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	Washington, D.C. 20585 PROCESS SELECTION AND INVESTMENT ANALYSIS.
	METHANATION FACILITY FOR PUROX PYROLYSIS SYSTEM OFF-GAS

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Prepared by: Sassi Corporation Indianapolis, Indiana Under Contract No. ACO1-79CS20449

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#### INTRODUCTION AND TECHNICAL SUMMARY

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The Sassi Corporation of Indianapolis, Indiana, is investigating the commercial viability of converting refuse (trash and garbage) to synthetic natural gas. This conversion is accomplished by:

- A. Shredding and preparing the refuse for conversion.
- B. Producing a gas of low calorific value from the refuse using the Union Carbide Purox Process.
- C. Methanating the Purox off-gas to a quality suitable for sale in the existing gas distribution system.

The last step of this conversion process, the Purox off-gas methanation, has . been studied by The Pritchard Corporation, whose technical expertise in this field was utilized to develop a process design and an estimate of its capital investment.

The Pritchard Corporation has submitted this Process Study and Investment Analysis to Sassi: The analysis is being published as part of The Sassi Corporation's contract reports to the U.S. Department of Energy's Office of Energy from Municipal Waste.

Pritchard has had previous experience with the Purox Process. In 1977, it supplied a small pilot unit to Union Carbide Corporation at South Charleston, West Virginia, to test the effects of Purox off-gas on various catalysts. Operation of the plant was conducted by Pritchard personnel, and the insight gained has been incorporated into the present effort. Similarly, Pritchard was retained by the Coyne Chemical Company, Philadelphia, Pennsylvania, to perform a study of the viability of refuse conversion to annonia in the City of Seattle, Washington. The process was developed but the economics did not warrant construction.

Pritchard designed and engineered the first U.S. plant using the British Gas Corporation's Catalytic Rich Gas (CRG) Process for Commonwealth Natural Gas Company at Chesapeake, Virginia. This plant operates successfully on either the propane or butane feedstock. A similar plant was fully designed and engineered for Coastal States Natural Gas Company by Pritchard to utilize naphtha as a feedstock. Construction of this plant was curtailed by the unavailability of the naphtha feedstock caused by the Middle East oil embargo in 1974.

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For Sassi's facility, the design developed by Pritchard upgrades low-BTU Purox off-gas, with a heating value of 590 BTU per cubic foot, to Synthetic Natural Gas (SNG), which is comprised mostly of methane and which has a heating value of 879 BTU per cubic foot. Upgrading is accomplished by a series of clean up and catalytic conversion steps. The clean-up steps encompass a benzol wash for removal of residual hydrocarbon liquids from the Purox off-gas, sulfur and chloride removal, carbon dioxide removal, and dehydration. The catalytic conversion steps consist of hydrogenation and methanation.

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Well-proven processes have been selected for each processing step, although the sequence of the processing steps is unique to treating Purox off-gas. The process steps selected are the result of comparing viable methods for each processing application. The selection is discussed in detail in Section 1, Process Selection.

Based on the scheme envisioned, Pritchard has prepared a process design for a facility which processes 46.87 MMSCFD of Purox off-gas, resulting in 26.4 MMSCFD of SNG. A detailed process description and process flow diagram may be found in Section 3, Process Description. A more detailed description of the mechanical aspects of the plant is also included in this report in the form of equipment specifications, layout, and operating requirements.

Our investment analysis reveals that capital requirements for the facility described here are approximately \$47,320,000, resulting in a payout, not including taxes or interest, of 8.3 years. Details substantiating the investment analysis which defines how the costs were determined may be found in Section 6, Investment Analysis.

\*MMSCFD = million standard cubic feet per day.

### 1. PROCESS SELECTION

#### Overview

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Before reporting on the details and justification of process selection, it is deemed appropriate and important to review the overall intent of this facility and the Purox Process concept, so that a meaningful understanding of the processing steps which Pritchard has studied can be achieved.

The concept of converting refuse to synthetic gas was conceived for the disposal of municipal and industrial refuse as an environmentally acceptable alternative to the conventional methods of refuse disposal currently adopted by cities, specifically burying or incineration with air.

Burying the waste material has long been an accepted practice; and provided there is sufficient overfill, such landfill sites when filled to capacity can provide areas for municipal recreation, etc. A spinoff from such buried refuse results when, following natural anaerobic digestion, methane can be withdrawn and usefully employed. However, disposal by such methods requires large land areas. As such landfills can be unsightly, the selection is very often limited to such areas as flood plains, quarries, etc.; i.e., land which is unfit for other use. In the selection of such sites the long-term effect of the leaching of non-degradable toxins into natural aquifers was often given little more than a cursury overview. Today, the picture is vastly different and such considerations severely limit the number of available sites.

The lack of suitable land may well have forced an upsurge in incineration plants. However, such plants emit gaseous pollutants and still require disposal of the ash by other means, normally burial. Such incineration plants, using air as an oxidant, do not produce high enough temperatures to completely render toxic metals into an innocuous state. The ash is still leachable, and thus requires as careful a disposal by burial as the raw refuse.

The Purox process is in itself an incineration process. However, the oxidant chosen is pure oxygen. This simple change in the oxidant for the combustion process, combined with the furnace design, makes the environmental impact of this incineration totally acceptable. The shaft furnace is not unlike a blast furnace. Shredded raw refuse is fed by

lock hopper into the top, and oxygen is fed into the bottom. The oxygen ignites the cindered refuse which has traveled down the furnace and has been totally charred by the rising hot gases. Because oxygen is used, an intense flame develops, such that the incombustibles fuse and blend into a siliceous lava which issues from the bottom of the furnace into a quench pit. This intense burning is called pyrolysis.

The resulting ash is a glassy friable material with very low leachate content. It has properties which favor it as a fill or aggregate.

The gases rising from the flame counter-currently react with the falling refuse and are in turn reduced to the pyrolysis off-gas which leaves the top of the incinerator. These gasses are valuable since they contain very little nitrogen. Had air been used as the oxidizing agent, as one finds in regular incinerators, this off-gas would have contained so much nitrogen as to render it useless as either a chemical feedstock or fuel. But since oxygen has been used, the off-gas from the Purox unit contains only as much nitrogen as was an impurity in the oxygen plus any molecular nitrogen that may have been formed by the cracking of nitrogenous compounds present in the refuse. The gas contains oils and tars which are removed by water scrubbing and electrostatic precipitation. The resulting gas has a low calorific value at the Purox plant outlet.

### Reasons for Upgrading Gas

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The gases obtained from the Purox unit have low calorific value but contain all the necessary constituents to produce a synthesis gas which may be used to produce various chemicals, including methane (or synthetic natural gas), which may be blended into an existing natural gas network. The gas from the Purox unit has intrinsic heat value, and arguments may be made for marketing this gas directly or burning it directly. Unfortunately the gas does not lend itself to either of these alternatives readily. The composition of the gas will vary with the "quality" of the refuse, which varies not only on a daily basis but also on a seasonal basis. Thus, burners will need to cope with varying calorific value gas. More importantly, the flue gas effluents from such burners may contain environmentally unacceptable amounts of sulfur oxides, chlorides, and nitrogen oxides, related to the "quality" of the refuse. To render the gas free of such impurities will require the same clean-up equipment and processing as required for the synthetic natural gas plant, and the problem of varying caloric value would still not be solved.

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By conversion of the gas to methane, the resulting product will be of constant calorific value, suitable for use with burners presently using natural gas (without modification to the burners) and suitable for transmission and use by all users whether commercial, industrial or residential without any modifications to existing equipment. The synthetic natural gas produced would be indistinguishable from the gas currently used. ρ

#### Methanation Process

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Although a detailed description of the proposed process is given in the Process Description section, a general overview is presented to acquaint the reader with the reasons and alternate solutions available to render an overall processing scheme which is commercially proven and viable.

The gas leaving the Purox unit is not unlike a coke oven gas in composition as it contains essentially the same constituents. However, they are present in the Purox gas in different proportions than in the coke oven gas. For instance, if all of the elemental carbon and hydrogen with the addition of water were converted to methane from coke oven gas, an excess of hydrogen would result. Similarly, if the same transformation was conducted on Purox off-gas, an excess of carbon (as carbon dioxide) would result. This similarity of component parts between Purox off-gas and coke oven gas, however, is a guide to the necessary pretreatments required by the process.

Such treatments should be well proven, since the overall concept of converting refuse to synthetic natural gas is novel. Therefore, it is most important that each individual unit operation must be proven, possibly in other overall processing schemes, such that each of these proven steps may be combined producing the overall concept.

The first step involves compression of the gas. The Purox unit operates at essentially atmospheric pressure. Since it is undesirable to operate any portion of the methanation process at sub-atmospheric pressure to avoid ingress of air, the gas must be compressed. However, the gas, although free of particulates, contains unsaturated hydrocarbons. Compression of this raw gas could result in polymer formation in the compressor since the propagation of these polymers is initiated by the heat of compression. To prevent this, experience was drawn from low caloric content gas plants using coke oven feed gas. Following such practice, the gas is increased to sufficient pressure by a fan to allow it to be scrubbed with a hydrocarbon liquid. The scrubbing operation removes any heavy hydrocarbons and polymers, which are subsequently returned to the Purox unit for total incineration. The gases are then compressed in screw-type compressors with water injection. The water not only serves to cool the compressor, but also washes the machines continuously to prevent buildup of materials. Such compressors are operating today in coke oven gas service.

The second step involves the hydrogenation of the unsaturated hydrocarbons in the gas. It is these hydrocarbons, particularly the acetylinic compounds, which are the polymer forming agents. Hydrogenation involves using the molecular hydrogen inherent in the gas to react with these unsaturated compounds, converting them to paraffins. A choice of proven processes introduced itself for this step and the gum-forming compounds could either be removed or converted. Had removal been the choice using, for example, the Rectisol process, then simultaneous removal of the carbon dioxide and hydrogen sulfide would have occurred. However, it was necessary to retain the carbon dioxide for reasons which are discussed later. The hydrogen sulfide, following its removal after regeneration of the Rectisol solution, would still need to be converted to elemental sulfur to render it environmentally acceptable. Since not all the sulfur present in the gas is as hydrogen sulfide, further clean-up would be required as the catalysts used in subsequent processing will be sensitive to sulfur poisoning. Therefore, conversion of the gum formers by hydrogenation was decided upon.

Hydrogenation is a relatively simple and well-proven process. It is normally carried out over a nickel-based catalyst. However, the presence of the carbon oxides in the feed gas poses a problem, since the methanation reaction is also promoted by certain nickel catalysts. British Gas Corporation has devised and operated a process for many years which will hydrogenate unsaturated hydrocarbons in the presence of the oxides of carbon. This process was successfully applied to coke oven gas at the Shotton Steel Works in Wales, U.K., during 1971-72 for some six to eight months. The tests were completed and no further work was done since natural gas from the North Sea deposits were being exploited, and no need was present for synthetic natural gas. Because of the similarity between Purox off-gas and coke oven gas, the proposed methanation plant is based on this process for the hydrogenation step.

The process is called the "NIMOX" process, and relies upon a sulfided nickel molybdate catalyst. Sulfur in the gas is necessary to keep the catalyst sulfided. This processing step provides the necessary conversions to render the gas suitable for further treatment by conventional means. The "NIMOX" process provides a bonus in that all sulfur compounds are hydrogenated to hydrogen sulfide and all organic chlorides to hydrogen chloride, allowing for easy removal of these substances.

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Following hydrogenation the third processing step involves the removal of the sulfur and chlorides from the gas. Again, a well-proven process has been selected, the Stretford process. This was chosen over others because it is the only practical process available; many plants are operating in the U.S.A.; and the sulfur is recovered as elemental sulfur which may be marketed, and not as H<sub>2</sub>S or SO<sub>2</sub> which are atmospheric pollutants. To guard against any sulfur slippage, two absorbent beds follow the Stretford unit containing promoted zinc oxide. This is standard practice in most synthetic gas plants where catalysts involved are particularly sensitive to sulfur.

The gas has now been fully treated to make it suitable for the fourth process step, the Catalytic Rich Gas and methanation process. The process adopted is the British Gas S.N.G. (Synthetic Natural Gas) process. Similar processes are offered by Japan Gas Company and by Lurgi in Germany. Selection of the British Gas process over the other available processes was based on the large number of successfully operating plants they have, coupled with their work and familiarity with coke oven gas at Shotten Steel Works, as previously explained. The process is fully explained in the Process Description section, but in essence it consists of the conversion of the saturated hydrocarbons formed in the hydrogenation step to methane using steam and hydrogen (the latter being present in the feed gas). This is followed by wet methanation in which the bulk of the carbon oxides are combined with hydrogen to form methane. The last step is dry methanation, wherein residual hydrogen combines with the carbon oxides to maximize the production of the methane gas. All reactions are extremely exothermic, and the reactions are moderated by the excess carbon dioxide which was allowed to pass through the second processing step. The heat generated is used for making steam, which is used within the process and to drive the feed gas compressor turbines.

The excess carbon dioxide is then removed from the synthetic natural gas with a recirculating amine solution. The Union Carbide Amine Guard process was selected. This is well-proven, mainly in ammonia synthesis plants where it serves the same function. Many carbon dioxide removal systems are available commercially. Selection of Amine Guard was established by economics and it is noteworthy that many commercial plants using other systems have changed over to this process.

Finally, the methane product is dried using glycol and is available for marketing as synthetic natural gas.

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### 2 BASIS FOR DESIGN

### Introduction

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This section deals with the selection of the design basis for the plant detailed in this report. The plant will convert pyrolysis gas, generated by burning refuse in a Purox refuse incinerator, to synthetic natural gas (SNG).

To establish the design basis requires the selection of the three design variables identified below:

Amount of refuse pyrolyzed and its heating value, Heating value of pyrolysis gas, and Thermal efficiency of the pyrolysis process.

The selection of these three design variables fixes the pyrolysis gas production rate, which in turn leads to the complete definition of the parameters defining plant size.

SASSI requested a basis for design of 2100 short tons per day of garbage be processed. This required a large variation in plant size based on the heating value of the garbage and the performance of the Purox Process. In order to avoid major plant size changes, Pritchard selected a single pyrolysis gas flow rate to design the plant and has evaluated the variation in the amount of garbage which can be processed based on the processing efficiencies.

Units

Throughout this document the English system of units is used. The Standard Cubic Foot (SCF) conditions are defined as an ideal, dry gas at 14.73 PSIA and 60  $^{\circ}$ F.

Specifications to Establish the Basis for Design

Pyrolysis Gas Production Rate

To efficiently study this plant design, a pyrolysis gas production rate was selected and fixed. The

### Pyrolysis Gas Production Rate (Cont.)

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pyrolysis gas production rate selected is 46.87 MMSCFD (million standard cubic feet per day). The range of the three design variables identified above which will give this fixed gas production rate is discussed with each variable in the following section.

### Heating Value of the Pyrolysis Gas

The heating value of the pyrolysis gas generated by the Purox Process is derived from the gas composition. Two pyrolysis gas compositions were studied. The first was obtained during tests conducted by Pritchard in September 1977 at the South Charleston Purox Pilot Plant. The second was provided by Union Carbide Corporation as reported in Bechtel's report to the City of Seattle. The former pyrolysis gas composition has been chosen as the design basis upon which the equipment has been sized. Pritchard performed a material balance on the alternate case to develop a product gas (SNG) composition.

Table 1 gives the pyrolysis gas composition and higher heating value (HHV) for the two gas compositions studied.

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component	Source: Pritchard (Design Basis)	Source: Union Carbide Corp. (Alternate Basis)
H2	17.3	28.9
ζŎ	24.0	35.8
CO2	19.6	23.4
CHA	21.0	5.5
$C_2$	4.7	2.7
C3	1.2	0.37
C4	1.3 .	0.33
C5+	3.0	1.0
Sulfide	0.02	0.00
U2	0.03	1 7
inert Gase	s /.2	1.7
H20	0.7	0.15
gher Heatin	g Value 590	376

TABLE 1. Pyrolysis Gas Average Composition and Higher Heating Value

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# Thermal Efficiency of the Pyrolysis Process

When refuse is processed in a Purox refuse incinerator, only a portion of the heating value of the refuse is recovered in the pyrolysis gas. The amount of heat recovered is defined as the efficiency of the pyrolysis process.

Two different values of the thermal efficiency of the pyrolysis process have been considered. The first, suggested by the SASSI Corporation, is a thermal efficiency of 61%. The second value, recommended by Union Carbide Corporation, is a thermal efficiency of 75%.

The effect of the Purox thermal efficiency on the amount of refuse processed is shown in Table 2.

### Amount of Refuse Pyrolyzed

To calculate the amount of refuse pyrolyzed, the following design basis has been used:

Heating value of the refuse - 5000 BTU/1b\*

Table 2 shows the amount of refuse which can be pyrolyzed in a plant of the selected size based on the thermal efficiency of the pyrolysis process and the heating value of the pyrolysis gas.

### Product Gas (SNG) Specification

The product gas (SNG) composition depends on the feed gas composition. The product gas composition which results from the design basis feed and the alternate basis feed is shown in Table 3.

\*Union Carbide Corporation

Table 2. Refuse Pyrolyzed at Two Plant Designs

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	Pyrolysis Gas Production Rate (MSCFD)	Pyrolysis Cas HHV (BTU/SCF)	Product Gas Rate (MSCFD)	Product Gas HHV (BTU/SCF)	Refuse Pyrolyzed @ 61% Eff. (T/D)	Refuse Pyrolyzed ê 758 Bff. (T/D)
Design Basi	s 46.87	590 <sup>1</sup>	26.4	6/8	4530	3690
Alternate Basis	46.87	376 <sup>2</sup>	14.1	956	2890	2350
Note 1	tohand tott at Court	h (thord actor				
Note T. Fr	I LUIRIU; LESE AL OULL					·
Note 2. Be	chtel's Seattle Repor	4				•
Note 3. T/	D - short ton/day					

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Table	3.	Product	Gas	(SNG)	Specification
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Composition	Design Basis	Alternate Basis
H <sub>2</sub>	0.2	0.3
co	0.1	0.2
Inerts	12.7	5.5
CH4	87.0	94.0
Total	100.0	100.0
HHV (BTU/SCF)	879	956
Temp. ( <sup>O</sup> F)	100	100
Pressure (psig)	30	30
Water Dewpoint ( <sup>O</sup> F)	0	0

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Ambient Conditions

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Process Design Temperatures Maximum 94<sup>0</sup>F Minimum -20<sup>0</sup>F Mechanical Design Temperatures Maximum 110<sup>0</sup>F Minimum -20<sup>0</sup>F

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### 3 PROCESS DESCRIPTION

### Introduction

The raw gas from the Purox furnace is cooled and passed through an electrostatic precipitator for removal of dust and heavy oil particles as part of the Union Carbide Purox Process Package. This gas then flows to the Methanation Plant for final clean-up, treatment, and upgrading to produce a pipeline-quality synthetic gas. The design consists of several process steps used in the following order:

- (a) Benzol wash system for removal of residual hydrocarbon liquids.
- (b) Feed gas compression.
- (c) Hydrogenation of olefinic compounds.
- (d) Sulfur and chloride removal.
- (e) Methanation to upgrade the heating value of the gas.
- (f) Carbon Dioxide (CO2) removal by monoethanolamine (MEA).
- (g) Glycol Dehydration.

The synthetic gas produced by these steps is a pipeline quality gas having a heating value of 879 BTU/SCF. Further upgrading of the gas to an even higher heating value is possible by hydrocarbon liquid injection.

### Benzol Wash\*

The pyrolysis gas from the Purox unit is compressed by Exhauster C-3A or B to a pressure of 15.8 psia to assure the operation of the Benzol system above-atmospheric pressure. From the Exhauster, the pyrolysis gas flows to the Benzol Absorber, T-1, where it is scrubbed by the circulating lean oil. The lean oil serves to remove residual benzenes and other hydrocarbon liquids which have remained in the pyrolysis gas. The absorber overhead gas flows to the feed gas compression system.

A rich oil from the bottom of the absorber is pumped via Rich Oil Pump P-4A or B, through Lean/Rich Exchanger E-7, and Rich Oil Heater E-6, both of which add heat to the Benzol Stripper, T-2. The rich oil is stripped of benzenes and aromatics by live steam injected into the base of the stripper. The regenerated lean oil is returned via Lean Oil Pump P-5A or B, through Exchangers E-7 and E-5, both of which cool the oil which is fed to the top of the Benzol Absorber.

The stripper overhead stream is cooled in Benzol Condenser E-8 before flowing to the Benzol Separator D-5. Three streams are sent from the separator as follows: α

Refer to Figures 1 and 2.

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### ACC. MR - MUILDINGS

CONTROL BUILDING

### BENZOL WASH UNIT

ACC. 05 - VESSELS & TANKS

D-5	BENZGL SEPARATOR
T-1	BENZOL AUSORBER
T-2	BENZOL STRIPPER
TK-2	BENZOL STORAGE TANK
TK-3	LEAN OIL STORAGE TARK

### ACC. 17 - HEAT EXCHANGERS

E-5A48	LEAN OIL COOLER
E-6	RICH OIL HEATER
E-7AAB	LEAH/RICH EXCHANGER
E-8	BENZOL CONDENSER

#### ACC. 49 - NECHANICAL & PACKAGED EQUIPMENT

C-3448	EXHAUSTER
P-4ABB	RICH OIL PUMP
P-SABB	LEAN OIL PUKP
P-6A&B	LEAN OIL MAKE-UP PUMP
P-7	BENZOL CONDENSATE PUMP

#### FEED GAS COMPRESSION UNIT

#### ACC. 19 - RECKANICAL & PACKAGED EQUIPMENT

PG-1488	FEED GAS COMPRESSOR PACKAGES
D-1ALB	INTERSTAGE SEPARATORS
D-2A48	INTERSTAGE SEPARATORS
D-3ALB	DISCHARGE SEPARATORS
D-4AAB	DISCHARGE SEPARATORS
TK-JAAB	COOLANT SURGE TANKS
E+1443	INTERSTAGE COOLERS
F-2AAR	INTERSTAGE COOLERS
F-3ALR	DISCHARGE COOLERS
	COMPRESSOR COOLANT COOLERS
C 1410	200223000 2002200 2002200
C-1482	FEED BAS CUMPRESSURS
P-1A.B.CAD	COOLANT PURPS
P-2A.B.CAD	COOLANT BOOSTER PURIPS
P-JALR	OTI SKTHMER PUMPS
1 - 4-10.0	ACCORDENCES AND THE STUDY OF THE
SE-1468	COMPRESSOR STAFE JURDING ORITER

### PURIFICATION UNIT

### ACC. 05 - VESSELS & TANKS

D-6	RECYCLE GAS SEPARATOR			
R-1A8B	HYDROGENATOR			
R-2A	CHLORIDE/SULFUR GUARD BEDS			
ACC. #6 - DIR Pow	ECT FIRED HEATERS & ER BOILERS			
F-1	START-UP FEED GAS FURNACE			
ACC. #7 - HEAT EXCHANGERS				
F-7-13 840	FFFD GAS HEATER			
E-27	COLD RECYCLE COOLER			
ACC. 09 - MEC	HANICAL & PACKAGED EQUIPMENT			
C-2 <b>A</b> &B	RECYCLE COMPRESSOR			
PG-2	CARBON DISULFIDE INJECTION			
	UNIT			

### PG-3 PACKAGE HYDROGEN PLANT

### STRETFORD UNIT

# ACC. 05 - VEJSELS & TANKS

F1L-1A48 D-7 D-8A48 TK-4 TX-5 TK-6 TK-7	SECONDARY SEPARATOR PRIMARY SEPARATOR FLASH DRUM PUMP TANK OXIDIZER SLURRY TANK SUMP TANK			
ACC. 17 - HE	AT EACIDIMALAS			
E-9 E-10 <b>AB</b> B	GAS/GAS EXCHANGER GAS COOLER			
ACC. 19 - MECHANICAL & PACKAGED EQUIPMENT				
B-2A&B M-1 M-2 P-9A&B	AIR BLOWER Contactor (Mixer) Slurry Tank Mixer Lean Solution Circulation Pump			
P-10 <b>A&amp;B</b> P-11	SLURRY PUMP SUNP PUMP			
CONVERSION UNIT				
ACC. #5 - V	ESSELS & TANKS			
R-3ALB	CRG REACTORS			
K-4 D_5	METHANATOR NO. 2			
D-9	METHANATOR EFFLUENT SEPARATOR			
0-14	CRG EFFLUENT SEPARATOR			
ACC. #6 - D	IRECT FIRED HEATERS & POWER BOILERS			
WHB-1 WHB-2	NO. 1 WASTE HEAT ROILER STEAH DRUM NO. 2 WASTE HEAT BOILER STEAM DRUM			

#### ACC. #7 - HEAT EXCHANGERS E-11 CRG FEED COOLER E-12 CRG EFFLUENT COOLER E-13 METHANATOR EFFLUENT COOLER NO. 1 E-14A, B&C METHANATOR EFFLUENT COOLER NO. 2 E-15A, B&C METHANATOR EFFLUENT COOLER NO. 3 E-25A&B GAS/GAS EXCHANGER E-26 CRG EFFLUENT STEAM CONDENSER

# CO2 REMOVAL & GLYCOL DEHYDRATION UNIT

ACC. #5 - VESSELS & TANKS

D-10 D-11 D-12 D-13 FIL-' T-3 T-4 TK-8 TK-9 D-15	K.O. DRUM REFLUX DRUM SOLUTION MIX TANK MEA CARBON FILTER SUMP FILTER CO2 STRIPPER CO2 ABSORBER MEA STORAGE TANK MEA SUMP HOT CONDENSENTE BEPARATOR
ACC. #7	HEAT EXCHANGERS
E-17 E-18 E-19 E-20 E-21 E-22 E-23 ACC. #9 -	MEA REBOILER MEA STEAM REBOILER MEA RELLAN 'ER STRIPPER OVERHEAD CONDENSER LEAN MEA/RICH MEA EXCHANGER GAS COOLER MEA COOLER MEA COOLER MECHANICAL & PACKAGED EQUIPMENT
P-12A88 P-13A88 P-14 P-15 PG-4 P-18A68	STRIPPER REFLUX PORT MEA CHARGE PUMP MEA MAKE-UP PUMP NEA SUMP PUMP SLYCOL DEMTORATION PA SEE P-16ABB GLYCOL PUMP CONDENSATE PUMP CONDENSATE PUMP

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Fig. 2. Process Flow Diagram: Benzol Wash

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- (a) Gas previously dissolved in the lean oil is sent from the top of D-5 to the suction of the exhauster under pressure control.
- (b) Benzene and other hydrocarbon liquids form a separate liquid phase which is sent from the mid height of D-5 to the Benzol Storage Tank, TK-2. It is intermittently pumped by Benzol Condensate Pump, P-7, to the Purox furnace for incineration.
- (c) The water phase is sent from the bottom of D-5 to the oily water drain system for disposal.

Make-up lean oil is stored in Lean Oil Storage Tank TK-3, and pumped to the system on surge level control by Lean Oil Makeup Pump P-6A or B.

### Feed Gas Compression\*

Each Feed Gas Compressor Package, PG-1A or B, is capable of compressing 60 percent of the normal design gas flow from atmospheric pressure to 258 psia. Each compressor is provided with recycle capabilities such that in normal operation one unit will be operating fully loaded and one unit on partial recycle.

Each compressor package consists of a three-stage screw-type compressor with coolant injected into the suction of each stage. The cylinders operate flooded to maintain a maximum gas temperature of 200°F. This temperature must be controlled to prevent polymerization and coking of the gum formers in the gas.

Coolant is injected into the gas stream flowing to the compressor's first stage where the two-phase mixture is compressed from 14.7 psia to 50 psia. The gas/coolant mixture flows to the Interstage Separator, D-1A or B, from which the coolant is separated and sent to the Coolant Surge Tank, TK-1A or B, under level control. The gas from D-1A or B is cooled in Interstage Cooler, E-1A or B. Coolant is again injected into the gas, and the two-phase mixture is sent to the second stage for compression from 45 psia to 120 psia. The gas/coolant mixture is again separated, this time in Interstage Separator D-2A or B, and the coolant is sent back to the Coolant Surge Tank, TK-1A or B, under level control. The gas is cooled in Interstage Cooler E-2A or B. For a third time coolant is injected into the gas stream before the third stage of compression. In the final compression step, the two-phase mixture is compressed from 115 psia to 265 psia before being sent to Discharge Separator D-3A or B. The gas phase is cooled in Discharge Cooler E-3A or B, and flows to Discharge Separator D-4A or B for final coolant separation with the coolant being sent to Discharge Separator D-2A and B, under level control.

<sup>\*</sup>Refer to Figure 3.



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Each compressor package has a separate coolant circulation system. The coolant is pumped from the Coolant Surge Tank, TK-1A or B, by Coolant Pump, PlA, B, C or D, through Compressor Coolant Cooler E-4A or B, where it is cooled by cooling water. From E-4A or B the coolant either flows to the first-stage compression coolant injection point or to Coolant Booster Pump P-2A or B, to be pumped to higher pressure for injection into the second or third stage compressor suction injection points. The compressors are steam turbine driven and also have lube oil and seal oil systems.

Oily water is skimmed from the top of TK-1A or B by Oil Skimmer Pumps, P-3A, B, C and D and sent to the oily water system.

### Hydrogenation\*

Using the 'NIMOX'' process, the compressed feed gas is heated by steam in Feed Gas Heater, E-24A, B, & C, and fired Startup Feed Gas Furnace, F-1.

The 550°F feed gas flows to the Hydrogenator, R-1A and B, where the unsaturated hydrocarbons are saturated and sulfur is converted to hydrogen sulfide in the presence of a nickel molybdate catalyst. The temperature rise across the reactor bed is limited to 150°F. As the temperature rise increases across the bed due to higher unsaturates in the gas, the  $\Delta$ T controller will allow gas cooled by Cold Recycle Cooler #1, E-27, and Cold Recycle Cooler #2, E-28, to be circulated from Recycle Compressor C-2A or B, to the reactor inlet. When no gas is required for the reactor temperature rise control, the compressor operates through the minimum flow bypass.

A Carbon Disulfide Injection Unit, PG-2, and Package Hydrogen Plant, PG-3, are included for presulfiding the catalyst and startup. The Carbon Disulfide Injection Unit is also used if H2S concentration to the hydrogenator drops below 100 ppm. This would desulfide the catalyst and could result in localized high-temperature areas where coking would likely occur.

# Sulfur and Chloride Removal

Purification of the gas is accomplished by two methods in the facility:

- 1. Stretford plant
- 2. Chloride/Sulfur Guard beds

The gas flows to the Stretford plant first where the sulfur is removed to a level of 4 ppm in the gas. The gas returns from the Stretford

<sup>\*</sup>Refer to Figure 4.



plant and flows through the Chloride/Sulfur Guard Beds, R-2 A and B, and R-2C and D, where the final trace sulfur and chlorides in the gas are removed by absorption using promoted zinc oxide before the gas flows to the catalytic upgrading system. Only one bed is actually needed but with two guard beds piped and valved for both series (with either bed first) and parallel operation, one bed may be removed from service for replacement of the zinc oxide while the other one remains in operation.

### Stretford Plant\*

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### General

The Stretford process removes hydrogen sulfide from sulfurbearing gas streams by converting it to elemental sulfur. The process is essentially a regenerative oxidation-reduction system which utilizes atmospheric oxygen as a regenerative agent.

The system can be divided into four parts; Absorption, Oxidation-Reduction, Regeneration, and Sulfur Separation/Recovery.

### 1. Absorption

The Stretford solution is an aqueous solution containing sodium carbonate, sodium metavanadate, Anthraquinone Disulfonic Acid (ADA), and Rochelle salt. Hydrogen sulfide is absorbed into the solution forming sodium hydrosulfide (reaction 1).\*\* The sodium carbonate also reacts with carbon dioxide in the gas stream, hydrolyzing and forming a carbonate, bicarbonate buffer system. This protects the system against rapid pH changes.

### 2. Oxidation-Reduction

The penta-valent vanadium, in solution, oxidizes the hydrosulfide, forming elemental sulfur (reaction 2), vanadium being present in a stoichiometric quantity with the hydrosulfide concentration. This reaction takes place in an oxygen-free environment since oxygen preferentially reacts with hydrosulfide forming thiosulfate. Next, ADA oxidizes the reduced vanadium back to the pentavalent stage (reaction 3).

<sup>\*</sup>Refer to Figure 5.

<sup>&</sup>quot;Reactions are shown on page 24.



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Fig. 5. Process Flow Diagram: Stretford Plant

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### 3. Regeneration

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Although part of the regeneration cycle (reaction 3) is described in the oxidation-reduction section, the regeneration step is completed as indicated by equation 4. Atmospheric oxygen is continuously used to oxidize the reduced ADA. Oxygen is introduced by sparging air through the solution.

4. Sulfur Separation and Recovery

When air is sparged through the solution, only part of the oxygen is consumed in the chemical reaction and none of the nitrogen is used. The nitrogen and excess oxygen pass upwards through the solution and exhaust to the atmosphere. As the gas bubbles rise, they adhere to the sulfur particles forming a froth which floats on the solution surface. This is the first sulfur separation stage. The second stage of sulfur separation is accomplished by mechanical means and described later.

The overall chemistry of the process can be summarized as follows:

(1)	$H_2S + Na_2CO_3 \longrightarrow$	NaHS + NaHCO3
(2)	$HS^- + V^{+5} \longrightarrow$	s + v <sup>+4</sup>
(3)	$V^{+4} + ADA \longrightarrow$	Reduced ADA + V <sup>+5</sup>
(4)	Reduced ADA + $0_2 \rightarrow$	ADA + H <sub>2</sub> O
(5)	$_{2H_2S} + O_2 \longrightarrow$	2S + 2H <sub>2</sub> O*

#### Details

The hydrogen sulfide Contactor, M-1, is a static mixer. The sour pyrolysis gas enters the mixer section, and flows co-current with the Stretford solution. The gas and liquid are intimately mixed throughout the mixer. During this process, hydrogen sulfide is removed from the gas stream. Other gases are also removed as a function of their solubility, or reactivity with the Stretford

\*Summary of reactions 1 through 4.

solution. The clean H<sub>2</sub>S-free gas leaving the contactor is called sweet gas, which is separated from the Stretford solution in the Primary Separator, D-7.

The sweet gas is filtered prior to leaving the battery limits of the Stretford process system. The Secondary Separator, FIL-1, removes solid and liquid droplets entrained in the gas stream. The liquid from the secondary separator flows to the Flash Drum, D-8.

Liquid from the primary separator also flows to the Flash Drum, D-8, where dissolved gases are flashed from the solution and vented to the low-pressure fuel system. The liquid is retained in the Flash Drum for 10 minutes to allow the vanadium to react with the hydrosulfide in an oxygen-free environment. The solution then flows to the Oxidizer, TK-5.

The Oxidizer, TK-5, serves to accomplish three functions: one, oxidation of reduced ADA; two, flotation of elemental sulfur; and three, stripping dissolved gases from solution. These functions are accomplished by bubbling air through the liquid using spargers located near the bottom of the tank. The spargers are open bottom cylinders with a perforated plate top. This design causes many small air bubbles to form, promoting oxygenation and flotation. Baffles in the oxidizer tank require the liquid to make three passes in the oxidizer, preventing back mixing and insuring that all liquid remains in the oxidizer approximately 46 minutes. A two-weir combination allows the sulfur froth to overflow into the Slurry Tank, TK-6, and the oxidized Stretford solution to underflow back to the Pump Tank, TK-4.

Oxidized Stretford solution is pumped from the Pump Tank to the Contactor by Circulation Pump P-9A or B, completing the absorption circuit. The operating temperature of the Stretford solution is controlled by adjusting the feed gas temperature thru Gas/Gas Exchanger E-9 and Gas Cooler E-10. The solution temperature is maintained for two reasons: one, water balance adjustment; and two, control sulfur fixation.

The sulfur recovery system is comprised of the Slurry Tank, TK-6, Slurry Tank Mixer, M-2, and Slurry Pump, P-10A or B. The Slurry Tank receives sulfur froth from the Oxidixer overflow.

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A mixer located in the Slurry Tank homogenizes the slurry. The slurry is pumped to a draining receiver where the sulfur is collected for disposal. The excess liquid is collected in the Sump Tank, TK-7, and returned to the Oxidizer by Sump Pump P-11. The Slurry Tank also serves to "level" froth surges in the system.

### Catalytic Upgrading \*

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### Catalytic Rich Gas (CRG) Reactor

The gas from the purification sections flows to the CRG Feed Cooler, E-11, where steam is generated from the excess heat in the gas. Saturated 450-psig process steam is mixed with the hot feed gas stream before entering the CRG Reactor, R-3A and B. This steam provides the water necessary for the reaction as defined in equations 1 and 2 below. The steam-to-gas ratio is closely controlled to protect the CRG catalyst from "carbon laydown" and to moderate the temperature rise across the bed. The CRG catalyst (modified nickel) causes the steam to react adiabatically with the feed to form methane, carbon dioxide, carbon monoxide, and hydrogen via the following reactions:

- (1)  $C_AH_B + A H_2O$  \_\_\_\_\_ (A +  $\frac{1}{2}B$ ) H<sub>2</sub> + A CO (reforming)
- (2)  $CO + H_2O$  H<sub>2</sub> + CO<sub>2</sub> (water gas)
- (3)  $CO + 3H_2$  \_\_\_\_\_  $CH_4 + H_2O$  (methanation)
- (4)  $CO_2 + 4H_2$  \_\_\_\_\_ CH<sub>4</sub> + 2H<sub>2</sub>O (methanation)

The first reaction will go to completion such that no higher hydrocarbons other than methane will exit the CRG reactor. Reactions 2, 3 and 4 reach an equilibrium state dependent upon the outlet conditions of the reactor. The reactor effluent consists of methane, carbon dioxide, hydrogen, and carbon monoxide, and unreacted steam at near chemical equilibrium according to the latter three reactions.

#### Methanator

The gas from the CRG reactor passes through the CRG Effluent Cooler, E-12, for removal of the heat of reaction before entering the first of two stages of methanation. The gas is further cooled in the Gas/Gas Exchanger, E-25A and B, and in the CRG Effluent Steam Condenser, E-26. Steam condensed is separated from the gas in D-14, the CRG Effluent Separator. From there the gas is reheated to  $482^{\circ}$ F in the shell side of E-25 and is ready to be fed to Methanator #1, R-4. In the methanation steps, hydrogen

<sup>\*</sup>Refer to Figure 6.



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reacts with carbon monoxide according to reactions 3 and 4 above, over CRG catalyst, to form methane. The methanation reaction is exothermic, resulting in a temperature rise across the reactor bed.

The gas enters Methanator No. 1, R-4, at  $482^{\circ}$ F. Methanator No. 1 reduces the carbon monoxide concentration to 0.6 mole percent. The first methanator is called the "wet" methanator, and the steam remains in the gas to moderate both the reaction rate and temperature rise. This methanator's effluent gas enters the Methanator Effluent Cooler No. 1, E-13, for removal of the heat of reaction, and then passes through Methanator Exchanger E-14A, B and C, and Methanator Effluent Cooler No. 2, E-15A, B and C where the steam in the gas is condensed. The condensed steam is separated from the gas in Methanator Effluent Separator, D-9.

The hydrocarbon gas portion of the stream flows overhead from the separator to the shell side of the Methanator Exchanger, where the gas is reheated to  $482^{\circ}$ F before entering Methanator No. 2, R-5, the "dry" methanator. The removal of the steam from the stream and reduction of the gas temperature both tend to promote the furthering of the reactions, which convert the carbon oxides to methane. The carbon monoxide in the gas is reduced to 0.07 mole percent when exiting this methanator, and the gas has now completed its conversion to SNG. The SNG is cooled in Methanator Effluent Cooler No. 3, E-16.

The four coolers in the methanation process step comprise a waste heat boiler which is used to generate 450 psig steam, for driving other process operations.

### CO<sub>2</sub> Removal<sup>\*</sup>

# Synthetic Gas Flow

The SNG from the Methanation Effluent Cooler is desuperheated to 350°F by Desuperheater, DS-1, and is then cooled and condensed in the tubes of the MEA Reboiler, E-17, which is a kettle-type reboiler providing the heat for stripping the MEA used in the CO<sub>2</sub> removal process.

The SNG is again cooled and condensed, this time to  $150^{\circ}$ F in the tubeside of the Gas Cooler, E-22. The Gas Cooler is operated with co-current flow of reformed gas and cooling water to prevent overcooling the gas.

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Refer to Figure 7.



Fig. 7. Process Flow Diagram:  $\omega_2$  Removal and Glycol Dehydration

The K.O. Drum, D-10, separates the liquid and vapor from E-22. The liquid goes to the process condensate header via level control.

The SNG from D-10 enters the bottom of the CO<sub>2</sub> Absorber, T-4, and is sparged into momoethanolamine (MEA) below the liquid level. The SNG flows upward through the column where it is contacted with the liquid MEA coming down the column which removes the CO<sub>2</sub> from the SNG. The column contains 20 two-pass valve trays and a mist pad covering the gas outlet to remove any entrained MEA. The overhead from the column at 110°F flows to the glycol contactor, T-5, for dehydration.

### MEA Circulation

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### Rich MEA

Rich MEA (loaded with CO<sub>2</sub>) exits the bottom of the CO<sub>2</sub> Absorber at 150°F and flows to the Lean MEA/ Rich MEA Exchanger, E-21, where the rich MEA is heated to 215°F against the cooling of the lean MEA. The rich solution then flows through a level control valve into the CO<sub>2</sub> Stripper, T-3. The level control valve controls the flow rate of MEA from the bottom of the absorber in order to keep an adequate level in the absorber. The liquid flows down over 17 two-pass valve trays against a reboiled steam flow. The CO<sub>2</sub> is removed from the MEA by steam stripping. At the bottom of the column, the liquid collects in a chimney tray and flows to two reboilers.

The largest reboiler, E-17, is heated by cooling reformed gas. The MEA Steam Reboiler, E-18, is heated with low-pressure saturated steam. The steam flow rate to E-18 is automatically controlled by a flow controller. The flow of steam is regulated to permit adequate stripping to prevent CO<sub>2</sub> breakthrough at the absorber. The flow of liquid MEA to the two reboilers is distributed by two manual butterfly valves. The vapor from each reboiler flows back to the stripper underneath the chimney tray. The liquid overflows a weir in each reboiler and flows to the bottom of the stripper where, having been stripped of the  $CO_2$ , it accumulates as lean MEA. The bottom of the stripper functions as the surge tank and pumping tank of the MEA system. The level in the tank fluctuates freely with the water balance and distribution of MEA throughout the rest of the system.

The CO<sub>2</sub> overhead from the MEA stripper flows to the tube side of the Stripper Overhead Condenser, E-20. Here water is condensed from the CO<sub>2</sub>. The resulting liquid/vapor stream is separated in D-11, the Reflux Drum. The CO<sub>2</sub> vapor at 110°F flows through a mist ped in the top of D-11. The liquid condensate in D-11 is pumped by Stripper Reflux Pump, P-12 A or B to the top of the CO<sub>2</sub> Stripper. The condensate enters the top of the stripper and flows down over 3 one-pass, bubble cap trays. The purpose of these trays is to wash entrained and vaporized amine from the CO<sub>2</sub> overhead thus reducing amine losses.

### Lean MEA

The lean MEA flows from the bottom of the stripper at 240°F to the Lean MEA/Rich MEA Exchanger, E-21, where the lean solution is cooled to 197°F. The solution goes to the MEA Charge Pump, P-13 A or B to be pumped to the MEA Cooler, E-23, which reduces the temperature to 110°F. There is a manual slipstream bypass on E-23 to prevent the MEA from getting too cold in the winter. The MEA flow is then metered through an automatic flow controller to the top of the  $O_2$  Absorber at the rate required to prevent  $O_2$  slippage to the glycol dehydration package.

### CO2 Removal System Auxiliaries

The MEA Carbon Filter, D-13, is a fixed carbon bed absorber which treats a 2% slipstream of cold, lean MEA. The vessel contains an inlet deflector plate followed by a layer of tabular alumina balls which sit on top of a 2-layer screen. The screen rests on the activated carbon, which is supported by tabular alumina balls. The flow through the filter goes back to the suction of P-13 and is controlled manually. The carbon is not regenerated.

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The MEA Reclaimer, E-19, separates amine from degradation products by vaporizing the amine in a batch-type distillation. The kettle-type reclaimer is fed with hot, lean MEA from the bottom of the CO<sub>2</sub> Stripper. The flow of MEA is controlled by a level controller in E-19, which keeps the tubes covered. There is no liquid overflow from the reclaimer. The amine is vaporized and flows back to the bottom of the stripper. The high pressure steam is supplied to the reclaimer under automatic pressure control. The liquid in the reclaimer is concentrated and the amine boils off until the temperature reaches 290°F. The contents of the reclaimer are then dumped manually for disposal. The reclaimer does not stay in continuous operation.

The normal operating concentration of the MEA solution is 35% by weight. This is highly corrosive and requires special corrosion inhibitors to prevent corrosion. A Solution Mix Tank, D-12, is used to prepare these inhibitors. D-12 is also provided with an air sparger using utility air. This air sparger keeps the corrosion inhibitors in an oxidized condition.

The MEA Storage Tank, TK-8, provides storage capacity adequate to empty any single piece of equipment in the MEA system. The MEA Make-up Pump, P-14, places solution into the circulating system. The tank can be fed from either D-12; cold, lean solution from E-23; or from the MEA Sump, TK-9.

A 750 gallon MEA Sump, TK-9, is provided to collect any spills or drains in the MEA system. The contents of the sump are removed by the MEA Sump Pump, P-15, which will pump 50 gpm of solution through the Sump Filter, FIL-1 (a cartridge filter), to the MEA Reclaimer, E-19. The contents of the sump can also be pumped to the Storage Tank, TK-8.

#### Water Balance

The MEA System will constantly need a small amount of make-up water. This is due to the fact that more water is carried out with the vapor streams leaving the stripper, the flash drum, and the absorber than is carried in with the reformed gas to the absorber. To make up this loss, a small stream of demineralized water flows to the Reflux Drum, D-11. The flow rate of this water is controlled automatically by a control valve. The flow rate is set to maintain a constant level in the bottom of the  $CO_2$  Stripper, T-3.

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# Glycol Dehydration Package\*

The Glycol Dehydration Package, PG-4, employs triethylene glycol to remove water vapor from the SNG, and consists of the following items of equipment:

Glycol Contactor, Glycol Regenerator with Integral Flash Drum, and Glycol Circulation Pump.

The SNG from the CO2 Absorber flows to the bottom of the Glycol Contactor, T-5. The SNG flows upward through the column, contacting the triethylene glycol, which absorbs the water vapor from the gas stream. The dried SNG exits the top of the contactor with a water dewpoint of less than 0°F, and after a final pressure reduction to achieve pipeline pressure, it is exported to the existing distribution system. The dilute glycol solution containing the absorbed water flows out the bottom of the contactor to the glycol regeneration system. The system operates at a much lower pressure than that in the contactor, so that most of the dissolved gas in the solution separates from the glycol and is used for fuel. The dilute glycol solution flows to the Glycol Regenerator, T-6, after being preheated by exchange with the hot lean glycol. In the regenerator, a direct-fired reboiler strips the water from the glycol solution and exits to the atmosphere. The regenerated triethylene glycol solution from the bottom of the regenerator is heat-exchanged with the incoming dilute solution. The concentrated solution then flows to a glycol accumulator, from which it is then pumped through the glycol cooler before entering the top tray of the contactor. The cooler assumes that the glycol entering the contactor is at a low contacting temperature to obtain a low water dew point.

Reflux requirements for the regenerator are low due to the wide boiling point range between water and triethylene glycol. The incoming glycol feed flows through a coil in the top of the regenerator to furnish cooling for the internal reflux.

The glycol reboiler is fired with natural gas to maintain a temperature of 400°F in the reboiler. The immersion firetube is equipped with burner, burner controls, flame arrestor and stack. A glycol filter is located on the incoming glycol feed line, after the preheat.

\*Refer to Figure 7.
# Material Balance

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The Material Balance found on the process flow diagrams designates the composition for each of the main process streams throughout the facility. The stream numbers form the key between the Material Balance and flow sheets.

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# Total Water Balance

The water, steam and condensate balance of the system are depicted on Figure 8, showing the connections between and quantities for all users and generators.

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Fig. 8. Process Flow Diagram: Utility System

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# 4. UTILITIES, PRODUCTS, ENERGY BALANCE

# AND AN ANALYSIS OF THE NET REVENUE

# Introduction

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This section summarizes the utilities consumed or generated by the plant. Also summarized are the plant's products and by-products. Included in this section is an energy balance for the plant and an analysis leading to the net revenue generated by the plant.

# Utilities

Boiler Feedwater (import)

Temperature	100 <sup>0</sup> F
Pressure	520 psig
Rate	66184 lb/hr / 132 GPM*

\*GPM based on 65°F base temperature.

# High-Pressure Steam (import)

Temperature460°FPressure450 psigRate265,980 lb/hr

Low-Pressure Steam (export)

Temperature Pressure Rate 298<sup>0</sup>F 50 psig 101,716 1b/hr

Condensate (export)

Temperature270°FPressure50 psigRate202,503 1b/hr / 405 GPM\*

\*GPM based on 65°F base temperature.

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High-Pressure Blowdown (export) 460<sup>0</sup>F Temperature 450 psig 1238 lb/hr Pressure Rate Low-Pressure Blowdown (export) 298<sup>0</sup>F Temperature 50 psig Pressure 84 1b/hr Rate Cooling Water (import) 95<sup>0</sup>F Temperature 50 psig Pressure 16635 GPM 25°F Rate Temperature Rise Electric Power (import) (For motor driven equipment, lights, instruments) 440 volt Voltage 60 Hz Frequency 2100 KW Load Products Pipeline Quality Gas 26.4 MMSCFD Rate 879 BTU/SCF HHV Carbon Dioxide (discharged to atmosphere) 18.0 MMSCFD Rate Sulfur (recovered as elemental sulfur) 0.04 Ton/day Rate Oily Liquids (recycled to Purox incinerator) 105 Ton/day Rate

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# Energy Balance for the Plant

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The energy balance for the plant is shown in Table 4.

Stream Name	Stream Rate	Energy Flow Rate <sup>1</sup> MMBTU/HR
*Input*		
Feed Gas	1.95 $\frac{\text{MMSCF}}{\text{hr}}$	-278.5
Boiler Feed Water	66,184 lb/hr	-429.7
High-Pressure Steam	265,980 lb/hr	-1419.5
Electric Power (1 KW = 3413 BTU/hr)	2100 KW	7.2
Start-up Feed Gas Heater		16.6
TOTAL INPUT		-2103.9

Table 4. Energy Balance for the Plant

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Stream Name	Stream Rate	Energy Flow Rate <sup>1</sup> MMBTU/HR
*Output*		•
Product Gas (SNG)	1.1 MMSCF/hr	-60.0
By Products		
Condensate	202,503 1b/hr	-1279.7
50-psig Steam	101,716 lb/hr	-546.7
Oily Liquids	32 bbl/hr	-3.3
SUBTOTAL PRODUCTS AND BY PRODUCTS		-1889.7
Other Streams		
Oily Water Stream		-123.2
CO <sub>2</sub> Stream (Vented to atmosphere)		-330.8
Blowdown Streams		-8.0
Water Vapor Stream (Vented to atmosphere)		-2.6
Air-Cooled heat exchangers		43.7
Water-Cooled heat exchanger		206.7
TOTAL OUTPUT		-2103.9

Table 4. (continued)

Note 1. Based on the Girdler enthalpy tables.

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# Economic Analysis of Feed, Products, and Utilities

Cost of the feed and utilities is shown in Table 5.

Table 5. Cost of the Feed and Utilities to the Plant

Import Stream	Stream Flow Rate	Cost/Unit	Cost of Import \$/Hr
Feed Gas	1152.2 MMBTU/hr (46.87 MMSCFD)	\$1.40/MMBTU <sup>1</sup>	1613.00
Boiler Feed Water	7935 gal/hr	\$1.26/1000 gal <sup>2</sup>	10.00
High-Pressure Steam	265,980 lb/hr	\$2.50/1000 1b <sup>3</sup>	665.00
Cooling Water	16635 GPM	\$0.06/1000 gal	60.00
Electric Power	2100 KW	\$0.03 KW/hr	63.00
TOTAL COST OF THE IMP	ORTS TO THE PLANT		2411.00

- NOTES 1. Price of methane had been assumed to be \$2.50/MMBTU. The feed gas to the plant is inferior to methane on two accounts. First, it has a low calorific value. Second, to use it directly requires the installation of special burners and polution control equipment. With these factors in mind, the feed gas has been estimated to cost \$1.40/MMBTU.
  - 2. Boiler Feed Water (BFW) has been estimated to cost \$0.75/1000 gallons as treated water at ambient temperature (65°F). The plant is supplied BFW at 100°F. The additional heat in the BFW has been priced at \$1.75/MMBTU. Accounting for the additional heat, the cost of the Boiler Feed Water at 100°F turns out to be \$1.26/1000 gallon.
  - 3. High-Pressure Steam has been valued roughly equal to methane and hence is assumed to cost \$2.50/1000 lb.

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Prices of the products from the plant are shown in Table 6.

Table 6'. Prices of the Products from the Plant

Export Stream	Stream Flow Rate	Cost/Unit	Export Stream Value, \$/hr
Product Gas (SNG)	968 MBTU/hr	\$2.50/MMBTU <sup>1</sup>	2420.00
Low-Pressure Steam	101,716 1b/hr	\$2.00/1000 lb <sup>2</sup>	203.00
Condensate	24300 gal/hr	\$4.15/1000 gal <sup>3</sup>	91.00
Sulfur	Negligible	\$30/ton	
Oily Liquid (recycled to incinerator)	32 Bbl/hr	\$15/Bb1 <sup>4</sup>	480.00
Carbon Dioxide	44 ton/hr	\$5/ton <sup>5</sup>	220.00
			7414 00

TOTAL VALUE OF THE EXPORTS FROM THE PLANT

3414.00

NOTES 1. Product Gas (SNG) has been assigned the same value as methane, i.e., \$2.50/MMBTU.

- 2. Low-Pressure Steam has been assigned a value of \$2.00/1000 lb.
- 3. Condensate price has been based on \$0.75/1000 gallon as treated water at ambient temperature (65°F). Condensate is available at 270°F and the additional heat present in the condensate has been priced at \$1.75/MBTU. Thus the value of the condensate at 298°F has been established as \$4.15/1000 gal.

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- 4. The oily liquid is recycled to the Purox incinerator. However, it does have an intrinsic value. Crude oil to which this oily liquid is equivalent has been priced at \$15/barrel and this same price has been used for the oily liquid.
- 5. Raw carbon dioxide produced by this plant has been assigned a value of \$5/ton.

Net Revenue from the Plant

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Table 7 below shows the net revenue generated by the plant on an hourly basis.

Table 7. Net Revenue from the Plant

Cost, \$/Hr					
\$3414.00					
\$2411.00					
\$1003.00					

Net revenue from Table 7 is \$1003.00/hr. Based on 8000 hr/year, the net revenue can be expressed on a yearly basis. Therefore,

Net Revenue = \$8.02 million/yr.

#### 5. PLANT DESCRIPTION

## Introduction

In this section the physical parameters of size, shape, and arrangement shall be defined so that an understanding of what the facility will look like can be achieved.

## Layout

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The arrangement and the overall area required by the equipment for all of the cleanup and conversion steps necessary to convert the pyrolysis gas to SNG can best be understood by referring to Figure 1. Although the equipment comprises one contiguous facility, the individual processing units are segregated as follows:

Benzol Wash Unit, Feed Gas Compression Unit, Purification Unit (Hydrogenation and Chloride/Sulfur Guard), Stretford Unit, Conversion Unit, and CO<sub>2</sub> Removal and Glycol Dehydration Unit.

The required 530 feet by 280 feet area includes a perimeter access road and sufficient space for maintenance access and is in accordance with governing codes. Also located within this area is a control building with sufficient space available for change rooms, lunch room, instrument shop, laboratory, and offices.

In developing the layout, this facility was placed behind or to the east of the refuse receiving/preparation and Purox units. Thus, a logical flow through the entire complex is achieved. A logical flow through the methanation facility was also followed, which minimizes the piping requirements and makes for a plant more easily understood and operated by the operating personnel.

#### Equipment Specification

The process specifications define the size and/or process requirements which are critical to the design and proper operation of the equipment. In some cases mechanical considerations govern equipment sizing; therefore, differences between the process specifications and the equipment layout do exist. The equipment layout shows how the equipment would actually be supplied while still adhering to the critical requirements of the process specifications. Equipment specifications are shown in the Appendices to this report. The Appendices are divided into these general categories:

Vessels and Tanks (Appendix A), Direct-Fired Equipment (Appendix B), Heat Exchangers (Appendix C), and Mechanical and Packaged Equipment (Appendix D).

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#### 6. INVESTMENT ANALYSIS

#### Base Estimate

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An order of magnitude/ratio estimate for the base case (46.87 MMSCFD pyrolysis gas, which is equivalent to 4530 T/D garbage when using the design basis composition and 61% efficiency) was developed using the procedure outlined below. (See Section 2 for additional data on capacity.)

(a) Major equipment was in-house priced using current cost data. Vendor data and pricing assistance were obtained for: \*

## Item

## D-7 Primary Separator FIL-1 A/B Secondary Separator T-1 Benzol Absorber F-1 A/B Start-up Feed Gas Furnace E-5 Lean Oil Cooler E-6 Rich Oil Heater E-7 Lean/Rich Exchanger E-8 Benzol Condenser E-24 Feed Gas Heaters E-27 Cold Recycle Cooler E-9 Gas/Gas Exchanger E-10 Gas Cooler E-11 CRG Feed Cooler E-12 CRG Effluent Cooler E-13 Methanator Effluent Cooler No. 1 E-14 Methanator Exchanger E-15 Methanator Effluent Cooler No. 2 E-16 Methanator Effluent Cooler No. 3 E-25 Gas/Gas Exchanger E-26 CRG Effluent Steam Condenser PG-1 Feed Gas Compressor Package PG-2 Carbon Disulfide Injection Package PG-3 Package Hydrogen Plant PG-4 Glycol Dehydration Package PG-5 CO2 Removal Package D-3 A/B Exhauster P-4 A/B Rich Oil Pump P-5 A/B Lean Oil Pump P-6 A/B Lean Oil Makeup Pump P-7 Benzol Condensate Pump

Peco CB&I G. C. Broach Locke Equipment Locke Equipment Locke Equipment Locke Equipment Western Supply Marley Co. Western Supply Marley Co. Ingersoll-Rand A.M.S. Systems Engr. Howe Baker Maloney-Crawford Union Carbide Garden City Gould Gould Gould Gould

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Vendor

Peco

Cost data listing begins on page 50.

(b) The Total installed cost (TIC) was developed by grouping like equipment items and factoring their cost by a TIC multiplier for that group. The multiplier covers commodity materials, field labor, field indirects and home office and was based on Pritchard's general experience in the industry. All back-up data by equipment item before factoring for the base case estimate are included in this section. The investment necessary for the methanation facility as herein defined is \$47,320,000

## Lower Capacity Plant Estimate

In order to obtain the total installed cost of the lower capacity plant (1050 T/D refuse pyrolyzed) an exponential procedure was applied to the capacity ratio. This procedure for adjusting estimated costs for different capacity plants is common to the industrial construction industry. In this case an exponent of 0.65 was chosen based on Pritchard's experience with facilities comprised of similar units. Specifically, the ratio of the lower capacity plant to the higher capacity plant was raised to the 0.65 power ([1050/4530\*]. $^{05} = .39$ ) to determine a multiplier for factoring the lower capacity plant's cost from that of the higher capacity plant. From these efforts it was determined that an investment of \$18,296,000 was required for the lower capacity.)

#### Accuracy

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The accuracy of an estimate of this type is very difficult to predict. The engineering is only completed to the extent that a very broad brush definition of the facility can be made, which is obviously reflected in the investment analysis. On the other hand, the estimate is the result of pricing each piece of equipment, which certainly improves the accuracy. We expect that there is a 1 in 10 chance that the estimate is within plus or minus a few percent and that the estimate could be expected to be accurate to within plus 25% or minus 5%.

# Items Not Included

The following items were not included in the TIC estimate:

Spare Parts Land Site Investigation or Improvements Piling Taxes & Royalties Premium Payments Duties Operating & Maintenance Cost

Items Not Included (continued)

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Escalation (Estimate as of third quarter 1980) Client's Costs Off-sites

Personnel and Maintenance Cost

#### Personnel Cost

The following lists the yearly personnel costs anticipated, including benefits:

1 1 1 4 12		Plant Manager (1/3 charged Ass't. Plant Manager (" Secretary/Clerical Chief Operator Operator Foreman Operators Chomist	to "	this "	facility) ")	\$14,000 10,000 10,000 30,000 80,000 180,000 25,000
Т	-	Chier Operator				80,000
4	-	Operator Foreman				30,000
12	-	Operators				180,000
1	_	Chemi st				25,000
<u> </u>	-					45,000
- 3	-	Lab Technicians				
2	-	Laborers				24,000
-				To	tal	\$418,000

Maintenance Cost

Maintenance costs for this type of facility are about 4% of the TIC per year or  $0.04 \times $47,320,000 = $1,892,800$ .

## Investment Payout

Although the methanation facility described herein cannot stand alone without the refuse preparation and Purox units, the battery limits concept employed for determining the total installed cost, the personnel and maintenance cost, the value of all feed stocks and utilities consumed, and the revenue produced by the primary and secondary products will permit a realistic determination of the economic parameter very often considered: that is, investment payout. Not including interest on capital or taxes the yearly income is:

Revenue from Energy Balance	\$8,020,000.
Personnel Cost	- 418,000.
Maintenance Cost	- 1,892,800
Net Revenue	\$5,709,200.

Payout = TIC/yearly income = \$47,320,000/\$5,709,200 = 8.29 years.

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#### CANSAS CITY MISSOUR

THE DEVELOPMENT AND COMPANY

Est. 124 Rev. 3 12/74

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KANSAS CITY, MISSOURI THE PRITCHARD CORPORATION

	ACCT.	Equipment	Commoditie.	Subcontracts	Field Labor	Total
	1.0 PLANT SITE					
	2.0 BUILDINGS					· · · · · · · · · · · · · · · · · · ·
	3.0 STRUCTURES					
	4.0 CONCRETE WORK					
	5,0 VESSELS	2,266,000				
	6.0 FURNACES & BOILERS	213,000				
	7.0 HEAT EXCHANGERS	1,600,000				
	B.O. COOLING TOWERS			13 203 000		
	9.0 MECHANICAL EQUIPMENT	<u>Z14,0001</u>		1 9/20 7/ 404		
	10.0 INSTRUMENTS & CONTROLS					
	11.0 PIPING					
	12.0 ELECTRICAL					
	13.0 INSULATION					
	14.0 PAINTING					
	15.0 CHEMICALS					
<u></u>	16.0 STARTOP ENGINEERS					
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	FRINGE BENEFITS					4
	20.0 CONST. EQMT. PREP. EXP., SMALL TOOLS					-
	21.0 TEMPORARY FACILITIES			+		1
	22.0 FIELD SUPV. & EXPENSE	<u></u>				1
	24.1 INSURANCE					1
		<u> </u>			+	1
_	TOTAL INDIRECT FIELD COSTS					
	CONTINGENCIES					1
	ESCALATION	<u>}</u>			<del></del>	
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	TOTAL SELLING PRICE	<b>= \$</b>	(1 The street)	+ Totally In	stalled	
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			SUBTO TAL DIR	ECT & INDIRECT COST	•	
	DRAFTING MH =					
	TOTAL SELLING PRICE =	<b>=</b>				
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	CROSS PROFIT + CONTINGENC	<u>(</u> = %	Chemicals	, Packing & Catal	yst - Installe	d <u>4,200,00</u>
	TOTAL SELLING PRICE-(GROSS	_ ^	ļ			
	PROFIT & CONTINGENCY)		PROFIT (GRO	55, NET)	4.1	HI BION
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" 5-5 D-8 AIB	y -			00081		
" 5-6 li-9	=   . -   .			25000		
· 5-7 D-14	-   - 			27000		
" 5-2 FIL-IA/E				223000		
- 5-9 h-1 A/B	3 :			796000		
" 5-10 K-2 A/B/C/D	י ד ר ו			745000		
" 5-11 K-3 A/B				50000		
· 5-13 5-4				000217		
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CONSTRUCTION COSTS

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THE PRITCHARD CORPORATION KANSAS CITY, MISSOURI E.W.O. No. 10B No. 2352 MADE BT. 13 APPRV.

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# J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

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SASSI CORDORATION CHE		Y						_DA	TE_					-
	SIZE & DESCRIPTION:     Horiz     Vert     ×       Dimensions:     3'0"     ID     ×     18'-0"     T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A-225-c Other       Pressure Temperature       Design     50     psig     150     OF       Working     0.4     psig     100     OF       INTERNALS     (Description & Material)     6"     THK.     S.S.     MIST ELIMINATOR     M/L     1       G" THK.     S.S.     MIST ELIMINATOR     M/L     1       TKAY     Supports:     4"X 3%"     BAK RINES     1       Weight:     Vessel     4100     1bs.       Internals     1bs.     1     1       Quote By	SIZE & DESCRIPTION:     Horiz     Vert     ×       Dimensions:     3'0" ID     × 12'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A.25-00ther       Pressure Temperature       Design     50 psig     150 OF       Morking     0.4 psig     100 OF       Working     0.4 psig     100 OF       INTERNALS     (Description & Material)     6" THK. S.S. MIST ELIMINATOR     M/L 1       Chary Suppers:     2" X ¾" BAR RINES     100     105.       Internals     105.       Using the second sec	SIZE & DESCRIPTION:     Horiz     Vert     X       Dimensions:     3'0" ID     X 12'-0" T-T       Shell Thk ½'       MATERIAL:     S.S.     C.S.A.265-000       Pressure Temperature       Design     50 psig     150 OF       Morking     0.4 psig     100 F       INTERNALS     (Description & Material)     6" THK. S.S. MIST ELIMINATOR       6" THK.     S.S. MIST ELIMINATOR     H/L ]       TRAY Supports:     2"X 3%" BAR RINES       Weight:     Vessel     4100 1bs.       Internals       Uote By     Date       Yeight       <	SIZE & DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 12'-0" T-T       Shell Thk ½?"       MATERIAL:     S.S.       C.S.A-25-C Other       Pressure Temperature       Design	SIZE & DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 1£'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A.225-c Other       Pressure Temperature       Design     50 psig     150 OF       Working     0.4 psig     100 OF       INTERNALS     (Description & Material)     0       6" THK.     S.S.     MIST ELIMINATOR     m/L ]       TKAY     Suppers:     4"X ¾" BAR RINES     0       Weight:     Vessel     4100     1bs.       Internals     1bs.     0     0       Field Fab     Shop Fab     0     0       Quote By     0     0     0       Date     5.f.     0     0       SCHEDULED DELIVERY     wks.after P.O.     0     0       Yeanted Area     S.f.     0     0     0       Yeanted Area     S.f.     0     0     0       Yeanted Area     S.f.     0     0     0     0       Yeanted Area     S.f.     0     0     0     0     0	SIZE & DESCRIPTION:     Horiz     Vert     X       Dimensions:     3'A" ID     X   E'-O" T-T	SIZE & DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'6" ID × 18'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A-225-00her       Pressure     Temperature       Design     50 psig     150 OF       Morking     0.4 psig     100 OF       INTERNALS     (Description & Material)     100 OF       6" THK.     S.S. MIST ELIMINATOR     11/L       6" THK.     S.S. MIST ELIMINATOR     11/L       Weight:     Vessel     4100 lbs.       Weight:     Vessel     4100 lbs.       Internals     lbs.     100 OF       Quote By     0     0     0       Quote By     0     0     0       9 ainted Area     s.f.     11     100 OF       Yereight     0     100 OF     100 OF       Opensition     100 OF     100 OF     100 OF       Yereight     0     100 OF </td <td>SIZE &amp; DESCRIPTION:     Horiz     Vert_X       Dimensions:     3'0" ID X 18'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.       C.S.A.25.c Other     Pressure       Pressure     Temperature       Design     S0 psig     150 0F       Morking     0.4 psig     100 0F       Working     0.4 psig     100 0F       INTERNALS     (Description &amp; Material)     800       6" THK. S.S. MIST ELIMINATOR     ML 1     800       TRAY Suppers:     4"X ¾" BAR RINES     100       Weight:     Vessel     4100     105.       Internals     105.     100     105.       Weight:     Vessel     4100     105.       Internals     105.     100     105.       Veight:     Yessel     4100     105.       Veight:     Vessel     4100     105.       Veight:     Vessel     4100     105.       Veight:     Shop Fab     100     100       Date     100     105.     100       Vessel     Shop Fab     100     100</td> <td>SIZE &amp; DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 1£'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A.25.c Other       Pressure     Temperature       Design     50 psig     150 0F       Morking     0.4 psig     100 0F       INTERNALS     (Description &amp; Material)     800       6" THK.     S.S. MIST ELIMINATOR     11/2       Weight:     Vessel     4100       Internals     105.       Weight:     Vessel     4100       Vote By     Date     100       Painted Area     S.f.     100       SCHEDULED DELIVERY     wks.after P.O.     100       YOURD OF PAYMENT:     1000     100       Job MIETHANATION OF PUTCY OFE-GES     MADE BY     000       Job MIETHANATION OF PUTCY OFE-GES     MADE BY     000  &lt;</td> <td>SIZE &amp; DESCRIPTION:     Horiz     Vert X       Dimensions:     3'0" ID X 18'-0" T-T       Shell Thk ½"       MATERIAL:     S.S. C.S.A.45.6 Other       Pressure Temperature       Design     50 psig       Morking     0.4 psig     100       0.4 psig     100     0F       Norking     0.4 psig     100       0.4 psig     100     0F       Neight:     Vessel     110       105.     11     1800       0.7 They Supports:     2 X 3% Bak Rines     100       11     100     105.     100       11     100     105.     100       11     100     100     100       11     100     100     100       11     100     100     100       11<!--</td--><td>SIZE &amp; DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 18'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A.MSSCOther       Pressure     Temperature       Design     .50 psig     150 0F       Morking     0.4 psig     100 0F       INTERNALS     (Description &amp; Material)     100 0F       INTERNALS     (Description &amp; Material)     18000       6" THK.     S.S. MIST ELIMINATOR     112 7       Weight:     Vessel     4100 1bs.     18000       TKAY     Supperst:     2.X 30" BAR     100 1bs.       Internals     1bs.     100 1bs.     100 1bs.       Weight:     Vessel     4100 1bs.     100 100 100 100 100 100 100 100 100 100</td><td>SIZE &amp; DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 18"-0" T-T       Shell Thk ½"     Image: Shell Thk ½"       MATERIAL:     S.S.     C.S.A.25-C Other       Pressure     Temperature       Design     50 psig     150 °F       Morking     0.4 psig     100 °F       Morking     0.4 psig     100 °F       INTERNALS     (Description &amp; Material)     800 °F       6" THK. S.S. MIST ELIMINATER     HL 7     800 °F       Weight:     Vessel     4100 Ibs.     11       Weight:     Vessel     4100 Ibs.     11       Field Fab     Shop Fab     10     10       Quote By     00     00     10       Date     7     10     10       Painted Area     S.f.     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       Vesch CEF-GES     Mode BY     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       SASSI     CORDATION</td><td>SIZE &amp; DESCRIPTION:     Horiz     Vert X       Dimensions:     3'a" ID     X 12'-0" T-T       Shell Thk ½'       MATERIAL:     S.S.     C.S.A-25-0ther       Pressure Temperature       Design     50     psig     150     OF       Morking     0.4     psig     100     OF       Morking     0.4     y3" Back Rines     110     1800       Tray Supports:     4" 37" Back Rines     110     1800     110       Weight:     Vessel     4100     1bs.     110     110       Weight:     Vessel     4100     1bs.     110     110       Guote By     Date     100     100     100     100     100       Painted Area     s.f.     110     110     110     110     110       SCHEDULED DELIVERY     wks.after P.0.     110     110     110     110</td><td>SIZE &amp; DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'a" ID × 18'-0" T-T       Shell Thk ½"     NATERIAL:     S.S. C.S. Also Other       MATERIAL:     S.S. C.S. Also Other     Image: Comparison of the state of the stat</td></td>	SIZE & DESCRIPTION:     Horiz     Vert_X       Dimensions:     3'0" ID X 18'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.       C.S.A.25.c Other     Pressure       Pressure     Temperature       Design     S0 psig     150 0F       Morking     0.4 psig     100 0F       Working     0.4 psig     100 0F       INTERNALS     (Description & Material)     800       6" THK. S.S. MIST ELIMINATOR     ML 1     800       TRAY Suppers:     4"X ¾" BAR RINES     100       Weight:     Vessel     4100     105.       Internals     105.     100     105.       Weight:     Vessel     4100     105.       Internals     105.     100     105.       Veight:     Yessel     4100     105.       Veight:     Vessel     4100     105.       Veight:     Vessel     4100     105.       Veight:     Shop Fab     100     100       Date     100     105.     100       Vessel     Shop Fab     100     100	SIZE & DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 1£'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A.25.c Other       Pressure     Temperature       Design     50 psig     150 0F       Morking     0.4 psig     100 0F       INTERNALS     (Description & Material)     800       6" THK.     S.S. MIST ELIMINATOR     11/2       Weight:     Vessel     4100       Internals     105.       Weight:     Vessel     4100       Vote By     Date     100       Painted Area     S.f.     100       SCHEDULED DELIVERY     wks.after P.O.     100       YOURD OF PAYMENT:     1000     100       Job MIETHANATION OF PUTCY OFE-GES     MADE BY     000       Job MIETHANATION OF PUTCY OFE-GES     MADE BY     000  <	SIZE & DESCRIPTION:     Horiz     Vert X       Dimensions:     3'0" ID X 18'-0" T-T       Shell Thk ½"       MATERIAL:     S.S. C.S.A.45.6 Other       Pressure Temperature       Design     50 psig       Morking     0.4 psig     100       0.4 psig     100     0F       Norking     0.4 psig     100       0.4 psig     100     0F       Neight:     Vessel     110       105.     11     1800       0.7 They Supports:     2 X 3% Bak Rines     100       11     100     105.     100       11     100     105.     100       11     100     100     100       11     100     100     100       11     100     100     100       11 </td <td>SIZE &amp; DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 18'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A.MSSCOther       Pressure     Temperature       Design     .50 psig     150 0F       Morking     0.4 psig     100 0F       INTERNALS     (Description &amp; Material)     100 0F       INTERNALS     (Description &amp; Material)     18000       6" THK.     S.S. MIST ELIMINATOR     112 7       Weight:     Vessel     4100 1bs.     18000       TKAY     Supperst:     2.X 30" BAR     100 1bs.       Internals     1bs.     100 1bs.     100 1bs.       Weight:     Vessel     4100 1bs.     100 100 100 100 100 100 100 100 100 100</td> <td>SIZE &amp; DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 18"-0" T-T       Shell Thk ½"     Image: Shell Thk ½"       MATERIAL:     S.S.     C.S.A.25-C Other       Pressure     Temperature       Design     50 psig     150 °F       Morking     0.4 psig     100 °F       Morking     0.4 psig     100 °F       INTERNALS     (Description &amp; Material)     800 °F       6" THK. S.S. MIST ELIMINATER     HL 7     800 °F       Weight:     Vessel     4100 Ibs.     11       Weight:     Vessel     4100 Ibs.     11       Field Fab     Shop Fab     10     10       Quote By     00     00     10       Date     7     10     10       Painted Area     S.f.     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       Vesch CEF-GES     Mode BY     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       SASSI     CORDATION</td> <td>SIZE &amp; DESCRIPTION:     Horiz     Vert X       Dimensions:     3'a" ID     X 12'-0" T-T       Shell Thk ½'       MATERIAL:     S.S.     C.S.A-25-0ther       Pressure Temperature       Design     50     psig     150     OF       Morking     0.4     psig     100     OF       Morking     0.4     y3" Back Rines     110     1800       Tray Supports:     4" 37" Back Rines     110     1800     110       Weight:     Vessel     4100     1bs.     110     110       Weight:     Vessel     4100     1bs.     110     110       Guote By     Date     100     100     100     100     100       Painted Area     s.f.     110     110     110     110     110       SCHEDULED DELIVERY     wks.after P.0.     110     110     110     110</td> <td>SIZE &amp; DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'a" ID × 18'-0" T-T       Shell Thk ½"     NATERIAL:     S.S. C.S. Also Other       MATERIAL:     S.S. C.S. Also Other     Image: Comparison of the state of the stat</td>	SIZE & DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 18'-0" T-T       Shell Thk ½"       MATERIAL:     S.S.     C.S.A.MSSCOther       Pressure     Temperature       Design     .50 psig     150 0F       Morking     0.4 psig     100 0F       INTERNALS     (Description & Material)     100 0F       INTERNALS     (Description & Material)     18000       6" THK.     S.S. MIST ELIMINATOR     112 7       Weight:     Vessel     4100 1bs.     18000       TKAY     Supperst:     2.X 30" BAR     100 1bs.       Internals     1bs.     100 1bs.     100 1bs.       Weight:     Vessel     4100 1bs.     100 100 100 100 100 100 100 100 100 100	SIZE & DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'0" ID × 18"-0" T-T       Shell Thk ½"     Image: Shell Thk ½"       MATERIAL:     S.S.     C.S.A.25-C Other       Pressure     Temperature       Design     50 psig     150 °F       Morking     0.4 psig     100 °F       Morking     0.4 psig     100 °F       INTERNALS     (Description & Material)     800 °F       6" THK. S.S. MIST ELIMINATER     HL 7     800 °F       Weight:     Vessel     4100 Ibs.     11       Weight:     Vessel     4100 Ibs.     11       Field Fab     Shop Fab     10     10       Quote By     00     00     10       Date     7     10     10       Painted Area     S.f.     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       Vesch CEF-GES     Mode BY     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       SCHEDULED DELIVERY     wks.after P.0.     10     10       SASSI     CORDATION	SIZE & DESCRIPTION:     Horiz     Vert X       Dimensions:     3'a" ID     X 12'-0" T-T       Shell Thk ½'       MATERIAL:     S.S.     C.S.A-25-0ther       Pressure Temperature       Design     50     psig     150     OF       Morking     0.4     psig     100     OF       Morking     0.4     y3" Back Rines     110     1800       Tray Supports:     4" 37" Back Rines     110     1800     110       Weight:     Vessel     4100     1bs.     110     110       Weight:     Vessel     4100     1bs.     110     110       Guote By     Date     100     100     100     100     100       Painted Area     s.f.     110     110     110     110     110       SCHEDULED DELIVERY     wks.after P.0.     110     110     110     110	SIZE & DESCRIPTION:     Horiz     Vert ×       Dimensions:     3'a" ID × 18'-0" T-T       Shell Thk ½"     NATERIAL:     S.S. C.S. Also Other       MATERIAL:     S.S. C.S. Also Other     Image: Comparison of the state of the stat

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# J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

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# Eat.- 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

	ESTIMATING SHE		N	ATE	AIA	L.	741		410	-	OR	TOT	<b>.</b> .	
. NO.	ORECRIPTION	BUANTITY		ĪT	T	Ĭ	Î	T		ÎT	Π	T	Î	
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# J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

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ESTIMATING SHEET

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# ENT. 72) ROV. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

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71 J. F. PRITCHARD AND COMPANY

KANSAS CITY, MISSOURI

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# KANSAS CITY, MISSOURI

J. F. PRITCHARD AND COMPANY Est. - 721 Rev. 1 10/74 ESTIMATING SHEET ۰. MATERIAL UNIT TOTAL LABOR TOTA UNIT QUANTITY DESCRIPTION ACCT. NO PRESSURE VESSELS 5.0 TAG # D-14 M.H. 23000 SERVICE: CRG EFFLUENT SEPARATOR SIZE & DESCRIPTION: Horiz Vert X Dimensions: 6'-0" I.D. X 8'-0" T-T Shell Thk .625 C.S.A.5/6-700ther MATERIAL: S.S. 1 Temperature Pressure 0F 275 225 psig Design OF 212 169 psig Working INTERNALS (Description & Material) i., MIL 7 00 6" THK. S.S. MIST ELIMINATOR ţ WSupports Weight: Vessel 9900 # /EA. 1bs. lbs. Internals ERECTION: Shop Fab Field Fab Quote By Date Freight Export Box , s.f. Painted Area s.f. Insulated Area wks.after P.O. SCHEDULED DELIVERY TERMS OF PAYMENT: x 5 0 0 0 4/2/79

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72 I. PRITCHARD AND COMPANY

TYPE OF JOB METHANATION OF PUROX OFF-GAS MADE BY

SASSI CORPORATION

KANSAS CITY, MISSOURI

\_CHECKED BY ....

PAGE NO\_

5-7\_

DATE DATE

ESTIMATE NO.\_\_\_

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J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

LABOR MATERIAL NIT TOTAL TOTAL QUANTITY UNIT DESCRIPTION ACCT. NO. PRESSURE VESSELS 5.0 TAG # FIL - IA + B M.H. 6000 SERVICE: SECONDARY SEPARATOR 2 WICONTROLS SIZE & DESCRIPTION: Horiz Vert Dimensions: 28" O.D. SHELL 10" SUMP 10" INLET & OUTLET FLANGE FLOW: 124,000 #/HE. Shell Thk MATERIAL: S.S. C.S. X Other Temperature N.OL.WT 26.53 Pressure 0F \_\_\_\_psig Design °<sub>F</sub> 228 psig 110 Working 1000 FILTER - C.S. WITH EDOXY LINING INTERNALS (Description & Material) 4600 #/EF. 1bs. Weight: Vessel 1bs. Internals ERECTION: Shop Fab Field Fab Quote By Date Freight Export Box \$ s.f. Painted Area s.f. Insulated Area wks.after P.O. SCHEDULED DELIVERY TERMS OF PAYMENT: ۱. 27000 4/2/71 TYPE OF JOB ILE THANATION OF PUEDX OFF-GAS MADE BY DATE. FOR SASCI CORPORATION DATE \_\_\_\_CHECKED BY\_\_\_\_ 2292 INDIANAPOLIS, INDIANA 5-8\_\_\_ PAGE NO\_ ESTIMATE NO. AT..... (place one copy in the equipment log)

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#### 50 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI Est. - 721 Rev. 1 10/74 IMATING SHEET

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# J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

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TYPE OF	JOB METHANATION DE PUROX OFF-GAS	MADE	BY						DA1	ræ		<u>12</u>		
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	PRESSURE VESSELS						•				Ш			
<u> </u>	TAG # R-4				$\Box$						$\downarrow\downarrow$		$\downarrow \downarrow$	
<u> </u>	SERVICE. METHANATOR NO. 1				4	60	0	0			$\downarrow$		$\downarrow \downarrow$	
	SERVICE. METHANALON											i	┽┽	
	SIZE & DESCRIPTION: Horiz Vert X										┯	$\square$	$\downarrow$	i 
	Dimensions: 8'-6" I.D. X 11'-0" T-T			┝─┼╸			<u> </u> .	┨ ┥╶┨			+	┝┼╸	+	_ <u> </u>
	MATH MANGANESE V& MOLY				+	$\square$	+	$\left  \right $		$\left  \right $	+	┢╌╋	┼┽	
	MATL. A-302-B UT-435 Shell Thk 19/6"	<u> </u>		$\left  \right $	+-	┝╌╄		┟╌╢		$\left  \right $	╉┙	┼╋	┽┷	
	MATERIAL: S.S. C.S. Other	<u> </u>		┝╌┨╴	┿	$\left  \cdot \right $	+-	┨╼╢		$\left  - \right $	╀	╆╋	+	
-	Pressure Temperature	<u> </u>	╂		╞	$\left  \cdot \right $	╇	╀╢		$\left  - \right $	+	┼╋	+-+	
	Design 220 psig 925 OF	<b></b>		╟┼	+-	$\left  + \right $	┿	+		╟─┼	╀	┼╋	┽┽	
	Working <u>175 psig 800 F</u>			╟┼		┝╌┼	╋	╀╀		╟┤	╀	┼╋	┿┥	<b> </b>
_	CATALYST VOLUME : 380 CU.FT.	<u> </u>		<u>u</u>	14	e	<u>  </u>	69	ckin		+	╇	╇	<b>∔</b> - <del>7</del> • -
	INTERNALS (Description & Material)		18								_	╇	<u> </u>	: .: +:
	9 MECH - BAH S STI WIDE MESH	3	1200	F		4	<u>ه ه</u>	0			┝╼╋╸	$\downarrow \downarrow$		
	Drawing 16"X 14" mixed ALLMING BALLS		20 4	ł	ld	k		2 a	cku	44		$\downarrow$		· · · ·
	K "A I" & ALINALAD BALLS				Τ		·			Ľ	Ц	Ц		
	Height: Vessel 33,500 lbs.					Π								
	Internalslbs.	.			·						Ц	].		11
-+	AND MORE NOT THES & SKIETS	1									Ц		$\square$	<u>                                     </u>
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	Field Fab Shop Fab	1		Τ	Π		Π		·				Ш	
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-+	Painted Areas.f.						$\square$		₽		$\downarrow\downarrow$	+-	$\downarrow \downarrow$	┽╄
	Insulated Areas.f.				$\square$					-#-	$\downarrow\downarrow$	┝╇	╄╋	┿
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	SCHEDULED DELIVERY wks.after P.O.		_		$\downarrow$		$\downarrow$	┝╌╄╸	-∦		╄┤	┝╋	╂╂	╉╋
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KANSAS CITY, MISSOURI J. F. PRITCHARD AND COMPANY Est. - 721 Rev. 1 10/74 ESTIMATING SHEET

			M 1/11/1	ATE#	IAL	rot	AL	_	UN	LA1	10R	101	AL	
. NO.	DESCRIPTION				Π	Τ	T	$\square$		Π				
5.0	PRESSURE VESSELS				┞╌┞	╇		┨╢		╉┥	-+-	╉╌╋	┾	
M.H.	TAG # R-5		<b>├</b>	┝╌╢╌╸	┢	+	+	$\left\  \cdot \right\ $		╉┥		┼╍╄╸	┽	+ - i
	SERVICE: METHANATOR No. 2		<b> </b>	$\left  - \right $	14	444	210			╉┥	r†-	╉┼	-+-	+
			1	<u> </u>  -	┼┥	+	+	┤╢		╼╢─┤	┝┼╸	┽┽	+	+
	SIZE & DESCRIPTION: Horiz Vert X		¶	╞╌┼╸	╇┥	+	╋	┼┥		╶╢─	$\left  \right $	+	÷	÷.
	Dimensions: 8'-6" T.D. X 11'-0" T-T		ļ	<u></u>	+	$\left  \right $		+-+	 				-+-	
	MATL MANGANESE V2 MOLY		<u> </u>	₩-+-	+-		_i_	+		_∦-	╈	- <u>+</u>	+	
	MATL A-3058 UT-435 Shell Thk 1 716"		<u> </u>	<b>╢</b> ─┼-	+	 - +		•		 	<u></u> .			+-
	MATERIAL: S.S. C.S. Other		<u> </u>		i				μ	_ <u> -</u>	++			•
1	Pressure Temperature	<u> </u>	1. 	!' <del></del>					- 		<u>.</u>		<del>:</del>	• •
   !	Design 200 psig 9:5 OF			-1				<u> </u>	÷		<u></u>	 	• • •	
	Working 150 psig 200 F	╎╷ ┉╢╌┈╍╼╼╴╸╼╼╸		<u> </u>		<del>.</del>			ļ. 		<del>.</del>			
	COTALNET VOLUME: 350 CU.FT.			Jul	<u>ch</u>	5 12	4	<u>P</u> -	<u>cki</u>	<u> </u>				
,	INTERNALS (Description & Material)	- 	1.4	<u>L</u>	+	<u>:</u>	<u> </u>	-+-	<u>  </u>	-#-	_ <u> </u>	┝╇	+-+	- 4
	8 MESH-304 S. STL. WIRE MESH	3	1200	>r 		4	0	⊃,⊂ 	, -,∳			<u> </u>	+	
	PACKING: 18"X 14" MIXED ALUMINA PALLE		ار <sup>و عل</sup> ر ز	-	$\frac{1}{1}$			1			- <u></u>	i *	<u> </u>	<u>\</u>
	V: " + 1" & ALUMINIA BALLS		-	1 <sup>m</sup>	<u>141</u>	1	1800-	91	251(1	<u> &lt;   R</u>	<u>_</u>	<del></del>	† 1	-
	Weight: Vessel 32,200 lbs.			╶╫╌┥	+	+	$\frac{1}{1}$	-+-	-#		- <u>+</u> -	<u>†</u> -†-		
1	InternalsIbs.	·	_			+	+	-+			-+-	+		
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	Field Fab Shop Fab	-		-#		+-	+	$\vdash$			-+-	╂╂	┿╸	
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Est. - 721 Rev. 3 10/74

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CT. NO.	DESCRIPTION			İТ	Π	T	Î.				Π	Τ
5.0	PRESSURE VESSELS		E.							+	┼╋	╈
<u>M.H.</u>	TAG # T-1 (Field Fab)		<u>– n.</u>	╟╌┼╸	20						$\uparrow \uparrow$	+
	SERVICE: BENZOL ABSORBER				┼╌	┢╼╋╍					$\square$	╈
		∦	<u> </u>	╢┼	╋┥	┝╋╸	╉				╆╋	┽
	SIZE & DESCRIPTION: Horiz Vert X	1	<b> </b>	╢╌┤╴	+-	┝╌┼	+	$\left  - \right $		┼┼╴	┼┤	+
	Dimensions: 22'-0' I.D. X 80'-0" T-T	4		∦∔		$\left  \right $		-+	· ·	$\left  - \right $	┿┥	+
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<u></u>	Shell Ink /2		╢───	╢╌┼	┿	┟╴┠	-	Ħ			╈	
	Pressure Temperature											$\square$
	Design 5 psig 150 °F	1										Ц
	Working I'l psig 102 °F										$\bot$	$\square$
	INTERNALS (Description & Material)											
	2 Hard Grid Beking			w	1ch	en		24	ekin			
	2- levels of wood will received				Τ				·		·	
	The Distributer C.S.	Z	1000			8	00	6			$\perp$	<b>_</b>
	Weight: Vessel 195,000 lbs.							1-	┨────	╢┥	$\downarrow$	_
	Internalslbs.			╢╢	$\perp$				┨───-	╢┥	+	÷
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_	Field Fab Shop Fab								<u> </u>		⊢	<u> </u>
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	Painted Area s.f.	_			┼┼	┿	$\left\{ + \right\}$	╉	╢	+	╟┼	┼
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# Est. - 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

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ESTIMATING SHEET

					70	TAL		UNIT_				
T ND.												Ì
5.0	PRESSURE VESSELS				┥┦				++	++	++	-
М.Н.	TAG # T-2 (Field Fab)								+	11	1	1
	SERVICE: BENZOL STRIPPER			- 24	24				11			Ţ
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	SIZE & DESCRIPTION: Horiz Vert X			╏╌┦╼╸	┝╌┠╼	┝╌┝╴	┞╌╫╴		┉┽╍┽	++	+++	 
	Dimensions: 20'-0" ID. X 56'-0" T-T			┟╌╁╾╸	└ ╵ ┝──╁──		¦ ∥ <del> </del>				- <del> </del>	_ <del>;</del> -
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<del>-</del>	Shell Thk 1/2 "	į 				┿╇	$\frac{1}{1}$					• - <del></del>
1	MATERIAL: S.S. C.S.A-225-cOther				++-		┼╌╟					 1
	Pressure Temperature	l <u>.</u>			·;;		-		مستبعب و			∲ <b>⊾</b> nia. ,
	Design <u>5.0 psig</u> <u>350</u> of						+-+	<u></u>				<del>.</del> .
	Working <u>1.0 psig 215</u> F						1		4		BUBLE PC 1	•••
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:	INTERNALS (Description & Material)	. 			÷÷-		+		h		 Ì	• •••
	A - LEVELS OF 11/2" RACHIG FINGS	ļ.			, <u>+</u>							• •
	73'TD X 15'L FA LEVEL 5700 C.F. EG.	 	}	ر فریمه از . سعد بیت	124	e in la	+ pe	. CK 19	ij	د. مد مدرد		
	TELY SUDSHTS: 4"X 1" BAR RINGS	∦							╬┿╪		<b></b>	
	Weight: Vessel 60,300 lbs.	<u> </u>		╉		+	-		+			
	Internalslbs.						-		++		<del>.</del> +-	
	Liquid Distributor C.S.	2	1000			80			╫┼		1	+
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	Field Fab Shop Fab			╉╋	+			<b></b>	+	+	+	+
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	Freight							<u>  </u>		++	<u>_</u>	- <u>;</u>
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	Insulated Areas.f.		1) 					<u>-</u>	<u>-11</u> -1 	<del></del>		
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	SCHEDINED DELIVERY wks.after P.O.							↓				
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	TK.2 Benzol Storage Tank		Ea	┥┽	8	00	20		╶╫╌┤	+	++	╉	┝
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	5.00 - 42" B x 16'-0" T/T							∦	_	┝╌┝	╄╋	+-	 †
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	Capacity - 1000 gais								_#_	$\square$	┶	$\downarrow$	-
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	Shop Fab				┨╌┼	-+-	╂─┼		#-	+		$\uparrow \uparrow$	
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Ent. - 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

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ENL 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

ESTIMATING SHEET MATERIAL UNIT TOTAL QUANTITY UNI DESCRIPTION ACCT. NO. FIELD FABRICATED STORAGE TANKS i.0 TAG # TK- 4 SERVICE: Pump Tank (Field Fab) 30000 Ea 1 SIZE AND DESCRIPTION (complete) 18'-6" Øx 26'-0" H w/ Cone roof Liquid level @ zi'-o" lined with 12000 1500 SF : roal tar epoxy مرامس 1 Volume\_\_\_\_ c.f. (C.S)A-285-COther Material: S.S. S.R & spot X-ray Working psig Pressure <u>atmos</u> OF 11 Temperature 110 1 : 1 s.f. Insulated Area s.f. Painted Area\_ 25,200 lbs. Weight S/C ERECTION: ACCESSORIES: Hydro Test Freight Export Box Quote By Date wks.after P.O. START ERECTION wks.after P.O. FINISH ERECTION TERMS OF PAYMENT: 42000 TYPE OF JOB Hethanation of Purox Off. Gas MADE BY JB 4/3/79 FOR SASSI Corp CHECKED BY ..... ESTIMATE NO 2392 5-18 AT Indianapolis, Ind. PAGE NO.

(place one copy in the equipment log)

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KANSAS CITY, MISSOURI

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	DESCRIPTION	QUANT U		3	ANHOURS		COST/UNIT		ATERIALS	SUB-CONT	 eź	LABOI	
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87 J. F. PRITCHARD AND COMPANY

KANSAS CITY, MISSOURI

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A/C No.	DESCRIPTION		UNIT	ANHOURS	RATE	S.C. MAT'L	MATERIALS	SUB-CONTI	а Т Т Т Т Т Т Т Т Т Т	40g
6.0	F-1AB Start-up Feed Gas Furnace A. 7.44 mm Btu/Hr Fl Hydra Section	Heater					0000			
	B. 24.78 MM BtulHr Reactor Feed	Heater					15300			
	FI Honter to be vertical tube C.S. all radiant heater w/multipasses									· · · · · · · · · · · · · · · · · · ·
	Reactor Fred Heater to be vertical									موجود و بالمرور وي آيد. موجود روي وي المرور الم موجود المرور المرور الم
	w/ alloy radiant tubes 4 cs									
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	Vendor guoted 2 separate Furnaces as opposed to 1 furnace w/ 2 sections a									
	stated in our reg. Vendor feels that it will provide better control and the cost									ر مشهور میشوند. با با از با میشوند، با با با با با با با با با با با با با
	Price per Braach 1/10/79	· · · · · · · · · · · · · · · · · · ·	, ,	, .	1	1			1	

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KANSAS CITY, MISSOURI

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	DESCRIPTION	QUANT 1		NA L	NHOURS		C051/	UNIT MAT'I	HATERIALS	SUB-CONTR.	LABOR	
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Est. - 721 Rev. 1 10/74

J. F. PRITCHARD AND COMPANY

KANSAS CITY, MISSOURI NG SHEET

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## Eat. - 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

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J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

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Est. - 721 Rev. 1 10/74

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91 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

ESTIMATING SHEET

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S-T. FIN TUBE, D-TUDE, EXCHANGESE         M.H. TAG #         ERVICE:       LEAN/RICH EXCHANGES         SERVICE:       LEAN/RICH EXCHANGES         S-T       OTHER         TYPE       SIZE         No. Shells/Unit       S.F.         Heat       Transfer Area         Heat       S.F.         Bare Tube Surface/Shell       S.f.         Bare Tube Surface/Shell       S.f.         Design Pressure       7/5 psig         70 PF       300 OF         Design Temp.       200 OF         200 OF       300 OF         Material       C.S. SE-516-GE.70         SA-172       TEMA CLASS: C         TUBE SIZE AND DESCRIPTION       IIIII         No. Tubes       0.0.         No. Tubes       0.0.         BNG       Length         FLANGES:       150 # EF         Ouoite Sy Locket Equip. Co.       Doo #         Date       18.7.00 D*         Painted Area       S.f.         Insulated Area       S.f.         ScheDULED DELIVERY 32.7.2.4 wks.after P.0.       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	. NO.				Π				Τ		$\square$			
M.H.       TAG #       E-7         SERVICE:       LEAN/FICH EXCHANGEE       5         SERVICE:       LEAN/FICH EXCHANGEE       5         STPE       STPE         NO. Shells/Unit       STPE         Heat Transfer Afrea       11.248         Bare Tube Surface/Shell       s.f.         Bare Tube Surface/Shell       s.f.         Design Pressure       75 psig         75 psig       90 psig         Design Temp.       200 °F         Material       C.S. SF-5/6-Ge.70         SA-179       TEMA CLASS: C         TUBE SIZE AND DESCRIPTION       111         No. Tubes       0.D.         No. Tubes       0.D.         BNG       Length         BNG       Length         BNG       Length         Field       Shop         Assembled       Freight         Ouote By       Locket Equip. Co:         Date       12/4/72       Freight         SCHEDULED DELIVERY & to XY       s.f.         Insulated Area       s.f.         SCHEDULE DELIVERY & to XY       wks.after P.0.         TERMS OF PAYMENT:       Export Box         Price SIRM       -30 DAYS FKo		S-T, FIN TUBE, U-TUBE, EXCHANGERS		┦───┤	-+	-			╢				÷	4
SERVICE:       LEAN/FICH EXCHANGER       5       527       210         S-7       OTHER       1	<u>M.H.</u>	TAG #		1.000	P				-#			,		
S-T       0THER         TYPE       SIZE         No. Shells/Unit       SIZE         Heat Transfer Area       11.949         Bare Tube Surface/Shell       s.f.         Bare Tube Surface/Shell       s.f.         Design Pressure       75 psig         Posign Pressure       75 psig         Material       C.S. SA-5/6-Ge.70         SA-179       TEMA CLASS: C         TUBE SIZE AND DESCRIPTION       IIII         No. Tubes       0.D.         BG       Length         BG       Length         FLANGES:       1/50 # RF         Weight EA.       12.500 [bs.         TOTAL WT. 91.000 #       ERECTION         Field       Shop       Assembled         Field       Shop       Assembled         Painted Area       s.f.       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII		SERVICE: LEAN/RICH EXCHANGER	5	10.35		L,	<u>لم</u>	4			· · · ·		•	••• ••
S-T       0THER         TYPE       SIZE         No. Shells/Unit					┊╴┽╸╸	• •			-#-	;+	⊦++ :			•
TYPE       SIZE         No. Shells/Unit       Heat Transfer Area (1, 24% S.F.         Bare Tube Surface/Shell       s.f.         Bare Tube Surface/Shell       s.f.         Heat Exchanged (Design) Btu/Hr.       BELL         Design Pressure       75 psig         Design Pressure       75 psig         Material       C.S. SE-5/6-GE.70         SAL       TEMA CLASS: C         TUBE SIZE AND DESCRIPTION       IIIE         No. Tubes       0.D.         No. Tubes       0.D.         No. Tubes       0.D.         BNG       Length         FLANGES:       ////////////////////////////////////		S-TOTHER			! 		_ <u> </u>		-	ېږ	• • • • • • • • • • • •	י <b>بر است. میدر ا</b> ا		
No. Shells/Unit		TYPE SIZE			┆ ╺╾╺ <u></u> ╍╼	•+		1			•		- erlanı "i#"	• •
Heat Transfer Area       11.248       S.F.         Bare Tube Surface/Shell       s.f.         Heat Exchanged (Design) Btu/Hr.       IUBE         Design Pressure       7/5 psig       90 psig         Design Temp.       200       0F       300       0F         Material       C.S. SA-5/6-GA.70       SA-179       Image: State And DESCRIPTION       Image: State And DESCRIPTION         No. Tubes       0.D.       Image: State And DESCRIPTION       Image: State And DESCRIPTION       Image: State And DESCRIPTION         No. Tubes       0.D.       Image: State And DESCRIPTION       Image: State And DESCRIPTION         No. Tubes       0.D.       Image: State And DESCRIPTION       Image: State And DESCRIPTION         No. Tubes       0.D.       Image: State And DESCRIPTION       Image: State And DESCRIPTION         BNG       Length       Image: State And DESCRIPTION       Image: State And DESCRIPTION         ING. Tubes       0.D.       No. Tubes       0.D.       Image: State And DESCRIPTION         BNG       Length       Image: State And DESCRIPTION       Image: State And DESCRIPTION       Image: State And DESCRIPTION         BNG       Length       Assembled       File       Image: State And DESCRIPTION       Image: State And DESCRIPTION         Quote By		No. Shells/Unit			╵╵╵ ┢╼╺╋╍╼	$\left  \right $	4-	، اب- ب			<b></b> !			4
Bare Tube Surface/Shell       s.f.         Heat Exchanged (Destign) Btu/Hr.       TUBE         Design Pressure       75 psig         Design Temp.       300       0F         Material       C.S. SA-SIG-GR.70       SA-179         TEMA       CLASS: C       TUBE         TUBE       0.D.       111         No. Tubes       0.D.       111         BNG       Length       111         FLANGES:       150 # RF       111         Weight EA.       18.200       1bs.         TOTAL WT.       91,000 #       111         Frield       Shop       Assembled         Quote By       Locket Equip. Co.       111         Date       18.4       18.4         Painted Area       s.f.       111         SCHEDULED DELIVERY <u>82 To 54</u> wks.after P.0.       111         TERMS OF PAYMENT:       111       111         Prices Firem - 30 Days Fkom, Quore Date       2116       110         YPE or Joe.       METHAN ATION       0F-GAS_MADE BY       Date       472.7         OR       SASSI Cof. D GRATION       CHECKED BY       DATE       472.7		Heat Transfer Area 11,248 S.F.				$\frac{1}{1}$	- +			1	n	•	• • •••	•
Heat Exchanged (Design) Btu/Hr.       TUBE         Design Pressure       75 psig       90 psig         Design Temp.       200       0F       300       0F         Material       C.S. SR-5/6-GE.70       SA-179       1111         TEMA       CLASS: C       1111         TUBE SIZE AND DESCRIPTION       1111         No. Tubes       0.0.         BNG       Length         FLANGES:       150 # CF         No. Tubes       0.0.         BNG       Length         Field       Shop         Assembled       1000 #         Printed Area       S.f.         Insulated Area       S.f.         SCHEDULED DELIVERY       32 To 24 wks.after P.O.         TERNS OF PAYMENT:       Printed Area         Prices FIRM - 30 DAYS FKOM Quore DATE       \$316100         VPE OF JOS       METHANNATION         Constant       OFF         METHANNATION       OFF         Canadian       CHECKED BY         Date       21/4/72         SchEDULED DELIVERY       22 To 24 wks.after P.O.         TERNS OF PAYMENT:       716100         Prices FIRM - 30 DAYS FKOM Quore DATE       \$316100		Bare Tube Surface/Shells.f.	<u></u>	_		┿	+	<u>.</u>	-		<mark>∔</mark>		+	•
SHELL       TUBE         Design Pressure       75       psig       90       psig         Design Temp.       200 $OF$ 300 $OF$ Material       C.S. SR-5/6-Ge.70       SA-179         TEMA       CLASS: C         TUBE SIZE AND DESCRIPTION         No. Tubes       0.D.         BNG       Length         BNG       Length         FLANGES:       150 # RF         Weight EA.       [8, 200] lbs.         TOTAL WT.       91,000 #         ERECTION       Freight         Jate       [g./4/72]         Freight       Export Box         Painted Area       s.f.         SCHEDULED DELIVERY & 2 To 24 wks.after P.O.       SIG         VPE OF JOB       METHANATION OF Puttox OFF-GAS.made BY         DATE       JATE       AJE         VPE OF JOB       METHANATION OF Puttox OFF-GAS.made BY       DATE         VPE OF JOB       METHANATION OF Puttox OFF-GAS.made BY       DATE		Heat Exchanged (Design) Btu/Hr		_ <u> </u>		+	+		<b>-</b>		<b></b>	••		•
Design Pressure       75 psig       90 psig         Design Temp.       300 OF       300 OF         Material       C.S. SR-5/6-GR.70 SA-179         TEMA       CLASS: C         TUBE SIZE AND DESCRIPTION         No. Tubes       0.D.         BNG       Length         FLANGES:       ////////////////////////////////////		SHELL TUBE				+		-			+	╋	╇	•••
Design Temp.       300       OF       300       OF         Material       C.S. SA-5/6-GA.70       SA-179         TEMA       CLASS: C         TUBE       SIZE AND DESCRIPTION         No. Tubes       0.D.         BNG       Length         BNG       Length         FLANGES:       //SO# RF         Weight EA.       //8, ±00         TOTAL WT.       91,000 #         Printed       Shop         Assembled       Assembled         Quote By       LockE E QUIP. Co.         Date       //g/4/78       Freight         Painted Area       S.f.         SchEDULED DELIVERY       % To A4 wks.after P.O.         TERMS OF PAYMENT:       Days Fkom. Quote Date         PRICES FIRM - 30 DAYS Fkom. Quote Date       \$ di (i) 00         YPE OF JOB       METHAN BILON       OF PUROX OFF-GAS MADE BY       Date         SASS1       C.O.F. DRATIAN       CHECKED BY       Date       4/2./7		Design Pressure 75 psig 90 psig			╫╌┥╌		┝┼	+	┞╴╢		╬╌┼╸	++	$\frac{1}{1}$	
Material       C.S. SR-5/6-GE.70       SA-179         TEMA       CLASS: C         TUBE SIZE AND DESCRIPTION         No. Tubes       0.D.         BWG       Length         FLANGES:       150 # RF         Weight EA.       18, \$.00         TOTAL WT.       91,000 #         Painted Area       S.f.         SCHEDULED DELIVERY       32.70         Muster Size       S.f.         SCHEDULED DELIVERY       32.70         Weish TS       S.f.         SCHEDULED DELIVERY       32.70         Muster Size       S.f.         SCHEDULED DELIVERY       32.70         Muster Size       S.f.         Muster Size       S.f.         SCHEDULED DELIVERY       32.70         TERMS OF PAYMENT:       30.00         PRICES FIRM - 30.00       30.00         SCHEDULED DELIVERY       30.00         SCHEDULED DELIVERY       30		Design Temp. <u>300 OF 300 OF</u>			∦	<b>i</b>		+-	Ļļ		╬┿	┿┾	┼┽	- 1
TEMA CLASS: C         TUBE SIZE AND DESCRIPTION         No. Tubes       0.D.         BNG       Length         FLANGES:       150 # RF         Weight EA. 18, # 00 lbs.         TOTAL WT. 91,000 #         ERECTION         Field       Shop         Assembled         Quote By       Locke Equip. Co.         Date       12/4/78         Freight       Export Box         Painted Area       S.f.         Insulated Area       S.f.         SCHEDULED DELIVERY <u>3.5 To #4</u> wks.after P.O.       If (100)         TERMS OF PAYMENT:       Date         PRICES FIRM - 30 DAYS FKOM. QUOTE DATE       If (100)         YPE OF JOB       METHANATION OF PLACO OFE-GAS MADE BY       DATE         OR       SASSI C.Of. PORATION       CHECKED BY       DATE		Material C.S. SA-516-GR.70 SA-179			╬┼		: ( <del>                                    </del>	-+-	+ +		++	┽┿	╇┥	1
TUBE SIZE AND DESCRIPTION         No. Tubes       0.D.         BNG       Length         FLANGES:       150 # EF         Weight EA.       18, 200 lbs.         TOTAL WT.       91,000 #         ERECTION       Field         Quote By       Locke Equip. Co.         Date       12,4 178         Freight       Export Box         Painted Area       s.f.         Insulated Area       s.f.         SCHEDULED DELIVERY       32 To 54 wks.after P.O.         TERMS OF PAYMENT:       PRICES FIRM - 30 DAYS FROM. QUOTE DATE         VPE OF JOB_ METHAN ATION OF PLAROX OFF-GAS. MADE BY       DATE         OR       SASSI Cof. PORATION		TEMA CLASS: C				+	$\downarrow\downarrow$	+-	╞		++	┥┽	┽┥	<b>r</b> : !
No. Tubes       0.D.         BNG       Length         FLANGES:       150 # RF         Weight EA.       18, 200 lbs.         TOTAL WT.       91,000 #         ERECTION       Freid         Quote By       Locke Equip. Co.         Quote By       Locke Equip. Co.         Date       12/4 178         Freight       Export Box         Painted Area       s.f.         Insulated Area       s.f.         SCHEDULED DELIVERY <u>\$2 To \$24</u> wks.after P.O.       Isin 61 00         TERMS OF PAYMENT:       PAIMENT:         PRICES FIRM - 30 DAYS FROM. Quote DATE       Isin 61 00         VPE OF JOB       METHANATION OF PLAKOX OFE-GAS MADE BY       DATE         OR       SASSI COF. PRATION       CHECKED BY       DATE		TUBE SIZE AND DESCRIPTION			╨┸	1		 -+-	╢ ╅╌╋		╉┿	$\frac{1}{1}$	+	r
No. Tubes       0.0.         BNG       Length         FLANGES: 150 # RF         Weight EA. 18, 200 lbs.         TOTAL WT. 91,000 #         ERECTION         Field       Shop         Assembled         Quote By       Locke Equip. Co.         Quote By       Locke Equip. Co.         Date       12/4/78         Freight       Export Box         Painted Area       s.f.         Insulated Area       s.f.         SCHEDULED DELIVERY       22 To 24 wks.after P.O.         TERMS OF PAYMENT:       PRICES FIRM - 30 DAYS FROM. Quote DATE         VPE OF JOB       METHANATION OF PLAKOX OFE-GAS MADE BY       DATE         OR       SASSI COF. PORATION       CHECKED BY						_	┇	 ~	4-4		╶╫╍┿	++	-	-
BNG       Length         FLANGES:       150 # RF         Weight EA.       18, ±00 lbs.         TOTAL WT.       91,000 #         ERECTION       Freight         Quote By       Locke Equip. Co.         Date       18,4178         Freight       Export Box         Painted Area       S.f.         Insulated Area       S.f.         SCHEDULED DELIVERY       22 To 24 wks.after P.O.         TERMS OF PAYMENT:       SIG6100         PRICES FIRM - 30 DAYS FROM. QUOTE DA TE       SI 6100         VPE OF JOB       METHANATION OF PURDX OFE-GAS MADE BY       DATE         OR       SASSI COF. PORATIAN       CHECKED BY       DATE		No. Tubes 0.D.				 	┥┽	4-			╶╫╾┽	╅╋	+	-
FLANGES: 150 # RF Weight EA. 18, \$20 lbs.         TOTAL WT. 91,000 #         ERECTION         Field Shop Assembled         Quote By Locke Equip. Co.         Date 18/4178         Freight         Export Box         Painted Area         Scheduled Area         Sched		BWG Length			┹┤		┧→	-+-	┥╸┥	l	╶╫╼┽	44		ł
Neight EA. 18, \$20 lbs.         TOTAL WT. 91,000 #         ERECTION         Field Shop Assembled         Quote By Locke Equip. Co.         Date 18/4/78       Freight         Export Box       Image: Strengt		ELONGES: 150 # PF					┵┥	- <del> </del> -	_			┥┥	-	-
TOTAL WT. 91,000 #         ERECTION         Field       Shop       Assembled         Quote By       Locke E Quip. Co.       Quote By         Date       12/4/78       Freight         Date       12/4/78       Freight         Painted Area       S.f.       Insulated Area         SCHEDULED DELIVERY       22 To 24       wks.after P.O.         TERMS OF PAYMENT:       Date       21 G100         Prices Firm       30 Days FROM Quote Date       21 G100         VPE OF JOB       METHANATION       OF PLARDX OFF-GAS MADE BY       Date         Question       CHECKED BY       Date       4/2/5		Weight EA. 18, 500 lbs.				$\downarrow$	$\downarrow$	4.	┥┥	<u> </u>	┛╫┤			+
ERECTION         FieldShopAssembled         Quote By Locke Equip. Co.         DateI2/4/78Freight         DateI2/4/78Freight         Export Box         Painted AreaS.f.         Insulated AreaS.f.         Scheduled Dellivery <u>22 To 24</u> wks.after P.O.         TERMS OF PAYMENT:         PRICES FIRM - 30 DAYS FKOM. Quote DATE         VPE OF JOBMETHANATION_OF PLACOX OFF-GAS_MADE BYDATE		TOTAL WT. 91,000 #							-	┣	╶╫╌┥	++	+-	+
Field       Shop       Assembled         Quote By       Locke Equip. Co.         Date       12/4/78         Freight       Export Box         Painted Area       S.f.         Insulated Area       S.f.         SCHEDULED DELIVERY       22 To 24         Wks.after P.O.       XI 6/00         TERMS OF PAYMENT:       XI 6/00         PRICES FIRM       30 DAYS FKOM QUOTE DATE         VPE OF JOB       METHANRTION       OF PLATON         OR       SASSI COF. PORATION       CHECKED BY		ERECTION			╟╢			_	_			$\rightarrow$	+	+.
Quote By Locke Equip. Co.         Date Ig 4178       Freight         Export Box         Painted Area       s.f.         Insulated Area       s.f.         SCHEDULED DELIVERY gg To 24 wks.after P.O.         TERMS OF PAYMENT:         PRICES FIRM - 30 DAYS FROM. QUOTE DATE         VPE OF JOB         METHANATION OF PUROX OFF-GAS MADE BY         DATE         TERMS 1 Cof. p ORATION		Field Shop Assembled								<b> </b>	┹┛	-+-	$\downarrow$	╞
Quote By       Locke Equip. Co.         Date       18/4/78       Freight         Export Box       Export Box         Painted Area       s.f.         Insulated Area       s.f.         Scheduled Delivery       22 To 24         wks.after P.O.       2161000         TERMS OF PAYMENT:       216100         Prices Firm - 30 Days       Fkom. Quote Date         VPE OF JOB       METHANATION       OF PLUROX         OR       SASSI Cof. DORATION       CHECKED BY										↓		┍╾┽╾┥	-+-	+
Date       18/4/78       Freight         Export Box       Export Box         Painted Area       s.f.         Insulated Area       s.f.         SCHEDULED DELIVERY       22 To 24         wks.after P.O.       SCHEDULED DELIVERY         SCHEDULED DELIVERY       22 To 24         Wks.after P.O.       SCHEDULED DELIVERY         TERMS OF PAYMENT:       SII 6100         PRICES FIRM - 30 DAYS FROM. QUOTE DATE       SII 6100         YPE OF JOB       METHANATION OF PILEOX OFF-GAS MADE BY       DATE         OR       SASSI COF. ORATION       CHECKED BY	<u> </u>	Quote By LOCKE EQUID. Co.								⋕			+	+
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OR SASSI COFPORATION OF PUROX OFF-GAS MADE BY DATE 4/21: 9299	- <u> </u>	TERMS UF PATMENT:	+			2	10	51	00	<b>,</b>	-	Π		
OR SASSI COLDORATION OF FUEDA OFFICIES MADE BY DATE	1	PRICES FIRM - 30 DAYS FROM QUOTE DATE		U	l	لنت	- 1 -	ـــَـد		DA1	 TE	4/	2	Īz
OR SASSI COLDORATION CHECKED BY DATE 9299	YPE O	PJOB METHANATION OF FURDA DEF-GAS	MADE	<b>G</b> Y							·			
	0R	SASSI COFPORATION CHE	CKED	@Y	 1					_DA1	1 6	9	29	

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(place one copy in the equipment log)



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#### KANSAS CITY, MISSOURI J. F. PRITCHARD AND COMPANY

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	Field Shop	-						-#	_	┝╌┼╌┤	╇	-
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	Quote By LockE E Walp, Col					$\square$	$\downarrow$			╏╌┠╌┨		<b> </b>
	DateE/71/1Export Box	(			$\square$		╧╋			┟╌┧╴┨	╾┼╌┦	+
							╶┼┥		_	┼┼┥	╶╉╼┙	┢
	Painted Area s.f.				┉┥┨	-	┍╼╂╼┥			┼┼┥	┟╌┨╌┙	┢
	Insulated Area s.f.		 <del>  </del>		-		- -		—∦-	$\frac{1}{1}$	-+-	+
	EAR RUEEALO NEW YORK					┝╂╌	┝┼╼	┝-╟		┽┼╴	$\vdash$	t
	SCHEDINED DELIVERY 22 TO 24 Wks.after P.	0.			┟╌┠╼╵	┝┽╸	++-			╉╋	┟┥╴	t
	TEDMS OF PAYMENT:							┟ <sub>┛</sub> ╋	-+	┉┼┼╴	┝╋	t
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	METHANATION OF PUROX OFF-GA	<u>S mae</u>	DE BY					DA	\TE_	_4/	5	1
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TYPE C	SASSI COEDORATIONCH	ECKE	D 8Y							a	20	

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#### 80 Ent. - 721 Ray, 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

NO.	DESCAIPTION QL	JANTITY		TT			Π			ΤŤ	Ť
	S-T, FIN TUBE, U-TUBE, EXCHANGERS								┝╺╁╺┥		+
М. Н.	TAG # E-Z			4							+
	SERVICE: FEED GAS HEATER	1	EA.		45	00	19			-+-	<b></b>
			┨	┝╾┼╌┥		<b>↓</b>	┥┥╢		i	┝╍┥╌┥	┝╍┽╺
	S-T OTHER			+	_	┝┥╸	┥╍╫		┨↓		┝╌┿╴
	TYPE         SIZE			┝┟╿		4		<u>–</u>	┟╺┽╌	┼╌┼─	-+-
	No. Shells/Unit					┧┽╸	┥┥		╫╌┼╼	<u>↓</u>	┝┼
	Heat Transfer Area 12,575 S.F. Bare Tube Surface/Shell					↓	·		╫╺┥╼ ┟──┼─	•	
	Heat Exchanged (Design) Btu/Hr.				┝╎	<b>.</b>			╟ ╫╌┽╵	• • - <del>-</del>	
	SHELL TUBE	. 	_¦ 	∥   ₩+	L	11		<b></b>	+	<u>i</u>	┹╌┿
. مېرىكلىرىنى يې سى	Design Pressure <u>275</u> psig <u>500</u> psig	·	! 	∦.   <del>∦</del> †	!   +-+					┿┿	<u>+</u>
	Design Temp. 470 OF 470 OF	ļ			<b>.</b>	44	+	•			- <u> </u> +
	Material C.S. SF 516- Gr. 70 ADM. SB-111			₩-₩-	;				<u> </u>	4+	+
<b></b>	TEMA CLASS: R ALLOY 445	ļ.		<b>∦</b> .∔-		++	-+	 	++		4-4
	TUBE SIZE AND DESCRIPTION	<u> </u>			; ! <del>.</del>	- <u> </u>	, 	;; •	-	┽┽	44
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	No. Tubes0.D	<u> </u>			╵╷ ┥╴┥	-+ +	_ <u> </u> .	⋕		++	
	BWG Length			╢┦	╶┼╾┥		-+.	╢	•		
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	ERECTION			╅┽	-+	_	+	╫—	- #		
	Field Shop Assembled	╂		╢┤	╉			-		┝╋┥	┝╋
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	Quote By Western Doppy	-		╶╫╶╎	1						Π
	Date <u>4/14/17</u> Export Box				$\uparrow$		<u>†</u> †	1			
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KANSAS CITY, MISSOURI Est. - 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY

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ESTIMATING SHEET

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	TAG # E-2			+	+-		╋	┥╴╢		╫╌┼	┿		+	
	SERVICE: COLD RECYCLE CODLET:	<u> </u>	EA.		4	+-7	مام			╬╌┼	┽	$\vdash$	+	! -
	(AIR COOLED EXCHAINGER)		<b>  </b>	┝╌┽╴	+-	$\left  - \right $	+-	┤╴╢		╈╼╉	+-	┼╌╉╴		ŧ
	SIZE AND TYPE OF BAYS		╂	┝┅┿╸		┯		╡╌╢		+ +		+	+	+
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	Finned Surface/Bay s.f.									-	Ц.		_	
	Bare Tube Surface/Bay s.f.			ĺĺ					 	-#	<u> </u>		$\downarrow$	1
	Heat Exchanged Btu/Hr.									li-	44	+	_	•
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	Tube Proce psig. Tube Temp 0	F									، 	_		
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	Material lube Metheduci													
	Type of Finn		╢	++		- +	<u>†</u> •	-+-	1		Π		Π	-
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	FAN:		╢	╢	┟┽		$\frac{1}{1}$		1-		$\uparrow \uparrow$	T		
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	DRIVER				+		++		╫		┽┥		++	-
	Exp.ProofTEFCOther	_		+	┟╌┤	-+	┼┥		╫	_∦-	+	-	+	
	Ng/Bay				┼┤	-+-	+	┝╼╌╄╼					╉╃	-
	HPV/Ø/Hz				+	+		┝╌┿			+-	┝┼╴	++	<u> </u>
	TYPE OF DRIVE: V-BeltGear			_	$\downarrow$		╇		╂	$-\parallel$	╇	┝╌┤╍	┿┥	┝
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	Field Shop Assembled					$\square$		┢	-∦		$\rightarrow$	╁┼	4	ł
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TYPE O	F JOB METHANATION OF PUROX OFF- GRE	MADE	BY					_						-
FOR	SASSI CORPORATION	HECKED I	9Y		-			_	DA	TE.		1 2 1	79	
AT	INCIANEDOLIS, INCIANE PAGE	E NO					E\$1	rim,	TEI	NO.		<u></u>	<u>حک</u>	Nu

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KANSAS CITY, MISSOURI Ent. - 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY ESTIMATING SHEET

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		UANTITY	UNI	Υ	70	TAL		UNIT		101	TAL	
CT NO					Π			ļ				
	<u>S-T, FIN TUBE, U-TUBE, EXCHANGERS</u>			╟╍┼╶┼	╂┨				┥┽	╉╋	┿┼	╢
М.Н.	TAG #			╏╎┤			┝╢╸		╾┼╍┽	┽╋	+	·•
	SERVICE: GAS GAS EXCHANGER		EA.	╟┥┽	킥긱	00	Η.	•		-+-+	+	-
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	TYPE SIZE			║ ┃ ┇ ╈╌┽─┥		┝╍┥╍	1-+		-			4
	No. Shells/Unit		 	╫╌┼╶┥		╏╍┽╼	┥╌╫╴			┉┼┉╎		, . <del>.</del>
	Heat Transfer Area 2530 S.F.	 	₩	$\  \cdot \ $		╞╶┼╴	┼╫				· •	
	Bare Tube Surface/Shells.t.		⋕		-+	┝╌┼╌	┤╾╫╴			<u> </u>	┝╍╋╶	•
	Heat Exchanged (Design) Btu/Hr		<u> </u>	╢┼┥	┝╍┼━	<u>                                     </u>	┉					•
	SHELL TUBE		╫	+		┼┼	┼╫		i	<u></u>		
	Design Pressure 260 psig 225 psig		+		-+-		+		╋┈┿╾	╬╼┽─		!
	Design Temp. 700 OF 850 OF		<u></u>				++		╞╺┥╸	+	+'r	:
	Material C.S. SA-516 Gr. 70 ADM. SE-IIL	<b></b>			$\frac{1}{1}$		· · · ·		+	++-	+	•
	TEME CLASS: R ALLOY 445	₽			∔∔	++	-+		+		++	٢
	TUBE SIZE AND DESCRIPTION		- <u> </u>	-+-+-	++	+	+		+ +	┯┿		1
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	BWG Length	╣			┥┽	┥┥	╶┿╺┾	. •	╢┽	$\dagger$		4
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	Quote By Western Supply				╶┼╌┥	-+		<u> </u>				-
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	Insulated AreaS.T.						+		- <u> </u>	-		
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	METHANATION OF PUROX OFF-GAS	MADE	<b>3</b> Y					DA1	re	<del>.4</del> 7	s-f-	4

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# EN.- 721 REV. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

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NO.	DESCRIPTION	UANTITY	UNI		<b>T</b>	701	T	7-7	UN		<b>T</b> -T	101	Ŷ
	S-T, FIN TUBE, U-TUBE, EXCHANGERS												
	TAG # F-IC			$\prod$	Ţ	T	Γ	Γ					
<u>м.н.</u>			Eh.		8	5	2	> c					
	SERVICE. GAS COOLER			11	7-	17	Т					L	
	C T OTHER			#-+	+	Ħ	1.			Π	T	$\prod$	
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			╫───	╬╌┪	-+-	Τt	-	1-	<b>†</b> "				
	No. Shells/Unit			╉╼┫	-+-		+	1-					
	Heat Transfer Area 6777 S.F.	1	<b>∦</b>			†'1	- †	-†-	T .				
	Heat Exchanged (Design) Btu/Hr.		╢───			Π		1-					
	SHELL TUBE		1								1		   
	Design Pressure \$75 psig 75 psig		1	Τ					 	i i		4	Ì
	Design Temp. 400 OF 400 OF								<b> </b>		:   		
	Material C & SA-5/6 Ge 70 ADR. SB-11			1.		1-	17		1	ļ			
	ALLOY 445		-	-#-		Τ			ļ	i			
	TUBE SIZE AND DESCRIPTION		-	1									
	1002 5722 7005 500								Ţ				
	No. Tubes 0.D.				$\Box$				1.		╧╧	⊢	 +
	BWG Length								_	4.			 +
	FLANGES, SHELL - 300*FF TUPE -150*RF						1.	<u> </u> _		- 4-		┝	
	Weightlbs.								4-			↓	-
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	ERECTION							4-4			+	<u>↓</u>	_
	Field Shop Assembled											┷┥	_
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	Quote By Western Supply							↓_	i II-		$\downarrow$	┿	_
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	Painted Areas.f.		_				_		╞╌╢╌		$\vdash$	┵┥	
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	METHANATION OF PUROX OFF-GAS	MADE	•Y						0	ATE.		¥7	2
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o	DESCRIPTION		1	IT	TT	Π	TI					
	S-T. FIN TUBE, U-TUBE, EXCHANGERS		<u> </u>		↓	<b>  </b>	╧╧		<u>∥</u> _	╉╾╉┉		n onlje
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	SERVICE: CRG FEED CODLER		1							╎╵ ╋╍╬╸		
	(UNFIRED STEAM BOILER)											
	S-TOTHER			+++	$\uparrow\uparrow$				- Î - Î		11	
	TYPE	······		╺╋╸┽	╉┽	-1-1		1		-		
	No. Shells/Unit			╢┥	++	╍┥╌┤		<b>∦</b> − ·		++		
	Heat Transfer Area 575 S.F.			╍╫╍┼	╍┥╍┥			╬╴ -	-++ +	<b>ب</b> ب ا		•
	Bare Tube Surface/ShellS.1.		+	╶╬╌┤		-+-		1-			i i	••
	Heat Exchanged (Design) Btu/Hr.					╶╋╍┥	∔∔ 	-∦	·	·		
	<u>SHELL TUBE</u>					+-						
	Design Pressure 500 psig \$50 psig		_			-+-	╋╋					
	Design Temp. 500 OF 800 OF				┫ ┪	-	╈╇			┢─┝─	┠┼━	- ;
	Material C.S. 56-516-70 SA-178-C					   -	+-+			┼┼╴	┼╌┼╌	Ļ.
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	CONSTRUCTION COLE: HERE SECTOR					$\downarrow$	$\downarrow$	_#	#	++	++	41
	TUBE SIZE AND DESCRIPTION					$\downarrow \downarrow$	!		· -#-	$\downarrow \downarrow$	++	+
	INTERNAL EY-PASS REPAIRS				┥┥	┧∔	+			┽┿	╇	+
	No. TubesLength				$\square$	$\downarrow\downarrow$	4-	<b>L</b> _ <b> </b> _		┽┽	- <del>   </del>	4;
	BWG					$\square$				┹	4-1	
	FLANGES: 300 # RF						1_	↓		44	$\downarrow$	
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	s.f.		l			$\downarrow\downarrow$	$\downarrow \downarrow$				┿┿	╈┽
<u> </u>	Insulated Area						$\square$			<b>↓</b> ↓	┶╋	╁┿
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01LEF) 2 5.F. 5.f.		┡ ╺╈╅╺┾╸╀╶┥ ╶╫╸┽╼┽╶╴	┝┿┿╍ ┝┿┽┥┙	╫╾╺╢ ╢╌╺╢		┝╍╁╌╂╵	
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<u>2 5.F.</u> s.f.		╢╎╎╎ ╶╈╍┾╍╅╵╸				┢╍╁╍┼	
2 <u>5.</u> F. <u>s.f.</u>		P 1 1	╪╍╪╍┽╴	╇	╽┥┿	┼╌┼╼┼	
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#### 85 EAL- 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ECTIMATING SHEET

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0		S-T, FIN TUBE, U-TUBE, EXCHANGERS		<u>  </u>										
	М.н.	TAG #3										ile antipacti		
1) <b>49</b> 046974		SERVICE: METHENATOF FEELNENT COOLER # 1									1 , 			
	; ; ;	(UNFIELD STEAM BOILSE)	<u>    </u>	EA.		5	6	20	0			i Inden	 	
		S-TOTHER	l	<u> </u>							 			
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		Heat Transfer Area 3.312 S.F.					Π					<u></u>		······································
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		Design Pressure 500 psig 250 psig					$\prod$					1	IT	، دو مد وي
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		Material C.S. SE-516-70 SE-EED-TIL					<u> </u>				!	<u>i</u>		; ~ 
		CONSTRUCTION COLE: ASKE SECT. VIII . DIV. I												, ji
		TUBE SIZE AND DESCRIPTION										Ī		
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		BWG Length												
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		Painted Areas.f.			$\parallel \uparrow$	T		$\top$				$\square$	TT	T
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		SCHEDULED DELIVERY wks.after P.O.		1	$\dagger$	1	$\uparrow \uparrow$		╞		IT	Ħ	$\uparrow \uparrow$	
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-	S	ASSI CORDORATION							Q.	ATE_		<u> </u>	-f-d-	<b>d</b>
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Est. - 721 Rav. 3 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI ESTIMATING SHEET

207. NO.	DESCRIPTION				MATI		70	TAL		<u></u>	LA	90A	701	IAL.	<b>7</b> -
	S-T, FIN TUBE, U-TUBE.	EXCHANGERS													ŀ
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	TYPE SIZE				╟╍┼	+			-		-!+		$\uparrow \uparrow$	$\uparrow$	+
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	Heat Exchanged (Design) Btu/H	^													:
	SHELL	TUBE		ļ					4			Ļ	1	+	
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	Design Temp. 550 0	<u> 550 of</u>				·				L					1
	Material C.S. St516-70	SF-179				 				-		$\square$			•
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	TUBE SIZE AND DESCRIPTION		·												;
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	ERECTION														]
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	SCHEDULED DELIVERY	_wks.after P.O.		ļ	₽-↓			$\square$	4-	<u></u> ∦		$\downarrow \downarrow$	╇	-	
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1 40 34V	METHANATION OF PU	ROX OFF-GAS		·	,					DAT	E	4/	12	12	<b>9</b> .
0r	ASSI CORPORATION	CHEC	KED BY_							.DAT	E				
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Est. - 721 Rev. 1 10/74 J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

ESTIMATING SHEET

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· NO.	DESCRIPTION	UANTITY	<b></b>			10	TAL			41 Y	·	10	TAL
	S-T, FIN TUBE, U-TUBE, EXCHANGERS							1	(				
М.Н.	TAG #		<b>†</b>	╣┥	╋	$\dagger$	+	+		╉	$\uparrow$	+	-+-
<u>مەتخەندۇ مە</u>	SERVICE: METHALLATOR FEELVENT CONSECTA		∦	+	╋	$\uparrow$	+	+	<b>  </b>	┤		+-	+
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	TYPESIZE	· · · · ·		╫╢	1	Ť		7=		-#-+	$\vdash$	+	-+
	No. Shells/Unit		#	╬╌┼	+	ήd	-	1	<b>H</b> '	++	-+-	+	+
	Heat Transfer Area 40,588 S.F.			╉╼╂	+		-+-		H	╵╉╼┨		+	+-
9444 - 9449 - 9467-1944	Bare Tube Surface/Shell			$\dagger$		†.†	- †	-+	<u>†</u> -				
,	Heat Exchanged (Design) Btu/Hr.				+					+ +	<b>+</b> -   :		
	SHELL TUBE				+	+-		~+~ 			++-   		
	Design Pressure 210 psig 75 psig		1		-	!		-	∳ <mark> </mark>			<u>-</u>	) 
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				++	- <u>i</u> -		-		<b>₩</b> ₩ };	-	1		
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	ERECTION				╈			+-	#		┢┼	-	
	Field Shop Assembled			+	-	++		-	∦		$\uparrow \uparrow$	+-	
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	Quote By Western Supply		1	$\dagger$	+	+-		-+ 1	₩	╢┤	$\uparrow$	+-	$\left  \right $
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	Export Box				+		-	+-	#	╧	$\uparrow \uparrow$		H
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	Painted Areas.f.				$\uparrow$	┼┦	+	+		-#		<b></b>	-+
	Insulated Area			╢┤	+	+	+	+	<b> </b>		H		Ì
				$\dagger$	+	+	-+-			-  -	Π	1	
	SCHEDULED DELIVERY wks.after P.O.			$\dagger$	+	╉┥	+	+	<b> </b>	╉┥	$\vdash$		
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J. F. PRITCHARD AND COMPANY KANSAS CITY, MISSOURI

ESTIMATING SHEET

ACCT. NO.	DRECRIPTION	QUANTITY	UNIT			07/	<u>.</u>	<u></u>	LA1		701	AL	_
.0	S-T, FIN TUBE, U-TUBE, EXCHANGERS												
М.Н.	TAG # E-16	1			H	$\uparrow$		1	$\mathbf{H}$	-	┟╌┨╴	+	ť
	SERVICE: METUANATOR FEELVENT CON ER # 3	1			Ħ	T		1		1	$\uparrow \uparrow$	1	t
	(UNEDED STEER POULES)	1	En		17	5	6			1-		$\uparrow$	ţ
	S-T OTHER	1	<u> </u>					1	╢┼	+-	┼╌┼	+-	ł
	TYPE SIZE	•			╉╉	+	$\left  - \right $		╺╫╼┽	-	++	+	+
	No. Shells/Unit	•		-+-	┼┼	1-	-	+	╡┥	+-	┼┼	+	-
}	Heat Transfer Area 1146 S.F.	16000		•					┈╋╼┼		$\uparrow \uparrow$	+-	-
į	Bare Tube Surface/Shells.f.				╧╧╧							Ţ	•
	Heat Exchanged (Design) Btu/Hr											$\downarrow$	
	<u>SHELL TUBE</u>									j.	Ļļ		
	Design Pressure <u>500</u> psig <u>350</u> psig												
	Design Temp. 500 OF 600 OF												
	Material C.S. SF-516-70 SA-178-C			- <b>-</b>		1-	ΙŢ					Τ	Ì
	CONSTRUCTION CODE: ASME SECT. VIII DIV. I					1-				Τ	Π	T	1
	TUBE SIZE AND DESCRIPTION					1-						<u> </u>	1
	INTERNAL BY-PASS REQUIPED								_			T	
	No. Tubes0.D				╡ ╡╴┽╴	↓.			$\blacksquare$	1	$\prod$	1	
	BWG Length		┝╌╌╺╇	$\downarrow$	Ļ.		$\downarrow$	<b>_</b>			$\downarrow$	1	
	FLANGES: 300# RF			<u> </u>	$\downarrow \downarrow$	1.		<b></b>	_	_			-
	Weightlbs.			_	┢╌╽╴		╏╺┥		┹┛		$\downarrow$	4	1
								1			$\square$	$\downarrow$	
	ERECTION				Ц							-	
	Field Shop Assembled							_					-
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-+	Quote By Western Supply				┼┼	+-	++	-∦	╢┥		$\downarrow \downarrow$	+	-
	Date <u>9(12)79</u> Freight	<b></b>	<b>  </b>	+-	$\left  \right $		$\left  \right $		╶╢┤		┼┼	+-	
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	Insulated Area S.T.				╀╉	+-	-+	-∦	-#	-+-	╎┼		-
					┢╢	+-	$\left  \right $		╉┥		$\left  \right $	+-	
	SCHEDULED DELIVERY WKS.atter P.U.			-+-	_	+	┞┼	-╢	╶╫╌┦	+-	<u></u> <u></u> <u></u> </b>		
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	METHONDELON AT DURAN ATT CO.	<u>  </u>			16	0	00	>	<u>    </u>				
TYPE OF JO	DE THETHUN ALTON AL THEOR ALE-GAS	MADE BY	<u> </u>					DAT	E.	<u>4/</u>	3	7	1

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		ESTIMATING SH	ΗE	ET											
cci	T NO	DESCRIPTION	9	UANTITY	M UNIT	ATER	146	101	AL.		UNI	LABO T	)n ,	TOT	<b>A</b> 1
כ		S-T, FIN TUBE, U-TUBE, EXCHANGERS						Ţ				Π	Π	T	T
	М.Н.	TAG # E-25				11	Ť	Ť	T			$\square$	Ħ	T	t
		SERVICE: GAS/GAS EXCHENGER						T		$\Box$			Π		Ī
				1	EA		9	80	20	0			Π		T
		S-TOTHER				-++	╶╫	T	1				Ħ	+	t
		TYPESIZE				•++	1	1	1-				Ħ	╈	t
		No. Shells/Unit				- † - †	1	╧	1-		<b>-</b>			+	†
		Heat Transfer Area 15,074 S.F.		٩٧٫٠٠٠			T	7	$\uparrow$				П	T	T
	_	Bare Tube Surface/Shells.	. f.				T	Ī	T				1-1	7-	Ţ
i		Heat Exchanged (Design) Btu/Hr							i	Π					
		SHELL TUBE			ļ.		-+-						 ,		

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S-TOTHER	ĺ								
TYPESIZE				11				$\square$	
No. Shells/Unit			- † - †					+++	
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Bare Tube Surface/Shells.f.				TĪ	T			i l'i	
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J.F. PRITCHARD AND CO. KANSAS CITY, MISSOURI E.M.O. No. JOB No. 2392 MADE Br. 40 APPRV

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CONSTRUCTION COSTS

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J.F. PRITCHARD AND CO. KANSAS CITY, MISSOURI E.W.O. No. JOB No. 2592 MADE By 23 APPRV.

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THE PRITCHARD CORPORATION KANSAS CITY, MISSOURI E.W.O. No. \_\_\_\_\_JOB No. 2392 MADE Br \_\_\_\_\_APPRV. \_\_\_\_\_

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