ANALYZING AND OPTIMIZING BITS PERFORMANCE IN THREE IRAQI OIL-FIELDS

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ABSTRACT

Drilling cost may be reduced significantly by increasing the rate Of penetration (ROP) of rock bit .One way to improve the ROP is the proper selection of the rock bit together with optimum Operating condition.

Three major Iraqi oil-fields have been studied. These fields are; South Rumaila, Bai-Hassan, and kirkuk Oil fields. The Purpose of this study is to select the most proper bit to drill given Section in these fields by using three selection methods, which are the cost per foot method (CPF)(12,13,18), the specific energy method (SE)(13,19,20), and the dull grading method(9,11,13).

Selection criteria showed obvious differences between the theoretical results and field applications. Some weak points in field applications are appeared through this study, such as; premature bit pulling out of the hole, improper bit selection for certain formation, reckless bit dull grading (human error), repeated utilization of X1G bit in consequent formations for all ten wells in Kirkuk Oil-field.

INTRODUCTION

Rotary drilling bits represent the most important part of the drilling string. They located at the lowest part of the string, which perform the action of cutting, shearing, and crushing the formations and then penetrate the beds.

Optimum selection of the bit is probably the most difficult phase of drilling optimization, and there is no adequate answer to the problem of choosing the right bit. Bit selection depends mainly on various factors, such as; type of formation to be drilled, bit design features, dull condition of the last bits, formation abrassiveness, and formation compressive strength(1,3,5,10,16).

Bit selection can not be accomplished with having good field data such as; good logs, bit records enough formation about mud, and hydraulics. Generally, the main aim of all efforts that have been done for bit selection is to increase penetration rate and then to reduced the drilling cost specially in deep and offshore drilling.

Rock bits can be classified generally into tow main types(11,18,21); the first type, is the roller cone bits (i.e. bits with moving parts), which include tow-cones, three-cones, and four cone bits. The tow cone bits are currently manufactured as milled tooth bits only, which restrict their use for soft formations. The four cone bits are manufactured as a milled tooth only and are used for drilling holes of large sizes (more than 26"). The three cone bits (which are the most widely used in drilling oil wells) are either milled tooth bits or tungsten carbide insert bits. The second type of bits are the drag bits (i.e. bits with no moving parts), which include diamond bits, the polycrystalline diamond compact bits (PDC), and the thermal stable polycrystalline bits (TSP).

EXPERIMENTAL WORK

Bit Selection Methods

Cost for foot method (CPF)[12,13]

This is a realistic approach for bit selection, which is based on minimum cost per foot. It relates bit cost, rig cost, trip time, rotating time, and total footage with an optimum relationship;

$$\left[\left[CPF = \frac{C_B + C_R(t+T)}{F} \right]\right] \quad (1)$$

Where C_B is bit cost ($), C_R is rig cost ($/hr), t is the round trip time (hrs), T is the rotating time (hrs), and F is the total footage drilled (ft).

The variety of rock bits available over a wide range of prices and capabilities makes cost per foot approach one of the most important factors in evaluating bit performance and economics. Bit selection by this method is performed by choosing the bit which gives the lowest cost per foot.

It is clear from equation(1) that CPF is inversely proportional to penetration rate, and is highly affected by bit cost and trip time. Therefore, for a given bit cost and hole section, the cost per foot is highly sensitive to any changes in rig cost, trip time, and rotating time. The trip time may not always be easy to determine. If the drilling operation is stopped and the bit is pulled-out for any reason, such a delay time if added will influence effectively the total trip time and will give inaccurate CPF.

Specific energy method[18,19]

This is a simpler and more practical method for bit selection, where the performance of the bit can be evaluated in each section of the formation drilled. Bit performance must be capable of being correlated with cost per foot criteria in order to simplify the analysis of well cost. The (SE) method will provide the drilling personnel with a simple practical onsite method for analyzing bit performance.

Rabia defined the specific energy (SE) as the energy required to remove a unit volume of the rock. It may use any consistent set of units. The specific energy equation can be given by the equation;

$$\left[SE = 20\frac{W \times N}{D \times PR}, \quad lb-in/in^3\right] \qquad (2)$$

or in metric units,

$$\left[SE = 2.35\frac{W \times N}{D \times PR}, \quad MJ/m^3\right] \qquad (3)$$

This method provides an indication of the interaction between bit and the rock, and therefore, it is highly dependent on bit type and design. This means that for a formation of a given strength, a soft formation bit will produce an entirely different value of SE from that produced by hard formation bit. The bit that gives the lowest value of SE in a given section is the most economical bit.

Dull-bit grading method[9,11,13]

The use of dull-bit evaluation method represents a key step for determining the bit wearing in the advance of rock bit technology. Generally, drilling engineers learned through their experience how to examine dull-bits in order to determine what type of bit to be run next, and how it should be run (i.e. what WOB, RPM, flow rate,...etc.).

The International Association of Drilling Contractors (IADC) established the first standardized dull-grading system in 1961. This was the origin of the familiar "Tooth-Bearing-Gauge" format for reporting bit wear in bit records. The original method for grading teeth and bearings wear consisted of 0-4 scale, where 4 represents teeth totally worn (flat or broken) and bearing that were either locked or missing.

In 1963, the dull grading system was extended to 0-8 scale, where 8 represents teeth totally worn out and bearings locked or missing. This system remained essentially unchanged through 1985. In 1985, the IADC decided to develop an improved standardized dull bit grading system that can be applied uniformly throughout the drilling industry. This system provides better description for the dull-bits including the roller-cone bits and fixed cutter bits. The new system provides a code for describing why the bit was pulled out of the hole. In 1992 the grading system expanded again to provide a better picture for the dull-bits.[21]

Optimum Bit Selection from Field Data

Three major Iraqi Oil fields have been selected, which are; South Rumaila, Bai-Hassan, and Kirkuk fields. Field data of these fields have been collected from the bit records of the Iraqi Drilling Company (IDC). The required field data are generally include bit cost, rig cost, actual rotating time, trip time, final footage drilled, penetration rate, bit diameter, bit type and size (IADC Code), weight on bit, rotary speed, and bit dulling conditions.

The lithologies for the three fields have been obtained from South Oil Company (SOC) and North Oil Company (NOC).

Three selection methods are used to select the most proper bit to drill certain depths. These methods are; cost per foot (CPF), specific energy (SE), and dull-grading methods.

CPF values in ($/m) have been calculated using equation (1), while SE values in (MJ/m^3) are calculated using equation (3). The dull-grading values have been taken directly from bit records. The dull method is considered inaccurate method due to human errors in reporting the dullness, which differ from one person to another.

Therefore, bit selection criteria is mainly based on CPF and SE methods. The calculations for the three methods are performed for each bit and the results are presented in the summary part.

Various considerations have been made in this study, which are:

1. Bit selection is based mainly on CPF method, then on SE method, and finally on dullness method.
2. The bit cost (C_B) is taken from the latest price list available.
3. The rig cost (C_R) is assumed to be (7350)$/day.
4. The round trip time (t) is assumed to be 12 hours for each 3000m.
5. Reused bits and core bits are excluded from the study.
6. Depth sections are selected according to the plots of SE vs. depth of each well.
7. The last bit in each well was not considered.

For south Rumaila oil-field

Ten wells have been selected from this field. Each well penetrated several formations starting from Dibdiba formation to Zubair formation. This field has been divided into fourteen depth sections according to SE-depth plots. Bits with different types and sizes have been used to drill the selected ten wells in this field. The calculations of the three methods have been done for all bits and the final comparison is presented in table (1) for the ten wells.

For Bai-Hasan oil field

Ten wells have been selected from this field. Each well penetrated several formations starting from Upper Faris formation to raech Jeribe formation. This field has been divided into eight depth sections according to SE-depth plots. Bits with different types and sizes have been used to drill the selected ten wells in this field. The calculations of the three methods have been done for all bits and the final comparison is presented in table (2) for the ten wells.

For Kirkuk oil-field

Ten wells have been selected from this field. Each well penetrated several formations starting from Upper Red beds of lower Faris formation to raech Jeribe formation of main limestone. This field has been divided into five depth sections according to SE-depth plots. Bits with different types and sizes have been used to drill the selected ten wells in this field. The calculations of the three methods have been done for all bits and the final comparison is presented in table (3) for the ten wells.

SUMMARY OF BIT-SELECTION RESULTS

In this section, the proper bits for different depth sections have been summarized according to the (IADC) code for each field.

For Bai-Hassan Oil Field

No	Depth Section (m)	Bit Size (in)	Bit Type According to (IADC) Code
1	0-300	171/2	1-1-4
2	300-500	171/2 171/2	1-1-4
3	500-820	121/4	1-1-4
4	820-1000	121/4	1-3-4
5	1000-1180	121/4	1-3-4
6	1180-1290	121/4 81/2	1-3-4
7	1290-1350	81/2	1-2-6
8	1350-1420	6	1-3-1

For Kirkuk Oil-Field

No.	Depth Section (m)	Bit Size (in)	Bit Type According to (IADC) Code
1	0-100	26	1-1-1
2	100-350	171/2 121/4	1-2-1 1-1-1
3	350-500	8 3/8	1-3-4
4	500-620	81/2 8 3/8	1-3-4
5	620-720	81/2	1-3-4

For South Rumaila Oil-Field

No	Depth Section (m)	Bit Size (in)	Bit Type According to (IADC) Code
1	0-480	171/2	1-4-7
2	480-700	121/4	1-1-4
3	700-1000	121/4	1-1-5
4	1000-1260	121/4	1-1-4
5	1260-1440	121/4	1-3-4
6	1440-1620	121/4	1-1-5
7	1620-1800	121/4	5-2-7

No	Depth Section (m)	Bit Size (in)	Bit Type According to (IADC) Code
8	1800-2080	121/4 81/2	1-1-4 2-1-5
9	2080-2240	121/4 81/2	1-1-5 1-3-5
10	2240-2360	121/4 81/2	2-1-4 1-3-4
11	2360-2780	81/2	5-1-7
12	2780-3100	81/2	5-1-7
13	3100-3260	81/2	5-2-7
14	3260-3350	81/2	5-3-7

CONCLUSIONS

1. Bit selection criteria showed considerable differences between theoretical results and field data. These differences may attribute to many reasons, such as; premature bit pulling out of the hole, improper bit selection for certain formations, reckless bit dull grading (human error), and repeated utilization of X1G bit in consequent formations for all ten wells in Kirkuk Oil-field.
2. This study conform the following rule of thumbs;

   -SE increases as the depth increases due to the decease in rate of penetration.

   -CPF increases as the depth increases due to the decease in rate of penetration.

RECOMMENDATIONS

There are several points and recommendations that should be considered in fieldwork:

1. The working life of the bit must be used totally through it's run.
2. The IADC code must be considered when selecting bits to drill certain formation.
3. The IADC dull grading system must be used accurately when grading the used bit after pulling it out of the hole.
4. New bits such as PDC bits and TSP bits are recommended to use *to* drill these formations.

NOMENCLATURE

C_B	Bit Cost($)
C_R	Rig Cost ($/hr)
CPF	Cost Per foot ($/ft)
D	Hole Diameter (in)
F	Total Footage Drilled (ft)
N	Rotary Speed (rpm)
PR	Penetration Rate (ft/hr)
SE	Specific Energy (lb-in/in ^{3})
T	Rotary Time (hrs)
t	Round Trip Time (hrs)
W	Weight on Bit(lb)

REFERENCES

1. Bentson H.G., "Rock-bit design, selection, and evaluation.", Smith Tool Co., (1966).
2. Black A.D., Gordan A. Tibbitts, John L. Sandstorm, and Bennie G. Dibona, "Effects of size on three-cone bit performance in laboratory drilled shale.", SPEJ, Aug. (1985).
3. Estes J.C., "Selecting the proper rotary rock bit.", JPT, Nov. (1971).
4. Estes J.C., "Guidelines for selecting rotary insert rock bit." Smith Tool Co. div., Sep. (1974).
5. Farrely M., and Rabia H., "Bit performance and selection.", SPE/IADC #16163, (1987).
6. Gabolde G., and Nguyen J., "Drilling data handbook.", (1991).
7. Garner L.L., "New concepts in rotary drilling bits.", Smith Tool Co. div., May (1969).
8. Goin D.L., and O'Brien T.B., "New bit design drill hard formations faster.", World Oil, June (1970).
9. Hampton S.D., Helmerich, Payne, Grris S., and Winters W.J., "Application of the 1987 roller bit dull grading system.", Hughes Tool Co., SPE/IADC #16143.
10. Hudeck R.R., "How to select and use drill bit profitably.", World Oil, Sep. (1969).
11. Hughes Christensen Co., "IADC dull grading system for roller bits.", (1996).
12. Jackson R.A., "Cost/foot: Key to economic selection of rock bits.", World Oil, June (1972).
13. McGhee D.Y., Gieck J.C. and Riensvold C.H., "The IADC roller bit dull grading system.", IADC/SPE #23938, (1992).
14. McGhee D.Y., Gieck J.C. and Riensvold C.H., "The IADC roller bit classification system.", IADC/SPE #23937, (1992).
15. Moffitt S.R., Pearce D.E.,and Lvie C.R.,"New roller cone bits with unique nozzle designs reduce drilling costs.", IADC/SPE #23871, (1992).

16. Murphy D., "Selecting the right rotary bit in the place to start cutting costs.", Oil and Gas Journal, Feb. 3, (1969).

17. Noevig T., Factors affecting rock bit selection.", Oil Gas-European Magazine, v 15,n 4, (1989).

18. Rabia H., "Oil well drilling engineering, principles and practices.", Graham & Tortman ltd., first edition, (1985).

19. Rabia H., "Specific energy as a criterion for bit selection.", JPT, July (1985).

20. Rabia H., Farrelly M., and Barr M.V., "New approach to drill bit selection.", SPE #15894, (1986).

21. Yassin S.K. Al-Ruba'ei, "Comparison of three methods used in evaluating bit dullness in three Iraqi oil-fields.", M.Sc. thesis, University of Baghdad, (1998).

Table (1) Final comparison table for south Rumaila oil-field

No	Section	Well No.	78	88	91	95	98	100	103	104	119	135
1	0-480	Type	OSC	DSJ	DSJ	DSJ	OSC	DSJ	OSC-3J	TS-2	DSJ	OSC-3A
		Size	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
		CPF	40.23	14.8	26.63	15.7	27.63	20.52	24.72	21.56	37	23.99
		SE	1109	293	637	248	867	446	462	640	643	529
		DULL	2-2-I	2-4-1	1-1-1	2-2-1	2-2-0	4-2-1/10	2-2-0	6-2-1/4	4-6-0	4-4-2
2	480-700	Type	XV	SDGH	SDGH	SDGH	X3A		ES5K	TS-2	SDS	
		Size	12.25	12.25	12.25	12.25	12.25		12.25	12.25	12.25	
		CPF	65.1	24.27	44.19	42.34	15.6		22.04	24.46	22.49	
		SE	2131	511	1717	1494	396		311	1234	304	
		DULL	6-6-I	7-1-1/5	6-8-1/6	4-6-1/8	2-2-0		4-1-5	7-4-1/4	1-1-0	
3	700-1000	Type		SDGH	SDGH	SDGH	XDJ		XV	XDV	SDS	XDV
		Size		12.25	12.25	12.25	12.25		12.25	12.25	12.25	12.25
		CPF		64.4	66.34	70.57	65.38		54.08	59	47.54	69.02
		SE		1799	2345	2491	2047		1755	3113	1783	2187
		DULL		4-1-1/8	5-5-1/10	5-6-1/6	5-3-0		1-1-1	4-6-I	5-3-1/5	4-4-0
4	1000-1260	Type		SDGH	SDGH	SDGH		SDS				XDV
		Size		12.25	12.25	12.25		12.25				12.25
		CPF		39.24	39.14	42.57		28.93				57.93
		SE		1280	1232	1486		1036				1771
		DULL		--------	4-2-1/6	5-1-7/8		4-8-1/4				6-5-0
5	1260-1440	Type	X3	SDGH	SDGH	SDGH			X1G		SDS	
		Size	12.25	12.25	12.25	12.25			12.25		12.25	
		CPF	53.4	48.96	50.25	63.58			34.41		49.78	
		SE	2277	2020	1516	1438			1203		1799	
		DULL	6-3-I	4-7-1/3	3-1-1/5	6-8-1/2			6-3-6		6-6-1/4	
6	1440-1620	Type	X1G	SDGH				SDGH	X1G		SDGH	XDV
		Size	12.25	12.25				12.25	12.25		12.25	12.25
		CPF	79.71	67.53				45.25	76.84		99.46	64.92
		SE	3732	2630				1637	2238		3092	1852
		DULL	7-7-I	5-4-1/2				5-3-1/10	7-5-1		6-6-1/5	5-4-0
7	1620-1800	Type		SDGH	SDGH		J-33	SDGH	XDJ		SDGH	
		Size		12.25	12.25		12.25	12.25	12.25		12.25	
		CPF		64.2	63.7		61.88	61.61	98.78		97.48	
		SE		2296	2039		1124	2236	2272		3007	
		DULL		4-4- --	5-2-1/3		2-4-3	5-8-1/4	-------		6-4-2/5	
8	1800-2080	Type	TM-2	XDG	XDG	XDV		SDGH	X3A	XDV	SDGH	XDV
		Size	8.5	8.5	8.5	12.25		12.25	12.25	12.25	12.25	12.25
		CPF	42.75	36.56	43.07	38.79		66.04	60.82	81.96	71.09	106.7
		SE	1554	1388	2049	903		2481	1926	3507	2369	3842
		DULL	4-4-I	4-7-1	3-4-1	4-2-1/10		4-8-1/2	3-5-LR	6-4-1/8	4-3-0	5-6-2
9	2080-2240	Type		X1G	X1G	X1G		SDGH			SDGH	XDV
		Size		8.5	8.5	8.5		12.25			12.25	12.25
		CPF		81.22	65.54	82.83		77.6			100.13	172.9
		SE		3359	2716	3072		2178			3479	5813
		DULL		6-8-1/10	4-4- --	4-8-GJ		3-2-1/6			6-6-1/8	6-5-2
10	2240-2360	Type	X1G	X1G	X1G		J-33			XDG		XV
		Size	8.5	8.5	8.5		12.25			8.5		12.25
		CPF	69.19	80.87	113.13		156.48			81.61		108.8
		SE	3716.6	3205	4966		2945			3096		3043
		DULL	4-6-I	--------	6-8-1/10		3-2-4			6-4-1/8		2-2-0

No	Section	Well No.	78	88	91	95	98	100	103	104	119	135
11	2360-2780	Type			F2	F2	J-33	F2			F2	
		Size			8.5	8.5	8.5	8.5			8.5	
		CPF			110.24	85.49	106.8	129.78			111.3	
		SE			3209	2377	2584	2798			2511	
		DULL			2-7-1/4	1-1-GJ	4-2-4	8-8-1/3			3-3-0	
12	2780-3100	Type	J-33		J-33	F3			J-33	J-33	F2	J-33
		Size	8.5		8.5	8.5			8.5	8.5	8.5	8.5
		CPF	143.5		131.2	142.6			159.4	122.9	132.08	122.2
		SE	5480		4134	3901			4811	4426	895	3244
		DULL	1-L.2C		8-8-1/4	6-8-1/3			7-5-5	6-6-1/4	8-6-1/5	7-3-3
13	3100-3260	Type		J-33		F3	J-33	F3	J-33		F3	J-33
		Size		8.5		8.5	8.5	8.5	8.5		8.5	8.5
		CPF		138.7		238.8	154.8	160.9	182		196.9	190
		SE		3752		6442	3654	4737	4969		5433	4474
		DULL		6-5- --		8-8- --	4-3-4	3-3-1/5	BT-4-2		6-6-1/5	7-4-4
14	3260-3350	Type	J-33		J-33		J-44	F3	J-44		F3	J-33
		Size	8.5		8.5		8.5	8.5	8.5		8.5	8.5
		CPF	452.6		262.8		384	326.3	805.7		304.1	426.4
		SE	7532		16719		8743	9474	17736		7307	10596
		DULL	5-6-1/8		8-4-1/2		BT-2-4	8-8-5/6	BT-4-2		8-6-1/3	6-5-3

Table (2) Final comparison table for Bai-Hassan oil field

No	Section	Well No.	62	69	70	71	72	74	76	77	79	80
1	0-300	Type	OSC-3A	X3A	SH-51	X3A	OSC	OSC-3	OSC-3AJ	X3A	S13J	
		Size	17.5	17.5	26	17.5	17.5	17.5	17.5	17.5	17.5	
		CPF	30.6	26.65	-------	61.58	55.3	49.4	45.39	44.7	29.56	
		SE	508	407	740.5	954	723	1447	732	654	900	
		DULL	5-5-1	4-6-1	4-3-1	4-5-1	3-4-1	8-4-1	6-4-1	2-2-1	7-5-1	
2	300-500	Type	OSC-3A	X3A	OSC-3AJ	X1G	S13		S13J	S13J	S13J	X3A
		Size	17.5	17.5	17.5	12.25	12.25		12.25	12.25	12.25	12.25
		CPF	30.6	26.65	172.5	66.5	47.4		32.83	36.1	30.5	30.25
		SE	508	407	3276	1671	827		1368	914	810	1051
		DULL	5-5-1	4-6-1	5-5-1	3-3-1	3-4-1		6-8-0	4-7-1	2-2-1	4-6-1
3	500-820	Type	X3A	J-3		X1G	S13	S13	S13J		X1G	
		Size	12.25	12.25		12.25	12.25	12.25	12.25		8.5	
		CPF	29.24	38.2		54.04	48.8	50.79	32.83		47.79	
		SE	892	1197		1477	918	1437	1368		1755	
		DULL	6-5-1	5-7-1		6-5-1	4-4-1	5-4-1	6-8-0		6-5-1	
4	820-1000	Type		S13	X1G	X1G	S13		S13J	S13J	X1G	X1G
		Size		12.25	8.5	12.25	12.25		12.25	12.25	8.5	12.25
		CPF		119.19	136.5	73.85	105.4		59.19	77	51.86	64.15
		SE		4693	1420	1229	2360		2380	2513	1078	2205
		DULL		5-6-1	4-4-1	5-5-1	4-4-1		5-8-0	5-8-1	6-6-1	4-5-1
5	1000-1180	Type	S13	J-3	X1G	X3	S13	S13		S13J		
		Size	12.25	12.25	8.5	12.25	12.25	12.25		12.25		
		CPF	121.93	91.34	119.97	175	116.16	91.5		98.1		
		SE	3531	3550	3217	3759	3296	2597		20.59		
		DULL	5-6-1	5-6-1	4-4-1	4-5-1	5-4-1	4-4-1		2-2-1		
6	1180-1290	Type		J-3	X1G	X3			X1G	S13J	X1G	
		Size		8.5	8.5	12.25			8.5	12.25	8.5	
		CPF		94.5	197.7	138.6		R.R	117.6	98.1	69.96	R.R
		SE		3216	4211	2908			3911	2059	2004	
		DULL		5-4-1	3-3-1	4-6-1			6-8-1	2-2-1	5-6-1	
7	1290-1350	Type		J-3	OSC-1GJ	X1G		X1G				
		Size		8.5	6”	8.5		8.5				
		CPF		92	74.89	210		191.15	R.R.			R.R.
		SE		1741	1388	4835		4041				
		DULL		2-2-1	3-5-1	5-3-1		4-5-1				
8	1350-1420	Type			OSC-1GJ	OWV						
		Size			6”	6”						
		CPF		L.B.	122.9	149.14	L.B.	L.B.	L.B.	L.B.		
		SE			2079	2388						
		DULL			5-6-1	4-4-1						

Table (3) Final comparison table for Kirkuk oil-field

No	Section	Well No.	234	345	346	347	348	349	350	351	352	353
1	0-100	Type	X3A	S33S	S3S	S33S	S3SJ	S3SJ	R1	R.R.	R1	OSC-3AJ
		Size	17.5	17.5	17.5	17.5	17.5	17.5	26		26	26
		CPF	67.86	118.9	131.2	91.36	124.9	105.6	416.3		522.2	298.8
		SE	1138	1055	3508	1371	1649	1132	928		2458	1761
		DULL	1-1-1	2-2-I	4-3-I	2-2-I	2-2-I	2-2-I	2-4-I		4-4-I	4-4-I
2	100-350	Type	S13	OSC-3AJ	OSC-1GJ	OSC-3AJ	X1G	OSC-1GJ	R3	R2	OSC-1GJ	OSC-1GJ
		Size	12.25	12	12	12	8.5	12	17.5	17.5	17.5	17.5
		CPF	69.7	51.9	111.3	49.4	104.8	69.7	153.9	132.6	188.4	211
		SE	1522	1062	4632	1283	2676	1308	2089	2738	3147	3274
		DULL	2-2-1	4-5-I	4-3-I	4-4-I	6-4-1	4-4-I	4-4-I	5-4-I	4-4-I	5-5-I
3	350-500	Type		X1G	X1G	X1G	X1G	X1G	X1G			
		Size		8 3/8	8 3/8	8 3/8	8.5	8 3/8	17.5			
		CPF		108.9	123.7	98.9	144.3	187.2	252.2			
		SE		2790	4754	2786	3647	2264	3705			
		DULL		6-4-I	5-2-I	6-6-I	6-4-I	5-5-I	4-4-I			
4	500-620	Type	S13	X1G	X1G		L.B.	X1G	X1G		X1G	X1G
		Size	12.25	8 3/8	8 3/8			8 3/8	8.5		8.5	8.5
		CPF	109	133.5	177.9			220.3	176.1		144.3	194.7
		SE	2415	3286	8440			2634	3341		1664	3456
		DULL	2-4-I	4-3-I	3-2-I			6-4-I	4-4-I		4-4-I	5-4-I
5	620-720	Type	L.B.	L.B.	L.B.	L.B.	L.B.	L.B.	X1G		X1G	
		Size							8.5		8.5	
		CPF							2361		203.1	
		SE							3117		2122	
		DULL							4-4-I		5-6-I	