CRITICAL MATERIALS REQUIREMENTS FOR PETROLEUM REFINING

A REPORT OF

THE NATIONAL PETROLEUM COUNCIL

MARCH, 1966

NATIONAL PETROLEUM COUNCIL
1625 K Street, N.W., Washington, D. C. 20006

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Onnie P. Lattu
Director

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

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CRITICAL MATERIALS REQUIREMENTS FOR PETROLEUM REFINING

A REPORT OF THE
NATIONAL PETROLEUM COUNCIL'S
COMMITTEE ON MATERIALS REQUIREMENTS
FOR PETROLEUM REFINING

EVERETT F. WELLS
CHAIRMAN OF THE COMMITTEE

MARCH 1, 1966

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* Served as Government Co-Chairman until June 30, 1965, when term as Refining Specialist, Office of Oil and Gas was completed.

TECHNICAL SUBCOMMITTEE

LIST OF INDIVIDUAL WORK ASSIGNMENTS

Section Number and Title	Subcommittee Member Preparing Initial Material
Process Units:	
1. Crude distillation (including desalting, vacuum and stabilization)	J. G. Wilson Assisted by G. A. Walker
2. Catalytic reforming and feed preparation	Ralph D. Jackson
3. Catalytic cracking	Roland A. Whealy
4. Delayed coking	R. V. Nutt
5. Hydrotreating	Ralph D. Jackson
6. Hydrocracking	D. R. Loper
7. Hydrogen plant	D. R. Loper
8. Alkylation	Joseph T. O'Brien
Off-Site and Auxiliary Facilities:	
9. Tankage and tank farm piping	D. R. Loper
10. Steam generation	J. G. Wilson Assisted by G. A. Walker
11. Power distribution	Joseph T. O'Brien
12. Antiknock additive mixing plants	Roland A. Whealy
13. Cooling water towers	Roland A. Whealy
14. Waste water separator and emulsion treating	Ralph D. Jackson
15. Instrument air	Roland A. Whealy
16. Plant air	Roland A. Whealy
17. Fire protection	Roland A. Whealy

General Assistance

Robert C. McCay
R. L. Tollett
Assisted by
E. B. McCormick

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON 25, D. C.

July 27, 1964

Dear Mr. Follis:

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.

In times of emergency, the Emergency Petroleum and Gas Administration under the U.S. Department of the Interior has claimancy responsibility for materials, and a detailed study of critical materials requirements is necessary as a standard against which to measure the validity of claims. In July 1963, the Council submitted a valuable report, "Materials Requirements for Oil and Gas Exploration, Drilling and Production, 1962."

We now request the Council to prepare a materials study for the refining segment of the industry. The Council should make such comments and recommendations as it considers appropriate.

Sincerely yours,

John A. Carver, Jr.
Assistant Secretary of the Interior

Mr. R. G. Follis
Chairman
National Petroleum Council
1625 K Street, N. W.
Washington, D. C. 20006

P A R T I

INTRODUCTION

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. This study deals with materials requirements for supplementing existing refining productive capacity or construction of new capacity. It is recognized that critical materials to maintain the existing refining capability will also be of prime importance under emergency conditions. It is felt, however, that this area was adequately covered and reported in the 1961 NPC Report on Maintenance and Chemical Requirements for U. S. Petroleum Refineries and Natural Gasoline Plants.

In order to supplement or to replace petroleum refining capacity, the petroleum industry is highly dependent on certain essential materials, including carbon and alloy steel, copper, aluminum, and non-ferrous alloys. These critical materials are subject to control and allocation in emergency situations by the Business and Defense Services Administration, U. S. Department of Commerce.

In an emergency, the Emergency Petroleum and Gas Administration under the U. S. Department of the Interior would have claimancy responsibility on behalf of the petroleum industry for materials, and a detailed study of critical materials requirements is necessary as a guide against which to measure the validity of claims. For this reason, the National Petroleum Council was requested to undertake this study.

This report is designed to give pertinent information for materials subject to such emergency controls as are necessary for the refining of petroleum. The results of the study are presented on a process basis with sufficient capacity range generally to represent crude throughputs of from 10,000 barrels per stream day to 150,000 barrels per stream day. In addition, critical materials requirements for refinery off-site and auxiliary facilities within their respective battery limits are considered. The refining processes considered are:

Section

1. Crude distillation (including desalting, vacuum and stabilization)
2. Catalytic reforming and feed preparation
3. Catalytic cracking
4. Delayed coking
5. Hydrotreating
6. Hydrocracking

7. Hydrogen plant

8. Alkylation

Off-site and auxiliary facilities considered are:

Section

9. Tankage and tank farm piping

10. Steam generation

11. Power distribution

12. Antiknock additive mixing plants

13. Cooling water towers

14. Waste water separator and emulsion treating

15. Instrument air

16. Plant air

17. Fire protection

Crude unit design was considered on the basis of processing both light (35.0° API) and heavy (19.8° API) crudes. Delayed coking was considered only for the residuum from the heavy crude. With respect to the sulfur levels of the crudes considered, it was assumed that the metallurgy involved should be defined as the minimum critical alloy required for a modern refining unit which would probably have to be modified as a specific corrosive situation might require. In most process capacity cases, actual unit materials requirements were used, modified as necessary in line with the foregoing general

assumption. In a few of the capacity cases where actual unit data were not available, it was necessary to interpolate or otherwise estimate the materials requirements. It is believed, however, that the materials requirements for the processes considered are realistic and sufficiently accurate for planning purposes. These materials requirements are presented in terms as recommended by the Department of Commerce (BDSA) for claimancy purposes.

The types of processes and capacity ranges as presented were selected as representing logical possibilities for creating diverse refinery prototypes as particular circumstances might require. Accordingly, the critical materials requirements for either an entire refinery of desired crude throughput and considerable complexity or for only a single new or replacement unit may be estimated. Partial replacement and/or repair of a damaged unit would require on-site inspection and evaluation, but the total materials requirements of such a unit would be useful even in these cases in evaluating the validity of claims.

The processes considered in this report were chosen to provide a fuels oriented refinery output and, accordingly, no estimates were made for critical materials requirements for the production of lubricants, petrochemical precursors, asphalt, etc.

Critical materials requirements for the production of these specialty products would of course also be of prime importance in the event of emergency conditions. These requirements, because of their nature, can best be studied as separate subjects.

Critical design, engineering and construction skills required to convert essential materials into processing facilities will also be of prime importance under emergency conditions. It is felt, however, that adequate analysis was given to this subject in the 1963 NPC Report on Petroleum and Gas Industries Manpower Requirements. Likewise, process chemicals and catalysts essential to sustaining operation of existing equipment would be of vital consideration in times of emergency, but it is felt that this area was adequately covered in the 1961 NPC Report on Maintenance and Chemical Requirements for U. S. Petroleum Refineries and Natural Gasoline Plants.

P A R T II

GENERAL ASSUMPTIONS AND ENGINEERING GROUND RULES

For the purpose of preparing the attached estimates of materials requirements for processes and auxiliary facilities, the following general assumptions and engineering ground rules were adopted.

1. Established National Standards such as ASTM, ASA, API and NEMA are used.

2. In general, all pressure vessels are designed on the basis of ASTM Grade A-285C carbon steel plate unless otherwise specified.

3. Plant electric power supply is assumed at 138,000 volts primary with secondary 13,800 volt distribution system.

4. Requirements for pumps and compressors are expressed in horsepower.

5. The process waste heat steam production available above processing requirements is assumed to be used for driving power. Drivers below 500 horsepower are assumed to be electric and motor starter requirements are included. Drivers above 500 horsepower are assumed to be steam turbine. Spare pumps are provided only to allow orderly shutdowns.

6. The utilization of refinery dry gas, residual supplemental fuel, and emergency propane or butane for fuel has been assumed. For design purposes, 1,000 Btu per cubic foot fuel heating value is assumed.

7. The availability of water for domestic use, cooling tower makeup and boiler feed is assumed.

8. Where air coolers are used, air cooling to 200° F is assumed with the use of conventional circulating water cooling towers below 200° F. A 25-30° F rise in cooling water temperature is assumed.

9. Critical materials required for utilities distribution within battery limits are included in the estimates for each process.

10. Sour water stripping is included at the process units involved.

11. Requirements for initial catalyst fills including critical material are estimated where applicable.

12. Required product caustic and inhibitor treating are included at the units where produced.

13. Heater efficiencies were assumed to be in the 70-75% range. In general, unless otherwise specified, waste heat steam generation for fuel economy is not included.

14. Utilities requirements of the various processes were estimated to provide a basis for developing the critical materials requirements of off-site and auxiliary facilities.

15. Steam requirements and generation are in terms of 650 psig steam.

16. In estimating total utilities requirements, appropriate allowance over and above that indicated in this study must be made for such miscellaneous items as winterizing, blowdown, etc.

17. Critical materials requirements for spare parts provision are included in the individual estimates.

18. Special facilities, such as laboratories, shops, other buildings and initial supporting tools and equipment are not included.

19. Critical materials for interconnecting processing and utilities lines between units and field tankage, cannot be determined without plot plans. Accordingly, no estimates in this category are made in this report, but can be estimated from readily available data as required.

20. Critical materials requirements for facilities for receiving crude and for shipping products varies so widely between pipeline and tankship receipts of crude oil and pipe line and tank car or tank truck deliveries of products; refinery locations and plot plans, it was considered difficult to develop estimates which would have any general application and value. Consequently, no materials requirements estimates have been included for these facilities.

III. PROCESS UNITS

PART III
PROCESS UNITS

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CRUDE DISTILLATION
(INCLUDING DESALTING, VACUUM AND STABILIZATION)

SECTION 1

CRUDE DISTILLATION
(INCLUDING DESALTING, VACUUM AND STABILIZATION)

A. DESCRIPTION AND ASSUMPTIONS

The crude unit considered for this study includes heaters, one or two crude columns depending on unit size, four side strippers for naphtha, kerosene, gas oil and heavy gas oil stripping, a vacuum column, depropanizer and debutanizer columns. A sour water stripping column has also been included. Desalting facilities consist of an electro-static separation unit.

In preparation of the estimates of critical materials requirements, the following assumptions have been made:

1. In all plant sizes the product slate will not change materially.

2. Preliminary studies indicate that quantities of materials will vary only slightly between light and heavy crude cases. Other conditions, such as layout and location, will be more of a varying factor. Therefore, the heavy crude case is to represent the average.

3. The philosophy of designing for sweet versus sour crudes is a questionable one. From experience, the actual crude run is seldom consistent with the original crude anticipated. The normal practice of allowing for variations in crude type has therefore been followed. This means that stainless materials will

normally be included in vessel and furnace installation for both sour and sweet plants. Quantities tabulated are for running average crude types.

4. If a completely sweet crude plant is required, the alloy materials will be a direct additive to the carbon steel quantities since liners, etc., replace the normal carbon steel corrosion allowances. If alloy or stainless materials are really scarce, carbon steel can be substituted by increasing corrosion allowances. However, if sour crudes are designed for, troubles can be anticipated in all areas operating above the 550°-600° range. The total of the stainless steel and carbon steel quantities is reasonably accurate. The break between the various categories can only be specified at the time of emergency consideration for a specific plant.

Diagram No. 1a

DESALTING/CRUDE DISTILLATION

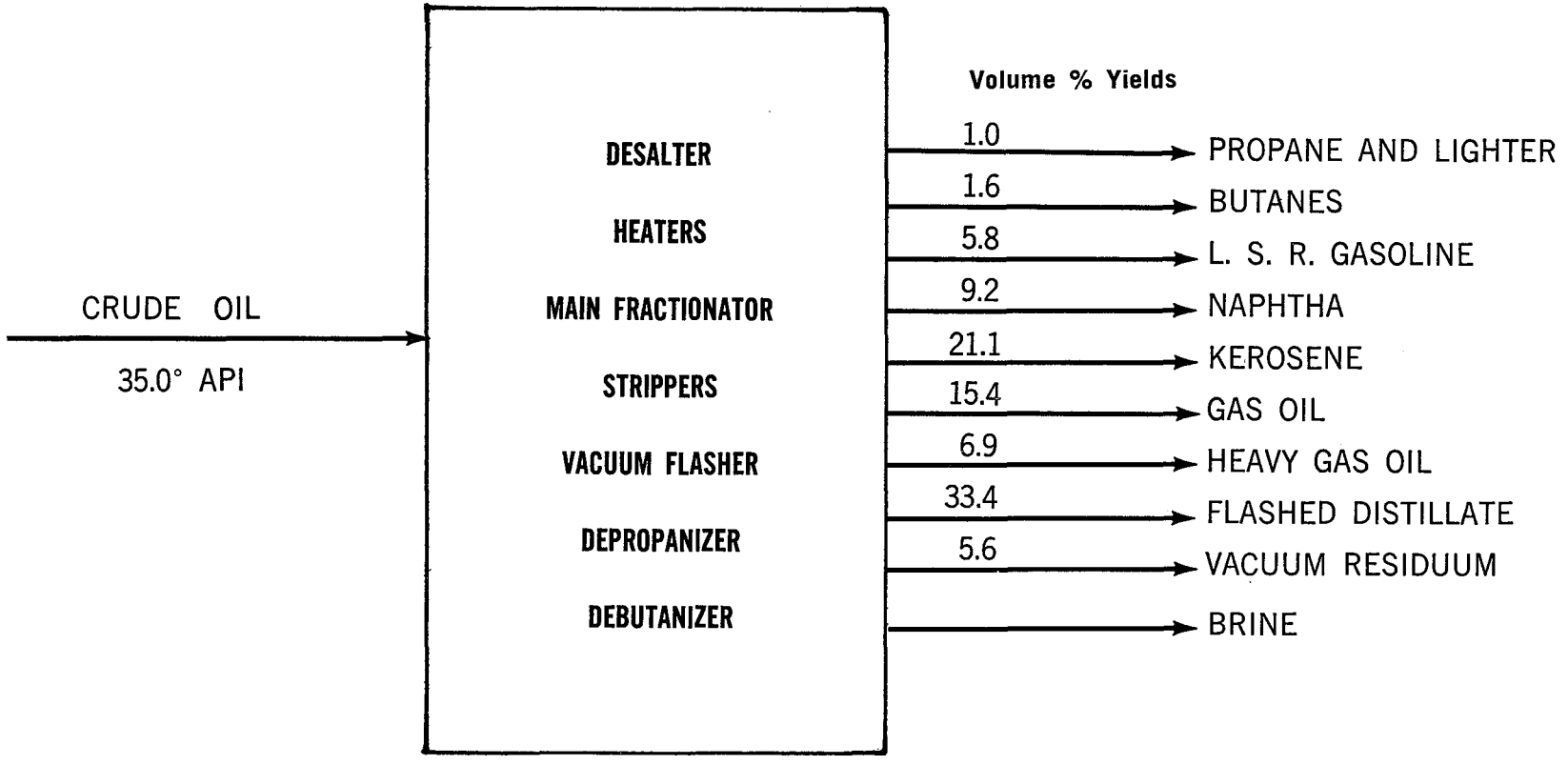
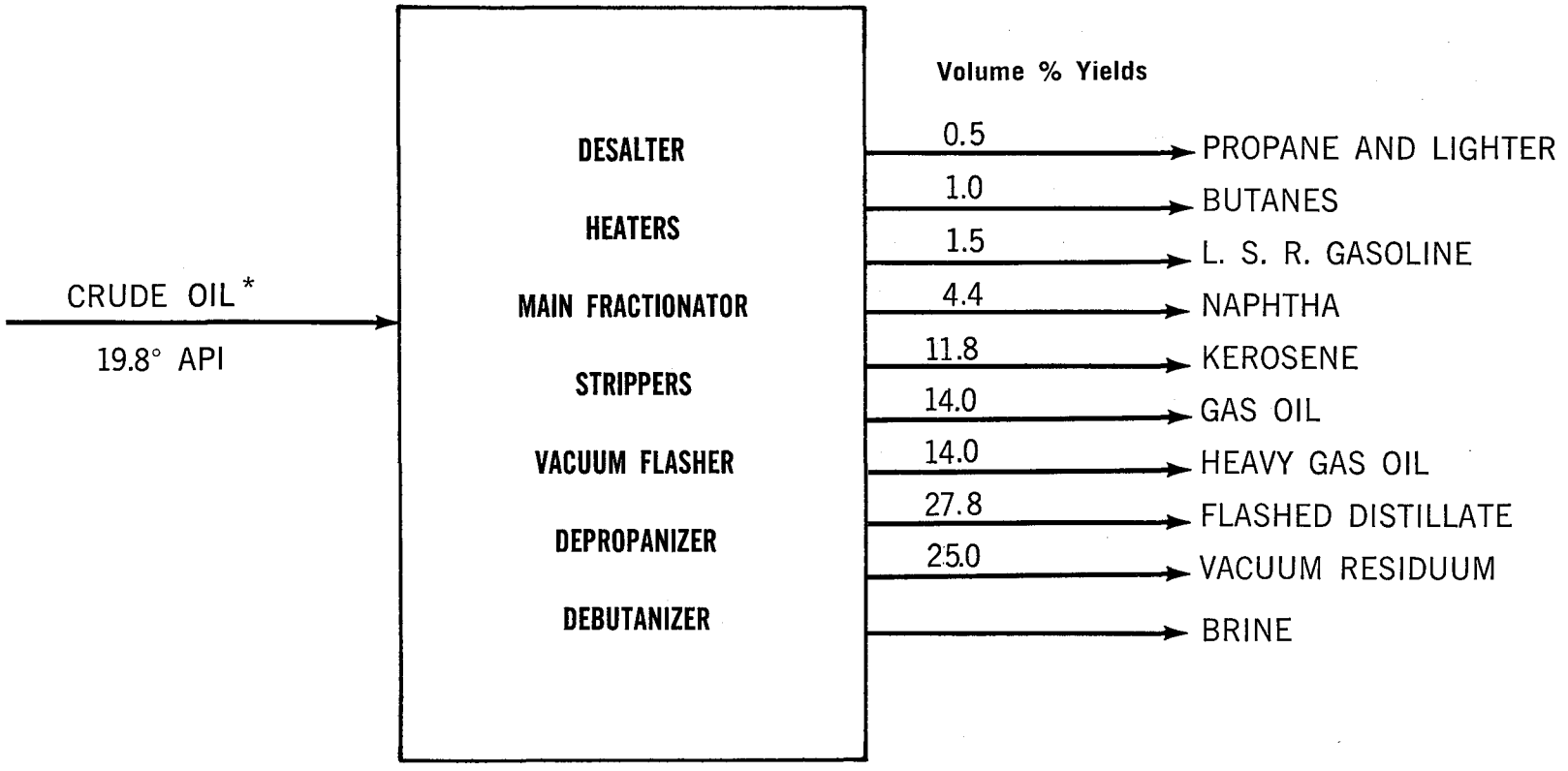


Diagram No. 1b

DESALTING/CRUDE DISTILLATION



*** Butanes and lighter content was increased consistent with including some light ends handling capacity during design step.**

Figure No. 1a

CRUDE AND VACUUM UNITS

Carbon Steel Requirements

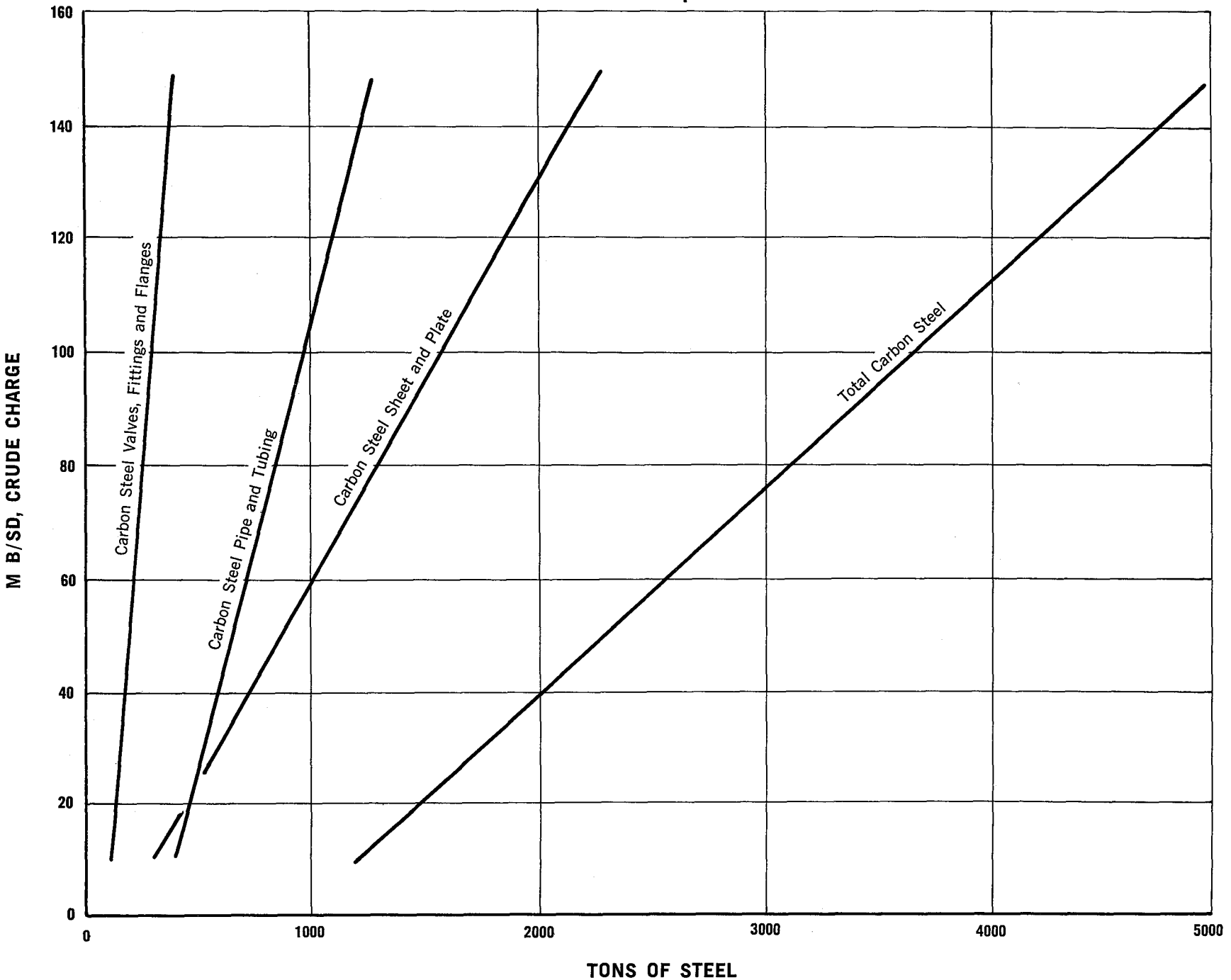
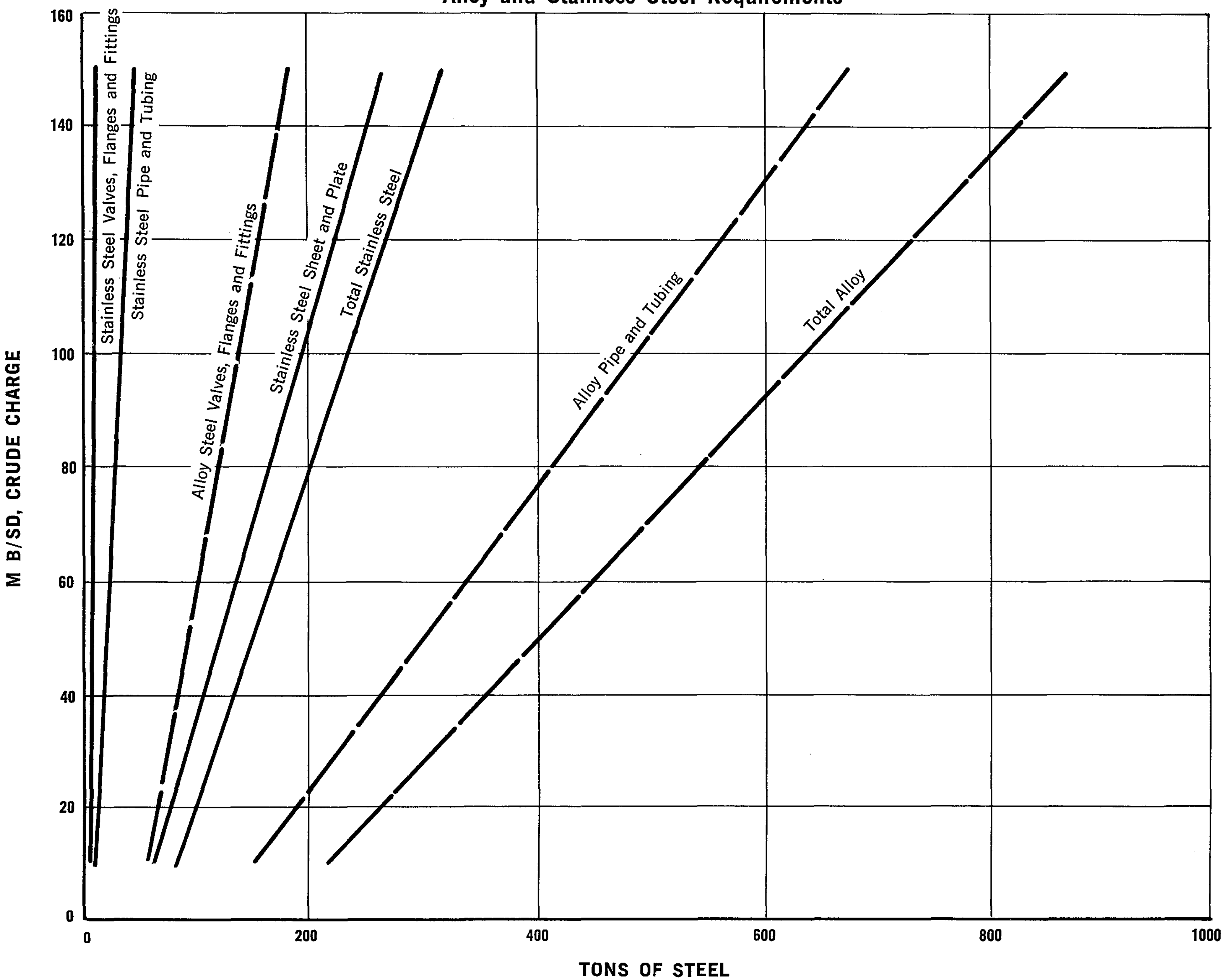


Figure No. 1b

CRUDE AND VACUUM UNITS

Alloy and Stainless Steel Requirements



CRUDE DISTILLATION (INCLUDING DESALTING, VACUUM AND STABILIZATION)

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD		
Crude Charge	10,000	75,000	150,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	300	1,200	2,300
(b) Pipe and tubing	400	850	1,300
(c) Valves, fittings and flanges	110	230	400
(d) Structural and other	400	760	1,200
(e) TOTAL	1,210	3,040	5,200
2. Alloy Steel (in tons)			
(a) Sheet and plate	-	-	-
(b) Pipe and tubing	170	375	710
(c) Valves, fittings and flanges	60	120	185
(d) Other	-	-	-
(e) TOTAL	230	495	895
3. Stainless Steel (in tons)			
(a) Sheet and plate	60	160	270
(b) Pipe and tubing	10	25	40
(c) Valves, fittings and flanges	5	10	15
(d) Other	-	-	-
(e) TOTAL	75	195	325

	UNIT CAPACITY B/SD		
Crude Charge	10,000	75,000	150,000
4. Copper			
(a) Wire and cable (in feet)			
(i) 600V, Single conductor (Size)			
12	70,000	88,000	100,000
10	25,000	40,000	60,000
8	10,000	20,000	50,000
6	3,000	5,000	7,000
4	5,000	8,000	15,000
2	4,000	10,000	18,000
1/0	500	800	1,000
2/0	2,000	3,000	4,000
3/0	1,000	1,800	2,000
4/0	2,000	3,500	4,000
250 MCM	2,000	5,000	6,000
300 MCM	800	1,500	2,000
350 MCM	1,500	2,700	3,000
500 MCM	-	-	100
(ii) 5KV, Single conductor (Size)			
4	1,200	2,000	2,500
2	2,000	3,000	3,500
1	-	-	-
1/0	-	-	-
2/0	-	-	2,200
3/0	1,000	1,400	-
4/0	-	-	-
250 MCM	-	-	800

Crude Charge	UNIT CAPACITY B/SD 10,000	75,000	150,000
(a) Wire and cable (cont'd.)			
(iii) 12KV, 3 conductor (Size)			
1/0	500	800	-
2/0	-	-	200
4/0	-	-	1,200
(b) Other (in tons)	12	15	20
5. Aluminum (in tons)	15	40	70
6. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
0-20	19	7	13
21-100	14	10	9
125	-	1	3
150	-	1	1
200	-	5	2
250	-	1	1
350	-	2	1
400	-	-	1
(b) Pumps and turbines (HP)			
500	-	2	-
600	-	-	2
1,200	-	-	1
(c) Miscellaneous drivers (HP)			
Fans and motors			
0-20	22	14	26
21-100	-	14	22

Crude Charge	UNIT CAPACITY B/SD 10,000	75,000	150,000
7. Electrical (number and type)			
(a) Transformers			
13,800/480V	1-1,000KVA	3-1,000KVA	4-1,000KVA
13,800/4160V	-	1-1,500KVA	1-3,750KVA
480/120V	1-10KVA	2-30KVA	3-30KVA
(b) Switchgear (cubicles)			
13,800V	-	4	6
(c) Motor control centers			
480V	1	3	4

	UNIT CAPACITY B/SD 10,000	75,000	150,000
8. Instrumentation (number)			
(a) Temperature transmitters	9	12	15
(b) Pressure indicators	17	21	23
(c) Flow transmitters	55	70	74
(d) Level instruments	15	15	15
(e) Local controllers	13	17	21
(f) Temperature elements	200	250	300
(g) Pressure elements	125	150	175
(h) Flow elements	12	12	12
(i) Level gauges	30	30	30
(j) Solenoid valves	10	13	15
(k) Control valves	60(1½-3")	80(2-6")	90(3-10")

Crude Charge	UNIT CAPACITY B/SD 10,000	75,000	150,000
8. Instrumentation (cont'd.)			
(l) Relief valves	5	8	8
(m) Multipoint temperature recorders	2	4	4
(n) Receiver controllers	55	80	85
(o) Receiver recorders	40	50	55
(p) Receiver indicators	5	8	9
(q) Alarm switches	20	30	40

CRUDE DISTILLATION (INCLUDING DESALTING, VACUUM AND STABILIZATION)

C. UTILITY REQUIREMENTS

Crude Charge	UNIT CAPACITY B/SD 10,000	75,000	150,000
1. Electricity (KVA)	465	3,500	7,000
2. Fuel Gas (SCFH)	52,000	390,000	780,000
3. Cooling Water (GPM)	670	5,000	10,000
4. Steam (lbs./hour)	9,600	72,000	144,000
5. Air (CFM)			
(a) Instrument air	100	200	300
(b) Plant air	200	400	500

SECTION 2

CATALYTIC REFORMING AND FEED PREPARATION

SECTION 2

CATALYTIC REFORMING AND FEED PREPARATION

A. DESCRIPTION AND ASSUMPTIONS

This study includes estimates of critical material for fixed bed non-regenerative type catalytic reforming units with hydrotreating of feed stock. The study considers units in capacity range from 5,000 to 40,000 B/SD of straight run, catalytic, or coker naphthas of a 200°F to 400°F ASTM boiling range. Debutanization and rerun columns are included for the stabilized light reformate (338°F - 380°F ASTM end point), and stabilized heavy reformate (410°F - 430°F ASTM end point).

This estimate, as prepared, includes corrosion protection consistent with present-day refinery practice. This assumes the normal variation in corrosion characteristics of the feed. However, if a controlled feed stock can be assured, or if on-stream efficiency can be sacrificed, a limited substitution of carbon steel for alloy steel is possible in the feed preparation section of this unit.

Diagram No. 2

CATALYTIC REFORMER WITH HYDROTREATER

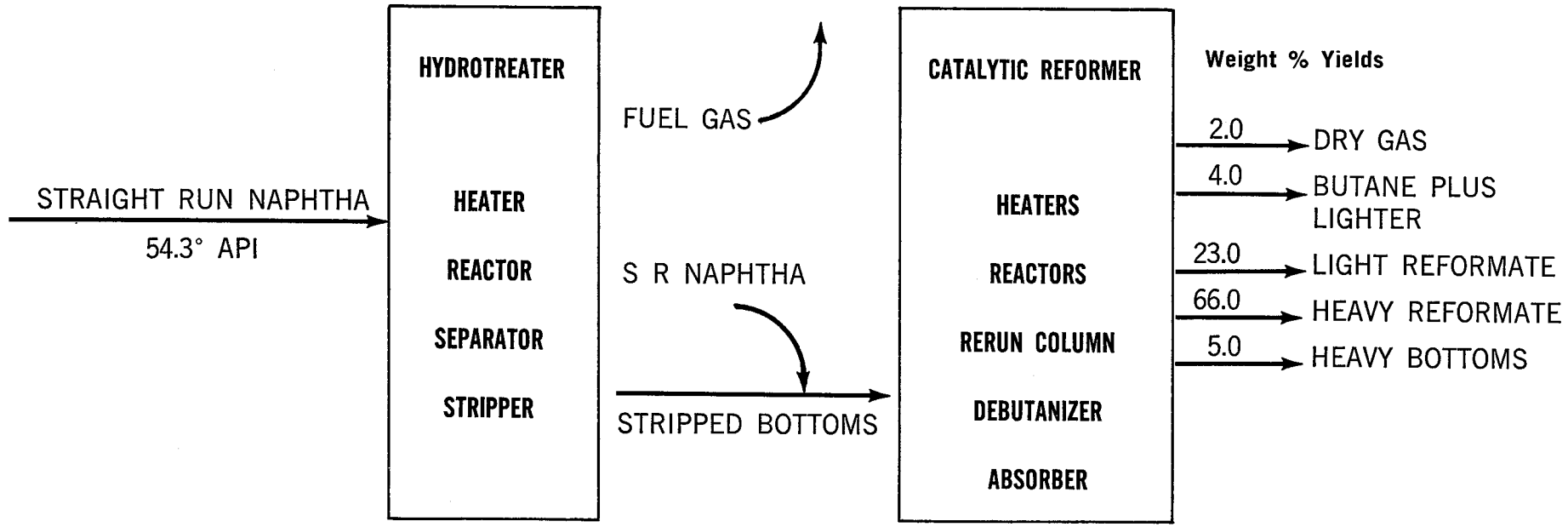
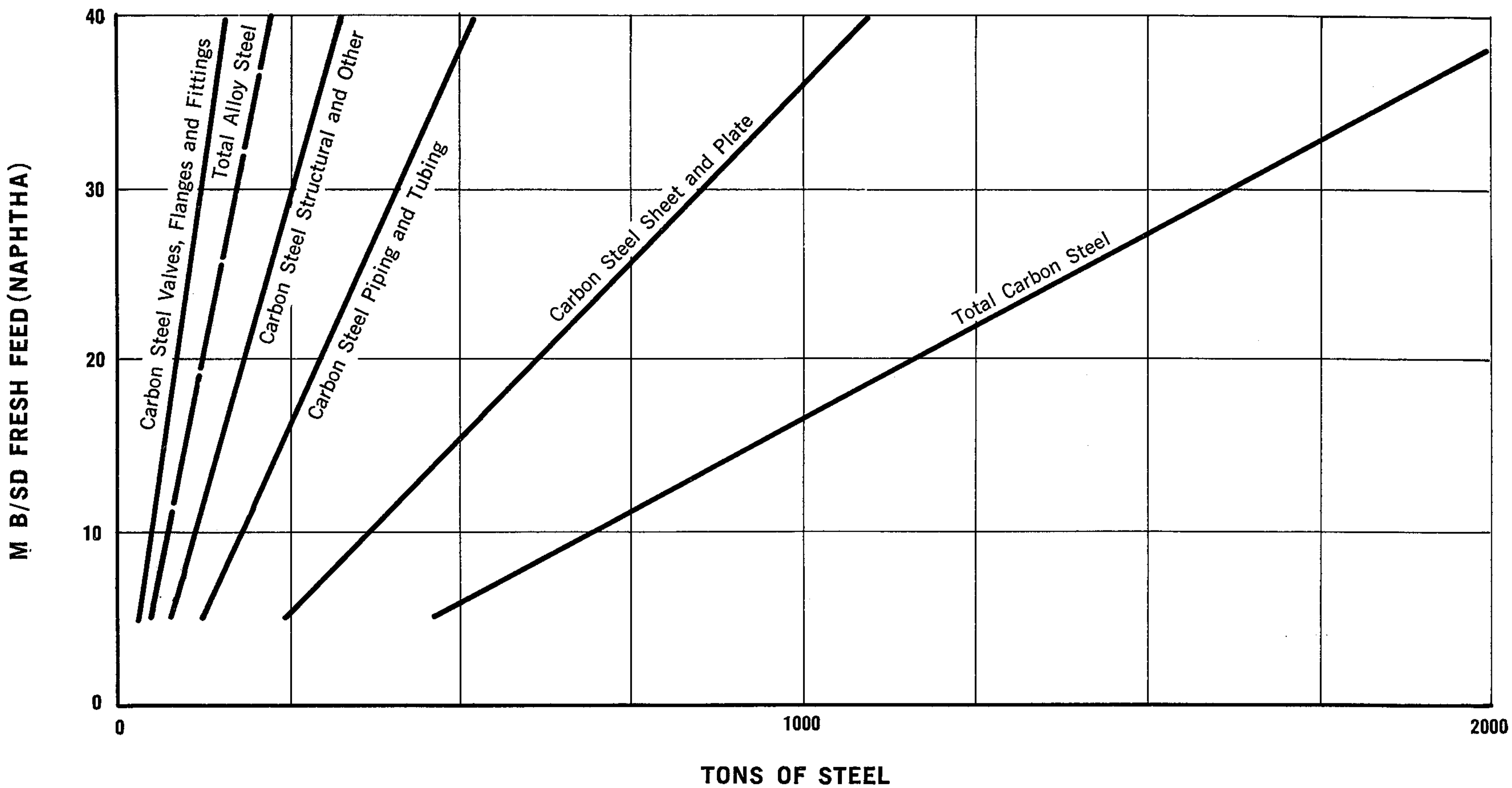


Figure No. 2

CATALYTIC REFORMER

Carbon and Alloy Steel Requirements



B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	40,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	240	625	1,100
(b) Pipe and tubing	120	280	520
(c) Valves, fittings and flanges	32	73	130
(d) Structural and others	76	187	330
(e) TOTAL	468	1,165	2,090
2. Alloy Steel (in tons)			
(a) Sheet and plate	-	-	-
(b) Pipe and tubing	49	126	220
(c) Valves, fittings and flanges	5	14	20
(d) Other	-	-	-
(e) TOTAL	54	140	240
3. Copper			
(a) Wire and cable (in feet)			
(i) 600V, Single conductor (Size)			
12	50,000	80,000	90,000
10	15,000	25,000	28,000
8	6,000	10,000	13,000
6	2,000	2,500	3,000
4	3,000	4,000	5,000

Fresh Feed	UNIT CAPACITY B/SD 5,000	20,000	40,000
(a) Wire and cable (cont'd.)			
(i) 600V, Single conductor (Size) (cont'd.)			
2	3,500	5,000	6,000
1/0	3,000	4,000	4,500
2/0	2,000	2,500	3,000
3/0	1,000	1,200	1,500
4/0	800	1,500	1,500
250 MCM	1,800	2,300	2,300
300 MCM	500	500	500
400 MCM	1,000	1,300	1,300
(ii) 5KV, Single conductor (Size)			
4	1,000	1,200	1,200
1	1,000	1,200	1,200
3/0	1,000	1,200	1,200
(iii) 15KV, 3 conductor (Size)			
350 MCM	500	1,000	1,000
(b) Other (in tons)			
Admiralty metal tubing	19	49	72
4. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
0-20	9	8	10
21-100	9	9	8
125-200	2	5	4
250-500	1	2	4

Fresh Feed	UNIT CAPACITY B/SD		
	5,000	20,000	40,000
(b) Compressors and drivers (HP)			
Turbines			
2,000-3,000	1	-	-
3,000-3,500	-	1	1

	UNIT CAPACITY B/SD		
	5,000	20,000	40,000
5. Electrical (number and type)			
(a) Transformers			
13,800/4,160V	-	-	1-3,500KVA
13,800/2,400V	1-2,000KVA	1-3,000KVA	-
4,160/480V	1-1,500KVA	1-1,500KVA	1-1,500KVA
480/240V	2-100KVA	3-100KVA	4-100KVA
(b) Switchgear			
2,400V	1	-	-
4,160V	-	1	1
(c) Motor control centers	1	2	3

	UNIT CAPACITY B/SD		
	5,000	20,000	40,000
6. Instrumentation (number)			
(a) Temperature elements	75	130	170
(b) Pressure elements	100	370	480
(c) Flow elements	34	43	60
(d) Level instruments	16	28	35

Fresh Feed	UNIT CAPACITY B/SD 5,000	20,000	40,000
6. Instrumentation (cont'd.)			
(e) Temperature transmitters	4	9	12
(f) Flow transmitters	30	40	60
(g) Pressure controllers	4	7	10
(h) Local controllers	4	4	6
(i) Controllers	53	68	90
(j) Multipoint temperature recorders	3	6	8
(k) Recorders	4	4	6
(l) Indicators	4	4	6
(m) Alarm switches	16	20	30
(n) Level gauges	18	31	55
(o) Control valves	40	55	75
(p) Solenoid valves	2	4	6
(q) Pressure relief valves	20	38	50

CATALYTIC REFORMING AND FEED PREPARATION

C. UTILITY REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	40,000
1. Electricity (KVA)	1,400	2,300	2,800
2. Fuel Gas (SCFH)	85,000	310,000	610,000
3. Cooling Water (GPM)	2,600	9,900	19,200
4. Steam (lbs./hour)	2,300	8,000	15,500
5. Air (CFM)			
(a) Instrument air	90	120	150
(b) Plant air	800	800	800

D. INITIAL FILL CATALYSTS

Fresh Feed	UNIT CAPACITY B/SD 5,000	20,000	40,000
1. Hydrotreater - Catalyst required Type: Cobalt-Molybdenum (cubic feet)	410	1,860	3,400
2. Catalytic Reformer - Catalyst required Type: Platinum (cubic feet)	575	2,550	4,800

SECTION 3

CATALYTIC CRACKING

SECTION 3(a)

CATALYTIC CRACKING

A. DESCRIPTION AND ASSUMPTIONS

For the purpose of this estimate, materials requirements are shown for fluid type of catalytic cracking units of capacity of 10,000, 35,000 and 60,000 barrels per stream day fresh feed.

The units are of the side-by-side type construction rather than stacked. Included is a gas plant capable of 75% recovery of propane with separation of propane and butane, gasoline stabilization and caustic treating. Provision is made for sour water stripping facilities.

This estimate is prepared on the basis of a typical unit such as would be constructed in peace time. In case of emergency, some of the alloy material could be replaced with heavier carbon steel consistent with corrosive characteristics of feedstock, increased downtime and maintenance costs.

The unit is designed for a 2% sulfur fresh feed with a boiling range from Diesel Oil to near Asphalt such as may be produced from a Smackover type crude.

Materials for a fresh feed heater and a CO Boiler are estimated separately in Sections 3b and 3c and may be added to this unit. They would normally be incorporated in a peace-time unit.

Diagram No. 3

CATALYTIC CRACKING UNIT

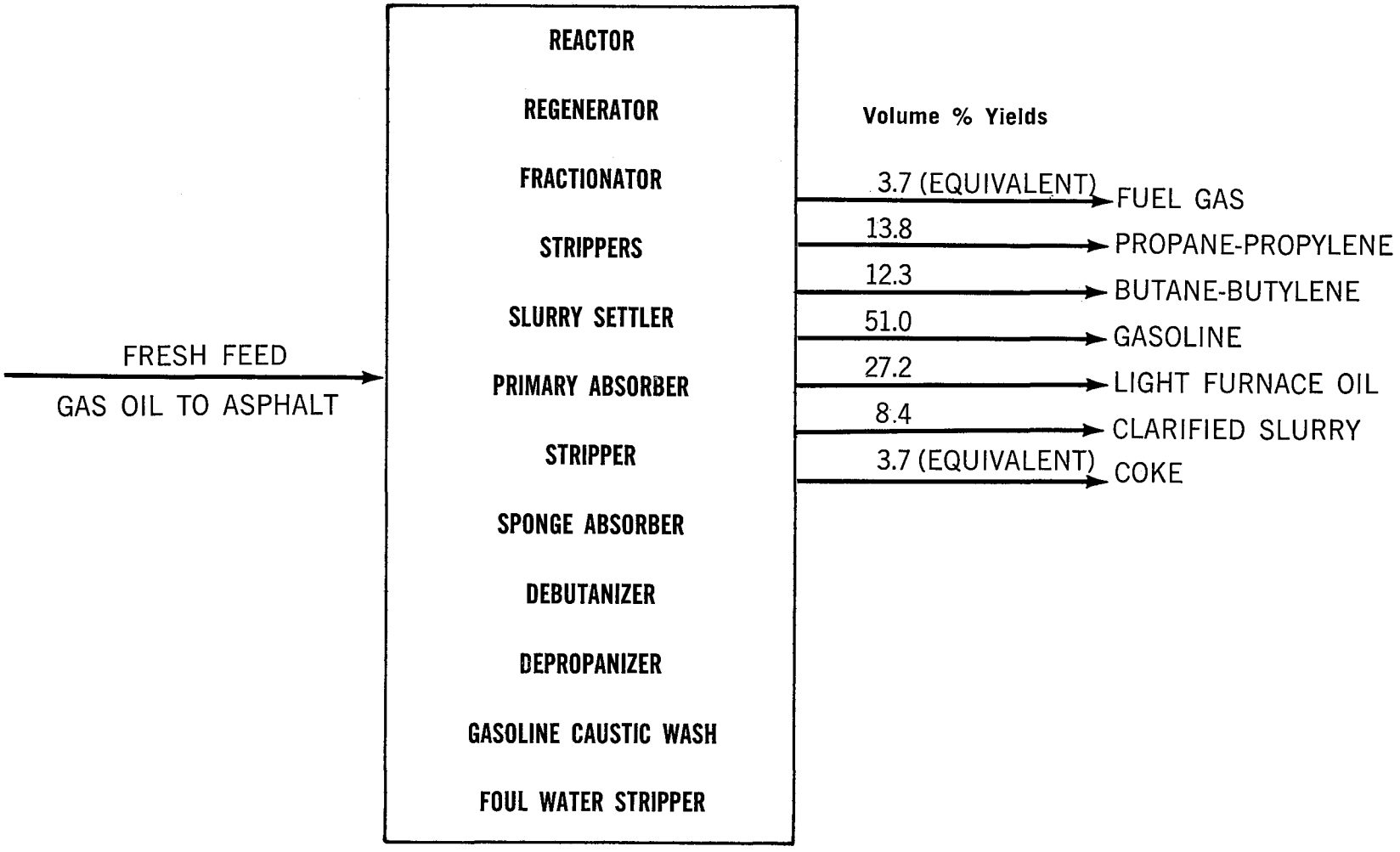


Figure No. 3-a-1

FLUID CATALYTIC CRACKING UNITS

Carbon Steel Requirements

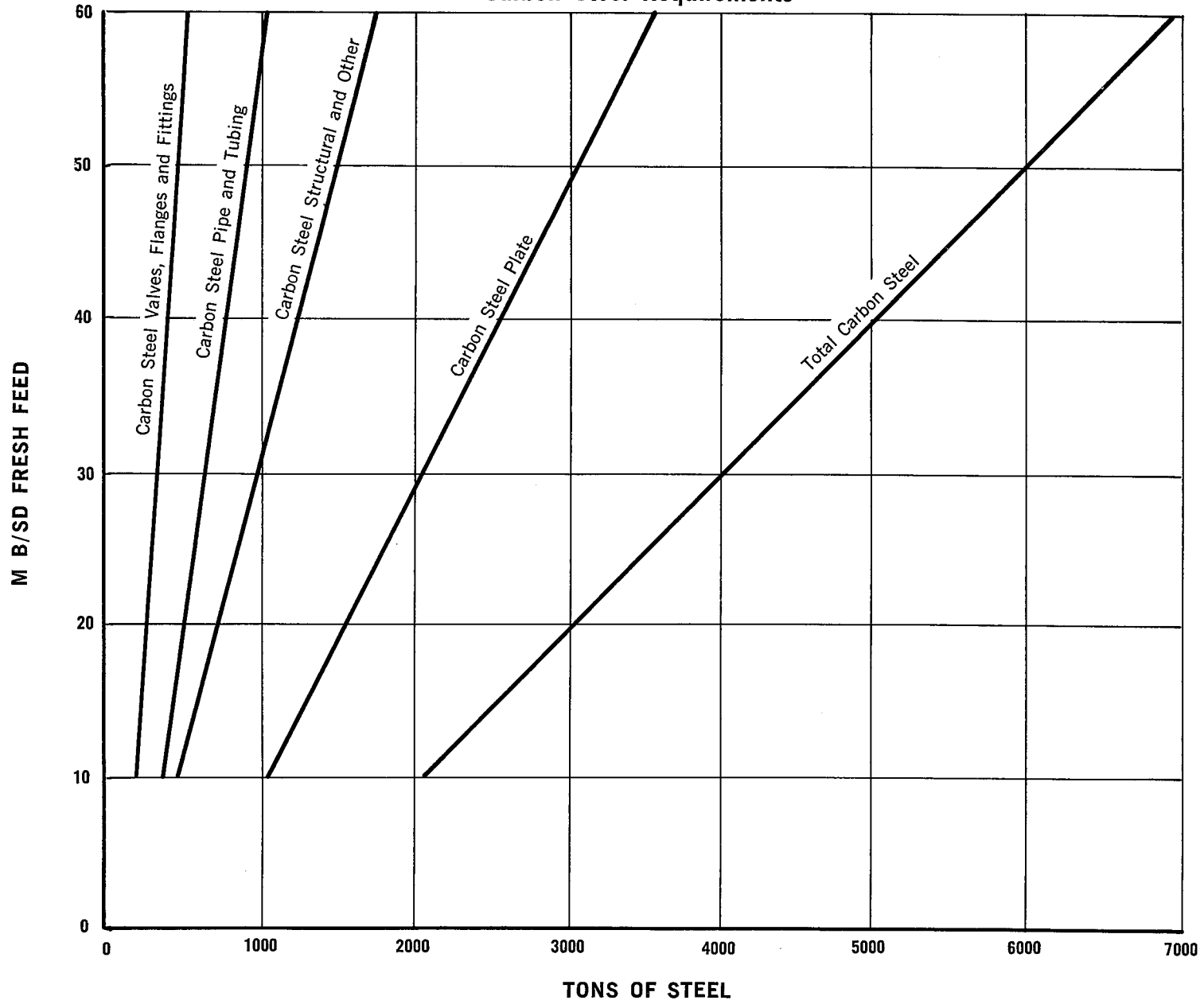
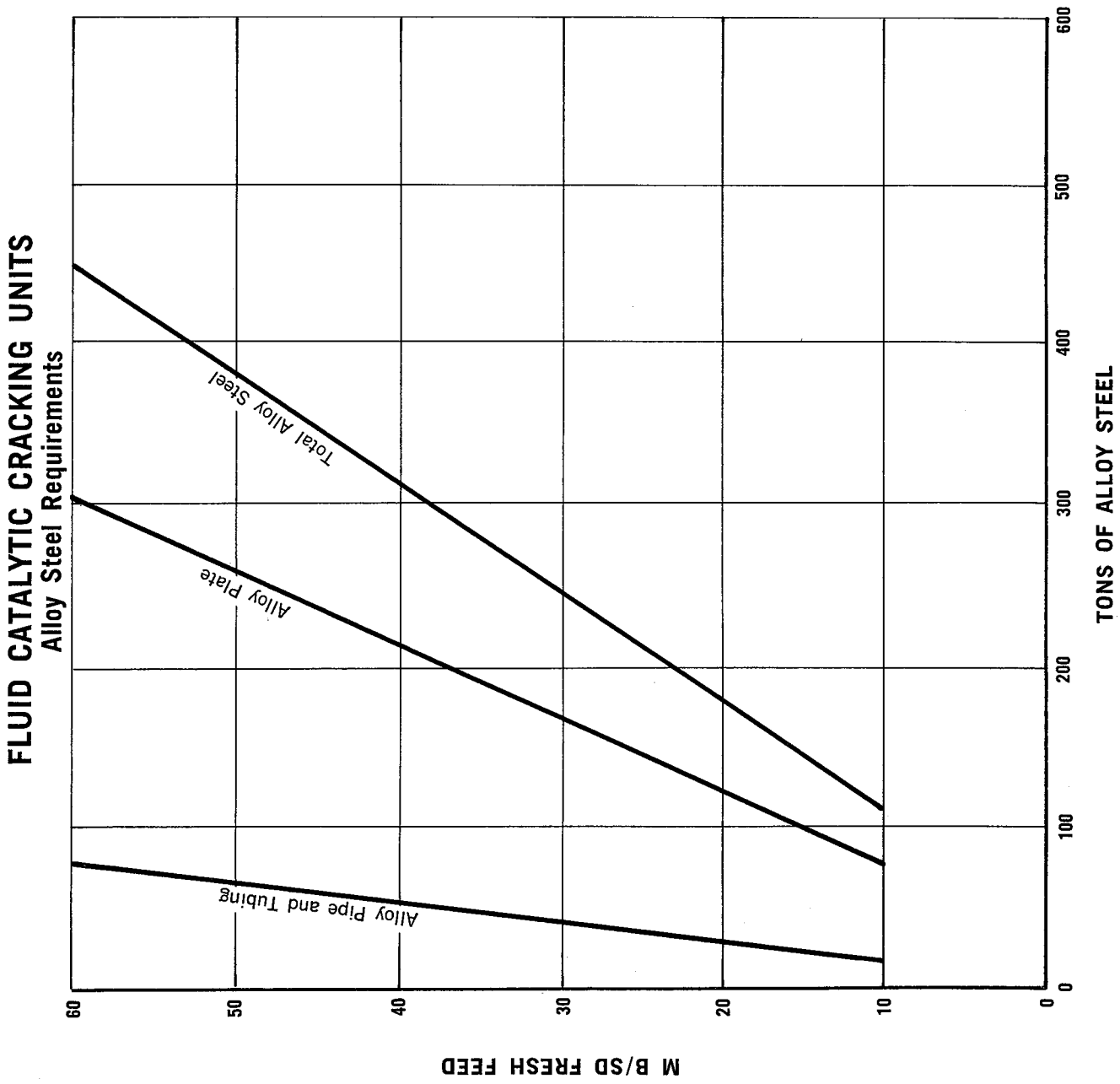


Figure No. 3-a-2



CATALYTIC CRACKING

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	35,000	60,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	1,060	2,315	3,625
(b) Pipe and tubing	368	750	1,085
(c) Valves, fittings and flanges	187	350	550
(d) Structural and others	480	1,100	1,726
(e) TOTAL	2,095	4,515	6,986
2. Alloy Steel (in tons)			
(a) Sheet and plate	80	193	306
(b) Pipe and tubing	16	48	80
(c) Valves, fittings and flanges	5	10	15
(d) Other	12	31	50
(e) TOTAL	113	282	451
3. Stainless Steel (in tons)			
(a) Sheet and plate	95	192	290
(b) Pipe and tubing	-	-	-
(c) Valves, fittings and flanges	-	-	-
(d) Other	-	-	-
(e) TOTAL	95	192	290

Fresh Feed	UNIT CAPACITY B/SD 10,000	35,000	60,000
4. Copper			
(a) Wire and cable (in feet)			
(i) 600V, Single conductor (Size)			
12	75,800	66,200	65,200
10	3,600	1,200	-
8	12,000	1,200	2,400
6	12,000	1,200	-
4	10,800	-	-
3	-	2,400	-
2	7,200	-	2,400
0	4,800	10,800	2,400
3/0	8,750	3,600	4,000
4/0	-	9,600	6,000
300 MCM	-	2,400	8,400
(ii) 6KV, Single conductor (Size)			
8	-	9,600	10,800
6	-	4,800	6,000
4	-	-	-
2	-	-	9,600
(iii) Instrument control cable			
a) No. 20 multi-conductor control cable (single wire)	200,000	200,000	200,000
b) Thermocouple lead wire - I/C	30,000	30,000	30,000
(b) Other (in tons)	54	100	145

Fresh Feed	UNIT CAPACITY B/SD 10,000	35,000	60,000
5. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
0-20	10	4	3
21-100	20	11	4
125	-	5	3
150	-	2	4
200	-	2	6
250	-	2	1
300	-	2	3
350	-	2	-
500	-	-	6
(b) Compressors and drivers (HP)			
Condensing turbines			
(i) Air blower	4,150	14,500	24,500
(ii) Wet gas compressor	2,110	7,500	12,500

	UNIT CAPACITY B/SD 10,000	35,000	60,000
6. Electrical (number and type)			
(a) Transformers (3 ø)			
13,800/4,160V	-	1-1,500KVA	1-5,000KVA
13,800/480V	1-1,000KVA	1-1,500KVA	1-1,500KVA
4,160/120V	1-150KVA	1-150KVA	1-150KVA
(b) Switchgear (cubicles)	2	3	3
(c) Motor control centers	1	2	2

Fresh Feed	UNIT CAPACITY B/SD 10,000	35,000	60,000
7. Instrumentation (number)			
(a) Temperature transmitters	10	10	10
(b) Pressure indicators	120	120	120
(c) Flow transmitters	35	35	35
(d) Level instruments	33	33	33
(e) Local controllers	10	10	10
(f) Temperature elements, thermocouple	70	70	70
(g) Pressure elements	20	20	20
(h) Flow elements	45	45	45
(i) Level gauges	50	50	50
(j) Control valves 1½" to 3"	72	60	30
(k) Control valves 4" to 6"	3	10	25
(l) Control valves 8" and over	-	5	20
(m) Relief valves	35	35	35
(n) Multipoint temperature recorders	2	2	2
(o) Receiver controllers	69	69	69
(p) Receiver recorders	22	22	22
(q) Receiver indicators	7	7	7
(r) Alarm switches	1 panel	1 panel	1 panel
(s) Transducers MV/air	100	100	100
(t) Flow indicators	10	10	10
(u) Thermometers	40	40	40

CATALYTIC CRACKING

C. UTILITY REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	35,000	60,000
1. Electricity (KVA)	1,020	2,950	5,060
2. Cooling Water (GPM)	11,520	40,300	68,750
3. Steam (lbs./hour)	112,100	393,000	690,000
4. Air (CFM)			
(a) Instrument air	150	150	150
(b) Plant air	200	200	200

CATALYTIC CRACKING

D. INITIAL FILL CATALYSTS

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	35,000	60,000
1. Equilibrium Catalyst (in tons)			
(for plant fill)	90	310	540
2. New Catalyst (in tons)			
(for inventory)	200	700	1,200

SECTION 3(b)

DIRECT FIRED, FRESH FEED HEATER FOR CATALYTIC CRACKING

A. DESCRIPTION AND ASSUMPTIONS

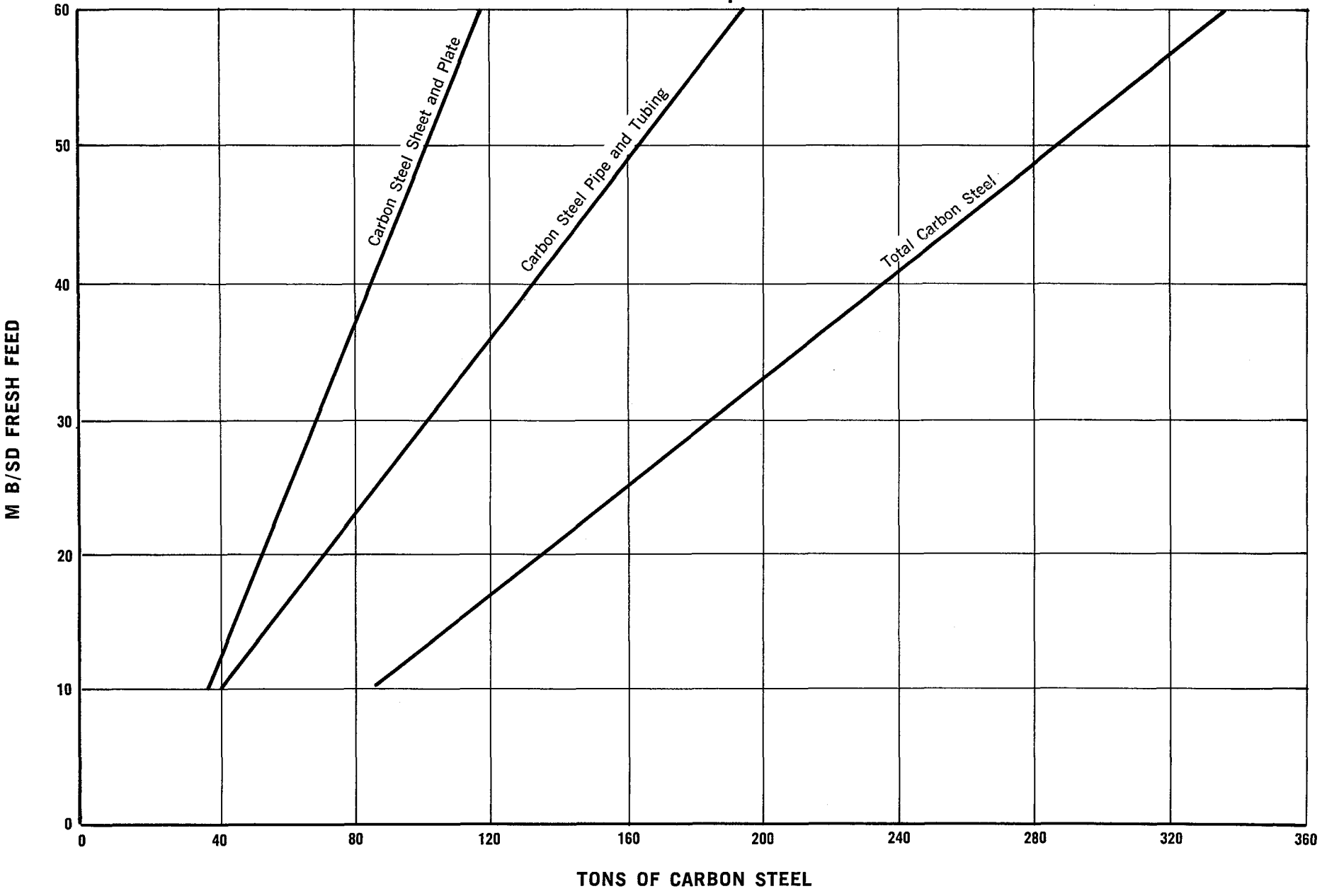
The heater, for the purposes of this estimate, is an upright gas fired unit designed to heat FCC feedstock taken from storage. Heater duty is calculated on a basis of oil in storage at 150°F and a 550°F feed to the FCC unit. No vaporization of the feedstock is assumed in these estimates.

For any capacity catalytic cracking unit within the range studied to which the feed is under typical storage conditions, a net savings of critical materials may be effected by the addition of a fresh feed heater.

Figure No. 3b

DIRECT FIRED FRESH FEED HEATER FOR FCC UNIT

Carbon Steel Requirements



B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	35,000	60,000
Heat Absorption Required (M Btu/hour)	30,000	105,000	180,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	38	78	118
(b) Pipe and tubing	40	115	190
(c) Valves, fittings and flanges	-	-	-
(d) Structural and others	5	18	31
(e) TOTAL	83	211	339
2. Stainless Steel (in tons)			
Other (castings)	3	5	8
3. Copper			
Wire and cable (in feet)			
Instrument control cable			
a) No. 20 multiconductor control cable (single wire)	1,600	3,600	6,000

Fresh Feed	UNIT CAPACITY B/SD 10,000	35,000	60,000
4. Instrumentation (number)			
(a) Temperature transmitters	3	4	6
(b) Flow transmitters	1	2	4
(c) Temperature elements	3	4	6
(d) Flow elements	1	2	4
(e) Control valves 1½" to 3"	1	2	4
(f) Control valves 4" to 6"	-	1	1
(g) Relief valves	1	2	2
(h) Multipoint temperature recorders	1	1	1
(i) Receiver controllers	2	3	5
(j) Receiver recorders	-	1	3
(k) Alarm switches	1 panel	1 panel	1 panel

DIRECT FIRED, FRESH FEED HEATER FOR CATALYTIC CRACKING

C. UTILITY REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	35,000	60,000
1. Fuel Gas (SCFH)	43,000	150,000	260,000

SECTION 3(c)

CO BOILER FOR CATALYTIC CRACKING

A. DESCRIPTION AND ASSUMPTIONS

CO Boiler as described below would normally be added to FCC Unit for efficient peace-time operation.

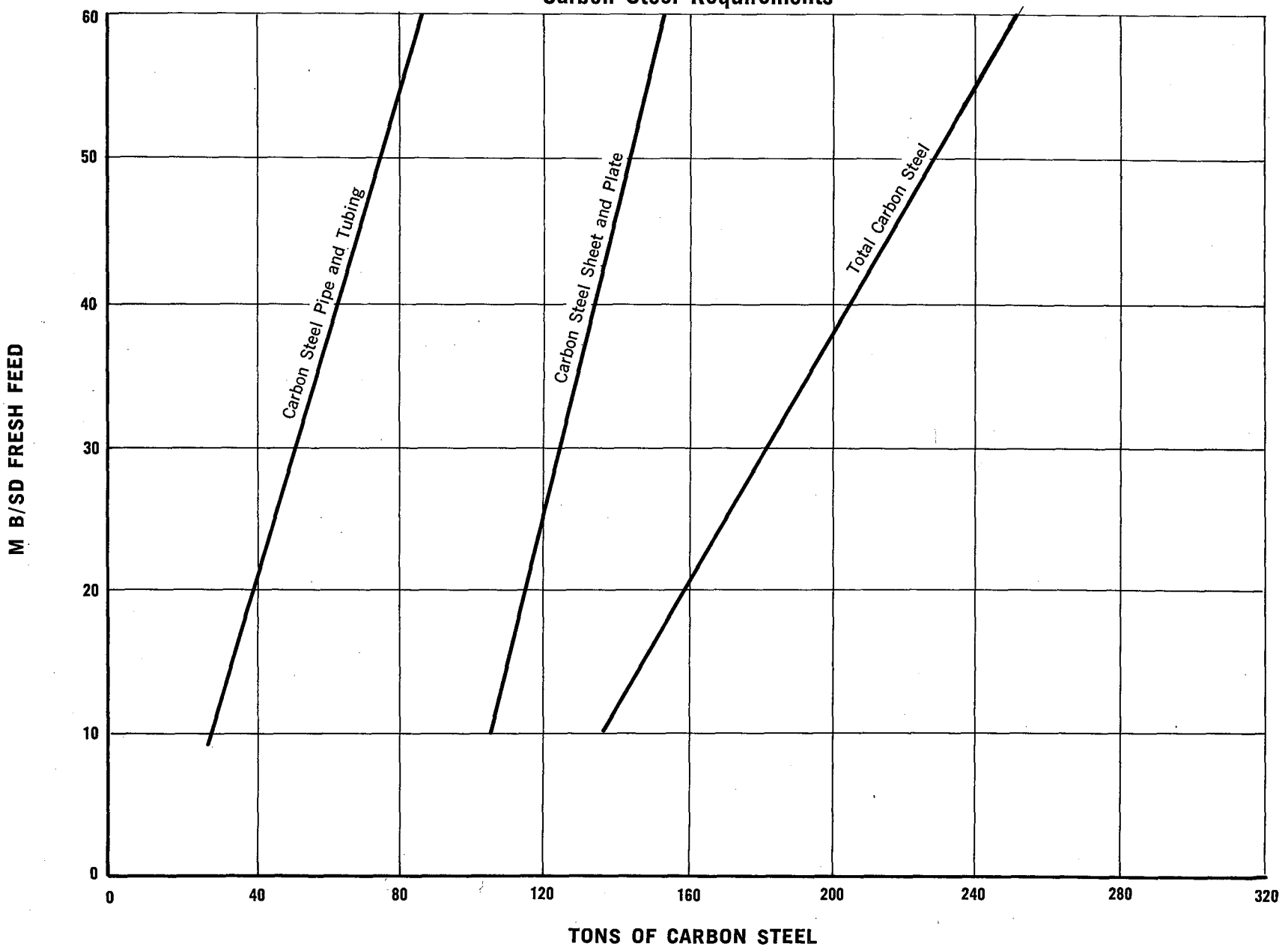
Ten percent of the indicated steam generated is from outside fuel.

Steel plate has been included for the ducts from the flue gas slide valves to the boiler and from the outlet of the boiler to the stack and for the stack.

Figure No. 3c

CO BOILER FOR FCC UNIT

Carbon Steel Requirements



CO BOILER FOR CATALYTIC CRACKING

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	35,000	60,000
Steam Generated (lbs./hour)	41,000	145,000	243,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	106	130	155
(b) Pipe and tubing	28	58	88
(c) Valves, fittings and flanges	1	2	2
(d) Structural and others	2	5	8
(e) TOTAL	137	195	253
2. Alloy Steel (in tons)			
Sheet and plate	5	10	15
3. Copper			
Wire and cable (in feet)			
a) 600V, Single conductor (Size)			
12	1,200	1,200	1,200
2	1,200	-	-
b) 6KV, Single conductor (Size)			
8	-	1,200	-
6	-	-	1,200

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	35,000	60,000
4. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
21-100	1	-	-
200	-	1	-
300	-	-	1
(b) Miscellaneous drivers (HP)			
Forced draft fan			
21-100	1	-	-
175	-	1	-
300	-	-	1
5. Electrical (number and type)			
(capacity included in catalytic cracking unit)			
6. Instrumentation (number)			
(a) Pressure indicators	2	2	2
(b) Flow transmitters	5	5	5
(c) Level instruments	1	1	1
(d) Pressure elements	4	4	4
(e) Flow elements	5	5	5
(f) Level gauges	2	2	2
(g) Control valves	3	3	3
(h) Relief valves	2	3	3
(i) Receiver controllers	3	3	3
(j) Receiver recorders	12	12	12
(k) Receiver indicators	2	2	2
(l) Alarm switches	1 panel	1 panel	1 panel
(m) Flameguards	1	1	1

CO BOILER FOR CATALYTIC CRACKING

C. UTILITY REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	35,000	60,000
1. Electricity (KVA)	53	155	265
2. Fuel Gas (SCFH)	5,000	15,000	25,000
3. Boiler Feed Water (GPM)	90	300	540

SECTION 4

DELAYED COKING

SECTION 4

DELAYED COKING

A. DESCRIPTION AND ASSUMPTIONS

1. Coking units sized from 2,500 B/SD to 35,000 B/SD feed were studied. Coking units sized from 5,000 B/SD to 35,000 B/SD have been reported herein. It is assumed sizes smaller than 5,000 B/SD (e.g. 2,500 B/SD coke with 10,000 B/SD crude unit) would not be too practical and the crude bottoms would be blended off as fuel or be used as asphalt feed stock.

2. In view of the extremely low con. carbon in the 35.2° API crude and the approximate 20% residual fuel production desired, no coking units were included for the light crude.

3. The alloy protection included gives coverage for a life at least in excess of five years. No differentiation for total quantities of alloy and stainless has been made between the sweet and sour crude cases. In either case, the feed to the coking unit would undoubtedly be high enough in sulfur to warrant stainless lining of the coke drums and bottom of the fractionator, plus alloy tubing and piping in the heater system.

   Dependent on sulfur levels, run lengths required, availability of materials and nature of the emergency, cutbacks could be made in alloy and stainless requirements with a resultant increase in carbon steel for additional corrosion allowance. However, an essentially all-carbon steel unit with high sulfur feed could be a less than six months unit.

4. Convective section coking heater steam generation is included to provide sufficient steam to drive the large horsepower requirement decoking water pump. A surface condenser and auxiliaries are included in this system. The unit will be balanced or a net steam producer. All other drives are motor.

5. Gamma ray level instruments and silicone injection have been included to minimize outages thereby reducing material requirements for the coke drums.

6. The coke handling system includes drag line bucket, storage area, reused water basins and storage. However, the overall tonnages of critical materials would not vary significantly if other commonly used handling methods were employed.

Diagram No. 4

DELAYED COKING UNIT

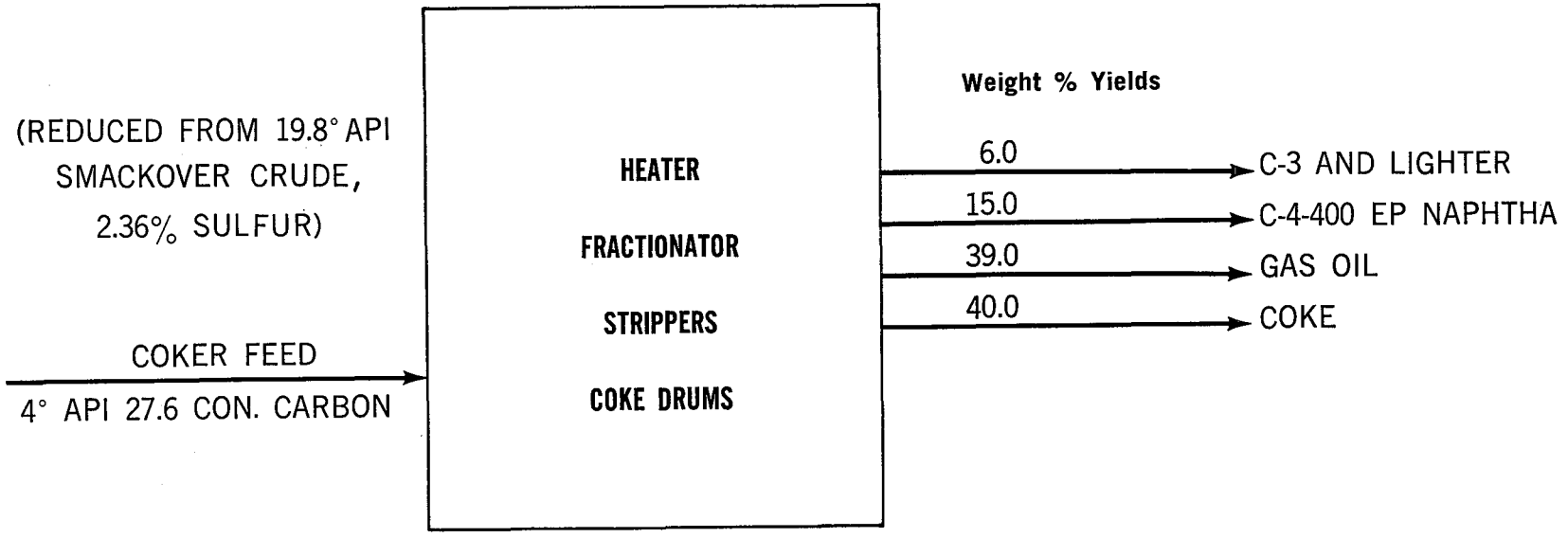
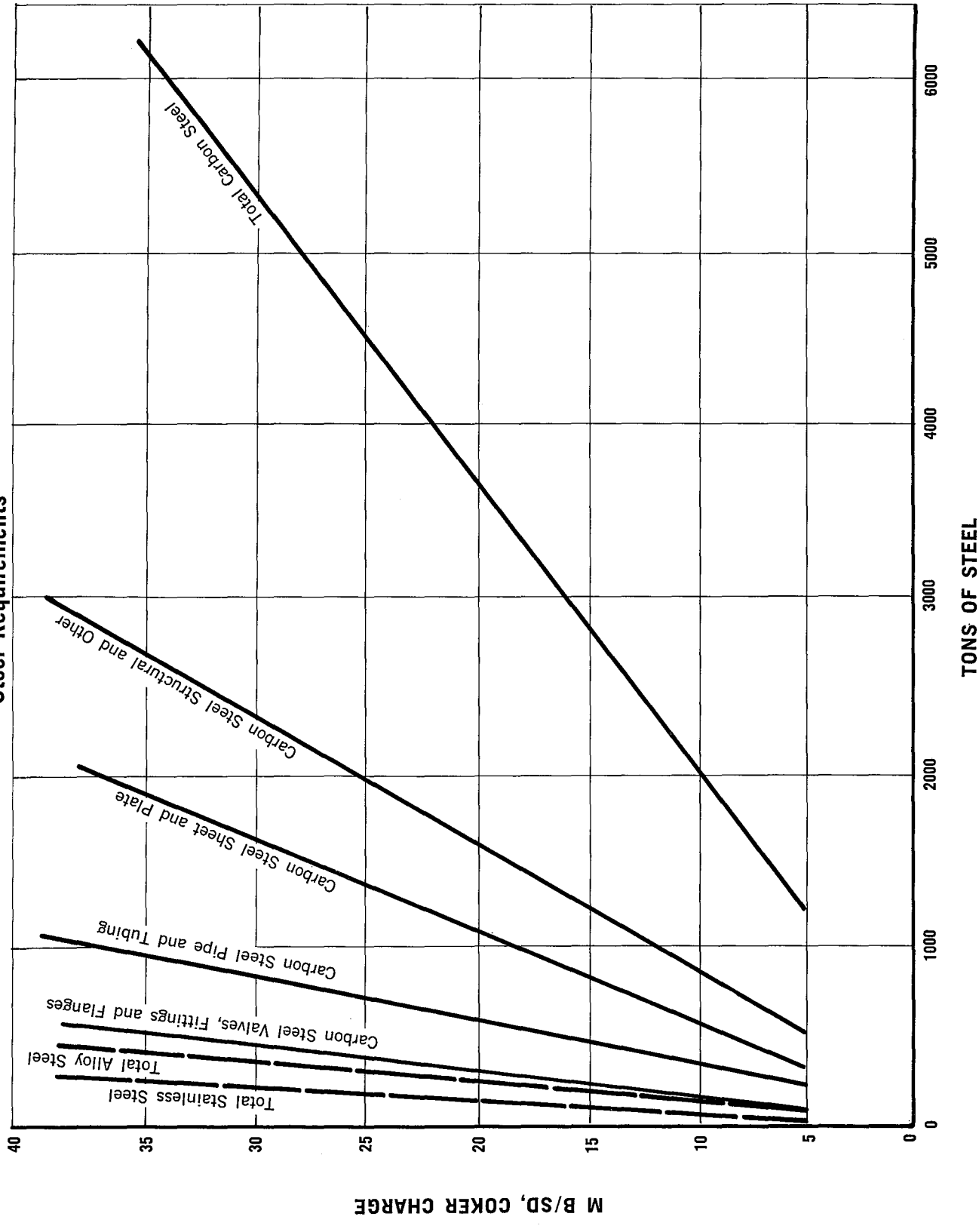


Figure No. 4

COKING UNIT

Steel Requirements



DELAYED COKING

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	35,000
Coke (tons/sd)	365	1,460	2,560
1. Carbon Steel (in tons)			
(a) Sheet and plate	330	1,155	1,930
(b) Pipe and tubing	242	607	946
(c) Valves, fittings and flanges	116	300	470
(d) Structural and others	500	1,650	2,750
(e) TOTAL	1,188	3,712	6,096
2. Alloy Steel (in tons)			
(a) Sheet and plate	-	-	-
(b) Pipe and tubing	73.5	210	343
(c) Valves, fittings and flanges	21.5	55	87.5
(d) Other	2.5	7.5	12.5
(e) TOTAL	97.5	272.5	443.0
3. Stainless Steel (in tons)			
(a) Sheet and plate	46	143	227
(b) Pipe and tubing	-	-	-
(c) Valves, fittings and flanges	-	-	-
(d) Other	5	15	25
(e) TOTAL	51	158	252

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	35,000
Coke (tons/sd)	365	1,460	2,560

4. Copper

(a) Wire and cable (in feet)

(i) 600V, Single conductor (Size)

12	40,000	70,000	100,000
10	15,000	25,000	40,000
8	6,000	10,000	17,500
6	1,500	1,200	2,500
4	4,000	3,000	6,000
2	1,500	3,500	4,000
1/0	2,000	4,000	10,000
2/0	2,000	3,000	4,000
3/0	1,500	2,000	3,000
4/0	800	1,200	1,500
250 MCM	2,000	4,000	6,000
350 MCM	-	-	2,000
400 MCM	2,250	2,700	3,600

(ii) 5KV, Single conductor (Size)

4	-	1,000	2,000
3/0	-	800	-

(iii) 15KV, 3 conductor (Size)

350 MCM	600	800	1,000

(b) Other (in tons) 11 36 58

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	35,000
Coke (tons/sd)	365	1,460	2,560
5. Aluminum (in tons)	4	12	24
6. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
0-20	12	8	8
21-100	13	12	17
125	-	-	-
150	-	1	-
200	-	-	-
250	-	1	2
300	-	-	1
400	-	2	3
(b) Pumps and turbines (HP)			
Condensing turbine			
1,100	1	1	2

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	35,000
Coke (tons/sd)	365	1,460	2,560

7. Electrical
(number and type)

(a) Transformers

13,800/4,160V	-	1-2,000KVA	1-3,750KVA
13,800/480V	1-750KVA	-	-
13,800/120V	1-45KVA	-	-
4,160/480V	-	1-750KVA	2-750KVA
4,160/120V	-	1-75KVA	1-112.5KVA

(b) Switchgear
(See Pumps and motors, Item 6(a) above)

(c) Motor control centers

8 vertical units	1	1	1
4 vertical units	-	-	1

(d) Cubicles

4,160V	-	7	10

	UNIT CAPACITY B/SD		
	5,000	20,000	35,000
	365	1,460	2,560

8. Instrumentation (number)

(a)	Temperature elements	120	160	280
(b)	Pressure elements	103	131	159
(c)	Flow elements	68	90	112
(d)	Level instruments	15	15	15
(e)	Level gauges	15	15	15

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	35,000
Coke (tons/sd)	365	1,460	2,560
8. Instrumentation (cont'd.)			
(f) Temperature transmitters	12	24	36
(g) Pressure transmitters	13	21	29
(h) Flow transmitters	38	50	62
(i) Local controllers	4	4	4
(j) Receiver controllers	36	48	60
(k) Receiver recorders	36	56	73
(l) Receiver indicators	36	46	56
(m) Multipoint temperature recorders	2	3	5
(n) Alarms	22	30	38
(o) Solenoid valves	8	10	12
(p) Control valves	48 (2-4")	60 (2-8")	72 (2-10")
(q) Relief valves	11	21	31
(r) Thermal relief valves	15	15	15
(s) Gamma ray level	2	6	10

C. UTILITY REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	35,000
Coke (tons/sd)	365	1,460	2,560
1. Electricity (KVA)	617	1,625	3,212
2. Fuel Gas (SCFH)	75,000	220,000	375,000
3. Cooling Water (GPM)	2,500	6,000	11,000
4. Boiler Feed Water (GPM)	35	105	175
5. Steam (lbs./hour)			
(a) Steam demand	15,000	35,000	65,000
(b) Steam generated in unit	15,000	45,000	75,000
(c) Net steam produced	-	10,000	10,000
6. Air (CFM)			
(a) Instrument air (65 psig)	100	160	200
(b) Plant air (100 psig)	1,500	2,000	4,000

SECTION 5

HYDROTREATING

SECTION 5

HYDROTREATING

A. DESCRIPTION AND ASSUMPTIONS

This study includes estimates of critical materials for a catalytic hydrotreating unit applicable to 5,000 to 40,000 B/SD feed rates of straight run, thermal, catalytic, and coker naphthas; straight run kerosene, jet fuel, and diesel fuels; and vacuum and coker distillates and gas oils.

It is recognized that the hydrotreating of specific naphtha or wide-range distillates stocks will require less process flexibility with a reduced total requirement of critical materials in construction than the versatile processing here described.

While this estimate of materials is prepared consistent with modern refining practice as it applies to alloy steel for corrosion protection, it is recognized that, with controlled feed stock characteristics, there may be a limited substitution of carbon for alloy steel in areas of high hydrogen sulfide concentration. However, since this unit is used primarily for the purpose of desulfurization of a wide variety of feed stocks, such substitutions must be carefully considered. Otherwise, on-stream time could be limited to a few months.

Diagram No. 5

HYDROTREATER

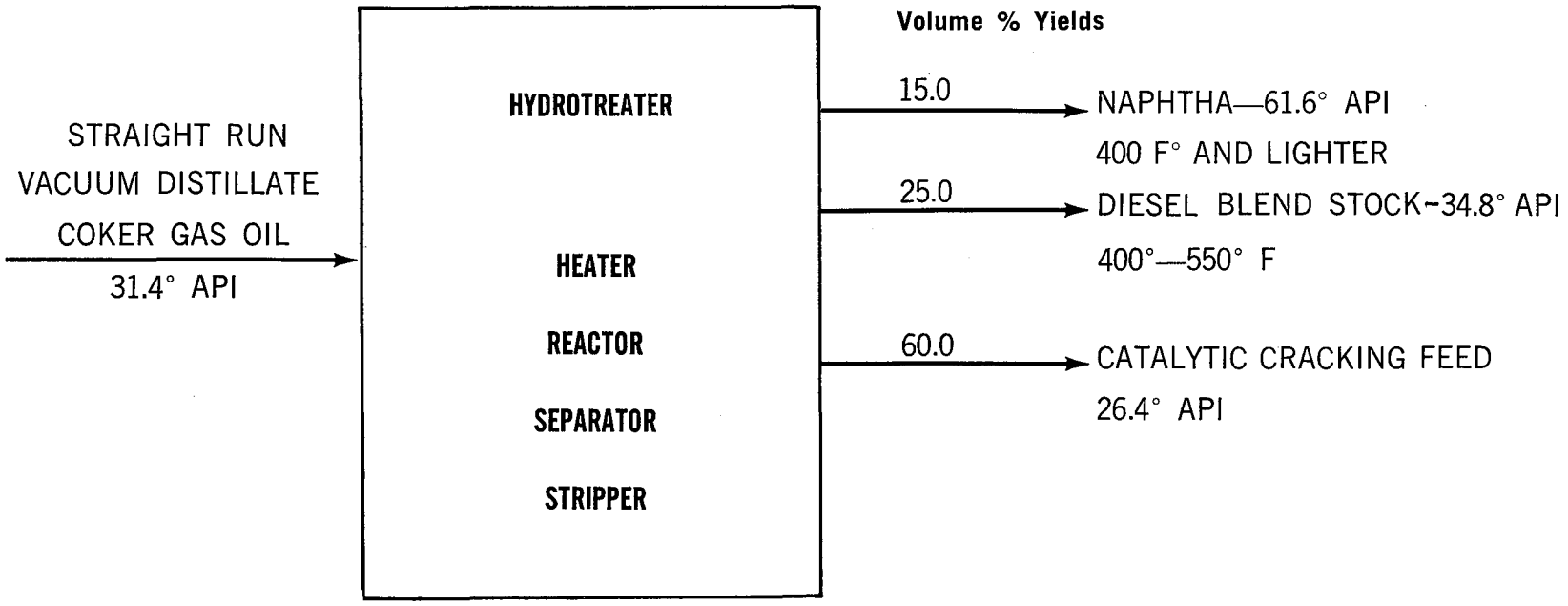
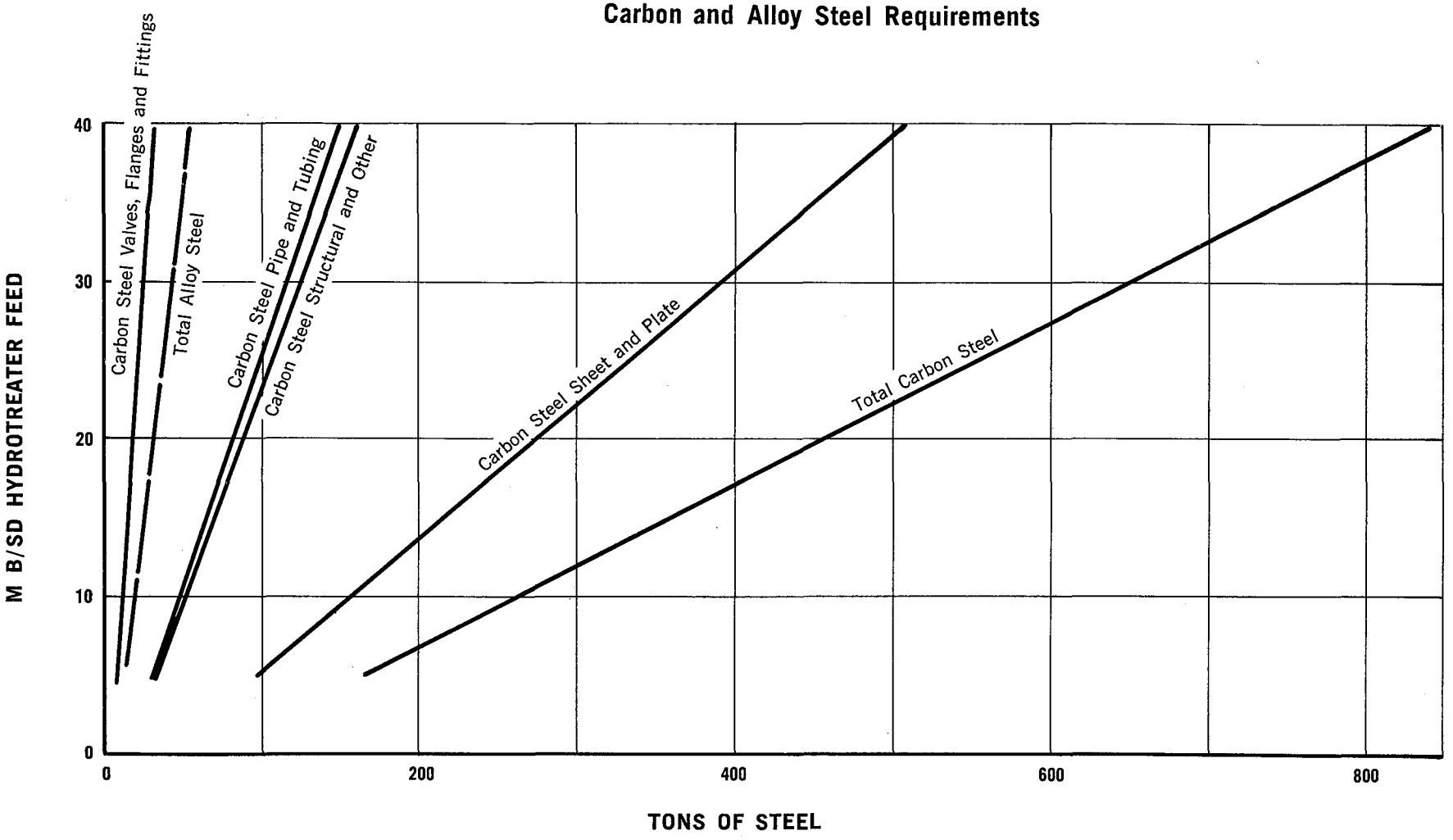


Figure No. 5

HYDROTREATER

Carbon and Alloy Steel Requirements



HYDROTREATING

B. TABULATION OF MATERIALS REQUIREMENTS

Fresh Feed	UNIT CAPACITY B/SD 5,000	20,000	40,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	97	275	510
(b) Pipe and tubing	30	83	150
(c) Valves, fittings and flanges	6	17	30
(d) Structural and others	32	90	160
(e) TOTAL	165	465	850
2. Alloy Steel (in tons)			
(a) Sheet and plate	-	-	-
(b) Pipe and tubing	12	32	52
(c) Valves, fittings and flanges	3	5	8
(d) Other	-	-	-
(e) TOTAL	15	37	60
3. Copper			
(a) Wire and cable (in feet)			
(i) 600V, Single conductor (Size)			
12	15,000	20,000	20,000
10	4,000	6,000	6,000
8	1,500	2,000	3,000
6	500	800	800
4	1,000	1,000	1,500
2	1,000	1,000	2,000
1/0	800	1,200	1,200

Fresh Feed	UNIT CAPACITY B/SD 5,000	20,000	40,000
3. Copper (cont'd.)			
2/0	500	500	500
3/0	300	300	300
4/0	200	300	500
300 MCM	500	500	500
(ii) 5KV, Single conductor (Size)			
4	500	500	500
3/0	1,000	1,000	1,200
(b) Other (in tons)			
Admiralty metal tubing	9	25	35
4. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
0-20	2	2	2
21-100	3	3	2
125-200	-	2	2
250-500	-	-	2
(b) Compressors and drivers (HP)			
Turbines			
2,500-3,000	1	-	-
3,000-3,500	-	1	1

Fresh Feed	UNIT CAPACITY B/SD 5,000	20,000	40,000
5. Electrical (number and type)			
(a) Transformers			
13,800/2,400V	-	-	1-1,000KVA
13,800/480V	1-750KVA	1-1,000KVA	1-1,000KVA
480/240V	2-50KVA	3-50KVA	2-100KVA
(b) Switchgear			
480V	1	1	1
(c) Motor control centers	1	1	2

		UNIT CAPACITY B/SD 5,000	20,000	40,000
6. Instrumentation (number)				
(a)	Temperature elements	25	50	65
(b)	Pressure elements	30	120	160
(c)	Flow elements	14	14	18
(d)	Level instruments	8	10	10
(e)	Temperature transmitters	2	3	4
(f)	Flow transmitters	10	12	20
(g)	Pressure controllers	2	3	3
(h)	Local controllers	1	1	2
(i)	Controllers	15	18	18
(j)	Multipoint temperature recorders	1	1	1
(k)	Recorders	1	1	1
(l)	Indicators	1	1	2
(m)	Control valves	16	18	18
(n)	Pressure relief valves	13	16	16

HYDROTREATING

C. UTILITY REQUIREMENTS

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	40,000
1. Electricity (KVA)	400	750	1,500
2. Fuel Gas (SCFH)	30,000	105,000	200,000
3. Cooling Water (GPM)	1,300	4,500	9,500
4. Steam (lbs./hour)	800	3,000	5,000
5. Air (CFM)			
(a) Instrument air	35	35	35
(b) Plant air	500	500	500

HYDROTREATING

D. INITIAL FILL CATALYSTS

	UNIT CAPACITY B/SD		
Fresh Feed	5,000	20,000	40,000
1. Cobalt-Molybdenum (cubic feet)	410	1,860	3,400

SECTION 6

HYDROCRACKING

SECTION 6

HYDROCRACKING

A. DESCRIPTION AND ASSUMPTIONS

1. Hydrocrackers designed for feed rates from 10,000 B/SD to 40,000 B/SD have been studied and requirements summarized. Although the upper size limit corresponds with a crude feed rate of approximately 100,000 B/SD, the 40,000 barrel unit is approaching the limit of present commercial practice.

2. Estimates are based on two-stage hydrocrackers, with the first stage primarily aimed at desulfurization and denitrification, and the second stage designed for maximum conversion with a minimum gas make.

3. Stainless steel is included for corrosion protection in the first stage reaction section. Alloy steel is required in both stages for protection against hydrogen attack. Omission of these materials would reduce plant life to a year or less and would be considered unsafe for operating personnel.

4. Reactors and separator vessels are designed using medium strength carbon steel or alloy steel as required for resistance to hydrogen damage. Vessels are designed per ASME Code, Section VIII.

5. For estimating purposes, reactor pressure has been set at 2,000 psig in both stages.

6. Reactors have been sized for commercially proven catalysts, with adequate catalyst volume to produce initial runs of 9-12 months without regeneration or replacement of the catalyst charge.

Diagram No. 6a

HYDROCRACKING

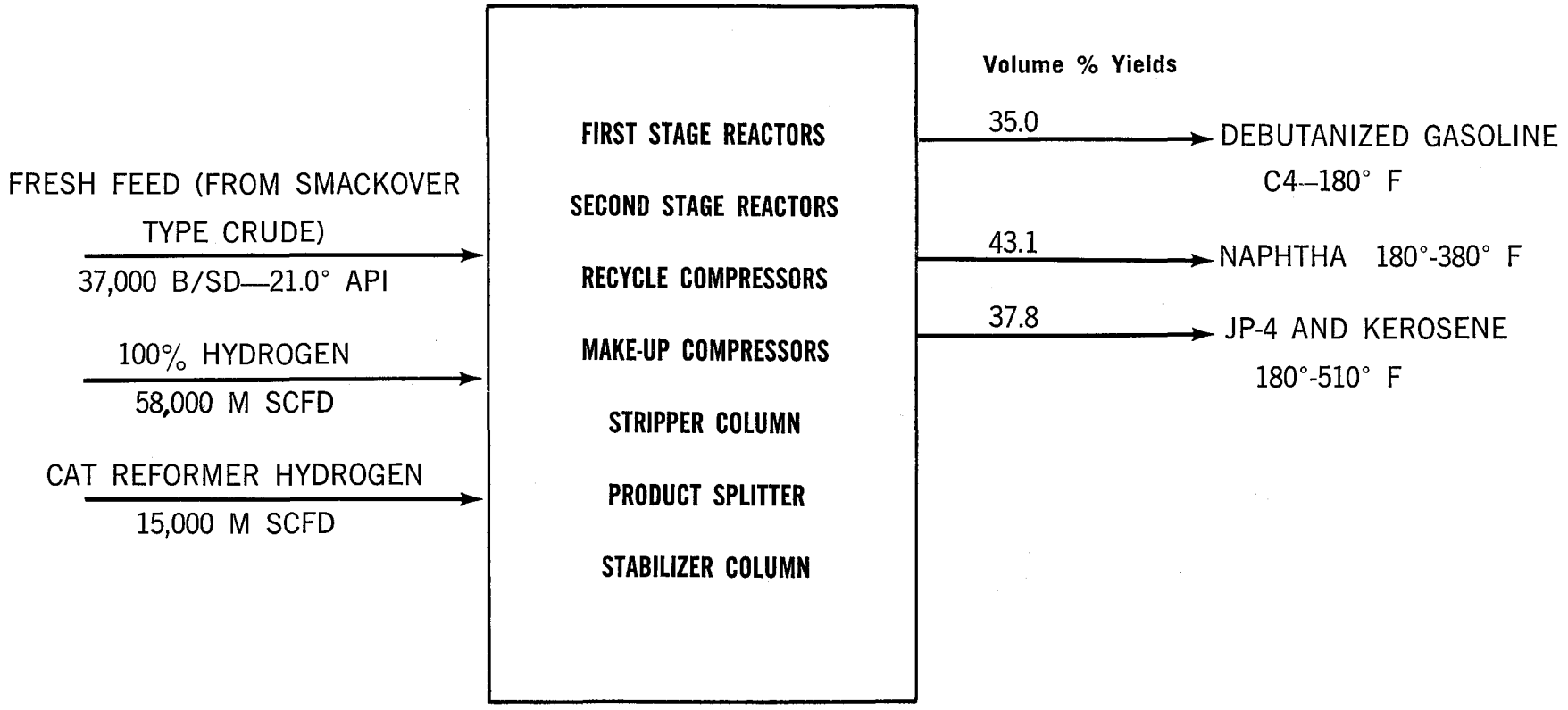


Diagram No. 6b

HYDROCRACKING

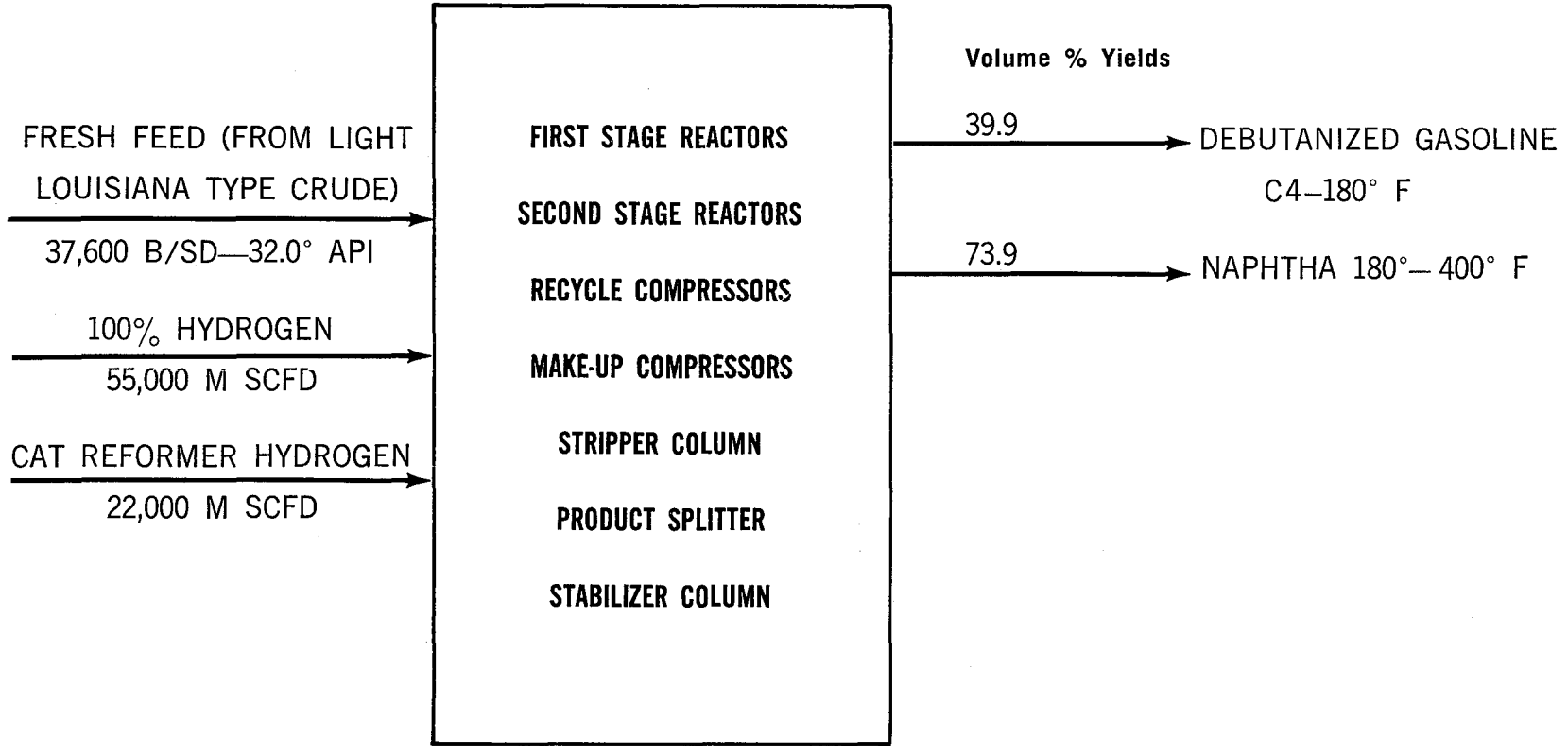
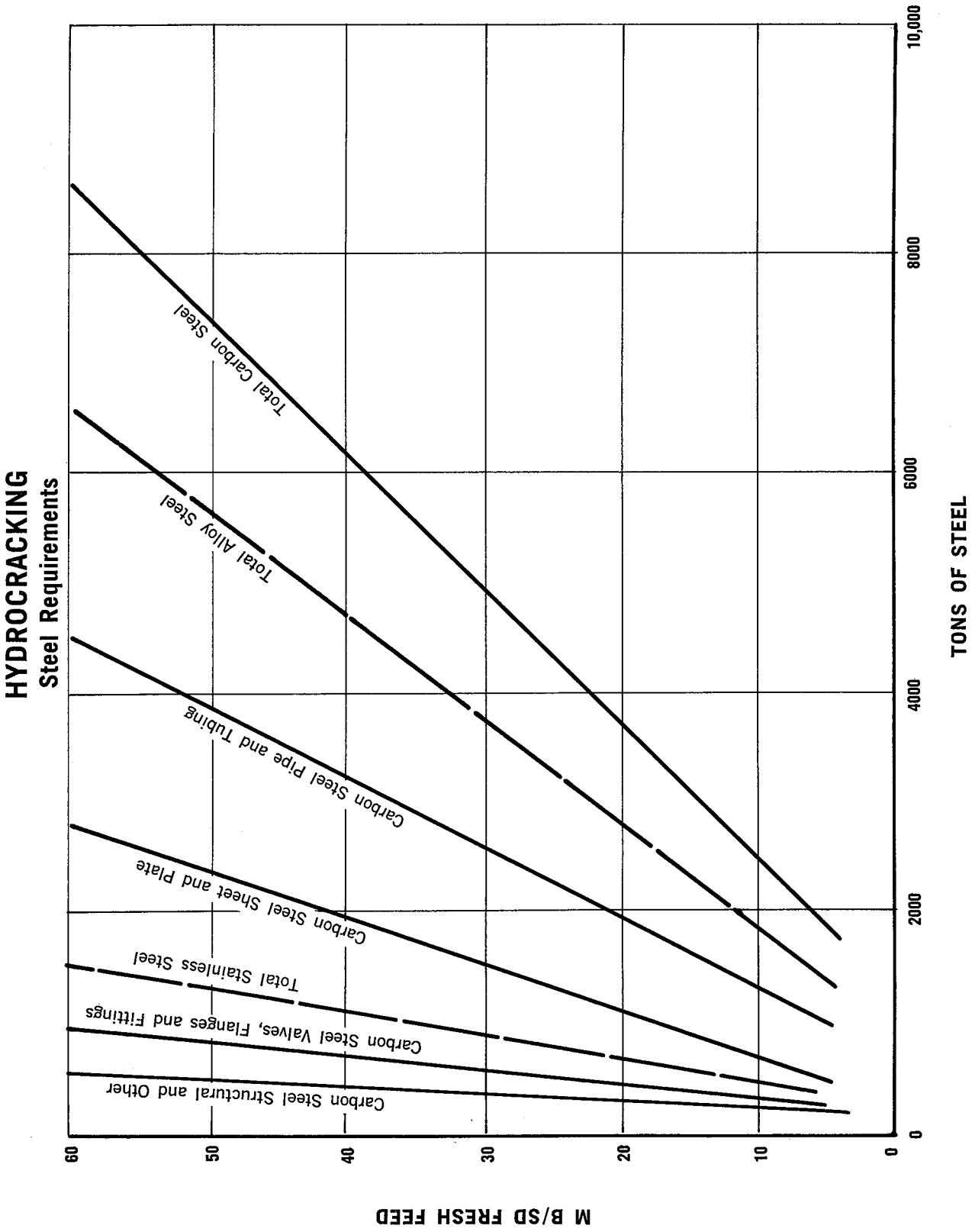


Figure No. 6


HYDROCRACKING
Steel Requirements
Total Carbon Steel
Total Alloy Steel
Carbon Steel Pipe and Tubing
Carbon Steel Sheet and Plate
Total Stainless Steel
Carbon Steel Valves, Flanges and Fittings
Carbon Steel Structural and Other
60
50
40
30
20
10
0
M B/SD FRESH FEED
0
2000
4000
6000
8000
10,000
TONS OF STEEL

HYDROCRACKING

B. TABULATION OF MATERIALS REQUIREMENTS

Fresh Feed	UNIT CAPACITY B/SD 10,000	20,000	40,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	745	1,178	1,958
(b) Pipe and tubing	1,240	1,985	3,140
(c) Valves, fittings and flanges	262	420	640
(d) Structural and others	141	223	362
(e) TOTAL	2,388	3,806	6,100
2. Alloy Steel (in tons)			
(a) Sheet and plate	1,120	1,790	2,830
(b) Pipe and tubing	492	795	1,272
(c) Valves, fittings and flanges	197	311	505
(d) Other	28	45	71
(e) TOTAL	1,837	2,941	4,678
3. Stainless Steel (in tons)			
(a) Sheet and plate	42	68	109
(b) Pipe and tubing	254	400	648
(c) Valves, fittings and flanges	112	179	283
(d) Other	21	34	54
(e) TOTAL	429	681	1,094

Fresh Feed	UNIT CAPACITY B/SD 10,000	20,000	40,000
4. Copper			
(a) Wire and cable (in feet)			
(i) 600V, Single conductor (Size)			
14	41,000	90,000	162,000
12	22,000	40,000	72,000
10	18,000	34,000	64,000
8	9,000	16,000	29,000
6	13,000	23,500	39,000
2	7,000	12,000	21,000
1	750	1,500	2,700
2/0	6,000	9,000	15,500
3/0	1,000	1,000	1,600
4/0	2,500	4,000	7,600
350 MCM	2,000	2,000	3,300
500 MCM	-	600	1,000
750 MCM	-	200	300
(ii) 2,400V feeders (Size)			
2	300	500	700
1/0	200	200	400
500 MCM	500	700	1,000
(iii) 15KV cable (Size)			
0/0	1,000	3,000	5,000
750 MCM	1,000	2,000	3,000
(b) Other (in tons)	52	98	163
5. Aluminum (in tons)			
Conduit, fittings and miscellaneous (no electrical conductors)	6	12	20

Fresh Feed	UNIT CAPACITY B/SD 10,000	20,000	40,000
6. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
0-20	4	3	1
21-100	5	7	8
101-500	4	7	10
(b) Pumps and turbines (HP)			
1,500	2	3	-
3,000	-	-	3
(c) Compressors and drivers (HP)			
(i) Recycle gas compressor - turbine	2-700HP 2-2,500HP	1-2,500HP 3-3,000HP	1-5,000HP 1-9,000HP
(ii) Hydrogen make-up and booster compressor - turbine	2-700HP	3-1,000HP	3-2,000HP
(d) Miscellaneous drivers (HP)			
Fans and motors			
0-20	12	8	-
21-100	12	16	24

Fresh Feed	UNIT CAPACITY B/SD 10,000	20,000	40,000
7. Electrical (number and type)			
(a) Transformers			
13,800/2,400V	1-6,000KVA	1-12,000KVA	2-12,000KVA
13,800/480V	1-1,500KVA	1-3,000KVA	1-6,000KVA
(b) Switchgear			
480V	2	2	2
2,400V	1	1	1
(c) Motor control centers			
480V	2	2	2
2,400V	2	2	2

	UNIT CAPACITY B/SD 10,000	20,000	40,000
8. Instrumentation (number)			
(a) Temperature elements	132	198	426
(b) Temperature indicators	24	36	92
(c) Control valves and positioners	48	72	156
(d) Alarms	34	51	112
(e) Level gauges	13	18	24
(f) Pressure indicators	96	128	164
(g) Field transmitters	66	96	184
(h) Field indicators, recorders and controllers	34	42	52
(i) Control panel instruments	51	76	163

C. UTILITY REQUIREMENTS

Fresh Feed	UNIT CAPACITY B/SD 10,000	20,000	40,000
1. Electricity (KVA)	3,000	6,000	10,000
2. Fuel Gas (SCFH)	200,000	300,000	600,000
3. Cooling Water (GPM)	8,500	17,000	25,500
4. Steam (lbs./hour)	78,000	130,000	208,000
5. Air (CFM)			
(a) Instrument air	85	125	200
(b) Plant air	250	300	400

D. INITIAL FILL CATALYSTS

	UNIT CAPACITY B/SD		
Fresh Feed	10,000	20,000	40,000
1. First Stage (cubic feet)	5,000	10,000	18,000
2. Second Stage (cubic feet)	5,000	10,000	18,000

SECTION 7

HYDROGEN PLANT

SECTION 7

HYDROGEN PLANT

A. DESCRIPTION AND ASSUMPTIONS

1. Hydrogen plants to produce 10 million to 60 million standard cubic feet of 95% pure hydrogen per day have been studied and materials requirements summarized.

2. Estimates are based on steam-methane reforming. Reformer pressure of 200 psig has been used. Product hydrogen will be at 100-125 psig.

3. Carbon dioxide removal is by MEA absorption.

4. Reformer tubes are estimated on the basis of HK (25 Cr-20 Ni) alloy.

5. Stainless steel is required for some heat exchanger shells and a small amount of piping in the low temperature section before CO_2 is removed from the reformed gas mix.

Diagram No. 7

HYDROGEN PLANT

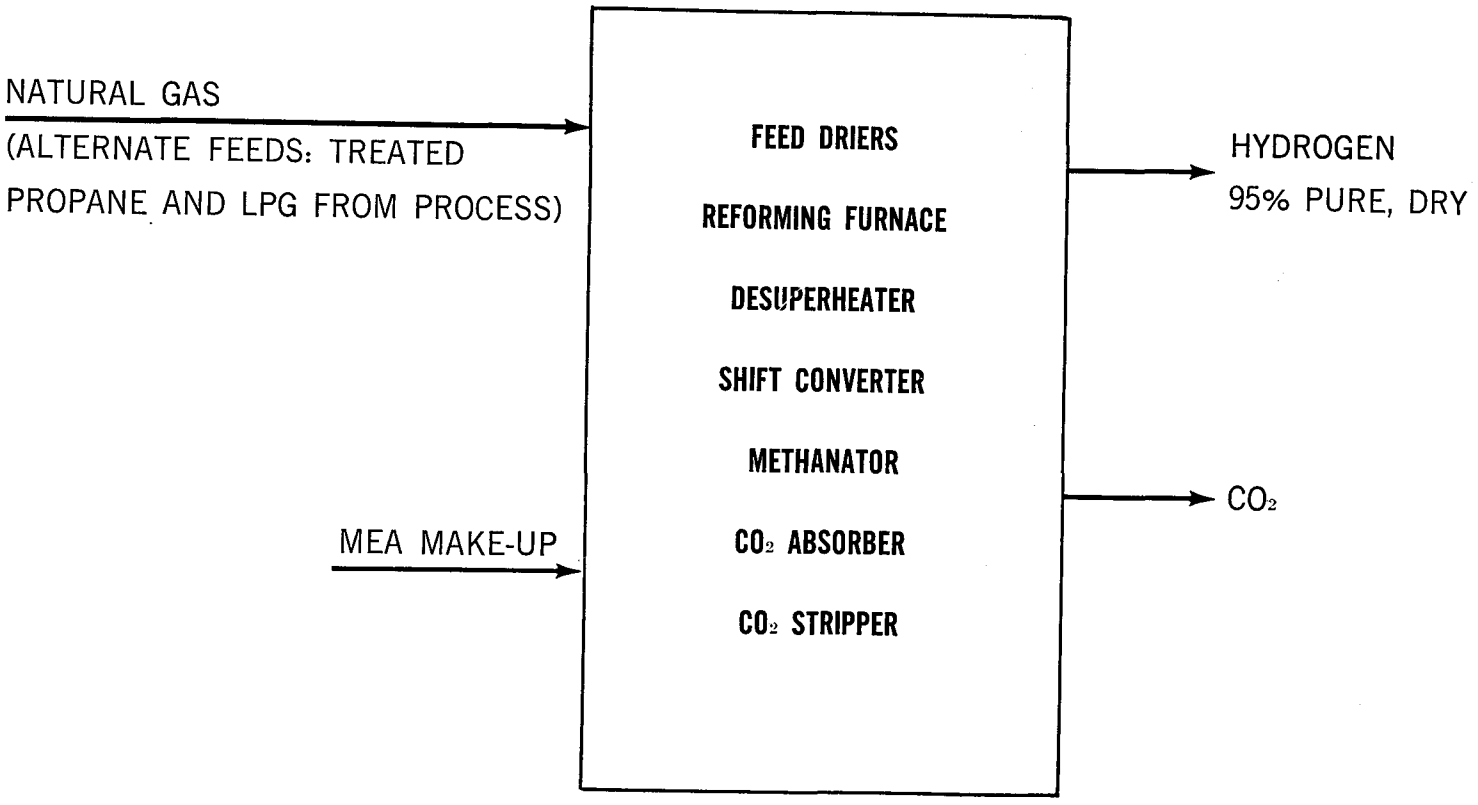
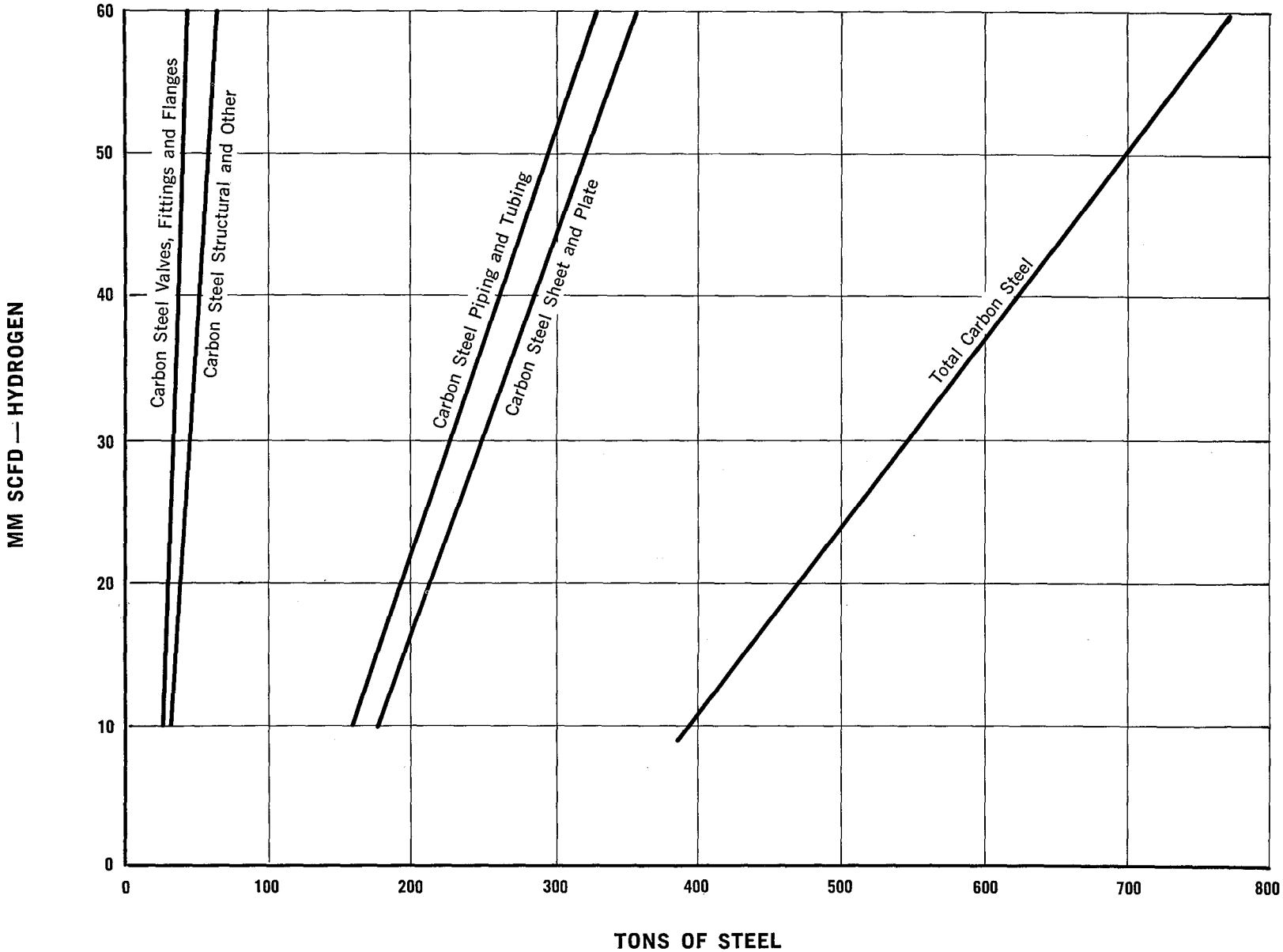


Figure No. 7

HYDROGEN PLANT

Carbon Steel Requirements



HYDROGEN PLANT

B. TABULATION OF MATERIALS REQUIREMENTS

Hydrogen Produced	UNIT CAPACITY M SCFD 10,000	40,000	60,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	188	286	356
(b) Pipe and tubing	164	262	325
(c) Valves, fittings and flanges	24	37	41
(d) Structural and others	26	47	52
(e) TOTAL	396	632	774
2. Alloy Steel (in tons)			
(a) Sheet and plate	28	42	46
(b) Pipe and tubing	26	39	43
(c) Valves, fittings and flanges	4	7	8
(d) Other	-	-	-
(e) TOTAL	58	88	97
3. Stainless Steel (in tons)			
(a) Sheet and plate	22	32	35
(b) Pipe and tubing	47	71	78
(c) Valves, fittings and flanges	5	7	8
(d) Other	1	2	3
(e) TOTAL	75	112	124

Hydrogen Produced	UNIT CAPACITY M SCFD 10,000	40,000	60,000
4. Copper			
(a) Wire and cable (in feet)			
(i) 600V, Single conductor (Size)			
14	13,000	18,000	23,000
12	3,000	4,100	6,200
10	300	400	600
8	1,500	2,000	3,000
6	6,000	8,000	10,000
4	1,000	1,200	1,800
2	1,000	2,000	3,800
1/0	1,200	3,000	4,800
3/0	1,000	1,200	1,200
350 MCM	600	1,000	1,500
(ii) 2,400V feeders (Size)			
1	2,000	2,400	3,200
300 MCM	1,200	1,800	2,300
350 MCM	1,200	1,800	2,400
(iii) 15KV cable (Size)			
500 MCM	2,200	3,200	4,000
(b) Other (in tons)	9	12	15
5. Aluminum (in tons)	2	4	6

Hydrogen Produced	UNIT CAPACITY M SCFD 10,000	40,000	60,000
6. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
0-20	4	3	3
21-100	3	5	5
101-400	3	4	4
(b) Compressors and drivers (HP)			
Motors			
21-100	1	1	1
(c) Miscellaneous drivers (HP)			
Furnace fans and motors			
0-20	2	-	-
21-100	-	2	2

	UNIT CAPACITY M SCFD 10,000	40,000	60,000
7. Electrical (number and type)			
(a) Transformers			
13,800/2,400V	2-1,000KVA	2-2,500KVA	2-5,000KVA
13,800/480V	2-1,000KVA	2-2,000KVA	2-4,000KVA

Hydrogen Produced	UNIT CAPACITY M SCFD 10,000	40,000	60,000
7. Electrical (cont'd.)			
(b) Switchgear			
480V	1	1	1
2,400V	1	1	1
(c) Motor control centers			
480V	4	6	8
8. Instrumentation (number)			
(a) Temperature elements	38	62	85
(b) Temperature indicators	15	28	42
(c) Control valves and positioners	40	60	80
(d) Alarms	30	35	42
(e) Level gauges	12	15	22
(f) Pressure indicators	47	60	78
(g) Field transmitters	57	72	86
(h) Field indicators, recorders and controllers	22	38	55
(i) Control panel instruments	42	58	72

C. UTILITY REQUIREMENTS

	UNIT CAPACITY M SCFD		
Hydrogen Produced	10,000	40,000	60,000
1. Electricity (KVA)	250	850	1,150
2. Fuel Gas (SCFH)	100,000	400,000	600,000
3. Cooling Water (GPM)	3,000	12,000	18,000
4. Boiler Feed Water (GPM)	70	280	420
5. Steam (lbs./hour)			
Net steam produced	7,000	18,000	26,000
6. Air (CFM)			
(a) Instrument air	30	90	120
(b) Plant air	120	300	400

D. INITIAL FILL CATALYSTS

	UNIT CAPACITY M SCFD		
Hydrogen Produced	10,000	40,000	60,000
1. Reformer (cubic feet)	300	1,200	1,800
2. Shift Converter (cubic feet)	1,000	4,000	6,000
3. Methanator (cubic feet)	250	1,000	1,500

SECTION 8

ALKYLATION

SECTION 8

ALKYLATION

A. DESCRIPTION AND ASSUMPTIONS

Alkylation facilities have been included in the study to allow for possible requirements of high octane gasoline components during conditions of emergency. In order to provide a reasonable basis for estimating critical materials requirements, a number of assumptions have been made. These are listed below:

1. Both sulphuric and hydrofluoric acid alkylation were considered. It was decided that the study should be based upon sulphuric acid alkylation because less alloy material would be required. This could be of real significance in times of shortages even though more carbon steel would be needed.

2. The materials listed in the tabulation include the normal alloys which would be in a unit to provide the most economical operation when considering plant service factor, cost of materials, etc. However, in case of a shortage in alloy materials, carbon steel could be used throughout except for very small quantities in a few critical areas, such as pump sleeves and seal rings, mixer parts, etc. This would reduce run length considerably less than those considered economical today. However, it is anticipated that run lengths of 6-12 months, which should be satisfactory for emergency situations, would be possible.

3. No facilities for production or regeneration of acid have been provided. It is assumed that supplies of fresh acid will be available

from regular acid producers and that arrangements to dispose of spent acid can be made with these same operators.

4. Feed preparation and storage have not been included.

Diagram No. 8

SULPHURIC ACID ALKYLATION PLANT

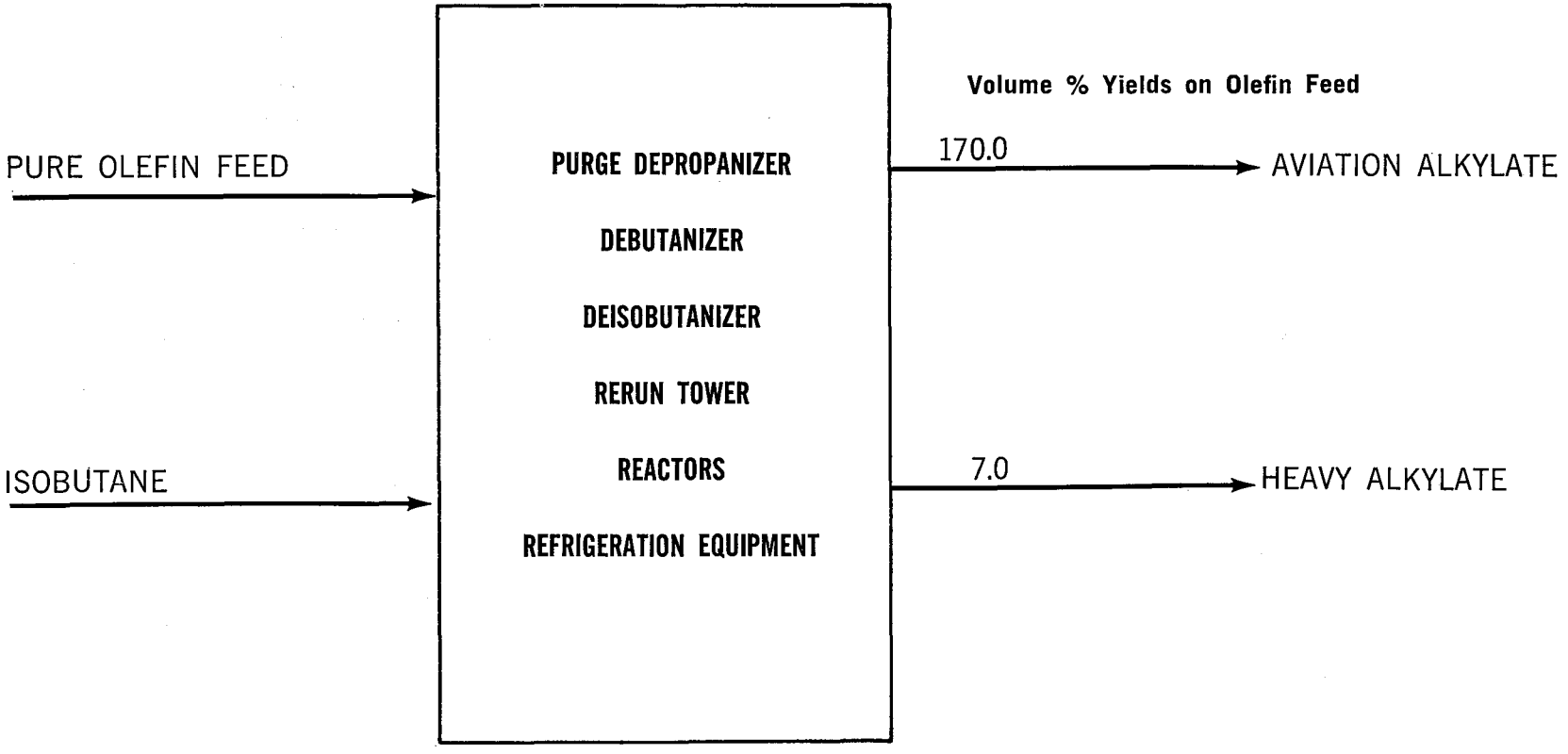
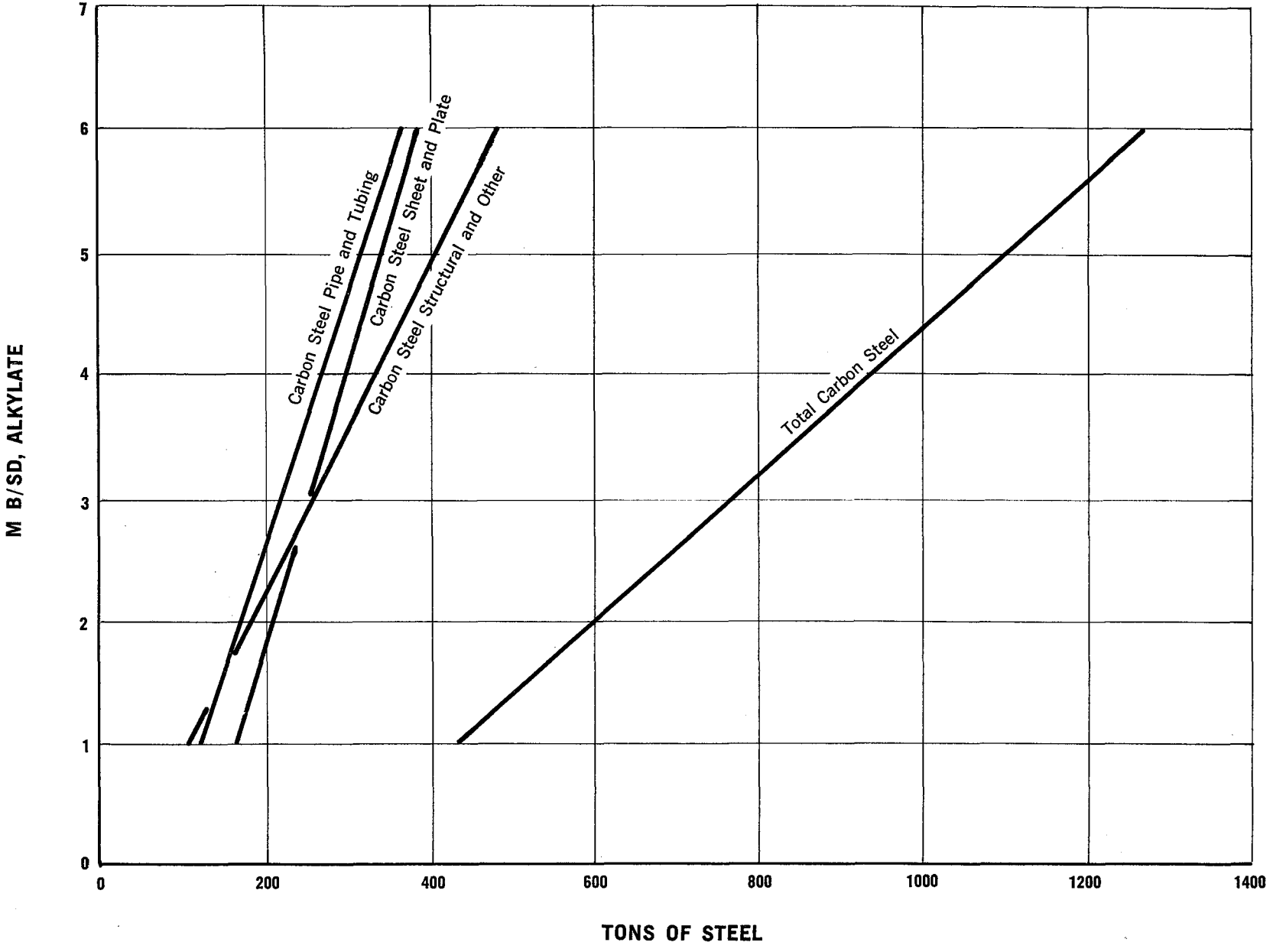


Figure No. 8

SULPHURIC ACID ALKYLATION PLANT

Carbon Steel Requirements



ALKYLATION

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD		
Aviation Alkylate Production	1,000	3,500	6,000
Olefin Feed	590	2,060	3,530
1. Carbon Steel (in tons)			
(a) Sheet and plate	177	291	394
(b) Pipe and tubing	122	245	368
(c) Valves, fittings and flanges	13	18	22
(d) Structural and others	115	310	490
(e) TOTAL	427	864	1,274
2. Stainless Steel (in tons)			
(a) Sheet and plate	-	-	-
(b) Pipe and tubing	-	-	-
(c) Valves, fittings and flanges	0.8	1.5	2.5
(d) Other (pump trim)	0.3	0.5	0.8
(e) TOTAL	1.1	2.0	3.3
3. Copper			
(a) Wire and cable (in feet)			
(i) 600V, single conductor (Size)			
12	20,000	20,000	15,000
8	600	12,000	12,000
4	4,500	5,000	-
600 MCM	-	1,200	2,400

	UNIT CAPACITY B/SD		
Aviation Alkylate Production	1,000	3,500	6,000
Olefin Feed	590	2,060	3,530
(a) Wire and cable (cont'd.)			
(ii) 5KV, Single conductor (Size)			
6	-	-	1,200
(b) Other (in tons)	1.0	1.8	2.0
4. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
0-20	34	34	25
21-100	2	5	6
400	-	-	1
(b) Compressors and drivers (HP)			
800	1	-	-
1,250	-	1	-
1,500	-	-	1
1,750	-	1	-
2,750	-	-	1
(c) Miscellaneous drivers (HP)			
Mixers and motors			
21-100	7	10	18

	UNIT CAPACITY B/SD		
Aviation Alkylate Production	1,000	3,500	6,000
Olefin Feed	590	2,060	3,530

5. Electrical
(number and type)

(a) Transformers

13,800/480V	2-750KVA	2-1,200KVA	1-1,500KVA
13,800/2,400V	-	-	1-1,500KVA
480/120V	2-15KVA	2-15KVA	2-15KVA

(b) Switchgear (cubicles)

600V	5	5	5
5KV	-	-	2

(c) Motor control centers

600V	4	4	4

	UNIT CAPACITY B/SD		
	1,000	3,500	6,000
	590	2,060	3,530

6. Instrumentation (number)

(a)	Flow elements	25	35	45
(b)	Flow transmitters	40	43	45
(c)	Flow recorders	25	21	20
(d)	Flow recorder controllers	15	20	25
(e)	Temperature elements	50	55	60
(f)	Temperature indicators	50	55	60
(g)	Temperature recorder controllers	10	10	10
(h)	Pressure elements	75	80	85

	UNIT CAPACITY B/SD		
Aviation Alkylate Production	1,000	3,500	6,000
Olefin Feed	590	2,060	3,530

6. Instrumentation (cont'd.)

(i)	Pressure indicators	75	80	85
(j)	Pressure recorder controllers	15	16	17
(k)	Level instruments	15	18	20
(l)	Level recorder controllers	15	18	20
(m)	Level gauges	15	18	20
(n)	Control valves	55	63	72
(o)	Low and high level alarms	10	10	10
(p)	Alarm switches	20	20	20
(q)	Multipoint temperature recorders	1	1	1
(r)	Relief valves	55	55	56

ALKYLATION

C. UTILITY REQUIREMENTS

	UNIT CAPACITY B/SD		
Aviation Aklylate Production	1,000	3,500	6,000
Olefin Feed	590	2,060	3,530
1. Electricity (KVA)	1,375	2,000	2,490
2. Cooling Water (GPM)	3,000	5,500	8,000
3. Steam (lbs./hour)			
(a) Total 650 lb. steam	27,500	65,000	96,000
(b) 650 lb. steam to compressor (exhausting to process system)	27,500	65,000	91,500
(c) Process requirements (reboilers, etc.)	21,500	60,000	96,000
(d) Added requirements for process over that produced from turbine exhausts	(6,000)	(5,000)	4,500
4. Air (CFM)			
(a) Instrument air	158	190	205
(b) Plant air	200	200	200

IV. OFF-SITE FACILITIES

PART IV

OFF-SITE AND AUXILIARY FACILITIES

TABLE OF CONTENTS

FIGURES

TABLES

SECTION 9

TANKAGE AND TANK FARM PIPING

SECTION 9

TANKAGE AND TANK FARM PIPING

A. DESCRIPTION AND ASSUMPTIONS

The estimated requirements for tankage are based on a study of the actual installed tankage at eight complete, modern refineries. Requirements for tankage which are, to some extent, influenced by operating policy - i.e. economic value placed on adequate tankage to permit continued operation under upset conditions - will vary from one location to another and from company to company. This study showed an average crude tankage capacity of 14 days; and an average rundown, intermediate and product tankage capacity of 47½ days. This may be higher than average for the industry.

For less-than-complete refineries (that is, any combination of the processes included in this report) estimates of the critical materials required may be prepared by using the above assumptions and readily available data.

Crude is usually stored in a minimum number of maximum size floating roof tanks. Actual tankage requirements depend primarily upon the means of crude supply to the refinery, since supply by barge or tankship results in non-uniform delivery. Accordingly, in B., TABULATION OF MATERIALS REQUIREMENTS (following), a range of requirements has been provided.

Included in this estimate are provisions for gasoline blending. No materials requirements for crude receiving and product shipping facilities are included.

In the refineries studied, product, rundown and intermediate storage were found to require totals of from 37 to 94 tanks. The numbers of tanks bore no relationship to refinery throughput. With the specific Committee assignment in mind, a total of 66 tanks has been chosen for utilization in rundown, intermediate and product storage. The distribution (by size and type) of this tankage is shown on the pertinent charts which are included in this Section.

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD			
Refinery Throughput	10,000	50,000	100,000	150,000
1. Carbon Steel (in tons)				
(a) Sheet and plate	2,260 to 2,480	7,672 to 9,554	14,450 to 16,330	21,005 to 23,120
(b) Pipe and tubing	1,040 to 1,205	4,130 to 5,300	5,025 to 6,750	9,340 to 12,390
(c) Valves, fittings and flanges	130 to 150	515 to 660	630 to 831	1,160 to 1,360
(d) TOTAL	3,430 to 3,735	12,317 to 15,514	20,105 to 23,911	31,505 to 36,270

(See Tables 1 through 3 for further detail on carbon steel requirements.)

	UNIT CAPACITY B/SD			
Refinery Throughput	10,000	50,000	100,000	150,000
2. Copper				
(a) Wire and cable (in feet)				
(i) 600V, Single conductor (Size)				
14	70,000	150,000	203,000	300,000
12	12,000	32,000	63,000	91,000
10	12,000	32,000	64,000	96,000
8	30,000	125,000	256,000	310,000
6	11,000	38,000	72,000	89,000
4	4,000	7,000	13,000	18,000
1/0	4,000	7,000	14,000	20,000
3/0	2,000	6,000	8,000	11,000
350 MCM	2,000	8,000	16,000	20,000
500 MCM	400	1,100	2,200	3,000
750 MCM	-	1,100	4,000	6,000
3. Pumps, Compressors, etc. (number of units)				
(a) Pumps and motors (HP)				
0-20	8	-	-	-
21-100	20	14	12	10
101-500	4	22	33	42
(b) Pumps and turbines (HP)				
600	-	-	2	-
800	-	-	-	2

Refinery Throughput	UNIT CAPACITY B/SD			
	10,000	50,000	100,000	150,000
4. Electrical (number and type)				
(a) Transformers				
13,800/480V	6-400 KVA	6-750 KVA	6-750 KVA 2-1,000 KVA	8-1,000 KVA
(b) Switchgear				
480V	6	6	8	8
(c) Motor control centers	6	8	12	16
5. Instrumentation (number)				
(a) Transmitters	210	315	417	510
(b) Field indicators, recorders and controllers	46	62	88	112
(c) Alarms	65	78	126	148
(d) Pressure indicators	232	286	318	410
(e) Temperature elements	138	186	233	320
(f) Control panel instruments	64	77	89	121
(g) Level gauges	112	118	124	184
(h) Control valves	64	82	98	126

C. UTILITY REQUIREMENTS

	UNIT CAPACITY B/SD			
Refinery Throughput	10,000	50,000	100,000	150,000
1. Electricity (KVA)	3,200	7,200	8,000	10,600
2. Steam (lbs./hour)				
Steam demand	19,000	48,000	112,000	161,000
3. Air (CFM)				
(a) Instrument air	100	150	190	250
(b) Plant air	200	500	750	1,000

TABLE 1

CARBON STEEL REQUIRED FOR CRUDE TANKAGE
FLOATING ROOF TANKS

	UNIT CAPACITY B/SD			
Refinery Throughput	10,000	50,000	100,000	150,000
Crude Tankage Required				
(a) Pipe line delivery (bbls.)	140,000	700,000	1,400,000	2,100,000
No. of tanks	2@ 70,000	4@ 175,000	8@ 175,000	11@ 190,000
Steel (tons)	334	1,538	3,080	4,535
(b) Barge delivery (bbls.)	240,000	800,000	1,500,000	2,200,000
No. of tanks	2@ 120,000	5@ 160,000	8@ 187,000	12@ 190,000
Steel (tons)	554	1,755	3,280	4,960
(c) Small tankship delivery (bbls.)	-	1,180,000	1,880,000	2,580,000
No. of tanks	-	6@ 193,000	10@ 188,000	14@ 190,000
Steel (tons)	-	2,580	4,100	5,820
(d) Large tankship delivery (bbls.)	-	1,575,000	2,275,000	2,975,000
No. of tanks	-	8@ 197,000	12@ 190,000	16@ 190,000
Steel (tons)	-	3,420	4,960	6,650

TABLE 2

CARBON STEEL REQUIRED FOR RUNDOWN,
INTERMEDIATE, AND PRODUCT TANKAGE

	UNIT CAPACITY B/SD			
Refinery Throughput	10,000	50,000	100,000	150,000
Total Tankage (bbls.) (47½ days)	475,000	2,380,000	4,750,000	7,125,000
Floating Roof (30%) (20 Tanks), bbls.	143,000	713,000	1,425,000	2,125,000
5 Tanks at	5,000	15,000	30,000	30,000
6 Tanks at	5,000-10,000	15,000-30,000	30,000-80,000	50,000-100,000
6 Tanks at	10,000-20,000	30,000-60,000	80,000-120,000	80,000-120,000
3 Tanks at	20,000+	60,000+	120,000+	140,000+
Carbon Steel Plate (tons)	880	2,170	3,580	5,260
Cone Roof (69%) (45 Tanks), bbls.	328,000	1,640,000	3,280,000	4,800,000
14 Tanks at	5,000	15,000	30,000	30,000
14 Tanks at	4,000-10,000	15,000-40,000	30,000-80,000	50,000-100,000
9 Tanks at	10,000-20,000	40,000-60,000	80,000-120,000	80,000-120,000
8 Tanks at	20,000+	60,000+	120,000+	140,000+
Carbon Steel Plate (tons)	1,095	3,710	7,280	10,120
Pressure Storage (1%) (bbls.)	4,750	23,800	47,500	100,000
Carbon Steel Plate (tons)	51	254	510	1,090
Total Steel for Rundown, Intermediate, and Product Tankage (tons)	1,926	6,134	11,370	16,470

TABLE 3

CARBON STEEL PIPING MATERIAL FOR TANK FIELD

Refinery Throughput	UNIT CAPACITY B/SD 10,000	50,000	100,000	150,000
(a) Crude by pipeline (bbls.)				
Crude tankage required	140,000	700,000	1,400,000	2,100,000
Product etc. tankage required	475,000	2,380,000	4,750,000	7,125,000
TOTAL	615,000	3,080,000	6,150,000	9,225,000
Tankfield piping (tons)				
Steel pipe	1,040	4,130	5,025	9,340
Valves, fittings, flanges	130	515	630	1,160
(b) Crude by barge (bbls.)				
Crude tankage required	240,000	800,000	1,500,000	2,200,000
Product etc. tankage required	475,000	2,380,000	4,750,000	7,125,000
TOTAL	715,000	3,180,000	6,250,000	9,325,000
Tankfield piping (tons)				
Steel pipe	1,205	4,270	5,100	9,390
valves, fittings, flanges	150	535	638	1,178
(c) Crude by small tankship (bbls.)				
Crude tankage required	-	1,180,000	1,880,000	2,580,000
Product etc. tankage required	-	2,380,000	4,750,000	7,125,000
TOTAL	-	3,560,000	6,630,000	9,705,000
Tankfield piping (tons)				
Steel pipe	-	4,760	5,400	9,640
Valves, fittings, flanges	-	595	675	1,215
(d) Crude by large tankship (bbls.)				
Crude tankage required	-	1,575,000	2,275,000	2,975,000
Product etc. tankage required	-	2,380,000	4,750,000	7,125,000
TOTAL	-	3,955,000	7,025,000	10,100,000
Tankfield piping (tons)				
Steel pipe	-	5,300	6,750	12,390
Valves, fittings, flanges	-	660	831	1,360

SECTION 10

STEAM GENERATION

SECTION 10

STEAM GENERATION

A. DESCRIPTION AND ASSUMPTIONS

This study has assumed that time will play a considerable part in selection of equipment. It has been found that package-type boilers in sizes of 30,000, 50,000 and 100,000 lbs./hour are readily available and, in the 650 psig pressure class, are perfectly adequate for almost all operations.

Boiler feed water treating facilities can be varied from straight filtering through the demineralization operation. For this study, a hot process system has been selected. It is believed to be adequate for all types of water requiring treatment for 650 psig boilers or less.

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY POUNDS PER HOUR		
Steam (Package Systems)	30,000	50,000	100,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	44.0	58.1	85.5
(b) Pipe and tubing	20.0	28.0	40.0
(c) Valves, fittings and flanges	2.5	3.5	5.0
(d) Structural and others	10.0	12.5	19.0
(e) TOTAL	76.5	102.0	149.5
2. Copper			
(a) Wire and cable (in feet)			
600V, Single conductor (Size)			
2	900	-	-
10	-	1,800	1,800
12	14,400	12,300	13,500
1/0	-	900	-
4/0	-	-	900
(b) Other (in tons)	0.2	0.3	0.5
3. Aluminum (in tons)			
Conduit	1.5	2.0	3.0

Steam (Package Systems)	UNIT CAPACITY POUNDS PER HOUR 30,000	50,000	100,000
4. Pumps, Compressors, etc. (number of units)			
(a) Pumps and motors (HP)			
(i) Boiler feed			
60	1	-	-
100	-	1	-
175	-	-	1
(ii) Water treating			
0-20	4	4	4
(b) Miscellaneous drivers (HP)			
Motors for air preheater			
0-20	1	1	1
5. Electrical (number and type)			
(a) Transformers	-	-	-
(b) Switchgear (cubicles)	1	1	1
(c) Motor control centers	1	2	2

	UNIT CAPACITY POUNDS PER HOUR		
Steam (Package Systems)	30,000	50,000	100,000
6. Instrumentation (number)			
Panel items:			
(a) Pressure controllers	1	1	1
(b) Ratio controllers	1	1	1
(c) Program controllers	1	1	1
(d) Draft gauges	1	1	1
(e) Pressure gauges	2	2	3
(f) Alarm lights and bells	1 ea.	1 ea.	1 ea.
(g) Miscellaneous switches and relays	8	8	12
(h) Control transformers	1	1	1
(i) Boiler meters	1	1	1
(j) Temperature recorders	-	-	1
Field items:			
(k) Fan control drives	1	1	2
(l) Flow transmitters	3	3	3
(m) Flame scanners	1	1	1
(n) Control valves	3	3	3
(o) Solenoid valves	5	5	6
(p) Level controllers	1	1	1
(q) Level switches	1	1	1
(r) Pressure transmitters	2	2	2

C. UTILITY REQUIREMENTS

Steam (Package Systems)	UNIT CAPACITY POUNDS PER HOUR 30,000	50,000	100,000
1. Electricity (KVA)	85	140	270
2. Fuel Gas (SCFH)	42,000	70,000	140,000
3. Boiler Feed Water (GPM)	70	115	230

SECTION 11

POWER DISTRIBUTION

SECTION 11

POWER DISTRIBUTION

A. DESCRIPTION AND ASSUMPTIONS

In carrying out the study of power supply and distribution, the following assumptions have been made:

1. Power will be available from public utility systems. No power generation facilities are included in the study.

2. Power will be available from the source of supply at 138,000 volts.

3. Voltage will be reduced at a central distribution center and distributed to the individual unit substations at 13,800 volts.

4. Individual unit material studies will include the equipment necessary to reduce voltage to that required for operation of the individual pieces of equipment.

5. All distribution within the refinery is assumed to be overhead on bare copper.

6. Transformers (138,000/13,800V) in appropriate sizes for each load situation must be provided at the distribution center.

7. Distribution from the 13,800V bus will require 13,800V switchgear for each individual circuit. Such circuits - depending on load, proximity of users to one another, and required necessity of unit independence - may serve one or more individual units.

Figure No. 9

COPPER REQUIREMENTS

138 KV—13.8 KV Power Transformers

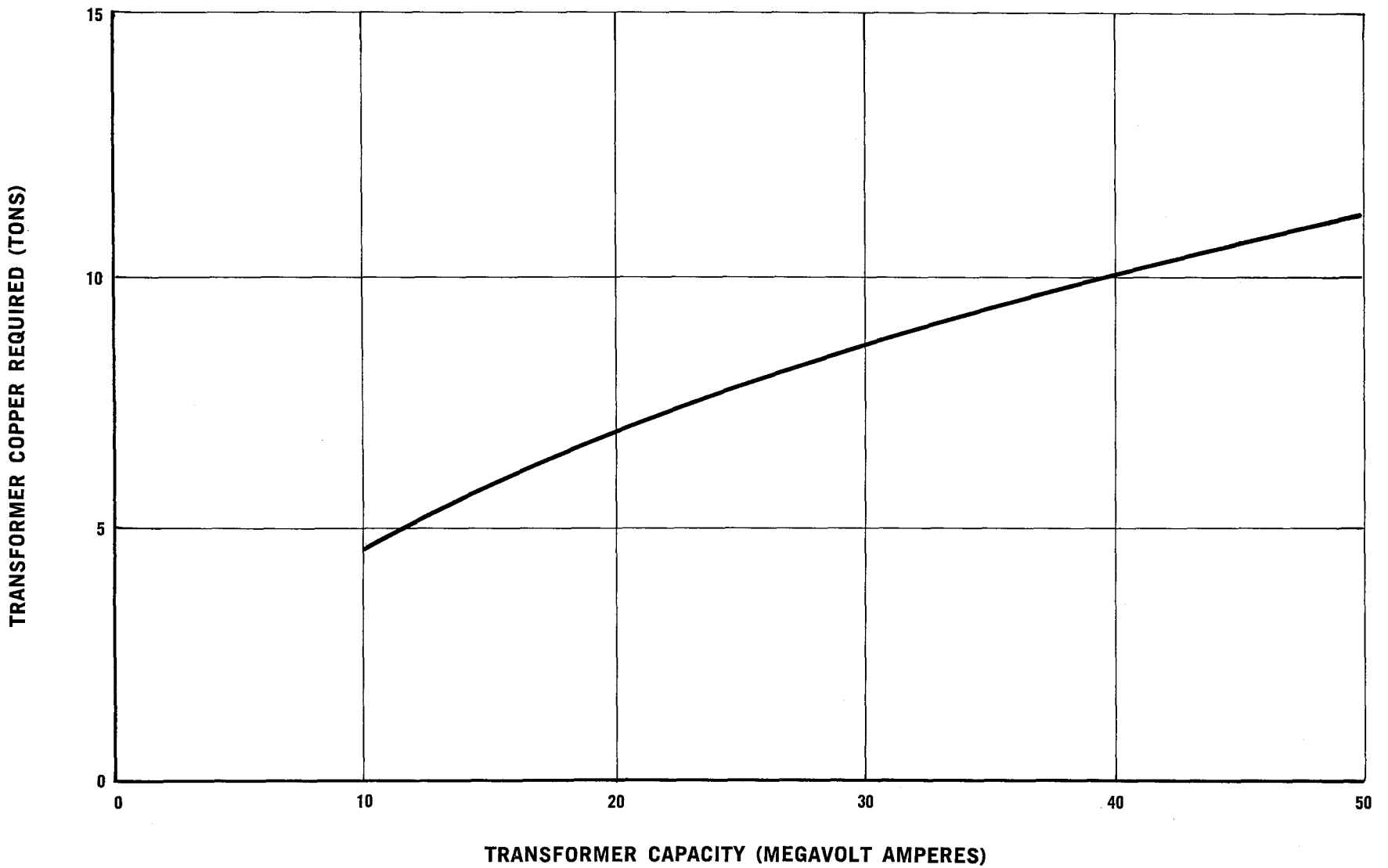
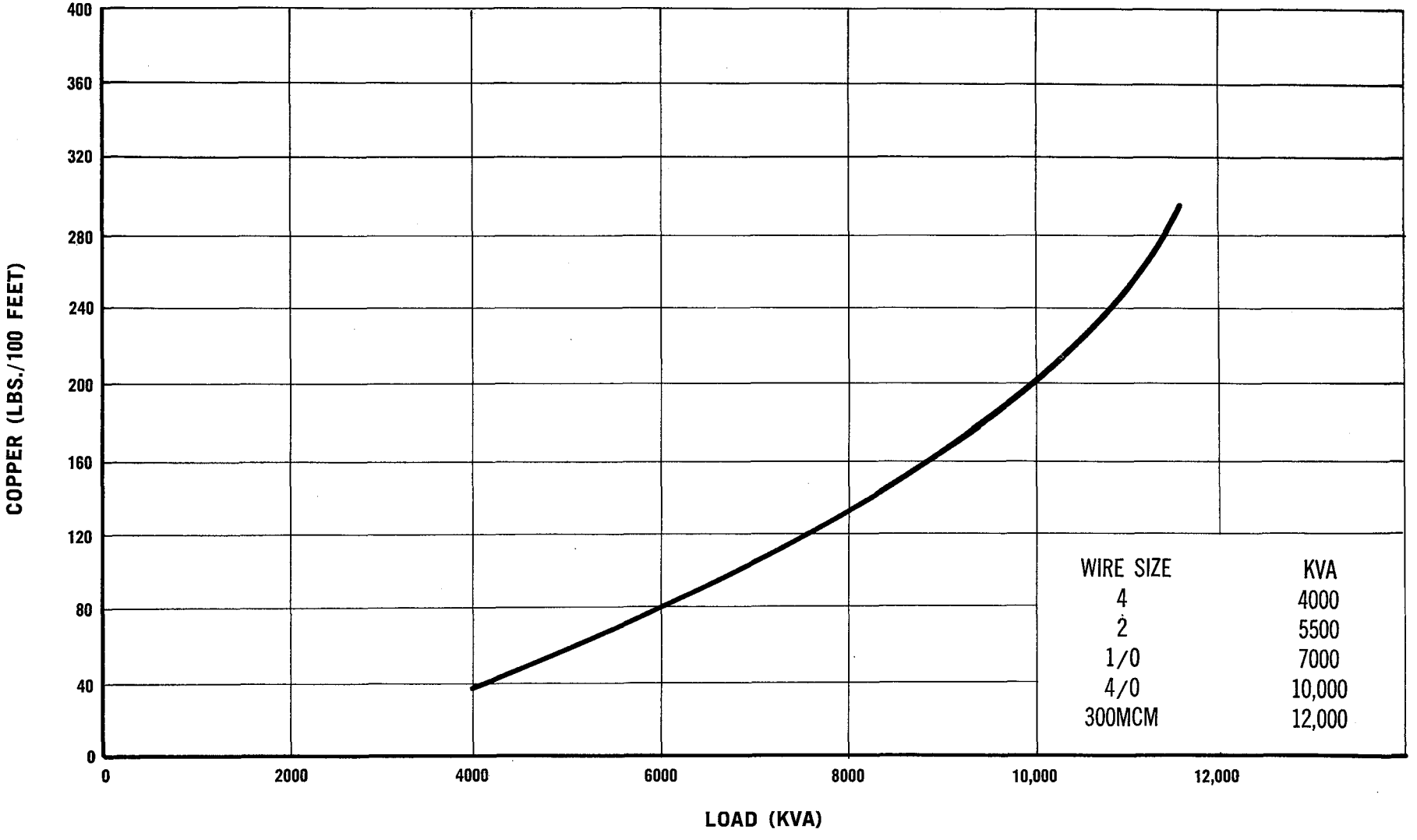


Figure No. 10

POWER DISTRIBUTION

at 13.8 KV



SECTION 12

ANTIKNOCK ADDITIVE MIXING PLANTS

SECTION 12

ANTIKNOCK ADDITIVE MIXING PLANTS

A. DESCRIPTION AND ASSUMPTIONS

The antiknock additive mixing plants are off-site facilities for adding antiknock compounds to both motor gasoline and aviation gasoline.

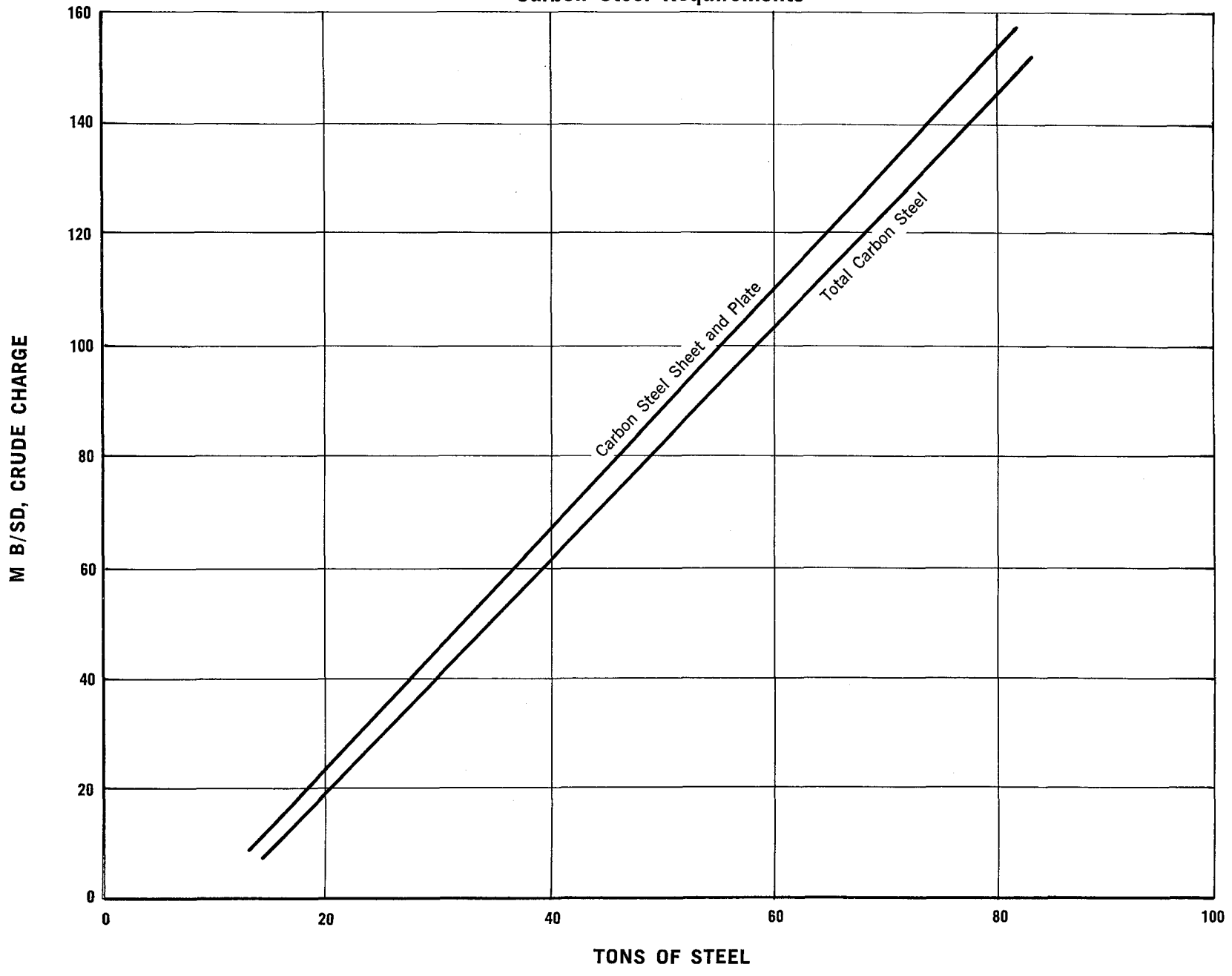
The steel requirements are estimated for refineries varying in capacity from 10,000 to 150,000 barrels crude input per day. The gasoline output is assumed to be 43% motor gasoline and 2% aviation gasoline, making a gasoline total of 45% of the crude input.

The mixing plants are sized to provide storage for a 30-day supply of antiknock compound, assuming the use of 1/2 pound of motor mix per barrel of motor gasoline and 1 pound of aviation mix per barrel of aviation gasoline.

Figure No. 11

ANTIKNOCK ADDITIVE MIXING PLANTS

Carbon Steel Requirements



ANTIKNOCK ADDITIVE MIXING PLANTS

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY B/SD		
Crude Charge	10,000	75,000	150,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	13.0	41.6	80.9
(b) Pipe and tubing	.8	.9	1.2
(c) Valves, fittings and flanges	1.0	1.1	1.4
(d) Structural and others	1.6	1.6	1.6
(e) TOTAL	16.4	45.2	85.1

(See Table 4 for detailed estimate of carbon steel requirements for refinery capacities for each 10,000 B/SD from 10,000 to 150,000 B/SD.)

2. Pumps, Compressors, etc.
(number of units)

Pumps and motors (HP)

0-20	2	2	2

3. Electrical

(Assumed to be incorporated with other refining facilities)

Crude Charge	UNIT CAPACITY B/SD 10,000	75,000	150,000
4. Instrumentation (number)			
(a) Turbine meters (0.2 to 100 GPM)	2 to 4	2 to 4	2 to 4
(b) Preamplifiers	2 to 4	2 to 4	2 to 4
(c) Counters	2	2	2
(d) Liquid sensors	2	2	2
(e) Temperature indicators	2	2	2
(f) Fluid filters	2	2	2
(g) Gasoline strainers	2	2	2
(h) Load cells	2 to 8	2 to 8	2 to 8
(i) Pressure gauges	8	8	8
(j) Control valves (for in-line blending)	2 to 4	2 to 4	2 to 4
(k) Automatic cut-off valves (for batch blending)	2	2	2
(l) Vacuum devices (recommended)	2	2	2
(m) Flow rate devices (optional for batch blending)	2	2	2
(n) Low air pressure switches (for pneumatic valve operations)	2	2	2
(o) Liquid level indicators (if load cells are not used)	2	2	2

C. UTILITY REQUIREMENTS

Crude Charge	UNIT CAPACITY B/SD 10,000	75,000	150,000
1. Electricity (KVA)	17.5	17.5	17.5

TABLE 4

STEEL REQUIREMENTS FOR
ANTIKNOCK ADDITIVE MIXING PLANTS

CRUDE INPUT B/SD	TYPE MIXING PLANT (GALLONS CAPACITY) MOTOR GASOLINE	AVIATION GASOLINE	CARBON STEEL (IN TONS) SHEET AND PLATE	PIPE AND TUBING	VALVES FITTINGS & FLANGES	OTHER	TOTAL
10,000	8,000 TC	4,400 TC	13.0	.8	1.0	1.6	16.4
20,000	15,000 TC	4,400 TC	18.3	.8	1.0	1.6	21.7
30,000	18,000 TC	4,400 TC	20.8	.8	1.0	1.6	24.2
40,000	22,000 TC	4,400 TC	23.2	.8	1.0	1.6	26.6
50,000	22,000 TC + 1 - 22,000 AS	4,400 TC	41.6	.9	1.1	1.6	45.2
60,000	"	4,400 TC	41.6	.9	1.1	1.6	45.2
70,000	"	4,400 TC	41.6	.9	1.1	1.6	45.2
80,000	"	4,400 TC	41.6	.9	1.1	1.6	45.2
90,000	22,000 TC + 2 - 22,000 AS	8,000 TC	62.8	1.1	1.3	1.6	66.8
100,000	"	8,000 TC	62.8	1.1	1.3	1.6	66.8
110,000	"	8,000 TC	62.8	1.1	1.3	1.6	66.8
120,000	"	8,000 TC	62.8	1.1	1.3	1.6	66.8
130,000	22,000 TC + 3 - 22,000 AS	8,000 TC	80.9	1.2	1.4	1.6	85.1
140,000	"	8,000 TC	80.9	1.2	1.4	1.6	85.1
150,000	"	8,000 TC	80.9	1.2	1.4	1.6	85.1

TC - Tank Car Delivery
AS - Additional Storage

SECTION 13

COOLING WATER TOWERS

SECTION 13

COOLING WATER TOWERS

A. DESCRIPTION AND ASSUMPTIONS

The cooling towers in this estimate are of an induced draft type, including tower basin, circulating water pump, and piping within the cooling tower limits.

Two sizes of towers are shown with capacities of 2,500 and 7,500 GPM. Basins are figured with a total capacity of eight minutes at the regular pumping rate, namely 20,000 and 60,000 gallons.

Operating conditions are as follows:

Hot Water Temperature	115°F
Cold Water Temperature	85°F
Wet Bulb Temperature	75°F Max.

Towers are equipped with induced draft fans and circulating pumps, but one extra circulating pump should be provided in each group of towers as a spare.

COOLING WATER TOWER

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY GPM	
Water Input	2,500	7,500
1. Carbon Steel (in tons)		
(a) Sheet and plate	-	
(b) Pipe and tubing	7.0	14.5
(c) Valves, fittings and flanges	1.0	1.5
(d) Structural and others	8.0	19.0
(e) TOTAL	16.0	25.0
2. Copper		
(a) Wire and cable (in feet)		
600V, Single conductor (Size)		
12	500	500
4	300	-
3/0	300	360
250 MCM	-	600
(b) Other (in tons)	0.5	1.0
3. Aluminum (in tons)	0.15	0.25
4. Pumps, Compressors, etc. (number of units)		
(a) Pumps and motors (HP)		
21-100	1	-
300	-	1

	UNIT CAPACITY GPM	
Water Input	2,500	7,500
4. Pumps, Compressors, etc. (cont'd.)		
(b) Miscellaneous drivers (HP)		
Fan drivers		
21-100	1	1
5. Electrical (number and type)		
(a) Transformers		
13,800/480V	1-150	1-450
(b) Switchgear (cubicles)	1	1
(c) Motor control centers	1	1
6. Instrumentation (number)		
Pressure indicators	1	1

C. UTILITY REQUIREMENTS

	UNIT CAPACITY GPM	
Water Input	2,500	7,500
1. Electricity (KVA)	124	354

SECTION 14

WASTE WATER SEPARATOR AND EMULSION TREATING

SECTION 14

WASTE WATER SEPARATOR AND EMULSION TREATING

A. DESCRIPTION AND ASSUMPTIONS

This study includes estimates of critical materials requirements for gravity type API oil-water separators with batch chemical treatment of water-oil emulsions.

B. TABULATION OF MATERIALS REQUIREMENTS

	UNIT CAPACITY GPM		
Waste Water	1,000	6,300	40,000
1. Carbon Steel (in tons)			
(a) Sheet and plate	8	17	99
(b) Pipe and tubing	-	3	16
(c) Valves, fittings and flanges	1	1	5
(d) Structural and others	4	14	80
(e) TOTAL	13	35	200
2. Copper (Relate to site location.)			
3. Pumps, Compressors, etc. (number of units)			
Pumps and motors (HP)			
21-100	2	2	-
125-200	-	-	3
4. Electrical (Relate to site location.)			

WASTE WATER SEPARATOR AND EMULSION TREATING

C. UTILITY REQUIREMENTS

	UNIT CAPACITY GPM		
Waste Water	1,000	6,300	40,000
1. Electricity (KVA)	60	50	300

SECTION 15

INSTRUMENT AIR

SECTION 15

INSTRUMENT AIR

A. DESCRIPTION AND ASSUMPTIONS

The instrument air system in this estimate is based on non-lubricated compressors which are single cylinder-single stage, double acting, with 75 lb. discharge pressure and are complete with unloader.

The compressor is followed by an after-cooler, oil filter, silica jel dryer to dry the air to -40°F dew point, a receiver of ample size and piping within instrument air battery limits.

INSTRUMENT AIR

B. TABULATION OF MATERIALS REQUIREMENTS

Dry Air Input	UNIT CAPACITY CFM 100	200
1. Carbon Steel (in tons)		
(a) Sheet and plate	0.5	0.75
(b) Pipe and tubing	0.5	0.5
(c) Valves, fittings and flanges	0.1	0.25
(d) Structural and others	0.25	0.5
(e) TOTAL	1.35	2.00
2. Copper		
(a) Wire and cable (in feet)		
600V, Single conductor (Size)		
12	300	300
3	300	-
3/0	-	300
3. Pumps, Compressors, etc. (number of units)		
Compressors and drivers (HP)		
21-100	1	1
4. Electrical		
(Assumed to be incorporated with other facilities)		

Dry Air Input	UNIT CAPACITY CFM 100	200
5. Instrumentation (number)		
(a) Pressure gauges	1	1
(b) Silica jel instrument air dryer with automatic steam regeneration, including oil filter, for -40°F dew point	1	1

C. UTILITY REQUIREMENTS

Dry Air Input	UNIT CAPACITY CFM 100	200
1. Electricity (KVA)	44	88
2. Cooling Water (GPM)	15	15

SECTION 16

PLANT AIR

SECTION 16

PLANT AIR

A. DESCRIPTION AND ASSUMPTIONS

The plant air system estimate is based on motor driven, 100 lb. discharge pressure compressors complete with unloader, receiver of ample size and piping within the compressor area.

B. TABULATION OF MATERIALS REQUIREMENTS

Air Input	UNIT CAPACITY CFM 200	500	1,000	2,000
1. Carbon Steel (in tons)				
(a) Sheet and plate	0.35	0.5	0.75	2.5
(b) Pipe and tubing	2.0	4.0	6.0	9.0
(c) Valves, fittings and flanges	0.25	0.25	0.4	0.75
(d) Structural and others	0.25	0.5	1.0	2.0
(e) TOTAL	2.85	5.25	8.15	14.25
2. Copper				
Wire and cable (in feet)				
(i) 600V, Single conductor (Size)				
12	300	300	300	300
3	300	-	-	-
4/0	-	300	600	-
(ii) 6KV, Single conductor (Size)				
2	-	-	-	300
3. Pumps, Compressors, etc. (number of units)				
Compressors and drivers (HP)				
21-100	1	-	-	-
125	-	1	-	-
250	-	-	1	-
500	-	-	-	1

Air Input	UNIT CAPACITY CFM 200	500	1,000	2,000
4. Electrical				
(Assumed to be incorporated with other facilities)				
5. Instrumentation (number)				
Pressure Indicators	2	2	2	2

C. UTILITY REQUIREMENTS

Air Input	UNIT CAPACITY CFM 200	500	1,000	2,000
1. Electricity (KVA)	44	110	220	440
2. Cooling Water (GPM)	15	20	25	30

SECTION 17

FIRE PROTECTION

SECTION 17

FIRE PROTECTION

A. DESCRIPTION AND ASSUMPTIONS

General design of the fire system may be assumed to include an 8 inch pipe loop around each process unit with a hydrant and monitor every 150 feet. Hydrants usually have 3 2½ inch hose connections and monitors have a capacity of 250 to 500 GPM. An adjustable nozzle to give a solid stream or fog is desirable on each monitor.

The estimate of pump capacity is based on the use of 4 to 6 hose streams or monitors at a time on a process unit fire, hose streams to be used in putting the fire out and cooling adjacent equipment. Six hose streams at 250 GPM each would require a pump capacity of 1,500 GPM. It is assumed this pump would be spared with one of the same capacity having a different type of drive - preferably a gasoline or diesel engine to make it independent of plant utilities. Electric motor and gasoline engine drives are used in this estimate.

Petroleum Insurance Underwriters recommend a 4-hour supply of water to back up the fire pump. This is probably more important in the case of a tank fire than a process unit

fire. In this estimate the cooling tower basin would be used as a primary water supply. If the 7,500 GPM cooling tower is installed with a 60,000 gallon basin, the fire pump would be supplied for a period of 40 minutes. Assuming that makeup water to the basin could be supplied at 750 GPM, the fire pump would be able to operate for a period of one hour. If it is felt that more water storage than this is necessary, provisions should be made for a larger cooling tower basin or some other supply of water.

FIRE PROTECTION

B. TABULATION OF MATERIALS REQUIREMENTS

1. Carbon Steel (in lbs.)

(a)	Wt. of 8" schedule 40 steel pipe per 100	2,855
(b)	Wt. of 8" 150 lb. steel gate valve with companion flanges	460
(c)	Wt. of 6" hydrant with 3-2½" hose connectors	350
(d)	Wt. of 4" hydrant for monitor	250

2. Copper

(a) Wire and cable (in feet)

600V, Single conductor (Size)	
12	300
300 MCM	300

(b) Other 75

3. Pumps and Compressors, etc. (number of units)

(a) Pumps and motors (HP)

150 (1,500 GPM, 125 lb., discharge centrifugal fire pump)	1

(b) Miscellaneous drivers

Gasoline engine and pump	1

4. Electrical

(Assumed to be incorporated with other facilities)

5. Instrumentation (number)

Pressure indicators (per unit)	2

C. UTILITY REQUIREMENTS

1. Electricity (KVA)	133
2. Cooling Water (GPM) (per unit)	1,500