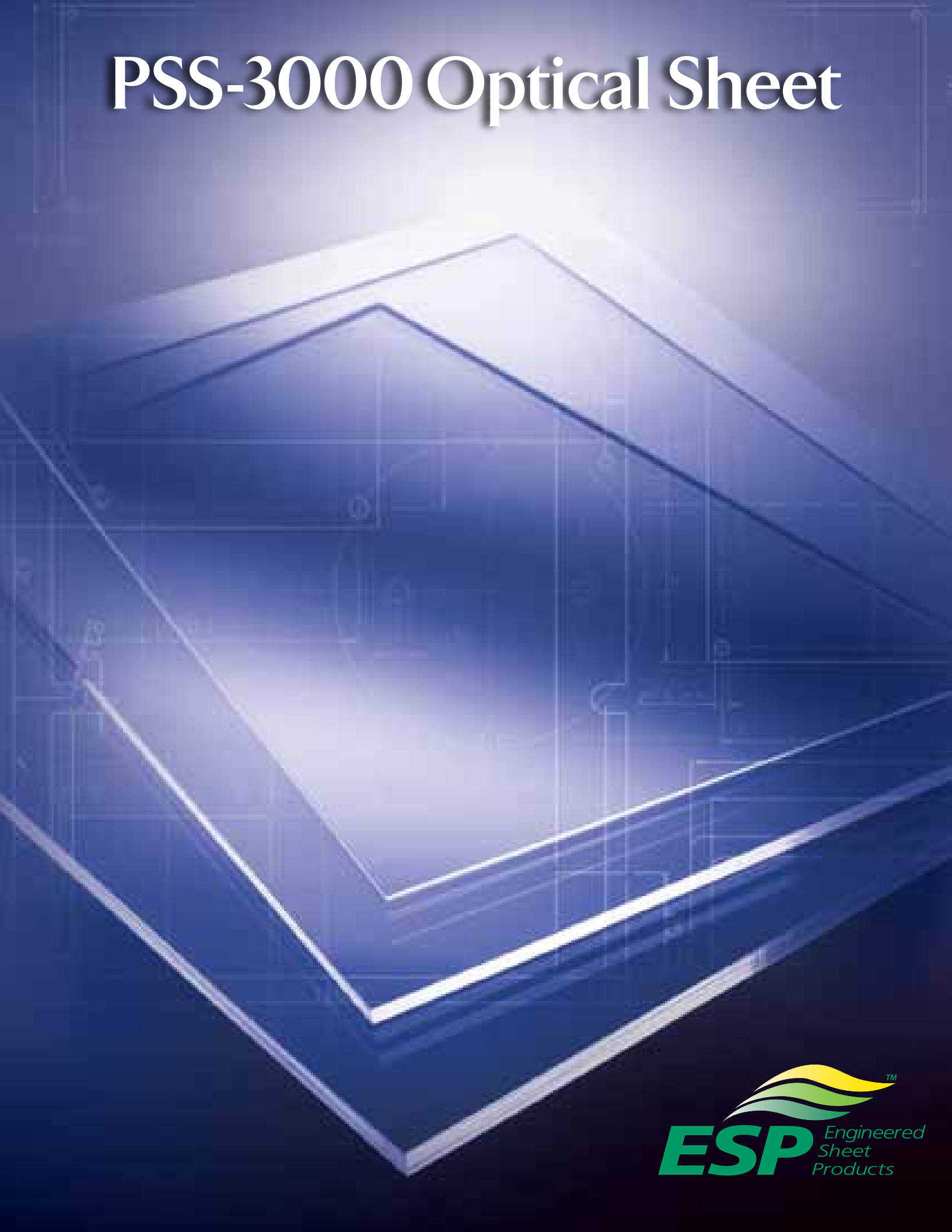
PSS-3000 Optical Sheet



ESP™ Engineered Sheet Products

PSS-3000 Optical Sheet | Overview

Advanced Technology for All-Around Performance

PSS-3000 optical sheet is produced using a technologically advanced thermoset resin and offers excellent optical properties, rugged durability and lightweight performance, as well as outstanding chemical resistance, mechanical properties and thermal stability. PSS-3000 sheet combines the optical quality and chemical resistance of glass with the lightweight performance of plastics.

Distortion-Free Optics

One of the most distinctive attributes of PSS-3000 sheet is its optical performance.

- High light transmission
- Low haze value

Rugged Durability

Few other engineered plastics can match the chemical and abrasion resistance offered by PSS-3000 sheet products.

- Withstands very hot or cold temperatures
- Virtually unaffected by most organic and inorganic chemicals

PERFORMANCE COMPARISON

	PSS-3000	ACRYLIC	POLYCARBONATE	GLASS
Optical Quality	●●	●●	⊘	●●●
Abrasion Resistance	●●	⊘	⊘	●●●
Chemical Resistance	●●	⊘	⊘	●●●
Lightweight / Low Density	●●	●●●	●●●	⊘
Impact Resistance	●	●	●●●	⊘

●●● Superior ●● Excellent ● Good ⊘ Poor

PRODUCT AVAILABILITY

STANDARD SHEET SIZE (Tolerances: ± 0.1 mm)	**Custom Sizes up to 960 mm x 480 mm (37.8” x 18.9”)**
STANDARD THICKNESS (Tolerances: ± 10%)	

(mm)	(in)	(mm)	(in)
0.5	0.020	3.0	0.12
0.7	0.028	4.0	0.16
1.0	0.039	5.0	0.20
1.5	0.059	6.0	0.24
2.0	0.079		

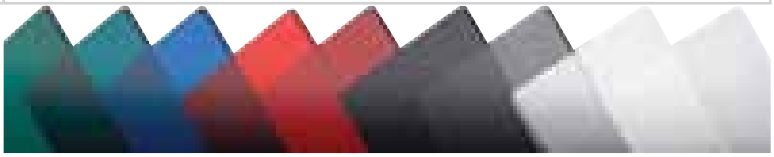
SURFACE FINISHES

Four Surface Finishes Available, One or Two Sides

- Smooth / Smooth
- Light Glare Reduction / 135 Gloss Units
- Medium Glare Reduction / 110 Gloss Units
- Heavy Glare Reduction / 85 Gloss Units

STANDARD COLORS

Clear (Colorless)	Brown
Neutral Gray	Red
Blue	Laser Red (650 nm)
Aqua (Blue-Green)	Laser Red (670 nm)
Amber	Green
Yellow	IR Transmitting Only



Custom Sizes, Thickness and Colors available upon request

PROPERTIES

	TEST CONDITIONS	UNITS	STANDARDS	PSS-3000
OPTICAL				Tests conducted on 3.0 mm thick sheet
Luminous Transmittance		%		92
Haze		%		0.03
Yellowness Index			ASTM E313	0.77
Refractive Index, η_e	23°C, 546 nm			1.50
Abbe Value				57
MECHANICAL				Tests conducted on 1.0 mm thick sheet
Tensile Stress at Break	50% RH / 23°C	MPa	ASTM D638-08	51
Tensile Elongation at Break	50% RH / 23°C	%	ASTM D638-08	14
Tensile Modulus	50% RH / 23°C	MPa	ASTM D638-08	1,582
Tensile Yield Stress	50% RH / 23°C	MPa	ASTM D638-08	44
Compressive Stress	50% RH / 23°C	MPa	ASTM D695-02a	58
Compressive Modulus	50% RH / 23°C	MPa	ASTM D695-02a	1,088
Compressive Yield	50% RH / 23°C	MPa	ASTM D695-02a	42
Maximum Load	50% RH / 23°C	N	ASTM D790-07	30
Flexural Stress	50% RH / 23°C	MPa	ASTM D790-07	91
Flexural Modulus	50% RH / 23°C	MPa	ASTM D790-07	2,724
Martens Hardness		N/mm^2	ISO 14577	103
Rockwell Hardness	50% RH / 23°C	M	ASTM D785	88
Pencil Hardness	7.5 N Force		ISO 15184	H
Taber Abrasion	500 g, 100 Cycles, 3.0 mm thick	%	ASTM D1044	9.66%
Steel Wool Abrasion	200 Cycles, #0000	%		2%
Izod Impact – Notched	25°C	Ft lb/inch	ASTM D256	0.2 – 0.4
Izod Impact – Unnotched	25°C	Ft lb/inch	ASTM D256	2 – 3
THERMAL				Tests conducted on 3.0 mm thick sheet
Specific Heat	25°C	J / g / °C	ASTM E1269	1.30
Thermal Expansion Coefficient		µm / (m °C)	ASTM E831	100
Heat Distortion Temperature	264 psi	°C	ASTM D648	55
Continuous Service Temperature		°C		100
Softening Temperature		°C	ASTM E1545	> 200
FLAMMABILITY				Tests conducted on 1.0 mm thick sheet
UL 94 Flammability Class	50% RH / 23°C		ASTM D3801/ D635-06	HB
Flash Ignition Temperature		°C	ASTM D1929	376
Self Ignition Temperature		°C	ASTM D1929	382
ELECTRICAL				Tests conducted on 1.0 mm thick sheet
Surface Resistivity	50% RH / 23°C, 500 V	Ohms	ASTM D257-99	28×10^{15}
Volume Resistivity	50% RH / 23°C, 500 V	Ohms-cm	ASTM D257-99	15×10^{15}
Dielectric Constant			ASTM D150	
At 100 Hz				4.4
At 1 kHz				4.2
At 1 MHz				3.6
BASIC				Tests conducted on 1.0 mm thick sheet
Specific Gravity		g / cm^3		1.31
Water Absorption	7 days, 25°C	%		0.7
Oxygen Permeability	0% RH / 23°C	$cm^3 / (100\ in^2 * day)$	ASTM D3801	0.1
Water Vapor Transmission Rate	100% RH / 38°C	$g / (100\ in^2 * day)$	ASTM F1249	0.27

PSS-3000 Optical Sheet | Optical Performance

Optical Clarity

Precision optics, low haze and high light transmission are important properties when considering optical plastics. PSS-3000 optical sheet has the lowest haze in comparison to other optical plastics.

PERFORMANCE COMPARISON

MEASUREMENT	UNITS	EQUIPMENT / STANDARDS	PSS-3000	POLYCARBONATE	ACRYLIC
Luminous Transmittance	%	HunterLab UltraScan Pro – D65 / 10°	92	88	92
Haze	%	HunterLab UltraScan Pro – D65 / 10°	0.03	0.22	0.35
Yellowness Index		ASTM E313	0.77	1.28	0.14
Abbe Value			57	29	59

*Testing conducted on 3 mm thick sheets.

Distortion-Free

PSS-3000 optical sheet is virtually free of residual internal stress and strain. It is cast flat with precise thickness control. These properties make it the best choice for devices that require high optical performance such as bar code scanners and optical filters.

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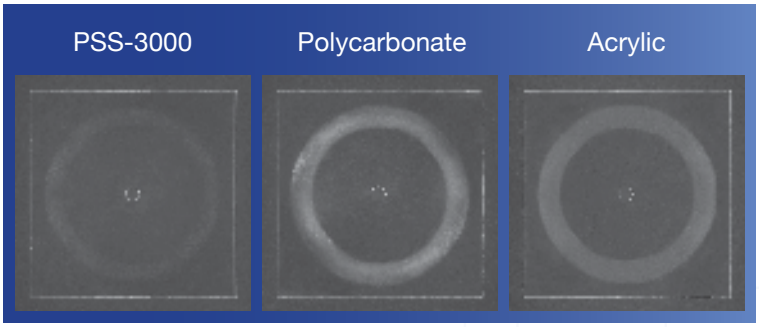
PSS-3000 Optical Sheet | Abrasion Performance

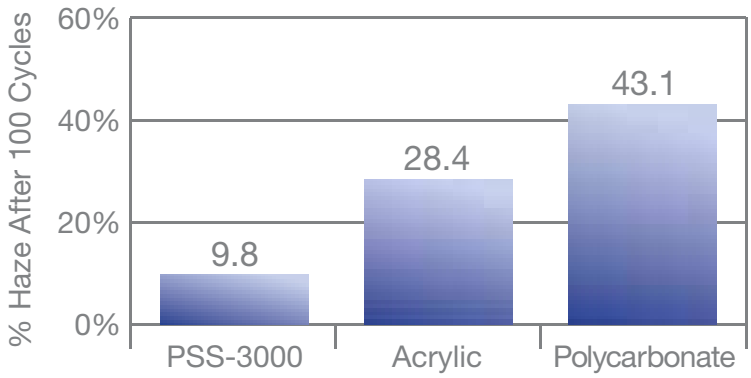
Abrasion Resistance

PSS-3000 optical sheet has superior abrasion resistance compared to other plastic materials. Durability and longevity of use are improved due to the resilience of PSS-3000 sheet.

The photos to the right demonstrate the superior performance of PSS-3000 sheet after 100 cycles of the Taber test.



PERFORMANCE COMPARISON



This chart compares increase in haze on 3.0 mm thick sheets after 100 cycles using a CS-10 wheel with a 500 gram weight at 72 rpm per ASTM D1044 and ASTM D1003-07. (Tested by Intertek)

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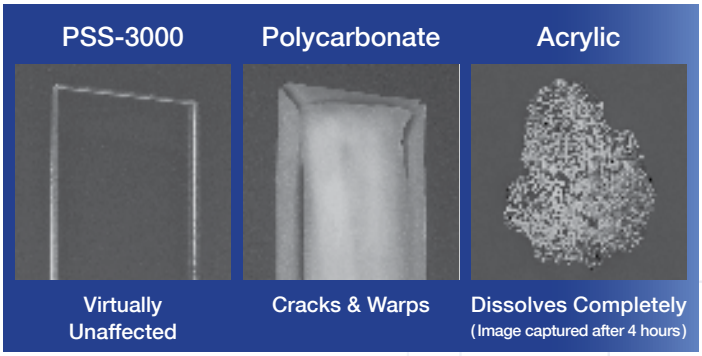
PSS-3000 Optical Sheet | Chemical Performance

Chemical Resistance

PSS-3000 optical sheet is virtually unaffected by most organic and inorganic chemicals as well as most substances encountered in harsh environments.

The photos to the right demonstrate the superior chemical resistence of PSS-3000 sheet when exposed to acetone for 7 days.



PERFORMANCE COMPARISON

CHEMICAL	PERCENT WEIGHT GAIN			COSMETIC CHANGE		
	PSS-3000	POLYCARBONATE	ACRYLIC	PSS-3000	POLYCARBONATE	ACRYLIC
Acetone	1.50	17.8	NA*	No visual change	Whitening / warping	Part dissolved
Coppertone® Sunscreen	0.55	0.18	0.55	No visual change	No visual change	Tacky cut edge
Ethyl Alcohol 95%	-0.21	0.07	0.14	No visual change	No visual change	Crazing / cracking
Unleaded Gasoline	-0.05	0.10	0.69	Slight yellowing	No visual change	Crazing / cracking
Hydrochloric Acid 10%	0.45	0.15	0.44	No visual change	No visual change	No visual change
Sodium Hydroxide 10%	0.20	0.03	0.41	No visual change	Hazy surface	No visual change
Windex® Cleaner	0.56	0.18	0.54	No visual change	No visual change	No visual change

This chemical resistance data was obtained using Chemical Resistance method D543 by submersing 3.0 mm thick pieces of uncoated PSS-3000 sheet, polycarbonate and acrylic into 7 common industrial and consumer chemicals and stored at 25°C for 7 days. At the end of the test period each sample was removed from the container, the residual chemical wiped off the sample and quickly weighed. The percentage weight gain was then calculated. (Testing conducted by STR)

*Part Dissolved

Coppertone® is a registered trademark of MSD Consumer Care, inc.
Windex® is a registered trademark of S.C. Johnson & Son, inc.

ESP™ Engineered Sheet Products

PSS-3000 Optical Sheet | Fabrication

PSS-3000 SHEET CUTTING RECOMMENDATIONS

I. Using a Laser Cutting Tool

All PSS-3000 sheets can be cut to any shape or size using a computer controlled laser with general tolerance of ± 0.1 mm. See table to the right for laser settings using a Universal® Laser Systems ILS 12.150D with two 50W laser tubes and air assist.

LASER SETTINGS

PSS-3000 SHEET THICKNESS (IN)	CUTTING SPEED (%)
0.030	27
0.040	25
0.060	18
0.080	12
0.118	7.5
0.195	4.8
0.240	4

*All vector cutting performed at 100% power.

II. Using a Computer Numerically Controlled (CNC) Cutting Tool

Customers that are used to processing plastic material that is softer than PSS-3000 sheet may have to increase the RPM of their milling machine and adjust milling linear speed depending on the thickness of the sheet. Otherwise, the risk of breaking or chipping the PSS-3000 sheet increases. Specific details are below:

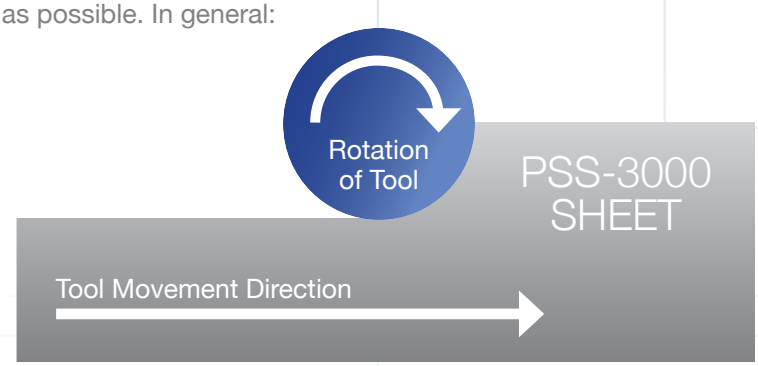
1. CUTTER SPINNING SPEED

The cutter spinning speed can be set as high as possible. In general:

- 5 mm diameter cutter: 25,000 rpm
- 1 mm diameter cutter: 40,000 rpm

2. CUTTER ROTATION DIRECTION

For best results, the cutter tool should move in the same direction as rotation of tool.



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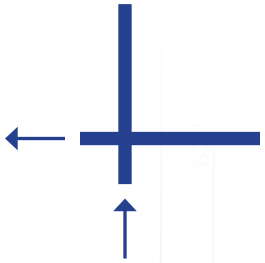
3. CUTTER LINEAR DIRECTIONAL SPEED

The X, Y and Z linear speeds will depend on how much material is going to be removed (thickness and size reduction).

4. CUTTING SQUARE ANGLES

90° tool movement is suggested for cutting square angles and to continue the cutter past the end of the sheet as shown to the right.



5.COOLING REQUIREMENTS

Cooling by liquid is not needed. Air flow to cool the cutter and remove the cut material is recommended.

6. EXAMPLE OF PARAMETERS FOR A 1.0 MM THICK SHEET USING CNC MACHINE

USING A SINGLE CUTTER

	CUTTER DIAMETER	
	5.5 mm	1.0 mm
FZ – linear speed on Z axis (cutter in-out)	1250 mm/min	450 mm/min
FA – linear speed on X and Y axis	2500 mm/min	675 mm/min
S – cutter spinning speed	28000 rpm	38500 rpm

III. Using a Knife Blade to Score PSS-3000 Sheet

A Tantung or Widia blade can be used to score PSS-3000 sheet. Note that thinner sheets (<1.0mm) may chip or crack when attempting to break the sheets apart.

ESP™ Engineered Sheet Products

SOLID STATE NUCLEAR TRACK DETECTORS MADE FROM *CR-39*® MATERIAL

With the growing awareness of health hazards from naturally occurring radon, and with greater importance being given to detecting radiation in medical, industrial and research environments, experts increasingly are turning to solid state nuclear track detectors (SSNTDs) to determine neutron doses and measure radon concentration. These powerful yet simple scientific tools measure the number of tracks produced by neutrons and alpha particles to give an accurate assessment of radiation dose and radon exposure.

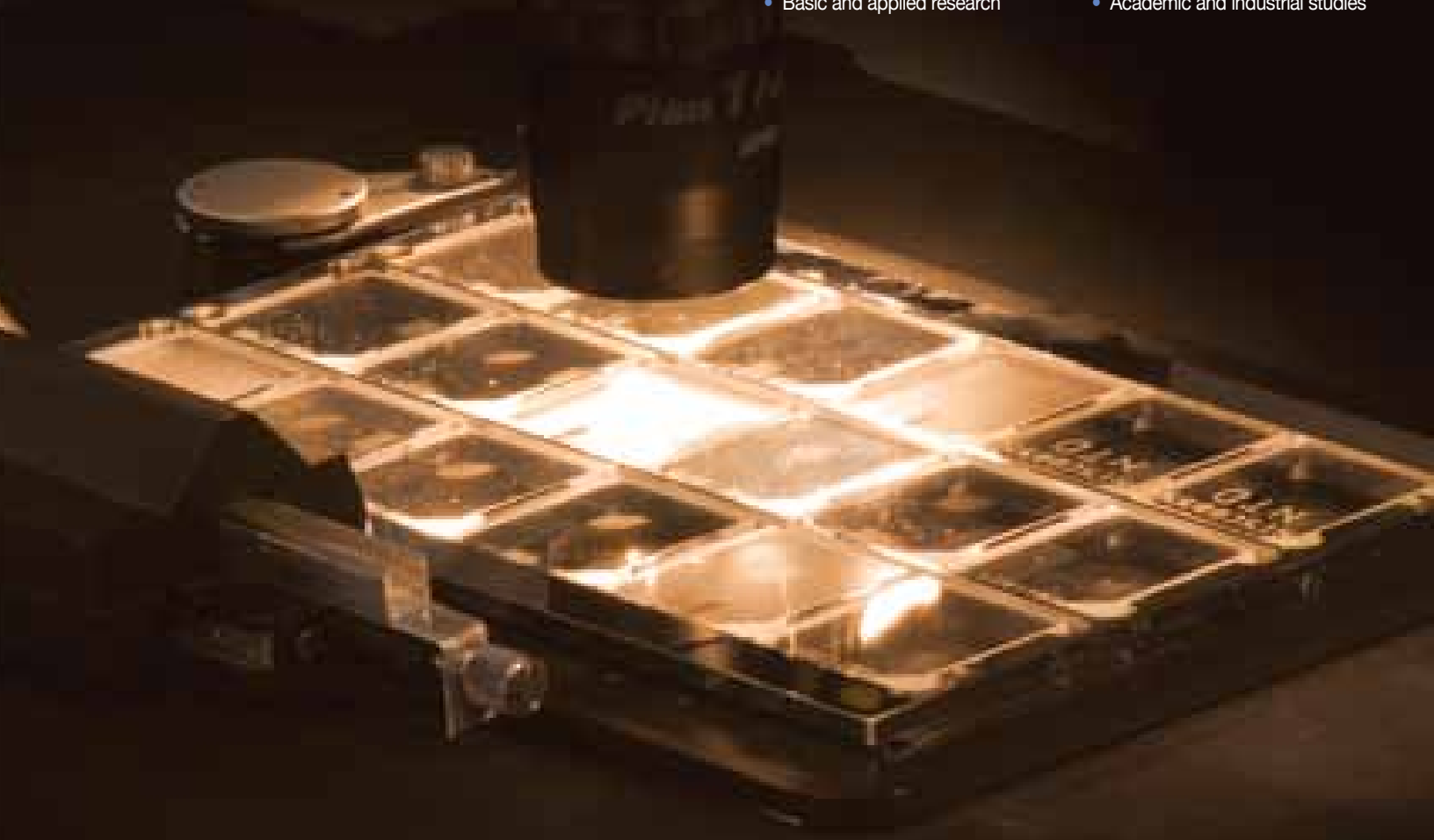
The most critical component of an SSNTD is the substrate material, and the most definitive SSNTD substrate material is ***CR-39***® material from Engineered Sheet Products. ESP technicians control the entire production process for SSNTDs made with ***CR-39***® material—from formulation onward. This vertical integration allows for customized sheet production and tight controls on the quality during production.

ADVANCED PERFORMANCE

- Provides a highly sensitive substrate that reveals detailed information for individual particles.
- Offers consistent material batches with low background tracks.
- Does not degrade, allowing for analysis at a later date. Measures over long periods of time, resulting in a more accurate reading compared to short-term monitoring.
- Enables simple, robust and inexpensive device construction that does not require complicated hardware or software.
- Produces permanent particle damage—nothing gets lost or averaged away.

APPLICATIONS

- Radon detection
- Autoradiography
- Cosmic radiation
- Basic and applied research
- Neutron dosimetry
- Positron emission tomography
- Dosimetry products
- Academic and industrial studies



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CR-39® MATERIAL ADVANTAGE

CR-39® material for SSNTDs is a specially formulated, clear, colorless sheet that is highly sensitive to the tracks of neutrons, protons, alpha particles and other charged and uncharged particles. This extreme sensitivity produces permanent particle damage and allows for detailed information, such as mass, charge, energy and direction, to be gathered for individual particles.

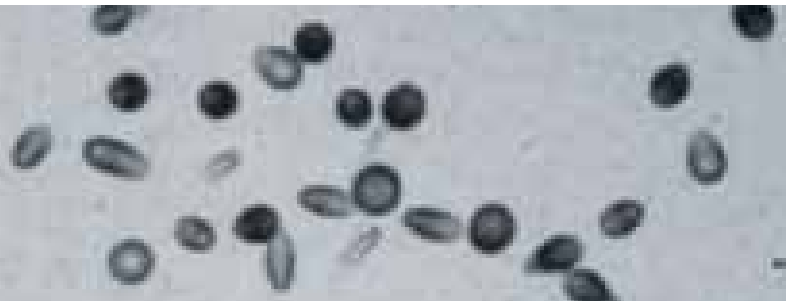
While other measurement methods sample radon concentration over very short periods of time, the age-resistance of SSNTDs made with ***CR-39***® material permit measurement over long periods to include short-term fluctuations, greatly increasing the accuracy of the reading exposure amounts. Sheets made from ***CR-39***® material also do not degrade, so detectors can be archived and analyzed at a later date.

INNOVATIVE TECHNOLOGY

A particle coming into contact with a detector made from ***CR-39***® material damages the material as it passes through and leaves a permanent trail, known as a track. Tracks can be observed and counted using a microscope once the detector is removed from the device and exposed to a caustic solution to enlarge the conical pits left by particles. This safe and simple process is known as etching.

The shape and size of each track provides additional information for specific particles. For example, a particle's energy level can be calculated by the size of its track. The direction from which the particle hit the sheet can be seen in the track's circular or elliptical shape at the point of contact.

This high level of visual detail—along with accuracy, simplicity and cost-effectiveness—is why SSNTDs made from ***CR-39***® material are leaving their own mark on the industry.



Microphotograph of particle tracks in CR-39 material from 222Rn decay.
Courtesy of INFN Bologna.

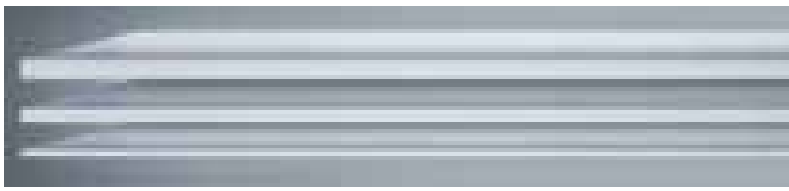
ADVANCED SOLUTIONS, DESIGNED AND ENGINEERED

ESP Engineered Sheet Products is a leading provider of high performance optical sheet solutions that are engineered to be lightweight, age and chemical resistant, mechanically durable and, above all, optically superior.

ENGINEERED SOLUTIONS

ESP offers design versatility through a wide range of standard and customizable product options.

- High-purity grade
- Finishing capabilities include engraved serialization codes
- Cut to any shape or size using a computer controlled laser
- Mechanical properties that can be varied to meet customer specifications



STANDARD AVAILABILITY

DIMENSIONS

[Tolerances: ± 0.1 mm]

- Custom sizes up to 620 mm

THICKNESS

[Tolerances: ± 5% of nominal value]

- 0.7 mm ; 1.0 mm ; 1.5 mm

BULK ETCH VELOCITY

Bulk etch rates (vB) of SSNTDs from ***CR-39***® material vary depending on the etching parameters. Here are examples of etching solution, temperatures and velocities used by some of our customers.

NaOH WATER SOLUTION	TEMPERATURE (°C)	BULK ETCH VELOCITY (um/h)
6N	40	0.100 +/- 0.002
6N	70	1.20 +/- 0.02
8N	80	4.20 +/- 0.21

When etched in an aqueous solution of sodium hydroxide (NaOH) or potassium hydroxide (KOH) at different temperatures and normalities, the post etch surface of the SSNTD has a fine transparency, enabling easy track counting.

BACKGROUND

ESP manufactures SSNTD sheets to have an extremely low background with high and consistent sensitivity to particles.

STORAGE

SSNTD sheets are sealed in aluminum bags filled with dry air and stored at about -20°C.

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