SUBJECT: Scientific Research and Experimental Development

NO: **94-1** Date: February 4, 1994

Plastics Industry Application Paper

The purpose of this application paper is to assist applicants within the plastics industry, and Revenue Canada staff in interpreting how the current version of Information Circular 86-4, ***Scientific Research and Experimental Development***, (IC 86-4), applies to this industry sector. The paper provides supplementary guidelines related to scientific research and experimental development (SR&ED), and it should be read as an extension of the guidelines contained in IC 86-4. If there is any conflict between this paper and IC 86-4, the circular has precedence.

Plastics Industry Application Paper

Contents

1 Introduction

The plastics industry is made up of companies engaged wholly or partly in producing plastic materials and additives; processing plastic materials into semi-finished and finished products; recycling and reclaiming waste products, and supplying machinery, moulds and dies. The plastic industry also includes companies such as resin manufacturers; the manufacturers of other materials used with plastics such as reinforcements, colourants, plasticizers, and other property modifiers; compounders, who mix these materials and produce a plastic that is ready to make into a product; manufacturers of machinery, equipment, dies and moulds used to process the plastics; fabricators or processors who make the plastic parts; and finally, the companies that take these plastic parts and incorporate them into finished products that are sold to consumers.

IC 86-4 provides an interpretation of section 37 and section 2900 of the Regulations regarding technical guidelines for SR&ED. The purpose of this application paper is to improve the understanding of these guidelines as they apply to the plastics industry. The main areas of concern are the technological advancement, the technological uncertainty, and the technical content of an SR&ED project. This paper does not deal with specific questions concerning allowable expenditures. More information about expenditure issues is available in the current version of Interpretation Bulletin IT-151, ***Scientific Research and Experimental Development Expenditures***. It is intended that this supplement will assist applicants to assess project eligibility.
As described in Part 2.7 of IC 86-4, the major issues to be addressed are the separation of eligible activities from excluded activities. This includes differentiating between eligible activities that advance technical knowledge and "routine engineering or routine development." It also includes distinguishing between eligible experimental development activities and ineligible commercial activities. The three criteria of technological advancement, technological uncertainty, and technical content are the primary factors that must be met to establish eligible activity. It is important to note that all three criteria must be met. General descriptions of these three criteria are set out in Part 2.10 of IC 86-4.

2 Technological Advancement

Part 2.10.1 of IC 86-4 describes the criterion of scientific or technological advancement as the SR&ED activity that generates information that advances the understanding of scientific relations or technologies to such an extent, that when a product or process is created or improved, it embodies the scientific or technological advancement. Part 4.1 of IC 86-4 provides further guidance by stating that for successful experimental deelopment, "**A technological advance is the incorporation, by means of experimental development, of a characteristic (capability), not previously existing or available in standard practice, into a new or existing process or product that enhances its performance**. Novelty, uniqueness, or innovation alone do not indicate the existence of a technological advance."

In the plastics industry, there are three major areas for SR&ED activities: materials, processes, and equipment. A company conducting SR&ED in these areas should have an objective, and propose a plan to achieve that objective. The company should then conduct systematic experiments and analyses to test the hypothesis involved in that plan. At the end of the experiments, the company will either have proved or disproved the hypothesis, and gathered new information in the process.

For SR&ED activities, it is necessary to take into consideration the "standard practice" of both the industry and the particular company. In general terms, the industry's "standard practice" can be defined as the body of knowledge within the public domain which would generally be considered readily available to a company. On the other hand, a company's "standard practice" is a combination of its own knowledge, and the body of knowledge in the public domain. Experimental development by a company that duplicates another company's proprietary knowledge could represent a technological advancement for the first company. The project's performance objectives do not have to be achieved as long as the company's technological knowledge is advanced. Part 4 of the IC 86-4 lists the issues that must be addressed.

2.1 Materials

Existing data sheets, as prepared and made available by suppliers, form the basis of the industry's standard practice. Each plastic end-product may contain several materials, including one or more polymers. Each of these polymers is available in various molecular weights and molecular weight distributions.

Work by a company, for example, to create or to attempt to create new polymers and plastics which are not already part of the industry standard practice, and not part of that company's proprietary information, could be considered as eligible SR&ED according to subsection 2900 (1) of the Regulations. The company must, however, be able to demonstrate that technological advancement has occurred, in addition to the other two criteria, even if the work to create the new material has not been successful. Both successes and failures may increase the level of scientific knowledge of a particular company, and thereby meet the criterion of scientific or technological advancement.

Product development frequently involves developing a product for a specific application that has to meet mechanical property requirements under both "static" and "dynamic" loading. Typical examples of mechanical properties under static load are tensile strength, tensile modulus, flexural strength, flexural modulus, and creep. Mechanical properties under dynamic load are those that are subject to impact load and periodic cycle loadings. An example would include the effect of engine vibrations, that could range from a few cycles per second to several thousand cycles per second, on a product being developed. Impact resistance and fatigue resistance are two characteristics associated with dynamic testing. Mechanical property characterization under static load is relatively straightforward and is the type of data found on data sheets, but mechanical property requirements under dynamic load are extremely varied and often depend upon the specific application. Mechanical properties under dynamic load are seldom found on data sheets.

Another feature of property requirements that is common in the plastics industry is that each application will have a number of primary requirements that must be met. Usually, there will also be several secondary requirements which are not addressed until after the primary requirements have been met. These primary and secondary requirements vary widely for each application. They are met by choosing materials, either alone or in combination, and the process made to fabricate the part.

The plastics industry must define application requirements in terms of performance requirements. This is in contrast to traditional practices of relying on material requirements when a material such as wood is to be used, and the specifications are based on that material. For example, it is common practice in the construction industry to specify building application requirements based on materials such as wood or brick, and not on a particular performance requirement. In the plastics industry, it may be necessary to first define the specific performance requirements, and then develop a material that satisfies those requirements. This process may constitute an eligible SR&ED activity where the material being developed embodies scientific or technological advancement.

2.2 Processes

In the area of processes, there are two major types of development; a modification to an existing process, and a completely new process. When a process is modified, it is often easier to define the technological advancement in terms of the materials being developed, rather than trying to define the technological advancement in the process. In a completely new process, it is often easier to define the technological advancement in terms of the new process, since often the objective is to make exactly the same material as before, but to make it more efficiently. Processes can use one piece of equipment or several pieces of equipment that are used together in some sequence or order.

2.3 Equipment

There are two major types of equipment development: modifications to existing equipment, and new types of equipment for new processes. When equipment is modified, it may be possible to define the technological advancement in terms of the end product or an increase in productivity. Typical advancements could include higher quality, new characteristics, and lower cost. Lower cost can result from increased speed, increased reliability (resulting in lower scrap production), and from using things such as power or raw materials more efficiently. Adapting a technology common in another field to the plastics industry may represent SR&ED as long as that practice is not standard in the industry. Technological advancement may also include developing new equipment or modifying existing equipment to produce a new end product, or an existing end product not previously made using that type of equipment, process, or material. When a new type of equipment is developed, there is usually a new principle or theory which can readily be described that is the basis for the technological advancement .

3 Technological Uncertainty

Technological or scientific uncertainty is the second test that must be considered before an activity qualifies as SR&ED. Part 2.10.2 of IC 86-4 describes technological uncertainty in terms of not knowing whether goals can be achieved, or not knowing which of several possible alternatives will meet the desired specifications and/or cost targets. To resolve these technological uncertainties, experimentation or analysis is needed. In this regard, Part 4.6 of IC 86-4 states that "if a complex engineering activity results in a new product or process, the development of which was the almost certain outcome of applying a progression of well-known techniques, it cannot be classified as an eligible experimental development activity."

Part 4.8 states that "work on the combination of standard technologies, devices, and/or processes is eligible if non-trivial combinations of established (well-known) technologies and principles for their integration carry a major element of technological uncertainty; this may be called a "system uncertainty." If the technological specifications or objectives to resolve the "system uncertainty" are such that the basic design of the underlying technologies must be changed to achieve integration, the current costs of the overall project may qualify. More often, it will be necessary to separate those activities which are eligible from those which are not. In such situations, a central problem is to determine the work which relates to the eligible activity (i.e., which routine engineering activities are carried out in "support" of the requirements of the eligible activity), and the work which does not."

Part 4.8 continues with the clarification that "when the specifications for components requiring advancements in technology do not significantly affect the design requirements of other components in complex projects, only individual studies carried out to meet the advanced design requirements of the activity are eligible. When advanced technological specifications necessitate redesigning closely related components, then the activities associated with redesigning the associated components are eligible. These considerations apply to the assessment of any custom design project (customization), pilot plants with commercial potential, and prototypes which are ultimately sold."

Within the three areas of SR&ED activities in the plastics industry (materials, processes and equipment), there are known principles that apply but there are also several unknown and often unexpected outcomes resulting from different combinations of materials and processes. Synergism occurs frequently in the plastics industry leading to problems and uncertainty that must be explored through experimentation and analysis. This is partly because polymers are not uniquely chemically defined phenomena. Besides having different molecular weights and molecular weight distributions, polymers, for example polyethylene, can be straight chain or branched, or a mixture of both. Plastics technology is relatively new, and the data available is not fully understood. It is for these reasons that some of the research and development activities done in the plastics industry may at first glance appear to be routine engineering development. The challenge is to show where they are not.

3.1 Materials

Of the three areas of materials, processes and equipment, the technological uncertainties regarding the development of materials are the easiest to describe because of the quantitative manner in which material properties can be measured.

For example, standard practice for a company involved in developing a material is based on industry data sheets plus that company's proprietary knowledge. With this information as a reference point, new combinations of materials may or may not yield predictable results both from a qualitative and quantitative point of view. It is the activities (e.g. analysis or testing) that a company undertakes to resolve these technological uncertainties that are required to make a project eligible.

3.2 Processes

There are two types of process development. When a project involves modifying an existing process, it may be easier to relate the technological uncertainty to the material property uncertainty. This leads to one type of experimental activity. When developing a new process, it is the different scientific principles or the approach used in the process itself that should illustrate the uncertainty factor. Different types of experiments would be done to resolve the technological uncertainties in this case. In both types of process development, cost constraints are a valid element of uncertainty. Process development can involve one piece of equipment or several pieces of equipment. The recent trend to combine several operations into a process is illustrated by the injection moulding industry and its development of post injection moulding operations that collect, sort and package the injection moulded parts. Some of the leading development work in robotics has been in this area.

3.3 Equipment

Routine engineering may predict, with certainty, the results or outcome of an engineering development in equipment. If the results cannot be predicted with certainty, then the development activity may not be routine engineering but instead may require experimental development. Eligible SR&ED involves having an objective, and then making a hypothesis that is tested experimentally or analyzed to obtain results that cannot be predicted accurately. With high temperatures, high pressures, and non-Newtonian flow liquids, achieving the desired level of performance often cannot be achieved through routine engineering. The development of hot runner systems used in injection moulding is a technology that illustrates this point. To obtain fast cycle times and high quality, consistent parts in terms of physical properties when moulding thin complex parts, melt conveying technology continues to be developed that delivers molten polymer to a multi-cavity mould in high temperature, high pressure environments. The materials, design and manufacturing methods involved in developing hot runner systems are all pioneering technology in which Canada is a world leader.

Even with mature hot runner system technology, new materials or product applications may create uncertainty, especially since hot runner systems operate at high temperatures and are subject to complex dynamic loading which is difficult to simulate. In addition, molten plastic behaviour and the effect of abrasive additives or corrosive byproducts on system components may not be well understood.

Not all machine development is necessarily related to producing new products or enhancing the capabilities of existing ones. The ultimate sophistication in technology is simplicity. A moulding machine operator may have a limited scientific or engineering background. Thus, developing a machine that incorporates technology that can only be operated by highly trained or educated specialists is normally of limited practical value. Eliminating the necessity of manual control functions, or designing machinery that is easier to manage because of built-in predictability or reliability, may be a valid SR&ED project when there are elements of technological uncertainty that must be overcome.

4 Technical Content

Part 2.10.3 of IC 86-4 emphasizes that technical content, evidenced by systematic investigation from hypothesis formulation, through testing by experimentation or analysis, to the statement of logical conclusions is an essential criterion for eligibility. It also requires that qualified personnel having relevant experience in science, technology or engineering be responsible for the direction or performance of the work.

As described in Part 3.2 of the circular, "It is a normal expectation for scientific research and experimental development that a planned approach to the project will be formulated; that is, a hypothesis will be advanced and a systematic series of experiments or analyses will be planned in order to test the hypothesis. **Each project should normally be documented, showing clearly why each major element is required and how it fits into the project as a whole.** To build on the results of testing in a systemic way requires organized documentation of work undertaken in the elements of the experimentation or analysis." Part 3.2 also states that "If claims for scientific research and experimental development are to be defended, it is important for a firm to maintain dated documentation of the original technological goals of the project, the progress of the work and how it has been carried out, and the project's conclusions."

4.1 Documentation

Adequate documentation of SR&ED projects is required as evidence to support the technological uncertainties to be resolved, the technological advancements achieved, and the technical work done. This documentation should not contain unnecessary detail and proprietary information not required for determining a project's eligibility. A one-page or a two-page technical summary for each project that gives a clear description of the project being performed is usually sufficient to present the relevant facts while also identifying sources of more detailed project information, if this is required. Revenue Canada has revised Form T661, ***Claim for Scientific Research and Experimental Development Expenditures Carried on in Canada*** to indicate the type and amount of information needed to satisfy their requirements for documentary evidence. Revenue Canada has also published a ***Guide to Form T661*** which provides further assistance in completing Form T661.

It is important to document details of the personnel involved in the project, their technical qualifications, and the amount of time they have spent on the project. The materials consumed in the project, and the equipment used must also be documented. A summary of the resources allocated to the project is important and should include estimates of both current and capital expenditures. This is particularly important in the case of capital expenditures for equipment in order to establish the intended and actual usage of the equipment during its useful life.

Besides the obvious requirement for details of the time spent on the project and the materials and equipment used in a project, there is a need for clear technical documentation. In addition, a finite time frame should be established for the project. Issues that have to be addressed include projects that are continuations of projects claimed in previous years. When a project initiated in a previous taxation year is continued in the current taxation year, it would generally suffice to include a photocopy of the previous year's report, and an outline of the project’s progress since last year. If the particular project was scheduled to be completed last year, but has been continued, the project description should set out the reasons why the project was extended or why its completion was delayed. If the project was ineligible last year, but is now considered eligible, explain why the project’s status changed. It is also important to predict when a project will be finished, as it is usually assumed that a project will be discrete, and have a finite time frame in which it will be carried out.

Special Issues

5 Prototypes and Pilot Plants

Questions involving prototypes and pilot plants are of major concern to the plastics industry. The questions that have been raised relate to the manufacture and use of prototype equipment, and also the issue of separating commercial production activities from SR&ED activities when prototypes, prototype production, and pilot plants are involved. In general terms, if a qualified SR&ED project is being carried on, one or more of the activities in the project may be the development of a prototype or pilot plant. Experimental production or prototype production may also be a qualified activity.

5.1 Definition

The ***Income Tax Act*** does not define prototypes or pilot plants, or specifically provide for their treatment. The terms are defined, however, in the glossary of terms set out in Appendix A of IC 86-4. Prototypes or pilot plants can be considered either as stages in a SR&ED project, or as a SR&ED project in itself. This point is dealt with in some detail in Part 7.1 (3) of the circular.

From a technological point of view, a prototype is normally understood to be a trial model or preliminary version. As defined in IC 86-4, "It is a basic experimental model possessing the essential characteristics of the intended product." Further, "... prototypes are to provide a test of the feasibility of the concept or hypothesis." However, in industry, the term "prototype" is commonly used to refer to the very first machine, component etc. constructed for a commercial purpose.

A pilot plant, as defined in the circular, is a "non-commercial scale plant in which processing steps are systematically investigated under conditions simulating a full production unit." However, industry sometimes refers to commercial scale projects as "pilot plants," whose transformation into a commercial facility may involve SR&ED activities, (see Part 7.9 of the circular).

In the context of the plastics industry, a prototype or pilot plant may be used to: improve understanding of scientific phenomena, study the behaviour of materials, develop an economically viable process for manufacturing a new product or process, improve an existing product or process, modify equipment for new applications, test new equipment under new conditions, provide samples of a tailored product for scientific research, determine a new method of achieving a desired result, or to investigate the cause and effect relationship between certain parameters.

5.2 Eligible activities

As in any SR&ED project, the tax treatment of the activities and costs involved in the development of prototypes and pilot plants are essentially governed by the definition of SR&ED in subsection 2900(1) of the Regulations, and the definition of SR&ED expenditures in section 37 of the ***Income Tax Act***. Prototypes or pilot plants may, in some circumstances, be of no further use for SR&ED and other purposes once the technological uncertainty has been resolved. Thus, successful or not, the associated activities would normally be considered eligible. It is not a criterion of eligibility whether the technical objectives of a project are fully or partially met.

However, if the project is in fact to develop a "custom product" or a "commercial facility," it is important that the SR&ED elements of a project be correctly described. Developing a "custom product" or "commercial facility" can involve a mix of activities, of which, only those associated with the SR&ED will be eligible. As noted previously, it is important that a company, mindful of its own standard practice, distinguish between SR&ED and non-SR&ED activities. Non-SR&ED activities, among other things, include standard practice activities not related to resolving the SR&ED technological uncertainty, and not leading to technological advancement. If developing a "custom product" or "commercial facility" is approached in this manner, the claim will not be affected by the subsequent non-SR&ED use or sale of the "custom product" or "commercial facility," regardless of whether the SR&ED project is successful.

5.3 Beta site testing

Frequently, experiments are carried out in production facilities to evaluate the process or equipment performance in a commercial environment, and to resolve the technological uncertainties that arise. This step, often referred to as beta site testing, may be essential since the success or failure of a SR&ED project can (in a practical manner) often be more easily determined after carrying out extended testing in a typical production environment such as that found in a customer's facility.

In certain situations, beta site testing may take place after legal ownership of equipment has been transferred to the customer. The change in ownership does not necessarily indicate that SR&ED activities have been completed. In fact, a significant portion of SR&ED may occur once beta site activity begins and the practical challenges of implementing the technology become apparent. During beta site testing, it is important to identify which activities are SR&ED, and to be aware of what is occurring at a technical level. Situations such as high scrap rates may indicate that the performance objectives of a project have not yet been achieved. However, it is the reason for the scrap problem and the nature of the experimental process undertaken to find a solution which determines whether these activities represent SR&ED. (This matter is discussed in Part 2.8 of the circular).

The qualifying expenditures must reflect only the incremental costs to run the experiments for the SR&ED activities. Often, much of the testing relating to the establishment of standards, such as quality control definitions, are carried out in the facilities used routinely in the daily operation of the taxpayer. These expenditures must also be documented as part of a pre-planned, systematic development program and, in cases like this, it is necessary to establish the specific periods of use. It is important to show that the SR&ED activities being claimed meet the three essential criteria, and to differentiate the activities from ineligible ones.

There are key indicators in determining if experimental development is ongoing: whether uncertainty regarding the technical success of the project still exists, whether a company is still seeking a technological advance, and whether experimentation or analysis is still being undertaken.

5.4 SR&ED vs commercialization

In most commercial systems, some amount of routine debugging or fine tuning is expected, and these activities would not normally be considered SR&ED. However, in the case of prototypes and pilot plants, extensive testing and analysis is often required to prove or validate the system's performance. In many cases, the operating concepts which are to be evaluated using a prototype or pilot plant can only be proven using a full-scale version.

The actual size or capacity of such equipment or facilities is not a factor. Indeed, the pilot plant facilities or prototypes for an established major corporation may be larger than the actual product facility or equipment for a small developing company. What is important is the actual use made of the facilities, equipment, or product. They must be used to resolve technological uncertainties if the associated activities are to be eligible SR&ED. To make a judgement in this industry, assessments must be made on a case-by-case basis by qualified technical personnel.

5.5 Experimental production

For certain experimental development projects, such as may take place in manufacturing processes or equipment, the only way to verify that the technological objectives have been achieved is to carry out actual production runs. The product or output from such activities is generally known as experimental production. Documentation must show what use was made of this experimental production; whether it was used solely for evaluation purposes, or in conjunction with normal commercial activities. For example, experimental production may be necessary to document that technological advancements are achievable in practice, to resolve further technological uncertainties, and to statistically evaluate the results of the SR&ED project.

6 Feasibility Studies

In general, feasibility studies are only considered as part of an eligible SR&ED project and not by themselves. There must normally be subsequent experimental work for the feasibility study to be eligible. Technical feasibility studies, which are eligible, have to be distinguished from all other types of studies (marketing, commercial or financial) which are not eligible as SR&ED. Once an eligible project is actually established, the feasibility study that was done for that project qualifies if the project is eligible. In cases where the feasibility studies and experimental work are in different tax years, the company should request any required adjustments to its previous returns filed.

7 Conclusion

In conclusion, it is recognized that the SR&ED program is an incentive program and it is Revenue Canada's intention to administer the program in a positive manner to implement the government's policy of encouraging industry in Canada to perform and increase the amount of research and development being done. Help is readily available from Revenue Canada to resolve problems emanating from the use of this program. Applicants should contact the science co-ordinator in their region.

8 Examples

The following examples are grouped together to illustrate some of the issues that may arise in dealing with materials, equipment, processes, and system uncertainty. Although all three criteria (technological advancement, technological uncertainty, and technical content) must be met in every project, the examples selected focus on one or more of these three criteria as related to qualifying projects.

New materials

Example 1

> The polymer initially offered by Company X cannot meet the high heat distortion requirement of a new application opportunity. The company understands the

principle of cross-linking of polymers, and formulates the hypothesis that if its currently offered thermoplastic polymer could be successfully cross-linked, it could form a thermoset polymer during customer processing that then might achieve the temperature resistance required for this new application. However, Company X is uncertain about the degree of cross-linking that might be required, and the other detrimental properties that might be unavoidably introduced. An experimental development program is formulated to develop a modified material that could potentially meet the new requirements. Either a positive result, and hence a new polymer product, or a negative result which demonstrates that the hypothesis was invalid, constitute a technological advancement and, therefore, the research and development conducted represents an eligible SR&ED project.

Example 2

Bob works with an injection moulder, DEF Plastics Ltd., which wants to develop a less costly material for making a part currently moulded from nylon 6,6. To further reduce costs, his company also wants to use the existing mould, which was specially designed for use with nylon. Bob formulates the hypothesis that he could perhaps replace the expensive engineering plastic, nylon, with a fibre-filled, inexpensive commodity plastic such as polypropylene. He is uncertain about whether changes in viscosity and rheology resulting from the presence of fibres would permit the use of the existing mould. Bob prepares samples of glass-fibre reinforced polypropylenes of various compositions and fibre content and attempts to injection mould parts which he then tests against the customer's performance requirements. He determines that a polypropylene of a specific molecular weight and at defined levels of glass-fibre filling can indeed be successfully moulded, and that it can match the properties of the part previously made from nylon.

This example illustrates how a less expensive raw material can be used in an established process to make a product that has properties that are equivalent to an existing commercial product. This technological advancement in the use of materials could not have been anticipated using the industry’s standard practice. But as a result of the qualifying SR&ED project, Bob has developed a more cost-effective material for injection moulding, and its use will eventually become standard industry practice.

Example 3

Developing a spray-applied polyurethane, which has to be fire-resistant, is an example which illustrates technological uncertainty. The industry's standard approach is to add liquid additives, such as brominated hydrocarbons, to one of the liquid components which are sprayed to form the polyurethane coating. An hypothesis was made that the solid mineral, vermiculite, which is a mica mineral containing chemically bound water, could be added to the polyurethane coating as it was being applied to provide improved fire-resistance. This material is not used in standard industry practice. There was technological uncertainty about the amount of solid material that could be added, the impact on material properties, and the fire resistance that could be achieved.

As a result of several experiments in which experimental batches were made and tested for fire resistance, unusual and unexpectedly good results were obtained from the vermiculite-containing samples. These results were confirmed in the standard fire tunnel test. In the ULC fire tunnel test, which is calibrated using asbestos cement board with a flame spread rating of 0, and red oak with a flame spread rating of 100, the polyurethane, by itself, obtained a flame spread rating of 220. The polyurethane with the liquid flame retardants added was almost the same, with a flame spread rating of 202. With the vermiculite added, the flame spread rating was 43, a very dramatic reduction that was unexpected, and a significant improvement over liquid flame-retardent additives. The objective was to develop a fire-resistant coating. The hypothesis that vermiculite could improve the flame spread rating of the polyurethane coating was proven as a result of this experimental development.

New processes

Example 1

This example deals with extrusion compounding lines in which, as a standard practice in the industry, thermoplastic is forced by pressure through a die at the end of the extruder and forms a strand that is cooled and then chopped into short lengths. Strand strength is important in this continuous process. If the strand breaks, the line has to be restrung by hand. With rubber-filled polyethylene, strand strength is very low when rubber loadings are higher than standard practice. This results in constant efforts to restring the line, which is not an economically viable process. There are no "standard practice" solutions available to resolve the problems encountered in trying to compound a high loading of rubber particles into polyethylene. The project qualifies as SR&ED.

A hypothesis was proposed to change the process and use a hot-faced die cutter, a new and different piece of equipment, to cut the extruded thermoplastic compound into short lengths directly at the die face, and thereby eliminate the need for strand strength. This new piece of equipment solved one key problem in compounding rubber-filled polyethylene, but caused other problems that had to be resolved. The die cutter was water cooled with the extrudate emerging into this water. The rubber particles absorbed water that had to be removed in order to injection mould the new compound. The absorption of the water by the rubber was unexpected, and thus it was necessary to add a drying step to the process to remove this water. The addition of the drying step to the compounding process had a further impact on the cost of making the product, and was another factor in deciding whether this development would be economically viable. This example illustrates how a change of equipment based on experimentation, and a resultant technological advancement may qualify as a SR&ED activity.

Example 2

Resin transfer moulding is a relatively new process in which glass-fibre reinforced plastic parts are made. With this process, inexpensive moulds can be made using composite materials instead of metals. The glass-fibre reinforcement is placed in the two-part mould. The mould is then closed before the resin (usually thermosetting polyester resin) is forced into the closed mould using low-pressure air. This process in itself is not enough to constitute SR&ED, however, there are many variations of this principle which are used or developed depending on the design of the part to be produced. This activity may be considered technological advancement.

To illustrate, the objective was to produce, in one step using resin transfer moulding, an insulated box comprising two fibreglass reinforced plastic skins sandwiching an insulating core of polyurethane foam. It was thought that this method would be the most economical. The contemplated process involved placing two layers of glass fibre mat in the mould with the polyurethane foam insulting layer between the two layers of glass fibre mat. To be successful, the liquid resin injected into the closed mould had to completely encase the glass fibre mat on both sides of the polyurethane foam. This was not easily accomplished. Special glass fibre mat had to be made that provided space at the outer surfaces for the resin to flow through and make a finished part that had resin on the surface instead of exposed glass fibres. This "high loft" glass fibre mat became a new raw material for resin transfer moulding.

This example illustrates that resin transfer moulding is not a single process but a family of processes that often has many undefined variables. Defining these variables using a scientific approach and generating information that advances the understanding of scientific relations or technologies makes this development project eligible SR&ED.

Example 3

This example involves both material development and process development that are combined in developing anti-skid shipping sacks. Multi-layered valved shipping sacks are produced using films manufactured by the tubular-blown film process. The production process permits the inclusion of a variety of mono films and co-extruded films in the bag construction to impart, for instance, barrier properties. Plastic sacks inherently have smooth, slippery surfaces, thus filled sacks may have poor stacking stability, particularly when fine powders are trapped between them. As a variant of this capability, the company proposed an improved method to give anti-slip characteristics to sacks to improve the stability of stacked-filled sacks.

Traditional solutions were unsatisfactory. The improved method consisted of making the outer layer of the sack from a film based on a conventional polyethylene containing a proportion of UHMWPE (ultra high molecular weight polyethylene). These two materials are incompatible. Since the UHMWPE does not fully homogenize with the conventional polyethylene, a roughish surface is obtained which has excellent anti-skid properties. However, the surfaces are smooth enough to allow good printability. Since the major proportion is conventional LDPE (low density polyethylene) or LLDPE (linear low density polyethylene), the physical properties of the sack are retained.

The SR&ED involved in developing this product included: the selection of materials; developing the relationships with concentration of the UHMWPE component; developing the processing techniques (including coextrusion); and measuring the performance of the sacks with a variety of sack end-use contents. This development differed from routine engineering because in standard practice, the non-homogeneous mixture of polyethylenes is not used, and the exact properties of a non-homogeneous mixture would not be known or found on any industry data sheets. Experimental development work was needed to define the material properties and the manufacturing process.

Example 4

There are presently investigations underway to develop an unattended injection molding machine that will consistently produce quality parts via a closed loop feedback control system. This new process entails monitoring and then controlling operating parameters critical to part quality, such as the pressure of the molten plastic and the rate of injection. The results of calculations made from the monitoring loop are then fed back to a controller to adjust the injection process. The acquisition of information, calculations, control instructions, and the evaluation of results must be carried out during the period of injection, which may be as short as a few tenths of a second. Presently, technology exists to measure certain parameters that affect part quality (rate of injection, pressure, etc.) and to control these parameters but only after manual intervention. Uncertainty exists in whether the control logic can be developed to the point that the controller can “learn” from the parameters it measures, and then take the appropriate action without operator assistance. It is unknown whether this process can be advanced to the point where the required performance characteristics can be met. A successful completion of the project will advance the company’s technology base, and may be applied to other equipment or processes.

Example 5

The Canadian-developed, K-Mixer system for compounding under low-shear conditions, and with unique temperature control, had been used by Company A for over 10 years for compounding of P.V.C. The fluxed discharge of the sheer-sensitive P.V.C. was transferred to a mill, and the resulting straps transported to stair-face cut pelletizers. Company A now wanted to extend the use of this compounding technique to other plastic systems for which the tight temperature control, high dispersive capability, and low capital costs could also prove advantageous. It was uncertain, however, which processing methods to transfer the fluxed discharge for the K-Mixer to the commercially available die-face cutting systems which would be necessary to produce the underwater cut pellets demanded by the polyolefin and other (non-P.V.C.) plastic markets. Conditions of K-Mixing, as well as the recipes required for specific applications, were also uncertain.

After research and development on many forms of downstream equipment to the

K-Mixer, the company eventually developed the designs for a modified extruder pump that could bridge the K-Mixer to the pelletizer. It also developed processing conditions for a range of new products. This technological advancement led to several new compounds such as A.B.S. masterbatches, flame-retardant polyolefins, and highly-filled polypropylenes. The technical uncertainty was resolved in this eligible SR&ED project by technological advancement in both modification of an existing process and the development of the processing conditions required to fully utilize the capabilities of this compounding system.

New equipment

Example 1

When designing extruder screws, the objective is to find a configuration which produces high-quality melt, as quickly as possible, using a screw of a given diameter, without causing plastic degradation. The screw's design must take into consideration the resin to be plasticized. There may be uncertainty about which design will achieve the desired level of performance with that particular grade of plastic. Even though a competitor may have previously developed a screw for a similar application, if this knowledge was proprietary, subsequent attempts by another company to independently develop a similar screw would represent a technological advancement for that company and qualify as SR&ED.

Example 2

Another example of an SR&ED project from the compounding sector of the plastics industry is the development of the high-speed, highly-controlled K-Mixer technology. This project offers an example of modifying older equipment (the Gelimat) to produce a unique form of compounding equipment with advantages such as high output rates, high dispersivity, absence of shear, ease of cleaning as changes are made from one compound to another, and low capital cost relative to conventional systems. Although mechanical development such as changes in the angles of the rotating blades and increased speed permitting timely fluxing of most plastics without any external application of heat, uncertainty remained as to practical ways to sense and control the temperature. A fraction of a second too long near the fluxing point could lead to an increase of over 50° C, and hence the potentially catastrophic degradation of plastics such as P.V.C.

Attempts at control by techniques such as by vibration and by thermocouples proved inadequate. Eventually, the development of a (patented) glass fibre-optics temperature-control system based upon sensing at millisec. intervals the infrared radiation given off by the material as it was heated permitted the fine temperature control (+/- 2°C) to process even P.V.C. to within a few degrees of its degradation temperature. This technological advancement in new equipment development during an eligible SR&ED project made this new mixing technology a commercial success for the compounding of P.V.C. and other shear-sensitive and/or temperature-sensitive plastics.

Example 3

Manufacturers of injection moulding equipment have been adopting technology from other industries and applying it to upstream and downstream operations to create automated moulding cells, resulting in productivity gains and cost savings. Much of this automation effort involves the use of robotics. The development of a new robot design, which may at first appear to be straightforward application of existing technology, requires a significant investment in SR&ED. For example, to increase certain robot performance characteristics such as speed, positioning accuracy or payload capacity, it may be necessary to develop new drive mechanisms, control software or rigid, lightweight structural components. While the new robot's external appearance may appear unchanged, incorporating one or more of these new developments may introduce significant performance improvements and hence, technological advancement. Furthermore, it is unknown how robot performance characteristics interact (i.e., to what extent increased robot speed affects positioning accuracy), so this development activity involves technological uncertainty.

Example 4

There have been recent developmental efforts in blow-moulding technology to improve the measurement and control of parison wall thickness, and to use techniques such as co-extrusion to produce multi-layer blow-moulded containers. The demand for products with new material and/or configurations much different than the conventional blow-molded bottle have precipitated the necessity for these advancements and introduced technological uncertainty. One such initiative was the design of a system to produce a container using a new resin to achieve a weight saving of 40% without loss of sidewall strength due to axial orientation. Uncertainty existed in the parison geometry, stretch ratio, shrinkage, factors, final part strength, and mould expansion based on assumed values of water and oil temperatures used in the mould. Although the performance goals established for the new system development have not been fully met, technological advancements have been achieved in the control hardware and software development necessary to optimize the thickness distribution of the parison in order to reduce the amount of plastic, and hence the cost of the finished part.