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PROCEDURE

For

SELECTING ROTARY DRILLING EQUIPMENT

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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.

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
		Annular Velocity, Ft/min														
Hole Size, In.	Drill-pipe Size, In.	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
4¾	2⅜	7	14	21	28	35	41	48	55	62	69	76	83	90	97	104
	2⅞	6	12	17	23	29	35	41	47	52	58	64	70	76	82	87
5⅝	2⅞	10	19	29	38	48	57	67	76	86	95	105	114	124	134	143
	3½	8	16	24	32	40	47	55	63	71	79	87	95	103	111	119
5⅞	2⅞	11	21	32	43	54	64	75	86	96	107	118	129	139	150	161
	3½	9	18	27	36	45	55	64	73	82	91	100	109	118	127	136
6	3½	10	19	29	39	48	58	68	78	87	97	107	116	126	136	145
6⅛	3½	10	21	31	41	52	62	72	82	93	103	113	124	134	144	155
6¼	3½	11	22	33	44	55	66	77	88	98	109	120	131	142	153	164
6¾	3½	14	27	41	54	68	82	95	109	122	136	150	163	177	190	204
7⅝	3½	19	37	56	75	94	112	131	150	169	187	206	225	243	262	281
	4½	15	31	46	62	77	93	108	124	139	155	170	186	201	216	232
7⅞	3½	20	41	61	81	102	122	142	162	183	203	223	244	264	284	305
	4½	17	34	51	68	85	102	119	136	153	170	187	204	222	239	256
8⅜	3½	24	47	71	94	118	142	165	189	213	236	260	283	307	331	354
	4½	20	41	61	81	102	122	142	163	183	204	224	244	265	285	305
8½	3½	24	49	73	98	122	147	171	196	220	245	269	294	318	343	367
	4½	21	42	64	85	106	127	149	170	191	212	233	255	276	297	318
8⅝	3½	25	51	76	101	127	152	177	203	228	254	279	304	330	355	380
	4½	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
8¾	3½	26	52	79	105	131	157	184	210	236	262	289	315	341	367	394
	4½	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	4½	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
9⅞	4½	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
	5½	27	55	82	110	137	165	192	220	247	274	302	329	357	384	412
10⅝	4½	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
	5½	34	67	101	135	169	202	236	270	303	337	371	405	438	472	506
11	4½	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
	5½	37	74	111	148	185	222	259	296	333	370	407	444	481	518	555
12¼	4½	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
	5½	49	98	147	196	244	293	342	391	440	489	538	587	635	684	733
	6⅝	43	87	130	173	216	260	303	347	390	433	476	520	563	606	650
13¾	4½	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
	5½	65	130	194	259	324	389	454	518	583	648	713	778	842	907	972
	6⅝	59	118	178	237	296	355	415	474	533	592	652	711	770	829	888
15	4½	84	167	251	334	418	501	585	668	752	835	919	1,002	1,086	1,170	1,253
	5½	79	159	238	318	397	477	556	636	715	795	874	953	1,033	1,112	1,192
	6⅝	74	148	222	296	369	443	517	591	665	739	813	887	961	1,035	1,108
17½	4½	117	233	350	467	583	700	817	933	1,050	1,167	1,284	1,400	1,517	1,634	1,750
	5½	113	225	338	450	563	676	788	901	1,013	1,126	1,239	1,351	1,464	1,576	1,689
	6⅝	107	214	321	428	535	642	749	856	963	1,070	1,177	1,285	1,392	1,499	1,606
26	4½	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
	5½	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
	6⅝	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
		Annular Velocity, Ft/min														
Hole Size, In.	Drill-pipe Size, In.	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
4¾	2⅜	110	117	124	131	138	145	152	159	166	173	180	186	193	200	207
	2⅞	93	99	105	111	117	122	128	134	140	146	152	157	163	169	175
5⅝	2⅞	153	162	172	181	191	200	210	219	229	238	248	257	267	277	286
	3½	127	134	142	150	158	166	174	182	190	198	206	214	222	229	237
5⅞	2⅞	171	182	193	203	214	225	236	246	257	268	278	289	300	311	321
	3½	145	154	164	173	182	191	200	209	218	227	236	245	254	263	273
6	3½	155	165	174	184	194	203	213	223	233	242	252	262	271	281	291
6⅛	3½	165	175	186	196	205	216	227	237	247	258	268	278	289	299	309
6¼	3½	175	186	197	208	219	230	241	252	263	273	284	295	306	317	328
6¾	3½	217	231	245	258	272	285	299	313	326	340	353	367	381	394	408
7⅝	3½	300	318	337	356	374	393	412	431	449	468	487	506	524	543	562
	4½	247	263	278	294	309	325	340	356	371	386	402	417	433	448	464
7⅞	3½	325	345	365	386	406	426	447	467	487	508	528	548	569	589	609
	4½	273	290	307	324	341	358	375	392	409	426	443	460	477	494	511
8⅜	3½	378	402	425	449	472	496	520	543	567	590	614	638	661	685	709
	4½	326	346	366	387	407	427	448	468	489	509	529	550	570	590	611
8½	3½	392	416	441	465	490	514	539	563	588	612	636	661	685	710	734
	4½	339	361	382	403	424	446	467	488	509	530	552	573	594	615	636
8⅝	3½	406	431	456	482	507	532	558	583	608	634	659	685	710	735	761
	4½	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
8¾	3½	420	446	472	499	525	551	577	604	630	656	682	708	735	761	787
	4½	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	4½	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
9⅞	4½	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
	5½	439	467	494	521	549	576	604	631	659	686	714	741	768	796	823
10⅝	4½	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
	5½	539	573	607	641	674	708	742	775	809	843	877	910	944	978	1,012
11	4½	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
	5½	592	629	666	703	741	778	815	852	889	926	963	1,000	1,037	1,074	1,111
12¼	4½	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
	5½	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
	6⅝	693	736	780	823	866	910	953	996	1,040	1,083	1,126	1,170	1,213	1,256	1,300
13¾	4½	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
	5½	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
	6⅝	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	4½	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
	5½	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
	6⅝	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
17½	4½	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
	5½	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
	6⅝	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	4½	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
	5½	4,215	4,479	4,742	5,006	5,269	5,533	5,796	6,060	6,323	6,587	6,850	7,114	7,377	7,640	7,904
	6⅝	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 × buoyancy factor (See Fig. 1)

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

2. Drill collars, round, weight in air:

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

   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:

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

   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

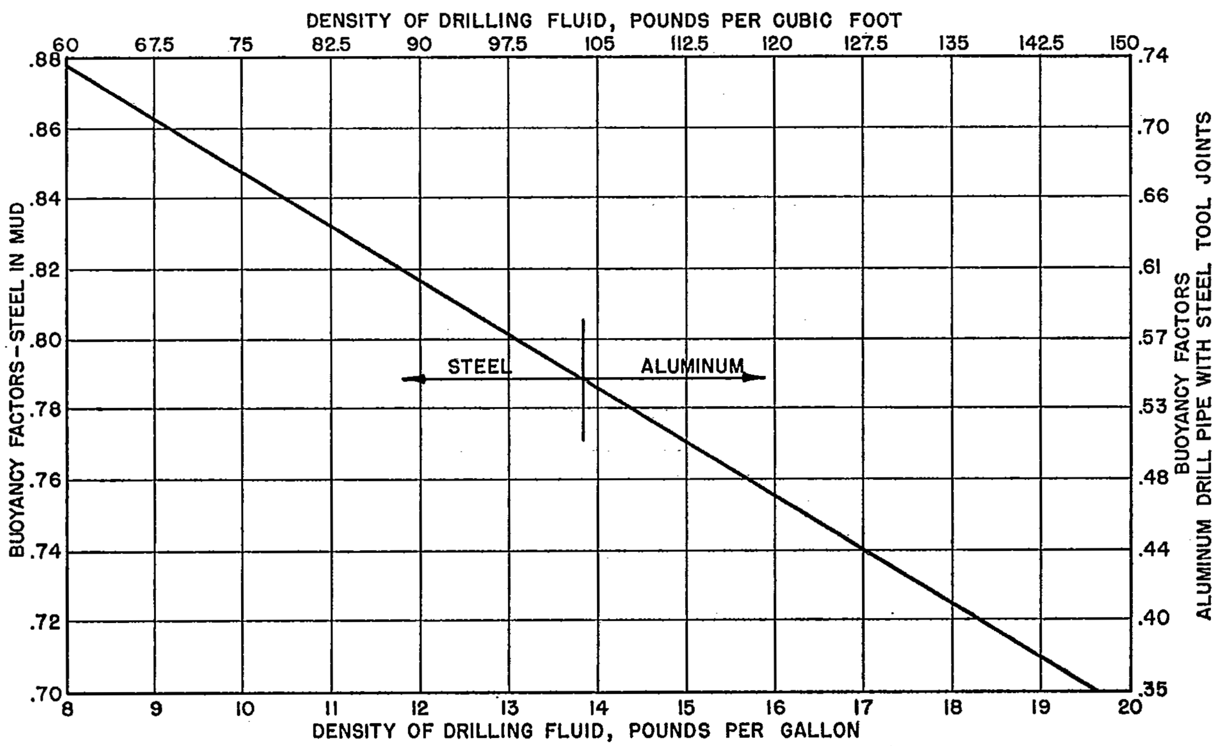


FIG. 1 — BUOYANCY FACTORS FOR METAL IN DRILLING FLUIDS

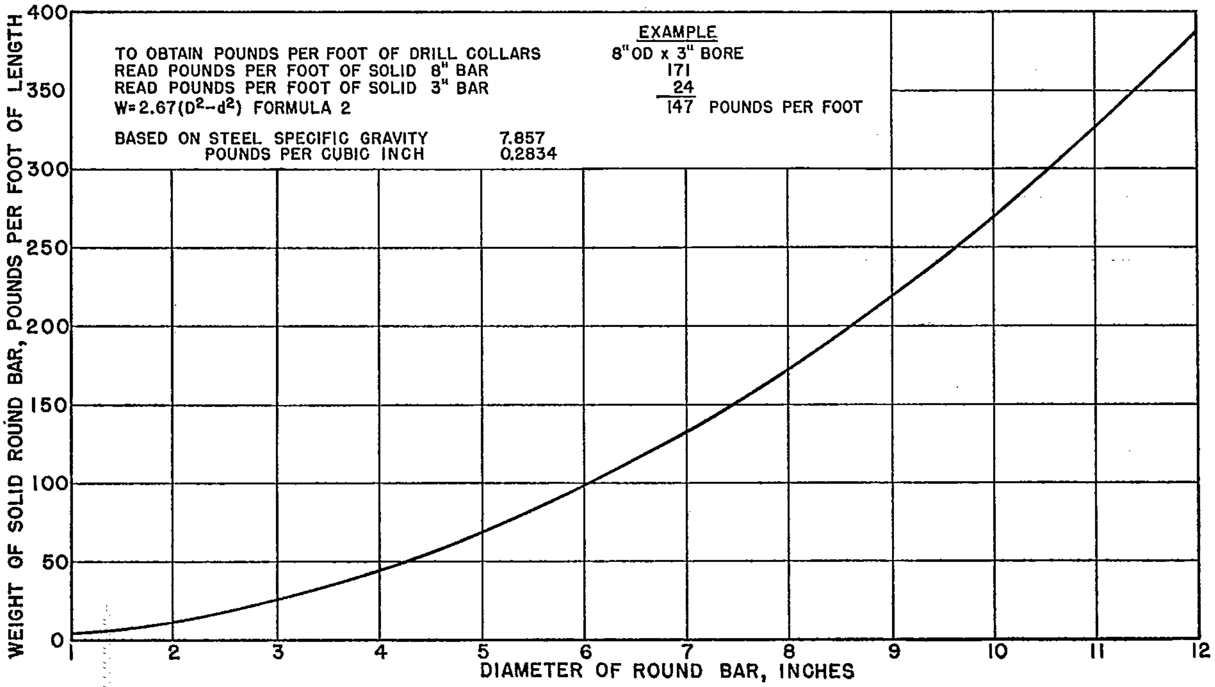


FIG. 2 — DRILL-COLLAR WEIGHTS, LB/FT IN AIR

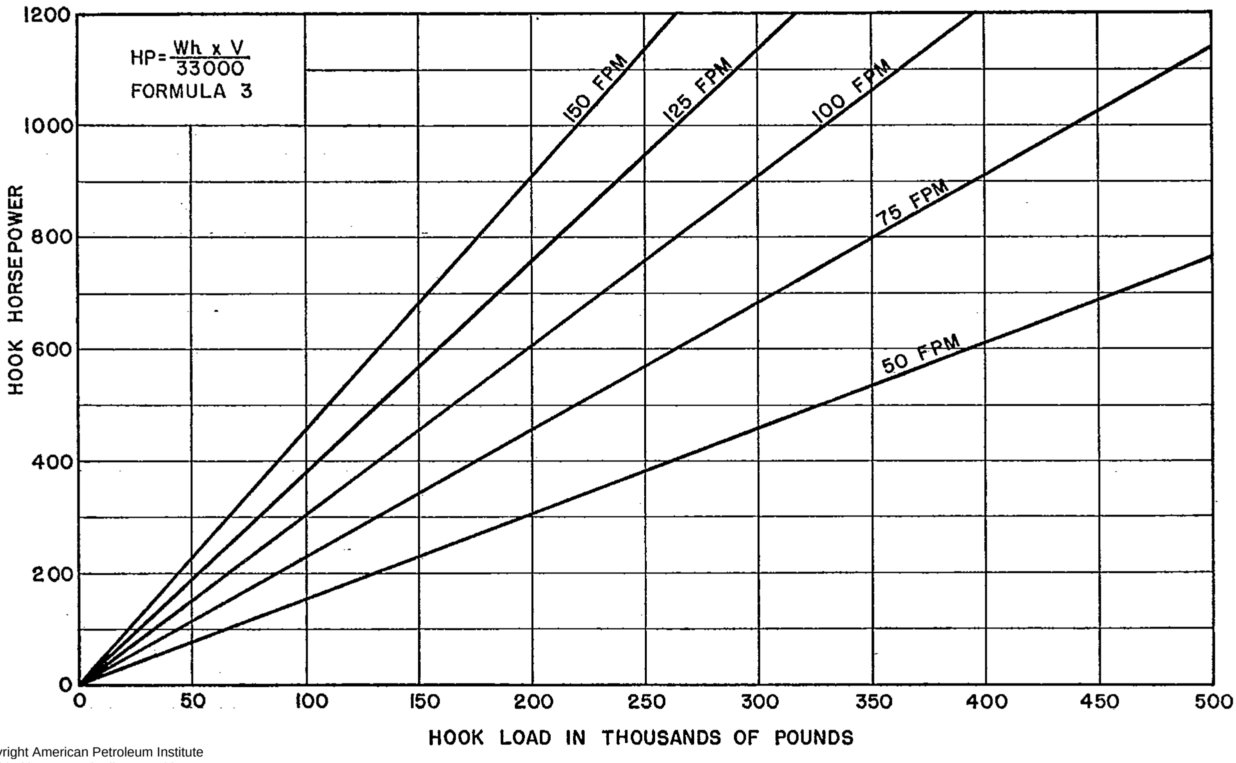


FIG. 3 — HOOK HORSEPOWER FOR HOISTING

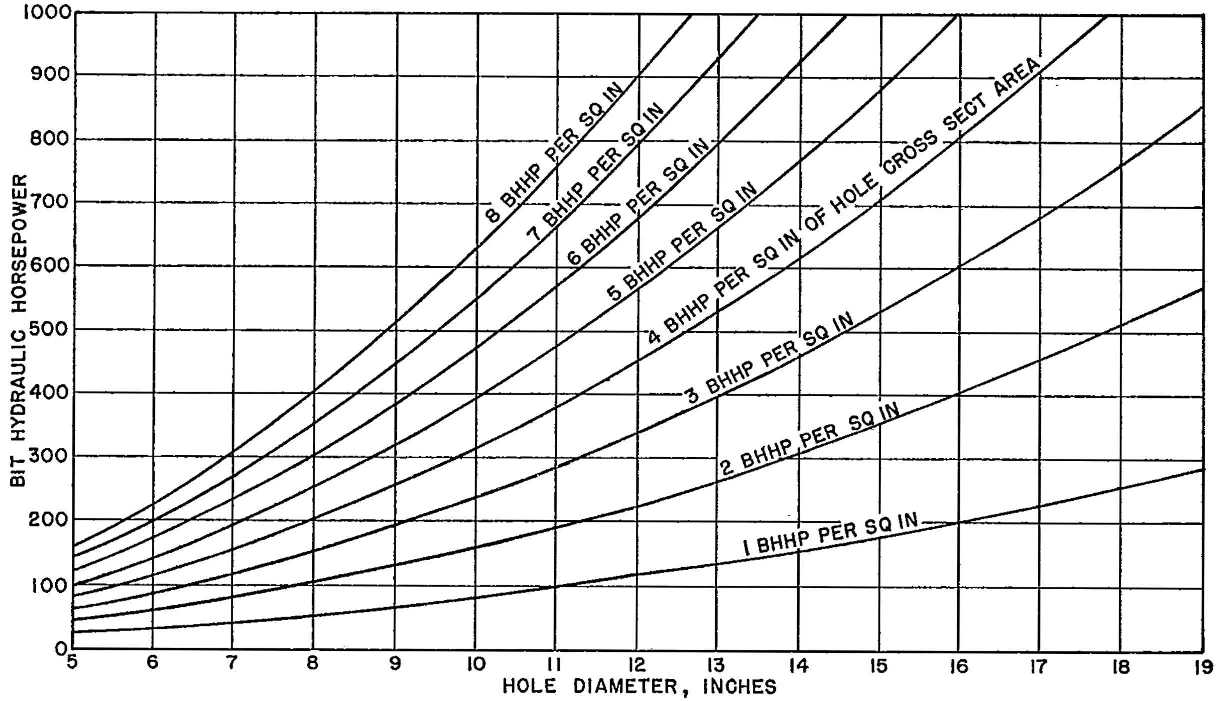


FIG. 4 — BIT HYDRAULIC NEEDS, AS A FUNCTION OF HOLE SIZE

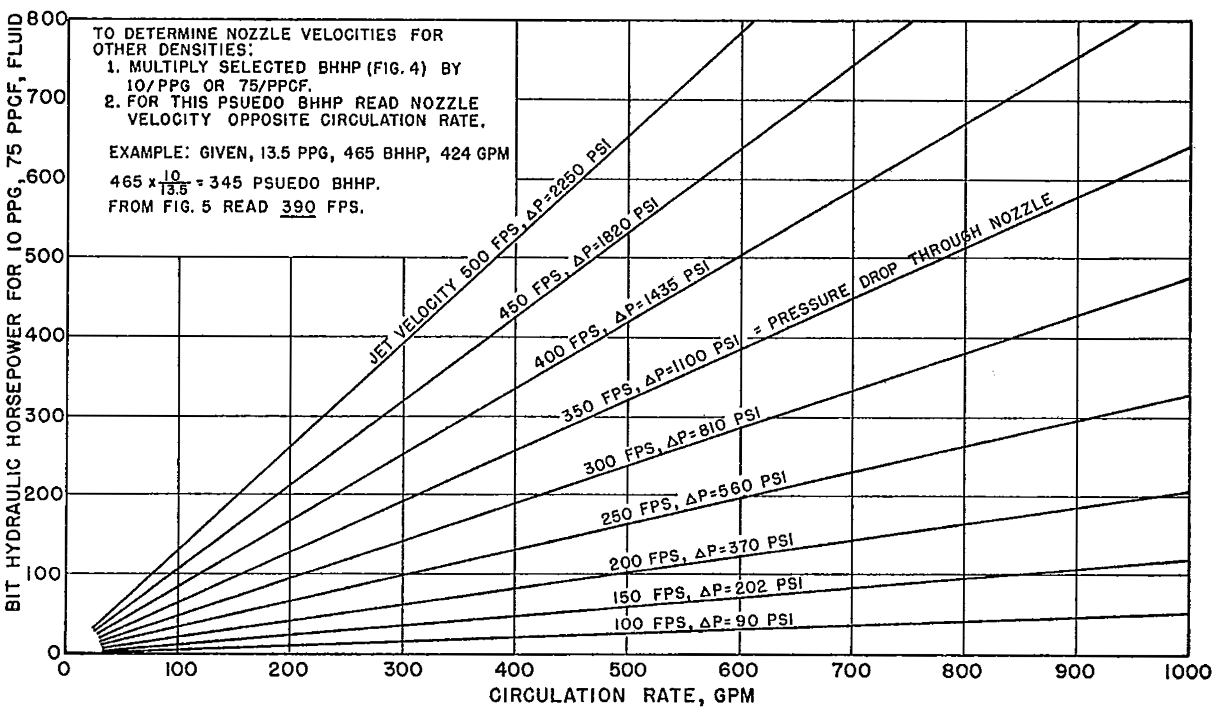


FIG. 5 — JET-BIT HYDRAULIC FACTORS

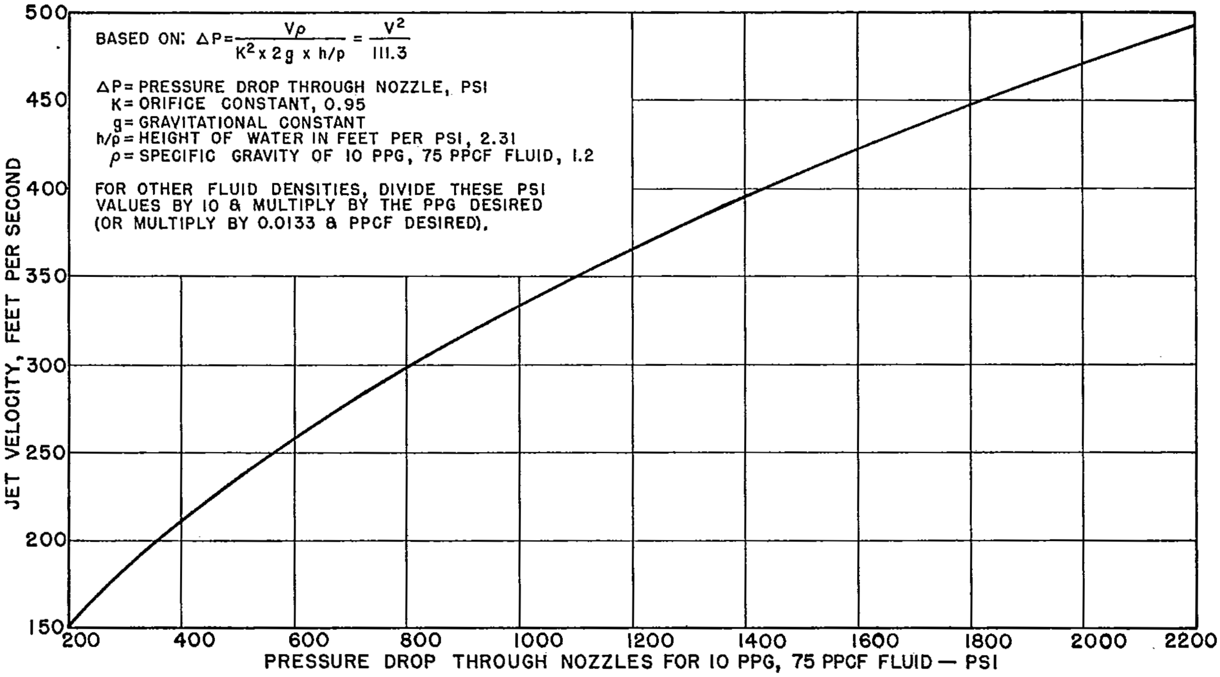
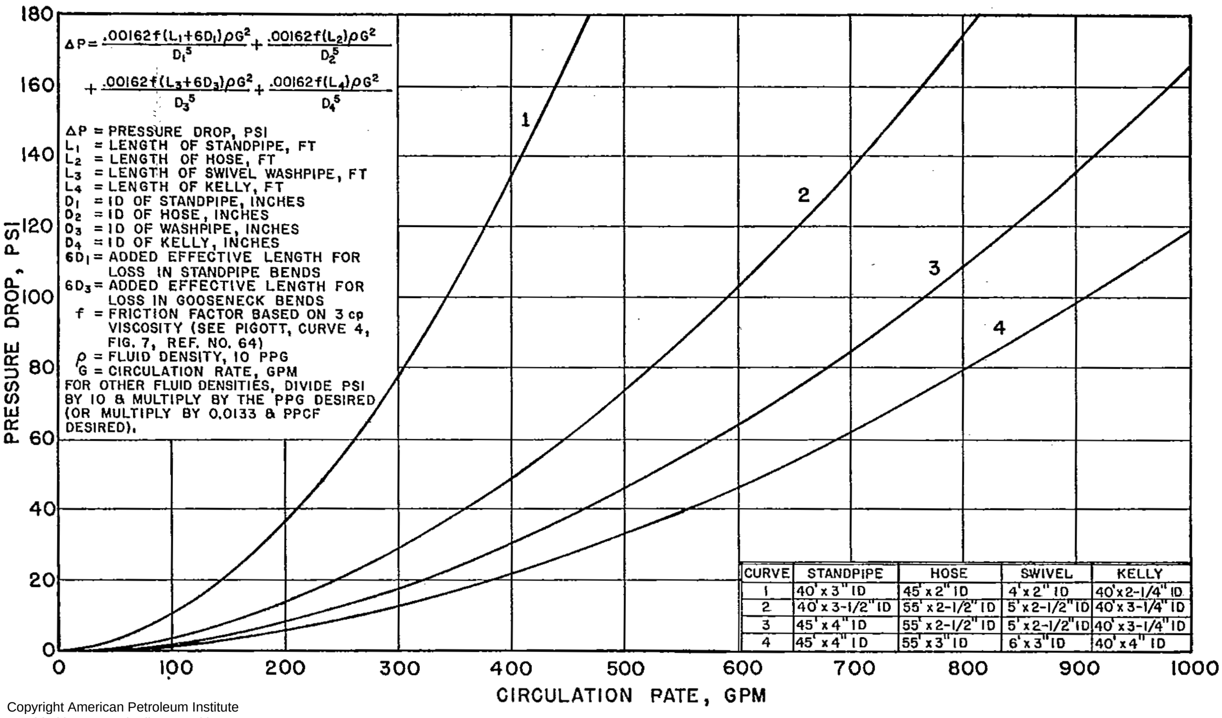


FIG. 6 — PRESSURE DROP THROUGH NOZZLES VS. JET VELOCITY



CURVE	STANDPIPE	HOSE	SWIVEL	KELLY
1	40' x 3" ID	45' x 2" ID	4' x 2" ID	40' x 2-1/4" ID
2	40' x 3-1/2" ID	55' x 2-1/2" ID	5' x 2-1/2" ID	40' x 3-1/4" ID
3	45' x 4" ID	55' x 2-1/2" ID	5' x 2-1/2" ID	40' x 3-1/4" ID
4	45' x 4" ID	55' x 3" ID	6' x 3" ID	40' x 4" ID

FIG. 7 — PRESSURE LOSS THROUGH SURFACE EQUIPMENT

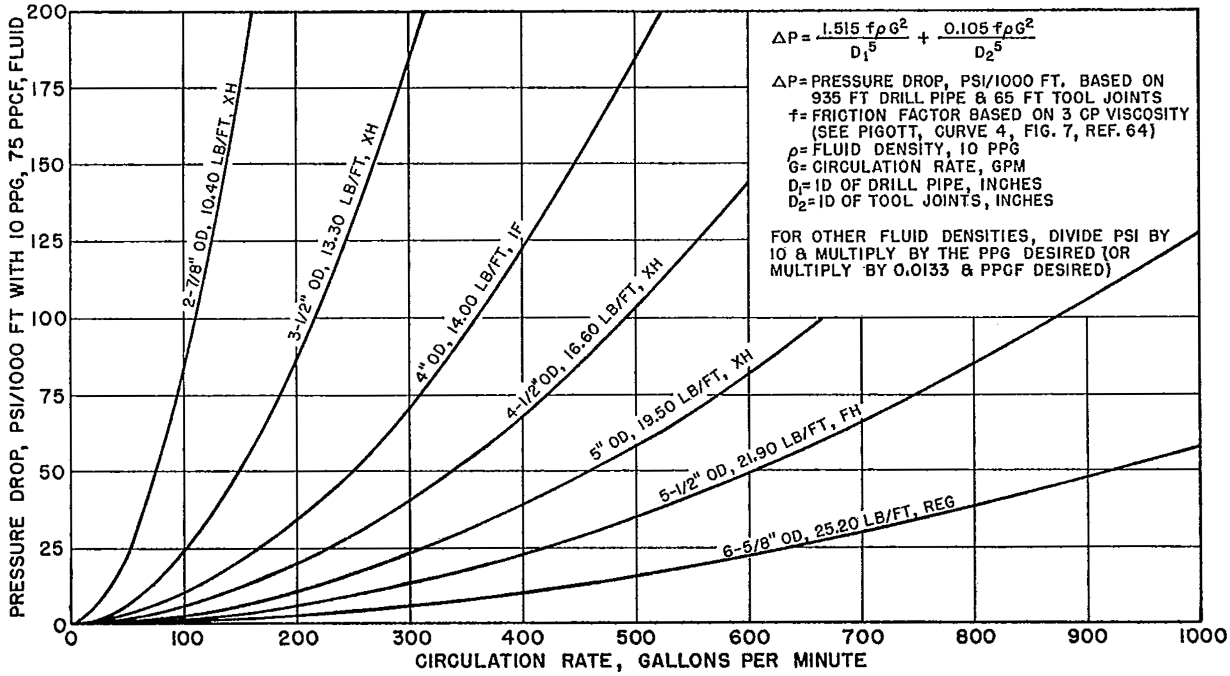


FIG. 8 — PRESSURE DROP THROUGH 1,000 FT OF DRILL PIPE

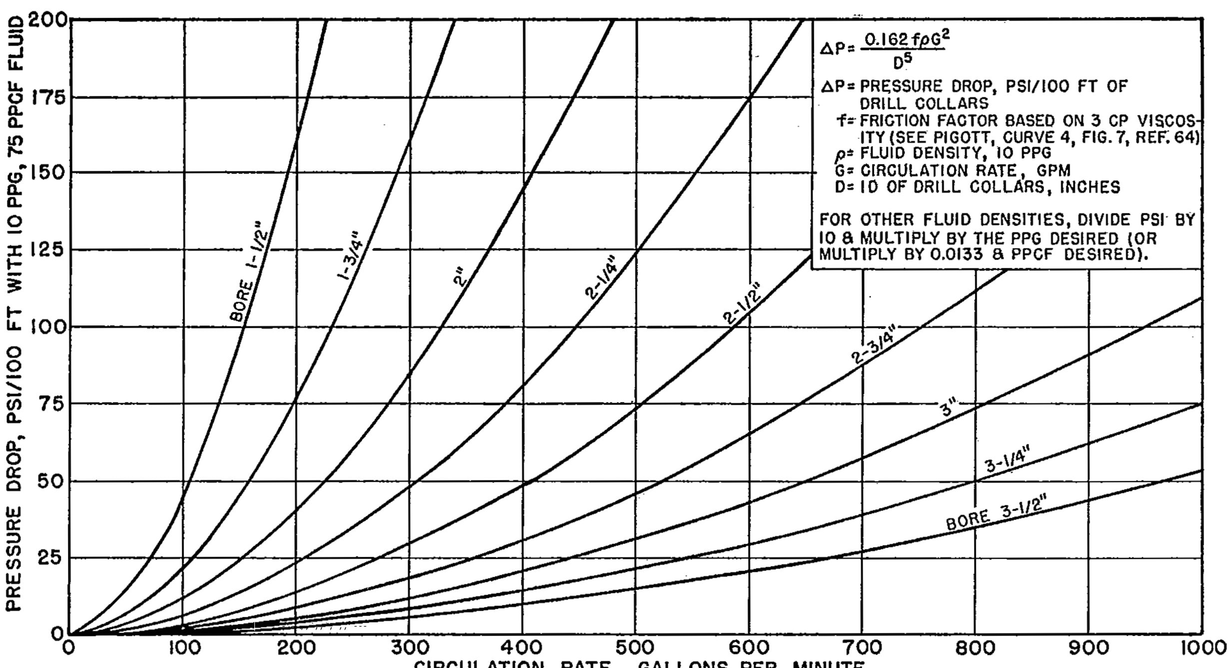


FIG. 9 — PRESSURE DROP THROUGH 100 FT OF DRILL COLLARS

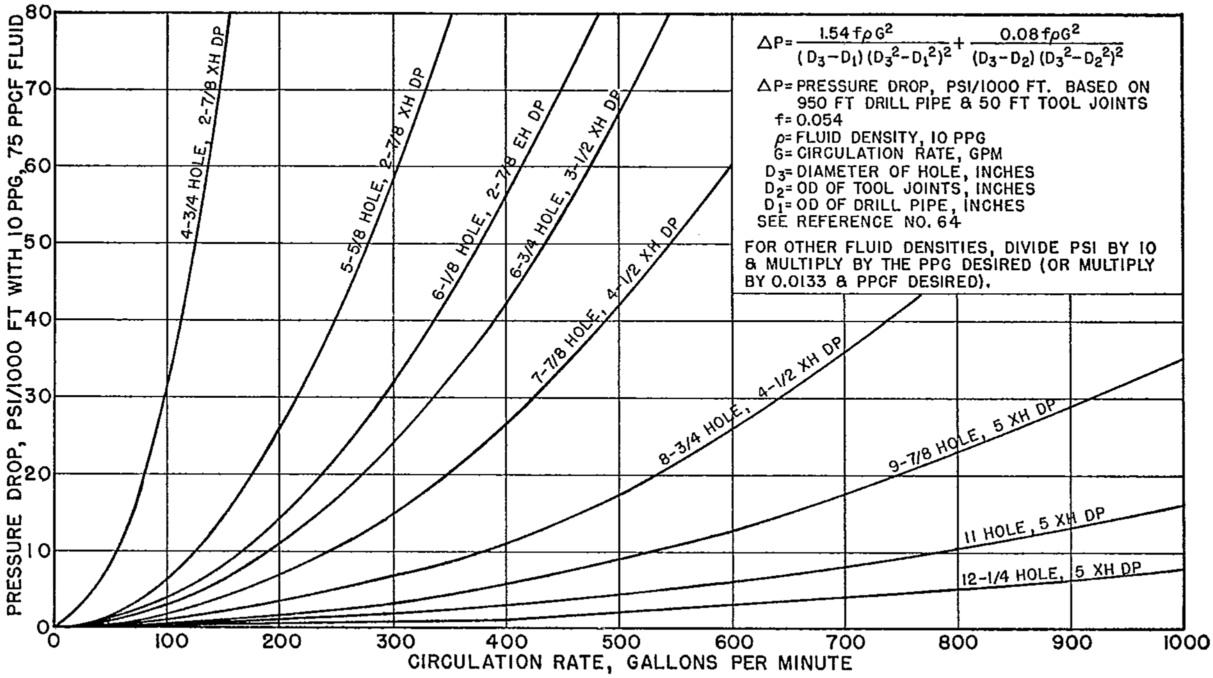


FIG. 10 — PRESSURE DROP IN ANNULUS PAST 1,000 FT OF DRILL PIPE

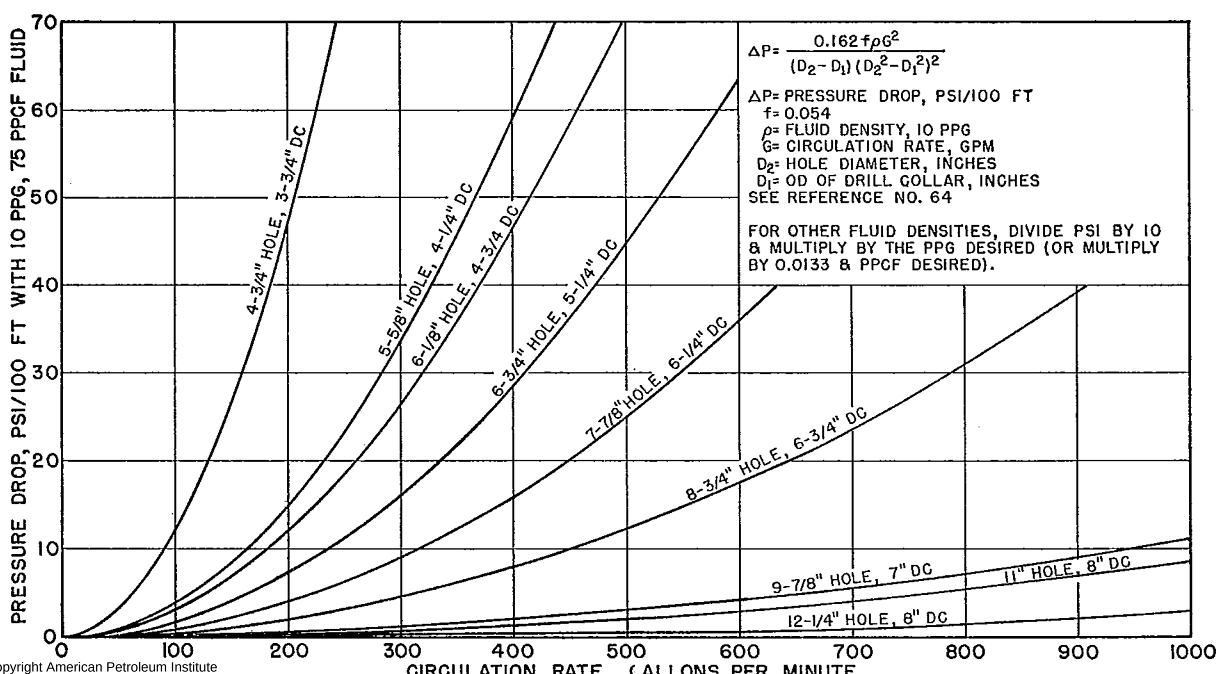


FIG. 11 — PRESSURE DROP IN ANNULUS PAST 100 FT OF DRILL COLLARS

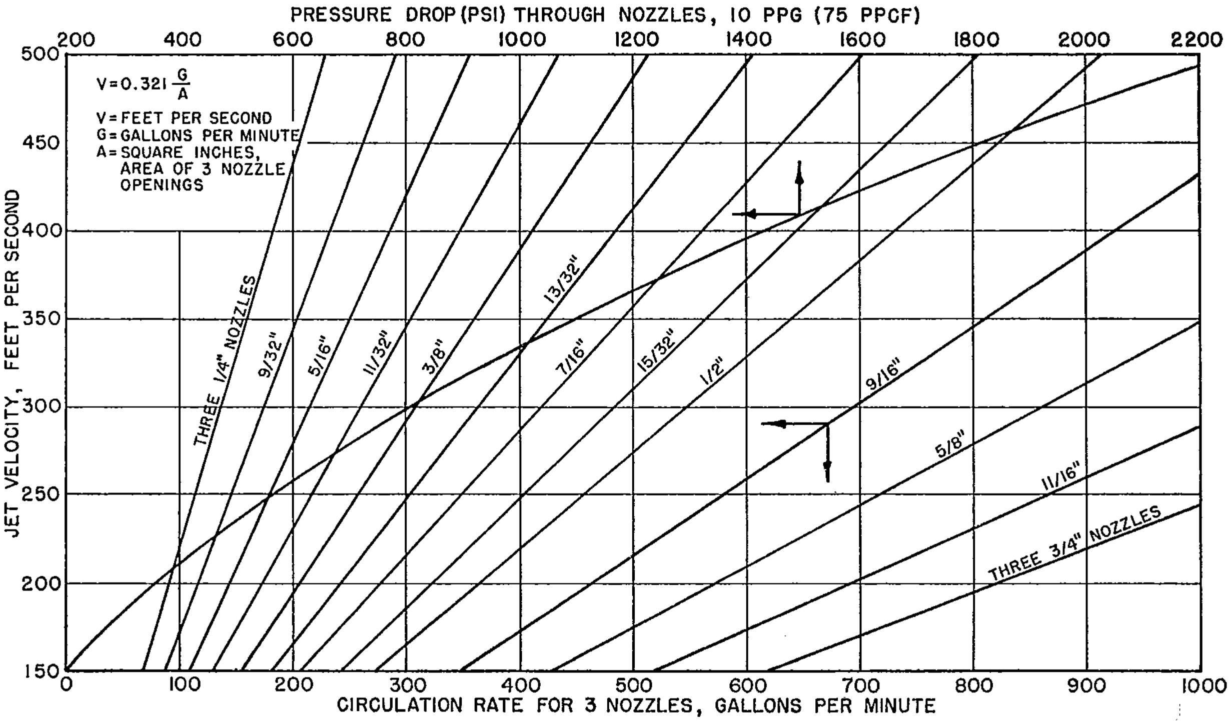


FIG. 12 — NOZZLE SELECTION CHART

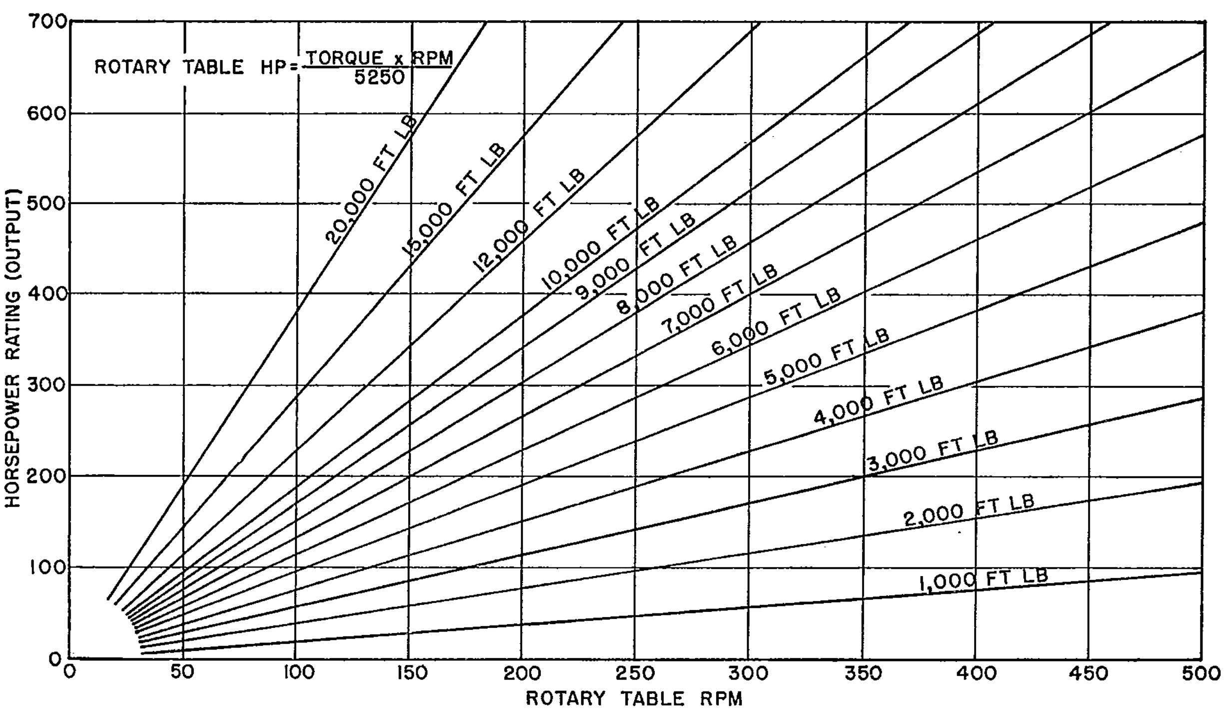


FIG. 13 — ROTARY-TABLE HORSEPOWER

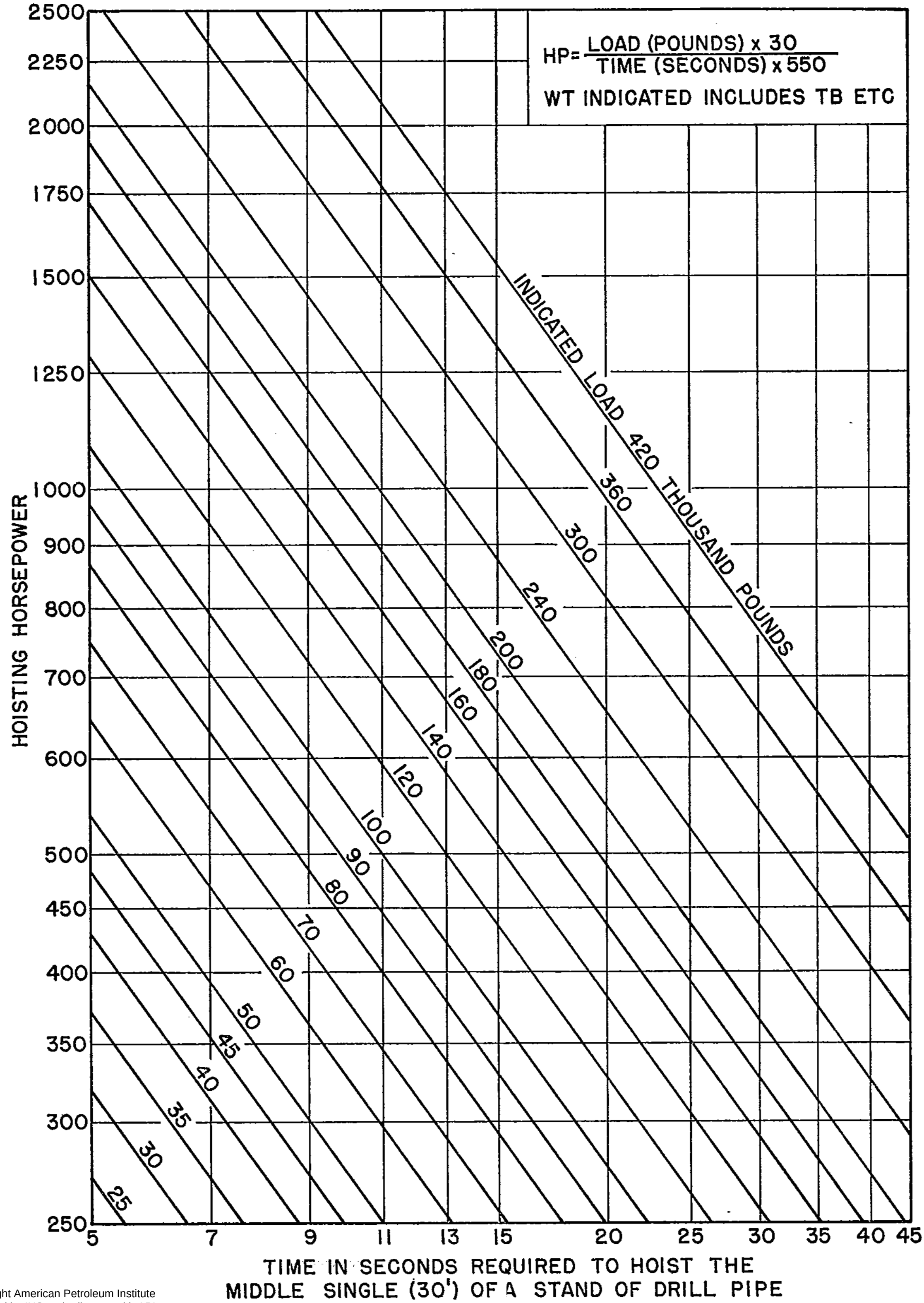

HP= LOAD (POUNDS) x 30 / TIME (SECONDS) x 550
WT INDICATED INCLUDES TB ETC
INDICATED LOAD 420 THOUSAND POUNDS
360
300
240
200
180
160
140
120
100
90
80
70
60
50
45
40
35
30
25
HOISTING HORSEPOWER
2500
2250
2000
1750
1500
1250
1000
900
800
700
600
500
450
400
350
300
250
5
7
9
11
13
15
20
25
30
35
40
45
TIME IN SECONDS REQUIRED TO HOIST THE MIDDLE SINGLE (30') OF A STAND OF DRILL PIPE

FIG. 14

SECTION 3

RATING OF THE RIG'S SEVERAL COMPONENTS

Many individual rig components which are not readily subject to non-destructive performance tests are covered already by API specifications and ratings. In many instances, the only ratings for equipment are the manufacturers' recommended capacities. In general, these have been found to be reliable and possibly on the conservative side. This applies particularly to the rated capacity of various items of suspension equipment.

Performance capabilities of certain other rig components, however, are readily subject to demonstrable tests as prescribed in the schedules included herewith, D10-B, Rig-rating Check List, sample of which and which can be summarized on API Form No. D10-B, Rig-rating Check List, sample of which follows.

API FORM NO. D10-B*

RIG-RATING CHECK LIST

Rig Owner____________________

Rig Identification____________________

Intended Area of Rig Use____________________

Data Submitted by:____________________ Date__________

A. CAPACITY FOR HANDLING CASING OR DRILL PIPE . . . . __________lb
(From Form No. D10-C, Schedule A)

B. SUBSTRUCTURE LOAD-SUPPORTING CAPACITY:
(From Form No. D10-C, Schedule B)

1. Maximum pipe setback capacity . . . . __________lb
2. Maximum rotary-table supporting capacity, irrespective of setback load . . . . __________lb
3. Corner loading capacity (for derricks only) . . . . __________lb

C. HOISTING AND BRAKING CAPABILITIES
(From Form No. D10-D, Schedule C)

	Hook HP	Hook Load	Hook Velocity
Observed hoisting performance	______	______M lb	______ft/min
Auxiliary brake performance	Max. hook load	______M lb	______ft/min

D. MUD PUMP PERFORMANCE CAPABILITY (OBSERVED)
(From Form No. D10-E, Schedule D)

	High-volume Service			High-pressure Service		
	gal/min	psi	HHP	gal/min	psi	HHP
1. Main pump	____	____	____	____	____	____
2. Stand-by	____	____	____	____	____	____
3. Stand-by	____	____	____	____	____	____

E. ROTARY-TABLE PERFORMANCE

Continuous Rotating Speed Range:

1. Rotary table: Make__________Model__________API Opening______
2. Independently driven table, max.__________RPM to min.__________RPM

*Rig-rating Check List (Pages 1-3) available in pads of 50 sheets at $1.00 per pad from API Division of Production, 300 Corrigan Tower Building, Dallas, Texas 75201.

3. Independent drive unit, make____________________Model____________________

4. Drive unit, engine or motor: Make____________________Model____________________

   Cont. HP rating____________________

5. Table driven through drawworks:

   Ratio I__________RPM to__________RPM Ratio III__________RPM to__________RPM

   Ratio II__________RPM to__________RPM Ratio IV__________RPM to__________RPM

F. DRILL-STRING SPECIFICATIONS

Drill Pipe

String:	#1	#2		
Nominal size	________	________	in.	
Weight per foot	________	________	lb	
API grade	________	________		
Length of string	________	________	ft	
Tool-joint size and style	________	________		
Tool-joint OD	________	________	in.	
Date of last inspection	________	________		
Inspection method	________	________		CLASS*
No. of joints by inspection	________	________		1
	________	________		PREMIUM
	________	________		2
	________	________		3

Other drill-pipe condition information, such as hardbanding, protectors, etc:

____

____

____

____

____

____

…and classification of used drill pipe are inclu… ed in Section 9, *API RP 7G: Drill Stem Design and Operating* …roduction, 300 Corrigan To… …g, Dallas, Texas 75201.

Drill Collars

Quantity	______	______	______	______
Max. OD (to nearest 1/16 in.)	______	______	______	______
Min. bore (to nearest 1/16 in.)	______	______	______	______
Average length	______	______	______	______
Approx. string weight	______	______	______	______
Tool-joint style and size	______	______	______	______

G. AUXILIARY EQUIPMENT

Mud Tanks

Number	Size	Capacity Each
______	______	______
______	______	______
______	______	______

Mud-mixing Equipment

a. Pumps

Number	Make	Type	Size
______	______	______	______
______	______	______	______

b. Prime Mover

Number	Make	Model	HP
______	______	______	______
______	______	______	______

Mud-agitating Equipment — Describe: ____________________________

____

____

____

Shale Shaker: Make ________________ Model ________________

Desander:

Make	Model	Capacity, gal/min
______	______	______
______	______	______

Desander Pump: Make ______ Type ______ Capacity, gal/min ______

Desander-pump Prime Mover: Make ______ Model ______ HP ______

Well-control Equipment

Blowout Preventers

No.	Make	Model	API Flange Size	Bore	Working Pressure

Choke Manifold — Describe: ______

Kelly Cock: Make ______ Model ______

Drill-pipe Safety Valve: Make ______ Model ______

Degasser: Make ______ Model ______

Mud-Gas Separator — Describe: ______

Blowout Preventer Closing Unit

Make ______ Model ______ No. of Outlets ______ No. of Stations ______

Accumulator volume (liquid and gas) ______ gal

Precharge pressure (before adding liquid) ______ psi

Final pressure (when fully charged with liquid) ______ psi

...ating valve? Yes ______ No ______

Generators

Number	Make	Model	Type	Capacity, KW

Generator Prime Mover

Number	Make	Model	HP

Lighting System

Vapor Proof: Yes__________ No__________

Describe: __________

Mud Storage — Describe: __________

Cement Storage Capacity: __________

Fresh-water Storage Capacity: __________

Fuel Storage Capacity: __________

Additional Equipment — Describe: __________

API FORM NO. D10-C*

SCHEDULE A

CAPACITY FOR HANDLING CASING OR DRILL PIPE

Hook-load capacity of any piece of equipment in the hoisting system is defined as that load in pounds that may be suspended by the hook which will load the particular piece of equipment up to its API or manufacturer's rated capacity. Hook-load capacity of the rig is therefore limited by that equipment having the least such capacity. These data apply to the following rig:

Rig identification:____________________

Rig hook-load capacity, for drill string is__________lb, as limited

by__________________below.
(weakest link)

Rig hook-load capacity, running casing is__________lb, as limited

by__________________below.

	Rating
1. Mast or Derrick	
Wind resistance with no drill-pipe setback	________mph
Wind resistance with______ft of drill-pipe setback	________mph
Racking capacity of______-in. drill pipe	________ft
Static hook-load capacity (with______lines strung to traveling block)	________M lb
2. Crown block________ (1) Make (2) Weight (3) No. of Sheaves	________tons
3. Traveling block________ (1) Make (2) Weight (3) No. of Sheaves	________tons
4. Hook	________tons
5. Swivel	________tons
6. Elevator links	________tons
7. Drill-pipe elevators	________tons
8. Casing elevators	________tons
9. Rotary drilling line (hook-load capacity)	________M lb

Classification	Size	Grade	Center	API breaking strength**	Safety factor	No. Lines

*API Form No. D10-C (Schedules A and B) is available in pads of 50 sheets at $1.00 per pad from API Division of Production, 300 Corrigan Tower Building, Dallas, Texas 75201.

...inal) for new wire ropes are shown in *API Spec 9A: Specification for Wire Rope,* available from API ...0 Corrigan Tower Building, Dallas, Texas 752..1.

API FORM NO. D10-C*

SCHEDULE B

SUBSTRUCTURE LOAD-SUPPORTING CAPACITY

Substructure: Make____

Model or type______________________________

Floor height . . . . ________ft

Width . . . . ________ft

Length . . . . ________ft

Height above ground to underside of rotary beams . . ________ft________in.

For use with derrick (or mast) having static hook load capacity of . ________M lb

Maximum pipe setback capacity . . . . ________M lb

Maximum rotary-table supporting capacity irrespective of setback load ________M lb

Corner loading capacity (for derricks only) . . . . ________M lb

Loads imposed by tensioning devices . . . . ________M lb

Additional loads . . . . ________M lb

*API Form No. D10-C (Schedules A and B) is 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-D*

SCHEDULE C

HOISTING AND BRAKING CAPABILITIES

Hook-horsepower rating and auxiliary brake capability are based on actual field performance, as measured by a standard test procedure. By this test procedure, hook-horsepower and braking capability are determined from observations made during tripping operations, whereby the speed of the middle single of a stand is combined with concurrent weight-indicator reading. The data submitted applies to the following rig:

Rig identification:____________________

Maximum hook-horsepower observed to be____________at hook load of________lb

as of____________ (Date) at____________ (Location)

and observed by__________________.

Rig equipped as follows:

Equipment	**Description (Type, Make, Model, Size, etc.)**
Drawworks	
Auxiliary brake	
Engine-hoist transmission system . . .	
Hoisting engines	

Observed Test Data — Hoisting

Drawworks Ratio	Hook Load, M lb	Sec to Pull Middle Single	Hook Velocity, ft/min	Calculated Hook Horsepower	No. Lines Strung

Observed Auxiliary Brake Performance

Hook Load, M lb	Sec to Lower Middle Single	Hook Velocity, ft/min	No. of Lines to Traveling Block	Remarks

*API Form No. D10-D (Schedule C) is 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-E*

SCHEDULE D

MUD PUMP PERFORMANCE CAPABILITY

Mud pump ratings are to be based on hydraulic horsepower they are capable of delivering continuously during normal drilling operations. Hydraulic horsepower is determined in the field by using standard test procedures, whereby pressure-gage observations and either measured or calculated mud volumes are used to calculate pump hydraulic horsepower output.

Rig identification: ________________________

Pump Specifications	(1) Main	(2) Stand-by	(3) Stand-by
Make (manufacturer)			
Model designation			
Rated input horsepower			
Rated RPM × stroke length	____ × ____ in.	____ × ____ in.	____ × ____ in.

Service Conditions	High Volume	High Pressure	High Volume	High Pressure	High Volume	High Pressure
Liner sizes: Max.-min.						
Corresponding rated WP						
GPM displaced @ rated RPM . .						
Observed Performance						
Dates tested						
Engines connected to mud pumps**						
Do the same engines drive rotary?						
Max. no-load pump RPM						
Pump RPM during tests						
Engine RPM during test						
Liner sizes during tests						
Standpipe pressure, psi						
GPM, measured						
GPM, calc. @ ____ % vol. eff. . .						
Pump output, HHP						

**Engines supplying power to mud pumps:

No.	Make	Model	Manufacturer's Continuous-duty Rating at Owner's Governed Speed
1.			____ HP @ ____ RPM
2.			____ HP @ ____ RPM
3.			____ HP @ ____ RPM
4			____ HP @ ____ RPM

*API Form No. D10-E (Schedule D) is available in pads of [illegible] sheets at $1.00 per pad from API Division of Production, 300 Corrigan Tower Building, Dallas, Texas 75201.

SECTION 4

RIG-RATING PARAMETERS

SAFE LOAD RATINGS

Manufacturers of derricks, masts, and substructures, in cooperation with API, furnish the users of such equipment with applicable safe load ratings. If specified safe load ratings for given conditions are not exceeded, no failure is likely. If these ratings are exceeded, failure is possible. At greater overloads, failure is probable, and at some critical loading, failure is certain.

Derricks and Masts

Derricks and masts are designed to a static hook-load capacity when using a specified number of lines and with an established position for the dead-line anchor. Any change in the number of lines strung or shift of the dead-line anchor position may materially alter the static hook-load capacity.

Substructures

When substructures are used with derricks and masts, refer to *API Std. 4E: Specification for Drilling and Well Servicing Structures**. API Std. 4E provides, among other things, that substructures carry name plates bearing specified information including:

Maximum pipe setback weight, pounds__________

Maximum rotary-table loading, pounds__________

Even though substructures are designed to support these two loads "acting simultaneously", it should never be presumed that capacity not utilized in one of the areas may be transferred, in whole or in part, to the other area. Each such rating is *maximum* for its area irrespective of loading in the other area.

Wire Lines

Nominal breaking strengths for new wire rope are shown in *API Spec. 9A: Specification for Wire Rope**, Tables 3.3 through 3.17.

Loads and safety factors: When a wire rope is reeved over a number of sheaves in a block-and-tackle system, the load on the fast line is greater than the total load divided by a number of parts of line, because of the loss caused by friction in the sheaves and in the bending of the rope around the sheaves. The efficiency factor of various parts of line for roller-bearing sheaves has been established as follows (see Section 6, Ref. 65):

6 parts of line, efficiency factor = 0.874
8 parts of line, efficiency factor = 0.841
10 parts of line, efficiency factor = 0.810
12 parts of line, efficiency factor = 0.770

*Available from API Division of Production, 300 Corrigan Tower Building, Dallas, Texas 75201.

The maximum load on the fast line may be determined from the following formula:

$$P = \frac{W}{N \times E}$$

Wherein:

P = load on fast line
W = hook load, in pounds, including travelling block
N = number of parts of line (lines strung to traveling block)
E = efficiency factor

DETERMINATION OF HOOK HORSEPOWER

Hook horsepower may be determined during tripping operations by observing weight-indicator readings and timing with a stopwatch the hoisting of the middle singles of various stands and referring these values to Fig. 14, Section 2. This chart is based on the following standard equation, assuming the average length of a single to be 30 ft.

$$\frac{\textit{Load (lb)} \times 30}{\textit{Time (sec)} \times 550} = \textit{horsepower}$$

The weight-indicator reading includes the weight of the block and hook and any pipe drag. Timing the middle single gives a steady condition and permits demonstration of maximum horsepower.

Because of the way in which governors affect engine performance, if it is desired to demonstrate the full horsepower of mechanical-drive internal-combustion engines it may be necessary to put the drawworks in the next higher gear several stands earlier than in usual operating practice to prevent the engines from coming up to governed speed. This is not true for torque-converter, electric, or steam drives.

The accuracy of the weight indicator may be checked from known values of equipment weight, weight of drill string, and mud buoyancy. The accuracy of stopwatch observation can be expected to be the same for start and stop as the tool joints pass the reference point. Altitude usually affects the maximum output of internal-combustion engines.

AUXILIARY BRAKES

For the primary purpose of reducing substantially one item of rig-operating expense, many drawworks incorporate some form of auxiliary brake which permits the lowering of heavy hook loads safely at retarded rates without incurring appreciable brake maintenance. Two general types of auxiliary brakes currently are in common use, viz: *a*, hydro-dynamic;

and *b*, eddy-current. In both types, work is converted into heat which then is dissipated through liquid cooling systems.

Auxiliary-brake capabilities may be determined during tripping operations by observing weight-indicator readings and timing with a stopwatch the lowering of the middle single of a stand while carrying the load exclusively with the auxiliary brake.

The operating principles employed are as follows.

Hydro-dynamic Brakes

A hydro-dynamic brake is a hydraulic device that absorbs power by converting mechanical energy into heat. Resistance is created exclusively by agitation of water circulated between the veined pockets of the rotor and stator elements, with the conversion of mechanical energy into heat taking place directly within the water itself. The amount of mechanical energy that can be absorbed in this manner is dependent upon the quantity and velocity of the water in the working chamber.

With any specific quantity of water in the working chamber, the velocity of the water circulated is increased with increased revolving speed of the rotor, with resulting increase in fluid friction. In this manner the torque capacity of a hydro-dynamic brake increases approximately in proportion to the square of the speed. If the speed is doubled, the torque resistance is increased four times. The revolving speed limitation of the rotor is mechanical, but the torque capacity of the brake increases with speed in the foregoing ratio up to the maximum recommended safe operating speed for each size brake.

The primary function of the circulating system is to supply cool water through the inlet of the brake to displace the heated water and thus prevent the formation of steam within the brake; also to remove the heated water from the circulating system.

The secondary function of the circulating system is to provide controls to permit the driller to vary the braking capacity to meet requirements. The capacity at any speed is adjustable by regulating the quantity of water being circulated between the veined pockets of the rotor and stators in the working chamber. The circulating system includes means for dissipating heat.

Many factors must be considered in determining proper size of brake for specific operating conditions. To simplify selection of brakes, performance charts are available from the manufacturers of hydro-dynamic brakes.

Eddy-current Brakes

An eddy-current brake is an electro-magnetic machine which includes primarily a driven element— being an all-iron rotor, and a stationary member which provides a variable and controllable magnetic field in which the driven element revolves. Magnetic forces, induced in the rotor, tend to oppose accelerated rotary movement. Eddy currents, produced in the iron rotor as it is rotated within the electromagnetic field of the stator, generate heat which is transferred to a liquid medium circulating through the machine. Thus mechanical energy is converted into heat and then is dissipated by a liquid cooling system. Magnetic forces and eddy currents in the iron rotor increase with increases in intensity of the electro-magnetic field and, to a limited extent, with increases in the speed of rotation.

The stator's magnetic field is produced by coils, separately excited from an extraneous source of direct-current electricity. Within prescribed limits of the machine, regulation of the excitation current controls the relative counter torque or braking effect available at various rotational speeds of the rotor.

Performance data on machines of various capacities are available from manufacturers of eddy-current brakes.

SECTION 5

GLOSSARY

HORSEPOWER (HP): $\frac{\textit{Force (lb)} \times \textit{speed (ft/min)}}{33{,}000}$

The rate of doing work (transferring energy) equivalent to lifting 33,000 lb 1 ft/min (33,000 ft-lb/min). This is also 550 ft-lb/sec.

Lifting a weight is a simple example of a force in motion. The same combination of force-times-speed in any direction—along the flat, on a slant, around a curve, or any combination—is the same horsepower. (Also, other transfers of energy may be stated as horsepower.)

HYDRAULIC HORSEPOWER (HHP):

$$\frac{\textit{Circulation rate (gpm)} \times \textit{differential pressure (psi)}}{1{,}714}$$

ELECTRIC HORSEPOWER (EHP): *Kilowatts* $\times$ *0.746*

THERMAL HORSEPOWER (THP): $\frac{\textit{Btu/min}}{42.42}$

INPUT HORSEPOWER: The horsepower that is put into an operating system.

OUTPUT HORSEPOWER: The horsepower that is put out by an operating system.

EFFICIENCY: The percentage relation of output to input.

MECHANICAL EFFICIENCY: The percentage relation of mechanical power output to mechanical power input.

HYDRAULIC EFFICIENCY: The percentage relation of hydraulic horsepower output to mechanical horsepower input. In some cases this may include mechanical efficiency.

VOLUMETRIC EFFICIENCY: The percentage relation between the actual delivered capacity of a pump and the calculated displacement of the pump.

TRANSMISSION LOSS: The difference between output horsepower and input horsepower. It may conveniently be expressed as percentage of input horsepower.

BRAKE HORSEPOWER (BHP): The horsepower output of an engine or motor measurable by a special brake or a dynamometer.

BIT HYDRAULIC HORSEPOWER (BHHP): The hydraulic horsepower equivalent of the gallons per minute and the pressure drop across the bit nozzles.

$$\frac{GPM \times psi}{1{,}714} = BHHP$$

BIT MECHANICAL HORSEPOWER: The horsepower required to rotate the bit only, not including that required to rotate the drill string contacting the walls.

ROTARY HORSEPOWER (RHP): The horsepower required to rotate the drill string and the bit.

$$\frac{\textit{Torque (ft-lb)} \times \textit{rpm}}{5{,}250} = RHP$$

TORQUE: The tangential force (pounds) times lever arm length.

HOOK HORSEPOWER (HOISTING HORSEPOWER):

$$\frac{\textit{Weight-indicator reading (lb)} \times \textit{length of middle joint (ft)}}{\textit{Time to hoist middle joint (sec)} \times 550}$$

PUMP INPUT HORSEPOWER: Mechanical horsepower put into the pump.

PUMP OUTPUT HORSEPOWER: Hydraulic horsepower put out by pump.

ENGINE HORSEPOWER (ENGINE RATING): Refer to *API Std 7B-11C*. This standard covers rating of internal combustion engines. The MAXIMUM rating is not usable. The INTERMITTENT rating is applicable to hoisting. The CONTINUOUS rating is applicable to pumping.

BRAKING CAPACITY: The load which the drawworks brake and auxiliary brake can retard to a constant reasonable speed, or hold.

DRILL PIPE: A portion of the drill string which transmits power to the bit.

DRILL COLLAR: Thick-walled pipe to provide stiffness and concentration of weight at the bit.

DRILL STRING: A combination of drill pipe, drill collars, and accessory components.

BIT PORT: A fluid-flow port in a bit.

JET NOZZLE: A fluid-flow port in a jet bit.

JET-TYPE BIT: A bit employing directed, rapid flow of fluid from a nozzle or nozzles.

DRILLING HYDRAULICS: The employment of the science of the effects of fluid velocities and pressures and forces involved.

ROTARY DRILLING RIG: Includes prime movers, hoisting, rotating, circulating, and auxiliary equipment necessary for well drilling.

STEAM RIG: A rotary drilling rig with steam boilers and steam-driven equipment.

ALL-ELECTRIC RIG: A rotary drilling rig using power from electric power line.

DIESEL-ELECTRIC OR GAS-ELECTRIC RIG: A rotary drilling rig using self-generated electric power.

MECHANICAL-ELECTRIC RIG: A rotary drilling rig using diesel or gas engines to drive pumps and generator.

MECHANICAL RIG: A rotary drilling rig driven by diesel or gas engines.

STRAIGHT MECHANICAL DRIVE: Internal-combustion engines connected to leads by clutches which can be slipped a moderate amount.

FLUID DRIVE: Special pump-and-turbine unit connecting engine to load, permitting some slip and flexibility.

HYDRAULIC DRIVE: A motor driven hydraulically by a pump.

TORQUE CONVERTER: Fluid drive which increases torque and reduces rpm.

REYNOLDS NUMBER (R_e): A dimensionless function that characterizes friction of fluid flow in pipes and is defined by the following:

$$R_e = \frac{vd\rho}{N}$$

Wherein:

v = mean velocity, ft/sec
d = diameter of pipe, ft
ρ = density, lb/cu ft
N = absolute viscosity, lb/ft-sec
= 0.000672 × viscosity in centipoise

Or, in oil-field engineering units:

$$R_e = 928 \left(\frac{vd_1\rho_1}{N_1}\right)$$

Wherein:

v = mean velocity, ft/sec
d_1 = diameter of pipe, in.
ρ_1 = density, lb/gal
N_1 = plastic viscosity, cp

or:

$$R_e = 379 \left(\frac{G\rho_1}{N_1\, d_1}\right)$$

Wherein:

G = flow rate, gal/min
d_1 = diameter of pipe, in.
ρ_1 = density, lb/gal
N_1 = plastic viscosity, cp

SECTION 6

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