Technical Service Memorandum #329

KR52 K-Resin® SBC for Shrink Film Applications

Introduction: K-Resin® Styrene Butadiene Copolymers (SBC) are the economical choice for shrink sleeve markets requiring transverse direction (TD) shrinkage ranging from 55 percent to 80 percent. K-Resin® SBC sleeves can be used for intricate shapes, and they feature good printability, toughness, excellent clarity, wrinkle resistance and high gloss. K-Resin® SBC grades can be blended with crystal polystyrene and retain toughness. There are multiple grades available, suitable for both steam and hot air ovens. These grades have low natural shrinkage, which is further enhanced by blending with polystyrene (PS).

KR52 was developed to achieve maximum shrinkage below 100°C (212°F) which is possible because of its low Vicat 61°C (142°F). While this grade can be run without adding PS, it was designed to target an addition of 20 percent polystyrene to improve stiffness and minimize natural and machine direction shrinkage. It also has improved printability compared to other commercial grades.

Shrink sleeve films may be clear and used in a diversified range of applications ranging from theft reduction, product identification, light protection, inventory streamlining, tamper evidence, breakage reduction, multiple-unit sales promotion, cross merchandising, upgrading visual appeal and product quality protection.

Processing of KR52 into oriented film:
The first step in making KR52 into a sleeve is the production of sheet that is typically 10 mils thick. Below are the recommended process parameters for extruding and orienting KR52 sheet. Please refer to TIB 201 – *Sheet Extrusion and Thermoforming* which provides more detailed information on extrusion of K-Resin® SBC.

Key points to keep in mind when processing KR52 into sheet to prevent the possibility of creating gels are:

- Minimize process temperatures
- Eliminate dead spots in the extruder and die where material can degrade

- When regrinding edge trim keep blades sharp to eliminate fines

General temperature ranges for producing KR52 sheet are:

- Extruder: 170°C to 200°C (338°F to 392°F)
- Die and adaptors: 180°C to 210°C (356°F to 410°F)
- Chill roll: 25°C to 30°C (77°F to 86°F)

The 10 mil sheet is oriented normally at a 5:1 stretch ratio which is used to make a 2 mil oriented film. This can be done on a tentering frame to make TD oriented film or can also be done in the machine direction (MD). TD oriented films may also have some MD orientation added to better control the MD shrinkage of the sleeve.

Below are the recommended process parameters for tentering of KR52 sheet into film. Since the Tg temperature is 70°C (158°C) and Vicat temperature is 61°C (142°F) orientation must be done above this temperature.

- TDO
  - TD stretch ratio 5:1 to a final film thickness 40 to 50 microns
  - Temperatures
    - Preheat 85°C−90°C (185°F to 194°F)
    - Stretch 80°C−95°C (176°F to 203°F)
    - Anneal 75°C−85°C (167°F to 185°F)

- MDO
  - MD stretch ratio between 1 and 1.2, if some orientation is needed also in the MD direction to control MD shrinkage. This will also bring some additional stiffness to the finished film.

If stretch temperatures are too low, typically below 80°C (176°F), natural shrinkage will increase. The sheet in the line may break more often causing additional down time. If stretch temperatures are too high, typically above 95°C (203°F), the shrink curve will be less steep, and maximum shrinkage will occur at a higher temperature.

While these are suggested processing temperatures, equipment and conditions can vary due to specific machine designs and capabilities.

KR52 was designed to be processed with 20 percent crystal polystyrene. Polystyrene enhances the KR52 by adding increased stiffness, lowering natural shrinkage and improving economics. The processing conditions above can be used irrespective of the amount of polystyrene which is added, up to 20 percent. Selection of a grade of crystal polystyrene can have some effect on film properties and processing. Higher flow, lower molecular weight polystyrene will mix better in the extrusion process and optimize optical properties, whereas higher molecular weight polystyrene will improve film toughness.

Additives:

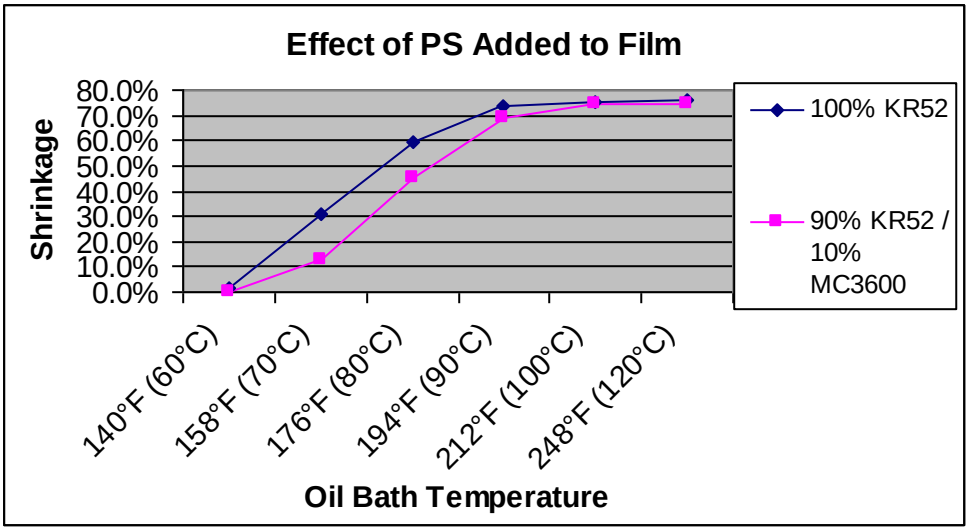
Concentrates are available for improving KR52 processing and performance. SKR17 is a concentrate that provides improved film slip (lower coefficient of friction) and improved

anti block. It is normally added at 1-3 percent loading. The addition of SKR17 will increase haze in the final film product. SKR19 is a concentrate that will improve the thermal stability and minimize gel formation. It is typically added at a 1-3 percent concentration loading.

KR52 Shrink Curve Characteristics.
A styrenic sleeve made using KR52 with an orientation of at least 5:1 can produce a sleeve that can have a maximum shrinkage of almost 80 percent. This high amount of shrinkage is necessary for packaging products that have complicated shapes with diverse circumferences. Oriented film made from KR52 demonstrates full shrinkage below 100°C (212°F), which allows production of high shrinkage sleeves suitable for labeling in steam tunnels. Evaluations of KR52 were made on both lab scale and commercial size lines to tenter the sheet into oriented film samples. These samples were prepared using multiple variables including, processing parameters such as line speed, and stretching rates, as well as orientation temperatures.

KR52 sheet samples (10 mils) were heated and oriented in the transverse direction (TD) at a 5:1 ratio into 2 mil film. Specimens were cut into 2 inch squares and placed into a heated oil bath to measure shrinkage in a temperature range from 60°C to 120°C at 10°C increments. Samples were left in the bath for 30 seconds and removed and measured in both the TD and MD direction to calculate the shrinkage in both directions. (Initial length – final length) / Initial length.

Chart 1.
KR52 shrink curve with and w/o PS.



Process Consideration and Effects:
Tentering temperatures during processing as well as percentage of polystyrene that is added to KR52 will affect the shrink curve as shown in Chart 2. If the film is oriented at too high of temperature the TD shrinkage can drop precipitously at 100°C (212°F)

Chart 2.
Effect of Stretch Temperature on Shrink Curves of KR52 with PS.

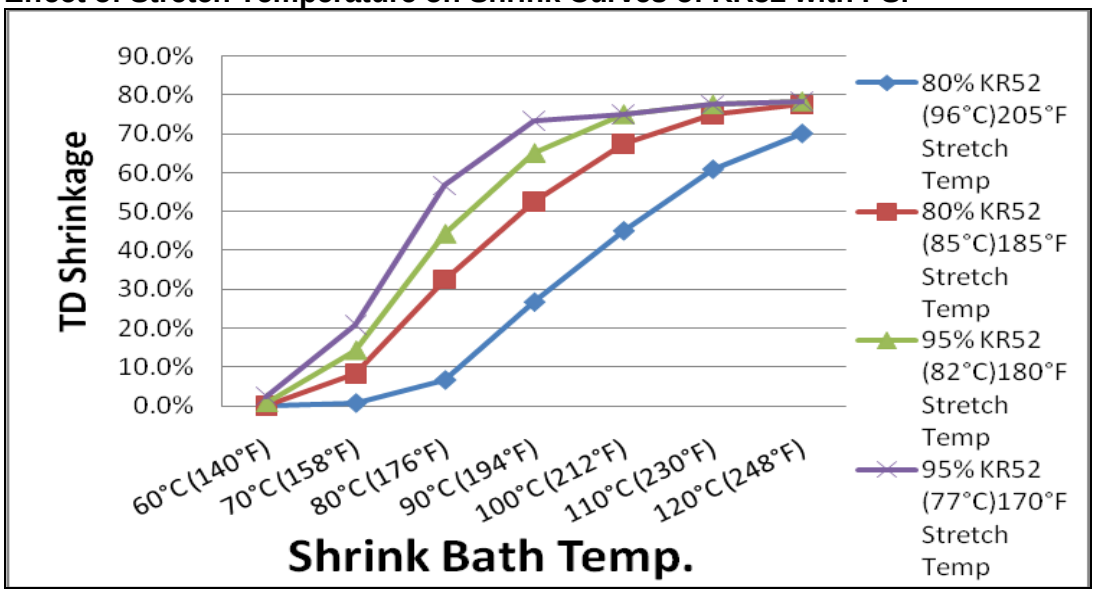
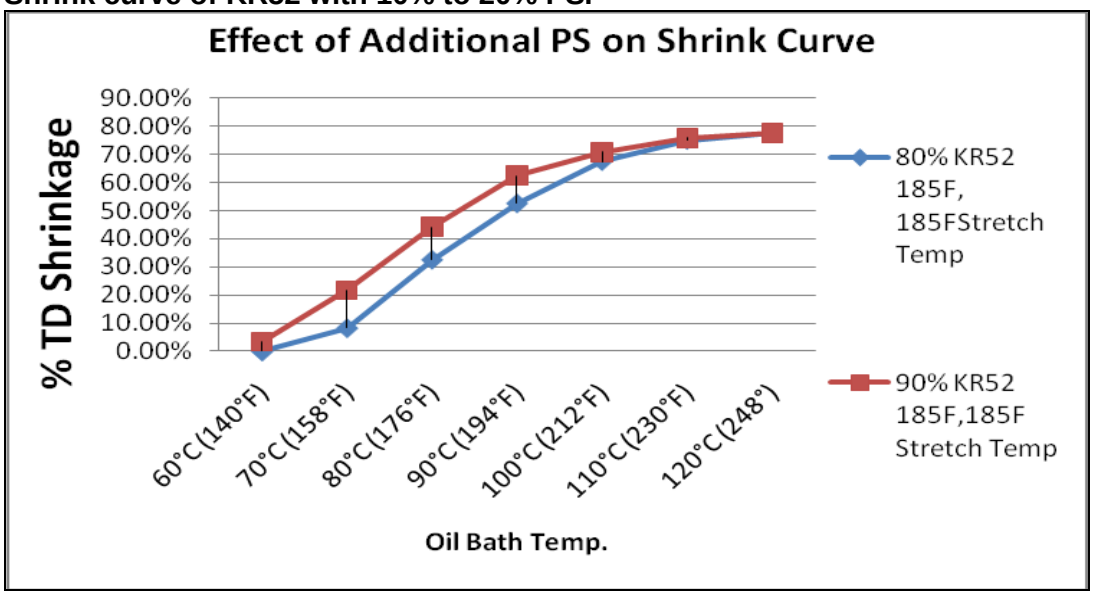


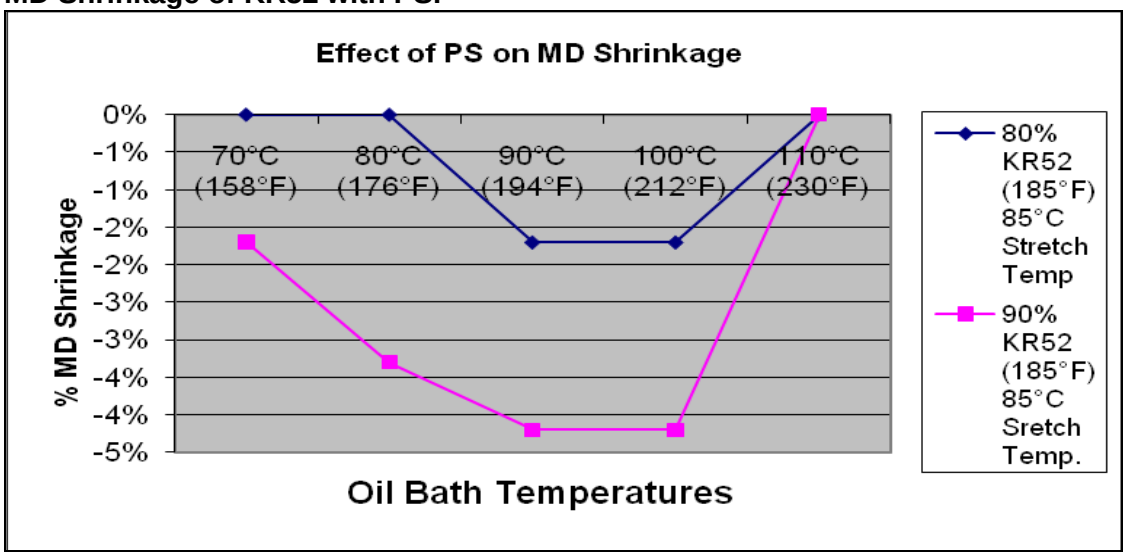
Chart 3.
Shrink curve of KR52 with 10% to 20% PS.



As shown in Chart 3 adding EA3710 (18 mf PS) to KR52 will reduce the steepness of the shrink curve at the lower temperatures, but the shrinkage percentage is approximately the same at 100°C (212°F).

MD shrinkage:
MD shrinkage is also affected by the percentage of polystyrene that is added to the blend. Chart 4 shows the effects of additional polystyrene on MD shrinkage at the same tentering temperature during demonstrating that the addition of polystyrene will reduce MD shrinkage of the oriented film.

Chart 4.
MD Shrinkage of KR52 with PS.



Natural Shrinkage:
Natural shrinkage is undesirable and should be minimized if at all possible.

Considerations to help reduce natural shrinkage include:

- Higher stretch temperature during tentering process
- Addition of more polystyrene
- Annealing of roll film at temperatures of 30°C (86°F) in controlled atmosphere for 3 – 10 days allowing some shrinkage before slitting for sleeves is reported to help reduce natural shrinkage by allowing the film to shrink prior to shipping and converting.

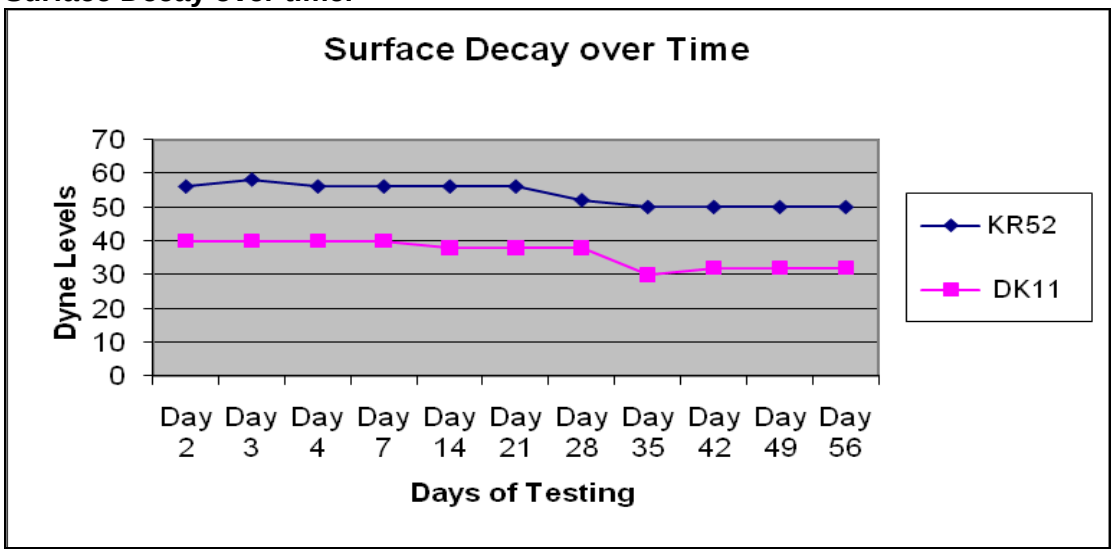
The type of polystyrene used will not have a significant effect on natural shrinkage.

Printing:
Excellent printability is desirable for shrink sleeves. KR52 was formulated with an anti-block that has much better printing characteristics than conventional SBC anti-block. KR52 can be easily corona treated to achieve a surface tension well above 40 dynes.

Chart 5 depicts surface tension decay over a period of 8 weeks on film samples of various polymer compositions. The films were measured at the time intervals noted on

the graph measuring with a dyne pen. KR52 surface tension decreased only 4 dynes in 8 weeks. DK11, a film grade using a more conventional anti-block could not be treated to as high a level and lost its treat faster and in greater magnitude.

Chart 5.
Surface Decay over time.



Summary: K-Resin® styrene butadiene copolymer films offer many of the performance attributes such as high gloss and TD shrinkage ranging from 40 percent to 80 percent which are required to produce a high quality shrink film. Bottles can be sleeved with no wrinkles, due to the low shrink force. They also feature good printability and ease of processing. KR52 and other grades can be made more economical by blending with polystyrene, which gives the film more stiffness and reduces the natural shrinkage.

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