AIR FORCE MATERIALS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND

CONTRACT AF 33(615)-1235
PROJECT 7381 TASK 738103

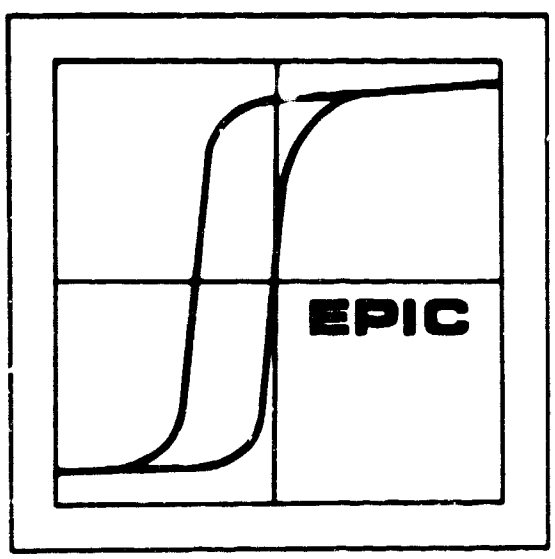
FLUOROCARBON GASES

Data Sheets

John T. Milek

DS-142

November 1964



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AIR FORCE MATERIALS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
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FOREWORD

This report was prepared by Hughes Aircraft Company under Contract No. AF 33-(615)-1235. The contract was initiated under Project No. 7381, Task No. 738103. The work was administered under the direction of the Air Force Materials Laboratory, Research and Technology Division, with Mr. R. F. Klinger acting as Project Engineer.

The Electronic Properties Information Center has been established to collect, index and abstract the literature on the electrical and electronic properties of materials and to evaluate and compile the experimental data from that literature. A modified coordinate index to the literature is machine-stored and printed for manual use. The Center publishes summary reports, thesauri, glossaries, data sheets and similar publications as sufficient information is evaluated and compiled. This report consists of the compiled data sheets on Fluorocarbon Gases.

Many persons have contributed to the program which this report represents. The author wishes especially to acknowledge the contributions of the following: John W. Atwood, C.L.M. Blocher, D.L. Grigsby, D.H. Johnson, H. Thayne Johnson, Thomas J. Lyndon, M.S. Neuberger, Emil Schafer and C.A. Schill.

ABSTRACT

A compilation of the electrical properties of various halocarbon or halogenated hydrocarbons known as Freons, Genetrons, Arctons, etc., is presented. A master identification chart relating the tradenames and numbers to the chemical name is included for easy reference.

Detailed electrical properties include Corona Effects, Dielectric Constant, Dielectric Strength and Dissipation Factor. Each property is compiled over the widest possible range of pressure, temperature, electrode geometry effects and types of electrodes from references obtained in a thorough literature search.

Physical and chemical property data are also included as well as electrical and electronic applications.

This report has been reviewed and is approved for publication.

H.T. Johnson, Head
Electronic Properties Information Center

for John W. Atwood
Project Manager

TAELE OF CONTENTS

Page

INTRODUCTION

In June 1961, a program was initiated under the direction of the Air Force to collect, index and abstract the literature on the electrical and electronic properties of materials and to evaluate and compile the experimental data from that literature. Placed at Hughes Aircraft Company in Culver City, California, the program, now called the Electronic Properties Information Center, was originally intended to cover ten major categories of materials: Semiconductors, Insulators, Ceramics, Ferroelectrics, Metals, Ferrites, Ferromagnetics, Electroluminescent Materials, Thermionic Emitters, and Superconductors.

During the first year, studies were completed on the Semiconductor and Insulator categories; and Ceramics was discontinued as a separate category and subsumed under the other nine. Vocabulary studies have now been completed on all categories, and retrospective documentation is virtually complete for Semiconductors and Insulators. A full index to the literature is maintained; and publications such as data sheets, summary reviews, glossaries, and thesauri are issued periodically. The use of the Center and these publications are available to anyone wishing information within the scope of the Center's objectives. A full list of publications to date appears at the end of this report.

This report contains data sheets on Fluorocarbon Gases. The data sheets have been compiled directly from the literature. Articles are allowed to accumulate until it is judged that a sufficient number are available on one material for adequate evaluation. The manual modified coordinate index is then used to retrieve all literature on the material to be compiled. Bibliographies are checked to make sure that valuable and relevant literature is not overlooked. Then the assembled literature is given to the specialist doing the evaluation and compilation.

Evaluation is confined to primary source data except when only secondary citations are available. If equally valid data are available from several sources, all are given. Data are rejected when judged questionable because of faulty or dubious measurements, unknown sample composition, or if more reliable data are available from another source. Selection of data is based upon that which is judged most representative, precise, reliable and covers the widest range of variables. The addition of new data to a previously evaluated property requires a reappraisal of the reported values. Older data may be deleted if the new data are judged more accurate or representative.

After a thorough analysis and evaluation, the data are compiled into data sheets which present it in its most optimum form. This will be, primarily, but not limited to, curves or tabular form. Where possible, graphs are adapted directly from the original sources. If this is not possible, they are drawn from data compiled from the articles. Where thought important, notes are entered with each graph to help the user.

The references, from which the data are drawn, are shown by reference numbers below each graph with the full bibliographic information at the end of the data sheets. The bibliography is referred to and listed in the order of entry into the Center (accession number). This provides a quick cross reference into the index used with the literature.

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FLUOROCARBON GASES

MASTER IDENTIFICATION CHART

Gas Designation	Chemical Name	Chemical Formula	Page
Arcton 0	Carbon Tetrafluoride	CF_4	8
Arcton 1	Trifluoromethane	CHF_3	101
Arcton 3	Chlorotrifluoromethane	$CClF_3$	30
Arcton 4	Chlorodifluoromethane	$CHClF_2$	17
Arcton 6	Dichlorodifluoromethane	CCl_2F_2	37
Arcton 7	Dichlorofluoromethane	$CFCl_2H$	53
Arcton 9	Trichlorofluoromethane	CCl_3F	97
Freon 11	Trichlorofluoromethane	CCl_3F	97
Freon 12	Dichlorodifluoromethane	CCl_2F_2	37
Freon 13	Chlorotrifluoromethane	$CClF_3$	30
Freon 13 B 1	Bromotrifluoromethane	$CBrF_3$	5
Freon 14	Carbon Tetrafluoride	CF_4	8
Freon 21	Dichlorofluoromethane	$CFCl_2H$	53
Freon 22	Chlorodifluoromethane	$CHClF_2$	17
Freon 23	Trifluoromethane	CHF_3	101
Freon 114	Dichlorotetrafluoroethane	$C_2Cl_2F_4$	56
Freon 115	Chloropentafluoroethane	C_2F_5Cl	26
Freon 116	Hexafluoroethane	C_2F_6	58
Freon C-318	Octafluorocyclobutane	C_4F_8	72
FX-30	Octafluoropropane	C_3F_8	89
Genetron 11	Trichlorofluoromethane	CCl_3F	97
Genetron 12	Dichlorodifluoromethane	CCl_2F	37
Genetron 218	Octafluoropropane	C_3F_8	89

GENERAL DESCRIPTION

This data sheet is a compilation of gases belonging to the fluorohydrocarbon gas family of dielectrics.

A wide range of fluorine-chlorine-hydrocarbon combinations are included and are commonly designated by various tradenames, e.g., Freon 12, Genetron 11, Arcton 6, etc. A master identification chart has been prepared to aid in identifying chemically these commercial products as well as to cite their chemical formula.

The arrangement of the fluorohydrocarbon gases is alphabetic by chemical name. The dielectric properties of gases most generally reported are corona, dielectric constant, and dielectric strength. The last property is markedly affected by type of metal electrodes, electrode gap distance, electrode shape or geometry, pressure and temperature.

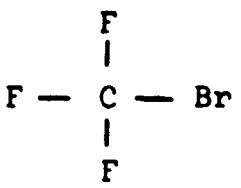
An excellent survey and compilation of these same gases has been published by Frank M. Clark in his book, "Insulating Materials for Design and Engineering Practice", New York, Wiley, 1962. This work has great value because of the intercomparison of the fluorohydrocarbon gases with other gases: SF_6, N_2, Air, etc, in the property parameters.

FLUOROCARBON GASES

BROMOTRIFLUOROMETHANE

Introduction

Bromotrifluoromethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula ($CBrF_3$) is depicted as follows:



and the gas is available from the du Pont de Nemours Company under the trade-name: Freon 13 B 1.

Its molecular weight is 148.9.

Physical Properties

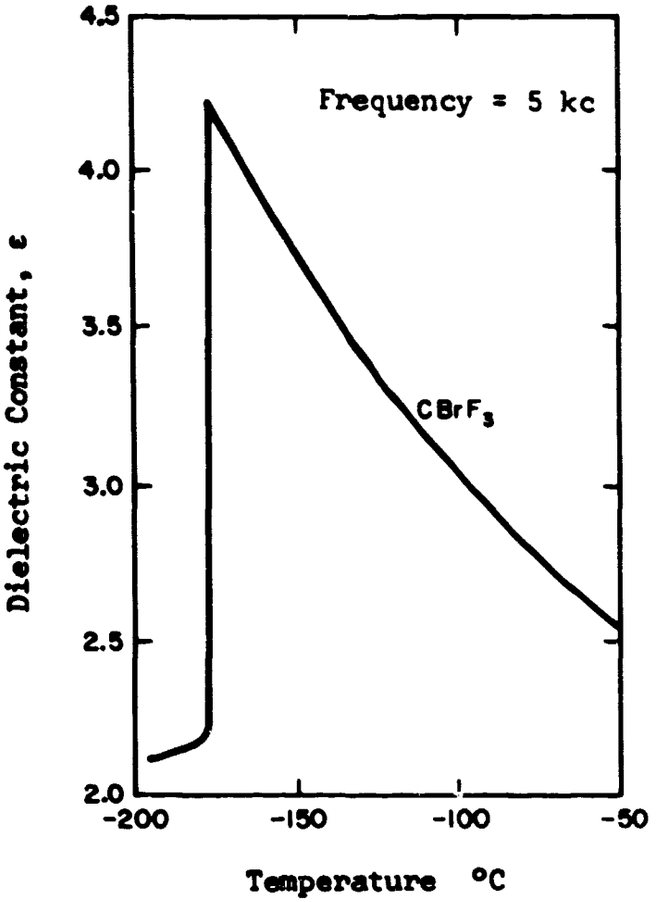
Boiling point (at 1 atm.)	-57.8°C	(-72.0°F)
Freezing point	-168°C	(-270°F)
Critical temperature	67.0°C	(152.6°F)
Critical pressure	39.1 atm.	(575 psia)
Density of liquid at 30°C	1.499 g/cc	(93.59 lbs/ft^3)

Applications

Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

BROMOTRIFLUOROMETHANE

DIELECTRIC CONSTANT



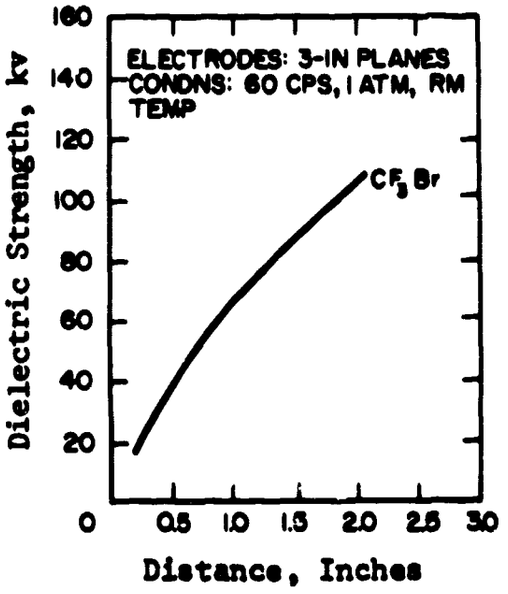
Dielectric constant as a function of temperature for bromotrifluoromethane.

[Ref. 1265]

BROMOTRIFLUOROMETHANE

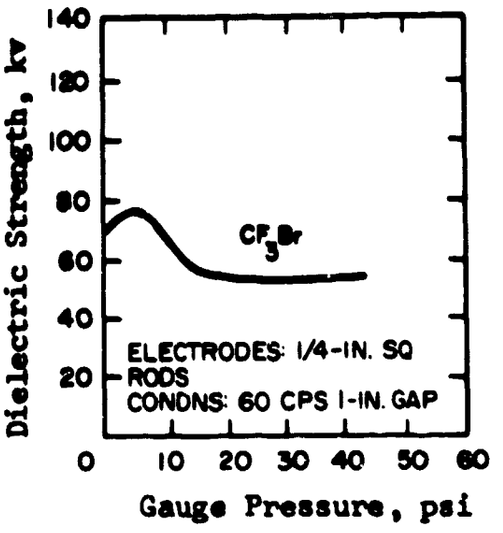
DIELECTRIC STRENGTH

		Ref.
Relative dielectric strength	1.49 (N_2 = 1)	6189



Dielectric strength of bromotrifluoromethane as a function of gap distance in a uniform electrical field.

[Ref. 6140]
&
[Ref. 16775]



Dielectric strength of bromotrifluoromethane as a function of pressure in a non-uniform field.

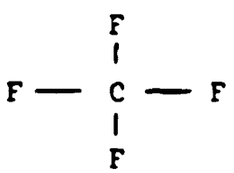
[Ref. 6140]
&
[Ref. 16775]

FLUOROCARBON GASES

CARBON TETRAFLUORIDE

Introduction

Carbon Tetrafluoride (Perfluoromethane) is a dielectric gas with electronegative behaviour or characteristics. The chemical formula (CF_4) is depicted as follows:



and the gas is available commercially in the U.S. as Freon - 14 (du Pont de Nemours) and in Great Britain as Arcton 0.

Its molecular weight is 88.01.

Physical Properties

Boiling point (at 1 atm.)	-128.0°C	(-198.4°F)
Freezing point	-184.0°C	(-299°F)
Critical temperature	-45.67°C	(-50.2°F)
Critical pressure	39.96 atm.	(543.2 psia)
Density of liquid at -80°C	1.317 g/cc	

Carbon Tetrafluoride

Applications

Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

CARBON TETRAFLUORIDE

DIELECTRIC CONSTANT

Dielectric Constant	Phase	Temperature	Ref.
1.0006	1 atm.	24.5 °C	6189, 16775

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CARBON TETRAFLUORIDE

DIELECTRIC STRENGTH

			Ref.
Relative dielectric strength	0.89 (N_2 = 1)	23°C 1 atm.	6189
Relative dielectric strength (uniform electrical field)	1.01 (Air = 1)		16775

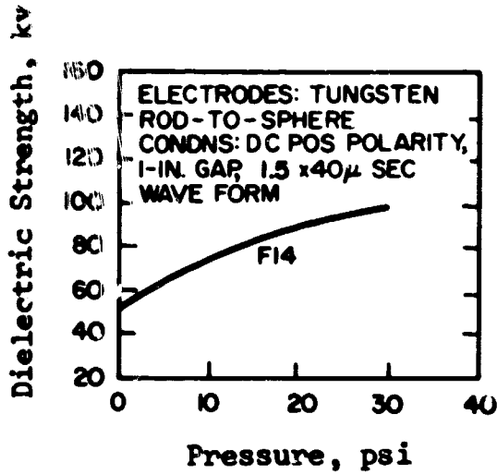
Compound	Abs. Pressure Atm.	Breakdown Voltage: Power Frequency, Sphere gap, cm 0.5	Power Frequency 1.0	Negative Direct 0.5	Negative Direct 1.0	Negative Impulse 0.5	Negative Impulse 1.0	Relative Electric Strength 0.5	Relative Electric Strength 1.0	Impulse Ratio 0.5	Impulse Ratio 1.0
		kv	kv	kv	kv	kv	kv				
CF_4	1	18.3	36.5	16.2	32.5	20.5	44.0	1.06	1.14	1.12	1.2
	2	36.6	71.4			41.0	85.0	1.13	1.27	1.13	1.19
(Arc-	3	55.0	104.5			60.5		1.21	1.28	1.10	
ton 0)	4	71.6				79.0		1.23		1.10	

[Ref. 1181]

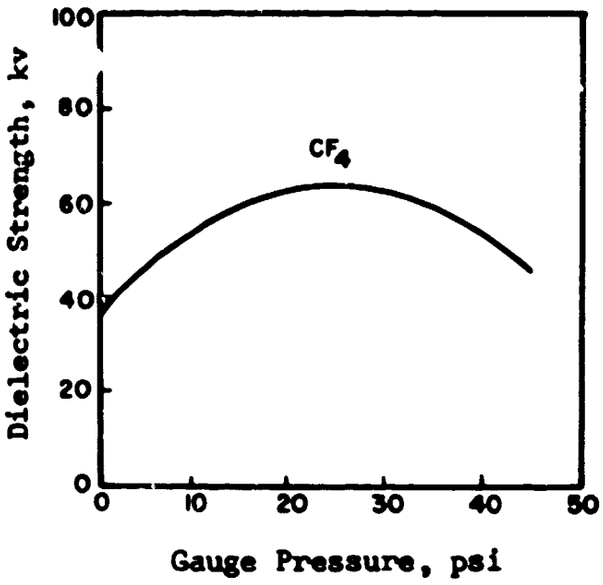
CARBON TETRAFLUORIDE

DIELECTRIC STRENGTH

Impulse dielectric strength as a function of pressure in a nonuniform electrical field.



[Ref. 6140]



The dielectric strength of Freon-14 as a function of pressure as tested under non-uniform conditions: 1/4 inch square rods, 1-inch gap distance, 60 cps.

[Ref. 16775]

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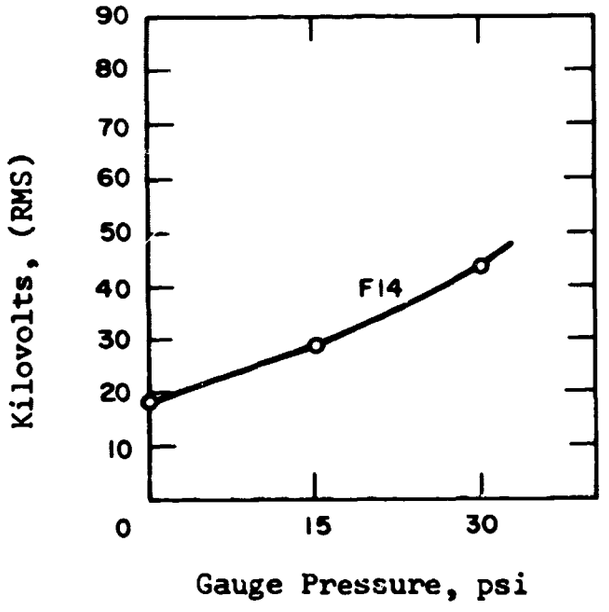
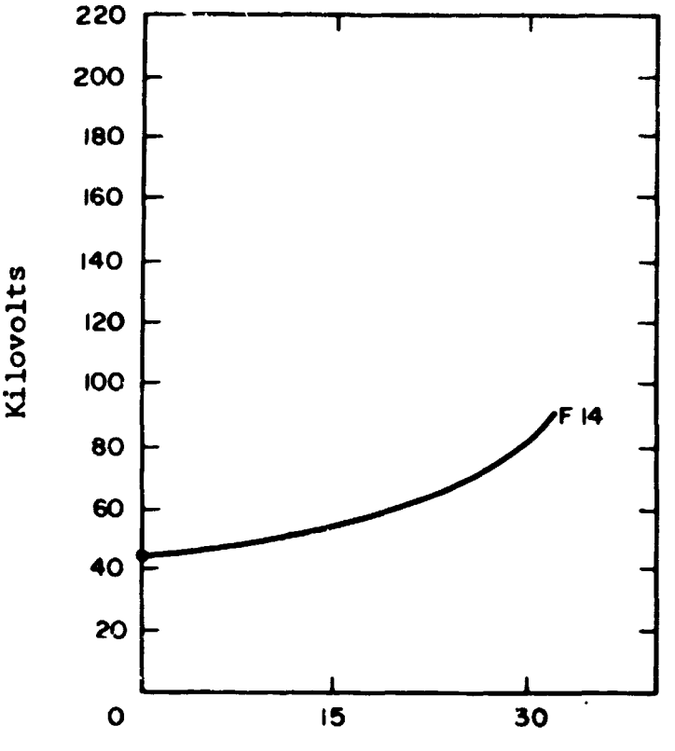
CARBON TETRAFLUORIDE

DIELECTRIC STRENGTH



60-cycle dielectric strength of Freon-14 as a function of pressure, tested between two 1-inch diameter spheres spaced 1/4 inch.

[Ref. 4299]

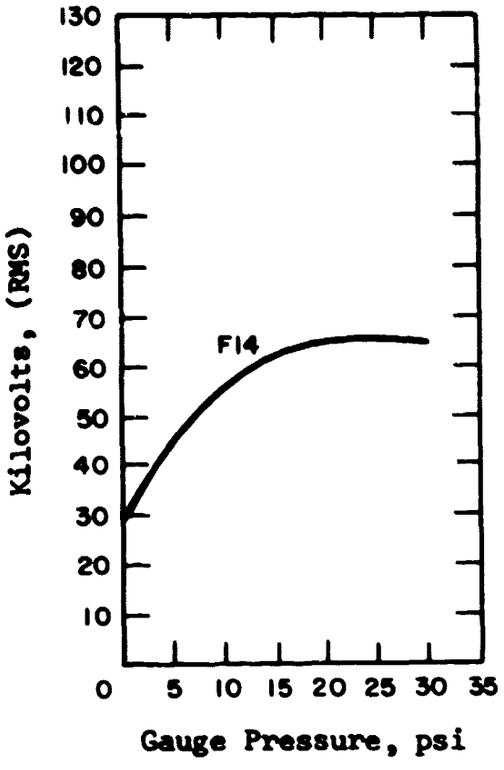


Impulse dielectric strength of Freon-14 as a function of pressure, tested between two 1-inch diameter spheres spaced 1/4 inch.

[Ref. 4299]

CARBON TETRAFLUORIDE

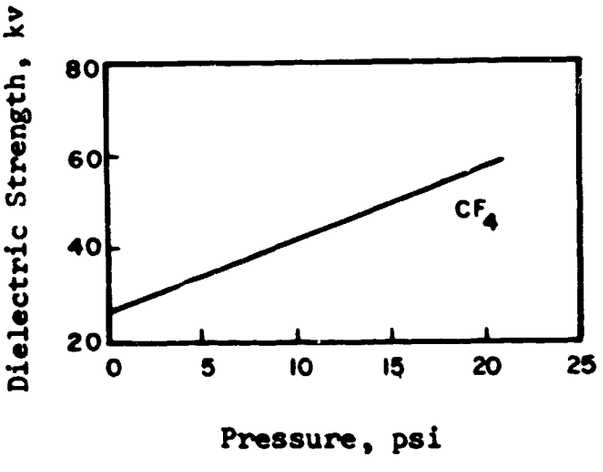
DIELECTRIC STRENGTH



60-cycle dielectric strength of Freon-14 as a function of pressure, tested between tungsten rod and 1-inch diameter sphere spaced 1 inch.

[Ref. 4299]

The effect of pressure on the dielectric strength of Freon-14: 60 cps, 3-inch planes (electrodes), 1/2 inch gap distance, room temperature.

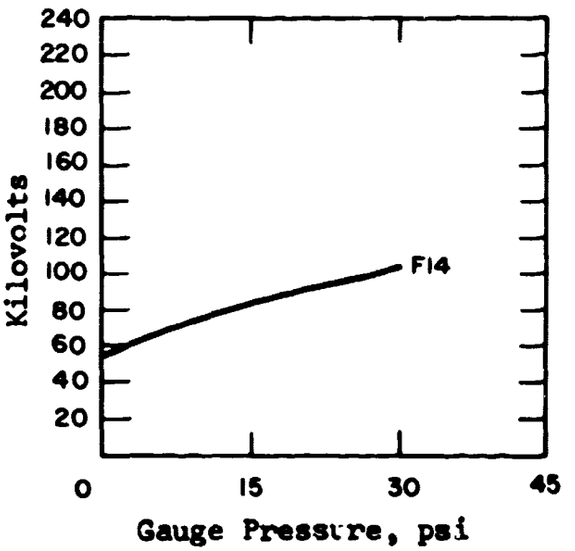


[Ref. 16775]

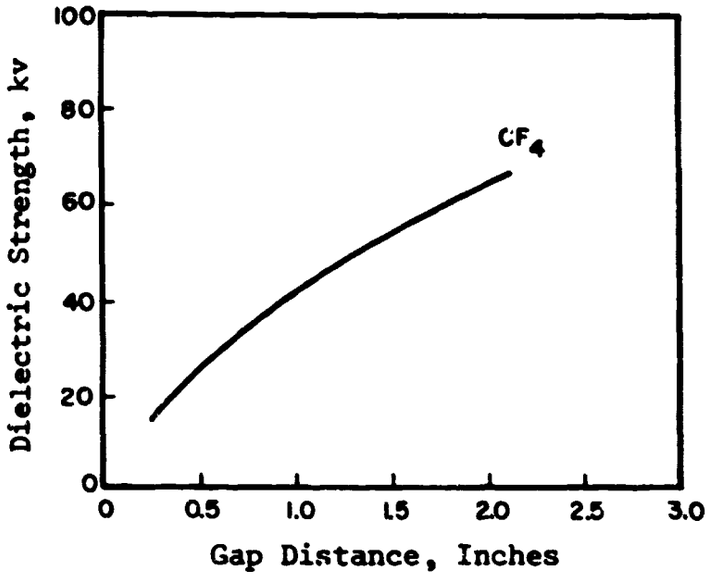
CARBON TETRAFLUORIDE

DIELECTRIC STRENGTH

Impulse dielectric strength of Freon-14 as a function of pressure, tested between tungsten rod and 1-inch diameter spheres spaced 1 inch. →



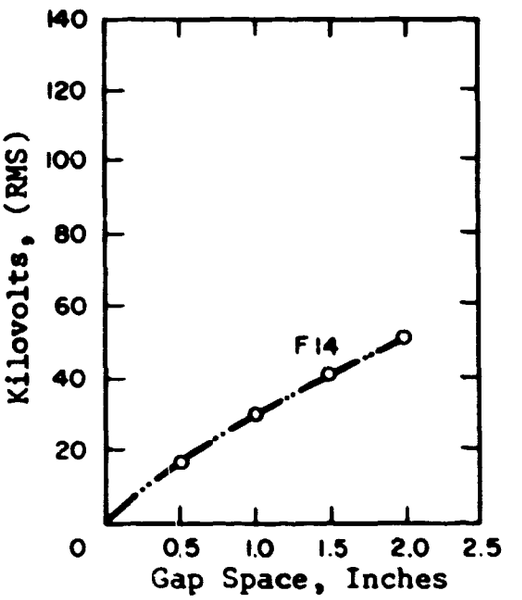
[Ref. 4299]



The effect of gap distance on 60 cps dielectric strength of Freon-14: 3-inch planes (electrodes), atmospheric pressure, room temperature. ←

[Ref. 16775]

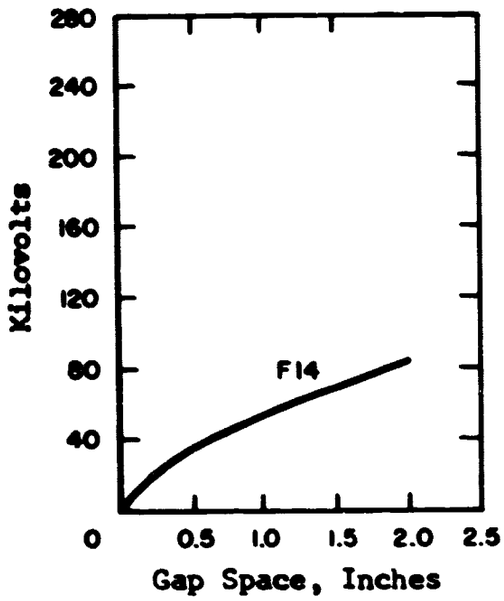
60-cycle dielectric strength of Freon-14 as a function of gap distance, tested between tungsten rod and 1-inch diameter sphere at atmospheric pressure. →



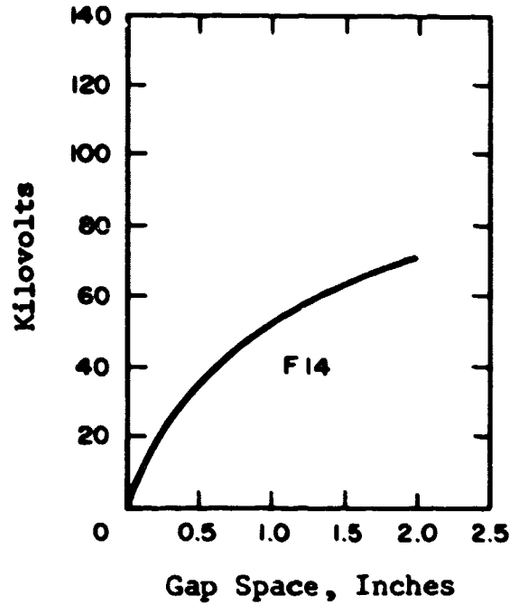
[Ref. 4299]

CARBON TETRAFLUORIDE

DIELECTRIC STRENGTH



Negative impulse tests on Freon-14 (1 1/2 x 40 microsecond wave), at atmospheric pressure, tested between tungsten rod and 1-inch diameter sphere.

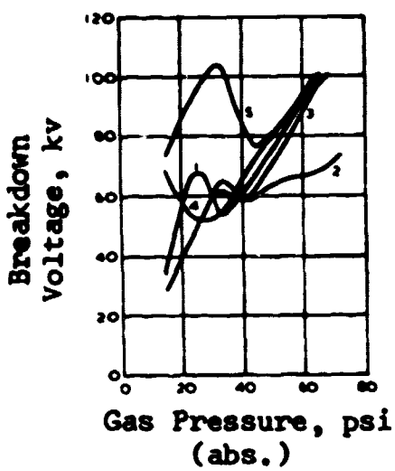


Positive impulse tests on Freon-14 (1 1/2 x 40 microsecond wave), at atmospheric pressure, tested between tungsten rod and 1-inch diameter sphere.

[Ref. 4299]

CARBON TETRAFLUORIDE

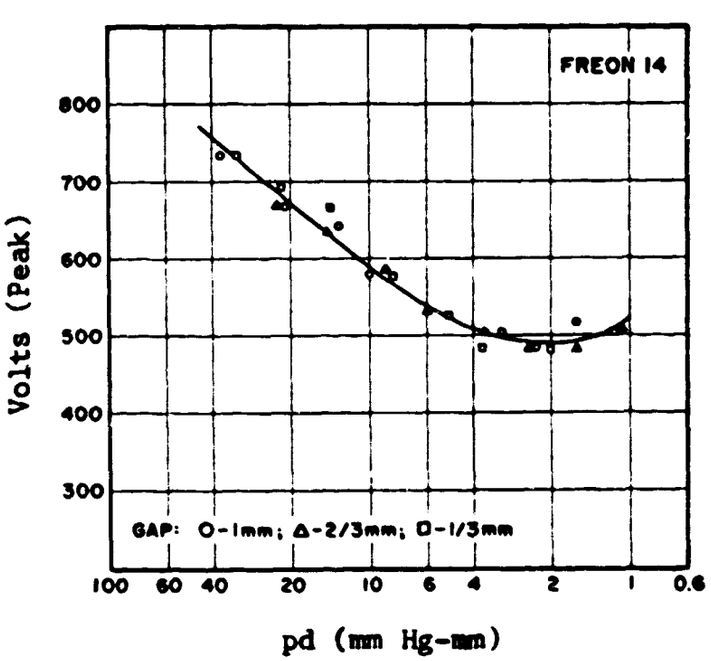
DIELECTRIC STRENGTH



1. CF_4 at 11 psi + CCl_2F_2
2. CF_4 at 14.7 psi + CCl_2F_2
3. CF_4 at 25.7 psi + CCl_2F_2
4. CCl_2F_2 at 14.7 psi + SF_6
5. SF_6 at 14.7 psi + CCl_2F_2

Positive point d.c. breadown voltage for various electronegative gas mixtures.

[Ref. 1181]



Paschen curve, Freon 14.

[Ref. 16238]

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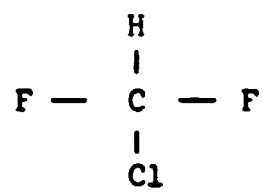
CHLORODIFLUOROMETHANE

Introduction

Chlorodifluoromethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula ($CHClF_2$) is depicted as follows:



and the gas is available from the du Pont de Nemours Co. under the tradename: Freon - 22 and in Great Britain by Arcton 4.

Its molecular weight is 86.48.

Physical Properties

Boiling point (at 1 atm.)	-40.80°C	(-41.44°F)
Freezing point	-160°C	(-256°F)
Critical temperature	96.0°C	(204.8°F)
Critical pressure	48.7 atm.	(716 psia)
Density of liquid at 30°C	0.525 g/cc	(32.8 lbs/ft^3)

Applications

Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

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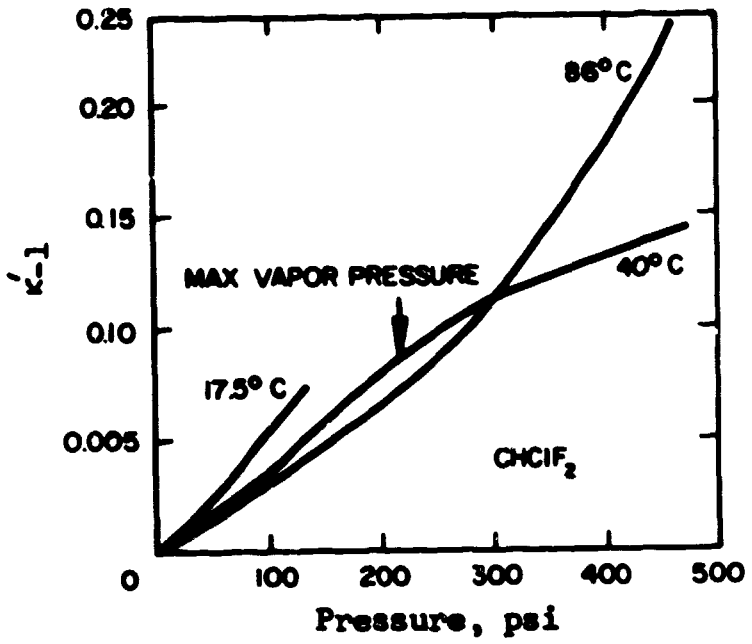
CHLORODIFLUOROMETHANE

DIELECTRIC CONSTANT

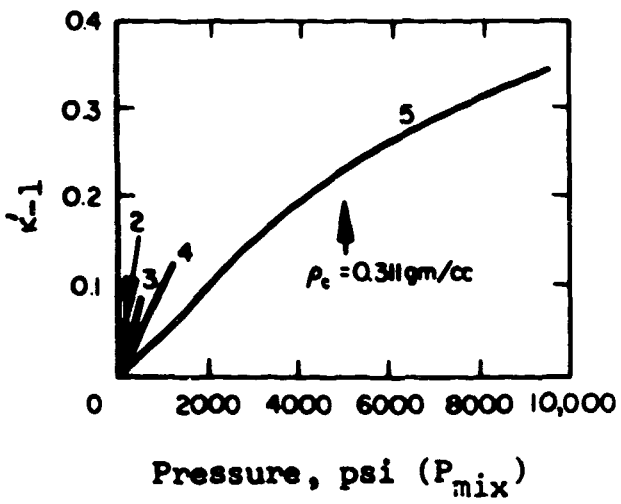
Dielectric Constant	Phase	Temperature	Ref.
6.11	liquid	24°C	6189
1.0035	vapor (0.5 atm.)	25.4°C	16775



κ'-1 as a function of pressure for chlorodifluoromethane at various temperatures (λ = 1.22 cm).

[Ref. 1538]

κ'-1 as a function of pressure for various mixtures of chlorodifluoromethane in nitrogen: 2) 65%, 3) 34%, 4) 13%, 5) 2.7%, $CHClF_2$. (λ = 1.22 cm, T = 24°C).



[Ref. 1538]

CHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

			Ref.
Relative dielectric strength	1.17	(N_2 = 1)	6189
Relative dielectric strength (uniform electrical field)	1.40	(Air = 1)	16775

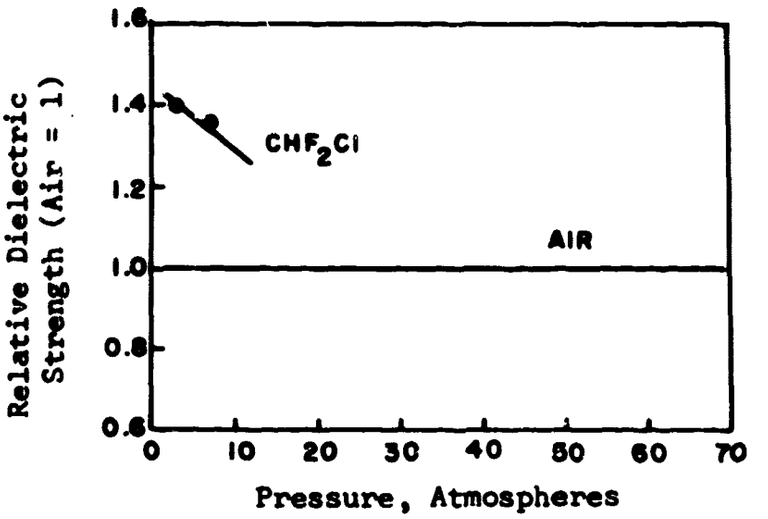
Compound	Abs. Pressure Atm.	Breakdown Voltage						Relative Electric Strength		Impulse Ratio	
		Power Frequency		Negative Direct		Negative Impulse					
		Sphere Gap, cm									
		0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0
		kv	kv	kv	kv	kv	kv				
CHF_2Cl	1	21.7	39.6	21.7	39.8	22.4	39.8	1.25	1.25	1.03	1.00
	2	40.0	74.5			37.5	71.0	1.25	1.33	0.94	0.95
(Arc-	3	57.7	108.0			54.5		1.27	1.32	0.94	
ton 4)	4	74.5						1.28			

[Ref. 1181]

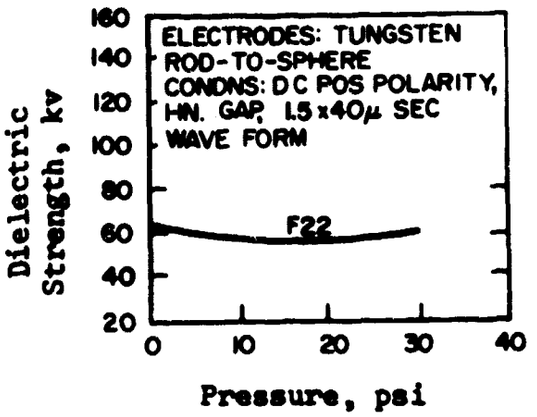
CHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

The relative dielectric strength of CHF_2Cl as a function of pressure (relative to air = 1).

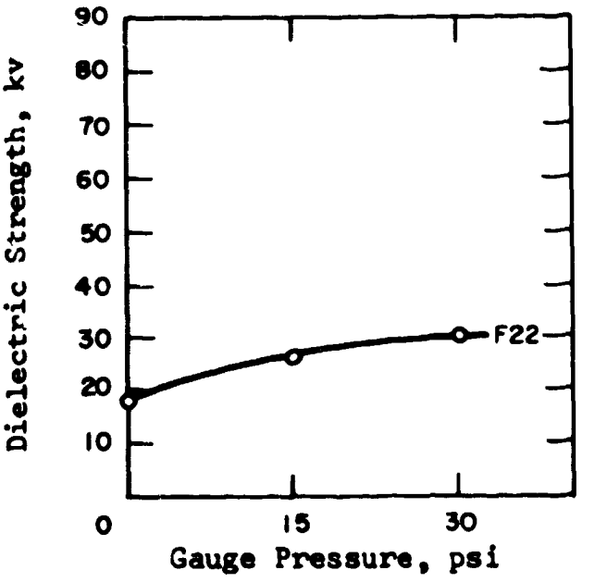


[Ref. 16775]



Impulse dielectric strength as a function of pressure in a non-uniform field.

[Ref. 6140]

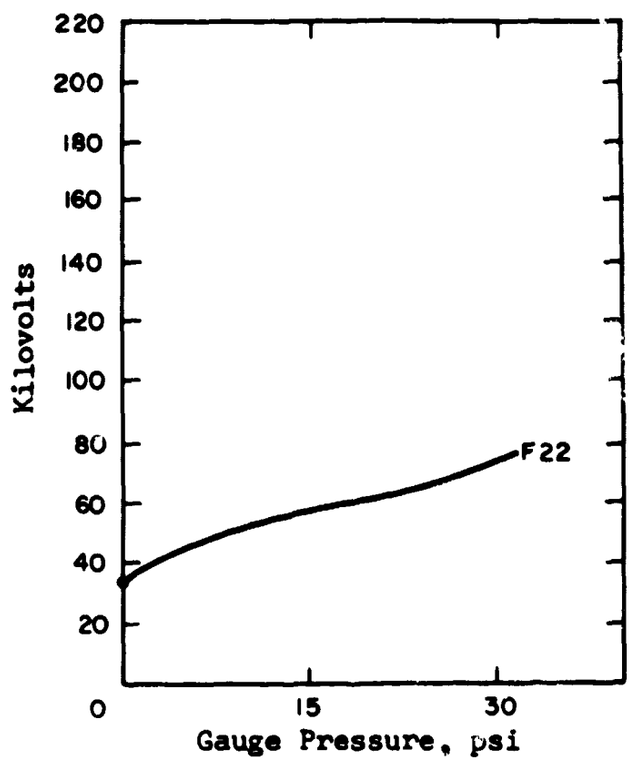


60 cps dielectric strength of Freon-22 as a function of pressure between two 1-inch diameter spheres spaced 1/4-inch apart.

[Ref. 4299]

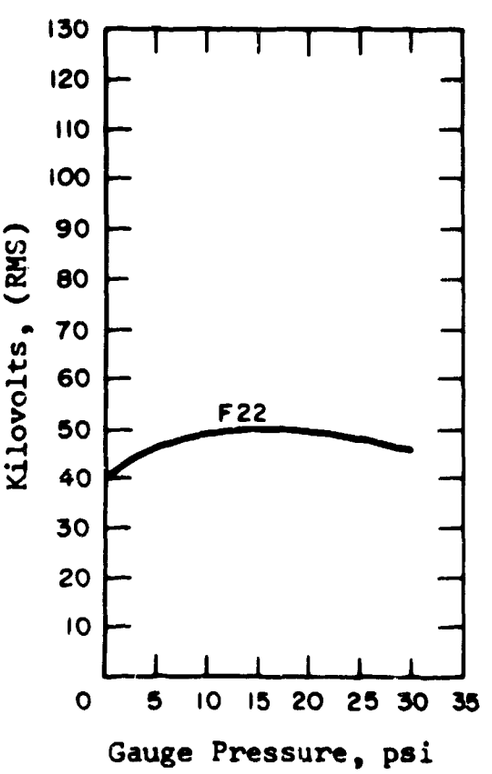
CHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH



Impulse dielectric strength of Freon-22 as a function of pressure between two 1-inch diameter spheres spaced 1/4 inch apart.

[Ref. 4299]



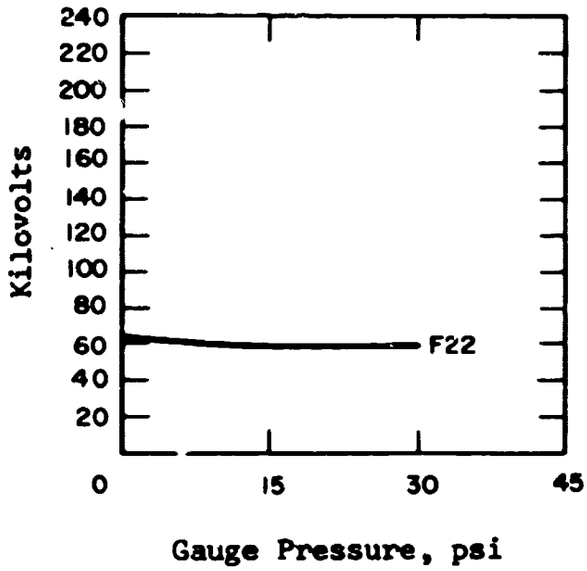
60 cycle dielectric strength as a function of pressure between a tungsten rod and a 1-inch diameter sphere spaced 1 inch.

[Ref. 4299]

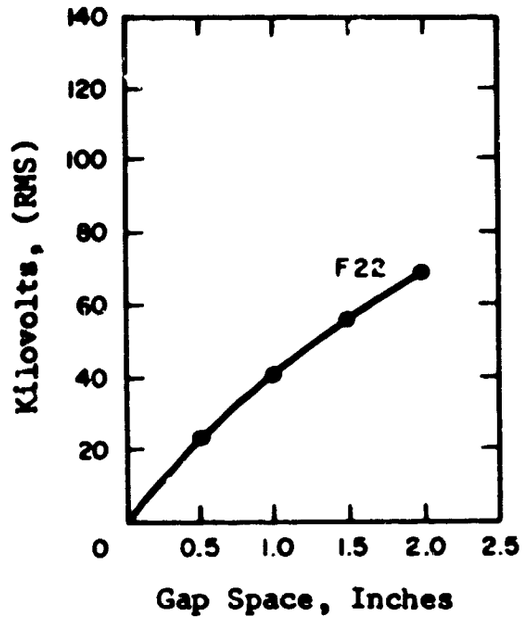
CHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

Impulse dielectric strength of Freon-22 as a function of pressure between a tungsten rod and a 1-inch diameter sphere spaced 1-inch.



[Ref. 4299]

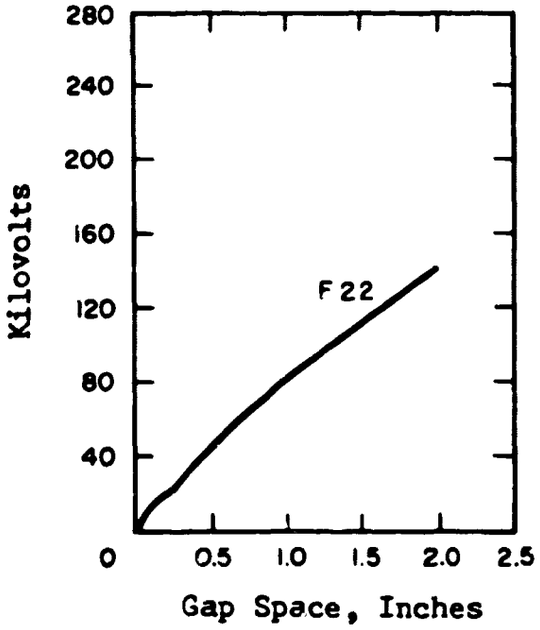


60-cycle dielectric strength of Freon-22 as a function of gap distance tested between tungsten rod and 1-inch diameter sphere at atmospheric pressure.

[Ref. 4299]

CHLORODIFLUOROMETHANE

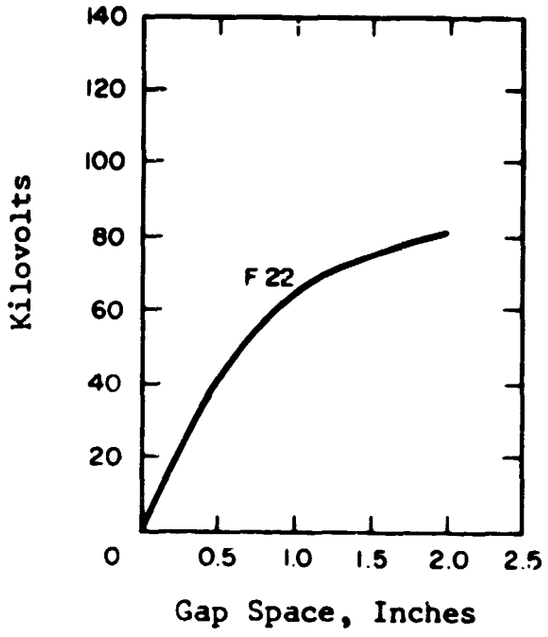
DIELECTRIC STRENGTH



Negative impulse tests (1 1/2 x 40 microsecond wave), at atmospheric pressure of Freon-22 between tungsten rod and 1-inch diameter sphere.

[Ref. 4299]

Positive impulse tests (1 1/2 x 40 microsecond wave), at atmospheric pressure of Freon-22 between tungsten rod and 1-inch diameter sphere.

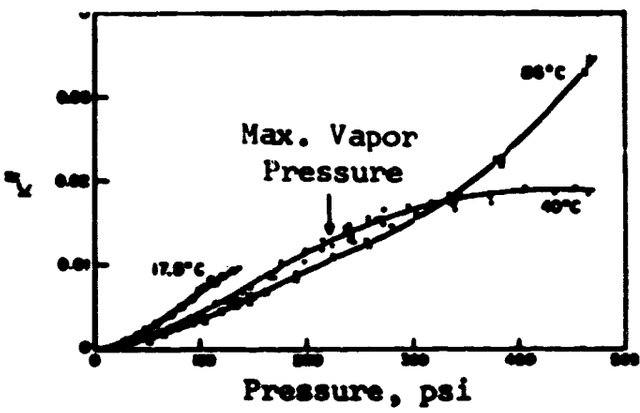


[Ref. 4299]

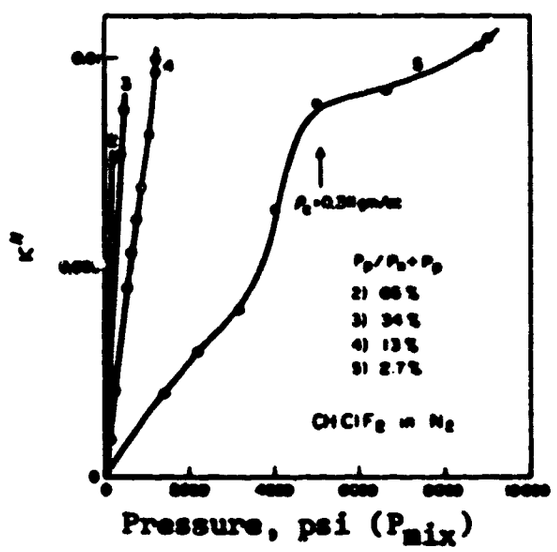
CHLORODIFLUOROMETHANE

LOSS FACTOR

κ'' as a function of pressure for chlorodifluoromethane at various temperatures (λ = 1.22 cm).



[Ref. 1538]

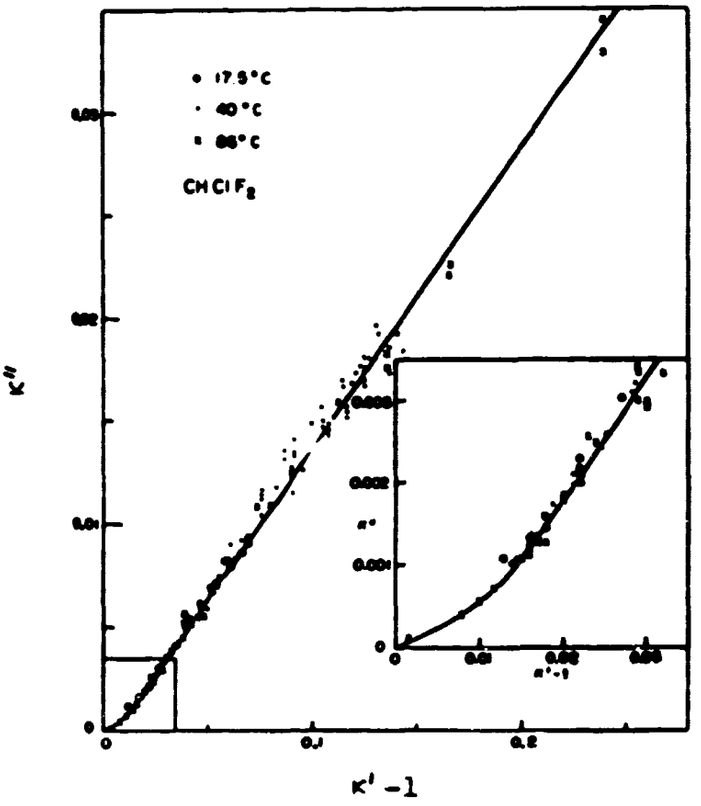


κ'' as a function of pressure for various mixtures of chlorodifluoromethane and nitrogen (λ = 1.22 cm, T = 24°C).

[Ref. 1538]

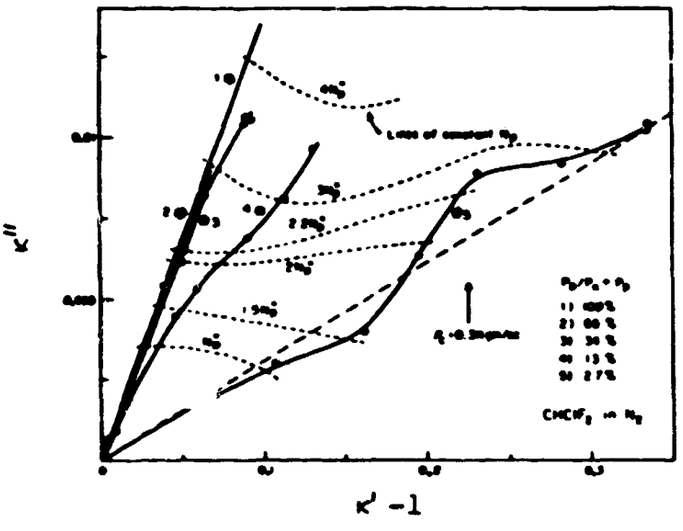
CHLORODIFLUOROMETHANE

LOSS FACTOR



κ'' as a function of $\kappa'-1$ for chlorodifluoromethane at various temperatures (λ = 1.22 cm).

[Ref. 1538]



κ'' as a function of $\kappa'-1$ for various mixtures of chlorodifluoromethane in nitrogen (λ = 1.22 cm, T = 24°C).

[Ref. 1538]

FLUOROCARBON GASES

CHLOROPENTAFLUOROETHANE

Introduction

Chloropentafluoroethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula (C_2F_5Cl) is depicted as follows:

$$C\,Cl\,F_2 - CF_3 \qquad \text{or} \qquad Cl-\underset{\underset{F}{|}}{\overset{\overset{F}{|}}{C}}-\underset{\underset{F}{|}}{\overset{\overset{F}{|}}{C}}-F$$

and the gas is available commercially under the tradename: Freon-115 from the du Pont de Nemours Company. Its molecular weight is 154.48.

Physical Properties

Boiling point (at 1 atm.)	-38.7°C (-37.7°F)
Freezing point	-106°C (-159°F)
Critical temperature	80.0°C (175.9°F)
Critical pressure	30.8 atm. (453 psia)
Density of liquid at 30°C	1.265 g/cc (78.99 lbs/ft^3)

Applications

Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

CHLOROPENTAFLUOROETHANE

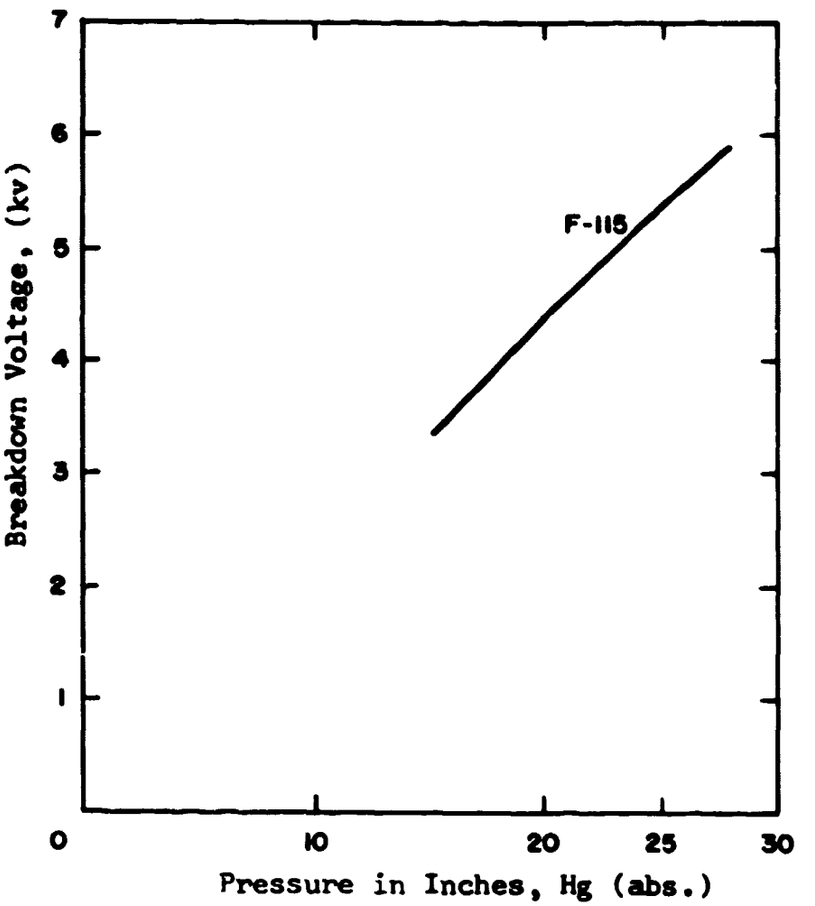
DIELECTRIC CONSTANT

Dielectric Constant	Pressure	Temperature	Ref.
1.0018	380 mm Hg	27.4°C	6189
1.00334	722 mm Hg	27.4°C	7531

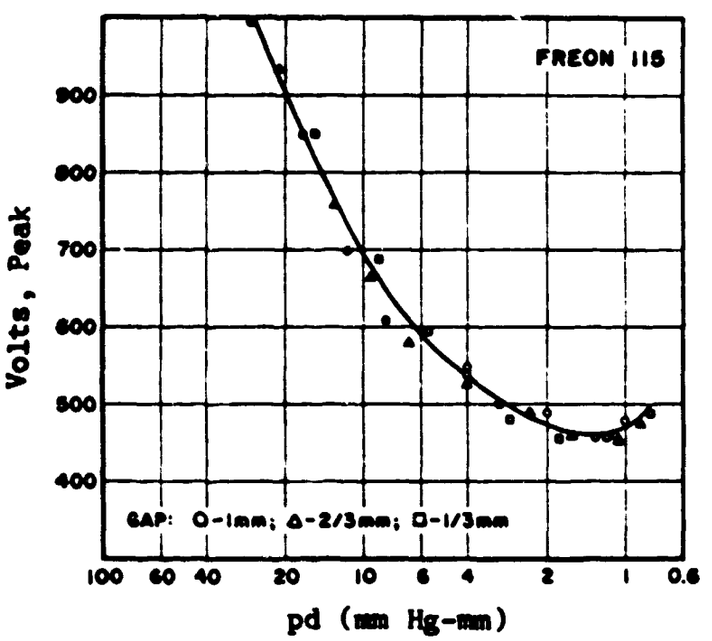
CHLOROPENTAFLUOROETHANE

DIELECTRIC STRENGTH

Breakdown voltage as a function of pressure for Freon-115, across a spark plug.



[Ref. 10489]



Paschen curve, Freon-115.

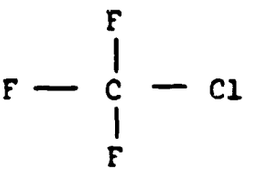
[Ref. 16386]

FLUOROCARBON GASES

CHLOROTRIFLUOROMETHANE

Introduction

Chlorotrifluoromethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula ($CClF_3$) is depicted as follows:



and the gas is available commercially under the tradenames: Freon - 13 (du Pont de Nemours) and Arcton 3 (British sources).

Its molecular weight is 104.47.

Physical Properties

Boiling point (at 1 atm.)	-81.4°C	(-114.6°F)
Freezing point	-181°C	(-294°F)
Critical temperature	28.9°C	(83.9°F)
Critical pressure	38.2 atm.	(561 psia)
Density of liquid at 30°C	1.298 g/cc	

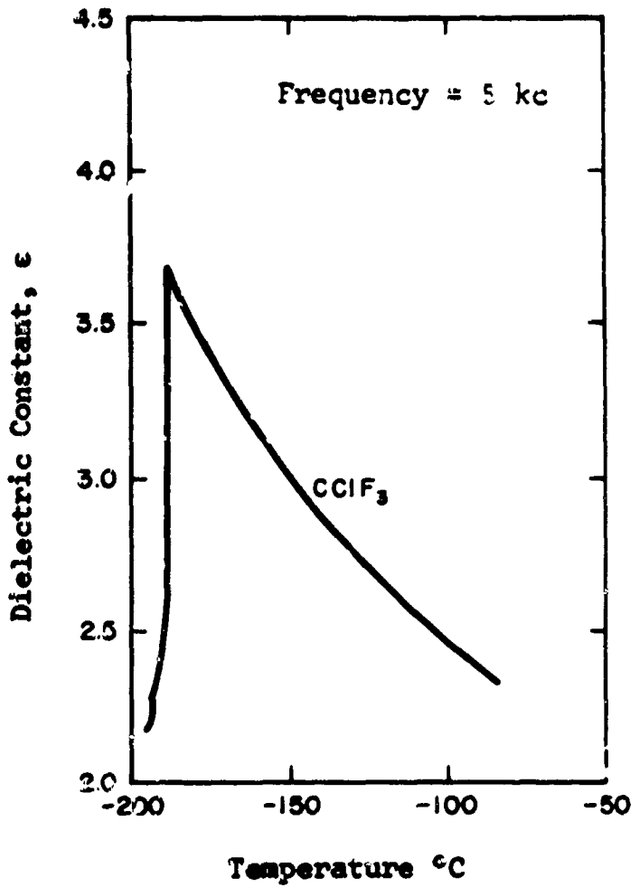
Applications

Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

CHLOROTRIFLUOROMETHANE

DIELECTRIC CONSTANT

Dielectric Constant	Phase	Temperature	Ref.
1.0013	Vapor (0.5 atm.)	29°C	6189, 16775



Dielectric constant of chlorotrifluoromethane as a function of temperature.

[Ref. 1265]

CHLOROTRIFLUOROMETHANE

DIELECTRIC STRENGTH

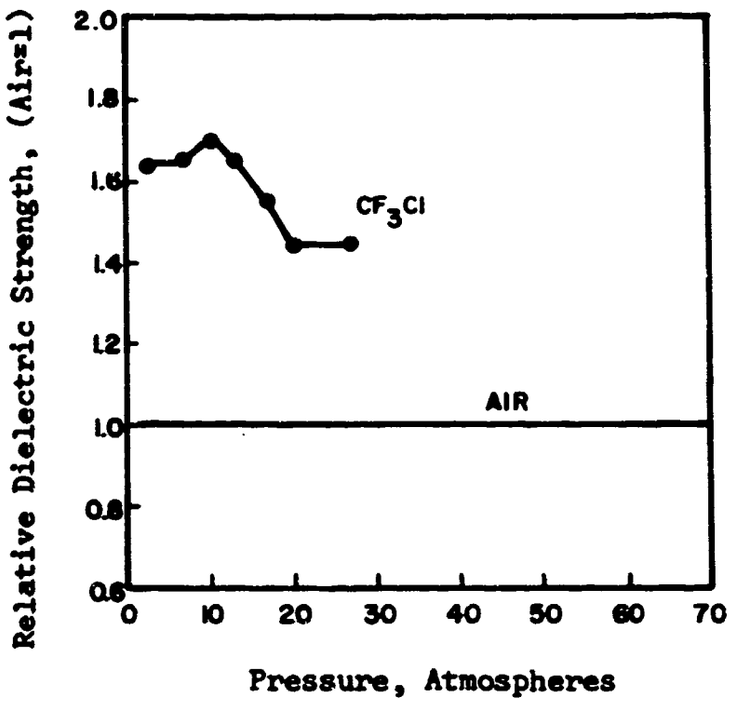
		Ref.
Relative dielectric strength	1.27 (N_2 = 1)	6189
Relative dielectric strength (average dielectric strength in a uniform electrical field)	1.43 (Air = 1)	16775

Compound	Abs. Pressure Atm.	Breakdown Voltage						Relative Electric Strength		Impulse Ratio	
		Power Frequency		Negative Direct		Negative Impulse					
		Sphere gap, cm									
		0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0
		kv	kv	kv	kv	kv	kv				
CF_3Cl (Arc-ton 3)	1	25.0	47.2	23.0	46.0	42.5	71.5	1.44	1.47	1.8	1.48
	2	48.5	90.5			70.0		1.52	1.61	1.44	
	3	71.5						1.57			
	4	93.5						1.60			

[Ref. 1181]

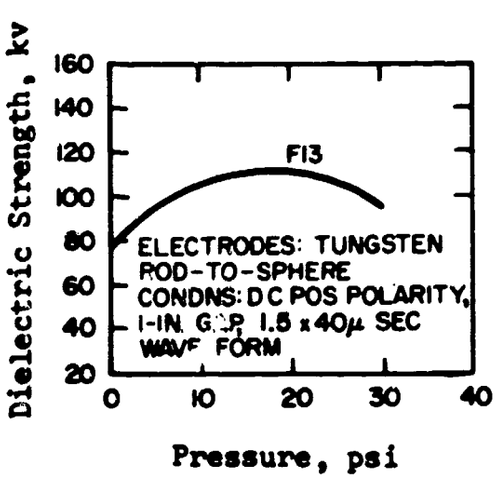
CHLOROTRIFLUOROMETHANE

DIELECTRIC STRENGTH



The relative dielectric strength of CF_3Cl (Freon-13) as a function of pressure (air = 1).

[Ref. 16775]

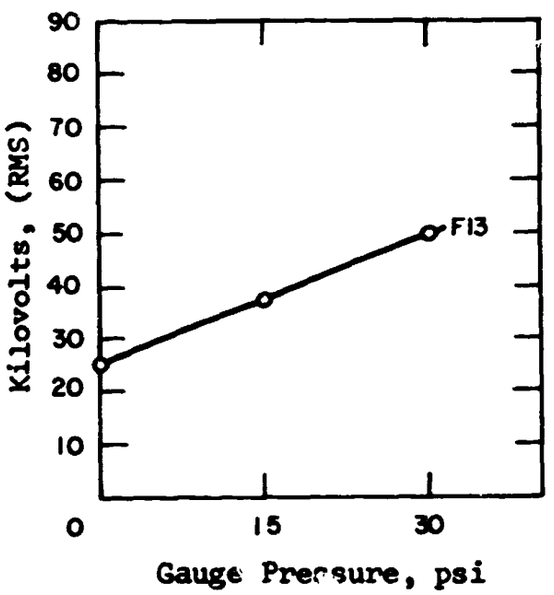


Impulse dielectric strength of Freon-13 as a function of pressure in a non-uniform field.

[Ref. 6140]

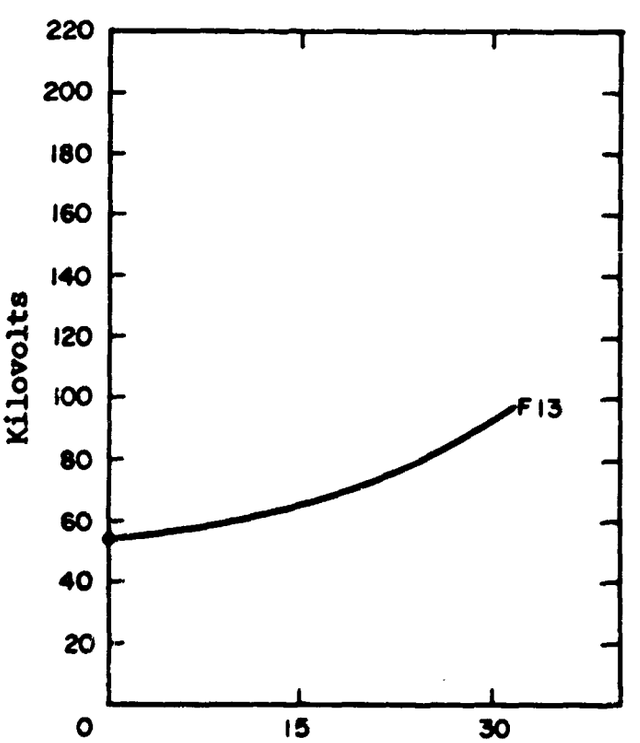
CHLOROTRIFLUOROMETHANE

DIELECTRIC STRENGTH



60-cycle dielectric strength of Freon-13 as a function of pressure as tested between two 1-inch diameter spheres spaced 1/4 inch.

[Ref. 4299]



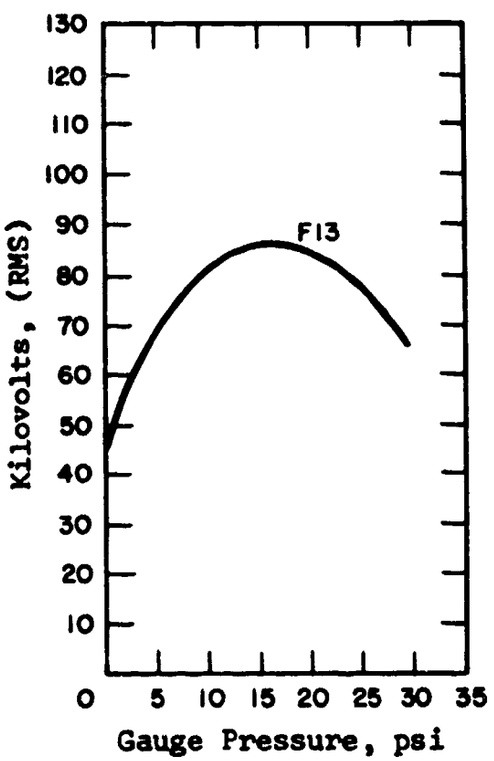
Impulse dielectric strength of Freon-13 as a function of pressure as tested between two 1-inch diameter spheres spaced 1/4 inch.

[Ref. 4299]

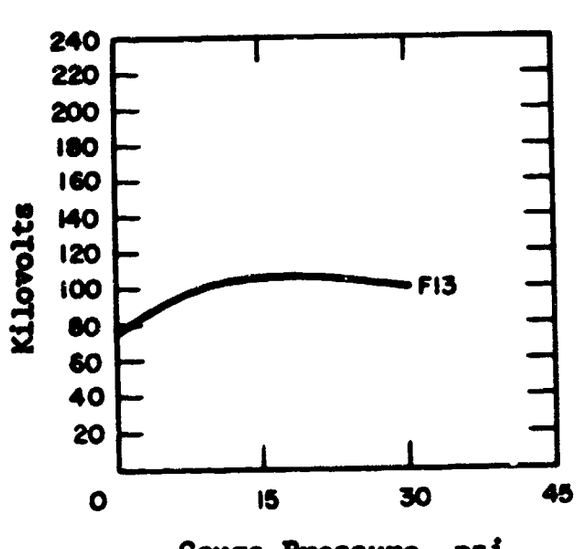
CHLOROTRIFLUOROMETHANE

DIELECTRIC STRENGTH

60-cycle dielectric strength of Freon-13 as a function of pressure as tested between tungsten rod and 1-inch diameter sphere spaced 1 inch.



[Ref. 4299]



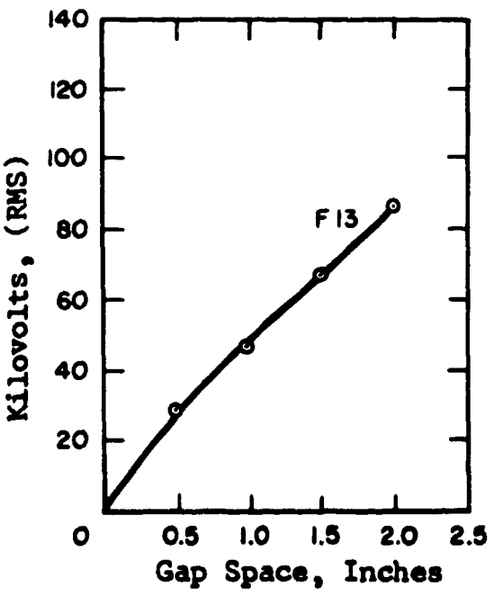
Impulse dielectric strength of Freon-13. Positive-wave tests made between tungsten rod and 1-inch diameter sphere spaced 1 inch.

[Ref. 4299]

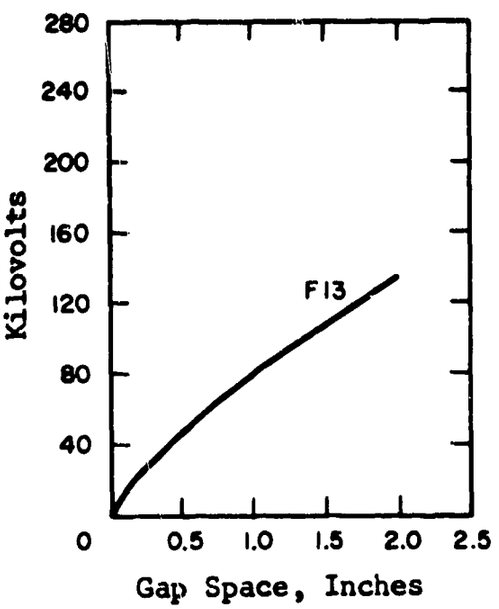
CHLOROTRIFLUOROMETHANE

DIELECTRIC STRENGTH

60-cycle dielectric strength of Freon-13 as a function of gap distance, tested between tungsten rod and 1-inch diameter sphere at atmospheric pressure. →



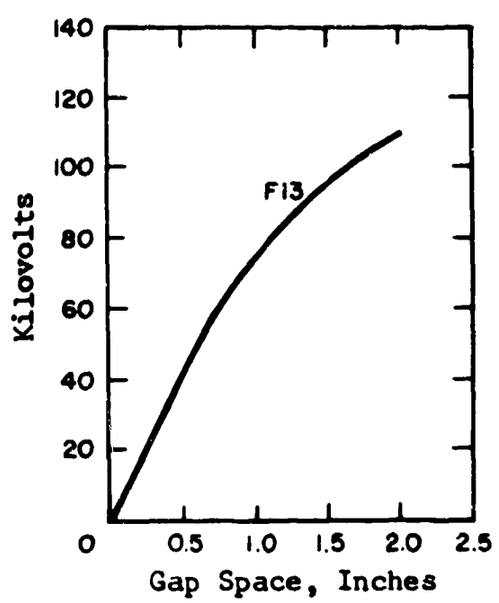
[Ref. 4299]



[Ref. 4299]

← Negative-impulse tests (1 1/2 x 40 microsecond wave) on Freon-13 at atmospheric pressure, between tungsten rod and 1-inch diameter sphere.

Positive-impulse tests (1 1/2 x 40 microsecond wave) on Freon-13 at atmospheric pressure, between tungsten rod and 1-inch diameter sphere. →



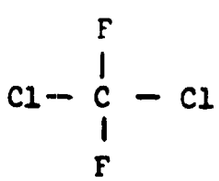
[Ref. 4299]

FLUOROCARBON GASES

DICHLORODIFLUOROMETHANE

Introduction

Dichlorodifluoromethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula (CCl_2F_2) is depicted as follows:



and the gas is available commercially under various tradenames: Freon-12 (du Pont de Nemours), Genetron-12 (General Chemical Co.) and Arcton 6 (British sources). Its molecular weight is 120.93. The du Pont de Nemours Freon Products Division recommends a 250°F maximum temperature for continuous exposure of Freon-12 to oil, steel and copper for thermal stability.

Physical Properties

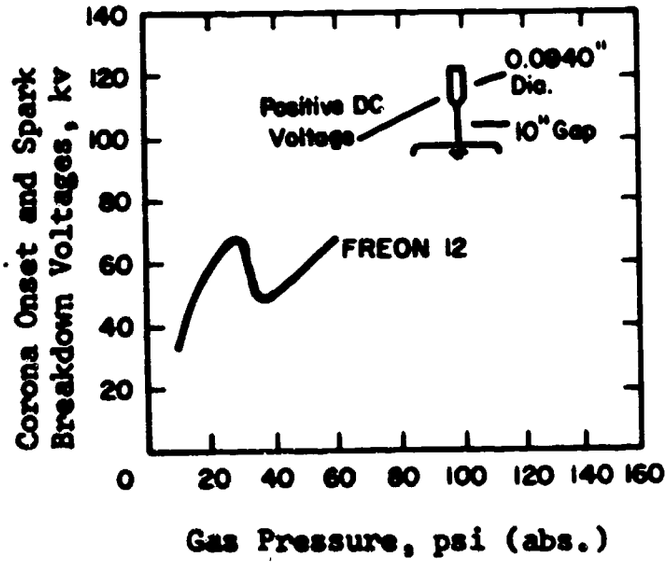
Boiling point (at 1 atm.)	-29.79°C	(-21.62°F)
Freezing point	-158°C	(-252°F)
Critical temperature	112.0°C	(233.6°F)
Critical pressure	40.6 atm.	(596.9 psia)
Density of liquid at 30°C	1.292 g/cc	(80.67 lbs/ft^3)

Applications

Dichlorodifluoromethane is used extensively in household and commercial refrigeration and air conditioning. Potential electronic applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

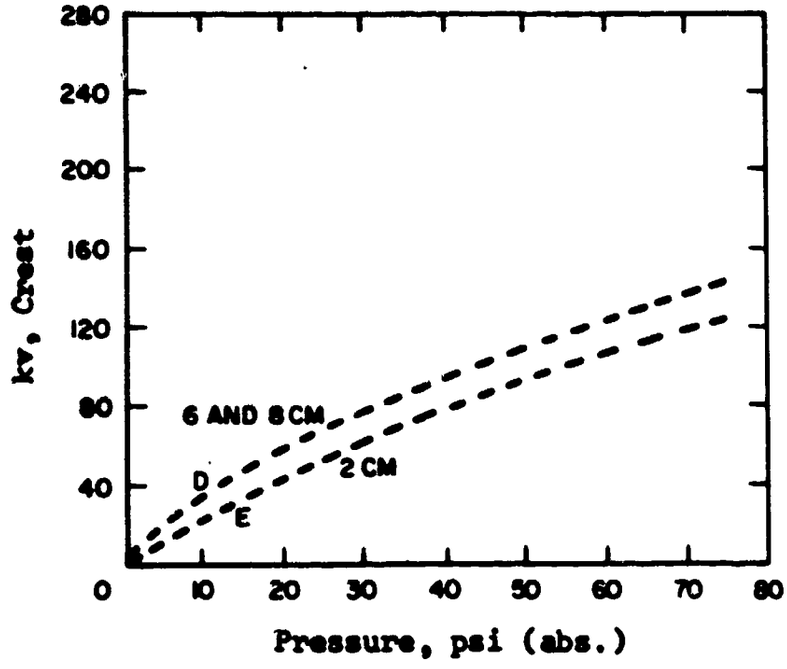
DICHLORODIFLUOROMETHANE

CORONA EFFECTS



Corona and spark breakdown of Freon-12 as a function of pressure.

[Ref. 1655]



60-cycle corona starting voltage of Freon-12, 1/2 inch square rods, gaps as noted.

[Ref. 5338]

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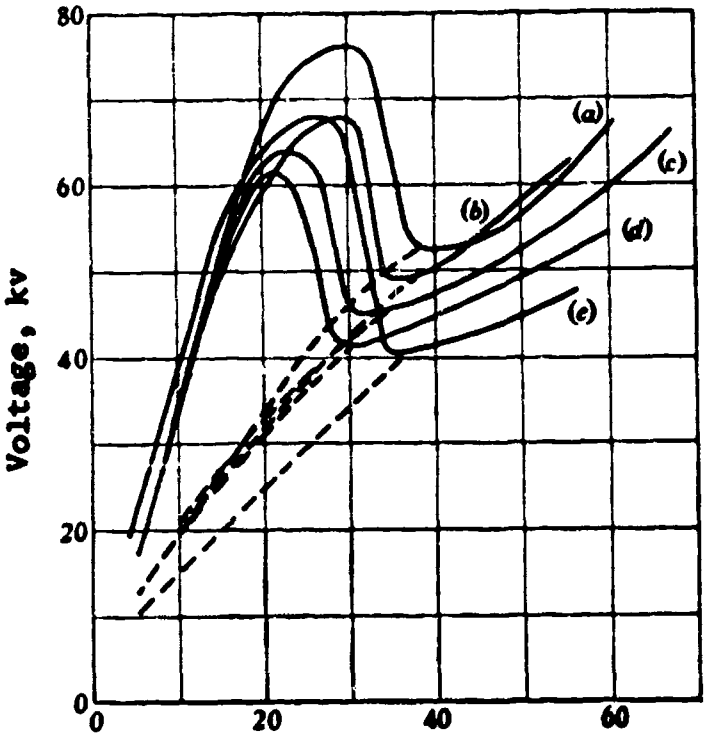
DICHLORODIFLUOROMETHANE

CORONA EFFECTS

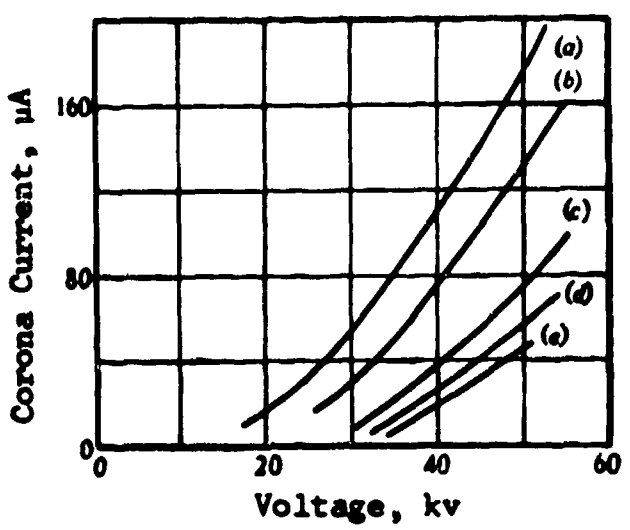
Corona-onset and spark-breakdown characteristics for Freon-12.

(a), (b),
(c) and (d)-Obtained with standard electrode configuration.
(e) - Obtained with a more divergent electrode configuration.

--- Corona-onset voltage
—— Spark-breakdown voltage



[Ref. 1853]



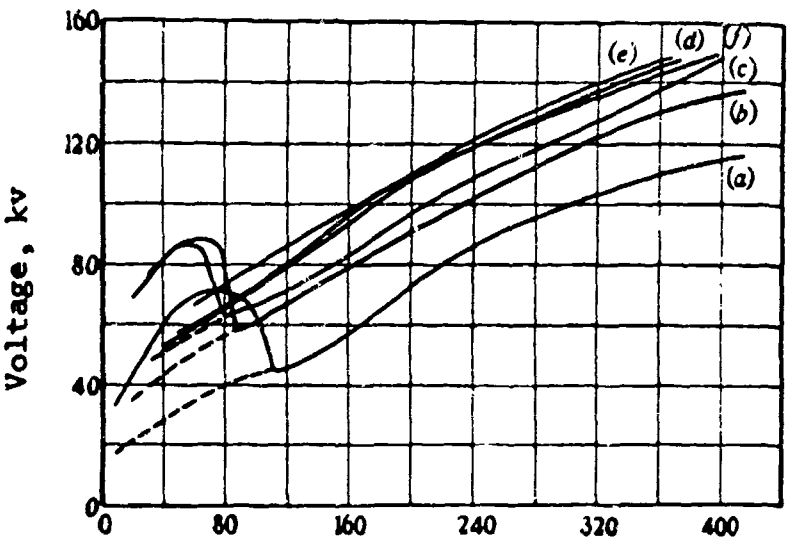
Corona-current as a function of voltage characteristics for Freon-12.

(a) 15 psi (abs.)
(b) 18.5 psi (abs.)
(c) 22.5 psi (abs.)
(d) 25 psi (abs.)
(e) 27 psi (abs.)

[Ref. 1853]

DICHLORODIFLUOROMETHANE

CORONA EFFECTS



Absolute Pressure, psi

Corona-onset and spark-breakdown characteristics for mixtures of Freon-12 and nitrogen.

(a) 10 psi abs., Freon 12 + N_2
(b) 20 psi abs., Freon 12 + N_2
(c) 30 psi abs., Freon 12 + N_2
(d) 40 psi abs., Freon 12 + N_2
(e) 50 psi abs., Freon 12 + N_2
(f) 60 psi abs., Freon 12 + N_2

--- Corona-onset voltage
—— Spark-breakdown voltage

[Ref. 1853]

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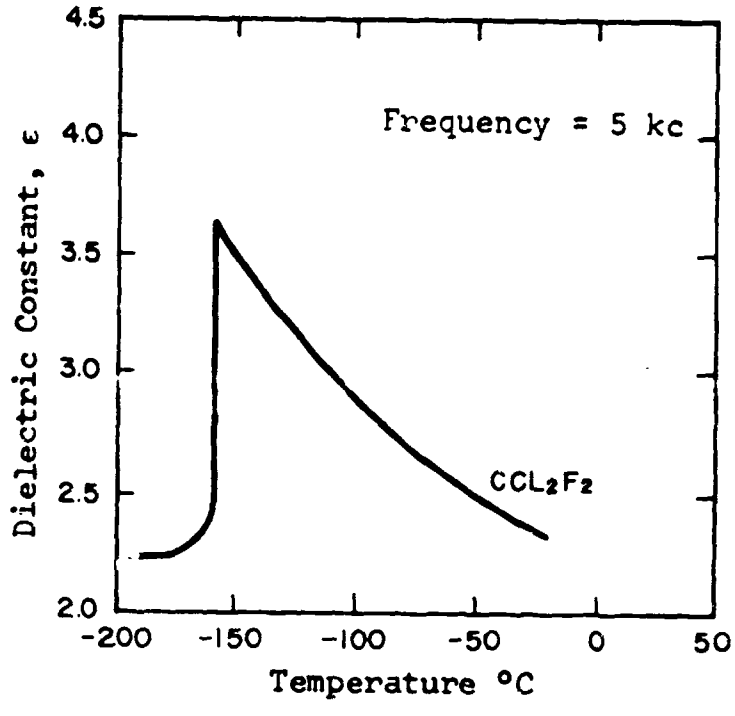
DICHLORODIFLUOROMETHANE

DIELECTRIC CONSTANT

Dielectric Constant	Pressure	Frequency	Temperature	Ref.
1.00325	760 mm	9200 Mc	20°C	1181
1.00029	-	10^{10} cps	23°C	1373
2.13	(Liquid Phase)	-	29°C	16775 &
1.0016	(Vapor, 0.5 atm.)	-	29°C	6189



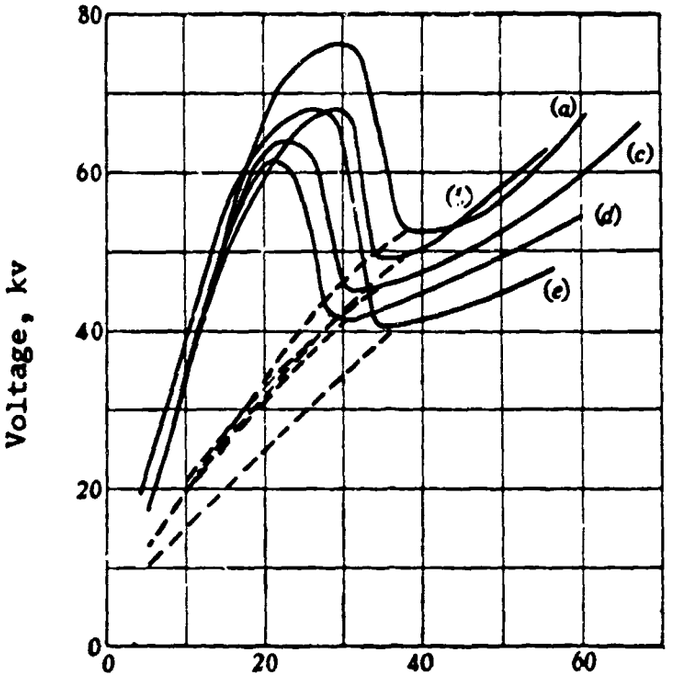
Dielectric constant as a function of temperature for dichlorodifluoromethane.

[Ref. 1265]

DICHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

		Ref.
Relative dielectric strength	2.06 (N_2 = 1)	6189
Relative dielectric strength (uniform electrical field)	2.42 (Air = 1)	16775



Corona-onset and spark-breakdown characteristics for Freon 12.

(a),(b),(c) and (d) Obtained with standard electrode configuration.
(e) Obtained with a more divergent electrode configuration.

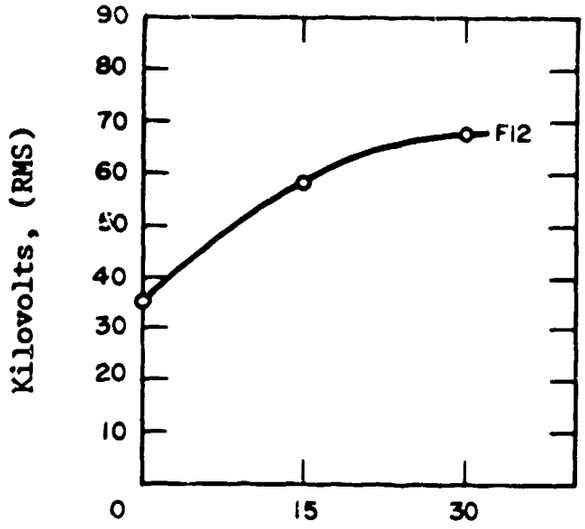
--- Corona-onset voltage
___ Spark-breakdown voltage

[Ref. 1853]

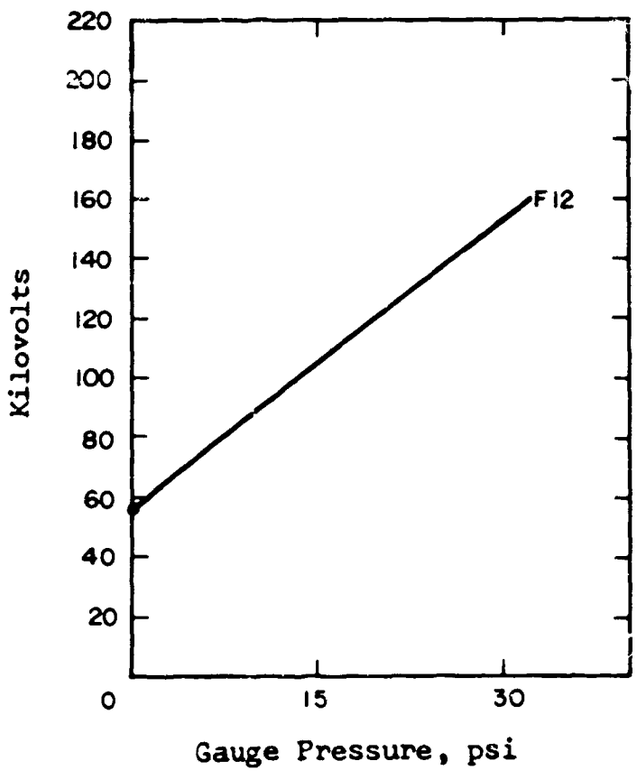
DICHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

60-cycle dielectric strength of Freon-12, tested between two 1-inch diameter spheres spaced 1/4 inch.



[Ref. 4299]



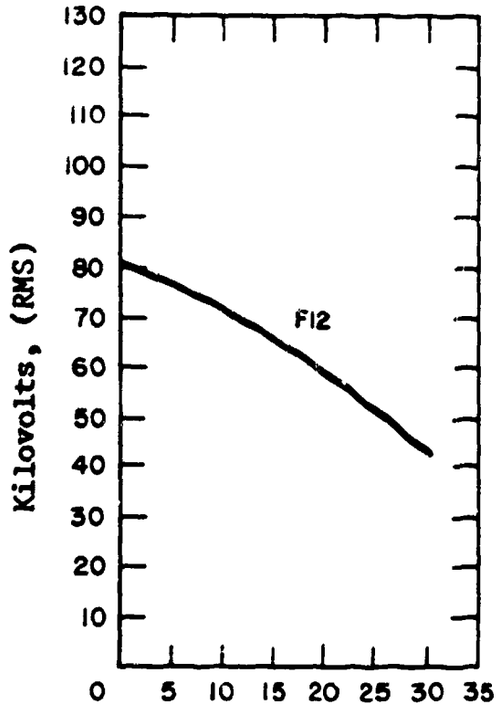
Impulse dielectric strength of Freon-12, tested between two 1-inch diameter spheres spaced 1/4 inch.

[Ref. 4299]

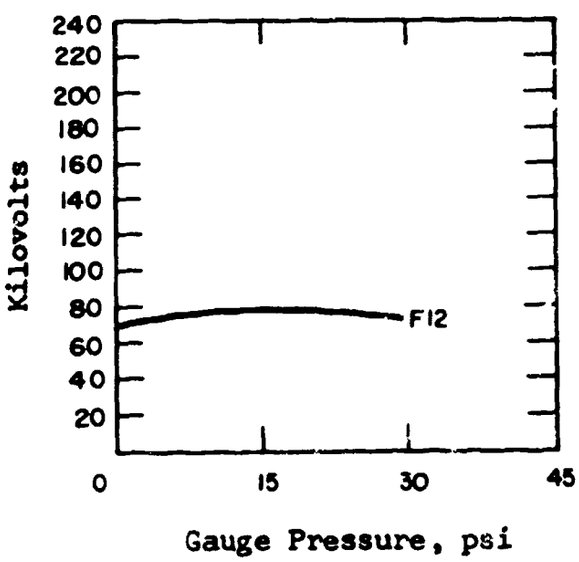
DICHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

60-cycle dielectric strength of Freon-12, tested between tungsten rod and 1-inch diameter sphere spaced 1 inch.



[Ref. 4299]



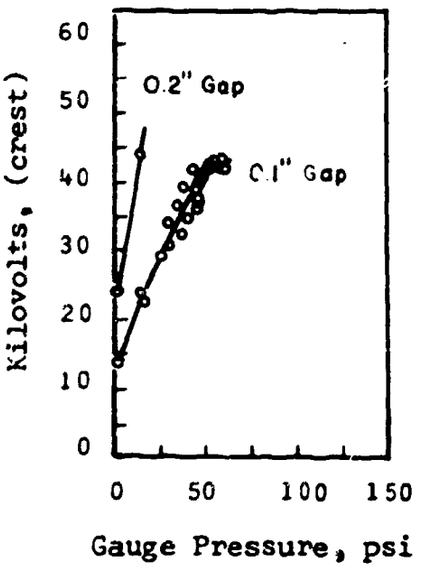
Impulse dielectric strength of Freon-12. Positive tests made between tungsten rod and 1-inch diameter sphere spaced 1 inch, 1 1/2 to 40 microseconds wave form.

[Ref. 4299]
&
[Ref. 16775]

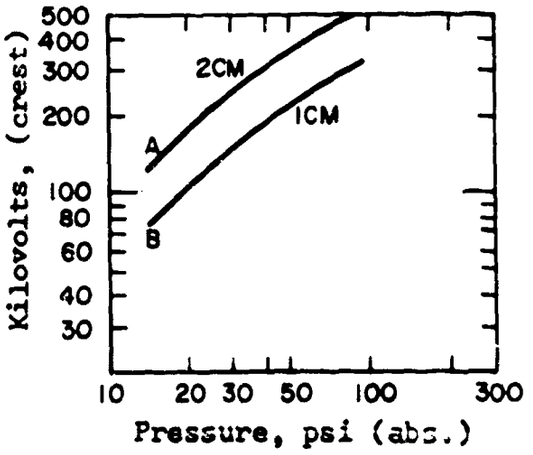
DICHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

Sparking voltage of Freon-12 as a function of pressure, pointed electrodes, gap distances as noted.



[Ref. 5005]

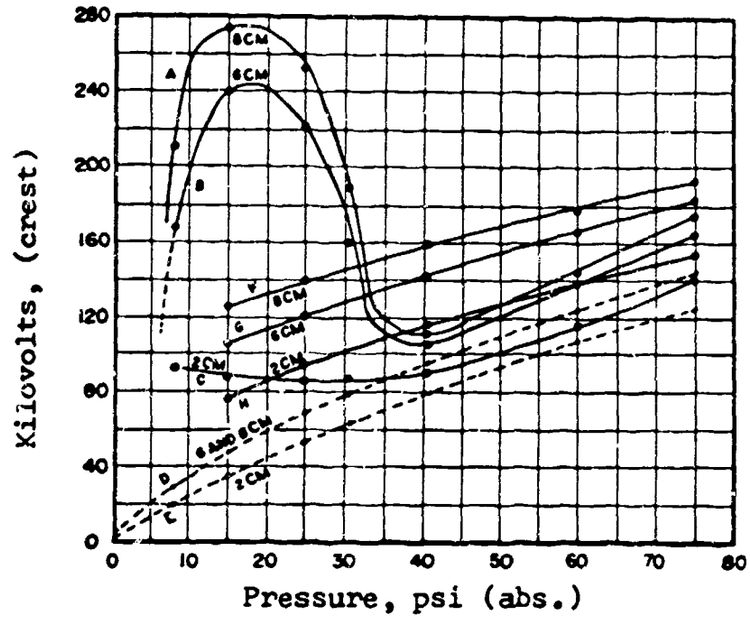


60-cycle (A) and impulse (B) breakdown of Freon-12 between 6.25 cm spheres, gaps as noted.

[Ref. 5338]

DICHLORODIFLUOROMETHANE

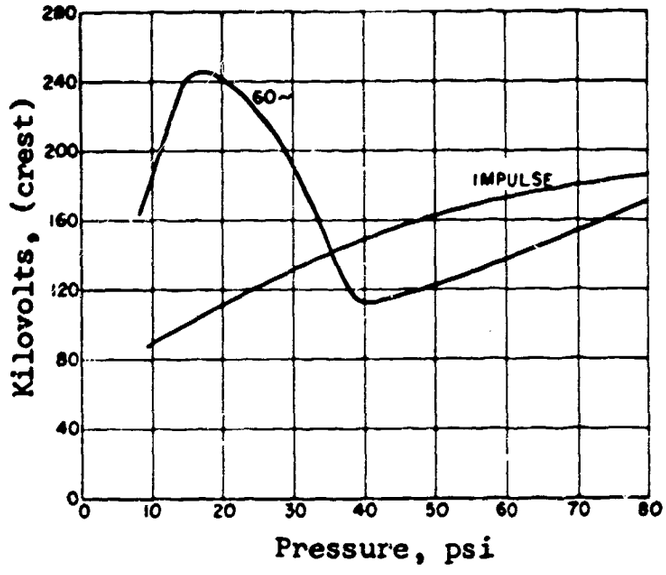
DIELECTRIC STRENGTH



60-cycle and impulse breakdown between 1/2-inch square rod gaps in CCl_2F_2.

Curves A, B, & C, = 60-cycle breakdown
Curves D & E = 60 cycle corona starting voltage
Curves F, G, & H = impulse breakdown

[Ref. 5338]



The effect of gas pressure on the breakdown of dichlorodifluoromethane (Freon-12); 1/2-inch square rod electrodes, 6-cm (2.362 inch) gap.

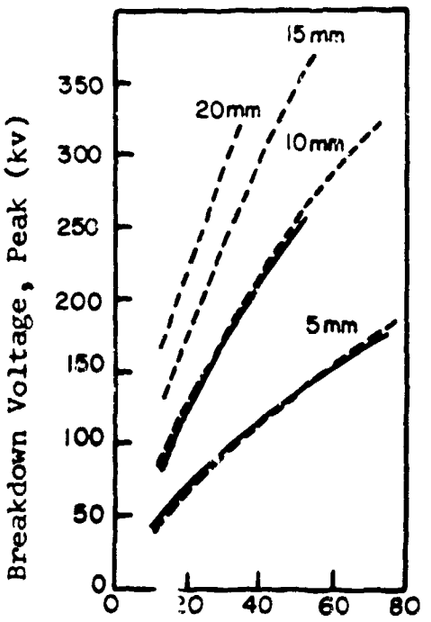
[Ref. 16775]

DICHLORODIFLUOROMETHANE

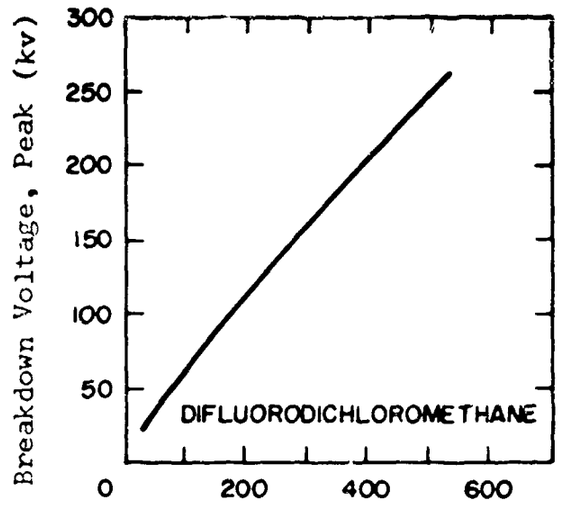
DIELECTRIC STRENGTH

Breakdown voltage between 5-cm diameter spheres for Freon-12 as a function of pressure. Gaps as noted.

—— Power frequency
--- Negative impulse



[Ref. 1589]
&
[Ref. 1181]

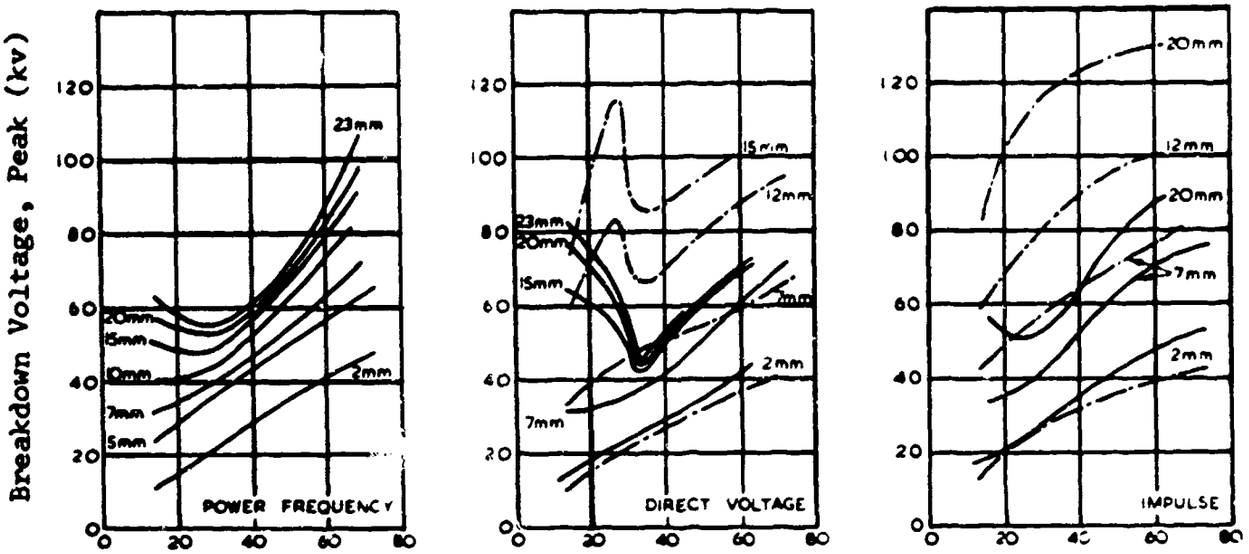


Paschen curve for Freon-12.

[Ref. 1181]

DICHLORODIFLUOROMETHANE

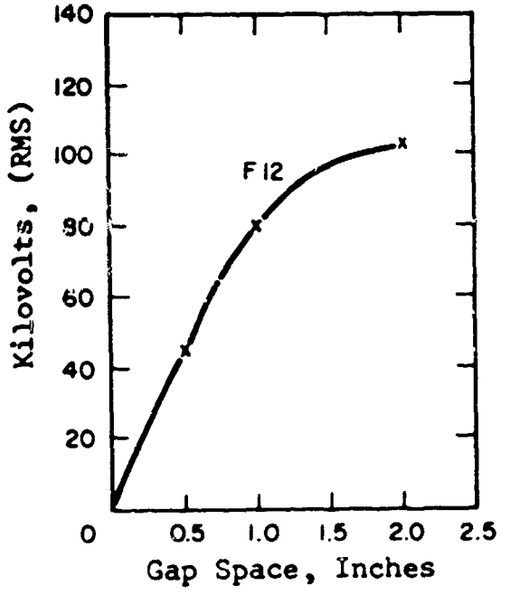
DIELECTRIC STRENGTH



Breakdown voltage with difluorodichloromethane and non-irradiated point-sphere electrodes.

—— Power frequency, positive d.c. and impulse
- - -Negative d.c. and impulse

[Ref. 1181]



60-cycle dielectric strength of Freon-12 as tested between tungsten rod and 1-inch diameter sphere at atmospheric pressure.

[Ref. 4299]

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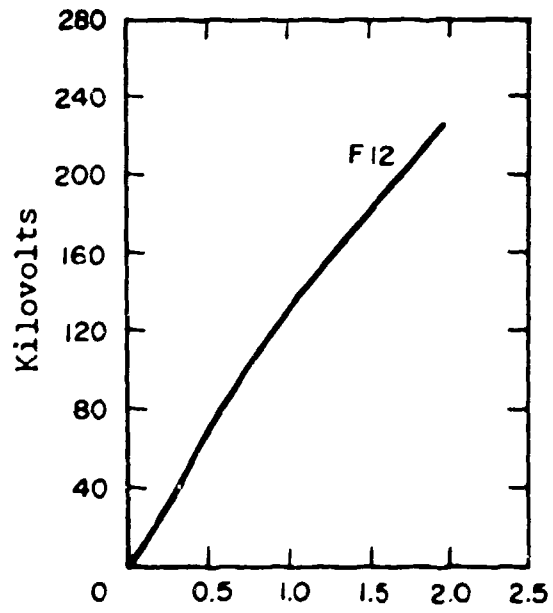
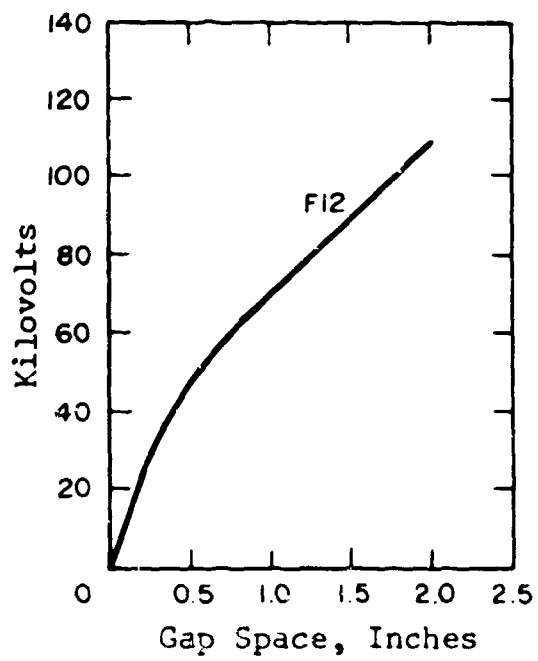
DICHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

60-cycle dielectric strength of Freon-12 as tested between a tungsten rod and 1-inch diameter sphere at atmospheric pressure.



[Ref. 4299]



Negative impulse tests (1 1/2 x 40 microsecond wave), at atmospheric pressure of Freon-12, between tungsten rod and 1-inch diameter sphere.

[Ref. 4299]

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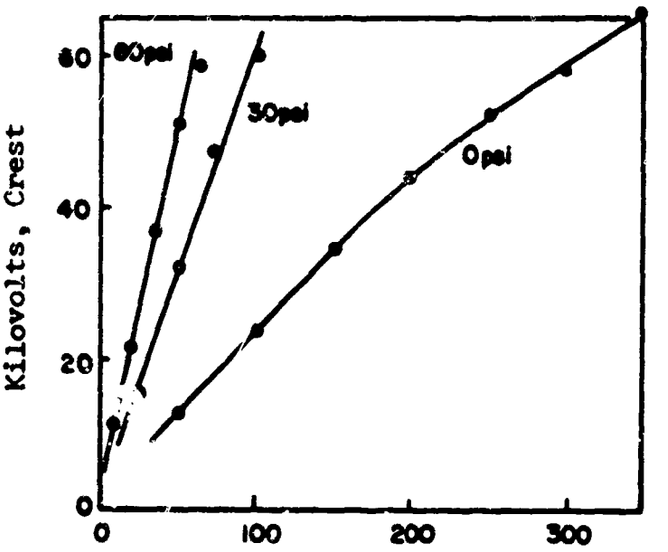
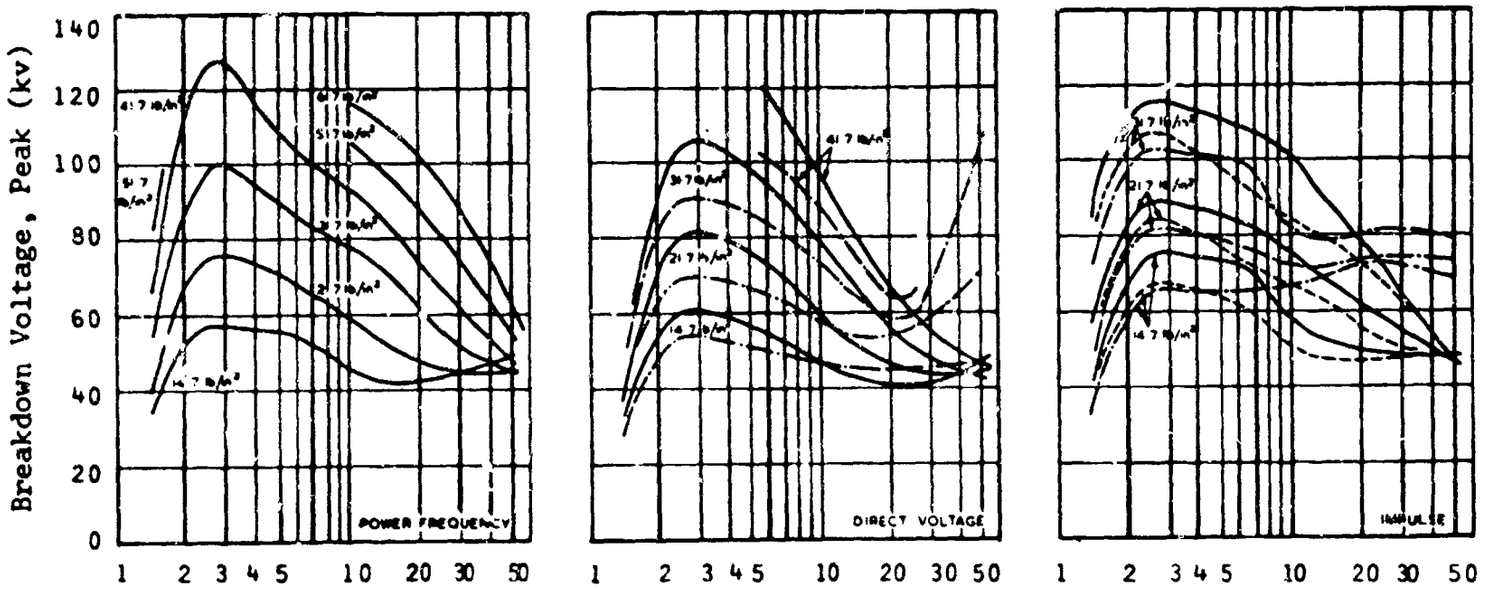
DICHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH

Sparking voltage of Freon-12 as a function of gap distance, spherical electrodes, and gauge pressures as noted.



[Ref. 5005]



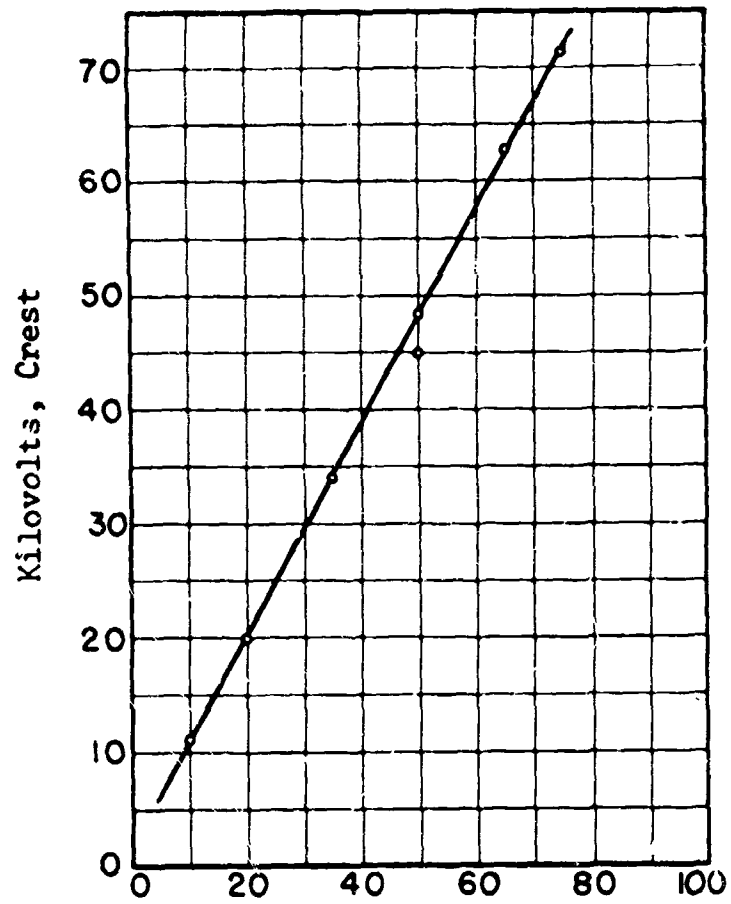
Breakdown voltage for difluorodichloromethane between coaxial cylinders.

—— Power frequency, positive d.c. and impulse
— — Negative d.c. and impulse
----- Positive impulse with radium

[Ref. 1181]

DICHLORODIFLUOROMETHANE

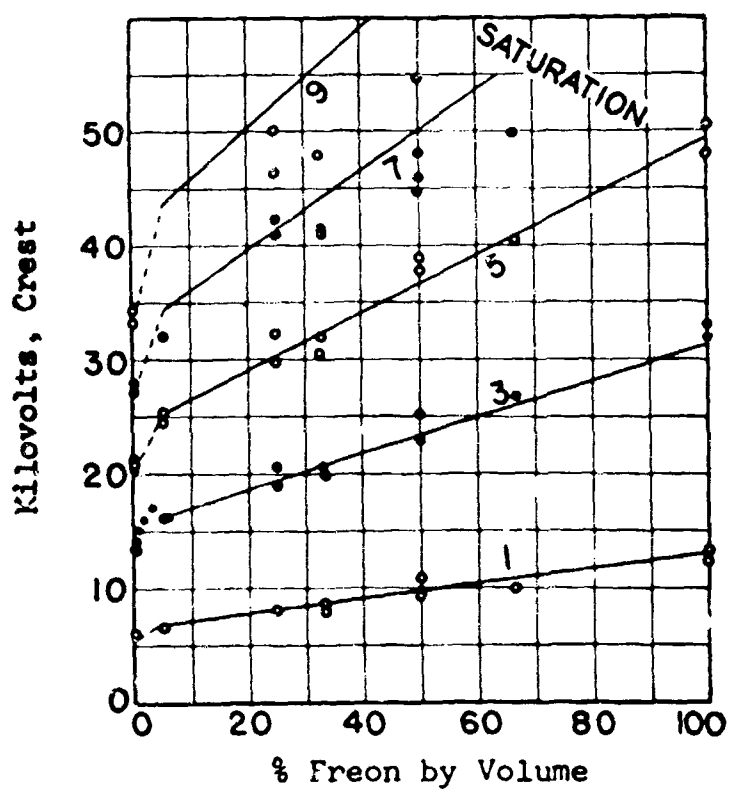
DIELECTRIC STRENGTH



[Ref. 5005]

Sparking voltages in a mixture of 50% Freon-12 and 50% Nitrogen.

Spherical electrodes
Pressure seven atmospheres (90 psig)



Sparking voltages in mixtures of Freon-12 and Nitrogen.

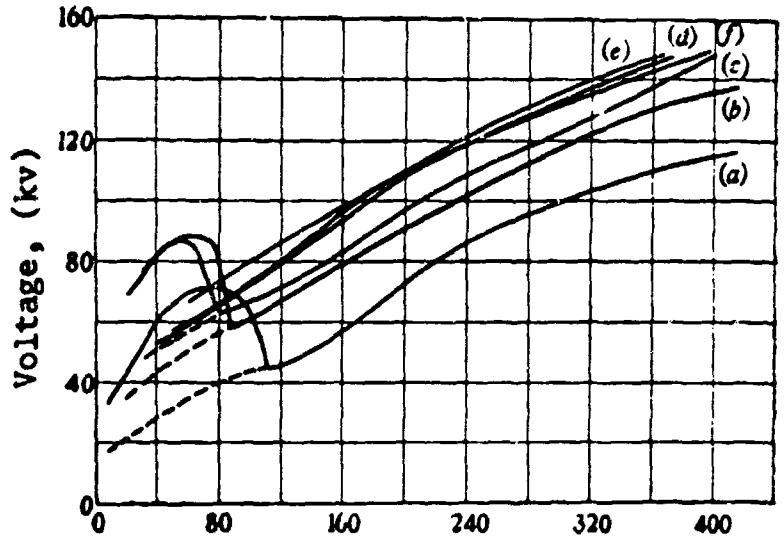
Spherical electrodes
Length of spark gap: 0.050 inch
Pressure in atm. as noted on curves
Points are experimental; lines are computed from

$$V = (88\,PS + 1.9)(1 + 1.08\,F)\text{kv}.$$

[Ref. 5005]

DICHLORODIFLUOROMETHANE

DIELECTRIC STRENGTH



Corona onset and spark breakdown characteristics for mixtures of Freon-12 and nitrogen.

(a) 10 psi (abs.), Freon 12 + N_2
(b) 20 psi (abs.), Freon 12 + N_2
(c) 30 psi (abs.), Freon 12 + N_2
(d) 40 psi (abs.), Freon 12 + N_2
(e) 50 psi (abs.), Freon 12 + N_2
(f) 60 psi (abs.), Freon 12 + N_2

- - - Corona onset voltage
——— Spark breakdown voltage

[Ref. 1853]

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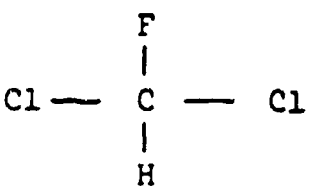
DICHLOROFLUOROMETHANE

Introduction

Dichlorofluoromethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula ($CFCl_2H$) is depicted as follows:



and the gas is available commercially under various tradenames: Freon - 21 du Pont de Nemours, Arcton - 7 (British sources).

Its molecular weight is 102.93.

Physical Properties

Boiling point (at 1 atm.)	8.92°C	(48.06°F)
Freezing point	-135°C	(-211°F)
Critical temperature	178.5°C	(353.3°F)
Critical pressure	51.0 atm.	(750 psia)
Density of liquid at 30°C	1.354 g/cc	(84.52 lbs/ft^3)

Applications

Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

DICHLOROFLUOROMETHANE

DIELECTRIC CONSTANT

Dielectric Constant	Phase	Temperature	Ref.
5.34	liquid	[illegible]°C	6189
1.0035	vapor (0.5 atm.)	30°C	6189

DICHLOROFLUOROMETHANE

DIELECTRIC STRENGTH

			Ref.
Relative dielectric strength	1.82	(N_2 = 1)	6189
Relative dielectric strength (uniform electrical field)	1.33	(Air = 1)	16775

Compound	Abs. Pressure Atm.	Breakdown Voltage						Relative Electric Strength		Impulse Ratio	
		Power Frequency		Negative Direct		Negative Impulse					
		Sphere Gap, cm									
		0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0
		kv	kv	kv	kv	kv	kv				
$CHFCl_2$	1	32.2	63.1	29.7	58.4	43.8	87.0	1.86	1.98	1.36	1.38
	2*	50.0	93.5					1.56	1.67		
(Arc-	3*	66.5						1.46			
ton 7)	4*	81.5						1.40			

* Nitrogen added to compound exerting one atmosphere absolute pressure.

[Ref. 1181]

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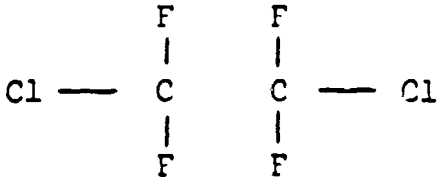
DICHLOROTETRAFLUOROETHANE

Introduction

Dichlorotetrafluoroethane is a dielectric gas with electro-negative behaviour or characteristics. The chemical formula ($C_2Cl_2F_4$) is depicted as follows:



and the gas is available commercially under the tradename: Freon - 114 (du Pont de Nemours). Its molecular weight is 170.93.

Physical Properties

Boiling point (at 1 atm.)	+3.55°C
Melting point	-94°C

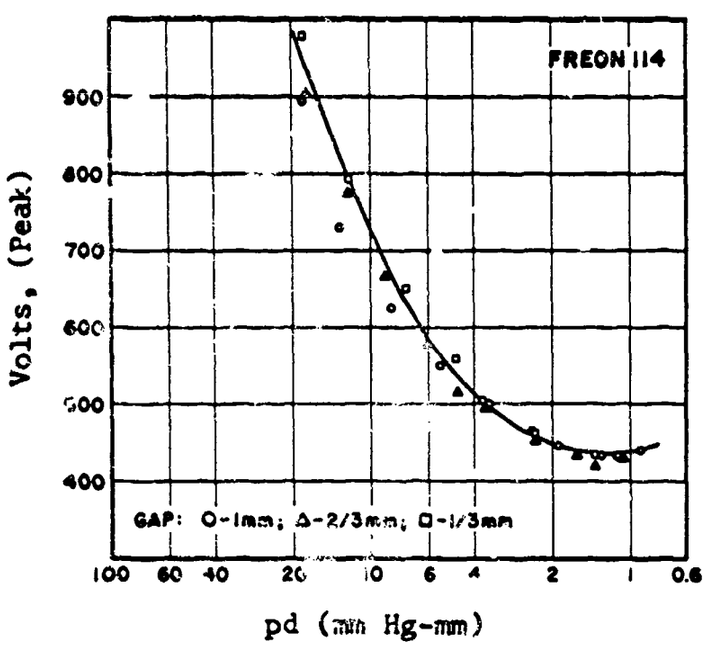
Applications

Potential applications include insulation in coaxial lines and waveguides and other dielectric purposes.

DICHLOROTETRAFLUOROETHANE

DIELECTRIC STRENGTH

			Ref.
Relative dielectric strength	2.8	(N_2 = 1)	1373



Paschen curve, Freon-114.

[Ref. 16386]

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HEXAFLUOROETHANE

Introduction

Hexafluoroethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula (C_2F_6) is depicted as follows:

$C F_3 - C F_3$ or

and the gas is available commercially as Freon - 116 from the du Pont de Nemours Company.

Its molecular weight is 138.02.

Physical Properties

Boiling point (at 1 atm.)	-78.2°C	(-108.8°F)
Freezing point	-100.6°C	(-149.1°F)
Critical temperature	24.3°C	(75.8°F)
Critical pressure	32.6 atm.	(480 psia)

Applications

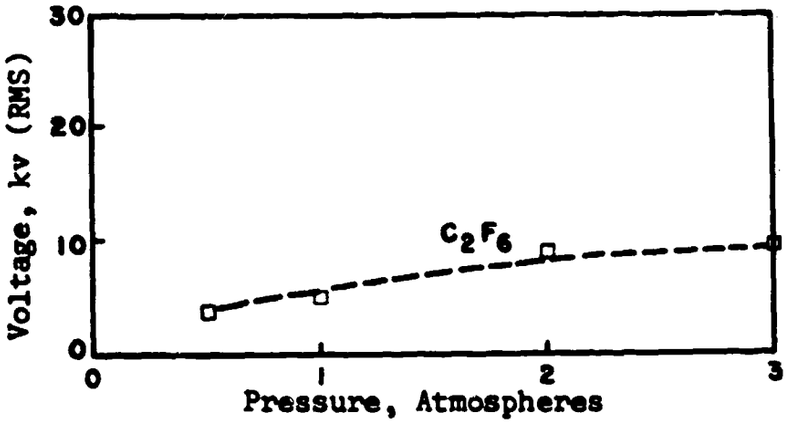
Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

HEXAFLUOROETHANE

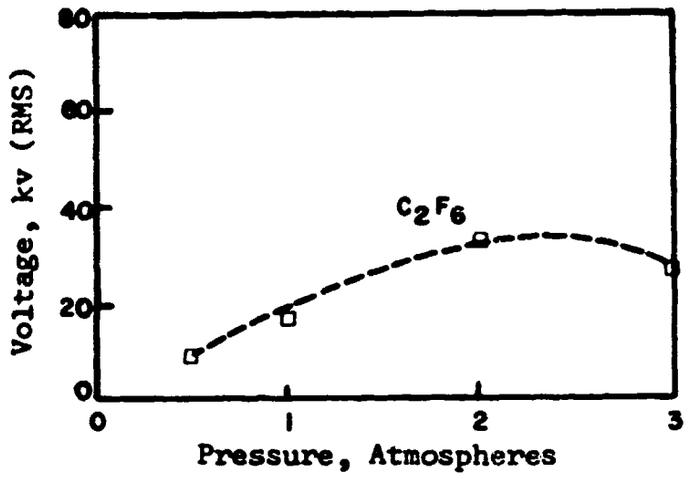
CORONA EFFECTS

Corona inception of C_2F_6 as a function of pressure, gap spacing = 0.1 inch.

Electrodes - 1/4" x 1/4" steel square rod-to-brass plane



[Ref. 16955]



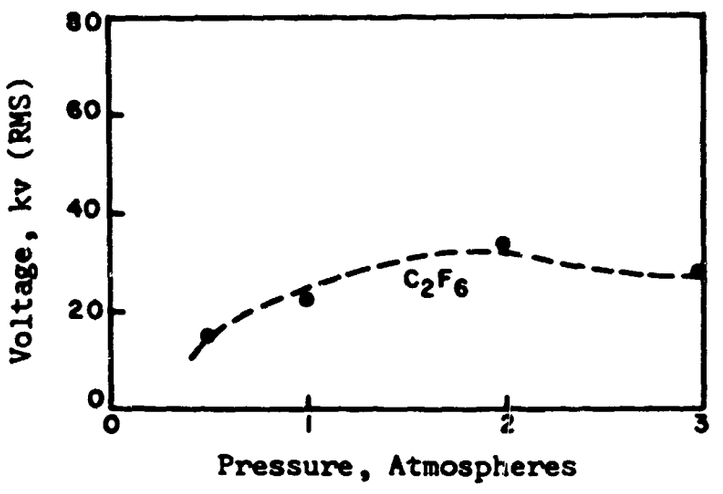
Corona inception of C_2F_6 as a function of pressure, gap spacing = 0.5 inch.

Electrodes - 1/4" x 1/4" steel square rod-to-brass plane

[Ref. 16955]

Corona inception of C_2F_6 as a function of pressure, gap spacing = 1.0 inch.

Electrodes - 1/4" x 1/4" steel square rod-to-brass plane



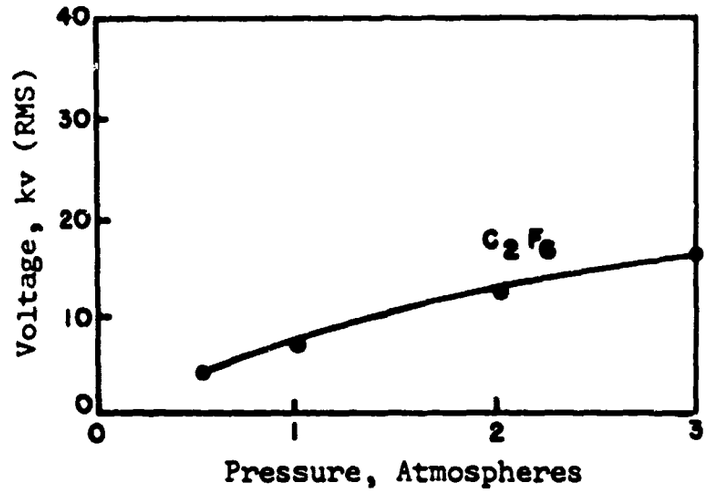
[Ref. 16955]

HEXAFLUOROETHANE

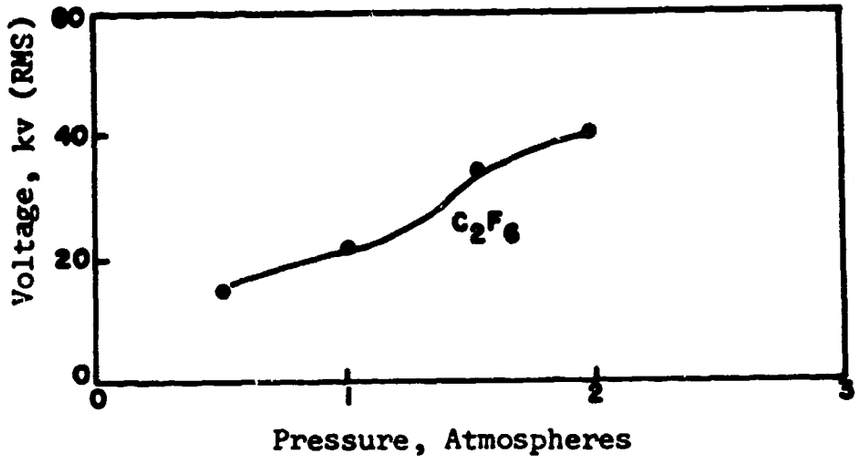
CORONA EFFECTS

Corona inception of C_2F_6 as a function of pressure, gap spacing = 0.1 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane



[Ref. 16955]



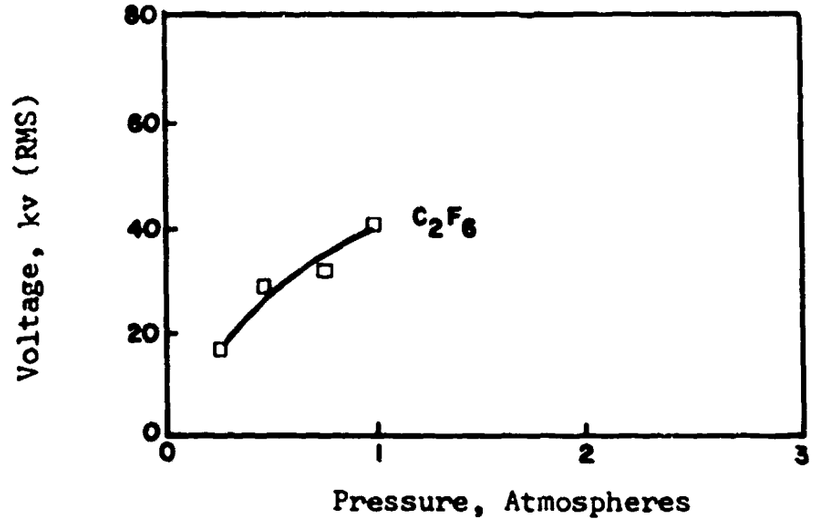
Corona inception of C_2F_6 as a function of pressure, gap spacing = 0.5 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane

[Ref. 16955]

Corona inception of C_2F_6 as a function of pressure, gap spacing = 1.0 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane



[Ref. 16955]

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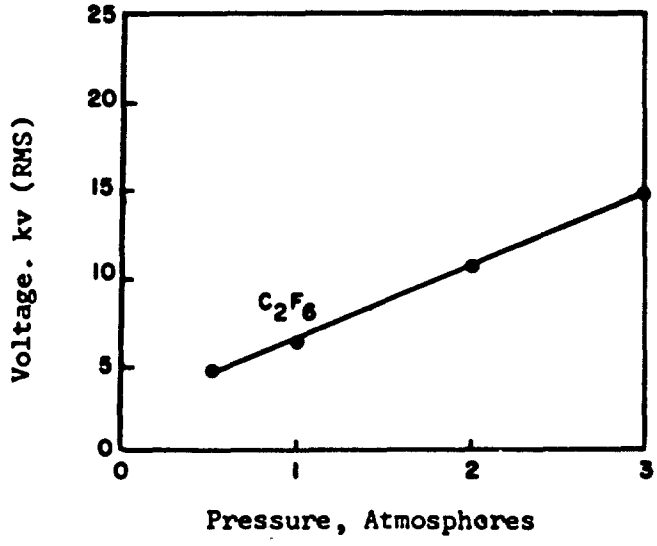
HEXAFLUOROETHANE

CORONA EFFECTS



Corona inception voltage as a function of pressure.
Gap distance = 1.0 inch.

[Ref. 16955]

Electrode - 0.0415 cm hemispherically tipped platinum needle-to brass plane

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HEXAFLUOROETHANE

DIELECTRIC CONSTANT

Dielectric Constant	Pressure	Temperature	Ref.
1.00197	711 mm Hg	23.0°C	10057 7531

HEXAFLUOROETHANE

DIELECTRIC STRENGTH

		Ref.
Relative dielectric strength	1.46 (N_2 = 1)	6189

Dielectric Strength* as a Function of Pressure

Pressure (abs.)	kv (RMS)
1/2 atm.	6.7
1 atm.	13.3
2 atm.	20.2
3 atm.	27.2

** kv crest ÷ 1.414 kv crest measured with 6.25 cm sphere - gap, (ASA 68.1 1953, AIEE no. 4)*60 cps breakdown voltage, 1/2" steel sphere, 2 mm gap, room temperature. [Ref. 10057] & [Ref. 7531]

Dielectric Strength as a Function of Electrodes and Spacing **

Conditions	Voltage
1/2 - inch radius hemisphere, 0.1 - inch gap	15 kv
1/2 - inch radius hemisphere, 0.25 - inch gap	38
Point to hemisphere, 0.1 - inch gap	13
Point to hemisphere, 0.25 - inch gap,	27

** 60 cps, atmosphere pressure, kilovolt breakdown, crest.

[Ref. 1275]

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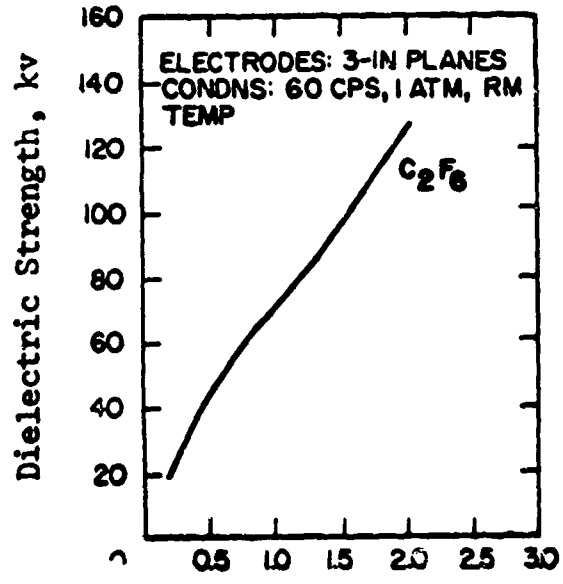
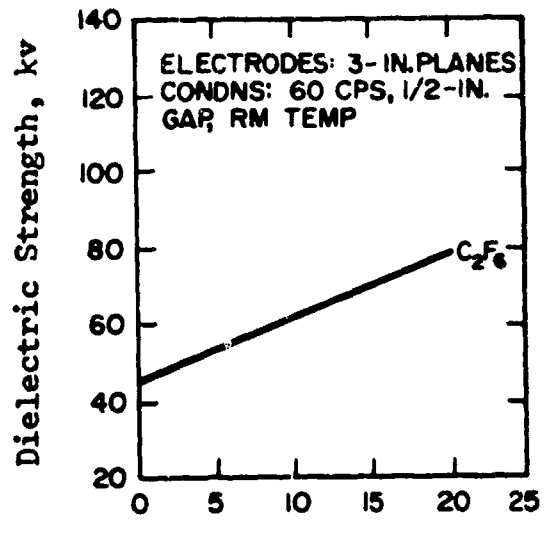
HEXAFLUOROETHANE

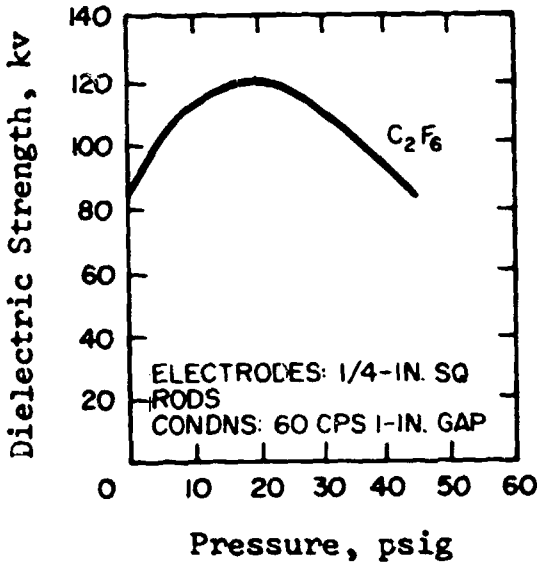
DIELECTRIC STRENGTH



Dielectric strength of C_2F_6 as a function of gap distance in a uniform electrical field



Dielectric strength of C_2F_6 as a function of pressure in a non-uniform electrical field.



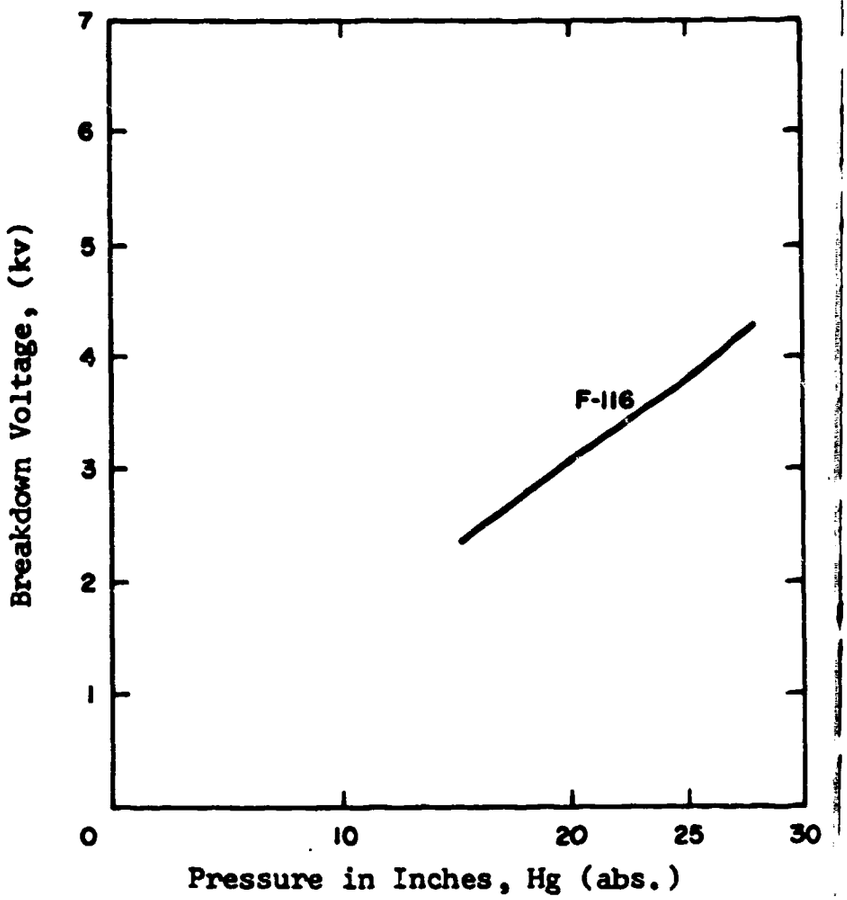
Dielectric strength of C_2F_6 as a function of pressure in a non-uniform electrical field.

[Ref. 6140]
&
[Ref. 16775]

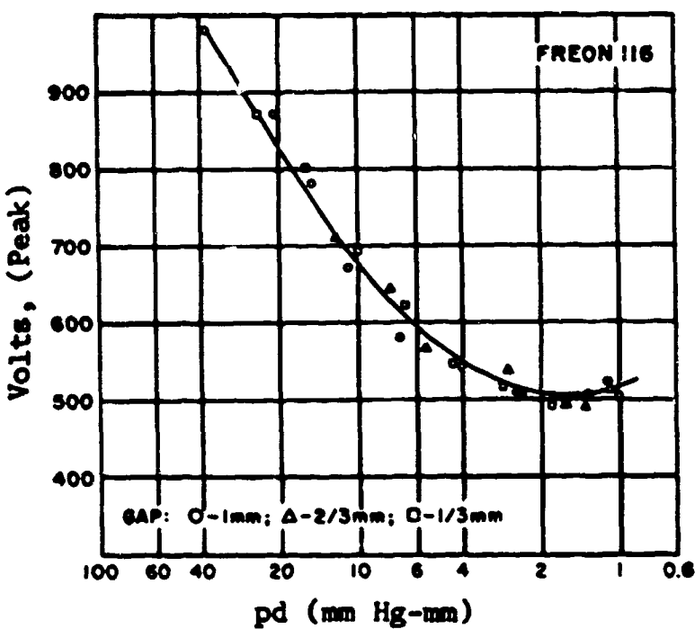
HEXAFLUOROETHANE

DIELECTRIC STRENGTH

Breakdown voltage of Freon-116 as a function of pressure across a spark plug.



[Ref. 10489]



Paschen curve for Freon-116.

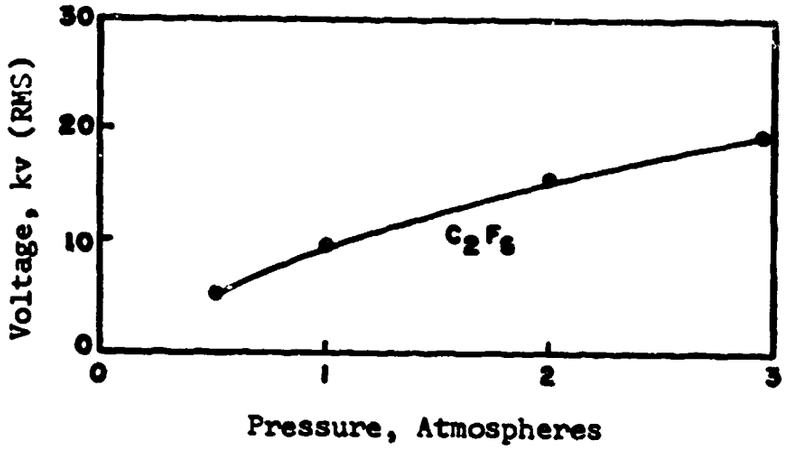
[Ref. 16775]

HEXAFLUOROETHANE

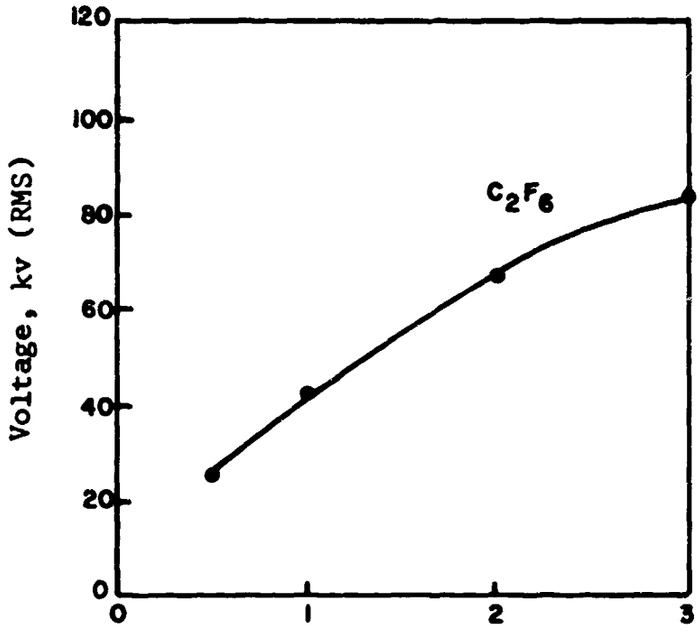
DIELECTRIC STRENGTH

Breakdown voltage of C_2F_6 as a function of pressure, gap spacing = 0.1 inch.

Electrodes - 1/4" x 1/4" steel square rod-to-brass plane



[Ref. 16955]



Breakdown voltage of C_2F_6 as a function of pressure, gap spacing = 0.5 inch.

Electrodes - 1/4" x 1/4" steel square rod-to-brass plane

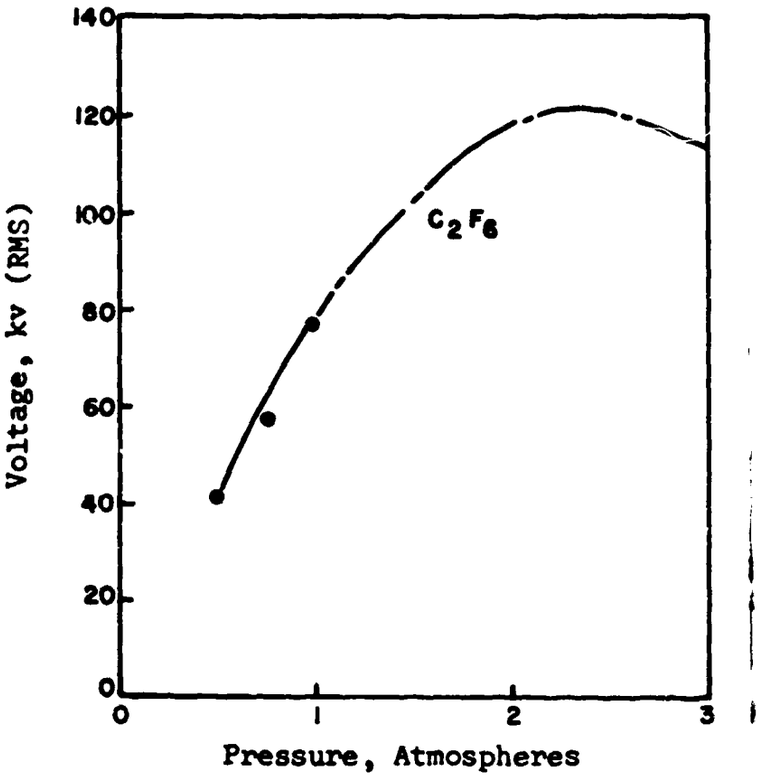
[Ref. 16955]

HEXAFLUOROETHANE

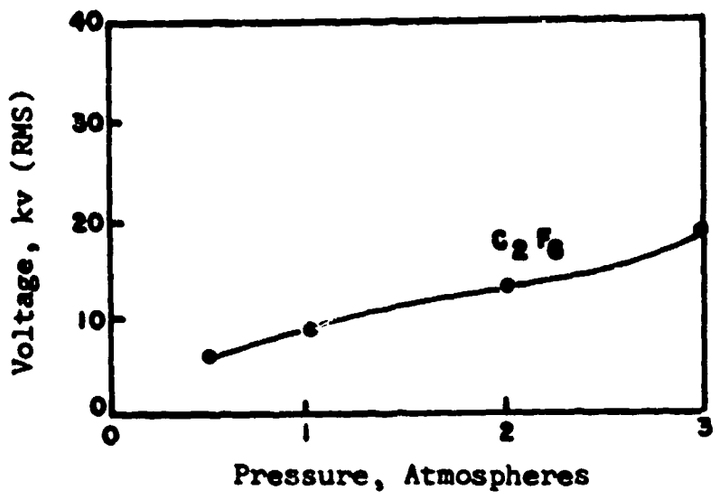
DIELECTRIC STRENGTH

Breakdown voltage of C_2F_6 as a function of pressure, gap spacing = 1.0 inch.

Electrodes - 1/4" x 1/4" steel square rod-to-brass plane



[Ref. 16955]



Breakdown voltage of C_2F_6 as a function of pressure, gap spacing = 0.1 inch.

Electrodes -

3/8" steel cylindrical rod-to-brass plane

[Ref. 16955]

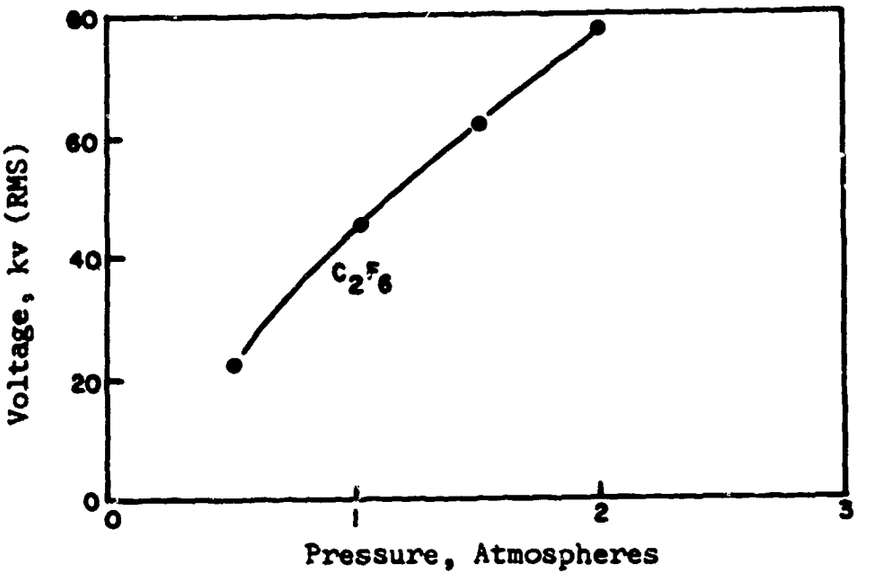
HEXAFLUOROETHANE

DIELECTRIC STRENGTH

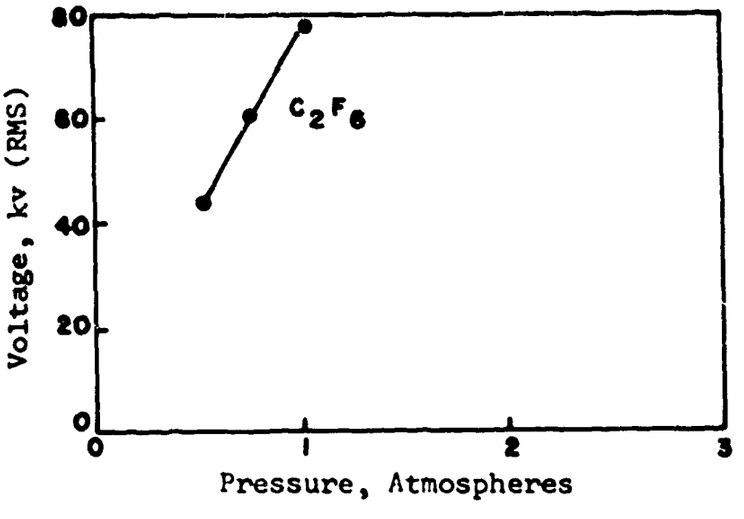
Breakdown voltage of C_2F_6 as a function of pressure, gap spacing = 0.5 inch.

Electrodes -

3/8" steel cylindrical rod-to-brass plane



[Ref. 16955]



Breakdown voltage of C_2F_6 as a function of pressure, gap spacing = 1.0 inch.

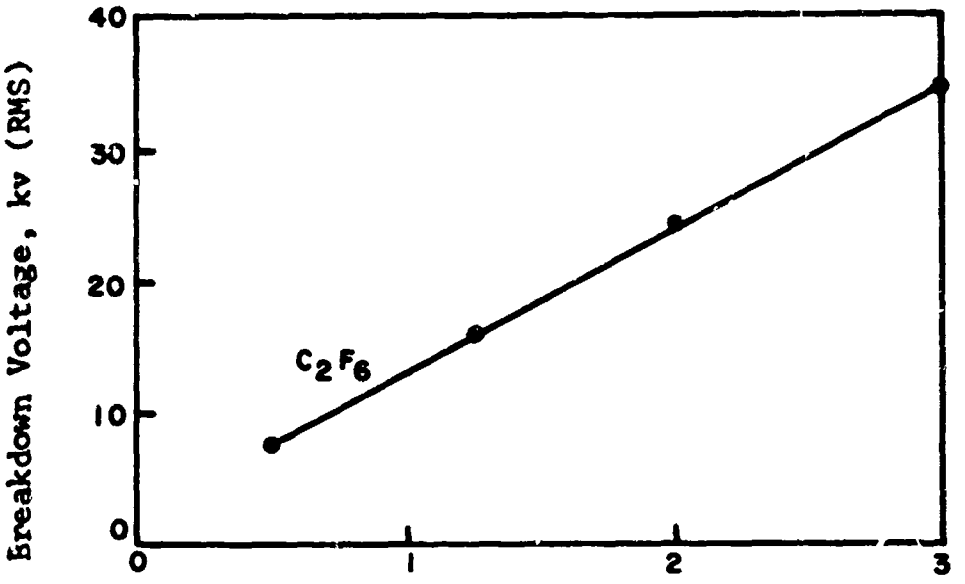
Electrodes -

3/8" steel cyclindrical rod-to-brass plane

[Ref. 16955]

HEXAFLUOROETHANE

DIELECTRIC STRENGTH

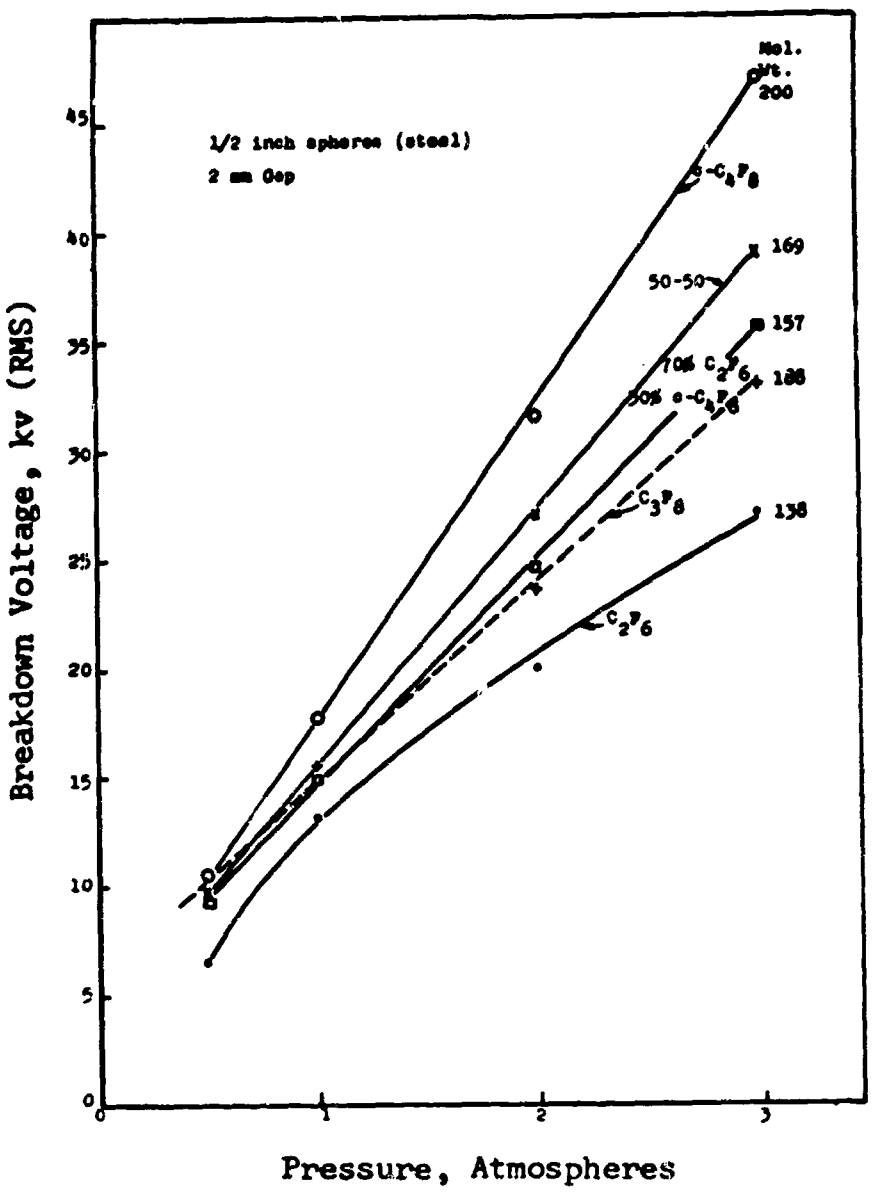


Breakdown voltage of C_2F_6 as a function of pressure.
Electrodes - 3/4" steel sphere-to-brass plane
Gap - 0.1 inch

[Ref. 16955]

HEXAFLUOROETHANE

DIELECTRIC STRENGTH

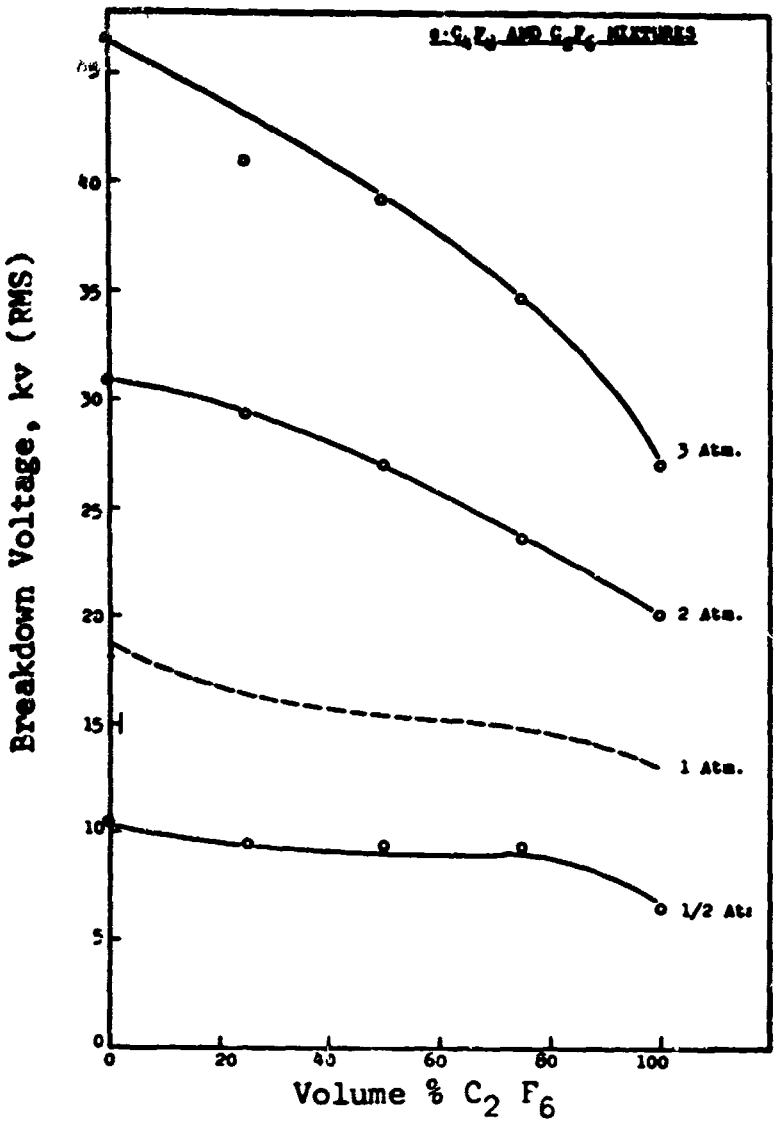


Breakdown voltage of C_2F_6 and mixtures with $c\text{-}C_4F_8$ as a function of pressure.

[Ref. 10067]

HEXAFLUOROETHANE

DIELECTRIC STRENGTH



Breakdown voltage of C_2F_6 and c-C_4F_8 mixtures as a function of pressure.

[Ref. 10067]

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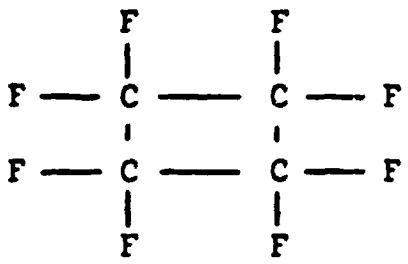
OCTAFLUOROCYCLOBUTANE

Introduction

Octafluorocyclobutane, a cyclic fluorocarbon, is an inert dielectric electronegative gas which is very stable at high temperatures (up to 300°C). The chemical formula (C_4F_8) is depicted as follows:



and the gas is commercially available under the tradenames of Freon C-318 from the E. I. du Pont de Nemours Company. Its combination of electronegativity, high molecular weight (200.04) and chemical stability are responsible for its outstanding electrical properties according to the manufacturer.

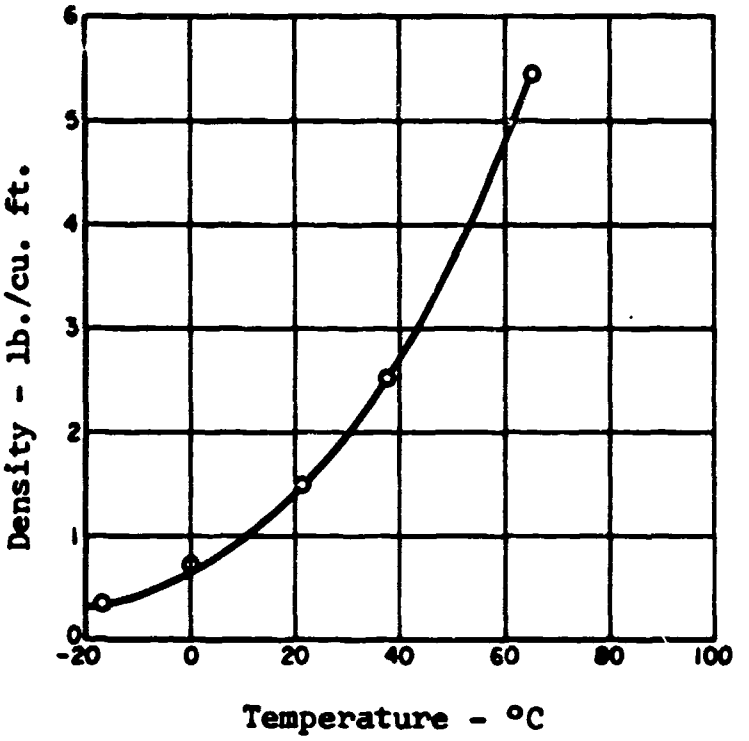
In an electric field, C_4F_8 absorbs electrons to form negative ions of low mobility. This results in a fairly stable space charge which tends to make the electric field more uniform, and it greatly reduces the tendency of the electrons to form a conductive path. The gas is dense, colorless, and odorless at atmospheric temperature and pressure.

FLUOROCARBON GASES

OCTAFLUOROCYCLOBUTANE

Physical Properties

Boiling point (at 1 atm.)	-5.82°C (21.47°F)
Freezing point	-41.4°C (-42.5°F)
Critical temperature	115.3°C (239.6°F)
Critical pressure	27.5 atm (403.6 psia)
Density of liquid at 30°C	1.480 g/cc (92.38 lbs/ft^3)



The density - temperature relation for saturated octafluorocyclobutane vapor.

[Ref. 16775]

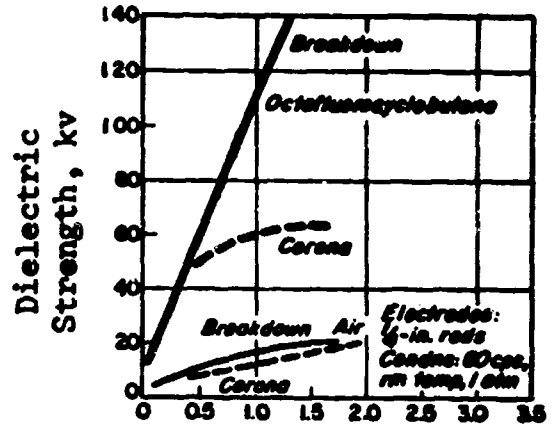
Applications

Potential electronic applications for octafluorocyclobutane includes transformers, power transmission cables, radar waveguides where the thermal stability and chemical inertness characteristics of the gas are attractive.

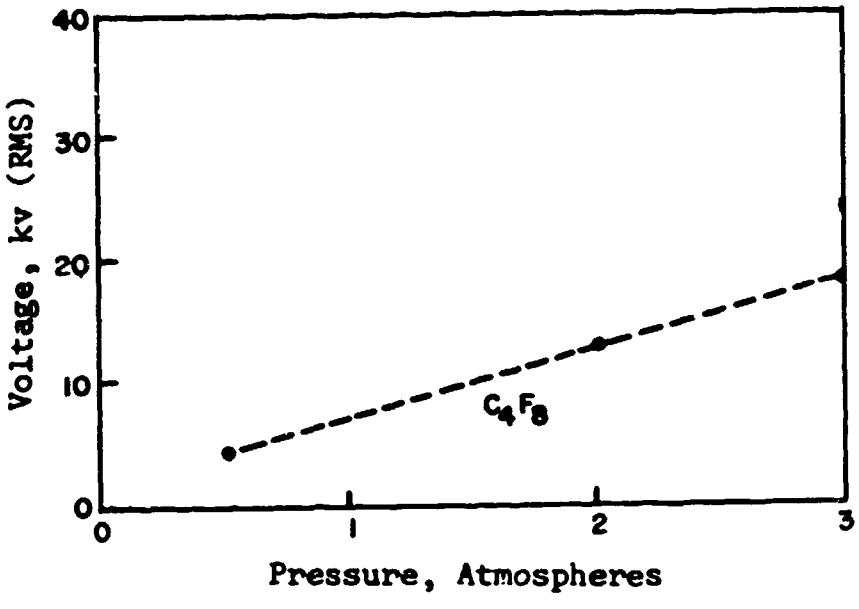
OCTAFLUOROCYCLOBUTANE

CORONA EFFECTS

Corona breakdown of octafluorocyclobutane as a function of gap distance.



[Ref. 6140]



Corona inception of C_4F_8 as a function of pressure, gap distance = 0.1 inch.

Electrodes -
1/4" x 1/4" steel square rod-to-brass plane

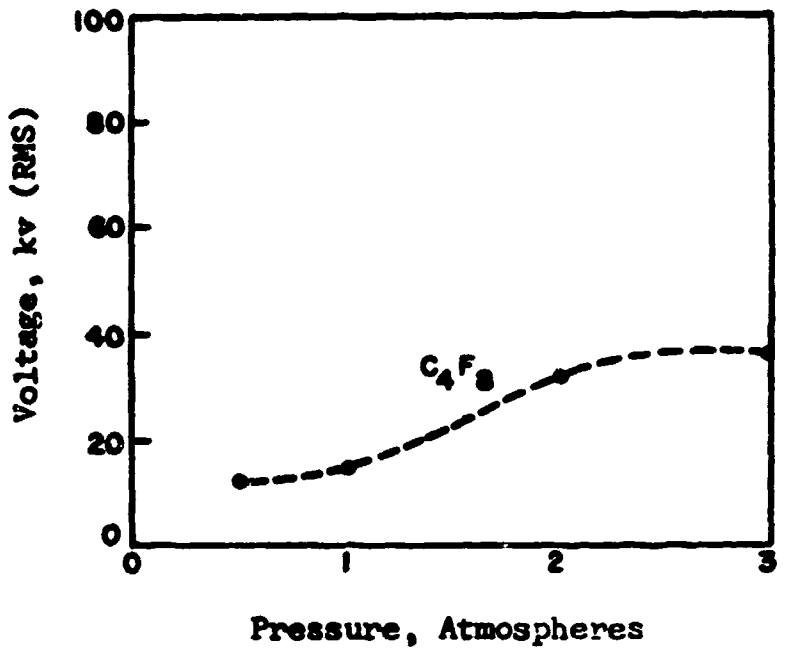
[Ref. 16955]

OCTAFLUOROCYCLOBUTANE

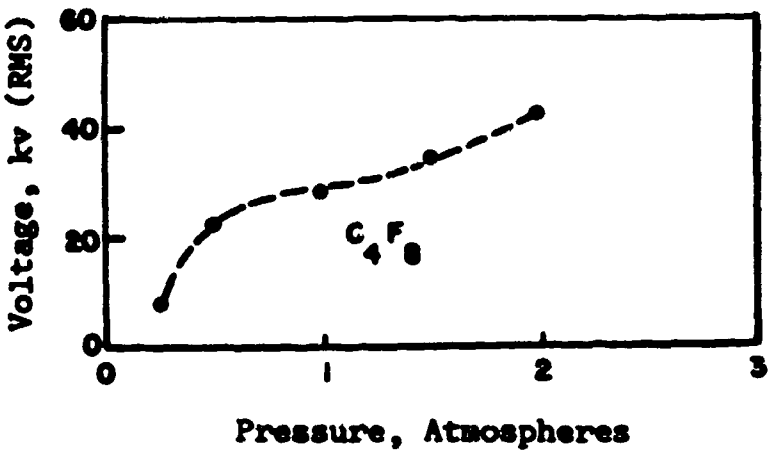
CORONA EFFECTS

Corona inception of C_4F_8 as a function of pressure, gap distance = 0.5 inch.

Electrodes -
1/4" x 1/4" steel
square rod-to-brass
plane



[Ref. 16955]



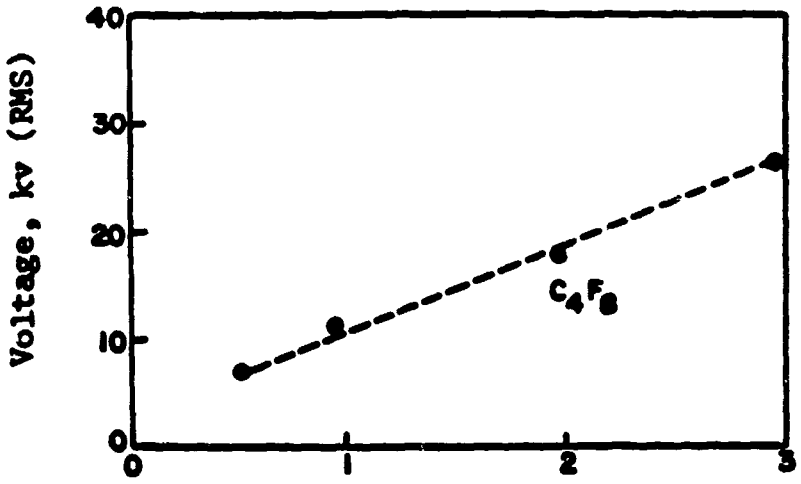
Corona inception of C_4F_8 as a function of pressure, gap distance = 1.0 inch.

Electrodes -
1/4" x 1/4" steel
square rod-to-
brass plane

[Ref. 16955]

OCTAFLUOROCYCLOBUTANE

CORONA EFFECTS



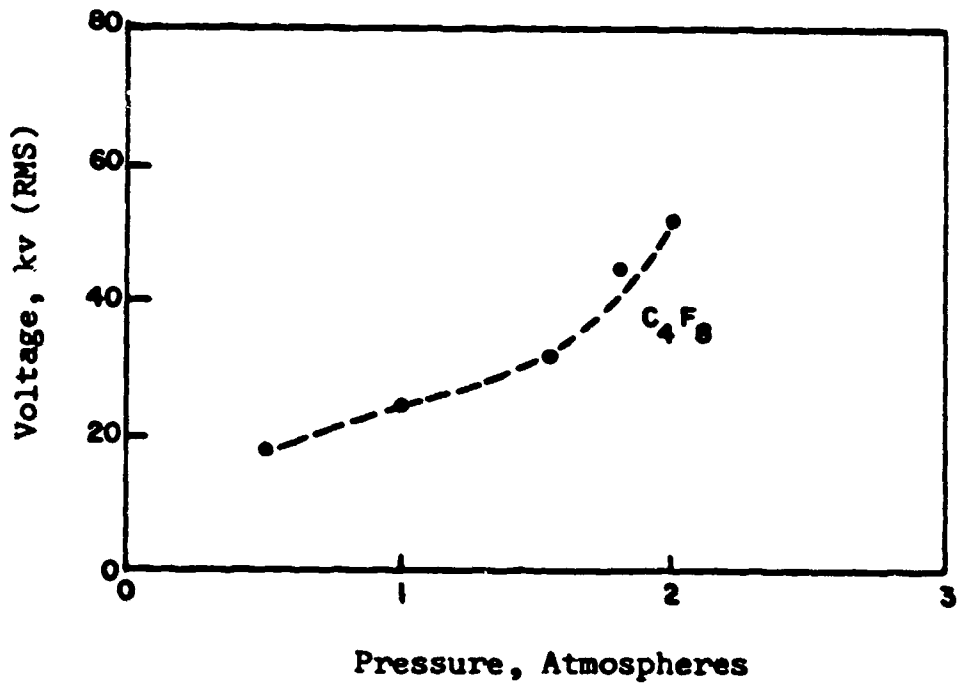
Corona inception of C_4F_8 as a function of pressure, gap distance = 0.1 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane

[Ref. 16955]

Corona inception of C_4F_8 as a function of pressure, gap distance = 0.5 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane



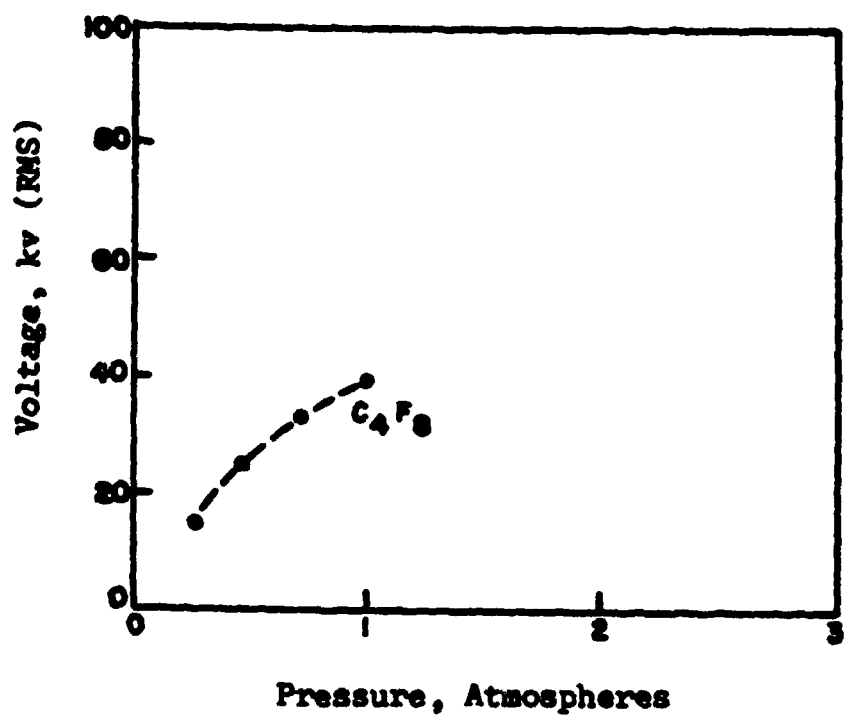
[Ref. 16955]

OCTAFLUOROCYCLOBUTANE

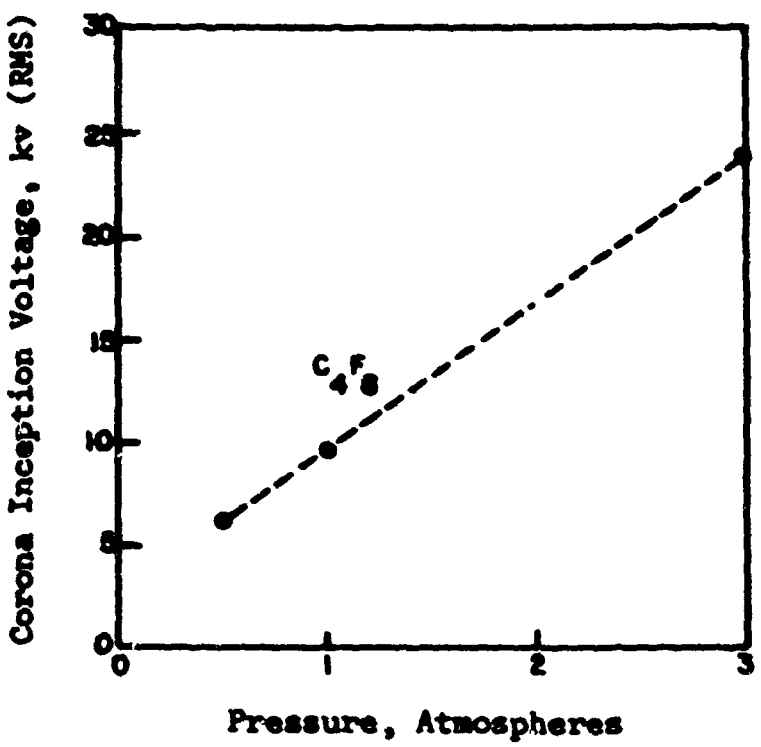
CORONA EFFECTS

Corona inception of C_4F_8 as a function of pressure, gap distance = 1.0 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane



[Ref. 16955]



Corona inception voltage of C_4F_8 as a function of pressure, gap distance = 1.0 inch.

Electrode -

0.0415 cm hemispherically tipped platinum needle-to-brass plane

[Ref. 16955]

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OCTAFLUOROCYCLOBUTANE

DIELECTRIC CONSTANT

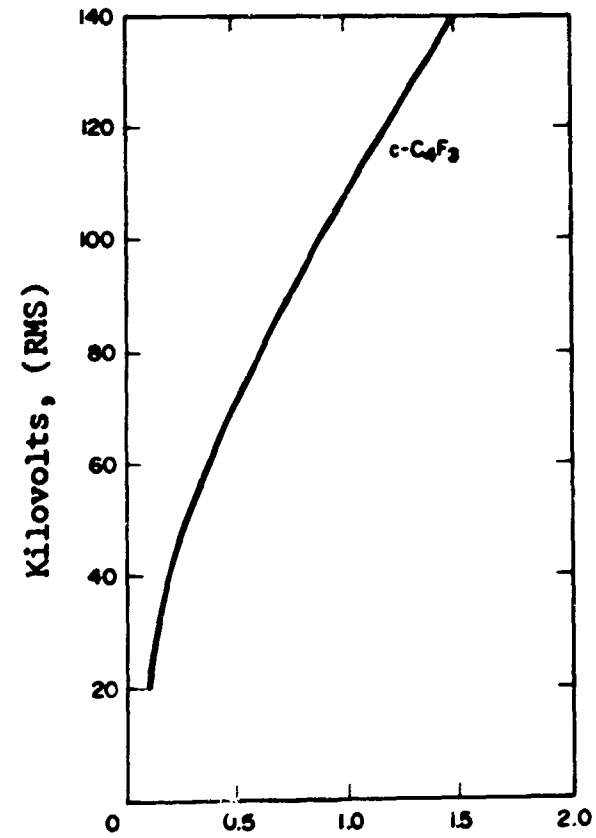
Dielectric Constant	Pressure	Temperature	Ref.
1.0034	760 mm Hg	10°C	7531 10057

OCTAFLUOROCYCLOBUTANE

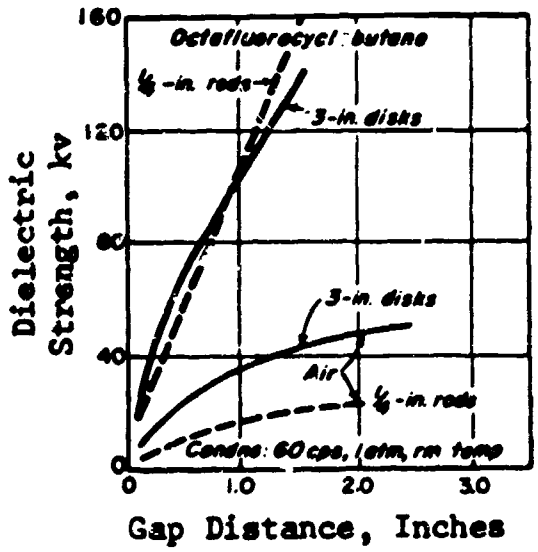
DIELECTRIC STRENGTH

Relative dielectric strength 2.44 (N_2 = 1) Ref. 6189

Dielectric strength of C_4F_8 as a function of gap distance in a uniform electrical field.



[Ref. 6140]
&
[Ref. 1860]



Dielectric strength of C_4F_8 as a function of gap distance in a uniform and non-uniform fields.

[Ref. 6140]
&
[Ref. 1860]

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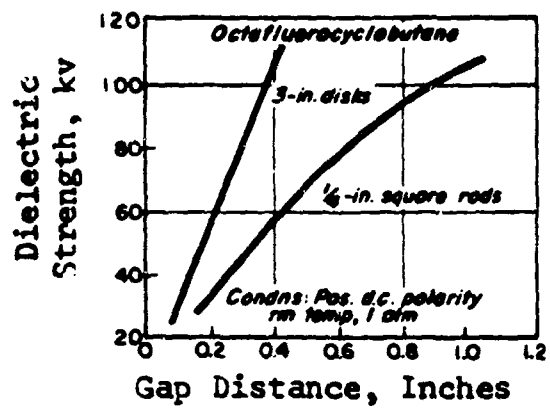
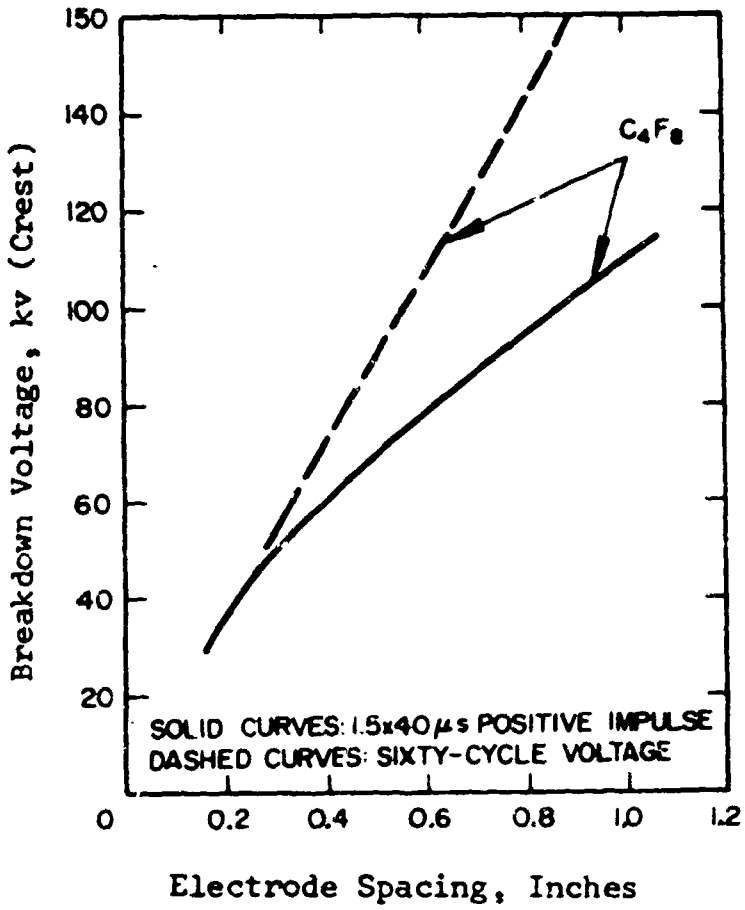
DIELECTRIC STRENGTH

Dielectric strength of C_4F_8 as a function of gap distance under impulse voltage of positive polarity in uniform and non-uniform fields.



[Ref. 6140]
&
[Ref. 1860]



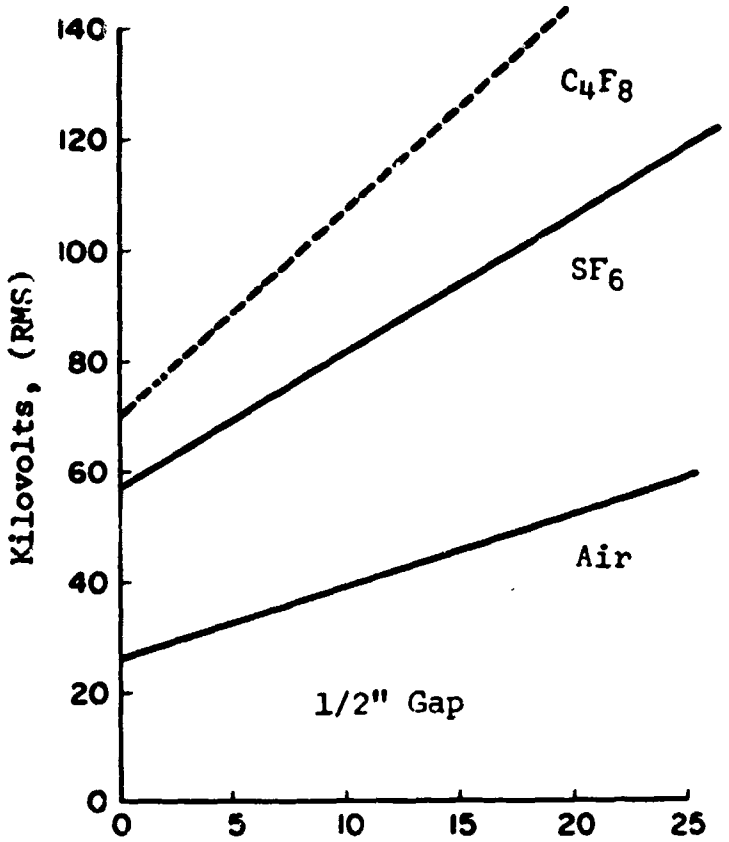
Comparison of impulse and 60 cycle breakdown characteristics of C_4F_8, 1/4 inch square rod-to-plane, atmospheric pressure as a function of gap distance.

[Ref. 10452]

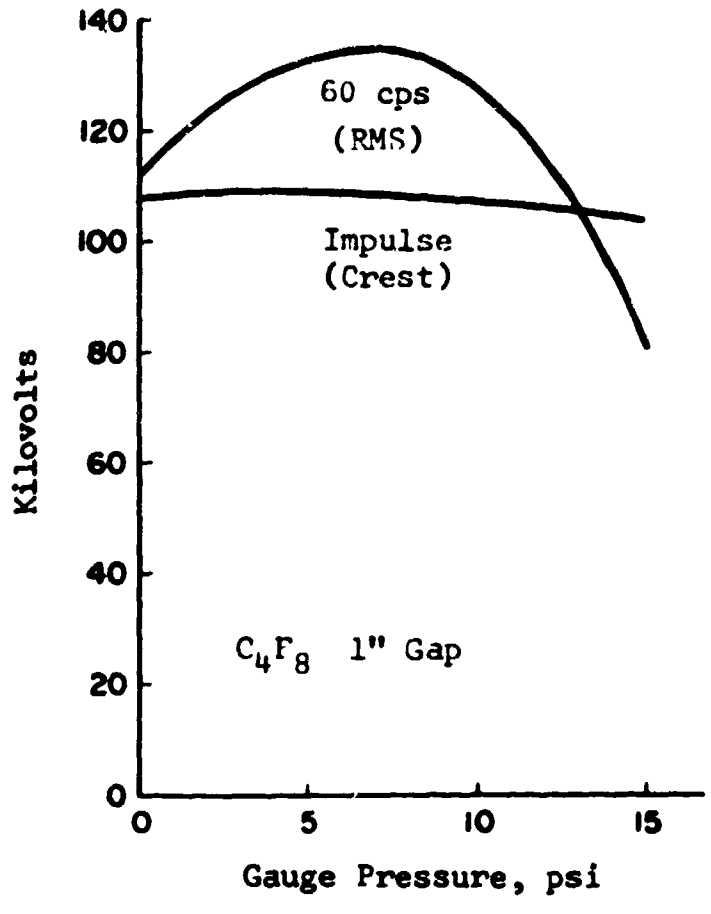
OCTAFLUOROCYCLOBUTANE

DIELECTRIC STRENGTH

Dielectric strength of C_4F_8 as a function of pressure in a uniform electrical field with 3 inch disks.



[Ref. 1860]

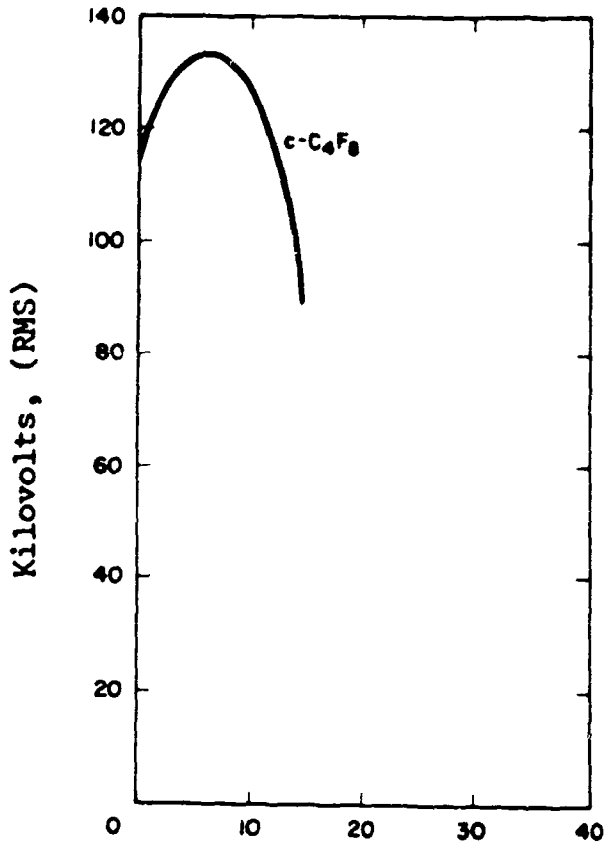


Dielectric strength of C_4F_8 as a function of pressure in a non-uniform electrical field with 1/4 inch rod, positive impulse wave (1.5 x 40 micro-seconds).

[Ref. 1860]

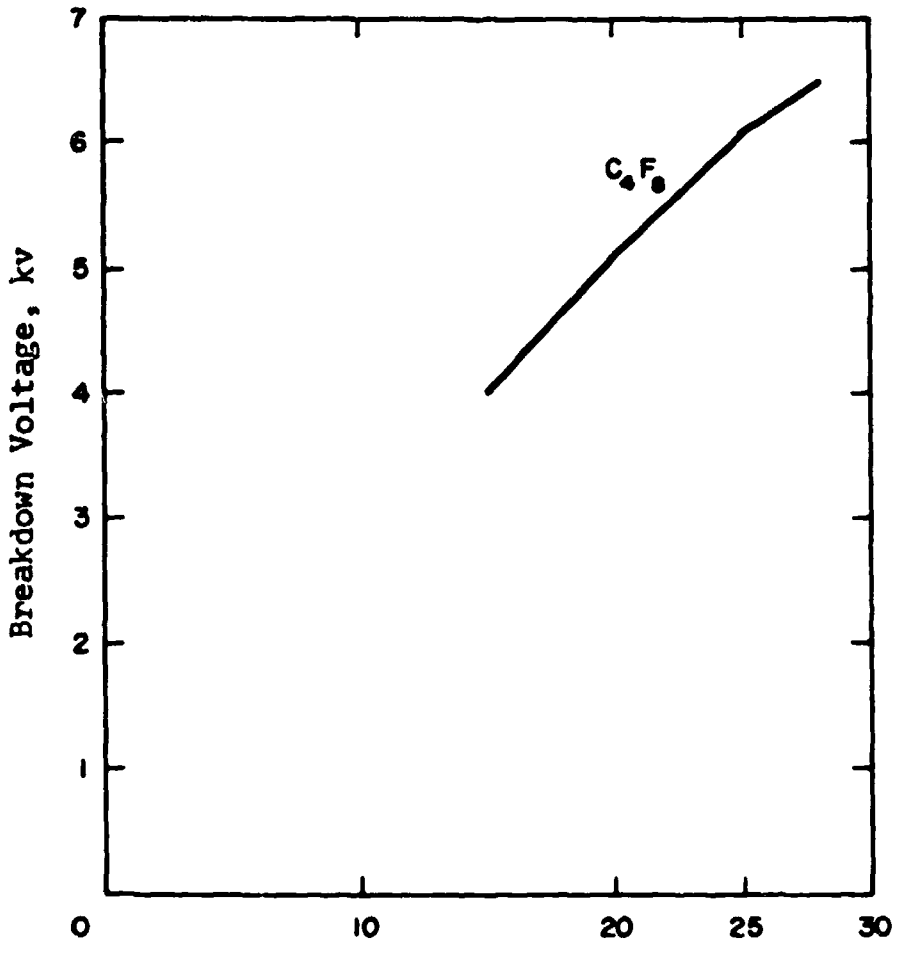
OCTAFLUOROCYCLOBUTANE

DIELECTRIC STRENGTH



[Ref. 1860]

Breakdown voltage of C_4F_8 as a function of pressure in a non-uniform electrical field, with 1/4-inch rods.



Breakdown voltage of C_4F_8 as a function of pressure across a spark plug.

[Ref. 10489]

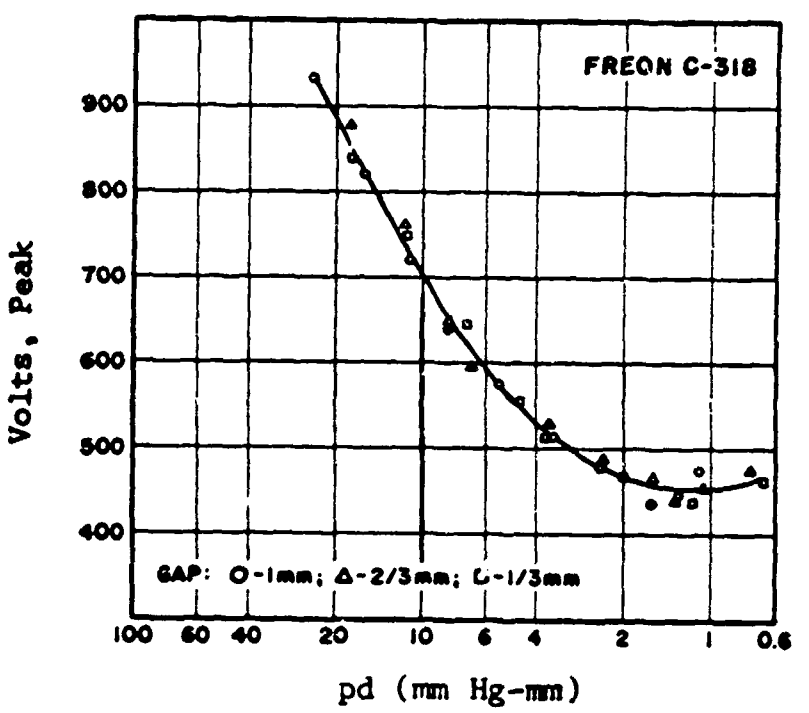
OCTAFLUOROCYCLOBUTANE

DIELECTRIC STRENGTH

Gas	Pressure	Dielectric Strength
Freon C-318	1/2 atm.	10.5 kv - RMS
	1	17.9
	2	31.4
	3	46.7
Freon C-318/ Nitrogen (50/50)	1/2 atm.	9.1 kv - RMS
	1	13.6
	2	21.6
	3	30.7
Freon C-318/ Freon-116 (50/50)	1/2 atm.	9.5 kv - RMS
	1	15.4
	2	27.2
	3	38.9

[Ref. 7531]
&
[Ref. 10057]

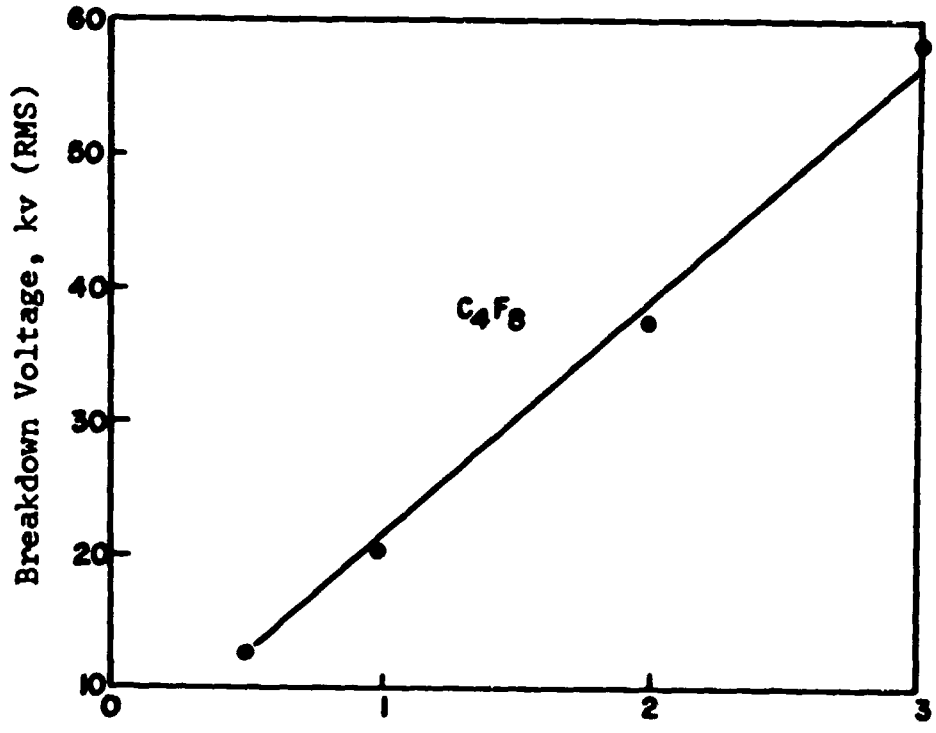
Paschen curve of Freon C-318.



[Ref. 16386]

OCTAFLUOROCYCLOBUTANE

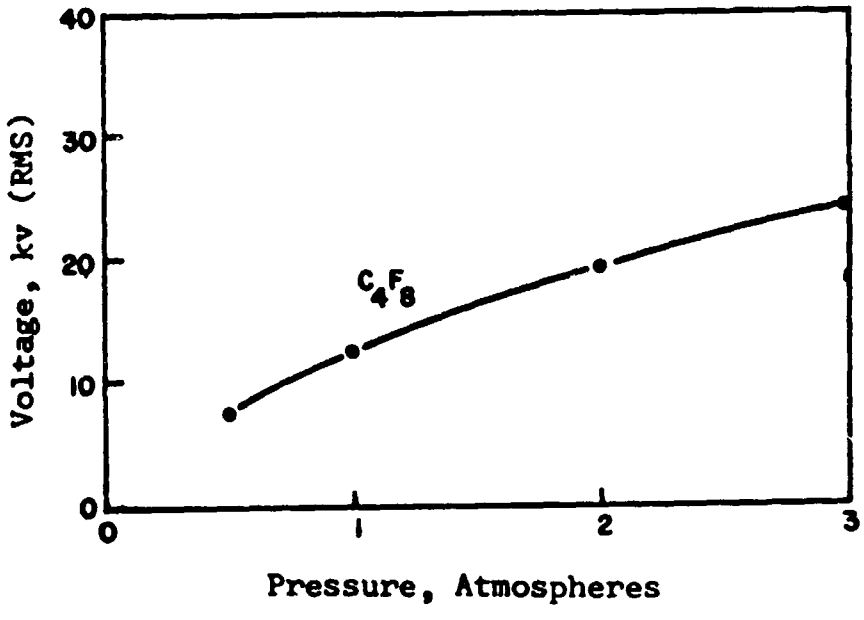
DIELECTRIC STRENGTH



Breakdown voltage of C_4F_8 as a function of pressure, gap distance = 0.1 inch.

Electrodes - 3/4" steel sphere-to-brass plane

[Ref. 16955]



Breakdown voltage of C_4F_8 as a function of pressure, gap spacing = 0.1 inch.

Electrodes -

1/4" x 1/4" steel square rod-to-brass plane

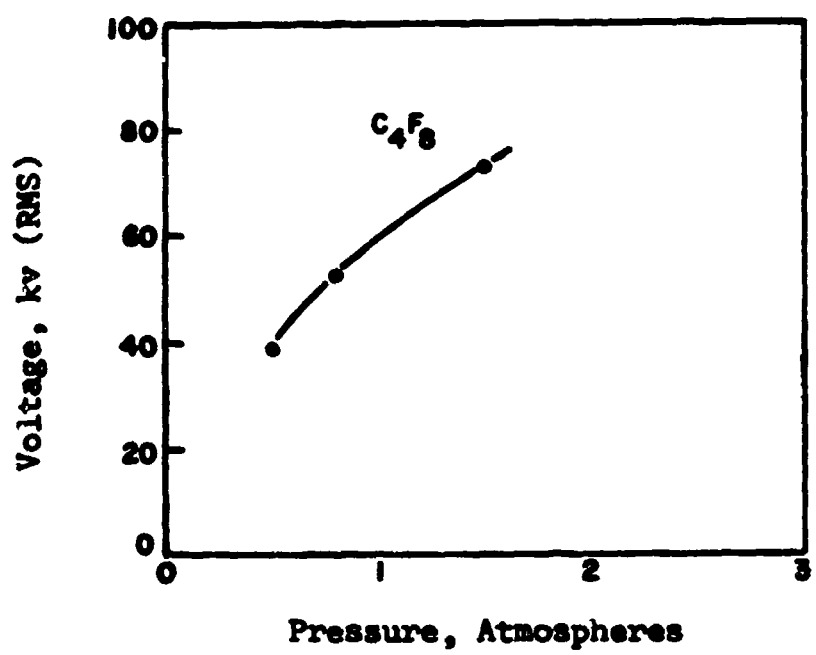
[Ref. 16955]

OCTAFLUOROCYCLOBUTANE

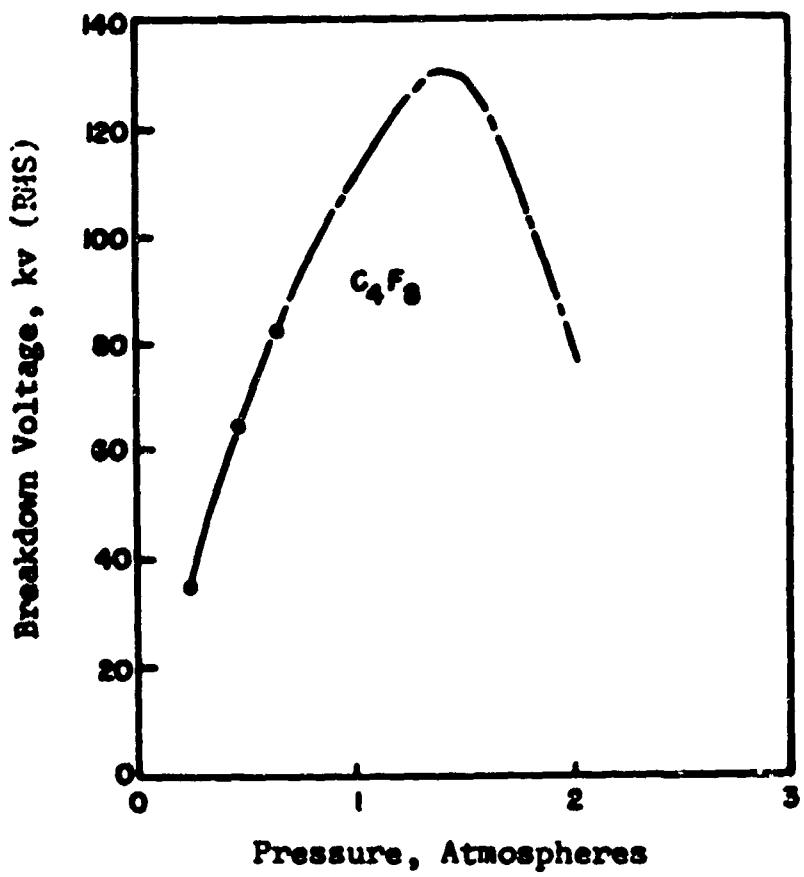
DIELECTRIC STRENGTH

Breadkown voltage of C_4F_8 as a function of pressure, gap spacing = 0.5 inch.

Electrodes - 1/4" x 1/4" steel square rod-to-brass plane



[Ref. 16955]



Breakdown voltage of C_4F_8 as a function of pressure, gap spacing = 1.0 inch.

Electrodes - 1/4" x 1/4" steel square rod-to-brass plane

—— Ref. 16955
--- Ref. 1275

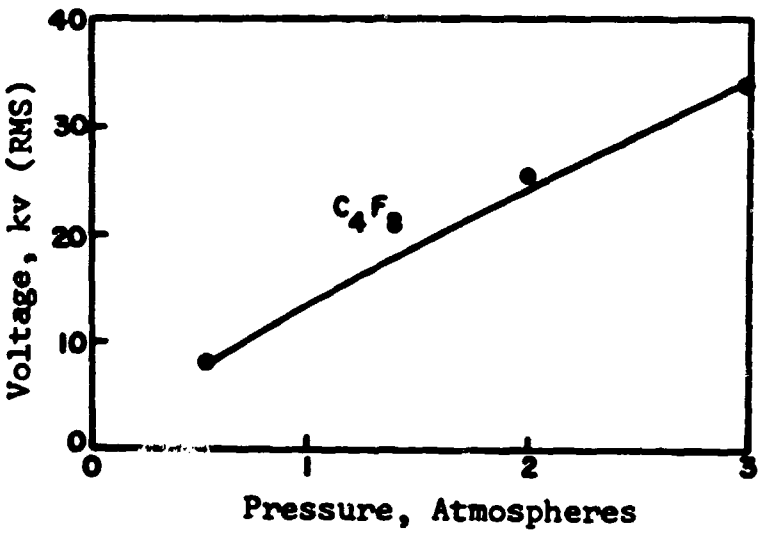
[Ref. 16955]

OCTAFLUOROCYCLOBUTANE

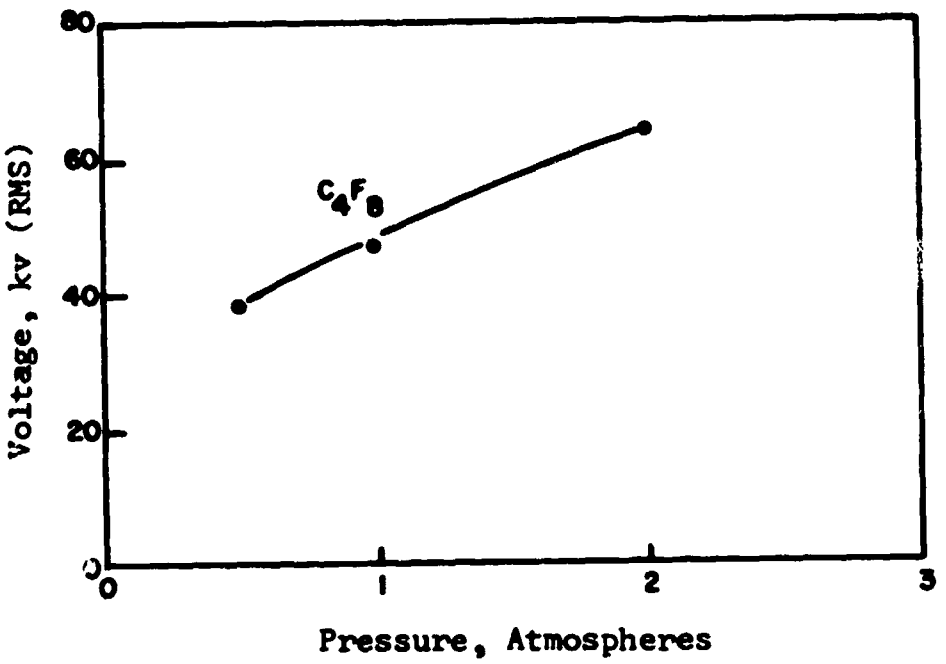
DIELECTRIC STRENGTH

Breakdown voltage of C_4F_8 as a function of pressure, gap spacing = 0.1 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane



[Ref. 16955]



Breakdown voltage of C_4F_8 as a function of pressure, gap spacing = 0.5 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane

[Ref. 16955]

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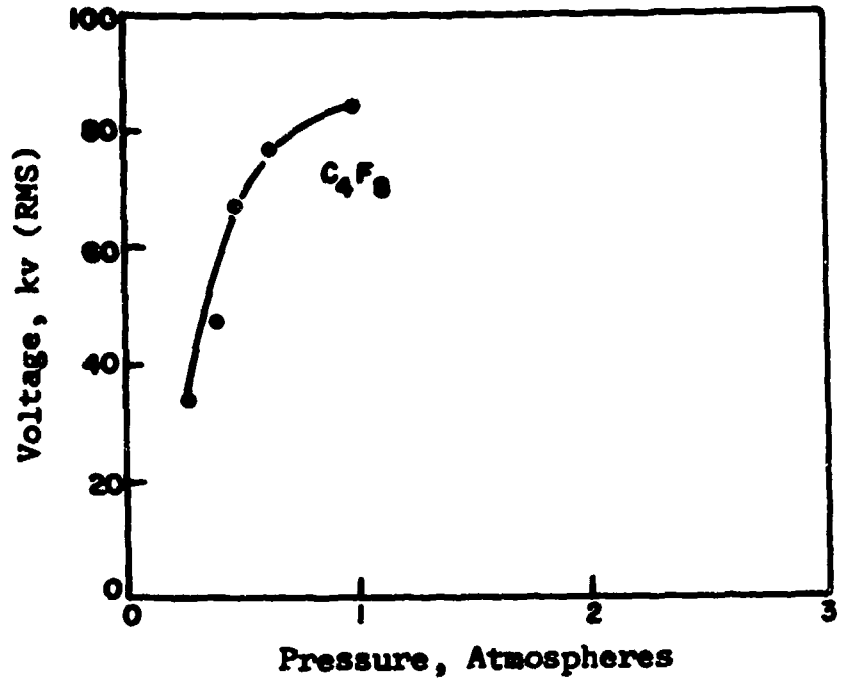
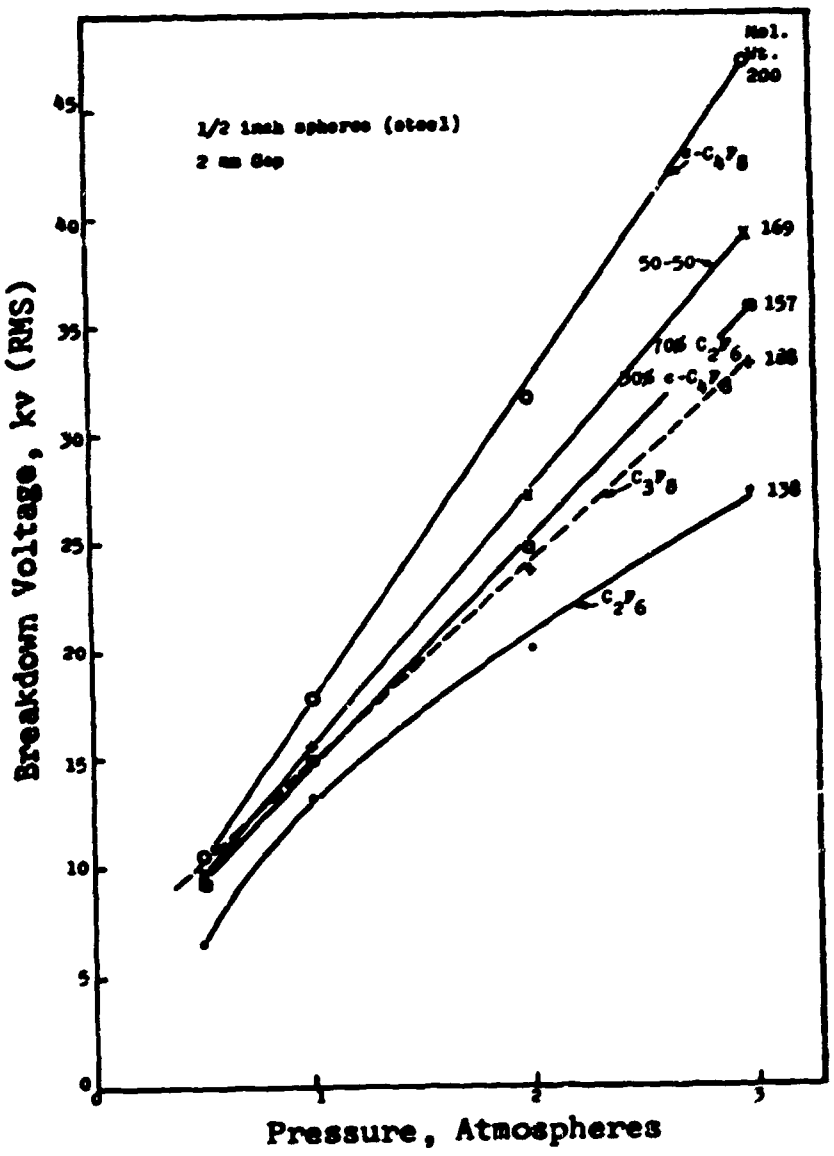
DIELECTRIC STRENGTH



Breakdown voltage of C_4F_8 as a function of pressure, gap spacing = 1.0 inch.

Electrodes - 3/8" steel cylindrical rod-to-brass plane

[Ref. 16955]



Breakdown voltage of C_4F_6 and C_2F_6 mixtures and C_4F_8 as a function of pressure.

[Ref. 10067]

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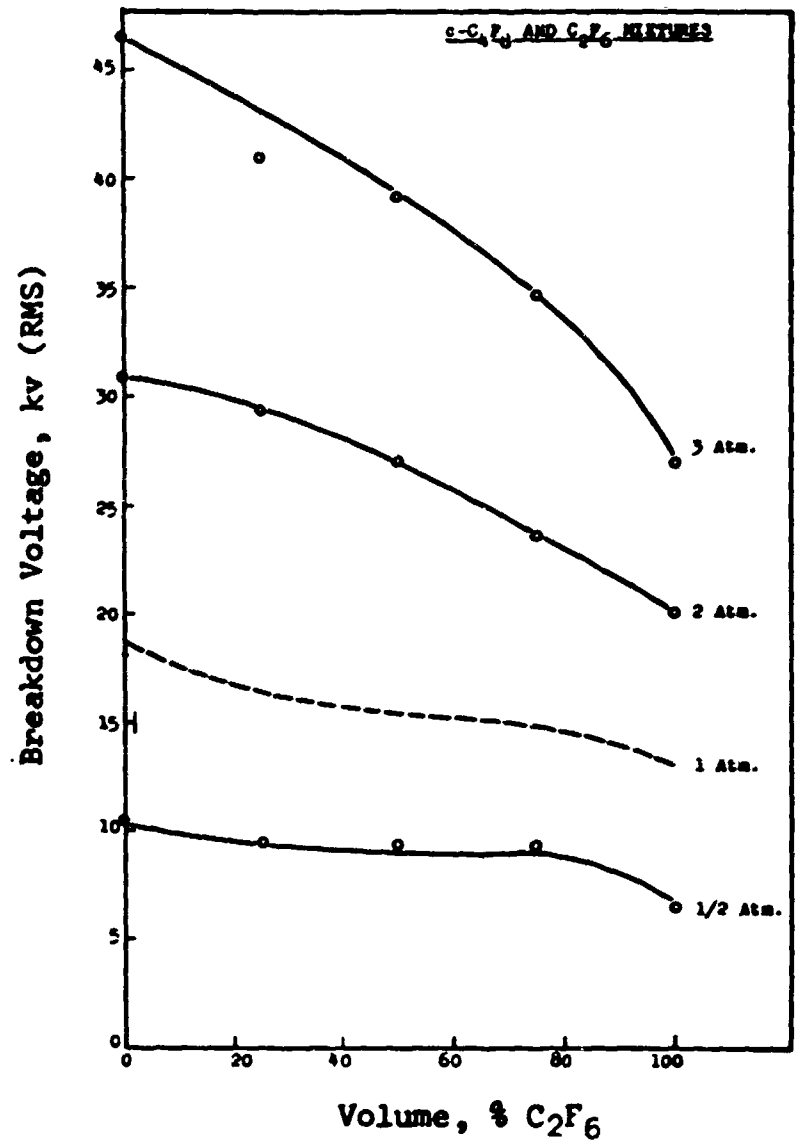
OCTAFLUOROCYCLOBUTANE

DIELECTRIC STRENGTH



Breakdown voltage of C_4F_8 and C_2F_6 mixtures as a function of volume % C_2F_6 at various pressure.

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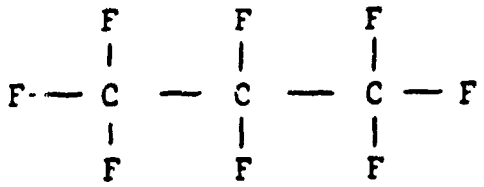
OCTAFLUOROPROPANE

Introduction

Octafluoropropane (also called Perfluoropropane) is a fluorochemical gaseous dielectric of inert, dense and nonflammable nature. It is a colorless, odorless gas and when liquified is a clear and colorless product. It is commercially available in purity of greater than 90% C_3F_8 under various tradenames: Genetron - 218 (Allied Chemical Corp.) and Fx-30 (Minnesota, Mining & Manufacturing Co.) The molecular structure is as follows:



with a formula weight of 188.

Physical Properties

Boiling point (760 mm Hg)	-38°C (-36°F)
Freezing point	approx. -160°C
Critical temperature	71°C (160°F)
Critical pressure	26.5 atm (390 psia)

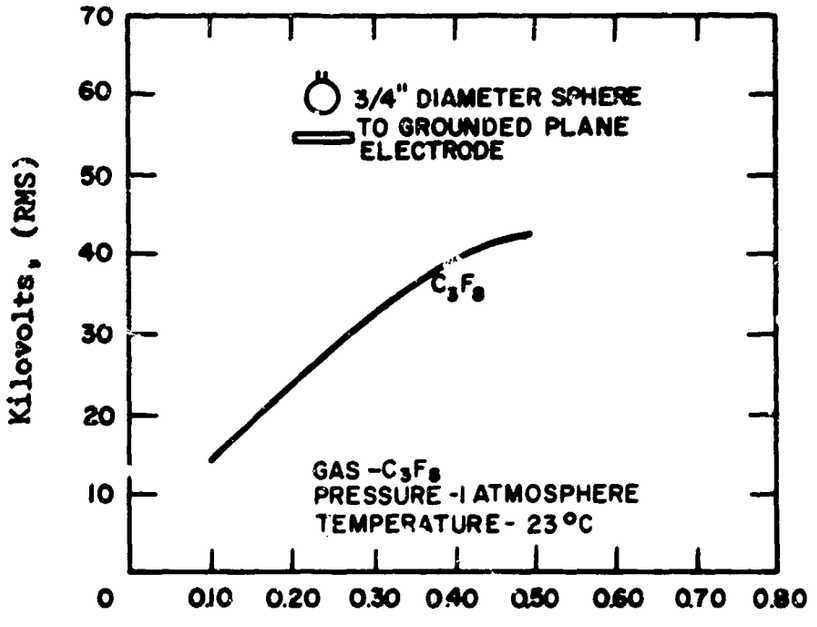
Applications

Tests have shown that Perfluoropropane (C_3F_8), in its application to sealed dry-type transformers, has 20% additional capacity for the same temperature rise as nitrogen-filled units at 100% loading.

OCTAFLUOROPROPANE

DIELECTRIC STRENGTH

Conditions	Voltage	Ref.
For gaps (0.2 - 0.5 in.) and 3/4-in. sphere to grounded plane	2.2 - 2.5 relative breakdown voltage. (Air = 1).	7530
0.2-in. gap, 1-in. diameter spheres	32 kv (RMS)	1275
0.3-in. gap, 0.1-in. rounded rod to 1-in. sphere	30 kv (RMS)	1275
0.1-in. gap, 3/4-in. ball to 1 3/4-in. plane (3 M Test no. 80)	13 kv	11055

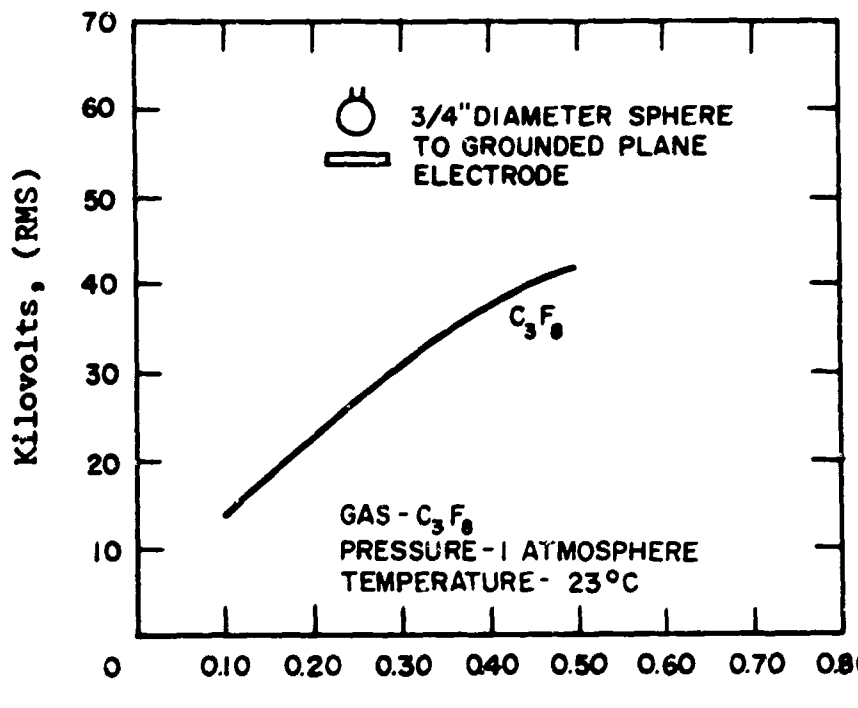


Dielectric strength of C_3F_8 as a function of gap distance. 60-cycle voltage strength.

[Ref. 1625]

OCTAFLUOROPROPANE

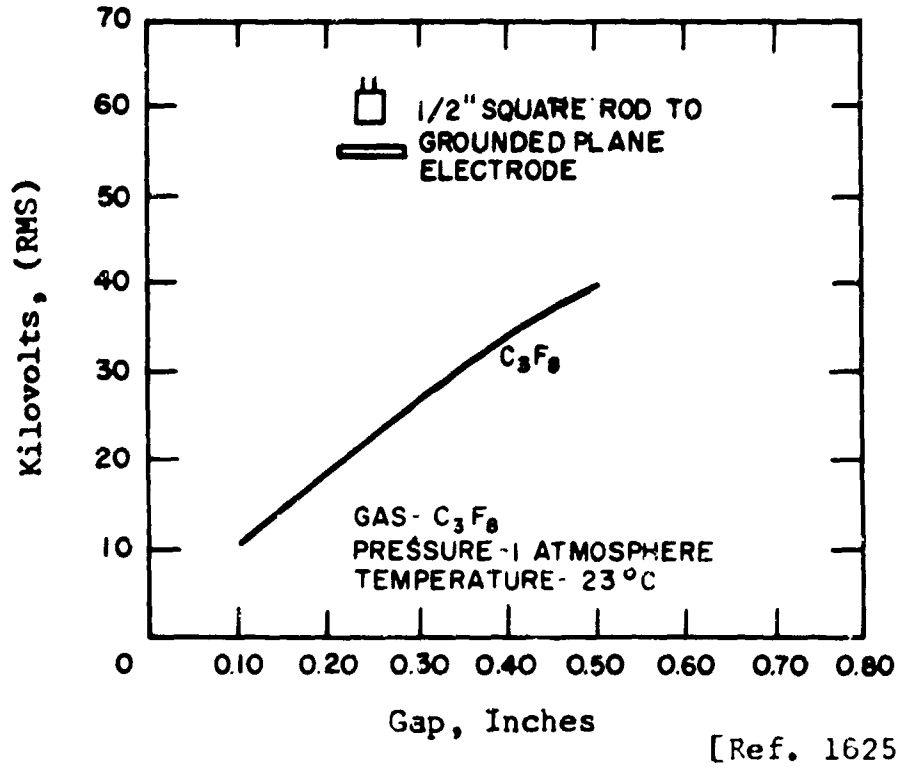
DIELECTRIC STRENGTH



Dielectric strength of C_3F_8 as a function of gap distance, one-minute withstand 60 - cycle voltage strength.

[Ref. 1625]

Dielectric strength of C_3F_8 as a function of gap distance, 60-cycle voltage strength.



[Ref. 1625]

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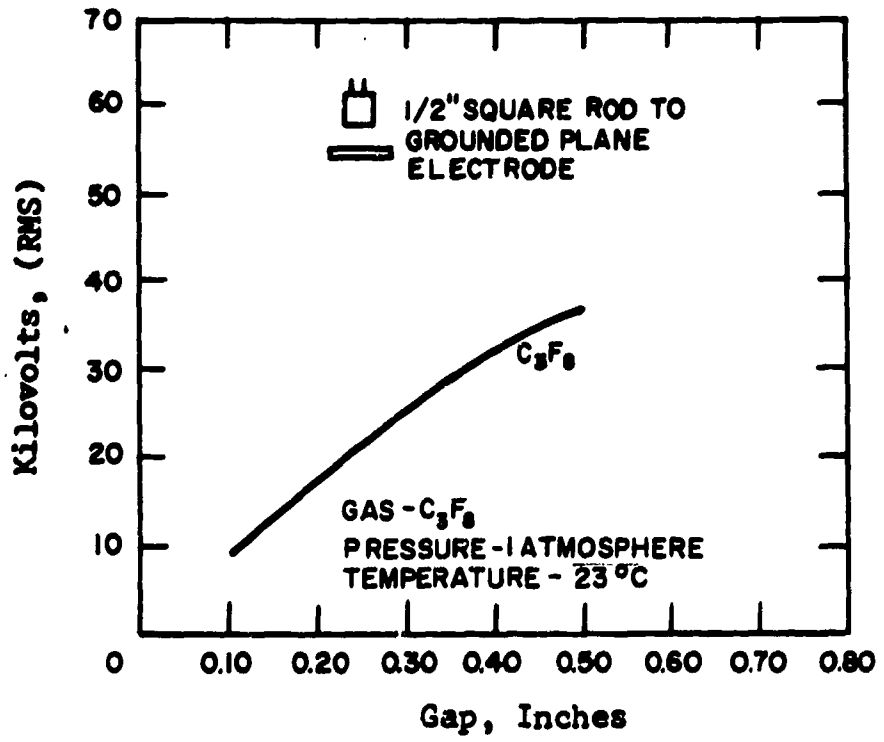
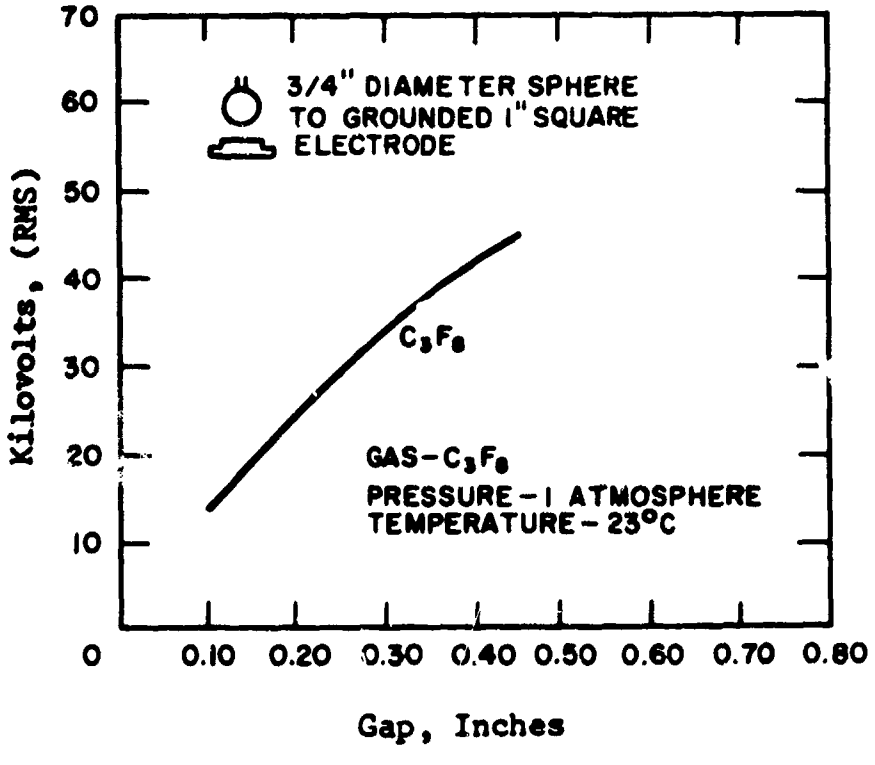
OCTAFLUOROPROPANE

DIELECTRIC STRENGTH

Dielectric strength of C_3F_8 as a function of gap distance, one-minute withstand 60-cycle voltage strength.



[Ref. 1625]



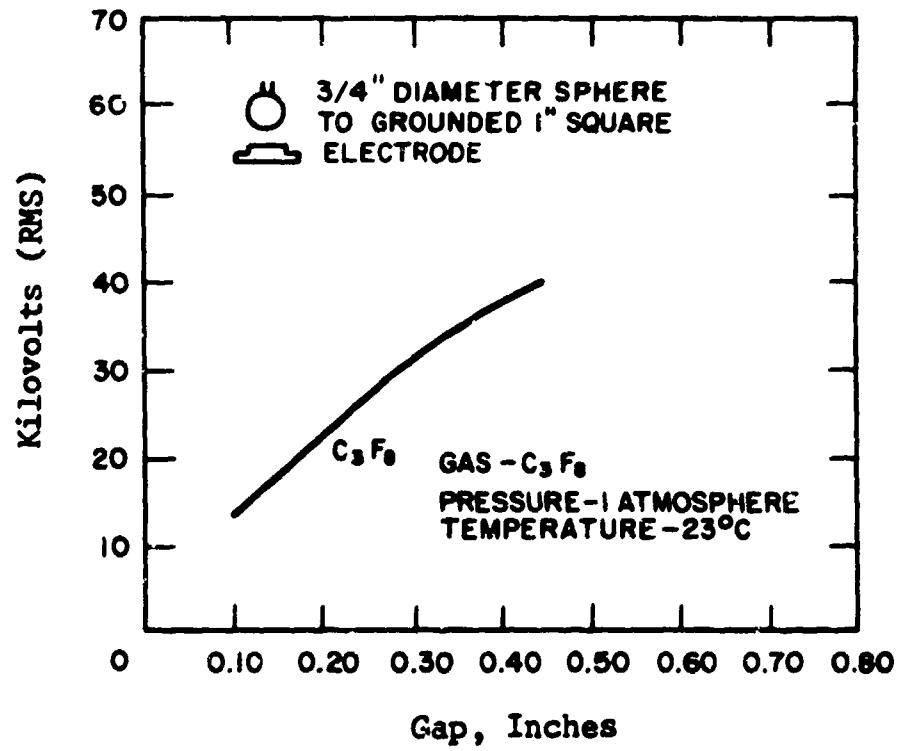
Rapidly applied 60-cycle voltage breakdown strength of C_3F_8 as a function of gap distance.

[Ref. 1625]

OCTAFLUOROPROPANE

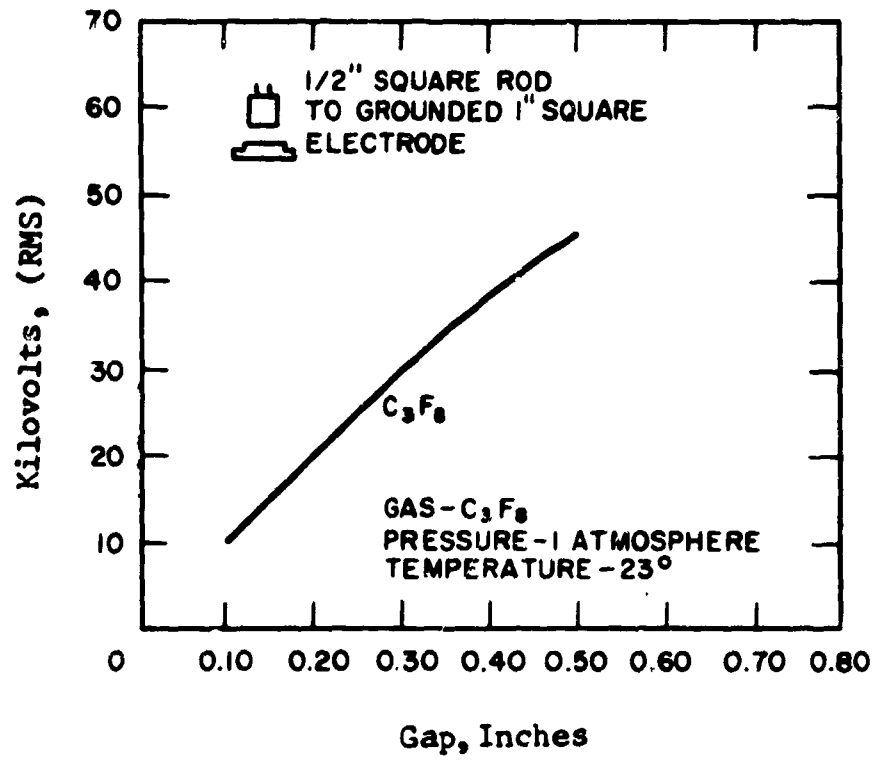
DIELECTRIC STRENGTH

One-minute withstand 60-cycle voltage strength of C_3F_8 as a function of gap distance.



[Ref. 1625]

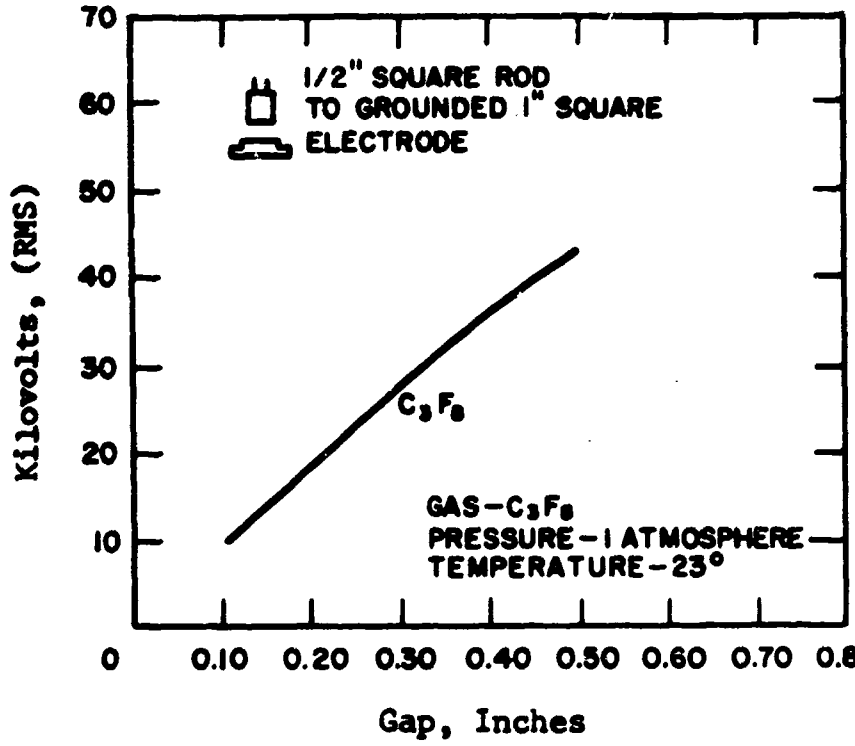
Rapidly applied 60 - cycle voltage breakdown strength of C_3F_8 as a function of gap distance.



[Ref. 1625]

OCTAFLUOROPROPANE

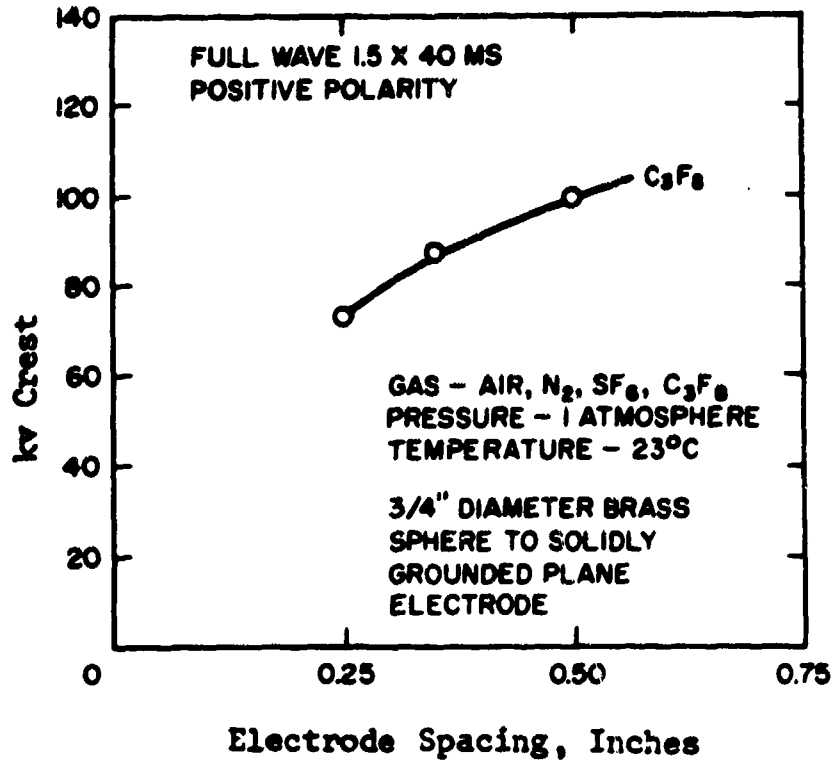
DIELECTRIC STRENGTH



One - minute withstand 60 cycle voltage strength of C_3F_8 as a function of gap distance.

[Ref. 1625]

Impulse voltage withstand strength of C_3F_8 as a function gap distance.



[Ref. 1625]

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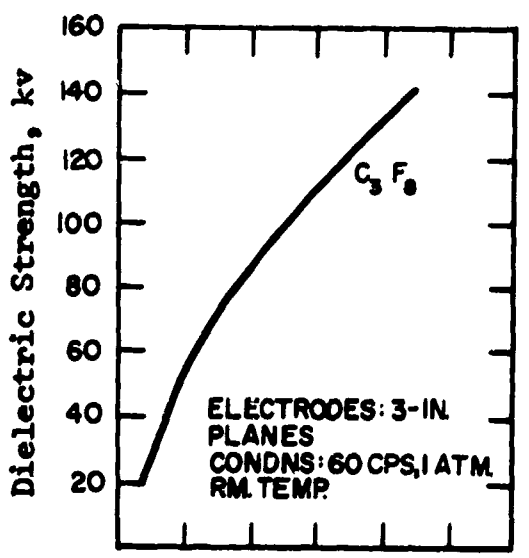
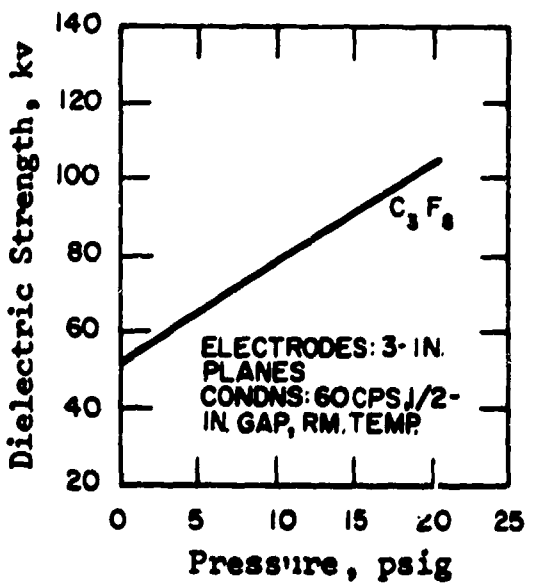
DIELECTRIC STRENGTH



Dielectric strength of C_3F_8 as a function of gap distance in a uniform electrical field.



Dielectric strength of C_3F_8 as a function of pressure in a non-uniform electrical field.

[Ref. 6140]

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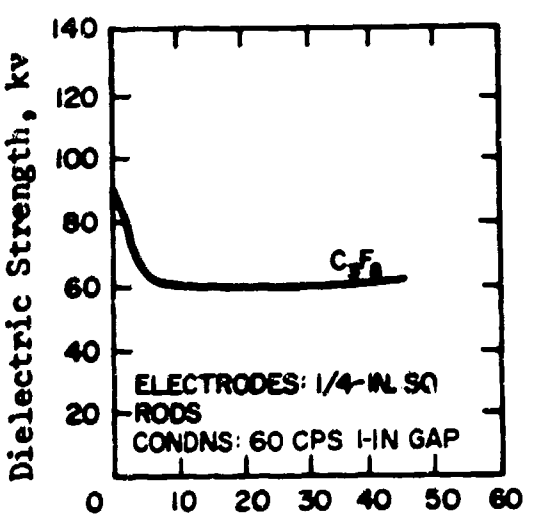
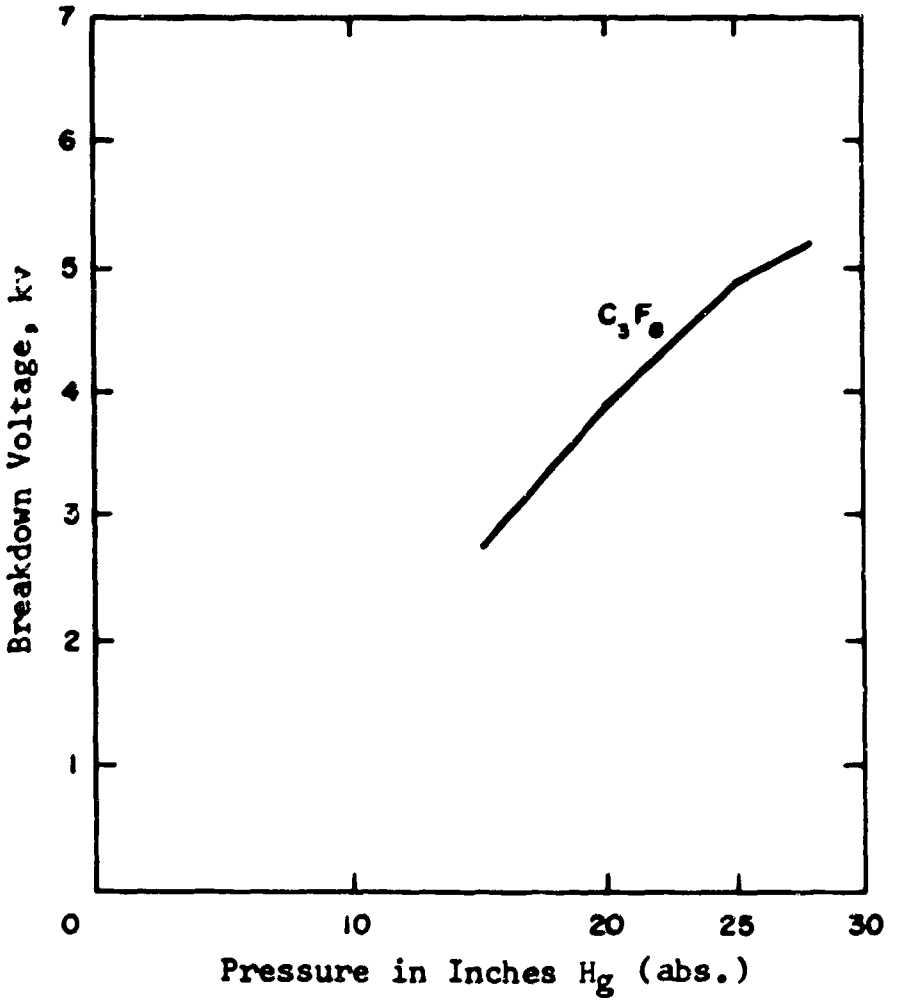


Dielectric strength of C_3F_8 as a function of pressure in a non-uniform electrical field.

[Ref. 6140]

Dielectric strength of C_3F_8 as a function of pressure across a spark plug.



[Ref. 10489]

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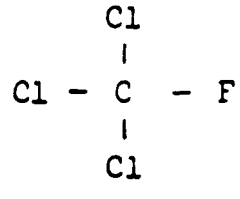
TRICHLOROFLUOROMETHANE

Introduction

Trichlorofluoromethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula (CCl_3F) is depicted as follows:



and the gas is available commercially under various tradenames: Freon-11 (du Pont de Nemours), Genetron 11 (General Chemical Co.) and Arcton 9 (British sources). Its molecular weight is 137.38.

Physical Properties

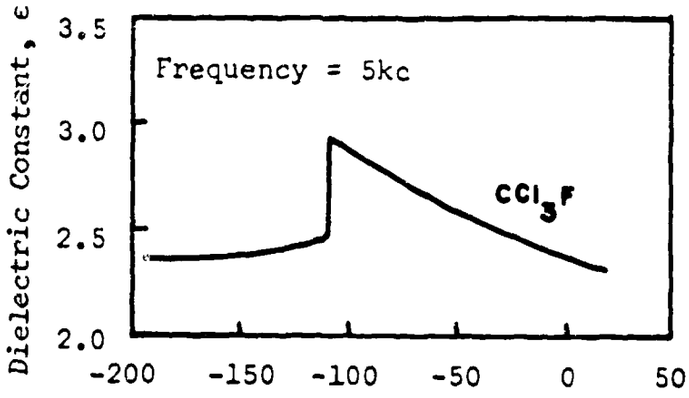
Boiling point (at 1 atm.)	23.77°C	(74.78°F)
Freezing point	-111°C	(-168°F)
Critical temperature	198.0°C	(338.4°F)
Critical pressure	43.2 atm.	(635 psia)
Density of liquid at 30°C	1.464 g/cc	(91.38 lbs/ft^3)

Applications

Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

TRICHLOROFLUOROMETHANE

DIELECTRIC CONSTANT



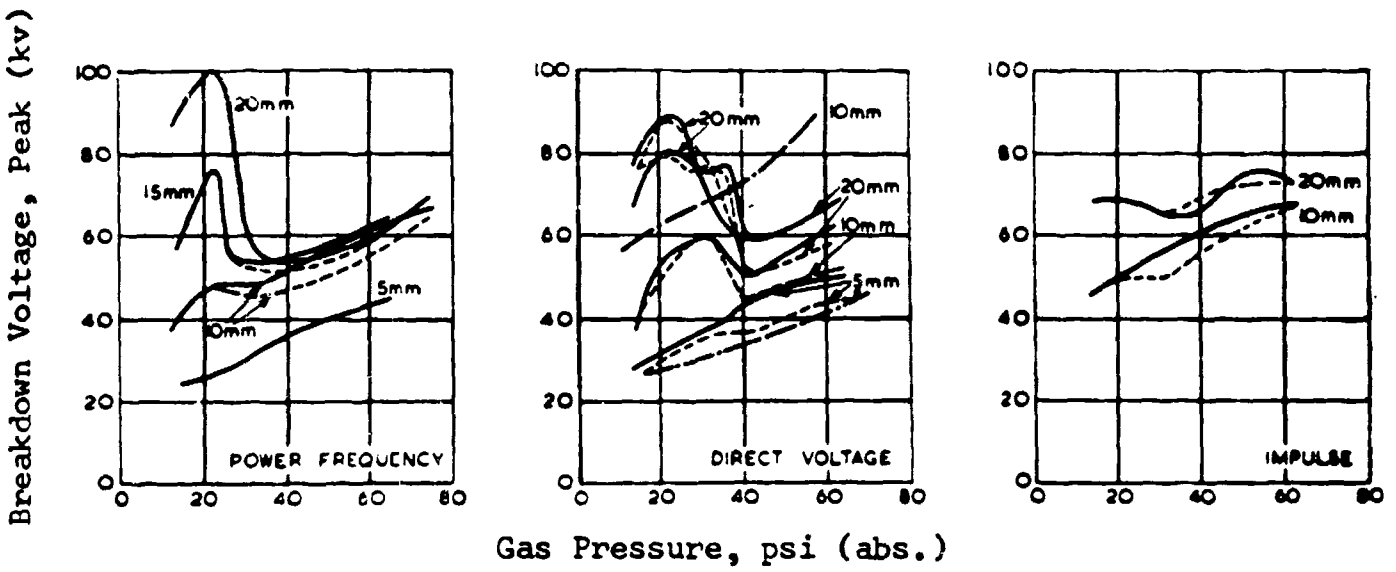
Dielectric constant as a function of temperature for trichlorofluoromethane.

[Ref. 1265]

Dielectric Constant	Phase	Temperature	Ref.
2.28	liquid	29°C	6189
1.0019	vapor (0.5 atm.)	26°C	6189 & 16775

TRICHLOROFLUOROMETHANE

DIELECTRIC STRENGTH



Gas Pressure, psi (abs.)

Breakdown voltage with point-sphere electrodes for trichlorofluoromethane at atmospheric pressure and nitrogen added to obtain higher pressure.

——— Power frequency, positive d.c. and impulse
—·—·— Negative d.c. and impulse
- - - - Power frequency, positive d.c. and impulse with radium

[Ref. 1181]

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TRICHLOROFLUOROMETHANE

DIELECTRIC STRENGTH

			Ref.
Relative dielectric strength	3.18	(N_2 = 1)	6189
Relative dielectric strength (uniform field)	3.50	(Air = 1)	16775

Compound	Abs. Pressure Atm.	Breakdown Voltage: Power Frequency, Sphere Gap, cm 0.5	Power Frequency, Sphere Gap, cm 1.0	Negative Direct, Sphere Gap, cm 0.5	Negative Direct, Sphere Gap, cm 1.0	Negative Impulse, Sphere Gap, cm 0.5	Negative Impulse, Sphere Gap, cm 1.0	Relative Electric Strength, Sphere Gap, cm 0.5	Relative Electric Strength, Sphere Gap, cm 1.0	Impulse Ratio, Sphere Gap, cm 0.5	Impulse Ratio, Sphere Gap, cm 1.0
		kv	kv	kv	kv	kv	kv				
CCl_3F (Arcton 9)	1	65.0	129.0	65.0		76.5		3.76	4.05	1.18	
	2*	96.5						3.02			
	3*	119.0						2.62			

* Nitrogen added to compound exerting one atmosphere absolute pressure.

[Ref. 1181]

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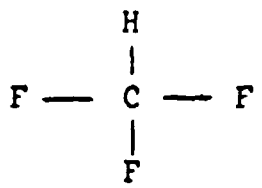
TRIFLUOROMETHANE

Introduction

Trifluoromethane is a dielectric gas with electronegative behaviour or characteristics. The chemical formula (CHF_3) is depicted as follows:



and the gas is available commercially under the following tradenames: Freon 23 (du Pont de Nemours) and Arcton - 1 (British sources).

Its molecular weight is 70.02.

Physical Properties

Boiling point (at 1 atm.)	-82.05°C	(-115.71°F)
Freezing point	-155.2°C	(-247.4°F)
Critical temperature	25.9°C	(78.6°F)
Critical pressure	47.7 atm	(701.4 psia)
Density of liquid at 30°C	1.223 g/cc	

Application

Potential applications include insulation in coaxial lines and waveguides as well as high voltage underground transmission installations.

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TRIFLUOROMETHANE

DIELECTRIC STRENGTH

		Ref.
Relative dielectric strength	0.82 (N_2 = 1)	6189

Compound	Abs. Pressure Atm.	Breakdown Voltage						Relative Electric Strength		Impulse Ratio	
		Power Frequency		Negative Direct		Negative Impulse					
		Sphere gap, cm									
		0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0
CHF_3 (Arcton 1)		kv	kv	kv	kv	kv	kv				
	1	15.8	28.5	14.8	27.8	18.8	31.0	0.91	0.90	1.19	1.09
	2	29.5	53.5			27.5	52.5	0.92	0.95	0.93	0.98
	3	41.0	78.0			38.0	75.5	0.90	0.97	0.93	0.97
	4	52.0	100.5			49.5	97.5	0.90	0.95	0.95	0.97

[Ref. 1181]

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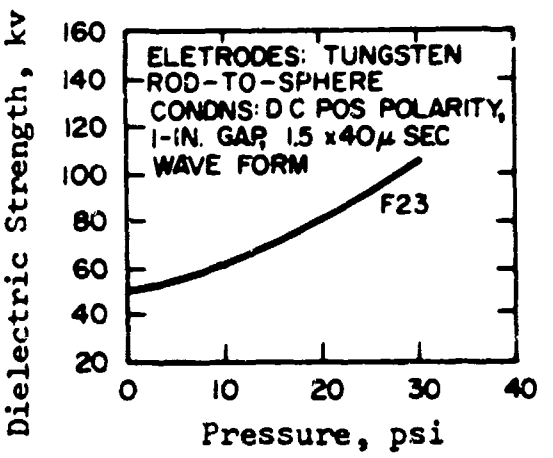
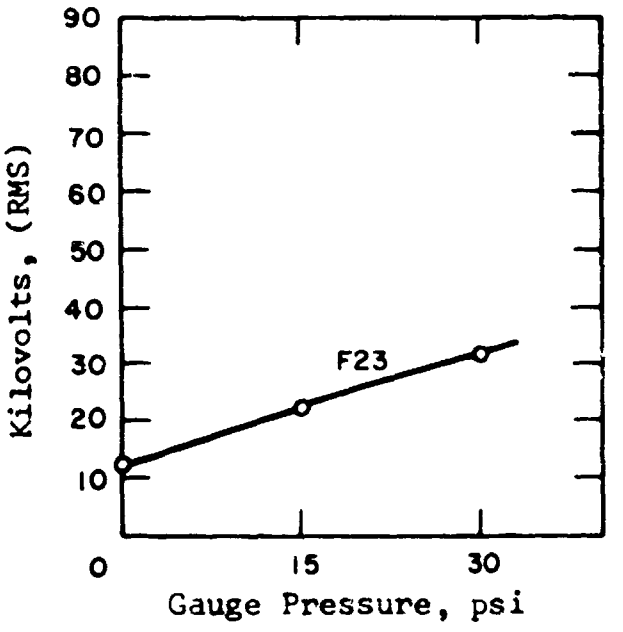
TRIFLUOROMETHANE

DIELECTRIC STRENGTH



Impulse dielectric strength as a function of pressure for Freon-23 in a non-uniform electrical field.

[Ref. 6140]



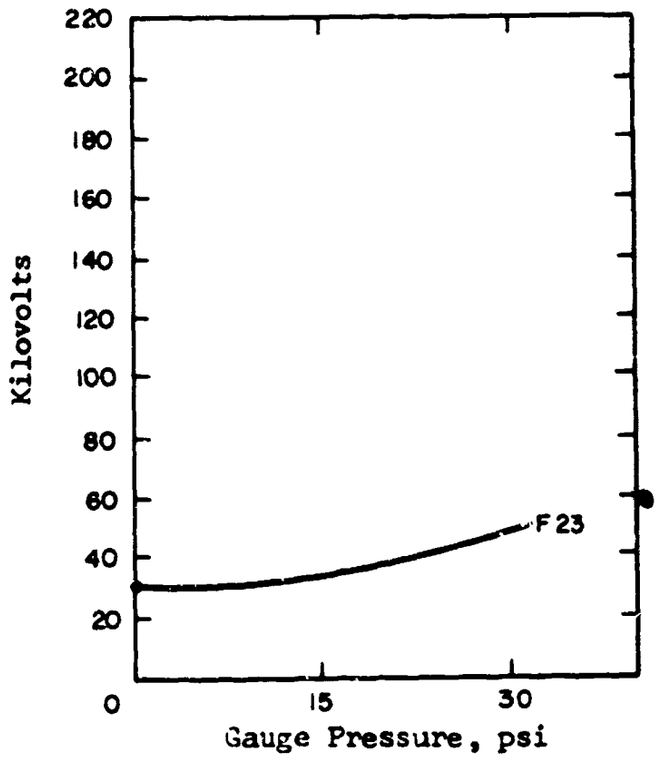
60-cycle dielectric strength of Freon-23 tested between two 1-inch diameter spheres spaced 1/4 inch.

[Ref. 4299]

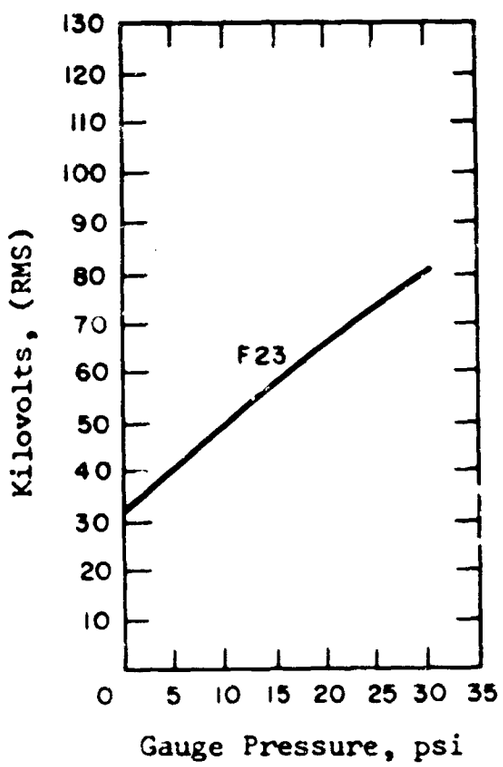
TRIFLUOROMETHANE

DIELECTRIC STRENGTH

Impulse dielectric strength of Freon-23 tested between two 1-inch diameter spheres spaced 1/4 inch.



[Ref. 4299]

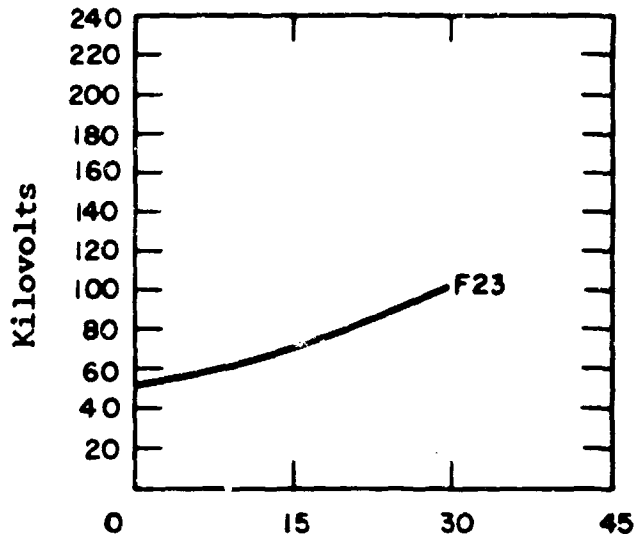


60-cycle dielectric strength of Freon-23 tested between tungsten rod and 1-inch diameter sphere spaced 1 inch.

[Ref. 4299]

TRIFLUOROMETHANE

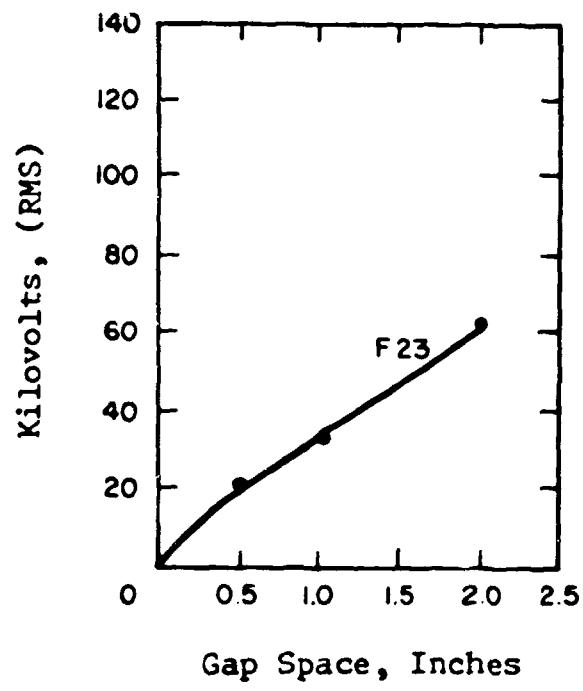
DIELECTRIC STRENGTH



Impulse dielectric strength of Freon-23. Positive wave tests made between tungsten rod and 1-inch diameter sphere spaced 1-inch.

[Ref. 4299]

60-cycle dielectric strength of Freon-23 tested between tungsten rod and 1-inch diameter sphere at atmospheric pressure.



[Ref. 4299]

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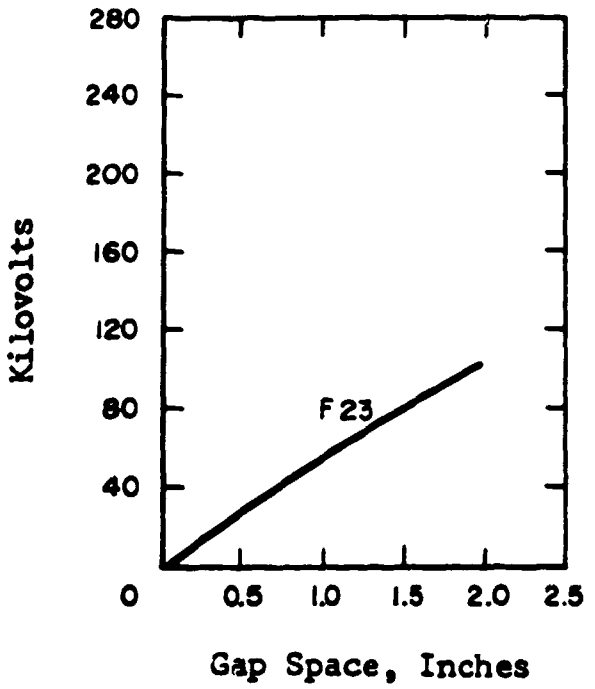
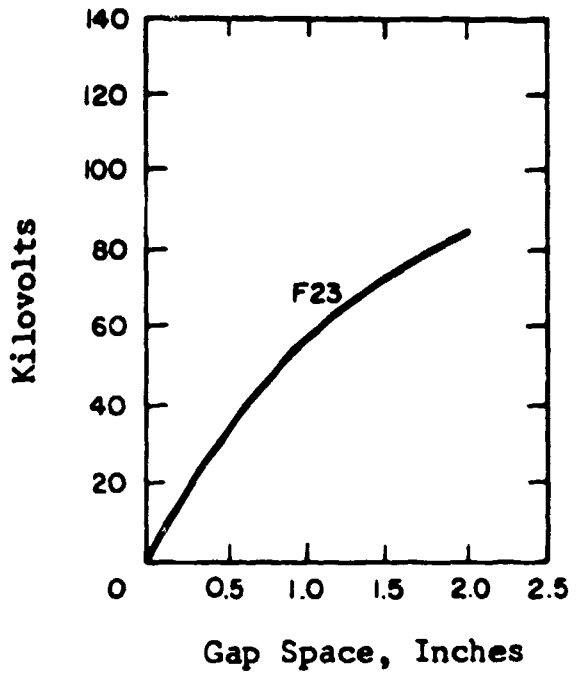
TRIFLUOROMETHANE

DIELECTRIC STRENGTH

Negative impulse tests (1½ x 40 microsecond wave) of Freon-23, at atmospheric pressure, tested between tungsten rod and 1-inch diameter sphere.





Positive impulse tests (1½ x 40 microsecond wave) of Freon-23, at atmospheric pressure, tested between tungsten rod and 1-inch diameter sphere.

[Ref. 4299]

REFERENCES

1181. HOWARD, P.R. Insulation Properties of Compressed Electronegative Gases. INST. OF ELECTRICAL ENG., PROC., v. 104 A, no. 14, Apr. 1957. p. 123-138.

1265. MILLER, R.C. and C.P. SMYTH. Molecular Shape and Rotational Freedom in the Tetrahalogenated Methanes in the Solid State. AMERICAN CHEM. SOC., J., v. 79, no. 1, Jan. 1957. p. 20-24.

1275. CAMILLI, G. and R.E. PLUMP. Fluorine-Containing Gaseous Dielectrics. INST. OF ELECTRICAL ENG., TRANS. I, = COMMUNICATIONS AND ELECTRONICS. v. 72, no. 6. p. 93-102.

1373. INSULATION STAFF REPORT. Gaseous Dielectrics. INSULATION. v. 7, no. 6, May, 1961. p. 43-46.

1538. PHILLIPS, C.S.E. Line Broadening and Dielectric Relaxation in Compressed Gases. J. OF CHEM. PHYS. v. 23, no. 12, Dec. 1955. p. 2388-2394.

1589. HOWARD, P.R. Compressed Gases as Insulants in High-Voltage Equipments. ELECTRICAL TIMES, v. 132, Oct. 31, 1957. p. 683-686.

1625. MANNING, M.L. Experience with the AIEE Subcommittee Test Cell for Gaseous Insulation. AIEE, TRANS., PT. 3. v. 78, Oct. 1959. p. 800-807.

1655. FOORD, T.R. Positive Point-to-plane Spark Breakdown of Compressed Gases. NATURE. v. 166, no. 4225, Oct. 21, 1960. p. 688-689.

1853. FOORD, T.R. Some Experiments on Positive Point-to-Plane Corona and Spark Breakdown of Compressed Gases. INST. OF ELECTRICAL ENG., PROC., v. 100, no. 78, pt. 2, Dec. 1953. p. 585-590.

4299. CAMILLI, G. and J.J. CHAPMAN. Gaseous Insulation for High-Voltage Apparatus. GEN. ELEC. REV., v. 51, no. 2, Feb. 1948. p. 35-41.

5005. SKILLING, H.H. and W.C. BRENNER. The Electrical Strength of Nitrogen and Freon Under Pressure. ELECTRICAL COMMUNICATIONS. v. 20, no. 4, 1942. p. 287-294.

5338. NONKEN, G.C. High-Pressure Gas as a Dielectric. AIEE, TRANS., v. 60, Dec. 1941. p. 1017-1020.

6140. CLARK, F.M. The Newer Insulating Gases. MATERIALS IN DESIGN ENG., v. 53, no. 2, Feb. 1961. p. 95-99.

6189. DU PONT DE NEMOURS, E.I. AND COMPANY. FREON PRODUCT DIVISION. Properties and Applications of the "Freon" Fluorocarbons. Freon Technical Bulletin B-2. 1962.

7530. ALLIED CHEM. CORP. Genetron 218 (C_3F_8). Product Data Sheet Preliminary. Oct. 1958.

7531. DU PONT DE NEMOURS, E.I. AND COMPANY. ORGANIC CHEMICALS DEPARTMENT. Freon High Dielectric Strength Gases. New Products Information. Bulletin 3a.

10067. DU PONT DE NEMOURS, E.I. AND COMPANY, ORGANIC CHEMICALS DEPARTMENT. "Freon 116" Hexafluoroethane -- "Freon-C318" Octafluorocyclobutane Mixtures. Brochure.

10489. ROME AIR DEVELOPMENT CENTER. GRIFFIS AIR FORCE BASE. Sulfur Hexafluoride in High-Power Microwave Systems. by. V. VANNICOLA. Technical Documentary Report No. RADC-TDR-62-443, Nov. 1962. ASTIA AD-289 854.

11055. MINNESOTA MINING AND MANUFACTURING COMPANY. CHEMICAL DIVISION. 3M Brand Octafluoropropane -- FX-30. Technical Information Introductory Data.

16238. NAT. AERONAUTICS AND SPACE ADMINISTRATION. On the Breakdown Voltages of Some Electronegative Gases at Low Pressures. by. S. SCHREIER, NASA TN D-1761. June, 1963.

16386. SCHREIER, S. On the Breakdown Voltages of Some Electronegative Gases at Low Pressures. IEE TRANS. ON POWER APARATUS AND SYSTEMS. v. 83, no. 5, May 1964. p. 468-471.

16775. CLARK, F.M. Insulating Materials for Design and Engineering Practice. N.Y., WILEY, 1962. Selected Pages.

16955. COYNER, E.C. and D. HANESIAN. Electrical Insulating Gases: Hexafluoroethane and Octafluorocyclobutane. In: SYMPOSIUM ON ELECTRICAL INSULATING GASES. Oct. 1, 1962. ASTM Special Technical Publication No. 346. Philadelphia. ASTM, 1964. p. 35-50.

PUBLICATIONS OF THE ELECTRONIC PROPERTIES INFORMATION CENTER

DS-101 Cadmium Telluride - Data Sheets. M. Neuberger. June 1962.

DS-102 Indium Phosphide - Data Sheets. M. Neuberger. June 1962.

DS-103 Indium Telluride - Data Sheets. M. Neuberger. June 1962.

DS-104 Magnesium Silicide - Data Sheets. M. Neuberger. June 1962.

DS-105 Polyethylene Terephthalate - Data Sheets. J.T. Milek. June 1962.

DS-106 Polytetrafluoroethylene Plastics - Data Sheets. Emil Schafer. June 1962.

DS-107 Polytrifluorochloroethylene Plastics - Data Sheets. Emil Schafer. June 1962.

DS-108 Zinc Telluride - Data Sheets. M. Neuberger. June 1962.

DS-109 Indium Arsenide - Data Sheets. M. Neuberger. July 1962.

DS-110 Aluminum Antimonide - Data Sheets. M. Neuberger. September 1962.

DS-111 Gallium Phosphide - Data Sheets. M. Neuberger. September 1962.

DS-112 Gallium Antimonide - Data Sheets. M. Neuberger. October 1962.

DS-113 Lead Telluride - Data Sheets. M. Neuberger. October 1962.

DS-114 Magnesium Stannide - Data Sheets. M. Neuberger. November 1962.

DS-115 Gallium Arsenide - Data Sheets. M. Neuberger. December 1962.

DS-116 Lead Selenide - Data Sheets. M. Neuberger. December 1962.

DS-117 (No longer available - Superseded by DS-137.)

DS-118 (No longer available - Superseded by DS-137.)

DS-119 (No longer available - Superseded by DS-137.)

DS-120 (No longer available - Superseded by DS-137.)

DS-121 Indium Antimonide - Data Sheets. M. Neuberger. February 1963.

DS-122 Steatite - Data Sheets. J.T. Milek. February 1963.

DS-123 Beryllium Oxide - Data Sheets. J.T. Milek. March 1963.

DS-124 Cadmium Sulfide - Summary Review and Data Sheets. M. Neuberger. April 1963.

DS-125 Magnesium Oxide - Data Sheets. J.T. Milek. June 1963.

DS-126 (No longer available - Superseded by DS-137.)

DS-127 Silicone Rubber - Data Sheets. J.T. Milek. June 1963.

DS-128 Cordierite - Data Sheets. J.T. Milek. June 1963.

DS-129 Forsterite - Data Sheets. J.T. Milek. August 1963.

DS-130 Pyroceram - Data Sheets. J.T. Milek. August 1963.

DS-131 Germanium - Data Sheets. M. Neuberger. September 1963.

DS-132 Zinc Selenide - Data Sheets. M. Neuberger. September 1963.

DS-133 Zinc Oxide - Data Sheets. M. Neuberger. October 1963.

DS-134 Cadmium Selenide - Data Sheets. M. Neuberger. November 1963.

DS-135 Zinc Sulfide - Data Sheets. M. Neuberger and D.L. Grigsby. December 1963.

DS-136 Aluminum Oxide - Data Sheets. J.T. Milek. March 1964.

DS-137 Silicon - Data Sheets. M. Neuberger. May 1964.

DS-138 Borosilicate Glasses - Data Sheets. J.T. Milek. June 1964.

DS-139 Aluminosilicate Glasses - Data Sheets. J.T. Milek. July 1964.

DS-140 Sulfur Hexafluoride - Data Sheets. J.T. Milek. October 1964.

DS-141 Niobium - Data Sheets. D.L. Grigsby. November 1964.

DS-142 Fluorocarbon Gases - Data Sheets. J.T. Milek. November 1964.

OTHER REPORTS

5171.2/8 Information Retrieval Program. Electronic/Electrical Properties of Materials. First Quarterly Progress Report. E.M. Wallace. October 10, 1962.

5171.2/17 Information Retrieval Program. Electronic/Electrical Properties of Materials. Second Quarterly Progress Report. E.M. Wallace. January 15, 1962.

5171.2/32 Information Retrieval Program. Electronic/Electrical Properties of Materials. Third Quarterly Progress Report. E.M. Wallace. April 15, 1962.

P62-18 Electrical and Electronic Properties of Materials-Information and Retrieval Program. Final Report. H. Thayne Johnson, Emil Schafer and Everett M. Wallace. June 1962.

S-1 Insulation Materials Descriptors Used in the Electrical and Electronic Properties of Materials Information Retrieval Program. Emil Schafer. July 1962.

S-2 Semiconductor Materials Descriptors Used in the Electrical and Electronic Properties of Materials Information Retrieval Program. Emil Schafer. September 1962.

5171.2/73 Information Retrieval Program. Electronic/Electrical Properties of Materials. Fourth Quarterly Progress Report. H.T. Johnson . September 15, 1962.

P63-15 Electrical and Electronic Properties of Materials Information Retrieval Program. H. Thayne Johnson, Donald L. Grigsby and Dana H. Johnson. April 1963.

P64-10 Electrical and Electronic Properties of Materials Information Retrieval Program. H. Thayne Johnson and Dana H. Johnson. April 1964.

S-3 A Survey Materials Report on Tetrafluoroethylene (TFE) Plastics. J.T. Milek. September 1964.

S-4 The Purpose and Functions of the Electronic Properties Information Center. H. Thayne Johnson. August 1964.

S-5 Role of the Technical Library in Support of an Information Center. M. Bloomfield. November 1964.