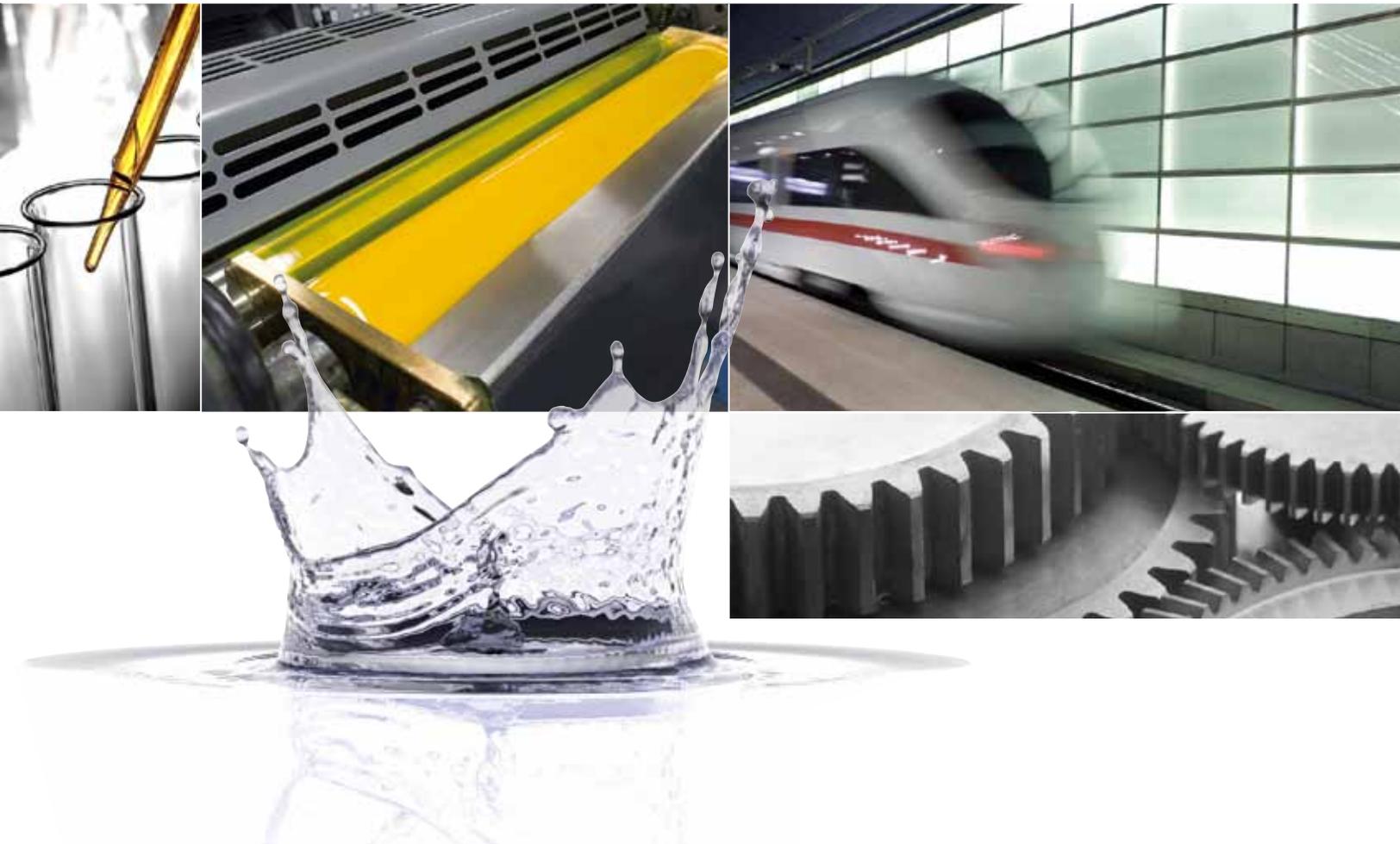


# Silwet\* Surfactants



agriculture

chemicals

plastics

lubrication

release

metal working

textiles

water treatment

construction

specialties

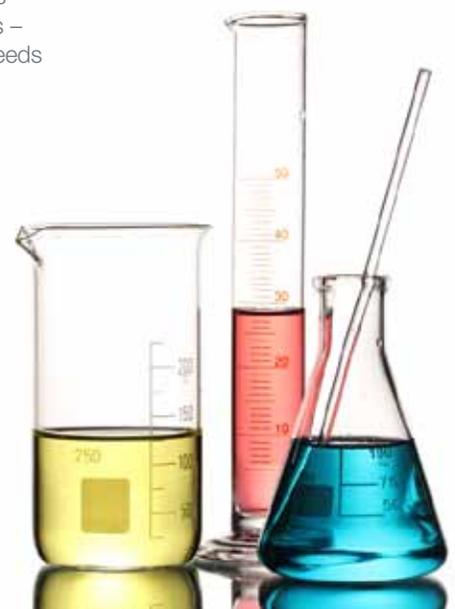




## Silwet\* Surfactants

Silwet surfactants are a very versatile line offering virtually unlimited capabilities in many diverse applications. How deep an active penetrates a substrate, how evenly a coating wets a surface, how well particles get dispersed in a formulation or how far and thin an aqueous product spreads on a leaf can make the difference between application success and failure.

Our Silwet surfactants can provide the critical performance difference in your applications. They have high surface activity and can dramatically reduce the interfacial tension at very low addition levels. Due to the combination of different chemistries - where each chemistry adds their respective set of properties - Momentive's Silwet surfactants can adapt to a multitude of needs and environments.



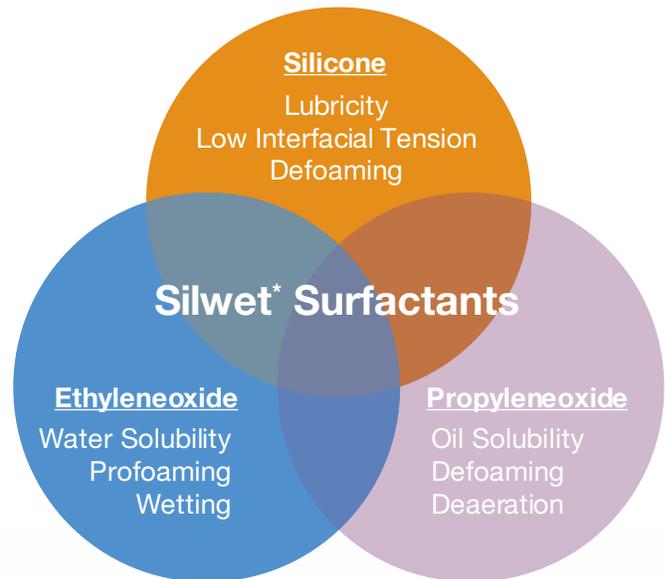
\*Silwet is a trademark of Momentive Performance Materials Inc.

## The Silwet\* Surfactant Portfolio

Most Silwet surfactants are block surfactants of silicone, ethyleneoxide (EO) and/or propyleneoxide (PO). Typically they have a pendant structure (Figure 1) or a linear (ABA)-structure (Figure 2). Silwet compositions depend on the respective magnitude of the variables x, y, m and n.

Silwet trisiloxanes are a unique range of products (Figure 3). These materials are referred to as superspreaders, because they can provide active spreading and penetration to water-based formulations (Figure 5).

- A molecule with significant silicone content will exhibit lubricity (e.g. fiber lubricants), release (shear stable, water based release agents) friction reduction (e.g. assembly of plastic parts), slip/mar resistance, gloss and sheen in polish applications, and moderate foam control.
- A product with high polyethyleneoxide content will be self-dispersible or soluble in water or polar solvents. It reduces the interfacial tension and thus aids the wetting, flow and leveling of formulations based on such solvents.
- A material of high polypropyleneoxide content will be self-dispersible or soluble in non-polar solvents. It reduces the interfacial tension of such solvents and thus aids the wetting, flow and leveling of formulations based on such solvents. It will often perform as a foam-control and deaeration agent (anti-cratering).

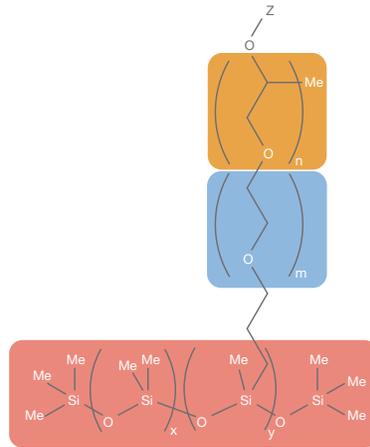


\*Silwet is a trademark of Momentive Performance Materials Inc.

## Pendant Structure

Figure 1

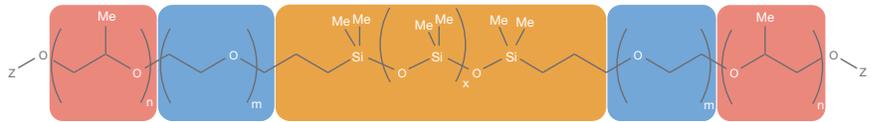
Silicone-polyether block surfactant  
Wide range, versatility



## Linear (ABA) Structure

Figure 2

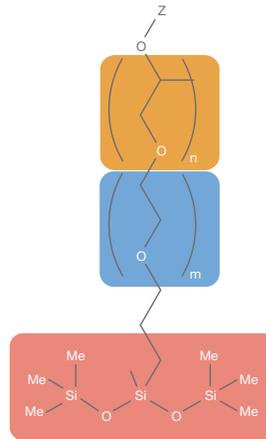
Silicone-polyether block surfactant  
Molecule orientation, softness



## Trisiloxane Structure

Figure 3

Alkyleneoxide Trisiloxane  
Superspreading



## Silwet\* Triangle

The Silwet triangle offers easy access to a range of Silwet surfactants. Each point within the triangle depicts a percent composition based on silicone, ethylene oxide (EO) and polypropylene oxide (PO). Each vertex equals a product containing 100% by weight of silicone (top), EO (bottom left) and PO (bottom right).

### Need foaming, antifogging, leveling or water solubility?

Surfactants nearest to ethyleneoxide, at the left hand vertex can be considered.

### Need defoaming in water or water based systems, deaeration or oil solubility?

Silwet surfactants closest to propyleneoxide, at the right hand vertex can be considered.

### Need release, lubricity, coefficient of friction reduction, slip, defoaming, surface tension reduction, sheeting or gloss?

Consider Silwet surfactants at the top of the pyramid with the highest silicone content.

### Need maximum static and dynamic surface tension reduction and thus wetting, spreading, leveling or antifog?

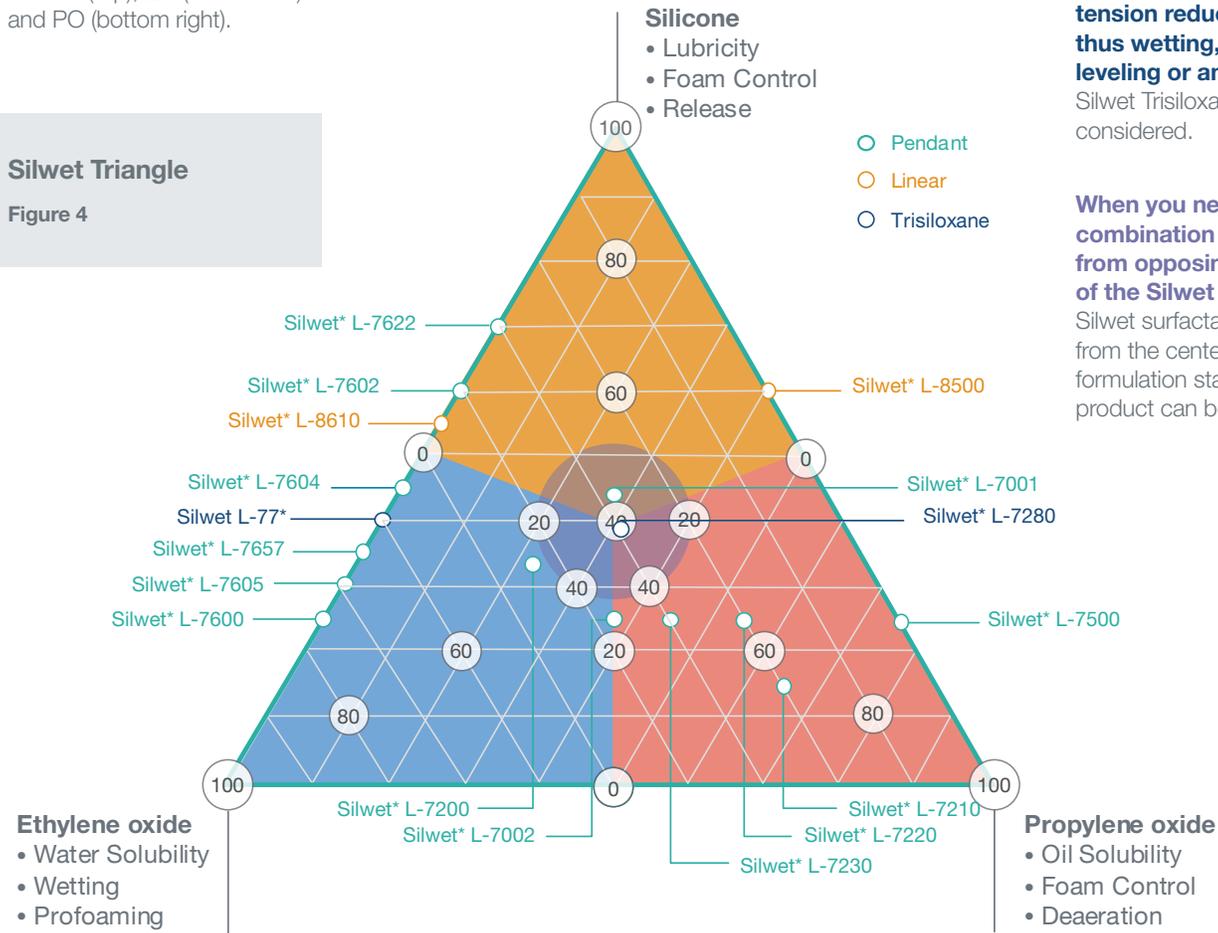
Silwet Trisiloxanes can be considered.

### When you need a combination of properties from opposing corners of the Silwet triangle?

Silwet surfactant grades from the center with the best formulation stability in your product can be considered.

## Silwet Triangle

Figure 4



\*Silwet is a trademark of Momentive Performance Materials Inc.

## Wetting

To provide efficient coverage, a formulation must stay evenly distributed on a surface. Insufficient wetting can be encountered if a formulation retreats from a surface leaving uncovered areas or craters. Silwet\* surfactants can significantly reduce the surface tension of formulations. This means that in most cases formulations containing small amounts of Silwet surfactants spread easier and more evenly on surfaces or penetrate substrates more deeply compared to the same formulation without.

Also, many low surface energy substrates - especially those with sharp edges - are difficult to cover.

Silwet surfactants offer low surface tension contribution of the silicone portion of the polymer. However, unmodified silicones are not soluble in water or polar solvents like methanol or ethanol. By attaching polyalkyleneoxide, Silwet surfactants can achieve higher solubility, while maintaining the benefits of the silicone.

We can provide a selection of products to support both aqueous and non-aqueous formulations, combined with a unique set of properties, depending on your

requirements such as, a water soluble product that supports foam or, alternatively, one that helps to suppress it.

## Spreading

While wetting can be achieved by applying a formulation on a surface by brush, roller or blade, in the case of spreading, the formulation proactively spreads onto a surface on its own. This is especially useful to reduce application time or if a formulation is applied by spray.

While all spreaders are wetting aids, not all wetting aids

provide spreading.

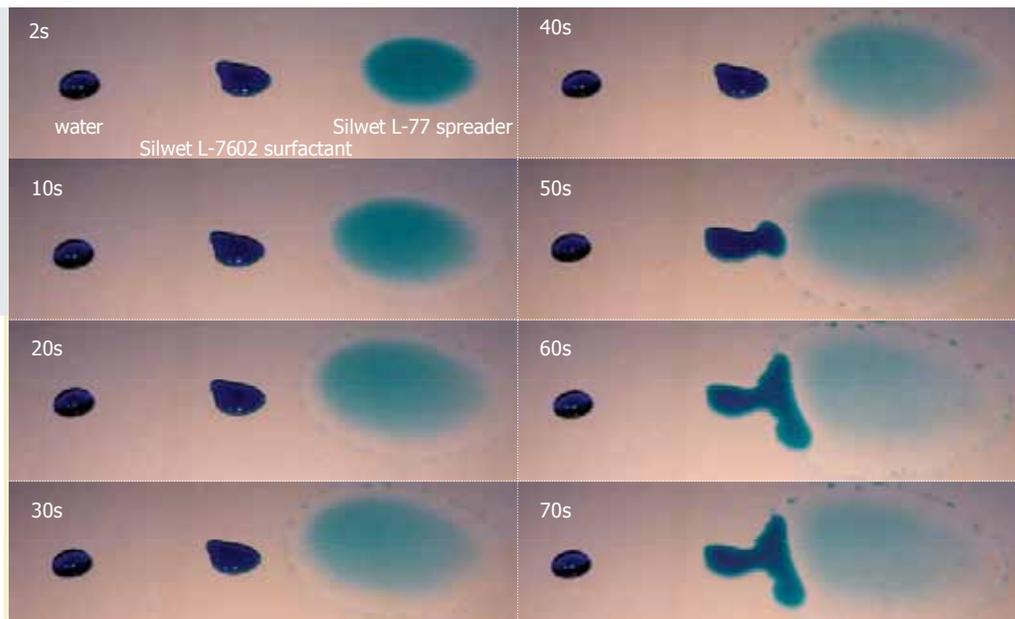
In general, spreading increases with lower surface tension, but that is not the only factor. Size and structure of the surfactant molecule also play key roles in spreading your product across a surface or into a substrate.

Due to their special design, Silwet trisiloxane surfactants and Silwet\* Hydrostable\* surfactants can provide excellent spreading performance and are thus referred to as superspreaders (Figure 5). The most common use levels in the range from 0.01% to 0.75 % weight are sufficient to achieve the desired effect.

**Figure 5**

Comparison of the spreading behavior of water, 0.5% weight Silwet L-7602 surfactant and 0.5% weight Silwet L-77\* spreader on polyethelene (PE) surface.

Note: Test results. Actual results may vary.



\*Silwet, Silwet L-77 and Hydrostable are trademarks of Momentive Performance Materials Inc.

## Gloss, Release & Antiblock

Silicone can provide excellent release and lubricity, especially for rubber-to-rubber, plastic-to-plastic or plastic-to-steel friction. For waterborne applications silicone emulsions are often used. These are white emulsions prone to creaming and separation, especially if diluted to low active content (0.5% to 5% weight-% are most commonly used).

Silwet\* surfactants translate this benefit of lubricity into a stable, soluble or dispersible form. In contrary to common emulsions no additional components - like emulsifiers and thickeners – are needed.

Where the silicone component dominates, another silicone property also comes into the foreground – a glossy appearance or color deepening effect on plastic surfaces, known from many polish formulations and conditioning agents. Again the water compatibility of Silwet surfactants allows formulating gloss providing products without the need to add other additives, which might diminish the effect.

## Foaming & Defoaming

The secret to stabilizing foam lies in the interface between the liquid and the entrapped air. Protoamers stabilize this interface preventing the bubbles from bursting. Defoamers destabilize the barrier forcing the air to escape more quickly.

Silicone – due to its low surface tension – is attracted to this interface and destabilizes it. As a result, Silwet surfactants with a high silicone content act as defoamers, while the surfactants with low silicone content and high water solubility act as foam stabilizers.

## Emulsifiers & Dispersants

Our specialty surfactants go straight to the oil/water or particle/water interface where stability is essential to prevent or delay separation. They are especially useful to compatibilize silicone based products or silicone coated particles, like pigments. Their low surface energy can make them effective at low dosage and their high molecular weight keeps them at the interface while protecting them against aggregation. 0.5% to 2.0% weight addition level, based on the weight of the dispersed phase are good starting levels. The finer the achieved particle size of the emulsion droplets or the larger the surface of the particle to disperse, the more Silwet surfactant is needed.

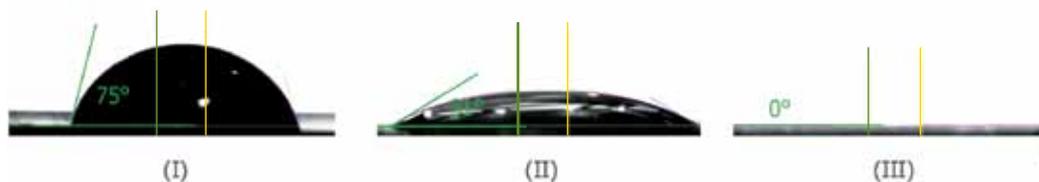
In many cases Silwet surfactants act synergistically with other organic emulsifiers, so your products durability can be increased.



\*Silwet is a trademark of Momentive Performance Materials Inc.

**Figure 6**

Contact angle measurements on polystyrene of (I) water and aqueous solutions of (II) 0.25% weight Octylphenoethoxylate and (III) 0.10% weight Silwet L-77\* Spreader.



Note: Test results. Actual results may vary.

## Aqueous Stability

The silicone backbone of Silwet\* surfactants is prone to hydrolysis under either acidic or alkaline conditions in aqueous systems. This effect is more pronounced with trisiloxanes where hydrolysis starts when the pH is below 6 (acidic) or higher than 8 (alkaline). This hydrolysis quickly degrades the silicone component and thus the superspreading properties that are critical in many applications. In order to overcome this hydrolysis, Momentive has developed and manufactures Silwet\* Hydrostable\*, which combines the exceptional spreading and wetting performance of Silwet trisiloxanes with an aqueous stability ranging from pH 2 to pH 12.

Typically, each type of Silwet surfactant shows long term stability within the pH-range listed below:

	Stable from:
<b>Silwet Trisiloxanes</b>	<b>pH 6.5 to 7.5</b>
Silwet Surfactants - pendant & linear	pH 5.5 to 8.5
Silwet Hydrostable surfactants	pH 2.0 to 12.0 (best case)

<sup>1</sup> Silwet hydrostable surfactants not shown in diagrams or tables.

<sup>2</sup> Due to their chemical structure, long term stability cannot be achieved in aqueous formulation. This pH-range allows moderate stability.

Surfactant	Wt.-%	Eq. surface tension [mN·m <sup>-1</sup> ]	Relative spread area	pH-Stability range
<b>Organic</b>	<b>0.5</b>	<b>~35</b>	<b>4</b>	<b>n/a</b>
Silwet L-77	0.1	20.5	172	6.5-7.5
Silwet Hydrostable 68	0.1	21.0	130	6.0-8.0
Silwet Hydrostable 611	0.1	25.8	100	6.0-11.0
Silwet Hydrostable 212	0.1	26.7	105	2.0-12.0

Note: Typical data are average data and actual results may vary. Typical data shall not be used as product specifications. Test results. Actual results may vary.



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**Table 1**

Silwet\* dose rate recommendations for selected applications.

Application and Use Levels	Recommended use level [weight %]
<b>Textile fiber processing</b>	
Fiber finish	0.5 - 2.0 <sup>1</sup>
Texturising finish	0.5 - 2.0 <sup>1</sup>
<b>Chemical specialities</b>	
Levelling agent	0.1 - 1.0
Anti-static agent	0.1 - 1.0
Anti-fog agent	0.1 - 1.0
Lubricant agent	0.5 - 100
<b>Solvent based coatings/inks</b>	
Mar resistance	0.05 - 2.0
<b>Water based coatings</b>	
Urethane bubble release	0.05 - 2.0
Flow and leveling	0.05 - 2.0
<b>Metal working</b>	
Cutting fluid	0.1 - 2.0
Rolling oil	0.2 - 1.0
<b>Plastic Processing</b>	
Anti-blocking agent	0.1 - 1.0
Anti-static	0.1 - 1.0
<b>Lubricant / release</b>	
Rubber and Plastic	0.5 - 1.0
Paint and glue receptivity	1.0 - 3.0
<sup>1</sup> Parts by weight additive per hundred parts textile	



\*Silwet is a trademark of Momentive Performance Materials Inc.

**Table 2**

Silwet\* product-property matrix

Silwet* Surfactants	Foam <sup>a</sup>	Wetting	Penetration	Gloss	Defoaming	Lubricity	Release	Pigments Disperse	O/W Emulsifier
Silwet L-77*	Foaming		++++	+	+++	+	+	++	+++
Silwet L-7001	Moderate	+	+	+		+		+	+
Silwet L-7002	Moderate	+	+		+			+	+
Silwet L-7200	Foaming	+	+	++++	+	+	++	+	+
Silwet L-7210	Defoaming	+	++	+			+	++	+++
Silwet L-7220	Defoaming		+	+				+	+++
Silwet L-7230	Foaming	+		+	+	+		+	+
Silwet L-7280	Moderate		++++	+	+++	+	+	++	+++
Silwet L-7500	Defoaming		++				+	++	
Silwet L-7600	Foaming	++	++		+			+	+
Silwet L-7602	Defoaming	++	++	+	+	+	++	++	+++
Silwet L-7604	Moderate	+	++	+	+				+
Silwet L-7605	Foaming	+	+		+				+
Silwet L-7608	Foaming		++++	+	+++	+	+	++	+++
Silwet L-7622	Defoaming			++++		++++	++++		
Silwet L-7657	Foaming	+	+		+				+
Silwet L-8500	Defoaming		++	+		++++	++++	+	
Silwet L-8610	Defoaming	++	++	+	+	+	++	+	+

<sup>a</sup> Foaming in aqueous systems

Note: Typical data are average data and actual values may vary. Typical data shall not be used as product specifications.



\*Silwet and Silwet L-77 are trademarks of Momentive Performance Materials Inc.

**Table 3**

Structural information on Silwet\* surfactants.

Silwet* Surfactants	Structure <sup>l</sup>	CAS- number	Ratio EO/ PO	Cap <sup>m</sup> [Z]	Molecular weight [g/mol]	Percent actives
Silwet L-77*	Trisiloxane	27306-78-1	All EO	CH <sub>3</sub>	600	100%
Silwet L-7001	Pendant	67762-85-0	40/60	CH <sub>3</sub>	20,000	75%
Silwet L-7002	Pendant	67762-87-2	50/50	(CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	8,000	100%
Silwet L-7200	Pendant	68937-55-3	75/25	H	19,000	100%
Silwet L-7210	Pendant	68937-55-3	20/80	H	13,000	100%
Silwet L-7220	Pendant	68937-55-3	20/80	H	17,000	100%
Silwet L-7230	Pendant	68937-55-3	40/60	H	29,000	100%
Silwet L-7280	Trisiloxane	134180-76-0	40/60	H	600	100%
Silwet L-7500	Pendant	68550-66-4	All PO	(CH <sub>2</sub> ) <sub>3</sub> CH <sub>3</sub>	3,000	100%
Silwet L-7600	Pendant	68938-54-5	All EO	CH <sub>3</sub>	4,000	100%
Silwet L-7602	Pendant	68938-54-5	All EO	CH <sub>3</sub>	3,000	100%
Silwet L-7604	Pendant	68937-54-2	All EO	H	4,000	100%
Silwet L-7605	Pendant	68938-54-5	All EO	CH <sub>3</sub>	6,000	100%
Silwet L-7608	Trisiloxane	67674-67-3	All EO	H	600	100%
Silwet L-7622	Pendant	68938-54-5	All EO	CH <sub>3</sub>	10,000	100%
Silwet L-7657	Pendant	68937-54-2	All EO	H	5,000	100%
Silwet L-8500	Linear	161755-53-9	All PO	H	2,800	100%
Silwet L-8610	Linear	102783-01-7	All EO	H	1,700	100%

Note: Typical data are average data and actual values may vary. Typical data shall not be used as product specifications.

<sup>l</sup> Generic structural types as displayed in Figure 3, Figure 4 & Figure 5.

<sup>m</sup> Variable, 'Z' as per generic structural types as displayed in Figure 3, Figure 4 & Figure 5.

<sup>n</sup> Estimated HLB-values calculated by the formula: Estimated HLB = weight-% (EO) · 20.



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**Table 4**

Solubility of Silwet\* surfactants in selection of solvents at 25°C (77°F) and at 0.1%, 1. 5%. 20% and 80% weights.

Silwet* Surfactants	Ratio EO/PO	Water	Hexanes	Acetone	Xylenes	CH <sub>2</sub> Cl <sub>2</sub>
Silwet L-77*	All EO	DDDIG	SDIDS	SSSSS	SSSSS	SSSSS
Silwet L-7001	EO/PO	SSDDS	IIIII	SSSSS	SSSSS	SSSSS
Silwet L-7002	EO/PO	SSSSS	IIIIIS	SSSSS	SSSSS	SSSSS
Silwet L-7200	EO/PO	SSSSG	IIIIIS	SSSSS	SSSSS	SSSSS
Silwet L-7210	EO/PO	SDDIG	IIIIIS	SSSSS	SSSSS	SSSSS
Silwet L-7220	EO/PO	DDDDI	SSSSS	SSSSS	SSSSS	SSSSS
Silwet L-7230	EO/PO	SSSSG	IIIIIS	SSSSS	SSSSS	SSSSS
Silwet L-7280	EO/PO	DDDG	SSDDS	SSSSS	SSSSS	SSSSS
Silwet L-7500	All PO	IIIIIG	SSSDS	SSSSS	SSSSS	SSSSS
Silwet L-7600	All EO	SSSSS	IIIII	SSSSS	SSSSS	SSSSS
Silwet L-7602	All EO	DDDDG	SIIIS	SSSSS	SSSSS	SSSSS
Silwet L-7604	All EO	SSSSS	IIIII	SSSSS	SSSSH	SSSSS
Silwet L-7605	All EO	SSSSS	IIIII	SSSSS	SSSSS	SSSSS
Silwet L-7608	All EO	SDDIG	SIIIS	SSSSS	SSSSS	SSSSS
Silwet L-7622	All EO	IIIIIG	SSIID	SSSSS	SSSSS	SSSSS
Silwet L-7657	All EO	SSSSS	IIIII	SSSSS	SSSSS	SSSSS
Silwet L-8500	All PO	IIIII	SSSSS	SSSSS	SSSSS	SSSSS
Silwet L-8610	All EO	SDIIG	SIIII	SSSSS	SSSSS	SSSSS

Note: Typical data are average data and actual values may vary. Typical data shall not be used as product specifications.

S = Soluble: Clear or slightly hazy solution.

D = Dispersible: Hazy, stable dispersion, partially soluble.

I = Insoluble: Unstable dispersion, separates on standing into two phases.

G = Gel: A clear Gel at low water concentration, except an opaque gel in the case of Silwet\* L-7500.



\*Silwet and Silwet L-77 are trademarks of Momentive Performance Materials Inc.

Table 5

Silwet\* Typical Physical Properties

Silwet Surfactant	Polyether Type	Cloud Point <sup>a</sup>	Viscosity <sup>b</sup> cSt	Surface Tension <sup>c</sup>	Estimated HLB <sup>d</sup>	Specific Gravity	Flash Point °C	CMC wt. %	VOC g/l (ASTM D-2369)
Silwet L-77*	All EO	k	20	20.5	Low	1.007	116	0.007	29.8
Silwet L-7001	EO/PO	39	1700	28.2	Med	1.030	97	0.002	8.6
Silwet L-7002	EO/PO	39	900	30.5	Med	1.028	123	0.003	11.7
Silwet L-7200	EO/PO	77	2500	34.2	High	1.064	123	0.002	10.1
Silwet L-7210	EO/PO	25	1000	30.3	Low	1.070	135	0.009	8.7
Silwet L-7220	EO/PO	24	1100	26.8	Low	1.017	143	0.010	7.0
Silwet L-7230	EO/PO	40	4000	32.4	Med	1.033	135	0.020	13.4
Silwet L-7280	EO/PO	k	35	21.5	Low	1.002	143	0.003	2.7
Silwet L-7500	All PO	i	140	i	Low	0.987	121	i	11.1
Silwet L-7600	All EO	64	110	25.1	High	1.066	74	0.005	12.2
Silwet L-7602	All EO	k	100	26.6	Low	1.027	127	0.003	13.3
Silwet L-7604	All EO	50	420	25.4	High	1.063	79	0.004	17.4
Silwet L-7605	All EO	93	210	30.2	High	1.068	138	0.030	5.4
Silwet L-7608	All EO	k	35	21.5	Low	1.020	118	0.010	12.1
Silwet L-7622	All EO	i	400	i	Low	1.019	110	i	13.9
Silwet L-7657	All EO	89	600	27.6	High	1.090	129	0.002	8.7
Silwet L-8500	All PO	i	250	i	Low	0.988	113	i	n.a.
Silwet L-8610	All EO	k	125	25.7	Low	1.032	132	0.005	n.a.

Note: Typical data are average data and actual values may vary. Typical data shall not be used as product specifications.

a Typical Values on Gardner Varnish Scale.

b Apparent Specific Gravity at 25/25°C (35/25°C for Silwet\* L-7605).

c Pensky-Martens, Closed Cup, ASTM method D93.

d Typical Viscosity at 25°C (35°C for Silwet\* L-7605).

e 1% Solutions, 5 minute reading ASTM D1173-53.

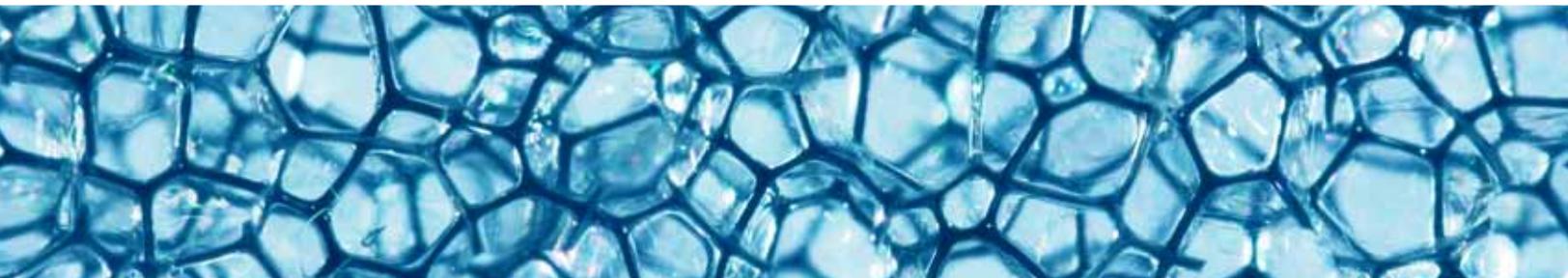
f Typical Values at 25°C on 0.1% (w/w) aqueous solutions using either De Nouy Ring or Wilhelmy Plate Method.

g Typical values measured visually on 1% (w/w) aqueous solutions.

h ASTM D-2392.

i Insoluble in water.

k Dispersible in water at 1% (w/w) but hazy ;cloud point at 0.1% is < 10 °C



\*Silwet and Silwet L-77 are trademarks of Momentive Performance Materials Inc.

# Application Selector

Table 6

## Silwet\* Surfactants

Markets	Applications	Silwet L-77*	Silwet L-7608	Silwet L-7280	Silwet L-7600	Silwet L-7602	Silwet L-7604	Silwet L-7605	Silwet L-7657	Silwet L-7622	Silwet L-8610	Silwet L-7001	Silwet L-7002	Silwet L-7200	Silwet L-7210	Silwet L-7220	Silwet L-7230	Silwet L-7500	Silwet L-8500
<b>Chemicals</b>	Wetting	•	•	•		o	o				o				o				
	Spreading	•	•	•		•	•		•										
	Flow & Leveling	•	•	•		•		•	•				•						
	Lubricant (aqueous)	o		o		o				•	o	•		•	o		o		
	Lubricant (non-aqueous)																	•	•
	Antifog	•	•	•		•	o				o			o				o	
	Sheeting	•	•	•	o	o						o							
	Slip, Mar Resistance		o								•		•						•
	Defoamer (aqueous)										•			•		•			•
	Defoamer (non-aqueous)				•	•			•			o							•
	Profoamer		•		•				•	•				o				•	
	Foam Stabilization													•				•	
	Oils Emulsification	o		o	o	•	o						•			•	•		
	Solids Dispersion	•	•	•	o		o	o	o			•	o		o	•	o	o	
<b>Polishes</b>	Finish, Gloss, Sheen					•	o			•		•	o			•			
	Grease Cleaner	•	•	•					•										
<b>Plastics &amp; Rubber</b>	Urethane Bubble Release					•	•												
	Metal to Plastic Lubricant											•	•					•	
	Lubricant				•	•	•												
	Antiblock & Release					•				•	o	•		o	o	•		•	
<b>Metal Working</b>	Cutting Fluids Additives											•	•						
	Rolling Oils Additives											•	•						

• = Suggested

o = Alternative



\*Silwet and Silwet L-77 are trademarks of Momentive Performance Materials Inc.

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