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SUMMARY REPORTS OF PROGRESS ON TRIPARTITE USBM/MOL/CANMET RESEARCH PROJECTS, 1986-1987

John E. Udd, E.D. Dainty, and L. Geller

MINING RESEARCH LABORATORIES

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SUMMARY REPORTS OF PROGRESS ON TRIPARTITE USBM/MOL/CANMET RESEARCH PROJECTS

by

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ABSTRACT

Through a Memorandum of Understanding between CANMET and the United States Bureau of Mines, an exchange of data and technology is taking place in three areas of mining research. These are: (1) Diesel Emissions Control; (2) Wire Ropes and Hoisting Technology; (3) Rock Mechanics and Ground Control.

The Ministry of Labour of the Province of Ontario is a third party to these joint projects.

In this report the authors summarize the progress that was made during the year 1986-1987.

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Keywords

CANMET, Diesel Emissions, Ground Control, Hoisting Technology, Joint Research, Memorandum of Understanding, Ontario Ministry of Labour, Rock Mechanics, Wire Ropes, United States Bureau of Mines

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RAPPORTS SOMMAIRES SUR L'AVANCEMENT DES PROJETS DE RECHERCHE TRIPARTITE USBM/MOL/CANMET

par

John E. Udd*
E.D. Dainty**
L. Geller**

RÉSUMÉ

Selon un protocole d'entente entre CANMET et le United States Bureau of Mines, un échange de données et de technologie est en cours dans trois secteurs de la recherche minière. Ce sont: (1) contrôle des émissions diesel; (2) technologie du hissage et des câbles de treuil; (3) mécanique des roches et contrôle du terrain.

Le ministère de la main d'oeuvre de la province d'Ontario est le troisième partenaire de ces projets conjoints.

Les auteurs résument, dans ce rapport, l'avancement réalisé au cours de l'année 1986-1987.

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Mots-clés

CANMET, émissions diesel, contrôle du terrain, technologie de hissage, recherche conjointe, Ministère Ontarien de la main d'oeuvre, mécanique des roches, câbles de treuil, United States Bureau of Mines

INTRODUCTION

by

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Under the auspicies of an "umbrella" Memorandum of Understanding between CANMET and the United States Bureau of Mines, dated April 2, 1981, CANMET/MRL is now participating in three cooperative research projects. This report contains summaries of the progress achieved since the last report was presented at the USBM/CANMET meeting held in Sudbury, Ontario, in May, 1986.

The first project which was initiated under the M.O.U., on Diesel Emissions, was started in December 1981. The project also involves the Ministry of Labour of the Province of Ontario, and was subsequently extended to a termination date of June 30, 1987. Details of the progress during 1986-1987 are included in a summary report which has been prepared by E.D. Dainty. The highlights are probably the technology transfer sessions of the past year, which have proven to be outstanding successes.

The second project, also tripartite and involving the province of Ontario's Ministry of Labour, on Wire Rope and Hoisting Technology, was commenced in September 1983 and extended to a termination date of September 30, 1988. The details are given in the summary report which has been prepared by Lorant Geller.

The third project, on Rock Mechanics and Ground Control, is now being started. The research cooperation, which once again involves the Ministry of Labour of Ontario, was formally authorized in a document which was signed on April 1, 1986. The tripartite M.O.U. was signed for a five-year period and will end on March 31, 1990.

The Management Committee met twice during the past year: in November, 1986, at Pittsburgh, PA, and in April, 1987, in Sudbury, Ontario. The work has begun through the formation of Technical sub-committees, which are now being organized. The details are given in a brief summary report which has been prepared by the undersigned.

Finally, as suggested last year it is recommended that the cooperation should now be extended into a fourth area: Dust Explosion Control. Both the U.S.B.M. and CANMET/MRL have been involved with research on this for some time. New facilities for a dust explosion laboratory have now been constructed at CANMET/MRL/CEAL. Because of several recent accidents in Canadian sulphide mines and processing plants, there is much concern with the problem. A draft M.O.U. has been prepared and is now being reviewed.

AN UPDATE AS OF April 30, 1987
STATUS OF USBM/MOL/CANMET COOPERATIVE DIESEL PROGRAM

by

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OVERVIEW

There has been one meeting of the Cooperative Diesel Research Advisory Panel (CDRAP) since the last update report of May 5, 1986. This took place in Montreal, Quebec, on May 14, 1986, in conjunction with the Annual General Meeting of the Canadian Institute of Mining and Metallurgy (CIM). Much of what was included in the 1986 update was tabled at that meeting.

As the formal Memorandum of Understanding for diesel R/D is to terminate in June of 1987, the next and probably final meeting of the CDRAP participants is to take place during the 1987 Annual General Meeting of the CIM in the Noranda Research Offices in Toronto, Ontario, on May 6, 1987.

The Canadian technology transfer industry/government NRC/IRAP/PILP agreement with Engine Control Systems (ECS) of Aurora, Ontario, has completed one year of its three year duration. The results of the first year are discussed below. When more of this program is complete, perhaps in one year from now, CANMET will institute formal technology transfer sessions with the industry, to which personnel from the United States Bureau of Mines (USBM) and the Ontario Ministry of Labour (MOL) will be invited to keep them informed of the developments.

The USBM completed two filtration and related technology transfer sessions in Louisville, Kentucky and Denver, Colorado on April 21 and 23, 1987, respectively. These were well-received by the industry (150 attendees each) and were characterized by excellence from every point of view. The presentations indicated that the USBM Twin Cities Research Center in Minneapolis is now well launched into research on the safe application of the ceramic filter, barium fuel additives, and a special research emphasis on dry-type exhaust systems including the ceramic filter for flameproof coal and oil shale applications. The USBM Pittsburgh Center continues the development of analytical intrumentation and procedures of diesel emissions with emphasis on discrimination between diesel soot and coal dust because of the dust burden limitation of 2.0 mg/m^3 in coal mines.

TECHNICAL HIGHLIGHTS

1. Equipment Development

a) The main problem with respect to the application of CERAMIC FILTERS is the prevention of soot build-up in the filters due to operation at engine exhaust temperatures which are too low to cause continuous combustion of the soot. The soot ignition temperature can be significantly depressed by applying catalysts to the ceramic element. Former generation catalysts exhibited serious negative performance characteristics including: (1) conversion of SO^2 to H^2SO^4; (2) higher Ames test activity; and (3) sometime conversion of NO to NO^2. However, three catalyst companies have now demonstrated the capacity to formulate catalysts to avoid these nagative effects. The consequence is that some of the advantages of current catalyst technology have been retained, and the advantage of soot ignition temperature depression has been added so that wider, passive, safer application of such filters is possible. The

installation of catalyzed filters to field machines will take place during the next phase of the Canadian PILP program by ECS. This information has been passed to the industry through presentation of SAE Paper No. 870014 during February, 1987 International Congress of the Society of Automotive Engineers, and in the above-mentioned USBM technology transfer sessions.

b) Following dynamometer studies of the CANMET VENTURI WATER SCRUBBER, underground proof tests of the system were completed in the research mine of Michigan Technological University under a USBM contract. The dynamometer results reported in the 1985 report were confirmed by the underground tests during May and June of 1986. This successful performance was reported in a paper entitled "Tests of a Prototype Venturi Scrubber System" (MRL-87-18) to be presented to the XXIInd International Conference of Safety in Mines Research Institutes in Beijing, China during November of 1987 and published in the proceedings. Efforts will then be made to commercialize this development.

c) The 100% METHANOL ENGINE (a modified Deutz F8L 413 FW diesel engine) has had several hundred hours of trouble-free surface operation in an INCO Limited Load-Haul Dump machine in Sudbury during 1986/87. The Ontario Ministry of Labour has approved its use underground by mandating a number of safety precautions. The emissions contained more aldehydes than expected. The machine is now operating underground. The machine apparently has a satisfactory power output, and contributes negligible soot and sulphur gases to the pollutants in the underground environment. Its first commercial application may be in a gold mine in Brazil.

2. Environmental Impact Assessments

The Canadian industry is beginning to show an interest in the use of the comprehensive Air Quality Index (AQI) criterion as the basis for ensuring suitable underground environments, particularly for LHD machine operators who are exposed to the highest concentrations of pollutants. Two companies in particular are undertaking studies to validate the theory that easily and reliably measured CO^2 can be used as a surrogate for (i.e., direct and approximately constant function of) the AQI and each of the five individual toxic components of diesel emissions included in the AQI as well. CANMET will undertake such a study with one company during the summer of 1987. If positive, the results will be applied to the second mine. Such easy measurements are a first step to automating mine ventilation systems. This potentially cost-saving and health-insuring approach is another most significant outcome from CANMET/USBM collaboration.

The following table, derived from underground measurements in Canada, provides an inkling as to how elegant this approach may be when CO^2 is used to maintain the environment at the prescribed maximum AQI = 3.

Summary of Measured AQI/CO^2 Control Levels for Catalytic Purifiers, Buoyancy Control and Diesel Particulate Filters

mine(s)	salt mine *1 MTU - 1982-83		average of metal mines 1, 2 & 4 CANMET/CEAL - 1982-85 *2		
hard-ware	monolithic catalyst	hockey stick	monolithic catalyst	unassisted filter	filter + additive
control AQI max	3.0	3.0	3.0	3.0	3.0
control % CO^2 max	0.10	0.13	0.09	0.15	0.25

*1 contract study for Canadian Salt

*2 paper No. 4, CIM Special Volume No. 36

There are several options for monitoring the CO^2: (1) long-term stain tubes; (2) Fuji continuous monitor plus recorder; (3) time-weighted average (TWA) sampling bag; and (4) radio transmitted continuous CO^2 concentrations. The in-mine study will determine which option is best suited to the approach.

3. Technology Transfer

A number of initiatives to transfer the developed technology to industry have materialized during 1986/87, as follows:

a) The 480-page CIM Special Volume No. 36 entitled "Heavy-Duty Diesel Emission Control: A Review of Technology" was published in conjunction with the CIM Annual General Meeting presentations of the first six papers at a technical session of three CIM divisions in May of 1986. This is a relatively comprehensive document of the collaborative research program containing summaries of dynamometer and in-mine equipment performance determinations, polynuclear aromatic hydrocarbon concentrations (some are carcinogens), Ames mutagenic activity, air quality surveys, etc., plus a bibliography.

b) Further to the two USBM technology transfer sessions mentioned in the Overview above, there was an Information Circular IC 9141 which was published and distributed to the participants. Its title is "Diesels in Underground Mines". This document contains 10 papers by USBM scientists and reprinted three CANMET papers in the appendix. This volume is an excellent one, and, coupled with the above CIM volume, represents a comprehensive survey of the related literature.

c) George Schnakenberg of the USBM presented a USBM/MOL/CANMET paper entitled "Diesel Emissions Control - A Joint U.S. and Canadian Program" to the International Mining Show Session on Underground Mining sponsored by the American Mining Congress in Las Vegas during October of 1986. Engine Control Systems (ECS) put forward a fine effort to display and promote filtration technology and dry flameproof systems at an attractive booth at this show.

d) The Canadian industry/government technology transfer program (NRC/IRAP/PILP) with ECS began on April 1, 1986. That company has completed the first phase - that of characterizing the exhaust temperatures of 12 engine types in 22 mining vehicles in six collaborating mines across Canada. This was done in order to diagnose which filtration system type to apply to which machines to minimize soot regeneration problems. This work is carefully defined

in SAE paper No. 870255 which was presented to the International Congress of the Society of Automotive Engineers in Detroit in February of 1987. The next phase of this program includes the application and field testing of catalyzed filters.

CONCLUSION

This collaborative research program has been successful in: (1) the development of emissions hardware; (2) analytical instrumentation development; (3) comprehensive analytical strategy development; (4) control strategy development; and (5) the study of health-impacting matters. Considerable success has resulted from efforts in each of these avenues. It now appears that the industry has the technology to gauge the quality of specific environments and to take remedial actions where indicated including the application of an array of emissions reduction devices.

AN UPDATE AS OF May 1, 1987 ON THE COOPERATIVE RESEARCH PROJECT ON WIRE ROPE AND HOISTING TECHNOLOGY

by

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Canadian Explosive Atmospheres Laboratory
Mining Research Laboratories

BACKGROUND

The need to investigate improved methods for the non-destructive testing of wire-ropes in mine-shafts has been recognized in Canada, and in other countries, by both industry and regulatory authorities. Since September, 1983, CANMET has, therefore, participated with the United States Bureau of Mines and the Ontario Ministry of Labour in a tripartite cooperative program towards this end. These activities were described in previous Summary Reports (numbers MRL85-69 and MRL86-63).

Two recent mine rope failures, which occurred in a New Brunswick mine, despite regular rope examinations with recognized EM type NDT instruments, have added urgency to the program. Several steps were taken as a consequence. These include a number of meetings both in Canada and the US, and, in particular, an overseas trip by Canadian members of the tripartite project group. Moreover, initial proposals were put forward for a national program in mine-shaft wire-rope research (reports MRL86-85 and 86-147). In addition, it was suggested that Mineral Development Agreement (MDA) funds be used to support provincial projects in the subject area.

The foregoing activities are briefly described in this progress report.

Project Group Meetings

A joint meeting was held in Pittsburgh, PA, November 18-20, 1986, with representatives of the USBM and the Ontario MOL. Both the Mining Research Laboratories and the Physical Metallurgy Research Laboratories Divisions of CANMET were represented. As usual, laboratory and mine visits were also organized, thus further increasing the usefulness of the meeting. Minutes of the meeting are available, which provide all details of interest. The reports submitted on the New Brunswick wire rope failure by laboratories in Britain, Canada and the US, as well as details of the overseas visit undertaken by two Canadian group members, were of particular interest.

Apart from the above-mentioned joint meeting, Canadian members of the cooperative project also met separately on December 12-13, 1985, and June 3, 1986, to maintain the momentum and to prepare for the planned visit overseas. This trip was carried out by Lorant Geller, on behalf of CANMET, and Largo Albert, on behalf of the Ontario Mining Association. The former visited Hungary and West Germany, while the latter went to France, Poland and West Germany. The visits were an unqualified success, and led to many valuable personal contacts and much useful information. Many aspects have been made use of in ongoing efforts to set up a Canada/Provincial research program, referred to hereunder.

Finally, trips were also undertaken to Winnipeg/Toronto (March 25-27, 1987) and to Fredericton (April 21-23, 1987) in connection with the Canada/Provincial project plans referred to above.

Tasks and Responsibilities

These were listed in some detail in the two earlier Summary Reports. The points of particular interest at this time concern:

1) ongoing work to organize a research program with federal/provincial input to enhance the understanding of the basic capabilities of existing NDT instruments, and as a corollary,

2) a follow-up of the valuable contacts established overseas. In the latter case those with the Chief Mine Inspectorate of Nordrhein-Westfalen are of special interest, following their President's letter to Dr. Jeffery.

Plans concerning the Federal/Provincial program may be summarized as follows:

- The principal objective of the proposed project is to enhance the understanding of, and to properly document, the basic capabilities of various mine-shaft wire-rope NDT instruments, and of the associated chart evaluation techniques which are used in Canadian practice.

  Secondary objectives involve questions pertaining to the regulatory aspects of NDT wire-rope testing in mine shafts, including such matters as certification and retirement criteria.

- The technical approach involves a series of laboratory and in-situ wire-rope examinations, with a range of recognized NDT instruments, on a range of ropes that characterize the sizes and constructions

most widely used in Canadian mines. Instrument Performance Standards should be documented in depth; both these and sample selection, marking, shipping, etc., should follow the provincially established Performance Requirements.

The laboratory rope samples should include both artificial and operational anomalies. Both field and laboratory rope samples should be tested destructively, after being duly examined non-destructively, again in line with provincial requirements.

- Anticipated benefits include both improved safety and economic aspects.

- A time frame of some 24 months is envisaged, and an overall cost of $200,000 has been estimated.

Plans concerning cooperation with CANMET's foreign contacts include an exchange of information and, possibly, the loan of instruments.

SUMMARY

Developments during the past year have been particularly interesting, involving events both inland and abroad. Much depends now on how funding plans succeed.

The next joint meeting with CANMET's tripartite partners is scheduled for Elliot Lake, in September, 1987.

AN UPDATE AS OF April 30, 1987
STATUS OF USBM/OMOL/CANMET COOPERATIVE PROJECT ON ROCK MECHANICS AND GROUND CONTROL

by

John E. Udd
Mining Research Laboratories

The tripartite Memorandum of Understanding, upon which the cooperative project on Rock Mechanics and Ground Control was founded for a five-year period, was signed on April 1, 1986.

Subsequently, a first meeting to initiate the project and to define the topics which would be addressed, was held at the USBM Pittsburgh Research Centre on November 18, 1986.

At that meeting it was decided that the most appropriate management structure for the project would consist of a Management Advisory Panel, to provide overall direction, reviews, and guidance, and a number of Technical Committees which would be devoted to specific topics. Four areas of research were selected for immediate attention. These were: "Rockbursts and Outbursts"; "Support Systems"; "Coal Mine Design"; "Metal/Non-metal Mine Design".

It was agreed that each party would identify participants for the Technical Committees and that these persons would be asked to decide amongst themselves on the dates and locations for initial meetings. It was hoped that all of the four Technical Committees would have met before the end of January, 1987.

The Management Advisory Panel agreed that it should meet semi-annually and that the next meeting would be held at CANMET's Elliot Lake Laboratory on April 21, 1987 (with the two following days to be devoted to mine tours and visits in both Elliot Lake and Sudbury).

During the following months, the members of the Committees were named. Unfortunately, however, only the Technical Committee on "Rockbursts and Outbursts" was able to meet (on March 12, 1987) before the second meeting of the Management Advisory Panel. The first meeting of the Rockbursts and Outbursts Committee was held in conjunction with a regular meeting of the Technical Advisory Committee of the Canada/Ontario/Industry Rockburst Research Project. It was believed, as proved to be the case, that holding meetings on related topics concurrently would promote a useful exchange of information.

At the second meeting of the Management Advisory Panel, on April 21, 1987, it was agreed that the remaining Technical Committees should be urged to meet as soon as possible. Memberships on the Committees were reviewed, and it was agreed that a U.S.A. member would chair meetings held in the United States, while a Canadian would chair meetings held in Canada. It was also agreed that the meetings should alternate between countries.

The next meeting of the Management Panel will be held at a U.S.A. location in the fall of 1987. In the meantime, some of the Technical Committees will hold meetings at CANMET's Bells Corners facilities during the first week of June. These meetings will be timed to coincide with another, at which the progress of projects being undertaken through the Canada/Ontario Mineral Development Agreement will be reviewed. Once again, it is believed that very valuable transfer of technology will result.

The present membership of the various committees is as shown on the accompanying diagram.

USBM/OMOL/CANMET COOPERATIVE PROJECT
ON
ROCK MECHANICS AND GROUND CONTROL

Structure of Committees

Management Advisory Panel

D.R. Forshey	U.S.B.M.	(Washington)
D.D. Bolstad	U.S.B.M.	(Spokane)
E.E. Hollop	U.S.B.M.	(Denver)
J.N. Murphy	U.S.B.M.	(Pittsburgh)
L.V. Wade	U.S.B.M.	(Twin Cities)
D. Brown	CANMET/CRL	(Devon)
D.B. Stewart	CANMET/CRL	(Devon)
G. Larocque	CANMET/MRL	(Bells Corners)
J.E. Udd	CANMET/MRL	(Bells Corners)
V. Pakalnis	OMOL	(Toronto)
P. Kivisto	OMOL	(Sudbury)

Rockbursts and Outbursts Technical Committee

B. Brady	U.S.B.M.	(Denver)
T. Iannacchione	U.S.B.M.	(Pittsburgh)
M. Jenkins	U.S.B.M.	(Spokane)
T. Triplett	U.S.B.M.	(Twin Cities)
D. Hedley	CANMET/MRL	(Elliot Lake)
T. Aston	CANMET/CRL	(Sydney)
D. Ames	OMOL	(Sudbury)
P. Campbell	OMOL	(Sudbury)

Support Systems Technical Committee

T. Barczak	U.S.B.M.	(Pittsburgh)
J. Goris	U.S.B.M.	(Spokane)
R. McKibbin	U.S.B.M.	(Spokane)
S. Tadolini	U.S.B.M.	(Denver)
A. Annor	CANMET/MRL	(Sudbury)
	CANMET/CRL	
D. Ames	OMOL	(Sudbury)
P. Campbell	OMOL	(Sudbury)

Coal Mine Design Technical Committee

R. King	U.S.B.M.	(Pittsburgh)
N. Kripakov	U.S.B.M.	(Denver)
L. Powell	U.S.B.M.	(Twin Cities)
G. Haslett	CANMET/CRL	(Sydney)
T. Smelser	U.S.B.M.	(Spokane)

Metal, Non-Metal Mine Design Technical Committee

G. Johnson	U.S.B.M.	(Denver)
M. Poad	U.S.B.M.	(Spokane)
R. Thill	U.S.B.M.	(Twin Cities)
D. Hanson	CANMET/MRL	(Elliot Lake)
J. Pathak	CANMET/MRL	(Bells Corners)
S. Bharti	Falconbridge Ltd. (CANMET/OMOL joint nominee)	