



# DUPONT™ 399X SERIES

## LEAD FREE SERIES - HEATED GLASS COMPOSITIONS

### PRODUCT DESCRIPTION

DuPont™ 399X Series Defogger Silver conductor compositions are provided for use in production of electrically heated glass. The 399X series will provide excellent printability and high print definition. Series members can be blended with each other to obtain a wide range of electrical resistance. These compositions have been designed to provide a robust fired layer that is resistant to environmental and chemical influences.

### PRODUCT BENEFITS

- Low laydown
- Wide range of electrical resistance
- Enhanced Green Strength
- Wide process window when co-firing over enamels
- Lead-Free\* and Cadmium-Free\*
- Robust printing performance
- Supplied ready to print

\*Cadmium and lead “free” as used herein means that these are not intentionally added to the referenced product. Trace amounts however may be present.

### PROCESSING

#### Blending

In order to obtain a specific resistance value, the pastes can be blended with each other. A computer program or semi logarithmic graphs can be used to determine blend recipes for specific heated window designs.

#### Drying

Allow printed paste to dry to desired green strength at between 125–150°C, if drying is needed.

### TYPICAL

Printing Parameters	
Screen mesh size (per inch)*	150 – 280
Emulsion thickness (µm)	12 - 25
Emulsion type	Terpene resistant
Enamel compatibility	Air Dried and some UV
Firing	
Average Glass Surface Temp. (°C)	600 - 670 over enamel 600 - 700 over glass
Furnace atmosphere	sulphite free
Soldering	
Burnish	Steel Wool or Fiberglass
Flux	Type R - rosin
Connector	Copper Clip or Braid pref. pre-tinned

\*stainless steel screens are used in laboratory testing

TABLE 1: COMPOSITION PROPERTIES

Test	Properties		
	3991	3992	3993
Silver Content (%)	78.8	61.5	59.6
Total Solids (%)	82.0 – 84.0	64.5 – 66.5	64.0 – 66.0
Viscosity (Pa·S) [Brookfield RVT #14 @ 10 rpm]	25 – 40		
Thinner	DuPont 9450		

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**TABLE 2: TYPICAL PHYSICAL PROPERTIES**

Test	Properties		
	3991	3992	3993
Resistivity			
Typical ( $\Omega/\text{ft}$ )	0.7	1.7	2.7
Typical ( $\text{m}\Omega/\text{sq}$ ) @ 8 $\mu\text{m}$	3.1	3.4	10.3
Rel. Range ( $\pm$ %)	20	20	20
Fired Thickness ( $\mu\text{m}$ ) Range Typical	10.0 – 14.0	8.0 – 12.0	8.0 – 10.0
Line Width ( $\mu\text{m}$ ) Range	350 – 800		
Color	Light Brown/Yellow Dark Brown		
Air side color			
Tin side color			
Solder metallurgy	Pb and Pb-free		
Adhesion (kg force)			
Pb containing Clips	40	25	32
Pb-free Clips	55	58	56

### Test procedures

Typical properties are based on laboratory tests, using the following conditions:

Printing: 200 mesh stainless steel screen, 12 $\mu\text{m}$  emulsion

Firing: 30 minute cycle, 11 zone belt furnace, peak temperature of 640°C

Adhesion Test: Soldered copper clip, 70Pb/27Sn/3Ag, and Pb-free (In content) reflowed with flame Substrate: 2"x4" soda lime silicate glass, 4 mm thick

Tables 1 and 2 show anticipated typical physical properties for DuPont 399X series based on specific controlled experiments in our labs and are not intended to represent the product specifications, details of which are available upon request.

## 399X PB-FREE BLEND DENSITIES AND RS

	Gardco WG- SS-83.2 Cup Wgt (g)	Gardco WG- SS-8.32 Cup Wgt (g)	Paste Density	Nominal R ( $\Omega/\text{ft}$ )	Nominal R ( $\text{m}\Omega/\text{sq}/8\mu\text{m}$ )	Nominal SR ( $\mu\Omega\text{-cm}$ )
<b>3991</b>	323.0	32.3	3.88	0.72	3.12	2.50
90:10	310.3	31.0	3.73	0.82	3.15	2.52
80:20	297.5	29.8	3.58	0.92	3.18	2.55
70:30	284.8	28.5	3.42	1.02	3.21	2.57
60:40	272.0	27.2	3.27	1.12	3.25	2.60
50:50	259.3	25.9	3.12	1.22	3.28	2.62
40:60	246.6	24.7	2.96	1.32	3.31	2.65
30:70	233.8	23.4	2.81	1.41	3.34	2.67
20:80	221.1	22.1	2.66	1.51	3.37	2.70
10:90	208.4	20.8	2.50	1.61	3.40	2.72
<b>3992</b>	195.6	19.6	2.35	1.71	3.43	2.75
90:10	195.6	19.6	2.35	1.80	4.12	3.06
80:20	195.2	19.5	2.34	1.89	4.80	3.36
70:30	194.8	19.5	2.34	1.98	5.49	3.67
60:40	194.4	19.4	2.33	2.07	6.18	3.97
50:50	194.0	19.4	2.33	2.16	6.87	4.28
40:60	193.6	19.4	2.33	2.24	7.55	4.58
30:70	193.2	19.3	2.32	2.33	8.24	4.89
20:80	192.8	19.3	2.32	2.42	8.93	5.19
10:90	192.4	19.2	2.31	2.51	9.61	5.50
<b>3993</b>	192.0	19.2	2.31	2.60	10.30	5.80

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	Gardco WG- SS-83.2 Cup Wgt (g)	Gardco WG- SS-8.32 Cup Wgt (g)	Paste Density	Nominal R ( $\Omega$ /ft)	Nominal R (m $\Omega$ /sq/8 $\mu$ m)	Nominal SR ( $\mu\Omega$ -cm)
<b>3991</b>	323.0	32.3	3.88	0.72	3.10	2.50
90:10	309.9	31.0	3.72	0.91	3.82	2.83
80:20	296.8	29.7	3.57	1.10	4.54	3.16
70:30	283.7	28.4	3.41	1.28	5.26	3.49
60:40	270.6	27.1	3.25	1.47	5.98	3.82
50:50	257.5	25.8	3.10	1.66	6.70	4.15
40:60	244.4	24.4	2.94	1.85	7.42	4.48
30:70	231.3	23.1	2.78	2.04	8.14	4.81
20:80	218.2	21.8	2.62	2.22	8.86	5.14
10:90	205.1	20.5	2.47	2.41	9.58	5.47
<b>3993</b>	192.0	19.2	2.31	2.60	10.30	5.80

### STORAGE AND SHELF LIFE

Containers should be stored, tightly sealed, in a clean, stable environment at room temperature (<25°C). Shelf life of material in unopened containers is six months from date of shipment. Some settling of solids may occur and compositions should be thoroughly mixed prior to use.

### SAFETY AND HANDLING

For information on health and safety regulations please refer to the specific product MSDS.



## DUPONT™ 399X SERIES

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