DuPont™ Dymel®

AEROSOL PROPELLANTS

Dymel® Helps You Meet the Challenge

With help from DuPont, the world's aerosol industry has resolved the environmental challenges of the past decade–especially the issue of ozone depletion.

A new challenge, however, of Volatile Organic Compounds (VOCs), or ground-level ozone, faces the aerosol industry.

DuPont is once again leading the drive to meet this challenge. In the following pages, you will find all you need to know about the range of DuPont aerosol propellants to help you in your decision to adopt Dymel® propellants–and to meet your challenges head-on, safely, profitably and responsibly.

The range of Dymel® propellants

Dymel® is the DuPont registered trademark for a range of propellants which are suitable for many aerosol production applications.

Vapor pressures

Vapor pressures of Dymel® A, Dymel® 152a, and Dymel® 134a are show in **Figure 1**. When blended with hydrocarbon propellants or low-boiling solvents, higher or lower pressures can be reached if required.

Wide range of solubility

Because they are soluble in each other, with hydrocarbon propellants and with a wide variety of common aerosol solvents and products, Dymel® propellants can be blended to provide effective delivery of water-based or solvent-based products. Dymel® A is exceptional in terms of its water solubility.

The Dymel® range currently comprises four individual propellants:

Dymel® A
Dimethyl Ether, CH_3OCH_3

Dymel® 152a
1,1-Difluoroethane, CHF_2CH_3

Dymel® 134a and Dymel 134a/P
1,1,1,2-Tetrafluoroethane, $CHFCF_3$

The Dymel® range also includes blends of two or more of these propellants. Depending on the application, they may also be blended with other compounds, such as hydrocarbons. The best choice for a given application depends on the desired combination of properties.

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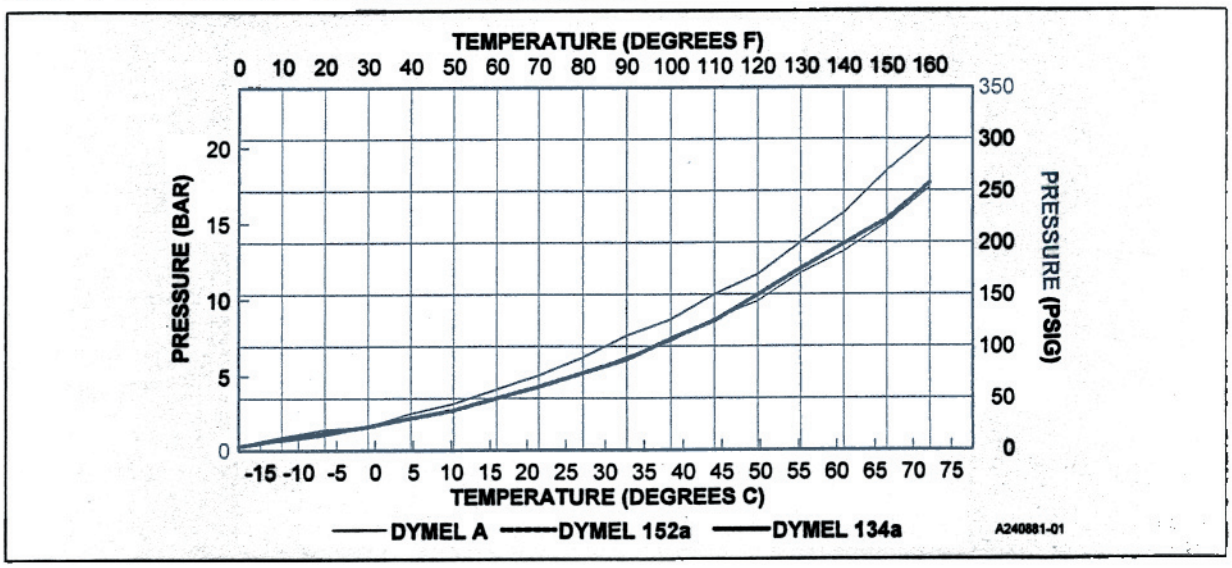
Figure 1. Saturated Vapor Pressures of Dymel Propellants



Current Applications of Dymel® Propellants

The range of applications for Dymel® as an aerosol propellant is already extensive and growing every day. Some of the industry-proven developments and applications are shown below:

	Dymel® A	Dymel® 152a	Dymel® 134a	Dymel® 134a/P (high purity)
Haircare	X	X		
Shaving cream		X		
Deoderants	X			
Antiperspirants	X	X		
Baby care		X		
Insulating foams	X	X	X	
Paints	X	X		
Adhesives	X			
Insecticides	X			
Perfumes	X			
Air freshners	X			
Medical/Pharmaceutical	X			X

Can I Use Dymel® Propellants In My Formulation?

Dymel® A

Solubility in water

- Can reduce formulation costs by allowing substitution of water for more expensive solvents such as alcohol
- Decreases foaming of water-based aerosols
- Some water-based formulations are less viscous than those containing hydrocarbons
- Can provide single-phase formulations where use of other propellants would result in two-phase formulations

Solubility in organics

- High solvency of polymeric resins, (for example, hairsprays, adhesives, etc.)

Aerosol flammability

- Although flammable, Dymel® A allows the formulation of non-flammable aerosols with water

Medium-high vapor pressures

- Produces medium-high pressure dry sprays when used alone or in blends
- Produces low-pressure sprays when formulated with solvents

Hydrolytic stability

- Remains stable over a broad pH range

Dymel® 152a

Medium-high vapor pressures

- Produces medium-high pressure dry sprays when used alone or in blends
- Produces low-pressure sprays when formulated with solvents

Hydrolytic stability

- Remains stable over a broad pH range

Aerosol flammability

- Although flammable, Dymel® 152a can be used to formulate aerosols posing a lower flammability hazard to the user

Dymel® 134a and Dymel® 134a/P (High Purity)

Dymel® 134a and Dymel® 134a/P (High Purity) have identical physical and chemical properties since they are both 1,1,1,2-tetrafluoroethane. However, Dymel® 134a/P is a high-purity grade of Dymel® 134a for use in medical and pharmaceutical applications.

Aerosol flammability

- Dymel® 134a and Dymel® 134a/P (High Purity) are non-flammable.

Dymel® blends

The optimum propellant for a given aerosol formulation is often a mixture of two or more Dymel® propellants or of Dymel® propellants and hydrocarbons,. Information on the physical properties of a large number of blends for a variety of formulations is available from DuPont.

Azeotropes

Dymel® azeotropes and their weight percent are:

Dymel® A/Propane (18/82)
Dymel® A/152a (46/54)
Dymel® A/134a (51/49)

Dymel® 152a/Propane (46/54)
Dymel® 152a/Isobutane (75/25)
Dymel® 152a/n-Butane (85/15)

Dymel® 134a/Propane (64/36)
Dymel® 134a/Isobutane (80/20)
Dymel® 134a/n-Butane (88/12)

The vapor pressure of the Dymel® A/152a is nearly identical to that of its components. They hydrocarbon-based azeotropes of Dymel® 152a and Dymel® 134a have vapor pressures significantly higher than either of the components forming them.

Because the vapor pressures of Dymel® A and Dymel® 152a are essentially identical, compositions far removed from that of the azeotrope do not undergo fractionation, even during vapor-phase discharge.

Non-azeotropic mixtures

The liquid composition of standard (non-azeotropic) mixtures of Dymel® propellants remains essentially constant as the aerosol product is discharged through a standard valve by liquid phase delivery. Non-azeotropic mixtures can fractionate, however, resulting in preferential loss of the lower-boiling (that is, higher vapor pressure) component when using vapor tap valves, during accidental spills, or through vapor phase loss of the propellant in storage. Detailed information is available from DuPont.

Dymel® Propellants and the Environment

DuPont offers products and services to help the aerosol industry meet environmental challenges safely.

Ozone depletion

The current DuPont range of Dymel® propellants, as listed in this brochure, has an ozone depletion potential (ODP) of zero.

Photochemical reactivity

The issue of volatile organic compounds (VOCs) has already become a problem for the aerosol industry in the USA. It will most likely become a challenge to be faced in many other countries.

Dymel® propellants are either non-VOC (Dymel® 152a and Dymel® 134a) or help in meeting the VOC challenge (Dymel® A + water).

The table below compares the ODP of various propellant products as well as their CO_2 global warming potential (GWP) and their Volatile Organic Compound (VOC) status.

	Dymel® A	**Dymel® 152a (HFC 152a)**	**Dymel® 134a (HFC 134a)**	**Butane**
ODP	0	0	0	0
GWP (100 yr Integrated Time Horizon	negligible	140	1300	negligible
VOC	yes	no	no	yes

Properties of Dymel® Propellants

Physical properties

The basic physical properties of the four Dymel® propellants, detailed in the table below, can be summarized as follows:

Dymel® A is a medium-high pressure propellant with a high degree of solubility in water (weight percent at autogenous pressure) and high solvency. It is miscible with most conventional solvents. Its LEL (lower explosive limit) in air is higher than that of hydrocarbon propellants.

Dymel® 152a is similar to Dymel® A in vapor pressure, but has a low water solubility, is a moderately weak solvent, and is flammable but, similar to Dymel® A, has a LEL about twice that of hydrocarbons.

Dymel® 134a and Dymel® 134a/P (High Purity) are the only non-flammable propellants of the Dymel® series. They have low water solubility and are poor solvents.

Stability

Dymel® propellants are stable when used alone or with conventional aerosol solvents, (for example, alcohols, esters and ketones) under general aerosol storage and use conditions. As is industry practice for new aerosol formulations, storage testing is recommended.

Dymel® A is not prone to peroxide formation in the pure state or in aerosol formulations.

Dymel® propellants are hydrolytically stable over a broad pH range.

Solubility

Dymel® propellants cover the range of Kauri-butanol values from about 8 to 60. They are miscible with each other, with hydrocarbon propellants and with a variety of common aerosol solvents such as alcohols.

Dymel® A has high solubility in both polar and non-polar solvents. It has 35 weight percent solubility in water and is the only liquefied gas aerosol propellant that allows formulation of single-phase products with large amounts of water. Formulations of Dymel® A with water and alcohol are of particular interest because the addition of a small amount of alcohol causes complete miscibility of Dymel® A and water in all proportions.

Dymel® 152a has low solubility in water but tolerates a few percent water in propellant/alcohol formulations with no phase separation.

Toxicity

Extensive animal studies, conducted in part at DuPont's Haskell Laboratory, have shown that Dymel® propellants pose no hazard to man relative to systemic toxicity, carcinogenicity, mutagenicity, or teratogenicity at or below an occupational exposure limit (8-hour TWA) of 1000 ppm, the highest value allowed for organic compounds. More detailed information on the toxicity of Dymel® propellants is available from DuPont.

Liquid density

Dymel® A has a liquid density similar to that of hydrocarbon propellants. The density of the other Dymel® propellants ranges from 1.4 to 1.9 times greater, resulting in heavier container fill weights which can enhance consumer appear.

Flammability of Dymel®

Product safety has always been an important issue in aerosol industry.

Dymel® A and Dymel® 152a are flammable. Dymel® 134a and Dymel® 134a/P (High Purity) are non- flammable.

However, the flammability of a pure propellant may not reflect the flammability of the total formulation of which it is a part. Therefore, tests should be run on final formulations to measure the hazard they may pose to the user. More detailed information is from DuPont.

Physical Properties of Dymel® Propellants

	Dymel® A Dimethyl Ether, CH3OCH3	Dymel® 152a 1,1-Difluoroethane, CHF2CH2	Dymel® 134a and Dymel® 134a/P (high purity) 1,1,2-Tetrafluoroethane CH2FCF2
Molecular weight	46.1	66.1	102.0
Boiling point, °C °F	-24.8 -12.7	-25.0 -13.0	-26.1 -14.9
Vapour pressure at 20°C, bar at 50°C, bar	4.09 10.55	4.16 10.79	4.67 12.22
Vapor pressure at 70°F, psig at 130°F, psig	63 174	63 177	71 199
Liquid density at 20°C, g/cc at 50°C, g/cc	0.66 0.61	0.91 0.83	1.22 1.10
Liquid density at 70°F, g/cc at 130°F, g/cc	0.66 0.60	0.91 0.82	1.22 1.08
Solubility in water at 20°C, wt% at 70°F, wt%	35 35	1.7 1.7	0.95 0.95
Water solubility in propellant at 20°C, wt% at 70°F, wt%	 6 6	 0.17 0.17	 0.095 0.095
Solubility parameter	7.3	7.0	6.6
Kauri-Butanol number	60	11	8
Flammability limits in air, vol%	3.3-18.0	3.9-16.9	none

Can I Use Dymel® Propellants In My Equipment?

Packaging
DuPont offers the following general recommendations for guidance, but recommends that packaging decisions be made jointly with component suppliers.

Valve stem and cup gaskets
Laboratory linear swell data for elastomers in the liquid phase of Dymel® propellants are available from DuPont. Swelling data can serve as a useful guide in selecting elastomers. However, other factors such as the amount of extraction, tensile strength and degree of hardness of the exposed elastomer must be considered. Final gasket choice also depends on the gasket material's compatibility with all of the formulation ingredients, including the actives. Storage tests on final aerosol formulations are required to ensure that the correct material has been chosen. Consultation with valve suppliers is also recommended before final choice.

Valves
Special care must be taken when using vapor tap valves. With a formulation containing a single propellant or an azeotrope, an oversize tap can result in propellant loss before all the container contents have been discharged. With a non-azeotropic propellant blend or a high solvent-to-propellant ratio, fractionation could occur causing a change in pressure.

Containers
Formulations that contain water may require corrosion inhibitors which should be chosen on the basis of storage stability tests.

Dymel® A should be thoroughly tested before packaging in lined containers because of the high solvency of the propellant.

Handling
All national, local and other regulatory agency requirements must be satisfied before a new storage and loading facility is brought into service. Some suggestions are given here based on DuPont experience to date. They are not intended to exhaust the subject. Additional information can be obtained from DuPont.

DuPont offers a safety audit inspection of the customer's storage and loading facilities by technical specialists before Dymel® A is first delivered to the customer's premises.

Electrical equipment
Dymel® 134a is nonflammable when used alone and thus requires no explosion-proof equipment. But when it is blended with other Dymel® propellants or with hydrocarbons, the blend should be handled in explosion-proof equipment.

Dymel® A, Dymel® 152a and blends containing these products should be handled in explosion-proof equipment.

A separate loading facility is recommended for flammable propellants. All equipment must be explosion-proof and of the proper electrical rating.

Flammable-gas detectors are recommended. Infrared or sensing flame devices can be used with all Dymel® propellants. Hot wire detectors are not recommended for use with halogenated propellants. Additional information is available from DuPont.

Equipment seals
For Dymel® 152a and 134a, seals of Neoprene W are recommended. For Dymel® A, Kalrez® is the only elastomer known which shows good resistance to swelling in laboratory immersion tests. However, mechanical factors in actual plant use could influence material selection. Silicone O-rings encapsulated in Teflon® are recommended generally for Dymel® A, including undercap filling machines. DuPont should be contacted for specific information.

Where are Dymel® Propellants Produced and How Are They Distributed?

Launched by DuPont laboratories in the United States in the early 1980s, Dymel® propellants are today rapidly becoming some of the most widely used non-CFC propellants for use in aerosols.

Worldwide manufacture and supply

Dymel® 152a is today manufactured only in the United States. Dymel® 134a is produced in the United States and in Japan while Dymel® 134a/P is produced in the United States. Dymel® A is produced both in the United States and in Europe.

Dymel® propellants are shipped to the customer by the fastest possible method depending on the destination and customer's storage facilities. Dymel® can be supplied in road tankers, ISO containers and ton containers, by road or by rail.

For more information about DuPont™ Dymel® propellants, please contact your local representative:

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