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ANTIOXIDANT SOLUTIONS FOR POLYURETHANE APPLICATIONS

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WELCOME TO



SI Group is committed to **developing innovative antioxidant technologies for polyurethane applications** (i.e. CASE, furniture, clothing, & automotive applications) that enable **emission reduction** complying with the most stringent VDA automotive and OEKO-TEX standards.

EXPANDED
product offerings

RELIABLE
global footprint

INNOVATIVE
solutions provider

Strong Pasts, Stronger Future



Our History

Roots dating back to the 1890's

Founded in 1906 as the Schenectady Varnish Company



Global Growth

Excellence in manufacturing & innovation as Crompton, Great Lakes Antioxidants, and Chemtura

Acquisitions & intelligent expansion as Schenectady Chemicals, and Schenectady International



Strong Executive Leadership Team

Led by President and CEO **David Bradley**

Expertise in the Markets We Serve



Plastics Solutions

Globally recognized innovative additives for plastics that deliver **superior application performance** and safer handling with an extensive portfolio of specialty additives.



Rubber & Adhesives Solutions

High-performance additives providing **durability, effectiveness & sustainability** to elastomer systems in tires, specialty rubber goods, and adhesives for automotive and industrial end-uses.



Industrial Solutions

Enhanced technologies for today's emerging challenges in the oilfield, finished fuels and lubricants, personal care, coatings, and nutrition markets.



Core Solutions

Key building block chemistries that **enable development** of performance additives, Active Pharmaceutical Ingredients (API) and finished goods in multiple industries.



Pharmaceuticals

Active pharmaceutical ingredients that offer critical components of **pain management solutions** and other specialty applications.



Industrial Resins

Wide-ranging resin solutions for friction, abrasives, refractory, paper impregnation, insulation, and composites that **comply with growing demands** around safety, compliance, efficiency, and fire protection.

Globally Connected, One Operating Platform



Global Leader in Stabilizers for Polymers
 offering
Industry's Broadest Portfolio of Solutions
 for **Plastics & Elastomers Value Chains**

ULTRANOX™
WESTON™
ANOX™
ALKANOX™
NDB™
ETHANOX™

NAUGARD™
WESTON™
ANOX™
LOWINOX™
TRIMENE BASE™

NDB™
NAUGARD™
LOWILITE™
POLYBOND™
ROYALTUF™
ULTRANOX™
FLEXAMINE™

LOWINOX™
LOWILITE™
WESTON™
NAUGARD™
ANOX™

Polyolefins

Manufacturing of PE & PP

Elastomers

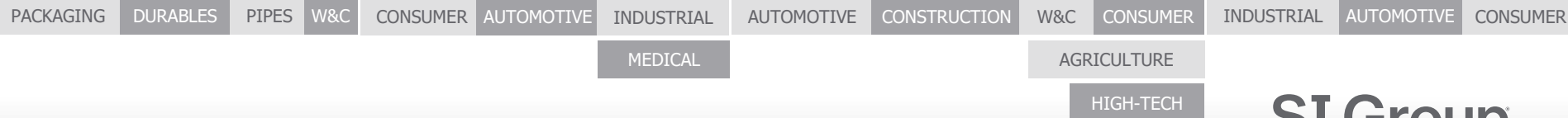
Manufacturing of EPDM, SBR, BR, NBR, SIS, SBS.....

Compounding

Formulating Polyolefins, Engineering Plastics and Elastomers
 PP, PE, PA, PS, EPDM, PC, ABS, PET, etc.

PU + Special

Manufacturing & formulating of Polyols, Foams, Case, Latex, PVC, Special Applications



ANTIOXIDANTS FOR ALL PU SEGMENTS

**BROAD SEGMENT &
APPLICATION
SPECTRA FOR OUR
ANTIOXIDANTS**

SI Group
The Substance Inside

POLYESTER POLYOL

POLYETHER POLYOL

ISOCYANATE MDI/ TDI

**PREPOLYMERS, CASE, TPU,
RIGID, MOLDED, FLEXIBLE FOAM
APPLICATIONS**

**POST-TREATMENT, CATALYST,
FLAME RETARDANTS**

INTRODUCTION TO PUR STABILISERS

SI Group offers one of the **world's largest** stabilizer technology platforms **for your polyether or polyester based polyurethane applications** **with our innovations.**

- **Solid or liquid** phenolic and amine-based antioxidants
- **Liquid blend** solutions
- High performance **ultra-low emissive** solutions
- **Zero-Phenol** and **Nonyl-Phenol-Free** liquid phosphites
- **UV stabilizers** to protect sensitive surfaces
 - **All stabilizers are BPA, BHT & PTZ free!**



BPA Bisphenol A, BHT Butylated Hydroxy Toluene & PTZ Phenothiazine

A comprehensive portfolio of antioxidant solutions and innovations

EFFECTIVE ANTI-SCORCH & UV STABILIZERS

For POLYURETHANES based on **POLYETHER** POLYOLS

FULL PORTFOLIO
OF ANTIOXIDANTS
FOR **POLYETHER**
POLYOLS

SI Group
The Substance Inside

NEAT PRIM. AO

- **NAUGARD™ PS 48** LIQUID STANDARD PHENOLIC AO
- ULTRA LOW EMISSIVE BEST IN CLASS **ANOX™ 1315** LIQUID PHENOLIC AO
- **ANOX™ PP 18** AND **ANOX™ 20** SOLID PHENOLIC AOs
- HIGH PERFORMANCE SOLID **LOWINOX™ 1790** FOR SPANDEX APPLICATION
- **NAUGARD™ 445** SOL. & **NAUGARD™ PS 30** LIQ. AMINE SCORCH SYNERGISTS

PHOSPHITES

- STANDARD **WESTON™ PDDP** PHOSPHITE *
- ZERO PHENOL PHOSPHITE **WESTON™ TDP ZP** FOR PU APPLICATIONS *
- ZERO NONYLPHENOL PHOSPHITE **WESTON™ 705** AS ALTERNATIVE TO TNPP
- ZERO PHENOL PHOSPHITE **WESTON 430™ ZP** FOR FLAME LAMINATION

BLEND AO SOLUTIONS

- **NAUGARD™ PS 4830** LIQUID BLEND AS STANDARD POLYOL STABILISER **
- **NAUGARD™ PS 3015** LIQUID BLEND, LOW FOG STANDARD POLYOL STABILISER
- **FOAMPLUS™ LE 5**, ULTRA LOW EMISSIVE FOR AUTOMOTIVE SLAB POLYOLS
- **LOWILITE™ UV B 1260** EFFICIENT LIQUID UV STABILIZER BLEND FOR PU

*currently not Europe, please request support by EHS for further information

** sampling stage,, please request support by your Technical Service Representative

EFFECTIVE ANTI-SCORCH & UV STABILIZERS

For POLYURETHANES based on **POLYESTER** POLYOLS

**FULL PORTFOLIO
OF ANTIOXIDANTS
FOR **POLYESTER**
POLYOLS**

SI Group
The Substance Inside

NEAT PRIM. AO AND PHOSPHITES

- **NAUGARD™ PS 48** LIQUID STANDARD PHENOLIC ANTIOXIDANT
- **ANOX™ 1315** ULTRA LOW EMISSIVE BEST IN CLASS LIQUID PHENOLIC AO
- **ANOX™ PP 18** and **ANOX™ 20** SOLID STANDARD PHENOLIC AOs
- STANDARD **WESTON™ PDDP** PHOSPHITE *
- ZERO PHENOL PHOSPHITE **WESTON™ TDP ZP** *
- **WESTON™ 705** ZERO NONYLPHENOL , LIQUID PHOSPHITE
- **LOWILITE™ UV B 1260**, LIQUID AO/UV STABILIZER

(*currently not Europe, please request support by EHS for further information)

Effective selection for PU applications based on **polyester polyols**. Nonylphenol, BHT or grades being Phenol free. Providing emission control combined with effective stabilization and compliance with strict industry standards.

OVERVIEW PRODUCT OFFERINGS PUR

Solutions Rating ● to ●●●●● excellent	AO Class	Physical Form	Polyol Storage Stability	Scorch Resistance	VOC/FOG Emissions	Foam Surface Discoloration (NOx/UV)
ANOX™ PP18	Phenolic	solid	●●●	●●	very low	●●●
ANOX™ 20	Phenolic	solid	●●●	●●	very low	●●●
ANOX™ 1315	Phenolic	liquid	●●●	●●	very low	●●●
NAUGARD™ PS48	Phenolic	liquid	●●●	●●	moderate	●●●
NAUGARD™ PS30	Aminic	liquid	●●●●	●●●	moderate	●●
NAUGARD™ 445	Aminic	solid	●●●●	●●●	very low	●●
ANOX™ PP18/ NAUGARD™ 445	Phenolic/ aminic	solid/solid	●●●●●	●●●●	very low	●●
ANOX™ PP18/ NAUGARD™ PS30	Phenolic/ aminic	solid/liquid	●●●●●	●●●●	moderate	●●
NAUGARD™ PS 4830	Phenolic/ aminic	liquid	●●●●●	●●●●	moderate	●●
NAUGARD™ PS 3015	Phenolic/ aminic	liquid	●●●●●	●●●●	low	●●
NAUGARD™ FOAMPLUS LE 5	Phenolic/ aminic	liquid	●●●●●	●●●●	very low	●●
LOWILITE™ UV B 1260	UV stabiliser	liquid	●●●	●●	very low	●●●●●
WESTON™ TDP ZP	Phosphite	liquid	●●●	●●	low	●●●
WESTON™ 705	Phosphite	liquid	●●●	●●	low	●●●
WESTON™ 430 ZP	Phosphite	liquid	●●●	●●	low	●●●

A unique range of specialty additives to transform the PUR industry

EXPERIMENTAL LAB TEST CONDITIONS

POLYURETHANE SLABSTOCK FOAM

Typical Foam Recipe	FOAM DENSITY	
	20 kg/m ³	40 kg/m ³
Component	php	php
Polyol	100	100
Silicone Surfactant	1.1	0.6
Amine Catalyst	0.4	0.2
Tin catalyst	0.5	0.3
Water (deionized)	5	2.5
TDI (80:20)	61	35
Stabilisation Package	AS REQUIRED 0.45 php	



20 cm x 20 cm x 20 cm
PUR foam

1. Low-density foam (20 kg/m³)

was prepared to maximize scorch effects

2. High-density foam (40 kg/m³)

was prepared and used for FOG/ VOC emission testing

- Slabstock polyol, minimal stabilised
- Loading @ approx. 4500 php AO
- MW Microwave scorch to simulate high heat exposure of industrial slabstock production

TEST METHODS

- Viscosity ASTM D445
- TGA ASTM E1131 - 08
- Polyol OIT ASTM E 2009-02
- NOx Gas Fading AATCC23-2015
- FOG /VOC Emissions VDA 278 (SGS Fresenius)
- ALDEHYDE Emissions VDA 275 & NESM0402
- MW scorch
- Storage stability

Gas Fading Results demonstrated with AATCC 164

Comprehensive technical performance validation was carried out to define the stabilization for a standard commercial polyol

NEAT SOLUTIONS

NAUGARD™ PS 48 and ANOX™ 1315
NAUGARD™ PS 30 and NAUGARD™ 445
WESTON™ 705 and WESTON™ TDP ZP



EFFECTIVE ANTI-SCORCH SOLUTIONS

- **NAUGARD™ PS 48:** a liquid standard antioxidant with good scorch protection of polyols for molded, CASE and TPU standard applications.
- **ANOX™ 1315:** an ultra low emissive liquid antioxidant with good scorch protection of polyols for molded, CASE and TPU standard applications.
- **NAUGARD™ PS 30 and NAUGARD™ 445:** liquid & solid amine synergist.
- **WESTON™ 705:** Zero Nonylphenol, very effective liquid phosphite, free of nonylphenol, functional alternative to replace TNPP for nearly all applications.
- **WESTON™ TDP ZP:** Zero Phenol (ZP), very effective liquid phosphite, free of phenol as a replacement for traditionally used phenol-containing phosphites.

SI Group

ANOX™ 1315

Liquid, Ultra Low Emissive Stabilization

ANOX™ 1315 offers good scorch protection but is three times less emissive than standard liquid phenolic types and superior to solid BHT

- Full compliance with automotive emission standards VDA 278 and OEKO-TEX Standard 100.
- **Polyether polyols:** simple alternative solution at 0,15 – 0,5 php .
- **Polyester polyols:** typical use levels range from 0,05 - 0,1 php .

ANOX™ 1315:

3,5-Bis (1,1-dimethylethyl)-4-hydroxy-benzenepropanoic acid, branched C13-15 alkyl esters. CAS number: 171090-93-0

BHT:

Butylhydroxytoluene; 2,6-Di-tert-butyl-p-cresol. CAS number: 128-37-0
php parts per hundred polyol

Application

For use in polyether and polyester polyol applications at producers and polyurethane processors; excellent choice for VOC and FOG **emission reduced** comfort foam & automotive polyol applications

TGA weight loss in %

Under N2, rate at 10°C/ min, 50°C to 400°C, 3 times

Antioxidant	state	5%	10%	15%	20%	25%	50%
BHT	solid	120	133	141	147	151	169
ANOX™ 1315	liquid	256	278	289	297	304	325

BHT: 5 % weight loss at 120 °C

ANOX 1315: 5 % weight loss at 256 °C

WESTON™ 705

Liquid Phosphite, NP Free Stabilization

WESTON™ 705, nonylphenol free.

As a secondary antioxidant offers as peroxide decomposer, good scorch protection especially in combination with our liquid antioxidants such as NAUGARD™ PS 48 or ANOX™ 1315

- As a liquid it offers very good compatibility with the polyol. Compared to traditional phosphites it is completely **nonylphenol (NP) free**.
- **Polyols:** a simple alternative for other phosphites and alternative at loadings at 0,05 – 0,2 php, can be used in a 1:1 or 1:2 combination with our phenolic antioxidants.

WESTON™ 705:

Chemical Abstract Number: 939402-02-5

EC Number: 700-485-5

Application

For use in polyether and polyester polyol applications at producers and polyurethane processors, especially where the replacement of TNPP is desired; excellent choice with improved scorch protection for emission reduced polyol applications

Typical physical properties of WESTON™ 705 phosphite

Appearance	Colorless liquid free of particulates
Phosphorous %	5,2
Assay	>98%
Specific Gravity @ 25°C/15,5°C	1.004-1.035
Acid No. (mg KOH/g)	<0,5

WESTON™ TDP ZP

Liquid Phosphite, Phenol Free Stabilization

WESTON™ TDP ZP as a secondary antioxidant offers as a peroxide decomposer good scorch protection especially in combination with our liquid AOs such as NAUGARD™ PS 48 or ANOX™ 1315

- As a liquid it offers good compatibility with polyols.
- Compared to traditional phosphites it is completely **phenol free**.
- **Polyols:** simple and alternative solution at loadings of 0,05 – 0,2 php, can be used in a 1:1 or 1:2 combination with our phenolic antioxidants.

WESTON™ TDP ZP:

Triisodecyl Phosphite C30H63O3P, CAS Number: 25448-25-3

Currently not offered in EUROPE

Application

For use in polyether and polyester polyol applications at producers and polyurethane processors, especially where the reduction of phenol emissions (caused by traditionally used phosphites) is desired. Excellent choice with improved scorch protection for emission reduced polyol applications

BLEND SOLUTIONS

NAUGARD™ PS 4830 v. PS 3015 v. DVS 390
FOAMPLUS LE 5



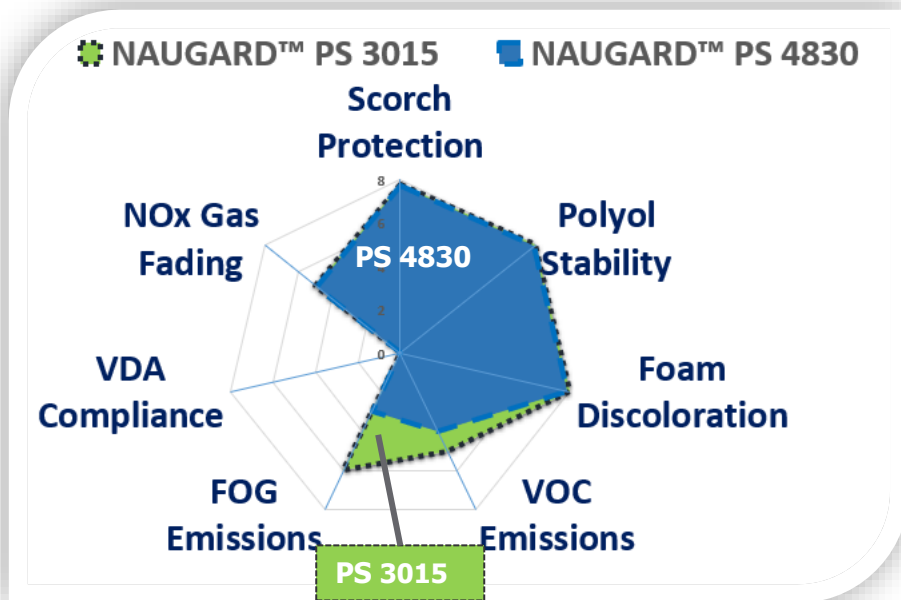
EFFECTIVE ANTI-SCORCH BLEND SOLUTIONS

- **NAUGARD™ PS 4830** for good **scorch protection** of **polyols** for molded, slabstock and CASE **standard applications**.
- **NAUGARD™ PS 3015** provides **major improvements** in **FOG emission reduction** for comfort foams and mattresses.
- **NAUGARD™ FOAMPLUS LE 5** as **ultra-low emissive AO** blend for medium to high density automotive foams compliant with VDA limits.

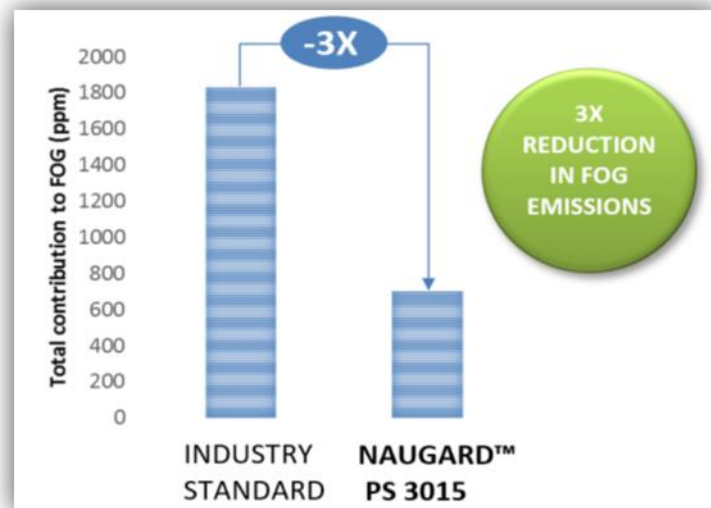
EFFECTIVE ANTI-SCORCH BLEND SOLUTIONS

NAUGARD™ PS 4830 v. PS 3015

AO liquid blend series that will satisfy your requirements depending on your needs!



(Spiderchart, relative rating. 0-8)



INDUSTRY STANDARD

2:1 blend of PS 48 (CAS number: 125643-61-0) and PS 30 (CAS number: 68411-46-1) equivalent to NAUGARD™ PS4830 as a functional alternative to AO 55 technology. Dosage @ 4500 ppm.

NAUGARD™ PS 4830, industry standard:

- good **scorch protection** of **polyols** for molded, slabstock and CASE **applications**.
- NAUGARD™ PS 3015** provides **major improvements** in **3 x less FOG emission** for comfort foams and mattresses.



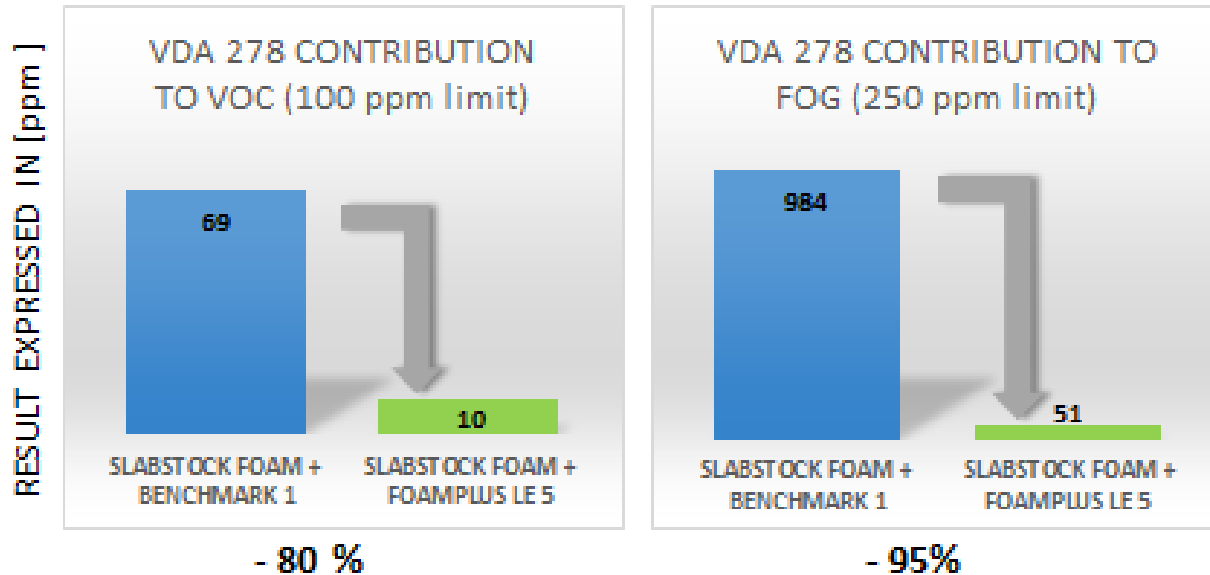
FOAMPLUS LE 5

NAUGARD™ FOAMPLUS LE 5

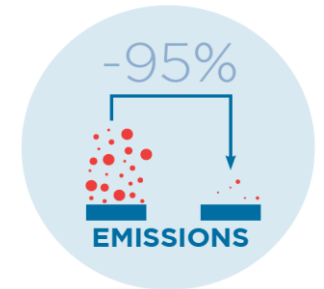
NAUGARD™ FOAMPLUS LE 5 for automotive foams. Protects against scorch and is designed for automotive PUR applications and foams where high end **emission control** is important.

- Ultra-low emissions enabling automotive VDA compliance
- For critical applications such as high-quality TPU, foams, clothing & automotive
- For good polyol stability and scorch protection

VDA 278 Tests Prove Ultra-Low Emissions and Compliance



VDA 278 TD GC/MS: Emission tests conducted on a high density slabstock foam (40-50 kg/m³), with a stabilization dosage level of 4500 ppm
Benchmark 1: NAUGARD™ PS 4830



- Improved EHS throughout the value chain from production to consumer
- Greater formulation flexibility and reliability

Compliance with automotive standards enabling better emission profile and improved branding



OUR CONTRIBUTION TO SOLVE YOUR NEEDS

SI Group's antioxidant solutions can play an integral role in solving your technical issues & complying with stringent standards, including:

- **Emission control** and **compliance** with automotive or Oekotex standards
- **Improved polyol stability** and **scorch protection of polyurethane applications** for greater production safety & better product quality
- **UV resistance** for sensitive light colored & white PU applications



In view of the many factors that may affect processing and application of SI Group products, the results of the use of such products may vary. Customers needs may also vary, and therefore, customers are responsible for carrying out their own investigations and tests in order to verify the suitability of the SI Group products for the customer's specific purposes. Furthermore, the data contained herein does not imply any guarantee of certain properties or results.

BACKUP FOR CONFERENCE HAND OUT

NAUGARD™ PS48

LIQUID, STANDARD PHENOLIC STABILIZATION

NAUGARD™ PS48 stabilizer is a liquid hindered phenolic for use as an antioxidant across many applications

- Offers **good scorch protection especially for CASE and rigid polyols.**
- Simple and **easy alternative** solution at typical use levels of 0,15 -0,5 php.
- Especially powerful when used in **synergistic combination** with other liquid aminic stabilizers such as **NAUGARD™ PS 30** or solid **NAUGARD™ 445** to boost performance for any other polyurethane segment such as **molded or flexible foam application.**

Application

For use in polyether and polyester polyol applications at producers and polyurethane processors; excellent choice for rigid and **CASE** polyols and as basis for slabstock polyols in combination with aminic boosters

NAUGARD™ PS 48: Phenolic C7-C9 Ester: benzenepropanoic acid, 3,5-bis (1,1-dimethyl-ethyl)-4-hydroxy-C7-C9 branched alkyl esters.
CAS number: 125643-61-0

NAUGARD™ PS30

LIQUID, MULTIPURPOSE AMINIC ANTIOXIDANT

NAUGARD™ PS30 stabilizer is a liquid amine antioxidant developed specifically for use in polyether polyols to reduce scorch associated with flexible urethane foam production.

- As a liquid, **NAUGARD™ PS30 stabilizer** can be easily blended into polyols at ambient temperatures in less time compared to conventional solid stabilization systems
- **NAUGARD™ PS30 stabilizer** is designed to be used in combination with phenolic and phosphite antioxidants to synergistically inhibit both physical and colour scorch associated with flexible urethane foam production. CAS: 68411-46-1

Appearance	Clear, reddish to brown liquid
Residual Diphenylamine (DPA)	0.05%
Viscosity, cSt @ 40 deg C	400
Gardner Color	2
Specific Gravity @ 25 deg C	0.98
Boiling Point	>200 deg C
Flash Point	180 deg C
Nitrogen Content	4.7%
Moisture	0.01%
Ash	0.01%

Application: Offers excellent scorch protection for any polyether polyol for foams for comfort, furniture, automotive and CASE applications

NAUGARD™ 445

SOLID, LOW EMISSIVE AMINIC ANTIOXIDANT

Highly effective and low emissive general purpose aminic booster with full antiscorch performance which is unparalleled much less emissive than a standard liquid aminic AO (equ. NAUGARD™ PS 30)

- It provides stabilization for polyol producers & polyurethane processors
- Simple and easy drop-in replacement for emissive AO 5057 at 250 – 2000 ppm requiring no capex or changes in production
- Offers excellent scorch protection in combination with ANOX™ 1315 or phosphite for flexible slabstock polyurethane foams and CASE applications
- CAS 10081-67-1

Typical physical properties of NAUGARD™ 445 stabilizer

Appearance	White powder or granules
Molecular weight [g/mol]	406
Melting Point [°C]	98-100
Color – APHA	20
Specific Gravity at 55 °C	1.14
Flash Point [TCC/°C]	277

Application: Offers excellent scorch protection & ultra low emissions for any polyol for flexible polyurethane foams for comfort, furniture, automotive and CASE application

NAUGARD™ PS 4830

LIQUID, STANDARD ANTIOXIDANT BLEND FOR SLABSTOCK APPLICATIONS

- **General purpose** stabilization **for polyol producers & polyurethane processors**
- Offers **excellent scorch protection** for flexible polyurethane **foams and CASE** applications
- Simple and **easy drop-in** replacement **at 3,000 – 4,500 ppm** requiring no capex or changes in production

NAUGARD™ PS 4830 : 2:1 mix of phenolic NAUGARD™ PS 48 (CAS number: 125643-61-0) and aminic NAUGARD™ PS 30 (CAS: 68411-46-1) **as a functional alternative to AO 55 technology.**

Application: Offers excellent scorch protection in polyols for flexible polyurethane foams such as mattresses, furniture and also CASE

NAUGARD™ PS 3015

LIQUID, FOG IMPROVED LOW EMISSIVE ANTIOXIDANT FOR SLABSTOCK COMFORT FOAMS AND MATTRESSES

3 times FOG reduction in FOG compared to industry standard

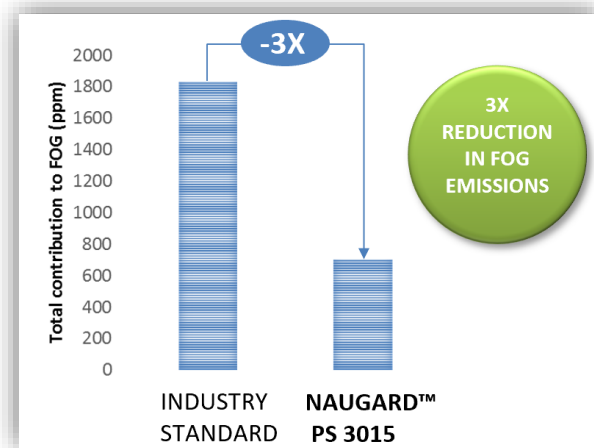
- **Low emissive general purpose stabilization for polyol producers & polyurethane processors**
- **Compliance with OEKO-TEX Standard 100**
- Offers **excellent scorch protection** for flexible polyurethane **foams and CASE** applications
- Simple and **easy drop-in** replacement **at 3,000 – 4,500 ppm** requiring no capex or changes in production

Typical physical properties of NAUGARD™ PS 3015 stabilizer blend

Appearance	Yellowish liquid
Pour point [°C]	< -50
Density @ 25 °C [g/cm ³]	0,947

Thermogravimetric Analysis (10 mg @ 10 K/minute under N₂)

Weight Loss [%]	5	10	25
Temperature [°C]	219	239	272



INDUSTRY STANDARD

2:1 mix of phenolic PS 48 (CAS number: 125643-61-0) and aminic PS 30 (CAS: 68411-46-1) equivalent to NAUGARD™ PS 4830 as a functional alternative to AO 55 technology.

Application: Offers excellent scorch protection in polyols for flexible polyurethane foams such as mattresses, furniture and also CASE

NAUGARD™ FOAMPLUS LE 5 LIQUID ULTRA LOW EMISSIVE AO BLEND

Application AUTOMOTIVE

The ultra low emissive, VDA 278 compliant liquid anti scorch blend solution for automotive slabstock polyols with **> 90 % emission reduction** compared to standard benchmark

NAUGARD™ FOAMPLUS LE 5 for automotive

- The higher thermal stability of **NAUGARD™ FOAMPLUS** enables **full compliance** with the **VDA 278** emission limits **of automotive specifications** with stricter national legislations on vehicle indoor air quality (VIAQ) and also has good results within the **VDA 275/ NES M0402** aldehyde emissions tests.
- Easy to use alternative, backed by our extensive global manufacturing assets and supply chain.

Tests conducted with a stabilization dosage level @ 4,500 ppm in a typical slabstock foam formulation. **Benchmark 1:** NAUGARD™ PS 4830

