K-RESIN®

Styrene-Butadiene Copolymers

THE CLEAR CHOICE™

TIB 204

Blown and Cast Film

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THE CLEAR CHOICE ™

Introduction

K-Resin® is the trademark for the Chevron Phillips Chemical Company LP family of clear styrene-butadiene copolymers (SBC). K-Resin SBC were brought to the marketplace in the early 1970s. Since that time K-Resin SBC have grown steadily in the marketplace as more and more applications have been developed utilizing their unique blend of sparkling clarity and toughness.

K-Resin SBC applications range across the spectra of conventional processing techniques. K-Resin SBC alone or in blends with general purpose crystal polystyrene (GPPS) can be extruded into sheet and thermoformed on conventional equipment at high output rates. The favorable economics of K-Resin SBC, along with their high productivity, have made possible *tough* clear drinking cups, lids, and other packaging solutions. K-Resin SBC process equally well in injection molding, providing good cycle times and design flexibility. In blow molding, K-Resin SBC will process on most conventional equipment, yielding a crystal clear bottle without expensive machine modifications, special molds, different screws or material drying. K-Resin SBC are blow molded in a broad range of sizes and shapes from small pill bottles and medical drainage units to very tall display bottles. K-Resin SBC can also be injection blow molded, with modest machine modification, into bottles with extremely high impact resistance which exhibit glass-like clarity.

Produced as a film, K-Resin SBC make a clear, stiff, high gloss film suitable for applications such as over/wrap, decorative films, labeling films, and flexible medical packaging. The high permeability of K-Resin film makes it an excellent candidate for produce packaging and K-Resin film's crease retention characteristics make it ideal for candy twist films. K-Resin film is readily heat sealed to a variety of sheeting materials, making it useful as a sealant layer in lid stock films. If extreme processing and regrinding conditions are avoided, K-Resin SBC can be reprocessed in multiple passes with minimal change in properties and processing. K-Resin SBC are also suitable for coextrusion with a variety of other packaging materials allowing K-Resin film to be used for a wide variety of applications.

A feature that makes K-Resin SBC more economically attractive when compared to other clear plastics is their low density. K-Resin SBC have a 20 to 30 percent yield advantage over most non-styrenic, clear resins. K-Resin SBC meet the requirements of FDA regulation

21 CFR 177.1640 and EEC Directive 90/128/EEC and all its amendments for food packaging. Limitations on these polymers for the storage are addressed in Technical Service Memorandum 288 (Food Packageability of K-Resin SBC). K-Resin SBC participate heavily in medical markets, qualify as USP Class VI-50 materials and can be sterilized by ethylene oxide gas, gamma irradiation or electron beam. More detailed information on the bio-compatibility of K-Resin SBC can also be obtained in Technical Service Memorandum 292 (Medical Applications of K-Resin SBC).

K-Resin SBC Grades

K-Resin SBC are available in several grades for film extrusion, KR10, DK11 and DK13. DK11 and DK13 have higher thermal stability than KR10. Physical properties for DK11 are equivalent to KR10 with high stiffness, excellent clarity, and good permeability. DK13 is not as stiff, has greater elongation, and improved tear resistance. They are all used in blown and cast film applications.

K-Resin SBC Film

K-Resin SBC film offers exceptional clarity combined with stiffness and excellent gloss. As a *blown film*, K-Resin SBC can be processed with biaxial orientation which makes it an excellent candidate for shrink films and labeling films. Its low shrink force reduces the likelihood of package deformation and its orientation produces labels that shrink uniformly to finished products. K-Resin film has 100 percent crease retention, making it ideal for candy twist wrap because the twist seal remains in place, keeping the package tightly sealed. K-Resin film can be easily pigmented to make tinted, high gloss transparent or opaque film for decorative films, which may be used as floral wrap or gift wrapping. K-Resin films offer good oxygen, carbon dioxide and water vapor permeability for produce packaging, which allows fresh cut fruits and vegetables to retain their freshness over longer time periods. K-Resin SBC may be coextruded with barrier or sealant layers for use in many food packaging applications. As a *cast film*, K-Resin SBC are suitable for lidstock applications which demand heat sealability to many different materials, heat resistance, and styrenic classification. In addition, K-Resin SBC may be processed on extrusion lamination and coating equipment to produce multilayered structures for the replacement of paper and foils.

Blown and Cast Film

K-Resin SBC can be manufactured into both *blown and cast films*. These two dissimilar processes each offer unique processing merits for K-Resin film production which are worth noting.

In *blown film* extrusion, molecular orientation of the polymer is achieved in both machine and transverse directions, yielding a film with biaxial properties. Cast film extrusion orients molecules in the machine direction only, producing a large difference in machine and transverse directional properties. The *blown film* process is capable of producing either tubes or flat films, depending on the operation of the take off equipment. This makes *blown film* equipment more versatile in today's market driven economy.

Cast film extrusion has advantages as well. The techniques used in the production of wide width films are more easily controlled than in the blown film process. Higher take off speeds are possible, which translates into lower cost per unit weight of film. *Cast film* extrusion offers better gauge control and gauge consistency, which are critical for thin films below 1 mil (25 microns). Lastly, optical properties such as gloss and haze percentage are typically better for any given material when produced on *cast film* equipment.

General Extrusion Equipment

With a few considerations, K-Resin film can be processed on many types of conventional extrusion equipment. Equipment manufacturers offer screw designs specifically for K-Resin SBC, although high density polyethylene (HDPE) and linear low density polyethylene (LLDPE) screw designs are also suitable for K-Resin SBC processing. Extruders may be either air or water cooled, providing they are capable of controlling all barrel zones within 5°F (3°C) of target. Screw cooling is typically not required and in some cases may be detrimental. Extruder feed sections should be equipped with adequate water cooling to prevent polymer bridging at the feed throat. Temperature controllers should indicate setpoint and actual temperatures, as well as percentage of heating/cooling. Extruders should be between 20:1 and 24:1 L/D ratios in length. To minimize the residence time of K-Resin SBC in the extruder, extruders having L/D ratios higher than 30:1 should be avoided for *blown film* extrusion. For *cast film*, extruders with up to 32:1 L/D ratios may be used due to the higher output rates, lower back pressures and shorter residence times associated with the process.

Screw Design

The design or selection of the extrusion screw is a major consideration in balancing output rate with melt quality. K-Resin SBC are shear sensitive and may be degraded by high shear screws. A compression ratio of 3.25:1 is recommended for both barrier and single stage screw designs. High shear mixing sections and mixing pins should be avoided for all screw designs. Screw designs which have high compression ratios (above 3.5:1) or special mixing sections should be avoided, but may be used at lower output rates. Gel counts are generally higher when high compression screw designs or special mixing sections are used.

In some cases, screws may be modified to reduce shear and improve melt quality. Enlarging the clearances in Maddock mixing sections or barrier screws is often a successful alternative to purchasing a new screw, particularly if K-Resin SBC is not the only material to be processed with the screw. However, some screw designs are not suitable for modification. Working with a reputable screw manufacturer to address the specific screw design requirements is strongly recommended.

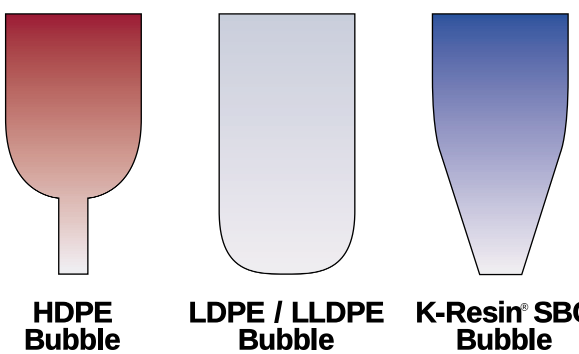
Blown Film Equipment

Film Die

A conventional bottom fed HDPE or LDPE spiral die may be used to produce K-Resin blown film with optimum clarity and toughness. Oscillating or stationary dies may be used; although stationary dies are preferred due to their simplicity. In each case, the die should have no stagnant flow areas and material residence time within the die should be minimized when processing K-Resin SBC. Modular and stacked dies should not be used if the polymer is used to form seals in the die, or polymer flow rates are expected to be very low. A die opening of 35 – 40 mils (0.9 – 1.0 mm) will yield a good balance between drawdown ratio and properties for monolayer K-Resin film. An opening of 40 – 60 mils (1.0 – 1.5 mm) is recommended for coextrusion of K-Resin SBC with olefins. Depending on the die design, larger die openings may result in port lines in the finished film, or limit drawdown capability.

Air Ring

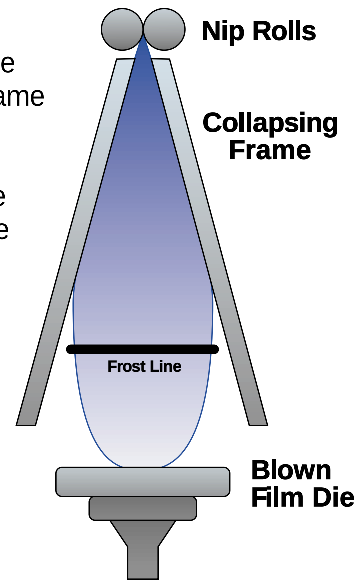
K-Resin SBC are amorphous materials, therefore they do not undergo a crystalline freezing transition. K-Resin SBC have relatively high densities, which translates into very efficient heat transfer rates for finished films. These two properties are the reason K-Resin film production requires no special cooling techniques such as internal bubble cooling (IBC) or chilled air at normal processing speeds. The air ring may be a single lip or dual lip design, with certain considerations. *Single lip* air rings should have short and upright cones and be equipped with a blower capable of controlling the air velocity at very low rates. Air velocity control is critical, and consistency of the air temperature and flow rate around the circumference of the air ring is necessary for maintaining a stable K-Resin film bubble.



Dual lip air rings should have upright cones and be designed such that low air velocity produces a sufficient venturi effect to lock the bubble in the pocket. If the lower air velocity required for K-Resin film processing does not produce a sufficient pressure differential in the air ring, the bubble will not remain stable in the pocket. Dual lip air rings with shallow and open cones are not recommended for K-Resin blown film production due to the shape of the K-Resin film bubble. However, when coextruding K-Resin SBC with other polymers, bubble shapes will tend to follow the other material's processing characteristics.

Special cooling techniques such as IBC or chilled air are recommended for coextrusion or very high production rates. Auxiliary bubble stabilization techniques such as bubble baskets or an iris can enhance bubble stability for both monolayer and coextruded film production.

Tower and Collapsing Frame



The tower includes the nip rolls, collapsing frame and any connected bubble stabilizers. Its purpose is to collapse the tubular film bubble into a flattened tube which is free of wrinkles and has the same dimensions as the original bubble. Having the die, air ring, collapsing frame and nip rolls perfectly aligned is critical for producing wrinkle free K-Resin film. The collapsing frame should be designed to contact the bubble a few inches above the frost line. Having the collapsing frame in this position will help keep the bubble stable, which will minimize film wrinkles. The tower should be relatively short, or adjustable, to bring the nip rolls fairly close to the die, 12 – 15 feet (3.6 – 4.6 m). However, taller towers maybe used, provided that all equipment is well alligned. In this case, a bubble cage is recommended to insure good stability. Film temperature should be maintained as warm as possible to minimize wrinkles, preferably 110 – 130°F (43 – 54°C). K-Resin SBC are fairly stiff materials with excellent crease retention, thus if wrinkles are allowed to form, they will be permanently set into the finished film.

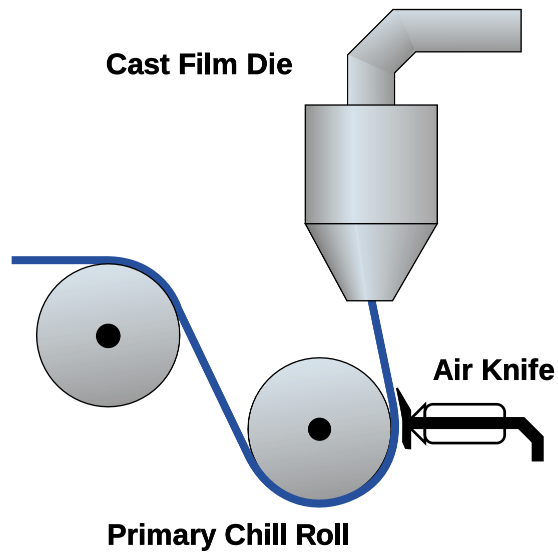
The collapsing frame controls the bubble between the top of the die and the nip rolls by using wooden slats, aluminum rollers or an air frame. Hardwood slats are preferred for monolayer K-Resin film because they impart enough drag to maintain bubble stability, but do not scratch the surface of the film if properly maintained. Aluminum rollers are inexpensive and may be used with many types of materials which offers the processors more flexibility. Air frames improve film cooling and in some cases film surface finish due to the absence of film contact with the collapsing frame. However, for this reason, air frames may cool monolayer K-Resin film too quickly, resulting in wrinkles. EVAs or LLDPEs may stick to wooden slats unless high levels of slip additives are used. In some cases, employing chilled air will reduce drag on the collapsing frame, but may also cool the bubble too quickly, sacrificing bubble stability control or producing wrinkles. Working with a reputable equipment manufacturer to address the specific requirements for the collapsing frame is strongly recommended.

Nip Rolls

Perfect symmetry of the nip rolls with the die, collapsing frame and winder is necessary for wrinkle free K-Resin film production. Nip rolls typically consist of one chrome plated and one rubber roll. Temperature control of the rolls is optional. However, heated rolls may significantly reduce line out time and wrinkles when extruding K-Resin film, while chilled rolls provide improved cooling for polyolefin or coextruded films, which results in increased output rates. The nip rolls must be free of imperfections, including dirt, when processing K-Resin film, as K-Resin SBC will reproduce any scratches, rough patches, or dents in the roll surfaces.

Film Die

Cast film dies should employ coat-hanger designs and be equipped with a restrictor bar and adjustable flex-lip die opening. Older cast film dies such as T-dies offer many stagnant areas where polymers can hang-up and degrade, significantly decreasing the quality of the film. A die opening of 35 – 40 mils (0.9 – 1.0 mm) is recommended for cast film extrusion with K-Resin SBC. However, draw resonance may be encountered if the drawdown ratio is too large. If draw resonance is encountered, decreasing the die opening or line speed may improve processing stability. Draw resonance is discussed further in a later section.



Air Knife, Edge Pins & Vacuum Box

To pin the molten web to the chill roll and stabilize the film edges, an air knife may be used to blow a gentle stream of air on the film at the point where it contacts the chill roll. In addition, edge pins may be used to reduce the amount of neck in and also help stabilize the film edges. These techniques are especially useful when producing thin films with large drawdown ratios. A vacuum box may also be used to stabilize the web during extrusion.

Air Gap

The air gap is the distance from the die exit to the point where the film contacts the chill roll. This distance can control drawdown ratio and cooling and shrinkage differences in multilayer films. The air gap is typically minimized for K-Resin cast film production. Cast film properties can be altered by adjusting the air gap, however optimization trials are required.

Chill Rolls

The chill rolls may be chrome plated and highly polished, matte finished, or embossed rolls. All rolls should be individually temperature controlled by a separate heat exchanger capable of maintaining roll temperatures of 40 – 200°F (4 – 93°C). It is advantageous to use a system which will control the temperature gradient across the entire roll as closely as possible, preferably within 5°F (3°C) maximum variation. The optimum chill roll temperature for K-Resin cast film production will vary with film structure, output rate and equipment. However, 120 – 180°F (49 – 82°C) is typically used for monolayer K-Resin cast film production.

General Post Extrusion Equipment

Corona Treater

Conventional treating equipment may be used to increase the wettability of K-Resin films. Corona treatment should produce a minimum of 44 – 48 dynes per centimeter surface energy. For best results, treat and print or laminate the film in line. If it is not possible to convert the film in line, the film should be processed as soon as possible after treating.

K-Resin SBC films, like most films, will lose their surface energy over time. The dissipation rate of the surface energy is dependent on initial treatment levels and storage conditions. If the surface energy of K-Resin film is lower than the level required for printing, the film may be retreated. However, power requirements are generally higher during a second treatment. Therefore, for the same power level of treatment, the surface energy will not be returned to the original level. Higher than normal storage temperatures will accelerate the loss of surface energy.

Slitter

Standard razor blade knives may be used to slit K-Resin films to a desired width. Knives should be kept sharp, and slitting should occur as close to the secondary nip rolls and winder as possible. Care should be taken to protect operators from injuries caused by improper slitter design or operation.

Winder

With good tension control, K-Resin film can be wound successfully on either center or surface winders. Center winders consistently produce higher quality rolls. Regardless of the winder used, it is critical that the winder be properly aligned with the upstream equipment and the film dimensions be maintained without added stress from the primary nip to the slitter. Baggy film or stretched film will hinder wrinkle free roll production.

Extruder Startup

It is very important to start the extrusion of K-Resin SBC with clean equipment. This can be accomplished by using polyethylene or commercial purging compounds to purge the system. Introducing K-Resin SBC to the system at operational rates is recommended, provided the K-Resin SBC will follow a polymer with at least a 1.0 melt index or higher flow rate, and the operating temperature is 350 – 400°F (177 – 204°C). If a higher viscosity material is present in the system or operational temperatures are above 400°F (204°C), the material should be purged from the system prior to introducing K-Resin SBC. An operating temperature of 350°F (177°C) will minimize K-Resin SBC degradation when it is introduced to the system after purging. Elimination of all contamination using the purge material can take several hours. Fractional melt index purges are recommended for removing K-Resin SBC from the system. Using operational rates will minimize purging time and offer improved cleaning. When using commercial purging compounds, follow the manufacturer's recommended processing information. The perceived waste of valuable machine time and material during this step is often a motivation for processors to ignore it. More often than not, more material is wasted running scrap film than would have been produced during purging.

Once the system has been purged, temperatures should be set to 350°F (177°C) prior to extrusion of K-Resin SBC. Residence time of K-Resin SBC at temperatures above 350°F (177°C) should be minimized at all times, particularly during startup and shutdown. Gels, or crosslinked butadiene, will readily form in K-Resin SBC if the material is idle in the extruder, adaptors or die for extended periods of time. Caution should be exercised during startup, as cold spots in the system can produce severe equipment damage if not detected. Always allow the system to soak for at least 30 minutes once the temperature set points are reached. It is not recommended to shutdown the system with K-Resin SBC in the die or extruder.

Purging

Purging is an integral part of any extrusion operation. Purging should be used to remove polymers from the system before and after material changes to remove degraded or colored polymers and to prepare a system for cleaning and shutdown. Fractional melt index LDPE or

HDPE resins will readily purge K-Resin SBC from most conventional blown and cast film equipment. Commercial purging compounds will also work well with K-Resin SBC. If an unexpected shutdown or system failure produces degraded K-Resin SBC, the system should be purged to remove all of the degraded material. Any carbonized material will be very difficult to remove through purging, regardless of its origin, and will ultimately require disassembly of the equipment for complete removal.

K-Resin SBC will not purge fractional melt polyethylenes in a reasonable amount of time under most circumstances. To return to K-Resin SBC production, a higher melt index LDPE should be used to remove the purge, followed by K-Resin SBC, preferably at operational rates. Minimizing residence time and operating temperature is recommended when processing K-Resin SBC. Therefore, using K-Resin SBC as a purging material can lead to degradation if output rates are low and temperatures are above 350°F (177°C).

Drying

K-Resin SBC are non-hygroscopic and require no drying under normal storage and processing conditions. However, should K-Resin SBC require drying due to surface moisture caused by high humidity, the material should be dried for one hour at 140 °F (60°C) or 110°F (43°C) for no more than 4 hours. Excessive drying at temperatures above 140°F (60°C) may cause pellet blocking or degradation of K-Resin SBC.

Antiblock & Slip

An antiblock must be used with K-Resin film to prevent film blocking. An excellent antiblock is a High Gloss-High Impact Polystyrene (HIPS), and should be added at approximately 2 – 3%. Lower levels may not prevent blocking and higher levels will increase the haze level of the finished film. Antiblock is needed when two K-Resin film layers come into contact during film production, either on a finished roll, or on the inside of the bubble. If K-Resin SBC are blended with more than 20% GPPS, no antiblock is typically required.

A slip additive may be used to reduce the coefficient of friction (COF) of K-Resin films. Kemamide E, an erucamide wax, is the preferred slip additive, and should be used at a level of 0.15%. In general, 0.15% Kemamide E in 1.0 mil (25 micron) thick film will lower the COF to 0.2. When using Kemamide E, antiblock *should be used at a reduced level of 1.5%*. This will maintain both clarity and antiblock characteristics.

Chevron Phillips Chemical Company LP makes a slip/antiblock concentrate, SKR17, which can be added at 1-3%. This is specially formulated for K-Resin SBC and maintains excellent clarity.

Extruder Shut Down

To prevent resin degradation, K-Resin SBC should not be allowed to heat soak at even moderate temperatures for extended periods of time.

Purging K-Resin SBC from the system at operational rates using a fractional melt index LDPE is recommended. This procedure saves time and material, while ensuring that residence time of K-Resin SBC is minimized. When a shutdown using K-Resin SBC is necessary, reduce operating temperatures to approximately 330°F (166°C) and idle the extruder at a few rpm to allow some movement of material through the extruder and die. This practice will result in less degradation of the K-Resin SBC, while minimizing material usage during the temperature change. Should an unexpected shutdown occur, (i.e., system or power failure, emergency, etc.), the system should be purged following the previous mentioned purging procedures.

Regrind

When reprocessing K-Resin SBC, use a chopper with sharp blades, narrow clearances and adequate ventilation to avoid heat buildup. Chopped K-Resin film may be blended back with virgin resin to reduce material cost. As shown in Table 1, multiple passes of K-Resin SBC through the extrusion process have minimal effect on the film's properties, providing the regrind is not degraded or contaminated.

Table 1

Effect of Reprocessing on K-Resin Film Properties (KR10)

100% Regrind, Extruder Pass			**1**	**3**	**6**
26" Dart Drop	gram		362	322	320
Spencer Impact	psi/mil (MPa/mm)		3290 (23)	2770 (19)	3570 (25)
Elmendorf Tear	gram	MD	8.2	7.5	9.5
		TD	18	24	19
Tensile Yield	psi (MPa)	MD	4450 (31)	4550 (31)	4450 (31)
		TD	2875 (20)	2750 (19)	2700 (19)
Tensile Break	psi (MPa)	MD	4700 (32)	4800 (33)	4750 (33)
		TD	3550 (24)	3200 (22)	2975 (21)
Elongation	%	MD	130	126	133
		TD	225	195	182

Other packaging films such as EVA, LDPE, LLDPE and HDPE may be blended with K-Resin SBC in the film reclaim stream. The effect on film properties depends on the blend composition and levels, as well as the processing conditions of the finished film. More information is available concerning the blendability of other polymers with K-Resin SBC from Technical Service Memorandum 316 (K-Resin SBC Blends).

Blown Film Processing Conditions

Melt Temperature

The recommended melt temperature range for K-Resin blown film production is between 360 – 400°F (182 – 204°C). To maintain this temperature range, set the extruder, transition and die temperatures at 350°F (177°C). During startup, record each extruder barrel zone's temperature and heating/cooling percentage for several hours. If any zone begins to override in temperature, or calls for 75% cooling or more continuously, then the K-Resin SBC may be subjected to excessive shear in that zone. In some cases, this may be corrected by increasing the temperature setting of the zone. However, the K-Resin SBC melt temperature should be maintained below 425°F (218°C), regardless of individual zone modifications.

Frost Line

In the extrusion of K-Resin SBC blown film, the point where the bubble reaches its final diameter marks the frost line position. This is the point where the film temperature falls below the softening temperature of K-Resin SBC. The frost line is not typically visible when processing K-Resin film due to the exceptional clarity of K-Resin film. The frost line should be adjusted to stay between two and four die diameters above the die. For the best bubble stability, the collapsing frame should contact the bubble four to six inches above the frost line. If the frame is not low enough, then a bubble basket, iris or other bubble stabilizer should be used just above the frost line.

Controlling the frost line height is critical to bubble stability and film properties. If the frost line is forced too low, bubble dancing will occur. This will cause wrinkles and gauge inconsistencies. To correct bubble dancing, less air velocity should be used in the air ring. This will reduce cooling, thus allowing the frost line height to move further from the die. Increasing extruder output or decreasing the line speed will have a similar effect.

If the frost line height is too high, bubble bouncing, which is a rapid change in frost line position and bubble diameter will occur. This will cause wrinkles and inconsistencies in the film. To correct bubble bouncing, more cooling of the bubble is required. Note the bubble shape diagram, which shows the correct K-Resin film bubble configuration, along with bubble dancing and bubble bouncing.

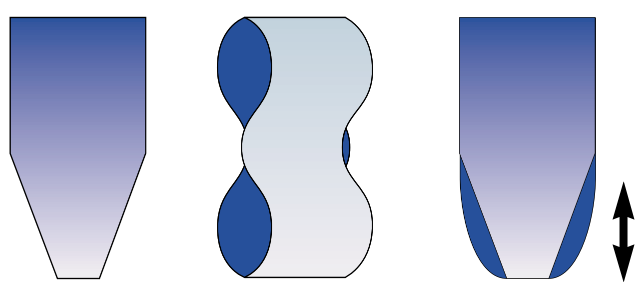


Table 2

Blown Film Temperature Settings

Extruder Barrel Temperatures, °F (°C)							
Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Adapters	Rotator	Die
340 (171)	350 (177)	350 (177)	350 (177)	350 (177)	380 (193)	380 (193)	380 (193)

Cast Film Processing Conditions

Melt Temperature

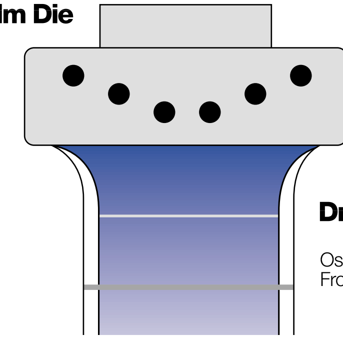
The recommended melt temperature range for K-Resin cast film production is between 380 – 420°F (193 – 216°C). To maintain this temperature, set the extruder, transition, and die temperatures to 400°F (204°C). Slightly higher melt temperatures in cast film promote better clarity and drawdown. Due to the reduced back pressures, residence time is typically shorter in cast film than in blown film, allowing for higher extrusion temperatures.

Frost Line

The frost line marks the position in the web where the polymer temperature has fallen below the softening point of the material. The frost line should be a straight line across the width of the web, either just before or in contact with the chill roll. Variation in frost line location indicates draw resonance. Variation in frost line shape indicates gauge inconsistencies. In both cases, resetting the die opening and confirming die temperatures are the required initial trouble shooting action. Note that frost line location may be difficult to determine when extruding K-Resin SBC due to their clarity.

Draw Resonance

Draw resonance is a drawing instability that occurs in extensional flow that is between the die and frost line. It is affected by four distinct variables: rheological properties of the material, line take off speed, draw distance and drawdown ratio. The two most easily adjusted parameters are draw distance and drawdown ratio. In general, if the die gap opening is decreased, a previously unstable web will move closer to or into a stable operating region.



K-Resin cast film processing is susceptible to draw resonance if the drawdown ratio becomes too large. The drawdown ratio for cast film is defined as the ratio of the initial extrudate cross-sectional area to the final extrudate cross-sectional area. Machine directional gauge inconsistency and edge oscillation are products of this phenomenon. The drawdown ratio should be maintained below 60:1 for K-Resin SBC cast film production.

K-Resin® Film Properties

K-Resin SBC film is known for its excellent impact, tensile and optical properties. Variables such as blowup ratio (BUR), drawdown ratio (DDR), additive level and gauge can have dramatic effects on film properties. More information regarding the effect of BUR, DDR, additive level and gauge on K-Resin film's impact strength, tensile strength, permeability, shrinkage and clarity is available from your regional marketing office.

Table 3

Cast Film Temperature Settings

Extruder Barrel Temperatures, °F (°C)						
Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Adapters	Die
380 (193)	400 (204)	400 (204)	400 (204)	400 (204)	400 (204)	400 (204)

Permeability

K-Resin film has relatively low barrier properties which makes it attractive in several food packaging applications. Packaged fruits and vegetables require a balance of oxygen, carbon dioxide and water vapor to maintain the ripening process and preserve freshness. K-Resin film permeability allows the introduction of oxygen and the release of carbon dioxide and water vapor. While K-Resin film slows the ripening process, once the package is opened, normal ripening resumes. This characteristic significantly increases shelf life of the packaged produce.

The permeability of K-Resin film may be altered by using additives or by coextruding K-Resin SBC with other types of polymers. This is very beneficial for applications which need a specific oxygen or carbon dioxide transmission rate. The addition of slip and antiblock additives do not significantly affect gas or water vapor transmission rates when used at recommended levels.

Blown Film Shrinkage

Shrinkage of K-Resin film is determined by a modified version of ASTM D2732. The percent of shrinkage in both the machine and transverse direction is directly related to the degree to which the film is oriented in processing. An increase in transverse direction shrinkage is correlated with an increased blowup ratio. An increase in machine direction shrinkage is correlated with increased drawdown ratio.

Shrink film made from K-Resin SBC is suitable for packaging goods with a variety of shapes and sizes. The low shrink force property, typical of K-Resin films allows the film to shrink to the package without deformation of the package. For KR10 film, the suggested tunnel temperature range is 325 – 350°F (163 – 177°C). For more information, refer to Technical Service Memorandum 302 (Shrink Wrapping with Film Made from K-Resin SB Copolymers).

Decorating

Corona treatment, at a level of at least 38 – 40 dynes per centimeter, increases the wettability of K-Resin film which helps the adhesion of most ink systems. For best results, treat and print or laminate the film in line. If it is not possible to convert the film in line, the film should be processed as soon as possible after treating. Inks with a nitro-cellulose base, as well as some water base inks, have been used successfully to print K-Resin films. For more information, refer to Technical Service Memorandum 305 (Decorating Methods for K-Resin SB Copolymers).

Heat Sealability

To produce bags or enclose products in a package, K-Resin film may be heat sealed utilizing conventional heat sealing techniques. K-Resin film typically seals under different processing conditions than most other packaging films. Under proper conditions, heat seal strength will approach film strength. Table 4 lists typical sealing temperature, dwell time, pressure and seal strength for two sealing systems: single and double sealing bar. These seals were formed using a Sencorp ASL/1 laboratory impulse sealer with 0.25 in (6.35 mm) temperature controlled sealing bars.

The suggested sealing conditions for K-Resin film are approximately 230 – 350°F (110 – 177°C), 0.3 – 0.5 seconds, and 50 psi (.35 MPa). These conditions will vary with different machines and products. For more information regarding the heat sealing performance of K-Resin films, contact the Chevron Phillips Chemical Company LP Plastics Technical Center.

Table 4

K-Resin SBC Film Heat Sealing Performance

Single Bar Sealing (0.25 in or 6.35 mm)									
Sealing Bar Temperatures, °F (°C)	240 (116)	260 (127)	280 (138)	300 (149)	320 (160)	340 (171)	360 (182)	380 (193)	400 (204)
Seal Strength, lb/in (N/m)	NS	NS	0.9 (.016)	1.3 (.023)	1.5 (.026)	1.9 (.033)	2.2 (.039)	2.7 (.047)	3.1 (.054)
Two Bar Sealing (0.25 in or 6.35 mm)									
Sealing Bar Temperatures, °F (°C)	200 (93)	210 (99)	220 (104)	230 (110)	240 (116)	250 (121)	260 (127)	270 (132)	280 (138)
Seal Strength, lb/in (N/m)	NS	NS	0.7 (.012)	1.1 (.019)	1.5 (.026)	1.9 (.033)	2.3 (.040)	—	—

Sealing Conditions & Nomenclature

Gauge	1 mil (25 microns)	NS	No Seal
Dwell Time	0.5 – 1.0 sec	—	Burn Through
Pressure	30 – 50 psi (.21 – .35 MPa)		

Film Troubleshooting Guide

Even in state-of-the-art operations, occasional processing problems may develop. Some of the most common problems found in K-Resin blown and cast film processing are listed here with their probable causes and solutions.

Blown Film Troubleshooting Guide

Problem	Possible Causes	Suggested Solutions
Wrinkles	1. Non-uniform bubble	1. (a) Adjust die opening to obtain a symmetrical bubble. (b) Verify die temperature is consistent around die. (c) Clean air ring. (d) Adjust cooling air velocity.
	2. Collapsing frame not properly adjusted or not symmetric	2. Adjust collapsing frame.
	3. Die not level	3. Level die.
	4. Nip rolls not level	4. Level nip rolls.
	5. Bubble not stable	5. (a) Adjust air ring to stabilize bubble. (b) Support bubble just above frost line with bubble basket, iris or similar device.
	6. Misalignment between nip rolls and die	6. Nip rolls must be parallel with each other and in the same plane. Nip rolls must be aligned over the center of the die.
	7. Improper or inconsistent winder tension	7. Adjust winder tension.
Lines in Film	1. Dirty die	1. (a) Pull die pin and clean. (b) Purge system. (c) Disassemble and clean die.
	2. Die face buildup	2. Shut down and clean die face.
	3. Rough edges in collapsing frame scratching film	3. Remove all rough edges in film path.
	4. Damaged nip roll surfaces	4. Repair nip rolls.
Excessive Gels or Black Specks in Film	1. Dirty die or extruder	1. Clean die and extruder.
	2. Broken screen pack	2. Change screen pack.
	3. Contaminated resin feed	3. (a) Cover feed hopper. (b) Check resin for contamination.
	4. Burned material sluffing off screw	4. Clean screw.
	5. Overriding temperature in extruder, adaptor, or die	5. Perform maintenance on cooling system or replace thermocouple.
Bubble Instability	1. Running too slow	1. Increase screw rpm and nip roll speed.
	2. Room air currents	2. Enclose tower or close doors and other sources of drafts.
	3. Uneven air flow from air ring	3. (a) Adjust air ring to obtain constant air velocity around ring. (b) Clean air ring.
	4. Improper location of collapsing frame	4. Adjust collapsing frames.
	5. Extruder or tower vibration transmitted	5. Isolate vibrations.

Blown Film Troubleshooting Guide

Problem	Possible Causes	Suggested Solutions
Bubble Bouncing	1. Not enough cooling	1. Increase air velocity to air ring or decrease air temperature.
	2. Line speed too slow	2. Increase line speed.
Bubble Dancing	1. Too much cooling	1. Reduce air velocity or increase air temperature.
	2. Line speed too fast	2. Decrease line speed.
Failures at Fold	1. Nip roll pressure too high	1. Decrease nip roll pressure. This pressure should be just enough to maintain bubble diameter.
Bubble Blow Outs	1. Gels or black specks in film	1. See gels and black specks.
	2. Film thickness to low	2. Increase film thickness.
Poor Tear Strength	1. Low blowup ratio	1. Increase blowup ratio.
	2. Lines in film	2. Clean die lips, extruder and tower.

Cast Film Troubleshooting Guide

Problem	Possible Causes	Suggested Solutions
Excessive Gels or Black Specks in Film	1. Dirty die or extruder	1. Clean die and extruder.
	2. Broken screen pack	2. Change screen pack.
	3. Contaminated resin feed	3. (a) Cover feed hopper. (b) Check resin for contamination.
	4. Burned material sluffing off screw	4. Clean screw.
	5. Overriding temperature	5. Perform maintenance on cooling system or in extruder, adapter or die.
Lines in Film	1. Dirty die lips	1. Clean die lips.
	2. Chill roll surface imperfections	2. Clean or repair chill roll.
	3. Scratches on idler rolls	3. Replace idler rolls.
Draw Resonance	1. Drawdown ratio too large	1. (a) Decrease die opening. (b) Decrease line speed. (c) Increase melt temperature.
	2. Draw distance too large	2. Reduce draw distance.
Puckering	1. Melt temperature too low	1. Increase melt temperature.
	2. Chill roll temperature too low	2. Increase chill roll temperature.
	3. Poor contact between film and chill roll	3. Use air knife to hold film against chill roll.
	4. Air from air knife too high or too low	4. Adjust air knife air velocity.

K·RESIN®
Styrene-Butadiene Copolymers
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