DCN #204-009-02-03

PRELIMINARY SITE VISIT REPORT

FARMER'S VALLEY REFINERY

CONTROL TECHNOLOGY ASSESSMENT OF PETROLEUM REFINERY OPERATIONS

Contract No. 210-81-7102

February 1982

Submitted to:

Phillip A. Froehlich, Project Officer
National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
4676 Columbia Parkway
Cincinnati, Ohio 45226

Submitted by:

Radian Corporation
Occupational Safety and Health Division
1864 South State Street
Salt Lake City, Utah 84115

REPORT NO.:
ECTB 102-14a

TABLE OF CONTENTS

TABLE OF FIGURES

1.0 INTRODUCTION

This preliminary survey report documents a one day visit made at Quaker State Refining's Farmer's Valley Refinery located near Bradford, Pennsylvania. The purpose of the visit was to review control technology strategies used by the refinery in controlling worker exposure to potentially toxic chemical agents and harmful physical agents. Five processing areas were the focus of this visit:

- Lube oil and wax processing
  - wax extraction unit using methyl ethyl ketone and toluene as solvents
  - furfural extraction of lube oils
  - clay filtering of lube oils and waxes
- Lube oil blending
- Lube oil packaging

This preliminary site visit was conducted on September 23, 1981 as part of a NIOSH control technology assessment program being performed by Radian Corporation.

The information contained in this report will provide the basis for selecting control technology strategies for the indepth study phase (III) of this program. When all of the preliminary site visits have been conducted, a summary report will be compiled. This report will summarize the findings of all the preliminary site visits and will recommend which control technologies and refineries will be studied indepth.

At the completion of the indepth study phase of this program, the indepth study results will be disseminated to the refining industry and related industries (in chemical, steel, etc).

Dissemination of information documenting good examples of control technology strategies which reduce worker exposure potential will hopefully reduce potential duplicative control technology development efforts and facilitate earlier application of available controls.

On September 23, 1981 two Radian employees and the NIOSH project officer visited the Farmer's Valley Refinery. Meetings with the following Quaker State personnel were held:

Dennis Cralley - Corporate Safety Coordinator
Ed Fleischer - Farmer's Valley Refinery Manager
Vasil Mriz - Assistant Refinery Manager

These people were very responsive and informative and their participation was greatly appreciated.

In general, due to the age of the Farmer's Valley Refinery units (15-40 years old), traditional industrial hygiene control technologies were noted. The refinery has a good housekeeping program and an active safety program. An indepth study at this refinery may be desirable to measure the effectiveness of the traditional health and safety controls at the MEK dewaxing unit, furfural extraction unit and clay filtering unit. The good housekeeping program and the lack of hydrocarbon odors noted during the preliminary visit indicate that the traditional controls used are effective.

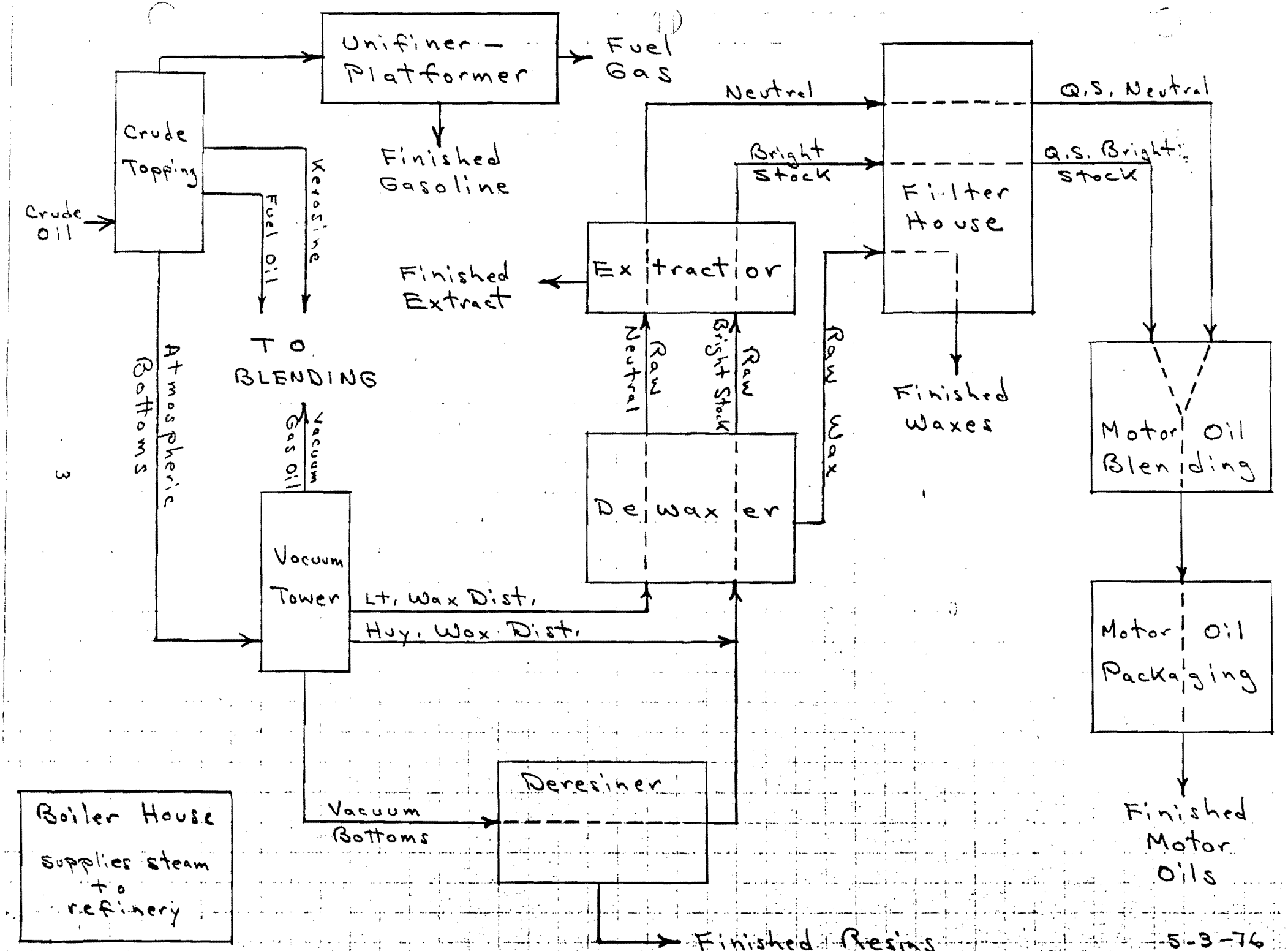


FIGURE 2-1 FARMER'S VALLEY REFINERY

5-3-76
JFB

2.0 PLANT DESCRIPTION

The Farmer's Valley Refinery of Quaker State Oil Refining Corporation is located in McKean County, Pennsylvania, outside of Smethport, Pa. The refinery processes approximately 7000 barrels per day of Pennsylvania type crudes. The refinery has been in operation for many years (≥40) and most of the present units were built during the 1930's, 40's and 50's. Figure 2-1 presents a simplified block flow diagram of the refinery operation.

Crude is brought in by pipeline from a truck unloading terminal two miles from the refinery and feeds from three tanks to the crude distillation unit (crude topping). The topping tower overhead containing naphtha product and lighter hydrocarbons goes to a Unifiner-Platformer unit where naphtha's are catalytically reformed to isoparaffins, benzene, toluene and xylenes (reformate). The reformate product from the unit goes to gasoline product and the lighter hydrocarbons (C_4 and lighter) are used as fuel gas by the refinery processing units. Kerosene and fuel oil products are also recovered from the crude topping unit.

Crude topping unit bottoms product (atmospheric bottoms) flows to a vacuum distillation tower. The vacuum tower overhead product (vacuum gas oil) goes to fuel oil blending with the kerosene and fuel oil cuts from the topping tower. Light wax distillate and heavy wax distillate products are drawn from the side of the vacuum tower and flow to lube oil and wax processing units. The vacuum tower bottoms product goes to the propane deresiner unit for treatment. Finished resins are sold to a chemical company for the manufacture of penetration grade asphalt. The deresined oil combines with the heavy wax distillate before lube-wax processing.

The light and heavy wax distillate and deresined oil (DRO) are block flow processed into finished lube oil and wax products. These lube oil products are the ones of primary interest to Quaker State, the largest producer of motor oils in the U.S. The wax distillates are dewaxed by conventional methyl ethyl ketone/toluene dewaxing process. This unit produces waxes which are filtered through bauxite before being sold as finished waxes. In addition, an oily wax byproduct is produced by the MEK unit and is sold as footesoil and petrolatum products. The dewaxed oils leaving the MEK unit go to a furfural extracting unit where trace amounts of unstable compounds are removed from the oils. The furfural treated oils (neutral and bright stock) are filtered through bauxite for final color improvement and blended into finished motor oils and packaged for sale.

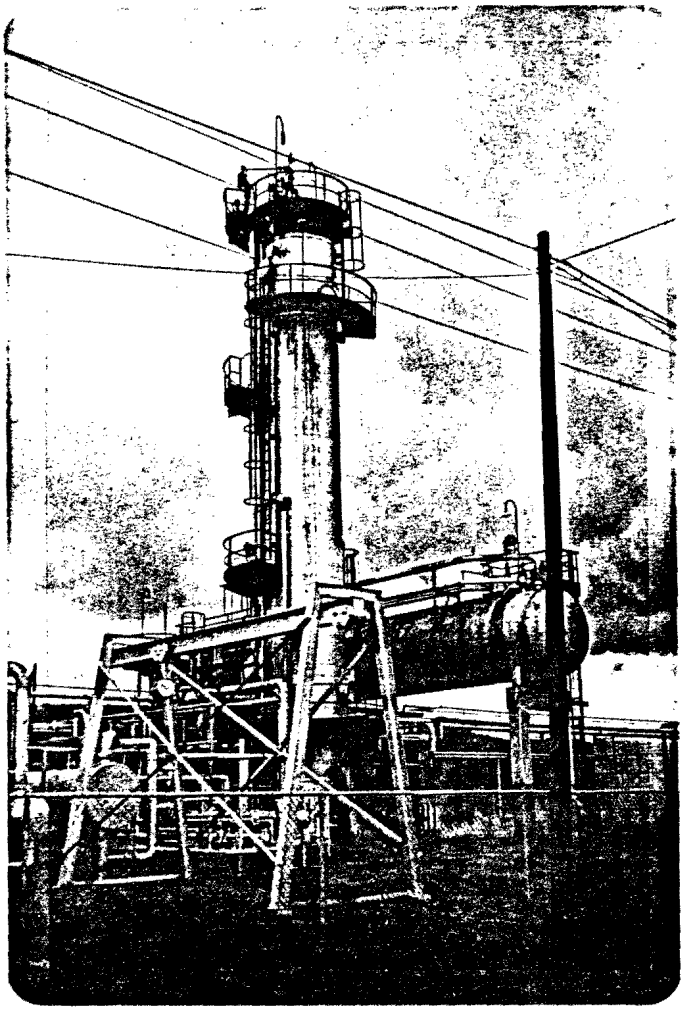
Process steam for refinery use is generated onsite in coal fired boilers. Plant water comes from water wells within the refinery. Refinery waste waters are treated by an API separator, dissolved air flotation unit, biological oxidation unit, clarifier and spray pond before discharged back into a creek.

The refinery operates every day of the year and employs 225 people:

Administrative (Salaried)	-40
Skilled Maintenance (Hourly)	-51
General Labor (Hourly)	-27
Operators (Hourly)	-107

Operators work three eight hour shifts a day (8 to 4, 4 to 12, 12 to 8) at the main processing units. Motor oil packaging and product loading units operate between 1 and 2 shifts per day, five days a week.

Figures 2-2 and 2-3 present photographs taken of the PDR unit and Furfural unit, respectively. These units are the newest lube oil treating units in the refinery and typify the type of construction of the era (1940's-1960's). Photographs of other process units were not obtainable due to safety regulations regarding potential ignition sources.



Propane and

Vacuum Bottoms

RDC Tower

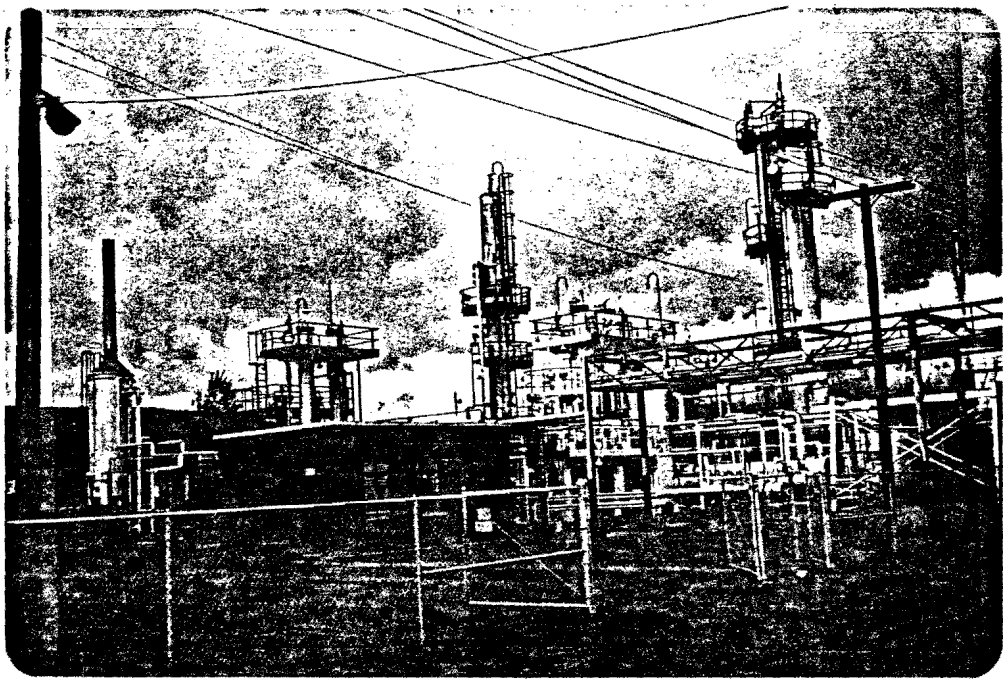
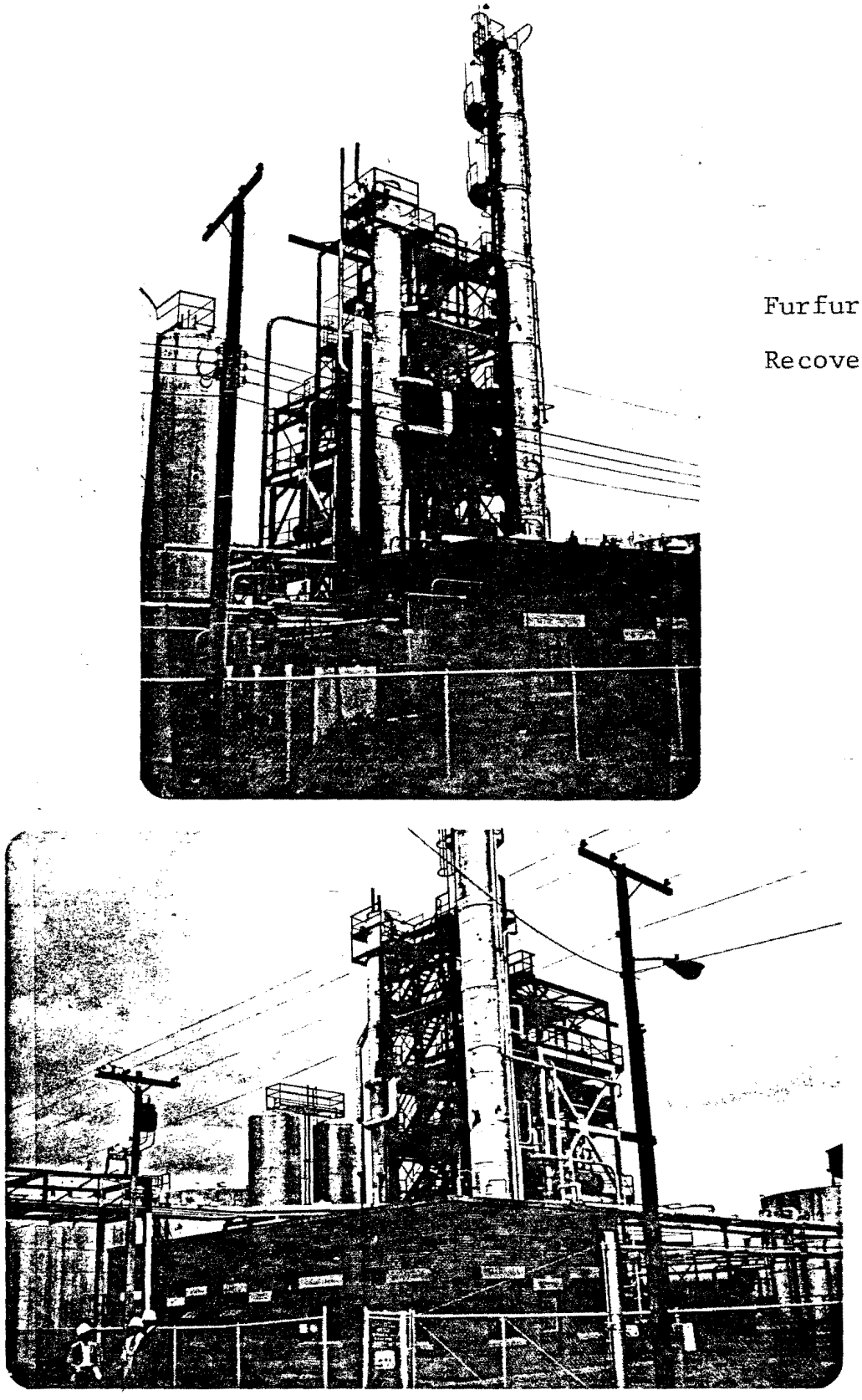


FIGURE 2-2 PDR UNIT



Furfural

Recovery

FIGURE 2-3 FURFURAL UNIT

3.0 PROCESS DESCRIPTIONS

The refinery units of interest during this preliminary site visit were:

- o Lube and wax processing
  - Methyl ethyl ketone/toluene (MEK) dewaxing unit
  - Furfural extraction unit
  - Bauxite filtering unit
- o Lube oil blending and packaging plant

Although this refinery also has a catalytic reforming unit and extensive wastewater treating facilities, these units were not studied. Brief process descriptions of each of the units reviewed follow.

3.1 MEK Dewaxing Unit

Dewaxing is the most difficult part of lube oil manufacture. The dewaxing process removes wax from lube oils to improve the low temperature fluidity characteristics of the oil. The oil is contacted with solvent and chilled, causing the wax to precipitate. The precipitated wax is separated from the mixture by vacuum filtration. The dewaxed oil and solvent are separated by distillation and steam stripping. Solvent is recycled. The wax, usually containing at least 10 percent oil, is solvent treated again under different conditions to obtain a deoiled wax product of the desired specifications. Refrigeration, filtration, and distillation are used to recover the wax and solvent.

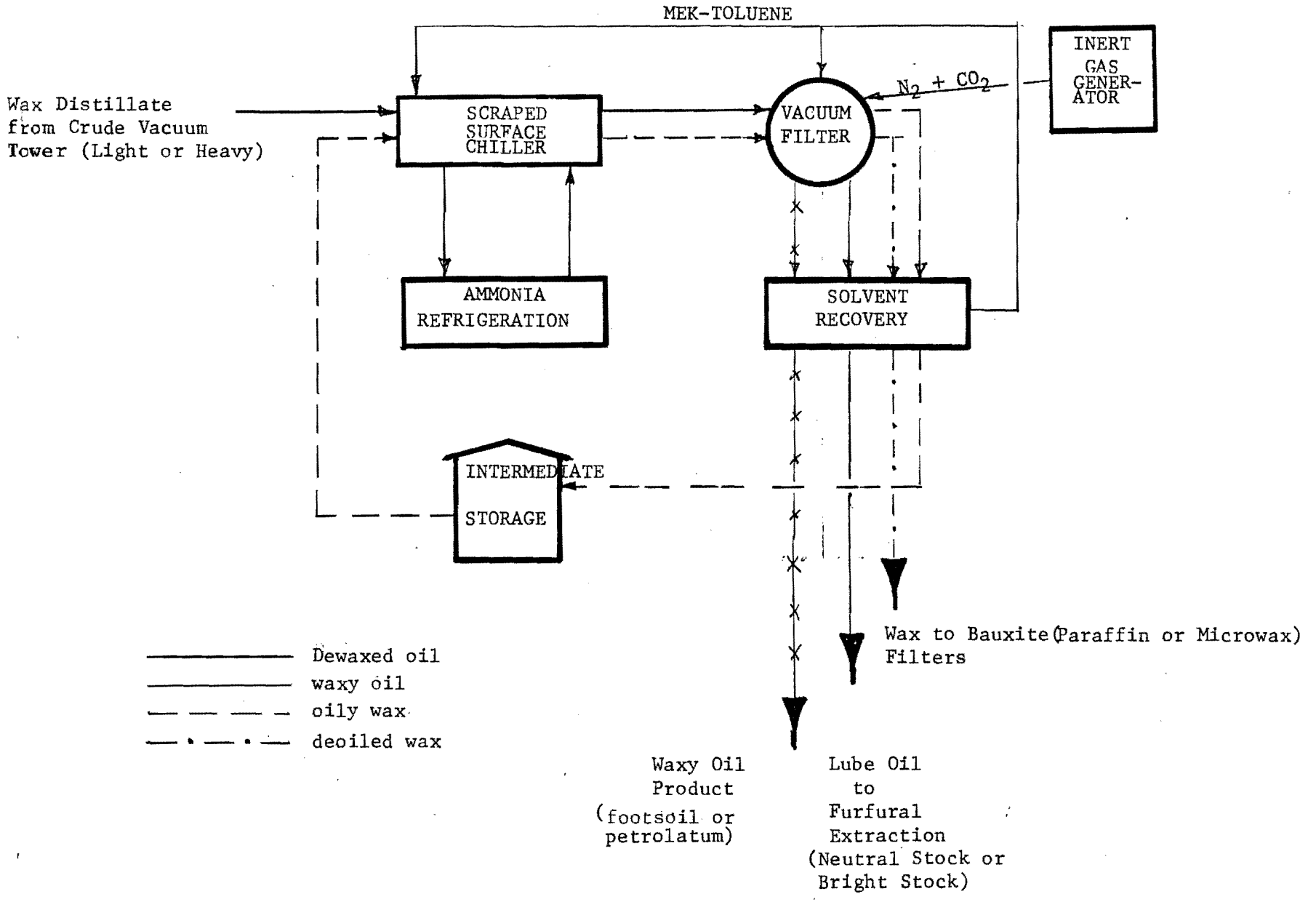
The most widely used solvent for oil dewaxing and wax

deoiling is a mixture of methyl ethyl ketone (MEK) and toluene or benzene. A 50-50 mixture of MEK and toluene are used as solvent at the Farmer's Valley refinery. At one time a MEK-toluene-benzene mixture was used, but the concern over employee exposures to benzene resulted in eliminating its use.

Like many other refiners, Farmer's Valley operates its dewaxing unit on a block flow operation. That is, one product (light wax distillate, DRO and heavy distillate, slack wax, or petrolatum) is dewaxed or deoiled at a time. This requires intermediate tankage to hold the partially processed products. Figure 3-1 shows a simplified process diagram of the dewaxing unit operation.

Wax distillate from the crude unit vacuum tower is mixed with MEK-toluene solvent and passed through scraped tube chillers (heat exchangers). Wax in the distillate crystallizes due to the lowered temperature and presence of the MEK-T solvent. Four rotary drum vacuum filters are used to filter the crystallized wax from the lube oil. The lube oil is steam stripped for solvent recovery and goes to the furfural extraction unit. The light distillate oil is called neutral stock and the heavy oil distillate plus DRO is called bright stock. The wax from the filter still has approximately 10% oil (oily wax). This oily wax is steam stripped for solvent recovery and sent to intermediate storage. After several days run on the wax distillate, the accumulation of oily wax must be processed. This oily wax is processed back through the unit and most of the remaining oil is removed. The oily filtrate produced has some wax in it (waxy oil) and is sold as a product after solvent recovery. Waxy oil from light wax distillate is called footesoil and waxy oil from heavy wax distillate and DRO is called petrolatum.

FIGURE 3-1 MEK DEWAXING UNIT



The deoiled wax from the filter drum is steam stripped for solvent recovery and goes to the bauxite clay filter for final treatment before sale. Wax product from the light wax distillate is called paraffin wax and wax product from the heavy wax distillate and DRO is called microwax.

Refrigeration for the scraped surface chillers is provided using ammonia as the refrigerant. Most newer plants use propane as the refrigerant. Inert gas required for blowing the wax filter cake off the fabric filters on the rotary vacuum drum is produced by an inert gas generator. This generator produces a N_2 and CO_2 stream by the controlled combustion of natural gas. Oxygen in the inert stream is kept at negligible levels by carefully controlling the combustion excess air.

Approximately 44,000 gallons of MEK and 36,000 gallons of toluene were made up to the unit in 1980 (i.e. losses).

3.2 Furfural Extraction Unit

There are several extraction processes used to improve the characteristics of lube oils. One of the most popular, furfural extraction, is used by the Farmer's Valley refinery to improve the lube oil viscosity index, color and carbon residue content. Figure 3-2 presents a simplified block flow diagram of the furfural extraction unit.

In operation, the neutral and bright stocks from the MEK-T dewaxing unit are block treated through the furfural unit. The untreated oil is well contacted with furfural in a packed column. The treated lube stock leaves the top of the contacting tower and is pumped to a fractionation and steam stripping tower where residual furfural is stripped from the lube oil for recovery.

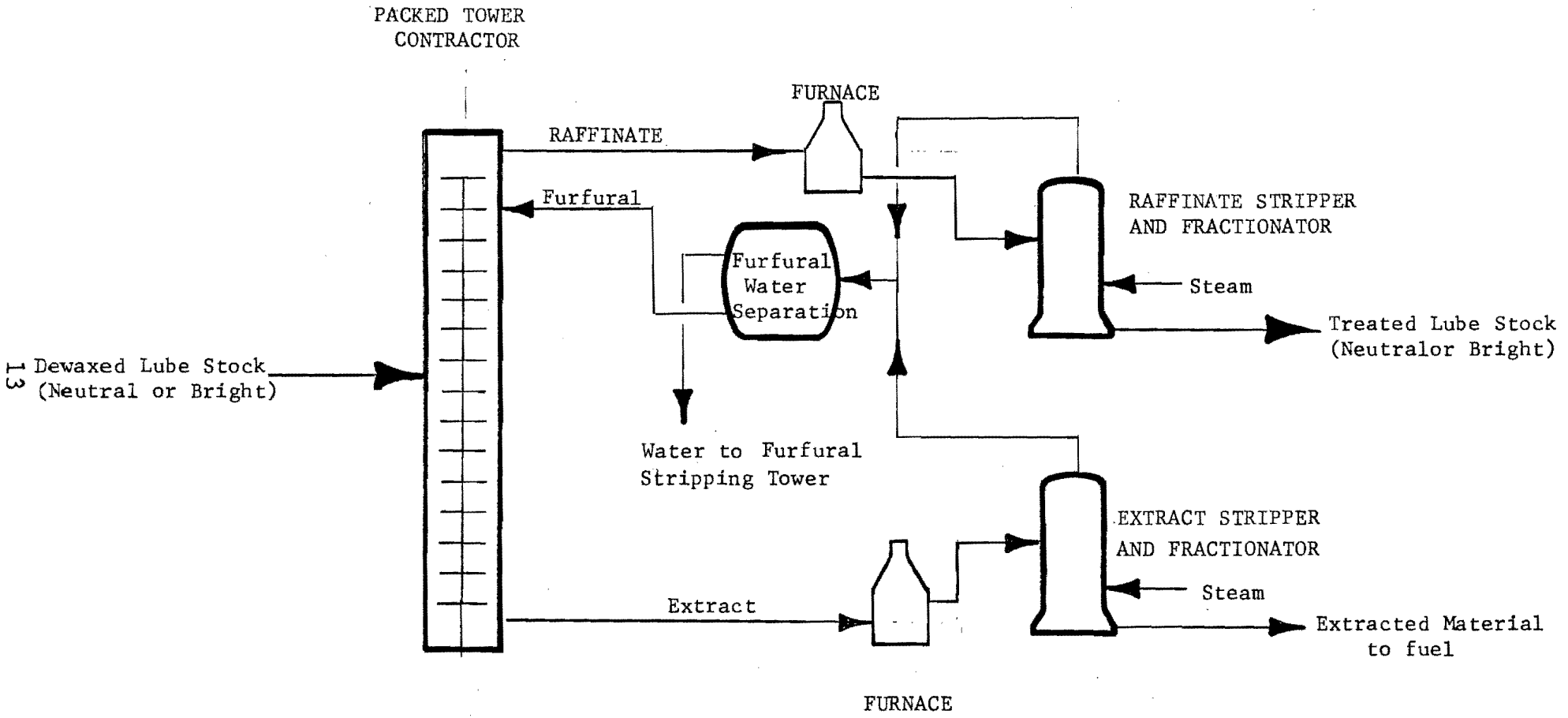


Figure 3-2 FURFURAL EXTRACTION UNIT

The steam stripped lube stock goes to storage before clay filtering and blending/packaging. Furfural and water stripped from the treated lube stocks are separated and the furfural is recycled back to the contractor. The water goes to a furfural stripper and then to the process sewer.

The extract (furfural and undesirable components) leaves the bottom of the contactor and is also steam stripped for the recovery of furfural. The furfural after water separation is recycled back to the packed contact tower and the water goes to the furfural stripper. The extract is used as fuel in the plant.

Approximately 16,000 gallons of furfural was made up to the unit in 1980 (i.e. losses).

3.3 Clay Filters

The color of a lube oil or wax product can be quickly deteriorated by the presence of traces of resinous materials and chemically active compounds. A number of compounds are used to adsorb these undesirable resinous chemicals: various types of mineral clays, activated earth or artificial adsorbents. The Farmer's Valley Refinery uses a 20-60 mesh bauxite for finishing lube oil stocks (neutral and bright) and some wax products. Figure 3-3 presents a simplified block flow diagram of this process.

The lube stock and waxes are heated and passed through beds of bauxite. The bauxite filters out the undesirable color and chemically reactive compounds. Once the adsorbtion/filtering capacity of the bauxite is used up, the bauxite is washed with naphtha, steam stripped to remove all of the

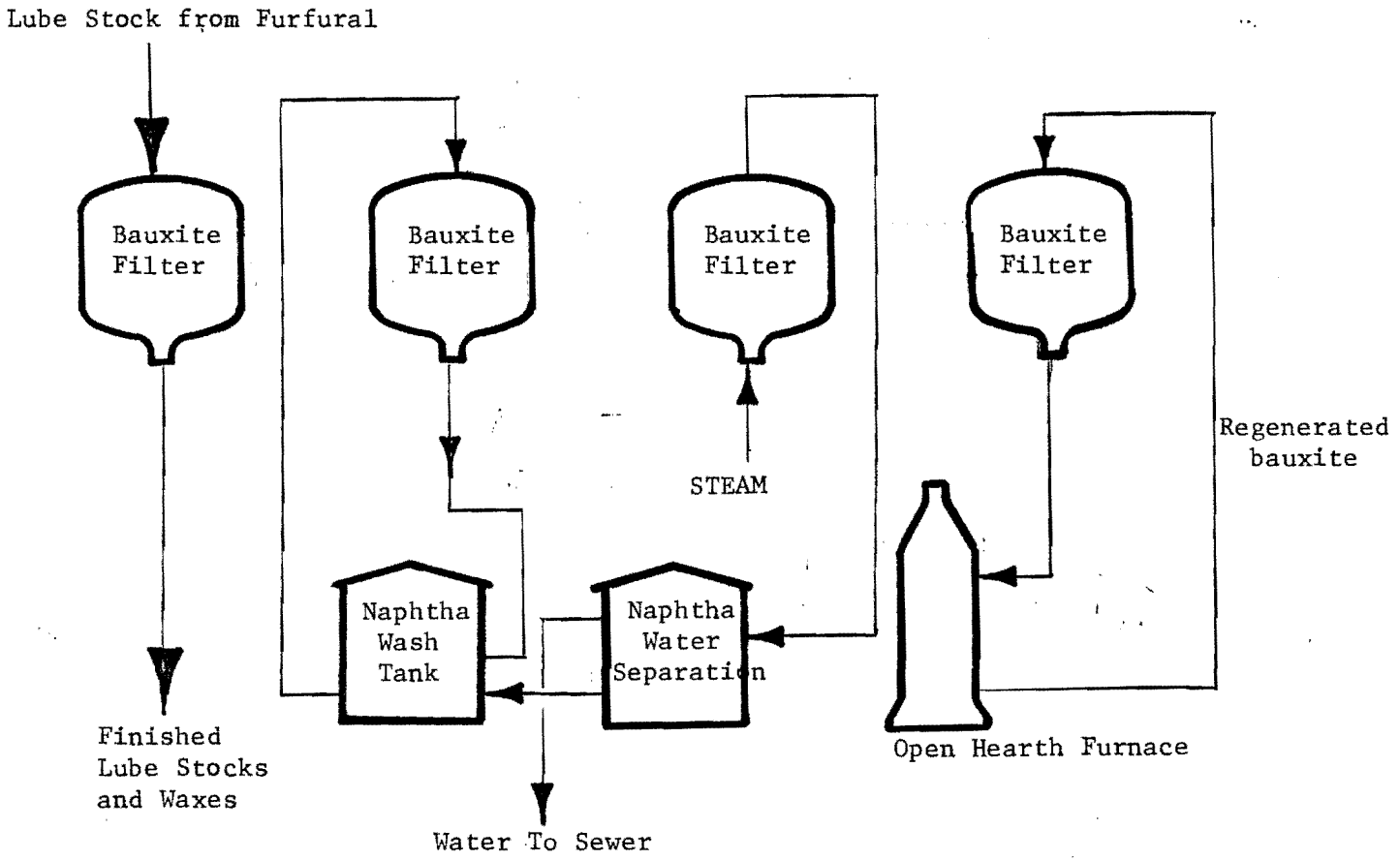


FIGURE 3-3 BAUXITE FILTERS

naphtha wash, and dumped from the filter bed. The dumped bauxite is then regenerated by burning off adsorbed hydrocarbons in an open hearth furnace. The regenerated clay is placed back in the filter bed and is ready again for finishing lube oils and waxes.

Presently in operation at Farmer's Valley are six 16-ton filters, sixteen 7-ton filters and eight 5-ton filters. Two to three filters are regenerated per day on the average. The handling and regeneration processes cause a loss of bauxite and in 1980 approximately 150 tons was required to make up losses. Naphtha used to wash down the bauxite before regeneration is recovered and reused in the operation.

3.4 Blending and Packaging Plants

At the blending plant, lube oil stocks are blended with each other and additives to meet motor oil specifications. All of the blending is done from lube stock and additive tanks, with pumps, control valves and meters. The blended oils are stored in intermediate tankage before being packaged by automatic packaging machines. Figure 3-4 presents a simplified flow diagram of the process. Additives used are concentrated in lube oil made to Quaker State specifications and are delivered by truck and rail cars and unloaded into additive storage tanks.

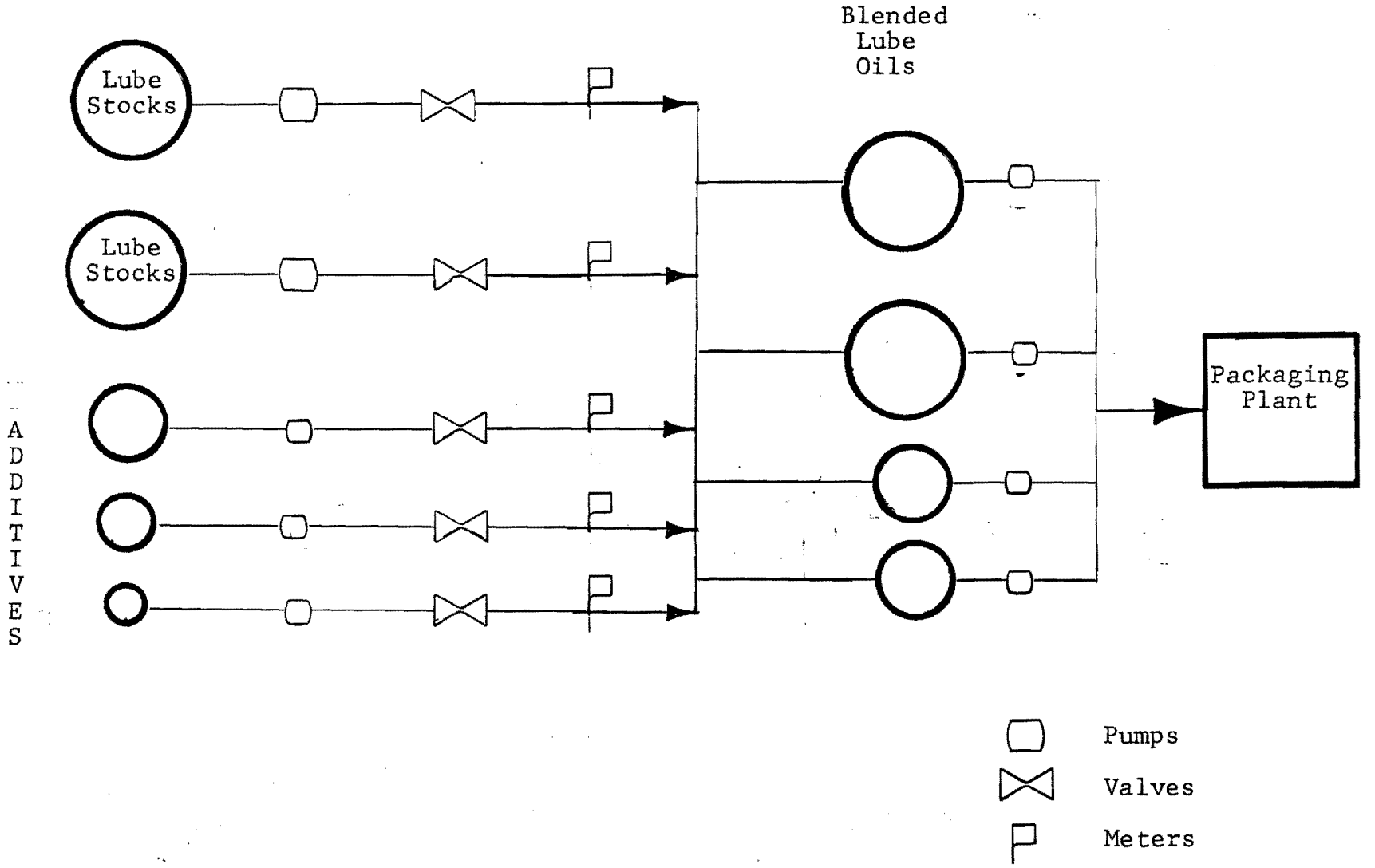


FIGURE 3-4 BLENDING AND PACKAGING PLANTS

4.0 GENERAL HEALTH AND SAFETY PROGRAMS

This section documents the general corporate and refinery wide health and safety programs present at the Farmers Valley Refinery. Presently, no full-time industrial hygienist serves Quaker State refineries. This appears to be common for small refiners. The corporate safety director has assumed a number of responsibilities related to industrial hygiene and has implemented a number of needed programs.

Several personnel monitoring projects have recently been conducted at the Farmer's Valley Refinery to identify areas of concern. Last summer (1981) passive dosimeter testing for furfural, methyl ethyl ketone, toluene, ammonia, and hydrogen sulfide was conducted for operating personnel that have the potential for exposure to these substances. Day shift personnel used the same dosimeters for three consecutive eight hour days. Results of this testing were not available from the laboratory at the time of this visit. These testing results will be used to formulate future industrial hygiene activities for the refinery.

As at most refineries, Farmer's Valley has an active safety program. This program includes:

- yearly fire training
- monthly safety meetings
- regular safety presentations by corporate safety coordinator on special topics (i.e. flammable liquids handling) and
- regular NPRA regional fire and safety meeting

After the visit to the Farmers Valley Refinery, a meeting of

the regional NPRA fire and safety group was attended. This group consisted of safety personnel from a number of small refineries in the Pennsylvania and West Virginia areas.

The meeting was held at one of the participants refinery and included an inspection of the refinery and discussions of fire and safety issues at all of the participating refineries. The meetings serve the purpose of problem solving by information transfer and problem identification by the refinery inspection conducted at the host refinery. In addition verbal commendations to those refineries which have good safety records, good housekeeping and good safety programs are made by meeting attendees. Although similar fire and safety meetings in other U.S. refinery regions are supported by NPRA, this group appears to be one of the most active ones. Because the meeting attendees are all small refiners with limited health and safety resources, these meetings appear to be a valuable part of their employee protection programs.

The Farmer's Valley Refinery also has an active respirator program. This program includes a recently implemented clean-face policy and respirator fit testing program. Quaker State believes that these programs in addition to well maintained respirators and adequately available respirators are the key to proper personnel protection from airborne toxics. When the yearly respirator fit testing is conducted, instruction on what toxic substances are present in the refinery and the toxic characteristics of the substances is given to refinery personnel.

Currently, other than preemployment physicals, no regular medical exams are given. Blood testing for lead is given once a year to those employees with the potential for lead exposure from gasoline blending with tetra-ethyl lead and tetra-methyl lead.

5.0 DESCRIPTION OF CONTROL STRATEGIES

For each of the processing areas studied, the following observed control strategies are described:

- Engineering controls
- Monitoring
- Personnel protective equipment
- Work practices

Engineering controls in this context are process equipment items which limit employee exposure such as special seals on pumps and compressors or pressurized control rooms. Monitoring strategies include personnel monitoring and ambient monitoring. Personal protective equipment includes: gloves, suits, respirators, etc. Work practices would include procedures which reduce the potential for worker exposure, such as work permit programs.

5.1 MEK Dewaxing Unit

The MEK-toluene dewaxing unit is somewhat divided into five areas: ammonia refrigeration building, scraped tube chiller section, filter building, solvent recovery section and the inert gas generation building. The unit has four persons working in it per eight-hour shift: operator, helper, refrigeration man and filter man. The unit is well maintained and general housekeeping is excellent. Process instrumentation is typical for the period of plant construction.

Engineering Controls

The ammonia refrigeration building houses the ammonia compressors and controls. An operator station is provided

in the center of the building for logging of pertinent process and mechanical data. The ammonia refrigeration plant building is of brick construction and has several doors and windows, some of which were open during the visit. Good ventilation was provided and only a very slight ammonia odor was present in the building.

The scraped tube chillers are located adjacent to the ammonia building and are covered by a roofed structure with essentially open side walls. No ammonia or MEK-Toluene odors were noticed.

The wax filter building is completely enclosed and has the four rotary vacuum filters located on the second floor and pumps located on the first floor. A mid building area also provides access to the bottom sides of the filters. An operator station is located on the second floor against the wall for logging process data and controlling the filter operation. A similar operator station is located on the first floor of the building right under second floor station. Because of the good housekeeping and the vacuum on the filter drums, only a slight sweet odor (MEK) was noticed in this building.

Adjacent to the filter building is the solvent recovery area. This area is open and contains a number of steam stripping towers, condensate drums and solvent storage vessels. A small brick control room is located against the first floor wall of the filter building. Because of the good housekeeping (every brick edge of the brick floor in this area was visible) and the openness of the area, no solvent odors were noticed.

The inert gas generator was located at the end of the solvent recovery area and was housed in a small building.

Nitrogen and carbon dioxide gas produced from the controlled combustion of propane provided a safe (oxygen free) gas for use in the rotary drum filters for wax cake removal from the filter media.

Monitoring

Continuous area monitoring is not conducted at this unit. However, Draeger tube monitoring is conducted for hydrocarbons, MEK, toluene and ammonia if a strong odor is present in one of the work areas. Also, personal dosimetry monitoring is conducted for these chemicals.

Personal Protective Clothing

In general personal protective clothing is not worn in this unit. An MSA Gas Mask model TC 14G88 is located in the ammonia refrigeration building for instances where minor ammonia leaks occur. Respirators are also readily available around the unit in the event of a solvent leak and spill.

Work Practices

Most procedures followed during unit operation, turnaround and upset are common to the industry. Replacement of the vacuum filter cloth is probably one of the most frequent major maintenance items. This occurs for each filter in a 12-16 month cycle. Normally one filter is taken out of service while the other three remain operational. The filter is blinded off, and water washed for at least 16 hours. Before the filter cover is removed, a laboratory man takes a hydrocarbon vapor reading. If hydrocarbons are still present the filter is washed again and retested. After washing the filter top is lifted off

by an overhead block and tackle and moved out of the way in the building. The filter cloth is removed and replaced with the whole operation requiring 2-3 days of filter down time.

5.2 Furfural Extraction

This unit is located at one end of the refinery across a road from the propane deresining (PDR) unit. One operator per shift is assigned to the furfural unit and one helper is shared between the furfural unit and the PDR unit. Again few control strategies other than good housekeeping and safety practices were noted. Respirators and rubber gloves are readily available for handling furfural leaks or spills.

Engineering Controls

The unit as laid out is completely open air except for the brick pump control room located at one corner of the unit. This type of construction typical in the refining industry minimizes build up of hydrocarbon vapors and worker exposure unless a large leak occurs. Little furfural odor was noted anywhere in the unit.

Monitoring

No continuous area monitoring is conducted at the furfural unit. Recent personnel monitoring for hydrocarbons and furfural was conducted using passive dosimeters and these results all showed furfural levels to be less than 3 ppm (8-hr TWA).

Personal Protective Clothing

No special personal protective clothing is typically

used in this unit other than safety helmet and rubber gloves.

Work Practices

No special procedures other than those normally practiced by the industry for unit operation and maintenance were noted. As mentioned earlier good housekeeping and safety practices are followed.

5.3 Bauxite Filtering

As described earlier this unit is used to filter waxes and lube oils for final color and stability characteristics. The unit is located adjacent to the MEK-T unit and is enclosed in a large metal building. One operator and one helper per shift run this unit.

Engineering Controls

During normal filtering operations, the clay filters are enclosed pressure vessels presenting little chance of worker exposure to hydrocarbons or clay. However, regeneration of the clay requires dumping the clay from the filter onto a conveyor which conveys the clay to the open hearth furnace. This operation is quite dusty. Dust shrouds are used to cover the conveyor belt to reduce dust emissions. In addition, the enclosed nature of the filter building reduces the chance of airborne clay particles reaching refinery workers at other units. A water scrubber on the flue gas vent of the open hearth furnace also prevents dust emissions from leaving the filter building area.

Monitoring

No area or personnel monitoring is conducted in the filter building area.

Personal Protective Clothing

Because dumping of the bauxite from the clay filters is a dusty operation, operating personnel are required to wear half-mask dust respirators during this operation. This coupled with the refinery's clean face policy and yearly respirator fit testing provides the dust protection program for this intermittent dusty operation.

Work Practices

In general, standard industry good housekeeping and safety procedures are followed.

5.4 Blending and Packaging Plant

These units unlike most of the other refinery units are not run continuously 24 hours a day. Depending on the time of year, operation is from 1 to 2 shifts per day, five days a week. The lube oil blending plant is run with one operator and one helper on day shift only. The motor oil packaging plant has 19 permanent employees plus additional laborers for loading trucks by hand. All operations, except for tankage and additive car unloading, are conducted in buildings.

Engineering Controls

As described earlier, most of the process operations

ongoing at these plants are contained within the process equipment: tanks, lines, valves, pumps, meters and cans. Worker exposures would occur due to leaks, tank gauging, unloading additive cars, can filling, and equipment maintenance. Because of the high boiling point liquids being processed, most potentially hazardous exposures would occur from skin contact. Automated blending and dispensing equipment is utilized. Employee contact with oil is minimal. Oil spills and damaged oil containers are the major source of contact. The blending/packaging plants at Farmer's Valley were quite old and some movement of packaged lube oils was done by hand (no fork lifts). Much package movement is accomplished using motorized conveyors. In addition, metal cans are still being used by Quaker State (soon to be discontinued) and these cans create major noise levels during the packaging operation. After the preliminary visit was conducted the packaging operation was converted to using fiber cans. No significant reduction in noise levels was noted.

Monitoring

Other than sound level surveys, no area or personnel monitoring is conducted in this area.

Personal Protective Clothing

Standard safety equipment is utilized at these plants: safety hat and appropriate gloves where necessary. Ear plugs or ear muffs are required by workers in high noise areas.

Work Practices

In general, standard industry good housekeeping and safety procedures were followed. As mentioned previously, some

of the moving and loading of packaged lube oils was done by manual labor instead of conveyors or fork lifts. However, conveyors, motorized and gravity, are used as much as possible.

6.0 CONCLUSIONS AND RECOMMENDATIONS

In general, due to the age of the Farmer's Valley Refinery units, only traditional industrial hygiene control strategies were noted. Periodic personnel monitoring and area monitoring during maintenance is conducted for hazardous vapors. The refinery had good housekeeping procedures and an active safety program. A corporate wide industrial hygiene program is being developed by Quaker State at this time. However, small refiners usually do not have ongoing industrial hygiene programs.

An indepth study at the Farmer's Valley refinery, however, may be desirable for evaluating the effectiveness of traditional health and safety controls and good housekeeping policies. This evaluation would also serve as a baseline for evaluating worker exposures related to new lube/wax processes. At least two other refineries that will be visited for preliminary site review have lube oil hydrotreaters (Quaker State - Congo and Sigmor - Three Rivers) which replace the need for furfural extraction and clay filtering. Analysis of worker exposure at old and new processing units would require a week at each refinery to collect samples and gather data. Two to three Radian personnel would be required at each location.

At least one other refinery to be visited has a new (1972) lube oil blending/packaging plant (Quaker State - Congo). A comparison of new and old facilities with regard to the effectiveness of controls at these facilities may also be of interest. Control technology evaluation at old and new processing units would require a week at each refinery to collect samples and gather data. Two to three Radian personnel would be required at each location.

One additional item of note was the NPRA regional fire and safety meeting attended between the preliminary visits to Quaker States' Farmer's Valley and Congo refineries. The function of this meeting was to have an exchange of ideas and problems between safety personnel of different refineries and have a plant inspection by the same group of people. These meetings are held a number of times a year at different host refineries. The dialog between safety personnel was very stimulating and items noted during the inspection tour were of interest to the host refinery and visiting refiners. This type of program would seem to be very beneficial to any refiner and in particular to smaller refiners with limited safety and health resources.