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# Project Summary

# Air Pollution Control Alternatives for Shale Oil Production Operations

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**Air pollution control (APC) technology is compiled for use by project developers as well as their respective regulatory approval agencies. The processes covered include mining, raw shale sizing and handling, various retorting schemes, spent shale combustion and disposal, and product upgrading. Available data on the traditional processes for nitrogen oxide ($NO_X$), sulfur compounds, particulate, volatile organic compounds (VOCs), and carbon monoxide (CO) control are discussed. In addition, the report discusses recently developed APC technology and processes not discussed elsewhere in the oil shale literature; e.g., catalytic mufflers on vehicles for $NO_X$, VOC, and CO control; staged combustion for $NO_X$ control; spent shale absorption of sulfur oxides ($SO_X$); improved filter bag materials, moving bed granular filters, and dry venturis for fine particulate control; and dry sorbent injection for $SO_X$ control. Data from seven shale oil project PSD applications are analyzed and compared. Finally, five representative shale oil recovery processes are analyzed at three levels of emission control. It is concluded that, if the most effective levels of control technology are applied to all five representative processes, the overall emission levels (in terms of weight of emission per unit of oil produced) will be essentially the same.**

**Based on the highest level of control, the emissions (in kilograms per 1000 $m^3$ of oil produced) that might be expected from a shale oil production plant under the best conditions are about: CO, 200; VOC, 100; $NO_X$, 700; $SO_X$, 200; and TSP, 200.**

***This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Introduction

Under the Clean Air Act (PL 95-95) oil shale developers must: (a) employ Best Available Control Technology (BACT), (b) ensure that National Ambient Air Quality Standards (NAAQS) are not violated, (c) not violate the prevention of significant deterioriation (PSD) ambient air quality increments, (d) not significantly degrade visibility in mandatory Class I areas, and (e) obtain up to 1 year of baseline data before applying for a PSD permit to construct and operate a facility. Since the environmental impact can be the limiting factor in developing a commercial oil shale industry, the EPA has conducted an on-going research program to assess existing pollution control technology, develop new technology, and quantify the air emission waste water discharge and solid wastes associated with the various types of shale oil recovery facilities.

The EPA's engineering study series, titled Pollution Control Technical Manuals (PCTMs), in particular provide a comprehensive analysis of the air, water, and solid emissions from specific shale oil recovery plants.

This report consolidates available air emissions data and air pollution control (APC) technology relevant to oil shale processing operations. It answers six questions:

> What shale oil production processes are available and how do they function?
>
> What are the sources of air pollutants from those processes?
>
> What APC technology options are applicable to each source; how do they function; what removal efficiency can be expected; what do they cost; and what rationale should be used to select the most effective one?
>
> What mass emissions per unit of throughput (e.g., kilograms/1000m$^3$ of oil) will be released by the various processes?
>
> What answers to the above questions have been proposed in actual PSD permit applications?

## Methodology and Findings

Key industry and government agency personnel were interviewed to gain their latest experiences, impressions of process performance, and intentions with regard to future developments. The emissions factors for mining, retorting, and upgrading processes were then evaluated. A matrix was prepared summarizing APC options for each unit process of certain selected shale oil production facilities. Each standard APC technique identified in the matrix is synopsized, and the newer and more innovative APC techniques are discussed more extensively. Table 1 summarizes the technologies presented.

Next, the PSD permit applications of seven shale oil projects were evaluated. This information was computerized and sorted to determine average emissions and relative percentages for each process. Significant differences in the estimating procedures for the various projects are discussed. The PSD permit applications analyzed are listed in Table 2.

Finally, as an example of specific case studies, the APC alternative for five shale oil production processes were determined,along with their associated mass emission rates: (1) direct heated (e.g.,Paraho); (2) travelling grate (e.g.,Superior, Allis-Chalmers, Dravo); (3) indirect heated (e.g,,Union B); (4) recycled solids (e.g.,Chevron, Lurgi); and (5) modified in-situ (e.g.,Occidental).

For this analysis, constant emission rates were established for mining and product upgrading operations. These were based primarily on the seven PSD applications,supplemented with literature values as needed. The area where technology selection had a profound effect on the estimated emissions was in the method of retorting the shale and the associated process used to scrub the offgas streams. Figures 1, 2, and 3, respectively, give the particulate, $NO_x$, and $SO_x$ emissions from the retorts of the five design cases.

These three figures indicate that there is wide variation in the base case emission levels for the five processes which are based on the present state-of-the-art technology as reflected in the seven PSD permit applications. For particulates, the emission levels vary from 200 to 800 kg/1000 m$^3$ of oil; for $NO_x$ the emission levels vary from 1000 to 8000 kg/1000 m$^3$; and for $SO_x$ the

***Table 1.*** *Air Pollution Control Technologies*

| *Pollutant* | *Control Technology* |
|---|---|
| *Particulate (Point Sources)* | *Baghouse* |
| | *Venturi scrubber* |
| | *Electrostatic precipitator* |
| | * *Dry Venturi* |
| *(Fugitive Sources)* | * *Surfactants* |
| | * *Liners* |
| | * *Wind screens* |
| | * *Chemicals* |
| | * *Water spray* |
| *Nitrogen Oxides* | * *Staged combustion* |
| | * *Ammonia injection* |
| | *Selective catalytic reduction* |
| *Sulfur Compounds* | *Stretford* |
| | *Lo-Cat* |
| | *Unisulf* |
| | *Alkaline scrubber* |
| | * *Activated carbon and hypochlorite* |
| | *Claus* |
| | *Scot (Shell-Claus offgas treating)* |
| | *Flue gas desulfurization (wet & dry)* |
| | * *$SO_x$ Absorption on spent shale* |
| *Carbon Monoxide and Hydrocarbons* | * *Catalytic mufflers* |

**Indicates systems given greater emphasis in this report because they are not covered in other shale oil documents.*

*Table 2. PSD Permit Applications Evaluated*

| *Project* | *Location* | *Oil Production $m^3$/day* | *Retort Process* |
|---|---|---|---|
| *Cathedral Bluffs* | *Rio Blanco County, CO* | *1,900* | *Modified in-situ with Union above-ground retort* |
| *Clear Creek* | *Grand Valley, CO* | *15,900* | *Chevron - fluidized bed with solids recycle* |
| *Utah Cottonwood Wash* | *Green River Basin, UT* | *5,000* | *$T^3$ retort with fluidized bed combustion of retort gas & fines* |
| *Paraho - Ute* | *Uinta Basin, UT* | *6,700* | *Paraho/direct heated* |
| *Syntana* | *Uinta County, UT* | *9,100* | *Superior - retort indirect heat with Tosco II retort for fines* |
| *Union Facility* | *Parachute Creek, CO* | *14,300* | *Indirect combustion, gas recycle* |
| *White River Project* | *Vernal, UT* | *16,900* | *Superior-direct heated<br>Union B-indirect heated<br>Tosco II-fines retort* |

emission levels vary from 350 to 3000 kg/1000 $m^3$.

APC Alternative No. 1 was the use of the activated carbon hypochlorite enhanced $H_2S$ removal process, an acid wash for improved ammonia removal,and the addition of a dry venturi-baghouse for post-combustion particulate control. Referring to Figures 1, 2, and 3, the emission levels for Alternative No. 1 show considerably less variation, particularly for $SO_x$ (from 100 to 250 kg/1000 $m^3$ of oil) and particulates (from 50 to 200 kg/1000 $m^3$ of oil). The variation of $NO_x$ emission is still considerable (from 1000 to 4000 kg/1000 $m^3$ of oil). Essentially, the acid wash removes only the residual ammonia without affecting the organic nitrogen content and has no effect on thermal $NO_x$; therefore, there is relatively little improvement in the $NO_x$ emission rate.

APC Alternative No. 2 was the addition of ammonia injection for $NO_x$ control from boiler and/or furnace combustion, the use of staged combustion for control of $NO_x$ emissions from the spent shale combustor, and the dry venturi-baghouse with increased space velocity which improves collection performance at the expense of increased pressure drop. Again, referring to Figures 1, 2, and 3, it is apparent that the addition of these controls essentially levels the performance of all five processes.

## Conclusion

The basic conclusion derived from the above analysis is that, although the air emission levels for the different retort processes with controls proposed in PSD permit applications between 1980 and 1985 can vary considerably (sometimes by as much as two orders of magnitude),the application of control techniques that are either improvements over existing technology or more suitable for a specific application, can reduce emissions and result in similar emission levels for all five processes. This conclusion needs to be qualified: some of the control techniques considered have not yet been applied specifically to the oil shale recovery process. However, these techniques have been proven at the full scale level in various other difficult control applications.

## Reference

Taback, H. J., et al., "The Effect of Oil Shale Recovery Processes on Air Emissions," *19th Oil Shale Symposium Proceedings,* Colorado School of Mines Press, Golden, CO, 1986.

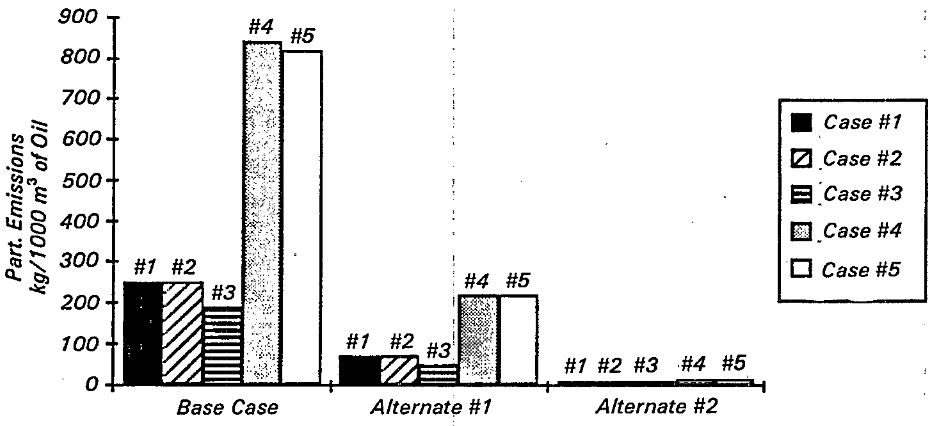


**Figure 1.** *Particulate emissions from retort gas combustion for five cases. (Taback, H. J., et al., 1986).*

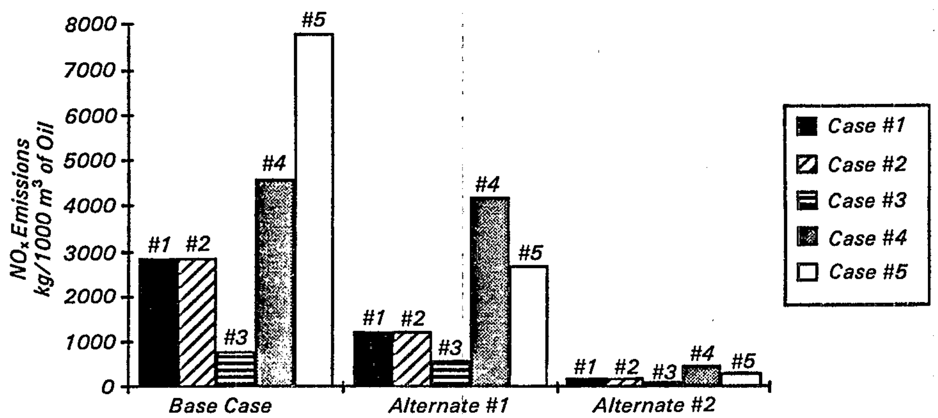


**Figure 2.** *Nitrogen oxides emissions summary for five cases. (Taback, H. J., et al., 1986).*

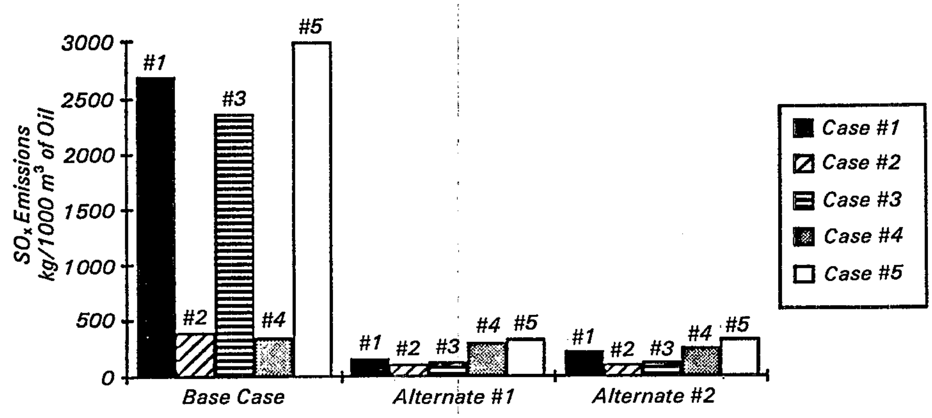


**Figure 3.** *Sulfur oxides emissions summary for five cases. (Taback, H. J., et al., 1986).*

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*The complete report, entitled "Air Pollution Control Alternatives for Shale Oil Production," (Order No. PB 88-196 027/AS; Cost: $44.95, subject to change) will be available only from:*
*National Technical Information Service*
*5285 Port Royal Road*
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