SCIENTIFIC RESEARCH AND EXPERIMENTAL DEVELOPMENT (SR&ED)

SECTOR-SPECIFIC GUIDELINES

CHEMICALS GUIDANCE DOCUMENT #1 - SHOP FLOOR SR&ED *

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* This document has been prepared by a Chemicals Industry and Canada Customs and Revenue Agency Joint Committee (see Appendix D)

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SECTOR-SPECIFIC GUIDELINES

CHEMICALS GUIDANCE DOCUMENT 1 - SHOP FLOOR SR&ED

1. INTRODUCTION

1.1. The purpose of this guidance document is to supplement Information Circular 86-4R3, by clarifying work that lies within the boundaries of SR&ED, and providing specific examples to assist those performing chemical-related SR&ED in the interpretation and practical application of the SR&ED Program.

1.2. Technical considerations in preparing shop floor SR&ED project descriptions constitute the primary focus of this guidance document. Current or capital expenditures and financial review are complementary issues.

1.3. SR&ED claimants should also refer to the Guide to Form T661-T4088 (E) and Interpretation Bulletin IT-151R5 [1] in addition to the relevant sections of the *Income Tax Act* and its Regulations when they are preparing their SR&ED Project Descriptions and allowable expenditures summaries.

1.4. In numerous circumstances the SR&ED cannot be carried out in a laboratory setting and some or all SR&ED is carried out in a production and/or manufacturing environment. Shop floor SR&ED (see Glossary) involves creating new or improving existing materials, devices, products or processes in a production or manufacturing environment. It usually involves experimental production or experimental process modification carried out either in conjunction or simultaneously with commercial work that is not SR&ED.

2. SR&ED CRITERIA

2.1. Shop floor projects involving the experimental development of new processes, products or materials, as well as the testing and analysis required to resolve scientific or technological problems in the chemicals sector can be claimed for SR&ED tax credits. The project must meet the definition of SR&ED in Subsection 248(1) of the Income Tax Act. As such, the work undertaken must satisfy the three criteria of:

- Scientific or technological advancement
- Scientific or technological uncertainty
- Scientific and technical content

See sections 3 to 5 for more detailed definitions of these three criteria.

Projects presented by companies must clearly satisfy the three criteria and be substantiated with supporting technical information.

2.2. The following direct support activities: engineering, design, operations research, mathematical analysis, computer programming, data collection, testing, and psychological research, can be claimed when carried out in support of a qualifying project, if this work is commensurate with the needs of the experimental development and the resolution of the identified problems.

2.3. Market research, sales promotion, quality control, routine testing, commercial production of a new or improved material, device, or product, or the commercial use of a new or improved process, style changes and routine data collection do not qualify as SR&ED under the *Income Tax Act*.

3. SCIENTIFIC OR TECHNOLOGICAL ADVANCEMENT

The criterion of scientific or technological advancement is as follows:

The search carried out in the scientific research and experimental development work must generate information that advances our understanding of scientific relations or technologies. In a business context, this means that when a new or improved product or process is created, it must embody a scientific or technological advancement in order to qualify.

3.1. A scientific or technological advance is:

(a) The discovery of scientific or technological knowledge that advances the understanding of scientific relations or technologies, and

(b) The incorporation by means of experimental development of a characteristic or capability not previously existing or available in standard practice, into a new or existing process, or product that enhances the product's performance.

The development can result in the technical enhancement of either new or existing products or processes.

3.2. Example

A new chemical compound has been developed and subjected to a series of performance tests in the laboratory. However before going to the market, it was necessary to determine its stability upon extended storage. In particular, it was necessary to ensure that its viscosity would be maintained within the set range regardless of its shelf life. After exhaustive testing under various storage conditions, it was determined that the stability of the compound was not satisfactory, and furthermore that the material would not retain the desired operating viscosity after extended storage even at ambient conditions. The developer of this compound did not know which component(s) were responsible for the instability of the product, nor was it known how the problem could be resolved on the basis of commonly available knowledge. A systematic investigation was therefore required combined with rigorous analytical work before the errant ingredients were identified, and more compatible substitutes developed.

Similarly, an existing product or process may need to be modified or enhanced to meet constraints that were not an original requirement. If the solutions were not readily available and were identified through a systematic process of experimental development, the experimental component of the work could be claimed.

3.3. The search for a meaningful advance in the body of scientific or technological knowledge should be the guiding element in every project. This requirement is satisfied whether or not the advance is achieved, i.e., determining that a hypothesis is incorrect is also a scientific or technological advance.

4. SCIENTIFIC OR TECHNOLOGICAL UNCERTAINTY

The criterion of scientific or technological uncertainty is as follows:

Whether or not a given result or objective can be achieved, and/or how to achieve it, is not known or determined on the basis of generally available scientific or technological knowledge or experience. This criterion implies that we cannot know the outcome of a project, or the route by which it will be carried out without removing the technological or scientific uncertainty through a program of scientific research or experimental development. Specifically, scientific or technological uncertainty may occur in either of two ways:

- it may be uncertain whether the goals can be achieved at all; or
- the claimant may be fairly confident that the goals can be achieved, but may be uncertain which of several alternatives (i.e., paths, routes, approaches, equipment configurations, system architectures, circuit techniques, etc.) will either work at all, or be feasible to meet the desired specifications or cost targets, or both of these.

The scientific or technological uncertainty in shop floor SR&ED arises when the intended scientific or technological advance, or the method for arriving at it is not apparent to qualified staff (such as chemists, engineers, technologists or operators) who are knowledgeable in the specific field of science and/or technology.

A chemical process on the shop floor is made up of a number of distinct and separate operations. These operations are systems in their own right, and the end product is achieved by subjecting various ingredients to a series of sequential processes or operations. Each of these separate processes or the integration of individual operations could be claimed as experimental development, as long as they meet the three criteria of scientific or technological advance, scientific or technological uncertainty and scientific and technical content. When the three criteria are not satisfied, the work will not meet the definition of SR&ED.

Scientific or technological uncertainty could arise from a new material formulation, new and increased performance requirements for existing or novel products, or from the development of a new type of manufacturing process for new or existing products.

Frequently there is a need to meet specific product cost targets imposed by the market. The imposition of cost constraints, on its own, does not create scientific or technological uncertainty; however, in an attempt to meet such a goal, technological problems may arise that create an element of scientific or technological uncertainty. Resolution of these problems can lead to work that may qualify as SR&ED.

Example

Over a 10-year period, a manufacturer of rigid insulating foam boards changed the blowing agent used in the manufacture of the foam a number of times. Each of these changes required plant trials of varying duration. Some of these changes involved SR&ED, while others did not.

The initial technology was developed with CFC-11 as the blowing agent. At the time CFC-11 was considered to be an ideal material since it was non-flammable, non-toxic and non-corrosive. Also the vapor had a high thermal insulating value.

The impetus for the initial change to HCFC-123 came from the realization that CFCs had an extremely long shelf life, damaged the ozone layer and also had the potential to cause the high greenhouse effect.

Although HCFC-123 was very similar in properties to CFC-11 (their boiling points were only 3^{o} C apart) some of their other properties (including their solubility in resins) were significantly different. These differences introduced a scientific or technological uncertainty related to the lack of knowledge as to what was needed to be changed in the manufacturing process when HCFC-123 was introduced. Thus the work involved in changing from CFC-11 to HCFC-123 was considered to be SR&ED.

HCFC-123 was more expensive than CFC-11, and in an attempt to reduce costs, the initial supplier of an alternative material AB-123 was replaced with another supplier of a competitive but cheaper material XY-123. This change in additive did not introduce an additional scientific or technological uncertainty since the supplier was certain that the new additive XY-123 was fully compatible with the manufacturer's HCFC-123 based process.

There were toxicity issues with HCFC-123 that were not completely resolved. When HCFC-141b arrived as a less toxic alternative, the manufacturer switched to this new material . Although the manufacturer acquired significant knowledge in the change from CFC-11 to HCFC-123, there were differences in properties between HCFC-141b and HCFC-123, which impacted on the foaming process and which necessitated further experimental development work. Under this circumstance, the change from HCFC-123 to HCFC-141b would be considered to constitute a scientific or technological uncertainty, which would make the work qualify as SR&ED.

5. SCIENTIFIC AND TECHNICAL CONTENT

5.1. The staff responsible for directing and performing the work must have the appropriate technical skills and experience (see Appendix A for illustrative examples).

The scientific research and experimental development work must incorporate a systematic investigation involving the formulation of a hypothesis, testing this hypothesis by experimentation or analysis, and then statement of logical conclusions.

5.2. Supporting information should be generated over the course of the project to demonstrate a systematic experimental investigation. These records/documentation would show the original technological goals, progress in the work undertaken, how the work has been carried out, and indicators that were used to identify if project objectives are met.

5.3. Examples of supporting information that could be available for on site examination by Canada Customs and Revenue Agency include:

- Background literature related to a project plan
- Records of experimental runs, test data and results
- Project note books and/or quantitative measurement data
- Lab books or records
- Internal design documents and drawings
- Any other relevant documentation (e.g., photos) that substantiates SR&ED work
- Staff resumes
- Prototypes or mock-ups
- Pilot-scale or bench-scale equipment used for experimentation.
- Annotated SPC charts
- Annotated Process logs
- Used parts of equipment
- Samples of material
- Shipping documentation for experimental products
- Evidence from customer/end user trials

5.4 Unplanned shop floor SR&ED may arise in some chemical processes when a process, which has functioned routinely for several months or years, begins to exhibit performance problems. This may include poorer yields or off-specification product. In these cases the process engineers and/or chemists would trouble shoot the process and carry out a systematic examination of the process for variance from the standard operating parameters, such as temperature, pressure, flow rates, retention times, levels of agitation, or specification of feed stock. After these options have been unsuccessfully investigated and tested (using the standard troubleshooting and debugging methods that are documented in operations manuals), a SR&ED project may be identified.

Example:

Nuclear Plant A must process 240 000 L of radioactive liquid waste in four separate 60 000 L batches. A plant-scale microfiltration (MF) system coupled with reverse osmosis (RO) and ion exchange (IX) effluent polishing is available for waste treatment. Although this waste stream has been treated on a regular basis through the plant-scale system over the past year, the chemistry of this stream can have unique week-to-week variations. The treatment of this waste stream is often not straightforward and operating procedures for the shop-floor system may need to be modified during a run to accommodate these variations. Moreover, the use of membrane technologies for these types of wastes is relatively new, in comparison with more mature technologies like evaporation.

During the first of four waste batches treated (using process parameters previously identified from prior runs), there were some unique problems identified. In particular, the suspended particulates were of such a size that they blocked the 0.2 micron pores on the MF system from time to time, which resulted in very high and unsafe back pressures. As a result, the MF system had to be shut down for membrane cleaning every 2 hours, and the run took 50 hours to complete, when it normally should take only 20 hours.

As a first attempt to correct the problem, the standard cleaning solvents were investigated during several of these shutdown periods in an attempt to remove the waste material off the pores on the MF system. In addition, the liquid backwash rate on the MF system was varied in the normal operating range during the entire processing run to determine if changes in the backwash cleaning frequency could slow down the rate of pore blockage. In spite of the best efforts of the process engineers and operators, however, the problem was unresolved during the treatment of the first 60 000-L batch of waste, and a SR&ED project was subsequently identified. A series of experiments were then carried out to determine how to modify the waste chemistry and process parameters, such that the remaining 180 000 L of waste could be routinely treated. Following the completion of the SR&ED project, the remaining three waste batches were successfully treated without further problems.

6. COMMERCIAL VS. EXPERIMENTAL PRODUCTION

6.1 When experimental production involves the development of a new process or product through experimental operation with a pilot plant, the experimental production can be claimed as SR&ED work. Using the traditional method for claiming overhead expenses (also see Reference [1]), the labour costs relating to resolving the scientific or technological uncertainties are all or substantially all related to SR&ED since these costs cannot be attributed to any other activity.

(See subsection 37(1) of the *Income Tax Act)*. When the traditional method for claiming overhead expenses is used, the cost of raw materials necessary for experimental production is all or substantially all attributable to the prosecution of SR&ED. This includes the cost of material consumed and the cost of material transformed into the experimental product. Other costs directly related and incremental to SR&ED will qualify for the SR&ED tax incentive. When the proxy method is used, the costs of materials consumed in the prosecution of SR&ED can be claimed, but no overhead expenditures as these costs are replaced by the prescribed proxy amount.

6.2 Experimental production in a commercial facility is eligible if it is necessary to resolve the scientific or technological uncertainties in achieving a scientific or technological advancement. With the traditional method for claiming overhead expenses (see Reference [1]), the salary will be considered to be “all or substantially all” attributable to the prosecution of SR&ED. With the proxy method however, the salary will be an allowable SR&ED expenditure only if the employee is directly engaged in the experimental production. Excluded work, if any, is not allowable.

6.3 A claim for SR&ED work that was carried out in a production setting should identify the SR&ED component of each run, the incremental costs incurred, and the knowledge acquired in the run. The recommended approach for allocation of costs to shop floor SR&ED work is outlined in 6.4 below, and an example is provided in 6.5.

6.4 Allocation of Costs for Shop Floor SR&ED:

The following methodology should be followed when allocating expenditures associated with shop floor SR&ED:

- Labour costs for employees performing the experimental production that was necessary is all or substantially all attributable to the prosecution of SR&ED, under the traditional method. If the proxy method is used, the employee must be directly engaged in performing the experimental production. Overhead costs are only allowable under the traditional method if they are directly related to the prosecution of SR&ED and they are incremental.
- Not all labour (e.g., the labour used in putting the product into a saleable state) will be directly attributable to the prosecution of SR&ED.
- In the traditional method, the costs of materials necessary for the experimental production is all or substantially all attributable to the prosecution of SR&ED. This is because the materials are consumed or transformed in performing the tests [2].
- In the proxy method, only the costs associated with materials consumed can be claimed. Materials transformed cannot be claimed [1, 2].
- The Technical Reviewer’s report should describe why the experimental production was required as part of the SR&ED project and whether the

materials used for testing are commensurate with the needs, and directly in support, of the SR&ED.

- Unless there are specific comments on the project in the Technical Reviewer's report, there is no technical basis for disallowing the costs of materials or project work related to experimental production.
- There will be full or partial recapture of ITC relative to materials when the experimental production is sold. There is no recapture on SR&ED salaries and SR&ED overheads incurred by the claimant. Also see Reference [3].

6.5 Example for Allocation of Costs for Shop Floor SR&ED

This is to demonstrate the type of backup information that is needed to support SR&ED claims. A normal project description in the claim would not have this level of detail.

Project Description:

A series of 30 shop-floor experiments were done on a mixed hazardous and radioactive aqueous waste stream, to determine if this waste type could be treated with membrane technologies (microfiltration and reverse osmosis). The use of membranes for this type radioactive waste is a new and untested application of the technology, and would represent a technological advance in the company's business environment.

Experienced engineers on staff systematically investigated the effects of several process parameters by means of a sequence of thirty experiments. This work included the investigation of the effects of liquid backwash frequencies and liquid cross flow velocities on clean water permeation rates and various contaminant removal efficiencies. The experimental results were documented in a system logbook by the two process operators, and a final report was prepared by two process engineers.

It was unclear if the envisioned treatment technology could produce an effluent quality that met all required Canadian discharge guidelines for hazardous substances. There were also technological uncertainties associated with the processing of this liquid waste with each membrane system (microfiltration and reverse osmosis). Finally, there was also system uncertainty associated with treating the waste by the multi-stage integrated treatment scheme.

The project met the definition of SR&ED since all three criteria were satisfied.

Work Claimed:

Based on the above project description, the following work was claimed as SR&ED:

1. Staff engineers planned a series of thirty experiments. Design of the experiments required 5 hours of various engineers' time.

2. One hundred hours of time was charged by each of the 2 process operators to set up the equipment with the new settings and process configurations. A total of 40 new membrane elements were installed for the experiments; the existing 40 (which were consumed) were disposed of. Engineers made the decision that if the membrane elements were not spent after the experiments, they would continue to be used for commercial runs.
3. The thirty experiments lasted 20 hours each for a total run time of 600 hours. Prior to each run the equipment was flushed for 2 hours with 1000 L of membrane cleaning solution. Each of two operators was claimed for 660 hours.
4. After the final experimental run the engineer instructed the two operators to let the equipment run in steady-state mode for another 40 hours, during which the waste was routinely treated. The steady-state operation was carried out after all technological uncertainties associated with the experiments had been resolved.
5. At the end of the last experiment, engineers determined that only one bank of 20 membrane elements had to be discarded as radioactive waste. A dated photograph of the discarded membrane elements was retained as supporting information for a SR&ED claim. The other 20 elements of the membrane bank showed no significant radiation damage upon inspection, so they were subsequently reused for commercial application. The process equipment was cleaned of process impurities and prepared for the production run. This took another 7.5 hours of each operator's time.
6. The engineering team analyzed all results, and a report issued, which required about 15 hours.

Assumptions:

1. New membrane elements cost $1000 per element. Since the process equipment (microfiltration and reverse osmosis plants) was used for commercial purposes (>90% of the time), it was not claimed as SR&ED.
2. Engineers decided to recycle the spent membrane cleaning solution (see Activity 3) back to the feed tank for further processing at a later time, and it was not claimed as an SR&ED expense.
3. The company claims overheads using the proxy method.
4. The following rates (excluding overheads) for staff were used in the calculation of SR&ED expenditures:

   Engineer: $45/hour
   Operator: $30/hour

Analysis of SR&ED Work to be claimed:
The following can be claimed based upon the activities listed in the example above:

Activity 1:
Engineer's time for planning experiments:

5hours * $45/hour = $225

Activity 2:
Operators' time for setting up equipment
2 operators *100 hours * $30/hours = $6000

Activity 3:
Operators' time for running experiments
2 operators * 660 hours * $30/hour = $39600

Activity 4:
Operators' time for routine processing
2 operators *40 hours * $30/hour = $2400

Activity 5:
Operators' time for changing elements and flushing system
2 operators * 7.5 hours * $30/hour = $450

Activity 6:
Engineer's time for analyzing results
15 hours * $45/hour = $675

Summary of SR&ED Work Allowable:

Capital: Membranes (only 20 can be claimed for SR&ED since the other 20 were used for commercial purposes). Therefore:
Capital = (40 – 20) elements * $1000/element = $20,000

Labour: Note that Activity 4 is routine operations for the staff and must be removed from the claim. Therefore:
Total Labour (Activities 1-6) = $225 + $6000 + $39600 + $2400 + $450 + $675

Claimed Labour = $49350 (total) – $2400 (activity 4) = $46950

No materials were consumed.

Overhead expenditures via Proxy Election = $46950 * 0.65 = $30517.50

7. EXCLUDED WORK AND COSTS

The following work and related expenditures cannot be claimed as SR&ED:

7.1. SR&ED work conducted outside Canada

For further details see IT–151R5: Scientific Research and Experimental Development Expenditures [1].

7.2 Cost of materials not used in SR&ED

7.3 Commercial utilization or production activities

7.4 Other Excluded Work:

The definition of SR&ED excludes work for the following:

- market research or sales promotion,

- quality control or routine testing of materials, devices, products or processes,
- research in the social sciences or the humanities,
- prospecting, exploring or drilling for, or producing, minerals, petroleum or natural gas,
- the commercial production of a new or improved material, device or product or the commercial use of a new or improved process,
- style changes, or
- routine data collection.

8. PREPARING A DETAILED PROJECT DESCRIPTION (CANADA CUSTOMS AND REVENUE AGENCY FORM T661, PART 2 Steps 1 and 2)

8.1. The scientific/technical personnel directly involved in the work should compile the supporting information for the project. These individuals should be available for discussions if Canada Customs and Revenue Agency requires a technical review.

8.2. A brief company profile will help show the relevance of the R&D project to your business.

8.3. Variations in presentation included in this guidance document (for example, see Part 2 Step 2.E.) demonstrate the flexibility in reporting format using real life examples.

8.4 A 2 –5 page summary of each project should be appended to the T661 form. The material on the following pages is intended to provide some models for the format of these attachments. Using the suggested format should expedite the claim.

Part 2 Steps 1 and 2 of the form may be presented in the following manner:

Part 2 Step 1 – Project Summary Information

Step 1.A. Project List (See Appendix B for cost of materials, supplies and labour)

Project Code: 93100 (continuing project)
Project Name: Optimize DA Catalyst Recipe for Consistency Improvements
Start Date: January 1, 1993 End Date: June 30, 1996
Total Labour Cost: $120,000 (for current tax year)
Raw Material Consumed: $0 (for current tax year)

Project Code: 93101 (continuing project)
Project Name: Development of an In-Situ FTIR Analyzer
Start Date: June 30, 1993 End Date: December 31, 1997
Total Labour Cost: $100,000 (for current tax year)
Raw Material Consumed: $0 (for current tax year)

Project Code: 93102 (continuing project)
Project Name: Understanding the fundamentals of glob formation in HDPE
Start Date: September 1, 1993 End Date: December 31, 1997
Total Labour Cost: $45,000 (for current tax year)
Raw Material Consumed: $10,000 (for current tax year)

Project Code: S-251-3 (continuing project)
Project Name: Release Coatings
Start Date: July 1997 End Date: June 1998
Total Labour Cost: $19,736 (for current tax year)
Raw Material Consumed: $422,402

Project Code: 4322 (continuing project)
Project Name: Polymer Manufacturing Trial
Start Date: July 10, 1998 End Date: July 9th, 1999
Total Labour Cost: $15,000 (for current tax year)
Raw Material Consumed: $70,000 (for current tax year)

Project Code: 4321 (continuing project)
Project Name: New XC Catalyst Shop Floor Trial
Start Date (plant trial portion only): August 22,1998 End Date: August 24,1998
Total Labour Cost: $25,000 (for current tax year)
Raw Material Consumed: $150,000 (for current tax year)

Step 1.B. Capital Expenditures (See Appendix C)

Step 1.C. Personnel (See Appendix A)

8.4 (cont.)

Part 2 Step 2 - Detailed Project Descriptions

Project 93100: (continuing project)
The goal of this on-going project is to minimize catalyst batch-to-batch variability in order to increase the consistency of our resin. This will be achieved through the development of a correlation between catalyst fabrication conditions and HDPE powder properties. For each batch the plant catalyst is tested on the lab-scale reactor. The powder properties (e.g. catalyst efficiency, bulk density, and powder morphology) will be correlated to the catalyst fabrication conditions. The information will be used to: (a) eliminate Lab Scale Reactor testing of catalyst batches by R&D personnel; (b) determine whether a batch is "in control" with respect to parameters of interest; if out of control, the batch will be scrapped; (c) predict the effect of catalyst batch on reactor operation and powder-drying system; (d) develop specific plans for improvements to catalyst fabrication hardware.

Project 93101: (continuing project)
The purpose of this project is to design and develop a quasi-portable, multi-purpose FTIR on-line analyzer, suitable for the plant environment, and adaptable to perform many different types of analyses. The project required a design that would allow the analyzer to be deployed in a wide variety of shop-floor settings including: i) radioactive slurry waste; ii) hazardous chemical waste; iii) oily mixed waste; and iv) multi-phase emulsions. The development of the FTIR went through several design iterations.

Project 93102: (continuing project)
In high-density polyethylene, cross-linked degraded polyethylene "globs" can be formed in our customer's blow moulding extruders causing considerable rejects and possible severe leaking problems. We studied the mechanisms of glob formation and measured the performance of various antioxidants to reduce the tendency to form globs using a systematic factorial design experimental approach. The majority of the globs were identified as degraded lightly cross-linked polyethylene by spectroscopic techniques.

Project S-251-3: (continuing project)
Our company manufactures and sells liquid materials that are used as release agents for the surface coating of films and specialty papers using a wide range of adhesive materials. In this project, a new type of release agent called "Reli-Tech XX" is being developed. Reli-Tech is intended to be used on ceramic surfaces, an application that our company had not attempted previously. Pilot plant studies were undertaken in the first half of 1997. Following the completion of the pilot plant studies, it was determined that full scale trials in the production plant would be necessary to evaluate the performance of the new release agent under various operating conditions. This evaluation was carried out in the period from mid 1997 to mid 1998. The project is now complete.

Project 4322: (continuing project)
This trial is a part of a multi-trial project aimed at increasing the knowledge of the effects of operating parameters (such as mixing rate, temperature, pressure), design (such as baffling), and control on polymer properties and end-use. It is expected that

about 10 trial runs (in total) will be required to gain adequate knowledge to enable our company to develop a new polymer production process. Although the actual trial lasted for only three days (Feb. 10-13, 1999), planning and pre-trial work has been carried out and charged to this SR&ED project since July 1998. The new polymer process technology and design represents the culmination of many hours of work from many different contributors across XXYY, including XXYY Research, Licensing and engineering resources.

Project 4321: (continuing project)
The XC catalyst is a new catalyst developed at the XXYY Research and Development Center. The PC catalyst, which is being used currently in the plant, is based on a different chemistry. The XC catalyst is made in a multi-step process that differs significantly from the process used to make the PC catalyst. XC is fully compatible with PC, although they have different responses. The XC-catalyst process seems to run well under research conditions and scale-up conditions. This is the first plant trial using this new catalyst. Although the actual trial lasted for only three days (Aug. 22-24, 1998), planning and pre-trial work has been carried out and charged to this SR&ED project since August 1997.

8.4 (cont.)

Part 2 Step 2.A. Scientific/Technological Objectives

What are the scientific or technological objectives, in quantitative or verifiable terms of the work you are claiming?

Project 93100:
The primary objective this year for this on-going multi-year project was to experimentally develop new and improved analytical procedures for the chemical analysis of various metals in 2A and DA catalyst systems. A secondary objective was to successfully deploy a fibre optics probe and commission a new lab-scale reactor. The experimental work will require the application of these sophisticated tools to develop an empirical correlation between plant catalyst preparation conditions and polymer properties. This is the first such study of its kind in the shop-floor environment (see Activities).

Project 93101:
The objective was to design and develop an FTIR analyzer sufficiently robust that it can handle a wide variety of process effluent streams and sludge from the plant, on-line. The unit must be capable of on-line measurement in the presence of significant quantities of suspended impurities including colloidal particles, fine particulate matter, and oily-water emulsions. When a new successful application is discovered, the on-line process analyzer could be installed to give the plant new process information suitable for the plant environment and adaptable to perform many different types of analyses. A key objective is to move the analyzer from place to place in order to perform plant in-situ analytical studies.

Project 93102:
Since the mechanisms of glob prevention and elimination are also not well understood, the objective of this work is to explore the fundamentals of glob formation. This also includes the characteristics of our HDPE products that increase the tendency to form globs. Another objective is to develop a new HDPE resin with an alternative antioxidant package, to reduce the tendency to form globs.

Project S-251-3
The objective of this study was to develop a new type of liquid coating release agent for use on ceramic surfaces. The surface properties of ceramic are substantially different from those of substrates such as paper or plastic films with which our company is conversant. The scientific or technological advancement objective sought in this project was primarily the development of a chemical product that would yield a satisfactory coating on a ceramic substrate, and secondly the development of a process for manufacturing this material on our existing facility.

Project 4322
The first objective of the trial is to determine the process and reactor mixing factors affecting the molecular weight of the polymer produced and its subsequent effect on product end-use performance. The second objective of the 3-day trial will be to conduct process step-change tests to develop Advanced Process Control models. There will be

several other trials necessary to complete the models and to develop a clear understanding of the technology.

Project 4321:
The main objectives for the first series of trials are to determine the process parameters on the shop floor necessary for making polymer products with the new XC catalyst system. This includes the experimental determination of the properties and concentrations of catalyst to be used in the shop-floor system.

The objective was achieved in several stages. In the first set of experiments, the XC catalyst was varied from 0 to 100%, while samples of transition material were collected to see if catalyst blends produced suitable end products. If the schedule were to permit it, there would be a transition to produce a second product; if not, the time would be used to ensure production of the first product.

8.4 (cont.)

Part 2 Step 2.B. Scientific/Technological Advancement

Project 93100:
Results from this project have provided us with a better understanding of which catalyst fabrication conditions (such as metal ratio, zinc concentration, OH/Cl ratio) would have an impact on the powder properties of interest (i.e. Catalyst efficiency, bulk density, and powder morphology).

The information garnered from the various control charts was successfully used to plan the following year's R&D and Manufacturing activities, e.g. new meters for catalyst raw material metering, increase frequency of side stream analysis, refinements to catalyst database, etc. In addition, the preliminary database was used to successfully predict V100 efficiency and powder morphology, which is a significant technology advance within the company. We also learned that coarse lab scale reactor powders often resulted in drying problems within the plant based on the study that showed correlations between various powder parameters and drying properties.

Project 93101:
Although FTIR technology is well known, the method has not previously been demonstrated for non-ideal waste solutions in the production setting which introduces numerous additional challenges.

In this study the engineers have successfully designed and developed an on-line FTIR analyzer that for the first time can analyze virtually any type of process waste or oily-water emulsion. Even in the presence of large quantities of particulate, colloidal material, and radiation fields, the unit has yielded correct analytical results with 95% confidence.

The company developed a new method for using the multi-purpose FTIR analyzer in the plant environment. This capability allowed engineers to research new and previously untried FTIR applications in the shop-floor environment. These new test methods have provided plant personnel the ability to acquire new process information, which helps to better understand fundamental processes.

Project 93102:
We now know the chemical composition of the globs, and the process conditions under which they are favoured. Our new package of antioxidants and various other additives, which we have developed experimentally in-house, has been successful in the prevention of these globs, and has minimized the substantial quantity of rejects which were previously the norm. From a scientific point of view the mixture eliminates the tendency of the polyethylene to cross link in the customer's extruders.

Project S-251-3:
We will better understand the mechanism for the different interactions of chemical ingredients and process parameters which determine several properties such as viscosity, level of reactive functional groups, and product colour in this class of release coatings. The work will also provide us with the optimal process parameters to allow the material to be made in our facility. The developed process, which will be capable of accommodating the re-cycling of recovered volatiles, will reduce production cost and eliminate disposal charges.

Project 4322:
The effects of process temperature, pressure, reactor baffling, and mixing rate on the polymer product properties are now known. Mathematical semi-empirical models have been developed based on the experimental data that allows the engineers to predict the molecular weight of the resultant polymer produced with 95% confidence. Advanced process control models have also been developed which now gives us the capability to preemptively control the process in a superior fashion.

Project 4321:
This plant trial has advanced our knowledge with respect to the actual properties and behavior of the XC catalyst system for the production of specialty polymers in comparison with existing blends of LLDPE and LDPE. We have been able to accurately define the process conditions necessary for the production of a variety of polymer products using this new catalyst based upon the plant trial. Results from this and other shop floor trials have provided data from pilot-scale runs to enable rigorous quantification of hydrogen response, optical properties, melt strength, and processability with this new XC catalyst process.

8.4 (cont.)

Part 2 Step 2.C. Scientific/Technological Uncertainty

Project 93100:
From a technological point of view, it was not clear which catalyst fabrication conditions (such as metal ratio, zinc concentration, OH/Cl ratio) would have an impact on the powder properties of interest (i.e. Catalyst efficiency, bulk density, and powder morphology) or if there would be any statistically significant correlation of value for an empirically-based mathematical model.

Project 93101:
The application of FTIR technology in the manufacturing environment introduces many technical challenges, none of which had previously been addressed. The effects of colloidal dispersions, oily water emulsions, fine radioactive particulate material, and strong radiation fields on the performance of the on-line analyzer were all unknown. There was no prior data on which the designs for the analyzer could be based.

The combination of the harsh operating environment and the technical expectations of the equipment introduced numerous technical uncertainties as to whether the FTIR application could work at all, or partially, in the shop-floor environment. In addition, it was uncertain if the equipment would operate consistently when it was operated in a quasi-portable manner.

Project 93102:
It was technically uncertain which of the following variables: i) catalyst type and concentration, ii) reactor conditions, iii) antioxidant packages, and iv) co-monomer concentrations, led to the peculiar glob formation that was unique to our high-density blow moulding resin. There were many potential sources that could be responsible for the tendency to form globs in customer's extruders; our competitor's resins did not show the same tendencies, and it was necessary to isolate the root cause through trial runs.

Project S-251-3:
Standard practice in our industry did not include knowledge of what the constituents of this type of release agent would have to be, or the process to be used to manufacture it using our existing production facility.

Modification to our existing manufacturing practice would be required and we did not know which of the various parameters such as concentration of reactants and additives, the type and loading of catalysts and temperature and pressure conditions would be optimum for the production of the material.

Project 4322:
Although the effects of various process conditions on this polymer's performance have been studied at the pilot scale, the impact of process scale-up on these responses has been shown to be significantly different based on our experiences in the plant setting. In particular, the effect of impeller rotation rate and baffling arrangements in the reactor introduces new variables that cannot be predicted from the pilot data. Since the new process has different process responses, it is technically unclear what new control strategies and models will be required until experimental data can be obtained from these plant trials. It is clear, however, that the conventional closed loop control strategies used in the pilot-scale system will not work on the shop floor.

Project 4321:
Since the XC process has never been run in the plant, there were many technical uncertainties related to how well the new catalytic process would scale up in terms of the types and quality of the products that were produced. In addition, preliminary

results had shown that the new XC catalyst type could adversely affect the yield of the desired product type.

It was also not clear if hexane extractables might exceed safe limits. Finally, there existed the very real possibility of chunk formation in the reactor that could result in numerous hours, and perhaps days of down time. Furthermore, the characteristics of the transitional material are unclear.

8.4 (cont.)

Part 2 Step 2.D. Project Activities *(Note that activities described below may not all qualify as SR&ED; for allowability of specific expenditures, refer to Chemicals Guidance Document 2 – Qualifying Work)*

Project 93100:
Major Activities
- plant catalyst tested on the new lab scale reactor
- powder properties (I2, I10 and bulk density) were control charted using a computer program
- catalyst preparation conditions (i.e. metal ratio, Zn concentration, OH/Cl ratio) were also control charted
- a preliminary correlation was developed
- improvements were made to the sampling system
- manufacturing installed a new meter to control the alkyl halide addition
- lab scale reactor bulk density and powder morphology information was used to predict drying problems in the unit

Other Activities
- safety training conducted on new systems
- safe operating procedures documentation written
- The project is now complete and no further activities are planned.

Project 93101:
Major Activities
- design for the analyzer was developed
- experimental study to determine how well the unit would perform for different waste types
- instrument designed and auxiliary equipment ordered
- review available commercial software that could be altered to fit this application
- software developed to operate the analyzer

Other Activities
- work in conjunction with electrical engineering to determine cost and assembly of instrument
- prepare safe operating procedure for analyzer
- conduct safety training for appropriate personnel
- scope potential clients within global company for analyzer

Project 93102:
Major Activities
- tests were developed to measure or predict the tendency of HDPE resins to form globs
- the nature of the globs themselves was examined
- the mechanisms of the formation of the globs were studied
- an experimental run in the HDPE plant was conducted
- the resin processing and performance characteristics were measured

- the tendency toward glob formation was examined on our blow moulding machines and at several customer accounts

Other Activities
- schedule "downtime" at HDPE for experimental run
- assign experimental numbers for samples run at HDPE
- create MSDS for trial product
- write specifications for blow moulding applications.

Project S-251-3:
Major Activities
- Ensure compliance with Canadian Environmental Protection Act (CEPA)
- Assign resource numbers for raw materials and trial product
- Assign specifications for raw materials and trial product
- Create material safety data sheets (MSDS) of trial product
- Create drumming label text
- Draft a trial manufacturing procedure
- Review process safety guidelines
- Review process hazard and operability (HAZOP)
- Review meeting responsible care codes requirements
- Trial manufacturing procedure finalized
- Initiate a process for new product introduction
- Required raw materials for intended batch size(s) purchased.
- Production operators trained to carry out experimental procedures consistent with company policy.
- Batch(es) scheduled using identified plant reactor(s)

Other Activities
- In early stages of plant trials we found that the quantities of raw materials charged were not properly balanced as the viscosity of finished material was outside desired specification range.
- We found that through re-balancing the charge formulation, we successfully could control the product viscosity.
- Colour in the product was not acceptable. Our investigations showed that colour development could be triggered by air leak in reactor. Once air leak was sealed, our colour problem resolved.
- We were able to analyze and quantify the concentration of each component in the recovered volatiles. Through proper adjustment of charge formulation we successfully managed to re-cycle all recovered volatiles collected from one batch into the next without having any effect on quality and/or performance of the product.

Project 4322:
Major activities
- Address all resource issues: materials, manpower, and technical assistance
- Product testing at XXYY Research facilities
- Produce a series of resins using a pre-determined catalyst and process conditions

- Vary temperature and observe the effect on product molecular weight distribution (MWD) and density. Adjust reaction conditions to maintain product specification. Sample for product testing at XXYY Research facilities
- Vary mixing rate and observe the effect on product MWD and density. Adjust reaction conditions to maintain product specification. Sample for product testing at XXYY Research facilities
- Vary baffle design and observe the effect on product MWD and density. Adjust reaction conditions to maintain product specification. Sample for product testing at XXYY Research facilities
- Conduct process control step tests, allowing product spec to vary.
- In this test considerable quantities of non-prime polymer will be produced to evaluate and reduce the outstanding technical uncertainties associated with the new technology.

Other activities
- Review process hazard and operability (HAZOP)
- Review meeting Responsible Care® codes requirements
- Review process safety guidelines
- Prepare reaction contingency plans
- Prepare a set of experimental operating instructions
- Create material safety data sheets (MSDS) for the trial product
- Identify potential markets and customers for trial product
- Assign specifications for raw materials and trial product

Project 4321:
Major activities
- Address all resource issues: materials, manpower, and technical assistance.
- Carry out a sequence of experiments with XC catalyst varying between 0% and 100%.

Other activities
- Ensure that meeting Canadian Environmental Act (CEPA)
- Review process hazard and operability (HAZOP)
- Review meeting responsible care codes requirements
- Review process safety guidelines
- Prepare reaction contingency plans
- Prepare a set of experimental operating instructions
- Create material safety data sheets (MSDS) for the trial product
- Assign specifications for raw materials and trial product

8.4 (cont.)

Part 2 Step 2.E. Supporting Information

Project 93100:
The data is summarized in the following lab books: CLB 1234, CLB 1235, CLB 1236, and CLB 1237. An internal propriety research report #1111 was issued at the end of the project.

Project 93101:
Much of the information is contained in the project files. This includes correspondence, design specifications, mathematical models, computer algorithms, schematics, etc. as well as a prototype of the analyzer.

Project 93102:
Quality Action Task Force Meeting minutes, Report of Call reports.

Project S-251-3:
- Documents listed under project activity
- Plant batch sheets of trial product
- Laboratory work completed reports
- Monthly highlight reports

Project 4322:
- Documents listed under methodology
- Plant log books
- Internal company reports

Project 4321:
- Selected internal company reports
- Selected documents listed under methodology.

9. GLOSSARY OF TERMS USED IN THIS GUIDANCE DOCUMENT

Some of the terminology used in this guidance document is provided below. Some other terms are also defined here for completeness.

Activity
An activity is a small increment of work within a project. The activity is usually the lowest level of accountability, and can refer to a technical specialty or process. It clearly defines the specific work performed, and can be attached to a specific individual or piece of equipment. Within the context of this guidance document, the SR&ED work is comprised of a series of inter-related activities. Assessment of eligibility for ITC purposes is made at the *"project"* level, not at the *"activity"* level.

Business environment
Business environment characteristics include business size, competition, area of industry, and access to technical resources. For example, an enterprise may not have practical access to information proprietary to a competitor, or known in specialist or academic circles.

Commonly available sources of knowledge or experience
Commonly available sources of knowledge or experience are those that can reasonably be assumed to be readily available to those with basic training or experience in the field of concern. These resources enable them to be sufficiently qualified to participate in scientific research and experimental development. They also include knowledge that is available in the business context of the firm. See also the Glossary entry on "Business environment."

Commercial production
Commercial production is the set of activities associated with the production of products, and it is expected that a profit will be made.

Custom Product/Commercial Asset
Assets resulting from SR&ED projects that could, at the onset of the project, reasonably be expected to be sold, i.e. a custom product, or used in the claimant's business, i.e. a commercial asset.

Directly in support
An activity is considered to be directly in support of scientific research and experimental development when it is reasonable to believe that the activity is required to carry out the scientific research and experimental development. That is, it has been shown to be an integral part of the systematic investigation of a problem, and is required in the search for a theoretical or practical solution.

Experimentation
Experimentation is an act or operation designed to discover, test, or illustrate a truth, principle, or effect – to make a test or trial.

Experimental Production

Experimental production means the output from the testing of an experimental process to verify whether or not the technological objectives are met.

Hypothesis
A hypothesis is a tentative supposition with regard to an unknown state of affairs, the truth of which is thereupon subject to investigation by any available method, either by logical deduction of consequences which may be checked against what is known, or by direct experimental investigation or discovery of facts not hitherto known and suggested by the hypothesis (McGraw-Hill, *Concise Encyclopedia of Science and Technology*).

Incremental
Increment is the level of small improvement or "continuous improvement" by which a machine or piece of equipment can be improved (as opposed to radical improvement).

Market research
Market research includes (but not exclusively) surveys to determine consumer attitudes to existing products, or to possible new products.

The research, for example, examines such factors as buying habits, use of leisure time, consumer needs or wants, and attitudes towards existing products and new products being test-marketed. Sales promotion is the selling activity that supplements advertising and personal selling, co-ordinating them, and making them effective.

Meaningful advance
A meaningful advance means the generation of new knowledge that reduces scientific or technological uncertainty. Note that this can be negative (i.e., the sought result could not be achieved) or positive, in which case the advance is embodied in the resulting process or products or in new knowledge. See also the Glossary entry on "Systematic investigation or search."

Pilot Plant
A pilot plant is a non-commercial scale plant in which processing steps are systematically investigated under conditions simulating a full production unit. The purpose of a pilot plant is to obtain engineering and other data needed to evaluate hypotheses, write product or process formulae, establish finished product technical specifications, or design special equipment and structures required by a new or improved fabrication process.

Project
A SR&ED project consists of a set of interrelated activities that meet the three criteria of SR&ED. Assessment of eligibility for ITC purposes is made at the *"project"* level, not at the *"activity"* level.

Prototype
A prototype is an original model on which something new is patterned, and of which all things of the same type are representations or copies. It is a basic experimental model possessing the essential characteristics of the intended product.

Routine Data Collection
Routine data collection can be characterized by the collection of data using repetitive, standardized procedures or protocols, seeking to establish whether parameters are within the usual boundaries. An example is the type of data collection that occurs in everyday commercial operations, where the primary objective of such analyses is product or process monitoring to demonstrate adherence to specifications, supervision of processes, and control of finished product characteristics. The costs of collecting such data do not qualify.

For activities associated with collecting or monitoring data to qualify, the data must be collected directly for the purpose of resolving a scientific or technological uncertainty associated with an allowable activity.

Social sciences
The social sciences include (but not exclusively) economics, geography, law, management, political science, and sociology. The humanities include, for example, art, philosophy, languages, history, and religion. Psychology is also a social science, but psychological research is not an excluded activity when it is undertaken directly in support of basic research, applied research, or experimental development.

Shop floor SR&ED: Work taking place in a production or manufacturing environment, that meets the 3-criteria for SR&ED.

Style change
Style change means changing the physical appearance or arrangement of an article without altering its utility, efficiency, function, or operating characteristics.

Systematic investigation or search
Systematic investigation or search is the use of a method that usually includes scientific or technological problem definition, hypothesis formulation, experimental tests, and deduction and conclusion to arrive at new or improved products or processes, or expanded knowledge. It includes analyses through physical, chemical, or biological experimentations, mathematical or computer simulations, or other analytical techniques.

System uncertainty
System uncertainty is recognizing that combinations of technologies, the components of which are generally well known, frequently carry a risk of failing to perform to acceptable standards. Thus, while each individual technology is known, the results of interactions among them as a whole may not be known, and must be determined by a program of systematic investigation to determine the results of such interactions.

Trouble-shooting
Trouble-shooting is routinely correcting equipment or processes by identifying problems. The goals may be to optimize a process in both the technical or economic sense, to adjust equipment performance or to evaluate it during breakdowns, improve working conditions, minimize production losses, or to control the generation and disposal of wastes.

Trouble-shooting occasionally brings out the need for further scientific research and experimental development, but more frequently it involves detecting faults in equipment or processes, and results in minor modifications of standard equipment and processes. Such detection and modification is not scientific research and experimental development.

10. REFERENCES

[1] IT-151R5: "Scientific Research and Experimental Development Expenditures";
http://www.ccra-adrc.gc.ca/E/pub/tp/it151r5em/it151r5-e.html

[2] SR&ED 2000-01: "Costs of Materials for SR&ED";
http://www.ccra-adrc.gc.ca/taxcredit/sred/sr200001-e.html

[3] "How to calculate the amount of investment tax credit (ITC) recaptured when a property is disposed of or converted to commercial use";
http://www.ccra-adrc.gc.ca/taxcredit/sred/recap-e.html

11. APPENDICES

Appendix A Personnel
Appendix B Materials, supplies and labour
Appendix C Capital equipment
Appendix D Chemical Industry and Canada Customs and Revenue Agency Joint Committee Membership
Appendix E Detailed Project Descriptions (Consolidated)

APPENDIX A

PERSONNEL in FTEs

Name	Academic Qualifications	Position	Years experience	93100	93101	93102	S-251-3	4322	4321
John Doe	B.Sc. Chem	Project Leader	12	0.5 PY					
Jane Doe	B.Sc. Chem	Research Leader	10	0.3 PY					
James Doe	Chemical Technologist	Technician	5	0.25 PY					
Jane Brown	B.Sc. Chem	Project Leader	15		0.6 PY				
Joan Brown	Instrument Mechanic	Instrumentation	20		0.3 PY				
Brad White	B.Sc. Chem Eng.	Project Leader	14			0.25 PY			
Gene White	B.Sc. Chem	Production Supervisor	23			0.1 PY			
Bill Black	High School grad	Operator	25			0.05 PY			
Fred Green	High School grad	Operator	26			0.05 PY			
James Bond	Ph.D. Chem.	Project Leader	21				0.05 PY		
Danny Brush	3-Year Comm. College Chem.	Senior Technician	19				0.01 PY		
Rodger Smith	2-Year Comm. College Civil Eng.	Operator	10				0.05 PY		
Andy Silver	3-Year Comm. College Civil Eng.	Operator	12				0.05 PY		
Mark Gold	High School grad	Operator	13				0.05 PY		
John Doe	Ph.D. Chem.	Project Lead	20					0.2PY	
Joe Max	Ph.D. Chem.	Sr. Project Scientist	15					0.1PY	
J. Doe	Ph.D. Chem.	Lead Scientist	22						0.2PY
J. A.	Ph.D. Chem. Eng.	Lead Engineer	18						0.1PY
J. B. Doe	B.Sc. Chem	Lead Chemist	12						0.05PY
J. C. Doe	Chemical Technologist	Technologist	8						0.05PY

Note: PY = person year

APPENDIX B

COST OF MATERIALS, SUPPLIES & LABOUR

All values CDN$

Project Code	93100	93101	93102	S-251-3*	4322	4321
Items						
Lab supplies	0				5,000	1,000
Meter	0					10,000
Software		0				2,000
Electronic parts		0				5,000
Raw materials			10,000	422,402	70,000	150,000
Totes				18,676	20,000	
Labour	120,000	100,000	45,000	19,736	15,000	25,000
Product disposed in trial production run	0	0	0	0	0	0

* Total cost of 10 batches

APPENDIX C

COST OF CAPITAL EQUIPMENT

Project Code	93100	93101	93102	S-251-3	4322	4321
Items						
Item A*	10,000					
Item B*	23,000					
Item C*		45,000				
Item D**			18,000			
Item E**			25,000			
Equipment				0		
Item X					100,000	
Item Y						193,000

*All or substantially all
**Shared use

APPENDIX D
SR&ED TAX CREDIT WORKING GROUP

Chair:

Mr. Ken Gilroy	519-339-4257	Tel
Technical Dir.-Eastern Canada R&D	519-339-3657	Fax
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APPENDIX E
DETAILED PROJECT DESCRIPTIONS (CONSOLIDATED)

PROJECT 93100: OPTIMIZE DA CATALYST RECIPE FOR CONSISTENCY IMPROVEMENTS

Part 2 Step 1 – Project Summary Information

Step 1.A. - Project List

Project Code: 93100 (continuing project)
Start Date: January 1, 1993 End Date: June 30, 1996
Total Labour Cost: $120,000 (for current tax year)
Raw Material Consumed: $0 (for current tax year)

Step 1.B. - Capital Expenditures

Capital Item	Cost
Item A	$10,000
Item B	$23,000

Step 1.C. - Personnel

Name	Academic Qualifications	Position	Years Experience	Time Allocation (PY)
John Doe	B.Sc. Chem	Project Leader	12	0.5 PY
Jane Doe	B.Sc. Chem	Research Leader	10	0.3 PY
James Doe	Chemical Technologist	Technician	5	0.25 PY

Part 2 Step 2 - Detailed Project Descriptions – (continuing project)

The goal of this on-going project is to minimize catalyst batch-to-batch variability in order to increase the consistency of our resin. This will be achieved through the development of a correlation between catalyst fabrication conditions and HDPE powder properties. For each batch the plant catalyst is tested on the lab-scale reactor. The powder properties (e.g. catalyst efficiency, bulk density, and powder morphology) will be correlated to the catalyst fabrication conditions. The information will be used to: (a) eliminate Lab Scale Reactor testing of catalyst batches by R&D personnel; (b) determine whether a batch is “in control” with respect to parameters of interest; if out of control, the batch will be scrapped; (c) predict the effect of catalyst batch on reactor operation and powder-drying system; (d) develop specific plans for improvements to catalyst fabrication hardware.

Part 2 Step 2.A. - Scientific/Technological Objectives

The primary objective this year for this on-going multi-year project was to experimentally develop new and improved analytical procedures for the chemical analysis of various metals in 2A and DA catalyst systems. A secondary objective was to successfully deploy a fibre optics probe and commission a new lab-scale reactor. The experimental work will require the application of these sophisticated tools to develop an empirical correlation between plant catalyst preparation conditions and polymer properties. This is the first such study of its kind in the shop-floor environment (see Activities).

Part 2 Step 2.B. - Scientific/Technological Advancement
Results from this project have provided us with a better understanding of which catalyst fabrication conditions (such as metal ratio, zinc concentration, OH/Cl ratio) would have an impact on the powder properties of interest (i.e. Catalyst efficiency, bulk density, and powder morphology).

The information garnered from the various control charts was successfully used to plan the following year's R&D and Manufacturing activities, e.g. new meters for catalyst raw material metering, increase frequency of side stream analysis, refinements to catalyst database, etc. In addition, the preliminary database was used to successfully predict V100 efficiency and powder morphology, which is a significant technology advance within the company. We also learned that coarse lab scale reactor powders often resulted in drying problems within the plant based on the study which showed correlations between various powder parameters and drying properties.

Part 2 Step 2.C. - Scientific/Technological Uncertainty
From a technological point of view, it was technically not clear which catalyst fabrication conditions (such as metal ratio, zinc concentration, OH/Cl ratio) would have an impact on the powder properties of interest (i.e. Catalyst efficiency, bulk density, and powder morphology) or if there would be any statistically significant correlation of value for an empirically-based mathematical model.

Part 2 Step 2.D. - Project Activities *(Note that activities described below may not all qualify as SR&ED; For allowability of specific expenditures, refer to Chemicals Guidance Document 2 – Qualifying Work)*
Major Activities:
- plant catalyst tested on the new lab scale reactor
- powder properties (I2, I10 and bulk density) were control charted using a computer program
- catalyst preparation conditions (i.e. metal ratio, Zn concentration, OH/Cl ratio) were also control charted
- a preliminary correlation was developed
- improvements were made to the sampling system
- manufacturing installed a new meter to control the alkyl halide addition
- lab scale reactor bulk density and powder morphology information was used to predict drying problems in the unit

Other Activities:
- safety training conducted on new systems
- safe operating procedures documentation written
- The project is now complete and no further activities are planned.

Part 2 Step 2.E. - Documentation or Supporting Physical Evidence
The data is summarized in the following lab books: CLB 1234, CLB 1235, CLB 1236, and CLB 1237. An internal propriety research report #1111 was issued at the end of the project.

PROJECT 93101: DEVELOPMENT OF AN IN-SITU FTIR ANALYZER

Part 2 Step 1 – Project Summary information

Step 1.A. – Project List

Project Code:	93101 (continuing project)		
Start Date:	June 30, 1993	End Date:	December 31, 1997
Total Labour Cost:	$100,000 (for current tax year)		
Raw Material Consumed:	$0 (for current tax year)		

Step 1.B. - Capital Expenditures

Capital Item	Cost
Item C	$45,000

Step 1.C. – Personnel

Name	Academic Qualifications	Position	Years Experience	Time Allocation (PY)
Jane Brown	B.Sc. Chem	Project Leader	15	0.6 PY
Joan Brown	Instrument Mechanic	Instrumentation	20	0.3 PY

Part 2 Step 2 - Detailed Project Descriptions (continuing project)

The purpose of this project is to design and develop a quasi-portable, multi-purpose FTIR on-line analyzer, suitable for the plant environment, and adaptable to perform many different types of analyses. The project required a design that would allow the analyzer to be deployed in a wide variety of shop-floor settings including: i) radioactive slurry waste; ii) hazardous chemical waste; iii) oily mixed waste; and iv) multi-phase emulsions. The development of the FTIR went through several design iterations.

Part 2 Step 2.A. - Scientific/Technological Objectives

The objective was to design and develop an FTIR analyzer sufficiently robust that it can handle a wide variety of process effluent streams and sludge from the plant, on-line. The unit must be capable of on-line measurement in the presence of significant quantities of suspended impurities including colloidal particles, fine particulate matter, and oily-water emulsions. When a new successful application is discovered, the on-line process analyzer could be installed to give the plant new process information suitable for the plant environment and adaptable to perform many different types of analyses. A key objective is to move the analyzer from place to place in order to perform plant in-situ analytical studies.

Part 2 Step 2.B. - Scientific/Technological Advancement

Although FTIR technology is well known, the method has not previously been demonstrated for non-ideal waste solutions in the production setting which introduces numerous additional challenges.

In this study the engineers have successfully designed and developed an on-line FTIR analyzer that for the first time, can analyze virtually any type of process waste or oily-water emulsion. Even in the presence of large quantities of particulate, colloidal material, and radiation fields, the unit has yielded correct analytical results with 95% confidence.

The company developed a new method for using the multi-purpose FTIR analyzer in the plant environment. This capability allowed engineers to research new and previously untried FTIR applications in the shop-floor environment. These new test methods have provided plant personnel the ability to acquire new process information, which helps to better understand fundamental processes.

Part 2 Step 2.C. - Scientific/Technological Uncertainty
The application of FTIR technology in the manufacturing environment introduces many technical challenges, none of which had previously been addressed. The effects of colloidal dispersions, oily water emulsions, fine radioactive particulate material, and strong radiation fields on the performance of the on-line analyzer were all unknown. There was no prior data on which the designs for the analyzer could be based.

The combination of the harsh operating environment and the technical expectations of the equipment introduced numerous technical uncertainties as to whether the FTIR application could work at all, or partially, in the shop-floor environment. In addition, it was uncertain if the equipment would operate consistently when it was operated in a quasi-portable manner.

Part 2 Step 2.D. - Project Activities *(Note that activities described below may not all qualify as SR&ED; For allowability of specific expenditures, refer to Chemicals Guidance Document 2 – Qualifying Work)*
Major Activities
- design for the analyzer was developed
- experimental study to determine how well the unit would perform for different waste types
- instrument designed and auxiliary equipment ordered
- review available commercial software that could be altered to fit this application
- software developed to operate the analyzer

Other Activities
- work in conjunction with electrical engineering to determine cost and assembly of instrument
- prepare safe operating procedure for analyzer
- conduct safety training for appropriate personnel
- scope potential clients within global company for analyzer

Part 2 Step 2.E. - Documentation or Supporting Physical Evidence
Much of the information is contained in the project files. This includes correspondence, design specifications, mathematical models, computer algorithms, schematics, etc. as well as a prototype of the analyzer.

PROJECT 93102: UNDERSTANDING THE FUNDAMENTALS OF GLOB FORMATION IN HDPE

Part 2 Step 1 – Project Summary Information

Step 1.A. – Project List

Project Code: 93102 (continuing project)
Start Date: September 1, 1993 End Date: December 31, 1997
Total Labour Cost: $45,000 (for current tax year)
Raw Material Consumed: $10,000 (for current tax year)

Step 1.B. - Capital Expenditures

Capital Item	Cost
Item D	$18,000
Item E	$25,000

Step 1.C. – Personnel

Name	Academic Qualifications	Position	Years Experience	Time Allocation (PY)
Brad White	B.Sc. Chem Eng.	Project Leader	14	0.25 PY
Gene White	B.Sc. Chem	Production Supervisor	23	0.1 PY
Bill Black	High School grad	Operator	25	0.05 PY
Fred Green	High School grad	Operator	26	0.05 PY

Part 2 Step 2 - Detailed Project Descriptions (continuing project)

In high-density polyethylene, cross-linked degraded polyethylene “globs” can be formed in our customer’s blow moulding extruders causing considerable rejects and possible severe leaking problems. We studied the mechanisms of glob formation and measured the performance of various antioxidants to reduce the tendency to form globs using a systematic factorial design experimental approach. The majority of the globs were identified as degraded lightly cross-linked polyethylene by spectroscopic techniques.

Part 2 Step 2.A. - Scientific/Technological Objectives

Since the mechanisms of glob prevention and elimination are also not well understood, the objective of this work is to explore the fundamentals of glob formation. This also includes the characteristics of our HDPE products that increase the tendency to form globs. Another objective is to develop a new HDPE resin with an alternative antioxidant package, to reduce the tendency to form globs.

Part 2 Step 2.B. - Scientific/Technological Advancement

We now know the chemical composition of the globs, and the process conditions under which they are favoured. Our new package of antioxidants and various other additives, which we have developed experimentally in-house, has been successful in the prevention of these globs, and has minimized the substantial quantity of rejects which were previously the norm. From a scientific point of view the mixture eliminates the tendency of the polyethylene to cross link in the customer’s extruders.

Part 2 Step 2.C. - Scientific/Technological Uncertainty
It was technically uncertain which of the following variables: i) catalyst type and concentration, ii) reactor conditions, iii) antioxidant packages, and iv) co-monomer concentrations, led to the peculiar glob formation that was unique to our high-density blow moulding resin. There were many potential sources that could be responsible for the tendency to form globs in customer's extruders; our competitor's resins did not show the same tendencies, and it was necessary to isolate the root cause through trial runs.

Part 2 Step 2.D. - Project Activities *(Note that activities described below may not all qualify as SR&ED; For allowability of specific expenditures, refer to Chemicals Guidance Document 2 – Qualifying Work)*
Major Activities
- tests were developed to measure or predict the tendency of HDPE resins to form globs
- the nature of the globs themselves was examined
- the mechanisms of the formation of the globs were studied
- an experimental run in the HDPE plant was conducted
- the resin processing and performance characteristics were measured
- the tendency toward glob formation was examined on our blow moulding machines and at several customer accounts

Other Activities
- schedule "downtime" at HDPE for experimental run
- assign experimental numbers for samples run at HDPE
- create MSDS for trial product
- write specifications for blow moulding applications.

Part 2 Step 2.E. - Documentation or Supporting Physical Evidence
Quality Action Task Force Meeting minutes, Report of Call reports.

PROJECT S-251-3: RELEASE COATINGS

Part 2 Step 1 – Project Summary Information

Step 1.A. – Project List
Project Code: S-251-3 (continuing project)
Start Date: July 1997 End Date: June 1998
Total Labour Cost: $19,736 (for current tax year)
Raw Material Consumed: $422,402

Step 1.B. - Capital Expenditures

Capital Item	Cost
Equipment	$nil

Step 1.C. – Personnel

Name	Academic Qualifications	Position	Years Experience	Time Allocation (PY)
James Bond	Ph.D. Chem.	Project Leader	21	0.05 PY
Danny Brush	3-Year Comm. College Chem.	Senior Technician	19	0.01 PY
Rodger Smith	2-Year Comm. College Civil Eng.	Operator	10	0.05 PY
Andy Silver	3-Year Comm. College Civil Eng.	Operator	12	0.05 PY
Mark Gold	High School grad	Operator	13	0.05 PY

Part 2 Step 2 - Detailed Project Descriptions (continuing project)
Our company manufactures and sells liquid materials that are used as release agents for the surface coating of films and specialty papers using a wide range of adhesive materials. In this project, a new type of release agent called “Reli-Tech XX” is being developed. Reli-Tech is intended to be used on a ceramic surfaces, an application that our company had not attempted previously. Pilot plant studies were undertaken in the first half of 1997. Following the completion of the pilot plant studies, it was determined that full scale trials in the production plant would be necessary to evaluate the performance of the new release agent under various operating conditions. This evaluation was carried out in the period from mid 1997 to mid 1998. The project is now complete.

Part 2 Step 2.A. - Scientific/Technological Objectives
The objective of this study was to develop a new type of liquid coating release agent for use on ceramic surfaces. The surface properties of ceramic are substantially different from those of substrates such as paper or plastic films with which our company is conversant. The scientific or technological advancement objective sought in this project was primarily the development of a chemical product that would yield a satisfactory coating on a ceramic substrate, and secondly the development of a process for manufacturing this material on our existing facility.

Part 2 Step 2.B. - Scientific/Technological Advancement
We will better understand the mechanism for the different interactions of chemical ingredients and process parameters which determine several properties such as viscosity, level of reactive functional groups, and product colour in this class of release coatings. The work will also

provide us with the optimal process parameters to allow the material to be made in our facility. The developed process, which will be capable of accommodating the re-cycling of recovered volatiles, will reduce production cost and eliminate disposal charges.

Part 2 Step 2.C. - Scientific/Technological Uncertainty
Standard practice in our industry did not include knowledge of what the constituents of this type of release agent would have to be, or the process to be used to manufacture it using our existing production facility.

Modification to our existing manufacturing practice would be required and we did not know which of the various parameters such as concentration of reactants and additives, the type and loading of catalysts and temperature and pressure conditions would be optimum for the production of the material.

Part 2 Step 2.D. - Project Activities *(Note that activities described below may not all qualify as SR&ED; For allowability of specific expenditures, refer to Chemicals Guidance Document 2 – Qualifying Work)*

Major Activities

- Ensure compliance with Canadian Environmental Protection Act (CEPA)
- Assign resource numbers for raw materials and trial product
- Assign specifications for raw materials and trial product
- Create material safety data sheets (MSDS) of trial product
- Create drumming label text
- Draft a trial manufacturing procedure
- Review process safety guidelines
- Review process hazard and operability (HAZOP)
- Review meeting responsible care codes requirements
- Trial manufacturing procedure finalized
- Initiate a process for new product introduction
- Required raw materials for intended batch size(s) purchased.
- Production operators trained to carry out experimental procedures consistent with company policy.
- Batch(es) scheduled using identified plant reactor(s)

Other Activities

- In early stages of plant trials we found that the quantities of raw materials charged were not properly balanced as the viscosity of finished material was outside desired specification range.
- We found that through re-balancing the charge formulation, we successfully could control the product viscosity.
- Colour in the product was not acceptable. Our investigations showed that colour development could be triggered by air leak in reactor. Once air leak was sealed, our colour problem resolved.
- We were able to analyze and quantify the concentration of each component in the recovered volatiles. Through proper adjustment of charge formulation we successfully managed to re-cycle all recovered volatiles collected from one batch into the next without having any effect on quality and/or performance of the product.

Part 2 Step 2.E. - Documentation or Supporting Physical Evidence

- Documents listed under project activity
- Plant batch sheets of trial product

- Laboratory work completed reports
- Monthly highlight reports

PROJECT 4322: POLYMER MANUFACTURING TRIAL

Part 2 Step 1 – Project Summary Information

Step 1.A. – Project List

Project Code: 4322 (continuing project)
Start Date: July 10th, 1998 End Date: July 9th, 1999
Total Labour Cost: $15,000 (for current tax year)
Raw Material Consumed: $70,000 (for current tax year)

Step 1.B. - Capital Expenditures

Capital Item	Cost
Item X	$100,000

Step 1.C. – Personnel

Name	Academic Qualifications	Position	Years Experience	Time Allocation (PY)
John Doe	Ph.D. Chem.	Project Lead	20	0.2 PY
Joe Max	Ph.D. Chem.	Sr. Project Scientist	15	0.1 PY

Part 2 Step 2 - Detailed Project Descriptions (continuing project)

This trial is a part of a multi-trial project aimed at increasing the knowledge of the effects of operating parameters (such as mixing rate, temperature, pressure), design (such as baffling), and control on polymer properties and end-use. It is expected that about 10 trial runs (in total) will be required to gain adequate knowledge to enable our company to develop a new polymer production process. Although the actual trial lasted for only three days (Feb. 10-13, 1999), planning and pre-trial work has been carried out and charged to this SR&ED project since July 1998. The new polymer process technology and design represents the culmination of many hours of work from many different contributors across XXYY, including XXYY Research, Licensing and engineering resources.

Part 2 Step 2.A. - Scientific/Technological Objectives

The first objective of the trial is to determine the process and reactor mixing factors affecting the molecular weight of the polymer produced and its subsequent effect on product end-use performance. The second objective of the 3-day trial will be to conduct process step-change tests to develop Advanced Process Control models. There will be several other trials necessary to complete the models and to develop a clear understanding of the technology.

Part 2 Step 2.B. - Scientific/Technological Advancement

The effects of process temperature, pressure, reactor baffling, and mixing rate on the polymer product properties are now known. Mathematical semi-empirical models have been developed based on the experimental data that allows the engineers to predict the molecular weight of the resultant polymer produced with 95% confidence. Advanced process control models have also been developed which now gives us the capability to preemptively control the process in a superior fashion.

Part 2 Step 2.C. - Scientific/Technological Uncertainty

Although the effects of various process conditions on this polymer's performance have been studied at the pilot scale, the impact of process scale-up on these responses has been shown to be significantly different based on our experiences in the plant setting. In particular, the effect of impeller rotation rate and baffling arrangements in the reactor introduces new variables that cannot be predicted from the pilot data. Since the new process has different process responses, it is technically unclear what new control strategies and models will be required until experimental data can be obtained from these plant trials. It is clear, however, that the conventional closed loop control strategies used in the pilot-scale system will not work on the shop floor.

Part 2 Step 2.D. - Project Activities *(Note that activities described below may not all qualify as SR&ED; For allowability of specific expenditures, refer to Chemicals Guidance Document 2 – Qualifying Work)*

Major activities

- Address all resource issues: materials, manpower, and technical assistance
- Product testing at XXYY Research facilities
- Produce a series of resins using a pre-determined catalyst and process conditions
- Vary temperature and observe the effect on product molecular weight distribution (MWD) and density. Adjust reaction conditions to maintain product specification. Sample for product testing at XXYY Research facilities
- Vary mixing rate and observe the effect on product MWD and density. Adjust reaction conditions to maintain product specification. Sample for product testing at XXYY Research facilities
- Vary baffle design and observe the effect on product MWD and density. Adjust reaction conditions to maintain product specification. Sample for product testing at XXYY Research facilities
- Conduct process control step tests, allowing product spec to vary.
- In this test considerable quantities of non-prime polymer will be produced to evaluate and reduce the outstanding technical uncertainties associated with the new technology.

Other activities

- Review process hazard and operability (HAZOP)
- Review meeting Responsible Care® codes requirements
- Review process safety guidelines
- Prepare reaction contingency plans
- Prepare a set of experimental operating instructions
- Create material safety data sheets (MSDS) for the trial product
- Identify potential markets and customers for trial product
- Assign specifications for raw materials and trial product

Part 2 Step 2.E. - Documentation or Supporting Physical Evidence

- Documents listed under methodology
- Plant log books
- Internal company reports

PROJECT 4321: NEW XC CATALYST SHOP FLOOR TRIAL

Part 2 Step 1 – Project Summary Information

Step 1.A. – Project List
Project Code: 4321 (continuing project)
Start Date: (plant portion only) August 22, 1998 End Date: August 24, 1998
Total Labour Cost: $25,000 (for current tax year)
Raw Material Consumed: $150,000 (for current tax year)

Step 1.B. - Capital Expenditures

Capital Item	Cost
Item Y	$193,000

Step 1.C. – Personnel

Name	Academic Qualifications	Position	Years Experience	Time Allocation (PY)
J. Doe	Ph.D. Chem.	Lead Scientist	22	0.2 PY
J.A.	Ph.D. Chem. Eng.	Lead Engineer	18	0.1 PY
J.B. Doe	B.Sc. Chem.	Lead Chemist	12	0.05 PY
J.C. Doe	Chemical Technologist	Technologist	8	0.05 PY

Part 2 Step 2 - Detailed Project Descriptions (continuing project)
The XC catalyst is a new catalyst developed at the XXYY Research and Development Center. The PC catalyst, which is being used currently in the plant, is based on a different chemistry. The XC catalyst is made in a multi-step process that differs significantly from the process used to make the PC catalyst. XC is fully compatible with PC, although they have different responses. The XC-catalyst process seems to run well under research conditions and scale-up conditions. This is the first plant trial using this new catalyst. Although the actual trial lasted for only three days (Aug. 22-24, 1998), planning and pre-trial work has been carried out and charged to this SR&ED project since August 1997.

Part 2 Step 2.A. - Scientific/Technological Objectives
The main objectives for the first series of trials are to determine the process parameters on the shop floor necessary for making polymer products with the new XC catalyst system. This includes the experimental determination of the properties and concentrations of catalyst to be used in the shop-floor system.

The objective was achieved in several stages. In the first set of experiments, the XC catalyst was varied from 0 to 100%, while samples of transition material were collected to see if catalyst blends produced suitable end products. If the schedule were to permit it, there would be a transition to produce a second product; if not, the time would be used to ensure production of the first product.

Part 2 Step 2.B. - Scientific/Technological Advancement
This plant trial has advanced our knowledge with respect to the actual properties and behavior of the XC catalyst system for the production of specialty polymers in comparison with existing blends of LLDPE and LDPE. We have been able to accurately define the process conditions necessary for the production of a variety of polymer products using this new catalyst based upon the plant trial. Results from this and other shop floor trials have provided data from pilot-

scale runs to enable rigorous quantification of hydrogen response, optical properties, melt strength, and processability with this new XC catalyst process.

Part 2 Step 2.C. - Scientific/Technological Uncertainty

Since the XC process has never been run in the plant, there were many technical uncertainties related to how well the new catalytic process would scale up in terms of the types and quality of the products that were produced. In addition, preliminary results had shown that the new XC catalyst type could adversely affect the yield of the desired product type.

It was also not clear if hexane extractables might exceed safe limits. Finally, there existed the very real possibility of chunk formation in the reactor that could result in numerous hours, and perhaps days of down time. Furthermore, the characteristics of the transitional material are unclear.

Part 2 Step 2.D. - Project Activities *(Note that activities described below may not all qualify as SR&ED; For allowability of specific expenditures, refer to Chemicals Guidance Document 2 – Qualifying Work)*

Major Activities

- Address all resource issues: materials, manpower, and technical assistance.
- Carry out a sequence of experiments with XC catalyst varying between 0% and 100%.

Other activities

- Ensure that meeting Canadian Environmental Act (CEPA)
- Review process hazard and operability (HAZOP)
- Review meeting responsible care codes requirements
- Review process safety guidelines
- Prepare reaction contingency plans
- Prepare a set of experimental operating instructions
- Create material safety data sheets (MSDS) for the trial product
- Assign specifications for raw materials and trial product

Part 2 Step 2.E. - Documentation or Supporting Physical Evidence

- Selected internal company reports
- Selected documents listed under methodology.