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THE IMPACT OF BENZENE ON REFINERY WASTEWATER SYSTEMS

by

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THE IMPACT OF BENZENE ON REFINERY WASTEWATER SYSTEMS

Since 1990 the Hydrocarbon Processing Industry (HPI) in the USA has been involved in a major transformation dictated by new stricter air and water quality control requirements. While most hydrocarbon processing plants have initially focused their attention on the complex issues related to the regulations contained in the 1990 Amendments to the Clean Air Act, an equally daunting task will be to reconstruct their waste water systems to comply with the Resource Conservation and Recovery Act (RCRA) and the Clean Water Act (CWA).

The list of hazardous contaminants is long and comprehensive, but one of the most evaluated and regulated components is Benzene. In order to provide understanding of the complexity of these new requirements as well as the effort and cost involved with compliance, a brief review of the pertinent federal regulations is provided below.

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act was promulgated in 1980 and is the first comprehensive federal regulation of solid waste. It was enacted to achieve two basic objectives: (1) protection of public health and the environment, and (2) the conservation of national resources.

In order to assist in achieving these goals, RCRA provides three programs: (1) the establishment of a hazardous waste control program, (2) the establishment of a land-disposal regulatory program, and (3) the creation of resource conservation programs to conserve resources and reduce the amount of solid waste requiring land disposal. These programs are administered and run by State and local governments, and where these choose not to do so, the responsibility falls on the Environmental Protection Agency (EPA).

In 1990, the EPA enacted two rules that essentially converted all wastewater produced in US refineries into hazardous wastes under RCRA regulations. One of these, the Toxicity Characteristic (TC) rule, expanded the original list of toxic compounds, which initially was absent of organics, by adding 25 organic components. Benzene, with a hazardous threshold of 0.5 ppm (0.5 mg/l), was included in this list. Table I, shows the list of old and new chemicals and TC threshold regulatory levels. All wastewater systems where any of these components exceed these levels are therefore considered hazardous and are subject to, and must be permitted under RCRA regulations.

Most of the impact of these regulations is presently on the design and operation of impoundments. The permitting requirements for design, installation and operation of tank systems containing hazardous wastes are contained in 40 CFR Part 264, Subpart J. These requirements address the design of all tank components, such as:

- Tank shell, top, bottom and foundations,
- Tank ancillary equipment (i.e., pipes, pumps, valves),
- Pressure control and overflow control devices, and
- Secondary containment system.

New tank systems must be designed in accordance with published design standards recognized by the regulatory agencies, such as American Petroleum Institute (API) standards 650 and 620 (for steel tanks) and American Concrete Institute (ACI) standards 318 and 350 (for concrete tanks).

The secondary containment system provided for the tanks must be designed to:

1. Prevent migration of hazardous waste or accumulated liquids to the soil, ground water or surface water,

2. Collect and detect releases and accumulated liquids until the collected material is removed, and

3. Provide sufficient capacity to contain 100 percent of the actual volume of the largest tank or tank system, plus the volume of rainwater which would be collected by a 25-year, 24-hour rainfall event.

Clean Water Act (CWA)

The Clean Water Act regulates the discharge of wastewater and stormwater to surface waters or to Publicly Owned Treatment Works (POTW's). The regulations are enforced through the establishment of National Pollution Discharge Elimination Systems (NPDES) permits.

Historically these permits were granted when industries demonstrated that they were using Best Technology Economically Available (BAT). These technologies generally consist of primary separation of oil and solids (API separators), followed by secondary separation steps such as air flotation, biological treatment (aeration ponds) and a final polishing step. It is now widely expected that, rather than continuing with limitations based on technology, EPA will regulate and enforce water quality based limits.

The first water quality standards were promulgated by EPA in 1983 (40 CFR 131). The states were to regulate and to enforce these standards, but progress has been slow and specific numeric criteria for water quality monitoring and compliance with regulations is still to be defined. However, the EPA has clearly stated that the purpose of the new water quality standards is to go beyond what can be achieved with BAT treatments.

Although EPA's policies for water quality control includes a wide range of areas, such as Spill Control Plans, Contaminated Sediments, Wetlands, Ground water Protection, etc., the requirements for refinery wastewater and stormwater systems are expected to be clarified in 1993-1994. Meanwhile, refineries are modifying these systems in compliance with RCRA and the Clean Air Act, hoping that future CWA requirements will not substantially outdate their new facilities.

Clean Air Act (CAA)

Prior to 1990, Air Emission Regulations were primarily based on reducing emission of Volatile Organic Compounds (VOC) with the idea of reducing smog. VOC react with nitrogen oxides in the presence of sunlight to form ozone. Ozone in the lower atmosphere is the primary constituent of smog. VOC emissions are regulated as a function of tank capacity and the vapor pressure of the product in the tank.

These regulations indicate that facilities emitting 40 tons or more per year of any air pollutants are considered a "major source" and are subject to rather stringent emission control standards. These are called New Source Performance Standards (NSPS).

The 1990 Amendments to the Clean Air Act required EPA to issue approximately 400 new regulations. Among them, the most important are described under Title 3 - Air Toxics. These regulations establish emission standards, monitoring and testing requirements for pollutants considered to be mutagenic and carcinogenic hazards. These standards are the National Emission Standards for Hazardous Air Pollutants (NESHAPs). Table II shows the 189 hazardous air pollutants that have been listed. Any emissions containing a listed chemical will be subject to new control standards yet to be specified. Benzene, however, is the single component that has been regulated in great detail, through the 1990 promulgation of the Benzene National Emission Standards for Hazardous Air Pollutants.

Benzene Neshaps

The Benzene Neshaps rule was published in March of 1990 and is described in 40 CFR 61.340-358. Most of the impact of this rule is on facilities with more than 10 Megagrams (tons) total annual benzene in their waste water streams.

For these facilities the rule generally requires that all water streams containing 10 ppm or more benzene must be treated to reduce the benzene concentration by 99 % or below 10 ppm, and be handled prior to treatment in units equipped with effective emission controls.

Why Benzene?

Extensive research has demonstrated that excessive exposure to benzene may result in headaches, dizziness, skin and respiratory tract irritation, and even convulsions and loss of consciousness. Long term exposure, even at relatively low concentrations, may result in serious hematological disorders such as anemia or leukemia.

The Occupational Safety and Health Administration (OSHA) has regulated all occupational exposures to Benzene in 29 CFR 1910.1028. Permissible exposure for an 8-hour period has been established at 1 ppm of benzene in air on a time weighted average basis. Short term exposures should not exceed 5 ppm over any 15 minute period.

By regulating Benzene bearing water streams, EPA has impacted almost every facility in the hydrocarbon processing industry. Benzene is present in wastewater and stormwater systems of refineries, aromatic production facilities, olefin plants, and even gas processing plants.

Compliance with Benzene Neshaps

Operators seem to agree that the simplest and most complete approach to full compliance with Benzene Neshaps is based on the 10 ppm rule. All streams with benzene concentrations of 10 ppm and higher are combined and managed in totally enclosed emission controlled systems, and then processed in Benzene strippers. Treated water, with typical benzene concentrations of 0.5 ppm or lower, is then combined with other wastewater streams for further processing in a conventional wastewater treatment plant. Some facilities, where sources of contamination are located far apart, have found it more practical and economical to treat individual streams at the source, or to group several streams and process them in several treatment units throughout the facility.

Figure 1 shows a centralized approach to Benzene Neshaps compliance. The requirement is to reduce benzene emissions levels below 1 Mg (ton)/year for any facility.

There are several options to strip Benzene from wastewater, such as vacuum or air stripping. However, the simplicity and relatively low cost of steam stripping is rapidly establishing this processing alternative as the industry standard.

The processing scheme is very simple and is schematically depicted in Figure 2. Wastewater at essentially ambient temperature is typically preheated in a feed-bottoms exchanger and then fed to the top tray of the column.

Hydrocarbon stripping is achieved by either bottom liquid reboiling or by injection of live low pressure steam. Column overhead vapors, comprised of all stripped hydrocarbons (benzene being one of them) and steam are partially condensed. Stripped hydrocarbons are disposed into a permitted flare or adsorbed in activated carbon beds, while water is returned to the column as reflux. Processed water from the stripper bottoms is cooled against tower feed and sent to downstream processing units.

Benzene stripper installations are relatively inexpensive with the cost mainly impacted by metallurgy. Typical costs are \$40,000 to \$100,000 per m^3/hr of wastewater. Steam consumption ranges from 90 to 130 kg steam/m^3 of wastewater, based on 3.5 kg/cm^2 saturated steam.

Operation is very simple. The main control variable to adjust is the steam rate, in order to accommodate fluctuations in the hydrocarbon content of the feed stream. Scaling and fouling have been reported as a concern in some cases, as salts are continuously deposited inside the equipment. In order to mitigate this problem and to maximize the on-line factor, chemical injection is often used with relatively good results.

The other important aspect of compliance with Benzene Neshaps is that of the totally enclosed emission controlled systems. Water collection and handling in totally enclosed, hard piped systems is very expensive. Surface impoundments, including those handling stormwater, must be typically replaced by emission controlled tanks with vapor recovery systems and/or special seals on floating roof tanks. Similarly, surface biodegradation may have to be replaced by totally enclosed bioreactors. The net result is that rather simple and inexpensive wastewater and stormwater systems must now be replaced with sophisticated and expensive equipment to insure compliance with the Benzene Neshaps.

Other Industries

Industries in the Petrochemical and Gas Processing fields are also affected by these new environmental regulations. Wastewater systems in aromatic production and olefin production facilities will have to undergo similar changes as those described above for refineries.

In the gas processing industry, BETX (Benzene, Ethylbenzene, Toluene and Xylene) emissions from reboilers of glycol dehydration units are starting to be regulated by most states.

As it is widely known, glycols have a clear preference for aromatics absorption from natural gas streams. Some of these aromatics are released to fuel gas from the regeneration system flash drums. The rest is stripped from the rich glycol solution and vented to atmosphere at the glycol reboilers.

This practice will no longer be acceptable, and vent gases will have to be recovered in emission controlled systems or be incinerated. Estimates for the number of glycol dehydration units operating in plant and field installations in the USA run as high as 40,000. It is not surprising then, that the expected cost to modify these units for full compliance with the Benzene Neshaps may be as high as $ 1 billion.

Conclusion

The difficult questions that everyone in the HPI is trying to answer are as follows:

- What will the overall effect be of all these regulations on the industry in the USA?
- Will the industry be able to comply with all these regulations without compromising its competitiveness in an increasingly international market?
- Will this deluge of regulations eradicate the small refineries and operators and leave the market in the hands of only the large corporations?
- Will the jobs created by new technologies compensate or even mitigate the disappearance of companies that cannot afford compliance?

The answers are not easy. The American Petroleum Institute has estimated that the initial cost for compliance with these environmental regulations will exceed $ 10 billion. An additional $ 4 billion was estimated for compliance with clean fuel requirements. The additional cost to the industry for compliance with OSHA's regulation 40 CFR 1990.119, Process Safety Management of Highly Hazardous Chemicals, has not yet been established.

The challenge to government agencies and the HPI alike is to proceed with this major transformation at such a pace that new technologies can be developed and experience can be gained to reduce its cost impact.

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TABLE I

Tc CONSTITUENT LEVELS

NEWLY ADDED CONSTITUENTS			
Constituent	Regulatory Level, mg/l.	Constituent	Regulatory Level, mg/l.
Benzene	0.5	Hexachlorobenzene	0.13
Carbon tetrchloride	0.5	Hexachloro-1,3-butadiene	0.5
Chlordane	0.03	Hexachlorethane	3.0
Chlorobenzene	100.0	Methyl ethyl ketone	200.0
Chloroform	6.0	Nitrobenzene	2.0
0-Cresol	200.0	Pentachlorophenol	100.0
m-Cresol	200.0	Pyridine	5.0
p-Cresol	200.0	Tetrachloroethylene	0.7
1,4-Dichlorobenzene	7.5	Trichloroethylene	0.5
1,2-Dichloroethane	0.5	2,4,5-Trichlorophenol	400.0
1,1-Dichloroethylene	0.7	2,4,6-Trichlorophenol	2.0
2,4-Dinitrotoluene	0.13	Vinyl chloride	0.2
Heptachlor	0.008		

EXISTING CONSTITUENTS (RETAINED AT CURRENT LEVELS)			
Constituent	Regulatory Level, mg/l.	Constituent	Regulatory Level, mg/l.
Arsenic	5.0	Silver	5.0
Barium	100.0	Endrin	0.02
Cadmium	1.0	Lindane	0.04
Chromium	5.0	Methoxychlor	10.0
Lead	5.0	Toxaphene	0.5
Mercury	0.2	2,4-D	10.0
Selenium	1.0	2,4,5-TP (silver)	1.0

TABLE II
HAZARDOUS AIR POLLUTANTS TO BE CONTROLLED BY MACT

Chemical Name	Vohap & TRE*	Vvhap +	Petroleum Refineries (PR)§
Acetaldehyde	95		
Acetamide	0		
Acetonitrile	70		
Acetophenone	95		
2-Acetylaminofluorene			
Acrolein	95		
Acrylamide	0		
Acrylic acid	0		
Acrylonitrile	95		
Allyl chloride	99	X	
4-Aminodiphenyl			
Aniline	70		
o-Anisidine	99		
Asbestos			
Benzene (incl. benzene from gasoline)	99	X	PR
Benzidine			
Benzotrichloride	99		
Benzylchloride	99		
Biphenyl	99	X	
Bis(2-ethylhexyl) phthalate (DEHP)			
Bis(chloromethyl)ether	99		
Bromoform	99		
1,3-Butadiene	99	X	X
Calcium cyanamide			
Caprolactam	99		
Captan			
Carbaryl			
Carbon disulfide	99	X	
Carbon tetrachloride	99	X	
Carbonyl sulfide			
Catechol			
Chloramben			
Chlordane			
Chlorine			PR
Chloroacetic acid		0	

Chemical Name	Vohap & TRE*	Vvhap +	Petroleum Refineries (PR)§
2-Chloroacetophenone	95		
Chlorobenzene	99		
Chlorobenzilate			
Chloroform	99		
Chloromethyl methyl ether			
Chloroprene	99	X	
Cresols/cresylic acid (isomers and mixture)	95		PR
o-Cresol	70		
m-Cresol	0		
p-Cresol	0		
Cumene	99	X	PR
2,4-D, salts and esters			
DDE			
Diazomethane			
Dibenzofurans			
1,2-Dibromo-3-chloropropane			
Dibutylphthalate			
1,4-Dichlorobenzene(p)	99		
3,3-Dichlorobenzidene			
Dichloroethyl ether (Bis(2-chloroethyl)ether)	95		
1,3-Dichloropropene	99		
Dichlorvos			
Diethanolamine	95		PR
N,N-Diethyl aniline (N,N-Dimethylaniline)	99		
Diethyl sulfate	0	X	
3,3'-Dimethoxybenzidine			
Dimethylaminoazobenzene			
3,3-Dimethyl benzidine	0		
Dimethyl carbamoyl chloride	95		
1,1-Dimethyl hydrazine	99		
Dimethyl phthalate	70		
Dimethyl sulfate	25		

Chemical Name	Vohap & TRE*	Vvhap +	Petroleum Refineries (PR)§
4,6-Dinitro-o-cresol, and salts			
2,4-Dinitrophenol	0		
2,4-Dinitrotoluene	70		
1,4-Dioxane (1,4-Diethyleneoxide)	95		
1,2-Diphenylhydrazine	0		
Epichlorohydrin (1-Chloro-2,3-epoxypropane)	95		
1,2-Epoxybutane			
Ethyl acrylate	99		
Ethyl benzene	99	X	PR
Ethyl carbamate (Urethane)			
Ethyl chloride (Chloroethane)	99	X	
Ethylene dibromide (Dibromoethane)	99		
Ethylene dichloride	99		
Ethylene glycol	0		
Ethylene imine (Aziridine)			
Ethylene oxide	99		
Ethylene thiourea			
Ethylidene chloride (1,1-Dichloroethane)	0		
Formaldehyde	95		
Heptachlor			
Hexachlorobenzene			
Hexachlorobutadiene	99	X	
Hexachlorocyclopentadiene			
Hexachloroethane	99	X	
Hexamethylene-1,6-diisocyanate			
Hexamethylphosphoramide			
Hexane	99	X	PR
Hydrazine			

*Volatile organic hazardous air pollutant and its target removal efficiency + Very volatile hazardous air pollutant. §Often found in petroleum refining operations

TABLE II
HAZARDOUS AIR POLLUTANTS TO BE CONTROLLED BY MACT

Chemical Name	Vohap & TRE*	Vvhap +	Petroleum Refineries (PR)§
Hydrochloric acid			PR
Hydrogen fluoride			PR
(Hydrofluoric acid)			
Hydroquinone	0		
Isophorone	70		
Lindane (all isomers)			
Maleic anhydride	0		
Methanol	70		PR
Methoxychlor			
Methyl bromide	99		
(Bromomethane)			
Methyl chloride	99	X	
(Chloromethane)			
Methyl chloroform	99		
(1,1,1-Trichloroethane)			
Methyl ethyl ketone	95		
(2-Butanone)			
Methyl hydrazine	70		
Methyl iodide			
(Iodomethane)			
Methyl isobutyl ketone	95		
(Hexone)			
Methyl isocyanate	0		
Methyl methacrylate	95		
Methyl tert butyl ether	99		PR
4,4-Methylene bis			
(2-chloroaniline)			
Methylene chloride	99	X	
Methylene diphenyl	0		
diisocyanate (MDI)			
4,4'-Methylenedianiline	70		
Naphthalene	99		PR
Nitrobenzene	95		
4 Nitrobiphenyl			
4 Nitrophenol	99	X	
2 Nitropropane		99	
N Nitroso-N methylurea			

Chemical Name	Vohap & TRE*	Vvhap +	Petroleum Refineries (PR)§
N-Nitrosodimethylamine			
Parathion			
Pentachloronitrobenzene			
(Quintobenzene)			
Pentachlorophenol			
Phenol	0		PR
p-Phenylenediamine	0		
Phosgene	99	X	
Phosphine			
Phosphorus			
Phthalic anhydride	25		
Polychlorinated			
biphenyls (Aroclors)			
1,3-Propane sultone			
beta-Propiolactone	25		
Propionaldehyde	99		
Propoxur (Baygon)			
Propylene dichloride	99		
(1,2 Dichloropropane)			
Propylene oxide	99		
1,2-Propylene imine			
(2-Methyl aziridine)			
Quinoline			
Quinone	95		
Styrene	99		
Styrene oxide			
2,3,7,8-Tetrachlorodibenzo-			
p-dioxin			
1,1,2,2-Tetrachloroethane	99		
Tetrachloroethylene	99	X	
(Perchloroethylene)			
Titanium tetrachloride			
Toluene	99		
2,4-Toluene diamine	25		
2,4-Toluene diisocyanate	95		
o-Toluidine	95		
Toxaphene (chlorinated			
camphene)			

Chemical Name	Vohap & TRE*	Vvhap +	Petroleum Refineries (PR)§
1,2,4 Trichlorobenzene	99		
1,1,2-Trichloroethane	99		
Trichloroethylene	99		
2,4,5-Trichlorophenol	99	X	
2,4,6-Trichlorophenol	95		
Triethylamine	99		
Trifluralin			
2,2,4-Trimethylpentane	99	X	
Vinyl acetate	99		
Vinyl bromide			
Vinyl chloride	99	X	
Vinylidene chloride	99	X	
(1,1-Dichlorethylene)			
Xylenes(isomers and mixture)	99		PR
o-Xylene	99		PR
m-Xylene	99		PR
p-Xylene	99		PR
Antimony compounds			
Arsenic compounds			
(inorganic incl. arsine)			
Beryllium compounds			
Cadmium compounds			
Chromium compounds			PR
Cobalt compounds			PR
Coke oven emissions			
Cyanide compounds			
Glycol ethers			
Lead compounds			
Manganese compounds			
Mercury compounds			
Fine mineral fibers			
Nickel compounds			PR
Polycyclic organic matter			
Radionuclides (incl. radon)			
Selenium compounds			

*Volatile organic hazardous air pollutant and its target removal efficiency + Very volatile hazardous air pollutant. §Often found in petroleum refining operations

WASTEWATER CONCEPTUAL TREATING FOR BENZENE NESHAPS COMPLIANCE

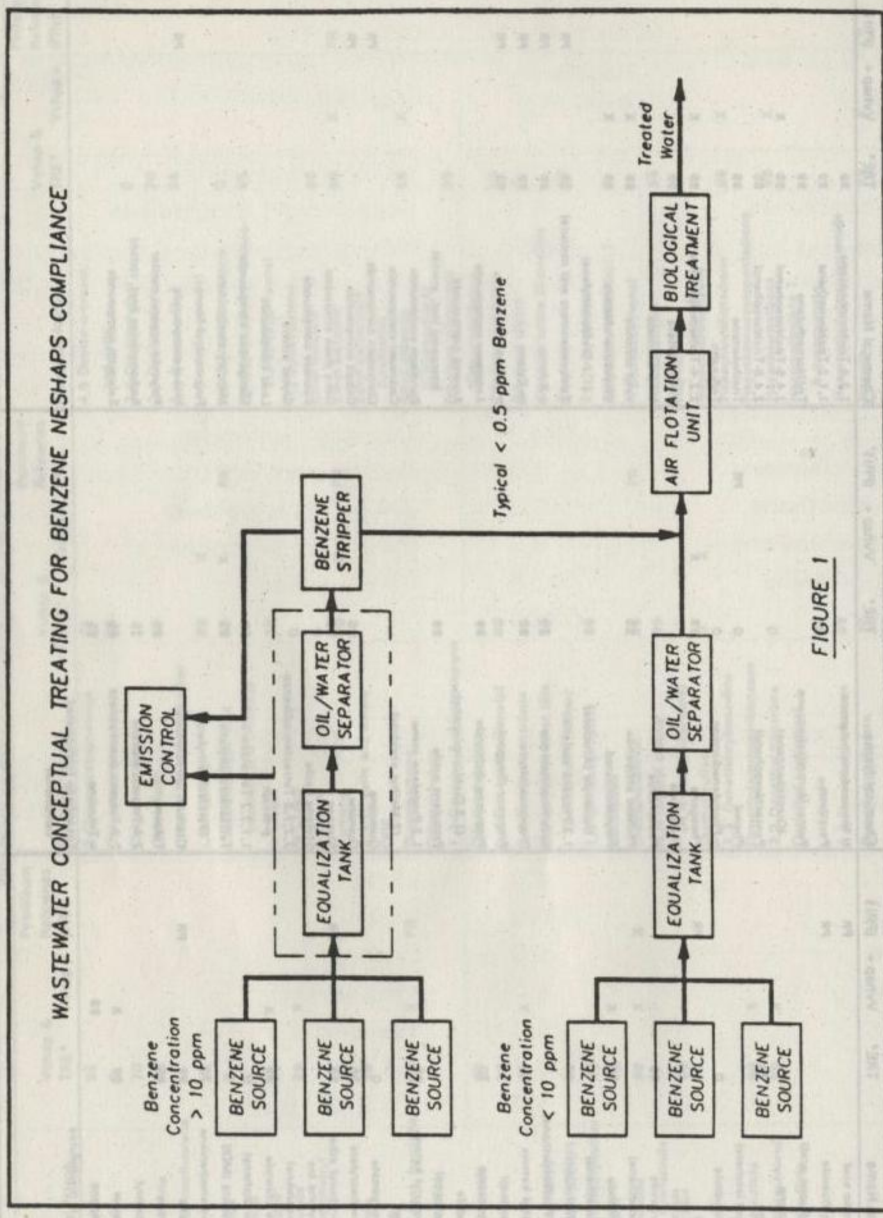

FIGURE 1

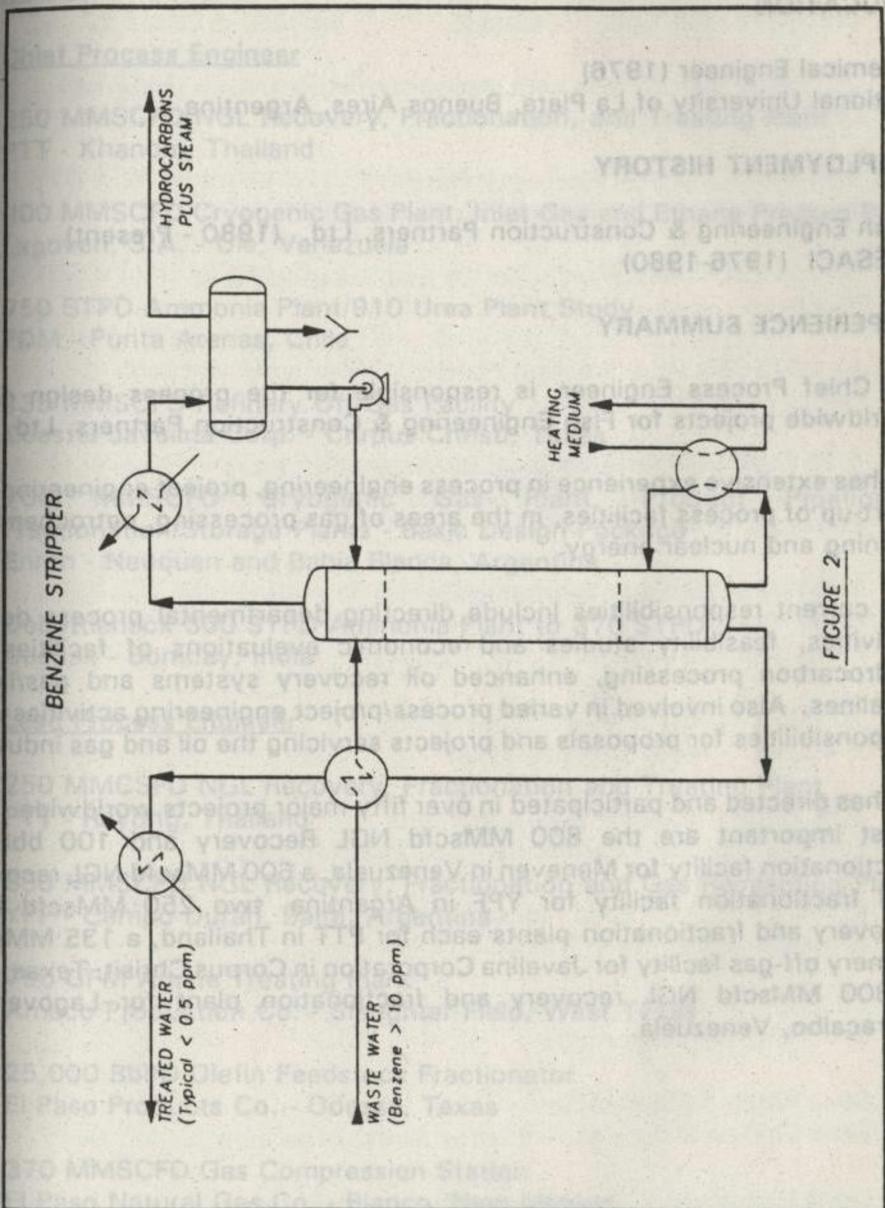
BENZENE STRIPPER
HYDROCARBONS PLUS STEAM
HEATING MEDIUM
TREATED WATER (Typical < 0.5 ppm)
WASTE WATER (Benzene > 10 ppm)

FIGURE 2

RICARDO J. OSTASZEWSKI

CHIEF PROCESS ENGINEER

EDUCATION

Chemical Engineer (1976)
National University of La Plata, Buenos Aires, Argentina

EMPLOYMENT HISTORY

Fish Engineering & Construction Partners, Ltd. (1980 - Present)
DESACI (1976-1980)

EXPERIENCE SUMMARY

As Chief Process Engineer, is responsible for the process design of all worldwide projects for Fish Engineering & Construction Partners, Ltd.

He has extensive experience in process engineering, project engineering and start-up of process facilities, in the areas of gas processing, petrochemical, refining and nuclear energy.

His current responsibilities include directing departmental process design activities, feasibility studies and economic evaluations of facilities for hydrocarbon processing, enhanced oil recovery systems and gas/liquid pipelines. Also involved in varied process/project engineering activities with responsibilities for proposals and projects servicing the oil and gas industry.

He has directed and participated in over fifty major projects worldwide. The most important are the 800 MMscfd NGL Recovery and 100 bbl/day fractionation facility for Meneven in Venezuela, a 600 MMscfd NGL recovery and fractionation facility for YPF in Argentina, two 250 MMscfd NGL recovery and fractionation plants each for PTT in Thailand, a 135 MMscfd refinery off-gas facility for Javelina Corporation in Corpus Chrisit, Texas, and a 300 MMscfd NGL recovery and fractionation plant for Lagoven in Maracaibo, Venezuela.

EXPERIENCE SUMMARY

MAJOR PROJECTS

<u>Chief Process Engineer</u>

250 MMSCFD NGL Recovery, Fractionation, and Treating Plant
PTT - Khanom, Thailand

300 MMSCFD Cryogenic Gas Plant, Inlet Gas and Ethane Product Pipelines
Lagoven, S.A. - Ulè, Venezuela

750 STPD Ammonia Plant/910 Urea Plant Study
FDM - Punta Arenas, Chile

135 MMSCFD Refinery Off-Gas Facility
Coastal Javelina Corp. - Corpus Christi, Texas

700 MMSCFD Cryogenic Gas Plant, Product Pipeline and Fractionation/Storage Plants - Basic Design Package
Enron - Neuquen and Bahia Blanca, Argentina

Debottleneck 300 STPD Ammonia Plant to 370 STPD
Deepak - Bombay, India

<u>Lead Process Engineer</u>

250 MMCSFD NGL Recovery, Fractionation and Treating Plant
PTT - Rayong, Thailand

600 MMSCFD NGL Recovery, Fractionation and Gas Reinjection Plant
YPF - Campo Duran, Salta, Argentina

750 GPM Amine Treating Plant
Amoco Production Co. - Slaughter Field, West Texas

25,000 Bbl/D Olefin Feedstock Fractionator
El Paso Products Co. - Odessa, Texas

370 MMSCFD Gas Compression Station
El Paso Natural Gas Co. - Blanco, New Mexico

RICARDO J. OSTASZEWSKI (Continued)

MAJOR ASSIGNMENTS (Continued)

5 MMSCFD Pilot/Gas Treating Plant
Corpoven - Caracas, Venezuela

20 Ton/D Sulfur Plant with Associated Amine/Sour Water Strippers
Corpoven - Caracas, Venezuela

800 MMSCFD NGL Recovery Plant
Meneven, S. A. - San Joaquin, Venezuela

100 M BBL/D NGL Fractionation and Treating Plant
Meneven - Jose, Venezuela

11 MMSCFD DEA Treating Plant
Petrobas, Brazil

4/25 MMSCFD Natural Gas/CO2 Separation Plant
Process Study (TEA, DEA, Benfield, Catacarb, Membranes)
Petrobas, Brazil

100 MMSCFD Gas Processing Plant
Feasibility Study
Pertamina - Pabelokan Island, Indonesia

10,000 BPD MTBE Plant Process Study
Enterprise - Mont Belvieu, Texas

204 MMSCFD Gas Processing Plant
Feasibility Study - Pertamina - Sumatra, Indonesia

8,000 BPSD TIP (Total Isomerization Unit)
American Petrofina of Texas

150,000 M Tons/Year Wax Hydrotreating Plant
YPF - La Plata, Argentina

Sour Water Stripping Plant
Esso Campana Refinery - Buenos Aires, Argentina

Light Hydrocarbon Emergency Shutdown System
Esso Campana Refinery - Buenos Aires, Argentina

RICARDO J. OSTASZEWSKI (Continued)

MAJOR ASSIGNMENTS (Continued)

Petroleum Secondary Recovery System (Water Injection)
YPF - La Plata, Argentina

20,000 BPSD Electrically Heated Wax Pipeline
YPF - La Plata, Argentina

2,700 MW Hydroelectric Power Plant
(Brake & Regulation Air System and Seal/Lubrication Oil System for the 14 Hydraulic Turbines of the Plant)
Salta Grande - Uruguay

600 GPM Water Polishing Plant (Effluent Treating System)
SEGBA - Buenos Aires, Argentina

300 MW Atucha Nuclear Power Plant
Emergency Shutdown System Modification (Borus Injection)
Atomic Energy National Commission - Argentina

156 MMSCFD Gas Processing Plant
Natural Gas Corporation of New Zealand - New Zealand