#### ANNEX XII

# OF THE

## IMPLEMENTING AGREEMENT

#### BETWEEN

## THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA

AND

THE MINISTRY OF ENERGY AND MINES OF THE REPUBLIC OF VENEZUELA

IN THE AREA OF

GEOCHEMISTRY

WHEREAS, the United States Department of Energy (hereinafter referred to as DOE) and the Ministry of Energy and Mines of Venezuela (hereinafter referred to as MEMV) desire to cooperate in the field of energy research and development;

WHEREAS, in the furtherance of their mutual interest DOE and MEMV entered into the Agreement in the field of Energy Research and Development signed March 6, 1980 (hereinafter referred to as the Energy R&D Agreement);

WHEREAS, DOE and MEMV have a mutual interest in technology exchange on the prediction of petroleum occurrence;

WHEREAS, DOE and MEMV have a mutual interest in improving their present modeling capability to predict the occurrence of petroleum from the thermal maturation of kerogen bearing source rocks in geologic formations;

WHEREAS, Venezuelan basins are known to be prolific petroleum producing areas and therefore prime candidates for source rock maturation and petroleum occurrence studies;

It is agreed as follows:

## Article 1

In accordance with Article V of the Energy R&D Agreement, the Venezuelan representatives of the Steering Committee have designated INTEVEP, S.A. to act

on behalf of MEMV under this Implementing Agreement. INTEVEP and DOE shall be hereinafter referred to as the Parties to this Implementing Agreement. The Assistant Secretary for Fossil Energy shall be primarily responsible for the programmatic aspects of this Implementing Agreement for DOE. Lawrence Livermore National Laboratory shall carry out DOE's technical responsibilities under Paragraphs B, C, D, E and F of Article 2 of this Implementing Agreement. Each Party shall designate one Project Manager for this Implementing Agreement; the Project Managers shall provide technical management and coordination of the tasks described in this Implementing Agreement.

#### <u>Article 2</u>

The Parties shall cooperate in research in the area of petroleum generation in the Maracaibo Basin as set forth below:

INTEVEP and LLNL shall perform a series of tasks over an initial period of 18 months. Further work may be required to complete all tasks at the end of the initial 18 month period. Any further work will be the subject of a further Amendment and Extension to this Annex XII.

#### A. <u>INTEVEP Experimental Tasks</u>

Task 1: Sealed-Bomb Pyrolysis

INTEVEP shall perform several sealed-bombed pyrolysis experiments using La Luna Shale samples from the Maracaibo Basin. The heating temperatures and times shall be chosen so that, at the lowest extreme, the conversion of kerogen to bitumen and gas is less than 25% of the kerogen, and the highest extreme, at least 75% of the generated oil is cracked to gas. Data and results shall be recorded and bitumen, oil and gas samples taken for further analysis.

Task 2: Simulated Distillation, GC-MS, C13 NMR Analysis

INTEVEP shall perform simulated distillation, gas chromatography-mass spectrometry and carbon isotope 13 nuclear magnetic resonance analyses on the various oil and bitumen products resulting from Task 1. Data and results shall be recorded for use in pyrolysis interpretation and modeling.

Task 3: GPC Analysis

INTEVEP shall perform gel permeation chromatography analysis on bitumen products resulting from Task 1. Data results shall be recorded for use in pyrolysis interpretation and modeling.

#### B. LLNL Experimental Tasks

#### Task 1: High Pressure Pyrolysis

LLNL shall perform high pressure pyrolysis experiments of the Burnham and Singleton type on La Luna shale samples provided by INTEVEP. The tests will be conducted in a self purging reactor at 2 different pressures and 3 different heating rates. Oil and gas evolution rates will be measured for use in determining oil and gas evolution kinetics. INTEVEP personnel shall participate in acquiring the data and information.

## Task 2: FIMS Analysis

LLNL shall acquire field ionization mass spectrometry analysis on extracted bitumen samples from Task Al to determine molecular weight distributions. Part of the task shall be accomplished by subcontract to a laboratory with specialized expertise in FIMS analysis. The data and results will be used to determine stoichiometric coefficients in pyrolysis modeling.

## Task 3: Gas Evolution Kinetics

LLNL shall perform gas evolution rate experiments on samples of La Luna shale, isolated kerogens and bitumen intermediates. Individual gas species will be identified using an on-line mass spectrometer. The data will be analyzed and rate expressions developed for the gas generation reactions. Gas samples will be taken and provided to INTEVEP for isotope analysis. INTEVEP personnel will participate in the experimentation.

## C. Interpretation of the Pyrolysis Results

INTEVEP and LLNL shall jointly combine the results from paragraphs A and B and develop a numerical model of the pyrolysis chemistry to run on a VAX or equivalent computer. Modification of the existing LLNL general pyrolysis model for Green River shale will be attempted to describe pyrolysis of the La Luna shale. If successful, the general model will be used to check results of the less complex VAX model. If modification of the general model for La Luna shale is not routinely accomplished further effort and funds will be required. Further work requirements will be proposed at the discretion of the INTEVEP and LLNL Project Manager and subject to approval by the Steering Committee.

# D. <u>Calculation of Pore Pressures</u>

LLNL shall determine a method to calculate pore pressures that are generated by hydrocarbon maturation and shall incorporate the appropriate equations into the general pyrolysis model. Solubilities and densities as a function of temperature and pressure will be estimated from literature data. The model will then be used to calculate over-pressured zones and primary migration fractions. Further work may entail comparisons with field data, and additional experiments may be required. Further work will be proposed at the discretion of the Project Managers and subject to approval by the Steering Committee.

# E. Determination of Sulfur Reactions

LLNL shall examine the literature on sulfur chemistry and combine the information obtained with data paragraphs A and B to determine the possibility of developing kinetic models for the fate of sulfur compounds underground. Additional experiments will be devised that would further define sulfur compound reaction during oil and gas generation. Completion of this work will likely require further effort. Further work will be proposed at the discretion of the Project Managers and subject to Steering Committee approval.

# F. Application to Geologic Basins

INTEVEP and LLNL shall jointly determine a thermal history for the Maracaibo Basin and compute hydrocarbon characteristic in the various parts of the Basin. Using corehole data supplied by INTEVEP, LLNL and INTEVEP personnel will jointly compare model predictions with hydrocarbon characteristics observed in the Basin. Completion of this work will likely require further effort. Further work will be proposed at the discretion of the Project Managers and subject to approval by the Steering Committee. All work under Paragraphs A and B is anticipated to be completed by the end of the first year of the project. Work under Paragraphs C. D. E and F will extend, at minimum, 6 months into year two of the project. Technical reports on the tasks of this Implementing Agreement will be issued by the party or parties concerned every four months which will include experimental conditions, raw laboratory data or other supporting data and their interpretation with the details of computer programs and/or physical or chemical model used. The Project Managers will report to the Steering Committee at the end of year one and propose the effort in man-years and funds required of the participants to complete the project.

# Article 3

- A. The performance of Article 2, Paragraph A, will be by INTEVEP and all costs pertaining to Paragraph A, including approximately 1700 man-hours of personnel effort, will be borne by INTEVEP.
- B. The performance of Article 2, Paragraphs B, D, and E will be done by LLNL and all costs, including approximately 4000 man-hours of personnel effort, pertaining to Paragraphs B, D and E will be borne by DOE, with the

exception of shipping costs for any shale, bitumen or oil samples required, and the expenses of any visiting INTEVEP personnel, which will be borne by INTEVEP. Obtaining and shipping the samples from Venezuela to Livermore, CA, will be the responsibility of INTEVEP.

- C. The costs of performing joint tasks C and F shall be borne as follows:
  - 1. INTEVEP Costs. INTEVEP shall provide approximately 1300 man-hours of INTEVEP personnel effort for Paragraph C work and approximately 1900 man-hours of INTEVEP personnel effort for Paragraph F work.
  - DOE Costs. DOE shall provide approximately 900 man-hours of LLNL personnel effort for paragraph C work and approximately 1000 man-hours of LLNL personnel effort for Paragraph F work.
  - 3. Other costs. Further work in addition to the above listed man-hours and financial contributions may be required to complete Paragraphs C through F. Any additional completion costs shall be identified by the Project Managers and proposed to the Steering Committee for approval at the end of the first year of the project.

## Article 4

The Parties shall support the widest possible dissemination of information arising from this Implementing Agreement in accordance with Article 2 of the Annex to the Energy R&D Agreement. If a Party has access to proprietary information as defined in Article 2 of the Annex to the Energy R&D Agreement which would be useful to the activities under this Implementing Agreement, such information shall be accepted for the task only on terms and conditions as agreed in writing by the Parties.

## Article 5

Rights to any invention or discovery made or conceived in the course of or under this Implementing Agreement shall be distributed as provided in Paragraph 1 of Article VI of the Energy R&D Agreement. As to third countries, rights to such inventions shall be decided by the Joint Steering Committee.

Each Party shall take all necessary steps to provide the cooperation form its inventors required to carry out this Article. Each Party shall assume the responsibility to pay awards to compensation required to be paid to its own nationals according to its own laws.

### <u>Article 6</u>

The existing terms and conditions of the Energy R&D Agreement shall continue and remain in full force and effect notwithstanding the terms of this Annex XII.

# Article 7

This Annex XII to the Implementing Agreement shall enter into force upon the later date of signature and shall remain in force for a period of 18 months. It may be amended or extended by mutual written consent of the Parties in accordance with Article V of the Energy R&D Agreement.

## Article 8

This Annex XII may be terminated at any time at the discretion of either Party, upon six (6) months advance notification in writing to the other Party by the Party seeking to terminate. Such termination shall be without prejudice to the rights which may have accrued under this Annex XII to either Party up to the date of such termination.

Done in Washington, D.C., USA.

On behalf of DOE Member Marvig Singe

Member George Stosur

Member Robert Folstein

14, 1987

THE JOINT STEERING COMMITTEE

On behalf of MEMV

Member Enrique Vasque:

Member Manuel Alayeto

Member Pedro Diaz