FINAL REPORT

Development of Azeotropic Blends to Replace TCE and nPB in Vapor Degreasing Operations

SERDP Project WP-2522

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No fluids in this study cleaned grease or solder flux residue as well as TCE or nPB.

Seven new azeotropic blends were discovered during this project. Four azeotropes failed the flash point test. One failed the vial-based screening test against marine-grade grease. Two of the azeotropic blends survived the flash point and solvency screening tests. They are designated AZ6 (80% Suprion, 20% *p*-chlorobenzotrifluoride, T_b = 110 °C) and AZ7 (65% HFE-7500, 35% *p*-chlorobenzotrifluoride, T_b = 125 °C).

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List of Acronyms

β	Volumetric expansion coefficient in K^{-1} (equivalent to $°C^{-1}$)
ρ	Density of a substance in g/mL
δ_D or D	Dispersion Hansen solubility parameter in $MPa^{1/2}$ (equivalent to $(kJ/L)^{1/2}$)
δ_P or P	Polar Hansen solubility parameter in $MPa^{1/2}$ (equivalent to $(kJ/L)^{1/2}$)
δ_H or H	H-bonding Hansen solubility parameter in $MPa^{1/2}$ (equivalent to $(kJ/L)^{1/2}$)
δ_T	Total Hansen solubility parameter (a.k.a. Hildebrand solubility parameter) in $MPa^{1/2}$; $\delta_T^2 = \delta_D^2 + \delta_P^2 + \delta_H^2$
γ_{LG} *or* γ	Liquid-gas interfacial tension a.k.a. surface tension in mN/m (equiv to mDyne/cm)
R_a	Hansen distance between solvent and solute in 2*D*, *P*, and *H* space in $MPa^{1/2}$
ACE	acetone, CAS:67-64-1
AE3	tetrafluoroethyltrifluoroethylether (AE3000), CAS:106-94-5
ASTM	American Society for Testing and Materials (http://www.astm.org/)
BAC	*tert*-butylacetate, CAS:540-88-5
BOH	*tert*-butylalcohol, CAS:75-65-0
C5F7	heptafluorocyclopentane, CAS:15290-77-4
CBTF	*para*-chlorobenzotrifluoride (a.k.a. PCBTF), CAS:98-56-6
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations (http://www.ecfr.gov/)
D or δ_D	Dispersion Hansen solubility parameter in $MPa^{1/2}$ (equivalent to $(kJ/L)^{1/2}$)
DCE	trans-1,2-dichloroethene, CAS:156-60-5
EL	ethyl lactate, CAS:97-64-3
EOH	ethanol, CAS:64-17-5
H or δ_H	H-bonding Hansen solubility parameter in $MPa^{1/2}$ (equivalent to $(kJ/L)^{1/2}$)
HAP	Hazardous air pollutant
HCFC	hydrochlorofluorocarbon
HEX	*n*-hexane, CAS:110-54-3
HFC3	pentafluorobutane (HFC365), CAS:405-58-6
HFC4	decafluoropentane (HFC-4310mee), CAS:138495-42-8
HFE	hydrofluoroether
HFE0	methoxyperfluoropropane (HFE-7000), CAS:375-03-1
HFE1	methoxyperfluorobutane (HFE-7100), CAS:163702-07-6
HFE3	methoxyperfluorohexane (HFE-7300) , CAS:
HFE5	ethoxyperfluoromethylhexane (HFE-7500) , CAS:297730-93-9
HFO	hydrofluoroolefin – a general class of compounds
HSP(s)	Hansen solubility parameter(s)
I16	iodoperfluorohexane (I-1600), CAS:355-43-1
I32	iodoheptafluoropropane (I-3200), CAS:677-69-0
MBK	methylisobutylketone (MIBK), CAS:108-10-1
MEK	methylethylketone (MEK), CAS:78-93-3
MOH	methanol, CAS:67-56-1
MPK	methylpropylketone, CAS:107-87-9

nPB or 1-BP	n-propylbromide or 1-bromopropane, CAS:106-94-5
ODS	Ozone-depleting substances (https://www.epa.gov/ozone-layer-protection/ozone-depleting-substances)
P or δ_P	Polar Hansen solubility parameter in $MPa^{1/2}$ (equivalent to $(kJ/L)^{1/2}$)
PAc	isopropylacetate, CAS:108-21-4
PGE	propyleneglycol monomethylether, CAS:107-98-2
POH	*iso*-propanol (IPA), CAS:67-63-0
R_a	Hansen distance between solvent and solute in 2D, P, and H space in $MPa^{1/2}$
RER	Relative evaporation rate – relative to n-butylacetate (RER = 100%)
T_b	Normal boiling point, temperature of boiling at 1 atm pressure.
TCE	trichloroethylene (TRI), CAS:79-01-6
W	Wetting index ($1000\ \rho / \eta\ \gamma$)
V_m	Molar volume mL/mol
VOC	Volatile organic compound, regulated for photochemical smog control (40CFR51.100(s))

Keywords

Vapor Degreasing; Solvent Blending; Formulation; Azeotropy; Azeotropic Blend; Low-Boiling Azeotrope; Defluxing; Precision Cleaning; Raman Spectroscopy; Ball-drop Viscometry; Hydrostatic Density; DuNuoy Ring Tensiometry; Hansen Solubility Parameters; Solvent Substitution; Solvent Replacement; Solder Paste; Solder Flux Removal; Gravimetric Analysis; Fractional Distillation; 1-Bromopropane; 1-BP; n-Propylbromide; nPB; Trichloroethylene; TCE; p-chlorobenzotrifluoride; PCBTF; Oxsol-100

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Four particular students deserve recognition for their part in the project.

- John Fecco performed many of the fractional distillations, designed the Raman chemometrics spreadsheet, debugged the reflow soldering process, designed and 3D-printed the PCB part placement templates, and constructed the cylinder degreasing apparatus. John graduated with a B.S. in Chemistry in May 2015.
- Robert Stanton was the ionic conductivity measurement expert. He also performed fractional distillations, Raman chemometrics, vial-based grease solvency tests, vial-based defluxing tests, ROSE testing of solder flux residue, vapor degreasing trials, and large-quantity solvent reclamation distillations. Robert graduated with a B.S. in Chemistry in May 2016.
- Nathan Thompson converted the HSP blend prediction software from Mathematica code to Python code. He worked with the PPDS software to predict the solvent vapor-liquid equilibrium behavior, installed the lab's 3D printing capability, and performed azeotrope searches with fractional distillation. Nathan graduated with a B.S. in Chemistry in May 2015, and entered the Computer Science Master's program at SHSU.
- Jacob Perry was the flash point testing expert. He has performed azeotrope searches with fractional distillation, vial-based grease solvency tests, vial-based defluxing tests, Raman chemometrics, ROSE testing of solder flux residue, large-quantity solvent reclamation distillations, and vapor degreasing trials. Jacob graduated with a B.S. in Chemistry in May 2015, entered the Chemistry Master's program at SHSU, and continued to work on this SERDP project for his M.S. Thesis work.

This project would not have been successful without the contacts in industry and government that are listed in Appendix A. We received samples, solvent, and valuable advice.

Abstract

Objective: Azeotropic blends that have similar properties as trichloroethylene (TCE) and n-propyl bromide (nPB) but without undesirable environmental, occupational, safety, and health properties were tested as sustainable drop-in replacements for TCE and nPB in vapor phase cleaning operations.

Background: Some facilities are moving from nPB and TCE to blends with trans-1,2-dichloroethylene (tDCE), but this is seen as an interim solution since tDCE is regulated as a VOC. Therefore, the statement of need (SON) limited the scope of this project to a search for azeotropic blends that do not contain tDCE. Fully-enclosed vapor degreasing and aqueous degreasing systems were also ruled out as potential technologies of study by the SON.

Materials and Methods: The Hansen solubility parameters and ESH data on over 22,000 substances were analyzed to find blend components that were likely to form non-flammable blends. The most promising blend recipes were fractionally distilled to determine if a low-boiling azeotrope formed. The azeotropes were characterized with low-resolution Raman spectroscopy. The flash point behavior was determined according to ASTM D56 Tag closed cup analysis. Those azeotropes that passed the flash point screen were tested in a vial-based grease solvency test. The most promising azeotropes at this point were blended in larger quantities so that vapor degreasing trials against nPB and TCE could be held in a Branson 125 7.6-L (2-gal) capacity vapor degreaser. The initial plan to deflux reflow-soldered printed circuit boards was not realized due to extreme variation in the amount of baseline ionic contamination on freshly soldered boards. This led to the development of a vial-based solder defluxing test, that is very repeatable and useful for comparative testing of solvents. The soils used in these tests were a heavy marine grease and a general purpose solder paste. The fluid properties of the azeotropes were also characterized to yield the Hansen solubility parameters, density, volumetric expansion coefficient, viscosity, surface tension, and wettability index.

Results: No fluids in this study cleaned grease or solder flux residue as well as TCE or nPB.

Seven new azeotropic blends were discovered during this project. Four azeotropes failed the flash point test. One failed the vial-based screening test against marine-grade grease. Two of the azeotropic blends survived the flash point and solvency screening tests. They are designated AZ6 (80% Suprion, 20% *p*-chlorobenzotrifluoride, T_b = 110 °C) and AZ7 (65% HFE-7500, 35% *p*-chlorobenzotrifluoride, T_b = 125 °C).

These two blends were evaluated in a Branson B125 vapor degreaser in comparison to the performance of nPB and TCE. All were required to clean marine-grade grease from SS316, Al7075, and brass parts with a 10-min vapor step, a 5-min 40-kHz ultrasonic step, a 5-min vapor rinse, and a 10-minute sub-zero drying step. The nPB and TCE removed 100% of the soil on all three part types as measured gravimetrically. The blend AZ6 removed less than 20% of the soil (16(±11)% on Al7075, 13(±2)% on SS316, and 4(±1)% on brass), and AZ7 removed less than 60% of the soil (55(±7)% on Al7075, 36(±3)% on SS316, and 15(±2)% on brass).

This is understandable in light of their Hansen solubility parameters. Each blend has a substantial amount of non-flammable hydrofluoroether solvent, which dramatically lowers the dispersion

intermolecular attractive forces in the blend. Therefore, these two blends are not feasible candidates for replacing nPB and TCE in vapor degreasing operations.

In the vial-based defluxing study, the nPB was able to remove 81(±11)% of the ionic contamination, and TCE was able to remove 94(±6)% of the ionic contamination. The performance of the azeotropic blends was poor with AZ6 removing 3.0(±0.8)% and AZ7 removing 13(±6)%. These tests utilized 1 hour of 40 kHz ultrasonic extraction by the solvent in a capped vial at ambient temperature. The poor performance of our new azeotropic blends in this ambient temperature test does not warrant confidence that cleaning would improve in vapor defluxing. Therefore, these two blends are not feasible candidates for replacing nPB and TCE in vapor defluxing operations.

Conclusions and Implications for Future Research:

Both blends AZ6 and AZ7 are based on the VOC-exempt solvent CBTF, which is a drop-in replacement for toluene in automotive paint formulations. Specialty Materials Company suggests a CEL of 25 ppm. This is low. However, the volatility of CBTF is < 0.1 of nPB and < 0.05 of TCE. This lower volatility means that CBTF blends would be much easier to control with cooling coils.

These azeotropes are not suitable for replacing nPB or TCE. However, AZ6 and AZ7 do have HSPs that suggest they might be useful against silicone grease, Krytox, pump oil, and jet oil. This prediction would need to be tested at locations that deal with these types of soils.

If there is a subset of DoD cleaning operations at installations that require the strong solvency of nPB or TCE, then a process modification must be considered. The installation of air-tight degreasers with engineered controls would be worth the investment if these particular cleaning operations are critically important to the war fighter (i.e. liquid oxygen components, gyroscopes, optics, etc). These systems are designed with very efficient solvent handling and vacuum drying of parts. This greatly reduces worker exposure and solvent losses. They are typically large, automated, and enclosed, but the efficiencies in solvent recovery are substantial offsetting the purchase and installation expense. Because the solvent vapor zone is fully contained and oxygen free, inexpensive and effective flammable solvents may be used. Working toward this type of process change would maintain confidence in mission-critical cleaning while greatly reducing the solvent related ESH and regulatory risks.

Whereas the results for our blends were not particularly impressive, there are other positive outcomes of this work. The full list of 188 individuals and 107 companies and agencies is included in Appendix A. The project produced ten standard operating procedures included in Appendix B that may be adopted at other facilities.

Objectives

Azeotropic blends that have similar solubility parameters and similar physical properties as trichloroethylene (TCE) and n-propyl bromide (nPB) but without undesirable environmental, occupational, safety, and health properties were tested as sustainable drop-in replacements for TCE and nPB in vapor degreasing operations,[1] also known generally as vapor phase cleaning.[2] This work aimed to achieve the following specific objectives:

1. To develop azeotropic solvent blend alternatives to trichloroethylene (TCE) and n-propyl bromide (nPB) used in DoD vapor degreasing (VDG) operations.
2. To enable sustainable use of VDG equipment in the DoD by recommending alternatives that are not hazardous air pollutants (HAPs), volatile organic carbon (VOC) solvents, ozone depleting substances (ODS), or solvents with a high global warming potential (GWP).
3. To produce a model-based approach to enable DoD users to continue to respond to future constraints on solvent-based cleaning operations.
4. To test the azeotropic alternatives head-to-head against TCE and nPB in VDG equipment with extensive characterization of the fluids and the cleaning effectiveness.

Finding azeotropic blends that clean as well as TCE and nPB will reduce the regulatory risk to DoD operations and will reduce the actual risk to personnel since both TCE and nPB have been listed as “Reasonably Anticipated to be Human Carcinogens” by the 14th Report on Carcinogens.[3]

A successful result was defined as a non-flammable, non-HAP, non-VOC, non-ODS, and non-GWP azeotropic blend that removes grease and ionic flux residue as well as TCE and nPB in identical test situations.

Background

Two solvents trichloroethylene (TCE) and n-propylbromide (nPB) are used in a wide variety of VDG applications, but the environmental, occupational, safety, and health (EOSH) profiles of these solvents are undesirable. For instance, the TWA-TLV for nPB was dropped from 10 ppm to 0.1 ppm following the ACGIH's reclassification of nPB as a "Confirmed Animal Carcinogen with Unknown Relevance to Humans"[4], and both TCE and nPB have been listed in the 14th Report on Carcinogens (RoC) in the table of substances "Reasonably Anticipated to be Human Carcinogens"[3].

For over ten years, the Joint Service Solvent Substitution Working Group (JS3WG) has been addressing the needs to move MIL-SPEC and MIL-PRF standards to NESHAP and VOC compliance.[5] The EPA held a workshop in 2014 to address the use of TCE, which included the participation of JS3WG, the Toxics Use Reduction Institute (TURI), Cal/OSHA, and others.[6]

Some facilities are moving from nPB and TCE solvents to blends containing trans-1,2-dichloroethylene (tDCE). However, this is seen as an interim solution since tDCE is regulated as a VOC. Therefore, other azeotropic blends are needed as specified in the statement of need (SON).[1]

This project performed the following tasks to address the above issues.

Initial Database and Procurement Phase

1. Purchase initial solvents (TCE, nPB, etc.) and vapor degreasing equipment.
2. Update and compile a HSP database with solvents from various databases (HSPiP[7], PPDS[8], PARIS III[9], and the BioPreferred program[10]).
3. Compute the Hansen distance of each solvent to TCE and nPB to examine the potential for a single-solvent drop-in replacement.
4. Generate the desirability ratings of relevant solvent properties.
5. Downselect the large list of solvents. Solvents boiling below 19 °C or above 150 °C are excluded. Solvents listed as HAPs or ODSs are also excluded. Some VOC solvents are retained for low-VOC blending purposes.

Blend Prediction Phase

6. Predict binary blends that come close to the HSPs of TCE and nPB using the SHSU-developed blend prediction software.[11]
7. Screen the blend recipes for miscibility using the SHSU-developed miscibility model.[12]
8. Rank the blend desirability.
9. Purchase blend components for the most promising blend recipes.
10. Screen the blend recipes for azeotropy using fractional distillation.

Laboratory Testing Phase

11. Test the prepared blends in a hierarchical manner. If a blend fails to produce a single-phase azeotrope, or the azeotrope fails flash point testing, then no further testing of that blend will take place.

Testing in Vapor Degreasing Equipment Phase

12. Receive input from BFK Solutions via a site visit to make corrections and suggestions to cleaning procedures and conditions.
13. Test the best blend recipes in head-to-head trials against nPB and TCE. The test samples are greased steel and aluminum plates, greased brass fittings, and vials of freshly-melted RMA solder paste.
14. Establish background clean levels of the degreasing samples gravimetrically and the defluxing samples using solvent extract conductivity measurements.
15. Soil the degreasing samples with heavy marine-grade grease and the glass vials with lightly-activated organic acid solder paste.
16. Clean the soiled parts and vials with TCE, nPB, and the azeotropic blends.
17. Characterize the cleaned parts using the same cleaning effectiveness panel of tests in 14.

The Materials and Methods section contains a description of the project in detail. A full outline of each method is available in Appendix B – Standard Operating Procedures.

Materials and Methods

Computational Modeling

The full database of 22,406 substances in the HSPiP software program (hansen-solubility.com) was used as a comprehensive source for the Hansen solubility parameters.[7] This database contains many other physical properties such as boiling point and relative evaporation rate – relative to n-butyl acetate. The HSPiP software was adequate for our purposes, but other packages were explored to evaluate their utility to this specific project.

The PARIS III software package (Program for Assisting the Replacement of Industrial Solvents) was evaluated.[9] This is a free tool published by the US EPA for the purpose of replacing industrial solvents with more benign alternatives. None of the flame-retardant substances of interest in this project were in the PARIS III database.

Likewise, the vapor-liquid equilibrium (VLE) software PPDS was evaluated.[8] This software package is used by industrial manufacturers to predict the VLE behavior of their chemical processes. As in the case of the PARIS III software, PPDS did not have the flame-retardant solvents in its database. Although PPDS provides a way to input new solvents into their database, it was determined that the more-familiar HSPiP software was adequate for our needs.

The initial filter was to remove substances with boiling points above 150 °C with the exception of ethyl lactate, which was included at the recommendation of our industrial contacts. Likewise, substances with boiling points below 25 °C were removed with the exception of trans-1-chloro-3,3,3-trifluoro-prop-1-ene (Solstice PF from Honeywell), which has a boiling point of 19 °C.

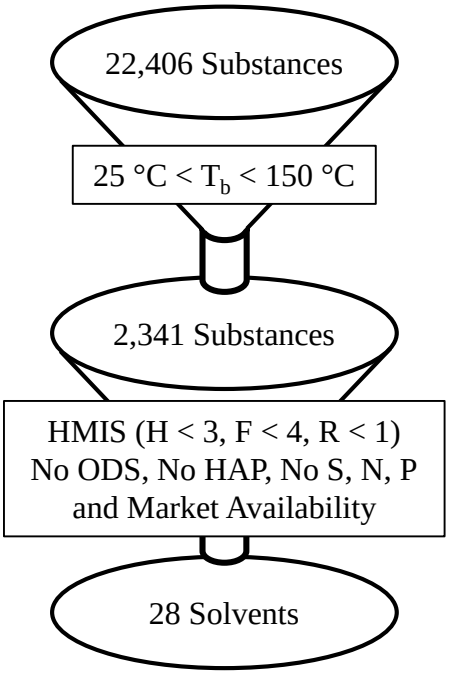

Figure 1: Initial solvent down-selection scheme

As Figure 1 shows, hazardous air pollutants (HAPs)[13] and ozone depleting substances (ODS) were avoided.[14] Some VOCs remained on the list to produce low-VOC blends.[15] The global warming potential (GWP) was not used as a down-selection criterion of input solvents. Rather, it may be used by the end user as a preference factor. The resulting list is shown in Table 1.

Table 1: The solvents that were explored as blend components. Listed are the Hansen solubility parameters (D, P, H in MPa1/2), flammability, global warming potential, and the Hansen distance (Ra in MPa1/2) from the average position of nPB and TCE in Hansen space. Sources for the GWP_{100} values are given.

Abbr	CAS	Flammability	*D*	*P*	*H*	R_a	GWP_{100}
Average of nPB and TCE HSPs →			17.2	5.5	5.1	0.0	
nPB	106-94-5	Low	16.4	7.9	4.8	2.9	<1[16]
TCE	79-01-6	Low	18	3.1	5.3	2.9	<1
CBTF	98-56-6	High	17.3	4	2.9	2.6	<1
MPK	107-87-9	High	16	7.6	4.7	3.2	<1[a]
MBK	108-10-1	High	15.3	6.1	4.1	4.0	<1[a]
MEK	78-93-3	High	16	9	5.1	4.2	<1[a]
BAC	540-88-5	High	15	3.7	6	4.8	<1[a]
Sols	102687-65-0	Low	15.1	4.1	2.8	5.0	1c[17]
PAc	108-21-4	High	14.9	4.5	8.2	5.7	<1[a]
AE3	406-78-0	Low	14	4.9	3.9	6.5	889[17]
C5F7	15290-77-4	Low	14.4	3.1	2.3	6.7	250[18]
I32	677-69-0	Low	14.6	3	1.6	6.7	<1[19]
PGE	107-98-2	High	15.6	6.3	11.6	7.3	<1[a]
HFC3	405-58-6	Low	16.4	0	0	7.6	804[17]
I16	355-43-1	Low	14.1	2.1	1.4	8.0	<1[19]
EL	97-64-3	High	16	7.6	12.5	8.1	<1[a]
PFBI	375-51-9	Low	13.9	2.2	1	8.4	<1[19]
HFE1	163702-07-6	Low	13.7	2.2	1	8.7	421[17]
HFE0	375-03-1	Low	13	4.2	1	9.4	530[17]
HFE5	297730-93-9	Low	13.3	2.0	1.0	9.5	<50[17]
HFE3	-	Low	13.8	0.2	0	10.0	<50[17]
Sup	69296-04-4	Low	12.8	2.0	1.3	10.2	<50[17]
BOH	75-65-0	High	15.2	5.1	14.7	10.5	<1[a]
POH	67-63-0	High	15.8	6.1	16.4	11.7	<1[a]
PFC6	355-42-0	Low	12.1	0	0	12.6	7910[17]
HFC4	138495-42-8	Low	11.6	0	0	13.5	1650[17]
EOH	64-17-5	High	15.8	8.8	19.4	15.0	<1[a]
MOH	67-56-1	High	14.7	12.3	22.3	19.2	<1[a]
a. – Non-halogenated organics have short lifetimes yielding low GWPs.							

For a full development of HSP theory, an eBook is included with the HSPiP software.[7] It is an updated version of the CRC Handbook published in 2007.[20] For convenience, the basic HSP theory is available from the Hansen solubility parameter web site.[21] In general, the square root of the cohesive energy density $(kJ/L)^{1/2}$, or $MPa^{1/2}$ (intermolecular attraction) is partitioned into a dispersion part (*D*), a polar part (*P*), and a hydrogen bonding part (*H*). The three parts form a convenient coordinate system for plotting the relative interaction behavior of solvents and substances. In a Hansen solubility plot (Figure 2), substances that are close together will spontaneously mix because they have similar intermolecular attractions.

Small Hansen distances indicate a propensity for interaction. "Like dissolves like." The Hansen distance (Eq 1) is the Euclidian distance between two points in Figure 2.

$$R_a = \sqrt{(2D_1 - 2D_2)^2 + (P_1 - P_2)^2 + (H_1 - H_2)^2} \tag{1}$$

The solvent blend recipe search software that was developed in-house was upgraded during this project. The authors of HSPiP have added similar capability to their software package. However, the in-house software has been modified to include the quantitative structure property relationship for predicting Godfrey's miscibility M-number. This QSPR was obtained from a former student's MS thesis.[12] The software was translated from Mathematica to Sage, which uses Python. Interestingly, the optimized code performed on the cloud at SageMath[22] took less than 1% of the computational time of the former Mathematica code.[11]

The blend recipe search software takes an HSP target – the *D*, *P*, and *H* values for TCE or nPB – and computes the best replacement recipe for all pairwise combinations of a flame retardant and flammable solvent. The three-way version computes the best three-component recipe of flame retardants and flammable solvents. These recipe lists were quite long. They were sorted first by Hansen distance to TCE or nPB (R_a), then boiling point, then likely flammability, and health rating.

Our software identifies which blends might be promising, and which blends are likely to be miscible. But, "Mother Nature" decides whether there is an azeotropic blend proportion. The most promising blends for replacing TCE and nPB were mixed at a 1:1 ratio and distilled to see if an azeotrope formed.

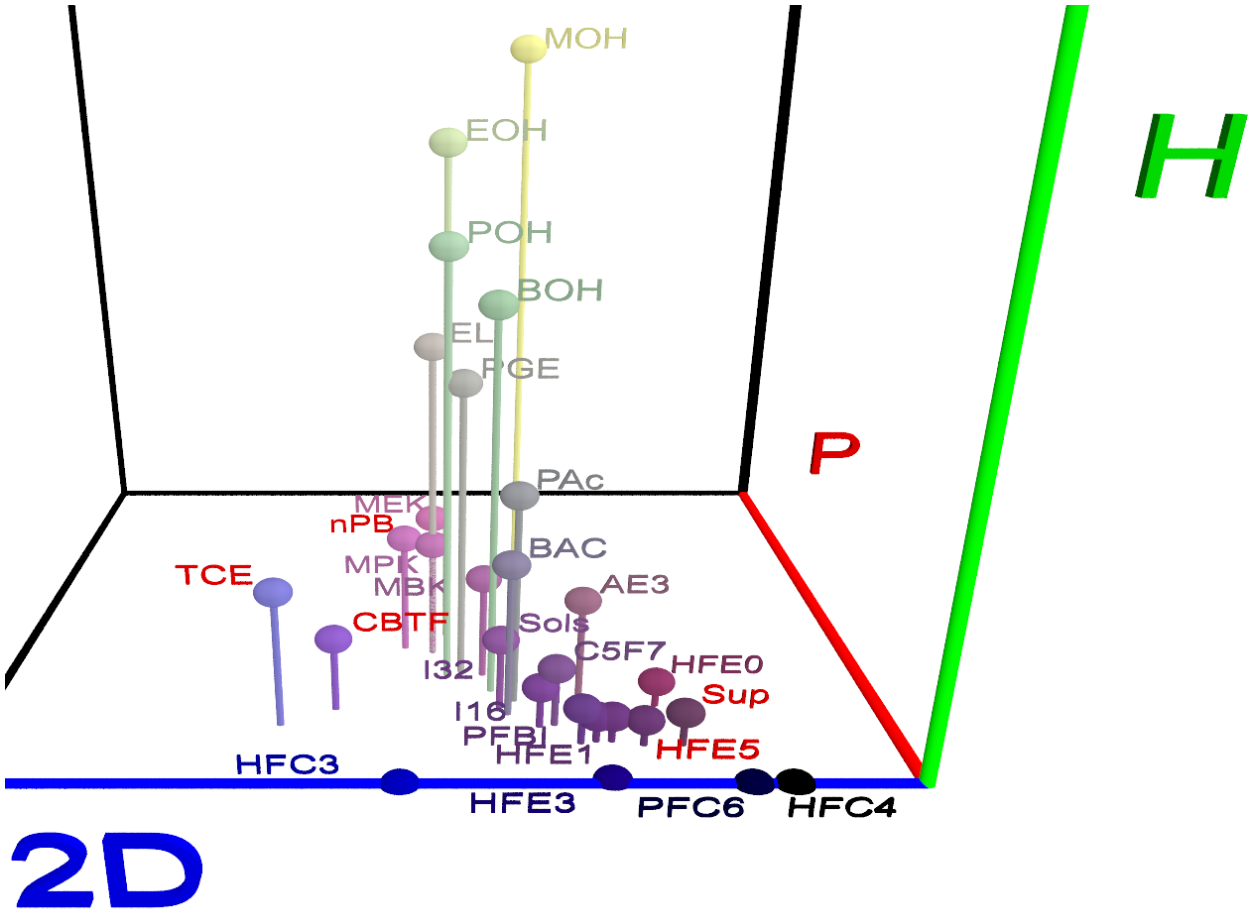

Figure 2: Solvents plotted in spherical Hansen space (2*D*, *P*, and *H in MPa*$^{1/2}$). Each data point is a blend of the colors of the HSP axes. The abbreviations are explained in the List of Acronyms.

Laboratory Testing

Standard operating procedures (SOPs) of the work performed on this project are included in the Appendix. Many of the techniques require the use of Excel spreadsheets. Please contact the PI for copies of these spreadsheets to take full advantage of the SOPs.

The baseline solvents were purchased in 5-gallon pails. The TCE was purchased from SolvChem, Inc. The nPB was purchased from Chemical Logic, Inc.

Procurement of the flame retardant solvents and developmental solvents were major challenges for the project in terms of costs and availability. Many of the solvents were not marketed as cleaning solvents, but were heat transfer fluids, refrigerants, or reactants for polymerization. Finding the correct person in a supplier's organization who had the authority to approve a direct purchase or a lab sample required hundreds of phone calls. The side benefit of this process was an excellent working relationship with the product engineers and managers at 3M, ChemLogic, Chemours, Daikin, DuPont, Honeywell, Houghton, Kyzen, MicroCare, Nugentec, Reliance, Sherwin-Williams, Sigma Aldrich, Solvay, SolvChem, and Specialty Materials Corporation. The full list of 188 project-related contacts and 107 companies and agencies is provided in Appendix A.

The companies listed were very cooperative at critical points in the project. The project would have failed if market prices were charged for all the solvents received for this grant. For instance, one sales representative quoted a price of $7,080 for 5 kg (1-gal) of trans-1,2-dichloroethylene. Some of the developmental fluids would have been even more costly. Many of the solvents were provided free of charge as research or testing samples.

The fractional distillations utilized standard organic glassware. To avoid grease contamination of our solvent fractions, PTFE inserts were used instead of grease to seal the ground-glass joints. Stainless steel chain was used in the fractioning column to prevent convective currents and to preserve a stable temperature gradient in the column. Small volumes (200 to 500 mL) were used for azeotrope testing. Large glassware up to 5 L was utilized for recycling solvents and azeotropic blends.

Fractional Distillation of binary blends is the best method for finding low boiling point azeotropes. Binary blends were evaluated first because they are simple to specify and monitor, and they are less easily broken by contamination. Interestingly, one attempt was made to treat a binary blend with a third component. The main solvent swapped azeotropic partners, making a different 2-component azeotrope that distilled from the three-component mixture in the still bottom.

Raman spectroscopy (Ocean Optics, R-3000) was used to characterize the composition of the distillate. Spectra of the pure solvents were obtained. Excel was used to mix the component spectra to create a composite spectrum. The composite spectrum was compared to the experimental spectrum of the distillate. Excel's Solver tool optimized the match between the composite and experimental spectra by changing the ratios of the two (or three) components while minimizing the sum of the squares of the residuals between the composite and experimental spectra. This procedure was very quick (< 1 min) and yielded the volume fraction of the solvent mixture.

Flash points for the solvents were confirmed in-house using the ASTM D56[23] – Tag closed cup flash point procedure with a flash point apparatus (Figure 3) from Koehler (Model K14600, koehlerinstrument.com). This provided confidence that the flash point behavior of the azeotropic blends would be accurately determined. This is an important issue because the behavior of halogenated solvents in the flash point determination can be misleading.[24] All of them participate in burning, but this is not the same as exhibiting a flash. Videos of this procedure for *n*-decane and methanol have been uploaded to YouTube.com.[25] The Discussion Section will provide more information on the flash and burning behavior of the solvents in this study.

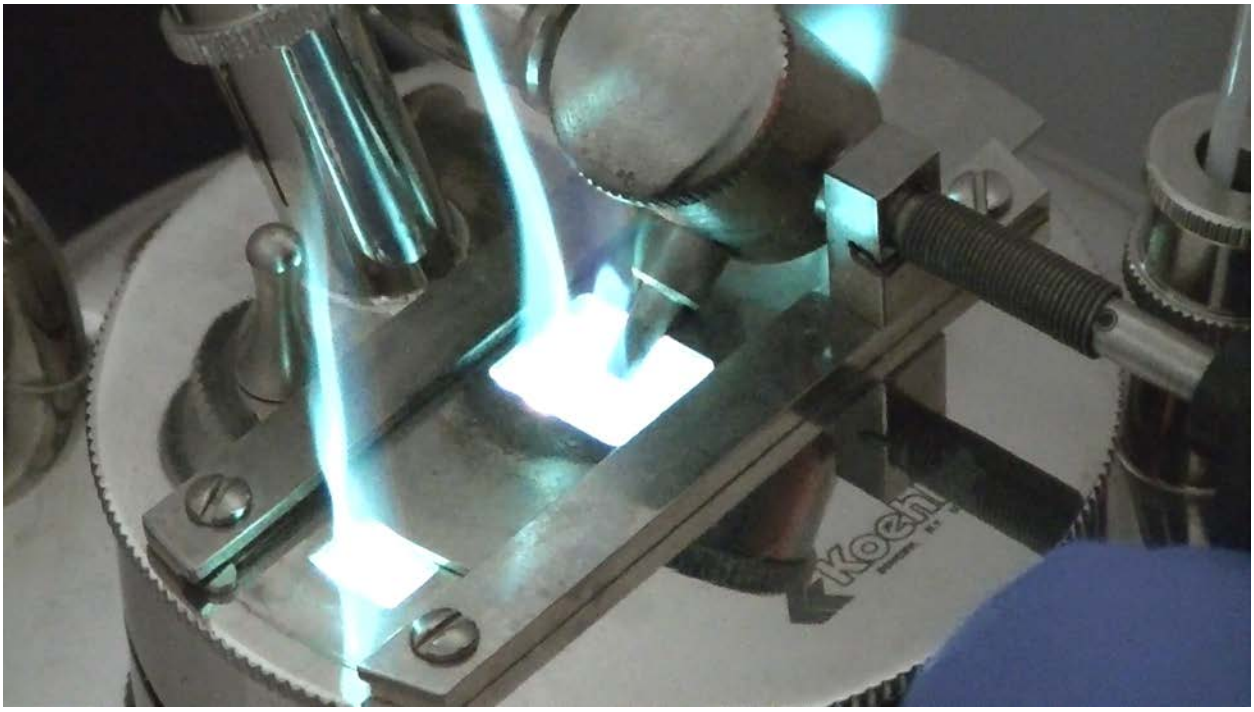

Figure 3: The flash point of *p*-chlorobenzotrifluoride (CBTF) confirmed using a Tag closed cup flash point tester and ASTM-D56

For baseline cleaning comparisons, we rented a medium-sized (10-gallon capacity) Branson 452R vapor degreaser from Reliance Specialty Products, Inc. For the main portion of the work, we purchased a small-sized (7.6-L, 2-gallon capacity) Branson B125 vapor degreaser from Degreasing Devices Co shown in Figure 4.

This older model degreaser was upgraded in-house with a sliding lid and a secondary set of subzero coils to bring it up to NESHAP compliance.[26] The subzero coils (seen in Figure 5) were constructed from copper tubing, which is an active metal. This is not recommended for full-time use in an industrial setting. However, the reactivity of the copper was not an issue for occasional use in a research setting where the solvent was only in the degreaser for short periods of time. The risk was that the degreaser would generate acidic vapors when halogenated solvents react with moisture on the copper surface. This risk was mitigated by ensuring that 1) the degreaser was always charged with freshly-distilled solvent, 2) used for a short cleaning operation, 3)

drained thoroughly after use, 4) dried thoroughly after draining, and 5) stabilized in between operations with an open tray of absorbent, acid-neutralizing sodium bicarbonate. For long term use of a given batch of solvent, small amounts of solvent stabilizer such as nitromethane may be used.

Figure 4: The 7.6-L (2-gallon) capacity Branson 125 vapor degreaser retrofitted with a sliding lid and sub-zero coils

One additional modification of the degreaser was necessary. The blends that were tested in the degreaser had boiling points above 100 °C, but the degreaser had a thermal bimetal foil circuit breaker installed on the heating mantle in the boiling sump that would shut off the heater at 100 °C. It was necessary to bypass this thermal switch. The degreaser was then able to boil the two azeotropes that we needed to test. In like manner to the copper coils, this solution would not be appropriate for unattended use in an industrial setting. A higher-temperature cutoff switch will be installed for future work.

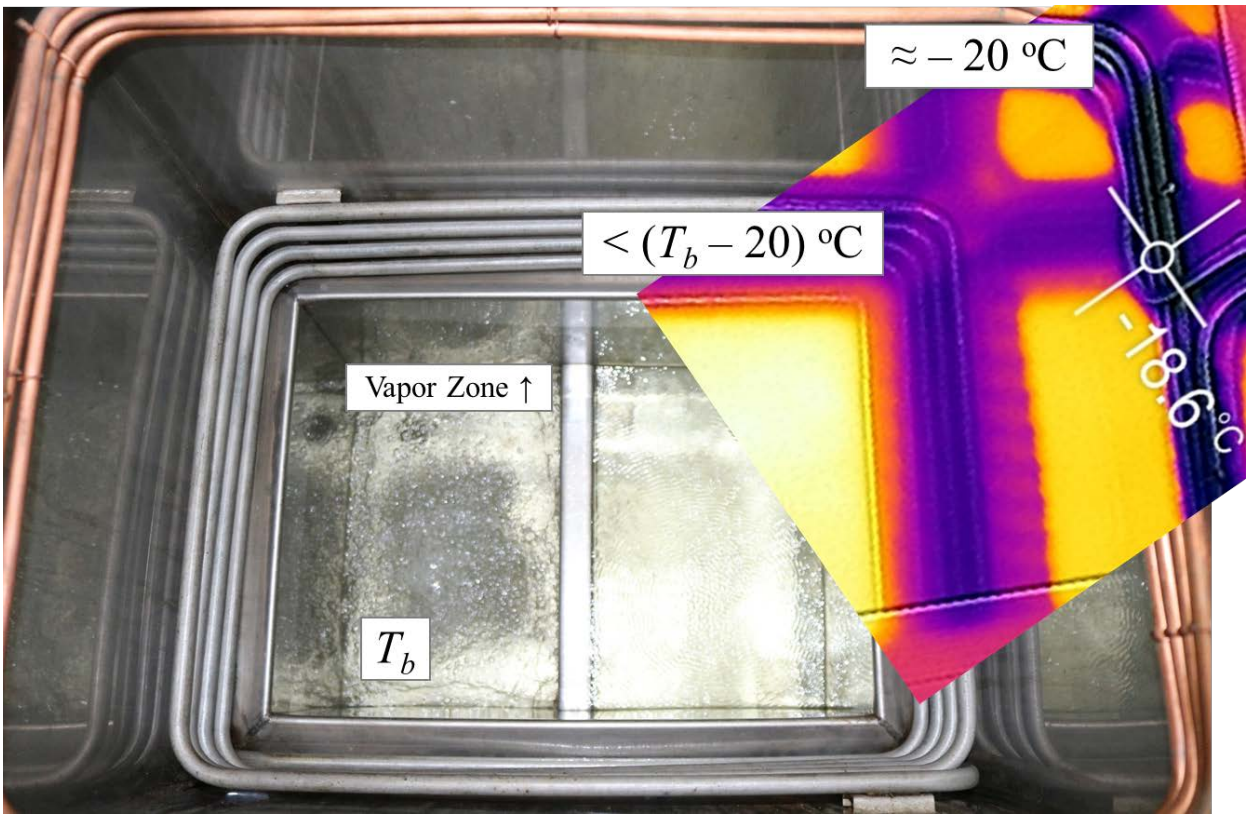

Figure 5: The inside of the Branson 125 vapor degreaser showing the temperature zones (thermal image), the vapor zone, and the copper sub-zero coils

Some of the developmental fluids such as PFBI were not available in quantities suitable for testing in the small capacity degreaser, so a lab-scale vapor degreaser was constructed from a 3-L graduated cylinder, a flexible silicone heater, coiled copper tubing, and a recirculating chiller. A photograph of this 250-mL capacity vapor degreaser is shown in Figure 6. Three substrates at a time could be cleaned in the basket in the vapor degreaser. For ultrasonics, the basket was removed from the vapor zone and placed into a beaker with the same solvent in a 40 kHz sonicator. The parts were subsequently exposed to fresh vapor in the cylinder degreaser as a rinse step and held in the subzero temperature zone for drying. A 500-mL test sample of solvent could be tested with 250 mL in the degreaser and 250 mL in the sonicator.

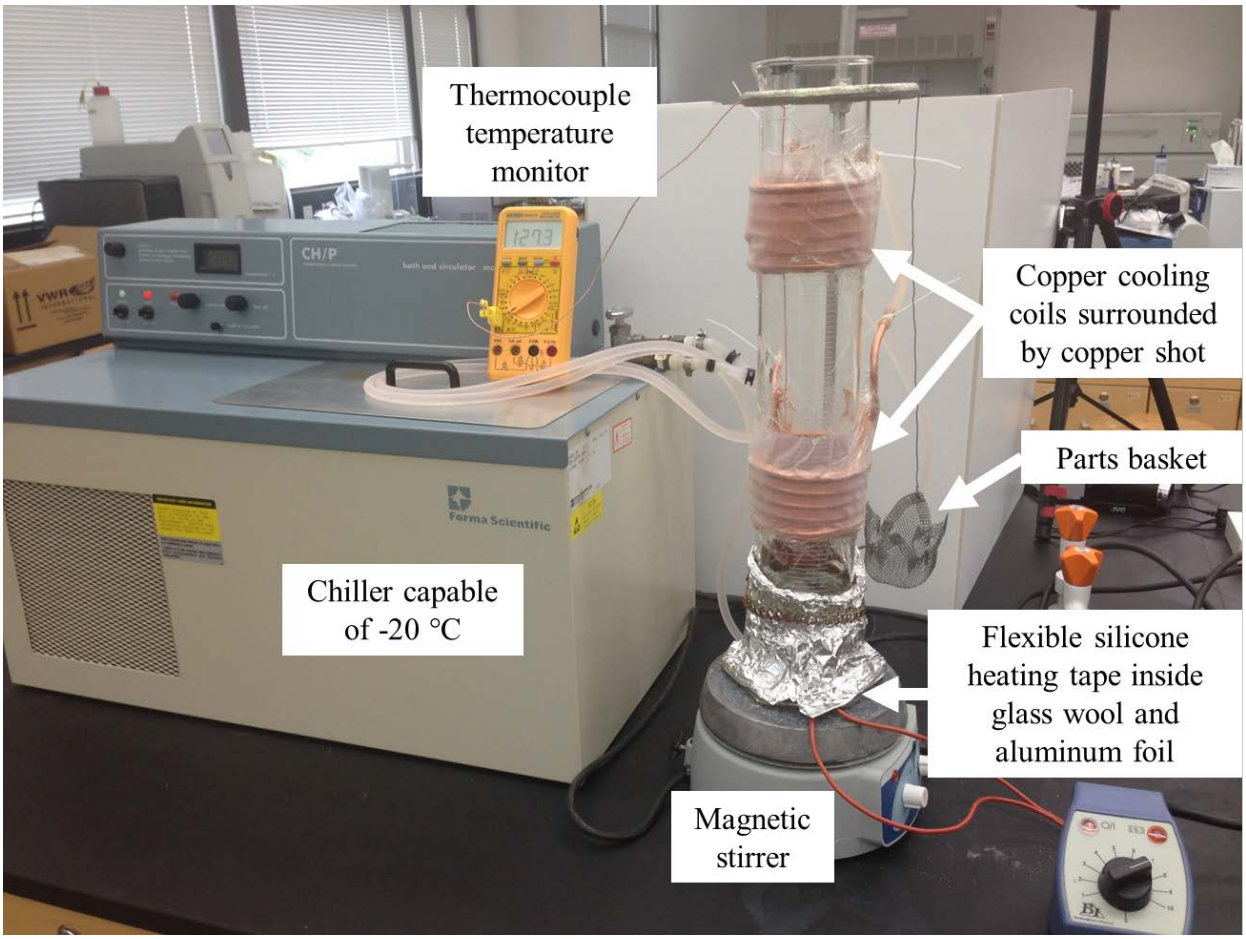

Figure 6: Cylindrical research vapor degreaser consisting of a silicone heater, magnetic stirrer, part basket, dual sub-zero cooling coils, thermocouple temperature monitor

A vial-based screening test for degreasing ability was developed for side-by-side comparison of many solvents. A small amount (~ 0.1 g) of grease was deposited into the bottom of a 4-mL glass vial with a large bore syringe. The precise amount of grease was computed by mass. Approximately 3 mL of solvent was added to the vial. The vials were gently shaken on a shaker plate for 1 hour. The vials were then emptied into pre-weighed aluminum pans. The solvent was evaporated and the transferred grease residue was evaluated. The percent mass transferred ($P_{transferred}$) was computed according to Eq 2, where m_0 is the initial mass of grease and m_t is the mass of grease transferred by the solvent.

$$P_{transferred} = \frac{m_t}{m_o} \tag{2}$$

We reached out to industry for suitable substrates and the response was large. Plasma Technology Inc provided many test coupons and materials. ART Technologies provided steel bearing races. We received threaded aluminum studs, titanium plates, aluminum plates, and

stainless steel plates. The vapor degreasing trials were performed on three substrates – 20 mm x 80 mm aluminum 7075 plates, 25 mm x 80 mm stainless steel 316 plates, and brass fittings with threads and through-holes as seen in Figure 7.

All test pieces were mechanically etched with serial numbers. The substrates were originally cleaned by hand-rubbing with lint-free wipers soaked in hexane. Baseline masses were measured on a Kern 5-place balance.

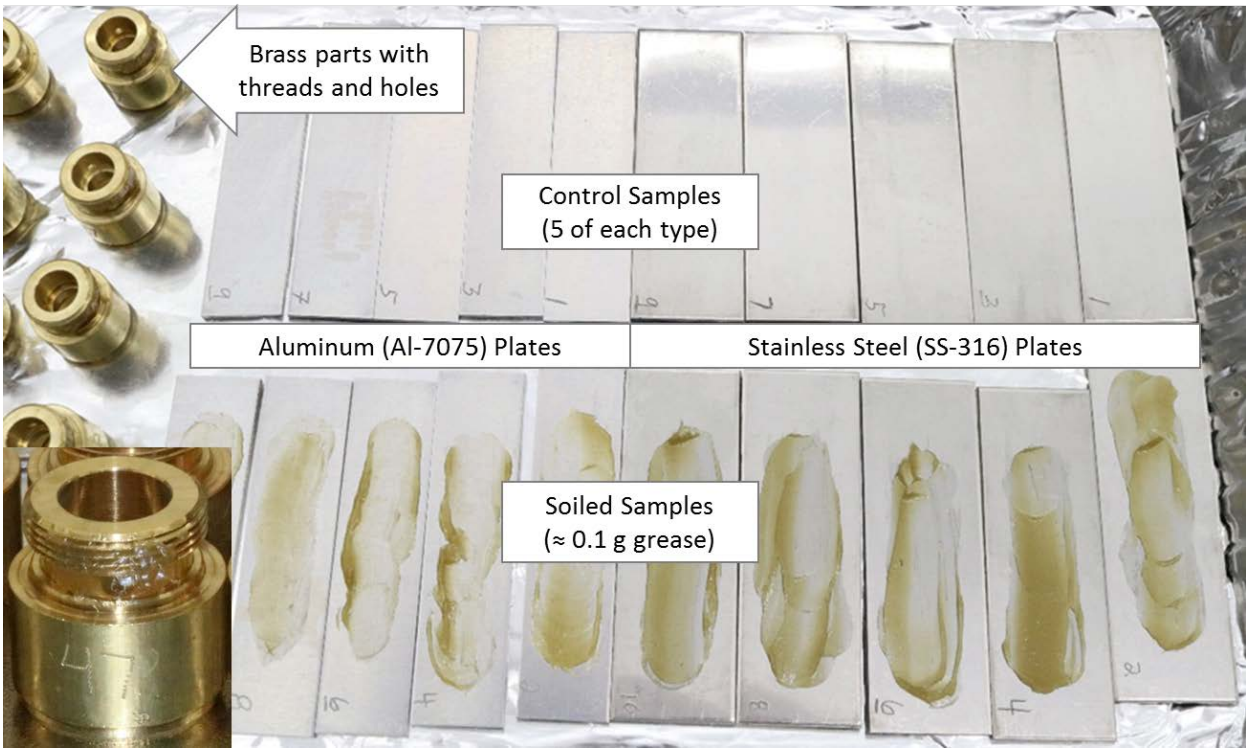

Figure 7: The degreasing study coupons (brass, Al-7075, and SS-316) showing a typical load of ≅ 0.1 g of marine grade grease

We received enthusiastic response from industry when we asked for soils that are difficult to remove from machined parts. Optiforms provided several stamping and machining oils (Fomblin 06/6, EDMS-25, Trim C350, and Cimcool cimperial 1070). W. S. Dodge Oil Co. sent SAE 140 gear oil, Outdoor Anti-Rust compound, Ruby 3-B cutting oil, and Deoplex 500/2 grease – a marine grade petroleum grease with excellent water wash-out resistance. The marine grade grease was tested with a panel of solvents and it was found to have Hansen solubility parameters close to nPB and TCE, therefore it was assigned HSPs that were the average values of those of nPB and TCE (D = 17.2 MPa$^{1/2}$, P = 5.5 MPa$^{1/2}$, and H = 5.1 MPa$^{1/2}$). This grease was used as the challenge soil for the degreasing portion of the project (Figure 7).

Approximately 0.1 g of the marine grade grease was smeared on the plates and into the threads of the substrates. The substrates were weighed, and the soil mass was computed. The soiled substrates were cleaned and weighed. The mass of soil removed was computed and compared to the original soil mass to yield a percent soil removed value for that particular cleaning method or

solvent system. In each study, five controls of each substrate type were analyzed along with five soiled substrates of each type.

Baseline performance of the B125 vapor degreaser cleaning procedure was confirmed using the target solvents nPB and TCE. The cleaning scheme involved 10 min in the vapor zone, 5 min in the ultrasonic sump, 5 min rinse in the vapor zone, and 10 min drying in the sub-zero coil zone.

The cleanliness studies were performed gravimetrically on a Kern (ABT 120-5DM) 5-place balance equipped with a serial printer. This produced very precise mass determinations because the balance sends the mass reading to the printer once the stability criteria are satisfied. Throughout the project the uncertainties in our substrate control masses were consistently ± 0.00006 g. Considering that our soil loading was in the 0.1-g range, the measurement uncertainty was regularly less than 1 part per thousand.

A variety of solder pastes (no clean, RMA, OM, leaded, and lead-free) and bulk fluxes (RMA and OM) were provided without charge from Alpha and FCT. The melting process of the solder paste is a critical factor in ion contamination residue. Therefore, the onset of melt temperatures for all the solders and fluxes were determined using differential scanning calorimetry (PolyDSC, Mettler-Toledo).

Defluxing effectiveness was measured using the resistivity of solvent extract (ROSE) method, which is outlined in a standard IPC Test Method (IPC-TM-650-2.2.25) The conductivity was measured initially with a VWR traceable conductivity probe (Catalog No. 89094-958). Later in the project the conductivity probe was upgraded to a Myron L probe (Ultrameter III 9PTKA).

Reflow soldering was initially performed using a Reflowster setup (http://reflowster.com/). This small consumer-oven system was capable of producing soldered boards, but the temperature variability within the oven was too large leading to large variability in the amount of solder flux ionic contamination. Later in the project we began using an HP 5890 GC oven to melt the solder paste (Figure 8). This worked so well that we strongly recommend the use of a GC oven by any other researchers who wish to troubleshoot reflow soldering processes in the lab.

The defluxing study was fraught with difficulties throughout most of the project year. Initially, small circuit boards were stencil pasted, populated with components, and reflow soldered. The ROSE testing was performed on the uncleaned boards to obtain a baseline value for ionic contamination. There was over 400% variability in the contamination values. Some boards were clean with no detectable contamination, while others showed ample signal. Throughout the next several months the process was studied. Different board types, solder pastes, heating temperatures, and conductivity meters were tested. The final result was a bulk solder paste vial test.

The bulk solder paste vial test produced consistent ionic contamination. A portion (0.5-2 g) of solder paste was placed in a 30 mL vial. Typically, five vials for each solvent and five controls were tested. The vials were capped tightly with aluminum foil and placed into a columnless GC oven (Figure 8). The oven was heated to 5 °C above the melting temperature of the solder paste and held for 10 minutes. The solder formed a uniform ball of solder in the bottom of the vial surrounded by light amber flux residue. After cooling, approximately 25 g of solvent was added to the vial to dissolve the flux residue. The vials containing solvent-solder-flux mixture were capped and sonicated at 40 kHz in a Branson 3510 sonicator for 1 hour. The solvent was transferred to a clean 30-mL vial and evaporated to dryness at 100 °C. The ROSE test was

performed on both vials to measure the ionic contamination transferred and left behind by each solvent. The final figure of merit was the percent of ionic contamination (P_{ion}) transferred by the solvent (Eq 3), where C_t is the blank-corrected conductivity of the transfer vials and C_o is the blank-corrected conductivity of the flux residue that remained in the original vial.

$$P_{ion} = \frac{C_t}{C_t + C_o} \tag{3}$$

Figure 8: The HP 5890 GC oven that served as a temperature-programmable reflow oven for the vial-based defluxing tests

Additional solvent and solvent blend properties were determined for the new azeotropic blends such as surface tension (γ) using the DuNuoy Ring method (ASTM D1331[27]) on a custom tensiometer[28], hydrostatic density (ρ) using the same apparatus, and viscosity (η) using the ball drop method (ASTM D1343[29]) modified to produce digital time measurements via video.

A photo of the video-assisted ball drop apparatus is shown in Figure 9. The viscometer tube was placed on a hinge. The video camera was aligned to view the top timing marks through a microscope slide tilted at a 45° angle. A front-silvered mirror was aligned with the lower timing marks. The video recording was started. The viscometer was rotated up until the ball reached the top, then rotated down to begin the measurement. Once the ball passed the top timing marks, a

light was directed onto the lower timing marks. The brightened image caused the camera to focus through the microscope slide onto the lower timing marks capturing the passing ball. Frame-by-frame analysis repeatedly measured the transit time to ±1 frame, which was ±0.03 seconds – much better than using a hand-operated stopwatch. Data was collected with both the steel ball and the glass ball.

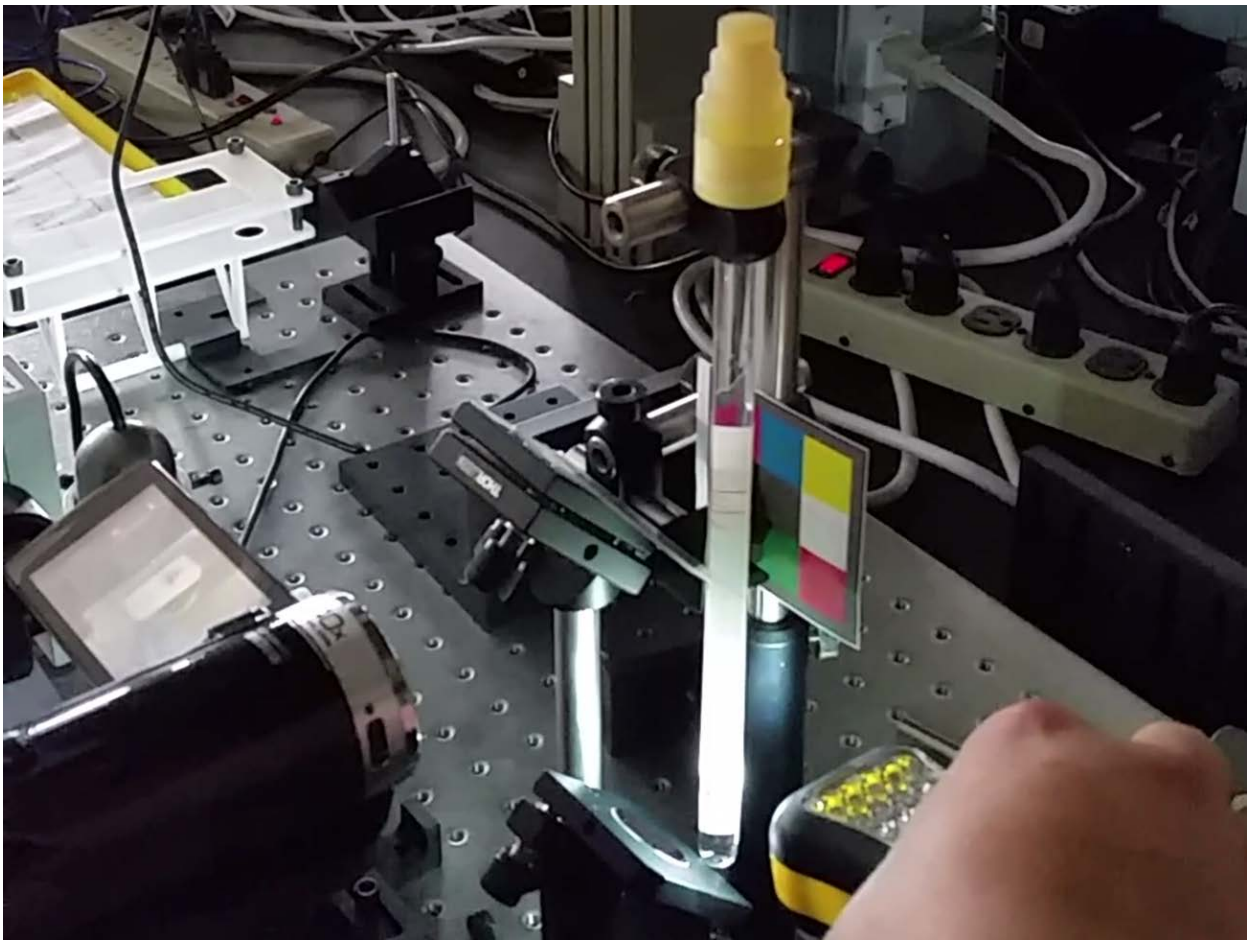

Figure 9: Video-based falling ball viscometry apparatus

Consultant Visitation and Support

BFK Solutions, LLC provided consultant support throughout the project, including making and referring many of the contacts for obtaining equipment, testing coupons, samples of soils and candidate solvents. Ed and Barbara Kanegsberg of BFK Solutions visited in June of 2015 to inspect our procedures, provide training for the student researchers, and to make suggestions for moving forward. They observed vapor degreasing operations in the Branson 452. They observed the flash point determination method. They made suggestions regarding the development of the small-scale cylinder vapor degreasing apparatus. They made suggestions regarding the development of reflow soldering capabilities. All of their suggestions were implemented, and

contact was maintained with the consultants via weekly teleconferences. Their input and involvement was critical to the success of this project. Near the end of the project, the PI and BFK Solutions gave a joint presentation on the degreasing portion of this SERDP grant at the NASF SUR/FIN 2016 conference. This presentation may be obtained from the SERDP project page or from the PI.

Results and Discussion

The results of the down-selection scheme in Figure 1 are shown in **Error! Reference source not found.**. The nomenclature for these various substances can be difficult, so the chemical abstracts service (CAS) numbers are given for most of the solvents. The abbreviations used throughout this report are shown. The full names for these substances are given in the List of Acronyms. The blend searching involved mixing a highly flammable solvent with a flame retardant solvent.

The safety data sheets are supplied in the Appendix. All the substances are shown in Figure 2 labeled with the abbreviations from **Error! Reference source not found.**. There are a few solvents that are close ($R_a < 5$) to nPB and TCE, namely MEK and MPK for nPB and CBTF for TCE. The Hansen distances of all these solvents from the average *D*, *P*, and *H* values of nPB and TCE are reported in Table 1.

Figure 2 suggests that the VOC-exempt solvent CBTF would be a good choice for replacing nPB and TCE. However, CBTF has a reported 43 °C flash point which was confirmed in-house at 41.5 °C (Figure 3). Thus, it cannot be used directly in a vapor degreaser. It will have to be blended with a flame retardant to make it safe for use in a vapor degreaser.

The blend software suggested that blends containing methanol might be able to benefit from its light molar mass. Methanol is not VOC-exempt. However, the VOC content is tracked by mass in grams per liter. Thus, one would obtain more “active ingredient” by mass with methanol than with any other solvent. Methanol is also favorable for miscibility since it often dissolves and mixes in environments that one would not expect from a straight-forward application of the Hansen solubility parameter theory.[7]

The solvent AE-3000 was interesting because of its higher P and H values. By itself it was not a strong solvent for our test grease, so an azeotrope with HFC-365 (Solkane 365) was explored.

Various low-boiling azeotropic blends were discovered via fractional distillation. In most cases the condensation temperature of the first fraction was substantially lower than the boiling point of the most volatile blend component. In the case of CBTF/Suprion, the boiling point was the same as Suprion, but the condensate was 20% CBTF by volume.

The composition of each new azeotrope was determined by Raman spectrophotometry and an additive chemometric fit, where the relative amounts of each component were varied until the sum of the individual spectra matched the experimental spectrum of the azeotrope. The residuals (calculated minus experimental) were squared and summed to compute the RMS difference value. The Solver tool in Excel was used to minimize this RMS difference by modifying the relative concentration of the blend component spectra. The default settings of the Generalized Reduced Gradient (GRG Nonlinear) method were able to find the same fit compositions (ca. ± 0.002) regardless of starting point.

One can see some remnants of a first-derivative nature in the residuals in many of the Raman spectra. This indicates some slight shift in the peak positions in the mixture relative to the pure solvent spectra. However, the RMS difference was never more than 4 parts in a thousand when compared to the integrated signal of the mixture spectrum.

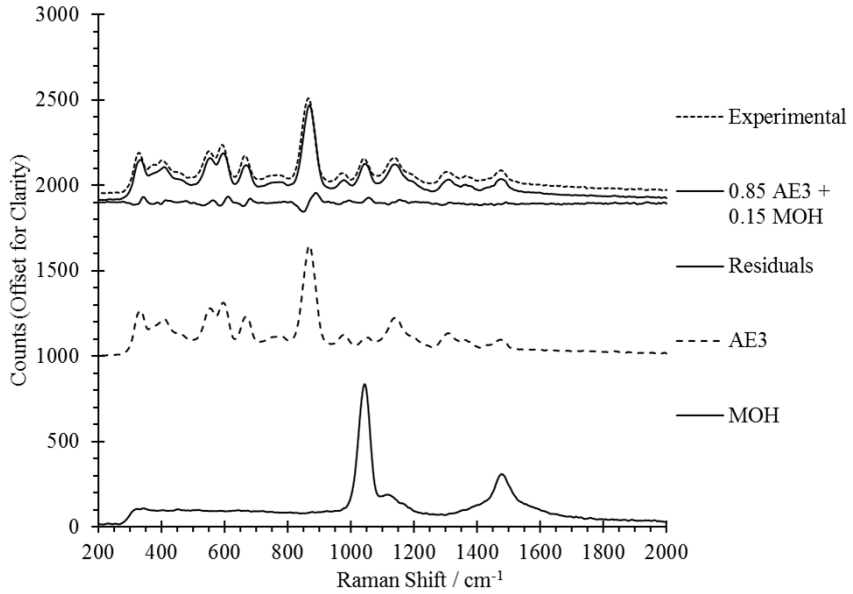

Figure 10: The Raman chemometric analysis of azeotrope number 1 of AE-3000 and methanol

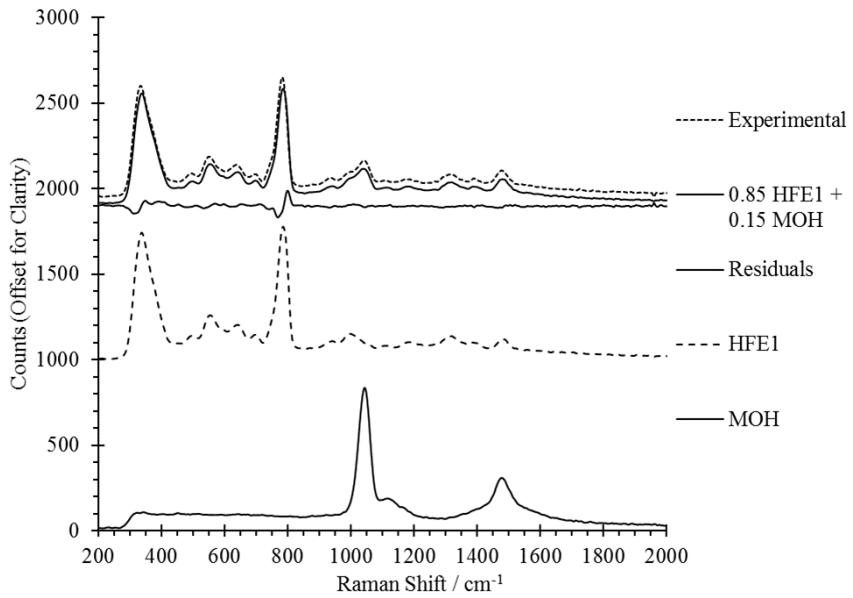

Figure 11: The Raman chemometric analysis of azeotrope number 2 of HFE-7100 and methanol

It is merely coincidental that both azeotropes (1 and 2) with methanol were at the ratio 85:15.

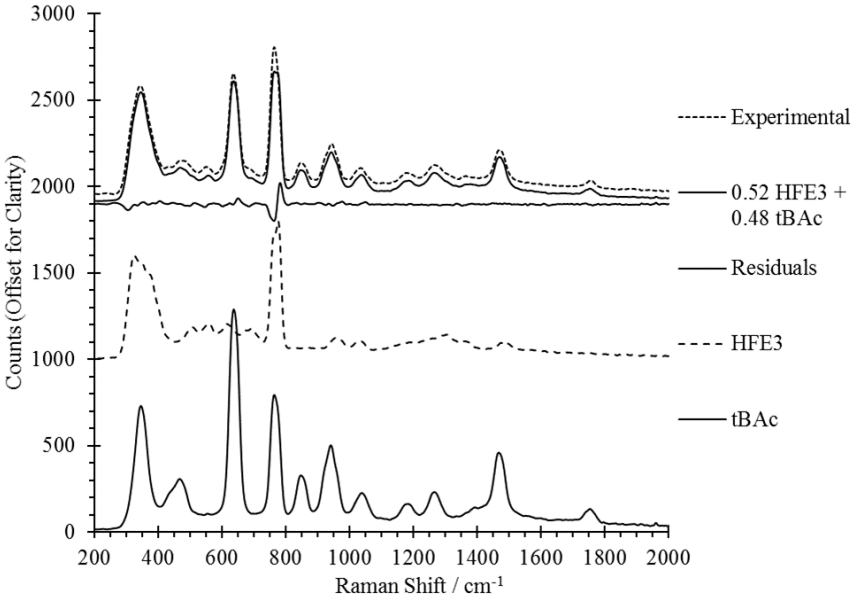

Figure 12: The Raman chemometric analysis of azeotrope number 3 of HFE-7300 and *tert*-butylacetate

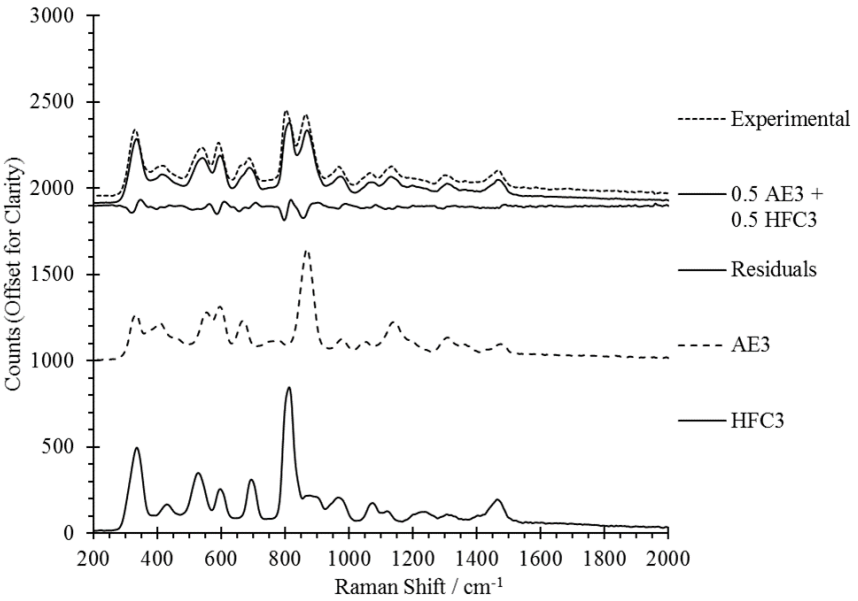

Figure 13: The Raman chemometric analysis of azeotrope number 4 of AE-3000 and Solkane 365

The 50:50 ratio indicates that AE3 and HFC3 exhibit similar intermolecular attractions.

The ethyl lactate and HFE-7500 formed a two-layer distillate. The distillate was transferred to a graduated cylinder to measure the volume ratios of each layer (Table 2). The top layer was 14% and the lower layer was 86% of the condensate volume. The top layer analysis is in Figure 14 and bottom layer in Figure 15.

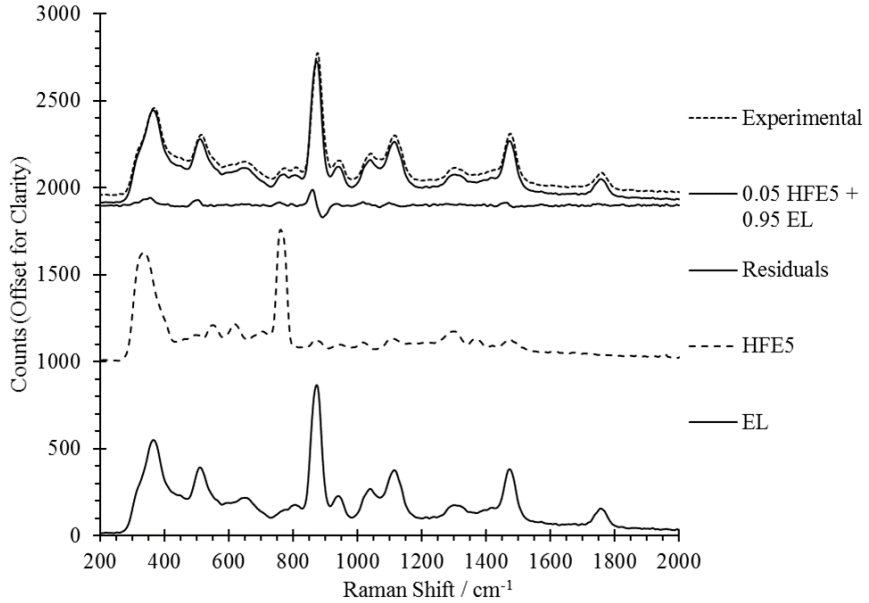

Figure 14: The Raman chemometric analysis of the light fraction (top layer) of the two-phase azeotrope number 5 of HFE-7500 and ethyl lactate

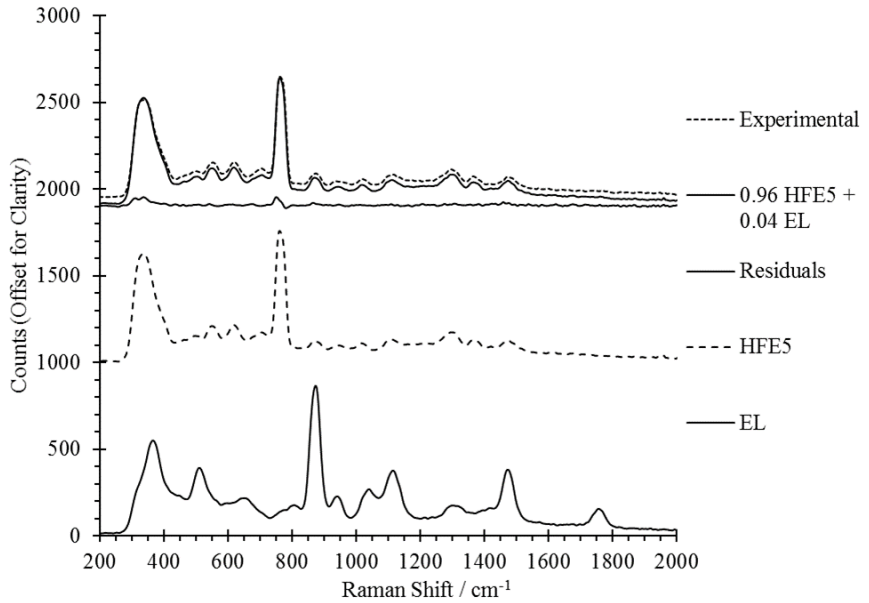

Figure 15: The Raman chemometric analysis of the heavy fraction (bottom layer) of the two-phase azeotrope number 5 of HFE-7500 and ethyl lactate

The two azeotropes containing CBTF are shown below. Both contain substantial amounts of fluorinated solvent, which helped suppress the CBTF flash point. Azeotrope 6 exhibited the same boiling point as the Suprion solvent, but with a substantial amount (20%) of CBTF.

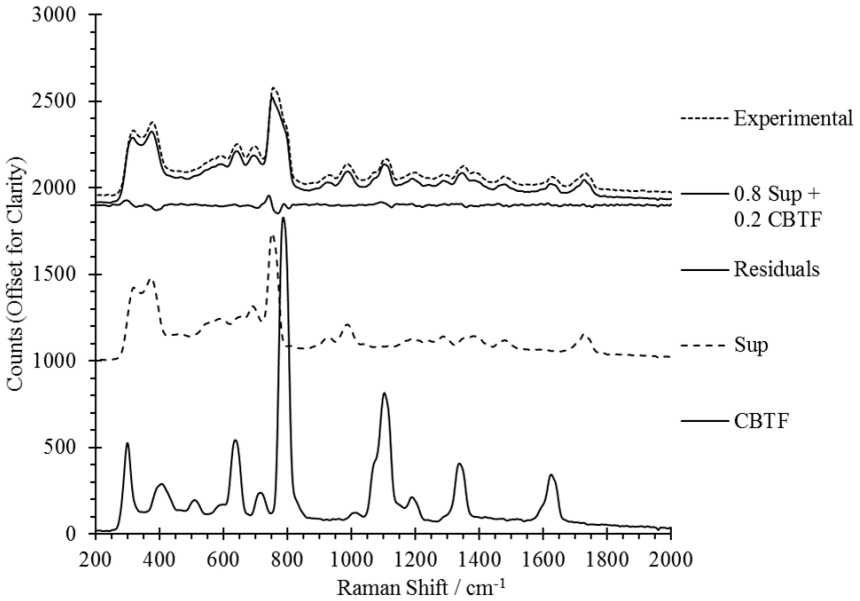

Figure 16: The Raman chemometric analysis of azeotrope number 6 of Suprion and *p*-chlorobenzotrifluoride

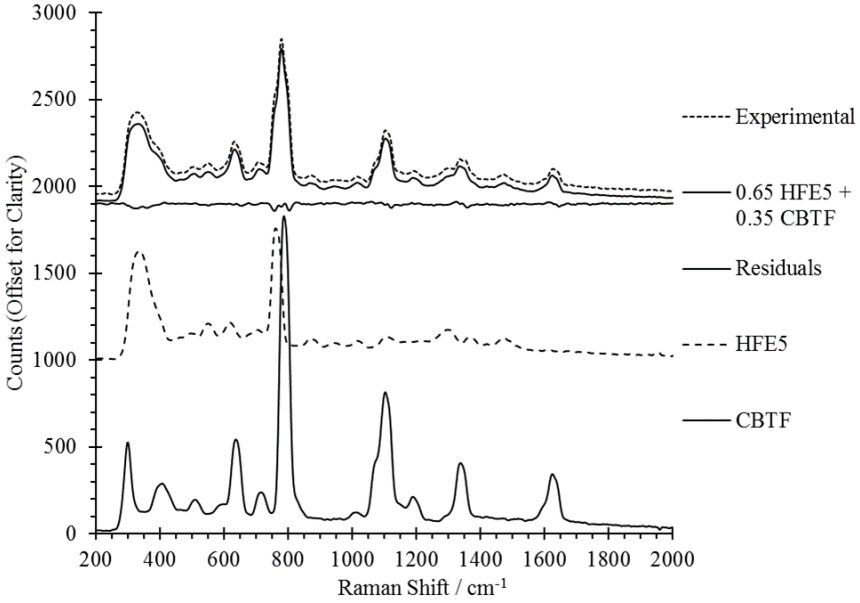

Figure 17: The Raman chemometric analysis of azeotrope number 7 of HFE-7500 and *p*-chlorobenzotrifluoride

Table 2: Compositions (% v/v), boiling points, and flash point behavior of the azeotropes discovered by this project

Abbr	Solvents #1	#2	χ^2	T_b /°C	T_{flash} /°C	Comments
AZ1	85% HFE1	15% MOH	410		45.5	
AZ2	85% AE3	15% MOH	390		48	
AZ3	53% HFE3	47% tBAc	480	84	≤ 21	
AZ4	50% AE3	50% HFC3	520		None	Very poor solvency.
AZ5	83% HFE5 5% in LF 96% in HF	17% EL 95% in LF 4% in HF	 430 390	112	≤ 50	Two phase liquid: Light fraction (LF) is 14% (v/v) Heavy fraction (HF) is 86% (v/v)
AZ6	80% Sup	20% CBTF	290	110	None	Carried forward to testing
AZ7	65% HFE5	35% CBTF	270	125	None	Carried forward to testing

The flash point test was the initial screening tool because solvents with flash points at or below their boiling points are precluded from use in a vapor degreaser. The flash point test is somewhat controversial. Some solvents were listed as having a flash point under ASTM D56 Tag closed cup method, but elsewhere as not having a flash point under DIN 22719 Pensky-Martens closed cup method (ASTM D93 and ISO 2719). Other solvents were listed in the opposite manner.

The Pensky-Martens apparatus traditionally uses a flame as a heat source, which in our estimation posed an unnecessary risk to the lab due to the large volume of flammable solvents. We favored the Tag closed cup tester because of the electric heater, although now the Pensky-Martens apparatus is available with an electric heater.

Another difficulty with flash point is the burning behavior of halogenated solvents and solvent mixtures. The ability of halogenated solvents to inert the vapor zone is exactly what this project is aiming to achieve. This does not mean that an azeotropic mixture of solvents will not burn. It does mean that it will not flash according to the criteria of the standard. This is acknowledged in ASTM D56 with the following text from Appendix X.

> X1.1 A condition during flash point testing can occur with certain mixtures whereby the nonflammable component of the sample tends to inert the vapor space above the liquid, thus preventing a flash. Under this condition, the flash point of the material is masked resulting in the reporting of incorrect high flash point or no flash point.

The inerting of the vapor space is the purpose of adding the highly fluorinated solvents to the blend recipes in this project.

> X1.2 This flash point masking phenomenon most frequently occurs with ignitable liquids that contain certain halogenated hydrocarbons such as dichloromethane (methylene chloride) and trichloroethylene.

X1.3 Under this condition, no distinct flash as defined in 3.1.1 is observed. Instead a significant enlargement of the test flame and a change in the color of the test flame.

The enlargement and change of color of the test flame was observed with our azeotropic blends that did not have a flash point.

The dramatic flash point of CBTF is shown in Figure 3. Notice that the flame propagated down to the surface of the solvent and exited the second window of the flash point tester. This is the required behavior. Prior to the flash point temperature, the solvent may enlarge the test pilot flame, may participate in burning, and may even dramatically change the color of the test pilot flame. All three behaviors are shown in Figure 18 for CBTF and in Figure 19 for HFE1.

All of the flash point tests were captured in digital video format and are available from the PI so that the flash point behavior may be further examined by others who are interested.

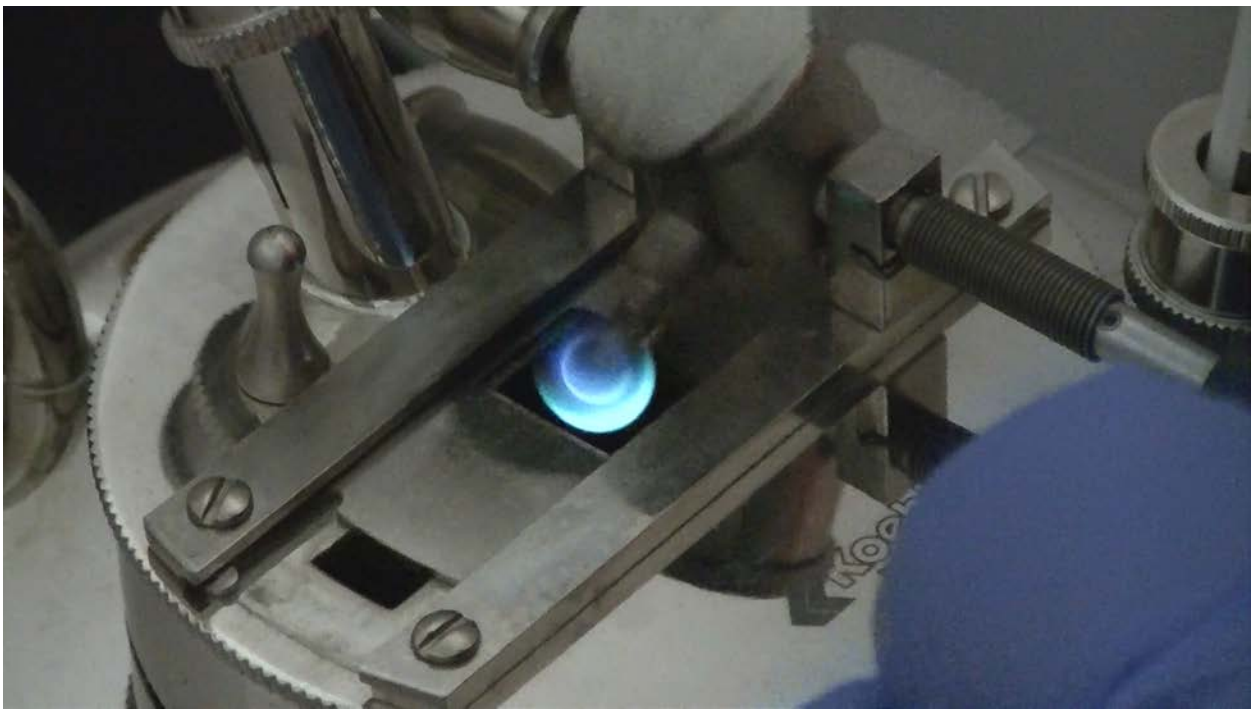

Figure 18: Photo of CBTF participating in burning below its flash point

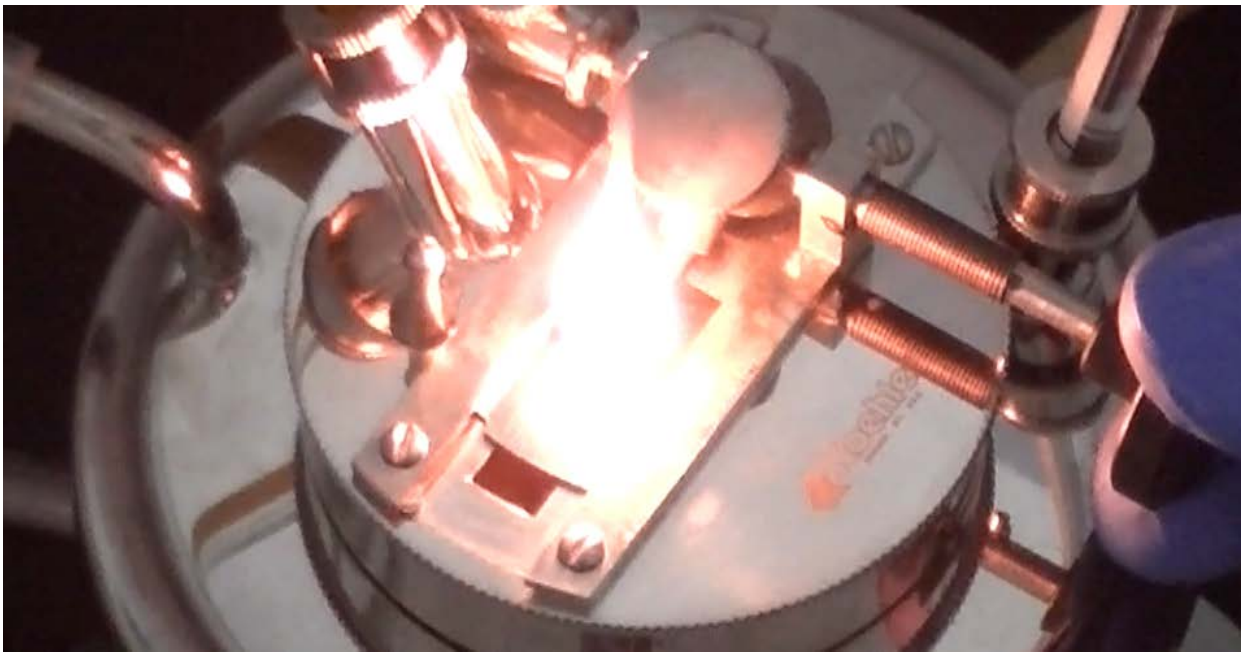

Figure 19: Photo of HFE-7100 participating in burning up to its boiling point

The behavior of azeotropes 6 and 7 is identical to that of the non-flammable HFE solvents as shown in the following figures.

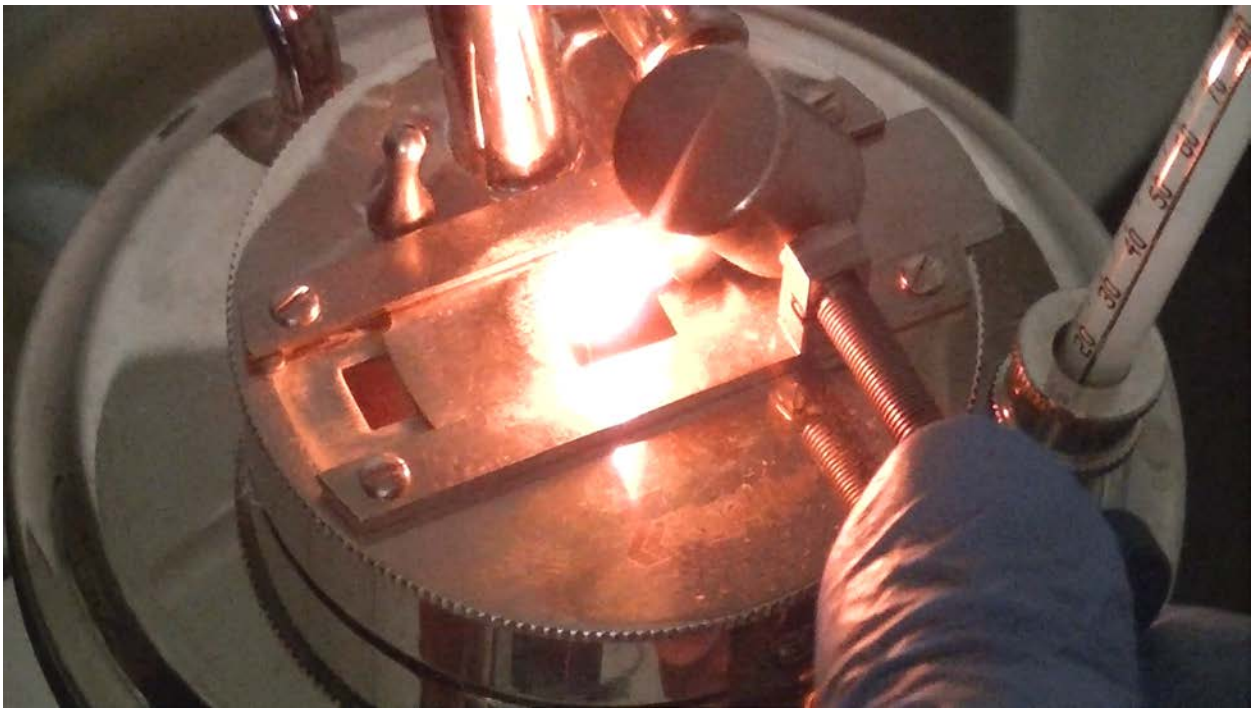

Figure 20: Photo of azeotrope 6 (20% CBTF and 80% Sup) participating in burning at its boiling point

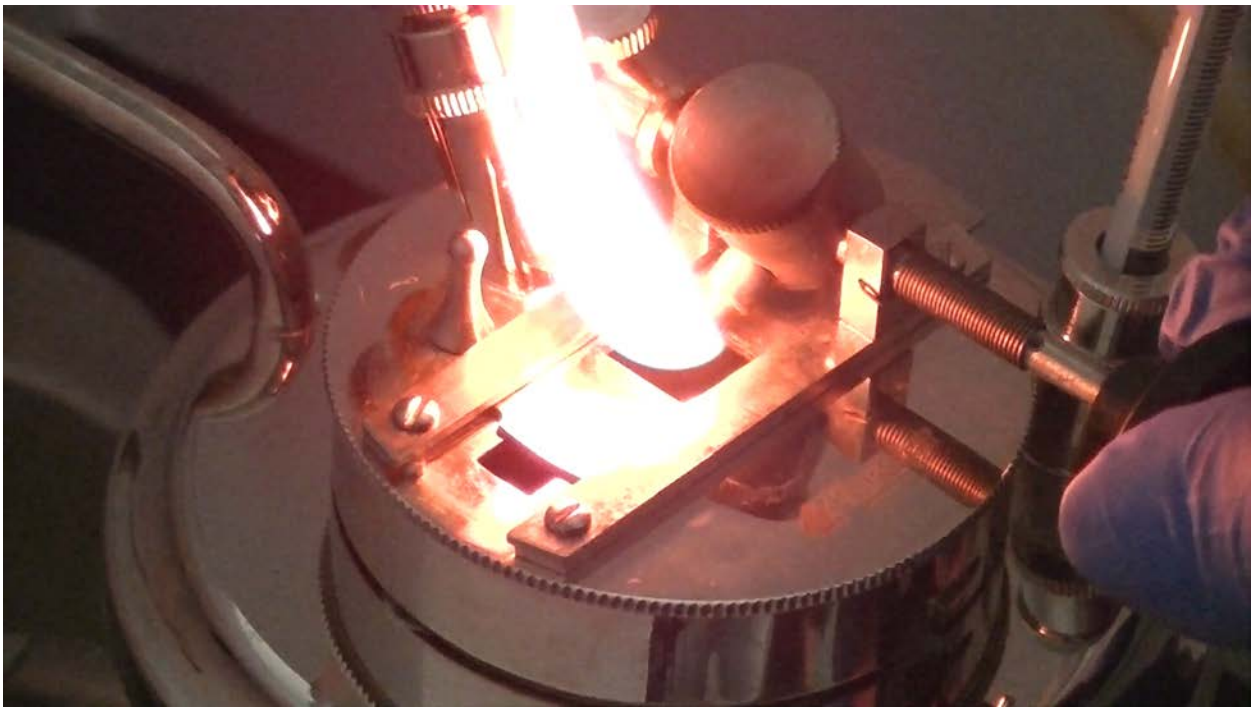

Figure 21: Photo of azeotrope 7 (35% CBTF and 65% HFE5) participating in burning at its boiling point

The results of the vial-based screening test are shown in Figure 22. This screening test is advantageous because it allows comparisons to flammable solvents because the solvents are enclosed in capped vials. The performance of EL and acetone (ACE) was poor. The solvents MEK and hexane (HEX) performed moderately well. The solvents targeted for replacement (TCE and nPB) removed the grease very well in this test.

Perfluorobutyliodide (PFBI) and CBTF seemed to clean well in this screening test as did the commercially-available *trans*-dichloroethylene blend HFE-71DE. The research sample of PFBI was too small to test further in this study, and the trans blend was included merely for benchmarking purposes.

The results of the screening test should be interpreted with caution, however. Some of the solvents and azeotropic blends merely loosened the grease from the glass causing it to fall out of the vial into the weigh pans in clumps. This does show the ability to loosen adhesion of the grease to glass, but it is not the expected removal of grease by dissolution into the cleaning solvent. This is the source of the discrepancy in the performance of azeotropes 6 and 7 between the vial screening tests and subsequent vapor degreasing testing.

The AE3000-HFC3 solvents did form an azeotrope (AZ4), but the screening test revealed that this azeotropic mixture would not be a strong candidate for replacing nPB or TCE. The tBAc-containing azeotrope (AZ3) showed promise in this test, but this azeotrope exhibited a flash point. The methanol-containing azeotropes (AZ1 and AZ2) had flash points, and thus, were not tested in the solvent screening test.

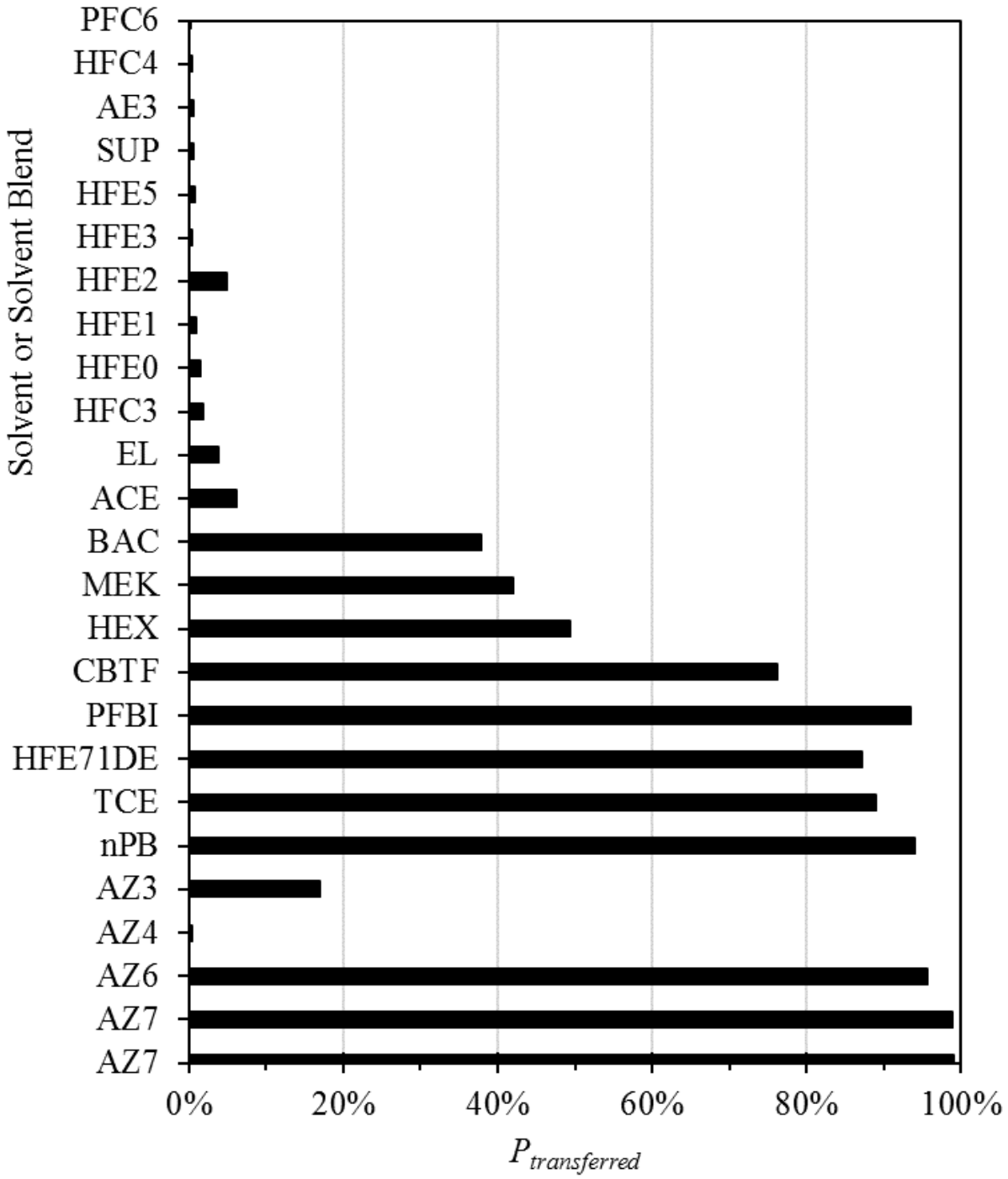

Figure 22: The results of the vial-based solvent screening test

The vapor degreasing ability of the new azeotropic blends (AZ6 and AZ7) was tested using the Branson 125 vapor degreaser. The effectiveness of the apparatus and the procedure was tested using nPB and TCE to ensure that the cleaning times and steps were adequate for cleaning.

The visual performance of the nPB and TCE was excellent. The steel and aluminum coupons appeared pristine after cleaning. The brass fittings were also visually clean. Even the threaded regions and through-holes were cleaned effectively as shown in Figure 23. The before and after photos of brass part number 47 are shown.

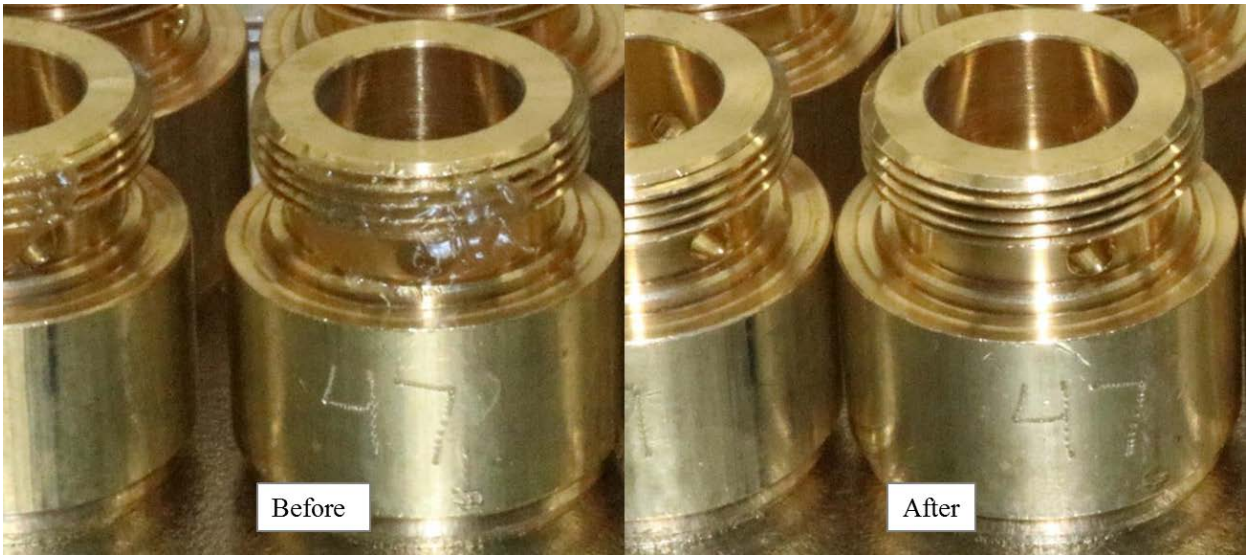

Figure 23: The visual performance of nPB in the Branson 125 against marine grade grease on brass fitting #47 shows that the degreasing protocol works well. The visual performance of TCE was identical.

The gravimetric performance of nPB shows that 100% of the grease was removed (Figure 24). In fact, the SS316 parts are showing a greater that 100% clean. This could occur in two ways. One way is a removal of some of the metal during cleaning, but this is unlikely. The other way, is that the clean mass was not actually clean. This is likely, since our baseline cleaning method for the initial part mass was to rub the part with a hexane-soaked wiper. In past studies, this was a good baseline cleaning method. But now we see that vapor degreasing with nPB in our degreaser with 10 min vapor, 5 min sonics, and a 5 min rinse in the vapor is superior to hand wiping with hexane for this particular grease.

These results were checked with TCE, and a similar result was obtained. Only this time, the brass fittings were cleaned to a slightly better level than the baseline mass as seen in Figure 25.

These degreasing studies utilized five coupons of each type of material and five control coupons of each type. The control coupons showed no significant mass gain or loss (≤ 0.00011 g).

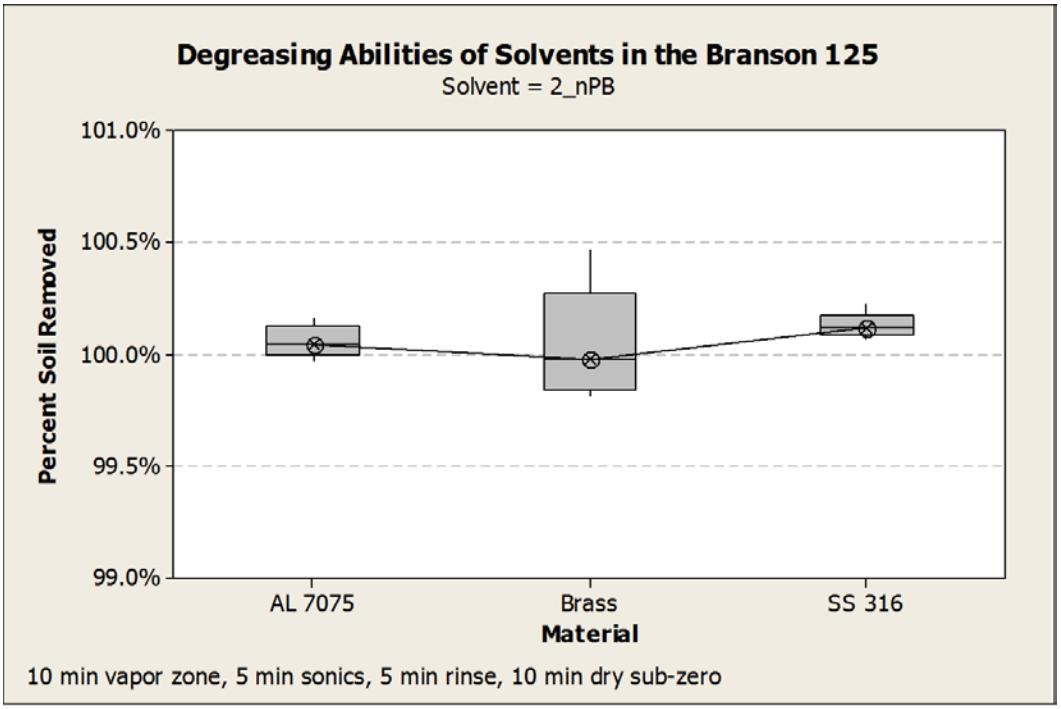

Figure 24: The gravimetric performance of nPB in the Branson 125 against marine grade grease

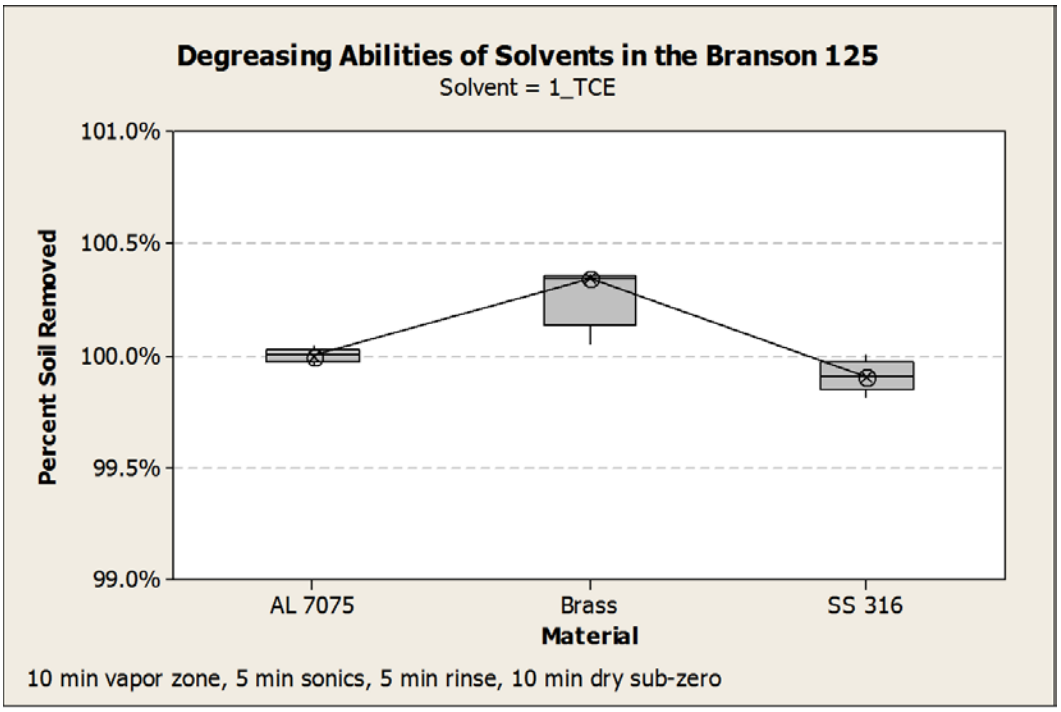

Figure 25: The gravimetric performance of TCE in the Branson 125 against marine grade grease

The visual performance of AZ6 – the Sup/CBTF blend – was not impressive (Figure 26). Only the after photo is shown because it is not very different than the before photo. One can see in the steel coupons (1-5 in the upper-left of Figure 26) that some cracking of the grease has occurred. It seemed that AZ6 was able to dissolve one of the oily components of the grease formulation, but was unable to remove the more viscous fraction of the grease. The vial test showed some hint of this behavior as well.

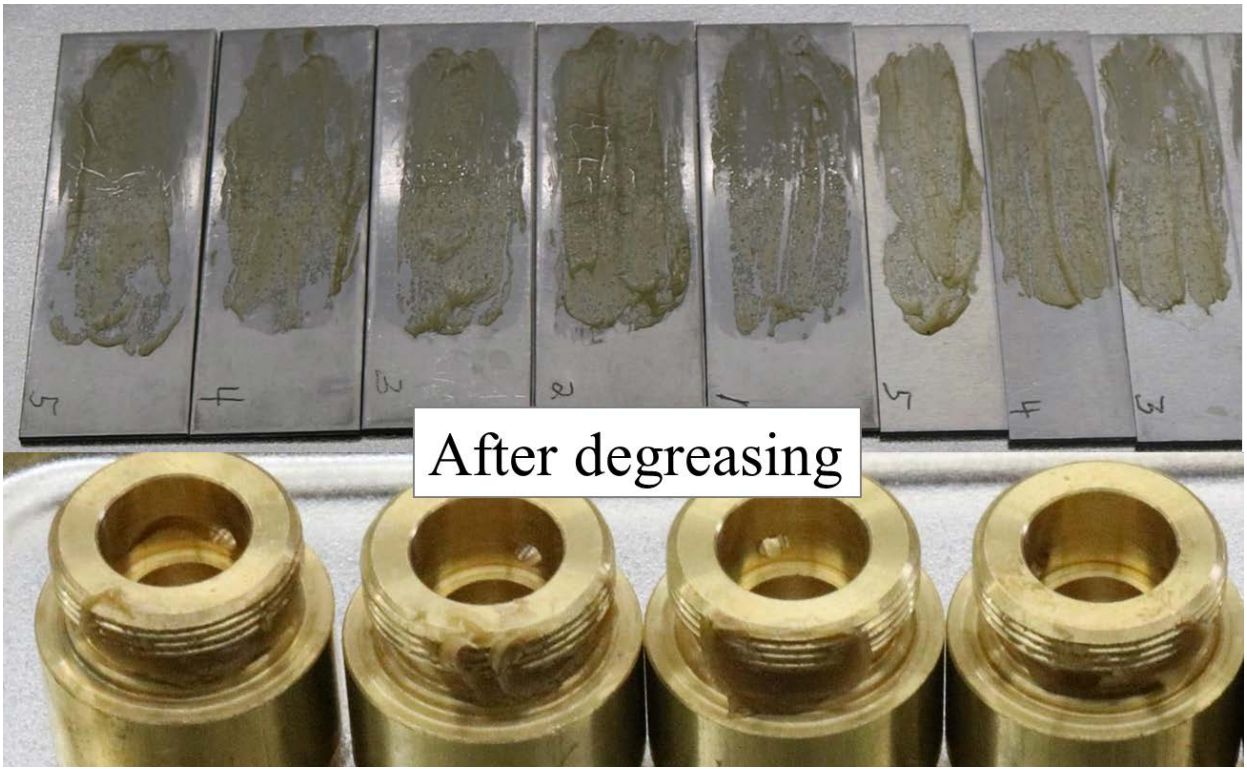

Figure 26: The visual performance of azeotrope number 6 (AZ6) in the Branson 125 against marine grade grease

The gravimetric results in Figure 27 reveal quantitatively the poor performance of this solvent blend AZ6 against this particular grease. The median performance on all 3 part types was below 20% soil removed. The narrow interquartile boxes and range lines encompass five parts and show how repeatable the behavior was on the brass and steel parts.

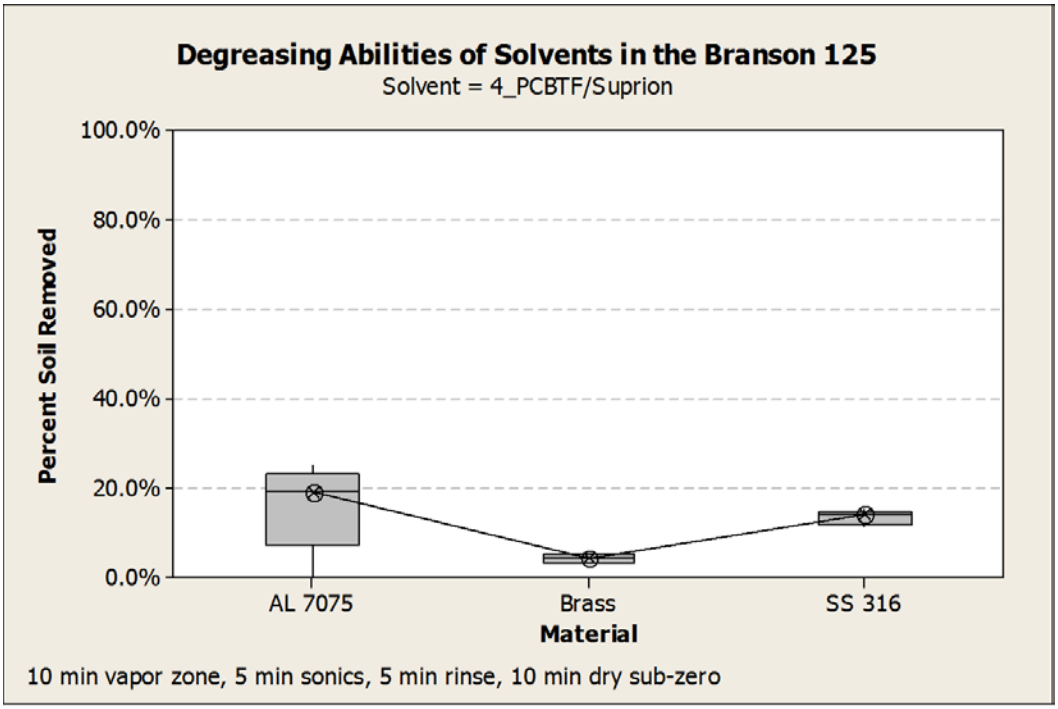

Figure 27: The gravimetric performance of azeotrope number 6 (AZ6) in the Branson 125 against marine grade grease

The visual performance of AZ7 – the HFE5/CBTF blend – was better than AZ6 but still not good (Figure 28). Much more of the grease was removed, but large areas of residue remained. The residue had a dry and cracked appearance, especially on the brass parts. This suggests that an oily component of the grease was preferentially removed by the blend.

The gravimetric results in Figure 29 show that slightly more than half of the grease was removed from the aluminum parts. Less than 40% was removed from the steel parts, and less than 20% was removed from the brass parts. It is interesting that the same pattern is exhibited by both azeotropes, meaning that aluminum was more successfully cleaned than steel. The brass fittings were the most difficult for both probably due to grease gripped by threads and holes.

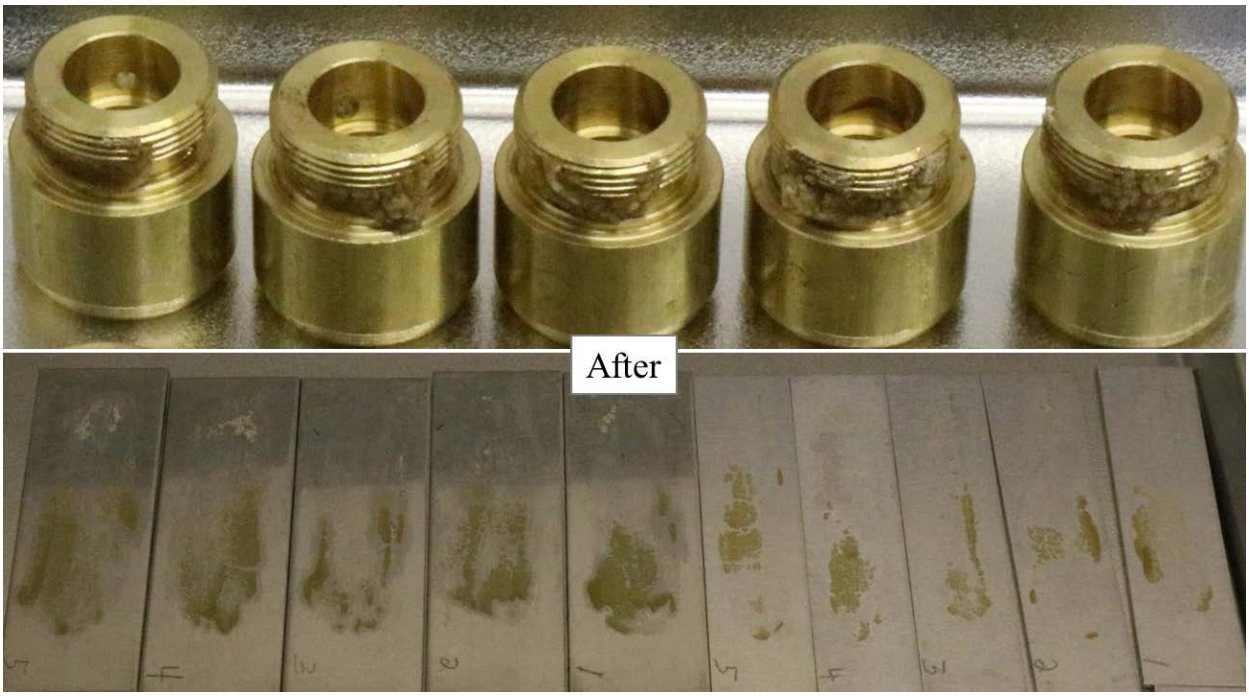

Figure 28: The visual performance of azeotrope 7 (AZ7) in the Branson 125 against marine grade grease

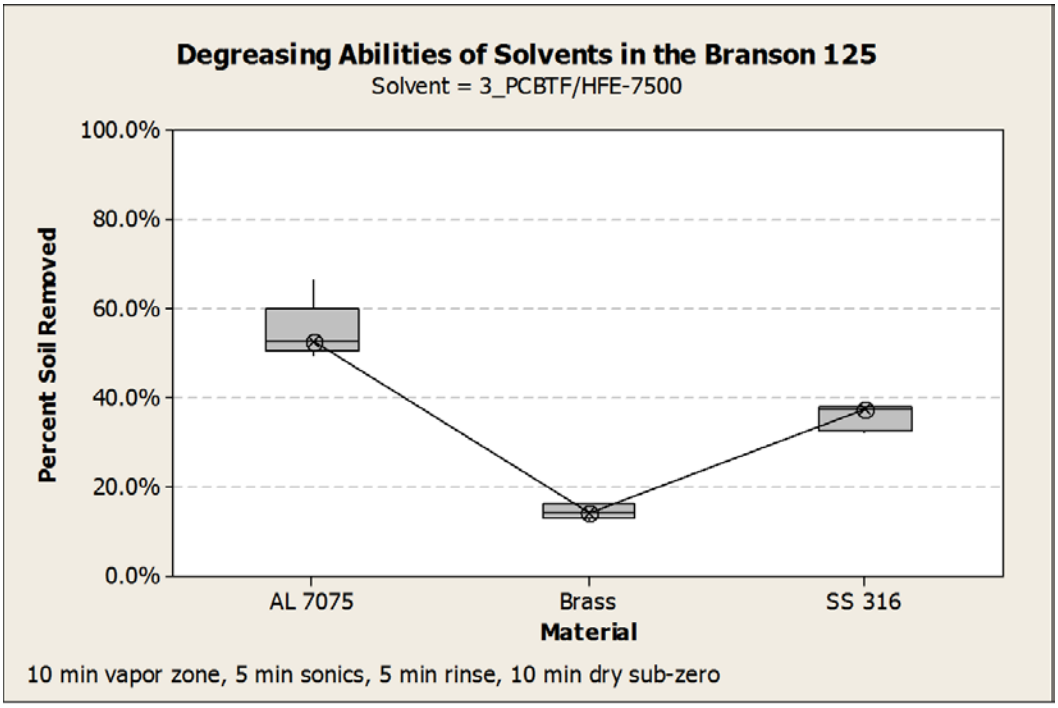

Figure 29: The gravimetric performance of azeotrope 7 (AZ7) in the Branson 125 against marine grade grease

The defluxing study for the target solvents and new blends was very difficult as mentioned in the Materials and Methods section. The reflow process was nonlinear and unrepeatable in the control samples when performed on circuit boards. Once the vial test method was developed, the repeatability improved.

The conductivity was measured of five blank vials containing 20 mL of 3:1 IPA: DI after 1 hr of ultrasonics. The resulting blank conductivity value was 0.65 (± 0.07) µS/cm. All conductivities of solder paste vials and solvent extracted vials were adjusted by subtracting this blank correction value to account for any ions extracted from the glass vial.

The data in Figure 30 shows the linear dependence of total ionic contamination upon initial solder paste mass. This figure indicates that the ionic contamination generation is a controlled process when the reflow takes place in a closed vial with uniform temperature control afforded by the GC oven. The vials used for each of the four solvents are indicated in the figure showing that there is no significant difference between the four trials in terms of contamination generated. Although, it does appear that one of the AZ6 samples is an outlier producing lower than expected conductivity.

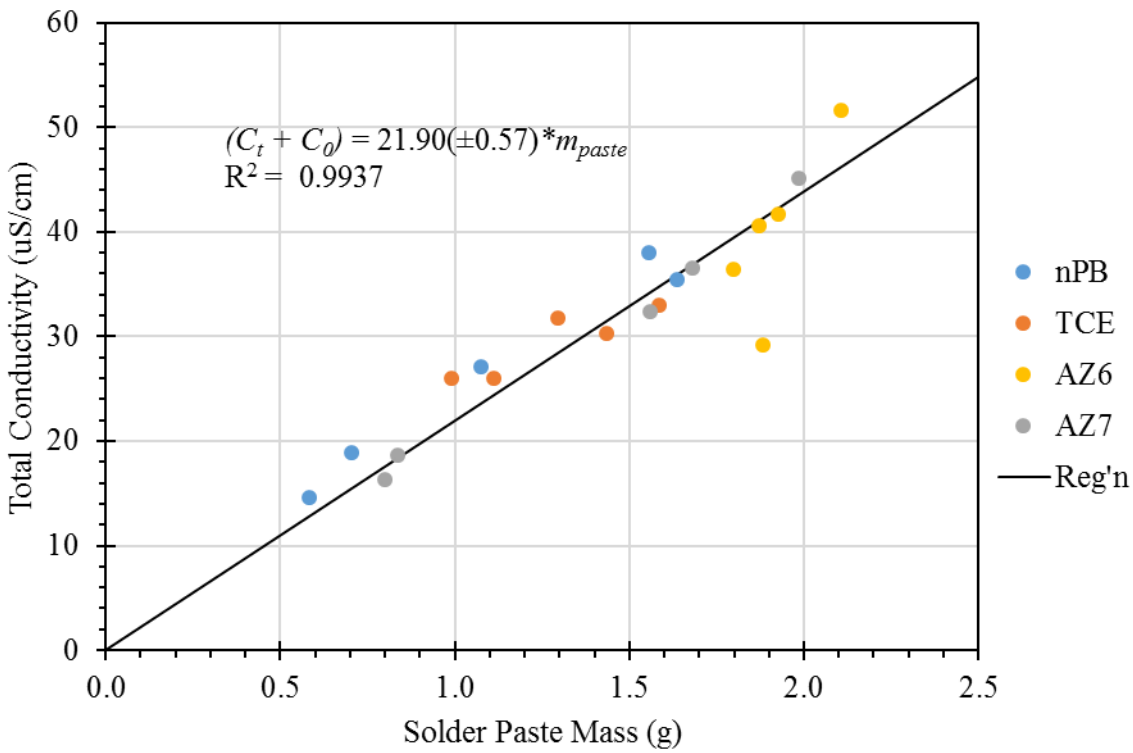

Figure 30: The total blank-corrected conductivity versus the initial mass of solder paste shows a linear trend in conductive contamination.

Figure 30 by itself is merely the denominator of Eq 3 – a measure of the total ionic contamination produced. The percent of ionic contamination transferred by the various solvents (P_{ion}) is shown in Figure 31. The behavior of five vials for each solvent are shown. The AZ6

blend removed a median value of 3% of the ionic contamination. The performance of AZ7 was better but still poor with a median removal of 15%. The performance of the solvents we are seeking to replace was much better with median values of 83% for nPB and 97% for TCE.

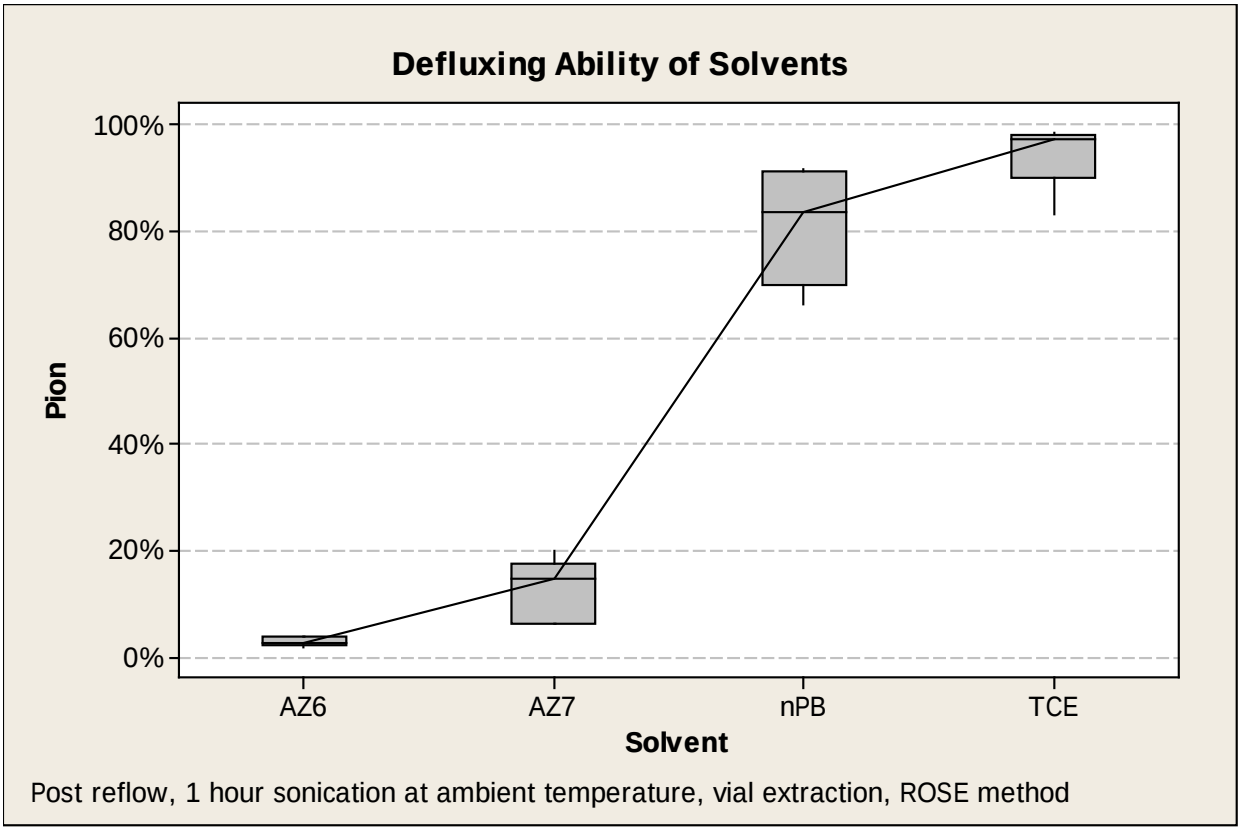

Figure 31: The ROSE testing performance of AZ6 and AZ7 compared to nPB and TCE using the vial-based defluxing test.

Even though the new azeotropic blends did not clean the marine grade grease well, nor did they perform well in defluxing activities, it is still worthwhile to fully characterize the physical properties of these new non-flammable, VOC-exempt vapor degreasing azeotropic blends. They may not be suitable for replacing nPB or TCE as was hoped, but their chemical and physical properties may still satisfy a need for cleaning other soils or replacing other solvents.

The Hansen solubility parameters in Figure 32 reveal why AZ7 performed better than AZ6, but still not as well as nPB or TCE against the grease used in this study. The HSPs of the ionic contaminants in flux residue are not shown because they are unknown. The HSPs for the azeotropes AZ6 and AZ7 are given in Table 3 along with the HSPs of the blend components for comparison purposes.

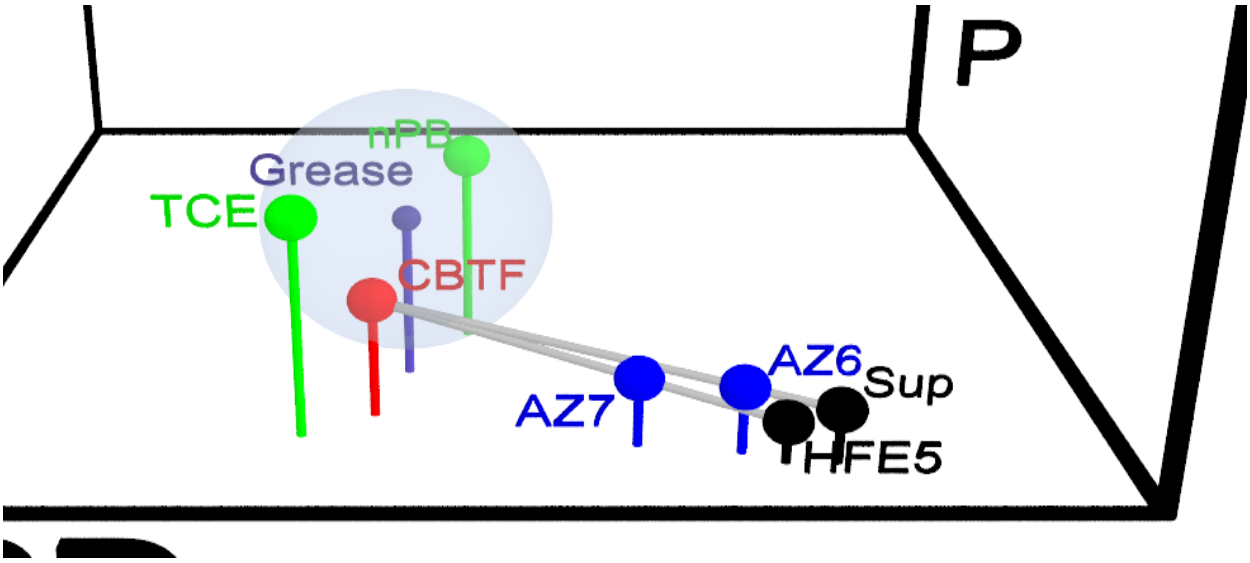

Figure 32: The Hansen solubility parameters of the azeotropes AZ6 and AZ7 with their blend components

The hydrostatic density, the volumetric expansion coefficient, viscosity, and the surface tension were measured at four temperatures ranging from 16 °C to 32 °C and adjusted to 25 °C. These values are shown in Table 3 with the experimental uncertainties in parentheses. The uncertainties are listed next to the appropriate place value. For example, the viscosity of HFE5 is listed as 1.08(3) cP, which indicates the value is 1.08 ± 0.03 cP.

The precision of the measurements is excellent with the exception of the Suprion volumetric expansion coefficient. There was some slight clouding with this solvent at low temperature. The values determined for HFE5, Sup, and CBTF matched their literature values to within experimental uncertainties with the exception of the viscosity of HFE5, which is 0.16 cP low.

The fluorinated blend components had a positive effect on the wettability of the CBTF increasing its wetting index from 64 to 84. This is the result of the increased density and the reduced surface tension.

Table 3: The Hansen solubility parameters (*D*, *P*, and *H*), densities (*ρ*), volumetric expansion coefficients (*β*), viscosities (*η*), surface tension (*γ*), and wetting index (*W*) values for the azeotropic blends 6 and 7 along with their blend components

Abbr	*D* MPa$^{1/2}$	*P* MPa$^{1/2}$	*H* MPa$^{1/2}$	*ρ* g/mL	*β* °C^{-1}	*η* cP	*γ* mN/m	*W*
HFE5	**13.3**	**2.0**	**1.0**	1.62(2)	1.55(2)×10^{-3}	1.08(3)	**16.2**	92.6(2)
Sup	**12.8**	**2.0**	**1.3**	1.57(6)	1.4(1.1)×10^{-3}	1.06(18)	**18**	82.2(8)
CBTF	**17.3**	**4.0**	**2.9**	1.333(3)	1.03(4)×10^{-3}	0.84(7)	**25**	63.6(1)
AZ6	13.7	2.4	1.6	1.521(2)	1.47(2)×10^{-3}	0.97(4)	18.8(1)	83.9(1)
AZ7	14.7	2.7	1.7	1.516(6)	1.58(5)×10^{-3}	0.94(5)	19.3(2)	83.6(1)
nPB	**16.4**	**7.9**	**4.8**	**1.3**		**0.49**	**25.9**	**105**
TCE	**18**	**3.1**	**5.3**	**1.5**		**0.53**	**28.7**	**99**

Bold text indicates literature values from suppliers and the HSPiP database.
Uncertainties for experimental data are in parentheses adjacent to the appropriate place value.

This particular soil – marine-grade grease – was chosen for this project because it was essentially a match for the HSPs of nPB and TCE. It provided a realistic challenge for finding a solvent blend that would successfully replace nPB and TCE. However, every soil occupies a different place in Hansen-space. Table 4 shows the HSPs for six soils that were characterized by this lab during a 2012 NASA project.[30] The R_0 value is the soil interaction radius. When a solvent is within the interaction radius of a soil ($R_a \leq R_0$), then solvency is likely. The R_a values are shown in Table 4 in boldface type when the particular solvent is likely to dissolve the soil. Even though the new azeotropes 6 and 7 were not able to dissolve the marine grease, both are predicted to interact well with Jet Oil and Krytox (a fluorinated grease). And AZ7 is predicted to clean pump oil, and two types of silicone grease.

Table 4: Evaluation of the likelihood of the new azeotropes 6 and 7 to clean other soils

					Hansen Distance (R_a in $MPa^{1/2}$)			
Soils	*D*	*P*	*H*	R_0	AZ6	AZ7	nPB	TCE
Marine Grease	17.2	5.5	5.1	3.0	8.4	6.7	**2.9**	**2.9**
Jet Oil	15.7	2.5	3.7	4.5	**4.5**	**2.9**	5.7	4.9
Krytox	14.4	3.7	1.5	2.2	**1.9**	**1.2**	6.7	8.2
Pump Oil	15.8	0.0	6.9	7.1	7.2	**6.3**	8.3	**5.6**
Sebacate	17.5	0.0	6.6	7.8	9.4	7.9	8.4	**3.5**
Silicone Grease 111	16.1	1.7	2.8	4.1	5.0	**3.2**	6.5	4.8
Silicone Grease 55	15.9	1.0	4.6	5.0	5.5	**4.2**	7.0	**4.7**

Bold R_a values indicate when $R_a \leq R_0$ predicting favorable solvency.

Conclusions and Implications for Future Research

Nothing in this study cleaned as well as TCE or nPB

Seven new azeotropic blends (Table 2) were discovered during this project. Four of the new azeotropes (AZ1, 2, 3, and 5) failed the flash point test. One of the non-flammable azeotropes (AZ4) failed the vial-based screening test against marine-grade grease, which was chosen because of its match to the HSPs of nPB and TCE. One of the azeotropes (AZ5) produced an unusable two-phase condensate.

Two (AZ6 and AZ7 in Table 2) of the azeotropic blends survived the flash point and solvency screening tests. These were evaluated in a Branson B125 vapor degreaser in a head-to-head comparison to the performance of nPB and TCE. The new blends (AZ6 and AZ7), nPB, and TCE were required to clean marine-grade grease from SS316, Al7075, and brass parts with a 10-min vapor step, a 5-min 40-kHz ultrasonic step, a 5-min vapor rinse, and a 10-minute sub-zero drying step. The nPB and TCE removed 100% of the soil on all three part types as measured gravimetrically. The blend AZ6 removed less than 20% of the soil (16(±11)% on Al7075, 13(±2)% on SS316, and 4(±1)% on brass), and AZ7 removed less than 60% of the soil (55(±7)% on Al7075, 36(±3)% on SS316, and 15(±2)% on brass).

This is understandable in light of their Hansen solubility parameters. Each blend has a substantial amount of non-flammable hydrofluoroether solvent, which dramatically lowers the dispersion intermolecular attractive forces in the blend. Therefore, these two blends are not feasible candidates for replacing nPB and TCE in vapor degreasing operations.

The defluxing studies on printed circuit boards exhibited an unacceptable amount of variation in the baseline studies. It was determined that the variability stems from two main sources: 1) variations in the thermal history of the solder melting step that arise in ovens which do not have an even heating zone and 2) escape of the volatile organic acids in the solder flux paste. To correct these issues, a GC oven was used to create a uniform heating environment for the melting of the solder paste, and 30-mL vials capped with aluminum foil were used to contain the volatile components of the solder paste during the melting step. The result is a vial-based defluxing test that is inexpensive and repeatable, making it an excellent tool for head-to-head solvent comparisons. This test in itself may turn out to be a substantial contribution by this SEED project to the field of PCB cleaning.

The nPB was able to remove 81(±11) % of the ionic contamination, and TCE was able to remove 94(±6) % of the ionic contamination. The performance of the azeotropic blends was poor with AZ6 removing 3.0(±0.8) % and AZ7 removing 13(±6) %. These tests utilized 1 hour of 40 kHz ultrasonic extraction by the solvent in a capped vial at ambient temperature. The poor performance of our new azeotropic blends in this ambient temperature test does not warrant confidence that cleaning would improve in vapor defluxing. Therefore, these two blends are not feasible candidates for replacing nPB and TCE in vapor defluxing operations.

Both blends AZ6 and AZ7 are based on the VOC-exempt solvent CBTF, which is a drop-in replacement for toluene in automotive paint formulations. It does not have a PEL, but Specialty Materials Company suggests a CEL of 25 ppm. This is low. However, it has a very low vapor pressure compared to TCE or nPB. For comparison purposes, if open containers of nPB, TCE,

and CBTF were allowed to achieve vapor-liquid equilibrium in a room (worst possible scenario), the concentration of TCE would be 79,000 ppm, nPB would be 146,000 ppm, and CBTF would only be 7,000 ppm. This is cut further in the azeotropic blends because AZ7 is only 35% CBTF and AZ6 is only 20% CBTF. The volatility of CBTF is < 0.1 of nPB and < 0.05 of TCE. This lower volatility means that CBTF blends would be much easier to control with cooling coils.

One advantage of the vial-based defluxing test method is the ability to contain volatile solvents during the extraction of ionic contamination. We received a sample of Solstice PF late in the project from Honeywell. It was not an azeotropic blend, and fell outside the scope of this project, but we were able to test it at the end of the project. The Solstice PF was able to remove 27(±16) % of the ionic contamination in the vial-based defluxing test. We were not able to use it in our Branson 125 vapor degreaser, however, because of its low boiling point of 19 °C.

The scope and aim of the original Statement of Need[1] was to find drop-in replacements that "will avoid the need to purchase and install costly new airless/air-tight degreasers to comply with emerging VOC standards, and it will secure the availability of sustainable solvents as future regulations lead industry to transition away from high GWP chemicals".

A major obstacle for this effort is evident in Figure 2 where nPB and TCE are on the outer edge of the cluster of solvents. Any solvent that is close to nPB and TCE will be flammable. Blending non-flammable components into these solvents only pulls them away from nPB and TCE chemically and reduces the solvency of the overall blend. This has been demonstrated by our project, and is not likely to change if MEK, MPK, or MBK were blended with suitable flame retardants. If the azeotrope lies close to these very volatile and flammable solvents, then they will likely fail the flash point criterion. If the azeotrope lies close to the flame retardant solvent, then the solvency will suffer as was the case with our AZ6 and AZ7 blends.

Whereas the results for our blends were not particularly impressive, the project has produced several standard operating procedures (cf. Appendix B) that may be adopted at DoD facilities should they wish to continue this work at their location. In particular, a relatively inexpensive Raman probe (RS-3000, Ocean Optics) was shown to be very useful in characterizing solvent blends. The degreasing vial test and the defluxing vial tests are inexpensive and safe to use for flammable solvents for comparison purposes. Likewise, several improvements were made to the fluid properties measurement procedures that utilize digital video analysis (flash point and falling-ball viscometry).

Moving forward, it may be required to more closely tailor the choice of solvent to the particular soil. If a soil does not require the extremely strong solvency of TCE or nPB, then these could be replaced by a more ESH-acceptable solvent. Using the HSPs in Table 4, one may find that there are common soils (like Krytox) that AZ6 and AZ7 are able to clean via vapor degreasing. In other situations, the HSPs of the commercially-available non-flammable solvents (**Error! Reference source not found.** and Figure 2) would guide solvent selection.

Any change to the solvent would require specific head-to-head tests tailored to each particular soil and substrate. Projects should be prioritized to produce the largest benefit for the smallest change to operations. It may be that certain Army depots could make the change from nPB and TCE while others could not.

If there is a subset of DoD cleaning operations at installations that require the strong solvency of nPB or TCE, then they must consider a process modification. The installation of air-tight

degreasers with engineered controls would be worth the investment if these particular cleaning operations are critically important to the war fighter (i.e. liquid oxygen components, gyroscopes, optics, etc).[31] These systems are designed with very efficient solvent handling and vacuum drying of parts. This greatly reduces worker exposure and solvent losses. They are typically large, automated, and enclosed, but the efficiencies in solvent recovery are substantial offsetting the purchase and installation expense. Because the solvent vapor zone is fully contained and oxygen free, inexpensive and effective flammable solvents may be used. Working toward this type of process change would maintain confidence in mission-critical cleaning while greatly reducing the solvent related ESH and regulatory risks.

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Appendix B – Standard Operating Procedures

GRAVIMETRIC ANALYSIS – GENERAL

SCOPE

This procedure outlines the use of the laboratory balance for collecting mass data.

PURPOSE

The purpose of this procedure is to ensure precise and accurate mass measurements.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

4. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.5. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR PROPER USE OF THE LABORATORY BALANCE

1. Preparation of samples.

    1.1. Always wear gloves or use clean tongs when handling samples for gravimetric analysis.

    1.2. Never handle a sample in a way that could decrease or increase the mass of the sample.

        1.2.1. Make sure to not remove any contamination from a sample that was purposely soiled.

        1.2.2. Make sure to not get the sample wet or add any contamination that was not intended.

        1.2.3. Make sure samples are placed on a clean surface before and after weighing.

        1.2.4. Do not allow soiled samples to transfer mass to each other, to other objects, and especially to the balance.

    1.3. Record the temperature and barometric pressure at the beginning of a set of tests.

2. Perform the balance internal calibration.

    2.1. Power on the balance by pressing the power button.

    2.2. Make sure that all of the draft shields are closed on the balance.

    2.3. Press the “Cal” button.

    2.4. Press enter.

    2.5. When the calibration is complete the screen will return to a mass reading of zero and a calibration report will be printed on the receipt printer.

3. Performing mass measurements.

    3.1. Always start with a clean balance.

    3.2. Always make sure that the balance reads zero before placing a sample on the balance

    3.3. Never place a sample on the balance in a manner that would contaminate the balance.

    3.4. Always place samples on the balance gently.

    3.5. Always center samples on the balance.

    3.6. Once a sample is placed on the balance, make sure that all of the draft shields are closed. The mass reading will stabilize and the mass will be printed automatically.

    3.7. Always remove samples from the balance gently.

    3.8. After a sample is removed from the balance, make sure that all of the draft shields are closed. Allow the mass reading to return to zero.

3.9. After the mass reading is stabilized at zero, the next sample may be placed on the balance.

3.10. Always take note of the order in which samples were weighed.

3.11. Always try to separate the masses of different types of samples on the receipt tape by pulling out the receipt tape enough to create a small space.

3.12. All receipt tapes should be kept together and stored for reference.

APPENDIX I

SOURCE DOCUMENTS

External Documents:	NONE
Internal Documents:	NONE
Generated Forms:	NONE
Related Forms:	NONE

LIQUID DENSITY AND SURFACE TENSION MEASUREMENT AND DATA ANALYSIS – GENERAL

SCOPE

This procedure outlines the collection of hydrostatic density and the liquid-vapor interfacial tension (surface tension) data for a single phase liquid.

PURPOSE

The purpose of this procedure is to characterize the density, the volumetric expansion coefficient, and the surface tension of solvents, solvent blends, and aqueous surfactant solutions.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

4. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.5. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR DENSITY AND SURFACE TENSION MEASUREMENT

1. Prepare the apparatus (in the event that the apparatus does not exist at the facility.) See the reference document for more detailed instructions.

    1.1. Construct a flat support platform for a digital laboratory balance.

    1.2. Cut a hole in the platform for the underhook of the balance.

    1.3. Mount the platform so that the balance will be securely held with minimal vibration.

    1.4. Place a raising and lowering platform, such as a hydraulic jack, that is capable of lowering at a very slow rate beneath the underhook of the balance.

    1.5. Hang a small bead chain from the under-hook of the balance.

    1.6. Attach a hook connector to the bead chain hanging from the under-hook of the balance.

    1.7. Connect the balance to a computer with data collection software such as Hyperterminal.

    1.8. Make the balance level.

2. Measure the density.

    2.1. Tare the balance.

    2.2. Obtain a small Pyrex sinker of standard volume. (VWR Inc.)

    2.3. Place the sinker on the hook connector.

Note: The hook connector should be very small so that the volume of the submerged sinker is not affected.

    2.4. Allow the mass reading to stabilize.

    2.5. Record the stable mass as the **dry mass**.

    2.6. Obtain a container of the sample liquid large enough so that the sinker can be submerged in the liquid without touching the bottom of the container.

    2.7. Place the sample container under the hanging sinker.

    2.8. Raise the platform so that the sinker enters the liquid sample.

    2.9. Keep raising the platform until the sinker is completely submerged and only one side of the hook connector is breaking the surface of the liquid.

    2.10. Allow the mass reading to stabilize.

    2.11. Record the stable mass reading as the **wet mass**.

    2.12. Lower the platform to remove the sinker from the sample.

    2.13. Remove the sinker from the hook connector.

2.14. Measure the temperature of the sample with a thermocouple.

3. Measure surface tension.

3.1. Obtain a platinum iridium tensiometer ring of standard diameter and wire thickness. (VWR Inc.)

3.2. Make sure that the ring is perfectly circular and flat, and that the part that the ring hangs from is perfectly perpendicular to the ring.

3.3. Clean the ring in a flame until it glows red.

3.3.1. Always remove the ring from the fire immediately when it starts glowing red.

3.4. Hang the ring from the hook connector hanging from the under-hook of the balance.

3.5. Obtain a container of your sample. The liquid does not have to be very deep in the container. However, the container should have a large enough diameter for the meniscus in the container to not affect the liquid's surface in the center of the container.

3.5.1. A 400 or 600 mL beaker has a good diameter for this purpose.

3.6. Place the sample container on the platform directly below the ring.

3.7. Raise the platform until the ring is just below the surface of the sample.

3.8. Make sure that the ring is in the center of the container.

3.9. Bend a thermocouple over the wall of the sample container in a way that allows the thermocouple to be submerged in the sample but close enough to the wall of the beaker to not interfere with the surface tension measurement. This allows constant measurement of the temperature.

3.10. Tare the balance.

3.11. Begin capturing data with the data collection program on the computer.

3.12. Make the platform drop at a slow and steady rate.

3.13. The ring should begin rising through the surface of the sample slowly.

3.14. The ring will pull the surface of the liquid upward with it.

3.15. The mass lifted should increase, and just before the ring disconnects from the liquid's surface, the mass lifted should begin decreasing.

3.15.1. If the mass lifted doesn't start to decrease before the ring disconnects from the surface of the liquid, then the platform was probably lowering too fast. If this happens, restart the measurement.

3.16. When the ring disconnects from the liquid's surface, the measurement is complete. The temperature should be recorded at the time this occurs.

3.17. Stop the data collection.

3.18. Save the data.

3.19. Obtain at least three measurements.

3.20. Always refresh the surface of the sample by removing a small amount of liquid from the surface with a disposable pipet between measurements.

OPERATING PROCEDURE

DENSITY AND SURFACE TENSION DATA ANALYSIS

1. Analysis of density data. For a copy of the analysis Excel workbook, contact the author of this procedure.

    1.1. Fill in the sinker volume in cubic centimeters and sinker dry mass in grams in cells B8 and B9 respectively.

    1.2. Fill in the names of the samples in column A starting in row 14.

    1.3. Fill in the temperatures for each sample in column B.

    1.4. Fill in the sinker wet mass in grams for each sample in column C.

    1.5. The spreadsheet will automatically calculate the liquid density in grams per mL in column D.

    1.6. This density value can be corrected to 25 °C.

        1.6.1. Take three density measurements at a temperature lower than 25 °C.

        1.6.2. Take three density measurements at a temperature higher than 25 °C.

        1.6.3. The span of these two temperatures should be about 10 to 20 °C.

        1.6.4. Convert the high and low temperature density measurements and the three ambient temperature density measurements to Kg/m^3.

        1.6.5. Use the following equation and nine six density measurements to do a regression to obtain the volumetric expansion coefficient (β).

$$\frac{d_0}{d_1} - 1 = \beta(t_1 - t_0)$$

        In this equation, d_0 is the density at the lowest temperature in Kg/m^3, d_1 is the density at a higher temperature in Kg/m^3, t_0 is the lowest temperature in °C, and t_1 is the higher temperature in °C.

        1.6.6. The low temperature density and β can be used to determine the density at 25 °C with the use of the equation from the previous step.

            1.6.6.1. The constant β is unique to every liquid. If a different sample is used, then a new β will need to be calculated.

        1.6.7. Use the information in the regression output to obtain an uncertainty value for the extrapolated density value.

2. Analysis of surface tension data. This analysis is performed in the same excel workbook as density analysis, because density measurements are important for the measurement of surface tension. For a copy of the analysis Excel workbook, contact the author of this procedure.

    2.1. In the Excel workbook, plot all of the mass lifted versus time data. This will be referred to as a force curve.

2.2. Towards the end of the force curve, the mass lifted should reach a maximum and decrease for a small amount of time to create a rounded curve downward before the meniscus breaks and the mass lifted drops almost vertically to zero.

2.2.1. If the mass lifted drops sharply to zero without first decreasing in small increments to create a curve downward, then the data is bad and the procedure needs to be performed again.

2.3. Find the maximum mass lifted in grams for each set of data by using the maximum function in Excel. (Always check the range on the Excel max() function to ensure it encompasses the true maximum.)

2.4. Put the maximum mass lifted in grams for each sample in the appropriate row of column E on the analysis sheet.

2.5. Make sure that the ring and wire radii are correct for the ring that was used in this experiment.

2.5.1. Use calipers to measure the ring parameters each time a new one is purchased.

2.6. Use a density value that has been corrected to the temperature of the surface tension measurement.

2.6.1. Correct the density value using the method given in the density data analysis section replacing 25 °C with the temperature of the surface tension measurement.

2.7. The spreadsheet will automatically calculate the surface tension of the liquid samples in dyne/cm, which is numerically equivalent to mN/m.

2.8. The surface tension value can be corrected to 25 °C.

2.8.1. Take a surface tension measurement at a temperature lower than 25 °C.

2.8.2. Take a surface tension measurement at a temperature higher than 25 °C.

2.8.3. The span of these two temperatures should be about 10 to 20 °C.

2.8.4. A plot of the hot, cold and ambient measurements should reveal a strong linear relationship between temperature and surface tension. The surface tension should decrease as temperature increases.

2.8.5. Perform a regression on the data to decide if the coefficients in the linear equation given are statistically significant.

2.8.6. If the coefficients are statistically significant (p-value < 0.05), use the equation to compute the surface tension value at 25 °C.

2.8.7. Calculate an uncertainty value for the surface tension using the standard error values from the regression output.

APPENDIX I
SOURCE DOCUMENTS

External Documents:

1. Darren L. Williams; et. al., *An Inexpensive, Digital Instrument for Surface Tension, Interfacial Tension, and Density Determination*, Ind. Eng. Chem. Res. 2008, 47 4286-4289.

Internal Documents: NONE
Generated Forms: NONE
Related Forms: NONE

BALL DROP VISCOSITY MEASUREMENT AND DATA ANALYSIS – GENERAL

SCOPE

This procedure outlines viscometer preparation, viscosity data collection, and viscosity data analysis in Microsoft Excel for determining the viscosity of liquid samples using a ball-drop viscometer.

PURPOSE

The purpose of this procedure is to characterize the viscosity of solvents, solvent blends, and aqueous surfactant solutions.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

4. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.5. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR BALL DROP VISCOMETER PREPARATION AND VISCOSITY DATA COLLECTION ON LIQUID SAMPLES

1. Prepare viscometer.

    1.1. Clean viscometer.

        1.1.1. Rinse, all viscometer parts that come in contact with the sample, twice with clean methanol, and allow to dry. This includes the tube, top, cap, and ball.

        1.1.2. Rinse, all viscometer parts that come in contact with the sample, twice with the sample liquid. This includes the tube, top, cap, and ball.

    1.2. Fill viscometer.

Note:
Always test fresh type I deionized water before any series of measurements, so that the viscometer constant may be calculated.

        1.2.1. Fill the tube with the sample liquid until the liquid level is about ¼ of an inch from the top of the tube.

        1.2.2. Add the steel ball to the tube.

        1.2.3. Fill the tube to the top with the sample liquid.

        1.2.4. Attach the top to the tube using the Teflon screw. The liquid will fill the capillary vent in the top and some of the sample liquid will be expelled from the capillary vent.

        1.2.5. Close the tube by screwing the cap onto the capillary vent in the top.

        1.2.6. Dry the outside out the tube and top using a lint-free lab wipe if needed.

        1.2.7. Invert the tube a few times, allowing the ball the fall from one end to the other.

            1.2.7.1. Check the tube for air bubbles during 1.2.7.

            1.2.7.2. If air bubbles are observed, empty the tube and repeat all steps from 1.2.

        1.2.8. If air bubbles are not observed and the steel ball passes through the timing zone in less than one second, empty the tube and repeat all steps from 1.2 using a glass ball.

    1.3. Insert viscometer into the rotating viscometer holder on the viscosity apparatus.

    1.4. Wait about 20 minutes for the viscometer and liquid to reach thermal equilibrium with the room.

2. Use of the viscosity apparatus for data collection.

    2.1. Prepare the video camera attached to the apparatus.

        2.1.1. Power on the video camera.

2.1.2. Ensure that the video camera is aligned with the starting timing lines to avoid parallax errors.

2.1.3. Check the alignment with the bottom timing lines using a flashlight.

2.2. Measuring the temperature.

2.2.1. Unscrew the cap from the capillary vent.

2.2.2. Insert the end of a thermocouple into the capillary vent just far enough to be submerged in the liquid.

2.2.3. After the temperature reading has stabilized, record the temperature.

2.2.4. Replace the capillary vent cap.

2.3. Taking a viscosity measurement.

2.3.1. Rotate the viscometer up using the rotating viscometer holder until the ball is at rest in the top of the viscometer.

2.3.2. Start recording with the video camera

2.3.3. State the name of the sample, the trial number, and the temperature aloud for the recording.

2.3.4. Rotate the viscometer down so that it rests vertically in front of the camera.

2.3.5. After the ball passes through the first set of timing lines, shine a light behind the second set of timing lines on the viscometer. This will cause the camera to focus on the reflection of the second set of timing lines.

2.3.6. After the ball passes through the second set of timing lines, stop the recording.

2.3.7. Repeat all steps from 2.2. and 2.3. a minimum of three times.

OPERATING PROCEDURE

BALL DROP VISCOSITY DATA ANALYSIS

1. Obtain the starting and finishing times for each measurement. These times will be in seconds and fractions of seconds. The fractions depend on how many frames per second are achieved by the video camera.

    1.1. Open the viscosity videos in Adobe Premiere Pro or other video software that allows frame-by-frame control.

    1.2. Watch the video of each measurement frame by frame to obtain the correct time stamps.

    1.3. The starting time is obtained by watching as the ball passes through the first set of timing lines. When the ball is exactly between the two lines, record the time stamp for that frame.

    1.4. The finishing time is obtained by watching as the ball passes through the second set of timing lines. When the ball is exactly between the two lines, record the time stamp for that frame.

2. Analysis of the viscosity measurement data. For a copy of the viscosity analysis Excel workbook, contact the author of this procedure.

    2.1. In cell B1 update the notes about the experiment.

    2.2. Update the ball density in cell D2, if necessary.

    2.3. Update the data for water in rows 5 through 9 by inserting the new data into columns with highlighted titles.

    2.4. Update the data for the tested samples starting in row 12 by inserting the new data into columns with highlighted titles.

    2.5. The experiment viscosities in centipoise are found in column L.

3. The viscosity can be corrected to 25 °C.

    3.1. First correct the density values to the temperature of each measurement according to the method given in the density and surface tension SOP.

    3.2. Using the calculations of the viscometer constant from water and a regression, create a temperature dependent viscometer constant equation.

    3.3. Use the temperature corrected density values and temperature corrected viscometer constant values to calculate the viscosity at the correct temperature for each measurement.

    3.4. Perform a regression of the temperature versus viscosity data to obtain an equation that can be used to correct the viscosity to 25 °C.

    3.5. Use the regression analysis to compute the uncertainty in the viscosity result.

APPENDIX I
SOURCE DOCUMENTS

External Documents:

1. ASTM Standard D1343, 1995 (2000), "Standard Test Method for Viscosity of Cellulose Derivatives by Ball-Drop Method," ASTM International, West Conshohocken, PA, 2000, DOI: 10.1520/D1343-95R00, www.astm.org.

2. Gilmont, Roger, “Falling Ball Viscometer Directions for Use”, Roger Gilmont Instruments, Inc.

Internal Documents: NONE
Generated Forms: NONE
Related Forms: NONE

FRACTIONAL DISTILLATION – GENERAL

SCOPE

This procedure outlines fractional distillation setup as well as instructions for the distillation process.

PURPOSE

The purpose of this procedure is to allow safe and accurate fractional distillation for azeotrope searching and for solvent reclamation distillations.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

4. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.5. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR PERFORMING A FRACTIONAL DISTILLATION

1. Setting up the distillation apparatus.

    1.1. Choose an appropriately sized boiling flask and heating mantle for the distillation.

        1.1.1. The flask should be large enough so that the liquid that needs to be distilled does not fill the boiling flask more than 75 percent of its maximum capacity.

        1.1.2. The flask should be small enough so that the liquid that needs to be distilled does not fill the boiling flask less than 50 percent of its maximum capacity.

        1.1.3. The heating mantle should be the appropriate size for the heating flask that you have chosen.

        1.1.4. The heating mantle should cover the lower 50 percent of the flask with good contact between the inside of the heating mantle and the boiling flask.

    1.2. Pour the liquid that needs to be distilled into the boiling flask.

    1.3. Add some boiling chips to the flask.

    1.4. Place the flask into the heating mantle inside of the fume hood.

    1.5. Attach a fractionating column to the boiling flask.

        1.5.1. Remember to either use stopcock grease or a Teflon sleeve on this connection because it will get very hot.

        1.5.2. Remember to clamp the fractionating column to a ring stand to hold it securely during the distillation.

    1.6. Attach a three way distilling head to the top of the fractionating column.

        1.6.1. Remember to either use stopcock grease or a Teflon sleeve on this connection because it will get very hot.

    1.7. Attach a thermometer adaptor to the top of the distilling head.

    1.8. Place a thermometer in the thermometer adaptor.

    1.9. Lower the thermometer until the end of the thermometer is just below the fork in the distilling head.

    1.10. Attach a condenser to the distilling head.

        1.10.1. Remember to secure the condenser to the distilling head using a clamp on the connection, a tightly wrapped rubber band from the water outlet on the condenser to the distilling head, or by clamping the condenser to another ring stand.

        1.10.2. The water outlet is the one closest to the distilling head.

        1.10.3. The water inlet is the one farthest from the distilling head.

OPERATING PROCEDURE

1.11. Attach a vacuum adaptor to the end of the condenser.

1.11.1. Remember to secure the vacuum adaptor to the condenser using a clamp on the connection, or a tightly wrapped rubber band from the water inlet on the condenser to the vacuum adaptor.

1.12. Attach an appropriately sized receiving flask to the vacuum adaptor.

1.12.1. Remember to secure the receiving flask by clamping it to another ring stand.

1.13. Run a rubber tube from the water tap to the water inlet on the condenser.

1.14. Run a rubber tube from the water outlet on the condenser to the drain.

1.15. Plug the heating mantle into a power regulator.

1.16. Plug the power regulator into an electrical outlet.

2. Performing a distillation.

2.1. Turn on the water tap so that the pressure is sufficient to rid the condenser water jacket of air.

2.1.1. The water flow can be decreased after the air has been forced out.

2.2. Turn on the power regulator and set it to about 50 percent of its maximum.

2.2.1. The regulator may need to be set to a lower setting for liquids with low boiling points, or a higher setting for liquids with high boiling points.

2.2.2. When the setting is correct, the liquid will be at a gentle rolling boil after it has had time to heat.

2.2.3. If the liquid doesn't boil or barely boils after giving it time to heat, the setting on the power regulator can be increased.

2.2.4. If the liquid boils up into the column after giving it time to heat, the setting on the power regulator should be decreased.

Note:
Never leave the distillation unsupervised for more than a few minutes.

2.3. The distillation should be checked about every five minutes after the liquid starts to boil to ensure that the liquid is boiling at the proper rate, and to ensure that the process is proceeding safely. (A timer is useful.)

2.3.1. In small distillations, it may need to be constantly observed or checked more often.

2.4. After the first drop of distillate is captured in the receiving flask, record the temperature reading on the thermometer.

2.5. From this point forward, check the temperature every time that the distillation is observed.

2.6. In some cases, low boiling azeotropic mixtures are formed. If the temperature reading is lower than the boiling temperature of any of the components in the original mixture, then this has probably occurred. If this has occurred:

2.6.1. If the purpose of the distillation was to create a low boiling azeotropic mixture, then continue the distillation until the temperature starts to rise.

2.6.2. If the purpose of the distillation was to separate the components of the original mixture, then stop the distillation and report that the mixture cannot be separated by distillation.

2.7. If the temperature reading is close to the literature boiling point of one of the components of the mixture, then continue the distillation.

2.7.1. If the purpose of the distillation was to create a low boiling azeotropic mixture, then it is still possible that an azeotropic or near azeotropic mixture was formed.

2.7.2. If the purpose of the distillation was to separate the components of the original mixture, then the distillation is on track to fulfill its purpose.

2.8. If separation is the goal, then the receiving flask needs to be changed each time the temperature starts to rise.

2.8.1. If the component that needs to be purified is the lowest boiling component of the mixture, then the distillation can be stopped the first time that the temperature starts to rise.

2.8.2. If several components need to be purified, then change the receiving flask each time the temperature rises and label each flask with the small temperature range at which it was collected.

2.9. Always stop the distillation before the boiling flask is dry.

3. Stopping the distillation.

3.1. Power off the power regulator.

3.2. Allow the boiling flask to cool until it can be handled comfortably.

3.3. Turn off the water tap.

3.4. Remove the flask from the heating mantle.

3.5. Allow the flask to continue to cool until it reaches room temperature.

3.6. Pour the remaining liquid from the flask into a waste bottle.

3.7. Label the waste bottle with the names of the remaining components of the distilled mixture, the words “Still Bottoms”, and the date.

APPENDIX I
SOURCE DOCUMENTS

External Documents:	NONE
Internal Documents:	NONE
Generated Forms:	NONE
Related Forms:	NONE

RAMAN SPECTROSCOPIC AND CHEMOMETRIC ANALYSIS – GENERAL

SCOPE

This procedure outlines sample preparation, Raman spectrophotometric data collection, and chemometric analysis for determining the volume percent composition of liquid solvent mixtures.

PURPOSE

The purpose of this procedure is to characterize solvent blend formulations, to identify changes in solvent blends, to potentially identify unknown solvent blends in unlabeled containers, and to characterize the potential azeotropic compositions of fractional distillation condensates.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

4. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

5. The Raman instrument contains a 785 nm laser that is not visible. Do not aim the laser probe at any part of your body, especially the eye.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.5. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR RAMAN SPECTRAL DATA COLLECTION

1. Prepare instrument.

    1.1. Check the Raman probe to see if the liquid standoff cap is in place. (This positions the beam so the focus will be inside the wall of a standard glass vial.)

        1.1.1. Screw the standoff cap stamped “L” onto the Raman probe, if necessary.

        1.1.2. Store the solids standoff cap “S” near the spectrometer with the verification cap “V” that contains a teflon insert.

2. Start instrument and computer.

    2.1. Turn on instrument and computer.

        2.1.1. Flip the rocker switch to on “1” on the Raman Systems RS-3000 Raman spectrometer.

        2.1.2. Turn the key to activate the laser.

        2.1.3. Turn on the PC near the Raman spectrometer.

        2.1.4. Ensure that a USB cable connects the PC to the spectrometer.

        2.1.5. Start the Raman Desktop software.

    2.2. Record any error messages, and discuss with your supervisor.

NOTE
Instrument validation only needs to be performed at the beginning of a series of tests if it has been a week or more since the last set of tests.

3. Validate instrument performance.

    3.1. Install the verification cap “V” on the Raman probe OR place a vial of solvent that will exhibit a familiar Raman spectrum into the black aluminum sample chamber.

    3.2. Insert the probe into the sample chamber till it is gently pressing against the vial.

    3.3. Place the sample cover over the sample chamber.

    3.4. Open the data collection toolbox in the Raman Desktop Software.

    3.5. Set the integration mode to “Integration Mode Standard”.

    3.6. Set the integration time to 10 s.

        3.6.1. Adjust the integration time if necessary to produce peaks in the range of 1000 counts.

    3.7. Set the dark spectrum mode to “Automatic Dark Subtract”.

    3.8. Set the measurement mode to “Single Measurement”.

3.9. Set the maximum frame time to 10 s.

3.10. Set the total frames to 1.

3.11. Collect a sample spectrum.

3.12. Inspect it to see if the instrument is performing correctly.

NOTE

The instrument is now validated to be in good working order unless errors occurred. Discuss any errors with your supervisor.

OPERATING PROCEDURE

OPERATIONS FOR ANALYSIS OF LIQUIDS AND SOLUTIONS

1. Collect data for solvent blend composition analysis.

    1.1. Place pure components into separate vials.

    1.2. Collect Raman spectra of pure components

        1.2.1. Data format = Raman Shift in Wavenumber

            1.2.1.1. Set the integration mode to “Integration Mode Standard”.

            1.2.1.2. Set the dark and sample integration times to 10 s.

            1.2.1.3. Set the dark spectrum mode to “Automatic Dark Subtract”.

            1.2.1.4. Set the measurement mode to “Single Measurement”.

            1.2.1.5. Set the maximum frame time to 10 s.

            1.2.1.6. Set the total frames to 1.

        1.2.2. Integration Time = 10 s

            1.2.2.1. Modify the integration time to produce a maximum peak height near 1000 counts for the components with the strongest Raman signal.

            1.2.2.2. Use this SAME INTEGRATION TIME for both components AND the mixture. **(** this is CRITICAL to the method.**)**

    1.3. Place the unknown solvent mixture into a vial.

    1.4. Collect a Raman spectrum of the unknown solvent mixture.

2. Export data as an Excel-compatible (csv) file.

OPERATING PROCEDURE

OPERATIONS FOR CHEMOMETRIC ANALYSIS OF THE UNKNOWN SOLVENT MIXTURE

1. Chemometric Analysis of solvent blend spectrum. For a copy of the chemometric analysis Excel workbook, contact the author of this procedure.

   1.1. On the “Raman Data” sheet, label a column using row 1 for each component and the mixture.

   1.2. Insert the counts data from the Raman spectral data starting in row 4 of the corresponding column.

   1.3. On the “Analysis” sheet, type the label of the mixture from the “Raman Data” sheet in cell C1. This automatically updates the mixture data on this sheet.

   1.4. Type the label of each component from the “Raman Data” sheet in cells D1 through F1. If the mixture only contains two components, leave cell F1 blank. This automatically updates the component data on this sheet.

   1.5. Select “Solver” under the “Data” tab of Excel.

   1.6. For a two component mixture, enter the following parameters into the “Solver Parameters” window:

      1.6.1. “Set Objective” = “$H$2” [the Sum of the Squares of the Residuals]

      1.6.2. “To:” = “Min”

      1.6.3. “By Changing Variable Cells:” = “$D$2”

      1.6.4. “Subject to the Constraints:” = “$D$2:$F$2 <= 1”; “$D$2:$F$2 >= 0”

      1.6.5. “Select a Solving Method:” = “GRG Nonlinear”

   1.7. For a three component mixture, enter the following parameters into the “Solver Parameters” window:

      1.7.1. “Set Objective” = “$H$2”

      1.7.2. “To:” = “Min”

      1.7.3. “By Changing Variable Cells:” = “$D$2:$E$2”

      1.7.4. “Subject to the Constraints:” = “$D$2:$F$2 <= 1”; “$D$2:$F$2 >= 0”

      1.7.5. “Select a Solving Method:” = “GRG Nonlinear”

   1.8. Click “Solve”. The percentage of each component in the mixture will appear in the cell below the label of the corresponding component.

CLOSED CUP FLASH POINT DETERMINATION – GENERAL

SCOPE

This procedure outlines all of the steps for determining the flash point of a liquid sample with a kinematic viscosity of less than 9.5 cSt at 25 degrees Celsius, using a closed cup flash point tester.

PURPOSE

The purpose of this procedure is to measure the flash point of a liquid sample using a closed cup flash point tester.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

4. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.5. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR DETERMINING THE FLASH POINT OF A LIQUID USING A CLOSED CUP FLASH POINT TESTER.

1. Prepare the flash point tester.

    1.1. Fill the bath of the flash point tester.

        1.1.1. Fill the bath with ethylene glycol, because the flash point of the sample is not known.

        1.1.2. The bath is full when ethylene glycol is expelled from the back of the flash point tester into the waste container.

    1.2. Connect the tester to a natural gas outlet using a rubber hose.

    1.3. Wipe out the test cup with a lint-free lab wipe (Kim wipe).

    1.4. Place the test cup into the tester slowly allowing for any excess ethylene glycol to be expelled into a waste container through the overflow path built into the tester and the bath to remain completely full.

    1.5. Measure 50 mL of the sample in a graduated cylinder.

    1.6. Pour the sample into the cup without getting the cup wet above the liquid level.

    1.7. Pop any bubbles in the liquid.

    1.8. Place the lid on the tester.

2. Performing the flash point determination.

    2.1. Perform the test with a fresh sample each time.

    2.2. Perform the test under dim lighting.

    2.3. Perform the test with a draft shield 18 inches long on each side, 24 inches high, and open in front.

    2.4. Turn on the natural gas.

    2.5. Barely turn the natural gas adjustment knob on the tester to allow the gas to reach the flame tip.

    2.6. Light the natural gas coming from the flame tip to obtain the test flame.

    2.7. Compare the size of the test flame to the flame size bead on the tester lid.

        2.7.1. If the test flame is smaller than the bead, adjust the natural gas adjustment knob to make the flame the same size as the bead.

        2.7.2. If the test flame is bigger than the bead, completely close the adjustment knob. Once the flame has gone out, try to open the adjustment knob less than it was opened previously. Light the gas to see the size of the flame. Repeat this process if necessary.

2.8. Start recording the test with a video camera.

2.8.1. Zoom the video image of the camera to focus on the top of the flash point apparatus. Ensure that the flame and both sliding windows are in view.

2.9. At the beginning of the recording state the name of the sample along with the boiling point if it is known.

2.10. Before each application of the test flame to the sample, state the temperature reading from the thermometer of the test cup.

2.11. Apply the flame to the sample.

2.11.1. Turn the knob connected to the flame tip counter clockwise. This will pull open a sliding door and apply the flame the hole closest to the flame tip.

2.11.2. Apply the flame to the sample for approximately one second.

2.12. Watch the hole farthest from the flame tip during application of the flame.

2.12.1. If the flame can be seen instantaneously propagating itself across the entire surface of the liquid, then the sample has flashed. The lowest temperature at which this occurs is the flash point.

2.12.2. An increase of the size, or a change in color of the test flame is not considered a flash.

2.13. If the sample flashes at this starting temperature, then the test needs to be performed at lower temperatures. In cases of extreme cooling being needed it is acceptable to report the flash point as being less than a certain temperature instead of trying to obtain the actual flashpoint.

2.13.1. To obtain temperatures lower than the ambient temperature, the tester along with the ethylene glycol bath can be placed in a chemical only laboratory refrigerator. Also, place a **closed container** of the sample in the refrigerator.

2.13.2. Lower temperatures can also be obtained by using an ice water bath instead of ethylene glycol. This bath can only cool down to zero degrees Celsius.

2.14. The starting temperature of the test should always be at least ten degrees Celsius below the flashpoint.

2.14.1. If the sample flashes less than ten degrees above the starting temperature, the test should be performed again with a lower starting temperature.

2.15. If the sample does not flash at the starting temperature, then turn on the heater by flipping the switch on the side of the tester base.

2.16. Adjust the control knob to attempt to make the temperature raise by one degree Celsius per minute.

2.16.1. The control knob may need to be adjusted during the test to maintain the temperature rise of one degree Celsius per minute.

2.16.2. During the test, periodically check the temperature and time the rise of the

temperature to assure that the rate of temperature rise is correct.

2.17. Apply the flame to the sample after every one degree of temperature rise.

2.18. If the boiling point of the sample is reached and the sample has yet to flash, then the sample is said to have no flash point.

APPENDIX I
SOURCE DOCUMENTS

External Documents:

1. ASTM Standard D56 - 05, 1995 (2010), "Standard Test Method for Flash Point by Tag Closed Cup Tester," ASTM International, West Conshohocken, PA, 2000, DOI: 10.1520/D0056-05R10, www.astm.org.

Internal Documents: NONE
Generated Forms: NONE
Related Forms: NONE

SOLVENT COMPARISON FOR CLEANING GREASE – GENERAL

SCOPE

This procedure outlines the method used for comparing the ability of different solvents to remove grease from a glass vial.

PURPOSE

The purpose of this procedure is to compare the performance of new solvents and solvent blends against a panel of known solvents by measuring gravimetrically the relative amounts of grease residue removed from a glass vial.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

4. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of heavy metal waste into the laboratory regulated solid waste container.

2.5. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.6. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR COMPARISON OF THE ABILITY OF SOLVENTS TO REMOVE GREASE

1. Producing grease contamination.

    1.1. Number enough clean, empty vials to have five replicate vials as blanks, and five replicate vials for each test solvent.

        1.1.1. Blanks are empty vials.

        1.1.2. Make sure that the caps are also numbered.

    1.2. Use an analytical balance (preferably to 0.00001 g) to weigh all of the vials with the caps on.

    1.3. Add a small amount of grease to the bottom of every vial, except for the five blank vials, using a wide-bore syringe.

        1.3.1. Take note of which numbers correspond to the blank vials.

Note: Do not to get grease on the top half of the vial!

    1.4. Weigh all of the vials again with the caps on.

2. Cleaning the grease from the vials.

    2.1. Remove the caps of all of the vials except for the blank vials.

    2.2. Fill each vial that contains grease half full with a test solvent. Five vials per solvent.

        2.2.1. Take note of which numbered vials contain which solvent.

        2.2.2. Do not add solvent to the blank vials.

    2.3. Place the caps back on the vials as they are filled.

    2.4. Weigh all of the vials again.

    2.5. Shake all of the vials for one hour at a high setting on a shaker.

    2.6. Number 5 clean aluminum weigh pans for each test solvent for use as transfer pans.

        2.6.1. Make sure the numbers correspond to the numbers that are on the vials on the shaker.

    2.7. Weigh all of the transfer pans.

    2.8. When the shaking period is over, pour the solvent from the vials into the corresponding transfer pans.

    2.9. Place the vials that were transferred from (without the caps), and the pans that were transferred to, in the an oven at 100 °C to evaporate the solvent.

    2.10. Take vials out of the oven as they get dry.

Note:
Do not allow the residue to get cooked to the vials or pans!

2.11. Allow the dry vials and pans to cool to room temperature.

2.12. Place the caps back onto the vials.

2.13. Weigh the dry vials and dry transfer pans.

3. Qualitative data collection of the extracted grease contamination.

3.1. Take pictures of the resulting residue in the bottom of the vials, and the receiving pans.

3.2. Examine the vials and pans, making note of any interesting observations.

GRAVIMETRIC DATA ANALYSIS

1. Analysis of the grease contamination data.

    1.1. Calculating the percent of the grease removed from the vials.

        1.1.1. Subtract the mass of the empty vials from the mass of the vials with grease to obtain the mass of grease added to each vial.

        1.1.2. Subtract the mass of the transfer pan from the mass of the pan with the transferred residue to obtain the mass of the grease residue that was transferred.

        1.1.3. Divide the mass of the grease residue that was transferred by the mass of grease added to each vial to obtain the fraction of grease that was transferred by the solvent.

        1.1.4. Multiply the fraction of grease that was transferred by the solvent by 100 to obtain the percentage of grease that was transferred by the solvent.

APPENDIX I
SOURCE DOCUMENTS

External Documents:	NONE
Internal Documents:	NONE
Generated Forms:	NONE
Related Forms:	NONE

VAPOR DEGREASING USING THE GRADUATED CYLINDER VAPOR DEGREASER – GENERAL

SCOPE

This procedure outlines the proper use of the small scale vapor degreaser that was constructed from a 2000 mL graduated cylinder by the research group of Dr. Darren L. Williams at SHSU.

PURPOSE

The purpose of this procedure is to characterize the vapor phase cleaning ability of small quantities of R&D solvents. The minimum recommended volume of solvent in this procedure is 300 mL in the degreaser.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

4. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.5. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR CLEANING USING THE GRADUATED CYLINDER VAPOR DEGREASER

1. Preparing the vapor degreaser.

    1.1. Rinse the inside of the cylinder with a small amount of the solvent that is going to be used for cleaning.

    1.2. Place the degreaser in a fume hood.

    1.3. Power on the temperature controlled bath circulator.

    1.4. Set the bath circulator to “cool”.

    1.5. Set the temperature to negative twenty-five degrees Celsius.

    1.6. Wait for the bath circulator to chill the bath to negative twenty degrees Celsius.

    1.7. Open the valve to allow the chilled bath to flow to the copper cooling coils on the degreaser.

    1.8. Put on a pair of nitrile gloves and eyes/face protection.

    1.9. Make sure that the degreaser is secured tightly on top of the magnetic stirrer.

    1.10. Pour 400 mL (300 mL minimum) of solvent into the cylinder.

    1.11. Place a magnetic stir bar in the bottom of the cylinder.

    1.12. Place a watch glass over the opening of the degreaser.

    1.13. Power the magnetic stirrer and adjust the knob to an optimal stir speed.

    1.14. Turn on the power regulator for the heating source and adjust the knob to a setting that will bring the solvent to a hard boil.

2. Cleaning with the vapor degreaser.

    2.1. Load pre-weighed and soiled items into the degreaser basket.

        2.1.1. Make sure to wear gloves or use a pair of clean tongs.

        2.1.2. Place the items into the basket in an organized manner.

        2.1.3. Do not stack or pile items.

    2.2. After the solvent has been boiling long enough to create a sufficient vapor zone that can be seen condensing on the walls of the degreaser, it is ready to clean.

    2.3. Fill the separate ultrasonic bath with enough water to be at the correct level after being displaced by a 250 mL beaker.

Note:
All ultrasonic operations are optional, but recommended since most commercial vapor degreasers have ultrasonic capabilities.

2.4. Add 150 mL of solvent to the 250 mL beaker that is being suspended in the water of the ultrasonic bath.

2.5. Place a watch glass over the top of the beaker.

2.6. Remove the watch glass from the top of the degreaser.

2.7. Very slowly lower the basket into the vapor zone above the boiling solvent.

2.7.1. The basket should be just above the surface of the liquid.

2.8. Hook the basket to the lip of the degreaser to hold it in that spot.

2.9. Replace the watch glass on the top of the degreaser.

2.10. Start the ten-minute ultrasonic bath degas cycle.

2.11. When the ultrasonic bath degas cycle comes to an end, move the basket very slowly from the degreaser to the ultrasonic bath.

2.12. Start the five-minute ultrasonic bath cycle.

2.13. Repeatedly raise and lower the basket in the ultrasonic bath until the end of the cycle.

2.14. Very slowly move the basket back to the vapor zone just above the boiling sump in the degreaser.

2.15. Hold the basket in that spot for five minutes.

2.16. Very slowly raise the basket to the top set of cooling coils.

2.17. Hold the basket next to the cooling coils for ten minutes to reduce solvent loss.

2.18. Remove the basket from the degreaser.

2.19. Place the watch glass back over the opening of the degreaser.

2.20. Unload clean items from the basket.

2.21. Weigh the parts to determine the percent soil removed.

2.22. Repeat from 2.1. for any additional items that need to be cleaned.

3. Preparing the degreaser for storage.

3.1. Power off the ultrasonic bath.

3.2. Power off the power regulator for the heating source.

3.3. Power off the magnetic stirrer.

3.4. Allow the solvent to cool back to room temperature.

3.5. Put on eyes/face protection and nitrile gloves.

3.6. Pour the dirty solvent from the degreaser into properly labeled containers for solvent-recovery distillation.

3.7. Close the valve on the bath circulator.

3.8. Power off the bath circulator.

3.9. Leave the watch glass off of the degreaser inside of the fume hood to allow any residual solvent to be evaporated over time.

APPENDIX I
SOURCE DOCUMENTS

External Documents:	NONE
Internal Documents:	NONE
Generated Forms:	NONE
Related Forms:	NONE

VAPOR DEGREASING USING THE MODIFIED BRANSON 125 VAPOR DEGREASER – GENERAL

SCOPE

This procedure outlines filling the vapor degreaser, cleaning with the vapor degreaser, emptying the vapor degreaser and preparing the vapor degreaser for storage.

PURPOSE

The purpose of this procedure is to safely and accurately operate the vapor degreaser for cleaning parts and for evaluating the cleaning ability of organic solvents and solvent blends.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. FLAMMABLE SOLVENTS ARE NOT TO BE USED IN VAPOR DEGREASING OPERATIONS.

2. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

3. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

4. An ORGANIC VAPOR half-face respirator is **required** for filling and draining operations.

5. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

6. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.5. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR CLEANING WITH THE MODIFIED BRANSON 125 VAPOR DEGREASER

1. Preparing the vapor degreaser.

    1.1. Power on the temperature controlled bath circulator.

    1.2. Set the bath circulator to “cool”.

    1.3. Set the temperature to negative twenty-five degrees Celsius.

    1.4. Wait for the bath circulator to chill the bath to negative twenty degrees Celsius.

    1.5. Open the valve to allow the chilled bath to flow to the top coils in the degreaser.

    1.6. Put on a respirator, eye/face protection and nitrile gloves.

    1.7. Remove any desiccant or sodium bicarbonate from the degreaser.

    1.8. Make sure that all of the emptying valves are closed.

    1.9. Pour two gallons of solvent into the ultrasonic tank, allowing the solvent to flow over the divider and into the boiling sump.

    1.10. Slide the lid degreaser lid closed.

    1.11. Flip the “Main Power” switch to “On”.

    1.12. Press the “Start” button to begin heating the boiling sump.

    1.13. Flip the “Ultrasonics” switch to “On” to allow the solvent in the ultrasonic tank to begin degassing.

2. Cleaning with the vapor degreaser.

    2.1. Load soiled items into the degreaser basket.

        2.1.1. Make sure to wear gloves or use a pair of clean tongs.

        2.1.2. Place the items into the basket in an organized manner.

        2.1.3. Do not stack or pile items.

    2.2. After the solvent has been boiling long enough to create a sufficient vapor zone that can be seen condensing on the back wall of the degreaser, it is ready to clean.

    2.3. Slowly slide the degreaser lid open.

    2.4. Very slowly lower the basket into the vapor zone above the boiling sump.

        2.4.1. The basket should be just above the surface of the liquid.

    2.5. Hold the basket in that spot for ten minutes.

    2.6. Slowly move the basket to the ultrasonic tank.

2.7. Slowly, raise and lower the basket in the ultrasonic tank for five minutes.

2.8. Slowly move the basket back to the vapor zone just above the boiling sump.

2.9. Hold the basket in that spot for five minutes.

2.10. Very slowly raise the basket to the top set of cooling coils.

2.11. Hold the basket next to the cooling coils for ten minutes to reduce solvent loss.

2.12. Remove the basket from the degreaser.

2.13. Slide the lid of the degreaser closed.

2.14. Unload clean items from the basket.

2.15. Repeat from 2.1. for any additional items that need to be cleaned.

3. Preparing the degreaser for storage.

3.1. Flip the “Ultrasonics” switch to “Off”.

3.2. Flip the “Main Power” switch to “Off”.

3.3. Wait for a few minutes.

3.4. Flip the “Main Power” switch back to “On”. This engages the cooling coils without engaging the heater. This is critical to prevent solvent loss and personnel exposure.

3.5. Allow the solvent to cool back to room temperature.

3.6. Flip the “Main Power” switch back to “Off”.

3.7. Put on a respirator, eyes/face protection and nitrile gloves.

3.8. Empty the dirty solvent into properly labeled containers for later distillation using the valves on the back of the degreaser.

3.9. Close the valve on the bath circulator.

3.10. Power off the bath circulator.

3.11. Power on an aspirator.

3.12. Using a hose from the aspirator, suck out any remaining solvent in the degreaser.

3.13. Power off the aspirator.

3.14. Dry the inside of the degreaser with an absorbent cloth.

3.15. Place the absorbent cloth in a fume hood to dry for future use.

3.16. Place an open container of sodium bicarbonate in the bottom of the degreaser.

3.17. Leave the lid of the degreaser open.

APPENDIX I
SOURCE DOCUMENTS

External Documents:	NONE
Internal Documents:	NONE
Generated Forms:	NONE
Related Forms:	NONE

SOLVENT COMPARISON FOR IONICS EXTRACTION FROM SOLDER PASTE – GENERAL

SCOPE

This procedure outlines the method of producing ionic contamination in a controlled manner, extraction of the ionic contamination with test solvents, quantification of the extracted contamination, and analysis of the data.

PURPOSE

The purpose of this procedure is to compare the ability of various solvents to remove ionic contamination from soldered materials. It may be used to test new solvents against the performance of existing solvents on a known solder paste. Or it may be used to test the ability of existing solvents to clean ionic contamination produced by new solder pastes.

PROCEDURE USE LEVEL	
	Critical Use
X	**General Use**
	Reference Use

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OPERATING PROCEDURE

SAFETY REQUIREMENTS

1. Before beginning this procedure, read all of the Safety Data Sheets for the chemicals at hand.

2. Contact your supervisor for information regarding the proper personal protection equipment (PPE) to be used in this procedure.

3. This procedure produces very hot samples. Care should be taken to avoid burns. Thermal gloves are available for handling hot materials.

4. Personnel engaged in the handling of chemicals that could present a hazard due to splashing are required to wear safety eyewear with side-shields, or work in a hood, or wear a safety face shield.

NOTE
Nitrile or equivalent gloves are used for incidental contact only.

5. Wear nitrile or equivalent gloves when handling chemicals. In case of an incidental spill, wear nitrile gloves during cleanup. Do not use latex gloves for organic solvent work.

OPERATING PROCEDURE

GENERAL INSTRUCTIONS

1. The sequence of operations in this procedure is not mandatory.

2. Waste Disposal

NOTE
Segregation of halogenated and non-halogenated waste streams is vital to the management of waste disposal costs. Likewise, recycling of solvent is a priority. **Do not mix solvents if you do not have to!**

2.1. Dispose of halogenated solvents in a properly labeled halogenated solvent waste container.

2.2. Dispose of non-halogenated solvents in a properly labeled non-halogenated solvent waste container.

2.3. Dispose of aqueous waste containing heavy metal waste in a properly labeled heavy metal aqueous waste container.

2.4. Dispose of heavy metal waste into the laboratory regulated solid waste container.

2.5. Dispose of contaminated PPE and laboratory expendables into the laboratory regulated solid waste container.

2.6. Dispose of uncontaminated PPE and laboratory consumables in the laboratory nonregulated solid waste container.

OPERATING PROCEDURE

OPERATIONS FOR COMPARISON OF THE ABILITY OF SOLVENTS TO REMOVE IONICS CONTAMINATION FROM SOLDERED MATERIALS

1. Producing ionic contamination.

    1.1. Number enough clean, empty, 30 mL vials to have five replicate vials as blanks, five replicate vials as controls, and five replicate vials for each test solvent.

        1.1.1. Blanks are empty vials and controls are vials with solder that do not get cleaned with a test solvent.

        1.1.2. Ensure that the caps are also numbered.

    1.2. Weigh all of the vials with the caps on.

    1.3. Add a small amount (0.5 to 1.5 g) of solder paste to the bottom of every vial except for the five blank vials.

        1.3.1. Take note of which numbers correspond to the blank vials.

Note:
Do not to get solder on the top half of the vial!

    1.4. Weigh all of the vials again with the caps on.

    1.5. Remove the caps of all of the vials.

    1.6. Use aluminum foil to tightly cover the tops of all of the vials.

        1.6.1. This prevents the ionic contamination from leaving the vial in gaseous form.

    1.7. Place all vials on a metal rack.

    1.8. Make note of the type of solder paste and its melting point.

    1.9. Cook the vials in the GC oven at 5 °C above the melting point of the solder paste until all of the solder is melted and forms a smooth ball of solder in the bottom of the vial.

        1.9.1. This takes approximately 10 minutes.

        1.9.2. Completely melt the solder, but do not overcook the flux residue.

    1.10. Remove the vials from the oven using thermally insulated gloves.

    1.11. Allow the vials to cool to room temperature.

    1.12. Replace the aluminum foil with the correct caps.

    1.13. Weigh all of the vials again.

2. Extracting the ionic contamination with the test solvents.

    2.1. Set the blank vials and control vials aside.

2.1.1. Take note of which numbered vials are the control vials.

2.2. Add each test solvent to five of the remaining vials.

2.2.1. Fill the vials approximately two thirds full (20 mL).

2.2.2. Take note of which numbered vials contain which solvent.

2.2.3. Do not add solvent to the blank vials or control vials.

2.3. Weigh each vial that contains solvent.

2.4. Ultrasound the vials that contain solvent for one hour in an ultrasonic bath.

2.5. Number 5 more clean vials and caps for each test solvent for use as transfer vials.

2.5.1. Make sure the numbers correspond to the numbers that are on the vials in the ultrasonic bath.

2.5.2. Make sure that these vials are marked in a way that will allow them to be identified as transfer vials.

2.6. Weigh all of the transfer vials.

2.7. When the ultrasound period is over, pour the solvent from the vials in the ultrasound into the corresponding transfer vials.

2.8. Place the vials that were transferred from and the vials that were transferred to in the oven at 100 °C to evaporate the solvent.

2.9. Take vials out of the oven as they become dry.

2.9.1. Do not allow the residue to get cooked to the vials!

3. Quantification of the extracted ionic contamination.

3.1. Prepare a solution that is three parts of isopropyl alcohol to one part of type I deionized water.

3.1.1. Be sure to make enough of the IPA/DI solution to have 20 mL for all of the vials used in this experiment.

3.1.2. Always make some extra IPA/DI solution!

3.2. Add 20 mL of the IPA/DI solution to every vial that was used in this experiment using a volumetric pipet.

3.3. Ultrasound all vials in an ultrasonic bath for one hour.

3.4. Measure the conductivity of all vials using a conductivity meter.

3.4.1. Calibrate the conductivity meter.

3.4.1.1. Rinse the well of the conductivity meter with a conductivity standard solution.

3.4.1.2. Fill the well of the conductivity meter with the conductivity standard solution.

3.4.1.3. Press the “Cal” button.

3.4.1.4. Adjust the conductivity to match the number on the bottle of the standard using the arrow buttons.

3.4.1.5. Press the “Cal” button again.

3.4.2. Measure the conductivity of every vial used in the experiment.

3.4.2.1. Rinse the well with the solution that is about to be tested.

3.4.2.2. Fill the well with the solution.

3.4.2.3. Press the “Cond.” Button.

3.4.2.4. Wait for the reading to stabilize.

3.4.2.5. Record the stabilized reading.

OPERATING PROCEDURE

CONDUCTIVITY AND GRAVIMETRIC DATA ANALYSIS

1. Analysis of the ionic contamination data.

    1.1. Calculating the percent conductivity transferred per gram of solder.

        1.1.1. Calculate the mass of solder added to the vial.

            1.1.1.1. Subtract the mass of the empty vial from the mass of the vial with solder paste to obtain the mass of solder paste added.

        1.1.2. Calculating the blank corrected conductivity.

            1.1.2.1. Average the conductivity of the five blank vials.

            1.1.2.2. Subtract the result from all other conductivities.

        1.1.3. Calculating the blank corrected conductivity per gram of solder paste.

            1.1.3.1. For all vials, divide the blank corrected conductivity by the initial mass of solder pasted added to the vial.

        1.1.4. Calculating the total conductivity per gram of solder paste.

            1.1.4.1. Add the conductivity of each of the original vials to the conductivity of the corresponding transfer vial to compute the total conductivity per gram of solder paste.

        1.1.5. Calculating the percent conductivity transferred per gram of solder.

            1.1.5.1. Divide the blank corrected conductivity of the transfer vials by the total blank corrected conductivity.

            1.1.5.2. Multiply by 100%.

APPENDIX I
SOURCE DOCUMENTS

External Documents:

1. IPC-TM-650 Test Methods Manual 2.3.25 D, "Detection and Measurement of Ionizable Surface Contaminants by Resistivity of Solvent Extract (ROSE)," IPC, Bannockburn, IL, 2012, www.ipc.org.

Internal Documents: NONE
Generated Forms: NONE
Related Forms: NONE

Appendix C – Safety Data Sheets

SAFETY DATA SHEET

No. X-0230EU-01
Identity (As Used on Label and List)

ASAHIKLIN AE-3000

1. IDENTIFICATION OF THE CHEMICAL AND OF THE MANUFACTURER, IMPORTER OR OTHER UNDERTAKING

Current Issue Date : July 2, 2003
Previous Issue Date :
1.1 Identification of the chemical

Trade name: ASAHIKLIN AE-3000

Chemical name: 1,1,2,2-tetrafluoroethyl-2,2,2-trifluoroethyl ether

1.2 Use of the substance/preparation

solvent

1.3 Company/undertaking identification

Manufacturer:
ASAHI GLASS CO.,LTD.
Chemicals Company
1-12-1, Yurakucho, Chiyoda-ku, Tokyo, 100-8405, Japan

Telephone Number for Information: +81-3-3218-5479

Facsimile Number for Information: +81-3-3218-7845

Supplier:
ASAHI GLASS EUROPE B.V.
World Trade Center, Amsterdam Strawinskylaan 1525, 1077XX, Amsterdam, Netherlands

Telephone Number for Information: +31-20-573-6040
Facsimile Number for Information: +31-20-575-3191

2. COMPOSITION / INFORMATION ON INGREDIENTS

- **Ingredients:** 1,1,2,2-tetrafluoroethyl-2,2,2-trifluoroethyl ether
- **CAS No.:** 406-78-0
- **EINECS No.:** N/E

- %: 99.9<
- **Hazard Symbols:** Not classified
- **Risk Phrases:** Not classified

This product does not contain any CFCs.

3. HAZARDS IDENTIFICATION

Not classified as dangerous by the classification rules in Directives 67/548/EEC on harmful substances and by directive on harmful compounds.

3.1 Emergency overview

May be harmful by inhalation, ingestion, or skin absorption. May cause irritation

3.2 Potential health hazards

- **Potential health hazards**
- **Inhaled:** N/E
- **In contact with skin:** Fat and oil are dissolved, so delipilization occurs when there is direct contact with the skin.
- **In contact with eyes:** N/E
- **Ingested:** N/E

4. FIRST AID MEASURES

- **Inhalation:** If high concentrations are inhaled, immediately remove to fresh air. Keep persons calm. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
- **Skin contact:** In case of skin contact, flush with water for 15 minutes. Get medical attention if irritation is present.
- **Eye contact:** In case of eye contact, immediately flush eyes with plenty of water for 15 minutes. Call a physician.
- **Ingestion:** No specific intervention is indicated as the compound is not likely to be hazardous by ingestion. Consult a physician if necessary. Do not induce vomiting because the hazard of aspirating the material into the lungs is considered greater than swallowing it.
- **Further medical advice:** N/E

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media: This substance is incombustible, so select and use a suitable fire fighting agent on the surrouding fire e.g. CO_2, dry powder foam or water extingushers.

Unusual fire and explosion hazards:

Containers may rupture under fire conditions. Decomposition may occur.

Special fire fighting precaution/instructions: Use water spray to cool containers. Self-contained breathing apparatus (SCBA) is required if drums rupture and contents are spilled under fire conditions.

6. ACCIDENTAL RELEASE MEASURES

In case of spill or other release:

NOTE: Review Fire and Explosion Hazard Data and Precautions to Be Taken in Handling and Storing before proceeding with clean up. Use appropriate Control Measures personal protective equipment during clean up.

Dike spill. Prevent liquid from entering sewers, waterways or low areas.
Ventilate area. Collect on absorbent material and transfer to steel drums or recovery/disposal.
Comply with Federal, State, and local regulations on reporting releases.

7. HANDLING AND STORAGE

Handling
Use with sufficient ventilation.
Provide adequate ventilation for storage, handling, and use, especially for enclosed or low spaces. Avoid contact of liquid with eyes and prolonged skin exposure. Do not allow product to contact open flame or electrical heating elements because dangerous decomposition products may form.

Storage
Avoid placing sealed containers under direct sunlight, but store them in a well-ventilated area, at room temperature.Don't store near heat, sparks or open flames.

8. EXPOSURE CONTROL / PERSONAL PROTECTION

Exposure guidelines
Ingredient name: 1,1,2,2-tetrafluoroethyl-2,2,2-trifluoroethyl ether
MAK-Values(1999): N/E
ACGIH(2001) TLV-TWA: N/E , **STEL:** N/E

Engineering controls
Normal ventilation for standard manufacturing procedures is generally adequate.
Local exhaust should be used when large amounts are released.
Mechanical ventilation should be used in low places.
An eye wash and safety shower should be nearby and ready for use.
Impermeable apron and boots to prevent skin contact.

Personal protective equipment
Respiratory protection: Ventilation Under normal manufacturing conditions, respiratory protection is required when using this product.
Self-contained breathing apparatus (SCBA) is required if a large spill occurs.

Skin protection: Impervious gloves should be used avoid prolonged or repeated exposure.
Eye protection: Chemical splash goggles should be available for use as needed to prevent eye contact.
Additional recommendations: An eye wash and safety shower should be nearby and ready for use. Impermeable apron and boots to prevent skin contact

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor: Clear colorless liquid. Slightly smell of ether.
Chemical formula: CF3CH2OCF2CF2H
Boiling point: 56.2deg.C
Melting point: N/D
Vapor pressure (25 deg.C): 31kPa
Flash point (method): Non-flammable (T.C.C.)
Lower explosive limit : N/D
Upper explosive limit : N/D
Autoignition temperature: N/D

Relative Density (25 deg.C): 1.47
Solubility (20 deg.C) in water: Almost insoluble
Solubility (20 deg.C) in solvent: N/D
pH value (20 deg.C): N/A
Viscosity (25 deg.C): 6.5X10-4 Pa
Partition coefficient : n-octanol / water: N/D
Other data (vapor density, miscibility, evaporation rate, conductivity, etc.): N/D

10. STABILITY AND REACTIVITY

Stability: Stable
Material is stable under normal conditions.
Conditions to avoid:
Material is stable under normal conditions. However, avoid open flames and high temperature and active metals. But alkaline or acid cause slightly decomposition.
Materials to avoid (Incompatibilities): Alkaline, acid, active reagent.
Hazardous decomposition products: Decomposition products are hazardous. This compound can be decomposed by high
temperatures (open flames, glowing metal surfaces, etc.) forming hydrofluoric acids-possibly carbonyl fluoride, perfluoro isobutylene (PFIB).and cooling.

11. TOXICOLOGICAL INFORMATION

1,1,2,2-tetrafluoroethyl-2,2,2-trifluoroethyl ether

Acute toxicity:
Oral LD50 (mouse): 2,000mg/kg<
Inhalation LC50 (rat): 24.8mg/L<

Genetic studies :
Ames Assay : Negative (OECD GL471 & 472)
Chromosomal Aberration Test : Negative (CHL Cell) (OECD GL 473)

Repeated Dose Oral Toxicity (28Day): NOEL 1000 mg/kg/d

Carcinogenic classification (ACGIH) : N/E

12. ECOLOGICAL INFORMATION

Bidegradability: 2% by BOD (OECD GL 301C)
Bioaccumulation: Bioconcentration factor 293-658 in carp (OECD GL 305C)
Other information:
Fish acute toxicity LC50 (Oryzias latipes) 125mg/l /48h< (ASAHIKLIN AC-2000)

13. DISPOSAL CONSIDERATIONS

Disposal method:
Recover by distillation or remove to permitted waste disposal facility.
Comply with Federal, State, and local regulations

Repair and maintenance precautions: N/E

Other precautions: N/E

14. TRANSPORT INFORMATION

Does not constitute dangerous goods within the meaning of transport regulations.

- UN No.: Not regulated
- ADR / RID Status: - -; Class: - -
- IMDG Status: - ; Class: - -
- ICAO / IATA Status: - -; Class:

15. REGULATORY INFORMATION

15.1 Information on the warning label

- Council Directive 92/32/EEC Status: N/E
- Information on the warning label : not classified
- EEC Classification: N/E
- Hazard symbol: N/E
- Risk phrases: N/E
- Safety phrases: N/E

15.2 National regulations

TSCA Status: Not listed.
Council Directive 92/32/EEC Status: N/E

- TSCA Inventory Status (USA) : This substance is not listed .
- SARA Section 302: N/E
- SARA Section 311, 312: N/E
- SARA Section 313: N/E
- Clean Air Act: N/E

WHMIS (CANADA): N/E

16. OTHER INFORMATION

- N/A: not applicable
- N/E: not established
- MAK: maximum workplace concentration
- ACGIH: American Conference of Govermental Industrial Hygienists

Safety Data Sheet according to EEC Directive 91/155
The product is not designed for special applications such as pharmaceutical ,medical use.
This Safety Data Sheet is offered only for your information, consideration and investigation.
Asahi Glass Co., Ltd. provides no warranties, either express or implied, and assumes no responsibility for the accuracy or completeness of the data contained herein.

SAFETY DATA SHEET

Version 5.5
Revision Date 12/02/2015
Print Date 02/17/2016

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name	:	*tert*-Butyl acetate
Product Number	:	B88209
Brand	:	Aldrich
Index-No.	:	607-026-00-7
CAS-No.	:	540-88-5

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses	:	Laboratory chemicals, Synthesis of substances

1.3 Details of the supplier of the safety data sheet

Company	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052

1.4 Emergency telephone number

Emergency Phone #	:	(314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Flammable liquids (Category 2), H225

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word	Danger
Hazard statement(s)	
H225	Highly flammable liquid and vapour.
Precautionary statement(s)	
P210	Keep away from heat/sparks/open flames/hot surfaces. No smoking.
P233	Keep container tightly closed.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242	Use only non-sparking tools.
P243	Take precautionary measures against static discharge.
P280	Wear protective gloves/ eye protection/ face protection.
P303 + P361 + P353	IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P370 + P378	In case of fire: Use dry sand, dry chemical or alcohol-resistant foam for

	extinction.
P403 + P235	Store in a well-ventilated place. Keep cool.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS
Repeated exposure may cause skin dryness or cracking.

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula	:	$C_6H_{12}O_2$
Molecular weight	:	116.16 g/mol
CAS-No.	:	540-88-5
EC-No.	:	208-760-7
Index-No.	:	607-026-00-7

Hazardous components

Component	Classification	Concentration
tert-Butyl acetate		
	Flam. Liq. 2; H225	<= 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.
For personal protection see section 8.

6.2 Environmental precautions

Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up

Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13).

6.4 Reference to other sections

For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Avoid inhalation of vapour or mist.
Use explosion-proof equipment.Keep away from sources of ignition - No smoking.Take measures to prevent the build up of electrostatic charge.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.
Storage class (TRGS 510): Flammable liquids

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
tert-Butyl acetate	540-88-5	TWA	200 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Upper Respiratory Tract irritation Eye irritation Adopted values or notations enclosed are those for which changes are proposed in the NIC See Notice of Intended Changes (NIC)		
		TWA	200.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Upper Respiratory Tract irritation Eye irritation		
		TWA	200.000000 ppm 950.000000 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		The value in mg/m3 is approximate.		

		TWA	200.000000 ppm 950.000000 mg/m3	USA. NIOSH Recommended Exposure Limits

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.4 mm
Break through time: 30 min
Material tested:Camatril® (KCL 730 / Aldrich Z677442, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Impervious clothing, Flame retardant antistatic protective clothing., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: liquid Colour: colourless
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	Melting point/range: < -57.99 °C (< -72.38 °F)
f)	Initial boiling point and boiling range	97 - 98 °C (207 - 208 °F) - lit.
g)	Flash point	4 °C (39 °F) - closed cup
h)	Evaporation rate	No data available

i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	Lower explosion limit: 1.5 - 1.7 %(V)
k)	Vapour pressure	56 hPa (42 mmHg) at 20 °C (68 °F)
l)	Vapour density	4.65
m)	Relative density	0.866 g/cm3 at 20 °C (68 °F)
n)	Water solubility	ca.6.7 g/l at 23 °C (73 °F) - OECD Test Guideline 105 - soluble
o)	Partition coefficient: n-octanol/water	log Pow: 1.64 at 21.7 °C (71.1 °F)
p)	Auto-ignition temperature	589 °C (1,092 °F) at 1,015 hPa (761 mmHg)
q)	Decomposition temperature	No data available
r)	Viscosity	< 1 mm2/s at 25 °C (77 °F) -
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information

Surface tension	64 mN/m at 20 °C (68 °F)
Relative vapour density	4.65

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
Vapours may form explosive mixture with air.

10.4 Conditions to avoid
Heat, flames and sparks.

10.5 Incompatible materials
Oxidizing agents

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - male - 4,100 mg/kg

Inhalation: No data available

LD50 Dermal - Rabbit - male and female - > 2,000 mg/kg

No data available

Skin corrosion/irritation
Skin - Rabbit
Result: No skin irritation - 4 h

Serious eye damage/eye irritation
Eyes - Rabbit
Result: No eye irritation - 72 h

Respiratory or skin sensitisation
- Guinea pig
Did not cause sensitisation on laboratory animals.
(Buehler Test)

Germ cell mutagenicity
No data available

reverse mutation assay
S. typhimurium
Result: negative

Mutagenicity (micronucleus test)
Rat - male and female
Result: negative

Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP:	No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information

Repeated dose toxicity	Mouse - male and female - inhalation (vapour) - NOAEL : 0.48 mg/l

RTECS: AF7400000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	semi-static test LC50 - Oncorhynchus mykiss (rainbow trout) - 240 mg/l - 96 h (OECD Test Guideline 203)
Toxicity to daphnia and other aquatic invertebrates	static test EC50 - Daphnia magna (Water flea) - 350 mg/l - 48 h (OECD Test Guideline 202)

12.2 Persistence and degradability

Biodegradability	aerobic - Exposure time 28 d

Result: 50 % - Inherently biodegradable.
(OECD Test Guideline 301D)

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1123 Class: 3 Packing group: II
Proper shipping name: Butyl acetates
Reportable Quantity (RQ): 5000 lbs

Poison Inhalation Hazard: No

IMDG
UN number: 1123 Class: 3 Packing group: II EMS-No: F-E, S-D
Proper shipping name: BUTYL ACETATES

IATA
UN number: 1123 Class: 3 Packing group: II
Proper shipping name: Butyl acetates

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Fire Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
tert-Butyl acetate	540-88-5	1993-04-24

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
tert-Butyl acetate	540-88-5	1993-04-24

New Jersey Right To Know Components

	CAS-No.	Revision Date
tert-Butyl acetate	540-88-5	1993-04-24

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Flam. Liq.	Flammable liquids
H225	Highly flammable liquid and vapour.

HMIS Rating

Health hazard:	1
Chronic Health Hazard:	
Flammability:	3
Physical Hazard	0

NFPA Rating

Health hazard:	0
Fire Hazard:	3
Reactivity Hazard:	0

Further information
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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.5 Revision Date: 12/02/2015 Print Date: 02/17/2016

MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATHESON TRI-GAS, INC.
150 Allen Road Suite 302
Basking Ridge, New Jersey 07920
Information: 1-800-416-2505

Emergency Contact:
CHEMTREC 1-800-424-9300
Calls Originating Outside the US:
703-527-3887 (Collect Calls Accepted)

SUBSTANCE: TERT-BUTANOL

TRADE NAMES/SYNONYMS:
T-BUTANOL; 1,1-DIMETHYLETHANOL; TRIMETHYLCARBINOL; TRIMETHYLMETHANOL; TRIMETHYL METHANOL; BUTYL ALCOHOL; 2-METHYL-2-PROPANOL; TERT-BUTYL ALCOHOL; TRIMETHYL CARBINOL; UN 1120; C4H10O; 00230215; RTECS EO1925000

CHEMICAL FAMILY: aliphatic, alcohols

CREATION DATE: Dec 01 2003
REVISION DATE: Dec 11 2008

2. COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: TERT-BUTANOL
CAS NUMBER: 75-65-0
PERCENTAGE: 100

3. HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=3 REACTIVITY=0

EMERGENCY OVERVIEW:
CHANGE IN APPEARANCE: hygroscopic
COLOR: colorless
PHYSICAL FORM: crystals, liquid
ODOR: pungent odor
MAJOR HEALTH HAZARDS: respiratory tract irritation, eye irritation, central nervous system depression
PHYSICAL HAZARDS: Flammable liquid and vapor. Vapor may cause flash fire.

POTENTIAL HEALTH EFFECTS:

INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, vomiting, difficulty breathing, headache, drowsiness, dizziness, loss of coordination, blurred vision
LONG TERM EXPOSURE: no information on significant adverse effects
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation
LONG TERM EXPOSURE: irritation
EYE CONTACT:
SHORT TERM EXPOSURE: irritation, blurred vision
LONG TERM EXPOSURE: irritation
INGESTION:
SHORT TERM EXPOSURE: nausea, vomiting, diarrhea, stomach pain, headache, drowsiness, dizziness, loss of coordination, unconsciousness
LONG TERM EXPOSURE: no information on significant adverse effects

4. FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. Get immediate medical attention.

SKIN CONTACT: Wash skin with soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention, if needed. Thoroughly clean and dry contaminated clothing and shoes before reuse.

EYE CONTACT: Flush eyes with plenty of water for at least 15 minutes. Then get immediate medical attention.

INGESTION: If a large amount is swallowed, get medical attention.

NOTE TO PHYSICIAN: For inhalation, consider oxygen.

5. FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Vapor/air mixtures are explosive.

EXTINGUISHING MEDIA: alcohol-resistant foam, carbon dioxide, regular dry chemical, water

Large fires: Use alcohol-resistant foam or flood with fine water spray.

FIRE FIGHTING: Move container from fire area if it can be done without risk. Dike for later disposal. Do not scatter spilled material with high-pressure water streams. Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. Withdraw immediately in case of rising sound from

venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck, evacuation radius: 800 meters (1/2 mile). Do not attempt to extinguish fire unless flow of material can be stopped first. Flood with fine water spray. Do not scatter spilled material with high-pressure water streams. Cool containers with water spray until well after the fire is out. Apply water from a protected location or from a safe distance. Avoid inhalation of material or combustion by-products. Stay upwind and keep out of low areas.

FLASH POINT: 52 F (11 C) (CC)
LOWER FLAMMABLE LIMIT: 2.4%
UPPER FLAMMABLE LIMIT: 8.0%
AUTOIGNITION: 892 F (478 C)
FLAMMABILITY CLASS (OSHA): IB

6. ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Remove sources of ignition. Stop leak if possible without personal risk. Reduce vapors with water spray. Small spills: Absorb with sand or other non-combustible material. Collect spilled material in appropriate container for disposal. Large spills: Dike for later disposal. Keep unnecessary people away, isolate hazard area and deny entry. Stay upwind and keep out of low areas.

7. HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.106. Grounding and bonding required. Keep separated from incompatible substances.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
TERT-BUTANOL:
TERT-BUTYL ALCOHOL:
100 ppm (300 mg/m3) OSHA TWA
150 ppm (450 mg/m3) OSHA STEL (vacated by 58 FR 35338, June 30, 1993)
100 ppm ACGIH TWA
100 ppm (300 mg/m3) NIOSH recommended TWA 10 hour(s)
150 ppm (450 mg/m3) NIOSH recommended STEL

VENTILATION: Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Provide local exhaust ventilation system. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: Wear appropriate chemical resistant gloves.

RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.
1600 ppm
Any supplied-air respirator operated in a continuous-flow mode.
Any powered, air-purifying respirator with organic vapor cartridge(s).
Any air-purifying respirator with a full facepiece and an organic vapor canister.
Any air-purifying full-facepiece respirator (gas mask) with a chin-style, front-mounted or back-mounted organic vapor canister.
Any self-contained breathing apparatus with a full facepiece.
Any supplied-air respirator with a full facepiece.
Emergency or planned entry into unknown concentrations or IDLH conditions -
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
Any supplied-air respirator with a full facepiece that is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
Escape -
Any air-purifying full-facepiece respirator (gas mask) with a chin-style, front-mounted or back-mounted organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: liquid
COLOR: colorless
CHANGE IN APPEARANCE: hygroscopic
PHYSICAL FORM: crystals, liquid
ODOR: pungent odor
MOLECULAR WEIGHT: 74.12
MOLECULAR FORMULA: (C-H3)3-C-O-H
BOILING POINT: 180 F (82 C)
MELTING POINT: 79 F (26 C)
VAPOR PRESSURE: 31 mmHg @ 20 C
VAPOR DENSITY (air=1): 2.6
SPECIFIC GRAVITY (water=1): 0.7887
WATER SOLUBILITY: soluble
PH: Not available
VOLATILITY: Not available
ODOR THRESHOLD: 73 ppm

EVAPORATION RATE: 1.05 (butyl acetate=1)
VISCOSITY: 3.3 cP @ 30 C
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not available
SOLVENT SOLUBILITY:
Soluble: alcohol, ether, acetone, benzene

10. STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressure.

CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat.

INCOMPATIBILITIES: metals, acids, oxidizing materials, combustible materials, metal salts

HAZARDOUS DECOMPOSITION:
Thermal decomposition products: oxides of carbon

POLYMERIZATION: Will not polymerize.

11. TOXICOLOGICAL INFORMATION

TERT-BUTANOL:
IRRITATION DATA: 500 ul/24 hour(s) skin-rabbit mild; 100 ul/24 hour(s) eyes-rabbit severe
TOXICITY DATA: >10000 ppm/4 hour(s) inhalation-rat LC50; >2 gm/kg skin-rabbit LD50; 2743 mg/kg oral-rat LD50
CARCINOGEN STATUS: ACGIH: A4 -Not Classifiable as a Human Carcinogen
LOCAL EFFECTS:
Irritant: inhalation, eye
ACUTE TOXICITY LEVEL:
Moderately Toxic: ingestion
TARGET ORGANS: central nervous system
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: kidney disorders, liver disorders, respiratory disorders, skin disorders and allergies
TUMORIGENIC DATA: Available.
MUTAGENIC DATA: Available.
REPRODUCTIVE EFFECTS DATA: Available.
ADDITIONAL DATA: Alcohol may enhance the toxic effects.

12. ECOLOGICAL INFORMATION

ECOTOXICITY DATA:
FISH TOXICITY: 6410000 ug/L 96 hour(s) LC50 (Mortality) Fathead minnow (Pimephales promelas)

INVERTEBRATE TOXICITY: 5504000 ug/L 48 hour(s) EC50 (Immobilization) Water flea (Daphnia magna)

OTHER TOXICITY: 2450000 ug/L 48 hour(s) LC50 (Mortality) Clawed toad (Xenopus laevis)

13. DISPOSAL CONSIDERATIONS

Dispose in accordance with all applicable regulations. Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): D001.

14. TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101:
PROPER SHIPPING NAME: Butanols
ID NUMBER: UN1120
HAZARD CLASS OR DIVISION: 3
PACKING GROUP: II
LABELING REQUIREMENTS: 3

CANADIAN TRANSPORTATION OF DANGEROUS GOODS:
SHIPPING NAME: Butanols
UN NUMBER: UN1120
CLASS: 3
PACKING GROUP/CATEGORY: II

15. REGULATORY INFORMATION

U.S. REGULATIONS:
CERCLA SECTIONS 102a/103 HAZARDOUS SUBSTANCES (40 CFR 302.4): Not regulated.

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355 Subpart B): Not regulated.

SARA TITLE III SECTION 304 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355 Subpart C): Not regulated.

SARA TITLE III SARA SECTIONS 311/312 HAZARDOUS CATEGORIES (40 CFR 370 Subparts B and C):
ACUTE: Yes
CHRONIC: No
FIRE: Yes
REACTIVE: No

SUDDEN RELEASE: No

SARA TITLE III SECTION 313 (40 CFR 372.65):
TERT-BUTYL ALCOHOL

OSHA PROCESS SAFETY (29 CFR 1910.119): Not regulated.

STATE REGULATIONS:
California Proposition 65: Not regulated.

CANADIAN REGULATIONS:
WHMIS CLASSIFICATION: Not determined.

NATIONAL INVENTORY STATUS:
U.S. INVENTORY (TSCA): Listed on inventory.

TSCA 12(b) EXPORT NOTIFICATION: Not listed.

CANADA INVENTORY (DSL/NDSL): Not determined.

16. OTHER INFORMATION

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Material Safety Data Sheet

Form: 210

Issue Date: 08/06/01
Supersedes: New
MSDS Number: Z02698

Zeon Chemicals L. P.

Section 1 - PRODUCT AND COMPANY IDENTIFICATION

Distributor / Importer:
Zeon Chemicals L.P.
4111 Bells Lane
Louisville, Kentucky 40211

Telephone Number:
1-800-735-3388
(502)-775-2000

Chemical Name:
1, 1, 2, 2, 3, 3, 4-Heptafluorocyclopentane
$C_5H_3F_7$

Emergency Telephone Number:
1-800-776-2460 Ext 7650
(502) 774-8126

Uses:
Solvent; Cleaning and Drying Agent

This MSDS applies to the following product(s):

Zeorora H

Section 2 - COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous Ingredients	CAS #	Amount	Exposure Limits	
			PEL	ACGIH BEI
			Manufacturer's Recommendation (see Section 11)	Inorganic Urinary Fluoride
1, 1, 2, 2, 3, 3, 4-Heptafluorocyclopentane	15290-77-4	>97 %	123 ppm TWA 500 ppm Ceiling	3[1] mg/g creatinine 10[2] mg/g creatinine [1] Prior to shift [2] End of shift

Other Ingredients	CAS #	Amount	Notes
			TWA = Time Weighted Average TLV = Threshold Limit Value AL = Action Level RD = Respirable Dust TD = Total Dust STEL = Short Term Exposure Limit Skin = Skin contact may be a significant route of exposure A2 = ACGIH Suspected Human Carcinogen A3 = ACGIH Animal Carcinogen A4 = ACGIH Not Classifiable as a Human Carcinogen PNOC = Particulates Not Otherwise Classified

Section 3 - HAZARDS IDENTIFICATION

Emergency Overview:	This material is a colorless non-flammable liquid with a slight distinctive odor. Harmful if inhaled or absorbed through skin. May produce vapors or mists that can cause eye, skin, and respiratory tract irritation. Prolonged or repeated exposure to vapors may cause headache, dizziness, and drowsiness. Toxic combustion products may be released under fire conditions.

Potential Health Effects From Overexposure: Possible routes of entry include skin & eye contact and process vapor or mist inhalation.

Contact with liquid, vapors, or mists may cause irritation to the eyes, nose, throat, skin, and respiratory tract. Processing under conditions of inadequate ventilation may produce symptoms of nausea, dizziness, or headaches. Exposure to vapors or mists may cause shortness of breath, lethargy, narcosis, unconsciousness, and possible cardiac arrhythmias. Prolonged or repeated exposure maybe toxic if inhaled or absorbed through the skin. Prolonged or repeated inhalation of vapors may cause lung, liver, heart, kidney, and reproductive effects based on animal data. See Section 11.

Appropriate precautions should be taken to minimize potential exposure to accidental ingestion, inhalation of process vapors or mists, and skin contact.

It may be possible under certain processing and handling conditions, e.g. processes that create vapors or mists to release this product in airborne concentrations in excess of the recommended exposure limits or guidelines. Customers and processors should do sufficient in-house industrial hygiene monitoring to assure compliance of their operations. In addition, customers and processors should confirm that the ACGIH Biological Exposure Index for fluoride is not exceeded in workers using this product.

Overexposure to decomposition or combustion products may cause irritation of the eyes, skin, and respiratory tract. Symptoms such as coughing, tearing, and irritation should be regarded as potentially hazardous and measures taken to avoid exposure. See Section 10 for information on combustion products.

Section 4 - FIRST AID MEASURES

If irritation occurs or persists from any route of exposure, remove the affected individual from the area and seek medical assistance.

Eye Contact: Flush eyes with running water for several minutes while holding eyelids open. Consult a physician if irritation persists.

Skin Contact: Remove contaminated clothing. Wash contact area with soap and water for 15 minutes. Seek medical attention if irritation / allergic skin reaction develops.

Vapor Inhalation: Remove the affected individual to fresh air. If breathing has stopped, administer artificial respiration and seek medical assistance immediately.

Section 5 - FIRE FIGHTING MEASURES

Extinguishing Media: Carbon dioxide or dry chemical is recommended for small fires. For large fires use aqueous foam or water spray.

Special Firefighting Procedures: Wear positive pressure self-contained breathing apparatus (SCBA) during the attack phase of firefighting operations and during cleanup in enclosed or poorly ventilated areas immediately after a fire. Personnel not having suitable respiratory protection must leave the area to prevent significant exposure to toxic combustion gases from any source.

Unusual Fire and Explosion Hazards: This product showed no sign of flammability, pyrophoric activity, autoignition, or explosive properties in laboratory tests. No flash point was observed below the boiling point (180.5^{o} F or 82.5^{o} C). At the

boiling point, the vapor burned when exposed to flame. Closed containers may rupture due to pressure buildup under fire conditions. Toxic gases may be formed upon combustion and represents a hazard to firefighters. See Section 10 for additional information on combustion products.

Section 6 - ACCIDENTAL RELEASE MEASURES

Wear respiratory protection and appropriate protective equipment to prevent skin and eye contact. Contain spill, ventilate area, and recover as much as possible for disposal. Absorb remaining residue with inert material and place into closed containers to await disposal. Wash spill area with soap and water. Do not allow product to enter municipal sewers or waterways.

Section 7 - HANDLING AND STORAGE

Use only with adequate ventilation. Avoid inhalation of vapors or mists. Avoid contact with eyes, skin, and clothing. Store in a well ventilated location. Keep container closed when not in use.

Section 8 - EXPOSURE CONTROLS/PERSONAL PROTECTION

Ventilation: Control airborne concentrations below the recommended exposure limits. Use only with adequate ventilation. Mechanical ventilation is recommended. Provide local exhaust ventilation to minimize exposure to vapors. Elevated exposure may exist in areas with poor ventilation. Operate the ventilation fan during all cleaning, drying , and maintenance operations. Circulate coolant in the cooling coils located at the top of the cleaning / drying tanks to minimize potential exposure.

Respiratory Protection: For protection against process vapors or mists, wear a NIOSH approved respirator suitable for the anticipated airborne concentration. Wear a positive pressure air-supplied respirator in situations where there may be potential for elevated airborne exposure. Wear respiratory protection during cleaning / drying tank loading and discharging operations.

Protective Equipment: During processing operations, safety goggles or safety glasses with face shield suitable for keeping liquid material out of the eyes should be worn when eye contact is anticipated. Rubber gloves and apron should be worn when skin contact is anticipated. Provide an eye wash facility and safety shower.

Respiratory protection and other personal protective equipment are strongly recommended during handling and use of this product and during maintenance operations.

Section 9 - PHYSICAL AND CHEMICAL PROPERTIES

Specific Gravity (H_2O=1): 1.58
Solubility in Water: Slight
% Volatile by Weight: 100
Flash Point: None detected below BP
Boiling Point: 180.5^{o}F (82.5^{o}C)
Vapor Density: Heavier than air
Vapor Pressure: 2590 Pa @ 23°C

Appearance and Odor: Colorless liquid with a slight distinctive odor.

Section 10 - STABILITY AND REACTIVITY

Stability: Stable
Hazardous Polymerization: Will not occur

Conditions to Avoid: Overheating, open flames.

Materials to Avoid: Alkali or alkaline earth metals e.g. powdered Al, Zn, Be, etc..

Hazardous Decomposition Products: Fumes produced when heated to decomposition temperatures may contain hydrofluoric acid and carbonyl fluoride. Combustion products must be considered toxic.

Section 11 - TOXICOLOGICAL INFORMATION

Acute oral LD_{50} (rat):	>2 g/kg
Acute inhalation LC_{50} (rat) 4 hr:	14,213 ppm
Acute dermal LD_{50} (rat):	>2 g/kg
Acute eye irritation (rabbit):	Reversible irritation of the conjunctiva; no effect on the cornea or iris
Acute skin irritation (rabbit):	Not irritating
Guinea pig skin sensitization:	None detected
Rat repeated-dose oral toxicity:	No effect even at highest dose tested (1000 mg/kg/day for 28 days)
Rat repeated-dose inhalation	Effects on hematology, serum electrolyte, urinary fluoride, kidney weight (with no histopathologic changes, and incisor teeth at 1054 ppm or more, 6 hr/day, 5 days/week for 90 days.
Rat inhalation teratology study:	Minor effects to fetus (delayed ossification and skeletal anomalies) at 3449 ppm, 6 hr/day for 14 days.
Dog cardiac sensitization study:	Sensitization seen at 0.1% in air or more. EC_{50} calculated as 0.24%; NOEL 0.05% (500 ppm).
Genotoxicity studies:	Not mutagenic in Ames assay. No chromosome aberrations seen in an *in vivo* micronucleus assay. No indication of a genotoxic risk to humans.

Section 12 - ECOLOGICAL INFORMATION

Biodegradation:	Not readily biodegraded by activated sludge
96-Hour LC_{50} (rainbow trout):	74.2 mg/L
Daphnia acute toxicity:	Immobility 85% at 90.9 mg/L; no effect at 32.4 mg/L (48 hr.)
Algal inhibition:	72-hour EC_{50} > 47.3 mg/L; no effect at 24.9 mg/L

Section 13 - DISPOSAL CONSIDERATIONS

Waste resulting from this product as supplied is not known to be classified as a hazardous waste per the current listings and characteristics contained in 40 CFR Part 261, and its Appendices. It is the generator's responsibility to determine, per the regulation, the applicability of the Resource Conservation and Recovery Act (RCRA), as well as all state, local, or other governmental agency waste disposal regulations, to the particular waste materials prior to treatment or disposal. Disposal of liquid wastes and solids containing free liquids by land filling is prohibited in most jurisdictions. Incinerate or use biological treatment in accordance with federal, state, and local regulations.

Section 14 - TRANSPORTATION INFORMATION

For domestic transportation purposes, this product is not defined or designated as a hazardous material by the U.S. Department of Transportation under Title 49 of the Code of Federal Regulations.

DOT Hazard Class	Not Regulated	UN/NA Hazard No.	Not Applicable
DOT Proper Shipping Name	Not Applicable	Reportable Quantity	Not Applicable
DOT Label	Not Applicable		

Section 15 - REGULATORY INFORMATION

TSCA Inventory Status: This product is listed on the U.S. EPA Toxic Substances Control Act Inventory.

TSCA SNUR: EPA intends to issue a Significant New Use Rule (SNUR) under Section 5(a)(2) of TSCA at some future date for this product. The use of 1, 1, 2, 2, 3, 3, 4-Heptafluorocyclopentane will be limited to solvent for fluoropolymer coating and cleaning / drying applications. Manufacture of the chemical for commerical purposes in the US will not be permitted. The product will be restricted to importation only.

TSCA 12(b) Export Notification Status: This product does not contain any components subject to export notification requirements.

SARA 313 Status: This product does not contain any components exceeding the *de minimis* amount subject to reporting under Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and of 40 CFR 372.

Additional Right-to-Know Information on Components:

Component	CAS #	Key (See below)	
1, 1, 2, 2, 3, 3, 4-Heptafluorocyclopentane	15290-77-4	7, 13	*

Key	Description	Key	Description
1.	Reserved	8.	MA Extraordinary Hazardous Substance above 1 ppm
2.	CA Listed Carcinogen	9.	MA Toxic or Hazardous Substance above 1%
3.	CA Listed Reproductive Toxin	10.	NJ Hazardous Substance above 1%
4.	PA Special Hazardous Substance above 0.01%	11.	NJ Special Health Hazard Substance above 0.1%
5.	PA Hazardous Substance above 1%	12.	NJ Environmental Hazardous Substance above 1%
6.	PA Non-Hazardous Substance above 3%	13.	NJ Non-Hazardous Substance above 1%
7.	PA Non-Hazardous Substance above 5%	14.	Canadian WHMIS Ingredient Disclosure List Substance

Section 16 - ADDITIONAL INFORMATION

Hazard Rating System Classifications:

	NFPA	**HMIS**	Key: 0=least; 1=slight; 2=moderate; 3=high; 4=extreme
Health	2	2	National Fire Protection Association rating identifies hazards during a fire emergency.
Flammability	1	1	Hazardous Materials Identification System rating applies to products as packaged.
Reactivity	0	0	

Reason for (Re)issue: New

User's Responsibility

This bulletin cannot cover all possible situations which the user may experience during processing. Each aspect of your operation must be examined to determine if, or where, additional precautions may be necessary. All health and safety information contained in this bulletin must be provided to your employees or customers. It is your responsibility to use this information to develop appropriate work practice guidelines and employee instructional programs for your operation.

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Parachlorobenzotrifluoride
PCBTF - by Special Materials Company

PCBTF MSDS

Contact us for updated Parachlorobenzotrifluoride MSDS.

SECTION 1 - PRODUCT AND COMPANY IDENTIFICATION

MSDS Number: M900 **Effective Date:** 3/04/2010 **Supersedes:** 11/7/2007

Product Name: Parachlorobenzotrifluoride
Product Code: SMC Spec. 900

Company Identification: Special Materials Company
70 West 40th Street
New York, New York 10018

Phone: (646) 366-0400

Fax: (646) 366-0595

CHEMTREC (emergency): 800-424-9300 **Outside USA**: (703) 527-3887

SECTION 2 – HAZARDS IDENTIFICATION

Emergency Overview

Clear colorless liquid, contact with eyes, skin and respiratory system may cause irritation. PCBTF exhibits a flash point of 109° F (42.8° C), however, this product is a non-regulated material under the DOT Hazardous Material Regulations and the IMDG Code because it does not sustain combustion. (49CFR 173.120(a); IMDG 2.3.1.3) Hazard Symbol: Xi. Risk Phrases - R36/37/38

Potential Health Effects

Inhalation: May produce symptoms of central nervous system depression, including headache, dizziness, nausea, loss of balance, and drowsiness.

Skin: Contact with skin may cause irritation, dermatitis.

Eye: Contact with eyes may cause pain and irritation.

Ingestion: May be irritating to digestive tract; may cause gastric distress, stomach pains.

Carcinogenicity: **NTP?** No **IARC MONOGRAPHS?** No **OSHA REGULATED?** No

SECTION 3 – COMPOSITION / INFORMATION ON INGREDIENTS

CAS#	Chemical Name	OSHA PEL		ACGIH TWA		SMC CEL		% Contained	EINECS/ELINCS
		PPM	MG/M^3	PPM	MG/M^3	PPM	MG/M^3		
98-56-6	p-Chlorobenzotrifluoride	NA	NA	NA	NA	25	185	99 -100	202-681-1

SECTION 4 – FIRST AID MEASURES

Inhalation: Remove affected person to fresh air; if symptoms persist seek medical attention.

Skin: Remove contaminated clothing; wash affected area with soap and water; launder contaminated clothing before reuse; if irritation persists, seek medical attention.

Eye: Check for and remove contact lenses. Flush eyes with water for 15 minutes; if irritation persists, seek medical attention.

Ingestion: Give two glasses of water for dilution; DO NOT induce vomiting; never give anything by mouth to an unconscious person; seek medical attention.

SECTION 5 – FIRE FIGHTING MEASURES

Flash Point (Method used): 109º F (42.8º C) TCC

Flammable Limits: **LEL:** 0.9%

UEL: 10.5%

Autoignition Temperature: > 932º F (>500º C)

NFPA Class: II

General Hazards:

PCBTF exhibits a flash point of 109° F (42.8° C), however, this product is a non-regulated material under the DOT Hazardous Material Regulations and the IMDG Code because it does not sustain combustion. Products of combustion include compounds of carbon, chlorine, fluorine, hydrogen and oxygen, including carbon monoxide. Toxic gases will form upon combustion.

Extinguishing Media: Carbon dioxide, water, water fog, dry chemical, chemical foam.

Fire Fighting Procedure: Self - contained respiratory equipment; cool containers to prevent pressure buildup and possible explosion when exposed to extreme heat. Caution - material will produce a flash before self extinguishing!

Unusual Fire / Explosion Hazards: Closed containers can explode due to buildup of pressure when exposed to extreme heat.

Hazardous Combustion Products: Smoke, fumes or vapors, oxides of carbon, chlorine, fluorine.

SECTION 6 – ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Contain liquids and prevent discharges to streams or sewers, control or stop the loss of volatile materials to the atmosphere. Large leaks may require environmental consideration and possible evacuation. Do not apply water to the leak. Spills or releases should be reported, if required, to the appropriate local, state, and federal agencies. If a significant spill occurs, evacuate area. If exposure conditions warrant, wear a NIOSH/MSHA-approved positive pressure self-contained breathing apparatus and full protective clothing. Shut off electrical service and protect from ignition. Contain spill or release with a dike to prevent flow into sewers or streams. Pump into container for disposal or reclamation. Soak up small spills with absorbent material.

SECTION 7 – HANDLING AND STORAGE

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Keep container closed when not in use; protect containers from abuse; protect from extreme temperatures. Keep this and other chemicals out of reach of children.

SECTION 8 – EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering Controls: The use of local exhaust ventilation is recommended. No other special controls are indicated.

Personal Protection

Respiratory Protection: For unknown concentrations or emergency situations a NIOSH approved respirator must be worn. Refer to 29 CFR 1910.134 or European Standard EN 149 for complete regulations.

Protective Gloves: North Silver Shield® or Viton® Gloves are recommended. Nitrile or PVC gloves can be used for short periods of time.

Eye Protection: Chemical safety goggles. Refer to 29 CFR 1910.133 or European Standard EN166.

Other Protective Clothing Or Equipment: Coveralls, apron, or other equipment should be worn to minimize skin contact, safety eyewash station nearby.

Work / Hygienic Practices: Practice safe workplace habits. Minimize body contact with this, as well as all chemicals in general.

SECTION 9 – PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor:	Clear Colorless Liquid, Naphthalenic odor
Boiling Point:	282º F (139º C)
Freezing Point:	- 36º F (- 33º C)
Vapor Pressure (MM Hg):	5.3 mm Hg @ 20º C
Vapor Density (Air=1):	6.2
Specific Gravity:	1.34
Evaporation Rate (n-Butyl Acetate= 1):	0.9
Solubility In Water:	Slight (29 ppm @ 23º C)
pH:	Not determined
Physical State:	Liquid
Viscosity:	Not Specified
Volatile Organic Compounds (Total VOC's):	Negligible

SECTION 10 – STABILITY AND REACTIVITY

Stability:	Stable
Conditions to Avoid:	Extreme temperatures.
Incompatibility (Materials to Avoid):	Strong oxidizers, strong acids
Hazardous Decomposition:	Decomposition will not occur if handled and stored properly. In case of a fire, oxides of carbon, hydrocarbons, chlorine, fluorine, fumes or vapors, and smoke may be produced.
Hazardous Polymerization:	Will not occur.
Conditions to Avoid:	None.

SECTION 11 – TOXICOLOGICAL INFORMATION

Hazardous Ingredients	CAS #	EINECS #	LD_{50} of Ingredient (Specify Species and Route)	LD_{50} of Ingredient (Specify Species)
p-chlorobenzotrifluoride	**98-56-6**	202-681-1	6,800 mg / kg Oral - rat	20,000 mg / m3 Inhalation - mouse

SECTION 12 – ECOLOGICAL INFORMATION

No data are available on the adverse effects of this material on the environment. Neither COD nor BOD data are available. Based on the chemical composition of this product it is assumed that the mixture can be treated in an acclimatized biological waste treatment plant system in limited quantities. However, such treatment should be evaluated and approved for each specific biological system. None of the ingredients in this mixture are classified as a Marine Pollutant. Volatility, and relative environmental partitioning characteristics, makes it unlikely that PCBTF represents a significant threat to aquatic or terrestrial environments.

SECTION 13 – DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD: Dispose of in accordance with Local, State, and Federal Regulations; this product is toxic to fish, do not discharge into lakes, ponds, streams or public waters. Product is classified as non - hazardous, however, non-hazardous materials may become hazardous waste upon contact with other products. Refer to "40 CFR Protection of Environment Parts 260 - 299" for complete waste disposal regulations. Consult your local, state, or Federal Environmental Protection Agency before disposing of any chemicals.

SECTION 14 – TRANSPORT INFORMATION

Contact SMC for more information.

SECTION 15 – REGULATORY INFORMATION

TSCA Toxic Substance Control Act)

All components of this product are listed on the U.S. Toxic Substances Control Act Chemical Inventory (TSCA Inventory) or are exempted from listing because a Low Volume Exemption has been granted in accordance with 40 CFR 723.50.

SARA Title III (311,312)

311/312 Hazard Categories.

Immediate Health.

313 reportable Ingredients: None

CERCLA Hazardous Substance

None

California Prop 65, Safe Drinking Water and Toxic Enforcement Act of 1986

There are no chemicals present known to the state of California to cause cancer or reproductive toxicity.

CPR (Canadian Controlled Products Regulations)

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations. WHMIS Classification: Not controlled.

IDL (Canadian Ingredient Disclosure List)

Components of this product identified by CAS number and listed on the Canadian Ingredient Disclosure List are shown in Section 2.

DSL / NDSL (Canadian Domestic Substances List / Non-Domestic Substances List)

Components of this product identified by CAS number are listed on the DSL or NDSL, or are otherwise in compliance with the New Substances Notification (NSN) regulations. Only ingredients classified as "hazardous" are listed in Section 2 unless otherwise indicated.

EINECS (European Inventory of Existing Commercial Chemical Substances)

Components of this product identified by CAS numbers are on the European Inventory of Existing Commercial Chemical Substances.

EC Risk Phrases	Symbol (s) Required For Label	EC Safety Phrases
R10 Flammable	Irritating	

R36/37/38 irritating to eyes, respiratory system and skin		S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S36 Wear suitable protective clothing

SECTION 16 – OTHER INFORMATION

Specific toxicity tests have not been conducted on this product. Our hazard evaluation is based on Information from similar products, the ingredients, technical literature, and/or professional experience.

HMIS HAZARD RATINGS	Health	1	*= Chronic Health Hazard	2= Moderate
	Flammability	2	0= Insignificant	3= High
	Physical Hazard	0	1= Slight	4= Extreme
	Personal Protective Equipment	C	Safety Glasses, Gloves, Apron	

Revision Summary;

Section 1 – Remove Pharmaceutical Grade, SMC Address Change

Section 3 – PEL, TWA and CEL Update

Section 5 - NFPA Class Update

Section 8 – Gloves Update

Section 11 – Update Toxicology per NTP Profile June 2009

MSDS Prepared by:

Special Materials Company

70 West 40th Street

New York, New York 10018

Tel.: 646-366-0400

www.smc-global.com

The information contained herein is believed to be accurate but is not warranted to be so. Data and calculations are based on information furnished by the manufacturer of the product and manufacturers of the components of the product. Users are advised to confirm in advance of need that information is current, applicable and suited to the circumstances of use. Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Furthermore, vendor assumes no responsibility for injury caused by abnormal use of this material even if reasonable safety procedures are followed. Any questions regarding this product should be directed to the manufacturer of the product as described in Section 1.

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SAFETY DATA SHEET

Ethyl-(S)-Lactate

REVISION DATE 04/08/05
REF. SD0310/2005-01

1. IDENTIFICATION OF THE SUBSTANCE / PREPARATION AND THE COMPANY / UNDERTAKING

Product name	PURASOLV® EL, PURASOLV® ELECT	
Use of the Substance	Solvent, Flavour, Specialty chemical	
Supplier	PURAC biochem Arkelsedijk 46 NL-4206 AC Gorinchem The Netherlands	PURAC bioquimica Gran Vial 19 -25 08160 Montmelo-Barcelona Spain
Telephone	++31 183 695695	++34 93 568 6300
Fax	++31 183 695604	++34 93 568 3955
Emergency telephone	++31 183 695695	++34 93 568 6300 (Ext 222)

2. COMPOSITION / INFORMATION ON INGREDIENTS

Chemical name of the substance Ethyl (S)-2-Hydroxy Propanoate

Synonyms Lactic Acid Ethyl Ester, Ethyl-L-Lactate

Components	**CAS-No.**	**EC-No.**	**RTECS-No.**	**Weight, %**
	687-47-8	211-694-1	0D5075000	100

 # Hazard classification
R10, R37, R41. For details see chapter 15**.**

3. HAZARDS IDENTIFICATION

Most important hazards Risk of serious damage to eyes. Irritating to eyes. Combustible liquid.

Specific hazards May degrease the skin. Effects of skin contacts may include erythema.

4. FIRST AID MEASURES

General advice Show this safety data sheet to the doctor in attendance.

Inhalation Move to fresh air.
Skin contact Wash off immediately with plenty of water.
Eye contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes.
Ingestion Induce vomiting if person is conscious. Consult a physician.

Major effects of exposure Inhalation of vapors is irritating to the respiratory system, and may cause coughing. Irritating to eyes. May degrease the skin.
Protection of firstaiders Wear tightly fitting safety goggles.

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For further information:

http://www.purac.com/

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	Water spray, carbon dioxide (CO2), dry powder, AFFF, foam.
Extinguishing media which must not be used for safety reasons	None.
Specific hazards	Thermal decomposition can lead to release of irritating gases and vapors.
Special protective equipment for firefighters	None.
Specific methods	Standard procedure for chemical fires. Cool containers / tanks with water spray.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Remove all sources of ignition. Wear tightly fitting safety goggles.
Environmental precautions	No special environmental precautions required.
Methods for cleaning up	Soak up with inert absorbent material (e.g. sand, silica gel, universal binder, sawdust). Shovel into suitable container for disposal. After cleaning, flush away traces with water.

7. HANDLING AND STORAGE

Handling	
Technical measures/ Precautions	Remove all sources of ignition. Avoid temperatures above 139°F (59°C).
Safe handling advice	Wear tightly fitting safety goggles. Handle in accordance with good industrial hygiene and safety practice.
Storage	
Technical measures/ Storage conditions	Keep container tightly closed. In order to prevent oxidation, the product is supplied under a nitrogen or argon blanket. After opening the packaging, it is recommended to use or store the product under inert conditions (e.g. nitrogen or argon).
Packaging material	High density polyethylene containers.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure	Insure adequate ventilation, especially in confined areas.
Control parameters	None.
Personal protection equipment	
Respiratory protection	In case of insufficient ventilation wear suitable respiratory equipment.
Hand protection	Solvent-resistant gloves (PVA / H4).
Eye protection	Tightly fitting safety goggles.
Skin and body protection	Solvent-resistant apron.
Hygiene measures	When using, do not eat, drink or smoke. Remove and wash contaminated clothing before re-use.

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9. PHYSICAL AND CHEMICAL PROPERTIES

Form	liquid
Color	colorless
Odor	mild, characteristic
Odor Threshold	0.18 ppm
pH	not applicable
Molecular Weight	118.15
Boiling point/range	307°F (153°C)
Melting point/range	26.6°F (-3 °C)
Decomposition temperature	> 307°F (153°C)
Autoignition temperature	752°F (400°C)
Flash point	139°F (59°C) (Tested according to: ISO 2719, closed cup**)**
Explosion limits	- lower: 1.5% @ 212°F (100°C) - upper: 11.4% @ 212°F (100°C)
Density	1.033 g/ml @ 68°F (20°C)
Vapor density	4.07 (Air = 1)
Vapor pressure	2.7 mbar @ 68°F (20°C), 172 mbar @ 212°F (100°C)
Solubility	Water solubility: completely miscible, miscible with most organic solvents Partition coefficient (n-octanol/water) log Pow = 0.06
Viscosity	2.8 mPa.S @ 68°F (20°C)
Surface Tension	30.6 mN/m @ 77°F (25°C)

10. STABILITY AND REACTIVITY

Stability	Stable at normal conditions. Hydrolyses in presence of water, acids, bases.
Conditions to avoid	Avoid temperatures above 139°F (59°C).
Materials to avoid	None.
Hazardous decomposition products	Carbon oxides.

11. TOXICOLOGICAL INFORMATION

Acute toxicity	LD50/oral/mouse = 2500 mg/kg LC50/inhalation/8h/rat > 5400 mg/m^3
Sub acute Toxicity (28 day inhalation)	NOAEL (systemic toxicity) 600mg/m^3, NOAEL (local toxicity) 200 mg/m^3
Local effects	Effects of skin contacts may include erythema. Irritating to eyes. Risk of serious damage to eyes. May cause irritation of the mucous membranes. Inhalation of high vapor concentrations can cause CNS-depression and narcosis.
Specific effects	Based on tests with L-lactic acid and its esters, there is no evidence to suggest carcinogenic nor mutagenic properties from lactic acid itself nor from the lactate portion of its esters. Developmental toxicity in rats: No effect at 3.619 g/kg/day.
Long term toxicity	Repeated or prolonged exposure may cause irritation of eyes and skin.
Further information	Lactate esters are readily hydrolyzed in vivo.

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12. ECOLOGICAL INFORMATION

Mobility	Completely miscible in water.
Persistence / degradability	Readily biodegradable, according to appropriate OECD test. Biochemical oxygen demand (BOD)=1.43 mg O_2/mg Chemical oxygen demand (COD)=1.66 mg O_2/mg.
Bioaccumulation	Unlikely, hydrolyses in presence of: water, acids, bases.
Ecotoxicity	EC50/48h/Daphnia = 683mg/lLC50/48h/Fish = 320 mg/l EC50/Algae = 2200 mg/l

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products	Subject to disposal regulations US EPA 40 CFR 2 62.
Contaminated packaging	Clean container with water. Empty containers should be taken for local recycling, recovery or waste disposal.

14. TRANSPORT INFORMATION

HI/UN No: 30/1192

ADR/RID Class 3 Item 31°(c) ADR/RID-Labels 3
Proper shipping name Ethyl Lactate, 3,31°(c)

IMO Class 3.3 IMDG Page 3343 IMO-Labels Flammable liquid
Packaging group. III EmS. F-E S-D MFAG. 330
Proper shipping name Ethyl Lactate, UN 1192

ICAO Class 3 UN/ID No. 1192 ICAO-Labels Flammable liquid
Packing group III
Proper shipping name Ethyl Lactate, UN 1192

US DOT (see further information below)
UN 1192 Class 3 DOT Labels Flammable liquid
Packaging group. III
Maximum quantity (passenger aircraft): 60 liters Maximum quantity (cargo aircraft): 220 liters

Further information
In the US, PURASOLV EL is a combustible liquid, and not regulated for non bulk shipments (truck). It is regulated for air and rail shipments.

15. REGULATORY INFORMATION

US Regulations	TSCA Inventory Status: Y SARA III: N California Proposition 65:N Carcinogen status: OSHA: N. NTP: N, IARC: N Gras as food flavor, ADI not specified. Massachusetts Substances List: Y Pennsylvania Right to Know List: Y
EU Status	According to National equivalent of EC-Dir. 67/548, as amended, the product is labeled as follows:
Symbol	Xi - Irritant
R-Phrases	R41 - Risk of serious damage to eyes R37 - Irritation to respiratory system R10 - Flammable
S-Phrases	S24 - Avoid contact with skin. S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S39 - Wear eye/face protection.

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16. OTHER INFORMATION

NFPA Ratings (Scale 0-4): 2(health)-2(flammability)-0(reactivity)
HMIS Rating: 1(health)-2(flammability)-0(reactivity)-B (protective equipment)

For further information on the safety assessment of lactic acid esters, see the paper titled: Safety Assessment of Lactate Esters, published in Regulatory Toxicology and Pharmacology, 27, 88-97, 1998.

Additional data on the calculated ecotoxicity of lactic acid and its salts and esters can be obtained in a report entitled 'The ecotoxicity and biodegradability of lactic acid, alkyl lactate esters and lactic acid salts' by Bowmer et al.
(Reference: Chemosphere 37: 1317-1333 (1998)).

This information only concerns the above mentioned product and is not valid if used with other product(s) or in any process. The information is to our best present knowledge correct and complete and is given in good faith but without warranty. It remains the user's own responsibility to make sure that the information is appropriate and complete for his special use of this product.

# Indicates updated section.

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SAFETY DATA SHEET

Ethanol

Section 1. Identification

GHS product identifier : Ethanol

Chemical name : ethanol

Other means of identification : ethyl alcohol; Denatured Alcohol; ALCOHOL; Ethyl alcohol (Ethanol)

Product use : Synthetic/Analytical chemistry.

Synonym : ethyl alcohol; Denatured Alcohol; ALCOHOL; Ethyl alcohol (Ethanol)

SDS # : 001114

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Emergency telephone number (with hours of operation) : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : FLAMMABLE LIQUIDS - Category 2

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Highly flammable liquid and vapor.
May form explosive mixtures with air.

Precautionary statements

General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking. Use explosion-proof electrical, ventilating, lighting and all material-handling equipment. Use only non-sparking tools. Take precautionary measures against static discharge. Keep container tightly closed. Use and store only outdoors or in a well ventilated place.

Response : IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower.

Storage : Store in a well-ventilated place. Keep cool.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : None known.

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Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : ethanol

Other means of identification : ethyl alcohol; Denatured Alcohol; ALCOHOL; Ethyl alcohol (Ethanol)

CAS number/other identifiers

CAS number : 64-17-5

Product code : 001114

Ingredient name	%	CAS number
ethanol	100	64-17-5

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : No known significant effects or critical hazards.

Over-exposure signs/symptoms

Eye contact : No specific data.

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Section 4. First aid measures

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use dry chemical, CO_2, water spray (fog) or foam.

Unsuitable extinguishing media : Do not use water jet.

Specific hazards arising from the chemical : Highly flammable liquid and vapor. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. The vapor/gas is heavier than air and will spread along the ground. Vapors may accumulate in low or confined areas or travel a considerable distance to a source of ignition and flash back. Runoff to sewer may create fire or explosion hazard.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

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Section 6. Accidental release measures

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not ingest. Avoid contact with eyes, skin and clothing. Avoid breathing vapor or mist. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Take precautionary measures against electrostatic discharges. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
ethanol	**ACGIH TLV (United States, 3/2012).** STEL: 1000 ppm 15 minutes. **OSHA PEL 1989 (United States, 3/1989).** TWA: 1000 ppm 8 hours. TWA: 1900 mg/m³ 8 hours. **NIOSH REL (United States, 1/2013).** TWA: 1000 ppm 10 hours. TWA: 1900 mg/m³ 10 hours.

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Section 8. Exposure controls/personal protection

	OSHA PEL (United States, 6/2010). TWA: 1000 ppm 8 hours. TWA: 1900 mg/m³ 8 hours.

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid. [CLEAR, COLORLESS LIQUID WITH A WEAK, ETHEREAL, VINOUS ODOR]

Color : Colorless. Clear.

Molecular weight : 46.08 g/mole

Molecular formula : C2-H6-O

Boiling/condensation point : 78.29°C (172.9°F)

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Section 9. Physical and chemical properties

Melting/freezing point	:	-114°C (-173.2°F)
Critical temperature	:	Not available.
Odor	:	Characteristic.
Odor threshold	:	Not available.
pH	:	Not available.
Flash point	:	Closed cup: 9.7°C (49.5°F)
Burning time	:	Not applicable.
Burning rate	:	Not applicable.
Evaporation rate	:	1.7 (butyl acetate = 1)
Flammability (solid, gas)	:	Not available.
Lower and upper explosive (flammable) limits	:	Lower: 3.3% Upper: 19%
Vapor pressure	:	5.7 kPa (42.948650611 mm Hg) [room temperature]
Vapor density	:	1.6 (Air = 1)
Specific Volume (ft ^{3}/lb)	:	1.2716
Gas Density (lb/ft ^{3})	:	0.7864 (25°C / 77 to °F)
Relative density	:	0.8
Solubility	:	Not available.
Solubility in water	:	1000 g/l
Partition coefficient: n-octanol/water	:	-0.35
Auto-ignition temperature	:	455°C (851°F)
Decomposition temperature	:	Not available.
SADT	:	Not available.
Viscosity	:	Dynamic (room temperature): 0.544 to 0.59 mPa·s (0.544 to 0.59 cP)

Section 10. Stability and reactivity

Reactivity	:	No specific test data related to reactivity available for this product or its ingredients.
Chemical stability	:	The product is stable.
Possibility of hazardous reactions	:	Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid	:	Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Do not allow vapor to accumulate in low or confined areas.
Incompatibility with various substances	:	Highly reactive or incompatible with the following materials: oxidizing materials and alkalis.
Hazardous decomposition products	:	Under normal conditions of storage and use, hazardous decomposition products should not be produced.
Hazardous polymerization	:	Under normal conditions of storage and use, hazardous polymerization will not occur.

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Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Not available.

Irritation/Corrosion

Not available.

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Not available.

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.

Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : No specific data.

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

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Section 11. Toxicological information

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
ethanol	-0.35	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Vapor from product residues may create a highly flammable or explosive atmosphere

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Section 13. Disposal considerations

inside the container. Do not cut, weld or grind used containers unless they have been cleaned thoroughly internally. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1170	UN1170	UN1170	UN1170	UN1170
UN proper shipping name	ETHANOL OR ETHYL ALCOHOL OR ETHANOL SOLUTIONS OR ETHYL ALCOHOL SOLUTIONS	ETHANOL MORE THAN 24 PER CENT ETHANOL, BY VOLUME; ETHANOL SOLUTION MORE THAN 24 PER CENT ETHANOL, BY VOLUME; ETHYL ALCOHOL MORE THAN 24 PER CENT ETHANOL, BY VOLUME; OR ETHYL ALCOHOL SOLUTION MORE THAN 24 PER CENT ETHANOL, BY VOLUME	ETHANOL OR ETHYL ALCOHOL OR ETHANOL SOLUTIONS OR ETHYL ALCOHOL SOLUTIONS	ETHANOL (ETHYL ALCOHOL) OR ETHANOL SOLUTION (ETHYL ALCOHOL SOLUTION)	ETHANOL
Transport hazard class(es)	3	3	3	3	3
Packing group	II	II	II	II	II
Environment	No.	No.	No.	No.	No.
Additional information	**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: 5 L **Cargo aircraft** Quantity limitation: 60 L **Special provisions** 24, IB2, T4, TP1	**Explosive Limit and Limited Quantity Index** 5 **Passenger Carrying Road or Rail Index** 60	-	-	**Passenger and Cargo Aircraft**Quantity limitation: 5 L **Cargo Aircraft Only** Quantity limitation: 60 L **Limited Quantities - Passenger Aircraft** Quantity limitation: 1 L

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

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Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined
United States inventory (TSCA 8b): This material is listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Fire hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
ethanol	100	Yes.	No.	No.	No.	No.

State regulations

Massachusetts : This material is listed.

New York : This material is not listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

Canada inventory : This material is listed or exempted.

International regulations

International lists : **Australia inventory (AICS)**: This material is listed or exempted.
China inventory (IECSC): This material is listed or exempted.
Japan inventory: This material is listed or exempted.
Korea inventory: This material is listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
New Zealand Inventory of Chemicals (NZIoC): This material is listed or exempted.
Philippines inventory (PICCS): This material is listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals : Not listed

Chemical Weapons Convention List Schedule II Chemicals : Not listed

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Section 15. Regulatory information

Chemical Weapons Convention List Schedule III Chemicals : Not listed

Canada

WHMIS (Canada) : Class B-2: Flammable liquid
Class D-2B: Material causing other toxic effects (Toxic).

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

Canada Label requirements : Class B-2: Flammable liquid
Class D-2B: Material causing other toxic effects (Toxic).

Hazardous Material Information System (U.S.A.)

Health	2
Flammability	3
Physical hazards	0

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)

Reprinted with permission from NFPA 704-2001, Identification of the Hazards of Materials for Emergency Response Copyright ©1997, National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association, on the referenced subject which is represented only by the standard in its entirety.

Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

History

Date of printing : 5/18/2015.

Date of issue/Date of revision : 5/18/2015.

Date of previous issue : 10/28/2014.

Version : 0.02

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Section 16. Other information

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United NationsACGIH – American Conference of Governmental Industrial Hygienists
AIHA – American Industrial Hygiene Association
CAS – Chemical Abstract Services
CEPA – Canadian Environmental Protection Act
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (EPA)
CFR – United States Code of Federal Regulations
CPR – Controlled Products Regulations
DSL – Domestic Substances List
GWP – Global Warming Potential
IARC – International Agency for Research on Cancer
ICAO – International Civil Aviation Organisation
Inh – Inhalation
LC – Lethal concentration
LD – Lethal dosage
NDSL – Non-Domestic Substances List
NIOSH – National Institute for Occupational Safety and Health
TDG – Canadian Transportation of Dangerous Goods Act and Regulations
TLV – Threshold Limit Value
TSCA – Toxic Substances Control Act
WEEL – Workplace Environmental Exposure Level
WHMIS – Canadian Workplace Hazardous Material Information System

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

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The MSDS format adheres to the standards and regulatory requirements of the United States and may not meet regulatory requirements in other countries.

"VERTREL" XF
6044FR Revised 29-SEP-2008

CHEMICAL PRODUCT/COMPANY IDENTIFICATION

Material Identification

"Vertrel" is a registered trademark of DuPont.

Corporate MSDS Number : DU008057
CAS Number : 138495-42-8
Formula : CF3CHFCHFCF2CF3
Molecular Weight : 252
CAS Name : Pentane, 1,1,1,2,2,3,4,5,5,5-decafluoro

Tradenames and Synonyms

1,1,1,2,2,3,4,5,5,5-Decafluoropentane
1,1,1,2,3,4,4,5,5,5-Decafluoropentane
2,3-Dihydroperfluoropentane
HFC-43-10mee
43-10mee

Company Identification

MANUFACTURER/DISTRIBUTOR
DuPont Fluoroproducts
1007 Market Street
Wilmington, DE 19898

PHONE NUMBERS
Product Information : 1-800-441-7515 (outside the U.S. 302-774-1000)
Transport Emergency : CHEMTREC 1-800-424-9300(outside U.S. 703-527-3887)
Medical Emergency : 1-800-441-3637 (outside the U.S. 302-774-1000)

COMPOSITION/INFORMATION ON INGREDIENTS

Components

Material	CAS Number	%
Pentane, 1,1,1,2,2,3,4,5,5,5-decafluoro-	138495-42-8	99

HAZARDS IDENTIFICATION

Potential Health Effects

Gross overexposure by inhalation to HFC-43-10mee may cause suffocation if air is displaced by vapors and central nervous system stimulation with increased activity or sleeplessness, tremors or convulsions. These effects may be followed by central nervous system depression with dizziness, confusion, incoordination, drowsiness or unconsciousness. Based on data from other fluorocarbons, gross overexposure may be associated with irregular heartbeat or heart rhythm, which may produce heart palpitation, dizziness, weakness, unconsciousness and death. It is unlikely that concentrations sufficient to produce irregular heartbeat or heart rhythm would be achieved from HFC-43-10MEE without first producing other signs of toxicity. Immediate effects of overexposure to HFC-43-10mee by skin contact may include slight irritation with itching, redness or swelling. Repeated and/or prolonged exposure may cause defatting of the skin with itching, redness or rash. Based on animal data, significant skin permeation, and systemic toxicity after skin contact, appears unlikely. Immediate effects of overexposure to HFC-43-10mee by eye contact may include eye irritation with tearing, pain or blurred vision. The major ingestion hazard of HFC-43-10mee is aspiration (liquid entering the lungs during ingestion or vomiting) which may result in "chemical pneumonia." Symptoms include coughing, gasping, choking, shortness of breath, bluish discoloration of the skin, rapid breathing and heart rate, and fever. Pulmonary edema or bleeding, drowsiness, confusion, coma and seizures may occur in more serious cases. Symptoms may develop immediately or as late as 24 hours after exposure, depending on how much chemical entered the lungs. Increased susceptibility to the effects of HFC-43-10mee may be observed in persons with pre-existing disease of the central nervous system or the cardiovascular system.

Carcinogenicity Information

None of the components present in this material at concentrations equal to or greater than 0.1% are listed by IARC, NTP, OSHA or ACGIH as a carcinogen.

FIRST AID MEASURES

First Aid

INHALATION

If inhaled, immediately remove to fresh air. Keep person calm. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

(FIRST AID MEASURES - Continued)

SKIN CONTACT

Flush skin with water after contact. Wash contaminated clothing before reuse.

EYE CONTACT

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

INGESTION

Material poses an aspiration hazard. If swallowed, do not induce vomiting. Immediately give 2 glasses of water. Never give anything by mouth to an unconscious person. Call a physician.

If vomiting occurs naturally, have victim lean forward to reduce the risk of aspiration.

Notes to Physicians

THIS MATERIAL MAY MAKE THE HEART MORE SUSCEPTIBLE TO ARRHYTHMIAS. Catecholamines such as adrenaline, and other compounds having similar effects, should be reserved for emergencies and then used only with special caution.

FIRE FIGHTING MEASURES

Flammable Properties

Flammable Limits in Air, % by volume
LEL : None
UEL : None

Flash Point : None
Method : Tag Closed Cup (ASTM D 56)

Flash Point : None
Method : Tag Open Cup (ASTM D 1310)

Fire and Explosion Hazards:

Use water spray or fog to cool containers. Drums may rupture under fire conditions. Decomposition may occur.

Extinguishing Media

Use media appropriate for surrounding material.

(FIRE FIGHTING MEASURES - Continued)

Fire Fighting Instructions

Self-contained breathing apparatus (SCBA) is required if drums rupture and contents are spilled under fire conditions.

ACCIDENTAL RELEASE MEASURES

Safeguards (Personnel)

NOTE: Review FIRE FIGHTING MEASURES and HANDLING (PERSONNEL) sections before proceeding with clean-up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean-up.

Evacuate personnel, thoroughly ventilate area, use self-contained breathing apparatus.

Initial Containment

Dike spill. Prevent material from entering sewers, waterways, or low areas.

Spill Clean Up

Immediately evacuate the area and provide maximum ventilation, especially in low places where heavy vapors might collect. Unprotected personnel should move upwind of spill. Only personnel equipped with proper respiratory and skin/eye protection should be permitted in area. Soak up with sawdust, sand, oil dry or other absorbent material. After all visible traces, including ignitable vapors, have been removed, thoroughly wet vacuum the area. Do not flush to sewer. If area of spill is porous, remove as much contaminated earth and gravel, etc. as necessary and place in closed containers for disposal.

HANDLING AND STORAGE

Handling (Personnel)

Avoid breathing vapors or mist. Avoid contact with eyes, skin, or clothing. Wash thoroughly after handling.

The use of gloves is recommended when working with the material containers. Material should not be dispensed from its container by pouring, except for small sample containers where fume hoods or where other ventilation is used to manage the exposure limits. The use of a drum pump is recommended for dispensing from shipping containers.

(HANDLING AND STORAGE - Continued)

Storage

Store in clean, dry area. Do not allow stored product to exceed 52 C(125 F) to prevent leakage or potential rupture of container from pressure and expansion. Protect from freezing temperatures. If solvent is stored below -10 C (14 F), mix prior to use.

EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls

Normal ventilation for standard manufacturing procedures is generally adequate. Local exhaust should be used when large amounts are released. Mechanical ventilation should be used in low or enclosed places.

Personal Protective Equipment

EYE/FACE PROTECTION:

Wear safety glasses or coverall chemical splash goggles.

RESPIRATORS:

Wear NIOSH approved respiratory protection, as appropriate. Self-contained breathing apparatus (SCBA) is required if large release occurs.

PROTECTIVE CLOTHING:

Where there is potential for skin contact have available and wear as appropriate impervious gloves, apron, pants, and jacket.

Protective gloves and chemical splash goggles should be used when handling liquid.

Exposure Guidelines

Exposure Limits
"VERTREL" XF

PEL	(OSHA)	: None Established
TLV	(ACGIH)	: None Established
AEL *	(DuPont)	: 200 ppm, 8 & 12 Hr. TWA 400 ppm, Ceiling

* AEL is DuPont’s Acceptable Exposure Limit. Where governmentally imposed occupational exposure limits which are lower than the AEL are in effect, such limits shall take precedence.

PHYSICAL AND CHEMICAL PROPERTIES

Physical Data

Boiling Point	: 55 C (131 F)
Vapor Pressure	: 226 mm Hg @ 25 C (77 F)
Solubility in Water	: 140 ppm
pH	: Neutral
Form	: Liquid
Color	: Clear, colorless
Density	: 1.58 g/cm3 @ 25 C (77 F) 13.2 lb/gal

STABILITY AND REACTIVITY

Chemical Stability

Stable at normal temperatures and storage conditions.

Incompatibility with Other Materials

Incompatible with alkali or alkaline earth metals - powdered Al, Zn, Be, Na, Mg, etc.

Incompatible with strong bases such as NaOH, KOH, etc.

Decomposition

Decomposes with heat. High temperatures (open flames, glowing metal surfaces, etc.) can decompose HFC-43-10mee forming hydrofluoric acids and possibly carbonyl halides.

HFC-43-10mee is incompatible with strong bases and can react to form salts of hydrofluoric acid and unsaturated compounds of unknown toxicity.

Polymerization

Polymerization will not occur.

TOXICOLOGICAL INFORMATION

Animal Data

HFC-43-10mee

Oral LD50: > 5,000 mg/kg in rats
Dermal ALD: > 5,000 mg/kg in rabbits
Inhalation, 4 hour LC50: 11,100 ppm in rats

Animal testing indicates that HFC-43-10mee is a slight skin irritant and a mild eye irritant, but is not a skin sensitizer. HFC-43-10mee did not cause cardiac sensitization

(TOXICOLOGICAL INFORMATION - Continued)

in dogs exposed to 1000 or 5000 ppm. The cardiac sensitization potential was not evaluated at or above 10,000 ppm due to clinical signs consistent with central nervous system toxicity. Single exposure to 5,000 ppm HFC-43-10mee by inhalation caused tremors. A different single exposure study by inhalation in rats caused incoordination, hyperactivity and prostration; pathological examination of rats from this study revealed kidney and lung changes, and external hair loss. Repeated exposures to 1,900 - 3,500 ppm caused tremors or convulsions, behavioral effects, and altered clinical chemistry. In developmental toxicity studies with laboratory animals, HFC-43-10mee was not uniquely toxic to the developing fetus. No animal data are available to define the carcinogenic or reproductive hazards of HFC-43-10mee. Tests have shown that HFC-43-10mee does not cause genetic damage in bacterial or mammalian cell cultures. It has not produced genetic damage in tests on animals.

ECOLOGICAL INFORMATION

Ecotoxicological Information

Aquatic Toxicity:

HFC-43-10mee:

96 hour LC50, fathead minnows: 27.2 mg/L
96 hour LC50, rainbow trout: 13.9 mg/L
48 hour LC50, Daphnia magna: 11.7 mg/L

DISPOSAL CONSIDERATIONS

Waste Disposal

Treatment, storage, transportation, and disposal must be in accordance with applicable Federal, State/Provincial, and Local regulations.

TRANSPORTATION INFORMATION

Shipping Information

DOT/IMO/IATA
Not Regulated.

REGULATORY INFORMATION

U.S. Federal Regulations

TSCA Inventory Status : Listed.

TITLE III HAZARD CLASSIFICATIONS SECTIONS 311, 312

Acute : Yes
Chronic : No
Fire : No
Reactivity : No
Pressure : No

1,1,1,2,2,3,4,5,5,5-DECAFLUOROPENTANE (CAS# 138495-42-8) is controlled by TSCA Section 5, Significant New Use Rule (SNUR; 40 CFR 721.5645) The approved uses are: precision and general cleaning, carrier fluid, displacement drying, printed circuit board cleaning, particulate removal and film cleaning, process medium, heat transfer fluid (dielectric and non-dielectric), and test fluid. Processors and users of this substance must also comply with the applicable general SNUR requirements set forth in 40 CFR 721 subpart A, including export notification requirements if applicable (40 CFR 721.20), and the applicable record keeping requirements set forth at 40 CFR 721.125.

LISTS:

SARA Extremely Hazardous Substance - No
CERCLA Hazardous Substance - No

OTHER INFORMATION

NFPA, NPCA-HMIS

NPCA-HMIS Rating
Health : 1
Flammability : 0
Reactivity : 1

Personal Protection rating to be supplied by user depending on use conditions.

The data in this Material Safety Data Sheet relates only to the specific material designated herein and does not relate to use in combination with any other material or in any process.

Responsibility for MSDS : MSDS Coordinator
> : DuPont Fluoroproducts
Address : Wilmington, DE 19898
Telephone : (800) 441-7515

(Continued)

# Indicates updated section.

This information is based upon technical information believed to be reliable. It is subject to revision as additional knowledge and experience is gained.

End of MSDS

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

- Trade name: SOLKANE ® 365 mfc
- Chemical Name: 1,1,1,3,3-pentafluorobutane
- Synonyms: HFC-365mfc
- Molecular formula: C4H5F5

1.2 Relevant identified uses of the substance or mixture and uses advised against

Uses of the Substance / Mixture

- Foaming agent
- Solvent

1.3 Details of the supplier of the safety data sheet

Company

SOLVAY FLUORIDES, LLC
3333 RICHMOND AVENUE
77098-3099, HOUSTON
USA
Tel: +1-800-7658292; +1-713-5256700
Fax: +1-713-5257805

1.4 Emergency telephone

FOR EMERGENCIES INVOLVING A SPILL, LEAK, FIRE, EXPOSURE OR ACCIDENT CONTACT: CHEMTREC 800-424-9300 within the United States and Canada, or 703-527-3887 for international collect calls.

SECTION 2: Hazards identification

Although OSHA has not adopted the environmental portion of the GHS regulations, this document may include information on environmental effects.

2.1 Classification of the substance or mixture

HCS 2012 (29 CFR 1910.1200)

Flammable liquids, Category 2	H225: Highly flammable liquid and vapor.
Simple Asphyxiant	May displace oxygen and cause rapid suffocation.

2.2 Label elements

HCS 2012 (29 CFR 1910.1200)

Pictogram

Signal Word

- Danger

Hazard Statements

- H225 Highly flammable liquid and vapor.
- May displace oxygen and cause rapid suffocation.

Precautionary Statements

Prevention

- P210 Keep away from heat/sparks/open flames/hot surfaces. No smoking.
- P233 Keep container tightly closed.
- P240 Ground/bond container and receiving equipment.
- P241 Use explosion-proof electrical/ ventilating/ lighting/ equipment.
- P242 Use only non-sparking tools.
- P243 Take precautionary measures against static discharge.
- P280 Wear protective gloves/ eye protection/ face protection.

Response

- P303 + P361 + P353 IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
- P370 + P378 In case of fire: Use dry sand, dry chemical or alcohol-resistant foam for extinction.

Storage

- P403 + P235 Store in a well-ventilated place. Keep cool.

Disposal

- P501 Dispose of contents/ container to an approved waste disposal plant.

2.3 Other hazards which do not result in classification

- Highly flammable.
- Hazardous decomposition products formed under fire conditions.
- Gaseous hydrogen fluoride (HF).

SECTION 3: Composition/information on ingredients

3.1 Substance

Hazardous Ingredients and Impurities

Chemical Name	Identification number CAS-No.	Concentration [%]
1,1,1,3,3-pentafluorobutane	406-58-6	>= 99

The specific chemical identity and/or exact percentage (concentration) of composition has been withheld as a trade secret.

3.2 Mixture

Not applicable, this product is a substance.

SECTION 4: First aid measures

4.1 Description of first-aid measures

In case of inhalation

- Remove to fresh air.
- Oxygen or artificial respiration if needed.
- If symptoms persist, call a physician.

In case of skin contact

- Wash off with soap and water.
- If symptoms persist, call a physician.

In case of eye contact

- Rinse thoroughly with plenty of water, also under the eyelids.
- If eye irritation persists, consult a specialist.

In case of ingestion

- If symptoms persist, call a physician.

- If victim is conscious:
- Clean mouth with water and drink afterwards plenty of water.

- If victim is unconscious:
- Not applicable

4.2 Most important symptoms and effects, both acute and delayed

In case of inhalation

Symptoms
- narcosis
- At high concentrations:
- Asphyxia

In case of skin contact

Effects
- Prolonged skin contact may defat the skin and produce dermatitis.

In case of eye contact

Effects
- slight irritation

In case of ingestion

Effects
- Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.

4.3 Indication of any immediate medical attention and special treatment needed

Notes to physician

- When symptoms persist or in all cases of doubt seek medical advice.

- Health injuries are not known or expected under normal use.

SECTION 5: Firefighting measures

Flash point	<= -17 °F (<= -27 °C) Method: DIN 51755 Part 1
Autoignition temperature	1076 °F (580 °C)
Flammability / Explosive limit	Lower flammability/explosion limit : 3.60 %(V) Upper flammability/explosion limit : 13.30 %(V)

5.1 Extinguishing media

Suitable extinguishing media

- powder

- Foam
- Aqueous film forming foam (AFFF).
- Carbon dioxide (CO2)

Unsuitable extinguishing media

- Water may be ineffective.

5.2 Special hazards arising from the substance or mixture

Specific hazards during fire fighting

- Highly flammable liquid and vapor.
- Vapors are heavier than air and may spread along floors.
- Risk of ignition.
- Vapors may form explosive mixtures with air.
- Hazardous decomposition products formed under fire conditions.

Hazardous combustion products:

- Gaseous hydrogen fluoride (HF).
- Carbon monoxide

5.3 Advice for firefighters

Special protective equipment for fire-fighters

- Wear self-contained breathing apparatus and protective suit.
- Full protective flameproof clothing
- Wear chemical resistant oversuit
- Special protective actions for fire-fighters
- In case of fire, use water spray.
- Keep product and empty container away from heat and sources of ignition.

Further information

- Evacuate personnel to safe areas.
- Keep containers and surroundings cool with water spray.
- After the fire, proceed rapidly with cleaning of surfaces exposed to the fumes in order to limit equipment damage.
- Approach from upwind.
- Avoid propagating the fire when directing the extinguishing agent as a jet onto the surface of the burning liquid.

SECTION 6: Accidental release measures

6.1 Personal precautions, protective equipment and emergency procedures

Advice for non-emergency personnel

- Prevent further leakage or spillage if safe to do so.
- Keep away from incompatible products

Advice for emergency responders

- Evacuate personnel to safe areas.
- Keep people away from and upwind of spill/leak.
- Remove all sources of ignition.
- Wear self-contained breathing apparatus and protective suit.
- Cover the spreading liquid with foam in order to slow down the evaporation.
- Ventilate the area.

6.2 Environmental precautions

- Should not be released into the environment.
- If the product contaminates rivers and lakes or drains inform respective authorities.

6.3 Methods and materials for containment and cleaning up

- Treat recovered material as described in the section "Disposal considerations".

6.4 Reference to other sections

- Refer to protective measures listed in sections 7 and 8.

SECTION 7: Handling and storage

7.1 Precautions for safe handling

- Used in closed system
- Use only in well-ventilated areas.
- Keep away from heat and sources of ignition.
- Heating can release vapors which can be ignited.
- To avoid ignition of vapors by static electricity discharge, all metal parts of the equipment must be grounded.
- When transferring from one container to another apply grounding measures and use conductive hose material.
- Preferably transfer by pump or gravity.
- Do not use sparking tools.
- Keep away from incompatible products

Hygiene measures

- Eye wash bottles or eye wash stations in compliance with applicable standards.
- When using do not eat, drink or smoke.
- Wash hands before breaks and at the end of workday.
- Handle in accordance with good industrial hygiene and safety practice.
- Gloves, overalls and boots have to be double layered (protection against cold temperature).

7.2 Conditions for safe storage, including any incompatibilities

Technical measures/Storage conditions

- Store in original container.
- Keep container closed.
- Keep in a cool, well-ventilated place.
- Keep in a contained area
- Keep away from heat/sparks/open flames/hot surfaces. No smoking.
- Ensure all equipment is electrically grounded before beginning transfer operations.
- Take measures to prevent the build up of electrostatic charge.

- Keep container tightly closed.

- Keep container closed when not in use.
- Keep tightly closed.

- Keep away from:
- Incompatible products

Packaging material

Suitable material
- glass
- Stainless steel
- Coated steels.

Unsuitable material
- in cardboard box
- Wooden box

7.3 Specific end use(s)

- Contact your supplier for additional information

SECTION 8: Exposure controls/personal protection

Introductory Remarks: These recommendations provide general guidance for handling this product. Because specific work environments and material handling practices vary, safety procedures should be developed for each intended application. Assistance with selection, use and maintenance of worker protection equipment is generally available from equipment manufacturers.

8.1 Control parameters

Components with workplace occupational exposure limits

Ingredients	Value type	Value	Basis
1,1,1,3,3-pentafluorobutane	TWA	1,000 ppm	Solvay Acceptable Exposure Limit

8.2 Exposure controls

Control measures

Engineering measures
- Provide appropriate exhaust ventilation at machinery.
- Apply technical measures to comply with the occupational exposure limits.

- Refer to protective measures listed in sections 7 and 8.

Individual protection measures

Respiratory protection
- Use respirator when performing operations involving potential exposure to vapor of the product.
- Use only respiratory protection that conforms to international/ national standards.
- Use NIOSH approved respiratory protection.
- Self-contained breathing apparatus in confined spaces/insufficient oxygen/in case of large uncontrolled emissions/in all circumstances when the mask and cartridge do not give adequate protection.

Hand protection
- Wear suitable gloves.
- Take note of the information given by the producer concerning permeability and break through times, and of special workplace conditions (mechanical strain, duration of contact).

Suitable material
- Fluoroelastomer

Eye protection
- Chemical resistant goggles must be worn.

Skin and body protection
- Flame-resistant clothing

- If splashes are likely to occur, wear:
- Apron
- Boots
- butyl-rubber

Hygiene measures

- Eye wash bottles or eye wash stations in compliance with applicable standards.
- When using do not eat, drink or smoke.
- Wash hands before breaks and at the end of workday.
- Handle in accordance with good industrial hygiene and safety practice.
- Gloves, overalls and boots have to be double layered (protection against cold temperature).

SECTION 9: Physical and chemical properties

Physical and Chemical properties here represent typical properties of this product. Contact the business area using the Product information phone number in Section 1 for its exact specifications.

9.1 Information on basic physical and chemical properties

Appearance	Form: Volatile. Physical state: liquid Color: colorless colorless
Odor	ether-like
Odor Threshold	no data available
pH	6.0 (1.7 g/l) pKa: Not applicable
Melting point/range	< -4 °F (< -20 °C)
Boiling point/boiling range	104.2 °F (40.1 °C) (756.81 mmHg (1,009 hPa))
Flash point	<= -17 °F (<= -27 °C) Method: DIN 51755 Part 1
Evaporation rate (Butylacetate = 1)	no data available
Flammability (solid, gas)	Not applicable
Flammability (liquids)	Highly flammable liquid and vapor.
Flammability / Explosive limit	Lower flammability/explosion limit: Type: Lower explosion limit 3.60 %(V) Upper flammability/explosion limit: Type: Upper explosion limit 13.30 %(V) Explosiveness: Not explosive
Autoignition temperature	1076 °F (580 °C)
Vapor pressure	324.78 mmHg (433 hPa) (68 °F (20 °C))
Vapor density	> 5
Density	Bulk density: Not applicable

	Relative density: 1.27 (68 °F (20 °C))
Solubility	Water solubility : 1.7 g/l (70.2 °F (21.2 °C))
	Solubility in other solvents: miscible with most organic solvents :
Partition coefficient: n-octanol/water	log Pow: 1.61 (68 °F (20 °C))
Thermal decomposition	no data available
Viscosity	Viscosity, dynamic : 0.4 mPa.s (77 °F (25 °C))
Explosive properties	no data available
Oxidizing properties	Not considered as oxidizing.

9.2 Other information

Henry's Constant	ca. 3800 Pa.m3 / mol (68 °F (20 °C)) Method: Calculation method considerable volatility, Air
Surface tension	73.8 mN/m (68 °F (20 °C))
Molecular weight	148 g/mol

SECTION 10: Stability and reactivity

10.1 Reactivity

- Risk of violent reaction.
- Risk of explosion.

10.2 Chemical stability

- Stable under recommended storage conditions.

- Strong oxidizers, alkali metals and alkaline earth metals may cause fires or explosions.
- Vapors are heavier than air and may spread along floors.

10.3 Possibility of hazardous reactions

- Strong oxidizers, alkali metals and alkaline earth metals may cause fires or explosions.

10.4 Conditions to avoid

- Heat, flames and sparks.

10.5 Incompatible materials

- Light and/or alkaline metals
- Powdered metals
- Alkaline earth metals
- Strong oxidizing agents

10.6 Hazardous decomposition products

- Gaseous hydrogen fluoride (HF).
- Carbon monoxide

SECTION 11: Toxicological information

11.1 Information on toxicological effects

Acute toxicity

Acute oral toxicity

LD50 : > 2,000 mg/kg - Rat

Acute inhalation toxicity

LC50 - 4 h : > 100000 ppm - Rat

Asphyxiation Hazard This product is a simple asphyxiant.

Acute dermal toxicity no data available

Acute toxicity (other routes of administration) no data available

Skin corrosion/irritation

Rabbit
No skin irritation

Serious eye damage/eye irritation

Rabbit
No eye irritation

Respiratory or skin sensitization

Guinea pig
Did not cause sensitization on laboratory animals.

Mutagenicity

Genotoxicity in vitro

In vitro tests did not show mutagenic effects

Genotoxicity in vivo

In vivo tests did not show mutagenic effects

Carcinogenicity no data available

This product does not contain any ingredient designated as probable or suspected human carcinogens by:

NTP
IARC
OSHA
ACGIH

Toxicity for reproduction and development

Toxicity to reproduction / fertility

NOAEC parent: 29,971 ppm(m)
Effects on fertility

NOAEC parent: 29,971 ppm(m)
Developmental Toxicity

Developmental Toxicity/Teratogenicity no data available

STOT

STOT-single exposure

LOAEL (Lowest observed adverse effect level) : 75100 ppm - Dog
cardiac sensitization following adrenergic stimulation

STOT-repeated exposure

Inhalation Single exposure - Dog
LOAEL: 75100 ppm
cardiac sensitization following adrenergic stimulation

Inhalation Repeated exposure - Rat
NOAEC: 6 mg/l 6980 ppm
Target Organs: Liver, Kidney
No persistent or cumulative effects were observed.

Inhalation 14 days - Rat
NOAEC: 48371 ppm
No adverse effect has been observed in chronic toxicity tests.

Inhalation Single exposure - Dog
NOEL: >= 7.5 %
cardiac sensitization following adrenergic stimulation

Inhalation Single exposure - Dog
NOAEL: >= 10 %
cardiac sensitization following adrenergic stimulation

Aspiration toxicity no data available

SECTION 12: Ecological information

12.1 Toxicity

Aquatic Compartment

Acute toxicity to fish

LC50 - 96 h : > 200 mg/l - Brachydanio rerio (zebrafish)

LC0 - 96 h : ca. 200 mg/l - Brachydanio rerio (zebrafish)

LC50 - 96 h : 450 mg/l - Fishes, Salmo gairdneri
semi-static test

Fresh water

LC50 - 96 h : > 100 mg/l - Oncorhynchus mykiss (rainbow trout)
semi-static test

Fresh water

Acute toxicity to daphnia and other aquatic invertebrates.

EC50 - 48 h : 980 mg/l - Daphnia magna (Water flea)
Fresh water

Toxicity to aquatic plants

NOEC - 72 h : 13.2 mg/l - Selenastrum capricornutum (green algae)
static test
Fresh water

EC50 - 72 h : > 114 mg/l - Selenastrum capricornutum (green algae)
static test
Fresh water

Chronic toxicity to fish

NOEC: ca. 38.2 mg/l - 30 Days - Pimephales promelas (fathead minnow)

Terrestrial Compartment

Toxicity to terrestrial plants

NOEC: >= 6,000 g/l
Endpoint: Growth rate

12.2 Persistence and degradability

Abiotic degradation

Stability in water

Hydrolyzis
not significant, Medium, Water, Soil
Photolysis
not significant, Medium, Water

Photodegradation

indirect photo-oxidation
Half-life indirect photolysis: ca. 10.8 y
Air

Biodegradation

Biodegradability

aerobic
Method: ready biodegradability/MITI
2 % - 28 Days
Not readily biodegradable.

12.3 Bioaccumulative potential

Bioconcentration factor (BCF)

Does not bioaccumulate.

12.4 Mobility in soil

Adsorption potential (Koc)

Adsorption
Soil/sediments
Koc: ca. 9
not significant

Adsorption
Soil/sediments
Koc: ca. 9
Method: Calculation method

12.5 Results of PBT and vPvB assessment no data available

12.6 Other adverse effectsOzone-Depletion Potential

Regulatory basis: Ozone-Depletion Potential
Ozone-Depletion Potential: 0
Ozone depletion potential; ODP; (R-11 = 1)
no effect on stratospheric ozone

Regulatory basis: Global warming potential (GWP)
Ozone-Depletion Potential: 794
Reference value for carbon dioxide: GWP = 1
GWP (ITH 100 y)
Source IPCC (International Panel on Climate Change)

Ecotoxicity assessment

Acute aquatic toxicity

. low toxicity for aquatic organisms.

SECTION 13: Disposal considerations

13.1 Waste treatment methods

Product Disposal

- In accordance with local and national regulations.
- Refer to manufacturer/supplier for information on recovery/recycling.
- or
- Must be incinerated in a suitable incineration plant holding a permit delivered by the competent authorities.
- The incinerator must be equipped with a system for the neutralization or recovery of HF.

Waste Code

- Environmental Protection Agency
- Hazardous Waste – YES

- RCRA Hazardous Waste (40 CFR 302)
- D001 - Ignitable waste – (I)

Advice on cleaning and disposal of packaging

- To avoid treatments, as far as possible, use dedicated containers.

SECTION 14: Transport information

Transportation status: IMPORTANT! Statements below provide additional data on listed transport classification.
The listed Transportation Classification does not address regulatory variations due to changes in package size, mode of shipment or other regulatory descriptors.

DOT

14.1 UN number	UN 1993
14.2 Proper shipping name	FLAMMABLE LIQUIDS, N.O.S. (Pentafluorobutane)
14.3 Transport hazard class	3
Label(s)	3
14.4 Packing group	
Packing group	II
ERG No	128
14.5 Environmental hazards	NO
Marine pollutant	

TDG

14.1 UN number	UN 1993
14.2 Proper shipping name	FLAMMABLE LIQUID, N.O.S. (Pentafluorobutane)
14.3 Transport hazard class	3
Label(s)	3
14.4 Packing group	
Packing group	II
ERG No	128

14.5 Environmental hazards **Marine pollutant**	NO

NOM

14.1 UN number	UN 1993
14.2 Proper shipping name	FLAMMABLE LIQUID, N.O.S. (Pentafluorobutane)
14.3 Transport hazard class	3
Label(s)	3
14.4 Packing group	
Packing group	II
ERG No	128
14.5 Environmental hazards **Marine pollutant**	NO

IMDG

14.1 UN number	UN 1993
14.2 Proper shipping name	FLAMMABLE LIQUID, N.O.S. (Pentafluorobutane)
14.3 Transport hazard class	3
Label(s)	3
14.4 Packing group	
Packing group	II
14.5 Environmental hazards **Marine pollutant**	NO
14.6 Special precautions for user	
EmS	F-E , S-E

For personal protection see section 8.

IATA

14.1 UN number	UN 1993
14.2 Proper shipping name	FLAMMABLE LIQUID, N.O.S. (Pentafluorobutane)
14.3 Transport hazard class	3
Label(s):	3
14.4 Packing group	
Packing group	II
Packing instruction (cargo aircraft)	364
Max net qty / pkg	60.00 L
Packing instruction (passenger aircraft)	353
Max net qty / pkg	5.00 L
14.5 Environmental hazards	NO

14.6 Special precautions for user
For personal protection see section 8.

Note: The above regulatory prescriptions are those valid on the date of publication of this sheet. Given the possible evolution of transportation regulations for hazardous materials, it would be advisable to check their validity with your sales office.

SECTION 15: Regulatory information

15.1 Notification status

Inventory Information	Status
United States TSCA Inventory	- Listed on Inventory
Mexico INSQ (INSQ)	- One or more components not listed on inventory
Canadian Domestic Substances List (DSL)	- Listed on Inventory
New Zealand. Inventory of Chemical Substances	- In compliance with the inventory
Australia Inventory of Chemical Substances (AICS)	- Listed on Inventory
Japan. CSCL - Inventory of Existing and New Chemical Substances	- Listed on Inventory
Korea. Korean Existing Chemicals Inventory (KECI)	- Listed on Inventory
China. Inventory of Existing Chemical Substances in China (IECSC)	- Listed on Inventory
Philippines Inventory of Chemicals and Chemical Substances (PICCS)	- One or more components not listed on inventory

15.2 Federal Regulations

US. EPA EPCRA SARA Title III

SARA Hazard Designation Sections 311/312 (40 CFR 370)

Fire Hazard	yes
Reactivity Hazard	no
Sudden Release of Pressure Hazard	no
Acute Health Hazard	no
Chronic Health Hazard	no

Section 313 Toxic Chemicals (40 CFR 372.65)
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

Section 302 Emergency Planning Extremely Hazardous Substance Threshold Planning Quantity (40 CFR 355)
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

Section 302 Emergency Planning Extremely Hazardous Substance Reportable Quantity (40 CFR 355)
This material does not contain any components with a SARA 302 RQ.

Section 304 Emergency Release Notification Reportable Quantity (40 CFR 355)
This material does not contain any components with a section 304 EHS RQ.

US. EPA CERCLA Hazardous Substances and Reportable Quantities (40 CFR 302.4)

This material does not contain any components with a CERCLA RQ.

15.3 State Regulations

US. California Safe Drinking Water & Toxic Enforcement Act (Proposition 65)

This product does not contain any chemicals known to the State of California to cause cancer, birth, or any other reproductive defects.

SECTION 16: Other information

NFPA (National Fire Protection Association) - Classification

Health	0 minimal
Flammability	3 serious
Instability or Reactivity	1 slight
Special Notices	None

HMIS (Hazardous Materials Identification System (Paint & Coating)) - Classification

Health	0 minimal
Flammability	3 serious
Reactivity	1 slight
PPE	Determined by User; dependent on local conditions

Further information

- Product evaluated under the US GHS format.

Date Prepared: 04/23/2015

- ACGIH — American Conference of Governmental Industrial Hygienists
- OSHA — Occupational Safety and Health Administration

- NTP National Toxicology Program
- IARC International Agency for Research on Cancer
- NIOSH National Institute for Occupational Safety and Health

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information, and belief at the date of its publication. Such information is only given as a guidance to help the user handle, use, process, store, transport, dispose, and release the product in satisfactory safety conditions and is not to be considered as a warranty or quality specification. It should be used in conjunction with technical sheets but do not replace them. Thus, the information only relates to the designated specific product and may not be applicable if such product is used in combination with other materials or in any other manufacturing process, unless otherwise specifically indicated. It does not release the user from ensuring he is in conformity with all regulations linked to its activity.

Material Safety Data Sheet

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SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: 3M™ Novec™ 71DE Engineered Fluid
MANUFACTURER: 3M
DIVISION: Electronics Markets Materials Division

ADDRESS: 3M Center, St. Paul, MN 55144-1000

EMERGENCY PHONE: 1-800-364-3577 or (651) 737-6501 (24 hours)

Issue Date: 03/12/12
Supercedes Date: 05/02/11

Document Group: 07-7119-6

Product Use:
Intended Use: For Industrial Use Only. Not Intended for Use as a Medical Device or Drug.

SECTION 2: INGREDIENTS

Ingredient	C.A.S. No.	% by Wt
1,2-Trans-dichloroethylene	156-60-5	49 - 51
Methyl nonafluorobutyl ether	163702-07-6	10 - 40
Methyl nonafluoroisobutyl ether	163702-08-7	10 - 40

SECTION 3: HAZARDS IDENTIFICATION

3.1 EMERGENCY OVERVIEW

Specific Physical Form: Liquid
Odor, Color, Grade: Clear, colorless liquid. Slight odor.
General Physical Form: Liquid
Immediate health, physical, and environmental hazards: May cause target organ effects.

3.2 POTENTIAL HEALTH EFFECTS

Eye Contact:
Moderate Eye Irritation: Signs/symptoms may include redness, swelling, pain, tearing, and blurred or hazy vision.

Skin Contact:
Moderate Skin Irritation: Signs/symptoms may include localized redness, swelling, itching, and dryness.

Inhalation:
Respiratory Tract Irritation: Signs/symptoms may include cough, sneezing, nasal discharge, headache, hoarseness, and nose and throat pain.

If thermal decomposition occurs:
May be harmful if inhaled.

May be absorbed following inhalation and cause target organ effects.

Ingestion:
Gastrointestinal Irritation: Signs/symptoms may include abdominal pain, stomach upset, nausea, vomiting and diarrhea.

May be absorbed following ingestion and cause target organ effects.

Target Organ Effects:
Central Nervous System (CNS) Depression: Signs/symptoms may include headache, dizziness, drowsiness, incoordination, nausea, slowed reaction time, slurred speech, giddiness, and unconsciousness.

3.3 POTENTIAL ENVIRONMENTAL EFFECTS

AQUATIC TOXICITY:

Testing results indicate that methyl nonafluoroisobutyl ether and methyl nonafluorobutyl ether have insignificant toxicity to aquatic organisms at their saturation point (Lowest LC50, EC50, or IC50 > substance water solubility). 1,2-Trans-dichloroethylene is harmful to aquatic organisms (10 mg/L < Lowest LC50, EC50, or IC50 < 100 mg/L). These compounds are highly volatile and have high Henry's Law constants and are thus expected to move rapidly through vaporization from solution in an aquatic compartment or from a soil surface in a terrestrial compartment to the atmosphere.

BIOCONCENTRATION:

Methyl nonafluoroisobutylether, and methyl nonafluorobutylether are highly insoluble and very volatile. Bioconcentration is therefore unlikely and not expected as they are not likely to enter aqueous waste streams from typical uses and disposal, or, in the case of a spill, remain in the aquatic or terrestrial compartments. The high potential for these components to move from aquatic or terrestrial environments to the atmosphere indicates bioconcentration is unlikely to occur as they are not expected to be bioavailable. Thus, emphasis has been placed on the atmospheric fate.

1,2-Trans-dichloroethylene has an octanol/water partition coefficient of <3 indicating it is unlikely to bioconcentrate.

ATMOSPHERIC FATE:

This product has Zero Ozone Depletion Potential (ODP).

Atmospheric Lifetime: approximately 6 days for 1,2-trans-dichloroethylene and approximately 4.7 yr and 3.7 yr for methyl nonafluorobutyl ether and methyl nonafluoroisobutyl ether, respectively.

Global Warming Potential (GWP): 320 (100 year ITH, WMO 1998 method) for n-butyl and iso-butyl isomers and essentially zero for 1,2-trans-dichloroethylene. The mixture has a global warming potential of 160 on weight basis (100 year ITH, WMO 1998 method).

Atmospheric degradation products are expected to include: for methyl nonafluoroisobutyl ether: predominantly isoperfluorobutyric acid, CO_2, HF, and perhaps also CF_3COOH; for methyl nonafluorobutyl ether: n-perfluorobutyric acid, CO_2, and HF.

SECTION 4: FIRST AID MEASURES

4.1 FIRST AID PROCEDURES

The following first aid recommendations are based on an assumption that appropriate personal and industrial hygiene practices are followed.

Eye Contact: Flush eyes with large amounts of water. If signs/symptoms persist, get medical attention.
Skin Contact: Remove contaminated clothing and shoes. Immediately flush skin with large amounts of water. Get medical attention. Wash contaminated clothing and clean shoes before reuse.
Inhalation: Remove person to fresh air. If signs/symptoms develop, get medical attention.
If Swallowed: Do not induce vomiting unless instructed to do so by medical personnel. Give victim two glasses of water. Never give anything by mouth to an unconscious person. Get medical attention.

SECTION 5: FIRE FIGHTING MEASURES

5.1 FLAMMABLE PROPERTIES

Autoignition temperature	410 ºC
Flash Point	No flash point
Flammable Limits(LEL)	None detected
Flammable Limits(UEL)	None detected

5.2 EXTINGUISHING MEDIA

Material will not burn.

5.3 PROTECTION OF FIRE FIGHTERS

Special Fire Fighting Procedures: Exposure to extreme heat can give rise to thermal decomposition. Wear full protective equipment (Bunker Gear) and a self-contained breathing apparatus (SCBA).

Unusual Fire and Explosion Hazards: No unusual fire or explosion hazards are anticipated. Extreme conditions of heat (welding, open flame, misuse, or equipment failure) may produce decomposition products that include hydrogen fluoride and hydrogen chloride.

Note: See STABILITY AND REACTIVITY (SECTION 10) for hazardous combustion and thermal decomposition information.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions, protective equipment and emergency procedures
Ventilate the area with fresh air.

6.2. Environmental precautions
For larger spills, cover drains and build dikes to prevent entry into sewer systems or bodies of water. Collect the resulting residue containing solution. Place in a closed container approved for transportation by appropriate authorities. Dispose of collected material as soon as possible.

Clean-up methods
Observe precautions from other sections. Call 3M- HELPS line (1-800-364-3577) for more information on handling and managing the spill. Contain spill. Working from around the edges of the spill inward, cover with bentonite, vermiculite, or commercially available

inorganic absorbent material. Mix in sufficient absorbent until it appears dry. Collect as much of the spilled material as possible. Clean up residue with detergent and water.

In the event of a release of this material, the user should determine if the release qualifies as reportable according to local, state, and federal regulations.

SECTION 7: HANDLING AND STORAGE

7.1 HANDLING

Contents may be under pressure, open carefully. Avoid breathing of vapors, mists or spray. For industrial or professional use only. No smoking: Smoking while using this product can result in contamination of the tobacco and/or smoke and lead to the formation of the hazardous decomposition products mentioned in the Reactivity Data section of this MSDS. Store work clothes separately from other clothing, food and tobacco products. Avoid contact with oxidizing agents. Use general dilution ventilation and/or local exhaust ventilation to control airborne exposures to below Occupational Exposure Limits. If ventilation is not adequate, use respiratory protection equipment. Avoid skin contact. Avoid continuous exposure of the material to extreme conditions of heat, i.e., above 150C (welding, open flame, misuse or equipment failure). Avoid exceeding a watt density of 50 watts/inch2 from a heater surface. Continuous exposure to 150C results in very slight decomposition of this product and, therefore, is a very conservative use temperature threshold. Applications involving exposure of the fluid to temperatures exceeding 150C should be reviewed with 3M Technical Service.

7.2 STORAGE

Store away from heat. Store out of direct sunlight. Keep container in well-ventilated area. Store away from oxidizing agents. Keep container tightly closed. Store away from strong bases. Contents may be under pressure if stored/shipped under elevated temperature. Open closure slowly to vent pressure.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 ENGINEERING CONTROLS

Use with appropriate local exhaust ventilation. Provide appropriate local exhaust ventilation on open containers. Do not use in a confined area or areas with little or no air movement. For those situations where the material might be exposed to extreme overheating due to misuse or equipment failure, use with appropriate local exhaust ventilation sufficient to maintain levels of thermal decomposition products below their exposure guidelines.

8.2 PERSONAL PROTECTIVE EQUIPMENT (PPE)

8.2.1 Eye/Face Protection

Avoid eye contact.
The following eye protection(s) are recommended: Safety Glasses with side shields
Indirect Vented Goggles
.

8.2.2 Skin Protection

Avoid skin contact with hot material. Wear heat insulating gloves when handling this material to prevent thermal burns.

Select and use gloves and/or protective clothing to prevent skin contact based on the results of an exposure assessment. Consult with your glove and/or protective clothing manufacturer for selection of appropriate compatible materials.
Gloves made from the following material(s) are recommended: Fluoroelastomer
Polymer laminate
.

8.2.3 Respiratory Protection

Avoid breathing of vapors, mists or spray.

Select one of the following NIOSH approved respirators based on airborne concentration of contaminants and in accordance with OSHA regulations: Half facepiece or fullface air-purifying respirator with organic vapor cartridges
. Select and use respiratory protection to prevent an inhalation exposure based on the results of an exposure assessment. Consult with your respirator manufacturer for selection of appropriate types of respirators. If thermal decomposition occurs, wear supplied air respiratory protection.

8.2.4 Prevention of Swallowing
Do not eat, drink or smoke when using this product. Wash exposed areas thoroughly with soap and water.

8.3 EXPOSURE GUIDELINES

Ingredient	Authority	Type	Limit	Additional Information
Methyl nonafluorobutyl ether	AIHA	TWA	750 ppm	
Ethene, 1,2-dichloro-	ACGIH	TWA	200 ppm	
Ethene, 1,2-dichloro-	OSHA	TWA	790 mg/m3	
Methyl nonafluoroisobutyl ether	AIHA	TWA	750 ppm	

SOURCE OF EXPOSURE LIMIT DATA:
ACGIH: American Conference of Governmental Industrial Hygienists
CMRG: Chemical Manufacturer Recommended Guideline
OSHA: Occupational Safety and Health Administration
AIHA: American Industrial Hygiene Association Workplace Environmental Exposure Level (WEEL)

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Specific Physical Form:	Liquid
Odor, Color, Grade:	Clear, colorless liquid. Slight odor.
General Physical Form:	Liquid
Autoignition temperature	410 ºC
Flash Point	No flash point
Flammable Limits(LEL)	None detected
Flammable Limits(UEL)	None detected
Boiling Point	41 ºC
Density	1.37 g/ml
Vapor Density	4.8 [*Ref Std:* AIR=1]
Vapor Pressure	383 mmHg [@ 25 ºC]
Specific Gravity	1.37 [*Ref Std:* WATER=1]
pH	*Not Applicable*
Melting point	*Not Applicable*
Solubility in Water	Slight (less than 10%)
Evaporation rate	70 [*Ref Std:* BUOAC=1]
Volatile Organic Compounds	685 g/l [*Test Method:* South Cost Air Qual Mgmt Dist]
Kow - Oct/Water partition coef	*No Data Available*
Percent volatile	100 %
VOC Less H2O & Exempt Solvents	685 g/l [*Test Method:* calculated SCAQMD rule 443.1]
Viscosity	0.43 centipoise [@ 25 ºC]

SECTION 10: STABILITY AND REACTIVITY

Stability: Stable.

Materials and Conditions to Avoid:
10.1 Conditions to avoid
Heat

10.2 Materials to avoid
Strong bases
Strong oxidizing agents

Hazardous Polymerization: Hazardous polymerization will not occur.

Hazardous Decomposition or By-Products

Substance	Condition
Hydrogen Chloride	At Elevated Temperatures - extreme conditions of heat
Hydrogen Fluoride	At Elevated Temperatures - extreme conditions of heat
Perfluoroisobutylene (PFIB)	At Elevated Temperatures - extreme conditions of heat
Toxic Vapor, Gas, Particulate	At Elevated Temperatures - extreme conditions of heat

Hazardous Decomposition: Perfluorinated Acid Fluorides

Hydrogen Fluoride has an ACGIH Threshold Limit Value of 3 parts per million (as fluoride) as a Ceiling Limit and an OSHA PEL of 3 ppm of fluoride as an eight hour Time_Weighted Average and 6 ppm of fluoride as a Short Term Exposure Limit. The odor threshold for HF is 0.04 ppm, providing good warning properties for exposure.

Decomposition of this product at temperatures above 300 degrees C can form perfluoroisobutylene (PFIB), but PFIB will only accumulate with continuous exposure to excessive heat in a sealed vessel. The formation rate for PFIB is about 1000 times less than the rate for primary thermal decomposition products such as HF. During normal use conditions, no health hazard is associated with the use of this material due to PFIB exposure.

SECTION 11: TOXICOLOGICAL INFORMATION

Please contact the address listed on the first page of the MSDS for Toxicological Information on this material and/or its components.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION

Test Organism	Test Type	Result
Water flea, Daphnia magna	48 hours Effect Concentration 50%	>400 mg/l
Bluegill, Lepomis macrochirus	96 hours Bioconcentration Factor	>250 mg/l

CHEMICAL FATE INFORMATION

Not determined.

See information in Section 3.3 - Potential Environmental Effects

SECTION 13: DISPOSAL CONSIDERATIONS

Waste Disposal Method: Reclaim if feasible. To reclaim or return, contact your 3M sales representative.
Incinerate in an industrial or commercial facility in the presence of a combustible material. As a disposal alternative, dispose of waste product in a facility permitted to accept chemical waste. Combustion products will include HF and HCl. Facility must be capable of handling halogenated materials.

EPA Hazardous Waste Number (RCRA): Not regulated

Since regulations vary, consult applicable regulations or authorities before disposal.

SECTION 14:TRANSPORT INFORMATION

ID Number(s):
98-0211-9219-4, 98-0211-9221-0, 98-0211-9222-8, 98-0211-9223-6, 98-0212-1172-1, 98-0212-3141-4, 98-0212-3142-2, 98-0212-3143-0, 98-0212-3502-7

For Transport Information, please visit http://3M.com/Transportinfo or call 1-800-364-3577 or 651-737-6501.

SECTION 15: REGULATORY INFORMATION

US FEDERAL REGULATIONS
Contact 3M for more information.

311/312 Hazard Categories:
Fire Hazard - No Pressure Hazard - No Reactivity Hazard - No Immediate Hazard - Yes Delayed Hazard - No

Section 313 Toxic Chemicals subject to the reporting requirements of that section and 40 CFR part 372 (EPCRA):

Ingredient	C.A.S. No	% by Wt
1,2-Trans-dichloroethylene (Ethene, 1,2-dichloro-)	156-60-5	49 - 51

STATE REGULATIONS
Contact 3M for more information.

CHEMICAL INVENTORIES
The components of this product are in compliance with the chemical notification requirements of TSCA.

Contact 3M for more information.

Additional Information: The components of this product are in compliance with the chemical notification requirements of ELINCS, METI, AICS, KECI, PICCS, CICS, CEPA.

INTERNATIONAL REGULATIONS
Contact 3M for more information.

ADDITIONAL INFORMATION

The U.S. Environmental Protection Agency (EPA) has listed the ingredients of 3M™ Novec™ 71DE as acceptable substitutes for ozone depleting substances in specific solvent cleaning and aerosol industry applications under its Significant New Alternatives

Program (SNAP). Section 612 of the Clean Air Act requires the EPA to administer this program to evaluate and approve alternatives for ozone depleting substances.

This MSDS has been prepared to meet the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200.

SECTION 16: OTHER INFORMATION

NFPA Hazard Classification

Health: 3 **Flammability:** 1 **Reactivity:** 0 **Special Hazards:** None

National Fire Protection Association (NFPA) hazard ratings are designed for use by emergency response personnel to address the hazards that are presented by short-term, acute exposure to a material under conditions of fire, spill, or similar emergencies. Hazard ratings are primarily based on the inherent physical and toxic properties of the material but also include the toxic properties of combustion or decomposition products that are known to be generated in significant quantities.

HMIS Hazard Classification

Health: 2 **Flammability:** 1 **Reactivity:** 0 **Protection:** X - See PPE section.

Hazardous Material Identification System (HMIS®) hazard ratings are designed to inform employees of chemical hazards in the workplace. These ratings are based on the inherent properties of the material under expected conditions of normal use and are not intended for use in emergency situations. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint and Coatings Association (NPCA).

Revision Changes:
Section 1: Product use information was modified.
Section 8: Engineering controls information was modified.
Section 8: Prevention of swallowing information was modified.
Section 10: Hazardous decomposition or by-products table was modified.
Section 16: HMIS explanation was modified.
Section 12: Ecotoxicological organism name was modified.
Section 9: Density information was modified.
Section 9: Vapor density value was modified.
Section 9: Vapor pressure value was modified.
Section 9: Boiling point information was modified.
Section 5: Flammable limits (UE) information was modified.
Section 5: Flammable limits (LEL) information was modified.
Section 5: Autoignition temperature information was modified.
Section 5: Flash point information was modified.
Section 9: Property description for optional properties was modified.
Section 9: Specific gravity information was modified.
Section 9: pH information was modified.
Section 9: Melting point information was modified.
Section 9: Solubility in water text was modified.
Section 9: Flash point information was modified.
Section 9: Flammable limits (LEL) information was modified.
Section 9: Flammable limits (UEL) information was modified.
Section 9: Autoignition temperature information was modified.
Section 2: Ingredient table was modified.
Section 8: Exposure guidelines ingredient information was modified.
Section 6: Personal precautions information was modified.
Section 6: Environmental procedures information was modified.
Section 6: Methods for cleaning up information was modified.
Copyright was modified.

Section 15: EPCRA 313 information was added.
Section 15: EPCRA 313 text was added.

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3M USA MSDSs are available at www.3M.com

Safety Data Sheet

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SECTION 1: Identification

1.1. Product identifier
3M™ Novec™ Engineered Fluid 7000

Product Identification Numbers
98-0212-2969-9, 98-0212-2970-7, 98-0212-2971-5, 98-0212-3531-6

1.2. Recommended use and restrictions on use

Recommended use
For Industrial Use Only. Not Intended for Use as a Medical Device or Drug.
Restrictions on use
One or more components in this material are approved for specific commercial use(s) under a U.S. EPA TSCA Significant New Use Rule or Consent Order. Approved uses include: heat transfer fluid, refrigerant, aerosol spray cleaner, medium for low temperature immersion baths (e.g., histology baths), deposition coating solvent, vapor degreasing, specialty foam blowing additive, and line flushing for substances requiring special handling (e.g., liquid oxygen).

Novec™ Engineered Fluids are used in a wide variety of applications, including but not limited to precision cleaning of medical devices and as a lubricant deposition solvent for medical devices. When the product is used for applications where the finished device is implanted into the human body, no residual Novec solvent may remain on the parts. It is highly recommended that the supporting test results and protocol be cited during FDA registration.

3M Electronics Markets Materials Division (EMMD) will not knowingly sample, support, or sell its products for incorporation in medical and pharmaceutical products and applications in which the 3M product will be temporarily or permanently implanted into humans or animals. The customer is responsible for evaluating and determining that a 3M EMMD product is suitable and appropriate for its particular use and intended application. The conditions of evaluation, selection, and use of a 3M product can vary widely and affect the use and intended application of a 3M product. Because many of these conditions are uniquely within the user's knowledge and control, it is essential that the user evaluate and determine whether the 3M product is suitable and appropriate for a particular use and intended application, and complies with all local applicable laws, regulations, standards, and guidance.

1.3. Supplier's details

MANUFACTURER:	3M
DIVISION:	Electronics Materials Solutions Division
ADDRESS:	3M Center, St. Paul, MN 55144-1000, USA
Telephone:	1-888-3M HELPS (1-888-364-3577)

1.4. Emergency telephone number
1-800-364-3577 or (651) 737-6501 (24 hours)

SECTION 2: Hazard identification

2.1. Hazard classification
Not classified as hazardous according to OSHA Hazard Communication Standard, 29 CFR 1910.1200.

2.2. Label elements
Signal word
Not applicable.

Symbols
Not applicable.

Pictograms
Not applicable.

2.3. Hazards not otherwise classified
None.

SECTION 3: Composition/information on ingredients

Ingredient	C.A.S. No.	% by Wt
Methyl perfluoropropyl ether	375-03-1	> 99.5

SECTION 4: First aid measures

4.1. Description of first aid measures

Inhalation:
Remove person to fresh air. If you are concerned, get medical advice.

Skin Contact:
Wash with soap and water. If signs/symptoms develop, get medical attention.

Eye Contact:
Flush with large amounts of water. Remove contact lenses if easy to do. Continue rinsing. If signs/symptoms persist, get medical attention.

If Swallowed:
No need for first aid is anticipated.

4.2. Most important symptoms and effects, both acute and delayed
See Section 11.1. Information on toxicological effects.

4.3. Indication of any immediate medical attention and special treatment required
Not applicable

SECTION 5: Fire-fighting measures

5.1. Suitable extinguishing media
Non-combustible. Use a fire fighting agent suitable for surrounding fire.

5.2. Special hazards arising from the substance or mixture
Exposure to extreme heat can give rise to thermal decomposition.

Hazardous Decomposition or By-Products

Substance	Condition
Carbon monoxide	During Combustion
Carbon dioxide	During Combustion

5.3. Special protective actions for fire-fighters
When fire fighting conditions are severe and total thermal decomposition of the product is possible, wear full protective clothing, including helmet, self-contained, positive pressure or pressure demand breathing apparatus, bunker coat and pants, bands around arms, waist and legs, face mask, and protective covering for exposed areas of the head.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Ventilate the area with fresh air.

6.2. Environmental precautions
Avoid release to the environment. For larger spills, cover drains and build dikes to prevent entry into sewer systems or bodies of water.

6.3. Methods and material for containment and cleaning up
Contain spill. Working from around the edges of the spill inward, cover with bentonite, vermiculite, or commercially available inorganic absorbent material. Mix in sufficient absorbent until it appears dry. Collect as much of the spilled material as possible. Place in a closed container approved for transportation by appropriate authorities. Collect the resulting residue containing solution. Clean up residue with an appropriate solvent selected by a qualified and authorized person. Ventilate the area with fresh air. Read and follow safety precautions on the solvent label and SDS. Seal the container. Dispose of collected material as soon as possible.

SECTION 7: Handling and storage

7.1. Precautions for safe handling
Contents may be under pressure, open carefully. Do not breathe thermal decomposition products. For industrial or professional use only. Avoid contact with oxidizing agents (eg. chlorine, chromic acid etc.)

7.2. Conditions for safe storage including any incompatibilities
Store in a well-ventilated place. Store at temperatures not exceeding 38C/100F Store away from acids. Store away from strong bases. Store away from oxidizing agents.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Occupational exposure limits
If a component is disclosed in section 3 but does not appear in the table below, an occupational exposure limit is not available for the component.

Ingredient	C.A.S. No.	Agency	Limit type	Additional Comments
Methyl perfluoropropyl ether	375-03-1	Manufacturer determined	TWA:250 ppm	

ACGIH : American Conference of Governmental Industrial Hygienists
AIHA : American Industrial Hygiene Association
CMRG : Chemical Manufacturer's Recommended Guidelines
OSHA : United States Department of Labor - Occupational Safety and Health Administration
TWA: Time-Weighted-Average
STEL: Short Term Exposure Limit
CEIL: Ceiling

8.2. Exposure controls

8.2.1. Engineering controls
Provide appropriate local exhaust ventilation on open containers. Provide appropriate local exhaust when product is heated. Use general dilution ventilation and/or local exhaust ventilation to control airborne exposures to below relevant Exposure Limits and/or control dust/fume/gas/mist/vapors/spray. If ventilation is not adequate, use respiratory protection equipment.

8.2.2. Personal protective equipment (PPE)

Eye/face protection

Select and use eye/face protection to prevent contact based on the results of an exposure assessment. The following eye/face protection(s) are recommended:
Safety Glasses with side shields

Skin/hand protection
No chemical protective gloves are required.

Respiratory protection

During heating:
Use a positive pressure supplied-air respirator if there is a potential for over exposure from an uncontrolled release, exposure levels are not known, or under any other circumstances where air-purifying respirators may not provide adequate protection.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

General Physical Form:	Liquid
Specific Physical Form:	Liquid
Odor, Color, Grade:	Colorless liquid with slight ether odor
Odor threshold	*No Data Available*
pH	*Not Applicable*
Melting point	-122.5 ºC
Boiling Point	34 ºC
Flash Point	No flash point
Evaporation rate	*No Data Available*
Flammability (solid, gas)	Not Applicable
Flammable Limits(LEL)	None detected
Flammable Limits(UEL)	None detected
Vapor Pressure	403 mmHg [@ 20 ºC]
Vapor Density	0.51 lb/ft3 [@ 25 ºC]
Density	1.41 g/ml
Specific Gravity	1.41 [*Ref Std:* WATER=1]
Solubility in Water	Negligible
Solubility- non-water	*No Data Available*
Partition coefficient: n-octanol/ water	*No Data Available*
Autoignition temperature	415 ºC
Decomposition temperature	*Not Applicable*
Viscosity	0.47 centipoise
Hazardous Air Pollutants	*Not Applicable*
Volatile Organic Compounds	*No Data Available*
Percent volatile	100 %
VOC Less H2O & Exempt Solvents	*No Data Available*

SECTION 10: Stability and reactivity

10.1. Reactivity
This material may be reactive with certain agents under certain conditions - see the remaining headings in this section.

10.2. Chemical stability
Stable.

10.3. Possibility of hazardous reactions
Hazardous polymerization will not occur.

10.4. Conditions to avoid
None known.

10.5. Incompatible materials
Strong acids
Strong bases
Strong oxidizing agents

10.6. Hazardous decomposition products

Substance	Condition
Carbonyl Fluoride	At Elevated Temperatures - extreme conditions of heat
Hydrogen Fluoride	At Elevated Temperatures - extreme conditions of heat
Toxic Vapor, Gas, Particulate	At Elevated Temperatures - extreme conditions of heat

Refer to section 5.2 for hazardous decomposition products during combustion.

If the product is exposed to extreme condition of heat from misuse or equipment failure, toxic decomposition products that include hydrogen fluoride and perfluoroisobutylene can occur. Extreme heat arising from situations such as misuse or equipment failure can generate hydrogen fluoride as a decomposition product.

SECTION 11: Toxicological information

The information below may not be consistent with the material classification in Section 2 if specific ingredient classifications are mandated by a competent authority. In addition, toxicological data on ingredients may not be reflected in the material classification and/or the signs and symptoms of exposure, because an ingredient may be present below the threshold for labeling, an ingredient may not be available for exposure, or the data may not be relevant to the material as a whole.

11.1. Information on Toxicological effects

Signs and Symptoms of Exposure

Based on test data and/or information on the components, this material may produce the following health effects:

Inhalation:
No known health effects.

Skin Contact:

Contact with the skin during product use is not expected to result in significant irritation.

Eye Contact:
Contact with the eyes during product use is not expected to result in significant irritation.

Ingestion:
No known health effects.

Toxicological Data
If a component is disclosed in section 3 but does not appear in a table below, either no data are available for that endpoint or the data are not sufficient for classification.

Acute Toxicity

Name	Route	Species	Value
Methyl perfluoropropyl ether	Inhalation-Vapor (4 hours)	Mouse	LC50 820 mg/l
Methyl perfluoropropyl ether	Ingestion	Rat	LD50 > 2,000 mg/kg

ATE = acute toxicity estimate

Skin Corrosion/Irritation

Name	Species	Value
Methyl perfluoropropyl ether	Rabbit	No significant irritation

Serious Eye Damage/Irritation

Name	Species	Value
Methyl perfluoropropyl ether	Rabbit	No significant irritation

Skin Sensitization

Name	Species	Value
Methyl perfluoropropyl ether	Mouse	Not sensitizing

Respiratory Sensitization
For the component/components, either no data are currently available or the data are not sufficient for classification.

Germ Cell Mutagenicity

Name	Route	Value
Methyl perfluoropropyl ether	In Vitro	Not mutagenic

Carcinogenicity
For the component/components, either no data are currently available or the data are not sufficient for classification.

Reproductive Toxicity

Reproductive and/or Developmental Effects
For the component/components, either no data are currently available or the data are not sufficient for classification.

Target Organ(s)

Specific Target Organ Toxicity - single exposure
For the component/components, either no data are currently available or the data are not sufficient for classification.

Specific Target Organ Toxicity - repeated exposure

Name	Route	Target Organ(s)	Value	Species	Test Result	Exposure Duration

Methyl perfluoropropyl ether	Inhalation	kidney and/or bladder	Some positive data exist, but the data are not sufficient for classification	Rat	NOAEL 82 mg/l	30 days
Methyl perfluoropropyl ether	Inhalation	blood | liver	Some positive data exist, but the data are not sufficient for classification	Rat	NOAEL 246 mg/l	30 days
Methyl perfluoropropyl ether	Inhalation	heart | endocrine system | hematopoietic system | nervous system | respiratory system	All data are negative	Rat	NOAEL 246 mg/l	30 days

Aspiration Hazard
For the component/components, either no data are currently available or the data are not sufficient for classification.

Please contact the address or phone number listed on the first page of the SDS for additional toxicological information on this material and/or its components.

SECTION 12: Ecological information

Ecotoxicological information

Please contact the address or phone number listed on the first page of the SDS for additional ecotoxicological information on this material and/or its components.

Chemical fate information

Please contact the address or phone number listed on the first page of the SDS for additional chemical fate information on this material and/or its components.

SECTION 13: Disposal considerations

13.1. Disposal methods
Dispose of contents/ container in accordance with the local/regional/national/international regulations.

Dispose of waste product in a permitted industrial waste facility. Combustion products will include halogen acid (HCl/HF/HBr). Facility must be capable of handling halogenated materials. Empty and clean product containers may be disposed as non-hazardous waste. Consult your specific regulations and service providers to determine available options and requirements.

EPA Hazardous Waste Number (RCRA): Not regulated

SECTION 14: Transport Information

For Transport Information, please visit http://3M.com/Transportinfo or call 1-800-364-3577 or 651-737-6501.

SECTION 15: Regulatory information

15.1. US Federal Regulations
This material contains one or more substances that are subject to a TSCA Consent Order. Contact 3M for more information.

311/312 Hazard Categories:

Fire Hazard - No Pressure Hazard - No Reactivity Hazard - No Immediate Hazard - No Delayed Hazard - No

This material contains a chemical which requires export notification under TSCA Section 12[b]:

Ingredient (Category if applicable)	C.A.S. No	Regulation	Status
Methyl perfluoropropyl ether	375-03-1	Toxic Substances Control Act (TSCA) 5 SNUR or Consent Order Chemicals	Applicable

This material contains a chemical regulated by an EPA Significant New Use Rule (TSCA Section 5)

Ingredient (Category if applicable)	C.A.S. No	Reference
Methyl perfluoropropyl ether	375-03-1	40CFR721.8145

15.2. State Regulations

Contact 3M for more information.

15.3. Chemical Inventories

The components of this material are in compliance with the China "Measures on Environmental Management of New Chemical Substance". Certain restrictions may apply. Contact the selling division for additional information.

The components of this material are in compliance with the provisions of Philippines RA 6969 requirements. Certain restrictions may apply. Contact the selling division for additional information.

The components of this product are in compliance with the chemical notification requirements of TSCA.

Contact 3M for more information.

15.4. International Regulations

Contact 3M for more information.

This SDS has been prepared to meet the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200.

SECTION 16: Other information

NFPA Hazard Classification
Health: 3 **Flammability:** 0 **Instability:** 0 **Special Hazards:** None

National Fire Protection Association (NFPA) hazard ratings are designed for use by emergency response personnel to address the hazards that are presented by short-term, acute exposure to a material under conditions of fire, spill, or similar emergencies. Hazard ratings are primarily based on the inherent physical and toxic properties of the material but also include the toxic properties of combustion or decomposition products that are known to be generated in significant quantities.

HMIS Hazard Classification
Health: 0 **Flammability:** 0 **Physical Hazard:** 0 **Personal Protection:** X - See PPE section.

Hazardous Material Identification System (HMIS® IV) hazard ratings are designed to inform employees of chemical hazards in the workplace. These ratings are based on the inherent properties of the material under expected conditions of normal use and are not intended for use in emergency situations. HMIS® IV ratings are to be used with a fully implemented HMIS® IV program. HMIS® is a registered mark of the American Coatings Association (ACA).

Document Group:	16-2638-1	**Version Number:**	17.01
Issue Date:	11/04/15	**Supercedes Date:**	02/05/15

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SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: HFE-7100 3M (TM) Novec (TM) Engineered Fluid
MANUFACTURER: 3M
DIVISION: Electronics Markets Materials Division

ADDRESS: 3M Center
St. Paul, MN 55144-1000

EMERGENCY PHONE: 1-800-364-3577 or (651) 737-6501 (24 hours)

Issue Date: 06/06/2005
Supercedes Date: 04/09/2004

Document Group: 07-6378-9

Product Use:
Intended Use: FOR INDUSTRIAL USE ONLY. NOT INTENDED FOR USE AS A MEDICAL DEVICE OR DRUG.
Specific Use: Cleaning and Coating Solvent; Heat Transfer Fluid

SECTION 2: INGREDIENTS

Ingredient	C.A.S. No.	% by Wt
METHYL NONAFLUOROISOBUTYL ETHER	163702-08-7	20 - 80
METHYL NONAFLUOROBUTYL ETHER	163702-07-6	20 - 80

SECTION 3: HAZARDS IDENTIFICATION

3.1 EMERGENCY OVERVIEW

Specific Physical Form: liquid
Odor, Color, Grade: Clear, colorless, liquid. Slight ethereal odor.
General Physical Form: Liquid
Immediate health, physical, and environmental hazards:

3.2 POTENTIAL HEALTH EFFECTS

Eye Contact:
Contact with the eyes during product use is not expected to result in significant irritation.

Skin Contact:
Contact with the skin during product use is not expected to result in significant irritation.

Inhalation:
If thermal decomposition occurs:

Respiratory Effects: Signs/symptoms may include cough, sneezing, shortness of breath, chest tightness, nasal discharge, and wheezing.

Ingestion:
No health effects are expected.

3.3 POTENTIAL ENVIRONMENTAL EFFECTS

A 3M Product Environmental Data Sheet (PED) is available.
This substance has chemical moieties that are resistant to biodegradation and is likely to only undergo partial biodegradation in the environment. The high potential of this substance to move from water to the atmosphere means its potential to bioconcentrate is likely to disappear rapidly from aerobic environments. Take precautions to prevent direct release of this product to the environment.
AQUATIC TOXICITY: Testing results indicate that this product has insignificant toxicity to aquatic organisms at its saturation point (Lowest LC50, EC50, or IC50 > substance water solubility). This substance is highly volatile and has a high Henry's Law constant and is thus expected to move rapidly through vaporization from solution in an aquatic compartment or from a soil surface in a terrestrial compartment to the atmosphere.
ATMOSPHERIC FATE: Zero Ozone Depletion Potential (ODP). Atmospheric Lifetime: approximately 4.1 yrs. Global Warming Potential (GWP): 280 (100 year ITH, IPCC1995 method). Global Warming Potential (GWP): 320 (100 yr ITH, IPCC2001 method). Atmospheric degradation products are expected to include: for methyl nonafluoroisobutyl ether: predominantly isoperfluorobutyric acid, CO2, HF, and perhaps also CF3COOH; for methyl nonafluorobutyl ether: n-perfluorobutyric acid, CO2, and HF.

SECTION 4: FIRST AID MEASURES

4.1 FIRST AID PROCEDURES

The following first aid recommendations are based on an assumption that appropriate personal and industrial hygiene practices are followed.

Eye Contact: Flush eyes with large amounts of water. If signs/symptoms persist, get medical attention.

Skin Contact: Wash affected area with soap and water. If signs/symptoms develop, get medical attention.

Inhalation: If signs/symptoms develop, remove person to fresh air. If signs/symptoms develop, get medical attention.

If Swallowed: If signs/symptoms develop, get medical attention. No need for first aid is anticipated.

SECTION 5: FIRE FIGHTING MEASURES

5.1 FLAMMABLE PROPERTIES

Autoignition temperature	405 ºC [*Details:* (ASTM E659-84)]

Flash Point	*Not Applicable*
Flammable Limits - LEL	[*Details:* NONE acc to ASTM E681-94, @100C]
Flammable Limits - UEL	[*Details:* NONE acc to ASTM E681-94, @100C]

5.2 EXTINGUISHING MEDIA
Material will not burn.

5.3 PROTECTION OF FIRE FIGHTERS

Special Fire Fighting Procedures: Water may be used to blanket the fire. Exposure to extreme heat can give rise to thermal decomposition. Wear full protective equipment (Bunker Gear) and a self-contained breathing apparatus (SCBA).

Unusual Fire and Explosion Hazards: No unusual fire or explosion hazards are anticipated. No unusual effects are anticipated during fire extinguishing operations. Avoid breathing the products and substances that may result from the thermal decomposition of the product or the other substances in the fire zone. Keep containers cool with water spray when exposed to fire to avoid rupture.

Note: See STABILITY AND REACTIVITY (SECTION 10) for hazardous combustion and thermal decomposition information.

SECTION 6: ACCIDENTAL RELEASE MEASURES

Accidental Release Measures: Observe precautions from other sections. Call 3M- HELPS line (1-800-364-3577) for more information on handling and managing the spill. Ventilate the area with fresh air. Contain spill. Working from around the edges of the spill inward, cover with bentonite, vermiculite, or commercially available inorganic absorbent material. Mix in sufficient absorbent until it appears dry. Collect as much of the spilled material as possible. Clean up residue with an appropriate organic solvent. Read and follow safety precautions on the solvent label and MSDS. Collect the resulting residue containing solution. Place in a metal container approved for transportation by appropriate authorities. Seal the container. Dispose of collected material as soon as possible.

In the event of a release of this material, the user should determine if the release qualifies as reportable according to local, state, and federal regulations.

SECTION 7: HANDLING AND STORAGE

7.1 HANDLING
Avoid skin contact with hot material. For industrial or professional use only. Contents may be under pressure, open carefully. No smoking: Smoking while using this product can result in contamination of the tobacco and/or smoke and lead to the formation of the hazardous decomposition products mentioned in the Reactivity Data section of this MSDS. Store work clothes separately from other clothing, food and tobacco products. Use general dilution ventilation and/or local exhaust ventilation to control airborne exposures to below Occupational Exposure Limits. If ventilation is not adequate, use respiratory protection equipment. Avoid continuous exposure of the material to extreme conditions of heat, i.e., above 150 C (welding, open flame, misuse or equipment failure). Avoid exceeding a watt density of 50 watts/inch2 from a heater surface. Continuous exposure to 150 C results in very slight decomposition of this product and therefore, is a very conservative use temperature threshold. Applications involving exposure of the fluid to temperatures exceeding 150 C or watt densities exceeding 50 watts/inch2 have been safely implemented. Applications which may exceed these use parameters should be reviewed with 3M Technical Service.

7.2 STORAGE
Keep container tightly closed. Keep container in well-ventilated area. Store away from heat. Store away from strong bases.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 ENGINEERING CONTROLS

Use with appropriate local exhaust ventilation. Provide local exhaust ventilation at transfer points. Provide appropriate local exhaust when product is heated. For those situations where the fluid might be exposed to extreme overheating due to misuse or equipment failure, use with appropriate local exhaust ventilation sufficient to maintain levels of thermal decomposition products below their exposure guidelines.

8.2 PERSONAL PROTECTIVE EQUIPMENT (PPE)

8.2.1 Eye/Face Protection

Avoid eye contact.
The following eye protection(s) are recommended: Safety Glasses with side shields.

8.2.2 Skin Protection

Avoid skin contact with hot material. Wear appropriate gloves, such as Nomex, when handling this material to prevent thermal burns.

Select and use gloves and/or protective clothing to prevent skin contact based on the results of an exposure assessment. Consult with your glove and/or protective clothing manufacturer for selection of appropriate compatible materials.
Gloves made from the following material(s) are recommended: Nitrile Rubber.

8.2.3 Respiratory Protection

Avoid breathing of vapors, mists or spray. Under normal use conditions, airborne exposures are not expected to be significant enough to require respiratory protection.
Select one of the following NIOSH approved respirators based on airborne concentration of contaminants and in accordance with OSHA regulations: Half facepiece or fullface air-purifying respirator with organic vapor cartridges. Consult the current 3M Respiratory Selection Guide for additional information or call 1-800-243-4630 for 3M technical assistance. If thermal degradation products are expected, use fullface supplied air respirator.

8.2.4 Prevention of Swallowing

Do not eat, drink or smoke when using this product. Wash exposed areas thoroughly with soap and water.

8.3 EXPOSURE GUIDELINES

Ingredient	Authority	Type	Limit	Additional Information
METHYL NONAFLUOROBUTYL ETHER	AIHA	TWA	750 ppm	
METHYL NONAFLUOROISOBUTYL ETHER	AIHA	TWA	750 ppm	

SOURCE OF EXPOSURE LIMIT DATA:
ACGIH: American Conference of Governmental Industrial Hygienists
CMRG: Chemical Manufacturer Recommended Guideline
OSHA: Occupational Safety and Health Administration
AIHA: American Industrial Hygiene Association Workplace Environmental Exposure Level (WEEL)

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Specific Physical Form:	liquid
Odor, Color, Grade:	Clear, colorless, liquid. Slight ethereal odor.
General Physical Form:	Liquid
Autoignition temperature	405 ºC [*Details:* (ASTM E659-84)]
Flash Point	*Not Applicable*
Flammable Limits - LEL	[*Details:* NONE acc to ASTM E681-94, @100C]

Flammable Limits - UEL	[*Details:* NONE acc to ASTM E681-94, @100C]
Boiling point	61 ºC [@ 760 mmHg]
Density	1.5 g/ml
Vapor Density	8.6 [*Ref Std:* AIR=1]
Vapor Pressure	202 mmHg [@ 25 ºC]
Specific Gravity	1.5 [*Ref Std:* WATER=1]
pH	*Not Applicable*
Melting point	-135 ºC
Solubility In Water	< 12 ppm
Evaporation rate	49 [*Ref Std:* BUOAC=1]
Volatile Organic Compounds	[*Details:* Exempt]
Percent volatile	100 %
VOC Less H2O & Exempt Solvents	[*Details:* Exempt]
Viscosity	0.6 centipoise [@ 23 ºC]

SECTION 10: STABILITY AND REACTIVITY

Stability: Stable.

Materials and Conditions to Avoid: Strong bases

Hazardous Polymerization: Hazardous polymerization will not occur.

Hazardous Decomposition or By-Products

Substance	Condition
Hydrogen Fluoride	At Elevated Temperatures - extreme conditions of heat
Perfluoroisobutylene (PFIB)	At Elevated Temperatures - extreme conditions of heat

Hazardous Decomposition: Perfluorinated Acid Fluorides

Hydrogen Fluoride has an ACGIH Threshold Limit Value of 3 parts per million (as fluoride) as a Ceiling Limit and an OSHA PEL of 3 ppm of fluoride as an eight hour Time_Weighted Average and 6 ppm of fluoride as a Short Term Exposure Limit. The odor threshold for HF is 0.04 ppm, providing good warning properties for exposure.

Decomposition of this product at temperatures above 300 degrees C can form perfluoroisobutylene (PFIB), but PFIB will only accumulate with continuous exposure to excessive heat in a sealed vessel. The formation rate for PFIB is about 1000 times less than the rate for primary thermal decomposition products such as HF. During normal use conditions, no health hazard is associated with the use of this material due to PFIB exposure.

SECTION 11: TOXICOLOGICAL INFORMATION

Please contact the address listed on the first page of the MSDS for Toxicological Information on this material and/or its components.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION

Test Organism	Test Type	Result
Fathead Minnow, Pimephales promelas	96 hours Lethal Concentration 50%	>7.9 mg/l
Green algae, Selenastrum capricornutum	96 hours Inhibitory Concentration 50%	>8.9 mg/l
Water flea, Daphnia magna	48 hours Effect Concentration 50%	>10 mg/l

CHEMICAL FATE INFORMATION

Test Type	Result	Protocol
	See Section 3.3.	

SECTION 13: DISPOSAL CONSIDERATIONS

Waste Disposal Method: Reclaim if feasible. As a disposal alternative, incinerate in an industrial or commercial facility in the presence of a combustible material. Combustion products will include HF. Facility must be capable of handling halogenated materials.

To reclaim or return, check product label for contact.

EPA Hazardous Waste Number (RCRA): Not regulated

Since regulations vary, consult applicable regulations or authorities before disposal.

SECTION 14:TRANSPORT INFORMATION

ID Number(s):
98-0211-8940-6, 98-0211-8941-4, 98-0211-8942-2, 98-0211-8943-0, 98-0211-8944-8, 98-0211-8946-3, 98-0212-1011-1, 98-0212-1035-0, 98-0212-1102-8, 98-0212-1128-3, 98-0212-1148-1, 98-0212-3138-0, 98-0212-3139-8, 98-0212-3140-6, 98-0212-3159-6

Please contact the emergency numbers listed on the first page of the MSDS for Transportation Information for this material.

SECTION 15: REGULATORY INFORMATION

US FEDERAL REGULATIONS

Contact 3M for more information.

311/312 Hazard Categories:
Fire Hazard - No Pressure Hazard - No Reactivity Hazard - No Immediate Hazard - No Delayed Hazard - No

STATE REGULATIONS
Contact 3M for more information.

CHEMICAL INVENTORIES
The components of this product are in compliance with the chemical notification requirements of TSCA.

Contact 3M for more information.

Additional Information: The components of this product are in compliance with the chemical registration requirements of ELINCS, METI, AICS, KECI, PICCS, CICS, CEPA.

INTERNATIONAL REGULATIONS
Contact 3M for more information.

ADDITIONAL INFORMATION

The U.S. Environmental Protection Agency (EPA) has listed 3M(TM) HFE-7100 as an acceptable substitute for ozone depleting substances in specific solvent cleaning and aerosol industry applications under its Significant New Alternatives Program (SNAP). Section 612 of the Clean Air Act requires the EPA to administer this program to evaluate and approve alternatives for ozone depleting substances.

This MSDS has been prepared to meet the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200.

SECTION 16: OTHER INFORMATION

NFPA Hazard Classification
Health: 3 **Flammability:** 1 **Reactivity:** 0 **Special Hazards:** None

National Fire Protection Association (NFPA) hazard ratings are designed for use by emergency response personnel to address the hazards that are presented by short-term, acute exposure to a material under conditions of fire, spill, or similar emergencies. Hazard ratings are primarily based on the inherent physical and toxic properties of the material but also include the toxic properties of combustion or decomposition products that are known to be generated in significant quantities.

HMIS Hazard Classification
Health: 0 **Flammability:** 1 **Reactivity:** 0 **Protection:** X - See PPE section.

Hazardous Material Identification System (HMIS(r)) hazard ratings are designed to inform employees of chemical hazards in the workplace. These ratings are based on the inherent properties of the material under expected conditions of normal use and are not intended for use in emergency situations. HMIS(r) ratings are to be used with a fully implemented HMIS(r) program. HMIS(r) is a registered mark of the National Paint and Coatings Association (NPCA).

Revision Changes:
Copyright was modified.
Section 14: ID Number(s) was modified.

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Material Safety Data Sheet

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SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: 3M™ Novec™ 7300DL Engineered Fluid
MANUFACTURER: 3M
DIVISION: Electronics Markets Materials Division

ADDRESS: 3M Center, St. Paul, MN 55144-1000

EMERGENCY PHONE: 1-800-364-3577 or (651) 737-6501 (24 hours)

Issue Date: 04/23/12
Supercedes Date: 01/06/12

Document Group: 19-5022-9

Product Use:
Intended Use: For industrial use only. Not intended for use as a medical device or drug.

SECTION 2: INGREDIENTS

Ingredient	C.A.S. No.	% by Wt
Pentane, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)-	132182-92-4	99 - 100

SECTION 3: HAZARDS IDENTIFICATION

3.1 EMERGENCY OVERVIEW

Specific Physical Form: Liquid
Odor, Color, Grade: Clear, colorless liquid. Faint odor.
General Physical Form: Liquid
Immediate health, physical, and environmental hazards:

3.2 POTENTIAL HEALTH EFFECTS

Eye Contact:
Vapors from heated material may cause eye irritation. Signs/symptoms may include redness, swelling, pain, tearing, and blurred or hazy vision.

Skin Contact:

Contact with the skin during product use is not expected to result in significant irritation.

Inhalation:
Vapors from heated material may cause irritation of the respiratory system. Signs/symptoms may include cough, sneezing, nasal discharge, headache, hoarseness, and nose and throat pain.

If thermal decomposition occurs:
May be harmful if inhaled.

Ingestion:
May be absorbed following ingestion and cause target organ effects.

Target Organ Effects:
Prolonged or repeated exposure may cause:
Liver Effects: Signs/symptoms may include loss of appetite, weight loss, fatigue, weakness, abdominal tenderness and jaundice.

Kidney/Bladder Effects: Signs/symptoms may include changes in urine production, abdominal or lower back pain, increased protein in urine, increased blood urea nitrogen (BUN), blood in urine, and painful urination.

SECTION 4: FIRST AID MEASURES

4.1 FIRST AID PROCEDURES

The following first aid recommendations are based on an assumption that appropriate personal and industrial hygiene practices are followed.

Eye Contact: Flush eyes with large amounts of water. If signs/symptoms persist, get medical attention.
Skin Contact: Wash affected area with soap and water. If signs/symptoms develop, get medical attention.
Inhalation: If signs/symptoms develop, remove person to fresh air. If signs/symptoms persist, get medical attention.
If Swallowed: Do not induce vomiting unless instructed to do so by medical personnel. Give victim two glasses of water. Never give anything by mouth to an unconscious person. Get medical attention.

SECTION 5: FIRE FIGHTING MEASURES

5.1 FLAMMABLE PROPERTIES

Autoignition temperature	408 ºC [*Details:* per ASTM E-659 method]
Flash Point	No flash point
Flammable Limits(LEL)	*Not Applicable*
Flammable Limits(UEL)	*Not Applicable*

5.2 EXTINGUISHING MEDIA
Material will not burn.

5.3 PROTECTION OF FIRE FIGHTERS

Special Fire Fighting Procedures: Water may be used to blanket the fire. Exposure to extreme heat can give rise to thermal decomposition. Wear full protective equipment (Bunker Gear) and a self-contained breathing apparatus (SCBA).

Unusual Fire and Explosion Hazards: No unusual fire or explosion hazards are anticipated.

Note: See STABILITY AND REACTIVITY (SECTION 10) for hazardous combustion and thermal decomposition information.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions, protective equipment and emergency procedures
Evacuate unprotected and untrained personnel from hazard area. The spill should be cleaned up by qualified personnel. Ventilate the area with fresh air. For large spill, or spills in confined spaces, provide mechanical ventilation to disperse or exhaust vapors, in accordance with good industrial hygiene practice. Warning! A motor could be an ignition source and could cause flammable gases or vapors in the spill area to burn or explode.

6.2. Environmental precautions
For larger spills, cover drains and build dikes to prevent entry into sewer systems or bodies of water. Place in a closed container approved for transportation by appropriate authorities. Dispose of collected material as soon as possible.

Clean-up methods
Observe precautions from other sections. Call 3M- HELPS line (1-800-364-3577) for more information on handling and managing the spill. Contain spill. Working from around the edges of the spill inward, cover with bentonite, vermiculite, or commercially available inorganic absorbent material. Mix in sufficient absorbent until it appears dry. Collect as much of the spilled material as possible. Clean up residue with an appropriate solvent selected by a qualified and authorized person. Ventilate the area with fresh air. Read and follow safety precautions on the solvent label and MSDS.

In the event of a release of this material, the user should determine if the release qualifies as reportable according to local, state, and federal regulations.

SECTION 7: HANDLING AND STORAGE

7.1 HANDLING
Do not eat, drink or smoke when using this product. Wash exposed areas thoroughly with soap and water. Avoid skin contact with hot material. For industrial or professional use only. Use general dilution ventilation and/or local exhaust ventilation to control airborne exposures to below Occupational Exposure Limits. If ventilation is not adequate, use respiratory protection equipment. Do not breathe thermal decomposition products. No smoking: Smoking while using this product can result in contamination of the tobacco and/or smoke and lead to the formation of the hazardous decomposition products mentioned in the Reactivity Data section of this MSDS. Store work clothes separately from other clothing, food and tobacco products.

7.2 STORAGE
Keep container in well-ventilated area. Keep container tightly closed. Store away from heat. Store away from strong bases.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 ENGINEERING CONTROLS
Provide appropriate local exhaust ventilation on open containers. Provide appropriate local exhaust when product is heated. For those situations where the material might be exposed to extreme overheating due to misuse or equipment failure, use with appropriate local exhaust ventilation sufficient to maintain levels of thermal decomposition products below their exposure guidelines.

8.2 PERSONAL PROTECTIVE EQUIPMENT (PPE)

8.2.1 Eye/Face Protection
During heating:
Avoid eye contact.

The following eye protection(s) are recommended: Indirect Vented Goggles
.

8.2.2 Skin Protection
Avoid skin contact with hot material.

Select and use gloves and/or protective clothing to prevent skin contact based on the results of an exposure assessment. Consult with your glove and/or protective clothing manufacturer for selection of appropriate compatible materials.
Gloves made from the following material(s) are recommended: Polyvinyl Alcohol (PVA)
Polymer laminate
. Wear appropriate gloves when handling hot material to prevent thermal burns.

8.2.3 Respiratory Protection
Under normal use conditions, airborne exposures are not expected to be significant enough to require respiratory protection.
During heating:
Avoid breathing of vapors. Use a positive pressure supplied-air respirator if there is a potential for exposure from an uncontrolled release, exposure levels are not known, or under any other circumstances where air-purifying respirators may not provide adequate protection.

8.2.4 Prevention of Swallowing
Do not eat, drink or smoke when using this product. Wash exposed areas thoroughly with soap and water.

8.3 EXPOSURE GUIDELINES

Ingredient	Authority	Type	Limit	Additional Information
Pentane, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)-	Manufacturer determined	TWA	100 ppm	

SOURCE OF EXPOSURE LIMIT DATA:
ACGIH: American Conference of Governmental Industrial Hygienists
CMRG: Chemical Manufacturer Recommended Guideline
OSHA: Occupational Safety and Health Administration
AIHA: American Industrial Hygiene Association Workplace Environmental Exposure Level (WEEL)

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Specific Physical Form:	Liquid
Odor, Color, Grade:	Clear, colorless liquid. Faint odor.
General Physical Form:	Liquid
Autoignition temperature	408 ºC [*Details:* per ASTM E-659 method]
Flash Point	No flash point
Flammable Limits(LEL)	*Not Applicable*
Flammable Limits(UEL)	*Not Applicable*
Boiling Point	208 ºF
Density	1.6 g/ml
Vapor Density	*No Data Available*
Vapor Pressure	0.81 psia [@ 68 ºF]
Specific Gravity	1.6 [*Ref Std:* WATER=1]
pH	*Not Applicable*
Melting point	*Not Applicable*
Solubility In Water	< 10 ppm

Evaporation rate	*No Data Available*
Volatile Organic Compounds	*Not Applicable*
Kow - Oct/Water partition coef	*No Data Available*
Percent volatile	100 %
VOC Less H2O & Exempt Solvents	*Not Applicable*
Viscosity	< 5 centipoise [@ 25 ºC]

SECTION 10: STABILITY AND REACTIVITY

Stability: Stable.

Materials and Conditions to Avoid:
10.1 Conditions to avoid
None known

10.2 Materials to avoid
Strong bases

Hazardous Polymerization: Hazardous polymerization will not occur.

Hazardous Decomposition or By-Products

Substance	Condition
Carbon monoxide	At Elevated Temperatures - extreme conditions of heat
Carbon dioxide	At Elevated Temperatures - extreme conditions of heat
Hydrogen Fluoride	At Elevated Temperatures - extreme conditions of heat
Toxic Vapor, Gas, Particulate	At Elevated Temperatures - extreme conditions of heat

SECTION 11: TOXICOLOGICAL INFORMATION

Please contact the address listed on the first page of the MSDS for Toxicological Information on this material and/or its components.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION

Not determined.

CHEMICAL FATE INFORMATION

Not determined.

SECTION 13: DISPOSAL CONSIDERATIONS

Waste Disposal Method: Reclaim if feasible. Incinerate in an industrial or commercial facility in the presence of a combustible material. Combustion products will include HF. Facility must be capable of handling halogenated materials.
As a disposal alternative, dispose of waste product in a facility permitted to accept chemical waste.

EPA Hazardous Waste Number (RCRA): Not regulated

Since regulations vary, consult applicable regulations or authorities before disposal.

SECTION 14:TRANSPORT INFORMATION

ID Number(s):
98-0212-3246-1, 98-0212-3247-9

Not regulated per U.S. DOT, IATA or IMO.

These transportation classifications are provided as a customer service. As the shipper YOU remain responsible for complying with all applicable laws and regulations, including proper transportation classification and packaging. *3M transportation classifications are based on product formulation, packaging, 3M policies and 3M understanding of applicable current regulations. 3M does not guarantee the accuracy of this classification information. This information applies only to transportation classification and* ***not*** ***the packaging, labeling, or marking requirements.*** *The original 3M package is certified for U.S. ground shipment only. If you are shipping by air or ocean, the package may not meet applicable regulatory requirements.*

SECTION 15: REGULATORY INFORMATION

US FEDERAL REGULATIONS
Contact 3M for more information.

311/312 Hazard Categories:
Fire Hazard - No Pressure Hazard - No Reactivity Hazard - No Immediate Hazard - Yes Delayed Hazard - Yes

This material contains a chemical which requires export notification under TSCA Section 12[b]:

Ingredient (Category if applicable)	C.A.S. No	Regulation	Status
Pentane, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)-	132182-92-4	Toxic Substances Control Act (TSCA) 5 SNUR or Consent Order Chemicals	Applicable

This material contains a chemical regulated by an EPA Significant New Use Rule (TSCA Section 5)

Ingredient (Category if applicable)	C.A.S. No	Reference
Pentane, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)-	132182-92-4	40CFR721.10061

STATE REGULATIONS
Contact 3M for more information.

CHEMICAL INVENTORIES
The components of this product are in compliance with the chemical notification requirements of TSCA.

The components of this material are in compliance with the new chemical notification requirements for the Korean Existing Chemicals Inventory.

All the components of this product are listed on China's Inventory of Chemical Substances.

Contact 3M for more information.

INTERNATIONAL REGULATIONS

Contact 3M for more information.

This MSDS has been prepared to meet the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200.

SECTION 16: OTHER INFORMATION

NFPA Hazard Classification

Health: 3 **Flammability:** 1 **Reactivity:** 0 **Special Hazards:** None

National Fire Protection Association (NFPA) hazard ratings are designed for use by emergency response personnel to address the hazards that are presented by short-term, acute exposure to a material under conditions of fire, spill, or similar emergencies. Hazard ratings are primarily based on the inherent physical and toxic properties of the material but also include the toxic properties of combustion or decomposition products that are known to be generated in significant quantities.

HMIS Hazard Classification

Health: 1 **Flammability:** 1 **Reactivity:** 0 **Protection:** X - See PPE section.

Hazardous Material Identification System (HMIS®) hazard ratings are designed to inform employees of chemical hazards in the workplace. These ratings are based on the inherent properties of the material under expected conditions of normal use and are not intended for use in emergency situations. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint and Coatings Association (NPCA).

Revision Changes:
Section 15: Ingredient comment heading was deleted.
Section 15: Inventories comment was deleted.

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SECTION 1: PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: 3M™ Novec™ 7500 Engineered Fluid
MANUFACTURER: 3M
DIVISION: Electronics Markets Materials Division

ADDRESS: 3M Center, St. Paul, MN 55144-1000

EMERGENCY PHONE: 1-800-364-3577 or (651) 737-6501 (24 hours)

Issue Date: 10/14/11
Supercedes Date: 08/25/11

Document Group: 09-5959-3

Product Use:
Intended Use: Heat Transfer Fluid. For Industrial Use Only. Not Intended for Use as a Medical Device or Drug.

SECTION 2: INGREDIENTS

Ingredient	C.A.S. No.	% by Wt
3-ethoxy-1,1,1,2,3,4,4,5,5,6,6,6-dodecafluoro-2-trifluoromethyl-hexane	297730-93-9	> 99

SECTION 3: HAZARDS IDENTIFICATION

3.1 EMERGENCY OVERVIEW

Specific Physical Form: Liquid
Odor, Color, Grade: Clear, colorless, odorless
General Physical Form: Liquid
Immediate health, physical, and environmental hazards:

3.2 POTENTIAL HEALTH EFFECTS

Eye Contact:
Mild Eye Irritation: Signs/symptoms may include redness, pain, and tearing.

Skin Contact:

Contact with the skin during product use is not expected to result in significant irritation.

Inhalation:
If thermal decomposition occurs:
May be harmful if inhaled.

Ingestion:
No health effects are expected.

3.3 POTENTIAL ENVIRONMENTAL EFFECTS

This substance has chemical moieties that are resistant to biodegradation and is likely to only undergo partial biodegradation in the environment.
The high potential of this substance to move from water to the atmosphere means its potential to bioconcentrate is likely to disappear rapidly from aerobic environments. AQUATIC TOXICITY:

Testing results indicate that this product has insignificant toxicity to aquatic organisms at its saturation point (Lowest LC50, EC50, or IC50 > substance water solubility).

This substance is highly volatile and has a high Henry's Law constant and is thus expected to move rapidly through vaporization from solution in an aquatic compartment or from a soil surface in a terrestrial compartment to the atmosphere.

ATMOSPHERIC FATE:

Zero Oxone Depletion Potential (ODP).
Atmospheric Lifetime: ~2.2 years (based on reaction with OH radicals)
Global Warming Potential (GWP): 90 (100 year ITH) (IPCC1995 method)
Global Warming Potential (GWP): 100 (100 year ITH) (IPCC2001 method)

SECTION 4: FIRST AID MEASURES

4.1 FIRST AID PROCEDURES

The following first aid recommendations are based on an assumption that appropriate personal and industrial hygiene practices are followed.

Eye Contact: Flush eyes with large amounts of water. If signs/symptoms persist, get medical attention.
Skin Contact: Wash affected area with soap and water. If signs/symptoms develop, get medical attention.
Inhalation: If signs/symptoms develop, remove person to fresh air. If signs/symptoms persist, get medical attention.
If Swallowed: No need for first aid is anticipated.

SECTION 5: FIRE FIGHTING MEASURES

5.1 FLAMMABLE PROPERTIES

Autoignition temperature	330 ºC
Flash Point	No flash point
Flammable Limits(LEL)	*Not Applicable*
Flammable Limits(UEL)	*Not Applicable*

5.2 EXTINGUISHING MEDIA
Material will not burn.

5.3 PROTECTION OF FIRE FIGHTERS

Special Fire Fighting Procedures: Water may be used to blanket the fire. Wear full protective equipment (Bunker Gear) and a self-contained breathing apparatus (SCBA). Exposure to extreme heat can give rise to thermal decomposition.

Unusual Fire and Explosion Hazards: No unusual fire or explosion hazards are anticipated. No unusual effects are anticipated during fire extinguishing operations. Avoid breathing the products and substances that may result from the thermal decomposition of the product or the other substances in the fire zone. Keep containers cool with water spray when exposed to fire to avoid rupture.

Note: See STABILITY AND REACTIVITY (SECTION 10) for hazardous combustion and thermal decomposition information.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1. Personal precautions, protective equipment and emergency procedures
Evacuate unprotected and untrained personnel from hazard area. The spill should be cleaned up by qualified personnel. Ventilate the area with fresh air. For large spill, or spills in confined spaces, provide mechanical ventilation to disperse or exhaust vapors, in accordance with good industrial hygiene practice. Warning! A motor could be an ignition source and could cause flammable gases or vapors in the spill area to burn or explode.

6.2. Environmental precautions
For larger spills, cover drains and build dikes to prevent entry into sewer systems or bodies of water. Place in a metal container approved for transportation by appropriate authorities. Dispose of collected material as soon as possible.

Clean-up methods
Observe precautions from other sections. Call 3M- HELPS line (1-800-364-3577) for more information on handling and managing the spill. Contain spill. Working from around the edges of the spill inward, cover with bentonite, vermiculite, or commercially available inorganic absorbent material. Mix in sufficient absorbent until it appears dry. Collect as much of the spilled material as possible. Clean up residue. Seal the container.

In the event of a release of this material, the user should determine if the release qualifies as reportable according to local, state, and federal regulations.

SECTION 7: HANDLING AND STORAGE

7.1 HANDLING
Avoid breathing of vapors, mists or spray. Use general dilution ventilation and/or local exhaust ventilation to control airborne exposures to below Occupational Exposure Limits. If ventilation is not adequate, use respiratory protection equipment. Avoid skin contact with hot material. Do not breathe thermal decomposition products. No smoking: Smoking while using this product can result in contamination of the tobacco and/or smoke and lead to the formation of the hazardous decomposition products mentioned in the Reactivity Data section of this MSDS. Store work clothes separately from other clothing, food and tobacco products. Avoid continuous exposure of the material to extreme conditions of heat, i.e., above 150 C (welding, open flame, misuse or equipment failure). Avoid exceeding a watt density of 50 watts/inch2 from a heater surface. Continuous exposure to 150 C results in very slight decomposition of this product and therefore, is a very conservative use temperature threshold. Applications involving exposure of the fluid to temperatures exceeding 150 C or watt densities exceeding 50 watts/inch2 have been safely implemented. Applications which may exceed these use parameters should be reviewed with 3M Technical Service.

7.2 STORAGE
Keep container tightly closed. Keep container in well-ventilated area. Store away from heat. Store away from strong bases.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 ENGINEERING CONTROLS

Use with appropriate local exhaust ventilation. Provide local exhaust ventilation at transfer points. Provide appropriate local exhaust when product is heated. For those situations where the fluid might be exposed to extreme overheating due to misuse or equipment failure, use with appropriate local exhaust ventilation sufficient to maintain levels of thermal decomposition products below their exposure guidelines.

8.2 PERSONAL PROTECTIVE EQUIPMENT (PPE)

8.2.1 Eye/Face Protection

Avoid eye contact.
The following eye protection(s) are recommended: Safety Glasses with side shields
.

8.2.2 Skin Protection

Avoid skin contact with hot material.

Wear appropriate gloves when handling hot material to prevent thermal burns.

8.2.3 Respiratory Protection

Under normal use conditions, airborne exposures are not expected to be significant enough to require respiratory protection. Avoid breathing of vapors, mists or spray. Use a positive pressure supplied-air respirator if there is a potential for exposure from an uncontrolled release, exposure levels are not known, or under any other circumstances where air-purifying respirators may not provide adequate protection.

If thermal decomposition products are expected, use fullface supplied air respirator.

8.2.4 Prevention of Swallowing

Do not eat, drink or smoke when using this product. Wash exposed areas thoroughly with soap and water.

8.3 EXPOSURE GUIDELINES

Ingredient	Authority	Type	Limit	Additional Information
3-ethoxy-1,1,1,2,3,4,4,5,5,6,6,6-dodecafluoro-2-trifluoromethyl-hexane	Manufacturer determined	TWA	100 ppm	

SOURCE OF EXPOSURE LIMIT DATA:
ACGIH: American Conference of Governmental Industrial Hygienists
CMRG: Chemical Manufacturer Recommended Guideline
OSHA: Occupational Safety and Health Administration
AIHA: American Industrial Hygiene Association Workplace Environmental Exposure Level (WEEL)

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Specific Physical Form:	Liquid
Odor, Color, Grade:	Clear, colorless, odorless
General Physical Form:	Liquid
Autoignition temperature	330 ºC
Flash Point	No flash point
Flammable Limits(LEL)	*Not Applicable*
Flammable Limits(UEL)	*Not Applicable*
Boiling Point	129 ºC

Density	1.63 g/ml [@ 20 ºC]
Vapor Density	Approximately 14.3 [*Ref Std:* AIR=1]
Vapor Pressure	847 Pa [@ 20 ºC]
Specific Gravity	1.63 [*Ref Std:* WATER=1]
pH	*Not Applicable*
Melting point	-100 ºC
Solubility In Water	< 0.004 ppm
Evaporation rate	*No Data Available*
Volatile Organic Compounds	[*Details:* Exempt]
Kow - Oct/Water partition coef	5.75
Percent volatile	100 %
VOC Less H2O & Exempt Solvents	[*Details:* Exempt]
Viscosity	.77 centistoke [@ 25 ºC]

SECTION 10: STABILITY AND REACTIVITY

Stability: Stable.

Materials and Conditions to Avoid:
10.1 Conditions to avoid
None known

10.2 Materials to avoid
Strong bases

Additional Information: Avoid continuous exposure to temperatures exceeding 150C

Hazardous Polymerization: Hazardous polymerization will not occur.

Hazardous Decomposition or By-Products

Substance	Condition
Hydrogen Fluoride	At Elevated Temperatures - extreme conditions of heat
Irritant Vapors or Gases	At Elevated Temperatures - extreme conditions of heat
Toxic Vapor, Gas, Particulate	At Elevated Temperatures - extreme conditions of heat

SECTION 11: TOXICOLOGICAL INFORMATION

Please contact the address listed on the first page of the MSDS for Toxicological Information on this material and/or its components.

SECTION 12: ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION

Not determined.

CHEMICAL FATE INFORMATION

Not determined.
See Section 3.3 - Potential Environmental Effects

SECTION 13: DISPOSAL CONSIDERATIONS

Waste Disposal Method: Reclaim if feasible. Incinerate in an industrial or commercial facility in the presence of a combustible material. As a disposal alternative, incinerate in an industrial or commercial facility in the presence of a combustible material. As a disposal alternative, dispose of waste product in a facility permitted to accept chemical waste. Combustion products will include HF. Facility must be capable of handling halogenated materials.

EPA Hazardous Waste Number (RCRA): Not regulated

Since regulations vary, consult applicable regulations or authorities before disposal.

SECTION 14:TRANSPORT INFORMATION

ID Number(s):
98-0212-2928-5, 98-0212-2929-3, 98-0212-2930-1, 98-0212-2932-7, 98-0212-3465-7

Not regulated per U.S. DOT, IATA or IMO.

These transportation classifications are provided as a customer service. As the shipper YOU remain responsible for complying with all applicable laws and regulations, including proper transportation classification and packaging. *3M transportation classifications are based on product formulation, packaging, 3M policies and 3M understanding of applicable current regulations. 3M does not guarantee the accuracy of this classification information. This information applies only to transportation classification and* ***not*** ***the packaging, labeling, or marking requirements.*** *The original 3M package is certified for U.S. ground shipment only. If you are shipping by air or ocean, the package may not meet applicable regulatory requirements.*

SECTION 15: REGULATORY INFORMATION

US FEDERAL REGULATIONS
Contact 3M for more information.

311/312 Hazard Categories:
Fire Hazard - No Pressure Hazard - No Reactivity Hazard - No Immediate Hazard - Yes Delayed Hazard - No

STATE REGULATIONS
Contact 3M for more information.

CHEMICAL INVENTORIES
The components of this product are in compliance with the chemical notification requirements of TSCA.

The components of this product are in compliance with notification requirements in the Philippines.

All the components of this product are listed on China's Inventory of Chemical Substances.

The components of this material are in compliance with the new chemical notification requirements for the Korean Existing Chemicals Inventory.

Contact 3M for more information.

INTERNATIONAL REGULATIONS

Contact 3M for more information.

This MSDS has been prepared to meet the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200.

SECTION 16: OTHER INFORMATION

NFPA Hazard Classification

Health: 3 **Flammability:** 1 **Reactivity:** 0 **Special Hazards:** None

National Fire Protection Association (NFPA) hazard ratings are designed for use by emergency response personnel to address the hazards that are presented by short-term, acute exposure to a material under conditions of fire, spill, or similar emergencies. Hazard ratings are primarily based on the inherent physical and toxic properties of the material but also include the toxic properties of combustion or decomposition products that are known to be generated in significant quantities.

HMIS Hazard Classification

Health: 1 **Flammability:** 1 **Reactivity:** 0 **Protection:** X - See PPE section.

Hazardous Material Identification System (HMIS®) hazard ratings are designed to inform employees of chemical hazards in the workplace. These ratings are based on the inherent properties of the material under expected conditions of normal use and are not intended for use in emergency situations. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint and Coatings Association (NPCA).

Revision Changes:
Section 9: Property description for optional properties was modified.
Section 8: Exposure guidelines ingredient information was modified.

DISCLAIMER: The information in this Material Safety Data Sheet (MSDS) is believed to be correct as of the date issued. 3M MAKES NO WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR COURSE OF PERFORMANCE OR USAGE OF TRADE. User is responsible for determining whether the 3M product is fit for a particular purpose and suitable for user's method of use or application. Given the variety of factors that can affect the use and application of a 3M product, some of which are uniquely within the user's knowledge and control, it is essential that the user evaluate the 3M product to determine whether it is fit for a particular purpose and suitable for user's method of use or application.

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3M USA MSDSs are available at www.3M.com

MSDS Number: **M3588** * * * * * *Effective Date:* ***07/06/06*** * * * * * *Supercedes:* ***08/17/05***

MSDS MATERIAL SAFETY DATA SHEET **CHEMTREC:** 800-424-9300 (USA)
---------- 703-527-3887(Outside USA and Canada)
CANUTEC: 613-996-6666

From: Mallinckrodt Baker, Inc
222 Red School Lane
Phillipsburg, NJ 08865

NOTE: Use CHEMTREC and CANUTEC phone numbers only in the event of a chemical emergency.

Emergency Telephone Number: 908-859-2151

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

M A L L I N C K R O D T **J. T. B A K E R**

METHYL ISOBUTYL KETONE

1. Product Identification

Synonyms: 2-Pentanone,4-methyl-; Hexone; MIBK; Isopropylacetone
CAS No.: 108-10-1
Molecular Weight: 100.16
Chemical Formula: CH3COCH2CH(CH3)2
Product Codes:
J.T. Baker: 4855, 5384, 9212, 9320, 9322, 9405
Mallinckrodt: 5923, 6247, 6264

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Methyl Isobutyl Ketone	108-10-1	90 - 100%	Yes

3. Hazards Identification

Emergency Overview

DANGER! HARMFUL OR FATAL IF SWALLOWED. FLAMMABLE LIQUID AND VAPOR. MAY FORM EXPLOSIVE PEROXIDES IN AIR. HARMFUL IF INHALED. AFFECTS CENTRAL NERVOUS SYSTEM, LIVER AND KIDNEYS. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate (Life)
Flammability Rating: 3 - Severe (Flammable)
Reactivity Rating: 2 - Moderate
Contact Rating: 2 - Moderate
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES; CLASS B

EXTINGUISHER
Storage Color Code: Red (Flammable)

Potential Health Effects

Inhalation:
Causes irritation to the nose and throat. Concentrations above the TLV may cause headache, dizziness, nausea, shortness of breath, and vomiting. Higher concentrations may cause central nervous system depression and unconsciousness.
Ingestion:
May produce abdominal pain, nausea. Aspiration into lungs can produce severe lung damage and is a medical emergency. Other symptoms expected to parallel inhalation.
Skin Contact:
Causes irritation to skin. Symptoms include redness, itching, and pain.
Eye Contact:
Vapors can irritate the eyes. Splashes cause severe pain and irritation.
Chronic Exposure:
Prolonged skin contact may defat the skin and produce dermatitis. Based on animal studies, chronic exposure may affect liver and kidneys.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders, eye problems, impaired respiratory function or central nervous system conditions may be more susceptible to the effects of this substance.

---

4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
Ingestion:
Aspiration hazard. If swallowed, vomiting may occur spontaneously, but DO NOT INDUCE. If vomiting occurs, keep head below hips to prevent aspiration into lungs. Never give anything by mouth to an unconscious person. Call a physician immediately.
Skin Contact:
Immediately flush skin with plenty of soap and water for at least 15 minutes. Remove contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention.

---

5. Fire Fighting Measures

Fire:
Flash point: 14C (57F) CC
Autoignition temperature: 448C (838F)
Flammable limits in air % by volume:
lel: 1.2; uel: 8.0
Flammable Liquid
Explosion:
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Vapors can flow along surfaces to distant ignition source and flash back. Contact with strong oxidizers may cause fire. Sealed containers may rupture when heated. Sensitivity to mechanical impact: Yes, if peroxides are formed. Sensitive to static discharge.
Fire Extinguishing Media:
Dry chemical, foam or carbon dioxide. Water may be ineffective. Water spray may be used to keep fire exposed containers cool, dilute spills to nonflammable mixtures, protect personnel attempting to stop leak and disperse vapors.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! If a leak or spill has not ignited, use water spray to disperse the vapors, to protect personnel attempting to stop leak, and to flush spills away from exposures. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker SOLUSORB® solvent adsorbent is recommended for spills of this product.

7. Handling and Storage

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from incompatibles. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment, including explosion proof ventilation. Before using bulk quantities of this material, test for presence of explosive peroxides. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL):
100 ppm (TWA)

-ACGIH Threshold Limit Value (TLV):
50 ppm (TWA), 75 ppm (STEL)
Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, a full facepiece respirator with organic vapor cartridge may be worn up to 50 times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact. Polyvinyl alcohol (PVA) is a recommended material for personal protective equipment.
Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:
Clear, colorless liquid.
Odor:

Slight camphor odor
Solubility:
Moderately soluble in water (1-10%).
Specific Gravity:
0.80 @ 20C
pH:
No information found.
% Volatiles by volume @ 21C (70F):
100
Boiling Point:
117C (243F)
Melting Point:
-85C (-121F)
Vapor Density (Air=1):
3.5
Vapor Pressure (mm Hg):
16 @ 20C (68F)
Evaporation Rate (BuAc=1):
1.6

---

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage. May form explosive peroxides in air.
Hazardous Decomposition Products:
Carbon dioxide and carbon monoxide may form when heated to decomposition.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Aldehydes, Nitric Acid, Perchloric Acid, Strong Oxidizers. Violent reaction with Potassium-tert-butoxide.
Conditions to Avoid:
Heat, flame, ignition sources, air, incompatibles

---

11. Toxicological Information

Oral rat LD50: 2080 mg/kg; Skin rabbit > 20 mL/kg; irritation eye rabbit, Standard Draize, 40 mg severe; investigated as a reproductive effector.

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--------\Cancer Lists\-----------------------------------------------------
                                        ---NTP Carcinogen---
Ingredient                              Known    Anticipated    IARC Category
-------------------------------------   -----    -----------    -------------
Methyl Isobutyl Ketone (108-10-1)        No          No            None
```

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12. Ecological Information

Environmental Fate:
When released into the soil, this material may biodegrade to a moderate extent. When released into the soil, this material may leach into groundwater. When released into the soil, this material may evaporate to a moderate extent. When released into water, this material may evaporate to a moderate extent. This material has an estimated bioconcentration factor (BCF) of less than 100. This material is not expected to significantly bioaccumulate. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material is expected to be readily degraded by photolysis. When released into the air, this material is expected to have a half-life between 1 and 10 days.
Environmental Toxicity:
This material is not expected to be toxic to terrestrial life. The LC50/96-hour values for fish are over 100 mg/l.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: METHYL ISOBUTYL KETONE
Hazard Class: 3
UN/NA: UN1245
Packing Group: II
Information reported for product/size: 20L

International (Water, I.M.O.)

Proper Shipping Name: METHYL ISOBUTYL KETONE
Hazard Class: 3
UN/NA: UN1245
Packing Group: II
Information reported for product/size: 20L

15. Regulatory Information

```
--------\Chemical Inventory Status - Part 1\---------------------------------
Ingredient                                      TSCA  EC   Japan  Australia
----------------------------------------------  ----  ---  -----  ---------
Methyl Isobutyl Ketone (108-10-1)                Yes  Yes   Yes      Yes

--------\Chemical Inventory Status - Part 2\---------------------------------
                                                        --Canada--
Ingredient                                      Korea  DSL   NDSL  Phil.
----------------------------------------------  -----  ---   ----  -----
Methyl Isobutyl Ketone (108-10-1)                Yes   Yes   No     Yes

--------\Federal, State & International Regulations - Part 1\----------------
                                          -SARA 302-    ------SARA 313------
Ingredient                                RQ    TPQ     List  Chemical Catg.
----------------------------------------  ---   -----   ----  --------------
Methyl Isobutyl Ketone (108-10-1)         No    No      Yes        No

--------\Federal, State & International Regulations - Part 2\----------------
                                                        -RCRA-    -TSCA-
Ingredient                                CERCLA     261.33     8(d)
----------------------------------------  ------     ------    ------
Methyl Isobutyl Ketone (108-10-1)         5000       U161       No


Chemical Weapons Convention:  No     TSCA 12(b):  No     CDTA:  Yes
SARA 311/312:  Acute: Yes      Chronic: Yes  Fire: Yes Pressure: No
Reactivity: Yes         (Pure / Liquid)
```

Australian Hazchem Code: 3[Y]E
Poison Schedule: S5
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the

MSDS contains all of the information required by the CPR.

---

16. Other Information

NFPA Ratings: Health: **2** Flammability: **3** Reactivity: **1**
Label Hazard Warning:
DANGER! HARMFUL OR FATAL IF SWALLOWED. FLAMMABLE LIQUID AND VAPOR. MAY FORM EXPLOSIVE PEROXIDES IN AIR. HARMFUL IF INHALED. AFFECTS CENTRAL NERVOUS SYSTEM, LIVER AND KIDNEYS. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT.
Label Precautions:
Keep away from heat, sparks and flame.
Avoid contact with eyes, skin and clothing.
Avoid breathing vapor.
Keep container tightly closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Label First Aid:
Aspiration hazard. If swallowed, vomiting may occur spontaneously, but DO NOT INDUCE. If vomiting occurs, keep head below hips to prevent aspiration into lungs. Never give anything by mouth to an unconscious person. Call a physician immediately. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. Get medical attention.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 3.
Disclaimer:
****

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****

Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

Material Safety Data Sheet
Methyl ethyl ketone

ACC# 14460

Section 1 - Chemical Product and Company Identification

MSDS Name: Methyl ethyl ketone
Catalog Numbers: AC149670200, AC149670250, AC9565367, S80081, BP209RB-115, BP209RB-19, BP209RB-200, BP209RB-50, BP209RS-200, BP209RS-50, BPM209RB-115, BPM209RB-19, BPM209RB-200, BPM209RB-50, BPM209RS-200, BPM209RS-28, BPM209RS-50, DWM2084, H209RB115, H209RB19, H209RB200, M208 1, M208 20, M208 4, M208-1, M208-20, M208-4, M2081, M20820, M2084, M209 1, M209 20, M209 4, M209 500, M209-1, M209-20, M209-200, M209-4, M209-500, M2091, M20920, M209200, M20920LC, M2094, M2094LC, M209500, M209FB115, M209FB19, M209FB200, M209FB50, M209RB115, M209RB19, M209RB200, M209RS115, M209RS200, M209RS50, M209S 4, M209S-4, M209S4, M209SS115, M209SS200, M209SS28, M209SS50
Synonyms: 2-Butanone; Ethyl methyl ketone; MEK; Methyl ethyl ketone.
Company Identification:
Fisher Scientific
1 Reagent Lane
Fair Lawn, NJ 07410
For information, call: 201-796-7100
Emergency Number: 201-796-7100
For CHEMTREC assistance, call: 800-424-9300
For International CHEMTREC assistance, call: 703-527-3887

Section 2 - Composition, Information on Ingredients

CAS#	Chemical Name	Percent	EINECS/ELINCS
78-93-3	Methyl ethyl ketone	>99%	201-159-0

Hazard Symbols: XI F
Risk Phrases: 11 36 66 67

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Appearance: colorless liquid. Flash Point: -7 deg C. **Danger!** May cause respiratory tract irritation. May cause severe eye and skin irritation with possible burns. May cause fetal effects. May cause central nervous system effects. Extremely flammable liquid and vapor. Vapor may cause flash fire.
Target Organs: Central nervous system, eyes, skin, mucous membranes.

Potential Health Effects
Eye: Causes eye irritation. May result in corneal injury.
Skin: May be absorbed through the skin in harmful amounts. Prolonged and/or repeated contact may cause irritation and/or dermatitis.

Ingestion: May cause irritation of the digestive tract. May cause central nervous system depression, characterized by excitement, followed by headache, dizziness, drowsiness, and nausea. Advanced stages may cause collapse, unconsciousness, coma and possible death due to respiratory failure.
Inhalation: Inhalation of high concentrations may cause central nervous system effects characterized by nausea, headache, dizziness, unconsciousness and coma. Causes respiratory tract irritation. Irritation may lead to chemical pneumonitis and pulmonary edema. May cause numbness in the extremities.
Chronic: Chronic inhalation may cause effects similar to those of acute inhalation. Prolonged or repeated skin contact may cause defatting and dermatitis. Animal studies have reported that fetal effects/abnormalities may occur when maternal toxicity is seen.

Section 4 - First Aid Measures

Eyes: Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid immediately. Do NOT allow victim to rub or keep eyes closed.
Skin: Get medical aid. Rinse area with large amounts of water for at least 15 minutes. Remove contaminated clothing and shoes.
Ingestion: Do NOT induce vomiting. If victim is conscious and alert, give 2-4 cupfuls of milk or water. Get medical aid immediately.
Inhalation: Get medical aid immediately. Remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Do NOT use mouth-to-mouth resuscitation. If breathing has ceased apply artificial respiration using oxygen and a suitable mechanical device such as a bag and a mask.
Notes to Physician: Treat symptomatically and supportively.

Section 5 - Fire Fighting Measures

General Information: As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Vapors can travel to a source of ignition and flash back. During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion. Flammable Liquid. Can release vapors that form explosive mixtures at temperatures above the flashpoint. Use water spray to keep fire-exposed containers cool. Water may be ineffective. Material is lighter than water and a fire may be spread by the use of water. Vapors may be heavier than air. They can spread along the ground and collect in low or confined areas. May polymerize explosively when involved in a fire. Containers may explode when heated.
Extinguishing Media: For small fires, use dry chemical, carbon dioxide, water spray or alcohol-resistant foam. For large fires, use water spray, fog, or alcohol-resistant foam. Do NOT use straight streams of water. Cool containers with flooding quantities of water until well after fire is out.

Section 6 - Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks: Absorb spill with inert material (e.g. vermiculite, sand or earth), then place in suitable container. Avoid runoff into storm sewers and ditches which lead to waterways. Clean up spills immediately, observing precautions in the Protective Equipment section. Remove all sources of ignition. Use a spark-proof tool. Provide ventilation.

Section 7 - Handling and Storage

Handling: Use only in a well-ventilated area. Ground and bond containers when transferring material. Avoid contact with eyes, skin, and clothing. Empty containers retain product residue, (liquid and/or vapor), and can be dangerous. Keep container tightly closed. Avoid contact with heat, sparks and flame. Avoid ingestion and inhalation. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose empty containers to heat, sparks or open flames.
Storage: Keep away from sources of ignition. Store in a cool, dry, well-ventilated area away from incompatible substances. Flammables-area.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls: Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits.
Exposure Limits

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Methyl ethyl ketone	200 ppm TWA; 300 ppm STEL	200 ppm TWA; 590 mg/m3 TWA 3000 ppm IDLH	200 ppm TWA; 590 mg/m3 TWA

OSHA Vacated PELs: Methyl ethyl ketone: 200 ppm TWA; 590 mg/m3 TWA; 300 ppm STEL; 885 mg/m3 STEL
Personal Protective Equipment
Eyes: Wear chemical goggles.
Skin: Wear appropriate protective gloves to prevent skin exposure.
Clothing: Wear appropriate protective clothing to prevent skin exposure.
Respirators: Follow the OSHA respirator regulations found in 29CFR 1910.134 or European Standard EN 149. Always use a NIOSH or European Standard EN 149 approved respirator when necessary.

Section 9 - Physical and Chemical Properties

Physical State: Liquid
Appearance: colorless liquid
Odor: sweetish odor - alcohol-like
pH: Not available.
Vapor Pressure: 71.2 mm Hg
Vapor Density: 2.5 (Air=1)
Evaporation Rate:2.7 (Ether=1)
Viscosity: 0.42 mPas 15 deg C
Boiling Point: 80 deg C @ 760mm Hg
Freezing/Melting Point:-87 deg C
Autoignition Temperature: 404 deg C (759.20 deg F)
Flash Point: -7 deg C (19.40 deg F)
Decomposition Temperature: Not available.
NFPA Rating: (estimated) Health: 1; Flammability: 3; Reactivity: 0
Explosion Limits, Lower:1.4 vol%@200F
Upper: 11.4 vol%@200F
Solubility: miscible with oils
Specific Gravity/Density:.8050g/cm3

Molecular Formula:C4H8O
Molecular Weight:72.11

Section 10 - Stability and Reactivity

Chemical Stability: Stable at room temperature in closed containers under normal storage and handling conditions.
Conditions to Avoid: Incompatible materials, ignition sources, excess heat.
Incompatibilities with Other Materials: Strong oxidizing agents, amines, ammonia, copper, isocyanates, caustics (e.g. ammonia, ammonium hydroxide, calcium hydroxide, potassium hydroxide, sodium hydroxide), chlorosulfonic acid, fuming sulfuric acid, potassium-tert-butoxide, pyridine, chloroform + alkali, hydrogen peroxides + nitric acid, 2-propanol, inorganic acids.
Hazardous Decomposition Products: Carbon monoxide, irritating and toxic fumes and gases, carbon dioxide.
Hazardous Polymerization: Has not been reported.

Section 11 - Toxicological Information

RTECS#:
CAS# 78-93-3: EL6475000
LD50/LC50:
CAS# 78-93-3:
Draize test, rabbit, skin: 500 mg/24H Moderate;
Draize test, rabbit, skin: 402 mg/24H Mild;
Inhalation, mouse: LC50 = 32 gm/m3/4H;
Inhalation, rat: LC50 = 23500 mg/m3/8H;
Oral, mouse: LD50 = 4050 mg/kg;
Oral, rat: LD50 = 2737 mg/kg;
Skin, rabbit: LD50 = 6480 mg/kg;
Carcinogenicity:
CAS# 78-93-3: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.
Epidemiology: No information available.
Teratogenicity: Embryo or Fetus: fetotoxicity, ihl-rat TCLo=1000 ppm. Specific Developmental Abnormalities: craniofacial and urogenital, ihl-rat TCLo=3000 ppm/7H; musculoskeletal, ihl-rat TCLo=1000 ppm.
Reproductive Effects: No information available.
Neurotoxicity: No information available.
Mutagenicity: Sex chromosome loss/non-disjunction: S. cerevisiae 33800 ppm.
Other Studies: See actual entry in RTECS for complete information.

Section 12 - Ecological Information

Ecotoxicity: Fish: Fathead Minnow: LC50 = 3220 mg/L; 96 Hr; Unspecified Bluegill/Sunfish: LC50 = 1690 mg/L; 96 Hr; Unspecified ria: Phytobacterium phosphoreum: EC50 = 51.9 mg/L; 25 min; Microtox test ria: Phytobacterium phosphoreum: EC50 =3373 mg/L; 30 min; Microtox test Fathead minnow LC50=3220 mg/L/96H Bluegill TLm=5640 to 1690 mg/L/24 to 96H
Environmental: Substance evaporates in water with T1/2= 3D (rivers) to 12D (lakes). Substance is not expected to bioconcentrate in aquatic organisms.
Physical: Substance photodegrades in air with T1/2 = 2.3 days.

Other: None information available.

Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.
RCRA P-Series: None listed.
RCRA U-Series: CAS# 78-93-3: waste number U159; (Ignitable waste, Toxic waste).

Section 14 - Transport Information

	US DOT	IATA	RID/ADR	IMO	Canada TDG
Shipping Name:	METHYL ETHYL KETONE				METHYL ETHYL KETONE
Hazard Class:	3				3
UN Number:	UN1193				UN1193
Packing Group:	II				II
Additional Info:					FLASHPOINT -9C

Section 15 - Regulatory Information

US FEDERAL

TSCA
CAS# 78-93-3 is listed on the TSCA inventory.
Health & Safety Reporting List
CAS# 78-93-3: Effective Date: October 4, 1982; Sunset Date: October 4, 1992
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.
SARA

Section 302 (RQ)
CAS# 78-93-3: final RQ = 5000 pounds (2270 kg)
Section 302 (TPQ)
None of the chemicals in this product have a TPQ.
SARA Codes
CAS # 78-93-3: acute, flammable.
Section 313
This material contains Methyl ethyl ketone (CAS# 78-93-3, 99%),which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.
Clean Air Act:

CAS# 78-93-3 is listed as a hazardous air pollutant (HAP). This material does not contain any Class 1 Ozone depletors. This material does not contain any Class 2 Ozone depletors.

Clean Water Act:

None of the chemicals in this product are listed as Hazardous Substances under the CWA. None of the chemicals in this product are listed as Priority Pollutants under the CWA. None of the chemicals in this product are listed as Toxic Pollutants under the CWA.

OSHA:

None of the chemicals in this product are considered highly hazardous by OSHA.

STATE

CAS# 78-93-3 can be found on the following state right to know lists: California, New Jersey, Florida, Pennsylvania, Minnesota, Massachusetts.

California No Significant Risk Level: None of the chemicals in this product are listed.

European / International Regulations

European Labeling in Accordance with EC Directives

Hazard Symbols:

XI F

Risk Phrases:

R 11 Highly flammable.
R 36 Irritating to eyes.
R 66 Repeated exposure may cause skin dryness or cracking.
R 67 Vapors may cause drowsiness and dizziness.

Safety Phrases:

S 16 Keep away from sources of ignition - No smoking.
S 9 Keep container in a well-ventilated place.

WGK (Water Danger / Protection)

CAS# 78-93-3: 1

Canada

CAS# 78-93-3 is listed on Canada's DSL List. CAS# 78-93-3 is listed on Canada's DSL List.
This product has a WHMIS classification of B2, D2A.
CAS# 78-93-3 is listed on Canada's Ingredient Disclosure List.

Exposure Limits

CAS# 78-93-3: OEL-AUSTRALIA:TWA 150 ppm (445 mg/m3);STEL 300 ppm (890 mg/m3) OEL-AUSTRIA:TWA 200 ppm (590 mg/m3) OEL-BELGIUM:TWA 200 ppm (590 mg/m3);STEL 300 ppm (885 mg/m3) OEL-DENMARK:TWA 100 ppm (290 mg/m3);Skin OEL-FINLAND:TWA 150 ppm (440 mg/m3);STEL 190 ppm;Skin OEL-FRANCE:TWA 200 ppm (600 mg/m3);Skin OEL-GERMANY:TWA 200 ppm (590 mg/m3) OEL-HUNGARY:TWA 200 mg/m3;STEL 600 mg/m3 OEL-INDIA:TWA 200 ppm (590 mg/m3);STEL 300 ppm (885 mg/m3) OEL-JAPAN:TWA 200 ppm (590 mg/m3) OEL-THE NETHERLANDS:TWA 200 ppm (590 mg/m3) OEL-THE PHILIPPINES:TWA 200 ppm (590 mg/m3) OEL-POLAND:TWA 200 mg/m3 OEL-RUSSIA:TWA 200 ppm; STEL 200 mg/m3 OEL-SWEDEN:TWA 50 ppm (150 mg/m3);STEL 100 ppm (300 mg/m3) OEL-SWITZERLAND:TWA 200 ppm (590 mg/m3);STEL 400 ppm OEL-TURKEY:TWA 200 ppm (590 mg/m3) OEL-UNITED KINGDOM:TWA 200 ppm (590 mg/m3);STEL 300 ppm OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA check ACGIH TLV
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM check ACGI TLV

Section 16 - Additional Information

MSDS Creation Date: 7/21/1999
Revision #4 Date: 3/14/2001

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no

liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.

SAFETY DATA SHEET

Methanol (Methyl Alcohol)

Section 1. Identification

GHS product identifier : Methanol (Methyl Alcohol)

Chemical name : methanol

Other means of identification : Methyl alcohol

Product use : Synthetic/Analytical chemistry.

Synonym : Methyl alcohol

SDS # : 001065

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Emergency telephone number (with hours of operation) : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : FLAMMABLE LIQUIDS - Category 2
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (respiratory tract) - Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Highly flammable liquid and vapor.
May displace oxygen and cause rapid suffocation.
Corrosive to the respiratory tract.

Precautionary statements

General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking. Use explosion-proof electrical, ventilating, lighting and all material-handling equipment. Use only non-sparking tools. Take precautionary measures against static discharge. Keep container tightly closed. Use only outdoors or in a well-ventilated area. Avoid breathing vapor.

Response : IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or physician if you feel unwell. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower.

Storage : Store locked up. Store in a well-ventilated place. Keep cool.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

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Section 2. Hazards identification

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : methanol

Other means of identification : Methyl alcohol

CAS number/other identifiers

CAS number : 67-56-1

Product code : 001065

Ingredient name	%	CAS number
methanol	100	67-56-1

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention if irritation occurs.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention. If necessary, call a poison center or physician. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : May cause respiratory irritation.

Skin contact : No known significant effects or critical hazards.

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Section 4. First aid measures

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : No known significant effects or critical hazards.

Over-exposure signs/symptoms

Eye contact : No specific data.

Inhalation : Adverse symptoms may include the following:
respiratory tract irritation
coughing

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use dry chemical, CO_2, water spray (fog) or foam.

Unsuitable extinguishing media : Do not use water jet.

Specific hazards arising from the chemical : Highly flammable liquid and vapor. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. The vapor/gas is heavier than air and will spread along the ground. Vapors may accumulate in low or confined areas or travel a considerable distance to a source of ignition and flash back. Runoff to sewer may create fire or explosion hazard.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

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Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not ingest. Avoid contact with eyes, skin and clothing. Avoid breathing vapor or mist. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Take precautionary measures against electrostatic discharges. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

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Section 7. Handling and storage

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
methanol	**ACGIH TLV (United States, 3/2012).** **Absorbed through skin.** STEL: 328 mg/m³ 15 minutes. STEL: 250 ppm 15 minutes. TWA: 262 mg/m³ 8 hours. TWA: 200 ppm 8 hours. **NIOSH REL (United States, 1/2013).** **Absorbed through skin.** STEL: 325 mg/m³ 15 minutes. STEL: 250 ppm 15 minutes. TWA: 260 mg/m³ 10 hours. TWA: 200 ppm 10 hours. **OSHA PEL (United States, 6/2010).** TWA: 260 mg/m³ 8 hours. TWA: 200 ppm 8 hours. **OSHA PEL 1989 (United States, 3/1989).** **Absorbed through skin.** STEL: 325 mg/m³ 15 minutes. STEL: 250 ppm 15 minutes. TWA: 260 mg/m³ 8 hours. TWA: 200 ppm 8 hours.

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

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Section 8. Exposure controls/personal protection

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: safety glasses with side-shields.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid. [CLEAR, COLORLESS, FLAMMABLE, POISONOUS LIQUID WITH CHARACTERISTIC PUNGENT ODOR]

Color : Colorless. Clear.

Molecular weight : 32.05 g/mole

Molecular formula : C-H4-O

Boiling/condensation point : 64.7°C (148.5°F)

Melting/freezing point : -97.8°C (-144°F)

Critical temperature : Not available.

Odor : Characteristic.

Odor threshold : Not available.

pH : Not available.

Flash point : Closed cup: 9.7°C (49.5°F)

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : 2.1 (butyl acetate = 1)

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Lower: 6%
Upper: 44%

Vapor pressure : 16.9 kPa (126.963291808 mm Hg) [room temperature]

Vapor density : 1.1 (Air = 1)

Specific Volume (ft ^{3}/lb) :

Gas Density (lb/ft ^{3}) : Not available.

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Section 9. Physical and chemical properties

Relative density : 0.79

Solubility : Not available.

Solubility in water : 1000 g/l

Partition coefficient: n-octanol/water : -0.77

Auto-ignition temperature : 455°C (851°F)

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Dynamic (room temperature): 0.544 to 0.59 mPa·s (0.544 to 0.59 cP)

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Do not allow vapor to accumulate in low or confined areas.

Incompatibility with various substances : Extremely reactive or incompatible with the following materials: oxidizing materials.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
methanol	LC50 Inhalation Gas. LC50 Inhalation Gas.	Rat Rat	145000 ppm 64000 ppm	1 hours 4 hours

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
methanol	Eyes - Moderate irritant Eyes - Moderate irritant Skin - Moderate irritant	Rabbit Rabbit Rabbit	- - -	24 hours 100 milligrams 40 milligrams 24 hours 20 milligrams	- - -

Sensitization

Not available.

Mutagenicity

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Section 11. Toxicological information

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Name	Category	Route of exposure	Target organs
methanol	Category 3	Not applicable.	Respiratory tract irritation

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : No known significant effects or critical hazards.

Inhalation : May cause respiratory irritation.

Skin contact : No known significant effects or critical hazards.

Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : No specific data.

Inhalation : Adverse symptoms may include the following:
respiratory tract irritation
coughing

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

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Section 11. Toxicological information

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Not available.

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
methanol	-0.77	<10	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Vapor from product residues may create a highly flammable or explosive atmosphere inside the container. Do not cut, weld or grind used containers unless they have been cleaned thoroughly internally. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

United States - RCRA Toxic hazardous waste "U" List

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Section 13. Disposal considerations

Ingredient	CAS #	Status	Reference number
Methanol (l); Methyl alcohol (l)	67-56-1	Listed	U154

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1230	UN1230	UN1230	UN1230	UN1230
UN proper shipping name	METHANOL	METHANOL	METHANOL	METHANOL	METHANOL
Transport hazard class(es)	3	3	3	3 (6.1)	3 (6.1)
Packing group	II	II	-	II	II
Environment	No.	No.	No.	No.	No.
Additional information	**Reportable quantity** 5000 lbs / 2270 kg [759.08 gal / 2873.4 L] Package sizes shipped in quantities less than the product reportable quantity are not subject to the RQ (reportable quantity) transportation requirements. **Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: 1 L **Cargo aircraft** Quantity limitation: 60 L **Special provisions** IB2, T7, TP2	**Explosive Limit and Limited Quantity Index** 1 **Passenger Carrying Road or Rail Index** 1 **Special provisions** 43	-	-	**Passenger and Cargo Aircraft**Quantity limitation: 1 L **Cargo Aircraft Only** Quantity limitation: 60 L **Limited Quantities - Passenger Aircraft** Quantity limitation: 1 L

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

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Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined
United States inventory (TSCA 8b): This material is listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Fire hazard
Immediate (acute) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
methanol	100	Yes.	No.	No.	Yes.	No.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	methanol	67-56-1	100
Supplier notification	methanol	67-56-1	100

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : This material is listed.

New York : This material is listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

California Prop. 65

WARNING: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.

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Section 15. Regulatory information

Ingredient name	Cancer	Reproductive	No significant risk level	Maximum acceptable dosage level
methanol	No.	Yes.	No.	No.

Canada inventory : This material is listed or exempted.

International regulations

International lists : **Australia inventory (AICS)**: This material is listed or exempted.
China inventory (IECSC): This material is listed or exempted.
Japan inventory: This material is listed or exempted.
Korea inventory: This material is listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
New Zealand Inventory of Chemicals (NZIoC): This material is listed or exempted.
Philippines inventory (PICCS): This material is listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals : Not listed

Chemical Weapons Convention List Schedule II Chemicals : Not listed

Chemical Weapons Convention List Schedule III Chemicals : Not listed

Canada

WHMIS (Canada) : Class B-2: Flammable liquid
Class D-1B: Material causing immediate and serious toxic effects (Toxic).
Class D-2A: Material causing other toxic effects (Very toxic).
Class D-2B: Material causing other toxic effects (Toxic).

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

Canada Label requirements : Class B-2: Flammable liquid
Class D-1B: Material causing immediate and serious toxic effects (Toxic).
Class D-2A: Material causing other toxic effects (Very toxic).
Class D-2B: Material causing other toxic effects (Toxic).

Hazardous Material Information System (U.S.A.)

Health	1
Flammability	3
Physical hazards	0

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Section 16. Other information

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)

Reprinted with permission from NFPA 704-2001, Identification of the Hazards of Materials for Emergency Response Copyright ©1997, National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association, on the referenced subject which is represented only by the standard in its entirety.

Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

History

Date of printing	:	5/20/2015.
Date of issue/Date of revision	:	5/20/2015.
Date of previous issue	:	10/16/2014.
Version	:	0.04
Key to abbreviations	:	ATE = Acute Toxicity Estimate BCF = Bioconcentration Factor GHS = Globally Harmonized System of Classification and Labelling of Chemicals IATA = International Air Transport Association IBC = Intermediate Bulk Container IMDG = International Maritime Dangerous Goods LogPow = logarithm of the octanol/water partition coefficient MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution) UN = United NationsACGIH – American Conference of Governmental Industrial Hygienists AIHA – American Industrial Hygiene Association CAS – Chemical Abstract Services CEPA – Canadian Environmental Protection Act CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (EPA) CFR – United States Code of Federal Regulations CPR – Controlled Products Regulations DSL – Domestic Substances List GWP – Global Warming Potential IARC – International Agency for Research on Cancer ICAO – International Civil Aviation Organisation Inh – Inhalation LC – Lethal concentration LD – Lethal dosage NDSL – Non-Domestic Substances List NIOSH – National Institute for Occupational Safety and Health

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Section 16. Other information

TDG – Canadian Transportation of Dangerous Goods Act and Regulations
TLV – Threshold Limit Value
TSCA – Toxic Substances Control Act
WEEL – Workplace Environmental Exposure Level
WHMIS – Canadian Workplace Hazardous Material Information System

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

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SAFETY DATA SHEET

Version 5.6
Revision Date 12/21/2015
Print Date 02/17/2016

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name	:	2-Pentanone
Product Number	:	W284203
Brand	:	Aldrich
CAS-No.	:	107-87-9

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses	:	Laboratory chemicals, Synthesis of substances

1.3 Details of the supplier of the safety data sheet

Company	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052

1.4 Emergency telephone number

Emergency Phone #	:	(314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Flammable liquids (Category 2), H225
Acute toxicity, Oral (Category 4), H302
Eye irritation (Category 2A), H319

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word: Danger

Hazard statement(s)

H225	Highly flammable liquid and vapour.
H302	Harmful if swallowed.
H319	Causes serious eye irritation.

Precautionary statement(s)

P210	Keep away from heat/sparks/open flames/hot surfaces. No smoking.
P233	Keep container tightly closed.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242	Use only non-sparking tools.
P243	Take precautionary measures against static discharge.
P264	Wash skin thoroughly after handling.

P270	Do not eat, drink or smoke when using this product.
P280	Wear protective gloves/ eye protection/ face protection.
P301 + P312 + P330	IF SWALLOWED: Call a POISON CENTER or doctor/ physician if you feel unwell. Rinse mouth.
P303 + P361 + P353	IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P337 + P313	If eye irritation persists: Get medical advice/ attention.
P370 + P378	In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish.
P403 + P235	Store in a well-ventilated place. Keep cool.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms	:	Methyl propyl ketone
Formula	:	$C_5H_{10}O$
Molecular weight	:	86.13 g/mol
CAS-No.	:	107-87-9
EC-No.	:	203-528-1

Hazardous components

Component	Classification	Concentration
Pentan-2-one		
	Flam. Liq. 2; Acute Tox. 4; Eye Irrit. 2A; H225, H302, H319	<= 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13).

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
Use explosion-proof equipment.Keep away from sources of ignition - No smoking.Take measures to prevent the build up of electrostatic charge.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

Store under inert gas.
Storage class (TRGS 510): Flammable liquids

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Pentan-2-one	107-87-9	STEL	150.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Pulmonary function Eye irritation		
		TWA	150.000000 ppm 530.000000 mg/m3	USA. NIOSH Recommended Exposure Limits
		TWA	200.000000 ppm 700.000000 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		The value in mg/m3 is approximate.		

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Splash contact
Material: butyl-rubber
Minimum layer thickness: 0.3 mm
Break through time: 60 min
Material tested:Butoject® (KCL 897 / Aldrich Z677647, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, Flame retardant antistatic protective clothing., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: liquid
b)	Odour	acetone-like
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	Melting point/range: -78 °C (-108 °F) - lit.
f)	Initial boiling point and boiling range	101 - 105 °C (214 - 221 °F) - lit.
g)	Flash point	7 °C (45 °F) - closed cup
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	Upper explosion limit: 8.2 %(V) Lower explosion limit: 1.5 %(V)

k)	Vapour pressure	36 hPa (27 mmHg) at 20 °C (68 °F)
l)	Vapour density	2.97 - (Air = 1.0)
m)	Relative density	0.809 g/cm3 at 25 °C (77 °F)
n)	Water solubility	72.6 g/l at 20 °C (68 °F) - OECD Test Guideline 105
o)	Partition coefficient: n-octanol/water	log Pow: 0.857 at 20 °C (68 °F)
p)	Auto-ignition temperature	No data available
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information

Surface tension	23.87 mN/m at 20 °C (68 °F)
Relative vapour density	2.97 - (Air = 1.0)

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
Vapours may form explosive mixture with air.

10.4 Conditions to avoid
Heat, flames and sparks.

10.5 Incompatible materials
Oxidizing agents, Strong bases, Reducing agents

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - 1,600 - 3,200 mg/kg
(OECD Test Guideline 401)

LC50 Inhalation - Rat - male and female - 4 h - > 25.5 mg/l
(OECD Test Guideline 436)

LD50 Dermal - Rabbit - 6,500 mg/kg

No data available

Skin corrosion/irritation
Skin - Guinea pig
Result: Mild skin irritation
(OECD Test Guideline 404)

Serious eye damage/eye irritation
Eyes - Rabbit
Result: Moderate eye irritation

(OECD Test Guideline 405)

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
No data available

In vitro mammalian cell gene mutation test
mouse lymphoma cells
Result: negative

Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
NTP:	No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: SA7875000

Lowered blood pressure, Central nervous system depression, narcosis, Nausea, Dizziness, Headache, Exposure to and/or consumption of alcohol may increase toxic effects.
To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

Stomach - Irregularities - Based on Human Evidence
Stomach - Irregularities - Based on Human Evidence

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	flow-through test LC50 - Pimephales promelas (fathead minnow) - 1,240 mg/l - 96 h
Toxicity to daphnia and other aquatic invertebrates	Immobilization EC50 - Daphnia magna (Water flea) - > 110 mg/l - 48 h (OECD Test Guideline 202)
Toxicity to algae	Growth inhibition EC50 - Pseudokirchneriella subcapitata - > 150 mg/l - 72 h (OECD Test Guideline 201)

12.2 Persistence and degradability

Biodegradability	aerobic - Exposure time 28 d Result: 70 % - Readily biodegradable (OECD Test Guideline 301D)

12.3 Bioaccumulative potential
No data available

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1249 Class: 3 Packing group: II
Proper shipping name: Methyl propyl ketone
Reportable Quantity (RQ):

Poison Inhalation Hazard: No

IMDG
UN number: 1249 Class: 3 Packing group: II EMS-No: F-E, S-D
Proper shipping name: METHYL PROPYL KETONE

IATA
UN number: 1249 Class: 3 Packing group: II
Proper shipping name: Methyl propyl ketone

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Fire Hazard, Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Pentan-2-one	107-87-9	1993-04-24

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Pentan-2-one	107-87-9	1993-04-24

New Jersey Right To Know Components

	CAS-No.	Revision Date
Pentan-2-one	107-87-9	1993-04-24

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Acute Tox.	Acute toxicity
Eye Irrit.	Eye irritation
Flam. Liq.	Flammable liquids
H225	Highly flammable liquid and vapour.
H302	Harmful if swallowed.
H319	Causes serious eye irritation.

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	3
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	3
Reactivity Hazard:	0

Further information

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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.6 Revision Date: 12/21/2015 Print Date: 02/17/2016

SAFETY DATA SHEET

Version 4.11
Revision Date 03/03/2015
Print Date 04/14/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name	:	1-Bromopropane
Product Number	:	B78106
Brand	:	Aldrich
Index-No.	:	602-019-00-5
CAS-No.	:	106-94-5

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses	:	Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052

1.4 Emergency telephone number

Emergency Phone #	:	(314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Flammable liquids (Category 2), H225
Skin irritation (Category 2), H315
Eye irritation (Category 2A), H319
Reproductive toxicity (Category 1B), H360
Specific target organ toxicity - single exposure (Category 2), H371
Specific target organ toxicity - single exposure (Category 3), Respiratory system, Central nervous system, H335, H336
Acute aquatic toxicity (Category 3), H402
Chronic aquatic toxicity (Category 3), H412

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word: Danger

Hazard statement(s)

H225	Highly flammable liquid and vapour.
H315	Causes skin irritation.
H319	Causes serious eye irritation.
H335	May cause respiratory irritation.
H336	May cause drowsiness or dizziness.
H360	May damage fertility or the unborn child.
H371	May cause damage to organs.

H412	Harmful to aquatic life with long lasting effects.

Precautionary statement(s)

P201	Obtain special instructions before use.
P202	Do not handle until all safety precautions have been read and understood.
P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P233	Keep container tightly closed.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242	Use only non-sparking tools.
P243	Take precautionary measures against static discharge.
P260	Do not breathe dust/ fume/ gas/ mist/ vapours/ spray.
P264	Wash skin thoroughly after handling.
P270	Do not eat, drink or smoke when using this product.
P271	Use only outdoors or in a well-ventilated area.
P273	Avoid release to the environment.
P280	Wear protective gloves/ protective clothing/ eye protection/ face protection.
P303 + P361 + P353	IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304 + P340 + P312	IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a POISON CENTER or doctor/ physician if you feel unwell.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P308 + P311	IF exposed or concerned: Call a POISON CENTER or doctor/ physician.
P308 + P313	IF exposed or concerned: Get medical advice/ attention.
P332 + P313	If skin irritation occurs: Get medical advice/ attention.
P337 + P313	If eye irritation persists: Get medical advice/ attention.
P362	Take off contaminated clothing and wash before reuse.
P370 + P378	In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P403 + P235	Store in a well-ventilated place. Keep cool.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms	:	Propyl bromide
Formula	:	C_3H_7Br
Molecular weight	:	122.99 g/mol
CAS-No.	:	106-94-5
EC-No.	:	203-445-0
Index-No.	:	602-019-00-5

Hazardous components

Component	Classification	Concentration
1-Bromopropane Included in the Candidate List of Substances of Very High Concern (SVHC) according to Regulation (EC) No. 1907/2006 (REACH)		
	Flam. Liq. 2; Skin Irrit. 2; Eye Irrit. 2A; Repr. 1B; STOT SE 2; STOT SE 3; Aquatic Acute 3; Aquatic Chronic 3; H225, H315, H319, H335, H336, H360, H371, H412	<= 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, Hydrogen bromide gas

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

6.3 Methods and materials for containment and cleaning up
Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13).

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
Use explosion-proof equipment.Keep away from sources of ignition - No smoking.Take measures to prevent the build up of electrostatic charge.

For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.
Storage class (TRGS 510): Flammable liquids

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
1-Bromopropane	106-94-5	TWA	0.1 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Developmental and reproductive toxicity (male & female) Central Nervous System impairment Hematologic effects Peripheral neuropathy 2014 Adoption Confirmed animal carcinogen with unknown relevance to humans		

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Splash contact
Material: Fluorinated rubber
Minimum layer thickness: 0.7 mm
Break through time: 467 min
Material tested:Vitoject® (KCL 890 / Aldrich Z677698, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, Flame retardant antistatic protective clothing., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: clear, liquid Colour: light brown
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	Melting point/range: -110 °C (-166 °F) - lit.
f)	Initial boiling point and boiling range	71 °C (160 °F) - lit.
g)	Flash point	22 °C (72 °F) - closed cup
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower flammability or explosive limits	Lower explosion limit: 4.6 %(V)
k)	Vapour pressure	No data available
l)	Vapour density	4.25 - (Air = 1.0)
m)	Relative density	1.354 g/cm3 at 25 °C (77 °F)
n)	Water solubility	soluble
o)	Partition coefficient: n-octanol/water	log Pow: 2.1
p)	Auto-ignition temperature	No data available
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information

Relative vapour density	4.25 - (Air = 1.0)

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
Vapours may form explosive mixture with air.

10.4 Conditions to avoid
Heat, flames and sparks.

10.5 Incompatible materials
Strong oxidizing agents, Strong bases

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
No data available

LC50 Inhalation - Rat - 30 h - 253 mg/l

Dermal: No data available

LD50 Intraperitoneal - Rat - 2,950 mg/kg

Skin corrosion/irritation
No data available

Serious eye damage/eye irritation
No data available

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
No data available

Carcinogenicity

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
May cause congenital malformation in the fetus. May damage the unborn child.
Presumed human reproductive toxicant

Reproductive toxicity - Rat - Inhalation
Paternal Effects: Spermatogenesis (including genetic material, sperm morphology,motility, and count).

Reproductive toxicity - Rat - Inhalation
Paternal Effects: Prostate, seminal vessicle, Cowper's gland, accessory glands.

May cause reproductive disorders. May damage fertility.

Specific target organ toxicity - single exposure
May cause damage to organs.
May cause respiratory irritation.
May cause drowsiness or dizziness.

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: TX4110000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

May cause irritation of the:, Eyes, Skin, May cause nervous system disturbances., Neurological disorders, May cause headache and dizziness., Loss of balance, Unconsciousness, Changes in the blood count, Immunosuppression., Liver injury may occur., toxic effects for reproduction

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	LC50 - Pimephales promelas (fathead minnow) - 67.3 mg/l - 96 h
Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia magna (Water flea) - 208.9 mg/l - 48 h

12.2 Persistence and degradability

Biodegradability Result: 19.20 % - Not readily biodegradable.

12.3 Bioaccumulative potential

No data available

12.4 Mobility in soil

No data available

12.5 Results of PBT and vPvB assessment

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.
Harmful to aquatic life with long lasting effects.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product

Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging

Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)

UN number: 2344 Class: 3 Packing group: II
Proper shipping name: Bromopropanes
Reportable Quantity (RQ):

Poison Inhalation Hazard: No

IMDG

UN number: 2344 Class: 3 Packing group: II EMS-No: F-E, S-D
Proper shipping name: BROMOPROPANES

IATA

UN number: 2344 Class: 3 Packing group: II
Proper shipping name: Bromopropanes

15. REGULATORY INFORMATION

SARA 302 Components

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Fire Hazard, Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
1-Bromopropane	106-94-5	1993-04-24

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
1-Bromopropane	106-94-5	1993-04-24

New Jersey Right To Know Components

	CAS-No.	Revision Date
1-Bromopropane	106-94-5	1993-04-24

California Prop. 65 Components

	CAS-No.	Revision Date
WARNING: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm. 1-Bromopropane	106-94-5	2004-12-07

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Aquatic Acute	Acute aquatic toxicity
Aquatic Chronic	Chronic aquatic toxicity
Eye Irrit.	Eye irritation
Flam. Liq.	Flammable liquids
H225	Highly flammable liquid and vapour.
H315	Causes skin irritation.
H319	Causes serious eye irritation.
H335	May cause respiratory irritation.
H336	May cause drowsiness or dizziness.
H360	May damage fertility or the unborn child.
H371	May cause damage to organs.
H402	Harmful to aquatic life.
H412	Harmful to aquatic life with long lasting effects.

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	3
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	3
Reactivity Hazard:	0

Further information

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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information
Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 4.11 Revision Date: 03/03/2015 Print Date: 04/14/2015

Fisher Scientific

Part of Thermo Fisher Scientific

SAFETY DATA SHEET

Creation Date 22-Sep-2009 **Revision Date** 21-May-2014 **Revision Number** 1

1. Identification

Product Name **Isopropyl acetate**

Cat No. : **O6111-1; O6111-212; O6111RS-50**

Synonyms 2-Acetoxypropane; 2-Propyl Acetate.

Recommended Use Laboratory chemicals.

Uses advised against No Information available

Details of the supplier of the safety data sheet

Company
Fisher Scientific
One Reagent Lane
Fair Lawn, NJ 07410
Tel: (201) 796-7100

Emergency Telephone Number
CHEMTREC®, Inside the USA: 800-424-9300
CHEMTREC®, Outside the USA: 001-703-527-3887

2. Hazard(s) identification

Classification
This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Flammable liquids	Category 2
Serious Eye Damage/Eye Irritation	Category 2
Specific target organ toxicity (single exposure)	Category 3
Target Organs - Central nervous system (CNS).	

Label Elements

Signal Word
Danger

Hazard Statements
Highly flammable liquid and vapor
Causes serious eye irritation
May cause drowsiness or dizziness

Precautionary Statements
Prevention
Wash face, hands and any exposed skin thoroughly after handling
Avoid breathing dust/fume/gas/mist/vapors/spray
Use only outdoors or in a well-ventilated area
Keep away from heat/sparks/open flames/hot surfaces. - No smoking
Keep container tightly closed
Ground/bond container and receiving equipment
Use explosion-proof electrical/ventilating/lighting/equipment
Use only non-sparking tools
Take precautionary measures against static discharge
Wear protective gloves/protective clothing/eye protection/face protection
Keep cool
Inhalation
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
Call a POISON CENTER or doctor/physician if you feel unwell
Skin
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower
Eyes
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
If eye irritation persists: Get medical advice/attention
Fire
In case of fire: Use CO2, dry chemical, or foam for extinction
Storage
Store in a well-ventilated place. Keep container tightly closed
Store locked up
Disposal
Dispose of contents/container to an approved waste disposal plant
Hazards not otherwise classified (HNOC)
Repeated exposure may cause skin dryness or cracking

3. Composition / information on ingredients

Component	CAS-No	Weight %
Isopropyl acetate	108-21-4	>95

4. First-aid measures

Eye Contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Obtain medical attention.

Skin Contact Wash off immediately with plenty of water for at least 15 minutes. Obtain medical attention.

Inhalation Move to fresh air. If breathing is difficult, give oxygen. If not breathing, give artificial respiration. Obtain medical attention.

Ingestion Do not induce vomiting. Obtain medical attention.

Most important symptoms/effects Breathing difficulties. Inhalation of high vapor concentrations may cause symptoms like headache, dizziness, tiredness, nausea and vomiting

Notes to Physician Treat symptomatically

5. Fire-fighting measures

Suitable Extinguishing Media Carbon dioxide (CO_2). Dry chemical. Use water spray to cool unopened containers. chemical foam. Cool closed containers exposed to fire with water spray.

Unsuitable Extinguishing Media No information available

Flash Point 4 °C / 39.2 °F
Method - No information available

Autoignition Temperature 460 °C / 860 °F
Explosion Limits
Upper 7.2%
Lower 1.76%
Sensitivity to Mechanical Impact No information available
Sensitivity to Static Discharge No information available

Specific Hazards Arising from the Chemical
Flammable. Vapors may travel to source of ignition and flash back. Containers may explode when heated. Vapors may form explosive mixtures with air.

Hazardous Combustion Products
Carbon monoxide (CO) Carbon dioxide (CO_2)
Protective Equipment and Precautions for Firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full protective gear.

NFPA

Health	Flammability	Instability	Physical hazards
2	3	0	N/A

6. Accidental release measures

Personal Precautions Use personal protective equipment. Ensure adequate ventilation. Remove all sources of ignition. Take precautionary measures against static discharges.

Environmental Precautions See Section 12 for additional ecological information.

Methods for Containment and Clean Up Soak up with inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Keep in suitable, closed containers for disposal. Remove all sources of ignition. Use spark-proof tools and explosion-proof equipment. Take precautionary measures against static discharges.

7. Handling and storage

Handling Avoid contact with skin and eyes. Do not breathe vapors or spray mist. Take precautionary measures against static discharges. Use only in area provided with appropriate exhaust ventilation. Use explosion-proof equipment. Use only non-sparking tools. Keep away from open flames, hot surfaces and sources of ignition. To avoid ignition of vapors by static electricity discharge, all metal parts of the equipment must be grounded. Wash hands before breaks and immediately after handling the product.

Storage Keep in a dry, cool and well-ventilated place. Keep container tightly closed. Keep away from heat and sources of ignition. Flammables area. Keep container tightly closed in a dry and well-ventilated place.

8. Exposure controls / personal protection

Exposure Guidelines

Component	ACGIH TLV	OSHA PEL	NIOSH IDLH
Isopropyl acetate	TWA: 100 ppm STEL: 200 ppm	(Vacated) TWA: 250 ppm (Vacated) TWA: 950 mg/m^3 (Vacated) STEL: 310 ppm (Vacated) STEL: 1185 mg/m^3 TWA: 250 ppm TWA: 950 mg/m^3	IDLH: 1800 ppm

Component	Quebec	Mexico OEL (TWA)	Ontario TWAEV
Isopropyl acetate	TWA: 250 ppm TWA: 1040 mg/m³ STEL: 310 ppm STEL: 1290 mg/m³	TWA: 250 ppm TWA: 950 mg/m³ STEL: 310 ppm STEL: 1185 mg/m³	TWA: 100 ppm STEL: 200 ppm

Legend

ACGIH - American Conference of Governmental Industrial Hygienists
OSHA - Occupational Safety and Health Administration
NIOSH IDLH: The National Institute for Occupational Safety and Health Immediately Dangerous to Life or Health

Engineering Measures Ensure adequate ventilation, especially in confined areas. Ensure that eyewash stations and safety showers are close to the workstation location. Use explosion-proof electrical/ventilating/lighting/equipment.

Personal Protective Equipment

Eye/face Protection Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin and body protection Wear appropriate protective gloves and clothing to prevent skin exposure.

Respiratory Protection No protective equipment is needed under normal use conditions.

Hygiene Measures Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Physical State	Liquid
Appearance	Colorless
Odor	vinegar-like
Odor Threshold	0.5 - 42 ppm
pH	No information available
Melting Point/Range	-73 °C / -99.4 °F
Boiling Point/Range	88.8 °C / 191.8 °F
Flash Point	4 °C / 39.2 °F
Evaporation Rate	No information available
Flammability (solid,gas)	Not applicable
Flammability or explosive limits	
Upper	7.2%
Lower	1.76%
Vapor Pressure	61 mbar @ 20 °C
Vapor Density	3.5
Relative Density	0.872
Solubility	No information available
Partition coefficient; n-octanol/water	No data available
Autoignition Temperature	460 °C / 860 °F
Decomposition Temperature	No information available
Viscosity	0.49 cP at 25 °C
Molecular Formula	C5 H10 O2
Molecular Weight	102.13

10. Stability and reactivity

Reactive Hazard None known, based on information available

Stability Stable under normal conditions. Moisture sensitive.

Conditions to Avoid Keep away from open flames, hot surfaces and sources of ignition. Incompatible products.

Exposure to moist air or water.

Incompatible Materials Acids, Bases

Hazardous Decomposition Products Carbon monoxide (CO), Carbon dioxide (CO_2)

Hazardous Polymerization Hazardous polymerization does not occur.

Hazardous Reactions None under normal processing.

11. Toxicological information

Acute Toxicity

Product Information No acute toxicity information is available for this product

Component Information

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Isopropyl acetate	3000 mg/kg (Rat)	20 mL/kg (Rabbit)	50600 mg/m^3, 8h (Rat)

Toxicologically Synergistic Products No information available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation Irritating to eyes

Sensitization No information available

Carcinogenicity The table below indicates whether each agency has listed any ingredient as a carcinogen.

Component	CAS-No	IARC	NTP	ACGIH	OSHA	Mexico
Isopropyl acetate	108-21-4	Not listed	Not listed	Not listed	Not listed	Not listed

Mutagenic Effects No information available

Reproductive Effects No information available.

Developmental Effects No information available.

Teratogenicity No information available.

STOT - single exposure Central nervous system (CNS)
STOT - repeated exposure None known

Aspiration hazard No information available

Symptoms / effects,both acute and delayed Inhalation of high vapor concentrations may cause symptoms like headache, dizziness, tiredness, nausea and vomiting
Endocrine Disruptor Information No information available

Other Adverse Effects The toxicological properties have not been fully investigated. See actual entry in RTECS for complete information.

12. Ecological information

Ecotoxicity
Do not empty into drains.

Component	Freshwater Algae	Freshwater Fish	Microtox	Water Flea
Isopropyl acetate	Not listed	265 mg/l LC50 48h	Not listed	1260 mg/L EC50 = 24 h

Persistence and Degradability Persistence is unlikely based on information available.
Bioaccumulation/ Accumulation No information available.

Mobility Will likely be mobile in the environment due to its volatility.

Component	log Pow
Isopropyl acetate	1.03

13. Disposal considerations

Waste Disposal Methods Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and national hazardous waste regulations to ensure complete and accurate classification.

14. Transport information

DOT

UN-No 1220
Proper Shipping Name ISOPROPYL ACETATE
Hazard Class 3
Packing Group II

TDG

UN-No 1220
Proper Shipping Name ISOPROPYL ACETATE
Hazard Class 3
Packing Group II

IATA

UN-No 1220
Proper Shipping Name ISOPROPYL ACETATE
Hazard Class 3
Packing Group II

IMDG/IMO

UN-No 1220
Proper Shipping Name ISOPROPYL ACETATE
Hazard Class 3
Packing Group II

15. Regulatory information

International Inventories

Component	TSCA	DSL	NDSL	EINECS	ELINCS	NLP	PICCS	ENCS	AICS	IECSC	KECL
Isopropyl acetate	X	X	-	203-561-1	-		X	X	X	X	X

Legend:
X - Listed
E - Indicates a substance that is the subject of a Section 5(e) Consent order under TSCA.
F - Indicates a substance that is the subject of a Section 5(f) Rule under TSCA.
N - Indicates a polymeric substance containing no free-radical initiator in its inventory name but is considered to cover the designated polymer made with any free-radical initiator regardless of the amount used.
P - Indicates a commenced PMN substance
R - Indicates a substance that is the subject of a Section 6 risk management rule under TSCA.
S - Indicates a substance that is identified in a proposed or final Significant New Use Rule
T - Indicates a substance that is the subject of a Section 4 test rule under TSCA.
XU - Indicates a substance exempt from reporting under the Inventory Update Rule, i.e. Partial Updating of the TSCA Inventory Data Base Production and Site Reports (40 CFR 710(B).
Y1 - Indicates an exempt polymer that has a number-average molecular weight of 1,000 or greater.
Y2 - Indicates an exempt polymer that is a polyester and is made only from reactants included in a specified list of low concern reactants that comprises one of the eligibility criteria for the exemption rule.

U.S. Federal Regulations

TSCA 12(b) Not applicable

SARA 313 Not applicable

SARA 311/312 Hazardous Categorization
Acute Health Hazard Yes
Chronic Health Hazard No

Fire Hazard	Yes
Sudden Release of Pressure Hazard	No
Reactive Hazard	No

Clean Water Act Not applicable

Clean Air Act Not applicable

OSHA Occupational Safety and Health Administration
Not applicable

CERCLA
Not applicable

California Proposition 65 This product does not contain any Proposition 65 chemicals

State Right-to-Know

Component	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Isopropyl acetate	X	X	X	-	X

U.S. Department of Transportation

Reportable Quantity (RQ):	N
DOT Marine Pollutant	N
DOT Severe Marine Pollutant	N

U.S. Department of Homeland Security
This product does not contain any DHS chemicals.

Other International Regulations

Mexico - Grade No information available

Canada
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR

WHMIS Hazard Class B2 Flammable liquid
D2B Toxic materials

16. Other information

Prepared By Regulatory Affairs
Thermo Fisher Scientific
Email: EMSDS.RA@thermofisher.com

Creation Date 22-Sep-2009
Revision Date 21-May-2014
Print Date 21-May-2014
Revision Summary This document has been updated to comply with the US OSHA HazCom 2012 Standard replacing the current legislation under 29 CFR 1910.1200 to align with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

Disclaimer

The information provided on this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text.

End of SDS

SAFETY DATA SHEET

Version 5.1
Revision Date 07/10/2014
Print Date 04/14/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name	:	Nonafluoro-1-iodobutane
Product Number	:	317845
Brand	:	Aldrich
CAS-No.	:	423-39-2

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses	:	Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052

1.4 Emergency telephone number

Emergency Phone #	:	(314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Skin irritation (Category 2), H315
Eye irritation (Category 2A), H319
Specific target organ toxicity - single exposure (Category 3), Respiratory system, H335

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word: Warning

Hazard statement(s)

H315	Causes skin irritation.
H319	Causes serious eye irritation.
H335	May cause respiratory irritation.

Precautionary statement(s)

P261	Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P264	Wash skin thoroughly after handling.
P271	Use only outdoors or in a well-ventilated area.
P280	Wear protective gloves/ eye protection/ face protection.
P302 + P352	IF ON SKIN: Wash with plenty of soap and water.
P304 + P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove

	contact lenses, if present and easy to do. Continue rinsing.
P312	Call a POISON CENTER or doctor/ physician if you feel unwell.
P321	Specific treatment (see supplemental first aid instructions on this label).
P332 + P313	If skin irritation occurs: Get medical advice/ attention.
P337 + P313	If eye irritation persists: Get medical advice/ attention.
P362	Take off contaminated clothing and wash before reuse.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms	:	Perfluorobutyl iodide 1-Iodoperfluorobutane
Formula	:	C_4F_9I
Molecular Weight	:	345.93 g/mol
CAS-No.	:	423-39-2
EC-No.	:	207-025-8

Hazardous components

Component	Classification	Concentration
1,1,1,2,2,3,3,4,4-nonafluoro-4-iodobutane		
	Skin Irrit. 2; Eye Irrit. 2A; STOT SE 3; H315, H319, H335	-

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed

no data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, Hydrogen fluoride, Hydrogen iodide

5.3 Advice for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

5.4 Further information
no data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.
For personal protection see section 8.

6.2 Environmental precautions
Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.Normal measures for preventive fire protection.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters
Contains no substances with occupational exposure limit values.

8.2 Exposure controls

Appropriate engineering controls
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Body Protection
impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator.For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: solid
b)	Odour	no data available
c)	Odour Threshold	no data available
d)	pH	no data available
e)	Melting point/freezing point	no data available
f)	Initial boiling point and boiling range	no data available
g)	Flash point	no data available
h)	Evapouration rate	no data available
i)	Flammability (solid, gas)	no data available
j)	Upper/lower flammability or explosive limits	no data available
k)	Vapour pressure	no data available
l)	Vapour density	no data available
m)	Relative density	2.01 g/cm3 at 25 °C (77 °F)
n)	Water solubility	no data available
o)	Partition coefficient: n-octanol/water	no data available
p)	Auto-ignition temperature	no data available
q)	Decomposition temperature	no data available
r)	Viscosity	no data available
s)	Explosive properties	no data available
t)	Oxidizing properties	no data available

9.2 Other safety information
no data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
no data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
no data available

10.4 Conditions to avoid
no data available

10.5 Incompatible materials
no data available

10.6 Hazardous decomposition products
Other decomposition products - no data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LC50 Inhalation - rat - 4 h - 14000 ppm

Dermal: no data available

no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP:	No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
no data available

no data available

Specific target organ toxicity - single exposure
May cause respiratory irritation.
no data available

Specific target organ toxicity - repeated exposure
no data available

Aspiration hazard
no data available

Additional Information
RTECS: EK5360000

12. ECOLOGICAL INFORMATION

12.1 Toxicity
no data available

12.2 Persistence and degradability
no data available

12.3 Bioaccumulative potential
no data available

12.4 Mobility in soil
no data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Acute Health Hazard

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
1,1,1,2,2,3,3,4,4-nonafluoro-4-iodobutane	423-39-2	

New Jersey Right To Know Components

	CAS-No.	Revision Date
1,1,1,2,2,3,3,4,4-nonafluoro-4-iodobutane	423-39-2	

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Eye Irrit.	Eye irritation
H315	Causes skin irritation.
H319	Causes serious eye irritation.

H335	May cause respiratory irritation.
Skin Irrit.	Skin irritation
STOT SE	Specific target organ toxicity - single exposure

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	0
Reactivity Hazard:	0

Further information

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Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Version: 5.1 Revision Date: 07/10/2014 Print Date: 04/14/2015

Safety Data Sheet

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Document Group:	10-4331-4	**Version Number:**	60.00
Issue Date:	03/19/15	**Supercedes Date:**	02/05/15

SECTION 1: Identification

1.1. Product identifier
3M™ Performance Fluid PF-5060

Product Identification Numbers
98-0211-8034-8, 98-0211-8067-8, 98-0212-4818-6, 98-0212-4843-4, ZF-0002-1169-6, ZF-0002-1871-7

1.2. Recommended use and restrictions on use

Recommended use
For Industrial Use Only. See Limitations on Use for supplemental information on intended applications including Medical Device applications., Heat Transfer and Solvent Deposition.
Restrictions on use
3M™ Performance Fluids are used in a wide variety of applications, including but not limited to precision cleaning of medical devices and as a lubricant deposition solvent for medical devices. When the product is used for applications where the finished device is implanted into the human body, no residual Performance Fluid solvent may remain on the parts. It is highly recommended that the supporting test results and protocol be cited during FDA registration.

3M Electronics Markets Materials Division (EMMD) will not knowingly sample, support, or sell its products for incorporation in medical and pharmaceutical products and applications in which the 3M product will be temporarily or permanently implanted into humans or animals. The customer is responsible for evaluating and determining that a 3M EMMD product is suitable and appropriate for its particular use and intended application. The conditions of evaluation, selection, and use of a 3M product can vary widely and affect the use and intended application of a 3M product. Because many of these conditions are uniquely within the user's knowledge and control, it is essential that the user evaluate and determine whether the 3M product is suitable and appropriate for a particular use and intended application, and complies with all local applicable laws, regulations, standards, and guidance.

1.3. Supplier's details

MANUFACTURER:	3M
DIVISION:	Electronics Materials Solutions Division
ADDRESS:	3M Center, St. Paul, MN 55144-1000, USA
Telephone:	1-888-3M HELPS (1-888-364-3577)

1.4. Emergency telephone number
1-800-364-3577 or (651) 737-6501 (24 hours)

SECTION 2: Hazard identification

2.1. Hazard classification

Not classified as hazardous according to OSHA Hazard Communication Standard, 29 CFR 1910.1200.

2.2. Label elements
Signal word
Not applicable.

Symbols
Not applicable.

Pictograms
Not applicable.

2.3. Hazards not otherwise classified
None.

SECTION 3: Composition/information on ingredients

Ingredient	C.A.S. No.	% by Wt
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	86508-42-1	100

SECTION 4: First aid measures

4.1. Description of first aid measures

Inhalation:
No need for first aid is anticipated.

Skin Contact:
Wash with soap and water. If signs/symptoms develop, get medical attention.

Eye Contact:
Flush with large amounts of water. Remove contact lenses if easy to do. Continue rinsing. If signs/symptoms persist, get medical attention.

If Swallowed:
No need for first aid is anticipated.

4.2. Most important symptoms and effects, both acute and delayed
See Section 11.1. Information on toxicological effects.

4.3. Indication of any immediate medical attention and special treatment required
Not applicable

SECTION 5: Fire-fighting measures

5.1. Suitable extinguishing media
Non-combustible. Use a fire fighting agent suitable for surrounding fire.

5.2. Special hazards arising from the substance or mixture
Exposure to extreme heat can give rise to thermal decomposition.

Hazardous Decomposition or By-Products

Substance	Condition

Carbon monoxide	During Combustion
Carbon dioxide	During Combustion

5.3. Special protective actions for fire-fighters
When fire fighting conditions are severe and total thermal decomposition of the product is possible, wear full protective clothing, including helmet, self-contained, positive pressure or pressure demand breathing apparatus, bunker coat and pants, bands around arms, waist and legs, face mask, and protective covering for exposed areas of the head.

SECTION 6: Accidental release measures

6.1. Personal precautions, protective equipment and emergency procedures
Ventilate the area with fresh air. For large spill, or spills in confined spaces, provide mechanical ventilation to disperse or exhaust vapors, in accordance with good industrial hygiene practice. Warning! A motor could be an ignition source and could cause flammable gases or vapors in the spill area to burn or explode.

6.2. Environmental precautions
Avoid release to the environment. For larger spills, cover drains and build dikes to prevent entry into sewer systems or bodies of water.

6.3. Methods and material for containment and cleaning up
Contain spill. Working from around the edges of the spill inward, cover with bentonite, vermiculite, or commercially available inorganic absorbent material. Mix in sufficient absorbent until it appears dry. Collect as much of the spilled material as possible. Place in a closed container approved for transportation by appropriate authorities. Clean up residue with an appropriate solvent selected by a qualified and authorized person. Ventilate the area with fresh air. Read and follow safety precautions on the solvent label and SDS. Seal the container. Dispose of collected material as soon as possible.

SECTION 7: Handling and storage

7.1. Precautions for safe handling
Avoid eye contact. Do not breathe thermal decomposition products. Avoid skin contact with hot material. For industrial or professional use only. Store work clothes separately from other clothing, food and tobacco products. Keep away from reactive metals (eg. Aluminum, zinc etc.) to avoid the formation of hydrogen gas that could create an explosion hazard. No smoking: Smoking while using this product can result in contamination of the tobacco and/or smoke and lead to the formation of hazardous decomposition products.

7.2. Conditions for safe storage including any incompatibilities
Store away from heat.

SECTION 8: Exposure controls/personal protection

8.1. Control parameters

Occupational exposure limits
No occupational exposure limit values exist for any of the components listed in Section 3 of this SDS.

8.2. Exposure controls

8.2.1. Engineering controls
Provide appropriate local exhaust when product is heated.

8.2.2. Personal protective equipment (PPE)

Eye/face protection

None required.

Skin/hand protection
Select and use gloves and/or protective clothing approved to relevant local standards to prevent skin contact based on the results of an exposure assessment. Selection should be based on use factors such as exposure levels, concentration of the substance or mixture, frequency and duration, physical challenges such as temperature extremes, and other use conditions. Consult with your glove and/or protective clothing manufacturer for selection of appropriate compatible gloves/protective clothing.

Respiratory protection

During heating:

Use a positive pressure supplied-air respirator if there is a potential for over exposure from an uncontrolled release, exposure levels are not known, or under any other circumstances where air-purifying respirators may not provide adequate protection.

Thermal hazards
Wear heat insulating gloves when handling hot material to prevent thermal burns.

SECTION 9: Physical and chemical properties

9.1. Information on basic physical and chemical properties

General Physical Form:	Liquid
Specific Physical Form:	Liquid
Odor, Color, Grade:	Colorless, odorless liquid.
Odor threshold	*No Data Available*
pH	*Not Applicable*
Melting point	*Not Applicable*
Boiling Point	50 - 60 ºC
Flash Point	No flash point
Evaporation rate	> 1 [*Ref Std:* BUOAC=1]
Flammability (solid, gas)	Not Applicable
Flammable Limits(LEL)	None detected
Flammable Limits(UEL)	None detected
Vapor Pressure	232 mmHg [@ 20 ºC]
Vapor Density	11.7 [@ 20 ºC] [*Ref Std:* AIR=1]
Density	1.7 g/ml
Specific Gravity	1.7 [*Ref Std:* WATER=1]
Solubility in Water	Nil
Solubility- non-water	*No Data Available*
Partition coefficient: n-octanol/ water	*No Data Available*
Autoignition temperature	*No Data Available*
Decomposition temperature	*Not Applicable*
Viscosity	0.4 centistoke
Volatile Organic Compounds	[*Details:* Exempt]
Percent volatile	100 %
VOC Less H2O & Exempt Solvents	[*Details:* Exempt]

SECTION 10: Stability and reactivity

10.1. Reactivity
This material may be reactive with certain agents under certain conditions - see the remaining headings in this section.

10.2. Chemical stability

Stable.

10.3. Possibility of hazardous reactions
Hazardous polymerization will not occur.

10.4. Conditions to avoid
Heat

10.5. Incompatible materials
Finely divided active metals
Alkali and alkaline earth metals

10.6. Hazardous decomposition products

Substance	Condition
Hydrogen Fluoride	At Elevated Temperatures - greater than 200 ºC
Perfluoroisobutylene (PFIB)	At Elevated Temperatures - greater than 200 ºC
Toxic Vapor, Gas, Particulate	At Elevated Temperatures - greater than 200 ºC

Refer to section 5.2 for hazardous decomposition products during combustion.

If the product is exposed to extreme condition of heat from misuse or equipment failure, toxic decomposition products that include hydrogen fluoride and perfluoroisobutylene can occur.

SECTION 11: Toxicological information

The information below may not be consistent with the material classification in Section 2 if specific ingredient classifications are mandated by a competent authority. In addition, toxicological data on ingredients may not be reflected in the material classification and/or the signs and symptoms of exposure, because an ingredient may be present below the threshold for labeling, an ingredient may not be available for exposure, or the data may not be relevant to the material as a whole.

11.1. Information on Toxicological effects

Signs and Symptoms of Exposure

Based on test data and/or information on the components, this material may produce the following health effects:

Inhalation:
Vapors from heated material may cause irritation of the respiratory system. Signs/symptoms may include cough, sneezing, nasal discharge, headache, hoarseness, and nose and throat pain.

Skin Contact:
Contact with the skin during product use is not expected to result in significant irritation.

Eye Contact:
Vapors from heated material may cause eye irritation. Signs/symptoms may include redness, swelling, pain, tearing, and blurred or hazy vision.

Ingestion:
No known health effects.

Toxicological Data
If a component is disclosed in section 3 but does not appear in a table below, either no data are available for that endpoint or

the data are not sufficient for classification.

Acute Toxicity

Name	Route	Species	Value
Overall product	Ingestion		No data available; calculated ATE > 5,000 mg/kg
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Inhalation-Vapor (4 hours)	Rat	LC50 > 41 mg/l
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Ingestion	Rat	LD50 > 5,000 mg/kg

ATE = acute toxicity estimate

Skin Corrosion/Irritation

Name	Species	Value
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Rabbit	No significant irritation

Serious Eye Damage/Irritation

Name	Species	Value
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Rabbit	No significant irritation

Skin Sensitization

For the component/components, either no data are currently available or the data are not sufficient for classification.

Respiratory Sensitization

For the component/components, either no data are currently available or the data are not sufficient for classification.

Germ Cell Mutagenicity

Name	Route	Value
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	In Vitro	Not mutagenic

Carcinogenicity

For the component/components, either no data are currently available or the data are not sufficient for classification.

Reproductive Toxicity

Reproductive and/or Developmental Effects

Name	Route	Value	Species	Test Result	Exposure Duration
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Ingestion	Not toxic to female reproduction	Rat	NOAEL 2,000 mg/kg/day	28 days
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Inhalation	Not toxic to female reproduction	Rat	NOAEL 49,821 ppm	13 weeks
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Ingestion	Not toxic to male reproduction	Rat	NOAEL 2,000 mg/kg/day	28 days
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Inhalation	Not toxic to male reproduction	Rat	NOAEL 49,821 ppm	13 weeks

Lactation

Name	Route	Species	Value
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Inhalation	Rat	Does not cause effects on or via lactation

Target Organ(s)

Specific Target Organ Toxicity - single exposure

For the component/components, either no data are currently available or the data are not sufficient for classification.

Specific Target Organ Toxicity - repeated exposure

Name	Route	Target Organ(s)	Value	Species	Test Result	Exposure Duration
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Inhalation	heart | endocrine system | bone, teeth, nails, and/or hair | hematopoietic system | liver | immune system | nervous system | eyes | kidney and/or bladder | respiratory system	All data are negative	Rat	NOAEL 49,821 ppm	13 weeks
Perfluoro Compounds, (Primarily Compounds With 6 Carbons)	Ingestion	heart | endocrine system | hematopoietic system | liver | nervous system | kidney and/or bladder | respiratory system	All data are negative	Rat	NOAEL 2,000 mg/kg/day	28 days

Aspiration Hazard
For the component/components, either no data are currently available or the data are not sufficient for classification.

Please contact the address or phone number listed on the first page of the SDS for additional toxicological information on this material and/or its components.

SECTION 12: Ecological information

Ecotoxicological information

Please contact the address or phone number listed on the first page of the SDS for additional ecotoxicological information on this material and/or its components.

Chemical fate information

Please contact the address or phone number listed on the first page of the SDS for additional chemical fate information on this material and/or its components.

SECTION 13: Disposal considerations

13.1. Disposal methods
Dispose of contents/ container in accordance with the local/regional/national/international regulations.

Dispose of waste product in a permitted industrial waste facility. Combustion products will include halogen acid (HCl/HF/HBr). Facility must be capable of handling halogenated materials. Empty and clean product containers may be disposed as non-hazardous waste. Consult your specific regulations and service providers to determine available options and requirements.

EPA Hazardous Waste Number (RCRA): Not regulated

SECTION 14: Transport Information

For Transport Information, please visit **http://3M.com/Transportinfo** or call 1-800-364-3577 or 651-737-6501.

SECTION 15: Regulatory information

15.1. US Federal Regulations
Contact 3M for more information.

311/312 Hazard Categories:

Fire Hazard - No Pressure Hazard - Yes Reactivity Hazard - No Immediate Hazard - No Delayed Hazard - No

15.2. State Regulations
Contact 3M for more information.

15.3. Chemical Inventories
The components of this material are in compliance with the provisions of Australia National Industrial Chemical Notification and Assessment Scheme (NICNAS). Certain restrictions may apply. Contact the selling division for additional information.

The components of this product are in compliance with the new substance notification requirements of CEPA.

The components of this material are in compliance with the China "Measures on Environmental Management of New Chemical Substance". Certain restrictions may apply. Contact the selling division for additional information.

The components of this material are in compliance with the provisions of the Korean Toxic Chemical Control Law. Certain restrictions may apply. Contact the selling division for additional information.

The components of this material are in compliance with the provisions of Japan Chemical Substance Control Law. Certain restrictions may apply. Contact the selling division for additional information.

The components of this material are in compliance with the provisions of Philippines RA 6969 requirements. Certain restrictions may apply. Contact the selling division for additional information.

The components of this product are in compliance with the chemical notification requirements of TSCA.

Contact 3M for more information.

15.4. International Regulations
Contact 3M for more information.

This SDS has been prepared to meet the U.S. OSHA Hazard Communication Standard, 29 CFR 1910.1200.

SECTION 16: Other information

NFPA Hazard Classification
Health: 3 **Flammability:** 0 **Instability:** 0 **Special Hazards:** None

National Fire Protection Association (NFPA) hazard ratings are designed for use by emergency response personnel to address the hazards that are presented by short-term, acute exposure to a material under conditions of fire, spill, or similar emergencies. Hazard ratings are primarily based on the inherent physical and toxic properties of the material but also include the toxic properties of combustion or decomposition products that are known to be generated in significant quantities.

HMIS Hazard Classification
Health: 0 **Flammability:** 0 **Physical Hazard:** 0 **Personal Protection:** X - See PPE section.

Hazardous Material Identification System (HMIS® III) hazard ratings are designed to inform employees of chemical hazards in the workplace. These ratings are based on the inherent properties of the material under expected conditions of normal use

and are not intended for use in emergency situations. HMIS® III ratings are to be used with a fully implemented HMIS® III program. HMIS® is a registered mark of the American Coatings Association (ACA).

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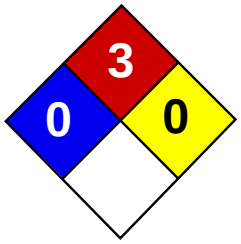

Health	0
Fire	3
Reactivity	0
Personal Protection	J

Material Safety Data Sheet

Propylene glycol monomethyl ether MSDS

Section 1: Chemical Product and Company Identification

Product Name: Propylene glycol monomethyl ether

Catalog Codes: SLP1744

CAS#: 107-98-2

RTECS: UB7700000

TSCA: TSCA 8(b) inventory: Propylene glycol monomethyl ether

CI#: Not applicable.

Synonym:

Chemical Name: 1-Methoxy-2-propanol

Chemical Formula: CH3OCH2CH(OH)CH3

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Propylene glycol monomethyl ether	107-98-2	100

Toxicological Data on Ingredients: Propylene glycol monomethyl ether: ORAL (LD50): Acute: 5660 mg/kg [Rat.]. DERMAL (LD50): Acute: 13000 mg/kg [Rabbit.].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of skin contact (irritant), of eye contact (irritant). Slightly hazardous in case of skin contact (permeator), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek medical attention.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Flammable.

Auto-Ignition Temperature: 137°C (278.6°F)

Flash Points: CLOSED CUP: 36°C (96.8°F).

Flammable Limits: LOWER: 3% UPPER: 12%

Products of Combustion: These products are carbon oxides (CO, CO2).

Fire Hazards in Presence of Various Substances: Highly flammable in presence of open flames and sparks, of heat.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
Flammable liquid, soluble or dispersed in water. SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use alcohol foam, water spray or fog. Cool containing vessels with water jet in order to prevent pressure build-up, autoignition or explosion.

Special Remarks on Fire Hazards:
Vapor may travel considerable distance to source of ignition and flash back. When heated to decomposition it emits acrid smoke and irritating fumes.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container.

Large Spill:
Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Eliminate all ignition sources. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Ground all equipment containing material. Do not ingest. Do not breathe gas/fumes/ vapour/spray. Wear suitable protective clothing If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes Keep away from incompatibles such as oxidizing agents.

Storage:
Flammable materials should be stored in a separate safety storage cabinet or room. Keep away from heat. Keep away from sources of ignition. Keep container tightly closed. Keep in a cool, well-ventilated place. Ground all equipment containing material. A refrigerated room would be preferable for materials with a flash point lower than 37.8°C (100°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.

Personal Protection: Splash goggles. Lab coat. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Boots. Gloves. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 100 STEL: 150 (ppm) from ACGIH (TLV) [1995] TWA: 369 STEL: 553 (mg/m3) from ACGIH [1995] Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Liquid. (Liquid.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 90.12 g/mole

Color: Colorless.

pH (1% soln/water): 7 [Neutral.]

Boiling Point: 120.1°C (248.2°F)

Melting Point: -95°C (-139°F)

Critical Temperature: Not available.

Specific Gravity: 0.92 (Water = 1)

Vapor Pressure: 12.5 mm of Hg (@ 20°C)

Vapor Density: 3.12 (Air = 1)

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol, diethyl ether.

Solubility: Soluble in cold water, hot water, methanol, diethyl ether.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Air sensitive.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact.

Toxicity to Animals:
Acute oral toxicity (LD50): 5660 mg/kg [Rat.]. Acute dermal toxicity (LD50): 13000 mg/kg [Rabbit.].

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Hazardous in case of skin contact (irritant). Slightly hazardous in case of skin contact (permeator), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Exposure can cause coughing, chest pains, difficulty in breathing.

Special Remarks on other Toxic Effects on Humans: Material is irritating to mucous membranes and upper respiratory tract.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Class 3: Flammable liquid.

Identification: : 1-Methoxy-2-propanol : UN3092 PG: III

Special Provisions for Transport: Not available.

Section 15: Other Regulatory Information

Federal and State Regulations:
Pennsylvania RTK: Propylene glycol monomethyl ether Massachusetts RTK: Propylene glycol monomethyl ether TSCA 8(b) inventory: Propylene glycol monomethyl ether

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada): CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F).

DSCL (EEC):
R10- Flammable. R36/38- Irritating to eyes and skin.

HMIS (U.S.A.):

Health Hazard: 0

Fire Hazard: 3

Reactivity: 0

Personal Protection: j

National Fire Protection Association (U.S.A.):

Health: 0

Flammability: 3

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References:
-Hawley, G.G.. The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987. -SAX, N.I. Dangerous Properties of Indutrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. -The Sigma-Aldrich Library of Chemical Safety Data, Edition II.

Other Special Considerations: Not available.

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SAFETY DATA SHEET

Isopropyl Alcohol (Isopropanol)

Section 1. Identification

GHS product identifier : Isopropyl Alcohol (Isopropanol)

Chemical name : Isopropyl alcohol

Other means of identification : propan-2-ol; 2-Propanol; isopropanol; isopropyl alcohol

Product use : Synthetic/Analytical chemistry.

Synonym : propan-2-ol; 2-Propanol; isopropanol; isopropyl alcohol

SDS # : 001105

Supplier's details : Airgas USA, LLC and its affiliates
259 North Radnor-Chester Road
Suite 100
Radnor, PA 19087-5283
1-610-687-5253

Emergency telephone number (with hours of operation) : 1-866-734-3438

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : FLAMMABLE LIQUIDS - Category 2
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Narcotic effects) - Category 3

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Highly flammable liquid and vapor.
May form explosive mixtures with air.
Causes serious eye irritation.
May cause drowsiness and dizziness.

Precautionary statements

General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking. Use explosion-proof electrical, ventilating, lighting and all material-handling equipment. Use only non-sparking tools. Take precautionary measures against static discharge. Keep container tightly closed. Use only outdoors or in a well-ventilated area. Avoid breathing vapor. Wash hands thoroughly after handling. Use and store only outdoors or in a well ventilated place.

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Section 2. Hazards identification

Response : IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or physician if you feel unwell. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water or shower. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical attention.

Storage : Store locked up. Store in a well-ventilated place. Keep cool.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Substance

Chemical name : Isopropyl alcohol

Other means of identification : propan-2-ol; 2-Propanol; isopropanol; isopropyl alcohol

CAS number/other identifiers

CAS number : 67-63-0

Product code : 001105

Ingredient name	%	CAS number
propan-2-ol	100	67-63-0

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention. If necessary, call a poison center or physician. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention. If necessary, call a poison center or physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention

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Section 4. First aid measures

immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : Can cause central nervous system (CNS) depression. May cause drowsiness and dizziness.

Skin contact : No known significant effects or critical hazards.

Frostbite : Try to warm up the frozen tissues and seek medical attention.

Ingestion : Can cause central nervous system (CNS) depression. Irritating to mouth, throat and stomach.

Over-exposure signs/symptoms

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : Adverse symptoms may include the following:
nausea or vomiting
headache
drowsiness/fatigue
dizziness/vertigo
unconsciousness

Skin contact : No specific data.

Ingestion : No specific data.

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use dry chemical, CO_2, water spray (fog) or foam.

Unsuitable extinguishing media : Do not use water jet.

Specific hazards arising from the chemical : Highly flammable liquid and vapor. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. The vapor/gas is heavier than air and will spread along the ground. Vapors may accumulate in low or confined areas or travel a considerable distance to a source of ignition and flash back. Runoff to sewer may create fire or explosion hazard.

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Section 5. Fire-fighting measures

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Do not ingest. Avoid contact with eyes, skin and clothing. Avoid breathing vapor or mist. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Take precautionary measures against electrostatic discharges. Empty containers retain product residue and can be hazardous. Do not reuse container.

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Section 7. Handling and storage

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits

Ingredient name	Exposure limits
propan-2-ol	**ACGIH TLV (United States, 3/2012).** TWA: 200 ppm 8 hours. STEL: 400 ppm 15 minutes. **OSHA PEL 1989 (United States, 3/1989).** TWA: 400 ppm 8 hours. TWA: 980 mg/m³ 8 hours. STEL: 500 ppm 15 minutes. STEL: 1225 mg/m³ 15 minutes. **NIOSH REL (United States, 1/2013).** TWA: 400 ppm 10 hours. TWA: 980 mg/m³ 10 hours. STEL: 500 ppm 15 minutes. STEL: 1225 mg/m³ 15 minutes. **OSHA PEL (United States, 6/2010).** TWA: 400 ppm 8 hours. TWA: 980 mg/m³ 8 hours.

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Section 8. Exposure controls/personal protection

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles.

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state : Liquid. [COLORLESS LIQUID WITH THE ODOR OF RUBBING ALCOHOL]

Color : Colorless.

Molecular weight : 60.11 g/mole

Molecular formula : C3-H8-O

Boiling/condensation point : 83°C (181.4°F)

Melting/freezing point : -90°C (-130°F)

Critical temperature : Not available.

Odor : Alcohol-like.

Odor threshold : Not available.

pH : Not available.

Flash point : Closed cup: 11.7°C (53.1°F)

Burning time : Not applicable.

Burning rate : Not applicable.

Evaporation rate : 1.7 (butyl acetate = 1)

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits : Lower: 2%
Upper: 12%

Vapor pressure : 4.4 kPa (33.002681467 mm Hg) [room temperature]

Vapor density : 2.1 (Air = 1)

Specific Volume (ft ^{3}/lb) : 1.2739

Gas Density (lb/ft ^{3}) : 0.785

Relative density : 0.79

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Section 9. Physical and chemical properties

Solubility : Not available.

Solubility in water : Not available.

Partition coefficient: n-octanol/water : 0.05

Auto-ignition temperature : 456°C (852.8°F)

Decomposition temperature : Not available.

SADT : Not available.

Viscosity : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Do not allow vapor to accumulate in low or confined areas.

Incompatibility with various substances : Highly reactive or incompatible with the following materials: acids and moisture.

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Hazardous polymerization : Under normal conditions of storage and use, hazardous polymerization will not occur.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
propan-2-ol	LC50 Inhalation Gas. LD50 Dermal LD50 Oral	Rat Rabbit Rat	45248 ppm 12800 mg/kg 5000 mg/kg	1 hours - -

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
propan-2-ol	Eyes - Moderate irritant	Rabbit	-	24 hours 100 milligrams	-
	Eyes - Moderate irritant	Rabbit	-	10 milligrams	-
	Eyes - Severe irritant	Rabbit	-	100 milligrams	-
	Skin - Mild irritant	Rabbit	-	500 milligrams	-

Sensitization

Not available.

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Section 11. Toxicological information

Mutagenicity

Not available.

Carcinogenicity

Not available.

Classification

Product/ingredient name	OSHA	IARC	NTP
propan-2-ol	-	3	-

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Name	Category	Route of exposure	Target organs
propan-2-ol	Category 3	Not applicable.	Narcotic effects

Specific target organ toxicity (repeated exposure)

Not available.

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : Can cause central nervous system (CNS) depression. May cause drowsiness and dizziness.

Skin contact : No known significant effects or critical hazards.

Ingestion : Can cause central nervous system (CNS) depression. Irritating to mouth, throat and stomach.

Symptoms related to the physical, chemical and toxicological characteristics

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : Adverse symptoms may include the following:
nausea or vomiting
headache
drowsiness/fatigue
dizziness/vertigo
unconsciousness

Skin contact : No specific data.

Ingestion : No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

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Section 11. Toxicological information

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : No known significant effects or critical hazards.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : No known significant effects or critical hazards.

Numerical measures of toxicity

Acute toxicity estimates

Not available.

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
propan-2-ol	Acute LC50 1400000 to 1950000 µg/l Marine water Acute LC50 4200 mg/l Fresh water	Crustaceans - Crangon crangon Fish - Rasbora heteromorpha	48 hours 96 hours

Persistence and degradability

Not available.

Bioaccumulative potential

Product/ingredient name	$LogP_{ow}$	BCF	Potential
propan-2-ol	0.05	-	low

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

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Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Vapor from product residues may create a highly flammable or explosive atmosphere inside the container. Do not cut, weld or grind used containers unless they have been cleaned thoroughly internally. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	TDG	Mexico	IMDG	IATA
UN number	UN1219	UN1219	UN1219	UN1219	UN1219
UN proper shipping name	ISOPROPANOL OR ISOPROPYL ALCOHOL	ISOPROPANOL; OR ISOPROPYL ALCOHOL	ISOPROPANOL OR ISOPROPYL ALCOHOL	ISOPROPANOL (ISOPROPYL ALCOHOL)	ISOPROPANOL
Transport hazard class(es)	3	3	3	3	3
Packing group	II	II	II	II	II
Environment	No.	No.	No.	No.	No.
Additional information	**Limited quantity** Yes. **Packaging instruction** **Passenger aircraft** Quantity limitation: 5 L **Cargo aircraft** Quantity limitation: 60 L **Special provisions** IB2, T4, TP1	**Explosive Limit and Limited Quantity Index** 1 **Passenger Carrying Road or Rail Index** 5	-	-	**Passenger and Cargo Aircraft**Quantity limitation: 5 L **Cargo Aircraft Only** Quantity limitation: 60 L **Limited Quantities - Passenger Aircraft** Quantity limitation: 1 L

"Refer to CFR 49 (or authority having jurisdiction) to determine the information required for shipment of the product."

Special precautions for user : **Transport within user's premises:** always transport in closed containers that are upright and secure. Ensure that persons transporting the product know what to do in the event of an accident or spillage.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code : Not available.

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Section 15. Regulatory information

U.S. Federal regulations : **TSCA 8(a) CDR Exempt/Partial exemption**: Not determined
United States inventory (TSCA 8b): This material is listed or exempted.

Clean Air Act Section 112 (b) Hazardous Air Pollutants (HAPs) : Not listed

Clean Air Act Section 602 Class I Substances : Not listed

Clean Air Act Section 602 Class II Substances : Not listed

DEA List I Chemicals (Precursor Chemicals) : Not listed

DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 302/304

Composition/information on ingredients

No products were found.

SARA 304 RQ : Not applicable.

SARA 311/312

Classification : Fire hazard
Immediate (acute) health hazard

Composition/information on ingredients

Name	%	Fire hazard	Sudden release of pressure	Reactive	Immediate (acute) health hazard	Delayed (chronic) health hazard
propan-2-ol	100	Yes.	No.	No.	Yes.	No.

SARA 313

	Product name	CAS number	%
Form R - Reporting requirements	Isopropyl alcohol	67-63-0	100
Supplier notification	Isopropyl alcohol	67-63-0	100

SARA 313 notifications must not be detached from the SDS and any copying and redistribution of the SDS shall include copying and redistribution of the notice attached to copies of the SDS subsequently redistributed.

State regulations

Massachusetts : This material is listed.

New York : This material is not listed.

New Jersey : This material is listed.

Pennsylvania : This material is listed.

Canada inventory : This material is listed or exempted.

International regulations

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Section 15. Regulatory information

International lists : **Australia inventory (AICS)**: This material is listed or exempted.
China inventory (IECSC): This material is listed or exempted.
Japan inventory: This material is listed or exempted.
Korea inventory: This material is listed or exempted.
Malaysia Inventory (EHS Register): Not determined.
New Zealand Inventory of Chemicals (NZIoC): This material is listed or exempted.
Philippines inventory (PICCS): This material is listed or exempted.
Taiwan inventory (CSNN): Not determined.

Chemical Weapons Convention List Schedule I Chemicals : Not listed

Chemical Weapons Convention List Schedule II Chemicals : Not listed

Chemical Weapons Convention List Schedule III Chemicals : Not listed

Canada

WHMIS (Canada) : Class B-2: Flammable liquid
Class D-2B: Material causing other toxic effects (Toxic).

CEPA Toxic substances: This material is not listed.
Canadian ARET: This material is not listed.
Canadian NPRI: This material is listed.
Alberta Designated Substances: This material is not listed.
Ontario Designated Substances: This material is not listed.
Quebec Designated Substances: This material is not listed.

Section 16. Other information

Canada Label requirements : Class B-2: Flammable liquid
Class D-2B: Material causing other toxic effects (Toxic).

Hazardous Material Information System (U.S.A.)

Health	*	2
Flammability		3
Physical hazards		0

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on SDSs under 29 CFR 1910. 1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.

The customer is responsible for determining the PPE code for this material.

National Fire Protection Association (U.S.A.)

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Section 16. Other information

Reprinted with permission from NFPA 704-2001, Identification of the Hazards of Materials for Emergency Response Copyright ©1997, National Fire Protection Association, Quincy, MA 02269. This reprinted material is not the complete and official position of the National Fire Protection Association, on the referenced subject which is represented only by the standard in its entirety.

Copyright ©2001, National Fire Protection Association, Quincy, MA 02269. This warning system is intended to be interpreted and applied only by properly trained individuals to identify fire, health and reactivity hazards of chemicals. The user is referred to certain limited number of chemicals with recommended classifications in NFPA 49 and NFPA 325, which would be used as a guideline only. Whether the chemicals are classified by NFPA or not, anyone using the 704 systems to classify chemicals does so at their own risk.

History

Date of printing : 5/20/2015.

Date of issue/Date of revision : 5/20/2015.

Date of previous issue : 10/28/2014.

Version : 0.02

Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United NationsACGIH – American Conference of Governmental Industrial Hygienists
AIHA – American Industrial Hygiene Association
CAS – Chemical Abstract Services
CEPA – Canadian Environmental Protection Act
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act (EPA)
CFR – United States Code of Federal Regulations
CPR – Controlled Products Regulations
DSL – Domestic Substances List
GWP – Global Warming Potential
IARC – International Agency for Research on Cancer
ICAO – International Civil Aviation Organisation
Inh – Inhalation
LC – Lethal concentration
LD – Lethal dosage
NDSL – Non-Domestic Substances List
NIOSH – National Institute for Occupational Safety and Health
TDG – Canadian Transportation of Dangerous Goods Act and Regulations
TLV – Threshold Limit Value
TSCA – Toxic Substances Control Act
WEEL – Workplace Environmental Exposure Level
WHMIS – Canadian Workplace Hazardous Material Information System

References : Not available.

Indicates information that has changed from previously issued version.

Notice to reader

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Section 16. Other information

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.
Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Solstice™ LBA

000000012786

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Solstice™ LBA
MSDS Number	:	000000012786
Product Use Description	:	Refrigerant, Foam blowing agent, Heat transfer fluid
Company	:	Honeywell International, Inc. 101 Columbia Road Morristown, NJ 07962-1057
For more information call	:	800-522-8001 +1-973-455-6300 (Monday-Friday, 9:00am-5:00pm)
In case of emergency call	:	**Medical: 1-800-498-5701 or +1-303-389-1414**
	:	**Transportation (CHEMTREC): 1-800-424-9300 or +1-703-527-3887**
	:	
	:	(24 hours/day, 7 days/week)

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

Form	:	liquid, clear
Color	:	colourless
Odor	:	slight
Hazard Summary	:	This product is not flammable at ambient temperatures and atmospheric pressure. Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing. Causes asphyxiation in high concentrations. The victim will not realize that he/she is suffocating. Excessive exposure may cause central nervous system effects including drowsiness and dizziness. Excessive exposure may also cause cardiac arrhythmia. Do not breathe vapours or spray mist. Avoid contact with skin, eyes and clothing. At higher temperatures,

(>250°C), decomposition products may include hydrochloric acid (HCl), hydrofluoric acid (HF) and carbonyl halides. The ACGIH Threshold Limit Values (2007) for Hydrogen Fluoride are TLV-TWA 0.5 ppm and Ceiling Exposure Limit 2 ppm.

Potential Health Effects

Skin	:	Not classified as a skin irritant in animal testing.
Eyes	:	No adverse health effects are expected.
Ingestion	:	Unlikely route of exposure. Effects due to ingestion may include: Gastrointestinal discomfort
Inhalation	:	Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing. Causes asphyxiation in high concentrations. The victim will not realize that he/she is suffocating. Excessive exposure may cause central nervous system effects including drowsiness and dizziness. Excessive exposure may also cause cardiac arrhythmia.
Chronic Exposure	:	None known.

Carcinogenicity

No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP, IARC, or OSHA.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Chemical nature : Substance

Chemical Name	CAS-No.	Concentration
trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0	>99.00 %

SECTION 4. FIRST AID MEASURES

Inhalation	:	Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Use oxygen as required, provided a qualified operator is present. Call a physician.
Skin contact	:	After contact with skin, wash immediately with plenty of water. If symptoms persist, call a physician. Take off all contaminated clothing immediately. Wash contaminated clothing before re-use.
Eye contact	:	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Call a physician if irritation develops or persists.
Ingestion	:	If victim is fully conscious, give a cupful of water. Do not induce vomiting without medical advice. Never give anything by mouth to an unconscious person. Call a physician immediately.

Notes to physician

Treatment	:	Treat symptomatically.

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media	:	The product is not flammable. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. Water spray Carbon dioxide (CO2) Dry chemical Foam
Specific hazards during firefighting	:	This product is not flammable at ambient temperatures and atmospheric pressure. However, this material can ignite when mixed with air under pressure and exposed to strong ignition sources. Container may rupture on heating. Cool closed containers exposed to fire with water spray. Do not allow run-off from fire fighting to enter drains or water courses.

Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing.
Exposure to decomposition products may be a hazard to health.
In case of fire hazardous decomposition products may be produced such as:
Hydrogen fluoride
Gaseous hydrogen chloride (HCl).
Carbon monoxide
Carbon dioxide (CO2)
Carbonyl halides

Special protective equipment for firefighters : In the event of fire and/or explosion do not breathe fumes.
Wear self-contained breathing apparatus and protective suit.
No unprotected exposed skin areas.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions : Immediately evacuate personnel to safe areas.
Keep people away from and upwind of spill/leak.
Wear personal protective equipment. Unprotected persons must be kept away.
Remove all sources of ignition.
Ventilate the area.
Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing.
Avoid accumulation of vapours in low areas.
Unprotected personnel should not return until air has been tested and determined safe.
Ensure that the oxygen content is >= 19.5%.

Environmental precautions : Should not be released into the environment.
Do not flush into surface water or sanitary sewer system.
Prevent further leakage or spillage if safe to do so.
Prevent spreading over a wide area (e.g. by containment or oil barriers).

Methods for cleaning up : Contain spillage, and then collect with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local / national regulations (see section 13).

SECTION 7. HANDLING AND STORAGE

Handling

Handling	:	Handle with care. Do not use in areas without adequate ventilation. Do not breathe vapours or spray mist. Avoid contact with skin, eyes and clothing. Pressurized container. Protect from sunlight and do not expose to temperatures exceeding 50 °C. Follow all standard safety precautions for handling and use of compressed gas cylinders. Use authorized cylinders only. Protect cylinders from physical damage. Do not puncture or drop cylinders, expose them to open flame or excessive heat. Do not pierce or burn, even after use. Do not spray on a naked flame or any incandescent material. Do not remove screw cap until immediately ready for use. Always replace cap after use.
Advice on protection against fire and explosion	:	Can form a combustible mixture with air at pressures above atmospheric pressure. Keep product and empty container away from heat and sources of ignition.

Storage

Requirements for storage areas and containers	:	Pressurized container: protect from sunlight and do not expose to temperatures exceeding 50 °C. Do not pierce or burn, even after use. Keep containers tightly closed in a dry, cool and well-ventilated place. Storage rooms must be properly ventilated. Ensure adequate ventilation, especially in confined areas. Protect cylinders from physical damage. Store away from incompatible substances.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Protective measures	:	Ensure that eyewash stations and safety showers are close to the workstation location. Do not breathe vapours or spray mist. Avoid contact with skin, eyes and clothing.
Engineering measures	:	Use with local exhaust ventilation. Perform filling operations only at stations with exhaust ventilation facilities.
Eye protection	:	Do not wear contact lenses. Wear as appropriate: Goggles or face shield, giving complete protection to eyes
Hand protection	:	Impervious gloves Gloves must be inspected prior to use. Replace when worn.
Skin and body protection	:	Wear as appropriate: Solvent-resistant gloves Solvent-resistant apron and boots If splashes are likely to occur, wear: Protective suit
Respiratory protection	:	In case of insufficient ventilation wear suitable respiratory equipment. Wear a positive-pressure supplied-air respirator. For rescue and maintenance work in storage tanks use self-contained breathing apparatus. Use NIOSH approved respiratory protection.
Hygiene measures	:	Handle in accordance with good industrial hygiene and safety practice. Avoid contact with skin, eyes and clothing. Do not breathe vapours or spray mist. Ensure adequate ventilation, especially in confined areas. Remove and wash contaminated clothing before re-use. Contaminated work clothing should not be allowed out of the workplace. Keep working clothes separately. Wash hands before breaks and immediately after handling the product.

Exposure Guidelines

Components	CAS-No.	Value	Control parameters	Update	Basis

trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0	TWA : time weighted average	(800 ppm)	2013	Honeywell:Limit established by Honeywell International Inc.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state	:	liquid, clear
Color	:	colourless
Odor	:	slight
Melting point/freezing point	:	< -90 °C Method: OECD Test Guideline 102
Boiling point/boiling range	:	19 °C
Flash point	:	Method: ISO 2719 Note: not applicable
Flammability	:	The product is not flammable. Method: Flammability (gases)
Lower explosion limit	:	Note: None
Upper explosion limit	:	Note: None
Vapor pressure	:	1,516 hPa at 30 °C(86 °F)
Vapor density	:	Note: (Air = 1.0), not determined
Density	:	1.27 g/cm3

Water solubility	:	1.90 g/l at 20 °C Method: OECD Test Guideline 105
Partition coefficient: n-octanol/water	:	log Pow: 2.2 at 25 °C
Ignition temperature	:	380 °C at 986.8 - 1,035.9 hPa Method: DIN 51794
Oxidizing properties	:	The substance or mixture is not classified as oxidizing.
Molecular Weight	:	130.5 g/mol

SECTION 10. STABILITY AND REACTIVITY

Possibility of hazardous reactions	:	Polymerization can occur.
Conditions to avoid	:	Protect from heat/overheating. Keep away from direct sunlight. Heat, flames and sparks. Do not mix with oxygen or air above atmospheric pressure.
Incompatible materials to avoid	:	Strong oxidizing agents Magnesium Aluminium
Hazardous decomposition products	:	In case of fire hazardous decomposition products may be produced such as: Carbon monoxide Carbon dioxide (CO2) Carbonyl halides Gaseous hydrogen chloride (HCl). Gaseous hydrogen fluoride (HF).

SECTION 11. TOXICOLOGICAL INFORMATION

Acute inhalation toxicity	:	LC50: 120000 ppm Exposure time: 4 h Species: rat
Skin irritation	:	Species: rabbit Result: No skin irritation Classification: Not classified as a skin irritant in animal testing. Method: OECD Test Guideline 404 Exposure time: 4 h
Sensitisation	:	Result: Does not cause skin sensitisation. Classification: Patch test on human volunteers did not demonstrate sensitisation properties.
	:	Cardiac sensitization Species: dogs Note: Cardiac sensitisation threshold (dog): 25000 ppm.
Repeated dose toxicity	:	Species: rat Application Route: Inhalation Exposure time: 4 Weeks NOEL: 4500 ppm Note: Subacute toxicity
Genotoxicity in vitro	:	Test Method: Mutagenicity (Salmonella typhimurium - reverse mutation assay) Result: negative
Genotoxicity in vivo	:	Species: rat Cell type: Bone marrow Method: Mutagenicity (micronucleus test) Result: negative
Genotoxicity in vivo	:	Test Method: Unscheduled DNA synthesis Species: rat Result: negative

Genotoxicity in vivo	:	Species: mouse Cell type: Bone marrow Method: Mutagenicity (micronucleus test) Result: negative
Reproductive toxicity	:	Species: rabbit Note: No-observed-effect level - 15,000 ppm
	:	Species: rat Note: No-observed-effect level - 10,000 ppm
Teratogenicity	:	Species: rabbit Note: No-observed-effect level - 15,000 ppm
	:	Species: rat Note: No-observed-effect level - 10,000 ppm

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity effects

Toxicity to fish	:	LC50: 38 mg/l Exposure time: 96 h Species: Oncorhynchus mykiss (rainbow trout) Method: OECD Test Guideline 203
Toxicity to daphnia and other aquatic invertebrates	:	Immobilization EC50: 82 mg/l Exposure time: 48 h Species: Daphnia magna (Water flea) Method: OECD Test Guideline 202
Toxicity to algae	:	Growth inhibition EC50: 106.7 mg/l Exposure time: 72 h Species: Pseudokirchneriella subcapitata (green algae)

Method: OECD Test Guideline 201

: Growth rate
NOEC: 115 mg/l
Exposure time: 72 h
Species: Pseudokirchneriella subcapitata (green algae)
Method: OECD Test Guideline 201

Elimination information (persistence and degradability)

Biodegradability : Result: Not readily biodegradable.
Value: 0 %
Method: OECD 301 D

Further information on ecology

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods : Observe all Federal, State, and Local Environmental regulations.

Note : Where possible recycling is preferred to disposal or incineration.

SECTION 14. TRANSPORT INFORMATION

DOT	UN/ID No.	:	UN 3163
	Proper shipping name	:	LIQUEFIED GAS, N.O.S. (Trans-1-Chloro-3,3,3-trifluoropropene)
	Class		2.2
	Packing group		
	Hazard Labels		2.2
IATA	UN/ID No.	:	UN 3163
	Description of the goods	:	LIQUEFIED GAS, N.O.S. (Trans-1-Chloro-3,3,3-trifluoropropene)
	Class	:	2.2
	Hazard Labels	:	2.2
	Packing instruction (cargo	:	200

	aircraft)		
	Packing instruction (passenger aircraft)	:	200
IMDG	UN/ID No.	:	UN 3163
	Description of the goods	:	LIQUEFIED GAS, N.O.S. (TRANS-1-CHLORO-3,3,3-TRIFLUOROPROPENE)
	Class	:	2.2
	Hazard Labels	:	2.2
	EmS Number	:	F-C, S-V
	Marine pollutant	:	no

SECTION 15. REGULATORY INFORMATION

Inventories

US. Toxic Substances Control Act	:	On TSCA Inventory	
Australia. Industrial Chemical (Notification and Assessment) Act	:	Not in compliance with the inventory	
	:	trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0
Canada. Canadian Environmental Protection Act (CEPA). Domestic Substances List (DSL)	:	Not in compliance with the inventory	
	:	trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0
Japan. Kashin-Hou Law List	:	On the inventory, or in compliance with the inventory	
Korea. Toxic Chemical Control Law (TCCL) List	:	On the inventory, or in compliance with the inventory	
Philippines. The Toxic Substances and Hazardous and Nuclear Waste Control Act	:	Not in compliance with the inventory	

	:	trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0
China. Inventory of Existing Chemical Substances	:	Not in compliance with the inventory	
	:	trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0
New Zealand. Inventory of Chemicals (NZIoC), as published by ERMA New Zealand	:	Not in compliance with the inventory	
	:	trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0

National regulatory information

SARA 302 Components	:	SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.
SARA 313 Components	:	SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.
SARA 311/312 Hazards	:	Acute Health Hazard Sudden Release of Pressure Hazard
California Prop. 65	:	This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

New Jersey RTK	:	trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0
Pennsylvania RTK	:	trans-1-Chloro-3,3,3-trifluoropropene	102687-65-0

WHMIS Classification : A: Compressed Gas
This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR.

SECTION 16. OTHER INFORMATION

		HMIS III	NFPA
Health hazard	:	2	2
Flammability	:	0	0
Physical Hazard	:	0	
Instability	:		0

Hazard rating and rating systems (e.g. HMIS® III, NFPA): This information is intended solely for the use of individuals trained in the particular system.

Further information

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text. Final determination of suitability of any material is the sole responsibility of the user. This information should not constitute a guarantee for any specific product properties.

Changes since the last version are highlighted in the margin. This version replaces all previous versions.
Previous Issue Date: 04/23/2013
Prepared by: Honeywell Performance Materials and Technologies Product Stewardship Group

Safety Data Sheet

DuPont™ Vertrel® SUPRION™ UP

Version 2.0

Revision Date 05/29/2015 Ref. 130000122903

This SDS adheres to the standards and regulatory requirements of the United States and may not meet the regulatory requirements in other countries.

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	DuPont™ Vertrel® SUPRION™ UP
Tradename/Synonym	:	Methoxytridecafluoroheptene isomers
Product Use	:	Cleaning agent, Carrier fluid, For professional users only.
Restrictions on use	:	Do not use product for anything outside of the above specified uses
Manufacturer/Supplier	:	DuPont 1007 Market Street Wilmington, DE 19898 United States of America
Product Information	:	+1-800-441-7515 (outside the U.S. +1-302-774-1000)
Medical Emergency	:	1-800-441-3637 (outside the U.S. 1-302-774-1139)
Transport Emergency	:	CHEMTREC: +1-800-424-9300 (outside the U.S. +1-703-527-3887)

SECTION 2. HAZARDS IDENTIFICATION

Not classified as a hazardous substance or mixture according to the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard 2012.

Other hazards
Vapours are heavier than air and can cause suffocation by reducing oxygen available for breathing., Misuse or intentional inhalation abuse may cause death without warning symptoms, due to cardiac effects.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No.	Concentration

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Methoxytridecafluoroheptene isomers		100 %

SECTION 4. FIRST AID MEASURES

General advice	:	Never give anything by mouth to an unconscious person. Victim to lie down in the recovery position, cover and keep him warm. Give oxygen or artificial respiration if needed. When symptoms persist or in all cases of doubt seek medical advice.
Inhalation	:	Remove from exposure, lie down. Move to fresh air. Keep patient warm and at rest. Artificial respiration and/or oxygen may be necessary. Consult a physician.
Skin contact	:	Take off all contaminated clothing immediately. Wash off with warm water.
Eye contact	:	In case of eye contact Hold eyelids apart and flush eyes with plenty of water for at least 15 minutes. Get medical attention.
Ingestion	:	Do not induce vomiting without medical advice. Never give anything by mouth to an unconscious person. Drink 1 or 2 glasses of water. If vomiting occurs, have victim lean forward to reduce the risk of aspiration. Consult a physician.
Most important symptoms/effects, acute and delayed	:	Dizziness
Protection of first-aiders	:	If potential for exposure exists refer to Section 8 for specific personal protective equipment.
Notes to physician	:	Treat symptomatically. Because of possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, that may be used in situations of emergency life support should be used with special caution.

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media	:	Water spray, Water mist, Dry chemical, Carbon dioxide (CO2)

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Unsuitable extinguishing media	:	No applicable data available.
Specific hazards	:	The product is not flammable. Hazardous decomposition products Hydrogen fluoride Carbon monoxide Carbonyl fluoride
Special protective equipment for firefighters	:	In the event of fire, wear self-contained breathing apparatus. Use personal protective equipment. Wear neoprene gloves during cleaning up work after a fire. Exposure to decomposition products may be a hazard to health.
Further information	:	Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. Evacuate personnel to safe areas. Cool containers/tanks with water spray. Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations.

SECTION 6. ACCIDENTAL RELEASE MEASURES

NOTE: Review FIRE FIGHTING MEASURES and HANDLING (PERSONNEL) sections before proceeding with clean-up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean-up.

Safeguards (Personnel)	:	Evacuate personnel to safe areas. Ventilate area, especially low or enclosed places where heavy vapours might collect. In case of insufficient ventilation, wear suitable respiratory equipment. Refer to protective measures listed in sections 7 and 8.
Environmental precautions	:	Prevent further leakage or spillage. Prevent spreading over a wide area (e.g. by containment or oil barriers). Do not allow contact with soil, surface or ground water. Prevent material from entering sewers, waterways, or low areas.
Spill Cleanup	:	Contain spillage, and then collect with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local / national regulations (see section 13). Do not flush with water. Do not let product enter drains.
Accidental Release Measures	:	Prevent spreading over a wide area (e.g. by containment or oil barriers).

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SECTION 7. HANDLING AND STORAGE

Handling (Personnel)	:	Avoid contact with skin, eyes and clothing. Avoid breathing vapours or mist. Provide sufficient air exchange and/or exhaust in work rooms. For personal protection see section 8.
Handling (Physical Aspects)	:	Material should not be dispensed by pouring from pail/drum shipping containers containing 5 gallons or more. The use of a drum pump is recommended for dispensing from pail/drum shipping containers with 5 gallons or more, except for smaller containers where adequate ventilation can be used to manage the exposure.
Dust explosion class	:	Not applicable
Storage	:	Protect from contamination. To prevent leaks or spillages from spreading, provide a suitable liquid retention system. Keep container tightly closed in a dry and well-ventilated place. Store in original container. Avoid freezing temperatures. If stored below -10°C (14°F), mix prior to use. No materials to be especially mentioned. For further information see Section 10 of the safety data sheet.
Storage period	:	No applicable data available.
Storage temperature	:	< 52 °C (< 126 °F)

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Personal protective equipment

Respiratory protection	:	Wear NIOSH approved respiratory protection as appropriate.
Hand protection	:	Material: Solvent-resistant gloves
Hand protection	:	Material: Neoprene
Hand protection	:	Material: Viton ® Glove thickness: 0.7 mm Wearing time: 2 h
Eye protection	:	Wear safety glasses or coverall chemical splash goggles.

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Skin and body protection : Where there is potential for skin contact, have available and wear as appropriate, impervious gloves, apron, pants, jacket, hood and boots.

Exposure Guidelines
Exposure Limit Values

Methoxytridecafluoroheptene isomers			
AEL *	(DUPONT)	500 ppm	8 & 12 hr. TWA

* AEL is DuPont's Acceptable Exposure Limit. Where governmentally imposed occupational exposure limits which are lower than the AEL are in effect, such limits shall take precedence.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance
Physical state : liquidliquid
Form : liquid
Color : clear, colourless

Odor : mild, musty

Odor threshold : No applicable data available.

pH : neutral

Melting point/freezing point : Freezing point
< -85 °C (-121 °F) at 1,013 hPa

Boiling point/boiling range : Boiling point
110.5 °C (230.9 °F) at 1,013 hPa

Flash point : Method: Tag closed cup - TCC

Method: ASTM D 56
does not flash

Evaporation rate : 2.2
(Butyl Acetate=1.0)

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Flammability (solid, gas)	:	The product is not flammable.
Upper explosion limit	:	Method: None per ASTM E681
Lower explosion limit	:	Method: None per ASTM E681
Vapor pressure	:	21.5 hPa at 20 °C (68 °F) estimated
	:	2.9 kPa at 25 °C (77 °F) estimated
Vapour density	:	No applicable data available.
Density	:	1.59 g/cm3 at 25 °C (77 °F) Method: ASTM D 4052
Specific gravity (Relative density)	:	1.59
Water solubility	:	0.00015 g/l at 24 °C (75 °F) slightly soluble
Solubility(ies)	:	No applicable data available.
Partition coefficient: n-octanol/water	:	Pow: 4.9 at 25 °C (77 °F) Method: High-performance liquid chromatography
Auto-ignition temperature	:	348 - 351 °C 1,013 hPa Auto-ignition temperature Method: ASTM E569
Decomposition temperature	:	No applicable data available.
Viscosity, kinematic	:	0.74 mm2/s at 25 °C (77 °F) Method: ASTM D 445
Viscosity, dynamic	:	1.17 mPa.s
% Volatile	:	100 %
Oxidizing Substance	:	The product is not oxidizing.

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SECTION 10. STABILITY AND REACTIVITY

Reactivity	:	Stable at normal ambient temperature and pressure.
Chemical stability	:	The product is chemically stable. No decomposition if stored and applied as directed. No decomposition if stored and applied as directed.
Possibility of hazardous reactions	:	No applicable data available.
Conditions to avoid	:	Avoid open flames and high temperatures.
Incompatible materials	:	Strong Lewis acids such as aluminum trichloride; Alkali metals, Alkaline earth metals, Powdered metals, Powdered metal salts
Hazardous decomposition products	:	Hazardous decomposition products formed under fire conditions.: Hydrogen fluoride, Carbon monoxide, Carbonyl fluoride

SECTION 11. TOXICOLOGICAL INFORMATION

Methoxytridecafluoroheptene isomers

Inhalation 4 h LC50	:	> 222.15 mg/l , Rat
Dermal LD50	:	> 5,000 mg/kg , Rat
Oral LD50	:	> 5,000 mg/kg , Rat
Skin irritation	:	No skin irritation, Rabbit
Eye irritation	:	No eye irritation, Rabbit
Skin sensitization	:	Does not cause skin sensitisation., Mouse
Repeated dose toxicity	:	Oral - gavage Rat - 28 d NOAEL: 1,000 mg/kgMethod: OECD Test Guideline 407 No toxicologically significant effects were found. Oral - gavage Rat

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- 90 d
NOAEL: 1,000 mg/kg
No toxicologically significant effects were found.

Inhalation
Rat
- 28 d
NOAEL: 5100 ppm,
No toxicologically significant effects were found.

Mutagenicity : Animal testing did not show any mutagenic effects.
Tests on bacterial or mammalian cell cultures did not show mutagenic effects.

Teratogenicity : Animal testing showed no developmental toxicity.

Carcinogenicity
The carcinogenicity classifications for this product and/or its ingredients have been determined according to HazCom 2012, Appendix A.6. The classifications may differ from those listed in the National Toxicology Program (NTP) Report on Carcinogens (latest edition) or those found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest edition).

None of the components present in this material at concentrations equal to or greater than 0.1% are listed by IARC, NTP, or OSHA, as a carcinogen.

SECTION 12. ECOLOGICAL INFORMATION

Aquatic Toxicity
Methoxytridecafluoroheptene isomers

96 h LC50 : Oryzias latipes (Orange-red killifish) > 0.096 mg/l
No acute toxicity effects at concentrations up to the limit of aqueous solubility

72 h EC50 : Pseudokirchneriella subcapitata (green algae) > 0.000477 mg/l
No acute toxicity effects at concentrations up to the limit of aqueous solubility

48 h EC50 : Daphnia magna (Water flea) > 0.157 mg/l
No acute toxicity effects at concentrations up to the limit of aqueous solubility

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Respiration inhibition	:	EC50 > 1000 ppm
21 d	:	NOEC Daphnia magna (Water flea) 0.107 mg/l OECD Test Guideline 211 No chronic toxicity effects were observed at concentrations up to the limit of aqueous solubility.

Environmental Fate

Methoxytridecafluoroheptene isomers

Biodegradability	:	39.5 % OECD Test Guideline 302 Inherently biodegradable.
Bioaccumulation	:	Cyprinus carpio (Carp) Bioconcentration factor (BCF) : 1,990 The substance has the potential to bioaccumulate.

SECTION 13. DISPOSAL CONSIDERATIONS

Waste disposal methods - Product	:	Reclaim by distillation, incinerate, or remove to permitted waste facility. Can be used after re-conditioning. If recycling is not practicable, dispose of in compliance with local regulations. The product should not be allowed to enter drains, water courses or the soil. Prevent wastewater, spent product, and materials containing or contaminated with product from entering waterways.
Contaminated packaging	:	If recycling is not practicable, dispose of in compliance with local regulations.

SECTION 14. TRANSPORT INFORMATION

Not classified as dangerous in the meaning of transport regulations.

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SECTION 15. REGULATORY INFORMATION

TSCA	:	Listed
SARA 313 Regulated Chemical(s)	:	This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.
California Prop. 65	:	Chemicals known to the State of California to cause cancer, birth defects or any other harm: none known

SECTION 16. OTHER INFORMATION

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Before use read DuPont's safety information.
For further information contact the local DuPont office or DuPont's nominated distributors.

Revision Date : 05/29/2015

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

Significant change from previous version is denoted with a double bar.

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SAFETY DATA SHEET

Version 4.6
Revision Date 03/02/2015
Print Date 04/14/2015

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name	:	Trichloroethylene
Product Number	:	251402
Brand	:	Sigma-Aldrich
Index-No.	:	602-027-00-9
CAS-No.	:	79-01-6

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses	:	Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052

1.4 Emergency telephone number

Emergency Phone #	:	(314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)
Skin irritation (Category 2), H315
Eye irritation (Category 2A), H319
Germ cell mutagenicity (Category 2), H341
Carcinogenicity (Category 1B), H350
Specific target organ toxicity - single exposure (Category 3), Central nervous system, H336
Acute aquatic toxicity (Category 3), H402
Chronic aquatic toxicity (Category 3), H412

For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)

H315	Causes skin irritation.
H319	Causes serious eye irritation.
H336	May cause drowsiness or dizziness.
H341	Suspected of causing genetic defects.
H350	May cause cancer.
H412	Harmful to aquatic life with long lasting effects.

Precautionary statement(s)

P201	Obtain special instructions before use.
P202	Do not handle until all safety precautions have been read and understood.
P261	Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P264	Wash skin thoroughly after handling.
P271	Use only outdoors or in a well-ventilated area.
P273	Avoid release to the environment.
P280	Wear eye protection/ face protection.
P280	Wear protective gloves.
P281	Use personal protective equipment as required.
P302 + P352	IF ON SKIN: Wash with plenty of soap and water.
P304 + P340 + P312	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or doctor/ physician if you feel unwell.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P308 + P313	IF exposed or concerned: Get medical advice/ attention.
P332 + P313	If skin irritation occurs: Get medical advice/ attention.
P337 + P313	If eye irritation persists: Get medical advice/ attention.
P362	Take off contaminated clothing and wash before reuse.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS - none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms	:	TCE Trichloroethene
Formula	:	C_2HCl_3
Molecular weight	:	131.39 g/mol
CAS-No.	:	79-01-6
EC-No.	:	201-167-4
Index-No.	:	602-027-00-9

Hazardous components

Component	Classification	Concentration
Trichloroethylene Included in the Candidate List of Substances of Very High Concern (SVHC) according to Regulation (EC) No. 1907/2006 (REACH)		
	Skin Irrit. 2; Eye Irrit. 2A; Muta. 2; Carc. 1B; STOT SE 3; Aquatic Acute 3; Aquatic Chronic 3; H315, H319, H336, H341, H350, H412	<= 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides, Hydrogen chloride gas

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
No data available

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

6.3 Methods and materials for containment and cleaning up
Soak up with inert absorbent material and dispose of as hazardous waste. Keep in suitable, closed containers for disposal.

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

Light sensitive. Handle and store under inert gas.
Storage class (TRGS 510): Non-combustible, acute toxic Cat.3 / toxic hazardous materials or hazardous materials causing chronic effects

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Trichloroethylene	79-01-6	TWA	10.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Central Nervous System impairment cognitive decrement Renal toxicity Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Suspected human carcinogen		
		STEL	25.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Central Nervous System impairment cognitive decrement Renal toxicity Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Suspected human carcinogen		
		Potential Occupational Carcinogen See Appendix C See Appendix A		
		See Table Z-2		
		TWA	100.000000 ppm	USA. Occupational Exposure Limits (OSHA) - Table Z-2
		Z37.19-1967		
		CEIL	200.000000 ppm	USA. Occupational Exposure Limits (OSHA) - Table Z-2
		Z37.19-1967		
		Peak	300.000000 ppm	USA. Occupational Exposure Limits (OSHA) - Table Z-2
		Z37.19-1967		

Biological occupational exposure limits

Component	CAS-No.	Parameters	Value	Biological specimen	Basis
Trichloroethylene	79-01-6	Trichloroacetic acid	15.0000 mg/l	Urine	ACGIH - Biological Exposure Indices (BEI)
	Remarks	End of shift at end of workweek			
		Trichloroethanol	0.5000 mg/l	In blood	ACGIH - Biological Exposure Indices (BEI)
		End of shift at end of workweek			
		Trichloroethylene		In blood	ACGIH - Biological Exposure Indices (BEI)
		End of shift at end of workweek			
		Trichloroethylene		In end-exhaled air	ACGIH - Biological Exposure Indices (BEI)
		End of shift at end of workweek			

8.2 Exposure controls

Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection
Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Fluorinated rubber
Minimum layer thickness: 0.7 mm
Break through time: 480 min
Material tested:Vitoject® (KCL 890 / Aldrich Z677698, Size M)

Splash contact
Material: Fluorinated rubber
Minimum layer thickness: 0.7 mm
Break through time: 480 min
Material tested:Vitoject® (KCL 890 / Aldrich Z677698, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a)	Appearance	Form: liquid, clear Colour: colourless
b)	Odour	No data available
c)	Odour Threshold	No data available
d)	pH	No data available
e)	Melting point/freezing point	Melting point/range: -84.8 °C (-120.6 °F) - lit.
f)	Initial boiling point and boiling range	86.7 °C (188.1 °F) - lit.
g)	Flash point	No data available
h)	Evaporation rate	No data available
i)	Flammability (solid, gas)	No data available
j)	Upper/lower	Upper explosion limit: 10.5 %(V)

	flammability or explosive limits	Lower explosion limit: 8 %(V)
k)	Vapour pressure	81.3 hPa (61.0 mmHg) at 20.0 °C (68.0 °F)
l)	Vapour density	No data available
m)	Relative density	1.463 g/mL at 25 °C (77 °F)
n)	Water solubility	No data available
o)	Partition coefficient: n-octanol/water	log Pow: 2.29log Pow: 5
p)	Auto-ignition temperature	410.0 °C (770.0 °F)
q)	Decomposition temperature	No data available
r)	Viscosity	No data available
s)	Explosive properties	No data available
t)	Oxidizing properties	No data available

9.2 Other safety information
No data available

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
No data available

10.4 Conditions to avoid
No data available

10.5 Incompatible materials
Oxidizing agents, Strong bases, Magnesium

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - 4,920 mg/kg

LC50 Inhalation - Mouse - 4 h - 8450 ppm

LD50 Dermal - Rabbit - > 20,000 mg/kg

No data available

Skin corrosion/irritation
Skin - Rabbit
Result: Severe skin irritation - 24 h

Serious eye damage/eye irritation
Eyes - Rabbit
Result: Eye irritation - 24 h

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
Laboratory experiments have shown mutagenic effects.
In vitro tests showed mutagenic effects

Carcinogenicity

This product is or contains a component that has been reported to be probably carcinogenic based on its IARC, OSHA, ACGIH, NTP, or EPA classification.

Possible human carcinogen

IARC:	1 - Group 1: Carcinogenic to humans (Trichloroethylene)
NTP:	Reasonably anticipated to be a human carcinogen (Trichloroethylene)
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

No data available

Specific target organ toxicity - single exposure
No data available

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available

Additional Information
RTECS: KX4550000

burning sensation, Cough, wheezing, laryngitis, Shortness of breath, Headache, Nausea, Vomiting, Exposure to and/or consumption of alcohol may increase toxic effects., Gastrointestinal disturbance, Kidney injury may occur., narcosis
To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	LC50 - Pimephales promelas (fathead minnow) - 41 mg/l - 96.0 h
	LOEC - other fish - 11 mg/l - 10.0 d
	NOEC - Oryzias latipes - 40 mg/l - 10.0 d
Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia magna (Water flea) - 18.00 mg/l - 48 h
Toxicity to algae	IC50 - Pseudokirchneriella subcapitata (green algae) - 175.00 mg/l - 96 h

12.2 Persistence and degradability
No data available

12.3 Bioaccumulative potential
Does not bioaccumulate.

12.4 Mobility in soil
No data available

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects
An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.
Harmful to aquatic life with long lasting effects.

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1710 Class: 6.1 Packing group: III
Proper shipping name: Trichloroethylene
Reportable Quantity (RQ): 100 lbs

Poison Inhalation Hazard: No

IMDG
UN number: 1710 Class: 6.1 Packing group: III EMS-No: F-A, S-A
Proper shipping name: TRICHLOROETHYLENE

IATA
UN number: 1710 Class: 6.1 Packing group: III
Proper shipping name: Trichloroethylene

15. REGULATORY INFORMATION

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
The following components are subject to reporting levels established by SARA Title III, Section 313:

	CAS-No.	Revision Date
Trichloroethylene	79-01-6	2007-07-01

SARA 311/312 Hazards
Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Trichloroethylene	79-01-6	2007-07-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Trichloroethylene	79-01-6	2007-07-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Trichloroethylene	79-01-6	2007-07-01

California Prop. 65 Components

	CAS-No.	Revision Date
WARNING! This product contains a chemical known to the State of California to cause cancer. Trichloroethylene	79-01-6	2011-09-01
WARNING: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.	79-01-6	2011-09-01

Trichloroethylene

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Aquatic Acute	Acute aquatic toxicity
Aquatic Chronic	Chronic aquatic toxicity
Carc.	Carcinogenicity
Eye Irrit.	Eye irritation
H315	Causes skin irritation.
H319	Causes serious eye irritation.
H336	May cause drowsiness or dizziness.
H341	Suspected of causing genetic defects.
H350	May cause cancer.
H402	Harmful to aquatic life.

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	0
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	0
Reactivity Hazard:	0

Further information

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Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

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