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Module 12
GUN & CHARGE PERFORMANCE

CONTENT

- *Definition of performance*
- *API 19b Recommended Practice*
- *Gun performance*
- *Charge performance*

DEFINITION OF PERFORMANCE

Gun and charge performance are inherently linked even though charge performance is not necessarily a ***complete*** representation of gun performance

- Operators define performance in terms of the resulting well productivity
- Service companies define performance in terms of the gun/charge functioning as being deployed, fired and retrieved safely
- Predictions of performance such as charge's penetration, EHD and inflow predictions are only estimations
- Estimations of the impact of gun performance on well productivity can be made via simulations

API 19b RECOMMENDED PRACTICE FOR EVALUATION OF WELL PERFORATOR

- 19b version issued in 2001
- Defines test conditions and specifications for the gun system and charges
- All report forms and data sheets to be filled up with the results of the test
- It also covers practices for inflow, permeability and hight temperature test conditions
- Berea sandstones and concrete targets are specified in terms of slurry formulations, curing times, target configuration and compressive strength

GUN & CHARGE PERFORMANCE

Gun performance include the correct functioning of all its components such as connectors, firing subs, ignitor, charges and safety mechanisms

Reports and studies can be use as references of gun performance along with track records of the supplier and publications

Charge performance refers to the performance of a specific type of charge as compared with the reference norm represented by the American Petroleum Institute API 19b norm

Courtesy of Schlumberger

GUN & CHARGE PERFORMANCE (Continued)

Charge performance is usually specified along with *some* performance features

- This example shows the specifications for Halliburton "MaxForce FRAC" charges
- The only performance result reported is for the entry hole diameter variation EHV (Last column)
- The data also specify the characteristics of the target but no performance

Gun Size (in.)	Charge Name	Explosive Load (g)	Explosive Type PN	Target Casing Specifications	EHD (in.)	EHV
2¾-inch 6spf 60°	150 MaxForce®-FRAC	15	RDX-102745134	4½-inch 13.5ppf P-110	0.35	2.4%
			HMX-102740045	4½-inch 13.5ppf P-110	0.35	2.4%
3⅛-inch 6spf 60°	230 MaxForce®-FRAC	23	RDX-102736069	4½-inch 13.5ppf P-110 5½-inch 23ppf P-110	0.41 0.40	2.3% 5.9%
			HMX-102732983	4½-inch 13.5ppf P-110 5½-inch 23ppf P-110	0.42 0.42	3.0% 3.8%
	210 MaxForce®-FRAC	21	RDX-102045430	4½-inch 11.7 L-80 5½-inch 23ppf P-110	0.46 0.43	4.7% 11.7%
			HMX-102127122	4½-inch 11.7 L-80 5½-inch 23ppf P-110	0.49 0.45	5.8% 13.8%
3⅜-inch 6spf 60°	230 MaxForce®-FRAC	23	RDX-102736069	5½-inch 23ppf P-110	0.40	3.5%
			HMX-102732983	5½-inch 23ppf P-110	0.40	4.3%
	210 MaxForce®-FRAC	21	RDX-102045430	5½-inch 17ppf L-80	0.43	13.1%
			HMX-102127122	5½-inch 17ppf L-80	0.45	11.7%

Courtesy of Halliburton

GUN & CHARGE PERFORMANCE (Continued)

Charge performance is usually specified along with *some* performance features

- This example shows the specifications for Schlumberger charges
- The performance results reported are for EHD, Burr and charge penetration
- The data also specify the characteristics of the target such as strength

Charge	Explosive type, maximum weight (g)	Shots per foot, phasing (°)	Entrance hole † (in.)	Burr avg /max (in.)	Area open to flow ($in.^2/ft$)	Penetration † (in.)	Temperature ‡ (°F)	Target strength (psi)	Test date
34B HyperJet II	RDX, 21.7	12, 135/45	0.39	0.10		19.8	340/240	7020	07-95
34B HyperJet II	HMX, 21.7	12, 135/45	0.39	0.09		22.8	400/300	5816	12-92
34JL UltraJet	HMX, 22.7	12, 135/45	TBD			TBD	400/300		
34JL UltraJet	HTX, 21.0	12, 135/45	TBD			TBD	500/460		
UltraJet 5008	RDX, 25.0	8, 135/45	0.54	0.11/0.22		20.2	340/240	6629	4-00
HyperJet 4505	RDX, 38.8	5, 72	0.57§			37.0§	340/240		
UltraJet 4505	HMX, 38.8	5, 72	0.46§			46.8§	400/300		
PowerJet 4505	HMX, 38.8	5, 72	TBD			TBD	400/300		
51J UltraJet	HNS, 38.5	5, 72	TBD			TBD	500/460		
PowerFlow 4621††	RDX, 19.4	12, 60	0.83‡‡	0.28‡‡	6.49=‡	5.9‡‡	340/240		
PowerFlow 4621	RDX, 19.4	12, 135/45	0.83‡‡	0.28‡‡	6.49=‡	5.9‡‡	340/240		
PowerFlow 4621§§	RDX, 19.4	21, 120/60	0.83‡‡	0.28‡‡	11.40‡‡	5.9‡‡	340/240		
PowerFlow 4621	HMX, 19.4	12, 60	0.83‡‡	0.32‡‡	6.49=‡	5.7‡‡	400/300		
PowerFlow 4621	HMX, 19.4	12, 135/45	0.83‡‡	0.32‡‡	6.49=‡	5.7‡‡	400/300		
PowerFlow 4621§§	HMX, 19.4	21, 120/60	0.83‡‡	0.32‡‡	11.40‡‡	5.7‡‡	400/300		
PowerFlow 5008	RDX, 30.0	8, 135/45	0.98	0.11/0.13	6.03	5.8	340/240	6333	11-99

† 7-in., 32-lbm, L-80 casing for all other charges ‡ Temperature ratings for 1 and 100 hr § Estimated from 4½-in. gun †† Frac Gun ‡‡ Estimated from 4⅝-in. guns
§§

Courtesy of Schlumberger

GUN & CHARGE PERFORMANCE (Continued)

Other considerations include

- Reported charge penetration can be compared using algorithms such as the Thompson correlation. Large (>20%) over estimations are common
- Other important feature is charge debris sometimes reported by the supplier
- Manufacturing reports for the shape charges and explosives can be obtained in particular where the service contractor does not manufacture its own charges
- Physical inspection of a fired gun is a common step which confirms that all charges were fired and there was no gun/charge malfunction

GUN & CHARGE PERFORMANCE (Continued)

Courtesy of NOV

SUMMARY

Gun and charge performance relates to two distinctive sets of equipment; the actual gun and accessories and the charges placed inside the carrier

- Gun performance relates to the actual functioning of the whole system through installation, deployment, firing and retrieval
- Charge performance relates to the actual performance of the shaped charges composed of the liner and the explosives.
- Firing, penetration, entry hole diameter and overall skin generated are the major measures of performance
- API 19b is used as a reference document and serves as the bench mark for shaped charges


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