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EPA OIL SHALE RESEARCH ACTIVITIES

by

E. R. Bates
Oil Shale Manager
U.S. Environmental Protection Agency
Cincinnati, Ohio

Abstract

In response to the slowdown in oil shale development activity and general budget reductions, EPA has substantially cut back its oil shale research activities. However, several new projects are going forward which should not only be of interest to developers and researchers but also support future regulatory and permitting decisions by the Agency. New activities include evaluation of the potential for using combusted Green River shale to adsorb SO_2 as a primary sulfur control technology, preparation of a new Pollution Control Technical Manual on the Unishale B and C processes, and preparation of two state-of-the-art reports addressing planning and designs for retorted oil shale disposal and control of gaseous emissions from retorting. Activities which have been ongoing for some time include investigation of leaching and hydraulic properties of retorted shales including co-disposal of wastewater and shale, field testing of Stretford and caustic scrubbing for control of H_2S in shale offgas, a compilation of available information on solid waste characteristics for various retorting technologies, and assessment of retorted shale as a liner for retorted shale disposal sites. A selected list of published EPA reports on oil shale is provided, including recently released reports on assessment of the auto-oxidation potential of retorted and raw oil shales, field evaluation of leachates from raw mined oil shales, and leaching and hydraulic properties of selected retorted shales.

Introduction

At the present time essentially all oil shale research within EPA is being conducted by the Air and Energy Engineering Research Laboratory which is part of EPA's Office of Research and Development. The oil shale program is part of a larger Synthetic Fuels Program administered by the AEERL which is located in Research Triangle Park, North Carolina. The primary purpose of the oil shale program is to provide technical support to EPA's Program Offices (such as the Office of Solid Waste and Office of Toxic Substances) and EPA Regional Offices (such as Region 8 in Denver). Other objectives are to provide technical support and information to other federal agencies, state agencies, industry, and others interested in the environmentally sound development of an oil shale industry.

Emphasis

The oil shale research program has been restructured in an effort to provide maximum support for Agency regulatory and permitting activities during a time of sharp budget reductions. The current emphasis is upon engineering studies, laboratory investigations, and selected pilot-scale tests of state-of-the-art control technology. Larger scale field studies, basic research, and technology demonstrations have been curtailed. Current research is targeted toward providing data and technical support to EPA Program and

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PROJECT OFFICER: Edward R. Bates (684-7774), U. S. EPA, Cincinnati, Ohio 45268
For Air and Energy Engineering Research Laboratory, ORD, RTP, NC

Regional Offices as they carry out Agency responsibilities including:

- Review of Premanufacturing Notices under the Toxic Substances Control Act
- Review and Issuance of Prevention of Significant Deterioration Permits under the Clean Air Act
- Review of Environmental Impact Statements under the National Environmental Policy Act
- Review of Environmental Monitoring Plans prepared for the U.S. Synthetic Fuels Corp. under the Energy Security Act
- Preparation of a Report to Congress on Mining Wastes (including oil shale) under the Resource Conservation and Recovery Act
- Permitting Activities under the Clean Water Act (NPDES) and Safe Drinking Water Act (underground injection control)

The current program is therefore designed to meet specific information needs in order to allow the Agency to better carry out its responsibilities in the above areas.

Current EPA Oil Shale Research Efforts

At the present time EPA has eight oil shale research projects underway as listed in Table 1, along with the performing organization (contractor or grantee) and the estimated date that a final report will be available. These projects are focused on two particular areas of environmental concern. Three projects are designed to provide information on the quantity and characteristics of gaseous emissions from oil shale retorting, along with the effectiveness and cost of conventional and innovative gaseous (especially SO_x and NO_x) pollution control systems. This information is of particular importance to PSD permitting, review of environmental impact statements, and evaluation of environmental monitoring activities for SFC projects. Four research efforts are directed at assessing the potential environmental impacts and evaluating control technology for oil shale solid waste disposal. Results from these efforts will assist in evaluating environmental impact statements, issuing permits for retorted shale disposal activities, reviewing Premanufacturing Notices, preparing a legislatively required report to Congress on mining wastes, and evaluating monitoring plans and activities for SFC projects. One project is multimedia and supports all the above mentioned activities.

Air Emission Assessment and Control

Two studies are being performed by KVB, Inc. under a subcontract from Metcalf and Eddy, Inc. The first study consists of field testing of two EPA owned pilot plants, a Stretford plant and a liquid caustic scrubber, on a slipstream of retort offgas from Geokinetics retorts 27 and 28 during the spring of 1984. The objective was to assess the performance of these two technologies as applied to removal of H_2S from a low heating value dilute offgas such as that produced at Geokinetics' Seep Ridge site. The results from this field testing program, summarized in two other papers to be presented at this symposium, are presented in detail in a final report which should be available in a few months. The second study is just being started by KVB for EPA and involves preparation of a state-of-the-art report on pollution control alternatives for air emissions from oil shale operations. The purpose of this effort is to pull together in one document a digest of the best and most relevant information available in the public sector on potential air emissions and controls for oil shale retorting. No original research is planned as part of this effort. Rather, it will produce an edited compilation of the work performed by many organizations over the last 10 years. This effort is just beginning, but we hope that it will produce a product available to the public by September 1986.

The third project focused on air emissions consists of a two-phased evaluation of an innovative approach to control of sulfur emissions; specifically, the potential effectiveness and possible difficulties of utilizing combusted retorted shale as a dry scrubbing agent to remove sulfur from retort offgas. The study by J&A Associates is targeted to evaluate the potential effectiveness of this novel sulfur control concept based on adsorbing SO_2 on the carbonate material

when part or all of the retort offgas, along with the retorted carbonaceous shale and any unretorted oil shale fines, are combusted to recover their energy value. This concept may be employed as an integral part of the retorting process as in the case of Lurgi or Chevron STB or could be employed as an add-on system for processes such as Unishale B or TOSCO II. Phase I of this study will produce an engineering analysis to identify the most important variables influencing this process; Phase II will consist of pilot scale testing at J&A's facilities near Golden, Colorado.

J&A is considering three cases in their analysis of combusted shale as a scrubbing agent. For direct-fired retorting they will examine the OXY MIS process coupled with Unishale C surface retorting. This case was selected and sized to represent Cathedral Bluffs' proposed project to SFC (Third Solicitation) except for substituting Unishale C for the Unishale B process. The Unishale C process employs spent shale combustion to recover the energy value from the carbonaceous retorted shale. For purposes of this study the MIS retort offgas is fed to the Unishale C retorted shale combustor to recover its energy value and remove H_2S (in the form of SO_2). It should be noted that the current plans of Cathedral Bluffs are unknown following the February 19, 1985, release of SFC's Phase I Business Plan which discouraged use of the Unishale B process for the Cathedral Bluffs project if SFC funding was desired. Unishale C was arbitrarily selected for this study as an example of a process that combusts the retorted shale.

The second case is the indirect fired Unishale C process which essentially consists of a Unishale B retort coupled with a retorted shale combustor. This case is selected and sized to represent the basic building block module proposed by Union to the SFC (Third Solicitation). It consists of two 1,590,000 liter/day (10,000 bbl/day) retorts that feed a single 3,180,000 liter/day (20,000 bbl/day) upgrade plant. Two such modules constitute Union's proposal to SFC. However, this study differs from Union's proposal to the SFC in that the combustor is used to scrub H_2S (in the form of SO_2) from the retort offgas, which was not proposed by Union.

The third case is use of SO_2 adsorption as an integral part of the retorting plant. This would be the case for Lurgi as proposed by Rio Blanco and for the Chevron STB process proposed for Clear Creek. We have selected the Lurgi example due to the greater amount of information available. J&A will look at a single Lurgi retorting system which would process 11,612 metric ton/day (12,800 short ton/day) of raw shale to produce 772,263 liter/day (4,857 bbl/day) of shale oil. Such systems could be replicated to reach desired plant size.

The above three cases were selected to provide for analysis of diverse retorting systems and at the same time produce information which may be useful to both SFC and EPA . The final report should be available about June 1986.

Environmental Impacts and Designs For Solid Waste Disposal

Four projects constitute EPA's current program in the oil shale solid waste area. One study by Colorado State University is designed to investigate the nature of leachates produced from retorted oil shale along with hydraulic properties, such as permeability and water holding capacity, of the shale which may control the quantity of leachate produced. RCRA and ASTM batch leaching tests, along with a specific column leaching test, referred to as the ESM (equilibrated soluble mass) test, have been employed to leach TOSCO II, Lurgi, Paraho, and Hytort retorted shales. Allis Chalmers, Chevron STB, and Unishale B retorted shales are scheduled for future tests. Included in this project is evaluation of the impacts on leachate characteristics due to co-disposal of oil shale wastewater with the retorted shale. Samples of co-disposal wastewaters have been obtained for Paraho (direct mode) and Lurgi retorting. During the next few months samples should also be available for Chevron STB and Unishale B. These wastewaters will be blended with the retorted shale from the same process and then will be leached in columns by the ESM method. Comparison to leachates produced in the same manner but with distilled water blended with the retorted shale should provide indication of any potential impacts resulting from co-disposal of wastewaters. The leachates will be analysed for both inorganic and organic contaminants. Some results from this laboratory effort have already been published (but not co-disposal) in report EPA-600/D-84-228,

"Leaching and Selected Hydraulic Properties of Processed Oil Shales." Complete results from this research should be available about December 1985. An analysis of liquid and vapor transport coefficients for retorted oil shale, co-sponsored by EPA and AMOCO, is the subject of a paper by David McWhorter and Glen Brown to be presented at this symposium.

A second effort by Colorado State University is just getting underway. EPA recently awarded a cooperative agreement to Colorado State University for the purpose of preparing a state-of-the-art report focused on the environmental problems, approaches, and control technology applicable to oil shale solid waste (spent shale) disposal sites. The primary intention is to assemble in one report what has been learned from many separate research efforts funded by various Federal and State agencies as well as private industry. Currently this information exists in many separate, and often obscure, published and unpublished sources. Locating, extracting, and evaluating what has been done, in order to determine what has been learned and what major questions remain, will not be an easy task. However, we believe that the final product will prove to be a very useful reference for all parties involved in oil shale: researchers, regulating agencies, and developers. In order to assist us in identifying all relevant information sources, environmental considerations, and control technology applicable to this effort, EPA has formed a small informal advisory group composed of individuals who have wrestled with this problem. Included in this advisory group are representatives from industry, other Federal Agencies, States of Colorado and Utah, and researchers from the consulting and academic worlds.

Some of the subject areas to be addressed in this report include:

- leachate control
- erosion control
- geotechnical stability
- diversion of upstream runoff
- revegetation
- top-cover construction

Examples of some of the kinds of data to be gathered in support of this effort include:

- chemical properties
  - mineralogy
  - organic chemistry
  - inorganic chemistry
  - leaching characteristics
  - cementing potential
- geotechnical properties
  - shear strength
  - compressibility
- hydrologic properties
  - permeability
  - water content
  - water retention
- plant growth properties
  - nutrients
  - toxicity
- characteristics of operations
  - quantities to be generated
  - co-disposal of process waters
  - co-disposal of raw shale fines
  - disposal temperature
- predictive models for
  - water balance
  - partially saturated flow
  - chemical transport
  - assessing regional impacts

It must be emphasized that the final report will not prescribe a specific design but rather will discuss various alternative designs and controls along with their associated short and long term environmental impacts and tradeoffs. The final product from this effort will not be available until about the end of 1987. However, some initial work sponsored by this effort (conducted by Robert Heistand on estimating the quantities of solid wastes from oil shale facilities) is the subject of a separate paper at this symposium.

The other two current research efforts in oil shale solid waste are concluding and will be available later this year. One is an assessment of oil shale solid waste characteristics with a summary of disposal control technology considerations. This

effort by Monsanto Company presents brief discussions of 15 retorting processes along with whatever information is currently available in the open literature regarding the physical and chemical properties of the solid wastes from these processes. The final report is currently being reviewed by the Agency and should be available to the public by September. For the past 4 years Denver Research Institute has been conducting a laboratory study for EPA to assess the potential usefulness and problems of using retorted shale to construct liners below retorted shale disposal sites. Two materials selected for intense study by DRI were TOSCO II, carbonaceous and decarbonized (burned) retorted shale and Lurgi decarbonized shale. The study includes not only evaluation of properties of these shales as potential liner material as they exit the retort, but also what modification could reasonably be made (such as mellowing, mixing of carbonaceous and decarbonized shales, aging, moisture content, compactive effort) to improve their performance as a liner. Desirable liner properties sought include low permeability, long term durability, self healing capacity, structural strength, and reduced tendency to form planes for mass slippage. The final report from this effort should be available about the end of 1985.

Multimedia

One study, Pollution Control Technical Manual (PCTM) for the Unishale B and C processes, is multimedia in scope but focused upon pollution control technology applications and costs. The product will be a manual very similar in content to the three PCTMs EPA published in 1983 covering the TOSCO II, Lurgi, and Modified In-situ processes. It was decided to publish this additional manual on the Unishale B and C processes due to the potential support of the U. S. Synthetic Fuel Corp. for Union Oil's Phase II expansion and the Cathedral Bluffs project and because of the expressed potential interest in using the Unishale B process by White River, Getty, Cities Service, and Mobil. We are receiving assistance from Union Oil and Cathedral Bluffs in preparing this manual which will key off of Union's proposed Phase II expansion on Parachute Creek but will also include discussion of other pollution control design alternatives such as proposed by Cathedral Bluffs.

Previous EPA Oil Shale Research

A selected list of the most significant EPA oil shale reports currently available is presented in Table 2 along with information on how these reports can be obtained. A more complete list of reports is available to anyone who may be interested. Requests for this more comprehensive list should be addressed to E. R. Bates, U.S. EPA, Cincinnati, Ohio 45268.

NOTICE

This paper has been subject to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Table 1: Current EPA Oil Shale Research Efforts

Descriptive Title	Contract or Cooperative Agreement #	Performing Organization	Estimated Date Report Available
Alkaline and Stretford Scrubbing Tests for H_2S Removal at Geokinetics	68-03-3166	Metcalf & Eddy (KVB, Inc.)	9/85
Pollution Control Alternatives for Air Emissions From Oil Shale Operations	68-03-3166	Metcalf & Eddy (KVB, Inc.)	9/86
Control of Sulfur Emissions Through Adsorption on Combusted Retorted Shale	68-03-1969	J & A Associates	6/86
Leaching and Hydraulic Properties of Retorted Oil Shale Including Co-Disposal with Wastewater	CR-807668	Colorado State University	12/85
Pollution Control Alternatives for Oil Shale Solid Waste Disposal	CR-812225	Colorado State University	12/87
Assessment of Solid Waste Characteristics and Control Technology for Oil Shale Retorting	68-01-6487	Monsanto	9/85
Assessment of Retorted Oil Shale as a Liner for Retorted Oil Shale Disposal Sites	CR-809223	Denver Research Institute	12/85
Pollution Control Technical Manual for Unishale B and C Retorting Processes	CR-811679	Denver Research Institute	6/86

Table 2: Selected List of EPA Oil Shale Reports

Title	Authors	Report # EPA-	NTIS #PB
Environmental Perspective on the Emerging Oil Shale Industry	E. Bates T. Thoem	*600/2-80-205a	81-186942a
Overview of Large Scale Surface Mining of Oil Shale: Piceance Basin, Colorado	R. Lappi D. Carey A. Pelofsky E. Bates J. Martin	*600/D-82-283	None
Pollution Control Technical Manual: TOSCO II Oil Shale Retorting with Underground Mining	Denver Research Institute	*600/8-83-003	83-200212
Pollution Control Technical Manual: Modified In-Situ Oil Shale Retorting Combined with Lurgi Surface Retorting	Denver Research Institute	*600/8-83-004	83-200121
Pollution Control Technical Manual: Lurgi Oil Shale Retorting with Open Pit Mining	Denver Research Institute	*600/8-83-005	83-200204
Quality and Quantity of Leachate From Raw Mined Colorado Oil Shale	D. McWhorter	*600/D-84-143	85-118057
Leaching and Selected Hydraulic Properties of Processed Oil Shales	D. McWhorter V. Nazareth	*600/D-84-228	85-146405
Project Summary: Groundwater Monitoring Recommendations for Oil Shale Development	L. Everett	*600/S4-83-055	None
Field Studies on Paraho Retorted Oil Shale Lysimeters: Leachate, Vegetation, Moisture, Salinity, and Runoff	M. Kilkelly H. Harbert III W. Berg	600/7-81-313	81-234742
Field Studies on USBM and TOSCO II Retorted Oil Shales: Vegetation, Moisture, Salinity, and Runoff	M. Kilkelly W. Berg H. Harbert III	600/7-81-139	82-109810
Control of Sulfur Emissions from Oil Shale Retorting	R. Lovell S. Dylewski C. Peterson	600/7-82-016	82-231945

Table 2 (Cont'd): Selected List of EPA Oil Shale Reports

Title	Authors	Report # EPA-	NTIS #PB
Environmental Monitoring Reference Manual for Synthetic Fuels Facilities	B. Henschel J. Stemmle	600/8-83-027	83-251850
Auto-Oxidation Potential of Raw and Retorted Oil Shale	D. Green	600/2-84-153	85-156248
Logan Wash Field Treatability Studies of Wastewaters From Oil Shale Retorting Processes	B. Desai D. Day T. Ctvrtnicek	600/2-84-115	84-211143
A Compendium of Reported Physical and Chemical Data For Petroleum and Synthetic Fuel Products: Volume I - Petroleum and Shale Oil Products	S. Quilivan A. Panahloo M. Ghassemi	560/4-84-001a	84-186063

* Publication is available free from ORD Publications, Center for Environmental Research Information, U.S. EPA, 26 W. St. Clair St., Cincinnati, Ohio 45268.

All other reports should be ordered from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. Prices vary.