



**Jet Research Center's** firing systems and ancillary equipment products are intended to be safe, versatile, and modular, offering state-of-the-art TCP completion solutions that can be tailored to specific customer needs. These systems are designed for a variety of applications, including high temperature, horizontal, and time-delay, which make the tool selection customizable and the job easier.

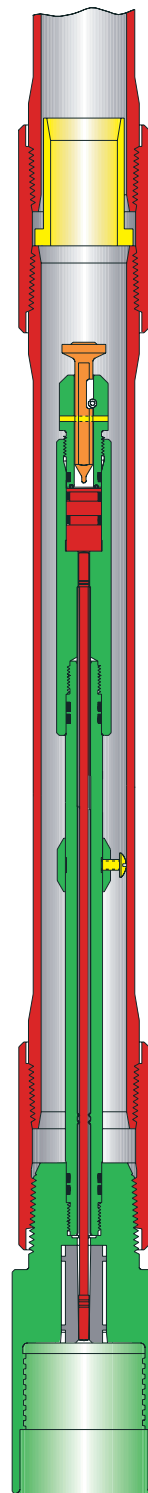


The Extended Mechanical Firing Head (MFH) is a special application tool. It should be used only when well conditions preclude the use of an alternate firing device. Whenever it is used on a job, the MFH must be used as prescribed by appropriate tool manuals.

**Operation**

The operation of the MFH depends on the amount of force delivered to the firing pin by the detonating bar. The firing pin must be hit with enough force to shear the spiral pin, which holds the firing pin in place, and to detonate the initiator. The firing pin is driven into a percussion detonator, which fires the guns.

The Detonation Interruption Device (DID) and a minimum of 10 ft of safety space must always be used with the Mechanical Firing Head.

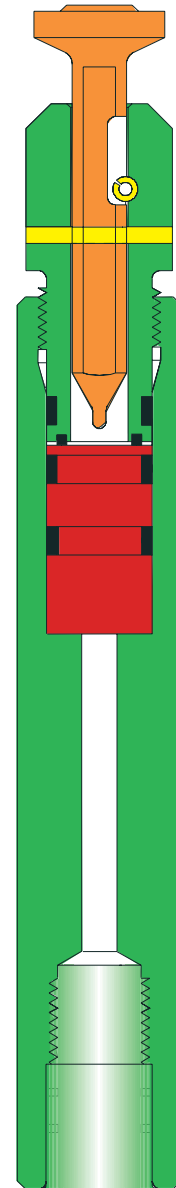


*Mechanical Firing Head*

# Mechanical Firing Head

## Mechanical Firing Head

<b>Thread Size and Type in. (mm)</b>	1.90 (48.26) NU 10 Rd pin x 2 3/8 (60.33) 6P Acme box	2 3/8 (60.33) EUE 8 Rd pin x 2 7/8 (73.03) 6P Acme box	1 7/16 (36.51) 8 UN 2 B Box x 1.90 (48.26) NU 10 RD Pin
<b>Assembly Number</b>	100005228	100005223	100155741
<b>Extreme Environment Kit</b>	100156259	100156259	N/A
<b>Redress Kit</b>	N/A	N/A	100014388
<b>Maximum OD</b>			
in. (mm)	2.75 (69.85)	3.375 (85.73)	2.0 (50.8)
<b>Minimum ID (No-Go)</b>			
in. (mm)	1.56 (39.62)	1.56 (39.62)	1.53 (38.86)
<b>Maximum Operating Pressure</b>	20,000 (1380)	20,000 (1380)	20,000 (1380)
<b>Minimum Operating Pressure</b>			
psi (bars)	None	None	None
<b>Flow Area</b>	N/A	N/A	N/A
<b>Temperature Rating</b>	Determined by explosives	Determined by explosives	Determined by explosives
<b>Tensile Strength</b>			
(FH body)	140,000 (63 400)	238,000 (107 900)	60,000 (27 200)
lb (kg)			
<b>Burst Pressure</b>	Determined by	Determined by	
psi (bars)	handling sub	handling sub	25,000 (1725)
<b>Collapse Pressure</b>	Determined by	Determined by	
psi (bars)	handling sub	handling sub	20,000 (1380)
<b>Overall Length</b>			
(w/o tubing sub)	4.58 (1.40)	4.58 (1.40)	1.59 (0.48)
ft (m)			



*Mechanical Firing Head  
Sub-Assembly*

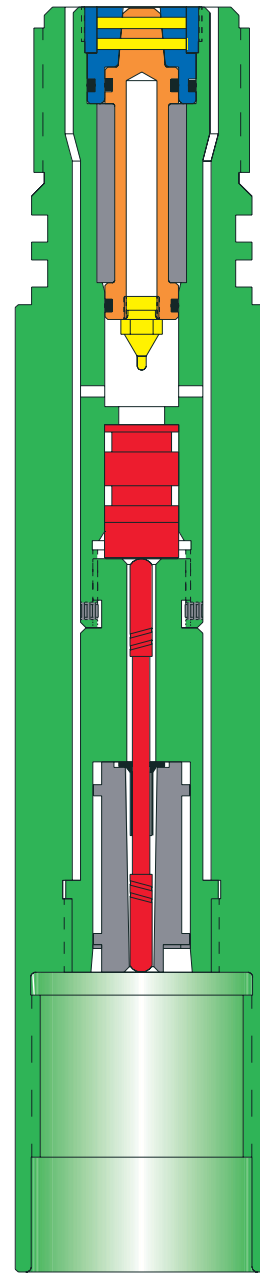
The Detonation Interruption Device (DID) provides additional safety for the VannGun™ System. This safety device contains an eutectic metal that protects the initiator from the firing pin at surface conditions. The eutectic metal has a very low melting point, but while it is in a solid state, the metal in the DID will stop the explosive train from being transmitted to the perforating assembly after the firing head has been detonated.

**Operation**

A minimum bottomhole temperature (BHT) of 135 °F is required to run the DID. Unless the DID is exposed to high surface temperatures, the eutectic metal will be solid when the assembly starts in the hole. When it is warmed to the BHT, the eutectic metal is liquified and allows the transfer of the explosive train from the firing head to the perforating assembly. If the guns are pulled out of the hole before they are fired, the eutectic metal will return to a solid state as it reaches the cooler temperatures near the surface. This device helps prevent accidental firing of the guns when they are started in the hole or pulled out.

**Features and Benefits**

- Is compatible with all firing heads
- Disables the perforating assembly at surface
- Can be used with redundant firing heads



*Detonation Interruption Device*

# Detonation Interruption Device

**Detonation Interruption Device**

<b>Thread Size and Type</b>	2 3/8 (60.33)	2 7/8 (73.03)
<b>in. (mm)</b>	6 Rd box x pin	6 Rd box x pin
<b>Housing Number</b>	100156049	100014226
<b>Assembly Number</b>	100155744	100155744
<b>Installation Tool</b>	120040863	120040863
<b>Maximum OD</b>	2.75 (69.85)	3.375 (85.73)
<b>in. (mm)</b>		
<b>Minimum ID</b>	N/A	N/A
<b>Maximum Operating</b>	23,000 (1590)	25,000 (1725)
<b>Pressure</b>		
<b>psi (bars)</b>		
<b>Minimum Operating</b>	None	None
<b>Pressure</b>		
<b>Flow Area</b>	N/A	N/A
<b>Minimum Required</b>	135 (57)	135 (57)
<b>Temperature Rating</b>	Determined by explosive	135 (57)
<b>°F (°C)</b>		
<b>Tensile Strength</b>	140,000 (63 400)	246,000 (111 500)
<b>lb (kg)</b>		
<b>Burst Pressure</b>	N/A	N/A
<b>Collapse Pressure</b>	23,000 (1590)	25,000 (1725)
<b>psi (bars)</b>		
<b>Overall Length</b>	1.15 (0.35)	1.17 (0.36)
<b>ft (m)</b>		

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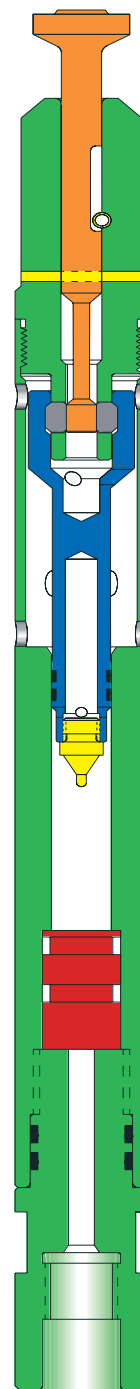
The Model II-D Mechanical Firing Head is a pressure-assisted mechanical firing head. The detonating car strikes the firing pin, releasing the firing piston. Hydrostatic pressure then forces the firing piston into the initiator.

### Operation

The Model II-D Firing Head requires a minimum of 1,500 psi hydrostatic pressure in the tubing to actuate the firing head properly. Adding more pressure to the tubing after the detonating bar has struck the firing pin will not actuate the firing head.

### Features and Benefits

- Cannot be detonated accidentally at surface
- Is ideal for use in mud environments where spudding may be necessary
- Can be used in deviated wells



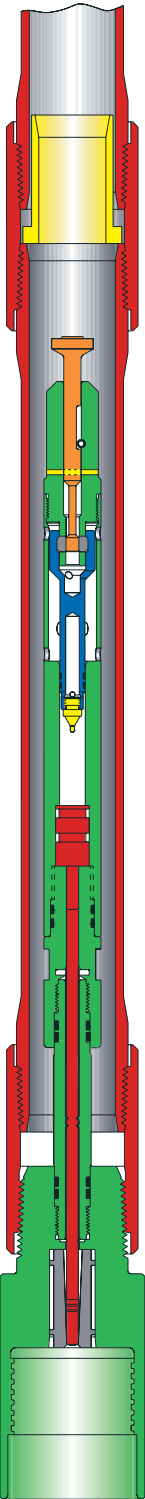
*Model II-D Mechanical  
Firing Head*

# Model II-D Mechanical Firing Head

## Model II-D Mechanical Firing Head

<b>Thread Size and Type</b> <b>in. (mm)</b>	1.90 (48.26) EUE	2 3/8 (60.33) EUE
	10 Rd pin x 2 3/8 (60.33)	8 RD pin x 2 7/8 (73.03)
	6P Acme box	6P Acme box
<b>Assembly Number</b>	1000014156	100005227
<b>Maximum OD</b>		
<b>in. (mm)</b>	2.75 (69.85)	3.375 (85.73)
<b>Minimum ID (No-Go)</b>		
<b>in. (mm)</b>	1.56 (39.62)	1.56 (39.62)
<b>Maximum Operating</b>		
<b>Pressure</b>		
<b>psi (bars)</b>	20,000 (1380)	20,000 (1380)
<b>Minimum Operating</b>		
<b>Pressure</b>		
<b>psi (bars)</b>	1,500 (103)	1,500 (103)
<b>Temperature Rating</b>	Determined by explosives	Determined by explosives
<b>Tensile Strength</b>		
<b>lb (kg)</b>	140,000 (63 400)	238,000 (107 900)
<b>Burst Pressure</b>	Determined by	Determined
<b>psi (bars)</b>	handling sub	handling sub
<b>Collapse Pressure</b>	Determined by	Determined by
<b>psi (bars)</b>	handling sub	handling sub
<b>Overall Length</b>		
<b>ft (m)</b>	4.58 (1.4)	4.58 (1.4)

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*Model II-D Mechanical  
Firing Head Assembly*



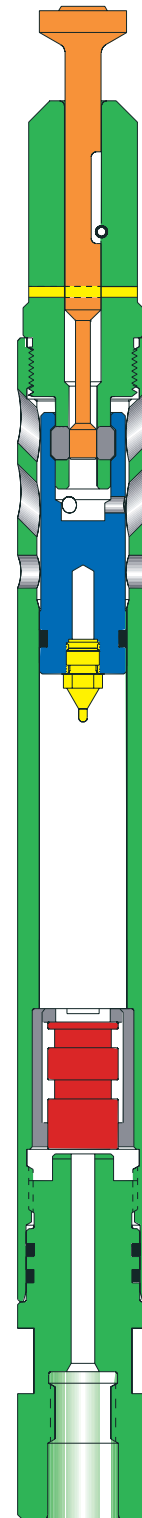
The Model III-D Mechanical Firing Head is a pressure-assisted mechanical firing head. The detonating bar strikes the firing pin, releasing the firing piston. Hydrostatic pressure then forces the firing piston into the initiator. The Model III-D Firing Head requires a minimal amount of hydrostatic pressure to actuate the firing head.

**Operation**

The Model III-D Firing Head requires a minimum of 250 psi hydrostatic pressure in the tubing to actuate the firing head properly. This minimal actuating pressure is ideal for applications that require maximum differential pressures. Adding more pressure to the tubing after the detonating bar has struck will not actuate the firing head.

**Features and Benefits**

- Cannot be detonated accidentally at surface
- Is ideal for use in mud environments where spudding may be necessary
- Can be used in deviated wells
- Requires minimal hydrostatic pressure to actuate the firing head



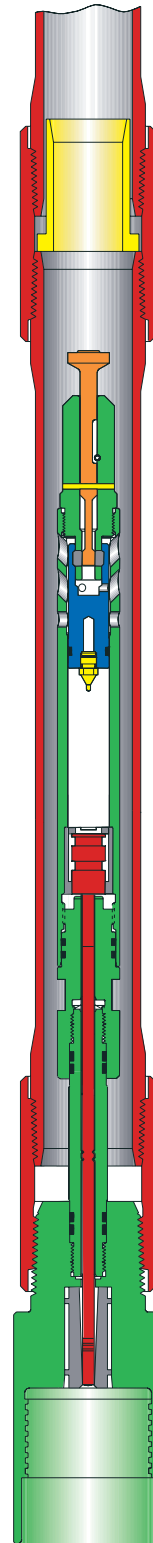
*Model III-D Mechanical  
Firing Head*

## Model III-D Mechanical Firing Head

### Model III-D Mechanical Firing Head

<b>Thread Size and Type</b> <b>in. (mm)</b>	1.90 (48.26) EUE	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE
	10 Rd pin x 2 <sup>3</sup> / <sub>8</sub> (60.33)	8 Rd pin x 2 <sup>7</sup> / <sub>8</sub> (73.03)
	6P Acme box	6P Acme box
<b>Assembly Number</b>	100155742	100005191
<b>Maximum OD</b>		
<b>in. (mm)</b>	2.75 (69.85)	3.375 (85.73)
<b>Minimum ID (No-Go)</b>		
<b>in. (mm)</b>	1.56 (39.62)	1.56 (39.62)
<b>Maximum Operating</b>		
<b>Pressure</b>	8,000 (550)	8,000 (550)
<b>psi (bars)</b>		
<b>Minimum Operating</b>		
<b>Pressure</b>	250 (17)	250 (17)
<b>psi (bars)</b>		
<b>Temperature Rating</b>	Determined by	Determined by
	explosives	explosives
<b>Tensile Strength</b>		
<b>lb (kg)</b>	140,000 (63 400)	238,000 (107 900)
<b>Burst Pressure</b>	Determined by	Determined by
<b>psi (bars)</b>	handling sub	handling sub
<b>Collapse Pressure</b>	Determined by	Determined by
<b>psi (bars)</b>	handling sub	handling sub
<b>Overall Length</b>		
<b>ft (m)</b>	4.58 (1.4)	4.58 (1.4)

These ratings are guidelines only. For more information, consult your local JRC representative.



Model III-D Firing Head  
Assembly

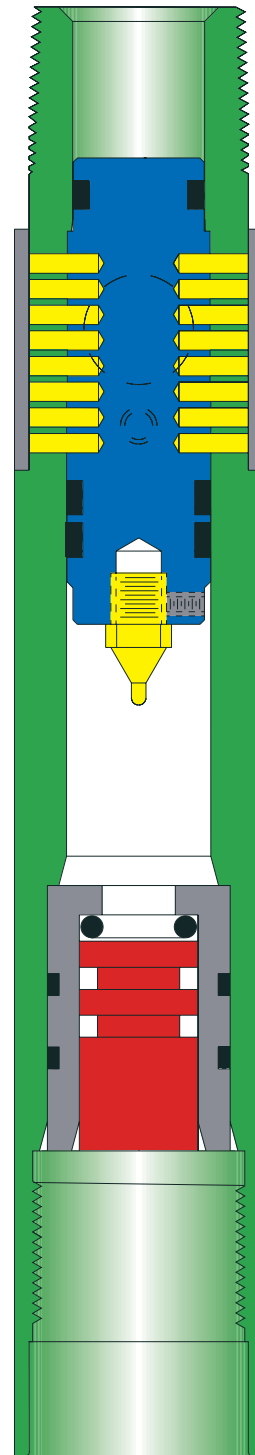
The 1 11/16-in. Pressure-Actuated Firing Head (PAF) can run with small OD tubing or coiled tubing to detonate small OD perforating guns. The PAF is detonated by pressure applied to the tubing string.

**Operation**

The 1 11/16-in. PAF consists of an upper housing with circulating ports, a firing piston that is shear-pinned in place across the circulating ports, and an initiator contained in a lower housing. Pressure applied to the tubing string shears the shear set, which forces the firing piston into the initiator to detonate the explosive component attached to the PAF. The downward movement of the firing piston opens the circulating ports.

**Features and Benefits**

- Can be run on the top and bottom of the gun assembly
- Initiates a bridge-plug and setting tool
- Initiates tubing cutters
- Detonates tubing punch charges for squeeze or circulating jobs
- Can be run to remain closed after detonation
- Can be modified to be run as a slickline retrievable firing head and a Time-Delay Firing Head



*Pressure-Actuated  
Firing Head*

## Pressure-Actuated Firing Head

Pressure-Actuated Firing Head	
Thread Size and Type	1.315 (33.40) NU-10 Rd
in. (mm)	pin x 1 7/16 (36.51) 8 UN-2B Box
Assembly Number	100005224
Maximum OD	1.688 (42.88)
in. (mm)	
Minimum ID	N/A
in. (mm)	
Maximum Operating Pressure	17,000 (1170)
psi (bars)	
Minimum Operating Pressure	2,200 (150)
psi (bars)	
Flow Area of Ports	0.44 (2.84)
in. <sup>2</sup> (cm <sup>2</sup> )	
Number and ID of Ports	2 @ 0.75 (19.05)
in. <sup>2</sup> (cm <sup>2</sup> )	
Temperature Rating	Det. by Explosive
°C (°F)	
Tensile Strength	65,000 (29,400)
lb (kg)	
Burst Pressure	N/A
psi (bars)	
Collapse Pressure	27,000 (1,860)
psi (bars)	
Overall Length	0.82 (0.25)
ft (m)	

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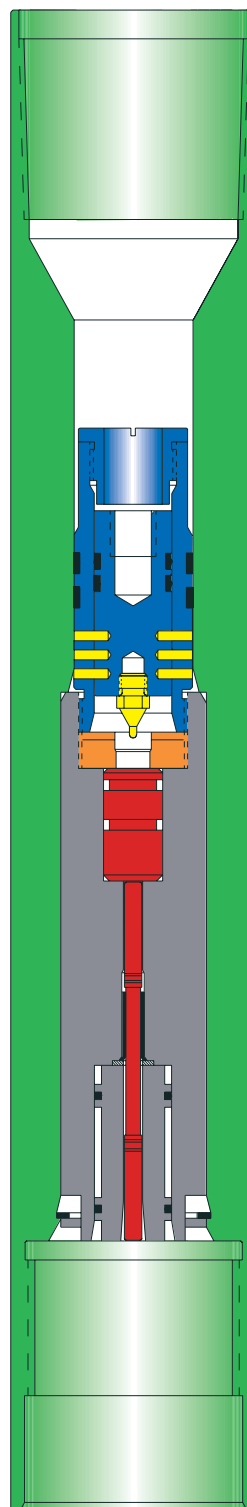
The Model K Series Firing Head was developed for conditions that are unfavorable for dropping a detonating bar in a horizontal well. The Model K Firing Head is a pressure-sensitive tool designed to hydraulically detonate at a prescribed pressure. These firing heads use tubing pressure applied to a piston-type firing pin.

### **Operation**

The Model K Series Firing Head is designed to provide a reliable and cost-effective method for firing guns using hydrostatic pressure. Each firing head contains a firing piston that is shear-pinned in place above and initiator. The number of shear pins used varies for each well situation. When enough hydrostatic pressure is applied to the piston, the shear pins shear, thereby allowing the firing pin on the lower end of the piston to be driven into the initiator. This action detonates the guns. These firing heads do not have a built-in delay.

### **Features and Benefits**

- Allow the operator to determine the exact time of firing the guns since the firing heads require a predetermined pressure before the guns can fire
- Work with full-opening or nonfull-opening down-hole tools
- Are ideal for balanced or overbalanced perforating
- Can be used for dual completions, drillstem testing, or production perforating
- Are well-suited for highly deviated well completions
- Can be run on the top or bottom of the perforating assembly
- Can be easily redressed



*Model K Series Firing Head*

# Model K Series Firing Head

**Model K Series Firing Head**

	Model K Firing Heads	Model K-II Firing Heads	
<b>Thread Size</b>	2 7/8 (73.03) EUE 8 Rd	1.9 (48.26) EUE 10 Rd	2 7/8 (73.03) EUE 8 Rd
<b>and Type</b>	box x 2 7/8 (73.03)	pin x 2 3/8 (60.33)	box x 2 7/8 (73.03)
<b>in. (mm)</b>	6P Acme box	Acme box	6P Acme box
<b>Assembly Number</b>	100014211	100005190	100014215
<b>Maximum OD</b>	3.375 (85.73)	2.75 (69.85)	3.375 (85.73)
<b>in. (mm)</b>			
<b>Minimum ID</b>	N/A	N/A	N/A
<b>Maximum</b>	13,000 (895)	19,500 (1345)	19,500 (1345)
<b>Operating Pressure</b>			
<b>psi (bars)</b>			
<b>Minimum Operating</b>	4,000 (275)	4,000 (275)	4,000 (275)
<b>Pressure</b>			
<b>psi (bars)</b>			
<b>Flow Area</b>	N/A	N/A	N/A
<b>Temperature Rating</b>	Determined by explosives	Determined by explosives	Determined by explosives
<b>Tensile Strength</b>	220,000 (99 700)	187,000 (84 800)	220,000 (99 700)
<b>lb (kg)</b>			
<b>Burst Pressure</b>	N/A	N/A	N/A
<b>psi (bars)</b>			
<b>Collapse Pressure</b>	30,000 (2070)	25,000 (1725)	30,000 (2070)
<b>psi (bars)</b>			
<b>Overall Length</b>	1.25 (0.38)	1.43 (0.44)	1.64 (0.50)
<b>ft (m)</b>			

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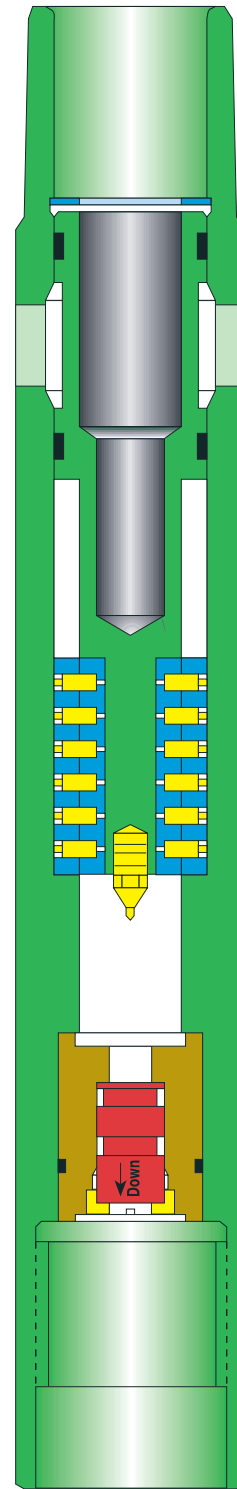
The KV-type firing head design combines a firing head with a vent assembly. The KV-II Firing Head makes the firing of the guns and the opening for the vent one operation rather than two. This tool allows the operator more accurate control of when the vent opens in relation to when the guns fire.

### **Operation**

In many tubing-conveyed perforating (TCP) applications, it is either desirable or necessary to keep the tubing closed until the guns have been detonated. In the past, the tubing was kept closed by a firing head with some type of vent assembly. Coordination between the two tools was sometimes hard to achieve, and the vent often opened either too soon or too late. The KV-II Firing Head combines a firing head and a vent assembly. A piston is sheared to cause the guns to detonate and the ports to open and equalize (or vent) pressure. This venting feature allows operators to run the tubing in the hole dry if needed. In the standard KV-II Firing Head, the ports open the instant the firing head is actuated and the guns detonate. To delay the gun detonation, one or more devices may be added to the assembly.

### **Features and Benefits**

- Useful in wells with open perforations where it is not possible to pressure up on the wellbore to actuate a firing head
- Useful in perforating and stimulation jobs where the tubing pressure exceeds the limitations of the casing
- Useful because the firing head and vent operate at one pressure
- Ideal for deviated wells
- Piston-mechanically locked after firing



*Model KV-II Series Firing Head*

## Model KV-II Series Firing Head

**Model KV-II Series Firing Head**

<b>Thread Size and Type in. (mm)</b>	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>7</sup> / <sub>8</sub> (72.88) EUE
	8 Rd pin	8 Rd pin x 2 <sup>7</sup> / <sub>8</sub>
	or 6P Acme box	6P Acme box
<b>Assembly Number</b>	100014153	100014155
<b>Maximum OD</b>		
in. (mm)	2.75 (69.85)	3.375 (85.85)
<b>Minimum ID</b>	N/A	N/A
<b>Maximum Operating</b>		
Pressure	25,000 (1725)	25,000 (1725)
psi (bars)		
<b>Minimum Operating</b>		
Pressure	3,000 (275)	4,000 (275)
psi (bars)		
<b>Flow Area</b>		
in. <sup>2</sup> (cm <sup>2</sup> )	2.79 (18.0)	3.14 (20.27)
<b>Temperature Rating</b>	Determined by explosives	Determined by explosives
<b>Tensile Strength</b>		
lb. (kg)	145,000 (65 700)	235,000 (106 600)
<b>Maximum Differential</b>		
Pressure	15,000 (1035)	15,000 (1035)
psi (bars)		
<b>Overall Length</b>		
ft (m)	1.53 (0.47)	1.66 (0.51)
<b>Minimum Makeup</b>		
Length	1.36 (0.42)	1.49 (0.45)
ft (m)		

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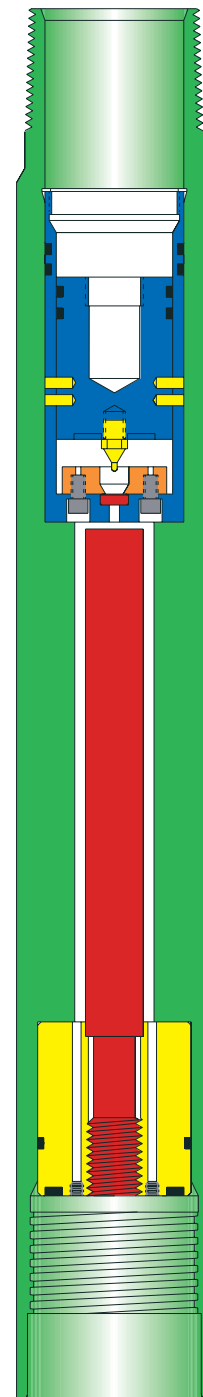
The Time-Delay Firer (TDF) allows under or overbalanced perforating through the use of a pressure-actuated firing head with a time-delay fuse. The delay fuse allows five to seven minutes for adjusting the actuating pressure in the tubing to achieve the desired pressure before firing the guns.

### Operation

The TDF is run with a predetermined number of shear pins for specific well conditions. The tubing is pressured to the maximum actuating pressure slowly. The maximum pressure shears the pins in the shear set and forces the firing piston into the primer. The primer ignites the pyrotechnic delay fuse. The delay fuse burns for a predetermined time, between five and seven minutes, depending on the bottomhole temperature and then the perforating assembly.

### Features and Benefits

- Allows independent perforating of selected zones
- Allows maximum use of under or overbalanced pressure
- Can be run in heavy mud systems
- Can be used with full-opening or nonfull-opening tools
- Reduces cost by allowing the running of multiple guns without gun spacers
- Is ideal for production completions, drillstem testing, and dual completions
- Is recommended for running on the top and bottom of gun assemblies
- Allows additional time-delay elements as needed for increasing delay time



*Time-Delay Firer*

## Time-Delay Firer

<b>Thread Size and Type</b> in. (mm)	1 <sup>7</sup> / <sub>16</sub> (36.51)	1.90 (48.26) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE
	8 UN-2B box x 1.315 (33.4)	10 Rd pin x 2 (50.8)	8 Rd pin x 2 <sup>7</sup> / <sub>8</sub> (73.03)
	NU-10 Rd pin	6P Acme box	6P Acme box
<b>Assembly Number</b>	100014157	100005231	100005230
<b>Maximum OD</b> in. (mm)	1.688 (42.88)	2.50 (63.5)	3.375 (85.73)
<b>Minimum ID</b>	N/A	N/A	N/A
<b>Maximum Operating</b> <b>Pressure</b> psi (bars)	17,000 (1170)	24,000 (1655)	13,000 (895)
<b>Minimum Operating</b> <b>Pressure</b>	2,200 (150)	4,000 (275)	4,000 (275)
<b>Flow Area</b> in. <sup>2</sup> (cm <sup>2</sup> )	0.64 (4.13)	N/A	N/A
<b>Temperature Rating</b> °F (°C)	425 (218) for 100 hours	415 (213) for 100 hours	415 (213) for 100 hours
<b>Tensile Strength</b> lb (kg)	56,000 (25 400)	160,000 (72 500)	220,000 (99 700)
<b>Burst Pressure</b> psi (bars)	N/A	N/A	N/A
<b>Collapse Pressure</b> psi (bars)	20,000 (1380)	30,000 (2070)	30,000 (2070)
<b>Overall Length</b> ft (m)	2.25 (0.69)	1.89 (0.58)	2.0 (0.61)

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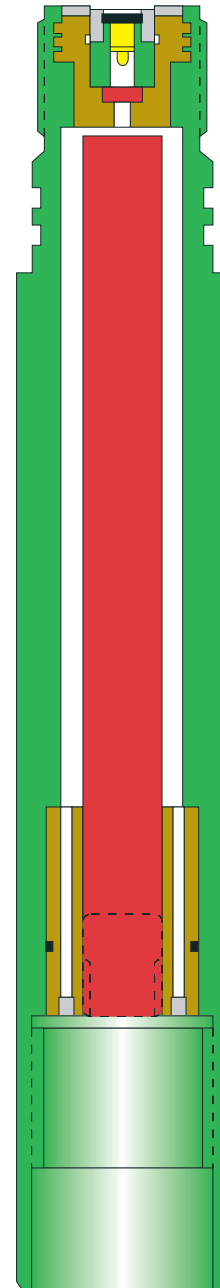
A delay fuse is an explosive device with a slow-burning fuse. Extended and modular delay fuses add time between the actuation of the firing head and the actual detonation of the guns. Each delay fuse lasts for seven minutes at 70 °F.

**Operation**

The extended delay assemblies contain one delay fuse and can be run with any other firing assembly. They are installed between the firing head and the guns. The modular delays are assembled with the firing head in one housing and become an integral part of the firing system. The modular delays are used primarily with the multi-action delay firing head, the 1 11/16 in. TDF firing head and the slickline-retrievable TDF firing head.

**Features and Benefits**

- Increase delay time when nitrogen is used to actuate the firing head to give additional time to bleed the nitrogen pressure down to the desired level
- Allow time for necessary actions to take place downhole, such as increasing pressure to open a pressure-actuated vent assembly



*Extended Delay  
and Modular Delay Fuses*

## Extended Delay and Modular Delay Fuses

**Extended Delay and Modular Delay Fuses**

<b>Thread Size and Type</b>	2 (50.8) 6P Acme	2 7/8 (73.03) 6P
<b>in. (mm)</b>	box x pin	Acme box x pin
<b>Assembly Number</b>	100005229	100009426
<b>Maximum OD</b>	2.5 (62.5)	3.375 (85.85)
<b>in. (mm)</b>		
<b>Minimum ID</b>	N/A	N/A
<b>Maximum Operating</b>	25,000 (1725)	25,000 (1725)
<b>Pressure</b>		
<b>psi (bars)</b>		
<b>Minimum Operating</b>	N/A	N/A
<b>Pressure</b>		
<b>Flow Area</b>	N/A	N/A
<b>Temperature Rating</b>	415 (213) for	415 (213) for
<b>Delay Fuse°F (°C)</b>	100 hours	100 hours
<b>Tensile Strength</b>	197,000 (89 300)	270,000 (122 400)
<b>lb (kg)</b>		
<b>Burst Pressure</b>	N/A	N/A
<b>Collapse Pressure</b>	30,000 (2070)	30,000 (2070)
<b>psi (bars)</b>		
<b>Overall Length</b>	1.39 (0.42)	1.39 (0.42)
<b>ft (m)</b>		
<b>Makeup Length</b>	1.10 (0.34)	1.10 (0.34)
<b>ft (m)</b>		

These ratings are guidelines only. For more information, consult your local JRC representative.

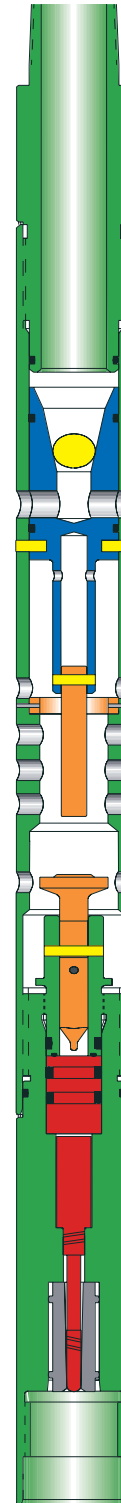
The Hydraulic-Actuator Firing (HAF) Head is a pressure-balanced tool that automatically fills the tubing string while it is running in the well. A stainless steel ball is dropped from the surface or circulated into position. Pressure applied to the tubing string actuates the HAF.

### Operation

A stainless steel ball is dropped from the surface or is circulated downhole into the hammer piston. Pressure applied to the tubing string shears the retaining pins and forces the hammer piston into the firing pin. The firing pin detonates the initiator, which starts the detonation of the perforating assembly. Circulation is regained as soon as the firing pin has been sheared.

### Features and Benefits

- Allows packerless completions
- Makes actuation easily observable
- Is useful in coiled tubing-conveyed completions, deviated wells, and through-tubing perforation
- Is reusable
- The smaller tool has a swivel incorporated into the firing head assembly
- The smaller tool has a swivel incorporated into the firing head assembly



*Hydraulic-Actuator Firing Head*

# Hydraulic-Actuator Firing Head

**Hydraulic-Actuator Firing Head**

<b>Thread Size and Type in. (mm)</b>	1.315 (33.40) NU-10Rd pin x 1 $\frac{7}{16}$ (36.51) 8UN-2B box	1.315 (33.40) NU-10Rd pin x 1 $\frac{7}{16}$ (36.51) 8UN-2B box	2 $\frac{3}{8}$ (60.33) EUE 8 Rd pin x 2 $\frac{7}{8}$ (73.03) 6p Acme box
<b>Assembly Number</b>	100156011*	100156025	100156150
<b>Maximum OD in. (mm)</b>	1.688 (42.88)	1.688 (42.88)	3.38 (85.85)
<b>Minimum ID in. (mm)</b>	N/A	N/A	N/A
<b>Maximum Operating Pressure psi (bars)</b>	20,000 (1380)	20,000 (1380)	20,000 (1380)
<b>Minimum Operating Pressure psi (bars)</b>	N/A	N/A	N/A
<b>Flow Area of Ports in.<sup>2</sup> (cm<sup>2</sup>)</b>	0.39 (2.52)	0.39 (2.52)	3.14 (20.26)
<b>Number and ID of Ports in. (mm)</b>	2 @ 0.5 (12.70)	2 @ 0.5 (12.70)	4 @ 1.0 (25.40)
<b>Temperature Rating °F (°C)</b>	Determined by explosives	Determined by explosives	Determined by explosives
<b>Tensile Strength lb (kg)</b>	50,000 (22 600)	50,000 (22 600)	210,000 (95 200)
<b>Burst Pressure psi (bars)</b>	29,000 (2000)	29,000 (2000)	27,000 (1860)
<b>Collapse Pressure psi (bars)</b>	40,000 (2760)	40,000 (2760)	25,000 (1725)
<b>Overall Length ft (m)</b>	2.94 (0.90)	2.27 (0.69)	2.57 (0.78)
<b>Ball OD in. (mm)</b>	0.625 (15.875)	0.625 (15.875)	1.375 (34.925)

These ratings are guidelines only. For more information, consult your local JRC representative.

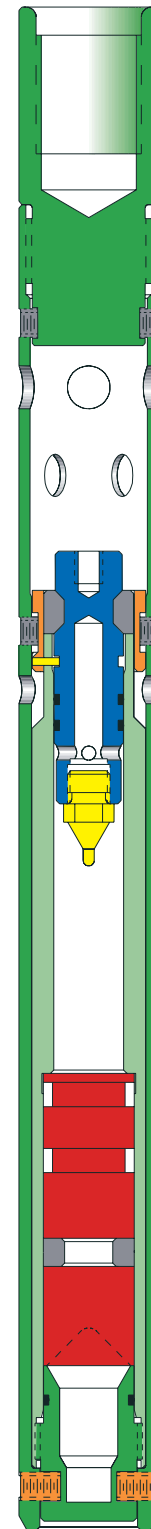
The VannJet is developed to actuate the firing head in extremely high-temperature situations and for other applications where it is not desirable to run the firing head attached to the perforating assembly.

### Operation

The VannJet firing head is run with the VannJet stinger. After the firing head is located on the top of the stringer, the slickline operator jars down to shear the brass retaining screws. When the retaining screws are sheared, the firing piston retaining dogs retract. The hydrostatic pressure then forces the firing piston into the initiator to detonate a shaped charge in the lower section of the VannJet. The explosives in the stinger are then detonated, and the explosive train continues to the VannGun™ assembly.

### Features and Benefits

- Has an initiator that is exposed to high temperature in the well for only a short time
- Incorporates a firing head that is not on the VannGun™ assembly
- Offers a high degree of safety in high-temperature operations
- Is designed to be run on a slickline
- Is actuated mechanically by jarring with wireline



*VannJet Model II*

## VannJet Model II

<b>Thread Size and Type</b>	1 <sup>5</sup> / <sub>16</sub> (23.81)
<b>in. (mm)</b>	10 UNS-2B box
<b>Assembly Number</b>	120079662
<b>Maximum OD</b>	1.25 (31.75)
<b>in. (mm)</b>	
<b>Minimum ID</b>	N/A
<b>Maximum Operating</b>	20,000 (1380)
<b>Pressure</b>	
<b>psi (bars)</b>	
<b>Minimum Operating</b>	1,250 (86)
<b>Pressure</b>	
<b>psi (bars)</b>	
<b>Flow Area of Ports</b>	N/A
<b>in.<sup>2</sup> (cm<sup>2</sup>)</b>	
<b>Temperature Rating</b>	437 (225) for 200 hr
<b>°F (°C)</b>	
<b>Tensile Strength</b>	25,000 (11 300)
<b>lb (kg)</b>	
<b>Burst Pressure</b>	N/A
<b>psi (bars)</b>	
<b>Collapse Pressure</b>	21,000 (1 450)
<b>psi (bars)</b>	
<b>Overall Length</b>	1.13 (0.34)
<b>ft (m)</b>	

These ratings are guidelines only. For more information, consult your local JRC representative.



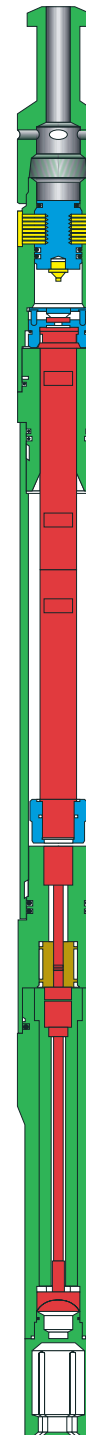
The Slickline-Retrievable Time-Delay Firer (TDF) Firing Head is a combination of two assemblies: the slickline-retrievable firing head and a 1 11/16 in. TDF firing head. It is a pressure-actuated firing head with a built-in pyrotechnic time-delay assembly.

### **Operation**

This firing head does not have to be run until after all pressure testing has been done and the heavy fluids have been displaced, which allows a reduced actuating pressure for the firing head. This assembly allows the operator to run guns in the hole on the end of tubing without a firing head. This assembly can be run in on slickline and attached to the firing head after the tubing is in the hole. It can also be retrieved on slickline.

### **Features and Benefits**

- Allows the guns to be run in the hole without any type of firing mechanism installed
- Allows the retrieval and reinstallation of a malfunctioning firing head without pulling the guns
- Allows greatly reduced actuating pressures of the firing head because the firing head does not have to be in place when the guns are run



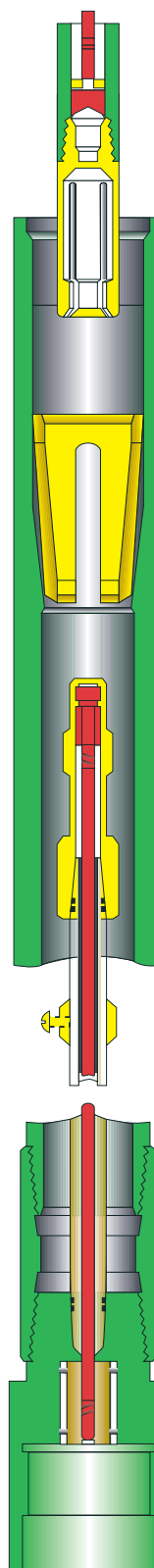
*Slickline-Retrievable TDF  
Firing Head*

# Slickline-Retrieveable TDF Firing Head

## Slickline-Retrieveable TDF Firing Head

<b>Thread Size and Type</b>	N/A
<b>Assembly Numbers</b>	100155739 Firing Head
	100014157 TDF
	100155952 Slickline -
	Retrieveable Stinger
<b>Maximum OD</b>	1.688 (42.88)
<b>in. (mm)</b>	
<b>Minimum ID</b>	N/A
<b>Maximum Actuating</b>	17,000 (1170)
<b>Pressure</b>	
<b>psi (bars)</b>	
<b>Minimum Operating</b>	2,200 (150)
<b>Pressure</b>	
<b>psi (bars)</b>	
<b>Flow Area</b>	N/A
<b>Temperature Rating</b>	Determined by explosives
<b>Tensile Strength</b>	N/A
<b>Burst Pressure</b>	N/A
<b>Collapse Pressure</b>	23,000 (1590)
<b>psi (bars)</b>	
<b>Overall Length</b>	3.83 (1.17)
<b>(1 delay fuse)</b>	
<b>ft (m)</b>	
<b>Additional Fuses</b>	0.87 (0.27)
<b>Length (each)</b>	
<b>ft (m)</b>	

These ratings are guidelines only. For more information, consult your local JRC representative.



*Slickline-Retrieveable TDF  
Firing Head Assembly*

The Mechanical Tubing Release (MTR) provides operators with the option of keeping or releasing the VannGun™ assembly from the tubing string. The MTR is usually run above the firing head and below the production ports below the packer. A standard shifting tool is used to operate the release mechanism in the MTR.

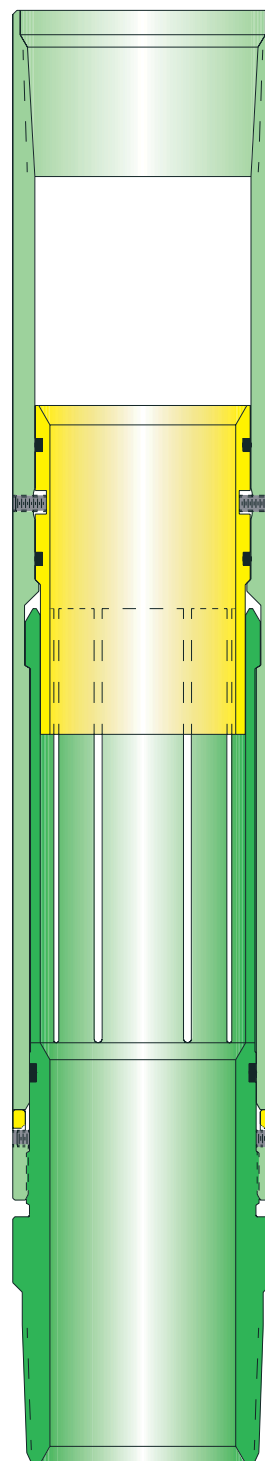
### **Operation**

The MTR consists of three main components: the upper housing, a lower finger release sub, and a latch. The latch retains the finger release sub in the housing. To operate the MTR the user must:

1. Select the proper shifting tool and run it into the hole on slickline through the MTR.
2. Pick back up to engage the latch and lightly jar the latch four or five times.
3. Go back down to verify the release of the Vann-Gun assembly.

### **Features and Benefits**

- Frees the tubing for other tools and operations such as logging, production testing, and treating
- Provides a low-cost way to release the gun assembly
- Uses standard off-the-shelf shifting tools
- Does not have a time limit on dropping the gun assembly
- Leaves perforations uncovered to eliminate flow restrictions



*Mechanical Tubing Release*

# Mechanical Tubing Release

## Mechanical Tubing Release

Thread Size and Type	2 3/8 (60.33) EUE 8 Rd box x pin	2 7/8 (73.03) EUE 8 Rd box x pin	3 1/2 (88.9) EUE 8 Rd box x pin
in. (mm)			
Assembly Number	100005286	100005281	100005284
(without latch)			
Maximum OD	3.06 (77.22)	3.38 (85.85)	3.95 (100.33)
in. (mm)			
Minimum ID (latch size)	1.50 (38.10) 1.63 (41.40) 1.81 (45.97) 1.88 (47.75)	1.88 (47.75) 2.125 (53.975) 2.25 (57.15)	2.25 (57.15) 2.75 (69.85)
in. (mm)			
Tensile Strength	120,000 (54 400)	120,000 (54 400)	120,000 (54 400)
lb (kg)			
Burst Pressure	12,000 (825)	12,000 (825)	11,000 (760)
psi (bars)			
Collapse Pressure	10,000 (690)	11,000 (760)	10,000 (690)
psi (bars)			

## MTR Shifting Tool and Key Numbers

Latch Size in. (mm)	Tool Number	Key Number	Key Maximum	Minimum in. (mm)
			Exp. OD in. (mm)	
1.50 (38.10)	42 B 0120	42 B 108	1.626 (42.275)	1.49 (37.85)
		42 B 443	1.70 (43.18)	1.422 (36.119)
1.625 (41.275)	42 B 0121	42 B 80	1.890 (48.006)	1.593 (40.462)
1.81 (45.97)	42 B 0117	42 B 37	2.078 (52.781)	1.75 (44.45)
	42 B 0237	42 B 681	2.12 (53.85)	1.69 (42.93)
1.88 (47.75)	42 B 0116	42 B 153	2.109 (53.569)	1.84 (46.74)
	42 B 0117	42 B 37	2.078 (52.781)	1.750 (44.45)
	42 B 0237	42 B 681	2.12 (53.85)	1.69 (42.93)
2.25 (57.15)	42 B 0118	42 B 287	2.593 (65.862)	2.156 (54.762)
		42 B 46		
2.125 (53.975)	42 B 0159	42 B 387	2.44 (61.98)	1.97 (50.04)
2.75 (69.85)	42 B 0147	42 B 348	2.952 (74.981)	2.718 (69.037)

## MTR Latch Part Numbers

Thread Size and Type	2 3/8 (60.33) EUE	2 7/8 (73.03) EUE	3 1/2 (88.9) EUE
in. (mm)	8Rd	8Rd	8Rd
Assembly Number	100005286	100005281	100005284
Latch ID Size in. (mm) Part Number	1.50 (38.10) 993.20545	1.880 (47.75) 993.20406	2.25 (57.15) 993.20422
	1.63 (41.40) 993.20546	2.125 (53.975) 993.20404	2.75 (69.85) 993.20421
	1.81 (45.97) 993.20547	2.250 (57.15) 993.20401	
	1.88 (47.75) 993.20543		

These ratings are guidelines only. For more information, consult your local JRC representative.

\*Latch must be ordered separately.

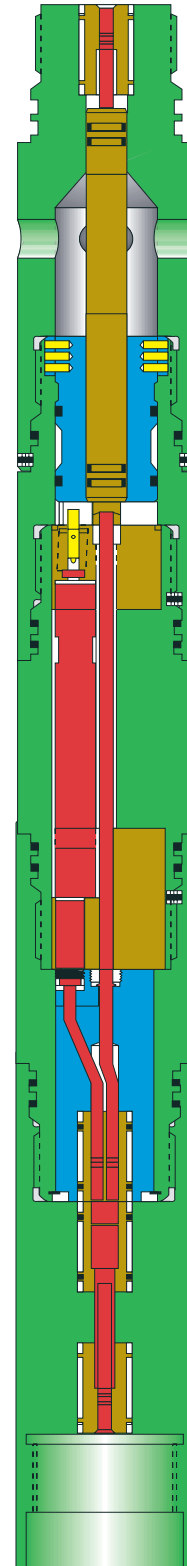
The Multiaction-Delay Firing Head is a pressure-actuated redundant firing system that can be run with any one of several other firing heads.

**Operation**

One side of the multiaction firing head will always be pressure-actuated. The other side of the firing head may be a bar drop-type head or another pressure-actuated firing head. Either side of the firing head may be used as the primary or backup firing system.

**Features and Benefits**

- Allows the use of a redundant firing head without having a firing head on the bottom of the gun string
- Allows multiple redundancy when a multiaction firing head is placed on both the top and bottom of the gun string
- Allows operators to postpone the decision of whether to use the bar drop or pressure side of the firing head as the primary firing mechanism
- Allows use of additional delay elements



*Multiaction-Delay  
Firing Head*

# Multiaction-Delay Firing Head

## Multiaction-Delay Firing Head

Thread Size and Type	2 <sup>3</sup> / <sub>8</sub> (60.33)	2 <sup>7</sup> / <sub>8</sub> (73.03)
in. (mm)	6P Acme box x pin	6P Acme box x pin
Assembly Number	100155753	100155750
Extreme Environment Kit	101206535	101206534
Redress Kit	100157222	100157221
Maximum OD	3.10 (78.74)	3.375 (85.85)
in. (mm)		
Minimum ID	N/A	N/A
Maximum Operating	18,000 (1240)	25,000 (1725)
Pressure		
psi (bars)		
Minimum Operating	4,000 (275)	4,000 (275)
Pressure		
psi (bars)		
Temperature Rating	Determined by explosives	Determined by explosives
Tensile Strength	170,000 (77 100)	201,000 (91 100)
lb (kg)		
Burst Pressure	N/A	N/A
Collapse Pressure	22,000 (1515)	29,000 (2000)
psi (bars)		
Overall Length	3.68 (1.12)	3.68 (1.12)
ft (m)		
Makeup Length	3.41 (1.04)	3.41 (1.04)

These ratings are guidelines only. For more information, consult your local JRC representative.

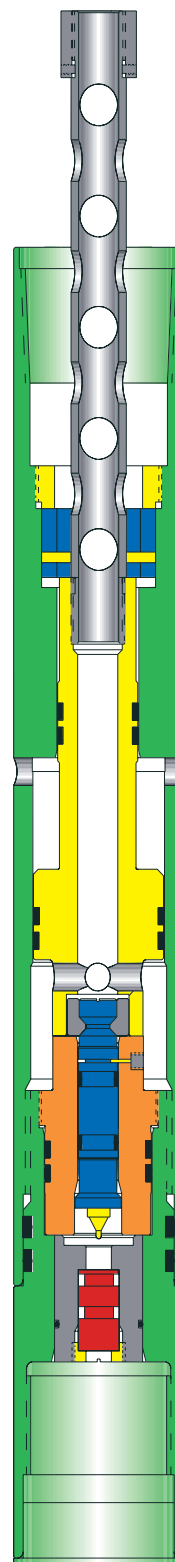
The Differential Firing Head (DFH) was designed to allow underbalanced perforating with a differential pressure-actuated firing system. The DFH works by requiring the internal pressure to be greater than the external pressure. This condition can be created when pressure is applied to the ID or when the OD pressure is reduced. The pressure required to actuate the DFH may be lower than that used for other pressure-operated firing heads because it is operated by differential pressure.

### Operation

The DFH is actuated after a predetermined differential pressure is created in the firing head ID. This differential pressure can be created when surface pressure is applied to the tubing or by reducing the hydrostatic pressure to the annulus. When the predetermined differential pressure is reached, the shear pins holding the dog retainer piston will shear, allowing the dog retainer to move up. The upward movement releases the dogs holding the firing piston in place, and the internal pressure drives the firing piston into the initiator or primer.

### Features and Benefits

- Allows underbalanced perforating in horizontal wells without a packer
- Is ideal for perforating with a sucker rod or submersible pump in place
- Offers added safety because it is pressure-balanced when being run into the well
- Allows maximum underbalanced pressure in low-pressure wells when mechanical firing is not desirable
- Can be used when equipment or well conditions will not permit the use of high pressures
- Allows the use of time-delay elements as needed



*Differential Firing Head*

# Differential Firing Head

## Differential Firing Head

<b>Thread Size and Type in. (mm)</b>	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE
	8 Rd box x 2 <sup>3</sup> / <sub>8</sub> (60.33)	8 Rd box x 2 <sup>7</sup> / <sub>8</sub>
	6P Acme box	6P Acme box
<b>Assembly Number</b>	120002262	100014232
<b>Extreme Environment Kit</b>	993.141	993.141
<b>Redress Kit</b>	120022208	100157024
<b>Maximum OD</b>		
in. (mm)	3.0 (76.20)	3.38 (85.85)
<b>Minimum ID</b>	N/A	N/A
<b>Maximum Operating</b>		
<b>Pressure (differential)</b>	10,000 (690)	5,000 (345)
psi (bars)		
<b>Minimum Operating</b>		
<b>Pressure (differential)</b>	1,000 (69)	1,000 (69)
psi (bars)		
<b>Flow Area</b>	N/A	N/A
<b>Temperature Rating</b>	Determined by	Determined by
	explosives or O-rings	explosives or O-rings
<b>Tensile Strength</b>		
lb (kg)	130,000 (58 900)	220,000 (99 700)
<b>Burst Pressure</b>		
psi (bars)	20,000 (1380)	20,000 (1380)
<b>Collapse Pressure</b>		
psi (bars)	20,000 (1380)	20,000 (1380)
<b>Overall Length</b>		
ft (m)	1.94 (0.59)	1.98 (0.60)

These ratings are guidelines only. For more information, consult your local JRC representative.



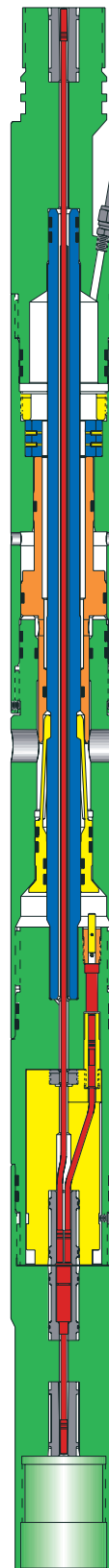
The Annulus-Pressure Firer-Control Line (APF-C) was developed as a dual-firing system that allows the perforating guns to be detonated by annular pressure, a drop bar, or tubing pressure. The APF-C system consists of a pressure transfer reservoir, a sleeve through the packer mandrel, an adapter below the packer, and a control line to transmit pressure from the annulus above the packer to the APF-C firing head assembly on top of the guns. Any of the mechanical pressure-firing heads can be attached to the top of the APF-C firing head.

### Operation

The APF-C system depends on the transfer of annular pressure through the packer down to the APF-C firing head. This pressure creates a differential pressure across the mandrel where the firing piston is housed. When the predetermined differential pressure is reached, the pins shear and the mandrel moves up and releases the firing piston, which is driven down by rathole pressure. The piston strikes the firing pin to set off the initiator. The operation of the drop bar or pressure-actuated firing head depends on which firing head system is used.

### Features and Benefits

- Can be used with nonfull-opening test tools and partially-filled tubing strings
- Can be used for drillstem testing or shoot-and-pull for gravel packs
- Can be used wherever a pressure-actuated tool is desirable
- Is ideal for deviated wells
- Provides a system of two firing heads on top of the guns
- Can be run with a mechanical or pressure-actuated firing head as a secondary firing mechanism
- Enhances safety because the annulus-operated portion is pressure-balanced before the packer is set and the tester valve is opened



*Annulus-Pressure  
Firer-Control Line*

## Annulus-Pressure Firer-Control Line

### Annulus-Pressure Firer-Control Line

<b>Thread Size and Type</b>	2 <sup>7</sup> / <sub>8</sub> (73.03)
<b>in. (mm)</b>	6P Acme box x pin
<b>Assembly Number</b>	100156138
<b>Extreme Environment Kit</b>	101016455
<b>Redress Kit</b>	100157210
<b>Maximum OD</b>	3.68 (93.47)
<b>in. (mm)</b>	
<b>Minimum ID</b>	N/A
<b>in. (mm)</b>	
<b>Maximum</b>	20,000 (1380)
<b>Operating Pressure</b>	
<b>psi (bars)</b>	250 (17)
<b>Minimum Operating</b>	
<b>Pressure</b>	
<b>psi (bars)</b>	Determined by explosives
<b>Temperature Rating</b>	
<b>°F (°C)</b>	or O-rings
<b>Tensile Strength</b>	174,000 (78 900)
<b>Burst Pressure</b>	N/A
<b>Collapse Pressure</b>	17,000 (1170)
<b>psi (bars)</b>	
<b>Minimum</b>	4.0 (1.22)

These ratings are guidelines only. For more information, consult your local JRC representative.

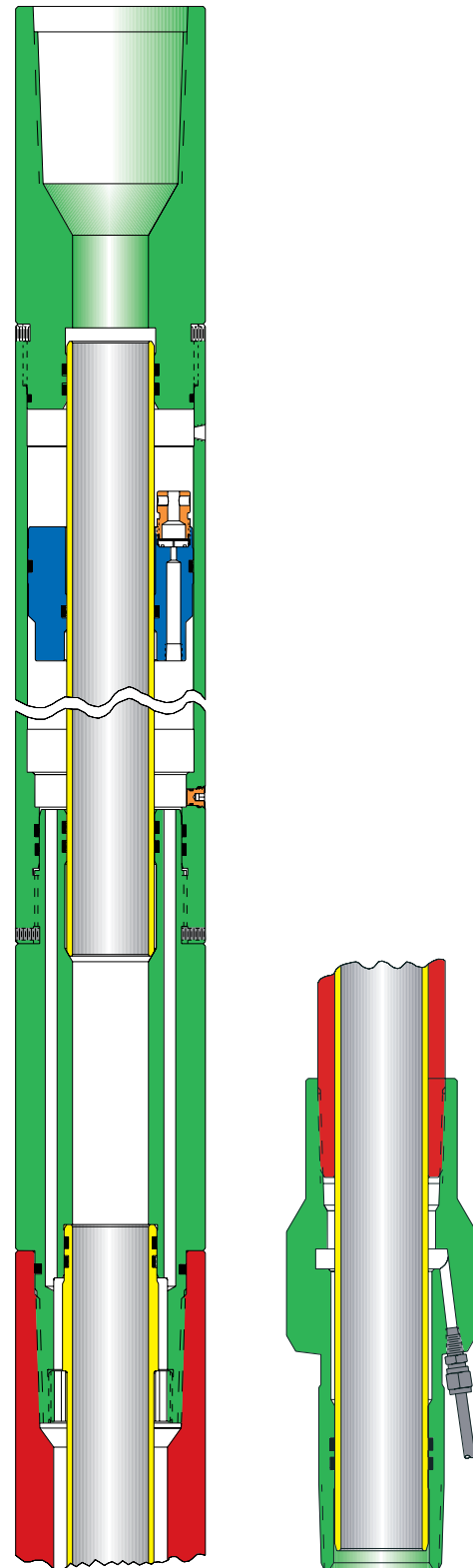
The Annulus-Pressure Transfer Reservoir (APTR) is an integral component of the Annulus-Pressure Firer-Control line (APF-C). The APTR is the mechanism that transmits pressure from above the packer to a differential pressure or pressure-actuated firing head on top of the perforating assembly.

### Operation

The APTR transmits annulus pressure into a microannulus created by the packer mandrel and the APTR mandrel. The pressure is ported to a control line sub on the lower end of the packer. A stainless steel control line connects the APTR to the pressure-responsive firing head on the perforating assembly.

### Features and Benefits

- Features a full-opening ID
- Is compatible with mud environments
- Is adapted for RTTS and CHAMP® packers
- Is ideal for applications that require a partial fluid column in the tubing string
- Eliminates the need for nitrogen



*Annulus-Pressure  
Transfer Reservoir*

# Annulus-Pressure Transfer Reservoir

**Annulus-Pressure Transfer Reservoir**

<b>Top Connection</b>	3 1/2 (88.90) 4 IF box x (98.43) 6 Stub Acme pin	4 1/2 (114.3) 4 IF box x pin
<b>Assembly Number</b>	100156028	101016453
<b>Redress Kit</b>	100005372	100157196
<b>Lower Connection</b>	2 7/8 (73.03) EUE 8 Rd box x pin	4 1/2 (114.3) 4 IF box x 3 1/2 (88.90) EUE 8 Rd pin
<b>Length Above Packer</b>	5.09 (1.55)	4.34 (1.32)
<b>ft (m)</b>		
<b>Length Below Packer</b>	1.02 (0.31)	1.33 (0.41)
<b>ft (m)</b>		
<b>Maximum OD</b>	5.00 (127)	6.12 (155.45)
<b>in. (mm)</b>		
<b>Minimum ID</b>	2.00 (50.8)	2.37 (60.20)
<b>in. (mm)</b>		
<b>Temperature Rating</b>	Determined by O-rings	Determined by O-rings
<b>Tensile Strength</b>	328,000 (148 700)	587,000 (266 200)
<b>lb (kg)</b>		
<b>Burst Pressure</b>	18,000 (1240)	22,000 (1515)
<b>psi (bars)</b>		
<b>Collapse Pressure</b>	15,000 (1035)	19,000 (1310)
<b>psi (bars)</b>		

These ratings are guidelines only. For more information, consult your local JRC representative.

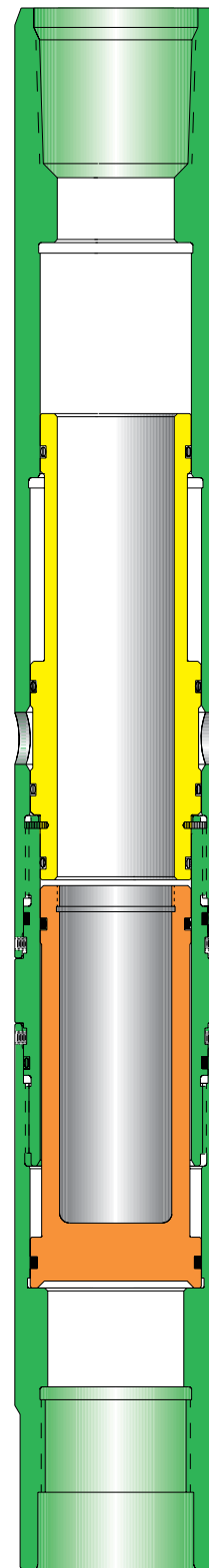
The Annulus-Pressure Firer-Control Vent (APF-C Vent) is a device that isolates the tubing from annulus fluid or pressure. The vent is actuated by rathole pressure after the perforating assembly has been detonated. It then provides a flowpath for the formation fluid into the tubing string.

### Operation

The APF-C Vent is run directly on top of the APF-C Firing Head. When the perforating assembly is detonated, the rathole pressure shifts an actuating piston into a power piston. The shift opens the flow ports to the tubing.

### Features and Benefits

- Is ideal for highly deviated or horizontal wells
- Requires minimal pressure to operate
- Eliminates nitrogen displacement or swabbing the tubing string to achieve desired underbalance



APF-C Vent

**APF-C Vent**

<b>Thread Size and Type in. (mm)</b>	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE 8 Rd box x 2 <sup>7</sup> / <sub>8</sub> (73.03) 6P Acme box	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE 8 Rd box x 2 <sup>7</sup> / <sub>8</sub> (73.03) 6P Acme box
<b>Assembly Number</b>	120038049	101016565
<b>Redress Kit</b>	100014384	100014382
<b>Minimum ID in. (mm)</b>	non full-bore	non full-bore
<b>Maximum Operating Pressure psi (bars)</b>	20,000 (1380)	20,000 (1380)
<b>Minimum Operating Pressure psi (bars)</b>	250 (17)	250 (17)
<b>Flow Area in.<sup>2</sup> (cm<sup>2</sup>)</b>	2.63 (16.97)	3.93 (25.34)
<b>Number &amp; ID of Ports</b>	4 ports w/1-in. (25.4 mm) ID	5 ports w/1-in. (25.4 mm) ID
<b>Temperature Rating °F (°C)</b>	Determined by O-rings	Determined by O-rings
<b>Tensile Strength lb (kg)</b>	150,000 (68 000)	170,000 (77 000)
<b>Burst Pressure psi (bars)</b>	25,000 (1725)	25,000 (1725)
<b>Collapse Pressure psi (bars)</b>	22,000 (1515)	15,000 (1035)
<b>Minimum Overall Length ft (m)</b>	2.37 (0.72)	2.43 (0.74)

These ratings are guidelines only. For more information, consult your local JRC representative.

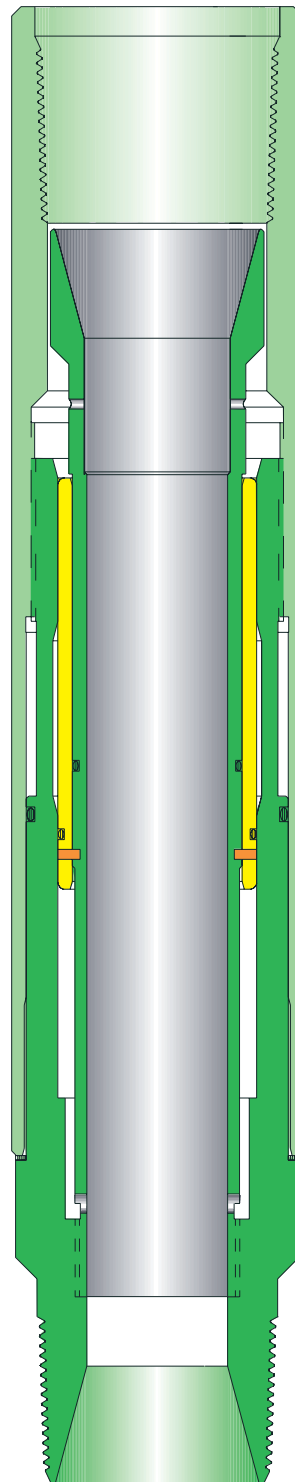
The Pressure-Actuated Tubing Release (PATR) is used to separate the guns from the tool string when mechanical or slicklike devices are not desirable. When separated, the guns drop off of the production tubing. Once the guns drop away, other tools and operations have no restrictions through the end of the tubing. In fact, the housing attached to the string has a greater ID than the tubing.

**Operation**

The PATR consists of four main components: an upper housing, lower finger release sub, inner sleeve, and retaining latch. The PATR is pressure-balanced until the standing valve is dropped into the inner sleeve. Tubing pressure is applied to shear the retaining pins in the latch. Once the latch has been shifted, the finger release sub with the sleeve releases from the housing and drops the perforating assembly into the rathole.

**Features and Benefits**

- Leaves the tubing string fully open
- Is ideal for use in remote areas where wireline is expensive or unfavorable
- Is ideal for situations where wireline can cause a safety hazard
- Provides access to the wellbore for production logging tools
- Is especially suited for releasing guns prior to stimulation treatments



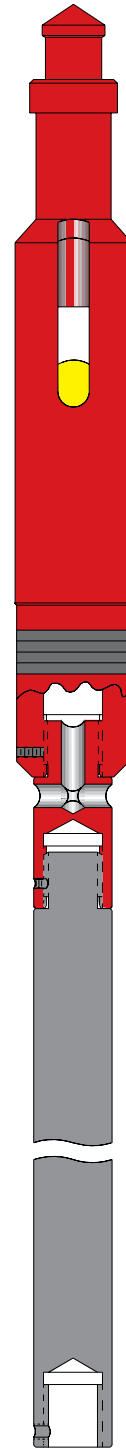
*Pressure-Actuated Tubing Release*

# Pressure-Actuated Tubing Release

**Pressure-Actuated Tubing Release**

Thread Size and Type	2 3/8 (60.33) EUE	2 7/8 (73.03) EUE	3 1/2 (88.9) EUE
in. (mm)	8 Rd box x pin	8 Rd box x pin	8 Rd box x pin
Assembly Number	100156751	100156744	1010156385
Maximum OD	3.38 (85.85)	3.75 (95.25)	4.19 (106.43)
in. (mm)			
Minimum ID	1.63 (41.40)	1.812 (46.02)	1.812 (46.02)
Before Release			
in. (mm)	2.31 (58.67)	2.828 (71.83)	3.5 (88.90)
After Release			
in. (mm)	90,000 (40 800)	120,000 (54 400)	130,000 (58 900)
Tensile Strength			
lb (kg)	10,000 (670)	10,000 (670)	10,000 (670)
Burst Pressure			
psi (bars)	9,000 (620)	10,000 (670)	10,000 (670)
Collapse Pressure			
psi (bars)	1.76 (44.70)	1.86 (47.24)	1.86 (47.24)
Standing Valve OD			
in. (mm)	1.89 (0.58)	1.59 (0.48)	1.70 (0.52)
Overall Length			
ft (m)			

These ratings are guidelines only. For more information, consult your local JRC representative.



*Pressure-Actuated  
Tubing Release*



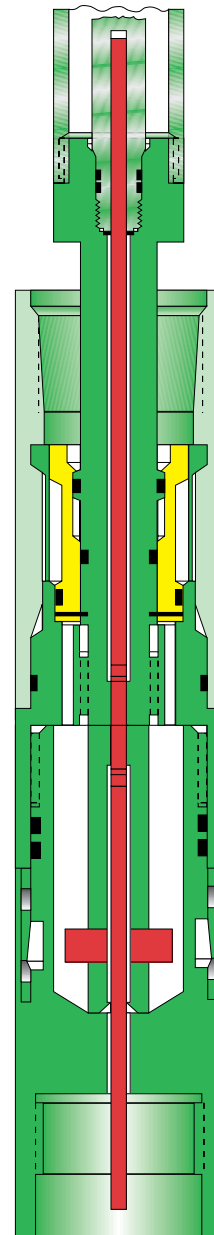
The Automatic Release (AR) allows the perforating guns to drop immediately after firing.

### Operation

The AR allows for dropping the perforating guns after they are fired. The guns may be fired either mechanically or by pressure. The releasing device is actuated by the pressure generated outside the perforating guns upon detonation, so the guns are released as soon as they fire.

### Features and Benefits

- Can be used with most mechanical and pressure-actuated firing heads
- Allows for immediate release of the guns
- Leaves the tubing fully open after the guns are released
- Eliminates the need to run wireline to shift the guns
- Reduces the chance of the guns sticking because of debris



## Automatic Release

Thread Size and Type	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03)	3 <sup>1</sup> / <sub>2</sub> (88.90) EUE	4 <sup>1</sup> / <sub>2</sub> (114.30)
in. (mm)	8 Rd	8 Rd	High Pressure	8 Rd	OD Box
<b>Assembly Numbers</b>	100005255 100005226	100005233	100014158 100010045	100005236 100156106	100155752
		100005234			
		100005235			
		100155754			
<b>Maximum OD</b>	2.88 (73.15)	3.38 (85.85)	3.38 (85.85)	3.78 (96.01)	4.5 (114.30)
<b>in. (mm)</b>					
<b>ID After Release</b>	2.125 (53.98)	2.72 (69.09)	2.527 (64.186)	2.99 (75.95)	3.67 (93.22)
<b>in. (mm)</b>					
<b>Maximum</b>	20,000 (1380)	20,000 (1380)	20,000 (1380)	20,000 (1380)	20,000 (1380)
<b>Operating Pressure</b>					
<b>psi (bars)</b>					
<b>Minimum</b>	1,500 (103)	1,500 (103)	500 (34)	1,500 (103)	1,500 (103)
<b>Operating Pressure</b>					
<b>psi (bars)</b>					
<b>Tensile Strength</b>	49,500 (22 400)	68,000 (30 800)	68,000 (30 800)	68,000 (30 800)	115,000 (52 100)
<b>lb (kg)</b>					
<b>Maximum</b>	15,000 (1035)	10,000 (690)	17,000 (1,170)	10,000 (690)	9,500 (655)
<b>Differential Pressure</b>					
<b>psi (bars)</b>					
<b>Overall Length</b>	2.06 (0.63)	2.23 (0.68)	2.23 (0.68)	2.23 (0.68)	2.23 (0.68)

These ratings are guidelines only. For more information, consult your local JRC representative.

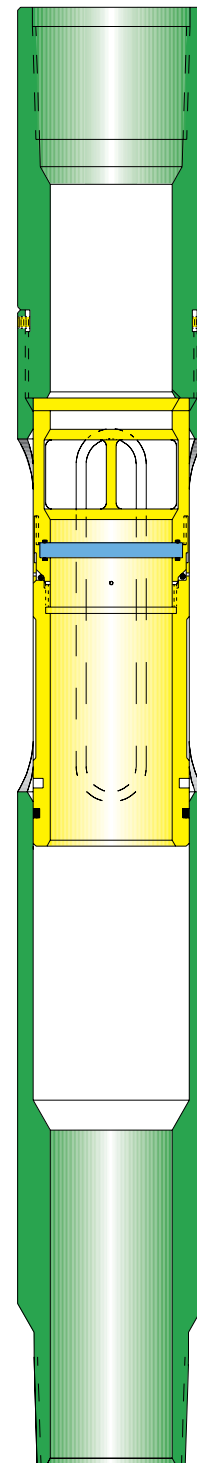
The ported Balanced Isolation Tool (BIT) assembly is used where either packer selection or well conditions preclude the use of a venting device. The ported BIT assembly replaces the fill disc assembly and is used in place of a perforated sub. The BIT prevents contamination of the fluid below it from the fluid above it. Debris or solids in the fluid above cannot pass through the glass disc that is in the floating piston. The glass disc prevents debris from setting on the firing head. Pressure is balanced across the glass barrier through equalizing ports in the piston. The ported BIT assembly is run between the firing head and packer. The recommended minimum distance from the BIT to the firing head is 30 ft.

## Operation

The basic components of the BIT are a floating piston with a glass disc, a ported lower housing, and a top housing. The ported BIT is run with clean fluid below it. The upward travel of the floating piston is limited by the bottom of the top sub. A pressure increase above the glass barrier causes the piston to move down and forces fluid below the glass barrier out of the bleeder ports. A pressure increase below the glass barrier forces the piston to move up or forces fluid out of the bleeder ports. The piston moves up or down within its limits to prevent the glass barrier from breaking. The glass barrier remains intact until the bar passes through it. As fluid enters or leaves the tubing through the ports, debris on the glass barrier is washed off.

## Features and Benefits

- Allows mud and debris to be circulated off the glass barrier through the flow ports above the glass barrier
- Allows displacement of the tubing with a lighter fluid or nitrogen before firing the guns
- Allows swabbing of the tubing to achieve differential pressure
- Allows stopping and circulating at any depth since flow ports are always open
- Can be run with either a mechanical or pressure-actuated firing head



*Balanced Isolation Tool*

# Balanced Isolation Tool

**Balanced Isolation Tool**

Thread Size and Type	1.90 (48.26) EUE	2 3/8 (60.33) EUE	2 7/8 (73.03) EUE	3 1/2 (88.90) EUE
in. (mm)	10 Rd box x pin	8 Rd box x pin	8 Rd box x pin	8 Rd box x pin
Assembly Number	120002203	100014322	100014323	100156936
Extreme Environment Kit	993.801	100014379	100157190	100157192
Redress Kit	100157195	100014377	100014378	100157191
Maximum OD	2.50 (63.50)	3.10 (78.74)	3.75 (95.25)	4.25 (107.95)
in. (mm)				
Minimum ID	1.61 (40.89)	2.0 (50.80)	2.44 (61.98)	3.0 (76.20)
in. (mm)				
Flow Area	2.03 (13.10)	3.14 (20.27)	4.68 (30.19)	7.07 (45.60)
in. <sup>2</sup> (cm <sup>2</sup> )				
Number of Ports	4	4	4	4
Tensile Strength	110,000 (49 800)	155,000 (70 200)	200,000 (90 700)	280,000 (126 900)
lb (kg)				
Collapse Pressure	16,000 (1100)	17,000 (1170)	18,000 (1240)	16,000 (1100)
psi (bars)				

These ratings are guidelines only. For more information, consult your local JRC representative.

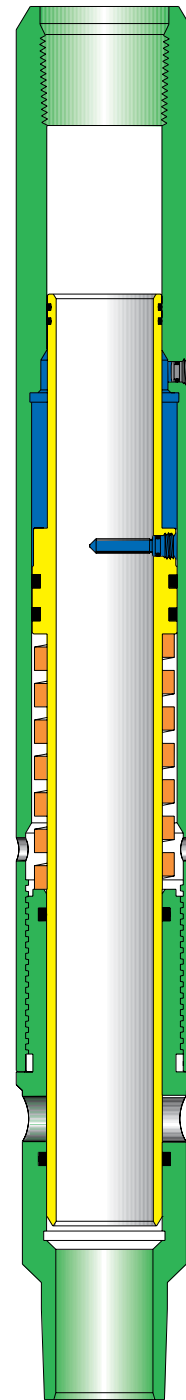
The Maximum Differential Bar Vent Assembly (MDBV) is a vent run between the perforating guns and the packer. After the packer is set, the opening of the vent creates communication between the tubing and rathole. The vent is opened by breaking the plug inside the tool and allowing the sleeve to uncover the ports. Running the MDBV allows the operator to run the tubing in the well with no hydrostatic pressure in the tubing.

### Operation

The MDBV is held closed by a chamber of silicone fluid, which keeps a spring compressed. When the silicone fluid is released from the chamber, the spring extends and opens the vent. Once the break plug is broken, the silicone fluid drains into the tubing. The MDBV should not be used when the hydrostatic pressure in the tubing exceeds 1,000 psi. If you wish to open the vent before dropping the detonating bar, you can drop a special tube that will open the vent and not fire the guns. When the bar is dropped, it will pass through the tube and fire the guns.

### Features and Benefits

- Operates with a minimum amount of fluid in the tubing
- Allows maximum differential pressure when perforating in lower-pressure formations
- Does not depend on tubing hydrostatic pressure to operate
- Is assisted mechanically by an operating spring to help ensure full and complete opening
- Can be used in wells with open perforations to achieve an underbalance when guns are fired to add new perforations



*Maximum Differential  
Bar Vent*

## Maximum Differential Bar Vent

Maximum Differential Bar Vent

Thread Size and Type	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE	3 <sup>1</sup> / <sub>2</sub> (88.9) EUE
in. (mm)	8 Rd box x pin	8 Rd box x pin	8 Rd box x pin
Assembly Number	100005291	100005294	100156853
Redress Kit	100014376	100005368	100157194
Maximum OD	3.36 (92.20)	3.88 (98.55)	4.50 (114.30)
in. (mm)			
Minimum ID	2.0 (50.80)	2.25 (57.15)	2.75 (69.85)
in. (mm)			
Maximum Operating	10,000 (690)	9,000 (620)	8,000 (550)
Pressure (Differential)			
psi (bars)			
Minimum Operating	None	None	None
Pressure (Differential)			
psi (bars)			
Temperature Rating (Limited by silicone fluid) °F (°C)	350 (176)	350 (176)	350 (176)
Tensile Strength	221,000 (100 200)	231,000 (104 700)	245,000 (111 000)
lb (kg)			
Burst Pressure	19,500 (1345)	19,000 (1310)	14,000 (965)
psi (bars)			
Collapse Pressure	16,500 (1135)	13,000 (895)	14,000 (965)
psi (bars)			
Overall Length	2.48 (0.75)	2.58 (0.79)	2.95 (0.90)
ft (m)			
Number of Ports	5	4	4
ID of Ports	1.0 (25.40)	1.13 (28.70)	1.75 (44.45)
in. (mm)			
Flow Area of Ports	3.92 (25.29)	4.01 (27.87)	9.58 (61.81)
in <sup>2</sup> (cm <sup>2</sup> )			

These ratings are guidelines only. For more information, consult your local JRC representative.

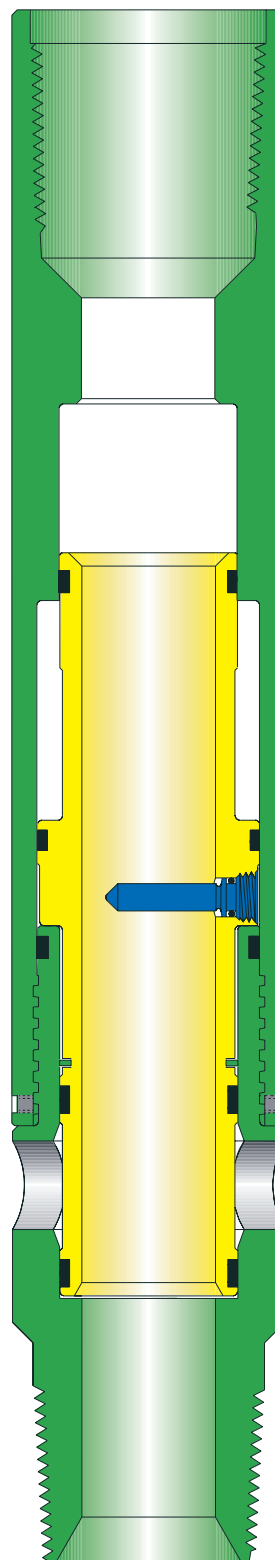
The Bar Pressure Vent (BPV) is designed to achieve a differential pressure between the formation and tubing string. The tool safely allows a differential pressure in wells with existing open perforations or in unperforated wells. The BPV is an internal sliding-sleeve tool, actuated by pressure in the tubing. It is run between the packer and the guns.

### Operation

The BPV consists of a ported housing and a sliding sleeve. The sliding sleeve is isolated from the tubing pressure by a break plug with a hollow center. The BPV is activated when the detonating bar is dropped through the tubing and shears the hollow break plug. This action allows the pressure in the tubing to force the sleeve upward, uncovering the ports. A lock ring locks the sleeve open. The detonating bar continues downward to strike the firing head. If the inward differential pressure across the tool exceeds 2,000 psi, it is strongly recommended that a pressure differential reduction stub be installed above the BPV. If you wish to open the vent before dropping the detonating bar, you can drop a special tube that will open the vent and not fire the guns. When the bar is dropped, it will pass through the tube and fire the guns.

### Features and Benefits

- Offers an inexpensive way to create the necessary underbalance
- Allows the hole to be totally contained at the well-head before the surge
- Once the port is opened, the sleeve is locked in place
- Can be run with any packer
- Does not rely on tubing manipulation; hydrostatic pressure in the tubing is the only force required



*Bar Pressure Vent*

## Bar Pressure Vent

Thread Size and Type	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>3</sup> / <sub>8</sub> (63.33) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE	3 <sup>1</sup> / <sub>2</sub> (88.90) EUE
in. (mm)	8 Rd box x pin	8 Rd box x pin	8 Rd box x pin	8 Rd box x pin
Assembly Number	101201951	100155788	100010328	100155789
Extreme Environment Kit	101201952	101224570	101224571	100157219
Redress Kit	100157211	100157216	100157217	100157218
Maximum OD	3.06 (77.72)	3.63 (92.20)	3.88 (98.55)	5.0 (127.0)
in. (mm)				
Minimum ID	1.50 (38.10)	2.0 (50.80)	2.25 (57.15)	2.75 (69.85)
in. (mm)				
Maximum	20,000 (1380)	15,000 (1035)	15,000 (1035)	15,000 (1035)
Operating Pressure				
psi (bars)	8,000 (550)	8,000 (550)	8,000 (550)	8,000 (550)
Differential Pressure				
psi (bars)	1,000 (69)	1,000 (69)	1,000 (69)	1,000 (69)
Minimum				
Operating Pressure	1.77 (11.40)	3.14 (20.27)	3.98 (25.65)	5.94 (38.32)
psi (bars)				
Flow Area	4 @ 1.0 (25.40)	4 @ 1.0 (25.40)	4 @ 1.13 (28.70)	4 @ 1.75 (44.45)
in. <sup>2</sup> (cm <sup>2</sup> )				
Number and ID	Determined by	Determined by	Determined by	Determined by
of Ports				
in. (mm)	O-rings	O-rings	O-rings	O-rings
Temperature Rating				
°F (°C)	140,000 (63 400)	146,000 (66 200)	160,000 (72 500)	400,000 (181 400)
Tensile Strength				
lb (kg)	24,000 (1655)	18,000 (1240)	19,000 (1310)	22,000 (1515)
Burst Pressure				
psi (bars)	20,000 (1380)	22,000 (1515)	17,000 (1170)	18,000 (1240)
Collapse Pressure				
psi (bars)	1.46 (0.44)	1.46 (0.44)	1.57 (0.48)	1.77 (0.54)
Overall Length				
ft (m)				

These ratings are guidelines only. For more information, consult your local JRC representative.



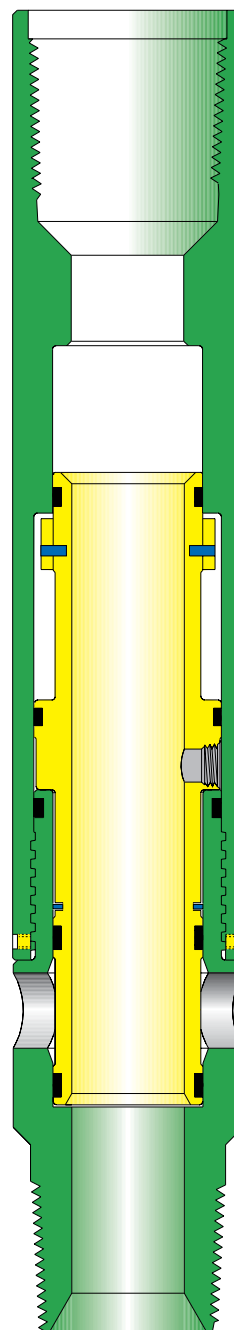
The Pressure-Operated Vent (POV) is designed to achieve a differential pressure between the formation and tubing string and to provide a way to open the vent and test the packer before the guns are fired. When the guns have been positioned and the packer has been set, the predetermined amount of fluid is added to the tubing. Adding the fluid into the tubing causes the POV to open and creates the proper pressure differential before firing. Nitrogen may also be used with, or in place of, the fluids to obtain the necessary hydrostatic pressure in the tubing.

### Operation

The POV consists of a ported housing, a sliding sleeve, and a set of shear pins. The sleeve is held in the closed position by a variable number of shear pins. The pins are isolated from annular pressure and are only exposed to the tubing hydrostatic. The POV will open when the proper amount of hydrostatic pressure is applied to the shear pins. The amount of hydrostatic it takes to open the POV depends on how many shear pins are installed in the tool. When the pins shear, the hydrostatic pressure forces the sleeve upward, which uncovers the flow ports. The sleeve is then locked into the open position.

### Features and Benefits

- Allows the vent to be opened without the guns being fired
- Allows the packer to be tested before the guns are fired
- Fills tubing automatically when run with VCV
- Can be run with mechanical or pressure-actuated firing heads
- Is useful in highly deviated wells
- Is compatible with any packer



*Pressure-Operated Vent*

## Pressure-Operated Vent

Pressure-Operated Vent

<b>Thread Size and Type</b>	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>3</sup> / <sub>8</sub> (63.33) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE	3 <sup>1</sup> / <sub>2</sub> (88.90) EUE
<b>in. (mm)</b>	8 Rd box x pin	8 Rd box x pin	8 Rd box x pin	8 Rd box x pin
<b>Assembly Number</b>	101201951	100155788	100010328	100155789
<b>Extreme Environment Kit</b>	101201952	101224570	101224571	100157219
<b>Redress Kit</b>	100157211	100157216	100157217	100157218
<b>Maximum OD</b>	3.06 (77.72)	3.63 (92.20)	3.88 (98.55)	5.0 (127.0)
<b>in. (mm)</b>				
<b>Minimum ID</b>	1.50 (38.10)	2.0 (50.80)	2.25 (57.15)	2.75 (69.85)
<b>in. (mm)</b>				
<b>Maximum</b>	20,000 (1380)	15,000 (1035)	15,000 (1035)	15,000 (1035)
<b>Operating Pressure</b>				
<b>psi (bars)</b>	8,000 (550)	8,000 (550)	8,000 (550)	8,000 (550)
<b>Differential Pressure</b>				
<b>psi (bars)</b>	1,000 (69)	1,000 (69)	1,000 (69)	1,000 (69)
<b>Minimum</b>				
<b>Operating Pressure</b>	1.77 (11.40)	3.14 (20.27)	3.98 (25.65)	5.94 (38.32)
<b>psi (bars)</b>				
<b>Flow Area</b>	1.77 (11.40)	3.14 (20.27)	3.98 (25.65)	5.94 (38.32)
<b>in.<sup>2</sup> (cm<sup>2</sup>)</b>				
<b>Number and ID</b>	4 @ 1.0 (25.40)	4 @ 1.0 (25.40)	4 @ 1.13 (28.70)	4 @ 1.75 (44.45)
<b>of Ports</b>				
<b>in. (mm)</b>	Determined by	Determined by	Determined by	Determined by
<b>Temperature Rating</b>				
<b>°F (°C)</b>	O-rings	O-rings	O-rings	O-rings
<b>Tensile Strength</b>	140,000 (63 400)	146,000 (66 200)	160,000 (72 500)	400,000 (181 400)
<b>lb (kg)</b>				
<b>Burst Pressure</b>	24,000 (1655)	18,000 (1240)	19,000 (1310)	22,000 (1515)
<b>psi (bars)</b>				
<b>Collapse Pressure</b>	20,000 (1380)	22,000 (1515)	17,000 (1170)	18,000 (1240)
<b>psi (bars)</b>				
<b>Overall Length</b>	1.46 (0.44)	1.46 (0.44)	1.57 (0.48)	1.77 (0.54)

These ratings are guidelines only. For more information, consult your local JRC representative.

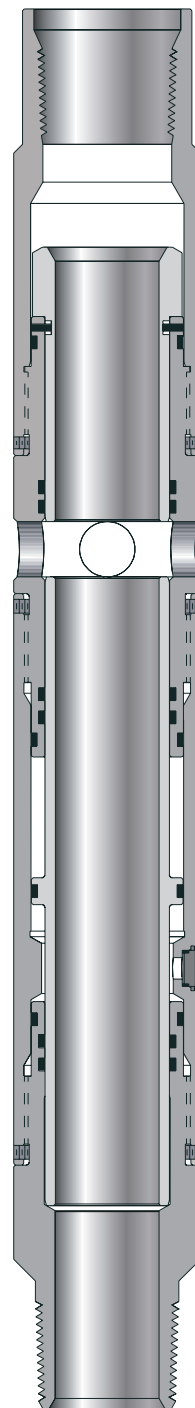
The Vann™ Circulating Valve (VCV) is designed to be used as a fillup valve or as a circulating valve for displacing well fluids before setting a packer. After the fluid is displaced, the operator applies pressure to the tubing or annulus to rupture a disc and close the VCV.

**Operation**

The VCV consists of a ported housing, a sliding sleeve, and a rupture disc, which must be ordered separately. The sliding sleeve, which has two air chambers, is open while the tool is run in the hole. The rupture disc is available for different pressure ratings as needed. The amount of hydrostatic pressure required to actuate the VCV depends on the rating of the rupture disc. Once the disc ruptures, the hydrostatic pressure enters the lower air chamber through the ruptured disc, forcing the sliding sleeve upward to cover the flow ports. Operating pressure can be pump pressure applied after the VCV is at the bottom of the well or applied by hydrostatic pressure when the tool is run in the hole.

**Features and Benefits**

- Can be used as a circulating and shutoff valve
- Is often run with other venting or production devices
- Is economical and reusable



*Vann™ Circulating Valve*

## Vann™ Circulating Valve

<b>Thread Size and Type</b>	2 3/8 (60.33) EUE	*2 7/8 (73.03) EUE
<b>in. (mm)</b>	8 Rd box x pin	8 RD box x Pin
<b>Assembly Number</b>	101015732	1200038456
<b>Maximum OD</b>	3.38 (85.85)	4.65 (188.11)
<b>in. (mm)</b>		
<b>Minimum ID</b>	1.875 (47.62)	2.12 (53.85)
<b>in. (mm)</b>		
<b>Maximum</b>	15,000 (1035)	15,000 (1035)
<b>Pressure Operating</b>		
<b>psi (bars)</b>	1,000 (69)	1,000 (69)
<b>Minimum</b>		
<b>Operating Pressure</b>	1,000 (69)	1,000 (69)
<b>psi (bars)</b>		
<b>Temperature Rating</b>	Determined by O-rings	Determined by O-rings
<b>°F (°C)</b>		
<b>Tensile Strength</b>	225,000 (102 000)	392,000 (177 700)
<b>lb (kg)</b>		
<b>Burst Pressure</b>	22,000 (1515)	20,000 (1380)
<b>psi (bars)</b>		
<b>Collapse Pressure</b>	18,000 (1250)	18,000 (1250)
<b>psi (bars)</b>		
<b>Overall Length</b>	2.11 (0.64)	3.45 (1.05)
<b>ft (m)</b>		
<b>Number of Ports</b>	4	6
<b>ID of Ports</b>	1.0 (25.4)	1.0 (25.4)
<b>in. (mm)</b>		
<b>Flow Area of Ports</b>	3.14 (20.26)	4.71 (30.39)
<b>in.<sup>2</sup> (cm<sup>2</sup>)</b>		

These ratings are guidelines only. For more information, consult your local JRC representative.

\*Optional connections are: 2 7/8-IF and 3 1/2-IF

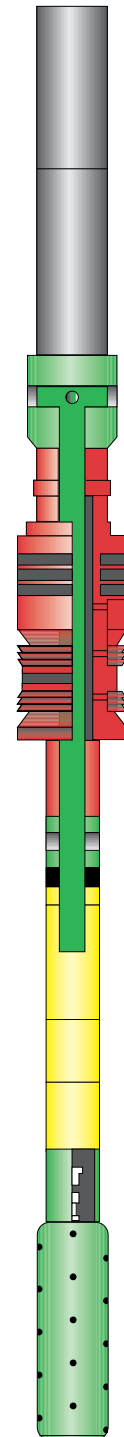
The Annulus-Pressure Crossover Assembly (APCA) allows the use of annulus pressure to actuate any one of several firing heads. This assembly is compatible with retrievable packers of all types and sizes.

### Operation

The APCA creates a pressure chamber above the firing head that is equalized with the pressure in the casing annulus. Once the packer has been set, the pressure on the annulus can be increased to actuate a pressure-actuated firing head. The pressures in the annulus and the tubing can also be manipulated to create the differential pressure necessary to actuate a differential-type firing head.

### Features and Benefits

- May be used as the annulus firing system on wells with nonfull-opening test tools and partially filled drillstring
- May be used as the annulus firing system on horizontal wells
- Allows the use of below-packer venting devices along this assembly



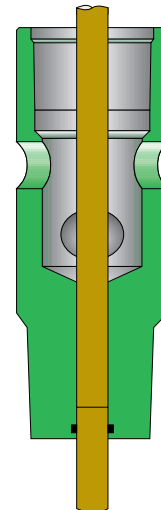
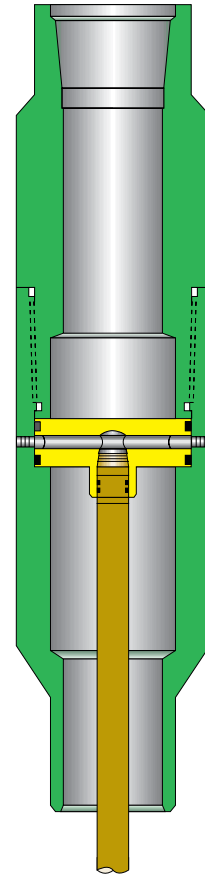
*Annulus-Pressure  
Crossover Assembly*

# Annulus-Pressure Crossover Assembly

## Annulus-Pressure Crossover Assembly

Thread Size and Type	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE
in. (mm)	8Rd	8Rd
Assembly Number	100014175	100155786
Maximum OD	3.56 (90.42)	5.0 (127)
in. (mm)		
Minimum ID	Non Full-bore	Non Full-bore
Maximum Operating Pressure	Determined by tubulars	Determined by tubulars
Maximum Differential Pressure	16,000 (1100)	16,000 (1100)
psi (bars)		
Flow Area	2.25 (14.52)	4.75 (30.65)
in. <sup>2</sup> (cm <sup>2</sup> )		
Temperature Rating	Determined by O-rings	Determined by O-rings
°F (°C)		
Tensile Strength	190,000 (86 200)	270,000 (122 400)
lb (kg)		
Burst Pressure	27,000 (1860)	22,000 (1515)
psi (bars)		
Collapse Pressure	16,000 (1100)	16,000 (1100)
psi (bars)		
Overall Length	12.35 (3.76)	12.60 (3.84)
ft (m)		
Minimum Makeup	9.15 (2.79)	9.40 (2.87)
Length		
ft (m)		

These ratings are guidelines only. For more information, consult your local JRC representative.



*Annulus-Pressure  
Crossover Assembly*

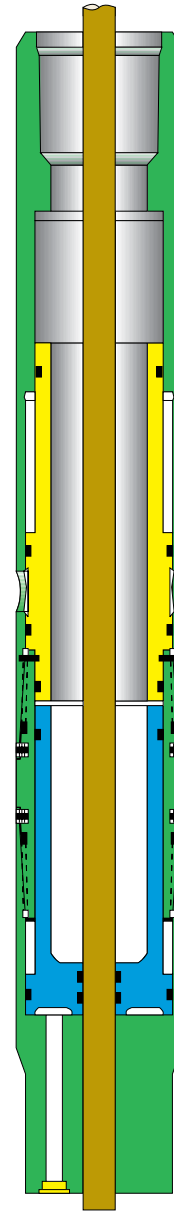
The Below-Packer Vent Device (BPVD) was developed for use with the Annulus-Pressure Crossover Assembly (APCA). Surface pressure applied to the annulus is transmitted through the APCA to a closed chamber below the BPVD and above a pressure-responsive firing head. The BPVD can be set to work before or after the perforating assembly is detonated.

### Operation

To open the BPVD, a predetermined annulus pressure is transmitted through the APCA to below the BPVD. This pressure then ruptures a disc in the lower housing of the BPVD. An actuating piston then forces the venting sleeve away from the production ports. This action establishes communication with the tubing string.

### Features and Benefits

- Does not require tubing hydrostatic pressure to operate
- Can operate in highly deviated wells
- Can be used in wells with low formation pressure
- Eliminates nitrogen requirements
- Allows maximum underbalance
- Is compatible with several types of firing heads
- Features reliable and very accurate pressure response



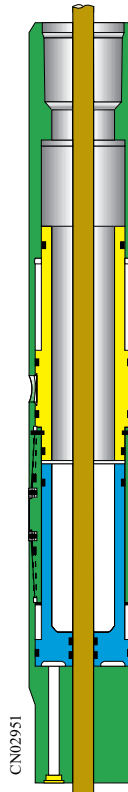
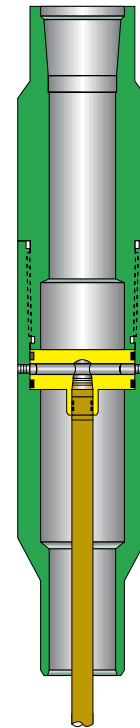
*Below-Packer  
Vent Device*

# Below-Packer Vent Device

## Below-Packer Vent Device

Thread Size and Type	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE
in. (mm)	8 Rd box x pin	8 Rd box x pin
Assembly Number	100155787	100014176
Maximum OD	3.38 (85.85)	3.88 (98.55)
in. (mm)		
Minimum ID	Non Full-bore	Non Full-bore
in. (mm)		
Maximum	15,000 (1035)	15,000 (1035)
Operating Pressure		
psi (bars)	1,000 (69)	1,000 (69)
Minimum		
Operating Pressure	Determined by O-rings	Determined by O-rings
psi (bars)		
Temperature Rating	Determined by O-rings	Determined by O-rings
°F (°C)		
Tensile Strength	150,000 (68 000)	170,000 (77 000)
lb (kg)		
Burst Pressure	25,000 (1725)	25,000 (1725)
psi (bars)		
Collapse Pressure	22,000 (1515)	15,000 (1035)
psi (bars)		
Overall Length	2.42 (0.74)	2.43 (0.74)
ft (m)		
Number of Ports	4	5
ID of Ports	1.0 (25.4)	1.0 (25.4)
in. (mm)		

These ratings are guidelines only. For more information, consult your local JRC representative.



Below-Packer  
Vent Device



**Description**

The Fill Disc Assembly (FDA) is used where either packer selection or well conditions preclude the use of a venting device. The FDA is used in place of a perforated sub, and replaces the Balanced Isolation Tool in wells with reasonably clean fluids. The glass disc prevents debris from settling on the firing head. Pressure is equalized across the glass disc. The FDA is run between the firing head and packer. The recommended minimum distance from the FDA to the firing head is 30 ft.

**Features and Benefits**

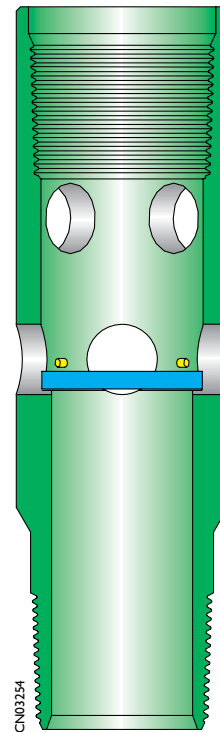
The FDA

- Allows debris to be circulated off the glass disc through the flow ports above the glass disc
- Acts as a perforated sub for circulating fluid displacement with nitrogen and swabbing
- Can be run with either a mechanical or pressure-actuated firing head

**Operation**

The FDA consists of a ported housing with a glass disc installed in the ID across the lower set of ports. The disc is not sealed, so pressure can equalize across the glass. Any debris falling out of the tubing or fluid above the glass will land on the glass disc. This debris can be circulated off the disc, or if it is not a large amount, it will be displaced out the ports by the detonating bar falling through it.

Once the bar breaks through the disc, it should be falling in clean fluid all the way to the firing head. In mud systems or wells with a known debris problem, the Balanced Isolation Tool is recommended in place of the FDA.



*Fill Disc Assembly*

### Fill Disc Assembly

Thread Size and Type	2 <sup>3</sup> / <sub>8</sub> (60.33) EUE	2 <sup>7</sup> / <sub>8</sub> (73.03) EUE	3 <sup>1</sup> / <sub>2</sub> (88.90) EUE
in. (mm)	8Rd box x pin	8Rd box x pin	8Rd box x pin
Assembly Number	100005295	100005297	100005299
Maximum OD	3.01 (76.45)	3.51 (89.15)	4.20 (106.68)
in. (mm)			
Minimum ID	1.98 (50.29)	2.44 (61.98)	3.0 (76.20)
in. (mm)			
Flow Area	6.28 (40.54)	7.88 (50.8)	14.13 (91.20)
in. <sup>2</sup> (cm <sup>2</sup> )			
Number of Ports	8	8	8
Tensile Strength	235,000 (106 400)	275,000 (124,700)	400,000 (181,600)
lb (kg)			
Overall Length	0.86 (0.26)	0.88 (0.27)	0.89 (0.27)
ft (m)			