

Perforating Solutions

Perforating Solutions maintains an unequalled success and safety record while continuously developing and introducing new and innovative products for tubing conveyed and wireline perforating.

Shaped Charges

Halliburton shaped charges lead the way in quality, reliability and performance. Halliburton ballistic engineers at Jet Research Center continue to develop and manufacture perforating systems for virtually any reservoir environment or intervention technique. Halliburton also has the capability and expertise to develop custom charges to maximize effective penetration into specific reservoirs.

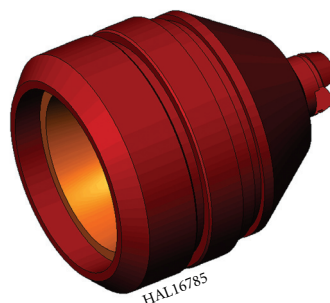
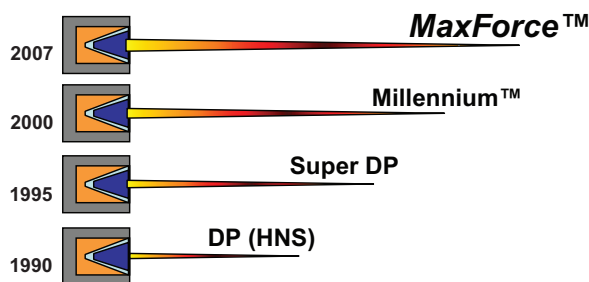
MaxForce™ Shaped Charges

The new MaxForce™ line of super-deep penetrating charges is Jet Research Center's latest advancement in shaped charge evolution. The MaxForce line of charges is manufactured with the highest level of quality assurance that results in a lower standard deviation to provide consistent charge performance.

Features

MaxForce deeper penetration charges:

- Increase productivity
- Penetrate past any near wellbore damage with deeper penetration
- Potentially intersect more natural fractures with deeper penetration
- Reduce pressure drop at perforations, which can potentially delay scale, paraffin, or asphaltene deposits



Dominator® Shaped Charges

The Dominator® shaped charges are designed to optimize perforating performance in reservoir rock and increase hydrocarbon production. To achieve that goal, Dominator charges were evaluated in terms of geometry and flow performance in sandstone targets at simulated downhole conditions instead of by their ability to penetrate API 19B Section I unstressed concrete. As a result, these new shaped charges far exceed the performance of current, comparable charges.

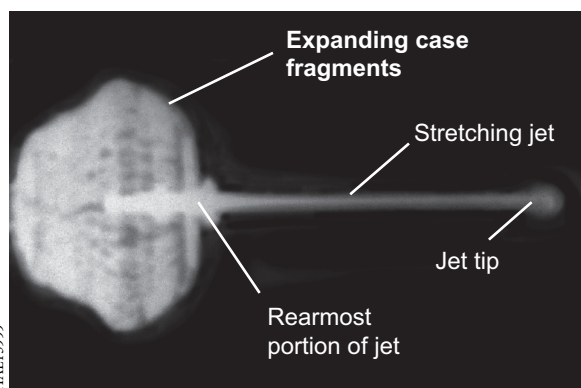
A Revolutionary Approach to Charge Development

To maximize well inflow performance for a specific reservoir, it is necessary to engineer the shaped-charge explosive jet-tip velocity profile with consideration to the target properties (compressive strength, particle grain size, pore fluid type, etc.). Optimized shaped charge design combined with perforating best practices per Halliburton's PerfPro® process ensure that all perforations are surged at the optimum underbalance pressure to minimize perforation skin effects. Naturally, shaped charges engineered for a given reservoir should be validated with API 19B Section IV testing (i.e. Perforation Flow Laboratory) at as close to in-situ properties as possible.

Dominator shaped charges were developed at Halliburton's Jet Research Center (JRC) Perforation Flow Laboratory by firing perforating charges into real rock under simulated downhole conditions that included rock effective stress, wellbore underbalance, and rock pore pressure. By analyzing post-shot results from the testing program, it was possible to rapidly develop a design with favorable jet characteristics.

Using the perforation flow laboratory in the design process also avoided the pitfalls associated with translating data from surface shot concrete targets to productivity estimations in downhole reservoirs.

The improvement in penetration performance is evident from the results. In one example, penetration increased by an average of 52% in the gas-filled samples and by an average of 37% in liquid-filled samples. These penetration results, along with improvement in core flow efficiency, contribute to increased flow performance.



Flash X-ray of a charge during detonation sequence



Actual charge performance in formation core samples comparing standard charge on left vs the Dominator® charge on the right.

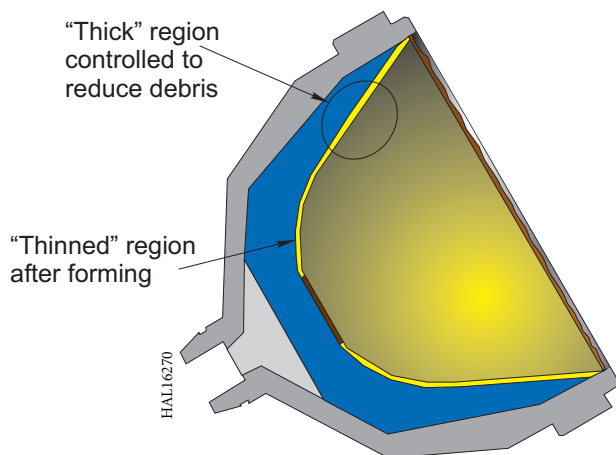
Mirage® Shaped Charges

The Mirage® line of BH shaped charges was introduced as an improved low debris system. The Mirage line provides more of a total perforating system debris reduction solution. With the Mirage line, gun debris associated with all components of the perforating assembly is reduced.

Previous BH guns systems required that the shaped charges be positioned and retained in the charge tube holder using bend tabs. The bend tab is a significant source of gun debris because of the metal slivers generated during gun detonation.

The improved Mirage system incorporates a new twist lock feature in the charge tube holder, eliminating the debris associated with the bend tabs.

In addition to metallurgical considerations, the geometry of the Mirage shaped charge liner is carefully controlled during the manufacturing process such that those portions of the liner that might contribute to slug creation are removed. This process results in a charge liner with a controlled geometry liner (CGL).



Mirage® Super Hole Perforator



Initial (Copper) 7-in. BH Liner Technology

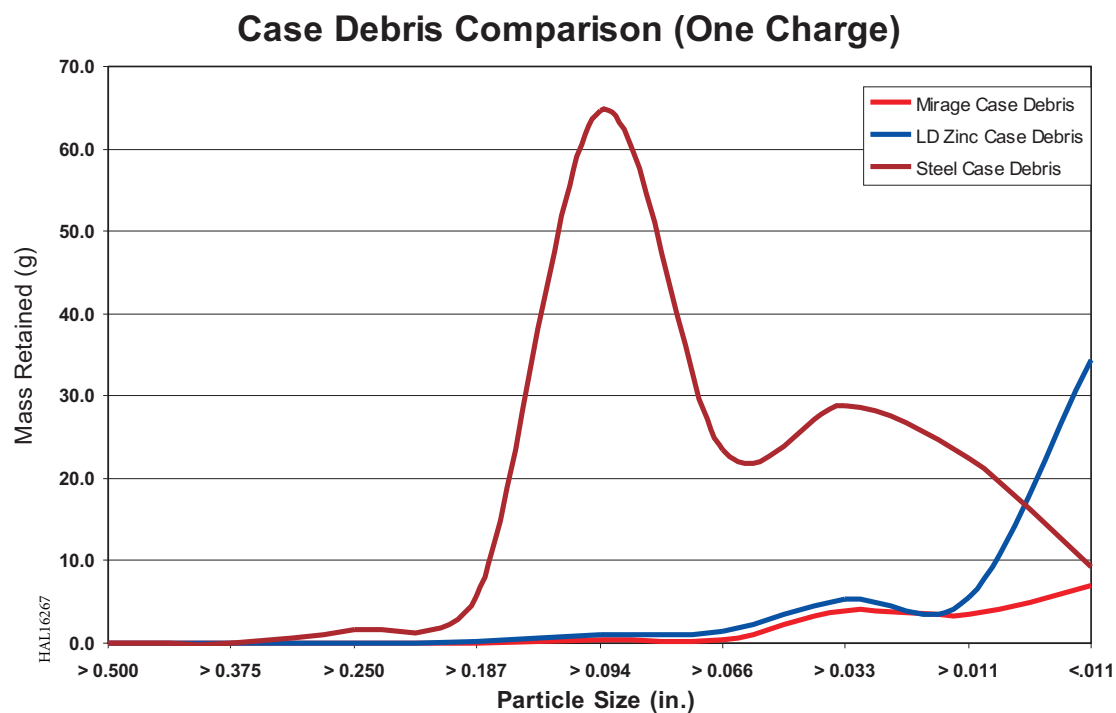


Current (Brass) 7-in. BH Liner Technology



Latest (Mirage®) 7-in. BH Liner Technology

The LD zinc charge cases with the Mirage® system have been optimized to reduce the particle size distribution as shown below.



Maxim™ Shaped Charges

The completion of wells in unconsolidated formations generally requires some form of sand control or gravel packing for flow assurance. For a cased and perforated sand control completion, the perforating strategy typically calls for perforations with the largest possible exit hole in the casing with as high a shot density (spf) as possible. The large casing exit hole improves the likelihood of placing sand or gravel into the perforation tunnel and the higher spf increases the effective flow area resulting in lower pressure drop across the completion during production.

As completion targets in deep water environments go deeper, drilling challenges are compounded forcing operators in many cases to set the casing shoe point higher than planned in order to safely reach deeper primary targets. Unfortunately, this scenario results in secondary pay zones that have multiple strings of casing across portions or the entire length of the pay zone. This situation presents a serious technical challenge because the typical big-hole (BH) perforating system cannot efficiently penetrate multiple casing strings and still produce an adequate casing exit hole. The results utilizing conventional BH perforating systems in the past yielded a large exit hole in the first casing string and a very small exit hole in the second casing string with minimal formation penetration.

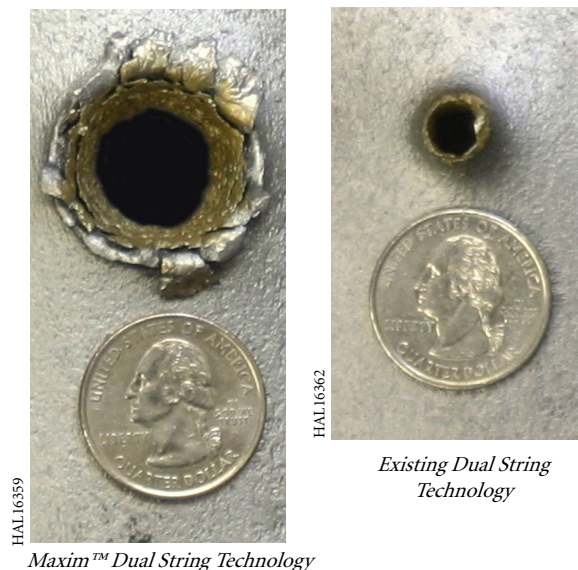
Revolutionary Shaped Charge Liner Design Meets the Challenge

Shaped charge design engineers at Halliburton's Jet Research Center (JRC) have unleashed the power of Maxim™ shaped charges by utilizing hydro-code modeling software and flash X-ray imaging to develop a proprietary shaped charge liner that optimizes the casing exit-hole size when penetrating multiple casing strings.

The effectiveness of the new Maxim shaped charge concept was demonstrated with the development of a 5-in. 8 spf 47 gram charge for a completion scenario with 7-5/8-in. 47.1 lb/ft P-110 and 9-5/8-in. 47 lb/ft P-110 casing.

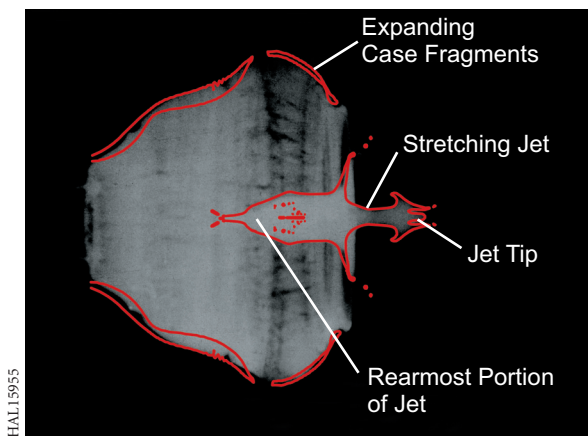
A standard 5-in. 12 spf 28 gram BH gun system was tested under the completion configuration described resulting in a casing exit-hole of 0.28-in.

The newly developed Maxim perforating system resulted in a casing exit-hole size of 0.66-in. with an impressive formation penetration of 6.0-in. These results show a significant 136% improvement in casing exit-hole size and 270% improvement in flow area on a per foot basis.



Maxim™ Dual String Technology

Existing Dual String Technology



Flash X-ray and hydro-code simulation of a shaped charge during detonation sequence.

Maxim™ Charge Performance Data

Charge Part No.	Gun OD	SPF	Explosive Load	Inner Casing	Exit Hole	Outer Casing	Exit Hole	Penetration*
101350449	5.00	8	47	7 5/8 47.1# P-110	0.75	9 5/8 47 P-110	0.66	6.00
101357518	5.75	10	56.5	8 5/8 60.8# P-110	0.78	11 3/4 65# P-110	0.63	7.50
101357518	7.00	14	56.5	9 5/8 473 IL-80	0.61	13 3/8 72# P-110	0.68	8.77

*Penetration is in cement measured from the OD of the outer casing.

KISS™ Low-Damage Perforating Charge

The KISS™ charge provides all the benefits expected from big-hole charges—yet produces significantly less damage in unconsolidated formations.

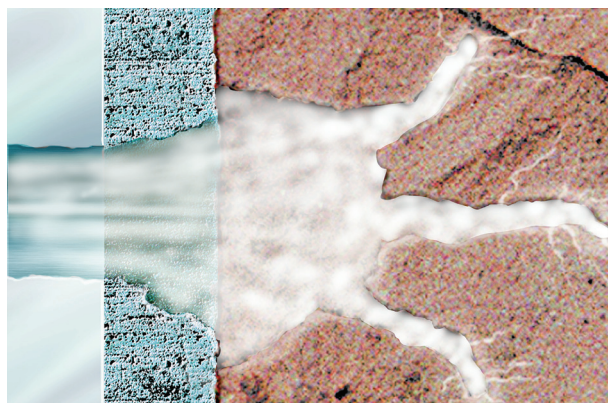
KISS charges limit perforating damage with minimal penetrator design charges, reducing damaged material eight-fold. Damaged material is near the casing with 200% of the cross-sectional area a possibility. Penetration past the cement is not a problem, and lower explosive weight charges are less susceptible to carrier failure.

In an extensive series of lab tests comparing KISS low-damage charges with conventional big-hole perforating charges under simulated downhole conditions, the KISS charge more than proved its superiority. In these tests:

- KISS charges created holes in the casing that were equal to or larger in diameter than those created by conventional big-hole perforating charges.
- Perforation depth was appropriately reduced, so there was far less damage to the formation as well as a significantly reduced crushed zone (less than 1/3 of a conventional big-hole charge).
- KISS charges easily penetrated 2-in. thick cement sheaths, proving they can be effective even in wellbores where washouts have occurred.
- Less damage occurred to the cement surrounding the entrance hole, and the cement damage area was smaller.

Features

- Can be run in standard VannGun® perforating guns and conveyed on tubing or wireline
- Complements Halliburton's StimGun™ service by producing an instantaneous, high-pressure surge into the formation to enhance perforating and stimulation results
- Specialists help determine if the KISS low damage perforating charge would be a productive choice for a specific well
- Low impact on unconsolidated formations for a positive impact on completions
- Better gravel packs due to greatly improved fluid injectivity—whether running a conventional gravel pack, a FracPac™ system, or a high-rate water pack
- Reduced fines movement
- Reduced sand production



The unique KISS™ perforating charge is designed to just penetrate the formation while the high pressure gas breaks through the crushed zone in the tunnel and creates fractures in the formation.

Charge Performance Data

Gun Size	Phasing	JRC P/N	Charge Name	Explosive Load (Grams)	Casing Size (in.)	Target Strength (psi)	EHD (in.)	Total Target Penetration (in.)	Penetration Normalized to 5000 psi (5% per 1000)	* Unofficial Data
CAPSULE GUNS										
1-11/16"	0	100005450	1-11/16" Dyna-Star® 4 SPF RDX DP	13.4	4-1/2"	5149	0.39	10.50		19B
1-11/16"	0	100005450	1-11/16" Dyna-Star 4 SPF RDX DP	13.4	4-1/2"	5909	0.40	12.46	13.03	QC
1-11/16"	0	100005449	1-11/16" Dyna-Star 6 SPF HMX DP	13.5	4-1/2"	6384	0.41	11.97	12.80	QC
1-11/16"	0	101398891	1-11/16" MILLENNIUM™ Dyna-Star 6 SPF HMX	8	4-1/2"	5426	0.29	24.00	24.51	QC
1-11/16"	0	101521848	1-11/16" MaxForce™ Deep Star™ 8 SPF HMX	8	4-1/2"	7170	0.27	19.90		19B
2-1/8"	0	101210198	2-1/8" MILLENNIUM Deep Star HMX	15.9	5-1/2"	5435	0.40	30.60	31.27	QC
2-1/8"	0	101383082	2-1/8" MILLENNIUM Dyna-Star 6 SPF HMX	15.9	5-1/2"	5633	0.39	29.07	29.99	QC
2-1/8"	0	100008259	2-1/8" Dyna-Star 6 SPF HMX DP	15.5	5-1/2"	5326	0.38	14.84	15.08	QC
2-1/8"	0	100005448	2-1/8" Dyna-Star 6 SPF RDX DP	15.5	5-1/2"	5538	0.42	16.61	17.06	RP43
2-1/8"	0	100005448	2-1/8" Dyna-Star 4 SPF RDX DP	15.5	5-1/2"	5292	0.35	15.50		19B
2-1/8"	90	101210198	2-1/8" MILLENNIUM Deep Star 4 SPF HMX DP	15.9	5-1/2"	5820	0.31	20.60		19B
2-1/8"	0/45/90	101210198	2-1/8" MILLENNIUM Deep Star 5.8 SPF HMX - PENTAPHASE Oscillating Spiral	15.9	5-1/2"	6740	0.30	20.60		19B
PORTED GUNS										
3-1/8"	90	101410556	3-1/8" GSC 4 SPF RDX DP	12	4-1/2"	5500	0.34	20.90	21.42	QC
4"	90	101288857	4" MILLENNIUM EXPRESS GSC	19.5	5-1/2"	5600	0.51	27.18	27.95	QC
SLICKWALL GUNS										
3-1/8"	60 / 90	101366678	3-1/8" MILLENNIUM IS 4 SPF HMX	21	4-1/2"	6200	0.40	38.30	40.60	QC
3-1/8"	90	101204537	4" Basic MILLENNIUM EXPRESS 4 SPF RDX	19.5	5-1/2"	6277	0.50	16.65	17.71	QC
4"	90	101204537	4" Basic MILLENNIUM EXPRESS 4 SPF RDX	19.5	5-1/2"	6277	0.50	24.94	26.53	QC
3-1/8"	60 / 90	101310802	4" Twisted Strip MILLENNIUM EXPRESS 4 SPF RDX W/ TWIST LOCK 1/2 RUBBER JACKET	19.5	5-1/2"	6277	0.50	16.65	17.71	QC
4"	60 / 90	101310802	4" Twisted Strip MILLENNIUM EXPRESS 4 SPF RDX W/ TWIST LOCK 1/2 RUBBER JACKET	19.5	5-1/2"	6277	0.50	24.94	26.53	QC
SCALLOPED GUNS										
1-9/16"	0	100157028	1-9/16" MILLENNIUM IS 4 SPF HMX	3.4	4-1/2"	5967	0.21	11.34	11.89	RP43
1-9/16"	60	100157028	1-9/16" MILLENNIUM IS 6 SPF HMX	3.4	2-7/8"	6949	0.23	8.30		19B
1-9/16"	60	384465	1-9/16" 4 SPF HMX BH	3.2	2-7/8"	7533	0.34	2.50		19B
2"	60	101208224	2" MILLENNIUM IS HMX	6.8	2-7/8"	6019	0.22	18.30		19B
2"	60	101603801	2" MaxForce IS HMX	7	2-7/8"	5697	0.24	20.30		19B
2"	60	101206246	2" IS 6 SPF-HMX BH	6.8	3-1/2"	7332	0.48	3.00		19B
2-3/8"	60	101590845	2-3/8" MaxForce IS 6 SPF HMX	10	3-1/2"	5663	0.28	19.90		19B
2-3/8"	60	101591373	2-3/8" 6 SPF HMX BH	10	3-1/2"	5663	0.48	5.80		19B
2-1/2"	60	101418095	2 1/2" MILLENNIUM II IS 6 SPF HMX	11.1	3-1/2"	5996	0.32	24.50		19B
2-1/2"	60	101244923	2-1/2" 6 SPF HNS DP	11.1	3-1/2"	7128	0.26	12.60		19B
2-1/2"	60	384466	2-1/2" 6 SPF HMX BH	11	3-1/2"	7469	0.58	2.40		19B
2-3/4"	60	101233817	2-3/4" MILLENNIUM 6 SPF HMX	15	4-1/2"	6394	0.30	26.00		19B
2-3/4"	60	101318485	2-3/4" 6 SPF MILLENNIUM HNS	15.1	4-1/2"	5694	0.30	27.55	28.51	QC
2-3/4"	60	101206793	2-3/4" 6 SPF RDX BH	14.7	4-1/2"	6109	0.67	5.50	5.80	RP43
2-3/4"	60	101270158	2-3/4" 6 SPF HMX BH	15	4-1/2"	7381	0.65	4.20		19B
2-7/8"	60	101233817	2-3/4" MILLENNIUM 6 SPF HMX (Hvy Wall Gun)	15	4-1/2"	6388	0.31	27.30		19B
2-7/8"	60	101233817	2-3/4" MILLENNIUM 6 SPF HMX (Hvy Wall Gun)	15	4-1/2"	5124	0.35	30.00		19B ³
2-7/8"	60	101388407	2-7/8" MILLENNIUM 6 SPF HNS	18.5	4-1/2"	6859	0.28	22.80		19B
3-1/8"	60	101366678	3-1/8" MILLENNIUM™ IS 6 SPF HMX	21	4-1/2"	6200	0.40	38.30	40.60	QC

Charge Performance Data

Gun Size	Phasing	JRC P/N	Charge Name	Explosive Load (Grams)	Casing Size (in.)	Target Strength (psi)	EHD (in.)	Total Target Penetration (in.)	Penetration Normalized to 5000 psi (5% per 1000)	* Unofficial Data
3-1/8"	60	101618998	3-1/8" MILLENNIUM Express IS DP 6 SPF RDX	21	4-1/2"					
3-1/8"	60	101618994	3-1/8" MILLENNIUM Express IS SDP 6 SPF RDX	21	4-1/2"					
3-1/8"	135/45	101351605	3-1/8" Mirage® 10 SPF HMX BH/LD	14	5"	6100	0.64	3.80	4.01	QC
3-3/8"	60	101233819	3-3/8" MILLENNIUM 6 SPF HMX	25	4-1/2"	6215	0.48	40.40	42.85	RP43
3-3/8"	60	101233819	3-3/8" MILLENNIUM 6 SPF HMX	25	4-1/2"	5754	0.45	37.50		19B
3-3/8"	60	101600039	3-3/8" MILLENNIUM Express IS 6 SPF RDX DP	23	4-1/2"	5704	0.42	25.60	26.5	QC
3-3/8"	60	101589595	3-3/8" MILLENNIUM Express IS 6 SPF RDX SDP	23	4-1/2"	5219	0.39	43.00	43.5	QC
3-3/8"	60	101365876	3-3/8" MILLENNIUM 6 SPF HNS	25	4-1/2"	6578	0.31	22.10		19B
3-3/8"	60	101320459	3-3/8" 6 SPF RDX DP	22	4-1/2"	7538	0.34	17.60		19B
3-3/8"	60	100005333	3-3/8" 6 SPF RDX DP	22	4-1/2"	6138	0.41	20.30	21.46	RP43
3-3/8"	60	100005332	3-3/8" 6 SPF HMX DP	26	5-1/2"	9846	0.38	18.28	22.71	RP43
3-3/8"	60	100008014	3-3/8" 6 SPF RDX SUPER DP	24	4-1/2"	5251	0.39	28.45	28.81	RP43
3-3/8"	60	100008249	3-3/8" 6 SPF HMX SUPER DP	25	4-1/2"	5967	0.40	26.20		19B
3-3/8"	60	100008249	3-3/8" 6 SPF HMX SUPER DP	25	5"	6097	0.40	28.70	30.27	RP43
3-3/8"	135/45	101351605	3-3/8" Mirage 12 SPF HMX BH/LD	14	5-1/2"	6100	0.63	4.15	4.38	QC
3-3/8"	60	100005321	3-3/8" 6 SPF RDX BH	24	4-1/2"	6101	0.86	4.66	4.92	QC
3-3/8"	60	100157017	3-3/8" 6 SPF HMX BH	24	4-1/2"	6490	0.88	4.76	5.11	QC
3-3/8"	150/30	100008251	3-3/8" Omni 12 SPF RDX BH	14	5-1/2"	7802	0.62	5.33	6.08	RP43
3-3/8"	150/30	100005312	3-3/8" Omni 12 SPF HMX BH	14	5-1/2"	6300	0.64	5.24	5.58	QC
3-1/2"	135/45	101542642	3-1/2" Mirage 12 SPF HMX BH/LD	15	5-1/2"	6100	0.65	4.20	4.43	QC
4"	90	101210636	4" MILLENNIUM HMX (4 SPF)	39	5-1/2"	5490	0.39	44.60	45.69	RP43
4"	90	101210636	4" MILLENNIUM HMX (4 SPF)	39	5-1/2"	6365	0.38	43.40		19B
4"	60	100005322	4-5/8" 6 SPF RDX DP	32	7"	5277	0.6	40.50	41.06	QC
4"	60	100005327	4-5/8" 6 SPF HMX DP	32	5-1/2"	5568	0.45	37.00		19B 4
4-1/2"	60	101210636	4" MILLENNIUM HMX (5 SPF)	39	7"	6775	0.37	39.60		19B
4-1/2"	150/30	101210674	4-1/2" MILLENNIUM 12 SPF HMX	22.7	7"	8484	0.38	26.80	31.47	RP43
4-5/8"	180	101446899	4-5/8" KleenZone® G-FORCE® HMX	39	7"	5208	0.36	42.80		19B
4-5/8"	350/10	101446899	4-5/8" KleenZone G-FORCE HMX	39	7"	5412	0.35	41.70		19B
4-5/8"	60	101210636	4" MILLENNIUM HMX (5 SPF)	39	7"	5502	0.37	52.00	53.31	RP43
4-5/8"	60	101210636	4" MILLENNIUM HMX (5 SPF)	39	7"	5518	0.35	43.60		19B
4-5/8"	60	101287306	4" 5 SPF HNS DP	39	7"	7559	0.33	31.20		19B
4-5/8"	60	100005322	4-5/8" 6 SPF RDX DP	32	7"	5325	0.43	30.46	30.95	RP43
4-5/8"	60	100005327	4-5/8" 6 SPF HMX DP	32	7"	5809	0.46	39.50	41.10	QC
4-5/8"	60	101332806	4-5/8" 6 SPF HNS DP	32	7"	5814	0.45	30.30	31.53	QC
4-5/8"	150/30	101210674	4-1/2" MILLENNIUM 12 SPF HMX	22.7	7"	8484	0.38	26.80	31.47	RP43
4-5/8"	150/30	101210674	4-1/2" MILLENNIUM 12 SPF HMX	22.7	7"	6322	0.38	24.40		19B
4-5/8"	150/30	100005324	4-5/8" Omni 12 SPF RDX DP	22.7	7"	9080	0.36	16.25	19.57	RP43
4-5/8"	150/30	100005325	4-5/8" Omni 12 SPF RDX DP/LD	22.7	7"	5685	0.32	17.41	18.01	RP43
4-5/8"	150/30	100014352	4-5/8" Omni 12 SPF HMX DP	22.7	7"	9080	0.37	16.09	19.37	RP43
4-5/8"	150/30	101343830	4-5/8" Omni 12 SPF HNS DP		7"	5020	0.35	28.00	28.03	QC
4-5/8"	150/30	100005340	4-5/8" Omni 12 SPF HMX DP/LD	22.7	7"	5685	0.30	18.37	19.00	RP43
4-5/8"	150/30	100005319	4-5/8" Omni 12 SPF RDX BH	25	7"	6840	0.74	6.41	7.00	RP43
4-5/8"	150/30	100005326	4-5/8" Omni 12 SPF RDX BH/LD	22.7	7"	7346	0.65	5.51	6.16	RP43
4-5/8"	150/30	100157006	4-5/8" 12 SPF HMX BH	25	7"	5723	0.75	7.02	7.27	QC
4-5/8"	150/30	100005311	4-5/8" Omni 12 SPF RDX SH	28	7"	6982	0.93	6.30	6.92	RP43
4-5/8"	150/30	100156995	4-5/8" Omni 12 SPF HMX SH	28	7"	5016	0.96	5.10	5.10	RP43

Charge Performance Data

Gun Size	Phasing	JRC P/N	Charge Name	Explosive Load (Grams)	Casing Size (in.)	Target Strength (psi)	EHD (in.)	Total Target Penetration (in.)	Penetration Normalized to 5000 psi (5% per 1000)	* Unofficial Data
4-5/8"	150/30	101228756	4-5/8" 12 SPF RDX SUPER HOLE/LD	28	7"	5124	0.81	5.40	5.43	QC
4-5/8"	150/30	101233690	4-5/8" 12 SPF HMX SUPER HOLE/LD	28	7"	5622	0.85	5.30	5.46	RP43
4-5/8"	135/45	100156990	4-5/8" 18 SPF RDX BH	20	7"	5553	0.73	6.18	6.35	RP43
4-5/8"	180	101287306	4-5/8" 4 SPF HNS DP	39	7-5/8"	6349	0.29	30.20		19B
5"	150/30	100005311	4-5/8" Omni 12 SPF RDX SUPER HOLE	28	7"	5192	0.91	6.90	6.97	RP43
5"	150/30	100005319	4-5/8" Omni 12 SPF RDX BH	25	7"	6508	0.84	8.80	9.46	QC
5"	150/30	100156995	4-5/8" Omni 12 SPF HMX SUPER HOLE	28	7"	6487	1.00	6.00	6.45	QC
5"	150/30	100005311	4-5/8" Omni 12 SPF RDX SUPER HOLE	28	7-5/8"	7877	0.83	6.65	7.61	RP43
5"	135	101307494	5" Mirage® 12 SPF RDX SUPER HOLE/LD	32	7-5/8"	6345	0.90	6.00		19B
5"	120 Cluster	101292616	5" 21 SPF RDX BH	21	7-5/8"	5411	0.72	5.30		19B 1
5-1/8"	135	101307494	5" Mirage 12 SPF RDX SUPER HOLE/LD	32	7-5/8"	5576	0.88	6.60		19B
5-1/8"	231.4	100157007	5-1/8" 14 SPF RDX SUPER HOLE	32	7-5/8"	5138	0.93	5.11	5.15	RP43
5-1/8"	231.4	100157011	5-1/8" 14 SPF HMX SUPER HOLE	32	7-5/8"	5250	0.94	5.83	5.90	RP43
5-1/8"	120 Cluster	101292616	5-1/8" 21 SPF RDX BH	21	7-5/8"	6246	0.74	5.65	5.99	QC
5-3/4"	150/30	100157007	5-1/8" 14 SPF RDX SUPER HOLE	32	8-5/8"	6498	0.75	5.87	6.31	QC
6-1/2"	135/45 138	101304878	6-1/2" Mirage 12 or 14 SPF RDX BH/LD	47	8-5/8"	7043	1.07	5.60		19B
6-1/2"	135/45 138	101304878	6-1/2" Mirage 12 or 14 SPF RDX BH/LD	47	9-5/8"	5088	0.91	6.80		19B 2
7"	135/45	101207997	7" MILLENNIUM™ 12 SPF HMX	39	9-5/8"	7006	0.36	43.30	47.63	RP43
7"	135/45	101207997	7" MILLENNIUM 12 SPF HMX	39	9-5/8"	6397	0.42	38.70		19B
7"	135/45 138	101304878	6-1/2" Mirage 12 or 14 SPF RDX BH/LD	47	9-5/8"	6178	1.07	6.10		19B
7"	135/45 138	101213474	7" 12 or 14 SPF RDX SUPER HOLE	56.5	9-5/8"	5975	1.29	5.80		19B
7"	135/45 138	101484232	7" Mirage 14 SPF RDX BH/LD	39	9-5/8"	6270	1.04	6.30		19B
7"	138	101212693	7" 12 SPF RDX SUPER HOLE/LD	56.5	9-5/8"	6040	1.16	5.00		19B
7"	60/120	101414821	7" Mirage 18 SPF HMX/LD	45	9-7/8"	5893	1.02	6.50		19B

Registered 19B data except fired in 7-5/8" 47# P110 casing

Registered 19B data except fired in 9-5/8" 71# N-80 casing

Registered 19B data except fired in air

Registered third party 19B data

MaxForce™, G-Force®, and KleenZone® are proprietary to Halliburton

Charge performance will vary due to well conditions.

For realistic data, contact JRC "Perforation Flow Lab" testing services.

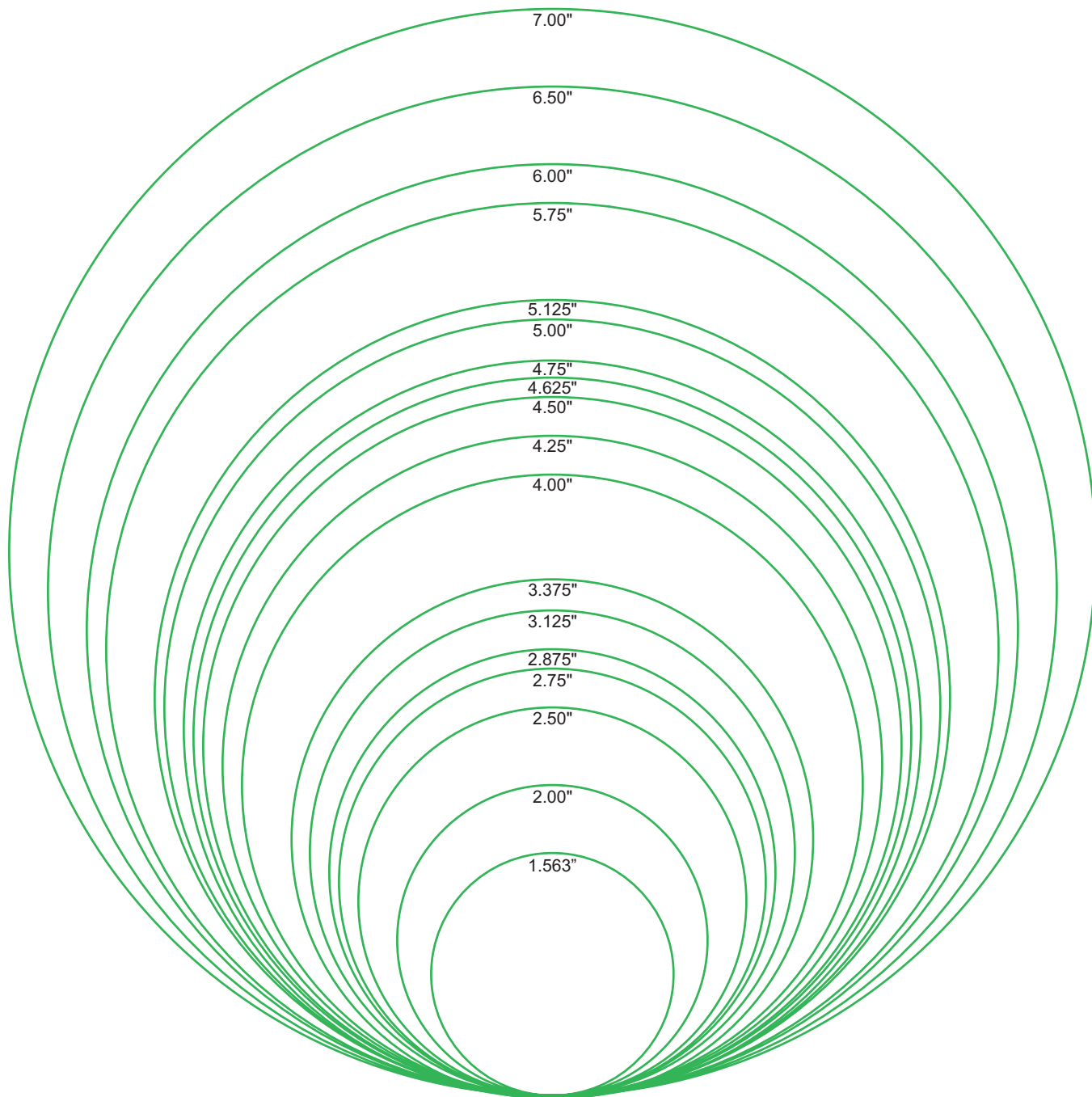
Penetration normalization is not certified by API for 19B.

RP43 Test are not endorsed by API and will not be available on new or improved JRC Charges.

Gun Systems

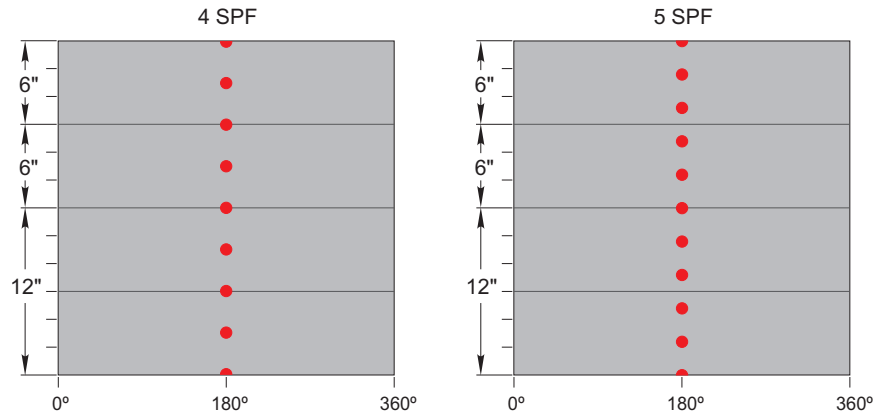
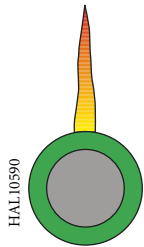
VannGun® Assemblies

1 9/16 in. to 7 in. and 4 SPF to 21 SPF

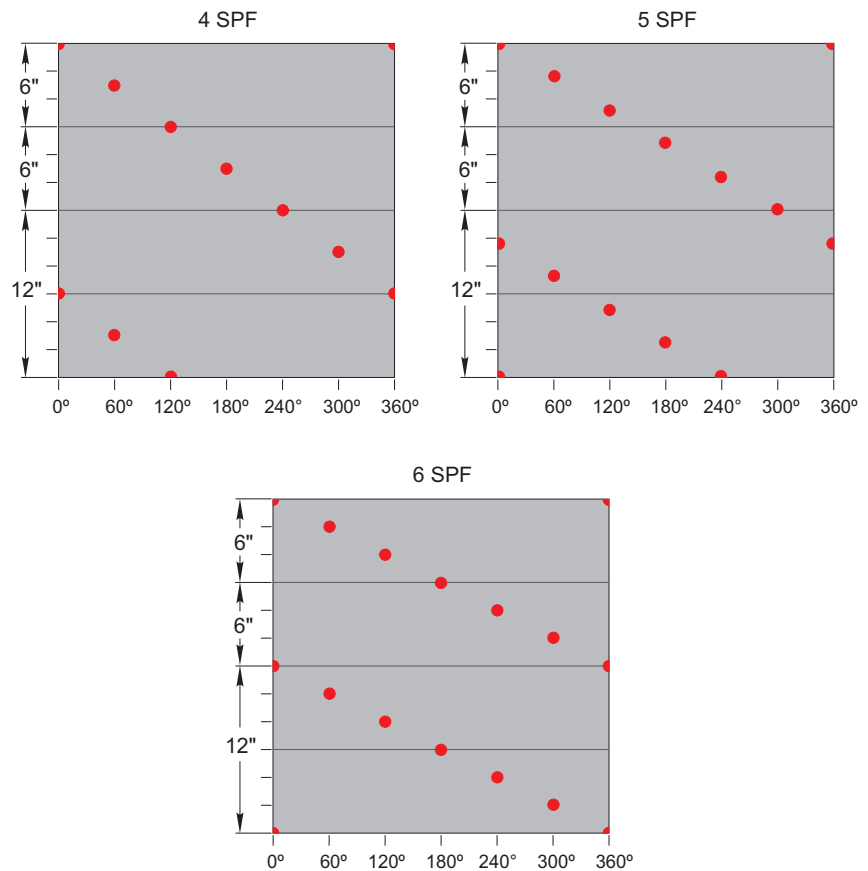
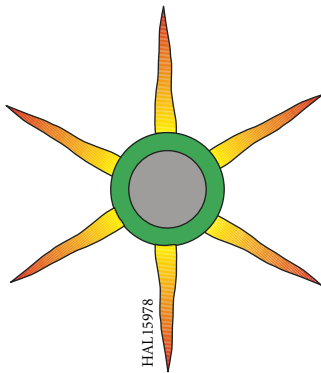


VannGun® Phasing and Shot Patterns*

0° Phasing 4 and 5 SPF

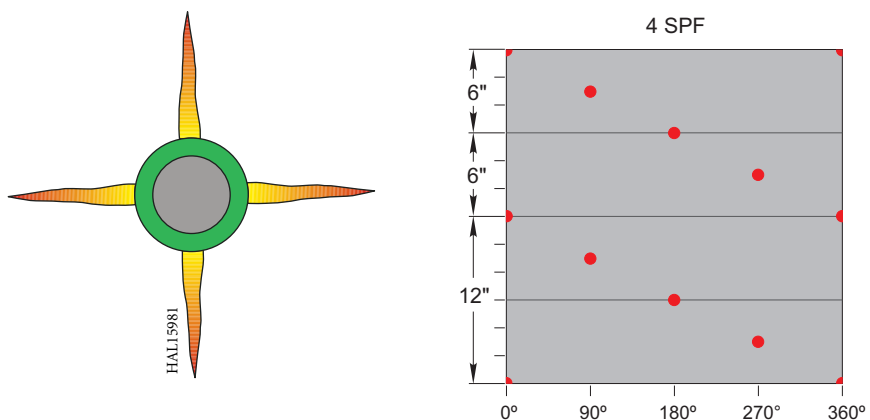


60° Phasing 4, 5, and 6 SPF

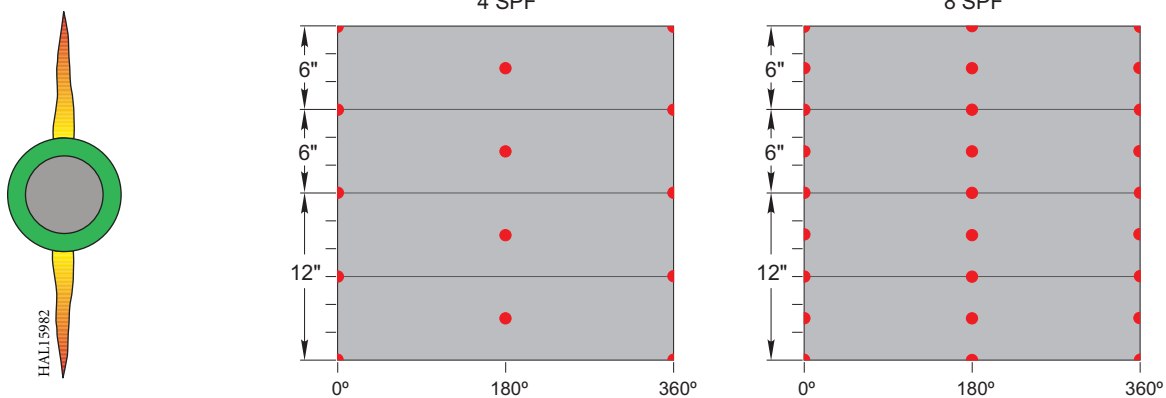


*Other shot densities and phasings are available upon request.

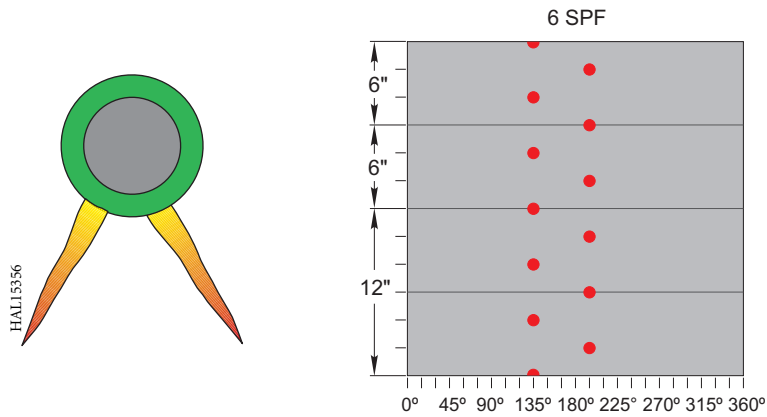
90° Phasing 4 SPF



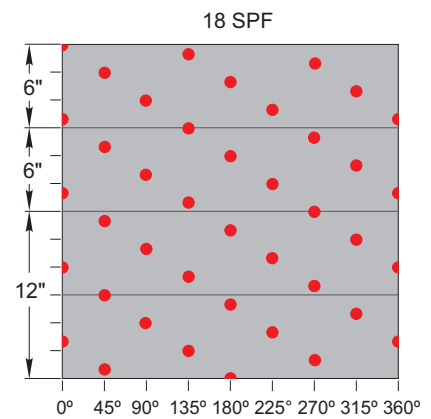
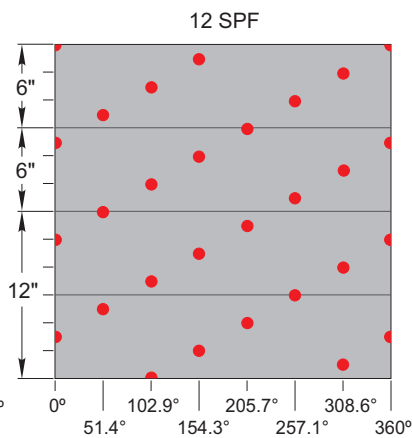
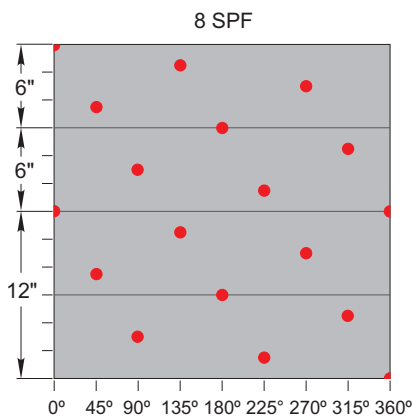
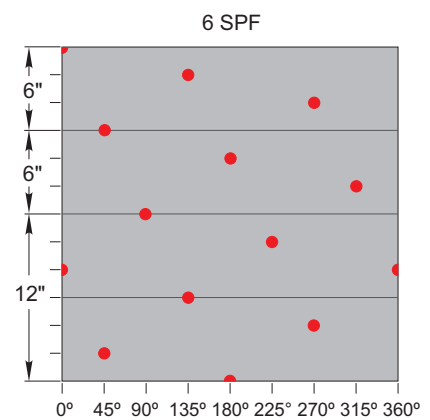
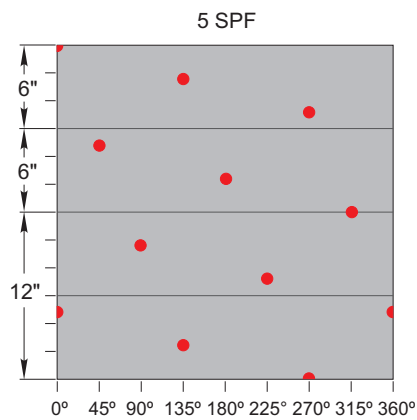
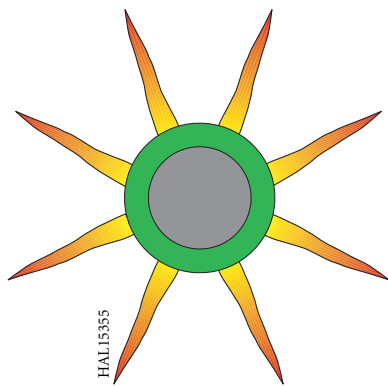
180° Phasing 4 and 8 SPF



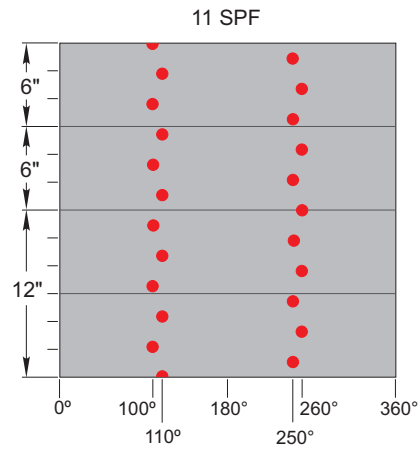
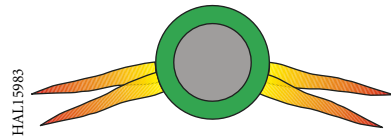
60° Phasing 6 SPF Two Planes



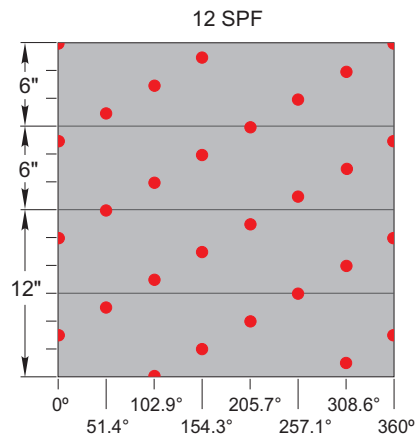
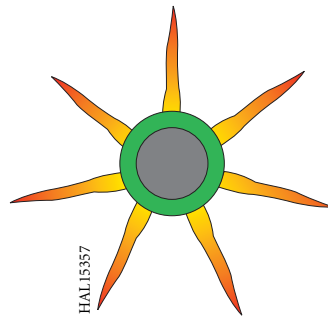
45°/135° Phasing 5, 6, 8, 12, and 18 SPF



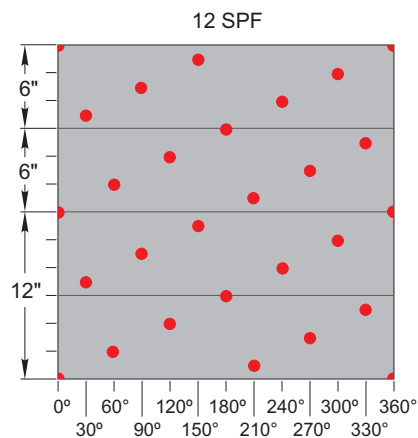
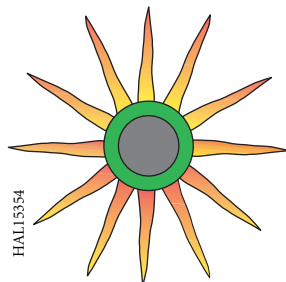
140°/160° Phasing 11 SPF



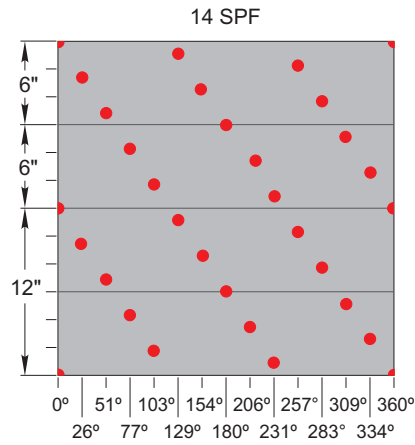
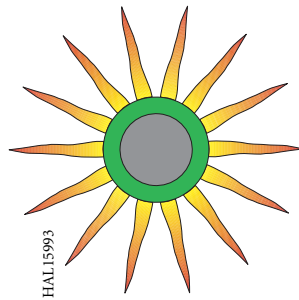
51.4°/154.3° Phasing 12 SPF



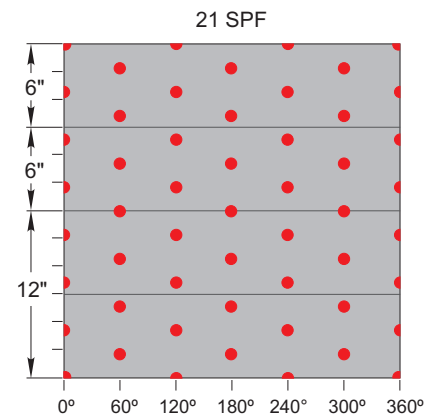
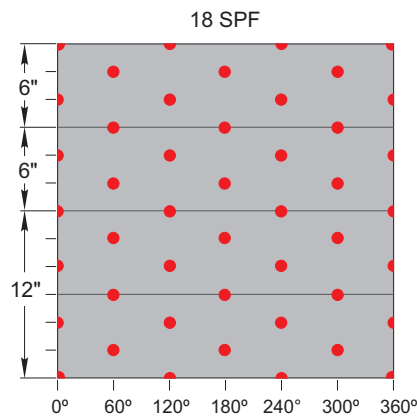
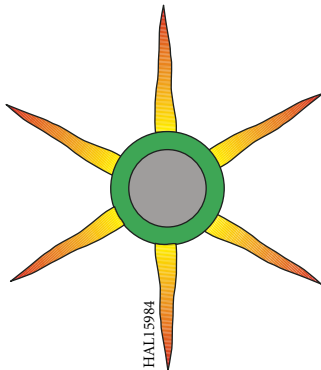
30°/150° Phasing 12 SPF



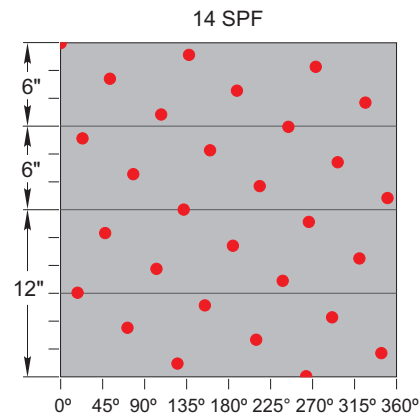
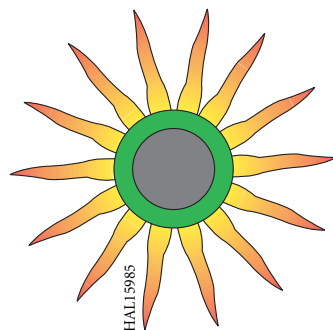
25.7°/128.5° Phasing 14 SPF



60°/120° Phasing 18 and 21 SPF



138° Phasing 14 SPF



Tensile ratings on the following tables are based on the box x pin connection.

1 9/16-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100157028	HMX	Millennium™	4	0°	Premium	Vann	20,000 (1379)	70,000 (31 746)	4 spf Millennium		
101210199	HMX	BH		60°					4 (1.22)	21 (9)	17 (8)
				90°					7 (2.13)	31 (14)	24 (11)
				180°					11 (3.35)	46 (21)	34 (15)
				0°			Premium	Industry Standard	20,000 (1379)	70,000 (31 746)	15 (4.57)
				60°			21 (6.40)	81 (37)			59 (27)
				90°							
				180°							
100157028	HMX	Millennium	6	60°	Premium	Vann	20,000 (1379)	70,000 (31 746)	6 spf Millennium		
101210199	HMX	BH		60°	Premium	Industry Standard	20,000 (1379)	70,000 (31 746)	4 (1.22)	21 (10)	17 (8)
									7 (2.13)	32 (14)	24 (11)
									11 (3.35)	48 (22)	34 (15)
									15 (4.57)	63 (28)	44 (20)
									21 (6.40)	85 (39)	59 (27)

2-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101208224	HMX	Millennium™	4	0°	Premium	Vann	20,000 (1379)	70,000 (31 746)	4 spf Millennium		
101603801	HMX	MaxForce™		60°					4 (1.22)	28 (13)	23 (10)
100008017	HMX	SDP		90°					7 (2.13)	44 (20)	35 (16)
100157018	HNS	DP		180°					11 (3.35)	66 (30)	51 (23)
101206246	HMX	BH		0°	Premium	Industry Standard	20,000 (1379)	70,000 (31 746)	15 (4.57)	87 (39)	63 (29)
				60°					21 (6.40)	120 (54)	92 (42)
				90°							
				180°							
101208224	HMX	Millennium	6	60°	Premium	Vann	20,000 (1379)	70,000 (31 746)	6 spf Millennium		
101603801	HMX	MaxForce		60°	Premium	Industry Standard	20,000 (1379)	70,000 (31 746)	4 (1.22)	28 (13)	23 (10)
100008017	HMX	SDP							7 (2.13)	44 (20)	35 (16)
100157018	HNS	DP							11 (3.35)	66 (30)	51 (23)
101206246	HMX	BH							15 (4.57)	87 (39)	63 (29)
									21 (6.40)	120 (54)	92 (42)
101208224	HMX	Millennium	6	60°	Premium	Vann	20,000 (1379)	70,000 (31 746)	6 spf Reduced Swell Gas Gun		
101603801	HMX	MaxForce		60°	Premium	Industry Standard	20,000 (1379)	70,000 (31 746)	2 (.61)	14 (6.3)	11 (4.9)
100008017	HMX	SDP							4 (1.22)	25 (11.3)	20 (9.1)
100157018	HNS	DP							5 (1.52)	31 (14)	24 (10.9)
101206246	HMX	BH							6 (1.83)	36 (16.3)	28 (12.7)
									7 (2.13)	42 (19)	32 (14.5)
									8 (2.44)	48 (21.7)	36 (16.3)
									9 (2.74)	53 (24)	40 (18.2)
									11 (3.35)	65 (29.5)	48 (21.8)

2 1/2-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101206251	HMX	Millennium™	4	0°	Premium	Vann	20,000 (1379)	121,000 (54 875)	4 spf Millennium		
101332418	HMX	SDP		60°					4 (1.22)	43 (20)	34 (15)
101244923	HNS	DP		90°					7 (2.13)	67 (30)	52 (24)
				180°					11 (3.35)	98 (44)	75 (34)
				0°	Premium	Industry Standard	20,000 (1379)	121,000 (54 875)	15 (4.57)	129 (59)	98 (44)
				60°					21 (6.40)	176 (80)	133 (60)
90°											
180°											
101418095	HMX	Millennium II™	6	60°	Premium	Vann	20,000 (1379)	121,000 (54 875)	6 spf Millennium II		
									4 (1.22)	43 (20)	34 (15)
				60°	Premium	Industry Standard	20,000 (1379)	121,000 (54 875)	7 (2.13)	67 (30)	52 (24)
									11 (3.35)	98 (44)	75 (34)
									15 (4.57)	129 (59)	98 (44)
									21 (6.40)	176 (80)	133 (60)
101206251	HMX	Millennium	6	60°	Premium	Vann	20,000 (1379)	121,000 (54 875)	6 spf Millennium		
101332418	HMX	SDP							4 (1.22)	45 (20)	34 (15)
101244923	HNS	DP		60°	Premium	Industry Standard	20,000 (1379)	121,000 (54 875)	7 (2.13)	70 (32)	52 (24)
									11 (3.35)	104 (47)	75 (34)
									15 (4.57)	133 (60)	98 (44)
									21 (6.4)	189 (86)	133 (60)
101418095	HMX	Millennium II	6	60°	Premium	Industry Standard	20,000 (1379)	121,000 (54 875)	6 spf Reduced Swell Gas Gun		
									4 (1.22)	43 (20)	34 (15)
									7 (2.13)	67 (30)	52 (24)
									11 (3.35)	98 (44)	75 (34)
									15 (4.57)	129 (59)	98 (44)

2 3/4-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101233817	HMX	Millennium™	4	60°	Standard	Industry Standard	18,000 (1241)	116,700 (52 934)	4 spf Millennium		
101318485	HNS	Millennium		120°	Standard	Industry Standard	18,000 (1241)	116,700 (52 934)	4 (1.22)	59 (27)	50 (23)
									5 (1.53)	74 (34)	63 (29)
									6 (1.83)	88 (40)	75 (34)
									7 (2.13)	95 (43)	79 (35)
									8 (2.44)	102 (46)	82 (37)
									9 (2.74)	115 (52)	93 (42)
									10 (3.05)	125 (57)	99 (45)
									11 (3.35)	134 (61)	105 (48)
									15 (4.57)	172 (83)	145 (66)
									21 (6.71)	241 (114)	193 (88)
100157026	RDX	SDP	6	60° Two Row	Premium	Vann	20,000 (1379)	134,000 (60 771)	6 spf SDP		
100010399	HMX	SDP							4 (1.22)	59 (27)	50 (23)
101251723	HNS	SDP		60° Two Row	Standard	Vann	18,000 (1241)	116,700 (52 934)	8 (2.44)	102 (46)	82 (37)
101206793	RDX	BH							11 (3.35)	134 (61)	105 (48)
101270158	HMX	BH							16 (4.88)	183 (83)	145 (66)
									22 (6.71)	252 (114)	193 (88)
101233817	HMX	Millennium	6	60°	Premium	Vann	22,000 (1517)	134,000 (60 771)	6 spf Millennium		
101318485	HNS	Millennium		60°	Standard	Vann	18,000 (1241)	116,700 (52 934)	4 (1.22)	59 (27)	50 (23)
				60°	Standard	Industry Standard	18,000 (1241)	116,700 (52 934)	7 (2.13)	95 (43)	79 (35)
									8 (2.44)	102 (46)	82 (37)
									11 (3.35)	134 (61)	105 (48)
									15 (4.57)	172 (83)	145 (66)
									16 (4.88)	183 (83)	145 (66)
									22 (6.71)	252 (114)	193 (88)

2 7/8-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101233817	HMX	Millennium™	6	60°	Premium	Vann	22,000 (1517)	142,000 (64 399)	6 spf Millennium		
101318485	HNS	Millennium		60°	Premium	Industry Standard	22,000 (1517)	142,000 (64 399)	4 (1.22)	62 (28)	54 (24)
									8 (2.44)	106 (48)	86 (39)
									11 (3.35)	138 (63)	110 (50)
									16 (4.88)	186 (84)	150 (68)
									22 (6.71)	258 (117)	198 (90)
101388406	HMX	Millennium	6	60°	Premium	Vann	25,000 (1724)	142,000 (64 399)	6 spf Millennium II		
101388407	HNS	Millennium		60°	Premium	Industry Standard	25,000 (1724)	142,000 (64 399)	4 (1.22)	62 (28)	54 (24)
101414743	HMX	Dominator®							8 (2.44)	106 (48)	86 (39)
									11 (3.35)	138 (63)	110 (50)
									16 (4.88)	186 (84)	150 (68)
									22 (6.71)	258 (117)	198 (90)
101233817	HMX	Millennium	6	60°	Premium	Vann	25,000 (1724)	142,000 (64 399)	6 spf Millennium Gas Gun		
101318485	HNS	Millennium		60°	Premium	Industry Standard	25,000 (1724)	142,000 (64 399)	4 (1.22)	64 (29)	55 (25)
101414743	HMX	Dominator							8 (2.44)	112 (51)	92 (42)
									11 (3.35)	148 (67)	120 (54)
									16 (4.88)	204 (93)	166 (75)
									22 (6.71)	281 (127)	221 (100)

3 3/8-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101320459	RDX	DP	4	60°	Premium	Vann	25,000 (1724)	238,000 (107 937)	4 spf DP		
				90°					4 (1.22)	86 (39)	77 (35)
				180°					7 (2.44)	126 (57)	109 (50)
				60°	Standard	Vann	20,000 (1379)	218,000 (98 883)	8 (2.44)	144 (65)	125 (57)
				90°					11 (3.35)	187 (85)	160 (73)
				180°					15 (4.88)	240 (109)	205 (93)
				60°	Standard	Industry Standard	20,000 (1379)	218,000 (98 883)	16 (4.88)	256 (116)	219 (99)
				90°					21 (6.41)	329 (150)	277 (126)
									22 (6.71)	361 (164)	290 (132)
100008014	RDX	SDP	4	60°	Premium	Vann	20,000 (1379)	218,000 (98 883)	4 spf SDP and Millennium		
101293450	RDX	SDP/LD		90°					4 (1.22)	86 (39)	77 (35)
101233819	HMX	Millennium™		180°					7 (2.44)	126 (57)	109 (50)
101365876	HNS	Millennium		60°	Standard	Vann	20,000 (1379)	218,000 (98 883)	8 (2.44)	144 (65)	125 (57)
				90°					11 (3.35)	187 (85)	160 (73)
				180°					15 (4.88)	240 (109)	205 (93)
				60°	Standard	Industry Standard	20,000 (1379)	218,000 (98 883)	16 (4.88)	256 (116)	219 (99)
				90°					21 (6.41)	329 (150)	277 (126)
									22 (6.71)	361 (164)	290 (132)
101600039	RDX	Millennium Express	4	60°	Standard	Industry Standard	20,000 (1379)	218,000 (98 883)	6 spf DP		
101589595	RDX	Millennium Express							4 (1.22)	86 (39)	77 (35)
									7 (2.44)	126 (57)	109 (50)
									8 (2.44)	144 (65)	125 (57)
									11 (3.35)	187 (85)	160 (73)
									15 (4.88)	240 (109)	205 (93)
									16 (4.88)	256 (116)	219 (99)
									21 (6.41)	329 (150)	277 (126)
									22 (6.71)	361 (164)	290 (132)

3 3/8-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101320459	RDX	DP	6	60°	Premium	Vann	25,000 (1724)	238,000 (107 955)	6 spf SDP and Millennium		
100008014	RDX	SDP		60°	Standard	Vann	20,000 (1379)	218,000 (98 883)	4 (1.22)	86 (39)	77 (35)
101293450	RDX	SDP/LD		60°	Standard	Industry Standard	20,000 (1379)	218,000 (98 883)	7 (2.44)	126 (57)	109 (50)
101233819	HMX	Millennium™		60° Two Row	Premium	Vann	25,000 (1724)	238,000 (107 955)	8 (2.44)	144 (65)	125 (57)
101309223	HMX	Dominator®		60° Two Row	Standard	Vann	20,000 (1379)	218,000 (98 883)	11 (3.35)	187 (85)	160 (73)
101365876	HNS	Millennium							15 (4.88)	240 (109)	205 (93)
100005321	RDX	BH							16 (4.88)	256 (116)	219 (99)
100157017	HMX	BH							21 (6.41)	329 (150)	277 (126)
									22 (6.71)	365 (166)	290 (132)
100008251	RDX	BH	12	30°/150° OMNI™	Premium	Vann	23,000 (1586)	238,000 (107 955)	12 spf BH		
100005312	HMX	BH		30°/150° OMNI	Standard	Vann	20,000 (1379)	218,000 (98 883)	4 (1.22)	89 (40)	77 (35)
101351605	HMX	BH/LD							8 (2.44)	150 (68)	125 (57)
									11 (3.35)	197 (88)	160 (73)
									16 (4.88)	271 (123)	219 (99)
									22 (6.71)	365 (166)	290 (132)

4-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100005322	RDX	DP	4	60° 90°	Premium	Vann	20,000 (1379)	278,000 (126 077)	4 spf DP		
100005327	HMX	DP		60°	Standard	Vann	18,000 (1241)	240,387 (109 038)	4 (1.22)	107 (49)	99 (45)
101332806	HNS	DP		90°					8 (2.44)	173 (78)	155 (70)
100008014	RDX	SDP		90°	Standard	Industry Standard	18,000 (1241)	240,387 (109 038)	11 (3.35)	223 (101)	197 (89)
101293450	RDX	SDP/LD							16 (4.88)	297 (135)	267 (121)
100008249	HMX	SDP							22 (6.71)	404 (183)	351 (159)
									4 spf SDP		
									4 (1.22)	110 (50)	99 (45)
									8 (2.44)	179 (81)	155 (70)
									11 (3.35)	230 (104)	197 (89)
									16 (4.88)	309 (140)	267 (121)
									22 (6.71)	420 (191)	351 (159)
100005322	RDX	DP	6	60°	Premium	Vann	20,000 (1379)	278,000 (126 077)	6 spf DP		
100005327	HMX	DP		60°	Standard	Vann	18,000 (1241)	240,387 (109 038)	4 (1.22)	111 (50)	99 (45)
101332806	HNS	DP		60°	Standard	Industry Standard	18,000 (1241)	240,387 (109 038)	8 (2.44)	189 (86)	155 (70)
100008014	RDX	SDP							11 (3.35)	233 (106)	197 (89)
101293450	RDX	SDP/LD							16 (4.88)	319 (144)	267 (121)
100008249	HMX	SDP							22 (6.71)	424 (192)	351 (159)
									6 spf SDP		
									4 (1.22)	114 (52)	99 (45)
									8 (2.44)	189 (86)	155 (70)
									11 (3.35)	244 (111)	197 (89)
									16 (4.88)	336 (152)	267 (121)
									22 (6.71)	448 (203)	351 (159)

4 1/2-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101355271	RDX	DP	5	60°	Standard	Vann	18,000 (1241)	240,387 (109 038)	5 spf SDP		
101210636	HMX	Millennium™		60°	Standard	Industry Standard	18,000 (1241)	240,387 (109 038)	4 (1.22)	107 (49)	99 (45)
101287306	HNS	DP							8 (2.44)	173 (78)	155 (70)
101356077	HNS	Dominator®							11 (3.35)	223 (101)	197 (89)
									16 (4.88)	297 (135)	267 (121)
									22 (6.71)	404 (183)	351 (159)
101293450	RDX	SDP/LD	6	60°	Standard	Vann	18,000 (1241)	240,387 (109 038)	6 spf DP		
100008249	HMX	SDP		60°	Standard	Industry Standard	18,000 (1241)	240,387 (109 038)	4 (1.22)	111 (50)	99 (45)
100005322	RDX	DP							7 (2.44)	126 (57)	109 (50)
100005327	HMX	DP							11 (3.35)	233 (106)	197 (89)
101332806	HNS	DP							15 (4.88)	240 (109)	205 (93)
100008014	RDX	SDP							21 (6.41)	329 (150)	277 (126)
101233819	HMX	Millennium									
101293450	RDX	SDP/LD									
101262511	HNS	SDP									
100008249	HMX	SDP									
100005319	RDX	BH	12	45°/135°	Standard	Vann	18,000 (1241)	240,387 (109 038)	12 spf SDP		
100005324	RDX	DP		45°/135°	Standard	Industry Standard	18,000 (1241)	240,387 (109 038)	4 (1.22)	111 (50)	99 (45)
100005325	RDX	DP/LD							7 (2.44)	126 (57)	109 (50)
100005340	HMX	DP/LD							11 (3.35)	233 (106)	197 (89)
100014352	HMX	DP							15 (4.88)	240 (109)	205 (93)
100157006	HMX	BH							21 (6.41)	329 (150)	277 (126)
101210674	HMX	Millennium									

4 5/8-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101210636	HMX	Millennium™	5	60°	Premium	Vann	20,000 (1379)	414,000 (187 755)	5 spf 39 g Millennium		
101287306	HNS	Millennium		60°	Standard	Vann	19,000 (1310)	385,000 (174 633)	4 (1.22)	156 (71)	135 (61)
									8 (2.44)	257 (117)	208 (94)
									11 (3.35)	333 (151)	265 (120)
									16 (4.88)	447 (203)	357 (162)
									22 (6.71)	611 (277)	469 (213)
100005322	RDX	DP	6	60°	Premium	Vann	20,000 (1379)	414,000 (187 755)	6 spf 32 g DP		
100005327	HMX	DP		60°	Standard	Vann	19,000 (1310)	385,000 (174 633)	4 (1.22)	147 (67)	134 (61)
101332806	HNS	DP							8 (2.44)	235 (107)	207 (94)
100008014	RDX	SDP							11 (3.35)	301 (137)	262 (119)
101293450	RDX	SDP/LD							16 (4.88)	405 (184)	354 (161)
100008249	HMX	SDP							22 (6.71)	544 (247)	464 (210)
100005311	RDX	SH	8	45°/135°	Premium	Vann	20,000 (1379)	414,000 (187 755)	8 spf SH		
101228756	RDX	SH/LD		45°/135°	Standard	Vann	19,000 (1310)	385,000 (174 633)	4 (1.22)	151 (69)	134 (61)
100156995	HMX	SH							8 (2.44)	245 (111)	207 (94)
101233690	HMX	SH/LD							11 (3.35)	316 (143)	262 (119)
									16 (4.88)	420 (191)	353 (160)
									22 (6.71)	574 (260)	462 (210)

4 5/8-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100005319	RDX	BH	11	140°/160°	Premium	Vann	16,000 (1103)	414,000 (187 755)	11 spf BH		
100005326	RDX	BH/LD		140°/160°	Standard	Vann	14,000 (965)	385,000 (174 633)	4 (1.22)	153 (69)	129 (59)
100157006	HMX	BH							8 (2.44)	252 (114)	197 (89)
120038060	HMX	BH/LD							11 (3.35)	326 (148)	248 (112)
100005324	RDX	DP							16 (4.88)	438 (199)	334 (151)
100014352	HMX	DP							22 (6.71)	600 (272)	436 (198)
101210674	HMX	Millennium™									
101343830	HNS	DP									
100005324	RDX	DP	12	30°/150° OMNI™	Premium	Vann	20,000 (1379)	414,000 (187 755)	12 spf Millennium		
100005325	RDX	DP/LD		30°/150° OMNI	Standard	Vann	19,000 (1310)	385,000 (174 633)	4 (1.22)	158 (72)	127 (58)
100014352	HMX	DP							8 (2.44)	262 (119)	194 (88)
100005340	HMX	DP/LD							11 (3.35)	340 (154)	244 (111)
101210674	HMX	Millennium							16 (4.88)	459 (208)	327 (148)
101343830	HNS	DP							22 (6.71)	626 (284)	427 (194)
100005319	RDX	BH							12 spf BH		
100005326	RDX	BH/LD							4 (1.22)	154 (70)	127 (58)
100157006	HMX	BH							8 (2.44)	254 (115)	194 (88)
120038060	HMX	BH/LD							11 (3.35)	328 (149)	244 (111)
100005311	RDX	SH							16 (4.88)	442 (200)	327 (148)
101228756	RDX	SH/LD							22 (6.71)	602 (273)	427 (194)
100156995	HMX	SH							12 spf SH		
101233690	HMX	SH/LD							4 (1.22)	150 (68)	127 (58)
									8 (2.44)	245 (111)	194 (88)
									11 (3.35)	315 (143)	244 (111)
									16 (4.88)	422 (191)	327 (148)
									22 (6.71)	575 (261)	427 (194)

4 5/8-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100005311	RDX	SH	14	25.7°/ 128.5°	Premium	Vann	20,000 (1379)	414,000 (187 755)	14 spf SH		
100156995	HMX	SH		25.7°/ 128.5°	Standard	Vann	19,000 (1310)	385,000 (174 633)	4 (1.22)	150 (68)	124 (56)
									8 (2.44)	244 (111)	188 (85)
									11 (3.35)	315 (143)	235 (107)
									16 (4.88)	422 (192)	314 (142)
									22 (6.71)	575 (261)	410 (186)
100156990	RDX	BH	18	45°/135°	Premium	Vann	20,000 (1379)	414,000 (187 755)	18 spf		
100157005	HMX	DP		45°/135°	Standard	Vann	19,000 (1310)	385,000 (174 633)	4 (1.22)	139 (63)	118 (54)
									8 (2.44)	222 (101)	176 (80)
									11 (3.35)	285 (129)	219 (99)
									16 (4.88)	379 (172)	291 (132)
									22 (6.71)	513 (233)	378 (171)

4 3/4-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100005324	RDX	DP	12	30°/150° OMNI™	Premium	Vann	21,000 (1447)	516,000 (234 014)	12 spf BH		
100005325	RDX	DP/LD		30°/150° OMNI	Standard	Vann	19,000 (1310)	480,000 (217 724)	4 (1.22)	169 (77)	144 (65)
100014352	HMX	DP							8 (2.44)	284 (129)	228 (103)
100005340	HMX	DP/LD							11 (3.35)	370 (168)	291 (132)
101210674	HMX	Millennium™							16 (4.88)	505 (229)	395 (179)
101343830	HNS	DP							22 (6.71)	685 (311)	521 (236)
100005319	RDX	BH							12 spf DP		
100005326	RDX	BH/LD							4 (1.22)	166 (75)	144 (65)
100157006	HMX	BH							8 (2.44)	277 (126)	228 (103)
120038060	HMX	BH/LD							11 (3.35)	361 (164)	291 (132)
100005311	RDX	SH							16 (4.88)	491 (223)	395 (179)
101228756	RDX	SH/LD							22 (6.71)	666 (302)	521 (236)
100156995	HMX	SH							12 spf Millennium		
101233690	HMX	SH/LD							4 (1.22)	173 (78)	144 (65)
									8 (2.44)	292 (132)	228 (103)
									11 (3.35)	381 (173)	291 (132)
									16 (4.88)	522 (237)	395 (179)
									22 (6.71)	709 (321)	521 (236)
									12 spf SH		
									4 (1.22)	165 (75)	144 (65)
									8 (2.44)	275 (125)	228 (103)
									11 (3.35)	357 (162)	291 (132)
									16 (4.88)	485 (220)	395 (179)
									22 (6.71)	657 (298)	521 (236)

5-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101321963	RDX	Maxim™	6	45°/135°	Premium	Vann			6 spf SH		
									4 (1.22)	175 (79)	152 (69)
									8 (2.44)	280 (127)	230 (104)
									11 (3.35)	359 (163)	288 (131)
									16 (4.88)	490 (222)	385 (175)
									22 (6.71)	648 (294)	502 (228)
101350449	RDX	Maxim	8	45°/135°	Premium	Vann	20,000 (1379)	427,000 (193 651)	12 spf SH		
									4 (1.22)	175 (79)	152 (69)
100005311	RDX	SH	12	30°/150° OMNI™	Premium	Vann	18,000 (1241)	427,000 (193 651)	8 (2.44)	280 (127)	230 (104)
101228756	RDX	SH/LD							11 (3.35)	359 (163)	288 (131)
100156995	HMX	SH							16 (4.88)	490 (222)	385 (175)
101233690	HMX	SH/LD							22 (6.71)	648 (294)	502 (228)
101307494	RDX	Mirage®									
100005311	RDX	SH	14	25.7°/ 128.5°	Premium	Vann	17,000 (1172)	427,000 (193 651)	14 spf SH		
101228756	RDX	SH/LD							4 (1.22)	177 (80)	152 (69)
100156995	HMX	SH							8 (2.44)	286 (130)	230 (104)
101233690	HMX	SH/LD							11 (3.35)	368 (167)	288 (131)
									16 (4.88)	504 (228)	386 (175)
									22 (6.71)	667 (302)	503 (228)

5-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101268719	RDX	SH	18	60°/120° 3/Plane	Premium	Vann	17,000 (1172)	427,000 (193 651)	18 spf SH		
									4 (1.22)	181 (82)	152 (69)
									8 (2.44)	296 (134)	229 (104)
									11 (3.35)	383 (174)	288 (130)
									16 (4.88)	527 (239)	385 (174)
									22 (6.71)	701 (318)	501 (227)
101292616	RDX	BH	21	60°/120° 3/Plane	Premium	Vann	16,000 (1103)	427,000 (193 651)	21 spf BH		
									4 (1.22)	185 (84)	152 (69)
									8 (2.44)	304 (138)	229 (104)
									11 (3.35)	393 (178)	287 (130)
									16 (4.88)	540 (245)	384 (174)
									22 (6.71)	717 (325)	500 (227)

5 1/8-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101240223	RDX	SH	6	135°	Premium	Vann	18,000 (1241)	520,000 (235 868)	6 spf SH		
									4 (1.22)	185 (84)	152 (69)
									8 (2.44)	304 (138)	229 (104)
									11 (3.35)	393 (178)	287 (130)
									16 (4.88)	540 (245)	384 (174)
									22 (6.71)	717 (325)	500 (227)
100005319	RDX	BH	12	OMNI™	Premium	Vann	16,000 (1103)	520,000 (239 929)	12 spf 22.7 g		
100005326	RDX	BH/LD		OMNI	Premium	Industry Standard	16,000 (1103)	520,000 (239 929)	4 (1.22)	181 (82)	157 (71)
100157006	HMX	BH							8 (2.44)	290 (132)	239 (108)
120038060	HMX	BH/LD							11 (3.35)	372 (169)	300 (136)
100005324	RDX	DP							16 (4.88)	505 (229)	401 (182)
100005325	RDX	DP/LD							22 (6.71)	672 (305)	523 (237)
100014352	HMX	DP							12 spf 28 g SH		
100005340	HMX	DP/LD							4 (1.22)	180 (81)	157 (71)
101210674	HMX	Millennium™							8 (2.44)	287 (130)	239 (108)
101343830	HNS	DP							11 (3.35)	368 (167)	300 (136)
100005311	RDX	SH							16 (4.88)	499 (226)	401 (182)
101228756	RDX	SH/LD							22 (6.71)	663 (301)	523 (237)
100156995	HMX	SH									
101233690	HMX	SH/LD									
101307494	RDX	Mirage®									

5 1/8-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100157007	RDX	SH	14	25.7°/ 128.5°	Premium	Vann	16,000 (1103)	520,000 (239 929)	14 spf 28 g SH		
100157011	HMX	SH							4 (1.22)	182 (82)	157 (71)
									8 (2.44)	292 (133)	238 (108)
									11 (3.35)	375 (170)	298 (135)
									16 (4.88)	511 (232)	399 (181)
									22 (6.71)	679 (308)	520 (236)
									14 spf 32 g SH		
									4 (1.22)	186 (84)	157 (71)
									8 (2.44)	302 (137)	238 (108)
									11 (3.35)	389 (176)	298 (135)
									16 (4.88)	531 (241)	399 (181)
									22 (6.71)	708 (321)	520 (236)
101292616	RDX	BH	21	60°/120° 3/Plane	Premium	Vann	16,000 (1103)	520,000 (239 929)	21 spf		
									4 (1.22)	190 (86)	156 (71)
									8 (2.44)	311 (141)	236 (107)
									11 (3.35)	402 (182)	296 (134)
									16 (4.88)	553 (251)	395 (179)
									22 (6.71)	734 (333)	515 (234)

5 3/4-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100157007	RDX	SH	14	25.7°/128.5°	Premium	Vann	17,000 (1172)	512,000 (232 200)	14 spf SH		
101307494	RDX	Mirage®	10	45°/135°	Premium	Vann	17,000 (1172)	512,000 (232 200)	4 (1.22)	216 (98)	192 (87)
101357518	RDX	Maxim™							8 (2.44)	344 (156)	293 (133)
									11 (3.35)	442 (200)	369 (167)
									16 (4.88)	647 (294)	496 (225)
									22 (6.71)	859 (389)	648 (294)
101292616	RDX	BH	21	60°/120°	Premium	Vann	16,000 (1103)	512,000 (232 200)	21 spf SH		
									4 (1.22)	216 (98)	192 (87)
									8 (2.44)	344 (156)	293 (133)
									11 (3.35)	442 (200)	369 (167)
									16 (4.88)	647 (294)	496 (225)
									22 (6.71)	859 (389)	648 (294)

6-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100156993	RDX	DP	12	51.4°/154.2°	Premium	Vann	15,000 (1034)	672,000 (304 762)	12 spf DP		
100156994	HMX	DP							4 (1.22)	272 (123)	216 (98)
100156992	HMX	BH							8 (2.44)	447 (203)	318 (144)
100156991	RDX	BH							15 (4.57)	706 (320)	497 (225)
									12 spf BH		
									4 (1.22)	251 (114)	216 (98)
									8 (2.44)	398 (181)	318 (144)
									15 (4.57)	608 (276)	497 (225)

6 1/2-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101228037	RDX	Mirage®	12	45°/135°	Premium	Vann	15,000 (1034)	480,000 (217 687)	12 spf BH Mirage		
101304878	RDX	Mirage							4 (1.22)	275 (125)	240 (109)
101213474	RDX	SH							8 (2.44)	431 (195)	354 (160)
101212693	RDX	SH/LD							16 (4.88)	733 (333)	582 (264)
101357518	RDX	Maxim™							12 spf SH/LD		
									4 (1.22)	277 (126)	240 (109)
									8 (2.44)	435 (197)	354 (160)
									16 (4.88)	743 (337)	582 (264)
101228037	RDX	Mirage	14	138°	Premium	Vann	15,000 (1034)	480,000 (217 687)	14 spf SH Mirage		
101304878	RDX	Mirage SH							4 (1.22)	277 (124)	240 (109)
101213474	RDX	SH							8 (2.44)	437 (198)	354 (160)
101357518	RDX	Maxim							16 (4.88)	754 (342)	582 (264)
									14 spf SH		
									4 (1.22)	283 (128)	240 (109)
									8 (2.44)	451 (205)	354 (160)
									16 (4.88)	784 (355)	582 (264)

6 1/2-in. High-Pressure Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101228037	RDX	Mirage®	12	45°/135°	Premium	Vann	20,000 (1379)	719,000 (326 132)	12 spf BH Mirage		
101304878	RDX	Mirage SH							4 (1.22)	298 (135)	268 (121)
101213474	RDX	SH							8 (2.44)	476 (216)	410 (186)
101212693	RDX	SH/LD							16 (4.88)	824 (370)	684 (310)
101357518	RDX	Maxim™							12 spf SH/LD		
									4 (1.22)	300 (136)	268 (121)
									8 (2.44)	481 (218)	410 (186)
									16 (4.88)	834 (378)	684 (310)
101228037	RDX	Mirage	14	138°	Premium	Vann	20,000 (1379)	480,000 (217 687)	14 spf SH Mirage		
101304878	RDX	Mirage SH							4 (1.22)	300 (136)	268 (121)
101213474	RDX	SH							8 (2.44)	482 (219)	410 (186)
101357518	RDX	Maxim							16 (4.88)	841 (382)	684 (310)
									14 spf SH		
									4 (1.22)	305 (138)	268 (121)
									8 (2.44)	496 (225)	410 (186)
									16 (4.88)	871 (395)	684 (310)

7-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
100005325	RDX	DP/LD	12	45°/135°	Premium	Vann	13,000 (897)	802,000 (363 719)	12 spf BH Mirage		
100005340	HMX	DP/LD		45°/135°	Premium	Industry Standard	13,000 (897)	802,000 (363 719)	4 (1.22)	326 (148)	292 (132)
101228037	RDX	Mirage®							8 (2.44)	494 (224)	421 (191)
101304878	RDX	Mirage							16 (4.88)	831 (377)	679 (308)
101213474	RDX	SH							12 spf SH/LD		
101212693	RDX	SH/LD							4 (1.22)	328 (149)	292 (132)
101207997	HMX	Millennium™							8 (2.44)	499 (226)	421 (191)
101357518	RDX	Maxim™							16 (4.88)	841 (381)	679 (308)
									12 spf Millennium		
									4 (1.22)	356 (161)	292 (132)
									8 (2.44)	565 (256)	421 (191)
									16 (4.88)	984 (446)	679 (308)
101228037	RDX	Mirage	14	138°	Premium	Vann	13,000 (897)	802,000 (363 719)	14 spf SH Mirage		
101304878	RDX	Mirage SH							4 (1.22)	328 (149)	291 (132)
101213474	RDX	SH							8 (2.44)	501 (227)	420 (190)
101357518	RDX	Maxim							16 (4.88)	847 (384)	677 (307)
									14 spf SH		
									4 (1.22)	334 (151)	291 (132)
									8 (2.44)	515 (234)	420 (190)
									16 (4.88)	877 (398)	677 (307)

7-in. Premium VannGun® Assemblies

Charge Part No.	Explosive Type	Charge Type	SPF	Phasing	Gun Material Type	Gun Thread	Pressure Rating psi (bar)	Tensile Strength lb (kg)	Weights		
									Length ft (m)	Loaded lb (kg)	Spacer lb (kg)
101414821	HMX	Mirage®	18	60°/120°	Premium	Vann	13,000 (897)	802,000 (363 719)	18 spf SH Mirage		
									4 (1.22)	334 (151)	291 (132)
									8 (2.44)	515 (234)	420 (190)
									16 (4.88)	877 (398)	677 (307)
101414821	HMX	Mirage	18	60°/120°	Premium	Vann	20,000 (1379)	802,000 (363 719)	18 spf SH Mirage XHP		
									4 (1.22)	334 (151)	291 (132)
									8 (2.44)	515 (234)	420 (190)
									16 (4.88)	877 (398)	677 (307)

Gun Washover/Fishing Specifications

Gun Size in.	Gun OD in.* (Gun OD after shooting)	Maximum Shot (Density) per foot SPF	Minimum Casing Size (for washing over w/o milling guns)
1.563	1.745	4	4 in.
	1.76	6	
2	2.166	4	4 in.
	2.203	6	
2.5	TBD*	4	4.5 in. 13.5 #/ft
	2.67	6	
2.75	2.97	4	4.5 in. 9.5 #/ft
	2.79	5	
	3.09	6	
3.125	3.25	9	5 in. 15 #/ft
3.375	3.68	4	5.5 in. 23 #/ft
	3.68	6	
	3.53	12	
4	4.26	6	6 5/8 in. 35 #/ft
4.625	4.87	5	7 in. 35 #/ft
	4.88	6	
	4.86	8	
	4.87	11	
	4.96	12	
	4.79	14	
5	5.2	12	7 in. 26 #/ft/**
	5.3	14	
	5.23	18	
5.125	5.41	6	7 5/8 in. 39 #/ft
	5.21	12	
	5.38	14	
	5.36	21	
6	6.79	12	9 5/8 in.
6.5	6.76	14	9 5/8 in. 71.8 #/ft
7	7.14	12	9 5/8 in. 58.4 #/ft
	7.15	14	

*Worst Case-Atmospheric pressure, submerged in water.

**It is possible to washover 5 in. guns in 7 in. 29-lb casing, but washover pipe to be used is not a common size and is difficult to find.

Gun Swell Information

Gun			Charge			Test Results		
OD	SPF	Shot Phase deg	Charge Part No.	Type	Explosive Weight gm	Tested In Air/Water	Maximum Swell in.	
1 9/16	6	60	100157028	Millennium™	3.4	water	1.760	
		0	100157028				1.705	
2	4	0	100008017	SDP	6.8	air	2.246	
	6	60	100008017			water	2.221	
		0	101208224	Millennium			2.177	
		60	101208224				2.225	
			101603801*	MaxForce®	7	air	2.193	
2.38	6	60	101590845	MaxForce	10	water	2.529	
2 1/2	6	60	101206251	DP	11	water	2.680	
			101418095*	Millennium II™	11.1	air	2.705	
2 3/4	4	22 LS	100158220	DP LD	13	water	2.781	
	5	180	100158220		13		2.810	
			100157026	SDP	14.7		2.971	
	6	60	100005329	DP	12.5		air	2.853
			100005329		12.5	2.898		
			100158220	DP LD	13	water	2.893	
			101206793	BH	14.7		2.850	
			100010399	SDP	14.7		2.954	
			101233817	Millennium	15		2.892	
			101233817		15		2.915	
	2 7/8	6	60	101233817	Millennium	15	water	3.047
2 7/8 HW	6	60	101233817	Millennium	15	air	3.044	
2.88	6	60	101388407	Millennium HNS	18.5	water	3.060	
3 1/8	6	60	101388406	Millennium	17.5	HMX	3.333	
3.38	5	60	101320075	Dominator®	25	water	3.497	
3 3/8	G-Force®	180	101233817	Millennium	15	water	3.42	
	4	60	100005322	DP	32	air	3.676	
			100005327		32	water	3.592	
		90	100005327		32		3.555	
		180	100008249		SDP		25	3.546
	6	60	100005333	DP	22	air	3.610	
			100008249	SDP	25	water	3.600	
			101207640	SDP LD	24		3.615	
		60 LS	100008249	SDP	25		3.600	
		60	101233819	Millennium	25		3.645	
			101309223	Dominator	25		3.695	
			8	180	100008251		BH	14
		12	30/150	100008251	14			3.520
	12	100005312		14	3.568			
	3 1/2	6	60	101309223	Dominator	25	air	3.845
4	4	90	101210636	Millennium	39	water	4.260	
	7	150	101228756	SH LD	28	water	4.280	

Gun Swell Information

Gun			Charge			Test Results	
OD	SPF	Shot Phase deg	Charge Part No.	Type	Explosive Weight gm	Tested In Air/Water	Maximum Swell in.
4.25	8	150	101228756	SH LD	28	water	4.487
4 5/8	G-Force®	180	100005327	DP	32	water	4.696
	4	10/350	101466192	KleenZone™	39	water	4.705
	5	60	101210636	Millennium™	39	air	4.944
		45/135	101321963	SH	56.5	water	4.904
	6	60	100005327	DP	32	air	4.876
			100005327		32	water	4.806
	8	180	100005326	DP LD	23	water	4.860
			100005326		23		4.780
			100005311	SH	28		4.770
	11	140/160	100005324	DP	22.7		4.868
	12	30/150	100014352		23		4.834
			100005340	DP LD	22.7		4.925
			100005326	BH LD	22.7		4.840
			100005311	SH	28		4.813
			101228756	SH LD			4.895
	14	25.7/128.5	100005311	SH	4.790		
18	45/135	100156990	BH	20	4.730		
5	8	135	101350449	Maxim™	47	water	5.202
	12	30/150	100005311	SH	28	water	5.196
	14	25.7/128.5	100005311				5.207
			101228756	SH LD			5.304
	18	60/120	101269719	SH			5.229
	21		101292616	BH	21		5.198
5 1/8	6	45/135	101240223	SH	56.5	water	5.413
	12	30/150	100005326	BH LD	22.7		5.210
	14	25.7/128.5	100157007	SH	32		5.332
	21	60/120	101292616	BH	20		5.268
5 3/4	14	25.7/128.5	101272769	SH LD	34	water	5.945
	21	3/plane 60	101292616	BH	21	water	6.065
6 1/2	14	138	101304878	Mirage® BH	47	water	6.685
	12	45/135	101212693	SH LD	56.5		6.715
6 1/2 HP	12	45/135	101212693	SH LD	56.5	water	6.762
7	12	45/135	101210063	SH LD	56.5	water	7.125
	14	138	101213474	SH			7.143
		18	3/plane 60	101498239	BH LD	45	water

*Special gun length requirements

The above chart was taken from actual tests conducted by Halliburton Technology on RDX and HMX charges. It can be used as a general guideline for all explosives. If you have questions regarding these systems, or systems that are not listed, please contact your local Halliburton representative.

All tests were conducted at ambient temperature and pressure.

Capsule Gun Systems

Dyna-Star® Capsule Gun

Jet Research Center's Dyna-Star® capsule gun is an economical, second-generation capsule perforating system. This system is partially expendable and uses a stainless steel strip in its through-tubing technology.

Applications

- 2.125-in. and 1.6875-in. gun systems at 4-spf and 6-spf
- 1.6875-in. system rated at 14,000 psi and up to 370°F (HMX version) in dry gas or fluid
- 2.125-in. system rated at 15,000 psi and up to 370°F (HMX version) in dry gas or fluid
- Rated up to 370°F (HMX version) in dry gas or fluid—may be used in hostile environments only if special precautions are taken. Contact JRC for more information

Features

- Deep penetrating charges
- Uses same charges as the Dyna-Cap® four-wire strip gun to minimize inventory
- Available in 0° phasing
- Rollover sleeves to keep the gun in its optimum orientation
- Can cut guns to required length in the field
- Economical operation
- Can use 18-ft long strips without tandem
- Ease of gun retrieval after shooting



Dyna-Star® Capsule Gun

Deep Star™ Capsule Gun

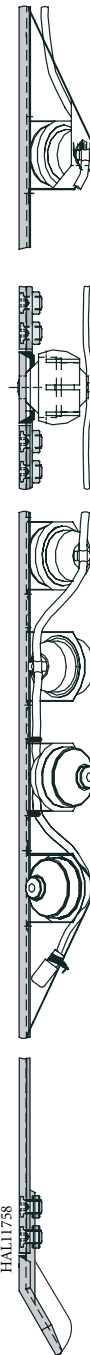
Jet Research Center's Deep Star™ perforating system is a third-generation, state-of-the-art, through-tubing capsule perforating system with improved charge performance and running characteristics.

Applications

- 2.125-in. and 1.6875-in. OD gun systems
- Rated at 15,000 psi and 350°F in dry gas, fluid, or hostile environments
- Higher ratings available upon request
- Designed for deep, high temperature, high pressure wells

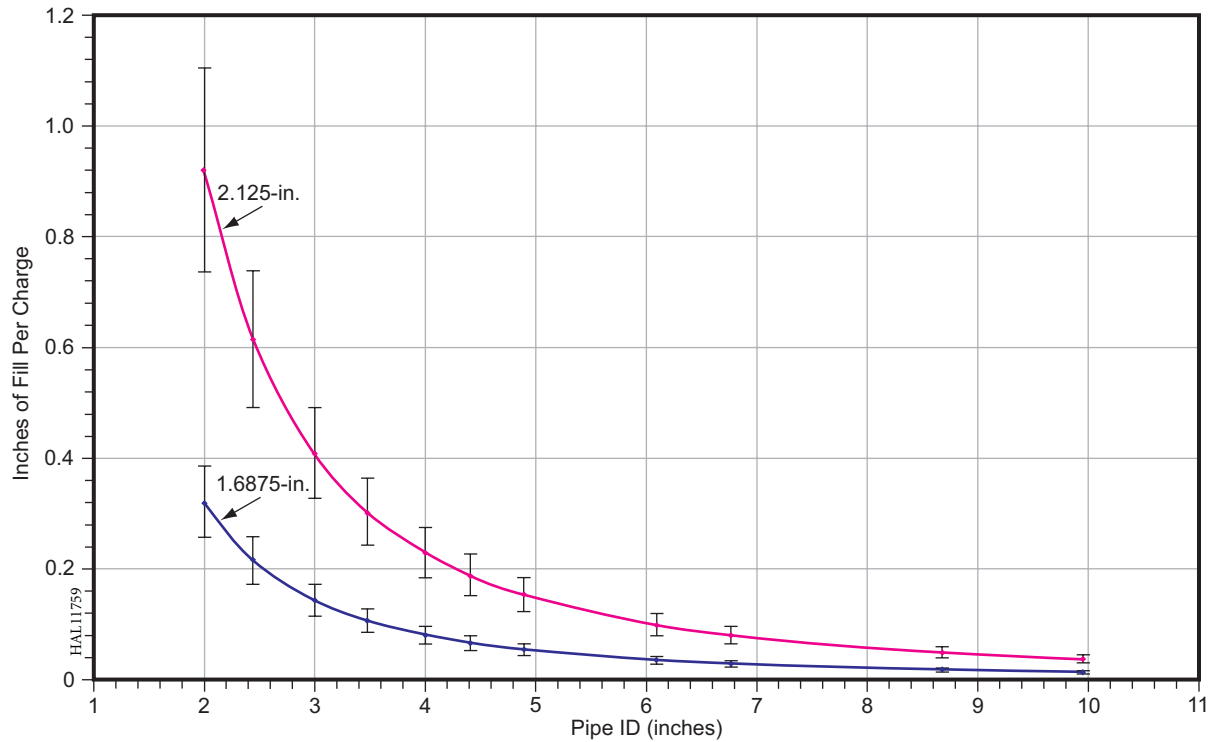
Features

- Extremely deep penetrating charges
- Higher shot densities without charge interference (up to 8-spf with the 1.6875-in. system-patent pending) attained using hydrodynamic modeling techniques
- Most available in seven phasings: 0°, 90° downside, 90° spiral, triphase (patented), pentaphase, heptaphase, and octaphase
- Compatible interval coverage with the innovative “gull-wing” tandem (patented), which minimizes strip deformation, allowing easier retrieval
- Hardware offset in conjunction with charge center gravity to optimize gun stability and orientation
- Corrosion-resistant steel alloy charge cases and carrier strips permit the use of the Deep Star system in hostile environments
- No gaps in shot pattern at joints in strips
- Ease of gun removal after shooting



2.125-in. 90° Spiral Phase Deep Star™ Capsule Gun

1.6875-in. and 2.125-in. Deep Star™ Debris Fill Data



Deep Star™ Fill Data (Shot in Water)

Pipe OD in.	Pipe Weight lb/ft	Pipe ID in.	Fill per 1 11/16-in. Charge in. (mm)	Fill per 2 1/8-in. Charge in. (mm)
2 3/8	4.7	1.995	0.322 (8.17)	0.920 (23.37)
2 7/8	6.5	2.441	0.215 (5.45)	0.615 (15.61)
3 1/2	9.3	2.992	0.143 (3.63)	0.409 (10.39)
4	11.0	3.476	0.106 (2.69)	0.303 (7.70)
4 1/2	11.6	4.000	0.080 (2.03)	0.229 (5.81)
5	15.0	4.408	0.066 (1.67)	0.188 (4.79)
5 1/2	17.0	4.892	0.053 (1.36)	0.153 (3.89)
7	32.0	6.094	0.034 (0.88)	0.099 (2.50)
7 5/8	33.7	6.765	0.028 (0.71)	0.080 (2.03)
9 5/8	47.0	8.681	0.017 (0.43)	0.049 (1.23)

Notes:

1. Fill data is approximate.
2. When shot in gas, the debris is smaller and will occupy less volume.

Ported Gun Perforating System

Jet Research Center's ported gun perforating systems provide users with economical, reusable guns for multi-purpose applications.

Applications

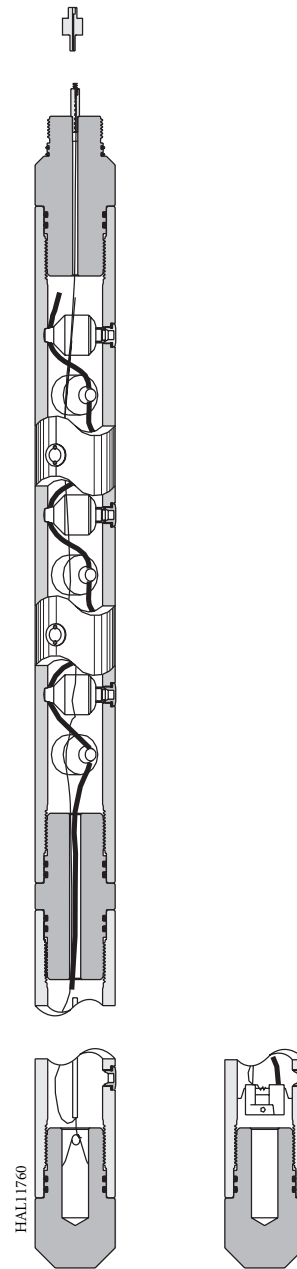
- Multi-zone shooting on a single run with select fire subs
- Hostile environment
- Short guns available for squeeze applications

Features

- Charges are protected from well fluids, formation pressure, and abrasion
- Debris retained in hollow carrier
- Carrier protects casing from detonation shock
- Charges for high-temperature environments are available upon request
- Charges are tested to API standards
- Charges are designed to minimize internal damage to the gun body, prolonging life
- The gun design has minimized charge interference

Options

- 3.125-in. to 5-in. gun sizes
- Big-hole and deep penetrating charges
- 90° and 120° phasing (other phase angles available upon request)



3.125-in. Ported Gun

Firing Heads

Detonation Interruption Device

The detonation interruption device (DID) provides added safety for the VannSystem® service by helping to prevent firing at surface conditions. This device contains a eutectic metal that has a very low melting point. When the metal is in a solid state, the firing head could detonate, but the explosive train will not transmit through the interrupt device to the guns.

Features

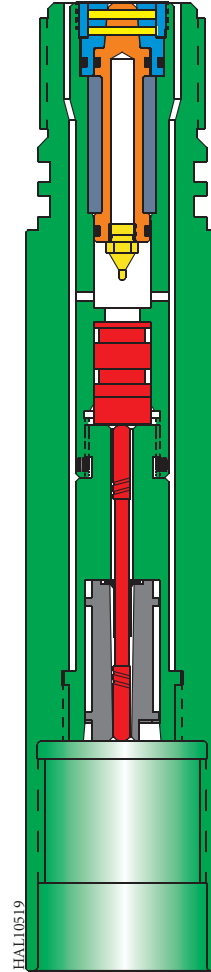
- Compatible with other firing heads
- Disables transmission of explosive train at the surface
- Used with redundant firing heads

Operation

The eutectic metal will remain solid as the assembly lowers into the hole (assuming the tool temperature is below 117°F). When exposed to the bottomhole temperature (minimum 135°F for operational purposes), the metal becomes liquid, allowing the transfer of the explosive train from the firing head to the gun.

To help prevent accidental gun detonation when lowering or retrieving unfired guns, the metal returns to a solid state upon reaching a cooler surface temperature.

Note: The eutectic material utilized actually melts at 117°F. At 117°F or above, the DID assembly will not prevent detonation. For safe operation, it should be assumed that detonation transfer will occur if the tool is at or above 110°F.



Detonation Interruption Device

Detonation Interruption Device (DID) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Required Temperature Rating °F (°C)	Tensile Strength lb (kg)
100155745	2 (50.8) 6 Acme 2G	2.50 (63.5)	1.58 (0.48)	N/A	135 (57)	121,000 (54 885)
101204860	2 3/8 (60.33) 6P Acme Box x Pin	2.75 (69.85)	3.70 (1.13)	20,000 (1380)	135 (57)	140,000 (63 400)
100155746	2 7/8 (73.03) 6P Acme Box x Pin	3.375 (85.73)	3.04 (0.93)	25,000 (1725)	135 (57)	246,000 (111 500)

Maximum temperature is determined by explosives.

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

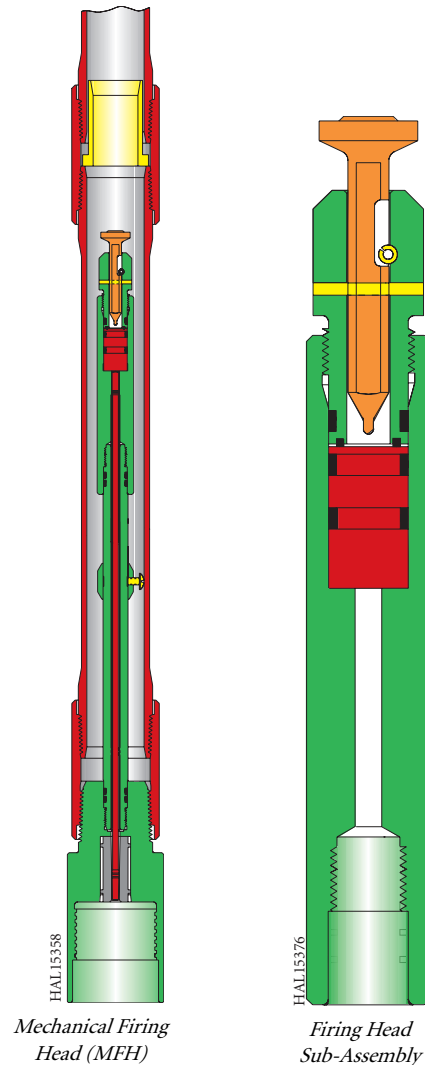
Mechanical Firing Head

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 according to Halliburton standard operating procedures.

Operation

The operation of the MFH depends on the amount of force delivered to the firing pin by the detonating bar. This 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 spacer must always be used with the MFH.



Mechanical Firing Head (MFH) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length (w/Tubing Sub) ft (m)	Maximum Operating Pressure psi (bar)	Minimum ID (No-Go) in. (mm)	Tensile Strength (FH Body) lb (kg)
100155741	1 7/16 (36.51) 8 UN 2 B Box × 1.90 (48.26) NU 10 Rd Pin	2.0 (50.8)	1.48 (.45)	20,000 (1380)	1.53 (38.86)	60,000 (27 200)
100005223	1.90 (48.26) NU 10 Rd Pin × 2 3/8 (60.33) 6P Acme Box	2.75 (69.85)	4.92 (1.50)	20,000 (1380)	1.56 (39.62)	140,000 (63 400)
100005228	2 3/8 (60.33) EUE 8 Rd Pin × 2 7/8 (73.03) 6P Acme Box	3.375 (85.73)	4.92 (1.50)	20,000 (1380)	1.56 (39.62)	238,000 (107 900)

Burst and collapse pressures are determined by handling sub.

Temperature rating is determined by explosives.

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

Model II-D Mechanical Firing Head

The model II-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.

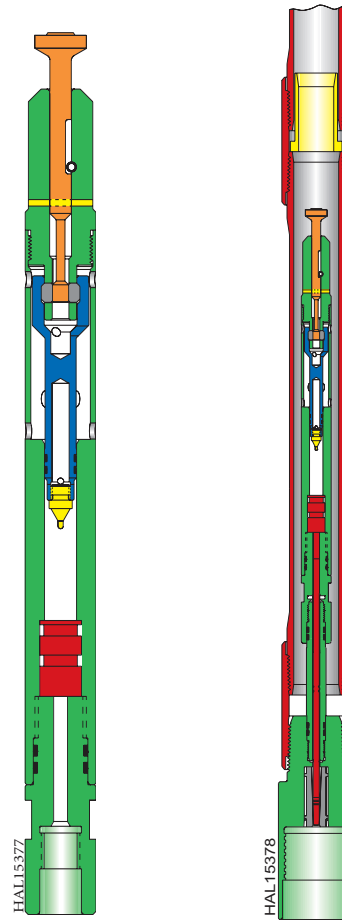
Features

- Cannot be detonated accidentally at surface
- Ideal for use in mud environments where spudding may be necessary
- Used in deviated wells

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.



Model II-D Mechanical
Firing Head

Model II-D Mechanical
Firing Head Assembly

Model II-D Mechanical Firing Head Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID (No-Go) in. (mm)	Makeup Length (w/tubing sub) ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength (FH body) lb (kg)
100014156	1.90 (48.26) EUE 10 Rd Pin × 2 3/8 (60.33) 6P Acme Box	2.75 (69.85)	1.56 (39.62)	4.92 (1.50)	20,000 (1380)	1,500 (103)	140,000 (63 400)
100005227	2 3/8 (60.33) EUE 8 Rd Pin × 2 7/8 (73.03) 6P Acme	3.375 (85.73)	1.56 (39.62)	4.92 (1.50)	20,000 (1380)	1,500 (103)	238,000 (107 900)

Burst and collapse pressures are determined by handling sub.

Temperature rating is determined by explosives.

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

Model III-D Mechanical Firing Head

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.

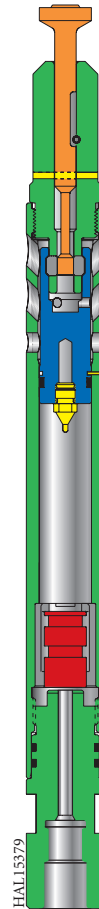
Features

- Cannot be detonated accidentally at surface
- Requires minimal hydrostatic pressure to actuate the firing head

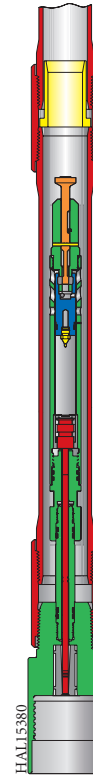
Operation

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.

If a detonating bar is dropped on the model III-D firing head with less than 250 psi hydrostatic pressure in the tubing, and the head does not fire, increasing the hydrostatic pressure in the tubing may cause it to fire.



Model III-D Mechanical Firing Head



Model III-D Mechanical Firing Head Assembly

Model III-D Mechanical Firing Head Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID (No-Go) in. (mm)	Makeup Length (w/Tubing Sub) ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength (FH Body) lb (kg)
100155742	1.90 (48.26) EUE 10 Rd Pin × 2 3/8 (60.33) 6P Acme Box	2.75 (69.85)	1.56 (39.62)	4.92 (1.50)	8,000 (550)	250 (17)	140,000 (63 400)
100005191	2 3/8 (60.33) EUE 8 Rd Pin × 2 7/8 (73.03) 6P Acme Box	3.375 (85.73)	1.56 (39.62)	4.92 (1.50)	8,000 (550)	250 (17)	238,000 (107 900)

Burst and collapse pressures are determined by handling sub.

Temperature rating is determined by explosives.

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

Pressure-Actuated Firing Head

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 applied pressure.

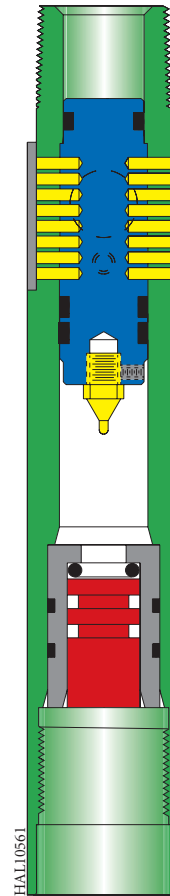
Features

- Can be run on the top and bottom of the gun assembly
- Initiates a bridge-plug 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 (TDF)

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.



*Pressure-Actuated
Firing Head (PAF)*

Pressure-Actuated Firing Head (PAF) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	No. and ID of Ports in. (mm)	Flow Area of Ports in. ² (cm ²)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Collapse Pressure psi (bar)
100005224	1.315 (33.40) NU-10 Rd Pin × 17/16 (36.51) 8 UN-2 B Box	1.688 (42.88)	2 @ 0.75 (19.05)	0.88 (5.68)	0.73 (0.22)	17,000 (1170)	2,200 (150)	65,000 (29 400)	27,000 (1860)

Temperature rating is determined by explosives.

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

Model K and K-II Firing Heads

The model K and K-II firing heads were developed for conditions that are unfavorable for dropping a detonating bar in a horizontal well. The model K and K-II firing heads are pressure-sensitive tools designed to hydraulically detonate at a prescribed pressure. These firing heads use tubing pressure applied to a piston-type firing pin.

Features

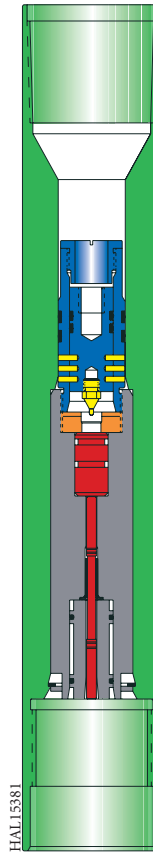
- Allows the operator to determine the exact time of firing the guns since the firing heads require a predetermined pressure before the guns can fire
- Works with full-opening or non-full-opening downhole tools
- Ideal for balanced or overbalanced perforating
- Can be used for dual completions, drillstem testing, or production perforating
- Well-suited for highly deviated well completions

- Can be run on the top or bottom of the perforating assembly
- Can be easily redressed

Operation

The model K and K-II firing heads are 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 an 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.



Model K-II Firing Head

Model K Firing Head Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Collapse Pressure psi (bar)
100014211	2 7/8 (73.03) EUE 8 Rd Box × 2 7/8 (73.03) 6P Acme Box	3.375 (85.73)	1.25 (0.38)	13,000 (895)	4,000 (275)	220,000 (99 700)	30,000 (2070)

Model K-II Firing Head Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Collapse Pressure psi (bar)
100005190	1.90 (48.26) EUE 10 Rd Pin × 2 3/8 (60.33) 6P Acme Box	2.75 (69.85)	1.24 (0.38)	19,500 (1345)	4,000 (275)	187,000 (84 800)	25,000 (1725)
100014215	2 7/8 (73.03) EUE 8 Rd Box × 2 7/8 (73.03) 6P Acme Box	3.375 (85.73)	1.64 (0.50)	19,500 (1345)	4,000 (275)	220,000 (99 700)	30,000 (2070)

Temperature rating is determined by explosives.

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

Model KV-II Firing Head

The model KV-II firing head makes the firing of the guns and the opening of 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.

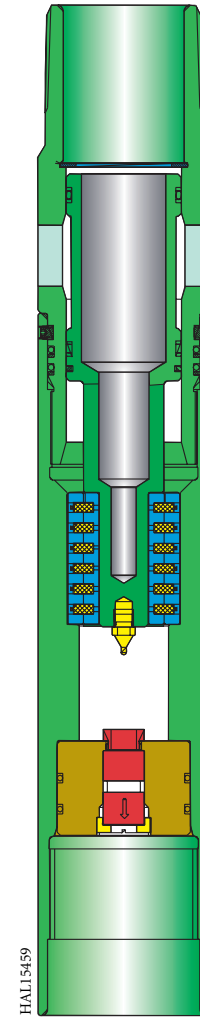
Features

- 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

Operation

In many tubing conveyed perforating 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 model KV-II firing head combines a firing head and a vent assembly.

In the model KV-II firing head, 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 in the tool open the instant the firing head is actuated and the guns detonate. To delay the gun detonation, one or more delay devices may be added to the assembly.



Model KV-II
Firing Head

Model KV-II Firing Head Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Flow Area in. ² (cm ²)	Minimum Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Maximum Differential Pressure psi (bar)	Tensile Strength lb (kg)
100014153	2 3/8 (60.33) EUE 8 Rd Pin × 2 3/8 (60.33) 6P Acme Box	2.75 (69.85)	2.79 (18.0)	1.33 (0.41)	25,000 (1725)	3,000 (206)	15,000 (1035)	145,000 (65 700)
100014155	2 7/8 (72.88) EUE 8 Rd Pin × 2 7/8 (72.88) 6P Acme Box	3.375 (85.73)	3.14 (20.27)	1.43 (0.44)	25,000 (1725)	4,000 (275)	15,000 (1035)	235,000 (106 600)

Temperature rating is determined by explosives.

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

Time-Delay Firer

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 4 to 6 minutes for adjusting the actuating pressure in the tubing to achieve the desired pressure before firing the guns.

Features

- 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 non-full-opening tools
- Reduces cost by allowing the running of multiple guns without gun spacers
- Ideal for production completions, drillstem testing, and dual completions
- Recommended for running on the top and bottom of gun assemblies
- Allows additional time-delay elements as needed for increasing delay time

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 4 and 6 minutes) depending on the bottomhole temperature and detonates the perforating assembly.



Time-Delay Firer (TDF)

Time-Delay Firer (TDF) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Temperature Rating °F (°C)	Tensile Strength lb (kg)	Collapse Pressure psi (bar)
100014157	1 7/16 (36.51) 8 UN-2 B Box × 1.315 (33.4) NU-10 Rd Pin	1.688 (42.88)	2.16 (0.65)	21,500 (1482)	2,200 (150)	425 (218) for 200 hours	56,000 (25 400)	26,300 (1813)
100005231	1.90 (48.26) EUE 10 Rd Pin × 2 (50.8) 6P Acme Box	2.50 (63.5)	1.69 (0.52)	25,000 (1723)	4,000 (275)	425 (218) for 200 hours	120,000 (54 432)	30,000 (2070)
100005230	2 7/8 (73.03) EUE 8 Rd Pin × 2 7/8 (73.03) 6P Acme Box	3.375 (85.73)	1.81 (0.55)	13,000 (895)	4,000 (275)	350 (176) for 500 hours	220,000 (99 700)	30,000 (2070)

Temperature rating is determined by explosives or elastomers. These ratings are guidelines only. For more information, consult your local Halliburton representative.

Multiaction-Delay Firing Head

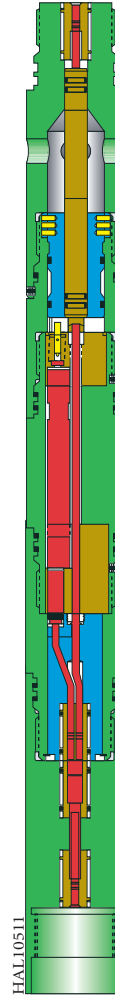
The multiaction-delay firing head is a pressure-actuated redundant firing system that can be run with any one of several other firing heads.

Features

- 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

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.



*Multiaction-Delay
Firing Head*

Multiaction-Delay Firing Head Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Collapse Pressure psi (bar)
100155753	2 3/8 (60.33) 6P Acme Box x Pin	3.10 (78.74)	3.41 (1.04)	18,000 (1240)	4,000 (275)	170,000 (77 100)	22,000 (1515)
100155750	2 7/8 (73.03) 6P Acme Box x Pin	3.375 (85.73)	3.41 (1.04)	25,000 (1725)	4,000 (275)	201,000 (91 100)	29,000 (2000)

Temperature rating is determined by explosives.

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

Annulus Pressure Firer-Control Line

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 or pressure-firing heads can be attached to the top of the APF-C firing head.

Features

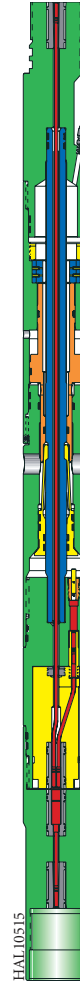
- Can be used with non-full-opening test tools and partially filled tubing strings
- Can be used for drillstem testing or shoot-and-pull for gravel packs
- Can be used wherever a pressure-actuated tool is desirable
- Ideal for deviated wells
- Provides a system of two firing heads on top of the guns

- 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

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 which detonates the initiator.

The operation of the drop bar or pressure-actuated firing head depends on which firing head system is used.



*Annulus Pressure
Firer-Control Line (APF-C)
Firing Head*

Annulus Pressure Firer-Control Line (APF-C) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Collapse Pressure psi (bar)
100156138	2 7/8 (73.03) 6P Acme Box x Pin	3.68 (93.47)	3.70 (1.13)	20,000 (1380)	250 (17)	174,000 (78 900)	17,000 (1170)

Temperature rating is determined by explosives.
These ratings are guidelines only. For more information, consult your local Halliburton representative.

Annulus Pressure Transfer Reservoir

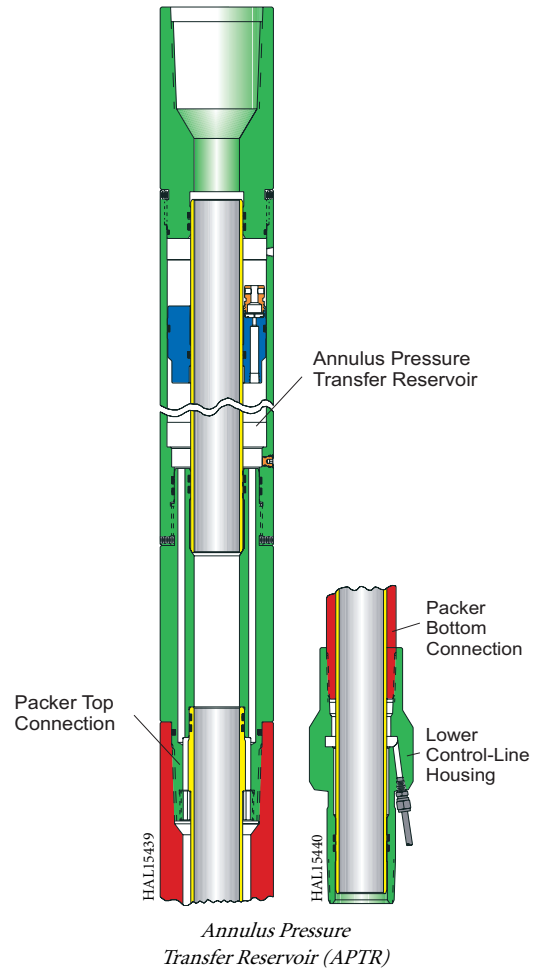
The annulus pressure transfer reservoir (APTR) is an integral component of the annulus pressure firer-control line (APF-C). The APTR is the mechanism that transmits pressure from above the packer to a differential pressure or pressure-actuated firing (PAF) head on top of the perforating assembly.

Features

- Features a full-opening ID
- Compatible with mud environments
- Adapted for RTTS™ and CHAMP® IV packers
- Ideal for applications that require a partial fluid column in the tubing string
- Eliminates the need for nitrogen

Operation

The APTR transmits annulus pressure into a micro-annulus 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.



Annulus Pressure Transfer Reservoir (APTR) Specifications

SAP No.	Maximum OD in. (mm)	Minimum ID in. (mm)	Top Assembly	Lower Assembly	Length Above Packer ft (m)	Length Below Packer ft (m)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
100156028	5.00 (127.00)	2.00 (50.8)	3 1/2 4 IF Box x 3 7/8 6 Stub Acme Pin	2 7/8 (73.03) EUE 8 Rd Box x Pin	5.09 (1.55)	1.02 (0.31)	328,000 (148 700)	18,000 (1240)	15,000 (1035)
101016453	6.12 (155.45)	2.37 (60.20)	4 1/2 4 IF Box x Pin	4 1/2 (114.3) 4-IF Box x 3 1/2 (88.90) EUE 8 Rd Pin	4.34 (1.32)	1.33 (0.41)	587,000 (266 200)	22,000 (1515)	19,000 (1310)

Temperature rating is determined by o-rings.

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

Slimhole Annulus Pressure Firer—Internal Control

5-in. Annulus Pressure Transfer Reservoir

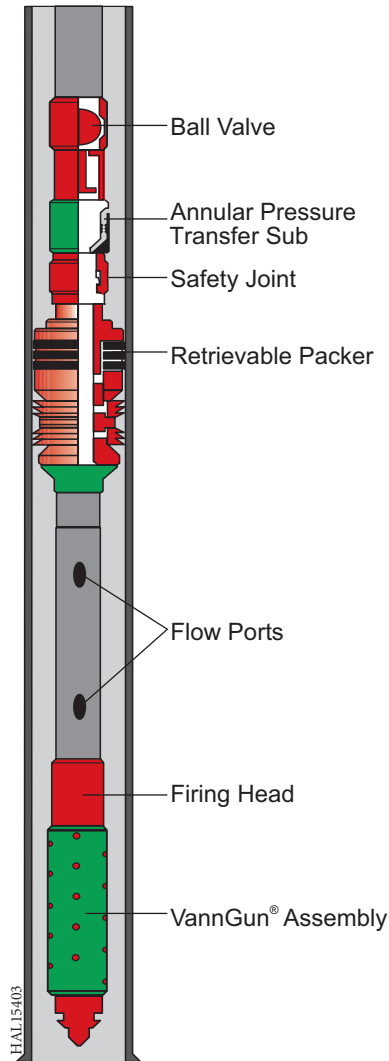
The slimhole annulus pressure transfer reservoir (APTR) system assembles in a similar manner to the 7-in. and 9 5/8-in. APTR systems. Only two design changes have been implemented in the new 5-in. APTR system. First, a series of concentric tubes below the packer replaces the control line from larger APTR systems. Second, a single tube mandrel runs through the packer, replacing the series of threaded tube mandrels from the larger APTR systems.

3 1/8-in. Internal Control

Concentric tubes eliminate the need for an external control line in slimhole casing.

3 1/8-in. Annulus Pressure Transfer Reservoir—Internal Control

The slimhole 3 1/8-in. (APF-IC) firing head is designed for use with the 5-in. APTR system with internal control. The firing head design remains the same as the 3 3/8-in. APF-C with diameter reductions in many of the component parts to achieve a true 3.13-in. OD.



*Slimhole Annulus Pressure Firer—
Internal Control (APF-IC)
Installation*

Slimhole Annulus Pressure Firer—Internal Control (APF-IC) Specifications

SAP No.	Thread Size and Type	Max OD in. (mm)	Min ID in. (mm)	No. of Ports	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
101301541	2 3/4-in. 6P Acme Box x Pin	3.13 (79.5)	1.25 (31.75)	2	56.41 (17.2)	20,000 (1378)	250 (17)	87,000 (39 463)	N/A	10,000 (689)

Temperature Rating 325°F (20K psi) with Extreme Environment Kit (162°C 1.406 kg/cm² with Extreme Environment Kit)
Call Technology for temperatures above 325°F (162°C).

Differential Firing Head

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.

Features

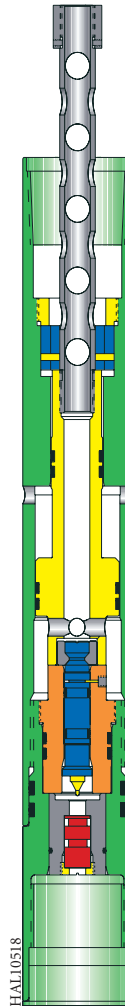
- Allows underbalanced perforating in horizontal wells without a packer
- Ideal for perforating with a sucker rod or submersible pump in place
- Offers added safety because it is pressure-balanced when being run into the well
- Helps allow maximum underbalanced pressure in low-pressure wells when mechanical 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

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 in 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.



Differential Firing Head (DFH)

Differential Firing Head (DFH) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure (Differential) psi (bar)	Minimum Operating Pressure (Differential) psi (bar)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
120002262	2 3/8 (60.33) EUE 8 Rd Box x 2 3/8 (60.33) 6P Acme Box	3.0 (76.20)	1.94 (0.59)	10,000 (690)	1,000 (69)	130,000 (58 900)	20,000 (1380)	20,000 (1380)
100014232	2 7/8 (73.03) EUE 8 Rd Box x 2 7/8 (73.03) 6P Acme Box	3.38 (85.73)	1.98 (0.60)	5,000 (345)	1,000 (69)	220,000 (99 700)	20,000 (1380)	20,000 (1380)

Temperature rating is determined by explosives or o-rings.

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

Hydraulic Actuator Firing Head and Swivel-Type Hydraulic Actuator Firing Head

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

The smaller swivel-type hydraulic actuator firing head (SHAF) has a swivel incorporated into the firing head assembly. The added swivel feature allows the lower portion of the firing head and the attached explosive assembly to rotate independently from the tubing string.

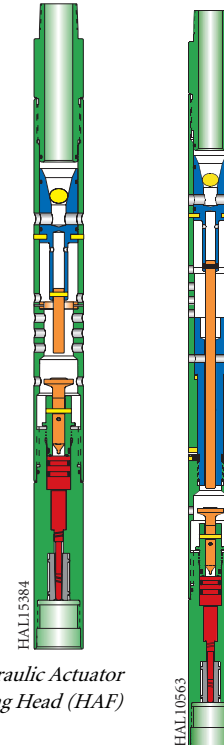
Features

- Allows packerless completions
- Makes actuation easily observable

- Useful in coiled tubing conveyed completions, deviated wells, and through-tubing perforating
- Reusable
- Rotation of explosive assembly from tubing string possible with swivel type

Operation

A stainless steel or ceramic 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.



Hydraulic Actuator Firing Head (HAF)

Swivel-Type Hydraulic Actuator Firing Head (SHAF)

Hydraulic Actuator Firing Head (HAF) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Ball OD in. (mm)	No. and ID of Ports in. (mm)	Flow Area of Ports in. ² (cm ²)	Makeup Length ft (m)	Maximum Operating Pressure (differential) psi (bar)	Actuating Pressure psi (bar)	Tensile Rating lb (kg)
100156011 (Swivel Type)	1.315 (33.40) NU-10 Rd Pin × 17/16 (36.51) 8UN-2B Box	1.69 (42.88)	0.625 (15.875)	2 @ 0.5 (12.70)	0.39 (2.52)	2.84 (0.87)	20,000 (1379)	3,200 (221)	50,000 (22 680)
100156025	1.315 (33.40) NU-10 Rd Pin × 17/16 (36.51) 8UN-2B Box	1.69 (42.88)	0.625 (15.875)	2 @ 0.5 (12.70)	0.39 (2.52)	2.18 (0.66)	20,000 (1379)	3,200 (221)	50,000 (22 680)
101007031	1.90 (48.26) EUE-10 Rd 3/4 TPF Pin 2 3/8 (60.33) 6P Acme Box	2.75 (69.85)	0.625 (15.875)	2 @ 0.5 (12.70)	0.39 (2.52)	2.28 (0.691)	20,000 (1379)	3,200 (221)	113,000 (51 256)
100156150	2 3/8 (60.33) EUE 8 Rd Pin × 2 7/8 (73.03) 6P Acme Box	3.38 (85.85)	1.375 (34.925)	4 @ 1.0 (25.40)	3.14 (20.26)	2.40 (0.73)	20,000 (1379)	2,000 (138)	135,600 (61 507)
101313489	2 7/8 (73.03) EUE 8 Rd Pin × 2 7/8 (73.03) 6P Acme Box	3.38 (85.85)	1.375 (34.925)	4 @ 1.0 (25.40)	3.14 (20.26)	2.40 (0.73)	20,000 (1379)	2,000 (138)	216,000 (97 976)

Temperature rating is determined by explosives.

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

Mechanical Metering Hydraulic-Delay Firing Head

The mechanical metering hydraulic-delay (MMHD) firing head provides a retrievable firing system with an adjustable delay for situations where longer delay times are needed. Delay time can be adjusted from 1 to 6 hours. The tool is designed with a 1/2 gallon fluid chamber below a weighted piston. The piston meters downward until it travels into a larger bore which allows it to free-fall and initiate a mechanical firing head.

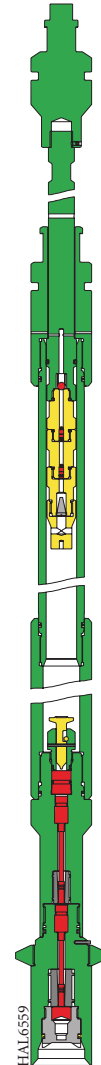
Delay time is affected by temperature, tool weight above the piston, and the number of jets used (maximum of two), and the adjustments can be made by running one or two fluid metering jets or by changing the amount of fluid.

Features

- Adjustable time-delay—May vary from 1 up to 6 hours
- Retrievability—Firing head can be pulled and another one run without affecting the rest of the bottomhole assembly
- Safety—With the ability to run the firing head and the guns separately, this system greatly reduces the chance of accidental or premature firing of guns

Operation

The MMHD assembly is run into the well using normal monobore completion techniques. The mechanical metering hydraulic-delay firing head is conveyed on a slickline or electric line. For safety and flexibility, the tool will not start metering until it is landed on the top gun. Once in place and released, the firing head starts to meter. The running tools can either be pulled into the lubricator, pulled completely out of the hole, or simply pulled up the hole to a safe distance and secured to await detonation. After the guns have fired, the firing head can be quickly relatched and retrieved using the same conveyance methods as during deployment.



Mechanical Metering Hydraulic-Delay (MMHD) Firing Head

Mechanical Metering Hydraulic-Delay (MMHD) Firing Head Assembly Specifications

SAP No.	Maximum OD in. (cm)	Stinger Fishing Neck in. (cm)	Maximum Stroke Length in. (cm)	Maximum Metering Stroke* Length (Available for Delay) in. (cm)	Overall Length* (Extended) ft (m)	Maximum Operating Pressure (Differential) psi (bar)	Temp Rating °F (°C)	Tensile Strength lb (kg)	Total Volume (Silicon) gal (liter)	Assembly Weight lb (kg)
101201927	Dependent on centralizers	1.75 (4.45)	54.86 (139.34)	46.50 (118.11)	12.44 (3.79)	13,000 (896.6)	350 (176.67)	51,100 (23 100)	1/2 (1.89)	152 (68.95)

*Length from top sub to firing head body (does not include weight bars and/or skirt)

Delay time of 1 hour minimum is recommended for safe operation of system.

Delay time of 6 maximum hours is dependent on temperature, silicon fluid, and number of jets.

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

Slickline-Retrievable Mechanical Firing Head

The slickline-retrievable mechanical firing head (SLRMFH) is designed to give customers flexibility in completing a well. It can be run attached to the guns, separately from the guns, or using an auto-release firing mechanism. The firing head latches onto the guns and provides a positive indication that it is attached. The SLRMFH can be retrieved if the firing head needs to be replaced.

The system can be run with either a mechanically operated firing head or a pressure-operated firing head. It is designed so that 80% of the parts are used in all three applications allowing for more flexibility with less inventory.

Features

- Saves rig time—If for any reason the firing head needs replacement, the guns remain in the hole and the firing head can be retrieved
- Positive engagement—When the firing head is run separately, the operator can tell when the firing head is latched onto the guns
- Safety—Guns can be run separately from the firing head adding a safety feature for the guns at the surface
- Flexibility—Guns can be run separately or attached. Unlimited number of runs can be made to replace firing head if needed

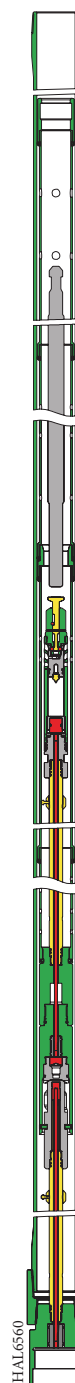
Operation

The SLRMFH was designed for 3 1/2- and 2 7/8-in. tubing strings. It can be run with either a mechanical drop firing head, or a pressure-operated firing head such as the 1 11/16 time-delay firer (TDF).

The top gun is assembled with the J-slot stinger. The guns are run into the well on tubing and then correlated on depth. The running tool is latched to the firing head at surface and run in on wireline/slickline.

As the firing head is lowered, it comes in contact with the J-slot stinger. The skirt on the firing head then automatically latches into position connecting the firing head with the J-slot stinger. An overpull is applied to give a positive latch indication. The running tool is released by jarring down and the slickline is pulled out of the well. The guns are fired by pressure or mechanical means.

The firing head can be retrieved by relatching to the firing head and jarring up. The jarring action shears the brass screws freeing the firing head from the J-slot stinger. If the firing head does not actuate, another firing head may be run as many times as required.



Slickline-Retrievable Mechanical Firing Head (SLRMFH)

Slickline-Retrievable Mechanical Firing Head (SLRMFH) Specifications

	SAP No.	Maximum OD in. (cm)	Minimum ID (No-Go) in. (cm)	Overall Length (Max) ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Minimum Operating Pressure Auto Release psi (bar)	Maximum Differential Pressure Auto Release psi (bar)	Tensile Strength of FH Body lb (kg)	Maximum Sustained Force Required to Shear Two Lugs lb (kg)	Weight lb (kg)
w/ Model III-D Mechanical FH	101226902	2.31 (5.87)	1.56 (3.96)	20.05 (6.11)	8,000 (550)	250 (17.2)	N/A	N/A	30,000 (13 600)	4,000 (1800)	120 (54.4)
w/ Pressure Actuated FH	101227170	2.31 (5.87)	1.56 (3.96)	20.05 (6.11)	17,000 (1170)	2,200 (150)	N/A	N/A	30,000 (13 600)	4,000 (1800)	100 (45.4)
w/ Model III-D Mechanical FH and Auto Release	101227212	2.31 (5.87)	1.56 (3.96)	20.05 (6.11)	8,000 (550)	250 (17.2)	1,500 (100)	10,000 (690)	30,000 (13 600)	4,000 (1800)	120 (54.4)

Burst and collapse pressures are determined by tubing.

Temperature rating is determined by explosives.

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

Slickline-Retrieveable Time-Delay Firer Firing Head

The slickline-retrieveable time-delay firer (TDF) firing head is a combination of two assemblies: the slickline-retrieveable 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.

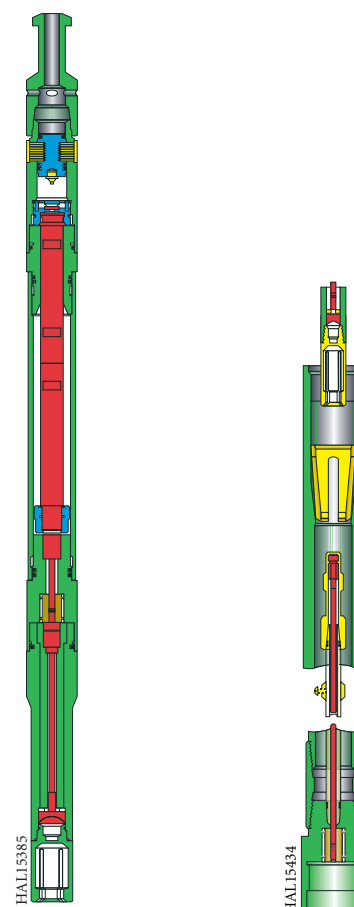
Features

- 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

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.



*Slickline Retrieveable Time-Delay Firer
(TDF) Firing Head*

Stinger Assembly

1 11/16-in. Slickline-Retrieveable Time-Delay Firer (TDF) Firing Head Specifications

SAP No.	Maximum OD in. (mm)	Overall Length (1 fuse) ft (m)	Additional Length per Fuse ft (m)	Temperature Rating °F (°C)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Collapse Pressure psi (bar)
100155739	1.688 (42.88)	3.83 (1.17)	0.87 (0.27)	425 for 200 hours (218 for 200 hours)	17,000 (1170)	2,200 (150)	23,000 (1590)

The assembly certification sheet which specifies the batch number and pin values is supplied with each assembly.

3 3/8-in. Vann™ Jet Stinger Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID (No-Go) in. (mm)	Makeup Length with 2-ft Sub ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength (FH Body) lb (kg)	Weight with 2-ft Sub lb (kg)
100155952	2 3/8 (60.33) EUE 8 Rd Box × 2 7/8 (73.03) 6P Acme Box	3.38 (85.85)	1.37 (34.80)	5.37 (1.64)	20,000 (1380)	None	238,000 (107 900)	73 (33)

Burst and collapse pressures are determined by handling sub.
Temperature rating is determined by explosives.

Extended Delay Fuses

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 six minutes at 70°F.

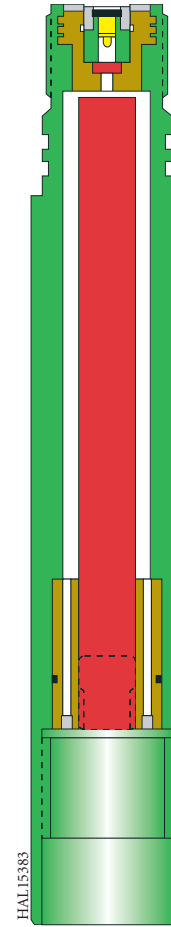
Features

- Increases 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
- Allows time for necessary actions to take place downhole such as increasing pressure to open a pressure-actuated vent assembly

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. time-delay firer (TDF) firing head, and the slickline-retrievable TDF firing head.



*Extended Delay Fuses
Assembly*

Extended Delay Fuses Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Temperature Rating Delay Fuse °F (°C)	Tensile Strength lb (kg)	Collapse Pressure psi (bar)
100005229	2 (50.8) 6P Acme Box × Pin	2.5 (62.5)	1.10 (0.34)	25,000 (1725)	425 (218) for 200 hours	197,000 (89 300)	30,000 (2070)
100009426	2 7/8 (73.03) 6P Acme Box × Pin	3.375 (85.73)	1.10 (0.34)	25,000 (1725)	425 (218) for 200 hours	270,000 (122 400)	30,000 (2070)

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

Modular Mechanical Firing Head

The modular mechanical firing head is designed to be a retrievable firing system utilizing a standard mechanical firing head with a specialized drop bar for detonation. This system will allow the operator the flexibility to run the gun assemblies independently of the firing system. Once the guns are in place, the firing head is set on the top module and released. The perforation assembly is detonated by use of a special fluted bar dropped from surface.

The most common application for this system is to be run with the modular guns in a monobore completion. Special consideration must be given to job set-up and execution to ensure that this tool functions properly.

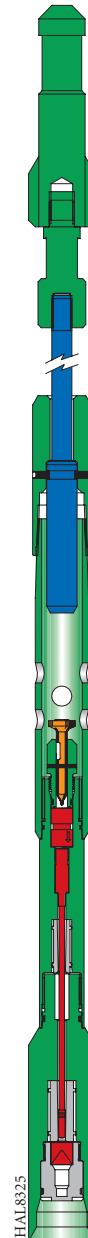
Features

- Safety—With the ability to run the firing head and the guns separately, this system helps to greatly reduce the chance of accidental or premature firing of the guns
- Retrievability—In the event of a mechanical malfunction, the firing head can be pulled, and another one run without interfering with the rest of the bottomhole assembly

Applications

The modular mechanical firing head is designed to be run on slickline and set on the top gun in a monobore completion by use of a JDC hydraulic running tool. The system is designed with the hammer held above the firing pin with brass shear screws. The two shear screws are rated at 875 lb each. The tool is actuated by dropping a specifically designed drop bar fitted for the proper casing. (Do not use a standard 1 1/4-in. drop bar.) The bar strikes the stinger with sufficient force to shear the brass screws and drive it into the firing pin.

The firing pin and hammer are pressure balanced; and therefore, are not limited to any specific depth and/or hydrostatic pressure beyond the tool specifications.



*Modular Mechanical
Firing Head*

Modular Mechanical Firing Head Specifications

SAP No.	Stinger Fishing Neck 2-in. Stinger in. (mm)	Stinger Fishing Neck 2 1/2-in. Stinger in. (mm)	Maximum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Overall Length* in. (mm)	Maximum Stroke Length in. (mm)	Shear Rating For Brass lb (kg)
120021629	1.38 (35.05)	1.75 (44.45)	13,000 (896.6)	59,000 (26 762)	72.30 (1836.42)	7.88 (200.15)	1,700 (771)

*Will vary with skirt

Maximum OD dependent on centralizers used.

Temperature rating is determined by explosives.

Weight dependent on centralizers and skirts.

Drop Bar Options

SAP No.	Casing and Tubing Size and Weight in./lb (cm/kg)	Casing ID in. (mm)	Total Bar OD in. (mm)
N/A	2 7/8 / 6.4 (7.30 / 2.9)	2.441 (62.0)	N/A
101227709	3 1/2 / 9.2 (8.89 / 4.17)	2.992 (76.0)	2.50 (63.5)
120125486	4 1/2 / 9.5-13.5 (11.43 / 4.3-6.12)	4.090 (103.9)	3.75 (95.3)
101227719	5 / 15-18 (12.7 / 6.80-8.16)	4.408 (111.9)	4.125 (104.8)
101227720	5 1/2 / 15.5-23 (13.97 / 7.03-10.43)	4.950 (125.7)	4.50 (114.3)

Skirt-Centralizer Selection Chart

SAP No.	Skirt OD in. (mm)	Centralizer OD in. (mm)
101207195	2 (50.8)	N/A
101201882	2.5 (63.5)	3.00 (76.2) 101207187
		3.50 (88.9) 101207198
		3.75 (95.3) 100014297
101228625	2 3/4 (69.9)	3.25 (82.6) 101213087
		3.50 (88.9) 100014299
101201884	3 1/8 (79.4)	3.875 (98.4) 101207193
101226987	3 3/8 (85.7)	3.75 (95.3) 100009581
		4.00 (10.16) 100156785
		4.40 (111.8) 100010177
101205671	4 5/8 (117.4)	5.61 (142.5) 100156224
		5.75 (146.1) 100156225

Side-Pocket Mandrel Firing Head

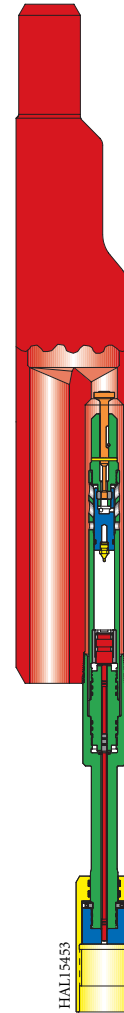
The side-pocket mandrel firing head (SPMFH) is designed for well conditions that preclude the use of a pressure-actuated firing head run with a Y-block. The side-pocket mandrel firing system is used on single-string, multizone completions and standard dual completions. A modified model III-D mechanical firing head is attached to the short string side of a side-pocket mandrel. The firing head is detonated with a kickover tool run on slickline.

Features

- Selectively fires multiple intervals
- Eliminates the need for nitrogen
- Allows maximum underbalance for low-pressure formations
- Offers economical value

Operation

The model III-D mechanical firing head is made up on the short string side of the side-pocket mandrel. When the perforating assembly is ready to be detonated, the operator runs a kickover tool down the long string on slickline. After the kickover tool is located in the side-pocket mandrel, the slickline operator jars down. The kickover tool hits the releasing pin on the model III-D. The firing piston is forced into the initiator by the hydrostatic pressure in the tubing string to detonate the VannGun® assembly.



Side-Pocket Mandrel Firing Head (SPMFH)

Side-Pocket Mandrel Firing Head (SPMFH) Specifications

SAP No.	Thread Size and Type (Long String Side) in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	Overall Length ft (m)
100155737 (Firing Head)	1.90 (48.26) EUE 10 Rd Pin × 2 3/8 (60.33) 6P Acme Box	2.75 (69.85)	N/A	2.36 (0.72)
221.00284 (7-in. Side-Pocket Mandrel)	2 3/8 (60.33) 4.7 lb OEEO-B Box × Box	5.54 (140.72)	1.926 (48.92)	5.79 (1.76)
221.00285 (9.625-in. Side-Pocket Mandrel)	2 3/8 (60.33) 4.7 lb OEEO-B Box × Box	6.62 (168.15)	1.926 (48.92)	5.79 (1.76)
101306060	3 1/2 CJ Hydril	8.00 (203.20)	N/A	N/A

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

Annulus Pressure Crossover Assembly

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.

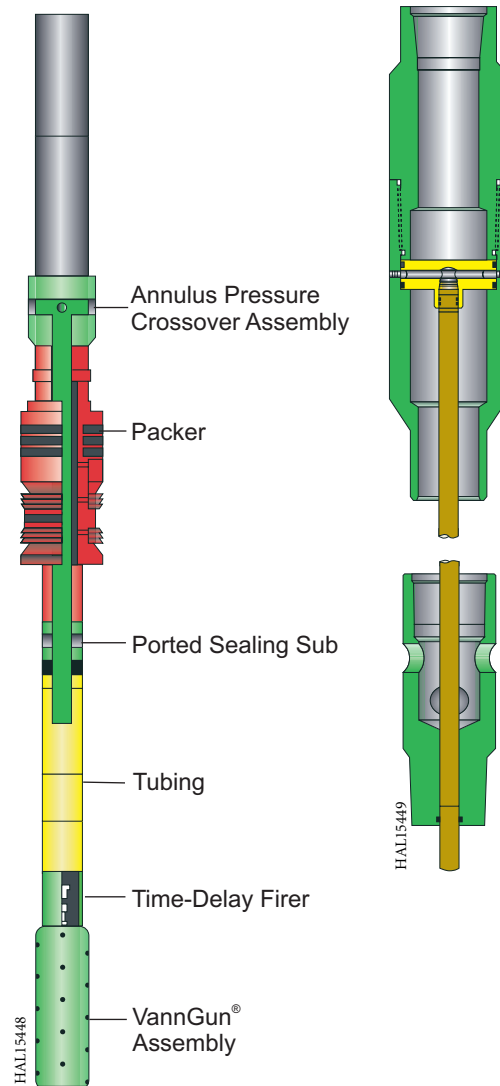
Features

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

Note: Not recommended for mud environment

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.



Annulus Pressure Crossover Assembly (APCA)

Annulus Pressure Crossover Assembly (APCA) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID	Flow Area in. ² (cm ²)	Minimum Makeup Length ft (m)	Overall Length ft (m)	Maximum Differential Pressure psi (bar)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
100014175	2 3/8 (60.33) EUE 8 Rd	3.56 (90.42)	Non-fullbore	2.25 (14.52)	9.15 (2.79)	12.35 (3.76)	10,000 (689)	104,000 (47 173)	11,200 (772)	11,700 (806)
100155786	2 7/8 (73.03) EUE 8 Rd	5.0 (127)	Non-fullbore	4.75 (30.65)	9.40 (2.87)	12.60 (3.84)	9,500 (655)	145,000 (65 770)	10,500 (723)	11,100 (765)
101241465	3 1/2 (88.9) API IF Tool Joint	5.015 (127.381)	Non-fullbore	4.75 (30.65)	9.40 (2.87)	12.60 (3.84)	10,500 (723)	145,000 (65 770)	13,210 (910)	22,500 (1551)

Maximum operating pressure is determined by tubulars.

Temperature rating is determined by explosives.

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

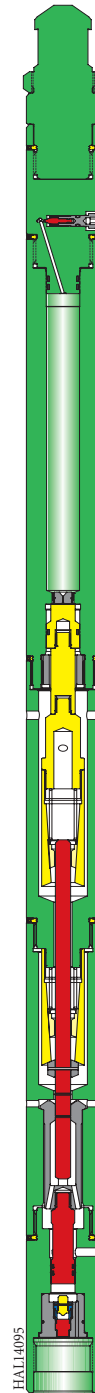
EZ Cycle™ Multi-Pressure Cycle Firing Head

The EZ Cycle™ firing head is a pressure-operated tool that can be cycled several times prior to firing the perforating guns. Several pressure operations can also be performed on the well including tubing testing, packer setting, and packer testing prior to firing the perforating guns. Even if pressure operations are higher than the operating pressure of the firing head, the EZ Cycle firing head should not fire until it has completed all of the preset cycles. The firing head is cycled by applying pressure at the tool to overcome a nitrogen-charged chamber which operates the cycling piston back and forth until the entire release rod has been pulled from the piston collet.

Each EZ Cycle firing head assembly includes a nitrogen chamber, cycling grapple piston, and firing piston with firing pin initiator assembly.

Features

- Ideal for completions and drillstem testing
- Time-delay elements can be used as needed for delay time
- Can be used in underbalanced or overbalanced perforating jobs
- It is a surface-safe firing head because it requires pressure to energize the firing piston
- Operates at low pressure
- Can be deployed connected to the gun assembly or run separate on slickline or coiled tubing
- Allows the retrieval and reinstallation of a malfunctioning firing head without pulling the guns
- Can be used when equipment or well conditions will not permit the use of high pressures



EZ Cycle™ Firing Head Assembly

Operating the EZ Cycle™ Firing Head

The tool is run in hole with a pre-charged nitrogen chamber, which is set according to the maximum bottomhole pressure. After positioning gun on depth and all operations prior to firing guns have been completed, the firing head is cycled to detonate the perforating guns. Pressure applied at the tool will move the cycle piston and traveling grapple up 0.375 in. pulling the release rod up 0.375 in. Releasing the applied pressure will allow the nitrogen charge to move the cycle

piston and traveling grapple down engaging another 0.375 in. of the release rod. These steps are continued until the release rod is completely retrieved from the firing piston collet. At this point, the bottomhole pressure will drive the firing piston into the firing pin detonating the initiator and the guns.

3.00 in. Multi-Pressure Cycle Firing Head Assembly Specifications

Upper Connection (External Fishneck) in. (cm)	Lower Thread Size and Type in. (cm)	Makeup Length in. (cm)	Maximum OD in. (cm)	Minimum ID in. (cm)	Temperature Rating °F (°C)	Operating Pressure Range psi (bar)		Tensile Rating* lb (kg)	Burst Pressure* psi (bar)	Collapse Rating* psi (bar)
2.313 (5.875)	2 3/8 (6.0325) 6P Acme Box	77.32 (196.393)	3.00 (7.62)	N/A	400 (204.4)	Low Pressure Assembly	High Pressure Assembly	100,000 (18 143)	40,000 (1379)	40,000 (1379)
						1,000-5,000 (68.95-344.74)	5,000-20,000 (344.74-1378.95)			

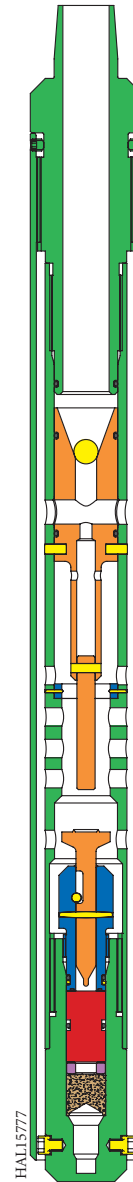
*Call your local Halliburton representative if conditions exceed this value.

Pump-Through Firing Head

The 1 11/16-in. pump-through firing head is designed to be run on coiled tubing and is used for breaking the ceramic flapper valve disk on a one-trip coiled tubing operation. The firing head originates from proven technology in the 1 11/16-in. pressure actuated pressure firing head. The components were hardened to withstand pumping erosion, and an outer tube is incorporated to allow fluid circulation to the bottom of the tool. A miniature shaped charge is set in the bottom of the firing head to shoot into the ceramic disk. The assembly is actuated by dropping a ball through the coiled tubing, which seats in the assembly to allow a pressure differential to actuate the firing head and shape charge.

Application

The pump-through firing head can be used to circulate debris off of a barrier, such as a ceramic disk, and then shoot into the barrier to break it up. This function is primarily developed toward circulating sand and other debris off of a ceramic disk in a production well, and then shooting into the disk to allow access below.



*Firing Head Assembly
1 11/16-in. Pump Through*

Pump-Through Firing Head Specifications

Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID* in. (mm)	Maximum Operating Pressure psi (bar)	Flow Area (before firing) in. ² (mm ²)	Temperature Rating	Axial Load Rating lb (kg)	Collapse Pressure psi (bar)	Overall Length in. (mm)	Mass lb (kg)	Maximum Flow Rate bbl/min (m ³ /min)
1.315 (33.40) NU-10RD Pin	2.3 (58.42)	0.44 (11.18)	3,000 (207) ± 10% at 70°F	0.15 (96.77)	As per explosives	54,400 (24 700)	23,200 (1600)	22.69 (576.32)	16.9 (7.68)	2.5 (0.397)

*Through ball seat
Minimum Operating Pressure is not applicable.
Burst Pressure is not applicable.

Ancillary Equipment

Fill Disk Assembly

The fill disk 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 (BIT) in wells with reasonably clean fluids. The glass disk prevents debris from settling on the firing head. Pressure is equalized across the glass disk.

The FDA is run between the firing head and packer. The recommended minimum distance from the FDA to the firing head is 30 ft (9.14 m).

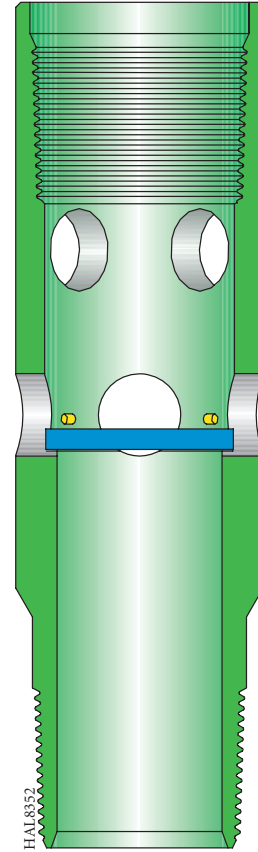
Features

- Allows debris to be circulated off the glass disk through the flow ports above the glass disk
- 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 disk installed in the ID across the lower set of ports. The disk is not sealed, so pressure can equalize across the glass. Any debris falling out of the tubing or fluid above the glass should land on the glass disk. This debris can be circulated off the disk, 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 disk, it should fall 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 Disk Assembly
(FDA)

Fill Disk Assembly (FDA) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	Flow Area in. ² (cm ²)	Number of Ports	Tensile Strength lb (kg)	Makeup Length ft (m)
100005295	2 3/8 (60.33) EUE 8 Rd Box × Pin	3.01 (76.45)	1.98 (50.29)	6.28 (40.54)	8	120,000 (54 431)	0.76 (0.23)
100005297	2 7/8 (73.03) EUE 8 Rd Box × Pin	3.51 (89.15)	2.44 (61.98)	7.88 (50.8)	8	150,000 (68 039)	0.71 (0.22)
100005299	3 1/2 (88.90) EUE 8 Rd Box × Pin	4.20 (106.68)	3.0 (76.20)	14.13 (91.20)	8	200,000 (90 718)	0.69 (0.21)

Balanced Isolation Tool

The balanced isolation tool (BIT) assembly is used where either packer selection or well conditions preclude the use of a venting device. The BIT assembly replaces the fill disk assembly and is used in place of a perforated sub. The BIT helps prevent contamination of the fluid below it from the fluid above it. Debris or solids in the fluid above should not pass through the glass disk that is in the floating piston. The glass disk helps prevent debris from setting on the firing head. Pressure is balanced across the glass barrier through equalizing ports in the piston.

The BIT assembly is run between the firing head and packer. The recommended minimum distance from the BIT to the firing head is 30 ft (9.14 m).

Features

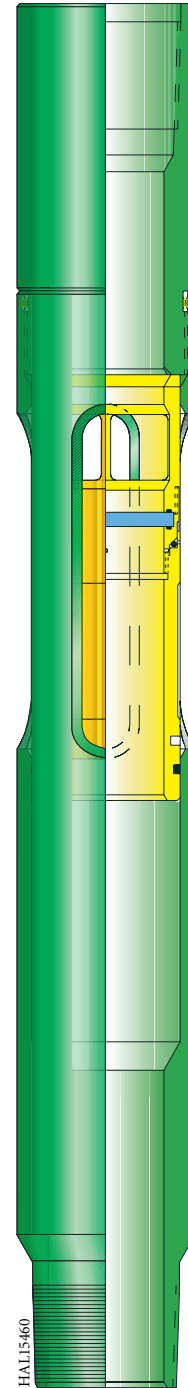
- Allows mud and debris to be circulated off the glass barrier through the flow ports above the glass barrier
- Allows displacement of the tubing with a lighter fluid or nitrogen before firing the guns
- Allows swabbing of the tubing to achieve differential pressure
- Allows stopping and circulating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

Operation

The basic components of the BIT are a floating piston with a glass disk, a ported lower housing, and a top housing. The 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 help 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.



Balanced Isolation Tool
(BIT)

Balanced Isolation Tool (BIT) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	No. of Ports	Total Flow Area in. ² (cm ²)	Overall Length ft (m)	Tensile Strength lb (kg)
120022203	1.90 (48.26) EUE 10 Rd Box × Pin	2.50 (63.50)	1.61 (40.89)	4	2.03 (13.10)	2.09 (0.64)	110,000 (49 800)
101318220	2 3/8 (60.33) EUE 8 Rd Box × Pin	2.895 (73.4)	1.99 (50.54)	4	3.09 (19.96)	2.02 (0.62)	100,000 (45 300)
100014322	2 3/8 (60.33) EUE 8 Rd Box × Pin	3.10 (78.74)	1.99 (50.54)	4	3.14 (20.27)	2.15 (0.65)	155,000 (70 200)
100014323	2 7/8 (73.03) EUE 8 Rd Box × Pin	3.75 (95.25)	2.44 (61.98)	4	4.68 (30.19)	2.41 (0.73)	200,000 (90 700)
100156936	3 1/2 (88.90) EUE 8 Rd Box × Pin	4.25 (107.95)	3.0 (76.20)	4	7.07 (45.60)	2.41 (0.73)	280,000 (126 000)

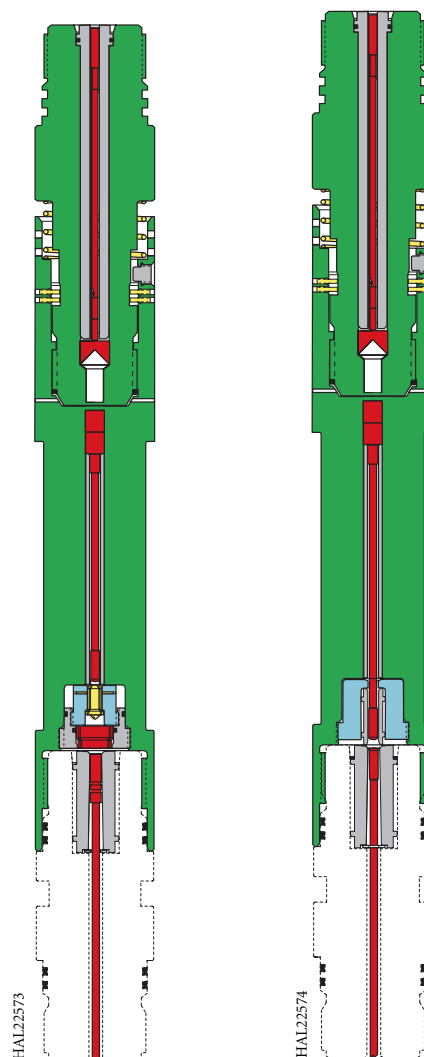
These ratings are guidelines only. For more information, consult your local Halliburton representative.

Ratchet Gun Connector

In addition to perforating new wells, Halliburton's ratchet gun connector system is ideal for reperforating producing wells since the well does not have to be killed and can be left on production. It also allows perforating with all production equipment in place. Connections are made inside the lubricator using a left-hand quick connect locking mechanism.

Features

- Can be snubbed into and retrieved from a live well
- Utilizes standard blowout preventers
- Can perforate long and multiple intervals in a single trip
- Does not have to kill producing zone to run or retrieve guns
- Perforates new wells
- Reperforates producing wells with all production equipment in place
- Perforates underbalanced or overbalanced assemblies
- VannGun® sections are quickly connected together
- Can be used with hydraulic workover (HWO)



*Ratchet Gun Connector
Assembly Using Sealed
Imitation Assembly*

*Ratchet Gun Connector
Assembly Using Non-
Sealed Insert Assembly*

Ratchet Gun Connector Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Tensile Strength lb (kg)
101000794	2 3/8 (60.33) 6P Acme Box x Pin	2.35 (59.69)	2.11 (0.64)	13,000 (896)	100,000 (45 360)
101000793	2 7/8 (73.03) 6P Acme Box x Pin	3.375 (85.73)	2.11 (0.64)	13,000 (896)	220,000 (100 000)

Temperature rating is determined by explosive.

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

AutoLatch™ Release Gun Connector

The AutoLatch™ release gun connector is designed to join VannGun® assemblies and enables VannGun sections to be run in and out of new or producing wells.

Using the AutoLatch system, VannGun assemblies are connected without rotation and can be operated with standard blowout preventer (BOP) rams, making this connector ideal for snubbing guns into and out of the wellbore with coiled tubing or a hydraulic workover (HWO) unit.

The AutoLatch connector can also be used to run VannGun assemblies on wireline when the length of the perforating assembly is limited by the lubricator length. The VannGun assemblies can be run in sections (limited by the weight rating of the wireline) and then, retrieved in sections. This system reduces the number of wireline runs to perforate longer intervals.

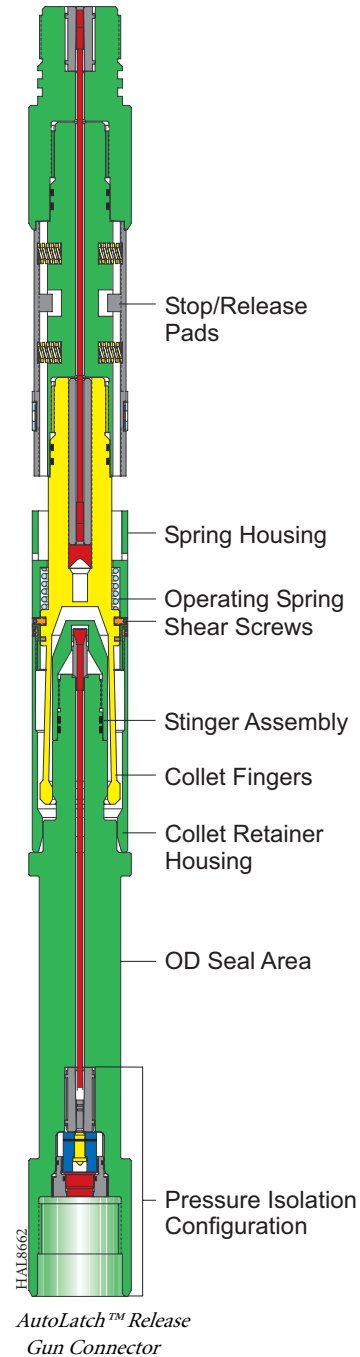
Features

- Can be used to perforate new or existing wells
- Can snub VannGun assemblies into and out of the well
- Utilizes standard BOPs
- Can be used with coiled tubing, HWO, or wireline
- Can retrieve VannGun assemblies without killing a producing zone
- Can perforate in underbalanced or overbalanced conditions
- May be used for monobore completions
- Can be used when oriented perforations are required
- Sections are quickly connected for time savings
- Can be designed to accommodate different BOP configuration

AutoLatch™ Release Gun Connector Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Tensile Strength lb (kg)
Upper Assembly: 101205866	2 3/8 (60.33) 6P Acme Box x Pin	2.88 (73.15)	4.46 (1.36)	20,000 (1380)	80,000 (35 000)
Lower Assembly: 101205878					
Upper Assembly: 100155775	2 7/8 (73.03) 6P Acme Box x Pin	3.625 (92.00)	3.47 (1.06)	20,000 (1380)	125,000 (56 800)
Lower Assembly: 101207115					

Temperature rating is determined by explosives. These ratings are guidelines only. For more information, consult your local Halliburton representative.



Isolation Sub-Assembly

The isolation sub-assembly (ISA) is live well intervention technology designed to provide extreme flexibility in well completions. The ISA allows completion or recompletion of the well without killing it. The well can be producing before, during, and after the guns are deployed in or out of the well.

The ISA is a lower cost alternative to other live well intervention assemblies. The ISA incorporates a threaded connection that is manually connected and disconnected.

Features

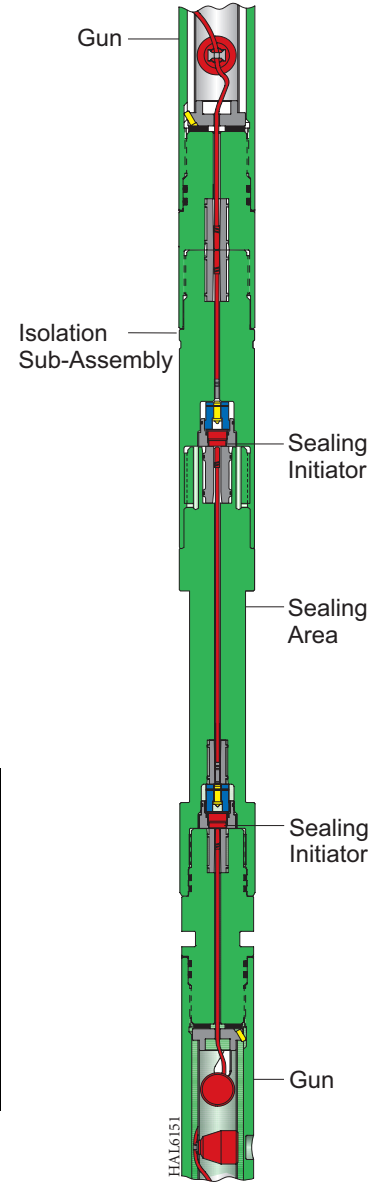
- Can run VannGun® assemblies on hydraulic workovers, coiled tubing, or wireline
- Can run VannGun sections to perforate a new well or add perforations to existing zones
- Can run or retrieve guns without killing the well
- Can perforate underbalanced or overbalanced
- Low cost
- Provides extreme flexibility in well completions

Isolation Sub-Assembly Specifications

SAP No.	Thread Size and Type in. (mm)	OD Isolation Sub-Assembly with OD Ram Lock in. (mm)	Maximum OD in. (mm)	Overall Length ft (m)	Maximum Operating Pressure psi (bar)	Tensile Strength lb (kg)
101228396	1 11/16-in. (42.86) 8P Stub Acme 2G	2 with 1 1/2 (50.8 with 38.1)	2.015 (51.18)	2.42 (0.74)	10,000 (689)	64,500 (29 250)
101222274	2 3/8 (60.33) 6P Acme 2G	2 3/4 with 2 (69.85 with 50.8)	2.765 (70.23)	2.28 (0.69)	10,000 (689)	108,000 (49 000)
101226330	2 7/8 (73.03) 6P Acme 2G	3 3/8 with 2 (85.73 with 50.8)	3.395 (86.23)	2.22 (0.68)	10,000 (689)	191,400 (86 800)

Temperature rating is determined by explosive.

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



Isolation Sub-Assembly

Quick Torque™ Connector

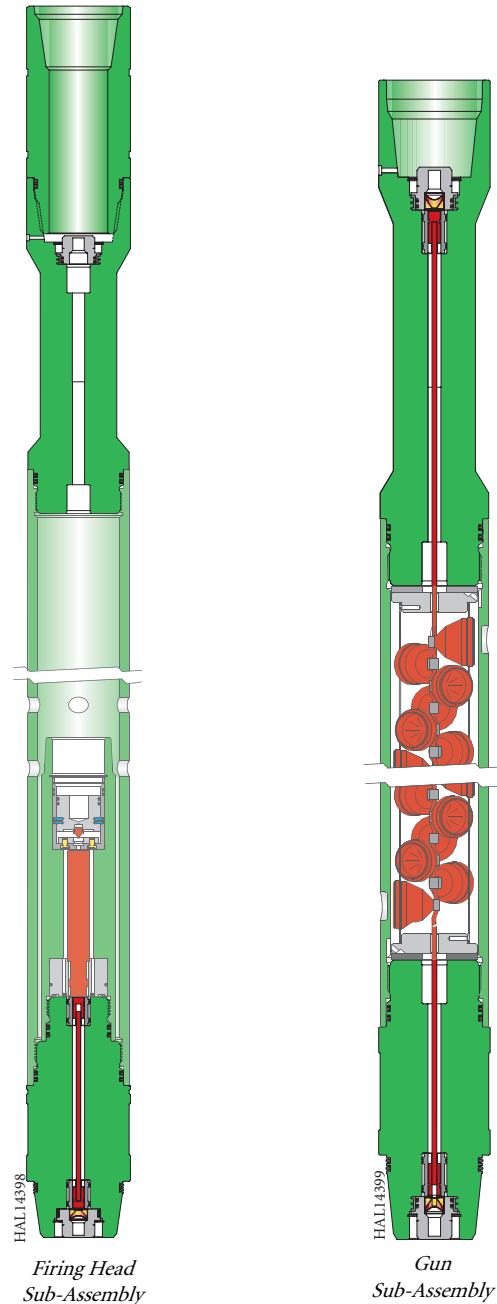
The Quick Torque™ connector consists of connectors that cover both ends of each gun section to enclose the assembly. The connectors have a common, self-aligning drillpipe thread that allows automatic or manual makeup. Explosive transfer occurs through a web, making the system self-contained for added safety. With these connectors, TCP gun assemblies can now be picked up by the rig equipment and properly made up using iron roughneck equipment without the need for human intervention. It simplifies the process and saves time by eliminating assembly of the components on the rig.

Features

- Standard NC38 thread makeup procedure
- Redressable
- Self-contained system increases personnel safety on the rig floor—no human intervention is needed
- Once the thread protectors are removed, all subsequent steps can be automated
- Efficient, automated system saves rig time
- Allows venting of any built-up pressure during shipping
- No exposed explosives
- Q125 material, sour service > 175° F

Operation

This system can be used on any rig with automatic or manual pipe handling equipment. It can be used with 4 5/8-in. standard or 4 5/8-in. self-orienting TCP gun systems, and a 3 3/8-in.-OD or smaller firing head.



Quick Torque™ Connector - 2 7/8-in. Guns

SAP No.	Thread Connection	Tool Maximum OD in. (mm)	Maximum Operating Pressure* psi (bar)	Temperature Rating* °F (°C)	Makeup Length in. (mm)	End Connections	Tensile Rating lb (kg)
101635158	Box Modified API-NC26	3.14 (79.95)	22,000 (1516)	Determined by explosives and elastomers	12.5 (317)	2 7/8-in. Gun Pin	280,500 (127 232)
101634159	Pin Modified API-NC26	3.14 (79.95)	22,000 (1516)	Determined by explosives and elastomers	9.3 (236)	2 7/8-in. Gun Pin	247,000 (112 354)

*Maximum Operating Pressure and Temperature Rating based on the elastomers.

Quick Torque™ Connector - 4 5/8-in. Guns

SAP No.	Thread Connection	Tool Max. OD in. (mm)	Maximum Operating Pressure* psi (bar)	Temperature Rating* °F (°C)	Makeup Length in. (mm)	End Connections	Tensile Rating lb (kg)
101351984	Pin Connector Assy, NC38 Pin x Acme Pin	4.75 (120.65)	20,000 (1379)	Determined by explosives and elastomers	6.75 (171)	4-6 Acme Pin x Modified NC38 Pin	493,500 (223,848) Limited by 4-6 Acme Pin Thd
101352042	Firing Head Connector Assy, NC38 Pin x Double Acme Pin	4.75 (120.65)	20,000 (1379)	Determined by explosives and elastomers	7.61 (193)	2 7/8-6 Acme and Pin x 4-6 Acme Pin x Modified NC38 Pin	493,500 (223,848) Limited by 4-6 Acme Pin Thd
101351885	Box Connector Assy, NC38 Box x Acme Pin	4.75 (120.65)	20,000 (1379)	Determined by explosives and elastomers	23.08 (586)	Modified NC38 Box x 4-6 Acme Pin	493,500 (223,848) Limited by 4-6 Acme Pin Thd
101354907	Crossover, Standard NC38 Box x Modified NC38 Pin	4.75 (120.65)	20,000 (1379)	Determined by explosives and elastomers	13.56 (344)	NC38 Box x Modified NC38 Pin	398,000 (180,530) Limited by NC38 Box
101381170	Firing Head Connector Assy, Firing Head on Bottom, NC38 Box x Double Acme Pin	4.75 (120.65)	20,000 (1379)	Determined by explosives and elastomers	23.08 (586)	Modified NC38 Box x 4-6 Acme Pin x 2 7/8-6 Acme Pin	493,500 (223,848) Limited by 4-6 Acme Pin Thd

*Maximum Operating Pressure and Temperature Rating based on the elastomers.

Quick Torque™ Connector - 5-in. Guns

SAP No.	Thread Connection	Tool Maximum OD in. (mm)	Maximum Operating Pressure* psi (bar)	Temperature Rating* °F (°C)	Makeup Length in. (mm)	End Connections	Tensile Rating lb (kg)
101514211	Box Modified API-NC38	5.0 (127)	20,000 (1379)	Determined by explosives and elastomers	22.8 (579)	5-in. Gun Pin	540,600 (245 212)
101535542	Box for Centralizer Modified API-NC38	5.0 (127)	20,000 (1379)	Determined by explosives and elastomers	25.2 (640)	5-in. Gun Pin	540,600 (245 212)
101514214	Pin Modified API-NC38	5.0 (127)	20,000 (1379)	Determined by explosives and elastomers	14.4 (365)	5-in. Gun Pin	540,600 (245 212)

*Maximum Operating Pressure and Temperature Rating based on the elastomers.

Detach™ Separating Gun Connector

The Detach™ separating gun connector allows operators to deploy long gun sections into the well. The guns are deployed downhole in a single trip and placed across the perforating zone supported by a gun hanger or plug. The guns are fired when desired and then, will automatically separate, which allows them to be retrieved in manageable sections or left in the hole. The Detach separating gun connector is ideal for use in monobore wells with rathole length restrictions and in rigless completions.

Rathole Length Restriction

In this application, insufficient rathole length causes the uppermost gun modules to remain adjacent to the perforated interval after they are fired where they may interfere with production from the well. With the Detach separating gun connector, gun sections can be removed from the perforated interval without having to kill the well.

Rigless Completion

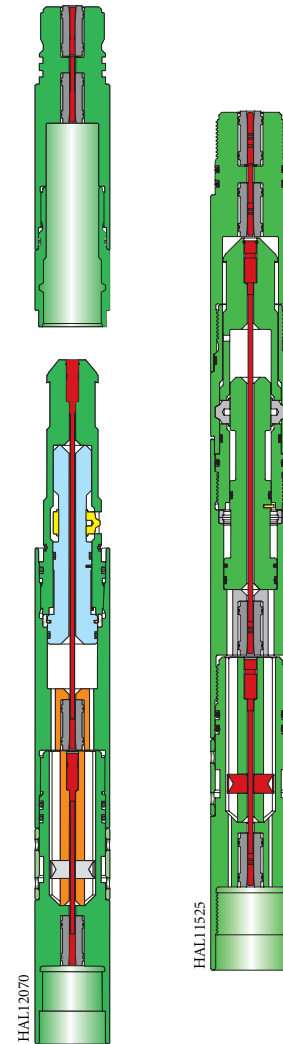
On wells where the completions are installed with wireline or coiled tubing, the Detach separating gun connector or modular gun system is the preferred method for perforating. No rig is required—saving both time and money.

Operation

When the firing head detonates the detonating cord initiator, the explosives train continues through the tool and detonates two shaped charges that punch holes in the vent sub. At this point, wellbore pressure is allowed to enter the assembly and move the mandrel lock piston upward, allowing the retaining dogs to move inward, releasing the stinger, and allowing the gun sections to separate.

Advantages

- Can deploy entire gun assembly to cover the zone of interest in a single trip and retrieve in manageable gun sections without killing the well
- Guns can be retrieved or left at bottom of the hole
- Allows perforating in either underbalanced or overbalanced conditions over the entire interval



Detach™ Separating Gun Connector

Detach™ Separating Gun Connector Specifications

SAP No.	Upper Thread Size and Type in. (mm)	Lower Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID	Makeup Length ft (m)	Minimum Operating Pressure psi (bar)	Tensile Rating lb (kg)	Burst Pressure	Collapse Pressure psi (bar)
101363724	2 3/8 (60.450) 6P Acme Pin	2 3/8 (60.450) 6P Acme Box	2.75 (69.850)	N/A	2.86 (0.87)	1,000 (69)	80,000 (36 300)*	N/A	20,000 (1379)
101286871	2 7/8 (73.03) 6P Acme Box x Pin	2 7/8 (73.03) 6P Acme Box	3.38 (85.85)	N/A	2.74 (0.83)	1,000 (69)	110,000 (49 800)	N/A	20,000 (1379)

Temperature rating is determined by explosive.

*Verification testing

EZ Pass™ Gun Hanger

The EZ Pass™ gun hanger is designed to be run in conjunction with Halliburton's Modular Gun System. This advanced design includes slips that stay retracted within the slip housing until the tool is set. After the perforating event, the slips will return to the running position and the tool auto releases.

If desired, the hanger can be fished with a standard pulling tool and retrieved from the well.

Features

- Running and setting procedures are similar to common bridge plugs and sump packers—uses standard setting equipment
- Can be set in larger ID after running through restrictions
- Retrievable and redressable
- May be configured to auto-release or stay set after gun detonation
- Can be deployed on wireline, tubing, or coiled tubing
- One size sets in multiple casing ranges

Operation

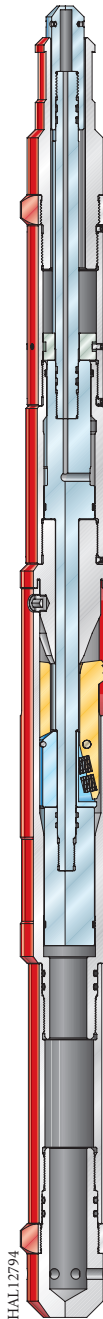
The EZ Pass gun hanger can be run independently or attached to the gun system.

If the gun hanger is run attached to the perforating assembly, it must be actuated using pressure. The assembly would be run in, positioned, and then pressure would be applied to the wellbore to set the tool. No explosive components would be necessary for this operation.

If the gun hanger is deployed and positioned similar to a wireline-set permanent or sump packer, the same power charge-type setting tools are used to set the hanger. After the setting tool is removed from the wellbore, the guns may be deployed as individual modules or as a complete assembly and are stacked on top of the hanger.

A releasing tool is needed to release the hanger and may be run on the bottom of the perforating assembly. When activated, the releasing tool fires a shaped charge and breaches the top of the hanger. This process allows the gun weight to be transferred to the inner mandrel, placing the hanger in the releasing position and forcing the slips away from the casing.

The EZ Pass gun hanger is designed with a 2.75 fishing neck and can be fished with a standard pulling tool. The slips will retract into the ID of the tool and helps allow it to be retrieved through a wellbore restriction.



EZ Pass™ Gun Hanger

EZ Pass™ Gun Hanger Specifications

Casing Size and SAP No.	Casing Weights* lb	Range of Casing IDs* in. (cm)	Tool Maximum OD (With Slips Retracted) in. (cm)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Temperature Rating °F (°C)	Tensile Rating lb (kg)	Collapse Pressure psi (bar)	Overall Length (Maximum) ft (mm)	Maximum Gun Weight lb (kg)	Weight lb (kg)
4 1/2 101320360	9.5 - 15.1	4.09 - 3.826 (10.4 - 9.72)	3.50 (8.89)	18,000** (1241)	500 (34.5)	400 (204.4)	74,000 (33 600)	18,000 (1241)	5.1 (1.55)	30,000 (13 600)	116 (52.6)
5 1/2 101315538	20 / 23 / 26	4.778 - 4.548 (12.14 - 11.55)	4.125 (10.5)	20,000** (1450)	500 (34.5)	400 (204.4)	74,000 (33 600)	20,000 (1450)	5.1 (1.55)	30,000 (13 600)	165 (74.8)
7 101321131	29 / 32 / 35	6.184 - 6.004 (15.70 - 15.25)	5.375 (13.65)	20,000** (1450)	500 (34.5)	400 (204.4)	74,000 (33 600)	20,000 (1450)	5.1 (1.55)	30,000 (13 600)	180 (81.7)

*Recommended

**Maximum Operating Pressure based on hydrostatic pressure and applied gun weight.

The EZ Pass™ hanger does not have minimum ID or Burst Pressure requirements.

NOTE: The EZ Pass gun hanger is designed with specific features to enhance its retrievability; however, due to the uncertainty of the wellbore conditions created by the perforating event, the retrieval of this tool cannot be assured.

Automatic-Release Gun Hanger—Rotational Set

For high volume testing and production, the automatic-release gun hanger (ARGH) allows perforating and testing of a zone without imposing downhole restrictions. The perforating assembly can be positioned and retained adjacent to the desired interval. The drillpipe or tubing is then removed. After all surface equipment is installed, the guns are detonated and then released automatically into the bottom of the well.

Features

With the ARGH:

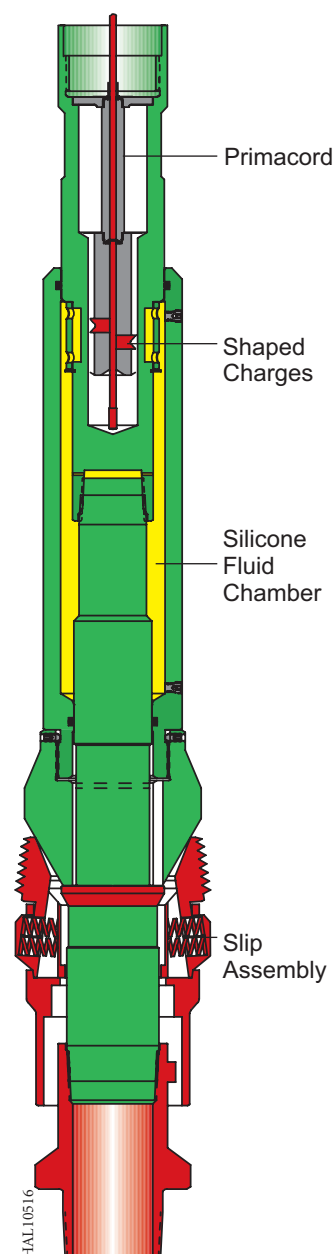
- No tubing is required between the guns and packer
- No wireline work is required to drop the assembly
- No restrictions are left in the casing below the packer
- The maximum desired underbalanced pressure can be used
- Production tubing can be run and tested independently from other tools
- The ARGH and guns are run on the workstring
- The risk of presetting the packer is reduced
- In BigBore™ monobore completions, the production tubing and permanent packer are installed before running the ARGH perforating assembly
- Remedial work can be performed without pulling production equipment (such as setting bridge plugs, adding perforations, running coiled tubing, etc.)
- Lower gun-firing pressures can be used since all production equipment is pressure-tested before the guns are installed in the well (no need to exceed previous test pressures)

Operation

The ARGH is made up on the bottom of the perforating assembly. A right-hand release on/off tool is made up on the top of the bottomhole assembly (BHA). After the BHA is correlated on depth, the operator picks up the string, turns it to the right, and slacks off weight on the ARGH. The ARGH should be set at this point.

With weight still on the BHA, the operator continues to turn the workstring to the right to release the on/off tool.

As the guns are detonated, the explosive train is continued to the ARGH. Two shaped charges are detonated into a sealed fluid chamber. This action eliminates the support to the slip assembly. The ARGH and perforating assembly are then released automatically and fall to the bottom.



Auto-Release Gun Hanger
Rotational Set

Automatic-Release Gun Hanger—Rotational Set Specifications

Casing OD in. (mm)	Casing Range lb/ft (kg/m)	Maximum OD in. (mm)	Length ft (m)	Minimum Tensile Rating lb (kg)	Minimum BHA Weight lb (kg)	Maximum Gun Weight lb (kg)
3 1/2 (88.9)	5.7-10.2 (8.48-15.18)	2.75 (69.85)	3.33 (1.02)	25,000 (11 300)	150 (68)	12,300 (5580)
4 1/2 (114.3)	9.5-13.5 (14.14-20.09)	3.75 (95.25)	4.88 (1.49)	85,000 (38 500)	300 (136)	40,000 (18 140)
5 (127)	11.5-18 (17.11-26.78)	3.75 (95.25)	4.88 (1.49)	85,000 (38 500)	300 (136)	40,000 (18 140)
5 1/2 (139.7)	13-26 (19.34-38.69)	4.5 (114.3)	5.92 (1.80)	120,000 (54 400)	500 (227)	40,000 (18 140)
7 (177.8)	17-38 (25.3-56.54)	5.5 (123.2)	6.04 (1.84)	120,000 (54 400)	600 (272)	40,000 (18 140)
7 5/8 (193.7)	20-39 (29.76-58.03)	5.5 (123.2)	6.04 (1.84)	120,000 (54 400)	600 (272)	40,000 (18 140)
9 5/8 (244.5)	29.3-53.5 (43.6-79.61)	8.0 (203.2)	7.08 (2.16)	120,000 (54 400)	600 (272)	40,000 (18 140)

Automatic-Release Gun Hanger—Automatic-J Mandrel

For high volume testing and production, the automatic-release gun hanger (ARGH) allows perforating and testing of a zone without imposing downhole restrictions. The perforating assembly can be positioned and retained adjacent to the desired interval. The drillpipe or tubing is then removed. After all surface equipment is installed, the guns are detonated and then released automatically into the bottom of the well.

Features

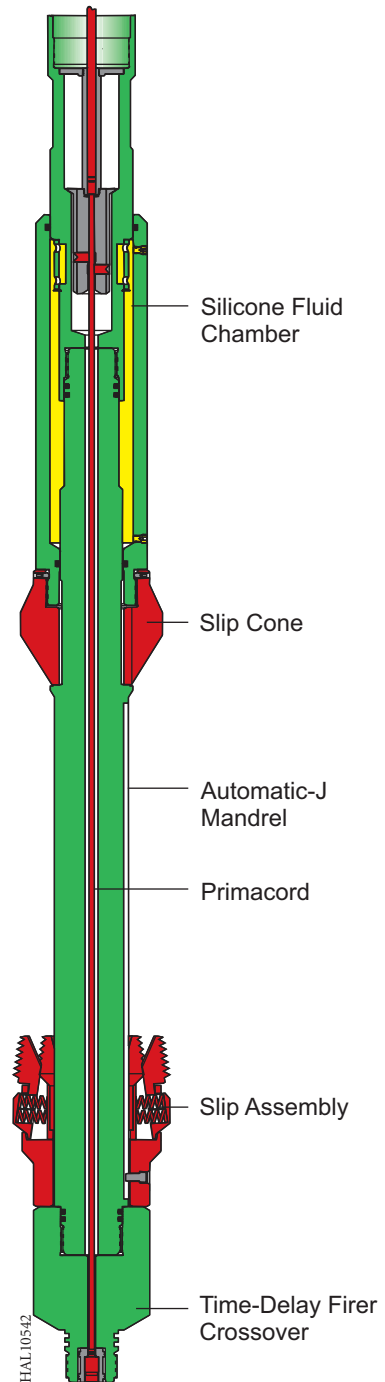
With the ARGH:

- No tubing is required between the guns and packer
- No wireline work is required to drop the assembly
- No restrictions are left in the casing below the packer
- The maximum desired underbalanced pressure can be used
- Production tubing can be run and tested independently from other tools

- The automatic-J ARGH and guns are run on wireline, slickline, coiled tubing, or the workstring
- In BigBore™ monobore completions, the production tubing and permanent packer are installed before running the ARGH perforating assembly
- Remedial work can be performed without pulling production equipment (such as setting bridge plugs, adding perforations, running coiled tubing, etc.)
- Lower gun-firing pressures can be used since all production equipment is pressure-tested before the guns are installed in the well (no need to exceed previous test pressures)

Operation

The automatic-J mandrel can be run on wireline, slickline, coiled tubing, or the workstring. Rotation is not required to set the automatic-J gun hanger. Upward and downward manipulation either sets or un-sets the hanger. As the guns are detonated, the explosive train is continued to the ARGH. Two shaped charges are detonated into a sealed fluid chamber. This action eliminates the support to the slip assembly. The ARGH and perforating assembly are then released automatically and fall to the bottom.



Automatic-Release
Gun Hanger (ARGH)
Automatic-J Mandrel

Automatic-J Mandrel Specifications

Casing OD in. (mm)	Casing Range lb/ft (kg/m)	Maximum OD in. (mm)	Length ft (m)	Maximum Operating Pressure* psi (bar)	Tensile Rating lb (kg)	Minimum BHA Weight lb (kg)	Maximum Gun Weight lb (kg)
2 7/8 (73.1)	2 7/8 6.4-6.50 (9.52-9.67)	2.25 (57.2)	4.49-4.87 (1.349-1.47)	20,000 (1379)	25,000 (11 300)	150 (68)	9,000 (4050)
3 1/2 (88.9)	3 1/2 5.75-10.2 (8.56-15.18)	2.75 (73.0)	4.87-5.28 (1.47-1.59)	N/A	25,000 (11 300)	150 (68)	12,300 (5580)
4 (101.6)	4 14.40 (21.43)	2.75 (73.0)	4.87-5.28 (1.47-1.59)	N/A	25,000 (11 300)	150 (68)	12,300 (5580)
3 1/2 (88.9) Slimhole	3 1/2 9.2-12.95 (13.69-19.27)	2.50 (63.5)	53.79-58.47 (16.40-17.82)	20,000 (1379)	25,000 (11 340)	150 (68)	20,000 (9072)
4 1/2 (114.3)	4 1/2 9.5-13.5 (14.14-20.09)	3.75 (95.25)	7.95-9.28 (2.40-2.80)	20,000 (1379)	85,000 (38 500)	300 (136)	40,000 (18 140)
5 (127)	5 15.0-18.0 (22.32-26.78)	3.75 (95.25)	7.95-9.28 (2.40-2.80)	20,000 (1379)	85,000 (38 500)	300 (136)	40,000 (18 140)
4 1/2 (114.3) Slimhole	4 1/2 15.1-16.9 (22.46-25.15)	3.50 (88.9)	58.34-67.29 (17.78-20.51)	N/A	25,000 (11 340)	200 (91)	20,000 (9072)
5 1/2 (139.7)	5 1/2 15.50-23 (23.06-34.22)	4.50 (114.3)	9.31-10.29 (2.80-3.10)	N/A	120,000 (54 400)	500 (227)	40,000 (18 140)
7 (177.8)	7 20-38 (29.76-56.54)	5.5 (123.2)	9.26-10.44 (2.79-3.14)	N/A	120,000 (54 400)	600 (272)	40,000 (18 140)
7 5/8 (193.7)	7 5/8 24-39 (35.71-58.03)	5.5 (123.2)	9.26-10.44 (2.79-3.14)	N/A	120,000 (54 400)	600 (272)	40,000 (18 140)
9 5/8 (244.5)	9 5/8 29.3-53.5 (43.6-79.61)	8.0 (203.2)	7.08 (2.16)	N/A	120,000 (54 400)	600 (272)	40,000 (18 140)
10 3/4 (273.05)	10 3/4 60.7 - 71.10 (90.31 - 105.78)	9.17 (233)	9.8 (299)	N/A	160,300 (72 700)	600 (272)	250,000 (113 400)

*As total gun weight increases, the maximum operating pressure decreases.

Temperature rating is determined by explosives.

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

Explosive Transfer Swivel Sub

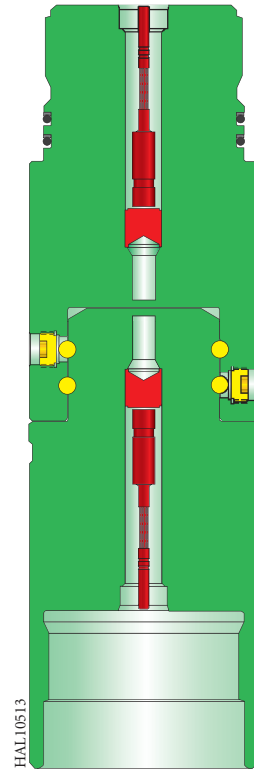
The explosive transfer swivel sub allows two sections of guns to rotate independently of one another. This independent rotation is important on long strings of guns in horizontal wells when they must be oriented in a specific direction. It is easier to orient several short sections of guns, rather than one long section.

Features

- Useful in horizontal wells when shots need to be oriented in a specific direction to the wellbore
- Bi-directional, allowing firing from either direction

Operation

This swivel sub can be run as a connector between two guns to allow them to rotate independently without breaking the explosive train. In other words, this sub passes on the explosive transfer to the next gun.



*Explosive Transfer
Swivel Sub Assembly*

Explosive Transfer Swivel Sub Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Maximum Operating Tensile Load* lb (kg)
101271529	2 3/8 (60.33) 6P Acme Box x Pin	2.75 (69.85)	1.13 (0.344)	20,000 (1379)	108,000 (48 988)	32,000 (14 515)
101271553	2 7/8 (73.03) 6P Acme Box x Pin	3.375 (85.73)	1.13 (0.344)	20,000 (1379)	190,000 (86 183)	40,000 (18 144)
101271546	4.00 (101.60) 6P Acme Box x Pin	4.625 (117.47)	1.16 (0.353)	20,000 (1379)	332,000 (150 593)	60,000 (27 216)
101284187	4.420 (112.27) 6P Acme Box x Pin	5.125 (130.18)	1.13 (0.344)	20,000 (1379)	416,000 (188 694)	60,000 (27 216)
101278821	5 1/8 (130.18) 6P Acme Box x Pin	5.750 (146.05)	1.16 (0.353)	20,000 (1379)	410,000 (185 973)	60,000 (27 216)

*Maximum operating tensile load is the point at which the ball bearing race will start to deform, and the tool will not function as designed. Temperature rating is determined by explosive.

Shearable Safety Sub

The shearable safety sub is designed to provide a gap in the explosive train, which could be severed at surface with the shear rams. The most common application is in the use of live well intervention.

The shearable safety sub provides two levels of defense against wellbore pressures. First, it provides a sub with a smooth profile that is utilized by closing the sealing rams to control pressure when the gun connection is made up or broken out. Secondly, if the well conditions become dangerous and the shear rams need to be activated, it provides an area in the gun assembly that does not contain explosives and can be safely severed by the shear rams.

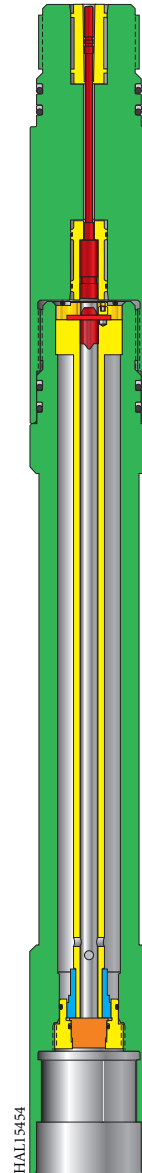
Features

- Continues the explosive train without use of continuous explosives
- Isolates pressure from below
- Allows a smooth sealing area for the pipe rams to seal against

- Uses standard explosives
- Contains standard 3 3/8-in. gun connections above and below
- Can be run with tubing, coiled tubing, wireline, and modular applications
- Can be sheared independently of the guns firing
- Can be redressed at minimal cost

This tool has been successfully sheared during testing using the following:

- Shaffer shear 7 1/16-in. 10k safety head
- Piston diameter of 14 in. (153 in.²)
- Sheared at 2,000 psi
- Force required to shear tool = (153 in.²) (2,000 psi) = 306,000 lb



Shearable Safety Sub

Shearable Safety Sub Specifications

SAP No.	Thread Size and Type	Maximum OD in. (mm)	Minimum ID	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Weight lb (kg)
101245799	2 7/8-in. Acme Box x Pin	3.375 (85.73)	N/A	2.50 (0.76)	20,000 (1380)	N/A	200,000 (90 700)	54.4 (24.6)

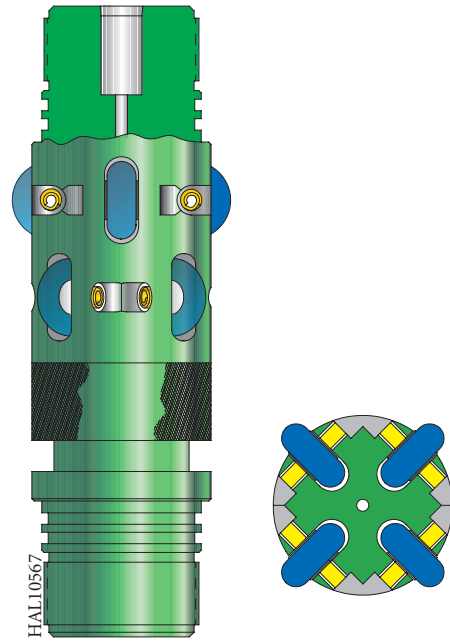
Temperature rating is determined by explosive.

Roller Tandem Assembly

Roller tandem assemblies are used to reduce the friction between the perforating guns and the casing. In some cases, the frictional drag can be reduced by as much as 90%.

Applications

- Running guns on coiled tubing in horizontal and highly deviated wells
- Dropping the guns into the rathole in highly deviated wells
- Can be deployed in conjunction with the modular gun system



Roller Tandem Assembly

Roller Tandem Assembly Specifications

SAP No.	Size in. (mm)	Effective OD in. (mm)	No. of Rollers	Roller Phasing	Tensile Strength lb (kg)	Makeup Length in. (mm)
120021632	2 3/4 (69.85)	3.06 (77.72)	6 (2 rows of 3)	60°	140,000 (63 503)	6.97 (177.04)
100155770	3 3/8 (85.72)	3.76 (95.50)	8 (2 rows of 4)	45°	246,000 (111 584)	7.70 (195.58)
100155771	4 5/8 (117.47)	5.63 (143.00)	8 (2 rows of 4)	45°	414,000 (187 787)	9.25 (234.95)
101313551	7 (177.80)	8.20 (208.28)	8 (2 rows of 4)	45°	444,000 (201 395)	15.52 (394.21)

Centralizer Tandem

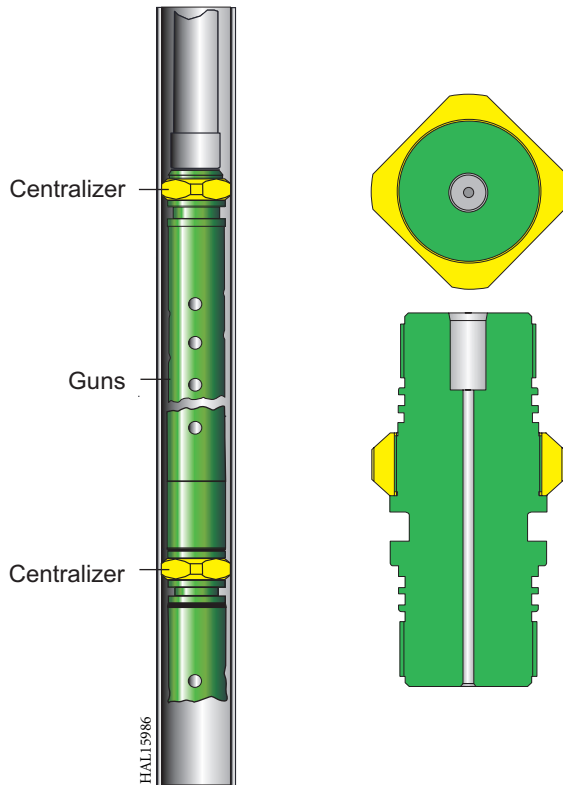
In certain types of TCP operations, it is desirable to centralize the guns and other tools in the casing. Halliburton has designed a full range of centralizers to meet this requirement for all gun sizes. The centralizers are designed to minimize the possibility of “hanging up” while running or pulling the guns and to maximize the flow area around the centralizers.

Application

Two of the primary applications for the centralizers are:

1. When perforating with big hole charges, it is recommended to centralize the guns to ensure that the exit holes in the casing will all be of a consistent size. If the guns are not centralized, the size of the exit holes will vary according to the clearance from the gun to the casing. This can cause problems with sand control operations.
2. In modular gun completions, it is necessary to centralize the gun modules to obtain a reliable explosive transfer between modules.

Contact your Halliburton representative for a list of available centralizers.

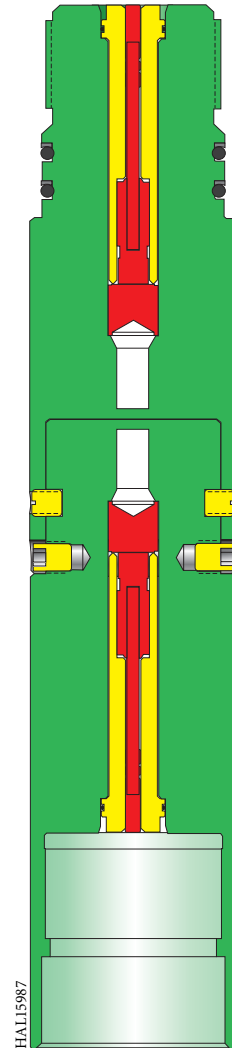


Centralizer Tandem

Emergency Release Assembly

The emergency release assembly was designed to run in conjunction with the automatic-release gun hanger assembly. When deploying the gun hanger on tubing or drill pipe, the emergency release is run between the gun hanger and guns to serve as a weak point in case the hanger gets stuck while running in the hole. Pulling or jarring on the pipe will cause the emergency release assembly to shear, allowing the retrieval of the guns and tubing from the well.

When deploying the gun hanger on wireline, the rope socket typically acts as the weak point.



Emergency Release Assembly

Emergency Release Assembly Specifications

SAP No.	OD Size in. (mm)	No. Shear Screws	Temperature Rating	Pressure Rating psi (bar)
101201127	3 3/8 (85.73)	8 steel shear screws rated at 5,600 lb per screw	Determined by explosives	25,000 (1724)

Annular Pressure-Control Line Vent

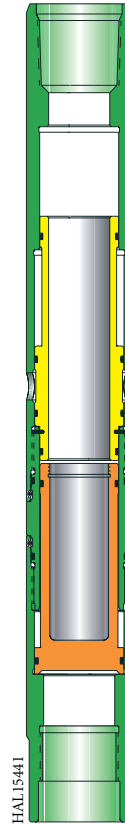
The annular pressure-control line (APF-C) vent is a device that isolates the tubing from annulus fluid or pressure. The vent is actuated by rathole pressure after the perforating assembly has been detonated. It then provides a flowpath for the formation fluid into the tubing string.

Features

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

Operation

The APF-C vent is run directly on top of the APF-C firing head. When the perforating assembly is detonated, gun pressure shifts an actuating piston into a power piston. This shift opens the flow ports to the tubing.



Annular Pressure-Control Line
(APF-C) Vent

Annular Pressure-Control Line (APF-C) Vent Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	No. and ID of Ports in. (mm)	Flow Area in. ² (cm ²)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
120038049	2 3/8 (60.33) EUE 8 Rd Box × 2 7/8 (73.03) 6P Acme Box	3.38 (85.85)	Non- full-bore	4@1.0 (25.4)	2.63 (16.97)	2.37 (0.72)	20,000 (1380)	150,000 (68 000)	22,000 (1515)	22,000 (1515)
101016565	2 7/8 (73.03) EUE 8 Rd Box × 2 7/8 (73.03) 6P Acme Box	3.88 (98.55)	Non- full-bore	5@1.0 (25.4)	3.93 (25.34)	2.43 (0.74)	20,000 (1380)	170,000 (77 000)	15,000 (1035)	15,000 (1035)

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

Annular Pressure-Control Line Swivel Sub

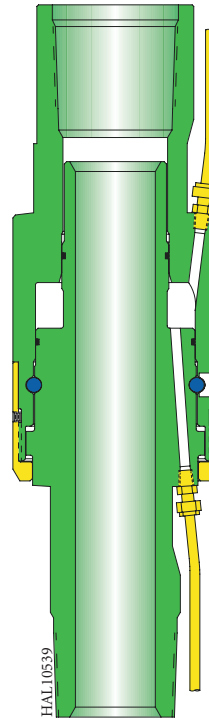
When run in conjunction with the annular pressure-control line (APF-C) firing head, the APF-C swivel sub provides a swivel point between the guns and packer when it is desired to have the guns rotate freely as when orienting shots in a deviated well.

Features

- Compatible with APF-C firing head and control line
- Can be run anywhere between the packer and the firing head
- Transmits pressure through the control line while rotating

Operation

The APF-C swivel is made up in the string between the packer and the firing head. A section of control line is made up from the packer to the top of the swivel. A second section of control line is made up from the bottom of the swivel to the APF-C firing head. Annulus pressure is transmitted from the packer, through the swivel to the firing head.



APF-C Swivel Sub

Annular Pressure-Control Line (APF-C) Swivel Sub Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	Tensile Strength lb (kg)	Operating Load Limit Rating lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)	Makeup Length ft (m)
101230619	2 7/8 EU 8rd Box x Pin	5.13 (130.30)	2.0 (50.8)	200,000 (90 718)	36,000 (16 329)	NA*	NA*	1.3 (0.39)

*The APF-C swivel sub is not designed to operate with differential pressure.

Annular Pressure-Control Line Tubing Release

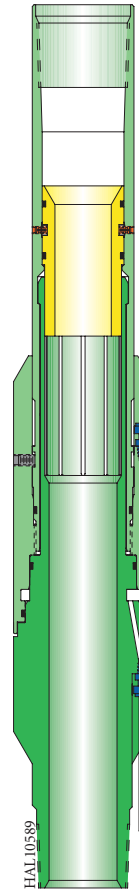
The 2 7/8-in. annular pressure-control line tubing release assembly (APF-C TR) provides a mechanical method of releasing the APF-C firing head and VannGun® assembly from the tubing string.

Features

- Releasing the gun assembly opens the tubing for other tools such as production logging, testing, and treating
- Low cost method to release gun assembly
- Utilizes off-the-shelf shifting tools
- No time limit on dropping the gun assembly
- Leaves perforations uncovered and helps eliminate flow restriction

Operation

The APF-C TR is run between the APF-C firing head and the 7- or 9 5/8-in. annulus pressure transfer reservoir (APTR). The control line for the APF-C is attached to the control line housing, which transfers the pressure through the APF-C TR and out the finger sub to a second control line. The second control line transfers the pressure down to the APF-C firing head. Releasing can be accomplished by the use of a standard Halliburton or Garret shifting tool.



APF-C Tubing Release (APF-C TR)

Annular Pressure Control Line Tubing Release (APF-C TR) Specifications

SAP No.	Upper Thread Size and Type	Lower Thread Size and Type	Makeup Length ft (m)	Maximum OD in. (mm)	Minimum ID in. (mm)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
87921	2 7/8 (73.03) EUE 8 Rd Box	2 7/8 (73.03) EUE 8 Rd Pin	2.24 (0.68)	4.62 (117.35)	Latch Sizes – 1.88 (47.75), 2.125 (53.98), or 2.25 (57.15)	120,000 (54 431)	12,000 (827)	11,000 (758)

Bar Pressure Vent

The bar pressure vent (BPV) is designed to achieve a differential pressure between the formation and tubing string. This tool helps to safely allow 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.

Features

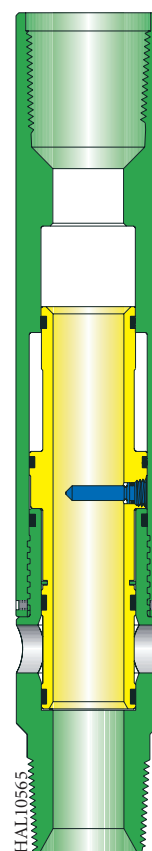
- Offers an inexpensive way to create the necessary underbalance
- Allows the hole to be totally contained at the wellhead before the surge
- Allows the sleeve to lock in place once the port is opened
- Can be run with any packer
- Does not rely on tubing manipulation (Hydrostatic pressure in the tubing is the only force required)

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 vent must be opened before dropping the detonating bar, dropping a special tube will open the vent and not fire the guns. When the bar is dropped, it will pass through the tube and fire the guns.



Bar Pressure Vent (BPV)

Bar Pressure Vent (BPV) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	No. and ID of Ports in. (mm)	Flow Area in. ² (cm ²)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Maximum Differential Pressure psi (bar)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
101201951	2 3/8 (60.33) EUE 8 Rd Box x Pin	3.06 (77.72)	1.50 (38.10)	4 @ 1.0 (25.40)	1.77 (11.40)	1.30 (0.40)	20,000 (1380)	1,000 (69)	8,000 (550)	140,000 (63 400)	24,000 (1655)	20,000 (1380)
100155788	2 3/8 (60.33) EUE 8 Rd Box x Pin	3.63 (92.20)	1.90 (48.26)	4 @ 1.0 (25.40)	3.14 (20.27)	1.30 (0.40)	15,000 (1035)	1,000 (69)	8,000 (550)	146,000 (66 200)	18,000 (1240)	22,000 (1515)
100010328	2 7/8 (73.03) EUE 8 Rd Box x Pin	3.88 (98.55)	2.25 (57.15)	4 @ 1.13 (28.70)	3.98 (25.65)	1.40 (0.43)	15,000 (1035)	1,000 (69)	8,000 (550)	160,000 (72 500)	19,000 (1310)	17,000 (1170)
100155789	3 1/2 (88.90) EUE 8 Rd Box x Pin	5.0 (127.0)	2.75 (69.85)	4 @ 1.75 (44.45)	5.94 (38.32)	1.57 (0.48)	15,000 (1035)	1,000 (69)	8,000 (550)	400,000 (181 400)	22,000 (1515)	18,000 (1240)

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

Below-Packer Vent Device

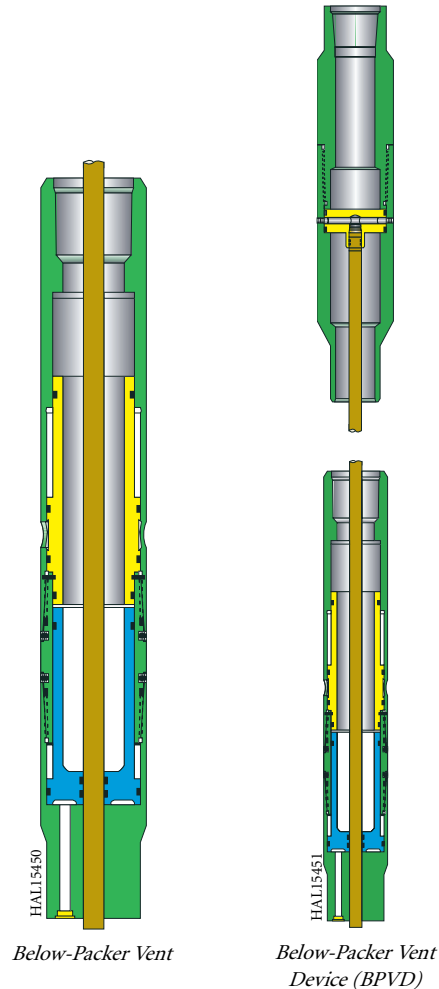
The below-packer vent device (BPVD) was developed for use with the annulus-pressure crossover assembly (APCA). Surface pressure applied to the annulus is transmitted through the APCA to a closed chamber below the BPVD and above a pressure-responsive firing head. The BPVD can be set to work before or after the perforating assembly is detonated.

Features

- 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
- Helps allow maximum underbalance
- Is compatible with several types of firing heads
- Can provide reliable and accurate pressure response

Operation

To open the BPVD, a predetermined annulus pressure is transmitted through the APCA to below the BPVD. This pressure then ruptures a disk 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.



Below-Packer Vent Device (BPVD) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	Makeup Length ft (m)	No. and ID of Ports in. (mm)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
100155787	2 3/8 (60.33) EUE 8 Rd Box x Pin	3.38 (85.85)	Non-full-bore	2.32 (0.71)	4 @ 1.0 (25.4)	15,000 (1035)	1,000 (69)	150,000 (68 000)	25,000 (1725)	22,000 (1515)
100014176	2 7/8 (73.03) EUE 8 Rd Box x Pin	3.88 (98.55)	Non-full-bore	2.26 (0.69)	5 @ 1.0 (25.4)	15,000 (1035)	1,000 (69)	170,000 (77 000)	25,000 (1725)	25,000 (1725)

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

Maximum Differential Bar Vent

The maximum differential bar vent (MDBV) assembly is run between the perforating guns and the packer. After the packer is set, the opening of the vent creates communication between the tubing and the 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.

Features

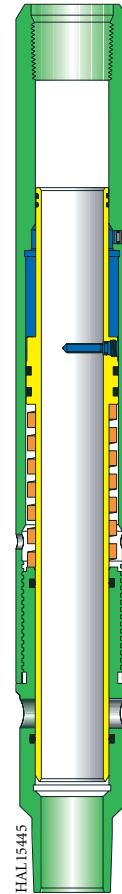
- Operates with a minimum amount of fluid in the tubing
- Helps allow maximum differential pressure when perforating in low-pressure formations
- Does not depend on tubing hydrostatic pressure to operate
- Assisted mechanically by an operating spring to help ensure full and complete opening
- Can be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

Operation

The maximum differential bar vent 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 will open with up to 1,000 psi (68.95 bar) in the tubing regardless of rathole pressure. If there is more than 1,000 psi (68.95 bar) in the tubing, and there is uncertainty about the rathole pressure, consider the bar pressure vent instead of the MDBV.

If the vent must be opened before dropping the detonating bar, dropping a special tube will open the vent and not fire the guns. When the bar is dropped, it will pass through the tube and fire the guns.



Maximum Differential Bar Vent

Maximum Differential Bar Vent (MDBV) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	No. and ID of Ports in. (mm)	Flow Area of Ports in. ² (cm ²)	Makeup Length ft (m)	Temperature Rating (Limited by Silicone Fluid) °F (°C)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
100005291	2 3/8 (60.33) EUE 8 Rd Box x Pin	3.36 (92.20)	2.0 (50.80)	5 @ 1.0 (25.40)	3.92 (25.29)	2.29 (0.70)	350 (176)	221,000 (100 200)	19,500 (1345)	16,500 (1135)
100005294	2 7/8 (73.03) EUE 8 Rd Box x Pin	3.88 (98.55)	2.2 (57.15)	4 @ 1.13 (28.70)	4.01 (27.87)	2.39 (0.73)	350 (176)	231,000 (104 700)	19,000 (1310)	13,000 (895)
100156853	3 1/2 (88.9) EUE 8 Rd Box x Pin	4.50 (114.30)	2.7 (69.85)	4 @ 1.75 (44.45)	9.58 (61.81)	2.75 (0.84)	350 (176)	245,000 (111 000)	14,000 (965)	14,000 (965)

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

Pressure-Operated Vent

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.

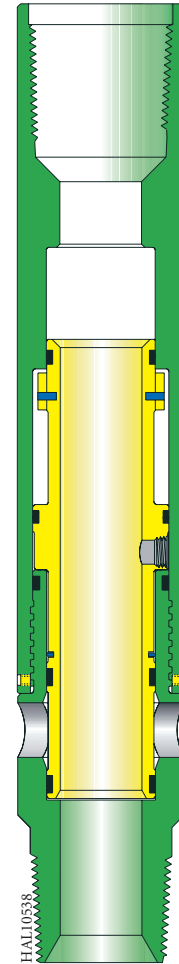
Features

- 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 Vann™ circulating valve

- Can be run with mechanical or pressure-actuated firing heads
- Useful in highly deviated wells
- Compatible with other packers

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.



Pressure-Operated Vent (POV)

Pressure-Operated Vent (POV) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	No. and ID of Ports in. (mm)	Total Flow Area in. ² (cm ²)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Maximum Differential Pressure psi (bar)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
101297298	2 3/8 (60.33) EUE 8 Rd Box × Pin	3.06 (77.72)	1.50 (38.10)	4 @ 1.0 (25.40)	1.77 (11.40)	1.30 (0.40)	20,000 (1380)	1,000 (69)	8,000 (550)	140,000 (63 400)	24,000 (1655)	20,000 (1380)
100014177	2 3/8 (60.33) EUE 8 Rd Box × Pin	3.63 (92.20)	1.90 (48.26)	4 @ 1.0 (25.40)	3.14 (20.27)	1.30 (0.40)	15,000 (1035)	1,000 (69)	8,000 (550)	146,000 (66 200)	18,000 (1240)	22,000 (1515)
100014178	2 7/8 (73.03) EUE 8 Rd Box × Pin	3.88 (98.55)	2.25 (57.15)	4 @ 1.13 (28.70)	3.98 (25.65)	1.40 (0.43)	15,000 (1035)	1,000 (69)	8,000 (550)	160,000 (72 500)	19,000 (1310)	17,000 (1170)
100014179	3 1/2 (88.90) EUE 8 Rd Box × Pin	5.0 (127.0)	2.75 (69.85)	4 @ 1.75 (44.45)	5.94 (38.32)	1.57 (0.48)	15,000 (1035)	1,000 (69)	8,000 (550)	400,000 (181 400)	22,000 (1515)	18,000 (1240)

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

Vann™ Circulating Valve

The Vann™ circulating valve (VCV) is designed to be used as a fill-up 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 disk and close the VCV.

Features

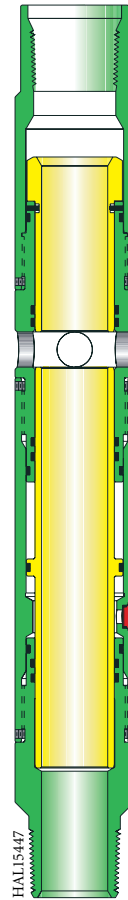
- Can be used as a circulating and shutoff valve
- Often run with other venting or production devices
- Economical and reusable

Operation

The VCV consists of a ported housing, a sliding sleeve, and a rupture disk, 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 disk 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 disk.

Once the disk ruptures, the hydrostatic pressure enters the lower air chamber through the ruptured disk, 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.



Vann™ Circulating Valve (VCV)

Vann™ Circulating Valve (VCV) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID in. (mm)	No. and ID of Ports in. (mm)	Flow Area of Ports in. ² (cm ²)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
101015372	2 3/8 (60.33) EUE 8 Rd Box x Pin	3.38 (85.85)	1.875 (47.62)	4 @ 1.0 (25.4)	3.14 (20.26)	1.96 (0.60)	15,000 (1035)	1,000 (69)	225,000 (102 000)	22,000 (1515)	18,000 (1250)
120038456	2 7/8 (73.03) EUE 8 Rd Box x Pin*	4.65 (188.11)	2.12 (53.85)	6 @ 1.0 (25.4)	4.71 (30.39)	3.25 (0.99)	15,000 (1035)	1,000 (69)	392,000 (177 700)	20,000 (1380)	18,000 (1250)

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

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

Automatic Release

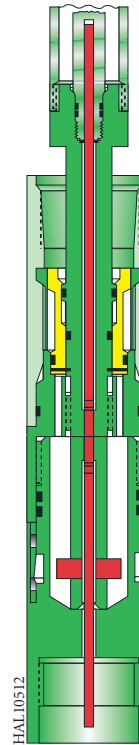
The automatic release (AR) allows the perforating guns to drop immediately after firing.

Features

- 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 gun's sticking because of debris

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.



Automatic Release (AR)

Automatic Release (AR) Assemblies List

SAP No.	Description
100005225	2 3/4-in. Auto Release with Mechanical Firing Head
100005226	2 3/4-in. Auto Release with Mechanical Firing Head Model II-D
100005233	3 3/8-in. Auto Release with Mechanical Firing Head
100005234	3 3/8-in. Auto Release with Mechanical Firing Head Model II-D
100155754	3 3/8-in. Auto Release with Mechanical Firing Head Model III-D
100005235	3 3/8 in. Auto Release with 2 1/2-in. TDF
100014158	3 3/8-in. Auto Release-High Pressure with 2 1/2-in. TDF
100010045	3 3/8-in. Auto Release-High Pressure with Mechanical Firing Head
101313281	3 3/8-in. Auto Release Firer with 2 1/2 in. TDF (3 1/2 NK3SB)
100005236	3 1/2-in. Auto Release with Mechanical Firing Head
100156106	3 1/2-in. Auto Release with Mechanical Firing Head Model II-D
101205564	3 1/2-in. Auto Release Firer, Low Pressure with Model II-D
101294470	3 1/2-in. Auto Release Firer with 2 1/2 in. TDF
101313282	3 1/2-in. Auto Release Firer with Model II-D
100155752	4 1/2-in. Auto Release with Mechanical Firing Head Model II-D
101294471	4 1/2-in. Auto Release Firer with 2 1/2 in. TDF
101213155	4 1/2-in. Auto Release Firer Low Pressure with Model II-D
101357916	4 1/2-in. Auto Release Firer with 2 1/2 in. TDF

Automatic Release (AR) Assemblies List

SAP No.	Description
101313025	5 1/2-in. Auto Release Firer with Model II-D
101310170	5 1/2-in. Auto Release Firer with Model II-D or III-D
101313059	5 1/2-in. Auto Release Firer with 3 3/8 in. TDF
101357918	5 1/2-in. Auto Release Firer with 2 1/2 in. TDF

Automatic Release (AR) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	ID After Release in. (mm)	Makeup Length ft (m)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Maximum Differential Pressure psi (bar)	Tensile Strength lb (kg)
100005225	2 3/8 (60.33) EUE 8 Rd	2.88 (73.15)	2.125 (53.98)	2.06 (0.63)	20,000 (1380)	1,500 (103)	15,000 (1035)	49,500 (22 400)
100005226	2 3/8 (60.33) EUE 8 Rd	2.88 (73.15)	2.125 (53.98)	2.06 (0.63)	20,000 (1380)	1,500 (103)	15,000 (1035)	49,500 (22 400)
100005233	2 7/8 (73.03) EUE 8 Rd	3.38 (85.85)	2.72 (69.09)	2.23 (0.68)	20,000 (1380)	1,500 (103)	10,000 (690)	68,000 (30 800)
100005234	2 7/8 (73.03) EUE 8 Rd	3.38 (85.85)	2.72 (69.09)	2.23 (0.68)	20,000 (1380)	1,500 (103)	10,000 (690)	68,000 (30 800)
100005235	2 7/8 (73.03) EUE 8 Rd	3.38 (85.85)	2.72 (69.09)	2.23 (0.68)	20,000 (1380)	1,500 (103)	10,000 (690)	68,000 (30 800)
100155754	2 7/8 (73.03) EUE 8 Rd	3.38 (85.85)	2.72 (69.09)	2.23 (0.68)	20,000 (1380)	1,500 (103)	10,000 (690)	68,000 (30 800)
100014158	2 7/8 (73.03) EUE 8 Rd	3.38 (85.85)	2.52 (64.186)	2.23 (0.68)	20,000 (1380)	500 (34)	17,000 (1170)	68,000 (30 800)
100010045	2 7/8 (73.03) EUE 8 Rd	3.38 (85.85)	2.52 (64.186)	2.23 (0.68)	20,000 (1380)	500 (34)	17,000 (1170)	68,000 (30 800)
100005236	3 1/2 (88.90) EUE 8 Rd	3.78 (96.01)	2.99 (75.95)	2.23 (0.68)	20,000 (1380)	1,500 (103)	10,000 (690)	68,000 (30 800)
100156106	3 1/2 (88.90) EUE 8 Rd	3.78 (96.01)	2.99 (75.95)	2.23 (0.68)	20,000 (1380)	1,500 (103)	10,000 (690)	68,000 (30 800)
100155752	4 1/2 (114.30) OD Box	4.5 (114.30)	3.67 (93.22)	2.23 (0.68)	20,000 (1380)	1,500 (103)	9,500 (655)	115,000 (52 100)
101357916	4 1/2 (114.30) OD Box	4.92 (126)	3.76 (96)	2.39 (.728)	13,000 (896)	7000 (483)	6000 (414)	87,200 (39 553)
101294470	3 1/2 (88.90) EUE 8 Rd	3.78 (96.01)	3.00 (76.2)	1.74 (0.53)	20,000 (1380)	7000 (483)	7500 (517)	53,300 (24 100)
101313059	5 1/2 (139.7) TS-3SB Pin	5.81 (148)	4.703 (119)	1.83 (0.56)	17,800 (1227)	4000 (276)	4700 (324)	106,100 (48 100)
101357918	5 1/2 (139.7) VAM Box	5.957 (151)	4.70 (119)	2.39 (0.73)	13,000 (896)	7000 (483)	4000 (276)	106,100 (48 100)
101313281	3 1/2 (88.90) NK3SB Box	Contact Halliburton TCP Representative						
101205564	3 1/2 (88.90) EUE 8 Rd							
101313282	3 1/2 (88.90) NK3SB Box							
100155752	4 1/2 (114.30) OD Blank							
101294471	4 1/2 (114.30) OD Blank							
101213155	4 1/2 (114.30) CS Hydril Box							
101313025	5 1/2 (139.7) OD Blank							

Mechanical Tubing Release

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.

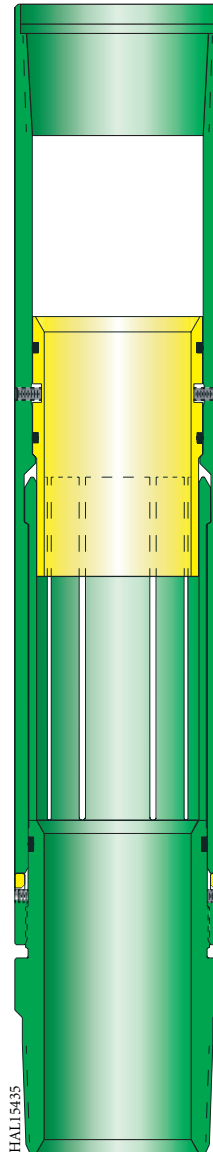
Features

- 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

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 do the following:

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 VannGun assembly.



Mechanical Tubing Release (MTR)

Mechanical Tubing Release (MTR) Specifications

SAP No. (w/o Latch)	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID (Latch Size) in. (mm)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)	Makeup Length ft (m)
100005286	2 3/8 (60.33) EUE 8 Rd Box × Pin	3.06 (77.22)	1.50 (38.10)	111,500 (50 576)	12,000 (825)	10,000 (690)	1.50 (0.46)
			1.63 (41.40)				
			1.81 (45.97)				
			1.88 (760)				

Mechanical Tubing Release (MTR) Specifications

SAP No. (w/o Latch)	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID (Latch Size) in. (mm)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)	Makeup Length ft (m)
100005281	2 7/8 (73.03) EUE 8 Rd Box × Pin	3.38 (85.85)	1.88 (47.75)	111,500 (50 576)	12,000 (825)	11,000 (760)	1.63 (0.50)
			2.13 (53.98)				
			2.25 (57.15)				
100005284	3 1/2 (88.9) EUE 8 Rd Box × Pin	3.95 (100.33)	2.25 (57.15)	111,500 (50 576)	11,000 (760)	10,000 (690)	1.88 (0.57)
			2.75 (69.85)				
101236790	5 (127) 15 lb (6.8 kg) New Vam Box × Pin	5.59 (142.01)	3.69 (93.68)	111,500 (50 576)	12,000 (825)	11,000 (760)	3.60 (1.10)
101435633	5 1/2-17.00 Vam Top HC Box X Pin Threads, 13 Chrome	6.50 (165)	4.313 (110)	168,000 (76 200)	6,800 (469)	5,000 (345)	4.7 (1.4)
101398862	4 1/2-12.6 Vam Top Threads, 13 Chrome	5.50 (140)	3.562 (90)	107,000 (48,500)	6,300 (434)	6,000 (414)	4.1 (1.25)
101399826	5 1/2-15.5 Vam Top Threads, 13 Chrome	6.50 (165)	4.313 (110)	168,000 (76,200)	6,400 (441)	4,000 (276)	4.8 (1.46)
101327124	4 1/2-12.6 Vamace Box X Pin, 13 Chrome	5.50 (140)	3.562 (90)	107,000 (48,500)	6,300 (434)	6,000 (414)	4.1 (1.25)

Mechanical Tubing Release (MTR) Shifting Tool and Key Number

Latch Size in. (mm)	Tool No. SAP No.	Key No. SAP No.	Key Maximum Exp. OD in. (mm)	Key Minimum OD in. (mm)
1.50 (38.10)	42 BO 245 101059081	42 B 818 101282505	1.64 (41.65)	1.49 (37.85)
1.625 (41.28)	42 BO 121 12005796	42 B 80 101059269	1.89 (48.006)	1.62 (41.148)
1.81 (45.97)	42 BO 117 101059064	42 B 37 101059122	2.076 (52.73)	1.75 (44.45)
	42 BO 237 101059079	42 B 681 101059193	2.156 (54.76)	1.69 (42.93)
1.88 (47.75)	42 BO 116 100008775	42 B 153 101059090	2.108 (53.569)	1.84 (46.74)
	42 BO 117 101059064	42 B 37 101059122	2.076 (52.73)	1.750 (44.45)
	42 BO 237 101059079	42 B 681 101059193	2.156 (54.76)	1.69 (42.93)
2.25 (57.15)	42 BO 118 100008776	42 B 287 101059109	2.592 (65.837)	2.156 (54.762)
2.125 (53.98)	42 BO 159 101015719	42 B 387 101059133	2.49 (63.25)	1.97 (50.04)
2.75 (69.85)	42 BO 146 100009659	42 B 349 101059118	3.156 (80.16)	2.718 (69.037)
3.69 (93.73)	42 BO 238 101010057	42 B 707 101059204	4.15 (105.41)	3.67 (93.218)
3.562 (90)	101399752	101399753		
4.313 (110)	101399109	101399113		

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

Pressure-Actuated Tubing Release

The pressure-actuated tubing release (PATR) is used to separate the guns from the toolstring when mechanical or slickline 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.

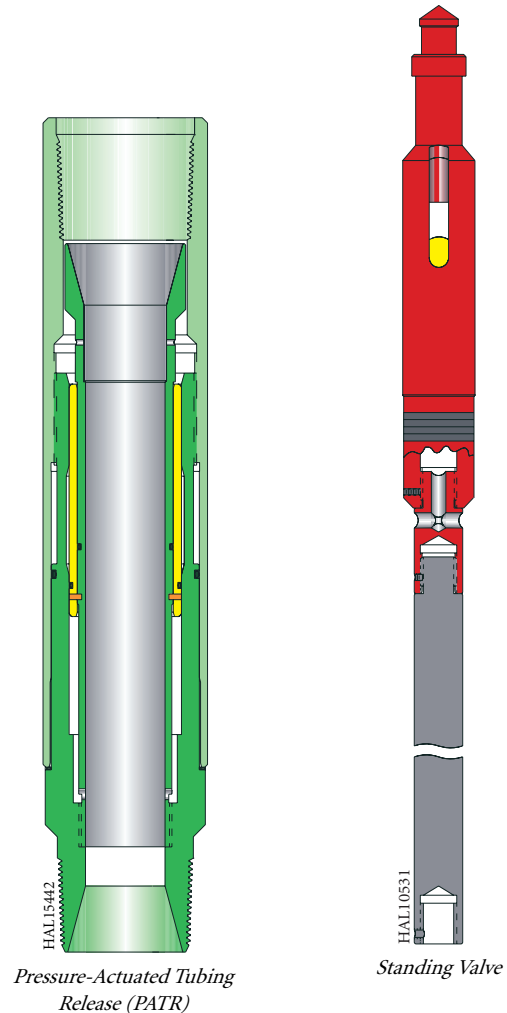
Features

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

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.



Pressure-Actuated Tubing Release (PATR) Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Minimum ID Before Release in. (mm)	Minimum ID After Release in. (mm)	Standing Valve OD in. (mm)	Makeup Length ft (m)	Tensile Strength lb (kg)	Burst Pressure psi (bar)	Collapse Pressure psi (bar)
100156751	2 3/8 (60.33) EUE 8 Rd Box × Pin	3.38 (85.85)	1.63 (41.40)	2.31 (58.67)	1.76 (44.70)	1.73 (0.53)	90,000 (40 800)	10,000 (670)	9,000 (620)
100156744	2 7/8 (73.03) EUE 8 Rd Box × Pin	3.75 (95.25)	1.812 (46.02)	2.828 (71.83)	1.86 (47.24)	1.72 (0.52)	120,000 (54 400)	10,000 (670)	10,000 (670)
101015385	3 1/2 (88.9) EUE 8 Rd Box × Pin	4.19 (106.43)	1.812 (46.02)	3.5 (88.90)	1.86 (47.24)	1.71 (0.52)	130,000 (58 900)	10,000 (670)	10,000 (670)

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

DPU® Downhole Power Unit

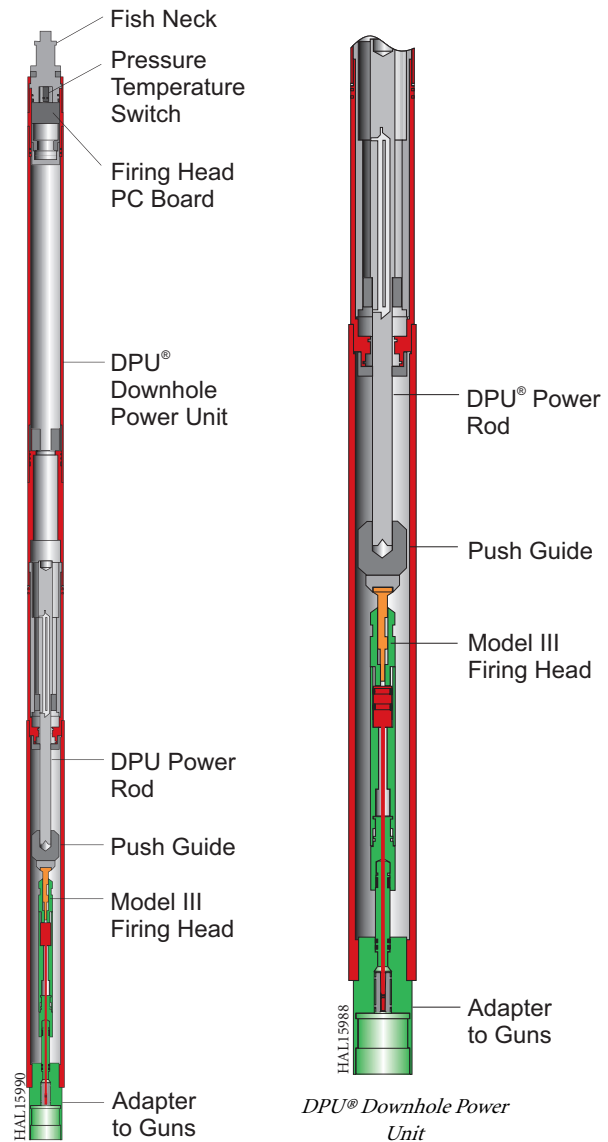
The DPU® downhole power unit firing head is an electromechanical device that is designed to produce a linear force that activates a pressure-assisted firing device. The pressure-assisted device fires the perforating guns. Before the DPU firing head was used to activate the pressure-assisted firing device, this type of perforating gun activation was run on tubing. The pressure-assisted firing device was previously activated by dropping a device from the surface. The DPU firing head is run on slickline.

For the DPU firing head to begin activation, several parameters must be present.

- **Pressure setting:** The DPU firing head has a surface-selected downhole pressure setting that must be met. Any time the well pressure at the DPU firing head drops below the selected pressure setting, the DPU firing head activation sequence is stopped
- **Downhole Temperature:** The DPU firing head requires a precise surface-selected downhole temperature. Any time the well temperature drops below the selected temperature setting, the DPU firing head activation sequence is stopped
- **Tool Movement:** The DPU firing head has an accelerometer that detects tool movement. If the accelerometer detects motion, the other operating parameters are inactive
- **Surface-Selected Timer:** The DPU firing head has a surface-selected timer that is activated if the three previous parameters are present

If these four parameters are present, the DPU firing head is activated and the rod begins to stroke out. Rod travel takes approximately 20 minutes before contracting the pressure-assisted firing device. When the DPU firing head rod contacts the pressure-assisted firing device, a pin is sheared and perforating is activated. After initial activation, the DPU runs for 25 minutes and then turns off.

The 3.66 OD DPU and 2.50-in. DPU firing head can be converted to run either the Model II-D or the Model III-D pressure-assisted firing heads.



Conversion Kits for DPU® Downhole Power Unit

Assembly No.	SAP No.	Maximum OD in. (mm)
146DFH20	00050531	3.66 (93.96)
146DFH11	00050462	2.50 (64.50)

SmartETD[®] Advanced Electronic Triggering Device

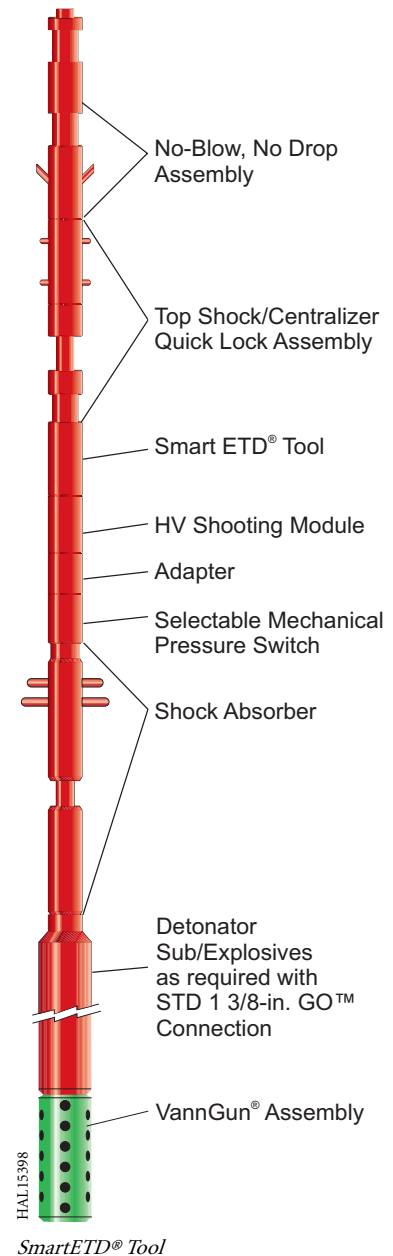
The SmartETD[®] tool is an advanced electronic triggering device that provides an accurate, safe, and reliable method to run and fire downhole explosive tools using slickline. With its built-in sensor and memory capabilities, it can record and store downhole temperature and pressure data that can be used by the slickline specialists to program firing parameters.

The SmartETD tool requires four parameters to be met prior to firing. These are motion, time (preset), pressure (preset), and temperature (preset). The timing sequence begins when the tool is exposed to pressure. After the tool stops, any motion resets the electronic timer. After the SmartETD timer has remained motionless for a specific period of time and has simultaneously encountered the preset temperature and pressure windows, it initiates the firing sequence. The SmartETD tool can log memory settings for pressure and temperature readings up to 12k data sets.

The SmartETD tool will fire the Halliburton rig environment RED[®] detonator, as well as API RP-67-compliant devices. It is also capable of resisting detonation.

SmartETD[®] Specifications

Features	
SAP No.	101038328
	146ETD14 Optional No-Blow No-Drop Assembly
Diameter in. (mm)	1.690 (42.93)
Length in. (mm)	60 (1524)
Max. Temperature °F (°C)	300 (149)
Max. Pressure psi (bar)	15,000 (103.42)
Control Parameters	
Pressure	yes (programmable)
Temperature	yes (programmable)
Time	yes (programmable)
Motion	yes
Tension	no
Resist Detonation Capability	yes
HES RED [®] Capability	yes
Memory Logging	
Pressure	yes
Temperature	yes
No. of Points (reading)	12k data sets



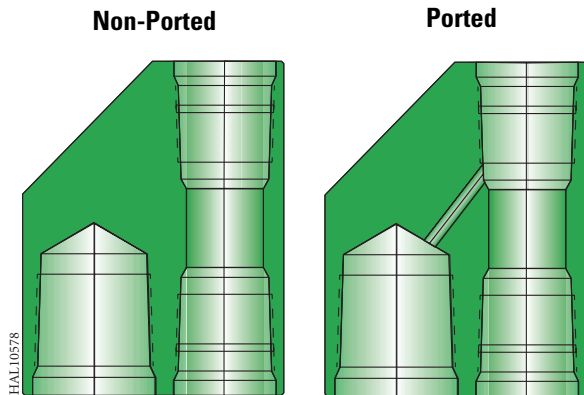
Y-Block Assembly

The Y-block assembly is used in dual completions and single selective completions to attach or hang guns from the long string.

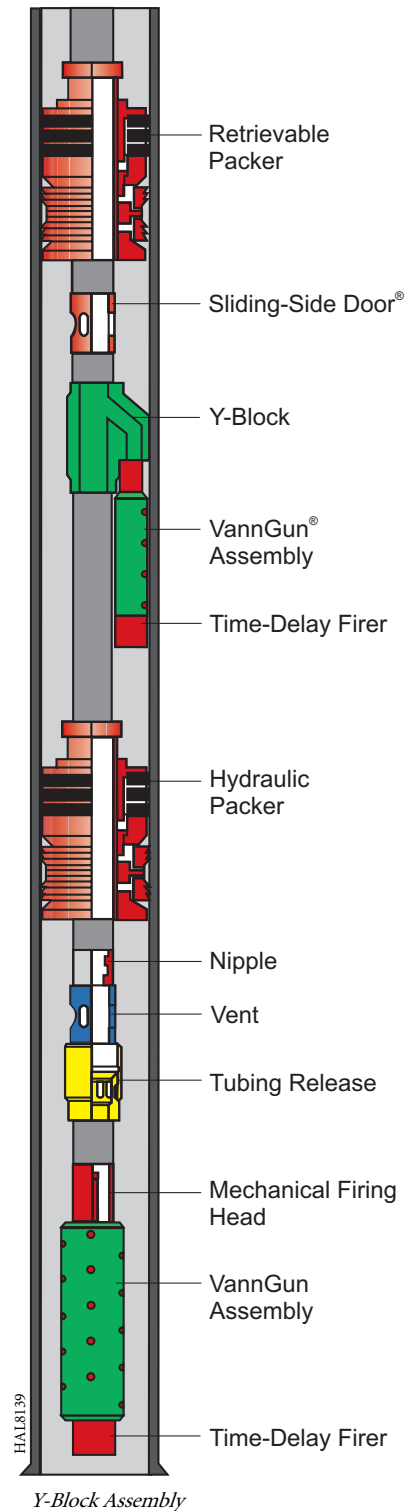
In single selective completions, this installation is run either for selectively shooting and testing two zones or for production when the application requires the option of producing two zones separately through one tubing string.

In dual completions, the assembly allows for the elimination of the tail pipe between the dual packer and the gun.

The Y-block assembly is available as a ported or non-porting assembly. The ported Y-block allows guns to be fired upon applying pressure to the long string. In the non-porting assembly, there is no communication between the long string and the short string.



Y-block assemblies are custom-made according to the casing ID, the tubing size and type, and the gun size. Consult your local Halliburton representative for ordering information.

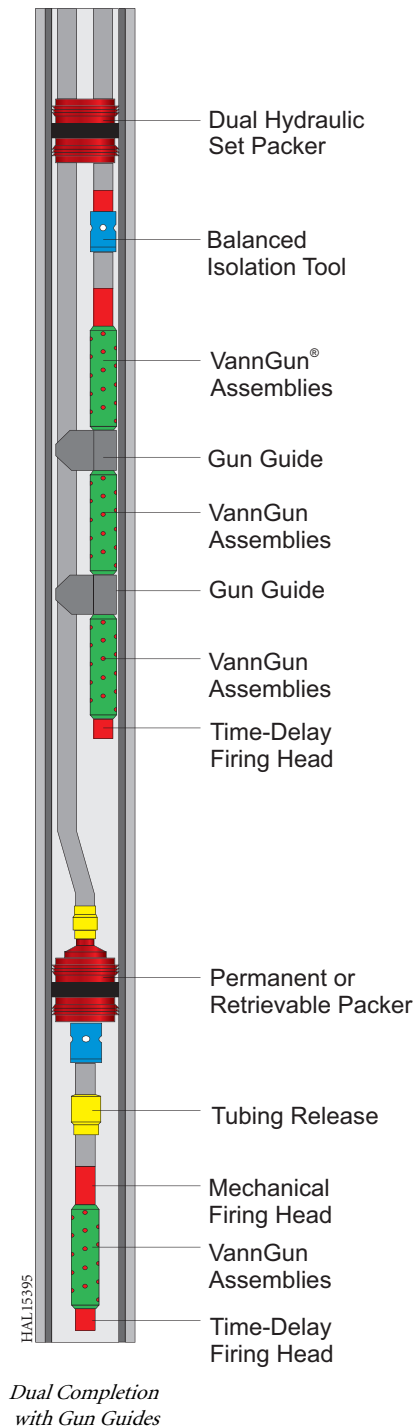
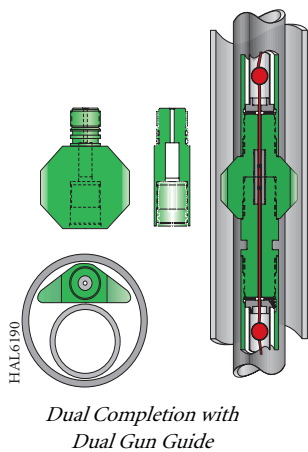
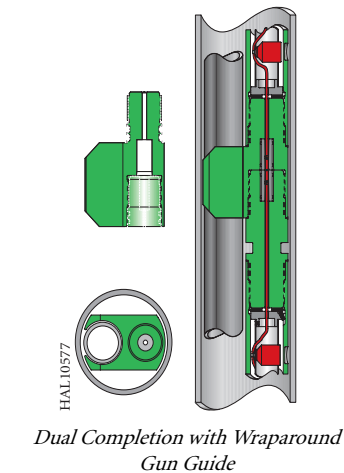


Gun Guides

Gun guides were developed by Halliburton to maintain the proper orientation of guns attached to the short string in a dual completion. The gun orientation must be maintained so that the charges shoot away from the long string. Gun guides are also used with Y-blocks in dual-string and single-string completions.

There are two types of gun guides. The delta-shaped or dual gun guide can be used when the casing ID is the same from top to bottom. If the casing at the top of the well is larger, then the wraparound guide must be used. The wraparound type may also be used in the wellbores with the same ID top to bottom.

Guides are available for most of the smaller size guns (3 3/8 in. or 85.73 mm and smaller) that are typically run on the short string side of a dual completion.



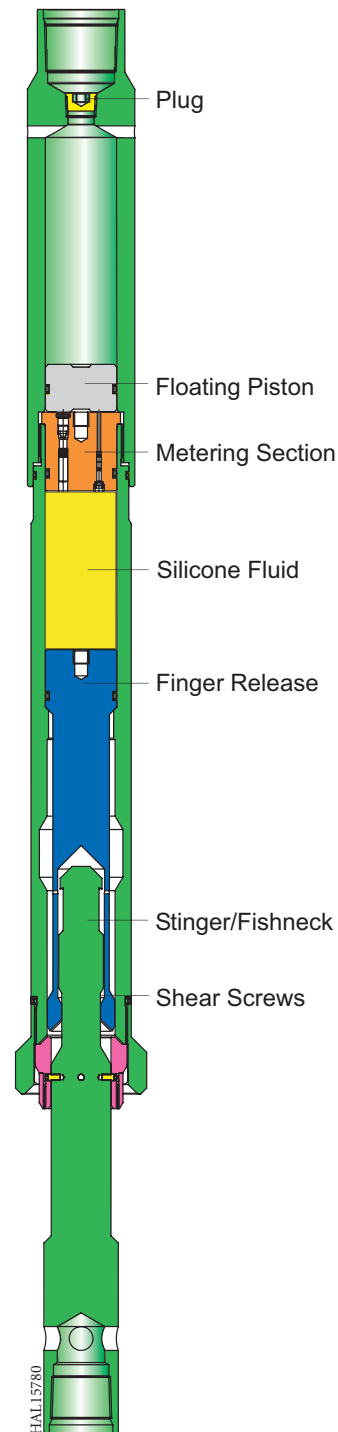
Hydraulic Metering Release Tool for the Single Trip System (STPP™-GH) Tool

The hydraulic metering release tool is one component of the single trip system that allows us to perforate and frac-pack a zone of interest in a single trip.

Numerous safety and economic benefits accompany this capability. These benefits become even more profound as well parameters become more severe. The ever-present goal is to reduce completion CAPEX and maximize net present value.

Features

- Save rig time with reduced pipe trips for faster completions
- Minimize fluid loss and formation damage
- Minimize associated well control risks
- Perforate under- or overbalanced
- Perform the sand control option most suitable for your well (FP, HRWF, GP)
- Complete deep, hot zones where fluid loss pills are not effective



*Hydraulic Metering
Release Tool*

Hydraulic Metering Release Assembly (Low Temperature)

Upper Thread Size and Type	Lower Thread Size and Type	Overall Length in. (cm)	Maximum OD in. (cm)	Effective OD* in. (cm)	Temperature Rating °F (°C)	Tensile Rating lb (kg)	Maximum Slack Off Weight on Tool lb (kg)	Minimum Slack Off Weight on Tool lb (kg)	Redressable	Weight lb (kg)
2 7/8 EU-RD	N/A	45.47 (115.49)	4.5 (11.43)	4.5 (11.43)	200 (93.33)	97,700 (44 315)	30,000 (13 607)	13,600 (6168)	Yes	156.46 (70.96)
				5.5 (13.97)						
				7.5 (19.05)						

*Effective OD of the tool is dictated by the OD of the skirt to be used.

**Maximum weight on gun hanger = gun weight + slackoff weight on hydraulic release tool.

***The tool is assembled with four shear screws of 3,400 lb each.

Hydraulic Metering Release Assembly (High Temperature)

Upper Thread Size and Type	Lower Thread Size and Type	Overall Length in. (cm)	Maximum OD in. (cm)	Effective OD* in. (cm)	Temperature Rating °F (°C)	Tensile Rating lb (kg)	Maximum Slack off Weight on Tool lb (kg)	Minimum Slackoff Weight on Tool lb (kg)	Redressable	Weight lb (kg)
2 7/8 EU-RD	N/A	45.47 (115.49)	4.5 (11.43)	4.5 (11.43)	200-350 (93.33-148.88)	97,700 (44 315)	30,000 (13 607)	13,600 (6168)	Yes	156.46 (70.96)
				5.5 (13.97)						
				7.5 (19.05)						

*Effective OD of the tool is dictated by the OD of the skirt to be used.

**Maximum weight on gun hanger = gun weight + slackoff weight on hydraulic release tool.

***The tool is assembled with four shear screws of 3,400 lb each.

Fast Gauge Recorder

The fast gauge recorder is a downhole gauge that records important pressure and temperature data in high-pressure, severe shock/vibration environments.

This gauge is typically used with StimGun^{TM*} assemblies or StimTube^{TM*} tools. The pressure profile collected is used to verify proper propellant burn as well as determine the fracturing response of the formation by analyzing post-job data with PulsFrac^{TM**} software.

The data the fast gauge recorder collects can be used to determine whether or not the job was executed properly, to validate computer models, and to make initial determinations of rock properties. The data can also be used to estimate fracture gradients.

The fast gauge recorder can perform within the rigors of perforating applications by withstanding shock loads of 100,000 g. The tool collects and records 115,000 data points per second to give exceptionally accurate and reliable information.

The programmable multi-speed feature allows flexibility in collecting pressure, acceleration, and vibration data at various sampling speeds and time intervals. The gauge starts sampling at a slow speed and when a pressure pulse or acceleration/vibration event occurs, the gauge automatically switches to a high sampling speed, then back to an intermediate speed, and finally back to a slow sampling speed. The process can be repeated until the memory is full.

Each gauge includes a shock mitigator which isolates the gauge from the tool, reducing shock and vibration (up to a factor of 10) that occurs when the gun ignites. Use of the shock mitigator lengthens the life of the recorder, battery, and sensors.

A special application of the 1 11/16-in. (42.86 mm) OD gauge is its use as a “drop bar” to fire a propellant or perforating gun. The gauge can be used with firing pin and fishneck attachments as the drop bar to trigger a gun firing head. It can be left there as long as necessary to collect pressure flow data. With this feature, the customer can retrieve pressure data from the gun and also determine if the gun actually fired.



Fast Gauge Recorder

**StimTube and StimGun are trademarks of Marathon Oil Company.*

***PulsFrac is a trademark of John F. Schatz Research and Consulting, Inc.*

Features

- Shock-hardened design
- High sampling speed
- Records pressure, acceleration, vibration, and temperature
- Programmable low, intermediate, and high speeds and time intervals
- Can be used as drop bar pressure gauge
- Computer programming and data readout
- Internal microprocessor control
- Automatic sensor testing and balancing
- Selectable pressure, temperature, and acceleration/vibration ranges
- Measures tool movement and acceleration/vibration up to $\pm 50,000$ g
- Current and internal/battery voltage readouts to verify proper gauge operation
- Internal temperature and battery data
- Selectable sampling rates up to 115,000 data points per second
- Auto stop/start recording modes
- Includes shock mitigator
- Up to 1,048,756 data points of memory
- Uses low-cost standard AA alkaline or lithium batteries

Fast Gauge Recorder Specifications

Gauge Dimensions	Maximum Acceleration and Vibration	Current Drain	Computer/ Communications	Software	Sensor Frequency Response	Power Requirements
1 11/16 in. OD \times 50 in. (22 lb)	$\pm 50,000$ g	500 μ A sleeping 100 mA sampling	750 MHz or greater PC, with standard RS-232	Windows 98*	0 to 10,000 Hz	6 to 12 volts, AA alkaline or lithium cells

*Windows 2000 or NT is recommended.

Sampling Rate	Temperature Range °F (°C)	Pressure Range psi (bar)	Data Resolution	Memory Capacity
115,000 points/second down to one sample every 10 seconds	-40 to 248 (-40 to 120)	35,000 (2413) peak 15,000 (1034) continuous	12 bits @ 115,000 data points/second	1,048,576 data points

Gamma Perforator Logging Tool

The gamma perforator is a ruggedized depth correlation tool designed specifically for operation with explosive equipment, such as perforating guns, packers and plugs, and coring guns. The tool can operate in liquid or gas-filled, openhole or cased hole wells. The gamma perforator is available in two sizes: 3.375-in. and 1.687-in. version.

The gamma perforator is not intended to provide a calibrated gamma measurement. No borehole corrections are performed in the algorithms, and calibration procedures are only used to ensure that the tool is working properly before and after jobs.

The tool has a built-in shock absorber system and does not require an external shock sub. In addition, the electronic components are covered with silicon potting to help dampen the shock wave that impacts components. All sub-assemblies required for perforating with different connections must be ordered individually.

Features

- Offers three configurations:
 - Normal perforating and plug setting
 - Stand-alone gamma/CCL-correlation
 - Side wall coring
- High resistance minimizes accidental firing risks
- Slimhole version allows perforating operations to be performed without the need to pull tubing from the well

Gamma Perforator Logging Tool Specifications

Tool Length	Length ft (m)	Diameter in. (mm)	Maximum Pressure psi (Mpa)	Maximum Temperature °F (°C)	Weight lb (kg)
GPLT	5.03 (1.5)	3.375 (85.7)	20,000 (137.9)	350 (176.7)	82 (37.2)
GPST	6.23 (1.9)	1.69 (42.9)	18,000 (124.1)	350 (176.7)	35 (15.9)

Detonators

Capsule RED® Detonators

The capsule RED® detonator is an advanced electro-explosive device designed for use with capsule perforating guns and other explosive devices where a pressure-resistant detonator is required. The design features of the capsule RED detonator provides significantly improved safety characteristics over conventional resistorized devices and allows wellsite activities to continue uninterrupted while perforating.

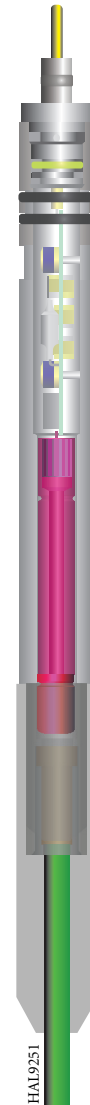
Features

- Does not use primary explosives
- Redundant electrical components for enhanced safety
- Ceramic firing capacitors for enhanced reliability
- Surface-mount circuit technology for ruggedness
- Metal housing for radio frequency shielding
- High-output explosive load and flyer plate for enhanced reliable detonation transfer
- Dual sealing methods at top of detonator
- Patented sealing for detonating cord interface

Specifications

- No-fire voltage level: 120 VDC
- Firing voltage: 155 to 190 VDC (nominal 175 VDC)
- Recommended firing method: "Dump firing." Deliver 250 VDC to the firing head
- Recommended firing polarity: positive or negative DC

- Requirements for radio silence waivers:
 - Transmitters with power less than 1 watt = no exclusion area
 - Handheld RF transmitters (cell phones and walkie-talkies) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - All other RF sources (land or offshore, mobile or fixed) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - Offshore workboats (or other 1-MHz, 1,000 watt or above transmitters) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - Stray voltage measurement, electric welding operation, or electrical cathodic protection systems = operation acceptable if stray voltage is less than 2 V
- Bleed-off time with power removed: 5 sec
- Semi-conductor bridge (SCB) resistance: 2 ohms
- No-fire DC power dissipation (stand-alone SCB without circuit): 5 watts minimum
- Energetic materials:
 - Ignition pyrotechnic mix = 50 mg THKP
 - Transition column = 400 mg HMX
 - Output pellet = 500 mg HMX
- Environmental rating: 375°F at 15,000 psi for one hour
- UN shipping classification: 1.4S



Capsule RED® Detonator

RED® GO™-Style Thermal Igniter

The RED® igniter is an advanced electro-explosive device used to initiate gas-generating power charges inside oilfield setting tools. The design features of the RED igniter provide significantly improved safety characteristics over conventional resistorized devices and allow many wellsite activities to continue uninterrupted while using power setting tools.

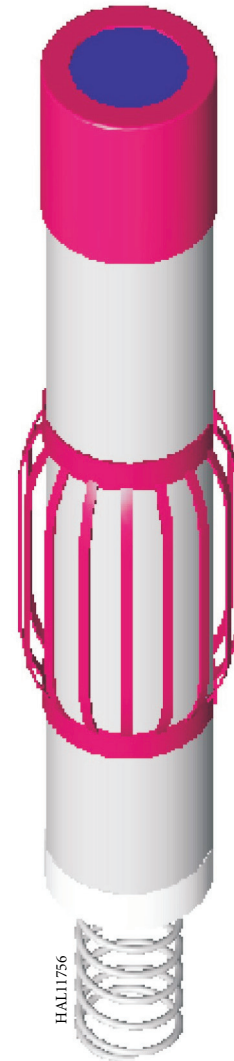
Features

- Mates with top subs and adapters for industry standard setting tools
- Redundant electrical components for enhanced safety
- Multiple ceramic firing capacitors for reliability
- Surface-mount circuit technology for ruggedness
- Thermally conductive semi-conductor bridge for stray power dissipation
- Metal housing for radio frequency shielding
- Thin aluminum end-closure for low debris characteristics

Specifications

- No-fire voltage level: 120 VDC
- Firing voltage: 155 to 190 VDC (nominal 175 VDC)
- Recommended firing method: "Dump firing." Deliver 250 VDC to the firing head
- Recommended firing polarity: positive or negative DC
- Requirements for radio silence waivers:
 - Transmitters with power less than 1 watt = no exclusion area

- Handheld RF transmitters (cell phones and walkie-talkies) operation—minimum distance radius from explosive workplace = no minimum distance restriction
- All other RF sources (land or offshore, mobile or fixed) operation—minimum distance radius from explosive workplace = no minimum distance restriction
- Offshore workboats (or other 1-MHz, 1,000 watt or above transmitters) operation—minimum distance radius from explosive workplace = no minimum distance restriction
- Stray voltage measurement, electric welding operation, or electrical cathodic protection systems = operation acceptable if stray voltage is less than 2 V
- Bleed-off time with power removed: 5 sec
- SCB resistance: 2 ohms
- SCB no-fire power dissipation: 5 watts minimum
- Energetic materials:
 - Ignition pyrotechnic mix = 150 mg THKP pressed in SCB header
 - Main load = .15 gm FFFG black powder and .75 gm THKP loose powders
- Temperature rating: 375°F for one hour
- UN shipping classification: 1.4G



RED® GO™-Style Thermal Igniter

Block RED® Detonators

The block RED® detonator is an advanced electro-explosive device used to initiate perforating guns. The design features of the block RED detonator provide significantly improved safety characteristics over conventional resistorized devices and allow wellsite activities to continue uninterrupted while perforating.

Features

- Does not use primary explosives
- Redundant electrical components for enhanced safety
- Ceramic firing capacitors for enhanced reliability
- Surface-mount circuit technology for ruggedness
- Metal housing for radio frequency shielding
- High-output explosive load and flyer plate for enhanced reliable detonation transfer
- Fluid-disabled to prevent gun damage in the event of a seal failure

Specifications

- No-fire voltage level: 120 VDC
- Firing voltage: 155 to 190 VDC (nominal 175 VDC)
- Recommended firing method: “Dump firing.” Deliver 250 VDC to the firing head
- Recommended firing polarity: positive or negative DC
- Requirements for radio silence waivers:
 - Handheld RF transmitters (cell phones and walkie-talkies) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - All other RF sources (land or offshore, mobile or fixed) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - Offshore workboats (or other 1-MHz, 1,000 watt or above transmitters) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - Stray voltage measurement, electric welding operation, or electrical cathodic protection systems = operation acceptable if stray voltage is less than 2 V
- Bleed-off time with power removed: 5 sec
- SCB resistance: 2 ohms
- SCB no-fire power dissipation: 5 watts minimum

- Energetic materials:
 - Ignition pyrotechnic mix = 50 mg THKP
 - Transition column = 400 mg HMX
 - Output pellet = 500 mg HMX
- Temperature rating: 375°F for one hour
- UN shipping classification: 1.4S



Block RED® Detonator

Top Fire RED® Detonators

The top fire RED® detonator is an advanced electro-explosive device used to initiate perforating guns, jet cutters, and severing tools. The design features of the top fire RED detonator provide significantly improved safety characteristics over conventional resistorized devices and allow wellsite activities to continue uninterrupted while perforating.

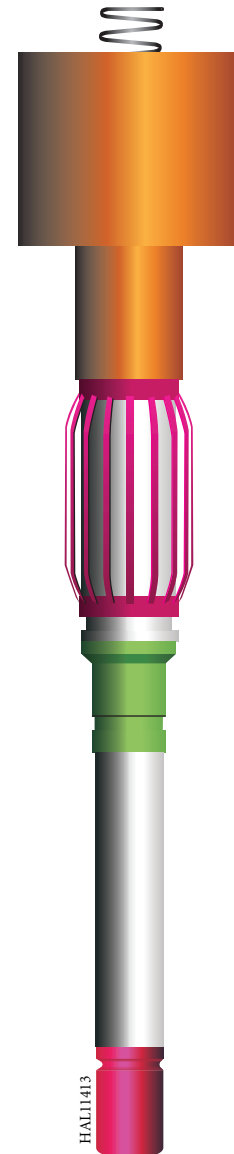
Features

- Does not use primary explosives
- Redundant electrical components for enhanced safety
- Ceramic firing capacitors for reliability
- Surface-mount circuit technology for ruggedness
- Thermally conductive semi-conductor bridge for stray power dissipation
- Metal housing for radio frequency shielding
- High-output explosive load and flyer plate assure reliable detonation transfer

Specifications

- No-fire voltage level: 120 VDC
- Firing voltage: 155 to 190 VDC (nominal 175 VDC)
- Recommended firing method: “Dump firing.” Deliver 250 VDC to the firing head
- Recommended firing polarity: positive or negative DC
- Requirements for radio silence waivers:
 - Handheld RF transmitters (cell phones and walkie-talkies) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - All other RF sources (land or offshore, mobile or fixed) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - Offshore workboats (or other 1-MHz, 1,000 watt or above transmitters) operation—minimum distance radius from explosive workplace = no minimum distance restriction
 - Stray voltage measurement, electric welding operation, or electrical cathodic protection systems = operation acceptable if stray voltage is less than 2 V
- Bleed-off time with power removed: 5 sec
- SCB resistance: 2 ohms

- SCB no-fire power dissipation: 5 watts minimum
- Energetic materials:
 - Ignition pyrotechnic mix = 50 mg THKP
 - Transition column = 400 mg HMX
 - Output pellet = 500 mg HMX
- Temperature rating: 375°F for one hour
- UN shipping classification: 1.4S



Top Fire RED® Style Detonator

Dynamic Modeling

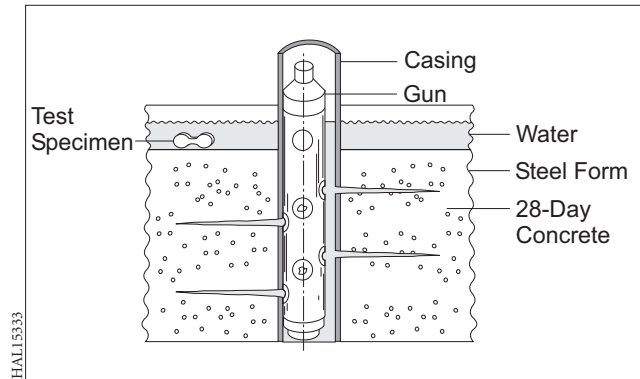
Dynamic modeling is used to understand perforation performance, tubing movement, shock loading, and wellbore pressure response during well intervention.

The ability to understand dynamic behavior is critical for Halliburton to deliver world-class solutions to its customers.

PerfPro® Process

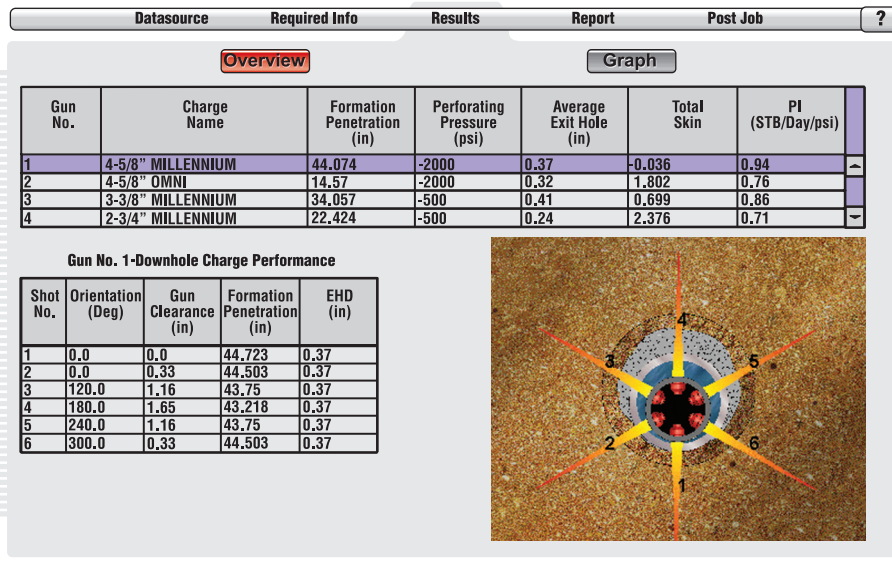
PerfPro® Process— Predicting In-Situ Charge Performance

Halliburton's PerfPro® charge performance calculations for penetration are based on proprietary models derived from theoretical and experimental studies carried out at Jet Research Center (JRC), a Halliburton Company. API RP-19B defines the procedure for evaluating gun system performance at surface conditions in unstressed concrete targets. A fully loaded gun system is perforated in actual casing surrounded by concrete, and the target penetration, casing entrance hole, and burr height are recorded. Halliburton's PerfPro program transforms API RP-19B Section I surface test data to downhole conditions by correcting for the formation compressive strength and effective stress. The associated downhole charge performance takes into account the gun positioning, casing grade, wellbore fluid density, and well condition.



API Section I
Concrete Target

PerfPro® Process



PerfPro® Charge Performance Calculations

The primary objective of the Halliburton PerfPro® process is to optimize gun selection and job execution to deliver the highest productivity index or lowest skin factor. Therefore, after charge performance values are calculated, the PerfPro program makes a productivity index and skin factor assessment. The PerfPro process accounts for skin factors due to perforation, drilling damage, partial penetration, non-Darcy flow, and well deviation. A fully three-dimensional

(3D) flow model is utilized, as described by Ansah et al. 2001, to characterize the skin component due to perforation geometry. Input well parameters and calculated charge performance values are linked to an artificial neural network, trained by the 3D finite element model, to generate the perforation skin component. The productivity index and total skin factor are corrected, utilizing analytical calculations for well inclination, partial penetration effect, non-Darcy flow, and drilling damage effects.

CHARGE PERFORMANCE REPORT

General Data

Reservoir fluid type	Oil		Mid-Perforation Depth	3250.0	ft - TVD
Borehole Diameter	12.25	in	Reservoir Pressure	1464.0	psi
Porosity	24.0	%	Reservoir Temperature	112.0	°F
Permeability	1191.0	md	Completion Fluid Type	Diesel	
Formation Compressive Strength	3891.0	psi	Completion Fluid Density	6.83	lb/gal
Drilling Damage Radius	3.0	in	Lithology	Sandstone	

Completion Data

Casing Description	1	
Outer Diameter	9.63	in
Inner Diameter	8.68	in
Grade	N-80	
Weight	47.0	lb/ft

Perforator Information

Charge Name	Gun 1 7" MILLENNIU M DP	Gun 2 4" MILLENNIU M SDP	Gun 3 4-1/2" MILLENNIU M SDP
Charge Type	DP	SDP	SDP
Charge Loading, gm	39.0	39.0	22.7
Phasing, deg	45.0	60.0	30.0
Shot Density, spg	12	5	12
Gun Position	Eccentered	Eccentered	Eccentered
Avg Formation Penetration, in	40.68	43.22	23.78
Avg Entrance Hole Dia*, in	0.36	0.29	0.28
Data			
Total Target Penetration, in	43.3	52.0	26.8
Entrance Hole Diameter, in	0.36	0.37	0.38

PRODUCTIVITY REPORT

Completion Data

Reservoir Fluid Type	Oil		Well Deviation @ Perfs	56.2	deg
Drainage Radius	1500.0	ft	Net Sand Thickness	27.0	ft
Pseudo-Skin due to Well Deviation	-0.697		Perforated Total Length	27.0	ft
Distance To Top Perf Interval	0.0	ft			
Skin due to Partial Penetration	0.0				

Reservoir Data

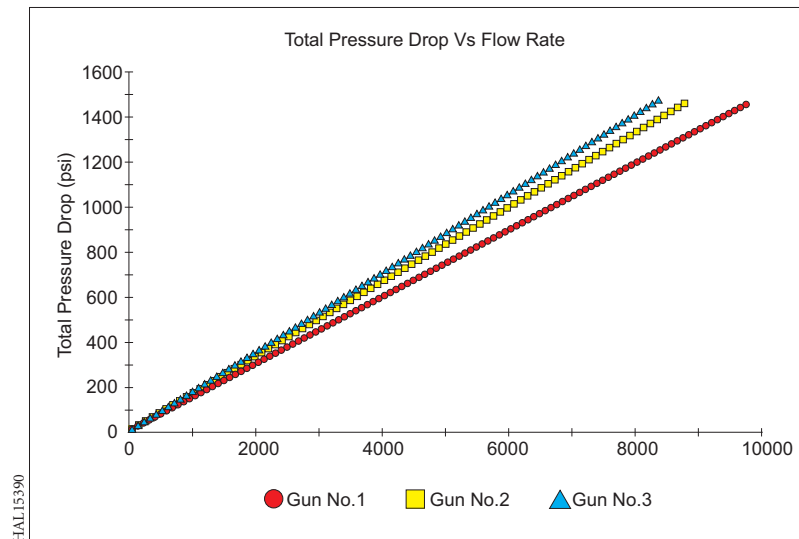
Permeability	1191.0	md	Reservoir Pressure	1464.0	psi
Anisotropic Ratio, kV/kH	0.2		Reservoir Temperature	112.0	°F
Formation Volume Factor	1.1	bbl/stb	Porosity	24.0	%
Formation Fluid Viscosity	4.36	cp	API Gravity	32.6	°API

Perforator Information

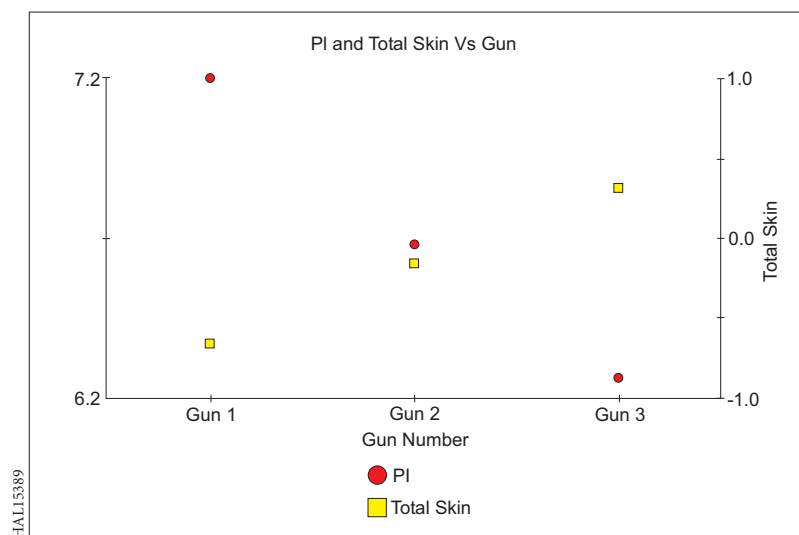
Charge Name	Gun 1 7" MILLENNIU M Eccentered	Gun 2 4" MILLENNIU M Eccentered	Gun 3 4-1/2" MILLENNIU M Eccentered
Gun Position	Eccentered	Eccentered	Eccentered
Shot Phasing, deg	45.0	60.0	30.0
Shot Density, spf	12	5	12
Avg Formation Penetration, in	40.68	43.22	23.78
Avg Entrance Hole Dia, in	0.36	0.29	0.28
Underbalance Condition, psi	-350.0	-350.0	-500.0

Productivity Analysis

	Total Skin	Perforation Skin	Productivity Index, STB/day/psi
Gun No. 1	-0.666	0.031	7.2
Gun No. 2	-0.158	0.539	6.682
Gun No. 3	0.319	1.016	6.261



PerfPro® Graph Example



PerfPro® Graph Example

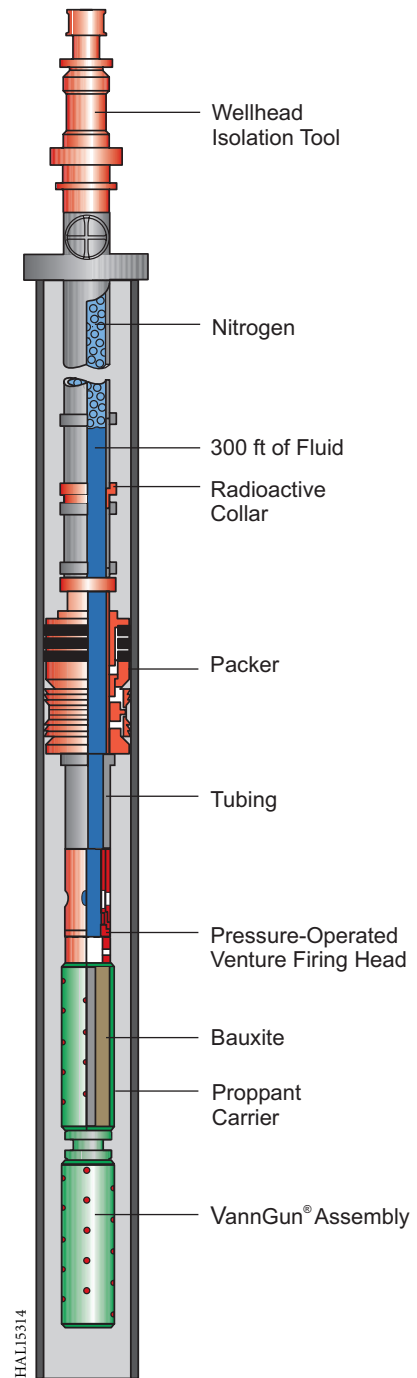
Near-Wellbore Stimulation and PulsFrac™ Software

In many formations, the remaining reservoir pressure or underbalance is insufficient to effectively clean the perforations as suggested by King et al. (1985) and others. In other cases, where formation competence is questionable and the risk of sticking perforating assemblies is greater, sufficient underbalance pressure is not possible, aid in lowering treating pressures is needed, or bypassing near-wellbore damage is needed, then near-wellbore stimulation could be a possible perforating solution. To address the perforation damage in these cases, some (Handren et al. 1993, Pettijohn and Couet, 1994; Snider and Oriold, 1996) have suggested near-wellbore stimulation using extreme overbalanced (EOB) perforating and propellant assisted perforating. Near-wellbore stimulation provides perforation breakdown in preparation for other stimulation methods, and therefore, eliminates the need for conventional perforation breakdown methods.

Near-wellbore stimulation can be achieved using energized fluids, propellants, or a combination of both, and all can be properly designed using the PulsFrac™* dynamic pressure modeling software. The PulsFrac software allows a job simulation to be performed to determine anticipated peak pressures, injection rates, injection volumes, and theoretical fracture lengths.

EOB - Energized Fluid Stimulation

EOB techniques involve pressuring the wellbore with compressible gases above relatively small volumes of fluid. The gases have a high level of stored energy. Upon expansion at the instant of gun detonation, the gases are used to fracture the formation and divert fluids to all intervals. The high flow rate through relatively narrow fractures in the formation is believed to enhance near-well conductivity by extending the fractures past any drilling formation damage.



*Typical Extreme
Overbalanced (EOB)
Perforating Assembly*

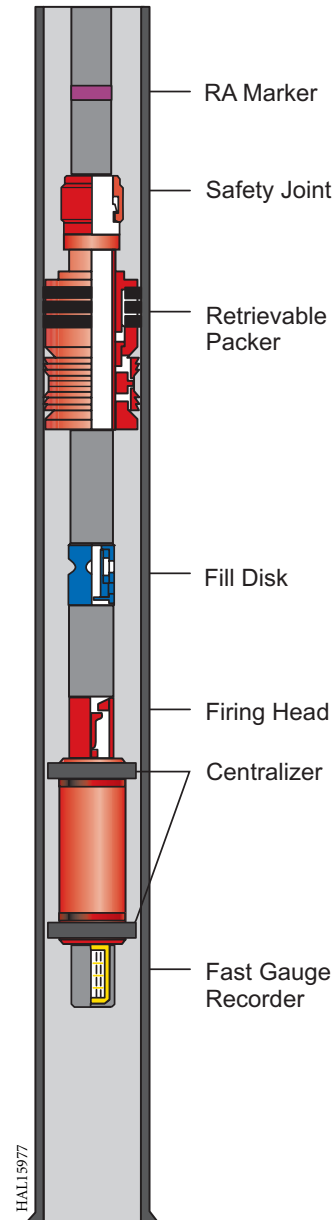
Building upon the success of EOB perforating, Marathon Oil Company incorporated proppant carriers into the perforation assembly to introduce proppants into the flow path as the gun detonates. The POWR*PERF™ process, patented by Marathon Oil Company, further enhances productivity by scouring the perforations to leave some residual conductivity on the fracture plane. Most EOB perforating jobs are designed with a minimum pressure level of 1.4 psi/ft of true vertical depth. For optimum results, it is suggested to utilize the highest possible pressure level without compromising wellbore integrity or operation safety.

Propellant Stimulation

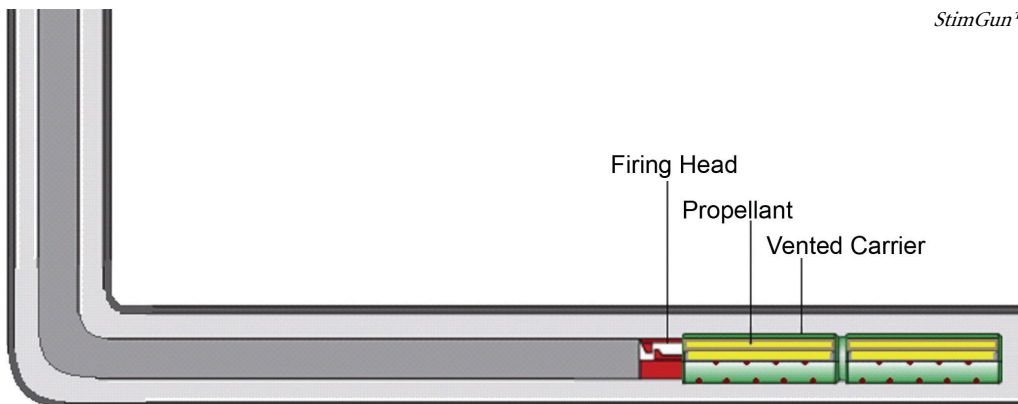
Propellant stimulation can be provided during the perforating event with propellant-assisted perforating. Propellant-assisted perforating using the StimGun™ assembly, patented by Marathon Oil Company, combines solid propellant technology with conventional perforating. The StimGun assembly may be utilized for either EOB or conventional underbalanced perforating. The hardware utilized for either system remains the same aside from added protection by using centralizer rings to protect the brittle propellant material. The propellant sleeve in the StimGun assembly simply slides over the perforation scalloped carrier and is held in position on the gun with the centralizer rings.

The propellant material is potassium perchlorate, an oxidizer that burns rapidly, creating carbon dioxide gas. As the shaped charges detonate, the propellant is ignited by extreme heat from the gun system. As it burns, the propellant generates carbon dioxide gas at high peak pressures typically well above the formation fracture gradient. The StimGun assembly is an effective method for mild stimulation (fractures on order of 2 to 9 ft) for treating near-wellbore problems.

Propellant stimulation can also occur using solid propellant conveyed in protective carriers. This type of propellant can virtually be unlimited in length by simply interconnecting the carriers to place across existing perforations, slotted liner, or in openhole. The propellant is ignited using a sealed ignition system, and similar to the StimGun assembly once the propellant is ignited it will generate carbon dioxide at high peak pressure, allowing for adequate stimulation of the desired formation interval. As with all near-wellbore stimulation techniques, PulsFrac™ software aids in proper job design and provides estimated peak pressures, injection rates, and volumes to ensure successful propellant stimulation.



StimGun™ Assembly



Near-Wellbore Stimulation

Increasing conductivity past near-wellbore damage is critical in maximizing a well's producibility. Halliburton provides multiple solutions suitable for various stimulation scenarios depending upon the well's restriction, completion methods, and reservoir characteristics.

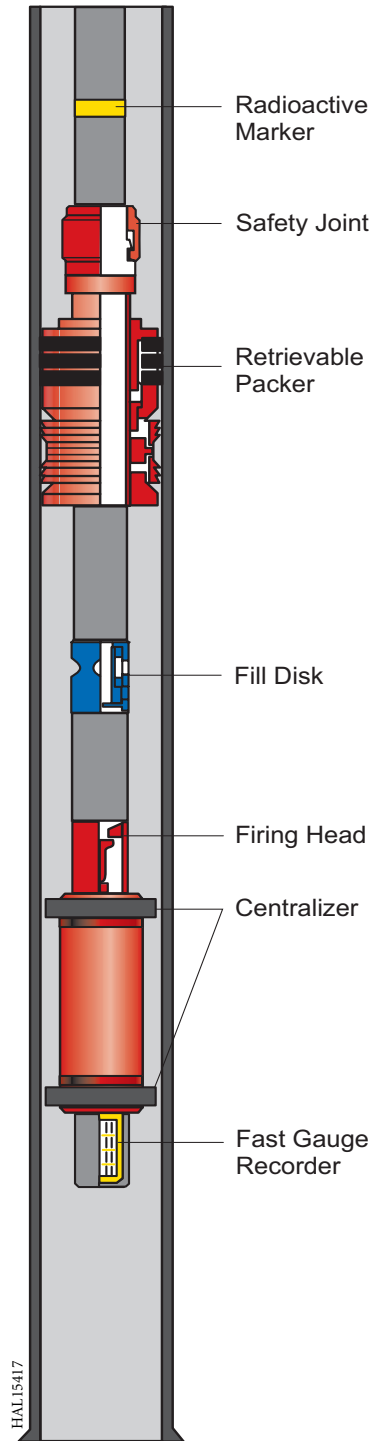
StimGun™* Assembly

The StimGun™ assembly is a process that combines perforating and perforation breakdown with propellant in a single tool and operation. The StimGun assembly has a propellant sleeve over a conventional Halliburton VannGun® perforating gun assembly. When the guns are detonated, the propellant sleeve is ignited, instantly producing a burst of high-pressure CO₂ gas. This gas enters the perforations, breaks through any damage around the perforation tunnel, and creates short fractures near the wellbore. As the gas pressure in the wellbore dissipates, the gas in the formation surges back into the wellbore carrying with it damaging fines. The StimGun assembly has been used with great success in conventional underbalanced perforating to obtain the benefits of both extreme overbalance from propellants and the surging effect from maximum underbalance.

Features

- Improved production or injectivity with greater uniformity in the perforation breakdown
- Improved connectivity to the undamaged reservoir matrix by extending fractures past damage induced by either drilling or completion practices
- Improved conventional underbalanced perforating by combining benefits of extreme overbalance in one operation
- Stimulation of near-wellbore on zones that cannot be treated conventionally with acid or hydraulic fracturing due to undesirable production from nearby gas cap or water contact
- Excellent pre-hydraulic fracture treatment assists in keeping perforations open and minimizes tortuosity effects, resulting in lower breakdown pressures and horsepower requirements on location

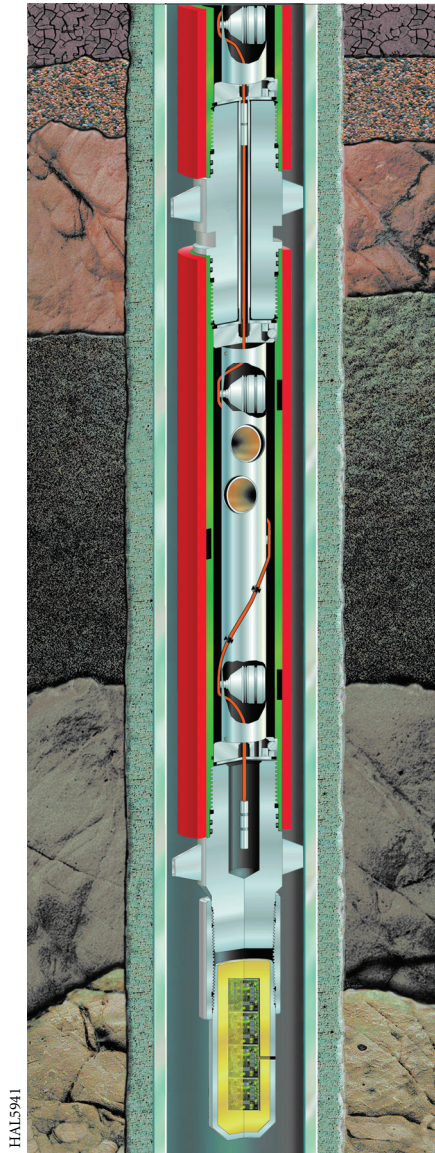
**StimGun is a trademark of Marathon Oil Company and is licensed to Halliburton by Marathon.*



StimGun™ Assembly

Operation

The StimGun™ assembly consists of a cylindrical sleeve of gas-generating propellant-potassium perchlorate that slides in place over the outside of a conventional hollow steel carrier perforating gun. The StimGun assembly can be conveyed on either wireline, coiled tubing, or in a conventional perforation configuration. StimGun sleeves are similar to PVC pipe and must be protected and positioned on the gun with an oversized retaining collar that is secured to the gun scallop. Additional sleeve protection is achieved through centralization of the gun sections at the tandems.



The StimGun™ tool can be run on Halliburton tubing-conveyed or wireline equipment.

StimGun™ Assembly Specifications

Gun Size in.	Sleeve SAP No.	Sleeve OD in. (mm)	Sleeve ID in. (mm)	Minimum Centralizer OD* in. (mm)	Propellant Mass** lb/ft (kg/m)
2 1/2	58179	3.11 (78.99)	2.50 (63.50)	3.50 (88.90)	2.01 (2.99)
2 3/4	58190	3.36 (85.34)	2.75 (69.85)	3.76 (95.50)	2.01 (2.99)
3 1/8	58193	3.72 (94.48)	3.21 (81.53)	4.13 (104.90)	2.33 (3.46)
3 3/8	58195	4.02 (102.10)	3.38 (85.85)	4.40 (111.76)	2.67 (3.98)
4	58196	4.71 (119.63)	4.05 (102.87)	5.09 (129.28)	3.68 (5.47)
4 5/8	57514	5.21 (132.33)	4.72 (119.88)	5.63 (143.00)	3.33 (4.96)
5 1/8	101240496	5.81 (147.63)	5.175 (131.44)	6.18 (156.97)	3.99 (5.94)
5 3/4	215347	6.45 (163.83)	5.75 (146.05)	6.95 (176.53)	4.68 (6.97)
7	58159	7.88 (200.15)	7.09 (180.08)	8.25 (209.55)	7.01 (10.43)

StimGun™ sleeves are manufactured in standard 3 ft (0.91 m) lengths and are rated for a service temperature of 350°F (177°C). The sleeves are non-reactive to most commonly used oilfield fluids, including acids.

*The StimGun sleeve is an oxidizer that is bonded with a resin or plastic, making it quite brittle; therefore, it is required that the perforating gun be centralized to this minimum OD to provide protection when the assembly is in the wellbore.

**CO₂ gas generated from a propellant burn is estimated at 7.06 scf per kg of material at standard conditions.

Retaining Collar Assembly Specifications

SAP No.	Gun Size in.	OD in. (mm)	ID in. (mm)	Sleeve OD in. (mm)	Minimum Centralizer OD in. (mm)	Flow Area through Collar in. ² (mm ²)
101233588	2 1/2	3.38 (85.85)	2.56 (65.02)	3.11 (78.99)	3.51 (89.15)	1.10 (709.67)
101233598	2 3/4	3.63 (92.20)	2.81 (71.37)	3.36 (85.34)	3.76 (95.50)	1.15 (741.93)
101233215	3 1/8	4.02 (102.10)	3.18 (80.77)	3.72 (94.48)	4.13 (104.90)	1.21 (780.64)
101240387	3 3/8 12 spf	4.27 (108.45)	3.43 (87.12)	4.02 (102.10)	4.40 (111.76)	1.71 (1103.22)
101222271	3 3/8	4.27 (108.45)	3.43 (87.12)	4.02 (102.10)	4.40 (111.76)	1.71 (1103.22)
101233163	4	4.96 (125.98)	4.06 (103.12)	4.71 (119.63)	5.09 (129.28)	2.00 (1290.32)
101227396	4 5/8	5.50 (139.70)	4.69 (119.12)	5.21 (132.33)	5.63 (143.00)	2.00 (1290.32)
101239368	5 1/8	6.05 (153.67)	5.19 (131.82)	5.81 (147.32)	6.18 (156.97)	2.21 (1425.80)
101303748	5 3/4	6.70 (170.18)	5.82 (147.82)	6.45 (163.83)	6.95 (176.53)	2.70 (1741.93)
101292913	7	8.15 (207.01)	7.07 (179.57)	7.88 (200.15)	8.25 (209.55)	3.75 (2419.35)

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

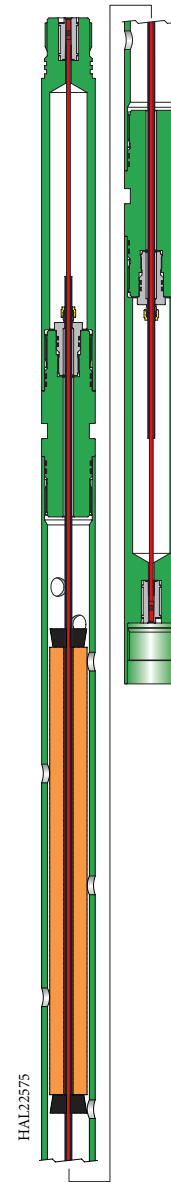
Propellant Stimulation Tool Assembly

The stimulation tool assembly is a process that uses the same solid propellant technology employed by the StimGun™ assembly to stimulate existing perforations, slotted liners, or openhole sections when it is not desirable to add perforations. The stimulation assembly is assembled with propellant and standard detonating cord to provide the ignition system. When the detonating cord is ignited, the solid propellant breaks up into many smaller pieces, allowing it to burn very rapidly and producing CO₂ gas. This gas enters the perforations, breaking through any damage around the perforation tunnel, creating short fractures near the wellbore. As the gas pressure in the wellbore dissipates, the gas in the formation surges back into the wellbore, carrying with it damaging fines. Stimulation assembly jobs are designed using Halliburton's PulsFrac™ simulator, which assists in achieving consistent results without compromising safety or wellbore integrity.

Operation

The stimulation assembly consists of a solid stick of gas-generating propellant-potassium perchlorate with detonating cord run through it. The assembly can be conveyed on either wireline, coiled tubing, or threaded pipe. Standard perforating safety, arming, and firing procedures are used. The industry standard detonating cord provides consistent, reliable, and instantaneous ignition over the entire length of the stimulation assembly.

When deployed on coiled tubing or threaded pipe, the stimulation assembly is run inside a vented hollow steel carrier.



Stimulation Assembly

Features

- Improved production or injectivity with greater uniformity in the perforation breakdown
 - Improved connectivity to the undamaged reservoir matrix by extending fractures past damage induced by either drilling or completion practices
 - Stimulation of near-wellbore on zones that cannot be treated conventionally with acid or hydraulic fracturing due to undesirable production from nearby gas cap or water contact
 - Excellent pre-hydraulic fracture treatment assists in keeping perforations open and minimizes tortuosity effects resulting in lower breakdown pressures and horsepower requirements on location
 - Selective stimulation of long openhole horizontal sections
- This assembly is currently available in 2 7/8 OD ported carriers. Contact TCP technology for more information.

Stimulation Tool Assembly Specifications

SAP No.	Tool Size in.	Upper Thread Size and Type	Lower Thread Size and Type	Overall Length ft (m)	Makeup Length ft (m)	Maximum OD in. (mm)	Temperature Rating ¹ °F (°C)	Pressure Rating ¹ psi (bar)	Tensile Rating ² lb (kg)	Redressable	Weight (No Explosives) lb (kg)
101566827	2 7/8	2 7/8 Gun Pin	2 7/8 Gun Box	26.25 (8.0)	25.98 (7.92)	2.88 (73.2)	300 (149)	8500 (578)	110,800 (50 250)	Yes	249 (113)

¹ Based on control line collapse rating

² 2 7/8 gun box at top sub

POWR*PERFSM Perforation/Stimulation Process

POWR*PERFSM perforation/stimulation process is a completion process that uses proven extreme overbalance perforating techniques. This method is coupled with the release of an erosive agent at the moment of VannGun[®] detonation to clean and scour near-wellbore damage and enhance conductivity of fractures created by extreme overbalance perforating.

Features

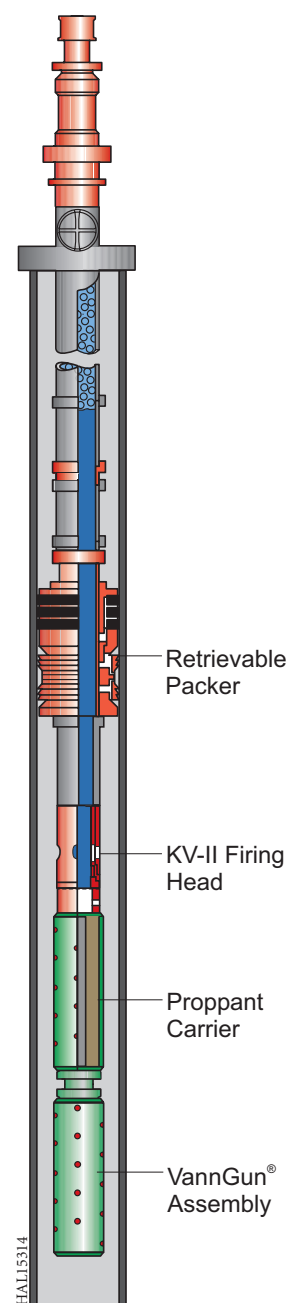
- Overcomes skin damage in low pressure, high permeability wells
- Can be a useful pre-frac evaluation tool
- Applicable to both new wells and wells with nearby water or gas
- Compatible with all casing sizes and tubulars

Operation

The POWR*PERF tool is run as a normal part of the completion assembly. A non-damaging fluid is added to the tubing to serve as a medium for carrying the bauxite into the formation. After the assembly has been positioned across the producing zone, the tubing is energized with nitrogen gas to create a pressure gradient of no less than 1.4 psi/ft (31 bar/m). A model KV-II firing head, which has been pre-set to function at the desired bottomhole pressure, detonates the VannGun assembly and opens flow ports to allow the fluid and nitrogen to rush toward the formation.

The fluid “spear” is driven ahead of the expanding nitrogen gas into the formation at velocities that can exceed 140 bbl/min. The bauxite material is ejected into the fluid stream at the moment of detonation by specially designed shaped charges. The combination of fluid and bauxite serves to fracture, erode, and scour all of the perforations, and to further enhance the fractures created by extreme overbalance perforating.

**POWR*PERF is a service mark/trademark of Marathon Oil Company and licensed by Halliburton.*



POWR*PERFSM
Perforation/Stimulation Process

PerfStim™* Process

The PerfStim™ process uses an extreme overbalanced condition to simultaneously perforate and stimulate a well. The process not only produces cleaner perforations in low-pressure formations, it also initiates fractures in the formation, reducing stimulation costs.

Features

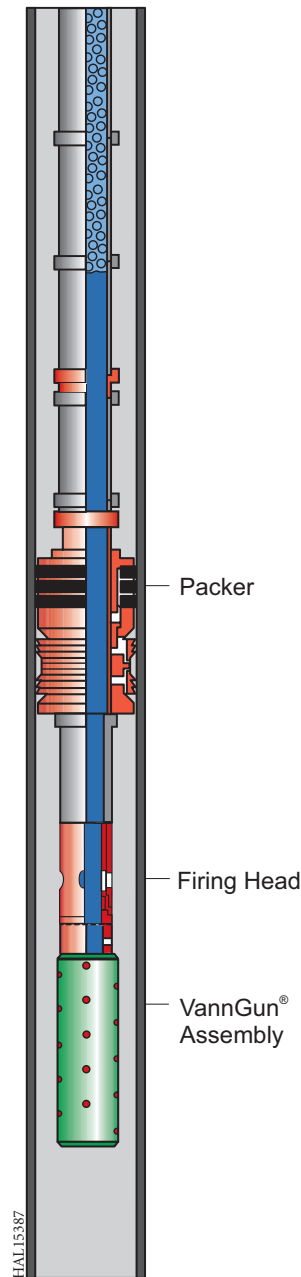
- Gets production flowing quickly
- Saves rig time
- Helps develop negative skin factors
- Gives an early evaluation of a well's potential
- Uses less horsepower than full scale stimulations

Operation

In the PerfStim process, an extreme overbalanced condition is created—pressure gradients of at least 1.4 psi/ft (31 bar/m).

When the perforating gun fires, the pressure drives a fluid “spear” into the perforation at velocities exceeding 3,000 ft/sec (900 m/sec) and at rates that can exceed 140 bbl/min. Crushed zone damage is removed and small fractures are created—improving initial production and treatment results.

**The PerfStim process is licensed to Halliburton by Oryx Energy Company. PerfStim is a trademark of Oryx Energy Company.*



Halliburton's VannSystem® toolstring is used in typical PerfStim™ procedures. The tubing conveyed system helps to allow for the highest possible bottomhole pressures. A small volume (usually no more than a 300-ft column) of non-damaging fluid is placed above the gun, then pressured with nitrogen. If needed, a liquid can be bullheaded on top of the nitrogen column. The VannGun® perforating assembly can remain attached to the toolstring or dropped into the rathole after the guns have been fired.

Oriented Perforating

The benefits of sand prevention or improved stimulation performance can be enjoyed using any of Halliburton's leading oriented perforation technologies. Halliburton oriented perforating solutions can be deployed using a wide range of conveyance methods providing reliable world-class results.

G-Force® Precision Oriented Perforating System

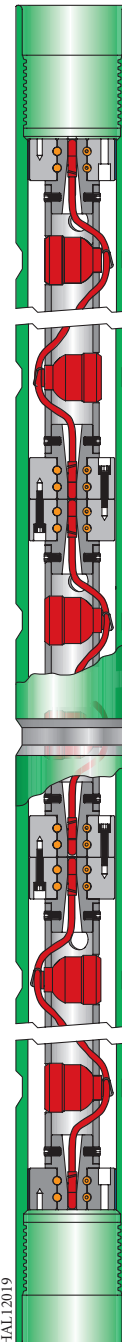
Historically, oriented perforating was attempted via external orienting devices and weights (external to the gun and exposed to the casing environment). In the externally oriented systems, there is added friction created by the guns moving axially down the casing wall, which can significantly work against the orienting mechanism. In addition, doglegs and other discontinuities during the deployment can cause loss of orientation.

It was conceived that if the rotating device could be taken inside the protective environment of the carrier, adverse factors that can significantly decrease the ability to orient the guns in a desired direction could be overcome, if not completely eliminated.

Halliburton's G-Force® system is comprised of an internal orienting charge tube assembly and gun carrier, which allows perforating in any direction irrespective of the gun's position relative to the casing.

Features

- Able to go through restrictions not possible with older systems
- Since the orienting mechanism of the internal orienting system is contained within the gun carrier, the fundamental orienting design is unaffected by potential restrictions in the completion string
- Able to run through tubing and orient in casing
- No need for fin tandems, eccentric tandems, and swivel subs
- Increased orientation accuracy: the operating range will be for wells of 25° deviation and greater. For deviated wells, the accuracy range is $\pm 5^\circ$
- Compatible with live well intervention systems such as the AutoLatch™ connector, ratchet connector, and the modular gun system
- Gun assemblies can be centralized in the casing
- Can be deployed on coiled tubing, wireline, slickline, or jointed pipe
- No external weight bars required means no gaps between loaded sections and no lost shots



G-Force® System

3.375-in. G-Force® System Specifications

SAP No.	Thread Size and Type in. (mm)	Gun OD in. (mm)	Length ft (m)	Maximum Shot Density	Shot Phasing	Perforation Planes	Vertical Shot Spacing in. (mm)	Maximum Diameter after Detonation in. (mm)	Distance from Top End of Gun to First Shot in. (mm)
101300078	2 7/8 (73.03) 6P Acme	3.375 (85.73)	22 (6.7)	4 spf (13 spm)	180°	2	2.8 (71.12)	3.42 (86.87)	8.50 (215.90)

SAP No.	Tensile Load lb (kg)	Collapse Pressure psi (bar)	Tandem Tensile Load lb (kg)	Survival Test Medium
101300078	238,000 (107 954)	25,000 (1725)	355,000 (161 025)	Fluid

4.625-in. G-Force® System Specifications

SAP No.	Thread Size and Type in. (mm)	Gun OD in. (mm)	Length ft (m)	Maximum Shot Density	Shot Phasing	Perforation Planes	Vertical Shot Spacing in. (mm)	Maximum Diameter after Detonation in. (mm)	Distance from Top End of Gun to First Shot in. (mm)
101305067	4.00 6P Acme (101.60 Acme)	4.625 (117.48)	22 (6.7)	4 spf (13 spm)	180°	2	2.8 (71.12)	4.69 (118.87)	8.50 (215.90)

SAP No.	Tensile Load lb (kg)	Collapse Pressure psi (bar)	Tandem Tensile Load lb (kg)	Survival Test Medium
101305067	403,000 (182 783)	20,000 (1378.95)	563,000 (255 372)	Fluid

G-Force® System Specifications

SAP No.	Gun OD in.	Length ft	Maximum Shot Density	Shot Phasing	Perforation Planes	Maximum Shots per Gun	Distance to First Shot in.	Charge
101450833	4 5/8	16.00	4 spf	10°-350°	2	52	7.94	101466192 - 39g DP HMX
101498446	4 5/8	22.00	4 spf	0°-180°	2	76	9.94	101210636 - 39g Millennium™
101435773	4 5/8	22.00	4 spf	0°	1	75	8.60	101210636 - 39g Millennium
101426443	4 5/8	22.00	4 spf	10°-350°	2	75	8.60	101210636 - 39g Millennium
101390900	4 5/8	22.00	4 spf	0°-180°	2	75	8.60	101210636 - 39g Millennium
101294752	3 3/8	4.83	4 spf	10°-350°	2	14	9.50	101366678 - 21g Millennium
101640605	3 3/8	4.83	4 spf	180°	1	14	9.50	101366678 - 21g Millennium
101515354	3 3/8	22.00	4 spf	0°-180°	2	72	9.25	101371884 - 25g Super DP
101407434	3 3/8	22.00	4 spf	0°-180°	2	72	9.25	101366678 - 21g Millennium
101406739	3 3/8	22.00	4 spf	0°	1	72	9.25	101366678 - 21g Millennium
101295030	3 3/8	2.00	4 spf	0° OR 180°	1 or 2	2	10.00	101366678 - 21g Millennium
101630791	2 7/8	16.00	4 spf	10°-350°	2	56	7.74	101571815 - 11.1g G-Force® HMX
101621606	2 7/8	4.00	4 spf	0° OR 180°	1 or 2	12	7.62	101571815 - 11.1g G-Force HMX
101600677	2 7/8	22.00	4 spf	10°-350°	2	78	7.62	101571815 - 11.1g G-Force HMX
101563379	2 7/8	22.00	4 spf	0° OR 180°	1 or 2	78	7.62	101571815 - 11.1g G-Force HMX

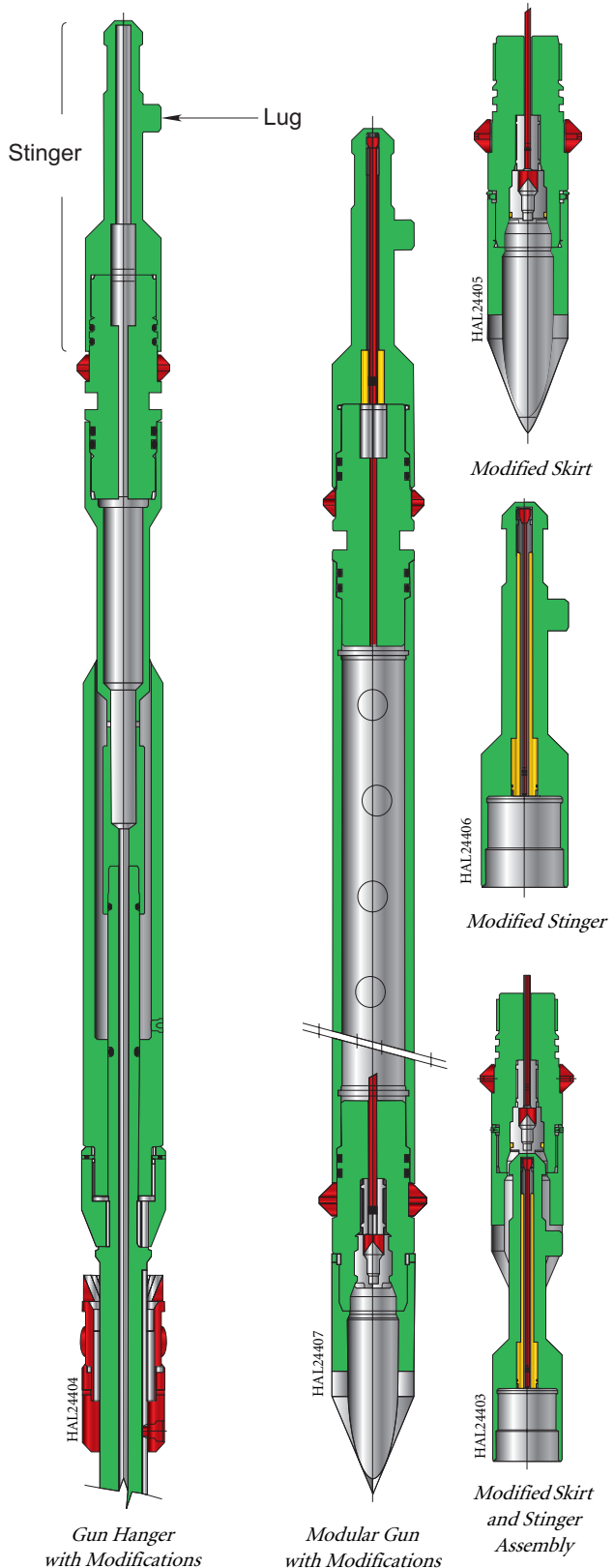
Oriented Perforating with Modular Guns

There are several methods available for orienting perforating guns in horizontal and highly deviated wells, such as the G-Force® system. In vertical wells it can be more difficult to orient perforations in a particular direction. One proven method is the oriented Modular Gun System.

To accomplish this, a standard auto-J gun hanger is used in conjunction with specially modified skirts and stingers for the modular guns. The stingers are made with locating lugs, and the skirts are modified to locate on the lugs.

The gun hanger is run in the well and set on wireline using normal procedures. A gyro steering tool is then run to determine the direction of the locating lug on the gun hanger stinger. The skirts and stingers on the remaining gun modules are then adjusted accordingly so that when they are landed, the shots will be oriented to the desired direction.

This system has been used successfully in standard applications when perforating for production, and in special applications such as shooting from a relief well into a well that is blowing out.

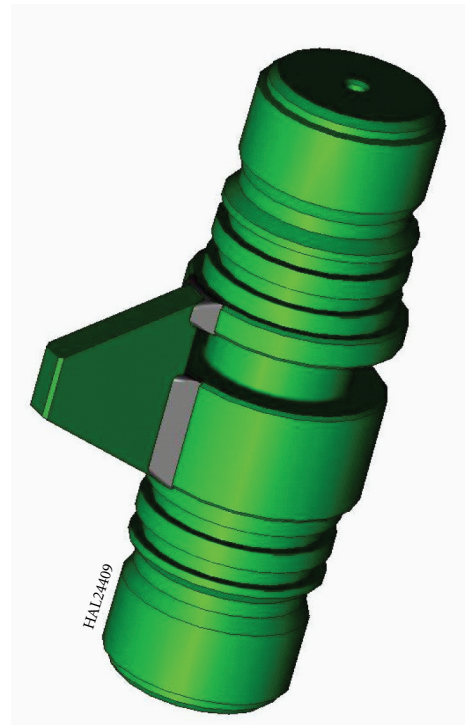


Finned Orienting Tandem

As perforating guns are run into the well, and transition from a vertical to deviated position occurs, the fin will orient to the high side of the wellbore. The finned tandem works on the principle of gravity whereby the weight of the perforating guns rotates towards the lowest side of the wellbore and is aided by the additional standoff from the casing wall created by the connected fin.

Features

- Built with an adjustable ring, which makes it possible to orient the shots in the casing to a predetermined direction
- Tensile strength of finned tandem equivalent to the standard gun connectors
- Available for most gun sizes
- Cost effective perforation orientation solution



Finned Orienting Tandem

Eccentric Orienting Tandem

For several years, Halliburton successfully ran oriented perforating jobs using a fin welded to a gun connection every 30 ft in conjunction with swivel assemblies.

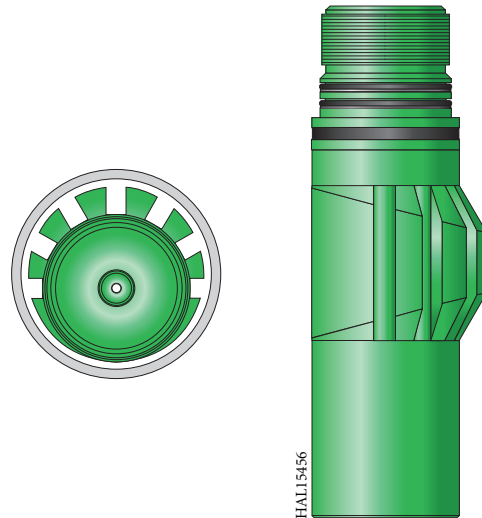
Now, a second method for orienting perforations referred to as eccentric subs has been developed. The eccentric sub is run in place of the finned tandem still in conjunction with a swivel assembly.

The eccentric tandem works on the same principle as the fins. As the guns are run into the well, and transition from a vertical to deviated position occurs, the natural tendency is for the fin to orient to the high side of the wellbore. The eccentric tandem works on the same principle. The eccentric tandems allows for a greater degree of accuracy with an overall smaller profile.

Features

Eccentric subs allow perforating guns to be oriented in situations where the fin system is not ideal due to restrictions in the casing, fishing concerns, welding concerns, etc. Several tests and wells have been perforated using this new technique in the North Sea area and the Gulf of Mexico.

- Built with an adjustable ring, which makes it possible to orient the shots in the casing to a predetermined direction
- Tensile strength of the eccentric sub equivalent to the standard gun connectors
- Available for most gun sizes
- Eliminates the use of welded fins on the connectors



Eccentric Orienting Tandem

Special Applications

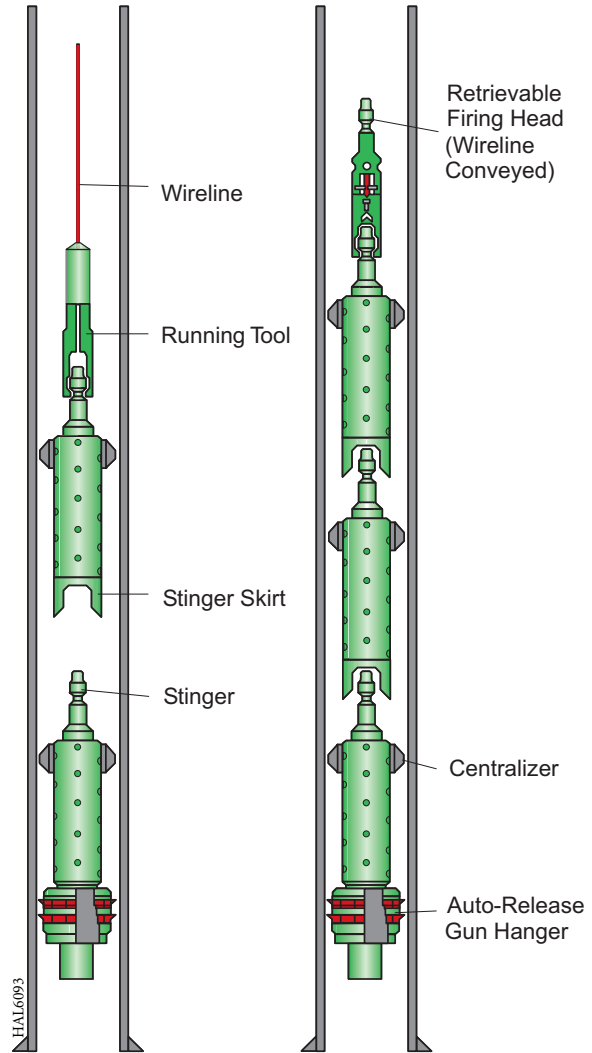
Modular Gun System

Through a special arrangement of perforating equipment, Halliburton's modular gun system permits the optimum number of guns to be removed via slickline or electric line so larger intervals can be perforated simultaneously. In fact, the modular gun system is so innovative, Halliburton has patented* this unique system, proving once again our commitment to bring the latest technology to the wellsite.

The modular gun system is run by Halliburton perforating specialists who know the equipment, know your well, and know the best techniques to fit your particular application. And of course, the modular gun system is backed by Halliburton's worldwide network of technical support, reliable equipment, and innovative performance—all of which are ready to go wherever and whenever needed.

Features

- Ideal for monobore completions
- With the modular gun system, you are able to stack an optimum number of guns downhole for perforating the maximum interval
- Several features make the modular gun system your best choice for perforating under a wide range of conditions
 - The guns are retrievable or can be left at the bottom of the hole
 - The system allows perforating in either underbalanced or overbalanced conditions over the entire interval
 - Wide range of gun sizes (2- to 7-in. OD) permits deployment over a wide range of casing, from 3 1/2 to 9 5/8 in.
- No rig is required—the system is ideal for rigless completions
- The modular gun system can be deployed via coiled tubing, electric wireline, or slickline, as well as with conventional tubing or drillstring
- The modular gun system allows a zone to be perforated and tested with no downhole restrictions below or above the packer
- Proven VannSystem® guns and firing heads are used in the modular gun system



Modular Gun System Configuration

*US Patent Number 5,366,014

The Modular Gun System Process

The modular gun system allows operators to deploy multiple gun sections to perforate long intervals. The gun modules are deployed downhole individually and stacked on each other at the perforating zone until the appropriate length is achieved with the lowermost gun module being supported by the gun hanger. This method avoids any gun length restrictions caused by the lubricator. The auto-release gun hanger positions the perforating assembly and allows it to remain adjacent to the desired interval. The guns are fired, via a pressure-actuated firing head, and are then, automatically released to the bottom of the hole where they can later be retrieved or left in the hole.

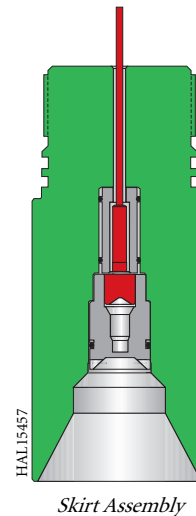
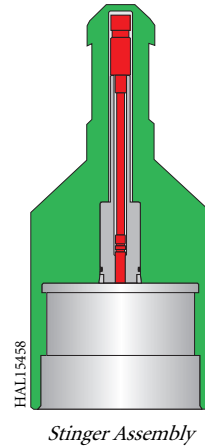
The modular gun system is ideal for use in wells with rathole length restrictions and rigless completions.

Rathole Length Restriction

In this application, insufficient rathole length causes the uppermost gun modules to remain adjacent to the perforated interval after they are fired—where they may interfere with production from the well. The modular gun system allows the guns to be retrieved in sections without having to kill the well.

Rigless Completion

On wells where the completions are installed with wireline or coiled tubing, the modular gun system is the preferred method for perforating. No rig is required, saving both time and money.

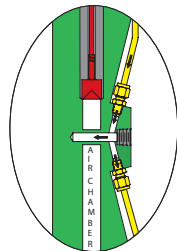


Select Fire™ Systems

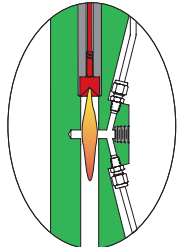
The Select Fire™ system offers flexibility in perforating, testing, and evaluating multiple zones in one trip. The Select Fire system saves rig time and tool charges to help multiply profits.

Features

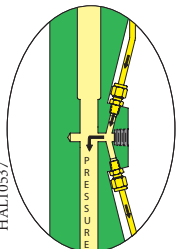
- Perforating and testing several individual zones — one at a time
- Selecting the order zones are perforated
- Customizing gun configurations for various applications
- Available for all VannGun® assemblies 2-in. and larger
- Helps develop essential information about the reservoir — potentially saving hundreds of thousands of dollars
- Saves rig time and tool charges to help multiply profits



Before Firing

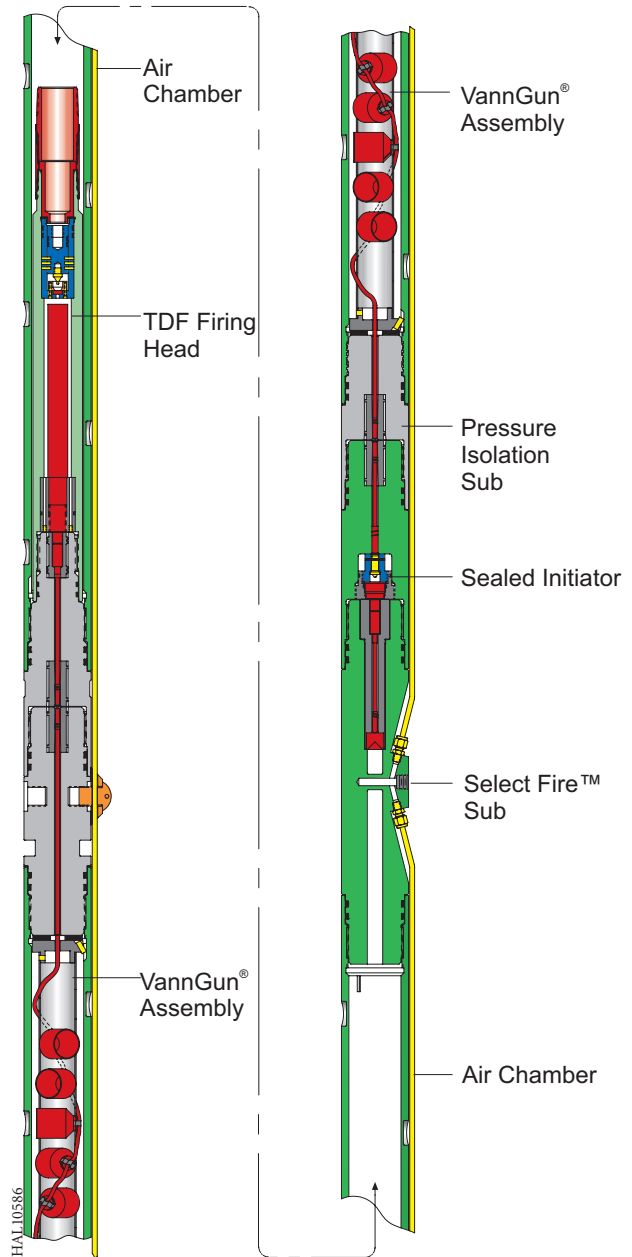


When gun #1 fires, the explosives train is continued to the Select Fire™ Sub, which fires a shaped charge downward.



Pressure may now enter into the air chamber. (Note: the isolation sub is used to prevent pressure from going upward from the Select Fire Sub).

Select Fire™ Sub Operation



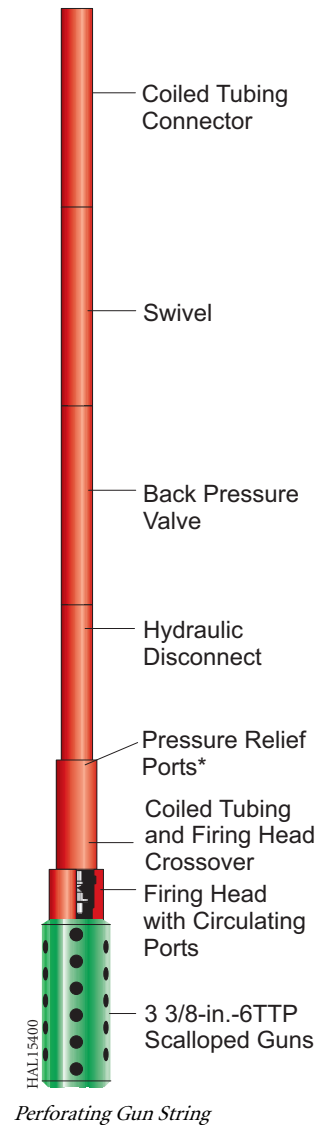
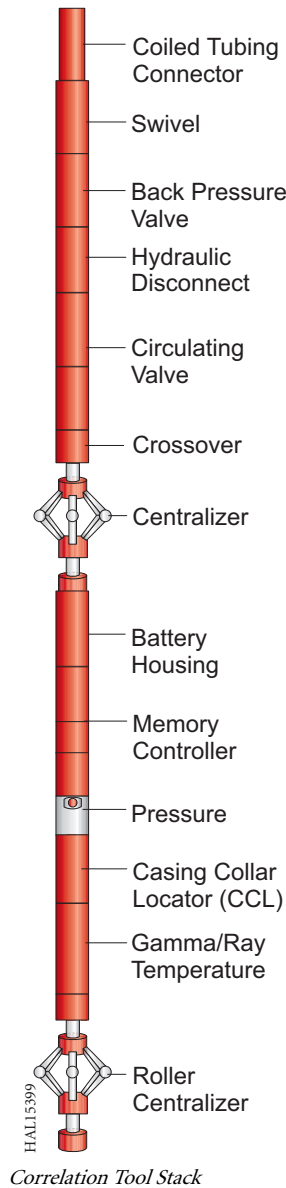
Select Fire™ Tubing Conveyed Perforating System

Coiled Tubing Conveyed Perforating

Conveying perforating guns to the zone of interest with coiled tubing has been effectively used for many years in a variety of applications. Benefits include faster run-in times when compared to conventional methods. And the guns can be detonated either with wireline or a pressure-activated firing head. Some of the applications include:

- **Perforating in Underbalanced Conditions**
Underbalanced conditions occur when hydrostatic pressure in the well is lower than formation pressure. Perforation under these conditions allows increased flow from the formation, which helps clean the perforations and helps reduce near-wellbore damage
- **Horizontal Well Perforating**
Coiled tubing conveyed perforating could be deployed in horizontal portions of the well where conventional methods of perforating are impractical or impossible
- **Coiled Tubing Used as the Production String**
The coiled tubing that conveys the perforating guns can also be used as the production tubing after well completion

Special features include an automatic-release gun hanger, which allows the coiled tubing to detach from the perforating guns before they are fired, avoiding damage to the coiled tubing. A modular gun system is also available in which the perforating guns are loaded at the surface, deployed downhole individually, and stacked at the perforating zone. This method helps eliminate any gun length restrictions caused by the lubricator.



*Pressure relief ports are added to the BHA for coiled tubing perforating jobs to help eliminate the possibility of a pressure increase due to thermal expansion in a closed chamber.

DrillGun™ Perforating Systems

Halliburton has developed the DrillGun™ assembly to be a drillable perforating system that provides reliable, quality performance while lowering overall wellsite costs by:

- Eliminating the high costs associated with wireline services
- Eliminating the need to switch to a mud system for workovers

The DrillGun perforating system is a new method that combines rugged, reliable Halliburton perforating components with the versatility of drillable materials. It is this type of innovative design that has made Halliburton the leader in perforating charge performance and delivery systems. Now, with the DrillGun perforating system, you have a drillable, disposable system that helps save you two of the most valuable commodities at the wellsite—time and money.

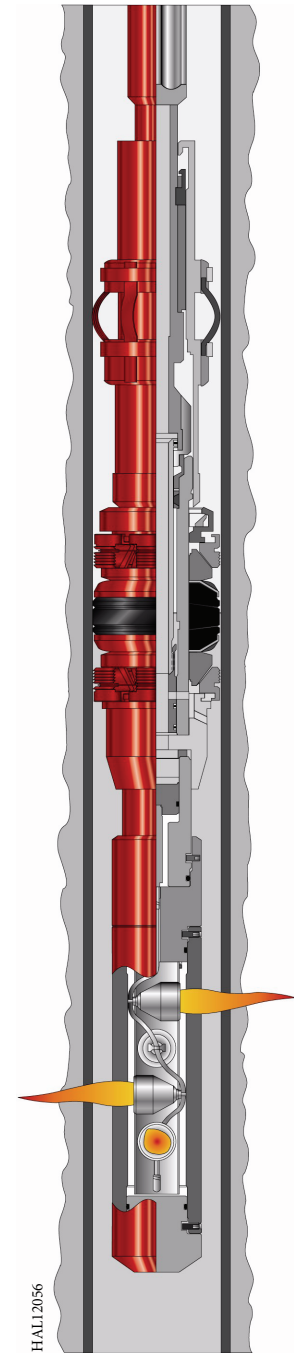
Components of the drillable perforating system are the drillpipe conveyed to the zone of interest; thereby eliminating mobilization or demobilization charges normally associated with wireline units. And, since no mud system is needed, clear fluids can remain in place for workover operations. Once in place, the firing head is actuated by pressure applied through the tubing. After perforating, the gun can be drilled out with conventional drilling methods.

The drillable perforating system is ideal for:

- Single-trip perforating, packer placement, and cementing on tubing
- Cementing and perforating in underbalanced conditions
- Plug-to-abandon operations
- Workover cementing with clear fluids
- Plugback set on wireline
- Limited entry drill stem testing

Components of the drillable perforating system include:

- Aluminum perforating gun
- High-performance, perforating charges
- Halliburton's industry-proven EZ Drill® SVB packer



HAL12056

DrillGun™ Assembly

DrillGun™ Perforating System - Quick, Economical Solution For Perforating In Unusual Conditions.

Savings on Rig Time

Operator's challenge—Carrizo Oil & Gas, Inc. needed to perform a squeeze job on a South Texas well. The customer had already switched to a lighter drilling fluid and did not want the high cost of changing to a mud system. As a result, the well would have to be perforated underbalanced.

Halliburton's solution—To meet this challenge, Halliburton recommended its DrillGun system.

Economic value created—As a result, Carrizo was able to perform the squeeze job without having to replace the lighter drilling fluid with an expensive mud system. This procedure saved rig time and the expense of a fluid change for a total economic value to the customer of \$20,000.

Block Squeeze Application

Operator's challenge—An operator working in the Permian Basin had to perform three block squeezes in a 7 5/8 in. liner from 14,400 ft to 14,800 ft. A primary cement job had not been possible, so instead of cement behind the casing, there was 15.5 ppg drilling mud. The well fluid was 10 ppg brine water. However, it would not be necessary to change the well fluid to 15.5 ppg drilling mud to cement.

Halliburton's solution—Halliburton logged the first DrillGun system on depth, perforated and performed the cement job at 4,230 psi underbalanced. For the next two DrillGun system runs, we tagged the first retainer and located it on depth to perform the squeeze.

Economic value created—The three aluminum perforating guns added only one hour each to the drill-out time. The customer estimates that this procedure saved \$52,000.

Plug-to-Abandon

Operator's challenge—To plug a well before abandoning it, an operator in Chambers County, Texas needed to perforate six zones.

Halliburton's solution—Halliburton recommended using its DrillGun rather than employing electric-line perforators which would normally be selected for the project. The first DrillGun system was started in the well on Sunday evening and was set the next day at a depth of 13,050 ft. The bottom zone was then squeezed. After the procedure was completed, the setting assembly was pulled out of the hole. It went back in with the second stage, and the job was performed at 8,590 ft. The next day, the final four jobs were run at 5,500 ft, 2,615 ft, 500 ft, and 350 ft, respectively.

Economic value created—All six stages were completed in 2 1/2 days. If electric-line perforators had been used, the total job would have taken up to six days. By using the Halliburton DrillGun system, the operator saved four days of rig-associated costs, consultants, and fluid standby time. An additional savings was realized by using the perforating DrillGun system instead of more expensive electric-line charges. The resulting estimated economic value to the customer is \$24,200.

DrillGun™ Assembly Specifications

SAP No.	Thread Size and Type in. (mm)	Maximum OD in. (mm)	Maximum Operating Pressure psi (bar)	Minimum Operating Pressure psi (bar)	Temperature Rating °F (°C)	Maximum Overall Length ft (m)
101288693 Aluminum	2 7/8 (73.03) EUE 8 Rd	4.00 (101.6)	15,000 (1020)	3,500 (241)	300 (148.9)*	4.40 (1.341)
101288692 Aluminum	2 7/8 (73.03) EUE 8 Rd	7.00 (177.8)	12,000 (816)	3,500 (241)	300 (148.9)*	4.40 (1.341)
101292015 Composite	2 7/8 (73.03) EUE 8 Rd	3.625 (92.1)	15,000 (1020)	3,500 (241)	300 (148.9)*	3.95 (1.204)

*For use in wells above 300°F (148.89°C), consult a Halliburton representative.

Setting Tools for the Auto-Release Gun Hanger

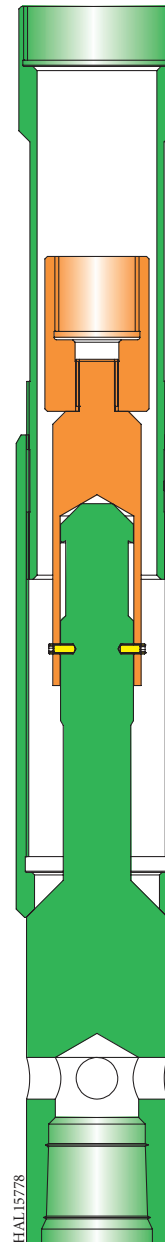
Running and Retrieving Tools

The running and retrieving tools for the modular gun system and the auto-release gun hanger gives customers flexibility in the conveyance of these tools in the well. There are four basic running tools that have been run with these systems: explosive set, jar down, hydraulic, and rotational set. Most of the tools are for wireline and slickline deployment of the systems. The on/off tool requires rotation to operate and is limited to tubing conveyed applications. All of these tools are reusable with a minimal amount of redressing.

Application

The running and retrieving tools are used for setting gun hangers in position, running modules, and retrieving modules. The tools break down into four categories: explosive set, jar down and jar up, hydraulic, and rotational set. There are many tools that can be used with the modular system. This manual has been written for the tools specially designed for the modular gun system or those recognized as a usable tool.

- Explosive set
 - Adapter kit for Baker #10 setting tool
 - Adapter kit for Baker #20 setting tool
- Jar down
 - Otis® SB and RB shear release and running tool
 - Camco JDC and JUC
- Hydraulic
 - Hydraulic JDC running and retrieving tool
- Rotational set
 - Right hand release on/off tool



*Running Tool Assembly Modular
3.12 in. OD for Baker #20 Setting Tool*