

# SILVADUR™ FLEX Application Guidelines

**Pad it. Exhaust it.**

**SILVADUR™ Antimicrobial Means Easy Application. First Time. Every Time.**

**May 07, 2020**

SILVADUR™ Antimicrobial is a liquid formulation that can be easily applied to any natural or synthetic fiber using most industry standard equipment for pad or exhaust methods. Simply defined, the pad process involves passing a fabric through a bath containing an antimicrobial product and water. The fabric is then dried to remove any excess water, leaving the antimicrobial product on the fabric. The exhaust method, on the other hand, is a batch process where fabric, garment, or yarn either in a static or dynamic set up is soaked in a circulated or non-circulated bath containing the antimicrobial product and water, and the antimicrobial product is transferred to the textile. Any excess water in the fabric is then removed and the fabric is dried, leaving the antimicrobial product on the fabric.

SILVADUR™ antimicrobial efficacy and wash durability performance when applied on a variety of textiles using either pad or exhaust methods has been extensively validated globally using internationally accepted standard methods. etc.

## SILVADUR™ Application Level

SILVADUR™ products can be applied using most industry standard conditions. If co-application of SILVADUR and auxiliary finishing chemicals is required, compatibility of the application solution should be determined in the laboratory prior to production-scale trials. It is highly recommended that SILVADUR™ be applied prior to any sacrificial, non-durable treatments during chemical finishing (e.g., before repellents, moisture wicking additives, softeners, etc.). Complete rinsing and neutralization of fabric prior to the addition of SILVADUR™ product is required in order to achieve the highest durability of the final silver-polymer system.

Below is the recommended SILVADUR™ product application level to deliver excellent antimicrobial and anti-odor performance on fabrics with high durability.

Antimicrobial Product	Weight % product in bath, 100% WPU	Weight % product in bath, 80% WPU	Target silver on weight of fabric (ppm)	# home laundering
SILVADUR™ 930 Flex	2.0	2.5	20	20
	3.0	3.8	30	40
	5.0	6.3	50	50
SILVADUR™ 960 Flex	1.3	1.7	20	20
	2.0	2.5	30	40
	3.3	4.2	50	50

## SILVADUR™ Products Pad-Applied on Various Textiles

A pad process is commonly used to add finishes to fabrics. In this process, the bath can be easily prepared by mixing SILVADUR™ with water and fabric softener directly in the trough of the padding machine, or by mixing in a separate tank and then transferring it to the padding machine. In this batch process, SILVADUR™ may need to be replenish over time if the working bath is depleted and the SILVADUR™ concentration decreases below the targeted dose level. Some mills may use an automatic dosing line or a metered pump to maintain a continuous process. In this case, the mill can dose each bath ingredient using separate metered pumps, or a working bath can be prepared separately in a large side tank (separate dilution vessel) that is then transferred into the padding machine. For either of these methods, ensure baths are continuously mixed. To achieve the targeted SILVADUR™ concentration on the final dry fabric (owg), the SILVADUR™ bath concentration must be calculated and prepared correctly based on the appropriate wet-on-dry or wet-on-wet pick-up. Below are general instructions to incorporate SILVADUR™ into the bath for the pad-applied process.

### SILVADUR™ Pad Applications

#### Instructions

1. Completely rinse and neutralize fabric.
2. In a separate dilution vessel, add 80% water based on required volume of the padding machine (Note 1).
3. Add SILVADUR™ product gradually to room temperature water with constant stirring at a concentration appropriate for obtaining proper final concentration based on the wet weight pick-up of fabric. If bath solution pH must be acidic, lower diluted application solution pH using a weak acid; avoid citric acid. Do NOT lower the pH of the bath solution below pH 4.5, and preferably maintain pH between 5.0 and 8.5 for color sensitive fabric (e.g., white fabric)
4. Add additional water with continued agitation up to 100% of bath volume. (Note 2).
5. Add this diluted solution of SILVADUR™ product to the main padding trough.
6. Pad apply using standard temperature and pressure in order to obtain desired SILVADUR™ product treatment based on the weight of the goods.
7. Dry fabrics below 180°C. No specific cure temperature is required.

**Note 1:** City Tap water is preferred; high hardness water, including underground water is not recommended. We recommend conducting a small-scale trial before full-scale production if uncertain on impact of water quality.

**Note 2:** Final fabric pH will remain at/below 7.0 even if SILVADUR™ 930 FLEX treatment bath is above 7.0 due to ammonia evaporation during drying.

## SILVADUR™ Performance on Pad-Applied Textiles

SILVADUR™ products are successfully applied using a pad process on various fabrics such as cotton, polyester, nylon, or blends and providing antimicrobial efficacy  $\geq 99$  percent reduction of *E. coli*, *K. pneumoniae*, and *S. aureus* after 24 hours of contact time. The fabrics also passed sensory odor control testing after 40 simulated laundering cycles. Some examples of antimicrobial efficacy for pad-applied SILVADUR™ on various fabrics can be viewed below.

Textiles	SILVADUR™ Antimicrobial Concentration	Antimicrobial Efficacy		
		Testing Methods	Microorganism	Percent Reduction*
<b>Fresh</b>				
100% Cotton, white, apparel				
100% Polyester, white, apparel	SILVADUR™ 930 Flex, 3.0%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	> 99.9%
100% Nylon, white, apparel				
<b>Simulated 20 Home Launderings**</b>				
100% Polyester, black, apparel	SILVADUR™ 930 Flex, 2.0%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	99.8% > 99.9%
79%Nylon / 22% Lycra, red, swimming suit	SILVADUR™ 930 Flex, 2.8%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% 99.7%
85% Cotton / 13% Polyester / 2% Elastane, blue, denim	SILVADUR™ 930 Flex, 2.0%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% > 99.9%
<b>Simulated 30 Home Launderings**</b>				
100% Polyester, white, athletic wear	SILVADUR™ 960 Flex, 2.0%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	99.3%
100% Nylon, Black, athletic wear	SILVADUR™ 960 Flex, 2.0%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	99.2%

\* The bacterial reduction was calculated relative to a standard non-SILVADUR-treated control against both test organisms.

\*\* These fabric samples were washed according to the ASTM E3162-18 method where one cycle of washing simulates 5 home launderings.

Examples below showed that SILVADUR™ treated fabrics continue to provide antimicrobial efficacy and odor control even under the challenging use environment of 40 washes. Odor control was evaluated using the International Antimicrobial Council (IAC) IACM 0710 test method, where Pasteurized cow's milk was added onto a fabric swatch in a tightly sealed container that is then incubated at 37 °C for 24 to 48 hours. The samples were evaluated subjectively and qualitatively for spoiled milk odor via human sensory odor panels. Odor perception was rated on a scale of 1 (no odor) to 5 (strong odor) and the scores are averaged from several panelists. A fabric passes this odor control method if the rating is less than 3 for treated fabric and 5 for untreated fabric. DuPont provides "INTELLIFRESH™" branding as an option for fabrics that pass this performance criteria.

Textiles	SILVADUR™ Antimicrobial Concentration	Antimicrobial Efficacy			Odor Control Test Method IACM 0710
		Testing Methods	Microorganism	Percent Reduction*	
<b>Simulated 40 Home Launderings**</b>					
Cotton, white with pearl blush & soft silver weft, towel	SILVADUR™ 930 Flex, 3.5%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% > 99.9%	Pass
Polyester, sock	SILVADUR™ 930 Flex, 5%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	99.1%	Pass
33% Polyester / 60% Cotton / 7% Lycra, white, apparel	SILVADUR™ 960 Flex, 3.7%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% > 99.9%	Pass

\* The bacterial reduction was calculated relative to a standard non-SILVADUR-treated control against both test organisms.

\*\* These fabric samples were washed according to the ASTM E3162-18 method where one cycle of washing simulates 5 home launderings.

## SILVADUR™ Products Exhaust-Applied on Various Textiles

SILVADUR™ Antimicrobial is a liquid formulation that can be easily applied to socks, towels, and other textile or apparel products that require individual finishing and are made from natural or synthetic yarns. The exhaust method is one of the widely used processes for applying antimicrobials. SILVADUR has an exhaustion efficiency of greater than 90 percent because it contains silver ions and an organic polymer that readily adheres to fabrics and yarns. This property gives it a distinct performance advantage. Other silver-based antimicrobials cannot be exhaust-applied, or they have very low exhaustion efficiencies, because they contain silver particles and inorganic materials that do not readily adhere to fabrics or yarns.

## SILVADUR™ Products Exhaust-Applied on Various Textiles

### SILVADUR™ Exhaust Applications

#### Instructions

1. Completely rinse and neutralize fabric.
2. In a separate dilution vessel, add approximately 80% water based on required volume of the exhaust machine.
3. Add SILVADUR™ Antimicrobial gradually to the water with constant stirring at room temperature at a concentration appropriate for obtaining proper final concentration based on the weight of fabric.
4. Add additional water with continued agitation up to 100% of bath volume.
5. Transfer this diluted solution of SILVADUR™ product to the main exhaust machine.
6. If needed, add weak acid (best choice: acetic acid) to lower the pH of the exhaust bath quickly. A suspension containing 90% water and 10% Buffer A has been shown to be an effective buffer. Buffer A contains 79% of 0.1M sodium acetate and 21% of 0.1M acetic acid. Avoid citric acid. Immediately wash pH probes after use.
7. Apply SILVADUR™ product according to the recommended conditions below to achieve > 80% SILVADUR™ efficiency. This guideline below is based on a study performed in the laboratory setting using a Werner Mathis AG BSH-12 Exhaust machine with fabric to liquid ratio maintained at 1:10 and targeted bath concentration of 30 ppm silver active. Conditions can be further optimized according to specific mill layout and machinery.

Antimicrobial Product	Fabric Type	pH	Temperature °C	Time Minutes	Note
SILVADUR™ 930 Flex	Cotton	4 - 6	23 - 70	5 to 60	> 90% uptake at pH 5, 10 min contact time
	Polyester	5 - 7	70 - 130	5 to 60	> 90% uptake, also at pH 6 at 23°C
	Nylon	5 - 7	70 - 130	10 to 60	> 90% uptake, also at pH 6 at 23°C, at time 10 min contact time
SILVADUR™ 960 Flex	Cotton	4 - 5	23	5 to 60	> 90% uptake at pH 5
	Polyester	6 - 8	23 - 130	5 to 60	> 90% uptake
	Nylon	7 - 9	23 - 130	5 to 60	> 90% uptake

8. The exhaust process could be conducted for 5-60 minutes with bath temperatures not exceeding 130°C. The higher the temperature, the higher the potential for discoloration. Diluted and pH adjusted solutions should not be stored for later use.
9. Dry treated goods using standard procedures depending on the fabric type; not to exceed 180°C.

## SILVADUR™ Performance on Exhaust-Applied Textiles

SILVADUR performance applied via exhaust has been extensively tested and validated globally on various types of finished textile goods. These evaluations show that SILVADUR™ products at 10 to 50 ppm of silver active ingredient on weight of fabric, before and after washing, provide a greater than 99 percent reduction of *E. coli*, *K. pneumoniae*, or *S. aureus* after 24 hours of contact time.

Textiles	SILVADUR™ Antimicrobial Concentration	Antimicrobial Efficacy		
		Testing Methods	Microorganism	Percent Reduction*
<b>Fresh</b>				
100% Cotton, white, apparel				
100% Polyester, white, apparel	SILVADUR™ 930 Flex, 3%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	> 99.9%
100% Nylon, white, apparel				
<b>Simulated 10 - 20 Home Launderings**</b>				
100% Polyester, charcoal, casual wear, 20 washes	SILVADUR™ 930 Flex, 2%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	99.0% 99.9%
100% Cotton, grey, towel, 20 washes	SILVADUR™ 930 Flex, 2%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	99.4%
Cotton, blue indigo, denim 20 washes	SILVADUR™ 930 Flex, 2%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% > 99.9%
100% Cotton, white, underwear, 20 washes	SILVADUR™ 930 Flex, 1.5%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% > 99.9%
Polyester/Cotton, black, sweat shirt, 10 washes	SILVADUR™ 930 Flex, 1%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% 99.9%
100% Cotton, white towel, 20 washes	SILVADUR™ 960 Flex, 1.0%	AATCC TM100	<i>K. pneumoniae</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% > 99.9%

\* The bacterial reduction was calculated relative to a standard non-SILVADUR-treated control against both test organisms.

\*\* These fabric samples were washed according to the ASTM E3162-18 method where one cycle of washing simulates 5 home launderings.

SILVADUR™ treated fabrics applied with exhaust process also continue to provide durable performance after 40 washes. Performance observed is similar to fabrics in which SILVADUR™ was applied using a pad process. The fabrics exhibited the antimicrobial efficacy with bacterial reduction ≥ 99 percent against *E. coli*, *K. pneumoniae*, or *S. aureus* after 24 hours of contact time. These fabrics also passed sensory odor control testing. The odor control evaluation was performed using the milk test as described herein. DuPont provides “INTELLIFRESH™” branding as an option for fabrics that exhibit ≥ 99% bacterial reduction and provide good odor control (a rating of 2 or less) after 40 washes.

Textiles	SILVADUR™ Antimicrobial Concentration	Antimicrobial Efficacy			Odor Control Test Method IACM 0710
		Testing Methods	Microorganism	Percent Reduction*	
<b>Simulated 40 Home Launderings**</b>					
100% Cotton, white, apparel	SILVADUR™ 960 Flex, 3%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	> 99.9%	Pass
100% Polyester, white, apparel	SILVADUR™ 960 Flex, 3%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	99.8%	Pass
100% Nylon, white, apparel	SILVADUR™ 960 Flex, 3%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	> 99.9%	Pass
100% Cotton, pink, towel	SILVADUR™ 930 Flex, 3%	ASTM E3160-18	<i>E. coli</i> , ATCC 25922	> 99.9%	Pass
92% Cotton / 8% Lycra, white, ladies innerwear	SILVADUR™ 930 Flex, 3%	AATCC TM100	<i>K. pneumonia</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% > 99.9%	Pass
80% Combed Cotton / 16.5% Nylon / 3.5% Spandex, white, sock	SILVADUR™ 930 Flex, 3%	AATCC TM100	<i>K. pneumonia</i> , ATCC 4352 <i>S. aureus</i> , ATCC 6538	> 99.9% > 99.9%	Pass

\* The bacterial reduction was calculated relative to a standard non-SILVADUR-treated control against both test organisms.

\*\* These fabric samples were washed according to the ASTM E3162-18 method where one cycle of washing simulates 5 home launderings.

## SILVADUR's Operating and Processing Performance Edge

The results of these national and international third-party tests clearly underscore SILVADUR's exceptional and durable antimicrobial activity, ease of processing, and performance advantages over other products on the market today. It is important to note that SILVADUR showed greater than 99 percent antimicrobial activity after the fabrics cited in the tests above were washed 40 times regardless the application methods used.

### There are several reasons for SILVADUR's excellent performance and competitive edge:

It is the only silver microbial control product that is a non-particulate liquid, so its silver ions adhere to fabrics much better and coverage is more uniform than products containing solid particles. In addition, there is no impact on the hand feel of the fabric.

It is the only microbial control product on the market with a polymer delivery system for silver ions. As a result, SILVADUR adheres better to substrates, such as cotton and polyester fabric, compared to other inorganic antimicrobials. Addition of binder is required in some other inorganic antimicrobials which may have adverse impact on finished fabric performance and hand feel.

The concentration of SILVADUR in the pad or exhaust bath can be easily adjusted to obtain a homogeneous silver concentration very close to the targeted level because of phase stability and complete solubility of the active material in the treatment bath.