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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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REINFORCEMENT OF THE PACKAGING TECHNOLOGY DEVELOPMENT CENTRE IN HO CHI MINH CITY

DP/VIE/86/046
THE SOCIALIST REPUBLIC OF VIET NAM

Technical report: Support to the Packaging Technology Development Centre to Cover the Country's Flexible Packaging Technology[*]

Prepared for the Government of Viet Nam
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of C. V. Detter,
expert in extrusion/co-extrusion of plastic films technology

Backstopping officer: J. Belo, Engineering Industries Branch

United Nations Industrial Development Organization
Vienna

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[*] This document has not been edited.

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ABSTRACT

PROJECT TITLE AND NUMBER: Expert in extrusion/co-extrusion of plastic film technology. DP/VIE/86/046/11-06/A/J-13320

OBJECTIVE

To establish a Packaging Technology Development Center at the Saigon Packaging Export Company in Ho Chi Minh City to cover the country's packaging industry development needs mainly in the field of flexible packaging technology.

CONCLUSION

A. The PTDC is well staffed but lacks some equipment necessary to do adequate quality control on finished films.

B. The PTDC needs additional resins and information on resins to adequately demonstrate these materials to industry.

RECOMMENDATIONS

A. Purchase additional testing equipment necessary for quality control of finished film.

B. Obtain information on and purchase additional resins to demonstrate the differences in grades of the same types of materials.

C. Add to purchasing specifications of future extruders to insure longer life of the equipment.

INTRODUCTION

The Packaging Technology Development Center began operation under the direction of the Saigon Packaging Export Company during 1990. They requested that UNIDO provide an Expert on extrusion/co-extrusion technology to assist in building the institution in the area of flexible packaging technology.

This report was prepared by Mr. CLYDE V. DETTER as a result of this mission. (see Job Description - Annex I)

Activity began in the USA on March 23 in an attempt to ascertain what film resins would be available in Viet Nam. This activity continued until his departure from Viet Nam on April 28.

OBJECTIVES

The original objectives are listed in the job description (Annex I). These were modified slightly as outlined in "TENTATIVE WORKING SCHEDULE FOR THE CO-EXTRUSION EXPERT" (Annex II) to include:

I. Training of PTDC's staff on material choices for a number of packages.

II. Advice on production planning and quality control.

III. Prepare a step by step guide for start up and running the machine.

IV. Prepare a training course for industry.

ACTIVITIES

I. Initial Assessment

I found the staff much more proficient in the operation of the equipment than I had expected. They did, however, need experience in start up of the equipment. At present they have no means for measuring the relative thickness of the three layers of film in the co-extrusion. I also found some instruction was needed in how different grades of the same material can affect the properties of the finished package.

II. Deviations from the Job Description

A. A major portion of the my time was spent in preparing the training seminar for industry and in writing instructional literature (ANNEX III through ANNEX XI)

B. A milk packaging film was successfully produced. This film is rather difficult to produce as it must be a bright white on the outside and black on the inside.

C. An agriculture mulch film (silver outside and black inside) was also successfully produced.

D. The production of the films described in items B and C did much in instructing the staff in what to consider in package design.

III. Conclusions

A. The PTDC is staffed with competent people and with experience will become quite proficient in the operation of the co-extrusion equipment.

B. The PTDC does need some equipment to effectively do proper quality control on film produced.

C. The PTDC should obtain additional information on available materials from a number of resin suppliers.

D. The PTDC should obtain a variety of resins for demonstration purposes.

IV. Recommendations

A. Purchase the following equipment to more effectively do quality control on film produced.

1. A microscope with a visual grid in the eyepiece to visually observe cross sections of film and determine the relative thickness of the component layers.
2. Apparatus to measure film impact resistance. See ANNEX XI under the section Apparatus.
3. Apparatus to measure tear resistance of plastic films. See ANNEX XII.

B. Obtain literature from several manufacturers on a variety of resins to include:

1. Heavy duty bag resins.
2. Clarity resins.
3. Laminating resins.

A listing of recent resin prices is presented in ANNEX XIII.

C. Obtain a variety of resins for use in demonstrating at least the three types of materials mentioned in item B above.

D. To insure long life of equipment, particularly equipment to be used in production, future purchases of extrusion equipment should include the following specifications:

1. The extruder barrel to have a XALOY liner.
2. The leading edge of the flight lands of the screw to be 1/16 inch (1.6 mm) #156 STELLITE.

ANNEX I

revised 1.12.1992

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

PROJECT IN THE SOCIALIST REPUBLIC OF VIET NAM

JOB DESCRIPTION
DP/VIE/86/046/11-06/A/J-13320

Title	Expert in extrusion/co-extrusion of plastic films - technology
Duration	Three weeks
Date required	February 1993
Duty station	Ho Chi Minh City, with possible travel within the country.
Purpose of project	The project has a single, institution-building immediate objective which is to establish a Packaging Technology Development Centre at the Saigon Packaging Export Company in Ho Chi Minh City to cover the country's packaging industry's development needs mainly in the field of flexible (plastic-based) packaging technology, regarding : (a) package development, design and material/process specifications; (b) process development, production engineering and technical support to industry for both, packaging materials and package production; (c) package and packaging materials testing and quality control support to industry; (d) preparation of packaging standards; (e) disseminating packaging-related information.to packaging materials and package producers and users.

Applications and communications regarding this Job Description should be sent to:

Project Personnel Recruitment Section, Industrial Operations Division
UNIDO, VIENNA INTERNATIONAL CENTRE, P.O. BOX 300, VIENNA, AUSTRIA

Duties

The expert will be assigned to the Packaging Technology Development Centre (PTDC) which has been set up by the Saigon Packaging Export Company, SPACEX, in terms of premises, operations and management responsibility. He will work in co-ordination with the Chief Technical Adviser (CTA) of the project and close co-operation with the national counterparts designated for his mission. The expert will specifically be expected to:

1. Help guide and oversee installation of the film extrusion equipment ordered and received.
2. Carry out production trials with selected alternative materials/specifications to evaluate the performance capabilities of the equipment installed.
3. Advise on the choice of substrates and components for initial commercial production with reference to local needs.
4. Advise the centre on a sound system of production planning and quality control for adoption.
5. Train counterpart technical staff on the production process with a view to helping them undertake process improvements in keeping with changing local/export needs.
6. Conduct a training programme for the production staff in plastic extrusion industry on the subject.
7. Advise on the additional equipment/materials that may have to be obtained by the centre for upgrading the product.

The expert will also be expected to prepare a final report, setting out the findings of his mission and his recommendations to the Government on further action, which might be taken.

Qualifications

University degree in plastic film extrusion. Experience in multilayer extrusion essential.

Language

Proficiency in English.

Background information

Flexible plastic packaging is predominantly used by the food processing industries for products such as: dried fruits and nuts, dried fish and marine products, frozen foods in general and processed marine products in particular. All these products are of primary relevance to Viet Nam, since exported fish and marine products are the largest foreign currency earners of the country and having the greatest potential for export growth, up to an estimated $1 billion dollars per year. It is therefore imperative for the country's industry to package its export products according to world standards, since the quality and appearance of the package reflects on price.

The present situation in Viet Nam, as regards packaging technology, is problematic. The major problems relate to technology: metal cans are of poor quality; corrugated and paper cartons are not strong enough to withstand abuse in shipping, particularly when exported, requiring wooden crating which add cost; wooden pallets and crates are "overconstructed" and costly; etc. A basis problem of the industry is that there is no institution dealing exclusively with packaging, as in many other developing and all the industrialized countries, to help resolve such technical problems. This is particularly true for flexible, plastics-based packaging, which play a critical role in the country's export drive. This is the issue the project primarily is concerned with, although packaging problems in general will also be addressed (i.e. package testing, standardization, dissemination of information).

ANNEX II

TRUNG TÂM PHÁT TRIỂN KỸ THUẬT BAO BÌ
PACKAGING TECHNOLOGY DEVELOPMENT CENTRE
300/50 Ong Ich Khiem st., District 11, HoChiMinhCity-Vietnam
Phone 53550-53527 Fax: 84-8-94500 Telex 811425-SAVI-VT

11.4.1993

TENTATIVE WORKING SCHEDULE FOR THE CO-EXTRUSION EXPERT

9.4.93 - 30.4.93

9.4.93 :Expert Arrival

10-11.4.93 :Weekend

12.4.93 : Morning:Meeting at Spacex
Mr.TRAN VAN TU,National Project Director
Visiting SPACEX Factory
Afternoon:Prepare working Plan

13.4.93-18.4.93:Training PTDC's staff on material choices ,structure for Milk packaging,Oil Packaging, Frozen Food Packaging,etc.

Advice on production planning system and quality control

Prepare a step-by-step guide for start and run the machine.

19.4.93-25.4.93:Training PTDC'sstaff on production and production planning.
Carry out production trials.

26.4.93-27.4.93:Prepare traning course for industry

28.4.93 : Training course:EXTRUSION TECHNOLOGY

29.4.93 : Final report

ANNEX III

EXTRUSION

General

More polyethylene is turned into finished items by extrusion than by any other processing technique. Extrusion is the process of applying heat and pressure to melt the plastic and force it through an accurately dimensioned die to produce shapes in the form of:

A. unsupported film, sheeting, tubes and other profiles.
B. film for coating paper, metal foil and other substrates.
C. coating around wire or cable.

The extruder is a relatively simple machine as far as its basic operation is concerned. Plastic pellets are fed into the funnel shaped hopper of the extruder. The plastic drops by gravity into the channels of a screw rotating within the hardened liner of an extruder barrel, and is forced forward by the rotating screw flights. As it moves, it is heated, melted, mixed, and compressed by a series of complicated flow patterns inside the screw channels.

On its way through the barrel, the granulated, solid plastic must be transformed to a homogeneous melt. A poorly mixed, non-homogeneous melt may yield an end product with non-uniform cross sectional dimensions and wavy surfaces. Film produced from a non-homogeneous melt may be of non-uniform gauge and may lack strength, gloss or clarity.

The melt leaves the screw and is passed through the screen pack, the breaker plate and the die adapter to the die. The screen pack serves primarily to act as a filter for foreign matter that may have gotten into the resin.

Heat which softens the resin is supplied in two ways -- by external heaters and by internal frictional shear forces brought about by the compounding and compressing action of the screw. The amount of such frictional heat supplied to the polymer is appreciable; in many extrusion operations, particularly at lower temperatures, it represents most of the heat supplied to the resin. Either electricity, steam, or hot oil can be used to heat the barrel. Electric resistance heating is most commonly used because it presents a minimum of maintenance problems.

(7) A second compression section which compresses the resin a second time.

(8) A second metering section that homogenizes the melt again and develops necessary pressure to feed the die. In the metering section the polymer is moved at a practically constant feed rate to obtain uniform output.

This is known as a two stage screw. For a screw of this type the barrel will be long, at least 24 times as long as the screw diameter. The barrel length divided by its diameter is called the length to diameter ratio or L/D.

The ratio of cross sectional areas of the metering section and the feed section in each stage is known as the compression ratio. This is usually simplified to the ratio of the feed section channel depth to the metering section channel depth.

The screen pack may influence extruder operation in several ways: back pressure in the screw metering zone will be increased by using a screen pack consisting of several dense or fine mesh screens. Higher back pressure at a given screw speed improves mixing and homogenizing and thus extrusion quality, though it reduces output slightly. (Output can be regained by increasing the screw speed.) The temperature of the melt may be raised somewhat by using a heavier screen pack which, by increasing pressure, generates additional frictional heat.

A film die must be designed in such a way that it maintains a constant melt temperature and meters the melt through the die lips at a constant rate and in a uniform cross section.

Chemically degraded particles may form through oxidation in the melt during a shutdown period. This may result in the production of inferior products, particularly film with gels (sometimes called "fisheyes") and black specks, for an extended period of time when operation is resumed. Special shutdown procedures must be used to protect against this common problem.

ANNEX IV

FILM EXTRUSION

General

Polyethylene film is usually defined as a polyethylene sheet no thicker than 254 microns (10 mils). Most polyethylene film commercially produced has a thickness of 127 microns (5 mils) or less. Films used for packaging usually have a gauge of between 7.6 and 178 microns (0.3 and 7.0 mils).

More polyethylene resin is consumed every year for film production than for any other end use. This is true because the relative cost of polyethylene is low. Also, because of the low specific gravity of polyethylene the yield in square centimeters per kilogram (square inches per pound) is greater than for most other plastic resins suitable for film making (polypropylene being the exception). Polyethylene film is ideal for packaging, as it is flexible, tough and highly resistant to chemical attack. It is a good moisture barrier and can easily be made into bags due to its excellent heat sealability and when properly treated, exhibits good printability. For these many reasons, it is well suited for packaging and protecting foods, dry goods, metal products, electronic components, chemicals and many other items.

There are two kinds of polyethylene film -- blown film (commonly called lay-flat film), and flat film. They are made by procedures which differ from each other mainly in the die sections of the extruder and the means of cooling the extruded film. Both types of film have their merits.

Blown film has a number of advantages over flat film. In blown film extrusion, molecular orientation is achieved in both the machine and transverse directions, the relative degree depending on the operating speed of the haul-off equipment and the blow-up ratio (bubble diameter/die diameter). This results in a film of more uniform strength in both directions. In flat-film extrusion, particularly at high haul-off rates, relatively high orientation takes place in the machine direction and virtually none in the transverse direction.

If the blown-tubing producer controls his extrusion conditions properly, he can achieve two things:

1. He can make the physical properties of the film practically equal in the machine and transverse directions. Such even distribution of properties gives blown film maximum toughness.

2. He can increase or decrease a given property.

The absence of one or two lengthwise seam seals in bags made of blown film is another advantage. Such bags have but one heat seal, across the bottom. In the production of bags, uniformity of the long lengthwise seal is a definite problem, unless the bag maker is operating his equipment under optimum conditions. Variations in film properties and other factors or even atmospheric conditions can affect the strength of this seal. Simpler, faster and lower-cost bag-making machinery can be employed when blown film is used.

Often times a blown film producer will slit the flattened tubing at one edge during windup. The tube may then be wound in a double layer as folded flat film having twice the width of the lay-flat tube. The tubing may also be slit at both edges and wound as two flat films on two winder cores or as a double layer on one core. This allows the film to be treated and printed as flat film. A variety of large surface area applications such as films used in construction or agriculture are made as blown tubing before being slit along one edge and wound as folded film. The flattened tube is then opened at the site of use. These techniques make it possible to produce either blown or flat film from the same extrusion equipment.

Film extruded as flat film has certain advantages over blown film. The techniques for extrusion of flat film in wide widths are more easily controlled than those for the same widths in flattened blown tubing. In flat film extrusion, somewhat faster haul-off speeds can be used. Higher haul-off speeds mean higher production rates thus lower cost per unit weight of film.

Good gauge control is easier for flat than for blown film, although technical advancements in blown-film die design in recent years have done much to reduce differences in gauge variations between the two techniques. In correcting gauge variations, adjustments on the wide flat film dies are more easily made than on blown tubing dies.

It is difficult to obtain both optimum properties and highest material output with one set of extrusion conditions. The conditions selected are usually based on a compromise between high product quality and high production rate within the limits of the equipment. The extrusion conditions needed to produce high-quality film at an acceptable output rate vary with the type, size, and age of the extruder, the screw speed, screw design, resin, ambient conditions, etc. There are, however, a few general principles that must be followed when extruding high quality blown or flat film.

Operating temperatures and screw speed must be carefully controlled. Uncontrolled variations in screw speed and/or temperature, affect the film gauge significantly. As explained before, most of the heat in the barrel is generated by the frictional shear forces or mechanical working which the polyethylene is given by the rotating screw. The extent of this working depends on the temperature of the barrel, the clearance between the screw and the barrel, the screw design, and the back pressure exerted by screen pack, breaker plate and die. All these extruder conditions must be kept in proper balance to produce high-quality film.

ANNEX V

BLOWN FILM EXTRUSION

In blown-film extrusion, the molten resin enters the die through the bottom. It is forced around a mandrel through a complex series of channels inside the die, shaped into a sleeve, and extruded through the ring-shaped die opening in the form of a rather thick tube. The tube, while still in the melt state, is expanded to a "bubble" of desired diameter and correspondingly lower film thickness. This expansion is done by the pressure of internal air admitted through the center of the mandrel.

The blown-up bubble is closed by the die at the bottom and at the top by the nip rolls (sometimes called pinch or squeeze rolls). Inside the bubble the air is maintained at constant pressure to insure uniform film width and gauge and even windup of wrinkle-free rolls. Other factors affecting film gauge, such as extruder output and take-off speed must also be strictly controlled. Control of the quantity and direction of the air which cools the film is critical. The width of the die opening, commonly called "die gap" must also be well adjusted to obtain uniform film gauge.

Gauge control is important in producing quality blown film. Film of less than 25 microns should have a maximum gauge variation of ± 2.5 microns. Heaver gauge film should have a maximum gauge variation of ±10%.

In blown-film extrusion, barrel temperatures are generally kept low, in the range between 135°C and 170°C, for low density polyethylene. Cooler resin temperatures permit faster production rates without raising the "frost" line too far above the die. The frost line is the ring-shaped zone where the bubble reaches its final diameter and some haze is first visible in the bubble because the film temperature falls below the softening range of the resin.

The height of the frost line above the die is important. The height of the frost line increases with the tube diameter and is useful for controlling orientation of the melt in the machine and transverse directions and some physical properties of the film such as tear strength. The frost line can be raised or lowered by means of extruder output, haul-off speed, and the volume of cooling air used to cool the bubble.

The frost line must always be as level as possible. Improper adjustment of the die opening may cause variations in film gauge and consequently non-uniform cooling and localized variation of the frost line height.

Die temperatures as low as 120°C may be used, but with ample cooling they may range up to 200°C. High die temperatures may result in better film transparency. As a general rule the die temperature should be about the same temperature as the melt.

Two important factors which control gauge quality are film cooling and die ring adjustment.

The rate of cooling the bubble is critical for attaining highest film quality and to avoid blocking in the nip rolls and on the windup roll. On most blown-tubing extruders, baffled air rings are used to project streams of cooled or room-temperature air uniformly along the surface of the film all around the hot bubble as it leaves the die. Generally, a large volume of low pressure air is preferred to a smaller volume under higher pressure. Controlling quantity and direction of this air is important because both are essential factors in film gauge control. Non-uniform gauge is often caused by the cooling air not being uniform around the perimeter of the blown tube.

Die ring adjustment in film gauge control is the other critical factor. Often considerable time is required before good gauge control is achieved. In adjusting a die one should strive for a symmetrically shaped bubble.

The ratio of bubble diameter to the die diameter is called the "blow-up ratio" and is one of the most important blown film variables. It can be varied from less than 1:1 up to about 6:1. Experience seems to indicate that the optimum balance of properties in both machine and transverse directions can be obtained at a blow-up ratio around 3:1, but this depends very much on the haul-off speed, frost line height, resin being used and other variables.

Toughness, transparency, haze and gloss are affected by blow-up ratio and resin type.

To summarize: blow-up ratio, frost line height, haul-off speed, and extruder output must all be balanced to produce blown film with good physical properties and uniform gauge at an economical rate.

Anti-blocking properties can be improved by lowering the film temperature. This can be done by reducing melt, die, and cooling-air temperatures, by increasing the amount of cooling air, by increasing the distance between die and nip rolls, and by supplying cooling water to one of the nip rolls. Blocking can also be reduced by reducing nip roll pressure.

For best film transparency the blown-film processor should run the extruder

(a) at high temperature, to the limit of his ability to cool the bubble for gauge control or to control blocking.

(b) with moderate, but not high, screw speeds;

(c) with a blow-up ratio of about 2 1/2:1.

Film properties in the machine and the transverse directions can be varied over an extremely wide range by changes in the extrusion conditions, especially in the blow-up ratio. Therefore, during processing, tensile and tear properties should be balanced in both directions.

The factors which affect blown-film properties most are extrusion temperature and blow-up ratio, and the effect of the same operational condition may be diametrically different on different properties, for example:

High toughness and transparency are obtained with somewhat higher melt temperature and high blow-up ratio.

Good slip and anti-blocking qualities are obtained with lower melt temperature and low blow-up ratio.

Wrinkles in blown film are always a problem. They intermittently occur on almost every film line and are annoying and costly. Wrinkled rolls must frequently be scrapped.

Wrinkling on the windup roll may be due to one, or a combination of several, of the following causes:

1. The frost line may be too high. This may cause poor gauge control around the circumference of the tube and uneven gauge in the film. This, in turn, can lead to an unbalanced pull in the nip and result in wrinkling. How to lower the frost line has already been discussed.

2. The die ring may be out of adjustment. This may cause gauge variations which again result in an uneven pull at the nip rolls.

3. "Bias" is a condition where the two halves of the tube circumference are of unequal lengths. This causes an unbalanced pull at the nip, resulting in ruffle-like wrinkles across the center of the wound roll. Occasionally, these wrinkles may be transmitted to the edge of the ascending tube. Uneven or thin gauge at the sides of the tubing may show as chevron-type wrinkles on the edges of the windup roll. Bias may be caused by air currents in the extrusion shop or by the die ring being out of adjustment. Air currents may be prevented from reaching the extruder by framework supported polyethylene film curtains around the machine. Extreme care must be exercised in compensating film gauge by adjusting the die ring. It must be kept in mind that the thinnest area of wound tube is usually the thickest film area as it leaves the die lips. Because it contains more heat, it continues to expand and grow thinner after other areas are "frozen".

4. The film may be too cold when it reaches the nip rolls, and its stiffness may cause crimping at the nip and wrinkling. This kind of wrinkling can be minimized by raising the film temperature at the nip rolls and thus making the film more flexible. This can be obtained by slightly lowering the height of the nip rolls, or carefully raising the melt temperature, or increasing the screw speed and nip roll speed or the extrusion rate. (Caution: Higher film temperature increases the danger of blocking.) See item 8 below.

5. The pressure across the face of the nip rolls may not be uniform because the rolls are either not parallel or slightly eccentric. Since the rubber surfaces of the nip rolls are in contact with the warm film, they often quickly deteriorate. In that case, they may need grinding or reconditioning to restore proper resiliency and uniformity.

6. The guides may not be properly aligned with the nip rolls. The nip rolls must be positioned exactly above the die center so that the tube will be pulled off exactly vertical during its ascent.

7. The ascending tube may be wobbling due to melt surging from the extruder or air currents in the shop. Supporting the tube by horizontal stationary guides at two or three locations may prevent such wobbling. Or the extruder may be protected by a film curtain, as described under item 3 above. The guides are especially recommended for large blow-up ratios.

8. The use of resins of higher density will increase the stiffness of the film and its susceptibility to wrinkling. How to prevent wrinkling at the nip rolls due to greater film stiffness is described under item 4 above.

9. As wrinkling is more prevalent at low gauges and high take-off rates, gauge control should become more precise as the gauge becomes thinner and the take-off rate faster. At the film gauges below 25 microns(1 mil) very close control of the above factors must be maintained to avoid wrinkles.

10. One of the most common causes of wrinkles is misalignment of the collapsing frame. Care should be taken that the collapsing frame is perfectly aligned with the bubble.

START UP AND SHUT DOWN PROCEDURES

The most important thing to achieve in utilizing proper start up and shut down procedures is to prevent resin from charring on the surface of metal that is exposed to the molten resin. While the resin is protected with antioxidants it will char when at higher temperatures. The charring process becomes quite rapid at temperatures above 150°C. For this reason care should be exercised to maintain some material flow through the extruders and die when they are above this temperature. Of course, if polypropylene is being extruded it is necessary to violate this rule. Due to its higher melting temperature.

START UP PROCEDURE

1. Apply silicon spray or silicone grease to the top surface of the die.

2. Start water circulation in the feed zones of all extruders.

3. Turn heat on to all heat zones.

4 Set operating temperature on all temperature controllers and check that all controllers and heaters are operating correctly. If the operating temperature is greater than 150°C do not set any controller higher than 150°C at this time. (See comment above regarding polypropylene.)

5. When temperatures reach the set point let all heat zones set for 30 minutes to allow time for all components to reach the set temperature before starting an extruder.

6. Clean the die gap with a brass gauge. (Brass "shim stock" as used in machine shops works well here.)

7. After the 30 minutes "soak" time start the extruders at low speed. When starting the extruders watch the motor load carefully for any sudden increase in amperage. If the motor load rises too much

stop the extruder as there is a blockage. Allow to "soak" another 10 to 15 minutes before starting the extruder again.

8. If the desired operating temperature is above 150°C the temperature settings may be increased after flow is established through the die.

9. Thread the tower and winder with a cord or a piece of film which will be used to lead the new bubble through the system.

10. Once the polymer being extruded is of the proper consistency and appears to be clear of degraded material turn the air ring blower on and set the screw speeds to start up speed. Also, set the nip rolls to start up speed.

11. Gather the extrudate together to form a bubble and stick it to the cord or film previously threaded through the system.

12. Start pulling the cord slowly to raise the bubble and continue to blow the bubble slowly.

13. Once the beginning of the bubble has passed through the open nip rolls close them.

14. If at any time it is necessary to reseal the top of the bubble be sure to puncture the upper bubble just above the new seal. This will allow the upper bubble to collapse and pass through the nip rolls.

15. Establish proper extrusion rates, take-away rate and bubble diameter to produce the desired film.

16. Start rotation.

SHUT DOWN PROCEDURE

1. Stop rotation.

2. Reduce extrusion speeds and take-away speed to shut down speeds.

3. If operating above 150°C reduce temperature controllers to 150°C or lower. (See comment above regarding polypropylene.)

4. Maintain a flow through the die until all temperatures are below 150°C. It is optional whether a bubble is maintained at this point.

5. When temperatures are below 150°C stop all extruders and take-away equipment.

7. Stop feed section water circulation on all extruders.

8. Turn off main switches.

ANNEX VII

QUALITY CONTROL

PRODUCTION TESTING

FILM GAUGE

The most important property to control in blown film production is film gauge. The most common and accepted method of measuring film thickness is the use of the micrometer. The micrometer usually found in a film quality control laboratory in the USA is a Testing Machines, Inc. Model 549

To check film gauge a sample representing the full width of the film is taken at each roll change. The thickness is then measured each 12 to 25 mm across the entire width. An average of the points across the width of the film is taken and is normally accepted as the gauge of the film. Statistical methods usually allow the discarding of the single highest and lowest measurements before the average is calculated.

Generally accepted film thickness specifications are as follows:

Less than 25 micron film	± 2.5 microns
Greater than 25 micron film	± 10% of the film thickness

For film thicker than 125 micron the gauge tolerance is frequently raised ± 15% due to the difficulty in maintaining good gauge control while producing the thicker film.

FILM WIDTH

The width variation of blown tubing should be held to a minimum. If width variation of the tube becomes excessive steps should be taken to reduce bubble movement. On rolls up to about 125 cm width a width variation of greater than 12 mm would be considered excessive and should be corrected.

The width variation of slit film (both edges slit) should be no greater than about 3 mm.

FILM PROPERTY TESTING

IMPACT STRENGTH

In many packaging applications the ability to resist impact stresses is important. To be able to compare impact strength of different films a test procedure described in ASTM D1709 - Impact Resistance of Polyethylene Film by the Free Falling Dart Method is used.

Another method sometimes used for measuring impact strength is described in ASTM D3420 - Dynamic Ball Burst (Pendulum) Impact Resistance of Plastic Film. The preferred method B, commonly called "Spencer Impact" requires the film restrained and supported by annular clamps.

Both tests are meaningful but because the dynamics of the Spencer Impact are inherently slower than the dart drop there is no direct correlation between the two tests.

TEAR STRENGTH

One of the most difficult film properties to characterize is tear strength. Tear strength is usually measured by ASTM D1922 - Propagation Tear Resistance of Plastic Film and Sheeting by Pendulum Method. This test is commonly known as the Elmendorf Tear test. It measures the resistance to tearing after a tear has been initiated. The apparatus used is an attachment to the apparatus used for the Spencer Impact above.

TENSILE PROPERTIES

Tensile properties of plastic films are usually determined by ASTM D882 - Tensile Properties of Thin Plastic Sheeting. The importance of tensile properties will be discussed later.

OPTICAL PROPERTIES

The clarity of a film may be measured by the procedure described in ASTM D1003 - Haze and Luminous Transmittance of Transparent Plastics. The value reported in this test is the percent haze. A lower haze value means that the film is more clear.

BARRIER PROPERTIES

Moisture vapor transmission rate of a film is measured by the procedure described in ASTM E96 - Water Vapor Transmission of Materials in Sheet Form.

The rate at which other gases permeate through plastic films is measured by the procedure detailed in ASTM D4134 - Gas Transmission Rate of Plastic Film and Sheeting

The importance of barrier properties will be discussed later.

ANNEX VIII

PRODUCTION PLANNING

In production planning some fairly simple guide lines will provide very significant improvements in efficiency.

1. Resin changes

Keep resin changes to an absolute minimum! Each time the resin is changed in an extruder production time and material is lost. If resin changes cannot be avoided plan the sequence of changes to minimize down time.

Higher density polyethylene will displace a lower density polyethylene much faster than a lower density polyethylene will displace a higher density polyethylene. Therefore plan the production schedule so resin changes take advantage of this property whenever possible. A change from high density polyethylene to low density polyethylene can (depending on the equipment) take as long as one to two hours before the change is complete. This is lost production time and lost materials. Of course, such changes are inevitable but an effort should be made to minimize them.

A similar rule applies to changing resins of different melt index. If possible start your production sequence with the highest melt index resin you can so that each change results in a lower melt index resin displacing a higher melt index resin.

2. Color changes

When running pigmented materials try to set the production sequence so that lighter colors are being replaced with darker ones as often as possible.

3. Size changes

Of course size changes will result in some lost production while the equipment is being lined out on a new size. However, the loss is minor when compared to resin or color changes.

ANNEX IX

FILM PRINTING AND PRINTABILITY

There are many applications for printed polyethylene films. Most polyethylene films can be printed utilizing the flexographic technique.

All such films must have excellent ink adhesion which is frequently determined by the Scotch-tape test. In this test, Scotch tape is firmly pressed on the printed film surface and then removed by a rapid pull. Good ink adhesion is indicated by no ink being removed by the tape. (Since thin-gauge film may tear under this procedure, it may be necessary to be backed by Scotch tape prior to pulling the test tape from the printed surface.)

The surface of polyethylene and polypropylene film is almost completely inert chemically (which is just what makes such film so useful for many purposes). Thus, the surface must be chemically altered to achieve good printability. Surface treatments have been developed which provide an excellent anchorage for a great variety of inks (as well as adhesives).

The most predominant means of treating polyethylene or polypropylene film to make one of the surfaces printable is the electronic (corona discharge) method. Such a treatment makes the surface receptive to ink essentially by oxidizing it slightly. Spreading of the ink solvent is enhanced so that the film is completely wetted and the ink permeates the roughness of the thin, oxidized surface layer. When the solvent has evaporated, ink pigment and the polyethylene surface are bonded chemically or physically or both. After drying, the ink cannot be removed by rubbing or otherwise without injuring the film surface.

In the electronic method, the polyethylene film, as it is carried around a metal drum or roll which is covered with a dielectric, which is under one or more electrodes carrying a high voltage charge. The high voltage creates a corona discharge between the air gap and the drum which performs the surface treatment.

ANNEX X

PACKAGE DESIGN

1. Choosing Materials For a Package.

When choosing materials for a particular package the requirements for the package should be carefully analyzed. For example:

A. What is to be packaged and what barrier properties will be required?
B. What physical properties are required?
C. What is desired in the final appearance of the package?

2. General Guidelines for Barrier Properties

A. Polyethylene

As polyethylene density is increased the barrier properties of film produced from the resin are improved. Film produced from high density polyethylene has a lower moisture vapor transmission rate than does film produced from low density polyethylene. The same is true for gas permeability (O_2, N_2, CO_2, etc). Also, as density increases grease proofness increases.

B. Polypropylene

Polypropylene has better barrier properties than even the highest density polyethylene.

3. General Guidelines for Physical Properties.

A. Polyethylene.

As resin density is increased the tensile strength at yield of the film produced from the resin is increased. On the other hand, films produced from higher density resins usually have poor puncture resistance and impact strength.

The grade of polyethylene can have a very profound effect on the properties of the film produced from it. For example, a film produced from a general purpose low density polyethylene will have inferior physical properties when compared to a film produced from a heavy duty industrial bag grade of polyethylene of equal density.

The same is true for high density polyethylenes. A high molecular weight high density polyethylene film will have very significant differences in physical properties from a medium molecular weight high density polyethylene film.

Linear low density polyethylene films generally have better physical properties than does low density polyethylene. Here again the grade of resin is important.

Ethyl vinyl acetate copolymer films generally have greater impact strength and tear resistance than other low density polyethylene films. This improvement is usually attained at a sacrifice in yield tensile strength.

Low density polyethylene films have a tendency to block (stick together) and not to slip when one film surface is contacting another film surface. This is overcome by the addition of anti-block and slip agents to the polyethylene. Low density polyethylene film resins may be purchased containing anti-block and slip agents or the anti-block and slip agents may be introduced by the use of a master batch.

B. Polypropylene

Blown polypropylene film while having a high yield tensile strength has a low impact strength and puncture resistance and tends to be brittle.

4. Appearance

A. Low Density Polyethylene

The outer layer of the package should be chosen with the package appearance in mind. Most low density polyethylene films have a pleasing high gloss appearance.

B. High Density Polyethylene

High density polyethylene has a dull matt finish and while it does not have as pleasing an appearance as low density polyethylene it can make a very attractive package with the proper choice of pigments and decoration.

5. Summary

From the proceeding discussion one can see that with the flexibility offered by a three layer co-extrusion film line a package may be tailored to fit the requirements of barrier properties, physical strength and appearance. One may tailor the package to take advantage of the best properties of up to three different materials and with blending of resins an infinite number of combinations are possible.

FILM IMPACT RESISTANCE
(Dart Drop)
Staircase Technique

Significance

This method is for determining the weight of a dart which will produce 50% failure of film specimens under standardized conditions. The test values give an indication of impact performance of resin films. Variations in extrusion conditions cause variations in impact resistance, making the procedure useful in evaluating different extrusion conditions and procedures, when compared to a standard procedure and conditions. Correlation between test results and end use of film can be established.

Apparatus

1. The apparatus is manufactured by Fred Allen Company, Houston, Texas.
2. Hemispherical Head: Method "A" (1.500 ± .005") in diameter. Method "B" (2.000 ± .005") in diameter.
3. An adequate number and size of weights so that the dart load may be properly adjusted.
4. A locking collar is necessary to hold weights firmly against the dart head.

Procedure

Film samples are conditioned at 23° ± 1°C and 50% ± 2% relative humidity for a minimum of 40 hours. The samples are to be tested at 23° ± 3°C.

The film is cut into strips 7" wide. The strip of film represents several specimens attached together. The specimen should be representative material, free of pinholes, wrinkles, folds and any other obvious imperfection which would affect the test results.

1. Determine the average thickness of the film specimens to nearest 0.001" from thickness measurements made at 3" intervals along the length of the strip and at 1" intervals across the end.
2. The clamping pressure is adjusted to 80 psi.
3. The height of the drop employing a 2" diameter part is adjusted to 60" above the center of the film specimen for impact strength of 300 grams or more. For film that has an impact strength of less than 300 grams, a 26" height is used while employing a 1.5" diameter dart.
4. For a starting point, select a weight near the expected impact failure weight.
5. Add weights to the dart and lock securely with the locking collar.
6. Insert film specimen in the clamp.
7. Release the electromagnet to drop the dart.

8. (a) If a failure occurs (X), remove one weight.
   (b) If a failure does not occur (0), add one weight.
9. Repeat these steps for a total of twenty drops.
10. If failures = 10 at this point, testing is complete. If not, complete testing as follows:
11. If failures = <10, continue until failures = 10
12. If failures = >10, continue until nonfailures = 10.

Parameters

The impinging surface of the dart head should be free of nicks, scratches, or other surface abnormalities. The clamping device should engage the film specimen evenly around its perimeter.

The film specimen should be examined to determine if slippage has occurred.

Standard

ASTM Method D1709-75.

Drop No.	Grams Weight Even Increments					
	65	80	95	110	125	140
1					X	
2				X		
3			0			
4				X		
5			0			
6				X		
7			X			
8		0				
9			0			
10				X		
11			0			
12				0		
13					X	
14				0		
15					X	
16				X		
17			0			
18				0		
19					X	
20				0		

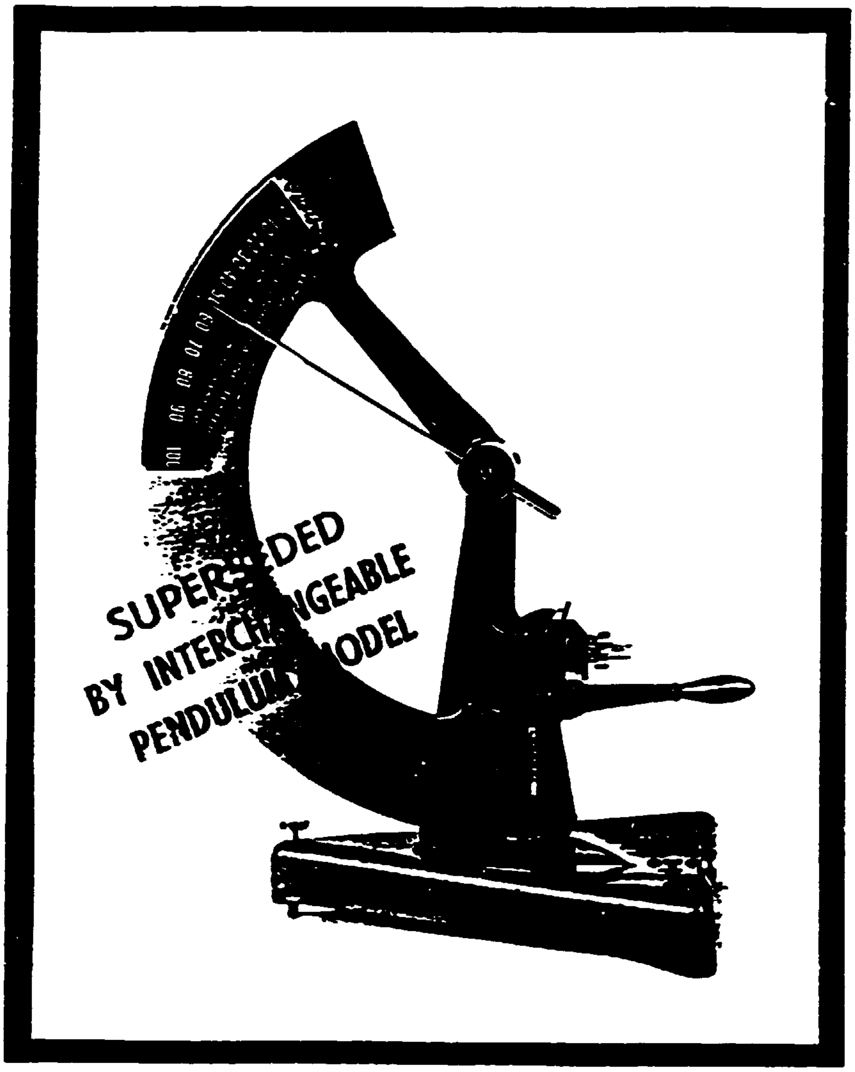
Example:

1 x 95 = 95
5 x 110 = 550
4 x 125 = 500
1145

$\frac{1145}{10} - 7.5^{*} = 107$ grams @ height 26" or 60"

* Half weight increment

THE ELMENDORF TEARING TESTER



SUPERSEDED BY INTERCHANGEABLE PENDULUM MODEL

CATALOG 60-100

FEATURES

- WORLD STANDARD
- EASE OF OPERATION
- LOW MAINTENANCE
- LONG LIFE
- DEPENDABILITY
- ACCURACY
- HIGH TEAR VELOCITY

INTRODUCTION

THE ELMENDORF TEARING TESTER is the recognized standard for measuring the tear resistance of paper, textiles, nonwovens, coated fabrics, foils, plastic films, laminates and other sheet materials. An examination of almost every piece of stationery, writing or printing paper, article of clothing, or packaging material which is no longer fit for service will show that the basic cause of unserviceability was some form of tear. The tear test provides more information about the wearing quality of materials than any other test. Performance is the finest test of any product's quality, therefore, the best test is the one which most closely approximates actual performance. The Elmendorf Tearing Tester does exactly that.

Plastics News resin pricing chart

As of May 6

Prices are in U.S. cents per pound for prime resin, unfilled, natural color, unless otherwise noted. An arrow, up or down, indicates a market price change in that direction from the previous week. A "P" indicates that a price change for that material is pending. A bullet (•) indicates a correction in the published price. Prices are generated from interviews with buyers and suppliers. *Plastics News* does not intend to specify the price of the materials listed. For price quotes on specific materials, contact the supplier.

Call Plastics News reporter Dan Charnas at (216) 836-9180 with resin pricing questions or informatio on changes.

VOLUME THERMOPLASTICS

Key: I-Annual volumes greater than 20 million pounds.
II-Annual volumes of about 2 million to 5 million pounds.

Resin/Grade	Volume category I	II
ABS		
Injection:		
• Medium-impact	80-83	85-87
High-impact	85-88	94-101
Pipe fittings	73-77	83-85
Extrusion:		
Pipe, general-purpose	68-72	78-83
Sheet, general-purpose	82-84	87-90
ACRYLIC, G-P	–	87-93
HDPE		
Blow molding:		
Copolymer (HIC)	28-29	30-32
Homopolymer (Dairy)	30-31	32-34
Drums	32-33	35-37
Injection, general-purpose	26-27	29-31
Extrusion:		
Film, HMW	30-31	33-35
Film, MMW	31-32	33-35
Pipe, HMW	40-42	43-46
Pipe, MMW	42-44	46-48
Sheet	30-31	32-35
Rotomolding, powder	–	38-43
LDPE		
Injection:		
General-purpose	–	38-40
Lid resin	37-38	40-42
Extrusion:		
Coating, paper	36-37	–
Film, liner	33-34	36-38
Clarity film	34-35	37-39
2-4% EVA film	35-36	38-40
Fractional melt	34-35	37-39
LLDPE		
Butene-1 comonomer:		
Injection, general-purpose	–	34-35
Extrusion, liner film	29-30	31-33
HAO comonomer:		
Injection, general-purpose	–	37-40
Lid resin	35-38	38-42
Extrusion, liner film	32-35	36-39
Fractional melt film	33-36	37-40
Rotomolding, powder	–	46-50
PET PACKAGING RESINS		
APET	68-70	73-75
Bottle resin	63-65	65-67
CPET	85-87	–
POLYPROPYLENE		
Homopolymer:		
Injection, general-purpose	28-30	32-34
Extrusion:		
Fiber	24-26	29-31
Film	29-31	32-34
Profiles	31-33	34-36
Sheet	30-32	32-34
Random copolymer:		
Injection	35-37	38-40
Film	34-36	37-39
Blow molding	36-[illegible]	39-42
Impact copolymer:		
High-impact	• 44-46	48-51
TPO (in-reactor)	[illegible]	70-73
POLYSTYRENE		
Crystal:		
Injection, general-purpose	◆ 45-46	48-50
High-heat	◆ 46-47	49-51
High-impact:		
Extrusion	◆ 46-48	49-51
Injection	◆ 47-49	50-53
High-heat, injection	◆ 48-50	52-54
Flame-retardant	◆ 72-74	75-78
EPS, cups	◆ 59-61	–
modified	◆ 56-57	60-61
unmodified	◆ 57-59	61-64
PVC RESIN		
Suspension resin:		
Injection, general-purpose	28-29	29-32
Pipe grade	27-28	28-30
Dispersion resin:		
Homopolymer, G-P	53-55	56-58

HIGH-TEMPERATURE THERMOPLASTICS

Key: I-Annual volumes of about 200,000 pounds.
II-Single, less-than-truckload purchases of 2,000-4,000 pounds.

Resin/Grade	Volume category I	II
FLUOROPOLYMER		
ECTFE	1100-1250	–
PTFE	580-650	–
PVDF	639-645	–
LIQUID CRYSTAL POLYMERS		
Injection		
Carbon-filled	–	–
Glass-filled	780-1280	–
Mineral-filled	890-1035	–
Extrusion	1210-1510	–
POLYAMIDE/IMIDE		
30% glass	1750	1850
POLYARYLATE	176-210	–
POLYETHERETHERKETONE (PEEK)		
Injection, general-purpose	–	3300
30% glass	–	2525
POLYETHERIMIDE (PEI)		
Injection, general-purpose	512	572
30% glass	418	523
POLYPHENYLENE SULFIDE (PPS)		
35% glass, 30% filler	174-185	235-250
40% glass	310-325	383-424
POLYSULFONE		
Injection, general-purpose	382	455
30% glass	331	439

ENGINEERING THERMOPLASTICS

Key: I-Annual volumes greater than 1 million pound
II-Annual volumes of 300,000-500,000 pounds.

Resin/Grade	Volume category I	II
ABS		
Injection:		
Extra high-impact	110-115	117-127
High-heat	115-120	123-136
Plating	107-113	–
Flame-retardant	- 117-123	131-147
Structural foam	103-106	117-124
Blends/alloys:		
PC/ABS	–	138-147
Nylon/ABS	–	165-177
PVC/ABS	–	120-128
ACETAL		
Homopolymer	123-127	135-140
20% glass	–	168-179

Continued on page

Backstopping officer's comments

The first recommendation of Mr. Detter, expert in plastic films extrusion/co-extrusion technology, concerns the purchase of additional testing equipment, which is necessary for quality control of produced single and multilayer films.

In this connection we should recall that the project document of the subject project does foresee the delivery of a much bigger set of testing equipment than the one actually delivered.

The reason for the shortage in testing equipment had been the higher actual cost of the pilot plant equipment with regard to the original forecasts in the project document.

The subject was already discussed in previous TPR meetings held in Ho Chi Minh City, however, no additional funds were made available to allow the establishment of the quality control facility at the intended level.

The success of the project on the establishment of the Packaging Technology Development Centre is not questionable, to the extent that new specific technologies, namely solventless lamination and co-extrusion of plastic films were integrated in the national industrial sector concerned, with appropriate development of know-how and skills of the national counterparts.

At the present stage it is important to stress that a follow-up project aimed at strengthening of the quality control and applied research laboratory of the Packaging Technology Development Centre would be extremely opportune and would contribute to further development within the flexible packaging materials field.