# SCIENTIFIC RESEARCH AND EXPERIMENTAL DEVELOPMENT (SR&ED)

## SECTOR-SPECIFIC GUIDELINES

## CHEMICALS GUIDANCE DOCUMENT #3 – CHEMICAL PROCESSES* - PART I

### Foreword:

This is the first of two parts of Chemicals Guidance Document 3, entitled “Chemical Processes”. It provides an overview of the scope and context of different types of batch and continuous chemical manufacturing processes. Part 2 of Chemicals Guidance Document 3 will deal with a series of continuous chemical processes, and will be issued in 2005. In Part 1 of the document, the Proxy method for claiming overheads will be illustrated, whereas in Part 2, a comparison between proxy and traditional methods will be given.

Two examples of batch manufacturing processes in the chemical sector are provided in Example 3.1 (Enhanced Lubricants) and Example 3.2 (Batch Processing of Product Z with Novel Catalyst Process). In Example 3.3, a continuous process involving the bio-treatment of wastewater is illustrated.

Industry members of a joint chemicals-CRA SR&ED committee have provided the three examples in Part 1. Although the list of topics covered is not exhaustive, they are expected to facilitate discussion and to help establish a common understanding of the technological aspects of typical SR&ED projects in the chemical sector. The examples are intended to illustrate how the technical material might be presented; there is no unique way to present the material in a claim.

For detailed SR&ED project documentation requirements and for the expenditure rules, please consult the extensive reference material available on the CRA SR&ED Web site.

* This document has been prepared by a Chemicals Industry and CRA joint Committee (see Appendix B)

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# SECTOR-SPECIFIC GUIDELINES

# CHEMICALS GUIDANCE DOCUMENT #3 – CHEMICAL PROCESSES

## 1. INTRODUCTION

**1.1** This document is one of a series of guidance documents that have been prepared by the Canada Revenue Agency (CRA) working in partnership with the chemical industry and the Canadian Chemicals Producers Association (CCPA). They are designed to help with the interpretation of the income tax legislation for claiming SR&ED in the chemical sector. It is important to recognize that this guidance document is based on the legislation and regulations.

**1.2** Chemicals Guidance Document 3 is applicable to the technical personnel and financial/accounting staff involved with the filing of a chemical company's SR&ED claim, and to the CRA staff who are involved with the review of SR&ED claims in the Chemicals sector. It could also be of interest to all of the following:

- Service companies to the chemical manufacturing sector that supply instrumentation, machinery and other equipment;
- Organizations that provide research, engineering and other consulting services such as consulting companies, universities, colleges and other institutions;
- Government agencies and departments, such as IRAP, Industry Canada, who are directly or indirectly involved with Chemicals research and development work in Canada.

**1.3** For the purposes of this document, the chemical manufacturing sector is considered to consist of companies engaged wholly or partly in the transformation of the natural raw materials of the earth, water and air, into products that we use every day. The chemicals produced are fundamental to the manufacture of virtually all products used in daily affairs: cars, paper, textiles, alloys, electronics, building materials, food and medicine. The sources include a vast array of metals, minerals, oil and natural gas, vegetable oil, animal fats, and other raw and reprocessed materials. According to Statistics Canada, chemical manufacturing includes: basic chemicals, plastic resins, synthetic rubber, fibres, fertilizers, agricultural chemicals, pharmaceuticals, paint, coatings, adhesives, soap and detergents, cleaning compounds, cosmetics, perfumes, and other chemical products. See also the following link at the Statistics Canada web site: http://stds.statcan.ca/english/spec-aggreg/goodsservices-2002/goods02-class-search.asp?criteria=325

**1.4** "Chemicals Guidance Doc. 3: Chemical Processes" provides specific examples of batch and continuous chemical processes (described in Section 2.1), while supplementing the following three documents:
"Chemicals Guidance Document 1 – Shop Floor SR&ED" **[1]**,
http://www.cra-arc.gc.ca/taxcredit/sred/publications/chemdoc-e.html

"Chemicals Guidance Document 2 – Qualifying Work" **[2]**
http://www.cra-arc.gc.ca/taxcredit/sred/publications/guidance_menu-e.html
SR&ED AP 2002-02R: Experimental Production and Commercial production with experimental development work – Allowable SR&ED Expenditures **[3].**
http://www.cra-arc.gc.ca/taxcredit/sred/publications/ap2002-02R-e.html

**1.5** The purpose of Chemicals Guidance Document 1: Shop Floor SR&ED **[1]** is two-fold, providing a description of:
i) Eligibility criteria for the SR&ED Program; and
ii) Types of chemical plant trials that can be claimed within the SR&ED Program.

The six examples range from relatively small projects to large multi-trial chemical projects with the company's usual manufacturing facilities. Areas of technology discussed in Chemicals Guidance Document 1 include wastewater treatment using multi-stage membrane systems, new catalyst technologies, plastics processing, and fluidized bed systems.

**1.6** In "Chemicals Guidance Document 2 - Qualifying Work" **[2]**, a detailed description is given of both the technical aspects of the SR&ED claim and the expenditure-related issues at nine development stages, from the lab to the full-scale production facilities. The primary goal of this document is to provide a practical tool for rapidly identifying the types of work and expenditures that can be claimed in each of nine development stages. A variety of typical chemicals-related projects that contain both SR&ED and non-SR&ED work and expenditures are presented to illustrate how to self-assess a potential claim.

**1.7** The goal of Chemicals Guidance Document 3 is to apply the principles of the first two documents to a variety of batch and continuous chemical projects. It is expected that the reader will have the skills to identify:
i) If a project meets the SR&ED criteria (Chemicals Guidance 1);
ii) The relevant work and expenditures that can be claimed in a project at a given stage of development (Chemicals Guidance 2); and
iii) How to separate the SR&ED work that can be claimed from any simultaneous, but excluded, commercial production work (SR&ED AP 2002-02R) and/or commercial use.

**1.8** There are three examples in Part 1 of this guidance document. The following assumptions were made for each of the three examples:
i) There is sufficient information in the project description to determine eligibility.
ii) The examples were kept brief while meeting SR&ED requirements. Therefore, all operational, health and safety, and/or environmental guidelines may not have been fully considered.
iii) All work claimed is carried out in Canada.

**1.9** Claimants are required to fill in the following parts of the T661 form **[4]**:
A. Scientific/Technological Objectives
B. Technology or Knowledge Base Level
C. Scientific/Technological Advancement

D. Description of Work/Activities in This Tax Year
E. Supporting Information

In each of the three examples in this guidance document the following additional sections were added:

- Background Information
- Business Objectives
- Analysis of Project
- Claim (including List of Personnel)

Note that:

i) Although the parts "Background Information" and "Business Objectives" are not required on the T661 form, their inclusion may assist with setting the context for the accompanying project description.

ii) The "Analysis of Project" and "Claim" parts have been provided to assist with the practical application of the SR&ED Program, and are provided for instructional purposes only. They should not be submitted with the claim.

**1.10** In the first section of each example the context of the project is provided in a "background" section. This is followed by the project description in the prescribed T661 format **[4].** An analysis of the project is then given which provides the rationale for why the project meets the definition of SR&ED. This is followed by the claim scenario, in which a determination is made if commercial production (CP) is taking place at the same time as experimental development (ED). An explanation is given as to whether the work meets the definition of Experimental Production (EP) or Commercial Production with Experimental Development (CP/ED), using principles outlined in Reference **[3]**. With the claim scenario defined, the relevant work and corresponding expenditures can be calculated using References **[2]** and **[3]**.

**1.11** Example 3.1 (Development of New Forming Lubricants) is an ED project where there is a claim made for EP. In comparison, Example 3.2 (Batch Process of Product Z), illustrates a ED project where there is a combination of both EP and CP/ED. Finally, in Example 3.3 (Bio-treatment of Wastewater), a claim that involves ED with simultaneous commercial use of an existing facility is provided. Both Examples 3.1 and 3.2 highlight batch processes, while Example 3.3 illustrates a continuous process. In Part 2 of the document a series of additional continuous examples will be added to highlight other SR&ED issues of interest to the Chemicals sector.

# 2. SOME ISSUES TO BE DISCUSSED IN EXAMPLES

## 2.1 Batch vs. Continuous Chemical Processes

Examples of both batch and continuous chemical processes are provided in this guidance document. Each type will be briefly described below.

### 2.1.1 Batch process

In a batch process, discrete quantities of raw materials to be converted are added to a processing vessel following a predetermined sequence and predefined operating conditions. When the transformation of the raw material is complete, the end products are removed from the vessel.

In a batch process many items of equipment could be connected by a network of piping. Each of them can be used for a specific chemical or physical transformation, such as reaction, distillation, or crystallization. A batch of material will enter the plant and move from tank to tank periodically, according to the sequence of transformations required for manufacturing the final product.

Batch processes are sometimes preferred for the small-scale production of high-priced products as in catalyst manufacturing, where a large number of very precise sequential steps are required to obtain the desired product.

### 2.1.2 Continuous process

A continuous process is one in which raw materials are continuously added and products are continuously withdrawn from the process vessel. The raw materials react as they flow through the equipment to give a continuous flow of product. A continuous process may be dedicated to manufacturing a single chemical at a constant rate 24-hours a day, and close to 365-days a year. The objective is literally to have the product flow out of a pipe at a steady rate all the time. At any point, only a small amount of material is at a particular stage in the process, but material at all stages of the reaction is present.

Commercial reactors generally process continuously because the overall investment and operating costs of a continuous process are lower than those of a batch process **[5]**. Examples of continuous processes include the production of polyethylene from ethylene. In this case, ethylene, higher alpha-olefins and catalyst are continuously fed into a reactor (either gas phase, solution phase or slurry phase) and polyethylene is continuously removed from the reactor. Another example would be a blown film line where resin is continuously fed into an extruder, the resin is melted, blown into a bubble, cooled and removed continuously from the film line.

## 2.2 Discussion of Factors to Consider When Claiming Experimental Production or Commercial Production with Concurrent Experimental Development

The Application Policy SR&ED 2002-02R: Experimental Production and Commercial production with experimental development work – Allowable SR&ED Expenditures highlights the current policy when there may be mix of experimental development (ED) involving commercial production (CP), or experimental development involving experimental production (EP). This is a situation that may occur for many batch and continuous chemical processes.

The first step is to decide whether there is ED and what work is involved. If the claim concerns a continuous process that is being improved or a new or improved product that is the output of such a process, then it is important to establish what part of the process is involved, the duration of the experiment(s), who is doing the work and what materials may be included.

Given that there is ED, the next step is to decide whether there is any work that is excluded by the definition of SR&ED (subsection 248(1), paragraphs e to k of the Income Tax Act; see Appendix A). In the chemical manufacturing sector, this will predominately be paragraph (i), the commercial production of a new or improved material, device, or product, or the commercial use of a new or improved process. (Note: There is a long-standing definition of commercial production (CP) found in IC 86-4R3 that states that it is “the set of activities associated with the production of products, and it is expected that a profit will be made.”). The issue to be addressed, therefore, is how one decides whether there is commercial production or commercial use of a process. If the output is scrapped or sold as scrap (at less than 10% of materials cost), this issue does not come into play. It is important, therefore, to determine based on nature of the ED, the potential technological impact of the experiment on the process.

ED projects **[1]** in the chemical sector may consist of one or more plant trials and are carried out using all, or a portion of, the production line equipment. ED projects may include:

*(a)* Plant trial(s) where there is experimental development involving experimental production (EP). *In this case no segregation of work and costs is required for the purposes of the SR&ED claim with respect to the required EP.*

*(b)* Plant trial(s) where there is experimental development involving commercial production (CP/ED). *In this case*, t*he claimant must identify and allocate all of the ED-related work.*

**It is important to note that there may be a combination of different types of chemical plant trials in an ED project, some of which involve EP, while others involve CP/ED.*

Table 1 provides some technical indicators that can be used to assess if the ED project involves EP, or if the ED project involves CP/ED.

**Table 1: Some Indicators and Other Evidence to Corroborate EP**

- Presence of additional technical personnel or supervision.
- Higher management approval for the trial, which would indicate that this is not business as usual.
- The ED involves a change to the process resulting in a potential risk of instabilities or oscillations of the process and/or a potential change to the technical specifications of the product.
- As part of an ED project, the client base of the chemical company needs to do their own testing trials on the properties of the finished new (experimental) product to resolve specific technological uncertainties related to whether the product meets certain basic specifications.
- The characteristics of the new product or process are potentially different compared with any existing or previous products or processes. This could, in the short-term lead to a risk of lower quality product or “off-grade”.
- The company could not foresee the results of the ED, and unexpected technological problems may arise during the ED project, potentially causing a lower grade of product than envisioned at the start of the ED project.
- Changes or potential changes to product (such as different chemical and/or physical characteristics of the product).
- Changes to process configuration or characteristics (such as flows, combinations, blends, equipment and components).
- Evidence that staff were involved in designing specific experiments and monitoring and analysing test data from the ED project.
- Evidence of meetings or other relevant sources of supporting information were available to substantiate and corroborate the planning and technological risk associated with the ED project.
- Evidence of experimental operating instructions and other consistent records were prepared for the ED project.
- Evidence of specific monitoring strategies and operating instructions for the ED project were communicated to the operating staff.
- Evidence of special tracking, classification or recognition of the project/product.
- Any other evidence or documentation available to indicate non-routine activities.

It should be noted that although the technical factors listed in Table 1 are not all-inclusive, they describe some of the most common types of indicators and other evidence corroborating ED projects involving EP. *It is strongly emphasized that the list of technical factors* ***must not*** *be used on a "check-list" basis, and* none of these technical indicators, in isolation, is determinative. Rather, the final assessment of whether the ED project involves EP or CP/ED should be made after reviewing all of the facts of the case. The three examples in the ensuing section will provide practical guidance on how to apply these EP indicators to some typical ED projects involving plant trials.

## 3. EXAMPLES - PART 1

### Example 3.1: Development of New Forming Lubricants Using Enhanced Boundary Additives

Start Date: March 2002
End Date: December 2002

SR&ED issues addressed:

1. Claim for EP
2. Materials consumed
3. Product trials at customer
4. Disposal Costs
5. Proxy Method
6. Contract Costs

### Background Information[1]

In the manufacture of formed metal parts it is necessary that a suitable lubricant be used. The purpose of the lubricant is to reduce friction between the working part or die and the metal that is formed. More demanding forming operations involving deep drawing or deformation of thick or unusually hard metal, and may require the use of either more lubricant, more active lubricants, or the use of special additives in the lubricant.

A metal forming company, XYZ, has difficulties manufacturing certain demanding parts. They have been forced to coat parts with a solid wax coating prior to applying a substantial amount of lubricant containing hazardous components, to affect the requisite deformation without part failure. Recent developments in the field of additive chemistry suggest that there could be certain types of non-hazardous additives that provide superior lubrication effectiveness in other applications that could potentially be incorporated into emulsion-type lubricants.

XYZ has approached their supplier company, ABC, to develop a new lubricant for use in their metal forming plant. Two full-scale field trials using the new lubricant would be carried out, as part of this project, on a designated forming press at XYZ. Owing to the large potential business opportunity (several million $/annum in lubricants), ABC decided to offer their new lubricant free of charge for the two experimental field trials at XYZ.

Although both ABC (supplier) and XYZ (customer) might be carrying out work that meets the SR&ED criteria for the development of the new lubricant, this project description only considers ABC's claim. It should be noted that XYZ may have a separate claim for their portion of the work, but it is not considered here.

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[1] ***Note that the "background section" is not required to be provided with the project description.*** However, if the claimant provides information related to "Background Information" it may be helpful to providing the context for the project.

## Business Objectives[2]

The business objectives for this project are to develop a high performance and environmentally friendly lubricant for use in forming thick gauge steel parts. This lubricant was not presently commercialized; however, if the development proved to be successful through the present work, there was a potential for commercialization following the experimental field trials at XYZ.

## T661 Form: Start of Project Description

### 1A. Scientific/Technological Objectives

The objective of this project was to determine whether a newly developed lubricant formulation could provide the required lubrication to form heavy gauge metal parts on a variety of metal forming presses, such that there would be no breakage of the formed metal parts. The lubricant needed to be environmentally benign, and have good spray and wetting characteristics, as well as having sufficient boundary lubrication strength.

### 1B. Technology or Knowledge Base Level

Prior to the initiation of this project, the ABC technical staff members (Table 1) were knowledgeable with respect to the types of lubricants used in metal forming. Furthermore, they had expertise in the development and testing of new formulations and an up-to date library of recent published developments in the field.

Owing to the fact that most cutting-edge new products were developed by competitors, there were limitations to the knowledge base owing to proprietary considerations. Few of the cutting edge developments are published in the technical literature.

Previous work that had been carried out at ABC to develop lubricants for combined performance and reduced toxicity had been unsuccessful. Various types of lubricant systems ranging from emulsion to solution synthetic technology were investigated without success, since hazardous components such as chlorine were always required to achieve optimal performance.

### 1C. Scientific/Technological Advancement

ABC sought to develop a new and enhanced lubricant for application in an existing metal forming plant. The new lubricant was expected to meet requirements that could not be met with other existing lubricant formulations. As well, through this work, ABC sought to gain an improved understanding of the role of enhanced additives for use in industrial forming compounds.

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[2] Not a requirement of T661 form

### 1D. Description of Work/Activities in This Tax Year

| Title | Description |
|---|---|
| New lubricant laboratory development at ABC (Work done prior to 2 Field Trials at XYZ)<br>(Feb 2002-April 2002) | Several lubricants were investigated in the lab during this period. Ten laboratory experiments were carried out to evaluate the impact of each lubricant's viscosity and wettability, as a function of varying additive concentrations.<br>A method for determining additive concentration was developed using standard refractometry techniques.<br>Contract analysis was done to characterize lubricity and boundary lubrication properties.<br>A suitable lubricant was developed for field trials at XYZ's facilities. |
| Field Trial #1 at XYZ (May 2002) | A total of 5000 gallons (20, 250-gallon totes of lubricant) was manufactured at ABC. From this, 2500 gallons was sent to XYZ for Field trial #1 on a designated test press at XYZ; the remaining 2500 gallons of lubricant was retained by ABC, for possible use in a follow-up field trial.<br>The typical lubricant consumption was about 250 gallons per 8-hour shift. A designated press was selected and steel blanks were isolated for Field trial #1. There were no problems in forming the first 90 parts; however, after about 90 parts were formed (over about four 8-hour shifts), the parts began to crack, and production was stopped after 100 parts were made. The parts splitting was thought to be due to inadequate part wetting as a result of poor spray characteristics of the lubricant. Further investigation showed that there was a progressive die temperature increase, which resulted in a loss of the dimensional tolerances. Moreover the dies had been damaged and required extensive rework.<br>From the initial 2500 gallons of lubricant sent to XYZ, 1000 gallons were used for the production of the 100 formed parts, while the remaining 1500 gallons of residual lubricant from XYZ's reservoir were returned to ABC. This residual lubricant was not recoverable, and it was discarded as a non-hazardous waste. |

| Title | Description |
|---|---|
| Analysis of Results and modification of formulation, June-Sept 2002. | A detailed analysis showed that there was an increase of 25% in the evaporation rate of the new lubricant relative to earlier versions, which caused the parts wettability to decrease. This could not have been determined prior to the Phase 1 field trial since the evaporation rate was not an anticipated parameter. In addition, the spray system at the plant appeared to have a modulating pressure, which resulted in lower spray pressures under certain conditions that ultimately affected the spray pattern.<br>Reformulation of the lubricant was necessary to reduce the evaporation rate and to allow for better thixotropic performance. This was done through the incorporation of some special polymeric additives. The modified lubricant was tested with a bench scale forming system. Use of the modified lubricant resulted in a 50% reduction of the evaporation rates at temperatures in the forming range. In addition, the spray characteristics were significantly improved such that the spray pattern was identical over a wide range of pressures. A new quality control test was introduced for determining the rheological properties. ABC determined that the modified lubricant was ready to be “stress tested”, and Field Trial #2 was planned at XYZ’s designated press. |
| Field Trial #2 at XYZ October 2002 | Because the new formulation was a simple modification of the original formula, it was possible to use the 2500 gallons of material in inventory (see Field Trial #1) as part of a new 5000-gallon batch. The 5000-gallon batch of the modified lubricant was manufactured and shipped to XYZ for Trial #2. The 5000 gallons were completely consumed in Trial #2, with 500 parts being successfully formed. No further technological problems were observed during Trial #2.<br>XYZ has requested that future work be carried out to optimize the spray performance on the presses to minimize the lubricant consumption. |

### 1E. Supporting Information

1. Lubricant information
2. Design plan documentation
3. Lab and production records for two field trials
4. QC records
5. Trial feedback reports
6. Enhanced Lubricant chemical and physical data
7. XYZ Field Trials Summary Report
8. ABC Plant Trials Summary Report
9. Bill for die repair

## End of T661 Form:

### Analysis of Project[3]

Work was carried out to develop a new enhanced lubricant that could be used for the manufacture of formed metal parts at the commercial scale. The new lubricant was not presently commercialized; however, if the development proved to be successful through the present work, there was a potential for commercialization following the two field trials. Experimentation was needed to overcome several technological uncertainties, such as the changes in the spray and the wetting characteristics of the lubricant.

The project meets the definition of SR&ED.

### Claim[3]:

The following analysis treats only the claim of ABC, the supplier. As stated at the outset of the project, XYZ might have an independent claim for the work that they carried out during the development of this product, but it is not considered here.

Since there was no simultaneous commercial work during any part of this project, including the two field trials, the SR&ED project involves EP. Summaries of the expenditures for this SR&ED Project are given in Tables 1 and 2. All personnel shown in Table 1 are employees of ABC, but both D. Smith and E. Smith are claimed for their time involved with the two field trials at XYZ.

ABC's total claim includes all relevant and applicable costs for labour, capital, and materials. If the traditional method is used, all overhead expenditures must be separately identified for the specific SR&ED project. If the proxy method is chosen, the allowable overheads are calculated as the prescribed proxy amount (PPA), which is 65% of the salary base for directly engaged SR&ED staff. The PPA represents a simplified method to compute the allowable overhead expenditures, but is only applicable to the proxy method (see also Reference **[2]**).

ABC's claim includes the cost of all materials manufactured at ABC that are subsequently consumed in the two field trials carried out at XYZ.

1. For Trial #1, 5000 gallons of material were manufactured at ABC, but only 2500 gallons were sent to XYZ for Trial #1. From this, 1000 gallons were consumed in Trial #1 at XYZ prior to the onset of parts breakage (after 100 parts were made). A total of 1500 gallons were returned unused to ABC due to these technical problems in Trial #1, but the material was not recoverable and it was subsequently scrapped.
2. For Trial #2, an additional 2500 gallons were manufactured at ABC, which was added to the 2500 gallons left over from the first batch. The total of 5000

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[3] ***The "Analysis of Project" and "Claim" sections have been provided to assist with the practical application of the SR&ED Program for these examples, and are provided for instructional purposes only. They should <u>not</u> be included by the claimant.***

gallons was shipped to XYZ, and all of it was consumed in the manufacture of 500 parts during Trial #2.

The total claim is for the 7500 gallons of material manufactured for the two field trials. The cost of material per gallon was $2.00, and the cost of disposal was $1.50/gallon.

*Note that disposal costs are not claimed for this example since the proxy method is used to estimate overhead expenditures. The disposal costs could only be claimed under the traditional method if such costs were deemed to be directly related and incremental to the prosecution of the SR&ED.*

The total cost of materials consumed using the proxy method is $15,000. There would also be a claim for all personnel listed above and any contract expenses incurred as a result of the SR&ED. This would include the $5,000 for chemical analysis testing at an independent laboratory.

Since there were no capital expenditures used in SR&ED for this project, ABC will not be claiming for any capital.

**Table 1: Company ABC - List of Personnel Claimed and Labour Expenditures[4]**

| **Name[5]** | **Role** | **Areas of Work** | **Qualifications** | **Experience Years** | **Project Hours ($/hr – NOT OVERHEAD RATES)** |
|---|---|---|---|---|---|
| A. Smith | R&D Manager | Project manager (at ABC) | P.Eng., MSc. | 20 | 100 ($40/hr) |
| B. Smith | Chemist | Product Development (at ABC) | MSc. | 30 | 200 ($35/hr) |
| C. Smith | Technician | Technical Support (at ABC) | Chemical Technologist | 10 | 50 ($20/hr) |
| D. Smith | Product Manager | Trial supervision (Field trials at XYZ) | P.Eng. | 15 | 40 ($40/hr) |
| E. Smith | Sales Engineer | On-site trials (Field Trials at XYZ) | P.Eng. | 10 | 60 ($35/hr) |
| F. Smith | Plant Manager | Supervised Plant Work (at ABC) | M.Eng., P.Eng. | 20 | 15 ($35/hr) |
| G. Smith | Foreman | Supervised batches (at ABC) | High School Diploma | 30 | 15 ($25/hr) |
| H. Smith | Operator | Batch maker (at ABC) | High School Diploma | 25 | 15 ($20/hr) |
| I. Smith | QC Manager | Supervised QC (at ABC) | BSc. | 10 | 4 ($25/hr) |
| J. Smith | QC Technician | Carried out QC testing (at ABC) | Chemical Technologist | 5 | 5 ($20/hr) |
| Total ABC Labour (Before Overheads) | | | | | $17,100 |

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[4] Not a requirement of T661.

[5] All personnel shown are employees of ABC.

## Table 2: Overall Expenditures Summary (Proxy Claim)[4]

| | |
|---|---|
| Total Labour Cost (Refer to Table 1) : | $17,100.00 |
| Material consumed (7500 gallon * $2/gallon) | $15,000.00 |
| Capital Expenditures | $ 0.00 |
| Contract Lab Analysis (outside lab analysis) | $ 5,000.00 |
| PPA = labour*.65 | $11, 115[a] |
| | |
| **Total Claimed (including PPA)** | **$48,215** |

[a] Note: PPA refers to "prescribed proxy amount"

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[4] Not a requirement of T661.

## Example 3.2: Batch Processing of Product Z with Novel Catalyst

Start Date: March 2002
End Date: December 2002

SR&ED issues addressed:

1. Claim for EP and CP/ED
2. Capital
3. Materials consumed and Materials transformed.
4. Recapture/materials transformed.
5. Modeling
6. Reproducibility and repeatability
7. Disposal Costs
8. Proxy Method

### Background Information[1]

A 50,000-L batch reactor is used to carry out the reaction that will be described here (see process flow sheet in Figure 1). This reactor is equipped with a twin-paddle agitator and a system of baffles to promote good mixing. Based on laboratory data, the reaction kinetics are known to be first-order with respect to reactants A and B.

The reaction may be represented schematically as follows:

$$[A] + [B] \overset{[C]\ (\text{catalyst})}{\rightleftarrows} [Z]\ (\text{desired product}) + [Y]\ (\text{volatile by-product}) + \text{trace residue}$$

In practice, 16 tonnes of A react with 25 tonnes of B in the presence of 4.1 kg of catalyst C to produce 37-40 tonnes of Z and 1-4 tonne of a volatile by-product Y, dependent upon the concentrations of reactive functionalities in reactants A and B. The yield of Y will also depend upon the specific reaction conditions such as the process temperature, pH, and liquid-phase turbulence employed.

This process was initially developed at the company's R&D labs with the intention that it would be utilized for a large-scale manufacturing operation. The technology has been successfully demonstrated at the pilot stage (100 L reactor), but now needs to be proven in a new commercial-scale production facility (50,000 L reactor). Many technological problems were anticipated in the move to commercial operation. Due to the magnitude of the scale-up involved (500:1), equipment such as impellers, baffles, and other mixing parameters could not simply be routinely scaled up from the pilot scale. Moreover, there were many other independent variables affecting the large-scale system as well as statistically significant multivariable interactions that could not be predicted accurately from a routine scale-up.

A process flow sheet of the process is shown in Figure 1. Prior to the introduction of any reactants, a vacuum is applied to the reactor to flush out any oxygen that is present. The reactor is then sealed and a dry nitrogen stream is introduced to maintain an inert

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[1] ***Note that the "background section" is not required to be provided with the project description.*** However, if the claimant provides information related to "Background Information" it may be helpful to providing the context for the project.

atmosphere at one atmosphere pressure. Liquid raw materials A and B are charged to the reactor in sequence (see steps 1 and 2). The agitator is turned on to initiate the mixing process. With the contents of the reactor well mixed, a consumable solid catalyst C is introduced (see step 3) at an overall concentration of 0.01% by mass. The reactor contents are heated and stabilized at the process temperature of approximately 150 degrees centigrade. The exact yield is known to be very sensitive to slight changes in process temperature and pH.

At a process temperature of 150 degrees, the by-product Y is volatile, and can be removed by the application of a slight vacuum to the reactor (see steps 4, 5, and 6). The by-product Y must be removed continuously from the reactor with vacuum, or its accumulation will interfere with the reaction rate and product quality.

The amount of by-product Y must be minimized to prevent target yield reduction to desired end product Z, and also to prevent reversion back to raw materials A and B. With the continuous removal of by-product Y, the reaction is allowed to proceed for a period of four hours. After this period, a 5-kg sample is withdrawn from the reactor to ensure that the sample lines are well purged, and an 8-ounce bottle is filled with the sample product. It is important that the viscosity of the resultant product be maintained between 300-350 cSt at 25°C. If the viscosity is not in this range, based on the product sample analysis, then additions of A, B, or Catalyst C must be made until the viscosity is within this target range. The adjustments can take up to two hours to complete.

With the viscosity of Product Z in the correct range, a neutralizing agent is added (see step 7). After the neutralization is complete, the colour of the batch (as measured by Gardner index) is determined. To meet the quality specifications, the Gardner index must be maintained at less than 10. If the Gardner index is above 10, a decolourizing agent must be added until the colour is within the correct range (see step 8). This iterative process of correcting and determining product colour may take up to 2 hours. It would not be possible to predict the amount of raw material additions from lab data at this point, because of significant differences with the turbulence and mixing characteristics in the large-scale reactor.

When the correct Gardner index is ultimately achieved, the batch is cooled down to 25-35 °C. At this point the resultant product is filtered at a rate of 50 L/min through a series of 200 μm, 100 μm, and 20 μm glazed bag filters, to remove precipitates that are formed during the neutralization and decolourization steps. In addition, the filtration process also removes the spent catalyst.

The turbidity of the clear filtrate from this process should not exceed 7 NTU; otherwise the product liquid is passed through the filtration process a second time to remove any residual precipitates.

Once the product meets the required specifications following the initial development phase, the product is sent to the drumming station or to a tanker truck. Following a final QA/QC check the product is shipped to a customer. For a 40 tonne batch, approximately 0.75 tonnes will be lost due to sampling, filtration, as well as, residual product losses at the bottom and sides of the reactor.

Filling about 200 of the 220 L drums will take about 15-17 hours. The entire processing of the batch will take between 35-40 hours to complete (see also claim section of this example), depending upon how many times it is necessary to adjust the batch for viscosity, to neutralize or decolourize, and filter the resultant product.

**Business Objectives**[2]

The business objectives were to develop the methodology for a large-scale process for the manufacturing of Product Z using a new catalyst that was developed at the company's R&D labs. This process was not presently commercialized; however, it was anticipated that after the initial development work, there was an excellent potential for commercialization following the initial plant-scale experimental trials. Senior management was aware of the risks involved with the experimental plans prior to any of the large-scale experimental trials being carried out.

**Start of T661 Form:**

### 1A. Scientific/Technological Objectives

The specific technological objectives of the project were to:

- Develop full-scale chemical manufacturing process to produce a final product Z, with viscosity (300-350 cSt), colour (1-10 Gardner), turbidity (1-7 NTU), and purity (99.9%) specifications;
- Determine specific optimum process conditions to:
  - i) minimize by-product Y,
  - ii) minimize reversion (to raw materials A and B),
  - iii) maximize yield of product Z;
- Investigate mass transfer limitations associated with large-scale mixing characteristics and baffling in tank;
- Understand mass transfer/kinetic model for this large-scale process;
- Determine optimal design configuration for efficient impeller design;
- Determine repeatability and reproducibility of all process data.

### 1B. Technology or Knowledge Base Level

The company had developed a new catalyst for a batch process from earlier lab-scale studies, claimed in a prior tax year. Laboratory trials had produced up to 100 L of Product Z, but there was no operating experience with either the use of the newly developed catalyst for the present large-scale (50,000 L) – application (500:1 scale-up factor), or with the following technological issues associated with a brand new complex chemical process:

- i) Effectiveness of the new catalyst for the large-scale process application, and the actual amount of catalyst that would be needed under manufacturing conditions;
- ii) Tank mixing parameters and kinetic rate data under large-scale process conditions;
- iii) Process operational parameters needed to obtain the maximum product yield.

### 1C. Scientific/ Technological Advancement

In carrying out this project the company sought to develop a new multi-phase catalytic chemical process for the first time on a large-scale (50,000 L) - manufacturing facility,

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[2] Not a requirement of T661 form.

following the recent completion of much smaller-scale (100 L) investigations at the company's R&D laboratories.

Specifically, the company sought to achieve the following technology advancements that would all be new to the company's existing knowledge base:

i) Develop a large-scale batch manufacturing process for a multi-phase catalysis application;
ii) Optimize the chemical process to maximize product yield and minimize reaction by-products and chemical reversion;
iii) Develop a semi-empirical mathematical model to simulate the large-scale and complex multi-phase catalytic process, based upon a combination of theoretical principles and data from the experimental trials.

In order to achieve these advancements the company would need to carry out a series of large-scale experimental trials, which are discussed in Section 1D.

### 1D. Description of Work/Activities in This Tax Year

| Title | Description |
|---|---|
| March 2002<br>Design of Experimental Plan | A. Doe, Project Manager, designed a series of 10 full-scale experimental trials to investigate the multiple variables impacting on the system. The experimental plan was designed to determine the reaction conditions under which the amount of volatile by-product Y was minimized. At the same time the goal was to optimize the conversion of A and B to product Z. Experiments were developed to obtain specific data for:<br>• Mass transfer limitations associated with large-scale mixing characteristics in tank;<br>• Mass transfer/kinetic model for large-scale process;<br>• Repeatability and reproducibility of process at optimal conditions.<br>The following experiments were also planned to obtain specific data with respect to process conditions where:<br>i) By-product Y was minimized,<br>ii) Reversion to raw materials was minimized, and<br>iii) Yield of product Z was maximized.<br>After each trial, the product would be analyzed for a wide variety of chemical properties. |

| Title | Description |
|---|---|
| May 2002<br>Trials 1, 2 | In the first two experimental trials the objective was to eliminate mass transfer limitations in the process. The complexity of each trial was significantly increased by the need to maintain viscosity, color, and turbidity within a very narrow range, while the yield was being optimized. Engineering staff did not expect to meet the customer's minimum specifications for product generated during these 2 trials. |
| Trial 1:<br>Removing Mass Transfer Limitations | In trial 1, the liquid turbulence was increased through the increase of agitation rate, and with use of baffles. The optimal turbulence level was quantified to minimize mass transfer resistances, so that the reaction was kinetics-controlled. When the rate was determined to be kinetic-limited, the amount of catalyst, in excess of that calculated from lab requirements, was determined by gradually increasing the catalyst concentration beyond the 0.01% by mass, until no further reaction rate increase was observed. At this point Trial 1 was terminated, and the contents of the tank were emptied. |
| Trial 2:<br>Steepest Ascent Yield Maximum Determination | In Trial 2, a "steepest ascent experimental methodology" was used to determine the process temperature and pH, for which the yield of product Z was maximized, minimal reversion had occurred, and the by-product Y was minimized. |
| June 2002<br>Trials 3-5<br>Reliability and Repeatability Of Process Data Study | Due to the complexity of the large-scale system and the large number of variables (and multivariable interactions) impacting on this process, Trials 3-5 were needed to obtain sufficient empirical data to be used for semi-empirical mathematical modeling of the process. Another objective of the three trials was to validate the repeatability of the data from trials 1-2. This number of trials for process modelling and repeatability was kept to the absolute minimum required. There was a great deal of technological risk still associated with these three trials, and none of the product was expected to meet the minimum customer's product specifications.<br>Following Trials 1-5 technical staff had sufficient confidence in the process to begin commercial production. From Trials 1-5, it was apparent that mixing patterns and liquid phase turbulence in the reactor were sub-optimal. |
| July 2002<br>Mathematical Modeling | Staff developed a semi-empirical mathematical model prior to Trial 6, which was based on input data from trials 1-5, and other relevant kinetic, mass transfer, and mixing data. The model was then applied to simulate the tank mixing, assuming minor changes to the impeller designs. The results showed that a new impeller could improve the process. |

| Title | Description |
|---|---|
| August 2002:<br>Impeller Study | To test the model, a series of three trials (Trials 6, 7, 8) were carried out using three different impellers. In each case a unique impeller was used, and all three impellers were purchased from existing shelf inventory. Model results were compared with actual process data, and the mathematical model was further refined. Results indicated that optimal mixing occurred with the Trial 8 impeller. |
| September 2002<br>Trials 9, 10<br>Reliability and Reproducibility Of Impeller Data | Two further Trials (9 and 10) were carried out to evaluate the reliability and reproducibility of the process data, with the Trial 8 impeller in place for both trials.<br>No SR&ED work was planned following Trial 10. |

### 1E. Supporting Information

- Document or defined process indicating managerial approval
- Experimental operating procedures and Test methods
- Detailed logs of start-up operations
- HAZOP reports
- Process operators' Log books
- Detailed mechanical drawings of impeller designs
- Catalyst physical and chemical data
- Company report on lab catalyst studies
- QC testing results
- Process Control testing results
- Experimental Trials Logs

## End of T661 Form:

### Analysis of Project[3]

The project involved the plant-scale development of a new multi-phase catalytic chemical process that was originally developed in-house. The development of this process was a technological advancement for the claimant.

The work described entailed a major change, in that it was necessary to develop a completely new process with an unproven catalyst technology. Moreover, ten experimental trials were needed to overcome technological uncertainties associated with a) process conditions to achieve maximum product yields; b) mass transfer/kinetic limitations; c) mixing parameters; d) model predictions for a large-scale system involving a large number of independent variables and many multi-variable interaction effects.

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[3] ***The "Analysis of Project" and "Claim" sections have been provided to assist with the practical application of the SR&ED Program for these examples, and are provided for instructional purposes only. They should not be included by the claimant.***

The project meets the definition of SR&ED.

**Claim[3]:**

In total, 10 trials were done. The first two trials were aimed at carrying out planned experiments to resolve specific identified technological uncertainties, and the entire product was scrapped since it did not meet the minimum customer's specifications. ED work for these two trials was claimed as EP, and if any products could be sold or converted to commercial use they would be subject to recapture.

The ED work in Trials 3-5 was claimed as EP, and products that could be sold or converted to commercial use would be subject to recapture. However, no claim was ultimately made for the materials transformed because the product met the minimum customer's specifications, and was sold for more than the cost of raw materials. In trials 6, 7, and 8 three different impeller designs were investigated (one per trial) during typical commercial trial process conditions, and these three trials were claimed as CP/ED. Trials 9 and 10 were exact replicates of Trial 8 (to verify reproducibility) and were also claimed as CP/ED.

Following Trial 10 the company planned no further SR&ED work, and the #8 impeller investigated for Trials 8-10 was retained in the reactor for subsequent commercial operations.

In summary this claim will be considered in four separate parts as follows:

I) 2 initial EP Trials (1-2) on large-scale system;

II) 3 follow-up EP Trials (3-5) done to verify repeatability and collect data for mathematical modeling. For illustrative purposes for this claim scenario, it will be assumed that the minimum specifications were achieved and product was sold. Hence the product will be subject to recapture rules. For Trials 1-5 the existing equipment was used, therefore, no capital was claimed.

III) 3 CP/ED Trials (6-8) to evaluate various impeller designs for optimal tank mixing and turbulence;

IV) 2 final CP/ED Trials (9-10) to validate process data from Trial 8.

- EP Trials 1 and 2 expenditure summaries are shown in Tables I a, b, c;
- EP Trials 3-5 expenditure summaries are shown in Tables I a, d.
- CP/ED Trials 6-10 expenditure summaries are shown in Tables II a-c.
- Total Claim summary is shown in Table III.

For all of the tables the overhead expenditure calculation using the proxy method is shown. The calculation for overhead expenditures using the traditional method is not used since it is expected that there will be significant company-to company variations within the chemical industry.

I) During EP Trials 1-5 it was not clear if the required product specifications would be met, since the experiments involved major

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[3] ***The "Analysis of Project" and "Claim" sections have been provided to assist with the practical application of the SR&ED Program for these examples, and are provided for instructional purposes only. They should <u>not</u> be included by the claimant.***

changes to the stability of the process. Each plant trial lasted 40 hours in total duration (see also background section). Hence labour costs for EP Trials 1-5 includes 40 h/trial for each of C. Doe, D. Doe, F. Doe, G. Doe, H. Doe, and I. Doe. The R&D Manager and Chemist, (A. Doe and B. Doe) were each claimed for 100 h/trial because they were involved with project planning before each trial, and analysis of results after each trial. The QC technician, K. Doe, was needed for 8 h during each trial, while the QC Manager, J. Doe, spent 4 h/trial on SR&ED-related work. It was also noted that:

I) the company maintained detailed experimental operating procedures;
II) several dedicated R&D personnel were present during the trials;
III) senior management in the company had signed off on the experimental trials, thereby acknowledging the significant technological risk associated with carrying them out; and
IV) it was unclear if the product would meet the required product quality specifications, such that some or all of the product may not be sold.

For EP Trials 1 and 2, where all of the product was disposed (and minimum specifications were not achieved), the costs of all labour, prescribed proxy amount (PPA), and materials were included in the SR&ED claim. *For these two trials, the disposal costs for byproduct Y and off-specification product Z, (both estimated at $1/kg i.e. $82,000 for the 2 trials) were not claimed since the proxy method was used. The disposal costs could only be claimed under the traditional method if these costs were determined to be directly related and incremental to the prosecution of the SR&ED.* Since commercial manufacturing equipment was used for these two trials there was no claim made for capital expenditures.

In comparison, for EP Trials 3-5, all manufactured product met the minimum specifications. As a result, most of the product was sold, with exception of a small fraction that was saved for chemical analysis testing. In this claim scenario, the costs of all labour and PPA were claimed but none of the material costs were claimed. No capital was claimed.

For the five CP/ED Trials, 6-10, the company had attained the needed confidence in the process, and product performance was indeed achieved. The company fully intended to sell all of the product from the 5 CP/ED trials.

II) Hence, for CP/ED Trials 6-10 the claim includes :

- Incremental labour work associated with collecting SR&ED-related data was claimed. The time of employees A. Doe (100 h/trial), B. Doe (100 h/trial), C. Doe (40 h/trial), D. Doe (40 h/trial), E. Doe (8 h/trial), and J. Doe (4 h/trial) was fully allocated to SR&ED for the entire length of Trials 6-10. M. Doe (300 h total time) and L. Doe (200 h total time) were specifically retained for the mathematical modeling and software development aspects of the work respectively, and were not required for any other plant duties. On the other hand, for all other plant employees, only one-third of their total trial time was claimed. This estimate was based on a best available time allocation for SR&ED type work for these employees, noting that they were also partially engaged with commercial work for these trials.

- All materials used in these trials were not incremental for SR&ED. There were no disposal costs either since the product was sold.
- Capital for data acquisition equipment ($60,000) and two impellers ($50,000/impeller) were also claimed. There was no intent to put the two impellers to commercial use. The company decided not to make a claim for the third impeller, since the company made a decision during the same tax year that the impeller would be subsequently redeployed for commercial use. All capital claimed was considered as “All or substantially all” (ASA) equipment. Expenditure summaries are shown in Tables II a-c.

## List of Personnel Parts I and II[4]

### Table Ia: List of Personnel for 5 EP runs

| Name | Role | Areas of Work | Qualifications | Experience Years | **Trials 1-2** Project Hours ($/hr – **NOT** OVERHEAD RATES) | **Trials 3-5** Project Hours ($/hr – **NOT** OVERHEAD RATES) |
|---|---|---|---|---|---|---|
| A. Doe | R&D Manager | Project manager | Ph.D., P.Eng. | 20 | 200 ($40/hr) | 300 ($40/hr) |
| B. Doe | Chemist | Product Development | MSc | 30 | 200 ($35/hr) | 300 ($35/hr) |
| C. Doe | Technician | Technical Support | Chemical Technologist | 10 | 80 ($20/hr) | 120 ($20/hr) |
| D. Doe | Product Manager | Trial supervision | P. Eng | 15 | 80 ($40/hr) | 120 ($40/hr) |
| E. Doe | Plant Manager | Supervised Plant Work | MEng,<br>P. Eng. | 20 | 16 ($45/hr) | 24 ($45/hr) |
| F. Doe | Shift Supervisor | Supervised batches | High School Diploma | 30 | 80 ($25/hr) | 120 ($25/hr) |
| G. Doe | Operator | Batch maker | High School Diploma | 20 | 80 ($20/hr) | 120 ($20/hr) |
| H. Doe | Operator | Batch maker | High School Diploma | 20 | 80 ($20/hr) | 120 ($20/hr) |
| I. Doe | Operator | Batch maker | High School Diploma | 20 | 80 ($20/hr) | 120 ($20/hr) |
| J. Doe | QC Manager | Supervised QC | BSc Chem. | 10 | 8 ($25/hr) | 12 ($25/hr) |
| K. Doe | QC Technician | Carried out QC testing | Chemical Technologist | 5 | 16 ($20/hr) | 24 ($20/hr) |
| TOTALS | | | | | $27,840 | $41,760 |

### Table Ib: List of Material Costs for EP Trials 1-2 Only

| MATERIAL | $/KG | TOTAL $ |
|---|---|---|
| A | 7 | 2*16000*7 = $224,000 |
| B | 3 | 2*25000*3 = $150,000 |
| CATALYST | 20 | 2*4.1*20 = $164 |
| TOTAL MATERIAL | | $374,164 |

### Table Ic: Expenditures Summary (EP Trials 1-2)[4]

| | |
|---|---|
| Total Labor Cost: | $ 27,840 (See Table Ia) |
| Material consumed/transformed | $374,164 (See Table Ib) |
| Capital Expenditures | $ 0.00 |
| **Trials 1, 2 Total Claimed, excluding overheads** | **$27,840 + $374,164 = $402,004** |
| **PPA = labour*.65** | **$ 27840* 0.65 = $18096** |

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[4] Not a requirement of T661 form.

## Table Id: Expenditures Summary (EP Trials 3-5) [4]

| | |
|---|---|
| Total Labor Cost: | $ 41,760 (See Table Ia) |
| Material consumed/transformed | $0.00 (product sold) |
| Capital Expenditures | $ 0.00 |
| **Trials 3-5 Total Claimed, excluding overhead** | **$41,760** |
| **PPA = labour*.65** | **$41,760* 0.65 = $27,144** |

## Table IIa: List Of Personnel For 5 CP/ED Trials 6-10[4]

| Name | Role | Areas of Work | Qualifications | Experience Years | Project Hours ($/hr – **NOT** OVERHEAD RATES) |
|---|---|---|---|---|---|
| A. Doe | R&D Manager | Project manager | Ph.D., P.Eng. | 20 | 500 ($40/hr) |
| B. Doe | Chemist | Product Development | MSc | 30 | 500 ($35/hr) |
| C. Doe | Technician | Technical Support | Chemical Technologist | 10 | 200 ($20/hr) |
| D. Doe | Product Manager | Trial supervision | P. Eng | 15 | 200 ($40/hr) |
| E. Doe | Plant Manager | Supervised Plant Work | MEng,<br>P. Eng. | 20 | 40 ($45/hr) |
| F. Doe | Shift Supervisor | Supervised batches | High School Diploma | 30 | 67 ($25/hr) |
| G. Doe | Operator | Batch maker | High School Diploma | 20 | 67 ($20/hr) |
| H. Doe | Operator | Batch maker | High School Diploma | 20 | 67 ($20/hr) |
| I. Doe | Operator | Batch maker | High School Diploma | 20 | 67 ($20/hr) |
| J. Doe | QC Manager | Supervised QC | BSc Chem. | 10 | 20 ($25/hr) |
| K. Doe | QC Technician | Carried out QC testing | Chemical Technologist | 5 | 13 ($20/hr) |
| L. Doe | Software Developer | Software code | B.A.Sc.<br>P.Eng. | 10 | 200 ($35/hr) |
| M. Doe | R&D Engineer | Data Analysis And Model Development | B.A.Sc.<br>P.Eng. | 10 | 300 ($35/hr) |
| TOTAL | | | | | $75 255 |

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[4] Not a requirement of T661 form.

## Table IIb: List of Material Costs for 5 CP/ED runs[4]

| MATERIAL | $/KG | TOTAL $ |
|---|---|---|
| A | 7 | 0 |
| B | 3 | 0 |
| CATALYST | 20 | 0 |

## Table IIc: Expenditures Summary (5 CP/ED Trials)[4]

| | |
|---|---|
| Total Labor Cost: | $ 75255 (See Table IIa) |
| Material consumed/transformed | $ 0.00 (product sold) |
| Capital Expenditures (Used all or substantially all for SR&ED)<br>1. Computer aided data acquisition system and sensors<br>2. Impellers | 160,000 total<br>$60,000<br>2 x $50,000/impeller = $100,000 |
| **Total Claimed, excluding overheads** | **$235,255** |
| **PPA = labour*.65** | **$ 75255* 0.65 = $48916** |

## Table III: Total SR&ED Claim

| TRIAL # | CLAIM, EXCLUDING PPA ($) | PPA ($) |
|---|---|---|
| 1-2 | $402,004 | $18,096 |
| 3-5 | $ 41,760 | $27,144 |
| 6-10 | $235,255 | $48,916 |
| Total Claim Summary (Trials 1-10) | $679,019 | $94,156 |
| **Total Claim, including PPA (Trials 1-10)** | **$679,019 + $94,156 = $773,175** | |

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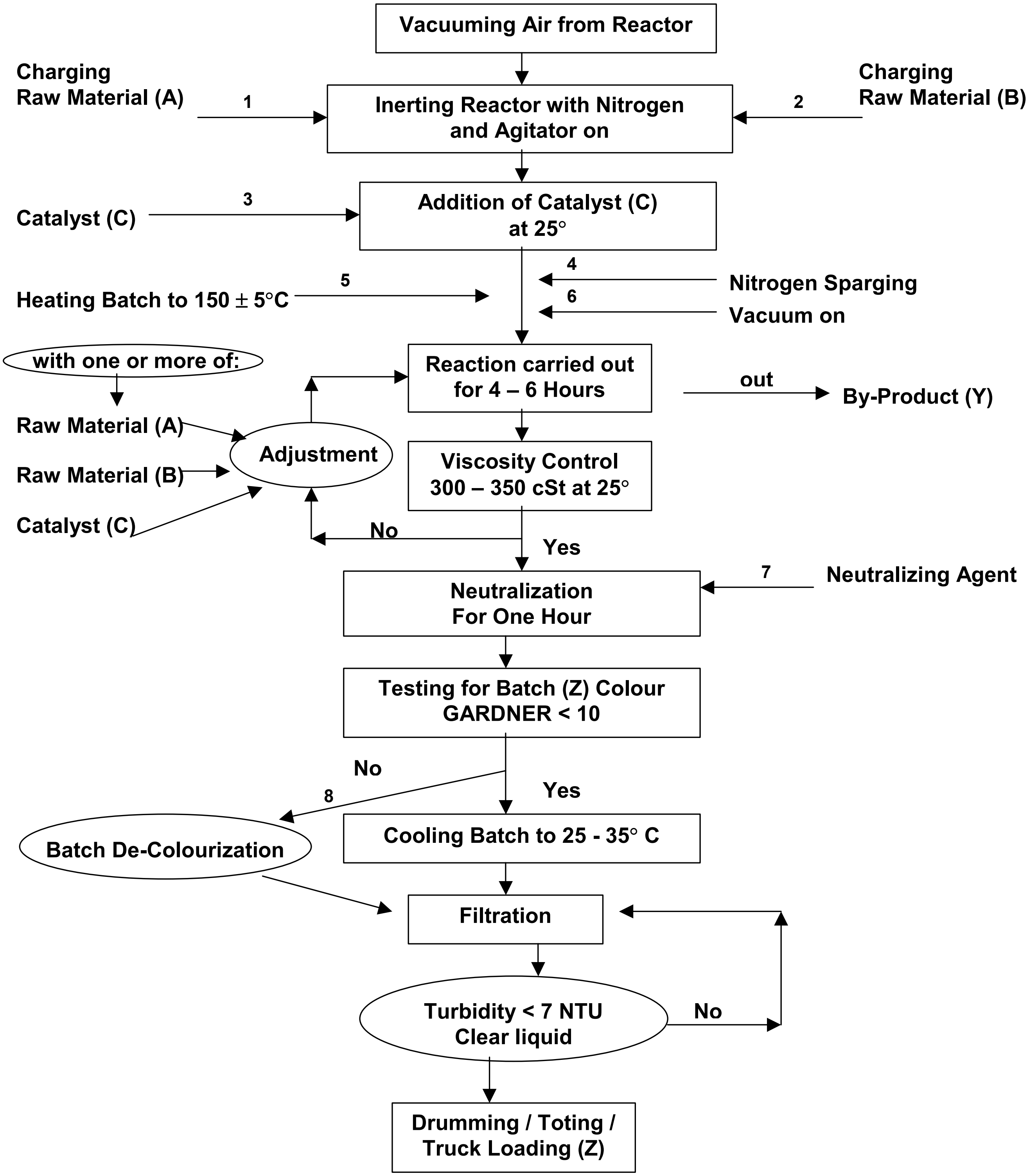
[4] Not a requirement of T661 form.

**Figure 1: Process Flow Diagram**



## Continuous Chemical Processing Examples

### Example 3.3: Bio-treatment of Wastewater

Start Date: June 2002
End Date: January 2003

SR&ED issues addressed:

1. Claim for ED (in simultaneous commercial use)
2. Capital
3. Materials consumed
4. Modeling
5. Reproducibility and repeatability
6. Proxy Method
7. Contract Costs

### Background Information[1]

The wide range of wastewater process effluents generated in the production of specialty chemicals must be treated to remove pollutants. A specialty chemicals company has spent considerable effort to develop a comprehensive multi-stage wastewater-treatment system to handle all waste streams generated in its operation. The effluents from these processes must meet all environmental regulations for the discharge of waste to municipal water treatment systems, and the emissions of volatile compounds to the atmosphere as established by Municipal regulations and the Provincial Ministry of the Environment.

In the past, ultra-violet radiation, activated carbon and precipitation techniques have been investigated but they are not as cost-effective as other technologies in use. Microorganisms can successfully break down organic constituents in the primary wastewater reduction process to eliminate organic contaminants as measured by Dissolved Organic Carbon (DOC) levels and specific contaminants of concern including aniline, toluene and methyl isobutyl ketone (MIBK). The bio-treatment of wastewater is a key step in the company's overall wastewater process (see Simplified Bioreactor Flow Chart, Figure 2), and one where the company feels additional efficiencies can be achieved.

To have an efficient system, the input variables must be well controlled to maintain the viability of the biological organisms responsible for degradation of organic compounds. Recent laboratory work (last year's SR&ED claim) has suggested that the use of pure oxygen (99.9%), as a feed to the bioreactor offered all of the following advantages: i) improved conditions for biological activity, ii) reduction of the contaminant levels in the waste stream, iii) decreased release of volatiles to the atmosphere, and iv) significant increase in the capacity of the system to handle new waste streams.

Plant testing was required to evaluate the process under conditions where the environment was more difficult to control and the composition of waste streams was under constant flux.

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[1] ***Note that the "background section" is not required to be provided with the project description.*** However, if the claimant provides information related to "Background Information" it may be helpful to providing the context for the project.

Trial runs using pure oxygen at various addition rates showed that it was possible to optimize the reduction of DOC, Total Kjeldahl Nitrogen (TKN), Volatile Organic Compounds (VOC) and the level of specific contaminants to below regulatory requirements, and thus improve the capacity of the system to handle the increased flow rates of typical waste streams.

### Business Objectives[2]

The business objective was to identify ways to improve the operation of the bioreactor for the elimination of contaminants in the plant's wastewater.

## Start of T661 Form:

### 1A. Scientific/Technological Objectives

The objective of this project was to determine the appropriate flow rates of oxygen (350 - 500 litres/min) and influent (100 - 150 litres/min.) required to maximize the rate of organic contaminant removal in the bio-reactor unit, while monitoring the effects of normal variations in operating conditions (pH, temperature, waste stream composition) on the system.

### 1B. Technology or Knowledge Base Level

The company has gained significant knowledge about treating typical waste streams after several years of operation of a biological wastewater treatment system. Optimizing pH, temperature and low-pressure airflow has controlled dissolved organic carbon and key contaminants in the waste stream. The company's engineers have shown their understanding by reducing DOC levels in the process wastewater by up to 50%. Despite these successes, there remains a great deal that is not known about the effect of operating conditions such as rates and type of oxygen feed.

### 1C. Scientific/Technological Advancement

The company sought to advance the waste bio-treatment process by replacing the low-pressure air feed with oxygen. The company's rationale was that, by using pure oxygen to enhance bioactivity and by eliminating the other gases present in air, the level of organic compounds in the waste stream and the rate of volatile emissions from the system would both be reduced. It was technologically unclear, however, if the removal of the other gases might interfere with some of the degradation processes.

The company also sought to advance existing technology by modeling the system and thereby provide a predictive tool for evaluating the most efficient way to operate the bio-treatment system.

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[2] Not a requirement of T661 form.

## 1D. Description of Work/Activities in This Tax Year

| Title | Description |
|---|---|
| Installation of pure oxygen supply<br>August 2002 | Work was completed on the installation of a pure oxygen supply to the bioreactor. Engineering work was completed to install baffles that would maximize mixing within the reactor. |
| Optimization of oxygen supply and influent rate<br>September – November, 2002 | A Statistical Experimental Design (SED) was developed using a commercially available software package. A number of responses were measured in a series of twelve trials in which the oxygen flow (5 levels between 300 and 500 L/min) and rate of influent addition (5 levels between 100 and 150 L/min) were varied. This is a response surface design quadratic model, which will allow estimation of linear, interaction and quadratic terms, and can be applied to all responses measured. The results allowed for modeling of the system and optimization of the two rate parameters for each response variable tested.<br>To allow for equilibration of the biological system and to include normal variations in waste stream composition, each individual trial was conducted for a period of 5 days. To accommodate process changes between trials, the entire SED was completed over a period of twelve weeks. During each of the trials, levels for DOC, VOC, TKN and selected contaminants in the effluent stream were monitored daily as indicators of contaminant reduction. Dissolved oxygen, temperature, oxygen uptake and pH were also monitored daily as key indicators of biological activity.<br>The determination of the level of selected contaminants in the wastewater was beyond the capability of the in-house laboratory and this work was contracted out to a Canadian environmental laboratory at a cost of $75 per sample. Samples were collected in duplicate and shipped to the lab on a daily basis. Operators were responsible for the daily sampling of each trial. This work was completed as a separate activity by operators and was done in addition to regular quality control sampling. |

| Title | Description |
|---|---|
| Analysis of Results<br>November 2002 | The experimental results were analyzed with the help of the statistical software package used in setting up the SED. This package allowed for the development of mathematical models to determine the optimal conditions for compound destruction, minimization of volatile emissions and the enhancement of biological activity in the bioreactor system. This model showed that a rate of pure oxygen addition of 425 L/min. and an influent rate of 120 L/min. would provide optimal biological activity and maximum reduction in the key contaminant characteristics studies. At these optimum rates, the bioreactor could treat 15% more waste and achieve a 20% reduction in DOC and TKN, and reduce VOCs and contaminants of concern to below detectable levels. |
| Verification of Model Prediction<br>November 2002 | An additional one-week trial was conducted with the optimal flow rates of oxygen and influent rates that the model predicted. The one-week trial allowed for the establishment of equilibrium in the system and verification of the model. Results of the trial confirmed both the enhanced biological activity and the reductions in DOC, TKN, VOC and contaminant levels. |

## 1E. Supporting Information

- Engineering designs for oxygen supply & flow meters
- Lab notebooks
- Email correspondence
- Analytical results
- Data analysis reports
- Flow Chart of Process
- Time Sheets

## End of T661 Form:

### Analysis of Project[3]

Work for this project was carried out on the continuous flow bioreactor currently in operation at the company's wastewater treatment facility. The results demonstrated that it was possible to increase degradation of the organic waste. Furthermore, pure oxygen could decrease the emission of volatile species to the atmosphere and did not interfere with the elimination of any of the key contaminants studied.

Work was also done to generate a reliable mathematical model of the process to optimize operating parameters. Application of the model resulted in a 20% waste reduction and an increased operating capacity of 15%. The mathematical modeling of the process was carried out in support of the project.

This project meets the requirements for SR&ED as defined in subsection 248(1)(c) of the ITA, with a technological advancement through "experimental development".

### Claim[3]:

The waste bio-treatment process has remained operational during conduct of the experimental trials described, and as such, involves ED occurring simultaneously with commercial use of an existing facility. *The work claimed for the SR&ED project will not include the costs for the normal day-to-day operation of the system, which is the work associated with commercial use of the facility. Rather, the claim outlined below will include only those relevant costs directly related to the ED work undertaken.*

A summary of the expenditures for this SR&ED Project is given in Tables 1 and 2. The total claim estimated in this case includes any relevant and applicable costs for labour, capital, and materials.

As part of the SR&ED claim, the company will be claiming capital expenditures for the acquisition of;

- Statistical software used for the analysis of data and modeling of the process.
- In-line dissolved oxygen analyzer
- Flow sensing equipment

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[3] ***The "Analysis of Project" and "Claim" sections have been provided to assist with the practical application of the SR&ED Program for these examples, and are provided for instructional purposes only. They should not be included by the claimant.***

The in-line dissolved oxygen analyzer and flow-sensing equipment were purchased specifically for conducting this SR&ED project and they will not be used for the routine monitoring of the system after completion of the ED work.

The capital costs for the purchase and installation of piping, valves, regulators and reactor baffles to provide the required supply of pure oxygen to the system was $12,500. As this is a permanent installation now used for regular operations, these costs will not be claimed.

Labour costs associated with normal operations of the system are not claimed. Operator time used specifically for collection of samples, monitoring of performance variables and modifications to the system as part of the ED work is claimed. This represented twenty hours over the length of the trial.

The cost of Contract lab analysis fees of $75/sample will be claimed. These are samples taken in addition to any samples taken for analysis as part of the normal quality control. The determination of concentrations for five components, considered representative of the system, will be made for each sample. Over the trial period of 100 days, experimental samples were taken in duplicate at a rate of one a day for a total cost of $15,000.

If the proxy method is chosen, allowable overheads are estimated as the prescribed proxy amount (PPA), which is calculated as 65% of the salary base for directly engaged SR&ED staff. In Table 2 an estimate for overhead expenditures using the proxy method is shown.

**Table 1: List of Personnel Claimed and Labour Expenditures[4]**

| Name | Role | Areas of Work | Qualifications | Experience Years | Project Hours ($/hr – **NOT** OVERHEAD RATES) |
|---|---|---|---|---|---|
| A. Barnes | R&D Manager | Project manager | P.Eng., MSc. | 20 | 125 ($40/hr) |
| B. Barnes | Engineer | Environmental Engineering | M.Eng | 30 | 250 ($35/hr) |
| C. Barnes | Lab Manager | Supervised Environmental Lab | MSc. | 22 | 25 ($35/hr) |
| D. Barnes | Chemist | Analytical Testing | BSc. | 10 | 150 ($25/hr) |
| E. Barnes | Technician | Sampling, Testing | Chemical Technologist | 15 | 100 ($20/hr) |
| F. Barnes | Technician | Sampling, Testing | Chemical Technologist | 10 | 100 ($20/hr) |
| G. Barnes | Statistician | Data Analysis and Modeling | MSc. | 20 | 25 ($40) |
| H. Barnes | Operator | Sampling | High School Diploma | 16 | 20($20) |
| TOTAL LABOUR COST | | | | | $23,775 |

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[4] Not a requirement of T661 form.

## Table 2: Overall Expenditures Summary[4]

| | |
|---|---|
| Total Labour Cost: | $23,775 |
| Material consumed (Oxygen) | $3,500 |
| Contract Laboratory – Chemical Analysis | $15,000 |
| Capital Expenditures | |
| • Statistical software used for the analysis of data and modeling of the process. | $8,500 |
| • In-line dissolved oxygen analyzer | $4,000 |
| • Flow sensing equipment | $3,500 |
| Total Claimed, excluding overheads | $58,275 |
| Proxy Overhead, PPA[b] = Labour*0.65 | $15,454 |
| Total Claim (including PPA) | $73,729 |

[b] Note: PPA refers to “prescribed proxy amount”

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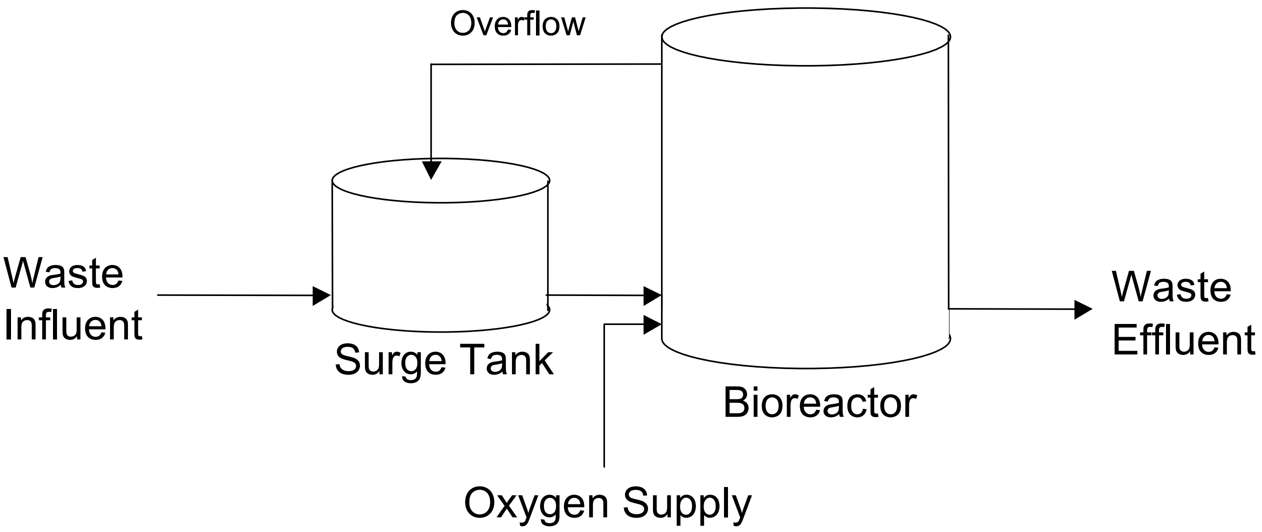
[4] Not a requirement of T661 form.

Figure 2: Simplified Bioreactor Flow Chart



## 4. REFERENCES

**[1]** Chemicals Guidance Document 1 - Shop Floor SR&ED
http://www.cra-arc.gc.ca/taxcredit/sred/publications/chemdoc-e.html

**[2]** Chemicals Guidance Document 2 – Qualifying Work
http://www.cra-arc.gc.ca/taxcredit/sred/publications/guidance_menu-e.html

**[3]** Application Policy SR&ED 2002-02R: Application Policy (AP) 2002-02R: Experimental Production and Commercial production with experimental development work – Allowable SR&ED Expenditures.
http://www.cra-arc.gc.ca/taxcredit/sred/publications/ap2002-02R-e.html

**[4]** T661: Claim for Scientific Research and Experimental Development (SR&ED) Carried out in Canada
http://www.cra-arc.gc.ca/E/pbg/tf/t661/README.html

**[5]** Barry L. Tarmy, "Encyclopedia of Chemical Technology (3rd edition)", 19 880, John Wiley and Sons, Toronto (1982)

## 5. APPENDICES

### Appendix A: Subsection 248(1) of the Income Tax Act

The law (subsection 248(1) of the *Income Tax Act*) defines SR&ED as:

"Systematic investigation or search that is carried out in a field of science or technology by means of experiment or analysis and that is:

(a) basic research, namely, work undertaken for the advancement of scientific knowledge without a specific practical application in view,

(b) applied research, namely, work undertaken for the advancement of scientific knowledge with a specific practical application in view, or

(c) experimental development, namely, work undertaken for the purpose of achieving technological advancement for the purpose of creating new, or improving existing, materials, devices, products or processes, including incremental improvements thereto,

and, in applying this definition in respect of a taxpayer, includes

(d) work undertaken by or on behalf of the taxpayer with respect to engineering, design, operations research, mathematical analysis, computer programming, data collection, testing and psychological research where the work is commensurate with the needs, and directly in support, of work described in paragraph (a), (b) or (c) that is undertaken in Canada by or on behalf of the taxpayer,

but does not include work with respect to

(e) market research or sales promotion,

(f) quality control or routine testing of materials, devices, products or processes,

(g) research in the social sciences or the humanities,

(h) prospecting, exploring or drilling for, or producing, minerals, petroleum or natural gas,

(i) the commercial production of a new or improved material, device or product or the commercial use of a new or improved process,

(j) style changes, or

(k) routine data collection.

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