Ontario Hydro

ORGANIC RESEARCH SECTION
1984 REVIEW AND 1985 PROGRAMS

Report No 85-42-K

R.W. Glass
Supervising Chemist
Organic Research Section
Chemical Research Department

ontario hydro
research division

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ABSTRACT

The achievements of the Organic Research Section in 1984 are reviewed. Major programs for 1985 are described and changes in the emphasis of future work are presented.

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740632-627-000	830.4	February 15, 1985	85-42-K

ontario hydro
research division

EXECUTIVE SUMMARY

ORGANIC RESEARCH SECTION
1984 REVIEW AND 1985 PROGRAMS

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This report reviews the major activities and accomplishments of the Organic Research Section in 1984 and presents the 1985 work program. The three major areas of the Section's research work are non-metallic materials which includes applications and uses of plastics, petroleum products, coatings and elastomers; reactor waste management; and activity transport/decontamination of nuclear systems.

In 1984, 50% of the Section's resources were used on studies in support of Nuclear Generation, 13% on Reactor Waste, and 37% on general activities and work in support of Utilization, Transmission and Distribution, and Thermal and Hydraulic programs.

About 60% of the Section's work was supported by transfer and revenue funds as a result of urgent short-term work requirements which resulted in 68% of the work falling into the technical investigation, consulting and testing categories.

Nuclear Generation

The largest program area in 1984 was Nuclear Generation and much of the work was short-term. Major activities dealt with safety application of materials, tritium transport through non-metallics and activity transport/decontamination of primary heat transport systems. In the latter area, a major effort was made in support of Pickering Units 1 and 2 decontamination.

In 1985 non metallic materials research will concentrate on performance in harsh nuclear environments. The tritium/materials research program will be expanded and efforts will concentrate on development of experimental capability, modelling, isotopic exchange and decontamination. Most decontamination/ activity transport research will contribute to the joint AECL/Ontario Hydro decontamination development program which is directed towards understanding the mechanisms of decontamination processes and improving their efficiency.

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Reactor Waste

In 1984 most research in this area was in support of Design and Development Division's Reactor Waste Disposal Program and involved characterization of compactable wastes, measurement of the performance of conditioned wastes and development of treatments and performance criteria for tritiated wastes.

The 1985 work program will continue to provide major support to the Reactor Waste Disposal Program and further compactable and non-processable waste characterization will be done. Expansion of the tritiated waste conditioning research to include wastes from fusion reactors is planned. Longer term research will include development of a disposal type leaching test and fundamental studies of radionuclide release mechanisms.

Environment

All work in this area in 1984 and 1985 is concerned with decontamination of insulating oils containing PCBs. The mobile decontamination unit was received in 1984 and will be commissioned in 1985 then turned over to Transmission Operations Division. Other studies completed in 1984 concerned PCB removal from groundcover and from silicone retrofitted transformers. It is expected that PCB research after 1985 will be reduced to a consulting role only.

Utilization

Activities in Utilization in 1984 and 1985 concentrated on the Energy Mines and Resources/Canadian Electrical Association funded study of the effects of thermal insulation upgrading on electrical insulation. Wiring temperatures under various levels of thermal insulation have been found not to exceed the CSA new construction ratings. In 1985, the focus will be on development of a finite element model to predict wiring life under various conditions such as circuit loading, duration of use, etc.

Transmission and Distribution

In 1984, research into epoxy spacer performance in SF_6 equipment was continued with Electric Power Research Institute and Canadian Electrical Association support. Gassing studies of paper wrapped conductors in transformer oils were undertaken to determine the effect of higher power operation of transformers. Both studies will continue in 1985 and in addition longer-term fundamental research into the dielectric properties of fluids, electrical relaxation, surface effects and intrinsic conductivity of solid insulation will be started.

General Research Program

Work in this program dealt with radiation safety, provision of specialized testing services and development of new testing procedures and material standards.

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To Mr. F.J. Kee
Director of Research

ORGANIC RESEARCH SECTION
1984 REVIEW AND 1985 PROGRAMS

1.0 INTRODUCTION

This report reviews the major activities and accomplishments of the Organic Research Section in 1984 and outlines the 1985 work program. It is intended as an overview of the Section's activities. More detailed information on projects/programs of interest may be obtained from the reports listed in Appendix IV or by contacting the Unit involved.

Figure 1 shows the organization of the Section together with the current assignments of personnel and major functions of each unit.

The Organic Research Section is involved with three major areas: non-metallic materials, nuclear waste, and activity transport/decontamination of nuclear components.

The area of non-metallic materials includes the application and performance of plastics, petroleum products, sealants, coatings, elastomers, composite materials, etc, to the power system. Although non-metallics are applied in all areas of the system, most of the Section's current effort is directed towards decreasing the operation and maintenance costs and addressing safety issues in the Nuclear Generation program.

In the Nuclear Waste program, effort has concentrated on the characterization and conditioning of low and medium level reactor wastes for storage and disposal and defining the performance of the conditioned wastes in a disposal environment.

Most of the nuclear decontamination work is part of a larger Divisional decontamination program with our effort directed towards the development and evaluation of decontamination processes.

2.0 1984 PROGRAM REVIEW

Figures 2, 3 and 4 show the distribution of the Section's work by Program Area, source of funding and by the category of work.

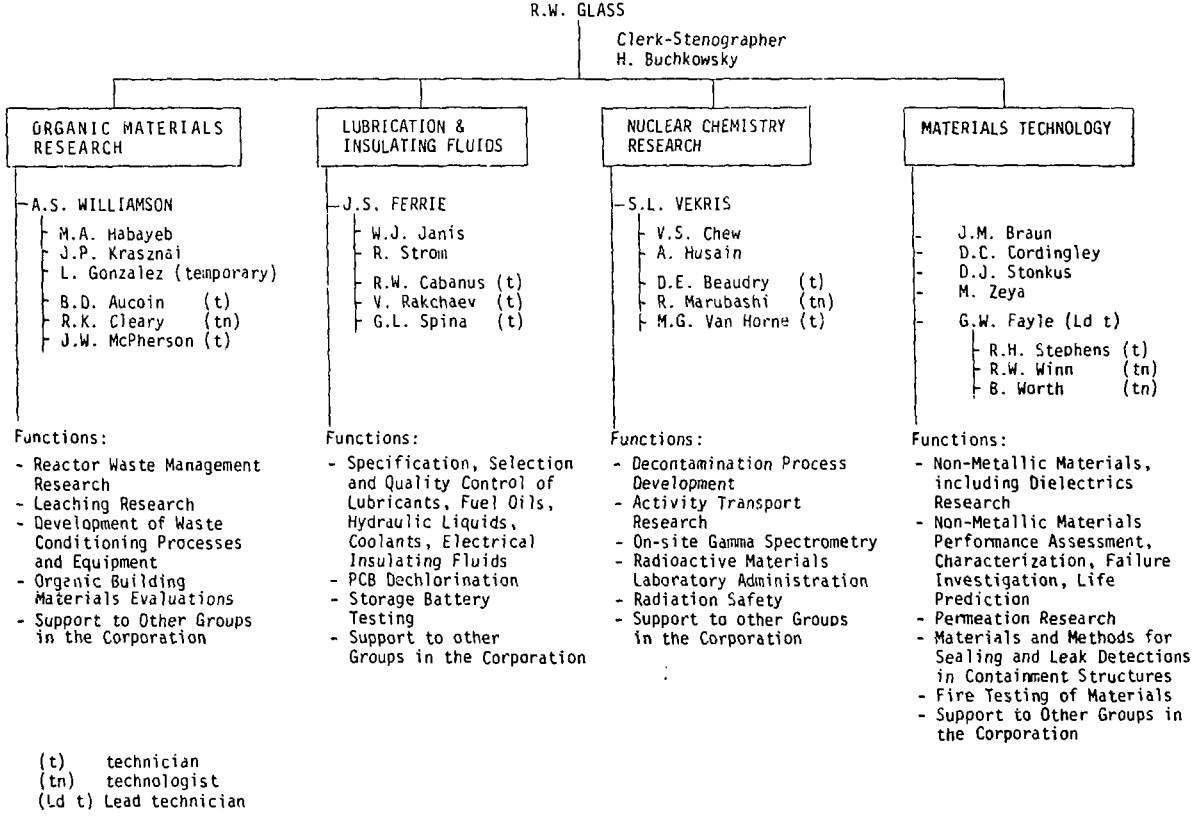


FIGURE I

ORGANIC RESEARCH SECTION

In 1984, Nuclear Generation used 50% of the resources while Nuclear Waste used 13%. The 'General' program area, which includes operating and maintaining the Radioactive Materials Laboratory for the Division, all of the routine testing of materials and miscellaneous activities to improve the Section's capabilities was a major area of activity (17%). Smaller efforts were conducted in support of the mobile PCB decontamination unit, dielectric materials and residential wiring systems.

Almost 60% of the Section's work was supported by transfer and revenue funds. This is $200,000 over the budgeted estimate and was a result of urgent, short-term work. As a result, research efforts in support of longer-term goals suffered. The large amount of short-term investigations, consulting and testing work in 1984 is also apparent from Figure 3.

Not shown in These Figures is the relatively large number of cooperative, externally funded programs conducted with other Sections within the Division, particularly the Mechanical and Electrical Departments in the area of batteries and the use of solid dielectrics in electrical switchgear.

2.1 Nuclear Generation ($1,100K; 65% transfer, 35% OM&A)

This is the largest program area with approximately 65% of the work supported by transfer funds primarily from Design and Development, Nuclear Generation and Technical and Training Services Divisions. Much of the work has been short-term involving technical investigations, testing and consultations on non-metallic materials used in the system as well as support for the decontaminations at Pickering units 1 and 2. The three major areas in this program are: safety applications of materials, tritium transport through non-metallics and activity transport/decontamination of primary heat transport systems.

2.1.1 Non-Metallic Materials ($580K)

2.1.1.1 Safety

The thermal stability of urethane foams proposed by Design and Development for the tritiated water transportation package was investigated under simulated high intensity fire conditions. Despite the high temperatures involved (800°C), only localized pyrolysis was recorded.

Work is continuing to improve the aging characteristics, flammability and acid gas evolution of nuclear control cables. Broader impact is achieved through participation in committee activities (CSA, IEC, IEEE nuclear cable specifications). Our vertical grouped cable fire test procedure was accepted by CSA and new quality control methods based on thermal analysis (oxygen induction times) were introduced to the industry.

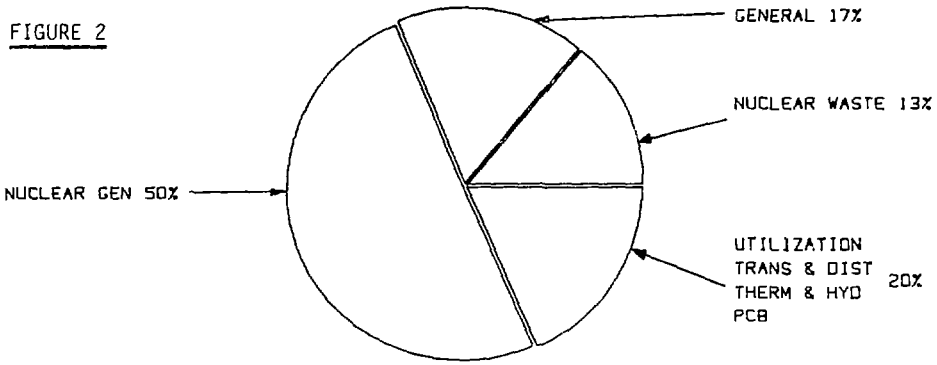
Support was provided to the garter spring repositioning and CIGAR inspection programs by developing new material casting procedures to overcome earlier component failures.

Sandia National Laboratory contracted Ontario Hydro to conduct performance tests on aged station batteries while the batteries were undergoing a simulated seismic event. Our contribution to this effort was to conduct the electrical tests on the batteries and to determine the nature of the failure. This work will continue in 1985.

DISTRIBUTION of FUNDS

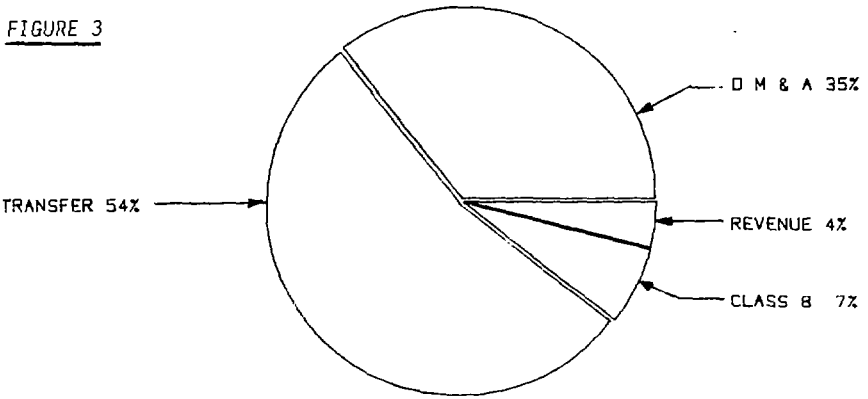
PROGRAM AREA

FIGURE 2



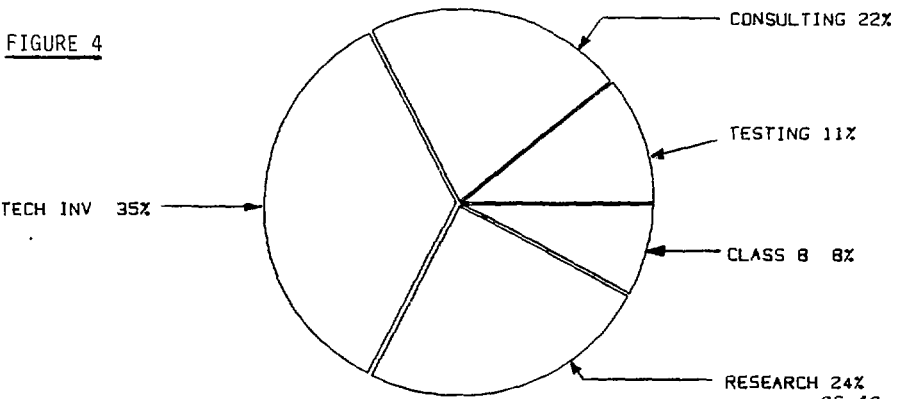
CLASS

FIGURE 3



CATEGORY

FIGURE 4



Leak site detection in containment envelopes of nuclear plants was investigated and CANDEV funding obtained for the program. Conventional detection techniques are severely limited for quantitative, remote sensing of leak sites; ultrasonic techniques were investigated in the laboratory and during in-station tests. Although the technique is only semi-quantitative at present, it was easy to use for remote leak sensing.

Work is continuing on two AECB-mandated projects to establish the long-term durability of the glass fibre reinforced plastic components used in the Pickering NGS and Bruce NGS B vacuum building dousing systems. Component aging is taking place in simulated vacuum building atmosphere and test results are periodically reported. Once completed, the aging data will be used to predict the long-term life of these components.

2.1.1.2 Lubricants, Coatings and Sealants, etc - Minor Jobs

A large number of minor jobs were done providing assistance to Design and Development, Nuclear Generation and Technical and Training Services Divisions as well as staff at the stations. In the area of lubricants, typical activities included:

- consultations on lubricant selection (equivalent lubricants, compatibility with other lubricants or materials of construction);
- minor investigations of deposits found in systems - explain their nature, possible source(s) and effect on the system to avoid costly downtime;
- provision of information on the physical and chemical properties of lubricants;
- consultations on the feasibility of reconditioning and/or reclamation of petroleum products; etc.

Technical consulations and specifications for the use of coatings, joint sealants, and roofing systems were provided to Design and Construction personnel for Pickering "B", Bruce "B" and Darlington NGS. Quality assurance tests were performed on batches of specialized coatings and joint sealants used in containment areas of nuclear generating stations under construction. These tests are required by the AECB.

Inspection of the Pickering "A" irradiated fuel bay liner was repeated in 1984 in the continued monitoring of the extent and rate of liner deterioration. No increase in the size or concentration of blisters has occurred since 1982. As a further monitoring aid, specimens of all epoxy liner systems used by Ontario Hydro were installed in the bay.

2.1.2 Tritium ($160K)

Non-metallic materials frequently are key components in safety systems for CANDU as well as for fusion reactors. A review of the specific needs for information on the interactions of tritium with these materials identified a detailed understanding of transport processes as being critical to most safety system

applications, eg, seals, glove box materials, plastic suits, etc. A major research program was developed and equipment purchased to establish a comprehensive facility to study tritium transport processes.

The major experimental effort in 1984 was a study of tritium permeation into protective coatings. The objective of the study was to characterize tritium and tritiated water permeation rates in conventional nuclear coatings. In the long run it is expected that improved coatings can be developed to mitigate concrete porosity in fusion plants and tritium handling environments. In addition, deuterated and tritiated water permeation rates through the tritiated water transportation package's closure gasket were determined at the request of Nuclear Materials Management Department.

Studies of solid scintillator materials were undertaken to assist Health and Safety Division in developing a discriminating (HTO vs HT) tritium monitor. Surface modification of the scintillant improved uniformity of moisture deposition on its surface without affecting scintillator efficiency.

2.1.3 Decontamination ($360K)

2.1.3.1 Development Programs

Short- and long-term projects to characterize surface oxides, quantify radioactivity transport and develop decontamination processes were undertaken. A wide variety of heat transport system metal specimens were obtained for characterization. Many of these, notably feeder pipe and end fitting liner sections, were uniquely valuable mainstream circuit components. Chemical and radiochemical analysis of the surface oxides showed large differences between oxides on the same metal at different locations in the circuit, leading to the conclusion that flow and degree of saturation of the coolant have a major influence on oxide growth rate and morphology and, therefore, also on decontamination potential. This explained the low decontamination factors of earlier Pickering CAN-DECONs and indicated that larger volumes of ion-exchange resins and longer exposure times would be necessary to achieve acceptable results.

Stainless steel is not easily decontaminated with the CAN-DECON process and alternative techniques for cleaning Pickering end fittings were evaluated. Three concentrated, single-step reagents were tested but none was effective on the very resistant reactor outlet oxide, probably due to its high chromium content. A process involving two or more steps with dilute reagents was then evaluated using a fully instrumented decontamination test loop and found to be somewhat more effective. This process will be studied further in 1985.

The conditions under which ferrous oxalate precipitates during a CAN-DECON were studied theoretically. A model which includes all of the important chemical equilibria occurring in a CAN-DECON solution was developed. Related thermodynamic constants were obtained from low temperature data using extrapolation procedures. Solution of model equations has enabled the specification of solution conditions under which ferrous oxalate precipitation can be avoided.

A project directed at avoiding costly disposal of obsolete spent fuel storage baskets as radioactive waste was undertaken. The radioactive contamination on stainless steel basket surfaces was characterized and its penetration depth in the base metal determined. Application of decontaminating reagents indicated that disposal of these baskets as non-radioactive scrap is a possibility.

A long-term study of the consequences of a sudden release of uranium oxide to the heat transport system continued during the year. The investigation of the surface charge behaviour of uranium oxide particles in aqueous suspensions was completed and estimates of electrochemical forces in uranium oxide deposition can now be made for an extended temperature range. An experimental study of the deposition of uranium oxide on magnetite surfaces at temperatures up to 300°C has begun.

2.1.3.2 Decontamination Support for Pickering Units 1 and 2

The urgent need to reduce reactor face radiation fields in Pickering Units 1 and 2 prior to pressure tube replacement resulted in a major short-term effort in support of CAN-DECON decontaminations. Sections of nine feeder pipes removed before and after decontamination were examined and found to have thicker oxide than any previously examined carbon steel specimens.

Metal test specimens installed in the heat transport system autoclaves during the decontamination showed that for all CAN-DECONs, the general corrosion level was acceptable. Some localized corrosion was detected and is being studied further.

Gamma spectrometry at the reactor face during the decontaminations identified the rates of field reduction and aided in the decision to terminate each decontamination.

2.1.3.3 System Monitoring

To assist in maintenance planning, the build-up of radioactive deposits on out-reactor surfaces is regularly monitored by gamma spectrometry of steam generators and feeder cabinets. Cobalt-60 is responsible for more than 90% of the fields at Pickering "A" and up to 60% at Bruce "A". Cobalt-60 trends follow predictions from models that fields will eventually plateau.

Metal test specimens installed in the heat transport system autoclaves were used to ensure that hot conditioning procedures in Pickering Unit 7 and Bruce Unit 5 had produced protective oxide films on carbon steel. The specimens have also been used as required to assess corrosion and other consequences of chemistry excursions such as decontaminations. Close to 4,000 specimens are now installed in Pickering and Bruce autoclaves.

2.2 Nuclear Waste ($380K; 75% transfer, 25% OM&A)

The major efforts in 1984 were in support of Design and Development Division's Reactor Waste Disposal Program which has the objective of having a disposal facility in operation by 1990. The main studies involved the characterization of compactable wastes and definition of the radionuclide retention properties

of conditioned wastes to develop source terms and radionuclide inventories in disposal. These data are needed for safety and environmental assessments of the various disposal options under consideration. Research continued on the conditioning of tritiated wastes to develop treatments and performance criteria for operation of the Tritium Removal Facility in 1986/87.

2.2.1 Characterization of Reactor Operating Wastes

The project objective is to characterize compactable wastes with respect to composition, beta-gamma radionuclide inventory and tritium and carbon-14 levels to assess the suitability of this waste for disposal. In the course of the work, 1072 bags of waste representing 18 bales have been examined. Free moisture was found in approximately 11% of the bags. 50 bags were selected for extraction of tritium and carbon-14. The waste is very heterogeneous containing paper towels, mops, floor sweepings, and plastics. 80-85% of the bags have a contact dose rate below 1 mR/h, 10-15% below 100 mR/h and about 5% over 100 mR/h. The beta-gamma activity found in bales ranged from 1-7 mCi with cobalt-60 contributing about 40%, cesium about 25% and the remainder from radionuclides with a half-life of one year or less. Tritium levels varied widely from a few microcuries to a maximum of 9 Ci/bag. 40% of the bags contained less than 1 mCi and 10% more than 1 Ci. About 65% of these bags contained less than 50 nCi carbon-14 per bag and 12% between 100 nCi and 1 μCi.

2.2.2 Waste Conditioning

Research on the conditioning of tritiated wastes continued. In this final stage of the project, conditioning treatments will be developed for organic and solid wastes and the efficiency of encapsulation and packaging treatments in minimizing tritium releases from the wastes will be determined. The objective is to achieve an average daily leach rate of less than 1×10^{-5}%. The work is scheduled to be completed in 1986.

A prototype, compact, full-scale liquid waste solidification unit designed for semi-automatic use with water extendible polyester has been built. The equipment is designed for a product throughput of 10 litres/minute. Commissioning of the unit was started in December 1984 and it is expected to have full scale demonstrations of the process with simulated wastes early in 1985.

2.2.3 Leaching Performance

Design and Development Division's reactor waste disposal studies indicated spent moderator ion exchange resin containing carbon-14 could not be disposed of without some conditioning to reduce carbon-14 leaching rates. Spent resin was immobilized in water extendible polyester and cement/epoxy matrices and the leaching performance of the waste forms determined. The cement/epoxy resin waste from had an average daily carbon-14 release of 5×10^{-4}% compared with 6×10^{-3}% for the water extendible polymer. A report of the research is in preparation.

Studies were completed on the prediction of long-term releases of cesium from cemented decontamination wastes using modified semi-infinite diffusion models to extrapolate from short-term experimental leaching data. This type of prediction is necessary to derive source terms for pathway modelling of releases

from waste disposal facilities that are not overly conservative. More work on the mechanisms affecting releases, particularly aging, corrosion of the waste form, scale effects, radiolysis, multiple barriers, water chemistry, flow rate, etc, needs to be done to refine the models.

2.3 Environment ($146K; 50% transfer, 50% OM&A)

All work in this program area was concerned with the decontamination of mineral and synthetic oils containing PCBs.

2.3.1 Mobile PCB Decontamination Unit

The process for the removal of PCB from insulating oil by reaction with sodium has progressed successfully from the laboratory and the pilot plant to the design and construction of a 45 ft mobile decontamination unit. Most of the activity during the year was to review minor design changes required during the construction of the unit at the manufacturer's plant. Upon completion of the unit, fire protection system discharge tests and a full-scale acceptance test using 1500 L of insulating oil containing 350 mg/kg chlorinated benzenes were successfully carried out by Section staff before the unit left the manufacturer's site. The plant is currently undergoing research and commissioning tests at the Kipling site. Preliminary operating data and proposed test and contingency plans were prepared in support of an Environmental Assessment document being prepared by Route and Site Selection Division for the mobile unit's technology and its use at the Kipling site. In addition, a licensing agreement was successfully negotiated between Ontario Hydro, B.C. Hydro and a private company, giving the company the non-exclusive, Canadian rights to use the processes disclosed in the Ontario Hydro and B.C. Hydro patents and patent applications.

2.3.2 PCB Removal from Groundcover

Capacitor rupture, transformer leakage and inadvertent spillage during handling result in the contamination of groundcover with PCB. Incineration is probably the best method of disposing of PCB in soils, but facilities for this are not available in Canada. Therefore, an alternative method, solvent extraction, was investigated in conjunction with the Canadian Electrical Association. Following a laboratory investigation, a pilot-scale extraction system was assembled and tested. It identified hot insulating oil as a safe, effective extraction solvent that is compatible with Ontario Hydro PCB destruction technology. Operation of this system has provided the data that is necessary for optimum removal of PCB from contaminated topsoil, gravel and clay.

2.3.3 PCB Removal from Silicone (Retrofilled) Transformers

It is often more economical to replace askarel in an existing transformer with an environmentally acceptable dielectric fluid than to buy a new unit. However, following draining, solvent flushing and refilling, there remains the job of removing residual PCB. Two 300 kVA transformers were retrofilled with silicone fluid and the residual PCB content was reduced from about 4000 mg/kg to below 50 mg/kg by circulating the fluid through either of two commercial carbon adsorption systems, bagged granular carbon or filter cartridges impregnated with powdered carbon. Decontamination costs were estimated at $4,000 - $4,500 per transformer.

2.4 Energy Conservation and Utilization ($140K; 10% transfer, 60% revenue, 30% OM&A)

A comprehensive 2 year study of the effects of thermal insulation upgrading on the life of electrical insulation components was initiated with support from Energy, Mines and Resources and the Canadian Electrical Association to identify (and hopefully remedy) possibly hazardous retrofit practices. Wiring component temperatures under various levels of thermal insulation blankets and load conditions were measured and found not to exceed the Canadian Standards Association wire ratings in new constructions. Thermal endurance of wire insulations (NMD-1, NMD-3 and NMD-7) were determined by accelerated oven aging.

2.5 Transmission and Distribution ($90K; 35% transfer, 65% OM&A)

Investigations into SF_6 insulated switchgear continued with both EPRI and CEA support. Programs are divided into studies of epoxy spacer surface characteristics (effects of flashover and/or SF_6 decomposition by-products), moisture effects on spacer/system performance and development of novel, inexpensive detection methods for SF_6 decomposition by-products. Patent protection is presently being sought for the newly developed devices which were successfully tested in the field during the course of the year. Studies were carried out in collaboration with Electrical Research Department with subcontracting to the University of Western Ontario for sophisticated surface analysis (ESCA, SIMS).

Studies of gassing of paper-wrapped conductors immersed in transformer oils were undertaken to assess the effects of hot spots in transformer windings. The objective of the work is to allow operation of power transformers above nameplate rating, ie, overheated. Studies of the effects of pressure, electrical stresses and moisture levels showed that water vapour bubble emissions occurred at 130-150°C and, as expected, bubble formation temperature was elevated by increasing hydrostatic pressure. These studies will continue in 1985.

To facilitate the retrieval of information in the field of electrical insulating fluids for the period 1960-1984, the important investigations and findings of the Insulating Fluids Research Group have been consolidated in a report. The report summarizes the novel test methods that were developed, special investigations relating to transformer oils, and studies on askarel replacement liquids, cable oils, oil reconditioning and reclaiming, arcing and gassing in transformers, deposits in transformers, and polychlorinated biphenyl decontamination. The appendix to this report contains extensive data on the properties of insulating fluids determined by this research.

2.6 General Research Programs ($380K; 30% transfer, 10% revenue, 60% OM&A)

The major portion of the effort in this program was in the area of Radiation Safety and providing specialized testing services for both internal and external clients. This work is described in more detail below. Other work (~$180K) involved the development of new testing procedures and providing assistance to the development of new or revised material standards as well as serving on a Research Division Task Group established to review the future needs of the Division for low and medium level radioactive material handling facilities.

2.6.1 Radiation Safety ($120K)

Staff of the Nuclear Chemistry Unit are responsible for the safe handling of radioactive material and other radiation sources in the Division. In 1984, support work for the Pickering retubing project resulted in increased demands for space in the Radioactive Materials Laboratory and requests from new groups for assistance and guidance in setting up radioactive experiments.

During the year a full-time Radiation Control Technologist position was established to handle some of the administrative and consulting duties. The radioisotope inventory records were transferred to a computer-based system to allow improved monitoring and control of the isotopes used at the Kipling complex.

The Division's interests were represented by participation in a Task Group that is revising Ontario Hydro's Radiation Protection Regulations, and by reviewing draft revisions of the Federal regulations on radiation protection, X-ray safety and the design of radioisotope laboratories.

Planning for the tritium laboratory included the selection of tritium monitors and assistance in the specification of many safety aspects of the building layout, ventilation system and automatic surveillance system.

2.6.2 Flat Rate Accounts ($140K)

A large number of tests were carried out on insulating, lubricating, fuel, hydraulic and coolant fluids for quality and adherence to specifications as well as testing of deposits from transformers, lubricating and cooling systems for evidence of malfunction. In addition, approximately 100 fire tests were performed for cable manufacturers to determine the flammability of control and power cables. Weatherometer exposure of cables, labels, etc, for CSA was continued.

3.0 1985 PROGRAM

3.1 Nuclear Generation

3.1.1 Non-Metallic Materials

Work will continue in many of the areas already discussed in the 1984 program. Aging of fibre reinforced plastic components used in the Pickering and Bruce "B" vacuum buildings, investigations of techniques to detect and quantify leaks from nuclear containment structures and work under contract to Sandia National Laboratory to evaluate the performance of aged station batteries is expected to be completed. The large amount of short-term investigative and consulting work is expected to continue at a similar level to that in 1984.

A major potential area of research is that of material performance in harsh nuclear environments. Studies of radiation resistance of materials and in particular lubricants, together with synergistic and dose rate effects represent key elements in developing a better understanding of material performance. This is a major program that will require the participation of several Departments and Divisions to both establish the needs and priorities of the work as well as carry out specific work packages in the program. Establishing that program is expected to require a significant effort.

On a related subject, support has been received by Electrical Research to investigate deuterated materials, as a possible market for surplus heavy water. Research by other organizations shows the potential of deuterated materials to exhibit improved aging performance as a result of increased oxidative resistance. The Organic Research Section's initial contribution to the program will be to substantiate these early claims of superior performance, particularly for lubricants - the most extensively studied materials so far. A better understanding of material performance improvements would, hopefully, lead to a new generation of deuterated materials of moderate cost, a prerequisite for the volume applications necessary to justify production.

3.1.2 Tritium

Tritium/materials research is clearly an extension of work performed in 1984 and before. However, the program has been re-examined in a much broader context, identifying tritium permeation as a central element of this program with ties to decontamination, tritiated waste conditioning and safety-related applications (suits, coatings, glove box, etc). The objective of the multi-year program is to develop the capability to measure permeation rates of essentially any non-metallic and gain the necessary understanding to characterize these in terms of surface and bulk interactions, isotopic exchange, etc. As a part of the program, modeling capabilities are to be developed, embodying all experimental findings and leading to the development of an interactive data base. During 1985, efforts are to be concentrated on development of experimental capabilities, modeling, isotopic exchange and decontamination; tritiated waste conditioning research is already much more advanced.

3.1.3 Decontamination/Activity Transport

Most projects in 1985 will contribute to the joint AECL/Ontario Hydro decontamination development program which is aimed at understanding the mechanisms of the decontamination process and improving its efficiency. When the fundamental work on the roles of the constituents of the CAN-DECON reagent has been completed, modified formulations will be tested in the laboratory.

Further unique specimens from Bruce and Pickering reactors will be evaluated to determine the effects of decontaminations on system surfaces and specify conditions for future decontaminations.

Work on two-step processes for stainless steels will be extended to Bruce scenarios and will include alternate first-step reagents.

On-site gamma spectrometry will continue. Laboratory studies will be undertaken to relate gamma spectra to surface radioisotope concentrations and thus provide additional information on system isotope inventories.

Measurements of uranium oxide deposition on magnetite will be completed and results compared with theory.

Processes for decontaminating obsolete fuel baskets will be compared and a recommended course of action proposed, possibly involving outside contractors.

3.2 Nuclear Waste

The main research activity in 1985 will again be in support of the Reactor Waste Disposal Program. In the short-term, further compactable and non-processable waste characterization will be done. Longer term research projects will include development of a disposal-type leaching test and fundamental studies of radionuclide release mechanisms. It is planned to expand tritiated waste research with support from CFFTP by defining tritiated wastes arising from fusion reactors, developing conditioning treatments and designing suitable processing equipment for these wastes.

3.2.1 Leaching Research

Leaching tests will be conducted to establish the performance of conditioned tritiated aqueous, organic and solid wastes and encapsulation/package combinations. This project will continue into 1986 to derive long term patterns. The study will also be expanded to consider fusion plant wastes.

Work will start on the development of a leaching test designed to more accurately define waste form performance in disposal than existing tests. The test will enable factors affecting radionuclide release such as waster chemistry, flow rate, grouts, backfills and soil features to be input to derive more realistic source terms for pathway modeling. In addition, research will be started to determine the influence of solubilization, exchange reactions, morphology, and corrosion of the waste forms on leaching rates to assess the effect on diffusion and transport models and develop modifications to improve their predictive accuracy.

3.2.2 Waste Characterization

Compactable wastes from the Pickering NGS "A" retubing operation will be characterized to determine the difference in radionuclide inventory from normal operating wastes and work will start on the characterization of filters and other non-processable wastes to determine conditioning requirements for disposal.

3.2.3 Waste Conditioning

The compact solidification equipment for aqueous wastes will be commissioned and demonstrated to interested parties in the first quarter of 1985. Following the demonstrations it is expected the plant will be dismantled and rebuilt in an even more compact form prior to use at the stations.

Research will be maintained on waste conditioning treatments, volume reduction and immobilization. It is planned to examine the applicability of electrophoresis to aqueous wastes, the potential of plasma arc incineration of miscellaneous wastes and evaluate novel immobilization matrices.

3.3 Environment

Commissioning tests of the mobile processing unit for PCB dechlorination will be completed and the information input to an Environmental Assessment submission. In addition, demonstration tests will be conducted for the Ontario Ministry of the Environment to ensure compliance with proposed regulations on the use of mobile PCB dechlorination processes. Following this work, the unit will be transferred to Transmission Operations Division and future PCB activities will be reduced to a consulting role.

3.4 Energy Conservation and Utilization

The EMR/CEA funded study on the thermal endurance of wiring to assess the effects of retrofit thermal insulation will continue. The focus of the study will be on the development of a finite element model to predict probable life under a variety of conditions, eg, circuit loading, duration of use, etc.

3.5 Transmission and Distribution

The major effort will be in the area of solid, liquid and gaseous dielectrics. Investigations into SF_6 insulated switchgear will continue with EPRI and CEA support. Studies will focus on epoxy spacer surfaces in contact with arcs and arcing by-products to examine surface degradation. Other studies will evaluate the moisture problems encountered in gas insulated substations and attempt to develop a comprehensive model to account for migration of moisture through leaks and permeation onto metallic surfaces and into the bulk of the spacers. Studies are continuing in collaboration with Electrical Research Department.

Studies of gassing in power transformers will continue, focussing on thermally upgraded insulating paper, in particular, paper-plastic composites. Stability of the paper limits the life of the system and thus the transformer rating.

In 1985, longer-term fundamental studies will be initiated in parallel with the current, more practically oriented projects. The dielectric properties of fluids, electrical relaxation functions, surface studies, intrinsic conductivity represent some of the areas of interest.

4.0 OVERVIEW

This report has presented the major achievements of the Organic Research Section during 1984 and outlined the major features of the 1985 Work Program. There are some changes to the emphasis of the work program in 1985 and beyond.

The work of the Section will continue to be strongly oriented towards short-term investigations; however, the areas of involvement will gradually be reduced to primarily those in which the Section has major long-term interests. In 1985, external contract work will be completed, or nearing completion, in the areas of seismic performance of batteries and the effects of thermal insulation on residential wiring. Most of the work related to PCB decontamination will be completed.

When resources become available, they will be deployed primarily in some of the more fundamental research aspects of dielectrics and in the aging of critical, organic material components in harsh environments (eg, fuelling machine lubricants, nuclear control cables, etc). In addition, there will be increased emphasis on obtaining experimental and theoretical data on the transport of tritium through non-metallics.

Work in support of the decontamination program will continue to respond to client needs. In 1984, short-term work in support of the Pickering decontaminations delayed progress on the original decontamination development program. However, the valuable new information gained from the Pickering decontaminations and the detailed evaluation of components removed from the primary heat transport systems has provided a clearer focus on the direction of the development program.

In the area of radioactive wastes, more long term research (such as leaching studies) will be possible now that the unit is back to full strength. Participation in the development of the European 5-year program on the disposal of low and medium level wastes has provided a valuable link with the European efforts and in 1985 even closer co-operation with the European and United States program will be actively pursued.

Finally, a wide range of new equipment was purchased during 1984 including a gas chromatograph equipped with a range of detectors for nuclear and non-nuclear components, a multichannel analyzer equipped with gamma detectors, data acquistions and microcomputers. In 1985, a Fourier Transform infra red spectrometer will be purchased as well as equipment to characterize the dielectric properties of materials. All of this new equipment will contribute significantly to the Section's major research goals as well as providing additional capabilities for the short-term investigative work.

5.0 ACKNOWLEDGEMENT

All of the Section staff contributed to the achievements of 1984 as well as to the description of them in this report. Their individual contributions are most gratefully acknowledged.

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for

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RWG:rdm

APPENDIX 1

1984 EXTERNAL CONTRACTS

1. Contracts Continued from 1983

Title	Amount of Contract ($K)	Funding Agency	Project Manager	Status as of Dec 31/84
Polymeric Phase Change Material OSX82-00047	45	NRC	D. Cordingley	Completed
Standard Fire Test Method for Grouped Cables 249 G 382	56	CEA	D. Stonkus	
Thermal Upgrading Effects on Electrical Wiring Components PO 56229	81	EMR/CEA	J.M. Braun	
Discriminating Tritium Monitor	20	CFFTP	J.M. Braun	
Removal and Destruction of PCB from Contaminated Soils 195 D 365	60	CEA	J. Ferrie	
Tritium Sorption of Coatings	25	CFFTP	A. Williamson	
2. Contracts Awarded in 1984				
Thermal Endurance of Electrical Wiring 306 U 415	55	EMR/CEA	J.M. Braun	
Externally Funded Flat Rate Jobs	22/a	MISCELLANEOUS	NA	
Moisture in GIS 217 T 424	30	CEA	F. Chu/ J.M. Braun	
Leak Site Detection	40	CANDEV	D. Cordingley	
SF_6 Spacer Surfaces RP 1360-10	30	EPRI	F. Chu/ J.M. Braun	

CEA - Canadian Electrical Association
NRC - National Research Council
EMR - Energy, Mines & Resources
CANDEV - CANDU Development
EPRI - Electric Power Research Institute
CFFTP - Canadian Fusion Fuels Technology Project

APPENDIX II

COMMITTEE AND TASK GROUP MEMBERSHIPS

1. Internal

Radiation Protection Regulations Revision Review Group (S.L. Vekris)

PCB Management Committee (R.W. Glass)

Standing Panel - Insulated Wire and Cable (D.J. Stonkus)

2. External

Commission of the European Communities Low and Medium Level Waste Management Research Group (A.S. Williamson)

International Atomic Energy Agency, Radioactive Waste Management Advisory Group (A.S. Williamson)

AECL/HQ/NBP/OH, Decontamination Review Committee (S.L. Vekris)

AECL/CSA/OH, Committee for Specification M286.46 on Aging of Elastomers in Nuclear Plants (D.C. Cordingley)

CSA C22.2 No 0.3: Test Methods for Electrical Wire & Cables (D.J. Stonkus)

CSA C21.1: Committee on Control and Instrumentation Cable (D.J. Stonkus)

IEEE/ICC: Committee 12-32 Type Test Class 1E Nuclear Cable (D.J. Stonkus)

IEEE/ICC: Committee 12-36 Smoke, Toxicity & Corrosion Products of Cable Combustion (D.J. Stonkus)

IEC 15B, Working Group 2: Radiation (D.J. Stonkus)

IEC 20B, Working Group 12: Burning Characteristics of Electrical Cables (D.J. Stonkus)

IEC CSC/TC10 Committee on Fluids for Electrotechnical Applications (J.S. Ferrie)

APPENDIX III

PUBLICATIONS, PRESENTATIONS AND PATENTS

1. Papers Published

A. Husain, "Charge Development at the Uranium Oxide - Solution Interface," J. Colloid and Interface Science, 102 (2), 389 (1984).

2. Papers in Press

M.A. Habayeb, "Leaching Performance of Cemented Decontamination Wastes," Nuclear and Chemical Waste Management.

3. Presentations

F.Y. Chu, H.A. Stuckless and J.M. Braun, "Generation and Effects of Low Level Contamination in SF_6 Insulated Equipment," presented at the Fourth International Symposium on Gaseous Dielectrics, Knoxville, Tennessee, April 29-May 3, 1984.

D.J. Stonkus, "Improving Radiation Resistance of PVC Cable Jacket," presented at the 42nd Annual Technical Conference of Society of Plastic Engineers, New Orleans, April 30-May 3, 1984.

J.M. Braun, F.Y. Chu and S. McIntyre, "Characterization of Degraded Epoxy Spacer Surfaces by Electron Spectroscopy," presented at the IEEE Conference on Electrical Insulation and Dielectric Phenomena, Clayton, Delaware, October 21-24, 2984.

4. Patents Awarded

W.J. Janis, J.S. Ferrie and J.M. Braun, "PCB Dechlorination Process," Canadian Patent #408116.

W.J. Janis, J.S. Ferrie and J.M. Braun, "PCB Dechlorination Process," South African Patent #82/9509.

C.H. Cheh and R.W. Glass, "Carbon Dioxide Removal Method Employing Packed Solid Calcium Hydroxide," United States Patent #422,479.

5. Patent Applications

R. Filter and D.J. Stonkus, "Loadbreak Bushing and Snuffer/Contact Assembly," Patents applied for in Canada, USA and the EEC.

APPENDIX IV

REPORTS ISSUED IN 1984

CATEGORY "A" REPORTS - 1984

Nuclear Generation

A. Husain, "Charge Development at the Uranium Oxide/Solution Interface," Report No 83-525-K, File 836.3332, Feb 13, 1984.

J.M. Braun, "Pressure Relief Duct Seal Failures - Pickering NGS "B"," Report No 84-68-H, File 835.6211, Apr 9, 2984.

S.J. Oda, "Evaluation of Thermal Insulations for Nuclear Shipping Flasks," Report No 84-70-K, File 835.4 X 837.82, Mar 20, 1984.

V.S. Chew, "Reagent Selection for Pickering Unit 2 End Fitting Decontamination," Report No 84-113-K, File 836.29, Apr 26, 1984.

J.S. Ferrie, "Auxiliary Boiler V-Pump Lubricants Unit 6 - Bruce GS 'B'," Report No 84-42-H, File 833.1-7, Feb 14, 1984.

G.W. Fayle, "Examination of Elastomeric Diaphragms on Pressure Relief Valve, Negative Pressure Containment System, Pickering NGS," Report No 84-270-K, File 835.613, Aug 3, 1984.

D.J. Stonkus, "Sealing CIGAR Wiring System," Report No 84-304-K, File 832.1, Sept 18, 1984.

A. Husain, "Auger Electron Spectroscopic Studies on Oxide Films of Some Primary Heat Transport System Materials," Report No 84-311-K, File 836.3332, Nov 23, 1984.

J.M. Braun, "Tritium Non-Metallic Materials Interactions - Research Needs," Report No 84-322-K, File 836.461, Dec 5, 1984.

V.S. Chew, "Evaluation of Corrosion Coupons - Pickering Unit 1, May 1, 1984 CAN-DECON Decontamination," Report No 84-393-H, File 836.29, Nov 19, 1984.

Nuclear Waste

S.H. Hawthorne, "Conditioning of Tritiated Wastes Part II - Solidification and Encapsulation," Report No 84-6-K, File 837.83, Feb 15, 1984.

M.A. Habayeb, "Effect of Presolidification Treatments on Leaching Performance of Simulated Decontamination Wastes Solidified with Water Extendible Polyester," Report No 84-29-K, File 837.83, Apr 16, 1984.

M.A. Habayeb, "Prediction of Long-Term Releases of Cs-134 from Cemented Decontamination Waste by Semi-Infinite Diffusion Models," Report No 84-209-K, File 837.83, Aug 31, 1984.

Transmission and Distribution

J.M. Braun, "Novel Surge Attenuating Semiconducting Compounds," Report No 84-2-Con, File 832.1, Jan 23, 1984.

D.J. Stonkus, "Evaluation of Oxide Inhibitors for Electrical Cables," Report No 84-34-K, File 833.227, Feb 17, 1984.

F.Y. Chu and J.M. Braun, "Arced Gas Analyzer for Fault Location in GIS," Report No 84-378-H, File 811.4, Nov 16, 1984.

Environment

W.J. Janis, "PCB Removal - Silicone Filled Transformers," Report No 84-114-K, File 832.733, June 5, 1984.

General

A. Husain, "A Computerized Radioisotope Inventory System," Report No 84-183-K, File 830.03, June 21, 1984.

R.W. Glass, "Radioactive Laboratory Requirements to the Year 2000," Report No 84-387-R, File 830.13, Nov 29, 1984.

CATEGORY "B" REPORTS - 1984

Nuclear Generation

D.E. Beaudry, "Gamma Spectrometry of NPD GS Components Before During and After CAN-DECON (December 18-21, 1983)," Report No C84-10-K, File 836.39, Feb 13, 1984.

V.S. Chew, "Characterization of Oxide on Pickering NGS, Unit 2 Boiler Hinges and Feeder Pipe, and NPD NGS Feeder Pipe," Report No C84-11-K, File 836.29, Feb 28, 1984.

F.W. Stubbs and V. Rakchaev, "Pump Lubricants - Pickering NGS 'B'," Report No C84-12-K, File 831.1-3C, Feb 15, 1984.

D.E. Beaudry, Gamma Sepctrometry of Pickering NGS Unit 2 Components Before, During and After CAN-DECON (January 4-9, 1984)," Report No C84-19-K, File 836.3332-PIC, Feb 13, 1984.

V.S. Chew, "Evaluation of Corrosion Coupons - Douglas Point 1983 CAN-DECON Decontamination," Report No C84-27-H, File 836.3332-DOU, Feb 24, 1984.

V.S. Chew, "Evaluation of Corrosion Coupons - Pickering Unit 2, Jan 84 CAN-DECON Decontamination," Report No C84-39-K, File 836.29, Apr 4, 1984.

V.S. Chew, "Oxide Characterization Pickering Unit 2 End Fitting Liners," Report No C84-55-K, File 836.29, Aug 23, 1984.

R.W. Winn, "Examination of an Aeroquip Hose Failure from Bruce NGS 'A'," Report No C84-63-K, File 836.65, Aug 16, 1984.

V.S. Chew, "Evaluation of Corrosion Coupons - Pickering Unit 2, April 1984 CAN-DECON Decontamination," Report No C84-65-K, File 836.29, Sept 11, 1984.

R.K. Cleary, "Inspection of Mothballed BHWP E7 and E8 Equipment and Piping," Report No C84-66-H, File 833.226, July 10, 1984.

V.S. Chew, "Oxide Characterization - Feeder Pipes from Pickering and NPD," Report No C84-73-K, File 836.29, Sept 11, 1984.

D.E. Beaudry, "Gamma Spectrometry of Pickering NGS Unit 2 Components Before, After and During CAN-DECON (April 4-11, 1984)," Report No C84-83-K, File 836.29, Oct 26, 1984.

V. Rakchaev, "Moderator Pump Lubricants - Pickering NGS 'B'," Report No C84-84-K, File 831.1C, Sept 12, 1984.

J.M. Braun, "Pickering NGS 'A' Non-Metallic Expansion Joints," Report No C84-87-H, File 835.62, Aug 31, 1984.

D.J. Stonkus, "Proposed Research Programs - Non Metallic Materials," Report No C84-88-K, File 830.11, Dec 6, 1984

D.E. Beaudry and A. Husain, "Gamma Spectrometry of Pickering NGS Unit 1 Components Before, After and During CAN-DECON (May 3-8, 1984)," Report No C84-89-H, File No 836.29, Nov 23, 1984.

D.E. Beaudry, "Gamma Spectrometry of Pickering NGS 'A', Unit 3 Boilers and Reactor Vault," Report No C84-95-K, File 836.3332-PIC, Nov 5, 1984.

D.E. Beaudry, "Gamma Spectrometry of Pickering NGS 'B', Unit 5 Boilers and Reactor Vault," Report No C84-96-K, File 836.3332-PIC, Nov 5, 1984.

V. Rakchaev, "Auxiliary Boiler Feed Pump Lubricants Pump 4, Unit 5 - Bruce NGS 'B'," Report No C84-99-K, File 831.1-7, Nov 12, 1984.

D.E. Beaudry, "Gamma Spectrometry of Pickering NGS 'A', Unit 4 Boilers and Reactor Vault," Report No C84-102-K, File 836.3332-PIC, Nov 12, 1984.

V.S. Chew, "Bruce Unit 5 Hot Conditioning - Analysis," Report No C84-100-K, File 836.3332-BRU, Dec 11, 1984.

D.E. Beaudry, "Gamma Spectrometry of Bruce NGS 'A' Unit 3 Boilers and Reactor Vault," Report No C84-113-K, File 836.3332-BRU, Dec 11, 1984.

V. Rakchaev, "Vacuum Pump Lubricating Oil - Pickering CMS," Report No C84-114-K, File 831.1-3, Nov 30, 1984.

V. Rakchaev, "Auxiliary Boiler Feed Pump Lubricants Pump 4, Unit 5 - Bruce NGS 'B'," Report No C84-117-K, File 831.1-7, Dec 18, 1984.

M.G. Van Horne, "Size Distributions of Unit 7 Feedwater Particulates," Report No C84-119-K, File 836.3332-PIC, Dec 11, 1984.

D.J. Stonkus, "Examination of Pickering 'A' Unit 1 Reactivity Deck Cables," Report No C84-123-K, File 832.105, Dec 13, 1984.

J.M. Braun, "39th Reinforced Plastics/Composites Conference, Houston, TX, January 16-19, 1984," Report No C84-17-K, File 830.5, Feb 9, 1984

Nuclear Waste

A.S. Williamson, "Trip Report: Workshop on Performance of Low and Medium Level Waste Packages in Disposal Conditions, Commissariat a L'Energie Atomique, Cadarache, France," Report No C84-122-K, File 837.81, Dec 14, 1984.

Transmission and Distribution

J.M. Braun, "1984 Conference on Electrical Insulation and Dielectric Phenomena, Claymont, De," Report No C84-106-K, File 832.2, Nov 15, 1984.

General

R.K. Cleary, "Field Inspection of Water Treatment Plant Tank Linings - Atikokan GS," Report No C84-2-H, File 833.414, Jan 17, 1984.

R.K. Cleary, "Kipling Complex Roof Inspection," Report No C84-3-H, Jan 27, 1984.

R.K. Cleary, "Adhesion of Acrylic Emulsion Floor Sealer to Sternson Florseal," Report No C84-25-H, File 833.11, Feb 20, 1984.

R.K. Cleary, "Inspection of Linings in Domestic Water and Clarifier Tanks," Report No C84-36-H, File 833.414, Mar 30, 1984.

V. Rakchaev, "Wire Rope Lubricants," Report No C84-51-H, File 831.48, June 8, 1984.

V. Rakchaev, "Qualification Tests on New Shell CL1047 Seal Oil," Report No C84-80-H, File 831.1-7, Sept 14, 1984.

R.K. Cleary, "Inspection of the Structural Steel Components of the Stairwells at the 60 Murray Street Parking Garage," Report No C84-103-K, File 833.2261, Nov 14, 1984.

V. Rakchaev, "Diesel Coolant Deposit - Milton TS," Report No C84-108-K, File 836.353, Nov 15, 1984.

V. Rakchaev, "Combustion Turbine Lubricating Oils - Thunder Bay TGS," Report No C84-125-K, File 831.1-9, Dec 28, 1984.