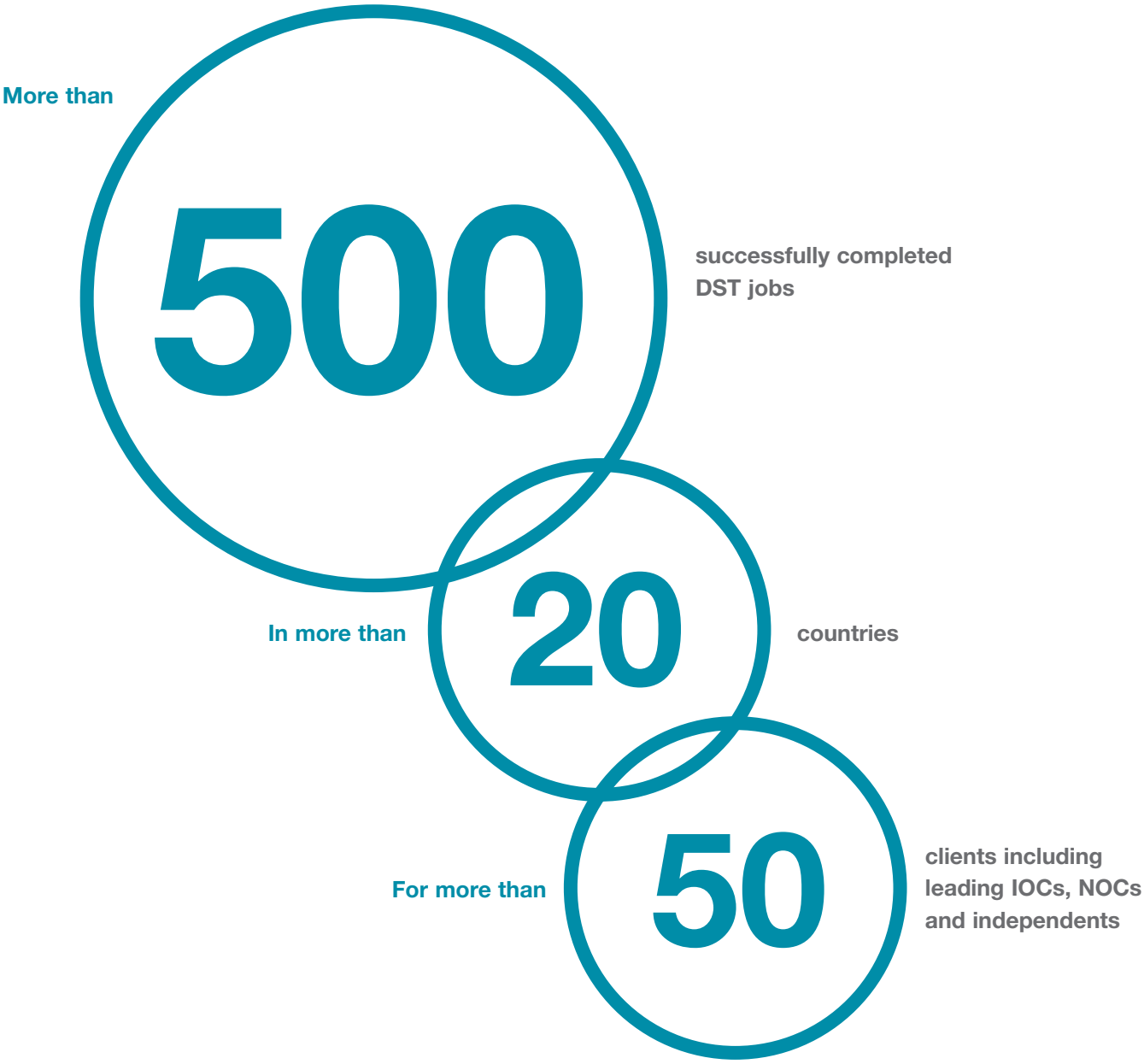
EXPRO

WELL FLOW MANAGEMENT™

Drill Stem Testing

www.exprogroup.com

The **accurate data** we provide from every drill stem test allows our customers to plan the **optimal exploitation** of their reservoirs.

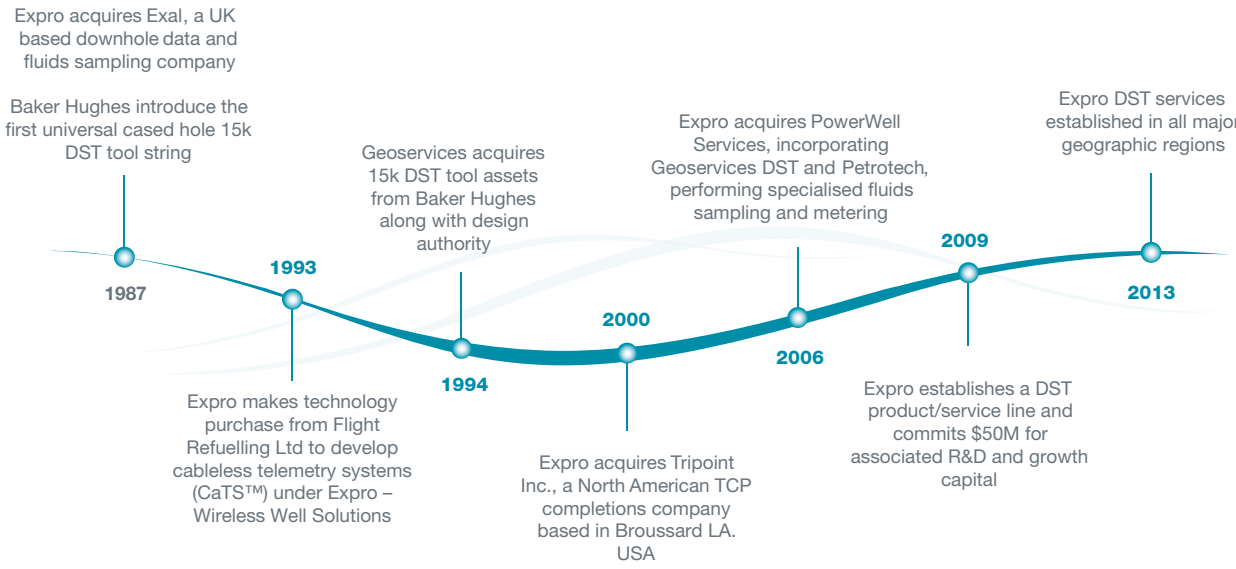


Drill Stem Testing

Expro offers the complete well test package, utilising some of the industry's most reliable technologies. We have invested in our infrastructure and people to enhance our global capabilities in all the key exploration and appraisal markets where we operate.

A drill stem test (DST) offers the fastest and safest method of evaluating the potential of a newly-discovered hydrocarbon-bearing formation. After the well has been drilled and cased, the first stage of a well test is to run a DST string in conjunction with a downhole data system with the option to include tubing conveyed sampling and tubing conveyed perforating systems.

Expro's DST Heritage



Our DST systems

The DST bottomhole assembly is designed around your test objectives and well parameters. We provide downhole systems, including perforating guns, with the functionality to effectively and safely perform the well test. These systems capture quality data such as bottomhole pressures and temperatures during flow (drawdown) and shut-in (build up) periods and representative single-phase formation fluid samples.

DST tools

Our core DST tools were introduced to the field in 1987 giving them a proven track record of over 25 years. At that time it was the first universally applied cased-hole DST tool string with 5" OD and 2.25" ID, rated to 15,000 psi and 350°F/177°C, as per NACE MR-01-75. The additional functionality from our new generation Expro DST tools means that we now provide fully integrated solutions across exploration and appraisal well testing at 15,000 psi differential pressure, up to 450°F/232°C.

Downhole data acquisition systems

In addition to conventional downhole memory gauges, Expro provide real-time surface readout data (SRO). Expro's Cableless Telemetry System (CaTS™) uses advanced wireless telemetry technology to transmit high quality bottomhole pressure and temperature data to surface in real-time using electromagnetic (EM) through-tubing/casing communication. Having access to surface readout data provides early confirmation that the quality and quantity of data collected is adequate to characterise the reservoir, leading to optimised timing of the well test operations.

Tubing conveyed sampling (TCS)

Collection of representative bottomhole fluid samples is a key objective in most DSTs. Expro's tubing conveyed sampling system provides a multi-unit, flexible, high-quality alternative to traditional wireline conveyed sampling. As the samplers are run with the DST string, no wireline intervention is required, reducing risk and rig time.

Tubing conveyed perforating systems (TCP)

Single trip underbalanced perforating utilising TCP guns is generally preferred in exploration and appraisal DSTs. Expro has been in the TCP business for over 30 years and provides industry leading TCP gun systems with a full range of in-house designed firing heads, gun releases, vent subs and other associated equipment.

The data that we deliver

Expro has continuously developed its capability to acquire accurate and reliable high quality data, allowing the customer to make informed decisions quickly, effectively and efficiently.

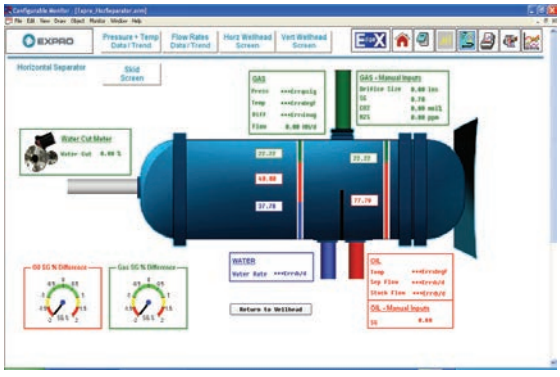
Expro's data acquisition services provide monitoring solutions that apply at all locations from sand face to burner tip. This includes the EDGE data acquisition system for surface process monitoring; precision quartz memory gauges for reservoir pressure and temperature data; and the CaTS wireless SRO system, providing real-time bottomhole data on demand for the dynamic optimisation of pressure drawdown and build-up periods, to ensure a valid well test in line with specific objectives and the potential to reduce high cost rig time.

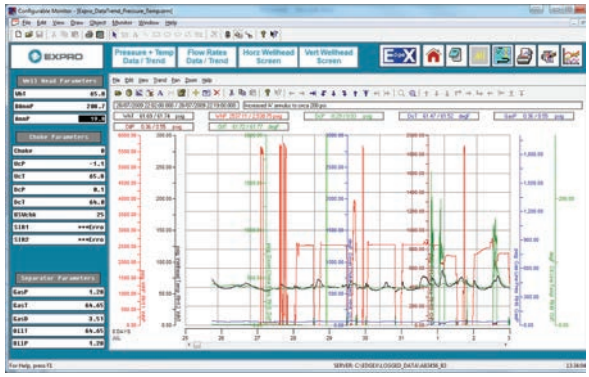
The CaTS system transmits data to surface in real time using electromagnetic (EM) signals. Having access to SRO data provides confidence in the data quality and quantity, leading to early decision making and optimisation of the testing program duration.

SRO benefits:

- Uses the well-proven CaTS wireless communications technology
- High specification quartz crystal sensors
- Features dual redundancy throughout the system for enhanced reliability
- Dual purpose gauge features both SRO and memory functionality
- Duplex comms (two-way communication with gauges)
- No need for wireline intervention to receive data at surface, reducing intervention risk
- Suitable for use in high H_2S/CO_2 harsh condition environments
- Compatible with onshore, jack-up and semi-submersible operations

The EDGE system captures both surface and downhole well data and collates the information into a single report format for our customers to review at, or remote from, the well site. EDGE features a complete visual and audible alarm system, which can be configured, with upper and lower limits, to alert the operator or perform shut-down operations when any abnormal conditions occur. It can monitor virtually any number of sensors, while simultaneously performing multiple operations on the data, both real-time and historic.





Largest single product line investment ever made by Expro

Our DST tools

General specifications:

Working pressure	15,000 psi / 103.42 Mpa
Working temperature	350°F / 177°C (up to 450°F/232°C)
O.D.	5.00" / 127mm
I.D.	2.25" / 57.2mm
Upper thread connection	3.75" S.A. 6 TPI box with saver sub-crossover to 3.5" IF or PH6 box
Lower thread connection	3.75" S.A. 6 TPI box with saver sub-crossover to 3.5" IF or PH6 pin
Tensile strength	350,000 lbf / 155,600 daN
Service condition	H_2S per NACE MR-01-75, CO_2

Our DST string includes:

Slip Joint

The Slip Joint is a telescopic tool with five feet of free travel from closed to fully open. It allows for tubing movement due to pressure and temperature change during well flowing (expansion) and stimulation (contraction) conditions. The tool is internally pressure and volume balanced and is splined to allow torque to be transmitted to the string below.

Annulus Operated Reversing Valve (AORV)

The AORV is a single shot circulating valve giving unrestricted flow between tubing and annulus. It is opened by applying annulus pressure to burst a pre-selected rupture disk. It is then permanently retained in the open position by a lock ring and cannot be reclosed. It is generally used as a back-up to a multi-cycle recloseable circulating valve and can also be installed below the shut-in ball valve as a contingent kill valve.

ExACT™ Tool

The ExACT™ tool is a fully annulus-operated combined multi-cycle circulating and downhole shut-in ball valve. It incorporates a nitrogen chamber which compensates for changes in annulus hydrostatic pressures at depth and a trap system (ARTS), which locks an operating reference pressure in the tool. The tool has three functional positions: ball open – ports closed; ball closed – ports closed; ball closed – ports open. The tool is governed by an indexing sleeve working in conjunction with smartcollet and interlock, and moved to the desired functional position by applying and bleeding annulus pressure (max. 2,000 psi). This tool is flexible and efficient, requiring minimal cycles (max. four) to get from one of the above functional positions to any other, and there are no waiting times between cycles. The ball can withstand 15,000 psi differential from above and below and can be opened with 7,500 psi differential from above or below, at less than 2,000 psi applied annulus pressure. The ports can withstand circulation rates in excess of 10 bbls/min, at low back-pressures.

The ExACT tool replaces the POTV and the tubing-operated MRST in the tool string.

Our DST tools

Multi Reverse Spot Tool (MRST)

The MRST is a tubing-operated multi-cycle circulating valve and provides a means of establishing communication between the tubing and annulus. It has three functional positions: closed, reverse and spot-circulate. It can be run in the well in either the closed or reverse positions, depending on the application. *This valve is not required if an ExACT tool is used.*

Pressure Operated Tester Valve (POTV)

The POTV is an annulus pressure-operated multi-cycle downhole ball valve, holding pressure from above and below. It is run in conjunction with a nitrogen chamber which compensates for changes in annulus hydrostatic pressures at depth and a trap system (ARTS), which locks an operating reference pressure in the tool . An optional indexing lock-open system allows the ball to remain open every second cycle. This lock open feature allows the POTV to act as a fluid by-pass when placing seals in a packer bore and aids in wireline and well kill procedures. The ball can withstand 15,000 psi differential from above and below and can be opened with full differential from above or below. *This valve is not required if an ExACT tool is used.*

Annulus Reference Trap System (ARTS)

The ARTS is used to trap a pressure in the reference section of the ExACT tool and POTV. The ExACT tool uses the ARTS-C, which is ruptured disk actuated; the POTV can use either ARTS-C or ARTS-B, which is differentially actuated. Once this reference pressure has been trapped, the ExACT tool or POTV can be operated through the application and removal of applied annulus pressure. A relief sleeve ensures that trapped pressure is bled off as the tool is retrieved from the well.

Gauge carriers and downhole memory guages

Expro utilises leading oilfield quartz gauges, housed in short (< 1m long) gauge carriers. The gauge carriers are NACE compliant and their pressure and temperature ratings, ODs, IDs and connections are consistent with the DST tools. The gauges can be 0.75” or 1.25” OD, depending on pressure and temperature rating, and can be configured in the carrier to record tubing or annulus pressure and temperature. The carriers can house up to four gauges, all tubing, or mixed tubing and annulus sensing.

Quartz gauge specifications:

Pressure	Std and HT: 0-20,000 psi (0 – 1,380 bar); XHT: 0-30,000 psi (0 – 2,070 bar)
Temperature	Std: 0 to 300°F (-20 to 150°C); HT: 0 to 350°F (-20 to 177°C); XHT: 0 to 400°F (-20 to 200°C)
Data points	4.2 million data points
Accuracy	Pressure+/- 0.02% FS; temperature +/- 0.3°F (+/- 0.15°C)
Resolution	<0.01psi (<0.001 bar); < 0.01°F (<0.005°C)

Self Fill Tubing Tester Valve (SF-TTV)

The flapper-type SF-TTV provides a means of filling and pressure testing the tubing string while running in the hole. The unique, patented bi-directional tubing-to-tubing bypass means the flapper never leaves its seat, therefore is protected from debris and washout. This valve provides for an unlimited number of string pressure tests and is locked out of service, leaving an unobstructed bore, by applying annulus pressure to burst a preselected rupture disk. The tubing-to tubing bypass design means the string is not compromised when pulling from a seal-bore packer and allows drain back of mud during heave conditions on floating vessels. In HP/HT application an upper and lower SF-TTV can be deployed, with the upper valve isolating the DST tools and pressure-temperature gauges from unnecessary multiple high pressure tests.

Downhole Safety Valve (DHSV)

The DHSV is a single-shot ball valve deployed in the open position and if required the ball can be closed by applying annulus pressure to burst a preselected rupture disk. Once closed, the ball will isolate well pressure but will still allow fluid to be pumped through from above for well-kill purposes. The pump-through pressures depend on mud hydrostatic and pressure below the ball.

Hydraulic Jar

The Hydraulic Jar is used to free stuck pipe and tools in the wellbore. This device delivers heavy impact blows to the test string by storing energy within the tool. The impact load is dependent on the amount of overpull on the jar as it meters open. It can be closed (re-cocked) by setting down weight for multi-use, as required. In well test applications the tool is run directly above the Safety Joint. The Hydraulic Jar is splined to allow torque to be transmitted below the tool.

Safety Joint and Overshot

The Safety Joint allows the tubing string above to be recovered in the event that the packer cannot be released after jarring. This ensures recovery of the DST tool and memory gauge data recorded during the well test. The Safety Joint is released by rotation of the test string. Should the Safety Joint be released, an Overshot can be run on a work string with heavy-duty jars to reconnect and recover the remainder of the bottomhole assembly.

Retrievable DST packers

Expro has a wide range of retrievable hookwall packers suitable for DST and shoot and pull perforating operations, for casing sizes ranging from 4 1/2" through 13 3/8". Our in-house flagship 7" high-strength BigCat™ packer is capable of withstanding 15,000 psi differential pressures from above and below at temperatures up to 400°F/204°C and is an efficient and viable alternative to a seal-bore packer in HP/HT well environments. It is set with minimal clockwise rotation (one eighth turn) of the string and releases to the safety position with straight pull.

Permanent seal-bore packers and locator seal assemblies

In applications where seal-bore packers are required, such as HP/HT wells, Expro has access to a range of permanent and semi-permanent seal bore packers, seal-bore extensions and locator seal assemblies. Where seals are floated in the seal-bore, Slip Joints are not required.

Our DST tool string configurations

Example one

DST string with ExACT™ tool, incorporating SRO and TCS

Tubing
Cross over
Slip Joints (as required)
Drill Collars
Radioactive marker sub
AORV
Drill Collars
ExACT™ tool inc. ARTS
Tubing conveyed sampling carrier (TCS)
Memory gauge carrier
CaTS™ SRO gauge carrier
SF-TTV
Hydraulic jar
Safety joint
Hold-down sub
BigCat™ retrievable packer
Perforated pipe
Debris sub
Tubing
Firing head
Safety spacer
TCP guns

Example two

DST string with POTV and MRST

Tubing
Cross over
Slip Joints (as required)
Drill Collars
AORV
Drill Collars
Radioactive marker sub
MRST
Drill Collars
POTV inc. ARTS
Memory gauge carrier
SF-TTV
Hydraulic Jar
Safety Joint
Hold-down sub
BigCat™ retrievable packer
Perforated pipe
Debris sub
Tubing
Firing head
Safety spacer
TCP guns

Example three

HPHT DST string using a permanent packer

Tubing
Crossover (if required)
Upper SF-TTV
Radioactive marker sub
AORV
Tubing spacer
ExACT™ tool inc. ARTS
Memory gauge carrier
AORV
DHSV
Memory gauge carrier
Lower SF-TTV
Seal locator
Permanent packer
Seal assembly
Perforated pipe
Debris sub
Tubing
Firing head
Safety spacer
TCP guns

Example four

DST string for shoot and pull TCP

Drillpipe
Cross over (if required)
Radioactive marker sub
AORV
Drill Collars
ExACT™ tool inc. ARTS
Memory gauge carrier (optional)
Hydraulic Jar
Safety Joint
Hold-down sub
Retrievable packer
Perforated pipe
Debris sub
Tubing
Firing head
Safety spacer
TCP guns

Our TCP systems

Expro has been a full service TCP provider to the industry for over 30 years, servicing the exploration and appraisal well testing, well completions and well stimulation markets. We have an outstanding track record in North America, including deepwater operations in the Gulf of Mexico.

In recent years we have strategically expanded our capabilities globally, where we have established successful operations in six countries within Sub-Saharan Africa. We have licences set up and in-process in other regions in line with delivering fully integrated well testing services.

We use industry-leading gun products underpinned by API RP 19B test data. We make our selection based on the best solution for our client's project; considering the gun performance specific to well conditions, logistics and any special requirements.

We provide gun sizes from 2 1/2" up to 7" OD with full phasing and shot densities in RDX, HMX and HNS explosives packages and charge types, such as deep penetrating, super-deep penetrating, big hole (for gravel packing), good hole and reactive liners. We can also offer stimulation products such as the StimGun.

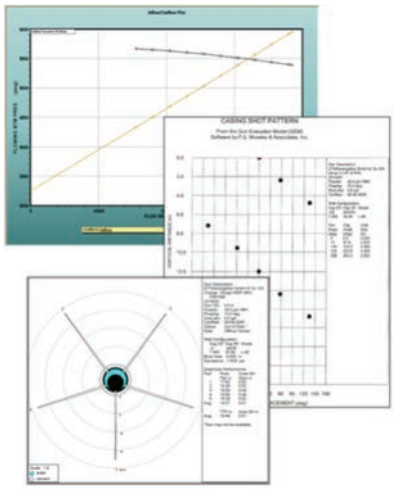
All Expro's mechanical, hydraulic and pyrotechnic firing heads, gun releases and associated accessories are designed in-house, with our firing heads having over 99% success rate.

Firing Devices

- Top fired dual firing head
- Mechanical firing head
- Safety impact mechanical firing head
- Pressure activated firing heads
- Pyrotechnic delay firing heads
- Hydraulic firing heads
- Auto-venting firing heads
- Auto-release firing heads
- Dual firing heads
- Slickline retrievable firing heads

Ancillary Tools

- Mechanical gun releases
- Pressure activated gun releases
- Production vent device
- Auto-stop-fill device
- Debris subs
- Ported subs
- Detonation interuption device
- Shock absorbers
- Radioactive marker subs
- Shot detection device



TCP job design

As part of the perforating job design and planning service, our team of reservoir engineers utilises Well Evaluation Model (WEM) and PulsFrac™ to optimise equipment selection and configuration. This includes gun string design, charge selection and shot density, shock loading, static and dynamic underbalancing, full nodal analysis and stimulation performance.

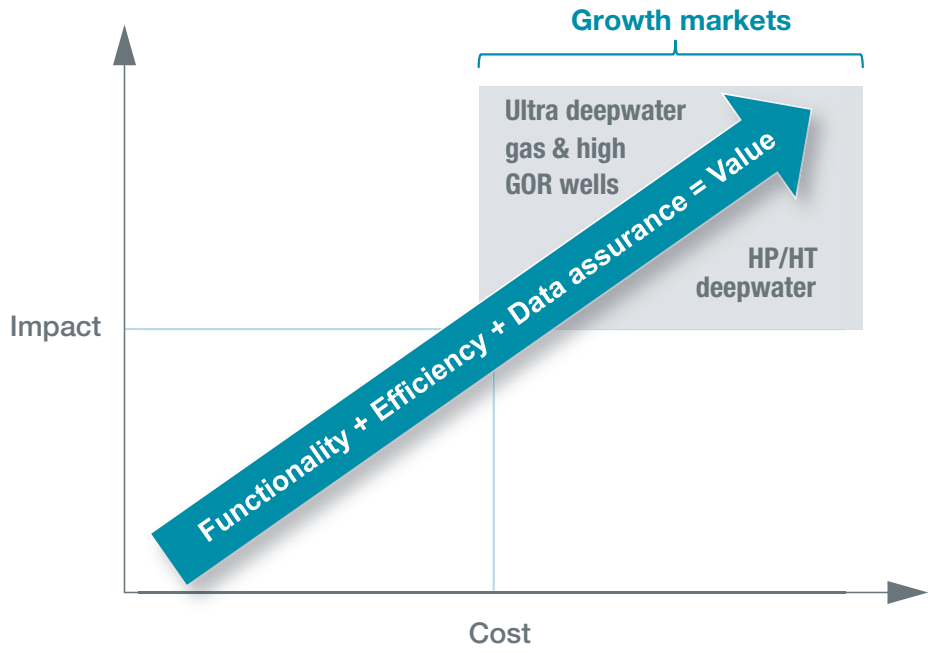
Expro firing heads have over 99% success rate

New technology & innovation

Expro is committed to advancing technology in the field of DST, with our investment driven by the requirements of existing and emerging growth markets. With close links to our long established Subsea development group, a dedicated DST engineering team, guided by seasoned DST professionals, work in-house to develop and introduce innovative DST tools to our range.

As the industry moves to harsher environments (ultra-deep waters and extreme HP/HT wells), Expro's focus is to safely deliver increased functionality and efficiency to enable the capture of accurate, valid data to meet specific well test objectives. The cost impact of not delivering in these key areas is substantial, considering the environment and the extremely high rig costs typically associated with deepwater and HP/HT wells.

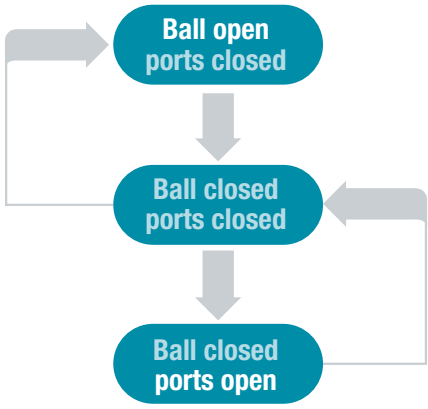
Our proposition is: ***Functionality + Efficiency + Data assurance = Value***. This is the basis for the new Expro DST tools.



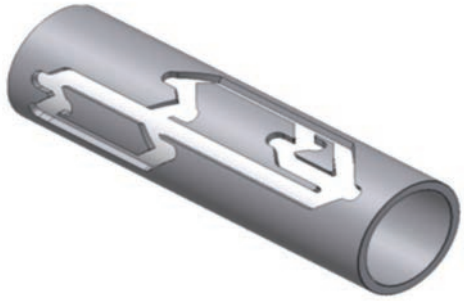
The key tools in the DST string are those which are multi-cycle and critical to meeting well test objectives, well integrity and control requirements.

ExACT™

The ExACT™ tool is an advanced multi-cycle, fully annulus pressure operated tool. It combines the functionality of a tester valve for downhole shut-ins, and a circulating valve for spotting cushions and treatment fluids, and reverse and forward circulating during well kill operations. ExACT therefore replaces the POTV and tubing-operated MRST in the tool string.



The unique smart-collet and interlocking system which operates in conjunction with the indexing sleeve makes this tool highly operationally flexible and efficient. It requires a maximum of four annulus pressure cycles to place the ball and circulating ports in any required position. The ball and ports are mechanically prevented from being open at same time. As the tool operates against a trapped reference pressure, there are no costly waiting times between cycles.



Self Fill Tubing Tester Valve (SF-TTV)

Expro's new generation flapper-type SF-TTV, is an innovative departure from traditional designs. The main purpose of the valve is to allow the tubing string to fill from below for multiple pressure tests whilst running in hole. After the final pressure test the valve requires to be locked out of service leaving an unobstructed bore. A lower and upper SF-TTV can be incorporated in HP/HT DST strings, with the upper SF-TTV isolating the DST tools and pressure/temperature gauges from unnecessary high pressure tests.

The Expro SF-TTV achieves all of the above using a unique patented, bi-directional tubing-to-tubing bypass. The flapper, which is housed in a ported inner sleeve sub-assembly, is pinned closed and never leaves its seat, therefore cannot wash out whilst running in hole. It is highly debris tolerant, meaning no debris can lodge across the seat and cause the valve to fail.

A string pressure test is achieved by pumping down the tubing, which at minimal rates, creates a back-pressure moving the flapper assembly downwards to close the bypass. On releasing the pressure, a spring returns the flapper assembly to the self-fill, run-in-hole position. There is no limit to the number of pressure tests, and when required, the SF-TTV is locked out of service by applying pressure to the annulus to burst a pre-selected rupture disk, shifting the flow mandrel up through the flapper before locking out.

The incorporated tubing-to-tubing bypass feature delivers additional functional benefits in the following scenarios:

- When exiting seal-bore packers during space-out operations, traditional flapper valves of this kind, will seal and therefore pressure lock. The solution is to incorporate an annulus-to-tubing bypass below the flapper which can compromise string integrity. This is not the case with our innovative tubing-to-tubing bypass.
- When making tubing string connections at the rotary table on floating vessels, traditional flapper valves will hold fluid, therefore hampering make-up operations, due to mud spilling over on the upstroke. This results in non-productive time and also has safety implications. Our tubing-to-tubing bypass allows fluid to drain back as the string is raised with rig heave.

New technology & innovation

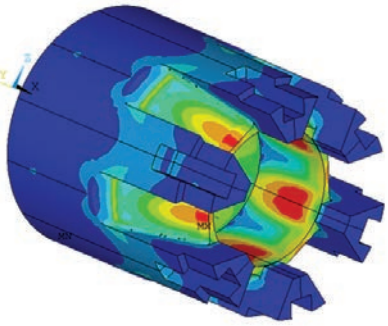
The BigCat™ HP/HT packer

The Expro BigCat packer is a premium high-strength, compression set, tubing-retrievable HP/HT packer, ideal for drill stem testing, perforating and stimulation operations.

With its unique slip and cone design, extensively tested with multiple loadings at 520,000 lbf, it is the only packer on the market capable of withstanding 15,000 psi differential pressure from above and below when set, at temperatures up to 400°F/204°C.

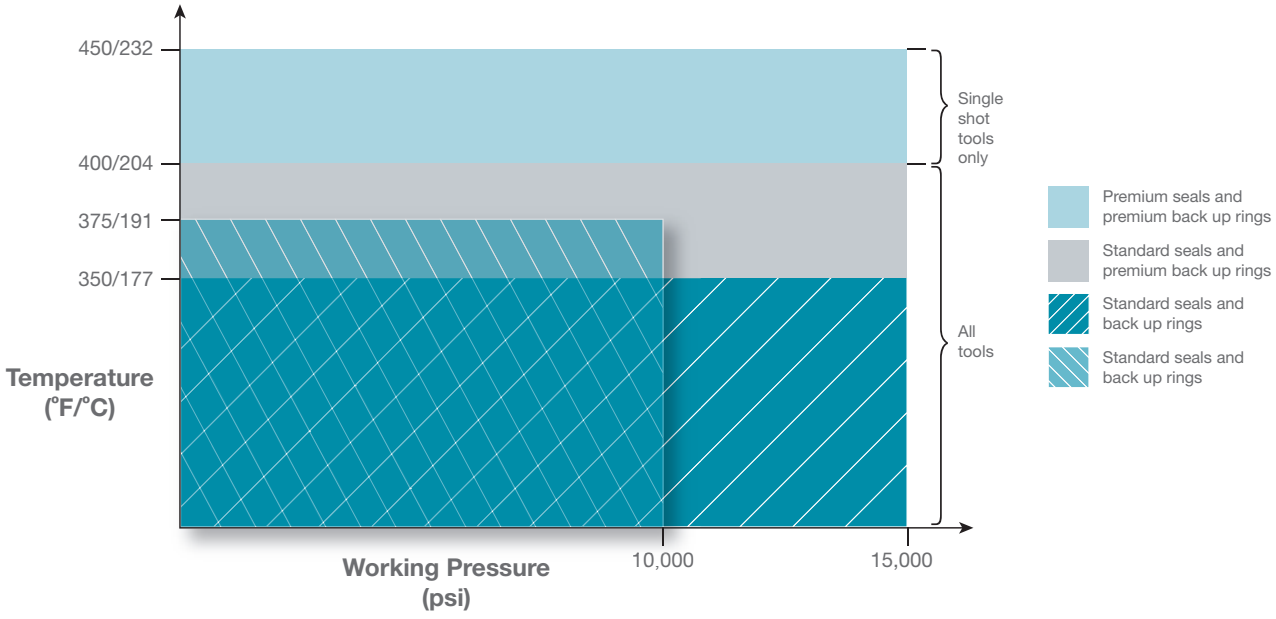
The modular hydraulic hold-down sub ensures that the packer remains set when subjected to excessive pressure from below during stimulation operations. An integral fluid bypass ensures efficient deployment. The packer requires only a small amount of right-hand rotation to set (one-eighth of a turn at the tool), and releases to the safety position with straight pull.

This BigCat packer is available with standard or premium element sealing systems, depending on the service requirements, and is a flexible and efficient alternative to seal-bore packers in HP/HT wells.



High temperature upgrade

As the industry moves to ultra-high and extreme temperatures, Expro has upgraded its DST tool string to operate at up to 450°F/232°C, whilst retaining its 15,000 psi differential pressure rating. This is achieved by dressing the tools with a premium sealing systems as follows:




Dedicated Expro DST engineering and operations team
2000 LBS
2000 LBS
2000 LBS
2000 LBS
2000 LBS
EXPRO

Applications, features & benefits

Product	Applications	Benefits	Features
Drill stem test (DST) tools	▪ DST – well testing ▪ Shoot & pull TCP	▪ Over 25 of DST experience ▪ Dedicated in-house DST engineering team developing new and innovative DST tools ▪ Highly trained and experienced field personnel ▪ 15k psi DST tools supplied as standard ▪ Commitment and focus - largest single product line investment ever made by Expro	**ExACT™ Tool** ▪ Combined fully annulus-operated multicycle circulating and ball valve for downhole shut-ins ▪ Minimal, fast cycling and high rate circulation capability saves rig time **Self Fill Tubing Test Valve (SF-TTV)** ▪ Unique patented tubing-to-tubing fluid bypass ▪ Flapper stays on seat, so no washouts and highly debris tolerant ▪ Pull from seal-bore packers without compromising string integrity ▪ Make up connections in heave conditions without mud spill-over, saving rig time **BigCat™ HPHT Packer** ▪ High strength ▪ Fully 15k psi from above and below at 400°F ▪ Viable tubing retrievable option to seal-bore packers in HP/HT wells ▪ Minimal rotation to set and straight pull to release and safety ▪ Integral fluid bypass; separate hold-down sub **High temperature upgrade** ▪ 400°F/204°C – applicable to all tools ▪ 450°F/232°C – applicable to single shot tools only
CaTS™ wireless surface readout (SRO)	▪ DST – well testing	▪ Dynamic optimisation of well test program ensures well test objectives are met ▪ Potential to reduce rig time and cost ▪ Intervention free operations lowers risk and increases safety ▪ Fully in-house developed and supported	▪ 15k psi / 150°C (302°F) ▪ Fully wireless long range communications SRO or short range communications and e-line ▪ Gauges situated below shut-in valve and either above or below packer ▪ Duplex – 2-way communications ▪ Dual redundant sensor and relay stations. ▪ Real-time SRO ▪ 1 sec memory logging - 1.8M data points ▪ Memory data retrieval in-situ
Tubing conveyed bottomhole PVT sampling	▪ DST – well testing	▪ Mulitple samplers ▪ Fire samplers on command, allows for unscheduled events ▪ Interventionless operations lowers risk, increases safety, reduces rig time and cost	▪ Concentric design ▪ Multiple samplers ▪ Samplers can be fired individually, in pairs or groups using rupture disks of electronic triggers
Tubing conveyed perforating (TCP) systems	▪ DST – well testing ▪ Well completions - shoot & pull TCP ▪ Well completions - run with completion ▪ Stimulation/frac	▪ Over 30 years of in-house design and operations expertise and track record ▪ Access to class-leading gun systems to provide the best solution ▪ Industry-leading firing head performance and reliability ▪ Highly trained and experienced field personnel ▪ Full TCP job design capability for optimised results	▪ Firing Head success rate at over 99% ▪ Range of mechanical, tubing and annulus pressure activated and pyrotechnic time-delay firing heads ▪ Fully redundant top-fired or top and bottom-fired firing systems ▪ Full range of mechanical and auto gun releases, vent subs and ancillary devices for E&A wells and production well applications

Expro's mission is **well flow management.** We provide services and products that **measure, improve, control** and **process** flow from high-value oil and gas wells, from exploration and appraisal through to mature field production optimisation and enhancement.

With a specific focus on **offshore, deepwater** and other **technically challenging environments,** we provide a range of mission critical services across **three key areas:**

- Well Test & Appraisal Services
- Subsea, Completion & Intervention Services
- Production Services

Our vision is to be the **market leader** in well flow management, using the industry's best people, to deliver the highest standards of **safety, quality** and **personalised customer service.**

Expro's **40+ years** of experience and innovation empowers the company to offer **tailor-made solutions** for customers across the energy sector. With 4,500 employees in over 50 countries, Expro offers a **truly global service solution.**

EXPRO

For more information contact:
DST-TCP@exprogroup.com

Or visit **www.exprogroup.com/contact**