

FLAME RETARDANTS

For Superior, Cost-Effective Performance





In This Brochure

Applications

<i>Performance in Plastics</i>	2
<i>Polyolefins</i>	2
<i>Polyesters</i>	3
<i>Mineral-filled PP Composites</i>	3
<i>Polystyrenes</i>	3
<i>PVC</i>	3
<i>Polyurethane Foams</i>	3
<i>Rubbers</i>	4
<i>Paints, Coatings & Adhesives</i>	5 & 6
<i>Textiles & Carpet</i>	6

Chemistry & Mechanisms 7

Dover Products at a Glance 8

Chemical & Physical Data 9

Solubility & Compatibility 10

Packaging..... 10

Technical Capability..... 11

Handling & Environmental News 12



DOVER'S FLAME RETARDANTS PROTECT PRODUCTS

WITHOUT BURNING UP PROFITS

Dover Chemical Corporation is a major supplier of additives for plastics, rubber, coatings, adhesives and textiles. We are the leading producer of chlorinated paraffins in the United States and Europe.

As a wholly owned subsidiary of ICC Industries Inc., we offer our customers the resources of a global leader, including state-of-the-art research and development laboratories. This technical strength and our vast experience with chlorinated paraffins enable Dover to develop a range of low cost, highly effective flame retardant additives.

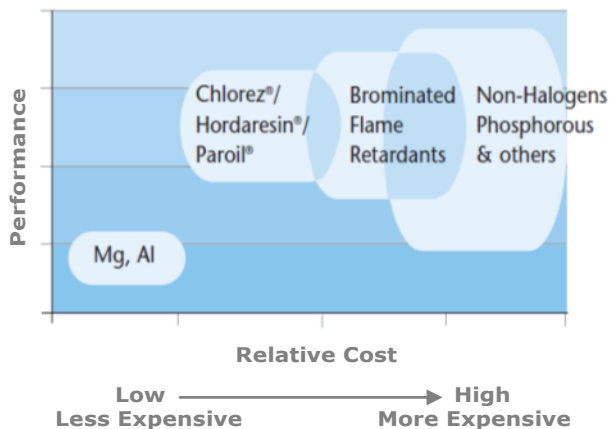
Chlorez® / Hordaresin®

Chlorez and Hordaresin, marketed in the United States and Europe respectively, are identical in structure and function. We manufacture these highly effective, environmentally friendly flame retardant additives and binders in our ISO 9001:2008 certified facility under Montreal Protocol limitations. Superior thermal stability makes them the first choice of plastics, rubber, coatings, adhesives, and textile fabricators who want to reduce cost without sacrificing performance.

Doversperse®

Dispersions and emulsions of resinous and liquid chlorinated paraffins are available as Doversperse products. These are useful in both cationic and anionic emulsion systems because of their non-ionic bases. In addition to contributing to flame-retardancy, they improve adhesion, impart chemical and water resistance, and allow the user to formulate aqueous rather than solvent systems. Application areas include adhesives, rubber coatings, inks, carpet backings, paper and fabric coatings.

Cost Performance in Polymer Applications Flame Retardancy & Polymer Performance



Doverguard®

Dover Chemical has developed a group of products based on the bromination and chlorination of a variety of olefins. Each has been developed to meet specific end use needs. These products are low cost, highly effective flame retardants and plasticizers that exhibit good color.

Paroil®

Paroil liquid chlorinated paraffins improve the flame resistance of polyolefins, unsaturated polyester, rubber, and other synthetic materials. In addition to flame-retardancy, liquid chlorinated paraffins are efficient plasticizers. Vinyl compounders can take advantage of this dual functionality by using a liquid chlorinated paraffin as a secondary plasticizer, while formulators of adhesives, caulks, and sealants will improve fire retardancy in their products by incorporating a non-volatile liquid chlorinated paraffin plasticizer. Dover Chemical is the leading manufacturer of liquid chlorinated paraffins and offers the broadest range of products to suit your particular requirements. Please ask your Dover Chemical representative for specific application literature.

- *Chlorez and Hordaresin are the most cost-effective flame retardants available.*
- *Chlorez and Hordaresin provide similar performance to brominated flame retardants at less cost in certain applications such as polyesters, styrenics, and polyolefins.*
- *Magnesium and aluminum, while relatively inexpensive, must be added at such high levels that polymer properties can be affected.*

ADVANTAGES FOR YOUR APPLICATION

Performance in Plastics

Chlorez and Hordaresin, used in combination with antimony oxide, are effective flame retardants in polystyrene, polyolefins and unsaturated polyesters. They outperform decabromodiphenyl oxide formulations with improved UV performance, and can be used in a variety of polymers to achieve UL-94-V-O ratings.


Chlorez and Hordaresin reduce flame retarding costs by:

- *Replacing higher cost additives, such as brominated aromatics or chlorinated acrylics*
- *Allowing processors to use less antimony oxide*

Chlorez and Hordaresin can also cut thermoplastics processing costs by helping to reduce energy requirements and/or processing time in thermoplastic compounding, due to their chemistry. They can act as lubricants in some polymer systems, allowing lower processing temperatures with increased extrusion output or faster injection molding fill rates. Because of its higher thermal stability, Chlorez 700-S is recommended for polystyrene, polyolefins and unsaturated polyesters.

Polyolefins

Thermal stability and color are key criteria in selecting additives for polyolefins. With more than 40 years' experience in color stable additive packages, Dover has produced the industry's lightest chlorinated paraffins. Color generation is reduced and black specs are avoided due to Chlorez and Hordaresin products' higher thermal stability levels and low initial color (47 on APHA scale, compared to competitor's 114).

	Dover Hordaresin NP-70	Competitor Sample
5 (min.)		
10 (min.)		
25 (min.)		

Chlorez and Hordaresin products' thermal stability inhibits production of corrosive by-products that can cause rusting in processing equipment. The softening points and lubricity allow processing of polyolefins and unsaturated polyesters at lower temperatures, thus reducing energy costs and improving quality. They also provide slip characteristics that create a less wearing interior surface in polyethylene cable conduits. These benefits are in addition to the initial cost savings of the additive compared to brominated flame retardants.



Chlorez and Hordaresin are combined with antimony oxide to flame retard polyethylene compounds. The optimum ratio of Chlorez or Hordaresin to antimony oxide is 1:1, but compounds containing as little as 15% Chlorez 700 and a minimum of 5% antimony trioxide can provide a flame retardancy of V-O by the UL-94 vertical test. (When seeing this rating, the amount of additive required depends on the melt index of polyethylene; additive levels increase with higher melt indices.)

Dover recommends the following products for polyolefin applications:

- *Chlorez 700 and Hordaresin NP-70 generally are used for standard grades of LDPE.*
- *Chlorez 700-S and Hordaresin CH-151 are recommended for use in HDPE and polypropylene because of their higher thermal stability.*

Unsaturated Polyesters

Chlorez 700 and Hordaresin NP-70 with antimony oxide offer an economical flame retardant system for reinforced polyesters. Various ratios of Chlorez or Hordaresin and antimony may be used, depending on the degree of flame retardancy required.

Mineral-Filled PP Composites

Experimental data from the laboratories of Ford Motor Company¹ and Dow Corning Corporation have established the efficacy and economics of using Chlorez 700 or Hordaresin NP-70 as coupling agents in mineral-filled polypropylene composites.

Ford Motor Company scientists conclude:

"Mica polypropylene composites with chloroparaffins exhibit sufficiently low cost combined with sufficiently high modulus to allow economic substitutions for certain applications normally executed with steel."

Ford also notes: *"The use of low-cost coupling agent and the lower-cost mica in comparison with glass fiber offers large potential cost savings in direct substitution for glass-filled polypropylene and glass-filled polystyrene, poly (styrene acrylonitrile) and poly-(styrene maleic anhydride)."*

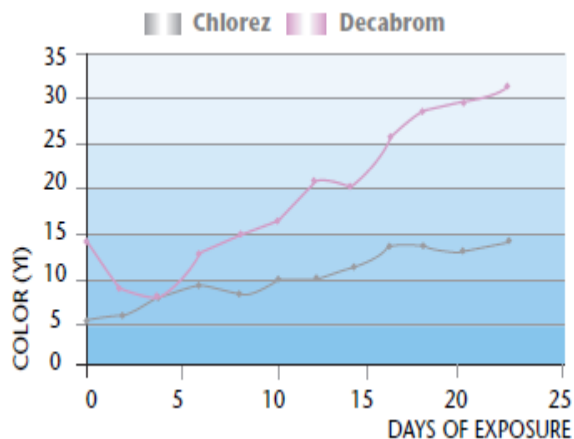
¹F. J. Meyer and S. Newman, *Improved Strength Mica-Propylene Composites*. 1979 SPI KP/C Conference. High-Impact Polystyrene (HIPS)

High-Impact Polystyrene (HIPS)

Chlorinated paraffins are one of the lowest-cost flame retardants. Chlorez 700-S was developed specifically for flame-retarding high-impact polystyrene. In the UL-94 test, V-O can be achieved in 1/16 inch cross sections in systems that include antimony trioxide as a flame retardant synergist. They have excellent thermal stability, a high melting point and other definite advantages:



- No poly-halogenated biphenyls or dioxins
- Low cost
- Improved melt flow
- Dramatically better UV stability than aromatic brominated flame retardants, such as Decabrom



Combinations of Chlorez and Hordaresin with brominated flame retardants yield compounds with improved physical properties at a reduced price. Increased lubricity improves flow and mold fill, enabling processors to produce thinner walled products at lower temperatures.

Flexible PVC

Plasticizers used in making PVC flexible also make it flammable. Paroil liquid chlorinated paraffins and Doverguard brominated and bromo-chlorinated aliphatic liquid products increase flame retardancy while acting as secondary plasticizers at low cost. They are highly effective, and have good color.

Polyurethane Foams

Doverguard products also function as economical flame retardants and plasticizers in polyurethane foam systems. Doverguard 8207-A is the standard, and offers low cost and highly efficient flame retardancy with good color in rigid and semi-rigid foams. Doverguard 8208-A contains phosphorous and is slightly more effective. Doverguard 8208-A can be used for rigid, and semi-rigid or RIM foams.

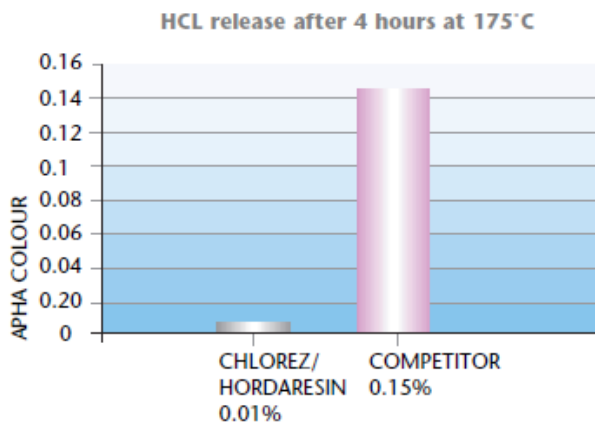
Rubbers

Due to their cost effectiveness, Chlorez and Hordaresin have been used for many years to flame retard rubber products such as SBR for conveyor belts and EPDM for electrical or roofing applications. Generally used in combination with antimony oxide, Chlorez and Hordaresin improve tensile strength and tear properties of Neoprene, SBR and Nitrile rubber.

Their superior thermal stability is important, as corrosive by-products can cause rusting in rubber belts' steel reinforcements or chemical attack on belts reinforced with synthetic fibers. In corrosion tests, the Chlorez and Hordaresin samples emerged rust-free from a full hour of exposure, while the competitive chlorinated paraffin product showed evidence of corrosion after just 10 minutes' exposure.



For water-based systems. Doversperse A-1 and Doversperse 3-NR are recommended. In EPDM rubber, Doverguard brominated and bromo-chlorinated liquid additives offer greater flame retardancy at low cost with good color.



PAINTS, COATINGS AND ADHESIVES

Flame retardant coatings, adhesives and intumescent paints produced with Chlorez and Hordaresin yield excellent results. Intumescent paints can contain these additives as primary flame retardant components. During the decomposition of burning, HCl given off catalyzes the intumescent reaction.

Chlorez and Hordaresin also:

- *Extend expensive vehicle solids—replace up to 20% of epoxy, chlorinated rubber, etc.*
- *Impart hardness*
- *Improve adhesion*
- *Resist water, acid, alkali and mold growth*
- *Are compatible with most paint solvents*
- *Are essentially non-toxic*

Doversperse A-1, a 65% water dispersion of Chlorez 700, may be substituted for Chlorez 700 or Hordaresin NP-70 on a dry basis in intumescent paints to reduce grinding time and eliminate agglomeration.

Doversperse A-1 and Doversperse 3-NR also promote adhesion in adhesives and UV curable inks.



Adhesives

Chlorez 700 and Hordaresin NP-70 are effective flame retardants in pressure-sensitive or hot melt adhesives. They are completely compatible in SBR and natural rubber-based formulations as well as with EVA and chlorinated polyethylene, and do not interfere with the desirable features of the blends. They also provide a creep-resistant formulation while replacing most or all of the tackifying resin in pressure-sensitive, latex and low-temperature hot melt adhesives.

Doverguard brominated liquid additives also offer an economical and effective flame retardant for adhesives.



Water & Chemical Resistant Paints

Chlorez 700 and Hordaresin NP-70 increase gloss and adhesion in physically-drying binders such as chlorinated rubber and polypropylene, cyclized rubber, styrene/butadiene copolymers and similar products.

They improve elasticity and impart plasticizing of paint films. They help paint to resist chemicals and seawater, and actually improve gloss retention under weathering conditions.

Because of their low-solution viscosity, Chlorez 700 and Hordaresin NP-70 can be used to increase solids content, particularly with high-viscosity binders.

Ink Varnishes

In phenolic ink varnishes, Chlorez and Hordaresin enhance gloss retention, increase adhesion and improve rub resistance while reducing ink penetration into the surface.

Alkyd Resin Paints

Chlorez 700 and Hordaresin NP-70 are particularly suitable for use combined with alkyd resins. Because of their all-around solubility and compatibility, they can be used as resins in the manufacture of different paints and coatings.

They are non-flammable and chemical-resistant, and are compatible with almost all known alkyd resins. Chlorez 700 and Hordaresin NP-70 can be used in any ratio, and give alkyd resin paints these properties:

- *Good gloss and gloss retention*
- *Rapid surface drying & easy application*
- *Satisfactory adhesion to difficult substrates*
- *Resistance to mild chemical attack*
- *Good water resistance, particularly when the paint is still wet*
- *Good scratch resistance*

Traffic Paints

Chlorez 700 and Hordaresin NP-70 are used in traffic paints as low-cost resin extenders, and to improve adhesion and resistance to water, chemicals, oil and gas.

Textiles and Carpet

Chlorez and Hordaresin have been used for many years to flame-retard fabrics and textiles, as they are low cost halogen sources. They are typically used as flame retardants for military cotton duck, as the resulting products are essentially non-toxic, durable, stable and water-resistant.

Doversperse A-1 and Doversperse 3-NR can be used in water-based systems, such as those used to produce automotive textile products. These liquid additives, along with Doverguard brominated and bromo-chlorinated aliphatic liquids, also are used as flame retardants for carpet backings.



Flame Retardant Types

There are many types of flame retardants, however, they can generally be divided into two classes—reactive and non-reactive.

Reactive flame retardants (such as tetra-bromo-bisphenol A, di-bromo-neopentyl glycol, vinyl chloride and bromo-or di-bromo-styrene) co-polymerize into the polymer back and therefore have little influence on mechanical properties.

Non-reactive type flame retardants include chlorinated paraffins, brominated organics, phosphate esters, aluminum trihydrate, magnesium hydroxide, borates and antimony trioxide.

The lowest cost additive is aluminum trihydrate, used mostly in polymers processed at low temperatures (epoxy, unsaturated polyesters, polyethylene and PVC). However, high loadings are required and this can affect the physical properties of the polymer.

Chlorinated paraffins are low cost and can be applied in all polymers processed under 240°C/460° F. Bromine is more effective on a weight basis, but based on cost performance, chlorinated paraffins are more effective than aromatic bromine flame retardants.

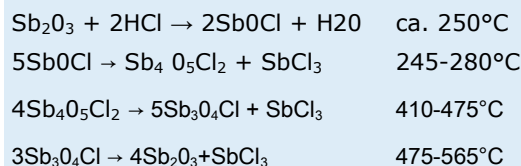
Chemistry

Chlorez and Hordaresin are made by chlorinating paraffin hydrocarbons with elemental chlorine:



Chlorine content and carbon chain length affect physical properties. Product specifications depend on raw materials used and the duration and conditions of chlorination, work-up and stabilization.

Chlorez and Hordaresin act as flame retardants by releasing hydrochloric acid (HCl), which poisons the flame. This vapor gas inhibition is greatly enhanced when a Group V metal oxide, especially antimony trioxide (Sb_2O_3), is present. Antimony trioxide alone does not work as a flame retardant, but when reacted with HCl forms antimony oxy chloride (SbOCl). Further reactions form antimony trichloride (SbCl_3), which acts as a radical scavenger to cool hot radicals and act as a vapor barrier to smother the flame.



Doversperse products typically contain 45% available chlorine for maximum flame retardant efficiency. They are useful in both cationic and anionic emulsion systems because of their non-ionic bases.

Bromine is sometimes the best choice for flame retardant applications because of its high level of effectiveness. Dover Chemical has developed several brominated and bromo-chlorinated aliphatic liquid flame retardants called Doverguard.



Lab test without flame retardant



Lab test with Chlorez/Hordaresin

DOVER FLAME RETARDANTS AT A GLANCE

Chlorez & Hordaresin

<i>Products</i>	<i>Advantages</i>	<i>Typical Applications</i>
Chlorez 700 & Hordaresin NP-70	Good thermal stability at lowest cost	Paints, coatings, rubber, adhesives, polyolefins
Chlorez 700-S & Hordaresin CH-151P	Better thermal stability	Polyolefins, polyesters, and styrenes

Doverguard

<i>Products</i>	<i>Advantages</i>	<i>Typical Applications</i>
Doverguard 8207-A	Low cost, high efficiency, good color	Rigid & semi-rigid polyurethane foams, PVC, EPDM rubber, carpet backing, adhesives, textiles
Doverguard 8208-A	Contains phosphorous; slightly more effective	Rigid, semi-rigid & RIM polyurethane foams; other applications above
Doverguard 8408	Low cost, high efficiency, good color	Carpet backing, textiles, adhesives

Doversperse

<i>Products</i>	<i>Advantages</i>	<i>Typical Applications</i>
Doversperse A-1	Increases hardness, improves adhesion, imparts chemical & water resistance	Aqueous systems for adhesives, inks, carpet backings and rubber, paper & fabric coatings
Doversperse 3-NR	Plasticizing & tackifying. Also improves adhesion & imparts chemical & water resistance	Same as above

CHEMICAL & PHYSICAL PROPERTIES

Chlorez & Hordaresin

<i>Typical Properties</i>	<i>Chlorez 700</i>	<i>Hordaresin NP-70</i>	<i>Chlorez 700-S</i>	<i>Hordaresin CH-151P</i>	<i>Chlorez 700-SS</i>
Color, APHA	130	105	100	100	95
% Chlorine	70.8	71.0	70.8	71.1	71.5
Specific Gravity/25°C	1.6	1.6	1.6	1.6	1.6
Bulk Density, g/l	1,619	1,619	1,619	1,619	1,619
Particle Size, % thru 297 Micron	96	96	96	87	N/A
% Volatiles	<0.1	<0.1	<0.1	<0.1	<0.1
Softening Point, °C	102	102	102	102	106
Heat Stability, % HCl	<0.1	0.01	0.05	<0.01	0.01
Physical Form	White Powder	White Powder	White Powder	White Powder	White Flake

Doverguard

<i>Typical Properties</i>	<i>Doverguard 8207-A</i>	<i>Doverguard 8208-A</i>	<i>Doverguard 8404</i>
Color, G	3	2	2
Poise/25°C	25	18	2
% Bromine	30	26	31
% Chlorine	31	32	23
% Phosphorous	-	1.2	-
Specific Gravity/50°C	1.40	1.40	1.325

Doversperse

<i>Typical Properties</i>	<i>Doversperse A-1</i>	<i>Doversperse 3-NR</i>
% Solids	65	66.5
Poise/25°C	64 ¹	150-300 ²
% Chlorine	45	40
SG/25°C	1.60	1.54
Appearance	Cream White	Cream White

¹ #5 Spindle, 20 rpm

² #6 Spindle, 10 rpm

Solubility

Chlorez and Hordaresin are soluble in:

- Aliphatic and aromatic hydrocarbons
- Chlorinated hydrocarbons and esters

(When petroleum hydrocarbons are used as the solvent, solutions are cloudy at low temperatures but the films dry clear.)

Compatibility

Chlorez and Hordaresin are compatible with:

- Drying oils
 - Alkyd resins
 - Polyvinyl ethers
 - Polyvinyl acetate
 - Polyacrylic esters
 - Chlorinated polyolefins
 - Unsaturated polyester resins
 - Polyvinylidene chloride copolymers
 - Vinyl toluene/acrylic ester copolymers
 - Polystyrene
 - Ethyl cellulose
 - Cyclized rubber
 - Chlorinated rubber
-

Packaging

Every product is packed in the type and size container that makes it easy for you to use.

Chlorez and Hordaresin

Bags

This valved paper bag is lined to prevent fiber contamination. It is convenient to transport, easy to lift, clean and pleasant to handle. There is no need to transfer the powder to another container—it can be fed straight into the production process. Capacity is 50 pounds or 25 kilograms.

Batch Inclusion Bags

Dover also can provide Chlorez and Hordaresin in 25 kilogram net weight batch inclusion bags. These can be added directly to the mixer— bag and all—to eliminate product handling and packaging waste.

Super Sacks

These polypropylene bags containing 1,000 pounds or 500 kilograms are more convenient for volume users of powder products.

Fiber Drums

This 30-gallon (114 liters) drum holds approximately 400 pounds (181.5 kgs) of flaked product.

Doversperse

Doversperse A-1 is packaged in fiber drums containing 300 pounds (136 kgs) and in totes containing 2,600 pounds (1,179 kgs). Doversperse 3-NR is packaged only in steel drums that contain 465 pounds (211 kgs).

Doverguard

Doverguard products are packaged in steel drums that contain from 525 pounds (238 kgs) to 625 pounds (283.6 kgs), depending upon the specific gravity of each product.

TECHNICAL CAPABILITIES

Acquired in 1975 by ICC Industries Inc., Dover Chemical is the leading producer of chlorinated paraffins, olefins and esters, and the second-largest liquid and solid organophosphite producer in the U.S. We have steadily expanded our product line to include chlorinated paraffins, organophosphites, antioxidants, flame retardants, lubricant additives, functional additives, brominated compounds, metallic stearates, drilling muds and alkyl phenols, including para-nonylphenol, di-nonylphenol, para-cumylphenol and di-cumylphenol.

As a wholly owned subsidiary of ICC Industries, Dover Chemical enjoys the resources associated with ICC's position as a global leader in the manufacturing, marketing and trading of chemical, plastic and pharmaceutical products. Originated as a trading enterprise, ICC has expanded its line of business to include manufacturing companies located in 23 locations throughout the United States, Europe, Israel, Russia, China, and Turkey.

Our research center, with state-of-the-art laboratories and testing facilities, enables us to develop new products to perform to your specifications and adapt to your changing needs. Our people have the knowledge and flexibility to make sure you get the timely chemical solutions you need.

Dover's computer-controlled, operator-monitored processes eliminate variability, which is the goal of modern manufacturing. Total Quality and product consistency is ISO 9001 certified.

Physical testing capabilities include the ability to measure full flexural, tensile, tear and compression properties on INSTRON equipment; Izod and drop weight impact measurements from room temperature to -50°F; heat deflection and Vicat softening point determinations; specific gravity; and melt flow. Rheological properties are measured using Brabender equipment.

Sample preparation capabilities are supported by a laboratory-size Banbury internal mixer, oil heated two-roll mills sheet and pellet extrusion line, state of the art Battenfeld injection molder, and a Leistritz twin screw compounding extruder.

Burn property measurement capabilities include the ability to run FAA, DOT and UL vertical and horizontal burn tests as well as limited oxygen index.

Accelerated weathering exposure studies are conducted with a QUV cabinet and a programmable Xenon Arc Weatherometer.

Analytical capabilities include FT infrared spectroscopy, differential scanning calorimetry, thermal gravimetric analysis, high pressure liquid and gas chromatography, gel permeation chromatography, mass spectroscopy, inductively coupled plasma spectroscopy, and wet chemistry analysis.

Testing not conducted in-house is done by outstanding organizations including Underwriters Laboratory (UL), the University of Akron, Polymer Diagnostics, Ohio State University, and South Florida Testing Services.

<i>Method</i>	<i>Parameter</i>
ASTM D-256	Izod Notched/Impact
ASTM D-638	Tensile Strength/Elongation
ASTM D-648	Heat Deflection
ASTM D-777	Burn
ASTM D-792	Specific Gravity
ASTM D-790	Flexural Modulus/Strength
ASTM D-903	Peel
ASTM D-1238	Melt Index
PSTC 6	Tack
PSTC 7	Creep Resistance



UL-94-5-V Test

HANDLING & ENVIRONMENTAL NOTES

Chlorez and Hordaresin have no restrictions on their manufacture or use in the United States, Canada or the European Union. These products are built on long-chain chlorinated paraffin molecules, C₂₀ or greater, with a minimum of 70 percent chlorination level.

Chlorez and Hordaresin are not classified as dangerous for the environment. They are non-genotoxic, and present no toxicity to aquatic life at levels found in the environment. Incineration studies on waste streams both with and without chlorinated paraffin have not shown any increase in dioxin formation.

Results of animal trials indicate that Chlorez and Hordaresin products can be considered virtually non-toxic and relatively harmless (according to W.S. Spector's Handbook of Toxicology). Many years of experience have shown that if these products are handled properly, no skin irritation will occur. When irritation does occur, it is our experience that it can be attributed to lack of proper hygiene or to hypersensitivity.

Most countries have accepted the Montreal Protocol, which was developed to reduce the level of ozone-depleting substances used in the production of materials. As the world's leading producer of resinous chlorinated paraffins, Dover utilizes enhanced production technology to ensure that Chlorez and Hordaresin products continue to provide ozone protection under Montreal Protocol limitations.







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