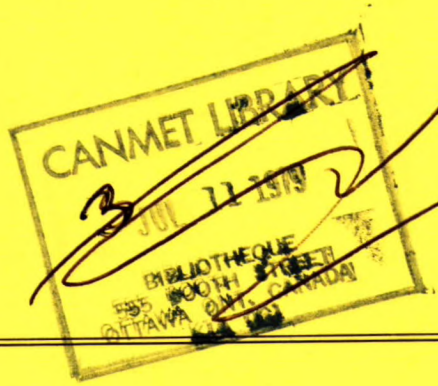
# CANMET

## REPORT 78–1

Canada Centre for Mineral and Energy Technology

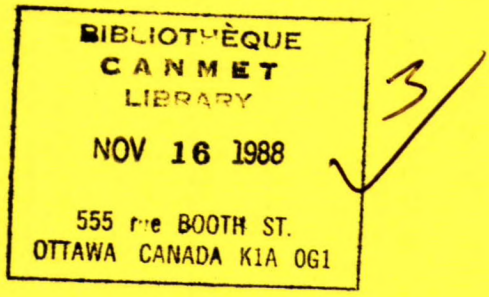
Centre canadien de la technologie des minéraux et de l'énergie






# SUMMARIES OF CANMET RESEARCH CONTRACTS 1975-1978

D.C. MISENER

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RESEARCH PROGRAM OFFICE

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# SUMMARIES OF CANMET RESEARCH CONTRACTS 1975-1978

Compiled by

D.C. Misener*

CANMET REPORT NO. 78-1

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*Contract administrator, Research Program Office, CANMET, Energy, Mines and Resources Canada, Ottawa, Canada

# FOREWORD

CANMET, in accordance with the Federal Government contracting-out policy, performs an increasing part of the R & D to support its missions through research contracts. Currently (1978-79) about 20% of the total CANMET budget is spent on R & D contracts, a proportion that is expected to rise.

A particularly significant aspect of the contracting-out policy is the transfer of technology to industry. This is accomplished largely through the contract itself. These summaries of contracts are published to increase technology transfer and to emphasize the importance of this aspect of CANMET's research efforts. It is planned to issue similar reports annually. Pit Slope project contracts, which were executed from 1972 to 1975, are not included in this report, as they have been widely publicized elsewhere.

CANMET R & D is organized in a program activity structure. There are two programs, Energy Research and Minerals Research, each with several activities. The summaries in this report are arranged according to this structure.

The supporting documents described in the summaries are, with few exceptions, available from CANMET library, 555 Booth Street, Ottawa, K1A 0G1, usually on microfilm. Further information is available from the scientific authorities named in the summaries.

D.C. Misener
Contract administrator

## AVANT-PROPOS

En conformité avec les politiques du Gouvernement fédéral de la remise des contrats, le CANMET émet de plus en plus de contrats de recherche afin d'atteindre ses objectifs de R & D. Pour l'année 1978-79 en cours, environ 20% du budget total du CANMET a été accordé aux contrats de R & D et cette proportion devrait augmenter.

Un aspect plutôt important de cette politique de la remise des contrats est la transmission de la technologie à l'industrie. Le contrat lui-même en est le principal instrument. Les sommaires des contrats sont publiées chaque année. Les contrats du projet sur la pente des mines à ciel ouvert réalisés entre 1972 et 1975 n'ont pas été mentionnés dans le rapport puisqu'ils ont déjà fait l'objet de réclame ailleurs.

Les travaux de R & D effectués au CANMET sont organisés en programmes et ensuite en activités. Les deux programmes sont la recherche sur l'énergie et la recherche sur les minéraux; chacun d'eux comporte plusieurs activités. Les sommaires du présent rapport ont été disposés selon la structure programmes/activités.

Les documents à l'appui décrits dans les sommaires sont, à part quelques exceptions, disponibles à la bibliothèque du CANMET au 555 rue Booth, Ottawa, K1A OG1. Pour de plus amples renseignements, s'adresser aux autorités scientifiques mentionnés dans les sommaires.

D.C. Misener
Administrateur des contrats

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# CANMET CONTRACT SUMMARY SHEET

**TITLE:** The development of an efficient, oil-fired warm-air domestic heating system-phase I

**CONTRACTOR:** ONEX Industries Limited

**SCIENTIFIC AUTHORITY:** T.D. Brown
Canadian Combustion Research Laboratory
**TEL:** 613-996-4570 Ext 182

**BEGIN/END:** Nov. 2, 1976 - March 31, 1977

**REQUISITION NUMBER:** 23440-6-9030

**FUNDING**

**CANMET:** $14,505.39

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $14,505.39

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Conservation Technology

**SUB-SUB-ACTIVITY:** Conventional Energy Technology

**PROJECT:** Oil Combustion Technology

## OBJECTIVES

To modify two standard gun-type oil burners according to specifications provided,
To design and fabricate two warm-air furnaces according to conceptual designs provided and,
To match the burners to the furnaces as operational systems and deliver the systems to CCRL.

## PROCEDURE

Manufacturing and modification was carried out in ONEX production plant.

## RESULTS

The two furnaces were modified, designed and fabricated as required and were delivered to CCRL for testing and evaluation.

## APPLICATION AND ONGOING WORK

Performance of the furnaces will be appraised and should lead to improved domestic furnace design.

## SUPPORTING DOCUMENTS

Engineering drawings are held by CCRL.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Solid waste gasification

**CONTRACTOR:** Westwood Polygas Ltd.

**SCIENTIFIC AUTHORITY:** M.M. Avedesian

**TEL:** 996-4570 Ext. 214

**BEGIN/END:** Jan. 10, 1978/Mar. 31, 1978

**REQUISITION NUMBER:** 23440-7-9050

**FUNDING**

**CANMET:** 84,894.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** 84,894.00

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Conservation Technology

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

1. To carry out the necessary modifications to achieve continuous operation for a five-day period of the Ainsworth gasifier at Ainsworth Lumber, Chasm, B.C.
2. To determine the effects of key process variables and identify problem areas for further development.
3. Document and analyze process data to better define gasification technology.

## PROCEDURE

1. Modified fuel supply.
2. Provided package boiler capable of being fired with producer gas or oil.
3. Designed, built and installed fuel arch breakers.
4. Modified gasifiers as required for continuous operation.
5. Operated complete gasifier steam generation system continuously for a period of five days and monitored all relevant process variables.
6. Prepared final report.

RESULTS - cont.

One of the still unknown functions within the reactor is effectiveness of the ash remover. The quantity of ash made was very small and the run time so short that the system has not been given a meaningful test. Condition of the ash produced during this run was such that it would have broken up and discharged through the system. Overall, the program could be termed a moderate success. Indications point toward continued success, warranting further modifications and testing to achieve full commercial operation.

## RESULTS

All modifications and additions to the gasification plant were carried out and made functional in accordance with the Work Statement as detailed in Appendix "B" and described under Modifications, page 8.

Observations during the trial run period indicated that modifications to the plant under this program greatly improved performance of the reactor, particularly of the fuel feed which plagued former operations.

A five-day continuous run was not achieved due to a cyclone pump failing, caused by excessive fine particulates carried through the system in an upset operating mode. The problem was not so serious that it could not have been corrected under reasonable operating conditions but freezing weather made correction extremely difficult. Inability to clean out the condensate tank eventually caused a shutdown five days after "light-up" of the gasifier.

The run provided valuable data and defined problems but nothing was fundamentally wrong with the process.

Most operating difficulties were encountered in such peripheral systems as: gas scrubbing, condensate cooling, and pumping.

## APPLICATION AND ONGOING WORK

Development work to commercialize the process into a marketable viable system is ongoing. The next phase will be to modify reactor 1 on the basis of knowledge and experience gained in the last test campaign to allow a gas production run for at least one full week. The process variables and control of the gasifier will be determined to achieve a steady state condition for continuous production of gas.

## SUPPORTING DOCUMENTS

The final report.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Microbial enzymatic cold water process for the extraction of bitumen from the bituminous sands of Alberta.

**CONTRACTOR:** University of Western Ontario, London, Ont.

**SCIENTIFIC AUTHORITY:** D.S. Montgomery

**TEL:**

**BEGIN/END:** Aug. 1, 1976 - July 31, 1977

**REQUISITION NUMBER:** 23440-6-9028

**FUNDING**

**CANMET:** $99,956

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $99,956

**PROGRAM:** Energy

**ACTIVITY:** Fossil Fuels

**SUB-ACTIVITY:** Oil Sand and Heavy Oil

**SUB-SUB-ACTIVITY:**

**PROJECT:** Improved Oil Yield Bitumen Separation Process

## OBJECTIVES

To select the best three cultures out of 55 previously identified as showing some promise of producing surface active agents for the separation of bitumen from tar sands by the cold water process.

To determine the concentrations and conditions of stress under which the three cultures are most effective.

To determine the physical, chemical, and structural properties of the microbial products for scientific and patent purposes.

To define by biochemical engineering studies the most efficient methods of producing microbial surfactants.

## PROCEDURE

Fifty five organisms were collected under a previous contract that were shown capable of growing on kerosene, to determine those that produce surface-active substances of interest in oil sand separation. Of this group, approximately 15 were classified and considered of sufficient merit to justify further study. Procedure under this 1976/77 contract was to select three of these cultures and study the biochemical factors involved in growing large quantities of these bacteria. The pH of the water, degree of aeration, agitation, nutrients, and temperature were optimized to produce the maximum quantity of surfactant in a given time. The surfactants were then evaluated in the laboratory simulated model of the Magna RT6S process, and in a low shear separation system.

## RESULTS

The effective organisms have been characterized in sufficient detail to obtain patent coverage. The conditions for large-scale production of these organisms have been defined.

## APPLICATION AND ONGOING WORK

The raw broths appear to contain the surfactive agents in their most active form. The large-scale testing in the 1-metric ton/hr pilot plant remains to be done under a future contract.

## SUPPORTING DOCUMENTS

"Microbial separation of bitumen from Athabasca tar sand"; U. of Western Ontario, Annual Report 1975.
Final Report Part I and Part II, Aug. 1976 - Athabasca tar sand.
Final Report Part I and Progress Report, April 1977 - Athabasca tar sand.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Improve and evaluate MAGNA coal water/solvent process for extraction of bitumen from tar sand

**CONTRACTOR:** MAGNA International Inc.

**SCIENTIFIC AUTHORITY:** D.S. Montgomery

**TEL:** 995-4259

**BEGIN/END:** Aug. 1, 1976 - July 31, 1977

**REQUISITION NUMBER:** 23440-6-9046

**FUNDING**

**CANMET:** $130,000

**CONTRACTOR:** 130,000

**DSS:**

**OTHER:**

**TOTAL:** $260,000

**PROGRAM:** Energy

**ACTIVITY:** Fossil Fuels

**SUB-ACTIVITY:** Oil Sand and Heavy Oil

**SUB-SUB-ACTIVITY:**

**PROJECT:** Improved Liquid Yield Bitumen Separation Process

## OBJECTIVES

To secure the necessary technical information to make projections as to the merit of applying the Magna RTGS cold water process of separating bitumen from tar sand on the commercial scale of 1500 tph (1360 tonne/h) tar sand, and to determine its competitive position with respect to the hot water process. One of the immediate objectives is to obtain accurate material balances over the individual process units as well as for the process as a whole. This is to identify the major sources of oil loss. A second objective is to measure the energy input to each unit to permit an energy cost analysis.

## PROCEDURE

Under a previous contract, MAGNA International built a 1-metric ton per hour separation plant. This was tested for technical soundness and operated on a variety of tar sand samples of greatly differing quality material; energy balances were determined over each unit which led to equipment modification.

## RESULTS

Substantial progress has been made in the milling procedure which has permitted the satisfactory operation of the equipment on tar sands with high clay content.

The material balances have indicated the areas of major oil loss, and efficiencies of the order of 90% have been achieved on low quality tar sand.

## APPLICATION AND ONGOING WORK

Although the present method of bitumen froth removal has proved very satisfactory on the 1-metric ton per hour scale, calculation shows that a different method will have to be employed on a larger scale. Opportunities exist to reduce the water and mineral matter in the oil, thus reducing work load on the centrifuges. A new contract has been awarded to share the costs of making these modifications in 1977/78.

## SUPPORTING DOCUMENTS

"Magna International progress reports" August 1, 1976 to Dec. 23, 1976; Jan. 3, 1977 to March 25, 1977; March 25, 1977 to June 30, 1977.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Feasibility of and requirements for developing near-surface mining systems

**CONTRACTOR:** R.M. Hardy & Assoc. Ltd.

**SCIENTIFIC AUTHORITY:** K. Barron, V. Srajer

**TEL:** (403) 284-0110

**BEGIN/END:** Jan. 1977 - May, 1977

**REQUISITION NUMBER:** 23440-6-9074

**FUNDING**

**CANMET:** $53,998.11

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $53,998.11

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Oil and gas

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

To investigate methods of mining oil sands underground for the purpose of extracting the oil from the mined sand or for the purpose of access to the deposit so that in situ extraction methods may be used. An important aspect of the study was to provide a program of research to further identify or quantify the parameters which will affect underground mining.

## PROCEDURE

The study involved a literature review, theoretical analysis and assessment of mining methods currently used in other materials or novel methods proposed for oil sands.

## RESULTS

The theoretical analyses and assessment of mining methods have been made within the framework of a model of oil sands behaviour which views oil sands as a four-component phase, hydrocarbon system. The study evaluated and made a comparison of the economics of those systems identified, and estimated the time period or conditions under which such systems may become competitive.

## APPLICATION AND ONGOING WORK

One output from this contract is the recommendation for a test excavation which may be used to determine fundamental data on in situ ground behaviour, support, and excavation techniques. CANMET is also considering supporting advanced studies to develop mining systems for exploiting oil sands.

## SUPPORTING DOCUMENTS

Report: "Underground mining of oil sands".

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Analysis of the products of rapid devolatilization and hydrogenation of hydrocarbon fuels (coal)

**CONTRACTOR:** University of Toronto, Aerospace Division

**SCIENTIFIC AUTHORITY:** D.S. Montgomery

**TEL:** 996-4570 Ext 144

**BEGIN/END:** April 1, 1977/March 31, 1978

**REQUISITION NUMBER:** 23440-6-9075

**FUNDING**

**CANMET:** 39,888

**CONTRACTOR:**

**DSS:** 10,000 bridge funds

**OTHER:**

**TOTAL:** 49,888

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Oil and Gas

**SUB-SUB-ACTIVITY:** Refining of bitumen and Heavy Oil

**PROJECT:** Determination of Chemical Compositions of Hydrocarbon Mixtures 333304

## OBJECTIVES

1. To build facilities capable of studying the rate of heating on the devolatilization of bitumen and coal
2. To evaluate the differences in product composition and yield when a range of Canadian coals are subjected to variable heating rate in different atmospheres including hydrogen at 1 and 100 atm.

## PROCEDURE

A conventional glass flow system was built for low pressure work. The sample was contained between two stainless steel screens heated electrically. A very thin chromel alumel thermocouple was employed capable of following a temperature rise of $10^4$ K/sec. A 90 amp current gives a heating rate of 6000°K/sec. The gases were cooled, sampled and analyzed by gas chromatography.

The high pressure system consisted of a stainless steel tube heated electrically. Hydrogen pressures of 100 atm and heating rates of 600°K/sec could be obtained.

## RESULTS

High heating rates were found to have little effect on the total weight loss of coal, but a dramatic effect on the product composition. High heating rates increased the yield of light hydrocarbons.

Operating at 1 atm of $H_2$ at a high heating rate gave 5% conversion of coal to light hydrocarbon gases and liquid products. Operating at 100 atm of $H_2$ at 600°K/s gave 10% conversion to benzene xylene tolerence alone.

## APPLICATION AND ONGOING WORK

Effects of varying rates of heating of coal and bitumen under different atmospheric conditions on the resulting product composition is required to optimize refining and conversion process.
The extent and nature of further work is under review.

## SUPPORTING DOCUMENTS

Rapid devolatilization of tar sands, March 31, 1976.
Final Reports: Rapid pyrolysis and hydropyrolysis of Canadian coals, May 1978.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** An economic study of coal as a make-up energy source in oil sands processing

**CONTRACTOR:** In Situ Engineering Ltd.

**SCIENTIFIC AUTHORITY:** M. Ternan, R. Ranganathan

**TEL:** 996-4570

**BEGIN/END:** Jan 20, 1977 to Feb 28, 1978

**REQUISITION NUMBER:** 23440-6-9100

**FUNDING**

**CANMET:** $63,439.33

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $63,439.33

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Oil and Gas

**SUB-SUB-ACTIVITY:** Refining of Bitumen and Heavy Oils

**PROJECT:** Extendoil

## OBJECTIVES

(a) Provide a coherent description of the prospective producing and upgrading processes in the oil sands scheme.

(b) Carry out conceptual designs of various combinations of processes and fuels for nine cases to permit determination of raw material/utility requirements and capital/operating costs.

(c) Calculate and present economics of cases developed in (b) so as to permit comparisons of alternative recovery techniques, upgrading processes, and make-up fuels.

## PROCEDURE

Phase I: Material and Energy Balances

Phase II: Conceptual Process Design

Phase III: Cost Estimate

Phase IV: Economics

Phase V: Report

## RESULTS

A report was completed containing information on data sources, bases for calculations, computation methods, and conclusions on various combinations of processes and fuels. Conclusions were that:

(a) The use of coal as a make-up fuel has a slight advantage over bitumen.

(b) The use of coal-derived SNG as a fuel appears to be economically unattractive.

(c) For strip mining, flexicoking is slightly more economical than CANMET's thermal hydrocracking process.

(d) For in situ bitumen, the CANMET thermal hydrocracking process is economically more attractive than flexicoking.

## APPLICATION AND ONGOING WORK

The study was helpful in comparing the economics of thermal hydrocracking and flexicoking for Athabasca mined bitumen and in situ bitumen. Six additional cases will be studied during 1978 to further evaluate the economics of thermal hydrocracking.

## SUPPORTING DOCUMENTS

Release of report is being withheld until extension of the contract is completed. These results will be integrated; a final report is to be published in Oct. 1978.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Study of hydrocarbon analyses - Saline Creek Diversion Tunnel, Fort McMurray, Alberta.

**FUNDING**

**CANMET:** $4,950.00

**CONTRACTOR:** Hydrocarbon Research Centre, Edmonton (Principal investigator - C.T. Steele).

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** V. Srajer

**TEL:** (403) 284-0110

**DSS:**

**OTHER:**

**BEGIN/END:** Feb. 11, 1977 - May 30, 1977.

**REQUISITION NUMBER:** 23440-6-9117

**TOTAL:** $4,950.00

**PROGRAM:** Energy

**ACTIVITY:** Sources

**SUB-ACTIVITY:** Oil and Gas

**SUB-SUB-ACTIVITY:**

**PROJECT:** Underground Mining

## OBJECTIVES

1) To analyze air samples taken during construction of Saline Creek Diversion tunnel.

2) To analyze gases released from oil sand samples at temperatures of 5°C and 25°C.

3) To determine the bitumen content of the oil sand samples.

The Saline Creek tunnel was the first underground excavation in oil sands. Mining Research Laboratories (MRL) undertook to monitor gas entering the tunnel during construction to obtain information on potential gas hazards in underground mining of oil sands. This contract was let to obtain information on the gas content and bitumen content of the oil sands in part of the assessment program.

## PROCEDURE

Samples were taken by MRL staff and delivered to Hydrocarbon Research Centre. Analyses were carried out by methods detailed in the report.

## RESULTS

All samples were analyzed as requested; results are given in the report.

## APPLICATION AND ONGOING WORK

The results of this work are being incorporated in the MRL report on gas emissions into the Saline Creek tunnel; this report is in preparation. A seminar may be held, in conjunction with AOSTRA, to report all Saline Creek results including MRL work on gas emission and AOSTRA contract work on ground control.

## SUPPORTING DOCUMENTS

Jha, K.N. and Steele, C.T. "Chemical composition of gase in Saline Creek Tunnel (Athabasca) oil sands"; Report to CANMET, 1977.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Mechanical upgrading and solvent extraction of Athabasca oil sands

**CONTRACTOR:** University of Toronto

**SCIENTIFIC AUTHORITY:** G.M. Ritcey

**TEL:** 613-995-4124

**BEGIN/END:** May 19, 1977 - March 31, 1978

**REQUISITION NUMBER:** 23440-7-9007

**FUNDING**

**CANMET:** 85,000.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** 85,000.00

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Oil and Gas

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

To develop technology pertaining to the treatment of oil sands by mechanical upgrading followed by solvent extraction, continuing a program begun during 1976-1977. Make a literature survey, determine the operating parameters for the release of the oil, and make an economic assessment of the solvent extraction process for recovery of bitumen from oil sands.

## PROCEDURE

The research investigation covered the parameters of rate of rotation, time, velocity of lifters, diameter, depth of charge and oil/sands ratio and mechanisms in the mechanical upgrading of the oil sands by a cold water process. Rotary contactors of 8.9-cm and 19.0-cm internal diameter, fitted with lifters were used. The relative importance of the diffusivity of various hydrocarbons in bitumen, and the viscosity of such solvents in bitumen were determined. Displacement studies were conducted in a bitumen-free sand core to provide information on the effects of viscosity, capillary, and other forces on solvent recovery. Wettability of the sand and the effect on residual saturation of the solvent was also investigated. The potential of water displacement of solvent from a gravity-drained bitumen-free sand was studied, as was the potential of steam stripping for solvent recovery, using 50 psi air-free steam.

## RESULTS

Research showed that the mechanism by which sand rejection occurred was through impacts between the lifters and the oil sands, the wall and the sands, and the shear fields within the lifter. Extraction was independent of time after 15 minutes and varied inversely with clearance between 2.54 and 3.81 mm. Separation of sand and bitumen was a function of clearance and charge. Diffusivity measurements of various hydrocarbons in bitumen showed a decrease with increasing molecular weight, decreasing with increasing branching of the hydrocarbon. Diffusivity was not controlled by its aromaticity. Pentane was found to have the highest and kerosene the lowest. A mixed solvent of an aromatic and paraffinic may provide high performance. Displacement efficiencies with toluene were shown to be independent of capillary forces, while wettability had a strong increasing effect on recovery. Water displacement data showed that solvent recovery was independent of the flow rate. Steam stripping indicated recoveries in excess of 98% for a solvent:steam ratio of 1:2.

## APPLICATION AND ONGOING WORK

The research and data collected in the 1977-1978 fiscal year was sufficiently encouraging to continue the project for a further year.

## SUPPORTING DOCUMENTS

Report in CANMET Library.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** A proposal to design, build and test a coal/oil slurry firing system on a utility boiler

**CONTRACTOR:** New Brunswick Electric Power Commission

**SCIENTIFIC AUTHORITY:** H. Whaley

**TEL:** 996-4570 Ext 183

**BEGIN/END:** Oct. 1, 1977 - Mar. 31, 1978

**REQUISITION NUMBER:** 023440-7-9033-2

**FUNDING**

**CANMET:** 127,037.50

**CONTRACTOR:** 127,037.50

**DSS:**

**OTHER:**

**TOTAL:** 254,075.00

**PROGRAM:** Energy

**ACTIVITY:** Energy Research & Technology Development

**SUB-ACTIVITY:** Oil and Gas

**SUB-SUB-ACTIVITY:** Coal Conversion Techno-Economic Studies

**PROJECT:** Phase 2 Engineering Studies: New Brunswick Power Corp. Coal-in-Oil 3.3.4.7.01.01

## OBJECTIVES

1. To design a system for the preparation of a stable slurry of heavy fuel oil and Minto NB coal.
2. To demonstrate the feasibility of using a coal/oil slurry as fuel for a small power generating boiler (10 MW).
3. To assess the performance of the boiler when firing with heavy fuel oil, coal/oil slurry and pulverized coal. To monitor pollutant emissions with these fuels.

## PROCEDURE

1. Commenced preliminary plant design and lay-out of equipment and boiler modification.
2. Selected fuel preparation process for production of coal/oil slurry using Minto NB coal/No. 6 fuel oil.
3. Experimental tests on slurry and control system. On-site preparations for equipment installation.
4. Installation of coal/oil system and equipment modifications.
5. Preliminary combustion tests for assessment.
6. Full scale boiler trials - coal, No. 6 fuel oil, and coal/oil slurry (10% wt).
7. Initial Report → Final Report → Phase 3

## RESULTS

1. Achieved by November 30, 1977
2. Achieved by December 15, 1977
3. Achieved by January 31, 1978
4. Achieved by February 15, 1978
5. Achieved by February 28, 1978
6. Achieved by March 31, 1978

(The above progress was monitored by visits to the plant in January and March).

## APPLICATION AND ONGOING WORK

This work leads to Phase 3 which extends the range of coal contents in slurries fired. Also a combination of mechanical slurry formation with the NRC coal beneficiation (Agglomeration) process will be investigated.

## SUPPORTING DOCUMENTS

Initial report expected soon.
Final report by June 30, 1978 - will be forwarded to RPO and TID when available.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Electron spin resonance of bitumen and hydrocracked products

**CONTRACTOR:** A. Manoogian, Dept. Physics
Ottawa University

**SCIENTIFIC AUTHORITY:** D.J. Patmore

**TEL:** 996-4570

**BEGIN/END:** Oct. 1977 - March 1978

**REQUISITION NUMBER:** 23440-7-9041

**FUNDING**

**CANMET:** $12,403.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $12,403.00

**PROGRAM:** Energy

**ACTIVITY:** Energy Research & Technical Develop.

**SUB-ACTIVITY:** Oil and Gas

**SUB-SUB-ACTIVITY:** Refining of Bitumen and Heavy Oils

**PROJECT:** Extendoil

## OBJECTIVES

To carry out ESR studies at 9 and 33 GHz Microwave frequencies on samples of bitumen feed, hydrocracked products, reactor liquid and reactor solid samples.

To confirm that Vanadium ion in the raw material is in the form of the $VO^{2+}$ radical complex.

To investigate the presence of $V^{3+}$ ion by carrying out studies of low values of magnetic field and at low temperatures down to 4.2 K (depending on the relaxation rate of $V^{3+}$ in the samples).

To investigate magnetic species in the samples at high values of magnetic field.

To describe the nature of the various metal complexes present.

## PROCEDURE

Selected samples from CANMET hydrocracking pilot plant were run on an electron spin resonance spectrometer and values for the spin Hamiltonian parameters determined. Spectra at both room temperature and 4.2 K were measured.

## RESULTS

The only species observed were $VO^{2+}$ and free radicals. Neither $V^{3+}$ nor any other metal ions could be identified. Values of the $VO^{2+}$ spin Hamiltonian parameters suggest a mixture of $N_4$, $S_4$ and $S_2O_2$ ligands. There was no significant variation of parameters from feed to hydrocracked product. Variations in relative intensities of signals from reactor samples as a function of time and additives were observed.

## APPLICATION AND ONGOING WORK

This work is being continued for a further year.

## SUPPORTING DOCUMENTS

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** A study of methane face control using water infusion technology in high-speed coal mining for possible application in Canadian coal mines.

**FUNDING**

**CANMET:** $24,048

**CONTRACTOR:**

**PROGRAM:** Energy Research

**CONTRACTOR:** Dames & Moore, Toronto, Ont.

**ACTIVITY:** Supply

**SCIENTIFIC AUTHORITY:** W.M. Gray

**DSS:**

**SUB–ACTIVITY:** Coal

**TEL:** (613) 996-4570

**OTHER:**

**SUB–SUB–ACTIVITY:**

**BEGIN/END:** Dec. 6, 1976 - March 1977

**REQUISITION NUMBER:** 23440-6-9072

**TOTAL:** $24,048

**PROJECT:** Mine Environment (ES 4)

## OBJECTIVES

To review methods of controlling methane concentrations at the coal face, particularly water-infusion technology; to prepare a report on current practices and their potential for meeting Canadian needs; to prepare a detailed research proposal for working-face control in a Canadian coal mine using rapid advance or rapid extraction techniques.

## PROCEDURE

A review of the literature on methane control was carried out and visits made to coal mines in Belgium, Britain and France that practice water infusion. Methane problems in Canadian coal mines were reviewed and the application of water infusion to these problems was considered in general terms. A report was written.

## RESULTS

The contractor's report contains chapters with the following titles: Methane in coal; Effect of geologic conditions on methane emission; Effect of mining conditions on methane emission; Estimation of methane content of coal seams; Underground water infusion techniques; Fluid stimulation; Canadian methane problems; Proposed application in Canada.

The water infusion techniques now available are applicable in a range of mining and geologic conditions and have been found to reduce dust concentration during mining. Infusion has been used so little to control methane, however, that no proven technique suitable for this purpose can be identified. Nevertheless, there is some evidence that water infusion can alter the migratory paths of the gas in the seam and thus possibly divert it from the working face. A purely investigative program to study the effects of water infusion on methane emission in a Cape Breton mine is outlined.

## APPLICATION AND ONGOING WORK

Preparation of a detailed proposal for research on methane control in a Canadian mine by water infusion will require a further contract. The terms of such a contract are under consideration.

## SUPPORTING DOCUMENTS

Dames and Moore, "A study of water infusion practices in coal mines, with particular reference to methane control, for possible application in Canadian coal mines"; Report to CANMET, March 1977.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Fluid bed coal drying

**FUNDING**

**CANMET:** $48,700

**CONTRACTOR:** 5,000 (Approx.)

**DSS:**

**OTHER:**

**TOTAL:** $53,700

**PROGRAM:** Energy Research

**ACTIVITY:** Energy Technology Development

**SUB–ACTIVITY:** Coal, Peat

**SUB–SUB–ACTIVITY:**

**PROJECT:** Fluidizing Bed Combustion

**CONTRACTOR:** Copeland Systems Ltd., Montreal, Que.

**SCIENTIFIC AUTHORITY:** F.D. Friedrich

**TEL:** 613-996-4570

**BEGIN/END:** June 15, 1976 - Sept. 15, 1976

**REQUISITION NUMBER:** 23440-6-9009

## OBJECTIVES

Large-scale coal drying is generally accomplished with heat from oil- or gas-fired furnaces. In conventional technology, using coal as a dryer fuel is handicapped because pulverized firing frequently requires washed coals, whereas money and energy could be saved by using unwashed coal. Even greater benefits could be obtained if the energy in coal washery rejects could be used for drying. The fluidized-bed combustor appears to offer potential for burning high-ash coals but a demonstration of its applicability is required. This could improve the efficiency of fossil energy resources and at the same time alleviate the disposal problem of washery rejects.

## PROCEDURE

Copeland Systems Limited conducted combustion tests in a 2-ft (0.6-m) dia pilot-scale fluidized-bed combustor with a high-ash Alberta coal and simulated washery rejects of thp same coal containing up to 70% ash. Data obtained from the tests were used to prepare preliminary designs and cost estimates for three sizes of combustor to suit coal drying applications: 220 million Btu/hr (64,460 kw), 110 million Btu/hr (32,230 kw) and 55 million Btu/hr (16,115 kw) inputs.

## RESULTS

The pilot-scale test results indicated that a fluidized-bed combustor can use washery rejects as fuel for coal drying. There appear to be no technological obstacle in scaling up to the size required for a commercial coal washing/drying plant, and the contractor is prepared to build on a guaranteed-performance basis. The payback period appears to be one to two years and reduced adverse environmental impact is a side-benefit.

## APPLICATION AND ONGOING WORK

Results of the pilot-scale trials were presented in a paper to the 1977 Canadian Chemical Engineering Conference. A federal-provincial agreement to sponsor a full-scale demonstration plant has not yet been reached but several coal mining companies have expressed interest.

SUPPORTING DOCUMENTS - cont'd

bed combustor for coal drying," ERP/ERL 77-63 (OP); presented at 27th Canadian Chemical Engineering Conference, Calgary, Alta; Oct. 23-26, 1977.

## SUPPORTING DOCUMENTS

1. "Combustion of coal in a fluidized-bed system", Aug. 11, 1976,
2. "Fluidized-bed coal combustor", Aug. 23, 1976,
3. "Fluidized-bed coal combustor", Phases IV and V, Aug. 30, 1976.

Unpublished reports to CANMET, copies held by Energy Research Program.

Friedrich, F.D., Lutes, I.G. and Wheeler, C.M. "Fluidized-

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Assessment of Canadian peat as an alternative fuel for power generation

**FUNDING**

**CANMET:** $29,999.38

**CONTRACTOR:** Montreal Engineering Co. Ltd., Montreal, P.Q.

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** T.E. Tibbetts

**TEL:** (613) 996-4570

**DSS:**

**OTHER:**

**BEGIN/END:** Jan. 1977 - 31 March 1977

**REQUISITION NUMBER:** 23440-6-9065

**TOTAL:** $29,999.38

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Coal and Peat

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

To assess the potential of Canadian peat resources as an alternative fuel for electric power generation; to assess technology available to utilize the resources for power; and to monitor international developments.

## PROCEDURE

The study was conducted in two phases.

Phase I - Evaluate the peat resources in Canada by compiling information from provincial resource departments and other institutions.

Phase II - (a) A study of various methods available now and in the future for
- extracting peat from bogs
- removing water from peat
- transporting peat
- processing and burning

(b) Preparation, in broad terms, of alternative schemes for exploitation of peat and its application to power generation together with order-of-magnitude estimates of cost of power thus produced.

## RESULTS

Canada's peat resources are an estimated 530 million tons, (480 million tonnes) largely in Manitoba, Ontario and Quebec. There is extensive European experience, especially in Ireland and Finland, with peat-fired power boilers; the cost of peat-generated power is high but in certain applications could be competitive with conventional fuels, especially where energy transportation costs are high and peat is locally available. The estimated cost of peat delivered to a power plant is about $2/million BTU ($0.0068/kw)(0.5¢/lb, 1.1¢/kg) peat at 50% moisture content. Electricity generated from peat should cost about 50 mills/kw hr.

## APPLICATION AND ONGOING WORK

A meeting was held with officials of Montreal Engineering attended by several experts from industry, government and university to review the report.

A follow-up proposal has been submitted for further study.

## SUPPORTING DOCUMENTS

Montreal Engineering Company Ltd.; "Assessment of Canadian peat as an alternative fuel for power generation"; report to CANMET, 1977.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Study of methane drainage practices in coal mines and their potential application to Canadian conditions.

**FUNDING**

**CANMET:** $26,700.00

**CONTRACTOR:** Dames & Moore, Toronto

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** R.N. Chakravorty

**TEL:** (403) 2B4-0110

**DSS:**

**OTHER:**

**BEGIN/END:** Dec. 6, 1976 - March 31, 1977

**REQUISITION NUMBER:** 23440-6-9071

**TOTAL:** $26,700.00

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Coal and Peat

**SUB-SUB-ACTIVITY:**

**PROJECT:** Working Environment

## OBJECTIVES

Research for the effective control of methane in underground coal mines is of utmost importance for the safe operation of coal mines and for maintaining productivity at the desired level. The most extensively used method for controlling high methane emissions in mine workings is methane drainage. Both in Europe and in U.S.A., a number of methods have been developed for draining methane from coal beds in advance of or during mining operations.

The study is conceded as the basis of evaluating and developing a suitable technology for methane drainage, keeping in view Canadian applications.

## PROCEDURE

By survey of English and foreign language literature and documenting the relevant information on methane drainage technology.

By contacting (visit and phone calls) the Canadian coal mines and discussing methane control practices with officials concerned.

By visiting and reviewing the methane drainage technology in foreign mines (U.K., U.S.A., France and Belgium) both for methane control and fuel, bearing in mind Canadian applications.

## RESULTS

Review of the methane drainage technology indicated that it would be feasible to adopt methane drainage under Canadian conditions but the particular system tried would depend on the nature of coal and the method of mining. Drilling holes in solid coal may yield good results where the coal is permeable but with less permeable coals and longwall method of working, cross measure boreholes may prove suitable. It may be possible to use drained methane as a fuel provided the desired purity could be maintained. Developing methane drainage technology by carry ing out an actual field trial is recommended.

## APPLICATION AND ONGOING WORK

Final report from the contractor was discussed at an in-house seminar and it was decided to initiate field trials on a pilot plant scale in one of the coal mines in the near future.

## SUPPORTING DOCUMENTS

Dames & Moore "A study of methane drainage practices in coal mines and their potential application to Canadian conditions"; Final report.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Alberta coal conversion study - Phase I

**CONTRACTOR:** ALGAS Resources Ltd.

**SCIENTIFIC AUTHORITY:** P.J. Read
**TEL:** 995-9351

**BEGIN/END:** Dec. 1/76 - Mar. 31/77

**REQUISITION NUMBER:** 23440-6-9086-1

**FUNDING**

**CANMET:** 196,000.00
**CONTRACTOR:** 196,000.00
**DSS:**
**OTHER:**
**TOTAL:** 392,000.00

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Coal and Peat

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

To provide a preliminary technical and economic evaluation of coal conversion processes and production systems; to define the order of preference on the basis of their projected discounted cash flow life cycle rates of return on investment; and to provide raw data for the later updating of system comparisons. The processes had to be applicable to Albertan subbituminous coals, to be currently operational or under active development at least to pilot plant stage, to be sufficiently documented to allow evaluation, and to produce a potentially marketable product such as SNG, low-heat-value gas, hydrogen, ammonia, liquid fuels or chemical feedstocks.

## PROCEDURE

The method of study was to assemble data originating from process developers, licensors and users, to examine recent comparisons of technology or plants, and to gain information by direct contact and through published literature on status, operational costs or other data relating to coal conversion technology. These data were amassed in blocks relating to subprocesses, each of which was examined for its relevance to Alberta and modified as necessary. The data blocks were then recombined to represent processes for production in Alberta of fuel or fuel-related products at various appropriate throughput rates, e.g., $7 \times 10^6$ $m^3$/day and $3.5 \times 10^6$ $m^3$/day of SNg.

## RESULTS

It was shown that it would be less attractive to manufacture gases from coal than liquids. As the major cost contributor in the process is the supply of hydrogen, this was expected. Some routes to liquid fuels were identified as economically feasible but these were not optimized in the study nor were comparisons made with synthesis of similar fuel products from heavy oils or oil sands. Optimization with respect to a particular coal might decrease costs: comparison with synthesis based on bitumens might indicate that, because of the smaller fraction of additional hydrogen needed, synthesis from coal may not be economically competitive.

## APPLICATION AND ONGOING WORK

Refer to scientific authority.

## SUPPORTING DOCUMENTS

Final reports on file with Technical Information Division.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Low severity coal liquefaction process

**FUNDING**

**CANMET:** 60,232.41

**CONTRACTOR:** 60,232.41

**DSS:**

**OTHER:**

**TOTAL:** 120,464.82

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Coal and Peat

**SUB-SUB-ACTIVITY:** Techno-Economic Studies

**PROJECT:** 334702: Phase 3, Engineering Studies

**CONTRACTOR:** Nova Scotia Research Foundation Corporation

**SCIENTIFIC AUTHORITY:** J.F. Kelly

**TEL:** 996-4570 Ext. 147

**BEGIN/END:**

**REQUISITION NUMBER:** DSS File #18SQ.23440-6-9086 -7

## OBJECTIVES

To continue study of the extraction, coking and rehydrogenation of solvent phases of the Arthur D. Little (ADL) coal liquefaction process as applied to Nova Scotia coal. The work will involve a systematic experimental bench-scale study of each phase and will include the building of a continuous flow system for rehydrogenation of solvent.

## PROCEDURE

The ADL extractive coking coal liquefaction process is being investigated using Nova Scotia bituminous coal from the Lingan mine. Bench scale stirred (or rocker type), heated autoclaves were the principal means of investigating the three stages – preparation of hydrogen donor solvent from raw anthracene oil, extraction of coal fines with donor solvent, and extraction/coking as a combined liquefaction-separation stage.

## RESULTS

A six-month experimental program on the liquefaction of Nova Scotia coal was completed. Conversions after 1-hour extraction were typically about 60% of the m.a.f. coal when using an anthracene oil as a donor solvent with a hydrogen content of 8.0 - 9.5%. After the coking stage, conversions were 37 - 43% of the m.a.f. coal, with the liquid yield about 30%. Although ADL have indicated that conversions of coal in the extraction stage are maximized at a solvent hydrogen content of 8.7%, the results of this study did not note significant differences in the range of 7.9 to 10.1% $H_2$. Solvent to coal ratios of 2:1 to 4:1 did not cause significant differences in yield. Extraction time appeared to affect conversion noticeably, increasing from 41% to 76% as extraction time increased from 0.5 h to 3.0 h.

## APPLICATION AND ONGOING WORK

The next phase of work will concentrate on methods to increase liquid yield without varying from the low pressure approach. Solvent, which is currently produced batchwise will be produced in a continuous flow apparatus. Apparatus is planned for future liquefaction which will allow higher hydrogen pressures if this is found necessary.

## SUPPORTING DOCUMENTS

Final report entitled "Low severity coal liquefaction process" by J.J. Starzomski and D.P. Sullivan, Nova Scotia Research Foundation Corporation, Project 3083, DSS File No. 18SQ.23440-6-9086; June 1978.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Impact of the partial substitution of methanol in industrial and automotive fuels

**CONTRACTOR:** Ontario Research Foundation

**SCIENTIFIC AUTHORITY:** J.F. Kriz

**TEL:** 996-4570 Ext. 159

**BEGIN/END:** 1977

**REQUISITION NUMBER:** 23440-6-9086-8

**FUNDING**

**CANMET:**

**CONTRACTOR:** 42,486.74

**DSS:** 38,079.00

**OTHER:**

**TOTAL:** 80,565.74

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Coal and Peat

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

1. To review recent literature on the use of methanol as a fuel substitute in Canada.
2. To conduct tests and generate data on methanol/fuel and methanol/water/fuel emulsions.
3. To assess the technological impact of the use of methanol on the future fuel supplies and recommend a possible approach and course of action.

## PROCEDURE

The effort focused on the following areas:
- methanol from coal processes
- utilization and air pollution
- phase separation and emulsification
- marketing and distribution

Information was accumulated in the form of abstracts, papers and reports from international sources and through numerous contacts and visits. Phase separation and emulsification tests were performed and operation of a diesel engine on methanol-diesel emulsions was examined.

## RESULTS

Results of the literature survey are incorporated in the body of the final report and 72 references are listed. A detailed documentation is presented in five appendices including the results of tests on phase separation and emulsification and on diesel engine operation. The project summary and several conclusions and recommendations are presented in the first sections of the final report. The most important achievement was demonstration of technological feasibility for operating a diesel engine on methanol diesel fuel emulsions. The emulsions were generated by incorporating an in-line mechanical emulsification unit and were of sufficient stability for direct diesel operation.

The production of methanol from Canadian coals was found technically feasible using commercially available technology. Some estimates for the potential use of methanol are given. The more likely requirement for methanol is seen in diesel fuel substitution in view of the predicted growth of the diesel fuel market.

## APPLICATION AND ONGOING WORK

Statement of work has been developed to continue this program to:

(1) Assess and compare the production of methanol and other liquid fuels from Canadian coals.

(2) Extend the methanol/diesel fuel tests carried out under this contract to provide more complete information on implementation of the emulsifying device.

## SUPPORTING DOCUMENTS

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Shaunavon coal utilization study

**FUNDING**

**CANMET:** 93,171.73

**CONTRACTOR:** 93,171.73

**DSS:**

**OTHER:**

**TOTAL:** 186,343.46

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Coal and Peat

**SUB-SUB-ACTIVITY:**

**PROJECT:**

**CONTRACTOR:** Saskatchewan Power Corporation

**SCIENTIFIC AUTHORITY:** M.M. Avedesian

**TEL:** 996-4570

**BEGIN/END:** November 22, 1977/March 31, 1978

**REQUISITION NUMBER:** 23440-7-9033-3

## OBJECTIVES

- to carry out a technical and economic study on the utilization of Shaunavon coal for power generation
- to carry out a baseline study of the reference case of a pulverized fuel fired boiler using dry cooling
- to evaluate and compare the technology of eleven advanced generation techniques
- to carry out a water survey on availability, quality, and cost for supplying make-up water and supporting a thermal generating station
- to collect coal samples for analysis and testing.

## PROCEDURE

The Shaunavon Coal Study was carried out to evaluate a number of power generation techniques. As the Shaunavon coal reserves are located in a water scarce area, the emphasis in all cases was on the minimum water utilization without undue capital and operating expenditures or forced dry air cooling. The plant size was limited to 300 MW gross and the plant was expected to start operation in 1987/88. The techno-economic evaluation was done in two phases. In the first, advanced power generation technologies were compared with one another. Work was also done on a conventional PF power plant using air cooling to provide the base case. An environmental study was carried out in addition to a water survey. Several coal samples from a drilling program were analyzed. The second phase was a more detailed evaluation of the AFBC.

## RESULTS

The Lurgi combined cycle and AFBC were those from the advanced technologies mature enough to be considered for a plant operating by 1987/88 and which could provide an alternative to the base case. PFBC, although showing good promise was not considered mature enough for the time frame. The cost of energy in terms of 1988 dollars was 4.65¢/kWh and 4.89¢/kWh for AFBC and the base case respectively. The AFBC cycle did not appear to have an advantage over the base case if low sulphur coal were utilized.

The environmental study showed a net positive socio-economic impact associated with both plant construction and operation. Theoretical model techniques applied to the limited field data available showed that water could be available in quantities of 25 to 190 litres from the lower aquifer. The quality of water is uncertain.

## APPLICATION AND ONGOING WORK

SPC submitted a proposal on April 25, 1978 to carry on the work into a detailed techno-economic assessment of the four contending advanced coal-to-electricity processes.

## SUPPORTING DOCUMENTS

3-volume report.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Studies on site selection, environmental considerations and conceptual designs of a fluidized combustion and coal gasification demonstration plant

**FUNDING**

**CANMET:** 153,000.00

**CONTRACTOR:** B.C. Hydro and Power Authority

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** P.J. Read

**TEL:** 995-9351

**DSS:**

**OTHER:**

**BEGIN/END:** Mar. 29/78 - Mar. 31/78

**REQUISITION NUMBER:** 23440-7-9102

**TOTAL:** 153,000.00

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Coal and Peat

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

The original objective was to provide, in conceptual design form, details of schemes which would enable B.C. Hydro and other Canadian industry to obtain realistic operating data and experience on three different advanced coal conversion routes:

a) production of substitute natural gas from coal using Lurgi gasification;
b) production of electric power from coal using Lurgi gasification to produce low-heat-value gas for subsequent combustion in gas turbines;
c) production of electric power from coal using direct combustion in pressurized fluidized bed burners applied to gas turturbines.

During the study it was determined that, in the case of substitute natural gas production using the Lurgi oxygen-blown gasification process, there was no need to build a plant to demonstrate this technology since it is already well substantiated.

## PROCEDURE

In the gasification-combined-cycle part of the study it was first determined that no existing turbines could be used. Then the combination of a Westinghouse (Canada) 12 MW(E) engine and Lurgi 2.7-m dia gasifier were chosen for the conceptual design. This is the smallest combination which contains all the unit processes representative of a larger scale commercial plant. The design was based on using a B.C. lignite containing 37.7% ash, 30% moisture, 0.5% sulphur, and with a high heating value of 8.4 MJ/kg which Lurgi had previously determined to be suitable for gasification. Assumption of this low grade coal allowed for test work on higher quality coals. Environmental control was maintained by two-stage scrubbing of the output of the gasifiers, recovery of sulphur, recirculation of tars, and biological treatment of gas liquors. Examined the possibility of using existing turbines but none suitable because of high entry temperature. Two different sizes were considered: one a combustion – turbine combination of 6 MW, the other a similar combination of 70 MW which could eventually be combined with a steam turbine to give a total input of 200 MW electric. The former was chosen as it could be placed on an existing B.C. Hydro site and the latter as a demonstration plant which could be built with present knowledge and which could yield all the necessary design parameters for a full-scale commercial plant.

## RESULTS

The terms of reference did not include comparison of the various routes to generation: the task was to present conceptual designs for these various routes in such a way that the sponsors could perceive their advantages and drawbacks. The conclusion was that fluid-bed combustion has distinct potential advantages over either combined cycle gasification or pulverized fuel combustion but that substantial development and demonstration are needed before a full-scale commercial plant can be designed. To be in a position to implement a commercial plant as early as possible, the larger (70 MW) unit demonstration at or near a mine site is preferred over the smaller approach. This is quite compatible with the need to demonstrate load-tracking compatibility and hot particulate removal at as large a size as possible. It would be feasible to offset at least some of the cost of the demonstration u unit by operating the plant as a commercial generating unit at the end of the demonstration if it were combined with a steam turbine for a total output of about 200 MW.

## APPLICATION AND ONGOING WORK

Serious consideration is being given to design and construction of a pressurized fluidized combustion demonstration plant.

## SUPPORTING DOCUMENTS

Final reports on file with Technical Information Division.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Canadian mining costs
Uranium mining examples

**CONTRACTOR:** Kilborn Engineering (B.C.) Ltd.

**SCIENTIFIC AUTHORITY:** G. Allen
**TEL:** 705-848-2236

**BEGIN/END:** Nov. 1977 - Mar. 31, 1978

**REQUISITION NUMBER:** 23440-7-9028

**FUNDING**

**CANMET:** 35,065.84
**CONTRACTOR:**
**DSS:**
**OTHER:**
**TOTAL:** 35,065.84

**PROGRAM:** Energy

**ACTIVITY:** Energy Resource Determination

**SUB-ACTIVITY:** Radioactive Minerals

**SUB-SUB-ACTIVITY:** Uranium Resource & Reserve Economic Assessment

**PROJECT:** Determination of Productive Capacity

## OBJECTIVES

Establish costs to bring into production and operate mines in different geographical locations in Canada. These cost figures are used to establish cut-off grades for prospective orebodies in Canada. To be considered were open pit, cut and fill and in situ leaching as mining methods, and acid and alkaline leach mills for each. This was required for three geographical areas for 500-, 1500- and 500-t/d operations.

## PROCEDURE

Each mining method was costed by estimating preproduction development and equipment data. The operating cost for the three mining methods were based on salaries and wages obtained from current union contracts and from information received from mining associations. The current cost of major consumable and maintenance supplies were obtained from selected suppliers, and, power and freight costs were determined from service companies. An equipment replacement allowance was also determined. Location-induced operating costs were obtained by reviewing a list of costs and estimating additional costs over base regions.

Mill capital costs were escalated from past experience to the present by using construction and equipment cost indexes. Similarly, mill operating costs were developed using data from southern Ontario and southern British Columbia.

## RESULTS

Three distinct geographical regions were outlined — southern Canada and the Maritime Provinces; northern Saskatchewan and the Yukon and Northwest Territories; and the Arctic Islands. Cost graphs for these regional settings using various sized operations and types of mills were produced for each of the mining methods. Backup data for each size of operation was given in sufficient detail to understand the makeup of each cost.

Generally, costs in Northern Saskatchewan, the Yukon, and the Northwest Territories were 50 to 250% higher than in southern Canada. The costs from the Arctic Islands were about 10% higher than in the northern mainland.

## APPLICATION AND ONGOING WORK

The material presented in this contract will be used for determining cut-off grades for reserve and resource evaluation purposes. Mining companies would also benefit by obtaining relative cost figures for schedules and proposals. Current thinking is to update this report every two or three years.

## SUPPORTING DOCUMENTS

None
Unpublished report to CANMET, March 1978;
microfilm copy held in CANMET Library, 555 Booth St., Ottawa, Ontario.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Development of a routine, accurate method for the determination of Pb-210

**CONTRACTOR:** Saskatchewan Research Council

**SCIENTIFIC AUTHORITY:** J.L. Dalton

**TEL:** 995-4133

**BEGIN/END:** August 1977/March 197B

**REQUISITION NUMBER:** 23440-7-9046

**FUNDING**

**CANMET:** $12,409.50

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $12,409.50

**PROGRAM:** Energy

**ACTIVITY:** Development

**SUB-ACTIVITY:** Nuclear Energy

**SUB-SUB-ACTIVITY:** Up-grading low grade uranium ores

**PROJECT:** Analytical Chemistry

## OBJECTIVES

(A) To provide a radiochemical method for accurate, routine determination of Pb-210, through the β-counting of its daughter, Bi-210.

(B) To provide radiochemical analysis of Ra-226, Th-230, and Pb-210 in 20 samples.

## PROCEDURE

A (i) By carrying out a literature search, ascertained the state-of-the-art for the determination of Pb-210.

(ii) By studying the chemistry of bismuth, determined a rapid, accurate method of separating bismuth from potential interferences.

(iii) Carried out the chemical separation, prepared the bismuth extract for β-counting and obtained a β-spectrum.

(iv) By running a Pb-210 standard in the method selected, determined accuracy of the chemical separations and counting technique.

(v) By analyzing ore samples containing a known amount of Pb-210, determined applicability of the method.

B (i) Using the procedure developed in A, analyzed the samples for Pb-210.

(ii) Using existing radio-chemical methods, analyzed the samples for Ra-226 and Th-230.

## RESULTS

(A) An analytical report has been submitted for the determination of Pb-210. The method involves dissolution of the sample, extraction with DDTC, precipitation of BiOCl, and the subsequent β-counting of BiOCl on a stainless steel planchet. Pb-210 is known to be extracted with bismuth but its interference can be eliminated by counting through an aluminum foil.

The accuracy of the method is judged to be within 5% of theoretical.

(B) Analytical results were provided for Pb-210, Ra-226, and Th-230 in 20 samples the results from 7 of which were in duplicate.

## APPLICATION AND ONGOING WORK

(A) The analytical method will be used in the on-going analytical requirements for the sub-sub-activity.

(B) The analytical results will be used in both CANMET and industrial laboratories as a check on analytical procedures.

## SUPPORTING DOCUMENTS

Report filed.
Analytical results available from the Scientific Authority.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Research on the low temperature toughness properties of cast steels

**CONTRACTOR:** Dominion Foundries and Steel Ltd., Hamilton, Ontario

**SCIENTIFIC AUTHORITY:** J.D. Boyd

**TEL:** (613) 593-7129

**BEGIN/END:** June 16, 1975 - March 31, 1976

**REQUISITION NUMBER:** 23440-5-1003

**FUNDING**

**CANMET:** $79,587.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $79,587.00

**PROGRAM:** Energy Technology Development Transportation

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Transportation

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

Demand for cast steel for Arctic conditions is expected to exceed production capacity of Canadian foundries within 10 years unless substantial improvements are achieved in the quality of the repaired steels. Low temperature toughness is of particular importance because it is related to the steel's resistance to crack initiation and propagation under critical conditions. Accordingly, this research program has the specific goal of corellating the low temperature toughness with chemical compositon and heat treatment of experimental cast steels.

## PROCEDURE

Sixteen experimental compositions were evaluated by melting and casting two, 200-lb (998.8-kg) slabs of each composition in addition to four control compositions. Two different heat treatments were employed. The evaluation consisted of determining the nil ductility transition temperature, complete Charpy impact transition curves and tensile properties, and metallographic examination. The effects of carbon, manganese, silicon, chromium, molybdenum, and nickel on toughness and tensile properties were determined by means of arithmetic and computer regression equations.

## RESULTS

The regression analysis provided a quantitative determination of the effects of six alloying elements on toughness and tensile properties of cast steels. It was shown that yield strength and hardness are most directly related to carbon content, and that nickel is the single most effective element for improving low temperature toughness.

The normalized-quenched-tempered steel gave better mechanical and impact properties than double normalized and tempered steel of the same composition. Results indicate that increasing the section size from 1 in. to 4 in. (25.4 mm to 101.6 mm) detracts from the impact properties for the same composition and heat treatment.

## APPLICATION AND ONGOING WORK

Results of this project provide quantitative data on the specific effects of six alloying and two heat treatments on the strength, ductility, impact toughness, and microstructure of cast steels. It represents a first step towards a more concentrated alloy development program aimed at producing new cast steels suitable for Arctic requirements.

This work is continuing at DOFASCO. The next phase will consist of four heat treatments.

## SUPPORTING DOCUMENTS

Kennedy, W.D. "Low temperature toughness properties of selected low alloy cast steels"; DOFASCO report to CANMET, July 1976.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Research on the low temperature toughness properties of cast steels

**CONTRACTOR:** Dominion Foundries and Steel Ltd.

**SCIENTIFIC AUTHORITY:** J.D. Boyd

**TEL:** 593-7129

**BEGIN/END:** Feb. 15, 1977/Mar. 31, 1978

**REQUISITION NUMBER:** 23440-6-9080

**FUNDING**

**CANMET:** 49,318.88

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** 49,318.88

**PROGRAM:** Energy

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Transportation

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

Demand for cast steel for uses in Arctic conditions is expected to exceed the production capacity of Canadian foundries within 10 years unless substantial improvements are achieved in the efficiency of the required steels. Low temperature toughness is of particular importance. Accordingly, this research contract has the specific goal of correlating the low temperature toughness with chemical composition and heat treatment of experimental cast steels.

## PROCEDURE

Four experimental compositions were evaluated in 4-in. thick sections. The compositions were selected based on the previous work on this project, and to meet the requirements of a representative specification for Arctic-grade cast steel. Four different heat treatments were evaluated for each composition. The evaluation consisted of determining the nil-ductility transition temperature, complete Charpy impact transition curves and tensile properties, and metallographic examination.

In addition to the experimental work, the opinions of potential users of such cast steels were solicited.

## RESULTS

The results from the present work for the specific effects of the 6 alloying elements (C, Mn, Si, Cr, Mo, Ni) on toughness differ considerably from results of the regression analyses in the previous work. The agreement for tensile properties is much better.

The effect of heat treatment is sensitive to the micro structure. Increasing the tempering temperature improves toughness and decreases strength more for acicular ferride steels than for polygomal ferride steels.

The users of cast steels feel that current specifications can be met with existing steels. The principal concern about new cast steels is their weldability.

## APPLICATION AND ONGOING WORK

This project is now complete. Quantitative data on the effects of alloying, heat treatment and section size are now available for the commercial development of cast steels with excellent low temperature toughness. The pertinent reports are being circulated to Canadian foundries.

## SUPPORTING DOCUMENTS

"Research on optimizing the low temperature toughness of cast steels"; W.D. Kenny, 21.3.78, Final Report on 23440-6-9080.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Technology assessment of long-distance liquid natural gas pipelines

**CONTRACTOR:** CANUCK Engineering Limited

**SCIENTIFIC AUTHORITY:** E. Smith, I.C.G. Ogle

**TEL:** 995-4044

**BEGIN/END:** 26/07/77 - 31/03/78

**REQUISITION NUMBER:** 23440-6-9014

**FUNDING**

**CANMET:** $100,817.32

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $100,817.32

**PROGRAM:** Energy

**ACTIVITY:** Research and Development Technology

**SUB-ACTIVITY:** Energy Transportation

**SUB-SUB-ACTIVITY:** Liquid Natural Gas Transportation

**PROJECT:** Liquid Natural Gas Pipelines

## OBJECTIVES

1. Establish the areas of well-developed technology relevant to LNG pipeline transport necessary to confirm technical feasibility.
2. Identify those areas lacking in knowledge, understanding, and technique, and outline R & D programs to rectify deficiencies.
3. Catalogue levels of Canadian competence in cryogenic plant storage, handling and engineering, design, manufacture, installation, and operation.
4. Collect cost estimates for design, installation and operation of dense and conventional vapour phase LNG pipeline transport and compare costs of service.
5. Review short and long term potential applications for LNG pipelines
6. Compile expected operating parameters for short and intermediate distance internally insulated lines for LNG transfer and delivery.

## PROCEDURE

1. Compiled bibliography on LNG pipelines and Canadian experience in cryogenic engineering.
2. Prepared a conceptual model of an LNG pipeline designed to deliver about 2.5 x $10^9$ SCF per year, running through an area of Canada corresponding to the route of the proposed Mackenzie Valley pipeline, including:
   a) outline design
   b) engineering and constructional requirements
   c) pumping and cooling requirements
   d) materials requirements
   e) start-up and operating procedures
   f) problems of unsteady state operation
   g) possible modes of failure or shutdown
   h) identification of equipment available and required
   i) cost comparison with conventional pipeline
3. Identified possible uses of the low temperatures available from the LNG along the route and at point of delivery.
4. Identified new or novel concepts that might be applied to LNG pipeline design or construction.
5. Determined ideal operating conditions and pipe specifications for ship to shore and intermediate (50-100 miles) distance LNG pipelines.

## RESULTS

A report was prepared documenting results of the various studies described under "procedure". The major conclusion of the report was that with present technology, major LNG line for long distance transmission would cost up to 30% more than an equivalent conventional vapour-phase line. Surprisingly a major proportion of this increased cost was for insulation which virtually doubled cost of the materials.
The study also showed that an internally insulated pipeline had attractive possibilities for short- and medium-distance transmission if certain technical difficulties could be overcome.

## APPLICATION AND ONGOING WORK

Phase II has identified a new concept in LNG pipelines for ship to shore transfer and intermediate distance transportation which appears to be a viable alternative to conventional LNG cryogenic pipeline transportation. Ongoing work will be directed towards the identification and investigation of scientific and engineering problems implicit in this application.

## SUPPORTING DOCUMENTS

"LNG Pipelines: A technology assessment" - 2 Volumes
"Assessment of operating parameters for short and intermediate internally insulated LNG pipelines"; A Supplement to Volumes 1 and 2 above.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Determination of free-standing height of backfill in pillar recovery operations

**FUNDING**

**CANMET:** $24,985.42

**CONTRACTOR:** Dames and Moore, Toronto, Ontario

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** G. Herget

**TEL:** 705-848-2236

**DSS:**

**OTHER:**

**BEGIN/END:** Nov. 16, 1976 - March 31, 1977

**REQUISITION NUMBER:** 23440-6-9056

**TOTAL:** $24,985.42

**PROGRAM:** Minerals Research

**ACTIVITY:** Mineral Technology Development

**SUB-ACTIVITY:** Underground Mining

**SUB-SUB-ACTIVITY:**

**PROJECT:** Bulk Mining at Depth

## OBJECTIVES

Backfill forms an integral part of ground support in steeply dipping ore bodies with weak walls and in pillar recovery operations. In most applications, waste products of mining are used for filling, therefore mine filling practice has a significant impact on the environment. To obtain maximum ore recovery in room and pillar systems, it is desirable to design backfill so that it is capable of providing a support function and to stand unsupported to a height of up to 200 ft (60 m). The primary objective of this contract was to accumulate technical information available on backfill systems, strength properties of fill, and to evaluate the support function of fill in a stope and pillar layout.

## PROCEDURE

The detailed work statement required:
1. Use of a mathematical model to develop methods of determining the maximum free-standing height for the following types of backfill: a) hydraulic mill tailings with 30:1 cement ratio, b) hydraulic mill tailings with 30:1 cement ratio containing 1-ft long sections with 8:1 cement ratio at 12-ft (4-m) vertical intervals, c) cemented rockfill with a 20:1 cement ratio.
2. Compare developed theories with information available on free-standing height of backfill in the literature and by communication with selected mines.
3. Assess backfill properties required to achieve vertical free-standing walls of fill in typical pillar recovery operations. A typical layout would be a set of 60-ft (18-m) wide stopes and 40-ft (12-m) wide pillars and a stope height of 200 ft (60 m).

## RESULTS

The contractor provided a review of mining practices, a comparison of various kinds of backfill, and developed a finite difference program to analyze the interaction of fill and stope walls in room and pillar mining. Some of the conclusions for the selected model were that stope excavation before backfilling can cause very significant displacements and plastic flow in pillars. 1:30 cemented hydraulic fill interacts little with the rockwalls and provides only nominal support. Strong cemented rockfill will stand unsupported under gravity alone with minor deformations when a face 250 ft (76 m) long and 200 ft (61 m) high is exposed. For a given volume of pillar, the mining by vertical retreat delays the onset of instability compared with conventional vertical slicing.

## APPLICATION AND ONGOING WORK

Results of the contract were discussed by the sub-committee on fill of the Canadian Advisory Committee of Rock Mechanics. Publication of results is planned for the Backfill Symposium in Sudbury held in May 1978. Further work is required on the computer model and for the year 1977/78 it is planned to apply the model to an actual backfill mining operation in northern Ontario.

## SUPPORTING DOCUMENTS

Dames and Moore, "A computer model to predict a free-standing height of backfill and pillar recovery operations"; DSS Contract No. OSQ76-00113; March 1977.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Data logging instrumentation

**CONTRACTOR:** Heathwood Engineering Assoc

**SCIENTIFIC AUTHORITY:** L. Geller

**TEL:** 6-4570 (Ext. 139)

**BEGIN/END:** Nov. 26, 1976 - March 31, 1977 (a)
Oct. 31, 1977 - March 31, 1978 (b)

**REQUISITION NUMBER:** 23440-6-9064 (a), 23440-7-9053 (b)

**FUNDING**

**CANMET:** $21,081.50 ...(a)
$ 6,400.00 ...(b)

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $27,481.50

**PROGRAM:** Mineral

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Development and Mining

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

(a) Develop and build instruments to measure and record the following variables on diamond drilling machines:

1. Speed (rpm) 2. load (lb) 3. penetration and penetration rate (in./min)
4. water flow (cfm) and pressure (psig)
5. true rod torque (ft-lb)

(b) Confirm operating ability of instruments previously built and provide, in addition, a. a permanent updatable memory and b. a flow transducer for abrasive materials.

## PROCEDURE

Requirements were first pinpointed by members of CDDA. Then the usual channels of request for proposals, evaluation, contract documentation etc. were followed through DSS.

Development work by Heathwood Eng. Assoc. was closely monitored by correspondence, telephone calls and personal contacts. In addition contacts were maintained with CDDA's Technical Committee.

Draft copy of final report was carefully scrutinized and corrected.

## RESULTS

Prototype equipment is now ready for use by the diamond drilling industry including a Penetrometer, Pressure Transducer, Flow Meter, Load-Torque-Speed Transducer, Display and Recording Cabinet, Operator's Pendant Switch and Power Pack.

Also final reports are available, including a "Design Manual" and a "User's Manual".

## APPLICATION AND ONGOING WORK

No ongoing work. Possible applications to be discussed with members of the diamond drilling industry.

## SUPPORTING DOCUMENTS

A "Design Manual" and a "User's Manual". Copies supplied to TID.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Determination of free standing height of backfill in pillar recovery operations

**CONTRACTOR:** Dames and Moore, Toronto, Ontario

**SCIENTIFIC AUTHORITY:** G. Herget

**TEL:** 705-848-2236

**BEGIN/END:** Nov. 1, 1977 - Mar. 31, 1978

**REQUISITION NUMBER:** DSS File No. 18SQ.23440-7-9045

**FUNDING**

**CANMET:** 31,938.51

**CONTRACTOR:** 4,000.00

**DSS:**

**OTHER:**

**TOTAL:** 35,938.51

**PROGRAM:** Minerals

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Development and Mining

**SUB-SUB-ACTIVITY:** Underground Mining

**PROJECT:** Bulk Mining at Depth (3.3.2.2.02)

## OBJECTIVES

Refine and verify a numerical model of backfill behaviour in stopes during pillar recovery.

## PROCEDURE

a) Refined and validated numerical modelling procedure.
b) Obtained and tested tailings fill samples from a stope in an operating mine.
c) Predicted the behaviour of the stope fill during removal of the adjacent pillar.
d) Modelled a stope containing cemented rock fill based on CANMET information.

## RESULTS

Results showed that the system employed was capable of predicting fill wall stability.

## APPLICATION AND ONGOING WORK

The predicted results will be evaluated in the light of field observations which will be obtained in the near future.

## SUPPORTING DOCUMENTS

Dames and Moore "Case studies to predict the free standing height of backfill in pillar recovery operations"; final report March 1978.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** A state of the art review of the field of comminution in relation to its application in minerals processing.

**CONTRACTOR:** Ronald E. Hamilton, Computer Process Control Consultant, 1087 Glendale Dr., Peterborough, Ont.

**SCIENTIFIC AUTHORITY:** F.J. Kelly

**TEL:** 995-4888

**BEGIN/END:** July 15, 1975 - March 1, 1976

**REQUISITION NUMBER:** 23440-5-1093

**FUNDING**

**CANMET:** $19,500.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $19,500.00

**PROGRAM:** Minerals Research

**ACTIVITY:** Mineral Technology Development

**SUB-ACTIVITY:** Processing

**SUB-SUB-ACTIVITY:**

**PROJECT:** Zn/Pb/Cu Sulphide Ores

## OBJECTIVES

To review and assess:

1. Current comminution practices and ideas, as current research on new approaches.
2. Predictions as to which of the approaches are expected to develop over the next five to ten years.

## PROCEDURE

An intensive survey of current comminution literature was made. The state of the art of comminution was discussed with recognized experts in the field. A comprehensive report on the state of the art was prepared.

## RESULTS

The review produced a report "Review of comminution practice". It provides a technical discussion and evaluation of the collected information and identified potentials for possible improvement. Also included is a list of persons interviewed, their comments, and a bibliography.

## APPLICATION AND ONGOING WORK

The review has resulted in two further contracts to define an experimental procedure to optimize a continuous grinding circuit for a fine-grained complex Zn/Pb/Cu pyrite ore of the New Brunswick type.

## SUPPORTING DOCUMENTS

Hamilton, R.E. "Review of comminution practice, bibliography of recent comminution literature".

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Definition of an experimental design to optimize a continuous grinding circuit consisting of a ball mill or rod and ball mill and classifier (hydroclone or screen) in closed circuit for a fine-grained complex Pb/Zn/Cu/pyrite ore of the New Brunswick type.

**CONTRACTOR:** R.E. Hamilton, Computer Process Consultant, 1087 Glendale Dr., Peterborough, Ont.

**SCIENTIFIC AUTHORITY:** F.J. Kelly

**TEL:** 995-4888

**BEGIN/END:** March 1, 1976 - March 31, 1976

**REQUISITION NUMBER:** 23440-5-9003

**FUNDING**

**CANMET:** $2,400.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $2,400.00

**PROGRAM:** Minerals Research

**ACTIVITY:** Mineral Technology Development

**SUB-ACTIVITY:** Processing

**SUB-SUB-ACTIVITY:**

**PROJECT:** Zn/Pb/Cu Sulphide Ores

## OBJECTIVES

To design series of grinding and classification experiments for developing a computer simulation model of a grinding circuit to improve recovery in fine-grained complex New Brunswick type ores. The model will be tested by CANMET on a small-scale continuous operation to evaluate its effectiveness. To prepare a report and indicate where the contractor's personal input into the model testing experiment, such as data handling, model development, and subsequent computer simulations would be used.

## PROCEDURE

Visited CANMET personnel and obtained information on the available grinding and classification units which could be used for the experiment.

## RESULTS

A report was received which outlined an experimental design procedure to develop the grinding system model. It includes estimates for testing time, manpower requirement, program development time, data analysis, model development and confirmation test work.

## APPLICATION AND ONGOING WORK

Some of the proposals and test schemes will be used in plans for further research into the modelling of grinding and classification systems for fine-grained New Brunswick sulphide ores.

## SUPPORTING DOCUMENTS

Hamilton, R.E. "Report on Contract OSQ5-0135"; March 1976.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Development of a simultaneous multi-stream, multi-element X-ray emission analysis system for slurries and solutions.

**CONTRACTOR:** Inax Instruments Ltd., Ottawa, Dntario

**SCIENTIFIC AUTHORITY:** J.L. Dalton, A. Stemerowicz

**TEL:** 995-4316 995-2778

**BEGIN/END:** 1 April 1976 - 31 March 1977

**REQUISITION NUMBER:** 23440-6-9005

**FUNDING**

**CANMET:**

**CONTRACTOR:**

**DSS:** $249,502.06

**OTHER:**

**TOTAL:** $249,502.06

**PROGRAM:** Minerals Research

**ACTIVITY:** Mineral Technology Development

**SUB-ACTIVITY:** Processing

**SUB-SUB-ACTIVITY:** Metallic Minerals

**PROJECT:**

## OBJECTIVES

The value of on-stream analysis of slurries in an ore-processing pilot plant cannot be overstated. Not only does this system monitor the process being investigated by providing instantaneous analyses of elements of interest but equally as important, the research scientist can determine from the trend of the analyses whether or not the various processing operations have reached equilibrium values.

At present all of the on-stream X-ray fluorescence analyzers employed in Canadian mineral processing plants are of the centrally-located type where each stream is analyzed sequentially.

The objectives of this project was (i) to develop and construct an alternative on-stream XRF analysis system in which the X-ray excitation source and detector could be located at each sampling point with electrical signals transmitted to a control room for signal analysis and data processing, and (ii) to assess the suitability of this concept and instrumentation for use in a pilot-plant operation.

## PROCEDURE

Inax developed three independent X-ray fluorescence stations, each capable of handling two slurry streams for use in the Ore Processing Laboratory (OPL), and a control console to be located in the analysis room of the OPL pilot plant. Signals from the six detectors are transmitted to the control console where they are analyzed and the integrated intensities from the elements of interest are processed with a microprocessor to determine elemental concentration. Communication with the microprocessor was provided with a Texas Instruments electronic data terminal. Software for the microprocessor was developed by Inax.

## RESULTS

Inax designed, constructed, and bench-tested the instrumentation at their plant, and field-tested it with previously analyzed lead-zinc ore fractions at OPL. One of the units has been used in mill operations but full-scale use of the three stations has not yet been undertaken.

## APPLICATION AND ONGOING WORK

The instrumentation will be used to provide on-line analysis capabilities for OPL. It is expected that appropriate calibration techniques will be examined and software developed.

## SUPPORTING DOCUMENTS

Inax, a simultaneous multi-stream, multi-element X-ray emission analysis for slurries and solutions; Design report.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Definition of an experimental design to optimize a continuous grinding circuit consisting of a ball mill and classifier (hydrocyclone or Screen) in closed circuit for a fine grained complex Pb/Zn/Cu pyrite ore of the New Brunswick type.

**CONTRACTOR:** Yves Bérubé, Dept. des Mines et Métallurgie
Université Laval, Cité Universitaire, Québec, Canada

**SCIENTIFIC AUTHORITY:** F.J. Kelly

**TEL:** 995-4888

**BEGIN/END:** June 1, 1976 - June 30, 1976

**REQUISITION NUMBER:** 23440-6-9022

**FUNDING**

**CANMET:** $2,600.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $2,600.00

**PROGRAM:** Mineral Research

**ACTIVITY:** Mineral Technology

**SUB-ACTIVITY:** Processing

**SUB-SUB-ACTIVITY:**

**PROJECT:** Zn/Pb/Cu Sulphide Ore

## OBJECTIVES

1. To develop a grinding and classification model to be used in a computer simulation of a grinding circuit to help improve recovery of valuable components in fine-grained complex New Brunswick type ores. This will be done on a small-scale continuous basis.

2. To develop mathematical model of grinding and classification circuit for reliable prediction of full-scale plant performance using data derived from small-scale plant test work as input.

   The contractor will also indicate how his personal input would be utilized, particularly in handling data, developing models and subsequent computer simulations as well as acting as consultant during investigations.

## PROCEDURE

Visited CANMET and consulted with laboratory staff to further clarify the requirement and to obtain information on facilities and individual grinding and classification units which could be used for the experiment.

## RESULTS

A report was received which outlined the mathematical models to be used, modelling procedure of a pilot-scale grinding circuit, milling circuit scale-up, summary of experiments to be carried and work experience of the university research group available for consultative purposes.

## APPLICATION AND ONGOING WORK

The experimental design proposed in this contract gave rise to a further contract with the Laval University Research Group for cooperative research on modelling of grinding and classification for fine-grained sulphide ores of the New Brunswick type.

## SUPPORTING DOCUMENTS

Hodouin, D. and Bérubé, Yves "The design of an experimental grinding circuit for a fine pyrite ore of the New Brunswick type", June, 1976.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Development of a process for recovering sulphur from sulphur monochloride.

**FUNDING**

**CANMET:**

**CONTRACTOR:** Canadian Industries Ltd., Montreal, Que.

**CONTRACTOR:** $24,799.06

**SCIENTIFIC AUTHORITY:** H.W. Parsons

**TEL:** (613) 994-5002

**DSS:**

**OTHER:**

**BEGIN/END:** Dec. 15, 1976 - May 15, 1977

**REQUISITION NUMBER:** 23440-6-9073

**TOTAL:** $24,799.06

**PROGRAM:** Minerals

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Processing

**SUB-SUB-ACTIVITY:**

**PROJECT:** Complex Zn/Pb/Cu Sulphide ores

## OBJECTIVES

The objectives were to evolve methods of recovering chlorine and elemental sulphur from sulphur monochloride ($S_2Cl_2$). The methods to be examined were:

1. thermal decomposition
2. chemical liberation of sulphur
   a. chlorination of cuprous chloride to produce sulphur.
   b. organic extraction
   c. use of molten sulphur as a condensing medium.

From these studies, a commercial process could be evolved to utilize the sulphur monochloride produced in the dry chlorination of complex Zn-Pb-Cu sulphide ores by producing chlorine suitable for recycling saleable sulphur.

## PROCEDURE

Thermal decomposition: apparatus was constructed to enable $S_2Cl_2$ to be used and decompose into gaseous sulphur and chlorine. Attempts were made to quench the reverse reaction.

Chemical reaction: reflex apparatus was set up for the reaction between powdered Cu Cl and and $S_2Cl_2$, with necessary filtration and drying equipment for the product. High temperature experimenting was done in steel bombs or Carrier tubes. Analysis of the products were done by atomic absorption spectroscopy and titrimetric methods.

## RESULTS

CIL was unsuccessful in attempts to separate elemental sulphur and chloride by thermal decomposition.

The rapid reaction of chlorine with molten sulphur indicated that liquid sulphur was not a suitable quenching medium.

CIL concluded there were no convenient ways of recovering chlorine from chlorinated organics, therefore, a cyclic system based on an organic intermediate was unlikely for the decomposition of $S_2Cl_2$.

An industrial process based on the high temperature chlorination-dechlorination of copper chlorides is technically feasible but difficult to engineer, is energy intensive, and costly from a capital and operating viewpoint.

## APPLICATION AND ONGOING WORK

CIL concluded that other routes producing elemental chlorine and sulphur in an oxidized form e.g., $SO_2$, $SO_3$, $H_2SO_4$, from $S_2Cl_2$ for direct chlorination of concentrate may ultimately prove economically more attractive than any of the systems studied. Work is completed.

## SUPPORTING DOCUMENTS

Parsons, H.W. CANMET Reports MRP 77-02, MRL 72-07(CF)

Doty, L.F. "Development of a process for recovering sulphur from sulphur monochloride"; CIL Final Report; May 13, 1977.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Evaluation of the Cominco hydrometallurgical lead process for recovery of lead from a pyrite low-grade lead concentrate.

**FUNDING**

**CANMET:** $61,500.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:**

**PROGRAM:** Minerals

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Processing

**SUB-SUB-ACTIVITY:**

**PROJECT:** Processing

**CONTRACTOR:** Cominco Limited, Trail, British Columbia

**SCIENTIFIC AUTHORITY:** J.E. Dutrizac

**TEL:** (613) 995-4823

**BEGIN/END:** Dec. 1, 1976 - May 31, 1977

**REQUISITION NUMBER:** 23440-6-9076

## OBJECTIVES

To apply the Cominco ferric chloride leaching process to low-grade lead concentrates:

1. To determine the conditions required for high recovery of lead with minimal loss of reagents in leach residues and bleed streams.
2. To determine size, composition and method of treating bleed streams required.
3. To determine purity of the lead product and to outline conditions required to produce an acceptably pure product on a continuous basis.
4. To estimate the operating cost of the process based on lead production of 50,000 and 10,000 tpy (45,350 and 9,072 tonnes).

## PROCEDURE

Relevant background information had previously been obtained by Cominco in examining ferric chloride leaching as a means of treating high-grade lead concentrates. A series of experiments was carried out to determine the mass balances needed to estimate costs of the process when applied to lower-grade lead ores similar to the massive sulphides of New Brunswick. A preliminary costing exercise was carried out using the experimental data from the test program together with previous knowledge obtained by Cominco.

## RESULTS

A complete, integrated flowsheet was developed and tested; all process streams were identified with respect to volume and composition. Methods of handling all impurities were developed. Over 99% lead recovery was obtained by leaching the concentrate in 2M $FeCl_3$ solution for 4 hr at 40°C; substantial quantities of the other valuable constituents in the concentrate were also recovered. The principal reagents needed for the complete process were sulphuric acid, lime and hydrochloric acid. The process produced high purity "Regular grade lead" containing less than 15 ppm (mg/kg) of any impurity. A fused salt electrolytic cell was proposed as the means of producing metallic lead from PbCl . A detailed economic evaluation of the process was performed and total operating costs were estimated to be 9.3¢/lb (20.5¢/kg), Pb for plant treating 100,000 tpy (90,700 tonnes) and 12.9¢/lb (28.2¢/kg) Pb for a 50,000-tpy (45,350-tonne) unit.

## APPLICATION AND ONGOING WORK

To investigate possibility of replacing lead blast furnace by a ferric chloride leaching process. Cominco is working with U.S. Bureau of Mines and a consortium of mining companies on further studies relating to a lead chloride fused salt electrolysis cell.

## SUPPORTING DOCUMENTS

Cominco "Evaluation of the Cominco hydrometallurgical lead process for the recovery of lead from a pyritic low-grade lead concentrate". Report held in CANMET library.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** A critical evaluation of mineral wool manufacturing processes

**FUNDING**

**CANMET:** $12,500.00

**CONTRACTOR:** Norman M.P. Low

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** A.A. Winer

**TEL:** 996-5449

**DSS:**

**OTHER:**

**BEGIN/END:** June - November, 1977

**REQUISITION NUMBER:** 23440-7-9010

**TOTAL:** $12,500.00

**PROGRAM:** Minerals

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Processing

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

Because of increasing need to conserve energy and improve processing technology, to study the technical and economic feasibility of producing mineral thermal insulation. No study of this type had been made for many years. The study was intended to conserve energy and mineral resources and reduce environmental pollution.

## PROCEDURE

A worldwide literature review was made. Field trips were made to plants and discussions held with insulation experts. Assessments were made of:

1) physical and chemical characteristics of mixtures and melts
2) various processes
3) energy balances
4) costs

An overall evaluation was made.

## RESULTS

The study was the first in many years. Much valuable information not readily accessible was obtained which was particularly timely due to the possible entry into the Canadian market of new mineral insulation producers. Five reports were completed by the contractor of which the final one was received in March 1978.

## APPLICATION AND ONGOING WORK

Three reports are in the process of being microfisched; the others are being rechecked but will be microfisched in the near future. The microfilming and distributing will be done by CANMET.

## SUPPORTING DOCUMENTS

A critical evaluation of mineral wool manufacturing processes in five parts by Norman M.P. Low and revisions suggested by A.A. Winer. These are expected to become CANMET reports.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Continuous underground ventilation monitor system

**FUNDING**

**CANMET:** $56,875.11

**CONTRACTOR:** Powers-Conspec

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** R. Tervo

**TEL:** 705-848-2236

**DSS:**

**OTHER:**

**BEGIN/END:**

**REQUISITION NUMBER:** 23241-5-1013

**TOTAL:** 56,875.11

**PROGRAM:** Minerals

**ACTIVITY:**

**SUB-ACTIVITY:**

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

To develop a system for continuous monitoring of an underground ventilation system for air flow, barometric pressure, temperature, relative humidity, fire, dust, radon, methane, carbon monoxide, oxides of nitrogen, oxides of sulphur, and other contaminants or hazards; to transmit the data to a central computer on surface, and to process the data and provide reports on underground conditions for the ventilation engineer on a continuous basis.

## PROCEDURE

Sensors for all the desired parameters except respirable dust were selected, modified as necessary and field-tested. A data transmission system was developed and tested. A control minicomputer was installed, programmed, and tested.

## RESULTS

The system has shown it to be capable of measuring each required parameter at 2-minute intervals and transmitting the data to a computer on surface. The computer can provide an instantaneous readout upon request; it can indicate an alarm condition if a sensor remains outside present high or low limits for a minimum time; it computes a rolling average of the data from each sensor, and at the end of each shift prints a report on average conditions for each sensor for the full shift; and it can assemble all the shift-end reports and compute a month-end report of each average condition. It is also capable of operating a board indicating the location and status for each sensor in the mine, i.e., green — O.K., red — out of limits.

## APPLICATION AND ONGOING WORK

This is the first of an anticipated three-year program.

## SUPPORTING DOCUMENTS

Powers-Conspec:
"Operation and Performance of an underground mine environment monitoring system".

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Analysis of diesel exhaust emitted from water scrubbers and catalytic purifiers.

**CONTRACTOR:** Ontario Research Foundation

**SCIENTIFIC AUTHORITY:** Paul Mogan

**TEL:** 613-996-4570

**BEGIN/END:** 23 April 1976 - 15 May 1977

**REQUISITION NUMBER:** 23440-5-1241

**FUNDING**

**CANMET:** $3,700

**CONTRACTOR:**

**DSS:** $88,600

**OTHER:**

**TOTAL:** $92,300

**PROGRAM:** Minerals Research

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Environment Health and Safety

**SUB-SUB-ACTIVITY:** Underground Environment

**PROJECT:**

## OBJECTIVES

Water scrubbers have been used for treating diesel exhaust for a number of years. However, little data documenting their performance exists, particularily regarding soot-capturing efficiency. This study was undertaken to determine the performance of wet scrubbers of the type in current use, because of increasing concern about the possible impact on worker health of diesel soot. The study was extended to evaluate an advanced concept exhaust treatment system combining a monolithic catalytic purifier and a wet scrubber.

## PROCEDURE

The exhaust from a typical diesel engine in general use underground was passed through exhaust treatment devices:

- a single pass wet scrubber with opiral diverters, full and 1/3 full of water.
- a packed bed wet scrubber containing 1-in. (25-mm) quartz nuggets.
- a monolithic catalytic purifier.
- the monolithic purifier in series with the packed bed wet scrubber.

Gaseous and particulate emissions were measured before and after the exhaust treatment devices for several typical engine speed-load combinations for underground mining.

## RESULTS

The performance of the two water scrubbers was remarkably similar at all engine loads normally encountered underground. They removed about 30% of the soot, 25% of the hydrocarbon, and 40 to 80% of the sulphur dioxide, but had no effect on carbon monoxide, carbon dioxide, or oxides of nitrogen.

The catalytic purifier effectively destroyed carbon monoxide and 70 to 92% of the hydrocarbons but converted at least 32 to 44% of the sulphur dioxide to the more toxic sulphur trioxide. Up to 80% of the sulphur dioxide disappeared. It was also observed that 25% of the nitric oxide was converted to the more toxic nitrogen dioxide under full load conditions and up to 40% at partial loads. When combined with a scrubber, soot capture reached 50% but apparently the sulphur trioxide and nitrogen dioxide were not removed.

## APPLICATION AND ONGOING WORK

This study has provided a scientific basis for selecting currently available diesel exhaust treatment devices for underground use. It was shown that the benefit from using the current generation of wet scrubbers is marginal, i.e., their use would only be justified when additional ventilation is abnormally costly, and where additional fogging problems would not be created. However, the soot capture efficiency of these simple devices was sufficiently high to indicate that more sophisticated wet scrubbers with accessory anti-fogging equipment should be developed as a viable exhaust treatment alternative. The persistence of the acid gases, $H_2SO_4$, and $NO_2$, in the effluent of the scrubber purifier combination demonstrates that this option is not viable at the present stage of development.

## SUPPORTING DOCUMENTS

Lawson, A. and Vergeer, H. "Analysis of diesel exhaust emitted from water scrubber and catalytic purifiers." ORF 77-01. Open file report available at the Mining Research Laboratory, CANMET, 555 Booth St. Ottawa, Ont.

APPLICATION AND ONGOING WORK - cont'd

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** To develop a new type of work suit and protective helmet for underground mine working conditions

**CONTRACTOR:** Mining Industry Research Organization of Canada (MIROC)

**SCIENTIFIC AUTHORITY:** G. Zahary

**TEL:** (705) 848-2236

**BEGIN/END:** Sept. 1976/Feb. 1978

**REQUISITION NUMBER:** 23440-6-9029

**FUNDING**

| | |
|---|---|
| **CANMET:** | $ 30,000.00 |
| **CONTRACTOR:** | 312,000.00 |
| **DSS:** | 160,037.50 |
| **OTHER:** | |
| **TOTAL:** | $502,037.50 |

**PROGRAM:** Minerals

**ACTIVITY:** Mineral Technology Development

**SUB-ACTIVITY:** Environment, Health and Safety

**SUB-SUB-ACTIVITY:** Underground Environment

**PROJECT:**

## OBJECTIVES

To develop prototypes and to test in underground mines the following items of miners gear:

- two types of work suits
- integrated protective helmet including
  - full face visor
  - improved hearing protection
  - improved illumination
- filtered forced air system
- improved battery pack

## PROCEDURE

Research, design and fabrication of the equipment was carried out on a number of sub-contracts with the majority of the work being done by the Noranda Research Centre. Prototypes were evaluated by the mining companies that make-up the Mining Industry Organization of Canada.

Individual items of equipment have been tested and some 75 complete sets were to be manufactured and made available for testing by April, 1978.

## RESULTS

Except for the new hearing protectors, which were commercially available, a set of personal protective gear for underground miners was developed. Application has been made to patent a work suit and helmet.

## APPLICATION AND ONGOING WORK

Decisions on manufacturing the equipment will be made following field testing. MIROC will undertake development of a separate lamp using a design developed in this contract, as well as an improved miners' work boot.

## SUPPORTING DOCUMENTS

"MIROC" Contract Report.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Development of dust and radon daughter sensors

**FUNDING**

**CANMET:** 34,756.46

**CONTRACTOR:** Powers-Conspec

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** R. Tervo

**TEL:** 708-848-2236

**DSS:**

**OTHER:**

**BEGIN/END:** September 1, 1976 - March 31, 1977

**REQUISITION NUMBER:** 23440-6-9033

**TOTAL:** 34,756.46

**PROGRAM:** Minerals

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Environmental Health and Safety

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

To develop continuous sensors for respirable dust and radon daughters in underground mine air.

## PROCEDURE

Various possible means of detecting and measuring respirable dust and radon daughters were evaluated as to applicability for continuous sensing. For dust sensing, the principle used in the Tyndall gravimetric dust sensor (laser-beam scattering) was chosen because it requires no moving parts. No suitable existing radon daughter measurement principle could be found, and a modification of the Lucas method for measuring radon was chosen as likely to be most satisfactory, although the probability of success was considered small.

## RESULTS

A prototype dust sensor was built and tested in the dust chamber at Elliot Lake Laboratory. The results indicated a need for several modifications that have already been completed, and the second prototype is now ready for testing in the dust chamber and underground. A prototype radon daughter sensor is under construction.

## APPLICATION AND ONGOING WORK

Both dust and radon daughter sensors are to be field-evaluated.

## SUPPORTING DOCUMENTS

Powers-Conspec, "Development of instruments for the continuous measurement of radon daughters and dust."

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Radiological analysis of vegetation from uranium mine tailings

**FUNDING**

**PROGRAM:** Minerals Research

**CANMET:** $ 6,244

**CONTRACTOR:** Saskatchewan Research Council, Saskatoon

**CONTRACTOR:**

**ACTIVITY:** Mining

**SCIENTIFIC AUTHORITY:** D. Moffett

**DSS:**

**SUB-ACTIVITY:** Waste Disposal

**TEL:** 705-848-2236

**OTHER:**

**SUB-SUB-ACTIVITY:**

**BEGIN/END:** July 1976 - December 31, 1976

**REQUISITION NUMBER:** 23440-6-9040

**TOTAL:** $ 6,244

**PROJECT:** Surface Treatment of Tailings

## OBJECTIVES

Vegetation of uranium tailings on abandonment is widely accepted as the most suitable first step in their reclamation and rehabilitation. However, there is a need to determine whether or not the grass grown in a rehabilitation program might be radioactive and represent a hazard to the biosphere.

## PROCEDURE

CANMET harvested the grass growing on the Nordic tailings area and SRC analyzed it for radium-226, lead-210, polonium-210, uranium and thorium.

## RESULTS

An investigation was carried out on the uptake of several long-lived radioisotopes by grasses growing on uranium tailings. Field plots of creeping red fescue, reed canarygrass, red top and timothy which have been growing for four years were sampled in this study. The tailings and the plant tissue were analyzed for uranium, thorium, radium-226, lead-210 and polonium-210. Sedimentation within the tailings area gave two zones: one of sands and one of slimes. The slimes contained significantly more radium-226, lead-210 and polonium-210 than the sands. There was no difference in uptake behaviour by grasses growing in the sands and those growing in the slimes. Creeping red fescue showed an anomolous uptake of lead-210, but other than this, all four grass species showed similar uptake behaviour. Only uranium and radium-226 were significantly higher in the grasses from the tailings than the control.

## APPLICATION AND ONGOING WORK

The results of the study will be published in the Canadian Journal of Soil Science. No further R and D activity is envisaged.

## SUPPORTING DOCUMENTS

Moffett, D. and Tellier, M., "Uptake of radioisotopes by vegetation growing on uranium tailings; Can J Soil In press.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Industrial hygiene survey of the uranium industry

**FUNDING**

**CANMET:** $34,960.97

**CONTRACTOR:** James F. MacLaren Limited, Willowdale, Ont.

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** W.M. Gray

**TEL:** 613-996-4570

**DSS:**

**OTHER:**

**BEGIN/END:** Sept. 27, 1976 - March 31, 1977

**REQUISITION NUMBER:** 23440-6-9043

**TOTAL:** $34,960.97

**PROGRAM:** Minerals Research

**ACTIVITY:** Mining

**SUB-ACTIVITY:** Environment, Health & Safety

**SUB-SUB-ACTIVITY:**

**PROJECT:** Health & Safety of Uranium Workers

## OBJECTIVES

To conduct a preliminary industrial hygiene survey of the uranium industry; to make a quantitative assessment of the occupations involving risk; to recommend more comprehensive workplace surveillance.

## PROCEDURE

A review of uranium mining and milling operations in Ontario and Saskatchewan was carried out, including visits to sites of operations. Environmental exposures at work places and associated health hazards were identified. A review of existing monitoring practices and of existing regulations and standards was made. Interviews were held with representatives from each of the major mines and mills, with representatives of labour and of industry associations, and with federal and provincial agencies concerned with research or regulations of various aspects of the uranium mining and milling industry. Various mines were rated as to hazard. Problem areas were identified and recommendations for further research were considered. A report was written.

## RESULTS

The contractor's report contains chapters with the following titles: Mining and milling operations; Health hazards in uranium mines and mills; Existing monitoring programs; Participants and regulations; Summary of interviews and opinions; Hazard rating; Problem areas and potential technical solutions.

Recommendations are made under the headings: Potential health hazards; Environmental monitoring; Medical surveillance; Control practices; Education; Guidelines, criteria and regulations; Other activities.

## APPLICATION AND ONGOING WORK

The report identifies subjects for further potential research and provides information that will assist in setting research priorities.

## SUPPORTING DOCUMENTS

James F. MacLaren Limited, "Industrial hygiene survey of the uranium mining and milling industry"; Report to CANMET; March 1977.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** A study of ventilation strategies for uranium mines

**FUNDING**

**PROGRAM:** Minerals

**CANMET:** $33,298.50

**CONTRACTOR:** Dames & Moore, Toronto

**CONTRACTOR:**

**ACTIVITY:** Technology Development

**SCIENTIFIC AUTHORITY:** R.N. Chakravorty

**DSS:**

**SUB-ACTIVITY:** Environment, Health & Safety

**TEL:** 403-284-0110

**OTHER:**

**SUB-SUB-ACTIVITY:**

**BEGIN/END:** Nov. 18, 1976 - March 31, 1977

**REQUISITION NUMBER:** 23440-6-9044

**TOTAL:** $33,298.50

**PROJECT:**

## OBJECTIVES

The Department of Energy, Mines and Resources is engaged in active research to ensure the health and safety of Canadian uranium workers. The most important aspect of such research relates to the development of ventilation strategies for underground uranium mines, because it is through the effective use of ventilating air that various pollutants, particularly dangerous radioactive contaminants, are controlled. Ventilation strategy deals with air flow network analysis and equipment capabilities, and is closely linked to legislated protective standards for mines and underground operating procedures.

## PROCEDURE

By surveying available literature on uranium mine ventilation practices and documenting the relevant information.

By visiting uranium mines in Canada and reviewing the ventilation systems with concerned officials.

By contacting through visits and phone calls the federal/provincial authorities to review statutory ventilation regulations.

By reviewing ventilation practices and design criteria in uranium mines outside Canada.

## RESULTS

Problems associated with the ventilation of uranium mines were carefully reviewed and documented and the ventilation practices of the Canadian mines were compared with some of the foreign mines in U.S.A., Mexico, South Africa and Europe. The design parameters considered necessary in planning an effective ventilation system were identified. Hazards associated with radiation are discussed and techniques for controlling radiation were documented. The need for computer application in designing the ventilation system was emphasized. Developing a system for systematic monitoring of pollutants at critical points in the mine was recommended.

## APPLICATION AND ONGOING WORK

Final report from the contractor was discussed in an in-house seminar and it was felt that greater research effort in the following areas would prove beneficial for achieving the objective of ensuring safer working environment:

(1) computer application for designing ventilation systems in uranium mines,
(2) systematic monitoring of pollutants in critical areas in operating mines.

## SUPPORTING DOCUMENTS

Dames & Moore, "A study of ventilation strategies for uranium mines". Final report from contractor.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** An instant working level meter with automatic individual radon daughter readout for uranium mines

**FUNDING**

**CANMET:** $1,500

**CONTRACTOR:** Argonne National Laboratory

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** J.L. Horwood

**TEL:** 995-4812

**DSS:**

**OTHER:**

**BEGIN/END:** July 23, 1976 - Dec. 31, 1976

**REQUISITION NUMBER:** 23440-6-9050

**TOTAL:** $1,500

**PROGRAM:** Minerals

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Environmental Health & Safety

**SUB-SUB-ACTIVITY:**

**PROJECT:**

## OBJECTIVES

To test an instant working level meter (IWLM) with automatic individual radon daughter readout for uranium mines. This instrument was designed and constructed at Argonne National Laboratory, Argonne, Illinois.

The IWLM evaluates the working level and individual Rn-daughter concentrations in uranium mine atmosphere within five minutes. The instrument is portable and fully automatic. The WL and the RaA, RaB, and RaC concentrations in pCi/l are displayed in digital form.

## PROCEDURE

The Rn-daughters are collected on a membrane filter at a low rate of 12 l/min. a spectroscope is performed with a silicon surface barrier detector, the B + Y counts are detected with a plastic scintillator and PM tube. No assumptions about Rn-daughter equilibrium are made. Only constancy of the Rn-daughter concentrations during the 2-minute sampling time is assumed. The unit is entirely solid state with exception of the photomultiplier. The WL range of the instrument is 0.01 - 100.

## RESULTS

Extensive testing of the Argonne IWLM was done under a wide range of conditions in mines of the major uranium producing region of Canada. It has accelerated research on the health and safety of uranium miners.

From August to December of 1976, CANMET staff were able to test the Argonne IWLM in more than two hundred determinations under varying conditions. These included: high radon levels in back-filled stopes of the Old Quirke mine being de-watered but not operating; various radon levels associated with operating conditions in the two largest producing mines - New Quirke, and Denison, the latter using trackless mining with consequent high levels of diesel emission; and threshold levels of airborne radiation in buildings.

As a result of these successful field tests, the purchase of an IWLM to be built by Argonne National Laboratory is being discussed.

## APPLICATION AND ONGOING WORK

The meter will be used for radon daughter measurement.

## SUPPORTING DOCUMENTS

None.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** A study to determine the chemical and physical stability of barium/radium sulphate sludges

**FUNDING**

**CANMET:** $10,160.00

**CONTRACTOR:** C.J. Bland, Dept. of Physics
University of Calgary

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** R.G.L. McCready

**TEL:** 705-848-2236

**DSS:**

**OTHER:**

**BEGIN/END:** Oct. 1976 - March 31, 1977

**REQUISITION NUMBER:** 23440-6-9057

**TOTAL:** $10,160.00

**PROGRAM:** Minerals Research

**ACTIVITY:** Mineral Technology Development

**SUB-ACTIVITY:** Environment, Health & Safety

**SUB-SUB-ACTIVITY:**

**PROJECT:** Effluent Control in Tailings Basins

## OBJECTIVES

A preliminary study to determine the stability of $Ba/RaSO_4$ sludges under varying conditions of temperature, pH and soluble sulphate concentrations. The study was designed to assess whether or not a potential hazard would result from changes in the physical and chemical parameters of the water associated with $Ba/RaSO_4$ sludges which accumulate during effluent treatment from uranium tailings.

## PROCEDURE

A triple radio isotope labelled barium/radium sulphate sludge was prepared and allowed to equilibrate under the various test conditions. Samples of the overlying solution were taken, after equilibration, and the levels of the $^{226}Ra$, $^{133}Ba$ and $^{35}SO_4$ determined to assess dissolution of the sludge.

## RESULTS

The release of radium ranged from 1.2 to 76 pCi/L. The minimum values were observed in the presence of 800 ppm. $SO_4^{-2}$ at a pH of 7.0-8.0, at 5°C. The maximum release (76 pCi/L) was noted in the presence of distilled water at 25°C. Generally, the release of $^{226}Ra$ and $^{133}Ba$ was high at the low pH of 2.0; it minimized near neutral pH and increased with increasing alkalinity. Increased solubility was noted at 25°C. Although increased soluble sulphate overlying the sludge should theoretically decrease solubility of $Ba/RaSO_4$ by three orders of magnitude, experimentally an increased solubility was observed. The author suggests that this may be due to surface phenomenon as the $^{35}S$ data shows extensive interchange of $SO_4^{-2}$ between the sludge and the solution. The sludge is most stable when the overlying solution contains 800 ppm sulphate. $Ra^{+2}$ and $Ba^{+2}$ are both known to be toxic and the continual release of these ions from the sludges may constitute an environmental hazard in the long term.

**APPLICATION AND ONGOING WORK** The results of this study have led to initiation of several research projects:

(1) Biodegradation of $Ba/RaSO_4$ by sulphate-reducing organisms.

(2) A feasibility study on the use of ion exchange acrylic fibres for removal of radium from effluents.

Further studies on the stability of $Ba/RaSO_4$ are required to determine:

(1) the effect of sludge ageing; (2) the effects of other soluble ions in the overlying water.

The removal and storage of radium was outlined as a major concern during the recent Ontario Environmental Assessment Board hearings in Elliot Lake.

**SUPPORTING DOCUMENTS**

Bland, C.J. and Gongales, D.E. "A report on a study to determine the chemical and physical stability of barium/radium sulphate sludges under varying conditions of temperature, pH, and dissolved sulphate concentrations; March 1977; Contract #OSU76-00147.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Radiological analysis of mine effluent for isotopes 226Ra and 228Ra

**FUNDING**

**CANMET:** $6,458.00

**CONTRACTOR:**

**DSS:**

**OTHER:**

**PROGRAM:** Minerals

**ACTIVITY:** Mineral Technology Development

**SUB–ACTIVITY:** Environment, Health & Safety

**SUB–SUB–ACTIVITY:** Waste Disposal & Reclamation

**CONTRACTOR:** Saskatchewan Research Council

**SCIENTIFIC AUTHORITY:** D. Moffett

**TEL:** 705-848-2234

**BEGIN/END:** June 1977/February 1978

**REQUISITION NUMBER:** 23440-7-9009

**TOTAL:** $6,458.00

**PROJECT:** Effluent Control in Tailings Basin

## OBJECTIVES

To establish the ratio of the two radio-isotopes radium-226 and radium-228 in effluents from Ontario uranium mines.

## PROCEDURE

Samples of surface and mine waters were collected at the three Ontario uranium mining camps of Elliot Lake, Bancroft and Agnew Lake. Each water sample was analyzed for total radium-226 and radium-228 to establish the ratio of these two isotopes.

## RESULTS

The observed ratios of radium-226 to radium-228 were as follows:

| | |
|---|---|
| Elliot Lake | 15:1 |
| Bancroft | 7:1 |
| Agnew Lake | 2:1 |

These ratios correspond well with those predicted from the ratios of uranium to thorium in the three orebodies. Uranium-238 is the parent of radium-226 and thorium-232 is the parent of radium-228. Some anomalous results were found for the mine water from an inactive mine at Elliot Lake and in the uranium-containing leach solution from Agnew Lake. In both of these cases there was a considerable excess of radium-228.

## APPLICATION AND ONGOING WORK

The constant ratio of radium-226 to radium-228 observed in the majority of the cases is indicative of equilibrium between the uranium and thorium series. Thus the radium-228 concentration in a water sample can be inferred from the radium-226 concentration. Radium-226 is considerably easier to measure and all mines have analytical capability to analyze for it although not for radium-228.

## SUPPORTING DOCUMENTS

Contract was for analysis.

Report in preparation by scientific authority and contractor.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Manual for radiological analytical methods for uranium mines

**CONTRACTOR:** Saskatchewan Research Council

**SCIENTIFIC AUTHORITY:** J.L. Dalton

**TEL:** 995-4316

**BEGIN/END:** 14/12/77 - 31/3/78

**REQUISITION NUMBER:** 23440-7-9061

**FUNDING**

**CANMET:** 9,040

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** 9,040

**PROGRAM:** Minerals

**ACTIVITY:** Technology Development

**SUB-ACTIVITY:** Environment, Health and Safety

**SUB-SUB-ACTIVITY:** Waste Disposal

**PROJECT:** Control of Effluents from Tailings Basins No. 436203

## OBJECTIVES

To provide a manual, suitable for use at a mine-site, describing radio-chemical analysis in general and analytical methods in detail, for selected members of the uranium and thorium decay series.

## PROCEDURE

A contract was awarded to an organization experienced in the radiochemical analysis of nuclides from the uranium and thorium decay chains. The terms of the contract were to provide a manual of radiochemical methods suitable for use at a mine site obtained through a literature survey and experience gained in the contractor's laboratory. Radiochemical analysis, in general was to be described, as well as detailed documentation on the methods selected. The methods had to meet the requirements of environmental guidelines with particular attention given to special equipment and analytical instrumentation. The methods were to be evaluated in the contractor's laboratory and the limit of detection, precision, and accuracy of each method stated.

## RESULTS

A manual meeting the terms of the contract was supplied by the contractor. Methods for the analysis of Ra-226, Ra-228, Th-230, Th-232, Th-228, Pb-210 and Po-210 were documented.

## APPLICATION AND ONGOING WORK

The manual will be well received by the uranium industry as it will assist in meeting environmental requirements imposed by regulatory agencies.

## SUPPORTING DOCUMENTS

Manual on file

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Automotive corrosion

**FUNDING**

**CANMET:** 600.00

**CONTRACTOR:** J.D. Palmer and Associates Eng. Ltd.

**CONTRACTOR:**

**SCIENTIFIC AUTHORITY:** G.J. Biefer

**TEL:** 593-7087

**DSS:**

**OTHER:**

**BEGIN/END:**

**REQUISITION NUMBER:** 23440-7-9075

**TOTAL:** 600.00

**PROGRAM:** Minerals

**ACTIVITY:** Mineral Technology Development

**SUB-ACTIVITY:** Transportation

**SUB-SUB-ACTIVITY:** Materials for Transportation

**PROJECT:** Automotive Materials

**OBJECTIVES**

To gain up-to-date information on the automotive corrosion problem from a specialist in this field.

**PROCEDURE**

Discussions were held at PMRL, 568 Booth Street, on Nov. 30, 1977, with J.D. Palmer. PMRL personnel included G.J. Biefer, R.D. McDonald, R.J. Brigham, J.T. Jubb, and A.F. Crawley.

**RESULTS**

The information supplied helped in the formulation of research on automotive corrosion. See Element 43710204, "Mitigation of Automotive Corrosion caused by Road De-icers", April 1, 1978.

**APPLICATION AND ONGOING WORK**

Project Element 43710204 is on-going.

**SUPPORTING DOCUMENTS**

Project Element Authorization Sheet 43710204.

R.D. McDonald and G.J. Biefer, "Visit by J.D. Palmer, Consulting Engineer, Automotive Corrosion"; PMRL Internal Report; MRP/PMRL 77-87 (TR); Dec. 1977.

# CANMET CONTRACT SUMMARY SHEET

**TITLE:** Burning trials of 100-lb (45.4-kg) samples of explosives

**CONTRACTOR:** Queen's University, Kingston, Ontario

**SCIENTIFIC AUTHORITY:** J.A. Darling

**TEL:** 613-996-4570

**BEGIN/END:** 22 July 1975 - 31 March 1976

**REQUISITION NUMBER:** 23440-5-1091

**FUNDING**

**CANMET:** $14,982.50

**CONTRACTOR:**

**DSS:**

**OTHER:**

**TOTAL:** $14,982.50

**PROGRAM:** Minerals

**ACTIVITY:** Administration of the Canada Explosives Act

**SUB-ACTIVITY:** Authorization and Testing

**SUB-SUB-ACTIVITY:** Explosives R and D

**PROJECT:**

## OBJECTIVES

The manufacture and transportation of explosives must not produce unacceptable hazards. This contract was extablished to assess the hazard arising from exposure to fire of sensitizers and Class 2 explosives containing sensitizers.

## PROCEDURE

Queen's University fabricated heating cannisters 32 in. (813 mm) long from 12-in. (305-mm) diameter schedule 40 pipe. The containers had orifices ranging from 1-3/4-in. (38-mm) diameter to 4-in. (101-mm) diameter. They were used to cook large samples of Class 2 explosives to destruction to assess the hazard of detonation in a fire due to crossover.

## RESULTS

Two sensitizers detonated when tested with a 3-in. (76-mm) orifice. Class 2 explosives sometimes reached with a low order explosion with 1-3/4-in. (38-mm) orifices.

The procedure was evaluated as a useful stop gap test for behaviour of explosives in a fire pending development of a more sophisticated pressure test.

## APPLICATION AND ONGOING WORK

This test is currently being used to evaluate thermal decomposition hazards during fire engulfment. An example of this use is the contract "Thermal Decomposition Test of a Slurry Explosive", April 1977.

## SUPPORTING DOCUMENTS

Queen's University Staff; "Thermal Decomposition of Solid and Liquid Explosives in Vented Cook-off Cannisters"; Unpublished report to the Canadian Explosives Research Laboratory, CANMET; June 1976.

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