and emergency conditions. The gas will be burned at the top of the flare stack. The system is designed to burn the entire CPO reactor outlet gas stream if necessary.

Waste streams generated during normal plant operation consist of blowdowns (from the saturator and boilers) and condensate (synthesis gas compressor). These waste steams are collected in the bottom section of the flare stack along with any condensate from the vent gas streams. LP steam is passed through a coil in the bottom of the stack to vaporize any light organics present in the waste water. The water is then pumped through a cooler and to the waste centrifuge which removes any oil from the water before the cleaned water is ejected to the sea. Oil recovered from the centrifuge is sent to the oil receiver.

Methanol Hold Tanks and Instrument Air

Two 4-hr hold tanks are included in the plant offsites. One tank is for off-spec product or crude from which the contents will be recycled to distillation. The other tank is a product methanol surge tank where product quality will be checked before sending it to bulk storage. Off-spec product in this tank will either be sent to the crude hold tank or directly to distillation for reprocessing.

Instrument and plant air is suppled from a package unit which produces 100 SCFM of plant air at 130 psig and 300 SCFM of instrument air at 125 psig dried to a dew point of -20°F.

Sea Water/Cooling Water Circuits

Cooling is provided by two systems: a fresh water closed loop and a once thru sea water circuit. All process related cooling duties are provided by the fresh water loop with the other loads being handled by sea water coolers. The circulating fresh cooling water is cooled by sea water in a plate-and-frame type exchanger.

Sea Water Desalination

Fresh water is produced by the desalination of sea water in a typical "marine type watermaker". This will consist of two parallel (1 operating + 1 stand-by) three stage flash evaporator systems that will meet drinking water and process water needs with a quality of less than 1 ppm chlorides.

B. RAW MATERIALS & UTILITIES IMPORTED

When operating the plant to product 3002.8 STPD of methanol, the anticipated daily (24-hour basis) normal requirements for raw material & utilities are as follow:

DESCRIPTION	UNITS	QUANTITY
Process Natural Gas	MMSCF	89.29
	MM Btu/ST MeOH	27.08
Packaged Boiler Fuel	MMSCF	-0-
	MM Btu/ST MeOH	-0-
Diesel Generators (2)	MMSCF	2.46
	MM Btu/ST MeOH	0.75
Total Natural Gas	MMSCF	91.75
	MM Btu/ST MeOH	27.83
Sea Water	MGAL	164248

Note: Small amounts of treatment chemicals for raw water, cooling water, boiler feedwater, boiler water and distillation column pH control will also be required.

NOMENCLATURE

MMSCF - Million standard cubic feet (60°F, 14.7 psia)
MM Btu/ST - Million Btu's per short ton
ST - Short ton (1 ST = 2000 lb)
MGAL - 1000 gallon
MLB - 1000 lb
Btu/SCF - Btu's per standard cubic foot (60°F, 14.7 psia)
MW - Megawatt
Ft3 - Cubic Foot

C. PRODUCT & WASTE STREAMS EXPORTED

When operating the plant to produce 30002.8 STPD of methanol, the anticipated daily (24-hour basis) normal production values are as follows:

DESCRIPTION	UNITS	QUANTITY
Product Methanol (100% contained)	ST	3002.8
Distillation Column Vent	MMSCF	1.95
	Btu/SCF (LHV)	575.2
Deaerator Vent	MLB	77.3
Package Boiler Flue Gas	MMSCF	161.9
Clean Water (Treated Blowdown)	MGAL	42.5
Saline Blowdown	MGAL	818.2
Sea Water	MGAL	163388

D. ELECTRICAL POWER SUMMARY

SERVICE	OPERATING POWER (KW)	INSTALLED POWER (KW)
AREA 01		
Process Condensate Pump	42	112
AREA 02		
Syngas/Circulator Turbine Condensate Pump	18	60
AREA 03		
Saturator Circulation Pump	3	15
AREA 04		
Column Reflux Pump	78	224
Column Bottoms Pump	30	90
Column Fusel Oil Pump	10	30
AREA 05		
Boiler Feedwater Pump	0	970
Air Compressor Turbine Condensate Pump	23	60
AREA 06		
Package Boiler	388	450
AREA 07		
Oxygen Plant	830	1040
AREA 10		
Blowdown Waste Pump	2	8
Waste Centrifuge	36	45
Inst. Air Compressor & Dryer	70	85
Crude Hold Tank Pump	38	112
Methanol Shift Tank Pump	16	45
Sea Water Pump	2606	3393
Cooling Water Pump	1382	3728
Fresh Water Pump	3	18
Sea Water Booster Pump	879	2238
Sea Water Strainer	21	26
Desalination Unit	20	50

D. **ELECTRICAL POWER SUMMARY (Cont'd)**

SERVICE	OPERATING POWER (KW)	INSTALLED POWER (KW)
Miscellaneous		
Lighting & Heating	225	300
Control Room & Instrumentation	100	175
Allowance (Cranes, Lube Oil, etc)	2380	2926
TOTAL	9200	16200

SECTION 3

DISCUSSION

A. CATALYTIC PARTIAL OXIDATION (CPO)

Catalytic Partial Oxidation for syngas production is considered to be the most suitable route to methanol on a plantship. This is not only in terms of cost, but also from safety, size and the environmental aspect.

As opposed to the conventional steam reforming route to methanol, the Catalytic Partial Oxidation route provides the following advantages:

1. CPO is a completely closed reactor system since all the heat is generated internally as opposed to a steam reformer which requires multiple external fire box burners and multiple process outlets.

2. The oxygen plant associated with the CPO route provides the blanketed inert nitrogen requirements along with the oxidant; hence, no additional natural gas is used to provide inerts. Furthermore, the CPO reactor and oxygen plant require approximately half of of the area required for a steam reforming plant and its associated flue gas heat recovery which is a source of NOx and hydrocarbon emissions.

3. Because CPO can operate on a "floating" steam to carbon ratio, a 50% or more reduction in low 750 PSIG steam generation is realized as opposed to a conventional steam reforming route which normally generates twice the amount of steam at 1500 PSIG.

4. In the CPO methanol process, water consumption is approximately one-eighth of that required in the steam reformer methane process. This allows one to use a simple 3-stage evaporative sea water to fresh water unit for all waters which includes boiler feedwater, drinking water, etc. as opposed to a demineralization plant with its associated chemicals.

5. CPO is very flexible in feedstock in that any vaporizable feed such as gas condensate can be converted to product if so desired.

6. The CPO process to methanol has simplicity of design and less operational units as compared to steam reforming.

7. Also, the CPO process to methanol has as much as a 25% reduction in capital cost and an energy saving as high as 10% as compared to steam reforming.

Since the CPO reactor is relatively new, there is a slightly higher risk than the conventional steam reforming route; however, Davy has built over 21 non-catalytic partial oxidation plants which either used a Texaco or Shell generator which operate at much higher temperatures and pressures than the proposed plantship CPO unit; hence, overall taking into account all the variable and short-comings of CPO vs. steam reforming, it was decided that the Catalytic Partial Oxidation route to methanol is the most favorable for a ship-mounted plant.

B. TUBE COOLED METHANOL CONVERTER (TCC)

After evaluating the various types of methanol loops, i.e., the I.C.I methanol quench "warm-shot" or "cold-shot" converters, the steam generating methanol converters, which are of the tubular spiral coil type high-differential pressure heat exchangers, and the tube cooled methanol which is a simple low-differential pressure gas to gas type exchanger, the TCC was selected because of the following advantages:

1. Single reactor capacity of over 3000 STPD of methanol as opposed to steam raising reactor which vary from 1500 to 2000 STPD depending on the type.

2. Mechanical soundness with minimum differential pressure and no tube sheet problems.

3. Ease of catalyst loading and unloading.

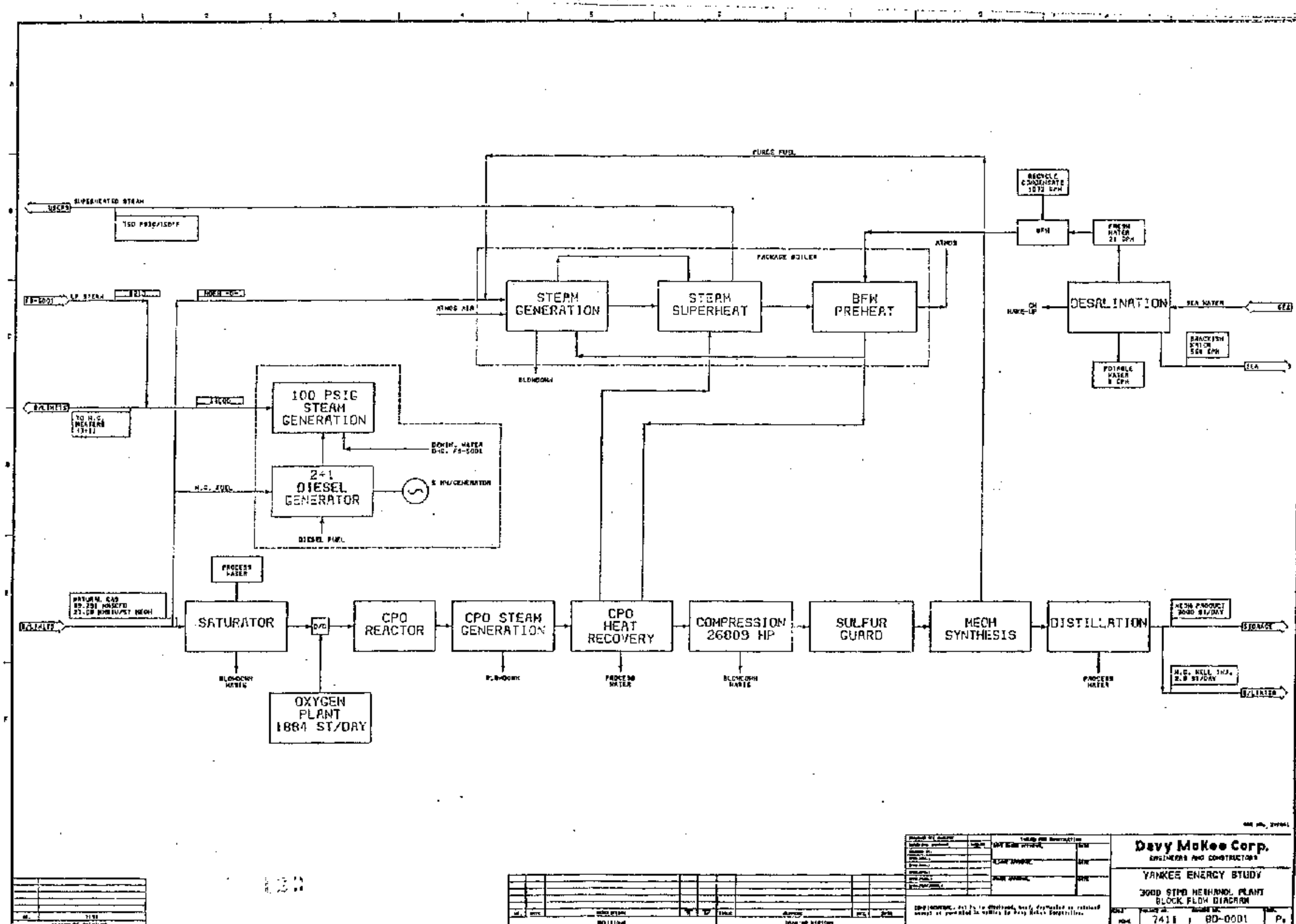
4. Minimum control loops, does not require quench control nor steam generation control.

5. Simple heat recovery.

6. Low rate of recycle gas which relates to circulating power.

7. Low catalyst volume.

With the TCC, we were able to achieve the best point of both the Quench and steam raising reactors.


SATURATOR
CPO REACTOR
CPO STEAM GENERATION
CPO HEAT RECOVERY
COMPRESSION 26809 HP
SULFUR GUARD
MEOH SYNTHESIS
DISTILLATION
OXYGEN PLANT 1884 ST/DAY
100 PSIG STEAM GENERATION
2+1 DIESEL GENERATOR
STEAM GENERATION
STEAM SUPERHEAT
BFW PREHEAT
DESALINATION
BFW
PURGE FUEL
PACKAGE BOILER
SUPERHEATED STEAM
150 PSIG/150°F
LP STEAM
ATMOS AIR
ATMOS
BLOWDOWN
DIESEL FUEL
PROCESS WATER
RECYCLE CONDENSATE 1072 GPM
FRESH WATER 21 GPM
SEA WATER
BRACKISH WATER 568 GPM
POTABLE WATER 8 GPM
STORAGE
Davy McKee Corp.
ENGINEERS AND CONSTRUCTORS
YANKEE ENERGY STUDY
3000 STPD METHANOL PLANT
BLOCK FLOW DIAGRAM
7411
BD-0001

SECTION 5

DESIGN ENGINEERING

A. GENERAL

Design engineering work done as part of previous study activities has been reviewed and modified as necessary to comply with the latest process design requirements and revised equipment lists. Further discussions have taken place with the ship designers to review plant layout, equipment design basis and integration with design of the ship and major parameters affecting the design of equipment modules, their installation on the ship and support requirements. Drawings have been modified and new drawings and documentation generated as indicated below.

B. PLANT LAYOUT

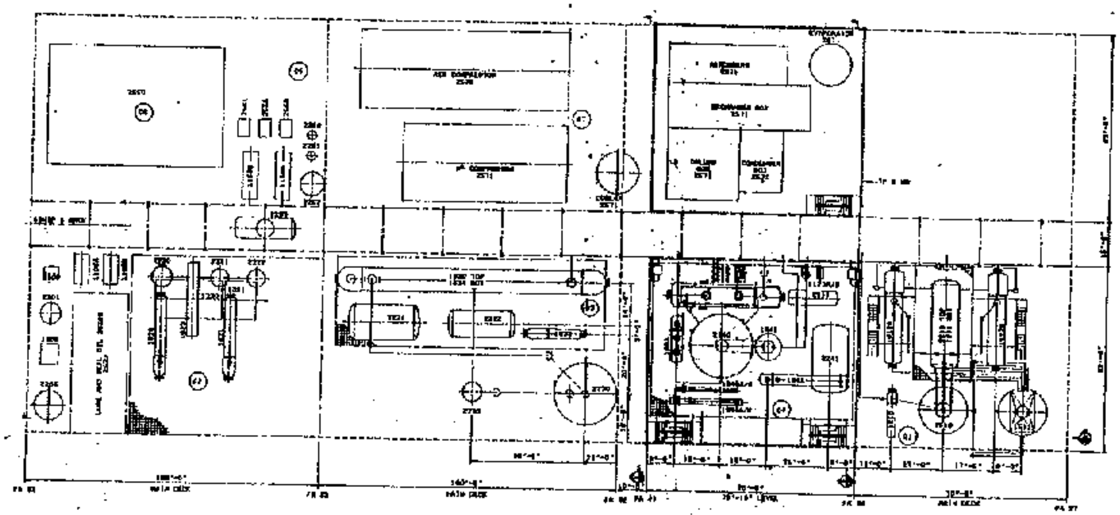
The principles used in previous plant ship layouts have been retained, i.e. housing distillation and the oxygen plant in the central "well" section of the ship, the grouping of equipment into major plant modules on the deck of the ship and the integration of storage, control, offsites and flare facilities with the rest of the ship design. However, significant changes in offsites and ancillary equipment have resulted in layout changes which are reflected on the updated arrangement drawings.

These changes include elimination of the Pressure Swing Absorber (PSA) Unit, substitution of a package boiler and diesel/gas fired electrical power generators for the gas turbine previously specified and the use of steam turbines for all major drives. The revised layout of plant is shown on the following drawings included with this report:

7411 - A-0001 Rev. 0
7411 - A-0002 Rev. 0
7411 - A-0003 Rev. 0

C. MODULAR DESIGN

Equipment from two sections of the process plant has been selected for more detailed study as possible candidates for inclusion in major plant modules. The two areas involved are the synthesis section and the distillation section of the plant but excluding the methanol converter and the distillation column respectively. Piping arrangement drawings and preliminary structural designs have been produced for these two modules and preliminary sizes and weights derived as shown on the preassembly data sheets attached (designated Preassembly 03 and 04 (7411-SK-1) is also included. These preliminary module designs provide the basis for discussion with potential module fabricators regarding design, fabrication and installation requirements and limitations.



EQUIPMENT LIST

ITEM NO.	NO.	DESCRIPTION
AREA 01 - CPO REACTOR WITH HEAT RECOVERY		
1110 A,B	1+1	PROCESS CONDENSATE PUMP
1510	1	CPO REACTOR
1511	1	START-UP HEATER
1810	1	OXYGEN HEATER
1811	1	CPO BOILER
1812 A,B	2	CPO FEED HEATER
1813	1	SEPARATOR WATER HEATER
1814	1	CPO COOLER
2210	1	CPO STEAM DRUM
2211	1	PROCESS CONDENSATE K.O. DRUM
AREA 02 - COMPRESSION		
1120 A,B	1+1	SYNGAS/CIRCULATOR TURBINE CONDENSER CONDENSATE PUMP N.S.
1320	1	SYNGAS COMPRESSOR
1320 T	1	SYNGAS/CIRCULATOR COMPRESSOR TURBINE
[illegible]	1	CIRCULATOR
1820	1	SYNGAS INTERCOOLER
[illegible]	1	SYNGAS SPILLBACK COOLER
[illegible]	1	SYNGAS/CIRCULATOR TURBINE CONDENSER
2220	1	SYNGAS SUCTION SEPARATOR
2221	1	SYNGAS INTERSTAGE SEPARATOR
2222	1	GUARD BED
[illegible]	1	LUBE/SEAL OIL SYSTEM
AREA 03 - METHANOL SYNTHESIS LOOP		
[illegible] A,B	1+1	SATURATOR CIRCULATOR PUMP N.S.
[illegible]	1	LOOP INTERCHANGER
[illegible]	1	LOOP START-UP HEATER
[illegible]	1	LOOP CONDENSER
2230	1	METHANOL CONVERTER
[illegible]	1	METHANOL SEPARATOR
[illegible]	1	LETDOWN VESSEL
[illegible]	1	FALLING FILM SATURATOR
AREA 04 - METHANOL DISTILLATION		
1140 A,B	1+1	COLUMN REFLUX PUMP N.S.
1141 A,B	1+1	COLUMN BOTTOMS PUMP N.S.
1142 A,B	1+1	COLUMN FUSEL OIL PUMP N.S.
1640	1	COLUMN REBOILER
[illegible]	1	COLUMN STEAM REBOILER
[illegible]	1	COLUMN PRIMARY CONDENSER
[illegible]	1	COLUMN SECONDARY CONDENSER
[illegible] A,B	1	PRODUCT COOLER
[illegible]	1	FUSEL OIL COOLER N.S.
[illegible] A,B	2	COLUMN BOTTOMS COOLER
2240	1	PRODUCT COLUMN
2241	1	COLUMN REFLUX DRUM
2540	1	CAUSTIC DOSING SET N.S.
AREA 05 - STEAM/CONDENSATE SYSTEM		
1150 A,B	1+1	BFW PUMP
1151 A,B	1+1	AIR COMPRESSOR TURBINE CONDENSATE PUMP N.S.
1150 T	1	BFW PUMP TURBINE
1351 T	1	AIR COMPRESSOR TURBINE N.S.
[illegible]	1	STEAM DESUPERHEATER N.S.
[illegible]	1	AIR COMPRESSOR TURBINE CONDENSER N.S.
2250	1	BOILER B.D. FLASH DRUM
[illegible]	1	HP FLASH DRUM
[illegible]	1	LP FLASH DRUM
[illegible]	1	DEAERATOR
2550	1	SODIUM SULFITE DOSING SET
2551	1	AMINE DOSING SET
AREA 06 - PACKAGE BOILER		
2560	1	PACKAGE BOILER
2561	1	PHOSPHATE DOSING SET
AREA 07 - GASEOUS OXYGEN PLANT		
2571	1	GASEOUS OXYGEN PLANT PACKAGE
AREA 10 - OFFSITES		
1100 A,B	1+1	BLOWDOWN WASTE PUMP N.S.
1101	1	CRUDE HOLD TANK PUMP N.S.
1102	1	METHANOL SHIFT TANK PUMP N.S.
1103 A-L	[illegible]	SEA WATER PUMP N.S.
1104 A,B	1+1	COOLING WATER PUMP N.S.
1105 A-C	[illegible]	FRESH WATER PUMP N.S.
1106 A,B	[illegible]	SEA WATER BOOSTER PUMP
1200	1	INSTRUMENT AIR COMPRESSOR UNIT
1400	1	WASTE CENTRIFUGE N.S.
1401 A-F	1	SEA WATER STRAINER N.S.
1500	1	BLOWDOWN WASTE COOLER N.S.
1501	1	FLARE STACK VAPORIZER COIL N.S.
1802 A-[illegible]	[illegible]	SEA WATER INTERCOOLER N.S.
2200	1	OIL RECEIVER N.S.
2201	1	INSTRUMENT AIR RECEIVER
2202	1	CRUDE HOLD TANK N.S.
2203	1	METHANOL SHIFT TANK N.S.
2204	1	COOLING WATER SURGE TANK
2205	1	FRESH WATER RESERVOIR N.S.
2400	1	FLARE STACK N.S.
2500	1	INSTRUMENT AIR DRYER PACKAGE
2501 A,B	1+1	WATER DESALINATION UNIT N.S.

N.S. = NOT SHOWN THIS DRAWING

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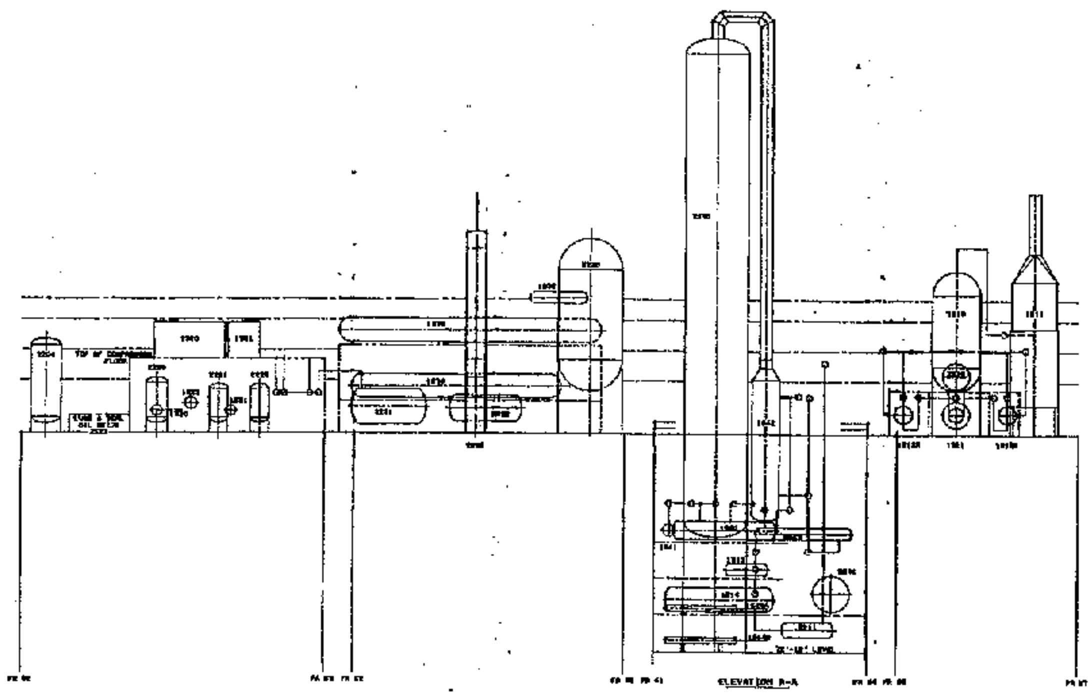
YANKEE ENERGY STUDY
EQUIPMENT ARRANGEMENT
FOR METHANOL PLANT
CPO ROUTE



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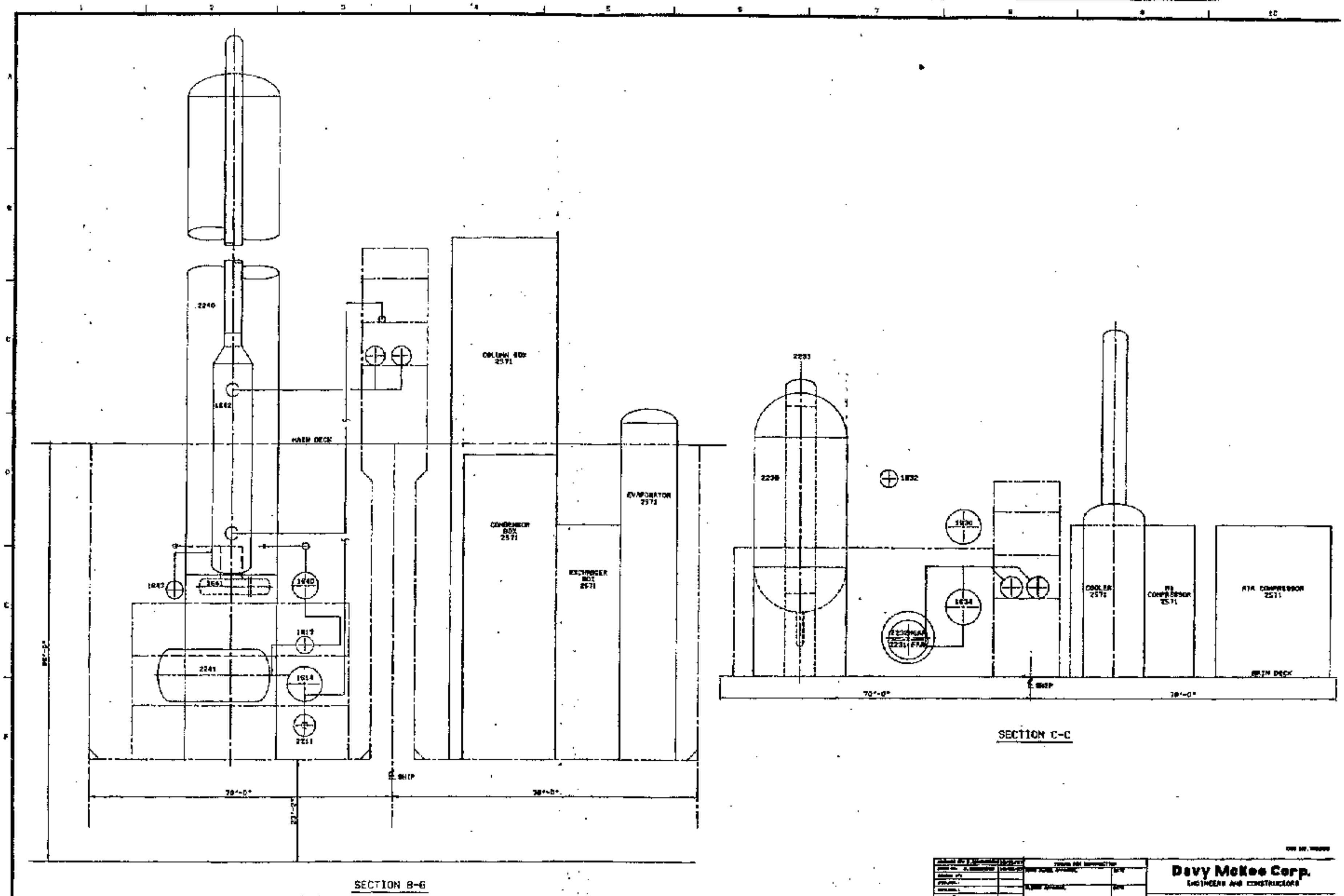
YANKEE ENERGY STUDY
EQUIPMENT ARRANGEMENT
FOR METHANOL PLANT
CPO ROUTE

229



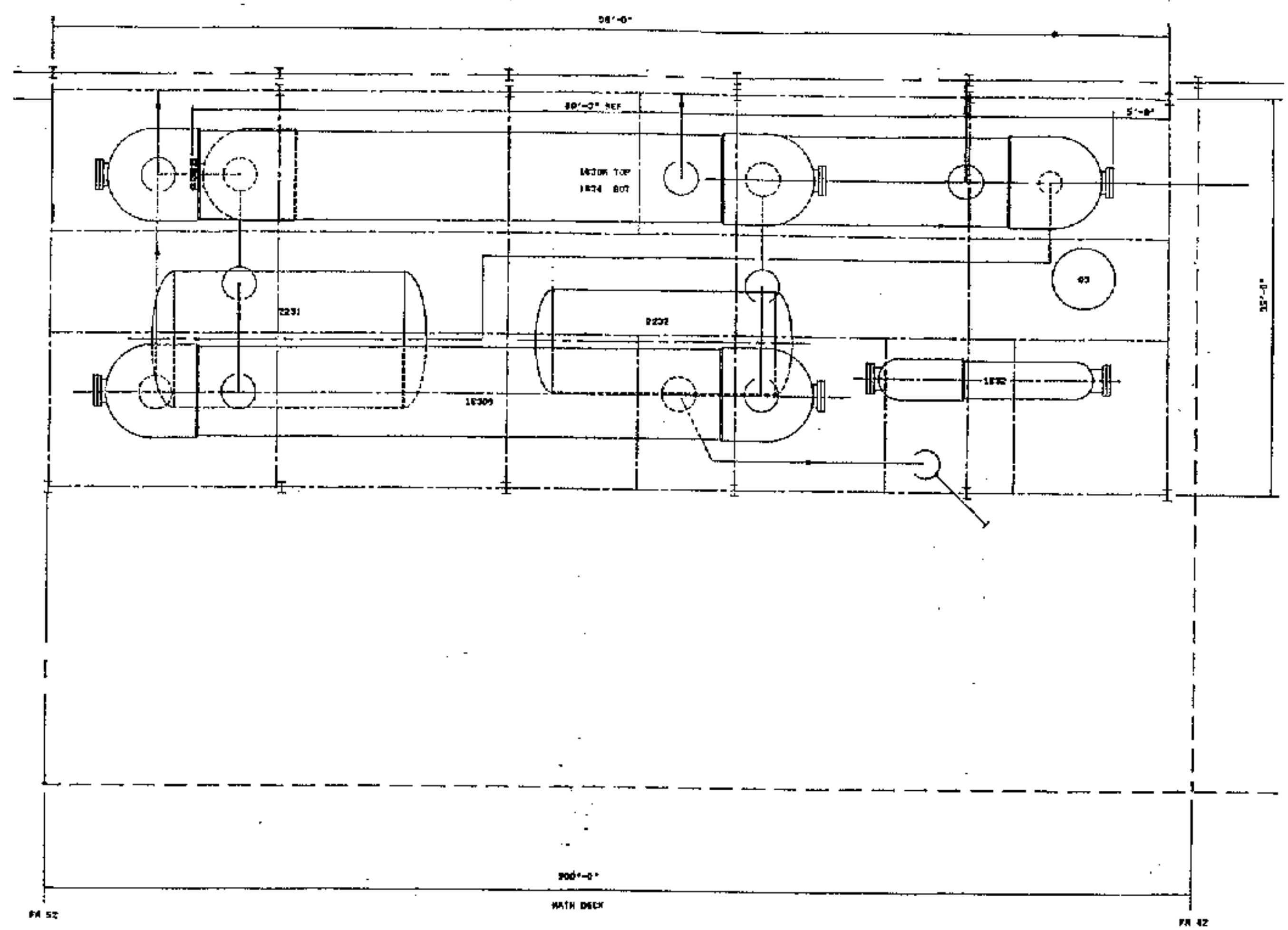
Davy McKee Corp.

ENGINEERS AND CONSTRUCTORS

YANKEE ENERGY STUDY

EQUIPMENT ARRANGEMENT

FOR METHANOL PLANT



Davy McKee Corp.
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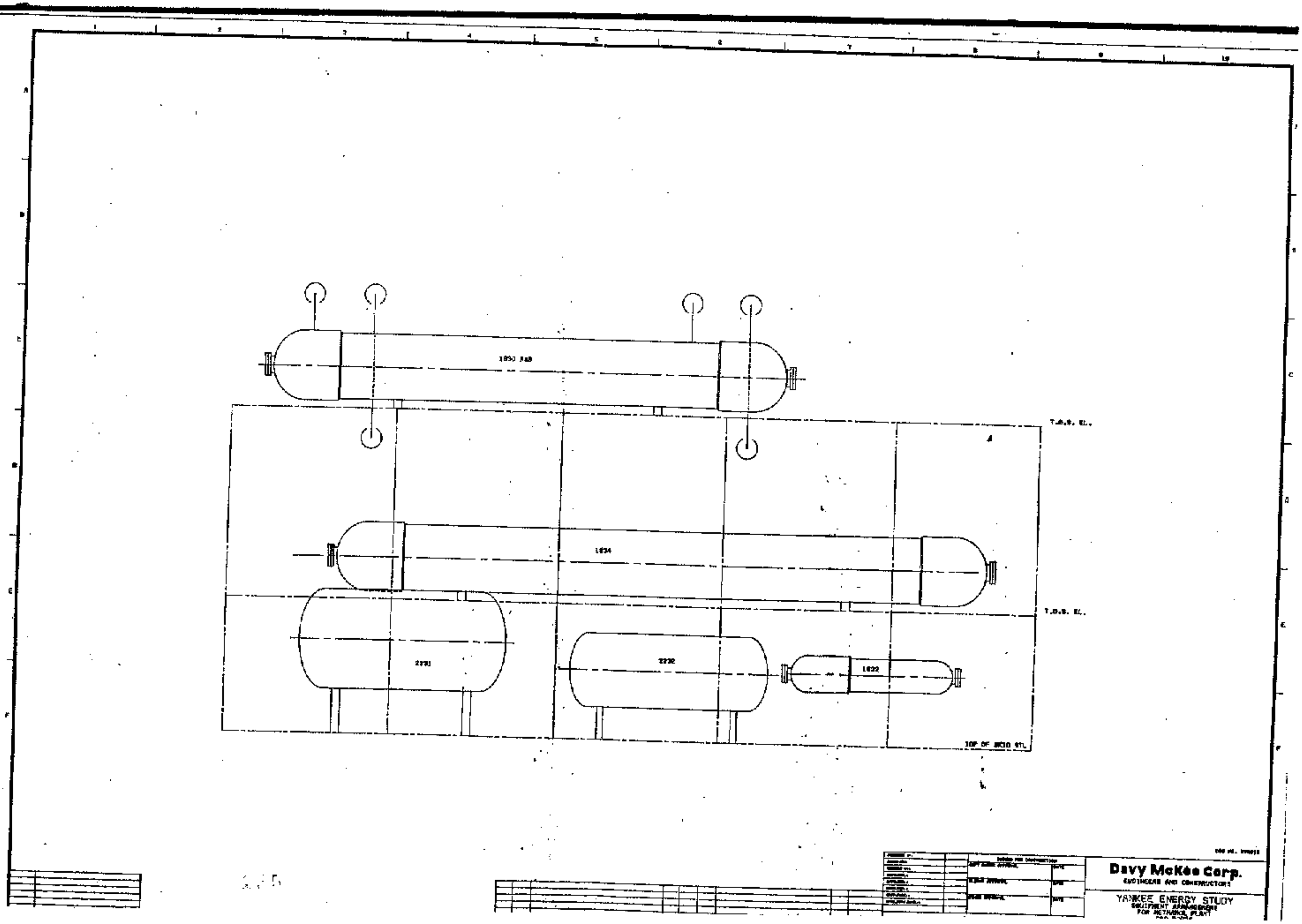
YANKEE ENERGY STUDY
EQUIPMENT ARRANGEMENT
FOR METHANOL PLANT
CPO ROUTE
SYNTHESIS LOOP MODULE


1850 A&B
1834
2231
2232
1822
T.O.S. EL.
T.O.S. EL.
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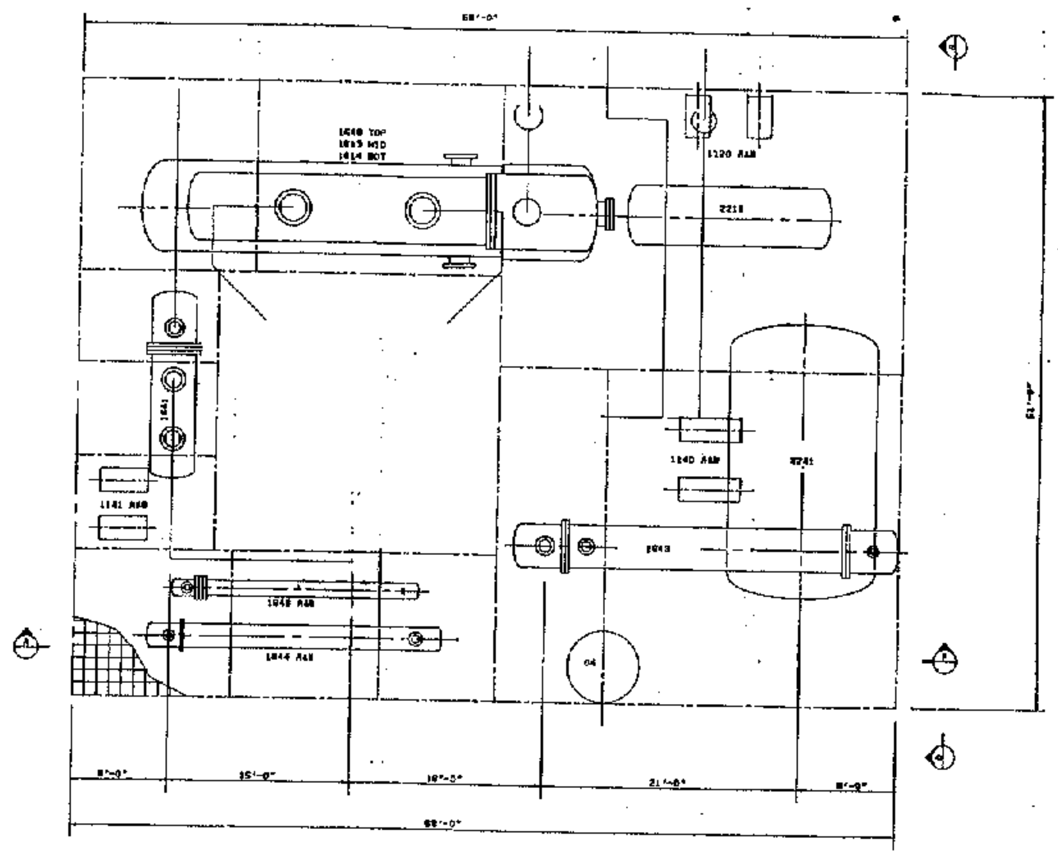
YANKEE ENERGY STUDY
EQUIPMENT ARRANGEMENT
FOR METHANOL PLANT



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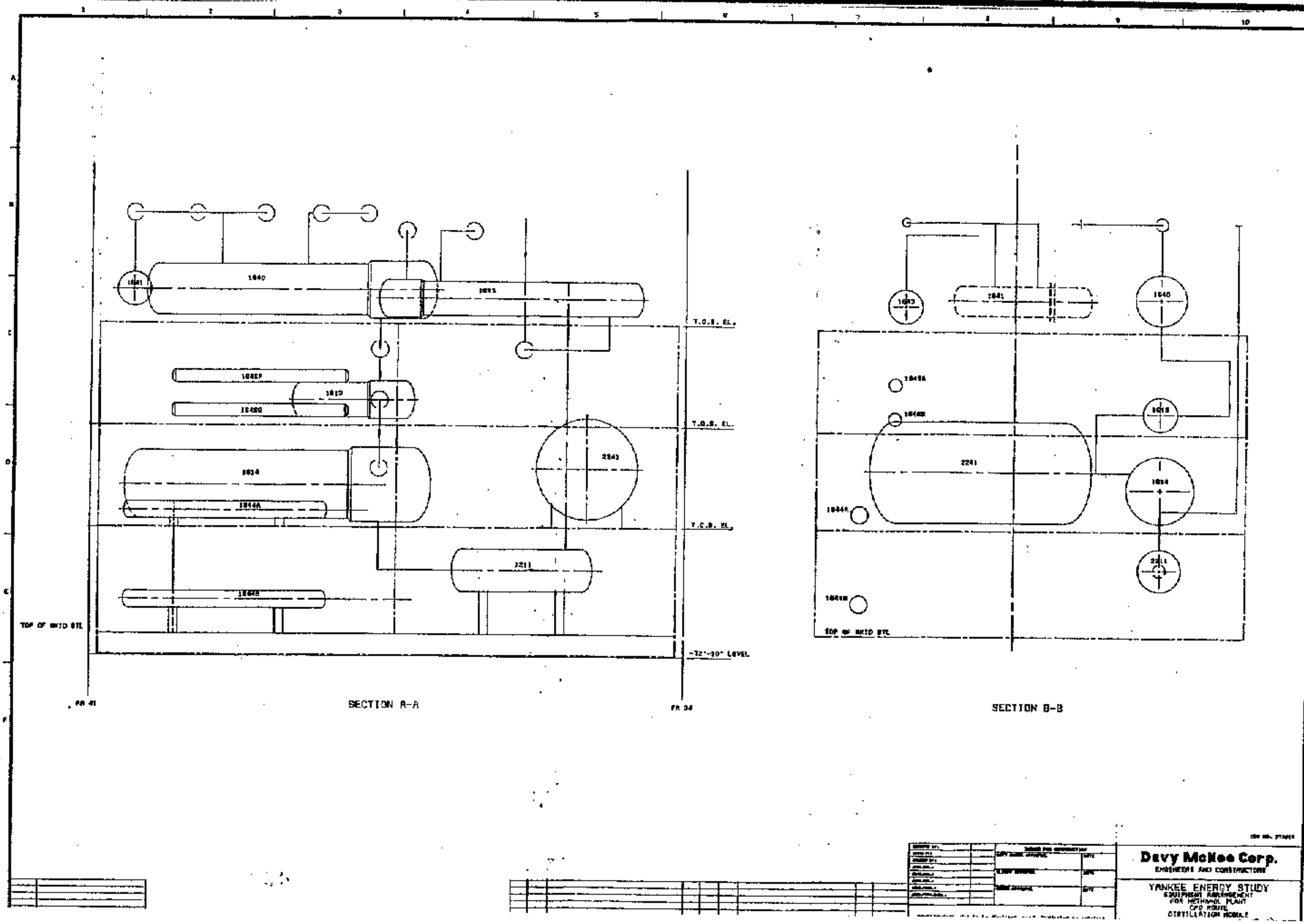
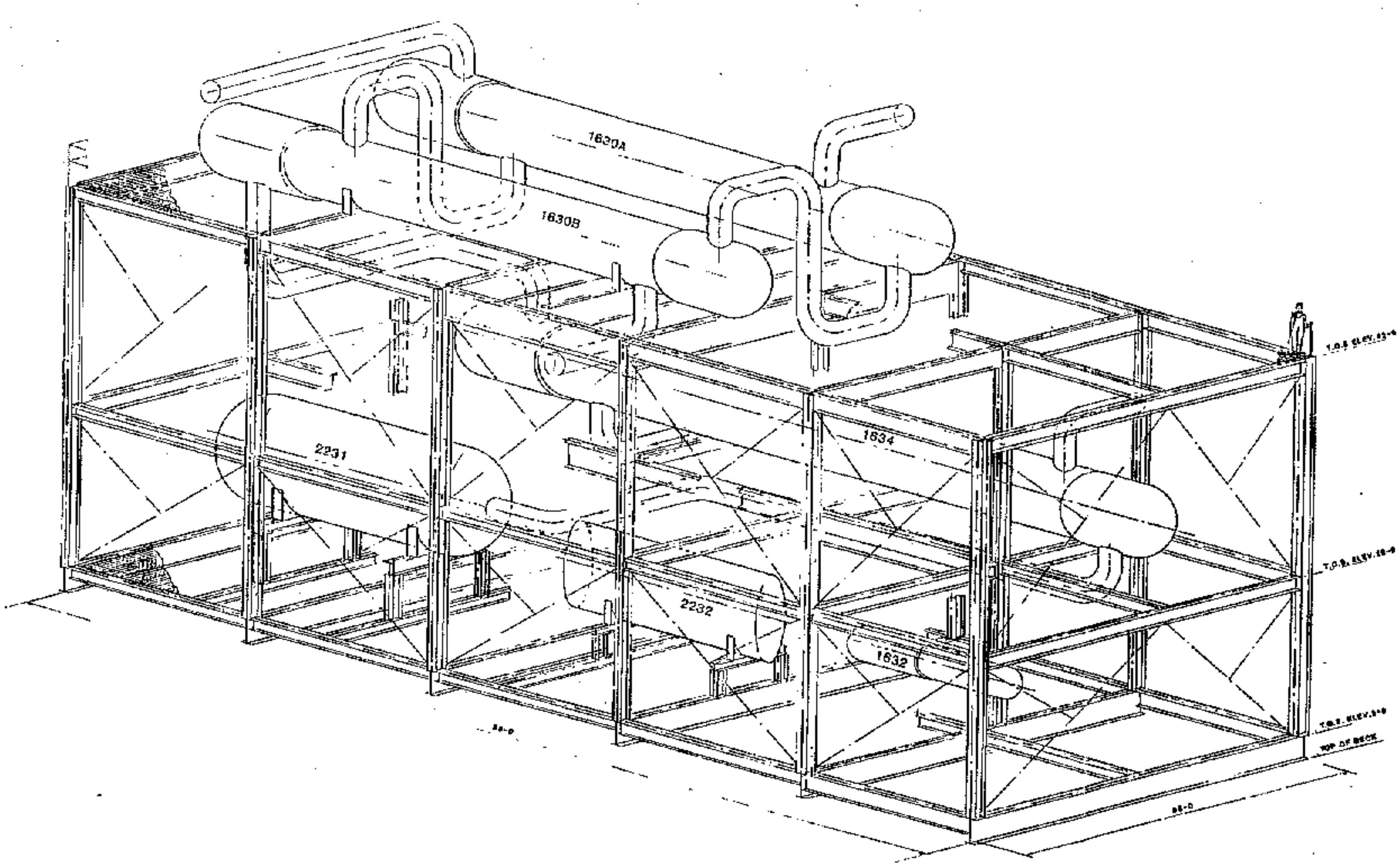
EQUIPMENT ARRANGEMENT
FOR METHANOL PLANT



SECTION A-A
SECTION B-B
T.O.S. EL.
T.C.B. EL.
TOP OF SKID STL
FR 41
FR 34
1840
1841
1843
1812
1814
1844A
1844B
2211
2241
Davy McKee Corp.
YANKEE ENERGY STUDY



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YANKEE ENERGY STUDY
ISOMETRIC VIEW OF SYNTHESIS LOOP MODULE

7411 SK-7

REVISIONS | DRAWING HISTORY | REFERENCE DRAWINGS

PREASSEMBLY DATA SHEET

REV.	DATE
PO	12/10/87

A. PREASSEMBLY # 03

B. TITLE SYNTHESIS

C. FLOWSHEET REF. FS.3001 PO

D. CONTAINED EQUIPMENT

EQUIPMENT	DESCRIPTION	WEIGHT (S TONS)
1630A/B	LOOP INTERCHANGER	471
1632	LOOP STARTUP HEATER	14
1634	LOOP CONDENSER	203
2231	METHANOL SEPARATOR	135
2232	LETDOWN VESSEL	11

E. SIZE (FEET) L X W X H

97'-6" X 35' X 57'

F. WEIGHT SUMMARY (S TONS)

EQUIPMENT	834
CONCRETE/INSULATION	9
FIREPROOFING	65
STRUCTURAL STEEL	205
PIPING	67
MISCELLANEOUS	10
TOTAL	1190