



Due Care



RELIANCE INDUSTRIES LIMITED

PET DIVISION

DUE CARE FOR USING RELPET – PET RESIN

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DUE CARE FOR USING RELPET – PET RESIN

1. Introduction:

The purpose of this note is to give detailed technical guidelines to users of “RELPEP” PET resin, highlighting “best practices” currently used in the PET industry. Surveys have shown that there is a large variance in standards of practices employed. This variance can lead to large differences in quality and productivity when molding & blowing “RELPEP”, unless *due care* is taken during the entire process.

A compelling need to exercise *due care* also arises from higher expectations of finished product quality both in domestic & export markets, as the pressure from bottle blowers, fillers and end-users to deliver consistent quality has progressively increased over the years.

In what follows, key “best practices” have been described in detail, with focus on methods, which help in early detection of resin/processing/ machine related deficiencies, so as to minimise value loss, as PET resin is converted in to different end products.

1.1 What is PET :

Polyethylene Terephthalate (PET) is a thermoplastic polyester. It is used for the production of bottles, sheet, strapping and injection moulded products. PET bottles are used in a wide range of applications such as carbonated soft drink (CSD), water (still/carbonated), Liquor (IMFL/Country Liquor), Edible Oil, pharmaceutical, food and beverages, agro chemicals, toiletries, cosmetics and consumer goods. PET is also used for non-bottle applications such as thin/thick sheet, dual-ovenable Crystallised PET (CPET) containers, injection moulded components and strapping.

The two litre carbonated soft drink (CSD) PET bottles developed in mid seventies is acclaimed as one of the outstanding packaging inventions of the last century due to following reasons:

- It introduced the concept of a family/large pack for the first time in the world for CSD.
- It involved the development of a totally new processing technique called “Injection Stretch Blow Moulding”(ISBM) for the first time in the world.
- It involved evaluation of different polymers, out of which PET emerged as the clear winner due to its superior creep resistance, drop strength, gloss retention properties and glass-like clarity.

1.2 PET Manufacturing Process

It is a condensation polymer made from purified terephthalic acid (PTA) & mono ethylene glycol (MEG) by continuous melt-phase polymerization process (CP) followed by Solid State Polymerization (SSP).

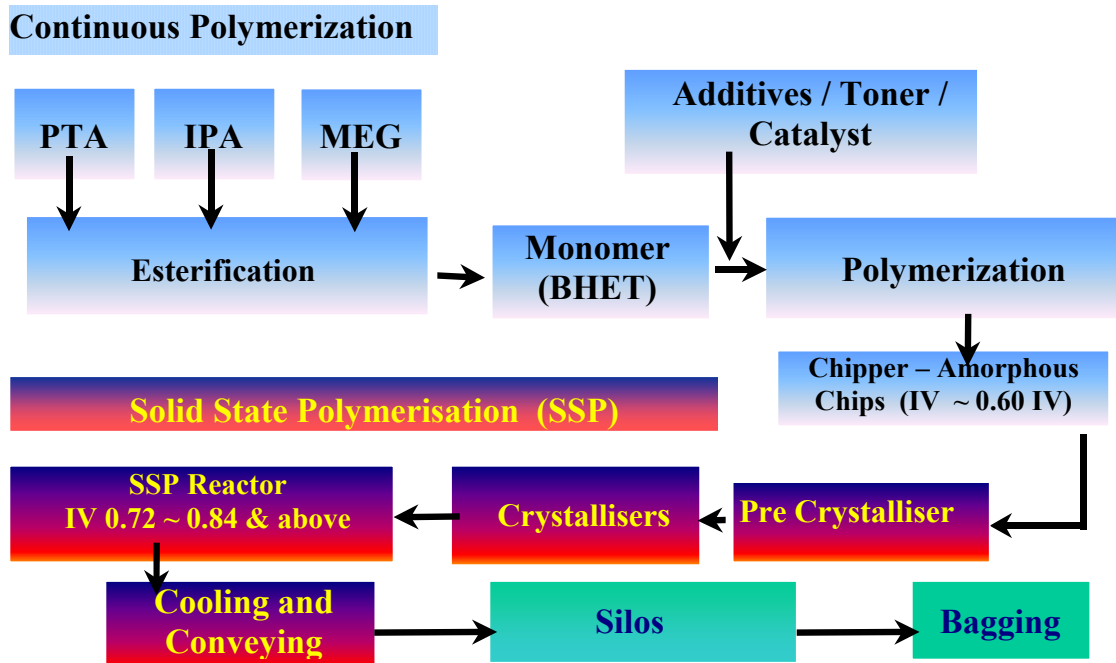
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RELPEP is a co-polyester, as purified isophthalic acid (PIA) is used as a co-monomer. Being a co-polyester, RELPET offers lower Melting Point, slower crystallisation rate and better stress crack resistance.

Slurry of PTA, PIA and MEG is prepared and fed to the esterification reactor, where monomer Bis hydroxyethylene terephthalate (BHET) is produced. The monomer is fed to the polycondensation reactors, where the amorphous base polymer with intrinsic viscosity (IV) of about 0.6 is formed. The polymer is extruded into chips.

These amorphous PET chips are crystallised and subjected to controlled heating cycle under inert atmosphere in Solid State Polymerisation (SSP) reactor. During this process the IV of the polymer is raised to the desired level and impurities such as acetaldehyde are simultaneously removed. These chips are cooled, de-dusted and conveyed to silos. The RELPET manufacturing process chart is shown below:

Relpet Manufacturing Process Flow Chart



1.3 Characteristics of PET and their significance

The critical parameters for PET resin quality are Intrinsic Viscosity (IV), Residual Acetaldehyde (AA) content, Colour (L, a & b), Crystallinity and Dust content. Brief description of each property and its significance is given below:

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1.3.1 **Intrinsic Viscosity (IV):** PET resins are classified on the basis of IV (like MFI in the case of polyolefins), which is a measure of average length of polymer molecular chains or molecular weight. It influences the melt viscosity and processing behavior of PET and properties of the end products. It is used by most PET producers to control the polymerization process, to assist customers in the selection of PET for specific application and to control the preform moulding process. Generally if an application requires higher strength/ESCR, a high IV is recommended. The IV of PET is determined from the flow times of polymer solution and pure solvent in a viscometer at a designated temperature. The IV value will vary depending on the type of solvent used and temperature conditions. In case of 'REL PET' IV is measured in an Ubbelohde Viscometer using Phenol + 1,1,2,2-Tetrachloroethane (60:40 w/w) solvent at 25°C.

1.3.2 **Residual Acetaldehyde (AA) Content:** Acetaldehyde (CH_3CHO) is generated during polycondensation process as a by-product of thermal degradation and gets entrapped in PET resin when molten polymer is cooled. Acetaldehyde is a harmless chemical but it does have a flavor.

Since it has low Boiling Point (21°C) and sweet fruity odour, it can influence taste of packed products, if present in excessive amounts. The technology used by Reliance ensures that AA content is controlled below 1 ppm in all RELPET resins.

AA also gets generated during processing of PET in to preforms/ bottles. Thus it is important to take utmost care while producing PET preforms / bottles (particularly for applications like water and soft drinks) to control generation of AA during preform moulding. The type of machine/mould and processing parameters used for PET have a major influence on AA level in moulded preforms/bottles.

At room temperature AA is a colourless vapour, which is soluble in water and most common organic solvents. When PET preform is made, the AA generated gets entrapped in a glassy matrix; i.e. it gets “dissolved” in the solidified PET. Over long time periods, it will evaporate from preform walls, but at a relatively slow rate. The important points on AA generation are:

- It is generated under heat, when PET is in molten condition.
- It is product of thermochemical degradation and, to a lesser extent of oxidative degradation.

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Three different types of AA analysed in PET resin and containers are:

- Residual AA measured in - Resin
- Preform AA - Preforms
- Headspace AA - Bottles

- Lower the AA content in the preform, the better it is for the contents. For e.g. Mineral water is more sensitive than most beverages and again flat water is more sensitive than Carbonated water to AA.

1.3.3 **Colour:** It is the visual sensation produced by light of different wavelengths throughout the visible region of the spectrum. By such perception an observer may distinguish between two objects of the same size, shape and structure.

It is a three-dimensional characteristic of the appearance of an object, light source or aperture. One dimension usually defines the lightness, and the other two together define the chromaticity.

The most widely used technique in PET industry is the colourimetric spectrophotometer, which measures the wavelength distribution of light reflected or transmitted by a sample and uses this to calculate comparative colour values. PET bottle producers are constantly striving to manufacture high quality products where appearance is an equally critical factor like any other property. Reflected/ transmitted colour, yellowness and haze affect the appearance of a bottle. The colour should be as close to neutral as possible. The colour values are generally measured on an L, a, b scale, by three components, i.e. L*, a* & b*.

- **‘L’ denotes** - Black to White. When L value is ‘0’, it indicates Black & ‘100’ indicates White. Black to White goes through ‘Grey’.
- **‘a’ denotes** – Red to Green. When ‘a’ value is ‘+ve’, it indicates Red & ‘-ve’ indicates Green.
- **‘b’ denotes** – Yellow to Blue. When ‘b’ value is ‘+ve’, it indicates Yellow & ‘-ve’ indicates Blue.

The L, a, b values are controlled in such a way that the preforms/bottles will have as close to neutral colour as possible.

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1.3.4 Crystallinity:

It is a measure of the degree of orderliness of PET molecule. The crystallinity is directly related to the density of polyester and is normally derived from the density value. Crystallinity should be above 50%, so that the chips do not soften and form agglomerates during drying prior to moulding. RELPET chips are supplied with crystallinity value of min. 50%.

1.3.5 Polymer Dust content:

It is essential that the 'Dust' content in PET polymer is minimal in order to have trouble-free processing, good clarity and no specks/marks in the finished container. In case of RELPET, dust content is kept less than 100ppm.

We would be glad to provide any further details on any characteristic of PET resin.

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2. RELPET Grades and their applications:

RELPET is available in four grades – G5761, G5801, G5841 and G5821QH. The specifications of these grades and their applications are shown in the “Selector Guide Table” given below:

Parameter	Unit	G5761	G5801
Intrinsic Viscosity (IV)	dl/g	0.76±0.02	0.80±0.02
Acetaldehyde (AA)	ppm	1.0 max.	1.0 max.
DEG	% (w/w)	1.4	1.4
'b' Colour	CIE	0 to -2.0	0 to -2.0
Crystallinity	%	>50	>50
Melting Point	°C	≅ 247	≅ 247
Fines	ppm	100 max.	100 max.
Weight of 100 Chips	g	1.25 – 1.75	1.25 – 1.75
Applications		<ul style="list-style-type: none"> ➤ Flat Water ➤ Edible Oil ➤ Non-Food products ➤ Small Jars 	<ul style="list-style-type: none"> ➤ CSD ➤ Carbonated Water / Water ➤ Edible oil ➤ Alcoholic Beverages ➤ Agrochemicals ➤ Pharmaceuticals ➤ Non-food products ➤ Wide mouth jars ➤ APET Sheet ➤ Strapping ➤ Hot Fill

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Parameter	Unit	G5841	G5821 QH
Intrinsic Viscosity (IV)	dl/g	0.84±0.02	0.82±0.02
Acetaldehyde (AA)	ppm	1.0 max.	1.0 max.
DEG	% (w/w)	1.4	1.4
'b' Colour	CIE	0 to -2.0	0 to -4
Crystallinity	%	> 50	> 50
Melting Point	°C	≅ 247	≅ 247
Fines	ppm	100 max.	100 max.
Weight of 100 Chips	g	1.25 – 1.75	1.25 – 1.75
Applications		<ul style="list-style-type: none"> ➤ CSD particularly for tropical conditions ➤ Carbonated water ➤ Agrochemicals ➤ Large bottles/jars ➤ APET Sheet ➤ Strapping ➤ CPET 	<ul style="list-style-type: none"> ➤ CSD particularly suitable for high speed blowing machines. ➤ Carbonated water

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RELPET Product has got the following National & International approvals:

United States Food & Drug Administration	USFDA
European Union	EEC
Bureau of Indian Standards	BIS
Indian Toxicological Research Centre	ITRC
Central Food Technological Research Institute	CFTRI

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3. Receipt, Handling and Discharge Procedures for RELPET Packages

3.1 Receipt of Material

- RELPET is available in three pack sizes:
 - 20 TEU with inner PE bulk liner
 - 1 ton FIBC (PP woven outer bag with PE liner)
 - 25 kg bag (PP woven outer bag with PE liner)

Due care must be paid right from the beginning, i.e. on receiving, storing and issuing “RELPET” material for moulding.

- All relevant documents received with the consignment should be checked and verified that they are in order.
- Weight of the entire consignment should be ascertained. The shortage if any, in the total weight of the consignment/bags should be communicated to RIL PET Divn.
- If there is any deviation, all the bags must be kept aside and not taken into process until discussed/agreed with RO/HO. RIL PET Div. should be informed immediately but not later than 48 hours after receipt of the consignment.
- Under no circumstances the truck should be unloaded if Modvat document is not delivered along with the consignment.
- A detailed procedure for handling ‘Transit related damages’ is as per Ann. I.

3.2 Unloading Procedures

- Bags should be properly and carefully unloaded from the trucks and transferred to covered warehouses using fork-lifts or trolleys (Pl. refer Ann. II for details of Procedure for unloading of 1 ton bags).
- Damage to bags or material due to improper handling during unloading, such as dragging of bags on truck/shop floor can affect subsequent processes/quality of finished product, if there is any external contamination/ingress of excess moisture due to damage/tearing of bag.

3.3 Handling Procedures

- Bags should be stored with sufficient care, for e.g. while using two different grades like G5801 and G5841, they should be stored separately, so as to prevent mix-ups,

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- The PET raw material must be stored properly on wooden pallets, so that there are no chances of any moisture ingress from the floor in to the bottom of bag during handling inside the factory. The bags should not be left open with some balance material. The raw material storage area should be properly covered to avoid any chances of external contamination.
- It is a good practice to clear the outer surface of bags, before shifting to the shop floor area/opening of the bag.
- Issue of RELPET bags for processing, should preferably be done on a ‘First in - First out’ (FIFO) basis.
- 1 MT Bags should be lifted/transported by using all the four loops available on the top of the bag. Hooks should not be pierced into the bag for lifting/transporting.

3.4 Discharging Procedure for 25 kg and 1.0 MT Bags

- In cases where automatic feeding from the bag is not possible, the bags should be opened nearest to the machine, so that external contamination during transportation of open bags inside plant is avoided.
- The suction nozzle used should always be kept inside the bag or drum (if used), else it can pickup dust from floor/surrounding air causing specks/contamination in Bottle. In case of 1 ton bag, it should be tied from outside (after putting nozzle) and if a drum is used then it should be properly covered with a securing lid.
- A magnetic separator is suggested to be used for checking any magnetic contaminants.
- In order to transfer the material from 1 ton bag to a 25 kg bag (due to space restrictions in shop floor for 1 Ton bag), care should be taken that these bags are fully covered/protected in the interim period, else it can lead to contamination in the finished container.
- The discharge procedure for 1 Ton bags is as per Annexure III

3.5 Importance of Clean Storage

- This dust free atmosphere is required as dust/contamination can appear as a speck on bottle, which is not acceptable, as aesthetics is one of the prime advantages of PET packaging.
- The over-all up-keep of the processing unit is to be maintained, with total emphasis on good housekeeping and dust-free atmosphere. PET bottles need to be manufactured in controlled conditions, as it is a primary package for food products. The working environment should meet the standards of end use application.

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- There is a need to install class 10,000 system for maintaining purity of the air used in total packing area for PET bottles for pharma application. It requires that no. of dust particles of size more than 0.50 μ , should not be more than 10,000 in one cubic foot of air. The total area from the point where bottle is ejected till it is shrink-wrapped, needs to be covered as per this standard. It is suggested to have a conveyor from bottle exit point to shrink wrapping machine.
- There are consultants in pharma industry, who advise on the up-gradation of factory premises as per the required standards for supply of bottles to pharma industry.

3.6 Reporting Procedure in case of receipt of Damaged bags

- Any transit damage to bags like soiling with oil, mud, other contaminants or transit wetness can cause processing problems. In the event of any type of transit damage, an appropriate certificate on the reverse side of the relevant lorry receipt, indicating the nature of damage and reasons thereof should be obtained by customer from the driver.

A detailed procedure for handling 'Transit related damages' is as per Annexure I.

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4. Processing Guide

4.1 Introduction

- PET bottle is made in 2 stages. A preform is first made, which is then preheated and stretch blow moulded to make the final PET container. The process is called Injection Stretch Blow Molding. If both the processes of production of the preform and its stretch blow molding are done in a single machine, it is called single-Stage process and if these two processes are done on two separate machines, it is called two-stage process. PET cannot be extrusion blow molded, as its vertical melt strength is low.
- RELPET material is to be dried in a de-humidifying dryer (as detailed in 6.2).
- Start with a completely clean hopper, barrel and mould/die before processing PET. Pl. refer Annexure IV for more details on ‘Start-up’ procedure.
- Both pigments and master batches are used for making translucent/opaque PET bottles and sheets. The pigment/master batch can be physically blended manually, but it is advisable to use a dosing unit for additives to achieve consistency and uniformity of dispersion. As many of the pigments are based on a low temperature melt carrier, hence water-cooled dosing is to be used.
- It is suggested to contact the colourant supplier for recommended addition levels.
- One of the growing/potential markets for PET Bottles is Pharma industry. It is recommended to follow some minimum processing guidelines for supply to this sector. The critical issues/guidelines are covered in Annexure V

4.2 Drying

PET resin is hygroscopic, that is it picks up moisture from air. RELPET when supplied has approx. 0.2% of moisture, which during transportation/storage, can increase up to a max. of 0.4% depending on transit/storage time before usage. It is essential for trouble-free processing & desired physical properties, to reduce moisture to less than 40ppm (0.004%) before processing which can be achieved only by a de-humidifying dryer. Hence an in-line desiccant hopper dryer is required to process PET, wherein desiccant dried air is passed over resin.

Hopper mounted Hot air dryer or a tray dryer are also being used by processors for drying PET, but these dryers essentially help in removing only surface moisture and cannot consistently remove moisture to less than 40ppm, which is required for trouble-free PET processing.

It should be noted that any problem, which occurs due to insufficient drying, cannot be corrected in further processing. It is possible that the preform/bottle may look clear, but the physical

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properties are lowered, which adversely affects field performance. The salient features for efficient drying of 'RELPEP' are summarised in the Ann. on PET DRYING (Annexure VI).

4.3 Temperature and other Settings

- RELPET should be processed at the minimum possible stock temperature, usually about 275°C. The recommended temperature range is 265-290°C, as excessive stock temperature can cause molecular breakdown, leading to faster crystallisation i.e. appearance of haziness.
- The recommended process parameters for preform moulding on Single-stage and Two-stage machines are covered in Ann. VII and VIII respectively.

4.4 Mould Sweating

- The moisture present in the environment can condense on the tool, which is termed as "Mould Sweating". Moist ambient air in the mould shop can easily lead to moisture condensing on the surface of the mould tool and on the cooling robot.
- PET processing requires fast cooling and hence the use of a chiller is a must. Chilled water is normally delivered at temperatures varying from 8 to 21°C, depending on humidity and other factors.
- A mild winter's day may be sufficient to affect productivity and preform quality. In the worst case, there will be watermarks on the preform, corrosion of the tool and preforms will not be freely released from the cooling station.
- In order to avoid effects of varying humidity resulting in mould sweating, it is recommended to install a 'Mould Sweat Protector' (MSP). Pl. refer Ann. IX for more details in this regard. MSP maintains humidity at an acceptable level and ensures that cooled components stay dry.

4.5 Use of Regrind

If PET regrind need to be used, proper care should be taken to avoid problems in processing and quality related. It can be effectively recycled if the following precautions are taken:

- Recycle should be clean and free from any contamination.
- Very fine particles should be removed to prevent choking of filters.
- Regrind is in amorphous form, hence should be blended less than 2-5%. If higher quantities are to be used, it should be crystallised before use, so that it doesn't agglomerate in dryer.
- It should be properly blended with virgin resin. It is suggested to use a dry blender for this purpose.

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5. Trouble Shooting for Injection Molding of Preforms & Stretch Blowing of Bottles

The final quality of finished bottle depends on quality of raw material, effective drying and trouble-free processing. A brief description of some of the common problems faced on shop floor along with Trouble-shooting guide is covered in Annexure X.

6. Inputs from Customers in case of Complaint.

The following inputs on product/process will help in speedy attendance to customer calls:

1. Nature of complaint (Problem in brief: Packaging/Transport/Processing/material related). If it is perceived to be transport related problem like 'Short weight, wrong product delivery, torn bags', etc. it should be recorded on LR copy.
2. Name of Product/merge: e.g. G5801 K/ G5841 T etc.
3. Actions taken at your end to resolve this complaint (till reporting of complaint).
4. Specific/immediate inputs required from RIL.
5. ID no. and all bag nos.
6. Invoice no./date or DCPI No./date,
7. Affected bag nos. and affected qty.
8. Details of occurrence of this problem in past. If yes, how it was attended/resolved
9. Details of m/c, mould, chiller, dryer (dehumidifying/Hot air/tray type) incl. hopper cap/productivity (kg/h).
10. Total process parameters incl. drying (Time/Temp.).
11. Is problem pertains to a specific machine/mould or observed on other m/cs also?
12. Samples of resin and corresponding perform & bottles where necessary.
13. Details of storage/unloading procedures.
14. Suggestions/any other related points.

7. Storage and Transportation of Finished Bottles

It is recommended that PET bottles be stored/transported in such a way that there is a minimal exposure to heat/sunlight.

PET is a heat-sensitive material and any exposure to heat results in shrinkage, which can vary from 0.5-1.5% depending on the time and temperature of exposure. The top and outside layer of PET bottles stored/transported had been found to have relatively more shrinkage.

It has been observed that some of the end-users follow the practise of transporting during nighttime, which have been reported to result in reducing the extent of this problem.

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8. PET Recycling


The concern for Recycled PET (RPET) is continuously growing in recent times. PET bottles which form the major market of PET packaging resin (94%) are the major concern from the point of recycling. More than 90% of PET is consumed in food packaging with drinks / beverages forming almost 80%. Since drinks and beverages are consumed mostly in residential houses, restaurants, stadia, railway stations, airports, entertainment venues and other public places, the importance of organised collection and recycling of post-consumer PET bottles need not be over-emphasised.

The PET bottle is 100% recyclable and most eco-friendly in nature. The need of the hour is however proper handling system at all stages. The end-consumers for e.g. should take care to remove the cap and label from the used PET bottle before disposing it off and also should not throw the empty bottles in a public place. In order to ease the handling at different stages, the PET bottle should be 'flattened' and baled before sending it to the intended area of usage.

The collection / recycling rate is still low and needs to be improved considerably because future growth of PET packaging resin is closely linked with the simultaneous increase of collection / recycling rates. It calls for more concerted efforts on part of everyone from the industry, viz. processors, end-users and PET raw material suppliers to play their roles effectively, so that PET bottles after usage, do not become a social/environmental issue and are utilised for production of many value-added products.

Today, many value-added products are being manufactured from post-consumer PET bottles like polyester fibres, upholstery, PET strapping, glass reinforced PET items for under-bonnet and other similar applications.

It should be however noted that PET cannot be recycled like other commodity polymers on conventional equipment. Therefore scavengers or rag pickers, who form one of the major source for plastic waste collection in developing countries, do not show interest in picking PET bottles. In developed countries, innovative and novel methods have been introduced for collecting post-consumer PET bottles. The measures taken to promote recycling of post-consumer and waste PET bottles are mechanical recycling, chemical recycling and incineration.

The collected PET bottles are sorted from other plastic bottles into clear, green and other colours. PET bottles can be sorted manually or using automatic systems. Primarily only manual sorting is resorted for PET bottles. The PET bottles carry the recycling symbol at the base or shoulder and the identification symbol for PET containers is 

The environmental efficiency of packaging materials is assessed by a technique called 'Eco-balance' study. This is a 'cradle-to-grave' analysis which estimates the energy consumed and wastes generated during the complete life cycle of a packaging material right from raw materials through finished

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product to recycling or disposal. The main factors considered are weight-to-volume ratio of solid wastes generated, energy consumed in manufacturing/delivering and air-borne/water-borne pollutants emitted during manufacturing.

This study was conducted on PET soft drink bottles along with glass bottles and Aluminium (Al) cans for a North American Association called NAPCORE (National Association for Plastic Container Recovery) by Franklin Associates, USA, and the findings of this study confirmed that PET bottles are more environmentally efficient than glass bottles and Al cans.

PET packaging resin due to its inherent strengths, such as food-contact safety, ecofriendliness and recyclability, is sure to maintain its growth particularly in food packaging. The consumer's preference for hygienic, clean, comfortable, convenient and light packaging is going to give further boost to PET packaging in future. Despite these strong market drivers, the future growth of PET packaging is strongly dependent upon simultaneous development of recycling programmes for post-consumer waste.

The success of PET recycling programmes depend upon several factors such as conducting awareness campaigns, developing effective and organised post-consumer waste collection systems, Promoting reclaimers / recyclers to produce value added end products from RPET and commitment from different bodies. Efforts are on for creating proper collection and recycling facilities. One such case in point is the installation of a hydraulic press for baling by Central Railways at Mumbai Central station.

It can be said that the survival of any packaging material in future depends not only on its technical and commercial advantages, but also equally on how much of its post-consumer waste is recovered and recycled.

9. Due Care Audit

Experience has shown that the *Due Care* procedures recommended above must be regularly and diligently audited. It is recommended that the user of "RELPEP" should assign this task to a separate Group or Team.

Top management should ensure that due care systems are complied properly, through periodic review of observations/reports from audits.

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ANNEXURE I

PROCEDURE FOR TRANSIT RELATED DAMAGES

Action By Customer

On receipt of consignment, ensure to check up whether it is a direct delivery or transshipment. In case of transshipment, confirm the status of bags/consignment on the truck.

In case of receipt of any defects in the consignment it should be brought to the notice of truck driver and with necessary remarks on the respective LR. If there are severe damages, insurance survey need to be conducted in consultation with our regional officer /concerned DCA.

Action by Regional Office

On receipt of any such complaint from the Customer or through the DCA, Regional Head will register the same into CCMS, visit the customer for assessing the loss as well as arrange a meeting with the transporter, conclude the salvage value or assist customer for the disposal of damaged goods / will arrange for the diversion. Initiate process of replacement.

Action at HO

Will propose the recovery from the transporter for the value of damaged consignment based on the salvage value proposed by the region in consultation with HO and for any other incidental expenses and credit the same to customer or make payment to the customer and to the other services

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ANNEXURE II

PROCEDURE FOR UNLOADING OF 1 TON BAGS

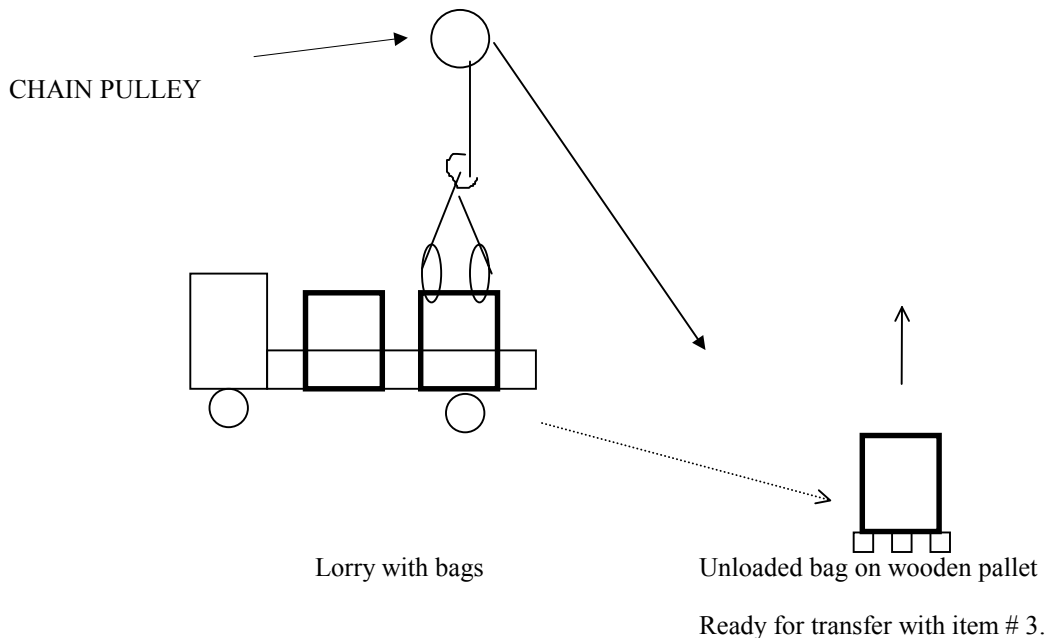
As at all places, OHT crane facility may not be available, a simple and economical alternative system to handle 1 Ton RELPET bags is described below.

The following items are required for handling 1 ton bags:

S. No.	ITEM
1	2T capacity chain pulley block
2	Wire ropes with hooks & crimped to with stand 2T load
3	2T Capacity pallet truck (hand operated)
4	Wooden pallets

The total cost inclusive of installation for a simple economical model shall be approx. Rs. 50, 000 for the above system. It is only indicative cost and may vary depending upon the site.

SCHEMATIC DIAGRAM



The above schematic diagram explains the basic arrangement. First, the lorry with RELPET 1 ton bags is positioned below the chain-pulley block. One of the bags at the rear end of truck is first lifted up with the help of a chain pulley and the lorry is moved forward. The bag is then **lowered down and** placed on a wooden pallet. The pallet, together with the bag, is then moved to the storage area with the help of hand operated pallet truck. This process will be repeated till all the bags are off-loaded. The whole operation may be completed approximately within an hour.

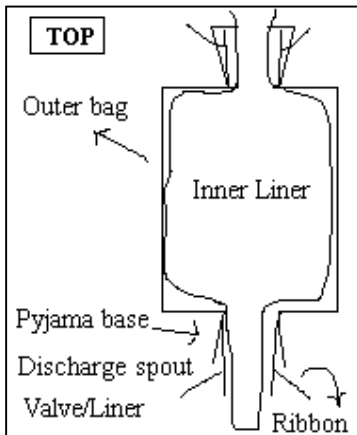
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ANNEXURE III

DISCHARGE PROCEDURE FOR 1 TON BAG

Construction of bag:

The bag is made of PP circular woven sack. The top is constructed to assist filling operation and the bottom to discharge the material by gravity. An "LLDPE" liner is placed inside the bag to protect the material. The liner height exceeds on both top and bottom sides. The inner spout has a ribbon for tying. Apart from these, the bag has four lifting loops and one folder for placing label. Following are details of top and bottom of the bag.

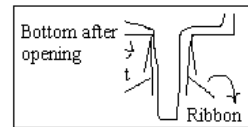
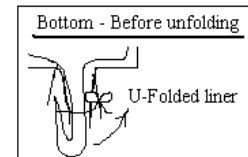


Top: There are two concentric spouts through which the liner is taken out.

Bottom: The bottom is with a pyjama construction. The pyjama when tightened becomes flat and matches with bottom of the bag. The same pyjama when loosened hangs like a spout. This spout consists of another spout called discharge spout. Through this the liner comes out. The discharge spout is having a ribbon for tying. The same ribbon can be used to control/stop the flow during the course of discharge operation if required.

Procedure to Discharge material from bottom:

- The material can be discharged from the bottom through gravity.
- Lift the bag by holding top four loops that are meant for this purpose.
- Loosen the Pyjama at the base. Then an opening to access discharge spout is made.
- Pull the inner assembly. The inner assembly consists of liner and the discharge spout. Refer the drawing at the right.
- Cut the bottom of the liner. If the bottom of liner is not traceable properly, then loosen the ribbon of discharge spout a little and then pull the liner and re-tighten the ribbon. Now the liner bottom is visible and can be cut easily.



- Loosen the ribbon and start the material discharges operation.
- Tightening the ribbon can control/stop the flow. The pyjama rope can also help in controlling the flow.

DUE CARE FOR USING RELPET – PET RESIN

ANNEXURE IV

PROCEDURE FOR START-UP OF MOULDING MACHINE

The recommended good practices of start-up and shut-down while moulding RELPET PET resins and tips on dealing with problems associated due to adverse situations like power failures and emergency stops are described below.

Normal Start-up

Set temperatures as recommended for product and switch on the heaters. After attaining the set temperatures, wait for at least 30 minutes for uniform spreading of heat.

Purge the material and ensure proper melting of the resin and then start the production.

First time purging should always be done in low injection pressure / speed to avoid injury to the operator.

Normal Shut down

Purge the material completely and leave the screw in the forward position so that there is no accumulation of material before the screw.

Switch off the heaters.

Restarting when the machine is shut down abruptly

There are occasions when the machine shuts down due to power failure or an emergency. During such instances, if the machine heating is restored within 10 ~ 15 minutes of failure, then the machine may be started as per 'Normal start-up' procedure as described above. If the heating is not restored in a reasonable time, then the material inside the barrel will solidify and harden. This will cause problem during restarting. Following are suggestions during such occasions.

Start nozzle and metering zone heaters first, and after half an hour to one hour of heating, start other heaters (This will minimise chances of degradation).

If the nozzle temperature is not attained in a reasonable time or in some cases where the machine has extended nozzle, use blowtorch* to heat the nozzle. Heaters may be damaged if exposed to the flame directly, hence direct the flame only onto bare areas. Purge till the entire trapped material is flushed.

Occasionally the trapped material may degrade due to over heating and cause problems like black specks. Normally the black specks disappear when purged with fresh material. If black specks continue then other polymers like polyethylene or polypropylene can be used for flushing.

* Note: Blowtorch is a burner, which uses inflammable gas. Relevant care in using such instruments is to be taken.

DUE CARE FOR USING RELPET – PET RESIN

ANNEXURE V

GUIDELINES / CRITICAL ISSUES FOR SUPPLYING PET BOTTLES TO PHARMA INDUSTRY

The issues relevant to pharma industry for usage/switchover to PET packaging are summarised below.

1. Hygiene / Working area environment

This Topic is covered under Sl. No. 5.4

2. Maintenance of records / calibration of equipment's :

1. The factors crucial to good quality bottles are Quality of resin, up-keep of factory & processing parameters; hence records of raw material used and processing parameters to be maintained for traceability. This is especially important as shelf life of pharma bottle is on an average 24 months and in case of a complaint; analysis is done at each stage.
2. To maintain proper records of processing parameters, including dryer function. It is suggested to measure Dew Point of air used, as this will determine quality of drying and also log book for critical parameters should be kept for all the m/cs to record range of values for each parameter. A competent authority should sign these records.
3. Calibration of measuring instruments to be done to ensure reliability of values. Wherever required the supplier should certify functioning including time period.
4. As only food grade colorants are to be used in pharma application, the Quality certificate for pigments should be procured with each lot purchased, certifying that it meets FDA regulations.

3. Storage / Processing of material

1. The PET raw material must be stored properly on wooden pallets, so as to take care of any moisture ingress from the bottom of bag during handling in factory. The bags should not be left open with some balance material. The raw material storage area should be properly covered to avoid any chances of external contamination.
2. It is suggested that the bags should be opened only near the machine and material should be transferred directly to the hopper to reduce contamination.
3. It is recommended that regrind should not be used, as it will affect quality of bottle to be used for pharma industry, as they cannot take any chances due to nature of end use.
4. The feeding of the colorant should be preferably automatic to avoid manual contact and to improve consistency of shade.
5. It is suggested to use oil-free compressors so that there is no possibility of contamination of bottles from the oil.
6. The frequency of maintenance for each machine to be established and regular maintenance to be carried out.
7. Fiberboard or any similar material not to be used in collection tray at exit of m/c, as this will lead to dust particles being carried in to bottle & contamination of product.

DUE CARE FOR USING RELPET – PET RESIN

8. The packing tray should not be from fibreboard or any similar material, as they are insect breeders. One should explore possibility of replacing it by plastic trays, which will be re-cycled between pharma manufacturer and PET converter and need to be only air washed before re-use.

4. Health / Work standards:

- 1 The physical health of shop floor personnel's, those who handle bottles should be in good condition, so as to avoid any contamination of liquid being packed. They need to be medically examined to ensure that they are not suffering from any of the contagious diseases, which can effect hygiene of the area and a certificate from a doctor to be obtained in this regard.
- 2 As the pharma industry has high standards of hygiene, hence protective wear should be used like face masks and hand gloves. Also good quality clothes to be wearred.
- 3 The working environment to be kept neat and clean. The use of netting and similar measures are recommended in the factory premises so as to reduce/eliminate the chances of any contamination in production area.

5. Quality tests:

- 1 Quality tests to be incorporated for checking quality of finished bottle like material distribution, base stability etc. along with frequency of tests as applicable.
- 2 In view of class 10,000 system, the bottles need to be shrink-wrapped and then put in a separate package.

6. Weight / Design of bottle:

1. Guidelines on arriving at suitable weights for different volumes need to be worked out and to be discussed with pharma manufacturers. The actual grammage will be defined by the market/end-user.

DUE CARE FOR USING RELPET – PET RESIN

ANNEXURE VI

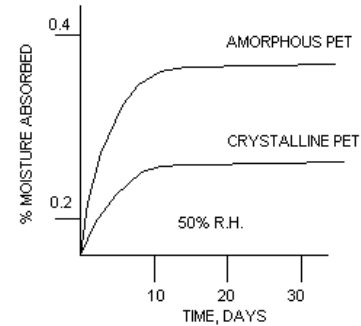
PET Drying

Introduction

One of the most important and critical factors in the processing of PET is that the material should be nearly free from moisture to avoid processing problems and defects in the finished products such as haziness, voids, sliver streaks, and also to derive better physical and mechanical properties.

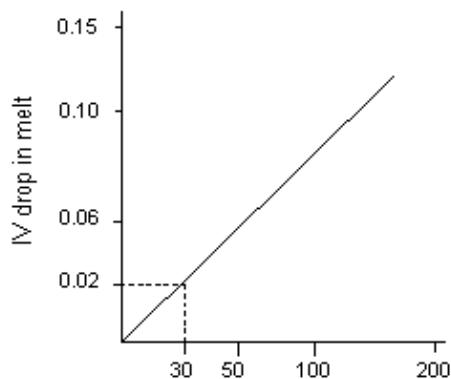
Moisture Absorption

The amount of moisture absorption depends on various factors like time, temperature, atmospheric humidity (dew point) and the crystallinity of the chip. PET in Amorphous form absorbs moisture more rapidly than in crystalline form. The high level of crystallinity in RELPET (>50%) helps in slower moisture absorption rate. Picture on right shows typical rate of moisture absorption by PET.



Why to Dry PET before processing?

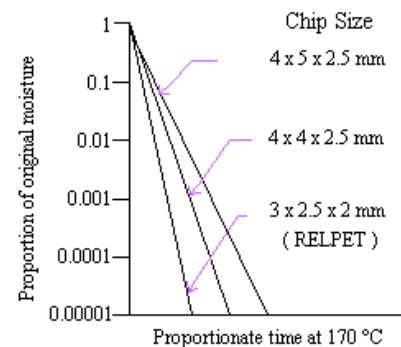
During plasticising in the extruder, presence of moisture breaks polymer chains leading to reduction in the molecular weight i.e. drop in IV. This will affect final container properties. Drop in IV makes the melt fluid (runnier), so the injection flow control, wall thickness distribution becomes difficult during preform moulding. Lower IV resins also crystallize faster than higher IV ones resulting in hazy/milky appearance.



To obtain maximum product performance, it is essential to reduce the moisture content to less than 0.004% (40 parts per million), or preferably about 30ppm prior to melting. Excessive drying temperatures also can lead to thermal and oxidative degradation. Picture on the left shows typical values of IV drop due to retained moisture in the PET during processing.

Moisture Removal - The Diffusion Process

The moisture, which is entrapped in the resin, will diffuse towards the center of the PET chip. Due to this, PET drying is different from other drying processes where surface moisture removal alone is the target. Because of this diffusion phenomenon, relatively long drying times and hot dry air are primary requirements. The drying time depends on size of the chip. Smaller the size, faster is the drying. Figure on the right indicates the relative time difference with different chip sizes, for achieving required level of dryness.



To achieve proper drying of PET recommended drying temperature is in the range of 150 ~ 180°C.

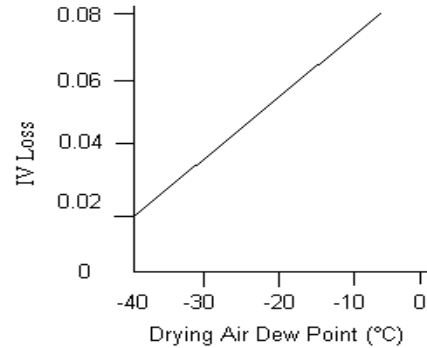
DUE CARE FOR USING RELPET – PET RESIN

Amorphous PET exhibits T_g (Glass transition temperature) around 80°C while the crystalline PET is almost nearer to the melting point. Because of this, crystalline PET can withstand the recommended drying temperatures, the amorphous PET tends to soften and form agglomerates at around 80°C.

The difference in the behavior of crystalline PET and amorphous PET during drying should be well understood. RELPET chips are supplied with high level of crystallinity (>50%), which ensure trouble free drying. Dried PET will re-absorb moisture very rapidly if exposed to the atmosphere. Hence, it is essential to arrange direct entry of material into feed throat from the hopper to avoid atmospheric contact of dried material.

De-Humidifying Dryer:

These types of dryers circulate hot and de-humidified dry air onto the resin, suck the air back, dry it and then pump again in a closed loop operation. This process reduces moisture level in the PET down to 40ppm or lower. The efficiency of moisture removal depends on the air dew point. If the air dew point is high, then some moisture remains in the chips and cause IV loss during processing. The graph on the left shows typical values of IV loss associated with different air dew points.



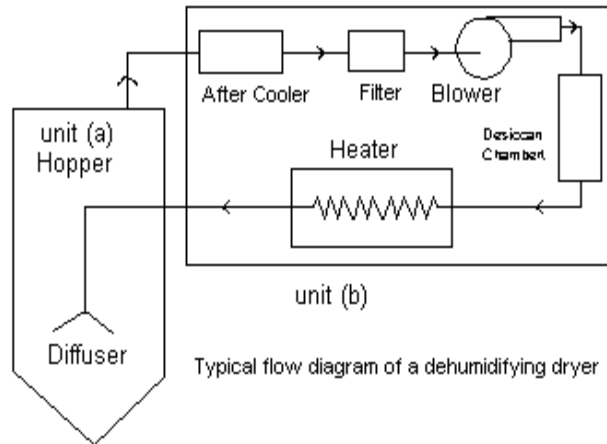
Dryer consists of two major parts:

Hopper: Material that needs to be dried is placed in this.

Drying unit: This is housed in a separate cabinet nearer to the hopper. The only connection between both the units is flexible hoses, which can withstand high temperatures. These hoses are used for carrying dry and return air. The following picture shows a typical flow chart of dehumidifying operation (regeneration is not shown).

The air first comes into contact with the material through the diffuser, which is attached at the lower portion of the hopper. Diffuser spreads the air across the entire cross section of the hopper. Most hoppers

will have a converging bottom as well as an internal distribution cone, to ensure plug flow of the chips through the system. The dry-air then passes upward and reenters the drying unit after passing through the after cooler and filter. This closed loop operation makes this an efficient drying process.



The air dryer is designed to remove moisture from the return air and to re-circulate. First, the air is cooled down in a heat exchanger to around 40 °C and then passed through a filter to remove any fines, which are carried by the return air. The performance of the desiccant depends on the inlet air temperature; hence, cooling the return air is very important. This air is then passed through a desiccant bed to remove the moisture in the air. The desiccant bed contains pellets or granules that absorb moisture and are known as molecular sieves.

Regeneration:

Once the desiccant reaches saturation level, it can no longer absorb any moisture. The operation of expelling moisture from the desiccant and drying it is called regeneration. Air heated up to 290°C is passed through the desiccant bed causing the desiccant to give up the moisture that was absorbed during drying, and this moisture is flushed out of the system through air.

DUE CARE FOR USING RELPET – PET RESIN

The air is heated by a separate heating system than the one used for the drying process. In an efficient system the drying operation and regeneration operations are carried out independently. This is made possible by providing two separate blowers one for drying and the other for regeneration and also, the desiccant is arranged either in two interchanging columns or in four columns fixed on a rotating.

This helps in uninterrupted drying operation during regeneration. There are also economic systems available in which the same drying blower is used for regeneration. In this system, the drying capacity reduces due to interruption in drying during regeneration.

Normally, all these systems are fitted with an auto loader on top of the hopper to maintain chips level in the hopper. A thermocouple to control air temperature is also attached at the air entry point to the hopper. A high temperature protection device is important to protect the material in the hopper from fusing together.

Key Parameters to achieve efficient drying

- **Chip temperature:** The actual chip temperature measured at the dryer exit point should be around 175°C.
- **Air temperature:** Drying air temperature is measured at the inlet to the dryer and this shouldn't exceed 190 to 200°C.
- **Air dew point:** This should preferably be at -40°C or lower measured at the air inlet to the dryer. It shouldn't be allowed to rise above -30°C.
- **Airflow:** Adequate airflow must be maintained across the bed. Although various equipment suppliers used different airflow rates, minimum flow rate of 3.8 m³/kg/hr must be maintained across the material.
- **Chip residence time (drying time):** Minimum 4 hours and preferably 6 hours. Resident time is calculated by dividing weight of material (kg), which can be filled in the hopper, by resin throughput (kg/hr).

Tips on up keeping the dryer for better performance:

Air filter: Routine filter cleaning of both drying and re-generative filters is essential. The filter protects the desiccant beds from dust. Great care must be taken not to damage the filter. Bad filter reduces airflow and affect drying. Replacement of filters must be according to original specification only.

Heat Exchanger: Due to blockages and scaling heat exchangers lose efficiency. This affects the efficiency of drying. Maintenance as per the manufacturer's recommendation should be carried.

Heater failure: Failure of heaters main/regeneration can lead to either inability to achieve the correct drying temperature and/or the inability to achieve the correct desiccant bed regeneration temperatures. It is required to ensure proper functioning of heaters, electrical contactors and temperature controllers by frequent checking.

Note: The set point temperature continues to indicate even with one of the defective heating elements because the heater may contain multiple heating elements. It is essential to check the heaters periodically, because, the hot air loses its heat as soon as it touches the material. If there is a temperature indicator to indicate chip temperature at the feed throat, then it is possible to identify this before hand.

Auto Loader: Clean dust collection bags and checks loader operation/level sensors regularly.

Ingress of ambient air: Ambient air is very wet compared to the drying air. If any ambient air enters the drying system that will adversely affect the dew point and hence drying efficiency. It is important to

DUE CARE FOR USING RELPET – PET RESIN

check periodically, for any air leaks inside the dryer cabinet and outside. Loose or damaged hoses are some of the root causes of this.

Repairs: Replace the parts removed for maintenance with appropriate gaskets and sealant and test for leaks.

Process control of dryer: Monitor dry air temperature and dew point. (Dew point indicator is optional equipment in most dryers).

It is a good practice to crosscheck all temperatures using a calibrated digital thermometer attached with a suitable probe. The dew point should be measured once in six months or as and when a maintenance work is undertaken. Monitor the airflow through the dryer.

Drying of Recycled PET

Normally recycled PET is in amorphous form, which is clear unless otherwise crystallized. This can result in processing problems because it clumps when dried at normal drying temperatures (175°C). So amorphous flake has to be re-crystallised before it is dried. In most practical situations, a minor addition of factory reground of rejected preforms/bottles doesn't give problems. The addition levels depend on process.

Conclusion

Drying is the most critical step in PET processing. Failure in meeting the correct drying criteria cannot be corrected in subsequent moulding operation.

Understanding important parameters:

Dew point: Dryness of air is measured in dew point. The temperature at which water vapor from the air begins to form droplets and condenses on surfaces that is colder than the dew point of the air. It is expressed in °F or °C. Lower the dew point, higher is the dryness of air.

Relative Humidity: It is the ratio of the amount of moisture in the air to the maximum amount of moisture the air can hold at the same temperature and pressure. For e.g. if RH is 100%, then the air can't hold any more water and if RH is 0% air is totally dry. RH is a function of temperature and warmer the air, more moisture it can hold.

Intrinsic Viscosity (IV): IV is a measure of the average molecular weight. It denotes the average length of molecular chain. Products moulded from higher IV material will have higher mechanical strength compared to products moulded from lower IV material. Molecular weight and IV are interrelated to each other.

DUE CARE FOR USING RELPET – PET RESIN

ANNEXURE VII

Process Parameters For Single Stage Machine

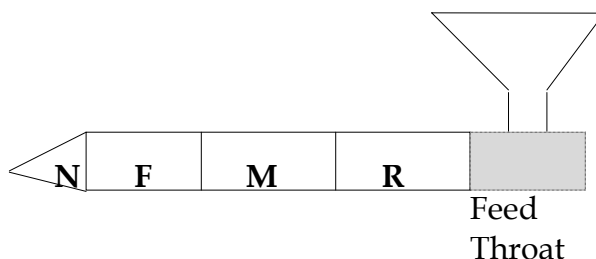
The recommended processing parameters for RELPET G5801 PET resin on single-stage fully automatic Injection Stretch Blow Moulding Machines are described below.

RECOMMENDED DRYER SETTINGS

Chips Residence Time	Temperature Range
< 4 hr	Not Recommended
≈ 4 hr	175 °C ~ 185 °C
5 ~ 6 hr	165 °C ~ 175 °C
> 6 hr	160 °C ± 5 °C

Note : De-humidifying type of dryers with minimum air circulation of 1.5 m³/min per kg/h of out put is recommended. Dew point of air should be around -40°C.

RECOMMENDED BARREL SETTINGS



BARREL					HOT RUNNER UNIT			
ZONES	Nozzle	Front	Middle	Rear	Blocks Left	Blocks Right	Nozzles Left	Nozzles Right
SUGGESTED	275	275	275	275	280	280	280	280

INJECTION PR.	AV. INJ. SPEED	HOLDING PR.	BACK PR.
90 ~ 120 bar	50 ~ 60 mm/sec	40 ~ 50 bar	5 ~ 10 bar

CHILLER WATER	10 ~ 15 °C.
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PRIMARY BLOWING	SECONDARY BLOWING
3 ~ 8 bar	> 14 bar

NOTE: Injection pressures indicated are gauge pressures. Effective cooling at feed throat is recommended to obtain uniform dosing under gravity filling.

DUE CARE FOR USING RELPET – PET RESIN

ANNEXURE VIII

Process Parameters For Injection Moulding Machine

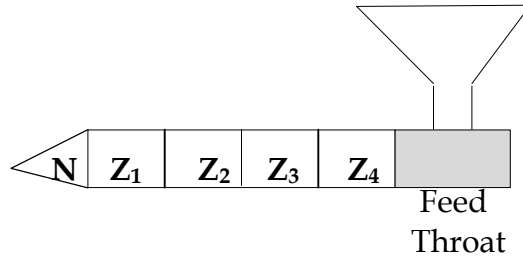
The recommended processing parameters for RELPET G5801 PET resin on fully automatic Injection Moulding Machines are described below.

RECOMMENDED DRYER SETTINGS

Chips Residence Time	Temperature Range
< 4 hr	Not Recommended
≈ 4 hr	175 °C ~ 185 °C
5 ~ 6 hr	165 °C ~ 175 °C
> 6 hr	160 °C ± 5 °C

Note : De-humidifying type of dryers with minimum air circulation of 1.5 m³/min per kg/h of out put is recommended. Dew point of air should be around -40°C.

RECOMMENDED BARREL SETTINGS



BARREL						HOT RUNNER
ZONES	Nozzle	Z1	Z2	Z3	Z4	
SUGGESTED	45%	295	290	285	280	280-300

INJECTION PR.	AV. INJ. SPEED	HOLDING PR.	BACK PR.
80 ~ 100 bar	50 ~ 60 mm/sec	40 ~ 50 bar	5 ~ 10 bar

	1 st.	2 nd.	3 rd	4 th	5 th
Pressure %	40	40	50	40	40
Speed %	40	40	50	40	40

CHILLER WATER	10 ~ 20 °C
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NOTE: Injection pressures indicated are gauge pressures. Effective cooling at feed throat is recommended to obtain uniform dosing under gravity filling.

DUE CARE FOR USING RELPET – PET RESIN

ANNEXURE IX

MOULD SWEAT PROTECTOR

The condensation formed on the mould parts (injection cores & cavities) is called mould sweating. Unlike in human body sweating, where the water comes out from the body, the sweating on the mould happens by condensation of water vapor in the surrounding air on the chilled mould parts.

The condensed water on the mould is a foe to the equipment and to the moulding process. Many times, it disrupts the whole production process making the moulding operation impossible or making whole operation run at lower speeds. Few of the problems faced because of sweating in PET preform making are:

1. Sticking of the preform to injection core
2. Haze in the preforms
3. Groove ring inside the preforms
4. Gate blockage due to water dripping from the injection cores or droplets on the cavity inner surface.

Rusting of mould and surrounding machine parts

How condensation occurs:

Mould sweating occurs due to higher dew point of atmospheric air than the surrounding mould parts, which causes water vapor in the air to condense on the chilled mould and machine parts.

To create a narrow difference in dew points between mould parts and the surrounding atmospheric air, usually the chiller temperature is increased. The increase in chiller temperature causes poor cooling of the parts and due to this, the cooling time is increased. This increases cycle time and also necessitates the reduction in the moulding temperatures, which may again result in other adjustments on the moulding machine, and the cyclic chain of parameter adjustment goes on. Under these circumstances obtaining optimum parameters corresponding to that condition is a difficult process and even after achieving the optimum parameters, there is no guarantee that the moulding parameters would be maintained for a long time, because the ambient conditions may vary.

The important factors, which contribute to condensation, are vapor pressure, % humidity and ambient temperature of the atmosphere. To keep the condensation under control, a dry atmosphere or cooler ambient conditions are required. Other parameter of atmospheric air pressure control is rather difficult if not impossible. Following are the brief description of two commonly used methods in overcoming the condensation.

1. **Air Conditioning:** This cools the mould surrounds. Cooling of air lowers the dew point differential between chilled mould parts and surrounding thus lowers the chances of condensation. If the ambient temperature, vapor pressure and % humidity is higher than the controllable limits of an air conditioner, then this method of control may not work.

This method may be tried in non-coastal regions where the moulding machine is already installed and a decision to purchase a unit is to be taken; because the Air conditioner has diverse applications if it doesn't give a satisfactory performance.

2. **De-humidifying:** This is a more scientific and foolproof way of controlling condensation. The principle of operation is that dry and cool air is pumped / circulated around the moulding area creating a dry weather. Capacity of the equipment should be decided based on the worst ambient conditions in a year.

DUE CARE FOR USING RELPET – PET RESIN

There are many types of de-humidifiers available commercially and they are most commonly known as MSP (mould sweat protectors). Based on the volume of area to be de-humidified and the worst ambient conditions relevant to a location, equipment suppliers can suggest the right capacity of the equipment.

DUE CARE FOR USING RELPET – PET RESIN

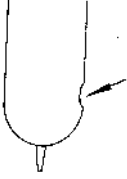
ANNEXURE X

Trouble-Shooting Guide For Single Stage Machines

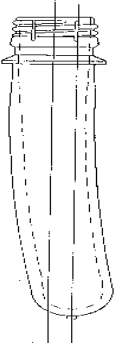
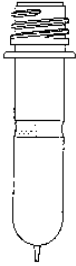
Part A : PRE-FORM MAKING

No	PROBLEM	REASON	SUGGESTION
1	Haze near the gate	1. Inadequate plasticisation of resin	<ul style="list-style-type: none"> * Raise H.R. nozzle temperature * Increase screw RPM or back pressure * check H.R. nozzle for cleanliness
		2. Resin not dry enough	<ul style="list-style-type: none"> * Dry resin adequately * Keep resin for more drying time or increase drying temp. * Check dryer filters and dryer for proper operation
2	Haze here and there	Material crystallised prior to injection.	<ul style="list-style-type: none"> * Prevent cooling in H.R. nozzle / block. Increase temperature * Replace adiabatic paper (Nomex paper in case of adiabatic type mould) * Clean H.R. nozzle tip
3	Poor transparency	1. Insufficient plasticisation	1. Raise resin temperature through one of the following <ul style="list-style-type: none"> * Raise barrel / mould temperature * Raise injection speed * Increase screw RPM
		2. Preform temperature too high	2. Maintain low preform temp. through <ul style="list-style-type: none"> * Lengthen curing time * Decrease injection speed * Lower barrel / mould temperature
		4. Insufficient mould cooling	3. Improve cooling efficiency
		5. Resin not dry enough	* As per # 1.2
4	Uneven wall thickness	1. Improper injection 2. Damaged core pins	1. Injection gate may be having restrictions. Remove by pruning 2. Check core pins for alignment / possible bend.

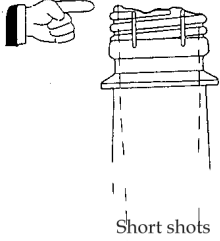
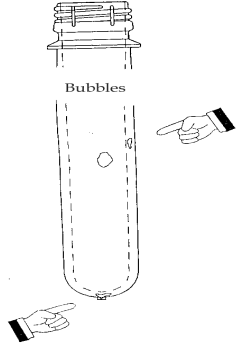
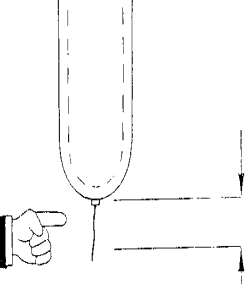
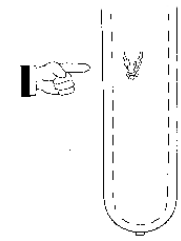
DUE CARE FOR USING RELPET – PET RESIN

No	PROBLEM	REASON	SUGGESTION
5	Sink marks 	1. Pressure inside mould too low. 2. Air / gas trapping	1. Raise injection secondary pressure <ul style="list-style-type: none"> • Increase shot size • Lower resin temperature • Increase holding on time 2. Clean / improve vents

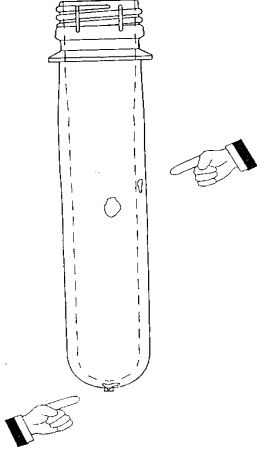
❖ Before starting to attempt filter-cleaning make sure to switch off the drying operation other wise the system would suck dust.

No	PROBLEM	REASON	SUGGESTION
6	Distortion of preform after heating. 	1. Preform temp. not uniform. 2. Preform wall thickness not uniform. 3. Mould cooling not uniform (uneven). 4. Over packing (Residual stress due to the particular moulding conditions).	1. See, “troubleshooting procedures of preform moulding”. 2. See, “troubleshooting procedures of preform moulding”. 3. Make mould cooling uniform (even). 4. Reduce holding pressure and holding time. * Check Air vents in injection moulding.
7	Groove ring 	Water condensation on the injection core/cavity	1. Wipe off water 2. Try increasing chiller water temperature 3. Install an air-conditioner / mould sweat protector over moulding area.

DUE CARE FOR USING RELPET – PET RESIN

No	PROBLEM	REASON	SUGGESTION
8	Short shot 	A. Incorrect shot capacity B. Injection speed/pressure too low C. Hold pressure/time too low D. Manifold temperature too low	A. Increase shot capacity B. Increase injection speed/pressure C. Increase hold pressure/time D. Increase manifold temperature
9	Bubbles 	A. Material contains moisture B. Decompression time too high (hot material being pulled from the gate area) C. Tip/manifold temperature too high D. Poor mould venting	A Check drier operation B Decrease decompression time C Decrease temperature D Clean mould venting
10	Strings 	A. Tip/Manifold temperature too high B. Poor valve gate operation if applicable C. Decompression time less. D. Holding pressure too high E. Mould cooling time too low	A. Decrease temperatures B. Check valve operation/timing C. Increase decompression time D. Decrease holding pressure E. Increase mould cooling time
11	Silver streaks (or) Splay Marks 	A. Manifold tip temperature too high B. Hold pressure/time too high C. Improper decompression time D. Injection speed too high	A. Decrease manifold tip temp. B. Decrease hold pressure/time C. Vary decompression time D. Decrease injection speed (Minimise residence time of resin)

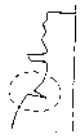
DUE CARE FOR USING RELPET – PET RESIN

No	PROBLEM	REASON	SUGGESTION
12	Bubbles 	Air or gas entrapping in the mould	A. Dry resin properly (Inspect and ensure dryer is operating properly by measuring dew point of dry air) B. Decrease back pressure C. Decrease screw RPM

Part B: STRETCH BLOW MOULDING

No	PROBLEM	REASON	SUGGESTION
1	Fails to blow up.	1. Preform temp. too low. (Preform curing time or injection time too long). 2. Blow air pressure too low. Note: Some times first blow fails. Hence, wait for few shots before taking any action.	1. Shorten curing time. 2. Check blow air pressure (min. 25 kgf/cm ²) 3. Check moulding conditions. 4. Check all temperatures for correctness 5. Check cooling water for temp. and pressure. 6. Check dryer for drying time and drying temp. 7. Check dryer is operating correctly.
2	Bottom comes away on blowing (Stretch rod goes through preform upon blowing).	1. Temperature of preform body is lower than bottom. Note: First blow fails sometimes, wait for few shots before taking action.	1. Decrease overall temperature 2. Shorten curing time. 3. Improve cooling of bottom. 4. Check dryer for drying temp. and drying time. 5. Check dryer is working correctly. 6. Try with material from other bag.

DUE CARE FOR USING RELPET – PET RESIN

No	PROBLEM	REASON	SUGGESTION
3	Whitening of parts spread across the container “Pearl-essence”	1. Preform temperature too low. 2. Material temperature low. Note: Occasionally this kind of trouble will arise when there is thermal imbalance in the injection core pins and injection cavities when starting.	1. Shorten curing time. 2. Change cushion. 3. Lengthen heating time. 4. Increase heating temperature. 5. Restrict water to individual cavity. 6. Check residence time of material in the dryer. 7. Check dryer is working correctly.
4	Whitening of part of the product (no gloss and transparency)	Preform temp. too high. Note: Crystallisation occurs if stretch temp. is not between 85 ~ 100°C (185-212°F)	1. Lengthen preform-cooling time. 2. Decrease barrel temperature. 3. Decrease screw RPM. 4. Decrease injection speed. 5. Lower cooling water temp. 6. Check cooling water temp. and pressure. 7. Check dryer for drying time and drying temperature. 8. Check dryer is working correctly.
5	Gate not forming in the center	1. Secondary blowing taking place too early. 2. Primary blow air pressure too high. 3. Temperature of lower part of preform too high. Longitudinal stretch speed too low.	1. Delay secondary blowing. 2. Reduce primary air pressure to 3 ~ 6 kgf/cm ² . 3. Lower temp. of this part. 4. Increase speed.
6	Depression below the neck area 	Collapsing due to vacuum creation	Introduce primary pressure early i.e. reduce delay or increase primary pressure till gate is not disturbed

DUE CARE FOR USING RELPET – PET RESIN

No	PROBLEM	REASON	SUGGESTION
7	Excess material at the base “Crater”	<ol style="list-style-type: none"> 1. Preform temperature too high. 2. Uneven preform wall thickness. 	<ol style="list-style-type: none"> 1. Keep preform temp. as low as possible through increasing curing time or by decreasing inj. Speed 2. Check core pins for straightness or clean / replace lip cavities.
8	Unsatisfactory contours. (Longitudinal direction)	<ol style="list-style-type: none"> 1. Preform temperature low. 2. Blow air pressure too low. 3. Insufficient air flow 	<ol style="list-style-type: none"> 1. Raise preform temperature. 2. Increase air pressure. 3. * Increase air flow volume. <p>* Provide adequate air vents / clean air vents.</p>
9	Unsatisfactory contours (Circumferentially)	<ol style="list-style-type: none"> 1. Uneven preform temperature & wall thickness. 2. Preform sticking to core pins due to condensation 	<ol style="list-style-type: none"> 1. Refer to “troubleshooting procedures for preform moulding. 2. Refer note on mould sweating
10	Streaks.	<ol style="list-style-type: none"> 1. Due to stretching of milky (hazy) portion. 2. Uneven preform temperature. 3. Stretch rod tip may be damaged 4. Due to stretching of milky (hazy) portion. 5. Uneven preform temperature. 6. Stretch rod tip may be damaged 	<ol style="list-style-type: none"> 1. See “troubleshooting procedures for preform moulding”. 2. See “troubleshooting procedures for preform moulding”. 3. Check for possible damage / loose pieces 4. See “troubleshooting procedures for preform moulding”. 5. See “troubleshooting procedures for preform moulding”. 6. Check for possible damage / loose pieces
11	Low impact strength.	<ol style="list-style-type: none"> 1. Material has deteriorated. 2. Not oriented or insufficiently oriented. 	<ol style="list-style-type: none"> 1. Moisture level in the material should not be more than 0.004% <ul style="list-style-type: none"> * Lower resin temperature. * Decrease drying time and drying temperature of material 2. Orient adequately.

DUE CARE FOR USING RELPET – PET RESIN

No	PROBLEM	REASON	SUGGESTION
12	Small lumps present.	<ol style="list-style-type: none"> 1. Water in the blow air. 2. Dust or dirt in the blow air. 3. Dirt in blow cavities. 	<ol style="list-style-type: none"> 1. Check air system dryer 2. Check air filters. 3. Clean blow cavities.
13	AA Content	<ol style="list-style-type: none"> 1. Dry resin adequately. 	<ol style="list-style-type: none"> 1. Check drying time and drying temperature. Moisture content in material should be < 0.004% 2. Process the material in lowest possible process window. 3. Minimum Back Pressure, screw rpm, barrel temperature etc.
14	Low side walk stiffness	Preform temperature too high.	Keep preform temperature as low as possible.
15	Top load of empty bottle too low (Look at sample bottle after top load test).	<ol style="list-style-type: none"> 1. Preform temperature too high. 2. Distribution of wall thickness was changed. 3. Material deteriorated 4. Wrong primary blow time 5. Unstable cooling water temp. and pressure 	<ol style="list-style-type: none"> 1. Keep preform temperature as low as possible. 2. Adjust moulding conditions. 3. Check dryer for drying time / temp. * Check dryer is working correctly. 4. Correct primary blow timer. 5. Check cooling water for temperature and pressure. <p>Note: Blowing at lower temperature gives better rigidity, but gives less thermal stability.</p>

