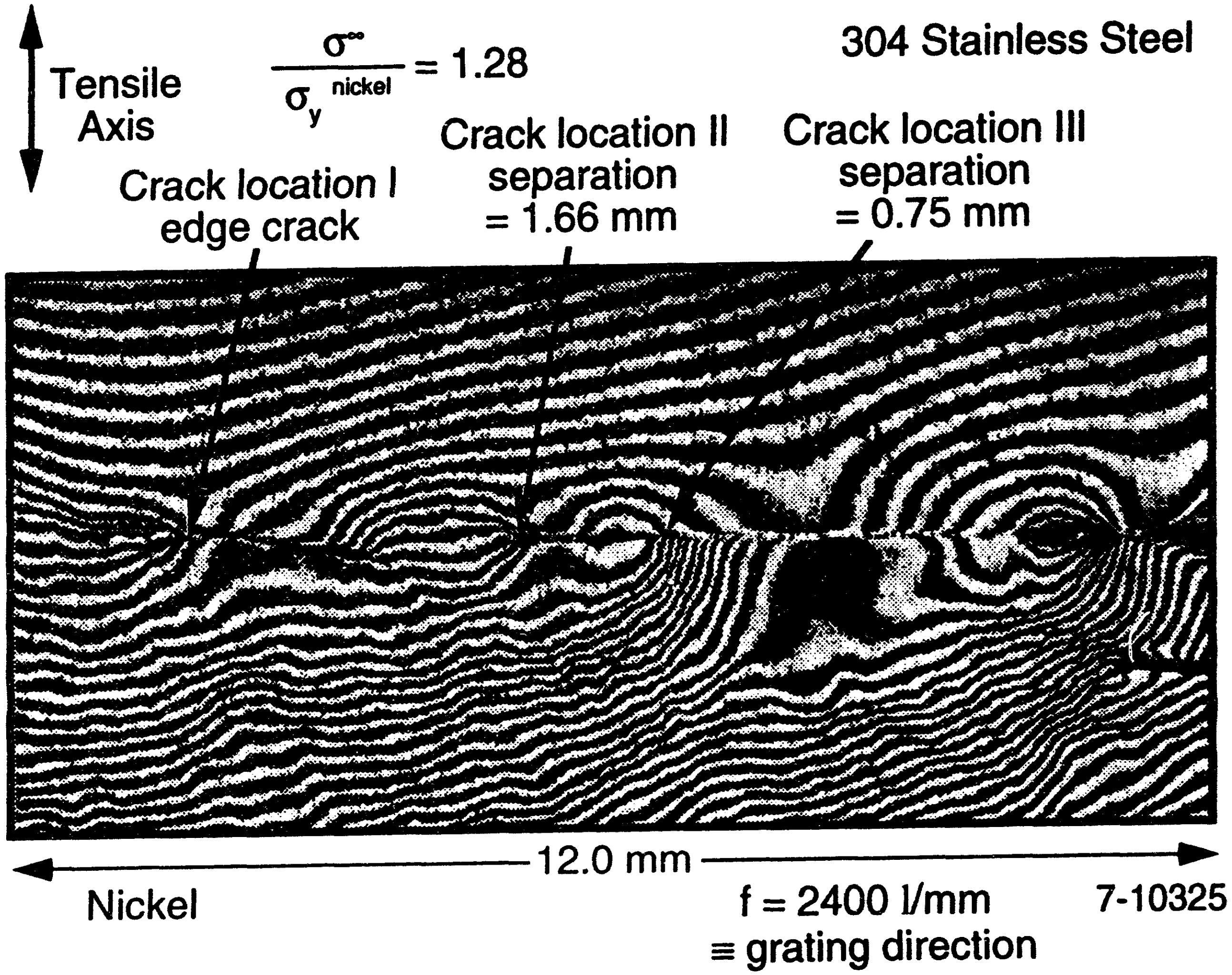
Moire Interferometry Gives Quantiative Displacement Information at Weld Defects/Crack Growth



Moiré interferometry is used to show the Y or tensile axis displacement fields for a defective 304 stainless steel /pure nickel filler metal weldment. The moiré pattern gives the quantitative displacement field for the weld defect region that forms at the filler/base boundary due to lack of fusion of the nickel filler metal to the 304 SS base metal. The displacement patterns can be used to quickly determine the severity of the defect and to assess the validity of many computer codes predicting failure of a structure. Field portable systems have been developed and used with success.

New Tools and Facilities at the DOE Laboratories Offer Superb Opportunities for the Petroleum Industry in Catalysis

- X-ray synchrotrons for basic catalysis studies
- Computer aided molecular design
- Theoretical analysis of catalytic performance, development of synthetic pillared clays, molecular sieve synthesis
- Scanning Tunneling Microscopy to determine heterogenous catalyst morphology

An example of technologies that exist at the national laboratories that may be of interest to the refinery industry include techniques and facilities that can be applied in support of the refinery development of catalysts. These include:

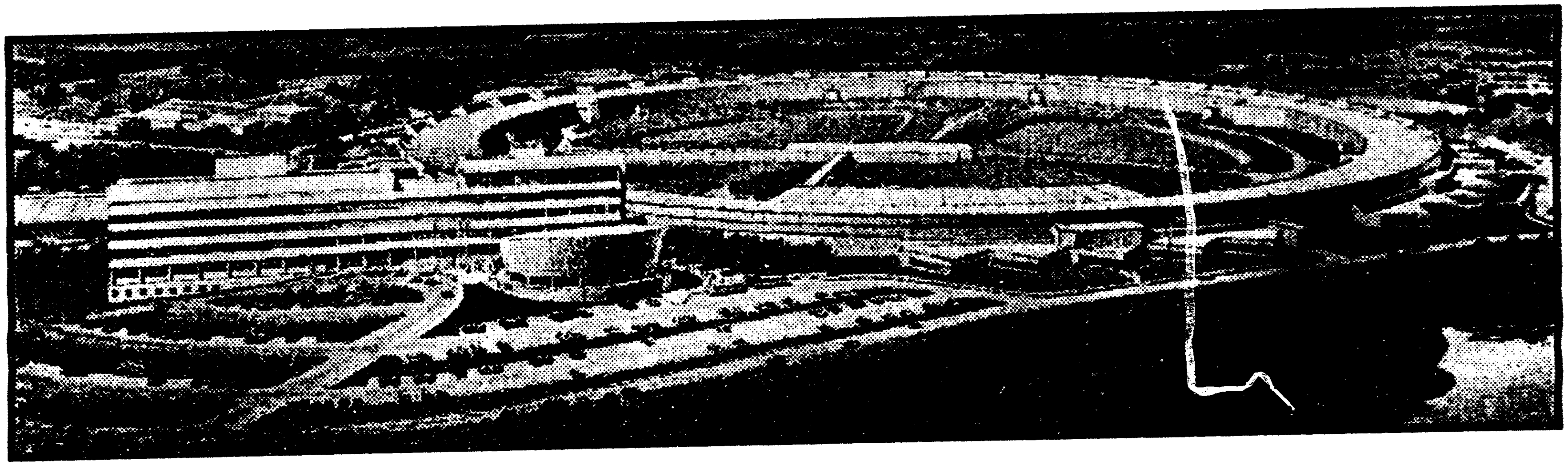
User facilities such as X-ray synchrotrons that can be used for basic catalyst studies. Such devices can allow very fine grained analysis of the catalytic process, including the direct observation of catalytic activity on the surface of the catalyst while the reaction is taking place.

The laboratories are heavily involved in computer aided molecular design that can be used "try out" different molecular configurations in support of catalyst development.

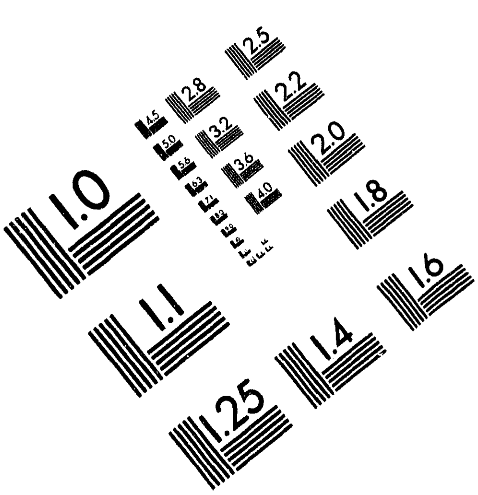
Other activities include the development of synthetic pillared clays that can either have catalytic activity, or can serve as molecular traps, synthesis of molecular sieves, and the theoretical analysis of catalysis performance.

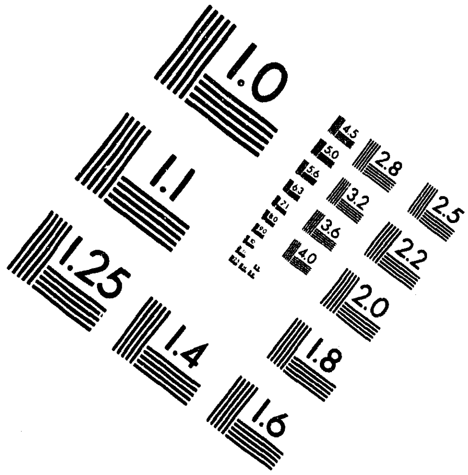
Scanning tunneling microscopy has also been used to study the morphology of heterogeneous catalysts.

Petroleum, Chemical, and Catalyst Companies Have Formed a Collaborative Access Team (CAT) on the Advanced Photon Source



This is an artist's conception of the Advanced Photon Source, which is being constructed by the Department of Energy. This user facility has a diameter greater than the height of the Sear's Tower, and will produce X-ray beams that are 10,000 times brighter than any existing source. These intense X-ray beams may be used for studies of polymerization, catalysis, and other materials studies of interest to the refining industry. A collaborative Access Team (CAT) comprised of petroleum, chemical, and catalyst companies will be setting up a beam line during 1994 for early access to the X-rays when the facility begins operation in 1995.



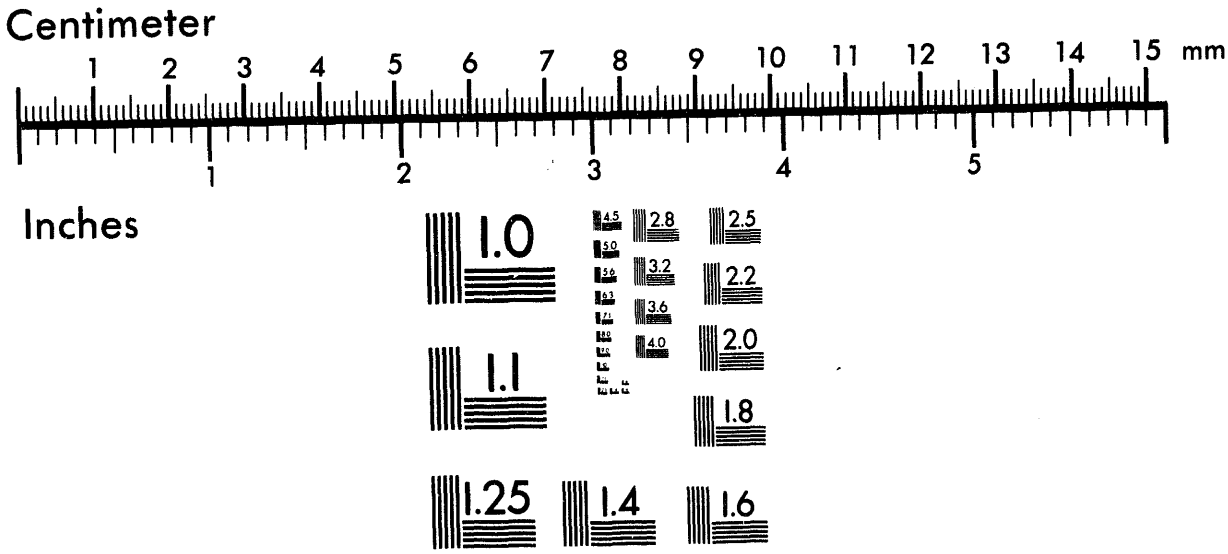


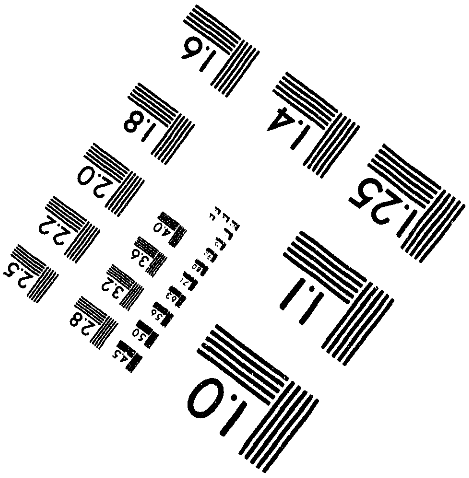
AIIM

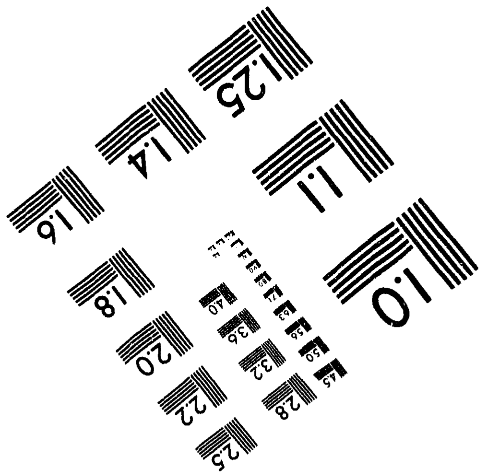
Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202



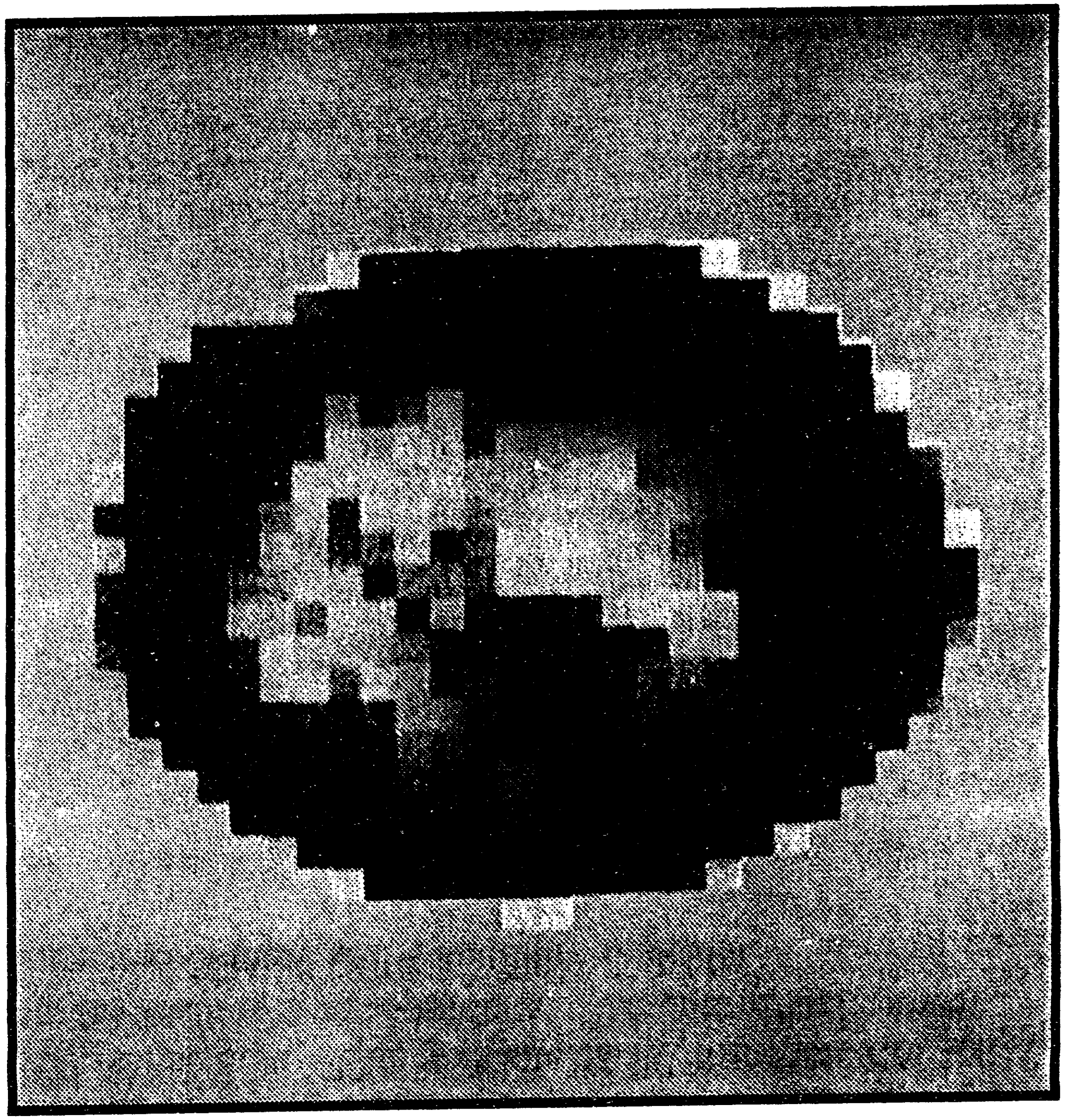




MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

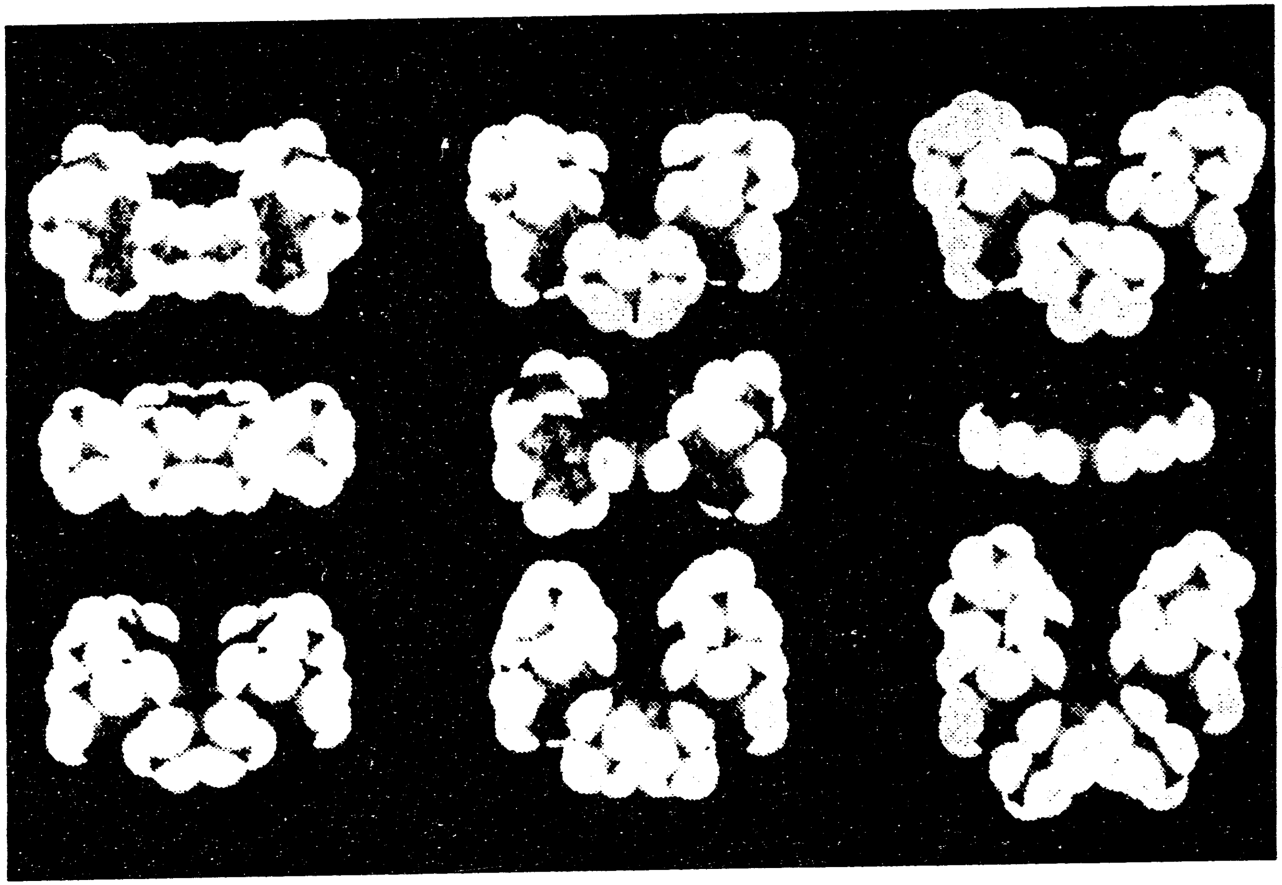
3 of 3

An X-Ray Synchrotron Light-Source Can Be Used to Measure Distribution of Metals in a Catalyst Particle



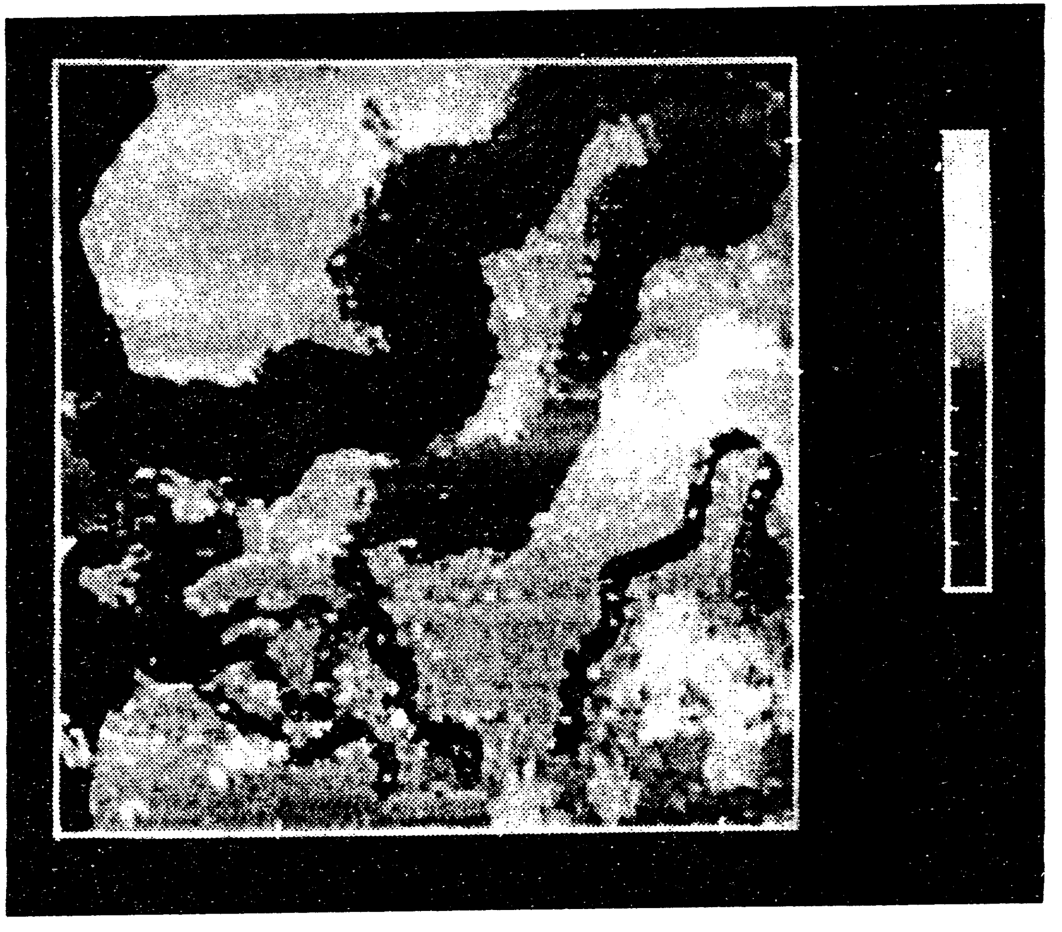
This is an example of the use of an X-ray synchrotron light-source to study the distribution of metals in a catalyst particle. The particle is 90 micrometers in diameter, and the resolution is at the level of 5 micrometers. The dark (black) areas on the surface represent the presence of Nickel and Vanadium deposits.

Molecular Modeling on the Computer Has Allowed the Design of Molecules Having Specific Properties that Facilitate Catalytic Activity



Molecular modeling on high speed computers can be used to allow the design of specialized molecules. This photo shows different configurations, including some that have been designed to form a "pocket" to help facilitate catalytic activity.

Scanning Tunneling Microscopes are Used to Reveal Heterogeneous Catalyst Morphology



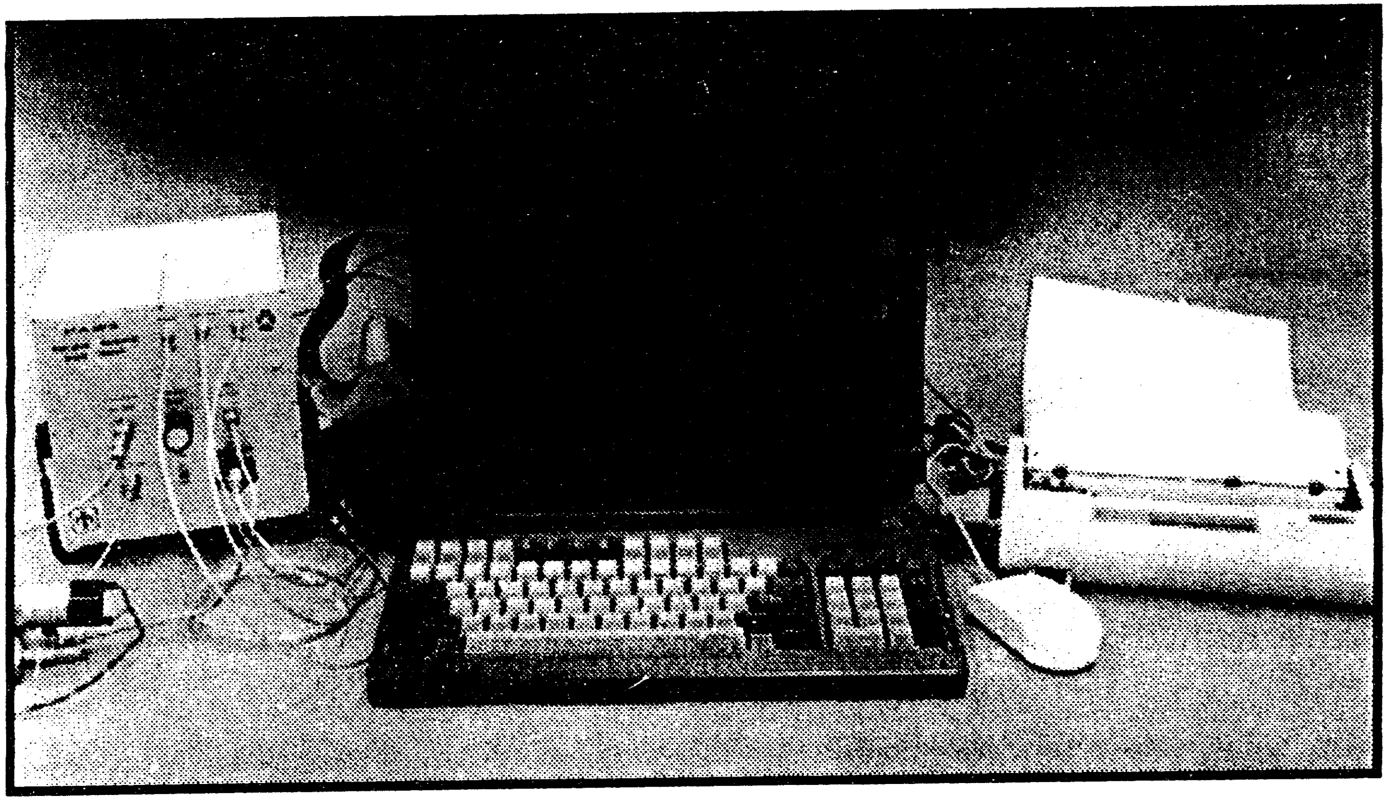
This is a photomicrograph of a catalyst surface, taken using a Scanning Tunneling Microscope to measure the morphology of a heterogeneous catalyst particle. The area scanned measures 300 nanometers on a side.

Advanced Sensor Technologies Being Developed Can Assist in Environmental and Process Control

- Thick-film cermet sensors for gas analysis in hostile environments
- Surface Acoustic Wave Sensors
- Microwave and millimeter wave spectrometry for remote gas sensing
- Mini/micro mass spectrometers for on-line gas sensing
- Ultrasonic velocity and viscosity measurements

The laboratories have considerable work in progress on the development of new sensor and instrumentation technologies. These include thick film cermet sensors that can be used in hostile environments, surface acoustic wave sensors that can selectively detect VOC's, millimeter and microwave spectrometry suitable for remote gas sensing, micro mass spectrometers that can be used for on-line gas sensing (a version is of interest for onboard monitoring of automobile exhaust), and ultrasonic velocity and viscosity measurement devices that are non invasive to the piping system.

A Portable Acoustic Wave Sensor is Being Commericalized for On-line VOC Emissions Measurements



This is a photo of a portable acoustic wave sensor that is being commercialized for on-line measurements of VOC emissions.

Thick Film Cermet Sensors Can Distinguish Multiple Gases in Hostile Environments

This is a photo of a thick film cermet sensor being developed by the laboratories. The sensor is compared in size to a nickel, and contains a heating array, sensing elements, and reference electrodes in a solid state ceramic configuration that allows operation at temperatures of up to 300 °C.

A CRADA to Assess Air Toxic Emissions, Understand Their Origin, Fate, and Mechanisms of Formation and Destruction is Being Negotiated With

TEXACO

AMOCO

Chevron

ARCO

Mobil

UNOCAL

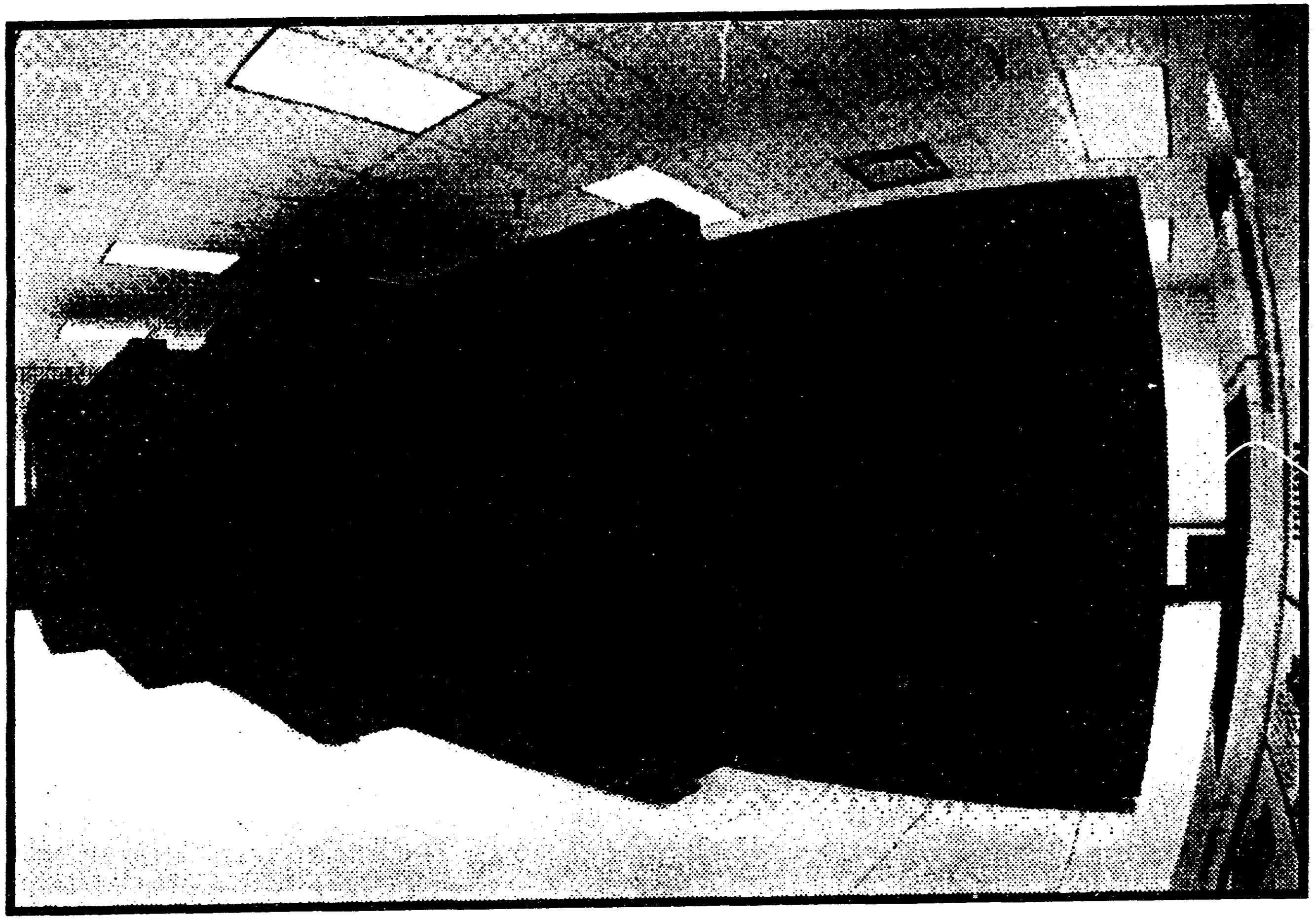
Six oil refinery companies are currently negotiating a CRADA to assess air toxic emissions, understand their origin, fate, and mechanisms of formation and destruction with some DOE national laboratories. This activity stems from a long term ongoing effort to better understand combustion processes at the national laboratories.

DOE Laboratories Have Developed Enormous Computer Modeling Capabilities for Complex Problems Applicable to Refinery Problems

- Reactive flows in engines, burners, etc.
- CVD processes
- Sprays and particulates
- Porous media flow – subsurface contaminants
- Flows over and through catalysts
- Process reactors
- 3D fluidized-bed reactors

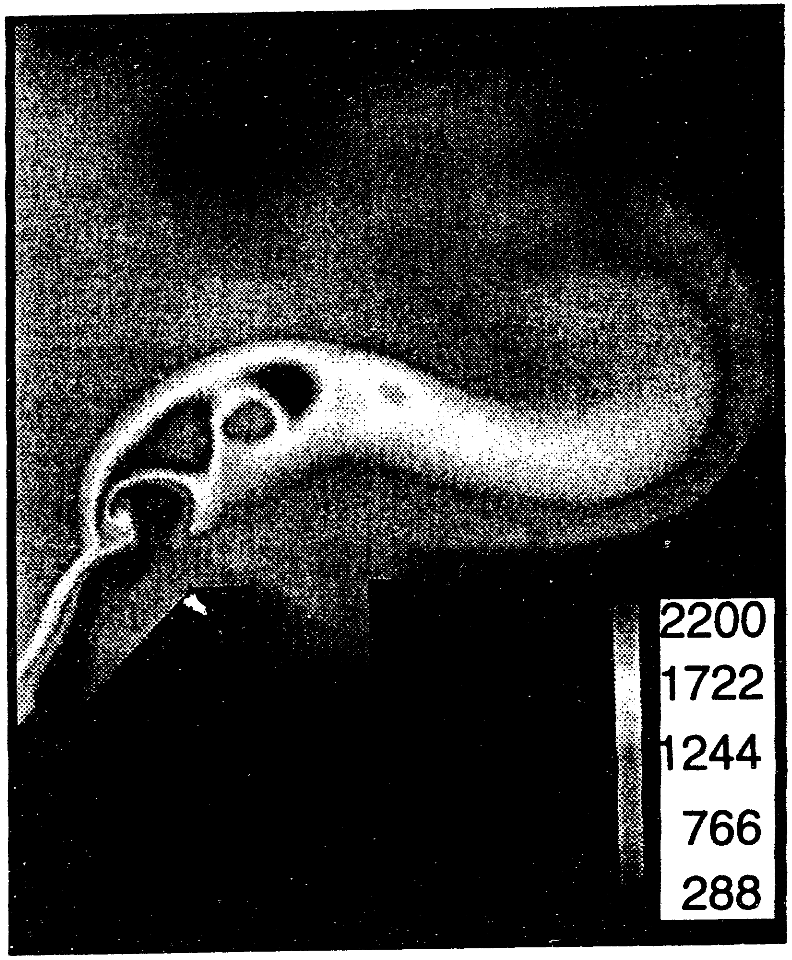
The laboratories have developed considerable computer facilities and expertise for modeling complex problems applicable to refineries. These include reactive flows in engines and burners, CVD processes, the modeling of sprays and particulates, porous media flow -- particularly of subsurface contaminants, the flow over and through catalysts, modeling of process reactors, and the modeling of erosion and corrosion of fluidized bed reactors. The next several slides will provide a few examples.

The DOE Laboratories Have Unparalleled Facilities and Staff for Advanced Computations



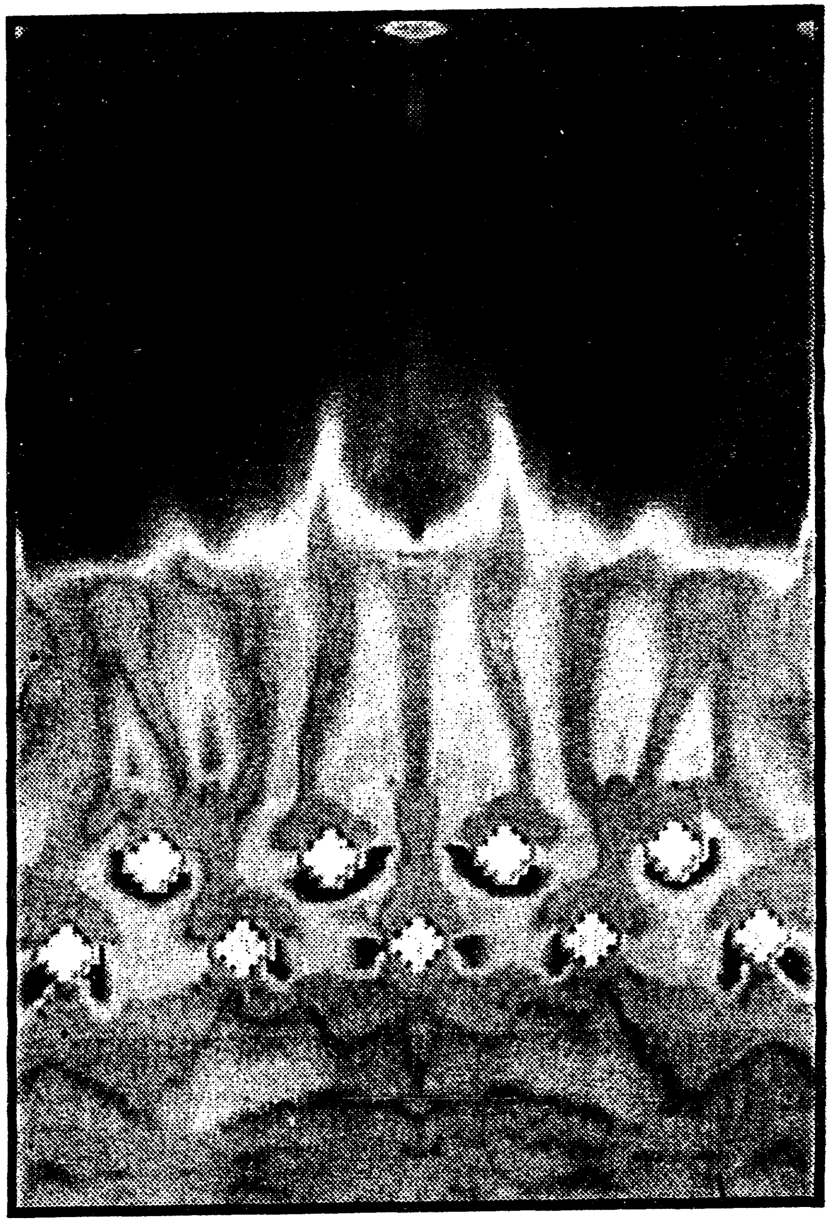
This is a photo of 5 parallel computers that are representative of the facilities that the laboratories can bring to bear on massive computational problems

Computer Models of an Industrial Burner Assists in the Design of an "Ultra Low NO_x" Burner



This is a computer generated model of a flame in a burner. By modeling the flame temperatures, engineers can modify the design of the burner to achieve lower NO_x performance. Similar modeling efforts can help design combustion processes to limit the amount of particulates, etc.

Validated Models of Fluidized Bed Reactors Allow Determination of Erosion, Corrosion, and Efficacy of Fluidized Catalytic Reactors



This is a computer generated flow map of a fluidized bed with heat exchanger tubes in place. The model predicts variations of the density of solids, the velocity and density of gases, and the particles motion. This model was used to study the erosion of heat transfer surfaces in fluidized bed combustors.

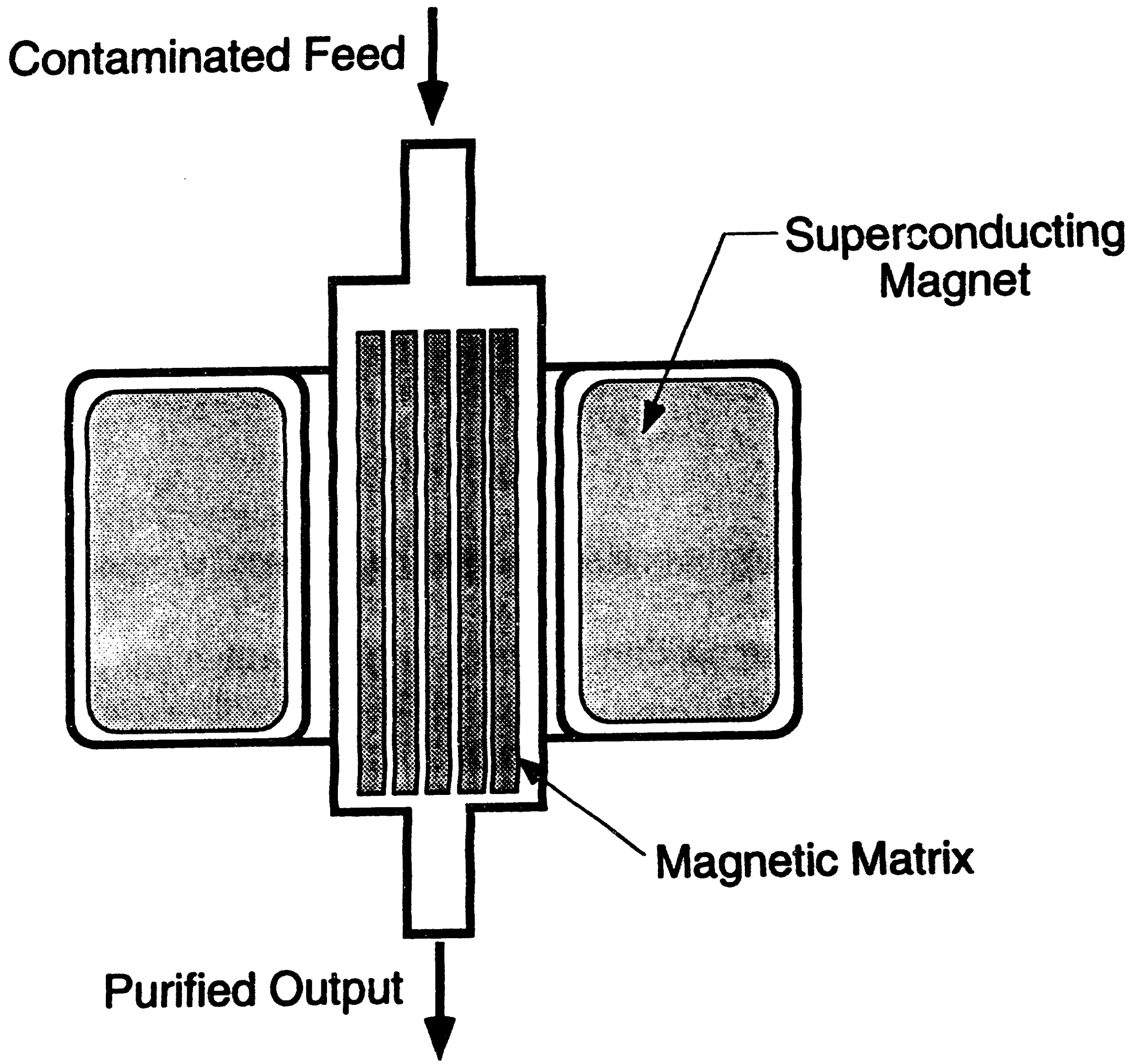
Separation Sciences Developed for DOE Purposes can be Utilized in Refinery Processes

- Advanced organic and inorganic membranes
- High gradient magnetic separation
- Open gradient magnetic separation
- Ion-exchange for metals removal
- Electrochemical recovery of metals from spent catalysts
- Electrodialysis for desalting, purification, and concentration
- Emulsion phase contactors
- Liquid-liquid extraction

The laboratories have developed skills, facilities, and expertise in the area of separations for DOE problems that can be used for refinery processes. These include:

Membranes, both organic and inorganic, magnetic separation facilities (both high gradient and open gradient techniques), ion-exchange for metal removal (discussed earlier), electrochemical recovery of metals from spent catalysts, electrodialysis for desalting, purification and concentration of organics and salts, emulsion phase contactors that utilize electrical charge to disperse and coalesce organics in aqueous media for intimate contact, and liquid-liquid extraction capabilities (discussed earlier).

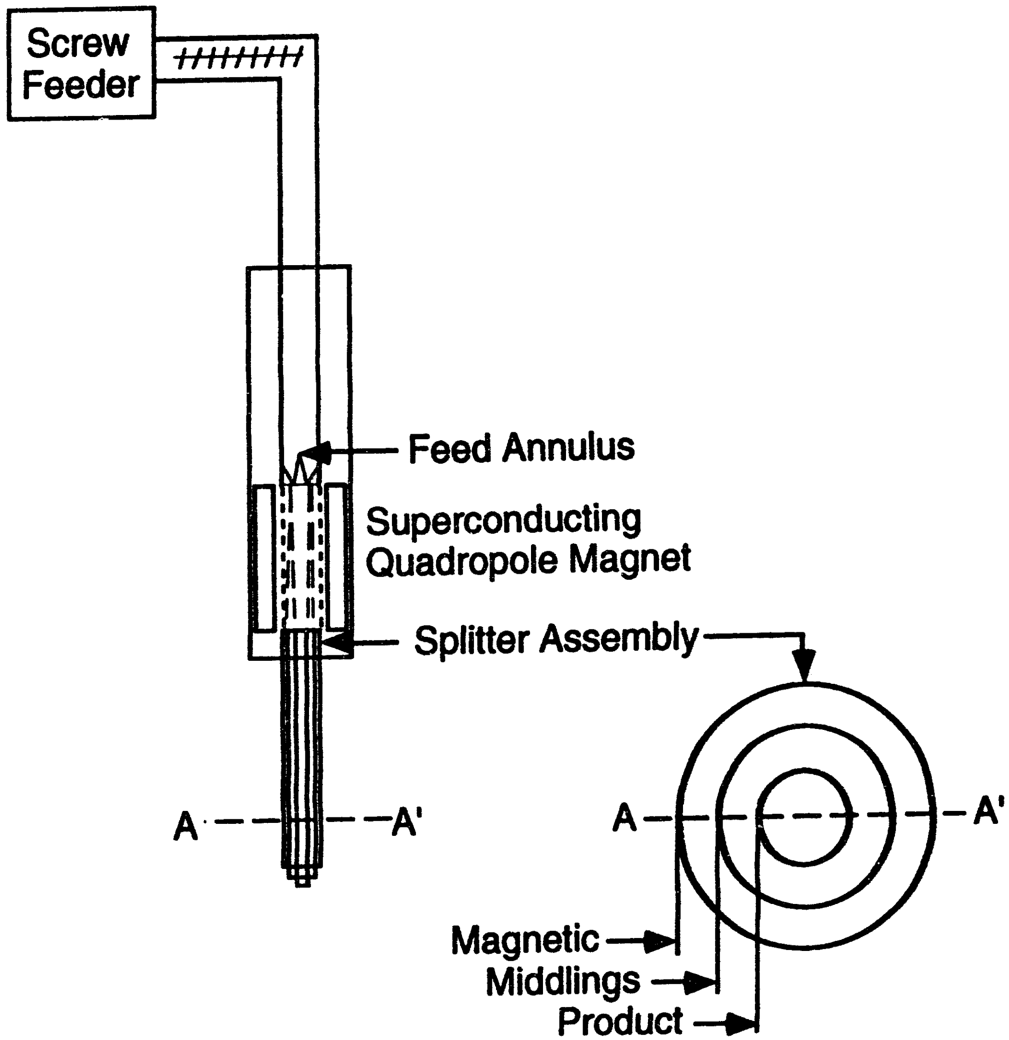
High Gradient Magnetic Separation (HGMS) Removes Paramagnetic Contaminants from a Liquid Slurry



High Gradient Magnetic Separation (HGMS) uses a matrix of magnetic material (such as steel wool) in the flow system, surrounded by a magnetic coil. When the coil is energized, magnetic particles contained in a liquid slurry are attracted to the matrix material, and removed from the slurry. Periodically, the flow is reversed and the magnetic field is turned off to flush the trapped impurities from the matrix.

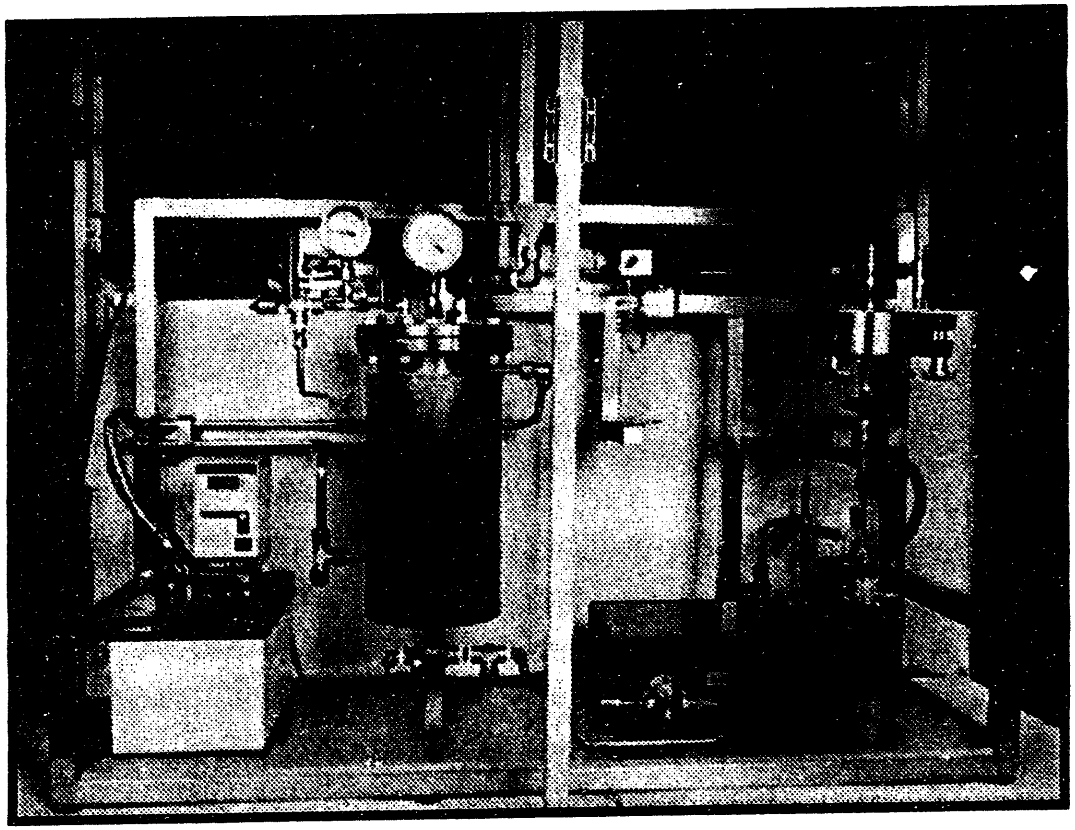
This type of magnetic separation is particularly suited for removing magnetic fines from liquid suspended slurries.

Open Gradient Magnetic Separation (OGMS) Can Separate Active and Inactive Fluid Cat-Cracking Catalysts



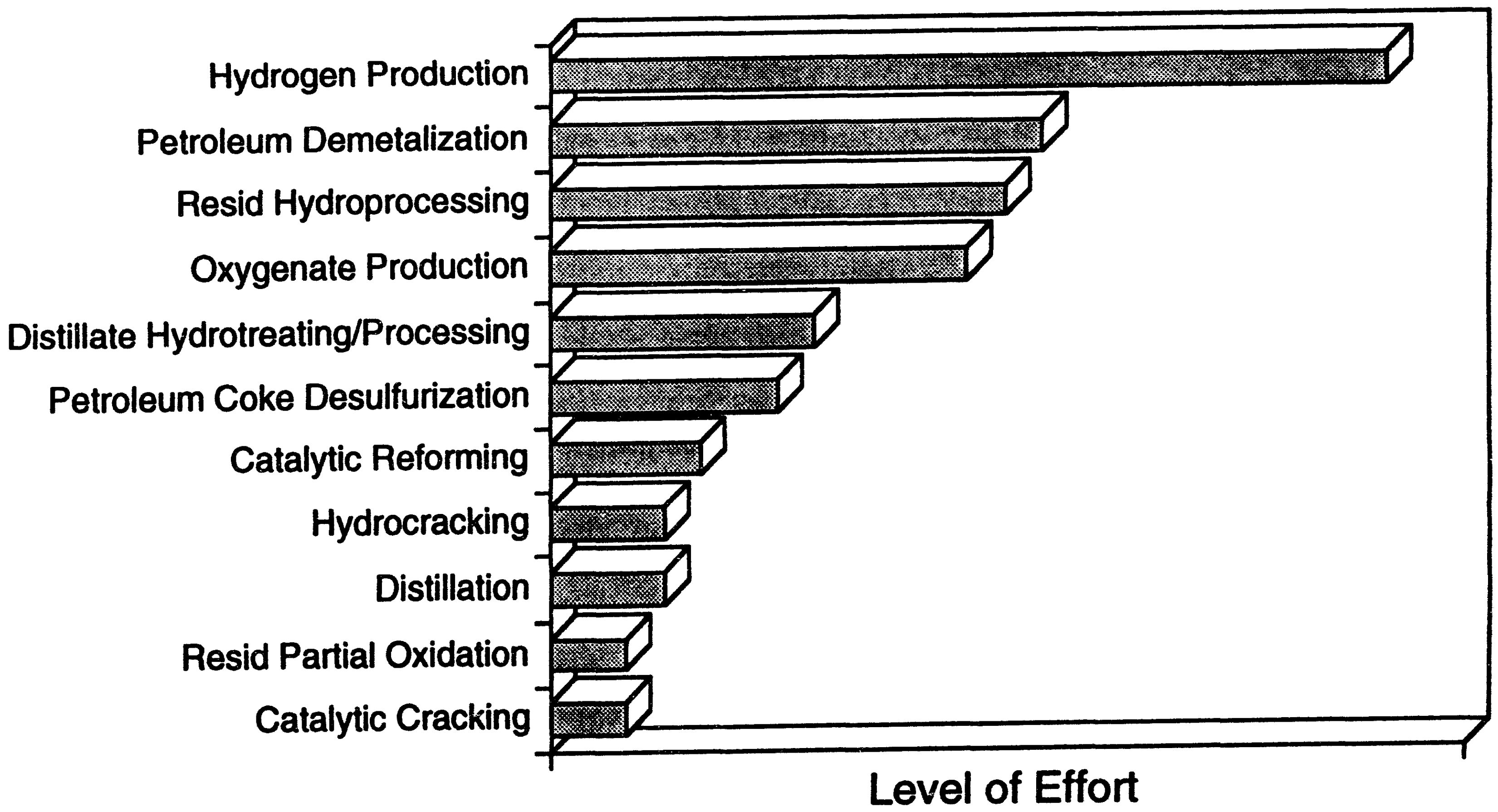
Open Gradient Magnetic Separation (OGMS) utilizes a continuous process, in which a dry powder containing materials of differing magnetic properties are dropped through an open bore. A super conducting quadrapole magnet creates a very steep gradient across the bore, and para-magnetic materials are moved to the outer circumference, and diamagnetic materials move towards the center of the bore. This apparatus lends itself to continuous operation, and the potential for using multiple stages in a separation process.

Inorganic Polymer Membranes Based on Polyphosphazenes Can Function in Harsh Environments



This photograph displays a bench scale membrane separation system that has been used to develop polymer membrane systems designed to operate in harsh environments. Work is in progress under a CRADA to develop bench and commercial scale systems based upon a family of inorganic polymers called polyphosphazenes. An integrated capability is in place for the synthesis, casting, and testing (gases and liquids). These membranes look particularly attractive in the area of halocarbon from water separations and other membranes are available for SO_x and other acid gas separations.

DOE Laboratories Have Process Development Capabilities That Can Augment Refinery Expertise



This chart shows the relative levels of laboratory capabilities for direct support in process technologies that are of interest to the refinery industry. The longest bar (Hydrogen production) represents ~ 110 man-years of effort over the past 5 years.

In this category, the laboratories have only recently begun efforts in such areas as resid hydroprocessing, etc. but have some approaches and techniques that can support the refinery industry in their efforts to improve processes.

DOE Laboratories Have Process Development Capabilities That Can Augment Refinery Expertise

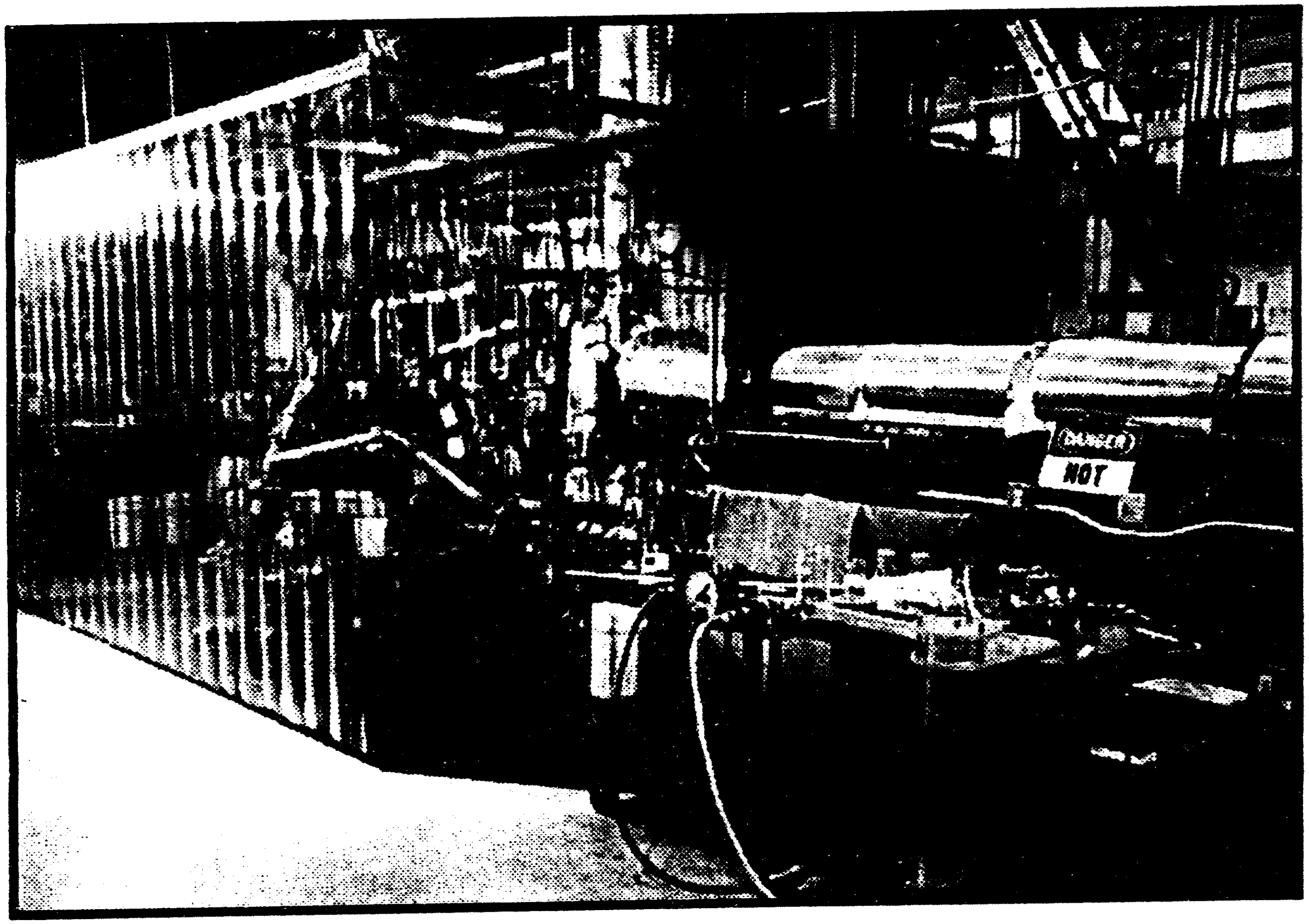
- Hydrogen production and management
- Thermodynamic measurements in support of the oil industry
- Engine and fuel testing facilities
- Oxygenate production

In hydrogen production, one of the processes currently under development with DOE sponsorship is the splitting of H_2S into H_2 and S, so that the hydrogen can be recycled in the plant, and not be discarded as waste water as is current practice with the Claus-SCOTT process.

The laboratories also have extensive capabilities for making very careful and fully supported thermodynamic measurements in support of the oil industry.

Other capabilities include complete engine and fuel testing facilities, and expertise in the production of oxygenate fuels, particularly alcohols.

A Vortex Fast Pyrolysis Reactor Has Been Developed to Convert Materials to Chemical Components for Synthesis



This is a Vortex Fast Pyrolysis Reactor, which was developed specifically to convert bulky, solid particulate material, such as biomass or solid waste, into chemical components for synthesis. This reactor uses external heating (rather than partial combustion), and achieves extremely high heating rates by injecting the solid bearing gas steam at a tangent to the reactor wall. This results in very rapid heat transfer, rapid heating and pyrolysis, and the ability to make fine cuts in the temperature profile seen by the feed material. Although developed for biomass applications, this reactor concept may be useful for other high solids operations in refinery settings.

Thermodynamics Laboratories in the DOE System Provide a Resource to the Petroleum Industry

- Thermochemistry measurements
- Adiabatic calorimetry
- Combustion calorimetry
- Vapor pressure measurements
- Densities
- Spectroscopic measurements

The thermodynamics capabilities in the DOE system can provide a resource for the petroleum industry. Capabilities include adiabatic and combustion calorimeters, vapor pressure and equilibrium measurements, densities, spectroscopic measurements, etc.

Testing Provides Support to the Petroleum Industry on the Performance of Fuels in Engines

- Emissions
- Alternative fuels
- Fuel-engine interactions (auto-oil)
- Engine durability, surface layer activation for on-line engine wear measurements
- Additives (deposit, valve seat sticking and recession)

Testing capabilities at the laboratories includes extensive emissions testing expertise and facilities, the use of alternative fuels (some of the largest alternative fuel fleets are operated by the laboratories for testing purposes), and fuel-engine interactions.

A unique surface layer activation technique for measuring engine durability in hours rather than days of testing has been developed by one of the labs. Other expertise includes the development of additives for inhibiting deposits, valve seat sticking, etc.

The Following Laboratories Contributed to the Information In This Presentation

Argonne National Laboratory

BDM-Oklahoma

Brookhaven National Laboratory

Idaho National Engineering Laboratory

Lawrence Berkeley Laboratory

Lawrence Livermore National Laboratory

Los Alamos National Laboratory

National Renewable Energy Laboratory

Oak Ridge National Laboratory

Pacific Northwest Laboratory

Sandia National Laboratory

Further information on DOE capabilities may be obtained from:

Daniel Wiley
Office of Industrial Technology
Energy Efficiency and Renewable Energy
Department of Energy
FAX 202-586-3180
FAX 202-586-7114 (alternate)

APPENDIX A

ONGOING RELEVANT R&D

AT

NATIONAL LABORATORIES

ARGONNE NATIONAL LABORATORY

CRADAS

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• Fouling Mitigation in Processing of Residuum and Heavy Oil	CHEVRON HTRI
• Ceramic Membrane Development	AMOCO CHEMICAL
• Methane Catalyst	AMOCO
• On-Line Process Controls	AMOCO
• Conversion of spent catalyst to marketable products	MILES, INC.
• Improved Resid Upgrading	AMOCO
• Fluidized Bed Upgrading of Heavy Oils and Residual Oils	CALIFORNIA SYNFUELS
• Hydrogen Sulfide Waste Treatment Using Plasma Chemical Technology	UOP
• Microwave Technology Evaluation	WAVEMAT

DOE (GOVERNMENT) FUNDED R&D

- Membrane Assisted Solvent Extraction/Membrane Assisted Distillation Stripping for Removal/Concentrations of VOC's
- Conversion of Catalyst Containing Non-Toxic Metals to Useful Products
- Vitrification of Spent Catalysts Containing Toxic Materials
- Development of Thick Cermet Film Multiple Gas Sensors for Measuring/Distinguishing Trace Concentrations of Different Gases
- Development of a Mini/micro Mass Spectrometer for Trace Gas Detection
- Passive and Active Microwave Spectrometry for Detection of Trace Gases from Remote Locations
- Development of Bi-functional Catalysts
- Development of Models to predict properties of Molecular Sieves
- Oxidation Coupling of Methane to Methanol

ARGONNE NATIONAL LABORATORY (cont'd)

DOE (GOVERNMENT) FUNDED R&D (CONT'D)

- Membranes for Pervaporation Applications
- Heat Integration of Distillation
- Structured Packings for Distillation
- Development of Complexing Agents for Removal of Heavy Metals from Waste Waters
- Solvent Extraction Processes for Removal of Inorganic Components from Aqueous Streams
- Two-Phase Flow and Heat Transfer Enhancement in Compact Heat Exchangers
- Fouling and Biocorrosion
- Development of Computer Codes for Predicting Hydrodynamics and Erosion in Fluidized Bed Systems
- Development of Computer Models for Predicting the Hydrodynamics and Pollutant Formation in Reacting Flow Systems
- Advanced Mass Spectrographic Methods for Characterization of Resids and Related Fossil Materials
- Magnetically Assisted Removal of Soluble Contaminants From Liquid Steams
- Recovery of H_2 and Sulfur from H_2S Waste

BROOKHAVEN NATIONAL LABORATORY

CRADAS

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• Low Temperature Liquid Phase Catalytic Synthesis of Methanol from Synthesis Gas	AMOCO
• Biochemical Production of Adsorbents from Fossil Fuel Wastes	EER LABS

DOE (GOVERNMENT) FUNDED R&D

- Biochemical Production of Surfactants from Low Grade Oils, Residuum, and Oil Wastes
- Biochemical Upgrading of Heavy Crude Oils and Residuum
- Application of Multitracer Technology to Petroleum Reservoir Studies
- Effects of Selected Thermophilic Microorganisms on Crude Oils at Elevated Temperatures and Pressures
- Liquid Phase Catalytic Synthesis of Higher Oxygenates form Synthesis Gas
- Adsorbent/Natural Gas Vehicle Storage Systems
- Hydrogen Storage on Carbon Adsorbents
- Mechanisms of Metal-Environment Interactions
- Combustion Kinetics and Reaction Pathways
- Fischer-Tropsch Synthesis with Fine Particle Catalysts
- Structure and Reactivity in Catalysis and Advanced Materials
- Hazardous Waste Management Disposal Operations
- Chemical Consequence Analysis
- In-situ Containment and Stabilization of Buried Waste
- Polymer Solidification
- Polyethylene Encapsulation of Single Shell Tank Waste and Ion Exchange Resin Wastes

BROOKHAVEN NATIONAL LABORATORY (cont'd)

- Microparticle Analysis by Laser Spectroscopy
- Continental and Oceanic Fate of Energy-Related Air Pollutants
- Aerosol Chemistry and Dynamics
- Atmospheric Tracer and Instrumentation Development
- Atmospheric Organic Chemistry: Investigation of Primary and Secondary Species
- CO_2 Mitigation Technologies
- Citrate Extraction of Heavy Metals
- Biodegradation of Selected Organic Compounds and Complexing agents of Radionuclides and Metals
- Biochemical and Molecular Approaches to Treatment and Stabilization of Radionuclides and Toxic Metals in Wastes
- Produced Water Risk Assessment

IDAHO NATIONAL ENGINEERING LABORATORY

CRADAS

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• Plasma Upgrading of Heavy Oil and Residuum	PHILLIPS
• Microbially Enhanced Oil Recovery and Biotechnology for Oil Field Operations	PHILLIPS
• Aerobic Biofilter for Hydrocarbon Vapor Treatment	EG&G ROTRON
• Polyphosphazene Membranes for Separations Under Harsh Conditions	UNION CARBIDE
• Automatic Contaminant Sample Analysis (with Los Alamos, et. al.)	ABC LABORATORIES
• Polyphosphazene Membranes for Hydrocarbon Separations	ELF ALTOCHEM
• Polyphosphazene Membranes for Separations Under Harsh Conditions	MEDIA PROCESS TECHNOLOGIES

INDUSTRY SPONSERED RESEARCH

TOPIC	INDUSTRIAL SPONSOR(S)
• Naturally Occurring Radioactive Materials in Oil and Gas Industry Equipment	API, GRI

DOE (GOVERNMENT) FUNDED R&D

- Environmental Modeling, Monitoring, and Assessments of Contaminated Sites
- Supercritical Water Oxidation of Toxic Materials
- Bioremediation and Treatment of Soils, Waste Water Streams, Volatile Organics

IDAHO NATIONAL ENGINEERING LABORATORY (cont'd)

- Chemical Treatment of Contaminated Waste Water Streams and Sludges
- Plasma Conversion of Fossil Fuels to Higher Value Products
- Polyphosphaze Membrane Development for Industrial Separation Processes
- Hydrogenation Catalysts for Treatment of Emissions, Feedstock Conversion
- Three Dimensional, Multiphase Multicomponent Thermal-Hydraulic Experiments and Code Development
- Human Factors Performance Related to Industrial Processes, Accidents, Spills
- Risk Assessment of complex Industrial Processes
- Industrial Plant Life Extension and Integrity Evaluations
- Robotic Sensing and Surveillance Systems
- Intelligent Process Sensing and control for Industrial Plant Applications

LAWRENCE BERKELEY LABORATORY

DOE (GOVERNMENT) FUNDED R&D

- Double Rotation Solid-State NMR for Studying Catalysis
- Additive Effects of Scrubber Chemistry
- Turbulent Combustion
- Combustion Chemistry
- Cloud Optical Properties
- Aerosol Chemistry
- Health Effects of Toxic Substances
- Energy Efficient, Low-NO_x and -CO Burners for Residential, Small Industrial, and Commercial Gas Appliances
- Improved Techniques for Sediment Toxicity
- VOC Contamination - Steam Flood Restoration Modeling
- NAPL - Multi-phase, Multi-component Modeling
- Lab Studies of Microbiology Transformation of Petroleum Hydrocarbon in Transient Subsurface Environment

LAWRENCE LIVERMORE NATIONAL LABORATORY

CRADAS

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• New Approaches to Automotive Combustion Systems and Control of NO_x Emission	CUMMINS ENGINE, GENERAL MOTORS
• The Origin and Fate of Toxic Combustion By-Products in Refinery Process Heaters: Research to Enable Efficient Compliance with the Clean Air Act	CHEVRON, MOBIL, ARCO, AMOCO, TEXACO, UNOCAL, GAS RESEARCH INSTITUTE
• Application of High Performance Computing to Automotive Design and Manufacturing	GENERAL MOTORS, FORD CHRYSLER
• Removal of Metals from Heavy Crude Oils using Liquid Exchange Reactions	PHILLIPS
• Biomimetic Catalysts for the Conversion of Methane to Methanol	AMOCO
• Hot Recycled Solid Processing of Oil Shale	AMOCO, CHEVRON-CONOCO
• Reduction of Nitrogen Oxide Emission for Lean Burn Engine Technology	GENERAL MOTORS, FORD, CHRYSLER
• Laminated Metal Composites	ROHR, SUTEK, PRATT & WHITNEY, ALCOA
• Aluminum-Aerogel Metal Matrix Composites	GENERAL MOTORS
• Superplastic Forming of Stainless Steel Automotive Components	AC ROCHESTER, ARMCO

DOE (GOVERNMENT) FUNDED R&D

- Chemical Kinetic Modeling of Hydrocarbon Oxidation

LAWRENCE LIVERMORE NATIONAL LABORATORY (cont'd)

- Development of Numerical Models for Prediction of Octane and Cetane Ratings of Fuel Mixtures and Additives
- Development of Computer Models for Predicting the Hydrodynamics and Pollutant Formation in Reacting Flow Systems
- Modeling Subsurface flow and Chemical Migration of Groundwater Contaminants in Porous Media
- Ultrasonic, Digital Radiography and Infrared Imaging for Non-Destructive Evaluation
- Combustion Models to Predict Performance and Emissions Characteristics of Reformulated Gasoline
- Catalysts from Platinum - Metal Oxide Aerogels
- Detection Systems to Measure Ultra-trace Concentrations of Metals in Fuel Oils and Waste Waters
- Fully Integrated Pyrolysis Processing Unit to Study Residuum Upgrading, Coprocessing (Plastics, Biomass, Coal, Solid Waste), and Metals Removal
- Chemical Reaction Kinetic Modeling for Optimizing Process Performance
- Municipal Solid Waste to Hydrogen
- Laboratory Test Facility for Aqueous Pyrolysis of Heavy Oil
- Laboratory-Scale to Full-Scale Pilot Plant for Solids Circulation Combustion for High Sulfur and Nitrogen Fuels
- Dual-band Infrared Imaging to Detect Corrosion, Thinning and Delaminations in Refinery Pipelines and Related Equipment
- Modeling of Granular Solids and Slurry Flow
- X-ray Tomographic Microscopy of Crack-Resistant Composites
- Matrix-Assisted Laser Desorption/Ionization Mass Spectrometry for Complex Mixture Analysis
- Thermoelectric Quantum Well Materials for Waste Heat Recovery
- Electrochemical, Solid Oxide, and Smart Structure Corrosion and Process Sensors
- Porous Carbons and Aerogels: Controlling Structure, Composition and Performance for Gas Adsorption, Energy Storage and Insulation
- Vapor Deposition of Multi-layers and Coatings for Corrosion, Abrasion and Thermal Barriers

LAWRENCE LIVERMORE NATIONAL LABORATORY (cont'd)

- **Site Characterization of Refinery Landsites**
- **High Temperature Catalytic Supports for Combustion and Processing**
- **Remote Optical Measurements of Airborne Chemicals**

LOS ALAMOS NATIONAL LABORATORY

CRADAS

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• Oil Recovery Technology Partnership (ORTP)	EXXON UNOCAL
- Fracture Mapping of Fields Producing from Fractured Limestone and Chalk Formations	
- Pore-scale Flow and Scaling to Improved Recovery Process	MOBIL CHEVRON
- Modeling of Fluidized Bed for Heavy Residual Oil	AMOCO
• Development of Corrosion-Resistant Tubulars (Production Pipe)	EXXON
• Computational Technology Initiative for the Petroleum Industry - being developed	
• Plasma Source Ion Implantation	GM
• Membrane Development	DOW CHEMICAL

DOE (GOVERNMENT) FUNDED R&D

- Internal Combustion Engine Modeling
- Development of Chelating Resins, Polymeric, and Ceramic Membranes for Separations
- Nano-Scale Polymer Foams with Controlled Cell Sizes
- Laser-Induced Methane to Methanol Conversion
- Neural Network and Intelligent Process Control
- Atmospheric Modeling
- Supercritical Water Destruction of Waste

NATIONAL INSTITUTE FOR PETROLEUM & ENERGY RESEARCH

INDUSTRY SPONSORED RESEARCH

TOPIC

- Specialized Analysis of Crudes and Fuels
- Refinery Product Problem Analysis
- Fuel Formulation
- Emissions of Alternative Fuels
- Hydro Processing of Specialty Products
- Evaluation of Cat Cracking Catalysts and Feedstocks
- Catalyst and Product Evaluations
- Additive Evaluations
- Properties of Future Diesel Fuels

A partial list of industrial clients who have sponsored such activities include:

PHILLIPS PETROLEUM COMPANY	AMOCO
UNOCAL	ARCO
LYONDELL PETROCHEMICAL	CONOCO
EXXON	MOBIL
UOP	EURON

DOE (GOVERNMENT) FUNDED R&D

- Thermodynamic Properties of Heavy Crudes
- Crude Oil Database
- Analytical Research to Improve Processes

NATIONAL INSTITUTE FOR PETROLEUM & ENERGY RESEARCH (cont'd)

DOE (GOVERNMENT) FUNDED R&D (con'td)

- Upgrading and Environmental Problems
- Coke Reduction
- Heavy Oil Upgrading
- Analysis of Crudes
- Emissions from Alternative Fuels
- Fuel and Refining Problems that Lead to Off-Spec Products
- Additives Effectiveness and Interaction with Fuels
- Waste Minimization and Recycling of Hydrocarbons

NATIONAL RENEWABLE ENERGY LABORATORY

CRADAS

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• Waste to Fuel Ethanol	AMOCO OIL
• Biomass Wastes into Fuel Ethanol	NEW ENERGY CORPORATION
• Recycling of Nylon - 6 into Monomeric Compounds	ALLIED SIGNAL

INDUSTRY SPONSORED RESEARCH

TOPIC	INDUSTRIAL SPONSOR(S)
• Fluid Catalytic Cracker Catalyst Development	AMOCO OIL

DOE (GOVERNMENT) FUNDED R&D

- Plastics recycling
- Photocatalytic oxidation of organics (VOCs, TCE, etc.)
- Development of cellulose ester membrances (organic/inorganic hybrid and mixed esters) for gas separation
- Increasing fuel flexibility in the refinery industry (oxygenates form biomass)
- High reactivity solids processing
- Syngas production and processing for fuels from biomass
- Production of hydrogen from reforming pyrolysis oils derived from biomass
- Hydrogen production via solar-thermal, photoelectrochemical, and photobiological processes

OAK RIDGE NATIONAL LABORATORY

CRADAS (IN NEGOTIATION)

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• The Biological Removal of Sulfur Heteroatoms form Petroleum	THRU PERF - TEXACO - OTHERS
• PCB Removal & Destruction	MORRISON & KNUDSEN
• Fluid Flow	DOW CORNING
• Particle Size Control	DOW CORNING
• Bioreactor Evaluation for TCE Destruction	ENVIROGEN
• Bioremediation	SCSC
• Advanced Bioreactor System	DOW CHEMICAL
• Scaling and Corrosion in Supercritical Water Oxidation	MODEC
• Electric Fields to Enhance Industrial Processing	ROHM HASS

INDUSTRY SPONSORED RESEARCH

TOPIC	INDUSTRIAL SPONSOR(S)
• Scaling and Corrosion in Supercritical Water Oxidation	MODEC
• Electric Field to Enhance Industrial Processing	ROHM HAAS

DOE (GOVERNMENT) FUNDED R&D

- Flow and Bubble Formation in Vapor-Liquid Process
- Bioconversion and Recycle of Lignocellulosic Materials
- Alternative Feedstocks for the Chemicals and Petroleum Industries
- Biofuels Feedstock Development
- NO_x Reduction Additives

OAK RIDGE NATIONAL LABORATORY (cont'd)

- Neural Networks for the Identification of Fuels
- Advanced Waste Minimization Methodology - Waste Minimization Evaluation Model
- Software for Prediction of Thermodynamic Properties
- Interactions of Solvents, Solutes, and Surfaces: Adsorption and Supercritical Extraction
- Multicomponent Separations by Continuous Chromatography
- Renewable Hydrogen Production for Fossil Fuel Processing
- Sludge Mixing/Mobilization

PACIFIC NORTHWEST LABORATORIES

CRADAS

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• Hydrothermal Destruction of Organics	ONSITE * OFSITE
• Petroleum Catalyst Recovery	PHILLIPS
• Waste Acid Recovery Demonstration	VIATEC
• Solid Superacid Catalysts	UNOCAL

INDUSTRY SPONSORED RESEARCH

TOPIC	INDUSTRIAL SPONSER(S)
• Ion Exchange for Heavy Metals	UOP
• Petroleum Sludge Treatment	ONSITE * OFSITE
• Hydrodeoxygenation of Biocrudes	VEBA PETROLEUM

DOE (GOVERNMENT) FUNDED R&D

- Hydrothermal Deduction of Organics
- Electrochemical Destruction of Organics
- Corona Destruction of VOC's in Off-Gas and Water
- Efficient Separations and Processes Integration Program
- Polymer Membrane Separations
- Extraction of TCE
- In-situ bioremediation
- Composting of Fuel Contaminated Soil
- Catalysis-by-Design
- Development of Membrane Reactor System
- Development of Ceramic Membrane Materials
- Alkane Oxidation

SANDIA NATIONAL LABORATORIES

CRADAS

CRADA TOPIC	INDUSTRIAL PARTNER(S)
• Study of Catalysts (physical structure, gas adsorption, electronic structure) using *ab initio* codes on massively parallel computers	BIOSYM TECHNOLOGIES, INC. EXXON
• Catalysts for Production of Oxidized Products	SHELL DEVELOPMENT, HOUSTON
• NO_x Reduction Catalysts	LOW EMISSIONS PARTNERSHIP (LEP)
• Inorganic Membrane Reactor Technology to Provide Improved Energy Utilization in High-Temperature Petrochemical Applications	AMOCO
• Hydrous Metal Oxide Catalysts for the Synthesis of Oxidized Products	SHELL
• The Origin and Fate of Toxic Combustion By-Products in Petrochemical Process Heaters: Research to Enable Efficient Compliance with the Clean Air Act	TEXACO, CHEVRON, MOBIL AMOCO, UNOCAL

DOE (GOVERNMENT) FUNDED R&D

- Conversion of Light Hydrocarbons to Alcohols Using Biomimetic Catalysts, Carbon-Based Catalysts
- Conversion of Carbon Dioxide Using Biomimetic Catalysts
- Molecular modeling of Macromolecular Structure of Complex Hydrocarbons and Fuels
- Nanostructured Metals, Oxide and Sulfides for Catalytic Applications
- Selective Dehydrogenation Catalysts and Membrance Reactors
- Development of Thin Film Hydrous Metal Oxide Catalysts for Fuels Applications

SANDIA NATIONAL LABORATORIES (cont'd)

- **Design and Development of Smart Membranes for Small Molecule Separations (several projects)**
- **Design and Development of Porous Materials for Small Molecule Adsorption and Storage**
- Catalyst Development for Direct Liquefaction
- Catalyst Assessment and Reactor Fluid Dynamics
- Catalytic Hydropyrolysis
- Refining of Coal-Derived Liquids
- Thermally Stable Jet Fuels
- Advanced Liquefaction Concepts
- Solar Detoxification of Organic Contaminants
- Technology Demonstration
- Opportunities in the Petroleum Industry - Vital Issues Panel for EPA Act section 2108 Report to Congress

APPENDIX B

MATRIX OF NATIONAL LABORATORY CAPABILITIES IN RELEVANT R&D AREAS

Research area		ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.1 Environmental Research and Development												
Waste Water Treatment												
Metals Removal		XX	XX	XX	S	S	XX			XX	XX	S
Enclosed Biotreatment systems		C	S	XX	S	S	S		S	S	XX	C
Reverse osmosis-membrane filters				S								
Precipitation of metal contaminants		S	S	S	C					XX	XX	
Adsorption on media (activated carbon			C			S				XX		S
Sand filtration								C				C
Solar Detox									S			S
Waste Water Sludges												
API Separator Sludge		C	C	S	C	S				C	S	
Tank Bottom Sludge			S	S		S		S		S		
Solid Waste Disposal												
Air Floatation Float Solids											S	
Spent Catalyst Handling		XX	C									C
Gaseous Emissions												
Flue Gas Emissions		XX	XX	S		S	XX			C		S
Combustion Processes		S	XX			XX	XX	XX	S			XX
Regulation of emissions		XX	XX	S		C				S		S
Site Remediation												
In-Situ treatment		S	XX	XX	S	XX	XX			XX	XX	XX
Total System Analysis		XX	XX	XX	S	XX	XX			XX		XX

XX = Strength — Defined as 30+ manyears of effort in this category over the last 5 years [i.e. 6my/year * 5years]
S = Significant Capability — Defined as 10 - 29 manyears of effort in this category over the last 5 years
C = Capability — Defined as 5 - 9.9 manyears of effort in this category over the last 5 years
Note: Activities of less than 5 manyears effort over the last 5 years should not be claimed on the form.

Research area		ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.2 Advanced Base Technology Development for Process Improvement												
Energy Efficiency Improvements/ Thermal Processes												
Organic/fluid fouling		XX		C				S				
Two-phase heat transfer enhancement		XX	S	C			XX		XX	XX		
Transport process in compact heat exchangers		XX	XX	C			XX		XX	S		
Studies of process unit integration		S	XX	C			XX		C			
Development of a Comprehensive Computer Simulation of a complex refinery of the future		C	S	XX	XX					XX		C
Catalysis												
Catalyst by Design		XX	XX	C	S	XX	XX	C		S	XX	XX
Solid Acid Catalyst Replacements for HF and H_2SO_4											XX	C
Catalytic Oxidation of Hydrocarbons		C	S	XX		C	C	C			XX	S
Environmental Control Catalysts							S					S
SO_2 --> SO_3						S						
Synthesis of Molecular Sieves		S	XX		S	C						S
Post Combustion Catalytic emissions Control		C		S			XX					C
Separation Science												
Distillation						C		C				
Membranes		C		XX	S					XX	XX	XX
Adsorption			C				C	C	XX	XX	XX	C
Extraction		XX						C			XX	
Combustion Science			XX			XX	XX		C	C		XX

XX = Strength — Defined as 30+ manyears of effort in this category over the last 5 years [i.e. 6my/year * 5years]

S = Significant Capability — Defined as 10 - 29 manyears of effort in this category over the last 5 years

C = Capability — Defined as 5 - 9.9 manyears of effort in this category over the last 5 years

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Research area		ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.2 **Advanced Base Technology Development for Process Improvement** *(cont'd)*												
Knowledge Based Control Systems												
Sensors		XX	C	XX			XX			XX		XX
Refinery Model Simulation		S	XX	XX	S					S	C	C
Chemical Reactor Phenomological Modeling												
Fluid Bed modeling, Erosion/corrosion		XX	XX	XX	C		XX			XX		C
Chemical Reaction modeling		S	XX	S		C	XX		C			XX
Materials Degradation / Long-Term Reliability / NDE												
NDE		XX	XX	XX			XX			XX		XX

XX = Strength — Defined as 30+ manyears of effort in this category over the last 5 years [i.e. 6my/year * 5years]
S = Significant Capability — Defined as 10 - 29 manyears of effort in this category over the last 5 years
C = Capability — Defined as 5 - 9.9 manyears of effort in this category over the last 5 years
Note: Activities of less than 5 manyears effort over the last 5 years should not be claimed on the form.

Research area	ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.3 Process Development											
Increasingly important											
Hydrocracking					C	C				C	
Resid Hydroprocessing	C	S			C		XX			C	C
Distillate hydrotreating/processing					C		XX				C
Oxygenate Production	C	XX	C		C		C	C	C		C
Resid partial Oxidation	C				C					C	
Flexicoking					C						
Distillation					C		S				
Hydrogen Production	S		C	S	C	XX	C	XX	C		C
Same Importance											
Catalytic Cracking					C						
Isomerization					C					C	
Alkylation					C					C	
Decreasing Role											
Delayed Coking					C						
Catalytic reforming	S	C			C						
Solvent deasphalting					C						
High-Risk process development											
Petroleum Coke Desulfurization		XX			C						
Petroleum Demetalization	S	XX	C		C		C		C		C
Hydrogen Production Technology	S		C	S	C	S		XX	S		C

XX = Strength — Defined as 30+ manyears of effort in this category over the last 5 years [i.e. 6my/year * 5years]

S = Significant Capability — Defined as 10 - 29 manyears of effort in this category over the last 5 years

C = Capability — Defined as 5 - 9.9 manyears of effort in this category over the last 5 years

Note: Activities of less than 5 manyears effort over the last 5 years should not be claimed on the form.

Research area		ANL	BNL	INEL	LANL	LBL	LLNL	NIPR	NREL	ORNL	PNL	SNL
5.3.4 Yield Improvement from Heavy Oils and Resids		S		S								S
5.3.5 Alternative Feedstocks												
Co-Processing		S	C							C		C
Plastics Recycling		S					S	C	S			C
Biomass Co-processing							S		XX	S	S	C
Coal Co-processing		S					S			XX		C
Natural Gas Utilization		C	XX	S			C	S		C	S	S

XX = Strength — Defined as 30+ manyears of effort in this category over the last 5 years [i.e. 6my/year * 5years]
S = Significant Capability — Defined as 10 - 29 manyears of effort in this category over the last 5 years
C = Capability — Defined as 5 - 9.9 manyears of effort in this category over the last 5 years
Note: Activities of less than 5 manyears effort over the last 5 years should not be claimed on the form.

PLENARY SESSION ON OTHER MATTERS

Session Chairman: **Skip Robinson (BP America)**

The Plenary Session on other issues was designed to provide the participants with a forum for discussion of items not on the agenda, e.g., program characteristics, implementation options, etc. The items discussed are summarized below.

Other Issues

- Drivers Impacting Program Startup

  Justification of a cooperative DOE/industrial program will require both industrial "push" and government "pull". The refining industry must express both want and need for a collaborative program, whilst the DOE must show that government support of the refining industry is in the best interests of the nation. In session discussions reviewing the impact of various drivers on the U.S. refining industry there was some disagreement on the role of foreign competition (product imports) on domestic refining. foreign competition is of curse a subject of concern to the U.S. government, particularly if it is onerous to an industry which is considered strategic to national security.

- Technical (Program)

  - What are the best areas for DOE/Industry collaboration?

    Technology plays an important role in refining, and for some companies provides a key competitive advantage. Government involvement in certain areas such as process development or operational enhancement could be viewed by some as an unwelcome intrusion. However environmentally focused programs had greater appeal due to the perceived universal cost of compliance and lack of opportunity for attaining competitive advantage. Thus determining the scope and breadth of the collaborative program is a key issue that needs to be resolved

  - Intellectual property rights

    Concern was expressed over ownership of new technology or technological enhancements discovered with government supported programs. The DOE has policies under existing programs that address intellectual property rights, patent ownership, etc.

  - Program Management

    Concern was expressed over how co-funded programs would be managed and controlled and how costs would be shared with the DOE

  - Timeliness

    The U.S. government fiscal cycle begins in October. Thus the '95 year will begin in October 94. It is unlikely that a major DOE/Refining program could be included in the '95 budget due to the long approval process faced by any government department. However the timing is good to gain approval for fiscal '96, which would start in Oct. '95.

- Industry Representation to DOE

  A key issue in establishing a joint DOE/industry collaborative program is who or how should industry represent themselves to the DOE. What kind of mix of refiners, suppliers, vendors, etc. would be considered an adequate representation of the industry? What percentage of participation is required, if any? Are any of the existing organizations adequate, such as API, NPRA, NPC, etc. or is a new organization, such as PERF required? If so, who should take the initiative to organize and manage the new body?

QUESTIONS & COMMENTS OF THE PARTICIPANTS

- The issue of whether the NPRA would be interested in representing the industry in discussions with DOE has been raised with the organization. Direction is being sought.
- Does there have to be unanimous agreement of all the members of NPRA?
- PERF will also discuss the options and may set up an appropriate group.
- The industry should consider an organization analogous to of the Natural Gas Council in order to deal with DOE. This is an important issue that needs to be addressed.
- Should company representatives (on an industry organization) be from research and development or operations?
- We should have more of these meetings (workshops) to encourage communication.
- What was the reaction of the upper-management-level officials of the oil companies you talked to relative to the question of industry representation? We got mixed recommendations: approximately one third suggested NPRA, another third recommended a new organization be created, and the remainder suggested PERF and other organizations, such as API and CRC.
- The industry must talk to DOE management at sufficiently high levels and stress the importance of the industry to the economy.
- What we are dealing with here is more complicated than just the technical aspects of a collaborative program. The DOE is asking for more - that we work in partnership with the Labs and put up money.
- DOE is acting as a government facilitator seeking to determine if we want to form a partnership.
- The refinery industry should have more involvement in the U.S. Clean Car Initiative to develop an 80 mpg car.
- The industry needs to pay more attention to the car industry and the impact of its advances on fuel composition.
- Can the DOE work with foreign-owned companies? Yes, if they do work in the U.S.

- **What's next? We have to await feedback from the NPRA and PERF meetings.**

WRAP-UP/CLOSING REMARKS

Speaker: Daniel Wiley
Office of Industrial Technologies
Energy Efficiency and Renewable Energy
Department of Energy

WRAP-UP/CLOSING REMARKS

WORKSHOP EXPECTATIONS, WERE THEY MET?

- The direct relationship of the Refinery of the Future program to the Mission of the Department of Energy was emphasized. Secretary of Energy Hazel O'Leary presented the strategic importance of the energy industry February 9, 1994 at the Cambridge Energy Research Associates annual energy conference in Houston.

- Additional, meaningful, input was obtained for the Refinery of the future industry "vision". In some cases the draft "vision" document was challenged, but for the most part the information obtained through the initial industry interview process was still pertinent.

- DOE has stimulated the refining industry to openly discuss its future technology needs, in particular as they relate to resolving regulatory requirements.

- The core competencies of ten DOE national laboratories were presented as a DOE capability available to support the technology needs of the refining industry.

WHAT DID WE HEAR?

- Excellent feedback was received from the breakout sessions, and summarized in plenary sessions.

- DOE Deputy Secretary Bill White has offered to address intellectual property and other legal issues that inhibit the establishment of a collaborative program with the refining industry.

- The ROF started as a process to provide strategic focus for the technology development programs in EE and FE. Although the need still exists for DOE to develop comprehensive, strategic, programs to support its technology development activities, this of itself is not sufficient evidence to justify DOE's involvement in such a program. What is needed is a strong message from the industry that outlines its future directions (vision), its critical problems and hence its needs; this message needs to be communicated to the appropriate levels of DOE management.

- The ROF "Vision" as presented at the Workshop is sufficient to establish the basis for a collaborative program to address the future needs of the refining industry.

- The Refining industry now has the opportunity to make the ROF a truly national program. Several major industrial partnerships with DOE include automotive (U.S. Car), and textiles (AMTEX).

- There are currently major policy opportunities for the refining industry to be publicly heard.

- The refining industry must find a way to overcome the industry's varied and conflicting interest to promote a vision of its future, and its problems, to the nation. This has to be the industry's initiative and vision, not DOE's.

- DOE will continue in a facilitating role. We want your ideas on how to do this. DOE will help facilitate the surfacing of all the right messages.

- There are many models to select from in developing an interaction with DOE. Industry must drive the process and develop viable technology options for survival.

WORKSHOP FOLLOW-UP ACTIONS

- The workshop proceedings will be issued to the participants. A number of individuals have expressed the opinion that no further work be done to improve or refine the industry "vision" that has been presented in the Refinery of the Future draft document. This document will continue to evolve with time, but is sufficient to establish a basis for a collaborative program to address the future technology needs of the refining industry.

- The unified presentation on national laboratory core competencies was positively received, with interest expressed in seeing the concept of a "single point of entry to DOE" further developed. DOE agreed to continue to work toward this objective.

- It was recognized that other DOE offices should be involved in the ROF program, notably Environmental Restoration and Waste Management. Both Energy Efficiency and Renewable Energy, and fossil Energy, have been working closely since the start of ROF program plan development. More recently, Energy Research and Defense Programs have been briefed on the program.

- DOE will continue to facilitate discussions, meetings, or other interactive modes to assist the refining industry in developing an industry "vision" of the future. This "vision" will have the most impact if it is truly representative of the refining industry's needs.

- DOE will take a lead role in championing the refining industry with EPA, as directed in the Domestic Natural Gas And Oil Initiative.

NPRA WORKSHOP EVALUATION

The NPRA conducted a survey of the Workshop attendees at the conclusion of the Workshop to obtain their views on the value of the Workshop and potential interest in collaborative research. The results of this survey are given in Attachment I. Specific comments submitted by attendees are summarized in Attachment II.

Attachment 1

Workshop Evaluation

	Refiners	Technology Firms	Consultants	Other	Total
Value of the Workshop[1]					
Usefulness of Information	2.9	2.8	3.0	3.3	3.0
Understanding of Purpose	2.7	2.9	3.0	3.5	2.9
Overall Value	2.9	2.8	3.1	3.2	2.9
Potential Interest in Collaboration Research[2]					
Strong	54	75	50	22	33
Moderate	38	25	50	22	33
None	8	-	-	-	3
Interest in Broad Range	23	25	33	44	28
Interest in Limited Scope	77	75	67	56	72
Continue to Pursue Activity	59	75	100	88	73
Review with Others	13	25	-	12	19
Both of the Above	18	-	-	-	8
DOE Should Continue Dialogue	88	94	100	100	93
Wait for Industry Response	12	6	-	-	7
Discontinue Effort	-	-	-	-	-

1 Rated on scale of 1 to 4, with 4 being the highest

2 Percent of respondents indicating response

Attachment 2

ROF Workshop Comments

REFINING AND PETROCHEMICAL MEMBER COMMENTS:

1. VALUE OF WORKSHOP

- Feel the program was effective to get the door open for National Labs and industry to work together.
- Value will depend upon what happens next. Need to develop process for collaboration between industry and National Labs/DOE/EPA.
- I was a little confused as to the objective of the workshop, thinking that the discussion would center around a vision of the refinery in 10-20 years. We discussed more short-term needs rather than long-term vision.
- Great start - wonderful example of TQM - value will be seen based on respective organizations. This program needs one interface organization, i.e., NPRA.
- Presentation on DOE/National Lab capabilities was very well done. This was a big step forward in making those capabilities more acceptable to the industry.
- Information from DOE was interesting and informative. We will pursue details further. I think results of certain work of National Labs would be appropriate for symposium such as the NPRA annual meeting.
- The workshop was very good. the only negative comment I have is that the breakout groups were so long that reaching consensus was cumbersome.
- Workshop provided good status report on progress and status to date on the ROF initiative.
- Much of the information is "obvious" as it's discussed - the key value was where everybody's interests seem to coincide.
- Refinery of Future is in essence being designed by political science, not real science and driven by confusing government mandates - not gas electric cars, emissions, ethanol, punitive tapes, subsidies. This will cloud industry's ability to clearly establish leveraged R&D goals. First priority is to synergize EPA and DOE.
- Success depends on what the DOE and the labs do.

- **Facilitators in some sessions allowed a free flow of ideas; in others they may have limited some of the brainstorming. I am sure we will get better at it as we go along!**

- **Needed more representation from companies in applied technology.**

- **Workshop purpose was unclear in pre-meeting literature. Facilitation of workshop sessions could have been better.**

- **More time should be spent on determining mechanism of working together, less time spent redefining vision of ROF and technology needs.**

- **good exchange of information - but much focus on "general" issues and less on specifics.**

2. POTENTIAL INTEREST IN COLLABORATIVE RESEARCH PROGRAM

- Strongest consensus among refining industry; re: need for government partnerships in R& D is in environmental area. I'd like to work toward making this happen. It also happens to be the industry's strongest driver. PERF could be industry spokes group for this initiative.

- The partnership between the refining industry and DOE is vital to the future viability of the domestic oil and gas industry. DOE needs to communicate the strategic value of our industry. We need to continue developing the national energy strategy.

- Broad range - at this time too early to properly limit scope - not enough knowledge to effectively limit. currently, EPA and states are significant interface with refiners on local level - need to address this interface and its relationship to the results of this effort - the R&D programs presented will be most effective if results can be integrated into the development of current and future regulations. In this manner, Industry, DOE, EPA, can reach a consensus agreement on results of R&D and then develop programs to implement regulating requirements. The development of a follow-up procedure, appears crucial for continued success. This procedure should include a mechanism for on-going interaction. There should also be a clearer definition of the relationship between DOE, EPA, Industry to define the ground rules and mechanism for interpretation.

- Limit scope to environmental

- In my opinion, we need an ongoing dialogue to establish the process for moving forward. Industry clearly needs to express interest. It would be very helpful for DOE to sponsor/facilitate an ongoing discussion.

- There are some concerns that arose which have not been satisfied for me: (1) Justifying the DOE and Technology budget increases of 25-30% when, as taxpayers, we have been lead to believe government is to shrink. (2) If refining sector does not work with DOE, and the National

Lab/Technology workshop - then why was agenda geared to technology issues?

- Definite potential here. An industry focal group is needed to alert industry of the work being done and the potential of the program. The NPRA should probably sponsor this group.

- Research partnership activities in certain specific areas would be welcomed by oil industry; needs to be focused, targeted, with milestones etc. to introduce sense of urgency and measures of progress for industry. Broad-based program initially will get no support. Need to establish curve on discussions and get on with it.

- DOE should continue dialogue with industry in the environmental area. PERF comes to mind as the appropriate vehicle for interaction. Beyond PERF, I think it will be difficult for the industry to coalesce to a group that can guide a large program. Maybe for now a series of well-publicized CRADA's will need to form the basis for a broader program later on. I think the DOE needs to take a very aggressive role in communicating with the industry.

- Devise mechanism to leverage industry R&D through DOE, universities, and private facilities. Require further clarification about DOE, allocation of R&D funds between industries and the availability of non-years R&D adjustment within DOE.

- Maybe joint NPRA of API funding could be possible. Work with these organizations.

- This is a good start in trying to pool our resources and making best use of our join thinking. We need to have a few successful programs going and will publicize so those that are tentative will come out and support this effort.

- Need to focus on what is the national energy policy. From this basis, develop strategies to identify research and development efforts for the industry.

- To an operating company, participation in early research is very limited. We would be interested in helping set priorities and utilizing commercial results.

- We need to begin implementation steps. Let's get going with some early successes. Don't see great value in "refining" the research plan.

- We need to have some way to bring the industry together on studies of common interest.

- Need to crystallize the process and develop the mechanism for carrying the interest forward.

- DOE should continue; but industry needs to respond to this initiative.

- Would like to see some mechanisms put in place to carry out some of the issues/programs discussed in this workshop.

CATALYST AND TECHNOLOGY COMPANIES:

1. VALUE OF WORKSHOP

- Too diverse a group; need more focus.
- A lot of the discussion appeared to be a restatement of the previously published papers.
- Information was not available far enough in advance. To be fair, there was apparently a breakdown between my secretary and MPRA - she thought I was registered . . . NPRA had no record of it.
- Advance materials - excellent.
- Meeting structure - very good; R&D plan session a little long.
- R&D meeting required tighter focus (e.g., we drifted into whether DOE should study global warming - in the process R&D session) and better sense of how the feedback would be/could be acted on.
- Unwillingness of facilitator and participants to entertain nontraditional ideas or thought processes (one session rejected FCC Technology Alternatives as heretical or too "radical"). Most seemed more comfortable with gently extending the edges of current or traditional practices.
- I realize the workshop was to "exchange" views, but now that views have been exchanged, I don't see how the ideas get implemented.
- The workshop focused attention on issues and problems that need to be addressed to meet the future needs of the refining industry. It also provided opportunity for mutual understanding.
- Would like to see more refining companies involved in this type of workshop.
- I don't believe all the participants understood the purpose of this workshop. Many of the participants derailed the process of problem definition because they did not understand the long term nature of this effort. By the way, I was clear on the purpose based on an earlier meeting with DOE personnel.

2. POTENTIAL INTEREST IN COLLABORATIVE RESEARCH PROGRAM

- As a technology provider, we are interested both in applying National Labs technology in commercial applications, and in leveraging R&D initiatives of our own via the DOE and National Labs.

- Would like to discuss problems involving on-site medium to larger scale demonstration plants.

- You all are up against an industry mindset that is anti-government, anti-regulation and reactive in approach. Tough group but worth trying to move forward. Good luck.

- National Lab's capabilities are quite impressive. There is nothing wrong with salesmanship and self-promotion to increase utilization by private industry.

- DOE should come forward and provide a meeting session for government and industry to solve national problems together. DOE can bring forth their experience in other industries to help the refining industry.

- Need better definition of how to address competitive concerns, protect confidential inf.., how to communicate projects, need more long-term thinking on how to get to the market. NPRA should facilitate this with DOE. Organizations like PERF will leave out "Nonrefiners". Need input from all interested parties. PERF too narrow in focus.

- This is just the beginning. There is a lack of communication between the industry and the government. There is a lack of a common frame of reference. Industry's definition of long-term is different from DOE's. We also don't seem to agree on what is basic vs. applied research. Efforts should continue to better communicate and develop a plan based on real needs.

CONSULTANTS:

1. VALUE OF WORKSHOP

- Two basic points: (1) Don't let the momentum stop to formulate similar programs as USCAR, textile, etc. and (2) Don't forget other Labs outside of the National Laboratory system (plenty of talent elsewhere).

- Excellent first effort. Need to develop action plan to implement the program.

- This was good, but it shows a very broad range of industry opinions on where we are and where we are going. shows the strong fragmentation in the industry.

- A start for an organized effort of industry/government association and communication.

- Session objectives were not totally clear resulting in early misunderstandings and start-up problems.

2. POTENTIAL INTEREST IN COLLABORATIVE RESEARCH PROGRAM

- I want to know more about DOE programs (especially technology transfer) and how to get my firm in this industry.
- Ensure that lines of communication are kept wide open. Consider electronic access to DOE/National Lab activities (similar to new EPA bulletin board).
- The ability to transfer knowledge learned from other forums to refinery application is high value potential. Industry wide data could be provided by DOE. Also analytical techniques is an area of interest.
- One issue more important than that of the National Labs is the coordination and exchange of information between companies. A good program to view would be joint meetings on mechanical integrity and deep water development in oil and gas sector.
- Limited research approach is best due to highly competitive refining industry with much proprietary ownership of technologies/data.