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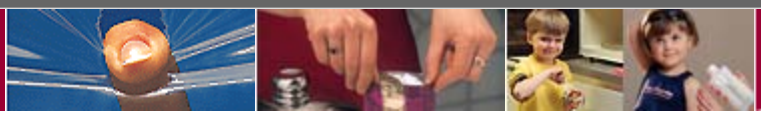
Product Information

Selar® PA



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DuPont™ Selar® PA3426 Blends With Nylon 6

General Information

Resin Description

Selar® PA3426 is an amorphous nylon (polyamide) resin that provides:

- Good O_2 and CO_2 barrier, especially at high humidities
- Excellent optical properties
- Melt strength superior to that of nylon 6
- Wide range of processing temperatures
- Ease and flexibility of processing

Blending even low percentages (20%) of Selar® PA 3426 with nylon 6, nylon 66, and nylon copolymers will result in a product that behaves like an amorphous polymer. These blends retain all of the advantages of the Selar® PA resin with some of the mechanical property advantages of semi-crystalline nylon.

Selar® PA is suitable for a variety of packaging applications that require clarity, barrier, and processing flexibility. Because of the excellent barrier at refrigerated conditions, Selar® PA 3426 and Selar® PA 3426 blends have benefits in meat and cheese packages, replacing the nylon 6, PVDC, or EVOH barrier layer.

The amorphous nature of Selar® PA 3426 makes this resin easy to extrude. Processing conditions ranging from 221 - 327°C (430 - 620°F) make it an attractive choice for co-extruded structures in film (blown and cast), extrusion coating, and sheet lines. Its thermoforming characteristics -- good drawability and uniform thickness in corners -- are excellent for both film and sheet.

Selar® PA 3426 is available in small, free-flowing pellets in 25-kg (55-lb) moisture barrier bags or 750-kg (1,653-lb) moisture barrier boxes. The resin can be processed by the same blown film, cast film, or cast sheet equipment used with semi-crystalline nylons. Selar® PA 3426-nylon 6 blends can be made by dry blending.

Safety

At ambient temperatures, handling Selar® PA barrier resin presents little hazard. The product has a low toxicity by ingestion and is neither a skin irritant nor a skin sensitizer. The resin should not be heated above 338°C (640°F). When overheated, decompositions with fume evolution may occur. As with most plastics, use local ventilation to avoid exposure to fumes that may irritate the eyes, nose, throat, and upper respiratory tract. Take care to protect the hands and other exposed parts of the body when working with molten polymer. If molten polymer contacts the skin, cool the affected area with cold water or ice. Do not attempt to peel the solidified polymer from the skin. Obtain medical attention for thermal burn. Loose pellets should be swept up promptly to prevent falls.

Disposal of scrap presents no special problems and can be by landfill or incineration in a properly operated incinerator. Disposal should comply with local, state, and federal regulations. For more detailed information on the safe handling and disposal of resins, an OSHA Material Safety Data Sheet can be obtained from the Regional Office serving you. The safety hazards common to all thermoplastic extrusion operations apply to Selar® PA 3426 and Selar® PA 3426 blends and require standard, industry-accepted safety practice. DuPont places a very high priority on safety and believes all personal injuries can and should be prevented.

The following protective measures should be considered:

- Use gloves and other protective clothing when handling hot polymer or operating machinery
- Wear approved safety glasses
- Use adequate ventilation
- Use accepted engineering designs and process controls
- Promptly clean up any resin pellet spills

FDA

All grades of Selar® PA comply with FDA regulation 21 CFR 177.1500 (a)(12) regarding food contact. Selar® PA can be used with all types of food, except those with more than 8% alcohol. There is no FDA limitation on the temperature of the food or the thickness of the Selar® PA in contact with the food.

Physical Properties

The following tables list typical properties of Selar® PA 3426 and Selar® PA 3426-nylon 6 blends. The choice of the type 6 nylon will likely affect the properties of the blends. Capron 8207F from AlliedSignal or Ultramid B4 from BASF were used in the blends in Tables 1 through 3. However, any non-nucleated nylon 6 may be suitable.

Selar® PA film, both cast and blown, is transparent. Haze below 1 - 2% is virtually as clear as glass. The index of refraction of Selar® PA 3426 is 1.597 for 1-mil film, while container glass is 1.575. The optical properties of nylon 6 depend on process: nylon 6 blown film is hazy; nylon 6 cast film is transparent. Adding Selar® PA 3426 to a type 6 nylon will improve the optical properties (see Table 2)

Table 1 - Selar® PA 3426-Nylon 6 Blends, Polymer Properties

		% Selar® PA 3426 in Blend					
Property	**Unit**	**0[a]**	**20**	**30**	**50**	**80**	**100**
Density, D1501	g/cc	1.13	1.14	1.15	1.16	1.18	1.19
Tg, Dry	°C(°F)	70(158)	79(174)	84(183)	94(201)	112(234)	125(257)
Melt Flow	at 275°C(527°F) at 2160g	24	19	20	12	11	15
IV	(m-cresol) 0.1% moisture	1.79					0.83

[a]Capron 8207F Type 6 nylon is a registered trademark of Allied Signal, Inc.

Table 2 - Selar® PA 3426-Nylon 6 Blends, Optical Properties[a]

		% Selar® PA 3426 in Blend					
Property	**Unit**	**0[b]**	**20**	**30**	**50**	**80**	**100**
Gloss, D2457							
Cast	20°	110	30	115	163	133	90
Blown	20°	20	160	150	150	130	130
Haze, D1003							
Cast	° Total	1.2	<1.0	<1.0	<1.0	<1.0	<1.0
Blown	° Total	14	1.2	<1.0	<1.0	<1.0	<1.0
Transparency, D1746							
Cast	°	55	60	60	70	50	70
Blown	°	10	75	70	80	80	70

[a]1-mil blown monolayer film
[b]Capron 8207F Type 6 nylon is a registered trademark of Allied Signal, Inc.

Table 3 - Selar® PA 3426-Nylon 6 Blends, Typical Film Properties[a]

			% Selar® PA 3426 in Blend					
Property	**Unit**		**0[b]**	**20**	**30**	**50**	**80**	**100**
Elmendorf Tear, D1922	g/mil	MD	31	31	41	34	12	16
	g/mil	TD	23	47	55	56	12	14
Graves Tear, D1004	g/mil	MD	430	470	425	500	920	810
	g/mil	TD	480	500	430	490	710	830
Spencer Impact, D3420	in-lb/mil		20	5.9	9.3	1.2	0.6	1.0
Yield Strength,* D882	kpsi	MD	3(0.021)	6(0.041)	6.5(0.045)	3.2(0.022)	c	c
	(kPa)	TD	3(0.021)	6(0.041)	5.6(0.039)	2.7(0.019)	c	c
Tensile Strength,* D882	kpsi	MD	6(0.041)	10(0.069)	8(0.055)	9(0.062)	7(0.048)	10(0.069)
	(kPa)	TD	7(0.048)	10(0.069)	7(0.048)	9(0.062)	7(0.048)	10(0.069)
Elongation*	%	MD	200	390	290	360	—	20
	%	TD	210	400	310	400	—	20
COF	Film/metal	0.2	0.2	0.2	0.2	0.3	0.3	
D1894	Film/film		0.4	0.6	>1	>1	>1	>1
Pin-hole Flex								
10^3 Cycles to Fail		MD	18	7	33	2	0.5	1
72°F/35% RH F456		TD	16	6	15	2.5	1	1

[a]1-mil blown monolayer film
[b]Capron 8207F Type 6 nylon is a registered trademark of Allied Signal, Inc.
[c]No yield detected
*X-Head 2 in/min
*Jaw Separtion 4 in

Barrier Properties

At wet conditions, 95 - 100% RH, Selar® PA 3426 is an excellent barrier to oxygen, carbon dioxide, and water vapor. It is equivalent to the EVOH oxygen barrier at the same wet conditions. At dry conditions, 0 - 5% RH, Selar® PA 3426 is a good barrier. At 0% RH, oxygen and carbon dioxide barrier properties are the same as for nylon 6. At 95 - 100% RH, the oxygen and carbon dioxide barrier of Selar® PA is substantially better than that of nylon 6 (see Figures 1 and 2). The moisture barrier properties of Selar® PA 3426 and other resins are shown in Table 4.

The barrier properties of nylon 6 blends fall between the performance of Selar® PA 3426 and nylon 6. However, as the humidity increases, adding even small amounts of Selar® PA 3426 improves the barrier more than would be predicted by a straight-line correlation (see Figure 3 for OPV data and Figure 4 for WVTR).

Table 4 - Moisture Barrier Properties 95% RH, 23°C (73°F) WVTR, g/100 in 2 day atm

Extrudable PVDC	0.3
HDPE	0.3
DuPont™ Selar® PA 3426	2.0
EVOH	4.0
Acrylonitrile Copoly	5.0
Polycarbonate	6.4
Nylon 6	12.4

Figure 1—Oxygen Permeation

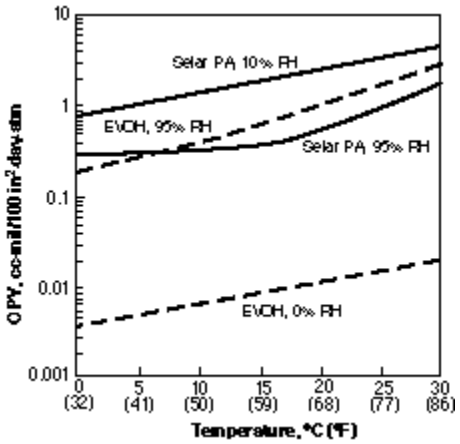


Figure 2—Carbon Dioxide Permeation

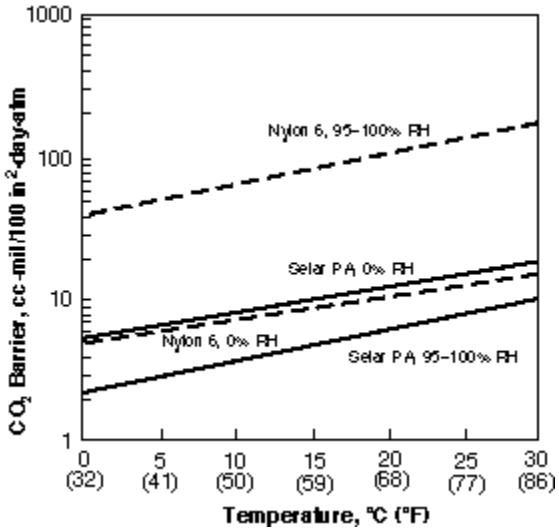


Figure 3—Oxygen Permeation of Selar® PA Blends with Nylon 6 at 95 - 100% RH

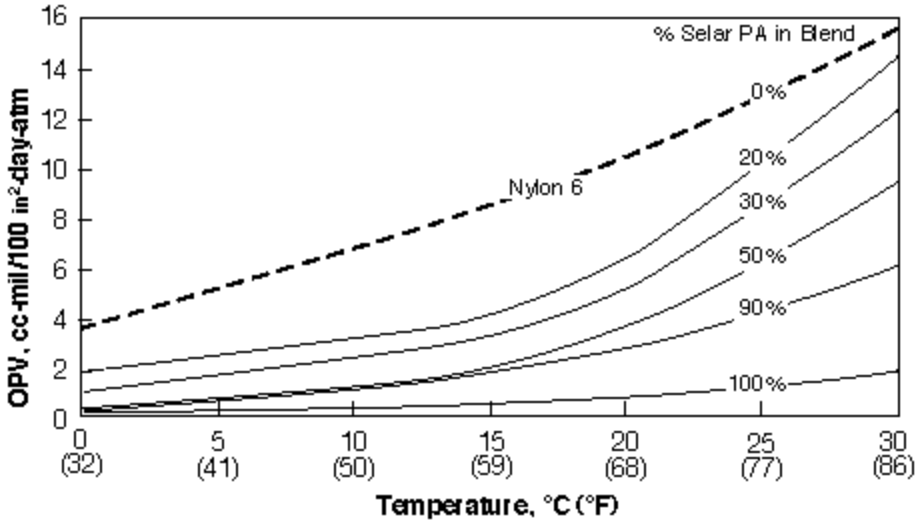


Table 5 - Oxygen Permeation of Selar® PA Blends with Nylon 6[a]

		% Selar® PA 3426 in Blend					
cc-mil/100 in²day atm		**0[b]**	**20**	**30**	**50**	**80**	**100**
0°C(32°F)	0-5% RH	0.9	0.9	0.9	0.9	0.9	0.8
0°C(32°F)	95-100% RH	3.7	2.0	1.3	0.5	0.4	0.3
30°C(86°F)	0-5% RH	4.0	3.9	3.9	3.9	3.9	3.8
30°C(86°F)	95-100% RH	15.0	14.0	12.0	9.1	5.6	1.5

[a]1-mil blown monolayer film
[b]Capron 8207F Type 6 nylon is a registered trademark of Allied Signal, Inc.

Figure 4—Water Vapor Transmission Rate of Selar® PA Blends with Nylon 6 at 95 - 100% RH

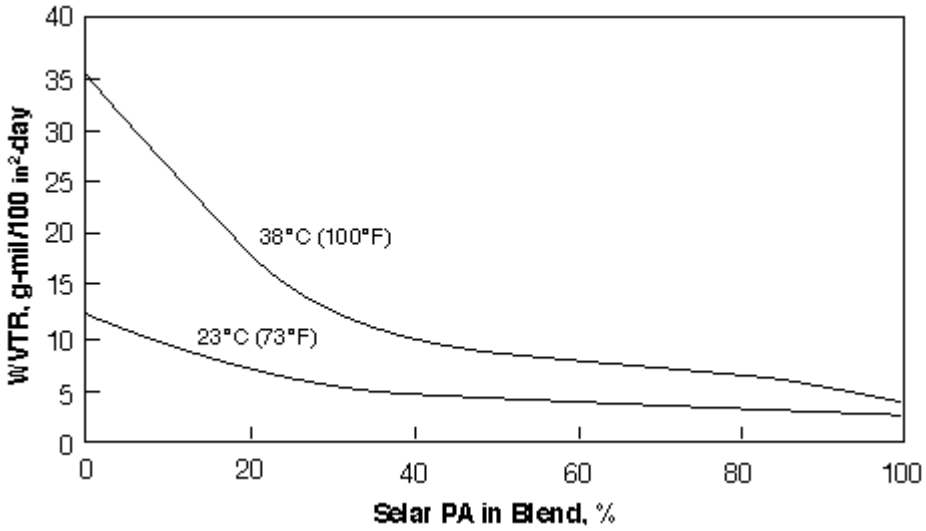


Table 6—Carbon Dioxide Permeation[a]

cc-mil/100 in² day atm		**Nylon 6[b]**	**DuPont™ Selar® PA 3426**
0°C(32°F)	0-5° RH	5	5.5
0°C(32°F)	95-100° RH	39	12.2
30°C(86°F)	0-5° RH	15	18.0
30°C(86°F)	95-100° RH	160	9.8

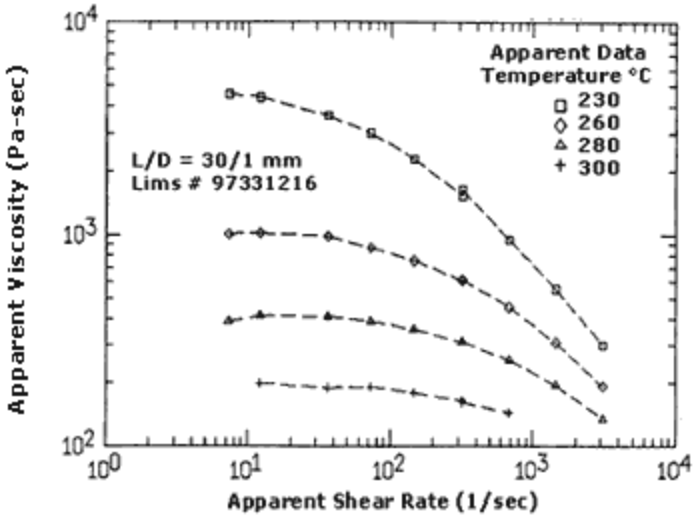
[a]1-mil blown monolayer film
[b]Capron 8207F Type 6 nylon is a registered trademark of Allied Signal, Inc.

Table 7—Water Vapor Transmission of Selar® PA Blends with Nylon 6[a]

		% Selar® PA 3426 in Blend					
g-mil/100 in^2 day		**0[b]**	**20**	**30**	**50**	**80**	**100**
23°C(73°F)	95° RH	12.44	6.14	5.10	2.92	1.97	1.85

[a]1-mil blown monolayer film
[b]Capron 8207F Type 6 nylon is a registered trademark of Allied Signal, Inc.

Figure 5—Rheology Curves for Selar® PA 3426



Chemical Resistance

The chemical resistance of various solvents is shown in Table 8. In general, Selar® PA 3426 has good resistance to aliphatic and aromatic hydrocarbons, dilute alkalis, higher molecular weight alcohols, and low concentrations of lower molecular weight alcohols. End-use testing is recommended for each application, however.

Table 8—Chemical Resistance of Selar® PA 3426

Chemical	Resistance
Dilute Mineral Acids	Good
Dilute Aqueous Bases	Good
Alcohols	
Ethanol	Poor
Isopropanol	Poor
Ethylene Glycol	Fair
Glycerine	Good
Hydrocarbons	
Aromatic	Good
Aliphatic	Good
Ketones	Good
Esters	Good
Acetic Acid	Poor

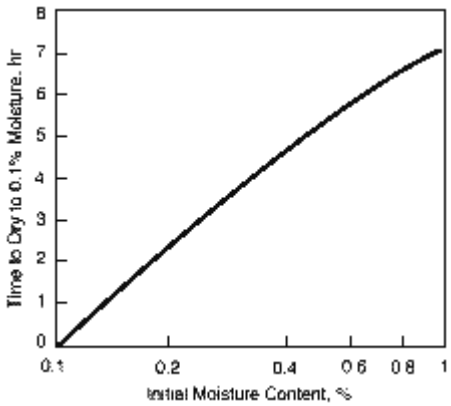
Processing the Resin

Drying

Selar® PA resin is shipped dry (<0.20% moisture) in moisture-proof packages and can be used as received. However, Selar® PA resin does absorb moisture and should be re-dried if the bags have been opened, if the resin has been exposed to relative humidities of greater than 50% for 1/2 hr or more, or if the melt temperature will exceed 282°C (540°F). Typical drying temperatures are in the range of 79 - 96°C (175 - 205°F).

If drying is needed, dehumidified hoppers or tray dryers that are capable of producing heated air with a dew point of -30 to -20°C (-22 to -4°F) are recommended. The dryer should be a regenerative-type, desiccant bed dryer with an exit air dew-point monitor. Typical drying temperatures are in the range of 82 -93°C (180 - 200°F) for tray drying and 71 - 82°C (160 -180°F) for hopper dryers. Figure 6 shows the time needed to dry Selar® 3426 to 0.1% moisture if dried at 88°C (190°F), the recommended drying condition. Thus, the more moisture in the resin, the longer it will take to dry. A 4-hr drying period at 88°C (190°F) is optimum for a resin containing 0.3% water.

Figure 6—Selar® PA 3426 Drying Time Curve



Dry-Blending

Blends of Selar® PA 3426 with nylon 6 can be made by dry blending prior to processing. Mixing should be done immediately before processing, in on-line mixers or in off-line mixers or shakers, provided the resin is not exposed to high humidities for greater than 1/2 hr. Consideration should be given to moderate mixing or barrier-type screws for production with dry-blend systems.

Additives

Selar® PA 3426 has a slight yellow color when the layer or wall thickness exceeds 10 mil. The addition of a blue tint (00022531) at a ratio of 1% by weight of colorant will neutralize the yellow tint. The colorant also includes an antistatic agent to minimize Selar® PA sticking to equipment walls. The film-to-film coefficient of friction of Selar® PA and Selar® PA blends is very high. Therefore, an antiblock agent, 2% by weight of 1080096S, is recommended to reduce the coefficient of friction and help prevent film wrinkles. This additive also provides slip enhancement and improves film handling. Both additives are available from Clariant Masterbatches Division, Minneapolis, MN, (763) 535-4511.

Screw Design

Selar® PA 3426 and blends of Selar® PA 3426 with nylon 6 can be processed using a typical polyolefin screw with L/D ratios of 24/1 to 30/1, compression ratios of 3/1 to 4/1, and equal feed, transition, and metering sections. A barrier screw or a screw with a moderate mixing section can also be used for processing salt-and-pepper blends of Selar® PA and nylon 6. Nylon screws are adequate, but not necessary.

Start-Up

Selar® PA has a broader process temperature range than typical semi-crystalline nylons. Start-up melt temperatures should be in the range of 238 - 249°C (460 - 480°F). If a lower melt temperature is needed, the temperature should be reduced after start-up, while monitoring drive power and head pressure. If a higher

temperature is needed, the start-up melt can be set to a higher value initially. Operating melt temperatures depend on the processing method. General guidelines are listed in Table 9.

Table 9—Operating Melt Temperatures

	Melt Temperature	
Processing Method	**°C**	**°F**
Blown Film	240-260	465-500
Cast Film	250-280	480-535
Sheet	230-260	445-500
Extrusion Coating*	305-325	580-615

*Additional drying is required; see Drying.

These guidelines are not absolute. Temperatures may vary depending upon, for example, drive horsepower, screw design, flow restrictions (pressure), temperature control, and product thickness.

If melt temperature is too high, the resin viscosity will be too low (too fluid) and may show evidence of degradation by either turning progressive shades of yellow or evolving gas and "frothing." If the problem cannot be promptly corrected, then consider a purge to HDPE or LDPE.

If the melt temperature is too low, the resin viscosity will be too high, may require excessive drive power, and may risk polymer "freeze-offs." The clarity of the product may also be affected. Melt temperature should never be below 210°C (410°F). Care should be taken to ensure that massive adaptors or head gates are adequately heated before introducing nylon resins.

Temperature Profile

A flat temperature profile is the usual method of processing Selar® PA resins. The suggested way to maintain temperature profile is to set the temperature at the screw to the melt temperature and then maintain that melt temperature throughout the system. However, the barrel rear zone should be set at 204°C (400°F) to minimize the risk of bridging in the feed section of the screw, and then increased in the next zone to melt temperature (see Table 10).

Extruder output rates for Selar® PA resins are higher than for a type 6 semicrystalline nylon. The ratio of Selar® PA resin output to type 6 nylon (Capron 8207F) output ranges from 1.5 to 3.5.

Table 10—Temperature Profiles for Mono- and Co-extruded Structures

Rear Barrel	204°C(400°F)
Other Barrel	Melt Temperature
Exit Barrel	Melt Temperature
After Melt Combining	Highest Melt Point in Co-ex Structure

Interruption During Operation

If production with Selar® PA resins is off-line or down, the screw speed should be maintained at 5 to 10 rpm to avoid degradation and possible "frothing" due to excessive time/temperature exposure of the resin. If the interruption exceeds 20 minutes, then a purge to HDPE should be considered.

Purging

Purging the system should be done with a heat stable polyolefin such as HDPE, MDPE, LDPE, LLDPE, or PP. The screw speed sequence should follow an alternately high and low schedule at 1- to 2-min intervals for at least 5 cycles. If necessary, let the system "soak" at low rpm for 10 min before cycling the screw speeds again. The purge/soak routine should be repeated as needed (see the suggested sequence in Table 11).

The purge temperature profile should be 210°C (410°F) or greater at the rear barrel zone, with the rest of the sections at the run or operating temperature. Maintain adaptor and dies (all laminar flow sections) at relatively high temperature to reduce viscosity of resin on the "walls" of internal flow passages and to promote flow. The high temperature must be selected to avoid degradation, evident by yellowness or gels.

Concurrent cycling of the adaptor and die temperature may be beneficial during the purge procedure. A typical cycle involving temperature would be to set the temperature equal to a low temperature, like the run temperature, and follow the sequence listed in Table 11. Then, set the temperature to a higher temperature, about 16 - 38°C (60 - 100°F) over the run temperature, and run the purge sequence. This temperature cycling should be repeated if necessary.

Table 11—Screw Speed Sequence for Purging

Stage	Screw rpm	Time Min
Purge	10	1
	100	1
	20	1
	70	1
	20	1
	80	1
	10	1
	70	1
	30	1
	90	1
Soak*	20	10
Purge*	70	1
	20	3
	90	4
	20	2
	70	3
	10	4
	80	2
	30	3
	100	4
	10	2
Soak*	20	10
	Total Time = 59 min	

*If necessary

Shutdown Procedure

Shutdown should follow a transition to a polyolefin like HDPE. The temperature profile should be above the minimum Selar® PA melt temperature -- 210°C (410°F) -- and follow purging procedure above.

Adhesives

Co-extrusion of Selar® resins almost always requires the use of co-extrudable adhesives to bond the

amorphous nylon to other functional layers. Bynel® co-extrudable adhesive resins from DuPont provide excellent adhesion to the amorphous nylon. Table 12 is meant as a guideline to help select the appropriate resin type.

Table 12—Coextrusion Tie Layers Selar® PA Barrier Resins

DuPont™ Bynel® CXA Series	Adheres Nylon to		
2000	Ethylene Polymers	Ionomer	
2100	Polycarbonates	Polyester	
3000	Polyolefins		
3800	Polyolefins	Styrenics	PVDC
3900	Polyolefins	EVOH*	
4000	Ethylene Polymers	EVOH	
4100	Ethylene Polymers	EVOH	
4200	Ethylene Polymers	EVOH	
5000	EVOH	Polypropylene	

*Selar® PA 3426-nylon 6 blends containing less than 30% Selar® PA 3426 may bond directly to EVOH.

Troubleshooting Guide

Bridging

- Reduce the barrel rear zone temperature
- Cool the hopper feed throat with water
- Use internal screw cooling for the first 4 to 5 turns of the feed section
- Alter the screw design (last resort)
- If bridging occurs and the problem cannot be promptly corrected, consider a heat-stable polyolefin such as HDPE, MDPE, LDPE, LLDPE, or PP

Wrinkles

- Add an antiblock additive; see Additives

Bubbles in the Melt

- Caused by excessive moisture or inadequate resin drying
- Partial screw bridging--starved feed (entrapped air)

Excessive Extruder Drive Power Requirement

- Increase the melt temperature
- Increase the temperature of the rear zone. Run with a humped temperature profile (elevate second barrel zone 32 - 62°C (50 - 80°F)
- Increase screw rpm to increase shear working

Sticking to the Chill Rolls

- Decrease chill roll temperature
- Decrease melt temperature

Poor Gauge Control

- Incorrect screw design
- Extruder drive variation
- Keep the adaptor and die body temperature equivalent to the temperature of the melt and make sure the frost line on the blown film line is level
- Clean die; use optimum purge procedures

Carbon Specks

- Streamline flow path in adaptor and die to prevent excessive resin holdup and clean the extruder/adaptor/die

Degradation

- Increase extruder output and streamline flow path to prevent excessive resin holdup
- Check temperature control system to eliminate any excessive temperature

Dull Surface

- Increase the melt temperature
- Increase the air gap