Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

THIRD SUMMARY REPORT OF THE STATUS OF CANADIAN CLM PROJECTS: IEA COAL-LIQUID MIXTURES IMPLEMENTING AGREEMENT ANNEX II BASE TECHNOLOGY

H. Whaley
Combustion and Carbonization Research Laboratory

JUNE 1984

Presented at the 4th Technical Committee Meeting IEA/CLM Implementing Agreement, Annex II CLM Base Technology "Co-operation in the Exchange of Base Technology Information for Coal Liquid Mixtures", San Juan Capistrano, CA
June 18, 1984

ENERGY RESEARCH PROGRAM
ENERGY RESEARCH LABORATORIES
DIVISION REPORT ERP/ERL 84-22(OP)

THIRD SUMMARY REPORT OF THE STATUS OF CANADIAN CLM PROJECTS: IEA COAL-LIQUID MIXTURES IMPLEMENTING AGREEMENT ANNEX II BASE TECHNOLOGY

by

Horace Whaley

INTRODUCTION

This report summarizes the status of projects under Canada's contribution to the IEA CLM implementing agreement, Annex II base technology. These projects fall into three main areas: preparation, combustion and characterization of coal-liquid mixtures.

Since the last meeting of the Annex II technical committee in Fukuoka, Japan in October 1983, The Netherlands has provisionally been accepted as a participant of Annex II. Canada and The Netherlands have been collaborating in a project at the International Flame Research Foundation (IFRF) in The Netherlands, in which the determination of the combustion parameters of a number of coal-water mixtures has been undertaken. This project will be described together with others being undertaken in support of the development of CLM technology in Canada.

TROISIÈME RAPPORT SOMMAIRE DE LA SITUATION DES PROJETS CANADIENS EN MATIÈRE DE MÉLANGES CHARBON-LIQUIDE: ACCORD D'EXÉCUTION DE L'AIÉ SUR LES MÉLANGES CHARBON-LIQUIDE ANNEXE II - TECHNOLOGIE DE BASE

par Horace Whaley

INTRODUCTION

Ce rapport est un résumé de la situation des projets entrepris par le Canada aux termes de l'accord d'exécution de l'AIÉ sur les MCL, Annexe II - Technologie de base. Ces projets se classent en trois grands domaines: la préparation, la combustion et la définition des mélanges charbon-liquide.

Depuis la dernière réunion du Comité technique de l'Annexe II tenue à Fukuoka, au Japon, en octobre 1983, les Pays-Bas ont été acceptés provisoirement comme participant à l'Annexe II. Le Canada et les Pays-Bas ont collaboré à un projet visant à déterminer les paramètres de combustion d'un certain nombre de mélanges de charbon et d'eau. Ces travaux ont été effectués aux Pays-Bas, à l'International Flame Research Foundation (IFRF). Le rapport présente une description de ce projet et d'autres travaux entrepris en vue de mettre au point une technologie canadienne des mélanges charbon-liquide.

Project No. 1: CWM Preparation Plant

The Cape Breton Development Corporation CBDC has signed a licensing agreement with AB Carbogel of Sweden for a CWM preparation process pilot-plant 4 t/h which treats good quality coal (3% ash 1.2% S) and makes a CWM (1.2% ash 0.6% S) for burner testing at Chatham, N.B. generating station (see Project No. 2). The preparation pilot-plant is illustrated in Fig. 1. Construction of the plant began in November 1982 and was completed early in July 1983 with fuel production for Chatham by late July 1983. About 2000 t of fuel has been shipped to Chatham for burner and boiler evaluations but a major problem has been product quality control. During the major part of the pilot-plant project during the last part of 1983 and early 1984 quality control procedures have been implemented in collaboration with AB Carbogel and Foster Wheeler. The plant is now scheduled to resume shipments to Chatham in June for the conclusion of the tests on both units there by July 1984. (See Project Manager's report and bar charts.) Throughout the winter months of November 1983 to April 1984 a winter handling program for the fuel was undertaken.

Project No. 2: Development of CWM Burners for Front-Wall and Tangentially Fired Boilers at Chatham, N.B.

New Brunswick Electric Power Commission, as the contractor on this project, issued two contracts for the design, supply, installation and testing of CWM burners. The first contract was to Foster Wheeler Canada Ltd. St. Catharines, Ontario for burners for the 12 MW(e) front-wall fired Unit No. 1. Foster Wheeler subcontracted the development work to their subsidiary Forney Engineering of Dallas, Texas. Subsequently, four burners were manufactured and installed in the boiler by October 1984 and testing was conducted on the unit in October and November. A number of atomizer materials were evaluated for resistance to erosive wear and installed for long term testing. At the present time, part of the long term wear evaluation has been completed and the performance tests are scheduled for July 1984.

The second contract for burners for tangentially fired 22 MW(e) Unit No. 2 was issued to Combustion Engineering Canada Ltd. of Ottawa, Ontario. The final design chosen from several was by CE Canada, and was evaluated by K.D.L. Windsor, Connecticut at the combustion test facility and the spray test facility. The four burners were installed by November 1984 and some preliminary testing on the boiler was completed. At the present time, performance testing on Unit No. 2 is scheduled for June 1984. (See bar charts and Project Manager's Report.)

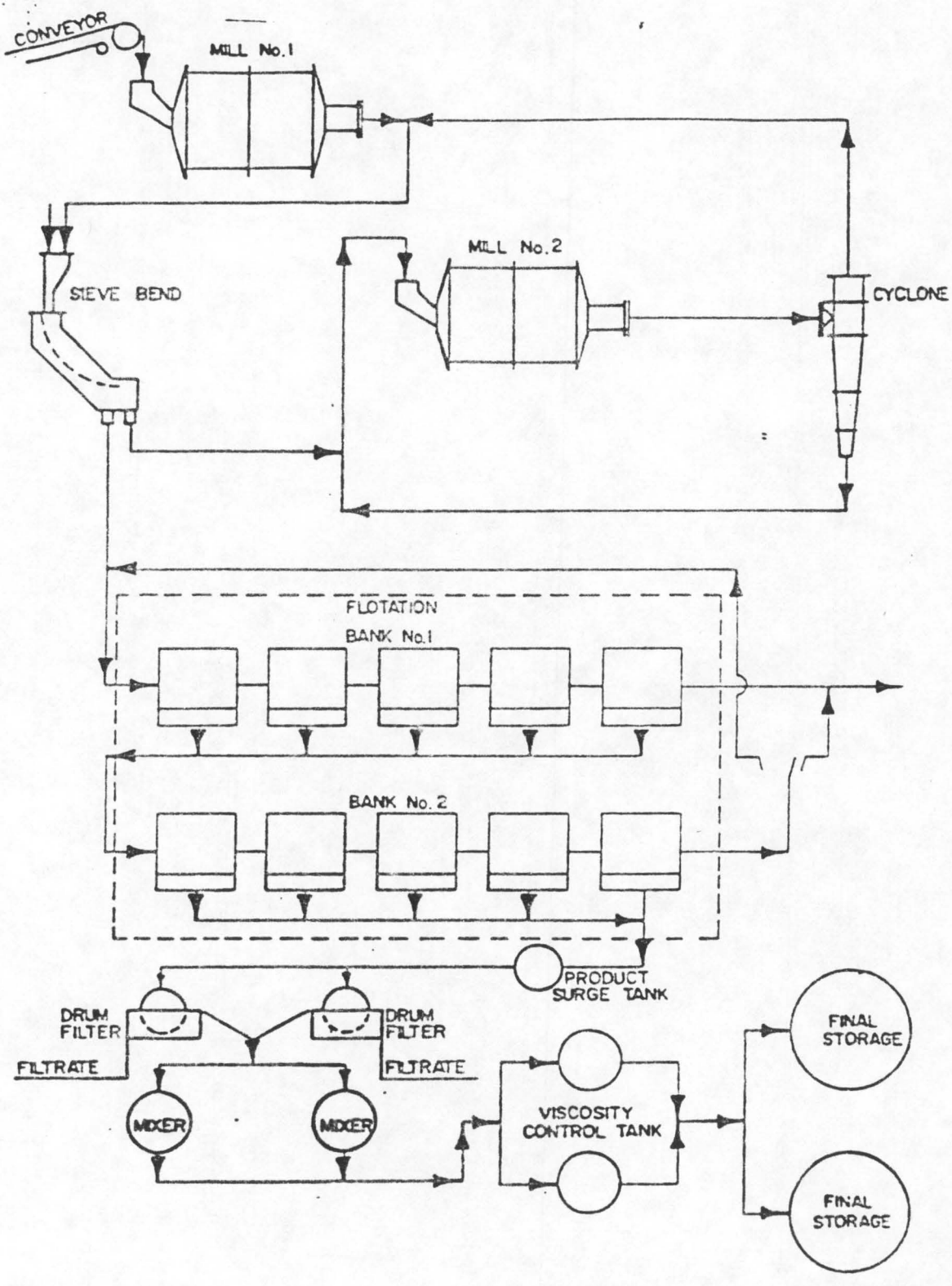

Fig. 1 - Coal-water mixture, pilot-plant flow diagram

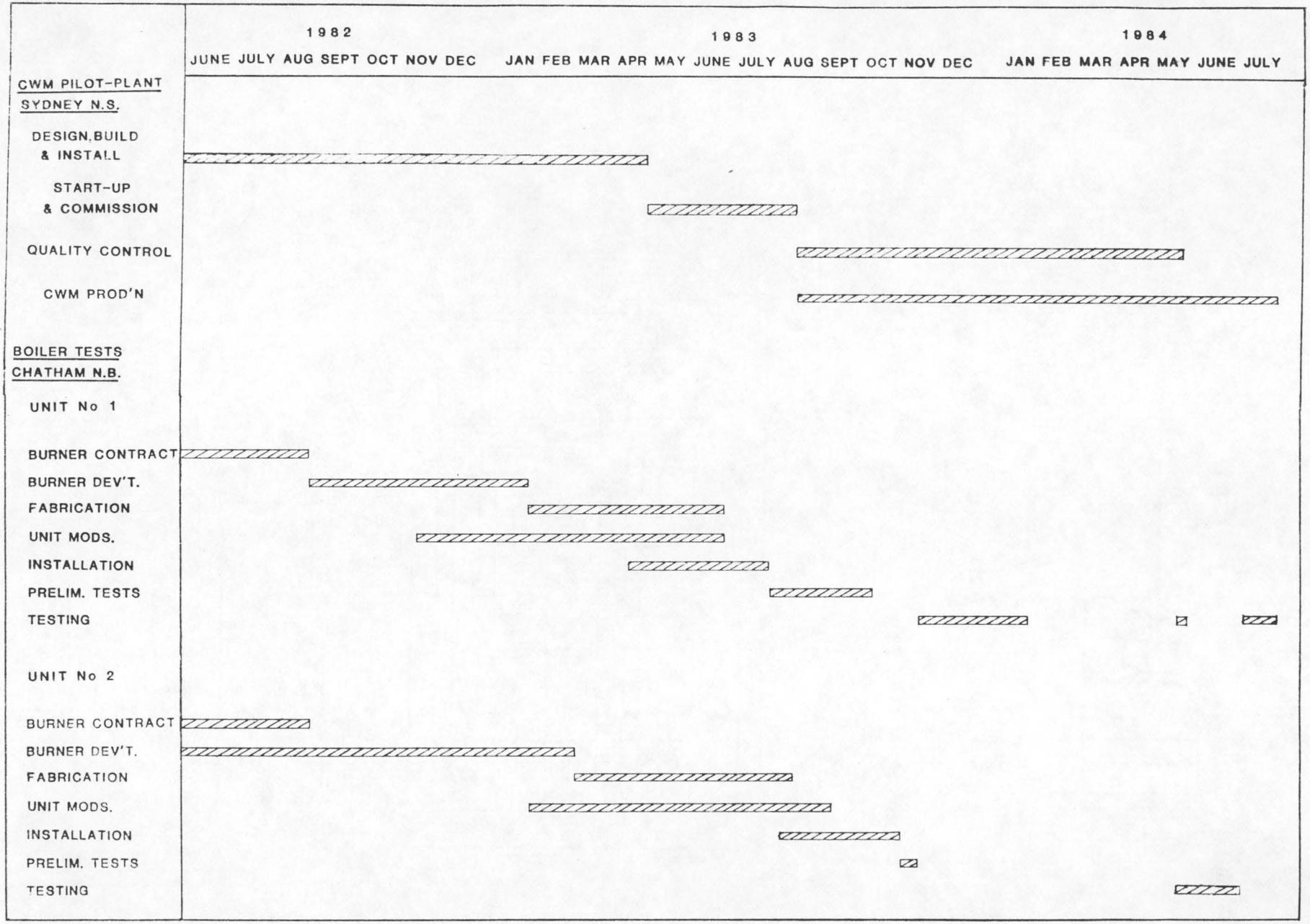

Fig. 2 - Schedule of CWM preparation and burning testing, Chatham CWM project

File-3-422b
Chatham Coal Water
Burner Development
Progress Report

THE NEW BRUNSWICK ELECTRIC POWER COMMISSION

Coal/Water Burner Development

May 3, 1984

1. Summary

All test burn work in the Chatham Station has been interrupted until approximately mid-June, at which time it is expected that there will be approximately six weeks of continuous operation.

To date 135 people from 11 different countries have visited the Chatham Plant.

Modification work and testing is underway at the CBDC fuel plant in Sydney, Nova Scotia. During the testing, quantities of coal/water mixture have been made for Japan, Sweden, Finland and Florida. The major activity is directed toward increasing the operating capacity of the plant.

2. Pilot Plant

Several modifications have been made to several pieces of equipment in the Pilot Plant. New equipment has been procured along with additional lab equipment, so that the quality of the fuel produced can be maintained more accurately.

Testing is underway by manufacturing quantities of fuel to be shipped to several countries including Japan, Sweden, Finland, USA.

As some of the original equipment did not perform as expected, a concentrated effort is underway to bring the capacity of the plant much closer to the maximum design.

3. Chatham

All work at the Chatham Plant is now on hold. Those operators which had been moved into the Chatham area from other stations, have been returned to their home stations until such time as quantities of fuel

...../2

are received and we are able to proceed with a continuous test in both Units 1 and 2.

Modifications have been made in Unit 2 and await fuel for testing.

4. Report

Considerable data is now being assembled and placed in a chronological order for the final report of the project. This includes the background data and all of the test data to date.

Data has been assembled with respect to handling of the fuel in winter. This is being analyzed.

5. Schedule

Under the present program, it is expected that sufficient quantities of fuel will be available for the Chatham plant by mid-June; and that the units will be operating between mid-June and late July, with the final project report being available by early Fall.

Yours truly,

D. M. Rankin
Project Manager

DMR/laj

Project No. 3: Coal-Water Mixture Derating Assessment of Oil-Design Utility Boilers

These projects, which were described in the third summary, have now been completed. The specific objectives were to identify the major derating parameters for generic oil-designed utility boilers typical of Eastern Canada, two sizes 60 MW(e) and 200 MW(e), and of two configurations. The fuel was specified as CWM 3% ash and 30% water and pulverized coal 9% ash and 10% moisture. The summary of results is shown in Fig. 3 and 4 for each boiler type, front-wall fired El Paso (very compact) and Carolina (liberal design) and tangentially fired box type (very compact) and pendant panel (liberal design).

The major conclusion was that smaller boilers and more compact designs are expected to have maximum derating effect which can be more than half of the design capacity. Tangentially-fired boilers are slightly more derated than are front-wall fired boilers of the same size and compactness of design.

Project No. 4: Fluidized Bed Combustion of Coal-Water Mixtures

Babcock and Wilcox Canada Ltd. is the designated contractor for this project and has carried out parameteric fluidized-bed combustion studies with a 0.3 m x 0.3 m pilot FBC and B & W's Alliance Research Center. Three coal-water fuels, including thickener underflow from a Western Canadian coal preparation plant; beneficiated Eastern Canadian coal prepared by the Carbogel process (design fuel) and an unbeneficiated Eastern Canadian coal prepared by the NRC and Scotia Liquicoal in Halifax, N.S., have been tested.

All experimental work on the three slurries has been completed. Stable combustion conditions were achieved with combustion efficiencies ranging from 92% to 98%. Some problems were encountered in achieving uniform mixing of the slurries which resulted in fluctuating bed O_2 levels of about ±1%. The combustion of the two low ash slurries was quite successful but the thickener underflow ran into such problems as fuel line segregation and plugging. Heat exchanger tubes were damaged and some leakage occurred. There was some bed instability and it was thought that this was caused by agglomeration and the high bed moisture content.

Increased gas velocities both of the fluidizing air and of the feedline helped to break up the agglomerates but stable combustion could not be achieved without adding coal to keep up the bed temperature. The combined combustion efficiency of the thickener underflow and coal was 94% compared to 92% for the underflow alone.

The draft of the final report was received in March 1984 with the final report expected in June 1984.

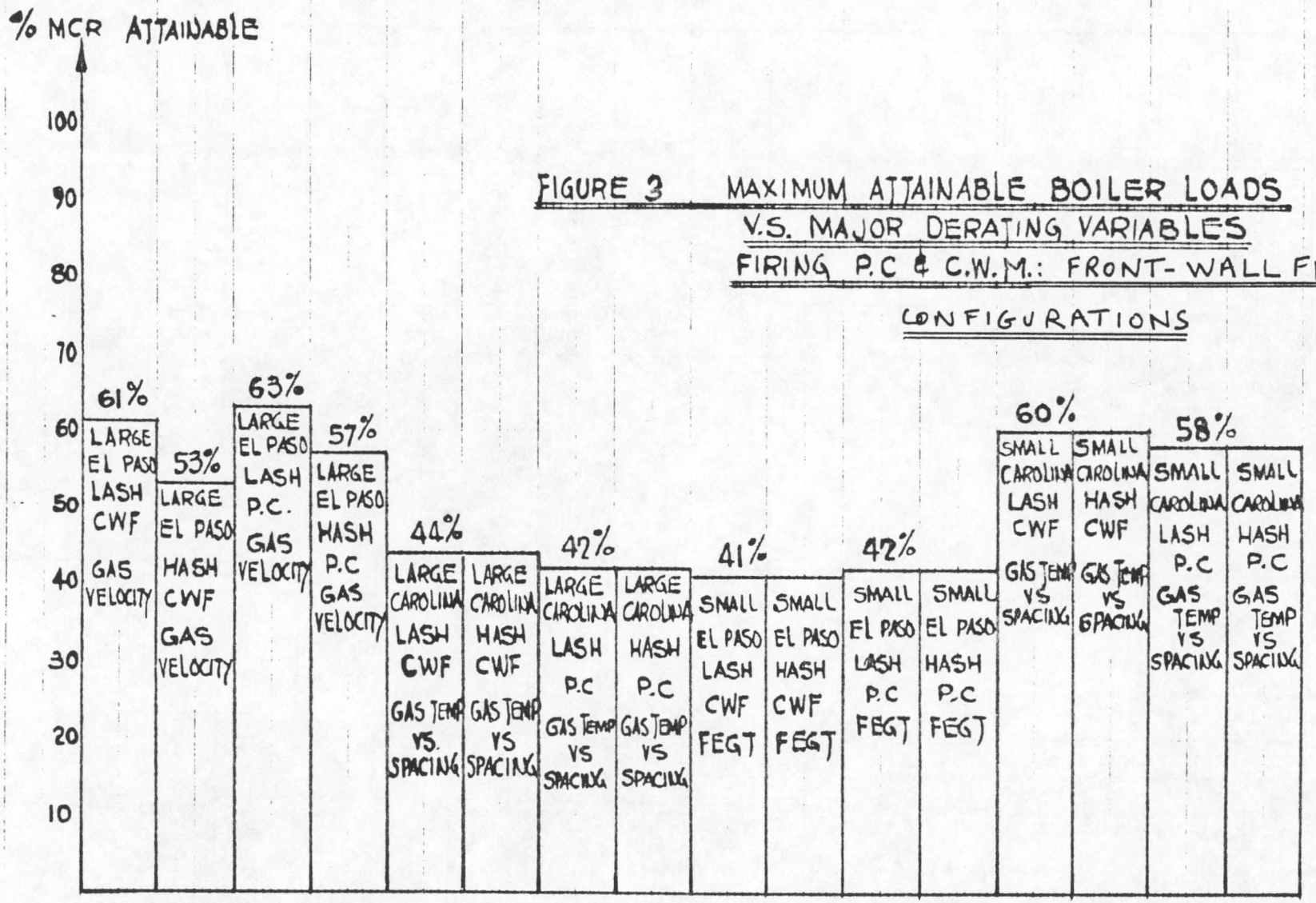

FIGURE 3 MAXIMUM ATTAINABLE BOILER LOADS V.S. MAJOR DERATING VARIABLES FIRING P.C & C.W.M.: FRONT-WALL FIRED CONFIGURATIONS

LASH = LOW ASH
HASH = HIGH ASH
FEGT = FURNACE EXIT GAS TEMPERATURE

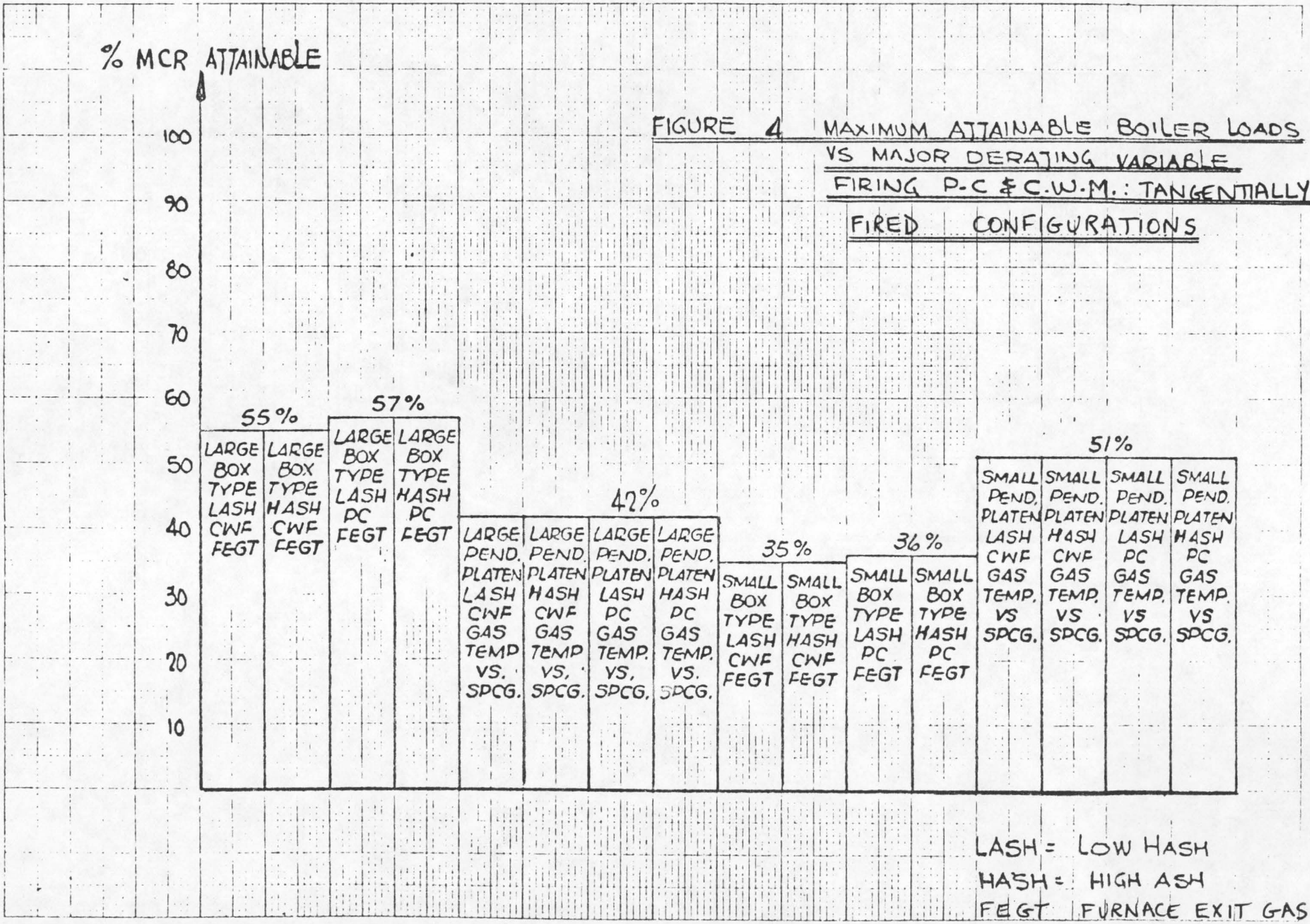

FIGURE 4 MAXIMUM ATTAINABLE BOILER LOADS VS MAJOR DERATING VARIABLE FIRING P-C & C.W.M.: TANGENTIALLY-FIRED CONFIGURATIONS

LASH = LOW HASH
HASH = HIGH ASH
FEGT FURNACE EXIT GAS TEMP.

IEA CLM ANNEX II PROJECT NO. 5

Spherical Agglomeration Applied to CLM's

Objectives: Recovery and beneficiation of waste fine coals by oil agglomeration followed by utilization in CLM's. Use of spherical agglomeration to produce cleaner CLM's by rejection of impurities liberated during size reduction for CLM preparation.

Organization: Chemical Engineering Section, Division of Chemistry, National Research Council, Ottawa Canada K1A 0R9.

Project Manager: C.E. Capes, NRC - Chemistry
K.F. Burrill, Scotia Liquicoal Ltd., Halifax, Nova Scotia

Recent Progress

1. Laboratory work continued on the formulation; rheology and other relevant characteristics of coal-water fuels made from agglomerates, both from waste fines and from run-of-mine coals beneficiated by oil agglomeration.

2. A variety of CLM's were prepared in demonstration quantities for combustion testing using the plant facilities of Scotia Liquicoal Limited. Coal feedstocks included recovered waste fines and Cape Breton thermal and metallurgical coals. Quantities varied from ca. 10 to 50 barrels for several CWM's up to a 25,000 USG lot of COWM.

3. A recent highlight was the demonstration of the preparation of several hundred gallons of agglomerated coal water oil (ACWO) fuel is an integrated process from waste fines to high quality CLM. Relatively high ash (ca. 20%) low-oil (ca. 3%) agglomerates were recovered from thickener underflow using the mobile pilot plant at the CBDC Victoria Junction Wash Plant during July - September 1983. These agglomerates were further upgraded to less than 5% ash at the Scotia Liquicoal plant and dispersed in water with the aid of appropriate surfactants to form ACWO fuel.

Publication

Capes, C.E., Coleman, R.D., Thayer, W.L., and Nakamura, M., "Agglomerative Coal Cleaning for Coal Liquid Mixtures." Paper presented at 3rd Annual Coal Liquid Mixtures Workshop, Centre for Energy Studies, Technical University of Nova Scotia, Halifax, N.S., October 1983.

C.E. Capes
April 4, 1984

IEA CLM ANNEX II PROJECT NO. 6

Development of CLM Burner Tip and Assembly

Objective: Development of an erosion-resistant burner tip and compatible burner assembly for CLM combustion.

Organization: Chemical Engineering Section, Division of Chemistry, National Research Council, Ottawa, Canada K1A 0R9.

Project Manager: W.L. Thayer, NRC - Chemistry
D.W. Burnett, CLM Technology Ltd., Halifax

Recent Progress

1. Two nozzles of annular orifice design have been under development and test using ceramic wear surfaces for erosion resistance. These are ceramic-modified Flo Sonic nozzle and a simpler NRC nozzle. Emphasis has been on the latter atomizer due to its simpler, more robust design which allows a wider range of fuel flows, types of fuels and atomizing conditions.

2. A number of combustion tests using the NRC nozzle were carried out in the TUNS tunnel using both coal-oil, coal-water and No. 6 fuel oil for baseline data. A very successful longer term combustion test using 25,000 USG of Scotia Liquicoal COW fuel was carried out at the Pugwash, N.S. plant of Canadian Salt Company.

3. The problem of conventional atomizer erosion even with No. 6 fuel oil is being addressed with the NRC ceramic nozzle. A robust NRC ceramic nozzle of fixed design dedicated to this fuel at 3 - 10 USGPM firing rates is in preparation for an extended burn in a utility boiler beginning in the summer of 1984.

Publication

Capes, C.E., Thayer, W.L., Bennett, A. and Jonasson, K., "The NRCC Nozzle Development Program." Paper presented at 3rd Annual Coal Liquid Mixtures Workshop, Centre for Energy Studies, Technical University of Nova Scotia, Halifax, N.S., October 1983.

C.E. Capes
April 4, 1984

Project No. 7: Coal-Liquid Mixture Combustion Parameters

The overall objectives of this project is to determine the basic combustion and heat transfer parameters of CLM's that have relevance to the Canadian CLM program of development.

The inhouse program is being carried out in the CCRL pilot-scale tunnel furnace, maximum thermal input 3 GJ/h and compromised of 28 individual calorimetric sections. Residence time and flame stability can be varied by the addition of an adiabatic pre-combustion section, if necessary. The burner consists of a variable swirl generator together with a commercial atomizer typical of those used for No. 6 fuel oil. Each fuel is compared to No. 6 fuel oil for reference purposes. At present the design fuel from the Cape Breton Development Corporation has been evaluated (Projects 1 and 2) and compared to both fuel oil and the parent coal feedstock (as pulverized coal).

In addition a contract has been issued to the Centre for Energy Studies, CES, Halifax, N.S. to study the combustion parameters of design fuel using the NRC atomizer (Project No. 6) with both air and steam atomization. The thermal input of the C.E.S. flame tunnel is 5 GJ/h and it is water cooled and equipped with a variable swirl generator. The data will be comparable with that obtained at CCRL.

In collaboration with the Netherlands, CANMET has participated in a collaborative study of the combustion characteristics of seven coal-water mixtures. The study was conducted at the International Flame Research Foundation in the Netherlands. The test matrix for the fuel supply included CWM's manufactured from coals having volatile matter contents from 19% to 37% (daf) and ash levels from 1.5% to 8.1% (db). Sulphur contents were in general low (21% S). Four commercial manufacturers of CWM were evaluated in the program. A major finding was that atomization quality leading to good carbon conversion efficiency depended very much on the slurry type (i.e. manufacturer) and that as expected high volatile coals burned better than low volatile coals.