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HYNOL PROCESS ENGINEERING:

PROCESS CONFIGURATION, SITE PLAN, AND EQUIPMENT DESIGN

By

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16. ABSTRACT The report describes the design of the hydropyrolysis reactor system of the Hynol process. (NOTE: A bench scale methanol production facility is being constructed to demonstrate the technical feasibility of producing methanol from biomass using the Hynol process. The plant is being designed to convert 50 lb/hr (22.7 kg/hr) of biomass to methanol. The biomass consists of wood, and natural gas is used as a co-feedstock. Compared with other methanol production processes, direct emissions of carbon dioxide can be substantially reduced by using the Hynol process.) Process flow rates and gas compositions are presented in process flow diagrams for the Hynol system and the hydropyrolysis reactor. Safety, permitting, and site development requirements are described for the Hynol facility. The details of the instrumentation and controls for the hydropyrolysis reactor are presented in a piping and instrumentation diagram. Details of the equipment design, cost, and schedule are also documented.

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FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

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ABSTRACT

A bench scale methanol production facility is being constructed to demonstrate the technical feasibility of producing methanol from biomass using the Hynol process. The plant is being designed to convert 50 lb/hr of biomass to methanol. The biomass consists of wood, and natural gas is used as a co-feedstock. Compared with other methanol production processes, direct emissions of carbon dioxide (CO_2) can be substantially reduced by using the Hynol process. This report covers the design of the hydropyrolysis reactor system of the Hynol process. Process flow rates and gas compositions are presented in process flow diagrams for the Hynol system and the hydropyrolysis reactor. Safety, permitting, and site development requirements are described for the Hynol facility. The details of instrumentation and controls for the hydropyrolysis reactor are presented in a piping and instrumentation diagram. Details of the equipment design, cost, and schedule are also documented.

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TABLES (CONCLUDED)

CONVERSION UNITS

1 kg = 2.205 lb = 1,000 g

1 Mg = 1,000,000 kg = 2,205 lb = 1.1 short ton

1 mm = 0.0394 inch

1 m = 1,000 mm = 10^6 μm = 3.28 ft = 39.4 inch

1 m^3 = 1,000 liter (L) = 35.3 ft^3

1 m^3/h = 0.589 cfm (same temperature and pressure)

1 Nm^3h = 0.622 scfm, Nm^3 @ 0°C, 101.3 kPa, scf @ 60°F, 1 atm

1 bar = 10^5 N/m^2 = 14.5 psi

1 kPa = 1,000 N/m^2 = 0.145 psi

°C = (°F - 32)/1.8

1 kJ = 0.948 Btu

1 kW = 3,412 Btu/hr = 1.34 hp

1 @/(m^2 • °C) = 0.1761 Btu/(hr • ft^2 • °F)

1 quad = 10^{15} Btu = 1.055 x 10^{18}J

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SECTION 1

INTRODUCTION

Producing methanol from biomass offers significant environmental, energy and economic advantages over other liquid fuel resources. Methanol is a clean fuel for transportation and its widespread availability will contribute to air quality improvement in most urban areas. Domestic production of methanol versus imported fuels brings energy security, local jobs, and fuel distribution advantages. Process simulation studies indicate that the Hynol process should result in improved efficiencies in methanol production through increased yields over conventional processes. The process involves production from combined use of biomass and natural gas as feedstocks, optimizing the stoichiometry for synthesis gas to produce the fuel. The use of biomass feedstock together with natural gas provides for reduced CO_2 emissions per unit of fossil fuel carbon processed compared with separate natural gas and biomass processes.

In accordance with the goals of the Energy Policy Act of 1992 and the National Energy Strategy of 1991/92, this project is aimed at the development of a technology that will minimize the cost of producing a liquid alternative vehicle fuel and maximize petroleum displacement while reducing greenhouse gas emissions from mobile sources. The most practicable strategy for achieving these goals is to displace petroleum fuels with methanol derived from renewable biomass supplemented with natural gas a co-feedstock. In the long term, development of methanol as a primary alternative fuel will facilitate the transition to fuel-cell powered vehicles that could ultimately replace internal combustion engines and greatly increase fuel economy while reducing the pollutant emissions responsible for noncompliance with environmental standards in urban areas.

Among the renewables, biomass is the only energy resource that can displace petroleum by conversion to a liquid fuel. Although the most practicable strategy for minimizing greenhouse gas emissions from mobile sources, which account for 30 percent of the United States total, is to displace gasoline with a liquid fuel derived from biomass, the amount of biomass that could be produced sustainably on a scale large enough to impact the needs of the transportation sector is estimated by Oak Ridge National Laboratory to be only 5.5 quads.[1] Since a 30 percent displacement of transportation fuel would require about 7.5 quads in the year 2010 and because about half of the biomass energy is lost when converted to liquid fuels by existing technologies, the biomass must be supplemented with an additional feedstock that is compatible with the chosen alternative fuel. High efficiency of energy conversion, from biomass to liquid fuel and a capability to leverage the biomass with a compatible feedstock are crucial to achieving

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[1] Graham, R., et al., "The Economics of Biomass Production in the United States," Second Biomass Conference of the Americas, Portland, Oregon, August 1995.

maximum displacement of petroleum. Process simulations show that the proposed technology can, in theory, leverage biomass with natural gas to produce more liquid fuel from a given biomass supply than any existing process, or combination of processes, while also leveraging the amount of liquid fuel that can be obtained from domestic natural gas resources and reducing net greenhouse gas emissions.

Producing methanol from the Hynol process, illustrated in Figure 1, improves the overall conversion efficiency of methanol production. When methanol is produced from natural gas, the gas mixture contains an excess of hydrogen that is not converted to methanol. Similarly, conventional biomass gasification synthesis gas is rich in CO, which must be reacted with steam to form waste CO_2 and hydrogen. Conventional biomass gasification systems are also burdened with the capital cost of the shift reactor and CO_2 removal processes that are necessary because the synthesis gas contains too little hydrogen[2]. The Hynol process allows for the efficient use of natural gas and biomass as co-feedstocks. However, operating natural gas reformers and biomass gasifiers on the same site and mixing the synthesis gases in order to achieve a more optimal stoichiometry is not a feasible alternative to the Hynol process. The methanol reactor is too sensitive to the stoichiometry of the feed gas when the ratios of hydrogen to CO is close to 2:1.[3] The Hynol process operates with an excess of hydrogen which is possible since unreacted hydrogen is recycled to react with biomass. The efficiency of the Hynol process is over 68 percent. This compares favorably with that of conventional biomass gasification where the efficiency can approach 55 percent. Process efficiencies for the Hynol process are based on an interactive computer simulation model which has been checked by the U.S. Environmental Protection Agency/Air Pollution Prevention and Control Division (EPA/APPCD).

There are three steps to methanol production using the Hynol process:

1. Biomass is introduced into the hydropyrolysis reactor (HPR) in the presence of recirculated H_2. The HPR produces primarily CH_4, H_2, and water.

2. Steam and natural gas are added to the HPR effluent in a reformer or steam pyrolysis reactor (SPR) where they react to produce H_2 and CO.

3. The output from the SPR is then cooled in a heat exchanger and enters the methanol synthesis reactor (MSR). The unreacted hydrogen and methane are recirculated from the methanol synthesis reactor back into the HPR.

With appropriate process design, the intermediate products can be used in the different process steps to supply required reactants and process heat. The unique features of this process that improve upon other gasification systems are the use of natural gas as a co-feedstock and the recycling of excess hydrogen derived from that natural gas to the gasifier. Because biomass

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[2] Katofsky, R., "The Production of Fluid Fuels from Biomass," Center for Energy and Environmental Studies, Princeton University, June 1993.

[3] Supp, E., How to Produce Methanol from Coal, Springer Verlag, Berlin, 1990.

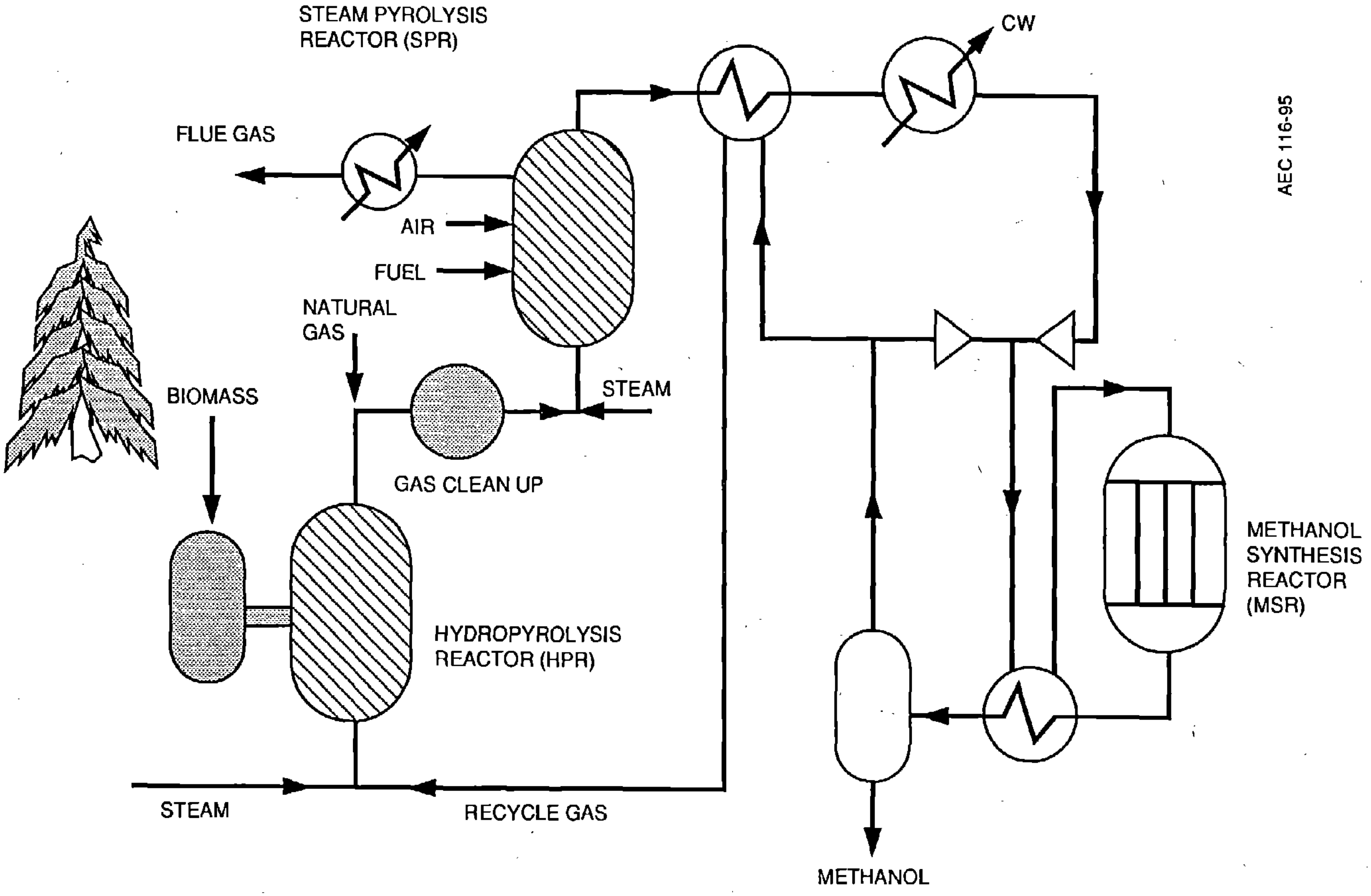


Figure 1. Hynol process schematic.

contains insufficient hydrogen to convert all of its carbon to alcohol, these improvements markedly enhance the alcohol yield and reduce production costs. Addition of natural gas provides a source of extra hydrogen that permits complete conversion of the carbon, and the addition of steam further increases alcohol production. When the excess hydrogen is recycled to the gasifier, alcohol yield is again leveraged due to its reaction with CO_2 to form the methanol precursor, CO; other biomass conversion processes must purge nearly half of the biomass-derived carbon as CO_2, thereby greatly reducing the potential alcohol yield. Because of these two advantages, alternative fuel production using the Hynol process would both utilize indigenous resources as feedstock and obtain maximum yield of clean fuel from those resources.

The goals of the overall demonstration project are twofold. First, the principal process components will be tested at specified conditions in a bench-scale unit with a biomass capacity of 22.7 kg/h (50 lb/hr) dry basis. Then, these tests will generate design, construction, process, and operating data for use in the construction of a large-scale plant.

The overall demonstration project consists of four phases:

- Phase I — Specifications of Pilot Plant
- Phase II — Hydrogasifier Design, Construction, and Operation
- Phase III — Methane Pyrolysis Reactor Design, Construction, and Operation
- Phase IV — Methanol Synthesis from Biomass in a Completely Integrated Pilot Plant

This report is the Phase II Design Report. It details the hydrogasifier design and describes the overall Hynol facility and the HPR system, including the piping and instrumentation diagram (P&ID) and control systems. This report also includes a cost summary and a schedule for completion of Phase II of this project.

1.1 SITE SELECTION

Acurex Environmental contacted a variety of organizations who were potential candidates for participating in a demonstration of the Hynol process. Demonstrations sites should have the following attributes:

- Land available for bench-scale unit
- Access to utilities
- Accessibility to biomass harvesting or disposal (for example, land fill operators)

Several city-owned land fills and sewage treatment plants were contacted to seek their participation in the project. These facilities also had access to digester gas or landfill gas. The candidates sites were asked to provide space for the bench-scale plant and potentially supply small amounts of feedstock. While some organizations were interested in the Hynol process as a potential means of reducing their waste disposal requirements, they all indicated that a bench-scale facility was too long term a project, and they were interested in a project that consumes a larger amount of biomass.

University research organizations were also contacted as candidate demonstration sites. Several university organizations have access to landfills if it were desirable to locate the facility directly on the landfill site. For a bench-scale facility, this consideration is not essential since the feedstock quantities should be relatively small. Operating a bench-scale facility would also be consistent with the goals of university research organizations.

1.2 FACILITY OVERVIEW

The bench-scale Hynol facility will be built at the University of California, Riverside, College of Engineering, Center for Environmental Research and Technology (CE-CERT). The facility will use biomass (initially white wood) and natural gas as feedstocks. After the facility successfully operates on wood and natural gas, waste biomass feedstocks such as tree trimmings will be used as a cofeedstock. The feedstocks will be processed into synthesis gas for methanol conversion. The HPR converts biomass into methane and the SPR converts CH_4 into CO and H_2. Temperatures inside the HPR and SPR are 800°C (1470°F) and 1,000°C (1,830°F) respectively. The pressure in both reactors is 30 to 40 bar (440 psi). Both reactors will be lined with internal refractory insulation and the outsides will be covered with a steam jacket. The outside wall temperature of the reactors is below 204°C (400°F). An external insulation layer will surround the outside of the reactors.

Gas exits the SPR and is cooled in a heat exchanger and processed in a methanol synthesis reactor. The methanol reactor system operates at 260°C (500°F) and with pressures ranging from 30 to 40 bar (440 to 588 psi). It is expected that product methanol will be stored in an 7,750 liter (2,000 gal) above ground storage tank. Approximately 1,500 liters (400 gal) of methanol will be produced per day for 24 hour operation.

The facility will also require a natural gas compressor, process gas compressor, air compressor, steam generator, and nitrogen supply. A compressed natural gas (CNG) fueling station may provide gas for CNG vehicle fueling and for the Hynol plant.

The system will initially operate with the HPR only, decoupled from the Hynol system. The HPR will require an external source of process gas. The process gas that is required for HPR feed contains H_2, CO, CO_2, CH_4, N_2, and water vapor. For an approximately 8-month period, H_2, CO, CO_2 and N_2 will be provided on site. Tube trailers will be parked at the site for the duration of test runs (about 2 weeks each) to provide the H_2, CO, and N_2. CO_2 will be stored as a liquid in high pressure cylinders. When operating the decoupled HPR (or HPR and SPR), the process gas will be burned in a flare. When all three of the Hynol reactors are operated as an integrated system, the methanol reactor will provide the process gas feed to the HPR.

1.3 REPORT CONTENTS

This report was completed under work assignments 1/044, 2/051, and 2/062 of EPA contract No. 68-D2-0063. The following work assignment tasks are incorporated into this report:

<u>WA 1/044</u>

- Task 1 — Assessing site requirements for construction of a bench-scale test facility.
- Task 2 — Modifying the existing Hydrocarb hydrogasifier design for the Hynol system.

- Task 3 — Preparing piping and instrumentation diagram (P&ID) for gasification system
- Task 4 — Preparing equipment lists and cost estimates for gasification system components

WA 2/051 and 2/062

- Task 1 — Permit Requirements
- Task 2 — Hot Gas Filter
- Task 3 — Biomass Feed System
- Task 4 — Water Scrubber
- Task 5 — Zinc Oxide Desulfurization Unit
- Task 6 — Prepare Final Report

The report covers the design of the hydropyrolysis reactor (HPR) system of the Hynol process. Flowrates and components of the overall Hynol process and HPR system are described in Section 2. Section 3 documents the site requirements in order to provide a basis for generating construction documents and facilitate obtaining permits. The materials generated, stored, and transported to and from the site are discussed here in order to identify materials handling permits, facilities, and other requirements. Codes and regulations that apply to the facilities and materials are presented next. Section 4 discusses the site plan, process areas, and facilities and how these will meet code requirements. Section 5 describes the details of piping, instrumentation, and controls for the HPR system. Equipment designs and hardware configurations are described in Section 6. Section 7 includes the equipment, consumable material, and site development costs, and Section 8 includes the schedule for the overall Hynol system construction and operation.

SECTION 2

DESIGN BASIS

The Hynol process combines biomass feedstocks with natural gas to improve the efficiency of biomass conversion. The basic Hynol process consists of two reactions: (1) hydrogenation (or hydropyrolysis) of the carbonaceous feedstock to produce methane followed by (2) the endothermic reaction of CH_4 with steam to produce H_2 and CO (steam pyrolysis or steam reforming).

Figure 2 shows a detailed process flow diagram for the integrated Hynol system. Compressors, heat exchangers, and other major equipment for the Hynol system are shown on this drawing. A flowsheet for the integrated system is presented in Appendix A. The flowsheet tracks the material flows for all of the streams related to the HPR system. The values are for the 25.8 kg/h bench-scale system. Gas compositions, volumetric flowrates, and elemental compositions are shown for each stream. Enthalpies for the gas streams are shown as the sum of the heat of formation plus ΔH_{298} (enthalpy of gas components at a reference temperature of 298 K). The enthalpies for the total HPR inputs ideally equals the HPR outlet enthalpy for a perfectly insulated system.

For methanol production, the CO formed in the steam pyrolysis step is catalytically combined with the hydrogen in a third step to produce methanol. Excess H_2 is recycled as a feed gas for hydropyrolysis. Biomass is fed into a reactor (HPR) and fluidized with recycled H_2-rich process gas at 30 bar and 800°C. Additional steam can be fed into the HPR or the SPR. The independent reactions taking place in the HPR can be expressed as:

$$C + 2H_2 \rightarrow CH_4 \tag{1}$$

$$C + H_2O \rightarrow CO + H_2 \tag{2}$$

$$CO_2 + H_2 \rightarrow CO + H_2O \tag{3}$$

The process gas compositions are shown in Table 1. Unconverted carbon is withdrawn from the reactor with ash in the form of char. Reactions (2) and (3) are endothermic and require additional energy input to the gasifier. This is why the conventional gasification processes need oxygen or air to supply combustion heat by burning some carbon in the feedstock within the gasifier. In the Hynol process, the thermal energy from recycled gas combined with

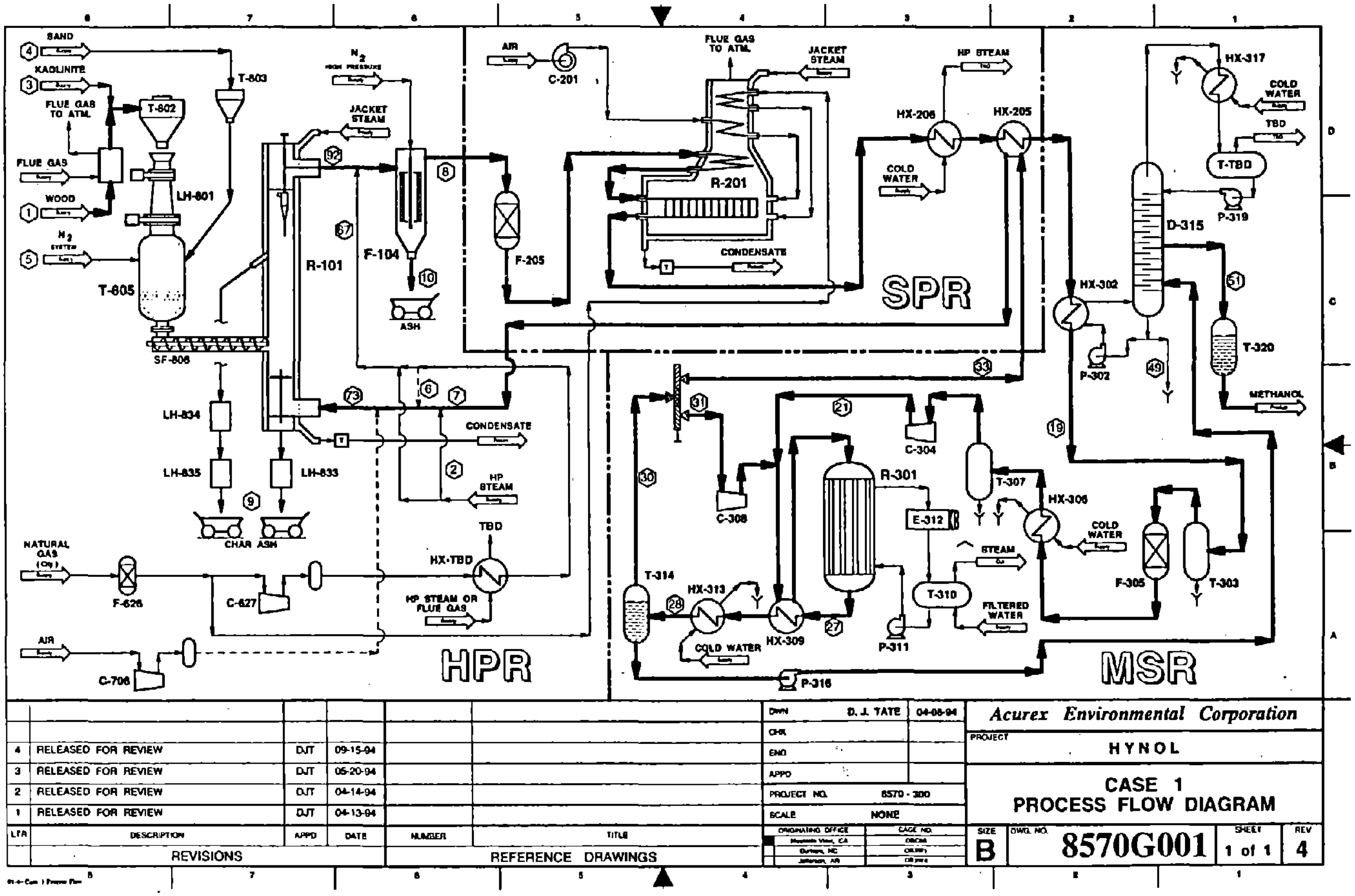


Figure 2. Hynol Case 1 process flow diagram.

TABLE 1. HYNOL GAS COMPOSITIONS (VOLUMETRIC %) AND FLOW RATES[a]

Stream	H_2	CO	CO_2	CH_4	H_2O	N_2	CH_3OH	mol/kg[b]
HPR out [92]	38.0	13.3	7.4	20.3	19.6	1.3	0	196
SPR out [19]	59.8	20.8	2.8	2.8	13.3	0.5	0	450
MSR out [28]	65.5	10.1	6.1	7.7	0.54	1.5	8.5	1,050
Recycle [7]	71.1	11.0	6.6	8.3	0.00	1.6	1.1	149

Wet biomass [1]: 2.0 kg/kg[a], **Steam [2b]**: 1.53 kg/kg, **Natural gas [67]**: 0.61 kg/kg

[a] ASPEN process simulation, R. Borgwardt, 10/94

[b] gmoles per kg on a bone dry basis. Stream [1] after drying contains 0.117 kg H_2O/kg.

reactions in the HPR allows for an energy neutral gasifier without the need for an internal or external heat supply. The hydrogasification reaction (1) between the carbon in feedstocks and the hydrogen in the recycled process gas is exothermic and provides sufficient heat for the reactions (2) and (3).

Before entering the SPR, the process gas from the HPR is cleaned to remove particulate and impurities which may contaminate catalysts in the subsequent reaction steps. Conventional hot gas clean-up methods can be used for this purpose. Feed natural gas can be added prior to the HPR filter to cool the gas stream and maintain a lower temperature operating environment. Other options include cooling the gas in a heat exchanger prior to the hot gas filter.

The process gas is then introduced to the steam reformer (alternatively called the SPR) where HPR outlet gas and methane feed react with steam to form CO and H_2. The steam reforming can be described by two independent reactions:

$$CH_4 + H_2O \rightarrow CO + 3H_2 \tag{4}$$

$$CO_2 + H_2 \rightarrow CO + H_2O \tag{5}$$

The reactions are performed at 30 bar and 1,000°C. A catalyst-packed tubular externally-fired furnace reactor similar to a conventional natural gas reformer furnace reactor is used for the SPR. Total steam feed for the Hynol process is about 1.3 kg per kg of bone dry biomass. Natural gas is feed into the SPR at a rate of 0.5 kg per kg of biomass. The H_2 and CO concentrations in the exit gas of the SPR are increased to 60 and 21 percent, respectively. The process gas is then passed through a gas heat exchanger where it is cooled down. The recovered heat is used to heat the recycled gas. The process gas is cooled for the methanol synthesis reactor (MSR) feed. The steam produced in this way is about 1.5 times the biomass feed in weight, which makes steam production energy self-sufficient within the system.

The MSR is a conventional methanol synthesis reactor using a copper-based low pressure catalyst. The cooled process gas then enters the MSR. The reactions taking place in the MSR are:

$$CO + 2H_2 \rightarrow CH_3OH \tag{6}$$

$$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O \tag{7}$$

Methanol synthesis occurs at 30 bar and 260°C. However, higher MSR pressures (up to 100 bar) are also feasible and can be tested in the "bench-scale" plant. The MSR reactions are highly exothermic so that the released process heat can be extracted from the MSR and used to dry the biomass feedstock. Methanol is separated from water in a condenser and fractionated to produce concentrated methanol. To increase the conversion of CO in the MSR, the uncondensed gas from the condenser is partially returned to the MSR. Using this approach, the recycle ratio of the internal loop is 4 moles per 1 mole of input process gas from the SPR. The net result is a 90-percent conversion of CO to methanol in the MSR. Unlike conventional processes where CO conversion in the MSR is the most critical parameter affecting the efficiency losses of the process, the Hynol process reprocesses the unconverted material by recycling the gas to the HPR and thus prevents losses of process gas constituents. For this reason, the Hynol process obtains a high thermal efficiency, even though the CO conversion through the MSR may be lower than that of conventional processes.

The condenser operates at 50°C. The gas exiting the MSR system is introduced to the gas heat-exchanger mentioned previously, after purging a small amount of gas (3.7 percent of the recycled gas), which eliminates the accumulation of inert nitrogen in the system and keeps the nitrogen concentration in the system below 2.5 mole %. The system is designed to accommodate a range of steam and natural gas feeds. The entry points of the steam and natural gas prior to the HPR or SPR can also be adjusted as indicated by revised process modeling assessments.

Gas compositions and flowrates can vary for different configurations of the Hynol process. Process modifications that have been modeled include the following:

- Adding steam prior to the HPR. Adding steam to the recycle gas mixture results in a lower average temperature to the HPR which may affect carbon conversion equilibrium and rate. Steam can also be superheated and then mixed with the recycle gas prior to the inter-heat exchanger (HX-205) which allows for greater heat recovery from the SPR. The HPR system will be designed for steam inputs before and after the HPR.

- Using a water scrubber rather than a hot gas filter (F-104) cools the HPR gas and adds water vapor to the gas mixture. The presence of the water scrubber does not affect the molar flowrates of HPR exit gases shown in Table 1 (except for steam). The steam input to the SPR is affected; however, the final SPR output should not be affected since the appropriate quantity of steam is added to the SPR inlet.

- The recycle ratio for the MSR affects the amount of CO and hydrogen that are recycled to the HPR.

- The purge gas flowrate and assumptions on nitrogen entrainment in the feedstock voidage affects the nitrogen content of the gas streams.

Table 2 shows an example of the differences in expected gas flowrates for a different process modeling configuration. The HPR system design is flexible enough to accommodate flowrates that represent expected differences in process modeling and process configuration. As an example, two different process simulations resulted in the following process changes:

- 15 percent variation in HPR input and output
- Factor of 10 variation in steam input prior to the HPR
- 25 percent variation in CO input
- Factor of 10 variation in CO_2 input
- 5 percent variation in hydrogen input
- Factor of 2 variation in methane input for recycle gas simulation

Variations in feed gas inputs can be accommodated within the turndown of most process valves. If very large turndowns are required to simulate required process configurations, parallel valves will be installed. Variations in mass flow, velocity, and specific heat need to be incorporated into process gas heater specifications.

2.1 HYNOL FACILITY CONFIGURATION

The design for the bench-scale biomass-to-methanol plant was updated for the Hynol Process. This report documents the process modifications for the Hynol process. The HPR system configuration for the Hynol process includes the following specifications:

System pressure:	30 bar
HPR temperature:	800°C

TABLE 2. ALTERNATE HYNOL GAS COMPOSITIONS (VOLUMETRIC %) AND FLOWRATES[a]

Stream	H_2	CO	CO_2	CH_4	H_2O	N_2	CH_3OH	mol/kg[b]
HPR out [92]	45.7	7.7	2.5	29.1	13.8	1.3	0	164
SPR out [19]	65.6	18.1	1.5	5.7	8.6	0.5	0	270
MSR out [28]	73.8	2.8	0.95	15.0	0.44	1.41	5.65	1,648
Recycle [7]	77.3	2.9	0.99	15.7	0.05	1.6	1.6	139
Wet biomass [1]: 2.0 kg/kg[a], Steam [2]: 1.30 kg/kg, Natural gas [67]: 0.55 kg/kg								

[a] Hynol simulation flow sheet D, Y. Dong, 9/8/94

[b] gmoles per kg of bone dry basis. Stream [1] after drying contains 0.117 kg H_2O/kg.

Solids feed: 26 kg/h
Steam feed to HPR: up to 5.1 kg/h (260°C)

HPR System Process Flow Diagram

The HPR system will initially be operated independently of the SPR and MSR. Two elements of the Hynol system will not be available for decoupled HPR operation and will need to be simulated. Recycle gas will be simulated by mixing gases from tube trailers with natural gas, steam, and vaporized liquid CO_2. Since the SPR will not be operating, the inter-heat exchanger will not operate at a high enough temperature because approach temperatures will be too low to provide the required HPR inlet temperature. An electric heater will provide additional heat to the recycle gas. Figure 1 represents an integrated system model that cannot produce the recycle gas for a decoupled HPR system. A flowsheet for the decoupled HPR system needs to consider the temperature of the simulated recycle gas since this gas will not be produced from system recycle but rather from bottled gases.

A process flow diagram for the HPR system is shown in Drawing 8570G002 in Appendix A. The hydrogen, CO, and nitrogen are fed from bottles and mixed to simulate the recycle gas in the fully integrated Hydrocarb system. The inlet gases at ambient temperature are heated in the heat exchanger by the HPR outlet gas. A separate boiler converts water to steam, which is injected after the heat exchanger. The mixture passes through an electrical heater before entering the burner where methane is injected.

The hydrogasifier is fed with a mixture of solids, primarily chipped wood with sand and an alkali absorbing (gettering) agent. The greenwaste and getter are mixed together and fed into a day bin and lockhopper; the sand and getter can be fed separately directly into the lockhopper or mixed with the biomass feed. A screw-feeder meters the solids into the reactor vessel where they are fluidized.

Methane is used to purge ports along the reactor vessel. Unreacted solids and ash are removed from the reactor in two ways. The solids are removed directly from the bottom of the reactor using a lockhopper system. Lighter ash is removed from the top of the bed from an overflow passage, on the side of the vessel, which empties into a lockhopper system.

An internally-mounted cyclone separates most particles from the exiting gas. The outlet gas passes through a filter which is pulse-cleaned with nitrogen. The hot outlet gas exchanges heat with the cold inlet gas.

Some elements of the integrated Hynol system were incorporated in the design of the HPR system. The SPR uses an air compressor, natural gas compressor, and should use a steam jacket. All of these systems are common with the HPR system and were incorporated into the HPR system design. Since the demand for methane and air vary with the different Hynol cases, the feed requirements were incorporated into the HPR system.

In order to operate the HPR for the most realistic test of the Hynol process, the flowrates for the HPR system need to be compared with those of the integrated HPR system. The net flow of each component, as well as the total enthalpy into the HPR, should be the same for the decoupled HPR and integrated Hynol system.

The HPR system process flow diagram includes the following features that are of interest and differ between the theoretical integrated system and the actual decoupled system:

1) H_2, CO, CO_2, and N_2 are added from bottled gases, heated with a heat exchanger, and then heated further with an electric heater. These gases simulate some of the recycled HPR feed.

2) Steam from a steam generator is added upstream of the electric heater. This flow (stream 68) simulates both water vapor that is in the recycle stream and steam that is added to the HPR system. The electric heater raises the temperature to 1,000°C. Higher temperatures are difficult to achieve with an electric heater.

3) Natural gas, mostly CH_4, is added downstream of the electric heater since the heater face temperature would be sufficiently high to decompose methane at the partial pressure in the gas stream. The natural gas that is added downstream of the heater simulates methane in the HPR recycle gas.

4) Provisions are also made to add natural gas downstream of the HPR. This stream represents the methane feed to the SPR. About 10 percent of this stream is split off and used to purge the cyclone in the HPR. The balance of the natural gas is added after the HPR. For decoupled HPR operation, most of the methane need not be added to the system.

5) Methanol is present in small percentages in the recycle gas. However, the methanol would dissociate in a heat exchanger with an 888°C outlet temperature. Therefore, for the decoupled HPR system, methanol should be added in the form of its constituent CO and H_2. The mass flow (associated with methanol vapor) entering the HPR is held constant between the decoupled and integrated systems.

6) Some lockhopper pressurization gas carries over into the HPR. The flowrate of stream 5 is equal to the flowrate of the biomass feed. Since the lockhopper is pressurized with nitrogen, the biomass voidage volume, as nitrogen gas, enters the HPR. The mass and enthalpy of the nitrogen should be considered in the energy balance for the process. They are included on the flowsheet for the decoupled HPR.

7) Natural gas is combusted to warm up the HPR prior to start-up. The corresponding flowrates are shown in the process flow diagram. Nitrogen that is heated with the electric heater will also be used during start-up operations. Nitrogen can flow through the electric heater which will prevent the heater wires from overheating prior to adding simulated recycle gas to the system. Air may also need to be added upstream of the electric heater to allow for periodic oxidation of the heater wires.

SECTION 3

SAFETY AND PERMIT REQUIREMENTS

This section documents the materials that are generated, stored, and transported to and from the site in order to identify materials handling permits, facilities, and other requirements. Codes and regulations that apply to the facility are presented afterwards.

3.1 MATERIAL FLOWS

Various materials will be received, stored, and shipped from the Hynol facility. Table 3 summarizes the material flows for the facility. Flowrates are shown for continuous process operation as well as product shipping and receiving. Storage quantities, containers, and pressures are also indicated in Table 3. Material flows in Table 3 represent those during facility operation. When the facility is not operating, most materials will continue to be stored on-site. Ash, sludge, and any waste water will be removed from the site. Methanol will be removed from the reactor system but will continue to be stored in the storage tank to service vehicle requirements. Natural gas and water will enter the facility via pipeline. Other materials will be shipped into and from the facility by truck.

Bottled Gases

Gases will be delivered by tube trailer for the initial phases of operation. CO_2 will also be delivered as a liquid in B size bottles, and additional nitrogen will be delivered in A size bottles. Deliveries of hydrogen, nitrogen, and CO tube trailers and CO_2 will stop once methanol is produced on-site. Nitrogen will continue to be stored on site in A size bottles.

Natural Gas

Natural gas is as a cofeedstock for the Hynol process. Natural gas is fed into the HPR (or SPR) at over 34 bar (500 psi). It also burned for heat energy in the SPR. Natural gas combustion in the SPR is at low pressure, below 7 bar (100 psi). Natural gas will be compressed in a fueling system for CNG vehicles. The gas will be compressed to 248 bar (3,600 psi) and stored in a series of high pressure bottles for transfer to vehicles. The compressor will be able to provide continuous flow sufficient for the Hynol process. During start up, a natural gas-fired burner heats the HPR. Gas line pressure will be sufficiently high to feed the SPR combustor without further compression.

TABLE 3. MATERIALS FLOWRATES AND STORAGE QUANTITIES

Material	Process flowrate	Shipping rate	Storage conditions		
			Quantity	Container	Pressure (gage)
Hydrogen—trailer	41.4 scfm	130,000 scf/d	260,000 scf	2 trailers	2,400 psi
Carbon monoxide—trailer	4.0 scfm	110,000 scf/4d	220,000 scf	2 trailers	2,400 psi
Nitrogen—trailer	1.4 to 48 scfm	120,000 scf/	240,000 scf	2 trailers	2,400 psi
Nitrogen—bottles	0.2 scfm	1,830 scf/wk	1,830 scf	6 A bottles	2,640 psi
Carbon dioxide—bottles	7.5 scfm (52 lb/hr)	1,253 lb/d	2,400 lb	40 B bottles	770 psi
Process gas	130 scfm	0	1,000 scf	3 A bottles	1,400 psi
Natural gas	30 scfm	0	3,000 scf	10 A bottles	3,600 psi
Air low pressure	5275 scfm	0	0	—	80 psi
Air high pressure	60 scfm	0	300 scf	1 A bottle	800 psi
Biomass, as received	—	8,400 lb/wk	17,000 lb	8×16 ft pile	—
Biomass, dry & chips	50 lb/hr	2,500 lb/2d[b]	5,000 lb	4×8×14 ft bin	—
Sand	0.5 lb/hr	350 lb/mo	1,000 lb	10 bags	—
Kaolinite	0.5 lb/hr	350 lb/mo	1,000 lb	10 bags	—
Ash	0.38 lb/hr	250 lb/mo[c]	1,250 lb	5 drums	—
Ash and bed material (sand and kaolinite)	1.4 lb/hr	1,000 lb/mo[c]	2,500 lb	10 drums	—
SPR catalyst (NiO)	—	850 lb/y[d]	850 lb	3 drums	—
Methanol catalyst (CuO)	—	850 lb/y[d]	850 lb	3 drums	—
ZnO pellets	—	560 lb/mo[d]	560 lb	2 drums	—
MnO Pellets	—	200 lb/mo[d]	200 lb	1 drum	—
Methanol	420 gal/d	0[e]	2,000 gal	Above ground tank	0 psig
City water	18.4 gal/hr	0	0	—	—
Distillation bottoms	2.3 gal/hr	Recycled	100 gal	Process tank	600 psi
Scrubber sludge	1 lb/hr (max)	350 lb/mo[c]	350 lb	1 drum	—

[a] Standard cubic feed at 60°F, 14.7 psi. See table of unit conversions.

[b] Chips will usually be produced on site.

[c] Material to be removed from the facility.

[d] Fresh catalysts will be delivered to facility and spent catalysts will be removed.

[e] No methanol is delivered during facility operation. When the facility is not operating, methanol deliveries up to 2,000 gal may be made to fill the storage tank for vehicle use. Fuel that is produced at the facility will be used in methanol vehicles.

Air

Natural gas is burned in air with natural gas in the HPR system during start up and in the SPR system during continuous operation. A compressor provides 55 bar (800 psi) combustion air for the HPR system during start-up. A blower provides 5.5 bar (80 psi) combustion air for the SPR.

Biomass

Biomass feed for the process will initially consist of clean white wood. Other feedstocks may be used later during the project. Wood will be processed on site to the consistency required for the biomass feed system. The wood will be ground or chipped to a particle size less than 10 mm and dried. Both as-received wood and processed wood will be stored on the site. On-site chipping is the preferred approach since control of the feed size is important for reliable feeding into the gasifier.

Methanol

Methanol is produced in the synthesis reactor and stored in an above ground storage tank. Vehicles will use some of the methanol product. Methanol product may also be removed from the site by tank truck. When the facility is not operating, methanol may also be shipped to the facility for vehicle use.

Process Gas

Process gas in the Hynol system is made up of feed gases and the products of the three reactor systems. The composition of process gas streams at the exit of each of the three reactor systems are shown in Section 2. Process gas circulates through the Hynol system. The quantities stored amount to the volume of gas in the reactors, piping, compressors, and buffer tanks. During shut down, process gas will be purged from the facility and replaced with nitrogen.

Other Solids Feed

Sand is expected to be added to the HPR to help fluidize the biomass. Sand will also retain heat and may help provide for stable gasification. Sand will also help abrade biomass and accelerate gasification. Sand will be added to the metering bin through a sand port.

Clay materials like kaolinite will also be added to the gasifier. These materials will absorb alkali metals like potassium and sodium and prevent their subsequent condensation in the reactor piping or insulation. Alkali metals can also form sand balls inside the gasifier which eventually plug the gasifier.

The material inside the gasifier is referred to as the bed. The bed will be composed of sand, clay, ash, and unreacted biomass. Clay materials may also be used to displace sand and comprise a larger fraction of the bed and improve alkali control.

Catalysts

A catalyst is used in the methanol synthesis reactor and the SPR. The sulfur removal system also contains material similar to catalysts. Catalysts consist of metal and metal oxide coatings over ceramic substrates. Catalyst substrates are typically 5 mm alumina pellets; however, many other sizes and shapes are used in other applications.

The catalysts for the Hynol system are shown in Table 4. The composition of catalysts is usually identified by the manufacturer; however, the morphology of the catalyst and coating are closely guarded secrets. Catalysts must be periodically replaced as they become deactivated by contaminants in the process gas.

Ash

Ash will be a byproduct of biomass gasification. Ash will contain minerals that are present in the biomass feed as well as unreacted carbonaceous material. Table 5 shows the composition of several wood ash samples. Bed material containing ash will be removed from the HPR. Ash that contains little bed material will also be removed from the hot gas filter vessel and from the top of the HPR bed.

Water

City water provides make-up water for steam generators. Steam is fed into the HPR and SPR. Steam passes through insulating steam jackets on the HPR and SPR. Water is recirculated from a steam drum above the methanol synthesis reactor and removes the heat generated from the conversion of process gas to methanol. Cooling water is also used to condense methanol vapor to liquid.

One configuration of the Hynol process uses a water scrubber to cool process gas exiting the HPR. The water scrubber absorbs contaminants in the gas stream.

Waste Water

Waste water will be produced in the water scrubber and distillation column. The water scrubber will collect particulates, alkali metal compounds, and H_2S from the outlet of the HPR. H_2S will be converted to H_2SO_4 in the aqueous solution. Some heavy hydrocarbons and tars may also be present in the waste water from the water scrubber. Solids will be accumulated in

TABLE 4. CATALYSTS FOR THE HYNOL FACILITY

System	Catalyst	Substrate
Sulfur removal	MnO ZnO	5-mm pellets
Steam reformer	NiO	12.7 × 9.5 × 4.8-mm rings
Methanol synthesis	CuO/ZnO	4-mm beads

TABLE 5. ELEMENTAL COMPOSITION OF WOOD ASH[a]

Run Number	Fuel Type	Al	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	PO_4	K	Ag	Na	Sr	Ti	V	Zn
1	Oak	3200	1880	0.22	121	0.63	169000	4.8	14.0	58.4	5680	6.3	5800	6580	BDL	4.50	6330	31000	BDL	608	1340	197	7.5	58.0
3A	Oak	4040	2080	0.24	162	0.68	220000	5.8	14.3	79.3	3920	8.8	7350	6080	BDL	5.75	8730	35200	BDL	950	1580	233	8.5	138
3B	Oak	3880	2010	0.24	149	0.75	227000	5.0	14.0	76.5	3810	9.0	7050	5750	BDL	5.50	8150	36600	BDL	805	1530	222	10.0	45.8
3C	Oak	4020	2080	0.25	173	0.93	209000	4.5	14.0	79.3	3510	9.0	7330	5850	BDL	6.00	8750	30800	BDL	858	1520	246	8.8	47.0
3 Mean	Oak	3980	2057	0.24	161	0.79	212000	5.1	14.1	78.4	3747	8.9	7243	5893	BDL	5.75	8543	34200	BDL	871	1543	234	9.1	76.9
3 Std. Dev.	Oak	87	40	0.01	12	0.13	7000	0.6	0.2	1.6	212	0.1	168	169	BDL	0.25	341	3027	BDL	73	32	12	0.8	52.9
2	Oak	6100	1970	0.18	127	BDL	210000	5.5	11.0	56.2	7600	5.0	5900	5650	BDL	5.00	6300	22900	BDL	620	1630	349	14.0	30.0
4	Oak	2460	2600	0.27	181	BDL	305000	3.5	12.5	75.0	1600	5.5	8350	8100	BDL	3.30	9100	48100	BDL	570	2240	84	3.3	27.8
6	Pine	7150	1550	BDL	200	3.90	192000	6.5	2.6	105.0	1990	17.0	30800	5700	BDL	2.85	23800	58000	BDL	1310	1160	86	1.3	655
14	Pine	7130	1440	BDL	250	6.25	193000	14.3	4.4	101.0	28200	11.0	28200	8150	BDL	16.50	21800	45700	15.0	1140	1190	57	1.1	1060
5	Pine	5620	1220	BDL	159	3.75	160000	5.0	2.3	91.4	1430	35.0	21400	3940	BDL	2.65	15300	43200	BDL	1110	905	109	1.4	417
16	Pine	7580	1800	BDL	260	1.18	227000	8.8	3.9	111.0	2690	5.5	34500	9830	2.2	5.50	24700	49100	11.0	1160	1390	89	BDL	449
9	Pine	7850	1290	BDL	221	4.45	197000	12.0	3.5	93.0	4440	14.0	28200	6250	BDL	3.25	18700	46600	14.5	1850	1100	146	3.2	1150
10	Pine	8800	1430	BDL	224	2.68	209000	11.8	3.6	102.0	7000	7.5	27900	7100	2.9	4.25	21300	46200	14.5	1810	1200	124	2.2	920
7	Pine	9050	1590	BDL	273	0.73	214000	11.5	4.4	88.3	3100	8.5	38600	10200	2.6	4.50	23700	48700	8.3	1440	1450	112	3.2	590
8	Pine	9280	1650	BDL	252	0.68	214000	14.5	4.0	120.0	5060	6.5	41700	7680	2.9	4.00	28400	55000	6.8	2620	1390	148	5.2	480
12	Pine	7950	1140	BDL	285	68.50	129000	18.3	4.4	205.0	4450	19.0	30000	8900	2.9	15.50	22000	46700	18.5	1410	1330	54	1.7	1660
13	Pine	5850	1190	BDL	185	14.0	160000	13.0	2.9	80.5	2120	12.3	214000	6680	3.1	5.50	16500	34100	12.8	1170	980	82	1.1	650

[a] Samples were analyzed by inductively-coupled argon plasma (ICAP) spectroscopy at a commercial laboratory. All results are reported as micrograms per gram (parts per million mass) of dry sample. Reported values were corrected for field blanks. (Source: Burnet, P. G., et al., "Effects of Appliance Type and Operating Variables on Woodstove Emissions," EPA-600/2-90-001a [NTIS PB 90-151457], January 1990.)

BDL = Below detection limit.

a settling chamber in the water scrubber. The sludge will be removed during a blowdown process. Sludge will be neutralized and disposed of off site.

If the methanol product is processed to form anhydrous methanol, the fuel will need to be processed in a distillation column. The water bottoms from the distillation column will contain some alcohols and hydrocarbons. Since this water is the product of the methanol reactor and was produced from a clean gas, it will contain no mineral impurities. The distillation water will be converted to steam and recycled back into the Hynol process as a feedstock. Distillation water will be stored in a 100-gal (approximately) buffer tank.

3.2 HAZARDOUS MATERIALS HANDLING

Several of the materials used in the facility are classified as hazardous because of their properties or specific EPA listing. The process will require the handling of flammable gases and methanol, a flammable liquid. Appropriate precautions will be exercised when handling all materials. A material safety data sheet (MSDS) will be provided by material suppliers for all materials. City water, as received wood, and air are the only materials from Table 3-1 that will not have an MSDS.

This section will be updated with information from MSDSs when they are available. A Hazardous Materials Management Plan (HMMP) will also be prepared for the facility. This document will list the quantities of hazardous materials that are stored on site.

Methanol

Methanol is a flammable liquid. It burns with an invisible flame which makes detecting a methanol fire more difficult than other fires. However, methanol fires burn with less intense radiant energy. Methanol is miscible with water; so, methanol fires can be fought with water. Alcohol compatible foams may be desirable for larger methanol fires. Methanol is biodegradable in the event of a spill; however, a methanol spill must still be prevented in order to prevent short-term adverse environmental impacts. Methanol spills must not be allowed to enter a sewer or storm drain. Provisions will be made to prevent rain water from mixing with an accidental methanol spill and entering the storm drain. Methanol ingestion leads to acute toxicity. Poison warnings will be placed near methanol dispensers.

Since methanol will be manufactured on site, the site operators will need to prepare an MSDS for this product. The MSDS will be produced from expected compositions and updated once methanol is produced on site. An MSDS for chemical grade methanol produced by Celanese Chemical Company is included in Appendix A.

Bottled Gases

All of the bottled gases are potential asphyxiants. Hydrogen and CO are flammable gases. Liquid CO_2 can cause freeze burns. All gases in the facility are under high pressure and must be handled with appropriate precautions. Hydrogen, nitrogen, and CO are also stored at 165 bar (2,400 psi). An MSDS will be obtained from the gas suppliers for each of the gases.

Process Gas

Process gas will be composed of similar components as the bottled gases. Process gas will be in the Hynol system at elevated temperatures.

Natural Gas

Natural gas is classified as a flammable. It contains primarily methane and smaller quantities of other hydrocarbons as well as a few percent of CO, CO_2, and N_2. The gas company will provide an MSDS for natural gas.

Biomass

Biomass feed will be produced from white wood. Ground biomass can present an explosion hazard if its particle size is sufficiently small. A sufficiently high moisture content of the biomass helps eliminate the explosion hazard. Chipped biomass will not result in particle sizes that represent an explosion hazard. However, some small particles may be produced and collected as dust. Measures will be taken to eliminate ignition sources and electrical hazards from processed biomass. An MSDS will be prepared by the site operators for the processed biomass.

Other Solids Feed

Risks associated with handling sand and pulverized clay appear to be minimal; however, an MSDS for each will be provided by the supplier. Clay materials may pose an inhalation hazard due to their fine particle size.

Ash

Ash may be classified as a hazardous materials because of its metals content. Determining whether ash is hazardous is based on the results of toxicity characteristic leaching procedure (TCLP). However, since the ash originated from biomass, it should be no more hazardous than burned wood. Efforts will be made to utilize the ash from this project as an agricultural supplement. Ash should contain potassium, valuable fertilizer. Used bed material will contain ash, sand, and kaolinite. Sand is also a valuable agricultural supplement for many soils.

Ash poses hazards for handling because it will be in the form of a fine dust. Since the ash will be produced on-site, the site operators will prepare an MSDS for the ash. The MSDS will be based on expected ash properties and updated after ash is produced on site.

Catalysts

Catalysts may be hazardous because they contain heavy metals. Fine dusts can be produced when catalysts are handled and these can present an inhalation hazard. Catalyst spills from accidental handling must be cleaned up to avoid possible ground water contamination if rain water or rinse water contacts the catalyst. MSDSs will be provided for fresh catalysts by the catalyst manufacturers. An MSDS may also be required for spent catalysts.

Waste Water

Waste water from the water scrubber will contain particulates, H_2SO_4, heavy hydrocarbons, and dissolved gases. Water circulates through the water scrubber, particles are removed, and the water is cooled and recirculated. The waste water will be treated in the following steps:

- Remove settled material as sludge
- Neutralize of sludge to a pH of 7
- Strip dissolved gases from the sludge and collect on a carbon absorption system
- Ship sludge for disposal

An MSDS will be prepared for the treated sludge.

3.3 PERMIT REQUIREMENTS

The Hynol facility will require following permits and approvals:

- Building permit
- Air emissions permit
- Methanol storage tank emissions permit
- Hazardous materials storage permit
- California Environmental Quality Act (CEQA) documentation
- Storm drain permit

All of these permits can be readily obtained for the project. The University provides building permits for CE-CERT projects. CE-CERT has reviewed the project requirements with University and City of Riverside officials, who have not indicated any problems with building permits, and have indicated that a CEQA environmental document will not be required for the project. Bourns Inc. and the University already have permits for hazardous material storage, and the quantities considered for this project will not adversely affect these permits. Since this project is co-sponsored by The South Coast Air Quality Management District (SCAQMD), no problems in obtaining permits for the MPR combustor, flare, and methanol storage are anticipated. Since the SCAQMD has been involved in the design of the plant, they are knowledgeable about the project, and have been helpful in providing information about the approach to permitting. The University of California, Riverside architects and engineers have been briefed on the proposed plant and have added input into the siting requirements and plant design. They will be used in final design stages as consultants to insure that the project complies with the University health and safety requirements.

Constructing and operating the Hynol facility will fall under the jurisdiction of several agencies and require a variety of permits. The anticipated permit requirements are shown in Table 6. The actual permit requirements will be determined upon further discussions with the agencies with permitting authority. Some permit requirements may not be fully defined until construction plans are submitted. In addition to permit requirements, codes, and regulations are also discussed in this section.

TABLE 6. PERMIT REQUIREMENTS FOR HYNOL FACILITY

Agency	Permit or activity
SCAQMD	Methanol storage tank Process combustion or experimental permit
City of Riverside	Conditional use permit Plot plan review Design board review Building permit — Site and hydrogasification system Building permit — Steam reforming system Building permit — Methanol synthesis system
Riverside Fire Department	Hazardous Materials Management Plan
California OSHA (Title 8)	Pressure vessel certifications Boiler permit Process Safety Management Plan

3.4 APPLICABLE CODES AND REGULATIONS

The primary codes and regulations that apply to this type of facility are shown below:

SCAQMD standards and prohibitions
Uniform Fire Code
National Fire Protection Association (NFPA) 30 Flammable and Combustible Liquids Code
NFPA 30A Automotive and Marine Service Station Code
NFPA 52 Compressed Natural Gas (CNG) Vehicular fuel systems
NFPA 321 Standard for Basic Classification of Flammable and Combustible Liquids
NFPA 325M Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids
NFPA 496 Standards for Purged and Pressurized Enclosures for Electrical Equipment
NFPA 497A Recommended Practice for Classification of Class I Hazardous Locations for Electrical Installations in Chemical Process Areas
NFPA 70 National Electric Code
Uniform Building Code
Uniform Plumbing Code
Uniform Mechanical Code
California Code of Regulations, Title 8, Industrial Relations
Boiler and Pressure Vessel Codes (ASME)
Code for Pressure Piping (ANSI)
29 CFR 1910 Occupational, Health, and Safety Administration 40 CFR 116 Designation of Hazardous Substances
40 CFR 117 Determination of Reportable Quantities for Hazardous Substances
40 CFR 260 Hazardous Waste Management
40 CFR 261 Identification and Listing of Hazardous Waste

Local authorities will address which codes are applicable and the procedures for the review process, submitting plans, and applying for permits. Additional local requirements may also apply.

3.5 ENVIRONMENTAL REQUIREMENTS

Several tiers of regulations may be applicable to the Hydrocarb project, at the federal, state, and local level. These include the National Environmental Policy Act (NEPA), the California Environmental Quality Act (CEQA), South Coast Air Quality Management District (SCAQMD) regulations, as well as the federal Clean Water Act (CWA) and other regulations.

National Environmental Policy Act (NEPA)

The purpose of NEPA is to assure that all federal projects take environmental impacts into consideration. NEPA may be applicable to this project since it is federally funded by EPA. Complying with NEPA involves preparation of either an Environmental Impact Statement (EIS) or a Finding of No Significant Impact (FONSI). These documents describe the site location and the impact of the project upon the surrounding environment, including animal habitats, groundwater, air quality, wetlands, etc.

California Environmental Quality Act (CEQA)

CEQA is the state version of NEPA, and it requires completion of an Environmental Impact Record. If required, a combined EIS/environmental impact report may be submitted to satisfy the requirements of both NEPA and CEQA.

-Reports that present the environmental impact of a facility such as the Hynol facility are often required under NEPA or CEQA. Due to the small size of the facility, it is expected that no environmental reports will be required and a negative declaration document will be prepared. This requirement needs to be verified.

SCAQMD Regulations

There are numerous potentially applicable SCAQMD regulations pertaining to the construction and operation of the demonstration plant. They are summarized in Table 7. Because of the research status of this project, the facility may be exempt from a number of rules under Regulation IV. The main combustion process for the Hynol system is the combustor for the SPR system. The combustor uses 21 Nm^3/h (34 scfm) of natural gas or 2 kJ/h (2.1 MMBtu/hr) which is at the limit of the SCAQMD exemption. Modifications to the SPR may bring it below the SCAQMD 1.9 kJ/h (2 MMBtu/hr) exemption limit. When the HPR is operated separately, the process gas will be burned in a flare at a rate of 7.6 kJ/h (8 MMbtu/hr) The decoupled HPR system will operate for several 1- to 2-week intervals. Afterwards, the HPR and SPR system will also be operated with the process gas flared. After this initial period of operation, the process gas will be fed into the methanol synthesis reactor.

SCAQMD will require a permit for the methanol storage tank. The tank will be equipped with vapor recover for fuel transfer operations between the tank and a vehicle. Emissions from working losses from tank filling with a tank truck will also be controlled with a

TABLE 7. POTENTIALLY APPLICABLE SCAQMD REGULATIONS

Rule	Title	Applicability
	REGULATION II PERMITS	
219	Equipment not requiring a written permit pursuant to Regulation 2	(b)(2) possible exemption for combustion equipment <1.9 kJ/h (<2 million Btu/hr) run on natural gas or methanol
	REGULATION IV PROHIBITIONS	
431.1	Sulfur content of gaseous fuels	Possible exemptions: (d)(2) <0.46 kJ/Nm^3 (<300 Btu/scf) (6) intermittent vents (7) <2.3 kg/day (5 lb/day) S
461	Gasoline transfer and dispensing	Vapor recovery for vehicle fueling
462	Organic Liquid Loading	Class B Facility, subject to: (b)(1)(B) vapor recovery system (b)(5) record keeping
463	Storage of Organic Liquids	Permit required for methanol storage tank Possible exemption: (c) <66L (<251 gallons
464	Waste water Separators	N/A
466	Pumps and Compressors	Maintenance
466.1	Valves and flanges	Maintenance
407	Liquid and gaseous air contaminants	Subject to: (a)(1) CO > 2,000 ppm vol. Exemption for: (a)(2) S < 500 ppm vol.
409	Combustion contaminants	Must be < 0.23 g/m^3
441	Research Operations	Possible exemption for all of Regulation IV as an experimental research operation
	REGULATION XI SOURCE SPECIFIC STANDARDS	
1166	VOC Emissions from Soil Contamination	N/A
1173	Fugitive Emissions of VOCs	Operator inspection, maintenance, and record keeping requirements for leaks from pumps, compressors, and pressure relief valves
	REGULATION XIII NEW SOURCE REVIEW	
1303	Requirements	BACT for new/modified permit modeling and emissions offsets
1304	Exemptions	
1309.1	Community Bank and Priority Reserve	(b)(2) Priority Reserve for Research Operations

vapor balance system. Working losses due to filling the tank with methanol from the facility may also need to be controlled. The vapors could be fed into the flare or into the SPR combustor.

Clean Water Act (CWA)

The Federal Clean Water Act may be applicable to the Hynol site. A permit may be required for storm water runoff or any waste water generated from the steam tanks.

Bourns Inc., the owners of the CE-CERT site, have an existing agreement with the city relating to the use of the storm drain. They do not store any hazardous materials in outdoor, uncovered areas. Therefore, there is no risk of contaminating storm run off water and the facility is not required to have a storm drain permit or to monitor storm run-off water. The Hynol facility will also comply with the requirements pertaining to storm drain at the Bourns site. All liquid and solids hazardous materials handling operations will take place under covered areas and within berms to prevent any possibility of hazardous materials being carried into the storm drain. No water will be diverted to the sewer.

3.6 NATIONAL FIRE PREVENTION ASSOCIATION (NFPA) CODES

NFPA defines hazardous area classifications for the handling of flammable liquids and gases as well as a variety of industrial materials. The area classifications determine the type of electrical equipment specified under NFPA codes and recommended practices. The hazardous area classes below are associated with the corresponding risks.

NFPA Division	Hazard
1	Flammable hazard present during normal operation and maintenance
2	Flammable hazard present not normally present
Unclassified	No flammable hazard

The equipment used in these areas will also be approved for service with the following materials.

Class I — Flammable gases, Groups B, C, and D (eg. hydrogen, CO, and methane)
Class I — Flammable liquids (flash point below 38°C (100°F), methanol)
Class II — Combustible dust, Group G (wood flour)
Class III — Combustible fibers, (wood working plants)

Division 1 areas must be surrounded by Division 2 areas. Division 1 and 2 areas must contain appropriate electrical equipment. Requirements for meeting Division 1 and 2 area classifications can be met with explosion proof equipment. Intrinsically safe wiring is an acceptable alternate for some applications. (Intrinsically safe components use such low energy levels as to preclude an ignition). Equipment installed beyond Division 2 areas does not need to meet hazardous area or explosion proof requirements.

NFPA code provide recommended practice for the electrical classification of chemical process areas. Classification diagrams in NFPA 497A cover the situation for the reactor units in the Hynol facility. Process equipment is categorized by size, pressure, and flowrate. The Hynol system fall into the following categories:

Small <1,320 L (5,000 gal)
Moderate and high pressure, 7 to 34 bar (100 to 500 psi), >34 bar (500 psi)
Low flowrate >100 gpm

Table 8 shows the extent of hazardous classification for various hazards. The electrical equipment in the Hynol facility will meet the requirements for electrical installations.

TABLE 8. HAZARDOUS LOCATIONS FOR ELECTRICAL INSTALLATIONS

Description	Reference, magnitude and material	Extent of classification[a]
Outdoor leak sources	NFPA 497A, Flammable gases, liquids, high pressure, moderate size and flow	15 ft radius down to ground level Division 2
Hydrogen storage	NFPA 497A, Hydrogen	15 ft radius Division 2
Multiple leakage sources	NFPA 497A, Flammable liquids, high pressure	3 ft around valves Division 2 10 ft from pump alley Division 2 3 ft radius from pumps Division 2 3 ft from vents Division 1 5 ft from vents Division 2 5 ft from potential leaks Division 2
Below grade areas near leak sources	NFPA 497A, Flammable gases and liquids	Division 1 with surrounding Division 2 area
Tank vents	NFPA 497A, Flammable liquid vapor	3 ft radius Division 2
Dispensing equipment	NFPA 30A, Flammable liquid service stations	18 in. from edge of dispenser, 20 ft horizontally from dispenser, 18 in. above ground Division 2
Aboveground tanks	NFPA 30, Flammable liquid	10 ft from tank Division 2
Vents	NFPA 30, Flammable liquid vapor	3 ft from vent Division 1 5 ft from vent Division 2
Tank truck unloading	NFPA 30, Flammable liquid	15 ft from tank truck
Equipment enclosures	NFPA 30A, Flammable liquid, NFPA 52 CNG	Within enclosure Division 1
Dispensing equipment	NFPA 52, CNG Dispensing	10 ft radius from dispenser, 20 ft horizontally from dispenser, 10 ft above ground Division 2

[a] Distances are specified in ft. 1 m = 3.28 ft.

3.7 FIRE AND SAFETY REQUIREMENTS

The following list summarizes some important safety and fire prevention provisions for the site. These provisions will be reviewed with local fire officials and implemented. Requirements for facility installations and safety documentation will also be reviewed with fire officials.

- First aid equipment onsite.
- UL-approved fire extinguishers onsite, subject to the following requirements:
  - Inspect and test each extinguisher once a month during project installation.
  - Affix a tag certifying the charge and workability of the extinguisher.
- Temporary fire protection for the site in accordance with ANSI-A10 "Safety Requirements for Construction and Demolition."
- Materials that meet the following specifications:
  - Building materials must be noncombustible and have a UL flame-spreading rating of 25 or less and a smoke rating of 50 or less.
  - Wood products must be UL-listed, pressure impregnated, and fire-retardant with a UL flame spread of 25 or less.
  - No PCB or asbestos or PCB- or asbestos-bearing equipment or materials will be used.
- Three copies of the Material Safety Data Sheet (MSDS), as specified in the OSHA Hazard Communication Standard.

Periodic safety reviews will be held to evaluate safety procedures and reenforce safety training with facility operators. Operational and safety procedures will be documented in a Process Safety Management Plan that is required by OSHA.

3.8 CALIFORNIA OSHA REQUIREMENTS

OSHA requirements cover pressure vessels, worker safety, and process safety.

California Division of Occupational Safety and Health, Pressure Vessel Requirements

California uses basically the American Society of Mechanical Engineers (ASME) codes. Pressure vessels must either be constructed and stamped in accordance with the rules of the applicable ASME Code, or be proved to provide equivalent safety.

All new pressure vessels that are built for the Hynol facility will be ASME-coded. It is expected that an existing methanol synthesis system that was built and successfully operated in Germany will be used for this project. This equipment was built to DIN rather than ASME codes. This system will be documented according to OSHA requirements for non-coded vessels (Appendix A).

Process Safety

Title 8 contains provisions for process safety for chemical plants and facilities that handle hazardous materials. Section 5189, Process Safety Management of Acutely Hazardous

Materials requires the following activities that will be implemented and documented in a Process Safety Management Plan.

- Process safety information
- Operating procedures
- Training
- Contractors (onsite workers)
- Pre-start up safety review
- Mechanical integrity
- Hot work permit
- Management of change in the process
- Incident investigation
- Emergency planning and response
- Injury and illness prevention program
- Scheduled and periodic inspections
- Employee participation
- Employer consultation

Federal OSHA compliance guidelines and recommendations for process safety are described in 29 CFR 1910.119. This document provides a helpful guideline for meeting process safety requirements.

3.9 HAZARDOUS MATERIALS REQUIREMENTS

The storage of hazardous materials is governed by 40 CFR 261. Materials are designated as hazardous either by their specific listing or by their properties. The hazardous status of all materials that will be stored at the facility will be determined. Materials that are residues from processes or unused materials that are residues are considered waste. Hazardous materials that are also wastes fall under special storage, handling, and transportation requirements for hazardous waste. Waste materials that may be produced and may also be designated as hazardous include the following:

- Water scrubber sludge
- Spent catalyst
- Ash and bed material with ash
- Non-recycled distillation bottoms

SECTION 4

SITE DESCRIPTION

The facility will be constructed at the University of California, Riverside, College of Engineering, Center for Environmental Research and Technology (CE-CERT).

The Hynol facility will be built in Riverside, California, on a newly developed site adjacent to CE-CERT laboratories. The site is in an industrial property with a nearby railroad siding for shipping and receiving heavy equipment. There is an existing access road to the property that can be used to bring in industrial gases, supplies, and equipment and to give access for construction and site development. Utilities are available for the CE-CERT laboratories, with ample natural gas, electric, and water reserves accessible. The site also has a 1,590-liter (6,000 gal) liquid nitrogen storage tank and a 2,100-liter (8,000 gal) liquid CO_2 storage tank which could be used to provide gases for the project.

The site plan calls for a site of approximately 4,000 m^2 (1 acre), with appropriate grading, fencing, and landscaping. Precautions will be taken to deal with safety and environmental hazards as required. The methanol storage area, for example, would be lined and bermed to insure containment of accidental spillage. The site will contain process areas and facilities. Most of the major equipment is identified in the process flow diagram in Drawing 8570G001 in Appendix A. This diagram covers the integrated Hynol system. Different configurations will apply when the HPR is initially operated without the other process units. The ratio includes:

- Biomass storage and processing
- Biomass feed (T-805)
- Hydrogasification reactor (R-101)
- Steam pyrolysis reactor (R-201)
- Gas cleanup (F-104, F-205)
- Gas compressors (C-304, C-308)
- Natural gas compressor (C-627)
- Methanol synthesis reactor (R-301)
- Flare area
- Methanol storage tank
- Catalyst, and ash storage
- Control room
- Steam and CO_2 generators
- Air compressors and blowers (C-706, C-201)
- Vehicle parking
- Gas trailer parking

4.1 FACILITIES DESCRIPTION

Site Data

CE-CERT is located at 1200 Columbia Avenue in Riverside, California. CE-CERT occupies buildings in the east end of a multibuilding-research facility owned by Bourns Inc. The Hynol site will be located in the currently vacant area to the east of the CE-CERT building. The layout of the Bourns and a topographical map in the vicinity of the site are shown in Appendix A. The Hynol facility will be located on a portion of Parcel B.

The following considerations apply to the CE-CERT location. The reactor area and control room can be located in the undeveloped area between a service road and railroad track right of way. The control room needs to be located in close proximity to the reactor area since much of the process gas control will be accomplished with manual valves. Low pressure air compressors are already in place adjacent to the east face of the building. A natural gas compressor area could be installed here. This area could serve as a natural gas vehicle fueling station and also provide natural gas to the hydrocarb facility. Air compressors could also be located here. Tube trailers will provide nitrogen and hydrogen for Phase 2 of the project when the HPR is operated independently. The tube trailers can be parked in the existing parking lot and connected to gas supply manifolds. Bottled nitrogen and CO can be stored in an area adjacent to the service road or the parking lot. The CE-CERT building can be used for operator offices and small parts storage.

The site is equipped with water, 440 and 460 V power, and 14 bar (200 psi) natural gas.

Site Plan

Figure 3 shows the site plan for the Hynol facility. The facility is arranged around the gasification system, SPR, gas cleanup facility, and methanol synthesis system. The layout of equipment is designed to meet hazardous area classification requirements defined by the National Fire Protection Association (NFPA). The northern end of the facility is beyond the area requiring classification for hazardous installations. The control room is located close to the exit of the CE-CERT building. Steam generators are located near the north end of the facility near access to water. CO_2 evaporators and air compressors will also be located in the northern end of the facility. The natural gas compressor system is located adjacent to the street to allow for vehicle fueling. The methanol storage tank is located in close proximity to the methanol synthesis unit.

The facility is laid out to allow for the eventual delivery and installation of all of the process systems. The southern and eastern sides of the facility will be paved to allow vehicle access.

Biomass Feed

Wood will be stored, processed, and fed into the HPR system. Wood will be piled in designated storage areas. The wood will be chipped, dried, and stored in a bin. The chipped wood will be carried by a conveyor to the lock hopper feed system. The feed system will transfer the chipped wood into the 30 bar (440 psi) HPR vessel.

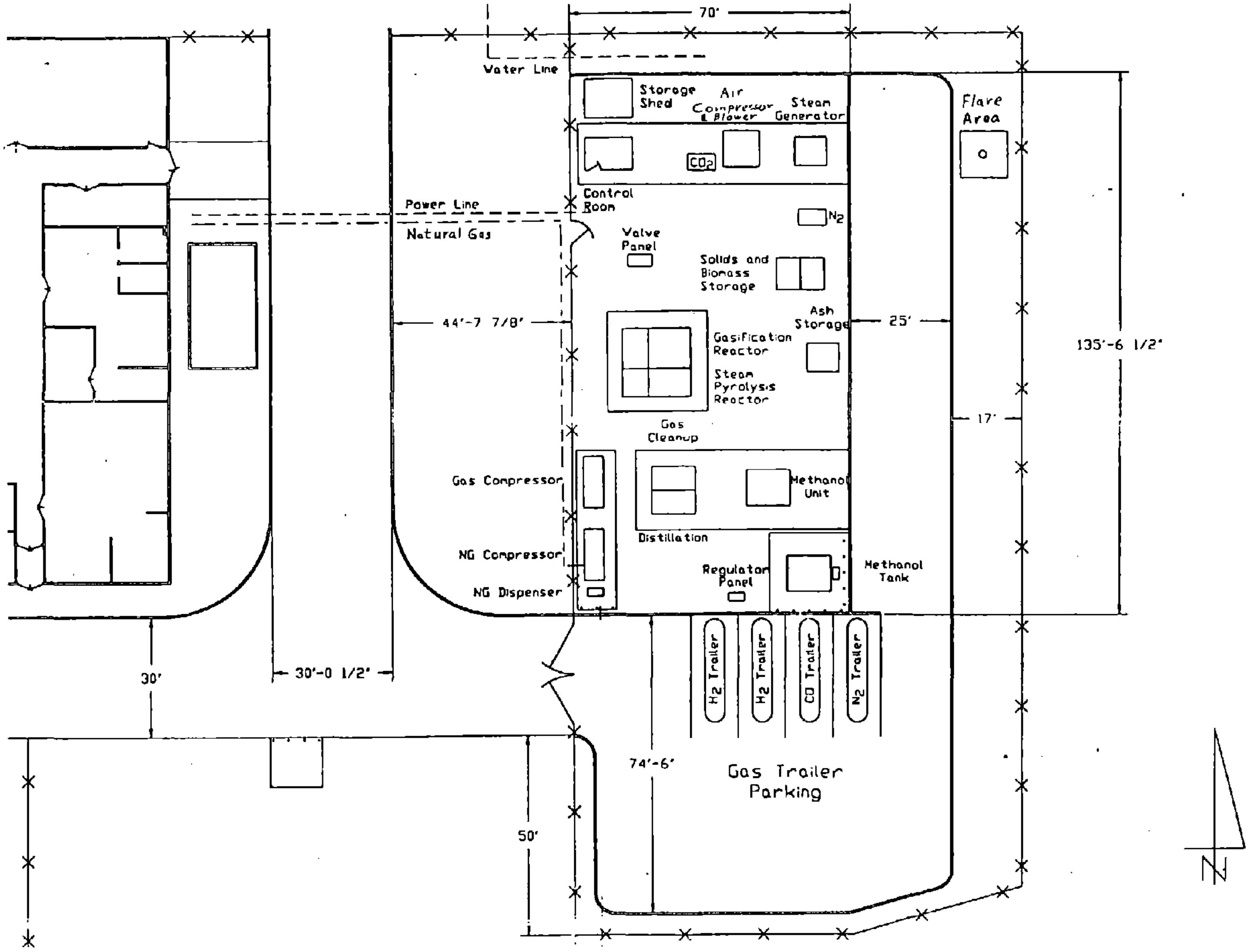


Figure 3. Hynol site plan.

The biomass feed system will be installed in a structure that holds the hydrogasifier (HPR) and steam reformer (SPR). All of the units are mounted in the same structure because of the requirement to minimize distance between reactors for low heat loss. The biomass feed system consists of a feed hopper and a transport system to lift the biomass to the top of a lock hopper. Biomass is transferred from the lock hopper into a metering bin and then into the HPR.

Hydrogasification

Biomass is fed into the HPR system and fluidized with process gas. The HPR products go to a filter, sulfur removal system, and then to the SPR system. Lock hoppers remove ash from the HPR. The HPR is a 607 mm (24 in.) internally insulated vessel. The vessel is surrounded by a 205°C (400°F) steam jacket.

Steam Pyrolysis

The SPR is an internally insulated vessel with a 205°C (400°F) steam jacket. The SPR is a shell and tube reactor with natural gas combusted on the shell side of the reactor and process gas reacting inside the tubes.

Methanol Synthesis

Process gas from the SPR is cooled and recompressed before it passes to the methanol synthesis system. The process gas passes through a inter-heat exchanger and reacts in the methanol reactor. The reactor is a shell and tube configuration with water boiling on the shell side to remove heat from the reaction inside the tubes. CO and H_2 react to form methanol inside the reactor tubes. The MSR system includes a steam tank and evaporator to control the temperature of the cooling water. The reactor and heat exchanger operate at 260°C (500°F) and are externally insulated. Reacted process gas is cooled in a condenser and liquid methanol is collected in a separation vessel.

Distillation System

A distillation column will be used to separate methanol from the methanol/water mixture that is produced in the reactor. Steam provides the energy for the distillation column. Separating the water from the methanol will allow the methanol to be used as a vehicle fuel. If water were not removed from the methanol, the product would present a disposal problem since it could not be used in methanol-fueled vehicles. Methanol with water might be used as a boiler fuel, but such an end uses has not been identified.

Natural Gas Compressor

A natural gas compressor system provides combustion gas for the HPR during start up and feedstock gas for the process, and also serves to fuel natural gas vehicles. Gas is stored in a set of cylinders at 248 bar (3,600 psi). In order to minimize the complexity of the natural gas compression system, gas for the Hynol system is drawn off of the 248 bar (3,600 psi) system. Natural gas for the SPR combustor will come directly from the gas line. The gas line pressure is 14 bar (200 psi) which is sufficiently high to feed the combustor.

Process Gas Compressors

Process gas is compressed by two compressors. One compresses gas before it enters the MSR system. The second compressor recirculates gas within the methanol synthesis loop.

Process Gas Flare

Process gas needs to be flared under some circumstances. During start up and shut down procedures, gas that is purged from the system must be burned. All of the process gas must be burned during the initial phases of operation when the HPR and SPR operate without the MSR. The flare area is located in a remote area of the site.

Methanol Storage

Methanol will be stored in an above ground storage tank. The methanol will be dispensed to provide fuel for methanol vehicles. The storage tank area will have access for fuel truck deliveries. Areas where fuel is handled will be surrounded by a berm to control spills. A covered fuel delivery area is being considered to eliminate any risk of methanol spills being carried away with rain water run off.

Catalyst and Ash Storage

Catalysts will be stored in drums and kept inside a shed. Ash and spent bed material will be transferred to drums and stored in a shed.

Control Room

The control room will house the system controls. The control computers, control panel, and alarms will be located in the control room. The control room will provide desks for three operators. The control room will be located close to the control valve panel.

Steam and CO_2 Generators

An electrically powered steam generator will be located on the north end of the facility. Liquid CO_2 will be converted to process gas for the initial operating phase where the HPR operates independently. Since heat is absorbed by the CO_2 when it converts from a liquid to a gas, heat must be added to the CO_2 to prevent icing of the gas regulators. CO_2 bottles will be stored in a water bath which will add heat to the liquid CO_2. The steam and CO_2 generators use non-explosion proof heaters and controls which are located beyond the hazardous classification areas.

Air Compressor and Blower

An air compressor provides combustion air to for the HPR warm-up burner. The burner operates before process gas is added to the HPR. A blower provides air for the SPR combustor. The air compressor and blower use conventional non-explosion proof motors and are located beyond the hazardous classification areas.

4.2 HAZARDOUS AREA CLASSIFICATIONS

Figure 4 shows the regions for hazardous area classifications for the Hynol facility. The hazardous area classifications were based on the NFPA codes and practices in Section 3.6. Reactors, flammable gas storage areas, gas compressors, the methanol tank, and fuel dispensers are within classified areas. The steam generator, control room, air compressor, and other electrical equipment are beyond the classified areas.

4.3 FIRE PROTECTION

Fire protection for the Hynol facility will meet the requirements of local fire officials. Flammable gas detectors will provide an additional means of determining whether there are leaks in the reactor system. The fire protection system will include the following:

- Flammable gas detectors in the reactor areas
- Fire alarms actuated by the following inputs:
  - Manual fire alarm in control room
  - Manual fire alarm in reactor area
  - Sensors (if any) activating fire alarm (location in vicinity or reactors)
- Fire alarms wired separately from the control system computer
- Visual and audible alarms activated near the control room

Given the small volume of gas contained in the reactors, a fire extinguisher system may not be warranted. Fire detectors might also be considered for the facility but are not planned at this time.

4.4 UTILITIES

The Hynol facility will require various utilities that are available from the site. Electricity will power the compressor, the control room, heaters, pumps, and the solids feed system. Wiring for controls and telephone access will also be required. Natural gas is used at low pressure as fuel for the SPR and at high pressure as a process gas and fuel for system start-up. Water will be used to generate steam as well as for gas cooling. Table 9 summarizes overall utility requirements for the facility.

Electric power is required for the compressors, electric heaters, outdoor lighting, and control room. Ample electric power is available on the south and east end of the CE-CERT building. Electric power requirements are shown in Table 10.

High pressure natural gas will be provided by a CNG fueling system. The fueling system will store gas at 248 bar (3,600 psi) for vehicle fueling. The gas will be regulated to the required pressures for the process systems. A 51-mm (2-inch) line will provide natural gas to the CNG fueling system at 14 bar (200 psi). A larger natural gas line is currently being routed into the CE-CERT building from an area behind this building.

The gas line for the Hynol facility will be routed in the ceiling of the CE-CERT building to its east side. The gas line will pass outside the building and be routed underground through

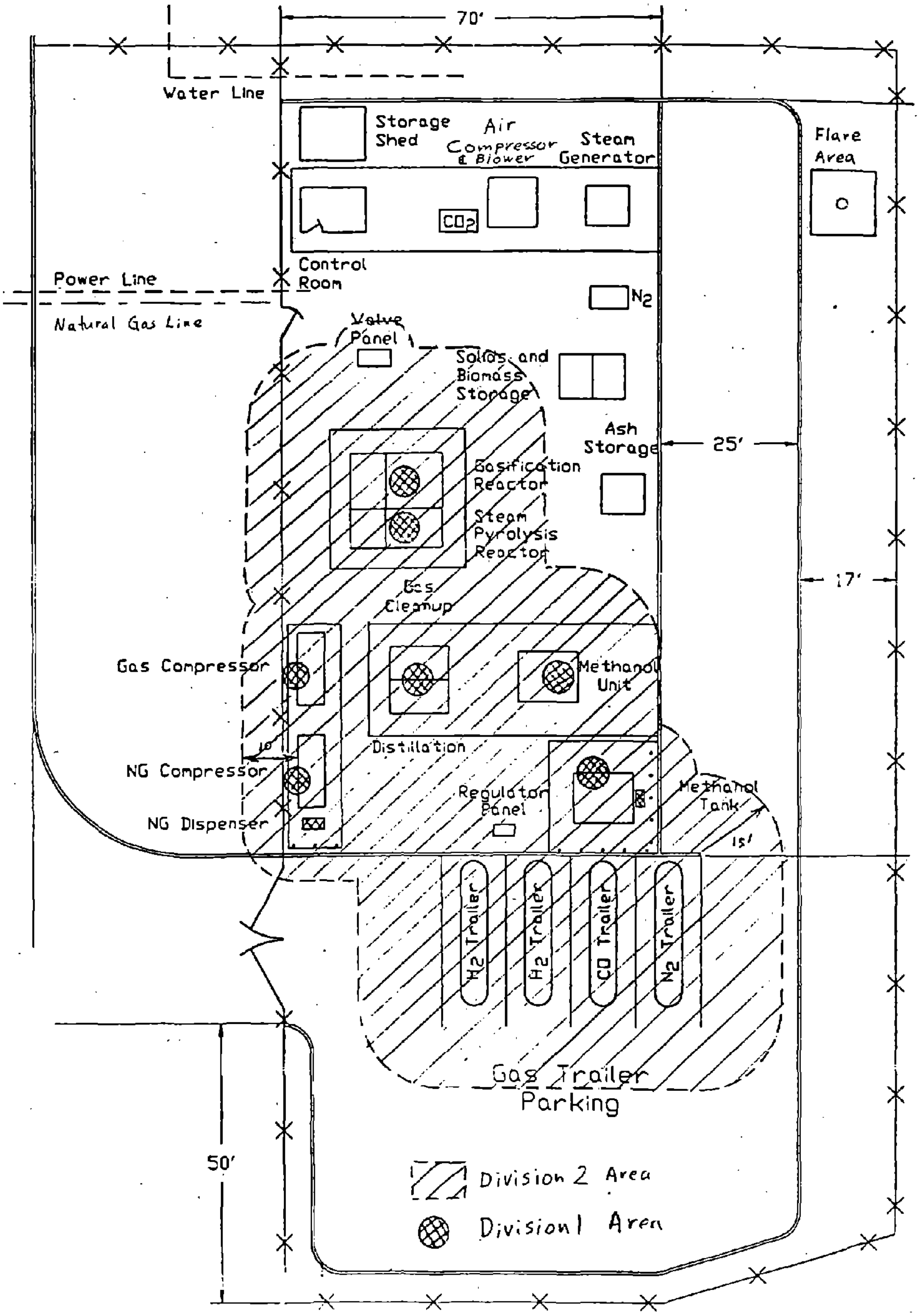


Figure 4. Hazardous area classifications for Hynol facility electrical installation.

TABLE 9. SUMMARY OF UTILITY REQUIREMENTS

Utility	Capacity
Electric power	50 A 440V[a] 50 A 460 V
Natural gas	48 Nm^3/h (30 scfm)
Water	15 L/m (4 gpm)
Communications	1 telephone, 1 modem, alarm signal

[a] Actual power requirements to be determined.

TABLE 10. ELECTRICITY REQUIREMENTS

System Component	Requirement (kW)
HPR system:	
Compressor — air, C-706	0.1
Compressor — natural gas, C-627	12
Control room	2
Heater, H-036	30
Heater — water	15
Pump — water, P-511	5
Subtotal for HPR system:	**64**
Additional requirements for integrated system:	
Compressor-air, C-207	52
Compressor, C-304	1
Compressor, C-308	2
Heater, H-203	30
Heater, HPR recycle, H-036	5
Pump, P-311 (1 hp)	0.5
Pump, P-315 (0.2 hp)	0.1
Screw-feeder, S-806 (2.5 hp)	2.0
SYSTEM TOTAL	**156**

the same trench that carries power, and control lines. Natural gas and water requirements are shown in Table 11.

Water will be obtained from an existing connection located adjacent to the guard shack. (It looks like a small fire hydrant). The water line will be routed above ground over a landscaped area. It will not pass over any pavement.

Power, natural gas, and telephone lines will be routed in a trench from the east end of the CE-CERT building. Power and communications lines will be routed in separate conduits. A spare or oversized conduit will be provided to accommodate additional electrical power requirements.

TABLE 11. NATURAL GAS AND WATER REQUIREMENTS FOR HYNOL PLANT

Utilities	System component	Requirement
Natural Gas	**HPR system:**	
	Recycle mixture [6]	7.2 to 13 Nm^3/h (4.5 to 8.1 scfm)
	SPR feedstock [67]	18.3 Nm^3/h (11.4 scfm)
	HPR system subtotal:	**25.6 to 31.3 Nm^3/h** **(15.9 to 19.5 scfm)**
	Additional requirements for integrated system:	
	SPR fuel gas [12]	16.9 Nm^3/h (10.5 scfm)
	TOTAL Natural gas:	**42.4 to 48.2 Nm^3/h** **(26.4 to 30 scfm)**
Water	**HPR system:**	
	Recycle mixture and steam feed [2]	0.4 to 5.3 L/h (0.1 to 1.4 gal/hr)
	HPR system total:	**0.4 to 5.3 L/h** **(0.1 to 1.4 gal/hr)**
	Additional requirements for integrated system:	
	SPR feed [80]	45.4 L/h (12 gal/hr)
	Make up water	18.9 L/h (5 gal/hr)
	TOTAL water:	**69.6 L/h** **(18.4 g/hr)**

4.5 SITE DEVELOPMENT

Site development will include grading the site, preparing concrete footings for process units, paving portions of the area with asphalt, covering the site with gravel or paving stones, and installing a fence. Utilities will also be routed to the site as part of the site development activities. Specifications will be prepared for asphalt work, utility routing, curbs, and fencing and the installation will be based on the plot plan.

Equipment Footings

Civil engineering drawings will provide the documentation for each concrete footing. A grading plan will be prepared to indicate the extent and slope of grading. A general soils report will be obtained and reviewed in preparing the grading plan. Table 12 shows the estimated height and weight of the major process units.

Grading

The site will require grading for preparation of the facility. A site grading plan was available from Bourns and shows the elevations for the site. It appears that there is sufficient land available to obtain fill and relocate removed material on the site.

Seismic Considerations

The entire southern California area is subject to seismic activity. The structures and foundations will be designed to meet local seismic requirements.

The Southern California area is subject to seismic activity which will require considerations for seismic factors in the design of structures and foundations. The design of concrete footings for reactor systems depends on the height and weight of the reactor systems. Appropriate footings and structures will be designed and reviewed by qualified structural engineers.

4.6 PAVEMENT AND DRAINAGE

The Hynol facility will be adjacent to an access driveway that leads to the Bourns facility. Truck parking and access areas will be paved with asphalt. Reactors and process areas will be laid on concrete pads. It is expected that unoccupied areas between process areas will be covered with gravel fill. Storm water runoff will be protected from accidental methanol spills. Requirements for pavement and grading include the following:

A. Methanol storage tank and process areas that handle liquid methanol will be covered. Rain water will flow into drains that will be directed to gutters in the pavement. The area surrounding the methanol storage tank and tank truck unloading area will be surrounded with a berm that can hold 110 percent of the contents of the methanol tank. The truck unloading area will also be covered and rain water will be directed to gutters in the pavement. This system will contain a methanol spill and it will also prevent rain during a methanol spill from carrying

TABLE 12. PROCESS SYSTEM SIZE AND WEIGHT ESTIMATE

System	Footprint/height/weight	Unit — weight (Mg)		Structure weight (Mg)	
Gasification and reforming	5.5 m x 5.5 m	T-805	2.0	Members	26.9
	(18 ft x 18 ft) footprint	R-101	8.0	Grating	3.1
	12 m (40 ft) height	F-104	4.0	Stairs	5
	61 Mg	R-201	8.0		
		F-205	1.0	Total	35
		HX-205	1.0		
		LH-834	0.5 x 4		
		Total	26		
Methanol synthesis	3.5 m x 3.8 m	R-301	3.0	Estimate 2/3 of	
	(11.5 ft x 12.5 ft) footprint	HX-309/313	1.5	Gasification	
	11.6 m (38 ft) height	T-314	0.5	structure	
	30 Mg	E-312	0.5		
		T-310	0.5	Total	23
		Total	7		
Distillation	10 ft x 8 ft footprint	Estimate	5	Estimate	15
	30 ft height				
	20 tons				
Methanol tank	11 ft x 8 ft footprint	Fuel	6.6	Tank	4.6
	5.5 ft height				
	11.2 Mg				
Natural gas compressor	1.5 m x 4 m	Bottles	3.0	Skid	4.0
	(5 ft x 13 ft) footprint	Compressors	2.0		
	1.2 m (4 ft) height				
	9 Mg				

[a] 1 Mg = 1,000 kg = 1.1 short tons

the methanol to the storm drain. Covering the bermed areas will eliminate the need to remove rain water from inside these areas.

It is expected that the cover over the methanol storage tank and fuel unloading area will be a pitched sheet metal roof over a steel structure. The structure will be designed to allow for a tank truck to maneuver underneath it. Footings for the structure will be off of the paved area where the tank truck travels.

The methanol condenser and other process areas that handle liquid methanol will be covered with sheet metal that is integrated into the support structure. Berms will be installed to collect possible methanol spills. Rain water from these smaller areas will either drip off of the edge of the pitched cover or flow into a drain that is directed to a gutter in the pavement. Figure 13 shows the areas that will be covered and protected with berms. The methanol processing areas will be isolated from the fuel storage areas in that the bermed areas will not inter connect. Liquid methanol pipe runs between process areas will either be over a bermed area or over a covered trench.

An alternative to covering the liquid methanol processing areas would require provisions for the removal of rain water that is collected in bermed areas. One approach is to open a valve that releases rain water when one is certain that no methanol spills have occurred. While effective, these types of systems may not meet the requirements of local officials.

Currently, the Bourns facility does not require a storm water permit or storm water run off monitoring because hazardous materials are not stored outside. A covered and bermed methanol storage area should maintain this status but needs to be reviewed with local officials.

B. Parking area and access road will be paved with asphalt.

C. Run off water from the Hynol facility pavement will be routed to the storm drain that is at a lower grade than the Hynol site. The existing storm drain is expected to handle the run off from the new pavement areas.

D. Rain water from the process areas will drain into gravel on the site and enter the soil below.

E. The site will be graded and compacted to accommodate concrete pads for the facility structures and pavement.

F. Pavement in the parking area will be based upon 9,070 kg (20,000 lb) axle loadings with a 6.3 km/hr (10 mph) maximum vehicle speed. No concrete wheel stops will be installed. The facility will be protected with steel pillars.

G. New pavement grades will be established with an attempt to maintain a minimum grade of 0.4 percent and a minimum grade of 0.4 percent in gutter flow lines.

Figure 5 identifies the covered and bermed areas for the Hynol facility. All areas that handle solid or liquid hazardous materials will be covered. The processed biomass storage area will be covered to keep out rain.

4.7 SECURITY

Site security will consist of the existing fence that surrounds the Bourns facility and a new fence the further encloses the Hynol facility. The fence will be a minimum of six feet high. The fence enclosing the Hynol site will be locked when the facility is not in use. The site will be illuminated for evening operation when in use. The site will be equipped with a fire and safety alarm system.

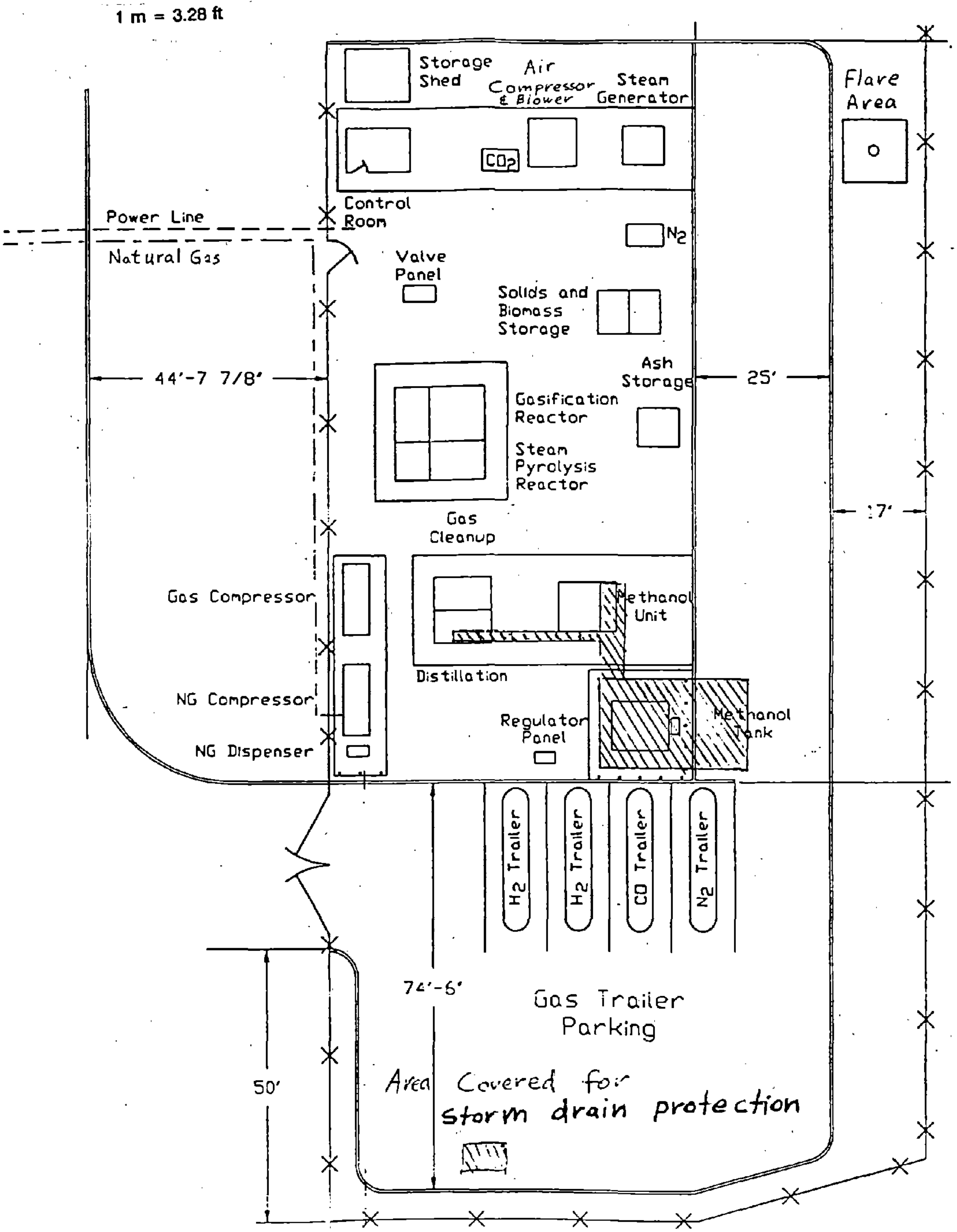


Figure 5. Covered process units and spill prevention berm.

4.8 LANDSCAPING AND SITE VISIBILITY

The strip of land adjacent to the access road across from the north end of the CE-CERT building will be landscaped. Landscaping will be designed for aesthetic purposes, ease of maintenance, and drought resistance (xeriscape). Landscaping will provide slope control and will consist of ground cover, shrubs, and small trees. Native species will be used if possible. No sprinkler system will be installed. Landscaping will be watered from a hose connection within the Hynol site. Watering will only be required to establish plants.

4.9 SIGNS AND GRAPHICS

A high quality, clearly delineated, and coordinated graphics package will identify the site, areas within the site and components. These graphics will present a positive image for the project. Proper identification will facilitate safety, identifying areas clearly, and conducting tour groups interested in the facility. Graphics will be added to enhance the aesthetics of the facility and assist operators in performing their tasks more efficiently and safely. The following are preliminary lists of identification and messages that will be communicated by words or graphics.

Identification

Biomass to Methanol Production Facility
Using the Hynol Process

University of California College of Engineering Center for
Environmental Research and Technology
in association with
Acurex Environmental Corporation
Hynol Corporation
Bourns Inc.

Sponsored by:
U.S. Environmental Protection Agency
South Coast Air Quality Management District
California Energy Commission

Control Room
Biomass Processing
Biomass Feed System
Hydropyrolysis Reactor (HPR)
Steam Pyrolysis Reactor (SPR)
Methanol Synthesis Reactor (MSR)
Gas Clean Up
Steam Generator
Air Compressor
Process Gas Compressor
Natural Gas Compressor
Methanol Fuel Storage Tank

Gas Flow Control Panel
Power Panel

Materials, Piping, and Conduits

Cold water
High Pressure Steam
Low Pressure Steam
Compressed Natural Gas
Compressed Air
Compressed Process Gas
Methanol
Ash
Waste Water
Intrinsically Safe Wiring
Control Wiring
Power Wiring

Messages and Information

No Smoking or Open Flames Within 25 ft (7.6 m)
Hynol System Process Flow Diagram
Hynol System P&ID
Emergency Exit
No Parking
Gas Trailer Parking

SECTION 5

HPR SYSTEM DESCRIPTION

The HPR system demonstrates the hydropyrolysis of biomass as part of the Hydrocarb process. Hot hydrogen and other process gases are fed into the HPR, where they react with biomass in a fluidized bed. H_2, CO, and N_2 are metered to simulate recycle gas. The gas mixture is heated in a ceramic heat exchanger and then further heated with electric heaters. Steam is added to the gas mixture, and the entire mixture is heated to 1,000°C. Natural gas is fed into the system downstream of the heaters.

The uncoupled HPR system is intended to simulate the HPR in an integrated Hydrocarb plant. The HPR system is different from the integrated system in several respects, including the following:

- HPR feed is provided from bottled hydrogen, CO, and N_2 rather than recycled gas
- CO_2 is stored as a liquid at 41 bar (600 psi). Feeding CO_2 into the gas stream requires adding heat to the bottle to make up for the CO_2 heat of vaporization.
- Methanol is omitted from the HPR feedstream since it would dissociate at the high temperatures in the SPR inter- heat exchanger. The mass of the methanol is represented as CO and H_2.
- Methane from the recycle stream is added to the HPR as part of the "natural gas" feed in order to eliminate potential sooting of the H-036 electric heaters
- Water will be injected into the feedstream as steam, reducing the burden and therefore the cost of the electric heater
- HPR feed gases have been adjusted so that their net enthalpy matches that of the integrated system HPR feed
- The heat exchanger following the HPR (HX-038) is similar to that following the MPR in the integrated system (HX-205). However, heat exchanger HX-038 will be exposed to 800°C rather than 1,000°C.

5.1 PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

The P&ID for the HPR system is shown in drawing 8570G003 in Appendix A. This drawing shows all of the instrumentation and controls for the HPR system with the bottled gas feed. The line designation list follows the drawing. Each gas supply passes sequentially through regulator pressure indicators control valves, orifice flowmeter, a flow control valve, and a check valve. Bottled H_2, CO, and N_2 are fed from separate or mixed tube trailers or individual 6-packs depending on cost and feasibility. A separate nitrogen supply is used since only N_2 flows through the system during startup. Two-way or three-way valves are used to allow the supply of gas to be switched during a run if one supply is depleted. The P&ID indicates the position of valves, regulator set points, and the location of instrumentation including thermocouples, pressure transmitters, and pressure switches. Valves are shown in their states during normal facility operation. For example, emergency nitrogen valve, FV-423, on sheet 3 is shown in the closed position (darkened). The shelf state of this valve is normally opened.

There are two additional N_2 supplies: a system supply and an emergency supply. The system supply of nitrogen is used for two main purposes. It feeds into the solids lockhopper, and it also passes through a heated, pressurized tank before it pulse-cleans the filter. The emergency supply replaces the inlet gases to the HPR vessel in the event of temperature or pressure excursions.

Bottled methane or compressed natural gas is injected into the burner along with compressed air (during startup only). The burner is equipped with a pilot light and operates using a burner management system (BMS) that runs on automatic solenoid switches.

Deionized water is converted to steam in a pressurized steam vessel; this steam feeds into the inlet gas stream after it exits the heat exchanger and just before it enters the heater.

Temperature readings at various points along the bed are measured using thermocouples. Pressure measurements at several points along the reactor are made with pressure differential transmitters. The pressure port lines are purged with methane to keep them free of particles. A sampling port is used to extract gas samples at the HPR outlet.

There are several levels of protection against over-pressurization. The first is the pressure regulators on the inlet gas supplies and the subsequent flow control valves and check valves. If the gas pressures become too high, the pressure relief valve (PSV 029) before the heat exchanger provides a safety vent for excess gas (which can be flared). A burst disk at the top of the vessel is a final level of protection against unexpected pressure increases.

There are also several levels of protection against system overheating. Temperature in the reactor vessel is monitored, and if it rises above a specified point, a high-temperature switch (TSH 809) shuts off the air, natural gas, and steam, and opens the emergency nitrogen supply. Similarly, if the temperature of the inlet gases become too high, a high-temperature switch (TSH 027) shuts off the air, natural gas, and steam, and opens the emergency N_2.

5.2 CONTROLS

The following systems are required for the control of the Hynol system:

Process safety alarm and interlocks

- HPR inlet temperature
- HPR recycle gas pressure
- Emergency N_2 pressure
- HPR temperature
- HPR pressure
- Heat exchanger pressure

Process controls

- Steam supply
- Gas heater
- Lower bed removal
- Upper bed removal
- Hot gas filter
- High pressure air supply
- High pressure natural gas supply
- Burner
- Gas supply
- Solids feed

Control systems are indicated by control loops in the P&ID. Each control loop connects identifies instruments, valves, and controls that interact with that system. System controls are performed by manual valve control, computer input, and automatic computer or controller operation. Table 13 lists the control systems as well as the instruments and control activation for each instrument. In some instances, the control actions differ for start up and operational modes.

5.2.1 STARTUP PROCEDURES

The HPR system will be started with the following sequence of events:

- Flow nitrogen through HPR
- Ignite flare
- Close bypass valve to raise pressure to 30 bar (440 psi)
- Turn on air flow
- Shut off nitrogen
- Turn on gas flow and ignite pilot and burner
- Turn on nitrogen flow
- Turn on electric heater
- Turn off natural gas burner
- Set gas mixture for Hynol conditions including natural gas and steam
- Turn on biomass feed

TABLE 13. SUMMARY OF CONTROL AND INTERLOCK FUNCTIONS

System	Tag No.	Indicator Description	Control Activation	Type	Mode
Steam	LSL-500	Hardware level switch — low	Turns on pump, P-511	Wired	All
Steam	LSH-500	Hardware level switch — high	Turns off pump, P-511	Wired	All
Steam	LSHH-500	Hardware level switch — high/high	Turns on alarm, LAHH-500	Wired	All
	LAHH-500	Level alarm — high/high		Computer	
Steam	LSLL-500	Hardware level switch — low/low	Turns on alarm, LALL-500	Wired	All
	LALL-500	Level alarm — low/low		Computer	
Steam	T -513	Tank / level gage	Manually fill tank when water level low	Manual	All
Steam	TE -514	Thermocouple	Tank T-509 temperature	Wired	All
	TIC -514	Hardware temp controller	TIC-514 controls heater, set point = 240°C	Wired	
	TSH -514	Hardware temperature switch	Over temperature interlock to tank heater	Wired	
Gas heater	TE -017	Thermocouple	TIC-017 control heater H-036, exit gas set point = 1,000°C	Wired	All
	TIC -017	Software temp controller		Computer	
Gas heater	TE -025	Thermocouple	TIC-017 turns off heater, face set point = 1,200°C	Wired	All
	TSH -025	Software temp switch		Computer	
HPR inlet gas temperature interlock	TE -027	Dual thermocouple		Wired	All
	TAL -027	Temp alarm from TE#1	Low set point initiates undertemp alarm TAL-027	Computer	
	TAH -027	Temp alarm from TE#1	High set point initiates overtemp alarm TAH-027	Computer	
	TSHH-027	Hardware temp switch from TE#2	System Interlock: Trips BMS	Wired	
			Shuts off FV-013, FV-504, FV-704, FV-706, FV-609 Hydrogen, steam, air, pilot air, methane	Wired	
			Turns off Steam Heater H-509 in T-509	Wired	
			Turns off heaters H-036, H-104, H-842	Wired	
			Opens emergency nitrogen FV-423	Wired	
			Opens flare vent PSV-838	Wired	
	TAHH-027	Temp alarm from TSHH	TSHH-027 initiates over temperature alarm TAHH-027	Computer	
HPR recycle gas pressure interlock	PT -027	Pressure transmitter		Wired	All
	PAL -027	Pressure alarm from PT	Low set point initiates underpressure alarm PAL-027	Computer	
	PAH -027	Pressure alarm from PT	High set point initiates overpressure alarm PAH-027	Computer	
	PSHH-027	Hardware pressure switch	System interlock (described for TSHH-027)	Wired	
	PAHH-027	Pressure alarm from PSHH	PSHH-027 initiates overpressure alarm PAHH-027	Computer	

TABLE 13. SUMMARY OF CONTROL AND INTERLOCK FUNCTIONS (CONTINUED)

System	Tag No.	Indicator Description	Control Activation	Type	Mode
Exhaust gas pressure interlock	PT -823	Pressure transmitter		Wired	All
	PAH -823	Pressure alarm from PT	High set point initiates overpressure alarm PAH-823	Computer	
	PSHH-823	Hardware pressure switch	System interlock (described for TSHH-027)	Wired	
	PAHH-823	Pressure alarm from PSHH	PSHH-823 initiates overpressure alarm PAHH-823	Computer	
Emergency N2 pressure interlock	PSL -411	Hardware pressure switch — low		Wired	All
	PAL -411	Pressure alarm — low	Low nitrogen pressure sounds alarm PAL-411	Computer	
	PSLL-411	Hardware pressure switch	System interlock (described for TSHH-027)	Wired	
	PALL-411	Pressure alarm from PSLL	Low nitrogen pressure sounds alarm PALL-411	Computer	
HPR temperature interlock	TE -809	Thermocouple		Wired	All
	TAH -809	Temperature alarm from TE	High set point initiates overtemp alarm TAH-809	Computer	
	TSHH-809	Software temp switch from TE	System Interlock (described for TSHH-027)	Computer	
	TAHH-809	Temp alarm from TSHH	TSHH-027 initiates over temperature alarm TAHH-809	Computer	
HPR temperature interlock	TE -810	Dual thermocouple		Wired	All
	TAH -810	Temp alarm from TE-810a	High set point initiates overtemp alarm TAH-810	Computer	
	TSHH-810	Hardware temp switch from TE-810b	System Interlock (described for TSHH-027)	Wired	
	TAHH-810	Temp alarm from TSHH	TSHH-027 initiates over temperature alarm TAHH-810	Computer	
HPR temp alarm	TE -811	Thermocouple		Wired	
	TAH -811	Temperature alarm - high	High set point initiates over temperature alarm TAH-811	Computer	
HPR temp alarm	TE -812	Thermocouple		Wired	
	TAH -812	Temperature alarm - high	High set point initiates over temperature alarm TAH-812	Computer	
HPR temp alarm	TE -813	Thermocouple		Wired	
	TAH -813	Temperature alarm - high	High set point initiates over temperature alarm TAH-813	Computer	
HPR pressure interlock	PT -030	Pressure transmitter		Wired	All
	PAL -030	Pressure alarm from PT	Low set point initiates low pressure alarm PAL-030	Computer	
	PAH -030	Pressure alarm from PT	High set point initiates high press alarm PAH-030 Alarm provides notice to operator. Vessel is protected by PSE-815.	Computer	
	PSHH-030	Software pressure switch	System Interlock (described for TSHH-027)	Computer	
	PAHH-030	Pressure alarm from PSHH	High-high set point initiates overpressure alarm PAHH-030	Computer	

TABLE 13. SUMMARY OF CONTROL AND INTERLOCK FUNCTIONS (CONTINUED)

System	Tag No.	Indicator Description	Control Activation	Type	Mode
Heat exchanger inlet pressure	PT -836	Pressure transmitter		Wired	All
	PSHH-836	Software pressure switch	High-high set point opens PSV-836.	Computer	
	PSV -836	Pressure safety valve	Operator may open PSV-836 by computer selection (HS-836).		
	HS -836	Computer select switch		Computer	
	PAHH-836	Pressure alarm from PSHH	High-high set point initiates overpressure alarm PAHH-836	Computer	
Bed removal	TE -814 FV -610 HS -610A HS -610B	Thermocouple Solenoid valve Computer select switch Local hardware hand switch	Natural gas flows through FV-610 to cool ash hopper at bottom of R-101. Gas flow also facilitates solids movement through V-832. Operator opens FV-610 based on temperature reading	Manual select on computer	Load LH-833
Bed removal	TE -814 TSH -814	Thermocouple Software temp switch high	V-832 opens only if TE-814 less than 400°C	Wired Computer	Load LH-833
Bed removal	PDSH-832	Hardware pressure switch	Top solids valve, V-832, opens only if pressure difference is less than 100 psi.	Computer	Load LH-833
Bed removal	ZS -834	Hardware valve position switch	Top solids valve, V-832, opens only if bottom solids valve, V-834 is closed (ZS-834).	Computer	Load LH-833
Bed removal	ZS -832	Hardware valve position switch	Bottom solids valve, V-834, opens only if top solids valve, V-832 is closed (ZS-832). Operator selects open or close for V-832, top solids valve. Operator pulses valve FV-610 to facilitate solids movement through V-832.	Manual select on computer	Load LH-833
Bed removal	PT -830 FV -409	Pressure transmitter Solenoid valve	Nitrogen flows through FV-409 to pressurize LH-833. All valves are closed.	Manual select on computer	Load LH-833
Bed removal	PT -830	Pressure transmitter	Bottom solids valve, V-834, opens only if pressure is less than 7 bar (100 psi).	Computer	Unload LH- 833
Bed removal	ZS -832 PV -829	Hardware valve position switch Solenoid valve	Bottom solids valve, V-834, opens only if top solids valve, V-832, is closed (ZS-832). Vent valve, PV-829, opens only if V-832 is closed (ZS-832).	Computer Computer	Unload LH- 833

TABLE 13. SUMMARY OF CONTROL AND INTERLOCK FUNCTIONS (CONTINUED)

System	Tag No.	Indicator Description	Control Activation	Type	Mode
Bed removal	ZS -834	Hardware valve position switch	Top solids valve, V-832, opens only if bottom solids valve, V-834 is closed (ZS-834). Operator opens vent valve, PV-829 Operator pulses valve FV-409 to facilitate solids movement through V-834. Operator selects open or close for V-834, bottom solids valve. Operator closes vent valve, PV-829	Manual select on computer	Unload LH- 833
Bed removal	PT -830	Pressure transmitter	Operator opens FV-409 to pressurize LH-833 with nitrogen. Solids valves, V-832 and V-834, are closed.	Manual select on computer	Unload LH- 833
Upper bed removal	TE -815	Thermocouple	Similar to "bed removal" as described above.	Computer	All
	TSH -815	Software temp switch high			
	FV -611	Solenoid valve			
	HS -611A	Computer select switch			
	HS -611B	Local hardware hand switch			
	PDSH-822	Hardware diff press switch			
	ZS -833	Hardware valve position switch			
	ZS -835	Hardware valve position switch			
	FV -410	Solenoid valve			
	PT -831	Pressure transmitter			
	PV -830	Solenoid valve			
Filter	PDT -055	Pressure deferential xmtr	Pulse Nitrogen solenoid valve FV-820 opens when pressure drop exceeds set point OR at programmable time interval OR by operator manual start at the computer. Pressure set point and valve open duration are variable.	Wired	Run
	PDSH-055	Pressure diff switch high		Computer	
	KS -055	Software time switch		Computer	
	HS -055	Computer select switch		Computer	
Filter	TE -104	Thermocouple		Wired	All
	TIC -104	Software temp controller	Heater H-104 is controlled by H-104 element temp	Computer	
Filter	TE -022	Thermocouple	Interlock disables heater H-104 in event of F-104 face over temperature	Wired	All
	TSH -022	Software temp switch		Computer	
Filter	TE -821	Thermocouple		Wired	All
	TIC -821	Software temp controller	Heater H-842 is controlled by H-842 element temp	Computer	
Filter	TE -841	Thermocouple	Interlock disables heater H-842 in event of T-842 face over temperature	Wired	All
	TSH -841	Software temp switch		Computer	

TABLE 13. SUMMARY OF CONTROL AND INTERLOCK FUNCTIONS (CONTINUED)

System	Tag No.	Indicator Description	Control Activation	Type	Mode
Air supply	C -706	Provides compressed air	Compressor on/off Other controls part of package	Manual	All
Natural gas supply	C -627	Provides natural gas	Compressor on/off Other controls part of package	Manual	All
Burner	BSE -019	Flame detector	Burner management system (BMS) controls burner lighting sequence:	Wired	All
			(Operator opens valves for air and gas FV-710, 711, 641, 642, 643)	Manual	
			Operator presses HS-019 on BMS to start sequence.	Wired	
			BMS closes FV-014 H_2 & CO during purge,	Wired	
	HS -019	BMS sequence start button	verifies FSL-011 flow for 3 minutes,	Wired	
			Disables FV-639 during purge and flame,	Wired	
	FSL -011	Hardware purge N2 flow switch	Opens FV-704 and FV-635 (continuous pilot),	Wired	
			Powers spark BX-021 for 30 sec,	Wired	
			Opens main air and gas FV-706 and FV-637 for main flame.	Wired	
			BMS shuts off FV-704, 706, 635, 637 if flame detector BSE-019 off.	Wired	
Gas Flow	PDIT-003	Pressure differential indicating transmitter	Operator controls hydrogen flowrate through FCV-004 based on PDIT readout.	Manual	All
Gas Flow	PDIT-007	Pressure differential indicating transmitter	Operator controls CO flowrate through FCV-008 based on PDIT readout.	Manual	All
Gas Flow	PDIT-011	Pressure differential indicating transmitter	Operator controls nitrogen flowrate through FCV-012 based on PDIT readout.	Manual	All
Gas Flow	PDIT-607	Pressure differential indicating transmitter	Operator controls natural gas/methane flowrate through FCV-605, 606, 607, 608, 617, 618, 619, 620, 621, 622, 623, 636, 638, or 640 based on PDIT readout.	Manual	All
Gas Flow	PDIT-703	Pressure differential indicating transmitter	Operator controls air flowrate through FCV-705 and 707 based on PDIT readout.	Manual	All

TABLE 13. SUMMARY OF CONTROL AND INTERLOCK FUNCTIONS (CONCLUDED)

System	Tag No.	Indicator Description	Control Activation	Type	Mode
Solids feed	PT -801	Pressure transmitter	See sequence table	Computer	All
	PSL -801	Software pressure switch			
	PSH -801	Software pressure switch			
	ZS -839	Hardware valve position switch			
	ZS -840	Hardware valve position switch			
	LSL -805	Hardware level switch low			
	PV -802	Solenoid valve			
	PV -406A	Solenoid valve			
	PV -406B	Solenoid valve			
Solids feed	PT -804	Pressure transmitter	Nitrogen flows through FCV-404 to pressurize T-805.	Manual	Screw feed solids
	PDIT-403	Pressure differential indicating transmitter			
Solids feed	SIC -805	Screw feeder controller	Controls speed of metering screw feeder SF-805	Wired	Screw feed solids
Solids feed	SIC -806	Screw feeder controller	Controls speed of transport screw feeder SF-806	Wired	Screw feed solids

5.2.2 Solids Feed

Solids feed is accomplished with a lock hopper and metering bin. Valves at the top and bottom of the lock hopper move the biomass across the pressure barrier. Metering screws in the feeder control the feed rate. A feed screw moves the biomass into the HPR. Metering screws and the feed screw operate continuously. The metering screw speed controls the rate of biomass feed into the HPR. The lock hopper operates with the following sequence which is summarized in Table 14. The lockhopper is pressurized while both valves are closed. The lower valve is opened and solids fall into the metering bin. The valve is closed and the hopper is depressurized. After the valve is depressurized, the top valve is opened and biomass enters to

TABLE 14. LOCK HOPPER FEEDER SEQUENCE KS-406

Description of event	Trigger or delay	PV-406A LockHpr	PV-406B tank	PV-802 BagHs	V-839 LH top	V-840 LH bot
Rest state		closed	open	closed	closed	closed
Init seq: open vent	LSL-805 low			open		
LH depressurized and V-840 closed: open LH top valve	PSL-801 < = 50 psi[a] AND ZS-840 closed				open	
LH valve delay	wait 20 sec					
Fill lock hopper	wait 10 sec					
Close LH top				close	close	
LH valve delay	wait 20 sec					
Pressurize LH		open				
Tank drain delay	wait 20 sec					
Close tank valve			close			
LH pressurized and V-839 closed: open LH bottom	PSH-801 > = 730 psi AND ZS-839 closed					open
LH valve delay	wait 20 sec					
Empty lock hopper	wait 10 sec					
Close LH bottom		close				close
LH valve delay	wait 20 sec					
Recharge tank			open			

[a] Set points indicated in English units. 1 bar = 14.5 psi

fill the hopper. The top valve is closed and the hopper is pressurized with nitrogen. The bottom valve is opened to allow the solids to fall into the metering bin. The bottom valve is closed and the procedure is repeated as required.

5.2.3 Solids Removal

Solids are removed from the HPR from lock hoppers, LH 833 and 835. For solids removal, the pressure is vented from the lockhopper while both valves are closed. The lower valve is opened and solids are removed. The valve is closed and the hopper is pressurized. After the valve is pressurized, the top valve is opened long enough to allow solids to partially fill the hopper. The top valve is closed and gas is vented from the bottom hopper. The bottom valve is opened to allow the solids to fall from the hopper. The bottom valve is closed and the procedure is repeated as required. Pulse jets of natural gas are available to assist in briefly fluidizing and clearing any material bridging over the hopper valves.

5.2.4 Gas Control

Bottled gases will simulate the recycle gas for the Hynol process (stream 65). Steam and natural gas will be added later to represent stream 7 of the integrated system. Bottled gas flow rates will be controlled with manual needle valves that are preset to the desired flow condition. The process control computer will calculate the flow from differential pressures across orifice plates. On/off control will be accomplished with a manual ball valve. The control system computer will initiate emergency shut downs of feed gases.

5.2.5 Gas Heating

A gas heater raises the gas stream temperature such that it simulates the conditions of the integrated hynol system. Feed gas is initially heated from ambient temperature in HX-038, however, these process conditions are different than those of the integrated Hynol system where the recycle gas is heated in HX-205 (see Figure 1). Natural gas is added downstream of the heater in order to avoid carbon formation on the heater wires.

5.2.6 Steam Injection

Steam is injected upstream of electric heater H-036. The steam simulates water vapor in the recycle gas, as well as steam added to the HPR and additional biomass moisture (currently both are zero). The steam mixes with the gas stream which can subsequently be heated up to 900°C.

5.2.7 Operating Procedures

After the HPR is started, operation of the HPR requires the following activities:

- Monitoring gas flow rates and temperatures
- Monitoring system pressure
- Adding biomass to the feed hopper
- Removing ash and bed material from the HPR
- Monitoring gas analyzers

These functions are all performed manually. The process monitoring computer will provide displays on temperature and pressure conditions, gas flow rates, and the position of lock hopper valves. The process controller will monitor instruments and activate alarms or shut down procedures as required.

5.2.8 Controlled Shutdown Procedures

A controlled shut down for the HPR system consists of the following steps.

5.2.9 Emergency Shutdown Procedures

Emergency shut down will stop all flow of flammable gases to the HPR and drop the system pressure. The emergency shut down sequence includes the following steps:

- Shut off flammable gases FV-001
- Shut off process steam flow FV-504
- Shut off natural gas flow FV-609
- Stop biomass flow SF-806
- Shut off all electric heaters (H-102, H-843, H-036, H-052) except H-566
- Open emergency relief valve FV-838
- Open emergency nitrogen valve FV-423
- Shut off air flow (FV-704, FV-712)

The nitrogen flow through FV-423 is a controlled with an orifice that results in a flow rate similar to the HPR flow rate at operating conditions.

Emergency shut down in initiated by the computer via inputs from over temperature and overpressure alarms. In addition, hardwired controls will trigger the emergency shut down procedure. Computer initiated signals are indicated as high/high alarms in hexagon symbols (see high pressure alarms PAHH-853 on Sheet 4 of Drawing 8570G003 in Appendix A). Hard wired switches are indicated by high/high sensors in circle symbols (e.g. PSHH-853).

5.2.10 Control Hardware

Process control will be accomplished with an industrial controller. Industrial controllers are more robust that PC-based control systems. The controller will be provide instrumentation data to a data acquisition computer. The controller will continue to operate even if the data acquisition computer fails to operate. Computer control inputs will be sent to the controller from the data acquisition computer.

For a bench-scale system, it is appropriate to control many actions manually. Most manual control functions will be accomplished by opening or closing a ball valve. Flow rates will be preset with needle valves. Fine adjustments can be made with needle valves during facility operation.

SECTION 6

HPR SYSTEM HARDWARE

The layout for the biomass feed, HPR, and SPR structure is shown in Figure 6. The reactor vessels are arranged adjacent to each other to minimize pipe runs and reduce heat losses. The MSR system is located on a separate structure. The gasification system structure will be assembled on site. The process reactors will be delivered and assembled on site. Detailed drawings for the HPR, hot gas filter, water scrubber, and desulfurization vessel are presented in Appendix B.

6.1 INSULATION

The HPR system has several different insulation and piping requirements as follows:

- The pipe runs carrying the process gas must be insulated.
- The HPR fluidization zone must be abrasion-resistant.
- Other sections of the vessel must be insulated but do not require abrasion-resistant material.

Heat losses were analyzed for an HPR system with 200°C steam-jacketed pipes. These heat losses were found to range from 400 to 660 watts per linear meter of pipe depending upon the configuration. Figure 7 shows the configuration of vacuum formed insulation for pipe runs. The fluidized section of the HPR will be insulated with an abrasion resistant refractory, backed with a low thermal conductivity layer, with an outer layer in ceramic paper.

6.2 HPR REACTOR

Table 15 shows the configuration of the HPR. The reactor has a 6 inch inner diameter which is made from refractory lined pipe in the fluidized section of the HPR. The freeboard section and plenum section of the HPR lined with preformed fiber insulation. Figure 8 shows the configuration of the hydrogasifier.

6.2.1 Cyclone

An internal cyclone captures fine materials from the HPR. The cyclone is mounted on the edge of the freeboard section of the HPR. Cyclone fines are returned to the bed from the cyclone dipleg. Cold flow tests indicated that it was important to prevent flow up the cyclone dipleg. Two methods were used to keep gas flow from entering up the cyclone dipleg. A gas ejector was used to create a suction at the bottom of the cyclone. This method was somewhat unconventional and used a small quantity of natural gas. Another technique is to place a hinged

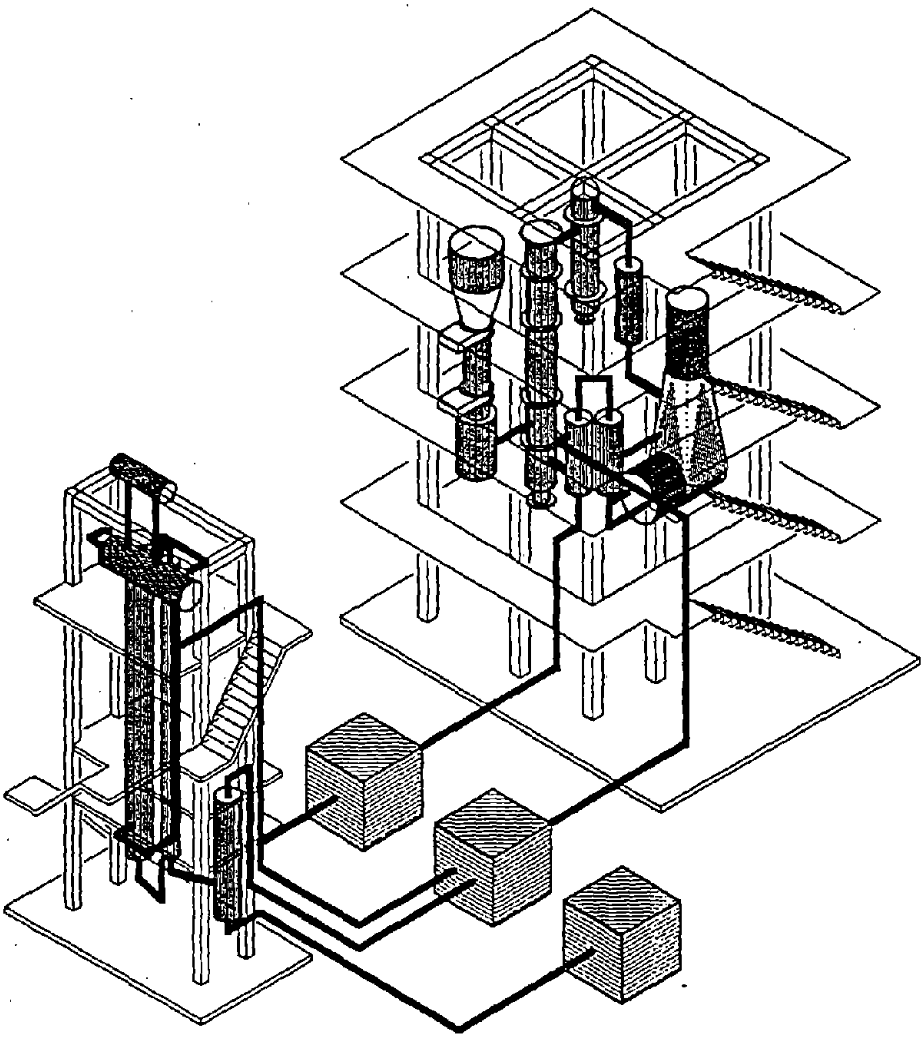
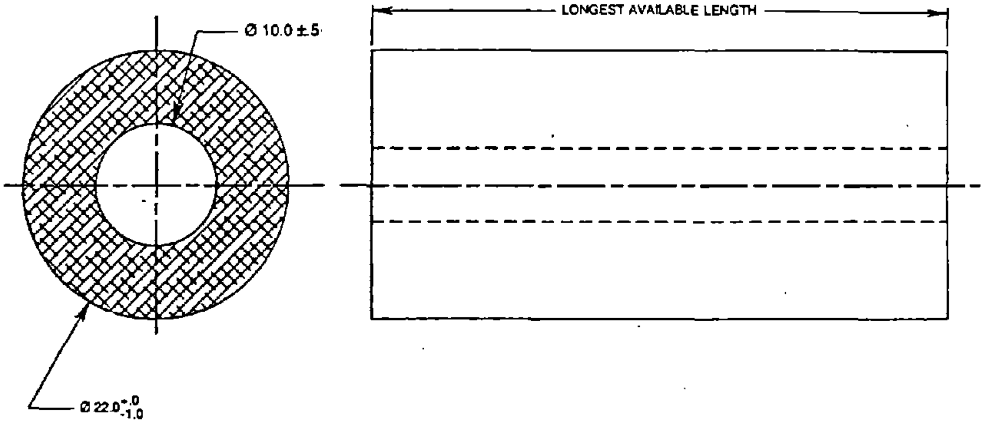


Figure 6. The Hynol facility with the methanol synthesis unit in the foreground, compressors in the middle, and the HPR/SPR/feed system in the background.



VACUUM-FORMED CERAMIC FIBER SLEEVE REQUIREMENT

SLEEVE DIMENSIONED TO FIT INSIDE SCHEDULE 60 24" PIPE (Ø 22.06 ACTUAL INSIDE DIAMETER OF THE PIPE)

NOT TO SCALE

A COMBINED LENGTH OF 10' WILL BE REQUIRED

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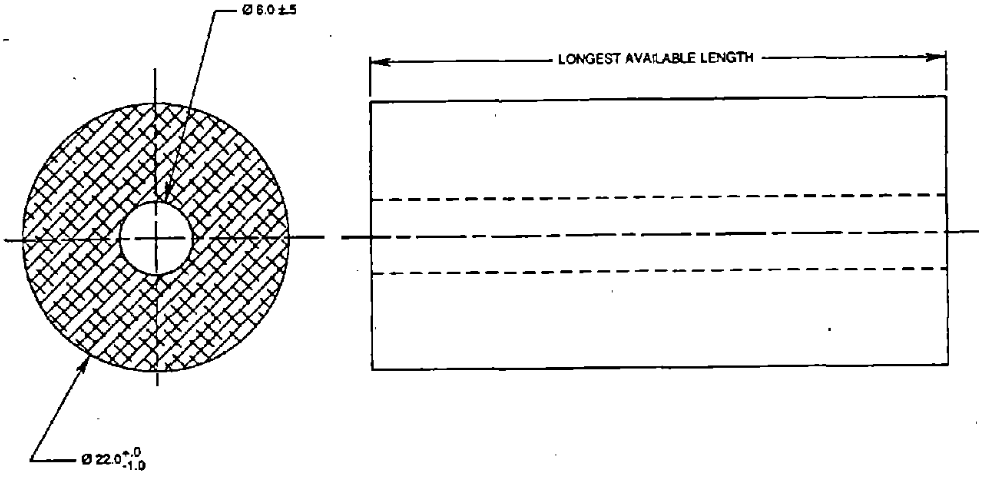
23 MARCH 93



VACUUM-FORMED CERAMIC FIBER SLEEVE REQUIREMENT

SLEEVE DIMENSIONED TO FIT INSIDE SCHEDULE 60 24" PIPE (Ø 22.06 ACTUAL INSIDE DIAMETER OF THE PIPE)

A COMBINED LENGTH OF 20' WILL BE REQUIRED

NOT TO SCALE

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Figure 7. Vacuum-formed insulation.

TABLE 15. SPECIFICATIONS FOR HYDROGASIFICATION REACTOR

Parameter	Specification
Reactor diameter	0.15 m (6 in.)
Reaction section	3.2 m (10.5 ft)
Bed height	1.2 m (4 ft)
Feed entrance above distributor plate	0.3 m (1 ft)
Reactor area	0.108 m^2
Feed gas flow	4.4 kmol/h 12.9 m^3/h (7.6 cfm)
Superficial velocity	0.2 m/s (0.67 ft/s)
Operating pressure	30 bar (441 psia)
Operating temperature	800°C (1,472°F)

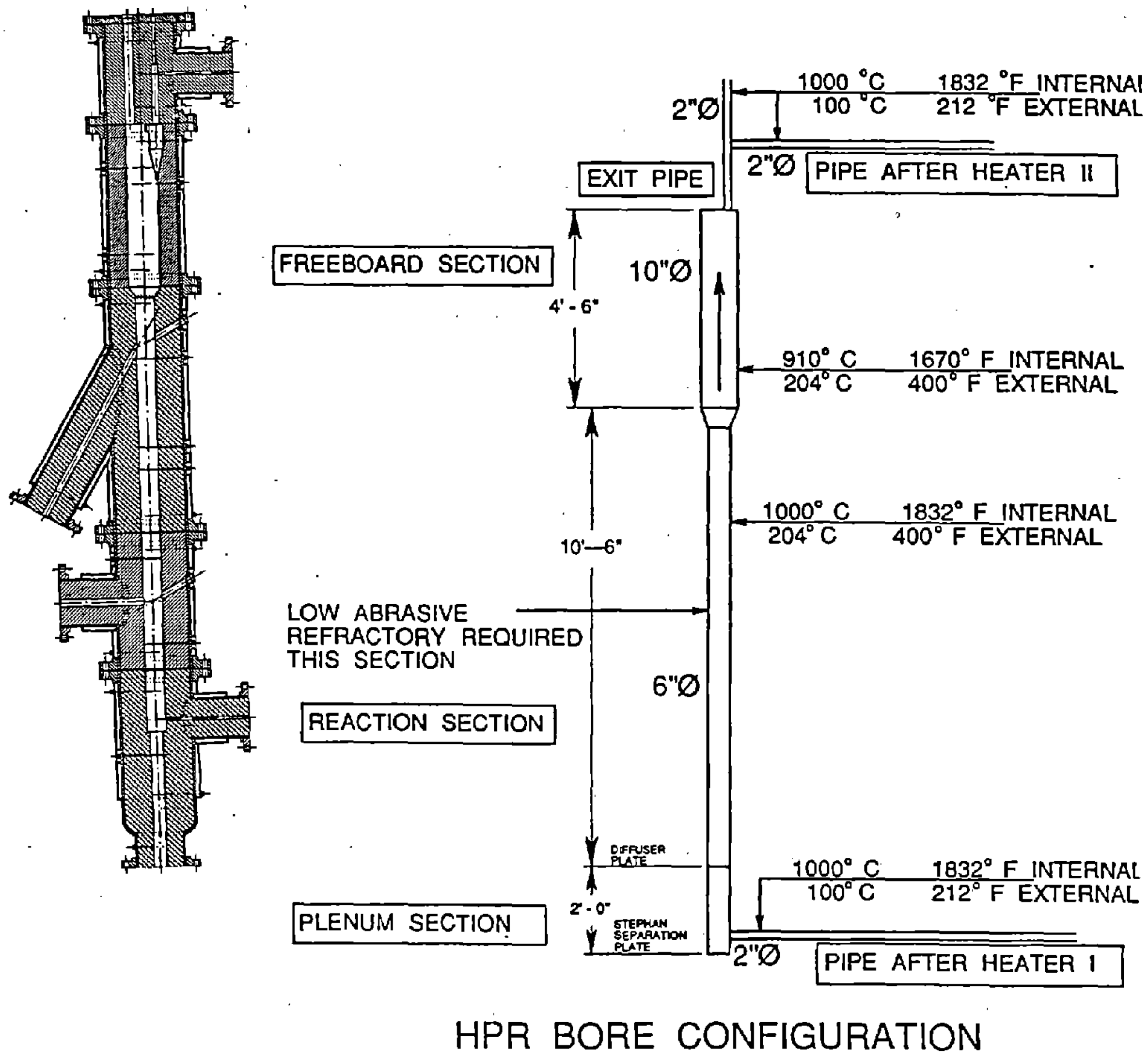


Figure 8. HPR vessel.

valve at the bottom of the cyclone. The valve opens when sufficient weight of material enters the dipleg. This technique is used in commercial applications.

6.3 HPR SOLIDS REMOVAL

Ash and bed material will be removed from lock hoppers LH-833 and LH-835. These will be insulated pressure vessels that are rated for the temperature of the ash and the system pressure. The temperature of the ash will be less than that of the HPR by the time it reaches the lock hopper. A stream of natural gas flows into the lock hopper to keep passages clear of solids. The natural gas will cool the ash to some extent. Heat losses from the uninsulated vessels will also result in low wall temperatures. Lock hopper valves are high temperature industrial valves with an inner diameter of 25 mm (1 inch).

6.4 BIOMASS FEED SYSTEM

The solids feed system consists of a bulk materials area and a feed tank area. In the bulk materials area, wood and a gettering agent are mixed together, while sand is stored separately. The mixed solids are introduced into the day bin which empties into the lockhopper. The sand is introduced separately into the lockhopper. At the bottom of the lockhopper, a metering screw regulates the entry of the solids into the HPR vessel.

Biomass particle size and shape

The particle size of biomass feed affects the performance of the feed system and the reaction time in a gasifier. The least dimension is the controlling factor in determining the reaction rate. Smaller particles will react more quickly; however, the processing cost (in commercial systems) increases with additional hardware and energy required for smaller particles. Smaller particles are also subject to charring in the feed system and very small particles tend to form plugs that clog feed systems.

Particle size affects the performance of the feed system. Uniformly sized particles feed better than particles with a range of sizes. Cubic-shaped particles tend to clog less readily than long strand-like particles. Therefore, particles that are produced by cutters or chippers tend to clog less than particles produced by hammer mills. Hammer mills impact wood and produce a particle with shattered fluffy ends that tend to stick together. A wood moisture content below 20 percent is required to prevent sticking in the lock hopper and screw feeder. For small-scale systems, saw dust and wood chips are options that are consistent with the abilities of a feed system. Smaller particle sizes will result in a more rapid reaction rate. Wood particles with their least dimensions greater than sawdust can also be tested within the capabilities of a bench-scale feed system.

Table 16 summarizes particle size dimensions for wood feeds. The smaller feed sizes are considered for laboratory and bench scale-systems because they are compatible with the size of the feed system and also provide faster reaction rates. Since small reactor systems will not have the same bed height as commercial systems, it may be desirable to test smaller particle sizes in these reactors.

TABLE 16. PARTICLE SIZE OPTIONS FOR BIOMASS FEED SYSTEMS

Material	Particle size (mm) Linear diameter Min.	Max.	Comments
Small scale system			
Sawdust, wood shop	0.05 to 2	2	Typical material from lumber yards
Sawdust, cut	0.4 to 2	3	Uniform size should feed better
Wood flour	0.05	0.5	Too small and fluffy to feed well
Wee chips	1.5	12 x 12	Feeds well, prepare with modified chipper
3 mm (1/8 in) Cut chips	3	3	Custom cut for laboratory reactor, simulates pulp chip scale min. dimension
Commercial system			
Pulp chip	3	20 to 25	Industry standard for biomass energy systems
Large chip	12 to 20	25 to 50	Larger size, possibly for 5,000,000 kg/day, lower cost

Sawdust from a lumber mill was tested by Acurex Environmental in a 0.15-m cold flow fluidized bed. The sawdust ranged in particle size (screen size) from 80 to 1,000 μm. Eighty percent of the material was over 300 μm. This material did not flow well under all circumstances, possibly because of higher than ideal moisture content. The material formed large plugs when it was added to the cold flow reactor. Adding sand as a fluidizing media allowed the sawdust to fluidize well. Some difficulty was exhibited when flowing through a 25-mm ball valve. Presumably drier more uniformly sized sawdust would flow more readily. The best type of sawdust would be uniform in size and be free of small powdery material. Such sawdust can be produced with a thin saw blade and flows without clogging. Special cut and size-controlled sawdust should be used for a bench-scale system. Relying on the particle size distribution and consistency of feed from lumber mill sawdust will be too risky.

Very fine material such as wood flour is unacceptable as a feedstock because of its tendency to plug in a feed system. Wood flour might have a 50 μm particle size. This material would also tend to char prematurely in the feed system.

Hand cutting can readily produce sufficient feed material for a 40-mm laboratory-scale reactor. Three to 10-mm cubes would be a reasonable size range, given the reactor inner diameter and the size of available sawdust. A 3-mm particle size will simulate the least dimension of some commercial feeds. Larger cubes up to 10 mm could also be tested. Producing 3-mm-particle size wood feed might be feasible for a 500 kg/day bench-scale system. However, the reaction time will be longer than that of sawdust.

Experience has shown that thin chips (wee chips) can be produced by modifying a commercial chipper. Moving the blades closer together will result in a chip as thin as 1.5 mm. This chip can also be fed with a screw feeder.

Commercial biomass to energy facilities uses a particle size referred to as a pulp chip. Experience has shown that this type of particle can be successfully fed into 500,000 kg/day gasification systems. For larger 5,000,000 kg/day systems, a larger particle size might be considered; however, the effect on fluidization and reaction rate would need to be investigated further.

Table 17 shows the specifications for the biomass feed system.

Alkali Getter Feed

Getter material is added in proportion to the expected alkali content of the biomass feed which is estimated from the ash content and alkali fraction of the ash. Table 18 shows that an

TABLE 17. BIOMASS FEED SYSTEM SPECIFICATIONS

Parameter	Value
Feed materials	Initially clean white wood Also tree trimmings and other waste materials
Sawdust bulk density	180 kg/m^3
Sawdust particle density	630 kg/m^3
Voidage	0.71
Maximum particle size	3 to 10 mm
Particle minimum dimension	1 to 5 mm
Sand bulk density	1400 kg/m^3
Sand particle size	0.3 mm
Kaolinite bulk density	1200 kg/m^3
Kaolinite particle size	0.1 mm
Operating biomass feed	22.8 kg/h (50 lb/hr)
Design feed rate	
Biomass	45.6 kg/h (100 lb/hr)
Sand	0.25 kg/h (0.55 lb/hr)
Kaolinite	0.25 kg/h (0.55 lb/hr)
Volumetric throughput	0.25 m^3/h (8.9 ft^3/hr)
Top valve diameter	150 mm (6 inch)
Bottom valve diameter	150 mm (6 inch)
Lock hopper volume	9.3 L (0.33 ft^3)
Metering bin volume	84.9L (3 ft^3)
Lock hopper diameter	150 mm (6 inch)
Metering bin diameter	200 mm (8 inch)
Vessel material	Steel
Number of metering screws	3
Metering screw diameter	50 mm (2 inch)
Injection screw diameter	67 mm (2.63 inch)

TABLE 18. ALKALI GETTER FLOWRATE

Parameter	Value
Biomass dry feed (kg/h)	22.8
Ash content range (wt %)	0.5 to 6.6
Ash content (kg/h)	
Maximum (design)	1.7
Minimum	0.11
Clean wood in PFD	0.17
Ash bulk density (kg/m3)	
Design ash flowrate (m3/h)	
Alkali content range (wt % of dry ash)	0.5 to 5
Alkali flowrate as K (g K/h)	
Maximum	85
Minimum	0.55
Clean wood in PFD	1.7
Design alkali flow (mol/h)	2.2
Alkali getter	Kaolinite
Composition	$Al_2O_2 \cdot {}_2SiO_2$
Alkali absorption (mole K/mole getter)	2 at 90% efficiency
Molecular weight (g/mol)	190
Design kaolinite feed (mol/h)	1.2
(g/h)	250
Bulk density (kg/m^3)	~1200
Volumetric flow (L/h)	0.2

alkali getter flowrate of 0.25 kg/h should be sufficient to capture the alkali in most wood feedstocks.

Sand Feed

Ash, char, and bed material can either be removed from the bottom of the HPR or from the ash overflow port at the top of the bed. If the HPR operates such that the bed height is below the removal port, ash and bed material will be removed together from the bottom port. If the HPR operates at maximum bed height, lighter ash and char may be removed from the top port and sand can remain in the HPR for a longer period of time. The rate of sand feed will be determined either by the amount of bed material removed from the HPR in order to remove ash and char or by a predetermined replacement rate. If all ash removal is performed from the bottom of the HPR, the estimates in Table 19 show the required sand feed rate for the HPR.

6.5 PROCESS GAS SUPPLY

Process gases will be provided in tube trailers. Tube trailer gas consumption is discussed in Section 2.

TABLE 19. SAND FEED INTO HPR

Parameter	Value
Biomass feed rate (0% moisture)	22.9 kg/h
Ash feed/removal rate	1.4 kg/h
Bed removal rate	6%/hr
Sand volume	1.37 liter (0.9 m high)
Sand mass	4.9 kg
Sand removal rate	0.3 kg/h

6.6 FEED GAS HEATER

Acurex Environmental has developed preliminary design specifications for the electric heater that maintains the HPR feed gas temperature at 800°C. Stream 7, the simulated recycle stream, exits the heat exchanger at 600°C and combines with steam, Stream 2, before entering the heater. The heated stream then enters the HPR vessel directly.

The water heater needed to convert water to steam at 277°C must provide at least 9 kW of power. However, the water heater should actually be sized at 15 kW to provide an appropriate capacity factor.

The temperature of the combined stream (stream 7 plus stream 2) which enters the heater was calculated to be 525°C. The electric heater must heat the inlet gas from this temperature to an outlet temperature of 1,000°C. Based on the specific heat of the mixed stream, the ideal required power outlet of the electric heater was calculated to be 20 kW. In order to provide for rapid startup and to accommodate heat losses from the vessel and associated piping, the heater should be sized for a capacity at least 50-percent greater than the actual gas heating requirements. Thus, this heater should be sized for at least 30 kW capacity. The expected process conditions are shown in Table 20.

The following equipment must be specified:

- Heating element assembly
- Pressure containment vessel
- Electrical feed-through connections
- Temperature sensing elements for process gas stream sensing
- Temperature sensing devices for the heating element surface
- Required controls, mounted in 0.5 m (19-inch) racks

An evaluation of the heating elements available suggests that the Kanthal SUPER elements are the most appropriate, despite their cost, because they provide the following:

TABLE 20. PROCESS CONDITIONS FOR ELECTRIC HEATER

Stream Description	Volumetric Gas Flow (kmol/h)				Temperature (°C)	Pressure (bar)	Specific heat Cp (kJ/kg°C)[a]	Mass flowrate (kg/hr)
	H_2	CO	N_2	$H_2$0 (steam)				
"Recycle" (Stream 7)	3.64	0.31	0.46	0.00	600	50	4.7	28.9
Steam (Stream 2)	0.00	0.00	0.00	0.72	277	50	2.2	12.9
Heater inlet (Stream 68)	3.64	0.31	0.46	0.72	525	50	5.4	41.8
Heater outlet (Stream 73)	3.64	0.31	0.46	0.72	1,000	50	5.4	41.8

[a] At constant pressure.

- Smaller pressure vessel size for elements operating at element surface temperatures higher than Al-Cr-Fe elements.

- Lower surface maintenance intervals. Periodically, an oxidation layer may accumulate on the heater element surface, requiring venting. During this procedure, air is run through the heater while it is turned off and the system is not operating. It is not necessary for this air to be supplied at pressure, and it should not come into contact with the reactor bed.

- Greater operating envelope capabilities for elements with significantly higher surface temperature capabilities

Proposed Heater Vessel Configuration

The heater configuration is a typical shell and tube heat exchanger, with the heater assembly substituted for the tube sheet and tubes. The heater vessel configuration and internal layout are shown in Figure 9. The internal diameter is about 0.38 m (15 inches), providing an active tube element length of 1.2 m (4 feet). The heating elements are in a hairpin configuration. About 0.3 m (12 inches) of the heating element consists of a "cold length" to allow for entry through the heater tube sheet. The vessel has a refractory lining 0.15 m (6 inches) thick. The total outside diameter of the vessel is 0.76 m (30 inches), and the total length is approximately 2.7 m (9 feet).

6.7 HOT GAS FILTER

The filter for the hot gas exiting the HPR operates at 50 bar and 800°C. The filter consists of one candle filter made of SiC (pall vitripore). The expected face velocity is 0.82 m/s (2.7 ft/min). The cleaning frequency depends on the dust load and resistance, and should average about once every 20 minutes. Figure 10 shows the filter vessel.

6.8 WATER SCRUBBER

A water scrubber was designed to remove particulate matter from the HPR effluent (Table 21). The water scrubber shown in Figure 11 is designed to cool the HPR gas to the boiling point of water at 30 bar. An alternate water scrubber was also designed to cool the process gas down to ambient temperature.

6.9 ZINC OXIDE DESULFURIZATION SYSTEM

A desulfuriztion vessel was designed to capture H_2S in the HPR gas stream. The specifications for the desulfuriztion vessel are shown in Table 22. The vessel is shown in Figure 12.

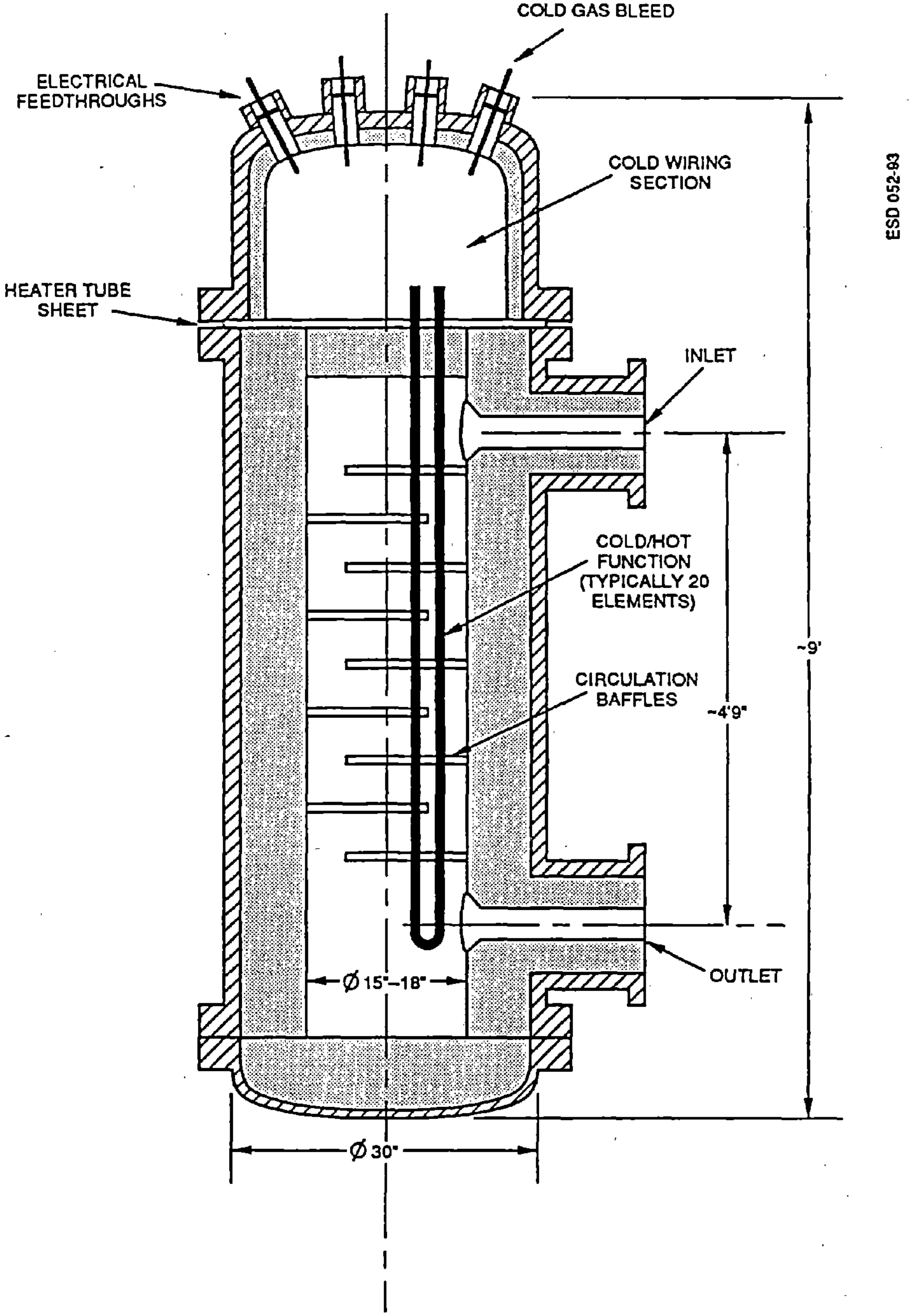


Figure 9. Heater assembly in pressure vessel.

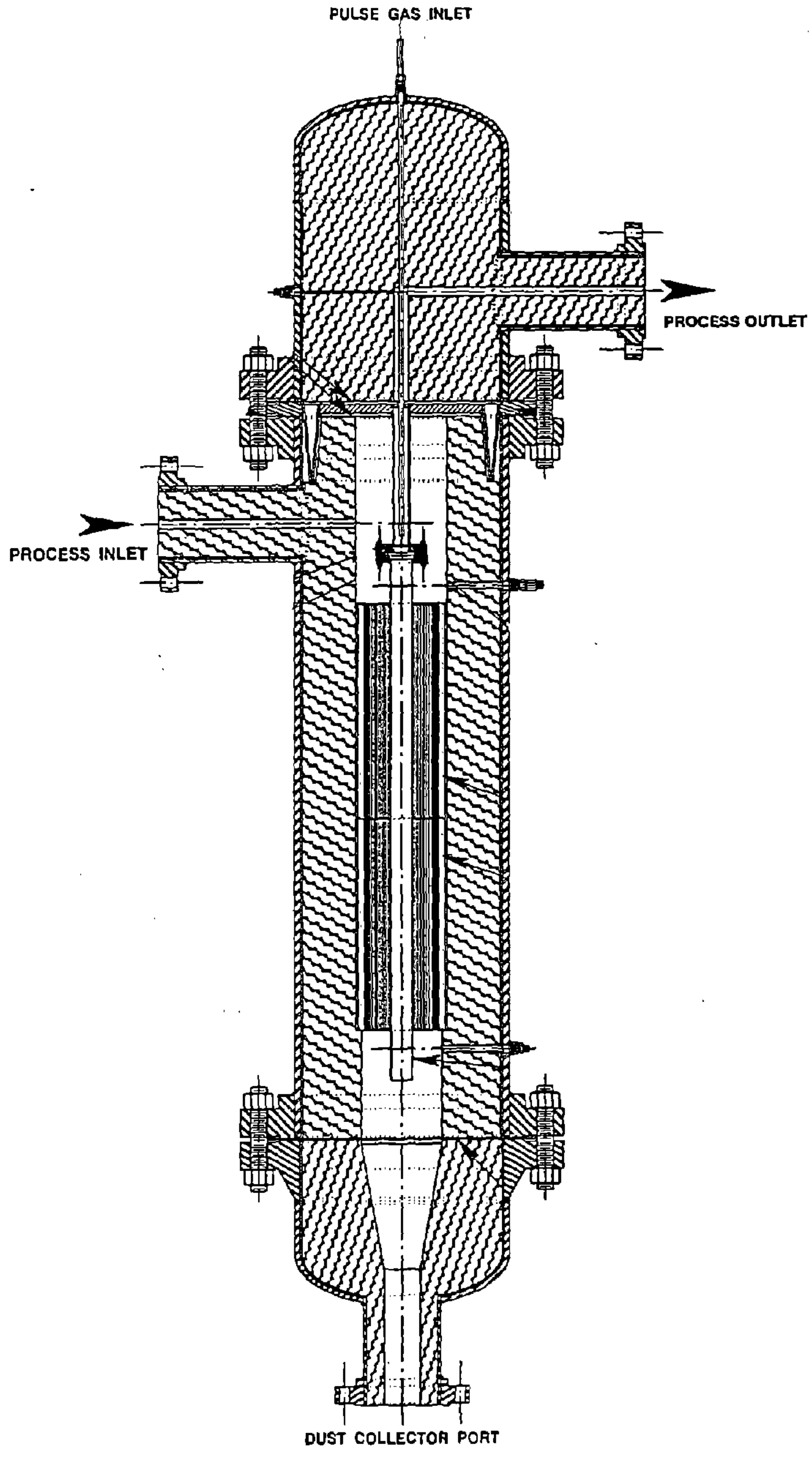


Figure 10. Hot gas filter.

TABLE 21. WATER SCRUBBER CONFIGURATION

Parameter	Value
Inlet gas flowrate (kmol/h)	5.7
(kg/h)	87.6
Inlet gas temperature (°C)	800
Inlet gas flow (m^3/h)	14.4
Inlet gas H_2O (kmol/h)	1.0
Exit gas flowrate (kmol/h)	4.7
(kg/h)	69.6
Exit gas temperature (°C)	60
Exit gas flow (m^3/h)	4.5
Gas heat capacity (kJ/kg°C)	3
Steam heat of vaporization (kJ/kg)	1796
Heat transfer: gas to water (kW)	54
Heat transfer: steam to water (kW)	9
Total heat transfer to water (kW)	63
Cooling water flowrate (kg/s)	0.5 (8 gpm)
Design water flowrate (kg/s)	1.3 (20 gpm)
Cooling water boiling point (°C)	250
Heat transfer below boiling point (kW)	9.8
Heat exchanger length (m)	1.5
Number of tubes	19
Tube outer diameter (mm)	19
Inlet gas flow (m^3/h)	0.88
Outlet gas flow (m^3/h)	0.24
Inlet gas flow @ 250 °C (m/s)	1.05
Outlet gas flow (m/s)	0.29

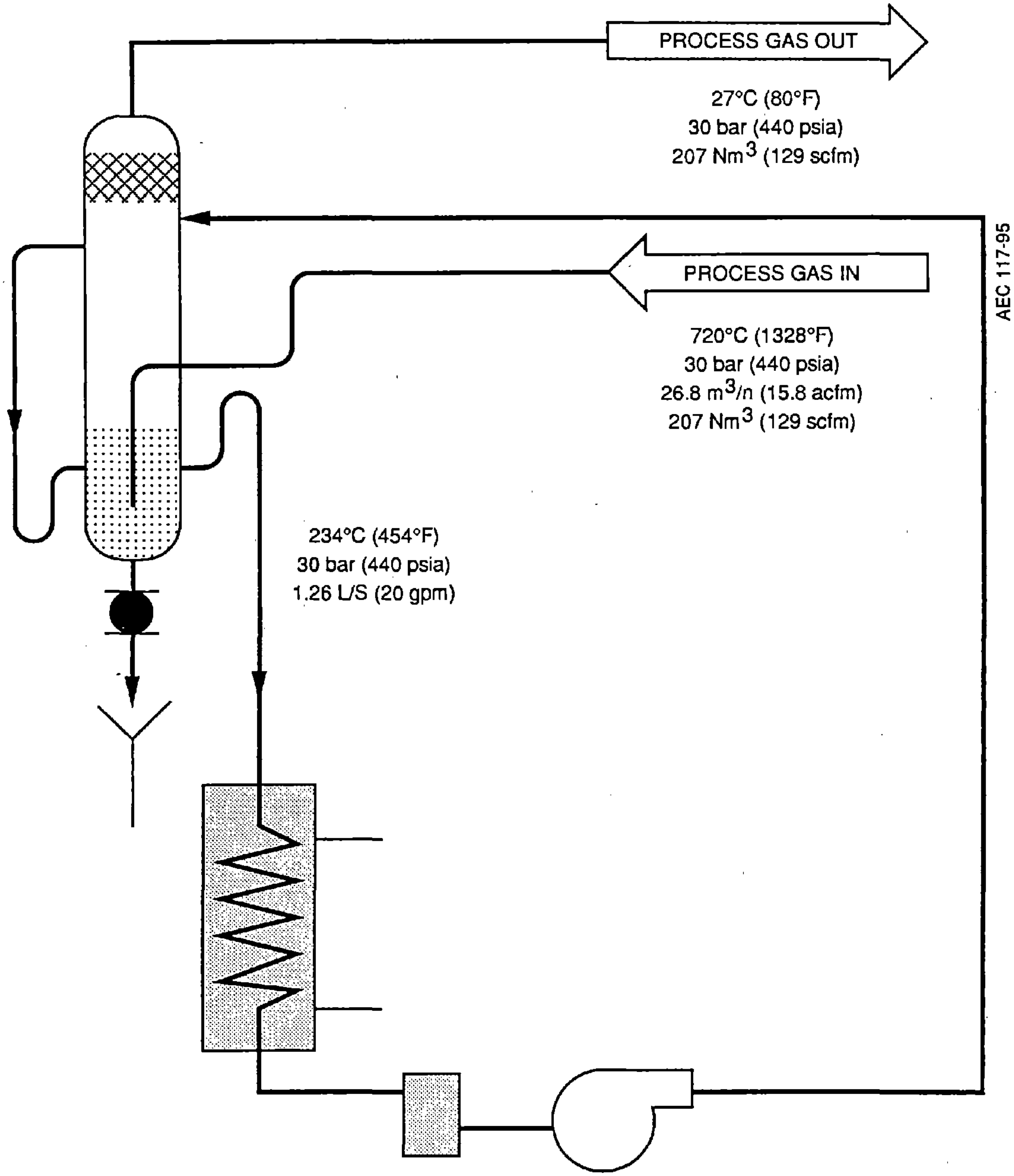


Figure 11. Water scrubber system.

TABLE 22. ZINC OXIDE DESULFURIZATION SYSTEM

Parameter	Value
Biomass dry feed (kg/h)	22.8
Feed sulfur content (wt %)	0.16
Sulfur flow (kg /h)	0.036
(kmol /h)	0.0011
Gasifier output (kmol/h)	5.7
Sulfur concentration (ppm_v)	200
ZnO capacity S/ZnO (kgs/kg ZnO)	0.3
Operating lifetime (h)	350
Captured sulfur per charge (kg)	12.6
ZnO consumed per charge (kg)	42
Capacity factor	3
Design ZnO (kg)	126
Zinc Oxide Granules	ICI Catalyst 32-4
ZnO (%)	90
CaO(%)	2
Al_2O_3 (%)	8
Surface area (m^2/g)	25
Bulk density (kg/m^3)	1100
Diameter (mm)	3 to 5
ZnO bed volume (m^3)	0.11 (4.0 ft^3)
Space velocity (h^{-1})	1120
Operating temperature (°C)	400
Operating pressure (bar)	30
Gas flowrate (m^3/h)	10.5
Bed diameter (m)	0.34 (1.13 ft^3)
Bed area (m^2)	0.09
Bed height (m)	1.2 (4.0 ft)
Superficial velocity (m/s)	0.032
Gas residence time (s)	37
MnO bed height (m)	0.3 (1 ft)
MnO granules	Catalyst type to be determined
Design Temperature (°C)	600
Design Pressure (bar)	37 (550 psi)

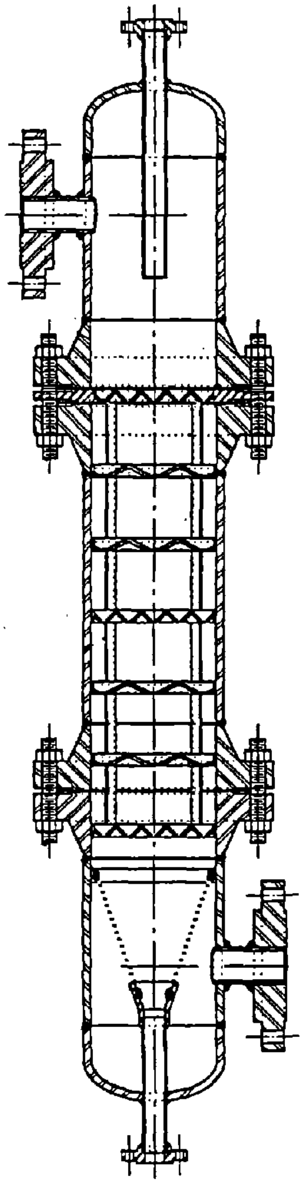


Figure 12. Zinc oxide desulfurization vessel.

SECTION 7

EQUIPMENT, SITE DEVELOPMENT, AND MATERIAL COST

Cost estimates were developed for the equipment, site development, and operating materials for the Hynol project. Tables 23 through 25 show equipment cost estimates for the HPR, SPR, and MSR systems. Table 26 shows cost estimates for site development. Tables 27 through 29 show the cost of expendable materials for HPR, SPR, and MSR testing.

TABLE 23. HPR EQUIPMENT COST

	Hynol HPR System Equipment Cost			
Tag No.	Component	Pressure (atm)	Description	Cost
R-101	Hydropyrolysis reactor	30	24", refractory lined	$52,440
T-805	Metering bin	30	24"	$10,000
SF-806	Screw feeder and motor	30		$10,000
LH-801	Lock hopper	30		$10,000
T-802	Pre-feed hopper	1		$2,000
T-803	Sand hopper	1		$500
SF-850	Metering screw and motor	30		$8,000
F-626	Natural gas filter	10		$500
C-627	CNG compressor skid	200		$60,000
T-421	Nitrogen buffer tank	30		$200
C-706	Air compressor skid	50	60 cfm @ 600 psig	$40,000
XX-804	Biomass chipper	1		$5,000
XX-805	Biomass conveyor	1		$5,000
T-051	CO2 heater tank	1		$500
LH-834	Ash hopper top	30		$2,000
LH-835	Ash hopper bottom	30		$2,000
LH-833	Ash hopper bottom	30		$2,000
F-104	Hot gas filter	30		$30,720
H-102	Filter heater	30		$1,000
T-842	Nitrogen buffer tank	60		$1,000
H-843	Buffer tank heater	60		$500
F-521	Reverse osmosis filter	1		$1,000
T-513	Boiler feedwater tank	1		$500
T-559	Steam generator, 750 psi	50		$65,000
H-036	Recycle gas heater	30		$60,000
HX-038	Inter-heat exchanger	30		$15,000
B-037	Burner	30		$3,700
	Total HPR equipment			$388,560
	Instrumentation and controls	EPA ordered ($120,000)		$0
	Instrumentation and controls	to be ordered		$40,000
V-839	Lock hopper valve, top	30		$800
V-840	Lock hopper valve, bottom	30		$800
	Piping			$5,000
	Tubing			$5,000
	Subtotal			$440,160
	Sales Tax	7.50%		$33,012
	Shipping	5.00%		$22,008
	Electrical Installation			$40,400
	Contingency	20.00%		$99,036
	HPR Structure			$99,060
	Total HPR system			$733,676

TABLE 24. SPR EQUIPMENT COST

	Hynol SPR System Equipment Cost			
Tag No.	Component	Pressure (atm)	Description	Cost
R-201	Steam pyrolysis reactor	30		$100,000
C-201	Combustion air blower	1.3		$3,000
HX-206	HP steam heat exchanger	30		$5,000
HX-205	Inter-heat exchanger	30		$20,000
F-205	Sulfur removal bed	1		$2,000
F-206	Water scrubber	30		$2,000
	Total SPR equipment			$132,000
	Piping with insulation			$2,000
	Tubing			$1,000
	Fittings			$2,000
	Instrumentation and controls			$30,000
	Subtotal			$167,000
	Sales Tax	7.50%		$12,525
	Shipping	5.00%		$8,350
	Mounting modifications			$10,000
	Electrical installation			$5,000
	Contingency	20.00%		$40,575
	Total SPR system			$243,450

TABLE 25. MSR EQUIPMENT COST

	Hynol MSR System Equipment Cost			
Tag No.	Component	Pressure (atm)	Description	Cost
R-301	Methanol reactor	50	$110,000 CE-CERT buys	–
E-312	Evaporator	50		–
T-310	Steam drum	50		–
P-311	Cooling water pump	50		–
HX-309	Inter-heat exchanger	50		–
HX-313	Heat exchanger	50		–
T-314	Methanol separator	50		–
	MSR system dismantling			$100,000
	MSR system installation			$20,000
C-308	Circulation loop compressor	50	360 scfm, 100 psig	$10,000
C-304	Recycle gas compressor	50	90 scfm, 400 psig	$10,000
T-307	Knock out drum 2	50		$500
HX-306	Heat exchanger	30		$3,000
F-305	Clean up bed	30		$2,000
T-303	Knock out drum 1	30		$500
HX-302	Distillation heat exchanger	30		$5,000
P-302	Bottoms pump	1		$500
D-315	Distillation column	1		$5,000
HX-317	Heat exchanger	5		$3,000
T-TBD	Condensate drum	5		$500
P-319	Reflux pump	1		$1,000
T-320	Methanol product drum	1		$500
T-321	Methanol storage tank	1	2000 gal	$25,000
	MSR Equipment			$66,500
	Instrumentation			$40,000
	Tubing and fittings			$5,000
	Gas clean up structure			$54,500
	Equipment subtotal			$166,000
	Sales Tax	7.50%		$12,450
	Shipping	5.00%		$8,300
	Electrical installation			$10,000
	Contingency	20.00%		$39,350
	Total MSR system			$356,100

TABLE 26. SITE DEVELOPMENT COST ESTIMATE

JOB NO. & PROJECT TITLE: #0332 HYNOL Site Work (Grading, Paving, Concrete, and Landscaping)
CLIENT: U.S. Environmental Protection Agency
JOB LOCATION University of California at Riverside - College of Engineering

TAKEOFF BY: DJT
PRICED BY:
CHECKED BY:

APPROVED BY:
DATE: 5/9/94
LAST REVISED: 6/2/93 1:28 AM

PROJECT COST TAKE-OFF

ITEM No.	MEANS ACCOUNT NUMBER	DESCRIPTION	QUANTITY	UNIT	UNIT COST MATERIAL	UNIT COST EQUIP. / MISC. or SUB - CONT.	MANHOURS NUMBER OF MEN	MANHOURS HRS / UNIT	MANHOURS $ / MH	CITY COST INDEX MATERIAL	CITY COST INDEX LABOR	INFLATION INDEX	TOTAL COST MATERIAL	TOTAL COST LABOR	TOTAL COST EQUIP. / MISC. or SUB - CONT.	TOTAL COST 8.25% TAX	FREIGHT	TOTAL
1	021.108.0500	Site clearing, 200 H.P. dozer and brush rake, light	2.53	ACRE		1,101.80	2	8.000	30.30	98.7%	111.6%	120.0%	0.00	1,639.73	3,295.84	164.70		5,100.36
2	021.144.0020	Stripping topsoil and stockpile, sandy loam, 200 H.P. dozer, good conditions	4,074.07	C.Y.		0.37	2	0.003	23.50	98.7%	111.6%	120.0%	0.00	895.26	1,790.41	89.52		2,775.19
3	022.242.4020	Excavating, bulk, 200 H.P. dozer, open site, 50' haul, common earth	6,666.67	C.Y.		0.69	2	0.007	23.59	98.7%	111.6%	120.0%	0.00	2,739.07	5,478.41	273.92		8,491.70
4	022.208.4220	Backfill, Structural, 200 H.P. dozer, from existing stockpile, 150' haul, common	6,666.67	C.Y.		1.40	2	0.013	23.50	98.7%	111.6%	120.0%	0.00	5,523.65	11,048.83	552.33		17,122.62
		earth, no compaction								100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
5	022.226.5700	Compaction, sheepsfoot, 12" lifts, 3 passes	6,666.67	C.Y.		0.14	2	0.002	23.59	98.7%	111.6%	120.0%	0.00	863.96	1,084.59	54.23		2,002.77
6	022.274.0100	Mobilization and demobilization for equipment in items 1 through 5, up to 25 miles	2.00	EACH		202.97	1	2.105	27.65	98.7%	111.6%	120.0%	0.00	155.91	480.80	24.04		660.76
7	022.304.0010	Prepare and roll sub-base	3,822.22	S.Y.		0.63	3	0.005	31.45	98.7%	111.6%	120.0%	0.00	2,575.74	2,863.65	143.18		5,582.58
8	025.254.0440	Curb and gutter, steel forms, 24" wide, straight	533.50	L.F.	5.01	0.05	6	0.011	33.11	114.0%	122.6%	120.0%	3,652.79	1,781.91	36.70	303.19		5,774.50
9	025.254.0441	Curb and gutter, steel forms, 24" wide, radiused	48.00	L.F.	4.05	0.12	6	0.027	33.11	114.0%	122.6%	120.0%	325.04	374.09	7.70	27.20		734.03
10	025.254.0300	Curb, no gutter, straight	206.00	L.F.	3.32	0.07	6	0.016	33.11	114.0%	122.6%	120.0%	936.17	863.27	19.84	78.23		1,897.50
11	033.126.0040	Ready mix concrete, 3000 psi	37.71	C.Y.	56.18					102.3%	110.2%	120.0%	2,599.24	0.00	0.00	214.44		2,813.68
12	033.172.4600	Placing concrete, vibrating, slab on grade over 6" thick, direct chute	37.71	C.Y.		0.41	6	0.048	28.18	102.3%	110.2%	120.0%	0.00	408.44	19.13	0.96		428.53
13	033.454.0150	Finishing slab surface, broom finish	1,268.00	S.F.		0.06	1	0.012	31.65	102.3%	110.2%	120.0%	0.00	628.00	88.18	4.41		720.59
14	033.134.0300	Curing concrete with sprayed membrane curing compound	12.68	C.S.F.	2.16		2	0.084	26.85	102.3%	110.2%	120.0%	33.51	75.71	0.00	2.76		111.98
15	031.154.0010	Forms in place, equipment foundations, 1 use, 18" high	955.50	SFCA	1.80	0.22	6	0.050	33.11	114.0%	122.6%	120.0%	2,358.05	13,962.43	287.57	208.82		16,816.07
16	032.107.0600	Reinforcing in place, A615 Gr.60, slab on grade, 2 mats, 12852 L.F. of #5	8.70	TON	610.50		4	3.478	40.00	124.5%	129.3%	120.0%	6,113.10	5,787.45	0.00	504.33		12,404.87
17	033.126.0040	Ready mix concrete, 3000 psi	107.08	C.Y.	56.18					102.3%	110.2%	120.0%	7,381.76	0.00	0.00	608.99		7,000.75
18	033.172.4600	Placing concrete, vibrating, slab on grade over 6" thick, direct chute	107.08	C.Y.		0.41	6	0.048	28.16	102.3%	110.2%	120.0%	0.00	1,159.98	54.33	2.72		1,217.01
19	033.454.0150	Finishing slab surface, broom finish	2,020.00	S.F.		0.06	1	0.012	31.65	102.3%	110.2%	120.0%	0.00	1,452.92	204.02	10.20		1,667.14
20	033.134.0300	Curing concrete with sprayed membrane curing compound	29.29	C.S.F.	2.16		2	0.084	26.85	102.3%	110.2%	120.0%	77.52	175.16	0.00	6.40		259.07
21	020.728.0010	Saw cutting asphalt, 4" depth	300.00	L.F.	0.30	0.51	2	0.015	29.65	98.7%	111.6%	120.0%	105.53	354.60	180.21	17.72		658.05
22	020.728.0400	Saw cutting concrete slab, mesh reinforced, 4" deep	60.00	L.F.	1.14	1.14	2	0.033	29.85	98.7%	111.6%	120.0%	81.30	158.83	80.72	10.74		331.59
23	022.258.2550	Chain trencher, 40 H.P., operator riding, 6" wide trench and backfill, 36" deep	450.00	L.F.	1.02	0.19	1	0.010	32.10	98.7%	111.6%	120.0%	545.24	193.45	99.07	49.94		887.69
24	022.254.0060	Excavating trench, 3' deep, 1/2 C.Y. tractor loader / backhoe	90.73	C.Y.		1.58	2	0.040	30.30	98.7%	111.6%	120.0%	0.00	294.52	169.38	8.47		472.37
25	022.254.3020	Backfill and compact trench, 3' deep, 1/2 C.Y. tractor loader / backhoe	40.22	C.Y.		4.17	3	0.089	29.15	98.7%	111.6%	120.0%	0.00	418.72	198.55	9.93		627.20
26	026.852.0600	1-1/2" Sch. 40 black steel pipe, threaded end, tar coated and wrapped	450.00	L.F.	3.71		2	0.100	34.19	98.6%	123.3%	120.0%	1,933.72	4,550.88	0.00	159.53		6,644.13
27	160.240.1000	6 conduits in trench, includes terminations and fittings, 4" diameter	750.00	L.F.	17.65		1	0.160	37.15	99.0%	120.9%	120.0%	11,271.15	6,467.67	0.00	929.87		18,668.69
28	160.240.0600	3" conduits in trenchs, includes terminations and fittings	856.25	L.F.	7.81		1	0.100	37.15	99.0%	120.9%	120.0%	7,944.53	4,614.95	0.00	655.42		13,214.90
29	160.240.0200	2" conduits in trenchs, includes terminations and fittings	1,150.00	L.F.	3.74		1	0.053	37.15	99.0%	120.0%	120.0%	5,100.58	3,305.70	0.00	421.54		8,838.83
30	033.126.0010	Ready mix concrete, 2000 psi, red	30.09	C.Y.	65.78					102.3%	110.2%	120.0%	2,429.95	0.00	0.00	200.47		2,630.42
31	033.172.4800	Placing concrete, vibrating, direct chute	30.09	C.Y.		0.41	6	0.048	28.16	102.3%	110.2%	120.0%	0.00	325.97	15.27	0.76		342.00
32	022.274.0100	Mobilization and demobilization for equipment in items 19, 20 & 21, up to 25 miles	2.00	EACH		202.97	1	2.105	27.65	98.7%	111.6%	120.0%	0.00	155.91	480.00	24.04		660.76
33	022.308.0300	Base course, crushed 1-1/2" stone, compacted 6" deep	732.33	S.Y.	5.71	0.37	5	0.003	30.22	98.7%	111.6%	120.0%	4,051.05	395.17	325.00	424.78		6,096.83
34	025.128.1070	Crushed stone granite chips 4" deep	6,591.00	S.F.	0.07		2	0.019	26.85	98.7%	111.6%	120.0%	515.22	8,922.20	0.00	42.51		9,479.93
35	022.308.0304	Base course, crushed 1-1/2" stone, compacted 12" deep	991.00	S.Y.	8.58	0.82	5	0.004	30.22	98.7%	111.6%	120.0%	10,070.69	891.25	733.07	867.49		12,562.50
36	025.104.0460	Asphaltic concrete pavement, 3" thick wearing course	991.00	S.Y.	5.17	0.38	12	0.002	29.40	98.7%	111.6%	120.0%	6,068.24	764.55	447.35	523.00		7,803.13
37	022.274.0100	Mobilization and demobilization for equipment in items 29, 31 & 32, up to 25 miles	7.00	EACH		202.97	1	2.105	27.65	98.7%	111.6%	120.0%	0.00	545.69	1,682.81	84.14		2,312.64
38	028.308.0500	Fence, 6 ga. chain link, 6' high plus 3 strands barbed wire, 2" posts 10' O.C.	490.00	L.F.	9.74	1.78	4	0.002	20.01	98.7%	111.6%	120.0%	5,649.77	2,436.89	1,034.77	517.84		9,639.28
39	028.308.1100	Fence, 3" corner posts	6.00	EACH	50.60	11.14	4	0.200	20.01	98.7%	111.6%	120.0%	359.58	188.50	79.19	33.63		658.90
40	028.308.1300	Fence, braces	10.00	EACH	13.59	5.57	4	0.100	29.01	98.7%	111.6%	120.0%	160.90	155.41	65.99	16.57		398.88
41		4" Sch 40 steel pipe posts, 3' high, filled with concrete and extending 2' into base	14.00	EACH	90.50	11.14	4	0.200	29.01	98.7%	111.6%	120.0%	1,550.38	435.16	184.78	137.15		2,307.47
42	029.204.3800	Spread conditioned topsoil, 6" deep, by hand	664.89	S.Y.	3.17		3	0.022	27.87	98.7%	111.6%	120.0%	2,494.78	1,654.40	0.00	205.82		4,355.00
43	029.104.0800	Sprinkler irrigation system, 1" supply	5,984.00	S.F.	0.24		3	0.003	30.52	98.7%	111.6%	120.0%	1,715.16	2,241.04	0.00	141.50		4,097.71
44	029.528.0640	Shrubs, Juniper Skyrocket, 4' - 5' high	25.00	EACH	36.30		3	0.229	27.87	98.7%	111.6%	120.0%	1,074.84	639.75	0.00	88.67		1,803.27
45	029.508.2400	Ground cover, English Ivy	5.98	M.S.F.	286.00		3	4.444	27.87	98.7%	111.6%	120.0%	2,027.01	2,977.56	0.00	167.23		5,171.80
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00
										100.0%	100.0%	100.0%	0.00	0.00	0.00	0.00		0.00

TOTAL FROM THIS SHEET = $215,334.62

TOTAL FROM PRECEEDING SHEETS =

RUNNING TOTAL = $215,334.62

TABLE 27. HPR OPERATION MATERIALS

	OPERATING COSTS Weekly operating costs	HPR		
No.	Description	Quantity	Cost per unit	Total cost
2.5	Utilities			
	Electricity (kWh)	10,253	0.1 $/kWh	1,025
	Natural gas (scf)	120,960	0.7 $/100 scf	847
	Water (gal)	1,325	0.02 $/gal	26
	Total for one week			1,898
2.2	Feedstock			
	Sawdust (lb)	4,800	0.1 $/lb	480
	Total for one week			480
2.3	Gases			
	HYDROGEN:			
	H2 trailer rent	2	1000 $/wk	2,000
	Trailer mileage	50	1.8 $/mi	90
	Hydrogen gas (100 scf)	2,346	4.25 $/100 scf	9,971
	CO:			
	CO trailer rent	1	1000 $/wk	1,000
	Trailer mileage	3,200	1.8 $/mi	5,760
	Carbon monoxide gas (100 scf)	171	6 $/100 scf	1,026
	NITROGEN:			
	N2 trailer rent	1	1000 $/wk	1,000
	Trailer mileage	50	1.8 $/mi	90
	Nitrogen gas (100 scf)	130	1.75 $/100 scf	228
	Nitrogen - startup, trailer rent	1	1000 $/wk	1,000
	Trailer mileage	50	1.8 $/mi	90
	Nitrogen - startup gas (100 scf)	720	1.75 $/100 scf	1,260
	Nitrogen 6 packs (100 scf)	4	2.5 $/100 scf	10
	Nitrogen 6 pack demurrage	1	9 $/6-pack	9
	CO2:			
	CO2 bottled gas (100 scf)	325	10 $/100 scf	3,250
	CO2 bottle demurrage	135	2 $/bottle	270
	Total for a one-week period			27,053
	Total operating costs for one week			$29,431
	Number of one week periods			4
	Total weekly operating costs			$117,726

TABLE 28. SPR OPERATION MATERIALS

	OPERATING COSTS	SPR		
	Weekly operating costs			
No.	Description	Quantity	Cost per unit	Total cost
7.5	Utilities			
	Electricity (kWh)	10,253	0.1 $/kWh	1,025
	Natural gas (scf)	242,000	0.7 $/100 scf	1,694
	Water (gal)	1,325	0.02 $/gal	26
	Total for one week			2,746
7.2	Feedstock			
	Sawdust (lb)	4,800	0.1 $/lb	480
	Total for one week			480
7.3	Gases			
	HYDROGEN:			
	H2 trailer rent	2	1000 $/wk	2,000
	Trailer mileage	50	1.8 $/mi	90
	Hydrogen gas (100 scf)	2,346	4.25 $/100 scf	9,971
	CO:			
	CO trailer rent	1	1000 $/wk	1,000
	Trailer mileage	3,200	1.8 $/mi	5,760
	Carbon monoxide gas (100 scf)	171	6 $/100 scf	1,026
	NITROGEN:			
	N2 trailer rent	1	1000 $/wk	1,000
	Trailer mileage	50	1.8 $/mi	90
	Nitrogen gas (100 scf)	130	1.75 $/100 scf	228
	Nitrogen - startup, trailer rent	1	1000 $/wk	1,000
	Trailer mileage	50	1.8 $/mi	90
	Nitrogen - startup gas (100 scf)	720	1.75 $/100 scf	1,260
	Nitrogen 6 packs (100 scf)	4	2.5 $/100 scf	10
	Nitrogen 6 pack demurrage	1	9 $/6-pack	9
	CO2:			
	CO2 bottled gas (100 scf)	325	10 $/100 scf	3,250
	CO2 bottle demurrage	135	2 $/bottle	270
	Total for a one-week period			27,053
	Total operating costs for one week			$30,279
	Number of one week periods			3
	Total weekly operating costs			$90,836

TABLE 29. MSR OPERATION MATERIALS

	OPERATING COSTS Weekly operating costs	MSR		
No.	Description	Quantity	Cost per unit	Total cost
8.4	Utilities			
	Electricity (kWh)	5,000	0.1 $/kWh	500
	Natural gas (scf)	242,000	0.7 $/100 scf	1,694
	Water (gal)	1,325	0.02 $/gal	26
	Total for one week			2,220
8.2	Feedstock			
	Sawdust (lb)	4,800	0.1 $/lb	480
	Total for one week			480
8.3	Gases			
	HYDROGEN:			
	H2 trailer rent	0	1000 $/wk	0
	Trailer mileage	0	1.8 $/mi	0
	Hydrogen gas (100 scf)	0	4.25 $/100 scf	0
	CO:			
	CO trailer rent	0	1000 $/wk	0
	Trailer mileage	0	1.8 $/mi	0
	Carbon monoxide gas (100 scf)	0	6 $/100 scf	0
	NITROGEN:			
	N2 trailer rent	0	1000 $/wk	0
	Trailer mileage	0	1.8 $/mi	0
	Nitrogen gas (100 scf)	0	1.75 $/100 scf	0
	Nitrogen - startup, trailer rent	0	1000 $/wk	0
	Trailer mileage	0	1.8 $/mi	0
	Nitrogen - startup gas (100 scf)	0	1.75 $/100 scf	0
	Nitrogen 6 packs (100 scf)	200	2.5 $/100 scf	500
	Nitrogen 6 pack demurrage	1	9 $/6-pack	9
	CO2:			
	CO2 bottled gas (100 scf)	0	10 $/100 scf	0
	CO2 bottle demurrage	0	2 $/bottle	0
	Total for a one-week period			509
	Total operating costs for one week			$3,209
	Number of one week periods			2
	Total weekly operating costs			$6,419

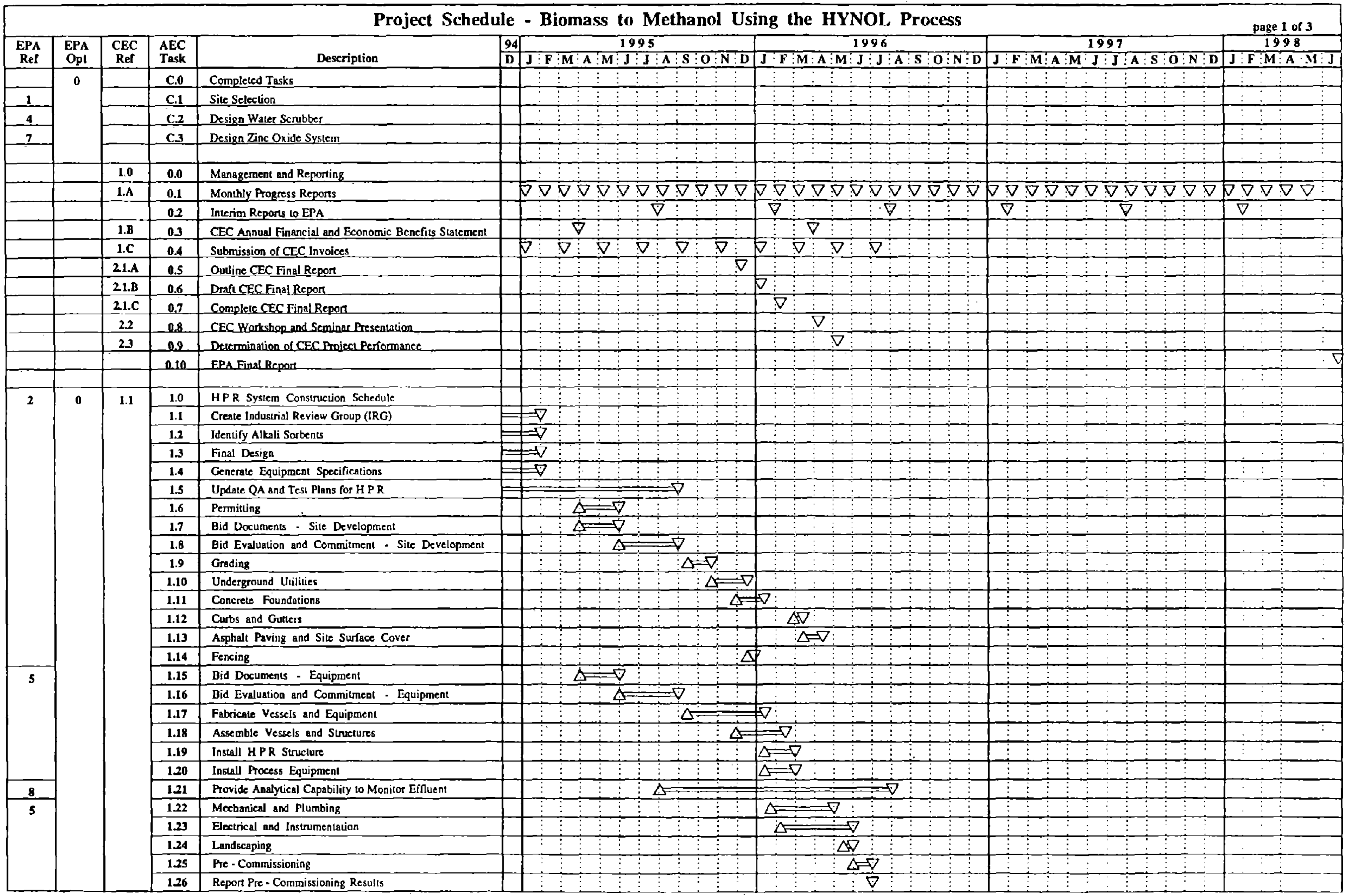
SECTION 8

PROJECT SCHEDULE

Figure 13 shows the project schedule corresponding to the tasks and major milestones in the Work Breakdown Schedule. The contract with EPA will start in August, while activities with funding from CEC and the SCAQMD will be start at a slower pace prior to this date. During the first 6 months of 1995, we expect to continue with site development activities such as completing the site plan and soliciting bids for construction work. Site development and HPR system procurement will take place during the first year of the project. The HPR/SPR structure will be installed with the HPR and biomass feed system which will be followed by the operation of the HPR on clean white wood. Testing of the performance of the hot gas clean up system will also take place at this time. The SPR will be delivered after HPR testing and installed shortly afterwards. The compressors and associated equipment for the MSR system will be procured while the reactor is being shipped. After SPR testing is completed, the MSR, compressors, and fuel tank will be installed.

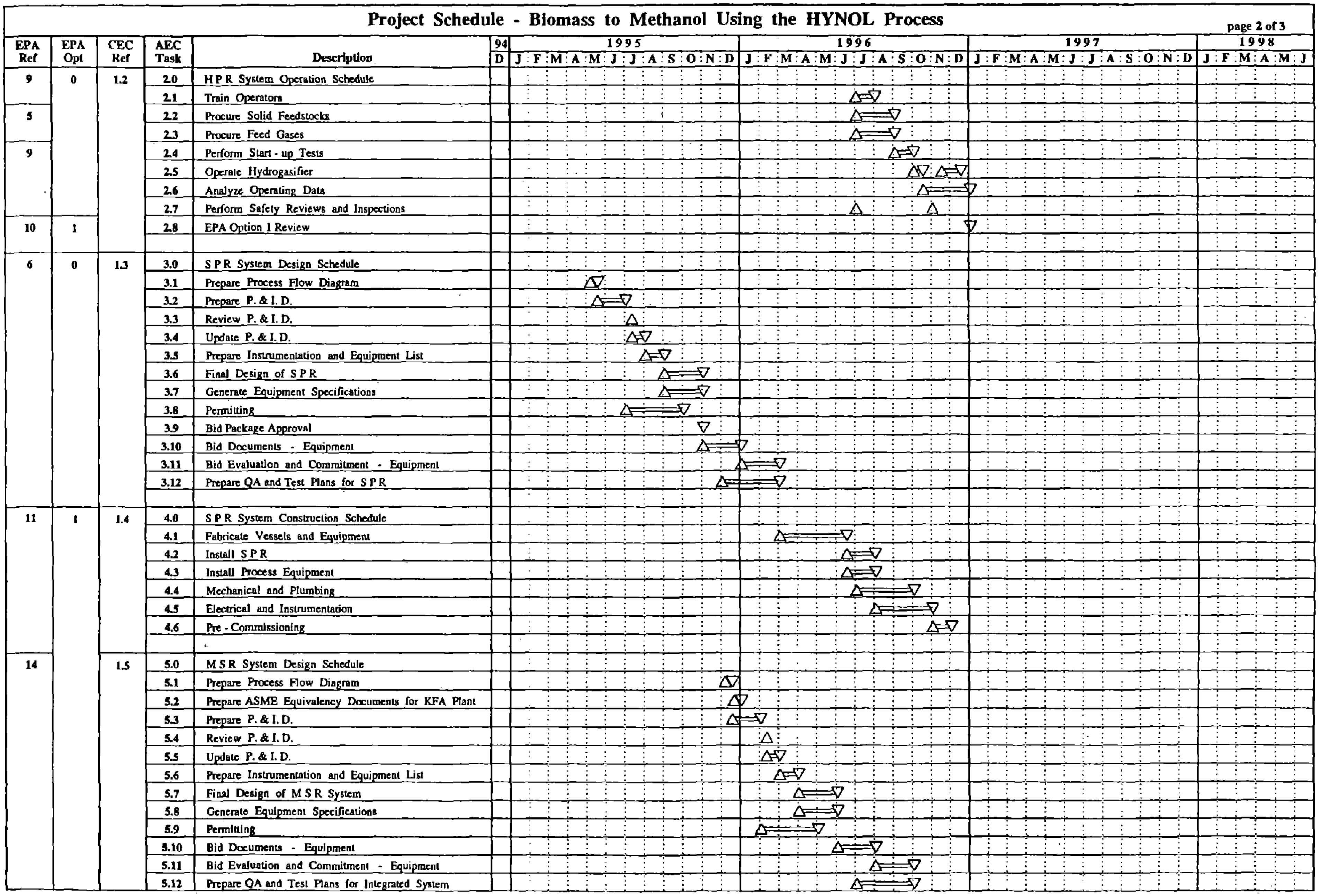
The project schedule allows for the completion of the HPR, SPR, and MSR systems in the first 2 years of the project. Additional operation of the integrated system with alternate feedstocks can be completed in the third year. Some alternative feedstocks will also be tested as part of the HPR operation in Task 2.

For Phase III, in the third year of the project, we plan to perform additional testing with wood feedstocks and alternate feedstocks. Such waste might include tree trimmings and wooden palates. The composition of these wastes would consist of a higher alkali content, but sulfur and chlorine content should not be sufficiently high that new gas clean up systems will be required. Alternate gas clean up systems can also be tested in the third-year option period. Both a hot gas cleaning system and a water scrubber system have been considered for particulate removal for the Hynol system. Alternate clean up systems can be tested in the third year of the program.



EPA Ref	EPA Opt	CEC Ref	AEC Task	Description
	0		C.0	Completed Tasks
1			C.1	Site Selection
4			C.2	Design Water Scrubber
7			C.3	Design Zinc Oxide System
		1.0	0.0	Management and Reporting
		1.A	0.1	Monthly Progress Reports
			0.2	Interim Reports to EPA
		1.B	0.3	CEC Annual Financial and Economic Benefits Statement
		1.C	0.4	Submission of CEC Invoices
		2.1.A	0.5	Outline CEC Final Report
		2.1.B	0.6	Draft CEC Final Report
		2.1.C	0.7	Complete CEC Final Report
		2.2	0.8	CEC Workshop and Seminar Presentation
		2.3	0.9	Determination of CEC Project Performance
			0.10	EPA Final Report
2	0	1.1	1.0	H P R System Construction Schedule
			1.1	Create Industrial Review Group (IRG)
			1.2	Identify Alkali Sorbents
			1.3	Final Design
			1.4	Generate Equipment Specifications
			1.5	Update QA and Test Plans for H P R
			1.6	Permitting
			1.7	Bid Documents - Site Development
			1.8	Bid Evaluation and Commitment - Site Development
			1.9	Grading
			1.10	Underground Utilities
			1.11	Concrete Foundations
			1.12	Curbs and Gutters
			1.13	Asphalt Paving and Site Surface Cover
			1.14	Fencing
5			1.15	Bid Documents - Equipment
			1.16	Bid Evaluation and Commitment - Equipment
			1.17	Fabricate Vessels and Equipment
			1.18	Assemble Vessels and Structures
			1.19	Install H P R Structure
			1.20	Install Process Equipment
8			1.21	Provide Analytical Capability to Monitor Effluent
5			1.22	Mechanical and Plumbing
			1.23	Electrical and Instrumentation
			1.24	Landscaping
			1.25	Pre - Commissioning
			1.26	Report Pre - Commissioning Results

Figure 13. Project schedule.



Project Schedule - Biomass to Methanol Using the HYNOL Process

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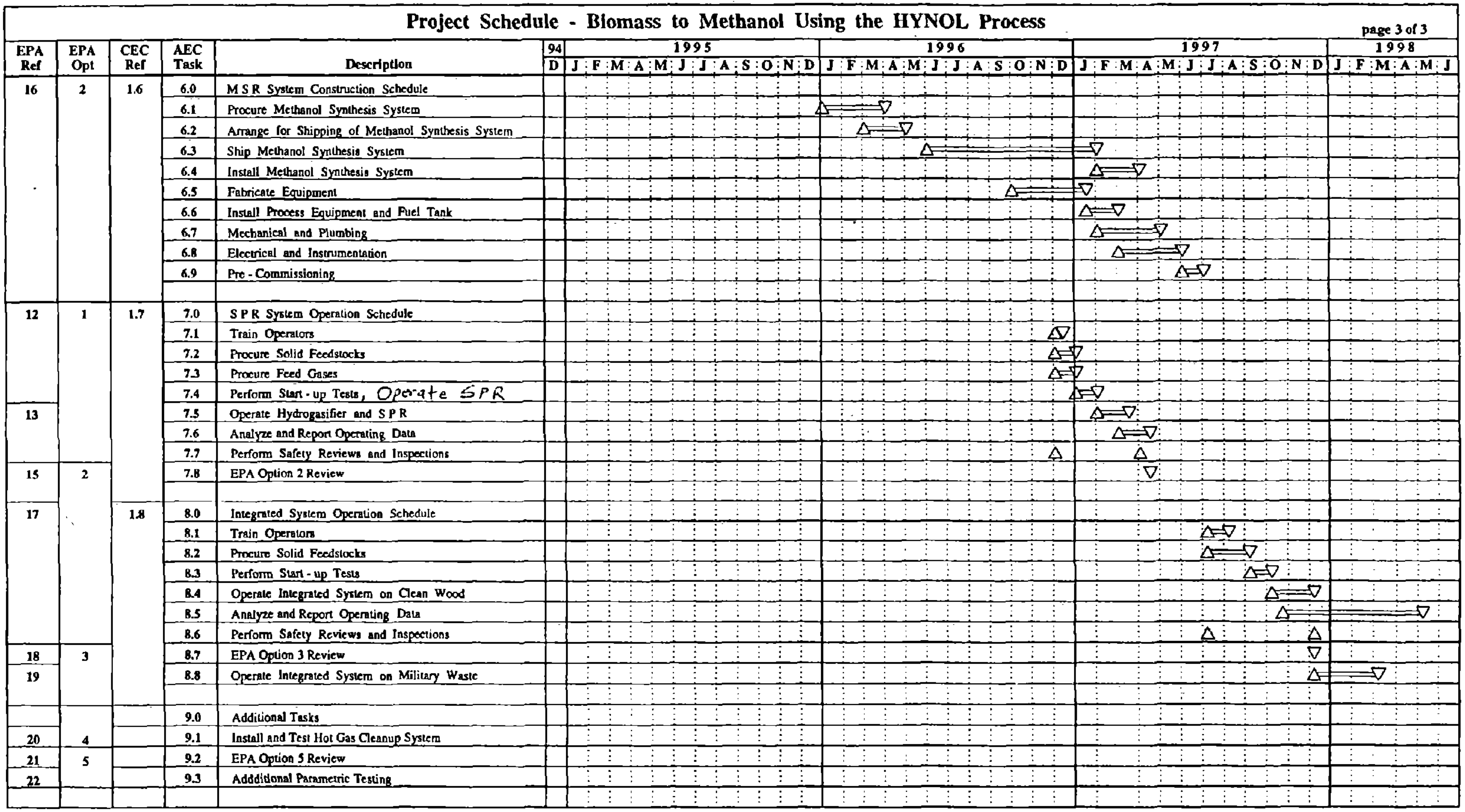
EPA Ref	EPA Opt	CEC Ref	AEC Task	Description
9	0	1.2	2.0	H P R System Operation Schedule
			2.1	Train Operators
5			2.2	Procure Solid Feedstocks
			2.3	Procure Feed Gases
9			2.4	Perform Start - up Tests
			2.5	Operate Hydrogasifier
			2.6	Analyze Operating Data
			2.7	Perform Safety Reviews and Inspections
10	1		2.8	EPA Option 1 Review
6	0	1.3	3.0	S P R System Design Schedule
			3.1	Prepare Process Flow Diagram
			3.2	Prepare P. & I. D.
			3.3	Review P. & I. D.
			3.4	Update P. & I. D.
			3.5	Prepare Instrumentation and Equipment List
			3.6	Final Design of S P R
			3.7	Generate Equipment Specifications
			3.8	Permitting
			3.9	Bid Package Approval
			3.10	Bid Documents - Equipment
			3.11	Bid Evaluation and Commitment - Equipment
			3.12	Prepare QA and Test Plans for S P R
11	1	1.4	4.0	S P R System Construction Schedule
			4.1	Fabricate Vessels and Equipment
			4.2	Install S P R
			4.3	Install Process Equipment
			4.4	Mechanical and Plumbing
			4.5	Electrical and Instrumentation
			4.6	Pre - Commissioning
14		1.5	5.0	M S R System Design Schedule
			5.1	Prepare Process Flow Diagram
			5.2	Prepare ASME Equivalency Documents for KFA Plant
			5.3	Prepare P. & I. D.
			5.4	Review P. & I. D.
			5.5	Update P. & I. D.
			5.6	Prepare Instrumentation and Equipment List
			5.7	Final Design of M S R System
			5.8	Generate Equipment Specifications
			5.9	Permitting
			5.10	Bid Documents - Equipment
			5.11	Bid Evaluation and Commitment - Equipment
			5.12	Prepare QA and Test Plans for Integrated System

Figure 13. Project schedule (continued).



Project Schedule - Biomass to Methanol Using the HYNOL Process

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EPA Ref	EPA Opt	CEC Ref	AEC Task	Description
16	2	1.6	6.0	M S R System Construction Schedule
			6.1	Procure Methanol Synthesis System
			6.2	Arrange for Shipping of Methanol Synthesis System
			6.3	Ship Methanol Synthesis System
			6.4	Install Methanol Synthesis System
			6.5	Fabricate Equipment
			6.6	Install Process Equipment and Fuel Tank
			6.7	Mechanical and Plumbing
			6.8	Electrical and Instrumentation
			6.9	Pre - Commissioning
12	1	1.7	7.0	S P R System Operation Schedule
			7.1	Train Operators
			7.2	Procure Solid Feedstocks
			7.3	Procure Feed Gases
			7.4	Perform Start - up Tests, Operate SPR
13			7.5	Operate Hydrogasifier and S P R
			7.6	Analyze and Report Operating Data
			7.7	Perform Safety Reviews and Inspections
15	2		7.8	EPA Option 2 Review
17		1.8	8.0	Integrated System Operation Schedule
			8.1	Train Operators
			8.2	Procure Solid Feedstocks
			8.3	Perform Start - up Tests
			8.4	Operate Integrated System on Clean Wood
			8.5	Analyze and Report Operating Data
			8.6	Perform Safety Reviews and Inspections
18	3		8.7	EPA Option 3 Review
19			8.8	Operate Integrated System on Military Waste
			9.0	Additional Tasks
20	4		9.1	Install and Test Hot Gas Cleanup System
21	5		9.2	EPA Option 5 Review
22			9.3	Addditional Parametric Testing

Figure 13. Project schedule (concluded).

APPENDIX A

SUPPLEMENTAL INFORMATION

8/31/95 Based o 50 lbs/hr dry wood, Flowsheet D, 9/8/94

REVISION 3 ▨ indicates calculated values

Stream #	1		2		3		4		5		6		7 same as 65		SUM OF INPUTS TO HPR 1+2+3+4+5+6+7	
Properties	BIOMASS		STEAM		KAOLINITE		SAND		N2 Makeup gas		CH4 to HPR		HPR In, postHX			
Q, kg/h	25.8		—		—		—		—		—		24.85		50.65	
Normal m3/h	—		—		—		—		—		—		91.77		—	
Actual m3/h	0.036		—		—		—		—		—		12.14		—	
MW	7,520		18.00		190.00		—		28.00		16.00		6.53		—	
Enthal. kcal/h	-40,077		-15,981		—		—		0		0		-35,255		-91,313	
T, °C	25		268		150		150		25		150		888			
P, atm	30		30		30		30		30		30		30		30	
Components:	kmol/hr	wt %	kmol/hr	mole %	kmol/hr	wt %	kmol/hr	wt %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %
H2	—		—		—		—		—		—		2.93	76.69	2.93	76.6900
CH4	—		—		—		—		—		—		0.58	15.28	0.58	15.2800
CO	—		—		—		—		—		—		0.15	3.80	0.15	3.8000
CO2	—		—		—		—		—		—		0.05	1.22	0.05	1.2200
H20	0.17	11.80	—	100.00	—		—		—		—		0.0019	0.20	0.00	0.0500
O2	—		—		—		—		—		—		—	—	—	—
N2	—		—		—		—		—		—		0.05	1.39	0.05	1.3900
H2S	—		—		—		—		—		—		—	—	—	—
CH3OH	—		—		—		—		—		—		0.06	1.57	0.06	1.5700
TOTAL	—		—	100.00	—		—		—		—		3.82	100.15	3.82	100.00
Elements:																
H	1.69	6.60	—	#DIV/0!	—		—		—		—		8.45	87.17	10.13	77.2520
C	0.98	45.81	—		—		—		—		—		0.84	8.63	1.82	13.8813
O	0.75	46.35	—	#DIV/0!	—		—		—		—		0.30	3.10	1.05	7.9877
N	0.01	0.42	—		—		—		—		—		0.11	1.10	0.11	0.8692
S	0.00	0.16	—		—		—		—		—		—	—	0.00	0.0098
Total elements	3.43	99.34	—	#DIV/0!	—		—		—		—		9.69	100.00	13.12	100.00
Inerts (kg/h)	0.17	0.66	—		—		—		—		—				0.17	
Enthalpy:	adjusted for moisture		JANAF		dH = m*Cp*dT		dH = m*Cp*dT		JANAF		JANAF		JANAF		1+2+3+4+5+6+7	

HYNPFD3.XLS

8/31/95

REVISION 3			ash + residual Carbon								2 + 6 + 7					
Stream #	**92**		**9**		**10**		**8**		**67**		**73**		**44**		**18**	
Properties	**HPR OUTLET**		**Char ash - HPR**		**Ash-F104**		**F-205 out**		**CH4 to cleanup**		**HPR gas inlet**		**SPR exit**		**Post HX-205**	
Q, kg/h	74.71		1.68		—		74.67		12.90		24.85		118.53		118.53	
Normal m3/h	117.89		—		—		117.86		19.30		91.77		246.85		246.85	
Actual m3/h	14.42		—		—		14.41		0.66		11.22		35.82		26.38	
MW	15.21		12.01		—		15.20		16.04		6.50		11.52		11.52	
Enthal. kcal/h	-91,736		422.7		—		-91,736		—		-51,236		-89,878			
T, °C	800		800		800		800		25		800		1000		664	
P, atm	30		30		30		30		30		30		30		30	
Components:	kmol/hr	mole %	kg/hr	wt %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %
H2	1.84	37.44	—		—		1.84	37.44	—		2.93	76.69	6.03	58.65	6.03	58.65
CH4	0.96	19.48	—		—		0.96	19.48	0.80	100.00	0.58	15.28	0.34	3.26	0.34	3.26
CO	0.66	13.42	—		—		0.66	13.43	—		0.15	3.80	2.17	21.09	2.17	21.09
CO2	0.38	7.72	—		—		0.38	7.72	—		0.05	1.22	0.30	2.87	0.30	2.87
H20	0.97	19.76	—		—		0.97	19.76	—		0.00	0.05	1.35	13.10	1.35	13.10
O2	—	—	—		—		—	—	—		0.00	—	—	—	—	—
N2	0.11	2.16	—		—		0.11	2.16	—		0.05	1.39	0.11	1.03	0.11	1.03
H2S	0.00	0.03	—		—		—	—	—		0.00	—	—	—	—	—
CH3OH	—	—	—		—		—	—	—		0.06	1.57	—	—	—	—
TOTAL	4.91	100.00	—		—		4.91	100.00	0.80	100.00	3.82	100.00	10.29	100.00	10.29	100.00
Elements:																
H	9.45	67.27	—	—	—		9.45	67.27	3.22	80.00	8.45	87.17	16.10	69.34	16.10	69.34
C	2.00	14.21	1.51	100.00	—		2.00	14.21	0.80	20.00	0.84	8.63	2.80	12.06	2.80	12.06
O	2.39	17.00	—	—	—		2.39	17.01	—	—	0.30	3.10	4.11	17.69	4.11	17.69
N	0.21	1.51	—	—	—		0.21	1.51	—	—	0.11	1.10	0.21	0.91	0.21	0.91
S	0.00	0.01	—	—	—		—	—	—	—	0.00	0.00	0.00	0.00	0.00	0.00
Total elements	14.05	100.00	1.51	100.00	—		14.04	100.00	4.02	100.00	9.69	100.00	23.22	100.00	23.22	100.00
Inerts (kg/h)	—		0.17				—		—							
Enthalpy:	1+2+3+4+5+6		Hydrocarb		Hydrocarb		60+67		JANAF		2+6+7					
			ash: h = -223 kcal/kg													
			C: h = 267.5 kcal/kg													

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Composition data

REVISION 3

Stream #	21		27		30		31		33		25		49		51	
Properties	Post-HX to MSR		MSR out		Cond. out		MSR Loop		Pre-HX Inlet		Purge		Distillate H20		Methanol	
Q, kg/h	118.53		343.0		271.59		246.22		24.85		0.52		19.43		51.96	
Normal m3/h	246.85		1,077.13		1,016.65		921.59		91.77		1.92		—			
Actual m3/h	9.09		70.11		36.92		33.47		3.38		0.07					
MW	11.52		11.97		6.50		6.50		6.50		6.50		18.00		32.04	
Enthal. kcal/h					-711,679				-30,520							
T, °C	50		260		50		50		50		50		50		25	
P, atm	30		30		30		30		30		30		1		1	
Components:	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole%	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %
H2	6.03	58.65	31.56	65.64	32.04	76.69	29.05	76.69	2.93	76.69	0.06	76.69	—	—	—	—
CH4	0.34	3.26	3.58	7.45	6.38	15.28	5.79	15.28	0.58	15.28	0.01	15.28	—	—	—	—
CO	2.17	21.09	2.55	5.31	1.59	3.80	1.44	3.80	0.15	3.80	0.00	3.80	—	—	—	—
CO2	0.30	2.87	5.93	12.34	0.51	1.22	0.46	1.22	0.05	1.22	0.00	1.22	—	—	—	—
H20	1.35	13.10	1.17	2.43	0.02	0.05	0.02	0.05	0.00	0.05	0.00	0.05	1.08	100.00	—	—
O2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N2	0.11	1.03	1.13	2.36	0.58	1.39	0.53	1.39	0.05	1.39	0.00	1.39	—	—	—	—
H2S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
CH3OH	—	—	2.15	4.47	0.66	1.57	0.59	1.57	0.06	1.57	0.00	1.57	—	—	1.62	100.00
TOTAL	10.29	100.00	48.09	100.00	41.78	100.00	37.88	100.00	3.82	100.00	0.08	100.00	1.08	100.00	1.62	100.00
Elements:																
H	16.10	69.34	88.39	72.09	92.29	87.17	83.67	87.17	8.45	87.17	0.18	87.17	2.16	66.67	6.49	66.67
C	2.80	12.06	14.22	11.60	9.14	8.63	8.28	8.63	0.84	8.63	0.02	8.63	0.00	0.00	1.62	16.67
O	4.11	17.69	17.74	14.47	3.28	3.10	2.98	3.10	0.30	3.10	0.01	3.10	1.08	33.33	1.62	16.67
N	0.21	0.91	2.27	1.85	1.16	1.10	1.05	1.10	0.11	1.10	0.00	1.10	0.00	0.00	0.00	0.00
S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total elements	23.22	100.00	122.62	100.00	105.87	100.00	95.98	100.00	9.69	100.00	0.20	100.00	3.24	100.00	9.73	100.00
Inerts (kg/h)																
Enthalpy:									JANAF							

Hynol Actual HPR System

5/4/94 Based on : 50 lbs/hr dry wood, from Y. Dong/M. Steinberg memo (8-3-93), CASE 1; scaling factor = 0.258

REVISION 7 ▨ indicates calculated values

													same as 65		1+2+3+4+5+6+7	
Stream #	1		2		3		4		5		6		7		SUM OF INPUTS TO HPR	
Properties	GREENWASTE		STEAM		KAOLINITE		SAND		N2 Makeup gas		"Recycle" CH4		HPR In, postHX			
Q, kg/h	25.800		5.26		2.70		0.30		1.23		5.17		40.01		80.47	
Normal m3/h	---		7.01		---		---		1.06		7.73		92.23		---	
Actual m3/h	0.036		0.41		0.0023		0.0001		0.04		0.26		9.18		---	
MW	7.528		18.00		190.00		---		28.00		16.05		10.41		---	
Enthal. kcal/h	-34,201		-16,532		-380.84		-36.75		0		-5778		-40,893		-91,393	
T, °C	150		235		150		150		25		25		600			
P, atm	30		30		30		30		30		30		30		30	
Components:	kmol/hr	wt %	kmol/hr	mole %	kmol/hr	wt %	kmol/hr	wt %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %
H2	---		---		---		---		---		---		2.93	76.24	2.93	62.7250
CH4	---		---		---		---		---		0.32	100.00	---	---	0.32	6.8933
CO	---		---		---		---		---		---		0.28	7.29	0.28	5.9942
CO2	---		---		---		---		---		---		0.53	13.87	0.53	11.4104
H20	0.17	11.80	0.29	100.00	---		---		---		---		---	---	0.46	9.8952
O2	---		---		---		---		---		---		---	---	---	0.0000
N2	---		---		---		---		0.04	100.00	---		0.10	2.60	0.14	3.0819
H2S	---		---		---		---		---		---		---	---	---	0.0000
CH3OH	---		---		---		---		---		---		---	---	---	0.0000
TOTAL	---		0.29	100.00	---		---		0.04	100.00	0.32	100.00	3.84	100.00	4.67	100.00
Elements:																
H	1.69	6.60	0.58	66.67	---		---		---	---	1.29	80.00	5.86	71.30	9.42	66.2293
C	0.98	45.81	---		---		---		---	---	0.32	20.00	0.81	9.89	2.12	14.9071
O	0.75	46.35	0.29	33.33	---		---		---	---	---	---	1.35	16.38	2.39	16.7755
N	0.01	0.42	---		---		---		0.09	100.00	---	---	0.20	2.43	0.30	2.0791
S	0.00	0.16	---		---		---		---	---	---	---	---	---	0.00	0.0091
Total elements	3.43	99.34	0.88	100.00	---		---		0.09	100.00	1.61	100.00	8.22	100.00	14.22	100.00
Inerts (kg/h)	0.17	0.66	---		2.700		0.296		---		---		---		3.17	
Enthalpy:	adjusted for moisture		JANAF		dH = m*Cp*dT		dH = m*Cp*dT		JANAF		JANAF		JANAF		includes steam enthalpy = 1+3+4+5+6+73	

Hynol Actual HPR System

5/4/94			kaolinite + sand +								Not shown on process					
REVISION 7	60+67-10		ash + residual Carbon								flow diagram		same as 8			
Stream #	**8**		**9**		**10**		**12**		**46**		**60**		**61**		**62**	
Properties	**Post-F104**		**Char ash - HPR**		**Ash-F104**		**CH4 to SPR**		**High-P N2**		**HPR OUTLET**		**HPR out-postHX**		**H2 In**	
Q, kg/h	87.45		6.18		---		9.24		1,514		74.55		87.45		5.92	
Normal m3/h	136.90		---		---		13.83		1,304		117.60		136.90		70.32	
Actual m3/h	15.49		---		---		0.16		42.5		14.38		11.44		2.39	
MW	15.33		12.01		---		16.04		28.00		15.21		15.33		2.02	
Enthal. kcal/h	-110,801		99		0		-10,330		99,909		-91,492		-124,269		0	
T, °C	720		800		800		25		288		800		460		25	
P, atm	30		30		30		86		61		30		30		30	
Components:	kmol/hr	mole %	kg/hr	wt %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %
H2	1.83	32.16	---		---		---	---			1.83	37.44	1.83	32.16	2.93	100.00
CH4	1.76	30.82	---		---		0.58	100.00			0.95	19.48	1.76	30.82	---	---
CO	0.66	11.53	---		---		---	---			0.66	13.42	0.66	11.53	---	---
CO2	0.38	6.63	---		---		---	---			0.38	7.72	0.38	6.63	---	---
H20	0.97	16.97	---		---		---	---			0.97	19.76	0.97	16.97	---	---
O2	0.00	0.00	---		---		---	---			0.00	0.00	0.00	0.00	---	---
N2	0.11	1.86	---		---		---	---	54	100	0.11	2.16	0.11	1.86	---	---
H2S	0.00	0.03	---		---		---	---			0.00	0.03	0.00	0.03	---	---
CH3OH	0.00	0.00	---		---		---	---			0.00	0.00	0.00	0.00	---	---
TOTAL	5.70	100.00	---		---		0.58	100.00	54	100	4.90	100.01	5.70	100.00	2.93	100.00
Elements:																
H	12.64	70.11	---	---	---		2.30	80.00	---	---	9.43	67.27	12.64	70.11	5.86	100.00
C	2.79	15.50	3.02	100.00	---		0.58	20.00	---	---	1.99	14.20	2.79	15.50	---	---
O	2.38	13.21	---	---	---		---	---	---	---	2.38	17.00	2.38	13.21	---	---
N	0.21	1.17	---	---	---		---	---	108.14	100.00	0.21	1.51	0.21	1.17	---	---
S	0.00	0.01	---	---	---		---	---	---	---	0.00	0.01	0.00	0.01	---	---
Total elements	18.03	100.00	3.02	100.00	---		2.88	100.00	108.14	100.00	14.01	100.00	18.03	100.00	5.86	100.00
Inerts (kg/h)	---		3.17								---		---			
Enthalpy:	JANAF		ash: h = -223 kcal/kg Hydrocarb				JANAF		JANAF		enthalpy =		JANAF		JANAF	
	60+67-10:		C: h = 267.5 kcal/kg								1+3+4+5+6+73-9					
	-105,914		kaolinite: h = 0								JANAF: -97140.9					

Hynol Actual HPR System

5/4/94

REVISION 7					62+63+64+66				90 + 91		7+2		same as 68		Startup only	
Stream #	63		64		65		66		67		68		68a		69	
Properties	CO in		N2 in		Pre-HX inlet		CO2 in		CH4 to cleanup		Preheater		Postheater		Air	
Q, kg/h	7.84		2.80		40.01		23.45		12.90		45.27		45.27		0.03	
Normal m3/h	6.72		2.40		92.23		12.79		19.29		99.25		99.25		0.02	
Actual m3/h	0.23		0.08		3.13		0.43		0.66		9.03		14.40		0.0008	
MW	28.01		28.00		10.41		44.00		16.05		10.95		10.95		28.84	
Enthal. kcal/h	-7,403		0		-57,544		-50,140		-14422		-57,426		-43,372		0	
T, °C	25		25		25		25		25		525		1000		25	
P, atm	30		30		30		30		30		30		30		30	
Components:	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole%	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %
H2	---	---	---	---	2,93	76.24	---	---	---		2.93	70.85	2.93	70.85	---	---
CH4	---	---	---	---	0.00	0.00	---	---	0.80	100.00	---	---	---	---	---	---
CO	0.28	100.00	---	---	0,28	7.29	---	---	---		0.28	6.77	0.28	6.77	---	---
CO2	---	---	---	---	0.53	13.87	0.53	100.00	---		0.53	12.89	0.53	12.89	---	---
H20	---	---	---	---	0.00	0.00	---	---	---		0.29	7.07	0.29	7.07	---	---
O2	---	---	---	---	0.00	0.00	---	---	---		---	---	---	---	0.00	21.00
N2	---	---	0.10	100.00	0.10	2.60	---	---	---		0.10	2.42	0.10	2.42	0.00	79.00
H2S	---	---	---	---	0.00	0.00	---	---	---		---	---	---	---	---	---
CH3OH	---	---	---	---	0.00	0.00	---	---	---		---	---	---	---	---	---
TOTAL	0.28	100.00	0.10	100.00	3.84	100.00	0.53	100.00	0.80	100.00	4.14	100.00	4.14	100.00	0.00	100.00
Elements:																
H	---	---	---	---	5.86	71.30	---	---	3.21	80.00	6.44	70.85	6.44	70.85	---	---
C	0.28	50.00	---	---	0.81	9.89	0.53	33.33	0.80	20.00	0.81	8.94	0.81	8.94	---	---
O	0.28	50.00	---	---	1.35	16.38	1.07	66.67	---	---	1.64	18.01	1.64	18.01	---	---
N	---	---	0.20	100.00	0.20	2.43	---	---	---	---	0.20	2.20	0.20	2.20	0.00	100.00
S	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total elements	0.56	100.00	0.20	100.00	8.22	100.00	1.60	100.00	4.02	100.00	9.10	100.00	9.10	100.00	0.00	100.00
Inerts (kg/h)									---							
Enthalpy:	JANAF		JANAF		62+63+64+66 JANAF: -57538.9		JANAF		JANAF		7+2 JANAF: -59081.4		JANAF		JANAF	

Hynol Actual HPR System

5/4/94							post H-036									
REVISION 7	6+67		12+70				68A + 6		same as 81		same as 84		same as 74			
Stream #	70		71		72		73		74		75		76		80	
Properties	Natural gas		Total CH4		Steam trap		"Recycle"		Water HPR,SPR		Water stm jkts		City water feed		Steam to SPR	
Q, kg/h	18.07		27.31		---		50.44		52.53		18.20		52.53		47.27	
Normal m3/h	27.02		40.86		0.00		106.97		---		---		---		63.03	
Actual m3/h	0.92		0.48		0.00		13.96		0.05		0.02		0.05		3.65	
MW	16.05		16.04		18.00		11.32		18.02		18.00		18.00		18.00	
Enthal. kcal/h	-20,200		-30,530		0		-50,996		-199,367		-69,074		-199,367		-148,570	
T, °C	25		25		235		872		25		25		25		235	
P, atm	30		86		30		30		1		1		1		30	
Components:	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %
H2	---		---	---	---	---	2.93	65.74	---		---	---	---	---	---	---
CH4	1.13	100.00	1.70	100.00	---	---	0.32	7.22	---		---	---	---	---	---	---
CO	---		---	---	---	---	0.28	6.28	---		---	---	---	---	---	---
CO2	---		---	---	---	---	0.53	11.96	---		---	---	---	---	---	---
H20	---		---	---	---	---	0.29	6.56	2.92	100.00	1.01	100.00	2.92	100.00	2.63	100.00
O2	---		---	---	---	---	---	---	---		---	---	---	---	---	---
N2	---		---	---	---	---	0.10	2.24	---		---	---	---	---	---	---
H2S	---		---	---	---	---	---	---	---		---	---	---	---	---	---
CH3OH	---		---	---	---	---	---	---	---		---	---	---	---	---	---
TOTAL	1.13	100.00	1.70	100.00	0.00	---	4.46	100.00	2.92	100.00	1.01	100.00	2.92	100.00	2.63	100.00
Elements:																
H	4.50	80.00	6.81	80.00	---	---	7.73	72.23	5.83	66.67	2.02	66.67	5.84	66.67	5.25	66.67
C	1.13	20.00	1.70	20.00	---	---	1.14	10.60	---	---	---	---	---	---	---	---
O	---	---	---	---	---	---	1.64	15.30	2.92	33.33	1.01	33.33	2.92	33.33	2.63	33.33
N	---	---	---	---	---	---	0.20	1.87	---	---	---	---	---	---	---	---
S	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total elements	5.63	100.00	8.51	100.00	0.00	---	10.71	100.00	8.75	100.00	3.03	100.00	8.76	100.00	7.88	100.00
Inerts (kg/h)	---															
Enthalpy:	JANAF		12+70		JANAF		JANAF		JANAF		JANAF		JANAF		JANAF	

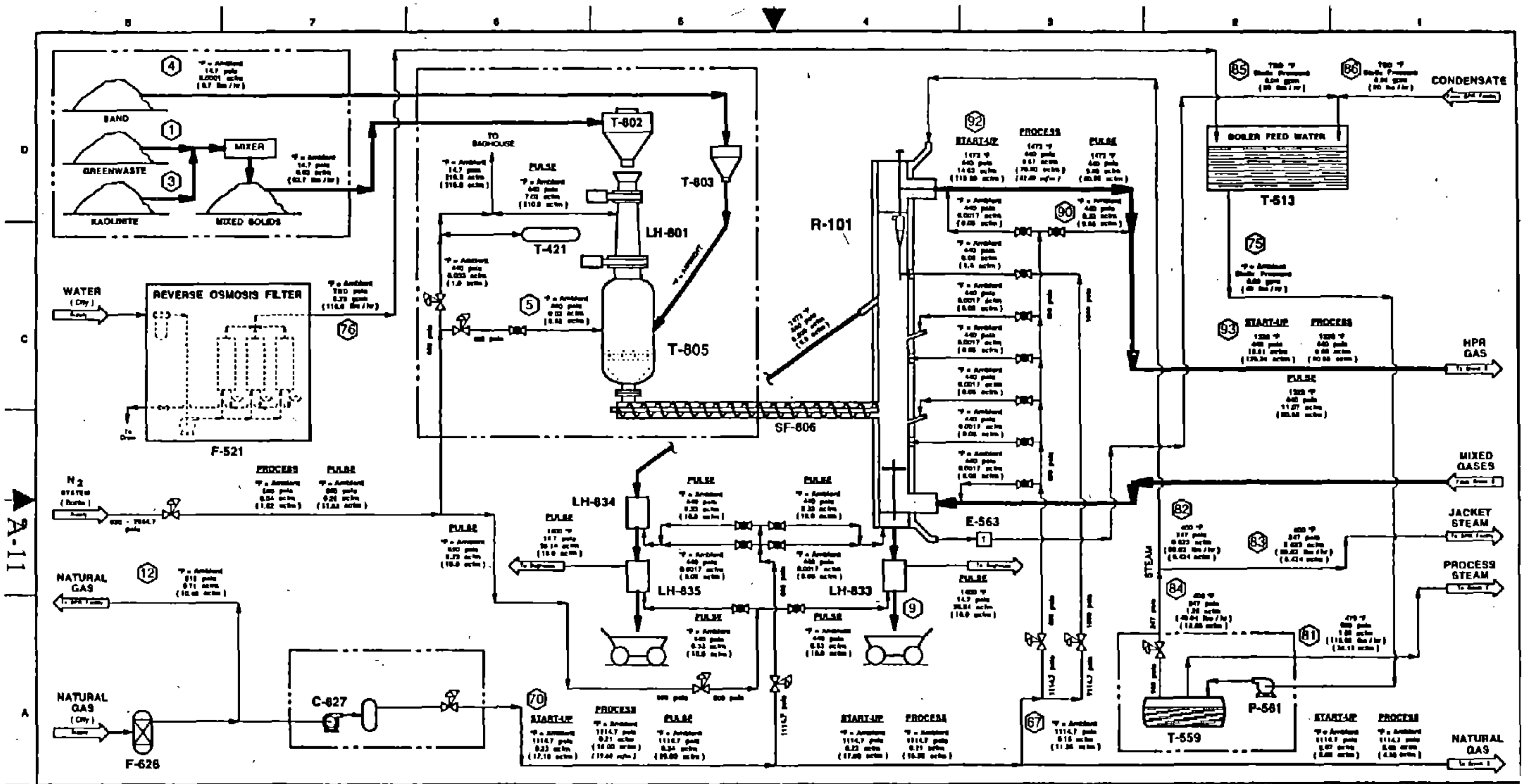
Hynol Actual HPR System

5/4/94

REVISION 7	2+80						82+83		same as 82		same as 83					
Stream #	81		82		83		84		85		86		90		91	
Properties	Steam HPR+SPR		HPR steam jkt		SPR steam jkt		Steam Jackets		HPR condensate		SPR condensate		CH4 to HPR out		CH4 purges	
Q, kg/h	52.53		9.10		9.10		18.20		9.10		9.10		10.97		1.94	
Normal m3/h	70.04		12.13		12.13		24.27		---		---		16.41		2.90	
Actual m3/h	4.06		1.18		1.18		2.36		0.01		0.01		0.56		0.35	
MW	18.00		18.00		18.00		18.00		18.00		18.00		16.04		16.04	
Enthal. kcal/h	-165,102		-28,692		-28,692		-57,385						-12,259		-1,356	
T, °C	235		204		204		204						25		800	
P, atm	30		16.8		16.8		16.8						30		30	
Components:	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %	kmol/hr	mole %
H2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
CH4	---	---	---	---	---	---	---	---	---	---	---	---	0.684	100.000	0.121	100.000
CO	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
CO2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
H20	2.92	100.00	0.51	100.00	0.51	100.00	1.01	100.00	0.506	100.000	0.506	100.000	---	---	---	---
O2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
N2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
H2S	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
CH3OH	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TOTAL	2.92	100.00	0.51	100.00	0.51	100.00	1.01	100.00	0.51	100.00	0.506	100.000	0.68	100.00	0.12	100.00
Elements:																
H	5.84	66.67	1.01	66.67	1.01	66.67	2.02	66.67	1.01	66.67	1.01	66.67	2.73	80.00	0.48	80.00
C	---	---	---	---	---	---	---	---	---	---	---	---	0.68	20.00	0.12	20.00
O	2.92	33.33	0.51	33.33	0.51	33.33	1.01	33.33	0.51	33.33	0.51	33.33	---	---	---	---
N	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
S	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Total elements	8.76	100.00	1.52	100.00	1.52	100.00	3.03	100.00	1.52	100.00	1.52	100.00	3.42	100.00	0.60	100.00
Inerts (kg/h)																
Enthalpy:	JANAF		JANAF		JANAF		JANAF						JANAF		JANAF	

Hynol Actual HPR System

5/4/94			90 + 92, or	
REVISION 7	60 + 91		60 + 67	
Stream #	**92**		**93**	
Properties	**HPR out + purges**		**To F-104**	
Q, kg/h	76.49		87.45	
Normal m3/h	120.51		136.90	
Actual m3/h	14.74		15.49	
MW	15.23		15.33	
Enthal. kcal/h	-98,438		-110,801	
T, °C	800		720	
P, atm	30		30	
Components:	kmol/hr	mole %	kmol/hr	mole %
H2	1.835	36.537	1.835	32.161
CH4	1.075	21.413	1.758	30.824
CO	0.658	13.096	0.658	11.528
CO2	0.378	7.534	0.378	6.632
H20	0.968	19.283	0.968	16.974
O2	---	---	—	---
N2	0.106	2.108	0.106	1.855
H2S	0.001	0.029	0.001	0.026
CH3OH	---	--	---	---
TOTAL	5.02	100.00	5.70	100.00
Elements:				
H	9.91	67.80	12.64	70.11
C	2.11	14.44	2.79	15.50
O	2.38	16.30	2.38	13.21
N	0.21	1.45	0.21	1.17
S	0.00	0.01	0.00	0.01
Total elements	14.62	100.00	18.03	100.00
Inerts (kg/h)				
Enthalpy:	JANAF		JANAF 60+67: -105,914	



4	PROOF COPY FLOWSHEET D	DJT	04-27-95
3	CORRECTED FLOW DATA	DJT	04-25-94
2	RELEASED FOR REVIEW	DJT	04-14-94
1	RELEASED FOR REVIEW	DJT	04-08-94
LTR	DESCRIPTION	APPD	DATE
	REVISIONS		

NOTE:
(ITALICS) — REFERS TO FLOWSHEET "D" DATED [illegible]

NUMBER	TITLE
REFERENCE DRAWINGS	

DWN	D. J. TATE	04-08-94
CHK		
ENG		
APPD		
PROJECT NO.	8570 - 300	
SCALE	NONE	

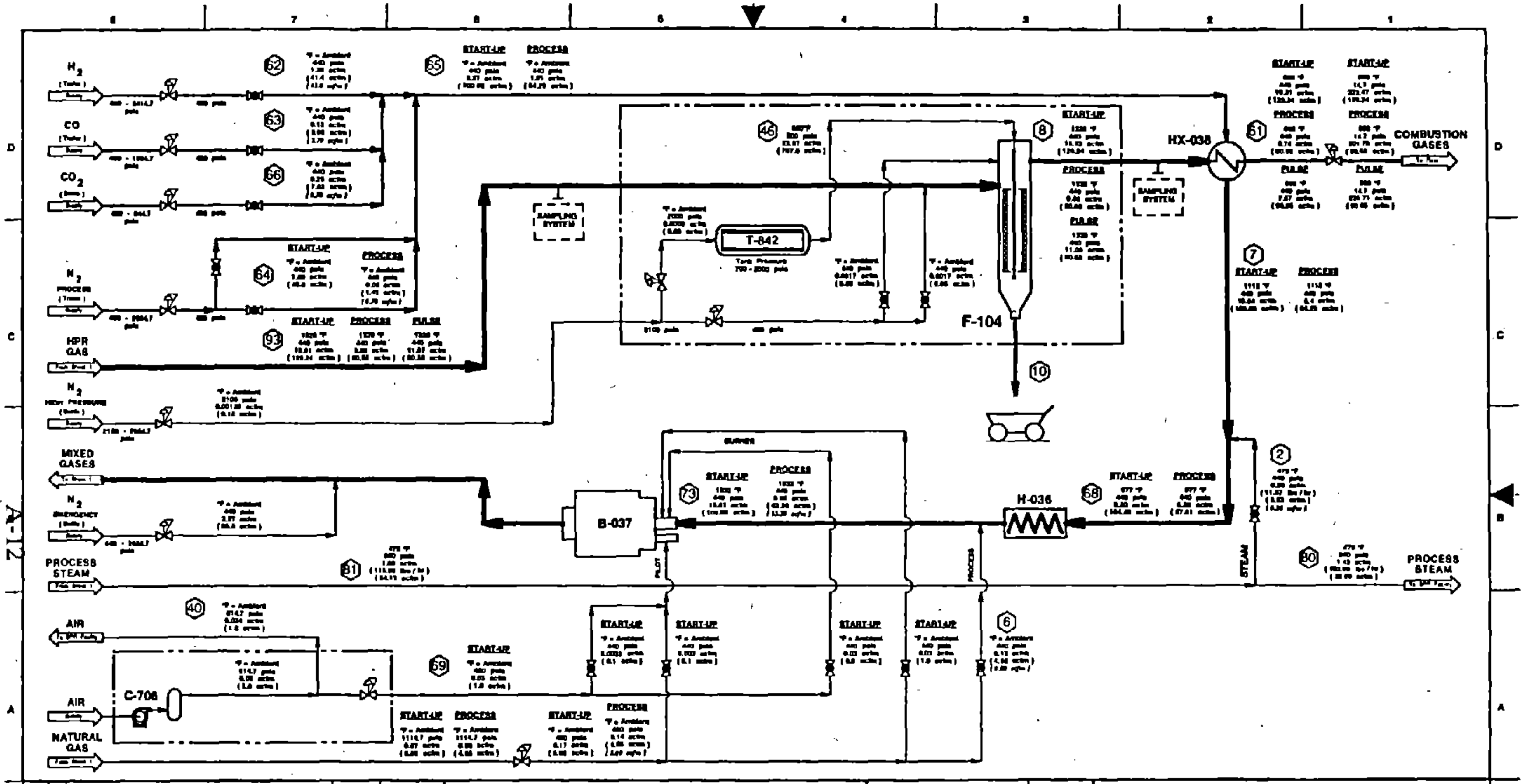
ORIGINATING OFFICE	CAGE NO
Mountain View, CA	[illegible]
Durham, NC	[illegible]
Jefferson, AR	[illegible]

Acurex Environmental Corporation

PROJECT
HYNOL

HPR
PROCESS FLOW DIAGRAM

SIZE	DWG. NO.	SHEET	REV
B	8570G002	1 of 2	4



NOTE:
(ITALICS) — REFERS TO FLOWSHEET "D" DATED [illegible]

LTR	DESCRIPTION	APPD	DATE
4	PROOF COPY FLOWSHEET D	DJT	04-27-95
3	CORRECTED FLOW DATA	DJT	04-25-94
2	RELEASED FOR REVIEW	DJT	04-14-94
1	RELEASED FOR REVIEW	DJT	04-08-94

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN D. J. TATE 04-08-94
CHK
ENG
APPD
PROJECT NO. 8570 - 300
SCALE NONE

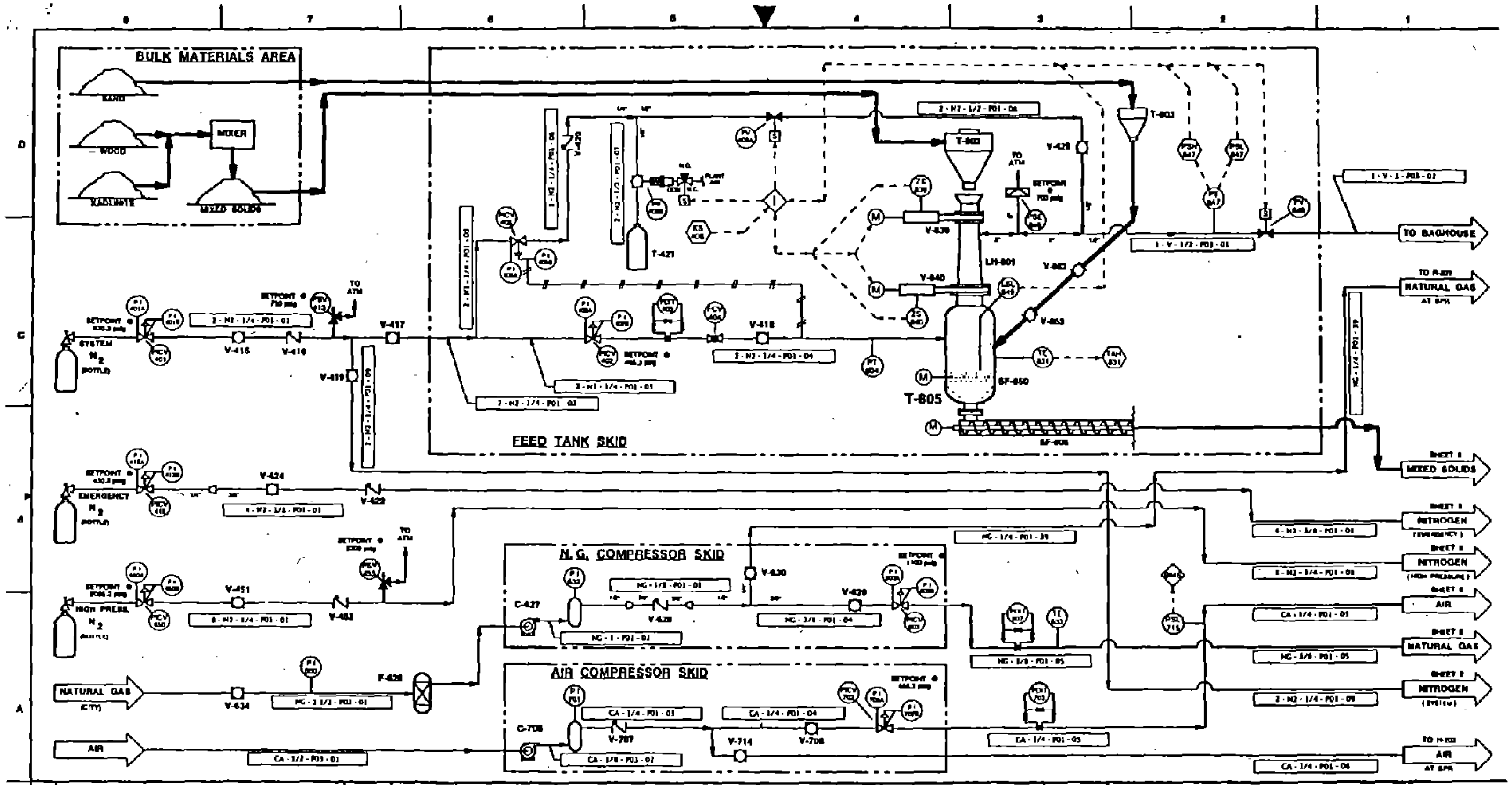
ORIGINATING OFFICE	CAGE NO.
Mountain View, CA	[illegible]
Durham, NC	[illegible]
Jefferson, AR	[illegible]

Acurex Environmental Corporation

PROJECT
HYNOL

HPR
PROCESS FLOW DIAGRAM

SIZE B
DWG. NO. 8570G002
SHEET 2 of 2
REV 4



3	CORRECTED PER NEW FLOW DATA	DJT	04-25-94
2	RELEASED FOR REVIEW	DJT	04-15-94
1	RELEASED FOR REVIEW	DJT	04-05-94
LTR	DESCRIPTION	APPD	DATE

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

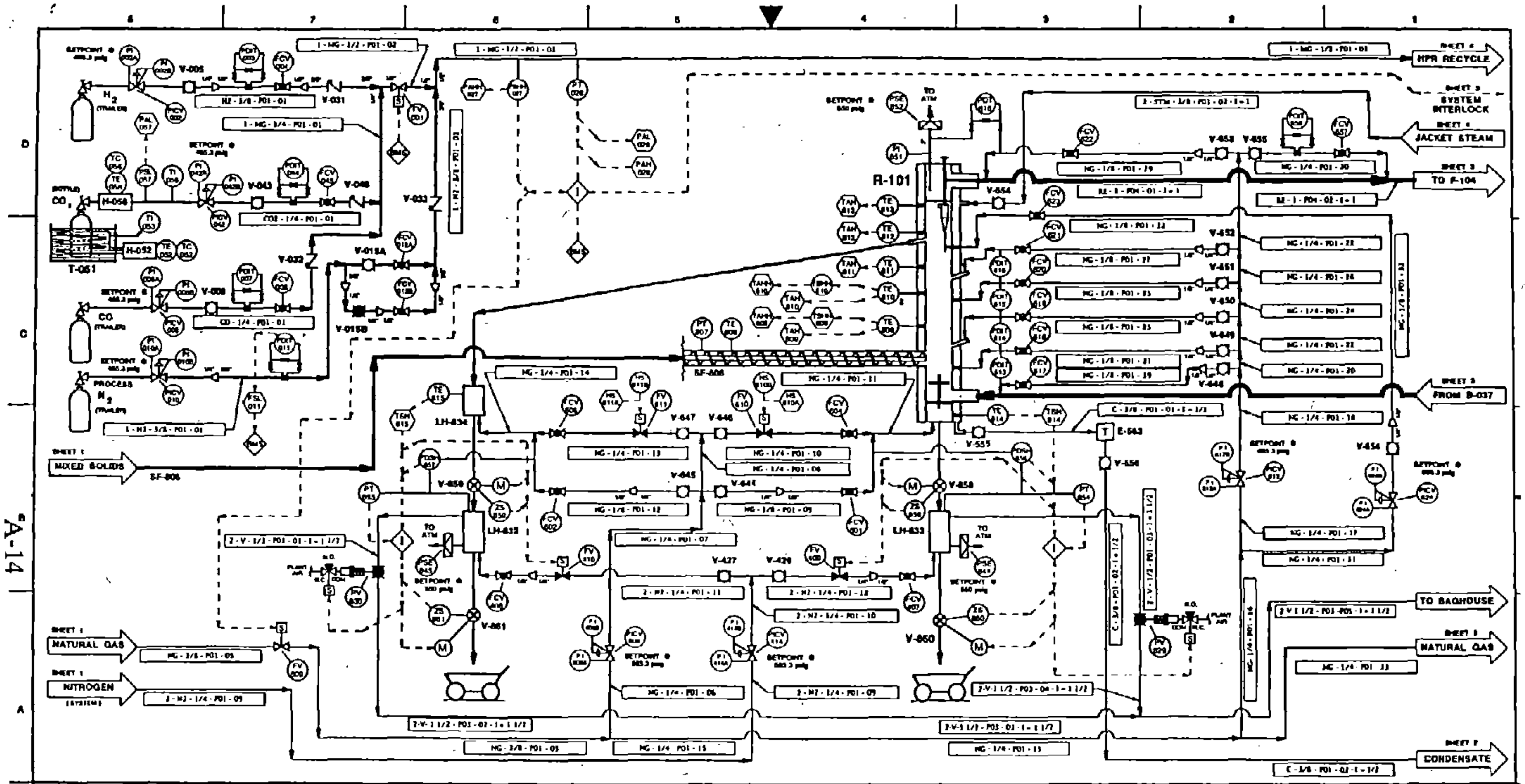
DWN	D. J. TATE	03-21-94
CHK		
ENG		
APPD		
PROJECT NO.	8570 - 300	
SCALE	NONE	

Acurex Environmental Corporation

PROJECT
HYNOL

HPR PROCESS AND INSTRUMENTATION DIAGRAM

SIZE	DWG NO.	SHEET	REV
B	8570G003	1 of 4	3



LTR	DESCRIPTION	APPD	DATE
3	CORRECTED PER NEW FLOW DATA	DJT	04-25-84
2	RELEASED FOR REVIEW	DJT	04-15-84
1	RELEASED FOR REVIEW	DJT	04-05-84

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	03-21-84
CHK		
ENG		
APPD		
PROJECT NO.	8570 - 300	
SCALE	NONE	

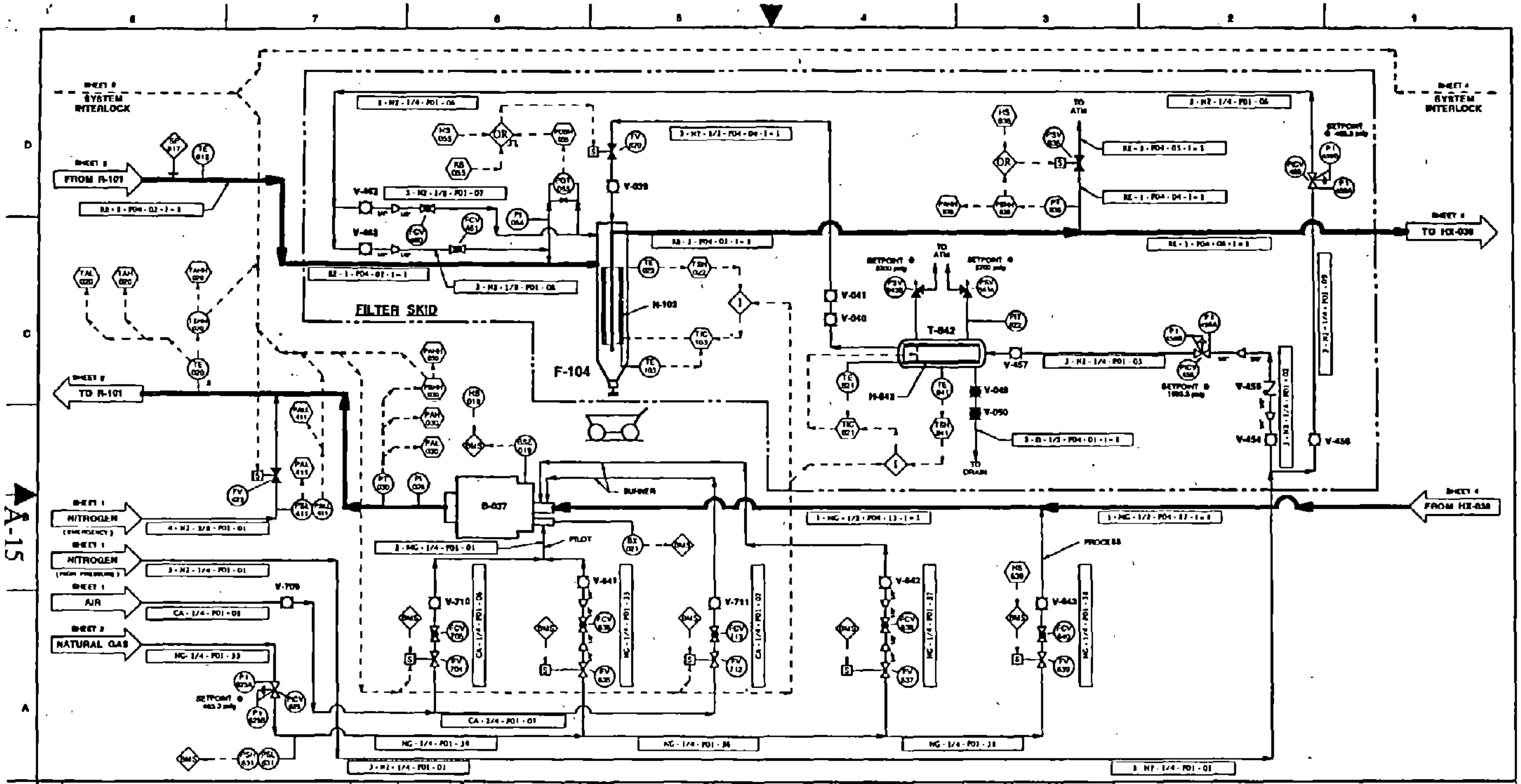
ORIGINATING OFFICE	CAGE NO
Mountain View, CA	[illegible]
Durham, NC	[illegible]
Jefferson, AR	[illegible]

Acurex Environmental Corporation

PROJECT
HYNOL

HPR PROCESS AND
INSTRUMENTATION DIAGRAM

SIZE B
DWG NO. 8570G003
SHEET 2 of 4
REV 3



LTR	DESCRIPTION	APPD	DATE
3	CORRECTED PER NEW FLOW DATA	DJT	04-25-94
2	RELEASED FOR REVIEW	DJT	04-15-94
1	RELEASED FOR REVIEW	DJT	04-05-94

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	03-21-94
CHK		
ENG		
APPD		
PROJECT NO.	8570 - 300	
SCALE	NONE	

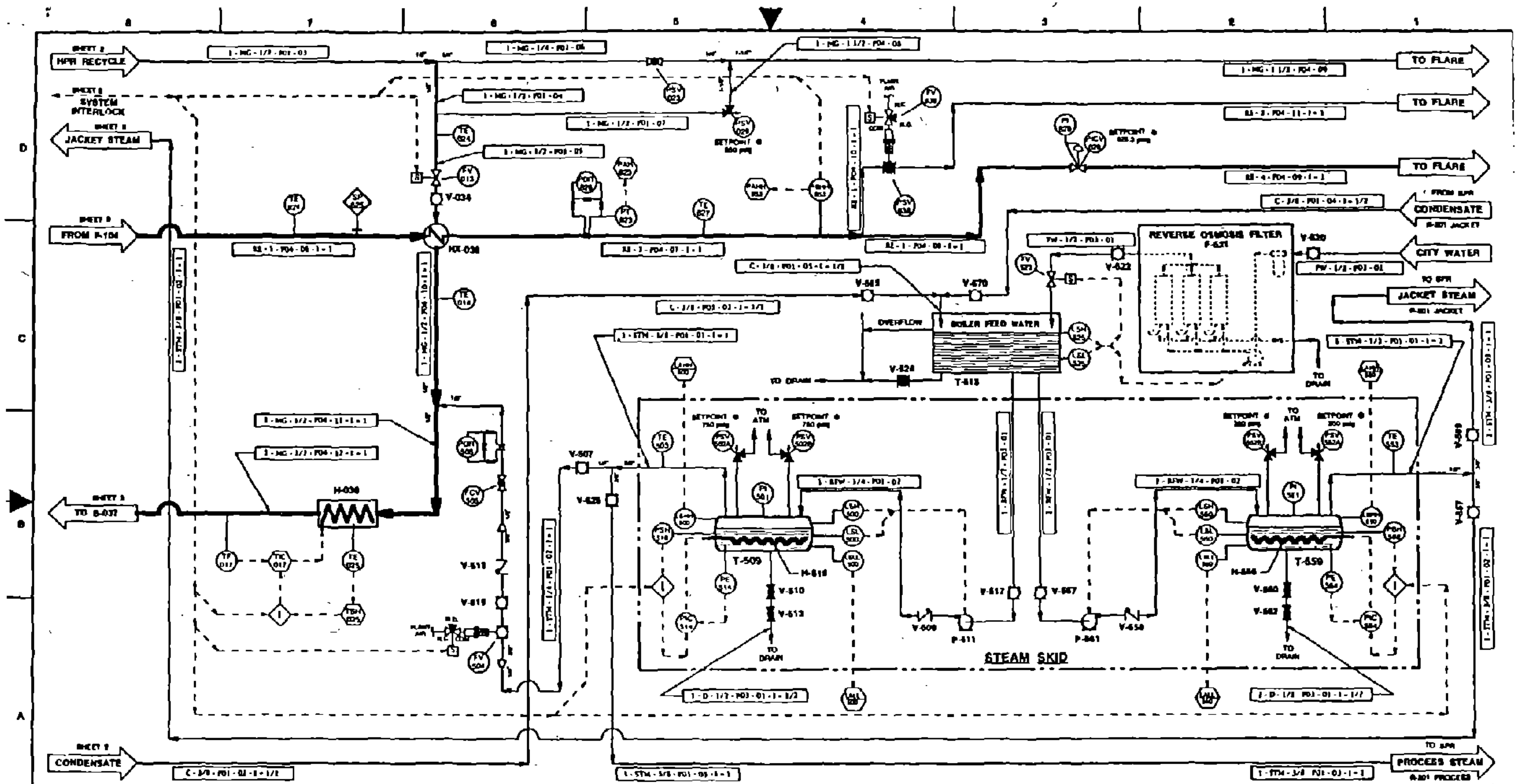
ORIGINATING OFFICE	CAGE NO
Mountain View, CA	0RCA1
Durham, NC	08JW1
Jefferson, AR	08JW4

Acurex Environmental Corporation

PROJECT
HYNOL

HPR PROCESS AND INSTRUMENTATION DIAGRAM

SIZE B
DWG. NO. 8570G003
SHEET 3 of 4
REV 3



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3	CORRECTED PER NEW FLOW DATA	DJT	04-25-94
2	RELEASED FOR REVIEW	DJT	04-15-94
1	RELEASED FOR REVIEW	DJT	04-05-94
LTR	DESCRIPTION	APPD	DATE

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

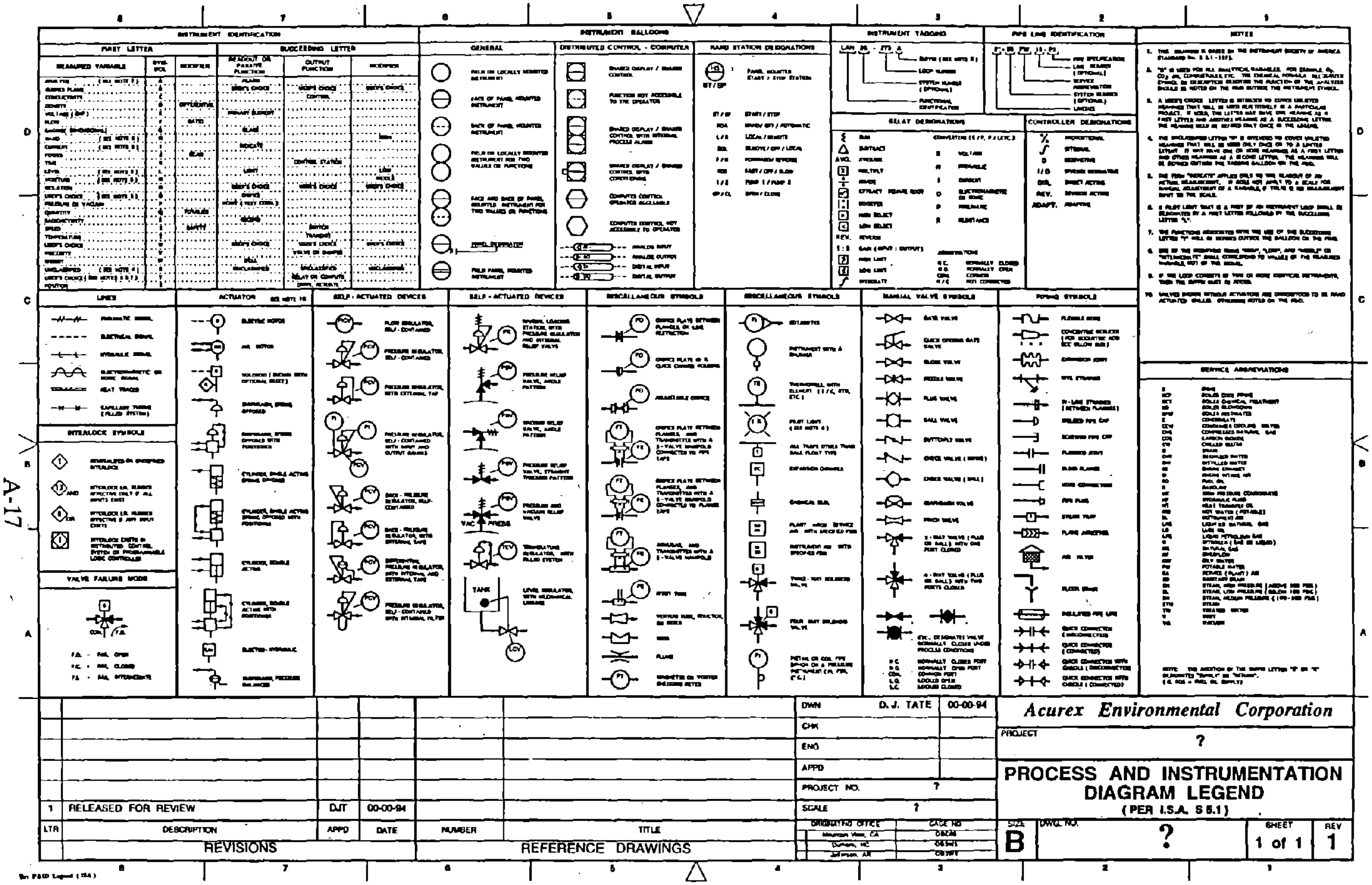
DWN D. J. TATE 03-21-94
CHK
ENG
APPD
PROJECT NO. 8570-300
SCALE NONE

Acurex Environmental Corporation

PROJECT
HYNOL

HPR PROCESS AND INSTRUMENTATION DIAGRAM

SIZE B
DWG. NO. 8570G003
SHEET 4 of 4
REV 3


INSTRUMENT IDENTIFICATION
FIRST LETTER
SUCCEEDING LETTER
INSTRUMENT BALLOONS
GENERAL
DISTRIBUTED CONTROL - COMPUTER
HAND STATION DESIGNATIONS
INSTRUMENT TAGGING
PIPE LINE IDENTIFICATION
NOTES
RELAY DESIGNATIONS
CONTROLLER DESIGNATIONS
LINES
ACTUATOR SEE NOTE 10
SELF - ACTUATED DEVICES
SELF - ACTUATED DEVICES
MISCELLANEOUS SYMBOLS
MISCELLANEOUS SYMBOLS
MANUAL VALVE SYMBOLS
PIPING SYMBOLS
SERVICE ABBREVIATIONS
INTERLOCK SYMBOLS
VALVE FAILURE MODE
1
RELEASED FOR REVIEW
DJT
00-00-94
LTR
DESCRIPTION
APPD
DATE
REVISIONS
NUMBER
TITLE
REFERENCE DRAWINGS
DWN
D. J. TATE
00-00-94
CHK
ENG
APPD
PROJECT NO.
?
SCALE
?
ORIGINATING OFFICE
CAGE NO
Acurex Environmental Corporation
PROJECT
?
PROCESS AND INSTRUMENTATION DIAGRAM LEGEND
(PER I.S.A. S5.1)
SIZE
B
DWG NO.
?
SHEET
1 of 1
REV
1

PIPELINE DESIGNATION NUMBER LIST AND OPERATING / DESIGN CONDITIONS

PROJECT NAME: HYNOL Hpr
PROJECT NUMBER: 8570 - 300
REVISION DATE: April 25, 1994 at 11:58 AM
FILE NUMBER: G003-1—HPR Line Designation LI

P01 = Type 316 Stainless Steel Tubing with Swagelok Fittings
P02 = Sch 80 Black Pipe with 3000-Pound Forged Steel Screwed Fittings
P03 = Sch 80 Galvanized Pipe with 3000-Pound Forged Steel Screwed Fittings
P04 = Sch 80 Type 316 Stainless Steel Pipe with 3000-Pound Forged Steel Socket Weld Fittings

LINE DESIGNATION NUMBER						P&ID No. AND SHEET No.	FLUID COMPOSITION (ALL PERCENTAGES ARE MOLE %)	DENSITY (lbs/ft3)	OPERATING FLOW S = Start-up, N = Normal, and P = Pulse		DESIGN FLOW (SCFM)	DESIGN VELOCITY (AFPS)	OPERATING PRESS. (psig)	DESIGN PRESS. (psig)	OPERATING TEMP. (°F)	DESIGN TEMP. (°F)
SYST. AREA	SERVICE ABBR.	PIPE SIZE	PIPE CODE	LINE No.	INSUL. & THICK.				(ACFM)	(SCFM)						
1	BFW	1/2	P03	01		8570G003 sh 4	Boiler Feed Water		0.23 gpm	115.6 lbs/hr	0.5 gpm	0.69	Static Head		Ambient	
1	BFW	1/4	P01	02		8570G003 sh 4	Boiler Feed Water		0.23 gpm	115.6 lbs/hr	0.5 gpm	8.84	545.3		Ambient	
2	BFW	1/2	P03	01		8570G003 sh 4	Boiler Feed Water		0.08 gpm	40 lbs/hr	0.5 gpm	0.69	Static Head		Ambient	
2	BFW	1/4	P01	02		8570G003 sh 4	Boiler Feed Water		0.08 gpm	40 lbs/hr	0.5 gpm	8.84	232.3		Ambient	
	C	3/8	P01	01	I= 1/2	8570G003 sh 2	Condensate		0.04 gpm	20.0 lbs/hr	0.5 gpm	2.66	232.3		TBD	
	C	3/8	P01	02	I= 1/2	8570G003 sh 2	Condensate		0.04 gpm	20.0 lbs/hr	0.5 gpm	2.66	Static Head		TBD	
	C	3/8	P01	03	I= 1/2	On SPR Facility	Condensate		0.04 gpm	20.0 lbs/hr	0.5 gpm	2.68	232.3		TBD	
	C	3/8	P01	04	I= 1/2	8570G003 sh 2	Condensate		0.04 gpm	20.0 lbs/hr	0.5 gpm	2.66	Static Head		TBD	
	C	3/8	P01	05	I= 1/2	8570G003 sh 2	Condensate		0.08 gpm	40.0 lbs/hr	0.5 gpm	2.66	Static Head		TBD	
	CA	1/2	P03	01		8570G003 sh 1	Air		2.00 S / 1.00 N	2.0 S / 1.0 N	5.00	51.25	0		Ambient	
	CA	3/8	P03	02		8570G003 sh 1	Air		0.05 S / 0.02 N	2.0 S / 1.0 N	5.00	2.04	600		Ambient	
	CA	1/4	P01	03		8570G003 sh 1	Air		0.05 S / 0.02 N	2.0 S / 1.0 N	5.00	15.81	600		Ambient	
	CA	1/4	P01	04		8570G003 sh 1	Air		0.02 S	1.00 S	2.00	6.33	600		Ambient	
	CA	1/4	P01	05		8570G003 sh 1 & 3	Air		0.03 S	1.00 S	2.00	8.10	465.3		Ambient	
	CA	1/4	P01	06		8570G003 sh 3	Air		0.0033 S	0.10 S	2.00	8.84	425.3		Ambient	
	CA	1/4	P01	07		8570G003 sh 3	Air		0.03 S	0.90 S	2.00	8.84	425.3		Ambient	
	CA	1/4	P01	08		8570G003 sh 1	Air		0.024 N	1.00 N	2.00	6.33	600		Ambient	
	CO	1/4	P01	01		8570G003 sh 2	Carbon Monoxide Gas (CO)		0.13 N	3.96 N	5.00	22.09	425.3		Ambient	
	CO2	1/4	P01	01		8570G003 sh 2	Carbon Dioxide Gas (CO2)		0.25 N	7.52 N	10.00	44.19	425.3		Ambient	
1	D	1/2	P03	01	I= 1/2	8570G003 sh 4	Hot Boiler Feed Water				7.0 gpm	9.59	545.3		479	
2	D	1/2	P03	01	I= 1/2	8570G003 sh 4	Hot Boiler Feed Water				7.0 gpm	9.59	232.3		400	
3	D	1/2	P04	01	I=1	8570G003 sh 3	Hot N2 Gas + Condensate				25.00	3.60	1985.3		550	
	FW	1/2	P03	01		8570G003 sh 4	Filtered Potable Water (City)		0.23 gpm	115.6 lbs/hr	0.5 gpm	0.69	TBD		Ambient	
	H2	3/8	P01	01		8570G003 sh 2	Hydrogen Gas (H2)		1.38 N	41.40 N	50.00	66.53	425.3		Ambient	
1	MG	1/4	P01	01		8570G003 sh 2	34.48 % CO, 65.52 % CO2		0.38 N	11.48 N	15.00	66.28	425.3		Ambient	
1	MG	1/2	P01	02		8570G003 sh 2	7.50% CO, 14.25 % CO2, 78.25 % H2		1.77 N	52.88 N	65.00	48.47	425.3		Ambient	
1	MG	1/2	P01	03		8570G003 sh 2 & 4	Start-up = 3.80 % CO, 7.22 % CO2, 39.66 % H2, 49.32 % N2 Normal = 7.31 % CO, 13.89 % CO2, 76.24 % H2, 2.57 % N2		3.37 S / 1.81 N	100.88 S / 54.29 N	125.00	93.22	425.3		Ambient	
1	MG	1/2	P01	04		8570G003 sh 4	Start-up = 3.80 % CO, 7.22 % CO2, 39.66 % H2, 49.32 % N2 Normal = 7.31 % CO, 13.89 % CO2, 76.24 % H2, 2.57 % N2		3.37 S / 1.81 N	100.88 S / 54.29 N	125.00	93.22	425.3		Ambient	
1	MG	1/2	P01	05		8570G003 sh 4	Start-up = 3.80 % CO, 7.22 % CO2, 39.66 % H2, 49.32 % N2 Normal = 7.31 % CO, 13.89 % CO2, 76.24 % H2, 2.57 % N2		3.37 S / 1.81 N	100.88 S / 54.29 N	125.00	93.22	425.3		Ambient	
1	MG	1/4	P01	06		8570G003 sh 4	CO, CO2, H2, N2		0.0 to 0.84	0.0 to 25.0	25.00	110.47	425.3		Ambient	
1	MG	1/2	P01	07		8570G003 sh 4	CO, CO2, H2, N2		3.37 S / 1.81 N	100.88 S / 54.29 N	125.00	93.22	425.3		Ambient	
1	MG	1 1/2	P04	08		8570G003 sh 4	CO, CO2, H2, N2		100.88 S / 54.29 N	100.88 S / 54.29 N	125.00	169.77	0		Ambient	
1	MG	1 1/2	P04	09		8570G003 sh 4	CO, CO2, H2, N2		100.88 S / 54.29 N	100.88 S / 54.29 N	125.00	169.77	0		Ambient	
1	MG	1/2	P04	10	I=1	8570G003 sh 4	Start-up = 3.80 % CO, 7.22 % CO2, 39.66 % H2, 49.32 % N2 Normal = 7.31 % CO, 13.89 % CO2, 76.24 % H2, 2.57 % N2		10.04 S / 5.40 N	100.88 S / 54.29 N	125.00	127.50	425.3		1112	
1	MG	1/2	P04	11	I=1	8570G003 sh 4	Start-up = 3.66 % CO, 6.94 % CO2, 38.13 % H2, 3.85 % H2O, 47.42 % N2 Normal = 8.79 % CO, 12.89 % CO2, 70.79 % H2, 7.15 % H2O, 2.38 % N2		9.50 S / 6.26 N	104.40 S / 67.81 N	125.00	118.55	425.3		977	
1	MG	1/2	P04	12	I=1	8570G003 sh 3 & 4	Start-up = 3.66 % CO, 6.94 % CO2, 38.13 % H2, 3.85 % H2O, 47.42 % N2 Normal = 6.79 % CO, 12.89 % CO2, 70.79 % H2, 7.15 % H2O, 2.38 % N2		15.15 S / 8.391 N	104.40 S / 57.81 N	125.00	185.91	425.3		1832	

PIPELINE DESIGNATION NUMBER LIST
AND OPERATING / DESIGN CONDITIONS

PROJECT NAME: HYNOL Hpr
PROJECT NUMBER: 8570 - 300
REVISION DATE: April 25, 1994 at 11:39 AM
FILE NUMBER: G003-1-HPR Line Designation LI

P01 = Type 316 Stainless Steel Tubing with Swagelok Fittings
P02 = Sch 80 Black Pipe with 3000-Pound Forged Steel Screwed Fittings
P03 = Sch 80 Galvanized Pipe with 3000-Pound Forged Steel Screwed Fittings
P04 = Sch 80 Type 316 Stainless Steel Pipe with 3000-Pound Forged Steel Socket Weld Fittings

Page 2

LINE DESIGNATION NUMBER						P&ID No. AND SHEET No.	FLUID COMPOSITION	DENSITY	OPERATING FLOW S = Start-up, N = Normal and P = Purge		DESIGN FLOW	DESIGN VELOCITY	OPERATING PRESS.	DESIGN PRESS.	OPERATING TEMP.	DESIGN TEMP.
SYST. AREA	SERVICE ABBR.	PIPE SIZE	PIPE CODE	LINE No.	INSUL. & THICK.		(ALL PERCENTAGES ARE MOLE %)	(lb/ft3)	(ACFM)	(SCFM)	(SCFM)	(AFPS)	(psig)	(psig)	(°F)	(°F)
1	MG	1/2	P04	13	I=1	8570G003 sh 3	Start-up = 4.02 % CH4, 3.51 % CO, 6.67 % CO2, 36.60 % H2, 3.70 % H2O, 45.51 % N2 Normal = 7.21 % CH4, 6.30 % CO, 11.96 % CO2, 65.68 % H2, 6.64 % H2O, 2.21 % N2		15.81 S / 9.05 N	108.95 S / 62.36 N	130.00	193.35	425.3	-	1832	
2	MG	1/4	P01	01		8570G003 sh 3	50.00 % Air, 50.00 % CH4		.0067 S	0.2 S	2.00	8.84	425.3		Ambient	
1	N2	3/8	P01	01		8570G003 sh 2	Nitrogen Gas (N2) Process		1.60 S / 0.05 N	48.00 S / 1.41 N	60.00	79.83	425.3		Ambient	
2	N2	1/4	P01	01		8570G003 sh 1	Nitrogen Gas (N2) System		0.04 N / 0.26 P	1.62 N / 11.62 P	15.00	44.87	635.3		Ambient	
2	N2	1/4	P01	02		8570G003 sh 1	Nitrogen Gas (N2) System		0.04 N	1.62 N	3.00	8.97	635.3		Ambient	
2	N2	1/4	P01	03		8570G003 sh 1	Nitrogen Gas (N2) System		0.01 N	0.62 N	2.00	5.98	635.3		Ambient	
2	N2	1/4	P01	04		8570G003 sh 1	Nitrogen Gas (N2) System		0.02 N	0.62 N	2.00	8.04	425.3		Ambient	
2	N2	1/4	P01	05		8570G003 sh 1	Nitrogen Gas (N2) System		0.023 N	1.00 N	2.00	5.98	635.3		Ambient	
2	N2	1/4	P01	06		8570G003 sh 1	Nitrogen Gas (N2) System		0.033 N	1.00 N	2.00	8.84	425.3		Ambient	
2	N2	1/2	P01	07		8570G003 sh 1	Nitrogen Gas (N2) System		0.033 N / 7.02 P	1.0 N / 210.0 P	250.00	186.43	425.3		Ambient	
2	N2	1/2	P01	08		8570G003 sh 1	Nitrogen Gas (N2) System		7.02 P	210.0 P	250.00	186.43	425.3		Ambient	
2	N2	1/4	P01	09		8570G003 sh 1 & 2	Nitrogen Gas (N2) System		0.23 P	10.0 P	15.00	44.87	635.3		Ambient	
2	N2	1/4	P01	10		8570G003 sh 2	Nitrogen Gas (N2) System		0.25 P	10.0 P	15.00	48.61	585.3		Ambient	
2	N2	1/4	P01	11		8570G003 sh 2	Nitrogen Gas (N2) System		0.33 P	10.0 P	15.00	66.28	425.3		Ambient	
2	N2	1/4	P01	12		8570G003 sh 2	Nitrogen Gas (N2) System		0.33 P	10.0 P	15.00	68.28	425.3		Ambient	
3	N2	1/4	P01	01		8570G003 sh 1 & 3	Nitrogen Gas (N2) High Pressure		0.00128 N	0.18 N	2.00	1.85	2085.3	3000	Ambient	
3	N2	1/4	P01	02		8570G003 sh 3	Nitrogen Gas (N2) High Pressure		0.0006 N	0.08 N	2.00	1.85	2085.3	3000	Ambient	
3	N2	1/4	P01	03		8570G003 sh 3	Nitrogen Gas (N2) High Pressure		0.0006 N	0.08 N	2.00	1.94	1985.3	3000	Ambient	
3	N2	1/2	P04	04	I=1	8570G003 sh 3	Nitrogen Gas (N2) High Pressure		23.97 N	767.0 P	850.00	272.30	885.3	3000	550	
3	N2	1/4	P01	05		8570G003 sh 3	Nitrogen Gas (N2) High Pressure		0.0007 N	0.10 N	2.00	1.85	2085.3	3000	Ambient	
3	N2	1/4	P01	06		8570G003 sh 3	Nitrogen Gas (N2) High Pressure		0.0031 N	0.10 N	2.00	8.10	485.3	600	Ambient	
3	N2	1/8	P01	07		8570G003 sh 3	Nitrogen Gas (N2) High Pressure		0.0017 N	0.05 N	1.00	33.75	425.3	600	Ambient	
3	N2	1/8	P01	08		8570G003 sh 3	Nitrogen Gas (N2) High Pressure		0.0017 N	0.05 N	1.00	33.75	425.3	600	Ambient	
4	N2	3/8	P01	01		8570G003 sh 1 & 3	Nitrogen Gas (N2) Emergency		2.97 N	89.00 N	110.00	148.36	425.3		Ambient	
	NG	1 1/2	P02	01		8570G003 sh 1	Natural Gas (CH4)		15.02 S / 14.37 N / 20.32 P	25.24 S / 24.14 N / 34.14 P	45.00	36.37	10		Ambient	
	NG	1	P02	02		8570G003 sh 1	Natural Gas (CH4)		0.29 S / 0.28 N / 0.40 P	25.24 S / 24.14 N / 34.14 P	45.00	1.75	1250		Ambient	
	NG	1/2	P01	03		8570G003 sh 1	Natural Gas (CH4)		0.29 S / 0.28 N / 0.40 P	25.24 S / 24.14 N / 34.14 P	45.00	11.68	1250		Ambient	
	NG	3/8	P01	04		8570G003 sh 1	Natural Gas (CH4)		0.20 S / 0.19 N / 0.30 P	17.10 S / 16.00 N / 26.00 P	35.00	16.20	1250		Ambient	
	NG	3/8	P01	05		8570G003 sh 1 & 2	Natural Gas (CH4)		0.23 S / 0.21 N / 0.34 P	17.10 S / 16.00 N / 26.00 P	35.00	18.38	1100		Ambient	
	NG	1/4	P01	06		8570G003 sh 2	Natural Gas (CH4)		0.0013 N / 0.13 P	0.1 N / 10.1 P	15.00	26.18	1100		Ambient	
	NG	1/4	P01	07		8570G003 sh 2	Natural Gas (CH4)		0.0025 N / 0.25 P	0.1 N / 10.1 P	15.00	48.61	585.3		Ambient	
	NG	1/4	P01	08		8570G003 sh 2	Natural Gas (CH4)		0.25 P	10.0 P	15.00	48.61	585.3		Ambient	
	NG	1/8	P01	09		8570G003 sh 2	Natural Gas (CH4)		0.0017 N	0.05 N	2.00	67.50	425.3		Ambient	
	NG	1/4	P01	10		8570G003 sh 2	Natural Gas (CH4)		0.33 P	10.0 P	15.00	66.28	425.3		Ambient	
	NG	1/4	P01	11		8570G003 sh 2	Natural Gas (CH4)		0.0017 N / .034 P	0.05 N / 10.05 P	15.00	66.28	425.3		Ambient	
	NG	1/8	P01	12		8570G003 sh 2	Natural Gas (CH4)		0.0017 N	0.05 N	2.00	67.50	425.3		Ambient	
	NG	1/4	P01	13		8570G003 sh 2	Natural Gas (CH4)		0.33 P	10.0 P	15.00	66.28	425.3		Ambient	
	NG	1/4	P01	14		8570G003 sh 2	Natural Gas (CH4)		0.0017 N / .034 P	0.05 N / 10.05 P	15.00	66.28	425.3		Ambient	
	NG	1/4	P01	15		8570G003 sh 2	Natural Gas (CH4)		0.22 S / 0.21 N	17.00 S / 15.9 N	25.00	43.60	1100		Ambient	
	NG	1/4	P01	16		8570G003 sh 2	Natural Gas (CH4)		0.15 N	11.35 N	15.00	26.16	1100		Ambient	
	NG	1/4	P01	17		8570G003 sh 2	Natural Gas (CH4)		0.13 N	9.95 N	15.00	26.16	1100		Ambient	

PIPELINE DESIGNATION NUMBER LIST
AND OPERATING / DESIGN CONDITIONS

PROJECT NAME HYNOL Hpr
PROJECT NUMBER 8570 - 300
REVISION DATE April 25, 1994 at 11:39 AM
FILE NUMBER G003-1—HPR Line Designation LI

P01 = Type 316 Stainless Steel Tubing with Swagelok Fittings
P02 = Sch 80 Black Pipe with 3000-Pound Forged Steel Screwed Fittings
P03 = Sch 80 Galvanized Pipe with 3000-Pound Forged Steel Screwed Fittings
P04 = Sch 80 Type 316 Stainless Steel Pipe with 3000-Pound Forged Steel Socket Weld Fittings

LINE DESIGNATION NUMBER						P&ID No. AND SHEET No.	FLUID COMPOSITION	DENSITY	OPERATING FLOW S = Start-up, N = Normal, and P = Pulse		DESIGN FLOW	DESIGN VELOCITY	OPERATING PRESS.	DESIGN PRESS.	OPERATING TEMP.	DESIGN TEMP.
SYST. AREA	SERVICE ABBR.	PIPE SIZE	PIPE CODE	LINE No.	INSUL. & THICK.		(ALL PERCENTAGES ARE MOLE %)	(lbs/ft3)	(ACFM)	(SCFM)	(SCFM)	(AFPS)	(psig)	(psig)	(°F)	(°F)
	NG	1/4	P01	18		8570G003 sh 2	Natural Gas (CH4)		0.30 N	9.95 N	15.00	60.76	465.3		Ambient	
	NG	1/8	P01	19		8570G003 sh 2	Natural Gas (CH4)		0.0017 N	0.05 N	2.00	67.50	425.3		Ambient	
	NG	1/4	P01	20		8570G003 sh 2	Natural Gas (CH4)		0.30 N	9.90 N	15.00	60.76	465.3		Ambient	
	NG	1/8	P01	21		8570G003 sh 2	Natural Gas (CH4)		0.0017 N	0.05 N	2.00	67.50	425.3		Ambient	
	NG	1/4	P01	22		8570G003 sh 2	Natural Gas (CH4)		0.30 N	9.85 N	15.00	60.76	465.3		Ambient	
	NG	1/8	P01	23		8570G003 sh 2	Natural Gas (CH4)		0.0017 N	0.05 N	2.00	67.50	425.3		Ambient	
	NG	1/4	P01	24		8570G003 sh 2	Natural Gas (CH4)		0.30 N	9.80 N	15.00	60.76	465.3		Ambient	
	NG	1/8	P01	25		8570G003 sh 2	Natural Gas (CH4)		0.0017 N	0.05 N	2.00	67.50	425.3		Ambient	
	NG	1/4	P01	26		8570G003 sh 2	Natural Gas (CH4)		0.30 N	9.75 N	15.00	60.76	465.3		Ambient	
	NG	1/8	P01	27		8570G003 sh 2	Natural Gas (CH4)		0.0017 N	0.05 N	2.00	67.50	425.3		Ambient	
	NG	1/4	P01	28		8570G003 sh 2	Natural Gas (CH4)		0.30 N	9.70 N	15.00	60.76	465.3		Ambient	
	NG	1/8	P01	29		8570G003 sh 2	Natural Gas (CH4)		0.0017 N	0.05 N	2.00	67.50	425.3		Ambient	
	NG	1/4	P01	30		8570G003 sh 2	Natural Gas (CH4)		0.32 N	9.65 N	15.00	66.28	425.3		Ambient	
	NG	1/4	P01	31		8570G003 sh 2	Natural Gas (CH4)		0.02 N	1.40 N	2.00	3.49	1100		Ambient	
	NG	1/8	P01	32		8570G003 sh 2	Natural Gas (CH4)		0.07 H / 0.05 L	1.40 N	2.00	67.50	985.3 H / 425.3 L		Ambient	
	NG	1/4	P01	33		8570G003 sh 2 & 3	Natural Gas (CH4)		0.07 S / 0.06 N	5.65 S / 4.55 N	10.00	17.44	1100		Ambient	
	NG	1/4	P01	34		8570G003 sh 3	Natural Gas (CH4)		0.17 S / 0.14 N	5.65 S / 4.55 N	10.00	40.51	465.3		Ambient	
	NG	1/4	P01	35		8570G003 sh 3	Natural Gas (CH4)		0.003 N	0.10 N	2.00	8.64	425.3		Ambient	
	NG	1/4	P01	36		8570G003 sh 3	Natural Gas (CH4)		0.17 S / 0.14 N	5.55 S / 4.55 N	10.00	40.51	465.3		Ambient	
	NG	1/4	P01	37		8570G003 sh 3	Natural Gas (CH4)		0.03 S	1.0 S	2.00	8.64	425.3		Ambient	
	NG	1/4	P01	38		8570G003 sh 3	Natural Gas (CH4)		0.15 N	4.55 N	10.00	44.19	425.3		Ambient	
	NG	1/4	P01	39		8570G003 sh 1	Natural Gas (CH4)		0.09 N	8.14 N	10.00	15.37	1250		Ambient	
	PW	1/2	P03	01		8570G003 sh 4	Potable Water (City)		0.23 gpm	115.6 lbs/hr	0.5 gpm	0.69	[illegible] TBD [illegible]		Ambient	
	RE	1	P04	01	I=I	8570G003 sh 2	24.61 % CH4, 12.56 % CO, 7.23 % CO2, 35.05 % H2, 18.50 % H2O, 0.03 % H2S, 2.02 % N2		14.63 S / 8.67 N / 9.69 P	119.59 S / 70.90 N / 80.90 P	145.00	59.17	425.3		1472	
	RE	1	P04	02	I=I	8570G003 sh 2 & 3	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.07 % H2O, 0.03 % H2S, 1.06 % N2		15.81 S / 9.05 N / 11.07 P	129.24 S / 80.55 N / 90.55 P	155.00	63.25	425.3		1472	
	RE	1	P04	03	I=I	8570G003 sh 3	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		15.82 S / 9.86 N / 11.09 P	129.34 S / 80.65 N / 90.65 P	155.00	63.25	425.3		1472	
	RE	1	P04	04	I=I	8570G003 sh 3	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		15.82 S / 9.06 N / 11.09 P	129.34 S / 80.65 N / 90.65 P	155.00	63.25	425.3		1472	
	RE	3	P04	05	I=I	8570G003 sh 3	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		473.48 S / 295.24 N / 331.85 P	129.34 S / 80.65 N / 90.65 P	155.00	206.17	0		1472	
	RE	1	P04	06	I=I	8570G003 sh 3 & 4	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		15.82 S / 9.86 N / 11.09 P	129.34 S / 80.65 N / 90.65 P	155.00	63.25	425.3		1472	
	RE	1	P04	07	I=I	8570G003 sh 4	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		10.81 S / 6.74 N / 7.57 P	129.34 S / 80.65 N / 90.65 P	155.00	43.21	425.3		860	
	RE	1	P04	08	I=I	8570G003 sh 4	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		10.81 S / 6.74 N / 7.57 P	129.34 S / 80.65 N / 90.65 P	155.00	43.21	425.3		860	
	RE	4	P04	09	I=I	8570G003 sh 4	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		323.47 S / 201.70 N / 226.71 P	129.34 S / 80.65 N / 90.65 P	155.00	80.92	0		860	
	RE	1	P04	10	I=I	8570G003 sh 4	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		10.81 S / 6.74 N / 7.57 P	129.34 S / 80.65 N / 90.65 P	155.00	43.21	425.3		860	

PIPELINE DESIGNATION NUMBER LIST
AND OPERATING / DESIGN CONDITIONS

PROJECT NAME: HYNOL Hpr
PROJECT NUMBER 8570 - 300
REVISION DATE: April 25, 1994 at 1:25 PM
FILE NUMBER G003-1-HPR Line Designation LI

P01 = Type 316 Stainless Steel Tubing with Swagelok Fittings
P02 = Sch 80 Black Pipe with 3000-Pound Forged Steel Screwed Fittings
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P04 = Sch 80 Type 316 Stainless Steel Pipe with 3000-Pound Forged Steel Socket Weld Fittings

LINE DESIGNATION NUMBER						P&ID No. AND SHEET No.	FLUID COMPOSITION	DENSITY	OPERATING FLOW		DESIGN FLOW	DESIGN VELOCITY	OPERATING PRESS.	DESIGN PRESS.	OPERATING TEMP.	DESIGN TEMP.
SYST AREA	SERVICE ABBR.	PIPE SIZE	PIPE CODE	LINE No	INSUL & THICK.		(ALL PERCENTAGES ARE MOLE %)	(lbs / ft3)	S = Start-up, N = Normal, and P = Pulse (ACFM)	(SCFM)	(SCFM)	(AFPS)	(psig)	(psig)	(°F)	(°F)
	RE	3	P04	11	I=1	8570G003 sh 4	30.82 % CH4, 11.53 % CO, 6.63 % CO2, 32.16 % H2, 16.97 % H2O, 0.03 % H2S, 1.86 % N2		323.47 S / 201.70 N / 226.71 P	129 34 S / 80 85 N / 90 65 P	155.00	140.85	0		850	
1	STM	3/8	P01	01	I=1	8570G003 sh 4	Process Steam		1.59 N	34.11 N	40.00	74.39	545.3		479	
1	STM	1/4	P01	02	I=1	8570G003 sh 4	Process Steam		0.20 N	3 52 N	10 00	78 60	425.3		479	
1	STM	3/8	P01	03	I=1	8570G003 sh 4	Process Steam		1.43 N	30.69 N	40.00	74.39	545 3		479	
2	STM	1/2	P01	01	I=1	8570G003 sh 4	Jacket Steam		1.25 N	12 85 N	20 00	43.29	232 3		400	
2	STM	3/8	P01	02	I=1	8570G003 sh 4 & 2	Jacket Steam		0.62 N	6 42 N	10.00	38.81	232 3		400	
2	STM	3/8	P01	03	I=1	8570G003 sh 4	Jacket Steam		0.62 N	6 42 N	10.00	38.61	232 3		400	
1	V	1/2	P03	01		8570G003 sh 1	Nitrogen, Air, Dust		7.02 P	210 00 P	250.00	85.81	425.3		Ambient	
1	V	3	P03	02		8570G003 sh 1	Nitrogen, Air, Dust		210.00 P	210.00 P	250.00	90 84	0		Ambient	
2	V	1/2	P01	01	I=1 1/2	8570G003 sh 2	Nitrogen, Combustion Gases, Dust		1.18 P	10.0 P	15.00	39.42	425.3		1400	
2	V	1 1/2	P03	02	I=1 1/2	8570G003 sh 2	Nitrogen, Combustion Gases, Dust		35.24 P	10.0 P	15.00	71.80	0		1400	
2	V	1/2	P01	03	I=1 1/2	8570G003 sh 2	Nitrogen, Combustion Gases, Dust		1.18 P	10.0 P	15.00	39.42	425 3		1400	
2	V	1 1/2	P03	04	I=1 1/2	8570G003 sh 2	Nitrogen, Combustion Gases, Dust		35.24 P	10.0 P	15 00	71.80	0		1400	
2	V	1 1/2	P03	05	I=1 1/2	8570G003 sh 2	Nitrogen, Combustion Gases, Dust		35 24 P	10.0 P	15.00	71.80	0		1400	

Product Bulletin

CELANESE CHEMICAL COMPANY, INC.

CELANESE CHEMICAL COMPANY, INC. 1250 WEST MOCKINGBIRD LANE DALLAS, TX 75247 PHONE: 214-689-4000

METHYL ALCOHOL

(Methanol)
(Carbinol) CH_3OH MW = 32.04
(Methyl Hydroxide)
(Monohydroxymethane)

Methyl alcohol is a clear, colorless, mobile, highly polar liquid with a mild odor. It is miscible with water, alcohol and ether.

Although the largest end uses for methyl alcohol are in formaldehyde production, dimethyl terephthalate and chemical intermediates, its uses as a solvent, extractant and fuel additive are also of considerable importance. Methyl alcohol is used extensively as an intermediate in the preparation of methyl acrylate and methyl methacrylate, methyl chlorides, methyl ethers, dimethyl sulfate and many other intermediates and dyes. It is used to solubilize phenolic laminating resins, ethyl cellulose, cellulose nitrate, gums, shellac, vegetable wax, and many other resins and oils. Miscibility with most organic solvents further enhances its solvent properties. Solutions of gums and resins in methyl alcohol usually have a lower viscosity than is possible with other alcohols. This alcohol is an excellent fuel for high-compression reciprocating engines as well as a component in jet and rocket fuels. It is used as an anti-freeze agent in gasoline. Clean burning and easy to handle, it is used to fuel heaters in insulated railroad freight cars carrying perishables.

Methyl alcohol is one of the basic raw materials of the organic chemical industry. The Celanese product is available with a purity of not less than 99.85 per cent. Celanese methyl alcohol meets Federal Specification O-M-232F (September 27, 1974) Grade A.

Methyl alcohol undergoes reactions typical of aliphatic alcohols.

CHEMICAL REACTIONS

1. Reaction With Hydrogen Halides
   $CH_3OH + HX \longrightarrow CH_3X + H_2O$
2. Reaction With Active Metals - Reaction As Acids
   $2CH_3OH \xrightarrow{2Na} 2CH_3ONa + H_2$
3. Oxidation
   $CH_3OH \xrightarrow{(O_2)} HCOOH + H_2O$
4. Ester Formation
   $CH_3OH + CH_3COOH \longrightarrow CH_3COOCH_3 + H_2O$
5. Reaction With Carbon Monoxide
   $CH_3OH + CO \longrightarrow CH_3COOH$

Methyl Alcohol, Chemical Abstracts Registry Number 67-56-1; Wiswesser Line-Formula Chemical Notation Q1

SPECIFICATIONS

METHYL ALCOHOL, REGULAR GRADE

Methyl Alcohol Content, wt. % min.	99.85
Color, Pt-Co Units, max.	5
Acidity, as Acetic, wt. %, max.	0.003
Permanganate Time, Minutes, min.	50
Acetone Content, wt. %, max.	0.003
Odor	Characteristic Free of Foreign Odors
Appearance	Clear and Free of Suspended Matter
Water, wt. %, max.	0.10

METHYL ALCOHOL, PREMIUM GRADE

Methyl Alcohol Content, wt.%, min.	99.85
Color, Pt-Co Units, max.	5
Acidity, as Acetic, wt. %, max.	0.003
Permanganate Time, Minutes, min.	50
Acetone Content, wt. %, max.	0.003
Ethyl Alcohol Content, wt. %, max.	0.010
Odor	Characteristic Free of Foreign Odors
Appearance	Clear and Free of Suspended Matter
Water, wt. %, max.	0.10

PHYSICAL PROPERTIES

Autoignition Temperature, °C	470.
Boiling Point at 760 mm Hg, ° C.	64.65
Boiling Point at 760 mm Hg, °F.	148.4
Coefficient of Cubical Expansion per °C at 55° C.	1.24×10^{-3}
Critical Pressure, atmospheres	78.7
Critical Temperature, °C.	240.0
Dielectric Constant, mhos, 25°C.	32.63
Electrical Conductivity at 25°C., mhos/cc.	1.5×10^{-9}
Evaporation Rate (BuAc = 1).	2.0
Flammable Limits (lower limit, vol. %).	6.7⁽¹⁾
(upper limit, vol. %).	36.0
Flash Point, Tag Open Cup, °F.	60
Tag Closed Cup, °F.	54
Freezing Point, °C.	– 97.8
Heat of Combustion, cal./gm., gas, 25°C.	5683
Heat of Combustion, cal./gm., liquid, 25°C.	5420
Heat of Fusion, cal./gm.	0.76

Heat of Vaporization, cal./gm. (at normal boiling point).	262.8
Molecular Weight (formula).	32.04
Reid Vapor Pressure, pounds per square inch.	2.2
Refractive Index, n_D^{20}	1.3285
Solubility at 20°C, wt. %, in water.	Complete
wt. %, water in	Complete
Solubility in alcohol, ether or water.	Complete
Specific Gravity, 20/20°C.	0.7923
Specific Heat of Liquid, cal./gm./°C at 20°C.	0.599
Specific Heat, cal./gm./°C at 0°C.	0.566
Surface Tension in Air at 20°C., dynes/cm.	22.55
Vapor Density (air = 1).	1.11
Vapor Pressure, mm Hg, 20°C.	96.0
Viscosity at 20°C. centipoises.	0.614
Weight, pounds per gallon at 20°C (68°F).	6.59

PRECAUTIONARY INFORMATION

Health Information

Methyl alcohol is highly toxic by oral ingestion; as little as one to four ounces can be fatal or result in permanent injury such as blindness. A physician must be called immediately to treat anyone who has ingested methanol. The vapor at high concentration causes irritation of the eyes and respiratory tract; inhalation of excessive amounts must be avoided. Repeated or prolonged contact with the liquid or vapor causes skin irritation.

The exposure limit for methyl alcohol is 200 ppm (260 mg/m^3) based on an 8-hour time weighted average.(2) Where exposure may exceed this limit approved respiratory protection should be readily available for use in accordance with government regulations. Workers handling methyl alcohol should wear chemical safety goggles and impervious gloves. In case of eye contact with methyl alcohol, flush immediately with plenty of water for at least 15 minutes and seek medical attention. For skin contact, flush with water. Remove contaminated clothing and wash before reuse. Discard damaged protective clothing and contaminated leather shoes. If swallowed, induce vomiting immediately by giving 2 glasses of warm water and inserting finger down individual's throat. Never give anything by mouth to an unconscious person.

For further information, refer to the Manufacturing Chemists Association's Chemical Safety Data Sheet SD-22.(3)

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(1) "Fire Protection Guide on Hazardous Materials", National Fire Protection Association, Sixth Edition, 1975.

(2) 29 Code Federal Regulations 1910.1000

Safe Handling Procedures

Methyl alcohol is a flammable liquid; it exhibits a potential fire hazard wherever it is stored, handled or used. It should be kept away from heat, sparks, and open flame. The vapors are toxic and heavier than air. Adequate ventilation of work and storage areas is essential. The concentration of the vapor should be kept outside the flammable limits.

Building and equipment design for handling methyl alcohol should conform to all applicable National Fire Protection Association standards. Electrical equipment should conform to Section 500 of the National Electrical Code.(4) No apparatus capable of providing an ignition source should be used. Because sparks from static electricity can ignite methyl alcohol vapor and air mixtures, it is imperative that safe handling procedures, such as adequate grounding and bonding, be developed and strictly observed.

The practices recommended in the M.C.A.(3) Manuals, TC-29, "Loading And Unloading Flammable Liquid Chemicals-Tank Cars," TC-8, "Recommended Practices For Bulk Loading And Unloading Flammable Liquid Chemicals To And From Tank Trucks," and Safety Guide SG-3 "Flammable Liquids: Storage And Handling Drum Lots And Smaller Quantities" and the M.C.A. (3) Chemical Safety Data Sheet SD-22 should be used as guidelines for handling methyl alcohol.

Small containers should be protected from physical damage and stored in a cool, well-ventilated flammable liquids storage area. Bulk storage tanks should be located outside and detached from other buildings. All sources of flame, sparks, ignition or excessive heat should be removed from storage areas. Storage of methyl alcohol should be in accordance with the provisions of the National Fire Protection Association(4) Pamphlet No. 30, "Flammable And Combustible Liquids Code."

Carbon steel (lined or unlined), 304SS, brass or copper are acceptable materials for construction for use with methyl alcohol. Aluminum is not acceptable from a color and contamination standpoint.

In the event of a spill, remove all sources of ignition. Keep personnel away from spill area. Dilute spilled material with large volumes of water. If spill is contained in a relatively safe location, cover with an approved foam as a precautionary measure for fire and fume protection. Dike large spills and dump into salvage tanks. Prevent washings from entering all waterways. Disposal should be carried out in compliance with federal, state, and local regulations regarding health, air, and water pollution. Notify authorities in the event of major spills. Incinerate waste in chemical incinerator.

PRODUCT SHIPPING INFORMATION

D.O.T. CLASS	Flammable Liquid	D.O.T. LABEL	Red(3)
FLASH POINT °F TAG OPEN CUP	60	TAG CLOSED CUP	54
CELANESE LABEL NUMBER			
DRUM		OCD-47	
SAMPLE		OCD-47-1	
TANK CAR-TANK TRUCK		OCD-47-2	
FREIGHT CLASSIFICATION		Methanol	

I. BULK SHIPMENTS

Tank truck	(Full) 40,000 Pounds Minimum
Tank car	(Full) 10,000 to 30,000 Gallons

II. Filling Points
San Pedro, California
Chicago, Illinois
Newark, New Jersey
Cincinnati, Ohio
New Kensington, Pennsylvania
Rock Hill, South Carolina
Bay City, Texas
Bayport, Texas
Bishop, Texas
Clear Lake, Texas
Pampa, Texas

II. DRUM SHIPMENTS
Are not presently available.

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(3) Manufacturing Chemists Association, Inc. 1825 Connecticut Avenue, N.W. Washington, D.C. 20009

(4) National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210

HEADQUARTERS

DALLAS, TX.
CELANESE CHEMICAL COMPANY, INC.
1250 West Mockingbird Lane
Dallas, TX. 75247
Phone: 214-689-4000
ITT Telex: 914-861-4049

DISTRICT OFFICES

BOSTON, MA.
55 William Street
Wellesley, MA. 02181
Phone: 617-235-1790

CHARLOTTE, NC.
P.O. Box 32414
Charlotte, NC. 28232
Phone: 704-554-2511

CHATHAM, NJ.
26 Main Street
Chatham, NJ. 07928
Phone: 201-635-2200

CHICAGO, IL.
4825 N. Scott Street
Schiller Park, IL. 60176
Phone: 312-678-6330

CLEVELAND, OH.
24700 Center Ridge Road
Westlake, OH. 44145
Phone: 216-835-4333

DETROIT, MI.
26711 Northwestern Highway
Suite 530, W.B. Doner Building
Southfield, MI. 48076
Phone: 313-353-9680

HOUSTON, TX.
5 Greenway Plaza E.
Suite 1710
Houston, TX. 77046
Phone: 713-621-8400

LOS ANGELES, CA.
21515 Hawthorne Blvd.
Union Bank Bldg. Suite 801
Torrance, CA. 90503
Phone: 213-772-3488

ST. LOUIS, MO.
734 West Port Plaza
Suite 271
St. Louis, MO. 63141
Phone: 314-434-9595

WILMINGTON, DE.
Suite 102
Ridgely Building
Concord Plaza
3519 Silverside Road
Wilmington, DE. 19810
Phone: 302-478-9005

INTERNATIONAL OFFICES

ASIA, AUSTRALASIA
THE FAR EAST AND THE AMERICAS
AMCEL CO., INC.
1250 West Mockingbird Lane
Dallas, Texas 75247
Phone: 214-689-4000
ITT Telex: 910-861-4049
Cable: CELANESE Dallas, Texas

EUROPE, AFRICA, MEDITERRANEAN
AMCEL EUROPE S.A.
Avenue Louise, 251
B-1050 Brussels, Belgium
Phone: 6498020
Telex: 22126
Cable: Amcel Brussels

STATE OF CALIFORNIA GEORGE DEUKMEJIAN, Governor

DEPARTMENT OF INDUSTRIAL RELATIONS
DIVISION OF OCCUPATIONAL SAFETY AND HEALTH
525 GOLDEN GATE AVENUE
SAN FRANCISCO

ADDRESS REPLY TO:
P.O. BOX 603
SAN FRANCISCO, CA 94101

NON-CODE VESSELS

California is basically an American Society of Mechanical Engineers (ASME) Code State. Pressure vessels must either be constructed and stamped in accordance with the rules of the applicable ASME Code, or be proven to provide equivalent safety.

It is the responsibility of the owner or user of a non-code constructed pressure vessel to request permission from the State of California, Department of Industrial Relations, Division of Occupational Safety and Health, Pressure Vessel Section, to use such non-code pressure vessel and to submit all of the following documentation where applicable:

1. All service conditions - pressure(s) including vacuum, temperature(s), cycles, etc.

2. The criteria on which the design is based and all calculations. The <u>Design</u> and <u>Calculations</u> shall be certified by a Professional Engineer (competent in the field of Pressure Vessel Design and registered in the State of California) as providing safety equivalent to the ASME Code.

   NOTE: The design shall:

   1. Be based on the ASME Code with a factor of safety of not less than 4, or

   2. Provide equivalence to all applicable requirements of the ASME Code Section VIII, Division 2.

3. A complete set of drawings including weld details. English language, U.S.A. units of measurement must be used.

4. A list of all of the pressure boundary materials or those materials subject to stress as the result of pressure. This list shall include the material specification used and should conform to the applicable ASME Standard, or their suitable equivalent. If reference is made to a standard or specification of a country other than the United States of America, attach a copy and indicate how the material is considered equivalent. The stress values used in all design calculations shall not exceed the lower limits shown in the material specification.

5. Mill test certifications shall be included for those materials as required by the ASME Standard. (English language, U.S.A. units of measurement)

6. Any welding procedures used in construction and the required welder's qualification records for those welders used in the

fabrication. These procedures and qualification shall be made in accordance with ASME Code, Section IX.

7. All non-destructive test procedures used and the results of tests.

8. A record of the hydrostatic test.

9. Documentation showing that the quality assurance program used by the manufacturer is equivalent to that required by the Code.

10. The manufacturer of the vessel shall identify the Inspection Agency whose personnel made the shop inspections and signed the Manufacturer's Data Report for the vessel.

11. The qualifications, or Certification by a Jurisdictional Authority, of the Inspection Agency.

12. Certification by the Inspection Agency that all inspectors making shop inspections of the vessel meet the qualifications required by the Jurisdictional Authority. The individual inspectors names and commission numbers, if any, shall be provided. The system of supervisorial control of such inspectors at the shop shall be included.

13. A copy of the manufacturer's "traveler" showing items inspected or verified by the shop inspector during fabrication.

14. A facsimile of the stamped nameplate used on the vessel.

15. A Manufacturer's Data Report, signed by the manufacturer and the shop inspector, shall be submitted containing the equivalent data required by the ASME Boiler and Pressure Vessel Code. (Do not use ASME Data Report Forms)

When the above information is received, it will be reviewed to determine whether the vessel can be accepted as meeting the requirements of the Safety Orders.

The vessel will be inspected by a qualified inspector holding a current California Certificate of Competency at the place of installation to make certain the above provisions have been complied with, and that the vessel is identified per the information submitted.

It is the prospective owner's responsibility to demonstrate that the equipment is built and installed and will be operated in compliance with the Safety Orders administered by this office and the manufacturer's installation and operational instructions.

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CITY OF RIVERSIDE PLANNING DEPARTMENT

FEE SCHEDULE --- EFFECTIVE JULY 1, 1993

CITY PLANNING COMMISSION

CU -	CONDITIONAL USE PERMIT - First lot/acre	$ 3,300
	Additional lot/acre or portion thereof	$ 66
	Initial Study	$ 407
	Variances after CUP approval	$ 671
	Revised CUP Plot Plan	$ 2,035
	Time Extension (per year)	$ 440
	Appeal	$ 671
RZ -	REZONING REQUESTS First lot/acre	$ 1,760
	Additional lot/acre or portion thereof	$ 44
	Initial Study	$ 407
	Time Ext (per year) Without Public Hearing	$ 429
	Time Ext (per year) With Public Hearing	$ 682
	Appeal	$ 671
	PLOT PLAN REVIEWS	
MP -	Manufacturing Park	~~$ 2,530~~
CI -	C-1-A (Shopping Centers)	$ 2,750
YS -	Contractor's Storage Yard	$ 2,530
OZ -	Official	$ 2,530
	Initial Study	$ 407
	Variances after Plot Plan Approval	$ 1,331
	Revised Plot Plans	$ 2,530
	Time Extension (per year)	$ 418
	Appeal	$ 671
PD -	PLANNED RESIDENTIAL DEV. First lot/acre	$ 4,180
	Additional lot/acre or portion thereof	$ 44
	Initial Study	$ 154
	Variances after PRD approval	$ 550
	Revised Plot Plan	$ 2,640
	Time Extension (per year)	$ 429
	Appeal	$ 671
VC -	VACATIONS OF RIGHTS-OF-WAYS	
	Pedestrian Walkway	$ 1,012
	Street or Alley	$ 3,355
	For each additional street	$ 110
	Initial Study	$ 407
	Appeal	$ 671
TP -	TRAFFIC PATTERN MODIFICATION	$ 3,355
	For each additional street	$ 110
	Appeal	$ 671
CC -	CONDOMINIUM CONVERSION	$ 1,650
	Appeal	$ 671
IZ -	INTERPRETATION OF ZONING TEXT	$ 1,177
	Appeal	$ 671
AM -	AMENDMENT TO ZONING TEXT	$ 2,200
	Initial Study	$ 407
	Request for CPC Initiation	$ 638
	Appeal	$ 671
SC -	STREET NAME CHANGE	$ 198
	Appeal	$ 165

SUBDIVISION

TM -	TENTATIVE TRACT MAP	$ 4,829
	Each lot including streets and easements	$ 44
	Initial Study	$ 407
	Variances after map approval	$ 1,342
	Time Extension (per year)	$ 407
	Appeal by applicant	$ 671
	Appeal by non-applicant	$ 0
PM -	PARCEL MAP	$ 3,630
	Initial Study	$ 407
	Variances after Parcel Map approval	$ 1,342
	Revised Parcel Map	$ 2,530
	Time Extension (per year)	$ 374
	Appeal by applicant	$ 671
	Appeal by non-applicant	$ 0
PW -	PARCEL MAP WAIVER	$ 3,080
	With Variances	$ 3,300
	Initial Study	$ 407
	Time Extension (per year)	$ 440
	Appeal	$ 671
CO -	CERTIFICATE OF COMPLIANCE	$ 2,178
	With Variances	$ 2,706
	Initial Study	$ 407
	Appeal	$ 671
	VESTING MAP	$ 4,842
	Each lot including streets and easements	$ 66
	Initial Study	$ 339
	Time Extension (per year)	$ 550
	Appeal by applicant	$ 671
	Appeal by non-applicant	$ 0
	REVISED TENTATIVE OR VESTING MAP	$ 2,200
	Each lot including streets and easements	$ 44
	Initial Study	$ 407
	Appeal by applicant	$ 671
	Appeal by non-applicant	$ 0
	REVERSION TO ACREAGE MAP	$ 4,290
	Initial Study	$ 407
	Time Extension (per year)	$ 407
	Appeal by applicant	$ 671
	Appeal by non-applicant	$ 0
	PRELIMINARY MAP	$ 4,290
	Each lot including streets and easements	$ 66

10% GENERAL PLAN SURCHARGE IS INCLUDED ON ALL FEES LISTED ON THIS SCHEDULE

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Revised 05/26/93

GENERAL PLAN/AREA PLANS

GP -	GENERAL PLAN AMENDMENTS	$ 3,160
	Additional lot/acre or portion thereof	$ 44
	Initial Study	$ 407
	Appeal	$ 671
SP -	SPECIFIC PLAN	$10,054
	Additional lot/acre or portion thereof	$ 99
	Initial Study	$ 1,705
	Appeal	$ 671
SP -	REVISED SPECIFIC PLAN	$ 5,344
	Additional lot/acre or portion thereof	$ 143
	Initial Study	$ 1,705
	Appeal	$ 671
DA -	DEVELOPMENT AGREEMENT	$ 5,830
	Amendment	$ 4,290
	Initial Study	$ 1,122
	Appeal	$ 671

ENVIRONMENTAL PROTECTION COMMISSION

IS -	INITIAL STUDY (Grading)	$ 605
	Additional lot/acre or portion thereof	$ 605
	up to a maximum of	$ 4,840
	Revised Initial Study (Grading)	$ 462
	Additional lot/acre or portion thereof	$ 462
	up to a maximum of	$ 4,840
	Appeal	$ 671
IS -	INITIAL STUDY (All other projects)	$ 407
	Revised Initial Study	
	75% of the appropriate fee required	
	Appeal	$ 220
ER -	ENVIRONMENTAL IMPACT REPORT	$13,400
	Appeal	$ 638
	DE MINIMIS FINDING APPEAL	$ 385

MISCELLANEOUS

(charged the 10% General Plan Surcharge)

TU -	TEMPORARY USE PERMITS & RECYCLING PERMIT	$ 64
	Non-commercial car washes	$ 0
NS -	NONCONFORMING STATUS REVIEW	$ 935
	Administrative referral	$ 110
	PUBLIC HEARING ADVERTISING/RE-ADVERTISING	$ 165
	MODIFICATION/CLARIFICATION OF CONDITIONS	$ 517
AL -	AIRPORT LAND USE COMMISSION	
	Appeals Public Hearing	$ 275
	Appeals Non-Public Hearing	$ 110

MISCELLANEOUS

(not charged the 10% General Plan Surcharge)

PHOTO COPIES OF PRINTED MATERIALS per page	.25¢
COPIES FROM MICROFICHE	$ 2
TITLE 19	$ 25
GENERAL PLAN DOCUMENT	$ 30
GENERAL PLAN MAP	$ 5

BOARD OF ADMINISTRATIVE APPEALS & ZONING ADJ.

VR -	VARIANCE	$ 1,031
	Additional lot/acre or portion thereof	$ 89
	Initial Study	$ 407
	Time Extension (per year)	$ 404
	Appeal by the applicant	$ 671
	Appeal by non-applicant	$ 0
	MINOR VARIANCE	$ 161
	Additional lot/acre or portion thereof	$ 66
	Initial Study	$ 66
	Time Extension (per year)	$ 121
	Appeal by the applicant	$ 121
	Appeal by non-applicant	$ 0
	MINOR VARIANCE PLANNING	$ 266
	Additional lot/acre or portion thereof	$ 44
	Time Extension (per year)	$ 66
	Appeal by the applicant	$ 77
	Appeal by non-applicant	$ 0
AA -	Administrative Appeal	$ 374
	Appeal of Determination of Building Official,	
	Fire Marshall & Code Compliance	
	Appeal	$ 132
CV -	CONDITIONAL OCCUPANCY VARIANCE (1st bldg.)	$ 770
	Each Additional Building	$ 33
	Appeal	$ 671

DESIGN REVIEW BOARD

PP/EL-	PLOT PLAN/ELEVATIONS *	$ 1,001
	Additional lot/acre or portion thereof	$ 132
	Revisions -- 50% of above fee	
LS/IR-	LANDSCAPE/IRRIGATION PLANS *	$ 759
	Additional lot/acre or portion thereof	$ 308
	Revisions -- 50% of above fee	

* See DR Staff for Single
Family Subdivisions

SIGNS (Cumulative Total of all Signs)	
Less than 40 square feet	$ 297
40 - 99 square feet	$ 627
100 square feet and over	$ 1,012
Sign Criteria - multi tenant	$ 924
Revisions -- 50% of above fee	
REVERSE FRONTAGE	
Landscape, irrigation & wall plans	$ 990
Revisions -- 50% of above fee	
SUBDIVISION SALES OFFICE	
Staff Review	$ 110
SPECIAL PROJECTS COMMITTEE (per project)	$ 341
2ND SIMULTANEOUS DESIGN REVIEW FILING	$ 517
3RD SIMULTANEOUS DESIGN REVIEW FILING	$ 484
INSPECTIONS for 3rd and subsequent	$ 33
RECONSIDERATION (½ original fee not to exceed $693)	
TIME EXTENSION (per year)	$ 528
APPEAL	$ 495

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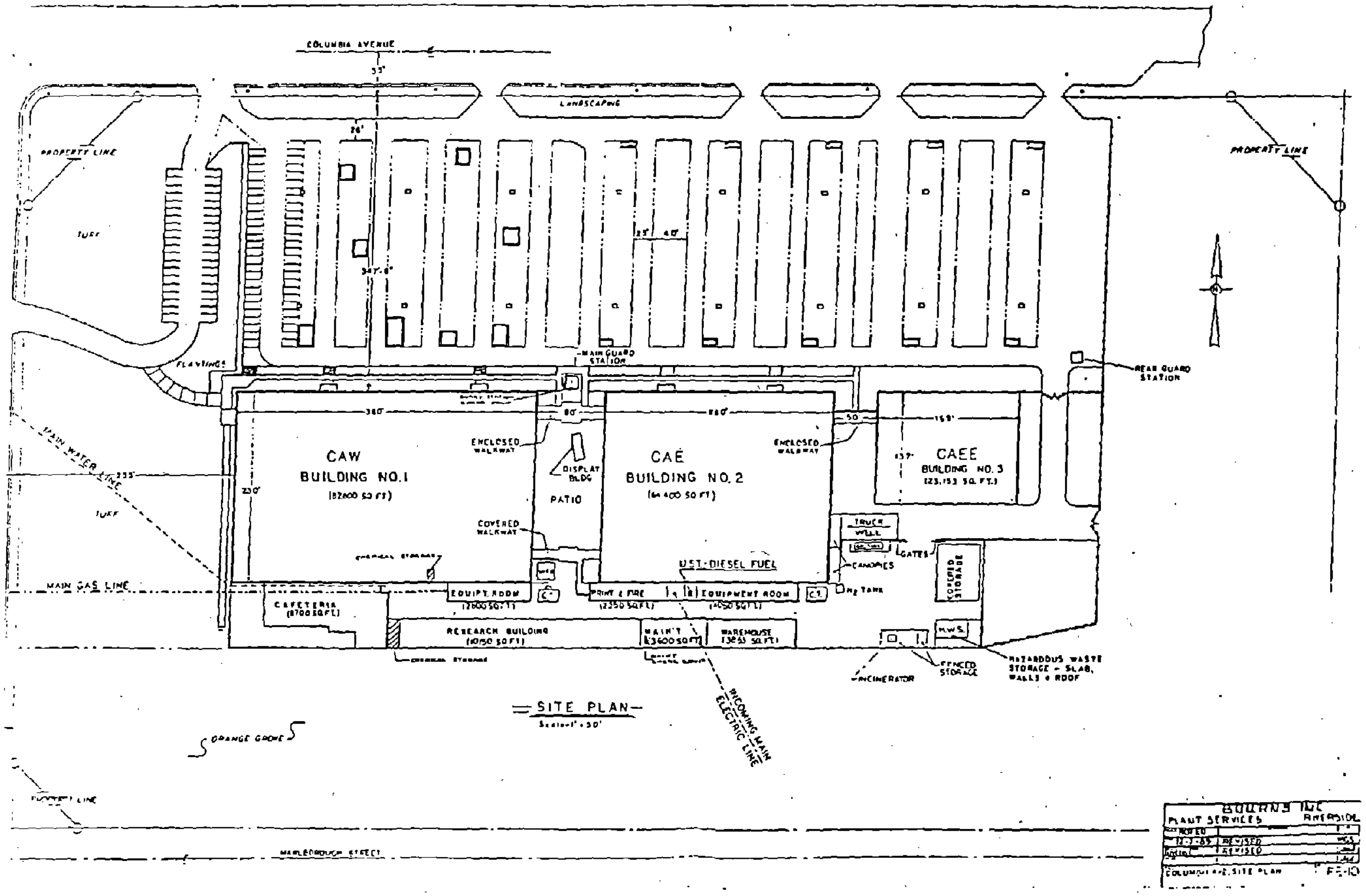
Revised 05/26/93

Bourns facility layout



Topographical map

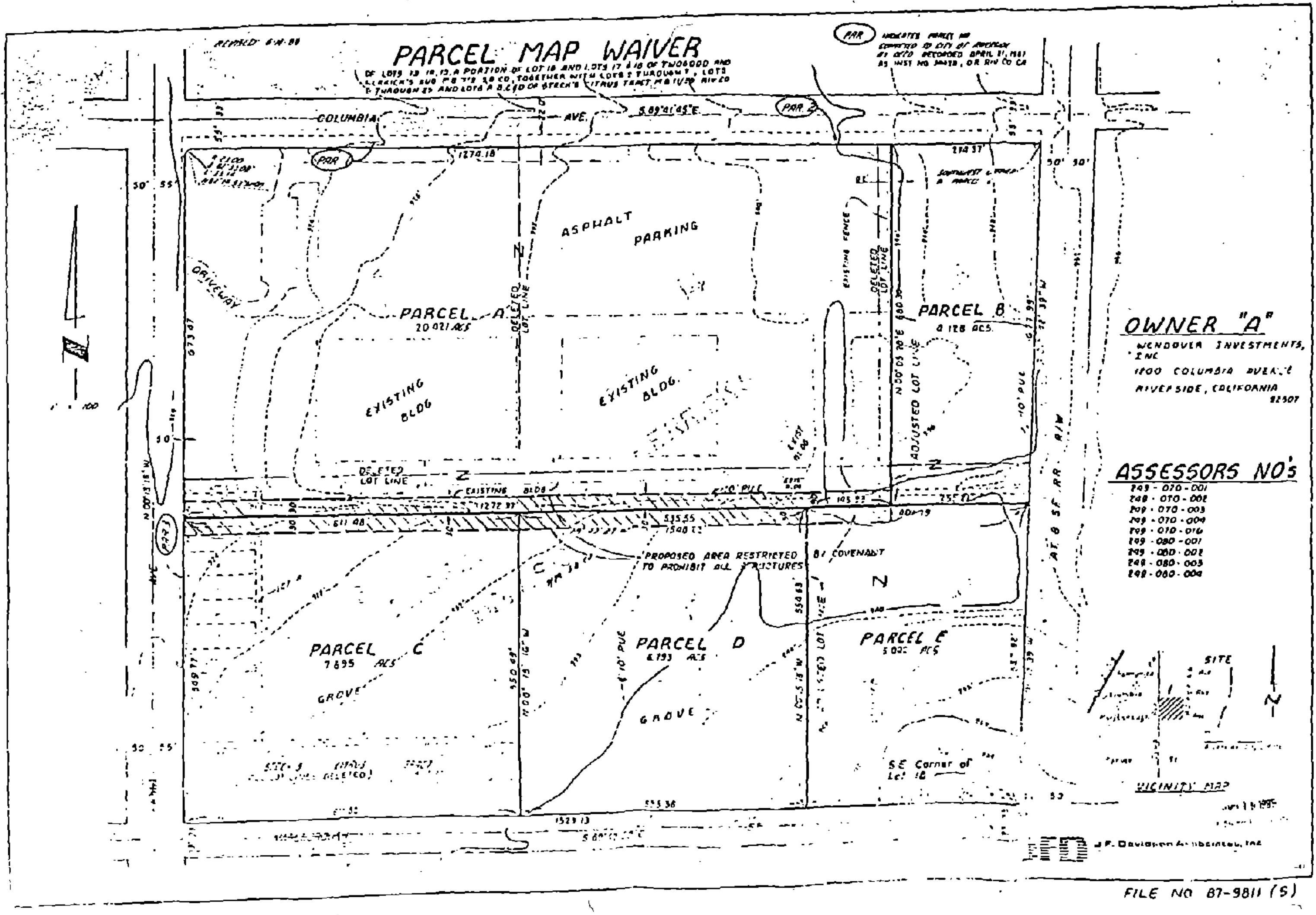


EXHIBIT A

STATEMENT OF WORK

1.0 GENERAL REQUIREMENTS

1.1 SCOPE OF WORK

This statement of work defines the technical and quality assurance requirements for the Contractor to prepare, demolish, excavate, backfill, form, install, pave, and finish all items specified herein, in accordance with these Specifications and/or as indicated in the documents listed in Section 1.4, APPLICABLE DOCUMENTS, of this Statement of Work. Questions concerning this Statement of Work shall be directed to Acurex Environmental Corporation (AEC) or to its designated Construction Inspector.

A preconstruction meeting shall be held prior to commencement of any work.

1.2 PROJECT LOCATION, TYPE, AND SITE CONDITIONS

This project is located at *CE-CERT, 1200 Columbia Avenue, Riverside, CA 92507*

The purpose of this project is to prepare the site for a biomass to methanol facility

The Work involves *grading and compaction, asphalt, concrete foundations, and fencing.*

1.3 TENANT INTERFACE

The Contractor shall guarantee that all existing structures outside of the work area will not be damaged by his on-site operations. Any damage to these facilities shall be repaired or replaced by the Contractor at his own expense.

The Contractor must guarantee that the operation of the adjacent facilities will not be adversely affected by operations of the Contractor at the site.

1.4 APPLICABLE DOCUMENTS

The Work shall be executed in conformance with the documents listed below. If there is, or seems to be, a conflict between the Drawings or this Specification and a referenced document, the matter shall be referred to AEC in writing for resolution.

The documents listed shall be of the issue in effect on the date of the Contract and shall form a part of this Specification.

Where these documents are not directly referenced in the body of the text, they are intended as basic information guides and material controls to the work to be done therein, and as such constitute a part of the requirements of this Specification.

1.4.1 Standards

A. American Concrete Institute (ACI)

SP-2	Manual of Concrete Inspection
301	Specifications for Structural Concrete for Buildings
305	Hot Weather Concreting
306	Cold Weather Concreting
315	Manual of Standard Practice for Detailing Reinforced Concrete

B. American Society for Testing and Materials (ASTM)

A36	Specification for Structural Steel
A82	Specification for Cold-Drawn Steel Wire for Concrete Reinforcement
A185	Specification for Welded Steel Wire Fabric for Concrete Reinforcement
A615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
C94	Specification for Ready Mix Concrete
D1557	Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-Pound Rammer and 18-inch Drop

C. Occupational Safety and Health Act (OSHA)

All Standards

D. National Fire Protection Association (NFPA)

All Standards

E. Uniform Building Code (UBC)

Code in total including State of the California Amendments

F. State of California

Department of Transportation Standard Specification Sections 10, 24, 26, 37, 39, 40, 90, 92, 93, and 94 and Standard Plan Sheets A35-A and A35-B

1.4.2 Drawings

The following Drawings are included herein and made a part of this Contract:

Drawing Number	Title
FE-10	COLUMBIA AVE SITE PLAN
B-30002	HYNOL PLOT PLAN
XXXX C 001	GRADING PLAN *{ To Be Determined }*
87-9811	TOPOGRAPHICAL MAP
XXXX M 001	*{ To Be Determined }*

It is not intended or to be inferred that the conditions as shown on the above listed Drawings constitute a representation by AEC, the Owner, or the agents of AEC or the Owner, that such conditions are actually existent, nor shall the Contractor be relieved of the liability under his Contract, nor shall AEC, the Owner, or any of their agents be liable for any loss sustained by the Contractor as a result of any variance between conditions as shown on the Drawings and the actual conditions revealed during the progress of the Work or otherwise.

The Contractor shall check all Drawings furnished him immediately upon their receipt, and shall promptly notify AEC of any omission or discrepancies. Omissions from the Drawings or the misdescription of Work which are manifestly necessary to carry out the intent of the Drawings, or which are customarily performed, shall not relieve the Contractor from performing such omitted or misdescribed details of Work, and they shall be performed as if fully and correctly set forth and described on the Drawings. In case of conflict between the printed text and the Drawings, the printed text shall govern.

Revisions of the above listed Drawings may be made when deemed necessary by AEC during the progress of the Work.

1.5 QUALITY ASSURANCE

A. Hold Points

Hold Points shall be mandatory Work stopping points for inspections, testing, or for work to be performed by Others, which require the Contractor to stop all Work related operations until notified by the AEC Construction Inspector that Work may again proceed. They may called out in this document under the different technical phases of the project.

B. Deviations and Nonconformances

No deviations from these Specifications will be accepted without prior written approval from AEC. Deviations will be considered departures from any requirements of these Specifications. Uncorrectable nonconformances are considered to be conditions which cannot be corrected within these Specifications by rework or replacement. All deviations or nonconformances shall be communicated to AEC in writing for resolution. Any request for approval of deviations or nonconformances to the contract documents shall be processed in accordance with CHANGES IN WORK of the Contract General Provisions (see EXHIBIT B).

C. Stop Work Action

Where, in the judgment of the AEC Construction Inspector, the Contractor or his subcontractors are performing work contrary to the conditions and terms of these Specifications, or where continued operations could cause damage, preclude further inspection, cause injury or loss of life, or render remedial actions ineffective for any product form/service provided by the Contractor or its subcontractors, the AEC Construction Inspector shall orally notify the Contractor to stop work and shall confirm such notification in writing within five (5) working days. The Contractor shall comply with such a notice in accordance with Article 11, "Warranty and Guarantee, Inspections, Correction, Removal or Acceptance of Defective Work," of the Contract General Provisions (see EXHIBIT B).

D. Tests

Tests to be provided by the Contractor include density and compaction tests for any recompacted existing fill, for the newly placed fill, and for the aggregate base course.

E. Inspections

The AEC Construction Inspector will be at the site during construction operations. This shall in no way relieve the Contractor of his responsibility to perform quality work to the limits specified in this document. Therefore, the Contractor shall take steps to ensure the quality of his work.

1.6 PERMITS

AEC will obtain, pay for, and supply the Contractor with all permits required by local city or county building departments, planning departments, and/or fire departments.

All other permits required for the construction operations, such as, but not limited to, dumping permits, hauling permits, etc., shall be the responsibility of the Contractor. The Contractor shall obtain such permits at his own expense.

1.7 DOCUMENTATION

The Contractor shall keep, and make available to AEC, records of all operations, equipment, and material movement. These records shall include, but not be limited to, equipment rental receipts, truck hauling records, landfill receipts, and all other records needed to assess the extent of the work.

The Contractor shall provide AEC with documentation that any imported backfill material is free of hazardous chemical contamination (see Section 2.3).

1.8 MEASUREMENT OF PAYMENT

The contract price for the job will become payable upon completion of all work specified herein, demobilization of all equipment, a satisfactory Final Inspection of the work by the AEC Construction Inspector, and a satisfactory post-work inspection of the facility by the Owner.

1.9 INSURANCE REQUIREMENTS

The Contractor shall procure and maintain the following insurance coverage at its own expense. Prior to the start of work, the Contractor shall provide certificates evidencing the insurance coverage and naming Acurex Environmental Corporation and the Owner, as additional insureds. (See ARTICLE 5 - INSURANCE, in EXHIBIT B)

A. Workmen's Compensation Insurance

The Contractor shall procure and maintain Workmen's Compensation Insurance in the amounts required by applicable state law.

B. Employer's Liability Insurance

The Contractor shall procure and maintain Employer's Liability Insurance in the amounts required by applicable state law.

C. Comprehensive General Liability Insurance

The Contractor shall procure and maintain Comprehensive General Liability Insurance in the amount of $1,000,000 for bodily injury and property damage.

D. Automobile Liability Insurance

The Contractor shall procure and maintain Automobile Liability Insurance in the amount of $1,000,000 per occurrence.

2.0 EARTHWORK

2.1 SCOPE OF WORK

This portion of the Specifications details the technical requirements necessary to complete all earthwork on the project site, in accordance with the Specifications and Documents. The Contractor shall provide all labor, supervision, equipment, materials, material disposal, and services to complete all site preparation work, demolition, shoring, excavation, hauling, filling, and finishing work. The following sections detail the requirements for each type of work.

- 2.4 SITE PREPARATION
- 2.5 DEMOLITION
- 2.6 SHORING
- 2.7 EXCAVATION
- 2.8 AREA FILL, BACKFILL, GRADING, AND COMPACTION

2.2 GENERAL REQUIREMENTS

All equipment and material shall be furnished and installed in accordance with the General Requirements.

The Contractor shall keep a copy of any construction drawings at the site at all times during his operation.
The Contractor shall provide adequate shoring, bracing, guys, and safety barriers in accordance with all national, state, and local safety codes and ordinances. Any deviation must be approved by AEC prior to beginning any excavation work. Such approval is required solely to inform AEC of the situation, and shall not be deemed to shift the responsibility for the adequacy or correctness of the situation from the Contractor.

The Contractor shall be solely responsible for all excavation procedures including lagging, shoring, and protection of adjacent property, structures, streets, and utilities, in accordance with all national, state, and local construction or safety codes and ordinances.

The Drawings indicate general and typical arrangement of areas of construction. Where conditions are not specifically indicated but are of similar character to arrangement shown, similar details of construction may be used, subject to review by the AEC Construction Inspector.

The Contractor shall limit disturbances to the site to the minimum necessary to complete the work. Structures, roads, parking areas, vehicles, and vegetation adjacent to the excavation site and hauling route shall be protected to the satisfaction of AEC and the Owner. Should any structure or material be damaged by the operations of the Contractor, the Contractor shall correct such damage at his own expense. The Contractor shall restore all disturbed areas not a part of the completed work to a condition as near to the original condition as possible. The Contractor shall be held liable for any damages to vehicles or personal property occurring as a result of the Contractor's operations at the site.

During excavation and filling phases, all public streets adjacent to the project shall be kept clean and free of all material deposits resulting from the operation.

The Contractor shall provide the means for preventing or lessening all dust nuisances and damages. Such means may include, but not necessarily be limited to, applying water, dust palliatives, or both, in accordance with local ordinances and regulations.

The Contractor shall provide temporary erosion control measures for excavation, storage, and backfill operations at the site. They may include, but not be limited to, covering all excavated soil with plastic sheeting and positioning hay bales around the periphery of the excavated soil.

2.3 MATERIALS AND EQUIPMENT

The Contractor shall furnish all tools, equipment, materials, and services necessary or required for the completion of the work in accordance with the Contract.

Temporary Toilet facilities for all workmen shall be provided and maintained by the Contractor through completion of the Work.

The Contractor shall provide all water for construction purposes such as dust control and compaction. Drinking water for the workmen shall be provided by the Contractor.

All other utilities required for use in the Work shall be provided and maintained by the Contractor.

All new fill material shall be free of chemicals, hazardous materials, and hazardous waste contamination. The Contractor, or an agent of the source of the fill material, shall provide AEC with documentation that the fill material is free from contamination. The Contractor shall submit the name of the source and a description of the proposed fill material to AEC for approval prior to beginning the work.

2.3.1 Fill Material

Type "A" Material: Top soil obtained from site excavations from existing surface to 9-inches deep.

Type "B" Material: Moderately to highly expansive soils consisting of the more cohesive, stiff, and highly plastic clays and clayey to cemented silts. The material shall be completely free from wood, roots, and other extraneous material, and shall not contain any rubble, clods, or rocks over 3-inches in greatest dimension.

Type "C" Material: Non-expansive subsurface soils consisting of all silts and sands which are free of vegetation, rubble, or other deleterious substances, having no clods or particles larger than 3-inches in maximum dimension, and which have a plasticity index not exceeding 12.

Type "D" Material: Select structural backfill material meeting all the qualifications of Type "C" Material, but comprised of non-plastic sands.

Type "E" Material: Clean, granular material free from organic matter and conforming to the following gradation:

SIEVE SIZE	PERCENT PASSING
1-inch	100
No. 4	0-5

Type "F" Material: Clean, free draining, granular material free from organic matter and conforming to the following gradation:

SIEVE SIZE	PERCENT PASSING
1-inch	100
No. 4	0

Type "G" Material: Clean sand of good quality and in accordance with U.B.C. Chapter 70, Section 7010(d).

Type "H" Material: Clean aggregate base course material conforming to the requirements of California

Specification Section 26 for Class 2 aggregate base, 3/4-inch maximum size.

Type "J" Material: Clean, washed, sound and durable, well graded crushed rock, crushed gravel or gravel of 1-1/2-inch maximum size and 3/8-inch minimum size.

Type "K" Material: Clean, washed, sound and durable 1/4-inch pea gravel.

NOTE: No Type "E" or Type "F" material shall be used until it has been accepted by the AEC Construction Inspector. Samples of the material proposed for use shall be submitted a sufficient time in advance of its intended use to enable its inspection and testing.

2.4 SITE PREPARATION

Site preparation requirements for this project *{ To Be Determined }*

If the Contractor requires temporary storage area, the AEC Construction Inspector will arrange for such storage space at the site.

All topsoil and vegetation such as roots, brush, heavy sods, heavy growths of grass, and all decayed vegetable matter, rubbish and other unsuitable material shall be stripped or otherwise removed from the natural surfaces of the plant area fills. Topsoil (Type "A" fill material) shall be stockpiled for use in the upper 6-inches of all landscaped areas. All stripping shall be disposed of by the Contractor in a manner acceptable to the AEC Construction Inspector. After topsoil and vegetation have been removed, the areas to receive fill material shall be proof-rolled with a heavy roller to locate any zones that are soft or spongy. If weak soils are detected they shall be replaced with properly compacted fill.

2.5 DEMOLITION

Demolition shall involve *{ To Be Determined }*

The Contractor shall furnish all labor, equipment, supervision, hauling, and service to complete the demolition work shown on the Drawings.

Demolition must not proceed until any and all required permits have been obtained.

2.6 SHORING

The use of shoring is at the Contractor's discretion. However, any damage resulting to the equipment or structures, due to failure of the soil or by any other action of the Contractor, shall be the sole responsibility of the Contractor. The Contractor shall indemnify AEC and the Owner against any loss resulting from any damage caused by the Contractor's operations.

2.7 EXCAVATION

The Contractor shall provide all labor, equipment, supervision, and hauling necessary to remove the soil and dispose of it in an approved landfill or AEC approved disposal site.

AEC shall provide a drawing of the excavation limits and shall provide inspection of the operation.

Except as otherwise shown or specified, any method of excavation within the work limits shown may be employed which, in the opinion of the Contractor, is considered workable. Existing paving, underground piping, adjacent structures and/or property shall be protected at all times from damage of undermining, uneven settlement, and impact. The Contractor shall take care not to disturb the natural or fill soils at, below, or adjacent to the excavation.

The excavation shall be kept free of water. The Contractor shall provide and operate all equipment necessary to accomplish this, and shall set-up diversion channels to aid in this respect should inclement weather become a possibility.

Dust, erosion, and noise shall be controlled at the site. The Contractor shall control dust emissions to the maximum extent possible. Water used for dust control shall be free of contamination.

Hauling shall be done during normal daylight working hours to prevent adverse effects upon all neighborhoods along the haul route. The Contractor shall restrict site construction operations to normal daylight working hours to minimize adverse effects of noise on the surrounding community. Hauling shall be in compliance with any regulations or codes established by any municipalities having jurisdiction at the site or along the haul route. The Contractor shall consult those municipalities to obtain any needed permits to accomplish the hauling phases of the project.

Where necessary, the Contractor shall provide for erosion control. Such provisions shall be in conformance with all local codes and ordinances, and to the satisfaction of the AEC Construction Inspector.

The excavation shall only be carried on to the limits as shown on the Drawing. If further material is removed without prior approval by AEC, the Contractor shall replace the extra cut material at his own expense. Any additional fill material made necessary by the Contractor's operations shall be paid for by the Contractor.
In addition to the Fixed Price Bid submitted by the Contractor in response to this Contract, the Contractor shall provide Acurex with an hourly Time and Material price for additional excavation and fill beyond the limits and scope shown on the drawings. This price will be used as a basis for any AEC approved Change Orders increasing the scope of the excavation work.

2.7.1 At Structures

Except as otherwise shown or specified, any method of excavation within the work limits shown may be employed which, in the opinion of the Contractor, is considered best. At those locations where the excavation extends below the static groundwater level, or the natural soils are saturated and of low strength, the Contractor shall take whatever precautions are necessary to maintain the undisturbed state of the foundation soils at and below the bottom of the excavation.

Material shall not be stockpiled to a depth greater than 5-feet above finished grade within 75-feet of any excavation or structure. However, it shall be the Contractor's responsibility to maintain stability of the soil adjacent to any excavation.

Where, in the opinion of the AEC Construction Inspector, the undisturbed condition of the natural soils below the excavation grades indicated or specified is inadequate for the support of the planned structure, the AEC Construction Inspector shall direct the Contractor to over-excavate to adequate supporting soils and refill the excavated space to the proper elevation in accordance with the procedure specified for backfill, or if under footings, refill the space with concrete. The quantity and placement of such material shall be as ordered by the AEC Construction Inspector and shall be paid for as extra work.

Should the excavation be carried below the lines and grades indicated on the drawings because of the Contractor's operations, the Contractor shall, at his own expense, refill such excavated space to the proper elevation in accordance with the procedure specified for backfill or, if under footings, the space shall be filled with concrete as directed by the AEC Construction Inspector Should the natural foundation soils be disturbed or loosened because of the Contractor's operations, they shall be recompacted or removed and the space refilled as directed by the AEC

Construction Inspector at the Contractor's expense.

Excavation shall extend a sufficient distance from walls and footings to allow for placing and removal of forms, installation of services, and for inspection, except where concrete is authorized to be deposited directly against excavated surfaces. Existing structures which remain as part of the final construction shall be protected at all times from damage of undermining and uneven settlement.

Where pipelines and sewers enter a structure, the requirement for trench excavation shall be complied with up to the excavation line of the structure unless specified or directed otherwise.

2.7.2 At Pipelines, Sewers, and Electrical Conduits

Unless otherwise indicated, excavation for pipelines and sewers shall be open cut. Trenching machines may be used except where their use will result in damage to existing facilities. Unless otherwise specified or indicated, the Contractor may use any method of excavation which will not damage or endanger adjacent structures or property or disturb the natural or fill soils at, below and adjacent to the excavation.

When additional gravel or crushed rock is required to stabilize a soft, wet, or spongy foundation caused by the operations of the Contractor, such gravel or crushed rock shall comply with Type "J" material for both material and placing, and shall be provided at the Contractor's expense.

All trenches shall be excavated a minimum of 6-inches below the barrels of pipes 4-inches and larger and 2-inches minimum for pipes smaller than 4-inches. Bell holes shall be excavated as necessary to provide above clearances. To suit field conditions, excavation below the depths shown or indicated herein may be ordered by the AEC Construction Inspector. Unsuitable material shall be removed and replaced with Type "J" material. Excess excavation and fill ordered by the AEC Construction Inspector will be paid for as extra work.

The maximum allowable width of trench measured 6-inches minimum above the top of the pipe shall be the pipe outside diameter exclusive of bells and collars plus 18-inches, or as shown on the drawings, and such maximum width shall be inclusive of all trench bracing, shoring and timbers. A minimum of 8-inches shall be maintained between pipe and trench wall or sheeting. Where pipes are placed in a common trench, a clear distance between pipes shall be maintained to allow backfill to be properly compacted with a minimum distance of 12-inches unless otherwise directed by the AEC Construction Inspector, or shown on the drawings.

At manholes, the maximum trench width shall be increased to provide at least 18 inches clear distance around the outside of the manhole.

Whenever the maximum allowable trench width is exceeded for any reason, the Contractor shall, at his expense, embed or cradle the pipe in concrete in a manner acceptable to the AEC Construction Inspector or provide evidence that the pipe can safely carry the additional loading imposed by the increased trench width .

In accordance with the requirements of Section 6750 of the Labor Code of the State of California, the Contractor shall submit a detailed drawing to the AEC Construction Inspector before excavation, showing the design of shoring, bracing, sloping or other provisions to be made for worker protection from the hazard of caving ground during the excavation of any trench or trenches 5-feet or more in depth.

The minimum required protection will be that described in the Construction Safety Orders of the Division of Industrial Safety. If the Contractor presents a drawing which varies from the shoring system standards established by the Construction Safety Orders, the drawing shall be prepared and signed by a registered civil engineer.
The AEC Construction Inspector will review the drawing submitted by the Contractor and return it with comments indicating unacceptable deficiencies; however, the Contractor shall be responsible for the adequacy of the design. Said review will be to assure AEC and the Owner of general compliance with the Labor Code and Safety Orders

and shall not be construed as a detailed analysis for adequacy of the support system, nor shall any provisions of the above requirements be construed as relieving the Contractor of overall responsibility and liability for the work.

The Contractor shall not start excavation until after the trench support drawing has been returned by the AEC Construction Inspector.

In addition, the Contractor shall obtain, pay for, and comply with all provisions of the permit required by Section 6500 of the California Occupational Safety and Health Act.

2.8 AREA FILL, BACKFILL, GRADING, AND COMPACTION

The Contractor shall provide all labor, equipment, material, supervision, and services to complete the hauling, filling, grading, and compacting operations.

Except as otherwise shown or specified, any method of backfilling within the work limits shown may be employed which, in the opinion of the Contractor, will provide the necessary compaction while not damaging adjacent structures or equipment. The Contractor may use any method of backfilling which will not damage or endanger the adjacent structures, piping, paving, or property adjacent to the work site.

Compaction where used below is defined as relative compaction and refers to the in-place dry density of the fill expressed as a percentage of the maximum dry density of the same material, as determined by the ASTM D1557 laboratory test procedure. In addition to required compaction tests provided by the Contractor, all compacted materials may be tested by the AEC Construction Inspector by in-place moisture and density tests. Excavations within 5-feet of, or under, structures shall be treated as structural excavation and backfill.

As used in this specification, the following definitions shall apply:

> "Engineered Fill" means all fill placed within areas supporting buildings, structures, equipment slabs, roadways, and all paved areas, walk-ways and slabs on grade. Limits of engineered fill shall extend 2-feet beyond foundations of structures and edges of roadway or paved areas and to thickness as shown on the drawings.
>
> "Embankment Fill" means all fill used in construction of dikes and embankments.
>
> "Site Fill" means fill placed in all areas except the engineered fill and embankment fill.

2.8.1 Area Fill

Area fill and grading includes all fill, other than structural backfill, required to bring the site to finished elevations as shown.

Areas receiving fill shall be scarified to a depth of 6-inches, brought to a moisture condition at least 4 percent over optimum moisture, if a clay subgrade, or to optimum moisture content, if a non-expansive subgrade, and shall be recompacted in place to at least 90 percent of the ASTM D1557 maximum dry density (clay subgrade) or 95 percent compaction (non-expansive subgrade). Site fill areas shall be compacted to at least 85 percent of maximum dry density.

Engineered Fill: Material for engineered fill shall be Type "C" or Type "D" material and shall be spread in layers not exceeding 6-inches loose thickness. Each layer shall be compacted to 90 percent of maximum dry density for fill 3-feet below the finished grade, and to 95 percent of maximum dry density for the top 3-feet.

Embankment Fill: Material for embankment fill shall be Type "B" material or a blend of Type "B" and Type "C" materials and shall be spread in layers not exceeding 6-inches loose thickness. Each layer shall be compacted to at least 90 percent of maximum dry density. When, in the opinion of the AEC Construction Inspector, the surface of any compacted layer is too smooth to bond properly with the succeeding layer, it shall be scarified to the satisfaction of the AEC Construction Inspector before the succeeding layer is placed thereon.

Site Fill: Material for remaining site fill shall be Type "B", Type "C" or Type "D" material. Material shall be compacted to at least 85 percent of maximum dry density.

2.8.2 At Structures

Fill Under Slabs: After the subgrade has been prepared, areas under all slabs in contact with earth shall receive a fill of either Type "J" or Type "F" fill material. Fill material shall be as specified. Structural base slabs shall be underlaid with Type "J" material. All other slabs on grade shall be underlaid with a layer of Type "F" or Type "J" material. The Type "F" or Type "J" material shall be compacted to 95 percent of maximum dry density and shall have a thickness, after compaction, of not less than 6-inches, or as shown on the drawings.

When Type "J" material is to be placed beneath base slabs, the Type "J" material shall be compacted by vibratory equipment. Where acceptable to the AEC Construction Inspector, the Contractor may substitute a suitable tractor or equivalent for vibratory compaction equipment. In that event compaction shall be accomplished by making two passes across the entire width of the drainage layer with the tractor operated at high speed; each pass giving complete coverage with the tractor treads.

All fill material under buildings, structures, equipment slabs, roadways, paved areas, walkways and slabs-on-grade shall be engineered fill, whether shown on the drawings or not. Engineered fill material and placement shall be as specified in this section of the specifications.

Replacement of Expansive Material Under Slabs, Foundations, and Pavements: Where expansive clays (Type "B" material) are encountered under structures, buildings, concrete slabs, roadways, and paved areas, the clay material shall be removed and replaced with Type "C" or Type "D" fill material as required to assure compliance with the following criteria:

At least 24 inches of Type "C" or Type "D" fill material plus 6-inches of Type "F" material shall be provided beneath the undersurface of floor slabs, exterior concrete slabs and similar items. At least 12-inches of Type "D" fill material shall be provided beneath shallow building foundations. At least 12-inches of Type "C" or "D" fill material shall be provided below the Type "H" material within asphalt concrete pavement areas to provide a higher quality subgrade than expansive clays.

Type "D" fill material supporting building foundations shall be compacted in horizontal lifts no thicker than 6-inches in compacted thickness with each lift being uniformly compacted to at least 95 percent compaction as defined above. Type "C" or Type "D" fill material supporting slabs and asphalt concrete pavement shall be placed in 6-inch layers and uniformly compacted to at least 90 percent for concrete slabs and 95 percent for asphalt concrete pavement.

Structures: After completion of foundation footings and walls and other construction below the elevation of the final grade, and prior to backfilling, all forms shall be removed and the excavation shall be cleaned of all debris. Unless otherwise shown, backfill shall be Type "D" material compacted to 90 percent of maximum dry density.

An impervious barrier shall be provided at the top of wall backfill to prevent infiltration of surface runoff water alongside walls. The barrier shall consist of asphalt paving, concrete, or at least 2-feet of Type "B" backfill compacted to 90 percent of maximum dry density.

The Contractor shall not proceed with backfill placement in excavated areas until acceptance is received from the AEC Construction Inspector. To determine if the Contractor is obtaining compacted backfill which will meet the specified requirements, frequent moisture content and density tests will be taken by the Contractor during these operations.

Backfill material shall be placed in uniform horizontal layers not exceeding 6-inches in loose depth and shall have a moisture content such that the required degree of compaction can be obtained. The thickness of the loosc layer may be increased when in-place density tests, satisfactory to the AEC Construction Inspector, show that the specified density can be obtained throughout the layer. Light construction equipment shall be used within 5-feet of structures to avoid overstressing the walls.

The Contractor shall maintain the surface of the backfill to prevent ponding water or collection of surface runoff and subsequent saturation of compacted or uncompacted layers. During inclement weather, the Contractor shall control surface runoff in such a manner so as to prevent erosion of the backfill or slope surfaces.

All retaining walls shall be backfilled on the earth side with Type "J" material.

2.8.3 At Pipelines, Sewers, and Electrical Conduits

Bedding: All pipes shall have a minimum of 2-inches of bedding material below the barrel of the pipe unless noted otherwise on the Drawings. Bedding material shall be Type "E" material and shall be shaped around the barrel of the pipe. Plastic piping shall have a bedding of Type "G" or Type "K" material with a depth below the pipe of 1/3 the pipe diameter but not less than 2-inches. Bedding shall be compacted to 95 percent of maximum dry density.

Where stabilization of the undisturbed foundation below the bedding is required because of soft, spongy, or unstable condition, Type "J" material shall be placed in the trench bottom. The quantity and placement of such material shall be as directed by the AEC Construction Inspector and will be paid for as extra work.

Initial Backfill: After the pipe has been properly laid and inspected, Type "D" material shall be placed around the pipe to a depth of 6-inches minimum over the pipe. The initial backfill material shall be placed in uniform horizontal layers not exceeding 6-inches in loose depth and compacted to a dry density of 95 percent of maximum dry density. Where compaction is done by jetting (if allowed be the AEC Construction Inspector), the thickness of each layer shall not exceed 4-feet. Material other than Type "D" will be permitted only after obtaining approval of the AEC Construction Inspector.

Each layer shall be compacted to the specified density prior to placing subsequent layers. The thickness of the loose layer may be increased when in-place density tests, satisfactory to the AEC Construction Inspector, show that the specified density can be obtained. No further backfilling will be permitted until the initial backfill has been accepted by the AEC Construction Inspector.

Subsequent Backfill: Backfill shall not be deposited in the trench in any manner which will damage or disturb the pipe or the initial backfill. Above the level of initial backfill, the trench shall be filled with Type "C" or Type "D" material unless otherwise indicated. The backfill material shall be placed in uniform horizontal layers not exceeding 6-inches in loose depth and shall have a moisture content such that the required degree of compaction can be obtained. Each layer shall be compacted to a dry density equal to 90 percent of maximum dry density as determined by the ASTM D1557 laboratory test procedure. The thickness of the loose layer may be increased when in-place density tests, satisfactory to the AEC Construction Inspector, show that the specified density can be obtained throughout the layer.

Compaction by jetting may be permitted when, as determined by the AEC Construction Inspector, the backfill material is of such character that it will be self-draining when compacted and that foundation materials will not soften or otherwise be damaged by the applied water and no damage from hydrostatic pressure will result to the pipe. The thickness of each layer prior to jetting shall not exceed 4-feet. Jetting of the upper 4-feet below finish grade will not be permitted. Jetting method shall be supplemented by the use of other compaction equipment when necessary to obtain the required compaction.

The grading and compaction will be considered complete when the fill has been properly compacted and has been finished-off at the proper subgrade level.

3.0 MECHANICAL

3.1 SCOPE OF WORK

This portion of the Specifications details the technical requirements necessary to complete all mechanical work on the project site, in accordance with the Specifications and Documents. The Contractor shall provide all labor, supervision, equipment, materials, material disposal, and services to complete all site mechanical work.

AEC shall furnish the following pre-purchased equipment items for installation by the Contractor.

Item	Quantity	Description
1	?	*{ To Be Determined }*
2	?	*{ To Be Determined }*
3	?	*{ To Be Determined }*
4	?	*{ To Be Determined }*
5	?	*{ To Be Determined }*
6	?	*{ To Be Determined }*

{ To Be Determined }

4.0 CONCRETE WORK

4.1 SCOPE OF WORK

The Contractor shall furnish all labor, supervision, equipment, materials, formwork, vertical and horizontal survey control, testing, and services to provide a concrete slab-on-grade over the existing methanol product tank. A plan view and typical cross sections are shown in the Drawings.

4.2 FORMWORK

Forms shall be smooth, mortar tight, true to the required lines and grade, and shall conform to the Drawings to shape, line, and dimensions of members. The forms shall have sufficient strength and rigidity to hold the concrete and to withstand the necessary pressure, tamping, vibration, and construction loads without deflection or springing out of shape during the placing of concrete. The formwork shall provide total support for all embedded metal. All metal items indicated for embedding in the concrete, shall be accurately placed, cleaned, and securely fastened to the formwork prior to placement of the concrete. All support for embedded items shall be from the formwork. No additional items shall be embedded after placing of concrete. The Contractor shall assume full responsibility for the adequate design and erection of all forms. Forms shall be inspected by the AEC Construction Inspector prior to concrete placement, and if, in the opinion of the AEC Construction Inspector, they are unsafe or inadequate in any respect, they shall be reworked or adequately replaced by the Contractor at the Contractor's expense. All lumber for use as formwork, shoring, or bracing shall be new, or of adequate strength and surface quality, for the task at hand. The Contractor may use the most advantageous panel size and joint locations. Neat patches and minor surface imperfections will be permitted. All exposed edges of concrete on both the inside and outside of structures shall be chamfered or beveled at an angle of 45 degrees, such bevel being 3/4-inch on each side. All exposed horizontal concrete edges shall have a 1/2-inch radius tooled in the wet concrete during the finishing operation.All chips, sawdust, and other foreign matter shall be removed from the formwork before any concrete is deposited therein. Before concrete is deposited within the forms, all inside surfaces of the forms shall be thoroughly coated with an AEC approved form sealer. Excess form coating material shall not be allowed to stand in puddles in the forms.

Forms, bracing, and shores shall be kept in place until removal is accepted by the AEC Construction Inspector, and in no case shall concrete formwork be removed earlier than 48 hours after placement of concrete. Forms shall not be stripped from concrete which has been placed in ambient temperatures under 50°F without first determining if the concrete has properly set.

4.3 CONCRETE REINFORCING STEEL

Reinforcement bars shall be deformed bars conforming to ASTM A615 and shall be Grade 40, 40,000 psi minimum yield strength. Wire shall conform to ASTM A82. Welded wire fabric for concrete reinforcement shall conform to ASTM A185, except that the weld shear strength requirement of Section 5b of those specifications shall be extended to include a wire size differential up to and including No. 6 gage. Supports for reinforcing bars in concrete slabs-on-grade shall be precast concrete blocks. Metal or plastic support legs shall not be used.

Steel reinforcement may be fabricated in the shop or in the field. All fabrication shall be in accordance with ACI 315, except as otherwise specified. Steel reinforcement for stirrups and tie bars shall be formed around a pin having a minimum diameter of 3 bar diameters. All other reinforcing steel shall be formed around a pin having a minimum diameter of 8 bar diameters. All bars shall be bent cold.

Before the bars are placed, the surfaces of the bars shall be cleaned of heavy flaked rust, loose mill scale, dirt, grease, or other foreign substances which are objectionable in the opinion of the AEC Construction Inspector. The reinforcement bars shall be kept in a clean condition after placement until they are embedded in the concrete.

Reinforcement bars shall be accurately placed and secured in a position so that they will not be displaced during the placement of the concrete, and special care shall be exercised to prevent any disturbances of the reinforcement bars in concrete that has already been placed. Straightening or rebending improperly bent bars will not be allowed. Heating or welding or bars will be permitted only upon specific approval of the AEC Construction Inspector. Measurements for bending and placing the bars, except for hooks and clearances, shall be to the centerline of the bars.

All splices of the bars shall be lapped splices conforming to the requirements of ACI 318. Field splices in locations other than those shown on the Drawings shall be designed in accordance with ACI 318. Adjacent sheets of welded wire fabric shall be spliced by lapping not less than one mesh pattern plus 2-inches (6-inch minimum); the lapped ends being securely wired or clipped together with standard clips.

The minimum cover for main reinforcement shall conform to the dimensions indicated on the Drawings. or shall be as shown below. The dimensions listed below indicate the clear distance from the edge of the main reinforcement to the concrete surface.

1. Formed concrete exposed to weather and/or in contact with soil:

(a)	No. 6 bars and larger	2-inches
(b)	No. 5 bars and smaller	1-1/2-inches

2. Unformed concrete in contact with soil:

(a)	All bar sizes	3-inches

Material improperly detailed or wrongly fabricated so that erection in the field necessitates extra work shall be the responsibility of the Contractor. The Contractor shall repair or replace, at his own expense, any part of the material proving defective in fabrication or damaged in shipment.

4.4 CONCRETE

All concrete shall be Portland Cement Type I concrete and shall have a 28-day compressive strength of 3000 psi, 2 to 3-inches of slump, and 1-inch maximum aggregate size. Minimum cement content shall be 5-1/2 sacks per cubic yard.

Scheduling for delivery of concrete shall be the responsibility of the Contractor. Equipment for transporting concrete shall be in accordance with provisions of ASTM C94 for ready-mixed concrete. Any concrete furnished by the Contractor which is allowed to become too stiff for effective placement or consolidation during transportation or conveying to the placement site shall not be used for construction.

Before placing concrete, the forms, reinforcing steel, and all other embedded items shall be approved by the AEC Construction Inspector for position, stability, and cleanliness. Concrete shall be deposited continuously so that the unit will be monolithic in construction. The concrete shall be worked into the corners and angles of the forms and around all reinforcement and embedded items without permitting the component concrete materials to segregate. Adequate equipment for handling and placing concrete containing the maximum aggregate size and low-slump concrete mixes shall be provided. Concrete shall be deposited as close as possible to its final position in the forms so that free drop flow within the mass does not exceed 5-feet, and consequent segregation is reduced to a minimum. Adequate protection shall be available to protect the concrete from sudden rain storms, from the sun and dry winds in the summer months, and freezing in the winter months.

Surfaces of soil upon which concrete is to be placed shall be clean and free from oil, standing or running water, mud, objectionable coatings, and debris. All surfaces shall be wetted before placing concrete.

Concrete shall be placed with the aid of mechanical vibrating equipment and supplemented by hand spading and tamping. The vibrating equipment shall be of the internal type and shall at all times be adequate in number of units and power of each unit to properly consolidate all concrete. The frequency of vibration shall not be less than 6,000 cycles per minute, submerged in concrete. The duration of vibration shall be limited to that necessary to produce satisfactory consolidation without causing objectionable segregation. In consolidating each layer of concrete, the vibrator shall be operated in a near vertical position, and the vibrating head shall be allowed to penetrate under the action of its own weight and re-vibrate the concrete in the upper portion of the underlying layer. Neither form nor surface vibrators shall be used. Vibrators shall not be used to move or spread concrete. Not less than one spare vibrator in good working condition for each placement shall be kept available for immediate use at the placement location; provisions shall be made for auxiliary power to provide continuity of vibration in case of power failure from the principal source. An experienced and competent operator shall be provided for each vibrator being used.

Concrete shall be placed before initial set has occurred and before it has contained its water content for more than 60 minutes or received truck agitation in excess of 300 revolutions.

When the ambient temperature is 40° F or below, cold weather precautions shall be taken per ACI 306. When the ambient temperature is 80° F or above, hot weather precautions shall be taken per ACI 305.

Finished slab surfaces shall be true plane surfaces, within a ±1/8-inch tolerance in 10-feet unless otherwise shown on the Drawings. Surfaces shall be pitched to drain as shown on the Drawings. The dusting of finish surfaces with dry materials will not be permitted. The finished slab shall be steel trowel finished by tamping the concrete with special tools to force to coarse aggregate away from the surface, then screeding and floating with straight edges to bring the surface to the required finish level. While the concrete is still green, but sufficiently hardened to bear a persons weight without deep imprint, it shall be floated either by hand or mechanical means to a true, even plane with no coarse aggregate visible. Sufficient pressure shall be used on the float to bring moisture to the surface. After surface moisture has disappeared, the surface shall be hand troweled to a smooth, even finish. Trowel marks shall be removed by hand steel troweling. Top edges of slabs shall have a 1/2-inch radius tooled into the wet concrete during finishing operations. After the final steel troweling, the surface shall receive a light broom finish.

All fresh concrete shall be adequately protected from the weather and sun, and from mechanical injury, until thoroughly set and of sufficient strength to prevent damage. The Contractor shall apply a coating of membrane curing compound. Membrane curing shall be by the use of Hunt's Process impervious membrane, or AEC approved equal, applied in two coats at a rate of not less than 1-gallon to 300 square feet of surface area per coat. The curing liquid shall have a temporary color sufficient to indicate the extent of its application. It shall finally form a hard, colorless surface within 30-minutes. The application of the compound shall commence immediately after finishing operations are completed; provided that in the event application of the compound is delayed, the concrete surface shall be kept continuously moist until the compound is applied. The compound shall be sprayed on the concrete surfaces by approved equipment having separate lines to the nozzle for material and for compressed air. Precautions shall be taken by the Contractor to avoid damage to the coatings for a period of not less than 10-days. Any such damage shall be repaired immediately by, and at the expense of the Contractor, to the satisfaction of the AEC Construction Inspector. Curing compound shall not be diluted by addition of solvents or thinners or altered in any manner.

5.0 SITE PAVING

5.1 SCOPE OF WORK

The Contractor shall furnish all labor, supervision, equipment, materials, material disposal, and services to provide all site paving work.

Areas to be paved shall include the excavation area shown in the Drawings, and any paved areas damaged by the Contractor's operations at the site.

5.2 MATERIALS

The paving materials used shall match as closely as possible the existing pavement section. Deviations from these Specifications shall be subject to approval by AEC.

The materials for the paving work shall include a prime coat, a tack coat, asphaltic concrete, and an asphalt emulsion fog seal coat. Quality and grading for aggregate base course shall conform to the requirements specified in Section 2.3, MATERIALS AND EQUIPMENT, and as installed according to Section 2.8, AREA FILL, BACKFILL, GRADING, AND COMPACTION, above.

The prime coat shall consist of a coating of liquid asphalt, Grade MC-250, conforming to California Specification, Section 93 or a coating of SS-1H asphalt emulsion conforming to California Specification, Section 37.

The tack coat shall consist of a coating of asphaltic emulsion, Grade RS-1, conforming to California Specification, Section 94.

Asphaltic concrete shall be proportioned in accordance with California Specification, Section 39, using Type B mineral aggregate, 1/2 in. maximum size as specified.

Asphalt binder shall be paving asphalt, Grade AR4000, conforming to California Specification, Section 92.

The asphalt emulsion fog seal coat shall be SSI type asphaltic emulsion conforming to California Specification, Section 37.

5.3 INSTALLATION

Prime Coat: The prime coat shall be applied to the base course in a continuous film, at a rate of 0.25 gallons per square yard for Grade MC-250 liquid asphalt, or 0.05-gallons per square foot for SS-1H asphalt emulsion, in conformance with California Specification, Section 39-4.

Tack Coat: A continuous tack coat shall be applied to the edges of existing asphaltic concrete, in conformance with California Specification, Section 39-4, to ensure a good bond between the old and new asphalt.

Asphaltic Concrete: Asphaltic concrete surfacing shall be spread and compacted in conformance with California Specification, Section 39. No asphaltic concrete surfacing shall be placed until the other construction work is completed. No pavement shall be placed when the atmospheric temperature is below 40° F. Total asphaltic concrete depth shall match existing paving except that in no case shall the depth be less than 2-inches.

Wherever possible, the asphaltic concrete paving shall be spread with a self-propelled paving machine, towed spreader, or tractor and spreader bar. Any irregularities in the surface shall be corrected directly behind the paver.

Excess material shall be removed immediately. Casting of mix over the paved area shall not be permitted. Any method of spreading asphaltic concrete which produces segregation or non-uniformity of texture of the surface shall not be used. Asphaltic concrete shall not be placed or rolled at an asphalt temperature less than 180° F.

The asphalt surfacing shall be sloped as shown or as required to match the existing grade, and to ensure that there will be no ponding. Maximum variations in finished surface of the asphalt concrete shall be ±1/4-inch in 10-feet.

Asphaltic concrete shall be rolled with a minimum 8-ton tandem steel wheeled power roller. Rolling shall commence as soon as possible after spreading the hot mix, so that it can be compacted without displacement. Rolling shall continue until thoroughly compacted and all roller marks have been removed. In areas too small or to close to adjacent structures for power rolling, a small roller, vibrator, or hand tamper shall be used to achieve thorough compaction. The Contractor shall take care in rolling and compacting operations not to damage any other Work in place. Any such damage shall be repaired at the Contractor's expense to the satisfaction of the AEC Construction Inspector.

The Contractor shall provide all necessary surveying equipment (transit, level, etc.) to ensure that the above requirements are adhered to.

All concrete edges and cutoffs shall be struck and left in a clean, straight line. No asphaltic concrete shall overlap concrete pads, slabs, or walkways.

Fog Seal: A fog seal coat shall be applied over all new asphaltic concrete surfaces in accordance with California Specification, Section 37.

It shall be the Contractor's responsibility to provide required testing of the materials used to verify that the materials do comply with the minimum requirements of these Specifications. The results of this testing shall be submitted to AEC for approval. AEC may conduct independent testing of materials and final pavement for verification of compliance at its own discretion. Such tests will be available for the Contractor's review, but will not relieve him of the responsibility of performing his own tests.

6.0 SITE SAFETY, SECURITY, AND CLEANUP

6.1 SAFETY

During the construction period, the Contractor shall be responsible for the safety of the operation. The Contractor shall require all employees, sub-contractors, suppliers, etc., performing work for the Contractor, to adhere to all national, state and local safety laws and regulations in the performance of the Work.

6.2 SECURITY

The Contractor shall be responsible for the security of the site from start to finish of his operations. Should the Contractor decide to install a system of temporary fences and gates for the purpose of maintaining a security system during construction, he shall do so at his own expense. The design and location of the fencing is up to the Contractor and shall be subject to approval by AEC. The Contractor may want to enclose an area that would provide security for his equipment. The fencing system used must not disturb the operations of tenants in the area during their business operations.

6.3 COMPLETION AND CLEANUP

At the completion of the Work, the Contractor shall remove all temporary services, facilities, hay bales, construction equipment, and any and all rubbish and debris from the site to the satisfaction of the AEC Construction Inspector and the Owner. Paved and concreted areas shall be flooded with water to test for proper drainage. Any low or uneven areas, or areas subject to ponding, shall be corrected to the entire satisfaction of the AEC Construction Inspector and the Owner. The Contractor shall clean the surface of the concreted and paved Work area, and areas surrounding the Work which may have become encrusted with soil and debris during construction operations, by hosing them down with water until clean.

After all cleanup is completed, the Contractor shall repaint any and all lines, parking spaces, and other markings disturbed during the Work. All painting shall match existing conditions.

(6) Baths not protected by hood or shield shall be provided with a removable cover which shall be placed over the bath during temporary shut downs and at end of periods of use.

(b) Nitrate Baths. In addition to the requirements of (a):

(1) No salt containing any cyanide or any organic compound shall be added to a salt bath containing nitrate. Proper warning signs to this effect shall be posted near all such baths.

(2) Nitrate baths shall not be operated at a temperature of greater than 1200 degrees F.

(3) Nitrate baths used to treat aluminum or its alloys shall not be operated at a temperature greater than 1000 degrees F. In such baths if the temperature reaches 1000 degrees F, or if the objects being treated and the bath appear to be beginning an exothermic reaction the operator shall withdraw the metal objects from the bath.

(4) Every nitrate bath over 10 cubic feet in capacity shall be provided with an automatic cut–off safety control which will shut off the source of heat when the temperature reaches the limits set forth in (2) or (3). This control shall be in addition to any regular controls whether they act automatically or manually.

(5) If external heating by gas or oil is used, the combustion chamber shall be arranged so that the sides of the chamber are bathed in hot gasses as uniformly as possible without any flame impinging directly on the containers and so that in case of failure of the container, molten salt will flow to a safe place and so that molten salt cannot drip or spatter into the combustion chamber.

(6) The molten salt container shall be emptied at regular intervals and inspected for deterioration. When inspection shows that deterioration has taken place to such an extent that failure is likely, or that uneven heating of the salt may occur, the container shall be replaced or repaired.

(7) No article shall be allowed to stay in the bottom of the bath. Accumulations of sediment or products of partial decomposition shall be removed regularly, as often as is necessary to prevent uneven heating of the bath. The chemical content of the bath should be checked frequently.

(8) Nitrate shall not be stored in the room with the bath. Storage in a separate building is recommended.

(9) Buildings in which nitrate baths are located should be of construction recommended by the National Board of Fire Underwriters Research Report, No. 2, 1954, for such location. Combustible materials in a room with a bath shall be kept to a minimum.

(10) Magnesium or magnesium alloy shall not be heat–treated in nitrate baths.

(11) When heat is turned off such a bath and before it is allowed to cool, a metal wedge long enough to reach from the bottom of the bath to above the surface shall be inserted to prevent explosion when bath is reheated.

NOTE: Authority cited: Section 142.3, Labor Code. Reference: Section 142.3, Labor Code.

HISTORY

1. Renumbering and amendment of Section 5203 to Section 5188 filed 12–10–87; operative 1–9–88 (Register 87, No. 51).

§ 5189. Process Safety Management of Acutely Hazardous Materials.

(a) Scope and Purpose.

These regulations contain requirements for preventing or minimizing the consequences of catastrophic releases of toxic, reactive, flammable or explosive chemicals. The establishment of process safety management regulations are intended to eliminate to a substantial degree, the risks to which employees are exposed in petroleum refineries, chemical plants and other facilities.

(b) Application.

(1) These regulations shall apply to a process which involves a chemical at or above the specified threshold quantities listed in Appendix A and a process which involves a flammable liquid or gas as defined in subsection (c).

EXCEPTION: (1) Flammable liquids stored in atmospheric tanks or transferred which are kept below their normal boiling point without benefit of chilling or refrigeration. (2) Hydrocarbon fuels used solely for workplace consumption (e.g. comfort heating propane, gasoline for motor vehicle refueling) if such fuels are not part of a process containing another acutely hazardous chemical covered by section 5189. (3) These regulations do not apply to retail facilities, oil or gas well drilling or servicing operations or normally unoccupied remote facilities.

(2) Explosives manufacturing operations shall comply with the provisions of Article 119 and these orders.

(3) The requirements of subsections (d) and (e) shall become effective within five (5) years according to the following phase–in schedule:

(A) No less than 25 percent shall be completed by August 10, 1994;

(B) No less than 50 percent shall be completed by August 10, 1995;

(C) No less than 75 percent shall be completed by August 10, 1996.

(D) All initial process hazards analyses shall be completed by August 10, 1997.

(4) Subsections (f) through (p) shall become effective on January 4, 1994.

(c) Definitions.

Acutely hazardous material. A substance possessing toxic, reactive, flammable or explosive properties and specific by subsection (b)(1).

Explosive. A substance identified in Title 49, Part 172 of the Code of Federal Regulations, the Department of Transportation effective on December 31, 1990.

Facility. The buildings, containers, or equipment which contain a process.

Flammable. Liquids or gases as defined in Section 5194(c) onsite and in one location in quantities of 10,000 pounds or more.

Hot Work. Electric or gas welding, cutting, brazing or any extreme heat, flame, or spark producing procedures or operations.

Major Accident. Any event involving fire, explosion, or release of a substance covered by this section which results in a fatality or a serious injury (as defined by Labor Code Section 6302) to persons in the workplace.

Normally unoccupied remote facility. A facility which is operated, maintained and serviced by employees who visit the unmanned facility only periodically to check its operation and perform necessary operating or maintenance tasks. No employees are permanently stationed to this facility. Facilities meeting this definition are not contiguous with and must be geographically remote from all other buildings, processes or persons.

Process. Any activity conducted by an employer that involves an acutely hazardous material, flammable substance or explosive including any use, storage, manufacturing, handling, or on–site movement of any of the preceding substances or combination of these activities. For purposes of this definition any group of vessels which are interconnected and separate vessels which are located such that an acutely hazardous material could be involved in a potential release shall be considered a single process.

Process Safety Management. The application of management programs, which are not limited to engineering guidelines, when dealing with the risks associated with handling or working near acutely hazardous materials, flammables, or explosives.

Replacement in Kind. A replacement which satisfies the design specification.

(d) Process Safety Information. The employer shall develop and maintain a compilation of written safety information to enable the employer and the employees operating the process to identify and understand the hazards posed by processes involving acutely hazardous, flammable and explosive material before conducting any process hazard analysis required by this regulation. The employer shall provide for employee participation in this process. Copies of this safety information shall be made accessible and communicated to employees involved in the processes, and include:

(1) Information pertaining to hazards of the acutely hazardous and flammable materials used in the process. This information shall consist of at least the following:

(A) Toxicity information;

(B) Permissible exposure limits as listed in Section 5155;

(C) Physical data;

(D) Corrosivity data;

(E) Thermal and chemical stability data;

(F) Reactivity data; and,

(G) Hazardous effects of incompatible mixtures which could forseeably occur.

NOTE: Material Safety Data Sheets meeting the requirements of Section 5194(g) may be used to comply with this requirement to the extent they meet the information provisions.

(2) Information pertaining to the technology of the process. Information concerning the technology of the process shall include at least the following:

(A) A block flow diagram or simplified process flow diagram;

(B) Process chemistry;

(C) Maximum intended inventory;

(D) Safe upper and lower limits for process variables such as temperatures, pressures, flows, levels and/or compositions; and,

(E) The consequences of deviations, including those affecting the safety and health of employees.

NOTE: For processes for which data is unavailable, the information concerning the technology of the process may be developed from a process/hazard analysis conducted in accordance with subsection (e).

(3) Information pertaining to the equipment in the process.

(A) Information pertaining to the equipment in the process shall include at least the following:

1. Materials of construction;

2. Piping and instrument diagrams (P&ID's);

3. Electrical classification;

4. Relief system design and design basis;

5. Ventilation system design;

6. Design codes employed including design conditions and operating limits;

7. Material and energy balances for processes built after September 1, 1992;

8. Safety systems (such as interlocks, detection and suppression systems, etc.); and,

9. Electrical supply and distribution systems.

(B) The employer shall document that the equipment complies with the criteria established in subsection (d)(3)(A) in accordance with recognized and generally accepted good engineering practices.

(C) For existing equipment designed and constructed in accordance with codes, standards, or practices that are no longer in general use, the employer shall determine and document that the equipment is designed, maintained, inspected, tested and operating in a safe manner.

(4) A copy of the process safety information and communication shall be accessible to all employees who perform any duties in or near the process.

(e) Process Hazard Analysis.

(1) The employer shall perform a hazard analysis appropriate to the complexity of the process for identifying, evaluating, and controlling hazards involved in the process and shall determine and document the priority order for conducting process hazard analyses based on the extent of process hazards, number of potentially affected employees, age of the process and process operating history, using at least one of the following methodologies.

(A) What–If;

(B) Checklist;

(C) What–If/Checklist;

(D) Hazard and Operability Study (HAZOP);

(E) Failure Mode and Effects Analysis (FMEA); or

(F) Fault–Tree Analysis.

NOTE: The employer may utilize other hazard analysis methods recognized by engineering organizations or governmental agencies. In the absence of (A) – (F) or other recognized hazard analysis methods, the employer may utilize a hazard analysis method developed and certified by a registered professional engineer for use by the process hazards analysis team.

(2) The hazard analysis shall address:

(A) The hazards of the process;

(B) Engineering and administrative controls applicable to the hazards and their relationships;

(C) Consequences of failure of these controls;

(D) Facility Siting;

(E) Human Factors;

(F) A qualitative evaluation of a range of the possible safety and health effects of the failure of controls on facility employees; and

(G) The identification of any previous incident which had a likely potential for catastrophic consequences in the workplace.

NOTE: The employer may utilize the facility's Risk Management Prevention Plan(s) (RMPP) prepared pursuant to Article 2, Chapter 6.95 (commencing with Section 25531) of Division 20 of the Health and Safety Code to the extent that is satisfies the requirements of subsections (e)(1) and (2).

(3)(A) The process hazard analysis shall be performed by a team with expertise in engineering and process operations, and the team shall include at least one operating employee who has experience and knowledge specific to the process being evaluated. The team shall also include one member knowledgeable in the specific process hazard analysis methodology being used. The final report containing the results of the hazard analysis for each process shall be available in the respective work area for review by any person working in that area.

(B) The employer shall consult with the affected employees and where appropriate their recognized representatives on the development and conduct of hazard assessments performed after the effective date of this section. Affected employees and where applicable their representatives shall be provided access to the records required by this section.

(4) The employer shall establish a system to promptly address the team's findings and recommendations; document any actions taken to implement the team's recommendations; develop a written schedule of when these actions are to be completed; assure that the recommendations are resolved in a timely manner; make them available to operating, maintenance and any other persons whose work assignments are in the facility, and who are affected by the recommendations or actions; and assure that the recommendations are evaluated in a timely manner or implement an alternative resolution which appropriately addresses the degree of hazard posed by the scenario.

(5) At least every five (5) years, the process hazard analysis shall be updated and revalidated, by a team meeting the requirements in subsection (e)(3), to assure that the process hazard analysis is consistent with the current process.

(6) Employers shall retain process hazard analyses and/or updates for each process covered by this section, as well as the documented actions described in subsection (e)(4).

(7) Upon request of any worker or any labor union representative of any worker in the area, the employer shall provide or make available a copy of the employer's RMPP.

(8) The employer shall conduct the process hazard analysis as soon as possible but not later than the dates shown in subsection (b)(3).

(f) Operating Procedures.

(1) The employer shall develop and implement written procedures that provide clear instructions for safely conducting activities involved in each process consistent with the process safety information and shall address at least the following.

(A) Steps for each operating phase:

1. Start–up;

2. Normal operation;

3. Temporary operations as the need arises;

4. Emergency operations, including emergency shutdowns, and who may initiate these procedures;

5. Normal shutdown; and,

6. Start–up following a turnaround, or after an emergency shutdown.

(B) Operating limits:

1. Consequences of deviation;

2. Steps required to correct and/or avoid deviation; and

3. Safety systems and their functions.

(C) Safety and health considerations:

1. Properties of, and hazards presented by, the chemicals used in the process;

2. Precautions necessary to prevent exposure, including administrative controls, engineering controls, and personal protective equipment;

3. Control measures to be taken if physical contact or airborne exposure occurs;

4. Safety procedures for opening process equipment (such as pipe line breaking);

5. Verification of raw materials and control of hazardous chemical inventory levels; and,

6. Any special or unique hazards.

(2) A copy of the operating procedures shall be readily accessible to employees who work in or near the process area or to any other person who works in or near the process area.

(3) The operating procedures shall be reviewed as often as necessary to assure that they reflect safe operating practices, including changes that result from changes in process chemicals, technology, and equipment; and changes to facilities.

(4) The employer shall develop and implement safe work practices to provide for the control of hazards during operations such as opening process equipment or piping and control over entrance into a facility by maintenance, contractor, laboratory or other support personnel. These safe work practices shall apply to employees and contractor employees.

(g) Training.

(1) Initial training. Each employee presently involved in operating or maintaining a process, and each employee before working in a newly assigned process, shall be trained in an overview of the process and in the operating procedures as specified in subsection (f). The training shall include emphasis on the specific safety and health hazards, procedures, and safe practices applicable to the employee's job tasks.

(2) Refresher and supplemental training. At least every three years, and more often if necessary, refresher and supplemental training shall be provided to each maintenance or operating employee and other workers necessary to ensure safe operation of the facility. The employer in consultation with employees involved in operation or maintenance of a process shall determine the appropriate frequency of refresher training.

(3) Training certification. The employer shall ensure that each employee involved in the operation or maintenance of a process has received and successfully completed training as specified by this subsection. The employer, after the initial or refresher training shall prepare a certification record which contains the identity of the employee, the date of training, and the signatures of the persons administering the training.

(4) Testing procedures shall be established by each employer to ensure competency in job skill levels and safe and healthy work practices.

(h) Contractors.

(1) The employer shall inform contractors performing work on, or near, a process of the known potential fire, explosion or toxic release hazards related to the contractor's work and the process, and require that contractors have trained their employees to a level adequate to safely perform their job. The employer shall also inform contractors of any applicable safety rules of the facility, and assure that the contractors have so informed their employees.

(2) The employer shall explain to contractors the provisions of the emergency action plan required in subsection (n).

(3) Contractors shall assure that each of their employees have received training to safely perform their job and that the contract employees shall comply with all applicable work practices and safety rules of the facility.

(4) The contractor's training program shall be performed in accordance with the requirements of subsection (g).

(5) The employer when selecting a contractor shall obtain and evaluate information regarding the contract employer's safety program.

(6) The employer shall periodically evaluate the performance of contract employers in fulfilling their obligations as specific in subsection (h)(3) of this section.

(7) The employer shall obtain and make available upon request a copy of the contract employer's injury and illness log related to the contractor's work in the process areas.

(i) Pre-start Up Safety Review.

(1) The employer shall perform a pre-start up safety review for new facilities and for modified facilities for which the modification necessitates a change in the process safety information.

(2) The pre-start up safety review shall confirm that prior to the introduction of acutely hazardous, flammable and explosive materials to a process:

(A) Construction and/or equipment are in accordance with design specifications;

(B) Safety, operating, maintenance, and emergency procedures are in place and are adequate;

(C) For new facilities, a process hazard analysis has been performed and recommendations have been resolved or implemented before start-up; and modified facilities meet the requirements contained in subsection (*l*); and,

(D) Training of each operating employee and maintenance worker has been completed.

(3) The Pre-Start Up Safety Review shall involve employees with expertise in process operations and engineering. The employees will be selected based upon their experience and understanding of the process systems being evaluated.

(j) Mechanical Integrity.

(1) Written procedures.

(A) The employer shall establish and implement written procedures to maintain the ongoing integrity of process equipment and appurtenances. These procedures shall include a method:

1. for allowing employees to identify and report potentially faulty or unsafe equipment; and

2. to record their observations and suggestions in writing.

(B) The employer shall respond regarding the disposition of the employee's concerns contained in the report(s) in a timely manner.

(C) The employer shall provide employees and their representatives access to the information required in subsection (j)(1).

(2) Inspection and testing.

(A) Inspections and tests shall be performed on process equipment.

(B) Inspection and testing procedures shall follow recognized and generally accepted good engineering practices.

(C) The frequency of inspections and tests shall be consistent with applicable manufacturer's recommendations and good engineering practices and more frequently if determined necessary as dictated by operating history.

(D) The employer shall have a certification record that each inspection and test has been performed in accordance with this subsection. The certification shall identify the date of the inspection; the name of the person who performed the inspection and test; and the serial number or other identifier of the equipment.

(3) Equipment deficiencies. The employer shall correct deficiencies in equipment which are outside acceptable limits defined by the process safety information in subsection (d) before further use, or in a safe and timely manner provided means are taken to assure safe operation.

(4) Quality assurance.

(A) The employer shall assure that in the construction of new plants and equipment modified, repaired, or fabricated equipment is suitable for the process aplication for which they will be used.

(B) Appropriate checks and inspections shall be performed as necessary to assure that equipment is installed properly and is consistent with design specifications and manufacturer's instructions.

(C) The employer shall assure that maintenance materials, spare parts and equipment, meet design specifications and applicable codes.

(k) Hot Work Permit.

(1) The employer shall develop and implement a written procedure for the issuance of "hot work" permits.

(2) The permit shall certify that the applicable portions of the fire prevention and protection requirements contained in Sections 4848 and 6777 have been implemented prior to beginning the hot work operations;

indicate the date(s) authorized for hot work; and identify the equipment or facility on which hot work is to be done. The permit shall be kept on file until completion of the hot work operations.

(*l*) Management Of Change.

(1) The employer shall establish and implement written procedures to manage changes (except for "replacement in kind") to process chemicals, technology, and equipment, and changes to facilities.

(2) The procedures shall assure that the following are addressed prior to any change:

(A) The technical basis for the proposed change;

(B) Impact of change on safety and health;

(C) Modifications to operating procedures;

(D) Necessary time period for the change; and,

(E) Authorization requirements for the proposed change.

(3) Employees involved in the process shall be informed of, and trained in, the change in the process as early as practicable prior to its start up.

(4) If a change covered by this subsection results in a change to the process safety information, such information shall be appended and/or updated in accordance with subsection (d).

(5) If a change covered by this subsection results in a change to the operating procedures, such procedures shall be appended and/or updated in accordance with subsection (f).

(m) Incident Investigation.

(1) The employer shall establish a written procedure for prompt reporting and investigating every incident which results in or could reasonably have resulted in a major accident.

(2) Incident investigations shall be initiated no later than 48 hours following the incident.

(3) An incident investigation team shall be established and consist of persons knowledgeable in the process involved including a contract employee if the incident involved work of the contractor, and other persons who are qualified to thoroughly investigate and analyze the incident.

(4) A written report shall be prepared at the conclusion of the investigation which includes at a minimum:

(A) Date of incident;

(B) Date investigation began;

(C) A description of the incident;

(D) The factors that contributed to the incident; and,

(E) Any recommendations resulting from the investigation.

(5) The report shall be reviewed with all operating, maintenance, and other personnel whose work assignments are within the facility where the incident occurred.

(6) The employer shall establish a system to promptly address and resolve the report findings and recommendations and shall implement the report recommendations in a timely manner, or take action to prevent a reoccurrence.

(7) Incident investigation reports shall be retained for five (5) years.

(8) The employer shall prepare a report and either provide a copy of the report or communicate the contents of the report to all employees and other personnel whose work assignments are within the facility, where the incident occurred at the time the incident occurred.

(n) Emergency Planning and Response. The employer shall establish and implement an Emergency Action Plan which shall contain at a minimum the elements of Section 3220.

NOTE: The employer may use the business plan for emergency response submitted pursuant to subdivision (a) of Section 25503.5 and subdivision (b) of Section 25505 of the Health and Safety Code, to the extent that the requirements of subsection (n) are met.

(o) Injury and Illness Prevention Program. The employer's Injury and Illness Prevention Program required by Section 3203 shall include applicable part(s) of this section.

(1) The scheduled and periodic inspections of facilities covered by this section and required by Section 3203(a)(4) shall be conducted by at least one person knowledgeable in the process.

(p) Employee Participation. The employer shall develop a written plan of action to ensure employee participation in process safety management which includes:

(1) Employer consultation with employees and their representatives on the conduct and development of the elements of process safety management required by this section; and

(2) Providing employees and their representatives with access to all information required to be developed by this section without regard to possible trade secret status of such information.

NOTE: Nothing in this subsection shall preclude the employer from requiring the persons to whom the information is made available under subsection (p)(2) to enter into confidentiality agreements prohibiting them from disclosing the information as set forth in Section 5194.

NOTE. Authority cited: Section 142.3, Labor Code. Reference: Sections 142.3 and 7856, Labor Code.

HISTORY

1. New section filed 7–10–92; operative 8–10–92 (Register 92, No. 28).
2. Amendment of section and new Appendix filed 1–4–94; operative 1–4–94 pursuant to Government Code section 11346.2(d) (Register 94, No. 1).

Appendix A to Section 5189—List of Acutely Hazardous Chemicals, Toxics and Reactives (Mandatory)

This Appendix contains a listing of substances which present a potential for a catastrophic event at or above the threshold quantity (TQ).

CHEMICAL name	CAS*	TQ**
Acetaldehyde	75–07–0	2500
Acrolein (2–Propenal)	107–02–8	150
Acrylyl Chloride	814–68–6	250
Allyl Chloride	107–05–1	1000
Allylamine	107–11–9	1000
Alkylaluminums	Varies	5000
Ammonia, Anhydrous	7664–41–7	10000
Ammonia solutions (> 44% ammonia by weight	7664–41–7	15000
Ammonium Perchlorate	7790–98–9	7500
Ammonium Permanganate	7787–36–2	7500
Arsine (also called Arsenic Hydride)	7784–42–1	100
Bis(Chloromethyl) Ether	542–88–1	100
Boron Trichloride	10294–34–5	2500
Boron Trifluoride	7637–07–2	250
Bromine	7726–95–6	1500
Bromine Chloride	13863–41–7	1500
Bromine Pentafluoride	7789–30–2	2500
Bromine Trifluoride	7787–71–5	15000
3–Bromopropyne (also called Propargyl Bromide)	106–96–7	100
Butyl Hydroperoxide (Tertiary)	75–91–2	5000
Butyl Perbenzoate (Tertiary)	614–45–9	7500
Carbonyl Chloride (see Phosgene)	75–44–5	100
Carbonyl Fluoride Cellulose Nitrate (concentration > 12.6% nitrogen)	9004–70–0	2500
Chlorine	7782–50–5	1500
Chlorine Dioxide	10049–04–4	1000
Chlorine Pentrafluoride	13637–63–3	1000
Chlorine Trifluoride	7790–91–2	1000
Chlorodiethylaluminum (also called Diethylaluminum Chloride)	96–10–6	5000
1–Chloro–2,4–Dinitrobenzene	97–00–7	5000
Chloromethyl Methyl Ether	107–30–2	500
Chloropicrin	76–06–2	500
Chloropicrin and Methyl Bromide mixture	None	1500
Chloropicrin and Methyl Chloride mixture	None	1500
Cumene Hydroperoxide	80–15–9	5000
Cyanogen	460–19–5	2500
Cyanogen Chloride	506–77–4	500
Cyanuric Fluoride	675–14–9	100
Diacetyl Peroxide (Concentration > 70%)	110–22–5	5000
Diazomethane	334–88–3	500
Dibenzoyl Peroxide	94–36–0	7500
Diborane	19287–45–7	100
Dibutyl Peroxide (Tertiary)	110–05–4	5000
Dichloro Acetylene	7572–29–4	250
Dichlorosilane	4109–96–0	2500
Diethylzinc	557–20–0	10000
Diisopropyl Peroxydicarbonate	105–64–6	7500
Dilaluroyl Peroxide	105–74–8	7500
Dimethyldichlorosilane	75–78–5	1000
Dimethylhydrazine, 1,1–	57–14–7	1000
Dimethylamine, Anhydrous	124–40–3	2500
2,4–Dinitroaniline	97–02–9	5000
Ethyl Methyl Ketone Peroxide (also Methyl Ethyl Ketone Peroxide; concentration > 60%)	1338–23–4	5000
Ethyl Nitrite	109–95–5	5000
Ethylamine	75–04–7	7500
Ethylene Fluorohydrin	371–62–0	100
Ethylene Oxide	75–21–8	5000
Ethyleneimine	151–56–4	1000
Fluorine	7782–41–4	1000
Formaldehyde (Formalin)	50–00–0	1000
Furan	110–00–9	500
Hexafluoroacetone	684–16–2	5000
Hydrochloric Acid, Anhydrous	7647–01–0	5000
Hydrofluoric Acid, Anhydrous	7664–39–3	1000
Hydrogen Bromide	10035–10–6	5000
Hydrogen Chloride	7647–01–0	5000
Hydrogen Cyanide, Anhydrous	74–90–8	1000
Hydrogen Fluoride	7664–39–3	1000
Hydrogen Peroxide (52% by weight or greater	7722–84–1	7500
Hydrogen Selenide	7783–07–5	150
Hydrogen Sulfide	7783–06–4	1500
Hydroxylamine	7803–49–8	2500
Iron, Pentacarbonyl	13463–40–6	250
Isopropylamine	75–31–0	5000
Ketene	463–51–4	100
Methacrylaldehyde	78–85–3	1000
Methacryloyl Chloride	920–46–7	150
Methacryloyloxyethyl Isocyanate	30674–80–7	100
Methyl Acrylonitrile	126–98–7	250
Methylamine, Anhydrous	74–89–5	1000
Methyl Bromide	74–83–9	2500
Methyl Chloride	74–87–3	15000
Methyl Chloroformate	79–22–1	500
Methyl Ethyl Ketone Peroxide (concentration > 60%)	1338–23–4	5000
Methyl Fluoroacetate	453–18–9	100
Methyl Fluorosulfate	421–20–5	100
Methyl Hydrazine	60–34–4	100
Methyl Iodide	74–88–4	7500
Methyl Isocyanate	624–83–9	250
Methyl Mercaptan	74–93–1	5000
Methyl Vinyl Ketone	79–84–4	100
Methyltrichlorosilane	75–79–6	500
Nickel Carbonly (Nickel Tetracarbonyl)	13463–39–3	150

CHEMICAL name	CAS*	TQ**
Nitric Acid (94.5% by weight or greater)	7697–37–2	500
Nitric Oxide	10102–43–9	250
Nitroaniline (para Nitroaniline	100–01–6	5000
Nitromethane	75–52–5	2500
Nitrogen Dioxide	10102–44–0	250
Nitrogen Oxides (NO; NO$_2$; N204; N203)	10102–44–0	250
Nitrogen Tetroxide (also called Nitrogen Peroxide)	10544–72–6	250
Nitrogen Trifluoride	7783–54–2	5000
Nitrogen Trioxide	10544–73–7	250
Oleum (65% to 80% by weight; also called Fuming Sulfuric Acid)	8014–94–7	1000
Osmium Tetroxide	20616–12–0	100
Oxygen Difluoride (Fluorine Monoxide)	7783–41–7	100
Ozone	10028–15–6	100
Pentaborane	19624–22–7	100
Peracetic Acid (concentration > 60% Acetic Acid; also called Peroxyacetic Acid)	79–21–0	1000
Perchloric Acid (concentration > 60% by weight)	7601–90–3	5000
Perchloromethyl Mercaptan	594–42–3	150
Perchloryl Fluoride	7616–94–6	5000
Peroxyacetic Acid (concentration > 60% Acetic Acid; also called Peracetic Acid)	79–21–0	1000
Phosgene (also called Carbonyl Chloride)	75–44–5	100
Phosphine (Hydrogen Phosphide)	7803–51–2	100
Phosphorus Oxychloride (also called Phosphoryl Chloride)	10025–87–3	1000
Phosphorus Trichloride	7719–12–2	1000
Phosphoryl Chloride (also called Phosphorus Oxychloride)	10025–87–3	1000
Propargyl Bromide	106–96–7	100
Propyl Nitrate	627–3–4	2500
Sarin	107–44–8	100
Selenium Hexafluoride	7783–79–1	1000
Stibine (Antimony Hydride)	7803–52–3	500
Sulfer Dioxide (liquid)	7446–09–5	1000
Sulfer Pentafluoride	5714–22–7	250
Sulfer Tetrafluoride	7783–60–0	250
Sulfur Trioxide (also called Sulfuric Anhydride)	7446–11–9	1000
Sulfuric Anhydride (also called Sulfer Trioxide)	7446–11–9	1000
Tellurium Hexafluoride	7783–80–4	250
Tetrafluoroethylene	116–14–3	5000
Tetrafluorohydrazine	10036–47–2	5000
Tetramethyl Lead	75–74–1	1000
Thionyl Chloride	7719–09–7	250
Trichloro (chloromethyl) Silane	1558–25–4	100
Trichloro (dichlorophenyl) Silane	27137–85–5	2500
Trichlorosilane	10025–78–2	5000
Trifluorochloroethylene	79–38–9	10000
Trimethyoxysilane	2487–90–3	1500

*Chemical Abstract Service Number.

**Threshold Quantity in Pounds (Almost necessary to be covered by this standard).

NOTE: Authority cited: Section 142.3, Labor Code. Reference: Sections 142.3 and 7856, Labor Code.

§ 5190. Cotton Dust.

(a) Scope and Application.

(1) This section applies to the control of employee exposure to cotton dust in all workplaces where employees engage in:

(A) Yarn manufacturing;

(B) Slashing and weaving operations;

(C) Work in waste houses for textile operations;

(D) Preparation of washed cotton from opening until the cotton is thoroughly wetted;

(E) Yarn manufacturing and slashing and weaving operations exclusively using washed cotton (as defined by Section 5190(n) only to the extent specified by Section 5190(n);

(F) Cottonseed processing or waste processing operations only to the extent Section 5190(h) Medical Surveillance, (k)(2)–(4) Recordkeeping Medical Records, and Appendices B, C, and D apply.

(2) This section does not apply to:

(A) The harvesting of cotton;

(B) The ginning of cotton;

(C) Ship and boatbuilding or ship repair and breaking operations, as defined by 8 Cal. Admin. Code 8347, and longshoring;

NOTE: Longshoring is defined as the loading, unloading, moving, or handling of cargo, ship's stores, gear, etc. into, in, on, or out of any vessel on the navigable waters of the United States.

(D) The handling or processing of woven or knitted material.

(E) Knitting, classing or warehousing operations except that employers with these operations, if requested by NIOSH, shall grant NIOSH access to their employees and workplaces for exposure monitoring and medical examinations for purposes of a health study to be performed by NIOSH on a sampling basis;

(F) The construction industry.

(b) Definitions.

Blow down. The general cleaning of a room or a part of a room by the use of compressed air.

Blow off. The use of compressed air for cleaning of short duration and usually for a specific machine or any portion of a machine.

Chief. The Chief of the Division of Occupational Safety and Health, or designee.

Cotton Dust. Dust present in the air during the handling or processing of cotton, which may contain a mixture of many substances including ground–up plant matter and other contaminants which may have accumulated with the cotton during the growing, harvesting, and subsequent processing or storage periods. Any dust present during the handling and processing of cotton through the weaving or knitting of fabrics, and dust present in other operations or manufacturing processes using raw or waste cotton fibers or cotton fiber byproducts from textile mills are considered cotton dust within this definition. Lubricating oil mist associated with weaving operations is not considered cotton dust.

APPENDIX B

EQUIPMENT DRAWINGS

L/M	8570 M 100	ASSEMBLY (List of Materials)
	8570 M 100	ASSEMBLY
	8570 M 101	TOP FLANGE
L/M	8570 M 102	GAS OUTLET SPOOL, REFRACTORY (List of Materials)
	8570 M 102	GAS OUTLET SPOOL, REFRACTORY
L/M	8570 M 103	CYCLONE SCRUBBER SPOOL, REFRACTORY (List of Materials)
	8570 M 103	CYCLONE SCRUBBER SPOOL, REFRACTORY
L/M	8570 M 104	OVERFLOW SPOOL, REFRACTORY (List of Materials)
	8570 M 104	OVERFLOW SPOOL, REFRACTORY
L/M	8570 M 105	SCREW CONVEYOR SPOOL, REFRACTORY (List of Materials)
	8570 M 105	SCREW CONVEYOR SPOOL, REFRACTORY
L/M	8570 M 106	GAS INLET SPOOL, REFRACTORY (List of Materials)
	8570 M 106	GAS INLET SPOOL, REFRACTORY
L/M	8570 M 107	GAS OUTLET SPOOL WELDMENT (List of Materials)
	8570 M 107	GAS OUTLET SPOOL WELDMENT
L/M	8570 M 108	CYCLONE SCRUBBER SPOOL WELDMENT (List of Materials)
	8570 M 108	CYCLONE SCRUBBER SPOOL WELDMENT
L/M	8570 M 109	OVERFLOW SPOOL WELDMENT (List of Materials)
	8570 M 109	OVERFLOW SPOOL WELDMENT
L/M	8570 M 110	SCREW CONVEYOR SPOOL WELDMENT (List of Materials)
	8570 M 110	SCREW CONVEYOR SPOOL WELDMENT
L/M	8570 M 111	GAS INLET SPOOL WELDMENT (List of Materials)
	8570 M 111	GAS INLET SPOOL WELDMENT
L/M	8570 M 112	CYCLONE SCRUBBER WELDMENT (List of Materials)
	8570 M 112	CYCLONE SCRUBBER WELDMENT

HYNOL

HYDROPYROLYSIS REACTOR (HPR)

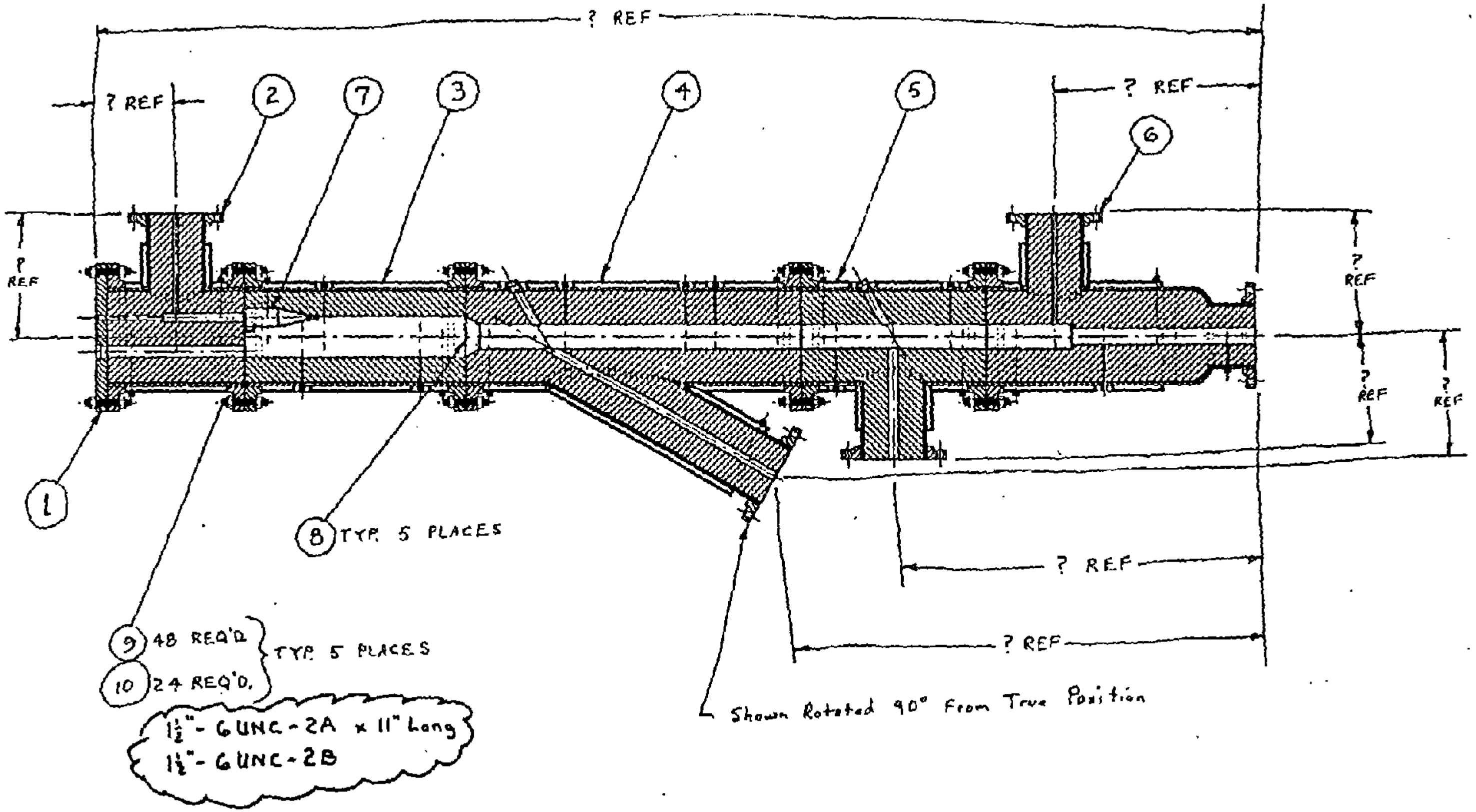
R-101

A.E.C. PROJECT No. 8574

Prepared by

ACUREX ENVIRONMENTAL
CORPORATION

MOUNTAIN VIEW, CALIFORNIA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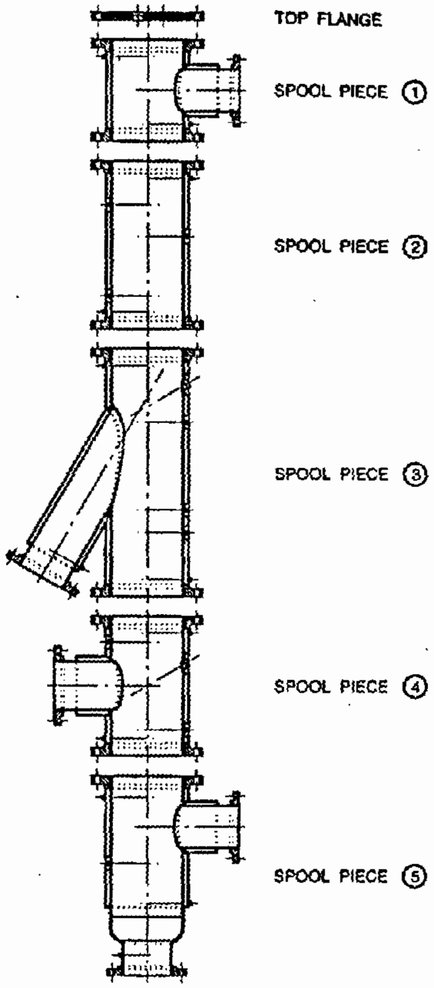
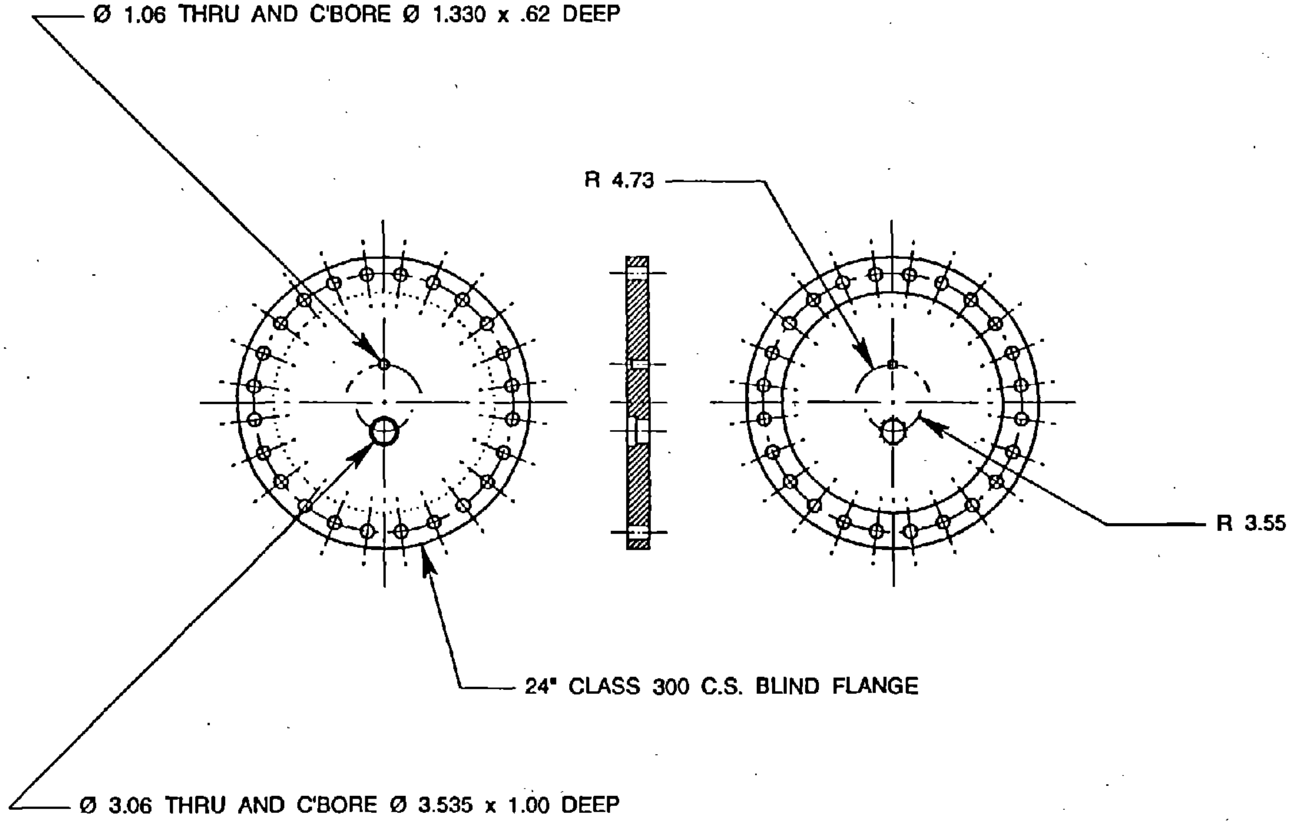
⑧ TYP. 5 PLACES
? REF
? REF
⑨ 48 REQ'D
⑩ 24 REQ'D.
TYP. 5 PLACES
1½" - 6UNC-2A x 11" Long
1½" - 6UNC-2B
Shown Rotated 90° From True Position



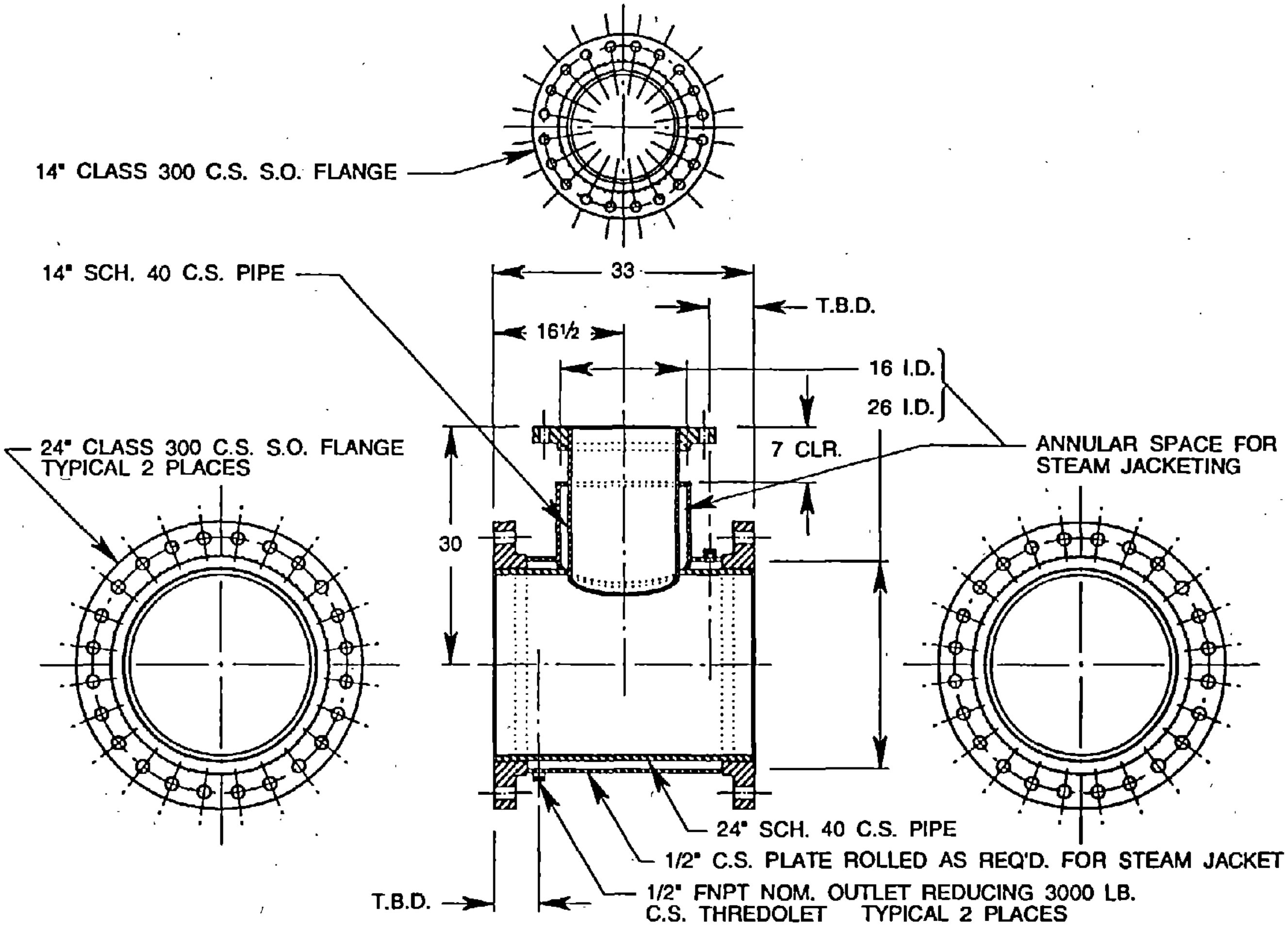
VESSEL R-101

SCALE: 3/8" = 1' - 0"



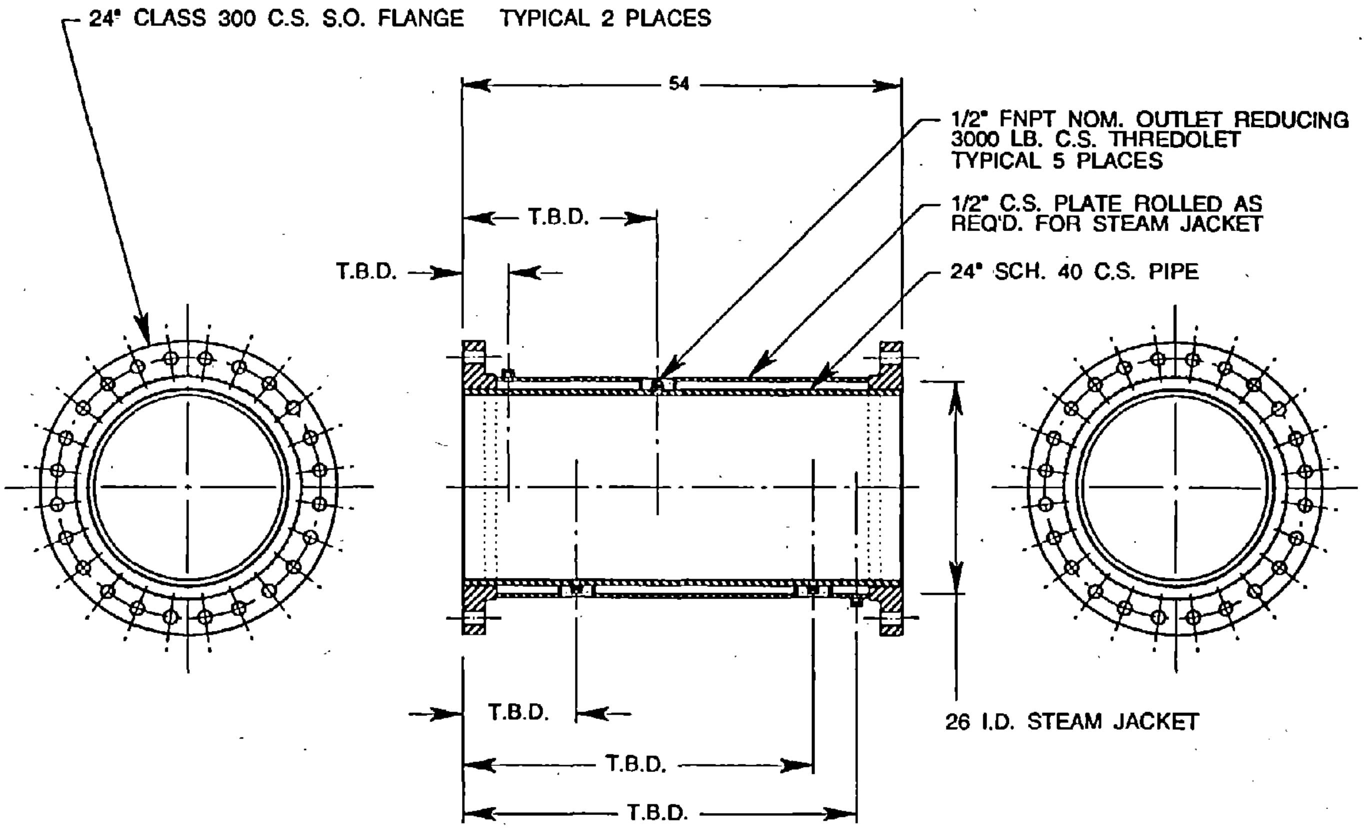
VESSEL R-101 TOP FLANGE

SCALE: 3/4" = 1'-0"



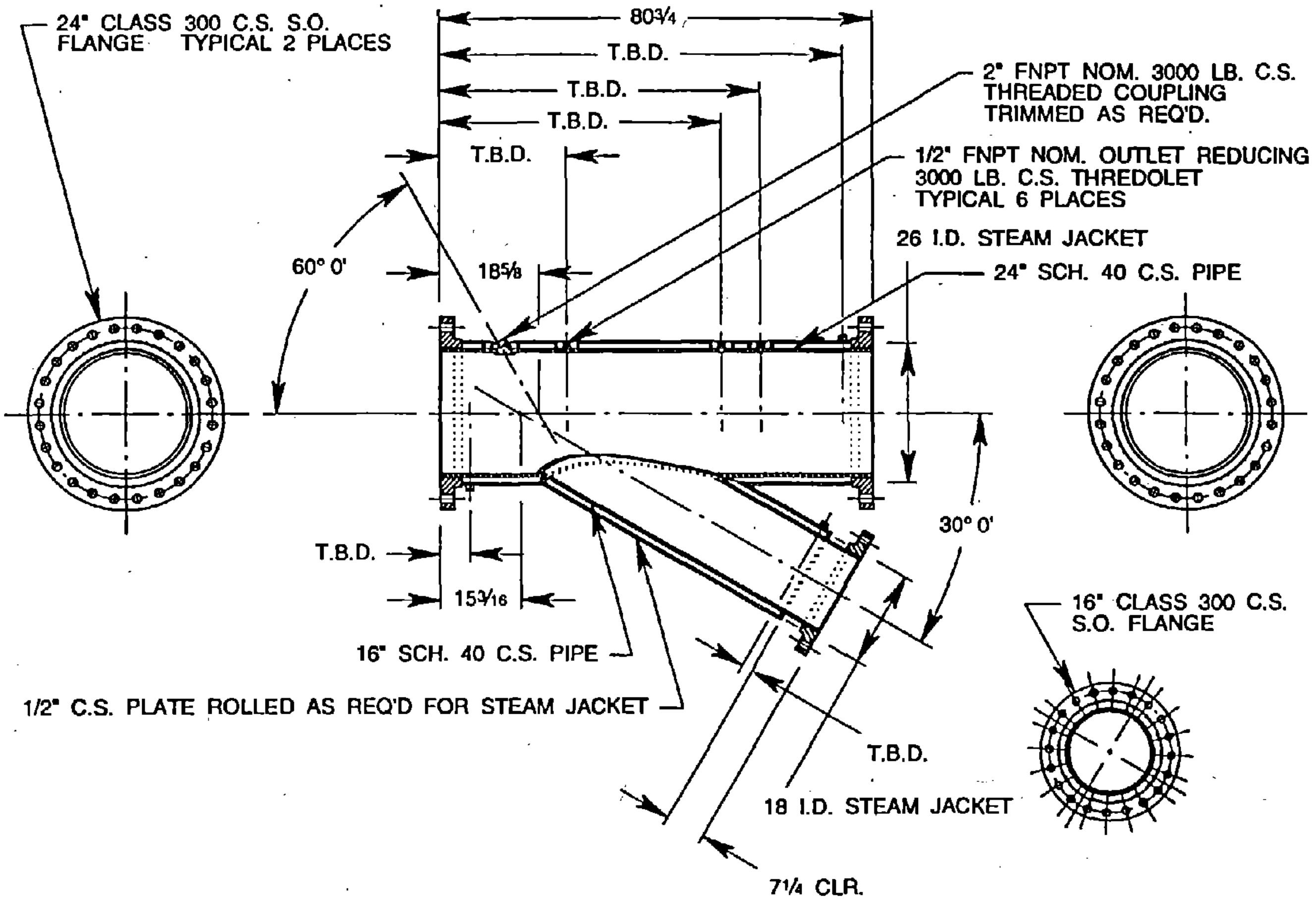
VESSEL R-101 - PRODUCT OUTLET PORT SPOOL PIECE ①

SCALE: 3/4" = 1'-0"



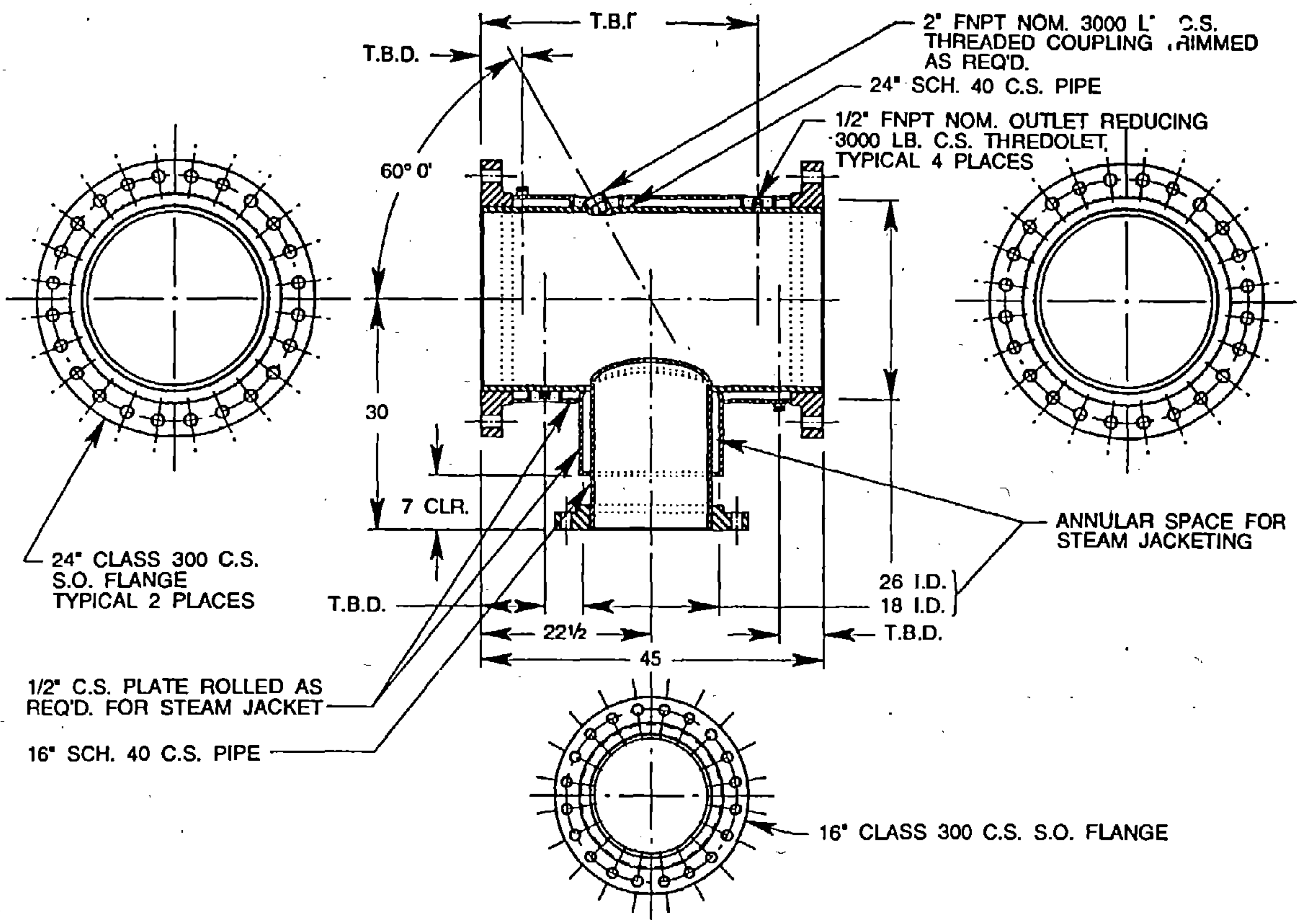
VESSEL R-101 - CYCLONE SPOOL PIECE ②

SCALE: 3/4" = 1'-0"



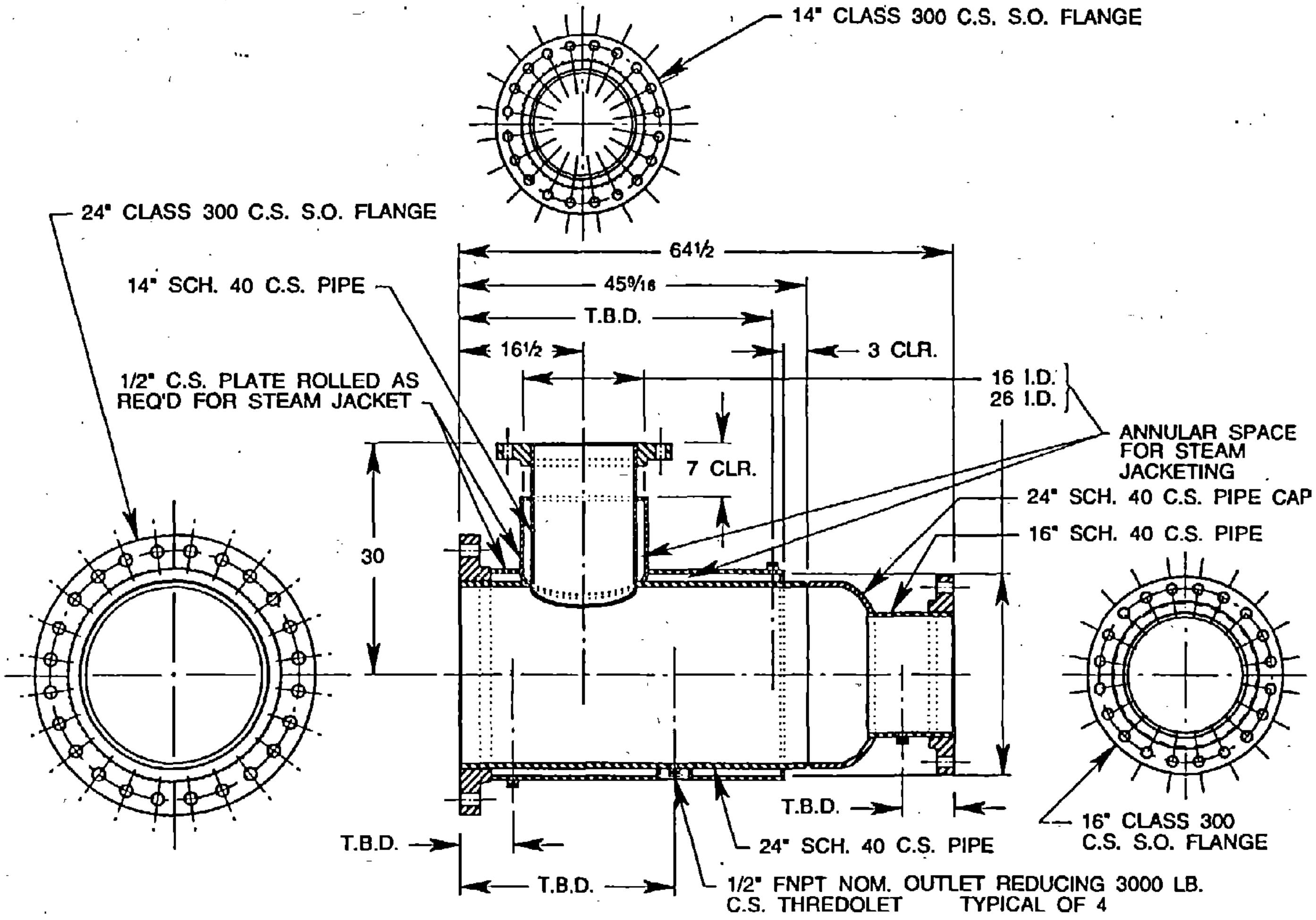
VESSEL R-101 - FEEDSTOCK OVERFLOW PORT SPOOL PIECE ③

SCALE: 1/2" = 1'-0"



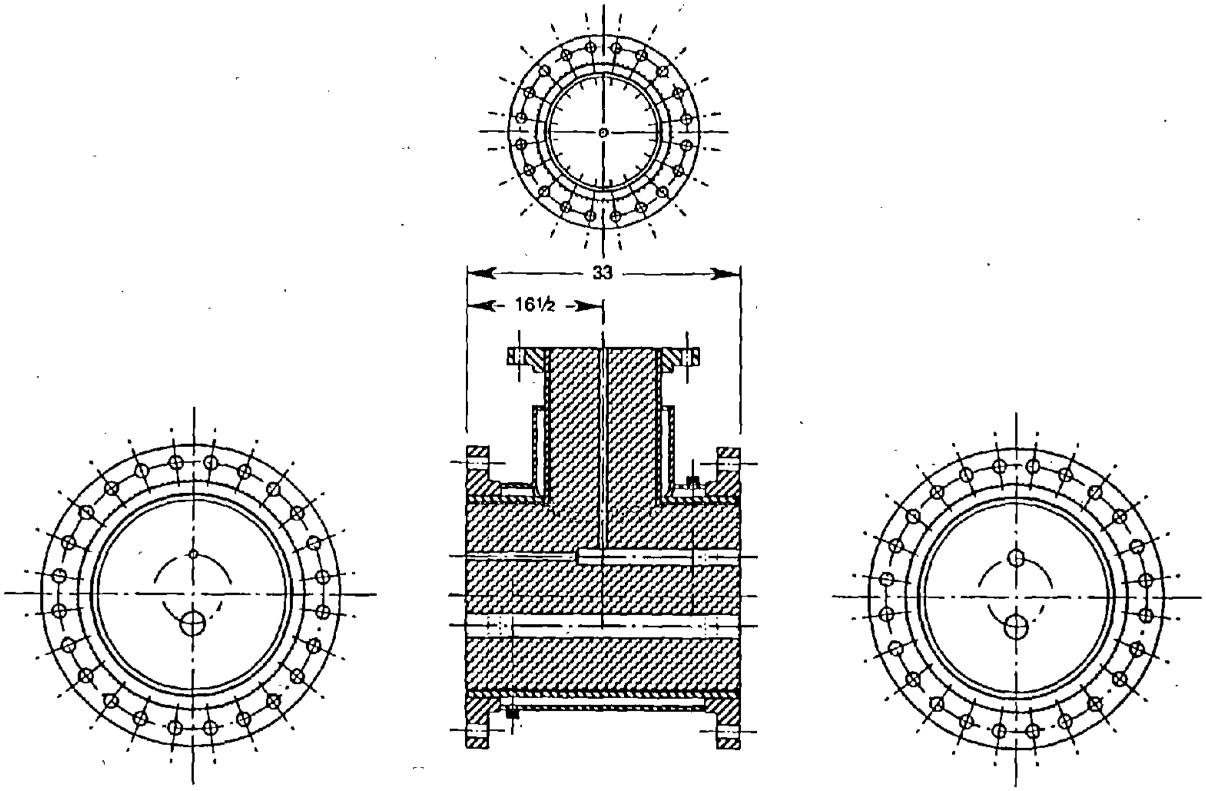
VESSEL R-101 - SCREW CONVEYOR PORT SPOOL PIECE ④

SCALE: 3/4" = 1'-0"



VESSEL R-101 - MIXED GASES INLET PORT & ASH OUTLET PORT SPOOL PIECE ⑤

SCALE: 3/4" = 1'-0"



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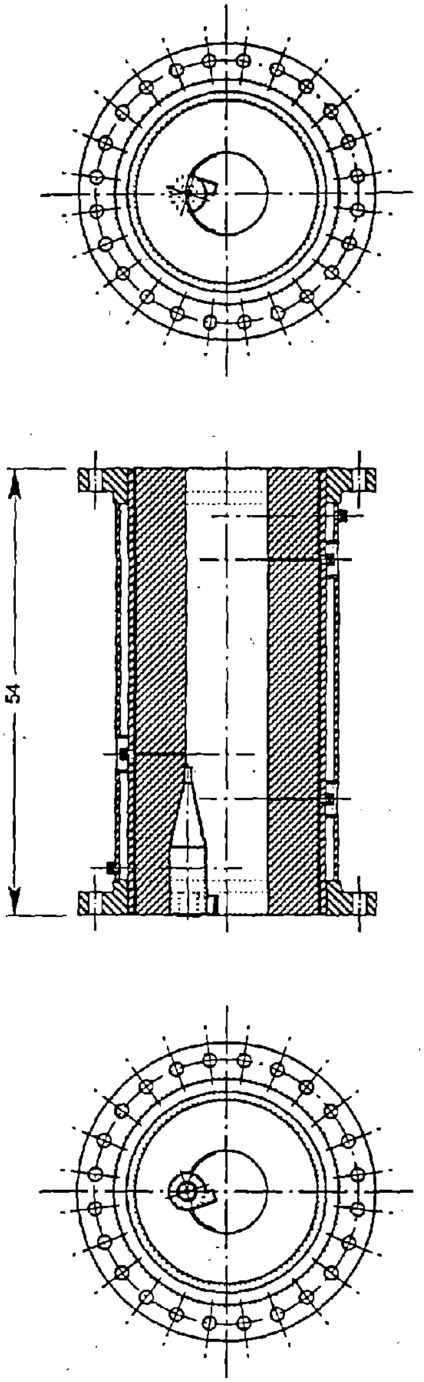
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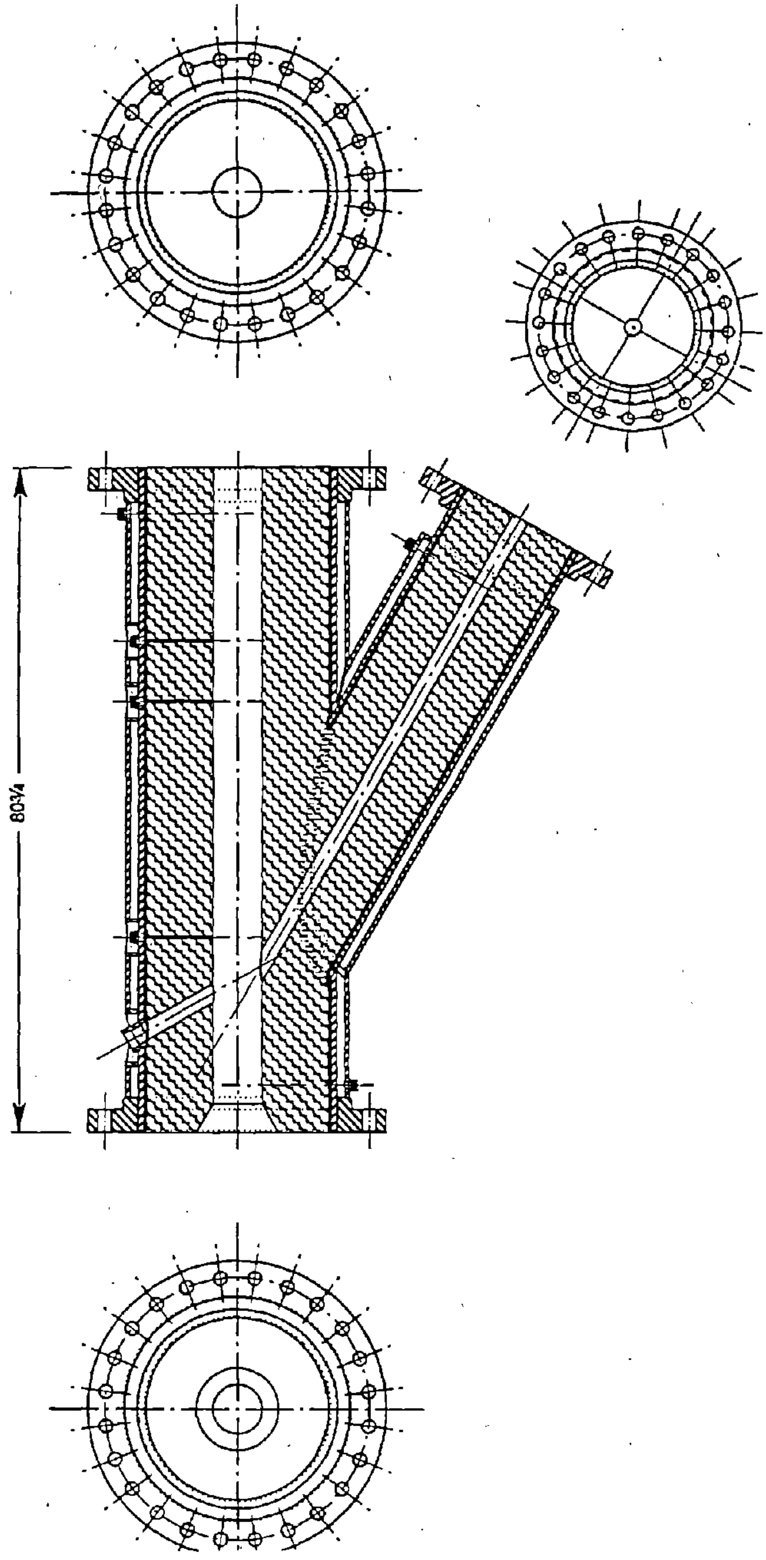

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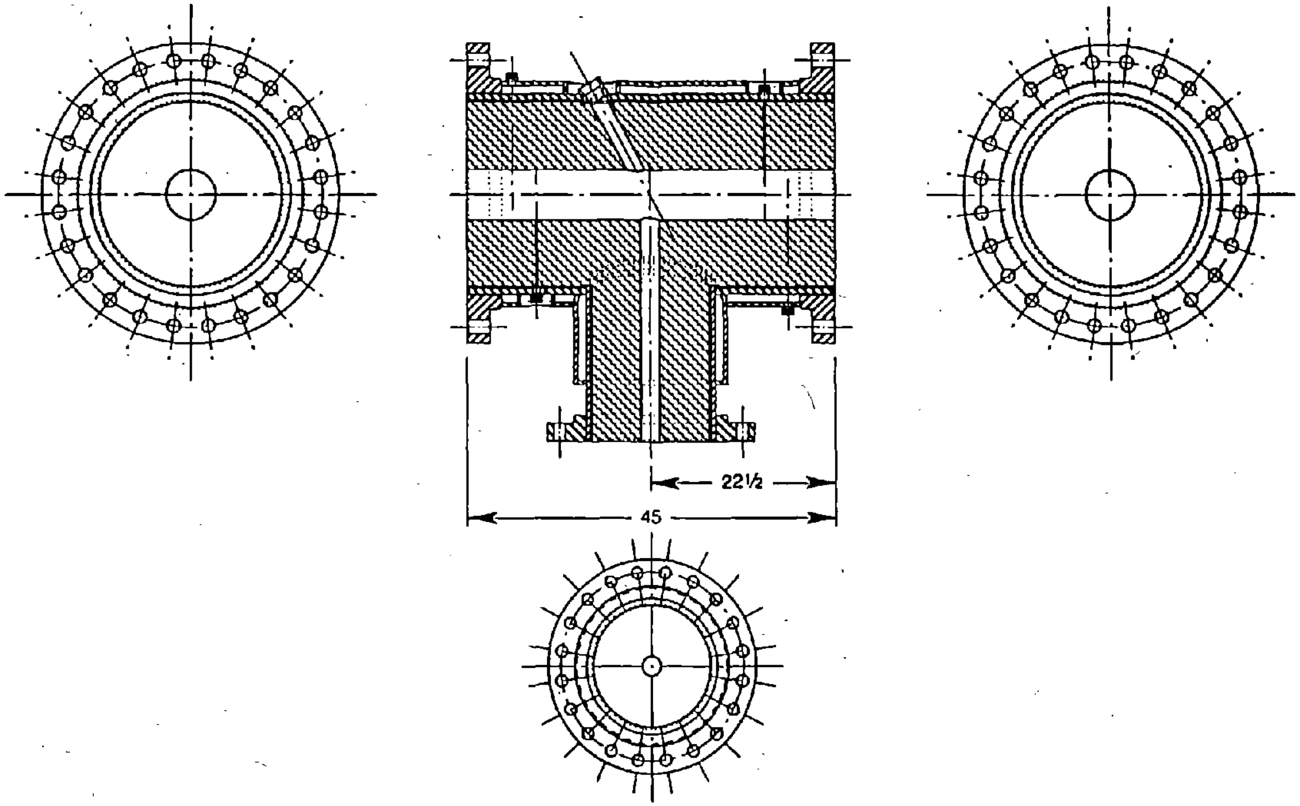

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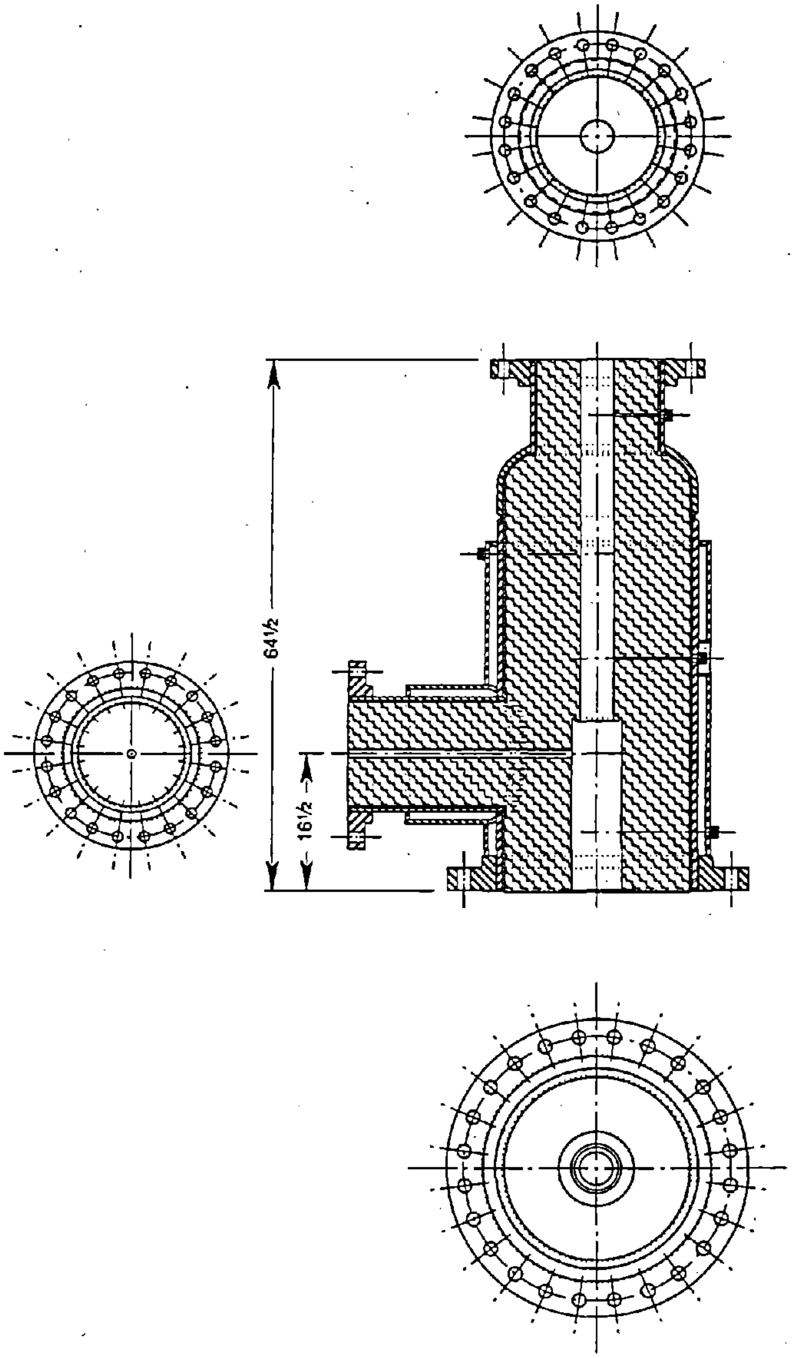

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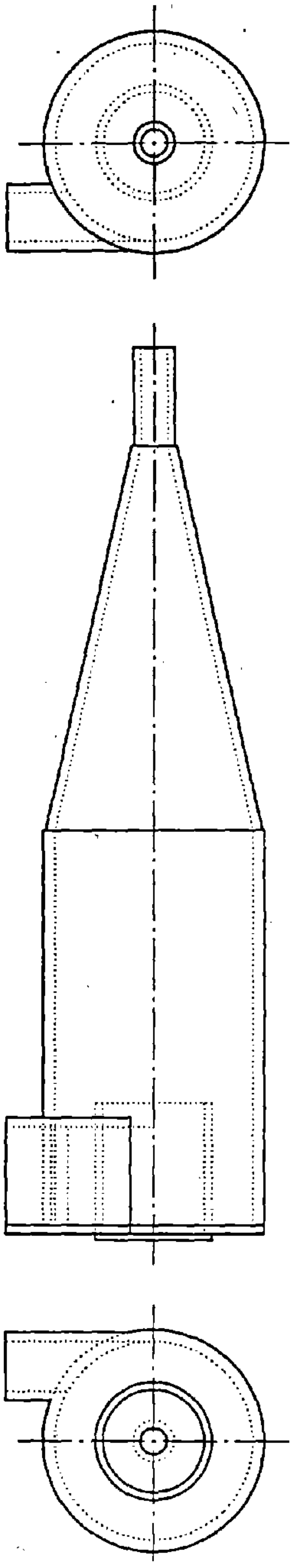

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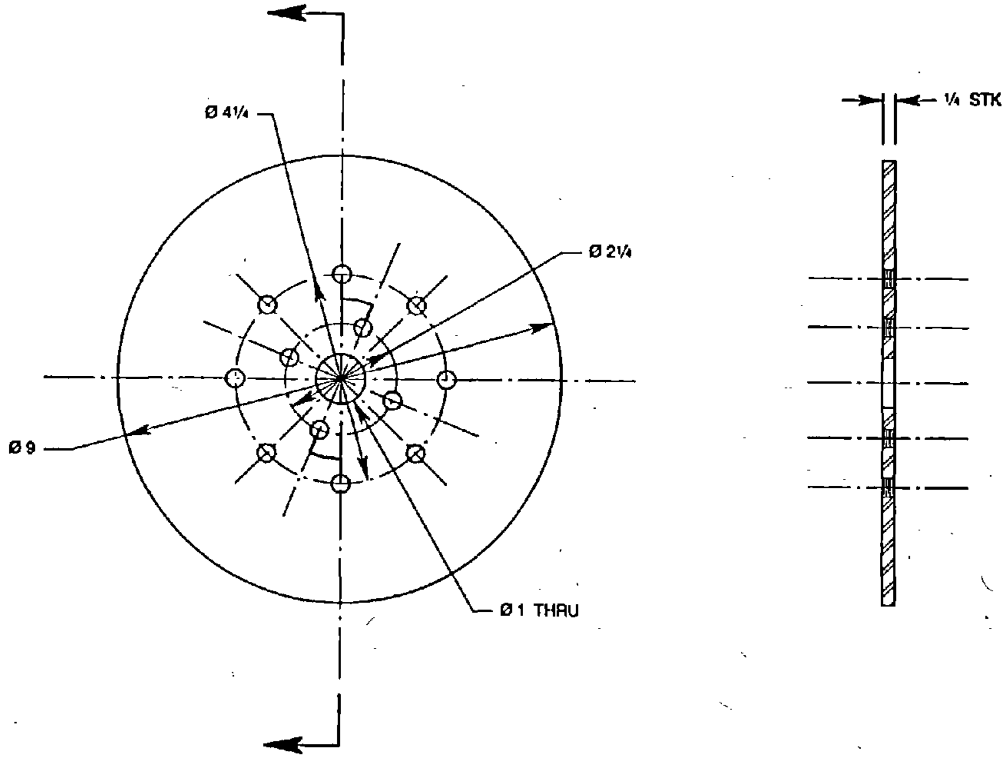

May 12, 1994

MINIMUM WALL THICKNESS CALCULATIONS FOR VESSEL R-101

24" O.D. CYLINDRICAL WALL

Maximum Working Pressure P = 550 psi
Outside Radius R = 12 in.
Material Stress Value S = 15,000 psi (SA-106 Grade B)
Joint Efficiency E = 0.85
Corrosion Allowance C. A. = 0.125 in.

Wall Thickness t = ((P * R) / ((S * E) + (0.4 * P))) + C. A.

t = 0.634 in.

24" O.D. ELLIPSOIDAL HEAD

Maximum Working Pressure P = 550 psi
Outside Diameter D = 24 in.
Material Stress Value S = 16,300 psi (SA-515 Grade 65)
Joint Efficiency E = 0.85
Corrosion Allowance C. A. = 0.125 in.

Wall Thickness t = ((P * D) / ((2 * S * E) + (1.8 * P))) + C. A.

t = 0.585 in.

Maximum Working Pressure P = 650 psi
Outside Diameter D = 24 in.
Material Stress Value S = 17,500 psi (SA-515 Grade 70)
Joint Efficiency E = 0.85
Corrosion Allowance C. A. = 0.125 in.

Wall Thickness t = ((P * D) / ((2 * S * E) + (1.8 * P))) + C. A.

t = 0.554 in.

MINIMUM WALL THICKNESS CALCULATIONS FOR VESSEL R-101

14" NOMINAL PIPE CYLINDRICAL WALL

Maximum Working Pressure P = 550 psi
Outside Radius R = 7.000 in.
Material Stress Value S = 15,000 psi (SA-106 Grade B)
Joint Efficiency E = 0.85
Corrosion Allowance C. A. = 0.125 in.

Wall Thickness t = ((P * R) / ((S * E) + (0.4 * P))) + C. A.

t = 0.422 in.

16" NOMINAL PIPE CYLINDRICAL WALL

Maximum Working Pressure P = 650 psi
Outside Radius R = 8.000 in.
Material Stress Value S = 15,000 psi (SA-106 Grade B)
Joint Efficiency E = 0.85
Corrosion Allowance C. A. = 0.125 in.

Wall Thickness t = ((P * R) / ((S * E) + (0.4 * P))) + C. A.

t = 0.464 in.

26" I.D. STEAM JACKET CYLINDRICAL WALL

Maximum Working Pressure P = 350 psi
Outside Radius R = 13.500 in.
Material Stress Value S = 15,000 psi (SA-106 Grade B)
Joint Efficiency E = 0.85
Corrosion Allowance C. A. = 0.125 in.

Wall Thickness t = ((P * R) / ((S * E) + (0.4 * P))) + C. A.

t = 0.492 in.

INTERNALLY INSULATED VESSEL R-101 R.O.M. COSTING

DESIGN PERAMETERS

OPERATING PRESSURE = 425.30 PSIG

MAXIMUM WORKING PRESSURE = 550.00 PSIG

DESIGN PRESSURE = 675.00 PSIG

HYDROSTATIC TEST PRESSURE = 1,450.00 PSIG

INTERNAL OPERATING TEMPERATURE = 1475 to 1830 °F

VESSEL SKIN TEMPERATURE,
OPERATING (NO JACKET STEAM) = 230 °F

VESSEL SKIN TEMPERATUNE,
MAXIMUM (NO JACKET STEAM) = 275 °F

VESSEL SKIN TEMPERATUNE,
DESIGN (WITH JACKET STEAM) = 400 °F

GASES, OPERATING FLOW

METHANE (NATURAL GAS, CH4) = 6.30 SCFM

CARBON MONOXIDE (CO) = 3.96 SCFM

CARBON DIOXIDE (CO2) = 7.52 SCFM

HYDROGEN (H2) = 41.40 SCFM

STEAM (H2O) = 3.52 SCFM

AIR = 0.00 SCFM

NITROGEN (N2) = 2.03 SCFM

FEEDSTOCK OFFGAS = 6.17 SCFM

TOTAL = 70.90 SCFM

GASES, MAXIMUM FLOW

METHANE (NATURAL GAS, CH4) = 7.40 SCFM

CARBON MONOXIDE (CO) = 3.96 SCFM

CARBON DIOXIDE (CO2) = 7.52 SCFM

HYDROGEN (H2) = 41.40 SCFM

STEAM (H2O) = 3.52 SCFM

AIR = 1.00 SCFM

NITROGEN (N2) = 48.62 SCFM

FEEDSTOCK OFFGAS = 6.17 SCFM

TOTAL = 119.59 SCFM

INDEX

DRAWING No.	TITLE
L/M 8506 M 300	ASSEMBLY (List of Materials)
8506 M 300	ASSEMBLY
L/M 8506 M 301	TOP REFRACTORY (List of Materials)
8506 M 301	TOP REFRACTORY
L/M 8506 M 302	MIDSECTION REFRACTORY (List of Materials)
8506 M 302	MIDSECTION REFRACTORY
L/M 8506 M 303	BOTTOM REFRACTORY (List of Materials)
8506 M 303	BOTTOM REFRACTORY
L/M 8506 M 304	TOP WELDMENT (List of Materials)
8506 M 304	TOP WELDMENT
L/M 8506 M 305	MIDSECTION WELDMENT (List of Materials)
8506 M 305	MIDSECTION WELDMENT
L/M 8506 M 306	BOTTOM WELDMENT (List of Materials)
8506 M 306	BOTTOM WELDMENT
L/M 8506 M 307	CANDLE FLANGE WELDMENT (List of Materials)
8506 M 307	CANDLE FLANGE WELDMENT
8506 M 308	24" WAFER CANDLE FLANGE
8506 M 309	CANDLE FLANGE OUTER SPRING
8506 M 310	CANDLE FLANGE INNER SPRING
8506 M 311	CANDLE INNER FLANGE PIECE
8506 M 312	CANDLE SUPPORT PIPE
8506 M 313	CANDLE MOUNTING PLATE
8506 M 314	CANDLE ADAPTER PLATE
8506 M 315	CANDLE BELL PLATE
8506 M 316	CANDLE (REFERENCE ONLY)
8506 M 317	ELECTRIC HEATER H-102 (REF.)
8506 M 318	PULSE TUBE

FOR R.O.M.
COSTING ONLY
DO NOT ORDER
MATERIAL OR FABRICATE
FROM THIS DRAWING

HYNOL

FILTER VESSEL

F - 104

A.E.C. PROJECT No. 8506

Prepared by

ACUREX ENVIRONMENTAL CORPORATION

MOUNTAIN VIEW, CALIFORNIA

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

TITLE **FILTER VESSEL F-104 ASSEMBLY**

PREPARED BY D.J. DATE [illegible]
CHK [illegible]
ENG [illegible]
APPD [illegible]
PROJECT NO. [illegible]

L/M 8506M300

LIST OF MATERIALS

SHEET 1 of 1 REV 3a

REVISIONS

LTR	DESCRIPTION	APPD	DATE
2	RELEASED FOR REVIEW	DJT	[illegible]
3	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

	TITLE
8506M300	FILTER VESSEL F-104 ASSEMBLY

APPLICATION

DASH NO.	NEXT ASSY	QTY	USED ON
01		1	8506

ITEM NO.	PART NUMBER	DESCRIPTION		QTY REQ'D PER DASH NO. -01	-02	-03	-04
1	8506M301	FILTER VESSEL F-104 TOP REFRACTORY		1	0	0	0
2	8506M302	FILTER VESSEL F-104 MIDSECTION REFRACTORY		1	0	0	0
3	8506M303	FILTER VESSEL F-104 BOTTOM REFRACTORY		1	0	0	0
4	8506M307	FILTER VESSEL F-104 CANDLE FLANGE WELDMENT		1	0	0	0
5	8506M314	FILTER VESSEL F-104 CANDLE ADAPTER PLATE		1	0	0	0
6	8506M315	FILTER VESSEL F-104 CANDLE BELL PLATE		1	0	0	0
7	8506M316	FILTER VESSEL F-104 CANDLE (REFERENCE ONLY)		1	0	0	0
8	8506M317	FILTER VESSEL F-104 ELECTRIC HEATER H-102 (REF.)		2	0	0	0
9	8506M318	FILTER VESSEL F-104 PULSE TUBE		1	0	0	0
10	PARKER 8-8 FH4BZ-IN	THERMOCOUPLE CONNECTOR, 1/2" TUBE O.D. x 1/2" MNPT	INCONEL ALLOY 600	1	0	0	0
11	PARKER 4-8 FBZ-SS	MALE CONNECTOR, 1/4" TUBE O.D. x 1/2" MNPT	TYPE 316 STAINLESS STEEL	1	0	0	0
12	PARKER 4-8 FH4BZ-SS	THERMOCOUPLE CONNECTOR, 1/4" TUBE O.D. x 1/2" MNPT	TYPE 316 STAINLESS STEEL	2	0	0	0
13	-----	HEAVY HEX NUT, WASHER FACED, 1-7/8" - 8UN - 2B	CARBON STEEL	96	0	0	0
14	-----	STUD BOLT, 1-7/8" - 8UN - 2A x 15-3/4" LONG	CARBON STEEL	24	0	0	0
15	-----	STUD BOLT, 1-7/8" - 8UNC - 2A x 14" LONG	CARBON STEEL	24	0	0	0
16	-----	HEX NUT, FINISHED, 1/4" - 20UNC	ROLLED ALLOYS RA 330	12	0	0	0
17	-----	FLAT WASHER, 1/4" NOMINAL	ROLLED ALLOYS RA 330	12	0	0	0
18	-----	STUD BOLT, 1/4" - 20UNC x 3-1/4" LONG	ROLLED ALLOYS RA 330	6	0	0	0
19	FLEXITALLIC No. CG-6X (304 SUPER - FLEXITE)	GASKET, 24" - 600# RAISED FACE FLANGES		3	0	0	0
20	-----	INSULATION PAPER, 1/4" THICK (SHAPE AS REQUIRED)		A/R	0	0	0
21	CONAX TG-14-B2-L	ELECTRICAL CONNECTOR, INSULATED HIGH PRESSURE GLAND		8	0	0	0
22	•	•		0	0	0	0
23	•	•		0	0	0	0
24	•	•		0	0	0	0
25	•	•		0	0	0	0

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Acurex Environmental Corporation

PROJECT HYDROCARB HPR

TITLE

FILTER VESSEL F-104
TOP REFRACTORY

PREPARED BY D.J. TATE [illegible]

CHK [illegible]

ENG [illegible]

APPD [illegible]

PROJECT NO. [illegible]

L/M8506M301

SHEET 1 of 1

REV 1

REVISIONS

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

	TITLE
8506M300	FILTER VESSEL F-104 ASSEMBLY

APPLICATION

DASH NO.	NEXT ASSY	QTY	USED ON
01	8506M300	1	8506

ITEM NO.	PART NUMBER	DESCRIPTION	QTY REQ'D PER DASH NO.			
			-01	-02	-03	-04
1	8506M304	FILTER VESSEL F-104 TOP WELDMENT	1	0	0	0
2	-----	INSULATION PAPER, 1/4" THICK ?	A/R	0	0	0
3	-----	INSULATION, ?	A/R	0	0	0
4	•	•	0	0	0	0
5	•	•	0	0	0	0
6	•	•	0	0	0	0
7	•	•	0	0	0	0
8	•	•	0	0	0	0
9	•	•	0	0	0	0
10	•	•	0	0	0	0
11	•	•	0	0	0	0
12	•	•	0	0	0	0
13	•	•	0	0	0	0
14	•	•	0	0	0	0
15	•	•	0	0	0	0
16	•	•	0	0	0	0
17	•	•	0	0	0	0
18	•	•	0	0	0	0
19	•	•	0	0	0	0
20	•	•	0	0	0	0
21	•	•	0	0	0	0
22	•	•	0	0	0	0
23	•	•	0	0	0	0
24	•	•	0	0	0	0
25	•	•	0	0	0	0

FOR R.O.M.
COSTING ONLY
DO NOT ORDER
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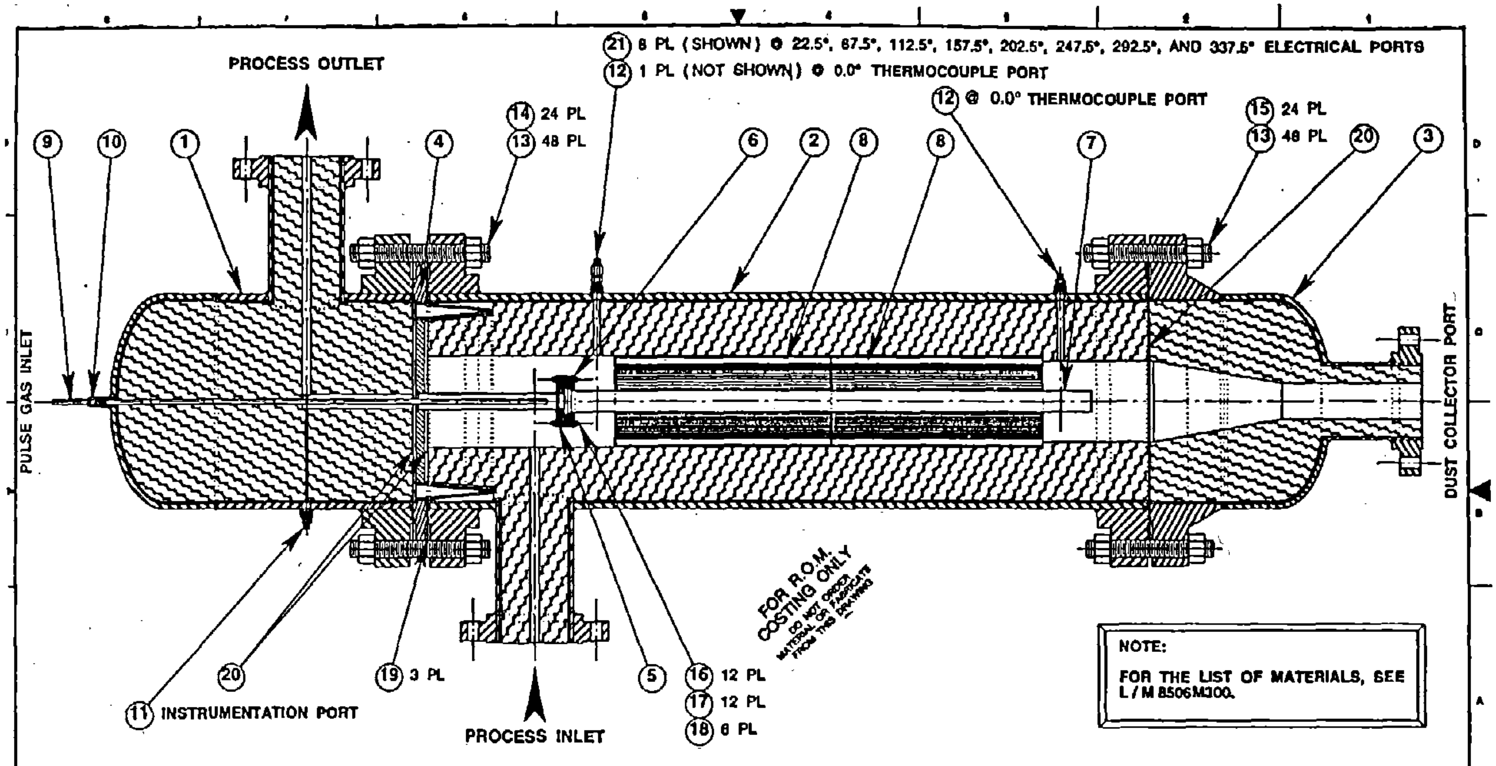
FROM THIS DRAWING



FOR R.O.M. COSTING ONLY
DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

NOTE:

FOR THE LIST OF MATERIALS, SEE L / M 8506M300.

LTR	DESCRIPTION	APPD	DATE
3	RELEASED FOR REVIEW	DJT	09-23-93
2	RELEASED FOR REVIEW	DJT	09-15-93
1	RELEASED FOR REVIEW	DJT	08-26-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

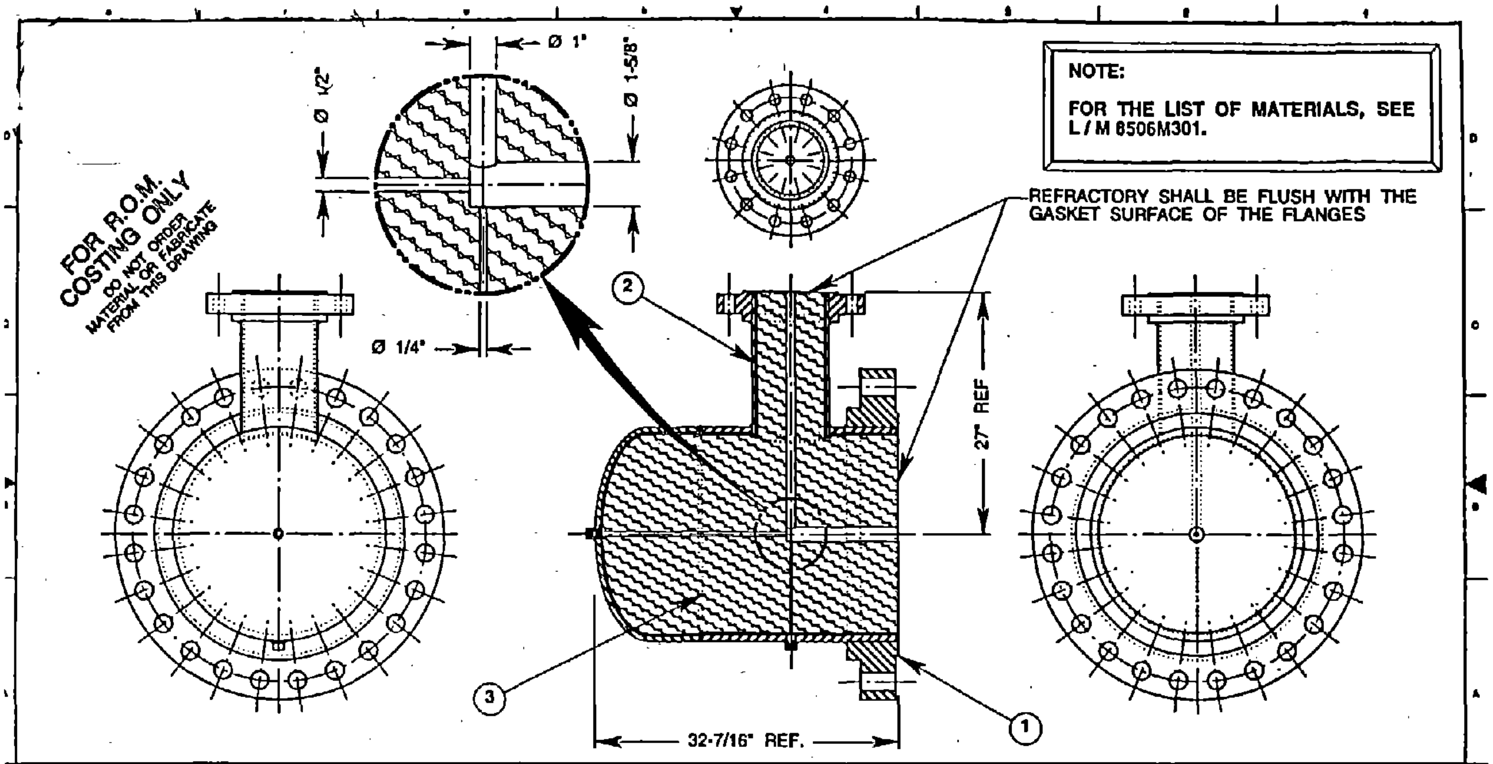
DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 10	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
ASSEMBLY

SIZE B
DWG. NO. 8506M300
SHEET 1 of 1
REV 3a



NOTE:

FOR THE LIST OF MATERIALS, SEE L/M 8506M301.

REFRACTORY SHALL BE FLUSH WITH THE GASKET SURFACE OF THE FLANGES

FOR R.O.M. COSTING ONLY
DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1/10	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
TOP REFRACTORY

SIZE B
DWG. NO. 8506M301
SHEET 1 of 1
REV 1a

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

TITLE

FILTER VESSEL F-104
MIDSECTION REFRACTORY

PREPARED BY DJ DATE [illegible]
CHK [illegible]
ENG [illegible]
APPD [illegible]
PROJECT NO. [illegible]

L/M8506M302

SHEET 1 of 1. REV 1

FOR R.O.M.
COSTING ONLY
DO NOT ORDER
MATERIAL OR FABRICATE
FROM THIS DRAWING

REVISIONS

LTR	DESCRIPTION	[illegible]	DATE
1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

	TITLE
8506M300	FILTER VESSEL F-104 ASSEMBLY

APPLICATION

DASH NO.	NEXT ASSY	QTY	USED ON
01	8506M300	1	8506

ITEM NO.	PART NUMBER	DESCRIPTION	QTY REQ'D PER DASH NO.			
			-01	-02	-03	-04
1	8506M308	FILTER VESSEL F-104 MIDSECTION WELDMENT	1	0	0	0
2	-----	INSULATION PAPER, 1/4" THICK ?	A/R	0	0	0
3	-----	INSULATION, ?	A/R	0	0	0
4	•	•	0	0	0	0
5	•	•	0	0	0	0
6	•	•	0	0	0	0
7	•	•	0	0	0	0
8	•	•	0	0	0	0
9	•	•	0	0	0	0
10	•	•	0	0	0	0
11	•	•	0	0	0	0
12	•	•	0	0	0	0
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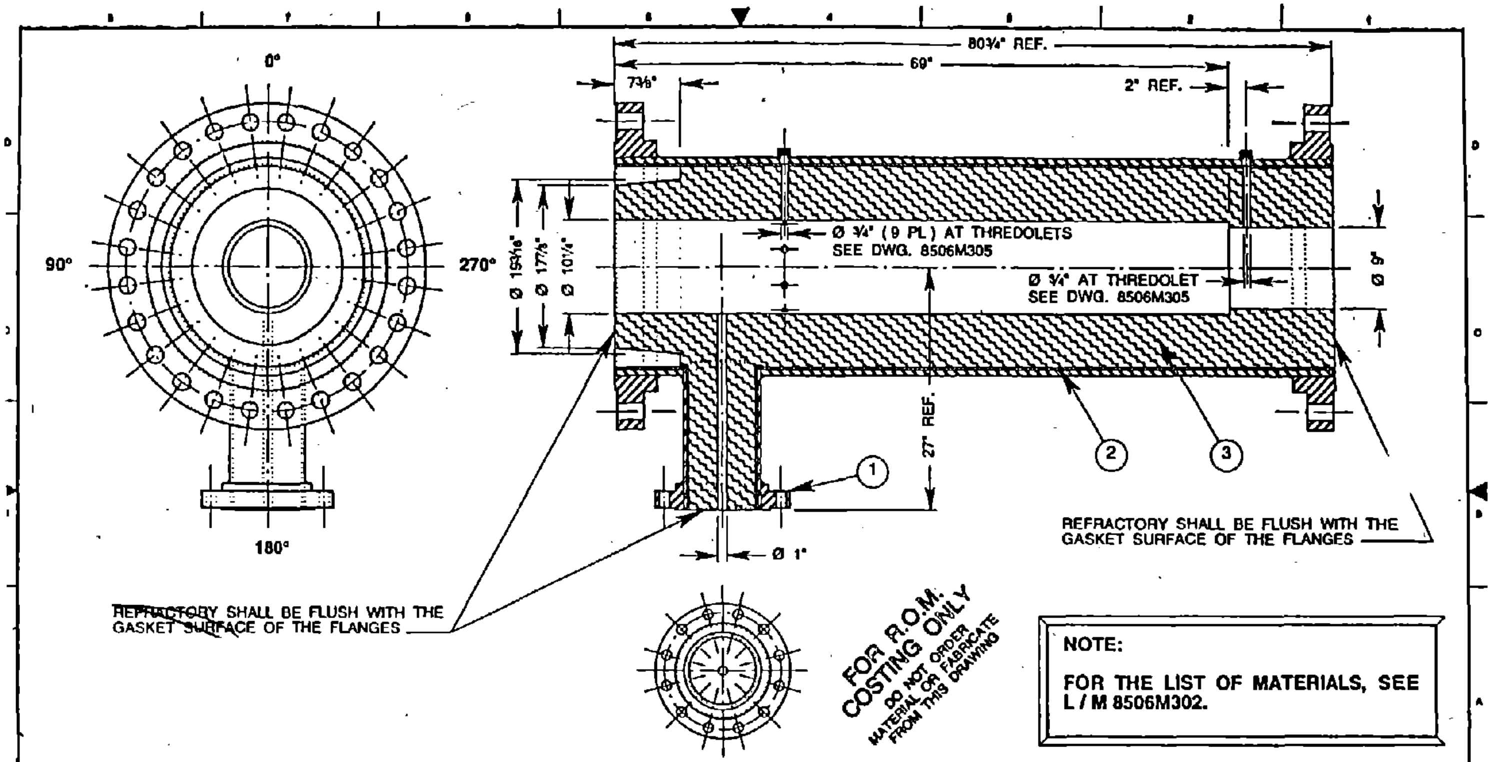
14	•	•	0	0	0	0
15	•	•	0	0	0	0
16	•	•	0	0	0	0
17	•	•	0	0	0	0
18	•	•	0	0	0	0
19	•	•	0	0	0	0
20	•	•	0	0	0	0
21	•	•	0	0	0	0
22	•	•	0	0	0	0
23	•	•	0	0	0	0
24	•	•	0	0	0	0
25	•	•	0	0	0	0



~~REFRACTORY~~ SHALL BE FLUSH WITH THE GASKET ~~SURFACE~~ OF THE FLANGES

REFRACTORY SHALL BE FLUSH WITH THE GASKET SURFACE OF THE FLANGES

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DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

NOTE:

FOR THE LIST OF MATERIALS, SEE L / M 8506M302.

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

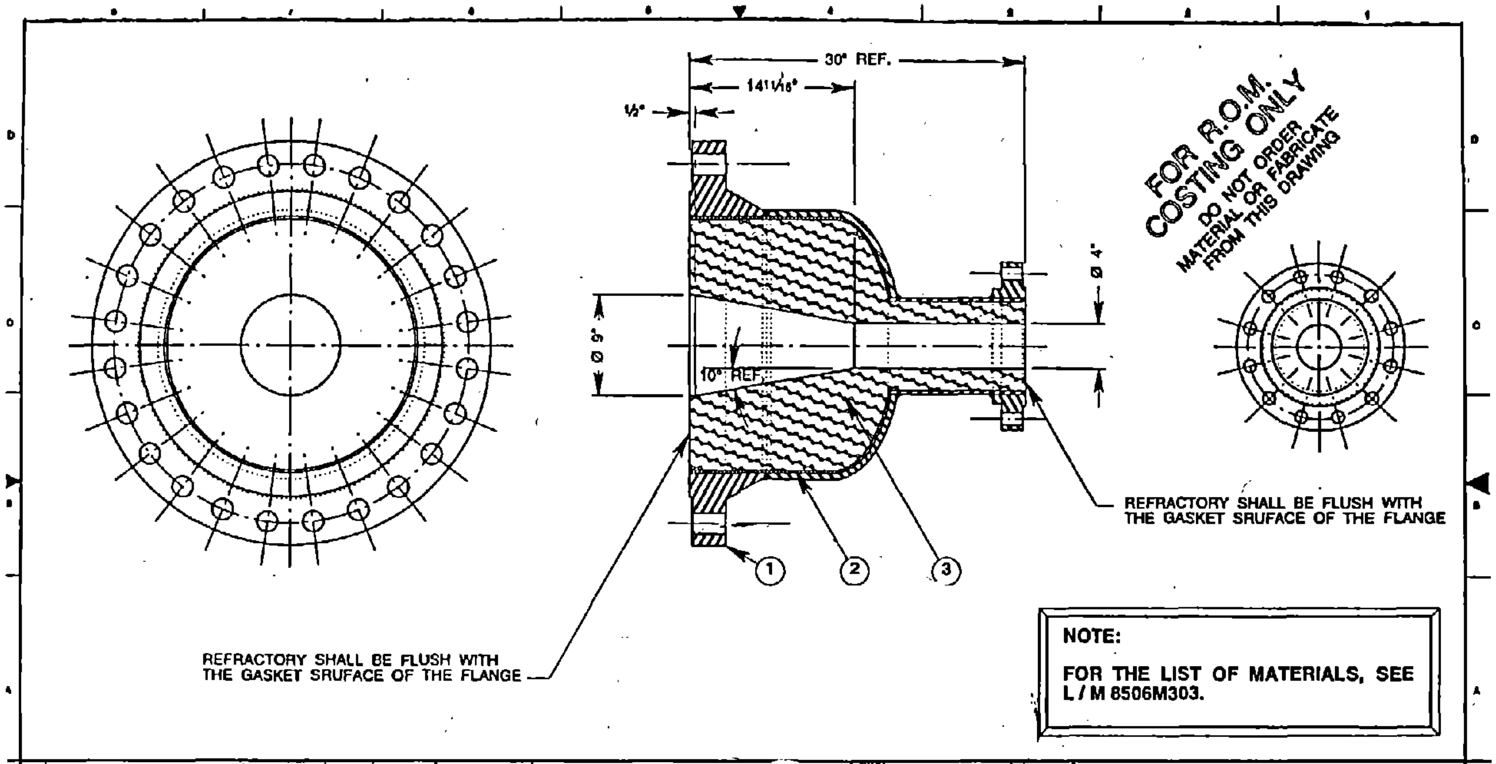
DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 10	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F-104
MIDSECTION REFRACTORY

SIZE	DWG. NO.	SHEET	REV
B	8506M302	1 of 1	1



REFRACTORY SHALL BE FLUSH WITH THE GASKET SRUFACE OF THE FLANGE

REFRACTORY SHALL BE FLUSH WITH THE GASKET SRUFACE OF THE FLANGE

FOR R.O.M. COSTING ONLY
DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

NOTE:

FOR THE LIST OF MATERIALS, SEE L / M 8506M303.

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	09-23-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 8	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
BOTTOM REFRACTORY

SIZE	DWG. NO.	SHEET	REV
B	8506M303	1 of 1	1

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

TITLE
FILTER VESSEL F-104
BOTTOM REFRACTORY

L/M8506M303

SHEET 1 of 1

REV 1

REVISIONS

1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

8506M300	FILTER VESSEL F-104 ASSEMBLY

APPLICATION

	NEXT ASSY	QTY	
01	8506M300	1	8506

ITEM NO.	PART NUMBER	DESCRIPTION	-01	-02	-03	-04
1	8506M306	FILTER VESSEL F-104 BOTTOM WELDMENT	1	0	0	0
2	·····	INSULATION PAPER, 1/4" THICK ?	A/R	0	0	0.
3	·····	INSULATION, ?	A/R	0	0	0
4	•	•	0	0	0	0
5	•	•	0	0	0	0
6	•	•	0	0	0	0
7	•	•	0	0	0	0
8	•	•	0	0	0	0
9	•	•	0	0	0	0
10	•	•	0	0	0	0
11	•	•	0	0	0	0
12	•	•	0	0	0	0
13	•	•	0	0	0	0
14	•	•	0	0	0	0
15	•	•	0	0	0	0
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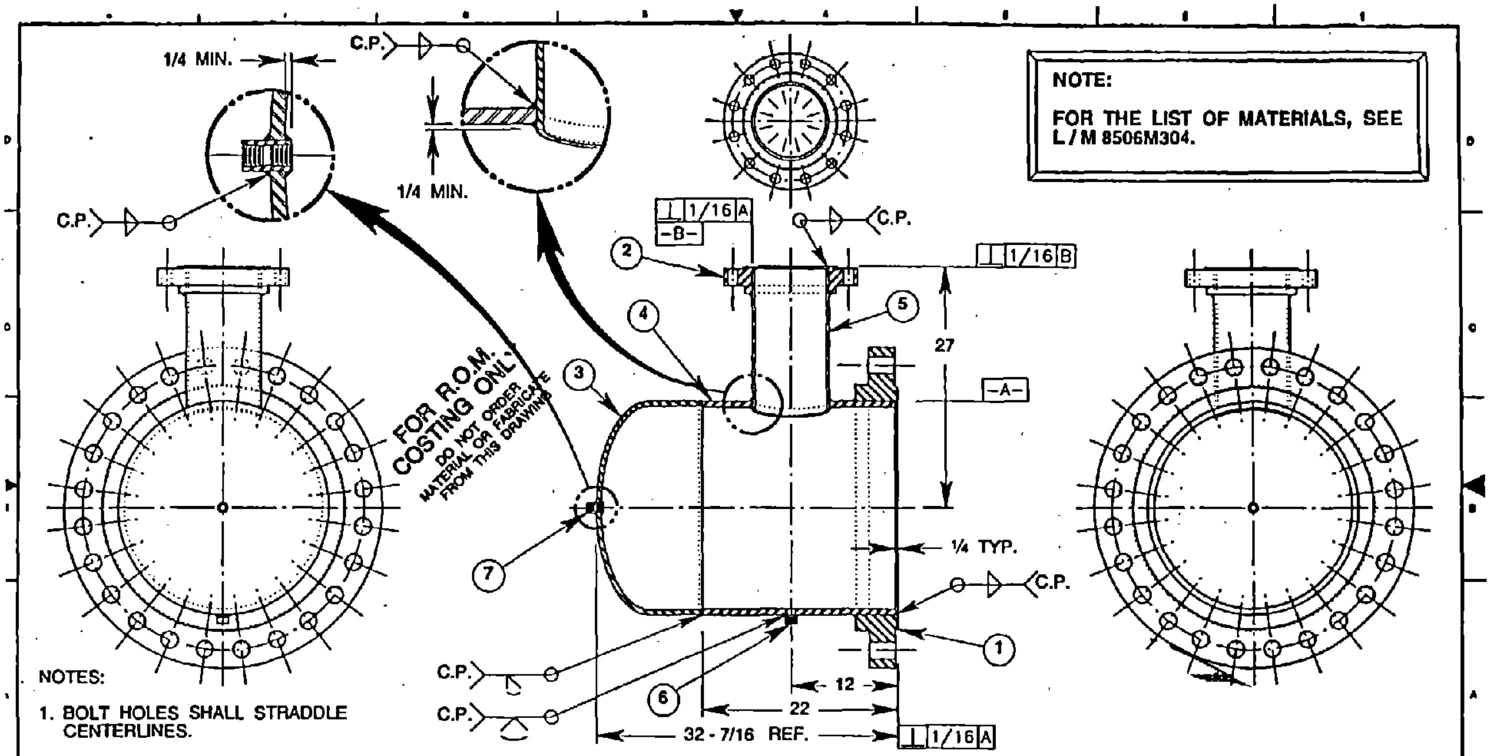
21	•	•	0	0	0	0
22	•	•	0	0	0	0
23	•	•	0	0	0	0
24	•	•	0	0	0	0
25	•	•	0	0	0	0

FOR R.O.M.
COSTING ONLY
DO NOT ORDER
MATERIAL OR FABRICATE
FROM THIS DRAWING



NOTE:

FOR THE LIST OF MATERIALS, SEE L / M 8506M304.

NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN D. J. TATE 08-25-93
CHK
ENG
APPD
PROJECT NO. 8506 - 400
SCALE 1/10

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
TOP WELDMENT

SIZE B
DWG NO. 8506M304
SHEET 1 of 1
REV 1

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

TITLE
FILTER VESSEL F-104
TOP WELDMENT

PREPARED BY [illegible] [illegible]
CHK [illegible]
ENG [illegible]
APPD [illegible]
PROJECT NO. [illegible]

L/M 8506M304

SHEET 1 of 1

REV 1

REVISIONS

LTR	DESCRIPTION	[illegible]	DATE
1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

	TITLE
8506M001	FILTER VESSEL F-104 TOP REFRACTORY

APPLICATION

DASH No.	NEXT ASSY	QTY	USED ON
01	8506M301	1	8506

ITEM No.	PART NUMBER	DESCRIPTION	[illegible]			
			-01	-02	-03	-04
1	-----	24" - 400 # RAISED FACE SLIP-ON FLANGE ASTM A-105 CARBON STEEL	1	0	0	0
2	-----	8" - 400 # RAISED FACE SLIP-ON FLANGE ASTM A-105 CARBON STEEL	1	0	0	0
3	-----	24" O.D. ASME CODE ELLIPTICAL DISHED & FLANGED HEAD WITH .375" MIN. WALL THICKNESS & 4" STRAIGHT FLANGE ASTM A-515 GRADE 65 OR 70 C. STL.	1	0	0	0
4	-----	24" SCH. 60 SEAMLESS PIPE x 21-3/4" LONG ASTM A-106 GRADE B C. STL.	1	0	0	0
5	-----	8" SCH. 60 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 18-9/16") ASTM A-106 GRADE B CARBON STEEL	1	0	0	0
6	BONNY FORGE, INC.	24" RUN PIPE x 1/2" FNPT NOM. OUTLET REDUCING 3000 # THREDOLET ASTM A-105 CARBON STEEL	1	0	0	0
7	VOGT SERIES No. 2324	1/2" NPT THREADED 3000 # PIPE COUPLING ASTM A-105 CARBON STEEL	1	0	0	0
8	.	.	0	0	0	0
9	.	.	0	0	0	0
10	.	.	0	0	0	0
11	.	.	0	0	0	0
12	.	.	0	0	0	0
13	.	.	0	0	0	0
14	.	.	0	0	0	0
15	.	.	0	0	0	0
16	.	.	0	0	0	0
17	.	.	0	0	0	0
18	.	.	0	0	0	0
19	.	.	0	0	0	0
20	.	.	0	0	0	0
21	.	.	0	0	0	0
22	.	.	0	0	0	0
23	.	.	0	0	0	0
24	.	.	0	0	0	0
25	.	.	0	0	0	0

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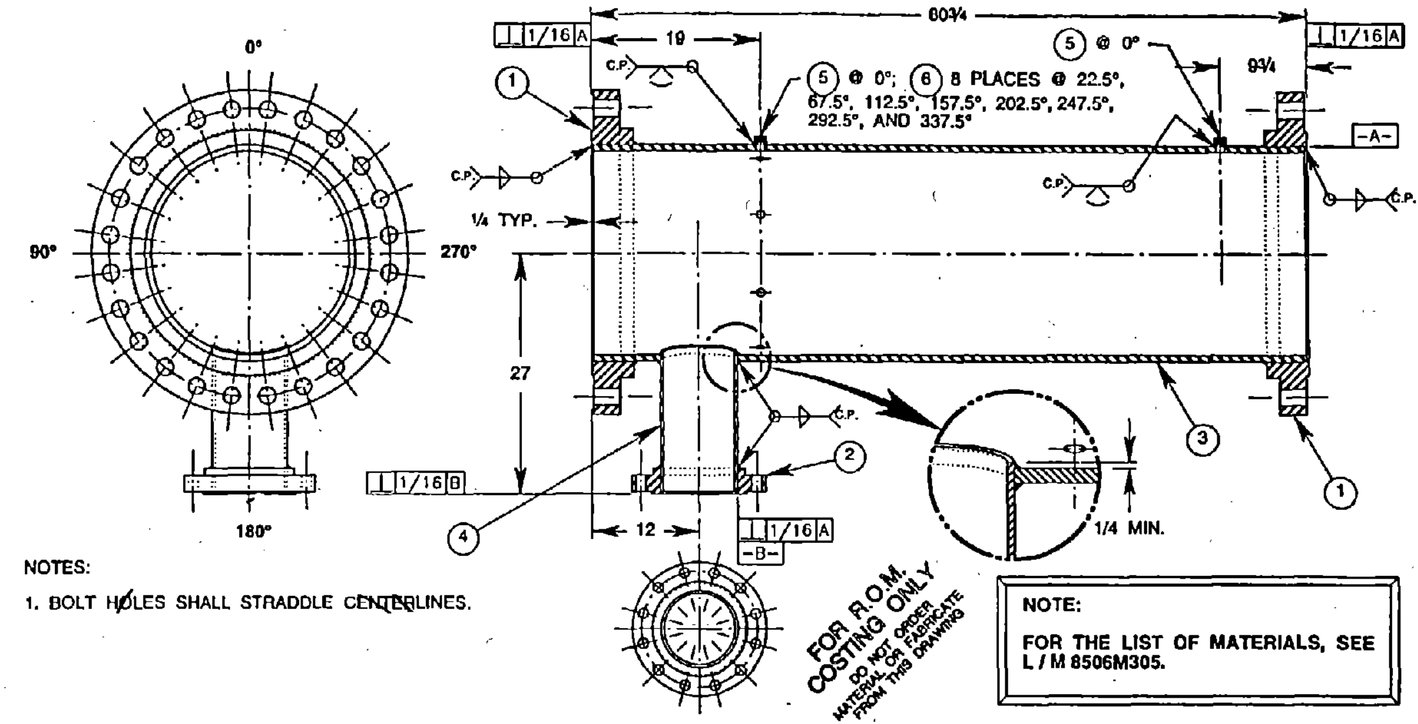

NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.

FOR R.O.M. COSTING ONLY
DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

NOTE:

FOR THE LIST OF MATERIALS, SEE L / M 8506M305.

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 10	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
MIDSECTION WELDMENT

SIZE B
DWG. NO. 8506M305
SHEET 1 of 1
REV 1

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

TITLE
FILTER VESSEL F-104 MIDSECTION WELDMENT

PREPARED BY DJ DATE

CHK

ENG

APPD

PROJECT NO.

L/M8506M305

LIST OF MATERIALS

SHEET 1 of 1

REV 1

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FROM THIS DRAWING

REVISIONS

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

	TITLE
8506M304	FILTER VESSEL F-104 MIDSECTION REFRACTORY

APPLICATION

DASH NO.	NEXT ASSY	QTY	USED ON
01	8506M302	1	8506

ITEM NO.	PART NUMBER	DESCRIPTION		[illegible]		
			[illegible]	[illegible]	[illegible]	[illegible]
1	-----	24" - 400 # RAISED FACE SLIP-ON FLANGE ASTM A-105 CARBON STEEL	2	0	0	0
2	-----	8" - 400 # RAISED FACE SLIP-ON FLANGE ASTM A-105 CARBON STEEL	1	0	0	0
3	-----	24" SCH. 60 SEAMLESS PIPE x 60-1/4" LONG ASTM A-106 GRADE B C. STL.	1	0	0	0
4	-----	8" SCH. 80 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 16-9/16") ASTM A-106 GRADE B CARBON STEEL	1	0	0	0
5	BONNY FORGE, INC.	24" RUN PIPE x 1/2" FNPT NOM. OUTLET REDUCING 3000 # THREDOLET ASTM A-105 CARBON STEEL	2	0	0	0
6	BONNY FORGE, INC.	24" RUN PIPE x 1/2" FNPT NOM. OUTLET REDUCING 3000 # THREDOLET ASTM A-105 CARBON STEEL	[illegible]	0	0	0
7	•	•	0	0	0	0
8	•	•	0	0	0	0
9	•	•	0	0	0	0
10	•	•	0	0	0	0
11	•	•	0	0	0	0
12	•	•	0	0	0	0
13	•	•	0	0	0	0
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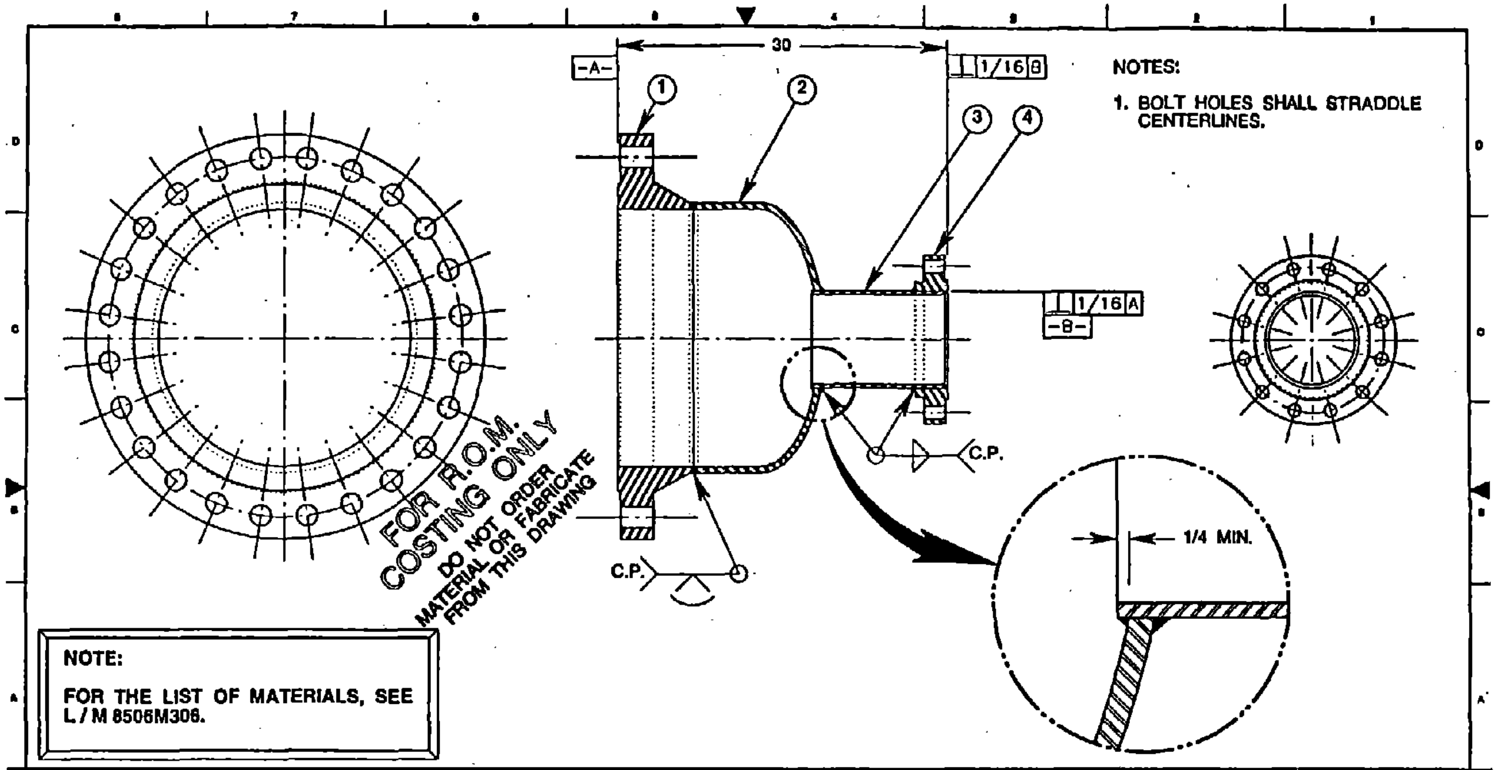
25	•	•	0	0	0	0



NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.

NOTE:

FOR THE LIST OF MATERIALS, SEE L/M 8506M306.

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F-104
BOTTOM WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8506M306	1 of 1	1

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

TITLE
FILTER VESSEL F-104
BOTTOM WELDMENT

PREPARED BY D.J. TATE

PROJECT NO.

L/M8506M306

SHEET 1 of 1

REV 1

REVISIONS

1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

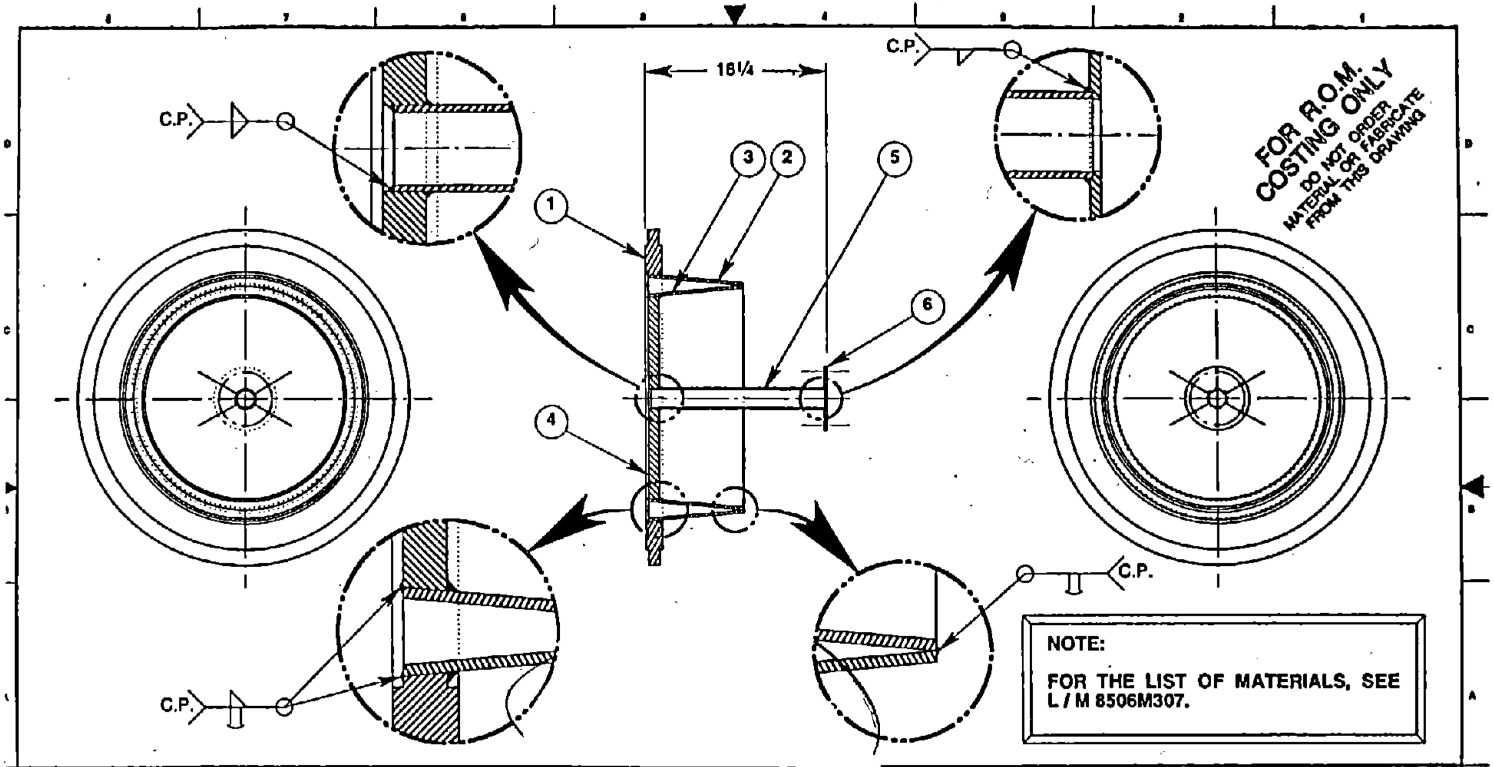
8506M303	FILTER VESSEL, F-104 BOTTOM REFRACTORY

APPLICATION

	NEXT ASSY	QTY	USED ON
01	8506M303	1	8506

	PART NUMBER	DESCRIPTION				
1	-----	24" - 400 # RAISED FACE WELDING NECK FLANGE BORED FOR SCH. 80 PIPE (22.062" I.D.) ASTM A-105 CARBON STEEL	1	0	0	0
2	-----	24" O.D. ASME CODE ELLIPTICAL DISHED & FLANGED HEAD WITH .375" MIN. WALL THICKNESS & 4" STRAIGHT FLANGE ASTM A-516 GRADE 65 OR 70 C. STL.	1	0	0	0
3	-----	6" SCH. 80 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 13-11/16") ASTM A-106 GRADE B CARBON STEEL	1	0	0	0
4	-----	6" - 400 # RAISED FACE SLIP-ON FLANGE ASTM A-105 CARBON STEEL	1	0	0	0
5	.	.	0	0	0	0
6	.	.	0	0	0	0
7	.	.	0	0	0	0
8	.	.	0	0	0	0
9	.	.	0	0	0	0
10	.	.	0	0	0	0
11	.	.	0	0	0	0
12	.	.	0	0	0	0
13	.	.	0	0	0	0
14	.	.	0	0	0	0
15	.	.	0	0	0	0
16	.	.	0	0	0	0
17	.	.	0	0	0	0
18	.	.	0	0	0	0
19	.	.	0	0	0	0
20	.	.	0	0	0	0
21	.	.	0	0	0	0
22	.	.	0	0	0	0
23	.	.	0	0	0	0
24	.	.	0	0	0	0
25	.	.	0	0	0	0

FOR R.O.M.
COSTING ONLY
DO NOT ORDER
MATERIAL OR FABRICATE
FROM THIS DRAWING



NOTE:

FOR THE LIST OF MATERIALS, SEE L / M 8506M307.

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 8	

ORIGINATING OFFICE	CAGE NO.
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
CANDLE FLANGE WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8506M307	1 of 1	1

FOR R.O.M.
COSTING ONLY
DO NOT ORDER
MATERIAL OR FABRICATE
FROM THIS DRAWING

Acurex Environmental Corporation

HYDROCARB HPR

FILTER VESSEL F-104 CANDLE FLANGE WELDMENT

L/M 8506M307

LIST OF MATERIALS

1 of 1

1

REVISIONS

1	RELEASED FOR REVIEW	DJT	

REFERENCE DRAWINGS

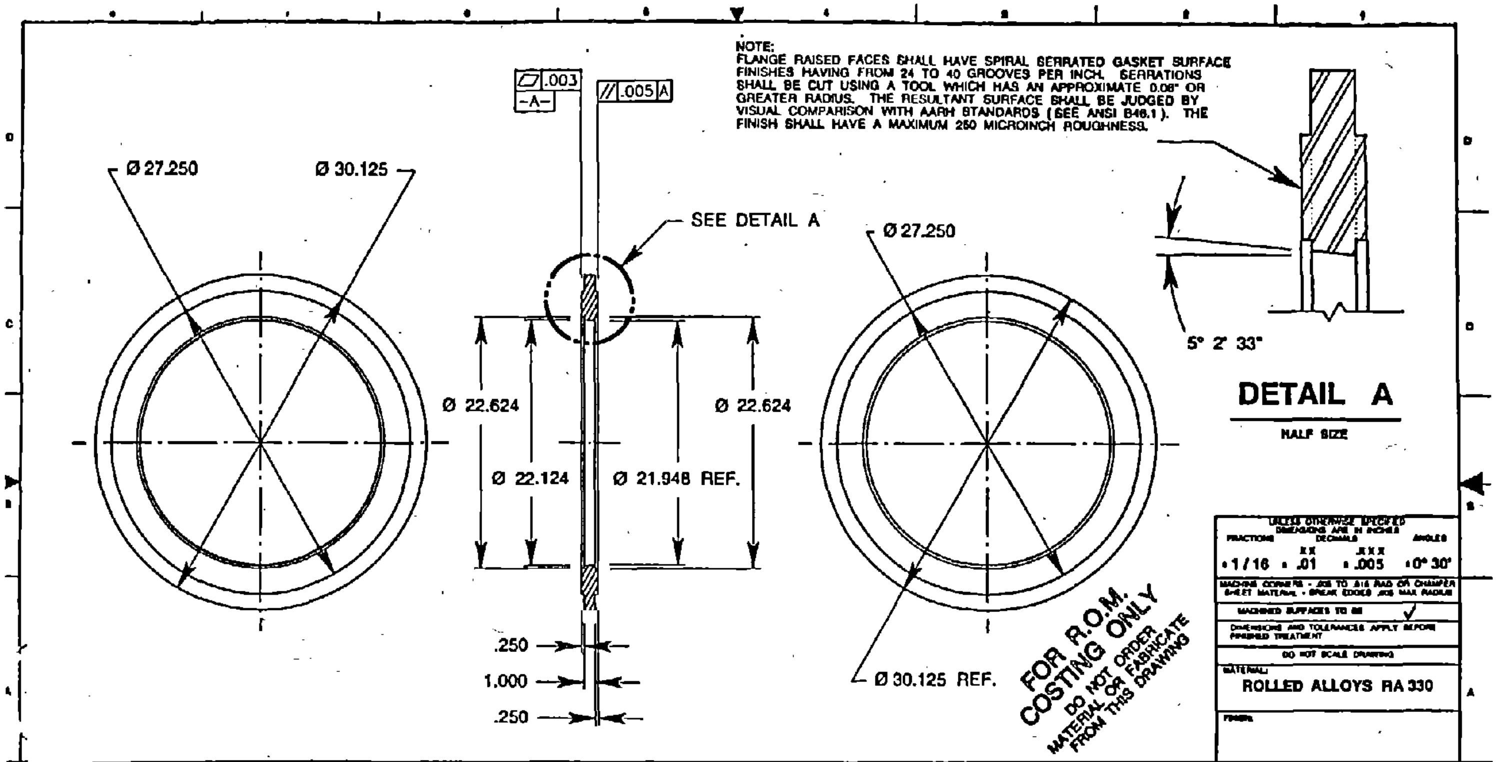
8506M300	FILTER VESSEL F-104 ASSEMBLY

APPLICATION

		QTY	
01	8506M300	1	8506

	PART NUMBER	DESCRIPTION				
1	8506M308	FILTER VESSEL F-104 24" WAFER CANDLE FLANGE	1	0	0	0
2	8506M309	FILTER VESSEL F-104 CANDLE FLANGE OUTER SPRING	1	0	0	0
3	8506M310	FILTER VESSEL F-104 CANDLE FLANGE INNER SPRING	1	0	0	0
4	8506M311	FILTER VESSEL F-104 CANDLE INNER FLANGE PIECE	1	0	0	0
5	8506M312	FILTER VESSEL F-104 CANDLE SUPPORT PIPE	1	0	0	0
6	8506M313	FILTER VESSEL F-104 CANDLE MOUNTING PLATE	1	0	0	0
7	•	•	0	0	0	0
8	•	•	0	0	0	0
9	•	•	0	0	0	0
10	•	•	0	0	0	0
11	•	•	0	0	0	0
12	•	•	0	0	0	0
13	•	•	0	0	0	0
14	•	•	0	0	0	0
15	•	•	0	0	0	0
16	•	•	0	0	0	0
17	•	•	0	0	0	0
18	•	•	0	0	0	0
19	•	•	0	0	0	0
20	•	•	0	0	0	0
21	•	•	0	0	0	0
22	•	•	0	0	0	0
23	•	•	0	0	0	0
24	•	•	0	0	0	0
25	•	•	0	0	0	0

NOTE:
FLANGE RAISED FACES SHALL HAVE SPIRAL SERRATED GASKET SURFACE FINISHES HAVING FROM 24 TO 40 GROOVES PER INCH. SERRATIONS SHALL BE CUT USING A TOOL WHICH HAS AN APPROXIMATE 0.06" OR GREATER RADIUS. THE RESULTANT SURFACE SHALL BE JUDGED BY VISUAL COMPARISON WITH AARH STANDARDS (SEE ANSI B46.1). THE FINISH SHALL HAVE A MAXIMUM 250 MICROINCH ROUGHNESS.



FOR R.O.M. COSTING ONLY
DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	± .01	± .005	±0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER
SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL:
ROLLED ALLOYS RA 330

FINISH:

REVISIONS

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REFERENCE DRAWINGS

NUMBER	TITLE

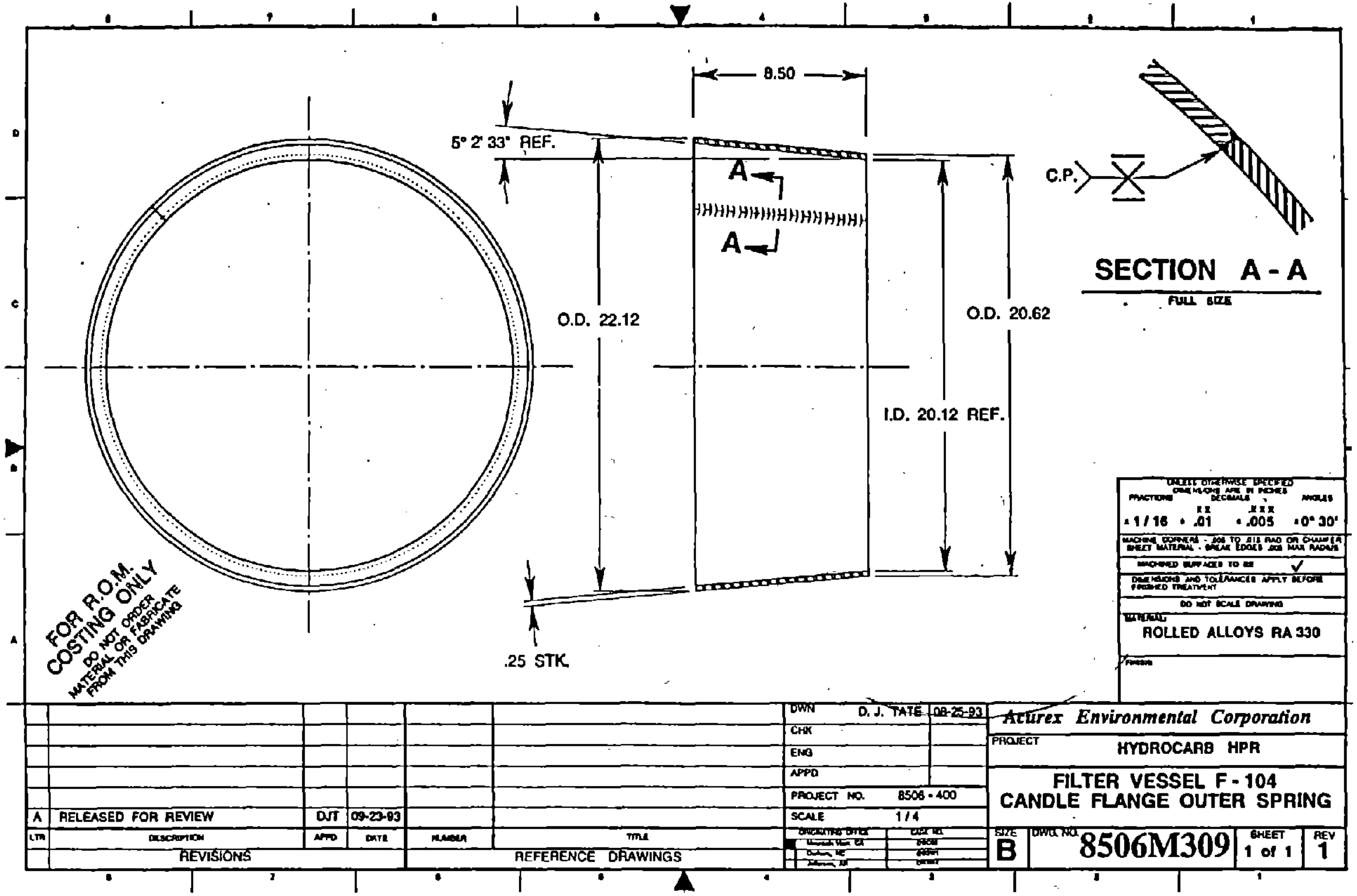
DWN D. J. TATE 08-25-93
CHK
ENG
APPD
PROJECT NO. 8506 - 400
SCALE 1/8

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F-104
24" WAFER CANDLE FLANGE

SIZE B
DWG NO. 8506M308
SHEET 1 of 1
REV 1



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	± .01	± .005	±0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL
ROLLED ALLOYS RA 330

FINISH

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

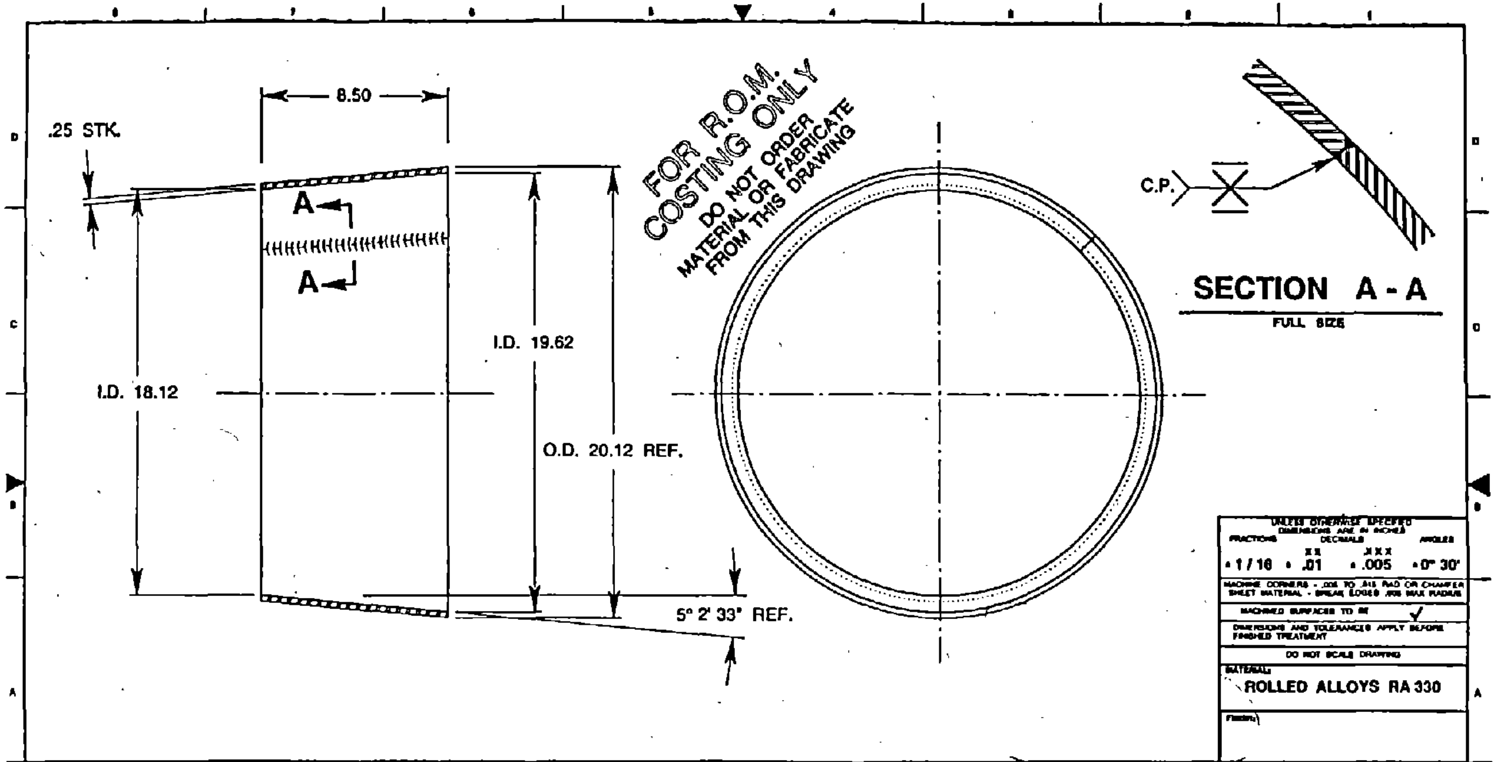
DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 4	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
CANDLE FLANGE OUTER SPRING

SIZE	DWG. NO.	SHEET	REV
B	8506M309	1 of 1	1



FOR R.O.M.
COSTING ONLY
DO NOT ORDER
MATERIAL OR FABRICATE
FROM THIS DRAWING

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
± 1/16	± .01	± .005	± 0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER
SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL
ROLLED ALLOYS RA 330

FINISH

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 4	

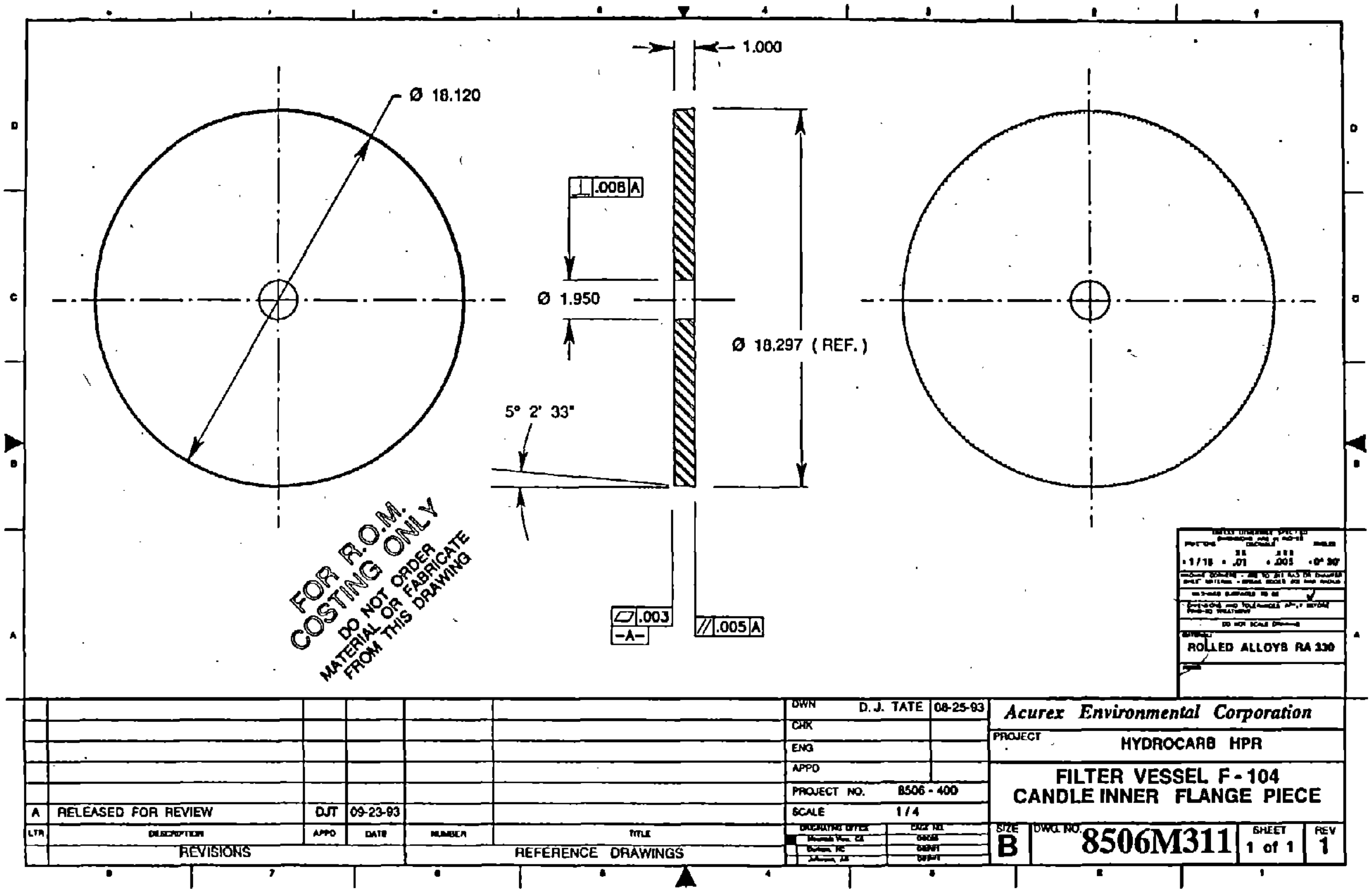
ORIGINATING OFFICE	CAGE NO.
Mountain View, CA	[illegible]
Durham, NC	[illegible]
Jefferson, AR	[illegible]

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
CANDLE FLANGE INNER SPRING

SIZE	DWG NO.	SHEET	REV
B	8506M310	1 of 1	1



MATERIAL: ROLLED ALLOYS RA 330

A	RELEASED FOR REVIEW	DJT	09-23-93				
LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE		
REVISIONS				REFERENCE DRAWINGS			

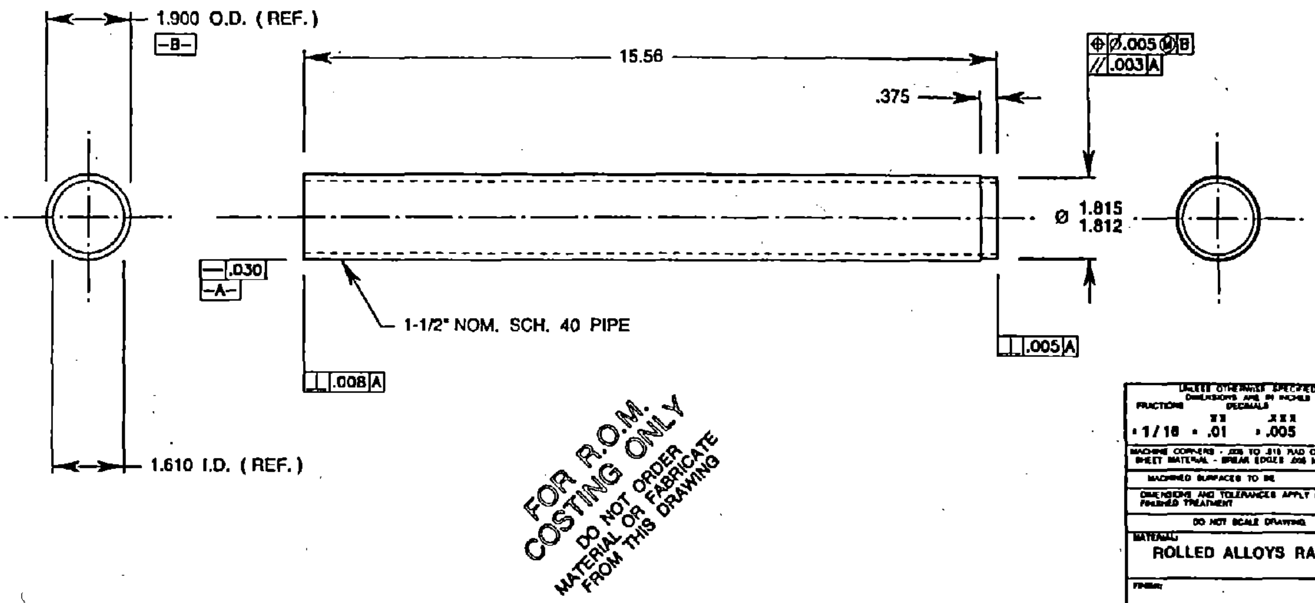
DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 4	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
CANDLE INNER FLANGE PIECE

SIZE B DWG. NO. 8506M311 SHEET 1 of 1 REV 1



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DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	±.01	±.005	±0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER
SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL: ROLLED ALLOYS RA 330

FINISH:

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

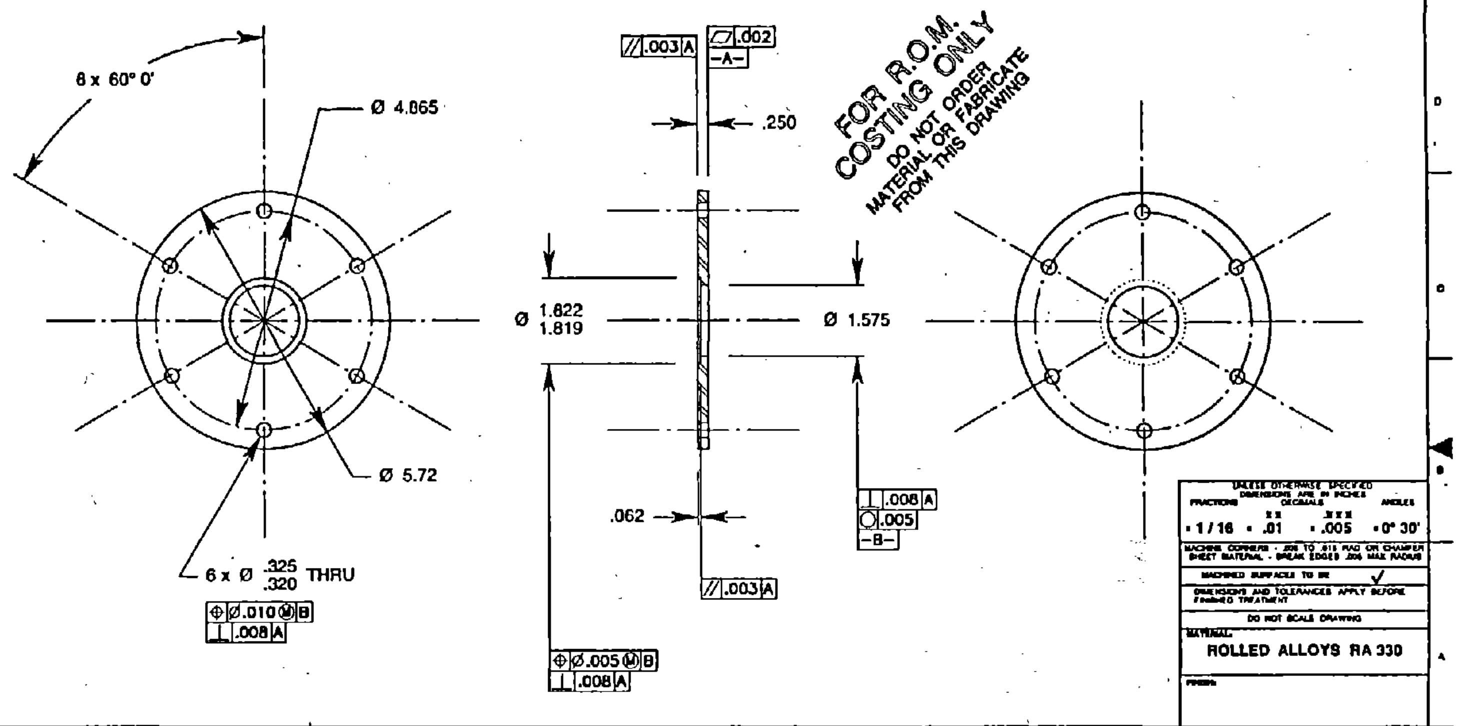
DWN D. J. TATE 08-25-93
CHK
ENG
APPD
PROJECT NO. 8506 - 400
SCALE 1/2

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F-104
CANDLE SUPPORT PIPE

SIZE B
DWG. NO. 8506M312
SHEET 1 of 1
REV 1



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
± 1/16	± .01	± .005	± 0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER
SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL
ROLLED ALLOYS RA 330

FINISH

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1 / 2	

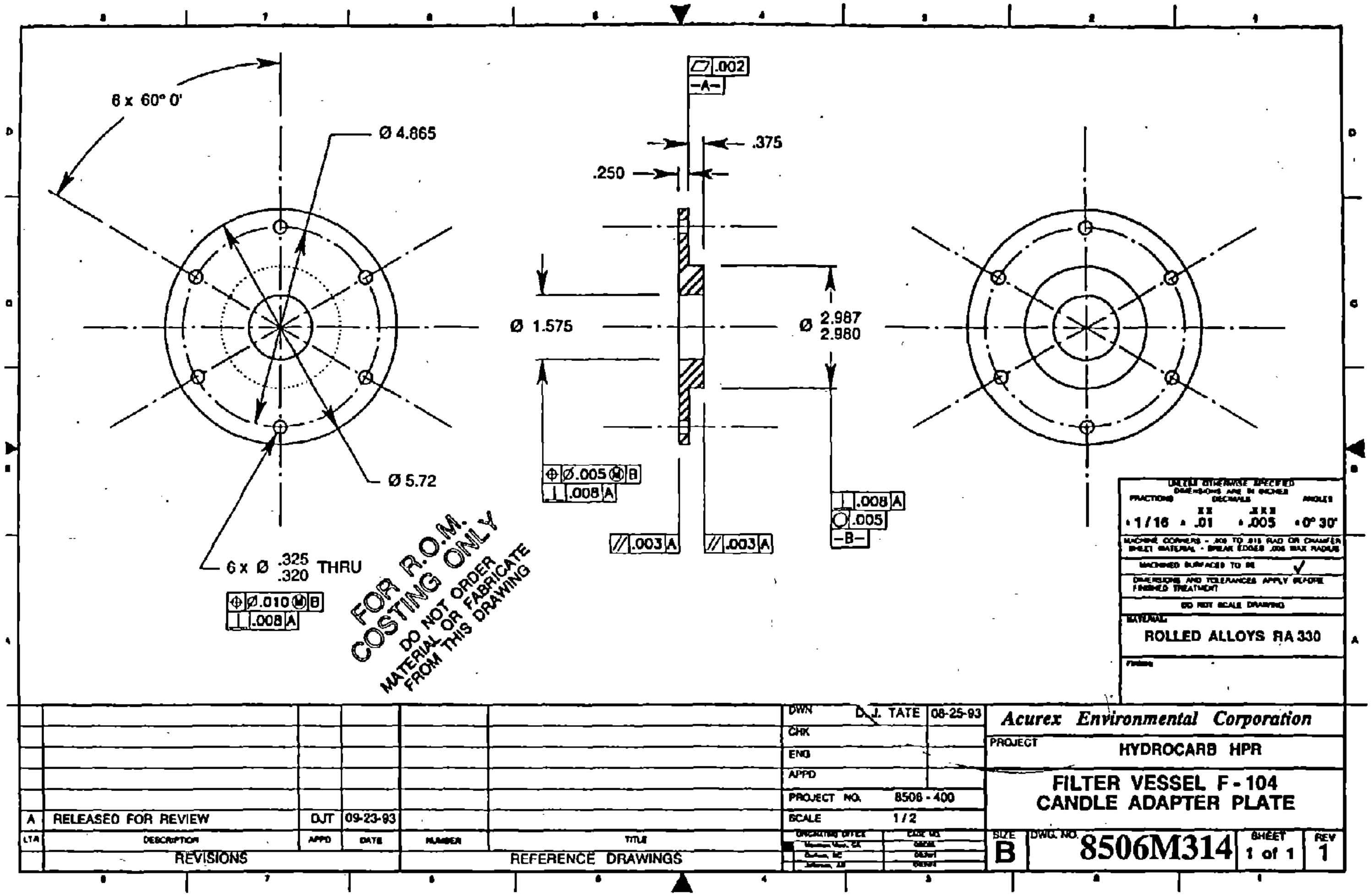
ORIGINATING OFFICE	CAGE NO.
■ [illegible]	[illegible]
☐ [illegible]	[illegible]
☐ [illegible]	[illegible]

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
CANDLE MOUNTING PLATE

SIZE	DWG. NO.	SHEET	REV
B	8506M313	1 of 1	1



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	±.01	±.005	±0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER
SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL
ROLLED ALLOYS RA 330

Finish

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

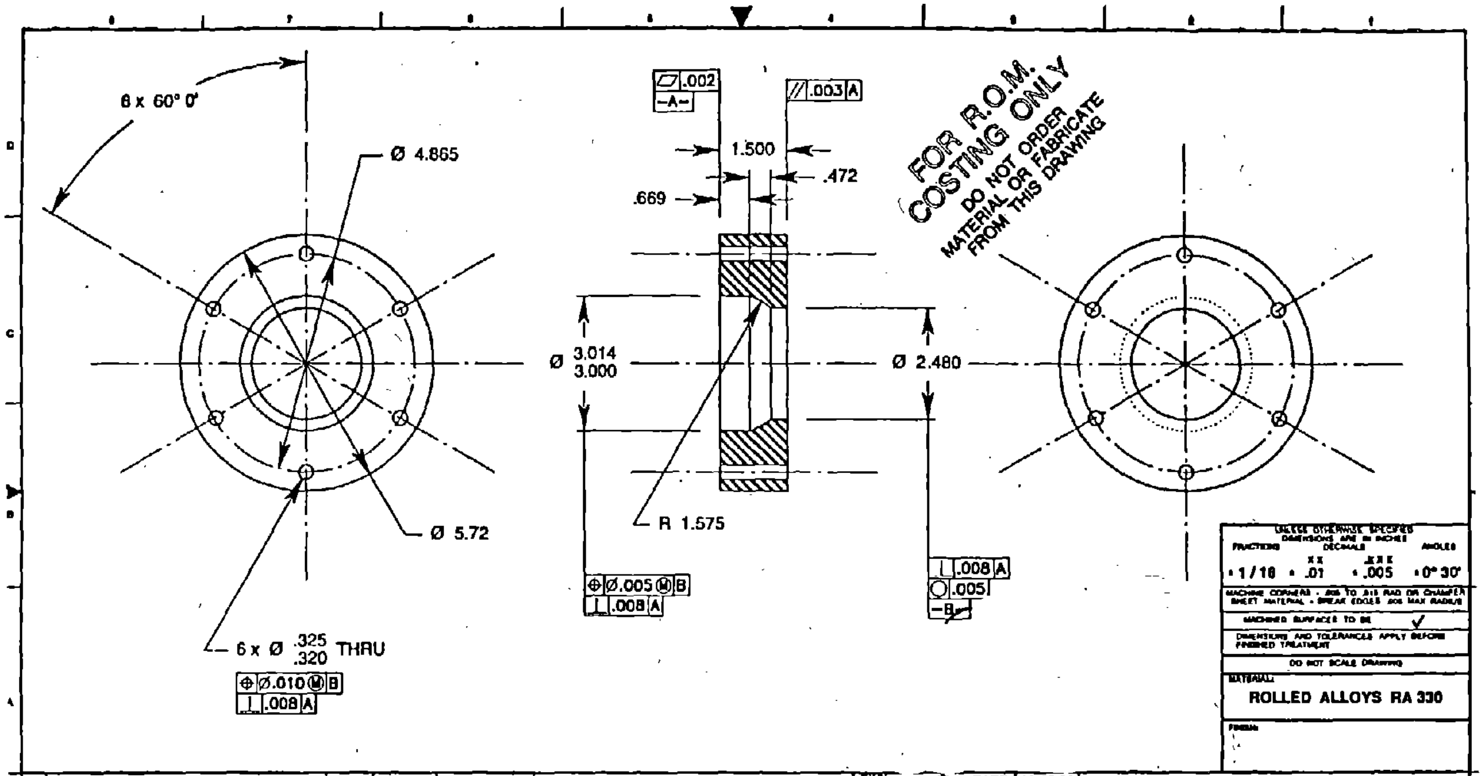
DWN	D.J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1/2	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F-104
CANDLE ADAPTER PLATE

SIZE	DWG. NO.	SHEET	REV
B	8506M314	1 of 1	1



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	±.01	±.005	±0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL:
ROLLED ALLOYS RA 330

FINISH:

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

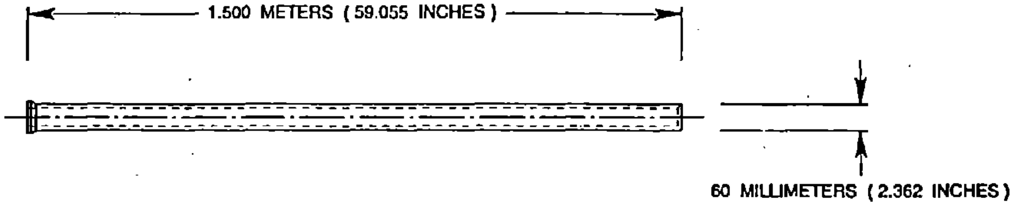
DWN D.J. TATE 08-25-93
CHK
ENG
APPD
PROJECT NO. 8506 - 400
SCALE 1/2

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
CANDLE BELL PLATE

SIZE B
DWG NO. 8506M315
SHEET 1 of 1
REV 1



FOR R.O.M.
COSTING ONLY
DO NOT ORDER
MATERIAL OR FABRICATE
FROM THIS DRAWING

PALL VITROPORE 1.5 METER
SILICON CARBIDE FILTER CANDLE
MODEL No. C - 23 - 60 - DCSC

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE

REFERENCE DRAWINGS

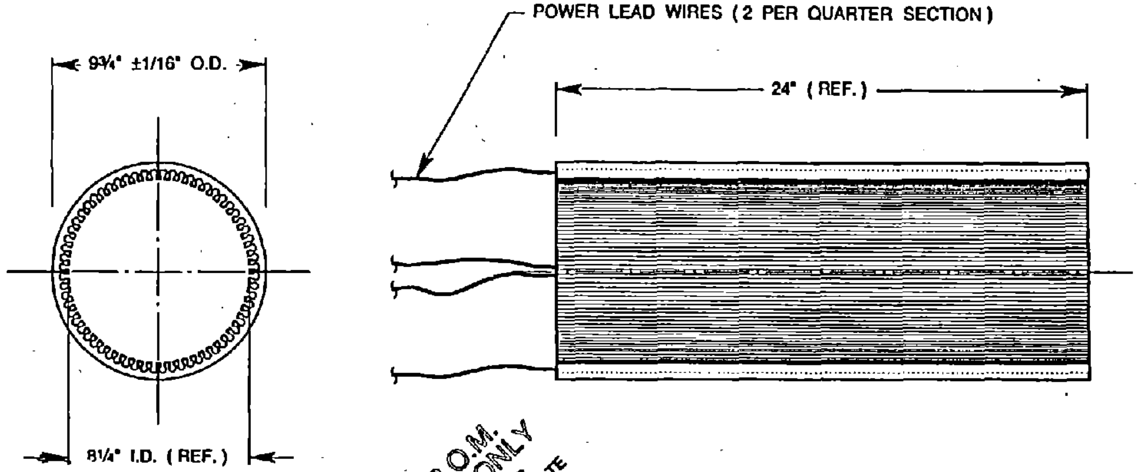
DWN D. J. TATE 08-25-93
CHK
ENG
APPD
PROJECT NO. 8506 - 400
SCALE 1/8

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F - 104
CANDLE (REFERENCE ONLY)

SIZE B DWG. NO. 8506M316 SHEET 1 of 1 REV 1



FOR R.O.M. COSTING ONLY
DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

THERMCRAFT MODEL No. RL 1003
(1850 °F, 230 VAC, 3 Ø, & 2260 WATTS)
FOUR QUARTER SECTIONS
PER CYLINDER

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	08-23-93

REVISIONS

NUMBER	TITLE
8506M300	FILTER VESSEL F-104 ASSEMBLY

REFERENCE DRAWINGS

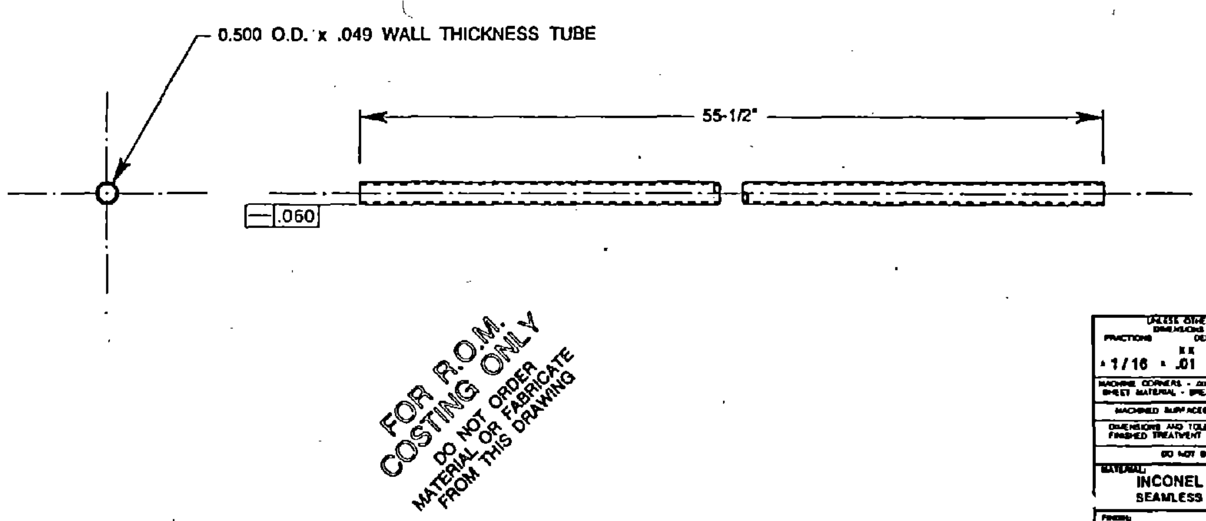
DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1/4	

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F-104
ELECTRIC HEATER H-102 (REF.)

SIZE	DWG. NO.	SHEET	REV
B	8506M317	1 of 1	1



FOR R.O.M. COSTING ONLY
DO NOT ORDER MATERIAL OR FABRICATE FROM THIS DRAWING

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	±.01	±.005	±0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER
SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO 63 ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL:
INCONEL ALLOY 600
SEAMLESS & ANNEALED

FINISH:

LTR	DESCRIPTION	APPD	DATE
A	RELEASED FOR REVIEW	DJT	09-23-93

REVISIONS

NUMBER	TITLE
8506M300	FILTER VESSEL F-104 ASSEMBLY

REFERENCE DRAWINGS

DWN	D. J. TATE	08-25-93
CHK		
ENG		
APPD		
PROJECT NO.	8506 - 400	
SCALE	1/2	

DRAFTING OFFICE	CAGE NO.
Mountain View, CA	[illegible]
Durham, NC	[illegible]
Jefferson, AR	[illegible]

Acurex Environmental Corporation

PROJECT HYDROCARB HPR

FILTER VESSEL F-104
PULSE TUBE

SIZE	DWG NO.	SHEET	REV
B	8506M318	1 of 1	1

INDEX

DRAWING No.	TITLE
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8574 M 100	ASSEMBLY
L/M 8574 M 101	TOP WELDMENT (List of Materials)
8574 M 101	TOP WELDMENT
L/M 8574 M 102	MIDSECTION WELDMENT (List of Materials)
8574 M 102	MIDSECTION WELDMENT
L/M 8574 M 103	BOTTOM WELDMENT (List of Materials)
8574 M 103	BOTTOM WELDMENT
L/M 8574 M 104	DIFFUSER TUBE ASSEMBLY (List of Materials)
8574 M 104	DIFFUSER TUBE ASSEMBLY
L/M 8574 M 105	TOP OVERFLOW PIPE SPOOL (List of Materials)
8574 M 105	TOP OVERFLOW PIPE SPOOL
L/M 8574 M 106	BOTTOM OVERFLOW PIPE SPOOL (List of Materials)
8574 M 106	BOTTOM OVERFLOW PIPE SPOOL
L/M 8574 M 107	GAS INLET PIPE SPOOL (List of Materials)
8574 M 107	GAS INLET PIPE SPOOL
L/M 8574 M 108	DIFFUSER TUBE WELDMENT (List of Materials)
8574 M 108	DIFFUSER TUBE WELDMENT
8574 M 109	DEMISTER PAD SUPPORT RING
8574 M 110	STILLING WELL BAFFLES
8574 M 111	SCREEN
8574 M 112	SCREEN CLAMP RING
8574 M 113	DIFFUSER TUBE FLANGE
8574 M 114	DIFFUSER TUBE
8574 M 115	DIFFUSER TUBE SPIDER
8574 M 116	SCREEN CLAMP RING TOP STANDOFF
8574 M 117	SCREEN CLAMP RING BOTTOM STANDOFF
?	?

HYNOL

GAS SCRUBBER VESSEL

S - 101

A.E.C. PROJECT No. 8574

Prepared by

ACUREX ENVIRONMENTAL
CORPORATION

MOUNTAIN VIEW, CALIFORNIA

Acurex Environmental Corporation

PROJECT: HYNOL

TITLE: GAS SCRUBBER VESSEL S-101

ASSEMBLY

PREPARED BY: D.J. TATE [illegible]

CHK [illegible]

ENG [illegible]

APPD [illegible]

PROJECT NO. 8574-[illegible]

L/M8574M100

LIST OF MATERIALS

SHEET: 1 of 1

REV: 2

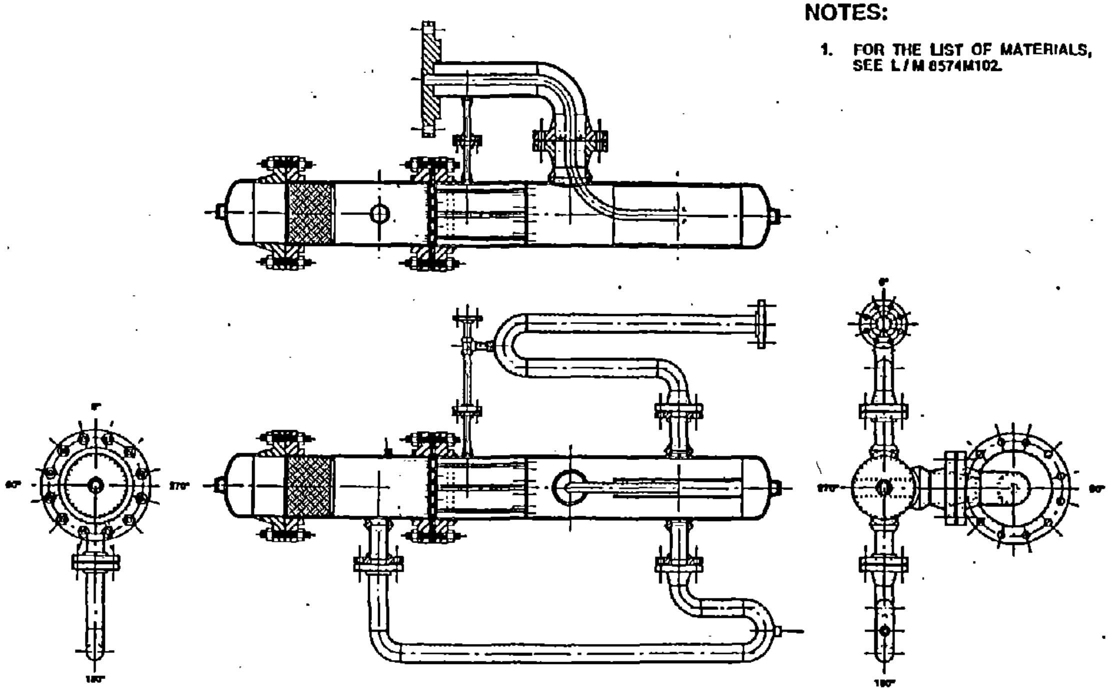
REVISIONS				REFERENCE DRAWINGS	
LTR	DESCRIPTION	APPD	DATE		TITLE
2	RELEASED FOR REVIEW	DJT	[illegible]	8574M100	ASSEMBLY

APPLICATION			
DASH NO.	NEXT ASSY	QTY	USED ON
01	·····	1	8574

ITEM NO.	PART NUMBER	DESCRIPTION		QTY REQD PER DASH NO.			
				-01	-02	-03	-04
1	8574M101	TOP WELDMENT		1	0	0	0
2	8574M102	MIDSECTION WELDMENT		1	0	0	0
3	8574M103	BOTTOM WELDMENT		1	0	0	0
4	8574M104	DIFFUSER TUBE ASSEMBLY		1	0	0	0
5	8574M105	TOP OVERFLOW PIPE SPOOL		1	0	0	0
6	8574M106	BOTTOM OVERFLOW PIPE SPOOL		1	0	0	0
7	8574M107	GAS INLET PIPE SPOOL		1	0	0	0
8	TBD	DEMISTER PAD	TYPE 316 STAINLESS STEEL	1	0	0	0
9	FLEXITALLIC No. CG - 3G	GASKET, 8" - 300# RAISED FACE FLANGE	TYPE 304 STAINLESS STEEL WITH WHITE ASBESTOS FILLER	3	0	0	0
10	FLEXITALLIC No. CG - 3L	GASKET, 4" - 300# RAISED FACE FLANGE	TYPE 304 STAINLESS STEEL WITH WHITE ASBESTOS FILLER	1	0	0	0
11	FLEXITALLIC No. CG - 3G	GASKET, 2" - 300# RAISED FACE FLANGE	TYPE 304 STAINLESS STEEL WITH WHITE ASBESTOS FILLER	3	0	0	0
12	FLEXITALLIC No. CG - 3B	GASKET, 1/2" - 300# RAISED FACE FLANGE	TYPE 304 STAINLESS STEEL WITH WHITE ASBESTOS FILLER	2	0	0	0
13	·····	HEAVY HEX NUT, WASHER FACED, 7/8" - 9 UNC - 2B	CARBON STEEL	48	0	0	0
14	·····	STUD BOLT, 7/8" - 9 UNC - 2A x 8-5/8" LONG	CARBON STEEL	12	0	0	0
15	·····	STUD BOLT, 7/8" - 9 UNC - 2A x 7-1/4" LONG	CARBON STEEL	12	0	0	0
16	·····	HEAVY HEX NUT, WASHER FACED, 3/4" - 10 UNC - 2B	CARBON STEEL	16	0	0	0
17	·····	STUD BOLT, 3/4" - 10 UNC - 2A x 5" LONG	CARBON STEEL	8	0	0	0
18	·····	HEAVY HEX NUT, WASHER FACED, 5/8" - 11 UNC - 2B	CARBON STEEL	48	0	0	0
19	·····	STUD BOLT, 5/8" - 11 UNC - 2A x 4" LONG	CARBON STEEL	24	0	0	0
20	·····	HEAVY HEX NUT, WASHER FACED, 1/2" - 13 UNC - 2B	CARBON STEEL	16	0	0	0
21	·····	STUD BOLT, 1/2" - 13 UNC - 2A x 3-1/4" LONG	CARBON STEEL	8	0	0	0
22	•	•		0	0	0	0
23	•	•		0	0	0	0
24	•	•		0	0	0	0
25	•	•		0	0	0	0

NOTES:

1. FOR THE LIST OF MATERIALS, SEE L/M 8574M102.



1	RELEASED FOR REVIEW	DJT	06-07-94	L/M 8574M100	MIDSECTION WELDMENT LIST OF MATERIALS
LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
REVISIONS				REFERENCE DRAWINGS	

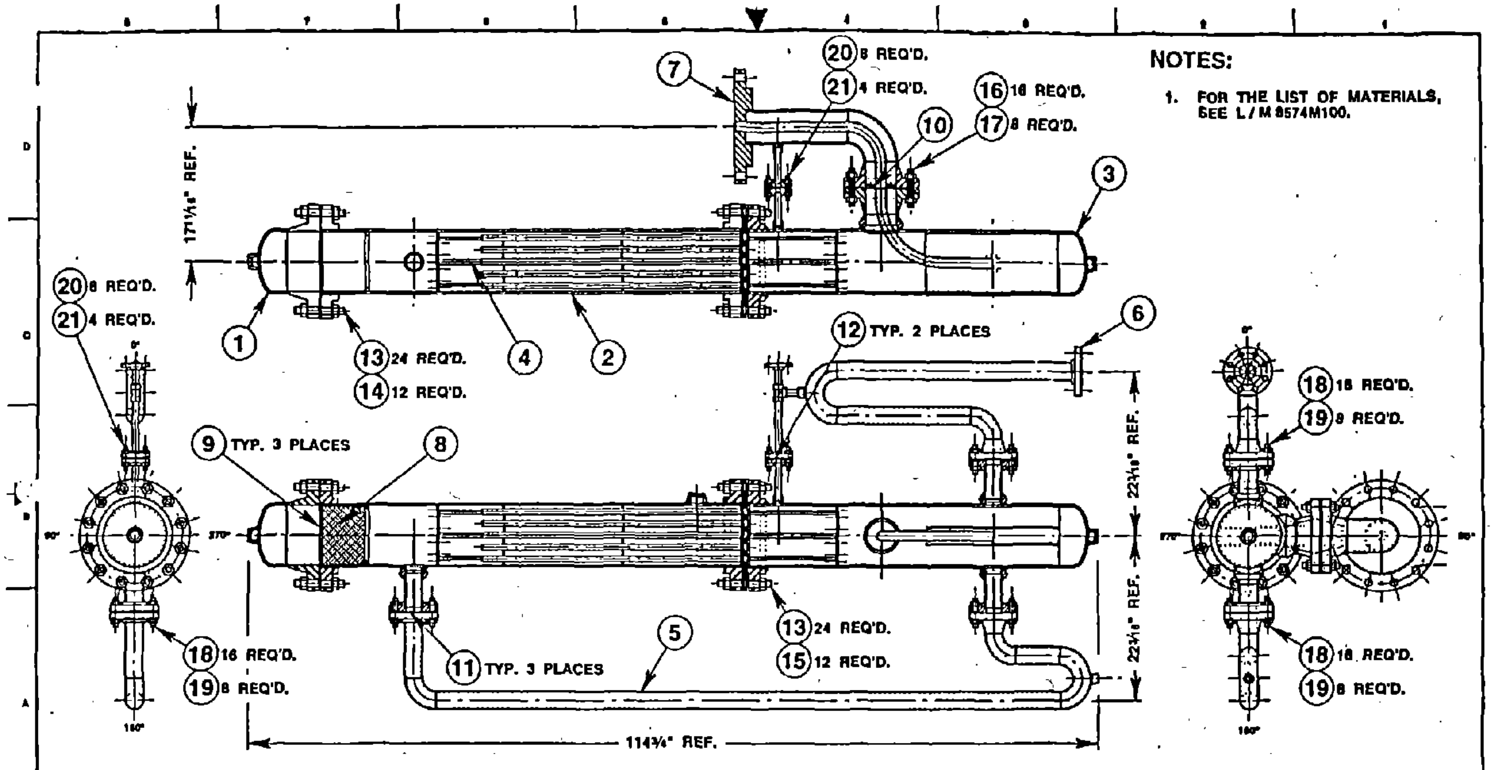
DWN	D. J. TATE	06-03-94
CHK		
ENG		
APPD		
PROJECT NO.	8574 - 400	
SCALE	1/12	

Acurex Environmental Corporation

PROJECT HYNOL

GAS SCRUBBER VESSEL S - 101
ASSEMBLY

SIZE	DWG. NO.	SHEET	REV
B	8574M100	1 of 1	1



NOTES:

1. FOR THE LIST OF MATERIALS, SEE L/M 8574M100.

				NUMBER	TITLE
				L/M 8574M107	GAS INLET PIPE SPOOL
				L/M 8574M106	BOTTOM OVERFLOW PIPE SPOOL
				L/M 8574M105	TOP OVERFLOW PIPE SPOOL
				L/M 8574M104	DIFFUSER TUBE ASSEMBLY
				L/M 8574M103	BOTTOM WELDMENT
2	RELEASED FOR REVIEW	DJT	06-24-94	L/M 8574M102	MIDSECTION WELDMENT
				L/M 8574M101	TOP WELDMENT
1	RELEASED FOR REVIEW	DJT	06-07-94	L/M 8574M100	ASSEMBLY WELDMENT LIST OF MATERIALS
LTR	DESCRIPTION	APPD	DATE		

REVISIONS

REFERENCE DRAWINGS

DWN	D. J. TATE	06-03-94
CHK		
ENG		
APPD		
PROJECT NO.	8574 - 400	
SCALE	1/12	

Acurex Environmental Corporation

PROJECT
HYNOL

GAS SCRUBBER VESSEL S-101 ASSEMBLY

SIZE	DWG. NO.	SHEET	REV
B	8574M100	1 of 1	2

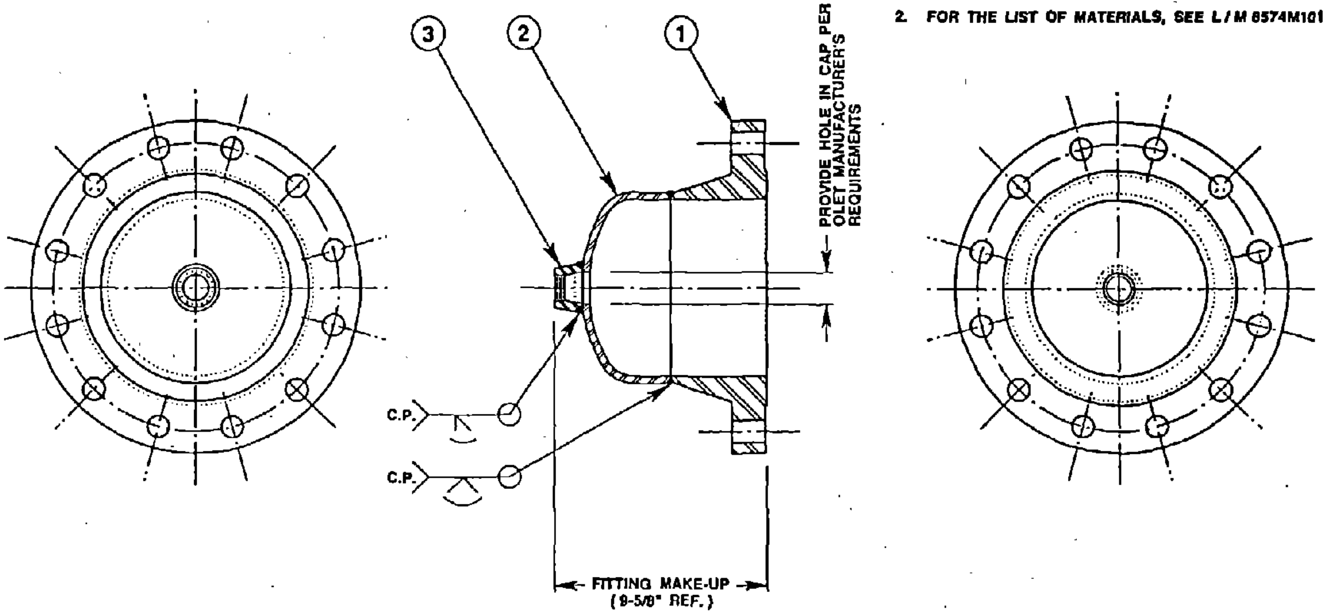
Acurex Environmental Corporation	PREPARED BY D.J. TATE		L/M8574M101
PROJECT **HYNOL**	CHK		LIST OF MATERIALS
TITLE GAS SCRUBBER VESSEL S-101 **TOP WELDMENT**	DSG APPD PROJECT NO.		SHEET 1 of 1 REV 2

REVISIONS				REFERENCE DRAWINGS		APPLICATION			
LTR	DESCRIPTION	[illegible]	DATE		TITLE	DASH NO.	NEXT ASSY	QTY	USED ON
2	RELEASED FOR REVIEW	DJT		8574M101	TOP WELDMENT	01	8574M100	1	8574
				8574M100	ASSEMBLY				

ITEM NO.	PART NUMBER	DESCRIPTION		QTY REQ'D PER DASH NO.			
				-01	[illegible]	[illegible]	[illegible]
1	-----	8" - 300 # RAISED FACE WELDING NECK FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
2	-----	8" NOMINAL ELLIPTICAL PIPE CAP WITH WALL THICKNESS TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
3	BONNY FORGE, INC.	1" FNPT NOM. OUTLET 3000 # FLAT THREDOLET	TYPE 316 STAINLESS STEEL	1	0	0	0
4	•	•		0	0	0	0
5	•	•		0	0	0	0
6	•	•		0	0	0	0
7	•	•		0	0	0	0
8	•	•		0	0	0	0
9	•	•		0	0	0	0
10	•	•		0	0	0	0
11	•	•		0	0	0	0
12	•	•		0	0	0	0
13	•	•		0	0	0	0
14	•	•		0	0	0	0
15	•	•		0	0	0	0
16	•	•		0	0	0	0
17	•	•		0	0	0	0
18	•	•		0	0	0	0
19	•	•		0	0	0	0
20	•	•		0	0	0	0
21	•	•		0	0	0	0
22	•	•		0	0	0	0
23	•	•		0	0	0	0
24	•	•		0	0	0	0
25	•	•		0	0	0	0

NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M101.



LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
2	RELEASED FOR REVIEW	DJT	08-24-94	L/M 8574M101	TOP WELDMENT LIST OF MATERIALS
1	RELEASED FOR REVIEW	DJT	08-07-94	8574M100	ASSEMBLY

REVISIONS

REFERENCE DRAWINGS

DWN	D. J. TATE	08-31-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-400	
SCALE	1/4	

Acurex Environmental Corporation

PROJECT HYNOL

GAS SCRUBBER VESSEL S-101
TOP WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8574M101	1 of 1	2

Acurex Environmental Corporation	PREPARED BY D.J.TATE	L/M8574M102
PROJECT **HYNOL**	CHK	
	ENG	
	APPD	LIST OF MATERIALS
TITLE GAS SCRUBBER VESSEL S-101 **MIDSECTION WELDMENT**	PROJECT NO.	SHEET 1 of 1 / REV 2

REVISIONS

LTR	DESCRIPTION	APPD	DATE
2	RELEASED FOR REVIEW	DJT	[illegible]

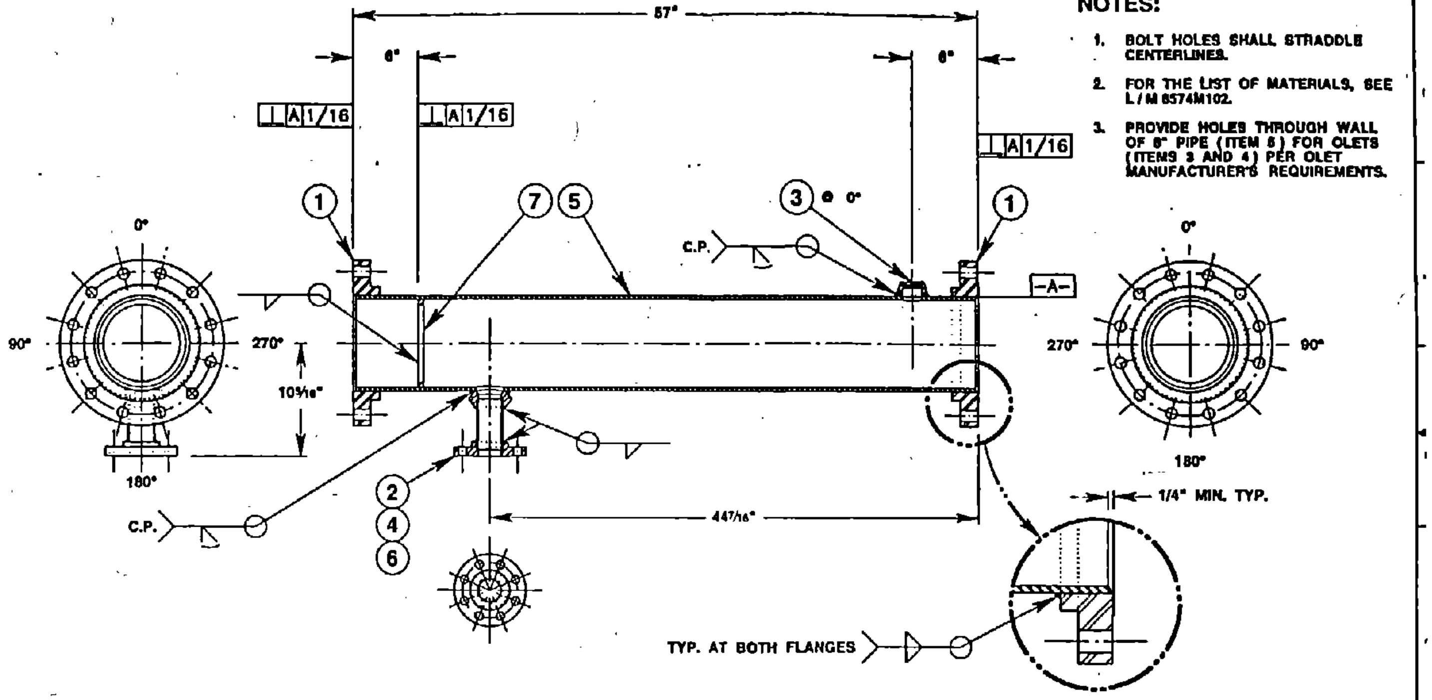
REFERENCE DRAWINGS

	TITLE
8574M102	MIDSECTION WELDMENT
8574M100	ASSEMBLY

APPLICATION

DASH NO.	NEXT ASSY	QTY	USED ON
01	8574M100	1	8514

ITEM NO.	PART NUMBER	DESCRIPTION		QTY REQ'D PER DASH NO. -01	-02	-03	-04
1	-----	8" - 300 # RAISED FACE SLIP - ON FLANGE	TYPE 316 STAINLESS STEEL	2	C	0	0
2	-----	2" - 300 # RAISED FACE SOCKET WELDING FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	:	0	0
3	BONNY FORGE, INC.	8" RUN PIPE x 1-1/4" FNPT NOM. OUTLET REDUCING 3000 # THREDOLET	TYPE 316 STAINLESS STEEL	1	:	0	0
4	BONNY FORGE, INC.	8" RUN PIPE x 2" NOM. SOCKET WELDING OUTLET REDUCING STANDARD WEIGHT SOCKOLET	TYPE 316 STAINLESS STEEL	1	:	0	0
5	-----	8" SCH. 40 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 66-1/2")	TYPE 316 STAINLESS STEEL	1	:	:	0
6	-----	2" SCH. 40 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 4-9/16")	TYPE 316 STAINLESS STEEL	1	:	:	0
7	8574M103	DEMISTER PAD SUPPORT RING		1	:	:	0
8	•	•		0	:	:	0
9	•	•		0	:	:	0
10	•	•		0	:	:	0
11	•	•		0	:	:	0
12	•	•		0	:	:	0
13	•	•		0	:	:	0
14	•	•		0	:	:	0
15	•	•		0	:	:	0
16	•	•		0	:	:	0
17	•	•		0	:	:	0
18	•	•		0	:	:	0
19	•	•		0	:	:	0
20	•	•		0	C	:	0
21	•	•		0	C	:	0
22	•	•		0	C	:	0
23	•	•		0	C	:	0
24	•	•		0	C	:	0
25	•	•		0	C	:	0



NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M102.
3. PROVIDE HOLES THROUGH WALL OF 8" PIPE (ITEM 5) FOR OLETS (ITEMS 3 AND 4) PER OLET MANUFACTURER'S REQUIREMENTS.

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
				8574M109	DEMISTER PAD SUPPORT RING
2	RELEASED FOR REVIEW	DJT	06-24-94	L/M 8574M102	MIDSECTION WELDMENT LIST OF MATERIALS
1	RELEASED FOR REVIEW	DJT	06-07-94	8574M100	ASSEMBLY

REVISIONS
REFERENCE DRAWINGS

DWN D. J. TATE 06-01-94
CHK
ENG
APPD
PROJECT NO. 8574-400
SCALE 1/8

Acurex Environmental Corporation

PROJECT
HYNOL

GAS SCRUBBER VESSEL S-101
MIDSECTION WELDMENT

SIZE B
DWG. NO. 8574M102
SHEET 1 of 1
REV 2

Acurex Environmental Corporation

PROJECT [illegible]

HYNOL

GAS SCRUBBER VESSEL S-101

BOTTOM WELDMENT

PREPARED BY [illegible] DJ DATE [illegible]
CHK [illegible]
ENG [illegible]
APPD [illegible]
PROJECT NO. [illegible]

L/M8574M103

LIST OF MATERIALS

SHEET 1 of 1

REV 2

REVISIONS

[illegible]	[illegible]	[illegible]	[illegible]
2	RELEASED FOR REVIEW	DJT	[illegible]

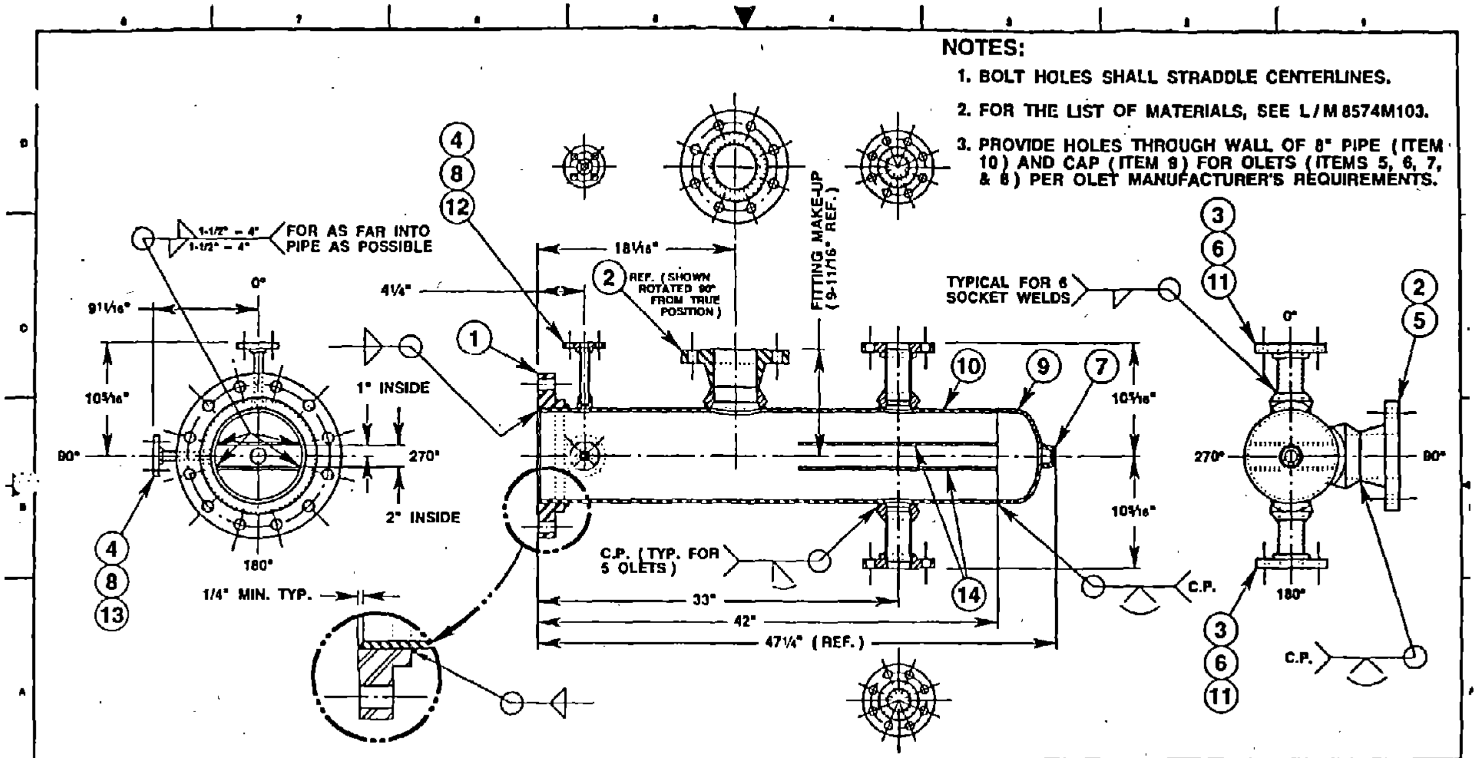
REFERENCE DRAWINGS

	[illegible]
8574M103	BOTTOM WELDMENT
8574M100	ASSEMBLY

APPLICATION

[illegible]	[illegible]	QTY	[illegible]
01	8574M100	1	8574

[illegible]	PART NUMBER	DESCRIPTION		[illegible]			
				[illegible]	[illegible]	[illegible]	[illegible]
1	.....	8" - 300 # RAISED FACE SLIP - ON FLANGE	TYPE 316 STAINLESS STEEL	1	0	0	0
2	.....	4" - 300 # RAISED FACE WELDING NECK FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
3	.....	2" - 300 # RAISED FACE SOCKET WELDING FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	2	0	0	0
4	.....	1/2" - 300 # RAISED FACE SOCKET WELDING FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	2	0	0	0
5	BONNY FORGE, INC.	8" RUN PIPE x 4" NOM. WELDING OUTLET REDUCING STANDARD WEIGHT WELDOLET	TYPE 316 STAINLESS STEEL	1	0	0	0
6	BONNY FORGE, INC.	8" RUN PIPE x 2" NOM. SOCKET WELDING OUTLET REDUCING STANDARD WEIGHT SOCKOLET	TYPE 316 STAINLESS STEEL	2	0	0	0
7	BONNY FORGE, INC.	1" FNPT NOM. OUTLET 3000 # FLAT THREDOLET	TYPE 316 STAINLESS STEEL	1	0	0	0
8	BONNY FORGE, INC.	8" RUN PIPE x 1/2" NOM. SOCKET WELDING OUTLET REDUCING STANDARD WEIGHT SOCKOLET	TYPE 316 STAINLESS STEEL	2	0	0	0
9	.....	8" NOMINAL ELLIPTICAL PIPE CAP WITH WALL THICKNESS TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
10	.....	8" SCHEDULE 40 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 41-3/4")	TYPE 316 STAINLESS STEEL	1	0	0	0
11	.....	2" SCHEDULE 40 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 4-9/16")	TYPE 316 STAINLESS STEEL	2	0	0	0
12	.....	1/2" SCHEDULE 40 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 6")	TYPE 316 STAINLESS STEEL	1	0	0	0
13	.....	1/2" SCHEDULE 40 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 4-3/8")	TYPE 316 STAINLESS STEEL	1	0	0	0
14	8574M110	STILLING WELL BAFFLES		2	0	0	0
15	•	•		0	0	0	0
16	•	•		0	0	0	0
17	•	•		0	0	0	0
18	•	•		0	0	0	0
19	•	•		0	0	0	0
20	•	•		0	0	0	0
21	•	•		0	0	0	0
22	•	•		0	0	0	0
23	•	•		0	0	0	0
24	•	•		0	0	0	0
25	•	•		0	0	0	0



NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M103.
3. PROVIDE HOLES THROUGH WALL OF 8" PIPE (ITEM 10) AND CAP (ITEM 9) FOR OLETS (ITEMS 5, 6, 7, & 8) PER OLET MANUFACTURER'S REQUIREMENTS.

LTR	DESCRIPTION	APPD	DATE
2	RELEASED FOR REVIEW	DJT	06-27-94
1	RELEASED FOR REVIEW	DJT	06-07-94

REVISIONS

NUMBER	TITLE
8574M110	STILLING WELL BAFFLES
L/M 8574M103	BOTTOM WELDMENT LIST OF MATERIALS
8574M100	ASSEMBLY

REFERENCE DRAWINGS

DWN	D. J. TATE	06-03-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-400	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT HYNOL

GAS SCRUBBER VESSEL S-101
BOTTOM WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8574M103	1 of 1	2

Acurex Environmental Corporation

PROJECT
HYNOL

TITLE
GAS SCRUBBER VESSEL S-101
DIFFUSER TUBE ASSEMBLY

L/M8574M104

LIST OF MATERIALS

SHEET 1 of 1

1

REVISIONS

1	RELEASED FOR REVIEW	DJT	

REFERENCE DRAWINGS

8574M104	DIFFUSER TUBE ASSEMBLY
8574M100	ASSEMBLY

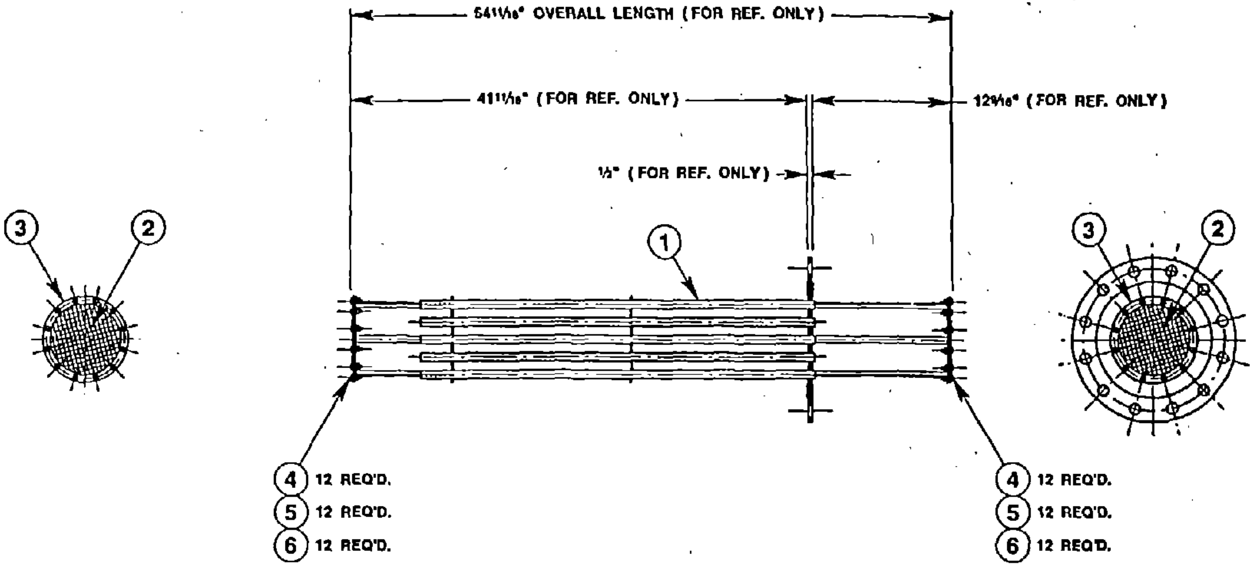
APPLICATION

01	8574M100	1	8574

ITEM NO.	PART NUMBER	DESCRIPTION		[illegible]			
				[illegible]	[illegible]	[illegible]	[illegible]
1	8574M108	DIFFUSER TUBE WELDMENT		1	0	0	
2	8574M111	SCREEN		2	0	0	
3	8574M112	SCREEN CLAMP RING		2	0	0	
4	-----	FINISHED HEX NUT, 1/4" - 20 UNC - 2B	TYPE 316 STAINLESS STEEL	24	0	0	
5	-----	HEX HEAD CAP SCREW, 1/4" - 20 UNC - 2A x 7/8" LONG	TYPE 316 STAINLESS STEEL	24	0	0	
6	-----	SPLIT LOCKWASHER, 1/4" NOMINAL	TYPE 316 STAINLESS STEEL	24	0	0	
7	•	•		0	0	0	
8	•	•		0	0	0	
9	•	•		0	0	0	
10	•	•		0	0	0	
11	•	•		0	0	0	
12	•	•		0	0	0	
13	•	•		0	0	0	
14	•	•		0	0	0	
15	•	•		0	0	0	
16	•	•		0	0	0	
17	•	•		0	0	0	
18	•	•		0	0	0	
19	•	•		0	0	0	
20	•	•		0	0	0	
21	•	•		0	0	0	
22	•	•		0	0	0	
23	•	•		0	0	0	
24	•	•		0	0	0	
25	•	•		0	0	0	

NOTES:

1. FOR THE LIST OF MATERIALS, SEE L/M 8574M104.



LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW. THIS IS A NEW DRAWING. PREVIOUS M104 REV. 1 WAS RENUMBERED AS M108 REV. 1	DJT	06-24-94

REVISIONS

NUMBER	TITLE
8574M112	SCREEN CLAMP RING
8574M111	SCREEN
8574M108	DIFFUSER TUBE WELDMENT
L/M 8574M104	DIFFUSER TUBE ASSEMBLY LIST OF MATERIALS
8574M100	ASSEMBLY

REFERENCE DRAWINGS

DWN D. J. TATE 06-23-94
CHK
ENG
APPD
PROJECT NO. 8574-400
SCALE 1/8

Acurex Environmental Corporation

PROJECT
HYNOL

GAS SCRUBBER VESSEL S-101
DIFFUSER TUBE ASSEMBLY

SIZE B
DWG. NO. 8574M104
SHEET 1 of 1
REV 1

Acurex Environmental Corporation

PROJECT: HYNOL

TITLE: GAS SCRUBBER VESSEL S-101

PIPE SPOOL

PREPARED BY: DJ
CHK
ENG
APPD
PROJECT NO. 8574-400

L/M8574M105

LIST OF MATERIALS

SHEET: 1 of 1
REV: 1

REVISIONS

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

	TITLE
8574M10	PIPE SPOOL
8574M100	ASSEMBLY

APPLICATION

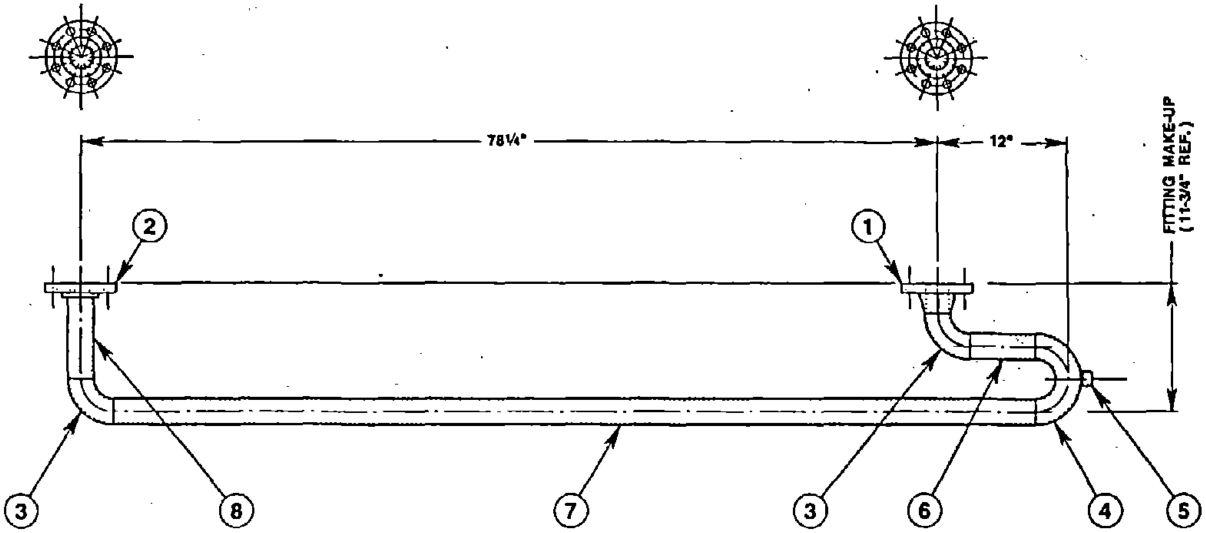
DASH NO.	NEXT ASSY	QTY	USED ON
01	8574M100	1	8574

ITEM NO.	PART NUMBER	DESCRIPTION	-01	-02	-03	-04
1	·····	•	1	0	0	0
2	·····	•	1	0	0	0
3	·····	•	1	0	0	0
4	•	•	1	0	0	0
5	•	•	1	0	0	0
6	•	•	1	0	0	0
7	•	•	1	0	0	0
8	•	•	1	0	0	0
9	•	•	0	0	0	0
10	•	•	0	0	0	0
11	•	•	0	0	0	0
12	•	•	0	0	0	0
13	•	•	0	0	0	0
14	•	•	0	0	0	0
15	•	•	0	0	0	0
16	•	•	0	0	0	0
17	•	•	0	0	0	0
18	•	•	0	0	0	0
19	•	•	0	0	0	0
20	•	•	0	0	0	0
21	•	•	0	0	0	0
22	•	•	0	0	0	0
23	•	•	0	0	0	0
24	•	•	0	0	0	0
25	•	•	0	0	0	0

Not up to Date

NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M105.



LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	06-07-94

REVISIONS

NUMBER	TITLE
L/M 8574M105	TOP OVERFLOW PIPE SPOOL LIST OF MATERIALS
8574M100	ASSEMBLY

REFERENCE DRAWINGS

DWN	D. J. TATE	06-03-94
CHK		
ENG		
APPD		
PROJECT NO.	8574 - 400	
SCALE	1/8	

ORIGINATING OFFICE	CAGE NO.
Mountain View, CA	[illegible]
Durham, NC	[illegible]
[illegible]	[illegible]

Acurex Environmental Corporation

PROJECT HYNOL

GAS SCRUBBER VESSEL S - 101
TOP OVERFLOW PIPE SPOOL

SIZE	DWG. NO.	SHEET	REV
B	8574M105	1 of 1	1

Acurex Environmental Corporation

PROJECT	HYNOL
TITLE	GAS SCRUBBER VESSEL S-101 PIPE SPOOL
PREPARED BY	DJ
PROJECT NO.	8574-400

L/M8574M106

LIST OF MATERIALS

SHEET	REV
1 of 1	1

REVISIONS

LTR	DESCRIPTION		
1	RELEASED FOR REVIEW	DJT	

REFERENCE DRAWINGS

	TITLE
8574M10	PIPE SPOOL
8574M100	ASSEMBLY

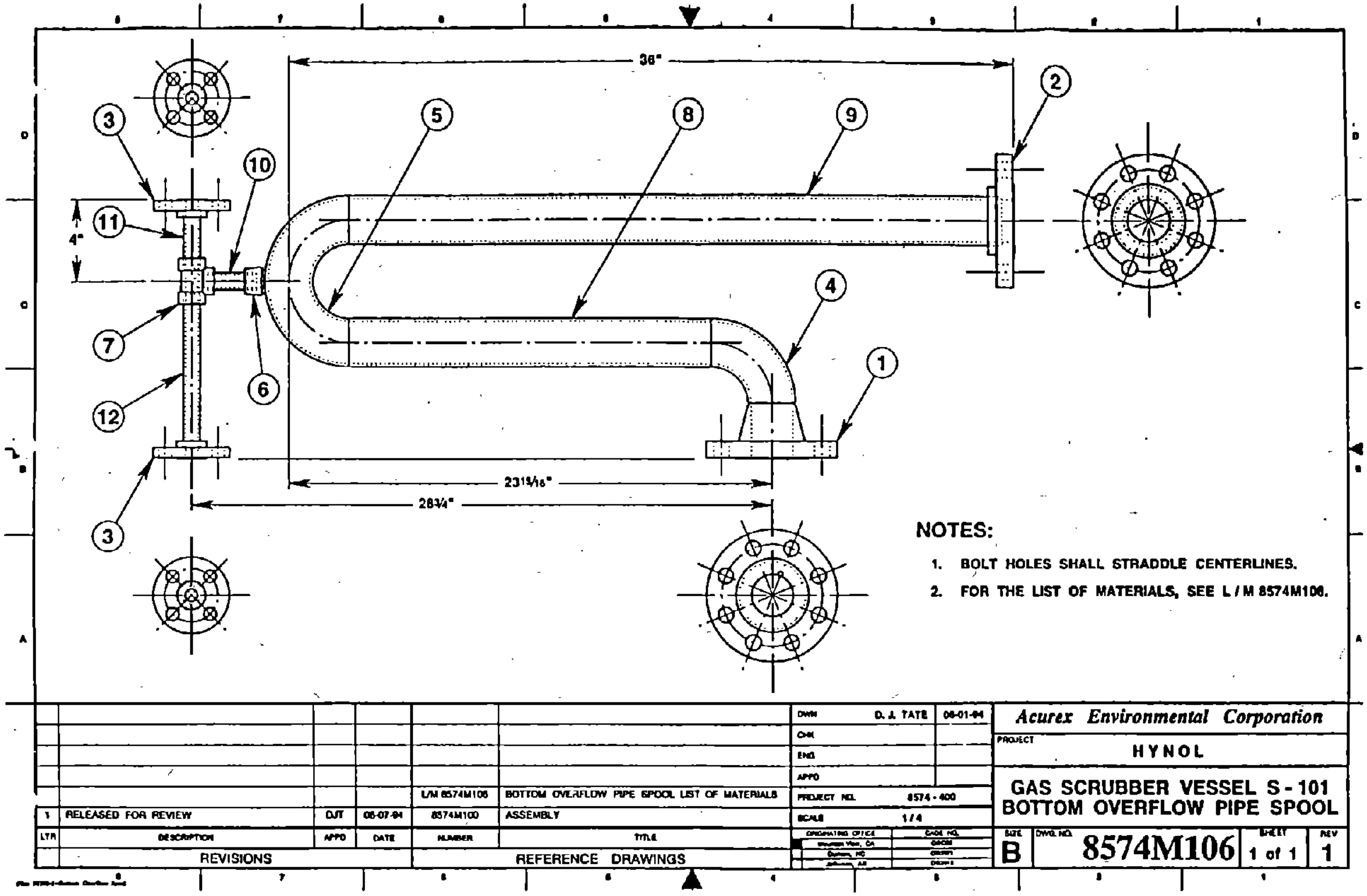
APPLICATION

	NEXT ASSY	QTY	USED ON
01	8574M100	1	8574

ITEM NO.	PART NUMBER	DESCRIPTION	-01	-02	-03	-04
1	.....	.	1	0	0	0
2	.....	.	1	0	0	0
3	.....	.	1	0	0	0
4	.	.	1	0	0	0
5	.	.	1	0	0	0
6	.	.	1	0	0	0
7	.	.	1	0	0	0
8	.	.	1	0	0	0
9	.	.	0	0	0	0
10	.	.	0	0	0	0
11	.	.	0	0	0	0
12	.	.	0	0	0	0
13	.	.	0	0	0	0
14	.	.	0	0	0	0
15	.	.	0	0	0	0
16	.	.	0	0	0	0
17	.	.	0	0	0	0
18	.	.	0	0	0	0
19	.	.	0	0	0	0
20	.	.	0	0	0	0
21	.	.	0	0	0	0
22	.	.	0	0	0	0
23	.	.	0	0	0	0
24	.	.	0	0	0	0
25	.	.	0	0	0	0

Dont

Next Text



NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M106.

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	08-07-94

REVISIONS

NUMBER	TITLE
L/M 8574M106	BOTTOM OVERFLOW PIPE SPOOL LIST OF MATERIALS
8574M100	ASSEMBLY

REFERENCE DRAWINGS

DWN D. J. TATE 08-01-94
CHK
ENG
APPD
PROJECT NO. 8574-400
SCALE 1/4

Acurex Environmental Corporation

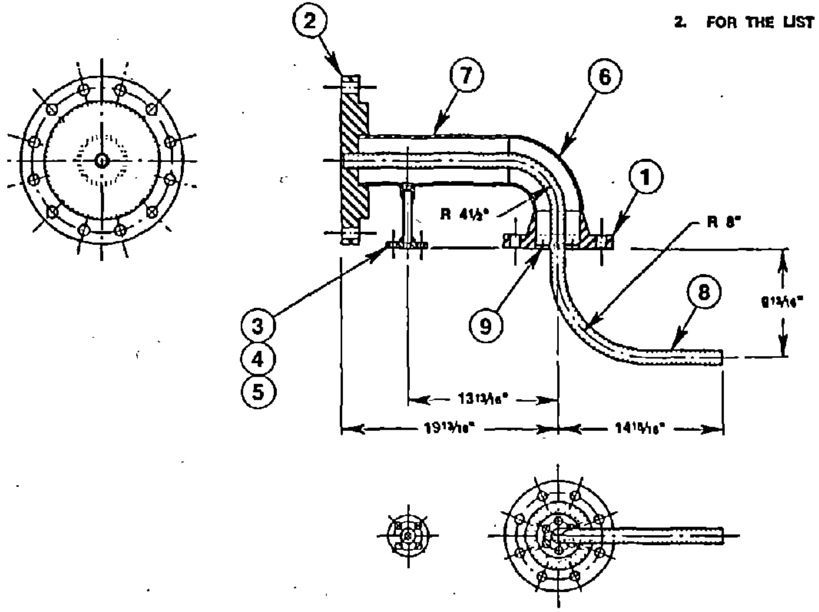
PROJECT HYNOL

GAS SCRUBBER VESSEL S-101
BOTTOM OVERFLOW PIPE SPOOL

SIZE B
DWG. NO. 8574M106
SHEET 1 of 1
REV 1

NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M107.



1	RELEASED FOR REVIEW	DJT	06-06-94
LTR	DESCRIPTION	APPD	DATE

REVISIONS

L/M 8574M107	GAS INLET PIPE SPOOL LIST OF MATERIALS
8574M100	ASSEMBLY
NUMBER	TITLE

REFERENCE DRAWINGS

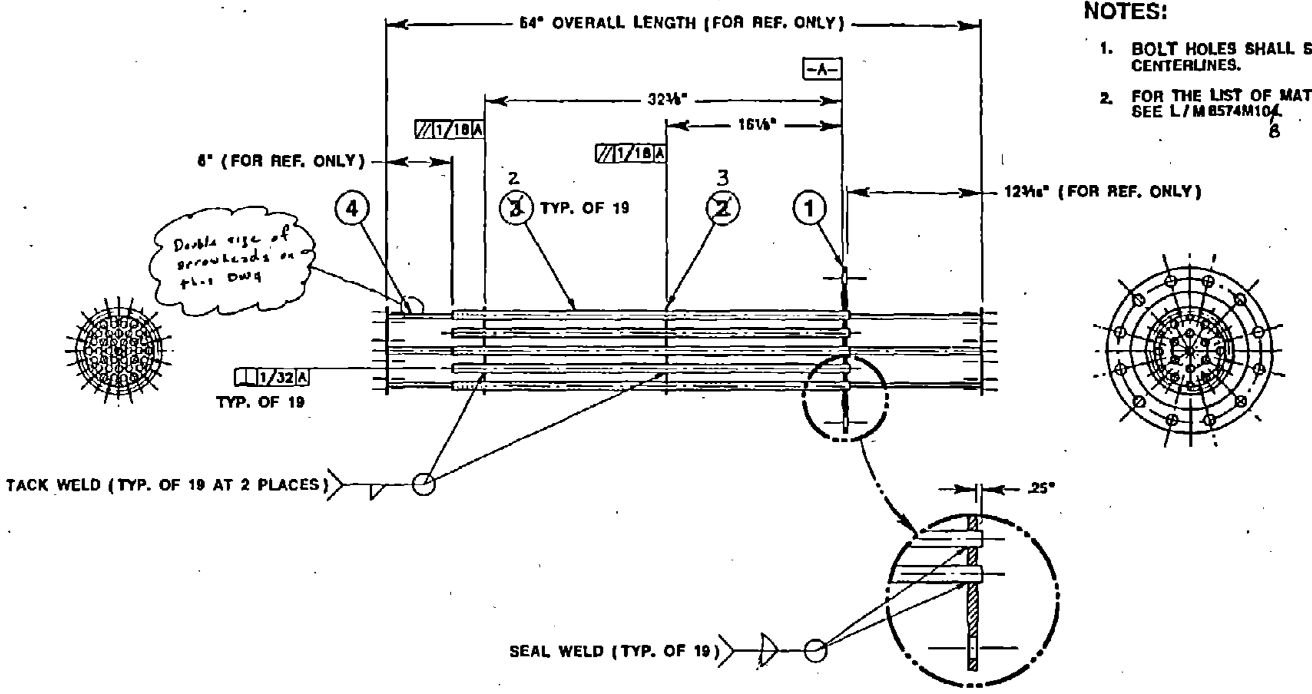
DWN	D. J. TATE	06-06-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-400	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT HYNOL

GAS SCRUBBER VESSEL S-101
GAS INLET PIPE SPOOL

SIZE	DWG. NO.	SHEET	REV
B	8574M107	1 of 1	1



NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M10~~4~~8

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
				L/M 8574M108	DIFFUSER TUBE WELDMENT LIST OF MATERIALS
1	CHANGED DWG. No. & RELEASED FOR REVIEW	DJT	06-24-94	8574M104	DIFFUSER TUBE ASSEMBLY

REVISIONS

REFERENCE DRAWINGS

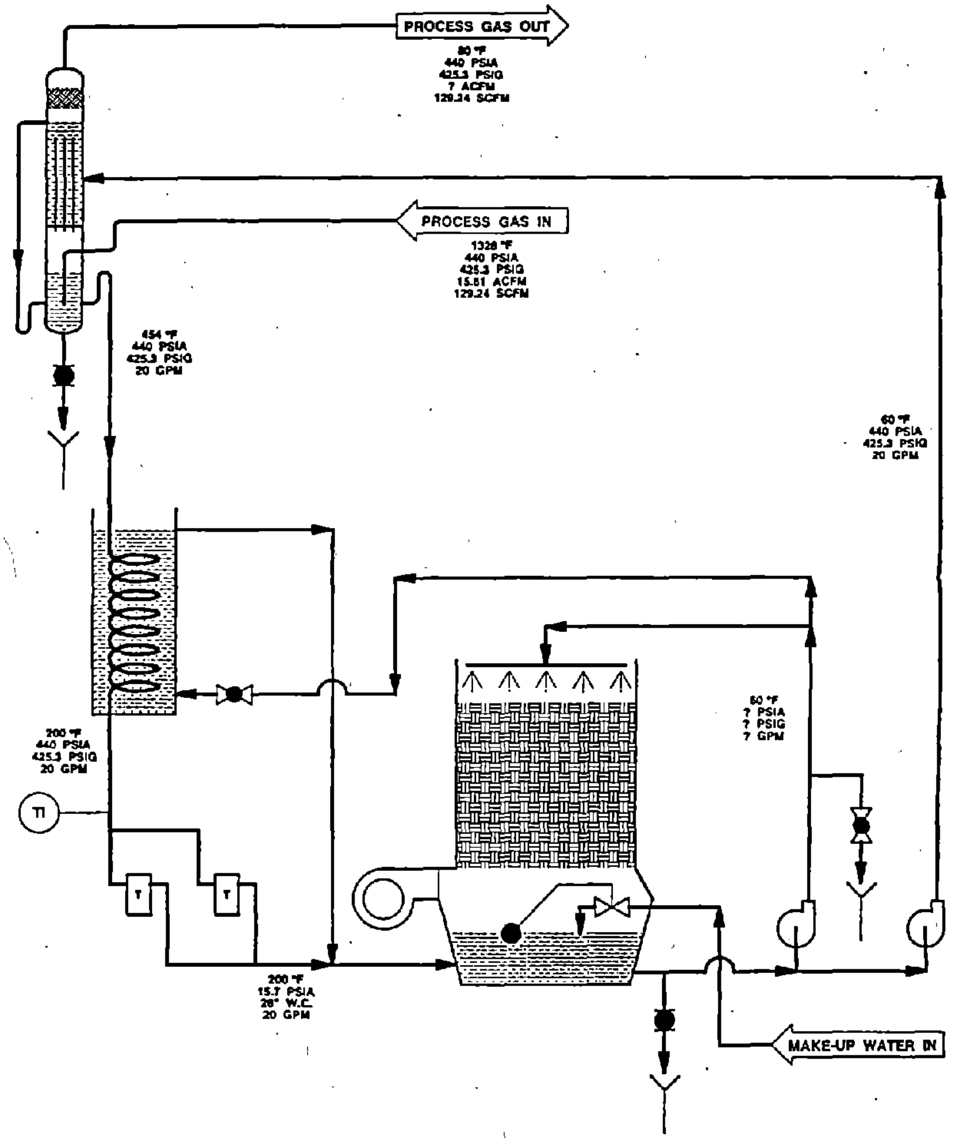
DWN	D. J. TATE	06-23-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-400	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT HYNOL

GAS SCRUBBER VESSEL S-101
DIFFUSER TUBE WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8574M108	1 of 1	1


PROCESS GAS OUT
80 °F
440 PSIA
425.3 PSIG
7 ACFM
129.24 SCFM
PROCESS GAS IN
1328 °F
440 PSIA
425.3 PSIG
15.81 ACFM
129.24 SCFM
454 °F
440 PSIA
425.3 PSIG
20 GPM
60 °F
440 PSIA
425.3 PSIG
20 GPM
60 °F
? PSIA
? PSIG
? GPM
200 °F
440 PSIA
425.3 PSIG
20 GPM
TI
T
T
200 °F
15.7 PSIA
28" W.C.
20 GPM
MAKE-UP WATER IN

INDEX

REVIEW PRINT

HYNOL

ZINC OXIDE

DESULFURIZATION VESSEL

F-205

A.E.C. PROJECT No. 8574

Prepared by

ACUREX ENVIRONMENTAL
CORPORATION

MOUNTAIN VIEW, CALIFORNIA

Acurex Environmental Corporation

PROJECT HYNOL

TITLE HYDROGEN SULFIDE DESSICANT VESSEL S-102

ASSEMBLY

PREPARED BY D.J. TATE

CHK

ENG

APPD

PROJECT NO. 8574-000

L/M 8574M150

LIST OF MATERIALS

SHEET 1 of 1

REV 1

REVISIONS

[illegible]	[illegible]	[illegible]	[illegible]
1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

	[illegible]
8574M150	ASSEMBLY

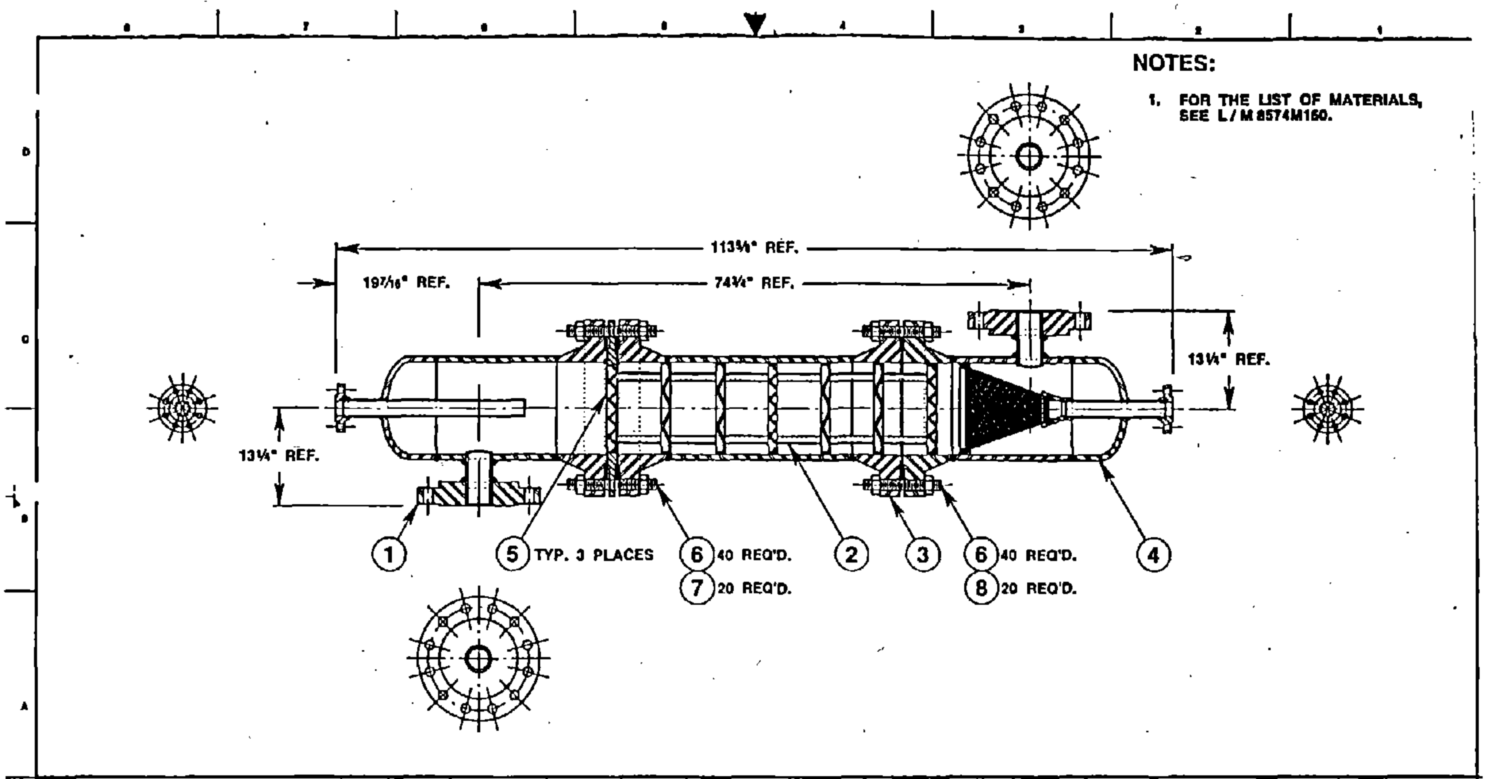
APPLICATION

[illegible]	NEXT ASSY	QTY	USED ON
01	---	1	8574

ITEM NO.	PART NUMBER	DESCRIPTION		[illegible]		
			[illegible]	[illegible]	[illegible]	[illegible]
1	8574M151	TOP WELDMENT	1	0	0	0
2	8574M154	BAFFLE WELDMENT	1	0	0	0
3	8574M152	MIDSECTION WELDMENT	1	0	0	0
4	8574M153	BOTTOM WELDMENT	1	0	0	0
5	FLEXITALLIC No. CG-6T	GASKET, 14"-600# RAISED FACE FLANGES TYPE 304 STAINLESS STEEL WITH GRAFOIL FILLER	3	0	0	0
6	-----	HEAVY HEX NUT, WASHER FACED, 1-3/8"-8UNC-2B TYPE 316 STAINLESS STEEL	80	0	0	0
7	-----	STUD BOLT, 1-3/8"-8UNC-2A x 12" LONG TYPE 316 STAINLESS STEEL	40	0	0	0
8	-----	STUD BOLT, 1-3/8"-8UNC-2A x 10-1/2" LONG TYPE 316 STAINLESS STEEL	40	0	0	0
9	•	•	0	0	0	0
10	•	•	0	0	0	0
11	•	•	0	0	0	0
12	•	•	0	0	0	0
13	•	•	0	0	0	0
14	•	•	0	0	0	0
15	•	•	0	0	0	0
16	•	•	0	0	0	0
17	•	•	0	0	0	0
18	•	•	0	0	0	0
19	•	•	0	0	0	0
20	•	•	0	0	0	0
21	•	•	0	0	0	0
22	•	•	0	0	0	0
23	•	•	0	0	0	0
24	•	•	0	0	0	0
25	•	•	0	0	0	0

NOTES:

1. FOR THE LIST OF MATERIALS, SEE L/M 8574M160.



LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
				8574M154	BAFFLE WELDMENT
				8574M153	BOTTOM WELDMENT
				8574M152	MIDSECTION WELDMENT
				8574M151	TOP WELDMENT
1	RELEASED FOR REVIEW	DJT	06-14-94	L/M 8574M160	ASSEMBLY LIST OF MATERIALS
	REVISIONS				REFERENCE DRAWINGS

DWN	D. J. TATE	06-13-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-600	
SCALE	1/12	

ORIGINATING OFFICE	CHGS NO.
Mountain View, CA	[illegible]
Durham, NC	[illegible]
Jefferson, AR	[illegible]

Acurex Environmental Corporation

PROJECT HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102

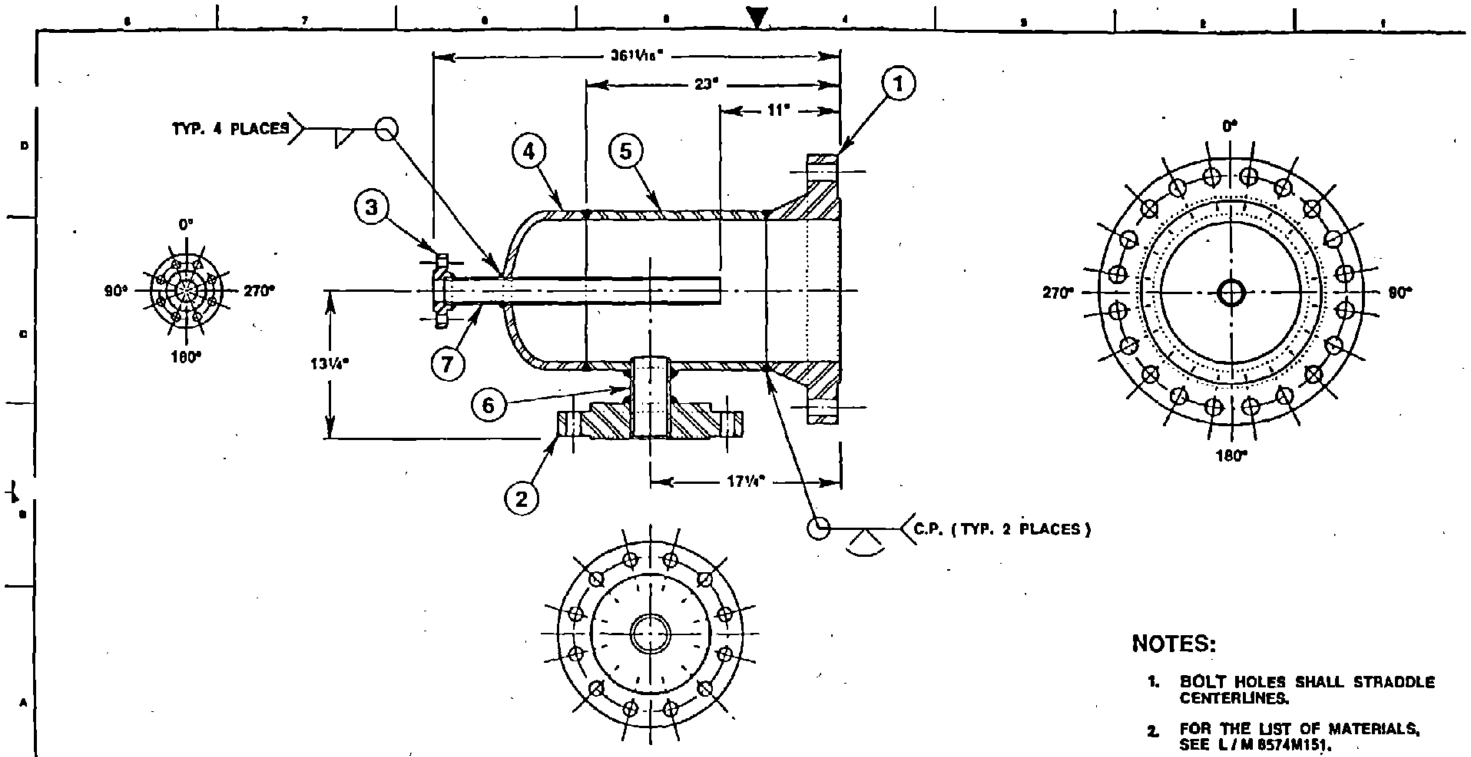
ASSEMBLY

SIZE	DWG. NO.	SHEET	REV
B	8574M150	1 of 1	1

Acurex Environmental Corporation			**L/M8574M151**
PROJECT **HYNOL**	CHK		**LIST OF MATERIALS**
TITLE HYDROGEN SULFIDE DESSICANT VESSEL S-102 **TOP WELDMENT**	PROJECT NO.		SHEET 1 of 1 / REV 1

REVISIONS				REFERENCE DRAWINGS		APPLICATION			
LTR	DESCRIPTION		DATE		TITLE		NEXT ASSY	QTY	USED ON
1	RELEASED FOR REVIEW	DJT		8574M151	TOP WELDMENT	01	8574M150	1	8574
				8574M150	ASSEMBLY				

ITEM NO.	PART NUMBER	DESCRIPTION		QTY REQ'D PER			
				-01	-02	-03	-04
1	.....	14" - 600 # RAISED FACE WELDING NECK FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
2	.....	3" - 600 # RAISED FACE SLIP-ON FLANGE	TYPE 316 STAINLESS STEEL	1	0	0	0
3	.....	2" - 600 # RAISED FACE SOCKET WELDING FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
4	.....	14" NOMINAL ELLIPTICAL PIPE CAP WITH WALL THICKNESS TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
5	.....	14" SCHEDULE 80 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 16-1/2")	TYPE 316 STAINLESS STEEL	1	0	0	0
6	.....	3" SCHEDULE 80 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 7-1/4")	TYPE 316 STAINLESS STEEL	1	0	0	0
7	.....	2" SCHEDULE 80 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 25")	TYPE 316 STAINLESS STEEL	1	0	0	0
8	•	•		0	0	0	0
9	•	•		0	0	0	0
10	•	•		0	0	0	0
11	•	•		0	0	0	0
12	•	•		0	0	0	0
13	•	•		0	0	0	0
14	•	•		0	0	0	0
15	•	•		0	0	0	0
16	•	•		0	0	0	0
17	•	•		0	0	0	0
18	•	•		0	0	0	0
19	•	•		0	0	0	0
20	•	•		0	0	0	0
21	•	•		0	0	0	0
22	•	•		0	0	0	0
23	•	•		0	0	0	0
24	•	•		0	0	0	0
25	•	•		0	0	0	0



NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M151.

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
				L/M 8574M151	TOP WELDMENT LIST OF MATERIALS
1	RELEASED FOR REVIEW	DJT	08-14-94	8574M150	ASSEMBLY

REVISIONS

REFERENCE DRAWINGS

DWN	D. J. TATE	08-14-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-600	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT
HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-10

TOP WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8574M151	1 of 1	1

Acurex Environmental Corporation

HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102

MIDSECTION WELDMENT

L/M8574M152

LIST OF MATERIALS

1 of 1	1

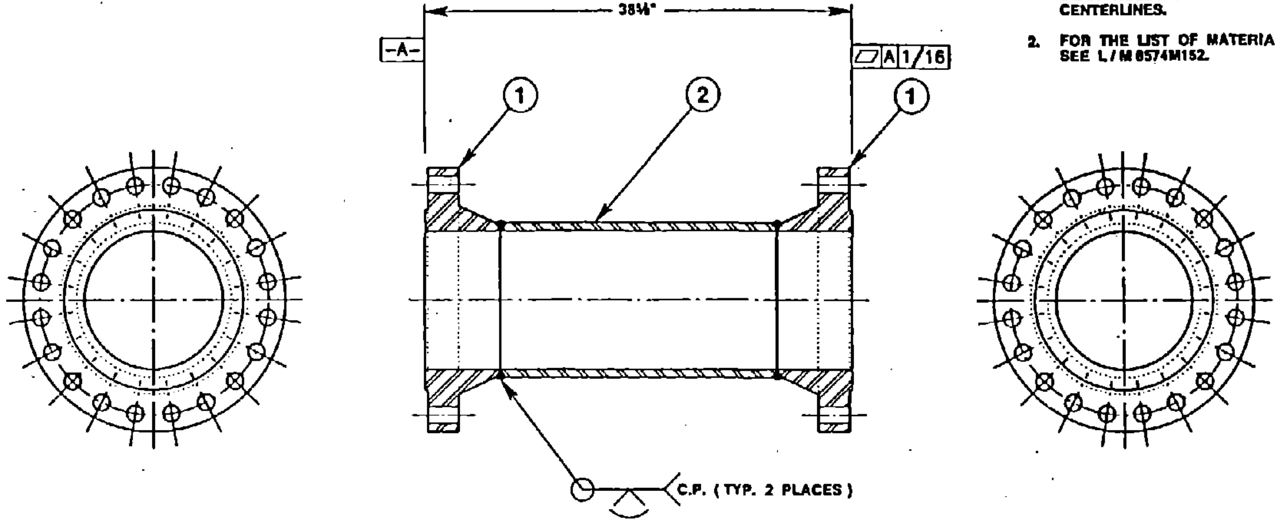
1	RELEASED FOR REVIEW	DJT		8574M152	MIDSECTION WELDMENT
				8574M150	ASSEMBLY

01	8574M150	1	8574

	PART NUMBER	DESCRIPTION	[illegible]	[illegible]	[illegible]	[illegible]
1	.....	14" × 600 # RAISED FACE WELDING NECK FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE TYPE 316 STAINLESS STEEL	2	0	0	0
2	.....	14" SCHEDULE 80 SEAMLESS PIPE × LENGTH AS REQUIRED (APPROX. 25-5/8") TYPE 316 STAINLESS STEEL	1	0	0	0
3	.	.	0	0	0	0
4	.	.	0	0	0	0
5	.	.	0	0	0	0
6	.	.	0	0	0	0
7	.	.	0	0	0	0
8	.	.	0	0	0	0
9	.	.	0	0	0	0
10	.	.	0	0	0	0
11	.	.	0	0	0	0
12	.	.	0	0	0	0
13	.	.	0	0	0	0
14	.	.	0	0	0	0
15	.	.	0	0	0	0
16	.	.	0	0	0	0
17	.	.	0	0	0	0
18	.	.	0	0	0	0
19	.	.	0	0	0	0
20	.	.	0	0	0	0
21	.	.	0	0	0	0
22	.	.	0	0	0	0
23	.	.	0	0	0	0
24	.	.	0	0	0	0
25	.	.	0	0	0	0

NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M152.



				L/M 8574M152	MIDSECTION WELDMENT LIST OF MATERIALS
1	RELEASED FOR REVIEW	DJT	08-16-94	8574M150	ASSEMBLY
LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
	REVISIONS			REFERENCE DRAWINGS	

DWN	D. J. TATE	08-16-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-500	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT
HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102
MIDSECTION WELDMENT

SIZE B DWG. NO. 8574M152 SHEET 1 of 1 REV 1

Acurex Environmental Corporation

PROJECT
HYNOL

TITLE
HYDROGEN SULFIDE DESSICANT VESSEL S-102

BOTTOM WELDMENT

L/M8574M153

LIST OF MATERIALS

SHEET 1 of 1

REV 1

REVISIONS

1	RELEASED FOR REVIEW	OJT	[illegible]

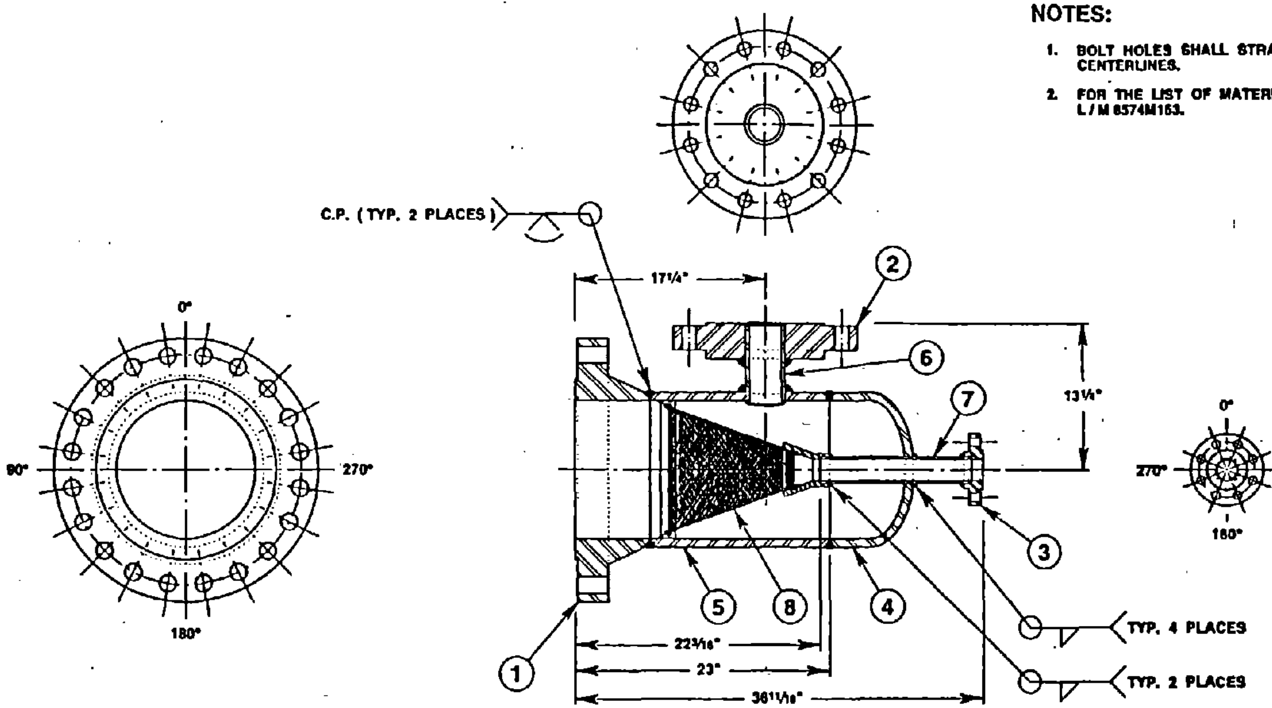
REFERENCE DRAWINGS

8574M153	BOTTOM WELDMENT
8574M150	ASSEMBLY

APPLICATION

01	8574M150	1	8574

[illegible]	PART NUMBER	DESCRIPTION		[illegible]	[illegible]	[illegible]	[illegible]
1	-----	14" - 600 # RAISED FACE WELDING NECK FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
2	-----	3" - 600 # RAISED FACE SLIP-ON FLANGE	TYPE 316 STAINLESS STEEL	1	0	0	0
3	-----	2" - 600 # RAISED FACE SOCKET WELDING FLANGE WITH BORE I.D. TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
4	-----	14" NOMINAL ELLIPTICAL PIPE CAP WITH WALL THICKNESS TO MATCH PIPE SCHEDULE	TYPE 316 STAINLESS STEEL	1	0	0	0
5	-----	14" SCHEDULE 80 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 16-1/2")	TYPE 316 STAINLESS STEEL	1	0	0	0
6	-----	3" SCHEDULE 80 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 7-1/4")	TYPE 316 STAINLESS STEEL	1	0	0	0
7	-----	2" SCHEDULE 80 SEAMLESS PIPE x LENGTH AS REQUIRED (APPROX. 13-13/16")	TYPE 316 STAINLESS STEEL	1	0	0	0
8	8574M155	CONE SCREEN WELDMENT		1	0	0	0
9	•	•		0	0	0	0
10	•	•		0	0	0	0
11	•	•		0	0	0	0
12	•	•		0	0	0	0
13	•	•		0	0	0	0
14	•	•		0	0	0	0
15	•	•		0	0	0	0
16	•	•		0	0	0	0
17	•	•		0	0	0	0
18	•	•		0	0	0	0
19	•	•		0	0	0	0
20	•	•		0	0	0	0
21	•	•		0	0	0	0
22	•	•		0	0	0	0
23	•	•		0	0	0	0
24	•	•		0	0	0	0
25	•	•		0	0	0	0



NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M153.

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
				8574M155	CONE SCREEN WELDMENT
				L/M 8574M153	BOTTOM WELDMENT LIST OF MATERIALS
1	RELEASED FOR REVIEW	DJT	08-16-84	8574M150	ASSEMBLY
	REVISIONS			REFERENCE DRAWINGS	

DWN	D. J. TATE	08-16-84
CHK		
ENG		
APPD		
PROJECT NO.	8574-900	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT
HYNOL
HYDROGEN SULFIDE DESSICANT VESSEL S-102
BOTTOM WELDMENT

SIZE B | DWG. NO. 8574M153 | SHEET 1 of 1 | REV 1

Acurex Environmental Corporation

HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102

BAFFLE WELDMENT

L/M8574M154

LIST OF MATERIALS

1 of 1

1

REVISIONS

1	RELEASED FOR REVIEW	DJT	

REFERENCE DRAWINGS

8574M154	BAFFLE WELDMENT
8574M120	ASSEMBLY

APPLICATION

01	8574M120	1	8574

	PART NUMBER	DESCRIPTION				
1	8574M158	BAFFLE FLANGE WELDMENT	1	0	0	0
2	8574M157	BAFFLE TRAY WELDMENT	8	0	0	0
3	8574M156	BAFFLE SPACER LEG	24	0	0	0
4	.	.	0	0	0	0
5	.	.	0	0	0	0
6	.	.	0	0	0	0
7	.	.	0	0	0	0
8	.	.	0	0	0	0
9	.	.	0	0	0	0
10	.	.	0	0	0	0
11	.	.	0	0	0	0
12	.	.	0	0	0	0
13	.	.	0	0	0	0
14	.	.	0	0	0	0
15	.	.	0	0	0	0
16	.	.	0	0	0	0
17	.	.	0	0	0	0
18	.	.	0	0	0	0
19	.	.	0	0	0	0
20	.	.	0	0	0	0
21	.	.	0	0	0	0
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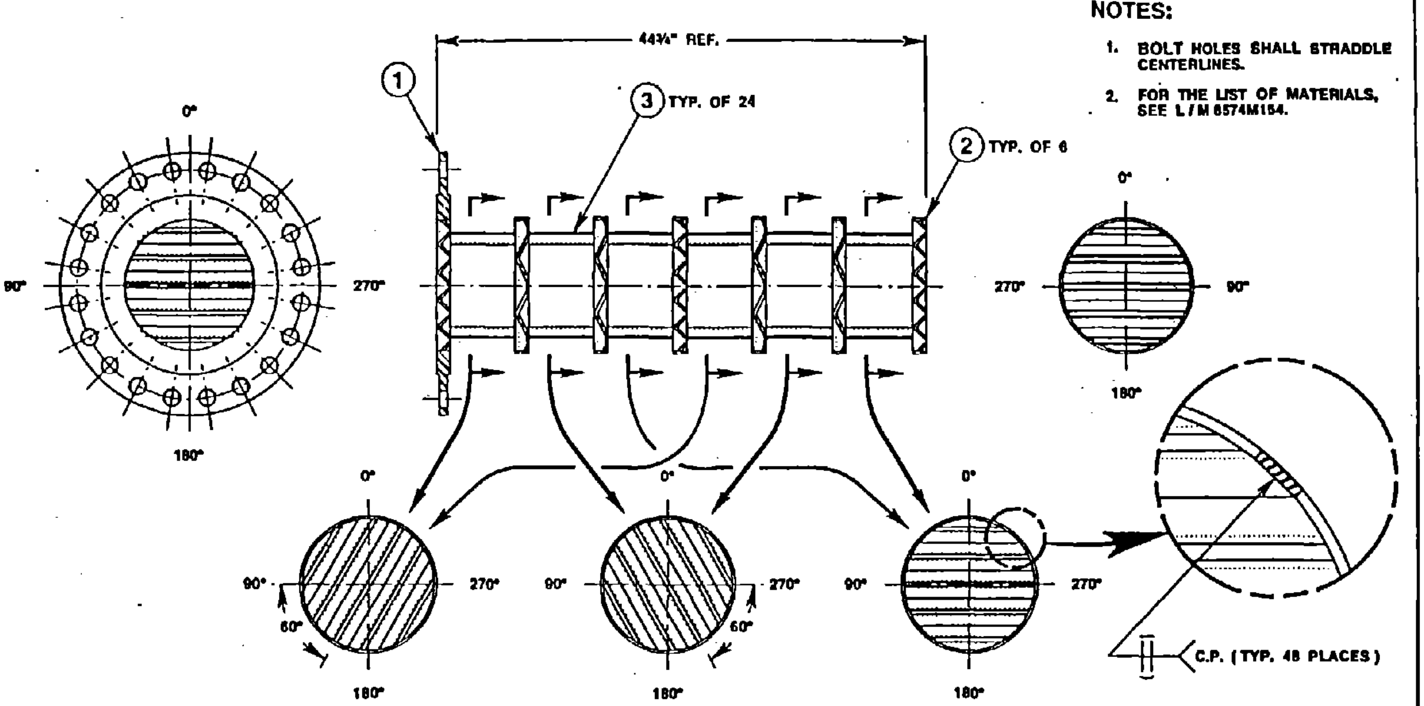
25	.	.	0	0	0	0



NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L/M 8574M154.

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	08-14-84

REVISIONS

NUMBER	TITLE
8574M158	BAFFLE SPACER LEG
8574M157	BAFFLE TRAY WELDMENT
8574M156	BAFFLE FLANGE WELDMENT
L/M 8574M154	BAFFLE WELDMENT LIST OF MATERIALS
8574M150	ASSEMBLY

REFERENCE DRAWINGS

DWN	D.J. TATE	08-13-84
CHK		
ENG		
APPD		
PROJECT NO.	8574-800	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT
HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL B-102
BAFFLE WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8574M154	1 of 1	1

Acurex Environmental Corporation

PROJECT: HYNOL

TITLE: HYDROGEN SULFIDE DESSICANT VESSEL S-102

CONE SCREEN WELDMENT

L/M8574M155

LIST OF MATERIALS

SHEET: 1 of 1

REV: 1

REVISIONS

[illegible]	[illegible]	[illegible]	[illegible]
1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

	[illegible]
8574M155	CONE SCREEN WELDMENT
8574M153	BOTTOM WELDMENT

APPLICATION

[illegible]	[illegible]	QTY	[illegible]
01	8574M153	1	8574

[illegible]	PART NUMBER	DESCRIPTION	[illegible]			
			[illegible]	[illegible]	[illegible]	[illegible]
1	8574M159	CONE SCREEN RING	1	0	0	0
2	8574M160	CONE SCREEN	1	0	0	0
3	8574M161	CONE SCREEN SOCKET	1	0	0	0
4	-	-	0	0	0	0
5	-	-	0	0	0	0
6	-	-	0	0	0	0
7	-	-	0	0	0	0
8	-	-	0	0	0	0
9	-	-	0	0	0	0
10	-	-	0	0	0	0
11	-	-	0	0	0	0
12	-	-	0	0	0	0
13	-	-	0	0	0	0
14	-	-	0	0	0	0
15	-	-	0	0	0	0
16	-	-	0	0	0	0
17	-	-	0	0	0	0
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20	-	-	0	0	0	0
21	-	-	0	0	0	0
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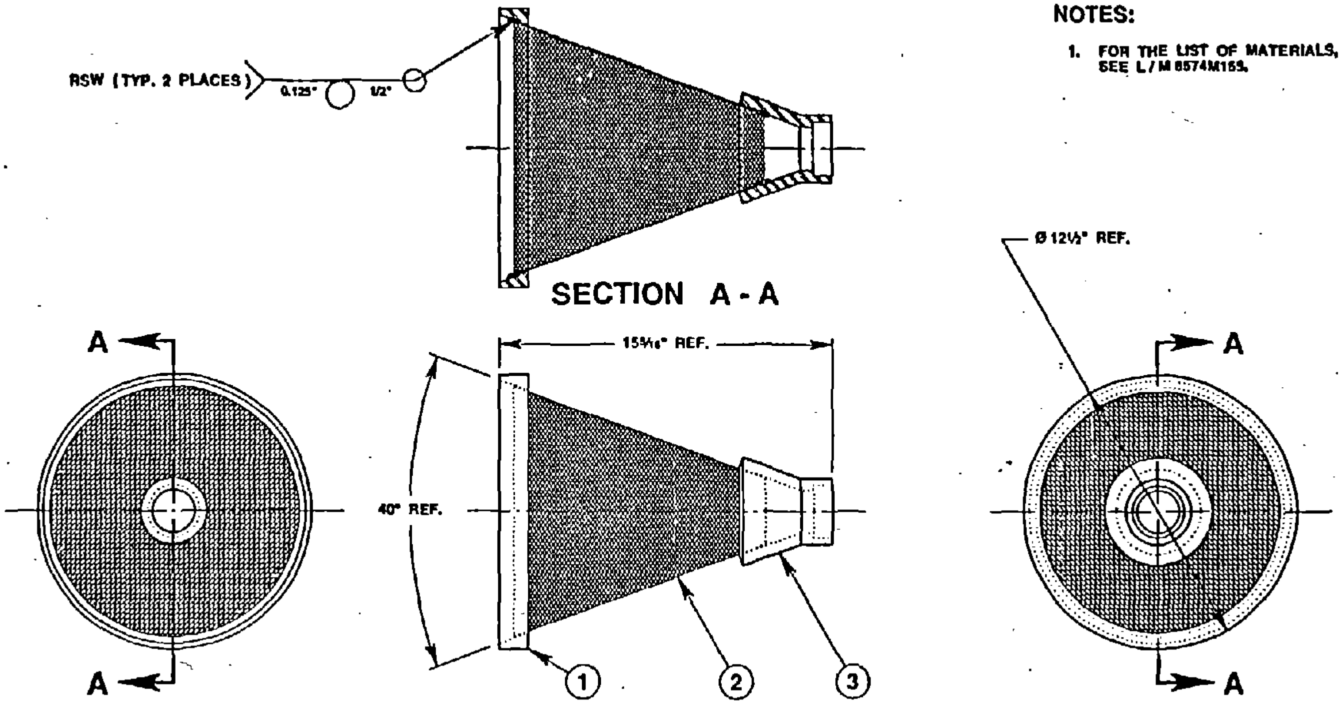
23	-	-	0	0	0	0
24	-	-	0	0	0	0
25	-	-	0	0	0	0



NOTES:

1. FOR THE LIST OF MATERIALS, SEE L/M 8574M155.

1	RELEASED FOR REVIEW	DJT	08-17-94
LTR	DESCRIPTION	APPD	DATE
	REVISIONS		

8574M161	CONE SCREEN SOCKET
8574M160	CONE SCREEN
8574M159	CONE SCREEN RING
L/M 8574M155	CONE SCREEN WELDMENT LIST OF MATERIALS
8574M153	BOTTOM WELDMENT
NUMBER	TITLE
REFERENCE DRAWINGS	

DWN	D. J. TATE	08-17-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-800	
SCALE	1/4	

Acurex Environmental Corporation

PROJECT

HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL 8-102

CONE SCREEN WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8574M155	1 of 1	1

Acurex Environmental Corporation

PROJECT HYNOL

TITLE HYDROGEN SULFIDE DESSICANT VESSEL S-102

BAFFLE FLANGE WELDMENT

L/M8574M156

LIST OF MATERIALS

SHEET 1 of 1

REV. 1

REVISIONS

1	RELEASED FOR REVIEW	OUT	

REFERENCE DRAWINGS

8574M156	BAFFLE FLANGE WELDMENT
8574M154	BAFFLE WELDMENT

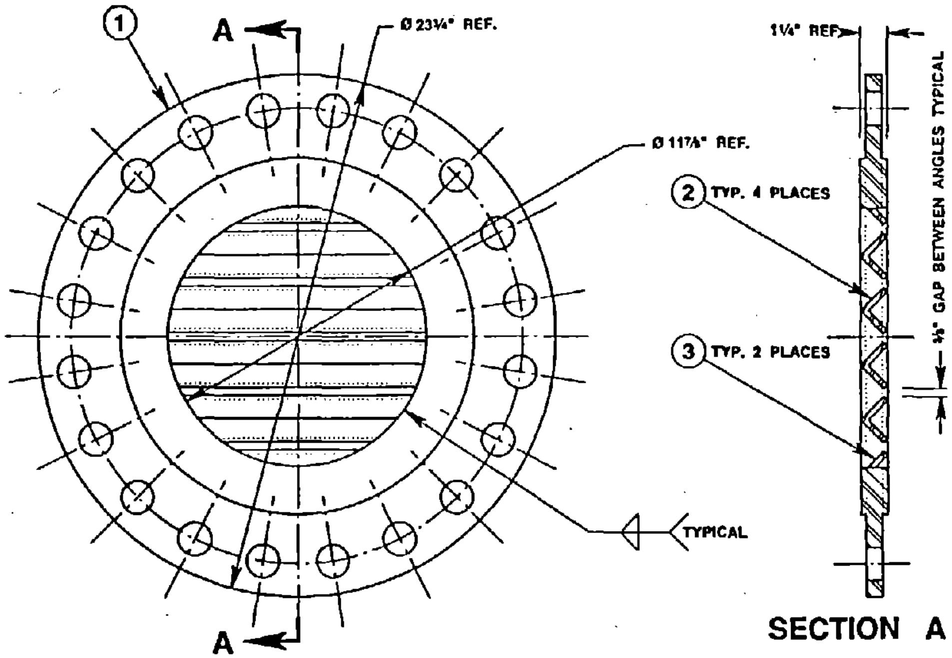
APPLICATION

	NEXT ASSY	QTY	
01	8574M154	1	8574

ITEM NO.	PART NUMBER	DESCRIPTION		-01	-02	-03	-04
1	8574M162	BAFFLE FLANGE		1	0	0	C
2	-----	1-1/2" x 1-1/2" x 1/4" ANGLE x LENGTH AS REQ'D.	ROLLED ALLOYS RA 330	A/R	0	0	0
3	-----	1/4" x 1" FLAT x LENGTH AS REQ'D. & SHAPED TO FIT	ROLLED ALLOYS RA 330	A/R	0	0	0
4	.	.		0	0	0	C
5	.	.		0	0	0	:
6	.	.		0	0	0	:
7	.	.		0	0	0	:
8	.	.		0	0	0	:
9	.	.		0	0	0	:
10	.	.		0	0	0	:
11	.	.		0	0	0	:
12	.	.		0	0	0	:
13	.	.		0	0	0	:
14	.	.		0	0	0	:
15	.	.		0	0	0	:
16	.	.		0	0	0	:
17	.	.		0	0	0	:
18	.	.		0	0	0	:
19	.	.		0	0	0	:
20	.	.		0	0	0	:
21	.	.		0	0	0	:
22	.	.		0	0	0	:
23	.	.		0	0	0	C
24	.	.		0	0	0	C
25	.	.		0	0	0	C

NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. FOR THE LIST OF MATERIALS, SEE L / M 8574M156.



SECTION A - A

LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	08-18-94

REVISIONS

NUMBER	TITLE
8574M162	BAFFLE FLANGE
L/M 8574M156	BAFFLE FLANGE WELDMENT LIST OF MATERIALS
8574M154	BAFFLE WELDMENT

REFERENCE DRAWINGS

DWN	D. J. TATE	08-18-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-800	
SCALE	1/8	

Acurex Environmental Corporation

PROJECT HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102

BAFFLE FLANGE WELDMENT

SIZE	DWG. NO.	SHEET	REV
B	8574M156	1 of 1	1

Acurex Environmental Corporation

PROJECT HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102

BAFFLE TRAY WELDMENT

PREPARED BY D.A. TATE

CHK

ENG

APPD

PROJECT NO 8574-[illegible]

L/M 8574M157

LIST OF MATERIALS

SHEET 1 of 1

REV 1

REVISIONS

1	RELEASED FOR REVIEW	DJT	[illegible]

REFERENCE DRAWINGS

8574M157	BAFFLE TRAY WELDMENT
8574M154	BAFFLE WELDMENT

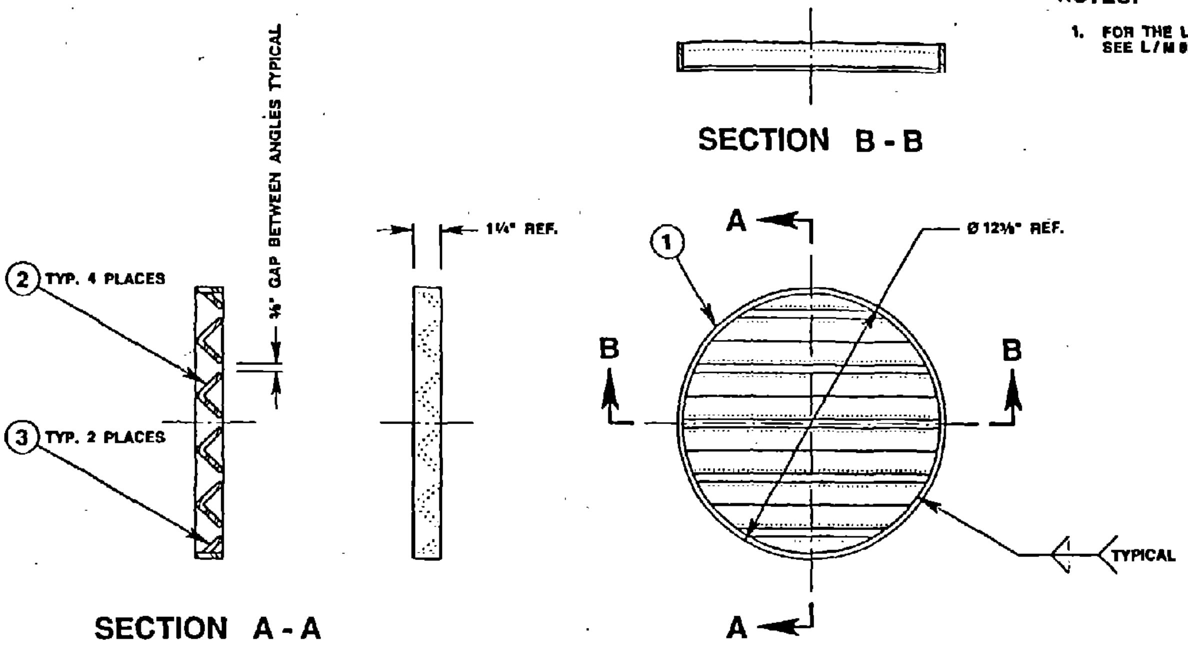
APPLICATION

		QTY	
01	8574M154	1	8574

	PART NUMBER	DESCRIPTION				
1	8574M163	BAFFLE TRAY RING	1	0	0	C
2	-----	1-1/2" x 1-1/2" x 1/4" ANGLE x LENGTH AS REQ'D. ROLLED ALLOYS RA 330	A/R	0	0	C
3	-----	1/4" x 1" FLAT x LENGTH AS REQ'D. & SHAPED TO FIT ROLLED ALLOYS RA 330	A/R	0	0	C
4	•	•	0	0	0	C
5	•	•	0	0	0	C
6	•	•	0	0	0	C
7	•	•	0	0	0	C
8	•	•	0	0	0	C
9	•	•	0	0	0	C
10	•	•	0	0	0	C
11	•	•	0	0	0	C
12	•	•	0	0	0	C
13	•	•	0	0	0	C
14	•	•	0	0	0	C
15	•	•	0	0	0	C
16	•	•	0	0	0	C
17	•	•	0	0	0	C
18	•	•	0	0	0	C
19	•	•	0	0	0	0
20	•	•	0	0	0	C
21	•	•	0	0	0	C
22	•	1	0	0	0	0
23	•	•	0	0	0	0
24	•	•	0	0	0	0
25	•	•	0	0	0	0

NOTES:

1. FOR THE LIST OF MATERIALS, SEE L/M 8574M157.



LTR	DESCRIPTION	APPD	DATE
1	RELEASED FOR REVIEW	DJT	06-16-94

REVISIONS

NUMBER	TITLE
8574M153	BAFFLE TRAY RING
L/M 8574M157	BAFFLE TRAY WELDMENT LIST OF MATERIALS
8574M154	BAFFLE WELDMENT

REFERENCE DRAWINGS

DWN	D. J. TATE	06-16-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-500	
SCALE	1/4	

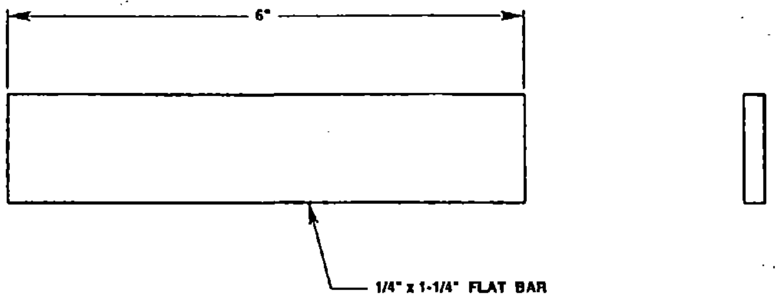
Acurex Environmental Corporation

PROJECT HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL B-102

BAFFLE TRAY WELDMENT

SIZE	DWG NO	SHEET	REV
B	8574M157	1 of 1	1



UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
± 1/16	± .01	± .005	± 0° 30'

MACHINE CORNERS - .005 TO .015 RAD OR CHAMFER
SHEET MATERIAL - BREAK EDGES .005 MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL:
ROLLED ALLOYS RA 330

FINISH:

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
1	RELEASED FOR REVIEW	DJT	05-21-94	8574M164	BAFFLE WELDMENT

REVISIONS — REFERENCE DRAWINGS

DWN	D.J. TATE	05-21-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-500	
SCALE	FULL SIZE	

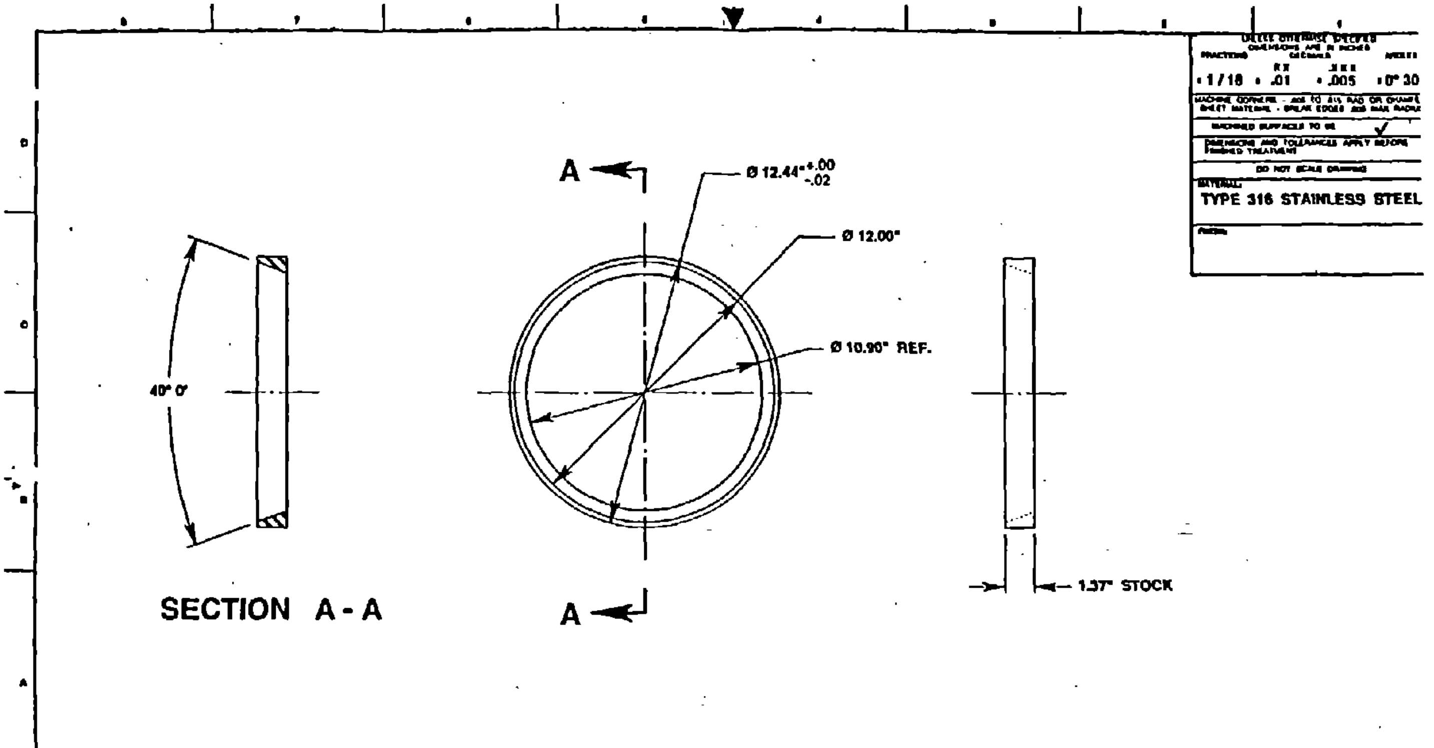
Acurex Environmental Corporation

PROJECT
HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102

BAFFLE SPACER LEG

SIZE	DWG. NO.	SHEET	REV
B	8574M158	1 of 1	1



TYPE 316 STAINLESS STEEL

±1/16 ± .01 ± .005 ±0° 30

DO NOT SCALE DRAWING

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
1	RELEASED FOR REVIEW	DJT	06-21-84	8574M155	CONE SCREEN WELDMENT

REVISIONS

REFERENCE DRAWINGS

DWN D. J. TATE 06-21-84
PROJECT NO. 8574-800
SCALE 1/4

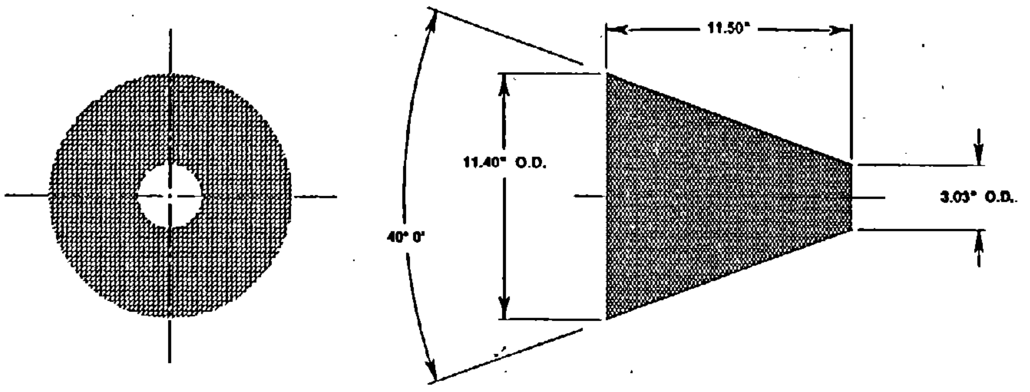
Acurex Environmental Corporation

PROJECT HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102

CONE SCREEN RING

SIZE B DWG NO. 8574M159 SHEET 1 of 1 REV 1



UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	±.01	±.005	±0° 30'

[illegible]

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL:
TO BE DETERMINED

FINISH:

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
1	RELEASED FOR REVIEW	DJT	08-21-84	8574M158	CONE SCREEN WELDMENT

REVISIONS

REFERENCE DRAWINGS

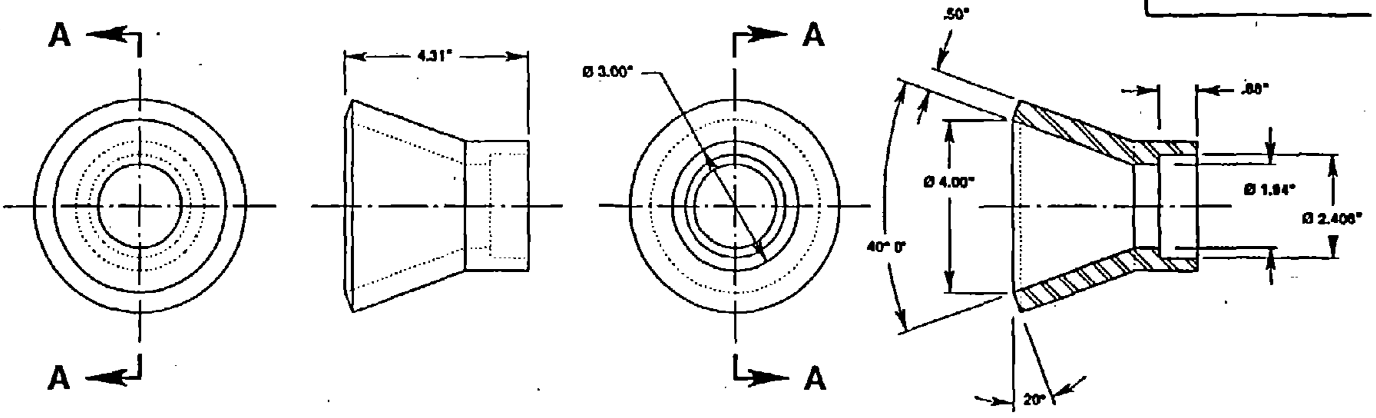
DWN	D. J. TATE	08-21-84
CHK		
ENG		
APPD		
PROJECT NO.	8574-600	
SCALE	1/4	

Acurex Environmental Corporation

PROJECT
HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S-102
CONE SCREEN

SIZE	DWG. NO.	SHEET	REV
B	8574M160	1 of 1	1



SECTION A - A

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLE
±1/16	± .01	± .005	±0° 3

MACHINED CORNERS - .005 TO .015 RAD OR CHAM
SHEET MATERIAL - BREAK EDGES .005 MAX RAD

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL:
TYPE 316 STAINLESS STEE

FINISH:

1	RELEASED FOR REVIEW	DJT	08-21-94	8574M155	CONE SCREEN WELDMENT
LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
	REVISIONS			REFERENCE DRAWINGS	

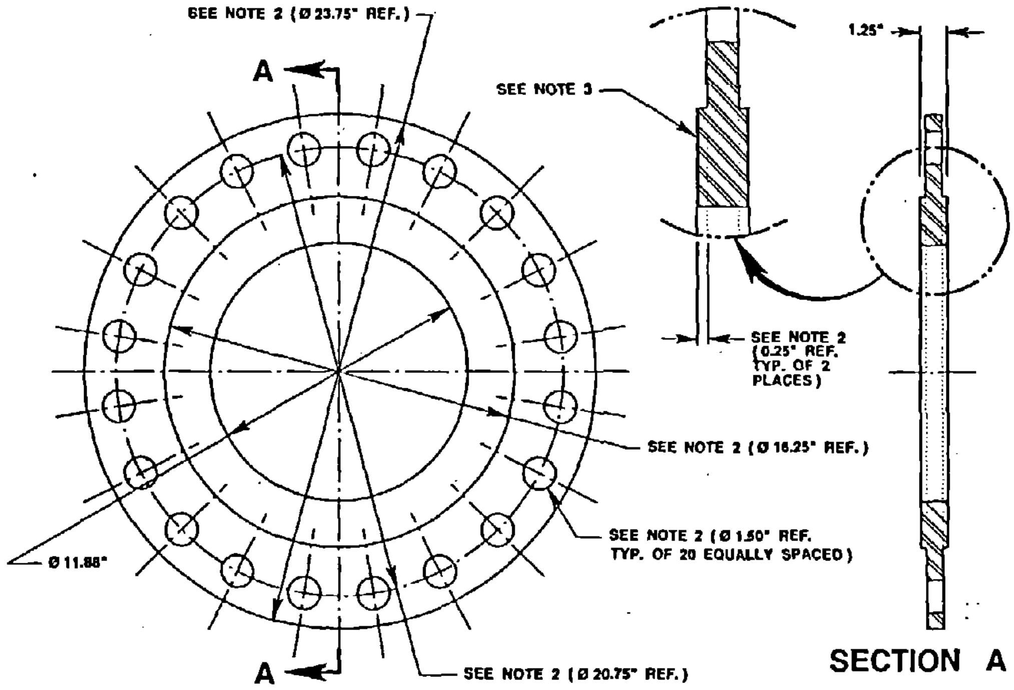
DWN	D. J. TATE	08-21-94
CHK		
ENG		
APPD		
PROJECT NO.	8574 - 800	
SCALE	HALF SIZE	

Acurex Environmental Corporation

PROJECT
HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL 8 - 102
.CONE SCREEN SOCKET

SIZE	DWG. NO.	SHEET	REV
B	8574M161	1 of 1	1



SECTION A - A

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	± .01	± .005	±0° 30'

MACHINE CORNERS - .XX TO .015 RAD OR CHAMFER SHEET MATERIAL - BREAK EDGES .XX MAX RADIUS

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL

ROLLED ALLOYS RA 330

FINISH

NOTES:

1. BOLT HOLES SHALL STRADDLE CENTERLINES.
2. ALL DIMENSIONS REFERENCED TO THIS NOTE SHALL CONFORM TO ANSI B 16.5 DIMENSIONS FOR CLASS 600 STEEL FLANGES.
3. THE RAISED FACES OF THIS FLANGE SHALL HAVE A SPIRAL SERRATED GASKET SURFACE FINISH HAVING FROM 24 TO 40 GROOVES PER INCH. SERRATIONS SHALL BE CUT USING A TOOL WHICH HAS AN APPROXIMATE 0.06" OR GREATER RADIUS. THE RESULTANT SURFACE SHALL BE JUDGED BY VISUAL COMPARISON WITH AARH STANDARDS (SEE ANSI B 46.1). THE FINISH SHALL HAVE A MAXIMUM 250 MICROINCH ROUGHNESS.

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
1	RELEASED FOR REVIEW	DJT	08-21-94	8574M158	BAFFLE FLANGE WELDMENT

REVISIONS — REFERENCE DRAWINGS

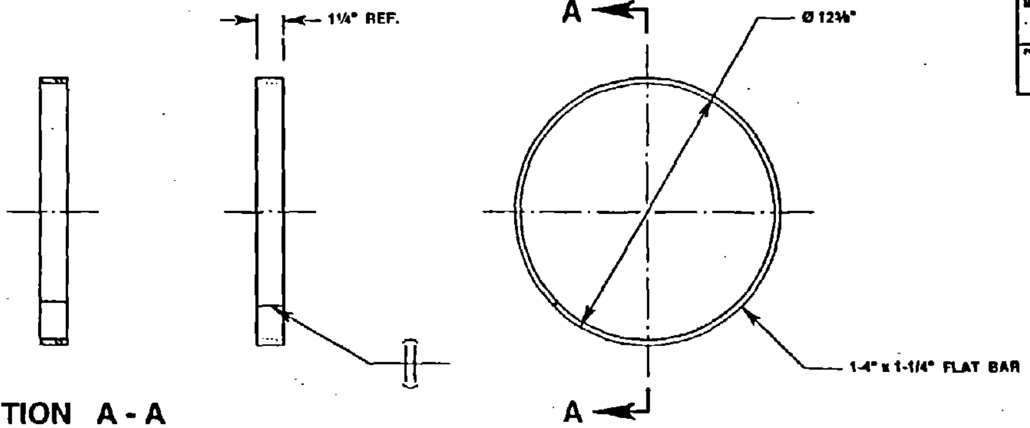
DRN	D. J. TATE	08-21-94
CHK		
ENG		
APPD		
PROJECT NO.	8574-500	
SCALE	1/4	

Acurex Environmental Corporation

PROJECT
HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL B-102
BAFFLE FLANGE

SIZE	DWG. NO.	SHEET	REV
B	8574M162	1 of 1	1



SECTION A - A

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES

FRACTIONS	DECIMALS .XX	DECIMALS .XXX	ANGLES
±1/16	±.01	±.005	±0° 3

MACHINE CORNERS - [illegible] TO [illegible] RAD OR CHAMF
SHEET MATERIAL - BREAK EDGES [illegible] MAX RADIU

MACHINED SURFACES TO BE ✓

DIMENSIONS AND TOLERANCES APPLY BEFORE FINISHED TREATMENT

DO NOT SCALE DRAWING

MATERIAL
ROLLED ALLOYS RA 330

FINISH

LTR	DESCRIPTION	APPD	DATE	NUMBER	TITLE
1	RELEASED FOR REVIEW	DJT	08-21-84	8574M157	BAFFLE TRAY WELDMENT

REVISIONS

REFERENCE DRAWINGS

DRN	D. J. TATE	08-21-84
CHK		
ENG		
APPD		
PROJECT NO.	8574 - [illegible]	
SCALE	1/4	

Acurex Environmental Corporation

PROJECT
HYNOL

HYDROGEN SULFIDE DESSICANT VESSEL S - 102
BAFFLE TRAY RING

SIZE	DWG. NO.	SHEET	REV
B	8574M163	1 of 1	1

INDEX

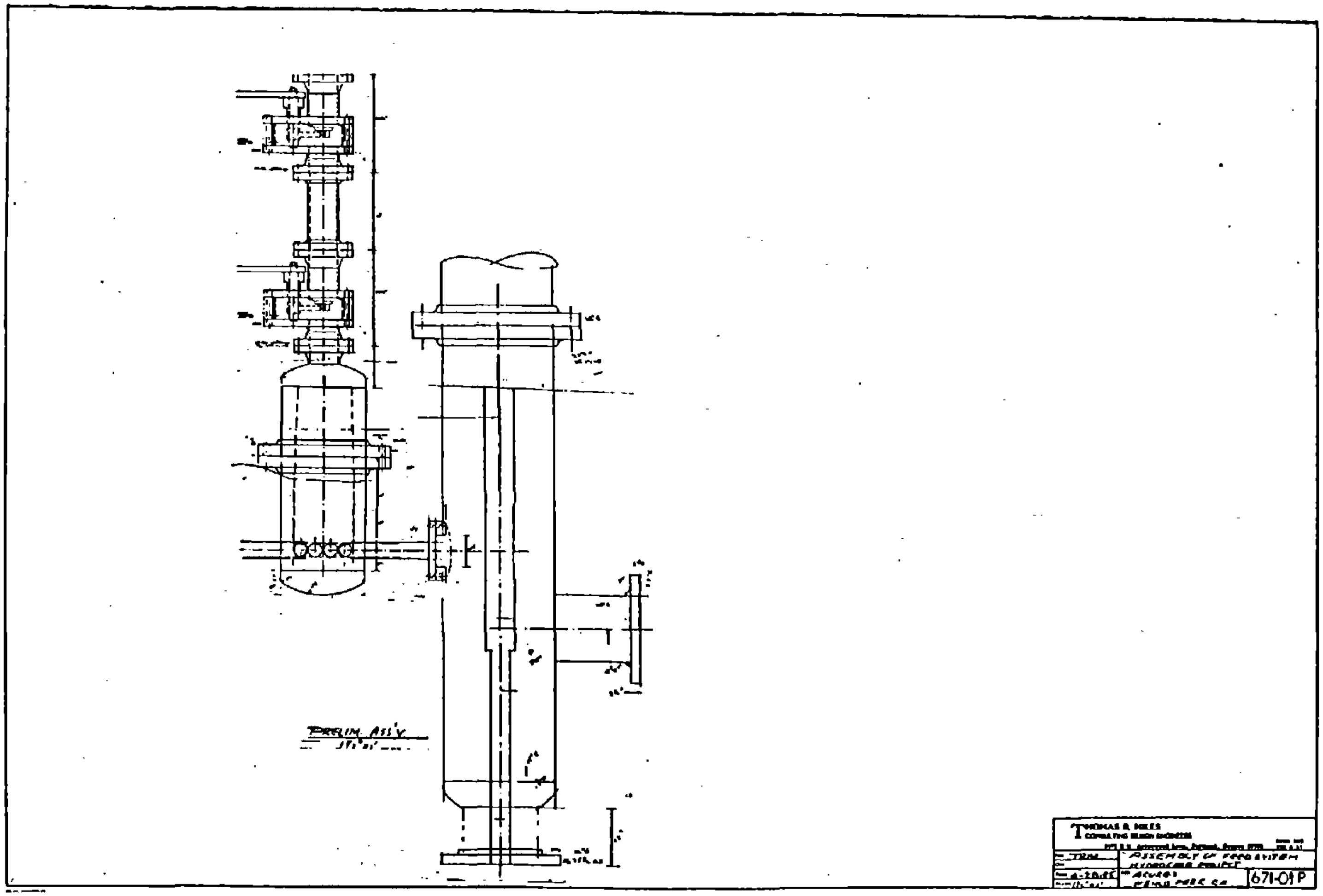
HYNOL

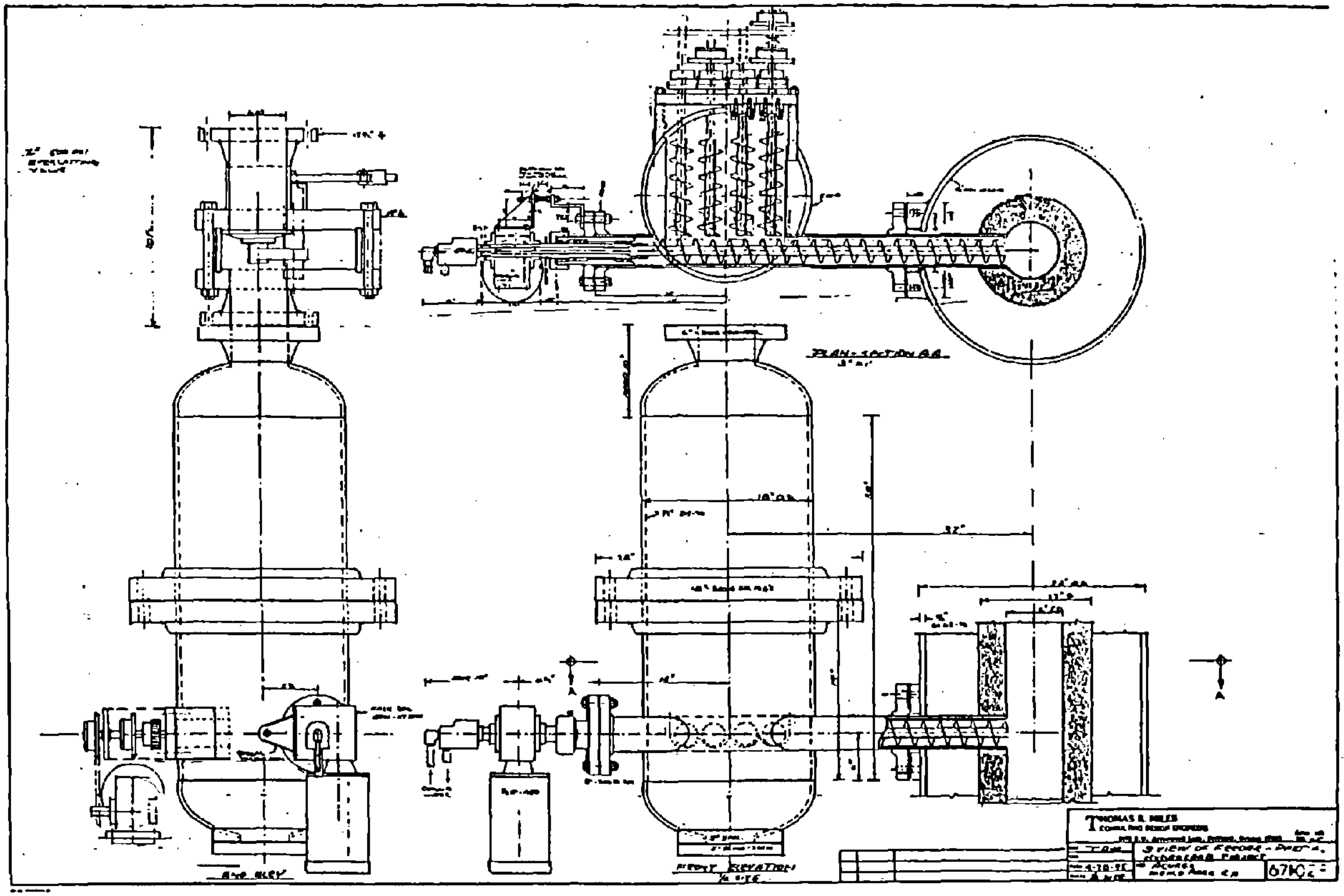
BIOMASS FEED SYSTEM

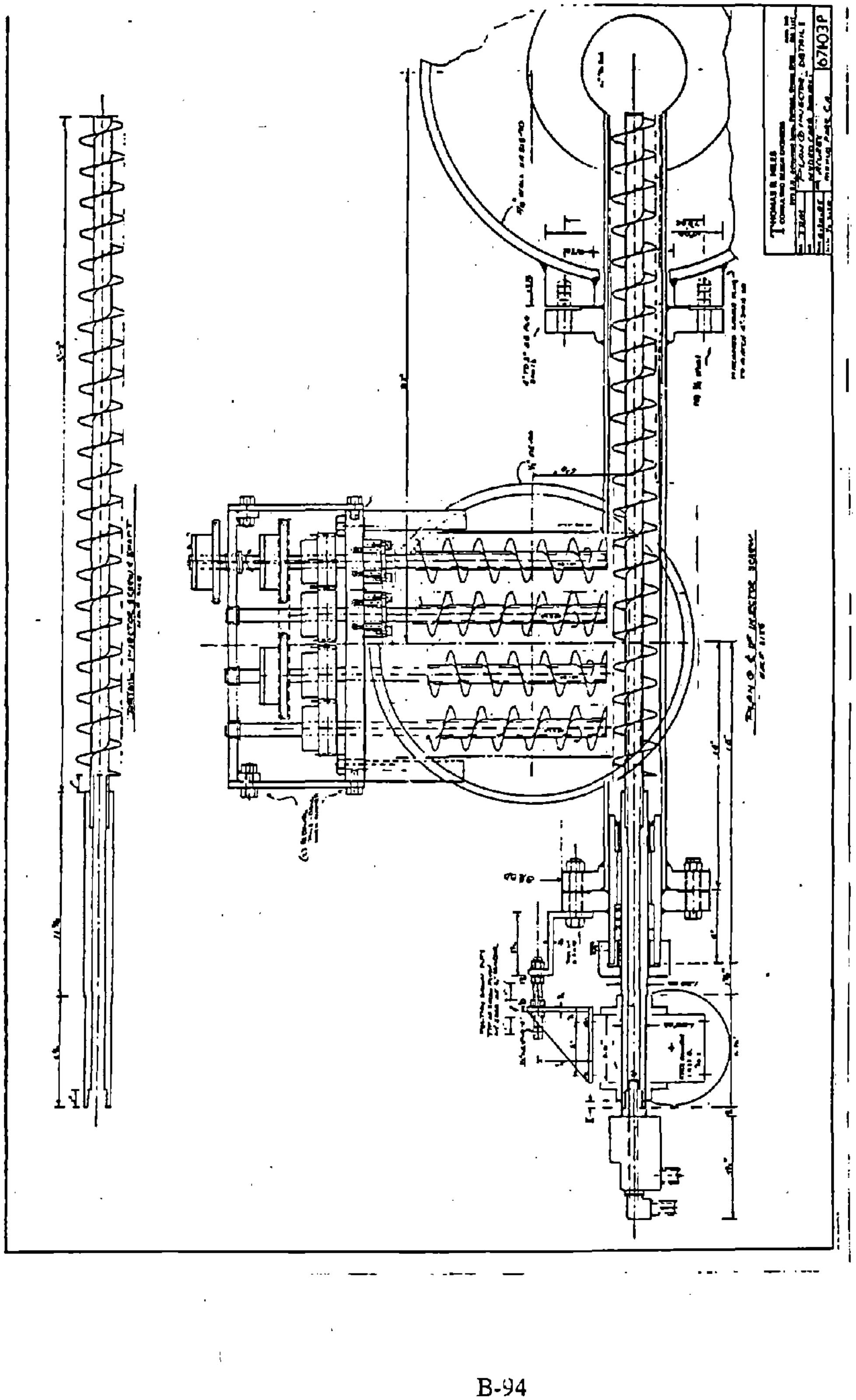
LH-801, T-805, SF-806

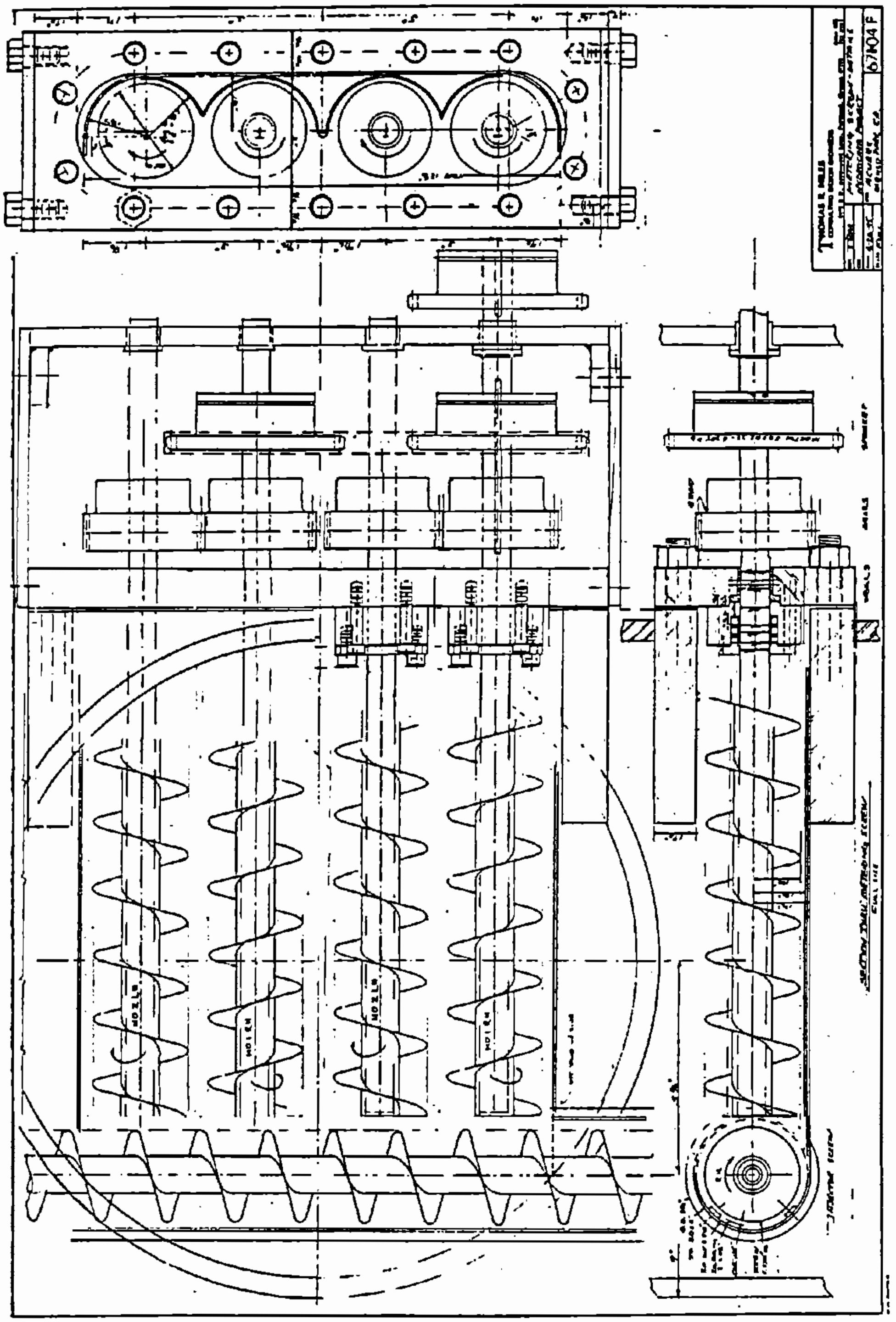
Prepared by

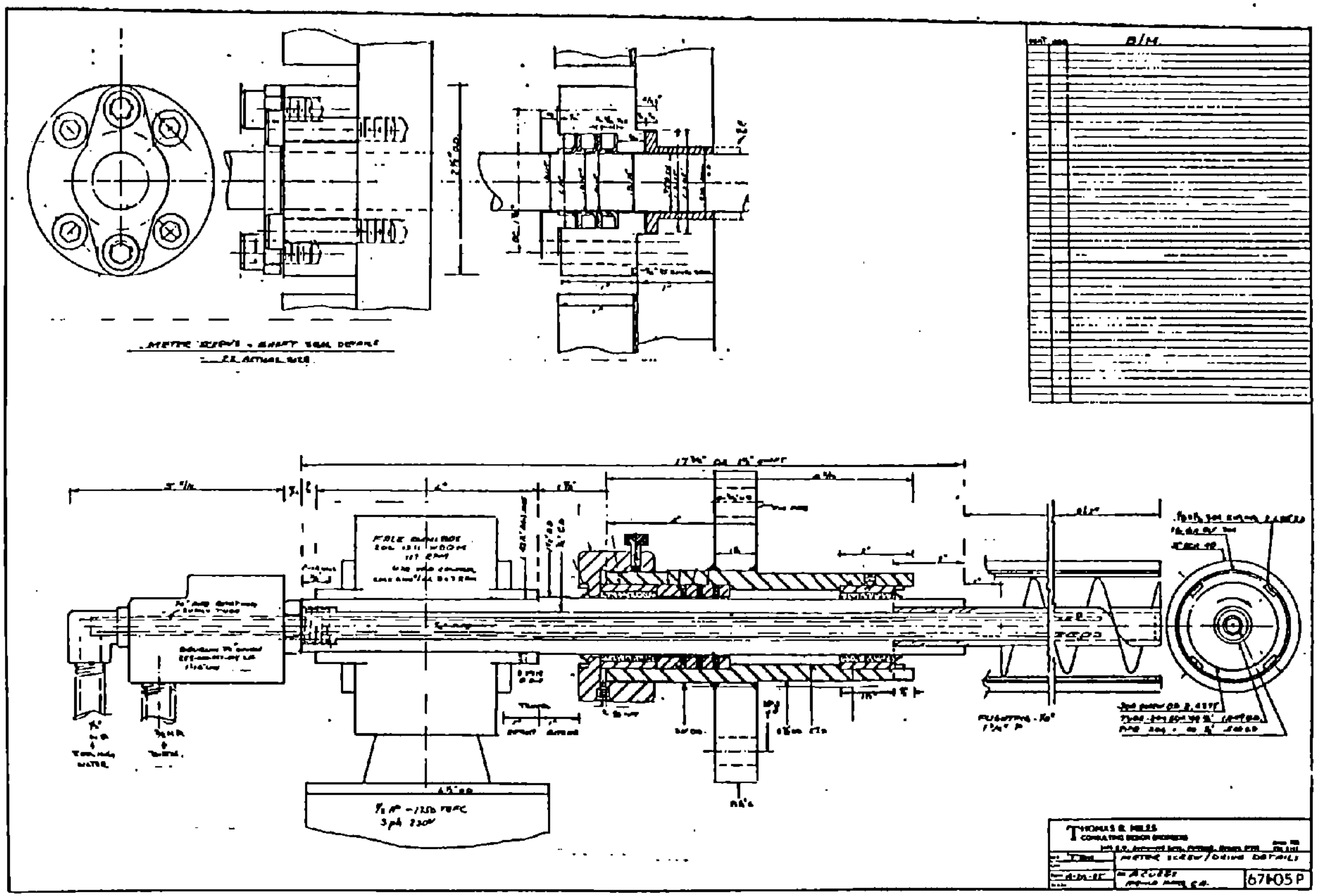
Thomas R. Miles
Consulting Design Engineers
5475 W. Arrowwood Lane
Portland, Oregon 97225


PRELIM ASS'Y
THOMAS R. MILES
CONSULTING DESIGN ENGINEERS
TRM
ASSEMBLY OF FEED SYSTEM
HYDROCARB PROJECT
671-01P


PLAN - SECTION A-A
FRONT ELEVATION
END ELEV
A
THOMAS R. MILES
CONSULTING DESIGN ENGINEERS
3 VIEW OF FEEDER
4-28-95
6710


THOMAS R. MILES
PLAN ⊙ INJECTOR; DETAIL I
67H03P
DETAIL - INJECTOR SCREW & SHAFT
PLAN @ ℄ OF INJECTOR SCREW

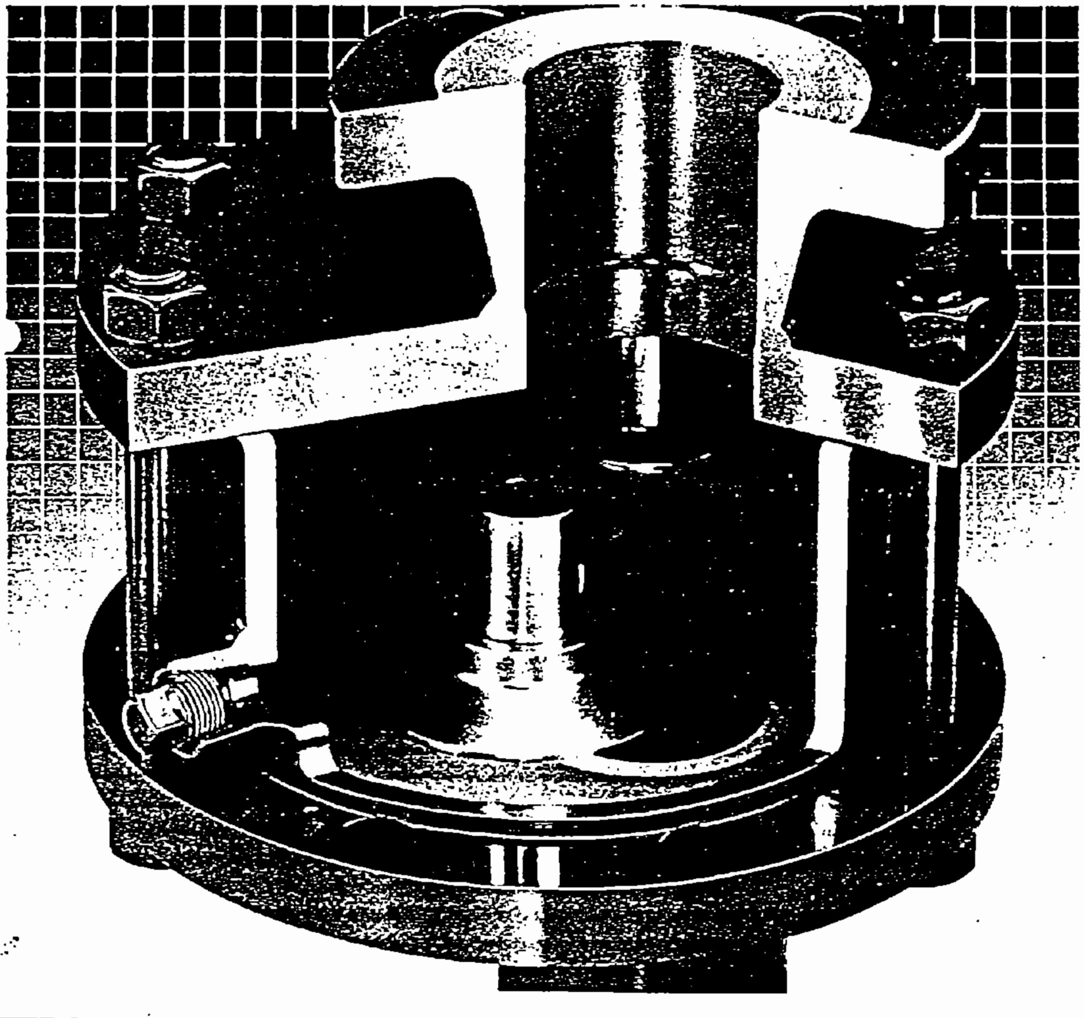

THOMAS E. MILLS
67104 F
SECTION THRU METERING SCREW
HORIZ


B/M
METER SCREW • SHAFT SEAL DETAIL
2X ACTUAL SIZE
2.5" OD
4.5" OD
3/4 HP – 1250 TEFC
3 ph 220V
THOMAS R. MILES
CONSULTING DESIGN ENGINEERS
METER SCREW/DRIVE DETAILS
67405P

EVERLASTING®

ROTATING DISC VALVES

- Temperatures to 1500 +F • Pressures to 10,000 psig • Abrasives • Corrosives • Coking • Slurries
- High Cycling • Bi-Directional • Intrinsically Fire Safe

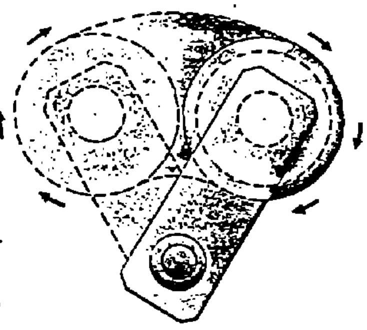


OVER 80 YEARS OF FIELD PROVEN SERVICE–WITH APPLICATIONS WORLDWIDE.

PROVEN CONCEPT Starting in 1904 the unique rotating shearing disc concept was the standard for steam locomotive boiler blowdown. Following this the packaged boiler industry has also accepted the Everlasting quick opening valve where our reputation remains unchallenged. The valve handles boiler blowdown, scale, chemicals, high pressures, temperatures, and flashing condensate, they have an average life of 16 years.

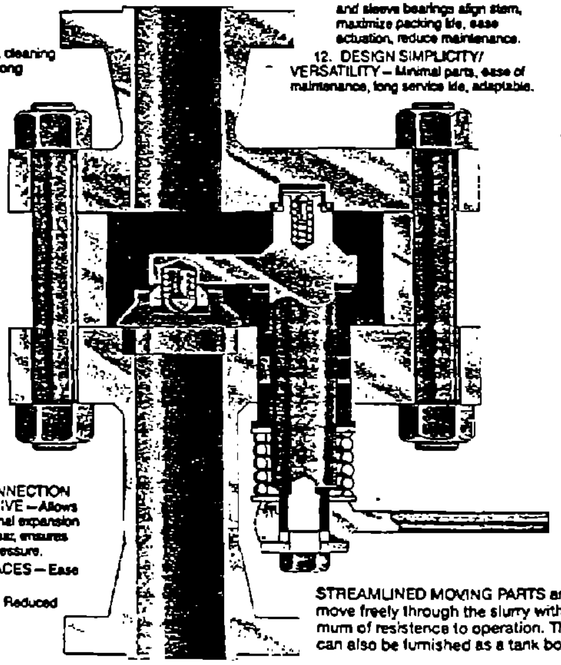
Our slurry valves are installed throughout the world in processes that are abrasive, corrosive or fouling and that have high pressure, temperature or cycling. The unique self lapping metal to metal seat design provides repeated tight shutoff in severe service, while sealing improves with use.

PRINCIPAL OF OPERATION The actuator moves the stem and lever arm a quarter turn which drives the disc. The entire sealing surface of the disc is constantly in contact with the seat or pad through force exerted by coiled springs. These springs allow the disc to move vertically. This compensates for thermal expansion and contraction of the valves components also overcoming the effect of any back pressure for which it was designed and prevents particles from lodging between the sealing surfaces. Differences in tangential disc to seat friction forces cause the disc to rotate on its seat as the valve cycles, thereby shearing and wiping away any process material that may accumulate. No other valve is similar.

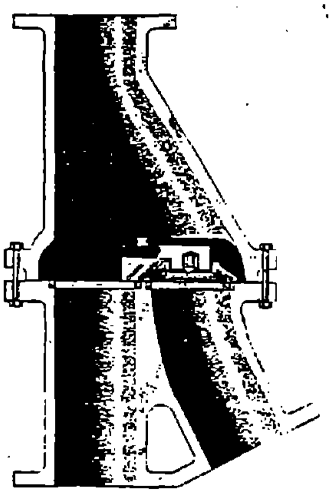


FEATURES AND BENEFITS

1. UNIQUE ROTATING/SHEARING DISC — Self lapping disc, enhanced seal cleaning action, cuts through solids, long lasting tight shut-off.
2. METAL TO METAL SEATING — abrasion resistance, wide temperature range.
3. WIDE BAND SEATING — High pressure capability, better sealing than industry standards, force distributed over larger area, less trim wear.
4. FULL PORT — abrasion resistance, no obstruction to flow, minimal pressure drop.
5. ROTATING STEM — Increased packing life, wide selection of actuators.
6. SELF DRAINING BODY — Reduced chance of jamming due to material entrainment, stagnation and degradation.
7. BODY PURGE CONNECTIONS — Ability to flush valve cavity and internals while in operation.
8. SPRING LOADED CONNECTION BETWEEN DISC AND DRIVE — Allows disc to compensate for thermal expansion or contraction, adjusts for wear, ensures tight shut-off, resists back pressure.
9. FLAT SEATING SURFACES — Ease of maintenance.
10. REPAIRABLE SEAT — Reduced inventory, less maintenance expense.
11. STEM BEARINGS — Trunion and sleeve bearings align stem, maximize packing life, ease actuation, reduce maintenance.
12. DESIGN SIMPLICITY/VERSATILITY — Minimal parts, ease of maintenance, long service life, adaptable.



STREAMLINED MOVING PARTS are made to move freely through the slurry with a minimum of resistence to operation. This design can also be furnished as a tank bottom valve.



THREE WAY, DIVERTING, OR CONVERGING. This valve is shown in cast configuration suitable to 300 psig. Fabricated version is available for higher pressures and temperatures.

DURABILITY AND PERFORMANCE FOR SHUT OFF AND ISOLATION APPLICATIONS

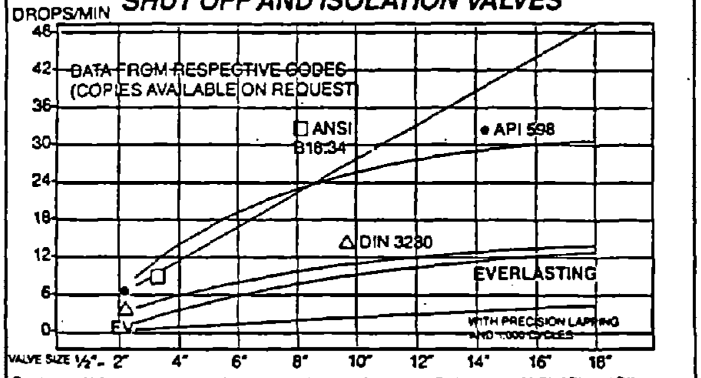
SELF LAPPING, WEARS IN–NOT OUT Rotation of the disc produces an action that in the process medium renews and polishes the metal seating surfaces with each operation. This concept is unique causing the Everlasting valve to wear in with use while all other valves are busy wearing out.

TIGHT SEAL ASSURED The wide seat and disc surfaces are routinely machine lapped during manufacture within several light bands of flatness. This produces a seal that is better than industry standards for SHUT OFF and ISOLATION valves. (Refer to graph). Precision lapping and factory cycling of the valve can reduce leak rates further.

CONSTRUCTION

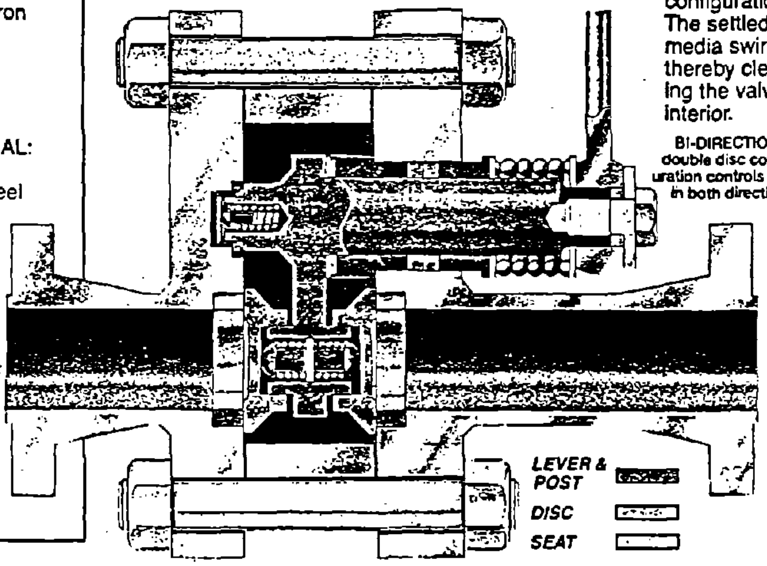
- SIZES: ½" to 24"
- END CONNECTIONS:
  Screwed, flanged, socket and butt weld
- BODY MATERIAL:
  Cast Iron/Ductile Iron
  Carbon Steel
  Stainless Steel
  Weldable Alloys
  Packing/Seals
  Grafoil or PTFE
- DISC/SEAT MATERIAL:
  Stellite #6
  440C Stainless Steel
- BASIS OF DESIGN:
  Vacuum to
  10,000 PSIG
  ANSI Classes
  150, 300, 600,
  900, 1500, 2500
- TEMPERATURES:
  -350 F to 1500+F
- ACTUATORS:
  Manual Lever
  Manual Wheel
  Pneumatic
  Hydraulic
  Electric

ALLOWABLE LEAK RATES
SHUT OFF AND ISOLATION VALVES



Everlasting Valves standard manufacturing practices produce a seal that exceeds ANSI, API, and DIN criteria

SELF CLEANING The valve body openness provides space for the product to be freely displaced by the lever arm and disc with each cycle. Fines can not compact in small open areas and possibly jam components as is the case with other valve concepts. Each time the valve opens to discharge product, a vortex is caused by the eccentric body to port configuration. The settled media swirls; thereby cleaning the valve's interior.



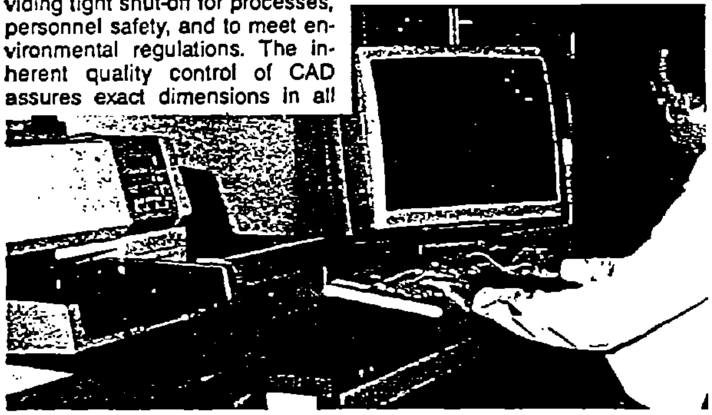
COMPUTER AIDED DESIGN & ROBOTIC WELDER

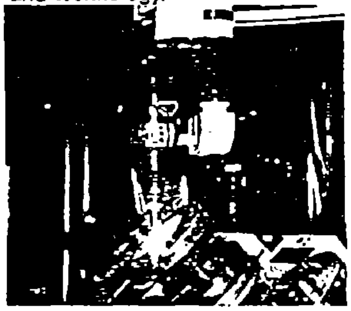
COMPUTER AIDED DESIGN

The engineers utilize CAD and advanced SUN hardware to create valves that will reduce and simplify your plant maintenance while providing tight shut-off for processes, personnel safety, and to meet environmental regulations. The inherent quality control of CAD assures exact dimensions in all parts and assembly drawings. Tolerances are precisely assigned and cross checked electronically, eliminating human error. Drawings are produced by electronic plotters and laser jet printers ensuring quality and accuracy for manufacturing interpretation.

ROBOTIC WELDER

Provides consistent full penetration code certified welds through computerized control. The manufacturing process incorporates innovative and proven procedures and technology.





PRODUCTS & MATERIALS

THE UNIQUE EVERLASTING concept has been incorporated in six distinct product lines.

- SLURRIES, Abrasive Particulate
- BOILER BLOW DOWN
- JACKETED
- STEAM SERVICE
- FIRE PROTECTION
- ABRASIVE SOLIDS

These products provide exceptional service in systems where abrasive and corrosive materials such as the following are transported through piping systems.

- COKING HYDROCARBONS
- CATALYSTS
- STEAM
- COKE
- COAL/COAL SLURRY
- TAR/TAR PITCH
- TITANIUM ORE
- TITANIUM DIOXIDE
- SILICON
- TAIL GAS
- WOOD CHIPS
- SHALE
- FLY ASH/ASH SLURRY
- LIMESTONE
- ALUMINUM
- ALUMINA
- COFFEE GROUNDS
- SULFUR
- SAND
- MINE TAILINGS
- SILICA
- FLAMMABLE LIQUIDS/GASES
- BOILER WATER
- MAGNESIUM SULPHATE
- DIATOMACEOUS EARTH
- OTHER ABRASIVES OR CORROSIVES

EVERLASTING VALVE COMPANY, INC.
108 Somogyi Ct., South Plainfield, NJ 07080 (908) 769-0700
Fax: (908) 769-8697
A subsidiary of Armstrong International, Inc.

BARRETT EQUIPMENT CO.
4111 STONE WAY NORTH
SEATTLE, WA 98103
(206)634-1776