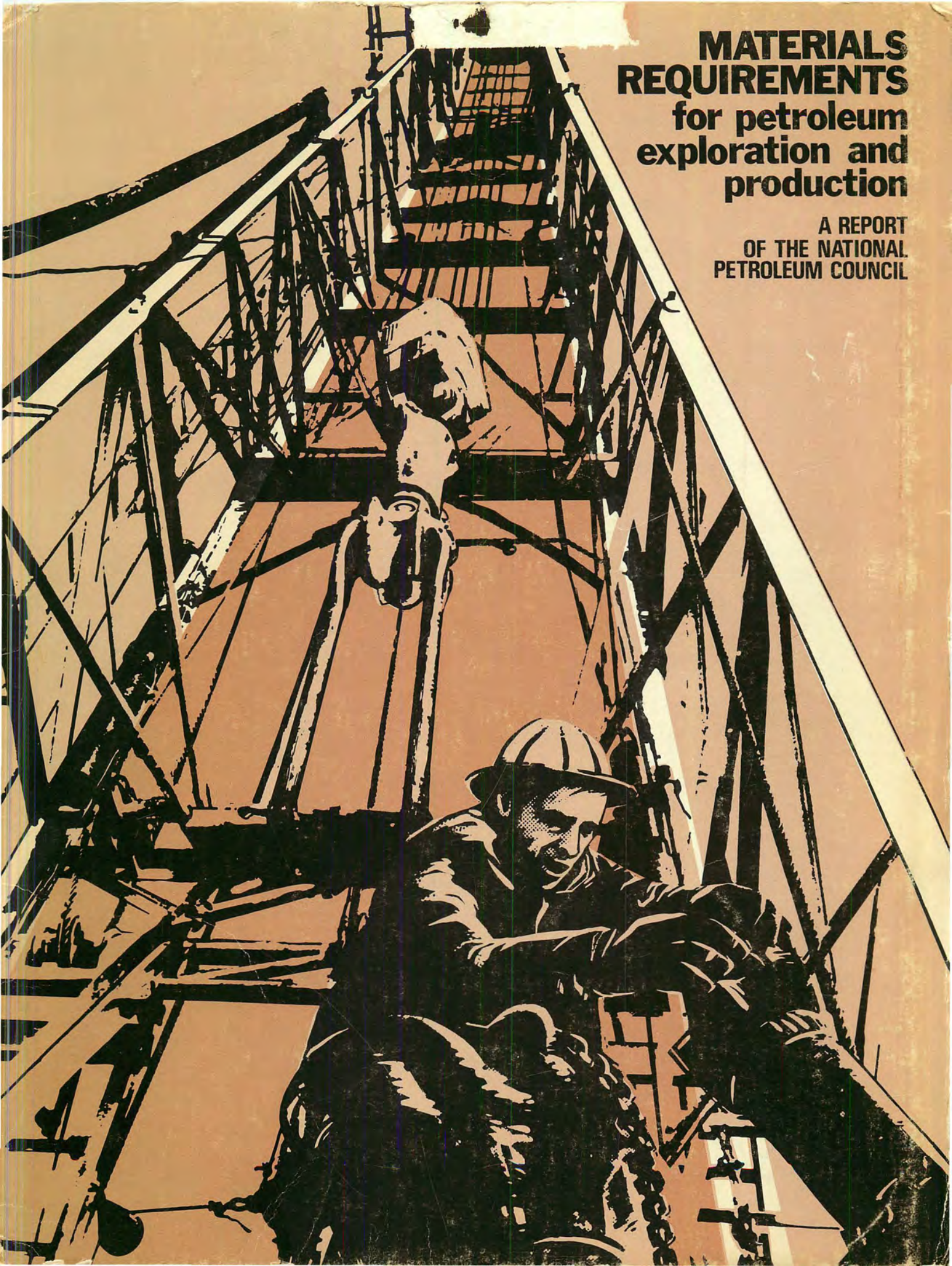

MATERIALS REQUIREMENTS for petroleum exploration and production

A REPORT OF THE NATIONAL PETROLEUM COUNCIL

Prepared by the
National Petroleum Council
in response to a request of the
Department of the Interior

Additional copies of this report may be obtained from the National Petroleum Council office.

MATERIALS REQUIREMENTS FOR PETROLEUM EXPLORATION AND PRODUCTION

MARCH 1969

Prepared by the

NATIONAL PETROLEUM COUNCIL'S COMMITTEE
ON MATERIALS REQUIREMENTS FOR PETROLEUM
EXPLORATION AND PRODUCTION

A. W. TARKINGTON, *Chairman*

with the assistance of the

Technical Subcommittee
W. O. Ham, Jr., *Chairman*

TABLE OF CONTENTS

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PREFACE

In a national emergency, the petroleum industry must be in a position to respond flexibly in order to sustain producing levels adequate to supply demand requirements. The responsibility of supplying the Nation's hydrocarbon demand requirements can be discharged, only, if the petroleum industry is allocated the materials necessary to meet an emergency condition in an orderly, effective, and flexible manner.

In the National Plan for Emergency Preparedness, published in December, 1964, under Executive Order 11051, the Business and Defense Services Administration (BDSA) in the Department of Commerce is designated the Resource Agency for production and allocation of all materials except those classified as fuel and energy. The Emergency Petroleum and Gas Administration (EPGA) in the Department of the Interior is designated the Resource and Claimant Agency for the petroleum industry in a national emergency. As claimant agent, the EPGA prepares forecasts of controlled and non-controlled critical materials requirements on both short and long range (up to 18 months and beyond) bases. Forecasts and requests for materials allotments and priorities are submitted to the BDSA by the EPGA and include Class A (special made) as well as Class B (standard) products. The BDSA then allocates controlled materials and authorizes priority ratings in accordance with guidelines issued by the Office of Defense Resources, an agency of the Executive Department which would be activated in a national emergency. The EPGA then has the responsibility of administering these materials allocations to the petroleum industry.

In 1967, about 75 per cent of the energy requirements in the United States were supplied by the petroleum industry; therefore, the continuance of an adequate supply to meet demand is essential to the National security. Crude oil and natural gas production can be maintained on a continuous and expanding basis only if the exploration, drilling, and production operations are conducted in an uninterrupted manner. To drill the required number of wells and maintain existing wells and related facilities, the petroleum industry is highly dependent upon certain essential materials such as carbon and alloy steel. The Department of the Interior must be apprised of the industry's normal materials consumption in order to support oil and gas companies, related contractors, and specialties manufacturers in obtaining materials.

In response to previous requests from the Department of the Interior, the National Petroleum Council developed materials consumption reports for the oil and gas exploration, drilling, and production segments of the petroleum industry in December 1953 and in July 1963 for the years 1952 and 1962, respectively. To further facilitate emergency materials allocation, the Department of the Interior has requested that the National Petroleum Council update the 1963 report for the year 1967 and provide indicative factors with which materials requirements can be determined during a national emergency. (See APPENDIX C.)

The National Petroleum Council, responsive to the request of the Department of the Interior, appointed a Materials Requirements for Petroleum Exploration and Production Committee. The Committee was appointed under the Chairmanship of Andrew W. Tarkington, President of Continental Oil Company, and the Co-Chairmanship of Onnie P. Lattu, Director of the Office of Oil and Gas, U. S. Department of the Interior. A Technical Subcommittee was appointed to carry out the requested study work. The Chairman and Co-Chairman of this Technical Subcommittee are W. O. Ham, Jr., Vice President of Continental Oil Company, and John Ricca, Deputy Director of the Office of Oil and Gas, U. S. Department of the Interior, respectively.

INTRODUCTION

In accordance with the basic charge to the National Petroleum Council, the objectives of this study are as follows:

1. To provide an historical and statistical base of critical materials consumption by the exploration and production segments of the petroleum industry in the United States for the year 1967.

2. To develop materials requirement guidelines, based upon 1967 materials consumption, which can be used in time of national emergency to help define critical materials requirements for the exploration and production segments of the petroleum industry in the United States.

For the purpose of this study, critical materials were defined as those basic materials necessary for the production of oil and gas which are controlled or could be in short supply during a national emergency. A detailed description of critical materials considered is provided in APPENDIX A together with the general assumptions and basic study guidelines upon which this report is based.

The exploration and production segments of the petroleum industry, hereafter referred to as industry, were defined, for the purpose of this study, as all activities required to discover, develop, and produce hydrocarbon reserves. These activities include all operations prior to the custody transfer of crude oil and/or natural gas to a pipeline or other transporting agency. All natural gas processing operations not associated with petroleum refineries also were included. (See APPENDIX B.)

OBJECTIVE NO. 1 of this study was accomplished by dividing the industry involved into six sections and developing the required information with small Work Groups consisting of recognized authorities appropriate to each section as per EXHIBIT 1. The elemental section titles are as follows:

1. EXPLORATION EQUIPMENT AND MATERIALS

2. DRILLING AND PRODUCTION RIG EQUIPMENT AND MATERIALS

3. WELL SERVICING EQUIPMENT AND MATERIALS

4. TUBULAR STEEL

5. SURFACE AND SUBSURFACE PRODUCTION EQUIPMENT AND MATERIALS

6. GAS PROCESSING PLANTS AND MATERIALS

A definition of the statistical guidelines for each of the above sections is provided in APPENDIX B. The data developed by each Work Group is presented in PART I of this report.

OBJECTIVE NO. 2 of this study was accomplished by combining the statistical data developed for PART I into broad categories that are directly relatable to the over-all functions of petroleum exploration and production. Appropriate graphs, factors, and tables, which can be used to estimate and support industry controlled materials requests, are presented under the following category headings:

1. EXPLORATION FOR OIL AND GAS RESERVES

2. DEVELOPMENT OF OIL AND GAS RESERVES

3. MAINTENANCE OF EXISTING PRODUCTION FACILITIES

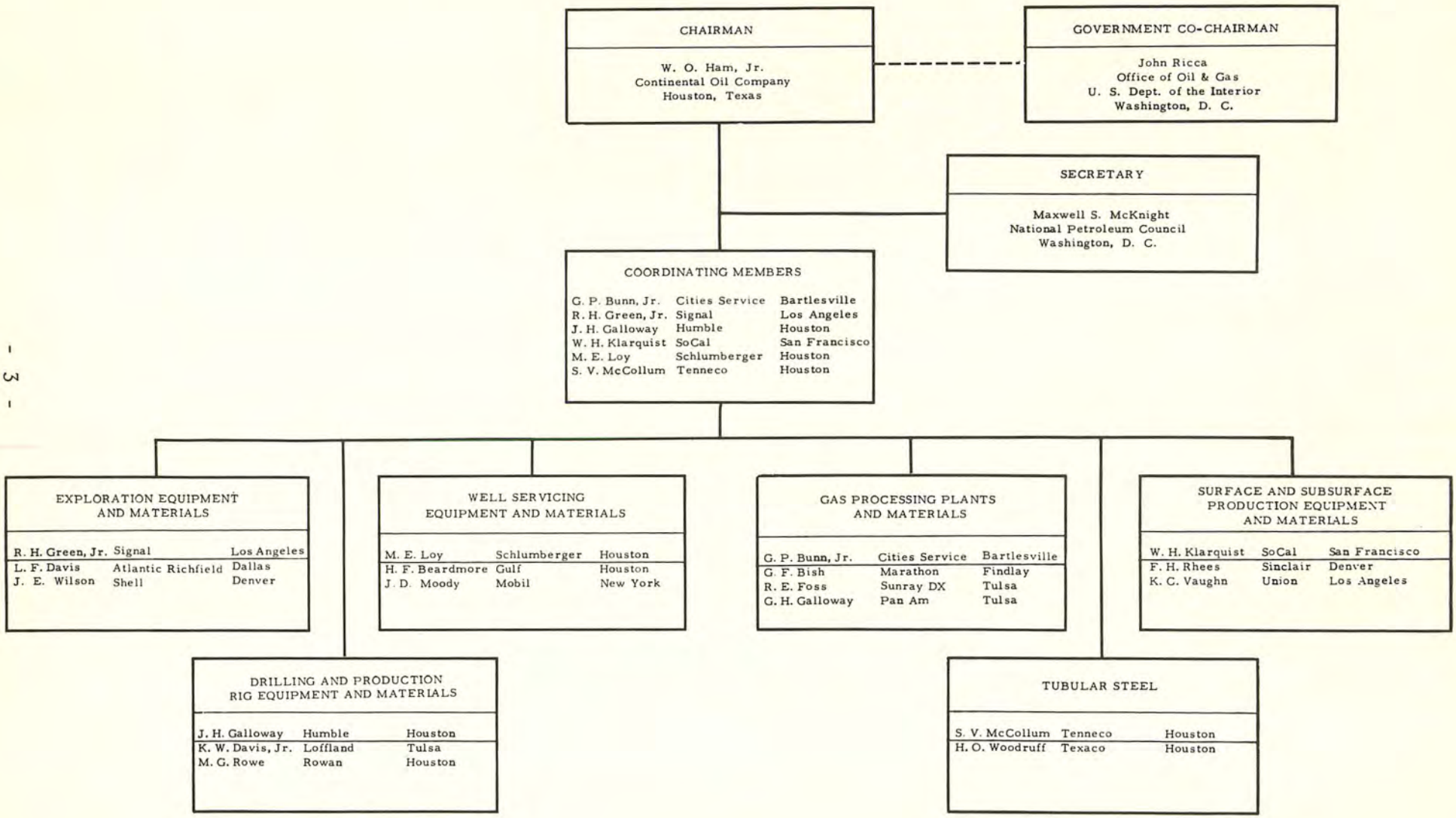
4. DEVELOPMENT OF ADDITIONAL PRODUCTION BY RESERVOIR STIMULATION

5. MATERIALS REQUIRED TO BUILD MOBILE EQUIPMENT ITEMS

The above information is presented in PART II of this report. Utilization of this data will result in the reasonable estimation of controlled materials required to sustain any given level of operation based upon current technology. It must be emphasized, however, that since the estimating parameters reflect weighted-average conditions, they can neither replace good judgment nor be construed as absolute; furthermore, design criteria and techniques can vary between companies as dictated by specific operating needs.

The analysis and interpretation of the facts and detailed data presented in PARTS I and II are summarized in the SUMMARY AND CONCLUSIONS section of this report.

EXHIBIT I
TECHNICAL SUBCOMMITTEE
OF THE
NATIONAL PETROLEUM COUNCIL'S
COMMITTEE ON MATERIALS REQUIREMENTS
FOR PETROLEUM EXPLORATION AND PRODUCTION



SUMMARY AND CONCLUSIONS

General Observations

1. The 1967 industry data were obtained in an environment characterized by technological advances that resulted in increased liquid hydrocarbon and gas production. At the same time, the industry experienced a decline in drilling activity. This decline is a continuation of a downward trend which began in 1956. Because of these anomalous conditions, no direct correlation can be made between total materials consumed and hydrocarbon production or reserves.

2. Improvement in industry technology is clearly demonstrated by a continuing increase in the percentage of discovered oil that will be recovered. The effect of technology is discussed at length in a recent National Petroleum Council report, IMPACT OF NEW TECHNOLOGY ON THE U. S. PETROLEUM INDUSTRY 1946-1965. In this report, it is estimated that the recovery efficiency has increased from 29 per cent in 1950 to 33.7 per cent in 1965 and that recovery efficiency will continue to increase to about 40.5 per cent by 1980.

3. Changing technology has resulted in the use of more controlled materials in certain areas, such as assisted recovery projects (waterflood, steam stimulation, pressure maintenance), and has required some changes in the type of controlled materials required for some operations. Industry anticipates that this trend will continue in the immediate future.

4. No major technological breakthroughs are foreseen in the next few years that will invalidate the materials requirement guidelines presented in this report.

5. The total annual materials required for surface and subsurface equipment has increased over the past five years from 80.2 to 94.1 pounds per daily barrel of hydrocarbon production. This change reflects the increase in materials required for expanding offshore operations, secondary recovery projects, and deep drilling activities. The industry's current emphasis on these activities is anticipated to continue in the immediate future.

Consumed Materials in 1967

The total controlled materials consumed by the exploration and production segments of the petroleum industry in the United States during 1967 was 2,597,936 tons, as follows:

Controlled Materials		Volume (Tons)
Carbon Steel	=	2,048,903
Alloy Steel	=	492,416
Stainless Steel	=	5,709
Copper	=	7,198
Copper Base Alloy	=	8,528
Aluminum	=	4,049
Nickel Alloy	=	2,319
Other Alloys, Castings, and Forgings	=	28,814
Total	=	2,597,936

A more detailed summary of the above total is included in TABLE 1. Although this tabulation indicates that 86 per cent of the controlled materials consumed in 1967 was in the surface and subsurface and tubular steel sections, the controlled materials' needs for the other sections were essential for the over-all operation of the exploration and production segments of the petroleum industry.

Of the total 2,597,936 tons of controlled materials consumed in 1967, about 193,000 tons (7 per cent) were used for maintenance of all equipment and facilities in service prior to 1967. The remaining tonnage was used for new equipment, wells, and sundry projects initiated in 1967. The majority of the 193,000 tons of maintenance materials consisted of carbon steel (72 per cent) and alloy steel (23 per cent).

Other Critical Materials

In addition to the controlled materials requirements, there are numerous other items which are critical and must be available to the petroleum industry if production levels are to be sustained and/or increased in a national emergency. Throughout this report, the major critical items, such as rubber, chemicals, drilling fluid additives, and explosives, have been delineated as to their necessity and, where applicable, the volumes used in 1967 have been quantified.

The development of transportation requirements, such as cars, trucks and trailers, is not a part of this study. Nevertheless, vehicles to perform service-type work and to transport men and supplies are essential for the uninterrupted supply of hydrocarbons. Where applicable and where transportation is a major part of the business, such as in well servicing, the vehicle requirements for 1967 have been enumerated. The values presented are for informational purposes only and should not be construed as maximum totals since the transportation requirements were not studied in depth.

Substitute Materials

Since, in a national emergency, needs could develop for possible substitution or replacement of controlled materials by other non-controlled

materials, substitute materials have been investigated and included throughout the report where feasible for the operation or application involved. However, at the present time, there is limited application for substitute materials. These materials are limited by stresses which are imposed by operating pressure, temperature, and mechanical loading. Also, corrosion and abrasion-resistance requirements limit their consideration.

Based upon current technology, the following equipment items could have potential for utilizing substitute materials:

Tubular Goods - For shallow low-pressure low-temperature and low-viscosity production, plastic and fiberglass pipe can be substituted in some instances for carbon and alloy steels required for casing, tubing, and standard line pipe.

Oil, Gas, and Water Separators - For low-pressure low-temperature non-viscous production, reinforced plastic or glass vessels might be substituted for carbon and alloy steels.

Tanks - For the handling of produced fluids which do not require heating to remove water from oil, reinforced plastic, glass, or treated wood might be substituted for carbon steel.

Computer Application

Industry's need for maintaining technical competence in a rapidly changing technologic and economic environment has necessitated an increasing utilization of and reliance on electronic computers and data processing equipment. This trend is anticipated to continue in the areas of exploration, oil field monitoring, and gasoline plant or process control. Computerized drilling rig control also could become a factor at some later date.

The installation of computers has effected a change in the functional operations performed by field personnel and improved operating efficiency and performance. To eliminate these computers or be deprived of replacement parts would necessitate major industry organizational revisions and would require added manpower (which may be unavailable in an emergency); furthermore, operational performance would decline.

Computer and electronic components require a minimum tonnage of controlled materials. The raw materials per se are not considered critical, but the supply of finished components could become critical. Most of the electronic hardware has been developed in the United States and many of the manufacturers possess the knowledge and have the equipment to convert the small amounts of controlled materials into finished products. However, due to competitive economic pressures, many of these components are now being manufactured and/or assembled in the Orient. If, in a national emergency, these current supply sources were not available, it would take time and capital to re-establish a domestic source of supply.

Throughout the report, where applicable, comments have been included to place each segment of the industry in perspective relative to its computer needs and application.

Materials Requirement Guidelines

Factors, graphs, and related data which can be used to support or estimate industry controlled materials requests have been developed. These data can be used as tools in a building-block manner to obtain the order of magnitude of materials required to sustain and/or expand to a given level of production activity and complements the EPGA's operating manual for DOMESTIC PRODUCTION AND NATURAL GAS PROCESSING. Although these graphical and factorial presentations, based on 1967 consumption and technology, represent the best estimates which can be made for various areas of the country, they are by necessity weighted-average parameters. Therefore, they cannot replace but must complement engineering judgment and design criteria dictated by specific operating needs. When these indicative factors are applied to a large number of projects or wells, it can be expected that the results obtained will represent reasonable approximations of the total controlled materials requirements.

The graphs, factors, and typical examples for utilizing these data are included in PART II.

TABLE 1

SUMMARY
1967 TOTAL CONTROLLED MATERIALS CONSUMPTION IN
PETROLEUM EXPLORATION AND PRODUCTION
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Other Alloys Castings & Forgings	Total Materials (Tons)	Total Materials (% of Total)
Section 1 - Exploration Equipment and Materials	1,633	961	91	485	-	112	-	-	3,282	0.13
Section 2 - Drilling and Production Rig Equipment and Materials	146,335	74,751	1,443	943	718	410	82	-	224,682	8.65
Section 3 - Well Servicing Equipment and Materials	14,040	11,565	515	120	483	414	15	-	27,152	1.04
Section 4 - Tubular Steel	1,433,533	338,061	-	-	-	-	-	-	1,771,594	68.19
Section 5 - Surface and Subsurface Production Equipment and Materials	365,278	63,948	3,168	3,693	5,452	2,036	2,155	28,814	474,544	18.27
Section 6 - Gas Processing Plants and Materials	88,084	3,130	492	1,957	1,875	1,077	67	-	96,682	3.72
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	2,048,903	492,416	5,709	7,198	8,528	4,049	2,319	28,814	2,597,936	100.00

NOTE: Other alloys, castings, and forgings include materials such as tungsten carbide, boron carbide, silver braze, chrome, and aluminum bronze.

PART I

MATERIALS CONSUMPTION DATA FOR 1967

PART I of this report includes the 1967 materials consumption data for the oil and gas exploration, drilling, and production segments of the petroleum industry in the United States as developed by each Work Group.

The need to maintain and expand the domestic producing activities is emphasized by the continuing growth in demand for hydrocarbon products. The historical level of activity, which reflects this growth since the previous National Petroleum Council report (Materials Requirements for Oil and Gas Exploration, Drilling and Production 1962) was completed, is illustrated in TABLES 2 through 8. The data in TABLES 2, 3, 4, 6, and 7 update information included in the previous report and TABLES 5 and 8 are new additions. Throughout each section of this report, the tabular data presented in the previous National Petroleum Council materials report have been updated and new information, where applicable, has been included.

The procedures used in developing these data and the required assumptions and engineering guidelines are included in APPENDICES A and B. The information for this type report is not available from any one given source; therefore, the data were collected from government and industry sources and composited into representative industry totals.

It will be noted that the annual materials requirements for the various segments of the industry have changed since publication of the previous National Petroleum Council materials report as shown in the following tabulation:

	1967 Total Controlled Materials Consumed		1962 Total Controlled Materials Consumed	
	(Tons)	(% of Total)	(Tons)	(% of Total)
Section 1 - Exploration Equipment and Materials	3,282	0.13	2,791	0.09
Section 2 - Drilling and Production Rig Equipment and Materials	224,682	8.65	237,575	7.78
Section 3 - Well Servicing Equipment and Materials	27,152	1.04	29,331	0.96
Section 4 - Tubular Steel	1,771,594	68.19	2,357,000	77.23
Section 5 - Surface and Subsurface Production Equipment and Materials	474,544	18.27	331,734	10.87
Section 6 - Gas Processing Plants and Materials	96,682	3.72	93,640	3.07
	2,597,936	100.00	3,052,071	100.00

The above changes reflect the variations in producing level of operations, environment of operations, and applied technology. More emphasis is currently being placed on offshore operations and computer application than in previous years. Continuing changes can be anticipated in the future. For this reason, the data in this report have been developed and presented, where applicable, on geographic, well depth, and related bases so that future changes in materials requirements can be estimated more readily. Current technology is anticipated to be valid for the next several years; consequently, predictions based on 1967 data also should be valid for the immediate future.

The geographic areas used in the development of this report are shown in FIGURE 1. These areas are representative of the various types of producing environments encountered in the United States domestic operations. Although these areas do not specifically cover the same geography as that described for the five PAD Districts or eight EPGA Regions, they are compatible for the purpose of materials consumption. For example, there is minimal difference between drilling and completing a well in Colorado (EPGA Region 6) and one in Utah (EPGA Region 7). The major technology and production variations are between onshore and offshore areas, and between deep or high pressure and normal operations.

TABLE 2

DEMAND, PRODUCTION, CAPACITY IN THE UNITED STATES
(CRUDE OIL AND NATURAL GAS LIQUIDS)

Year	Demand (M B/D)	Production (M B/D)	Capacity (M B/D)
1963	10,551	8,518	11,259
1964	10,816	8,713	11,463
1965	11,304	8,881	11,756
1966	11,850	9,460	12,024
1967	12,271	10,088	12,455

Reference 1, 2, and 3, Appendix C.

TABLE 3

NATURAL GAS WITHDRAWALS AND MARKETED
PRODUCTION IN THE UNITED STATES

Year	Gross Withdrawals (MMCF)	Marketed Production (MMCF)
1963	16,973,368	14,746,663
1964	17,440,300	15,462,143
1965	17,963,100	16,039,753
1966	18,932,642	17,206,628
1967	19,699,375	18,054,383

Reference 4, Appendix C.

TABLE 4

ACTIVE PRODUCING WELLS IN THE UNITED STATES
(AT YEAR END)

Year	Oil Wells	Gas Wells	Total Wells
1963	588,657	102,966	691,623
1964	588,225	103,084	691,309
1965	589,203	111,680	700,883
1966	583,302	124,092	707,394
1967	579,241	121,788	701,049

Reference 2, 3, and 4, Appendix C.

TABLE 5

NUMBER OF STRIPPER WELLS IN THE UNITED STATES

Year	Number of Wells (At Year End)	Number of Abandonments (During Year)	Per Cent of Oil Production (During Year)
1963	401,031	14,363	17.8
1964	394,107	14,476	16.8
1965	398,299	15,456	17.0
1966	380,549	16,207	12.2
1967	360,316	20,233	10.5

Reference 5, Appendix C.
NOTE: A stripper well is defined as a well that is pumped at the rate of 10 barrels per day or less.

TABLE 6

NUMBER OF NEW WELLS DRILLED
IN THE UNITED STATES
(EX STRAT AND CORE TESTS)

Year	Oil Wells	Gas Wells	Dry Holes	Service Wells	Total Wells	Exploratory Wells	Development Wells
1963	20,288	4,751	16,347	2,267	43,653	10,664	30,722
1964	20,620	4,855	17,488	2,273	45,236	10,747	32,216
1965	18,761	4,724	16,025	1,922	41,432	9,466	30,044
1966	16,780	4,377	15,227	1,497	37,881	10,313	26,071
1967	15,329	3,659	13,246	1,396	33,630	8,878	23,356

Prior to 1967, strat and core tests were not included in published totals and, therefore, were not included in this table. The addition of the 188 strat and core tests drilled in 1967 to the above total results in a grand total of 33,818 wells as shown on TABLE 9.

Reference 6, 7, 8, and 9, Appendix C.

TABLE 7

NUMBER OF DEEP WELLS DRILLED
IN THE UNITED STATES
(15,000 FT. AND BELOW)

Year	Wells Drilled (Number)	Average Depth Per Well (Feet)
1963	271	16,241
1964	308	16,610
1965	330	16,735
1966	388	17,252
1967	402	16,839

Reference 10, Appendix C.

TABLE 8

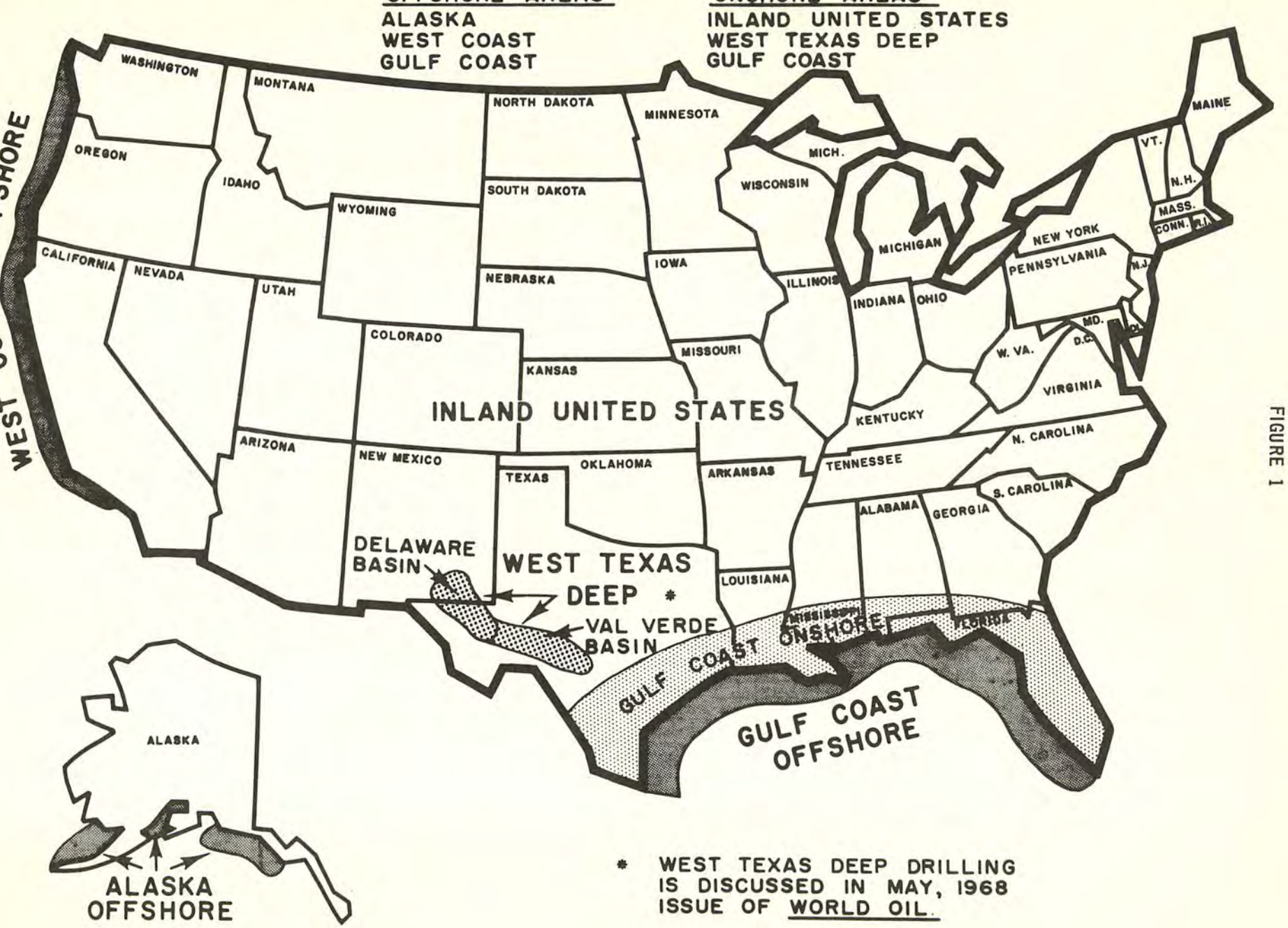
WELLS DRILLED IN THE UNITED STATES
BY GEOGRAPHIC AREA DURING 1967

Area		Oil Wells	Gas Wells	Dry Holes	Strat & Core Tests	Service Wells	Total All Wells	Exploratory Wells	Development Wells
Alaska Offshore (Cook Inlet)	No.	37	4	33	0	0	74	33	41(3)
	Avg. Depth	10,520'	11,880'	10,020'	-	-	10,120'	10,120'	10,580'
Gulf Coast Offshore (Texas-Louisiana)	No.	396	160	401	3	9	969	357(31)	600(245)
	Avg. Depth	10,590'	9,790'	10,050'	1,770'	6,220'	10,450'	10,560'	10,500'
West Coast Offshore	No.	70	0	17	14	2	103	14	73(2)
	Avg. Depth	5,200'	-	7,200'	3,830'	6,773'	5,370'	7,980'	5,140'
Alaska Onshore	No.	0	0	0	0	0	0	0	0
	Avg. Depth	-	-	-	-	-	-	-	-
Gulf Coast Onshore (So. Louisiana & Texas RRC #2 & 3)	No.	1,051	377	1,177	22	20	2,647	956(29)	1,649(289)
	Avg. Depth	6,650'	9,630'	8,400'	1,620'	4,500'	7,790'	9,300'	7,050'
Inland United States	No.	13,775	3,097	11,613	149	1,365	29,999	7,509(102)	20,976(1304)
	Avg. Depth	3,390'	5,050'	4,010'	2,010'	2,060'	3,740'	4,600'	3,570'
West Texas Deep (Delaware-Val Verde 20,000' plus)	No.	0	21	5	0	0	26	9	17
	Avg. Depth	-	21,200'	21,600'	-	-	21,260'	21,350'	21,230'
Total All Areas	No.	15,329	3,659	13,246	188	1,396	33,818	8,878(162)	23,356(1843)
	Avg. Depth	3,820'	5,890'	4,620'	2,080'	2,130'	4,280'	5,400'	4,000'
	Total Footage	58,633,418'	21,580,180'	61,142,865'	390,837'	2,976,937'	144,724,237'	47,838,640'	93,517,823'

( ) - Denotes the number of multiple completions. Nearly all of these are dual zone.

Reference 7, 10, and 11, Appendix C.

LOCATION OF GEOGRAPHIC AREAS USED IN STUDY



* WEST TEXAS DEEP DRILLING IS DISCUSSED IN MAY, 1968 ISSUE OF WORLD OIL.

FIGURE 1

SECTION 1 - EXPLORATION EQUIPMENT AND MATERIALS

The investigation of materials requirements in 1967 necessary to conduct geophysical (seismic, gravimetric, and magnetic), geochemical, and geological exploration surveys for oil and gas revealed that only the seismic industry consumed measurable quantities of controlled materials. For this reason, the materials data presented are based upon the seismic-industry consumption, but for all practical purposes, they encompass the entire exploration segment of the petroleum industry.

To compile the data needed for this report, a typical seismic crew was selected for each appropriate environment based upon 1967 usage. The three basic crew-types are: Conventional Dynamite Land Crew, Non-Dynamite Surface-Source Land Crew, and both Dynamite and Non-Dynamite Surface-Source Marine Crews. The equipment components considered for each type of crew are listed below. The materials requirements to equip a typical crew are included in PART II under the heading MATERIALS REQUIRED TO BUILD MOBILE EQUIPMENT ITEMS.

Conventional Dynamite Land Crew

1 - Recording Cab
1 - Shooting Cab
4 - Shot-hole Drills
4 - Water Trucks
Geophones, Cables, and Drill Pipe

Non-Dynamite Surface-Source Land Crew

1 - Recording Cab
3 - Surface-Source Vehicles
Geophones and Cables

Marine Crews

1 - Recording Cab
1 - Shooting Cab or one Non-Dynamite Surface-Source
Streamer Cables and Electronic Positioning Devices

Historical seismic activity has been developed and is included in TABLE 1-1. Specifically during 1967, there were 278 domestic seismic crews operating the full year for a total of 3,337 crew months. Of these 278 crews, approximately 29 were Marine Crews, 199 were Dynamite Land Crews, and 50 were Surface-Source Land Crews. Based upon this crew activity and the equipment components, the total controlled materials in service in the seismic industry was developed and is presented in TABLE 1-2.

The normal equipment life as currently experienced in the seismic industry is five years. Utilizing this equipment life and the seismic data developed in this report, the total controlled materials consumption for 1967 was determined and is included in TABLE 1-3.

Other materials consumed in large quantities during 1967, not presently considered controlled but which could be in short supply during a national emergency, are listed below:

Item	Quantity
Rubber	150 Tons
Plastic (Neoprene and Polyethylene)	200 Tons
Seismograph High Explosives	30,000 Tons
Ammonium Nitrate Blasting Agent	10,000 Tons
Electric Blasting Caps	4,000,000
Magnetic Tapes (Individual)	1,000,000
Magnetic Tape 1" and 1/2" wide reels, 1200' long	70,000

Normal transportation items, consisting of automobiles, pickup trucks, and four-wheel drive vehicles as well as the original chassis of seismic vehicles and the hulls of boats, are not included in this report.

TABLE 1-1

SEISMIC, GRAVIMETRIC, AND MAGNETIC CREW ACTIVITY IN THE UNITED STATES

Year	Seismic Crews (Crew Months)	Gravimetric and Magnetic Crews (Crew Months)
1963	3,966	208
1964	4,102	304
1965	4,247	224
1966	3,672	163
1967	3,337	130

Reference 12, Appendix C.

TABLE 1-2

TOTAL CONTROLLED MATERIALS IN SERVICE
FOR THE SEISMIC INDUSTRY DURING 1967
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Aluminum	Total
Equipment						
Recording Units (278 Crews)	517	-	142	47	133	839
Shooting Cabs (229 Crews)	669	25	35	25	-	754
Non-Dynamite Surface Sources (50 Crews)	438	16	23	16	-	493
Seismic Shot-Hole Drills (200 Crews)	2,900	1,840	-	24	-	4,764
Water Trucks (200 Crews)	1,920	74	128	-	-	2,122
Drill Pipe (200 Crews)	-	700	-	-	-	700
Position Location Devices (29 Crews)	54	-	15	5	14	88
Geophone Cables						
Land (250 Crews)	150	-	-	75	-	225
Marine (29 Crews)	62	-	-	8	-	70
Geophones (250 Crews)	31	16	-	3	9	59
Operating Supplies						
Blasting Cap Wire (200 Crews)	-	-	-	320	-	320
Bits (200 Crews)	-	244	-	-	-	244
Miscellaneous						
Computer Center*	440	70	105	255	365	1,235
TOTAL CONTROLLED MATERIALS IN SERVICE (1967)	7,181	2,985	448	778	521	11,913

* There are 60 Computer Centers required for 278 crews. In addition to the controlled materials listed for computers, 3,000 ounces of gold are required.

TABLE 1-3

1967 SEISMIC INDUSTRY CONTROLLED MATERIALS CONSUMPTION
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Aluminum	Total
Equipment (5-Year Life)						
Recording Units	104	-	29	10	27	170
Shooting Cabs and Non-Dynamite Surface Sources	222	8	12	8	-	250
Seismic Shot Hole Drills	580	370	-	5	-	955
Water Trucks	385	15	26	4	-	430
Drill Pipe	-	294	-	-	-	294
Position Location Devices	11	-	3	1	3	18
Geophone Cables (1-Yr. Life)	212	-	-	83	-	295
Geophones	31	16	-	3	9	59
Operating Supplies						
Blasting Cap Wire	-	-	-	320	-	320
Bits	-	244	-	-	-	244
Miscellaneous						
Computer Centers*	88	14	21	51	73	247
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	1,633	961	91	485	112	3,282

* A Computer Center referenced above normally consists of the following items:

1 - Central Processing Unit (equipped with a minimum 32,000-word memory, 1.75 microsecond cycle time, two In-Out channels, and 2 million random access bit storage).
1 - Convolver (equipped with a minimum 0.5 microsecond function time).
1 - Analog to Digital and Digital to Analog Converter.
1 - Multiplexer.
1 - Analog Processing Unit.
1 - Analog Section Plotter.
1 - Delay Line Box.

The controlled materials above are for 12 computer replacements. In addition to the controlled materials listed for computers, 600 ounces of gold are required.

SECTION 2 - DRILLING AND PRODUCTION RIG EQUIPMENT AND MATERIALS

Drilling activity in the United States during the past five years continued the steady decline that began in the late 1950's, following the postwar peak years. This trend is reflected by the decline in total wells drilled as illustrated in TABLE 6. During the five-year period from 1963 to 1967, the total footage drilled has declined from about 185 million feet in 1963 to 145 million feet in 1967. While the total number of wells drilled declined 23 per cent from 1963 to 1967, exploratory wells drilled declined 17 per cent. Of the total wells drilled, the exploratory-well percentage increased from 24.4 per cent in 1963 to 27.1 per cent in 1967. This increase is more an indication of decline in development drilling rather than an increased emphasis on exploratory drilling.

As noted in TABLE 2-1, the number of total active rigs, both rotary and cable tool, has decreased 25 per cent since 1963 or about the same order of magnitude as the reduction in wells drilled. From TABLE 2-2, it can be noted that the percentage of active rotary rigs making hole does not vary appreciably. Wells and feet drilled per active rig remain essentially constant around 14.8 wells and 64,000 feet per year.

The number of oil-company-owned rigs has continued to decline. Ninety-eight per cent of the available rotary rigs in 1967 were reported to be contractor-owned. The rig numbers quoted and used in this report do not represent an exact count of all classes of rigs. Certain figures were computed by differences and factors as explained in APPENDIX B.

The total drilling and production rig controlled materials consumed in 1967 are included in TABLE 2-3. A breakdown of the drilling rig operations controlled materials consumed by well type and equipment category is listed in TABLE 2-4 and the production rig controlled materials consumed are listed in TABLE 2-5. The values presented in these tables should not be used out of context since they illustrate numerically the relative controlled materials requirements and not necessarily specific requirements. The techniques employed in developing these numbers are described in APPENDIX B.

TABLE 2-6 includes the 1967 controlled materials consumption for repair and maintenance for Rotary Rigs, Cable Tool Rigs, Inland Submersible Barges, Offshore Tenders, and Offshore Mobile Platforms. This table reflects the large requirements for the offshore, excluding tubular steel (drill pipe, tool joints, drill collars), fixed platforms, and auxiliary vessels. Tubular steel and fixed platforms materials are included in SECTIONS 4 and 5, respectively, while supply vessels and crew boats were not within the scope of this study.

TABLE 2-7 includes the controlled materials for drilling rig equipment by well type and geographic area. The areal distribution is an indication of drilling activity and illustrates the relative importance of Inland United States and that development drilling requires about two-thirds of the controlled materials used.

Although only six new offshore mobile platforms were reported constructed for use in the United States, TABLE 2-8, the estimated 24,000 tons of carbon steel used is about one-third of the total consumption to operate

1,716 drilling rigs. Maintenance of the 68 offshore mobile platforms operating in 1967 also represents a significant, 23,040 tons of carbon steel, consumption. Details of offshore mobile platform materials consumed are shown in TABLE 2-9.

An industry estimate of active production rigs for 1967 totals 3,400 units, TABLE 2-10. There are no known published counts of production (workover and well servicing) rigs. These numbers and the material weights for four depth-capacity rigs described in PART II were used to estimate the controlled materials consumed found in TABLE 2-5. Since the method of developing production rig controlled materials is different from that used in the 1963 NPC Report, which was a survey of manufacturers, there can be minimal correlation between them. The current estimate is several times that in the 1963 NPC Report.

The ratio of auxiliary equipment to the number of production rigs estimated for 1967 consumption was as follows:

Depth Capacity (Feet)	Triplex Pump & Power Sub	Rotating Tubing Stripper
4,000	1:20	None
4,000 - 8,000	1:8	1:10
8,000 - 14,000	1:5	1:5
Below 14,000	1:3	1:5

The 5,000 tons of wireline used are based on contractor estimates correlated with supplier estimates. Total oil industry use of wirelines in 1967 was 17,000 tons -- 12,000 for drilling and 5,000 for production.

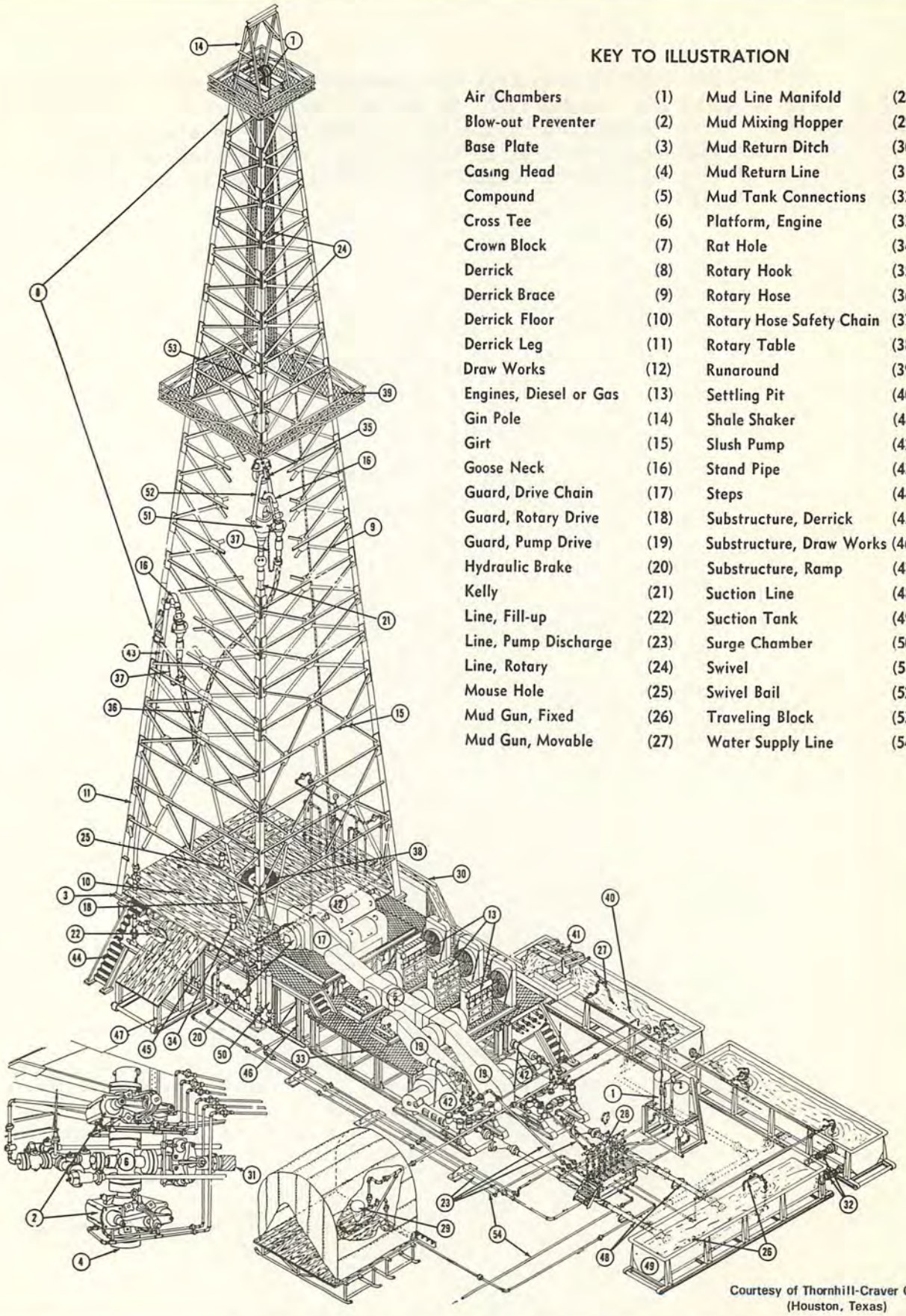
TABLE 2-11 shows the 1967 requirements for drilling rig engines as 283,130 horsepower in 756 units for rotary rigs and 15,500 horsepower in 62 units for cable tool rigs. The material in prime movers was not included in controlled materials requirements for drilling rigs shown in previous tables.

TABLE 2-12 includes drilling rig electric machinery requirements, which amount to replacement of 24,819 kilowatts of generator capacity and 15,626 horsepower of electric motors per year.

Other critical materials required in drilling operations not normally controlled include rubber products and drilling fluid additives. Rubber requirements for drilling are essential and substantial in the order of several hundred tons. The principle use is in hoses (rotary, vibration, suction), valve inserts, blowout preventer packoff elements, and pulsation dampeners. Commercial diamonds for drill and core bits also could become critical.

TABLE 2-13 shows estimates of drilling fluid additives used in the United States in 1967. It can be noted that the trend in barite and bentonite use in the petroleum industry reported by the U. S. Bureau of Mines shows that use of these materials is not in proportion to total wells drilled, but is more nearly related to deep well drilling.

Off-line digital computers are commonly used for quick calculation of hydraulics and rotary speed-drill collar weight programs. However, computer service is not essential to drilling operations. On-line computer control of drilling operations is in the research and development stage. General use of process control computers on drilling rigs is not anticipated in the near future.



KEY TO ILLUSTRATION

Air Chambers	(1)	Mud Line Manifold	(28)
Blow-out Preventer	(2)	Mud Mixing Hopper	(29)
Base Plate	(3)	Mud Return Ditch	(30)
Casing Head	(4)	Mud Return Line	(31)
Compound	(5)	Mud Tank Connections	(32)
Cross Tee	(6)	Platform, Engine	(33)
Crown Block	(7)	Rat Hole	(34)
Derrick	(8)	Rotary Hook	(35)
Derrick Brace	(9)	Rotary Hose	(36)
Derrick Floor	(10)	Rotary Hose Safety Chain	(37)
Derrick Leg	(11)	Rotary Table	(38)
Draw Works	(12)	Runaround	(39)
Engines, Diesel or Gas	(13)	Settling Pit	(40)
Gin Pole	(14)	Shale Shaker	(41)
Girt	(15)	Slush Pump	(42)
Goose Neck	(16)	Stand Pipe	(43)
Guard, Drive Chain	(17)	Steps	(44)
Guard, Rotary Drive	(18)	Substructure, Derrick	(45)
Guard, Pump Drive	(19)	Substructure, Draw Works	(46)
Hydraulic Brake	(20)	Substructure, Ramp	(47)
Kelly	(21)	Suction Line	(48)
Line, Fill-up	(22)	Suction Tank	(49)
Line, Pump Discharge	(23)	Surge Chamber	(50)
Line, Rotary	(24)	Swivel	(51)
Mouse Hole	(25)	Swivel Bail	(52)
Mud Gun, Fixed	(26)	Traveling Block	(53)
Mud Gun, Movable	(27)	Water Supply Line	(54)

Courtesy of Thornhill-Craver Co., Inc.
(Houston, Texas)

TABLE 2-1

ANNUAL DRILLING RIG ACTIVITY IN THE UNITED STATES

Year	Rotary Rigs			Active Cable Tools	Total Active
	Available	Active	% Active		
1963	3,270	2,291	70.1	661	2,952
1964	3,272	2,293	70.1	673	3,066
1965	3,162	2,303	72.8	480	2,783
1966	3,093	2,060	66.6	454	2,514
1967	2,628	1,716	65.3	492	2,208

Reference 13, Appendix C.

TABLE 2-2

ANNUAL RIG OPERATING RATES IN THE UNITED STATES

Year	Rotary Rigs		Average Annual Drilling Rate Per Total Active Rig	
	No. Making Hole	% Active Rigs Making Hole	Wells	Thousands Feet
1963	1,501	66	14.8	62.5
1964	1,502	66	14.8	61.9
1965	1,388	60	14.5	64.1
1966	1,270	62	14.7	66.9
1967	1,135	66	14.9	65.6

Reference 13, Appendix C.

TABLE 2-3

1967 DRILLING AND PRODUCTION RIG CONTROLLED MATERIALS CONSUMPTION
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
DRILLING RIG OPERATIONS								
Drilling Rig Equipment	76,348	62,320	1,340	505	481	401	-	141,395
Inland Submersible Barges	9,500	48	19	38	19	-	-	9,624
Offshore Floating Tenders	4,200	14	6	42	6	-	-	4,268
Offshore Mobile Platforms								
Maintenance	23,200	1,299	35	140	38	-	-	24,712
New	24,000	860	38	200	38	-	-	25,136
PRODUCTION RIG OPERATIONS								
Production Rigs	8,337	10,205	3	13	134	9	82	18,783
Mobile Offshore Platforms	750	5	2	5	2	-	-	764
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	146,335	74,751	1,443	943	718	410	82	224,682

TABLE 2-4

1967 DRILLING RIG CONTROLLED MATERIALS CONSUMED
BY WELL TYPE AND EQUIPMENT CATEGORY
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Total
EXPLORATORY WELLS							
Drilling Rig Equipment	24,459	20,199	433	163	156	129	45,539
Inland Submersible Barges	3,850	19	8	15	8	-	3,900
Offshore Floating Tenders	-	-	-	-	-	-	-
Offshore Mobile Platforms							
Maintenance	23,040	1,298	35	138	38	-	24,549
New	24,000	860	38	200	38	-	25,136
DEVELOPMENT WELLS							
Drilling Rig Equipment	50,982	41,518	893	337	321	268	94,319
Inland Submersible Barges	5,650	29	11	23	11	-	5,724
Offshore Floating Tenders	4,200	14	6	42	6	-	4,268
Offshore Mobile Platforms							
Maintenance	-	-	-	-	-	-	-
New	-	-	-	-	-	-	-
STRAT & CORE TESTS							
Drilling Rig Equipment	83	57	1		-	-	141
Inland Submersible Barges	-	-	-	-	-	-	-
Offshore Floating Tenders	-	-	-	-	-	-	-
Offshore Mobile Platforms							
Maintenance	160	1	-	2	-	-	163
New	-	-	-	-	-	-	-
SERVICE WELLS							
Drilling Rig Equipment	824	546	13	5	4	4	1,396
Inland Submersible Barges	-	-	-	-	-	-	-
Offshore Floating Tenders	-	-	-	-	-	-	-
Offshore Mobile Platforms							
Maintenance	-	-	-	-	-	-	-
New	-	-	-	-	-	-	-
ALL WELLS							
Drilling Rig Equipment	76,348	62,320	1,340	505	481	401	141,395
Inland Submersible Barges	9,500	48	19	38	19	-	9,624
Offshore Floating Tenders	4,200	14	6	42	6	-	4,268
Offshore Mobile Platforms							
Maintenance	23,200	1,299	35	140	38	-	24,712
New	24,000	860	38	200	38	-	25,136
TOTAL CONTROLLED MATERIALS FOR DRILLING RIG OPERATIONS (1967)	137,248	64,541	1,438	925	582	401	205,135

NOTE: These totals exclude tubular steel for drill pipe, tool joints, and drill collars.

TABLE 2-5

1967 PRODUCTION RIG CONTROLLED MATERIALS CONSUMED
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
Basic Rig	7,815	1,310	3	13	7	5	-	9,153
Tools and Auxiliary Equipment	522	3,895	-	-	127	4	82	4,630
Wire Lines	-	5,000	-	-	-	-	-	5,000
Total Production Rigs	8,337	10,205	3	13	134	9	82	18,783
Mobile Offshore Platforms	750	5	2	5	2	-	-	764
TOTAL CONTROLLED MATERIALS FOR PRODUCTION RIG OPERATION (1967)	9,087	10,210	5	18	136	9	82	19,547

NOTE: 1. The basic rig values above exclude engines, running gear, road transmission, and tools.
2. Production Rigs are defined as those normally used for well workover and servicing operations.

TABLE 2-6

1967 DRILLING RIG AND PLATFORM REPAIR AND MAINTENANCE
CONTROLLED MATERIALS CONSUMED
(TONS)

	Number Active	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Total
Rotary Rigs	1,716	74,508	61,511	1,340	490	481	391	138,721
Depth Classification								
6,000 Feet	858							
12,000 Feet	613							
17,500 Feet	245							
Cable Tool Rigs	492	1,840	809	-	15	-	10	2,674
Total Rigs	2,208	76,348	62,320	1,340	505	481	401	141,395
Inland Submersible Barges	95	9,500	48	19	38	19	-	9,624
Offshore Tenders	26	4,200	14	6	42	6	-	4,268
Offshore Mobile Platforms	68	23,040	1,298	35	138	37	-	24,548
TOTAL CONTROLLED MATERIALS FOR DRILLING RIG, PLATFORM REPAIRS, AND MAINTENANCE (1967)		113,088	63,680	1,400	723	543	401	179,835

NOTE: These totals exclude tubular steel for drill pipe, tool joints, drill collars, fixed platforms, and auxiliary vessels.

Reference 14, Appendix C.

TABLE 2-7

1967 DRILLING RIG EQUIPMENT CONTROLLED MATERIALS
CONSUMED BY WELL TYPE AND GEOGRAPHIC AREA
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Total
ALASKA OFFSHORE							
Exploratory Wells	535	466	10	4	4	3	1,022
Development Wells	570	496	10	4	4	3	1,087
Strat & Core Tests	-	-	-	-	-	-	-
Service Wells	-	-	-	-	-	-	-
GULF COAST OFFSHORE							
Exploratory Wells	1,967	1,771	35	13	13	11	3,810
Development Wells	2,884	2,608	52	19	19	16	5,598
Strat & Core Tests	1	1	-	-	-	-	2
Service Wells	15	11	-	-	-	-	26
WEST COAST OFFSHORE							
Exploratory Wells	201	173	4	1	1	1	381
Development Wells	653	538	12	4	4	3	1,214
Strat & Core Tests	24	16	-	-	-	-	40
Service Wells	9	6	-	-	-	-	15
GULF COAST ONSHORE							
Exploratory Wells	3,656	3,252	66	24	24	20	7,042
Development Wells	5,590	5,002	101	37	37	31	10,798
Strat & Core Tests	7	5	-	-	-	-	12
Service Wells	14	9	-	-	-	-	23
WEST TEXAS DEEP							
Exploratory Wells	551	539	10	5	4	3	1,112
Development Wells	1,231	1,205	22	8	9	7	2,482
Strat & Core Tests	-	-	-	-	-	-	-
Service Wells	-	-	-	-	-	-	-
INLAND UNITED STATES							
Exploratory Wells	17,549	13,998	308	116	110	91	32,172
Development Wells	40,054	31,669	696	265	248	208	73,140
Strat & Core Tests	51	35	1	-	-	-	87
Service Wells	786	520	13	5	4	4	1,332
ALL AREAS							
Exploratory Wells	24,459	20,199	433	163	156	129	45,539
Development Wells	50,982	41,518	893	337	321	268	94,319
Strat & Core Tests	83	57	1	-	-	-	141
Service Wells	824	546	13	5	4	4	1,396
TOTAL CONTROLLED MATERIALS FOR DRILLING RIG EQUIPMENT (1967)	76,348	62,320	1,340	505	481	401	141,395

NOTE: These totals exclude tubular steel for drill pipe, tool joints, drill collars, drill barges, and offshore platforms.

TABLE 2-8

CONTROLLED MATERIALS CONSUMED FOR 1967 MOBILE PLATFORMS CONSTRUCTED AND USED IN THE U. S.
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Total
FOR EXPLORATORY DRILLING						
Gulf Coast Offshore						
1 - Self Propelled Surface Floater	4,000	20	10	45	10	4,085
2 - Jack Up - 150 Feet or Less Water	7,600	800	8	30	10	8,448
1 - Semisubmersible	4,200	10	5	40	4	4,259
Total Gulf Coast Offshore	15,800	830	23	115	24	16,792
West Coast Offshore						
1 - Non Propelled Surface Floater	4,000	20	10	45	10	4,085
1 - Semisubmersible	4,200	10	5	40	4	4,259
Total West Coast Offshore	8,200	30	15	85	14	8,344
TOTAL MOBILE PLATFORMS FOR EXPLORATORY DRILLING	24,000	860	38	200	38	25,136
FOR WORKOVERS						
Gulf Coast Offshore						
2 - Jack Up - 70 Feet Water	5,000	600	5	20	7	5,632

NOTE: These totals exclude drilling equipment.

Reference 14, Appendix C.

TABLE 2-9

1967 MOBILE PLATFORM REPAIR AND MAINTENANCE CONTROLLED MATERIALS CONSUMED
(TONS)

	Number Active	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Total
PLATFORM TYPE							
Surface Floaters (Self Propelled & Non Propelled)	8	3,200	16	8	36	8	3,268
Submersible Platforms	24	6,000	36	12	36	12	6,096
Semisubmersible Platforms	5	2,100	5	3	20	2	2,130
Jack Up - 150 Feet or Less Water	21	7,980	840	8	32	11	8,871
Jack Up - 250 Feet or More Water	8	3,600	400	4	12	4	4,020
TOTAL DRILLING PLATFORMS	66	22,880	1,297	35	136	37	24,385
Coring Vessels	2	160	1	-	2	-	163
TOTAL EXPLORATION PLATFORMS	68	23,040	1,298	35	138	37	24,548
GEOGRAPHIC AREA							
Gulf Coast Offshore							
Drilling		18,650	1,057	29	111	30	19,877
Core Tests		80	1	-	1	-	82
Total		18,730	1,058	29	112	30	19,959
Alaska Offshore							
Drilling		2,210	125	3	13	4	2,355
Core Tests		40	-	-	0.5	-	40.5
Total		2,250	125	3	13.5	4	2,395.5
California Offshore							
Drilling		2,020	115	3	12	3	2,153
Core Tests		40	-	-	0.5	-	40.5
Total		2,060	115	3	12.5	3	2,193.5
TOTAL EXPLORATION PLATFORMS		23,040	1,298	35	138	37	24,548
Workover Platforms							
Gulf Coast Offshore	3	750	6	2	5	2	769

TABLE 2-10

1967 ACTIVE PRODUCTION RIGS AND ANNUAL ENGINE REPLACEMENTS

Number	Depth Classification Feet	Engine Horsepower Per Rig	Annual Replacements 8-Year Life Engines	Horsepower
850	4,000	150	106	15,900
1,700	4,000 - 8,000	250	213	53,250
680	8,000 - 14,000	350	85	29,750
170	Below 14,000	400-500	21	9,450
3,400			425	108,350

TABLE 2-11

1967 DRILLING RIG ENGINE REQUIREMENTS

Rotary Rig Depth Classification Feet	Active Rigs	Number Engines/ Rig	HP/Engine	HP/Rig	Years Life	1967 Replacements Engines	Horsepower
6,000	858	2	300	600	6	286	85,800
12,000	613	3	420	1,260	6	307	128,730
17,500	245	4	420	1,680	6	163	68,600
	1,716					756	283,130
Cable Tool Rig	492	1	250	250	8	62	15,500
Total	2,208					818	298,630

TABLE 2-12

ROTARY RIG ELECTRICAL SYSTEMS

Rotary Rig Depth Classification Feet	Active Rigs	Generator Capacity, KW Per Rig	Total	Electric Motors, HP Per Rig	Total
6,000	858	2- 25	42,900	25	21,450
12,000	613	2- 60	73,560	75	45,975
17,500	245	2-100	49,000	150	36,750
Total	1,716		165,460		104,175
1967 Replacements at 15% Per Year			24,819 KW		15,626 HP

TABLE 2-13

1967 DRILLING FLUID ADDITIVES USED IN THE UNITED STATES

Item			Quantity In Thousands
Barite		=	950 Tons
Bentonite		=	413 Tons
Attapulgite Clay		=	50 Tons
Lignosulfonate		=	60 Tons
Lignite		=	30 Tons
Quebracho		=	10 Tons
Caustic Soda		=	20 Tons
Soda Ash		=	15 Tons
Starch		=	15 Tons
CMC (Sodium Carboxymethyl Cellulose)		=	5 Tons
Starch Preservative		=	1 Ton
Hydrated Lime		=	40 Tons
Lost Returns Material:	Fibrous	=	10 Tons
	Walnut Hulls	=	15 Tons
	Mica	=	15 Tons
Asphalt		=	19 Tons
Diesel Oil		=	2,000 Barrels
Detergents (Liquid)		=	1,000 Gallons
Aromatic Oils		=	150 Gallons
Naphthenic Acid		=	950 Pounds
Sodium Sulfonate		=	3,500 Pounds
Tallow Fatty Acids		=	2,000 Pounds
Rosin Products		=	1,750 Pounds

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Trend in Petroleum Industry Consumption of Barite and Bentonite Mined in the United States

U. S. Bureau of Mines Minerals Yearbook - Domestic Petroleum Industry Consumption and Per Cent of Total U. S. Consumption

	Barite*		Bentonite	
	M Tons	% of Total	M Tons	% of Total
1963	907	89	432	27
1964	931	87	435	25
1965	987	84	453	24
1966	1,022	85	463	22
1967	950	85	413	20

* Barite Table 5 "Ground and Crushed Barite Sold by Producers."

SECTION 3 - WELL SERVICING EQUIPMENT AND MATERIALS

The activity in the well servicing phase of the petroleum industry is closely related to the number of wells drilled and number of workover jobs performed. Drilling activity has been decreasing over the past years; however well depth and improved technology, requiring more petrophysical data, have necessitated additional materials. Also, the increasing industry efforts to place reservoirs under secondary recovery and to sustain production rates through stimulation techniques have resulted in maintaining the controlled materials requirements for well-service-type operations at a high level.

Controlled materials requirements for the well servicing industry in 1967 were obtained from an analysis of industry surveys and subsequent consolidation and appropriate factoring techniques. The resultant totals by type of operation for 1967 are listed in TABLE 3-1. A listing of controlled materials consumed by area for new wells drilled in 1967 and pre-1967 wells is included in TABLE 3-2. The information in TABLE 3-2 was developed by combining the materials totals with published drilling and producing well statistics and with industry-derived well servicing activity.

Other non-controlled materials consumed in large quantities by the well servicing industry include magnesium, explosives, rubber goods, chemicals and admixes, and computer rentals. A listing of these items and quantities used in 1967 are in TABLE 3-3.

Although vehicles and chassis are not included in the compilation of controlled materials, the well servicing industry would be inoperable without adequate transportation. This need is supported by the fact that specialized service equipment is in most instances permanently mounted on a large truck or trailer chassis. Trained technologists, auxiliary equipment, tools, and supplies are transported to and from well sites in various sized trucks. Equivalent transportation also is needed for wells located on platforms in offshore areas.

The approximate onshore vehicle replacement requirements for the well servicing industry in 1967 are as follows:

Item	Quantity
Large Trucks	120
Medium-duty Trucks	25
Tractors	140
Trucks (1 and 2-Ton)	45
Pickups (1/2 and 3/4-Ton)	310
Cars and Station Wagons	550

The large trucks noted above are off-highway type, usually diesel, tandem axle in the 44,000 to 50,000 pound gross vehicle weight class. The medium-duty trucks are off-highway type, gasoline or diesel, single rear axle in the 25,000 to 30,000 pound gross vehicle weight class. Tractors also are off-highway type,

TABLE 3-1

1967 WELL SERVICING INDUSTRY CONTROLLED MATERIALS CONSUMPTION
(TONS)

Type Operation	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
Cementing	6,981	7,020	205	52	259	172	2	14,691
Drill Stem Testing and Treating	3,759	3,780	110	28	140	92	1	7,910
Logging	1,815	421	110	22	46	82	7	2,503
Perforating	1,485	344	90	18	38	68	5	2,048
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	14,040	11,565	515	120	483	414	15	27,152

NOTE: 1. The above data does not include truck chassis, cars, pickups, barges, and similar-type transportation vehicles.

2. The Logging and Perforating operations include 1,500 tons of carbon steel and 34 tons of copper wire used in electric wire-line cables.

TABLE 3-2

1967 WELL SERVICING INDUSTRY CONTROLLED MATERIALS CONSUMPTION
BY GEOGRAPHIC AREA AND WELL TYPE
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
OFFSHORE								
Alaska - New Wells	104	91	4	1	4	3	-	207
- Old Wells	-	-	-	-	-	-	-	-
Gulf Coast - New Wells	2,020	1,592	77	21	70	62	3	3,845
- Old Wells	265	218	9	3	9	8	1	513
West Coast - New Wells	64	53	2	1	2	2	-	124
- Old Wells	-	-	-	-	-	-	-	-
ONSHORE								
Alaska - New Wells	-	-	-	-	-	-	-	-
- Old Wells	-	-	-	-	-	-	-	-
Gulf Coast - New Wells	1,956	1,590	72	19	66	59	3	3,765
- Old Wells	334	275	12	3	12	10	1	647
Inland U. S. - New Wells	8,605	7,174	314	67	296	250	6	16,712
- Old Wells	637	525	23	5	22	19	1	1,232
West Texas Deep - New Wells	48	41	2	-	2	1	-	94
- Old Wells	7	6	-	-	-	-	-	13
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	14,040	11,565	515	120	483	414	15	27,152

NOTE: New Wells refer to those drilled in 1967; Old Wells refer to those drilled prior to 1967.

TABLE 3-3

OTHER MATERIALS CONSUMED IN LARGE QUANTITIES
BY THE WELL SERVICING INDUSTRY IN 1967

Item		Quantity
Magnesium	=	34 Tons
Explosives /1/	=	28 Tons
Rubber Goods, Basic Polymers and Fillers /2/		
Buna N	=	119 Tons
Styrene Butadine (SBR)	=	114 Tons
Natural Rubber	=	112 Tons
Neoprene	=	69 Tons
Urethane	=	8 Tons
Carbon Black	=	340 Tons
Rubber Hose (Industrial and Specification)		
1/4" thru 1/2" I.D.	=	221,000 feet
5/8" thru 1" I.D.	=	157,000 feet
1-1/4" thru 2" I.D.	=	57,500 feet
3-1/3" thru 5-1/2" I.D.	=	32,500 feet
Chemicals and Admixes		
Muriatic Acid	=	146,600 Tons
Fracturing Proppants		
1. Silica Sand	=	232,500 Tons
2. All Others	=	2,965 Tons
Acidizing Additives	=	5,912 Tons
Radioactive Tracer Materials	=	25,000 Millicuries
Cement	=	8,728,550 Barrels
Bentonite	=	51,250 Tons
Cementing and Fracturing Additives (including loss circulation and friction-reducing materials)	=	35,880 Tons
Special Bearings /3/	=	$ 355,000
Film /4/	=	$1,000,000
Electronic Components and Parts /5/	=	$6,500,000
Computers /6/	=	$3,000,000

/1/ Explosives include only Cyclonite and similar materials for making shaped charges used in gun perforating; no estimate is made for other types of explosives needed for other services.
/2/ Basic Polymers and Fillers have been listed instead of finished rubber goods.
/3/ Special Bearings are specification only and do not include shelf type.
/4/ Film is only the special 8-7/8" wide, 120' long rolls used in logging services.
/5/ Electronic Components cover only individual components - transistors, semiconductors, resistors, capacitors, chokes, and related items, used in building equipment; it does not include completed assemblies or computers.
/6/ Computer costs are estimated on a dollar monthly rental basis.

SECTION 4 - TUBULAR STEEL

This section of the report includes the tubular steel required for drilling and production operations. The casing, tubing, line pipe, drill pipe and tool joints, drill collars, and special pipe consumed in the United States in 1967 has been developed on a geographic basis. This information was obtained by applying accepted industry design criteria, wear, and replacement experience, and environment requirements to known or published values of manufactured tubular goods.

The domestic mill shipments and the tubular steel consumed, imported, and exported in the United States are included in TABLES 4-1 and 4-2. From TABLE 4-1, it can be noted that in 1967 the tons of oil country tubular goods shipped per thousand feet of hole drilled are equal to 8.7. This value is less than the 11.1 tons per thousand feet of hole drilled as indicated in TABLE 4-2, because the 8.7 factor does not include the tubular goods used from inventories, imports, unreported mill shipments, rejects, line pipe used as oil country, use of secondhand pipe, drill collars, or tool joints.

The total 1967 tubular steel controlled materials consumption is itemized in TABLE 4-3. A summary of the tubular steel consumed by geographic area for new wells drilled in 1967 is included in TABLE 4-4. A detailed listing of tubular steel for each geographic area and for various well depths can be found in TABLES 4-5 through 4-10. The service well casing, tubing, and line pipe consumption by geographic area are included in TABLES 4-11 and 4-12.

Tubular goods requirements for maintenance purposes were determined from industry experience and valued at 41,100 tons in 1967. This total is divided as follows:

Item	Carbon Steel	Alloy Steel	Total
Casing	11,195	0	11,195
Tubing	29,905	0	29,905
Total	41,100	0	41,100

Although a quantity of line pipe was replaced during 1967, the replacements in most instances consisted of used tubing or substitute tubular products made from fiberglass or plastic. A minimum tonnage of new steel line pipe was required for maintenance operations in 1967.

Tubular steel may be replaced by a substitute material in some instances. The portion of tubular steel that can be replaced by non-controlled materials is limited by the pressure rating and tensile strength of the replacement materials. The per cent of the tubular steel that may be replaced by fiberglass and plastic pipe in special applications is -- 70 per cent of the Line Pipe, 6 - 10 per cent of the Tubing, and 3 - 5 per cent of the Casing. However, good engineering practice precludes the use of substitutes to this extent. It was assumed that no alloy steel would be replaced by non-controlled materials.

TABLE 4-1

DOMESTIC MILL SHIPMENTS OF OIL COUNTRY TUBULAR GOODS AND TOTAL U. S. FOOTAGE DRILLED

Year	Oil Country Tubular Goods Shipped (M Tons)	New Footage Drilled (MM Feet)	Tons of Oil Country Tubular Goods Shipped Per M Feet of Hole Drilled
1963	1,432	184.4	7.8
1964	1,584	189.9	8.3
1965	1,501	181.5	8.3
1966	1,326	166.0	8.0
1967	1,258	144.7	8.7

NOTE: The Oil Country Tubular Goods Shipped represents that shipped from United States mills for domestic consumption only. It does not include use from inventories, imports, unreported mill shipments, rejects, line pipe used as oil country goods, use of secondhand pipe, drill collars, or tool joints.

Reference 15, Appendix C.

TABLE 4-2

TUBULAR STEEL CONSUMED, IMPORTED, EXPORTED - 1967
(TONS)

Item	Carbon Steel	Alloy Steel	Total
Tubing, Casing, Drill Pipe, Drill Collars, and Tool Joints	1,301,463	301,247	1,602,710
Line Pipe	130,692	36,188	166,880
Special Pipe	1,378	626	2,004
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	1,433,533	338,061	1,771,594
Recap of above Tubing, Cashing, Drill Pipe, Drill Collars, and Tool Joints 1,602,710-ton Total			
Total Tubing, Casing, and Drill Pipe Shipped from American Mills	1,020,000	320,000	1,340,000
Less Exports	36,000	46,000	82,000
Shipped for Domestic Consumption	984,000	274,000	1,258,000
Imports	156,000	-	156,000
Used from Inventories, Unreported Mill Shipments, Rejects, Line Pipe Used as Oil Country Goods and Use of Secondhand Pipe			158,958
Total Tubing, Casing, and Drill Pipe			1,572,958
Drill Collars			16,752
Tool Joints			13,000
TOTAL TUBING, CASING, DRILL PIPE, DRILL COLLLARS, AND TOOL JOINTS			1,602,710*

* Represents an Average Consumption of 11.1 tons per thousand feet of hole drilled.

TABLE 4-3

1967 TUBULAR STEEL CONTROLLED MATERIALS CONSUMPTION
(TONS)

Item	Carbon Steel	Alloy Steel	Total
Casing	1,033,550*	247,388	1,280,938
Tubing	201,727**	38,573	240,300
Line Pipe	130,692	36,188	166,880
Drill Pipe and Tool Joints	49,434	15,286	64,720
Drill Collars	16,752	-	16,752
Special Pipe	1,378	626	2,004
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	1,433,533	338,061	1,771,594

* Includes 11,195 tons used for casing replacement in wells drilled prior to 1967.

** Includes 29,905 tons used for tubing replacement in wells drilled prior to 1967.

TABLE 4-4

TUBULAR STEEL CONSUMED BY GEOGRAPHIC AREA
FOR NEW WELLS DRILLED IN 1967

(TONS)

Geographic Area	Casing		Tubing		Line Pipe		Drill Pipe and Tool Joints		Drill Collars		Special Pipe		Total
	Carbon Steel	Alloy Steel	Carbon Steel	Alloy Steel	Carbon Steel	Alloy Steel	Carbon Steel	Alloy Steel	Carbon Steel	Alloy Steel	Carbon Steel	Alloy Steel	
OFFSHORE													
Alaska	7,830	8,181	542	569	170	80	868	298	284	-	3	2	18,827
Gulf Coast	137,587	74,990	11,883	8,680	3,910	2,620	4,201	1,970	1,877	-	528	147	248,193
West Coast	7,653	885	76	10	252	118	316	8	84	-	4	2	9,408
ONSHORE													
Gulf Coast	339,745	94,600	19,504	10,900	12,080	8,050	7,419	3,490	3,317	-	885	403	500,393
West Texas Deep	10,282	2,757	-	414	1,210	520	4,295	2,320	1,610	-	3	2	23,413
Inland United States	519,258	65,975	139,817	18,000	113,070	24,800	32,335	7,200	9,580	-	155	70	930,260
TOTAL	1,022,355	247,388	171,822	38,573	130,692	36,188	49,434	15,286	16,752	-	1,378	626	1,730,494

NOTE: 1. Does not include tubular goods used in downhole and surface maintenance.

2. Alloy drill collars not reported, limited use for special application only.

TABLE 4-5

TUBULAR STEEL CONSUMED IN OFFSHORE ALASKA - 1967
(CARBON STEEL, ALLOY STEEL)
(TONS)

Item	Exploration Wells	Development Wells	Total Wells
Casing and Tubing			
0' - 2,500' Wells	4	32	36
2,500' - 5,000' Wells	96	359	455
5,000' - 10,000' Wells	1,506	3,543	5,049
10,000' - 15,000' Wells	3,682	7,151	10,833
15,000' + Wells	242	507	749
Total	5,530	11,592	17,122
Service Wells			0
Line Pipe			250
Drill Pipe and Tool Joints			1,166
Drill Collars			284
Special Pipe			5
TOTAL TUBULAR STEEL CONSUMED - 1967			18,827

TABLE 4-6

TUBULAR STEEL CONSUMED IN GULF COAST OFFSHORE - 1967
(CARBON STEEL, ALLOY STEEL)
(TONS)

Item	Exploration Wells	Development Wells	Total Wells
Casing and Tubing			
0' - 2,500' Wells	37	135	172
2,500' - 5,000' Wells	254	552	806
5,000' - 10,000' Wells	13,187	36,064	49,251
10,000' - 15,000' Wells	57,464	96,131	153,595
15,000' + Wells	8,287	19,638	27,925
Total	79,229	152,520	231,749
Service Wells			1,391
Line Pipe			6,530
Drill Pipe and Tool Joints			6,171
Drill Collars			1,877
Special Pipe			475
TOTAL TUBULAR STEEL CONSUMED - 1967			248,193

TABLE 4-7

TUBULAR STEEI CONSUMED IN WEST COAST OFFSHORE - 1967
(CARBON STEEL, ALLOY STEEL)
(TONS)

Item	Exploration Wells	Development Wells	Total Wells
Casing and Tubing			
0' - 2,500' Wells	2	83	85
2,500' - 5,000' Wells	198	1,016	1,214
5,000' - 10,000' Wells	300	3,035	3,335
10,000' - 15,000' Wells	223	798	1,021
15,000' + Wells	418	1,494	1,912
Total	1,141	6,426	7,567
Service Wells			1,057
Line Pipe			370
Drill Pipe and Tool Joints			324
Drill Collars			84
Special Pipe			6
TOTAL TUBULAR STEEL CONSUMED - 1967			9,408

TABLE 4-8

TUBULAR STEEL CONSUMED IN GULF COAST ONSHORE - 1967
(CARBON STEEL, ALLOY STEEL)
(TONS)

Item	Exploration Wells	Development Wells	Total Wells
Casing and Tubing			
0' - 2,500' Wells	608	1,727	2,335
2,500' - 5,000' Wells	8,604	17,038	25,642
5,000' - 10,000' Wells	36,725	77,532	114,257
10,000' - 15,000' Wells	102,170	133,022	235,192
15,000' + Wells	24,284	61,515	85,799
Total	I72,391	290,834	463,225
Service Wells			1,524
Line Pipe			20,130
Drill Pipe and Tool Joints			10,909
Drill Collars			3,317
Special Pipe			1,288
TOTAL TUBULAR STEEL CONSUMED - 1967			500,393

TABLE 4-9

TUBULAR STEEL CONSUMED IN WEST TEXAS DEEP - 1967
(CARBON STEEL, ALLOY STEEL)
(TONS)

Item	Exploration Wells	Development Wells	Total Wells
Casing and Tubing			
15,000' + Wells	2,348	11,105	13,453
Service Wells			0
Line Pipe			1,730
Drill Pipe and Tool Joints			6,615
Drill Collars			1,610
Special Pipe			5
TOTAL TUBULAR STEEL CONSUMED - 1967			23,413

TABLE 4-10

TUBULAR STEEL CONSUMED IN INLAND UNITED STATES - 1967
(CARBON STEEL, ALLOY STEEL)
(TONS)

Item	Exploration Wells	Development Wells	Total Wells
Casing and Tubing			
0' - 2,500' Wells	10,900	53,700	64,600
2,500' - 5,000' Wells	14,500	83,300	97,800
5,000' - 10,000' Wells	48,600	288,000	336,600
10,000' - 15,000' Wells	43,400	137,000	180,400
15,000' + Wells	19,650	24,000	43,650
Total	137,050	586,000	723,050
Service Wells			20,000
Line Pipe			137,870
Drill Pipe and Tool Joints			39,535
Drill Collars			9,580
Special Pipe			225
TOTAL TUBULAR STEEL CONSUMED - 1967			930,260

TABLE 4-11

SERVICE WELL CASING AND TUBING CONSUMPTION
BY GEOGRAPHIC AREA - 1967
(CARBON STEEL, ALLOY STEEL)

Geographic Area	Tubular Steel Consumed (Tons)
Alaska Offshore	0
Gulf Coast Offshore	1,391
West Coast Offshore	1,057
Gulf Coast Onshore	1,524
West Texas Deep	0
Inland United States	20,000
TOTAL	23,972

TABLE 4-12

LINE PIPE CONSUMPTION BY GEOGRAPHIC AREA - 1967
(CARBON STEEL, ALLOY STEEL)

Geographic Area	Tubular Steel Consumed (Tons)
Alaska Offshore	250
Gulf Coast Offshore	6,530
West Coast Offshore	370
Gulf Coast Onshore	20,130
West Texas Deep	1,730
Inland United States	137,870*
TOTAL	166,880

* Includes 11,970 tons for secondary recovery projects and 125,900 tons for flow lines.

SECTION 5 - SURFACE AND SUBSURFACE PRODUCTION EQUIPMENT AND MATERIALS

Materials consumption for use in surface and subsurface production equipment is directly related to the number of new producing wells drilled, the number of existing producing wells requiring maintenance, and the number of new or expanded assisted recovery projects, such as waterflooding, thermal stimulation, and gas injection. Although there has been a decline in the number of producing wells drilled over the past few years, controlled materials necessitated by improved technology and an increase in the number of stimulation or pressure maintenance projects have offset the new well materials requirements decline. Also, improvements continue to be made in the equipment and materials used to produce oil, condensate, and gas. While these improvements have reduced individual materials requirements in many instances, total requirements have increased due to new technology, offshore operations, deep, high-pressure discoveries and the need to produce larger volumes of fluid to recover available oil.

Total materials requirements for surface and subsurface equipment, excluding tubular goods, have increased from 331,734 tons as reported for 1962 in the 1963 NPC Report to 474,544 tons in 1967. Of the 142,810-ton increase, 60,000 tons are attributable to offshore platforms. Wellheads and Christmas tree valves needed for offshore, deep, high-pressure wells account for another 15,538 tons of the increased materials requirements. Deeper pump settings and equipment to handle large fluid volumes experienced in waterflood operations are reflected in the 11,583-ton increase for pumping units and sucker rod pumps. Rapidly increasing use of thermal stimulation and/or assisted recovery techniques plus the inclusion of materials requirements for gas injection and miscible phase assisted recovery techniques make up another 11,799 tons. Lastly, some significant part of the 142,810-ton increase in materials requirements can be attributed to the fact that in the past five years, daily liquid hydrocarbon production has increased from some 8,275,000 barrels in 1962 to 10,088,000 barrels in 1967. The increasing production trend is reflected by the data in TABLE 2.

The use of production rates and the total materials requirements in 1962 and 1967 provide a means for comparing data. While such a comparison has limited application as predictive information, it does indicate a trend toward increased materials requirements as offshore operations increase, as wells become deeper, and as larger volumes of fluid must be handled in assisted recovery projects. This comparison is as follows:

-- In 1962, 331,734 tons of materials were consumed. During 1962, the average production was 8,275,000 barrels per day. This represents 80.2 pounds of material per daily barrel of production.

-- In 1967, 474,544 tons of materials were consumed. During 1967, the average production was 10,088,000 barrels per day. This represents 94.1 pounds of material per daily barrel of production.

Extrapolation of this comparison for future materials requirements is not absolute because of the many variables that must be considered. Nevertheless, it is reasonable to conclude that materials requirements will continue to increase in the immediate future and preparedness plans must consider these increasing requirements if production levels are to be sustained.

The development of controlled materials requirements for 1967 was initiated by grouping surface and subsurface equipment items into identifiable categories such as waterflood equipment, sucker rod pumps, and surface gas handling equipment. The items that were considered in each category are included in APPENDIX B. The basic data was obtained through industry surveys. This information then was consolidated and appropriately factored to obtain the total controlled materials consumed in 1967 as presented in TABLE 5-1.

The bases for dividing controlled materials consumed by category and geographic area, as illustrated in TABLE 5-2, were published levels of operation, industry experience, and engineering judgment. The supporting information for TABLE 5-2 which includes the materials requirements for new wells, stimulation and assisted recovery projects, and maintenance and repairs is included in TABLES 5-3, 5-4, and 5-5, respectively.

In addition to the controlled materials discussed above, there are two items which are not considered controlled but could become critical in a national emergency -- electronic components and chemicals.

Computers are playing an increasing role in the producing operations phase of the oil and gas industry. Numerous companies are presently utilizing small compact 32,000-word, core-memory computers to monitor and control facilities as well as provide limited off-line capability at a central office. Where in use, these computers have effected a change in the functional operations performed by field personnel and have improved operating efficiency and performance. To eliminate these computers would necessitate major organizational revisions and added manpower, in addition to decreasing operational performance. For this reason, an industry survey was made to determine the anticipated computer usage for these purposes. From the 1967 level of 16 such computers, the results of this survey indicate that the producing industry computer usage will increase approximately threefold over the next ten years.

Computer and electronic components, such as diodes, transistors, printed circuits, integrated circuits, and magnetic cores, require a minimum of raw materials. Since most of these components were developed in the United States and many of the manufacturers possess the knowledge and have the equipment to convert the small amounts of raw material into the finished product, the raw materials, in themselves, are not considered critical. Though the raw materials might not be critical, the supply of finished components could become critical.

Due to labor costs and other factors, many of these electronic components are now being made and/or assembled in Japan, Formosa, and Hong Kong. If, in a national emergency, these oriental sources of supply were not available, it would take time and capital for U. S. manufacturers to re-establish

their ability to furnish these electronic components. It is also important to note that there is a similarity between the computers used in industry and those required for military purposes.

There are numerous chemicals required in the treating and handling of produced fluids. Some chemicals and chemical compounds that could become critical include among others -- various amines; alcohols such as methanol, ethanol, and isopropanol; acids such as sulfuric, sulfamic, nitric, and oxalic; various phenols; and miscellaneous chemicals such as glycols, toluene, formaldehydes, and phenolic resins.

There is limited application for substitute materials that can be effectively used for surface and subsurface equipment. Substitute materials are limited by stresses which are imposed by operating pressure, temperature and mechanical loading. Also, corrosion and abrasion-resistance requirements limit consideration of substitute materials. Based upon current technology, only the following equipment items have potential for utilizing substitute materials:

Oil, Gas, and Water Separators -- for low-pressure low-temperature non-viscous production, reinforced plastic or glass vessels might be substituted.

Tanks -- for water and oil, that does not require heating, reinforced plastic, glass, or treated wood might be substituted.

Presently, these substitute items cannot be economically justified; therefore, no tonnage estimates are provided.

The controlled materials requirements for automotive units are not included in the total materials consumed as presented; nevertheless, transportation of men and supplies is a prerequisite to maintaining the uninterrupted operation of surface and subsurface equipment. The following approximate automotive replacement requirements for 1967 are included for information purposes:

Item	Quantity
Heavy Trucks (3 Tons +)	2,500
Medium-Duty Trucks (1 and 3-Ton)	15,000
Pickups (1/2 and 3/4-Ton)	11,000
Cars	10,000

TABLE 5-1

1967 SURFACE AND SUBSURFACE PRODUCTION EQUIPMENT
CONTROLLED MATERIALS CONSUMPTION
(TONS)

Item	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Other Alloys Castings & Forgings	Total
Wellhead Equipment	13,700	5,600	144	-	-	140	30	-	19,614
Christmas Tree Valves	560	7,300	600	-	25	-	10	289	8,784
Subsurface Equipment	5,000	3,850	15	-	3	28	2	2,300	11,198
Sucker Rod Pumps	10,560	1,930	670	-	2,510	-	480	-	16,150
Sucker Rod & Pull Rods	17,620	30,860	-	-	-	-	-	-	48,480
Misc. Sucker Rod Pumping Equipment	300	-	-	-	-	-	-	-	300
Pumping Units	41,000	7,600	-	-	1,200	-	980	-	50,780
Hydraulic-Submersible-Turbine Down Hole Pumps	638	556	95	1,432	14	-	20	937	3,692
Gas Lift Equipment (Subsurface)	115	1,530	145	4	13	9	40	61	1,917
Gas Lift Compressors	4,038	1,589	109	156	162	122	71	4,104	10,351
Surface Oil Handling Equipment	76,800	496	68	32	36	308	69	376	78,185
Surface Gas Handling Equipment	34,247	1,051	500	148	134	199	212	7,260	43,751
Waterflood Equipment	2,000	10	30	60	10	5	5	40	2,160
Thermal Stimulation Equipment	1,600	15	45	10	4	10	10	30	1,724
Gas & Misc. Phase Injection Equipment	3,000	500	12	30	2	20	11	6,500	10,075
Surface Pumps	654	224	374	1	649	26	85	2,295	4,308
Internal Combustion Engines	200	630	-	10	140	150	5	2,800	3,935
Electrical Equipment	2,000	30	10	1,800	250	600	10	250	4,950
Automation, Control Equipment & Instruments	1,846	128	340	10	225	415	65	1,497	4,526
Hand & Power Tools	150	25	1	-	-	4	25	50	255
Welding Rod & Supplies	9,250	24	10	-	75	-	25	25	9,409
Offshore Fixed Platforms	140,000	-	-	-	-	-	-	-	140,000
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	365,278	63,948	3,168	3,693	5,452	2,036	2,155	28,814	474,544

NOTE: Other alloys, castings, and forgings include materials such as tungsten carbide, boron carbide, silver braze, chrome, and aluminum bronze.

TABLE 5-2

1967 SURFACE AND SUBSURFACE PRODUCTION EQUIPMENT
CONTROLLED MATERIALS CONSUMED BY CATEGORY AND GEOGRAPHIC AREA

Category	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Other Alloys Castings & Forgings	Total
Materials Used for New Wells	323,031	43,794	2,237	2,558	2,815	1,940	1,509	20,611	398,495
Materials Used for Stimulation & Assisted Recovery Projects	6,362	508	85	96	15	34	26	6,372	13,498
Materials Used for Maintenance & Repair	35,885	19,646	846	1,039	2,622	62	620	1,831	62,551
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	365,278	63,948	3,168	3,693	5,452	2,036	2,155	28,814	474,544
Geographic Area									
OFFSHORE									
Alaska	24,268	40	4	25	3	4	1	33	24,378
Gulf Coast	117,022	597	63	73	43	55	16	499	118,368
West Coast	2,969	70	7	19	5	6	2	58	3,136
ONSHORE									
Alaska	221	63	3	4	5	2	2	28	328
Gulf Coast	17,682	5,059	248	286	432	158	171	2,258	26,294
West Texas Deep	184	53	2	14	2	1	2	13	271
Inland United States	202,932	58,066	2,841	3,272	4,962	1,810	1,961	25,925	301,769
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	365,278	63,948	3,168	3,693	5,452	2,036	2,155	28,814	474,544

TABLE 5-3

1967 SURFACE AND SUBSURFACE PRODUCTION EQUIPMENT
CONTROLLED MATERIALS CONSUMED FOR NEW WELLS
(TONS)

Item	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Other Alloys Castings & Forgings	Total
Wellhead Equipment	13,690	5,590	144	-	-	140	30	-	19,594
Christmas Tree Valves	532	6,935	570	-	24	-	9	275	8,345
Subsurface Equipment	4,750	3,657	14	-	3	27	2	2,185	10,638
Sucker Rod Pumps	528	96	33	-	125	-	25	-	807
Sucker Rods & Pull Rods	8,810	15,430	-	-	-	-	-	-	24,240
Misc. Sucker Rod Pumping Equipment	210	-	-	-	-	-	-	-	-
Pumping Units	36,900	6,840	-	-	1,080	-	882	-	45,702
Hydraulic-Submersible-Turbine Down Hole Pumps	192	167	28	430	4	-	6	281	1,108
Gas Lift Equipment (Subsurface)	80	1,072	101	3	9	6	28	43	1,342
Gas Lift Compressors	3,917	1,541	106	151	157	118	69	3,981	10,040
Surface Oil Handling Equipment	72,960	471	65	30	34	293	66	357	74,276
Surface Gas Handling Equipment	32,535	998	475	141	127	189	201	6,897	41,563
Surface Pumps	621	213	355	1	617	25	81	2,180	4,093
Internal Combustion Engines	190	598	-	10	133	142	5	2,660	3,738
Electrical Equipment	1,980	30	10	1,782	247	594	10	247	4,900
Automation, Control Equipment & Instruments	1,791	124	330	10	218	403	63	1,452	4,391
Hand & Power Tools	120	20	1	-	-	3	20	40	204
Welding Rod & Supplies	4,625	12	5	-	37	-	12	13	4,704
Offshore Fixed Platforms	138,600	-	-	-	-	-	-	-	138,600
TOTAL CONTROLLED MATERIALS FOR NEW WELLS (1967)	323,031	43,794	2,237	2,558	2,815	1,940	1,509	20,611	398,495

TABLE 5-4

1967 SURFACE AND SUBSURFACE PRODUCTION EQUIPMENT
CONTROLLED MATERIALS CONSUMED FOR STIMULATION AND ASSISTED RECOVERY PROJECTS
(TONS)

Item	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Other Alloys Castings & Forgings	Total
Waterflood Equipment	1,900	9	29	57	9	5	5	38	2,052
Thermal Stimulation Equipment	1,552	14	44	10	4	10	10	29	1,673
Gas & Misc. Phase Injection Equipment	2,910	485	12	29	2	19	11	6,305	9,773
TOTAL CONTROLLED MATERIALS FOR STIMULATION AND ASSISTED RECOVERY PROJECTS (1967)	6,362	508	85	96	15	34	26	6,372	13,498

TABLE 5-5

1967 SURFACE AND SUBSURFACE PRODUCTION EQUIPMENT
CONTROLLED MATERIALS CONSUMED IN MAINTENANCE AND REPAIR
(TONS)

Item	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Other Alloys Castings & Forgings	Total
Wellhead Equipment	10	10	-	-	-	-	-	-	20
Christmas Tree Valves	28	365	30	-	1	-	1	14	439
Subsurface Equipment	250	193	1	-	-	1	-	115	560
Sucker Rod Pumps	10,032	1,834	637	-	2,385	-	455	-	15,343
Sucker Rods & Pull Rods	8,810	15,430	-	-	-	-	-	-	24,240
Misc. Sucker Rod Pumping Equipment	90	-	-	-	-	-	-	-	90
Pumping Units	4,100	760	-	-	120	-	98	-	5,078
Hydraulic-Submersible-Turbine Down Hole Pumps	446	389	67	1,002	10	-	14	656	2,584
Gas Lift Equipment (Subsurface)	35	458	44	1	4	3	12	18	575
Gas Lift Compressors	121	48	3	5	5	4	2	123	311
Surface Oil Handling Equipment	3,840	25	3	2	2	15	3	19	3,909
Surface Gas Handling Equipment	1,712	53	25	7	7	10	11	363	2,188
Waterflood Equipment	100	1	1	3	1	-	-	2	108
Thermal Stimulation Equipment	48	1	1	-	-	-	-	-	51
Gas & Misc. Phase Injection Equipment	90	15	-	1	-	1	-	195	302
Surface Pumps	33	11	19	-	32	1	4	115	215
Internal Combustion Engines	10	32	-	-	7	8	-	140	197
Electrical Equipment	20	-	-	18	3	6	-	3	50
Automation, Control Equipment & Instruments	55	4	10	-	7	12	2	45	135
Hand & Power Tools	30	5	-	-	-	1	5	10	51
Welding Rod & Supplies	4,625	12	5	-	38	-	13	12	4,705
Offshore Fixed Platforms	1,400	-	-	-	-	-	-	-	1,400
TOTAL CONTROLLED MATERIALS FOR MAINTENANCE AND REPAIR (1967)	35,885	19,646	846	1,039	2,622	62	620	1,831	62,551

SECTION 6 - GAS PROCESSING PLANTS AND MATERIALS

This section of the report includes all of the controlled materials requirements for gas processing operations within the plant fences. Processing plants for both field and main gas transmission lines are included. Dehydration and desulfurization facilities also are included when constructed in conjunction with gas processing plants. In addition to gas processing plants, all field compressors are included. Compressors for main line gas transmission stations are not included.

The 1967 controlled materials consumption data include those materials required in the construction of 42 new plants and in the expansion of 20 existing plants. Construction during 1967 was completed on five types of plants -- Refrigeration, Refrigerated-Absorption, Cryogenic, Fractionation, and Sulfur. Each of these plant types is discussed in detail in PART II. A summary of the number of new plants constructed and the expansions which were made in 1967 for each plant type are itemized below:

	Number	Total Capacity
NEW PLANT CONSTRUCTION		
Refrigeration	10	66 MMCF/D
Refrigerated-Absorption	21	2,990 MMCF/D
Cryogenic	2	200 MMCF/D
Fractionation	1	1,050 M Gal/D
Sulfur	8	139 Long Tons/D
Total	42	
EXISTING PLANT EXPANSIONS		
Refrigeration	2	14 MMCF/D
Refrigerated-Absorption	7	920 MMCF/D
Fractionation	2	1,060 M Gal/D
Miscellaneous Additions	9	--
Total	20	

The materials requirements data were developed through actual construction analysis, published design data, and application of conventional design to plant requirements. The total controlled materials consumed in 1967, classified by usage and by major equipment components, are included in TABLES 6-1 and 6-2.

Material for the expansion of existing plants in 1967 is equal to about one-half of the new-plant controlled materials requirements. Relative to new plant installations, construction in 1967 is down compared to that in 1962 as reported in the 1963 NPC Report. Maintenance materials in 1967 were included for 826 plants versus 783 in 1962.

Helium plants and liquefied methane plants are not incorporated in the total materials consumed since construction of these plants in 1967 was limited and these plants do not represent a "normal-annual-material" requirement; however, controlled materials requirements data and descriptions of typical plants are included in PART II for information and estimating purposes. The controlled materials utilized for small vapor recovery and stabilization systems associated with oil production are included in SECTION 5 with the other surface producing facilities.

In addition to the controlled materials required for gas processing facilities, the operation of gas processing plants requires the use of a variety of chemicals such as those for gas treating, liquids treating, and water treating. A list of the critical chemicals necessary for operating gas plants and the estimated quantities used in 1967 are itemized in TABLE 6-3.

The computer application for gas processing plant construction and operation in 1967 is based on the utilization of a typical computer installation by an industry natural gas liquids department. It was assumed that smaller operators would not utilize computers to the same degree as large operators. The type of work performed with computers and the computer-time allocations for 1967 are listed below:

Type of Work	Computer Time (Hours/Year)
Gas business systems, measurements, purchases, and royalties	1,800
Management reports, supply and demand, marketing net back, wholesale accounting	1,800
Engineering, processing, design yield studies, project development	2,880
Total	6,480

TABLE 6-1

1967 GAS PROCESSING PLANTS CONTROLLED MATERIALS CONSUMPTION
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
New Plant Construction	42,527	897	207	871	711	383	29	45,625
Existing Plant Expansion	17,203	475	65	410	316	226	3	18,698
Unreported New Construction to Existing Facilities	6,677	230	37	148	142	82	13	7,329
Compressors	6,996	1,006	101	202	393	207	11	8,916
TOTAL MATERIAL FOR NEW CONSTRUCTION	73,403	2,608	410	1,631	1,562	898	56	80,568
Annual Maintenance Material for Existing Plants	14,681	522	82	326	313	179	11	16,114
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	88,084	3,130	492	1,957	1,875	1,077	67	96,682

TABLE 6-2

1967 GAS PROCESSING PLANTS CONTROLLED MATERIALS CONSUMPTION
BY MAJOR EQUIPMENT COMPONENTS
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
Boilers - Heaters - Cooling Towers - Heat Exchangers	6,143	249	36	265	1,467	127	3	8,290
Process Vessels and Tanks	35,525	30	23	-	-	-	50	35,628
Pumps - Motors Electrical	4,498	717	-	1,477	-	88	-	6,780
Instruments and Controls	310	16	259	5	-	1	3	594
Pipes - Valves - Fittings	26,986	822	67	8	15	-	-	27,898
Structural Steel - Insulation - Buildings, Etc.	7,626	290	6	-	-	654	-	8,576
Compressors	6,996	1,006	101	202	393	207	11	8,916
TOTAL CONTROLLED MATERIALS CONSUMED (1967)	88,084	3,130	492	1,957	1,875	1,077	67	96,682

TABLE 6-3

CRITICAL CHEMICALS REQUIRED FOR GAS PLANT OPERATIONS

Type of Chemical	Quantity (Tons/Year)
Gas Treating	
Ethylene Glycol	1,350
Di-Ethylene Glycol	1,080
Tri-Ethylene Glycol	2,250
Mono-Ethanol Amine	1,350
Liquids Treating	
Caustic Soda	1,850
Perco Reagent	485
Water Treating	
Chlorine	130
Glucosates	90
Sodium Chloride	9,750
Soda Ash	62
Sulfuric Acid 66° Baume'	5,500
Commercial Compounded Chemicals (Boiler Compounds, Algae Chemicals, Scale Control Chemicals)	2,215
Miscellaneous	
Ethyl Mercaptan	500
Mercury	9
Methanol	945

PART II

MATERIALS REQUIREMENT GUIDELINES FOR MAJOR INDUSTRY OPERATING PHASES

PART II of this report presents materials requirement guidelines which can be used to support industry's materials requests. These indicative factors represent weighted-average conditions based upon materials requirements for the activity experienced during 1967.

Because of the wide variance in design criteria and performance requirements, sound engineering judgment must be used in conjunction with the data presented in this part of the report. However, if properly used, the data will permit the reasonable estimation of materials requirements for a large number of projects.

PART II was developed and is presented under the below-listed headings. These headings represent the major industry phases directly related to petroleum reserves and production.

1 EXPLORATION FOR OIL AND GAS RESERVES

2 DEVELOPMENT OF OIL AND GAS RESERVES

3 MAINTENANCE OF EXISTING PRODUCTION FACILITIES

4 DEVELOPMENT OF ADDITIONAL PRODUCTION BY RESERVOIR STIMULATION

5 MATERIALS REQUIRED TO BUILD MOBILE EQUIPMENT ITEMS

An example problem and solution, discussion of the technique requir to utilize the graphs and factors, and qualifying comments are included in each appropriate section.

1 - EXPLORATION FOR OIL AND GAS RESERVES

Based upon past experience, only seismic and exploratory drilling consume significant quantities of controlled materials in the process of exploring for new hydrocarbon reserves. These two operations are neither directly comparable nor similarly time related to the discovery of reserves. Materials requirement guidelines, therefore, have been developed separately for these two operations.

Seismic Operations

Seismic operations do not vary significantly in materials requirements for various areas, other than offshore versus onshore. The remaining variance is primarily in transportation requirements which are beyond the scope of this report.

Today's seismic operations include the use of dynamite and mechanical sound sources. The materials requirements for these two system types are different.

Based upon the above comments and 1967 materials consumption, a series of factors have been developed that represent the average controlled materials consumed by a typical seismic crew of each type for both land and marine operations. These factors are presented in TABLE 1-1.

TABLE 1-1

CONTROLLED MATERIALS CONSUMED BY A TYPICAL SEISMIC CREW - ANNUALLY

(TONS)

Crew Type	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Aluminum	Total
Land Based						
-- Conventional Dynamite	6.560	3.892	.298	2.070	.257	13.077
-- Surface Source	2.908	.100	.232	.488	.257	3.985
Marine Based						
-- Conventional Dynamite or Surface Source	3.638	.046	.272	.458	.345	4.759

An example of how the information contained in the above table can be used is as follows:

Problem: What weight of the various controlled materials will be consumed by 100 marine-based surface source crews in one year?

Solution: It will require 100 times the materials required for the average marine-based surface source crew as presented in TABLE 1-1 as follows:

Controlled Materials				Weight (Tons)
Carbon Steel	=	3.638 Tons/Crew (100 Crews)	=	363.8
Alloy Steel	=	.046 Tons/Crew (100 Crews)	=	4.6
Stainless Steel	=	.272 Tons/Crew (100 Crews)	=	27.2
Copper	=	.458 Tons/Crew (100 Crews)	=	45.8
Aluminum	=	.345 Tons/Crew (100 Crews)	=	34.5
Total				475.9

Exploratory Drilling Operations

In the normal process of exploratory drilling, the majority of the wells drilled are completed as dry holes. Also, it is normal practice to allocate funds and materials for exploratory wells on the basis of their being dry and to later supplement the funds and materials should the well prove to be a producer. For these reasons, exploratory wells are treated herein as dry holes.

There are wide variances in materials requirements for wells of different depths and geographic areas. For this reason, factors and curves are provided relating materials requirements to well depth as applicable for average wells in several geographic areas. These areas are considered to be representative of the various operating environments.

The factors for developing future requirements are presented on an individual well basis by geographic area in the following manner:

1. A table of factors (TABLE 1-2) indicates the materials consumed for drill pipe and tool joints, drill collars, and well servicing equipment for each geographic area.

2. A graph of casing requirements versus depth for each geographic area (FIGURES 2, 5, 8, 11, 14, and 17).

3. A graph of total carbon steel and alloy steel requirements versus depth for the drilling rig operations for each geographic area (FIGURES 3, 6, 9, 12, 15, and 18).

4. A graph of controlled materials other than carbon and alloy steel versus depth for the drilling rig operations for each geographic area (FIGURES 4, 7, 10, 13, 16, and 19).

Although the above information is presented on an individual well basis, it should only be used as a comparative tool or as a building block to determine materials requirements for a large number of wells.

An example of how the predictive tools can be used is as follows:

Problem: What total weight of controlled materials will be required on an annual basis to drill 100, West Texas Deep, exploratory wells to an average depth of 21,000 feet?

Solution:

1. Obtain the total materials required for drill pipe, tool joints and drill collars from TABLE 1-2 and multiply by the depth and the number of wells.

2. Obtain the total materials required for well servicing per well from TABLE 1-2 and multiply by the number of wells.

3. Determine the total materials required for casing per well from FIGURE 17 and multiply by the number of wells.

4. Determine the total materials required for drilling rig operations from FIGURE 18 and multiply by the number of wells.

5. Add the totals obtained in items 1 through 4 above.

Equipment		Weight (Tons)
Drill Pipe and Tool Joints	= 12.00 Tons/1,000 Ft./Well (21,000 Ft.) (100 Wells)	= 25,200
Drill Collars	= 2.00 Tons/1,000 Ft./Well (21,000 Ft.) (100 Wells)	= 4,200
Well Servicing Equipment	= 7,283 Pounds/Well (100 Wells) ÷ 2000 Pounds/Ton	= 364
Casing	= 568 Tons/Well (100 Wells)	= 56,800
Drilling Rig Equipment	= 134 Tons/Well (100 Wells)	= 13,400
Total		99,964

This same solution technique can be used for any geographic area and any particular controlled material by using the appropriate table entries and graphs.

TABLE 1-2

CONTROLLED MATERIALS REQUIREMENTS FACTORS
FOR AN EXPLORATION WELL

Equipment by Area (With description of relationship to 1 well	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
ALASKA OFFSHORE								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	1.13	.39	-	-	-	-	-	1.52
Drill Collars per 1000 ft. (Tons)	.37	-	-	-	-	-	-	.37
Well Servicing Equipment per Well (Pounds)	2,810	2,471	100	28	100	80	3	5,592
GULF COAST OFFSHORE								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	.42	.19	-	-	-	-	-	.61
Drill Collars per 1000 ft. (Tons)	.18	-	-	-	-	-	-	.18
Special Pipe per 1000 ft. (Tons)	.03	.01	-	-	-	-	-	.04
Well Servicing Equipment per Well (Pounds)	4,223	3,327	160	43	146	129	7	8,035
WEST COAST OFFSHORE								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	.66	.01	-	-	-	-	-	.67
Drill Collars per 1000 ft. (Tons)	.18	-	-	-	-	-	-	.18
Well Servicing Equipment per Well (Pounds)	1,463	1,207	54	13	50	54	1	2,842
GULF COAST ONSHORE								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	.34	.16	-	-	-	-	-	.50
Drill Collars per 1000 ft. (Tons)	.17	-	-	-	-	-	-	.17
Special Pipe per 1000 ft. (Tons)	.04	.01	-	-	-	-	-	.05
Well Servicing Equipment per Well (Pounds)	1,501	1,220	56	15	51	45	2	2,890
INLAND UNITED STATES								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	.29	.06	-	-	-	-	-	.35
Drill Collars per 1000 ft. (Tons)	.08	-	-	-	-	-	-	.08
Well Servicing Equipment per Well (Pounds)	604	504	22	5	21	18	-	1,174
WEST TEXAS DEEP								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	7.80	4.20	-	-	-	-	-	12.00
Drill Collars per 1000 ft. (Tons)	2.00	-	-	-	-	-	-	2.00
Well Servicing Equipment per Well (Pounds)	3,714	3,165	131	33	130	106	4	7,283

NOTE: Well Servicing Materials Requirements are presented in pounds rather than tons because of the very critical requirement for some materials in quantities too small to express in tons.

FIGURE 2

CASING AND TUBING MATERIALS REQUIREMENTS – EXPLORATION WELL

ALASKA OFFSHORE

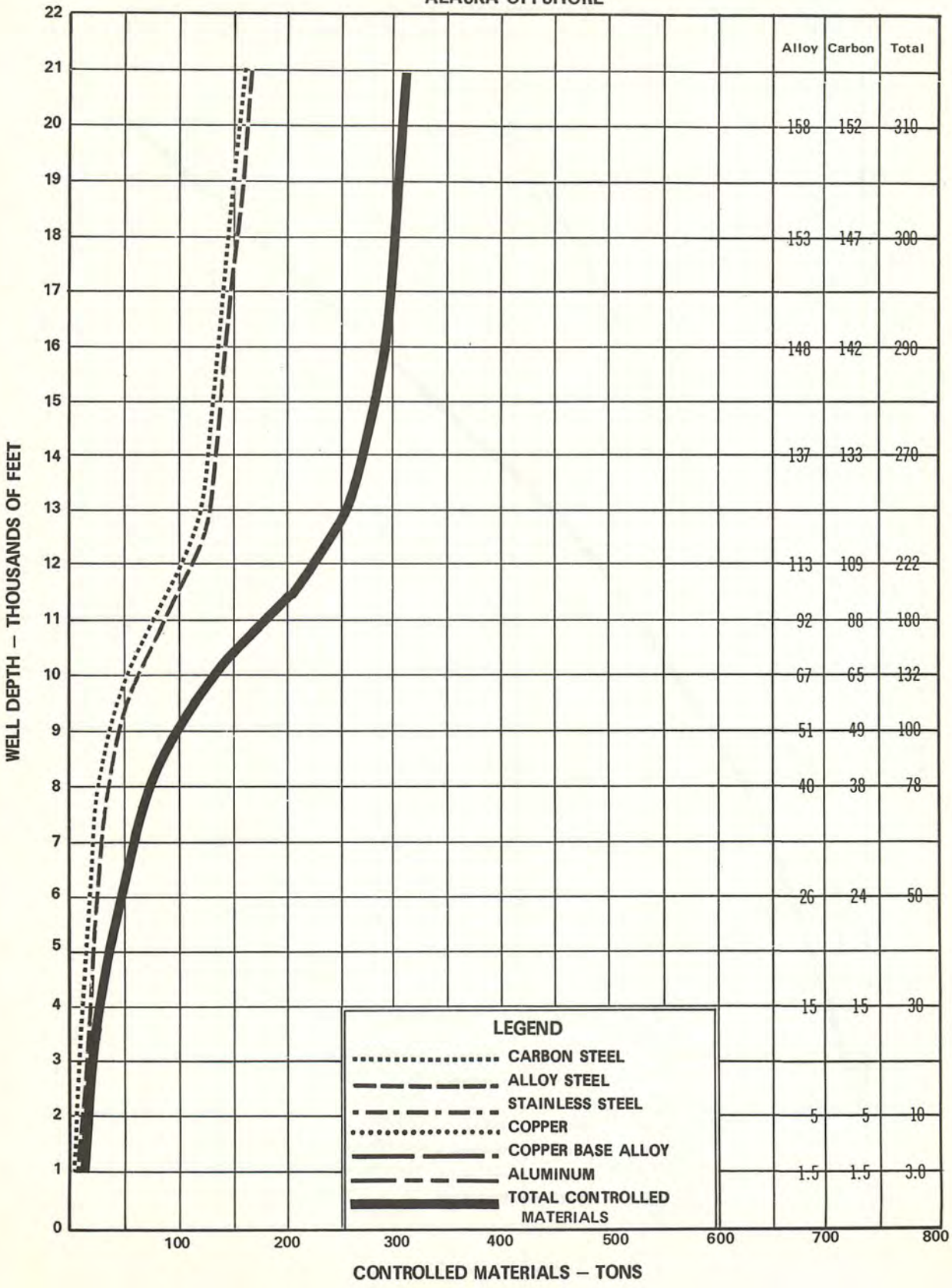


FIGURE 3

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

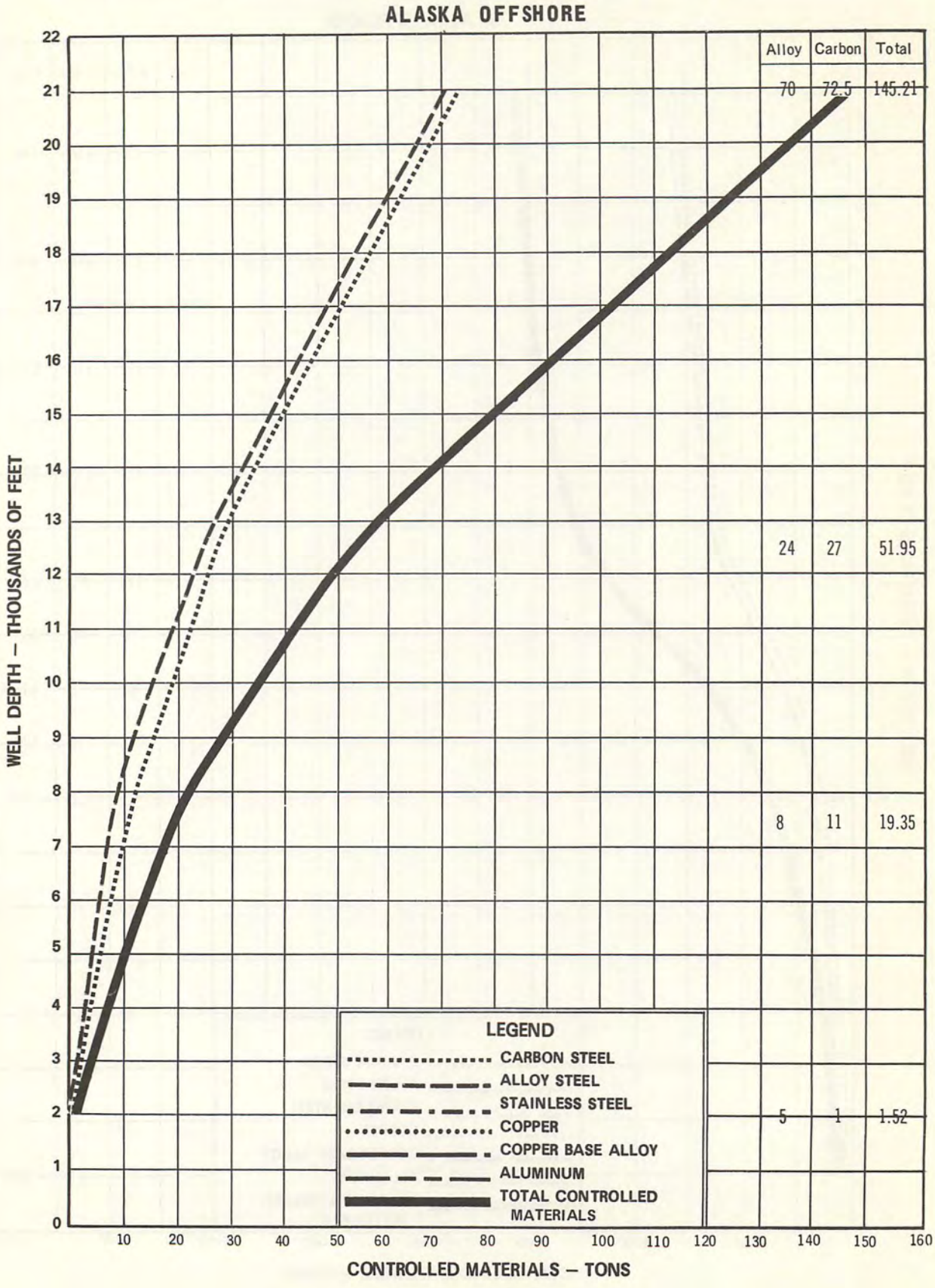


FIGURE 4

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

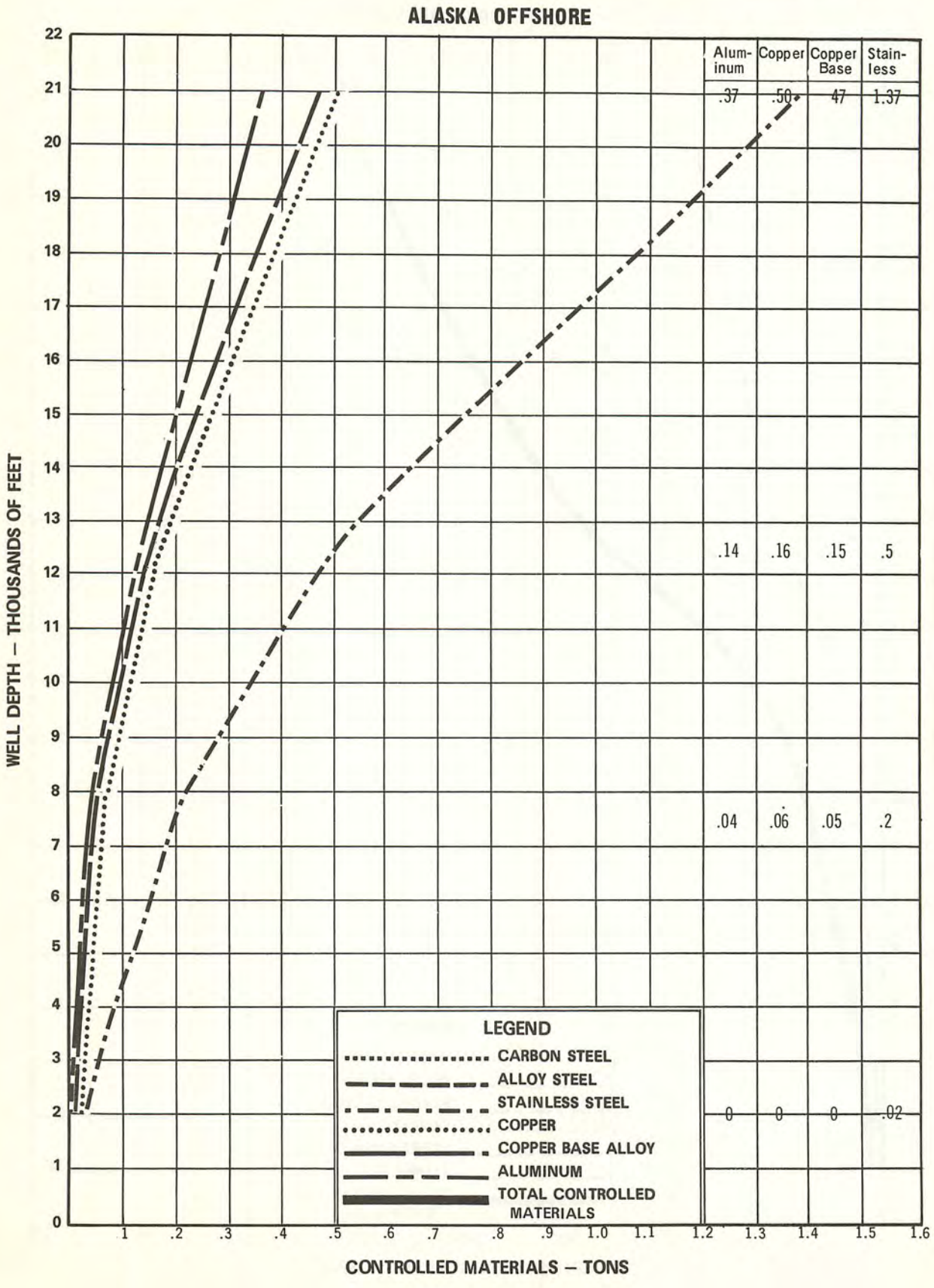
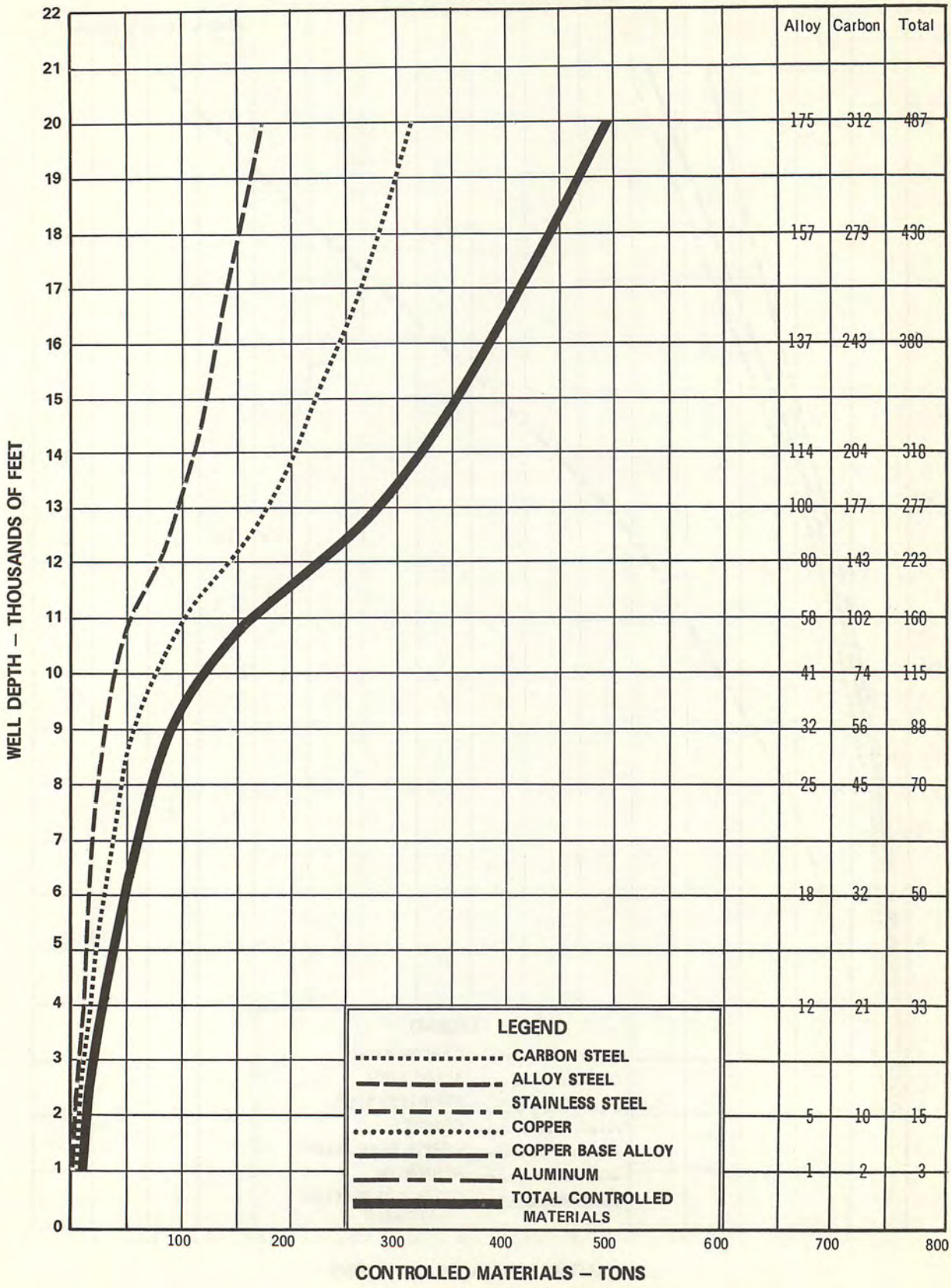


FIGURE 5

CASING AND TUBING MATERIALS REQUIREMENTS – EXPLORATION WELL

GULF COAST OFFSHORE



Alloy	Carbon	Total
175	312	487
157	279	436
137	243	380
114	204	318
100	177	277
80	143	223
58	102	160
41	74	115
32	56	88
25	45	70
18	32	50
12	21	33
5	10	15
1	2	3

FIGURE 6

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

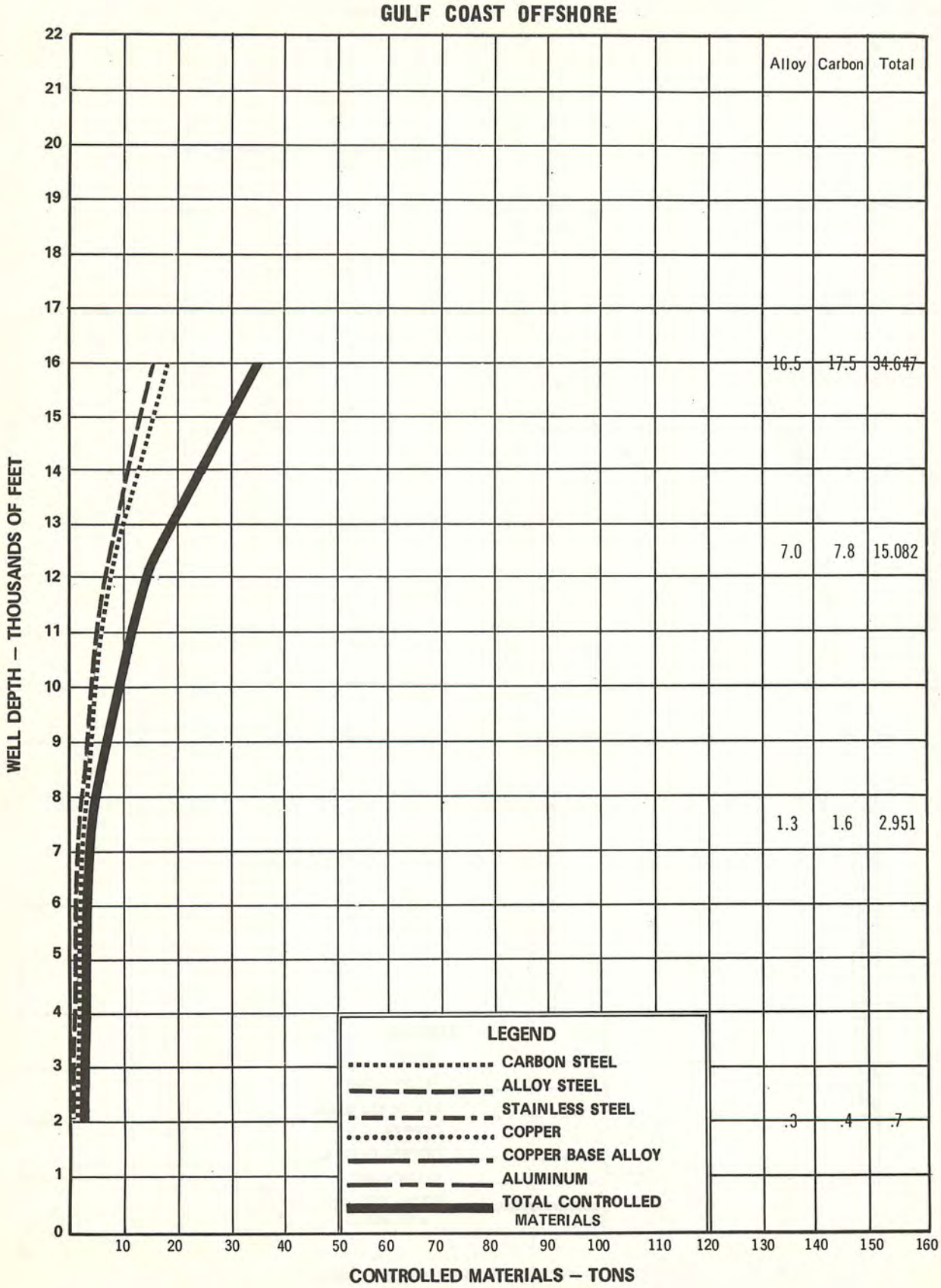


FIGURE 7

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

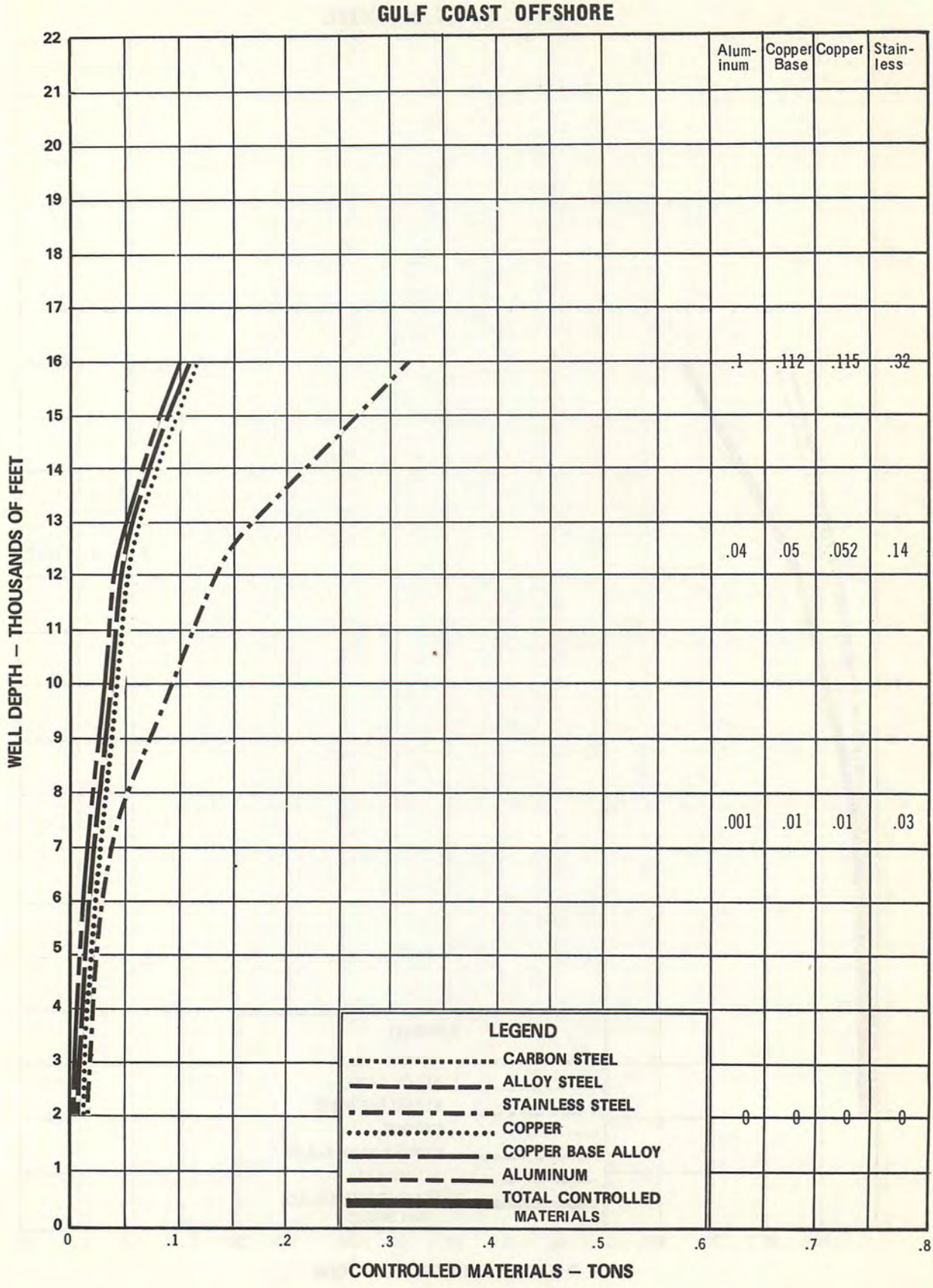


FIGURE 8

CASING AND TUBING MATERIALS REQUIREMENTS – EXPLORATION WELL
WEST COAST OFFSHORE

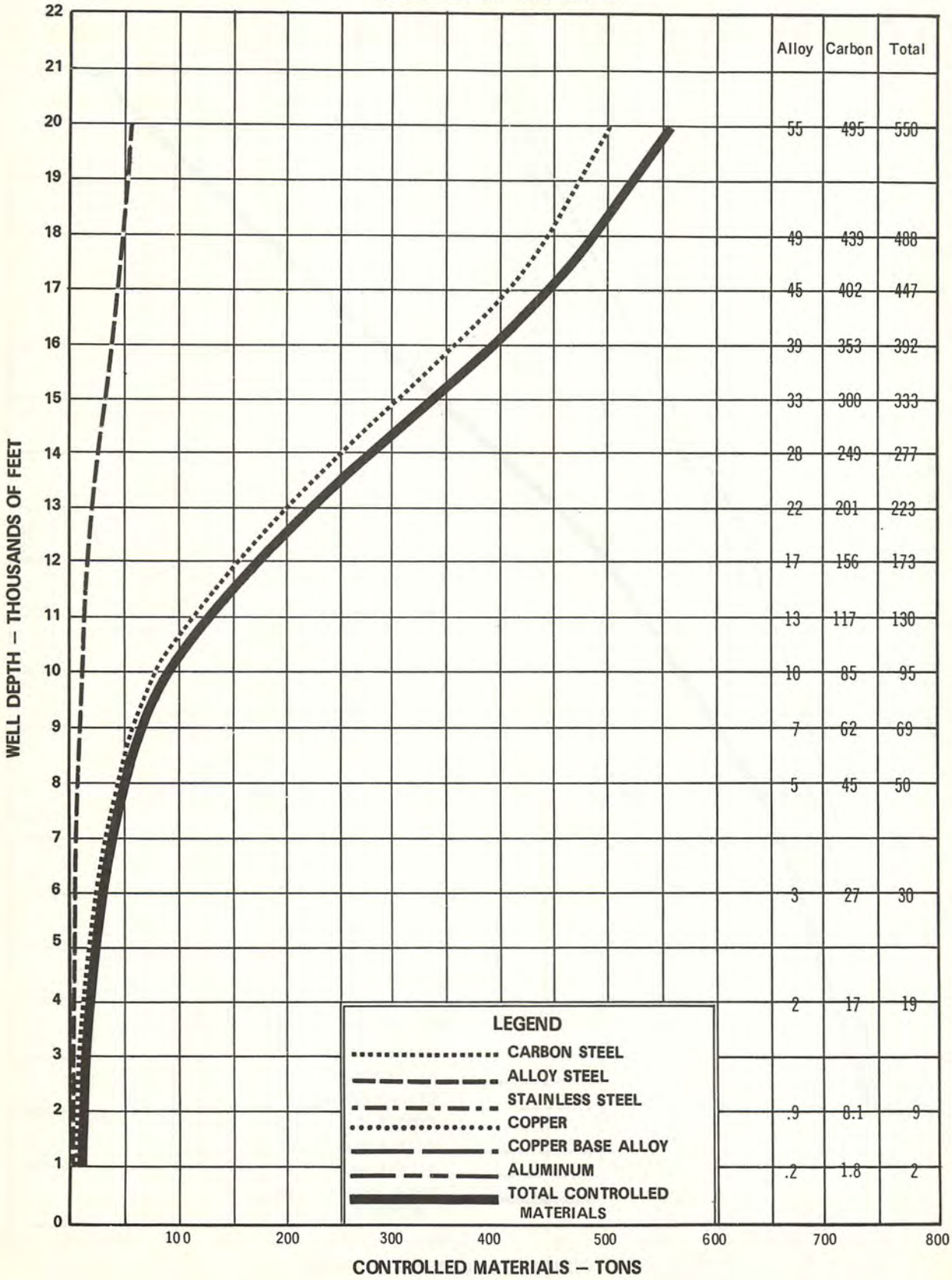


FIGURE 9

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

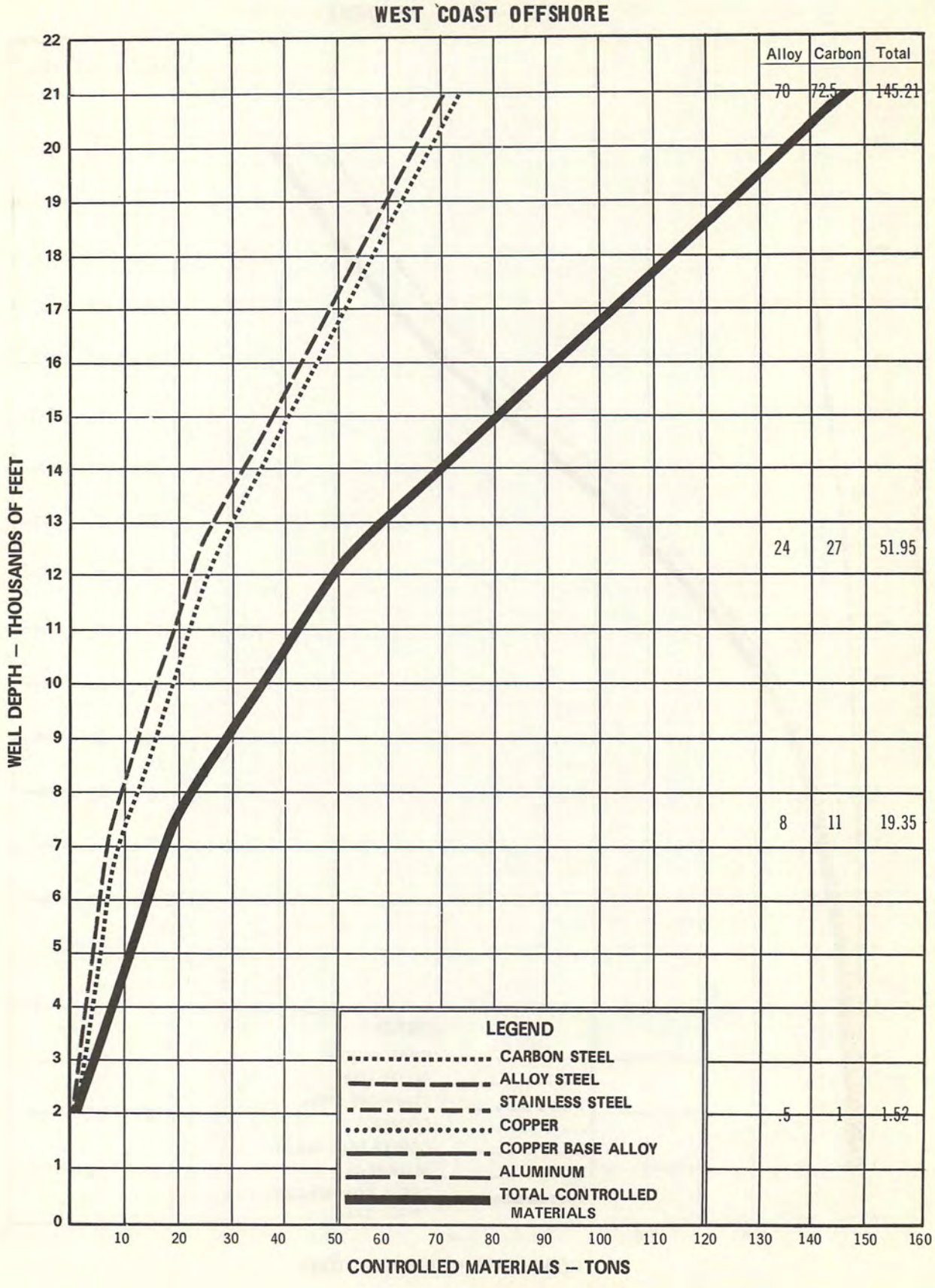


FIGURE 10

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

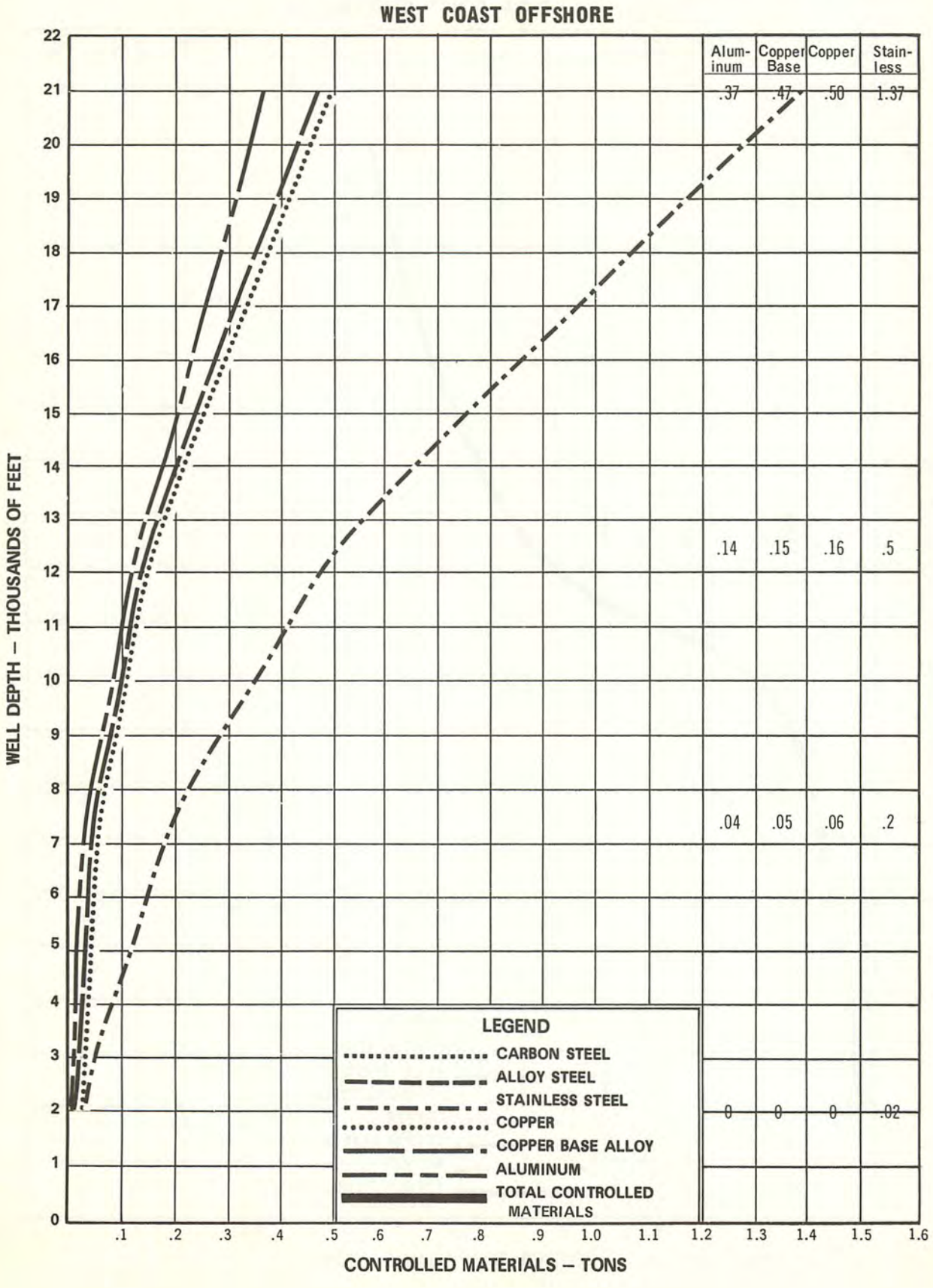


FIGURE 11

CASING AND TUBING MATERIALS REQUIREMENTS – EXPLORATION WELL

GULF COAST ONSHORE

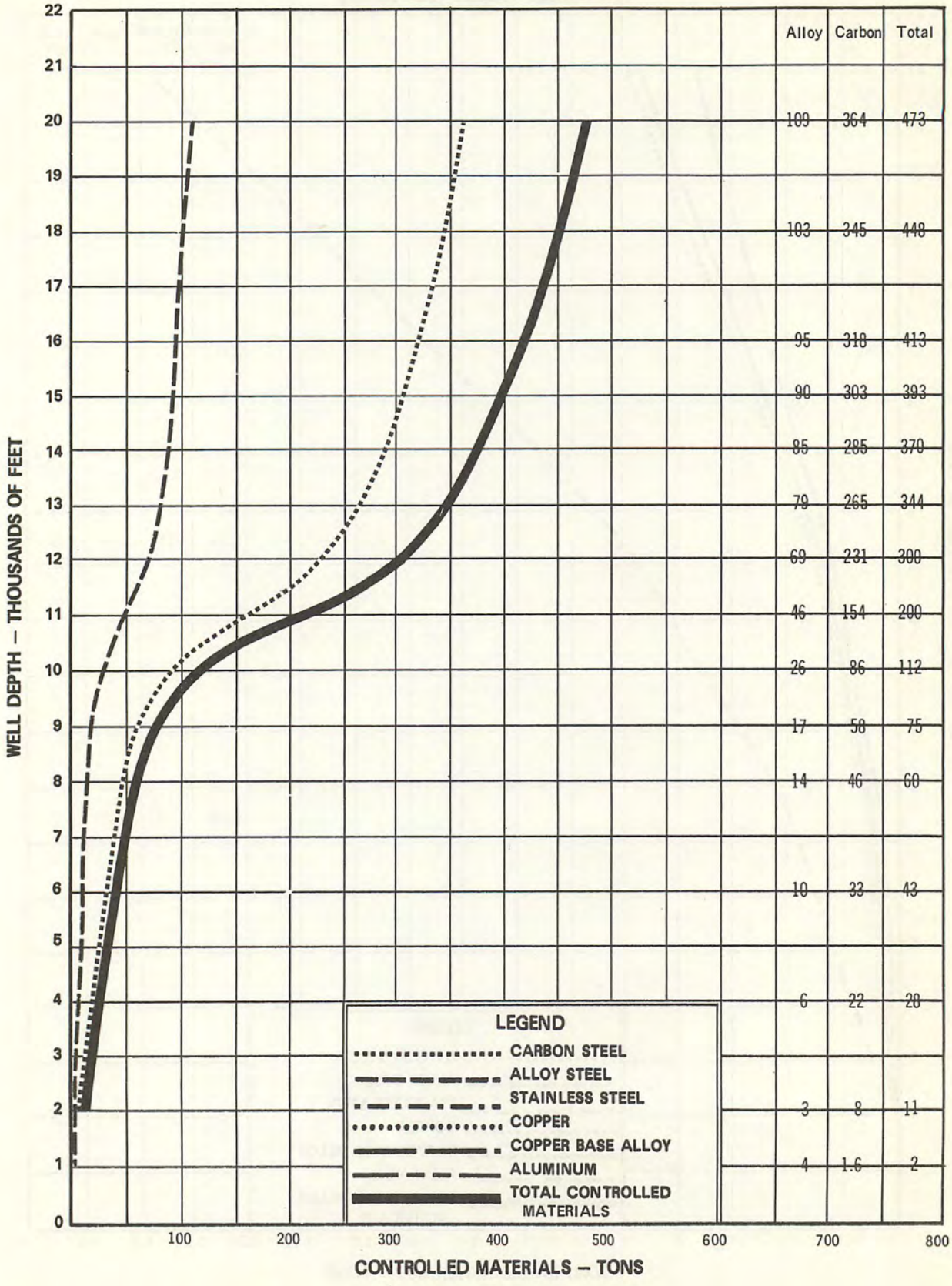


FIGURE 12

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

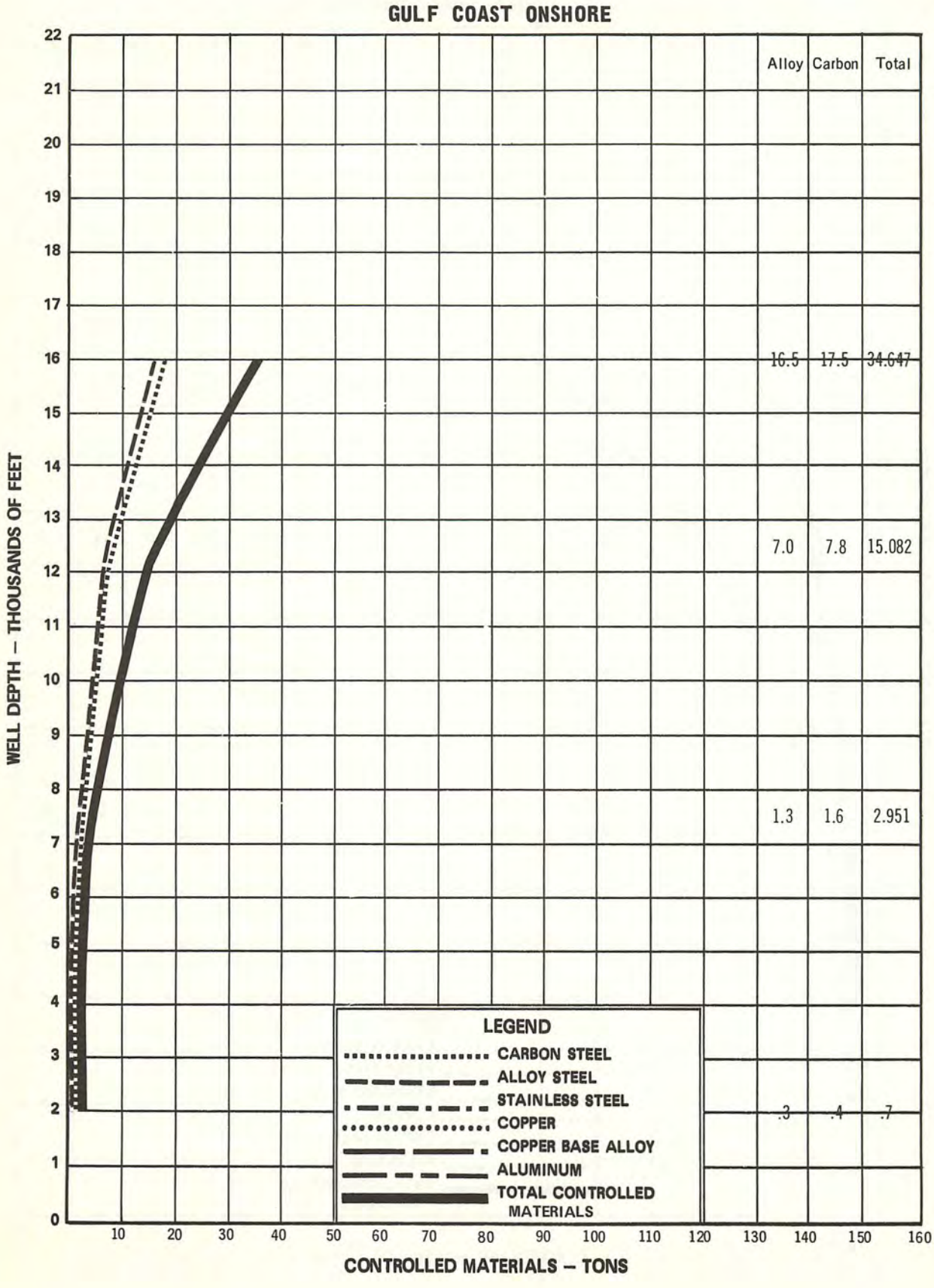


FIGURE 13

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

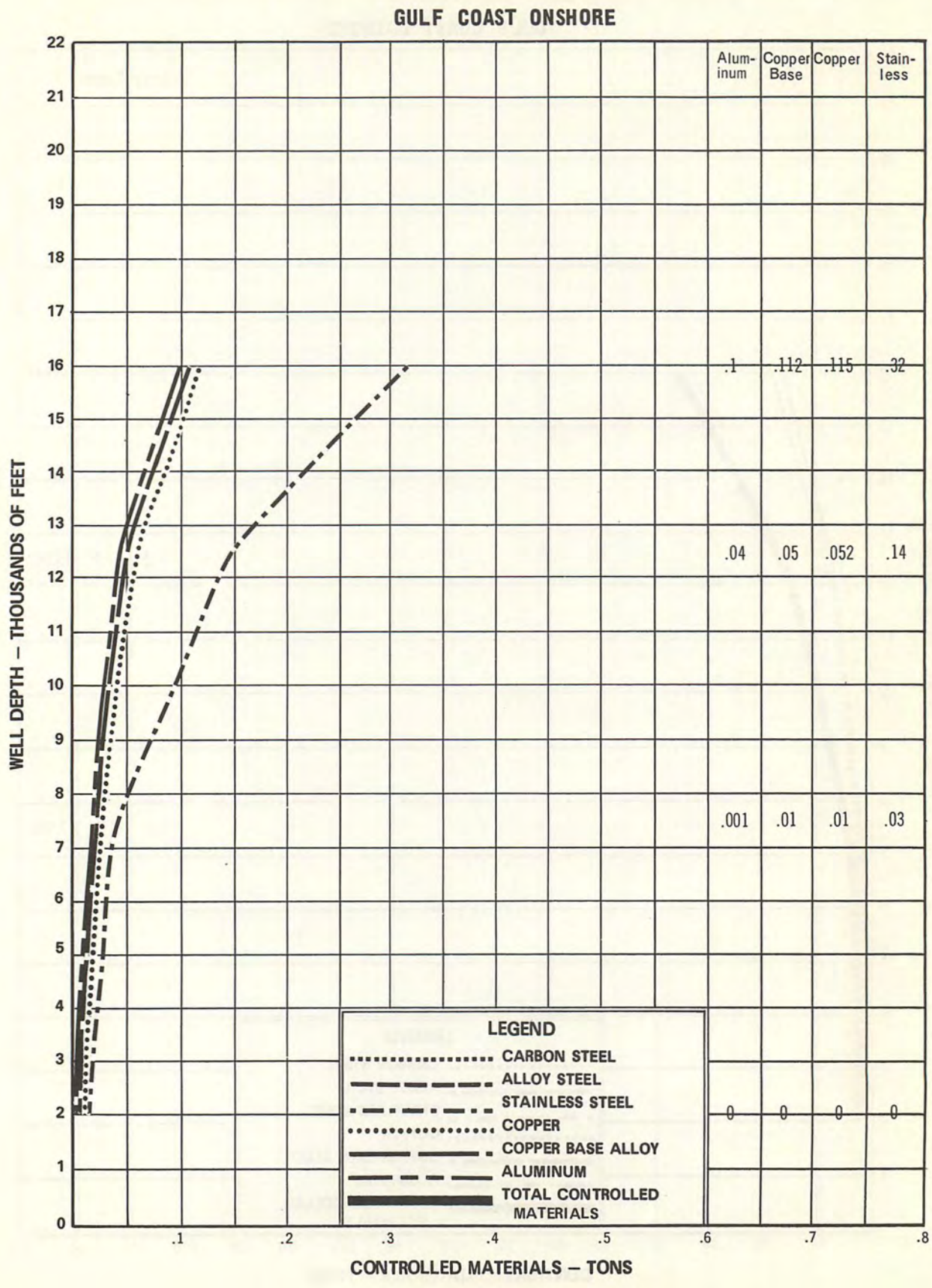


FIGURE 14

CASING AND TUBING MATERIALS REQUIREMENTS – EXPLORATION WELL

INLAND UNITED STATES

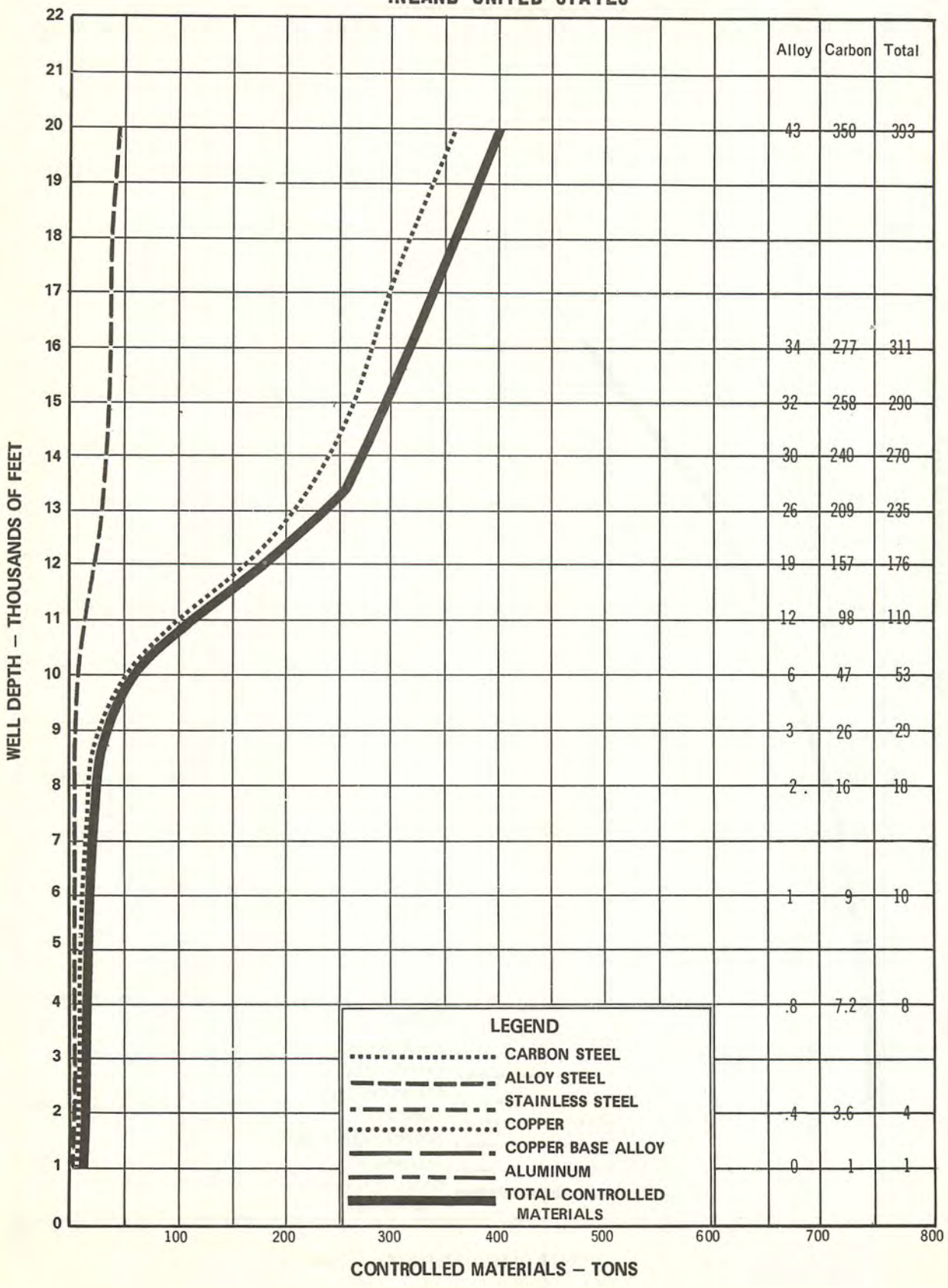


FIGURE 15

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

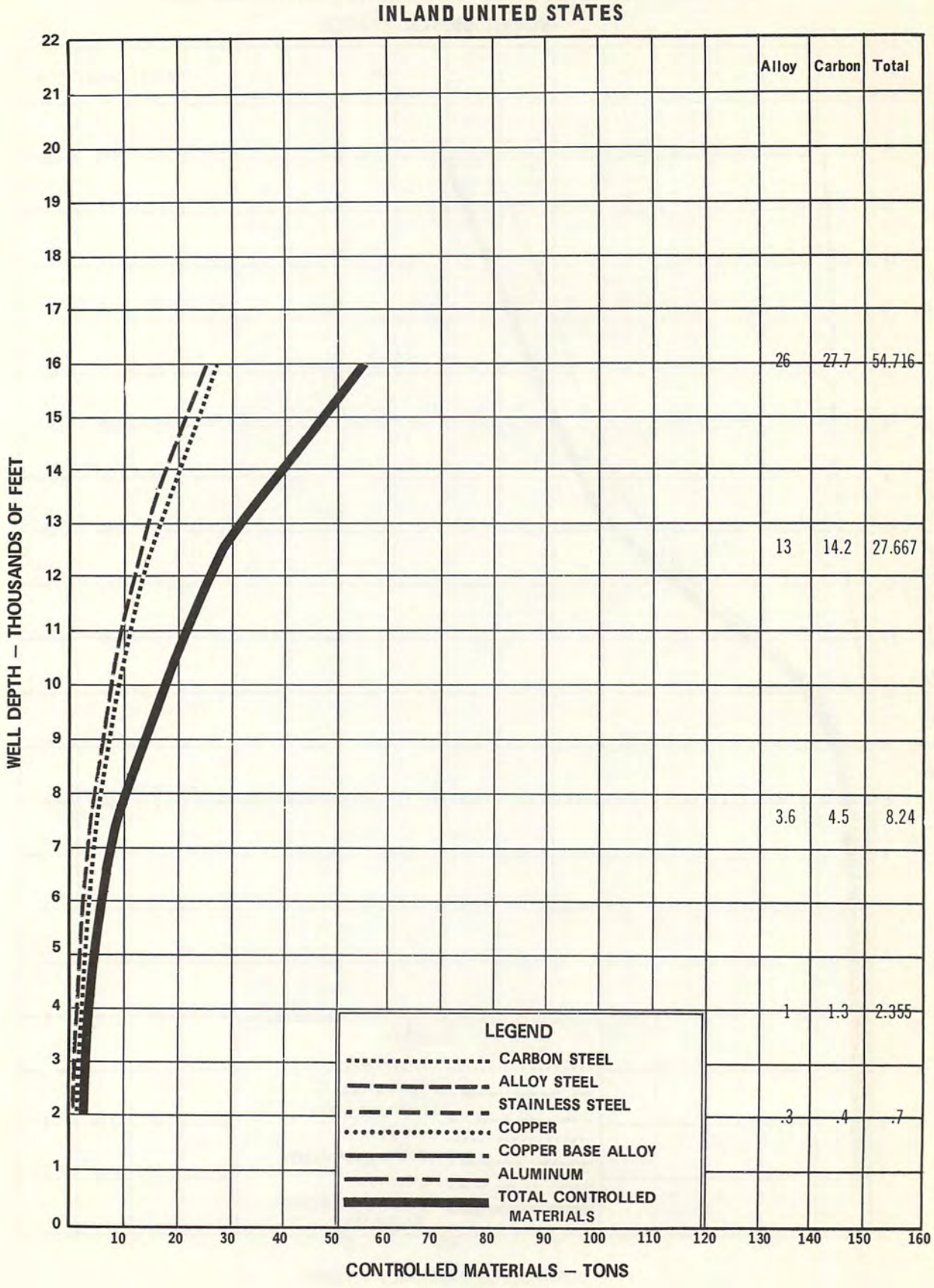


FIGURE 16

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

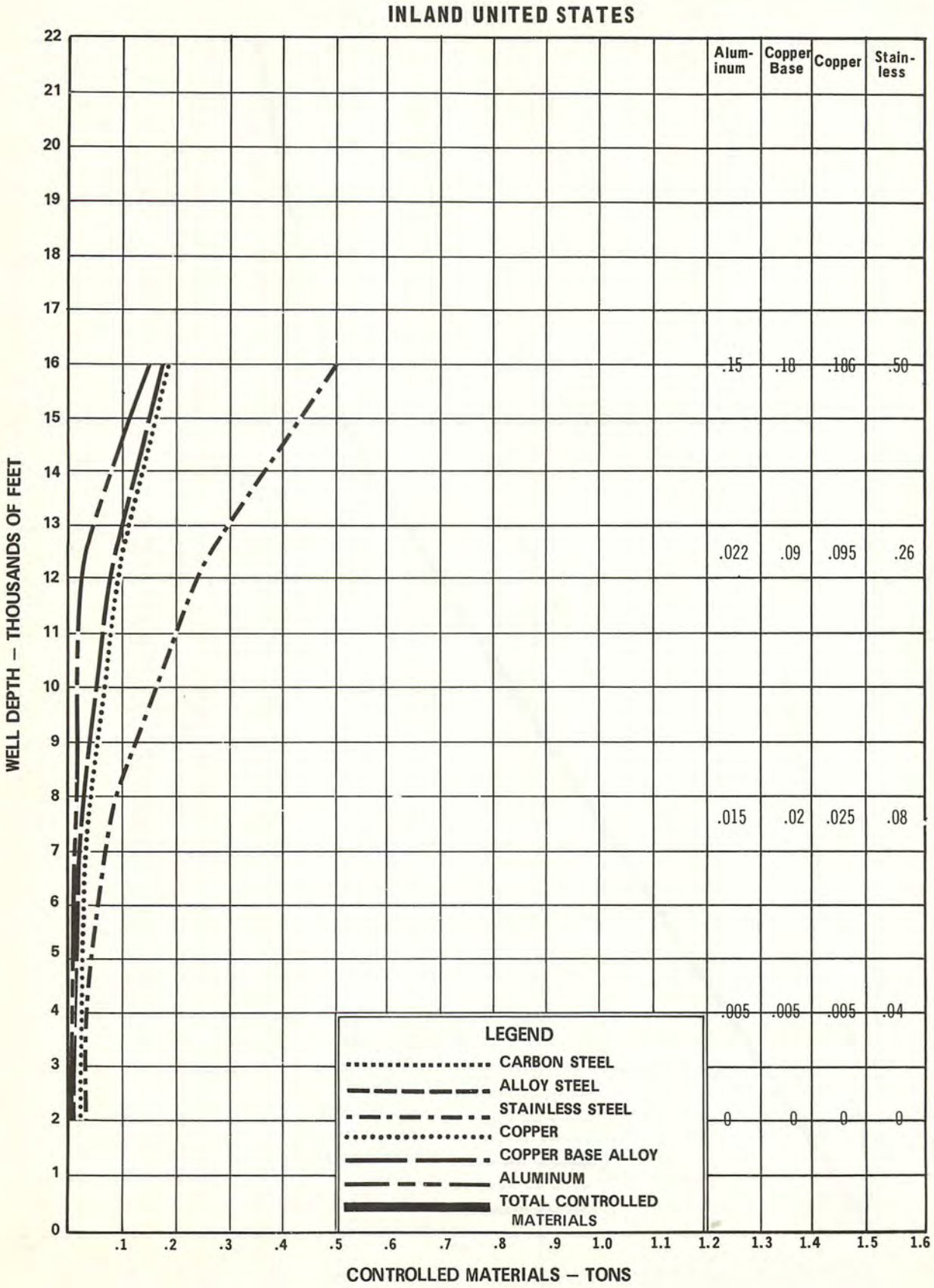


FIGURE 17

CASING AND TUBING MATERIALS REQUIREMENTS – EXPLORATION WELL

WEST TEXAS DEEP

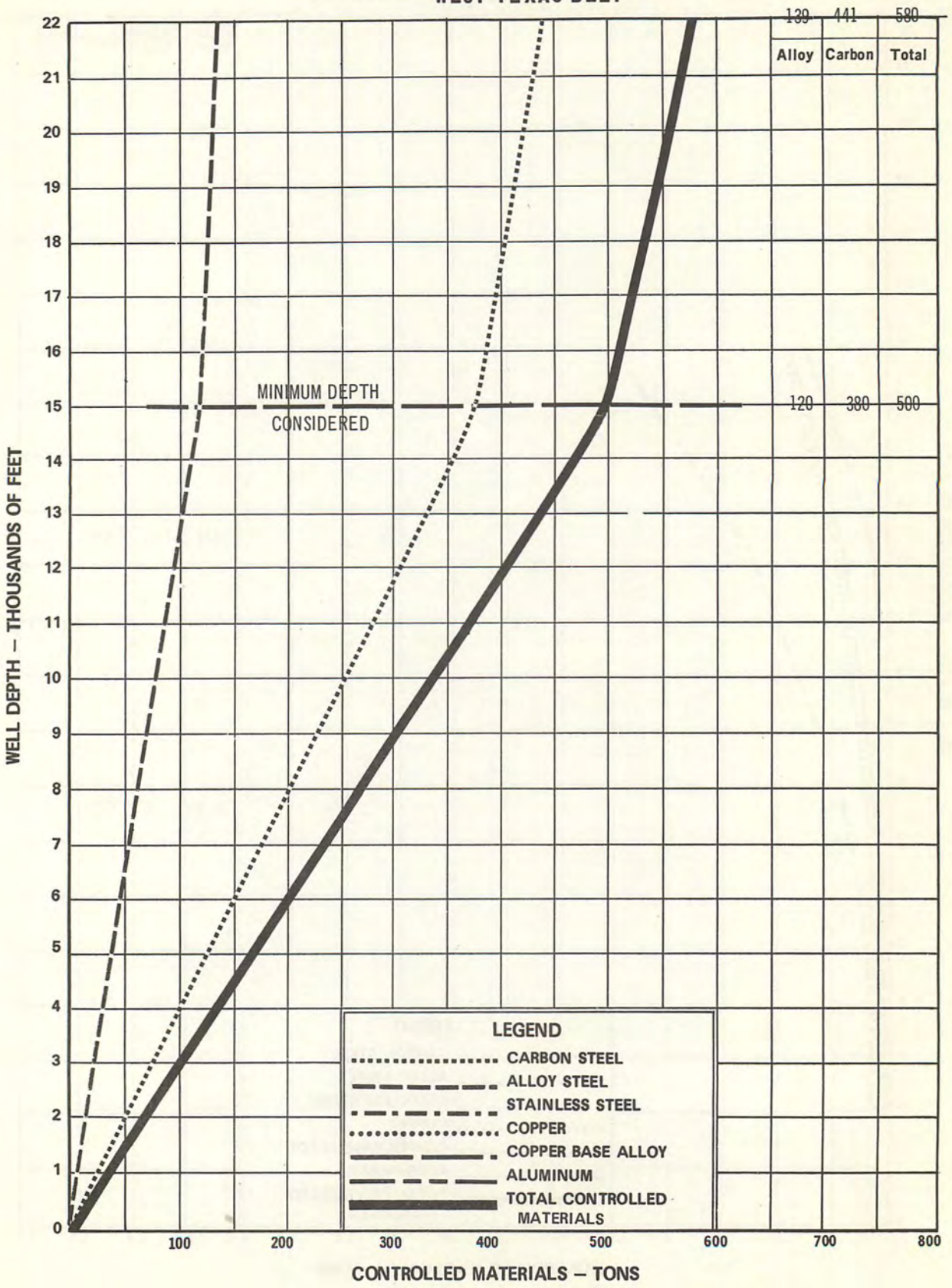


FIGURE 18

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

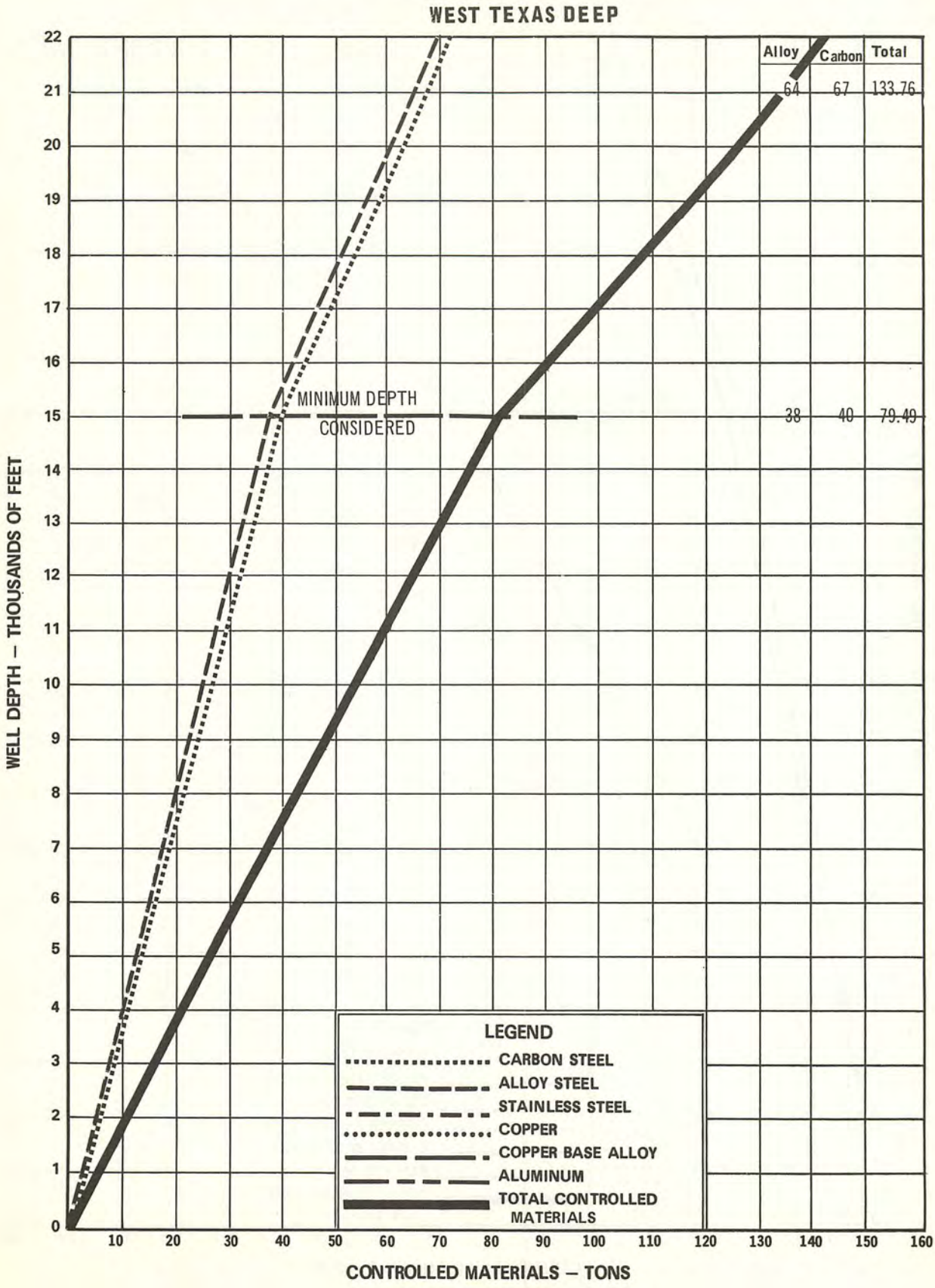
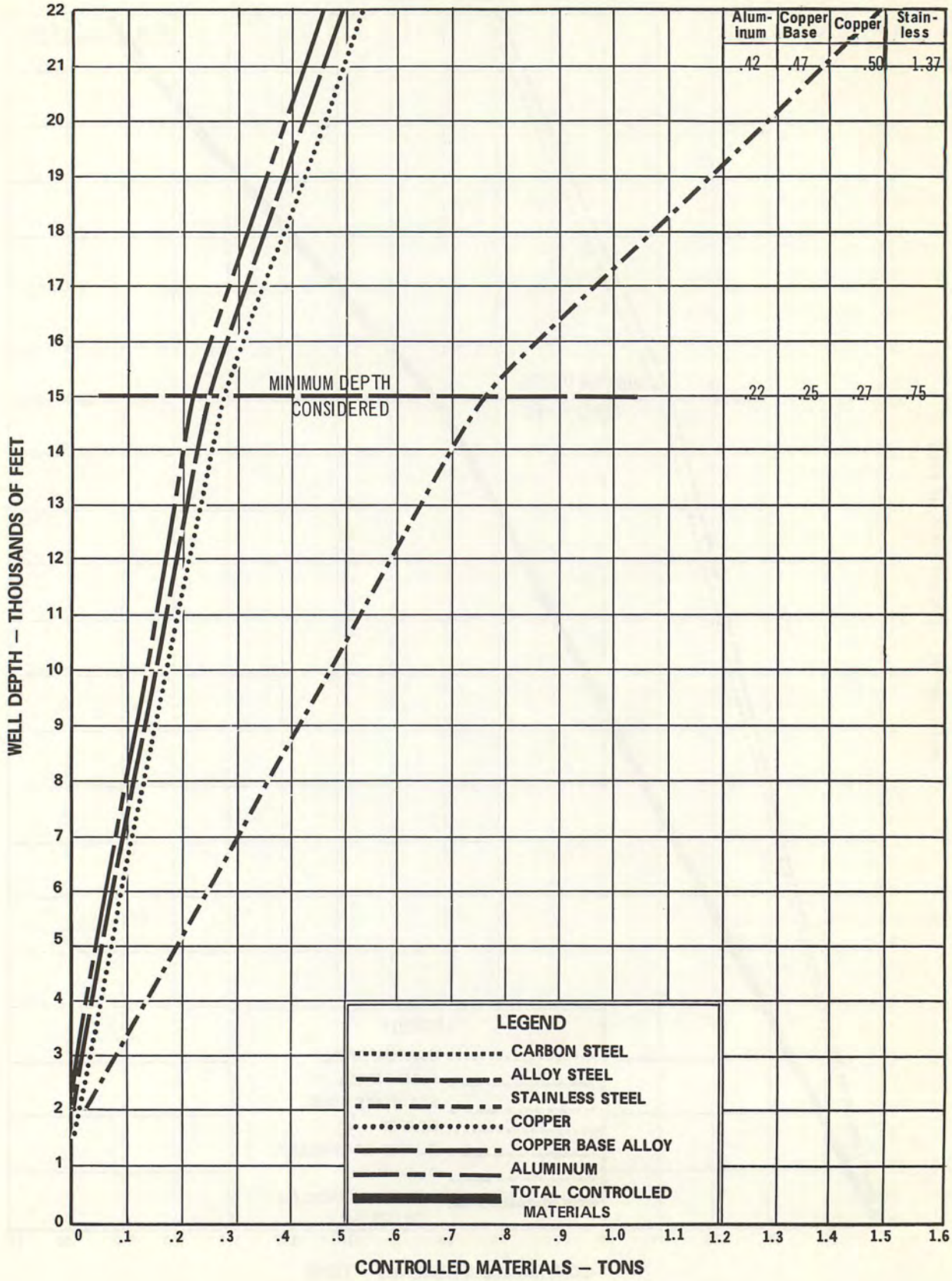


FIGURE 19

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – EXPLORATION WELL

WEST TEXAS DEEP



2 - DEVELOPMENT OF OIL AND GAS RESERVES

Materials requirements for the development of oil and gas reserves are presented in the following two categories:

-- Development Well and Well-Related Materials Requirements.

-- Gas Processing Plant Materials Requirements.

It should be noted that since development wells are normally planned as producers, the information herein presented assumes all development wells are producers.

Development Well and Well-Related Materials Requirements

Development well and well-related materials requirements include the materials necessary to drill, complete, and produce a well. More specifically, these materials requirements are those necessary to provide and sustain the following items:

1 - Drilling equipment required to drill and complete a well.

2 - Well servicing equipment to log, test, cement, perforate, and treat a well.

3 - Tubular goods required to drill, case, and complete a well.

4 - Surface and subsurface production equipment required to produce a well.

Materials requirements for drill pipe and tool joints, drill collars, flow line, and well servicing equipment have been developed on an individual well basis for each area. This information is presented in TABLE 2-1.

Casing, tubing, and drilling equipment materials required to drill and complete development wells have been developed and are presented on FIGURES 20 through 37, inclusive. These figures are graphical presentations of materials requirements for one well on a depth versus weight basis.

Materials requirements for the construction and installation of production platforms have been developed by geographic offshore area. These data are presented on a graph of weight versus water depth in FIGURES 38, 39 and 40. Immediately preceding FIGURE 38 is a description of the criteria involved in developing offshore platform data.

The controlled materials requirements for surface and subsurface facilities have been developed on an average total domestic industry well basis. This approach was used because individual well needs in geographic areas vary in relation to well spacing, type completion, and type of lease operation. Therefore, the total industry average was considered the most valid estimating tool. The factors for surface and subsurface equipment

include all materials, except those outlined above, that are required to deliver produced fluids to the point of custody transfer to a pipeline or other transporting system. These factors are presented in TABLE 2-1.

Although the above described data is presented on an individual well basis, it should only be used as a comparative tool or as a building block to determine materials requirements for a large number of wells.

An example of how the graphs and factors can be used is as follows:

Problem: What total weight of controlled materials will be required to drill and develop oil production from a Cook Inlet reservoir requiring 92 wells at an average depth of 10,000 feet? It is planned to use two, 2-rig, 48-well platforms set in an average water depth of 120 feet.

Solution:

1. Obtain the materials required per well for drill pipe and tool joints, and drill collars from TABLE 2-1 and multiply by the depth and the number of wells.

2. Obtain the materials required per well for well servicing, surface and subsurface equipment, and flow lines from TABLE 2-1 and multiply by the number of wells.

3. Determine the materials required for casing and tubing per well from FIGURE 20 and multiply by the number of wells.

4. Determine the total materials per well required for drilling rig operations from FIGURE 21 and multiply by the number of wells.

5. Determine the materials required for platforms from FIGURE 38 and multiply by the number of platforms.

6. Add the totals obtained in items 1 through 5 above.

Equipment			Weight (Tons)
Drill Pipe and Tool Joints	= 1.52 Tons/1000 Ft./Well (10,000 Ft.) (92 Wells)	=	1,398
Drill Collars	= .37 Tons/1000 Ft./Well (10,000 Ft.) (92 Wells)	=	340
Well Servicing Equipment	= 5,592 Pounds/Well (92 Wells) ÷ 2000 Pounds/Ton	=	257
Surface and Subsurface Equipment	= 12.75 Tons/Well (92 Wells)	=	1,173
Flow Line for Oil Well	= 5.00 Tons/Well (92 Wells)	=	460
Casing and Tubing	= 250 Tons/Well (92 Wells)	=	23,000
Drilling Rig Equipment	= 31 Tons/Well (92 Wells)	=	2,852
Platform Requirements	= 7,200 Tons/Platform (2 Platforms)	=	14,400
Total			43,880

This same solution technique can be used for any geographic area and any particular controlled material by using the appropriate table entries and graphs.

TABLE 2-1

CONTROLLED MATERIALS REQUIREMENTS FACTORS
FOR A DEVELOPMENT WELL

Equipment by Area (With description of relationship to 1 well)	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	.1
ALASKA OFFSHORE								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	1.13	.39	-	-	-	-	-	1.52
Drill Collars per 1000 ft. (Tons)	.37	-	-	-	-	-	-	.37
Well Servicing Equipment per Well (Pounds)	2,810	2,471	100	28	100	80	3	5,592
Surface & Subsurface Equipment per Well (Tons)	9.04	3.20	.10	.12	.13	.09	.07	12.75
Flow Line Materials per Oil Well (Tons)	3.40	1.60	-	-	-	-	-	5.00
Flow Line Materials per Gas Well (Tons)	10.20	4.80	-	-	-	-	-	15.00
GULF COAST OFFSHORE								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	.42	.19	-	-	-	-	-	.61
Drill Collars per 1000 ft. (Tons)	.18	-	-	-	-	-	-	.18
Special Pipe per 1000 ft. (Tons)	.03	.01	-	-	-	-	-	.04
Well Servicing Equipment per Well (Pounds)	4,223	3,327	160	43	146	129	7	8,035
Surface & Subsurface Equipment per Well (Tons)	9.04	3.20	.10	.12	.13	.09	.07	12.75
Flow Line Materials per Oil Well (Tons)	3.00	2.00	-	-	-	-	-	5.00
Flow Line Materials per Gas Well (Tons)	9.00	6.00	-	-	-	-	-	15.00
WEST COAST OFFSHORE								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	.66	.01	-	-	-	-	-	.67
Drill Collars per 1000 ft. (Tons)	.18	-	-	-	-	-	-	.18
Well Servicing Equipment per Well (Pounds)	1,463	1,207	54	13	50	54	1	2,842
Surface & Subsurface Equipment per Well (Tons)	9.04	3.20	.10	.12	.13	.09	.07	12.75
Flow Line Materials per Oil Well (Tons)	3.40	1.60	-	-	-	-	-	5.00
Flow Line Materials per Gas Well (Tons)	10.20	4.80	-	-	-	-	-	15.00

NOTE: Well Servicing Materials Requirements are presented in pounds rather than tons because of the very critical requirement for some materials in quantities too small to express in tons.

TABLE 2-1 (CONTINUED)

CONTROLLED MATERIALS REQUIREMENTS FACTORS
FOR A DEVELOPMENT WELL

Equipment by Area (With description of relationship to 1 well)	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
GULF COAST ONSHORE								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	.34	.16	-	-	-	-	-	.50
Drill Collars per 1000 ft. (Tons)	.17	-	-	-	-	-	-	.17
Special Pipe per 1000 ft. (Tons)	.04	.01	-	-	-	-	-	.05
Well Servicing Equipment per Well (Pounds)	1,501	1,220	56	15	51	45	2	2,890
Surface & Subsurface Equipment per Well (Tons)	9.04	3.20	.10	.12	.13	.09	.07	12.75
Flow Line Materials per Oil Well (Tons)	3.00	2.00	-	-	-	-	-	5.00
Flow Line Materials per Gas Well (Tons)	9.00	6.00	-	-	-	-	-	15.00
INLAND UNITED STATES								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	.29	.06	-	-	-	-	-	.35
Drill Collars per 1000 ft. (Tons)	.08	-	-	-	-	-	-	.08
Well Servicing Equipment per Well (Pounds)	604	504	22	5	21	18	-	1,174
Surface & Subsurface Equipment per Well (Tons)	9.04	3.20	.10	.12	.13	.09	.07	12.75
Flow Line Materials per Oil Well (Tons)	4.10	.90	-	-	-	-	-	5.00
Flow Line Materials per Gas Well (Tons)	12.30	2.70	-	-	-	-	-	15.00
WEST TEXAS DEEP								
Drill Pipe & Tool Joints per 1000 ft. (Tons)	7.80	4.20	-	-	-	-	-	12.00
Drill Collars per 1000 ft. (Tons)	2.00	-	-	-	-	-	-	2.00
Well Servicing Equipment per Well (Pounds)	3,714	3,165	131	33	130	106	4	7,283
Surface & Subsurface Equipment per Well (Tons)	9.04	3.20	.10	.12	.13	.09	.07	12.75
Flow Line Materials per Oil Well (Tons)	7.00	3.00	-	-	-	-	-	10.00
Flow Line Materials per Gas Well (Tons)	24.50	10.50	-	-	-	-	-	35.00

NOTE: Well Servicing Materials Requirements are presented in pounds rather than tons because of the very critical requirement for some materials in quantities too small to express in tons.

FIGURE 20

CASING AND TUBING MATERIALS REQUIREMENTS – DEVELOPMENT WELL

ALASKA OFFSHORE

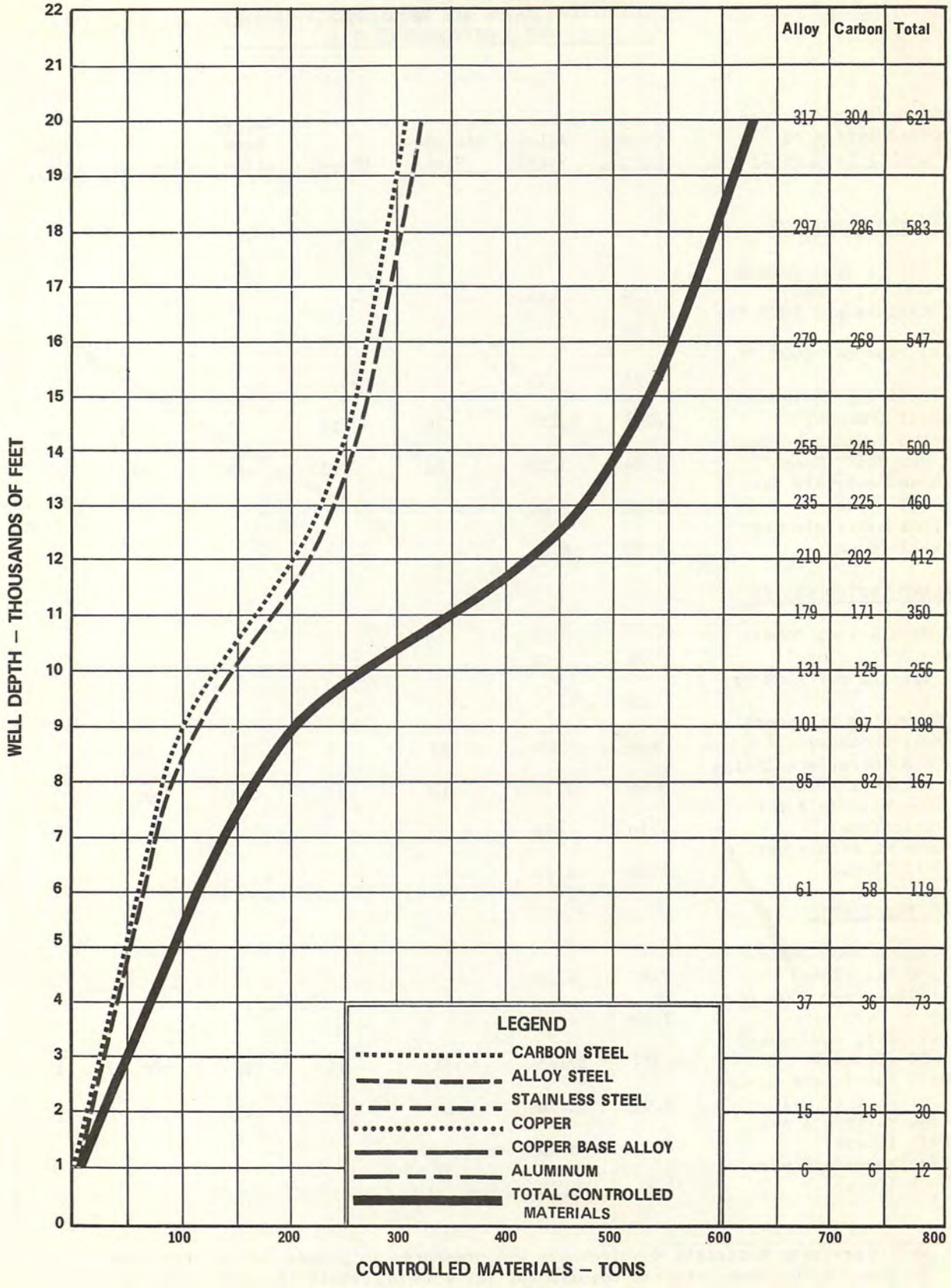


FIGURE 21

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

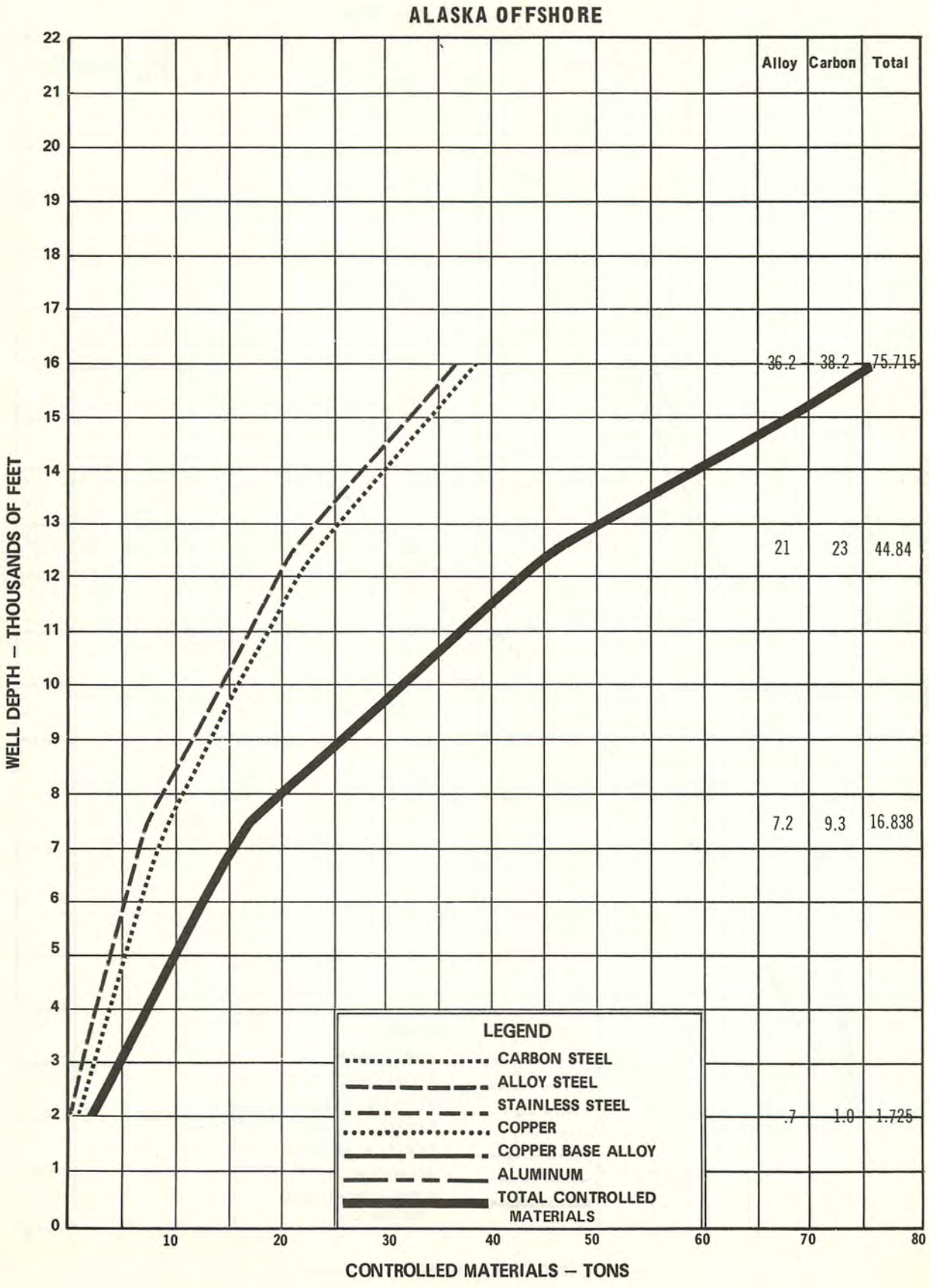


FIGURE 22

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

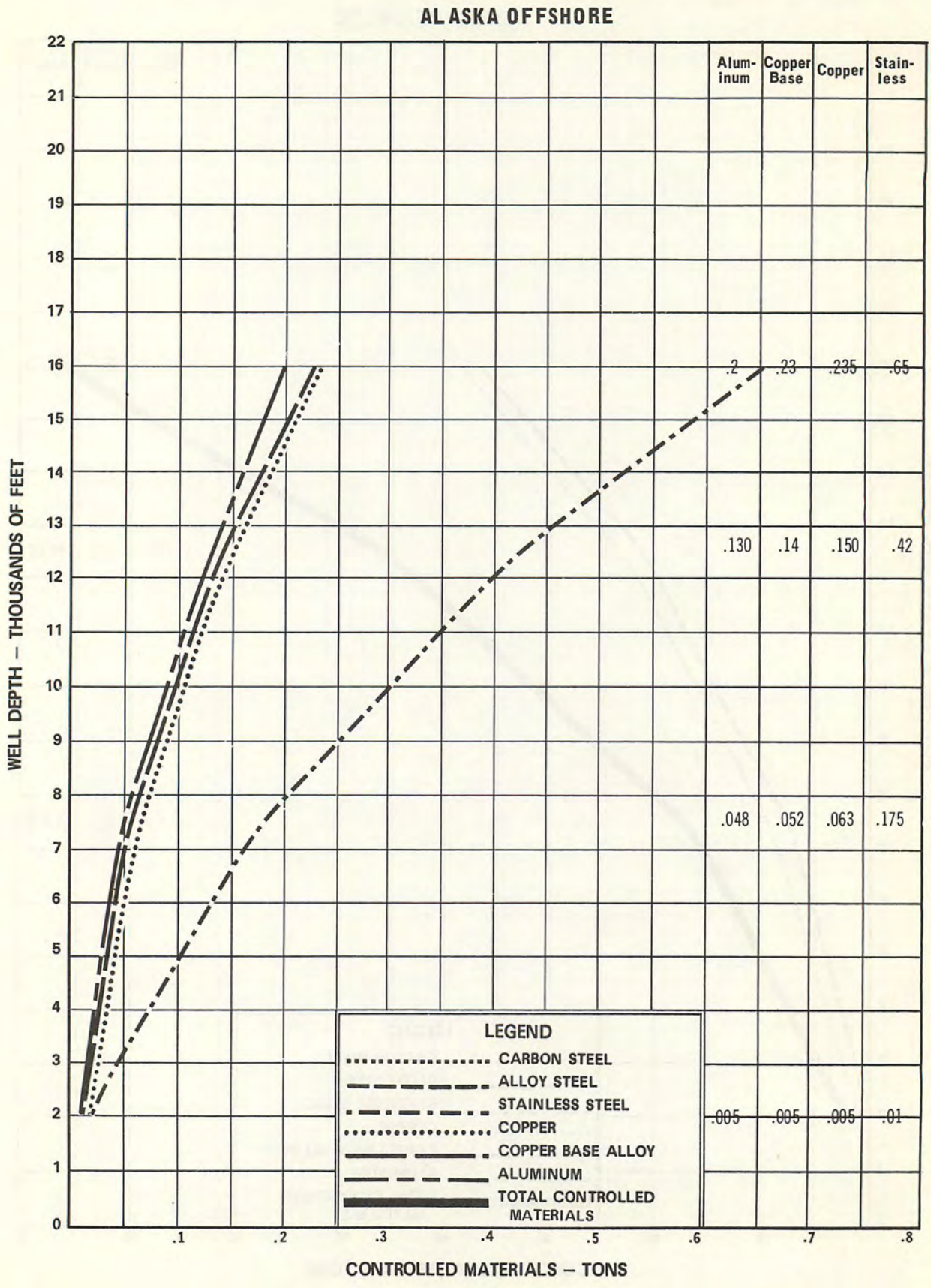


FIGURE 23

CASING AND TUBING MATERIALS REQUIREMENTS – DEVELOPMENT WELL

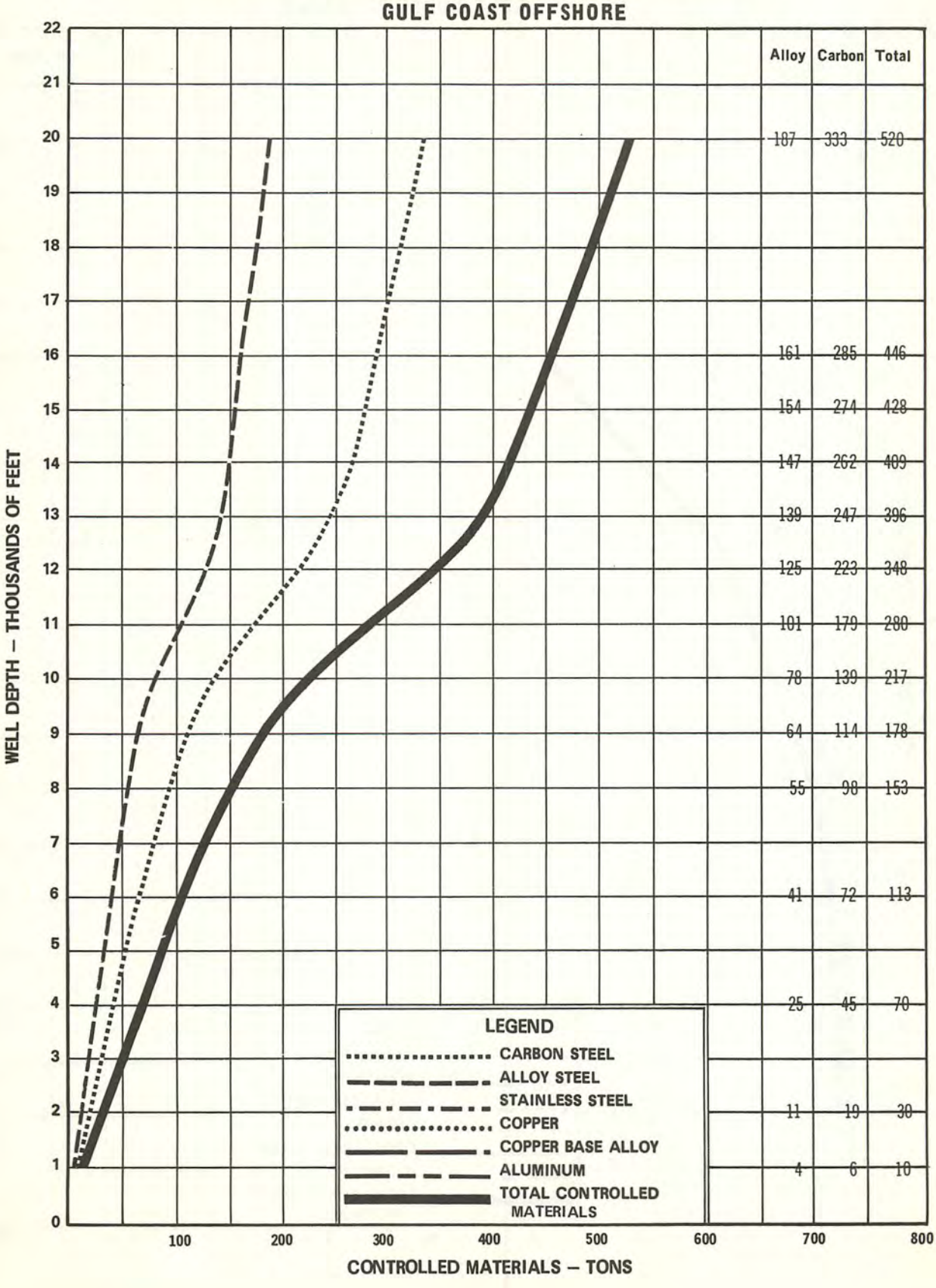


FIGURE 24

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

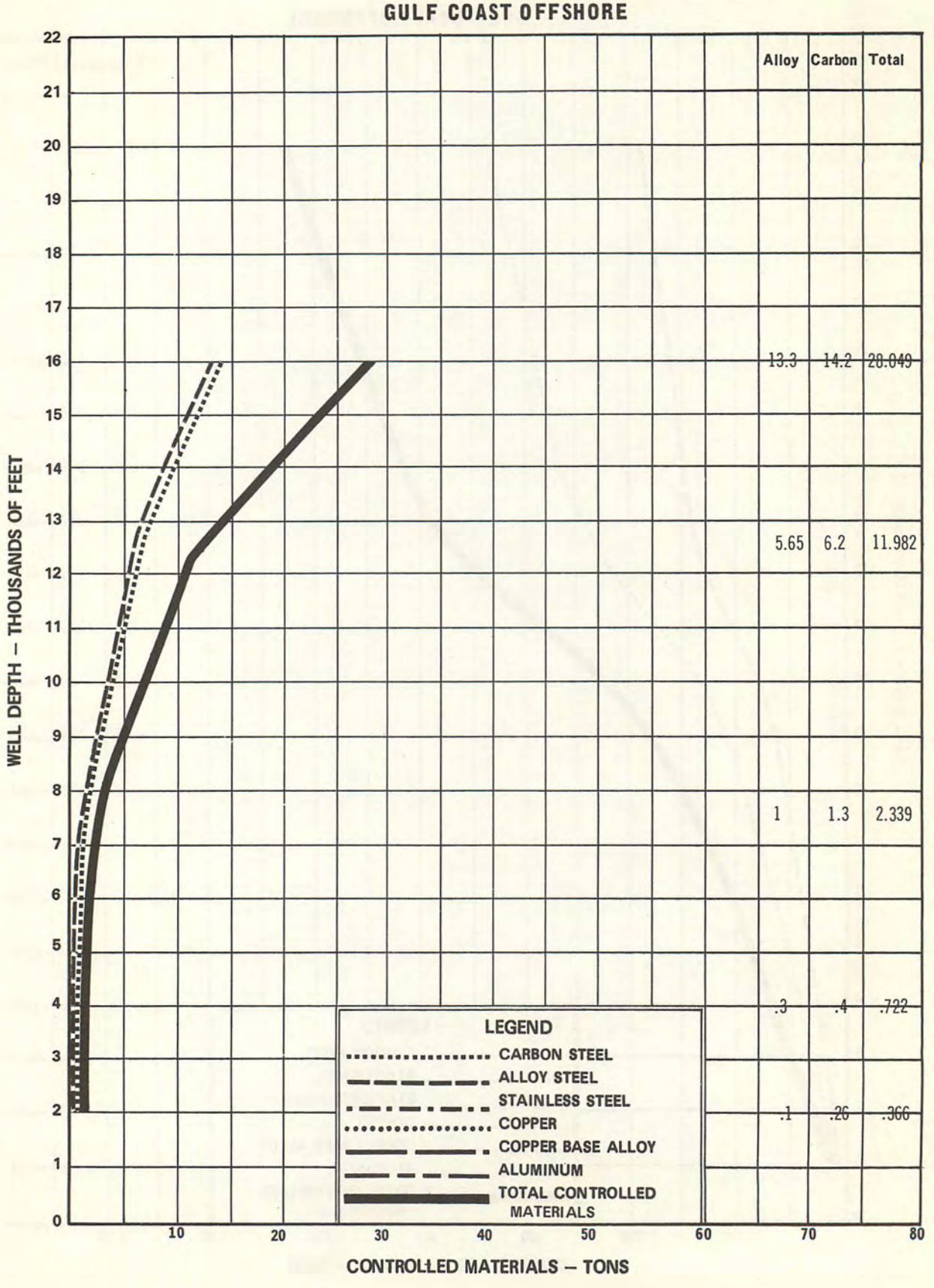


FIGURE 25

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

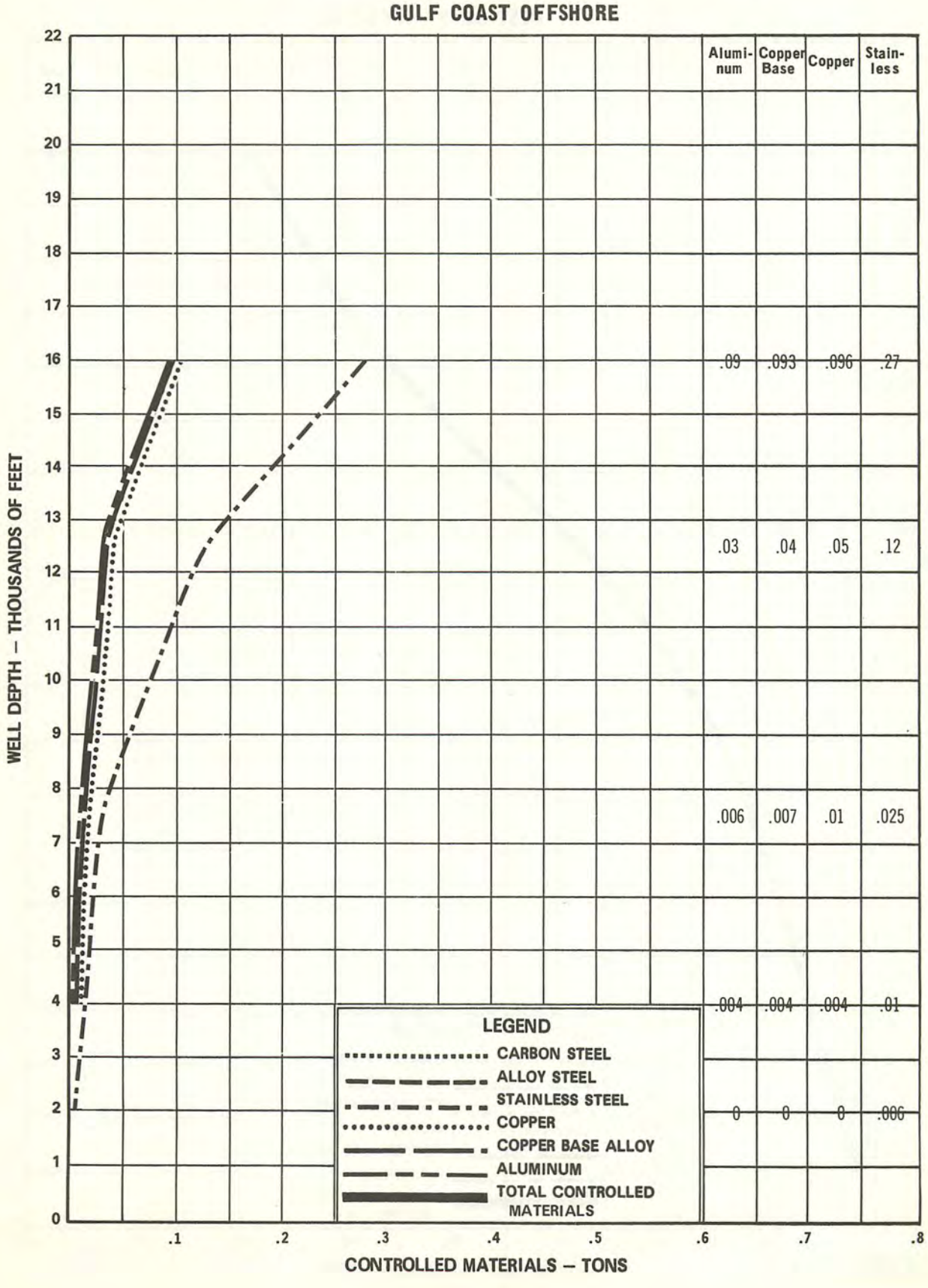


FIGURE 26

CASING AND TUBING MATERIALS REQUIREMENTS – DEVELOPMENT WELL

WEST COAST OFFSHORE

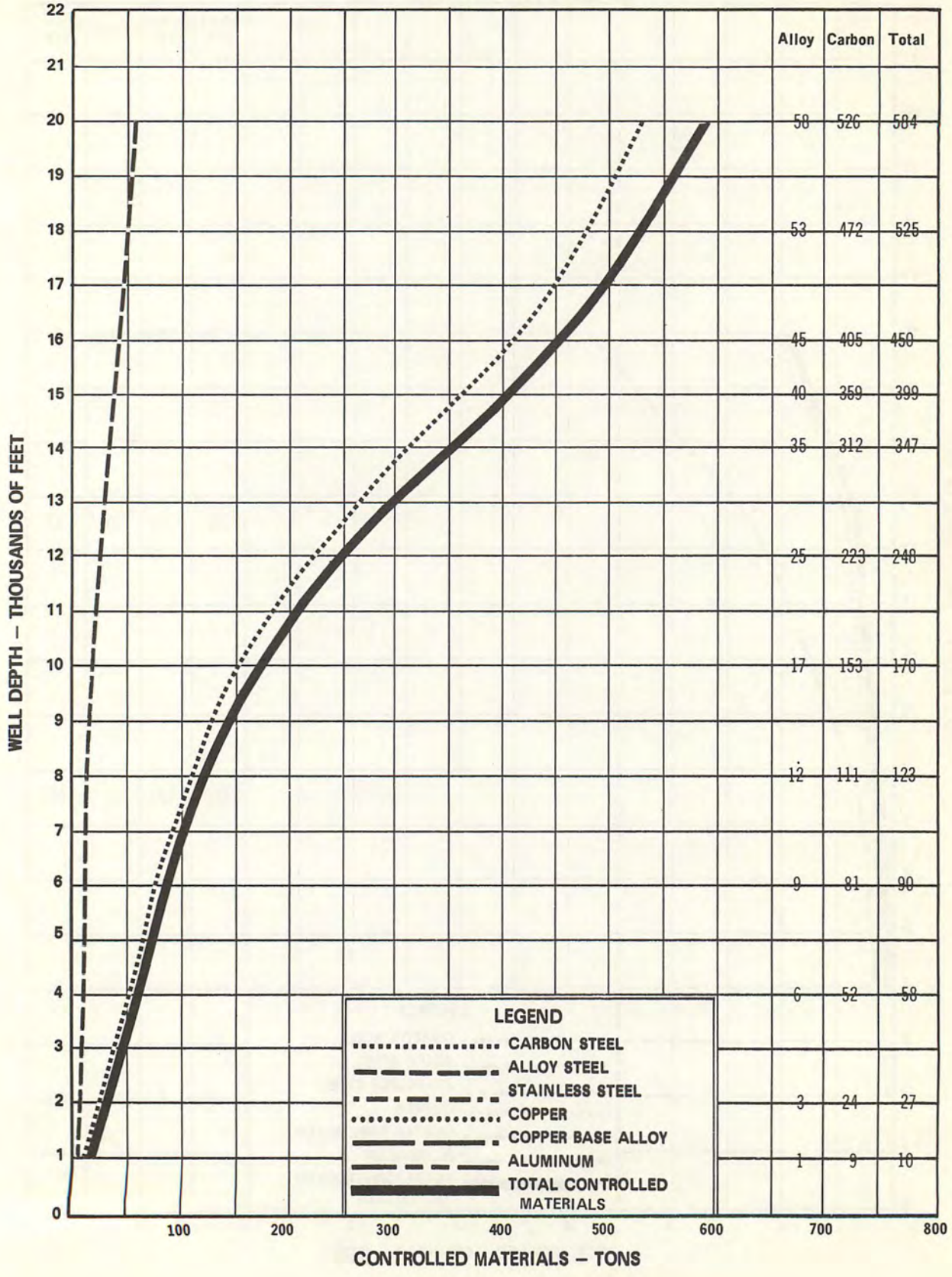


FIGURE 27

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

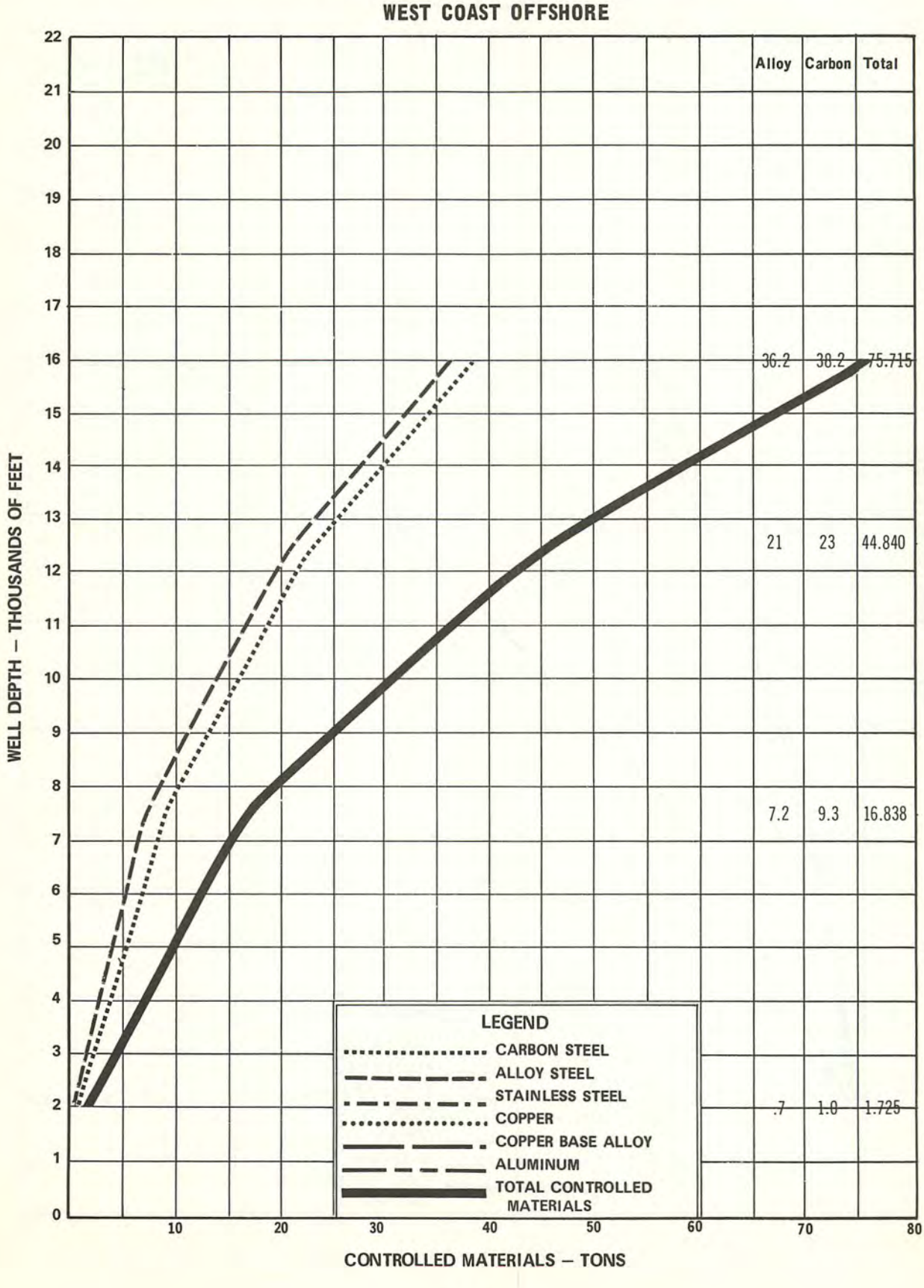


FIGURE 28

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

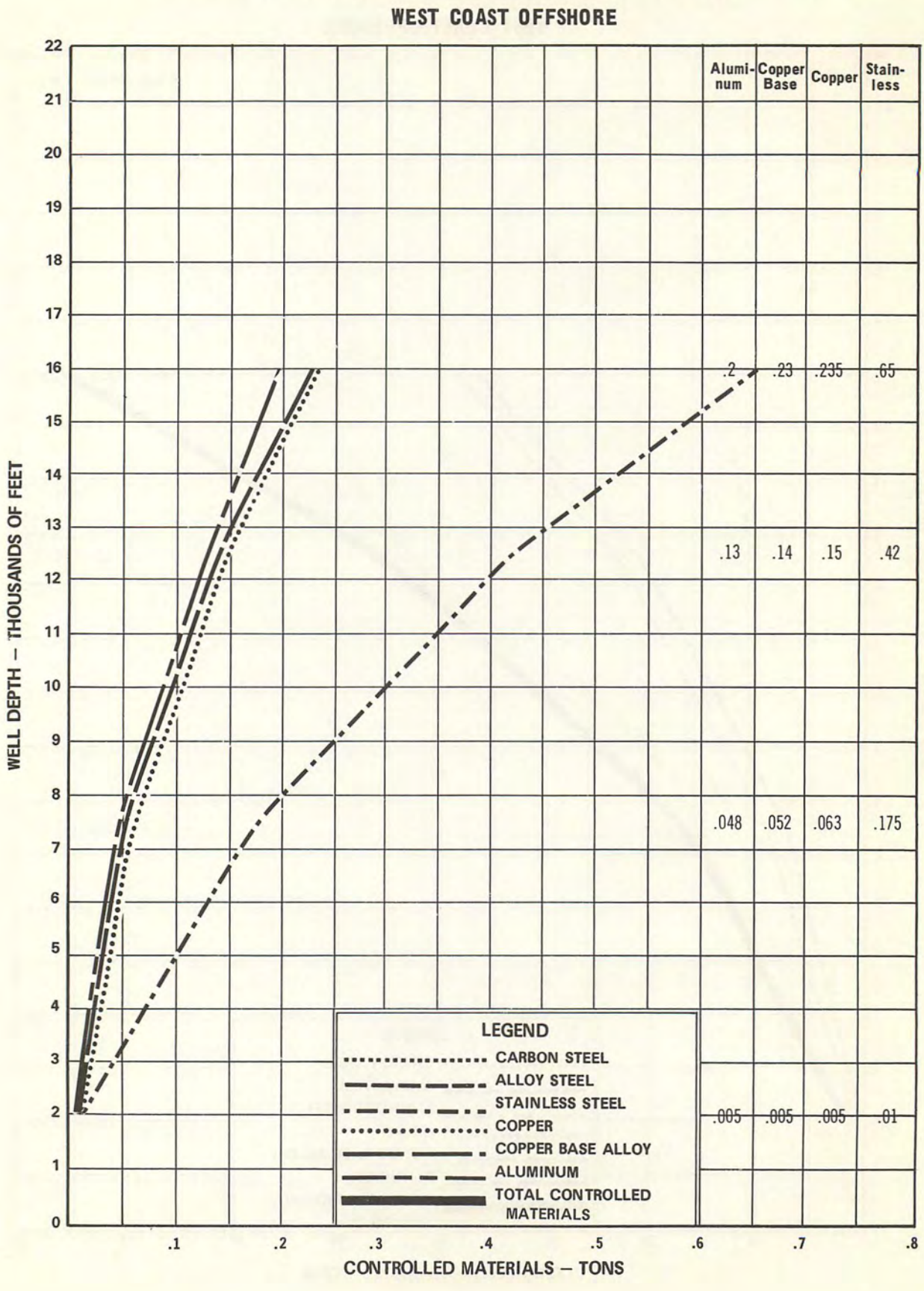


FIGURE 29

CASING AND TUBING MATERIALS REQUIREMENTS – DEVELOPMENT WELL

GULF COAST ONSHORE

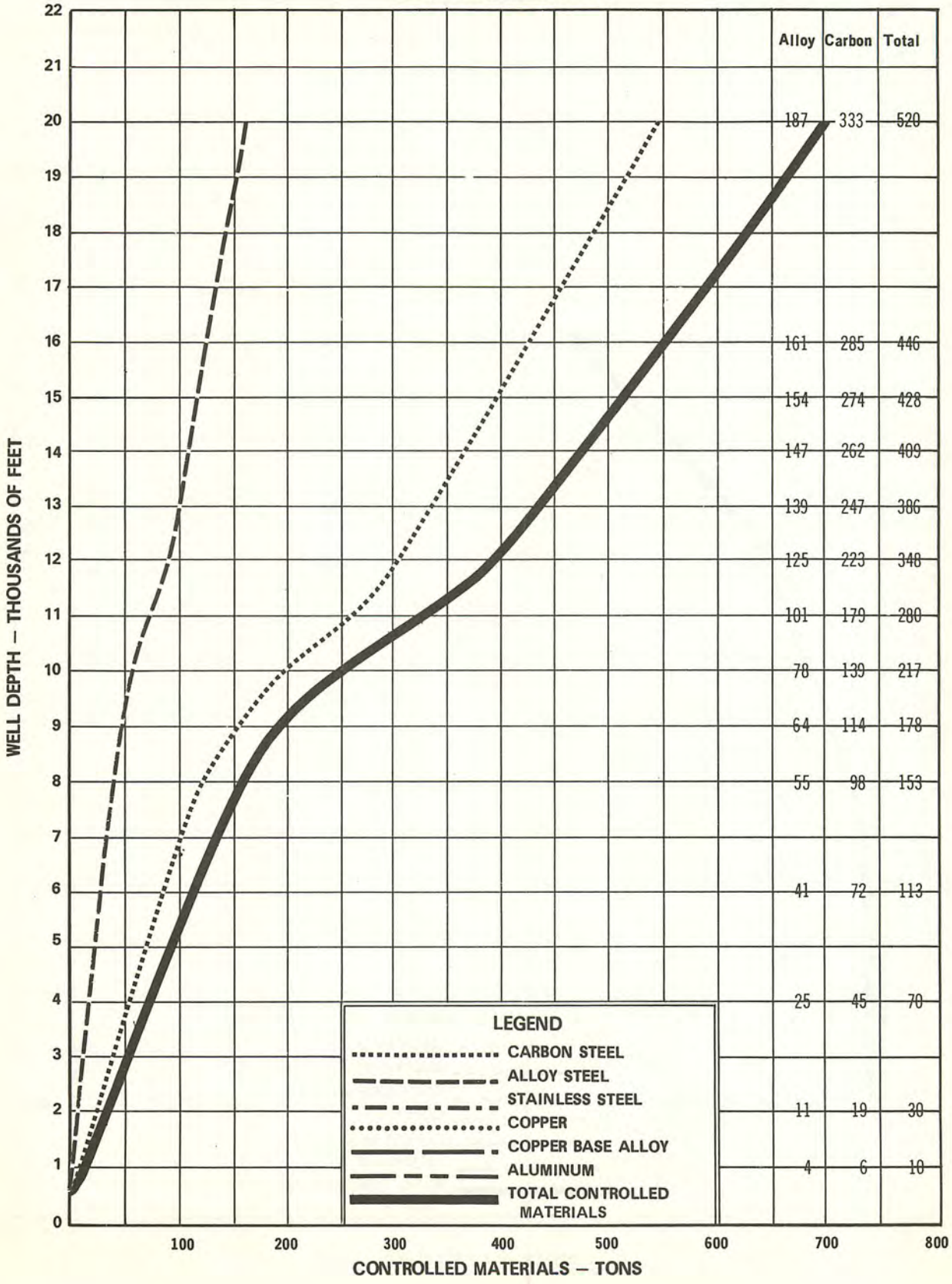


FIGURE 30

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

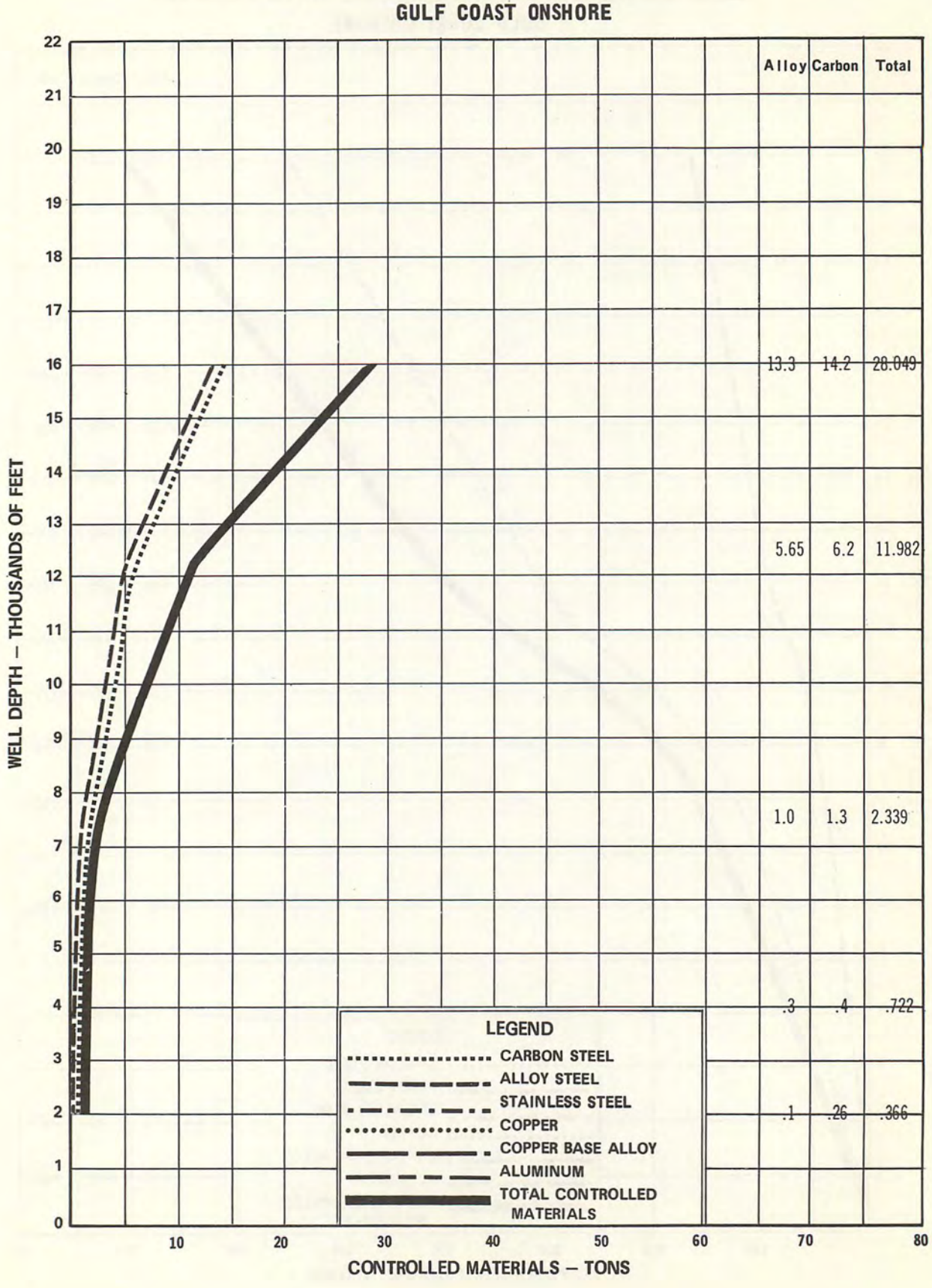


FIGURE 31

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

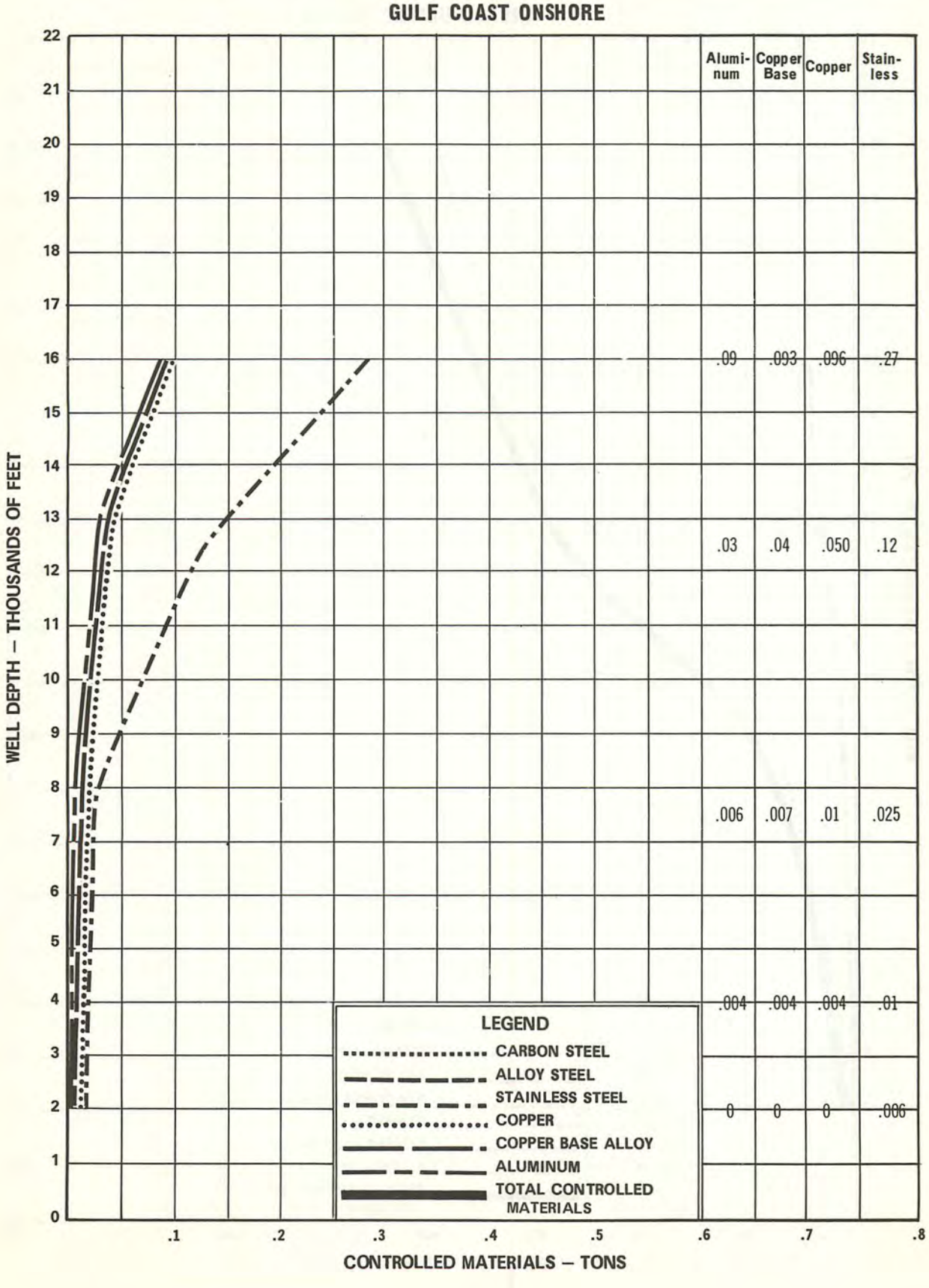


FIGURE 32

CASING AND TUBING MATERIALS REQUIREMENTS – DEVELOPMENT WELL

INLAND UNITED STATES

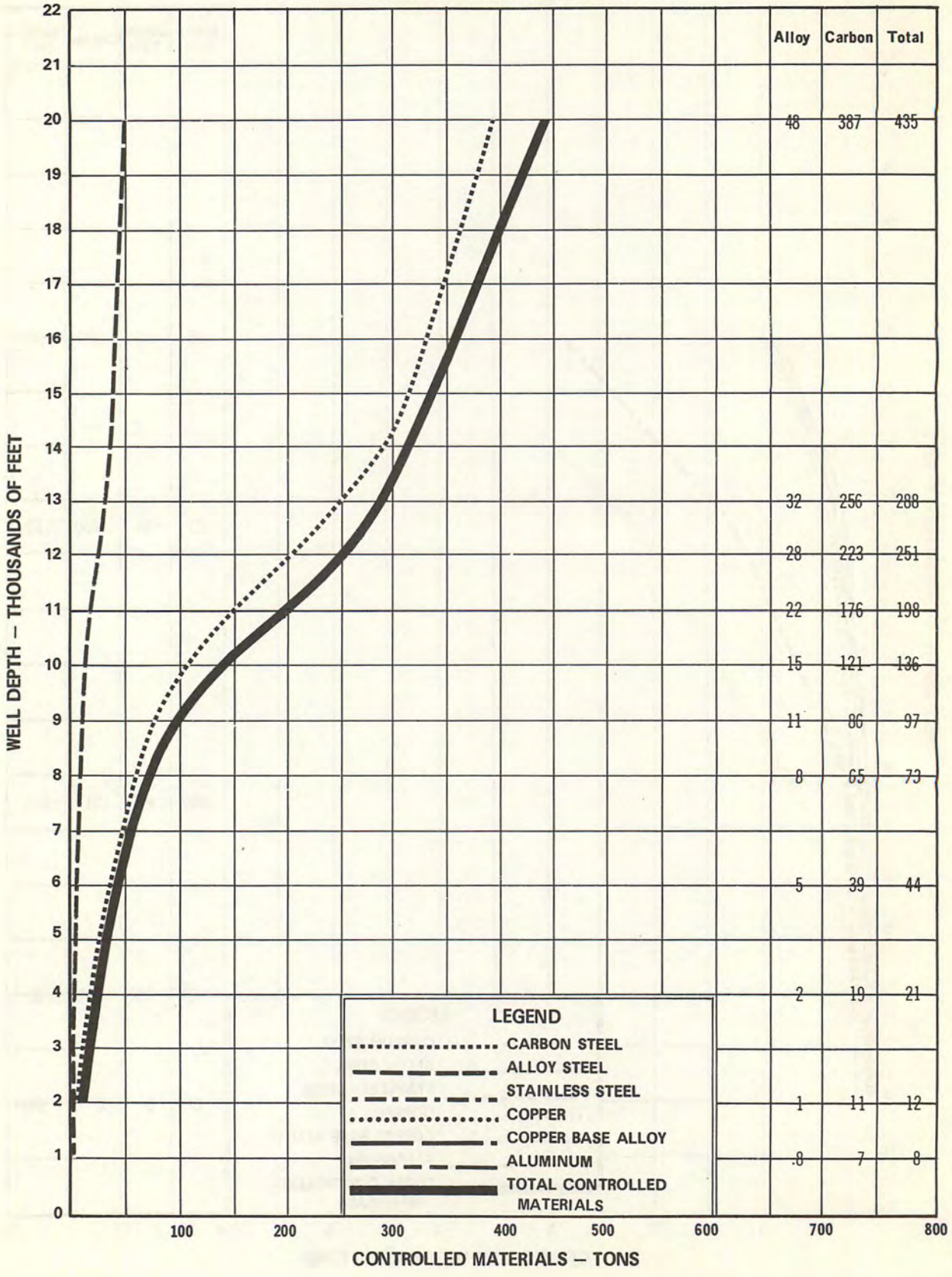


FIGURE 33

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

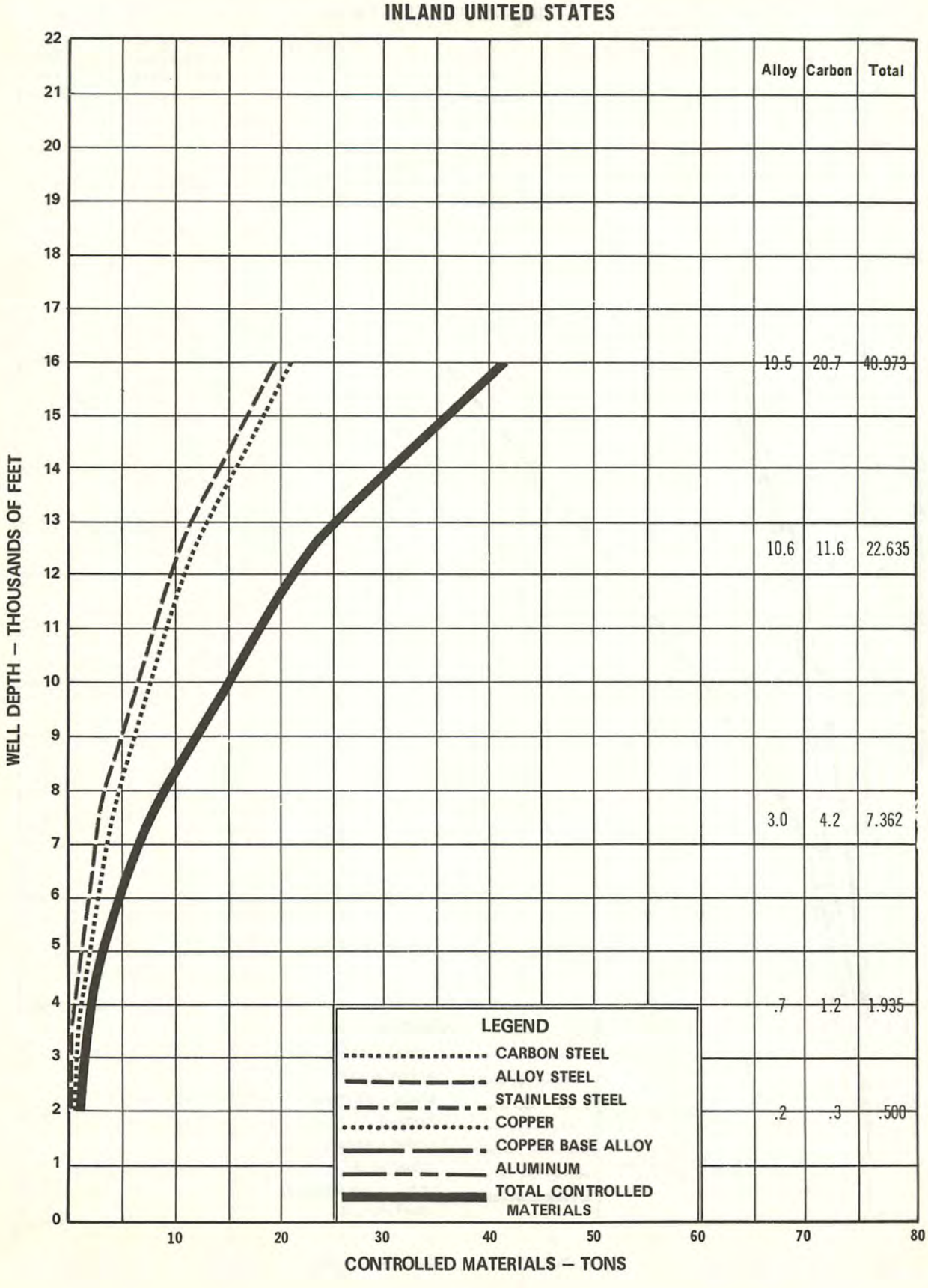


FIGURE 34

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

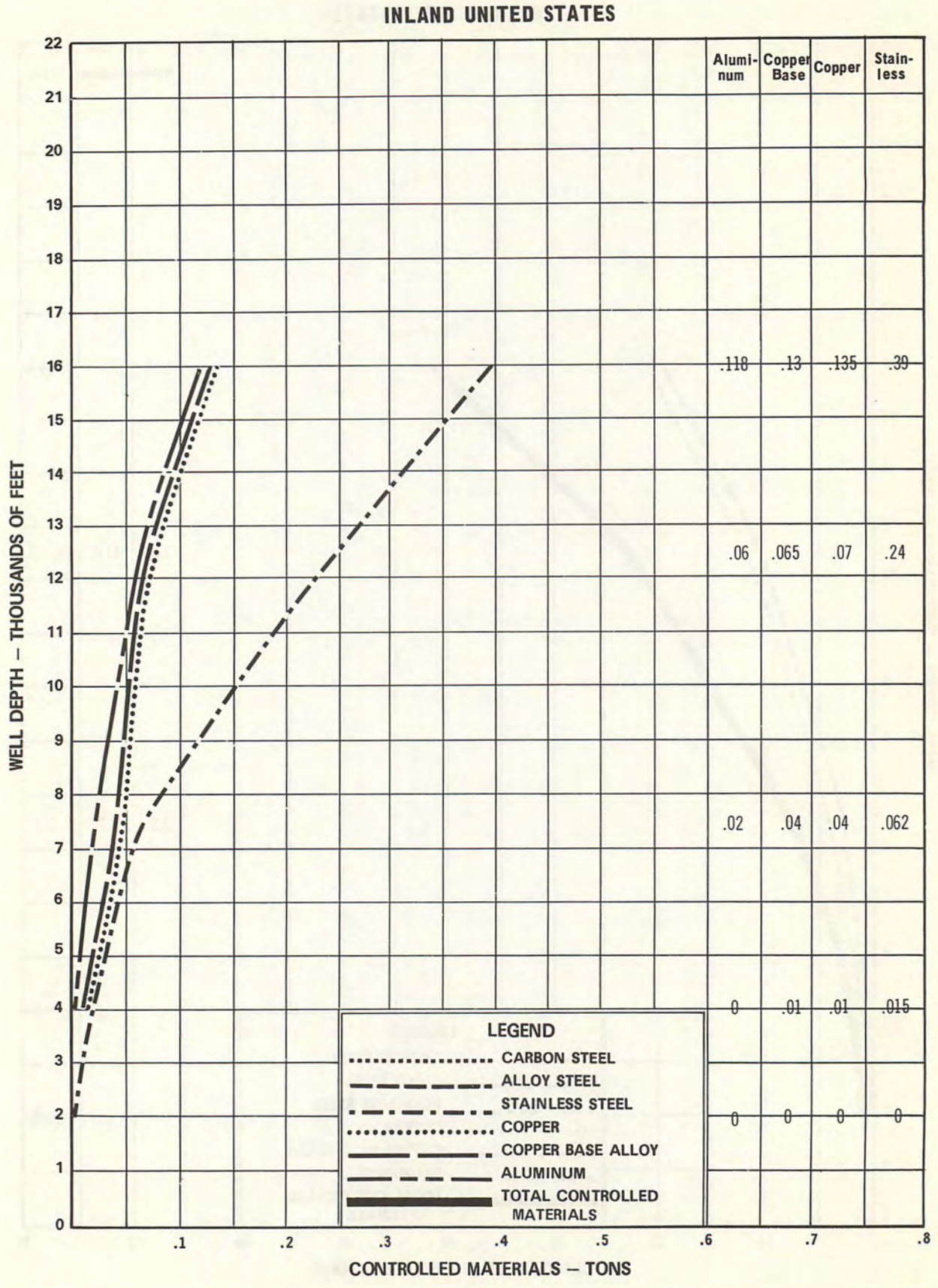


FIGURE 35

CASING AND TUBING MATERIALS REQUIREMENTS – DEVELOPMENT WELL

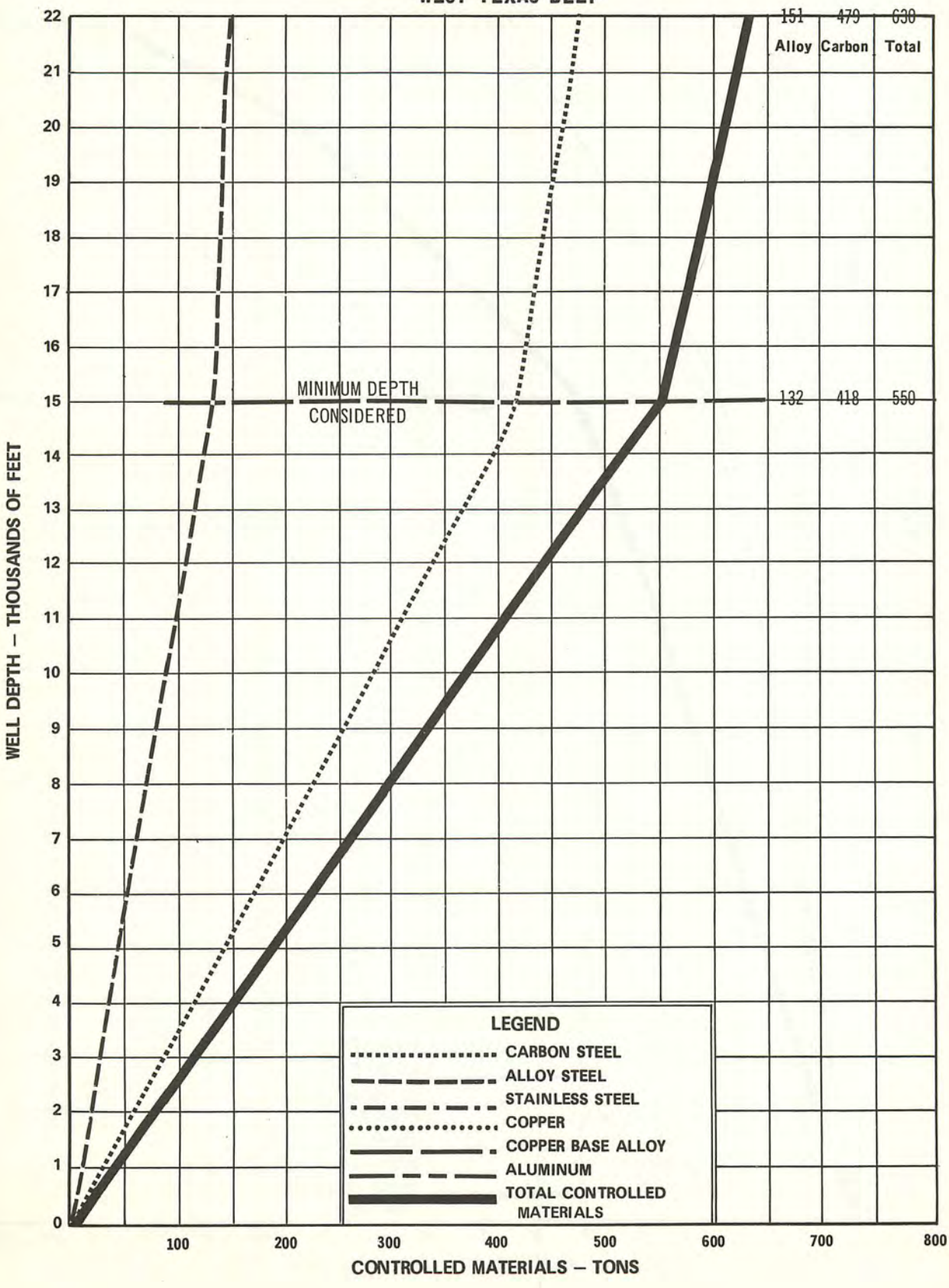


FIGURE 36

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL

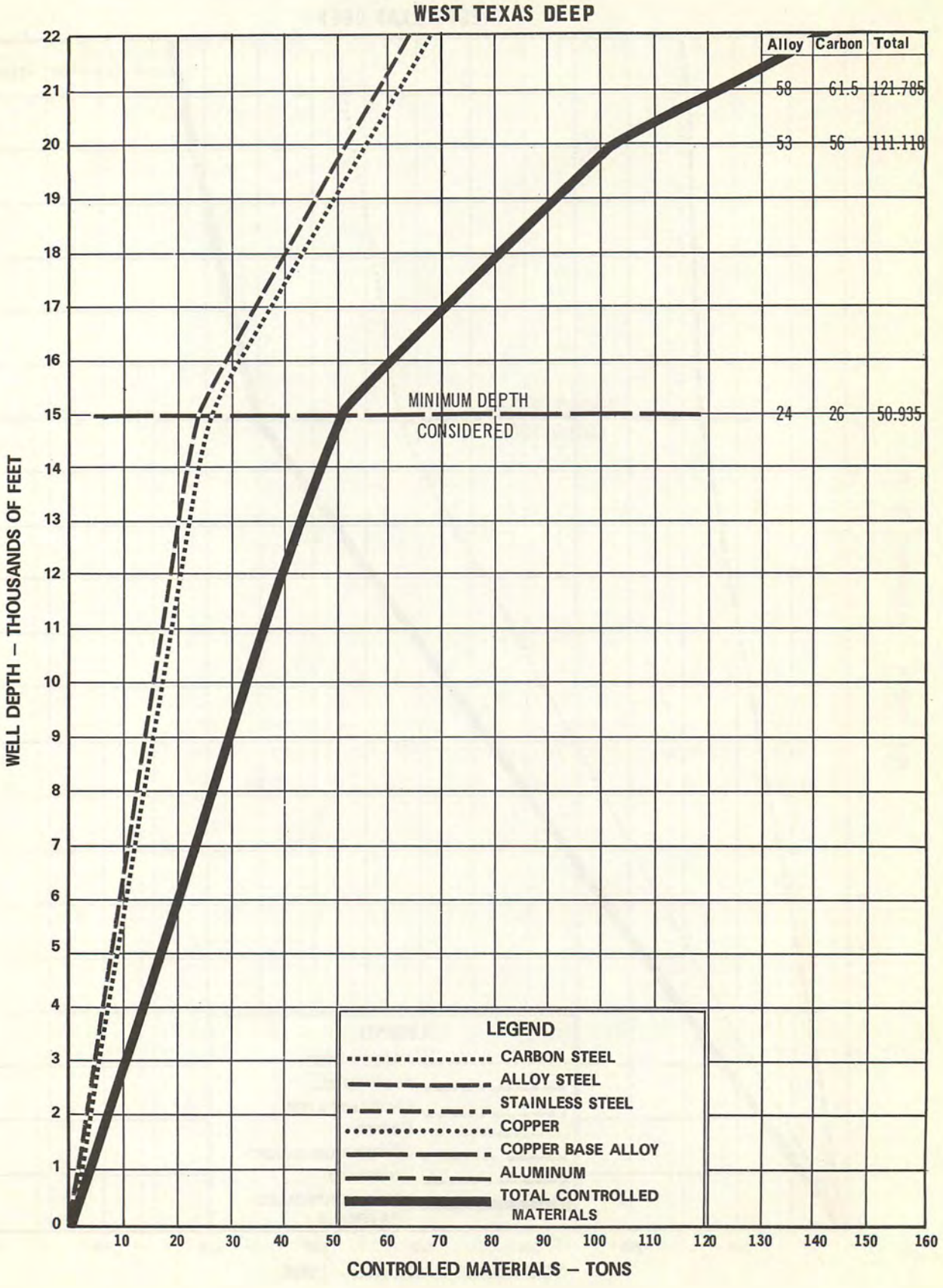
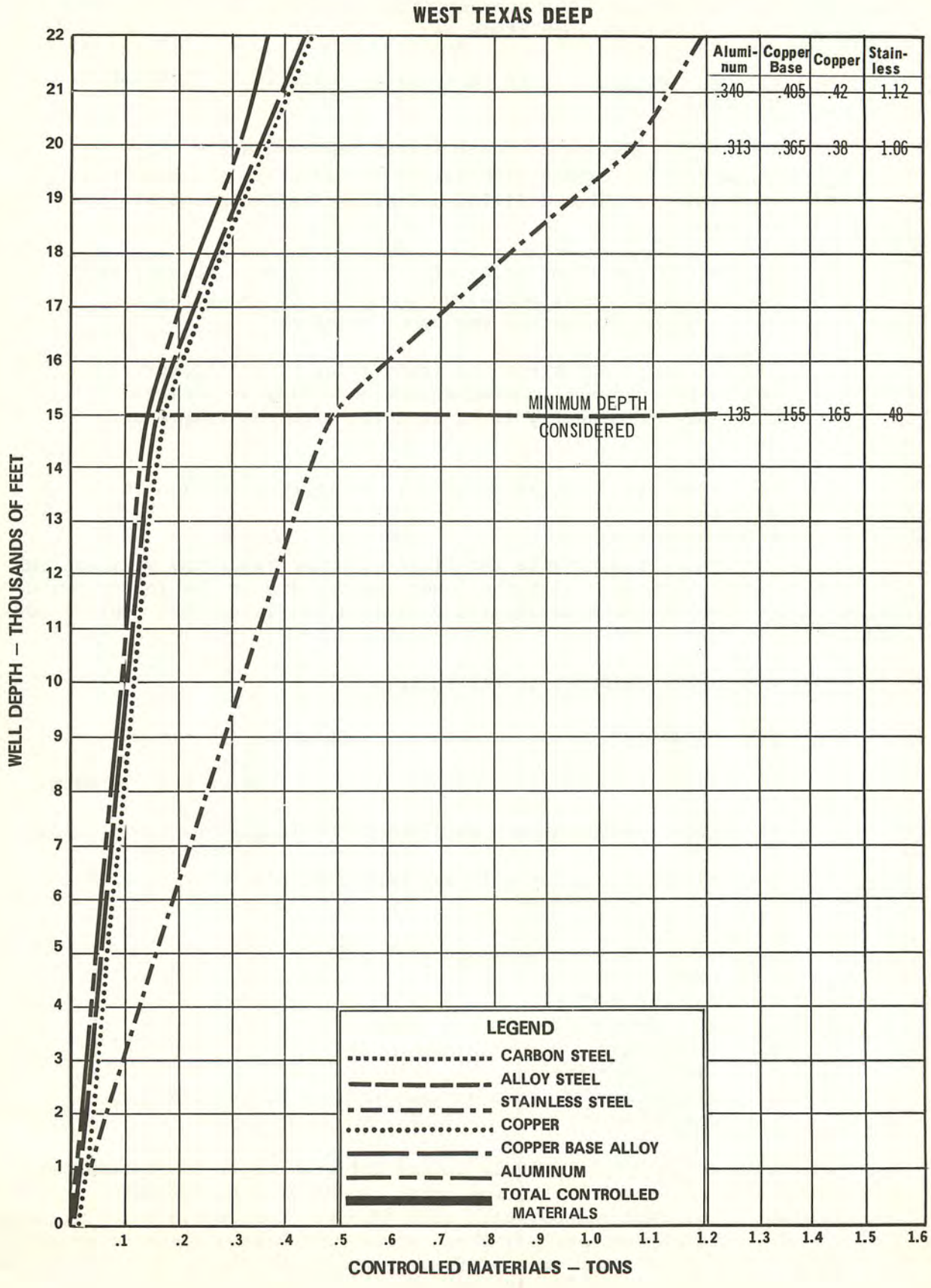


FIGURE 37

CONTROLLED MATERIALS REQUIREMENTS FOR DRILLING EQUIPMENT – DEVELOPMENT WELL



Fixed Offshore Platforms

A Fixed Offshore Platform is defined as a structure, secured to the sea bed by means of piling, which is used to support drilling and producing equipment and facilities. The components or parts which make up a Fixed Offshore Platform include such items as:

1. Piling - which are used to transfer loads to the foundation material.

2. Jacket or caissons or tower (including bracing) - which is fixed to the sea bed with piling and supports the superstructure on which drilling and producing equipment is located.

3. Superstructure (consisting of trusses, girders, beams, deck and integral compartments) on which can be installed the drilling and production equipment required.

4. Miscellaneous appurtenances (consisting of helicopter pad, walkways, ladders, landing stages and integral piping) - which are permanently fixed or built into the component parts.

5. Conductor pipe - which is used to provide protection for well casing.

Materials requirements for Fixed Offshore Platforms vary not only with water depth, but also with the loads imposed and/or the loads that may be imposed. Some of the more important factors and loads that must be considered are:

1. Foundation material at the location.

2. Wave heights.

3. Drilling equipment and supplies to be located on the platform.

4. Production equipment and supplies to be located on the platform.

5. Derrick loads imposed with set back pipe plus hook load.

6. Environmental loads caused by

   a. wave forces
   b. current forces
   c. wind forces
   d. ice forces
   e. earthquake forces
   f. miscellaneous, such as aquatic growth, erosion, and corrosion.

With design criteria varying widely in and for each major U. S. offshore producing area, no single estimating curve can be used to determine materials requirements. For this reason, each area (Alaska, California and Gulf Coast) is handled separately and each of these areas will have a range of materials required. These reasonable ranges of materials requirements for each of the areas are shown in FIGURES 38, 39, and 40.

FIGURE 38

CONTROLLED MATERIALS REQUIREMENTS FOR FIXED OFFSHORE PLATFORMS

ALASKA – COOK INLET

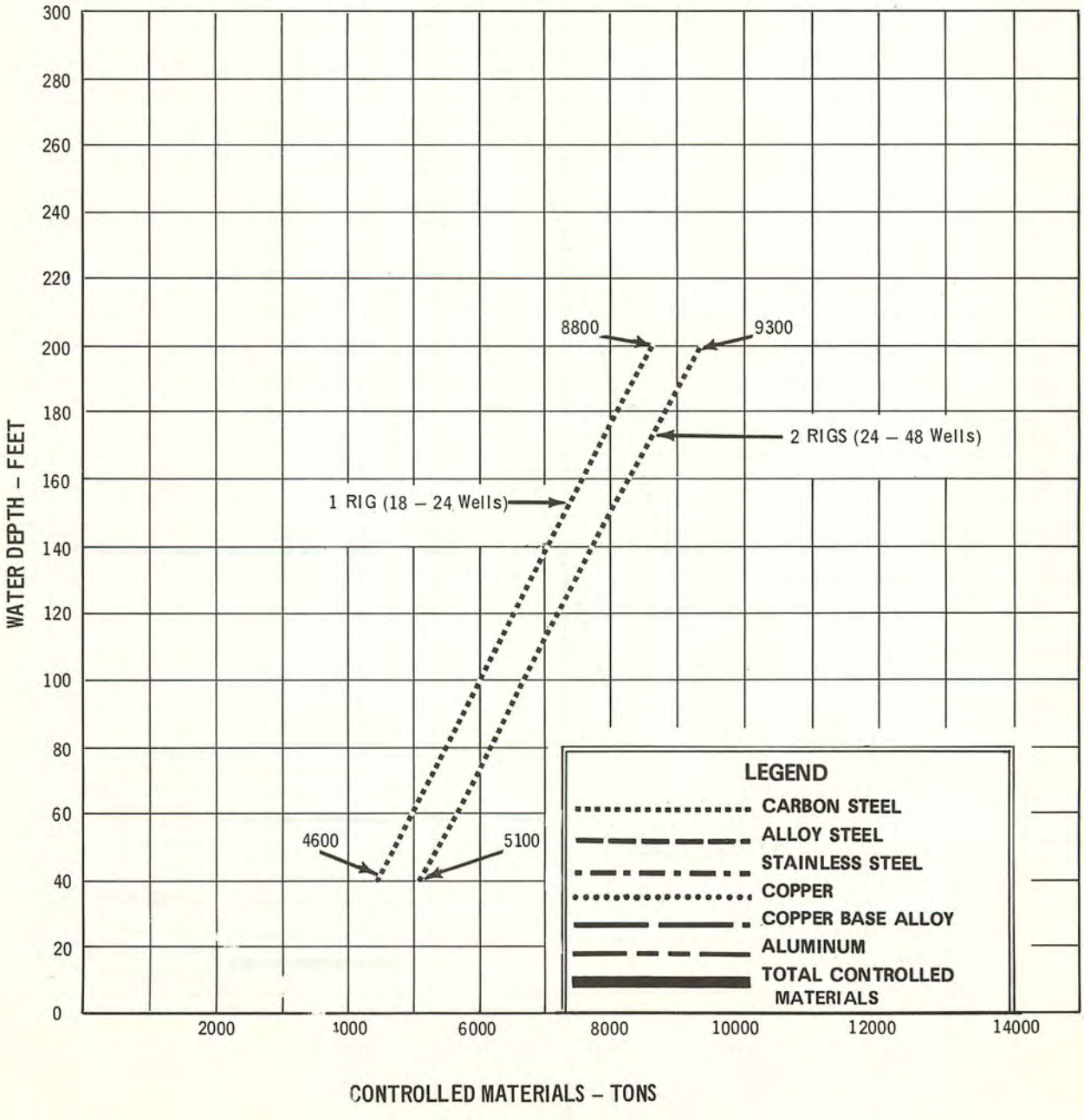


FIGURE 39

CONTROLLED MATERIALS REQUIREMENTS FOR FIXED OFFSHORE PLATFORMS

CALIFORNIA – SOUTH OF POINT CONCEPTION

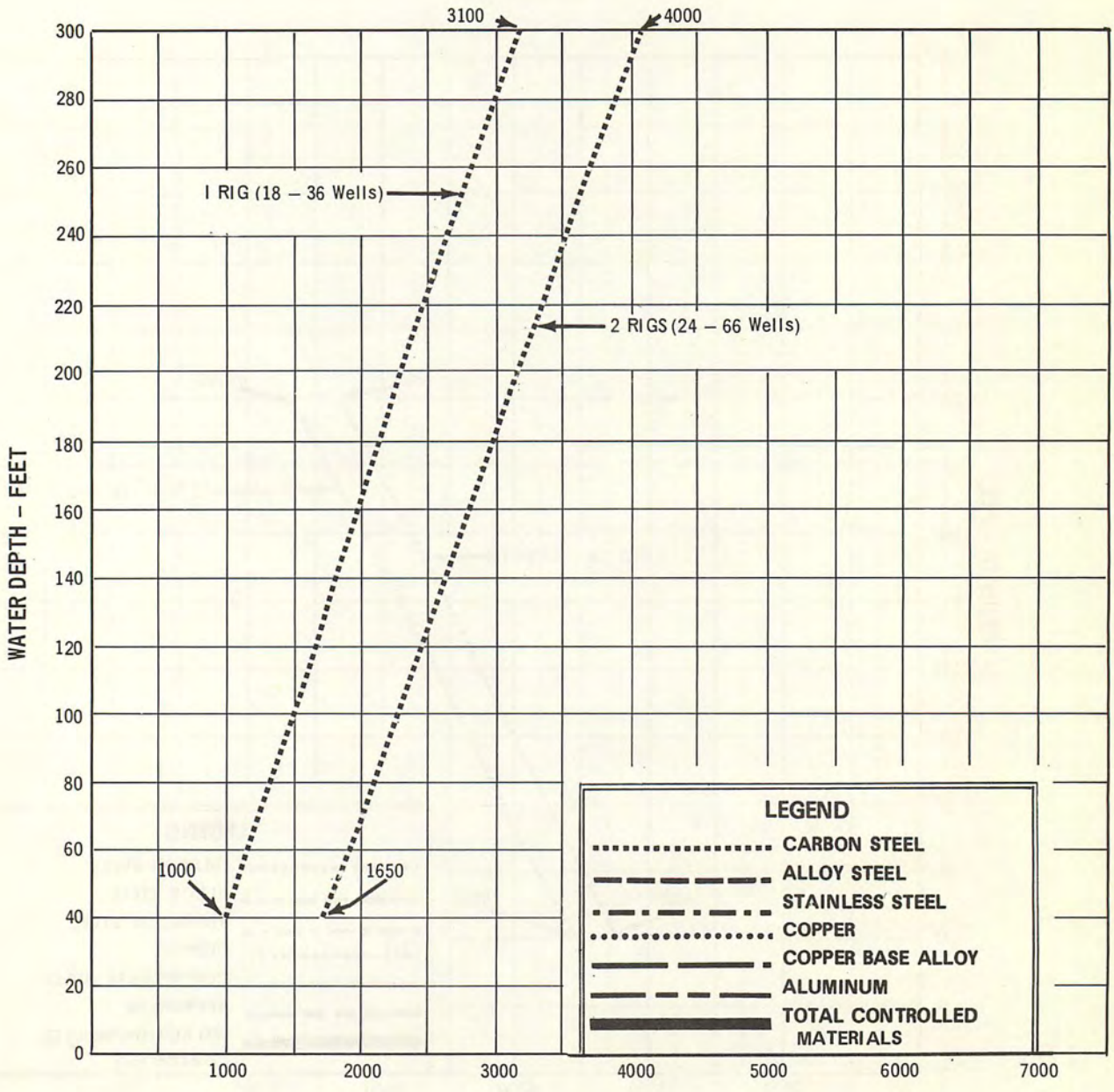
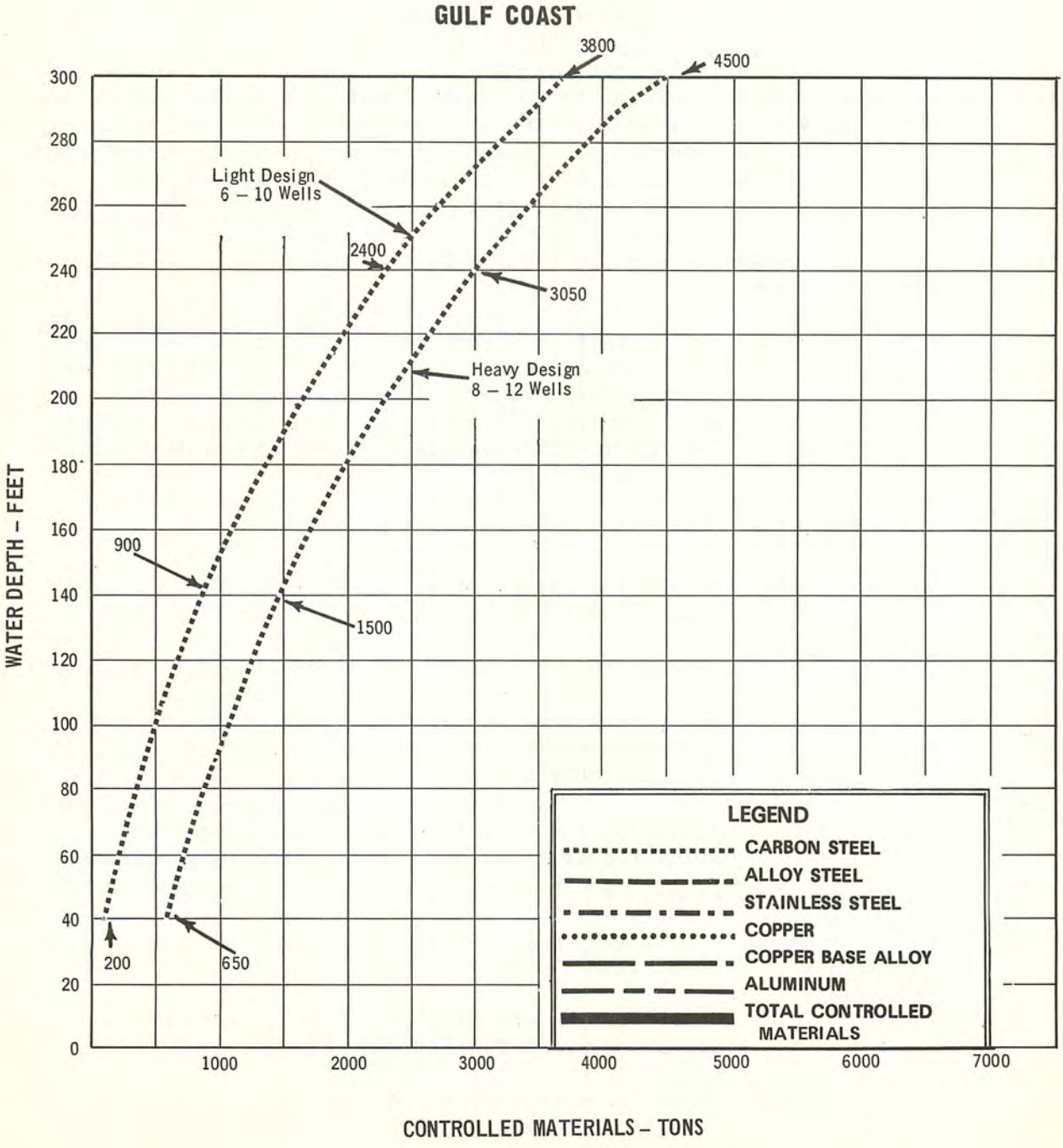


FIGURE 40

CONTROLLED MATERIALS REQUIREMENTS FOR FIXED OFFSHORE PLATFORMS



Gas Processing Plant Materials Requirements

Gas processing plant materials requirements are presented separately from development well requirements for the sake of simplicity. It should, however, be noted that although gas processing plants are not directly relatable to development wells, they are a necessary part of developing gas reserves.

Materials requirement guidelines have been developed for use in estimating materials required to build each of the various plant types. These tools consist of a description of the plant and equipment considered, followed by one or more graphs relating materials tonnages to plant inlet capacity for each plant type. Although design conditions will cause some variance in individual materials requirements for one plant, the over-all total tonnage for an individual plant and the specific materials for a large number of plants can be approximated reasonably.

Product storage requirements are not included in the above-mentioned graphs since they are related to the daily liquid production rather than inlet gas volumes. Storage requirements vary greatly, depending upon proximity to product pipeline, underground storage, terminal facilities, and sales outlet. A supplemental graph, FIGURE 49, has been included for estimating the materials requirements for product storage

An example of how the various predictive information can be used is presented below:

Problem: What weight of carbon steel, copper, copper base alloy, aluminum, nickel alloy, stainless steel, and alloy steel will be required to build four refrigerated absorption plants each capable of processing 200 MMSCFD of inlet gas and storing 100,000 gallons of product?

Solution:

1. Obtain the plant carbon steel requirements for one plant from FIGURE 42.

2. Obtain the per cent of the plant carbon steel requirements that is composed of copper and copper base alloy from the tabulation of percentages presented with the descriptive comments immediately preceding FIGURE 42.

3. Determine the weight of copper and copper base alloy required for one plant by multiplying items 1 and 2 above together.

4. Obtain the weight of aluminum required for one plant from FIGURE 43.

5. Obtain the weight of nickel alloy, stainless steel, and alloy steel from FIGURE 44.

6. Determine the carbon steel requirements for product storage for one plant from FIGURE 49.

7. Multiply the results from items 1, 3, 4, 5, and 6 by the number of plants to determine the total controlled materials.

Controlled Materials (Plant)				Weight (Tons)
Carbon Steel	=	2,400 Tons/Plant (4 Plants)	=	9,600
Copper	=	.028 (2,400 Tons/Plant) (4 Plants)	=	269
Copper Base Alloy	=	.024 (2,400 Tons/Plant) (4 Plants)	=	230
Aluminum	=	31.5 Tons/Plant (4 Plants)	=	126
Nickel Alloy	=	4 Tons/Plant (4 Plants)	=	16
Stainless Steel	=	8.2 Tons/Plant (4 Plants)	=	33
Alloy Steel	=	68 Tons/Plant (4 Plants)	=	272
Subtotal				10,546
(Storage)				
Carbon Steel	=	158 Tons/100,000 Gals. (4 Plants)	=	632
GRAND TOTAL				11,178

The total controlled materials also can be obtained from FIGURE 44. For a 200 MMSCFD inlet gas plant capacity, the total controlled materials equal 2,635 tons per plant or 10,540 tons for four plants.

This same solution technique can be applied to any of the materials and plant types by using the appropriate descriptive comments, percentages, and graphs or tables.

Refrigeration Plants

Refrigeration Plants are plants in which liquids are recovered from a natural gas stream by simple condensation. The cooling of the gas stream is accomplished with a conventional refrigeration system. The gas stream temperature is not reduced below -40° F. Normally, these plants do not handle large volumes of gas.

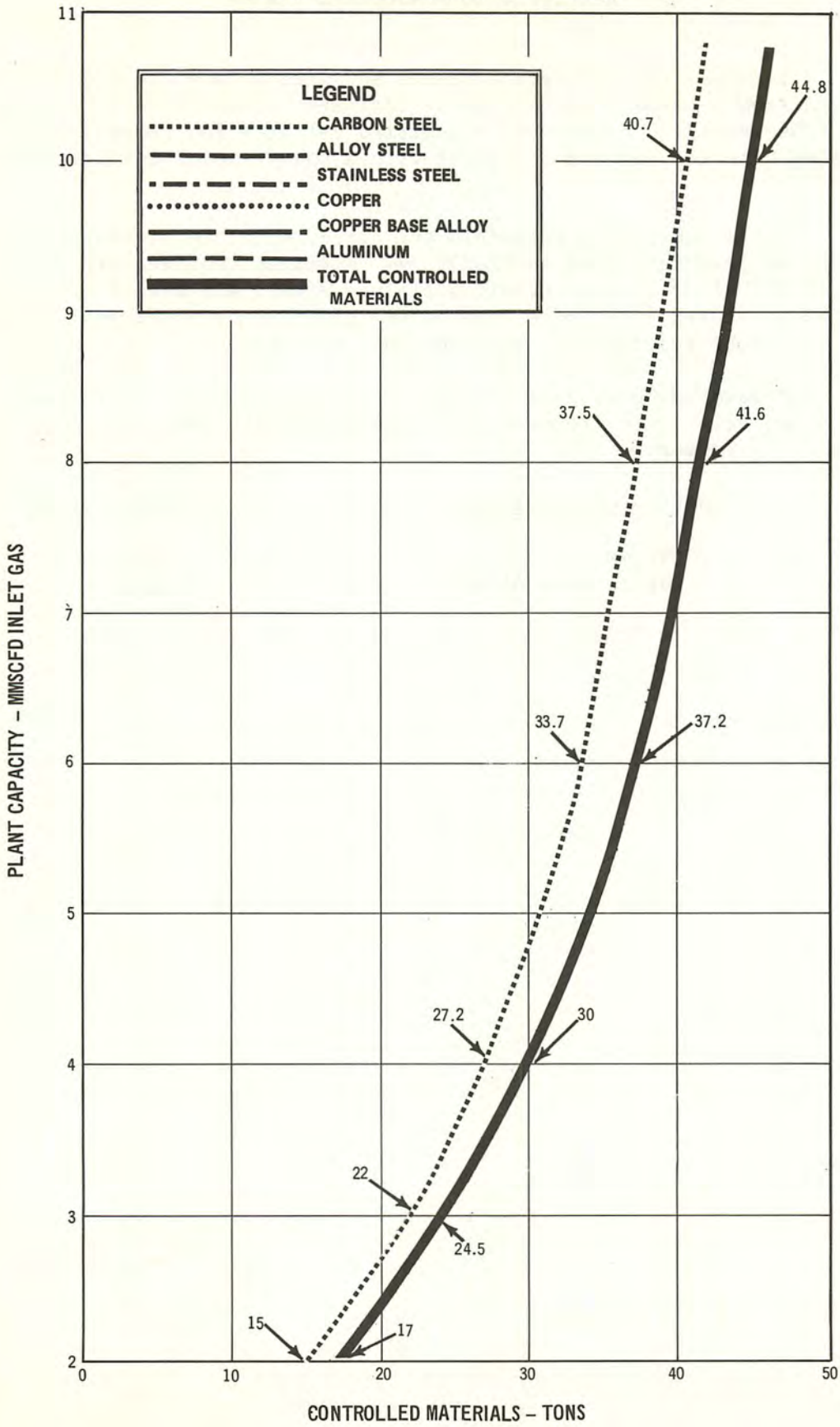
Total controlled materials and carbon steel requirements are presented in graphical form in FIGURE 41. This graph relates materials requirements to designed inlet gas capacity.

Presented below is a listing of the percentage factors related to carbon steel weight that will permit determination of the weights of the other controlled materials required to build a plant:

Controlled Materials	% of Carbon Steel
Alloy Steel	4.4
Stainless Steel	.4
Copper	2.2
Copper Base Alloy	1.6
Aluminum	2.2
Nickel Alloy	.2
Total	11.0%

FIGURE 41

MATERIALS REQUIREMENTS FOR STRAIGHT REFRIGERATION PLANTS



Refrigerated Absorption Plants

Refrigerated Absorption Plants are plants in which liquids are recovered from a natural gas stream by intimate contact with a suitable liquid (absorbent). The process is carried out at a low temperature caused by cooling both the gas and absorbent with a conventional refrigeration system.

Total controlled materials and carbon steel requirements are presented in graphical form in FIGURE 42. Aluminum requirements are presented in FIGURE 43. Alloy steel, stainless steel, and nickel alloy are presented in FIGURE 44. These figures are graphical representations relating materials weight requirements to inlet gas capacity.

Presented below is a listing of the factors, as a percentage of carbon steel weight requirements, for determining the remaining controlled materials requirements:

Controlled Materials	% of Carbon Steel
Copper	2.8
Copper Base Alloy	2.4
Total	5.2%

FIGURE 42

MATERIALS REQUIREMENTS FOR REFRIGERATED ABSORPTION PLANTS

(CARBON STEEL, TOTAL CONTROLLED)

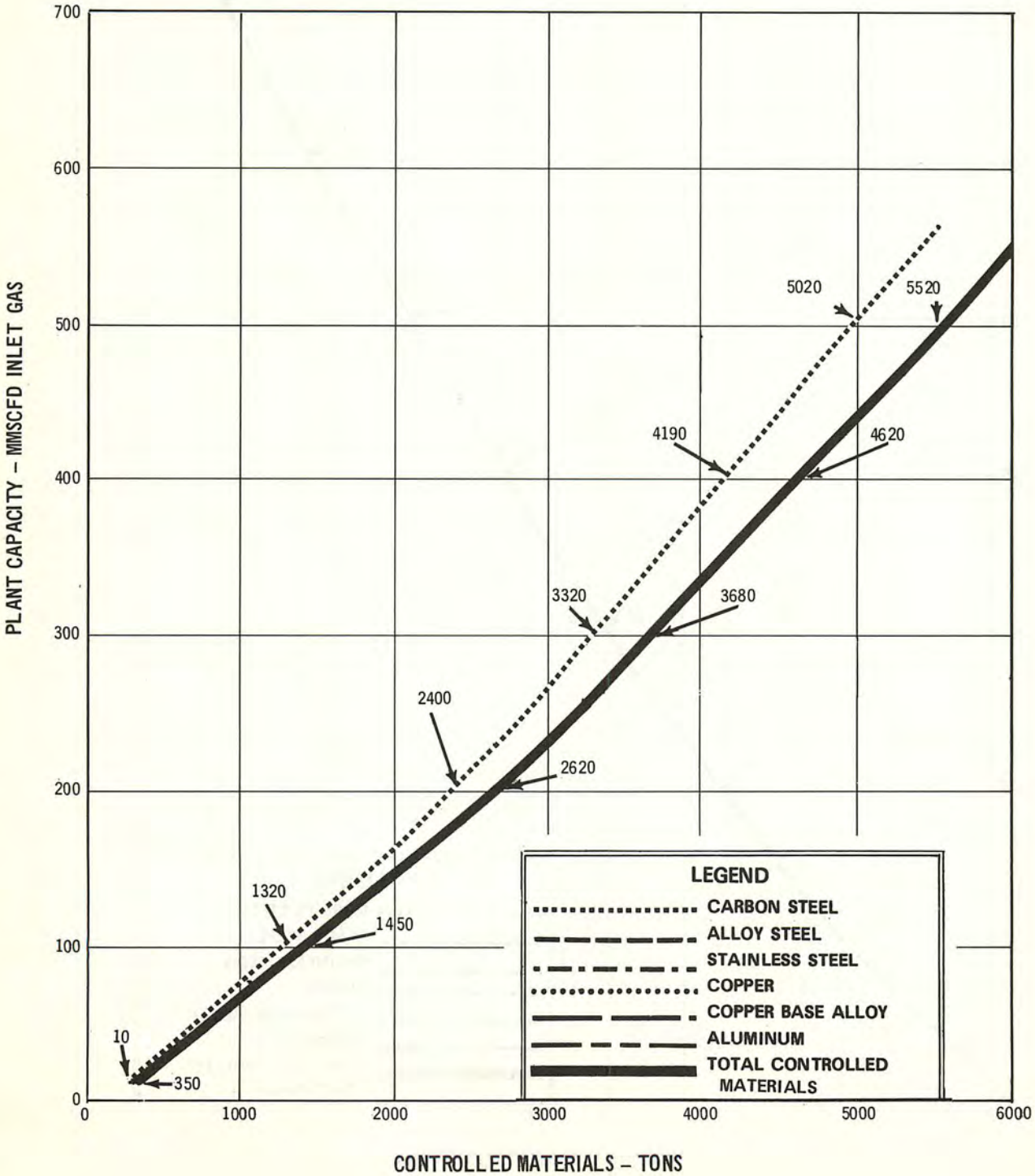


FIGURE 43

MATERIALS REQUIREMENTS FOR REFRIGERATED ABSORPTION PLANTS

(ALUMINUM)

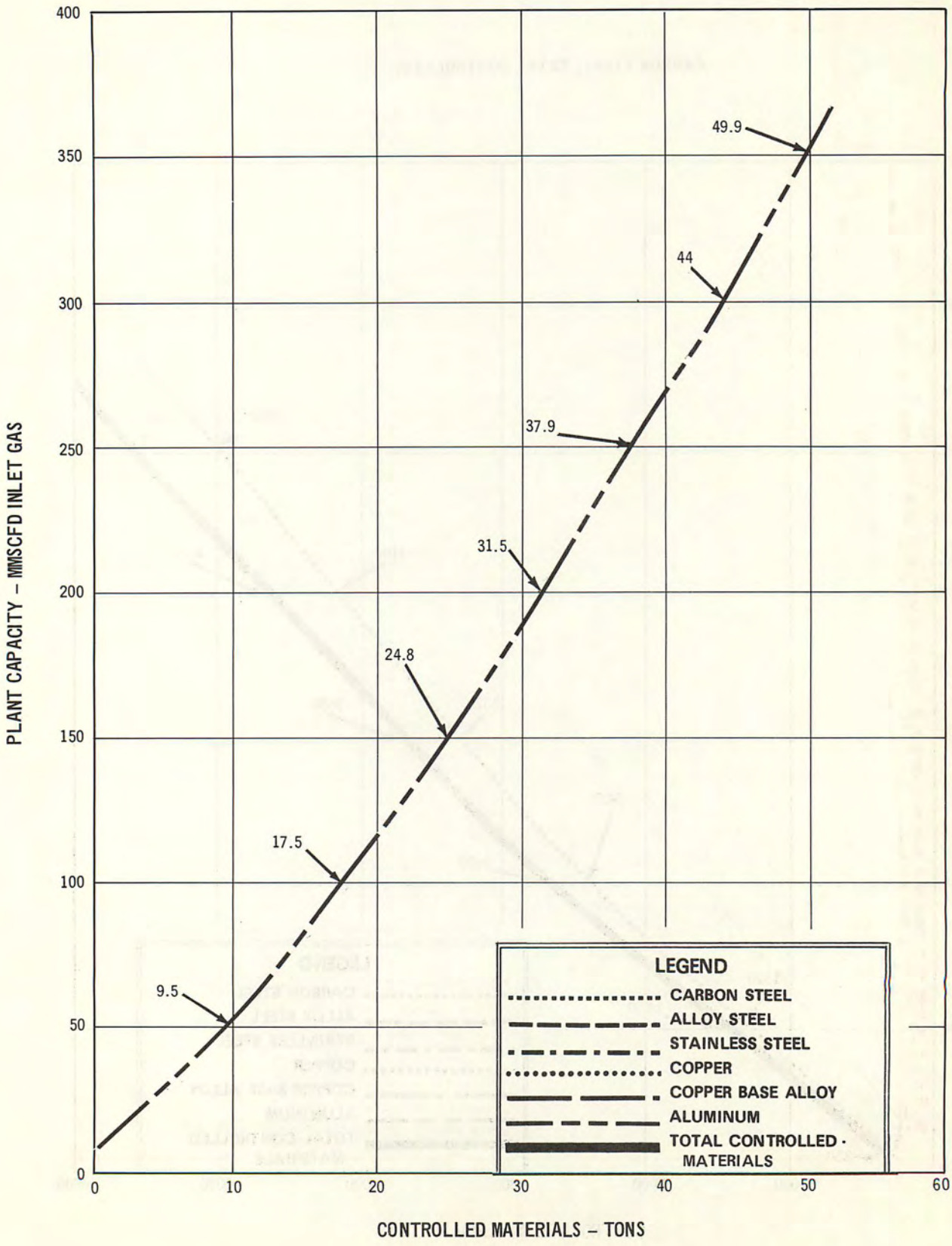
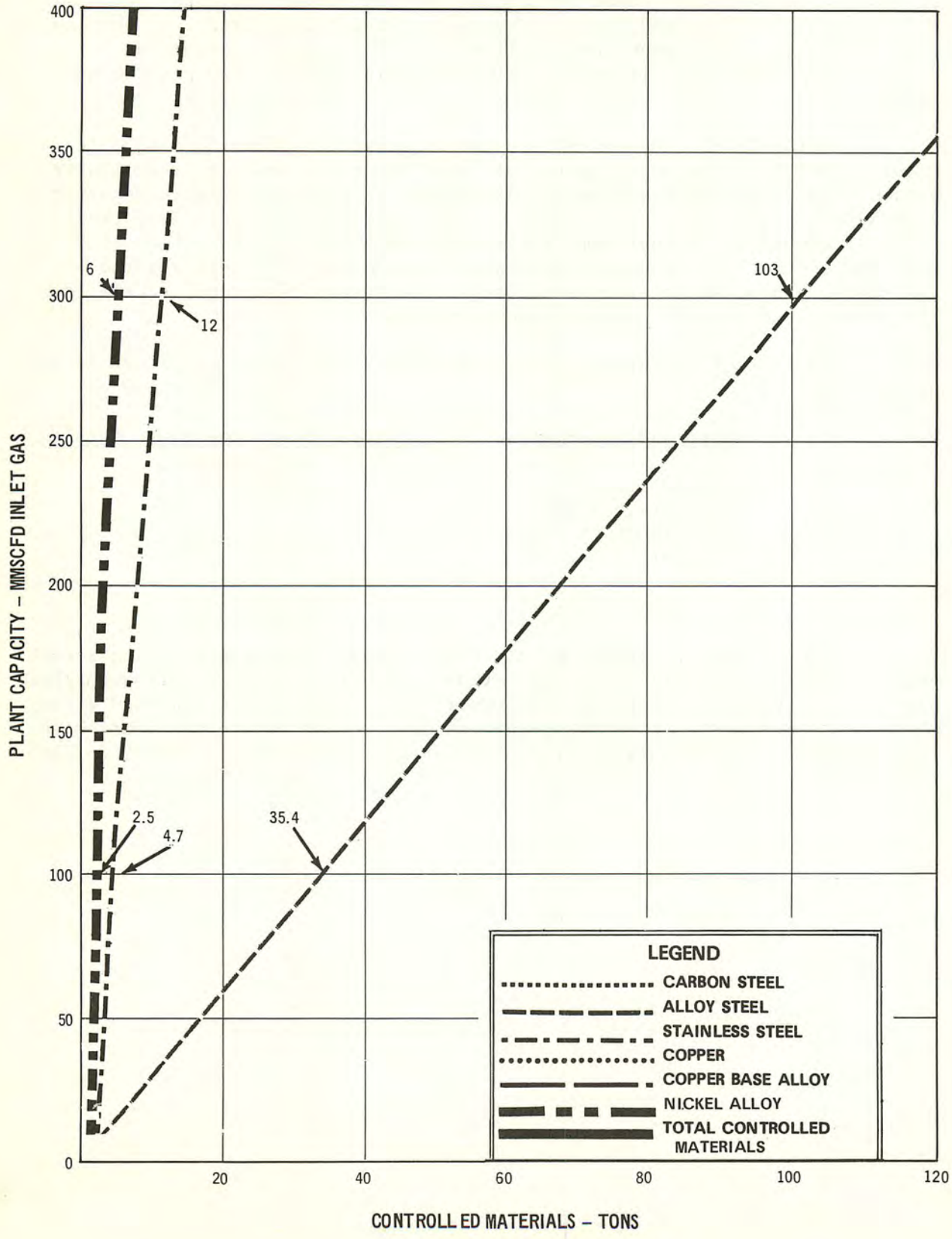


FIGURE 44

MATERIALS REQUIREMENTS FOR REFRIGERATED ABSORPTION PLANTS

(ALLOY STEEL, STAINLESS STEEL, NICKEL ALLOY)



Cryogenic Plants

Cryogenic Plants are those plants in which liquids are recovered by simple condensation caused by cooling the gas stream to temperatures in the range of -140° F and lower. Cryogenics itself is a branch of physics relating to the development and utilization of very low temperatures. Cooling for the plants listed is achieved by expansion of the process gas stream.

FIGURES 45, 46, and 47 present in graphical form the materials requirements for cryogenic plants. It will be noted, however, that FIGURE 47 presents the material requirements as related to low temperatures together with actual requirements for plants of three different sizes. The significance of FIGURE 47 is that some flexibility does exist with respect to material selection. As noted, aluminum requirements were high for the 200 MMSCFD plant, while alloy steel and nickel alloy requirements were low. The reverse was true for lower capacity plants.

A list of weighted average percentages applicable to FIGURE 47 are presented below:

Controlled Materials	% of Total Low Temperature Metals
Alloy Steel	26
Stainless Steel	50
Aluminum	15
Nickel	9
Total	100%

Two unique cryogenic plants have achieved importance during recent years. These plants are liquefied methane and helium plants. Although these plants are beyond the scope of this report and have not been reported elsewhere in this report, materials requirements to construct these plants have been developed. This data is presented for typical plants in TABLES 2-2 and 2-3.

FIGURE 45

MATERIALS REQUIREMENTS FOR CRYOGENIC GAS PROCESSING PLANTS

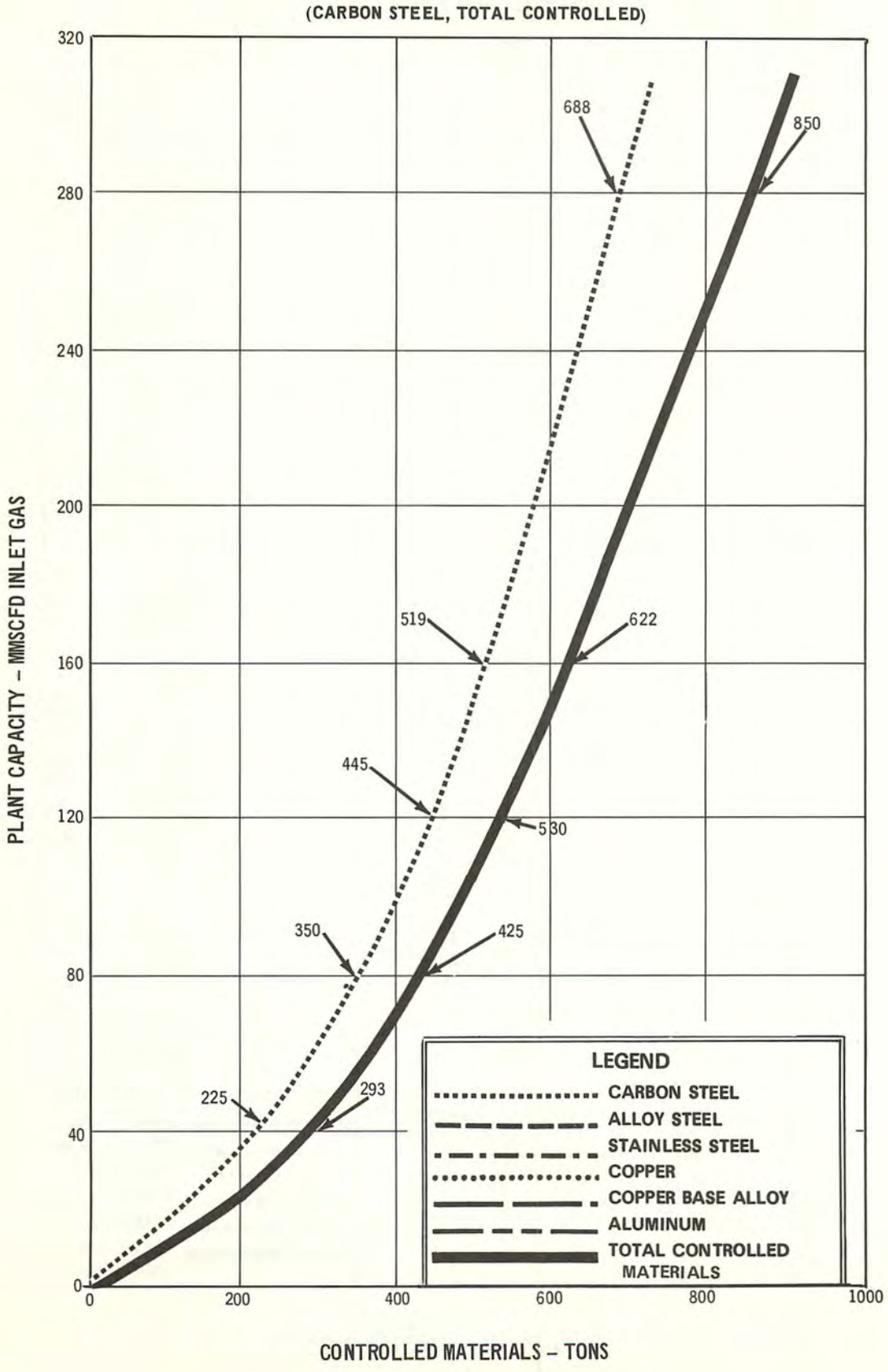


FIGURE 46

MATERIALS REQUIREMENTS FOR

CRYOGENIC GAS PROCESSING PLANTS

(COPPER, COPPER BASE ALLOY)

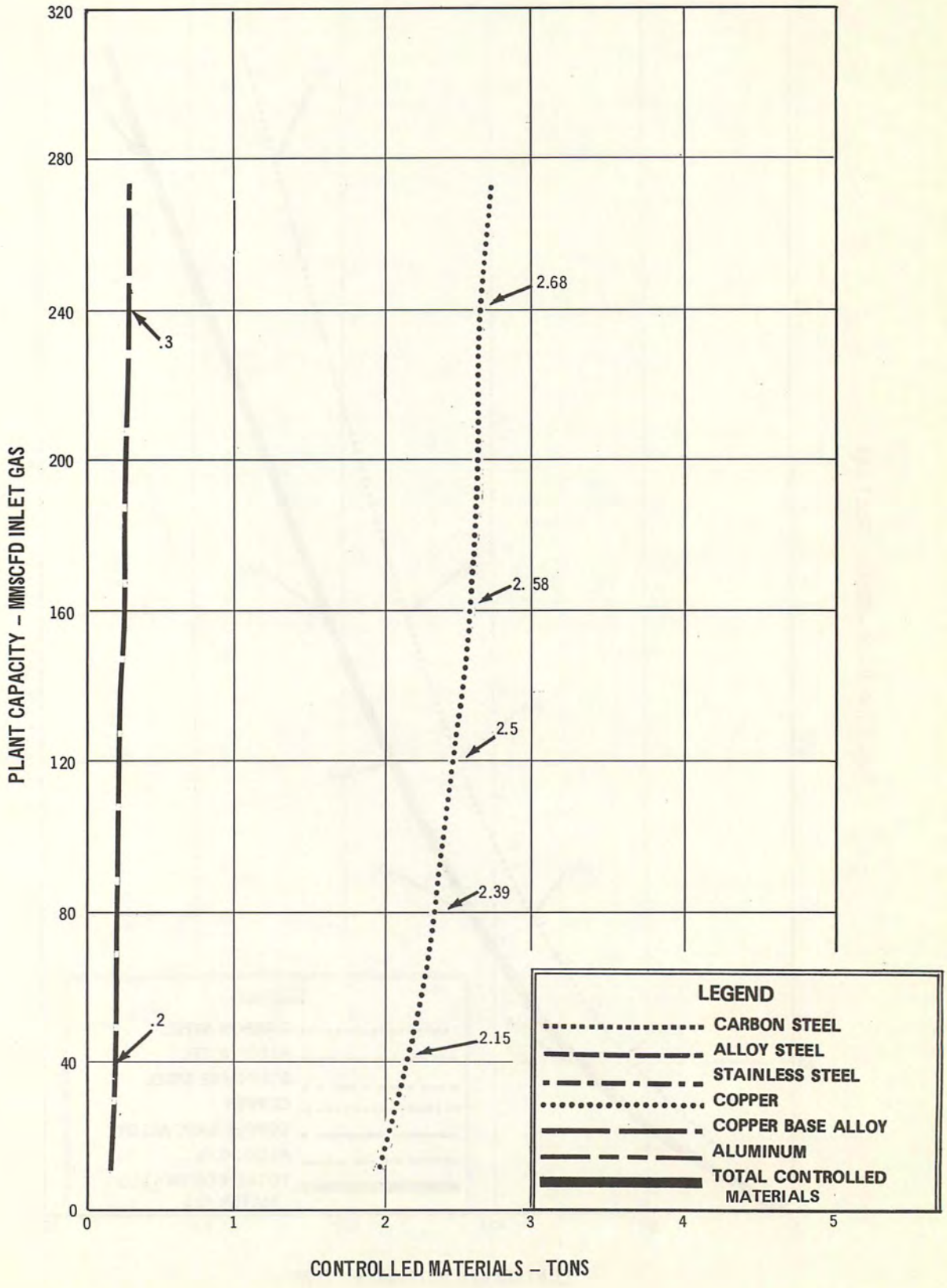


FIGURE 47

MATERIALS REQUIREMENTS FOR CRYOGENIC GAS PROCESSING PLANTS

(STAINLESS STEEL, ALLOY STEEL, NICKEL ALLOY, ALUMINUM)

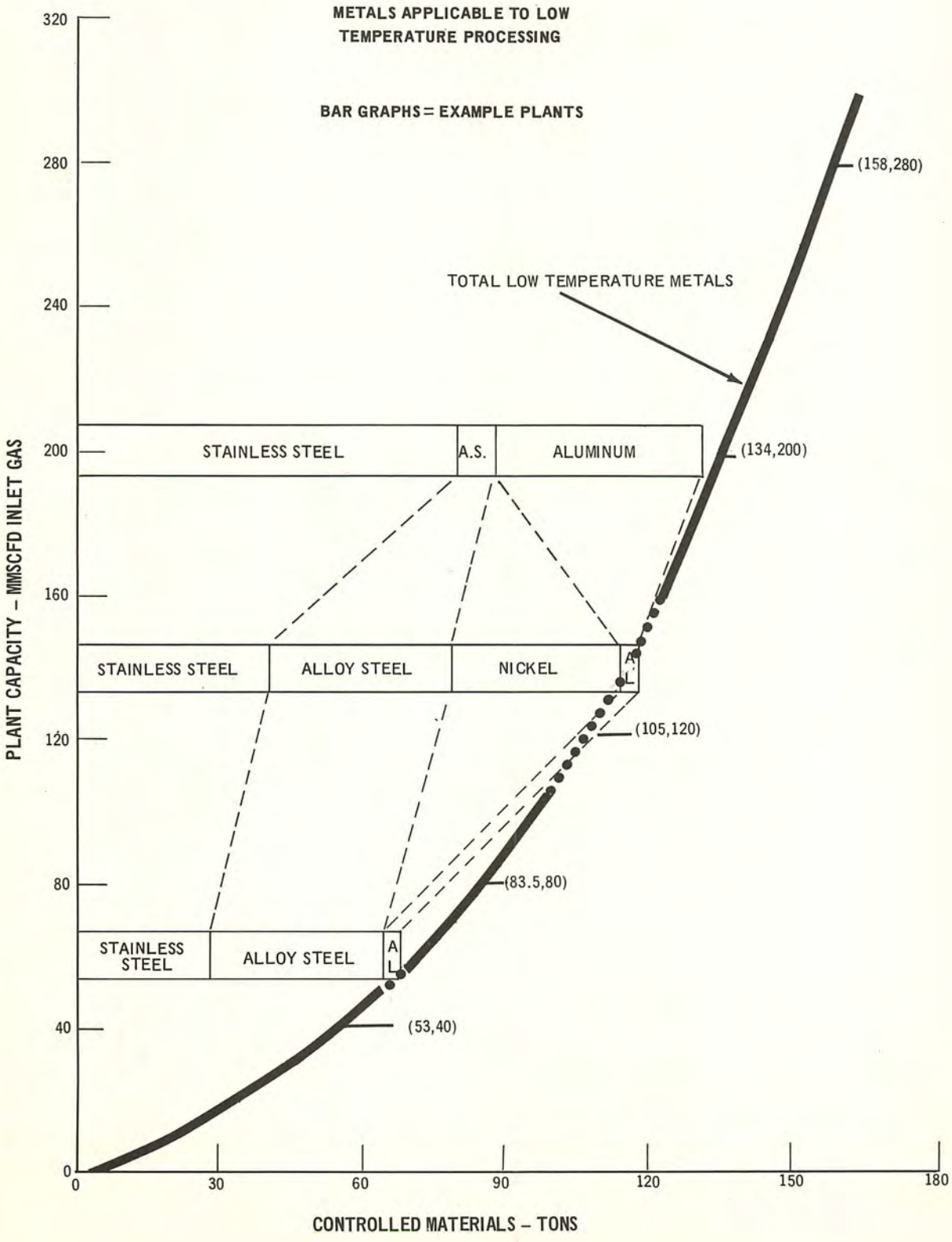


TABLE 2-2

LIQUEFIED METHANE PLANT
CAPACITY 172 MMCF/D
CONTROLLED MATERIALS REQUIREMENTS
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
Heat Exchangers	750	-	-	-	-	214	-	964
Process Vessels & Tanks	2,000	60	52	-	-	1,100	-	3,212
Pumps - Motors & Electrical	90	5	5	64	1	5	-	170
Instruments & Controls	5	4	3	1	1	1	-	15
Pipe, Valves & Fittings	1,200	-	340	-	-	20	-	1,560
Structural Steel & Reinforcing	3,450	15	-	-	-	-	-	3,465
Compressors & Drives	505	6	200	15	8	10	-	744
Total	8,000	90	600	80	10	1,350	-	10,130

TABLE 2-3

HELIUM PLANT
CAPACITY 517 MMCF/D
CONTROLLED MATERIALS REQUIREMENTS
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Aluminum	Total
Heat Exchangers	579	160	1	8	245	993
Process Vessels & Tanks	737	75	5	-	-	817
Pumps - Drivers - Electrical	60	-	-	33	-	93
Instruments & Controls	43	-	-	4	-	47
Pipe - Valves - Fittings	1,251	60	37	2	4	1,354
Structural Steel - Buildings	128	-	-	-	-	128
Compressors - Generators - Drivers	317	-	-	4	-	321
Miscellaneous	12	-	-	-	-	12
Boilers	492	-	-	-	-	492
Total	3,619	295	43	51	249	4,257

Fractionation Plants

Fractionation Plants include those plants in which liquids are the feedstocks. The liquid components are recovered from natural gas streams by the processes referred to previously. These liquids are then "fractionated" into commercially pure products. The fractionation plants are listed separately only when not built as a part of a gas processing plant.

Curves are not included since only one plant was constructed during the year. Materials requirements for the one plant, with a capacity to produce 1,050,000 gallons of products daily were as follows:

Controlled Materials	Weight (Tons)
Carbon Steel	1,320
Alloy Steel	4
Stainless Steel	5
Copper	7
Copper Alloy	1
Aluminum	9
Nickel Alloy	-
Total	1,346

Sulfur Plants

Sulfur Plants include those plants recovering elemental sulfur by processing a concentrated hydrogen sulfide stream.

Total controlled materials requirements to construct a sulfur plant are presented in graphical form in FIGURE 48. This graph relates materials requirements to sulfur production capacity in long tons.

The following tabulation is provided to permit allocation of weights to the various controlled materials:

Controlled Materials	% of Total
Carbon Steel	97.3
Alloy Steel	1.7
Copper	.2
Aluminum	.8
Total	100.0

FIGURE 48

MATERIALS REQUIREMENTS FOR SULFUR PROCESSING PLANTS

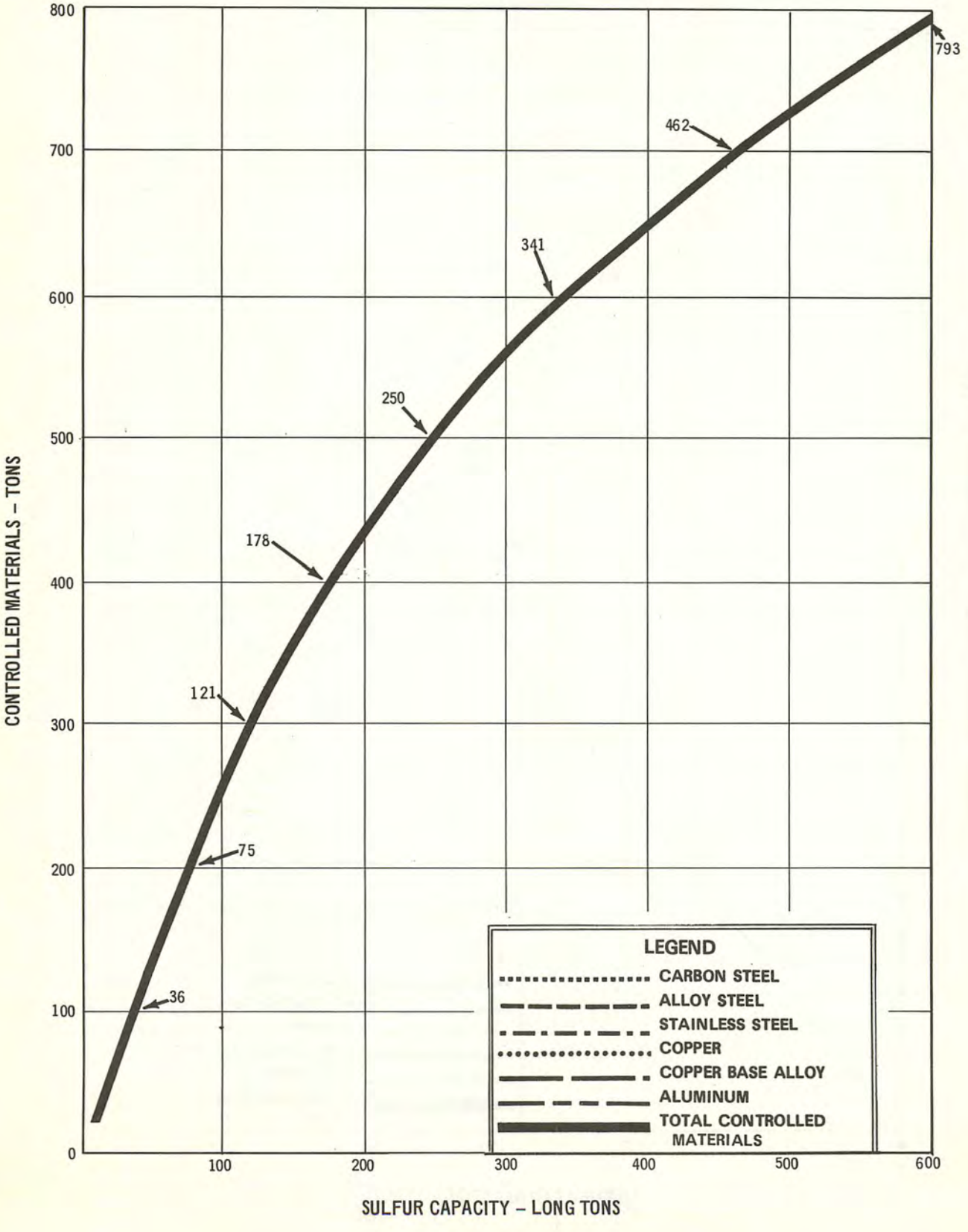
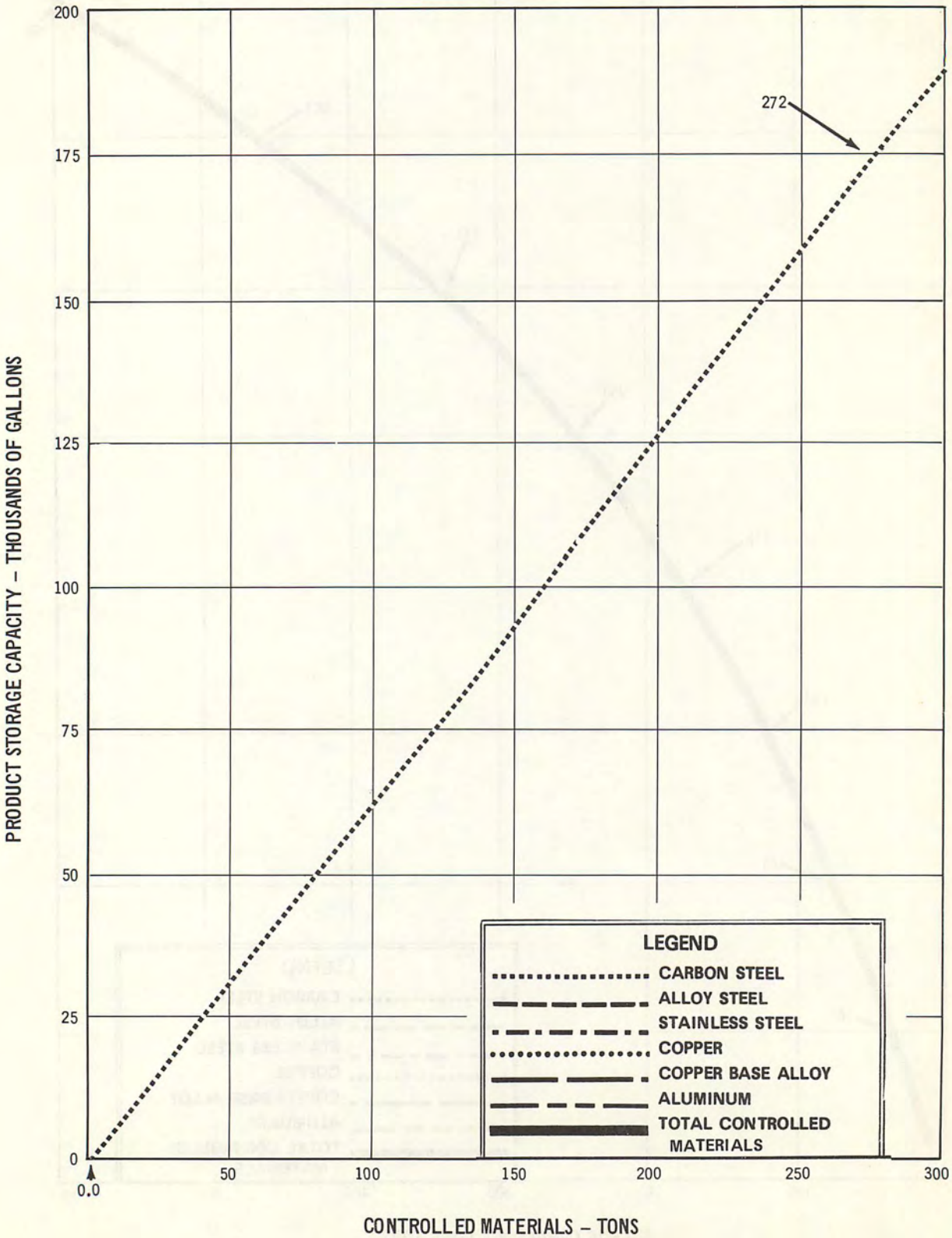


FIGURE 49

MATERIALS REQUIREMENTS FOR PRODUCT STORAGE

(CARBON STEEL)



3 - MAINTENANCE OF EXISTING PRODUCTION FACILITIES

To continue producing operations with existing wells and facilities, an amount of maintenance and repairs is required. Well servicing equipment and production rig equipment must be used to keep wells in producible condition. Tubular goods must be repaired and replaced to permit well production. Surface and subsurface equipment must be repaired, replaced, or supplemented in order to facilitate existing well production. Gasoline plants also must be repaired to allow continued gas processing from existing sources.

The amount of maintenance materials required during a given period of time is related to the number of facilities being maintained. Since the number of wells and plants being maintained are continually changing, factors have been determined to estimate the average single domestic well's annual maintenance requirements. This also has been done for gas plants as illustrated in TABLE 3-1.

The information presented in TABLE 3-1 should be used only to estimate or support claims for maintenance materials for a large number of wells or plants. The information presented should result in reasonable approximations of total industry maintenance requirements.

An example of how TABLE 3-1 can be used is presented below:

Problem: What weight of total controlled materials are required to adequately maintain the producing facilities for an area presently containing 200,000 wells and 300 gas processing plants?

Solution: Obtain the total materials requirements for one well and one gas processing plant from TABLE 3-1 and multiply these values by the number of wells and gas processing plants to be maintained.

			Weight (Tons)
Wells	=	453 Pounds/Well (200,000 Wells) ÷ 2,000 Pounds/Ton	= 45,300
Plants	=	16.4 Tons/Plant (300 Plants)	= 4,920
Total			50,220

This same solution technique can be applied to any of the controlled materials presented by using the appropriate table entry.

TABLE 3-1

CONTROLLED MATERIALS REQUIREMENTS TO MAINTAIN EXISTING PRODUCTION FACILITIES
(POUNDS PER WELL)

Maintenance Function	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Other Alloys Castings & Forgings	Total
Production Unit Materials Requirements to Maintain Existing Wells	24	29	-	-	1	-	-	-	54
Well Servicing Operations for 701,049 Existing Wells	36	30	1	-	1	1	-	-	69
Repairs or Replacement of Tubular Equipment for Existing Wells	117	-	-	-	-	-	-	-	117
Repairs to Surface and Subsurface Equipment for Existing Wells	138	56	2	3	7	-	2	5	213
TOTAL CONTROLLED MATERIALS FOR MAINTENANCE PER AVERAGE WELL	315	115	3	3	9	1	2	5	453
TOTAL CONTROLLED MATERIALS FOR MAINTENANCE OF GAS PROCESSING PLANTS - TONS/PLANT	14.7	0.6	0.1	0.4	0.4	0.2	-	-	16.4

NOTE: Surface and subsurface category excludes maintenance for waterflood equipment, thermal stimulation, and gas and miscible phase injection.

4 - DEVELOPMENT OF ADDITIONAL PRODUCTION BY RESERVOIR STIMULATION

The number of reservoir stimulation projects, such as waterflooding, thermal recovery, and gas injection, have increased substantially during recent years. These projects can greatly accelerate production rate as well as increase reserves. Because of their importance to production rates and reserves, the materials requirements to install such projects have been considered and included in this report.

Tools with which to estimate reservoir stimulation materials requirements have been developed in graphical form relating project size or injection capacity to tons of materials. This information is presented in FIGURES 50 through 54, inclusive. Specific design conditions relating to each of these graphical presentations are discussed below.

Waterflood Plants (FIGURE 50)

An average waterflood plant's materials requirements would include those materials necessary to build the following equipment:

Raw Water Storage Tank
Transfer and Circulating Pumps
Chemical Storage Tanks
Filters
Clean Water Storage Tanks
Instruments and Controls

It should be noted that the non-carbon steel materials required for the above equipment can vary widely depending on water quality required and degree of automation utilized to control plant operation.

Water Injection Pumps (FIGURE 51)

The materials required to build water injection pumps were developed separately from the waterflood plant because pressure considerations and type of pump used cause these materials to vary independently from the plant. For the purposes of this presentation, it was assumed that water was to be injected at 2,500 psig and that piston pumps graduating from small triplexes to large quintuplexes would be employed.

Thermal Projects (FIGURE 52)

The primary type of thermal reservoir stimulation being employed today is some form of steam injection project. For this reason, materials required for steam injection are presented and include the following equipment items:

Water Feed Tank and Transfer Pump
Water Treating Facilities
Treated Water Storage Tank
Deareator
Water Feed Pumps
Steam Generator and Control Equipment

Gas Injection Projects (FIGURE 53)

The materials required for compressors are presented in FIGURE 53. It will be noted that this graph represents gas injection horsepower rather than gas injection capacity as a function of controlled materials. Horsepower is a more meaningful parameter than capacity for these projects because inlet pressure conditions cause capacity-weight relationships to vary widely.

Line Pipe for Fluid Injection Projects (FIGURE 54)

The industry experience for line pipe requirements for each of the three above injection projects has been developed and is presented in FIGURE 54. Water injection flow line requirements are based on a 2,500 psig injection pressure. Gas injection flow line requirements are based on a 5,000 psig plant discharge pressure.

An example of how this data can be used is as follows:

Problem: What weight of total controlled materials will be required to install fifty 20 million BTU/hour steam injection projects?

Solution:

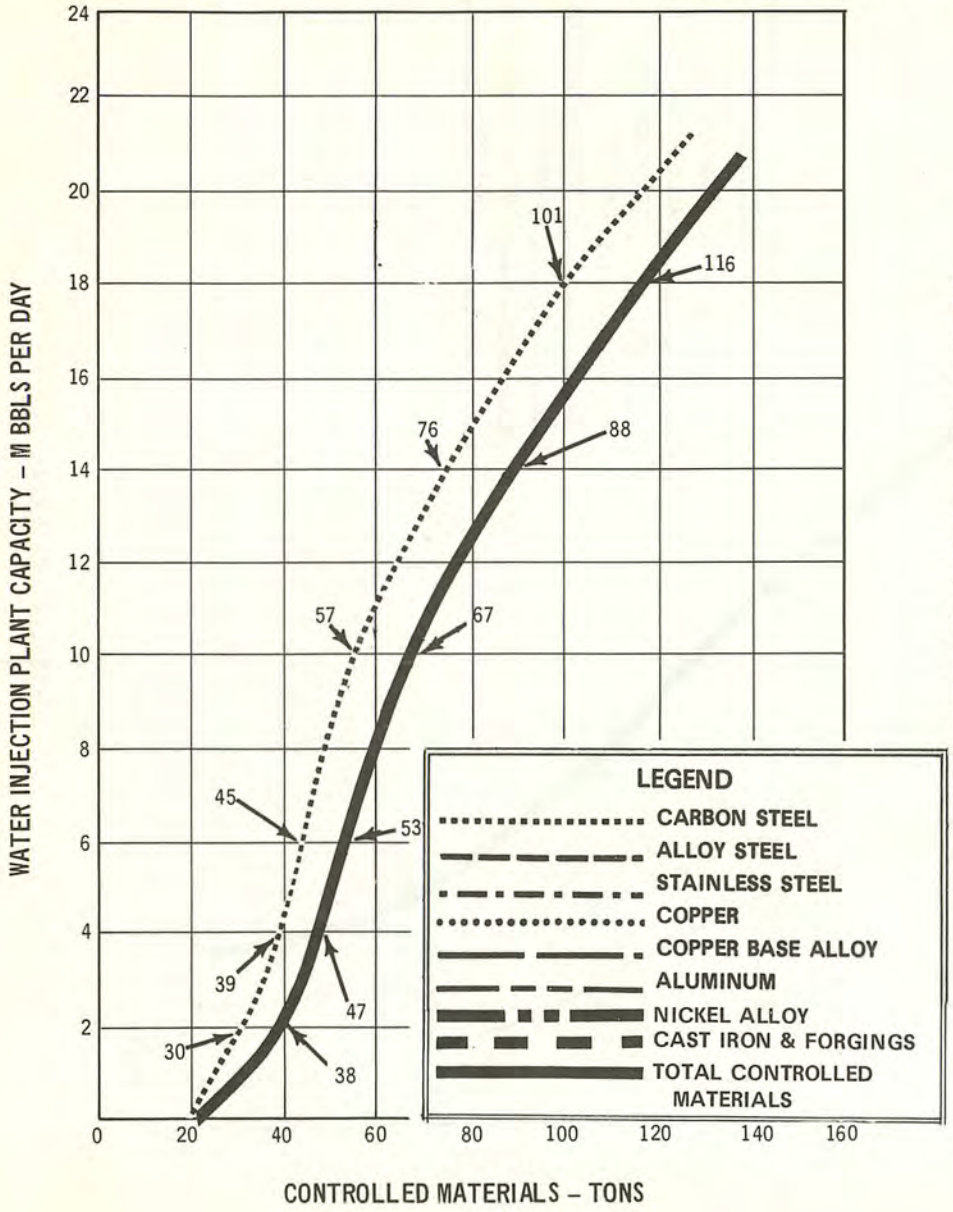
1. Obtain the total materials requirements for one project from FIGURE 52 and multiply by the number of projects.

2. Obtain the total materials required as line pipe for 10 million BTU/hour from FIGURE 54 and multiply by the appropriate BTU factor for the project and by the number of projects.

		Weight (Tons)
Equipment	= 23.7 Tons/20 MMBTU/Hour/Plant (50 Plants)	= 118.5
Line Pipe	= 1.5 Tons/10 MMBTU/Hour (2) (50 Plants)	= 150.0
Total		268.5

CONTROLLED MATERIALS REQUIREMENTS FOR WATER INJECTION PROJECTS

(EXCLUDES WATER SOURCE AND INJECTION PUMPS)



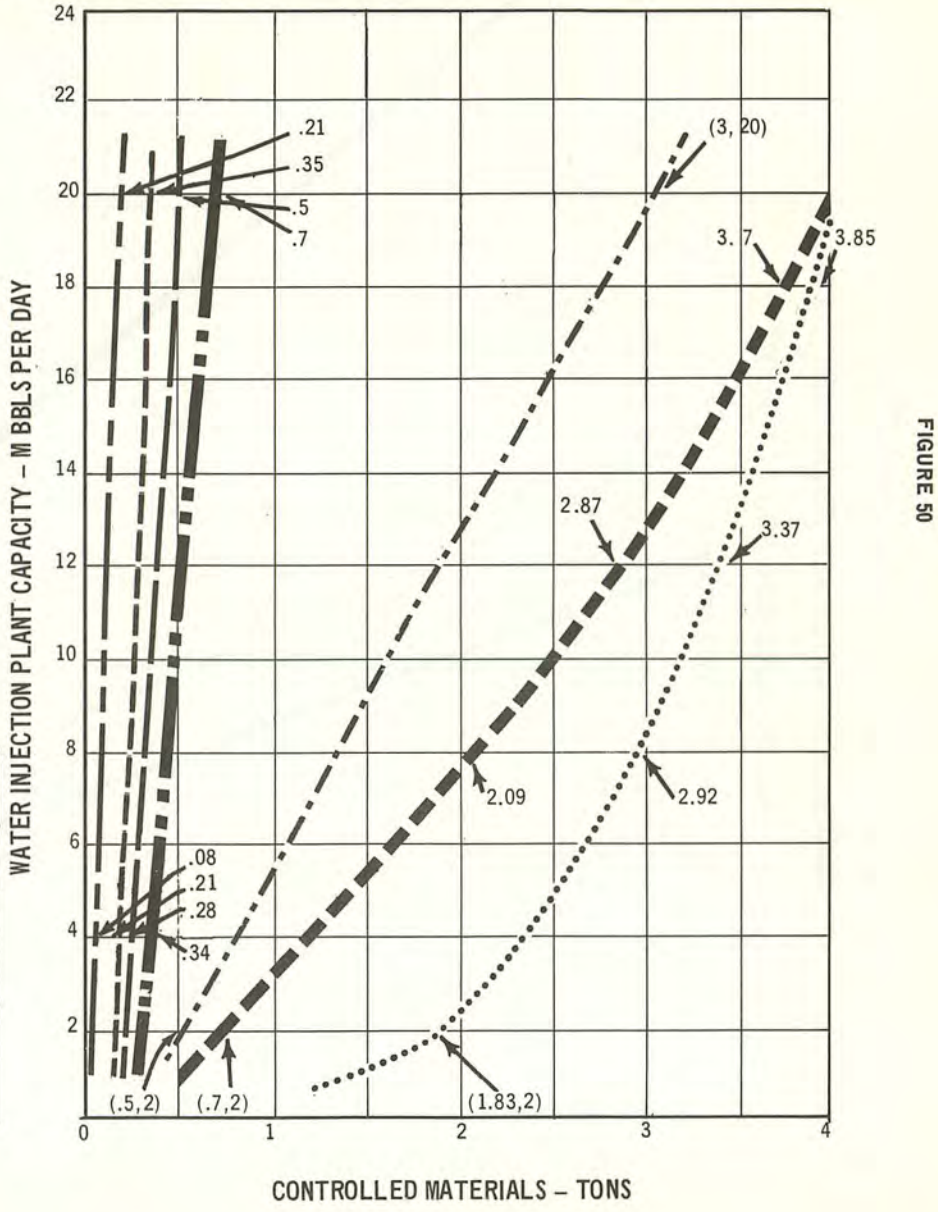
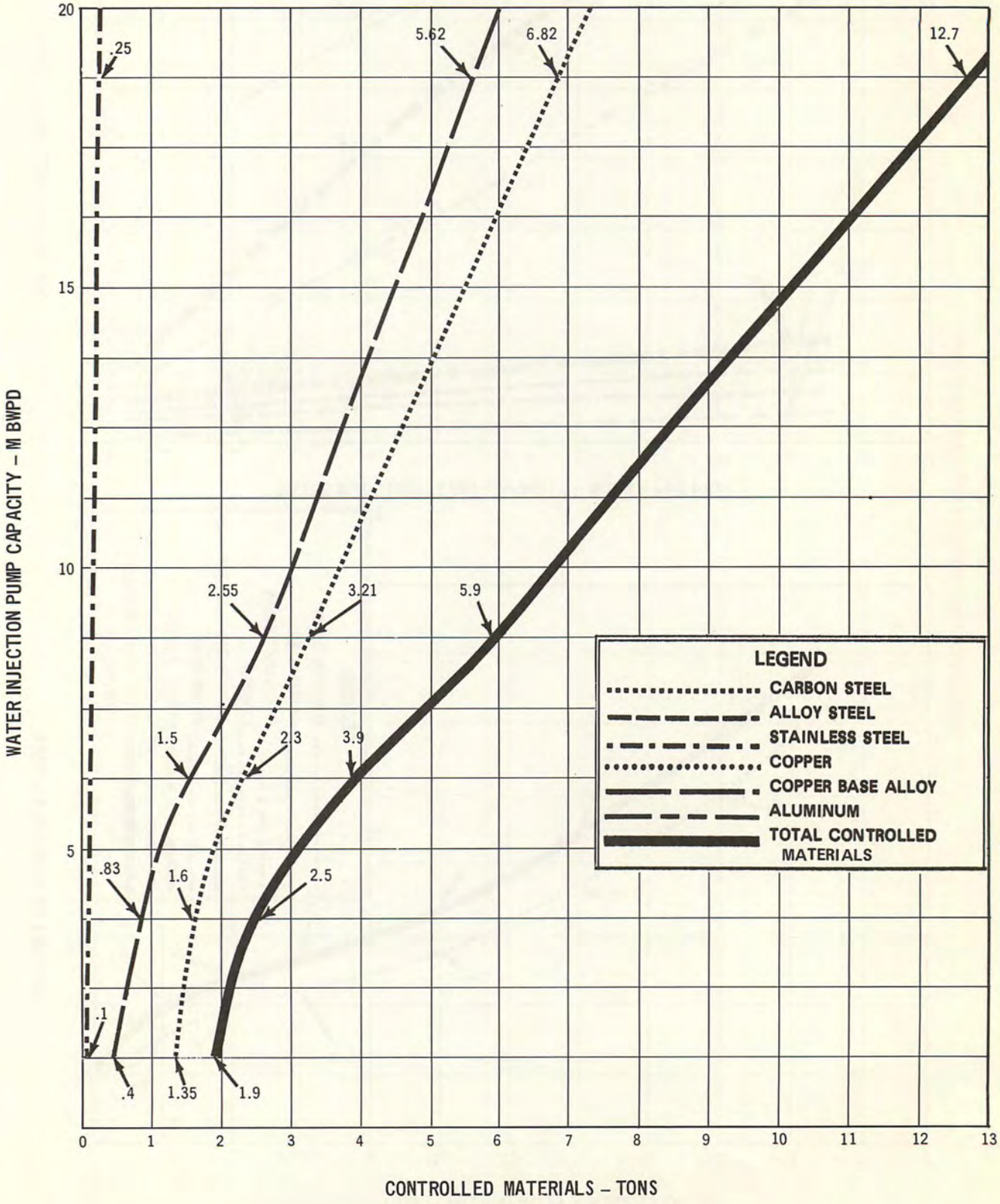


FIGURE 50

FIGURE 51

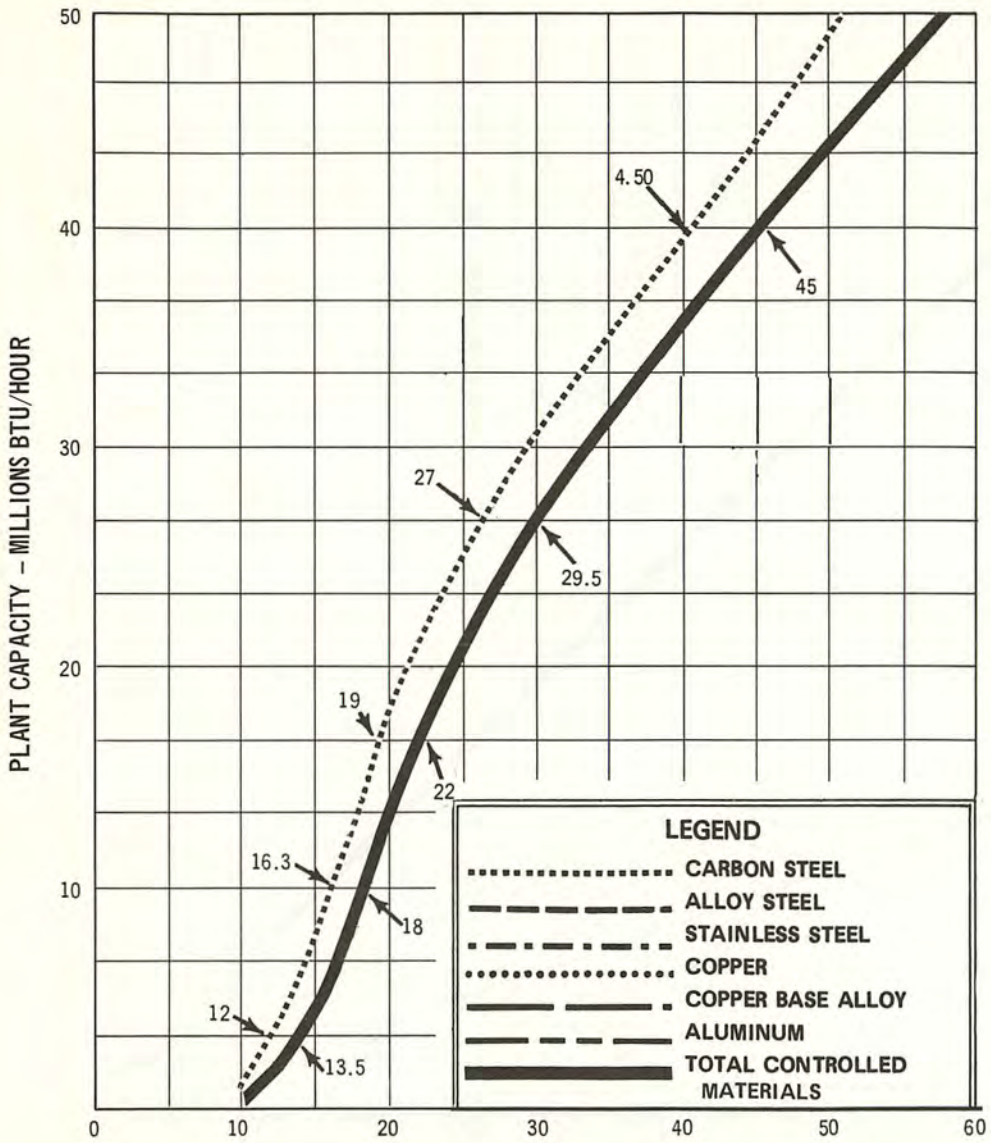
CONTROLLED MATERIALS REQUIREMENTS FOR WATER INJECTION PROJECT PUMPS

(EXCLUDES MOTORS)



CONTROLLED MATERIALS REQUIREMENTS FOR THERMAL PROJECTS

(STEAM INJECTION)



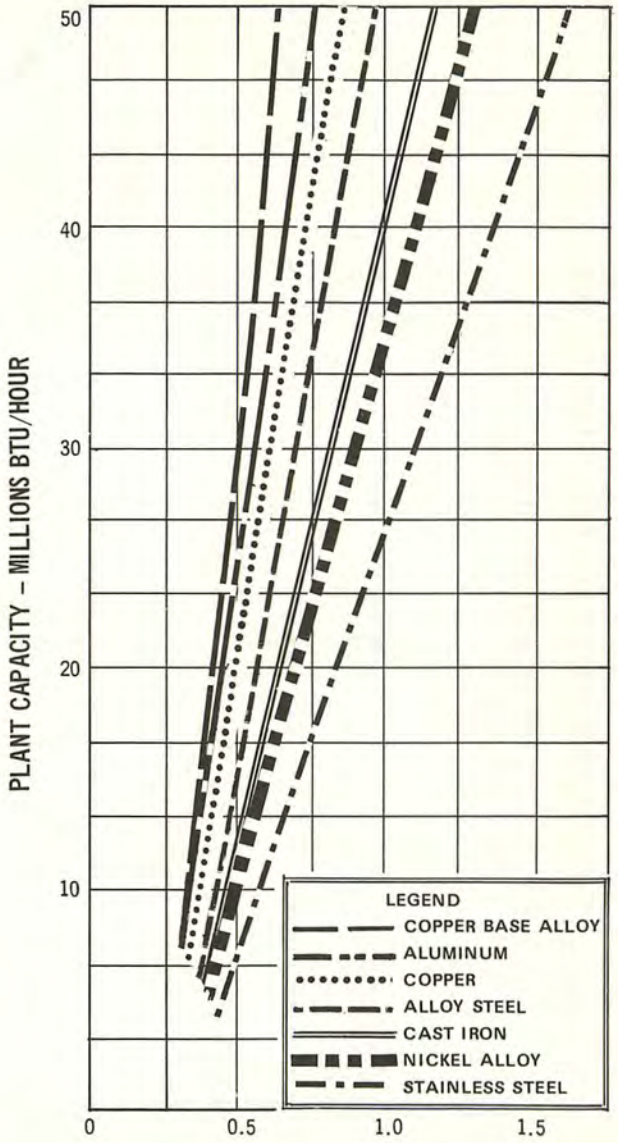


FIGURE 52

FIGURE 53

CONTROLLED MATERIALS REQUIREMENTS FOR GAS INJECTION PROJECTS

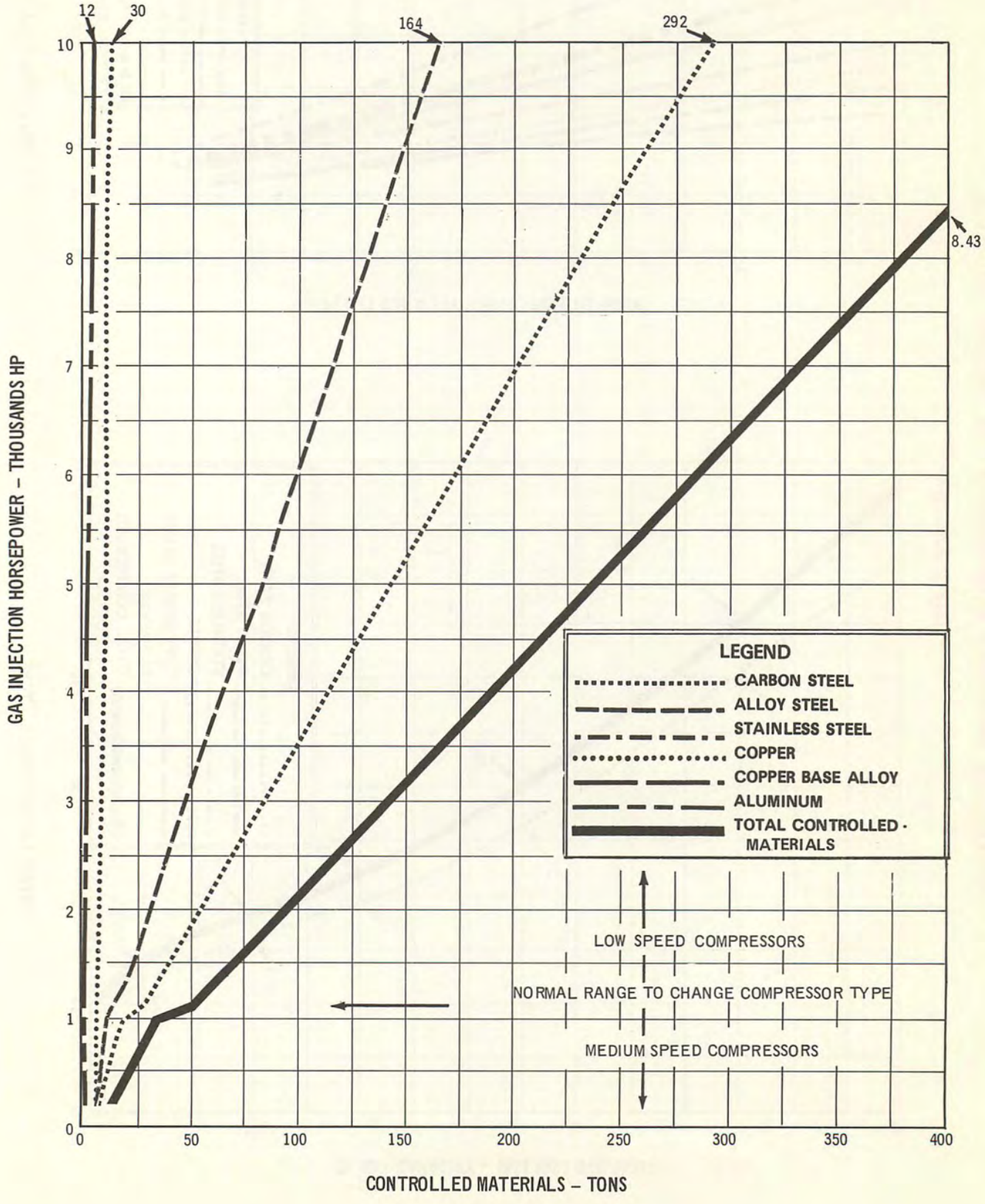
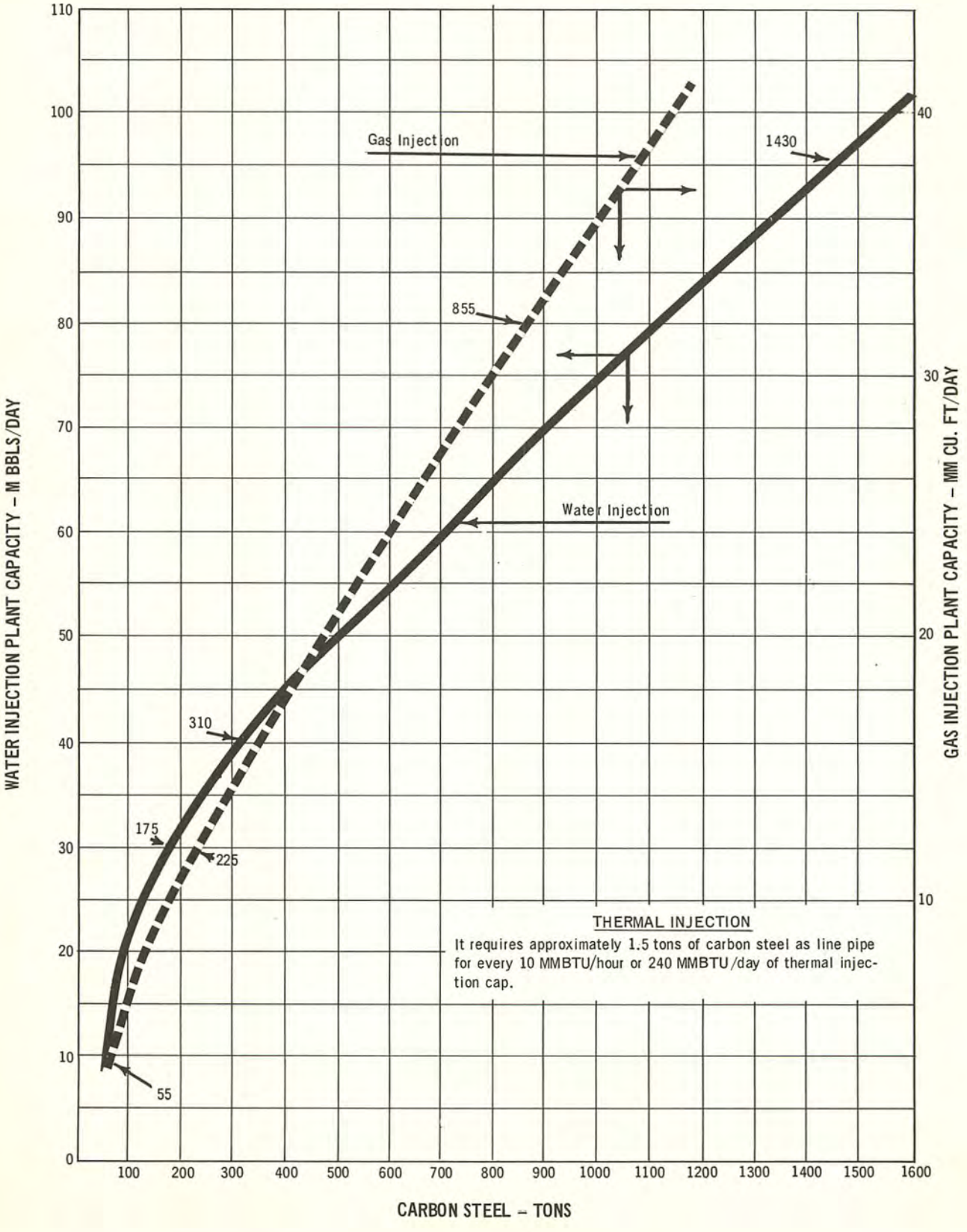


FIGURE 54

CONTROLLED MATERIALS REQUIREMENTS AS LINE PIPE FOR FLUID INJECTION PROJECTS



5 - MATERIALS REQUIRED TO BUILD MOBILE EQUIPMENT ITEMS

This section is provided for use in estimating the controlled materials required to build new pieces of mobile exploration, drilling, and well servicing equipment. The items of equipment herein discussed are those that are neither totally consumed on one project nor permanently located at the operation site. The materials required to sustain the normal maintenance for these pieces of equipment have been included in the factors and graphs presented in the previous sections of PART II.

Specifically, the information presented in this section consists of a detailed breakout of the controlled materials required to construct the following equipment items:

Seismic Crew Equipment	- by type of crew
Rotary Rig Equipment	- by size classification
Cable Tool Equipment	
Production Unit Equipment	- by size classification
Well Servicing Equipment	- by type of service

This information was developed from industry surveys and represents typical materials distribution for equipment as presently constructed. Invididual purchaser needs may necessitate variance in the materials required for a single piece of equipment, but the numbers presented are considered representative of the average.

An example illustrating how the tabulated information can be used is presented below:

Problem: What weight of controlled materials will be required to build and equip 20 new marine surface source seismic crews?

Solution: Obtain the controlled materials necessary to equip one such crew from TABLE 5-3 and multiply by the number of crews.

Controlled Materials					Weight (Tons)
Carbon Steel	10.39	Tons/Crew	(20 Crews)	=	207.8
Alloy Steel	0.35	Tons/Crew	(20 Crews)	=	7.0
Stainless Steel	1.55	Tons/Crew	(20 Crews)	=	31.0
Copper	1.61	Tons/Crew	(20 Crews)	=	32.2
Aluminum	2.49	Tons/Crew	(20 Crews)	=	49.8
Total					327.8

Similar calculations may be performed using the data presented in TABLES 5-1 through 5-8, inclusive.

TABLE 5-1

CONTROLLED MATERIALS REQUIRED TO EQUIP A CONVENTIONAL LAND DYNAMITE SEISMIC CREW

(TONS)

Equipment	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Aluminum	Total
1 - Recording Unit	1.86	-	0.51	0.17	0.48	3.02
1 - Shooting Cab	2.92	0.11	0.15	0.11	-	3.29
4 - Seismic Shot-Hole Drills	14.50	9.20	-	0.12	-	23.82
4 - Water Trucks	9.60	0.37	0.64	-	-	10.61
Drill Pipe	-	3.50	-	-	-	3.50
Geophone Land Cables	0.60	-	-	0.30	-	0.90
Geophones	0.12	0.06	-	0.01	0.04	0.23
Operating Supplies						
Blasting Cap Wire	-	-	-	1.60	-	1.60
Bits	-	1.22	-	-	-	1.22
Miscellaneous						
Computer Center*	1.60	0.24	0.38	0.88	1.53	4.63
TOTAL CONTROLLED MATERIALS PER CREW	31.20	14.70	1.68	3.19	2.05	52.82

* In addition to the controlled materials listed for the Computer Center, 10.8 ounces of gold also will be required.

TABLE 5-2

CONTROLLED MATERIALS REQUIRED TO EQUIP A SURFACE SOURCE LAND SEISMIC CREW
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Aluminum	Total
Equipment						
1 - Recording Unit	1.86	-	0.51	0.17	0.48	3.02
3 - Non-Dynamite Surface Sources	8.76	0.32	0.46	0.32	-	9.86
Geophone Land Cables	0.60	-	-	0.30	-	0.90
Geophones	0.12	0.06	-	0.01	0.04	0.23
Miscellaneous						
Computer Center*	1.60	0.24	0.38	0.88	1.53	4.63
TOTAL CONTROLLED MATERIALS PER CREW	12.94	0.62	1.35	1.68	2.05	18.64

* In addition to the controlled materials listed for the Computer Center, 10.8 ounces of gold also will be required.

TABLE 5-3

CONTROLLED MATERIALS REQUIRED TO EQUIP A DYNAMITE OR SURFACE SOURCE MARINE SEISMIC CREW
(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Aluminum	Total
Equipment						
1 - Recording Unit	1.86	-	0.51	0.17	0.48	3.02
1 - Shooting Cab /1/	2.92	0.11	0.15	0.11	-	3.29
Position Location Devices /2/	1.86	-	0.51	0.17	0.48	3.02
Geophone Marine Cables	2.15	-	-	0.28	-	2.43
Miscellaneous						
Computer Center /3/	1.60	0.24	0.38	0.88	1.53	4.63
TOTAL CONTROLLED MATERIALS PER CREW	10.39	0.35	1.55	1.61	2.49	16.39

/1/ Marine non-dynamite source assumed same materials requirements as shooting cab.

/2/ Position location devices assumed same materials requirements as recording units.

/3/ In addition to the controlled materials listed for the Computer Center, 10.8 ounces of gold also will be required.

TABLE 5-4

CONTROLLED MATERIALS REQUIRED TO BUILD ROTARY RIGS OF VARIOUS DEPTH RATINGS
(POUNDS)

	Draw-works	Mast and Sub-Structures	Swivel	Rotary	Compound	2 Mud Pumps	Crown & Travel. Block	Preventers and Choke Manifolds	Houses, Tanks Tools & Auxiliary	Total	Rig Engines With Skids	Total Road Weight
6,000' RIG												
Carbon Steel	19,175	115,880	47	8,194	16,230	23,057	5,493	-	204,048	392,124		
Alloy Steel	10,225	35,570	1,658	1,446	6,814	25,005	10,457	30,730	18,629	140,534		
Stainless Steel	-	-	-	-	-	-	-	-	3,045	3,045		
Copper	100	-	-	-	6	-	-	-	1,500	1,606		
Copper Base Alloy	-	-	-	-	-	-	-	-	1,503	1,503		
Aluminum	-	-	-	-	-	38	-	-	1,150	1,188		
TOTAL	29,500	151,450	1,705	9,640	23,050	48,100	15,950	30,730	229,875	540,000	20,000 600 HP	560,000
12,000' RIG												
Carbon Steel	31,600	144,097	53	9,214	39,585	32,266	8,970	-	247,116	512,901		
Alloy Steel	16,925	44,160	3,447	1,626	26,370	33,329	15,990	71,630	26,226	239,703		
Stainless Steel	-	-	-	-	-	-	-	-	3,895	3,895		
Copper	200	-	-	-	10	-	-	-	1,700	1,910		
Copper Base Alloy	-	-	-	-	-	-	-	-	1,976	1,976		
Aluminum	-	-	-	-	-	55	-	-	1,560	1,615		
TOTAL	48,725	188,257	3,500	10,840	65,965	65,650	24,960	71,630	282,473	762,000	60,000 1,260 HP	822,000
17,500' RIG												
Carbon Steel	36,400	166,839	64	9,214	52,800	43,150	12,684	-	277,549	598,700		
Alloy Steel	19,350	49,800	6,936	1,626	27,280	42,957	21,465	90,800	44,362	304,576		
Stainless Steel	-	-	-	-	-	-	-	-	4,674	4,674		
Copper	250	-	-	-	15	-	-	-	2,200	2,465		
Copper Base Alloy	-	-	-	-	-	-	-	-	2,497	2,497		
Aluminum	-	-	-	-	-	68	-	-	2,020	2,088		
TOTAL	56,000	216,639	7,000	10,840	80,095	86,175	34,199	90,800	333,302	915,000	85,000 1,680 HP	1,000,000

NOTE: Alloy Steel includes "Other Alloys" Listed by Manufacturer.
All the above weights are based upon typical engine-powered mechanical rigs.

TABLE 5-5

CONTROLLED MATERIALS AND ELECTRICAL MACHINERY REQUIRED TO BUILD MOBILE DRILLING PLATFORMS

(TONS)

	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Total	Electrical Machinery Motors (HP)	Electrical Machinery Generators (KW)
Inland								
Submersible Barge	1,000	5	2	4	2	1,013	850	1,000
Offshore								
Surface Floaters (Self-Propelled & Nonpropelled)	4,000	20	10	45	10	4,085	2,800	2,750
Submersible Platforms (Fixed Height)	2,500	15	5	15	5	2,540	800	1,000
Semi-Submersible Platforms	4,200	10	5	40	4	4,259	1,150	1,200
Jack-Up - 150" or Less Water	3,800	400	4	15	5	4,224	1,000	1,000
Jack-Up - 250' or More Water	4,500	500	5	15	5	5,025	2,400	2,400
Workover Platforms	2,500	15	5	15	5	2,540	800	800

		Pounds
Subsea Control System (Used in Deep Water with Floating Rigs)	Carbon Steel	8,300
	Alloy Steel	13,000
	Stainless Steel	650
	Copper	100
	Copper Base Alloy	80
	Aluminum	470
	Nickel Alloy	5

TABLE 5-6

CONTROLLED MATERIALS REQUIRED TO BUILD CABLE TOOL RIGS

Controlled Material	Pounds
Carbon Steel	40,000
Alloy Steel	9,140
Copper	190
Aluminum	125
TOTAL	49,455
250 HP Skid-Mounted Engine -	8,250

TABLE 5-7

CONTROLLED MATERIALS REQUIRED TO BUILD
PRODUCTION RIGS OF VARIOUS DEPTH RATINGS
(POUNDS)

	Normal Equipment Life (Years)	Well Depth Capacity			
		4,000 Ft.	4,000 - 8,000 Ft.	8,000 - 14,000 Ft.	Below 14,000 Ft.
Basic Rig - Less Engines Running Gear, Road Transmission & Tools					
Carbon Steel		30,000	36,000	43,000	53,500
Alloy Steel		3,500	6,300	7,800	11,500
Stainless Steel		10	10	25	35
Copper		20	60	80	100
Copper Base Alloy		20	30	50	60
Aluminum		25	25	25	25
Nickel Alloy		-	-	-	-
Total	8	33,575	42,425	50,980	65,220
Road Weight		40,000	50,000	70,000	90,000
Triplex Pump					
Carbon Steel	9	9,070	9,070	18,990	18,990
Alloy Steel	3.8	32,400	32,400	38,990	38,990
Stainless Steel		-	-	-	-
Copper		-	-	-	-
Copper Base Alloy	5	1,680	1,680	4,315	4,315
Aluminum		-	-	-	-
Nickel Alloy	7	1,040	1,040	4,580	4,580
Total		44,190	44,190	66,875	66,875
Power Sub	6				
Rotating Tubing Stripper	2				
Line Wiper	2				
Carbon Steel		816	911	1,423	2,190
Alloy Steel		4,373	4,539	7,067	11,870
Stainless Steel		-	-	-	-
Copper		-	-	-	-
Copper Base Alloy		-	-	-	-
Aluminum		-	-	-	-
Nickel Alloy		-	-	-	-
Total		5,189	5,450	8,490	14,060
Elevators, Bails, Catheads, Tubing Spiders, Blowout Preventers					
Carbon Steel		-	-	-	-
Alloy Steel	3	1,870	2,070	3,880	4,680
Stainless Steel		-	-	-	-
Copper		-	-	-	-
Copper Base Alloy		-	-	-	-
Aluminum		-	-	-	-
Nickel Alloy		-	-	-	-
Total	3	1,870	2,070	3,880	4,680
		Engine Horsepower			
Engines	8	150	250	350	400 - 500

TABLE 5-8

CONTROLLED MATERIALS REQUIRED TO BUILD VARIOUS WELL SERVICING UNITS
(POUNDS)

Type Unit and Major Components Included	Carbon Steel	Alloy Steel	Stainless Steel	Copper	Copper Base Alloy	Aluminum	Nickel Alloy	Total
LOGGING OR PERFORATING UNIT - Special body, cable drum, electrical collector, auxiliary transmission, right angle winch drive, mud winch, air clutch, multichannel photographic recorder, gasoline or diesel driven generator, control panels, cable sheaves, cable measuring and recorder drive device, cable tension device, field printer.	15,000	1,500	750	150	170	820	25	18,415
DOUBLE PUMP CEMENTING UNIT - Truck mounted: Triplex type pumps, gas turbine or diesel engines, mechanical or torque converter transmissions, various piping, valves and tanks for both high and low pressure systems, electric controls and wiring.	10,500	15,500	25	280	20	500	100	26,925
Skid mounted: As above but includes materials for skid	15,500	15,500	25	280	20	500	100	31,925
ACIDIZING AND FRACTURING UNIT - Triplex type pumps, gas turbine or diesel engines, mechanical or torque converter transmissions, various piping, valves and tanks for both high and low pressure system, electronic controls and wiring.	2,500	12,900	500	200	10	100	10	16,220

APPENDIX A

GENERAL ASSUMPTIONS AND BASIC STUDY GUIDELINES

GENERAL ASSUMPTIONS

1. Published National Petroleum Council reports, where available and applicable, were considered the primary source of information and are used in the preparation of this report.

2. Data from Government sources such as the USBM (United States Bureau of Mines), USDC (United States Department of Commerce), BDSA (Business and Defense Services Administration), and USBC (United States Bureau of Census) are used as the major supplement to National Petroleum Council reports.

3. When data was not available from the above sources, published information from recognized industry organizations was considered the secondary source and used in the preparation of this report. Examples of these organizations and magazines are:

   - AAODC (American Association of Oilwell Drilling Contractors)
   - AGA (American Gas Association)
   - AIME (American Institute of Mining, Metallurgical, and Petroleum Engineers)
   - AISI (American Iron and Steel Institute)
   - API (American Petroleum Institute)
   - IPAA (Independent Petroleum Association of America)
   - PESA (Petroleum Equipment Suppliers Association)
   - SEG (Society of Exploration Geophysicists)
   - World Oil, Oil and Gas Journal, Petroleum Engineer, Drilling, Offshore Magazines

4. Individual company and industry surveys were used in the absence of data from the above information sources.

5. Established national standards by the USBS (United States Bureau of Standards), ASTM (American Society for Testing Materials), ASA (American Standards Association), ASME (American Society of Mechanical Engineers), and Petroleum Refinery Piping Code and Boiler and Pressure Vessel Codes are used throughout.

6. Although it is recognized that technology is advancing rapidly, it is assumed that no major technologic breakthroughs will occur that will have a major effect on the use of controlled materials. Therefore, the report is based on conventional and currently used techniques for discovering, developing, and producing hydrocarbons.

7. The data developed as a basis for this report was compiled from annual totals and averages as applicable.

8. Controlled materials excluding materials used in standard chassis for specifically designed oil industry transportation units (trucks, vehicles, trailers, service barges, tugs, boats, ships) required to conduct operations have been included and are so designated. However, normal-type transportation units which can be readily available such as aircraft, automobiles, standard trucks, and marine equipment are excluded.

9. Materials requirements for transportation (pipelines) of hydrocarbons beyond the point of lease sale or natural gas liquids beyond the gas processing plant fence are not included in the 1967 controlled materials consumed totals.

10. Tonnage values, except as otherwise noted, are expressed in short tons (2,000 pounds per ton); barrels are expressed in standard API - 42 gallons per barrel.

DESCRIPTION OF CONTROLLED MATERIALS

Carbon Steel

Carbon steel is that steel for which no minimum contents of alloying elements are specified, for which the specified minimum copper content does not exceed 0.40 per cent, or for which the specified maximum content of the following elements does not exceed the percentage given: manganese 1.65 per cent, silicon 0.60 per cent, copper 0.60 per cent.

Alloy Steel

Alloy steel is that steel (except stainless steel) for which the maximum of the range of content of the following elements exceeds the following respective limits: manganese 1.65 per cent, silicon 0.60 per cent, copper 0.60 per cent. Or, it is that steel for which a definite range or a definite minimum quantity of alloying elements to obtain a desired effect is specified or required to produce the desired physical properties.

Stainless Steel

Stainless steel is any heat and corrosion-resisting steel that contains 50 per cent or more iron or steel and 10 per cent or more chromium whether or not nickel, molybdenum or other elements are added.

Copper

Copper is the pure metal or 99.9 per cent copper plus silver in which the silver component may be as much as 0.102 per cent and is counted as copper in the 99.9 per cent.

Copper Base Alloy

Copper base alloys include any alloy in which copper equals or exceeds 40 per cent by weight of the entire composition.

Aluminum

Aluminum includes the pure metal or any alloy in which the alloying material does not exceed 20 per cent by weight.

Nickel Alloy

Nickel alloys include the pure metal or any alloy in which the specified nickel content exceeds 5 per cent but does not contain more than 50 per cent iron, 40 per cent copper, or 50 per cent aluminum.

Other Critical Materials, Computers, Substitute Materials

Other materials not normally considered "controlled" but which are essential for the uninterrupted supply of hydrocarbons were considered and are included. Examples of such materials include but are not limited to rubber, chemicals, admixes, and drilling fluids.

Computers and their specific application to exploration and production operations also were investigated and discussed where applicable. The units of measurement for computers varies from section to section within the report because of the normal mode of operation. For example: Computers are normally built and installed for a specific production monitoring function, whereas computer time is normally rented as a small piece of the over-all computer usage for well servicing operations. Therefore, the units of measurement used in this report are those considered most meaningful by the particular segment of the industry involved.

The feasibility of using substitute materials has been investigated and quantified where practicable.

APPENDIX B

SPECIFIC ASSUMPTIONS AND ENGINEERING GUIDELINES

EXPLORATION EQUIPMENT AND MATERIALS

1. Includes all controlled materials requirements to conduct geophysical (seismic, gravimetric and magnetic), geochemical and geological exploration surveys up to the point of commencing drilling operations for the purpose of testing subsurface horizons.

DRILLING AND PRODUCTION RIG EQUIPMENT AND MATERIALS

1. Includes all controlled materials required to sustain drilling operations for both rotary and cable tool rigs, and production or workover rigs.

2. Computation of Drilling Rig Count in PART I, TABLE 2-1.

   Rotary Rigs Available

   Reed count published by Drilling Magazine. Prior to 1967, this included all rotary rigs available. The 1967 count did not cover 0-3,000-foot rigs which was estimated at 220 and increased the total to 2,628.

   Rotary Rigs Active

   Reed count published by Drilling Magazine. The per cent active (65.3 per cent) was applied to the 2,628 to obtain 1,716 active.

   Total Rigs Active -- World Oil Count = 2,208

   Cable Tool Active -- World Oil Count (2,208 - Active Rotary (1,716) = 492.

3. Computation of Controlled Material Consumption by Drilling Rigs in 1967.

   a. The average consumption of controlled materials per rig day was computed by a major contractor.

   b. The total U. S. consumption is the average per rig day times the total U. S. active rig days.

   c. Three rotary rig sizes were selected as representative and the number of each estimated in proportion to the Reed count published by Drilling Magazine.

      6,000' - 858
      12,000' - 613
      17,500' - 245

   d. The total controlled materials in each size rig, PART II, TABLE 5-4, was computed from manufacturers' and contractors' information.

e. The weight of controlled materials in each size rig times the average per cent of rig weight consumed per day is the consumption per rig day for each size.

f. Rig days required to drill wells in each API depth category and by geographic areas selected for this study were obtained from curves based on days versus depth data secured from bit companies. Exploratory wells were assigned 20 per cent more time than development wells. The well depth distribution by geographic areas was estimated from the Joint Association of Industry Drilling Costs Report for 1965.

g. Total available active rig days were allocated to areas in proportion to requirements estimated above.

h. Controlled materials consumption per rig day for the appropriate size rig multiplied by allocated rig days produced the numbers in PART I, TABLE 2-7. All cable tool rig time was allocated to Inland United States.

i. Controlled materials requirements for the various types of marine rigs were furnished by a shipyard with the estimate of 10 per cent per year replacement which was used in PART I, TABLES 2-4 and 2-9.

j. The number of active offshore mobile platform rigs by types was used in PART I, TABLE 2-6 as reported in Offshore Magazine. The number of inland submersible barge rigs is as reported in Drilling Magazine. The number of new offshore mobile platforms in PART I, TABLE 2-8 is as reported by Offshore Magazine.

4. Estimates of engine generator and electric motor requirements are based on contractors' and manufacturers' experience.

5. The graphs for drilling equipment controlled materials versus depth by geographic area were developed in the same manner as the estimates of controlled materials use for 1967.

WELL SERVICING EQUIPMENT AND MATERIALS

1. Includes all controlled materials required to perform completion wellbore stimulation and remedial work but excludes tubular goods, production rigs, and production equipment such as packers which are left in the well.

2. The number of well servicing operations such as drill stem tests, logging runs, and cementing jobs for each geographic area was based upon industry experience. This data coupled with 1967 materials consumed information form the basis for PART I, TABLE 3-2.

TUBULAR STEEL

1. Includes all controlled materials used by the oil and gas industry for casing, tubing, drill pipe, drill collars, tool joints, and line pipe required to deliver production to the point of custody transfer of fluid hydrocarbons to a pipeline or other transporting agency.

2. Oil country tubular goods used in each area were determined by random selected casing programs for each area and depth using U. S. STEEL COMBINATION CASING STRING MANUAL, and adjusted for industry practices.

3. The distribution of tubular steel consumed in drilling to the various areas is based on total footage drilled and drilling conditions in each area as determined from industry sources.

4. Line pipe consumed is based on the number and type of completions and an average of five pounds per foot for one-half mile of flow-line.

5. Based on industry practices, the amount of steel used for surface maintenance, downhole repairs, redrilling, deepening, and casing repair jobs was developed. This value was applied as a per cent to the total number of inland producing wells and factored by the number of tons for an average inland well depth.

6. The percentages of substitute materials that could be used to replace controlled materials were obtained from industry suppliers.

SURFACE AND SUBSURFACE PRODUCTION EQUIPMENT AND MATERIALS

1. Includes all controlled materials required to complete and operate production wells and service wells. Fixed offshore platforms and assisted recovery and production stimulation equipment also are included.

2. The specific items which were investigated for each major category of surface and subsurface equipment are as follows:

Wellhead Equipment

Casing and tubing landing heads, casing and tubing hangers, test well flanges, steel tees and crosses, stud bolts and nuts, Grayloc connectors, steel ring gaskets.

Christmas Tree Valves

Tubing master valves, wing valves, flow controllers (adjustable and fixed chokes), differential shut-off valves.

Subsurface Equipment

Tubing anchors, tubing catchers, tubing chokes and shut-off valves, packers, gas anchors, pump shoes, tubing check valves.

Sucker Rod Pumps

Barrel tubes, liners, cages, balls, seats, plungers.

Sucker Rods and Pull Rods

Sucker rods, pony rods, pull rods, polished rods, hollow rods, rod couplings.

Miscellaneous Sucker Rod Pumping Equipment

Paraffin scrapers, pump hold-downs, rod centralizers, polished rod clamps, rod rotators, stuffing boxes.

Pumping Units and Jacks (Sucker Rod Pumps)

Beam pumping units (counterbalanced either by weights on beam or crank or by air or hydraulic cylinders), pumping jacks, gear reducers, motor rails, skids, carrier bar, surface hydraulic cylinder pumping units complete with wellhead mounting bracket, hydraulic pump and polished rod connector, equipment guards and skids.

Hydraulic Pumping (Subsurface)

Subsurface hydraulic pumps, hydraulic fluid control equipment such as volume and pressure controllers, wellhead lubricator and valves, seating shoe, tubing and macaroni clamps, tubing-macaroni mandrels.

Submersible Electric Centrifugal Pumps

Surface generators, electrical control panel, electrical cable, cable clamps, electric motor driven downhole pump including gas separator, seals, screens, anchors.

Gas Lift Equipment

Flow controllers, meters and intermitters, tubing mandrels, gas lift valves, kick-off valves, blank valves, check valves. Also includes wellhead plunger, catcher, tubing shoe and plunger used in plunger lift installations.

Surface Oil Handling Equipment

Valves on flow switching manifolds; oil-gas-water separators including baffles, floats and level controls, meters, safety valves, samplers; direct and indirect fired heaters; water knockouts; treaters and heater treaters; tanks including valves, baffles, hatches, coils, ladders, stairs, walkways; custody transfer metering units including provers, chemical pumps; and integral piping on all of the above items.

Surface Gas Handling Equipment

Valves on flow switching manifolds, meters and meter runs, condensate and/or water separators, dehydrators, direct and indirect fired heaters, condensate measuring and metering equipment, glycol injectors, sales booster compressors including scrubbers, intercoolers, skid bases, integral piping on all of the above items.

Assisted Recovery and Production Stimulation Equipment

A. Waterflood Equipment

Water source pumps, filters, circulating pumps, back wash and slurry tanks, mixing tanks, control equipment, meters, valves, integral piping and skids on packaged unit.

B. Thermal Equipment

Water source pumps, filters, water treatment facilities, charging pumps, steam generators including control equipment, safety-valve shutdowns, skids, integral piping, valves and fittings, metering equipment and valves.

C. Gas Injection Equipment

Gas compressors including intake scrubbers, intercoolers, meter runs, manifolds, control equipment, integral piping and valves, skids.

Surface Pumps

All centrifugal, positive displacement, worm gear, proportioning pumps used in oilfield production operations for surface movement of fluids - for subsurface hydraulic pumping - for subsurface injection of fluids.

Internal Combustion Engines

Gasoline, diesel, natural gas, LPG fueled engines for driving such equipment as: pumping units, surface oil-water-hydraulic fluid pumps, water well pumps, small generators (less than 50 KW), sump pumps, and compressors.

Fixed Offshore Platforms

Legs, bracing, decks, helicopter pads, ladders, walkways, landing stages, fenders, cranes, davits, superstructures, and other fixed equipment or facilities not normally removable.

Electrical Equipment

Field generating sets (greater than 50 KW), transformers, line starters, circuit breakers, meters, conductor cable, electric motors and motor skids all of which are used in oilfield production operations on pumping units, surface oil-water-chemical-hydraulic fluid pumps, water well pumps, small booster compressors, tank mixers.

Automation, Specialized Equipment and Instruments

Computers or devices which control a programmed series of events and record or telemeter information on the results of such events. Devices such as flow no-flow sensors, per cent water-cut sensors, high-low fluid and pressure sensors, gauges, valve actuators, alarm systems, electrical time-cycle controllers, telemetering devices, data-recording devices, orifice meters, and liquid-volume meters are items considered under this category.

Hand and Power Tools

Wrenches, threading tools, ditchers, power hand drills and cutting devices, welding and cutting torches, welding rods and electrodes, air compressors and air tools.

GAS PROCESSING PLANTS AND MATERIALS

1. Includes all controlled materials within the plant fences. Processing plants for both field and main gas transmission lines are included. Dehydration and desulfurization also are included when constructed in conjunction with gas processing plants.

2. In addition to gas processing plants, all field compressor units are included. Compressors for main line gas transmission stations are not included.

3. Materials requirements were developed from actual construction analysis, published design data, and application of conventional design to plant requirements.

4. Materials for helium plants and liquefied methane plants are not included in the 1967 total materials consumed since these types of plants do not represent "normal-annual-material" requirements.

APPENDIX C

ACKNOWLEDGMENTS, REFERENCES, CORRESPONDENCE

ACKNOWLEDGMENTS

The assistance and data provided by the numerous industry suppliers, specialty manufacturers, drilling contractors, drilling and production rig manufacturers, workover and well servicing contractors, drilling mud suppliers, shipyards, and oil companies are gratefully acknowledged.

Special thanks also are due government agencies, industry associations, and magazine publishers for permission to utilize published information and statistics.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20240

C
O
P
Y

May 29, 1967

Dear Mr. Donnell:

In fulfilling the responsibilities assigned to the Secretary of the Interior by the President with respect to preparedness planning for the petroleum industry there is a recognized need to know the critical materials requirements under emergency conditions including those conditions resulting from nuclear attack.

The National Petroleum Council has conducted several very important studies of this type in recent years. On July 16, 1963, the Council published a report on a study of annual requirements for oil country tubular goods and other steel products necessary in the exploration, drilling and production of oil and gas reserves in the United States. On March 1, 1966, the Council reported on a materials study dealing with materials requirements for supplementing existing refining productive capacity or construction of new capacity; a series of general assumptions and engineering ground rules were established for the purpose of preparing estimates of materials requirements for refining processes and auxiliary facilities in this study.

We request that the study of materials requirements for oil and gas exploration, drilling and production published in July 1963 be updated and that general assumptions and engineering ground rules similar to those contained in the March 1966 refining material study be developed for use in estimating requirements. Insofar as feasible, factors and formulae should be developed as estimating devices for converting manufactured controlled products into basic material needs by category, such as steel, copper, aluminum, etc.

Sincerely yours,

/s/ J. Cordell Moore

Assistant Secretary of the Interior

Mr. J. C. Donnell II
Chairman
National Petroleum Council
1625 K Street, N. W.
Washington, D. C. 20006

APPENDIX D

LIST OF TABLES

APPENDIX D *(Cont'd.)*

APPENDIX D *(Cont'd.)*

APPENDIX D *(Cont'd.)*

APPENDIX E

LIST OF FIGURES AND EXHIBITS

APPENDIX E *(Cont'd.)*

APPENDIX E *(Cont'd.)*

EXHIBITS