
API BUL D10
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PROCEDURE
For
SELECTING ROTARY DRILLING EQUIPMENT

OFFICIAL PUBLICATION



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TABLE OF CONTENTS

	Page
Foreword	2
Sect. 1: Job Rating the Well.....	3
Sect. 2: Table, Formulae, and Graphs.....	6
Sect. 3: Rating of the Rigs Several Components.....	16
Sect. 4: Rig-rating Parameters	25
Sect. 5: Glossary	27
Sect. 6: Bibliography	29

PROCEDURE FOR SELECTING ROTARY DRILLING EQUIPMENT

FOREWORD

a. This bulletin (First Edition, Dec. 1965) was prepared by a Subcommittee on Rating Capacity of Rotary Drilling Rigs, J. E. Hellinghausen, The Atlantic Refining Company, chairman, which functioned under the jurisdiction of the American Petroleum Institute's Steering Committee on Drilling and Production Practice. This edition supersedes the First Edition, was prepared by an ad hoc task group chaired by J. E. Hellinghausen, Atlantic Richfield Co., and was approved by the API Executive Committee on Drilling and Production Practice. Its purpose is to describe a system of analysis which will help to select a suitable rig for drilling a specific well, avoiding use of a rig that is either too large or too small.

b. This procedure presumes that depth ratings alone are not definitive, because wells in different areas require emphasis on different rig functions. For example, in drilling hard rock with frequent bit changes, hoisting capacity is of primary importance and hydraulic capacity needed to clean the bottom of the hole and circulate out cuttings is of lesser importance because of the low rate of penetration. In drilling soft formations the penetration rate is often limited by the effectiveness of bottom-hole scavenging, and the hydraulic energy available at the bit

becomes very important. Since fewer bit changes are needed to drill soft formations, hoisting capacity is of lesser importance. Drill-string torque and rotary-table horsepower are also much greater with increased rates of penetration into soft formations.

c. Procedures outlined in the bulletin are divided into two categories, aims of which are:

1. To provide a plan of analysis which will be useful in determining the performance capabilities of the several rig functions which are *required* for the drilling of a specific well (Sections 1 and 2).
2. To prescribe a means of testing, demonstrating, or rating the performance capability of the components of a specific rig (Sections 3 and 4).

d. It is recognized that no existing rig will exactly fit the well requirements, and that compromise between the two will be necessary. This recommendation will permit those compromises to be reached intelligently.

e. It is also recognized that quality of supervision and rig personnel, and age and condition of rig equipment are of great importance in selecting a rig. These considerations are beyond the scope of this publication and are excluded from it.

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SECTION 1

JOB RATING THE WELL

To choose the best rig for drilling a particular well, it is necessary first to job rate the well. Anticipated well depth, geologic conditions, casing plan, and other data influence drilling-rig requirements, and an analysis of the well or drilling plan will assist materially in establishing rig needs. (See p. 4 and 5.)

A table, formulae, and graphs are included in Section 2 to help in completing API Form No. D10-A, Drilling-plan Analysis.* Form No. D10-A (see pages 4 and 5) provides for several depth intervals (or hole sections) of the well with the lowermost depth of each section being the controlling depth in making calculations. Formation drillability usually can be classified as very soft, soft, medium, hard, or very hard. Hole size, throughout the analysis, is presumed to equal the diameter of the bit used in drilling the hole.

Drill-collar weight, corrected for buoyancy, should at least equal the bit weight desired for the hole being drilled. The inside diameter of the drill pipe and the bore of the drill collars significantly affect the fluid pressure drop and hence the hydraulic horsepower spent inside the drill string. This loss inside the drill string may be minimized through use of drill strings of large internal diameter in combination with moderate circulation rates. (See Fig. 1, 2, 8, and 9.)

In the hoisting analysis, buoyancy is assumed to be offset by hole friction and may be disregarded. The desired safe working capacity of the derrick ordinarily is a function of the maximum anticipated hook load and the number of lines strung; but under certain conditions, consideration must be given instead to the parting strengths of drill-pipe or casing strings. Dynamic braking requirements, if critical, should be determined and specified on Form No. D10-A, Drilling-plan Analysis.

*API Form No. D10-A, Drilling-plan Analysis (Pages 1 and 2), are available in pads of 50 sheets at \$1.00 per pad from API Division of Production, 300 Corrigan Tower Building, Dallas, Texas 75201. Forms illustrated in Section 3 herein are also available in pads of 50 sheets at \$1.00 per pad.

All graphs in Section 2, relating to the hydraulic section of the analysis, are based on a mud density of 10 lb/gal (75 lb/cu ft). Corrected pressure losses (also hydraulic horsepower) for mud of densities other than these, may be readily calculated since relationships between friction head and density are essentially linear. Numerical values presented on the graphs are essentially the same as those in common use. The amount of hydraulic energy which can be usefully employed in the removal of cuttings from under the bit cannot be predicted accurately, since not all the factors that influence such needs have been evaluated. Currently, it is general practice to make an empirical approach to bit hydraulic needs by relating them to hole cross-sectional areas in amounts ranging from 1 or 2 bit hydraulic horsepower per square inch of hole area in the slowest of hard-rock drilling, to as much as 6 or 8 BHHP/sq in. in soft-formation drilling (see Fig. 4).

Pressure losses in the annulus are minor when considered only from the standpoint of energy consumed, but may become of major concern if loss of circulation is probable. This is true, in deep wells particularly, where formations are weak and where heavy muds are required. Rapid pipe movements also may contribute to loss of circulation since such movements produce significant down-hole pressure surges, which increase with length of pipe immersed. In areas where running-in rates of either the drill string or the casing must be restricted, the reduced velocity should be specified on Form No. D10-A, Drilling-plan Analysis.

In the completion of the Drilling-plan Analysis, reasonable rig-performance capabilities for each of the several hole sections will be determined. However, the rig chosen for drilling the well may require accepting, for the sake of economy, less than preferred capabilities for some sections of the hole. Ordinarily, concessions in this respect should take into account rig days rather than the footage involved.

API FORM NO. D10-A*
DRILLING-PLAN ANALYSIS

Lease Name & Well No. _____ County or Parish _____ State _____

API Well No. _____

Field or Area _____ Projected Total Depth _____

Geological Formation at Surface _____ At TD _____

HOLE AND CASING PLAN					
To depth of, ft					
Hole diameter, in.					
Formation drillability					
Casing to be run, OD, in.					
Lb/ft and API grade					
Amount, ft					
Lb/ft and API grade					
Amount, ft					
Lb/ft and API grade					
Amount, ft					
Weight of string in air, M lb					
Minimum parting load, M lb					
Weight of casing string in mud, M lb					
Required low running velocity, ft/min					
DRILL STRING — PREFERRED					
Drill-collar weight in air, M lb					
Bottom section, OD × bore, in.					
Section length, ft					
Top section, OD × bore, in.					
Section length, ft					
Drill pipe, OD, in.					
Lb/ft and API grade					
Amount, ft					
Weight, air, M lb					
Parting load, M lb					
Drill-string weight in air, M lb					
Minimum required hoisting velocity, ft/min					
Hook horsepower at maximum weight and minimum velocity					
Drill-string weight in mud, M lb					
Required low running velocity, ft/min					
DERRICK REQUIREMENTS					
Critical hook load, M lb					

*API Form No. D10-A, Drilling-plan Analysis (Pages 1 and 2), are available in pads of 50 sheets at \$1.00 per pad from API Division of Production, 300 Corrigan Tower Building, Dallas, Texas 75201.

API Form No. D10-A
Drilling-plan Analysis — Continued

API Well No. _____
Lease Name & Well No. _____

HYDRAULIC NEEDS					
Drilling fluid, type					
Density, lb/gal, lb/cu ft					
Buoyancy factor					
Bit hydraulic horsepower, selected					
Annular velocity, selected, ft/min					
Circulation rate, gal/min					
Nozzle velocity, ft/sec					
Pressure losses (nominal) surface equipment, psi					
Through drill pipe, psi					
Through drill collars, psi					
Across bit nozzles, psi					
Drill-collar hole annulus, psi					
Drill-pipe hole annulus, psi					
Total pressure loss, nominal, psi					
Surface pressure, corrected, psi					
Hydraulic horsepower at surface					
ROTARY NEEDS					
Rotary drive, type					
Table bore, in.					
Static load capacity, M lb					
Rpm range, max-min					
Torque capacity, ft-lb					
Rotary horsepower					
AUXILIARY EQUIPMENT					
Blowout preventers, class					
Size, through bore, in.					
Stack arrangement					
Closing unit, accumulator capacity, gal-psi					
Number control outlets					
Number control stations					
Choke manifold, size/class					
MISCELLANEOUS					

SECTION 2

TABLE, FORMULAE, AND GRAPHS

TABLE 1
CIRCULATION RATE
(Gal/min)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Hole Size, In.	Drill-pipe Size, In.	Annular Velocity, Ft/min														
		10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
4 3/4	2 3/8	7	14	21	28	35	41	48	55	62	69	76	83	90	97	104
	2 1/2	6	12	17	23	29	35	41	47	52	58	64	70	76	82	87
5 5/8	2 7/8	10	19	29	38	48	57	67	76	86	95	105	114	124	134	143
	3 1/2	8	16	24	32	40	47	55	63	71	79	87	95	103	111	119
5 7/8	2 7/8	11	21	32	43	54	64	75	86	96	107	118	129	139	150	161
	3 1/2	9	18	27	36	45	55	64	73	82	91	100	109	118	127	136
6	3 1/2	10	19	29	39	48	58	68	78	87	97	107	116	126	136	145
6 1/8	3 1/2	10	21	31	41	52	62	72	82	93	103	113	124	134	144	155
6 1/4	3 1/2	11	22	33	44	55	66	77	88	98	109	120	131	142	153	164
6 3/4	3 1/2	14	27	41	54	68	82	95	109	122	136	150	163	177	190	204
7 5/8	3 1/2	19	37	56	75	94	112	131	150	169	187	206	225	243	262	281
	4 1/2	15	31	46	62	77	93	108	124	139	155	170	186	201	216	232
7 7/8	3 1/2	20	41	61	81	102	122	142	162	183	203	223	244	264	284	305
	4 1/2	17	34	51	68	85	102	119	136	153	170	187	204	222	239	256
8 5/8	3 1/2	24	47	71	94	118	142	165	189	213	236	260	283	307	331	354
	4 1/2	20	41	61	81	102	122	142	163	183	204	224	244	265	285	305
8 1/2	3 1/2	24	49	73	98	122	147	171	196	220	245	269	294	318	343	367
	4 1/2	21	42	64	85	106	127	149	170	191	212	233	255	276	297	318
8 5/8	3 1/2	25	51	76	101	127	152	177	203	228	254	279	304	330	355	380
	4 1/2	22	44	66	88	110	133	155	177	199	221	243	265	287	309	331
	5	20	40	60	81	101	121	141	161	181	202	222	242	262	282	302
8 3/4	3 1/2	26	52	79	105	131	157	184	210	236	262	289	315	341	367	394
	4 1/2	23	46	69	92	115	138	161	184	207	230	253	276	299	322	345
	5	21	42	63	84	105	126	147	168	189	210	231	252	273	295	316
9	4 1/2	25	50	74	99	124	149	174	198	223	248	273	297	322	347	372
	5	23	46	69	91	114	137	160	183	206	228	251	274	297	320	343
9 7/8	4 1/2	32	63	95	126	158	189	221	252	284	315	347	378	410	441	473
	5	30	59	89	118	148	178	207	237	266	296	325	355	385	414	444
	5 1/2	27	55	82	110	137	165	192	220	247	274	302	329	357	384	412
10 5/8	4 1/2	38	76	113	151	189	227	265	302	340	378	416	454	491	529	567
	5	36	72	108	143	179	215	251	287	323	359	394	430	466	502	538
	5 1/2	34	67	101	135	169	202	236	270	303	337	371	405	438	472	506
11	4 1/2	41	82	123	164	206	247	288	329	370	411	452	493	534	575	617
	5	39	78	118	157	196	235	274	313	353	392	431	470	509	548	588
	5 1/2	37	74	111	148	185	222	259	296	333	370	407	444	481	518	555
12 1/4	4 1/2	53	106	159	212	265	318	371	424	477	530	583	636	689	741	794
	5	51	102	153	204	255	306	357	408	459	510	561	612	663	714	765
	5 1/2	49	98	147	196	244	293	342	391	440	489	538	587	635	684	733
	6 5/8	48	87	130	173	216	260	303	347	390	433	476	520	563	606	650
13 3/4	4 1/2	69	138	207	275	344	413	482	551	620	689	758	826	895	964	1,033
	5	67	134	201	268	335	402	469	535	602	669	736	803	870	937	1,004
	5 1/2	65	130	194	259	324	389	454	518	583	648	713	778	842	907	972
	6 5/8	59	118	178	237	296	355	415	474	533	592	652	711	770	829	888
15	4 1/2	84	167	251	334	418	501	585	668	752	835	919	1,002	1,086	1,170	1,253
	5 1/2	79	159	238	318	397	477	556	636	715	795	874	953	1,033	1,112	1,192
	6 5/8	74	148	222	296	369	443	517	591	665	739	813	887	961	1,035	1,108
17 1/2	4 1/2	117	233	350	467	583	700	817	933	1,050	1,167	1,284	1,400	1,517	1,634	1,750
	5 1/2	113	225	338	450	563	676	788	901	1,013	1,126	1,239	1,351	1,464	1,576	1,689
	6 5/8	107	214	321	428	535	642	749	856	963	1,070	1,177	1,285	1,392	1,499	1,606
26	4 1/2	268	535	803	1,070	1,338	1,605	1,873	2,140	2,408	2,675	2,943	3,211	3,478	3,746	4,013
	5 1/2	263	527	790	1,054	1,317	1,581	1,844	2,108	2,371	2,635	2,898	3,162	3,425	3,688	3,952
	6 5/8	258	516	774	1,032	1,289	1,547	1,805	2,063	2,321	2,579	2,837	3,095	3,353	3,611	3,868

TABLE 1 (Continued)
CIRCULATION RATE
(Gal/min)

1	2	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Hole Drill-pipe Size, In. Size, In.		Annular Velocity, Ft/min														
		160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
4 $\frac{3}{4}$	2 $\frac{3}{8}$	110	117	124	131	138	145	152	159	166	173	180	186	193	200	207
	2 $\frac{7}{8}$	93	99	105	111	117	122	128	134	140	146	152	157	163	169	175
5 $\frac{5}{8}$	2 $\frac{7}{8}$	153	162	172	181	191	200	210	219	229	238	248	257	267	277	286
	3 $\frac{1}{2}$	127	134	142	150	158	166	174	182	190	198	206	214	222	229	237
5 $\frac{7}{8}$	2 $\frac{7}{8}$	171	182	193	203	214	225	236	246	257	268	278	289	300	311	321
	3 $\frac{1}{2}$	145	154	164	173	182	191	200	209	218	227	236	245	254	263	273
6	3 $\frac{1}{2}$	155	165	174	184	194	203	213	223	233	242	252	262	271	281	291
6 $\frac{1}{8}$	3 $\frac{1}{2}$	165	175	186	196	205	216	227	237	247	258	268	278	289	299	309
6 $\frac{1}{4}$	3 $\frac{1}{2}$	175	186	197	208	219	230	241	252	263	273	284	295	306	317	328
6 $\frac{3}{4}$	3 $\frac{1}{2}$	217	231	245	258	272	285	299	313	326	340	353	367	381	394	408
7 $\frac{5}{8}$	3 $\frac{1}{2}$	300	318	337	356	374	393	412	431	449	468	487	506	524	543	562
	4 $\frac{1}{2}$	247	263	278	294	309	325	340	356	371	386	402	417	433	448	464
7 $\frac{7}{8}$	3 $\frac{1}{2}$	325	345	365	386	406	426	447	467	487	508	528	548	569	589	609
	4 $\frac{1}{2}$	273	290	307	324	341	358	375	392	409	426	443	460	477	494	511
8 $\frac{5}{8}$	3 $\frac{1}{2}$	378	402	425	449	472	496	520	543	567	590	614	638	661	685	709
	4 $\frac{1}{2}$	326	346	366	387	407	427	448	468	489	509	529	550	570	590	611
8 $\frac{3}{4}$	3 $\frac{1}{2}$	392	416	441	465	490	514	539	563	588	612	636	661	685	710	734
	4 $\frac{1}{2}$	339	361	382	403	424	446	467	488	509	530	552	573	594	615	636
8 $\frac{5}{8}$	3 $\frac{1}{2}$	406	431	456	482	507	532	558	583	608	634	659	685	710	735	761
	4 $\frac{1}{2}$	353	376	398	420	442	464	486	508	530	552	574	596	618	641	663
	5	322	343	363	383	403	423	443	463	484	504	524	544	564	584	605
8 $\frac{3}{4}$	3 $\frac{1}{2}$	420	446	472	499	525	551	577	604	630	656	682	708	735	761	787
	4 $\frac{1}{2}$	368	391	414	437	460	482	505	528	551	574	597	620	643	666	689
	5	337	358	379	400	421	442	463	484	505	526	547	568	589	610	631
9	4 $\frac{1}{2}$	397	421	446	471	496	521	545	570	595	620	644	669	694	719	744
	5	366	388	411	434	457	480	503	525	548	571	594	617	640	663	685
9 $\frac{7}{8}$	4 $\frac{1}{2}$	504	536	567	599	630	662	694	725	757	788	820	851	883	914	946
	5	473	503	533	562	592	621	651	680	710	740	769	799	828	858	888
	5 $\frac{1}{2}$	489	467	494	521	549	576	604	631	659	686	714	741	768	796	823
10 $\frac{5}{8}$	4 $\frac{1}{2}$	605	643	680	718	756	794	832	869	907	945	983	1,021	1,058	1,096	1,134
	5	574	610	645	681	717	753	789	825	861	896	932	968	1,004	1,040	1,076
	5 $\frac{1}{2}$	539	573	607	641	674	708	742	775	809	843	877	910	944	978	1,012
11	4 $\frac{1}{2}$	658	699	740	781	822	863	904	945	987	1,028	1,069	1,110	1,151	1,192	1,233
	5	627	666	705	744	783	823	862	901	940	979	1,018	1,058	1,097	1,136	1,175
	5 $\frac{1}{2}$	592	629	666	703	741	778	815	852	889	926	963	1,000	1,037	1,074	1,111
12 $\frac{1}{4}$	4 $\frac{1}{2}$	847	900	953	1,006	1,059	1,112	1,165	1,218	1,271	1,324	1,377	1,430	1,483	1,536	1,589
	5	816	867	918	969	1,021	1,072	1,123	1,174	1,225	1,276	1,327	1,378	1,429	1,480	1,531
	5 $\frac{1}{2}$	782	831	880	929	978	1,027	1,075	1,124	1,173	1,222	1,271	1,320	1,369	1,418	1,466
	6 $\frac{5}{8}$	693	736	780	823	866	910	953	996	1,040	1,083	1,126	1,170	1,213	1,256	1,300
13 $\frac{3}{4}$	4 $\frac{1}{2}$	1,102	1,171	1,240	1,309	1,377	1,446	1,515	1,584	1,653	1,722	1,791	1,860	1,928	1,997	2,066
	5	1,071	1,138	1,205	1,272	1,339	1,406	1,473	1,540	1,606	1,673	1,740	1,807	1,874	1,941	2,008
	5 $\frac{1}{2}$	1,037	1,102	1,166	1,231	1,296	1,361	1,425	1,490	1,555	1,620	1,685	1,749	1,814	1,879	1,944
	6 $\frac{5}{8}$	948	1,007	1,066	1,125	1,185	1,244	1,303	1,362	1,422	1,481	1,540	1,600	1,658	1,718	1,777
15	4 $\frac{1}{2}$	1,337	1,420	1,504	1,587	1,671	1,754	1,838	1,921	2,005	2,088	2,172	2,256	2,339	2,423	2,506
	5 $\frac{1}{2}$	1,271	1,351	1,430	1,510	1,589	1,669	1,748	1,828	1,907	1,986	2,066	2,145	2,225	2,304	2,384
	6 $\frac{5}{8}$	1,182	1,256	1,330	1,404	1,478	1,552	1,626	1,700	1,773	1,847	1,921	1,995	2,069	2,143	2,217
17 $\frac{1}{2}$	4 $\frac{1}{2}$	1,867	1,984	2,100	2,217	2,334	2,450	2,567	2,684	2,800	2,917	3,034	3,151	3,267	3,384	3,501
	5 $\frac{1}{2}$	1,802	1,914	2,027	2,140	2,252	2,365	2,477	2,590	2,703	2,815	2,928	3,040	3,153	3,266	3,378
	6 $\frac{5}{8}$	1,713	1,820	1,927	2,034	2,141	2,248	2,355	2,462	2,569	2,676	2,783	2,890	2,997	3,104	3,211
26	4 $\frac{1}{2}$	4,281	4,548	4,816	5,083	5,351	5,618	5,886	6,154	6,421	6,689	6,956	7,224	7,491	7,759	8,026
	5 $\frac{1}{2}$	4,215	4,479	4,742	5,006	5,269	5,533	5,796	6,060	6,323	6,587	6,850	7,114	7,378	7,642	7,905
	6 $\frac{5}{8}$	4,126	4,384	4,642	4,900	5,158	5,416	5,674	5,932	6,190	6,447	6,705	6,963	7,221	7,479	7,737

FORMULAE

1. Buoyancy:

Weight in mud = weight in air $\times$ buoyancy factor (See Fig. 1)

$$BF = 1 - \frac{\text{specific gravity, mud}}{\text{specific gravity, metal}}$$

2. Drill collars, round, weight in air:

$$W = 2.67 (D^2 - d^2) \text{ (See Fig. 2)}$$

Wherein:

W = weight, lb/lineal foot

D = outside diameter, in.

d = ID or Bore, in.

Specific gravity of steel = 7.857

3. Hook horsepower, hoisting:

$$HP = \frac{Wh \times V}{33,000} \text{ (See Fig. 3)}$$

Wherein:

Wh = hook load, lb

V = load velocity, ft/min

4. Hydraulic horsepower:

$$HHP = \frac{GPM \times \Delta P}{1,714}$$

Wherein:

GPM = gal/min

ΔP = pressure difference, psi

5. Pressure loss, correction for mud density:

$$\Delta Pc = \frac{\Delta P \times D}{10 \text{ (or 75)}}$$

Wherein:

ΔPc = pressure loss, corrected

ΔP = pressure loss, 10 lb/gal mud (or 75 lb/cu ft)

D = actual mud density, lb/gal (or lb/cu ft)

6. Rotary horsepower:

$$HP = \frac{2\pi T N}{33,000} = \frac{T N}{5,250}$$

Wherein:

T = torque, ft-lb

N = table revolutions per minute

7. Average specific gravity of aluminum drill pipe with steel tool joints = 3.65

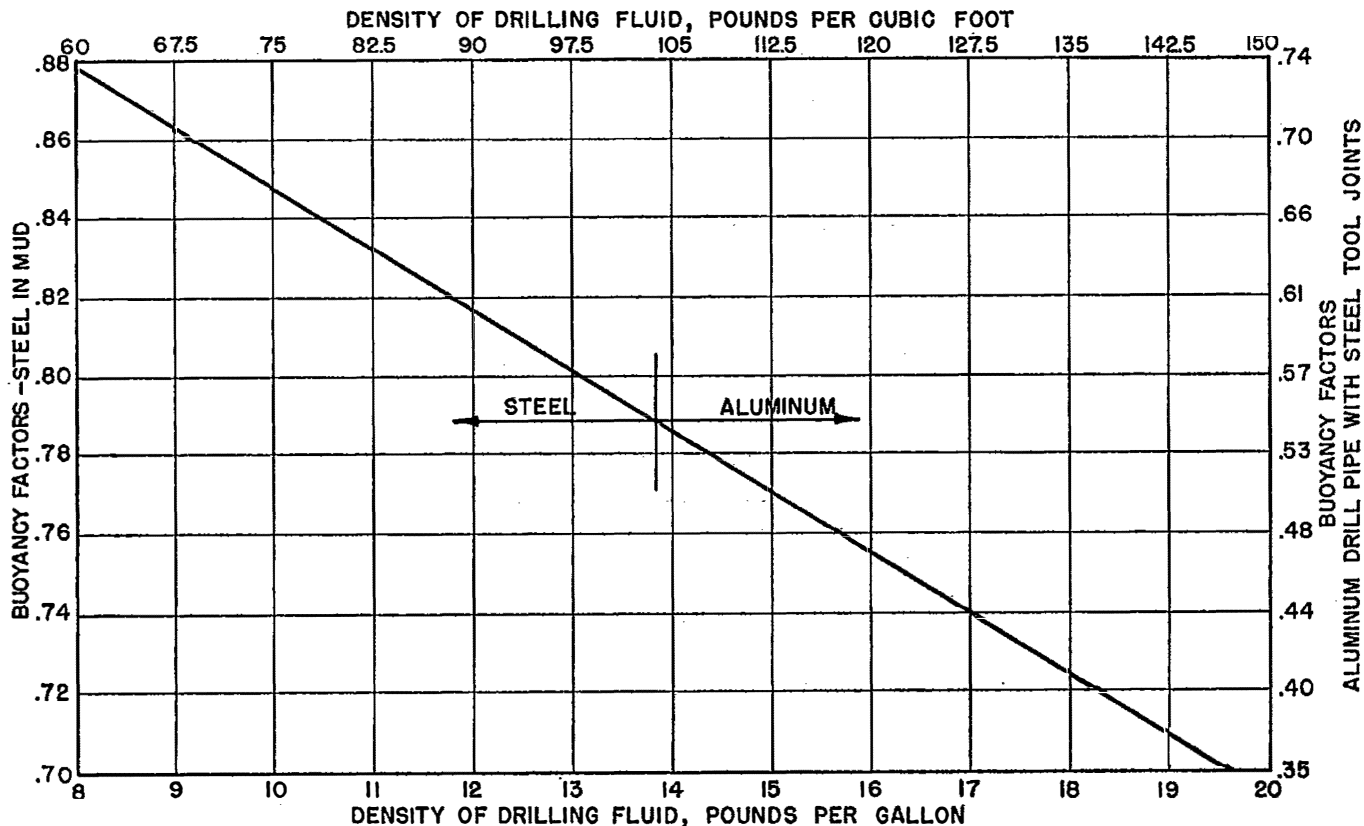


FIG. 1 — BUOYANCY FACTORS FOR METAL IN DRILLING FLUIDS

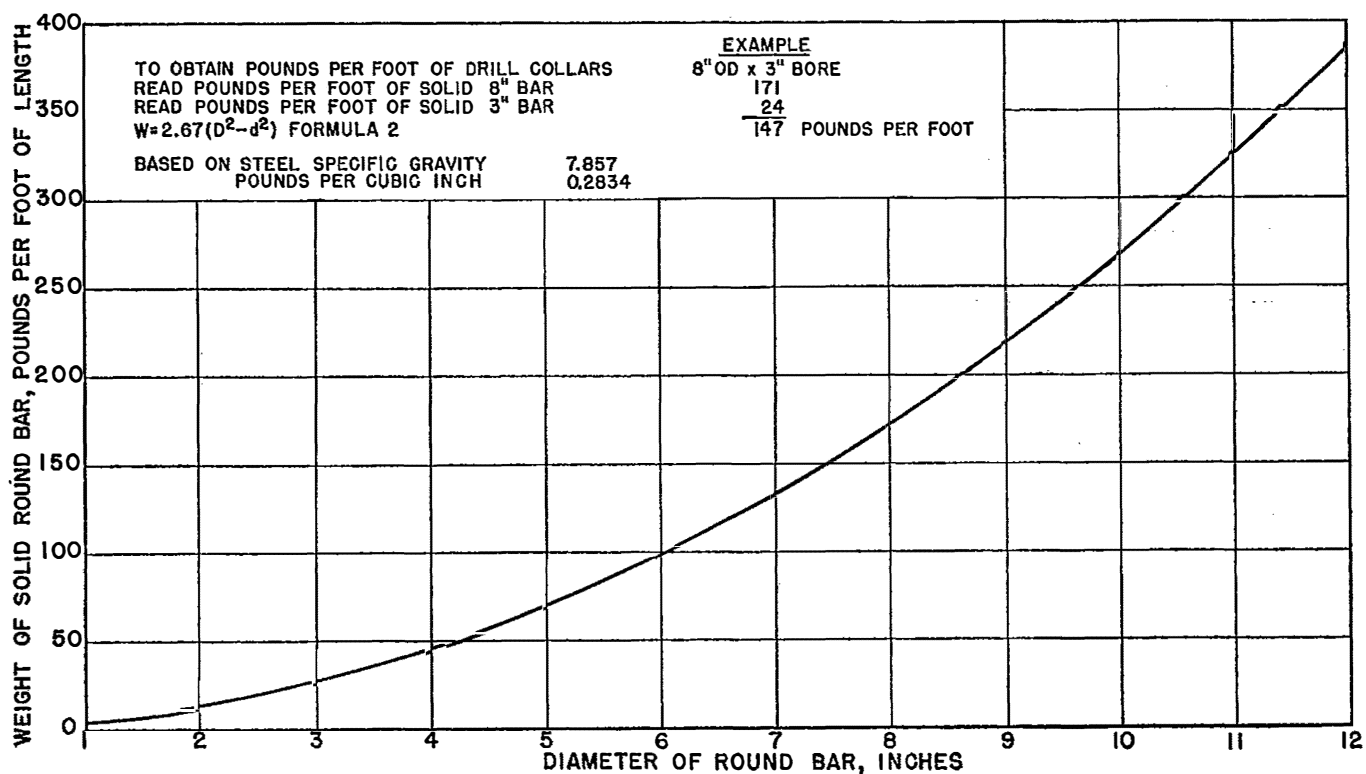


FIG. 2—DRILL-COLLAR WEIGHTS, LB/FT IN AIR

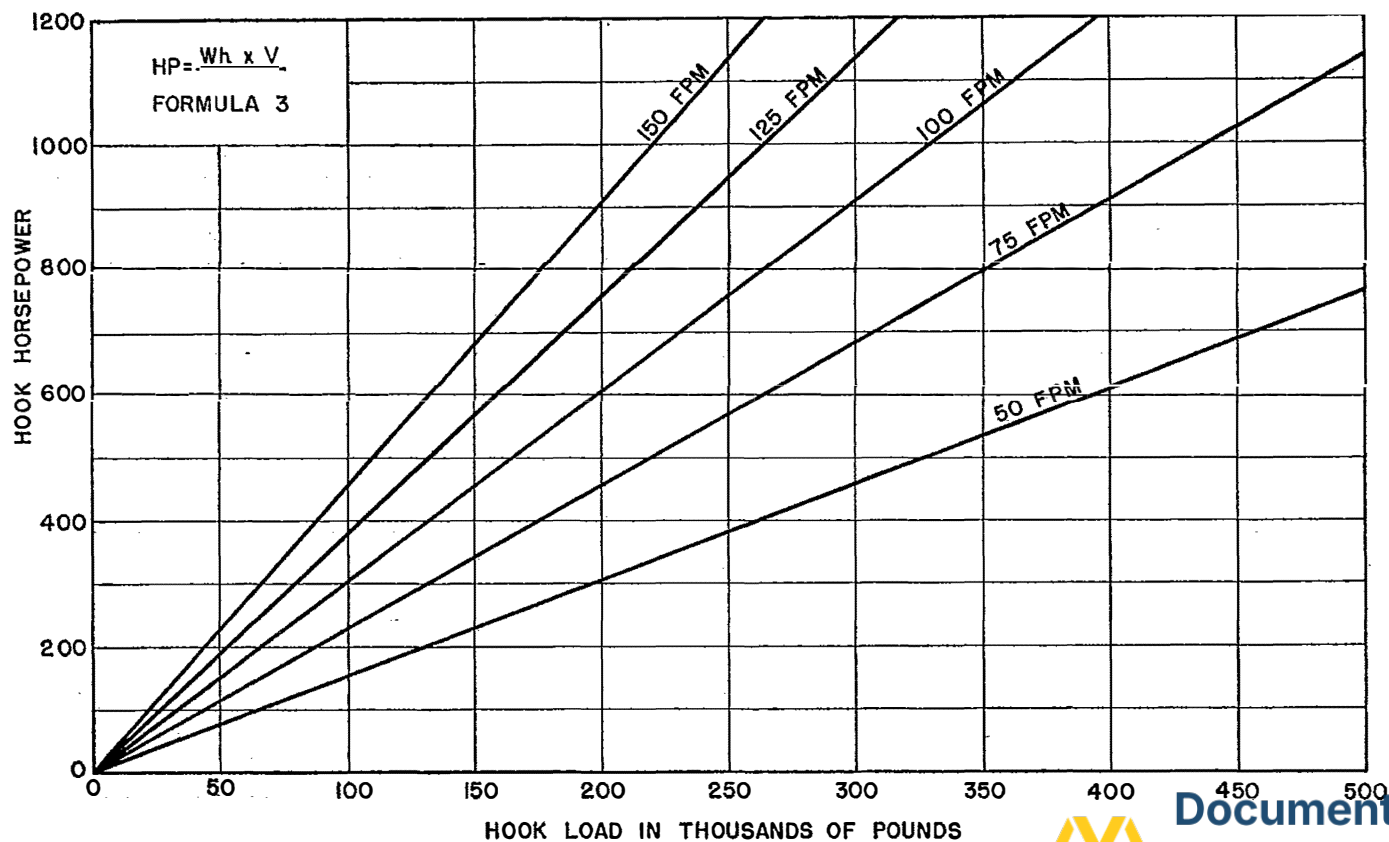


FIG. 3—HOOK HORSEPOWER FOR HOISTING