Industrial Contract Delivery Report - Calibrated CTMFD Neutron Detection Units –Purdue Univ./Covert Defenses, LLC PERA Award ID: AWD00000423 – April 21, 2025

Executive Summary

April 21, 2025

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In conjunction with the industrial contract, four (4) calibrated centrifugally tensioned metastable fluid detector (CTMFD) detection units (DUs) – comprising glassware containing detection fluid (decafluoropentane-DFP) affixed to a holder frame have been fabricated for delivery. These 4 DUs (A-B-C-D) are shown in Fig. 1a.

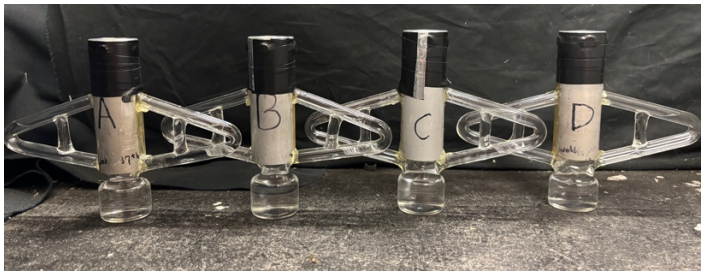


Fig. 1a. Images of the 4 CTMFD Detection Units A-B-C-D

Each of the four DUs was fabricated using handblown glassware, for which the central bulb volume is ~20 cc (with slight variations between the bulbs due to being manually produced). Each diamond-shaped glass bulb is affixed to an aluminum holder/bracket using 2-part epoxy. The holder includes a threaded cap that allows the shaft of a DeWalt router to be attached to the DU. The coupling between the motor and the bulb is depicted in Figure 1b.

Figure 1b - Photographs Depicting how the Bulb is Attached to the Motor Shaft

The CTMFD DUs were calibrated for detection efficiency using a certified strength neutron source. Each CTMFD's DU was calibrated at various negative pressure (Pneg) states for neutron detection using an Am-Be isotope neutron source emitting ~2×10^4 n/s.

The test configuration is shown in Fig. 2. The Am-Be to CTMFD DU distance was maintained at 1m for each of the four units. The Pneg states were varied from 0.4 MPa (4 bar) to 0.7 MPa (7 bar) in 0.05 MPa (0.5 bar) increments. The data were obtained over a live time of up to 1 hour (or 75 detection events), whichever occurred first.

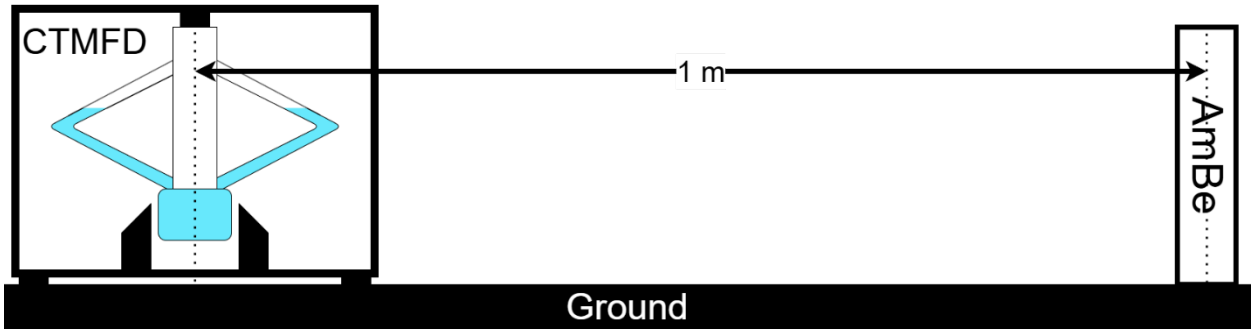


Figure 2. Schematic of Source-Detector Layout for Calibration of CTMFD Dus.

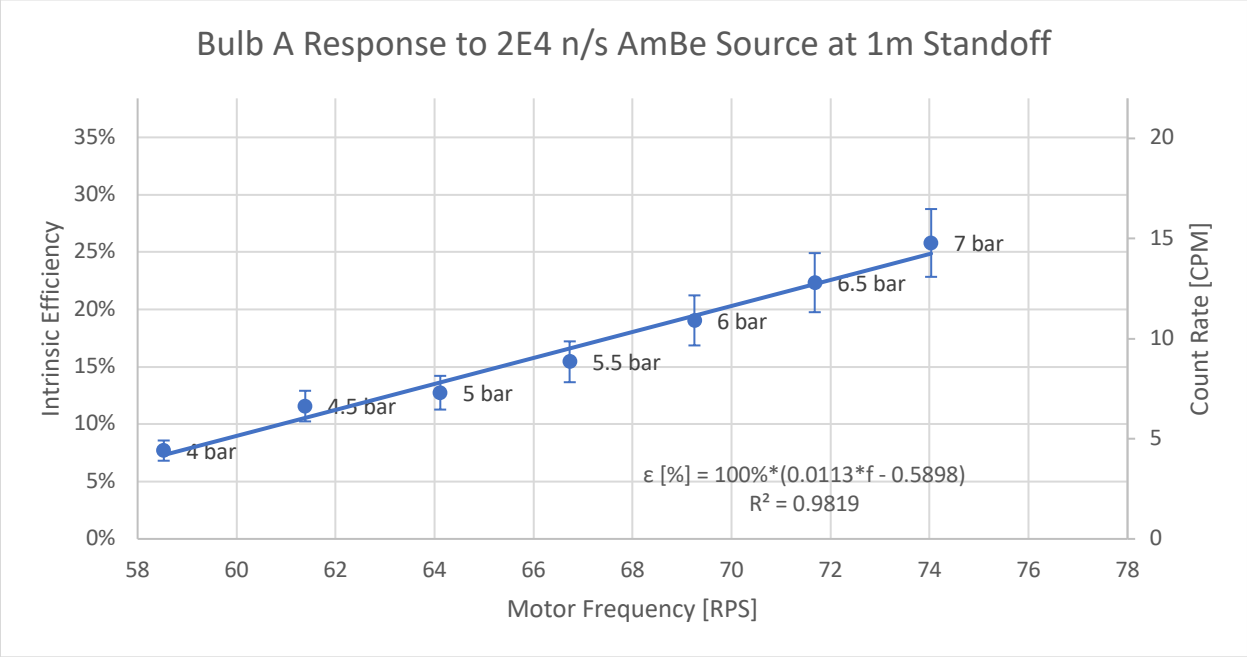
The calibration results reveal consistent performance, with the intrinsic detection efficiency varying from about 7.7% at Pneg = 0.4 MPa (4 bar) to ~25% at Pneg = 0.7 MPa (7 bar).

Figures 3 through 6 provide the individual DU calibration certificates and response curve fits (and associated uncertainties).

The safety data sheet for the DFP sensing fluid is provided in Appendix A.

Fig. 3. Specifications and results from AmBe source calibration of 20cc CTMFD bulb 2025-02 A

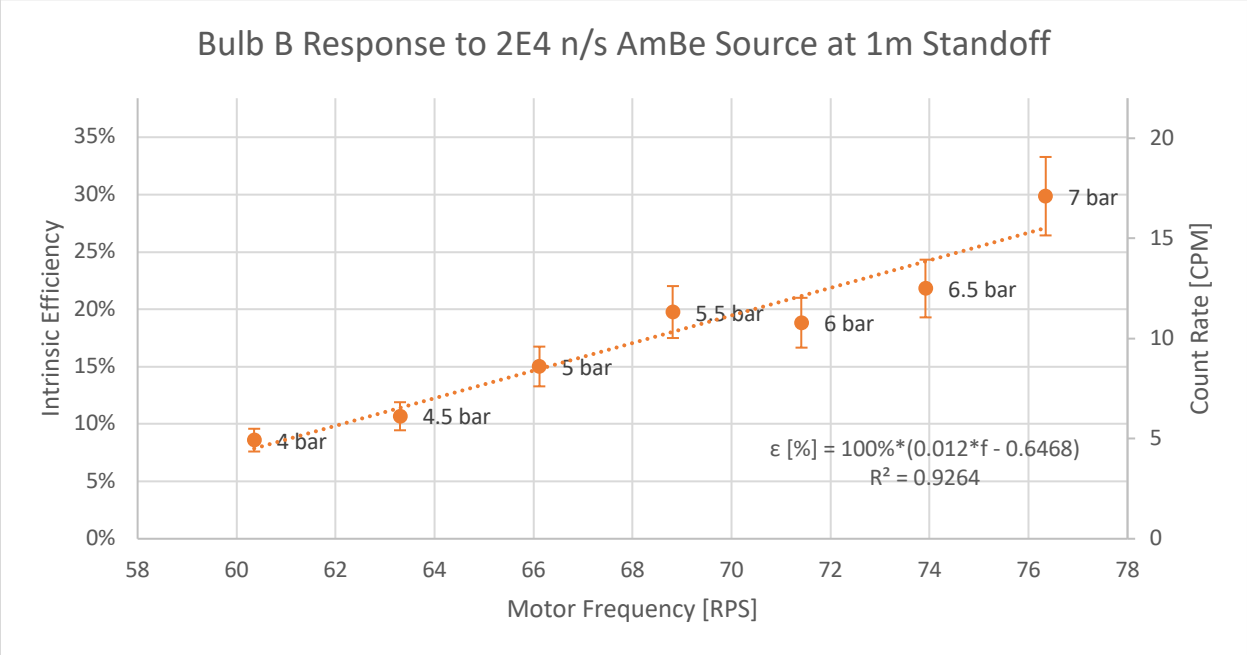
Bulb ID	2025-02 A
Bulb mass [g]	164.6
AmBe intensity [n/s]	20000
Standoff distance [m]	1
Bulb temperature [C]	22.2
Meniscus diameter [cm]	13.68
Rotation frequency [RPS]	58-74
Count rate [CPM]	4.4-14.8
Count rate error	11.5%
Efficiency [%]	7.7-25.8%
Calibration background	<10% measurement



*Intrinsic efficiency is calculated using inverse square law based on the cross-sectional area of sensitive bulb volume, source-detector standoff distance, source intensity, and detector count rate.

Fig. 4. Specifications and results from AmBe source calibration of 20cc CTMFD bulb 2025-02 B

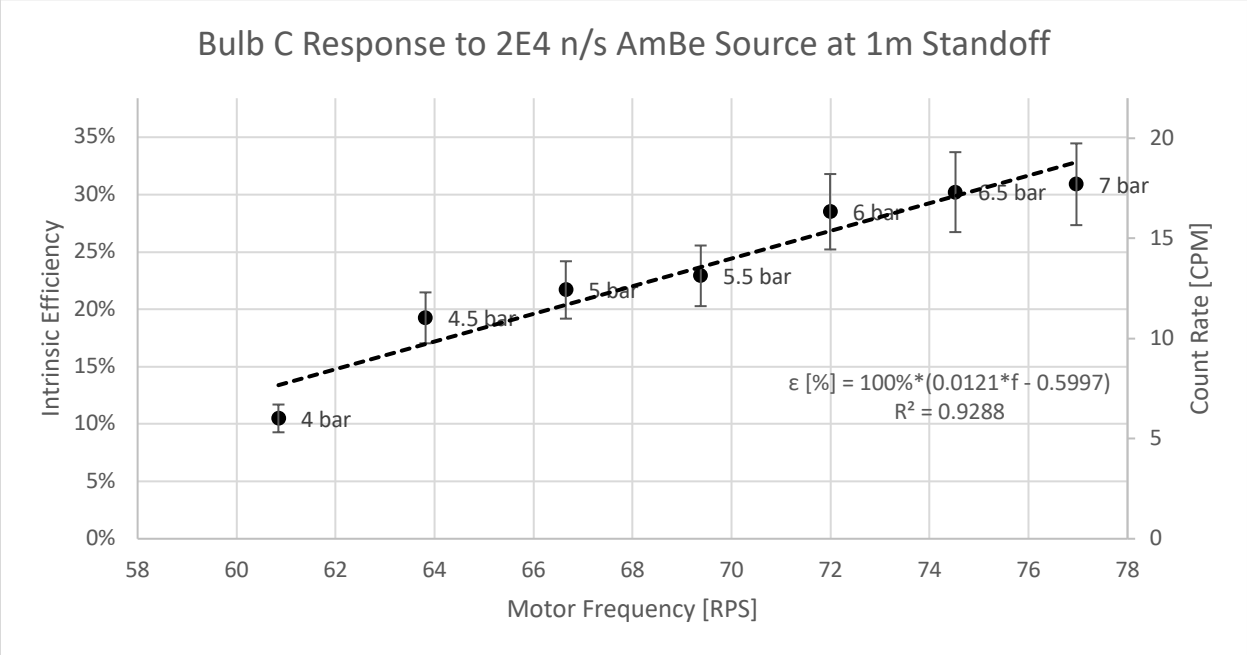
Bulb ID	2025-02 B
Bulb mass [g]	168.1
AmBe intensity [n/s]	20000
Standoff distance [m]	1
Bulb temperature [C]	21.8
Meniscus diameter [cm]	13.27
Rotation frequency [RPS]	60-76
Count rate [CPM]	4.9-17.1
Count rate error	11.5%
Efficiency [%]	8.6-29.9
Calibration background	<10% measurement



*Intrinsic efficiency is calculated using inverse square law based on the cross-sectional area of sensitive bulb volume, source-detector standoff distance, source intensity, and detector count rate.

Fig. 5. Specifications and results from AmBe source calibration of 20cc CTMFD bulb 2025-02 C

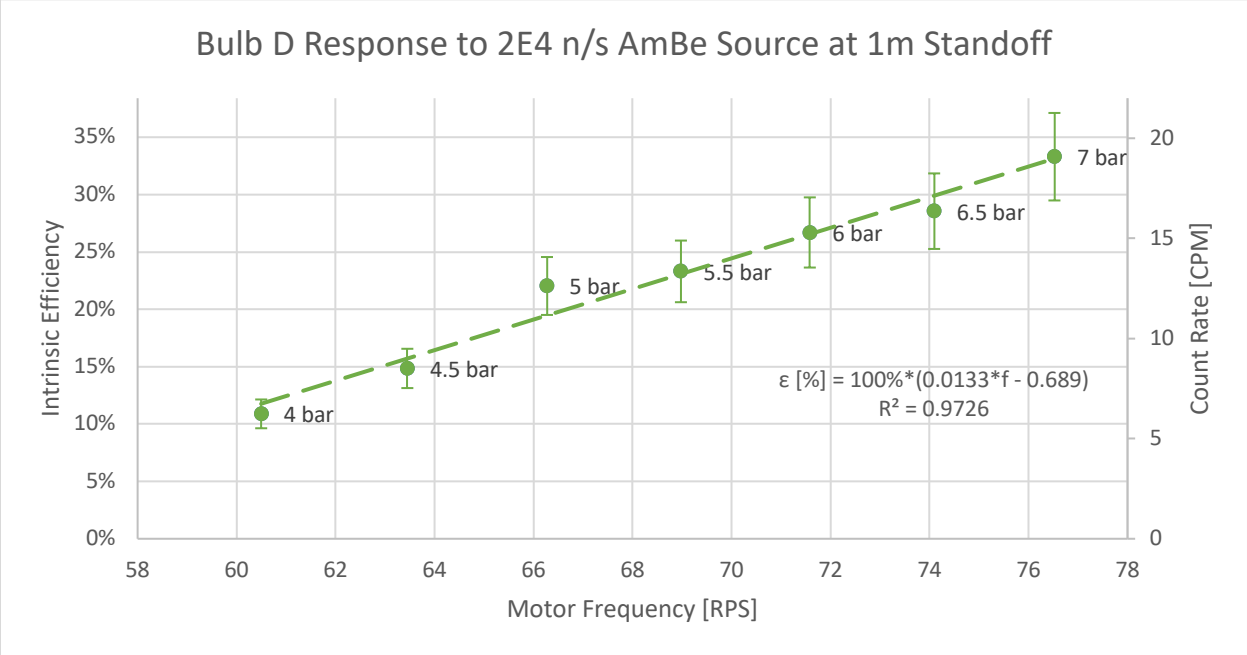
Bulb ID	2025-02 C
Bulb mass [g]	170.6
AmBe intensity [n/s]	20000
Standoff distance [m]	1
Bulb temperature [C]	21.7
Meniscus diameter [cm]	13.16
Rotation frequency [RPS]	61-77
Count rate [CPM]	6.0-
Count rate error	11.5%
Efficiency [%]	10.5-
Calibration background	<10% measurement



*Intrinsic efficiency is calculated using inverse square law based on the cross-sectional area of sensitive bulb volume, source-detector standoff distance, source intensity, and detector count rate.

Fig. 6. Specifications and results from AmBe source calibration of 20cc CTMFD bulb 2025-02 D

Bulb ID	2025-02 D
Bulb mass [g]	165.9
AmBe intensity [n/s]	20000
Standoff distance [m]	1
Bulb temperature [C]	21.7
Meniscus diameter [cm]	13.24
Rotation frequency [RPS]	60-77
Count rate [CPM]	6.2-19.1
Count rate error	11.5%
Efficiency [%]	10.9-33.3
Calibration background	<10% measurement



*Intrinsic efficiency is calculated using inverse square law based on the cross-sectional area of sensitive bulb volume, source-detector standoff distance, source intensity, and detector count rate.

Appendix A – Detection fluid Safety Data Sheet

SAFETY DATA SHEET

Vertrel™ XF specialty fluid

Version	Revision Date:	SDS Number:	Date of last issue: 05/08/2020
8.5	10/08/2020	1326741-00043	Date of first issue: 02/27/2017

SECTION 1. IDENTIFICATION

Product name : Vertrel™ XF specialty fluid

SDS-Identcode : 130000000559

Manufacturer or supplier's details

Company name of supplier : The Chemours Company FC, LLC

Address : 1007 Market Street
Wilmington, DE 19801 United States of America (USA)

Telephone : 1-844-773-CHEM (outside the U.S. 1-302-773-1000)

Emergency telephone : Medical emergency: 1-866-595-1473 (outside the U.S. 1-302-773-2000) ; Transport emergency: +1-800-424-9300 (outside the U.S. +1-703-527-3887)

Recommended use of the chemical and restrictions on use

Recommended use : Cleaning agent

Restrictions on use : For professional users only.
Do not use or resell Chemours™ materials in medical applications involving implantation in the human body or contact with internal body fluids or tissues unless agreed to by Seller in a written agreement covering such use. For further information, please contact your Chemours representative.

SECTION 2. HAZARDS IDENTIFICATION

GHS classification in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200)

Not a hazardous substance or mixture.

GHS label elements

Not a hazardous substance or mixture.

Other hazards

Vapors 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.
Rapid evaporation of the product may cause frostbite.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Mixture : Substance

Substance name : 1,1,1,2,2,3,4,5,5,5-Decafluoropentane

CAS-No. : 138495-42-8

Components
No hazardous ingredients

SECTION 4. FIRST AID MEASURES

If inhaled	:	If inhaled, remove to fresh air. Get medical attention if symptoms occur.
In case of skin contact	:	Wash with water and soap as a precaution. Get medical attention if symptoms occur.
In case of eye contact	:	Flush eyes with water as a precaution. Get medical attention if irritation develops and persists.
If swallowed	:	If swallowed, DO NOT induce vomiting. Get medical attention if symptoms occur. Rinse mouth thoroughly with water.
Most important symptoms and effects, both acute and delayed	:	May cause cardiac arrhythmia. Inhalation may provoke the following symptoms: Dizziness
Protection of first-aiders	:	No special precautions are necessary for first aid responders.
Notes to physician	:	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. FIRE-FIGHTING MEASURES

Suitable extinguishing media	:	Water spray Alcohol-resistant foam Carbon dioxide (CO2) Dry chemical
Unsuitable extinguishing media	:	None known.
Specific hazards during fire fighting	:	Exposure to combustion products may be a hazard to health.
Hazardous combustion products	:	Hydrogen fluoride carbonyl fluoride Carbon oxides
Specific extinguishing methods	:	Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. Use water spray to cool unopened containers. Remove undamaged containers from fire area if it is safe to do so. Evacuate area.

Special protective equipment for fire-fighters	:	Wear self-contained breathing apparatus for firefighting if necessary. Use personal protective equipment.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	:	Follow safe handling advice (see section 7) and personal protective equipment recommendations (see section 8).
Environmental precautions	:	Avoid release to the environment. Prevent further leakage or spillage if safe to do so. Prevent spreading over a wide area (e.g., by containment or oil barriers). Retain and dispose of contaminated wash water. Local authorities should be advised if significant spillages cannot be contained.
Methods and materials for containment and cleaning up	:	Soak up with inert absorbent material. For large spills, provide diking or other appropriate containment to keep material from spreading. If diked material can be pumped, store recovered material in appropriate container. Clean up remaining materials from spill with suitable absorbent. Local or national regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which regulations are applicable. Sections 13 and 15 of this SDS provide information regarding certain local or national requirements.

SECTION 7. HANDLING AND STORAGE

Technical measures	:	See Engineering measures under EXPOSURE CONTROLS/PERSONAL PROTECTION section.
Local/Total ventilation	:	Use only with adequate ventilation.
Advice on safe handling	:	Handle in accordance with good industrial hygiene and safety practice, based on the results of the workplace exposure assessment Take care to prevent spills, waste and minimize release to the environment.
Conditions for safe storage	:	Do not expose drums to direct heat or temperature above 46°C (115°F) to avoid pressurizing and possibly distorting the drums. 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.

Keep in properly labeled containers.
Store in accordance with the particular national regulations.

Materials to avoid	:	No special restrictions on storage with other products.
Recommended storage temperature	:	< 115 °F / < 46 °C
Storage period	:	> 10 y
Further information on storage stability	:	The product has an indefinite shelf life when stored properly.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Ingredients with workplace control parameters

Contains no substances with occupational exposure limit values.

Engineering measures : Ensure adequate ventilation, especially in confined areas.
Minimize workplace exposure concentrations.

Personal protective equipment

Respiratory protection : General and local exhaust ventilation is recommended to maintain vapor exposures below recommended limits. Where concentrations are above recommended limits or are unknown, appropriate respiratory protection should be worn. Follow OSHA respirator regulations (29 CFR 1910.134) and use NIOSH/MSHA approved respirators. Protection provided by air purifying respirators against exposure to any hazardous chemical is limited. Use a positive pressure air supplied respirator if there is any potential for uncontrolled release, exposure levels are unknown, or any other circumstance where air purifying respirators may not provide adequate protection.

Hand protection

Material	:	Viton®
Glove thickness	:	0.7 mm
Wearing time	:	120 min
Remarks	:	Choose gloves to protect hands against chemicals depending on the concentration specific to place of work. For special applications, we recommend clarifying the resistance to chemicals of the aforementioned protective gloves with the glove manufacturer. Wash hands before breaks and at the end of workday. Breakthrough time is not determined for the product. Change gloves often!

Eye protection : Wear the following personal protective equipment:
Safety glasses

Skin and body protection	:	Skin should be washed after contact.
Hygiene measures	:	If exposure to chemical is likely during typical use, provide eye flushing systems and safety showers close to the working place. When using do not eat, drink or smoke. Wash contaminated clothing before re-use.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	liquid
Color	:	colorless
Odor	:	slight, ether-like
Odor Threshold	:	No data available
pH	:	7
Melting point/freezing point	:	-118.7 °F / -83.7 °C
Initial boiling point and boiling range	:	128.75 °F / 53.75 °C (1,013 hPa)
Flash point	:	Method: ASTM D 56, Tag closed cup does not flash
Evaporation rate	:	No data available
Flammability (solid, gas)	:	Not applicable
Flammability (liquids)	:	No data available
Upper explosion limit / Upper flammability limit	:	Upper flammability limit Method: ASTM E681 None.
Lower explosion limit / Lower flammability limit	:	Lower flammability limit Method: ASTM E681 None.
Vapor pressure	:	313 hPa (77 °F / 25 °C)
Relative vapor density	:	8.7
Density	:	1.58 g/cm³ (77 °F / 25 °C)
		1.60 g/cm³ (68 °F / 20 °C)

Solubility(ies)		
Water solubility	:	0.10 - 0.14 g/l (68 °F / 20 °C)
Partition coefficient: n-octanol/water	:	log Pow: 2.7 (75 °F / 24 °C)
Autoignition temperature	:	No data available
Decomposition temperature	:	No data available
Viscosity		
Viscosity, dynamic	:	6.7 mPa.s (77 °F / 25 °C)
Viscosity, kinematic	:	No data available
Explosive properties	:	Not explosive
Oxidizing properties	:	The substance or mixture is not classified as oxidizing.
Particle size	:	Not applicable

SECTION 10. STABILITY AND REACTIVITY

Reactivity	:	Not classified as a reactivity hazard.
Chemical stability	:	Stable under normal conditions.
Possibility of hazardous reactions	:	None known.
Conditions to avoid	:	None known.
Incompatible materials	:	None.
Hazardous decomposition products	:	No hazardous decomposition products are known.

SECTION 11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure

Inhalation
Skin contact
Ingestion
Eye contact

Acute toxicity

Not classified based on available information.

Skin corrosion/irritation

Not classified based on available information.

Serious eye damage/eye irritation

Not classified based on available information.

Respiratory or skin sensitization

Skin sensitization

Not classified based on available information.

Respiratory sensitization

Not classified based on available information.

Germ cell mutagenicity

Not classified based on available information.

Carcinogenicity

Not classified based on available information.

IARC No ingredient of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

OSHA No component of this product present at levels greater than or equal to 0.1% is on OSHA's list of regulated carcinogens.

NTP No ingredient of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

Reproductive toxicity

Not classified based on available information.

STOT-single exposure

Not classified based on available information.

STOT-repeated exposure

Not classified based on available information.

Aspiration toxicity

Not classified based on available information.

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

No data available

Persistence and degradability

No data available

Bioaccumulative potential

No data available

Mobility in soil

No data available

Other adverse effects

No data available

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods

Waste from residues : Dispose of in accordance with local regulations.

Contaminated packaging	:	Empty containers should be taken to an approved waste handling site for recycling or disposal. If not otherwise specified: Dispose of as unused product.

SECTION 14. TRANSPORT INFORMATION

International Regulations

UNRTDG
Not regulated as a dangerous good

IATA-DGR
Not regulated as a dangerous good

IMDG-Code
Not regulated as a dangerous good

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code
Not applicable for product as supplied.

Domestic regulation

49 CFR
Not regulated as a dangerous good

SECTION 15. REGULATORY INFORMATION

CERCLA Reportable Quantity
This material does not contain any components with a CERCLA RQ.

SARA 304 Extremely Hazardous Substances Reportable Quantity
This material does not contain any components with a section 304 EHS RQ.

SARA 302 Extremely Hazardous Substances Threshold Planning Quantity
This material does not contain any components with a section 302 EHS TPQ.

SARA 311/312 Hazards	:	No SARA Hazards
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.

US State Regulations

Pennsylvania Right To Know

1,1,1,2,2,3,4,5,5,5-Decafluoropentane	138495-42-8

Additional regulatory information

1,1,1,2,2,3,4,5,5,5-Decafluoropentane	138495-42-8

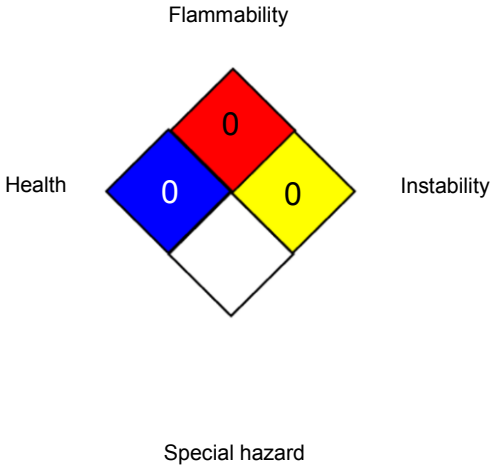
The United States Environmental Protection Agency (USEPA) has established a Significant New Use Rule (SNUR) for one of the components in this product.
See 40 CFR § 721.5645

This material contains one or more substances which requires export notification under TSCA Section 12(b) and 40 CFR Part 707 Subpart D:

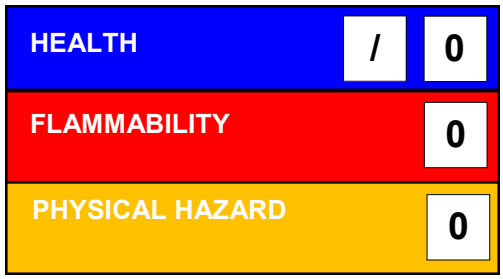
SECTION 16. OTHER INFORMATION

Further information

NFPA 704:



HMIS® IV:



HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. The "*" represents a chronic hazard, while the "/" represents the absence of a chronic hazard.

Full text of other abbreviations

AIIC - Australian Inventory of Industrial Chemicals; ASTM - American Society for the Testing of Materials; bw - Body weight; CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act; CMR - Carcinogen, Mutagen or Reproductive Toxicant; DIN - Standard of the German Institute for Standardisation; DOT - Department of Transportation; DSL - Domestic Substances List (Canada); ECx - Concentration associated with x% response; EHS - Extremely Hazardous Substance; ELx - Loading rate associated with x% response; EmS - Emergency Schedule; ENCS - Existing and New Chemical Substances (Japan); ErCx - Concentration associated with x% growth rate response; ERG - Emergency Response Guide; GHS - Globally Harmonized System; GLP - Good Laboratory Practice; HMIS - Hazardous Materials Identification System; IARC - International Agency for Research on Cancer; IATA - International Air Transport Association; IBC - International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk; IC50 - Half maximal inhibitory concentration; ICAO - International Civil Aviation Organization; IECSC - Inventory of Existing Chemical Substances in China; IMDG - International Maritime Dangerous Goods; IMO - International Maritime Organization; ISHL - Industrial Safety and Health Law (Japan); ISO - International Organisation for Standardization; KECI - Korea Existing Chemicals Inventory; LC50 - Lethal Concentration to 50 % of a test population; LD50 - Lethal Dose to 50% of a test population (Median Lethal Dose); MARPOL - International Convention for the Pre-

vention of Pollution from Ships; MSHA - Mine Safety and Health Administration; n.o.s. - Not Otherwise Specified; NFPA - National Fire Protection Association; NO(A)EC - No Observed (Adverse) Effect Concentration; NO(A)EL - No Observed (Adverse) Effect Level; NOELR - No Observable Effect Loading Rate; NTP - National Toxicology Program; NZIoC - New Zealand Inventory of Chemicals; OECD - Organization for Economic Co-operation and Development; OPPTS - Office of Chemical Safety and Pollution Prevention; PBT - Persistent, Bioaccumulative and Toxic substance; PICCS - Philippines Inventory of Chemicals and Chemical Substances; (Q)SAR - (Quantitative) Structure Activity Relationship; RCRA - Resource Conservation and Recovery Act; REACH - Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals; RQ - Reportable Quantity; SADT - Self-Accelerating Decomposition Temperature; SARA - Superfund Amendments and Reauthorization Act; SDS - Safety Data Sheet; TCSI - Taiwan Chemical Substance Inventory; TSCA - Toxic Substances Control Act (United States); UN - United Nations; UNRTDG - United Nations Recommendations on the Transport of Dangerous Goods; vPvB - Very Persistent and Very Bioaccumulative

Sources of key data used to compile the Material Safety Data Sheet	:	Internal technical data, data from raw material SDSs, OECD eChem Portal search results and European Chemicals Agency, http://echa.europa.eu/
Revision Date	:	10/08/2020

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 is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and shall not be considered a warranty or quality specification of any type. The information provided relates only to the specific material identified at the top of this SDS and may not be valid when the SDS material is used in combination with any other materials or in any process, unless specified in the text. Material users should review the information and recommendations in the specific context of their intended manner of handling, use, processing and storage, including an assessment of the appropriateness of the SDS material in the user's end product, if applicable.

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