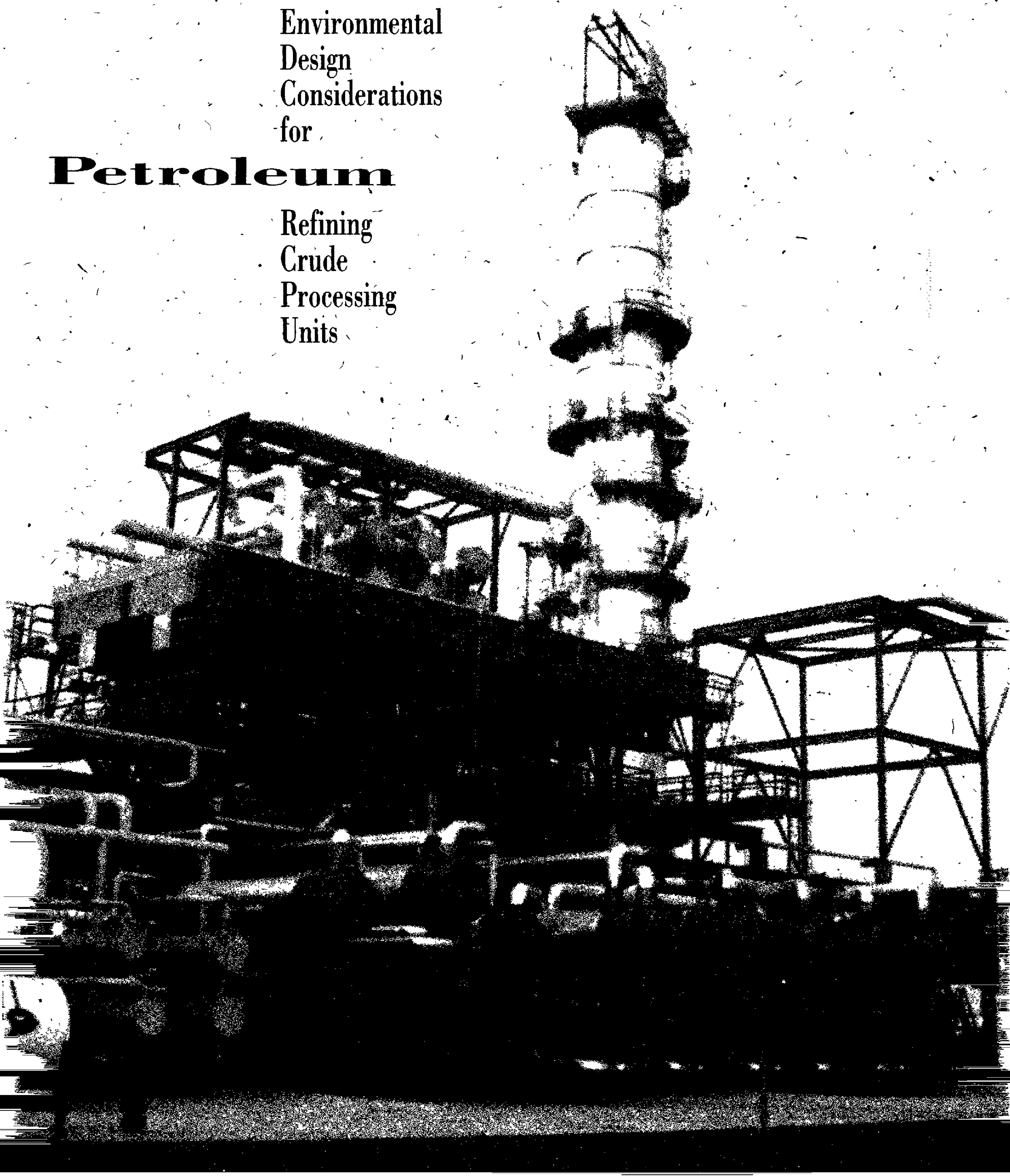
Executive Summary

Environmental Design Considerations for Petroleum Refining Crude Processing Units



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Health and Environmental Affairs Department

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Section 1: EXECUTIVE SUMMARY

1.1 Basis of Study

The Pollution Prevention Task Force (PPTF) of the American Petroleum Institute (API) has developed the following working definition of pollution prevention:

> "Pollution prevention is a multi-media concept that reduces or eliminates pollutant discharges to air, water, or land and includes the development of more environmentally acceptable products, changes in processes and practices, source reduction, beneficial use and environmentally sound recycling."

The PPTF and the API Committee on Refinery Environmental Control (CREC) recognize the importance of developing pollution prevention strategies for refineries. This study was initiated to investigate how the crude unit in a typical refinery could be designed to minimize multi-media environmental releases while still efficiently performing the traditional functions of a crude unit.

This report presents the findings of the study. The report is intended to serve as a reference for refinery designers during the preliminary design phase of building a new crude unit or revamping an existing crude unit.

A generic methodology for conducting pollution prevention studies on process units was developed and was then applied to the refinery crude unit (refer to Section 4). This methodology approched pollution prevention from two perspectives, or cases:

Case 1 - The design of a model new crude unit.

Case 2 - The revamp of a conventional existing crude unit, applying the principles learned in Case 1.

A typical ten-year-old U.S. Gulf Coast crude unit of 175,000 BPSD capacity was chosen to serve as the reference point or Base Case.

The technical contents of this report include: crude charge and product slates, process flow diagrams, major equipment lists, raw material use, water use, energy, equipment costs, and multi-media releases. These releases include: point source air emissions, fugitive air emissions, solid and hazardous waste production, and wastewater inventory.

The study investigated in detail these specific methods of pollution prevention:

- modification of vacuum tower to dry operation and reduced flash zone pressure to minimize cracking of feed;
- dry operation to reduce the quantity of sour condensate;
- use of vacuum pumps to replace all or part of the steam jet ejector system to provide the vacuum for the vacuum tower;
- use of reboiled sidestrippers on the atmospheric tower rather than open steam stripping to reduce the quantity of sour condensate;
- replacement of first generation low NO_x burners with new generation low NO_x burners in furnaces;
- use of catalytic and non-catalytic processes for the selective reduction of NO_x;
- reuse of stripped sour water to replace clean process water as desalter water; and

- heat integration for maximum energy utilization (commonly referred to as pinch analysis).

1.2 Limitations of Study Results

Numerous pollution prevention concepts have been evaluated and reported in this study, but no optimum or "best" design is implied. This study was as comprehensive as time allowed, but doubtlessly there are other pollution prevention measures that have potential application to crude units. Each refiner will need to make an assessment of his refinery's requirements and then consider the ideas that best suit those needs. Corporate planning, engineering, regulatory, and operations personnel will be able to use the ideas and techniques reported in this study as an initial step toward a more thorough case-by-case evaluation of pollution prevention for the crude units at individual refineries.

1.3 Pollution Prevention Ideas for Model New Crude Unit

For a model new crude unit (Case 1), the following pollution prevention ideas may be considered in the design stage and are reported in Section 6:

- Apply pinch analysis to the crude preheat train heat integration (refer to Appendix I). Increase crude preheat temperature and minimize heat losses to air and cooling water.

- Increase crude distillation column pumparounds from two to four. Reboil sidestrippers with a heat transfer oil rather than by steam stripping.

- Lower vacuum column flash zone pressure from 35 to 20 mmHgabs. This will lower furnace fired duty and reduce cracking of the feed to lighter products and wet oil/recovered oil.

- Use a liquid ring vacuum pump in place of the third stage steam jet ejector on the vacuum tower overhead.

- Strip desalter brine for benzene removal before sending brine to wastewater treatment. Send recovered benzene to gasoline blending.

- Install new generation low NO_x burners. Use selective catalytic reduction (SCR) to reduce NO_x in furnace flue gas.

- Scrub furnace flue gas for removal of SO_x when firing high sulfur fuel oil.

- Optimize water reuse by application of sidestream softening to blowdown streams.

- Apply advanced process control to optimize energy utilization. Install analyzers to provide continuous pollutant monitoring.

- Employ specialized hardware and inspection & maintenance (I&M) to eliminate fugitive emissions of volatile organic compounds (VOC):
  - Select leakless or graphite packed valves.
  - Use sealless design pumps or pumps with double seals.
  - Minimize flanges and install sealing rings on leaking flanges.
  - Blind, plug, or cap open-ended vent and drain valves.

- Route relief valves to flare and add rupture disks.

- Pipe compressor seal vents back to process and vent compressor distance pieces to refinery flare.

- Install a maintenance drain-out (MDO) system to eliminate open discharges from drains.

- Totally close-loop all samplers.

1.4 Pollution Prevention Ideas for Revamp of Conventional Crude Unit

For the revamp of an existing conventional crude unit (Case 2), the following pollution prevention ideas may be considered and are reported in Section 7:

- Apply pinch analysis to the crude preheat train heat integration. Increase crude preheat temperature and minimize heat losses to air and cooling water. Keep equipment and piping relocation to a manageable minimum.

- Reboil the atmospheric column sidestrippers (except for high boiling point Atmospheric Gas Oil) with heat transfer oil rather than by steam stripping. Install two new sidestrippers and modify one existing sidestripper.

- Lower vacuum column flash zone pressure from 35 to 20 mmHgabs. Use liquid ring vacuum pump in place of the third stage steam jet ejector on the vacuum tower overhead. Add parallel ejectors to the first and second stages.

- Strip desalter brine for benzene removal.

- Retrofit new generation low NO_x burners and install SCR units for post-combustion NO_x reduction.

- Scrub flue gas for removal of SO_x when firing high sulfur fuel oil in heaters.

- Optimize water reuse by application of sidestream softening to blowdown streams.

- Apply advanced process control to optimize energy utilization. Install analyzers to provide continuous pollutant monitoring.

- Employ specialized hardware and I&M to reduce fugitive emissions of VOC:

  - Improve I&M program (leak definition, monitoring frequency, and repair response time).

  - Selectively retrofit leakless or graphite packed valves.

  - Selectively retrofit sealless design pumps or pumps with double seals.

  - Minimize flanges and install sealing rings on leaking flanges.

  - Blind, plug, or cap open-ended vent and drain valves.

  - Route relief valves to flare and/or add rupture disks.

- Pipe compressor seal vents back to process and vent compressor distance pieces to refinery flare.

- Install a MDO system to eliminate open discharges from drains.

- Totally close-loop all samplers.

1.5 Summary of Findings

Air emissions, wastewater effluents, solid wastes, energy consumption, and costs are summarized in Table 1.1. Figures 1.1 through 1.4 give graphical representations of air emissions, wastewater loads, and solid waste generation.

The findings of this pollution prevention study on refinery crude units are summarized below:

- A generic systematic methodology for conducting pollution prevention studies on process units can be applied to the crude unit in a typical refinery.

- There is a correlation between energy efficiency and environmental effectiveness: the more efficient the crude unit, the less it pollutes.

- The total energy usage in the crude unit can be reduced by improving heat integration in the crude preheat train through pinch analysis.

- Reductions in wastewater generation can be achieved by energy reduction and stream recycling.

- Reductions in solid and hazardous wastes can be achieved by water recycling and preventing the mixing of hazardous and non-hazardous waste streams. If the heaters burn high sulfur fuel, limestone scrubbing for SO_x reduction will generate non-hazardous sludge.

- NO_x emissions can be reduced by new generation low NO_x burners, SCR units, and Flue Gas Recirculation (FGR).

- The total annual benzene quantity (TAB) in wastewater can be reduced by steam stripping.

- Fugitive emissions from piping components can be reduced by hardware improvements and stringent inspection & maintenance programs.

TABLE 1.1: SUMMARY OF FINDINGS
MULTI-MEDIA RELEASES FROM 175,000 BPSD CRUDE UNIT

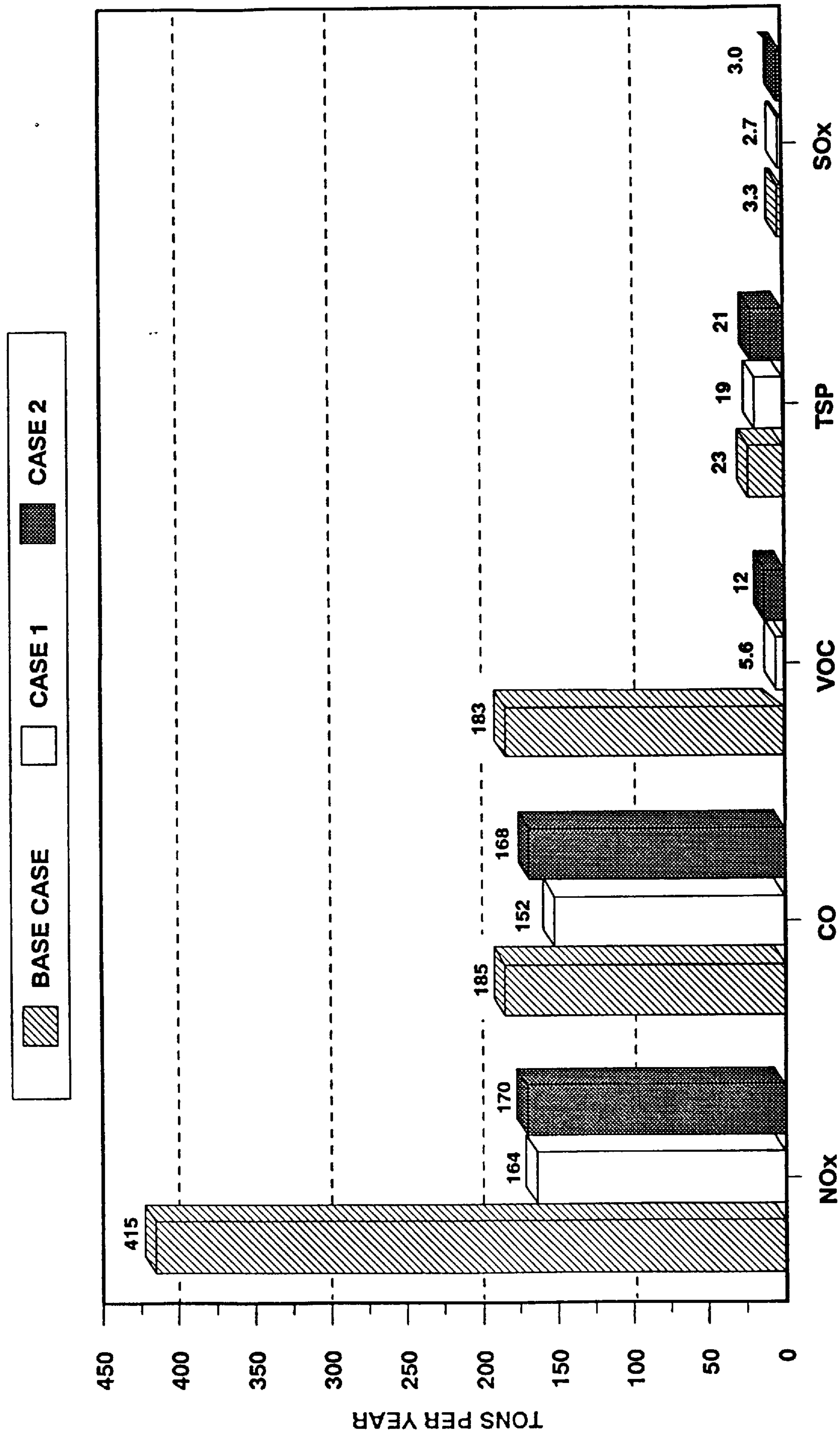
HEATERS FIRING FUEL GAS

	AIR EMISSIONS, TON/YR					WASTE WATER, GPM	SOLID WASTE, TONS/DAY		ENERGY		
	NO_x	CO	VOC	TSP	SO_x		HAZARDOUS	NON-HAZARDOUS	MMBTU/HR	KW	CAPITAL COST $MM
BASE CASE (Conventional Crude Unit)	415	185	183	23	3.3	584	6.3	0	948	2,670	128.7
CASE 1 (Model New Crude Unit)	164	152	5.6	19	2.7	339	0.5	2.7	786	3,153	164.3
Reductions (Base Case - Case 1)	251	33	177	4	0.6	245	5.8	-2.7	162	-483	-35.6
CASE 2 (Revamp of Conventional Crude Unit)	170	168	12	21	3.0	342	0.5	3.7	864.5	3,033	28.7
Reductions (Base Case - Case 2)	245	17	171	2	0.3	242	5.8	-3.7	83.5	-363	n/a

CRUDE HEATER FIRING 1 wt% SULFUR FUEL OIL

	AIR EMISSIONS, TON/YR					WASTE WATER, GPM	SOLID WASTE, TONS/ DAY		ENERGY		
	NO_x	CO	VOC	TSP	SO_x		HAZARDOUS	NON-HAZARDOUS	MMBTU/HR	KW	CAPITAL COST $MM
BASE CASE (Conventional Crude Unit)	597	171	190	187	2,105	584	6.3	0	948	2,670	128.7
CASE 1 (Model New Crude Unit)	172	142	11	134	149	339	0.5	12.5	786	3,310	169.8
Reductions (Base Case - Case 1)	425	29	179	53	1,956	245	5.8	-12.5	162	-640	-41.1
CASE 2 (Revamp of Conventional Crude Unit)	179	156	18	157	176	342	0.5	15.3	864.5	3,190	34.7
Reductions (Base Case - Case 2)	418	15	172	30	1,929	242	5.8	-15.3	83.5	-520	n/a

FIGURE 1.1
AIR EMISSIONS
FROM 175,000 BPSD CRUDE UNIT
(HEATERS FIRING FUEL GAS)



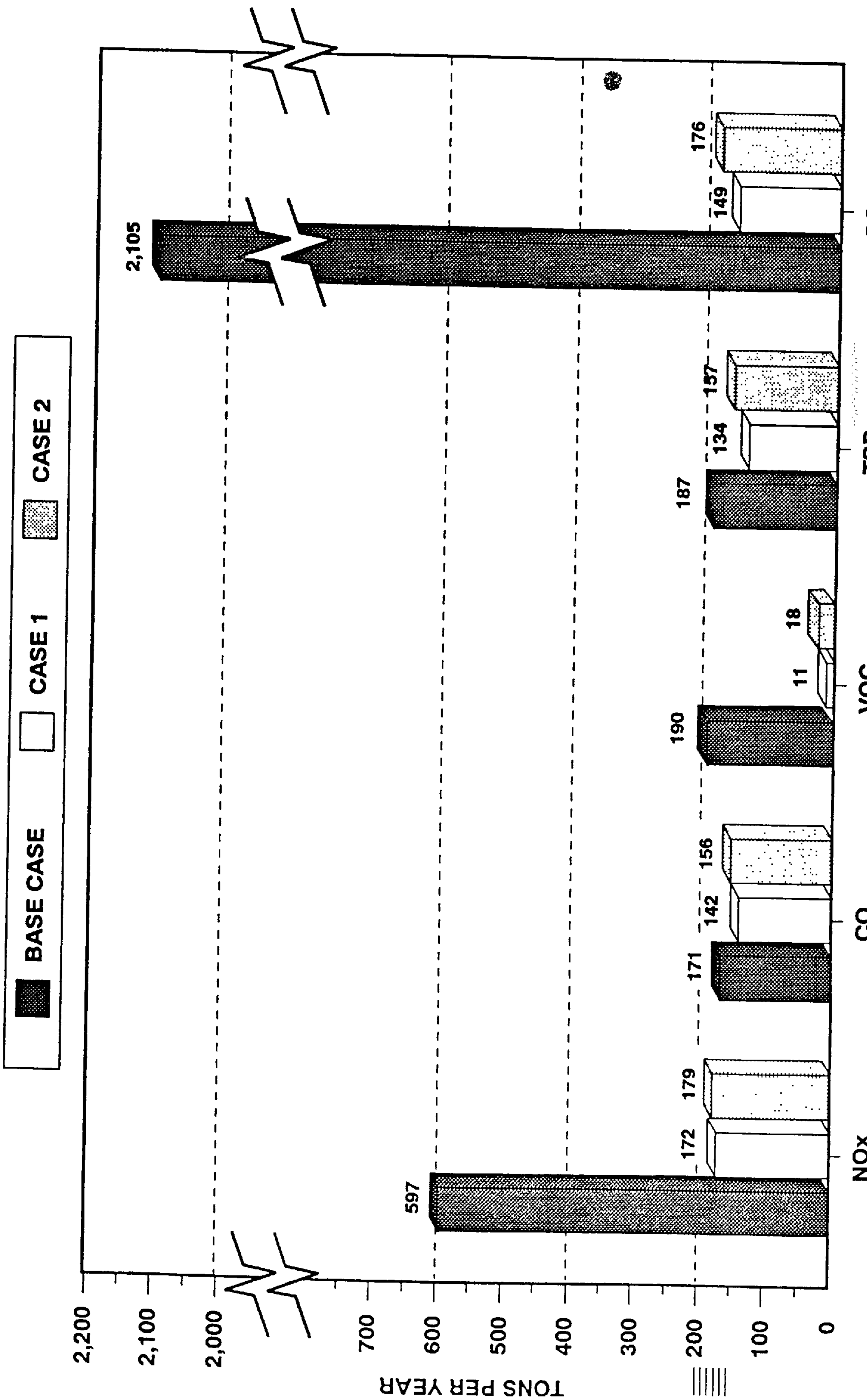


FIGURE 1.2
AIR EMISSIONS
FROM 175,000 BPSD CRUDE UNIT
(ATMOSPHERIC CRUDE HEATER FIRING 1 WT% SULFUR FUEL OIL)

FIGURE 1.3

WASTE WATER LOADS FROM 175,000 BPSD CRUDE UNIT

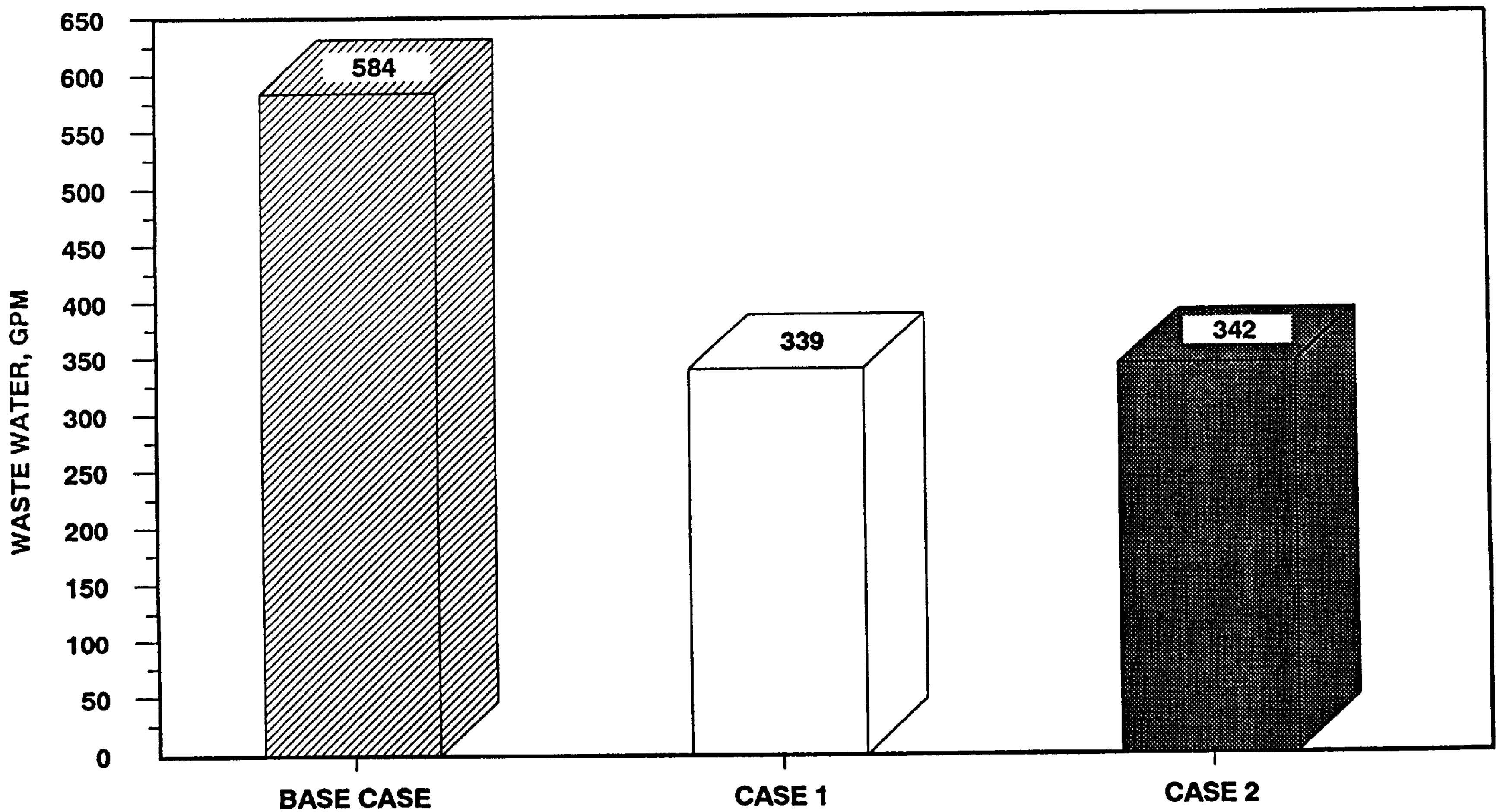
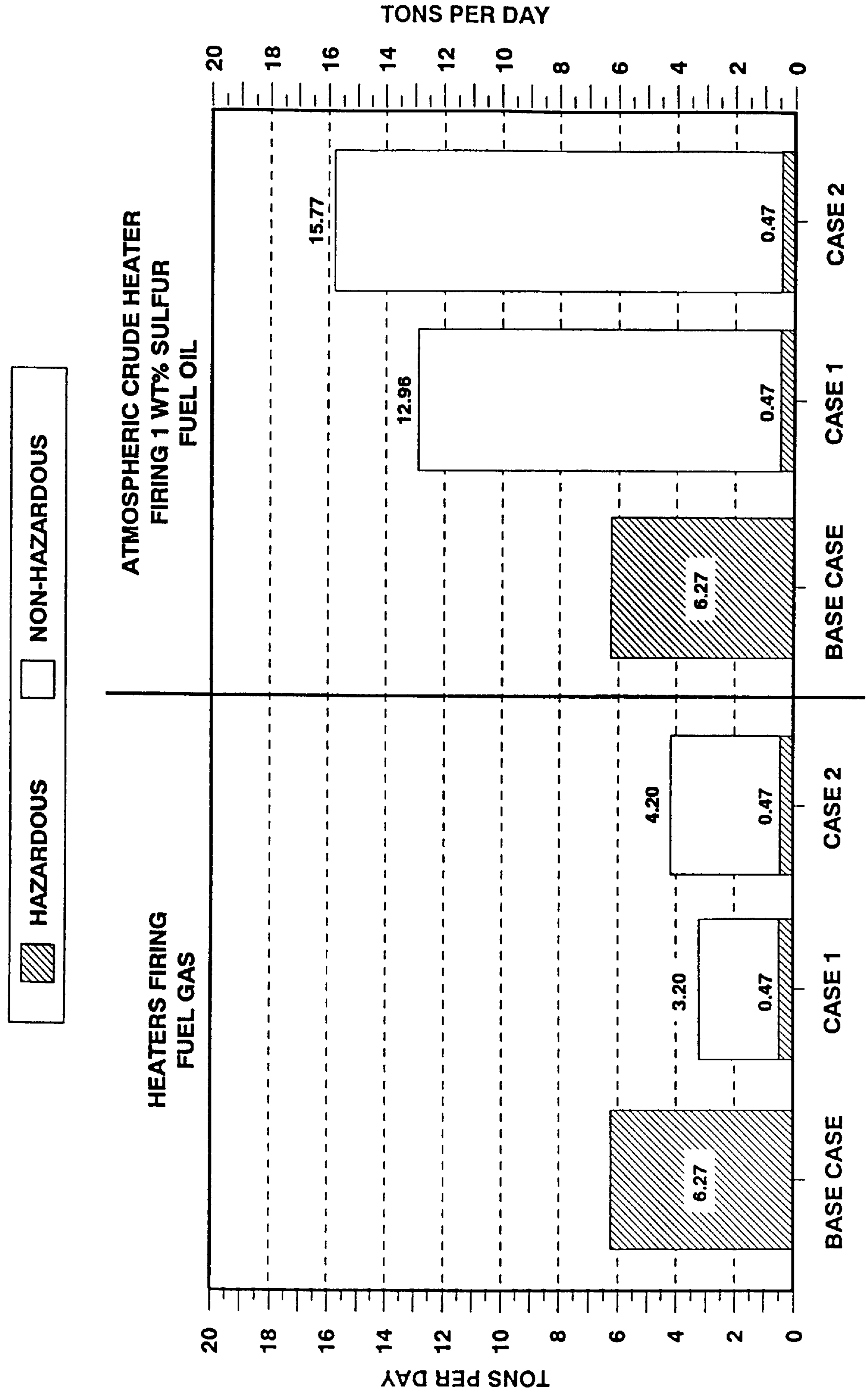


FIGURE 1.4
SOLID WASTE GENERATION
FROM 175,000 BPSD CRUDE UNIT



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