

**ARTI REFRIGERANT DATABASE**  
**DATA SUMMARIES - VOLUME 1:**  
**SINGLE-COMPOUND REFRIGERANTS**

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## TABLE OF CONTENTS

INTRODUCTION .....	1
Purpose .....	1
Contents .....	1
Limitations .....	2
Database Form .....	2
Computerized Version .....	3
Report Version .....	4
Documents .....	4
Ordering Information .....	5
Additions .....	5
ARTI REFRIGERANT DATABASE - DATA SUMMARIES .....	7
Identifiers .....	8
Common Uses .....	9
Physical Properties .....	9
Environmental Data .....	10
Safety Data .....	11
Production Data .....	12
REFRIGERANT PROFILES: SINGLE-COMPOUND REFRIGERANTS .....	13
R-10 .....	15
R-11 .....	18
R-11B2 .....	23
R-12 .....	24
R-12B1 .....	29
R-12B2 .....	31
R-12I2 .....	33
R-13 .....	34
R-13B1 .....	37
R-13I1 .....	40
R-14 .....	42
R-20 .....	45
R-20B1 .....	48
R-20B3 .....	49
R-20I3 .....	51
R-21 .....	52
R-22 .....	56
R-22B1 .....	60
R-22I1 .....	62
R-23 .....	63
R-30 .....	67
R-30B1 .....	70
R-30B2 .....	72

R-30I2 .....	73
R-31 .....	74
R-31I1 .....	75
R-32 .....	76
R-40 (methyl chloride) .....	79
R-40B1 .....	82
R-40I1 .....	84
R-41 .....	86
R-50 (methane) .....	88
R-110 .....	90
R-111 .....	92
R-112 .....	93
R-112a .....	95
R-113 .....	97
R-113a .....	101
R-113B2 $\alpha\alpha$ .....	103
R-113B2 $\alpha\beta$ .....	104
R-113aB2 .....	105
R-114 .....	106
R-114a .....	110
R-114B1 .....	112
R-114B2 .....	113
R-115 .....	115
R-115I1 .....	119
R-116 .....	120
R-E116 .....	123
R-120 .....	124
R-121 .....	125
R-121a .....	127
R-122 .....	128
R-122a .....	130
R-122b .....	131
R-123 .....	132
R-123a .....	137
R-123b .....	139
R-123B1 .....	140
R-123B2 .....	142
R-124 .....	143
R-124a .....	147
R-124aI1 .....	149
R-125 .....	150
R-E125 .....	154
R-130 .....	156
R-130a .....	158
R-131 .....	159
R-131a .....	160
R-131b .....	161
R-132 .....	162
R-132a .....	163

R-132b .....	164
R-132c .....	166
R-133 .....	167
R-133a .....	168
R-133b .....	171
R-134 .....	172
R-134a .....	174
R-E134 .....	178
R-E134a .....	180
R-140 .....	181
R-140a .....	183
R-141 .....	186
R-141a .....	187
R-141b .....	188
R-142 .....	192
R-142a .....	193
R-142b .....	194
R-143 .....	198
R-143a .....	200
R-E143 .....	203
R-E143a .....	204
R-150 .....	206
R-150a .....	208
R-151 .....	210
R-151a .....	211
R-152 .....	212
R-152a .....	213
R-E152 .....	217
R-E152a .....	218
R-160 .....	220
R-160B1 .....	223
R-161 .....	225
R-E161 .....	227
R-170 (ethane) .....	228
R-E170 (dimethyl ether) .....	231
R-211 .....	233
R-212 .....	234
R-213.....	235
R-214.....	236
R-215.....	237
R-216.....	238
R-216aa .....	239
R-216ba.....	240
R-216ca .....	241
R-216cb .....	242
R-C216 .....	243
R-CE216ca1 .....	244
R-CE216ca12.....	245
R-217.....	246

R-217ba .....	247
R-217bal1 .....	248
R-217ca.....	250
R-217cal1.....	251
R-218 .....	253
R-220 .....	256
R-220aa .....	257
R-220da .....	258
R-223da .....	259
R-225ba .....	260
R-225ca.....	261
R-225cb.....	263
R-225da .....	265
R-226 .....	266
R-226ba .....	267
R-226ca .....	268
R-226cb.....	269
R-226da .....	270
R-226ea .....	271
R-227 .....	272
R-227ca.....	273
R-227ea .....	275
R-234 .....	278
R-234cb .....	279
R-234da .....	280
R-235 .....	281
R-235ba .....	282
R-235ca .....	283
R-235cb.....	284
R-235cc .....	286
R-235da .....	287
R-235fa .....	288
R-E235da1 .....	289
R-236 .....	290
R-236ca .....	291
R-236cb .....	292
R-236ea .....	294
R-236fa .....	296
R-E236ea1 .....	299
R-241 .....	301
R-242 .....	302
R-243 .....	303
R-243da .....	304
R-243db .....	305
R-244 .....	307
R-244ca .....	308
R-245 .....	309
R-245ca .....	310
R-245cb.....	312

R-245ea .....	314
R-245eb .....	315
R-245fa .....	317
R-E245ca2 .....	321
R-E245cb1 .....	322
R-E245fa1 .....	324
R-E245fa2 .....	326
R-250 .....	327
R-251 .....	328
R-252 .....	329
R-253 .....	330
R-254 .....	331
R-254ca .....	332
R-254cb .....	333
R-254ea .....	335
R-254eb .....	336
R-254fa .....	337
R-254fb .....	338
R-E254cb1 .....	339
R-260 .....	341
R-261 .....	342
R-261ba .....	343
R-262 .....	344
R-263 .....	345
R-263ca .....	346
R-263ea .....	347
R-263eb .....	348
R-263fa .....	349
R-263fb .....	350
R-270 .....	351
R-270aa .....	352
R-270da .....	353
R-271 .....	354
R-C270 (cyclopropane) .....	355
R-272 .....	357
R-272ca .....	358
R-272ea .....	359
R-272fa .....	360
R-272fb .....	361
R-281 .....	362
R-281ea .....	363
R-281fa .....	364
R-290 (propane) .....	365
R-C314 .....	369
R-C316 .....	370
R-C317 .....	371
R-318 .....	372
R-318lcc .....	373
R-318mbb .....	374

R-C318 .....	375
R-CE318ccc1 .....	379
R-31-10 .....	380
R-C324 .....	382
R-C326ccc .....	383
R-C336 .....	384
R-C336ccc .....	385
R-C336cce .....	386
R-C336cec .....	387
R-329 .....	389
R-329mcc .....	390
R-E329mcc2 .....	392
R-C334 .....	394
R-338 .....	395
R-338mcc .....	396
R-338mce .....	398
R-338mcf .....	399
R-338mec .....	400
R-338mee .....	401
R-338pcc .....	403
R-C344ccd .....	405
R-347 .....	406
R-347mcc .....	407
R-347mec .....	408
R-E347mcc3 .....	410
R-E347mmy1 .....	412
R-E347pce2 .....	414
R-C354ccf .....	415
R-356 .....	416
R-356mcf .....	417
R-356mec .....	418
R-356mff .....	419
R-356mmz .....	421
R-365 .....	423
R-365mfc .....	424
R-C390 (cyclobutane) .....	426
R-43-10meec .....	427
R-41-12mccc .....	429
R-51-14mcccc .....	430
R-600 (butane) .....	432
R-600a (isobutane) .....	435
R-601 (pentane) .....	439
R-601a (isopentane) .....	442
R-601b (neopentane) .....	444
R-602 (hexane) .....	446
R-602a (isohexane) .....	448
R-602b (neohexane) .....	449
R-602c (3-methylpentane) .....	450
R-602d (2,3-dimethylbutane) .....	451



R-603 (heptane)	452
R-610 (ether)	454
R-611 (methyl formate)	456
R-630 (methylamine)	458
R-631 (ethylamine)	460
R-631a (dimethylamine)	462
R-702 (hydrogen)	464
R-702p (para-hydrogen)	466
R-704 (helium)	467
R-717 (ammonia)	469
R-718 (water)	473
R-720 (neon)	475
R-728 (nitrogen)	476
R-729 (air)	478
R-732 (oxygen)	479
R-740 (argon)	481
R-744 (carbon dioxide)	483
R-744A (nitrous oxide)	486
R-746 (nitrogen dioxide)	488
R-748 (ozone)	490
R-764 (sulfur dioxide)	492
R-771 (nitrogen trifluoride)	495
R-784 (krypton)	497
R-788 (tetramethyl silane)	498
R-7104 (tetrafluorosilane)	499
R-7131 (xenon)	501
R-7146 (sulfur hexafluoride)	503
R-1110	505
R-1111	507
R-1112	508
R-1112a	509
R-1113	510
R-1114	512
R-1120	513
R-1121	515
R-1121a	516
R-1122	517
R-1122a	518
R-1123	519
R-1130	520
R-1130a	522
R-1130c	524
R-1130t	525
R-1131	527
R-1131a	528
R-1132	529
R-1132a	530
R-1140	532
R-1140B1	534

R-1141 .....	535
R-1150 (ethylene) .....	537
R-1216 .....	539
R-1225 .....	541
R-1243 .....	542
R-1243zf .....	543
R-1250 .....	544
R-1261 .....	545
R-1270 (propylene) .....	546
R-C1314 .....	549
R-1316 .....	550
R-C1316 .....	552
R-1318 .....	553
R-1390 (butylene) .....	554
acetone .....	555
cyclopentane .....	557
difluoromethyl-bis(trifluoromethyl) amine .....	559
hexafluoropropene oxide .....	560
isobutene .....	562
methyl-bis(trifluoromethyl) amine .....	564
perfluorobutyl ethylene .....	565

## Introduction

This report provides data summaries from the *ARTI Refrigerant Database*. Volumes 1 and 2 present refrigerant profiles for single-compound refrigerants and refrigerant profiles, respectively. [Volume 3](#) presents data summaries for compatibility and toxicity. They are part of a series to provide a record of the database entries in printed form.

### Purpose

The Refrigerant Database is an information system on alternative refrigerants, associated lubricants, and their use in air conditioning and refrigeration. It consolidates and facilitates access to property, compatibility, environmental, safety, application, and other information. It provides corresponding information on older refrigerants, to assist manufacturers and those using alternative refrigerants to make comparisons and determine differences. The underlying purpose is to accelerate phase out of chemical compounds of environmental concern.

### Contents

The database identifies sources of specific information on R-22, R-23, R-32, R-41, R-116, R-123, R-124, R-125, R-134, R-134a, R-141b, R-142b, R-143a, R-152a, R-218, R-227ea, R-236fa, R-245ca, R-245fa, R-290 (propane), R-C318, R-717 (ammonia), R-718 (water), R-744 (carbon dioxide), R-1270 (propylene), ethers, and others as well as azeotropic and zeotropic blends of these fluids. These blends include R-400, R-401A, R-401B, R-401C, R-402A, R-402B, R-403A, R-403B, R-404A, R-405A, R-406A, R-407A, R-407B, R-407C, R-407D, R-408A, R-409A, R-409B, R-410A, R-410B, R-411A, R-411B, R-412A, R-413A, R-414A, R-414B, R-415A, R-416A, R-500, R-501, R-502, R-503, R-504, R-505, R-506, R-507A, R-508A, R-508B, R-509A, and others for which information is available even though standard designations may not have been assigned yet. It addresses lubricants including alkylbenzene, polyalkylene glycol, polyolester, and other synthetics as well as mineral oils. It also references documents addressing compatibility of refrigerants and lubricants with metals, plastics, elastomers, motor insulation, and other materials used in refrigerant circuits.

The database provides bibliographic citations and abstracts for publications that may be useful in research and design of air-conditioning and refrigeration equipment. The complete docu-

ments are not included, though some may be added at a later date. Incomplete citations or abstracts are provided for some documents. They are included to accelerate availability of the information and will be completed or replaced in future updates.

### **Limitations**

The Refrigerant Database is intended as a means to assist users in locating sources of information on alternative refrigerants. But, the database is:

- neither a comprehensive nor authoritative reference source,
- not a substitute for independent data collection by users,
- not a substitute for examination of the data, information on how they were arrived at, assumptions, and caveats in the cited documents, and
- not an endorsement of suitability or accuracy of the referenced publications.

The information in the database was obtained from published and unpublished sources, or calculated from them, without verification. Some of the data may be imprecise or incorrect, as manifested - in some cases - by inclusion of conflicting data based on disagreement among identified sources. Similarly, errors may have occurred in assembling and processing the database. Users are cautioned to check the data and associated limitations and caveats in the referenced documents and other sources before use, particularly if such use might risk harm to life or property. Newer or more complete data may be available from refrigerant suppliers or elsewhere.

Materials compatibility, properties, safety considerations, and other characteristics affecting suitability or desirability may be influenced by a number of factors. Among them are specific application conditions, preparation such as drying before use, additives including fillers, impurities, catalytic interactions with other materials used, and changes in compounding between one source or batch and another. Similarly, new findings or corrections may supersede previously published data. The database is an aid in locating data that may be pertinent; it is not and should not be viewed as the source of data for research, design, analysis, or other purposes.

### **Database Form**

The database is available in both computerized ("electronic") and report ("manual" or "listing") versions.

### Computerized Version

The computerized version includes both data summaries and bibliographic citations organized into a number of segments ("files"). These segments can be searched individually or together, in any combination.

The computerized database provides 606 specially-prepared data summaries, including refrigerant (single compound and blend) profiles, tabular compatibility summaries for plastics and

### Distribution of the Refrigerant Database

	computerized (diskette)	report (listing)	documents (copies)
data summaries			
• refrigerant profiles	yes	no	<sup>a</sup>
• compatibility	yes	no	<sup>a</sup>
• toxicity	yes	no	<sup>a</sup>
bibliographic citations and synopses (detailed abstracts)			
• recently added and key	yes	yes	<sup>a</sup>
• copper supplement <sup>b</sup>	yes	<sup>b</sup>	<sup>a</sup>
• archival and historical	yes	no	<sup>a</sup>
search and retrieval software	yes <sup>c</sup>	no	no
additions and changes flagged	no	yes	no
distributed on cost-recovery basis			
• subscription (periodic updates)	yes	yes	no
• as ordered	no	yes	yes <sup>d</sup>

<sup>a</sup> Data summaries, citations, and synopses may be printed with the computerized version.

<sup>b</sup> The Copper Development Association (CDA) sponsored supplement provides additional citations and synopses, most of which address compatibility with or use of copper in air-conditioning and refrigeration systems. The supplement is included and searchable with the computerized version, but published as a separate report.

<sup>c</sup> Use of the search and retrieval software is subject to acceptance of the license agreement for it; both accompany the computerized version.

<sup>d</sup> Distribution is limited to documents in the public domain or for which authorization has been obtained. Others may be ordered from their publishers, which are identified in the bibliographic citations.

elastomers, and toxicity reviews for refrigerants. The refrigerant profiles cover designations, common uses, chemical and trade names, other identifiers, molecular mass, critical properties (pressure, temperature, specific volume, and density at the critical point), physical and thermo-physical properties for selected conditions, safety classifications, toxicity and flammability data, exposure limits, atmospheric lifetime, ozone depletion potential, global warming potential, halogen global warming potential, commercialization, phaseout, and other data.

The computerized version also provides more than 6,100 citations. They are organized into a primary file that includes recently added and key references, a supplement on copper in air conditioning and refrigeration, and an archival group covering historical and superseded documents.

The search and retrieval software provided with the computerized version enables very fast searches for user-selected terms or combinations of terms. The search program offers several automated features to simplify use. They include optional prompting by search category, an automated "thesaurus" of synonyms and related terms, chain searches to broaden or narrow prior searches, a "wildcard" capability to allow entry of word segments, and a configuration capability to customize a number of options. The program also allows printing of selected portions of the database. Printing the entire database would yield more than 8,000 pages, so a printed version is available for those who prefer to use the database manually.

### **Report Version**

A listing of the recent and key citations is provided in report form. The citations are grouped under the primary or first subject addressed; they are not cross-referenced under other topics. The computerized version, therefore, is better suited to search for information by subject.

Citations and summaries from the supplement on copper in air conditioning and refrigeration are published separately. They also are arranged by subject.

Archival and historic citations are included in a third report. They are presented in reverse chronological order, beginning with the most recent. These citations remain accessible through the computerized version.

### **Documents**

The database also includes a collection of published and unpublished documents, copies of which can be ordered individually. Approximately one third of the documents cited in the database are included in this collection. They include documents that are not protected by copyright or proprietary restrictions. They also include documents for which the authors or copyright owners granted permission for reproduction and distribution. Documents that are not dis-

tributed through the database can be obtained from their publishers, libraries, and other sources (please refer to the database User's Manual for suggestions).

### **Ordering Information**

The computerized version of the database and the report version for recently added and key references can be ordered along with a subscription for updates. The report versions of the copper supplement, archival citations, and data summaries are available as separate documents distributed through the database.

An order form for the Refrigerant Database, which indicates the pricing, accepted methods of payment, and applicable terms and conditions, may be downloaded from the Internet from <http://www.arti-21cr.org/db>. Alternatively, a copy may be obtained by mail or fax by calling +1-703/524-8800 or faxing +1-703/522-2349. Questions should be sent by e-mail to [database@spectrum-internet.com](mailto:database@spectrum-internet.com). Please note that the same form may be used to obtain the computerized database and remaining scheduled updates, the report version and remaining scheduled updates for primary and key references, and database documents by completing the corresponding portions of the form.

### **Additions**

Future updates and expansions to the database are planned. Please help in making it more useful, and facilitating use of alternative refrigerants, by submitting the following:

- corrections to errors identified in the database,
- copies of helpful papers - whether your own or written by others - for citation, and
- suggestions for improving the database.

Authors or those holding rights to published or unpublished works pertinent to the database are invited - and encouraged - to authorize their reproduction and unrestricted distribution through the database. Product literature normally is not included, but technical bulletins and papers providing relevant information, whether on proprietary or generic substances, will be considered.

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Thank you for your help with and use of the database. Its objective is to accelerate phase out of chemical compounds of environmental concern by sharing the information needed to do so.



## ARTI Refrigerant Database - Data Summaries

The parameter descriptions that follow summarize the information included in data summaries for refrigerants, also referred to as *refrigerant profiles*. Each entry consists of the following parts:

- a label to identify and/or explain the data,
- a data value, typically rounded to common representation or limits of precision, generally expressed metric units or dimensionless form (metric units conform to the International System, SI, modified to use the Celsius scale for temperatures in place of the Kelvin scale),
- units of measure if applicable,
- converted data and units in the inch-pound (IP) system for data expressed in metric units,
- qualifying information on the data such as the animal species, exposure duration, and fraction of responses for toxicity test results, exposure periods, or manufacturer identity where the source is a safety data sheet, and
- four-digit alphanumeric Refrigerant Database ("RDB") number (discussed below).

The specific data included for each single-compound refrigerant or blend depend upon availability. Multiple values are cited for the same or related parameters in some cases, for example when conflicting data were published by multiple credible sources. The purpose of the database is to assist users in locating data rather than to endorse or verify specific data or to resolve inconsistencies and conflicts. Older data generally are deleted for simplification when the original source reports later results or when scientific consensus is reported, but that does not suggest endorsement of the newer data. Please refer to the discussion of data limitations on [page 2](#). The data values shown are included to assist users, but the primary information for each entry is the four alphanumeric digit "RDB" number in the right-most column, which indicates the document or other source from which the data were taken. Those sources may be located by searching for the number prefixed by "RDB" (for example *RDB9901*) in the database.

## Identifiers

The refrigerant number shown in the heading is the standard designation based on those assigned by or recommended for addition to ANSI/ASHRAE Standard 34-1997, *Designation and Safety Classification of Refrigerants*, as well as pending addenda and common industry extensions thereto. These familiar designations are used almost universally, usually preceded by "R-", "R", the word "Refrigerant", composition-designating prefixes (for example "CFC-", "HCFC-", "HFC-", or "HC-"), or manufacturer trade names. Nonstandard and pending designations generally are flagged as such or identified in notes included with the common uses.

The chemical formula indicates the molecular makeup of the single-compound refrigerants, namely those consisting of a single chemical substance. The blend composition is substituted for refrigerant blends, namely those consisting of two or more chemicals that are mixed to obtain desired characteristics. The composition consists of two parts. The first identifies the components, in order of increasing normal boiling points and separated by slashes. The second part, which is enclosed in parentheses, indicates the mass fractions (as percentages) of those components in the same order. The profiles also indicate alternative chemical names, the common and historic names, index numbers for common reference databases, empirical and structural chemical formulae, and standard container colors. Among the identifiers shown are the:

- standard designation following American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), Standard 34-1997 (*Designation and Safety Classification of Refrigerants*) as well as addenda, pending addenda (flagged), and common industry extensions to it (flagged),
- variants using the "R-", "R", "R ", composition-designating prefixes (for example "CFC-", "HCFC-", or "HFC-"),
- common fluorochemical number and variants,
- halon number for chemicals also used or considered as fire suppressants,
- chemical name following the International Union of Pure and Applied Chemistry (IUPAC) convention,
- chemical name following other common conventions,
- common names,
- structural formula following the IUPAC convention,
- structural formula following other common conventions,
- empirical formula following the Hill convention,
- other formulae including some flagged as "not recommended" to enable location by them

- Chemical Abstracts Service (CAS) registry number,
- Beilstein registry number,
- European Inventory of Existing Chemical Substances (EINECS) number,
- Merck index (volume and number),
- National Institute of Occupational Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS) index number,
- trade name(s),
- historical name(s),
- names used for rule making notices for proprietary refrigerants in U.S. Environmental Protection Agency (EPA) Significant New Alternatives Program (SNAP) notices,
- standard container color name and Pantone number as assigned by Air-Conditioning and Refrigeration Institute (ARI) Guideline N (*Assignment of Refrigeration Container Colors*),
- composition for blends
- both mass and mole formulations for blends, and
- standard mass formulation tolerances for blends with ASHRAE safety classifications.

In some cases, primarily for proprietary blends, additional identifying information is included in the description of common uses.

### **Common Uses**

The uses focus on application as refrigerants followed, if applicable, by terse indications of other applications if known. Limiting considerations such as toxicity, flammability, reactivity, or environmental concerns are cited for some substances.

This section also includes notes on pending changes in standard designations and safety classifications.

### **Physical Properties**

The refrigerant profiles indicate key physical, thermodynamic, and transport properties at representative conditions, including the normal boiling point, 20 °C (68 °F), 60 °C (140 °F), and the critical point.

The molecular mass is a calculated value based on the atomic weights recognized by International Union of Pure and Applied Chemists (IUPAC). It indicates the mass in grams of a mole of the refrigerant or, for blends, the mass-weighted average of a mole of the mixture.

The normal boiling point (NBP) is the temperature at which liquid refrigerant will boil at standard atmospheric pressure, namely 101.325 kPa (14.6959 psia). The NBP and most dimensional units in the tables are shown in both metric (SI) and inch-pound units of measure. Both the bubble point (temperature at which a bubble first appears, hence the temperature at which boiling begins, for a blend) and dew point typically are shown for blends.

The critical temperature ( $T_c$ ) is the temperature at the critical point of the refrigerant. The  $T_c$  values shown for blends are the mass weighted averages of the component  $T_c$ s unless actual values have been determined.

The critical pressure ( $P_c$ ) is the pressure at the critical point.

The NBP and critical properties suggest the application range for which an individual refrigerant might be suitable. Those with extremely low NBP lend themselves to ultra-low temperature refrigeration, for example in cryogenic applications. Those with high NBPs generally are limited to high-temperature applications, such as for use in chillers or high-temperature heat pumps. Both capacity and efficiency decline in a typical vapor-compression (reverse Rankine) cycle, the one most commonly used, when condensing temperatures approach the  $T_c$ . The  $P_c$  will exceed the operating pressure, except in transcritical cycles, which are uncommon except for R-744 (carbon dioxide).

### **Environmental Data**

The atmospheric lifetime ( $\tau_{atm}$ ) is an indication of the average persistence of the refrigerant, if released into the atmosphere, until it decomposes or reacts with other chemicals. The values shown are composite atmospheric lifetimes. Separate lifetimes also are shown if known for the tropospheric (lower atmosphere where we live), stratospheric (next layer where global depletion of ozone is a concern), and higher layers, since the atmospheric chemistry changes between layers.

The ozone depletion potential (ODP) is a normalized indicator, based on a value of 1.000 for R-11, of the ability of refrigerants (and other chemicals) to destroy stratospheric ozone molecules. The data shown are the modeled values adopted by the international scientific assessment. The ODPs shown for blends are mass-weighted averages. The values shown typically are *modeled ODP* values, the most indicative of environmental impacts. *Semi-empirical* ODP and regulatory values adopted in the Montreal Protocol also are indicated for some refrigerants.

The semi-empirical ODPs are calculated values that incorporate adjustments for observed atmospheric measurements. The concept is conceptually more accurate, but it is difficult to measure the data needed for representative adjustments accurately.

The regulatory values generally are required for specific purposes, but may not be updated with newer findings after adoption. The ODP values listed in the annexes to the Montreal Protocol, for example, have not been updated since 1987 for chlorofluorocarbons (CFCs) and 1992 for hydrochlorofluorocarbons (HCFCs). A note in the Protocol indicates that the values "are estimates based on existing knowledge and will be reviewed and revised periodically."

The global warming potential (GWP) is a similar indicator of the potency to warm the planet by action as a greenhouse gas. The values shown are relative to carbon dioxide (CO<sub>2</sub>) for an integration period of 100 yr. Both the ODP and GWP are calculated from the  $\tau_{\text{atm}}$ , measured chemical properties, and other atmospheric data. The GWPs shown for blends are mass-weighted averages.

The  $\tau_{\text{atm}}$ , ODP, and GWP values indicated for blends were calculated for the nominal blend compositions.

The database also indicates halocarbon global warming potential (HGWP) and photochemical reactivity at ground level if known.

### **Safety Data**

The safety section is subdivided into classifications, recommended exposure limits, acute (short-term, single exposure) and chronic (long-term, repeated exposure) toxicity data, flammability data, and detection (appearance and odor) information. The exposure limits are further separated into short-term occupational, long-term occupational, and emergency exposures. Depending on the refrigerant, more than 100 parameters - some with differing values for species or exposure durations in toxicity tests - are reported. The following brief summary addresses only the chronic toxicity and flammability indices used to determine standard refrigerant safety classifications.

The first value is an occupational exposure limit, namely the Threshold Limit Value - Time Weighted Average (TLV-TWA) or a consistent measure. It is an indication of chronic (long-term, repeat exposure) toxicity of the refrigerant. Some of the consistent toxicity indices are the workplace Environmental Exposure Level (WEEL) guides and the Permissible Exposure Limit (PEL). These measures indicate adopted limits for workplace exposures for trained personnel for typical workdays and work weeks.

The Lower Flammability Limit (LFL) is the lowest concentration at which the refrigerant will burn in air under prescribed test conditions. It is an indication of flammability. The absence of an LFL or even an indication of nonflammable does not assure that a substance will not burn or exacerbate an existing fire under some conditions, such as when mixed with other fuels (such as lubricants) or at elevated pressures and temperatures.

The Heat of Combustion (HOC) is an indicator of how much energy the refrigerant will release when it burns in air, assuming complete reaction to the most stable products in their vapor state. Negative values indicate endothermic reactions (those that require heat to proceed) while positive values indicate exothermic reactions (those that liberate heat).

The ASHRAE Standard 34 safety group is an assigned classification that is based on the TLV-TWA (or consistent measure), LFL, and HOC. It comprises a letter (A or B) that indicates relative toxicity followed by a number (1, 2, or 3) that indicates relative flammability. These classifications are widely used in mechanical and fire construction codes, to determine requirements to promote safe use. Most of these code provisions are based on ASHRAE Standard 15, *Safety Code for Mechanical Refrigeration*.

### **Production Data**

The final section of the refrigerant profiles indicates initial commercialization if known and the last year production is allowed in developed countries under the Montreal Protocol.

## Refrigerant Profiles: Single-Compound Refrigerants







temperature:	283.0 °C (541.4 °F)	3211
	283.3 °C (541.9 °F)	7809
pressure:	4413 kPa (640.1 psia)	3211
	4560 kPa (661.4 psia)	7809
density:	558 kg/m <sup>3</sup> (34.8 lb/cf)	3211
specific volume:	1.79 L/kg (0.0287 cf/lb)	3211

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	35 yr	9501
ODP (ozone depletion potential):	1.20 (model-derived relative to R 11)	9501
	1.1 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	1400 relative to CO <sub>2</sub> for 100 yr integration	9501

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	9710
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 3-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 3-0-0	MSDS
	Olin: 3-0-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	3 in absence of flame or hot objects	4B64
IARC/CIRC human carcinogenicity group:	2B, possibly carcinogenic	8802
NIOSH caution:	potential occupational carcinogen (limit exposures to lowest feasible)	5204
ACGIH carcinogenicity category:	A2, suspected human carcinogen	9504
DFG carcinogenicity class:	IIIB: suspect, to be evaluated	5561
· occupational exposure warnings -----		
ACGIH caution:	cutaneous absorption potential	9504
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	200 ppm v/v (potential occupational carcinogen)	5204
NIOSH SCP IDLH (immediately dangerous):	300 ppm v/v for 30 min (SCP excluded potential carcinogenic effects)	3903
NIOSH STEL (short-term exposure limit):	2 ppm v/v TWA for 60 min	5204
ACGIH TLV-STEEL (short-term exp limit):	10 ppm v/v TWA for 15 min	9504
· occupational exposure limit -----		
OSHA PEL-C (exposure ceiling):	25 ppm v/v (must not exceed)	3904
OSHA acceptable maximum peak:	200 ppm for 5 min in 4 hr (peak allowed over ceiling for specified interval)	3904
MAK (maximum workplace concentration):	II, 1: 100 ppm v/v avg for 30 min	7101
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	10 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
ACGIH TLV-TWA (time-weighted average):	5 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	10 ppm v/v TWA for 8 hr/day (or 42) hr/wk being examined for changes	5561 7101

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

· emergency exposure limit -----		
AIHA ERPG-3 (life-threatening):	750 ppm v/v for 1 hr	4B82
AIHA ERPG-2 (injurious or impairing):	100 ppm v/v for 1 hr	4B82
AIHA ERPG-1 (odor or mild effects):	20 ppm v/v for 1 hr	4B82
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 15 min: 30,000 ppm (fatal concentration by inhalation for half of test animals)	6110
	rat, 4 hr, JTBaker: 8,000 ppm (fatal concentration by inhalation for half of test animals)	MSDS
	rat, 4 hr, Olin: 6,200 ppm (fatal concentration by inhalation for half of test animals)	MSDS
ALC (approximate lethal concentration):	rat, 4 hr: 4,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
dermal LD50 (lethal dosage, 50%):	rabbit, Olin: 1,800 mg/kg (fatal dose by skin contact for half of test animals)	MSDS
	rat, JTBaker: 5,070 mg/kg (fatal dose by skin contact for half of test animals)	MSDS
oral LD50 (lethal dosage, 50%):	rat, JTBaker: 2,350 mg/kg (fatal dose by ingestion for half of test animals)	MSDS
	rat, Olin: 2,800 mg/kg (fatal dose by ingestion for half of test animals)	MSDS
cardiac sensitization (CS) EC50:	dog, 5 min: 4,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic/CNS effect EC50:	rat, 10 min: depressant 8,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic/CNS effect NOEL:	rat, 1 hr: 2,500 ppm v/v (no observed effect level in ALC or LC50 studies)	5365
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
flash point:	none (nonflammable as tested)	3903
autoignition temperature:	Olin: none	MSDS
· detection -----		
appearance:	Olin: clear, colorless liquid	MSDS
odor:	Olin: ethereal odor	MSDS
odor sensing, lower threshold:	Olin: 10-50 ppm v/v	MSDS
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	~1912 by M. LeBlanc	4147
last year production allowed:	1995 (under Article 2D) in developed countries under the Montreal Protocol	8C01



	SIC (Italy) Edifren 11	7601
	Union Carbide Ucon(R) 11	7601
	VVB Dresden Frigedohn 11	7601
ARI container color / Pantone number:	orange / 021	6601

**PHYSICAL**

· properties -----

molar mass:	137.3672032 g/mol (0.302843 lb/mol)	8820
normal freezing/melting/triple point:	-110.5 °C (-166.8 °F)	8401
· normal boiling point -----		
temperature:	23.7 °C (74.7 °F)	8401
density, saturated liquid:	1479 kg/m3 (92.35 lb/cf)	8401
density, saturated vapor:	5.85 kg/m3 (0.365 lb/cf)	8401
specific volume, saturated liquid:	0.676 L/kg (0.0108 cf/lb)	8401
specific volume, saturated vapor:	170.9 L/kg (2.7369 cf/lb)	8401
heat of vaporization:	181.4 kJ/kg (78.0 Btu/lb)	8401
velocity of sound, saturated liquid:	736 m/s (2415 ft/s)	8401
velocity of sound, saturated vapor:	138 m/s (452 ft/s)	8401
viscosity, saturated vapor:	10.14 µPa·s (0.01014 cp)	8401
viscosity, saturated liquid:	410 µPa·s (0.410 cp)	8401
thermal conductivity, liquid:	0.0872 W/m·K (0.0504 Btu/hr·ft°F)	8401
thermal conductivity, vapor:	0.0084 W/m·K (0.0049 Btu/hr·ft°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, liquid:	1488 kg/m3 (12.42 lb/gal)	8401
· normal pressure, 21.1 °C (70 °F) ----		
density, liquid:	1486 kg/m3 (12.40 lb/gal)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	88.7 kPa (12.86 psia)	8401
density, saturated liquid:	1488 kg/m3 (92.90 lb/cf)	8401
density, saturated vapor:	5.17 kg/m3 (0.323 lb/cf)	8401
specific volume, saturated liquid:	0.672 L/kg (0.0108 cf/lb)	8401
specific volume, saturated vapor:	193.4 L/kg (3.0983 cf/lb)	8401
velocity of sound, saturated liquid:	749 m/s (2456 ft/s)	8401
velocity of sound, saturated vapor:	137 m/s (450 ft/s)	8401
viscosity, saturated liquid:	425 µPa·s (0.425 cp)	8401
viscosity, saturated vapor:	10.0 µPa·s (0.0100 cp)	8401
thermal conductivity, saturated liquid:	0.0882 W/m·K (0.0510 Btu/hr·ft°F)	8401
thermal conductivity, saturated vapor:	0.00824 W/m·K (0.00476 Btu/hr·ft°F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	313 kPa (45.4 psia)	8401
heat of vaporization:	166.9 kJ/kg (71.8 Btu/lb)	8401
· critical point -----		
temperature:	198.0 °C (388.3 °F)	8401
pressure:	4408 kPa (639.3 psia)	8401
density:	554 kg/m3 (34.6 lb/cf)	8401
specific volume:	1.81 L/kg (0.0289 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime (tatm):	45 yr	9501
ODP (ozone depletion potential):	1.000 (model-derived relative to R 11)	9501
	1.000 (semi-empirical relative to R 11)	9501
	1.0 (estimate used for the	6904

Montreal Protocol)  
 GWP (global warming potential): 4600 relative to CO2 for 100 yr integration 9501  
 HGWP (halocarbon GWP): 1.000 relative to R 11 for infinite integration period

**SAFETY**

• classification -----  
 safety group (ASHRAE Standard 34): A1 8601  
 NFPA 704 degrees of hazard (H-F-R-S): ARI recommendation: 2-0-0 3A15  
 BOC Gases: 1-0-0 MSDS  
 Elf Atochem: 2-0-0 MSDS  
 health-flammability-reactivity  
 [-special]: 0=no, 4=severe  
 NPCA HMIS hazard ratings (H-F-R): AlliedSignal: 2-0-0 MSDS  
 BOC Gases: 1-0-0 MSDS  
 DuPont: 1-0-1 MSDS  
 health-flammability-reactivity  
 0=insignificant, 4=extreme  
 UL Comparative Hazard to Life Group: 5(a) in absence of flame or hot objects 4B64  
 ACGIH carcinogenicity category: A4, not classifiable as a human carcinogen 9504  
 DFG pregnancy risk group: C (no risk fear below MAK/BAT) 5561  
 • short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 2,000 ppm v/v 5204  
 ARI "IDLH" recommendation: 5,000 ppm v/v for 30 min 3A15  
 NIOSH SCP IDLH (immediately dangerous): 10,000 ppm v/v for 30 min 3903  
 • occupational exposure limit -----  
 NIOSH REL-C (exposure ceiling): 1,000 ppm v/v (must not exceed) 3903  
 ACGIH TLV-C (exposure ceiling): 1,000 ppm v/v (must not exceed) 9504  
 MAK (maximum workplace concentration): IV: 2,000 ppm v/v momentary 60 min 5561  
 • long-term occupational limit -----  
 OSHA PEL (permissible exposure limit): 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk 3904  
 exposure limit consistent to OSHA PEL: ARI PEL-Ceiling: C1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk 3A15  
 MAK (maximum workplace concentration): 1,000 ppm v/v TWA for 8 hr/day and 40 (or 42) hr/wk 5561  
 • emergency exposure limit -----  
 NRC EEGL (emergency exposure level): 1 hr: 1,500 ppm v/v ceiling guidance level for single emergency exposures 7414  
 24 hr: 500 ppm v/v ceiling guidance level for single emergency exposures 7414  
 Refrigerant Concentration Limit (RCL): 1,100 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)  
 • special-purpose exposure control ---  
 NRC CEGL (continuous exposure level): 90 day: 100 ppm v/v ceiling guidance for prolonged exposure in closed environments 7414  
 • acute (short-term) toxicity -----

LC50 (lethal concentration, 50%):	rat, 15 min: 130,000 ppm (fatal concentration by inhalation for half of test animals)	6110
	rat, 4 hr: 26,200 ppm (fatal concentration by inhalation for half of test animals)	5C53
ALC (approximate lethal concentration):	rat, 30 min: 100,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5147
	rat, 4 hr, 0/4: >35,600 ppm (lowest exposure tested with one or more deaths by inhalation)	65H3
	rat, 4 hr, 1/4: 66,000 ppm (lowest exposure tested with one or more deaths by inhalation)	65H3
	rat, 4 hr, 3/6: 24,900 ppm (lowest exposure tested with one or more deaths by inhalation)	5C53
oral LD50 (lethal dosage, 50%):	rat, Elf Atochem: >3,725 mg/kg (fatal dose by ingestion for half of test animals)	MSDS
	rat: 3,752 mg/kg (fatal dose by ingestion for half of test animals)	6595
cardiac sensitization (CS) EC50:	dog, 5 min: 12,500 ppm v/v (effective concentration in half of test animals)	6110
cardiac sensitization threshold/LOEL:	dog 1/12: 3500-6100ppm, ~4,800 ppm v/v (lowest observed effect level in test animals)	5644
	dog: 5,000 ppm v/v (lowest observed effect level in test animals)	4A66
cardiac sensitization (CS) NOEL:	dog, 5min: 900-1300 ppm, ~1100 ppm v/v (no observed effect level in test animals)	5644
anesthetic/CNS effect EC50:	rat, 10 min, stimulant: 35,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic/CNS effect LOEL:	rat, 2 hr, ?/4: 35,000 ppm v/v (lowest observed effect level in ALC or LC50 studies)	5365
anesthetic/CNS effect NOEL:	rat, 2 hr, 0/4: 12,500 ppm v/v (no observed effect level in ALC or LC50 studies)	5365
flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
heat of combustion (by ASHRAE 34-92):	0.9 MJ/kg (387 Btu/lb)	2318
flash point:	ICI: does not flash none (nonflammable as tested)	MSDS 3903
autoignition temperature:	>750 °C (>1382 °F)	5931
autodecomposition temperature:	DuPont: >593 °C (>1099 °F)	MSDS
former UL Classification:	nonflammable (withdrawn for revision of the classification)	6938

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

· detection ----- system, category SBQT2)

appearance:	colorless	7414
odor:	ICI: nearly odorless	MSDS
	faint ethereal	5367
odor sensing, lower threshold:	5 ppm v/v	5141

**PRODUCTION**

first commercial use as a refrigerant:	1932 by T. Midgley, associates	5C39
last year production allowed:	1995 in developed countries	8C01
	under the Montreal Protocol	



## R-11B2

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----- REFRIGERANT DATA SUMMARY -----
R-11B2      dibromochlorofluoromethane      see
BCFC        CBr2ClF                          CAS number 353-55-9      RDB#
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**IDENTIFIERS**

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common name(s):  R-11B2; R11B2; R 11B2
                  BCFC-11
                  halon 1112
chemical name (by IUPAC convention):  dibromochlorofluoromethane
alternative chemical names/formulae:  methane, dibromochlorofluoro-
                                       chlorodibromofluoromethane      LPCR
                                       CBr2ClF
                                       not recommended: Br2ClCF
CAS number:      353-55-9 Chemical Abstracts
                  Service Registry Number
ARI container color / Pantone number:  none, use light green grey/413 6601

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**PHYSICAL**

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· properties -----
molar mass:      226.2698032 g/mol (0.498840      8820
                  lb/mol)
· normal boiling point -----
temperature:     80.0 °C (176.0 °F)              7601

```

**SAFETY**

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· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601
· flammability -----
flash point:     Lancaster-PCR: none              LPCR

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**PRODUCTION**

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last year production allowed:  unrestricted (but vulnerable)  8C01

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## R-12

----- REFRIERANT DATA SUMMARY -----  
 R-12            dichlorodifluoromethane            see  
 CFC            CCl2F2                                    CAS number 75-71-8            RDB#  
 -----

**COMMON USE(S)**

refrigerators, freezers, drinking fountains, mobile air conditioners, centrifugal chillers, commercial and transport refrigeration, ice machines, heat pump water heaters; component of refrigerants 400, 500, 501, and 505; direct contact freezing of foods (food freezant); aerosol propellant often with refrigerants 11 or 114; foam blowing agent for plastics; diluent for sterilant gas mixtures; dielectric gas

R-12 was initially synthesized in 1928 by T. Midgley, A. Henne, and R. McNary; it was the first fluorocarbon refrigerant to be commercialized, in 1931.

**IDENTIFIERS**

common name(s): R-12; R12; R 12  
 CFC-12  
 chlorofluorocarbon 12  
 fluorocarbon 12  
 fluorochemical 12; FC 12  
 halocarbon 12  
 halochemical 12  
 halon 122

chemical name (by IUPAC convention): dichlorodifluoromethane  
 alternative chemical names/formulae: methane, dichlorodifluoro-  
 difluorodichloromethane  
 CCl2F2

CAS number: 75-71-8 Chemical Abstracts  
 Service Registry Number

EINECS number: 200-893-9 (European Inventory  
 of Existing Chemical  
 Substances)

NIOSH RTECS number: PA8200000 (Registry of Toxic  
 Effects of Chemical  
 Substances)

trade name(s): AlliedSignal Genetron(R) 12    MSDS  
 Asahi Glass Fron AF-12  
 Daikin Daiflon(R) 12  
 DuPont Freon(R) 12                            MSDS  
 Elf Atochem Forane(R) 12                    MSDS  
 HRP (UK) HARP(R) 12  
 ICI Arcton(R) 12                            MSDS  
 Solvay Kaltron(R) 12  
 Solvay Solkane(R) 12

historical name(s): Allied Corp refrigerant 142  
 Elf Atochem Racon(R) 12                    6938  
 Eskimon (USSR)                            7601  
 Fluoder Algeon 12                            7601  
 Hoechst Frigen(R) 12

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



temperature:	112.0 °C (233.5 °F)	8401
pressure:	4136 kPa (599.9 psia)	8401
density:	565 kg/m <sup>3</sup> (35.3 lb/cf)	8401
specific volume:	1.77 L/kg (0.0284 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	100 yr	9501
ODP (ozone depletion potential):	0.82 (model-derived relative to R 11)	9501
	0.9 (semi-empirical relative to R 11)	9501
	1.0 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	10,600 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	3.1 ±0.3 relative to R 11 for infinite integration period	5964

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	ARI recommendation: 2-0-0	3A15
	health-flammability-reactivity [-special]: 0=no, 4=severe	
	AlliedSignal: 2-0-1	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
	BOC Gases: 1-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
	Elf Atochem: 2-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 1-0-1	MSDS
	BOC Gases: 1-0-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
	DuPont: 1-0-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	6 in absence of flame or hot objects	4B64
ACGIH carcinogenicity category:	A4, not classifiable as a human carcinogen	9504
DFG pregnancy risk group:	C (no risk fear below MAK/BAT)	5561
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	15,000 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	50,000 ppm v/v for 30 min	3903
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	5561
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	1,000 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day	5561

	40 (or 42) hr/wk	
· emergency exposure limit ----- NRC EEGL (emergency exposure level):	1 hr: 10,000 ppm v/v ceiling guidance level for single emergency exposures	7414
	24 hr: 1,000 ppm v/v ceiling guidance level for single emergency exposures	7414
Refrigerant Concentration Limit (RCL):	22,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· special-purpose exposure control --- NRC CEGL (continuous exposure level):	90 day: 100 ppm v/v ceiling guidance for prolonged exposure in closed environments	7414
· acute (short-term) toxicity ----- ALC (approximate lethal concentration):	rat, 30 min: >800,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5147
	rat, 4 hr: >800,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5147
dermal LD50 (lethal dosage, 50%):	rat: >2,000 mg/kg (fatal dose by skin contact for half of test animals)	5368
oral LD50 (lethal dosage, 50%):	rat: >1,000 mg/kg (fatal dose by ingestion for half of test animals)	5C42
cardiac sensitization (CS) EC50:	dog, 5 min: 77,000 ppm v/v (effective concentration in half of test animals)	6110
	dog, 10 min: 120,000 ppm v/v (effective concentration in half of test animals)	6684
cardiac sensitization threshold/LOEL:	dog, 5 min, 5/12: 50,000 ppm v/v (lowest observed effect level in test animals)	5644
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/5: 40,000 ppm v/v (no observed effect level in test animals)	5B42
anesthetic/CNS effect EC50:	rat, 10 min: stimulant 250,000 ppm v/v (effective concentration in half of test animals)	6110
	rat, 2 hr: 400,000 ppm v/v (effective concentration in half of test animals)	5365
anesthetic/CNS effect LOEL:	human, ?/? : 50,000 ppm v/v (lowest observed effect level)	5271
anesthetic/CNS effect NOEL:	rat, 2 hr: 200,000 ppm v/v (no observed effect level in test animals)	5355
	human, ?/? : 1,000 ppm v/v (no observed effect level)	5271
· flammability ----- LFL-UFL (flammability limits in air):	none (nonflammable as tested)	0036
heat of combustion (by ASHRAE 34-92):	-0.8 MJ/kg (-344 Btu/lb)	2318

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

flash point:	none (nonflammable as tested)	3903
autoignition temperature:	>750 °C (>1382 °F)	5931
	BOC Gases: none	MSDS
autodecomposition temperature:	Elf Atochem: >427 °C (>800 °F)	MSDS
former UL Classification:	nonflammable (withdrawn for revision of the classification system, category SBQT2)	6938
· detection -----		
	appearance: colorless	5141
	odor: AlliedSignal: faint ethereal	MSDS
	nearly odorless	5367

**PRODUCTION**

first commercial use as a refrigerant:	1931 by T. Midgley, associates	5C39
last year production allowed:	1995 in developed countries under the Montreal Protocol	8C01



**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 NFPA 704 degrees of hazard (H-F-R-S): Amerex: 2-0-0 MSDS  
 health-flammability-reactivity  
 [-special]: 0=no, 4=severe  
 NPCA HMIS hazard ratings (H-F-R): Amerex: 2-0-0 MSDS  
 Elf Atochem: 1-0-0-H MSDS  
 health-flammability-reactivity  
 0=insignificant, 4=extreme

· acute (short-term) toxicity -----  
 LC50 (lethal concentration, 50%): rat, 15 min: 200,000 ppm 6110  
 (fatal concentration by  
 inhalation for half of test  
 animals)  
 rat, 4 hr: 100,000-130,000 ppm 5526  
 (fatal concentration by  
 inhalation for half of test  
 animals)

ALC (approximate lethal concentration: rat, 2 hr, 2/4: 200,000 ppm 5365  
 (lowest exposure tested with  
 one or more deaths by  
 inhalation)

cardiac sensitization (CS) EC50: dog, 5 min: 19,000 ppm v/v 6110  
 (effective concentration in  
 half of test animals)

cardiac sensitization (CS) NOEL: 5,000-10,000 ppm v/v (no 5526  
 observed effect level in test  
 animals)

anesthetic/CNS effect EC50: rat, 10 min: stimulant 50,000 6110  
 ppm v/v (effective  
 concentration in half of test  
 animals)

anesthetic/CNS effect LOEL: rat, 2 hr, ?/4: 100,000 ppm 5365  
 v/v (lowest observed effect  
 level in ALC or LC50 studies)

anesthetic/CNS effect NOEL: rat, 2 hr, 0/4: 75,000 ppm v/v 5365  
 (no observed effect level in  
 ALC or LC50 studies)

· flammability -----  
 LFL-UFL (flammability limits in air): none (nonflammable as tested) 3726  
 flash point: Elf Atochem: nonflammable MSDS  
 autodecomposition temperature: Elf Atochem: >427 °C (>800 °F) MSDS

· detection -----  
 appearance: Elf Atochem: clear, colorless MSDS  
 odor: Elf Atochem: slight ethereal MSDS

**PRODUCTION**

last year production allowed: 1993 (under Article 2B) in 8C01  
 developed countries under the  
 Montreal Protocol



## R-12B2

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----- REFRIERANT DATA SUMMARY -----
R-12B2      dibromodifluoromethane      see
BFC         CBr2F2                        CAS number 75-61-6      RDB#
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**COMMON USE(S)**

fire suppressant; intermediate in production of polymers

**IDENTIFIERS**

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common name(s):  R-12B2; R12B2; R-12B2
                  BFC-12B2
                  halon 1202
chemical name (by IUPAC convention):  dibromodifluoromethane
alternative chemical names/formulae:  methane, dibromodifluoro-
                                      difluorodibromomethane
                                      CBr2F2
                                      not recommended: CF2Br2
CAS number:      75-61-6 Chemical Abstracts
                  Service Registry Number
Beilstein registry number:  1732515
EINECS number:    200-885-5 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number:  PA7525000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
historical name(s):  Brom-12              7737
                   DuPont FCD-623       7737
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:  209.8155064 g/mol (0.462564      8820
              lb/mol)
normal freezing/melting/triple point:  -110.0 °C (-166.0 °F)      7601
· normal boiling point -----
temperature:  24.5 °C (76.1 °F)              7601
· critical point -----
temperature:  198.2 °C (388.8 °F)            7601

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential):  1.7 (model-derived relative to 2701
R 11)
1.25 (semi-empirical relative 2701
to R 11)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601
· short-term occupational limit -----
NIOSH IDLH (immediately dangerous):  2,000 ppm v/v              5204
NIOSH SCP IDLH (immediately dangerous:  2,500 ppm v/v for 30 min      3903
· occupational exposure limit -----
MAK (maximum workplace concentration):  II, 1: 200 ppm v/v avg for 30  5561

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	min	
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk	3903
NIOSH REL (recommendd exposure limit):	100 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	100 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
• acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 15 min: 55,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5C41
	rat, 3 hr, 0/2: 19,000 ppm (lowest exposure tested with one or more deaths by inhalation)	7737
	rat, 6 hr, 0/2: 11,500 ppm (lowest exposure tested with one or more deaths by inhalation)	7737
anesthetic/CNS effect LOEL:	rat, 14 min: 10,000 ppm v/v (lowest observed effect level in test animals)	5C42
• flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
flash point:	none (nonflammable as tested)	3903
<b>PRODUCTION</b>		
last year production allowed:	unrestricted (ut vulnerable)	8C01



## R-13

## ----- REFRIGERANT DATA SUMMARY -----

R-13	chlorotrifluoromethane		see
CFC	CClF3	CAS number 75-72-9	RDB#

**COMMON USE(S)**

extremely-low-temperature refrigeration, usually in the lower stage of cascaded systems; high-capacity industrial refrigeration plants (e.g., gas fractionation); component of refrigerant 503; plasma etchant

**IDENTIFIERS**

common name(s):	R-13; R13; R 13 CFC-13 chlorofluorocarbon 13 fluorocarbon 13 fluorochemical 13; FC 13 halocarbon 13 halochemical 13	
chemical name (by IUPAC convention):	chlorotrifluoromethane	
alternative chemical names/formulae:	methane, chlorotrifluoro- monochlorotrifluoromethane trifluorochloromethane CClF3	
	not recommended: CF3Cl	
CAS number:	75-72-9 Chemical Abstracts Service Registry Number	
EINECS number:	200-894-4 (European Inventory of Existing Chemical Substances)	
NIOSH RTECS number:	PA6410000 (Registry of Toxic Effects of Chemical Substances)	
trade name(s):	AlliedSignal Genetron(R) 13 BOC Gases Halocarbon 13 Daikin Daiflon(R) 13 DuPont Freon(R) 13 Elf Atochem Forane(R) 13 ICI Arcton(R) 13	MSDS MSDS MSDS MSDS MSDS
historical name(s):	Allied Corp refrigerant 241 Hoechst Frigen(R) 13	
ARI container color / Pantone number:	light blue (sky) / 2975	6601

**PHYSICAL**

· properties -----		
	molar mass:	104.4586096 g/mol (0.230292 lb/mol) 8820
	normal freezing/melting/triple point:	-183.1 °C (-297.7 °F) 8401
· normal boiling point -----	temperature:	-81.3 °C (-114.3 °F) 8401
	density, saturated liquid:	1520 kg/m3 (94.90 lb/cf) 8401
	density, saturated vapor:	6.93 kg/m3 (0.432 lb/cf) 8401
	specific volume, saturated liquid:	0.658 L/kg (0.0105 cf/lb) 8401
	specific volume, saturated vapor:	144.4 L/kg (2.3131 cf/lb) 8401

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

heat of vaporization:	149.3 kJ/kg (64.2 Btu/lb)	8401
velocity of sound, saturated liquid:	709 m/s (2327 ft/s)	8401
velocity of sound, saturated vapor:	131 m/s (430 ft/s)	8401
viscosity, saturated liquid:	338 $\mu\text{Pa}\cdot\text{s}$ (0.338 cp)	8401
viscosity, saturated vapor:	8.90 $\mu\text{Pa}\cdot\text{s}$ (0.00890 cp)	8401
thermal conductivity, liquid:	0.0858 W/m $\cdot$ K (0.0496 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, vapor:	0.0062 W/m $\cdot$ K (0.0036 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· normal pressure, 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
density, vapor:	4.385 kg/m $^3$ (0.2738 lb/cf)	8401
· normal pressure, 21.1 $^{\circ}$ C (70 $^{\circ}$ F) ---		
density, vapor:	4.368 kg/m $^3$ (0.2727 lb/cf)	8401
· 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
pressure, saturated vapor:	3182.0 kPa (461.51 psia)	8401
density, saturated liquid:	920 kg/m $^3$ (57.41 lb/cf)	8401
density, saturated vapor:	267.07 kg/m $^3$ (16.673 lb/cf)	8401
specific volume, saturated liquid:	1.087 L/kg (0.0174 cf/lb)	8401
specific volume, saturated vapor:	3.7 L/kg (0.0600 cf/lb)	8401
velocity of sound, saturated liquid:	174 m/s (572 ft/s)	8401
velocity of sound, saturated vapor:	104 m/s (342 ft/s)	8401
viscosity, saturated liquid:	59 $\mu\text{Pa}\cdot\text{s}$ (0.059 cp)	8401
viscosity, saturated vapor:	16.8 $\mu\text{Pa}\cdot\text{s}$ (0.0168 cp)	8401
thermal conductivity, saturated liquid:	0.0519 W/m $\cdot$ K (0.0300 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, saturated vapor:	0.02302 W/m $\cdot$ K (0.01330 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· critical point -----		
temperature:	29.2 $^{\circ}$ C (84.6 $^{\circ}$ F)	8401
pressure:	3915 kPa (567.8 psia)	8401
density:	576 kg/m $^3$ (35.9 lb/cf)	8401
specific volume:	1.74 L/kg (0.0278 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{\text{atm}}$ ):	640 yr	9501
ODP (ozone depletion potential):	1.000 (model-derived relative to R 11)	2702
	1.0 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	10,000 relative to CO $_2$ for 100 yr integration	9501
HGWP (halocarbon GWP):	17.9 relative to R 11 for infinite integration period	DW

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-0-0	MSDS
	Elf Atochem: 2-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-0-0	MSDS
	DuPont: 1-0-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	6 in absence of flame or hot objects	0036
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary	60 5561

min

· long-term occupational limit -----  
 exposure limit consistent to OSHA PEL: AlliedSignal prelim PEL: 1,000 MSDS  
 ppm v/v TWA for 8 hr/day and  
 40 hr/wk

MAK (maximum workplace concentration): 1,000 ppm v/v TWA for 8 hr/day 5561  
 40 (or 42) hr/wk

· acute (short-term) toxicity -----  
 LC50 (lethal concentration, 50%): rat, 15 min: >800,000 ppm 6110  
 (fatal concentration by  
 inhalation for half of test  
 animals)  
 rat, 2 hr, 0/4: >600,000 ppm 5365  
 (fatal concentration by  
 inhalation for half of test  
 animals)  
 rat, 4 hr, ElfAtochem: >800,000 MSDS  
 ppm (fatal concentration by  
 inhalation for half of test  
 animals)

cardiac sensitization (CS) EC50: dog, 5 min: approx. 800,000 6110  
 ppm v/v (effective  
 concentration in half of test  
 animals)

anesthetic/CNS effect EC50: rat, 10 min: >800,000 ppm v/v 6110  
 (effective concentration in  
 half of test animals)

anesthetic/CNS effect LOEL: rat, 2 hr, 0/4: >600,000 ppm 5365  
 v/v (lowest observed effect  
 level in ALC or LC50 studies)

· flammability -----  
 LFL-UFL (flammability limits in air): none (nonflammable as tested) 0036  
 heat of combustion (by ASHRAE 34-92): -3.0 MJ/kg (-1290 Btu/lb) 2318  
 flash point: AlliedSignal: nonflammable MSDS  
 DuPont: will not burn MSDS  
 ICI: does not flash MSDS  
 autoignition temperature: AlliedSignal: not applicable MSDS  
 autodecomposition temperature: DuPont: >800 °C (>1472 °F) MSDS

· detection -----  
 appearance: DuPont: clear, colorless MSDS  
 odor: AlliedSignal: faint ethereal MSDS

**PRODUCTION**

first commercial use as a refrigerant: 1945 5C39  
 last year production allowed: 1995 in developed countries 8C01  
 under the Montreal Protocol

## R-13B1

----- REFRI GERANT DATA SUMMARY -----  
 R-13B1 bromotrifluoromethane see  
 BFC CBrF3 CAS number 75-63-8 RDB#  
 -----

**COMMON USE(S)**

very low temperature refrigeration, especially with single-stage systems; industrial refrigeration with centrifugal (turbo) compressors, for example in gas liquefaction; widely used fire suppressant (halon 1301): This refrigerant and its use may be covered by U.S. patents 2,531,372 and 2,531,373; other U.S. and foreign patents may apply.

**IDENTIFIERS**

common name(s): R-13B1; R13B1; R 13B1  
 BFC-13B1  
 fluorochemical 13B1; FC 13B1  
 halon 1301  
 chemical name (by IUPAC convention): bromotrifluoromethane  
 alternative chemical names/formulae: methane, bromotrifluoro-  
 monobromotrifluoromethane  
 trifluorobromomethane  
 trifluoromonobromomethane  
 CBrF3  
 not recommended: BrCF3; CF3Br  
 CAS number: 75-63-8 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: PA5425000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): BOC Gases Halocarbon 13B-1 MSDS  
 Daikin Daiflon(R) 13B1  
 DuPont Freon(R) 13B1 3511  
 Hoechst Frigen(R) 13B1 4779  
 historical name(s): Brom-13 7737  
 DuPont FCD-722 7737  
 Eston Chemicals KULENE(R) 131  
 ICI Arcton(R) 13B1  
 ARI container color / Pantone number: pinkish red (coral) / 177 6601

**PHYSICAL**

· properties -----  
 molar mass: 148.9099096 g/mol (0.328290 8820  
 lb/mol)  
 normal freezing/melting/triple point: -168.1 °C (-270.7 °F) 4101  
 · normal boiling point -----  
 temperature: -57.7 °C (-71.9 °F) 3209  
 heat of vaporization: 118.8 kJ/kg (51.1 Btu/lb) 3209  
 velocity of sound, saturated liquid: 604 m/s (1981 ft/s) 4101  
 velocity of sound, saturated vapor: 114 m/s (375 ft/s) 4101  
 · normal pressure, 20 °C (68 °F) -----  
 density, vapor: 6.288 kg/m3 (0.3925 lb/cf) 4101  
 · 20 °C (68 °F) -----  
 pressure, saturated vapor: 1433.1 kPa (207.85 psia) 3209

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	1618.2 kPa (234.70 psia)	MSDS
density, saturated liquid:	1575 kg/m <sup>3</sup> (98.29 lb/cf)	3209
density, saturated vapor:	115.57 kg/m <sup>3</sup> (7.215 lb/cf)	3209
specific volume, saturated liquid:	0.635 L/kg (0.0102 cf/lb)	3209
specific volume, saturated vapor:	8.7 L/kg (0.1386 cf/lb)	3209
velocity of sound, saturated liquid:	286 m/s (937 ft/s)	4101
velocity of sound, saturated vapor:	107 m/s (349 ft/s)	4101
viscosity, saturated liquid:	162 µPa·s (0.162 cp)	4101
viscosity, saturated vapor:	16.7 µPa·s (0.0166 cp)	4101
thermal conductivity, saturated liquid:	0.0477 W/m·K (0.0275 Btu/hr·ft <sup>2</sup> ·°F)	4101
thermal conductivity, saturated vapor:	0.00995 W/m·K (0.00575 Btu/hr·ft <sup>2</sup> ·°F)	4101
· 60 °C (140 °F) -----		
pressure, saturated vapor:	3458 kPa (501.6 psia)	3209
· critical point -----		
temperature:	67.1 °C (152.7 °F)	4101
pressure:	3964 kPa (574.9 psia)	3209
density:	745 kg/m <sup>3</sup> (46.5 lb/cf)	3209
specific volume:	1.34 L/kg (0.0215 cf/lb)	3209

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	65 yr	9501
ODP (ozone depletion potential):	12 (model-derived relative to R 11)	9501
	13 (semi-empirical relative to R 11)	9501
	10.0 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	6900 relative to CO <sub>2</sub> for 100 yr integration	9501

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-0-0	MSDS
	DuPont: 1-0-1	MSDS
	Elf Atochem: 1-0-0-H	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	6 in absence of flame or hot objects	0036
DFG pregnancy risk group:	C (no risk fear below MAK/BAT)	7101
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	40,000 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	50,000 ppm v/v for 30 min	3903
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	7101
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommended exposure limit):	1,000 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504



MAK (maximum workplace concentration): 1,000 ppm v/v TWA for 8 hr/day 7101  
40 (or 42) hr/wk

• acute (short-term) toxicity -----  
LC50 (lethal concentration, 50%): rat, 4 hr: estimated >800,000 5526  
ppm (fatal concentration by  
inhalation for half of test  
animals)

ALC (approximate lethal concentration): rat, 1 hr, 0/10: >770,000 ppm 5C79  
(lowest exposure tested with  
one or more deaths by  
inhalation)  
rat, 7 hr, 40%: 370,000 ppm 5340  
(lowest exposure tested with  
one or more deaths by  
inhalation)

cardiac sensitization (CS) EC50: dog, 5 min: 200,000 ppm v/v 6110  
(effective concentration in  
half of test animals)

cardiac sensitization threshold/LOEL: dog, 10 min, 1/18: 75,000 ppm 65E7  
v/v (lowest observed effect  
level in test animals)

cardiac sensitization (CS) NOEL: dog, 10 min, 0/62: 50,000 ppm 65E7  
v/v (no observed effect level  
in test animals)  
dog, 10 min, 0/6: 150,000 ppm 5755  
v/v (no observed effect level  
in test animals)

anesthetic/CNS effect EC50: rat, 10 min: stimulant 420,000 6110  
ppm v/v (effective  
concentration in half of test  
animals)

anesthetic concentration: human, 30 min: 43,000-45,000 5340  
ppm v/v

anesthetic/CNS effect LOEL: rat, 26 min: 500,000 ppm v/v 5C42  
(lowest observed effect level  
in test animals)  
rat, 1 hr, ?/10: 560,000 ppm 5C79  
v/v (lowest observed effect  
level in test animals)

• flammability -----  
LFL-UFL (flammability limits in air): none (nonflammable as tested) 0036  
flash point: none (nonflammable as tested) 3903  
autoignition temperature: BOC Gases: none MSDS  
Dupont: >850 °C (>1562 °F) MSDS  
autodecomposition temperature: Elf Atochem: >427 °C (>800 °F) MSDS

• detection -----  
appearance: colorless gas 5340  
odor: ethereal 3743  
odorless 5340

**PRODUCTION**

first commercial use as a refrigerant: late 1950s  
last year production allowed: 1993 (under Article 2B) in 8C01  
developed countries under the  
Montreal Protocol



(fatal concentration by inhalation for half of test animals)

cardiac sensitization threshold/LOEL: 4,000 ppm v/v (lowest observed 65G3 effect level in test animals)

cardiac sensitization (CS) NOEL: 2,000 ppm v/v (no observed 65G3 effect level in test animals)

anesthetic/CNS effect LOEL: rat, 15 min: 100,000 ppm v/v 65G2 (lowest observed effect level in test animals)

• flammability -----  
 LFL-UFL (flammability limits in air): PS: nonflammable as tested MSDS  
 flash point: Pacific Scientific: nonflammable MSDS

• detection -----  
 appearance: Pacific Scientific: colorless MSDS  
 odor: Pacific Scientific: with odor MSDS



viscosity, saturated liquid:	307 $\mu\text{Pa}\cdot\text{s}$ (0.307 cp)	8401
viscosity, saturated vapor:	8.38 $\mu\text{Pa}\cdot\text{s}$ (0.00838 cp)	8401
thermal conductivity, liquid:	0.0973 W/m $\cdot$ K (0.0562 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, vapor:	0.0054 W/m $\cdot$ K (0.0031 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· normal pressure, 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
density, vapor:	3.673 kg/m $^3$ (0.2293 lb/cf)	8401
· normal pressure, 21.1 $^{\circ}$ C (70 $^{\circ}$ F) ---		
density, vapor:	3.659 kg/m $^3$ (0.2284 lb/cf)	8401
· critical point -----		
temperature:	-45.6 $^{\circ}$ C (-50.2 $^{\circ}$ F)	8401
pressure:	3750 kPa (543.9 psia)	8401
density:	626 kg/m $^3$ (39.1 lb/cf)	8401
specific volume:	1.60 L/kg (0.0256 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{\text{atm}}$ ):	50,000 yr	6694
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	5700 relative to CO $_2$ for 100 yr integration	9501
HGWP (halocarbon GWP):	700 relative to R 11 for infinite integration period	DW

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-0-0 Matheson: 1-0-0 health-flammability-reactivity [-special]: 0=no, 4=severe	MSDS MSDS
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-0-0 DuPont: 1-0-1 health-flammability-reactivity 0=insignificant, 4=extreme	MSDS MSDS
UL Comparative Hazard to Life Group:	6 in absence of flame or hot objects	0036
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 15 min, DuPont: 895,000 ppm (lowest exposure tested with one or more deaths by inhalation)	MSDS
	rat, 1 hr, 0/10: >780,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5C79
cardiac sensitization threshold/LOEL:	dog, 10 min, 3/6: 600,000 ppm v/v (lowest observed effect level in test animals)	5C79
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/6: >200,000 ppm v/v (no observed effect level in test animals)	5C79
anesthetic/CNS effect LOEL:	rat, 1 hr, ?/10: 780,000 ppm v/v (lowest observed effect level in test animals)	5C79
anesthetic/CNS effect NOEL:	rat, 10 day, 0/20: 226,000 ppm v/v (no observed effect level in test animals)	5C79

· flammability -----  
 LFL-UFL (flammability limits in air): none (nonflammable as tested) 0036  
   flash point: DuPont: will not burn MSDS  
   autoignition temperature: BOC Gases: none MSDS  
   DuPont: >1,100 °C (>2,000 °F) MSDS

· detection -----  
   appearance: DuPont: clear, colorless MSDS  
   odor: Daikin: faint ethereal odor MSDS  
   DuPont: none MSDS  
   Matheson: odorless MSDS

**PRODUCTION**  
 first commercial use as a refrigerant: 1955 5C39  
 last year production allowed: unrestricted 8C01



pressure:	5384 kPa (780.9 psia)	3211
density:	496 kg/m <sup>3</sup> (31.0 lb/cf)	3211
specific volume:	2.02 L/kg (0.0323 cf/lb)	3211

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	0.51 +1.5, -.5 yr	6695
ODP (ozone depletion potential):	<0.001 (model-derived relative to R 11)	5782
GWP (global warming potential):	5 relative to CO <sub>2</sub> for 100 yr integration	9501

**SAFETY**

• classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
UL Comparative Hazard to Life Group:	3 in absence of flame or hot objects	4B64
IARC/CIRC human carcinogenicity group:	2B, possibly carcinogenic	8802
NIOSH caution:	potential occupational carcinogen (limit exposures to lowest feasible)	5204
ACGIH carcinogenicity category:	A3, animal carcinogen	9504
DFG carcinogenicity class:	IIIB: suspect, to be evaluated	5561
DFG pregnancy risk group:	B (risk probable below MAK/BAT)	5561
• short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	500 ppm v/v (potential occupational carcinogen)	5204
NIOSH SCP IDLH (immediately dangerous):	1,000 ppm v/v for 30 min (SCP excluded potential carcinogenic effects)	3903
NIOSH STEL (short-term exposure limit):	2 ppm v/v TWA for 60 min	5204
• occupational exposure limit -----		
OSHA PEL-C (exposure ceiling):	50 ppm v/v (must not exceed)	5204
MAK (maximum workplace concentration):	II, 1: 20 ppm v/v avg for 30 min	7101
• long-term occupational limit -----		
ACGIH TLV-TWA (time-weighted average):	10 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	10 ppm v/v TWA for 8 hr/day (or 42) hr/wk being examined for changes	5561 7101
• emergency exposure limit -----		
NRC EEGL (emergency exposure level):	1 hr: 100 ppm v/v ceiling guidance level for single emergency exposures	7413
	24 hr: 30 ppm v/v ceiling guidance level for single emergency exposures	7413
AIHA ERPG-3 (life-threatening):	5,000 ppm v/v for 1 hr	9503
AIHA ERPG-2 (injurious or impairing):	50 ppm v/v for 1 hr	9503
AIHA ERPG-1 (odor or mild effects):	not appropriate	9503
• special-purpose exposure control ---		
NRC CEGL (continuous exposure level):	90 day: 1 ppm v/v ceiling guidance for prolonged exposure in closed environments	7413
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 10 min: 26,000 ppm (fatal concentration by inhalation for half of test)	5980

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



	animals)	
	rat, 15 min: 76,000 ppm (fatal	6110
	concentration by inhalation	
	for half of test animals)	
cardiac sensitization (CS) EC50:	dog, 5 min: 16,000 ppm v/v	6110
	(effective concentration in	
	half of test animals)	
anesthetic/CNS effect EC50:	mouse, 10 min: 7,800 ppm v/v	5980
	(effective concentration in	
	half of test animals)	
• flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
	flash point:	none (nonflammable as tested) 3903
• detection -----		
	appearance:	colorless liquid 7413

## R-20B1

----- REFRI GERANT DATA SUMMARY -----  
 R-20B1 bromodichloromethane see  
 HBC CHBrCl2 CAS number 75-27-4 RDB#  
 -----

**IDENTIFIERS**

common name(s): R-20B1; R20B1; R 20B1  
 HBCC-20B1  
 halochemical 20B1  
 halon 1021  
 chemical name (by IUPAC convention): bromodichloromethane  
 alternative chemical names/formulae: methane, bromodichloro-  
 CHBrCl2  
 not recommended:  
 BrCCl2H; CBrCl2H; BrCl2HC  
 CAS number: 75-27-4 Chemical Abstracts  
 Service Registry Number  
 Beilstein registry number: 1697005  
 EINECS number: 200-856-7 (European Inventory  
 of Existing Chemical  
 Substances)  
 Merck Index (volume-number): 12-1438  
 NIOSH RTECS number: PB5310000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----  
 molar mass: 163.82804 g/mol (0.361179 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: 88.0 °C (190.4 °F) PCRL

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · occupational exposure warnings -----  
 substance under study: ACGIH 8810

## R-20B3

```

----- REFRIERANT DATA SUMMARY -----
R-20B3      tribromomethane      see
HBC         CHBr3                CAS number 75-25-2      RDB#
-----

```

**COMMON USE(S)**

historical use constrained by high normal boiling point; present use also constrained by ozone depletion potential; chemical intermediate; solvent; drinking water contaminant from water chlorination

**IDENTIFIERS**

```

common name(s):  R-20B3; R20B3; R 20B3
                  HBC-20B3
                  halochemical 20B3
                  halon 1003
chemical name (by IUPAC convention):  tribromomethane
alternative chemical names/formulae:  methane, tribromo-
                                      bromoform
                                      methane tribromide
                                      methenyl tribromide
                                      CHBr3
                                      not recommended:
                                      CBr3H; Br3HC
CAS number:      75-25-2 Chemical Abstracts
                  Service Registry Number
Beilstein registry number:  1731048
EINECS number:    200-854-6 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number:  PB5600000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:  252.73064 g/mol (0.557176      8820
              lb/mol)
normal freezing/melting/triple point:  8.3 °C (46.9 °F)      5204
· normal boiling point -----
temperature:  149.4 °C (300.9 °F)      5204
· 20 °C (68 °F) -----
density, saturated liquid:  2890 kg/m3 (180.42 lb/cf)      7601

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601
IARC/CIRC human carcinogenicity group:  3, not classifiable      8802
ACGIH carcinogenicity category:  A3, animal carcinogen      9504
DFG carcinogenicity class:  IIIB: suspect, to be evaluated  5561
· occupational exposure warnings -----
ACGIH caution:  cutaneous absorption potential  9504
substance under study:  ACGIH      8810
· short-term occupational limit -----

```

NIOSH IDLH (immediately dangerous):	850 ppm v/v	5204
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	0.5 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	0.5 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	0.5 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
flash point:	none (nonflammable as tested)	3903

## R-2013

----- REFRIGERANT DATA SUMMARY -----  
 R-2013 triiodomethane see  
 HIC CHI3 CAS number 75-47-8 RDB#  
 -----

**COMMON USE (S)**

under limited consideration as a blend component for alternatives and as a fire suppressant; constrained by limited toxicity and and decomposition at 210 °C (410 °F)

**IDENTIFIERS**

common name(s): R-2013; R2013; HIC-2013  
 halochemical 2013  
 iodoform  
 chemical name (by IUPAC convention): triiodomethane  
 alternative chemical names/formulae: tri-iodomethane  
 methane, triiodo-  
 CHI3  
 not recommended:  
 CI3H; HI3C; I3HC  
 CAS number: 75-47-8 Chemical Abstracts  
 Service Registry Number  
 Beilstein registry number: 1697010  
 EINECS number: 200-874-5 (European Inventory  
 of Existing Chemical  
 Substances)  
 Merck Index (volume-number): 12-5054  
 NIOSH RTECS number: PB7000000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----  
 molar mass: 393.73205 g/mol (0.868031 8820  
 lb/mol)  
 normal freezing/melting/triple point: 118.9 °C (246.0 °F) 5204  
 · normal boiling point -----  
 temperature: 210.0 °C (410.0 °F) 5204

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · long-term occupational limit -----  
 NIOSH REL (recommendd exposure limit): 0.6 ppm v/v TWA for 10 hr/day 5204  
 and 40 hr/wk  
 ACGIH TLV-TWA (time-weighted average): 0.6 ppm v/v TWA for 8 hr/day 9504  
 and 40 hr/wk  
 · flammability -----  
 LFL-UFL (flammability limits in air): none (nonflammable as tested) 5204  
 flash point: none (nonflammable as tested) 5204

## R-21

----- REFRIGERANT DATA SUMMARY -----  
 R-21                    dichlorofluoromethane                    see  
 HCFC                    CHCl2F                    CAS number 75-43-4                    RDB#  
 -----

**COMMON USE(S)**

R-21 was the first fluorocarbon synthesized as a potential refrigerant in 1928 by T. Midgley, A. Henne, and R. McNary; used in domestic refrigerators beginning in 1935 for approximately one year; displaced by refrigerant 12 despite favorable thermodynamic properties, due to incompatibility with polymers and decomposition in the presence of water; used as a heat transfer fluid in early spacecraft in the USA, but displaced by fluorochemical 114; current use constrained by chlorine content and concerns with health effects including action as a convulsant and anesthetic in high concentrations; candidate blend component in Russia in service fluids for existing equipment to replace refrigerant 12

**IDENTIFIERS**

common name(s): R-21; R21; R 21  
 HCFC-21  
 fluorocarbon 21  
 fluorochemical 21; FC 21  
 halocarbon 21  
 halochemical 21  
 halon 112  
 hydrochlorofluorocarbon 21  
 chemical name (by IUPAC convention): dichlorofluoromethane  
 alternative chemical names/formulae: methane, dichlorofluoro-  
 dichloromonofluoromethane  
 fluorodichloromethane  
 CHCl2F  
 not recommended:  
 CC12FH; CFC12H  
 Cl2FHC; FCl2HC  
 CAS number: 75-43-4 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: PA8400000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): Allied Chemical Genetron(R) 21  
 Elf Atochem Forane(R) 21                    MSDS  
 historical name(s): Allied Corp refrigerant 42  
 Ausimont Algofrene(R) Type 5  
 Crosley Radio Thermon                    2113  
 DuPont Freon(R) 21  
 ICI Arcton(R) 7  
 Kinetic Chemicals F21  
 Kinetic Chemicals Freon 21  
 Montecatini (I) Algofrene 21                    7601  
 VVB Dresden Frigedohn 21                    7601  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

· properties -----		
	molar mass:	102.9224432 g/mol (0.226905 lb/mol) 8820
	normal freezing/melting/triple point:	-130.3 °C (-202.6 °F) 8814
· normal boiling point -----		
	temperature:	8.9 °C (48.0 °F) 8814
	density, saturated liquid:	1406 kg/m <sup>3</sup> (87.74 lb/cf) 8814
	density, saturated vapor:	4.61 kg/m <sup>3</sup> (0.288 lb/cf) 8814
	specific volume, saturated liquid:	0.712 L/kg (0.0114 cf/lb) 8814
	specific volume, saturated vapor:	216.7 L/kg (3.4715 cf/lb) 8814
	heat of vaporization:	239.5 kJ/kg (102.9 Btu/lb) 8814
	velocity of sound, saturated liquid:	784 m/s (2573 ft/s) 8814
	velocity of sound, saturated vapor:	159 m/s (521 ft/s) 8814
	viscosity, saturated vapor:	10.06 µPa·s (0.01006 cp) 8814
	viscosity, saturated liquid:	435 µPa·s (0.435 cp) 8814
	thermal conductivity, liquid:	0.1116 W/m·K (0.0645 Btu/hr·ft <sup>2</sup> ·°F) 8814
	thermal conductivity, vapor:	0.0081 W/m·K (0.0047 Btu/hr·ft <sup>2</sup> ·°F) 8814
· normal pressure, 20 °C (68 °F) -----		
	density, vapor:	4.416 kg/m <sup>3</sup> (0.2757 lb/cf) 8814
· normal pressure, 21.1 °C (70 °F) ---		
	density, vapor:	4.398 kg/m <sup>3</sup> (0.2745 lb/cf) 8814
· 20 °C (68 °F) -----		
	pressure, saturated vapor:	153.2 kPa (22.21 psia) 8814
	density, saturated liquid:	1380 kg/m <sup>3</sup> (86.12 lb/cf) 8814
	density, saturated vapor:	6.79 kg/m <sup>3</sup> (0.424 lb/cf) 8814
	specific volume, saturated liquid:	0.725 L/kg (0.0116 cf/lb) 8814
	specific volume, saturated vapor:	14.7 L/kg (0.2358 cf/lb) 8814
	velocity of sound, saturated liquid:	747 m/s (2450 ft/s) 8814
	velocity of sound, saturated vapor:	160 m/s (525 ft/s) 8814
	viscosity, saturated liquid:	384 µPa·s (0.384 cp) 8814
	viscosity, saturated vapor:	10.5 µPa·s (0.0105 cp) 8814
	thermal conductivity, saturated liquid:	0.1069 W/m·K (0.0618 Btu/hr·ft <sup>2</sup> ·°F) 8814
	thermal conductivity, saturated vapor:	0.00860 W/m·K (0.00497 Btu/hr·ft <sup>2</sup> ·°F) 8814
· 60 °C (140 °F) -----		
	pressure, saturated vapor:	521 kPa (75.6 psia) 8814
	heat of vaporization:	208.1 kJ/kg (89.5 Btu/lb) 8814
· critical point -----		
	temperature:	178.3 °C (353.0 °F) 8814
	pressure:	5181 kPa (751.4 psia) 8814
	density:	526 kg/m <sup>3</sup> (32.8 lb/cf) 8814
	specific volume:	1.90 L/kg (0.0305 cf/lb) 8814
<b>ENVIRONMENTAL</b>		
	average atmospheric lifetime (τ <sub>atm</sub> ):	2.0 yr 9501
	ODP (ozone depletion potential):	0.010 (model-derived relative to R 11) 5782
		0.04 (estimate used for the Montreal Protocol) 6904
	GWP (global warming potential):	210 relative to CO <sub>2</sub> for 100 yr integration 9501
<b>SAFETY</b>		
· classification -----		
	safety group (ASHRAE Standard 34):	B1 8601
	NFPA 704 degrees of hazard (H-F-R-S):	Elf Atochem: 2-0-0 MSDS

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	health-flammability-reactivity [-special]: 0=no, 4=severe	
UL Comparative Hazard to Life Group:	between 4 and 5 in absence of flame or hot objects	5173
• short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	5,000 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	50,000 ppm v/v for 30 min	3903
• occupational exposure limit -----		
MAK (maximum workplace concentration):	II, 1: 20 ppm v/v avg for 30 min	5561
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
	vacated: 10 ppm v/v TWA for 8 hr/day and 40 hr/wk	3903
NIOSH REL (recommndd exposure limit):	10 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	10 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	10 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
• emergency exposure limit -----		
NRC EEGL (emergency exposure level):	1 hr: 100 ppm v/v ceiling guidance level for single emergency exposures	7414
	24 hr: 3 ppm v/v ceiling guidance level for single emergency exposures	7414
• special-purpose exposure control ---		
NRC CEGL (continuous exposure level):	90 day: 1 ppm v/v ceiling guidance for prolonged exposure in closed environments	7414
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 4 hr, Elf Atochem: 49,000 ppm (fatal concentration by inhalation for half of test animals)	MSDS
ALC (approximate lethal concentration):	rat, 2 hr, 2/4: 100,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5365
	rat, 4 hr: 49,900 ppm (lowest exposure tested with one or more deaths by inhalation)	7436
cardiac sensitization (CS) EC50:	dog, 10 min: 25,000 ppm v/v (effective concentration in half of test animals)	6684
cardiac sensitization threshold/LOEL:	dog, 10 min, 2/12: 10,000 ppm v/v (lowest observed effect level in test animals)	7435
cardiac sensitization (CS) NOEL:	dog, 10 min: 5,000 ppm v/v (no observed effect level in test animals)	7435
anesthetic/CNS effect LOEL:	rat, 2 hr, ?/4: 25,000 ppm v/v (lowest observed effect level in ALC or LC50 studies)	5365
	rat, Elf Atochem: 200 ppm v/v (lowest observed effect level)	MSDS

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



anesthetic/CNS effect NOEL:	in ALC or LC50 studies) rat, 2 hr, 0/4: 10,000 ppm v/v (no observed effect level in ALC or LC50 studies)	5365
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	0036
flash point:	none (nonflammable as tested)	3903
autoignition temperature:	554 °C (1030 °F)	5906
	572 °C (1062 °F)	5174
autodecomposition temperature:	Elf Atochem: >427 °C (>800 °F)	MSDS
· detection -----		
appearance:	colorless	7414
odor:	nearly odorless	7414
	slight, ether-like odor	5340
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1935 by Crosley Radio Corp.	2113
last year production allowed:	2029 in developed countries under the Montreal Protocol	8C01

## R-22

----- REFRIERANT DATA SUMMARY -----  
 R-22 chlorodifluoromethane see  
 HCFC CHClF2 CAS number 75-45-6 RDB#  
 -----

**COMMON USE(S)**

most-widely used refrigerant: air conditioners, heat pumps, applied systems, chillers (with piston, scroll, screw, and centrifugal compressors), commercial refrigeration, dehumidifiers; component of refrigerants 401A, 401B, 401C, 402A, 402B, 403A, 403B, 405A, 406A, 409A, 409B, 411A, 411B, 412A, 414A, 414B, 501, 502, 509A, and others; foam blowing agent especially for polystyrenes, polyethylenes, polyurethanes, polyisocyanurates, and phenolics; aerosol propellant for non-food uses; inert ingredient for medical sterilant gases using ethylene oxide (e.g., AlliedSignal Oxyfume(R) 2002); fire suppressant; intermediate to manufacture fluoropolymers

**IDENTIFIERS**

common name(s): R-22; R22; R 22  
 HCFC-22  
 not recommended: HFA-22  
 fluorocarbon 22  
 fluorochemical 22; FC 22  
 halocarbon 22  
 halochemical 22  
 hydrochlorofluorocarbon 22  
 chemical name (by IUPAC convention): chlorodifluoromethane  
 alternative chemical names/formulae: methane, chlorodifluoro-  
 difluorochloromethane  
 difluoromonochloromethane  
 monochlorodifluoromethane  
 CHClF2  
 not recommended:  
 CClF2H; CHF2Cl  
 CAS number: 75-45-6 Chemical Abstracts  
 Service Registry Number  
 Beilstein registry number: 1731036  
 EINECS number: 200-871-9 (European Inventory  
 of Existing Chemical  
 Substances)  
 NIOSH RTECS number: PA6390000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): AlliedSignal Genetron(R) 22 MSDS  
 Asahi Glass Fron AF-22  
 Ausimont Algofrene(R) 22  
 Ausimont Meforex(R) 22 MSDS  
 Daikin Daiflon(R) HCFC-22 MSDS  
 DuPont Freon(R) 22 MSDS  
 Elf Atochem Forane(R) 22  
 HRP (UK) HARP(R) 22  
 ICI Arcton(R) 22 CSDS  
 Pennwalt/Atochem Isotron(R) 22  
 Solvay Solkane(R) 22

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



ODP (ozone depletion potential):	0.034 (model-derived relative to R 11)	5301
	0.05 (semi-empirical relative to R 11)	9501
	0.055 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	1900 relative to CO2 for 100 yr integration	9501
HGWP (halocarbon GWP):	0.345 ±0.025 relative to R 11 for infinite integration period	5964
	0.35 relative to R 11 for infinite integration period	6B35
	0.37 relative to R 11 for infinite integration period	4B16
photochemical reactivity (grnd level):	0.6 relative to methane	4511

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	ARI recommendation: 2-0-0	3A15
	AlliedSignal: 2-0-1	MSDS
	Ausimont: 2-0-0	MSDS
	BOC Gases: 1-0-0	MSDS
	Elf Atochem: 2-1-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 2-0-1	MSDS
	BOC Gases: 1-0-0	MSDS
	DuPont: 1-0-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	5(a) in absence of flame or hot objects	5175
IARC/CIRC human carcinogenicity group:	3, not classifiable	8420
ACGIH carcinogenicity category:	A4, not classifiable as a human carcinogen	9504
DFG pregnancy risk group:	C (no risk fear below MAK/BAT)	5561
· short-term occupational limit -----		
ARI "IDLH" recommendation:	50,000 ppm v/v for 30 min	3A15
NIOSH STEL (short-term exposure limit):	1,250 ppm v/v TWA for 15 min	5204
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 1,000 ppm v/v momentary 60 min	5561
· long-term occupational limit -----		
NIOSH REL (recommended exposure limit):	1,000 ppm v/v TWA for 10 hr/day and 40 hr/wk	5204
ACGIH TLV-TWA (time-weighted average):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
exposure limit consistent to OSHA PEL:	ARI: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	3A15
MAK (maximum workplace concentration):	500 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
	applies only to pure substance	5561
	see note on R-31 contamination	5561
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	25,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	

· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 15 min: 350,000 ppm	6110
	(fatal concentration by inhalation for half of test animals)	
	rat, 4 hr: 220,000 ppm (fatal concentration by inhalation for half of test animals)	3718
	rat, 4 hr: 220,000 ppm (fatal concentration by inhalation for half of test animals)	6127
ALC (approximate lethal concentration):	rat, 2 hr, 1/4: 300,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5365
cardiac sensitization (CS) EC50:	dog, 5 min: 140,000 ppm v/v (effective concentration in half of test animals)	6110
cardiac sensitization threshold/LOEL:	dog, 5 min, 2/12: 50,000 ppm v/v (lowest observed effect level in test animals)	5644
cardiac sensitization (CS) NOEL:	dog, 5 min, 0/12: 25,000 ppm v/v (no observed effect level in test animals)	5644
anesthetic/CNS effect EC50:	rat, 10min: depressant 140,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic/CNS effect LOEL:	rat, 2 hr, ?/4: 50,000 ppm v/v (lowest observed effect level in ALC or LC50 studies)	5365
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
heat of combustion (by ASHRAE 34-92):	2.2 MJ/kg (946 Btu/lb)	2318
flash point:	ICI: does not flash	MSDS
	none (nonflammable as tested)	5204
autoignition temperature:	632 °C (1170 °F)	5175
	BOC Gases: none	MSDS
	Solvay: 635 °C (1175 °F)	MSDS
autodecomposition temperature:	DuPont: 632 °C (1170 °F)	MSDS
former UL Classification:	practically nonflammable (withdrawn for revision of the classification system, category SBQT2)	6938
· detection -----		
	appearance: AlliedSignal: clear, colorless	MSDS
	odor: Elf Atochem: faint ethereal	MSDS
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1936 by T. Midgley, associates	
last year production allowed:	2029 in developed countries under the Montreal Protocol	8C01



**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized







	ICI Arcton(R) 1	
	ICI Arcton(R) 23	
ARI container color / Pantone number:	light blue grey / 428	6601
<b>PHYSICAL</b>		
· properties -----		
	molar mass: 70.0138496 g/mol (0.154354 lb/mol)	8820
normal freezing/melting/triple point:	-155.2 °C (-247.3 °F)	8401
· normal boiling point -----		
	temperature: -82.1 °C (-115.8 °F)	8401
	density, saturated liquid: 1443 kg/m3 (90.09 lb/cf)	8401
	density, saturated vapor: 4.65 kg/m3 (0.290 lb/cf)	8401
	specific volume, saturated liquid: 0.693 L/kg (0.0111 cf/lb)	8401
	specific volume, saturated vapor: 215.0 L/kg (3.4444 cf/lb)	8401
	heat of vaporization: 240.7 kJ/kg (103.5 Btu/lb)	8401
velocity of sound, saturated liquid:	806 m/s (2645 ft/s)	8401
velocity of sound, saturated vapor:	165 m/s (542 ft/s)	8401
	viscosity, saturated liquid: 392 µPa·s (0.392 cp)	8401
	viscosity, saturated vapor: 8.91 µPa·s (0.00891 cp)	8401
	thermal conductivity, liquid: 0.1357 W/m·K (0.0784 Btu/hr·ft°F)	8401
	thermal conductivity, vapor: 0.0065 W/m·K (0.0037 Btu/hr·ft°F)	8401
· normal pressure, 20 °C (68 °F) -----		
	density, vapor: 2.934 kg/m3 (0.1832 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
	density, vapor: 2.923 kg/m3 (0.1825 lb/cf)	8401
· 20 °C (68 °F) -----		
	pressure, saturated vapor: 4201.9 kPa (609.44 psia)	8401
	density, saturated liquid: 776 kg/m3 (48.47 lb/cf)	8401
	density, saturated vapor: 285.13 kg/m3 (17.800 lb/cf)	8401
	specific volume, saturated liquid: 1.288 L/kg (0.0206 cf/lb)	8401
	specific volume, saturated vapor: 3.5 L/kg (0.0562 cf/lb)	8401
velocity of sound, saturated liquid:	162 m/s (530 ft/s)	8401
velocity of sound, saturated vapor:	131 m/s (428 ft/s)	8401
	viscosity, saturated liquid: 58 µPa·s (0.058 cp)	8401
	viscosity, saturated vapor: 19.1 µPa·s (0.0191 cp)	8401
thermal conductivity, saturated liquid:	0.0642 W/m·K (0.0371 Btu/hr·ft°F)	8401
thermal conductivity, saturated vapor:	0.04668 W/m·K (0.02697 Btu/hr·ft°F)	8401
· critical point -----		
	temperature: 25.9 °C (78.7 °F)	8401
	pressure: 4836 kPa (701.4 psia)	8401
	density: 525 kg/m3 (32.8 lb/cf)	8401
	specific volume: 1.90 L/kg (0.0305 cf/lb)	8401
<b>ENVIRONMENTAL</b>		
average atmospheric lifetime (tatm):	243 yr	9501
ODP (ozone depletion potential):	<0.0004 (model-derived relative to R 11)	9501
GWP (global warming potential):	14,800 relative to CO2 for 100 yr integration	9501
HGWP (halocarbon GWP):	6 relative to R 11 for infinite integration period	4511
	8.32 relative to R 11 for infinite integration period	DW

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

**SAFETY**

• classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 1-0-1	MSDS
	BOC Gases: 1-0-0	MSDS
	Elf Atochem: 2-0-0	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 1-0-1	MSDS
	BOC Gases: 1-0-0	MSDS
	DuPont: 1-0-1	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	6 by estimate (not UL test) in	5906
	absence of flame or hot	
	objects	
• long-term occupational limit -----		
exposure limit consistent to OSHA PEL:	AlliedSignal PEL: 1,000 ppm	MSDS
	v/v TWA for 8 hr/day and 40	
	hr/wk	
	DuPont AEL: 1,000 ppm v/v TWA	5604
	for 8 hr/day and 40 hr/wk	
	ICI OEL: 1,000 ppm v/v TWA for	5168
	8 hr/day and 40 hr/wk	
• emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	41,000 ppm v/v (preliminary	
	value under review, based on	
	draft ASHRAE 34aa)	
• acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr, 0/6: >663,000 ppm	6513
	(lowest exposure tested with	
	one or more deaths by	
	inhalation)	
cardiac sensitization (CS) EC50:	dog, 10 min: >500,000 ppm v/v	6684
	(effective concentration in	
	half of test animals)	
cardiac sensitization threshold/LOEL:	dog, 5-10 min: >800,000 ppm	5136
	v/v (lowest observed effect	
	level in test animals)	
cardiac sensitization (CS) NOEL:	dog, 5-10 min: 800,000 ppm v/v	5136
	(no observed effect level in	
	test animals)	
	dog: 500,000 ppm v/v (no	6458
	observed effect level in test	
	animals)	
anesthetic/CNS effect LOEL:	rat, 4 hr, ?/6: 186,000 ppm	6513
	v/v (lowest observed effect	
	level in ALC or LC50 studies)	
	human 1/1: analgesia 800,000	5828
	ppm v/v (lowest observed	
	effect level)	
anesthetic/CNS effect NOEL:	rat, 6 hr, 0/25: 51,000 ppm	7631
	v/v (no observed effect level	
	in ALC or LC50 studies)	
• flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	4511
heat of combustion (by ASHRAE 34-92):	-12.5 MJ/kg (-5374 Btu/lb)	2318
flash point:	AlliedSignal: no flash point	MSDS
	TOC, DuPont: will not burn	MSDS

autoignition temperature:	765 °C (1409 °F)	3960
	>750 °C (>1382 °F)	5931
	BOC Gases: none	MSDS
autodecomposition temperature:	Elf Atochem: >427 °C (>800 °F)	MSDS
former UL Classification:	nonflammable (withdrawn for revision of the classification system, category SBQT2)	5931
· detection -----		
	appearance: DuPont: clear, colorless	MSDS
	odor: DuPont: slight ethereal	MSDS
	ICI: odorless	CSDS
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01





oral LD50 (lethal dosage, 50%):	exposure tested with one or more deaths by inhalation) mouse, 24 hr: 563 mg/kg (fatal dose by ingestion for half of test animals)	6569
cardiac sensitization (CS) EC50:	dog, 5 min: 24,000 ppm v/v (effective concentration in half of test animals)	6109
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/12: 17,900 ppm v/v (no observed effect level in test animals)	65A0
anesthetic/CNS effect EC50:	rat, 10 min: depressant 9,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic concentration:	22 min: 15,000 ppm v/v	6452
• flammability -----		
LFL-UFL (flammability limits in air):	13-23 % v/v	5204
	14.6-21.8 % v/v	2525
autoignition temperature:	662 °C (1224 °F)	4B64
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1926 by W. Carrier	4147
last year production allowed:	unrestricted (short lifetime)	8C01





NIOSH SCP IDLH (immediately dangerous: · occupational exposure limit -----	5,000 ppm v/v for 30 min	3903
MAK (maximum workplace concentration):	II, 1: 400 ppm v/v avg for 30 min	5561
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	200 ppm v/v TWA for 8 hr/day and 40 hr/wk	3903
NIOSH REL (recommendd exposure limit):	200 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	200 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	200 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 30 min: 39,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5C42
anesthetic/CNS effect LOEL:	rat, 26 min: 4,750 ppm v/v (lowest observed effect level in test animals)	5C42
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
flash point:	none (nonflammable as tested)	3903





## R-31

----- REFRIGERANT DATA SUMMARY -----  
 R-31 chlorofluoromethane see  
 HCFC CH<sub>2</sub>ClF CAS number 593-70-4 RDB#  
 -----

**COMMON USE(S)**

component of azeotropic refrigerants 505 and 506; withdrawn from  
 commercial use due to identification as a probable carcinogen

**IDENTIFIERS**

common name(s): R-31; R31; R 31  
 HCFC-31  
 fluorocarbon 31  
 fluorochemical 31; FC-31  
 halocarbon 31  
 halochemical 31  
 hydrochlorofluorocarbon 31  
 chemical name (by IUPAC convention): chlorofluoromethane  
 alternative chemical names/formulae: methane, chlorofluoro-  
 methyl chlorofluoride  
 CH<sub>2</sub>ClF  
 CAS number: 593-70-4 Chemical Abstracts  
 Service Registry Number  
 historical name(s): Allied Corp refrigerant 41

**PHYSICAL**

· properties -----  
 molar mass: 68.4776832 g/mol (0.150967 8820  
 lb/mol)  
 normal freezing/melting/triple point: -133.0 °C (-207.4 °F) 7601  
 · normal boiling point -----  
 temperature: -9.1 °C (15.6 °F) 7601  
 · 20 °C (68 °F) -----  
 density, saturated liquid: 1271 kg/m<sup>3</sup> (79.35 lb/cf) 7601

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.010 (model-derived relative 5782  
 to R 11)  
 0.02 (estimate used for the 6904  
 Montreal Protocol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 DFG carcinogenicity class: IIIA2: carcinogenic in animals 5561  
 · long-term occupational limit -----  
 exposure limit consistent to OSHA PEL: AlliedSignal PEL: 0.1 ppm v/v  
 TWA for 8 hr/day and 40 hr/wk

**PRODUCTION**

last year production allowed: 2029 in developed countries 8C01  
 under the Montreal Protocol



## R-32

## ----- REFRIGERANT DATA SUMMARY -----

R-32	difluoromethane		see
HFC	CH2F2	CAS number 75-10-5	RDB#

**COMMON USE(S)**

under consideration as a long-term replacement with equipment redesign for applications once served by refrigerant 22; key blend component in alternatives including refrigerants 407A, 407B, 407C, 407D, 410A, 410B, 504, and others; low critical temperature, comparatively high pressures, and limited flammability impede broad consideration for use alone

**IDENTIFIERS**

common name(s):	R-32; R32; R 32 HFC-32 fluorocarbon 32 fluorochemical 32; FC 32 halocarbon 32 halochemical 32 hydrofluorocarbon 32 not recommended: HFA-32	2909
chemical name (by IUPAC convention):	difluoromethane	
alternative chemical names/formulae:	methane, difluoro- methylene difluoride methylene fluoride carbon fluoride hydride CH2F2 not recommended: CF2H2; H2F2C; F2H2C	
CAS number:	75-10-5 Chemical Abstracts Service Registry Number	
EINECS number:	200-839-4 (European Inventory of Existing Chemical Substances)	
trade name(s):	AlliedSignal Genetron(R) 32 Ausimont Meforex(R) 32 Daikin fluorocarbon HFC-32 DuPont HFC-32 Elf Atochem Forane(R) 32 ICI Klea(R) 32 Solvay Solkane(R) 32 ZCIRI Kehua (PRC) HFC-32	MSDS MSDS MSDS MSDS MSDS
historical name(s):	Allied Corp refrigerant 140 DuPont Freon(R) 32	5862
ARI container color / Pantone number:	none, use light green grey/413 with red / 185 band	6601

**PHYSICAL**

properties -----		
molar mass:	52.0233864 g/mol (0.114692 lb/mol)	8820
normal freezing/melting/triple point:	-136.8 °C (-214.3 °F)	6B07
normal boiling point -----		

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

temperature:	-51.7 °C (-61.0 °F)	8401
density, saturated liquid:	1213 kg/m3 (75.72 lb/cf)	8401
density, saturated vapor:	2.99 kg/m3 (0.187 lb/cf)	8401
specific volume, saturated liquid:	0.824 L/kg (0.0132 cf/lb)	8401
specific volume, saturated vapor:	334.7 L/kg (5.3611 cf/lb)	8401
heat of vaporization:	381.9 kJ/kg (164.2 Btu/lb)	8401
velocity of sound, saturated liquid:	971 m/s (3185 ft/s)	8401
velocity of sound, saturated vapor:	207 m/s (680 ft/s)	8401
viscosity, saturated liquid:	281 µPa·s (0.281 cp)	8401
viscosity, saturated vapor:	9.25 µPa·s (0.00925 cp)	8401
thermal conductivity, liquid:	0.1901 W/m·K (0.1098 Btu/hr·ft°F)	8401
thermal conductivity, vapor:	0.0083 W/m·K (0.0048 Btu/hr·ft°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	2.192 kg/m3 (0.1368 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	2.183 kg/m3 (0.1363 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	1474.6 kPa (213.87 psia)	8401
density, saturated liquid:	981 kg/m3 (61.27 lb/cf)	8401
density, saturated vapor:	40.86 kg/m3 (2.551 lb/cf)	8401
specific volume, saturated liquid:	1.019 L/kg (0.0163 cf/lb)	8401
specific volume, saturated vapor:	24.5 L/kg (0.3921 cf/lb)	8401
velocity of sound, saturated liquid:	584 m/s (1915 ft/s)	8401
velocity of sound, saturated vapor:	206 m/s (675 ft/s)	8401
viscosity, saturated liquid:	125 µPa·s (0.125 cp)	8401
viscosity, saturated vapor:	12.7 µPa·s (0.0127 cp)	8401
thermal conductivity, saturated liquid:	0.1390 W/m·K (0.0803 Btu/hr·ft°F)	8401
thermal conductivity, saturated vapor:	0.01430 W/m·K (0.00826 Btu/hr·ft°F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	3933 kPa (570.5 psia)	8401
heat of vaporization:	175.5 kJ/kg (75.5 Btu/lb)	8401
· critical point -----		
temperature:	78.1 °C (172.6 °F)	8970
	78.2 °C (172.7 °F)	9125
pressure:	5782 kPa (838.6 psia)	8401
density:	424 kg/m3 (26.5 lb/cf)	8401
	429 kg/m3 (26.8 lb/cf)	9125
specific volume:	2.36 L/kg (0.0378 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	5.6 ±1.4 yr	6695
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	3B12
GWP (global warming potential):	880 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.11 relative to R 11 for infinite integration period	4511
	0.13 relative to R 11 for infinite integration period	3730
	0.14 relative to R 11 for infinite integration period	6B35
	ICI: 0.15 relative to R 11 for infinite integration period	CSDS

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A2	8601
NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 2-4-0	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 2-4-0	MSDS
	DuPont: 1-4-1	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
· long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	1,000 ppm v/v TWA for 8 hr/day	5C14
	and 40 hr/wk	
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	32,000 ppm v/v (preliminary	
	value under review, based on	
	draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr: >760,000 ppm	6171
	(lowest exposure tested with	
	one or more deaths by	
	inhalation)	
cardiac sensitization (CS) EC50:	dog, 10 min: >350,000 ppm v/v	6684
	(effective concentration in	
	half of test animals)	
cardiac sensitization threshold/LOEL:	dog, 10 min, 1/12: 250,000 ppm	6170
	v/v (lowest observed effect	
	level in test animals)	
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/1: 200,000 ppm	6170
	v/v (no observed effect level	
	in test animals)	
anesthetic/CNS effect LOEL:	rat, 4 hr, 10/10: 85,900 ppm	5740
	v/v (lowest observed effect	
	level in ALC or LC50 studies)	
anesthetic/CNS effect NOEL:	rat, 6 hr, 0/10: 49,500 ppm	5741
	v/v (no observed effect level	
	in subchronic or chronic	
	study)	
· flammability -----		
LFL-UFL (flammability limits in air):	12.7-33.5 % v/v	2525
	14-31 % v/v	4511
	AlliedSignal: 12.7-33.4 % v/v	MSDS
	Daikin: 13.3-29.3 % v/v	MSDS
LFL-UFL (flammability limits, 95 °C):	11.4-33.8 % v/v	2525
LFL-UFL (with spark ignition):	13.5-31.4 % v/v	2525
LFL-UFL (with hot-wire ignition):	14.2-28.9 % v/v	2525
heat of combustion (by ASHRAE 34-92):	9.4 MJ/kg (4034 Btu/lb)	2318
flash point:	ALSig: gas, not applicable	MSDS
autoignition temperature:	648 °C (1198 °F)	3960
	685 °C (1265 °F)	5C14
	AlliedSignal: 750 °C (1382 °F)	MSDS
autodecomposition temperature:	AlliedSignal: >250 °C (>482 °F)	MSDS
· detection -----		
appearance:	colorless	5C14
odor:	slight ethereal	5C14
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01



## R-40 (methyl chloride)

```

----- REFRIGERANT DATA SUMMARY -----
R-40      chloromethane      see
HCC       CH3Cl             CAS number 74-87-3      RDB#
-----

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**COMMON USE(S)**

identified as a "refrigerant" in historical (1700s) accounts, but such use was as a topical anesthetic for amputations; first used as a refrigerant in vapor-compression machines in 1878; widely used in refrigerators and commercial refrigeration in the 1920s and 1930s, but displaced by refrigerant 12 and others in the late 1930s and 1940s; limited interest resurfaced in 1944 and 1945 due to wartime shortages of refrigerant 12

**IDENTIFIERS**

```

common name(s):  R-40; R40; R 40
                 HCC-40
                 chlorochemical 40
                 halocarbon 40
                 halochemical 40
chemical name (by IUPAC convention):  chloromethane
alternative chemical names/formulae:  methane, chloro-
                                     methyl chloride
                                     monochloromethane
                                     CH3Cl
                                     not recommended: CClH3; H3ClC
CAS number:      74-87-3 Chemical Abstracts
                 Service Registry Number
NIOSH RTECS number:  PA6300000 (Registry of Toxic
                       Effects of Chemical
                       Substances)
historical name(s):  chlormethyl ether      2113
                   E. I. DuPont de Nemours Artic
                   Kinetic Chemical Artic
                   Roessler and Hasslacher Artic
ARI container color / Pantone number:  none; use light green grey/413 6601
                                     with red / 185 band

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**PHYSICAL**

```

· properties -----
molar mass:      50.48722 g/mol (0.111305      8820
                 lb/mol)
normal freezing/melting/triple point:  -97.8 °C (-144.0 °F)      1136
· normal boiling point -----
temperature:     -23.0 °C (-9.4 °F)           MSDS
                 -24.0 °C (-11.3 °F)           7809
                 -24.2 °C (-11.6 °F)           1136
heat of vaporization:  428.7 kJ/kg (184.3 Btu/lb)      0036
· 20 °C (68 °F) -----
pressure, saturated vapor:  490.0 kPa (71.07 psia)      MSDS
· critical point -----
temperature:     143.1 °C (289.6 °F)           0036
pressure:        6674 kPa (968.0 psia)         0036
density:         353 kg/m3 (22.0 lb/cf)         0036

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

specific volume: 2.83 L/kg (0.0454 cf/lb) 0036

**ENVIRONMENTAL**

average atmospheric lifetime (t<sub>atm</sub>): 1.3 yr 9501  
 ODP (ozone depletion potential): 0.02 (model-derived relative to R 11) 9501  
 GWP (global warming potential): 16 relative to CO<sub>2</sub> for 100 yr integration 9501

**SAFETY**

• classification -----  
 safety group (ASHRAE Standard 34): B2 8601  
 NFPA 704 degrees of hazard (H-F-R-S): BOC Gases: 1-4-1 MSDS  
 health-flammability-reactivity  
 [-special]: 0=no, 4=severe  
 NPCA HMIS hazard ratings (H-F-R): BOC Gases: 1-4-1 MSDS  
 health-flammability-reactivity  
 0=insignificant, 4=extreme  
 UL Comparative Hazard to Life Group: 4 in absence of flame or hot objects 4B64  
 IARC/CIRC human carcinogenicity group: 3, not classifiable 8802  
 NIOSH caution: potential occupational carcinogen (limit exposures to lowest feasible) 5204  
 ACGIH carcinogenicity category: A4, not classifiable as a human carcinogen 9504  
 DFG carcinogenicity class: IIIB: suspect, to be evaluated 5561  
 DFG pregnancy risk group: B (risk probable below MAK/BAT) 5561  
 • occupational exposure warnings -----  
 ACGIH caution: cutaneous absorption potential 9504  
 • short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 2,000 ppm v/v 5204  
 NIOSH SCP IDLH (immediately dangerous): 10,000 ppm v/v for 30 min 3903  
 ACGIH TLV-STEL (short-term exp limit): 100 ppm v/v TWA for 15 min 9504  
 • occupational exposure limit -----  
 OSHA PEL-C (exposure ceiling): 200 ppm v/v (must not exceed) 3904  
 OSHA acceptable maximum peak: 300 ppm for 5 min in 3 hr 3904  
 (peak allowed over ceiling for specified interval)  
 Dow Hyg Guide excursion: 75ppm MSDS  
 (peak allowed over ceiling for specified interval)  
 MAK (maximum workplace concentration): II, 1: 100 ppm v/v avg for 30 min 5561  
 • long-term occupational limit -----  
 OSHA PEL (permissible exposure limit): 100 ppm v/v TWA for 8 hr/day and 40 hr/wk 3904  
 ACGIH TLV-TWA (time-weighted average): 50 ppm v/v TWA for 8 hr/day and 40 hr/wk 9504  
 exposure limit consistent to OSHA PEL: Dow Hygiene Guide: 25 ppm v/v MSDS  
 TWA for 8 hr/day and 40 hr/wk  
 MAK (maximum workplace concentration): 50 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk 5561  
 • emergency exposure limit -----  
 AIHA ERPG-3 (life-threatening): 1,000 ppm v/v for 1 hr 4B83  
 AIHA ERPG-2 (injurious or impairing): 400 ppm v/v for 1 hr 4B83  
 AIHA ERPG-1 (odor or mild effects): not appropriate ppm v/v for 1 hr 4B83  
 • acute (short-term) toxicity -----

LC50 (lethal concentration, 50%):	rat, 30 min, BOC Gases: 4,300 ppm (fatal concentration by inhalation for half of test animals)	MSDS
· flammability -----		
LFL-UFL (flammability limits in air):	8.0-18.9 % v/v	6633
	8.1-17.2 % v/v	0036
flash point:	Dow: -46 °C (-51 °F)	MSDS
	OC, BOC Gases: 0 °C (32 °F)	MSDS
	not applicable for gas	5204
autoignition temperature:	632 °C (1170 °F)	3960
	632 °C (1170 °F)	4B64
· detection -----		
appearance:	BOC Gases: colorless gas	MSDS
	Dow: water-white liquified gas	MSDS
odor:	BOC Gases: slightly sweet odor	MSDS
	Dow: odorless	MSDS
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1878 by C. Vincent	2115

## R-40B1

----- REFRIGERANT DATA SUMMARY -----  
 R-40B1 bromomethane see  
 HBC CH3Br CAS number 74-83-9 RDB#  
 -----

**COMMON USE(S)**

limited use in early refrigeration, but displaced (primarily by  
 refrigerant 12) in the late 1930s and 1940s due to its high toxicity;  
 widely used as a fumigant and pesticide before planting

**IDENTIFIERS**

common name(s): R-40B1; R40B1; R 40B1  
 HBC-40B1  
 bromochemical 40B1  
 halochemical 40B1  
 halon 1001  
 chemical name (by IUPAC convention): bromomethane  
 alternative chemical names/formulae: methane, bromo-  
 methyl bromide  
 monobromomethane  
 CH3Br  
 not recommended: CBrH3  
 CAS number: 74-83-9 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: PA4900000 (Registry of Toxic  
 Effects of Chemical  
 Substances)

**PHYSICAL**

· properties -----  
 molar mass: 94.93852 g/mol (0.209304 8820  
 lb/mol)  
 normal freezing/melting/triple point: -93.7 °C (-136.7 °F) 7601  
 · normal boiling point -----  
 temperature: 3.6 °C (38.5 °F) 7601  
 4.6 °C (40.3 °F) 4B64  
 · critical point -----  
 temperature: 191.0 °C (375.8 °F) 7601

**ENVIRONMENTAL**

average atmospheric lifetime (τ<sub>atm</sub>): 0.7 yr 9501  
 ODP (ozone depletion potential): 0.37 (0.2-0.5) (model-derived 9501  
 relative to R 11)  
 0.57 (semi-empirical relative 9501  
 to R 11)  
 0.6 (estimate used for the 6904  
 Montreal Protocol)  
 GWP (global warming potential): 5 relative to CO<sub>2</sub> for 100 yr 9501  
 integration

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 NFPA 704 degrees of hazard (H-F-R-S): BOC Gases: 3-1-0 MSDS

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 3-1-0	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	2 in absence of flame or hot objects	4B64
IARC/CIRC human carcinogenicity group:	3, not classifiable	8802
NIOSH caution:	potential occupational carcinogen (limit exposures to lowest feasible)	3903
ACGIH carcinogenicity category:	A4, not classifiable as a human carcinogen	9504
DFG carcinogenicity class:	IIIB: suspect, to be evaluated	7101
· occupational exposure warnings -----		
ACGIH caution:	cutaneous absorption potential	9504
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	250 ppm v/v (potential occupational carcinogen)	5204
NIOSH SCP IDLH (immediately dangerous):	2,000 ppm v/v for 30 min	3903
· occupational exposure limit -----		
OSHA PEL-C (exposure ceiling):	20 ppm v/v (must not exceed)	3904
· long-term occupational limit -----		
ACGIH TLV-TWA (time-weighted average):	1 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
· emergency exposure limit -----		
AIHA ERPG-3 (life-threatening):	200 ppm v/v for 1 hr	9503
AIHA ERPG-2 (injurious or impairing):	50 ppm v/v for 1 hr	9503
AIHA ERPG-1 (odor or mild effects):	not appropriate	9503
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 8 hr, BOC Gases: 302 ppm (fatal concentration by inhalation for half of test animals)	MSDS
· flammability -----		
LFL-UFL (flammability limits in air):	10-16 % v/v	5204
	none (nonflammable as tested)	4B64
flash point:	not applicable for gas	5204
autoignition temperature:	537 °C (999 °F)	4B64
	BOC Gases: 537 °C (999 °F)	MSDS
· detection -----		
appearance:	BOC Gases: colorless	MSDS
odor:	BOC Gases: slightly sweet odor	MSDS

## R-4011

```

----- REFRIGERANT DATA SUMMARY -----
R-4011      iodomethane
HIC         CH3I                               CAS number 74-88-4      see
                                                RDB#
-----

```

**COMMON USE(S)**

under limited consideration as a blend component, constrained by concerns with toxicity

**IDENTIFIERS**

```

common name(s):  R-4011; R4011; R 4011
                  HIC-4011
                  halochemical 4011
                  halon 10001
chemical name (by IUPAC convention):  iodomethane
alternative chemical names/formulae:  methane, iodo-
                                      methyl iodide
                                      moniodomethane
                                      CH3I
                                      not recommended: CIH3
CAS number:      74-88-4 Chemical Abstracts
                  Service Registry Number
Beilstein registry number:  969135
EINECS number:   200-819-5 (European Inventory
                  of Existing Chemical
                  Substances)
Merck Index (volume-number):  12-6161
NIOSH RTECS number:  PA9450000 (Registry of Toxic
                  Effects of Chemical
                  Substances)

```

**PHYSICAL**

```

· properties -----
molar mass:  141.93899 g/mol (0.312922      8820
              lb/mol)
normal freezing/melting/triple point:  -66.7 °C (-88.1 °F)      3903
· normal boiling point -----
temperature:  42.8 °C (109.0 °F)           3903

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)  8601
  DFG carcinogenicity class:  IIIA2: carcinogenic in animals  5561
· occupational exposure warnings -----
  ACGIH caution:  cutaneous absorption potential  9504
· short-term occupational limit -----
  NIOSH IDLH (immediately dangerous):  100 ppm v/v      5204
  NIOSH SCP IDLH (immediately dangerous):  800 ppm v/v for 30 min  3903
· occupational exposure limit -----
  NIOSH REL-C (exposure ceiling):  2 ppm v/v (must not exceed)  3903
· long-term occupational limit -----
  OSHA PEL (permissible exposure limit):  5 ppm v/v TWA for 8 hr/day and 3904
                                      40 hr/wk
  ACGIH TLV-TWA (time-weighted average):  2 ppm v/v TWA for 8 hr/day and 9504

```

40 hr/wk

- emergency exposure limit -----
  - AIHA ERPG-3 (life-threatening): 125 ppm v/v for 1 hr 4B80
  - AIHA ERPG-2 (injurious or impairing): 50 ppm v/v for 1 hr 4B80
  - AIHA ERPG-1 (odor or mild effects): 25 ppm v/v for 1 hr 4B80
- flammability -----
  - LFL-UFL (flammability limits in air): none (nonflammable as tested) 3903
  - flash point: not applicable for gas 3903

## R-41

----- REFRIGERANT DATA SUMMARY -----  
 R-41 fluoromethane see  
 HFC CH3F CAS number 593-53-3 RDB#  
 -----

**COMMON USE(S)**

candidate both as a single-compound and as a blend component to  
 replace refrigerant 13; consideration constrained by flammability

**IDENTIFIERS**

common name(s): R-41; R41; R 41  
 HFC-41  
 fluorocarbon 41  
 fluorochemical 41; FC 41  
 halocarbon 41  
 halochemical 41  
 chemical name (by IUPAC convention): fluoromethane  
 alternative chemical names/formulae: methane, fluoro-  
 methyl fluoride  
 CH3F  
 not recommended: CFH3  
 CAS number: 593-53-3 Chemical Abstracts  
 Service Registry Number  
 EINECS number: 209-796-6 (European Inventory  
 of Existing Chemical  
 Substances)  
 NIOSH RTECS number: PA9154000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): BOC Gases Fluoromethane MSDS  
 historical name(s): Allied Corp refrigerant 40

**PHYSICAL**

· properties -----  
 molar mass: 34.0329232 g/mol (0.075030 8820  
 lb/mol)  
 normal freezing/melting/triple point: -143.3 °C (-226.0 °F) 8401  
 · normal boiling point -----  
 temperature: -78.1 °C (-108.6 °F) 8401  
 density, saturated liquid: 881 kg/m3 (55.00 lb/cf) 8401  
 density, saturated vapor: 2.23 kg/m3 (0.139 lb/cf) 8401  
 specific volume, saturated liquid: 1.135 L/kg (0.0182 cf/lb) 8401  
 specific volume, saturated vapor: 448.1 L/kg (7.1780 cf/lb) 8401  
 heat of vaporization: 488.8 kJ/kg (210.2 Btu/lb) 8401  
 velocity of sound, saturated liquid: 1142 m/s (3748 ft/s) 8401  
 velocity of sound, saturated vapor: 245 m/s (804 ft/s) 8401  
 viscosity, saturated liquid: 351 µPa·s (0.351 cp) 8401  
 viscosity, saturated vapor: 7.12 µPa·s (0.00712 cp) 8401  
 thermal conductivity, liquid: 0.2487 W/m·K (0.1437 8401  
 Btu/hr·ft°F)  
 thermal conductivity, vapor: 0.0101 W/m·K (0.0059 8401  
 Btu/hr·ft°F)  
 · normal pressure, 20 °C (68 °F) -----  
 density, vapor: 1.428 kg/m3 (0.0891 lb/cf) 8401

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	1.422 kg/m3 (0.0888 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	3405.5 kPa (493.93 psia)	8401
density, saturated liquid:	599 kg/m3 (37.41 lb/cf)	8401
density, saturated vapor:	80.29 kg/m3 (5.012 lb/cf)	8401
specific volume, saturated liquid:	1.669 L/kg (0.0267 cf/lb)	8401
specific volume, saturated vapor:	12.5 L/kg (0.1995 cf/lb)	8401
velocity of sound, saturated liquid:	455 m/s (1493 ft/s)	8401
velocity of sound, saturated vapor:	224 m/s (735 ft/s)	8401
viscosity, saturated liquid:	85 µPa·s (0.085 cp)	8401
viscosity, saturated vapor:	12.7 µPa·s (0.0127 cp)	8401
thermal conductivity, saturatd liquid:	0.1237 W/m·K (0.0714 Btu/hr·ft°F)	8401
thermal conductivity, saturated vapor:	0.03431 W/m·K (0.01983 Btu/hr·ft°F)	8401
· critical point -----		
temperature:	44.1 °C (111.4 °F)	6C01
pressure:	5897 kPa (855.3 psia)	6C01
density:	317 kg/m3 (19.8 lb/cf)	6C01
specific volume:	3.16 L/kg (0.0506 cf/lb)	6C01

**ENVIRONMENTAL**

average atmospheric lifetime (τatm):	3.7 yr	6694
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	140 relative to CO2 for 100 yr integration	9501
HGWP (halocarbon GWP):	0.02 relative to R 11 for infinite integration period	DW

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-4-0 health-flammability-reactivity [-special]: 0=no, 4=severe	MSDS
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-4-0 health-flammability-reactivity 0=insignificant, 4=extreme	MSDS
· flammability -----		
LFL-UFL (flammability limits in air):	probably flammable	
· detection -----		
appearance:	BOC Gases: colorless	MSDS
odor:	BOC Gases: agreeable ether- like odor	MSDS MSDS

**PRODUCTION**

last year production allowed:	unrestricted	8C01
-------------------------------	--------------	------

## R-50 (methane)

## ----- REFRIGERANT DATA SUMMARY -----

R-50	methane		see
HC	CH4	CAS number 74-82-8	RDB#

**COMMON USE(S)**

primary component of natural gas as a fuel; component of air (2 ppm in dry atmospheric air)

**IDENTIFIERS**

common name(s):	R-50; R50; R 50 HC-50 hydrocarbon 50 marsh gas	
chemical name (by IUPAC convention):	methane	
alternative chemical names/formulae:	methyl hydride CH4	
CAS number:	74-82-8 Chemical Abstracts Service Registry Number	
NIOSH RTECS number:	PA1490000 (Registry of Toxic Effects of Chemical Substances)	
historical name(s):	fire damp	
ARI container color / Pantone number:	none, use light green grey/413 6601 with red / 185 band	

**PHYSICAL**

· properties -----		
molar mass:	16.04246 g/mol (0.035368 lb/mol)	8820
normal freezing/melting/triple point:	-182.2 °C (-296.0 °F) -182.5 °C (-296.5 °F)	0036 7413
· normal boiling point -----		
temperature:	-161.5 °C (-258.7 °F)	0036
heat of vaporization:	510.6 kJ/kg (219.5 Btu/lb)	3208
· critical point -----		
temperature:	-82.5 °C (-116.5 °F)	0036
pressure:	4638 kPa (672.7 psia)	0036
density:	162 kg/m3 (10.1 lb/cf)	0036
specific volume:	6.18 L/kg (0.0990 cf/lb)	0036

**ENVIRONMENTAL**

average atmospheric lifetime (tatm):	adjusted: 12.2 ±3.1 yr	6695
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	24 relative to CO2 for 100 yr integration	9501
photochemical reactivity (grnd level):	1.000 relative to methane	4511

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A3	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 0-4-0 Pennzoil: 0-4-0	MSDS MSDS





NIOSH IDLH (immediately dangerous):	300 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	300 ppm v/v for 30 min	3903
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	1 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	1 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	1 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	1 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
· flammability -----		
LEL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
flash point:	none (nonflammable as tested)	3903
	peak limit in preparation	7101

## R-111

----- REFRIERANT DATA SUMMARY -----  
 R-111 pentachlorofluoroethane see  
 CFC CC13CC12F CAS number 954-56-3 RDB#  
 -----

**IDENTIFIERS**

common name(s): R-111; R111; R 111  
 CFC-111  
 fluorocarbon 111  
 fluorochemical 111; FC 111  
 chemical name (by IUPAC convention): pentachlorofluoroethane  
 alternative chemical names/formulae: ethane, pentachlorofluoro-  
 CC13CC12F; CC13-CC12F  
 not recommended:  
 CC12FCC13; CC12F-CC13  
 C13CC12F; C13C-CC12F  
 empirical formula: C2Cl5F  
 CAS number: 954-56-3 Chemical Abstracts  
 Service Registry Number  
 historical name(s): Allied Corp refrigerant 32  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----  
 molar mass: 220.2833032 g/mol (0.485642 8820  
 lb/mol)  
 normal freezing/melting/triple point: 100.0 °C (212.0 °F) 7601  
 · normal boiling point -----  
 temperature: 135.0 °C (275.0 °F) 2909  
 137.0 °C (278.6 °F) 7601  
 · 25 °C (77 °F) -----  
 density, saturated liquid: 1740 kg/m3 (108.62 lb/cf) 7601

**ENVIRONMENTAL**

ODP (ozone depletion potential): 1.0 (estimate used for the 6904  
 Montreal Protocol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

last year production allowed: 1995 in developed countries 8C01  
 under the Montreal Protocol



**ENVIRONMENTAL**

ODP (ozone depletion potential): 1.0 (estimate used for the Montreal Protocol) 6904

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

· short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 2,000 ppm v/v 5204  
 NIOSH SCP IDLH (immediately dangerous): 15,000 ppm v/v for 30 min 3903

· occupational exposure limit -----  
 MAK (maximum workplace concentration): II, 2: 1000 ppm v/v avg for 30 min 5561

· long-term occupational limit -----  
 OSHA PEL (permissible exposure limit): 500 ppm v/v TWA for 8 hr/day 3904  
 and 40 hr/wk  
 NIOSH REL (recommendd exposure limit): 500 ppm v/v TWA for 10 hr/day 3903  
 and 40 hr/wk  
 ACGIH TLV-TWA (time-weighted average): 500 ppm v/v TWA for 8 hr/day 9504  
 and 40 hr/wk  
 MAK (maximum workplace concentration): 200 ppm v/v TWA for 8 hr/day 5561  
 40 (or 42) hr/wk  
 being examined for changes 7101

· acute (short-term) toxicity -----  
 LC50 (lethal concentration, 50%): rat, 15 min: 20,000 ppm (fatal concentration by inhalation for half of test animals) 6110

ALC (approximate lethal concentration: rat, 4 hr: 15,000 ppm (lowest exposure tested with one or more deaths by inhalation) 5169

dermal LD50 (lethal dosage, 50%): rat: >7,500 mg/kg (fatal dose by skin contact for half of test animals) 5161

oral LD50 (lethal dosage, 50%): rat: >25,000 mg/kg (fatal dose by ingestion for half of test animals) 5C42

cardiac sensitization (CS) EC50: dog, 5 min: 1,200 ppm v/v (effective concentration in half of test animals) 6110

anesthetic/CNS effect EC50: rat, 10 min: stimulant 2,400 ppm v/v (effective concentration in half of test animals) 6110

anesthetic/CNS effect LOEL: rat, 4 hr: 3,000 ppm v/v (lowest observed effect level in ALC or LC50 studies) 6590

· flammability -----  
 LFL-UFL (flammability limits in air): none (nonflammable as tested) 5161  
 flash point: none (nonflammable as tested) 3903

· detection -----  
 appearance: white 5367  
 odor: slightly camphor-like 5367

**PRODUCTION**

last year production allowed: 1995 in developed countries under the Montreal Protocol 8C01



## R-112a

```

----- REFRIERANT DATA SUMMARY -----
R-112a      1,1,1,2-tetrachloro-2,2-difluoroethane      see
CFC         CCl3CClF2                                     CAS number 76-11-9      RDB#
-----

```

**COMMON USE(S)**

potential refrigerant for high boiling-point requirements, currently impeded by chlorine content; additive to raise the flash point of solvents

**IDENTIFIERS**

```

common name(s):  R-112a; R112a; R 112a
                  CFC-112a
chemical name (by IUPAC convention):  1,1,1,2-tetrachloro-2,2-
                                       difluoroethane
alternative chemical names/formulae:  1,1-difluorotetrachloroethane
                                       2,2-difluorotetrachloroethane
                                       ethane, 1,1,1,2-tetrachloro-
                                       2,2-difluoro-
                                       1,1-difluoro-1,1,1,2-
                                       tetrachloroethane
                                       CCl3CClF2; CCl3-CClF2
not recommended:
   CClF2CCl3; CClF2-CCl3
   Cl3CCClF2; Cl3C-CClF2
empirical formula:  C2Cl4F2
CAS number:         76-11-9 Chemical Abstracts
                   Service Registry Number
NIOSH RTECS number:  KI1425000 (Registry of Toxic
                   Effects of Chemical
                   Substances)
trade name(s):      DuPont Freon(R) 112a           3903
historical name(s):  Allied Corp refrigerant 131
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:       203.8290064 g/mol (0.449366      8820
                  lb/mol)
normal freezing/melting/triple point:  40.6 °C (105.1 °F)      2250
· normal boiling point -----
temperature:      91.5 °C (196.7 °F)      2250
                  91.7 °C (197.1 °F)      5161
· critical point -----
temperature:      279.2 °C (534.6 °F)      2250
pressure:         4830 kPa (700.5 psia)      2250
density:          754 kg/m3 (47.1 lb/cf)      2250
specific volume:  1.33 L/kg (0.0212 cf/lb)      2250

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601
· short-term occupational limit -----
NIOSH IDLH (immediately dangerous):  2,000 ppm v/v      5204

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

NIOSH SCP IDLH (immediately dangerous:	15,000 ppm v/v for 30 min	3903
ACGIH TLV-STEL (short-term exp limit):	500 ppm v/v TWA for 15 min	9504
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	5561
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	500 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	500 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr: 15,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5C42
dermal LD50 (lethal dosage, 50%):	rat: >11,000 mg/kg (fatal dose by skin contact for half of test animals)	5161
oral LD50 (lethal dosage, 50%):	rat: >25,000 mg/kg (fatal dose by ingestion for half of test animals)	5C42
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	5161
flash point:	none (nonflammable as tested)	3903
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	1995 in developed countries under the Montreal Protocol	8C01

## R-113

----- REFRIERANT DATA SUMMARY -----  
 R-113            1,1,2-trichloro-1,2,2-trifluoroethane            see  
 CFC             CCl2FCClF2    CAS number 76-13-1            RDB#  
 -----

**COMMON USE(S)**

limited use in centrifugal chillers; very limited use in  
 high-temperature heat pumps; aerosol solvent usually propelled with  
 refrigerant 12; widely used as an industrial solvent particularly for  
 cleaning electronic circuit boards and, historically, for dry  
 cleaning; blowing agent

**IDENTIFIERS**

common name(s): R-113; R113; R 113  
 CFC-113  
 TTE; TCTFE  
 fluorocarbon 113  
 fluorochemical 113; FC 113  
 halocarbon 113

chemical name (by IUPAC convention): 1,1,2-trichloro-1,2,2-  
 trifluoroethane

alternative chemical names/formulae: ethane, 1,1,2-trichloro-1,2,2-  
 trifluoro-  
 1,1,2-trichlorotrifluoroethane  
 trichlorotrifluoroethane  
 CCl2FCClF2; CCl2F-CClF2  
 not recommended:  
 Cl2FCClF2; Cl2FC-CClF2

empirical formula: C2Cl3F3  
 CAS number: 76-13-1 Chemical Abstracts  
 Service Registry Number

EINECS number: 200-936-1 (European Inventory  
 of Existing Chemical  
 Substances)

NIOSH RTECS number: KJ4000000 (Registry of Toxic  
 Effects of Chemical  
 Substances)

trade name(s): AlliedSignal Genetron(R) 113    MSDS  
 Asahi Glass Fron AF-113  
 Daikin Daiflon(R) 113  
 DuPont Freon(R) 113                                    MSDS  
 DuPont Freon(R) TF                                    MSDS  
 Elf Atochem Forane(R) 113                            MSDS  
 Hoechst Frigen(R) 113

historical name(s): Allied Corp refrigerant 226  
 Carrier Corporation Carrene 3  
 ICI Arcton(R) 113  
 ICI Arcton(R) 63  
 Union Carbide Ucon(R) 113                            7601  
 VVB Dresden Frigedohn 113                            7601

ARI container color / Pantone number: dark purple (violet) / 266    6601

**PHYSICAL**

· properties -----

molar mass:	187.3747096 g/mol (0.413091 lb/mol)	8820
normal freezing/melting/triple point:	-36.2 °C (-33.2 °F)	8401
· normal boiling point -----		
temperature:	47.6 °C (117.7 °F)	8401
density, saturated liquid:	1508 kg/m <sup>3</sup> (94.15 lb/cf)	8401
density, saturated vapor:	7.42 kg/m <sup>3</sup> (0.463 lb/cf)	8401
specific volume, saturated liquid:	0.663 L/kg (0.0106 cf/lb)	8401
specific volume, saturated vapor:	134.7 L/kg (2.1575 cf/lb)	8401
heat of vaporization:	144.3 kJ/kg (62.0 Btu/lb)	8401
velocity of sound, saturated liquid:	626 m/s (2053 ft/s)	8401
velocity of sound, saturated vapor:	119 m/s (390 ft/s)	8401
viscosity, saturated vapor:	10.31 µPa·s (0.01031 cp)	8401
viscosity, saturated liquid:	500 µPa·s (0.500 cp)	8401
thermal conductivity, liquid:	0.0636 W/m·K (0.0368 Btu/hr·ft <sup>2</sup> °F)	8401
thermal conductivity, vapor:	0.0095 W/m·K (0.0055 Btu/hr·ft <sup>2</sup> °F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, liquid:	1575 kg/m <sup>3</sup> (13.14 lb/gal)	8401
· normal pressure, 21.1 °C (70 °F) ----		
density, liquid:	1573 kg/m <sup>3</sup> (13.12 lb/gal)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	36.7 kPa (5.32 psia)	8401
density, saturated liquid:	1575 kg/m <sup>3</sup> (98.32 lb/cf)	8401
density, saturated vapor:	2.88 kg/m <sup>3</sup> (0.180 lb/cf)	8401
specific volume, saturated liquid:	0.635 L/kg (0.0102 cf/lb)	8401
specific volume, saturated vapor:	34.8 L/kg (0.5570 cf/lb)	8401
velocity of sound, saturated liquid:	716 m/s (2348 ft/s)	8401
velocity of sound, saturated vapor:	116 m/s (381 ft/s)	8401
viscosity, saturated liquid:	709 µPa·s (0.709 cp)	8401
viscosity, saturated vapor:	9.5 µPa·s (0.0095 cp)	8401
thermal conductivity, saturated liquid:	0.0693 W/m·K (0.0400 Btu/hr·ft <sup>2</sup> °F)	8401
thermal conductivity, saturated vapor:	0.00827 W/m·K (0.00478 Btu/hr·ft <sup>2</sup> °F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	150 kPa (21.8 psia)	8401
heat of vaporization:	140.2 kJ/kg (60.3 Btu/lb)	8401
· critical point -----		
temperature:	214.1 °C (417.3 °F)	8401
pressure:	3392 kPa (492.0 psia)	8401
density:	576 kg/m <sup>3</sup> (36.0 lb/cf)	0036
specific volume:	1.79 L/kg (0.0286 cf/lb)	8401
· ENVIRONMENTAL		
average atmospheric lifetime (τ <sub>atm</sub> ):	85 yr	9501
ODP (ozone depletion potential):	0.90 (model-derived relative to R 11)	9501
	0.9 (semi-empirical relative to R 11)	9501
	0.8 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	6000 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	1.35 ±0.05 relative to R 11 for infinite integration period	5964

**SAFETY**

· classification -----  
   safety group (ASHRAE Standard 34): Al 8601  
   NFPA 704 degrees of hazard (H-F-R-S): ARI recommendation: 2-0-0 3A15  
   AlliedSignal: 2-0-1 MSDS  
   BOC Gases: 1-0-0 MSDS  
   NPCA HMIS hazard ratings (H-F-R): AlliedSignal: 1-0-1 MSDS  
   BOC Gases: 1-0-0 MSDS  
   DuPont: 1-0-1 MSDS  
   health-flammability-reactivity  
   0=insignificant, 4=extreme  
   UL Comparative Hazard to Life Group: between 4 and 5 in absence of 5174  
   flame or hot objects  
   ACGIH carcinogenicity category: A4, not classifiable as a 9504  
   human carcinogen  
 · short-term occupational limit -----  
   NIOSH IDLH (immediately dangerous): 2,000 ppm v/v 5204  
   NIOSH SCP IDLH (immediately dangerous: 4,500 ppm v/v for 30 min 3903  
   NIOSH STEL (short-term exposur limit): 1,250 ppm v/v TWA for 15 min 3903  
   ACGIH TLV-STEL (short-term exp limit): 1,250 ppm v/v TWA for 15 min 9504  
 · occupational exposure limit -----  
   MAK (maximum workplace concentration): IV: 1,000 ppm v/v momentary 60 7101  
   min  
 · long-term occupational limit -----  
   OSHA PEL (permissible exposure limit): 1,000 ppm v/v TWA for 8 hr/day 3904  
   and 40 hr/wk  
   NIOSH REL (recommendd exposure limit): 1,000 ppm v/v TWA for 10 3903  
   hr/day and 40 hr/wk  
   ACGIH TLV-TWA (time-weighted average): 1,000 ppm v/v TWA for 8 hr/day 9504  
   and 40 hr/wk  
   MAK (maximum workplace concentration): 500 ppm v/v TWA for 8 hr/day 7101  
   40 (or 42) hr/wk  
 · emergency exposure limit -----  
   NRC EEGL (emergency exposure level): 1 hr: 1,500 ppm v/v ceiling 7414  
   guidance level for single  
   emergency exposures  
   24 hr: 500 ppm v/v ceiling 7414  
   guidance level for single  
   emergency exposures  
   Refrigerant Concentration Limit (RCL): 2,600 ppm v/v (preliminary  
   value under review, based on  
   draft ASHRAE 34aa)  
 · special-purpose exposure control ---  
   NRC CEGL (continuous exposure level): 90 day: 100 ppm v/v ceiling 7414  
   guidance for prolonged  
   exposure in closed  
   environments  
 · acute (short-term) toxicity -----  
   LC50 (lethal concentration, 50%): rat, 15 min: 130,000 ppm 6110  
   (fatal concentration by  
   inhalation for half of test  
   animals)  
   rat, 4 hr: 52,500 ppm (fatal 6804  
   concentration by inhalation  
   for half of test animals)  
   ALC (approximate lethal concentration): rat, 2 hr: 110,000 ppm (lowest 6B56  
   exposure tested with one or  
   more deaths by inhalation)  
   rat, 4 hr, 1/6: 45,000 ppm 6804

	(lowest exposure tested with one or more deaths by inhalation)	
dermal LD50 (lethal dosage, 50%):	rabbit: >11,000 mg/kg (fatal dose by skin contact for half of test animals)	7541
oral LD50 (lethal dosage, 50%):	rat: 43,000 mg/kg (fatal dose by ingestion for half of test animals)	7441
cardiac sensitization (CS) EC50:	dog, 5 min: 7,000 ppm v/v (effective concentration in half of test animals)	6110
cardiac sensitization threshold/LOEL:	dog, 10 min, 10/29: 4,800 ppm v/v (lowest observed effect level in test animals)	65A0
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/12: 2,600 ppm v/v (no observed effect level in test animals)	65A0
anesthetic/CNS effect EC50:	mouse, 30 min: 57,000 ppm v/v (effective concentration in half of test animals)	6165
	rat, 10 min: stimulant 28,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic/CNS effect NOEL:	rat, 2 hr: 25,000 ppm v/v (no observed effect level in ALC or LC50 studies)	5365
• flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
heat of combustion (by ASHRAE 34-92):	0.1 MJ/kg (43 Btu/lb)	2318
flash point:	AlliedSignal: none	MSDS
	DuPont: will not burn	MSDS
	Elf Atochem: nonflammable	MSDS
	ICI: does not flash	MSDS
autoignition temperature:	680 °C (1256 °F)	5174
	AlliedSignal: 770 °C (1418 °F)	MSDS
	BOC Gases: none	MSDS
autodecomposition temperature:	DuPont: 300 °C (572 °F)	MSDS
	Elf Atochem: >427 °C (>800 °F)	MSDS
former UL Classification:	practically nonflammable (withdrawn for revision of the classification system, category SBQT2)	5931
• detection -----		
appearance:	AlliedSignal: colorless	MSDS
	BOC Gases: water-white liquid colorless	MSDS 7414
odor:	DuPont: slight ethereal	MSDS
	nearly odorless	5367
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1934 by T. Midgley, associates	5C39
last year production allowed:	1995 in developed countries under the Montreal Protocol	8C01

## R-113a

```

----- REFRIERANT DATA SUMMARY -----
R-113a      1,1,1-trichloro-2,2,2-trifluoroethane      see
CFC         CCl3CF3                                     CAS number 354-58-5      RDB#
-----

```

**COMMON USE(S)**

precision cleaning agent

**IDENTIFIERS**

```

common name(s):  R-113a; R113a; R 113a
                  CFC-113a
                  CFE, TF
                  fluorocarbon 113a
                  fluorochemical 113a; FC 113a
chemical name (by IUPAC convention):  1,1,1-trichloro-2,2,2-
                                        trifluoroethane
alternative chemical names/formulae:  ethane, 1,1,1-trichloro-2,2,2-
                                        trifluoro-
                                        1,1,1-trichlorotrifluoroethane
                                        trichlorotrifluoroethane
                                        CCl3CF3; CCl3-CF3
not recommended:
    CF3CCl3; CF3-CCl3
    Cl3CCF3; Cl3C-CF3
    F3CCCl3; F3C-CCl3
empirical formula:  C2Cl3F3
CAS number:        354-58-5 Chemical Abstracts
                  Service Registry Number
EINECS number:    206-564-6 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number:  KJ3975000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
historical name(s):  Allied Corp refrigerant 230
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass: 187.3747096 g/mol (0.413091      8820
             lb/mol)
normal freezing/melting/triple point: 14.2 °C (57.6 °F)      2250
· normal boiling point -----
temperature: 45.7 °C (114.3 °F)      2250
· 20 °C (68 °F) -----
density, saturated liquid: 1625 kg/m3 (101.45 lb/cf)      7601
· critical point -----
temperature: 209.2 °C (408.6 °F)      2250
pressure: 4880 kPa (707.8 psia)      2250
density: 769 kg/m3 (48.0 lb/cf)      2250
specific volume: 1.30 L/kg (0.0208 cf/lb)      2250

```

**SAFETY**

```

· classification -----

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

safety group (ASHRAE Standard 34): none (no application pending) 8601  
· flammability -----  
flash point: none (nonflammable as tested) 5367

**PRODUCTION**

last year production allowed: 1995 in developed countries 8C01  
under the Montreal Protocol





R-113B2 $\alpha\beta$ 

## ----- REFRIGERANT DATA SUMMARY -----

R-113B2 $\alpha\beta$	1,2-dibromo-1-chloro-1,2,2-trifluoroethane	see
BCFC	CBrClFCBrF <sub>2</sub>	CAS number 354-51-8
		RDB#

**IDENTIFIERS**

common name(s): R-113B2 $\alpha\beta$ ; R113B2 $\alpha\beta$ ;  
 R 113B2 $\alpha\beta$  (not R-113B2 $\beta$ )  
 BCFC-113B2 $\alpha\beta$   
 R-113B2, R113B2, BCFC-113B2  
 halon 2312, halon 2312 $\beta$

alternative chemical names/formulae: CBrClFCBrF<sub>2</sub>; CBrClF-CBrF<sub>2</sub>  
 not recommended:  
 CBrF<sub>2</sub>CBrClF; CBrF<sub>2</sub>-CBrClF

empirical formula: C<sub>2</sub>Br<sub>2</sub>ClF<sub>3</sub>  
 CAS number: 354-51-8 Chemical Abstracts  
 Service Registry Number

ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----

molar mass:	276.2773096 g/mol (0.609087 lb/mol)	8820
-------------	-------------------------------------	------

· normal boiling point -----

temperature:	93.5 °C (200.3 °F)	2250
--------------	--------------------	------

· critical point -----

temperature:	291.2 °C (556.2 °F)	2250
pressure:	5150 kPa (746.9 psia)	2250
density:	968 kg/m <sup>3</sup> (60.4 lb/cf)	2250

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34):	none (no application pending)	8601
------------------------------------	-------------------------------	------

· flammability -----

flash point:	none (nonflammable as tested)	2250
--------------	-------------------------------	------

## R-113aB2

```

----- REFRIERANT DATA SUMMARY -----
R-113aB2      1,1-dibromo-1-chloro-2,2,2-trifluoroethane      see
BCFC          CBr2ClCF3          CAS number 754-17-6          RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-113aB2; R113aB2; R 113aB2
                  BCFC-113aB2
chemical name (by IUPAC convention):  1,1-dibromo-1-chloro-2,2,2-
trifluoroethane
alternative chemical names/formulae:  ethane, 1,1-dibromo-1-chloro-
2,2,2-trifluoroethane
1,1-dibromo-1-chloro-
trifluoroethane
1-chloro-1,1-dibromo-
trifluoroethane
CBr2ClCF3; CBr2Cl-CF3
not recommended:
Br2ClCCF3; Br2ClC-CF3
CF3CBr2Cl; CF3-CBr2Cl
empirical formula:  C2Br2ClF3
CAS number:        754-17-6 Chemical Abstracts
Service Registry Number
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:  276.2773096 g/mol (0.609087      8820
lb/mol)
normal freezing/melting/triple point:  43.5 °C (110.3 °F)      2250
· normal boiling point -----
temperature:  91.5 °C (196.7 °F)      2250
· critical point -----
temperature:  288.1 °C (550.6 °F)      2250
pressure:    5100 kPa (739.7 psia)      2250
density:     973 kg/m3 (60.7 lb/cf)      2250

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601
· flammability -----
flash point:  none (nonflammable as tested)  2250

```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized

```





HGWP (halocarbon GWP): 7.20 relative to R 11 for DW  
infinite integration period

**SAFETY**

- classification -----  
 safety group (ASHRAE Standard 34): A1 8601  
 NFPA 704 degrees of hazard (H-F-R-S): ARI recommendation: 2-0-0 3A15  
 health-flammability-reactivity  
 [-special]: 0=no, 4=severe
- NPCA HMIS hazard ratings (H-F-R): AlliedSignal: 2-0-0 MSDS  
 BOC Gases: 1-0-0 MSDS  
 DuPont: 1-0-1 MSDS  
 health-flammability-reactivity  
 0=insignificant, 4=extreme
- UL Comparative Hazard to Life Group: 6 in absence of flame or hot 4B64  
 objects
- ACGIH carcinogenicity category: A4, not classifiable as a 9504  
 human carcinogen
- short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 15,000 ppm v/v 5204  
 NIOSH SCP IDLH (immediately dangerous): 50,000 ppm v/v for 30 min 3903
- occupational exposure limit -----  
 MAK (maximum workplace concentration): IV: 2,000 ppm v/v momentary 60 5561  
 min
- long-term occupational limit -----  
 OSHA PEL (permissible exposure limit): 1,000 ppm v/v TWA for 8 hr/day 3904  
 and 40 hr/wk  
 NIOSH REL (recommendd exposure limit): 1,000 ppm v/v TWA for 10 3903  
 hr/day and 40 hr/wk  
 ACGIH TLV-TWA (time-weighted average): 1,000 ppm v/v TWA for 8 hr/day 9504  
 and 40 hr/wk  
 MAK (maximum workplace concentration): 1,000 ppm v/v TWA for 8 hr/day 5561  
 40 (or 42) hr/wk  
 being examined for changes 7101
- emergency exposure limit -----  
 NRC EEGL (emergency exposure level): 1 hr: 10,000 ppm v/v ceiling 7414  
 guidance level for single  
 emergency exposures  
 24 hr: 1,000 ppm v/v ceiling 7414  
 guidance level for single  
 emergency exposures
- Refrigerant Concentration Limit (RCL): 20,000 ppm v/v (preliminary  
 value under review, based on  
 draft ASHRAE 34aa)
- special-purpose exposure control ---  
 NRC CEGL (continuous exposure level): 90 day: 100 ppm v/v ceiling 7414  
 guidance for prolonged  
 exposure in closed  
 environments
- acute (short-term) toxicity -----  
 LC50 (lethal concentration, 50%): rat, 30 min: 720,000 ppm 5179  
 (fatal concentration by  
 inhalation for half of test  
 animals)  
 rat, 2 hr: >600,000 ppm (fatal 5355  
 concentration by inhalation  
 for half of test animals)  
 rat, 4 hr, ElfAtochem: 600,000 MSDS  
 ppm (fatal concentration by

	inhalation for half of test animals)	
oral LD50 (lethal dosage, 50%):	rat: >2,250 mg/kg (fatal dose by ingestion for half of test animals)	65H5
cardiac sensitization (CS) EC50:	dog, 10 min: 46,000-100,000 ppm v/v (effective concentration in half of test animals)	6684
	dog, 5 min: 25,000-50,000 ppm v/v (effective concentration in half of test animals)	5644
cardiac sensitization threshold/LOEL:	dog, 5 min, 1/12: 25,000 ppm v/v (lowest observed effect level in test animals)	5644
anesthetic/CNS effect EC50:	rat, 10 min: 250,000 ppm v/v (effective concentration in half of test animals)	5855
anesthetic/CNS effect LOEL:	mouse: 50,000-120,000 ppm v/v (lowest observed effect level in test animals)	6586
anesthetic/CNS effect NOEL:	rat, 2 hr: 100,000 ppm v/v (no observed effect level in ALC or LC50 studies)	5365
• flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	0036
heat of combustion (by ASHRAE 34-92):	-3.1 MJ/kg (-1333 Btu/lb)	2318
flash point:	none (nonflammable as tested)	3903
autoignition temperature:	>750 °C (>1382 °F)	5931
autodecomposition temperature:	DuPont: 593 °C (1099 °F)	MSDS
former UL Classification:	nonflammable (withdrawn for revision of the classification system, category SBQT2)	5931
• detection -----		
appearance:	colorless	7414
odor:	DuPont: slight ethereal	MSDS
	nearly odorless	5367
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1933 by T. Midgley, associates	5C39
last year production allowed:	1995 in developed countries under the Montreal Protocol	8C01

## R-114a

## ----- REFRIGERANT DATA SUMMARY -----

R-114a	1,1-dichloro-1,2,2,2-tetrafluoroethane	see
CFC	CCl <sub>2</sub> FCF <sub>3</sub>	RDB#
	CAS number 374-07-2	----

**COMMON USE(S)**

isomer of refrigerant 114 usually found with it, in small amounts, since their similar properties (especially boiling points) make separation difficult

**IDENTIFIERS**

common name(s):	R-114a; R114a; R 114a CFC-114a fluorocarbon 114a fluorochemical 114a; FC 114a
chemical name (by IUPAC convention):	1,1-dichloro-1,2,2,2-tetrafluoroethane
alternative chemical names/formulae:	ethane, 1,1-dichloro-1,2,2,2-tetrafluoro- 1,1-dichlorotetrafluoroethane assymetric dichlorotetrafluoroethane CCl <sub>2</sub> FCF <sub>3</sub> ; CCl <sub>2</sub> F-CF <sub>3</sub> not recommended: CF <sub>3</sub> CCl <sub>2</sub> F; CF <sub>3</sub> -CCl <sub>2</sub> F CF <sub>3</sub> CFCl <sub>2</sub> ; CF <sub>3</sub> -CFCl <sub>2</sub> Cl <sub>2</sub> FCCF <sub>3</sub> ; Cl <sub>2</sub> FC-CF <sub>3</sub>
empirical formula:	C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>
CAS number:	374-07-2 Chemical Abstracts Service Registry Number
EINECS number:	206-774-8 (European Inventory of Existing Chemical Substances)
historical name(s):	Allied Corp refrigerant 320 3975
ARI container color / Pantone number:	none, use light green grey/413 6601

**PHYSICAL**

· properties -----		
	molar mass:	170.9204128 g/mol (0.376815 lb/mol) 8820
	normal freezing/melting/triple point:	-56.6 °C (-69.9 °F) 1136 -94.1 °C (-137.5 °F) 3975
· normal boiling point -----		
	temperature:	3.0 °C (37.4 °F) 3975 3.0 °C (37.4 °F) 7601 3.6 °C (38.5 °F) 2250
· critical point -----		
	temperature:	145.5 °C (293.9 °F) 3975 145.7 °C (294.3 °F) 6812
	pressure:	3303 kPa (479.0 psia) 3975 3304 kPa (479.2 psia) 1136 4920 kPa (713.6 psia) 2250
	density:	820 kg/m <sup>3</sup> (51.2 lb/cf) 2250
	specific volume:	1.22 L/kg (0.0195 cf/lb) 2250

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



1.72 L/kg (0.0276 cf/lb) 1136

**SAFETY**

· classification -----  
    safety group (ASHRAE Standard 34): none (no application pending) 8601  
· flammability -----  
    flash point: none (nonflammable as tested) 5367

**PRODUCTION**

    last year production allowed: 1995 in developed countries 8C01  
  under the Montreal Protocol





	inhalation for half of test animals)	
cardiac sensitization (CS) EC50:	dog, 5 min: 2,500 ppm v/v (effective concentration in half of test animals)	6110
anesthetic/CNS effect EC50:	rat, 10 min: stimulant 10,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic/CNS effect LOEL:	rat: 3,400 ppm v/v (lowest observed effect level in test animals)	5C42

**PRODUCTION**

last year production allowed:	1993 (under Article 2B) in developed countries under the Montreal Protocol	8C01
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## R-115

----- REFRIGERANT DATA SUMMARY -----  
 R-115 chloropentafluoroethane see  
 CFC CClF2CF3 CAS number 76-15-3 RDB#  
 -----

**COMMON USE(S)**

component of refrigerant 502; limited use as a single-compound refrigerant for refrigerated display cases in Japan; industrial refrigeration with centrifugal (turbo) compressors); dielectric fluid; formerly used, until phased out pursuant to the Montreal Protocol, as an aerosol propellant for foods and other uses, as an aerating agent for foamed or sprayed food products and as a food additive for vapor depression; also formerly used as a plasma etchant

**IDENTIFIERS**

common name(s): R-115; R115; R 115  
 CFC-115  
 CPFE 5C41  
 fluorocarbon 115  
 fluorochemical 115; FC 115  
 halocarbon 115  
 chemical name (by IUPAC convention): chloropentafluoroethane  
 alternative chemical names/formulae: 1-chloro-1,1,2,2,2-pentafluoroethane  
 ethane, chloropentafluoroethane, 1-chloro-1,1,2,2,2-pentafluoro-  
 monochloropentafluoroethane  
 CClF2CF3; CClF2-CF3  
 not recommended:  
 CF3CClF2; CF3-CClF2  
 ClF2CCF3; ClF2C-CF3  
 F3CClF2; F3C-CClF2  
 empirical formula: C2ClF5  
 CAS number: 76-15-3 Chemical Abstracts  
 Service Registry Number  
 EINECS number: 200-938-2 (European Inventory  
 of Existing Chemical  
 Substances)  
 NIOSH RTECS number: KH7877500 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): AlliedSignal Genetron(R) 115 MSDS  
 Asahi Glass Fron AF-115  
 Daikin Daiflon(R) 115  
 DuPont Freon(R) 115 MSDS  
 Elf Atochem Forane(R) 115 MSDS  
 ICI Arcton(R) 115 MSDS  
 historical name(s): Allied Corp refrigerant 410  
 Hoechst Frigen(R) 115  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

properties -----

molar mass:	154.466116 g/mol (0.340539 lb/mol)	8820
normal freezing/melting/triple point:	-99.4 °C (-146.9 °F)	8401
· normal boiling point -----		
temperature:	-38.9 °C (-38.1 °F)	8401
density, saturated liquid:	1558 kg/m <sup>3</sup> (97.28 lb/cf)	8401
density, saturated vapor:	8.41 kg/m <sup>3</sup> (0.525 lb/cf)	8401
specific volume, saturated liquid:	0.642 L/kg (0.0103 cf/lb)	8401
specific volume, saturated vapor:	119.0 L/kg (1.9054 cf/lb)	8401
heat of vaporization:	125.4 kJ/kg (53.9 Btu/lb)	8401
velocity of sound, saturated liquid:	610 m/s (2002 ft/s)	8401
velocity of sound, saturated vapor:	113 m/s (372 ft/s)	8401
viscosity, saturated liquid:	336 µPa·s (0.336 cp)	8401
viscosity, saturated vapor:	9.72 µPa·s (0.00972 cp)	8401
thermal conductivity, liquid:	0.0712 W/m·K (0.0411 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, vapor:	0.0082 W/m·K (0.0047 Btu/hr·ft <sup>2</sup> ·°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	6.555 kg/m <sup>3</sup> (0.4092 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ----		
density, vapor:	6.529 kg/m <sup>3</sup> (0.4076 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	789.3 kPa (114.48 psia)	8401
density, saturated liquid:	1315 kg/m <sup>3</sup> (82.07 lb/cf)	8401
density, saturated vapor:	61.82 kg/m <sup>3</sup> (3.859 lb/cf)	8401
specific volume, saturated liquid:	0.761 L/kg (0.0122 cf/lb)	8401
specific volume, saturated vapor:	16.2 L/kg (0.2591 cf/lb)	8401
velocity of sound, saturated liquid:	359 m/s (1177 ft/s)	8401
velocity of sound, saturated vapor:	109 m/s (357 ft/s)	8401
viscosity, saturated liquid:	153 µPa·s (0.153 cp)	8401
viscosity, saturated vapor:	12.3 µPa·s (0.0123 cp)	8401
thermal conductivity, saturated liquid:	0.0525 W/m·K (0.0303 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, saturated vapor:	0.01789 W/m·K (0.01034 Btu/hr·ft <sup>2</sup> ·°F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	2078 kPa (301.3 psia)	8401
heat of vaporization:	62.9 kJ/kg (27.1 Btu/lb)	8401
· critical point -----		
temperature:	80.0 °C (175.9 °F)	8401
pressure:	3120 kPa (452.5 psia)	8401
density:	613 kg/m <sup>3</sup> (38.3 lb/cf)	8401
specific volume:	1.63 L/kg (0.0261 cf/lb)	8401
<b>ENVIRONMENTAL</b>		
average atmospheric lifetime (τ <sub>atm</sub> ):	1700 yr	6695
ODP (ozone depletion potential):	0.40 (model-derived relative to R 11)	9501
	0.6 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	10,300 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	36.0 relative to R 11 for infinite integration period	DW
<b>SAFETY</b>		
· classification -----		
safety group (ASHRAE Standard 34):	A1	8601

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-0-0	MSDS
	Elf Atochem: 2-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-0-0	MSDS
	DuPont: 1-0-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	6 in absence of flame or hot objects	5931
· long-term occupational limit -----		
NIOSH REL (recommndd exposure limit):	1,000 ppm v/v TWA for 10 hr/day and 40 hr/wk	5204
ACGIH TLV-TWA (time-weighted average):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
exposure limit consistent to OSHA PEL:	ICI LTEL: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	CSDS
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	69,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 2 hr, 0/4: >600,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5365
	rat, 4 hr, 0/4: >800,000 ppm (lowest exposure tested with one or more deaths by inhalation)	7616
	rat, 4 hr, 0/4: >800,000 ppm (lowest exposure tested with one or more deaths by inhalation)	7617
oral LD50 (lethal dosage, 50%):	dog: >1,200 mg/kg (fatal dose by ingestion for half of test animals)	7239
	rat, DuPont: >1,200 mg/kg (fatal dose by ingestion for half of test animals)	MSDS
cardiac sensitization (CS) EC50:	dog, 10 min: 320,000 ppm v/v (effective concentration in half of test animals)	6684
cardiac sensitization threshold/LOEL:	dog, 5 min, 1/13: 150,000 ppm v/v (lowest observed effect level in test animals)	5644
anesthetic/CNS effect LOEL:	rat, 3½-4 hr, ?/4: 800,000 ppm v/v (lowest observed effect level in ALC or LC50 studies)	7616
anesthetic/CNS effect NOEL:	rat, 2 hr, 0/4: 600,000 ppm v/v (no observed effect level in ALC or LC50 studies)	5365
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2250
heat of combustion (by ASHRAE 34-92):	-2.1 MJ/kg (-903 Btu/lb)	2318
flash point:	none (nonflammable as tested)	5204
autoignition temperature:	880 °C (1616 °F)	3960
autodecomposition temperature:	DuPont: >700 °C (>1292 °F)	MSDS
former UL Classification:	nonflammable (withdrawn for revision of the classification)	5931

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

· detection ----- system, category SBQT2)

appearance:	DuPont: clear, colorless	MSDS
odor:	AlliedSignal: faint ethereal	MSDS

**PRODUCTION**

last year production allowed:	1995 in developed countries under the Montreal Protocol	8C01
-------------------------------	--	------







velocity of sound, saturated liquid:	522 m/s (1712 ft/s)	8401
velocity of sound, saturated vapor:	110 m/s (361 ft/s)	8401
viscosity, saturated liquid:	314 $\mu\text{Pa}\cdot\text{s}$ (0.314 cp)	8401
viscosity, saturated vapor:	9.18 $\mu\text{Pa}\cdot\text{s}$ (0.00918 cp)	8401
thermal conductivity, liquid:	0.0691 W/m·K (0.0399 Btu/hr·ft·°F)	8401
thermal conductivity, vapor:	0.0075 W/m·K (0.0043 Btu/hr·ft·°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	5.796 kg/m <sup>3</sup> (0.3619 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	5.774 kg/m <sup>3</sup> (0.3604 lb/cf)	8401
· critical point -----		
temperature:	19.9 °C (67.8 °F)	8401
pressure:	3042 kPa (441.2 psia)	8401
density:	622 kg/m <sup>3</sup> (38.8 lb/cf)	8401
specific volume:	1.61 L/kg (0.0258 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{\text{atm}}$ ):	10,000 yr	6694
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	11,400 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	205 relative to R 11 for infinite integration period	DW

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-0-0 health-flammability-reactivity [-special]: 0=no, 4=severe	MSDS
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-0-0 DuPont: 1-0-1 health-flammability-reactivity 0=insignificant, 4=extreme	MSDS MSDS
UL Comparative Hazard to Life Group:	6 by estimate (not UL test) in absence of flame or hot objects	5906
· long-term occupational limit -----		
exposure limit consistent to OSHA PEL:	DuPont AEL: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk ICI LTEL: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	5605 CSDS
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	69,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 1 hr, 0/10: >800,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5C79
	rat, 4 hr, 0/4: >800,000 ppm (lowest exposure tested with one or more deaths by inhalation)	7616
cardiac sensitization threshold/LOEL:	dog: >200,000 ppm v/v (lowest	6120

	observed effect level in test animals)	
cardiac sensitization (CS) NOEL:	dog: 200,000 ppm v/v (no observed effect level in test animals)	6120
anesthetic/CNS effect LOEL:	rat, 1 hr, ?/10: 780,000 ppm v/v (lowest observed effect level in test animals)	5C79
anesthetic/CNS effect NOEL:	rat, 10 day, 0/20: 121,000 ppm v/v (no observed effect level in test animals)	5C79
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2A06
flash point:	none (nonflammable as tested)	2250
autoignition temperature:	870 °C (1598 °F)	3960
	BOC Gases: none	MSDS
	DuPont: >870 °C (>1598 °F)	MSDS
· detection -----		
appearance:	DuPont: clear, colorless	MSDS
odor:	BOC Gases: odorless	MSDS
	DuPont: slight ethereal	MSDS
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01

## R-E116

----- REFRIERANT DATA SUMMARY -----  
 R-E116           trifluoromethoxy-trifluoromethane           see  
 FE               CF3-O-CF3                                    CAS number 1479-49-8           RDB#  
 -----

**COMMON USE(S)**

candidate alternative for refrigerant 13B1 for extremely-low temperature applications both as a single-compound and blend component; candidate as a blend component for ultra-low temperatures to replace refrigerants 13, 23, 116, and 503; manufacture or use may be covered by U.S. patent 4,041,148

**IDENTIFIERS**

                                  common name(s):   R-E116; RE116; R E116  
   FE-E116; FOC-E116  
   fluorochemical E116; FC E116  
   fluoroether E116; E-116  
   halochemical E116  
 chemical name (by IUPAC convention):   trifluoromethoxy-  
   trifluoromethane  
 alternative chemical names/formulae:   methane, trifluoromethoxy-  
   trifluoro-  
   bis(trifluoromethyl) ether  
   hexafluoroether  
   perfluoroether  
   CF3OCF3; CF3-O-CF3  
   not recommended:  
   F3COCF3; F3C-O-CF3  
                                   empirical formula:   C2F6O  
   CAS number:   1479-49-8 Chemical Abstracts  
   Service Registry Number  
 ARI container color / Pantone number:   none, use light green grey/413 6601

**PHYSICAL**

· properties -----  
   molar mass:   154.0112192 g/mol (0.339537   8820  
   lb/mol)  
 · normal boiling point -----  
   temperature:   -58.7 °C (-73.7 °F)           1136

**ENVIRONMENTAL**

ODP (ozone depletion potential):   0.000 (model-derived relative  
   to R 11)

**SAFETY**

· classification -----  
                   safety group (ASHRAE Standard 34):   none (no application pending)   8601

**PRODUCTION**

first commercial use as a refrigerant:   not known to be commercialized  
                   last year production allowed:   unrestricted                   8C01





under the Montreal Protocol







Protocol)

**SAFETY**

· classification -----  
    safety group (ASHRAE Standard 34): none (no application pending) 8601

· acute (short-term) toxicity -----  
    oral LD50 (lethal dosage, 50%): rat: 7,500 mg/kg (fatal dose 5C42  
    by ingestion for half of test  
    animals)

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized

last year production allowed: 2029 in developed countries 8C01  
under the Montreal Protocol

## R-122a

```

----- REFRIGERANT DATA SUMMARY -----
R-122a      1,1,2-trichloro-1,2-difluoroethane      see
HCFC        CHClFCCL2F                               CAS number 354-15-4      RDB#
-----

```

**IDENTIFIERS**

```

common name(s): R-122a; R122a; R 122a
                HCFC-122a
                fluorochemical 122a; FC 122a
chemical name (by IUPAC convention): 1,1,2-trichloro-1,2-
                difluoroethane
alternative chemical names/formulae: ethane, 1,1,2-trichloro-1,2-
                difluoroethane
                CHClFCCL2F; CHClF-CCl2F
                not recommended:
                CCl2FCClFH; CCl2FCClFH
                CCl2FCHClF; CCl2FCHClF
                CClFHCCl2F; CClFH-CCl2F
empirical formula: C2HCl3F2
CAS number:      354-15-4 Chemical Abstracts
                Service Registry Number
historical name(s): Allied Corp refrigerant 117

```

**PHYSICAL**

```

· properties -----
                molar mass: 169.3842464 g/mol (0.373428      8820
                lb/mol)
· normal boiling point -----
                temperature: 72.5 °C (162.5 °F)      7802
· 20 °C (68 °F) -----
                density, saturated liquid: 1559 kg/m3 (97.31 lb/cf)      7601

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.014 (model-derived relative 5782
to R 11)
0.08 (0.02-0.08) (estimate 6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: 2029 in developed countries 8C01
under the Montreal Protocol

```

## R-122b

```

----- REFRIGERANT DATA SUMMARY -----
R-122b      1,1,1-trichloro-2,2-difluoroethane      see
HCFC        CHF2CCl3                               CAS number 354-12-1      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-122b; R122b; R 122b
                 HCFC-122b
                 fluorochemical 122b; FC 122b
chemical name (by IUPAC convention):  1,1,1-trichloro-2,2-
                                     difluoroethane
alternative chemical names/formulae:  ethane, 1,1,1-trichloro-2,2-
                                     difluoroethane
                                     CHF2CCl3; CHF2-CCl3
                                     not recommended:
                                     CCl3CF2H; CCl3-CF2H
                                     CCl3CHF2; CCl3-CHF2
                                     CF2HCCl3; CF2H-CCl3
empirical formula:  C2HCl3F2
CAS number:        354-12-1 Chemical Abstracts
                  Service Registry Number
historical name(s):  Allied Corp refrigerant 130

```

**PHYSICAL**

```

· properties -----
molar mass:  169.3842464 g/mol (0.373428      8820
              lb/mol)
· normal boiling point -----
temperature:  73.0 °C (163.4 °F)              7802
· 20 °C (68 °F) -----
density, saturated liquid:  1566 kg/m3 (97.76 lb/cf)      7601

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential):  0.23 (model-derived relative      5782
                                   to R 11)
                                   0.08 (0.02-0.08) (estimate      6904
                                   used for the Montreal
                                   Protocol)

```

**SAFETY**

```

· classification -----
· safety group (ASHRAE Standard 34):  none (no application pending)  8601

```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized
last year production allowed:  2029 in developed countries      8C01
                               under the Montreal Protocol

```

## R-123

----- REFRIGERANT DATA SUMMARY -----  
 R-123            2,2-dichloro-1,1,1-trifluoroethane            see  
 HCFC            CHCl2CF3    CAS number 306-83-2            RDB#  
 -----

**COMMON USE(S)**

widely used in new centrifugal chillers (primary replacement for refrigerants 11 and 113) and retrofit of those designed for refrigerant 11; under consideration for high-temperature, steam-generating, industrial heat pumps; candidate foam blowing agent especially for polyurethanes, polystyrenes, polyisocyanurates, and phenolics; limited use as a specialty solvent and blend component for solvents; fire suppressant for streaming systems (e.g., American Pacific "Halotron I", DuPont "FE-232", and NAFG "Blitz") and blend component for flooding systems (e.g., NAFG "NAF-S-III")

**IDENTIFIERS**

common name(s): R-123; R123; R 123  
 HCFC-123  
 not recommended: HFA-123  
 fluorocarbon 123  
 fluorochemical 123; FC 123  
 halocarbon 123  
 halochemical 123  
 halon 232  
 hydrochlorofluorocarbon 123  
 chemical name (by IUPAC convention): 2,2-dichloro-1,1,1-trifluoroethane  
 alternative chemical names/formulae: 1,1-dichloro-2,2,2-trifluoroethane (not recommended)  
 ethane, 2,2-dichloro-1,1,1-trifluoro-  
 dichlorotrifluoroethane  
 trifluorodichloroethane  
 dichloro(trifluoromethyl)-methane  
 CHCl2CF3; CHCl2-CF3  
 not recommended:  
 CF3CHCl2; CF3-CHCl2  
 Cl2CHCF3; Cl2CH-CF3  
 Cl2HCCF3; Cl2HC-CF3  
 HCl2CCF3; HCl2C-CF3  
 empirical formula: C2HCl2F3  
 CAS number: 306-83-2 Chemical Abstracts  
 Service Registry Number  
 Beilstein registry number: 1736763  
 EINECS number: 206-190-3 (European Inventory  
 of Existing Chemical  
 Substances)  
 NIOSH RTECS number: KI1108000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): AlliedSignal Genetron(R) 123    3452  
 Asahi Glass Asahiklin AK-123

	Ausimont Meforex(R) 123	MSDS
	Daikin fluorocarbon HCFC-123	MSDS
	DuPont Suva(R) 123	7212
	Elf Atochem Forane(R) 123	4767
	HRP (UK) HARP(R) 123	
	Solvay Solkane(R) 123	MSDS
	ZCIRI Kehua (PRC) HCFC-123	
historical name(s):	Allied Corp refrigerant 220	
	DuPont Suva(R) Centri-LP	4504
	Hoechst Refrigerant R 123	
ARI container color / Pantone number:	light blue grey / 428	6601

**PHYSICAL**

· properties -----		
	molar mass:	152.9299496 g/mol (0.337153 lb/mol) 8820
normal freezing/melting/triple point:		-107.1 °C (-160.9 °F) 4319
· normal boiling point -----	temperature:	27.8 °C (82.1 °F) 7607
	density, saturated liquid:	1457 kg/m3 (90.93 lb/cf) 7607
	density, saturated vapor:	6.47 kg/m3 (0.404 lb/cf) 7607
	specific volume, saturated liquid:	0.687 L/kg (0.0110 cf/lb) 8401
	specific volume, saturated vapor:	154.5 L/kg (2.4753 cf/lb) 8401
	heat of vaporization:	170.2 kJ/kg (73.2 Btu/lb) 7607
	velocity of sound, saturated liquid:	693 m/s (2273 ft/s) 7607
	velocity of sound, saturated vapor:	129 m/s (422 ft/s) 7607
	viscosity, saturated vapor:	10.84 µPa·s (0.01084 cp) 8401
	viscosity, saturated liquid:	404 µPa·s (0.404 cp) 8401
	thermal conductivity, liquid:	0.0756 W/m·K (0.0437 Btu/hr·ft°F) 8401
	thermal conductivity, vapor:	0.0093 W/m·K (0.0054 Btu/hr·ft°F) 8401
· normal pressure, 20 °C (68 °F) -----	density, liquid:	1477 kg/m3 (12.32 lb/gal) 7607
· normal pressure, 21.1 °C (70 °F) ---	density, liquid:	1474 kg/m3 (12.30 lb/gal) 7607
· 20 °C (68 °F) -----	pressure, saturated vapor:	75.6 kPa (10.97 psia) 7607
	density, saturated liquid:	1477 kg/m3 (92.18 lb/cf) 7607
	density, saturated vapor:	4.92 kg/m3 (0.307 lb/cf) 7607
	specific volume, saturated liquid:	0.677 L/kg (0.0108 cf/lb) 8401
	specific volume, saturated vapor:	203.4 L/kg (3.2578 cf/lb) 8401
	velocity of sound, saturated liquid:	723 m/s (2371 ft/s) 7607
	velocity of sound, saturated vapor:	128 m/s (420 ft/s) 7607
	viscosity, saturated liquid:	443 µPa·s (0.443 cp) 8401
	viscosity, saturated vapor:	10.6 µPa·s (0.0106 cp) 8401
	thermal conductivity, saturated liquid:	0.0778 W/m·K (0.0450 Btu/hr·ft°F) 8401
	thermal conductivity, saturated vapor:	0.00889 W/m·K (0.00514 Btu/hr·ft°F) 8401
· 60 °C (140 °F) -----	pressure, saturated vapor:	286 kPa (41.5 psia) 7607
	heat of vaporization:	155.7 kJ/kg (67.0 Btu/lb) 8401
· critical point -----	temperature:	183.7 °C (362.6 °F) 7607
		183.8 °C (362.8 °F) 7713
	pressure:	3662 kPa (531.1 psia) 3711
	density:	550 kg/m3 (34.3 lb/cf) 0915
	specific volume:	1.82 L/kg (0.0291 cf/lb) 0915

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	1.4 $\pm$ 0.4 yr	6695
average stratospheric lifetime ( $\tau_{str}$ ):	47 yr	5508
ODP (ozone depletion potential):	0.012 (model-derived relative to R 11)	9501
	0.02 (semi-empirical relative to R 11)	9501
	0.02 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	120 relative to CO2 for 100 yr integration	9501
HGWP (halocarbon GWP):	0.0185 $\pm$ 0.0015 relative to R 11 for infinite integration period	5964
	0.019 relative to R 11 for infinite integration period	6307
photochemical reactivity (grnd level):	4.8 relative to methane	4511

**SAFETY**

• classification -----		
safety group (ASHRAE Standard 34):	B1	8601
NFPA 704 degrees of hazard (H-F-R-S):	ARI recommendation: 2-0-0	3A15
	AlliedSignal: 2-0-1	MSDS
	Ausimont: 2-0-0	MSDS
	Elf Atochem: 2-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 2-0-1	MSDS
	DuPont: 1-0-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
DFG carcinogenicity class:	IIIB: suspect, to be evaluated	5561
• short-term occupational limit -----		
ARI "IDLH" recommendation:	4,000 ppm v/v for 30 min	3A15
recommended short-term exposure limit:	DuPont EEL: 1,000 ppm ( $\leq$ 1 hr)	4C50
	DuPont EEL: 2,500 ppm ( $\leq$ 1 min)	4C50
• long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	50 ppm v/v TWA for 8 hr/day and 40 hr/wk	8611
exposure limit consistent to OSHA PEL:	AlliedSignal PEL: 10 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
	DuPont AEL: 50 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
	Elf Atochem AEL: 50 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
• emergency exposure limit -----		
NRC EEGL (emergency exposure level):	1 min: 1,900 ppm v/v ceiling guidance level for single emergency exposures	6A01
Refrigerant Concentration Limit (RCL):	3,500 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 30 min: 74,000 ppm (fatal concentration by inhalation for half of test animals)	6165
	rat, 4 hr: 32,000 ppm (fatal	6139

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



## Refrigerant Database

	concentration by inhalation for half of test animals)	
ALC (approximate lethal concentration):	rat, 4 hr, 3/6: 32,000 ppm (lowest exposure tested with one or more deaths by inhalation)	6139
dermal LD50 (lethal dosage, 50%):	rabbit, 24 hr, 0/10: >2,000 mg/kg (fatal dose by skin contact for half of test animals)	6148
	rat, 24 hr, 0/5: >2,000 mg/kg (fatal dose by skin contact for half of test animals)	6147
oral LD50 (lethal dosage, 50%):	rat, 1/1: 9,000 mg/kg (fatal dose by ingestion for half of test animals)	6140
cardiac sensitization (CS) EC50:	dog, 5 min: 19,000 ppm v/v (effective concentration in half of test animals)	6146
cardiac sensitization threshold/LOEL:	dog, 5 min, 4/6: 20,900 ppm v/v (lowest observed effect level in test animals)	6146
cardiac sensitization (CS) NOEL:	dog, 5 min, 0/3: 10,300 ppm v/v (no observed effect level in test animals)	6146
anesthetic/CNS effect EC50:	mouse, 10 min: 27,000 ppm v/v (effective concentration in half of test animals)	5980
	rat, 15 min: 7,080 ppm v/v (effective concentration in half of test animals)	6153
anesthetic/CNS effect LOEL:	g.pig, 10-15 min, ?/10: 10,000 ppm v/v (lowest observed effect level in test animals)	6216
anesthetic/CNS effect NOEL:	rat, 1 hr, 0/6: 2,700 ppm v/v (no observed effect level in test animals)	6153
	rat, subchronic: 2,500 ppm v/v (no observed effect level in test animals)	6145
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
heat of combustion (by ASHRAE 34-92):	2.1 MJ/kg (903 Btu/lb)	2318
flash point:	AlliedSignal: none	MSDS
	Ausimont: not flammable	MSDS
	DuPont, TOC: none	MSDS
autoignition temperature:	730 °C (1346 °F)	5C10
	AlSig HCFC-123: 714°C (1317°F)	6938
	DuPont Suva(R): 730°C (1346°F)	5931
	Elf Atochem: 714°C (1317°F)	6938
autodecomposition temperature:	AlliedSignal: >250°C (>482°F)	MSDS
former UL Classification:	practically nonflammable (withdrawn for revision of the classification system, category SBQT2)	6938
· detection -----		
appearance:	DuPont: clear, colorless	MSDS
odor:	AlliedSignal: faint ethereal and sweetish odor	MSDS MSDS

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

**PRODUCTION**

first commercial use as a refrigerant: 1989  
last year production allowed: 2029 in developed countries 8C01  
under the Montreal Protocol

## R-123a

```

----- REFRIERANT DATA SUMMARY -----
R-123a      1,2-dichloro-1,1,2-trifluoroethane      see
HCFC        CHClFCClF2                               CAS number 354-23-4      RDB#
-----

```

**COMMON USE(S)**

impurity in refrigerant 123 (commonly up to 5% for refrigerant use and up to 12% for fire suppressant use); formerly considered as a low-pressure refrigerant

**IDENTIFIERS**

```

common name(s):  R-123a; R123a; R 123a
                  HCFC-123a
                  fluorochemical 123a; FC 123a
                  halochemical 123a
chemical name (by IUPAC convention):  1,2-dichloro-1,1,2-trifluoro-
                                        ethane
alternative chemical names/formulae:  1,2-dichloro-1,2,2-trifluoro-
                                        ethane (not recommended)
                                        ethane, 1,2-dichloro-1,1,2-
                                        trifluoro-
                                        1,2-dichlorotrifluoroethane
                                        dichlorotrifluoroethane
                                        trifluorodichloroethane
                                        CHClFCClF2; CHClF-CClF2
not recommended:
    CClF2CClFH; CClF2-CClFH
    CClF2CHClF; CClF2-CHClF
    CClFHCClF2; CClFH-CClF2
    ClCF2CHFCl; ClCF2-CHFCl
empirical formula:  C2HCl2F3
CAS number:        354-23-4 Chemical Abstracts
                  Service Registry Number
EINECS number:    205-549-4 (European Inventory
                  of Existing Chemical
                  Substances)
historical name(s):  Allied Corp refrigerant 216
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:      152.9299496 g/mol (0.337153      8820
                  lb/mol)
normal freezing/melting/triple point:  -78.0 °C (-108.4 °F)      2250
· normal boiling point -----
temperature:     30.0 °C (85.9 °F)      4A09
· critical point -----
temperature:     188.6 °C (371.4 °F)      7713
pressure:       4470 kPa (648.3 psia)      0918
density:        625 kg/m3 (39.0 lb/cf)      7713
specific volume: 1.82 L/kg (0.0291 cf/lb)    0918

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential):  0.09 (model-derived relative  5782

```

to R 11)  
 0.06 (0.02-0.06) (estimate 6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----  
     safety group (ASHRAE Standard 34): none (no application pending) 8601

· acute (short-term) toxicity -----  
     anesthetic/CNS effect LOEL: mouse: 70,000 ppm v/v (lowest 6586  
     observed effect level in test  
     animals)

· flammability -----  
     LFL-UFL (flammability limits in air): none (nonflammable as tested) 2525

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: 2029 in developed countries 8C01  
 under the Montreal Protocol

## R-123b

```

----- REFRIGERANT DATA SUMMARY -----
R-123b      1,1-dichloro-1,2,2-trifluoroethane      see
HCFC        CHF2CCl2F                               CAS number 812-04-4      RDB#
-----

```

**COMMON USE(S)**

impurity in refrigerant 123 (usually <<1%)

**IDENTIFIERS**

```

common name(s):  R-123b; R123b; R 123b
                  HCFC-123b
                  fluorochemical 123b; FC 123b
                  halochemical 123b
chemical name (by IUPAC convention):  1,1-dichloro-1,2,2-trifluoro-
                                        ethane
alternative chemical names/formulae:  2,2-dichloro-1,1,2-trifluoro-
                                        ethane (not recommended)
                                        ethane, 1,1-dichloro-1,2,2-
                                        trifluoro-
                                        dichlorotrifluoroethane
                                        trifluorodichloroethane
                                        CHF2CCl2F; CHF2-CCl2F
                                        not recommended:
                                        CCl2FCF2H; CCl2F-CF2H
                                        CCl2FCHF2; CCl2F-CHF2
                                        CF2HCCl2F; CF2H-CCl2F
empirical formula:  C2HCl2F3
CAS number:         812-04-4 Chemical Abstracts
                    Service Registry Number
historical name(s):  Allied Corp refrigerant 225
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:  152.9299496 g/mol (0.337153      8820
              lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential):  0.13 (model-derived relative      5782
                                   to R 11)
                                   0.06 (0.02-0.06) (estimate      6904
                                   used for the Montreal
                                   Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601

```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized
last year production allowed:          2029 in developed countries      8C01
                                        under the Montreal Protocol

```

## R-123B1

```

----- REFRIGERANT DATA SUMMARY -----
R-123B1      2-bromo-2-chloro-1,1,1-trifluoroethane      see
HBCFC       CHBrClCF3                               CAS number 151-67-7      RDB#
-----

```

**COMMON USE(S)**  
anesthetic

**IDENTIFIERS**

```

common name(s):  R-123B1; R123B1; R 123B1
                 HBCFC-123B1
                 fluorochemical 123B1; FC 123B1
                 halochemical 123B1
                 halothane
chemical name (by IUPAC convention): 2-bromo-2-chloro-1,1,1-
                                     trifluoroethane
alternative chemical names/formulae: 1-bromo-1-chloro-2,2,2-
                                     trifluoroethane
                                     ethane, 2-bromo-2-chloro-
                                     1,1,1-trifluoro-
                                     bromochlorotrifluoroethane
                                     trifluorobromochloroethane
                                     CHBrClCF3; CHBrCl-CF3
not recommended:
                 BrClHC-CF3; BrClHC-CF3
                 CF3CBrClH; CF3-CBrClH
                 CF3CHBrCl; CF3-CHBrCl
                 HBrClCCF3; HBrClC-CF3
empirical formula: C2HBrClF3
CAS number:      151-67-7 Chemical Abstracts
                 Service Registry Number
Beilstein registry number: 1736947
EINECS number:   205-796-5 (European Inventory
                 of Existing Chemical
                 Substances)
NIOSH RTECS number: KH6550000 (Registry of Toxic
                 Effects of Chemical
                 Substances)
trade name(s):   ICI Fluothane(R)
ARI container color / Pantone number: none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:      197.3812496 g/mol (0.435151      8820
                 lb/mol)
normal freezing/melting/triple point: -117.8 °C (-180.0 °F)      5204
· normal boiling point -----
temperature:     50.2 °C (122.4 °F)                2250
· 20 °C (68 °F) -----
pressure, saturated vapor: 32.4 kPa (4.70 psia)      5204
· critical point -----
temperature:     223.0 °C (433.4 °F)                2250
pressure:        4800 kPa (696.2 psia)              2250
density:         750 kg/m3 (46.8 lb/cf)              2250

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

specific volume: 1.33 L/kg (0.0214 cf/lb) 2250

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 ACGIH carcinogenicity category: A4, not classifiable as a 9504  
 human carcinogen  
 DFG pregnancy risk group: B (risk probable below MAK/BAT) 5561

· occupational exposure limit -----  
 NIOSH REL-C (exposure ceiling): 2 ppm v/v for 60 min (must not 5204  
 exceed)

MAK (maximum workplace concentration): II, 1: 10 ppm v/v avg for 30 5561  
 min

· long-term occupational limit -----  
 ACGIH TLV-TWA (time-weighted average): 50 ppm v/v TWA for 8 hr/day 9504  
 and 40 hr/wk  
 MAK (maximum workplace concentration): 5 ppm v/v TWA for 8 hr/day 40 5561  
 (or 42) hr/wk  
 being examined for changes 7101

· acute (short-term) toxicity -----  
 ALC (approximate lethal concentration: mouse, 10 min: 22,000 ppm 6452  
 (lowest exposure tested with  
 one or more deaths by  
 inhalation)

cardiac sensitization (CS) EC50: dog, 10 min: 20,000 ppm v/v 6684  
 (effective concentration in  
 half of test animals)

anesthetic concentration: human, 30 min: 2,000 ppm v/v 6452  
 anesthetic/CNS effect LOEL: g.pig, 10-15 min, 10/10: 10000 6216  
 ppm v/v (lowest observed  
 effect level in test animals)

· flammability -----  
 LFL-UFL (flammability limits in air): none (nonflammable as tested) 2250  
 flash point: none (nonflammable as tested) 5204

## R-123B2

```

----- REFRIERANT DATA SUMMARY -----
R-123B2      1,2-dibromo-1,1,2-trifluoroethane      see
HBFC         CHBrFCBrF2                            CAS number 354-04-1      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-123B2; R123B2; R 123B2
                 HBFC-123B2
                 fluorochemical 123B2; FC 123B2
                 halochemical 123B2
chemical name (by IUPAC convention): 1,2-dibromo-1,1,2-trifluoro-
                                     ethane
alternative chemical names/formulae: ethane, 1,2-dibromo-1,1,2-
                                     trifluoroethane-
                                     CHBrFCBrF2; CHBrF-CBrF2
                                     not recommended:
                                     CBrF2CBrFH; CBrF2-CBrFH
                                     CBrF2CHBrF; CBrF2-CHBrF
                                     CBrFHCBBrF2; CBrFH-CBrF2
empirical formula: C2HBr2F3
CAS number:       354-04-1 Chemical Abstracts
                  Service Registry Number
ARI container color / Pantone number: none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
      molar mass: 241.8325496 g/mol (0.533150      8820
                        lb/mol)
· normal boiling point -----
      temperature: 76.0 °C (168.8 °F)                2250
· critical point -----
      temperature: 267.7 °C (513.9 °F)                2250
      pressure:    4900 kPa (710.7 psia)                2250
      density:     846 kg/m3 (52.8 lb/cf)                2250
      specific volume: 1.18 L/kg (0.0189 cf/lb)        2250

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34): none (no application pending) 8601
· acute (short-term) toxicity -----
  LC50 (lethal concentration, 50%): mouse, 10 min: 20,000 ppm      5980
                                     (fatal concentration by
                                     inhalation for half of test
                                     animals)
  anesthetic/CNS effect EC50: mouse, 10 min: 4,000 ppm v/v      5980
                                     (effective concentration in
                                     half of test animals)
· flammability -----
      flash point: none (nonflammable as tested) 2250

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized

```





	DuPont Suva(R) 124	MSDS
	Elf Atochem Forane(R) 124	MSDS
historical name(s):	Allied Corp refrigerant 310	
	Kinetic Chemicals Freon 124	
ARI container color / Pantone number:	deep green (DOT green) / 335	6601

**PHYSICAL**

· properties -----		
	molar mass:	136.4756528 g/mol (0.300877 lb/mol) 8820
	normal freezing/melting/triple point:	-199.1 °C (-326.5 °F) 8401
· normal boiling point -----	temperature:	-12.0 °C (10.5 °F) 8401
	density, saturated liquid:	1474 kg/m3 (91.99 lb/cf) 8401
	density, saturated vapor:	6.66 kg/m3 (0.415 lb/cf) 8401
	specific volume, saturated liquid:	0.679 L/kg (0.0109 cf/lb) 8401
	specific volume, saturated vapor:	150.3 L/kg (2.4069 cf/lb) 8401
	heat of vaporization:	165.8 kJ/kg (71.3 Btu/lb) 8401
	velocity of sound, saturated liquid:	673 m/s (2209 ft/s) 8401
	velocity of sound, saturated vapor:	128 m/s (419 ft/s) 8401
	viscosity, saturated vapor:	10.08 µPa·s (0.01008 cp) 8401
	viscosity, saturated liquid:	371 µPa·s (0.371 cp) 8401
	thermal conductivity, liquid:	0.0800 W/m·K (0.0462 Btu/hr·ft°F) 8401
	thermal conductivity, vapor:	0.0093 W/m·K (0.0054 Btu/hr·ft°F) 8401
· normal pressure, 20 °C (68 °F) -----	density, vapor:	5.836 kg/m3 (0.3643 lb/cf) 8401
· normal pressure, 21.1 °C (70 °F) ---	density, vapor:	5.812 kg/m3 (0.3628 lb/cf) 8401
· 20 °C (68 °F) -----	pressure, saturated vapor:	326.9 kPa (47.42 psia) 8401
	density, saturated liquid:	1372 kg/m3 (85.68 lb/cf) 8401
	density, saturated vapor:	20.28 kg/m3 (1.266 lb/cf) 8401
	specific volume, saturated liquid:	0.729 L/kg (0.0117 cf/lb) 8401
	specific volume, saturated vapor:	49.3 L/kg (0.7900 cf/lb) 8401
	velocity of sound, saturated liquid:	545 m/s (1787 ft/s) 8401
	velocity of sound, saturated vapor:	128 m/s (422 ft/s) 8401
	viscosity, saturated liquid:	250 µPa·s (0.250 cp) 8401
	viscosity, saturated vapor:	11.3 µPa·s (0.0113 cp) 8401
	thermal conductivity, saturated liquid:	0.0697 W/m·K (0.0403 Btu/hr·ft°F) 8401
	thermal conductivity, saturated vapor:	0.01132 W/m·K (0.00654 Btu/hr·ft°F) 8401
· 60 °C (140 °F) -----	pressure, saturated vapor:	997 kPa (144.6 psia) 8401
	heat of vaporization:	123.1 kJ/kg (52.9 Btu/lb) 8401
· critical point -----	temperature:	122.2 °C (252.0 °F) 9125
		122.3 °C (252.1 °F) 7714
	pressure:	3624 kPa (525.6 psia) 8401
	density:	559 kg/m3 (34.9 lb/cf) 7714
		560 kg/m3 (34.9 lb/cf) 7713
		560 kg/m3 (35.0 lb/cf) 8401
		560 kg/m3 (35.0 lb/cf) 9125
	specific volume:	1.79 L/kg (0.0286 cf/lb) 8401

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	6.1 ±1.5 yr	6695
---	-------------	------

## Refrigerant Database

average stratospheric lifetime ( $\tau_{str}$ ):	130 yr	5508
ODP (ozone depletion potential):	0.026 (model-derived relative to R 11)	9501
	0.022 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	620 relative to CO2 for 100 yr integration	9501
HGWP (halocarbon GWP):	0.10 relative to R 11 for infinite integration period	4511
photochemical reactivity (grnd level):	1.2 relative to methane	4511

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 2-0-1	MSDS
	Ausimont: 2-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 1-0-1	MSDS
	DuPont: 1-0-1	MSDS
	Elf Atochem: 1-0-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	6 in absence of flame or hot objects	5176
· long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	4B88
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	10,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 4 hr: 262,500 ppm (fatal concentration by inhalation for half of test animals)	5170
ALC (approximate lethal concentration):	rat, 4 hr, 0/6: 230,000 ppm (lowest exposure tested with one or more deaths by inhalation)	6180
	rat, 4 hr, 6/6: 300,000 ppm (lowest exposure tested with one or more deaths by inhalation)	6180
cardiac sensitization (CS) EC50:	dog: 40,000 ppm v/v (effective concentration in half of test animals)	7407
cardiac sensitization threshold/LOEL:	dog, 10 min, 4/10: 25,000 ppm v/v (lowest observed effect level in test animals)	5808
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/10: 10,100 ppm v/v (no observed effect level in test animals)	5808
anesthetic/CNS effect EC50:	10 min: 140,000 ppm v/v (effective concentration in half of test animals)	5C39
anesthetic/CNS effect LOEL:	dog, 10-90 min, ?/6: 400,000 ppm v/v (lowest observed effect level in test animals)	5828

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	rat, 30 min, ?/10: 100,000 ppm	5806
	v/v (lowest observed effect level in test animals)	
	rat, 4 hr, ?/6: 160,000 ppm	6180
	v/v (lowest observed effect level in test animals)	
anesthetic/CNS effect NOEL:	rat, 4 hr, 0/6: 48,000 ppm v/v	6180
	(no observed effect level in test animals)	
• flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
heat of combustion (by ASHRAE 34-92):	0.9 MJ/kg (387 Btu/lb)	2318
flash point:	AlliedSignal: not applicable	MSDS
	nonflammable	4B88
autoignition temperature:	637 °C (1179 °F)	5176
	Dupont: 715 °C (1319 °F)	MSDS
autodecomposition temperature:	AlliedSignal: >250°C (>482°F)	MSDS
• detection -----		
appearance:	AlliedSignal: clear, colorless	MSDS
odor:	Daikin: faint sweet odor	MSDS
	faint ethereal odor	4B88
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1992	
last year production allowed:	2029 in developed countries	8C01
	under the Montreal Protocol	



**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	guinea pig, 2hr: >200,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5169
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2A06

**PRODUCTION**

last year production allowed:	2029 in developed countries under the Montreal Protocol	8C01
-------------------------------	--	------







· properties -----		
	molar mass:	120.021356 g/mol (0.264602 lb/mol) 8820
	normal freezing/melting/triple point:	-100.6 °C (-149.1 °F) 8401
· normal boiling point -----		
	temperature:	-48.1 °C (-54.7 °F) 8401
	density, saturated liquid:	1515 kg/m3 (94.58 lb/cf) 8401
	density, saturated vapor:	6.80 kg/m3 (0.424 lb/cf) 8401
	specific volume, saturated liquid:	0.660 L/kg (0.0106 cf/lb) 8401
	specific volume, saturated vapor:	147.2 L/kg (2.3573 cf/lb) 8401
	heat of vaporization:	164.0 kJ/kg (70.5 Btu/lb) 8401
	velocity of sound, saturated liquid:	698 m/s (2289 ft/s) 8401
	velocity of sound, saturated vapor:	128 m/s (419 ft/s) 8401
	viscosity, saturated liquid:	406 µPa·s (0.406 cp) 8401
	viscosity, saturated vapor:	9.64 µPa·s (0.00964 cp) 8401
	thermal conductivity, liquid:	0.0924 W/m·K (0.0534 Btu/hr·ft°F) 8401
	thermal conductivity, vapor:	0.0089 W/m·K (0.0051 Btu/hr·ft°F) 8401
· normal pressure, 20 °C (68 °F) -----		
	density, vapor:	5.072 kg/m3 (0.3167 lb/cf) 8401
· normal pressure, 21.1 °C (70 °F) ---		
	density, vapor:	5.052 kg/m3 (0.3154 lb/cf) 8401
· 20 °C (68 °F) -----		
	pressure, saturated vapor:	1204.5 kPa (174.70 psia) 8401
	density, saturated liquid:	1219 kg/m3 (76.08 lb/cf) 8401
	density, saturated vapor:	77.83 kg/m3 (4.859 lb/cf) 8401
	specific volume, saturated liquid:	0.821 L/kg (0.0131 cf/lb) 8401
	specific volume, saturated vapor:	12.8 L/kg (0.2058 cf/lb) 8401
	velocity of sound, saturated liquid:	355 m/s (1166 ft/s) 8401
	velocity of sound, saturated vapor:	119 m/s (392 ft/s) 8401
	viscosity, saturated liquid:	150 µPa·s (0.150 cp) 8401
	viscosity, saturated vapor:	13.1 µPa·s (0.0131 cp) 8401
	thermal conductivity, saturated liquid:	0.0619 W/m·K (0.0358 Btu/hr·ft°F) 8401
	thermal conductivity, saturated vapor:	0.01472 W/m·K (0.00851 Btu/hr·ft°F) 8401
· 60 °C (140 °F) -----		
	pressure, saturated vapor:	3167 kPa (459.4 psia) 8401
	heat of vaporization:	52.5 kJ/kg (22.6 Btu/lb) 8401
· critical point -----		
	temperature:	66.2 °C (151.1 °F) 8401
	pressure:	3629 kPa (526.3 psia) 8401
	density:	571 kg/m3 (35.7 lb/cf) 8401
	specific volume:	1.75 L/kg (0.0280 cf/lb) 8401

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	32.6 ±11.4 yr	6695
average stratospheric lifetime (τ <sub>str</sub> ):	400 yr	5508
ODP (ozone depletion potential):	<0.00003 (model-derived relative to R 11)	9501
GWP (global warming potential):	3800 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.58 ±0.07 relative to R 11 for infinite integration period	5964
	0.65 relative to R 11 for infinite integration period	DW
	0.84 relative to R 11 for	4511

	infinite integration period	
	0.90 relative to R 11 for	6B35
	infinite integration period	
	ICI: 0.70 relative to R 11 for	CSDS
	infinite integration period	
photochemical reactivity (grnd level):	0.3 relative to methane	4511
<b>SAFETY</b>		
• classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 2-0-1	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 1-0-1	MSDS
	DuPont: 1-0-1	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
• long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	1,000 ppm v/v TWA for 8 hr/day	5C15
	and 40 hr/wk	
• emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	69,000 ppm v/v (preliminary	
	value under review, based on	
	draft ASHRAE 34aa)	
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 4 hr: >769,000 ppm (fatal	5754
	concentration by inhalation	
	for half of test animals)	
ALC (approximate lethal concentration):	rat, 4 hr, 0/10: >769,000 ppm	5754
	(lowest exposure tested with	
	one or more deaths by	
	inhalation)	
cardiac sensitization (CS) EC50:	dog, 10 min: 139,000 ppm v/v	5755
	(effective concentration in	
	half of test animals)	
cardiac sensitization threshold/LOEL:	dog, 10 min, 1/6: 100,000 ppm	5755
	v/v (lowest observed effect	
	level in test animals)	
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/6: 75,000 ppm	5755
	v/v (no observed effect level	
	in test animals)	
anesthetic/CNS effect LOEL:	rat, 4 hr, >5/10: 769,000 ppm	5754
	v/v (lowest observed effect	
	level in ALC or LC50 studies)	
anesthetic/CNS effect NOEL:	rat, 4 hr, 0/5: 709,000 ppm	6457
	v/v (no observed effect level	
	in test animals)	
• flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
heat of combustion (by ASHRAE 34-92):	-1.5 MJ/kg (-645 Btu/lb)	2318
	flash point:	5C15
	autoignition temperature:	733 °C (1351 °F)
	autodecomposition temperature:	AlliedSignal: >250°C (>482°F)
	former UL Classification:	practically nonflammable
		5931
	(withdrawn for revision of the	
	classification system,	
	category SBQT2)	
• detection -----		
	appearance:	colorless
		4C01

odor: very faint ethereal odor 5C15

**PRODUCTION**

last year production allowed: unrestricted 8C01

## R-E125

## ----- REFRIGERANT DATA SUMMARY -----

R-E125	difluoromethoxy-trifluoromethane	see
HFE	CHF2-O-CF3	RDB#
	CAS number 3822-68-2	

**COMMON USE(S)**

candidate alternative for refrigerants 12, 22, and 134a; candidate replacement for refrigerant 115 as a blend component for low-temperature applications; manufacture or use may be covered by U.S. patent 3,362,180

**IDENTIFIERS**

common name(s):	R-E125; RE125; R E125 HFE-E125; HFOC-E125 fluorochemical E125; FC E125 fluoroether E125; E-125 halochemical E125	
chemical name (by IUPAC convention):	difluoromethoxy- trifluoromethane	
alternative chemical names/formulae:	trifluoromethoxy- difluoromethane ethane, difluoromethoxy- trifluoro- pentafluorodimethyl ether 8218 difluoromethyl trifluoromethyl ether CHF2OCF3; CHF2-O-CF3 not recommended: CF2HOCF3; CF2H-O-CF3 CF3OCF2H; CF3-O-CF2H CF3OCHF2; CF3-O-CHF2 F2HCOCF3; F2HC-O-CF3 F3COCF2H; F3C-O-CF2H F3COCHF2; F3C-O-CHF2 HF2COCF3; HF2C-O-CF3	
empirical formula:	C2HF5O	
CAS number:	3822-68-2	Chemical Abstracts Service Registry Number

**PHYSICAL**

· properties -----		
	molar mass:	136.0207560 g/mol (0.299874 lb/mol) 8820
	normal freezing/melting/triple point:	-156.1 °C (-249.0 °F) 3404
· normal boiling point -----		
	temperature:	-33.9 °C (-29.0 °F) 7B15 -35.1 °C (-31.2 °F) 8218 -42.0 °C (-43.5 °F) 2255
	heat of vaporization:	161.2 kJ/kg (69.3 Btu/lb) 3408
· critical point -----		
	temperature:	80.7 °C (177.3 °F) 2255 81.3 °C (178.4 °F) 7714
	pressure:	3351 kPa (486.0 psia) 8218
	density:	576 kg/m3 (36.0 lb/cf) 7713

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	579 kg/m <sup>3</sup> (36.1 lb/cf)	7714
specific volume:	1.71 L/kg (0.0274 cf/lb)	3404

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	165 yr	9501
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	15,300 relative to CO <sub>2</sub> for 100 yr integration	9501

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 1 hr: <125,000 ppm (fatal concentration by inhalation for half of test animals)	5550
ALC (approximate lethal concentration):	mouse, 1 hr: >90,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5550
	rat, 4 hr: >100,000 ppm (lowest exposure tested with one or more deaths by inhalation)	7B15
anesthetic/CNS effect LOEL:	mouse, 1 hr: stimulant 500,000 ppm v/v (lowest observed effect level in test animals)	5550
anesthetic/CNS effect NOEL:	mouse, 1 hr: 90,000 ppm v/v (no observed effect level in test animals)	5550

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-130

----- REFRIGERANT DATA SUMMARY -----  
 R-130            1,1,2,2-tetrachloroethane            see  
 HCC            CHCl2CHCl2            CAS number 79-34-5            RDB#  
 -----

**COMMON USE(S)**  
 industrial solvent

**IDENTIFIERS**

common name(s): R-130; R130; R 130  
 HCC-130  
 halochemical 130  
 chemical name (by IUPAC convention): 1,1,2,2-tetrachloroethane  
 alternative chemical names/formulae: ethane, 1,1,2,2-tetrachloro-  
 sym-tetrachloroethane  
 symmetrical tetrachloroethane 7744  
 acetylene tetrachloride 7744  
 dichloro-1,1-dichloroethane  
 dichloro-2,2-dichloroethane  
 CHCl2CHCl2; CHCl2-CHCl2  
 not recommended:  
 CCl2HCCl2H; CCl2H-CCl2H  
 Cl2HCCC12H; Cl2HC-CCl2H  
 HCl2C-CHCl2; HCl2C-CHCl2  
 empirical formula: C2H2Cl4  
 CAS number: 79-34-5 Chemical Abstracts  
 Service Registry Number  
 EINECS number: 201-197-8 (European Inventory  
 of Existing Chemical  
 Substances)  
 NIOSH RTECS number: KI8575000 (Registry of Toxic  
 Effects of Chemical  
 Substances)

**PHYSICAL**

· properties -----  
    molar mass: 167.84808 g/mol (0.370042            8820  
    lb/mol)  
 normal freezing/melting/triple point: -36.1 °C (-33.0 °F)            3903  
    -43.8 °C (-46.8 °F)            7601  
 · normal boiling point -----  
    temperature: 146.3 °C (295.3 °F)            7601  
    146.7 °C (296.1 °F)            3903  
 · 20 °C (68 °F) -----  
    density, saturated liquid: 1600 kg/m3 (99.88 lb/cf)            7601

**ENVIRONMENTAL**

ODP (ozone depletion potential): <0.001 (model-derived relative 5782  
 to R 11)

**SAFETY**

· classification -----  
 IARC/CIRC human carcinogenicity group: 3, not classifiable            8802  
 NIOSH caution: potential occupational            3903

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	carcinogen (limit exposures to lowest feasible)	
ACGIH carcinogenicity category:	A3, animal carcinogen	9504
DFG carcinogenicity class:	IIIB: suspect, to be evaluated	5561
• occupational exposure warnings -----		
ACGIH caution:	cutaneous absorption potential	9504
• short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	100 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	150 ppm v/v for 30 min	3903
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	5 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	1 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	1 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	1 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
• acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr: 1,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
• flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
flash point:	none (nonflammable as tested)	3903







## R-131a

```

----- REFRIERANT DATA SUMMARY -----
R-131a      1,1,2-trichloro-1-fluoroethane      see
HCFC        CH2ClCCl2F                          CAS number 811-95-0      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-131a; R131a; R 131a
                  HCFC-131a
                  fluorochemical 131a; FC 131a
chemical name (by IUPAC convention): 1,1,2-trichloro-1-fluoroethane
alternative chemical names/formulae: ethane, 1,1,2-trichloro-1-
                                     fluoro-
                                     1-fluoro-1,1,2-trichloroethane
                                     CH2ClCCl2F; CH2Cl-CCl2F
not recommended:
                  CCl2FCClH2; CCl2F-CClH2
                  CCl2FCH2Cl; CCl2F-CH2Cl
                  CClH2CCl2F; CClH2-CCl2F
empirical formula: C2H2Cl3F
CAS number:       811-95-0 Chemical Abstracts
                  Service Registry Number
historical name(s): Allied Corp refrigerant 12A

```

**PHYSICAL**

```

· properties -----
molar mass: 151.3937832 g/mol (0.333766      8820
             lb/mol)
normal freezing/melting/triple point: -104.7 °C (-156.5 °F)      2250
· normal boiling point -----
temperature: 88.0 °C (190.4 °F)      2250
· 20 °C (68 °F) -----
density, saturated liquid: 1492 kg/m3 (93.15 lb/cf)      7601
· critical point -----
temperature: 284.4 °C (543.9 °F)      2250
pressure: 5000 kPa (725.2 psia)      2250
density: 582 kg/m3 (36.3 lb/cf)      2250
specific volume: 1.72 L/kg (0.0275 cf/lb)      2250

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.060 (model-derived relative 5782
to R 11)
0.05 (0.007-0.05) (estimate 6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

last year production allowed: 2029 in developed countries 8C01
under the Montreal Protocol

```







## R-132b

## ----- REFRIGERANT DATA SUMMARY -----

R-132b	1,2-dichloro-1,1-difluoroethane	see
HCFC	CH <sub>2</sub> ClCClF <sub>2</sub>	RDB#
	CAS number 1649-08-7	-----

**COMMON USE(S)**

consideration constrained by toxicity at low concentrations;  
 investigated as a solvent to replace CFC-113, but eliminated in 1987  
 when found to cause sterility in exposed rats (see RDB3133)

**IDENTIFIERS**

common name(s): R-132b; R-132b; R 132b  
 HCFC-132b  
 fluorochemical 132b; FC 132b

chemical name (by IUPAC convention): 1,2-dichloro-1,1-  
 difluoroethane

alternative chemical names/formulae: ethane, 1,2-dichloro-1,1-  
 difluoroethane  
 CH<sub>2</sub>ClCClF<sub>2</sub>; CH<sub>2</sub>Cl-CClF<sub>2</sub>  
 not recommended:  
 CCl<sub>2</sub>CClH<sub>2</sub>; CCl<sub>2</sub>F-CClH<sub>2</sub>  
 CCl<sub>2</sub>FCH<sub>2</sub>Cl; CCl<sub>2</sub>F-CH<sub>2</sub>Cl  
 CClH<sub>2</sub>CClF<sub>2</sub>; CClH<sub>2</sub>-CClF<sub>2</sub>

empirical formula: C<sub>2</sub>H<sub>2</sub>Cl<sub>2</sub>F<sub>2</sub>

CAS number: 1649-08-7 Chemical Abstracts  
 Service Registry Number

EINECS number: 216-714-2 (European Inventory  
 of Existing Chemical  
 Substances)

historical name(s): Allied Corp refrigerant 111

**PHYSICAL**

• properties -----

molar mass:	134.9394864 g/mol (0.297491 lb/mol)	8820
normal freezing/melting/triple point:	-101.2 °C (-150.2 °F)	2250
• normal boiling point -----	temperature: 46.8 °C (116.2 °F)	2250
density, saturated vapor:	515.00 kg/m <sup>3</sup> (32.150 lb/cf)	5371
• 20 °C (68 °F) -----	density, saturated liquid: 1416 kg/m <sup>3</sup> (88.42 lb/cf)	7601
• critical point -----	temperature: 220.0 °C (428.0 °F)	2250
	pressure: 4900 kPa (710.7 psia)	2250
	density: 594 kg/m <sup>3</sup> (37.1 lb/cf)	2250
	specific volume: 1.68 L/kg (0.0270 cf/lb)	2250

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	5 yr	0408
ODP (ozone depletion potential):	0.047 (model-derived relative to R 11)	5782
	<0.05 (model-derived relative to R 11)	0408
	0.05 (0.008-0.05) (estimate)	6904

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

used for the Montreal  
Protocol)  
GWP (global warming potential): <340 relative to CO2 for 100 yr integration 0408

**SAFETY**

· classification -----  
safety group (ASHRAE Standard 34): none (no application pending) 8601

· acute (short-term) toxicity -----  
LC50 (lethal concentration, 50%): mouse, 10 min: 43,000 ppm 5980  
(fatal concentration by  
inhalation for half of test  
animals)  
mouse, 30 min: 12,500 ppm 6165  
(fatal concentration by  
inhalation for half of test  
animals)  
anesthetic/CNS effect EC50: mouse, 30 min: 12,900 ppm v/v 6165  
(effective concentration in  
half of test animals)

· flammability -----  
LFL-UFL (flammability limits in air): none (nonflammable as tested) 5371

· detection -----  
appearance: colorless 5371

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized 5371  
last year production allowed: 2029 in developed countries 8C01  
under the Montreal Protocol





## R-133

```

----- REFRIGERANT DATA SUMMARY -----
R-133      1-chloro-1,2,2-trifluoroethane      see
HCFC       CHClFCHF2                          CAS number 431-07-2      RDB#
-----

```

**COMMON USE(S)**

formerly considered as a refrigerant for centrifugal chillers, but not pursued in light of toxicity and stability findings

**IDENTIFIERS**

```

common name(s):  R-133; R133; R 133
                  HCFC-133
                  fluorocarbon 133
                  fluorochemical 133; FC 133
                  halocarbon 133
                  halochemical 133
                  hydrochlorofluorocarbon 133
chemical name (by IUPAC convention):  1-chloro-1,2,2-trifluoroethane
alternative chemical names/formulae:  ethane, 1-chloro-1,2,2-
trifluoro-
CHClFCHF2; CHClF-CHF2
not recommended:
  CClFHCf2H; CClFH-CF2H
  CF2HCClFH; CF2H-CClFH
  CHF2CHClF; CHF2-CHClF
empirical formula:  C2H2ClF3
CAS number:        431-07-2 Chemical Abstracts
                  Service Registry Number
historical name(s):  Allied Corp refrigerant 215

```

**PHYSICAL**

```

· properties -----
molar mass:  118.4851896 g/mol (0.261215      8820
lb/mol)
· normal boiling point -----
temperature:  13.0 °C (55.4 °F)              5323
              17.0 °C (62.6 °F)              7601

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential):  0.070 (model-derived relative  5782
to R 11)
0.06 (0.02-0.06) (estimate      6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601

```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized
last year production allowed:          2029 in developed countries      8C01
under the Montreal Protocol

```

## R-133a

```

----- REFRIERANT DATA SUMMARY -----
R-133a      2-chloro-1,1,1-trifluoroethane      see
HCFC        CH2ClCF3                          CAS number 75-88-7      RDB#
-----

```

**COMMON USE(S)**

not known to be used as a refrigerant, but sometimes present as a contaminant or as a decomposition product (e.g., in refrigerant 123); formerly considered as a refrigerant for centrifugal chillers, but not pursued based on toxicity findings; also considered as a refrigerant in absorption cycles for heat pumps and as an aerosol propellant, alone or in blends; chemical intermediate in manufacture of and impurity in halothane (fluorochemical 123B1)

**IDENTIFIERS**

```

common name(s):  R-133a; R133a; R 133a
                  HCFC-133a
                  fluorocarbon 133a
                  fluorochemical 133a; FC 133a
                  halocarbon 133a
                  halochemical 133a
                  hydrochlorofluorocarbon 133a
chemical name (by IUPAC convention):  2-chloro-1,1,1-trifluoroethane
alternative chemical names/formulae:  1-chloro-2,2,2-trifluoroethane
                                      ethane, 2-chloro-1,1,1-
                                      trifluoro-
                                      1,1,1-trifluoro-2-chloroethane
                                      1,1,1-trifluorochloroethane
                                      1,1,1-trifluoroethyl chloride
                                      2,2,2-trifluorochloroethane
                                      CH2ClCF3; CH2Cl-CF3
not recommended:
                  CClH2CF3; CClH2-CF3
                  CF3CClH2; CF3-CClH2
                  CF3CH2Cl; CF3-CH2Cl
                  ClCH2CF3; ClCH2-CF3
empirical formula:  C2H2ClF3
CAS number:        75-88-7 Chemical Abstracts
                  Service Registry Number
EINECS number:    200-912-0 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number:  KH8008500 (Registry of Toxic
                  Effects of Chemical
                  Substances)
historical name(s):  Allied Corp refrigerant 210

```

**PHYSICAL**

```

· properties -----
molar mass:      118.4851896 g/mol (0.261215      8820
                  lb/mol)
normal freezing/melting/triple point:  -105.5 °C (-157.9 °F)      7601
· normal boiling point -----
temperature:     6.1 °C (43.0 °F)                5980

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	6.9 °C (44.5 °F)	2250
density, saturated vapor:	517.00 kg/m <sup>3</sup> (32.275 lb/cf)	5371
· 20 °C (68 °F) -----		
pressure, saturated vapor:	174.4 kPa (25.29 psia)	MSDS
· critical point -----		
temperature:	162.5 °C (324.5 °F)	2250
pressure:	4940 kPa (716.5 psia)	2250
density:	604 kg/m <sup>3</sup> (37.7 lb/cf)	2250
specific volume:	1.66 L/kg (0.0265 cf/lb)	2250

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.008 (model-derived relative to R 11)	5782
	0.06 (0.02-0.06) (estimate used for the Montreal Protocol)	6904

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 3-0-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
IARC/CIRC human carcinogenicity group:	3, not classifiable	8802
· long-term occupational limit -----		
exposure limit consistent to OSHA PEL:	AlliedSignal PEL: 1 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 10 min: 250,000 ppm (fatal concentration by inhalation for half of test animals)	5980
	mouse, 30 min: 150,000 ppm (fatal concentration by inhalation for half of test animals)	6165
	rat, 4 hr: 150,000 ppm (fatal concentration by inhalation for half of test animals)	8811
	rat, ? 4 hr: 140,000 ppm (fatal concentration by inhalation for half of test animals)	8811
cardiac sensitization (CS) EC50:	dog: 40,000 ppm v/v (effective concentration in half of test animals)	8811
anesthetic/CNS effect EC50:	20,000 ppm v/v (effective concentration in half of test animals)	8811
	mouse, 10 min: 80,000 ppm v/v (effective concentration in half of test animals)	5980
	mouse, 30 min: 43,000 ppm v/v (effective concentration in half of test animals)	6165
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	5371
flash point:	AlliedSignal: none	MSDS
· detection -----		

appearance: colorless 5371  
odor: AlliedSignal: faint ethereal MSDS

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: 2029 in developed countries 8C01  
under the Montreal Protocol

## R-133b

```

----- REFRIERANT DATA SUMMARY -----
R-133b      1-chloro-1,1,2-trifluoroethane      see
HCFC        CH2FCClF2                          CAS number 421-04-5      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-133b; R133b; R 133b
                  HCFC-133b
                  fluorocarbon 133b
                  fluorochemical 133b; FC 133b
                  halocarbon 133b
                  halochemical 133b
                  hydrochlorofluorocarbon 133b
chemical name (by IUPAC convention): 1-chloro-1,1,2-trifluoroethane
alternative chemical names/formulae: ethane, 1-chloro-1,1,2-
trifluoro-
CH2FCClF2; CH2F-CClF2
not recommended:
CClF2CFH2; CClF2-CFH2
CClF2CH2F; CClF2-CH2F
CFH2CClF2; CFH2-CClF2
empirical formula: C2H2ClF3
CAS number: 421-04-5 Chemical Abstracts
Service Registry Number
historical name(s): Allied Corp refrigerant 206

```

**PHYSICAL**

```

· properties -----
molar mass: 118.4851896 g/mol (0.261215 lb/mol) 8820
· normal boiling point -----
temperature: 12.0 °C (53.6 °F) 7601

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.043 (model-derived relative to R 11) 5782
0.06 (0.02-0.06) (estimate used for the Montreal Protocol) 6904

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601
· acute (short-term) toxicity -----
anesthetic/CNS effect EC50: mouse, 30 min: 12,900 ppm v/v (effective concentration in half of test animals) 6165

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: 2029 in developed countries under the Montreal Protocol 8C01

```



average atmospheric lifetime ( $\tau_{atm}$ ):	10.6 +21.2, -10.6 yr	6695
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	1200 relative to CO2 for 100 yr integration	9501
HGWP (halocarbon GWP):	0.21 relative to R 11 for infinite integration period	DW

**SAFETY**

· classification -----		
NPCA HMIS hazard ratings (H-F-R):	DuPont: 1-0-2	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
· long-term occupational limit -----		
exposure limit consistent to OSHA PEL:	DuPont AEL: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	69,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr, 0/6: >460,000 ppm (lowest exposure tested with one or more deaths by inhalation)	6188
cardiac sensitization threshold/LOEL:	dog, 33%: 100,000 ppm v/v (lowest observed effect level in test animals)	6802
cardiac sensitization (CS) NOEL:	dog, 0%: 75,000 ppm v/v (no observed effect level in test animals)	6802
anesthetic/CNS effect LOEL:	rat, 4 hr, ?/6: 200,000 ppm v/v (lowest observed effect level in ALC or LC50 studies)	6188
anesthetic/CNS effect NOEL:	rat, 4 hr, 0/6: 120,000 ppm v/v (no observed effect level in ALC or LC50 studies)	6188
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
heat of combustion (by ASHRAE 34-92):	4.3 MJ/kg (1849 Btu/lb)	2318
autoignition temperature:	630 °C (1166 °F)	3960
· detection -----		
appearance:	clear, colorless liquified gas	5864
odor:	slight ethereal odor	5864

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-134a

## ----- REFRIGERANT DATA SUMMARY -----

R-134a	1,1,1,2-tetrafluoroethane	see
HFC	CH2FCF3	RDB#
	CAS number 811-97-2	-----

**COMMON USE(S)**

domestic and commercial refrigeration, automobile air conditioners, transport refrigeration, centrifugal chillers; primary alternative for refrigerants 12 and 500; blend component for alternatives including refrigerants 404A, 407A, 407B, 407C, 407D, 413A, 416A, and others; foam blowing agent especially for polystyrenes, polyurethanes, polyisocyanurates, and phenolics; aerosol propellant; pharmaceutical propellant for metered dose inhalers; fire suppressant, usually as a blend component, for streaming systems (e.g., NAFG "NAF P-III")

**IDENTIFIERS**

common name(s):	R-134a; R134a; R 134a	
	HFC-134a	
	TFE	7274
	fluorocarbon 134a	
	fluorochemical 134a; FC 134a	
	halocarbon 134a	
	halochemical 134a	
	hydrofluorocarbon 134a	
	not recommended: HFA-134a	
chemical name (by IUPAC convention):	1,1,1,2-tetrafluoroethane	
alternative chemical names/formulae:	ethane, 1,1,1,2-tetrafluoro-	
	CH2FCF3; CH2F-CF3	
	not recommended:	
	CF3CFH2; CF3-CFH2	
	CF3CH2F; CF3-CH2F	
	CFH2CF3; CFH2-CF3	
	F3CCFH2; F3C-CFH2	
	F3CCH2F; F3C-CH2F	
	FCH2CF3; FCH2-CF3	
	H2FCCF3; H2FC-CF3	LPCR
empirical formula:	C2H2F4	
CAS number:	811-97-2 Chemical Abstracts	
	Service Registry Number	
EINECS number:	212-377-0 (European Inventory	
	of Existing Chemical	
	Substances)	
trade name(s):	AlliedSignal Genetron(R) 134a	3453
	Asahi Glass Asahiklin AK-134a	
	Ausimont Meforex(R) 134a	MSDS
	Daikin fluorocarbon HFC-134a	MSDS
	DuPont Suva(R) 134a	6739
	Elf Atochem Forane(R) 134a	4768
	HRP (UK) HARP(R) 134a	
	ICI Klea(R) 134a	6302
	RGI Quick Change (with MO/PAG)	
	Rhodia Isceon 134a	
	Solvay Solkane(R) 134a	MSDS





	<0.0005 (semi-empirical relative to R 11)	9501
GWP (global warming potential):	1600 relative to CO2 for 100 yr integration	9501
HGWP (halocarbon GWP):	0.28 relative to R 11 for infinite integration period	6739
	ICI: 0.30 relative to R 11 for infinite integration period	CSDS
photochemical reactivity (grnd level):	0.6 relative to methane	4511
<b>SAFETY</b>		
· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	ARI recommendation: 2-0-0	3A15
	AlliedSignal: 2-0-1	MSDS
	Elf Atochem: 2-1-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 1-0-1	MSDS
	DuPont: 1-0-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
DFG pregnancy risk group:	C (no risk fear below MAK/BAT)	7101
· short-term occupational limit -----		
ARI "IDLH" recommendation:	50,000 ppm v/v for 30 min	3A15
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	7101
· long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	4B86
exposure limit consistent to OSHA PEL:	ARI: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	3A15
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	7101
· emergency exposure limit -----		
NRC EEGL (emergency exposure level):	1 hr: 4,000 ppm v/v ceiling guidance level for single emergency exposures	6A01
	24 hr: 1,000 ppm v/v ceiling guidance level for single emergency exposures	6A01
Refrigerant Concentration Limit (RCL):	50,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· special-purpose exposure control ---		
NRC CEGL (continuous exposure level):	90 day: 1,000 ppm v/v ceiling guidance for prolonged exposure in closed environments	6A01
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 15 min: >800,000 ppm (fatal concentration by inhalation for half of test animals)	5A79
ALC (approximate lethal concentration):	rat, 30 min, 2/4: 750,000 ppm (lowest exposure tested with one or more deaths by inhalation)	6525

	rat, 4 hr, 0/6: 359,300 ppm	6529
	(lowest exposure tested with one or more deaths by inhalation)	
	rat, 4 hr, 5/6: 566,700 ppm	6529
	(lowest exposure tested with one or more deaths by inhalation)	
cardiac sensitization (CS) EC50:	dog, 10 min: 205,000 ppm v/v	6684
	(effective concentration in half of test animals)	
cardiac sensitization threshold/LOEL:	dog, 10 min, 2/10: 75,200 ppm v/v	6527
	(lowest observed effect level in test animals)	
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/10: 49,800 ppm v/v	6527
	(no observed effect level in test animals)	
anesthetic/CNS effect EC50:	mouse, rapid: 270,000 ppm v/v	7274
	(effective concentration in half of test animals)	
	rat, 10 min: 280,000 ppm v/v	5A79
	(effective concentration in half of test animals)	
anesthetic/CNS effect LOEL:	dog, 1 hr, ?/? : 160,000 ppm v/v	8111
	(lowest observed effect level in ALC or LC50 studies)	
	rat, 4 hr, ?/6: 205,200 ppm v/v	6529
	(lowest observed effect level in ALC or LC50 studies)	
anesthetic/CNS effect NOEL:	dog, 1 hr, 0/? : 80,000 ppm v/v	8111
	(no observed effect level in ALC or LC50 studies)	
	rat, 4 hr, 0/6: 81,000 ppm v/v	6529
	(no observed effect level in ALC or LC50 studies)	
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
heat of combustion (by ASHRAE 34-92):	4.2 MJ/kg (1806 Btu/lb)	2318
flash point:	none (nonflammable as tested)	4682
autoignition temperature:	743 °C (1369 °F)	6938
	770 °C (1418 °F)	4682
	Dupont: >743 °C (>1369 °F)	MSDS
autodecomposition temperature:	Elf Atochem: >427 °C (>800 °F)	MSDS
former UL Classification:	practically nonflammable	6938
	(withdrawn for revision of the classification system, category SBQT2)	
· detection -----		
appearance:	clear, colorless gas	4940
odor:	faint ethereal odor	6B26
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1990	
last year production allowed:	unrestricted	8C01

## R-E134

----- REFRIGERANT DATA SUMMARY -----  
 R-E134 difluoromethoxy-difluoromethane see  
 HFE CHF2-O-CHF2 CAS number 1691-17-4 RDB#  
 -----

**COMMON USE(S)**

candidate alternative for refrigerant 114, alone and as a blend component, though believed to have been rejected as such for naval applications based on compatibility tests with air purification systems; examined in early 1990s as a foam-blowing agent or aerosol propellant, but not commercialized; originally identified as an anesthetic to replace halothane, but found to be unsuitable; use as a refrigerant may be covered by U.S. patent 4,961,321

**IDENTIFIERS**

common name(s): R-E134; RE134; R E134  
 HFE-E134; HFOC-E134  
 fluorochemical E134; FC E134  
 fluoroether E134; E-134  
 halochemical E134  
 chemical name (by IUPAC convention): difluoromethoxy-  
 difluoromethane  
 alternative chemical names/formulae: methane, difluoromethoxy-  
 difluoro-  
 bis(difluoromethyl) ether  
 di(difluoromethyl) ether  
 1,1,3,3-tetrafluorodimethyl  
 ether  
 CHF2OCHF2; CHF2-O-CHF2  
 not recommended:  
 CF2HOCF2H; CF2H-O-CF2H  
 HF2COCHF2; HF2C-O-CHF2  
 empirical formula: C2H2F4O  
 CAS number: 1691-17-4 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 118.0302928 g/mol (0.260212 8820  
 lb/mol)  
 normal freezing/melting/triple point: -240.0 °C (-400.0 °F) 5550  
 · normal boiling point -----  
 temperature: 4.7 °C (40.4 °F) 9318  
 5.2 °C (41.3 °F) 8703  
 6.2 °C (43.1 °F) 3327  
 density, saturated liquid: 1425 kg/m3 (88.96 lb/cf) 4101  
 density, saturated vapor: 5.42 kg/m3 (0.338 lb/cf) 4101  
 specific volume, saturated liquid: 0.702 L/kg (0.0112 cf/lb) 4101  
 specific volume, saturated vapor: 184.6 L/kg (2.9570 cf/lb) 4101  
 velocity of sound, saturated liquid: 734 m/s (2409 ft/s) 4101  
 velocity of sound, saturated vapor: 142 m/s (466 ft/s) 4101  
 viscosity, saturated liquid: 395 µPa·s (0.395 cp) 4101  
 · normal pressure, 20 °C (68 °F) -----  
 density, vapor: 5.084 kg/m3 (0.3174 lb/cf) 4101

· 20 °C (68 °F) -----		
pressure, saturated vapor:	174.9 kPa (25.37 psia)	4101
density, saturated liquid:	1388 kg/m <sup>3</sup> (86.65 lb/cf)	4101
density, saturated vapor:	9.03 kg/m <sup>3</sup> (0.564 lb/cf)	4101
specific volume, saturated liquid:	0.721 L/kg (0.0115 cf/lb)	4101
specific volume, saturated vapor:	110.8 L/kg (1.7748 cf/lb)	4101
velocity of sound, saturated liquid:	675 m/s (2215 ft/s)	4101
velocity of sound, saturated vapor:	143 m/s (469 ft/s)	4101
viscosity, saturated liquid:	334 µPa·s (0.334 cp)	4101
viscosity, saturated vapor:	11.0 µPa·s (0.0110 cp)	4101
thermal conductivity, saturatd liquid:	0.0952 W/m·K (0.0550 Btu/hr·ft°F)	4101
thermal conductivity, saturated vapor:	0.01227 W/m·K (0.00709 Btu/hr·ft°F)	4101
· 60 °C (140 °F) -----		
pressure, saturated vapor:	624 kPa (90.5 psia)	4101
· critical point -----		
temperature:	147.1 °C (296.8 °F)	3327
	153.4 °C (308.1 °F)	9318
	153.5 °C (308.3 °F)	3407
	160.8 °C (321.4 °F)	4A58
pressure:	3751 kPa (544.0 psia)	9318
	4228 kPa (613.2 psia)	4101
density:	529 kg/m <sup>3</sup> (33.0 lb/cf)	3327
specific volume:	1.89 L/kg (0.0303 cf/lb)	3327

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	29.7 yr	9501
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	9318
GWP (global warming potential):	6900 relative to CO <sub>2</sub> for 100 yr integration	9501

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 3 hr: >950,000 ppm (fatal concentration by inhalation for half of test animals)	5550
cardiac sensitization threshold/LOEL:	monkey, 30min: ~R 11 at 50,000 ppm v/v (lowest observed effect level in test animals)	5550
anesthetic concentration:	mouse, 2 min: 307,500 ppm v/v	5550
	mouse, 5 min: 182,500 ppm v/v	5550
	mouse, 30 min: 130,000 ppm v/v	5550
	mouse, 60 min: 100,000 ppm v/v	5550
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	5550
autodecomposition temperature:	less than critical temperature	8703

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-E134a

```

----- REFRIGERANT DATA SUMMARY -----
R-E134a      fluoromethyl-trifluoromethyl ether      see
HFE          CH2F-O-CF3                               RDB#
-----
    
```

**COMMON USE(S)**

considered as an alternative for refrigerants 12 and 134a, impeded by difficulties in synthesis; manufacture or use may be covered by Japanese patent 04-110386

**IDENTIFIERS**

```

common name(s):  R-E134a; RE134a; R E134a
                  HFE-E134a; HFOC-E134a
                  fluorochemical E134a; FC E134a
                  fluoroether E134a; E-134a
                  halochemical E134a
chemical name (by IUPAC convention):  difluoromethoxy-
                                       trifluoromethane
alternative chemical names/formulae:  methane, difluoromethoxy-
                                       trifluoro-
                                       fluoromethyl-trifluoromethyl
                                       ether
                                       CH2FOCF3; CH2F-O-CF3
not recommended:
   CF3OCFH2; CF3-O-CFH2
   CF3OCH2F; CF3-O-CH2F
   CFH2OCF3; CFH2-O-CF3
empirical formula:  C2H2F4O
    
```

**PHYSICAL**

```

· properties -----
      molar mass:  118.0302928 g/mol (0.260212      8820
                  lb/mol)
· normal boiling point -----
      temperature:  -20.0 °C (-4.0 °F)              7B15
    
```

**ENVIRONMENTAL**

```

average tropospheric lifetime (τtrop):  3-6 yr      5829
ODP (ozone depletion potential):  0.000 (model-derived relative
to R 11)
    
```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)  8601
    
```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized
last year production allowed:  unrestricted      8C01
    
```



DFG carcinogenicity class:	IIIB: suspect, to be evaluated	7101
• occupational exposure warnings -----		
ACGIH caution:	cutaneous absorption potential	9504
• short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	100 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	500 ppm v/v for 30 min	3903
• occupational exposure limit -----		
MAK (maximum workplace concentration):	II, 2: 20 ppm v/v avg for 30 min	7101
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	10 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	10 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	10 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	10 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	7101
• acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr: 2,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
• flammability -----		
LFL-UFL (flammability limits in air):	6-15.5 % v/v	5204





to R 11)  
 0.1 (estimate used for the Montreal Protocol) 6904  
 GWP (global warming potential): 140 relative to CO2 for 100 yr 9501  
 integration

**SAFETY**

- classification -----
  - safety group (ASHRAE Standard 34): none (no application pending) 8601
  - UL Comparative Hazard to Life Group: 4-6 by estimate (not UL test) 5854  
 in absence of flame or hot objects
  - IARC/CIRC human carcinogenicity group: 3, not classifiable 8802
  - ACGIH carcinogenicity category: A4, not classifiable as a human carcinogen 9504
  - DFG carcinogenicity class: IIIB: suspect, to be evaluated 5561
  - DFG pregnancy risk group: C (no risk fear below MAK/BAT) 5561
- short-term occupational limit -----
  - NIOSH IDLH (immediately dangerous): 700 ppm v/v 5204
  - NIOSH SCP IDLH (immediately dangerous): 1,000 ppm v/v for 30 min 3903
  - ACGIH TLV-STEL (short-term exp limit): 450 ppm v/v TWA for 15 min 9504
- occupational exposure limit -----
  - NIOSH REL-C (exposure ceiling): 350 ppm v/v for 15 min (must not exceed) 3903
  - MAK (maximum workplace concentration): II, 2: 1000 ppm v/v avg for 30 min 5561
- long-term occupational limit -----
  - OSHA PEL (permissible exposure limit): 350 ppm v/v TWA for 8 hr/day and 40 hr/wk 3904
  - ACGIH TLV-TWA (time-weighted average): 350 ppm v/v TWA for 8 hr/day and 40 hr/wk 9504
  - MAK (maximum workplace concentration): 200 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk 5561
- emergency exposure limit -----
  - AIHA ERPG-3 (life-threatening): 3,500 ppm v/v for 1 hr 9503
  - AIHA ERPG-2 (injurious or impairing): 700 ppm v/v for 1 hr 9503
  - AIHA ERPG-1 (odor or mild effects): 350 ppm v/v for 1 hr 9503
- acute (short-term) toxicity -----
  - LC50 (lethal concentration, 50%): rat, 15 min: 38,000 ppm (fatal concentration by inhalation for half of test animals) 6110
  - ALC (approximate lethal concentration): rat, 4 hr: 18,400 ppm (lowest exposure tested with one or more deaths by inhalation) 6452
  - cardiac sensitization (CS) EC50: dog, 10 min: 5,100-10,700 ppm v/v (effective concentration in half of test animals) 65A0
  - dog, 5 min: 7,000 ppm v/v (effective concentration in half of test animals) 6110
  - cardiac sensitization threshold/LOEL: dog, 10 min, 3/18: 5,100 ppm v/v (lowest observed effect level in test animals) 65A0
  - cardiac sensitization (CS) NOEL: dog, 10 min, 0/12: 2,300 ppm v/v (no observed effect level in test animals) 65A0
  - anesthetic/CNS effect EC50: rat, 10 min: depressant 5,000 ppm v/v (effective concentration in half of test animals) 6110

	animals)	
anesthetic concentration:	15 min: 1,000 ppm v/v	6452
· flammability -----		
LFL-UFL (flammability limits in air):	7.4-16.5 % v/v	2525
	7.5-12.5 % v/v	3903

**PRODUCTION**

last year production allowed:	1995 (under Article 2E) in developed countries under the Montreal Protocol	8C01
-------------------------------	--	------

## R-141

```

----- REFRIERANT DATA SUMMARY -----
R-141      1,2-dichloro-1-fluoroethane      see
HCFC      CH2ClCHClF                        CAS number 430-57-9      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-141; R141; R 141
                  HCFC-141
                  fluorochemical 141; FC 141
chemical name (by IUPAC convention):  1,2-dichloro-1-fluoroethane
alternative chemical names/formulae:  ethane, 1,2-dichloro-1-fluoro-
                                      CH2ClCHClF; CH2Cl-CHClF
not recommended:
                  CClFHCClH2; CClFH-CClH2
                  CClH2CClFH; CClH2-CClFH
                  CHClFCH2Cl; CHClF-CH2Cl
empirical formula:  C2H3Cl2F
CAS number:        430-57-9 Chemical Abstracts
                  Service Registry Number
historical name(s):  Allied Corp refrigerant 11A

```

**PHYSICAL**

```

· properties -----
molar mass:      116.9490232 g/mol (0.257828      8820
                  lb/mol)
normal freezing/melting/triple point:  -6.0 °C (21.2 °F)      2250
· normal boiling point -----
temperature:     75.7 °C (168.3 °F)      7601
                  76.0 °C (168.8 °F)      2250
· 20 °C (68 °F) -----
density, saturated liquid:  1381 kg/m3 (86.24 lb/cf)      7601
· critical point -----
temperature:     269.1 °C (516.4 °F)      2250
pressure:        4440 kPa (644.0 psia)      2250
density:         444 kg/m3 (27.7 lb/cf)      2250
specific volume:  2.25 L/kg (0.0361 cf/lb)      2250

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential):  <0.001 (model-derived relative 5782
to R 11)
0.07 (0.005-0.07) (estimate      6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601

```

**PRODUCTION**

```

last year production allowed:  2029 in developed countries      8C01
under the Montreal Protocol

```

## R-141a

```

----- REFRIGERANT DATA SUMMARY -----
R-141a      1,1-dichloro-2-fluoroethane      see
HCFC        CHCl2CH2F                          CAS number 430-53-5      RDB#
-----

```

**IDENTIFIERS**

```

common name(s): R-141a; R141a; HCFC-141a
                fluorochemical 141a; FC 141a
alternative chemical names/formulae: CH2ClCHClF; CH2Cl-CHClF
not recommended:
                CClFHCClH2; CClFH-CClH2
                CClH2CClFH; CClH2-CClFH
                CHClFCH2Cl; CHClF-CH2Cl
empirical formula: C2H3Cl2F
CAS number: 430-53-5 Chemical Abstracts
                Service Registry Number
historical name(s): Allied Corp refrigerant 20

```

**PHYSICAL**

```

· properties -----
                molar mass: 116.9490232 g/mol (0.257828      8820
                lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): <0.001 (model-derived relative 5782
to R 11)
0.07 (0.005-0.07) (estimate      6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

last year production allowed: 2029 in developed countries      8C01
under the Montreal Protocol

```

## R-141b

## ----- REFRIGERANT DATA SUMMARY -----

R-141b	1,1-dichloro-1-fluoroethane	see
HCFC	CH3CCl2F	RDB#
	CAS number 1717-00-6	

**COMMON USE(S)**

considered but not selected as a replacement for refrigerant 11;  
widely used as a foam blowing agent especially for polyurethanes,  
flexible polystyrenes, polyisocyanurates, and phenolics; solvent and  
blend component for solvents

**IDENTIFIERS**

common name(s):	R-141b; R141b; R 141b	
	HCFC-141b	
	not recommended: HFA-141b	
	fluorocarbon 141b	
	fluorochemical 141b; FC 141b	
	halocarbon 141b	
	halochemical 141b	
chemical name (by IUPAC convention):	1,1-dichloro-1-fluoroethane	
alternative chemical names/formulae:	ethane, 1,1-dichloro-1-fluoro-	
	methyl dichlorofluoromethyl	
	CH3CCl2F; CH3-CCl2F	
	not recommended:	
	CCl2FCH3; CCl2F-CH3	
	H3CCCl2F; H3C-CCl2F	
empirical formula:	C2H3Cl2F	
CAS number:	1717-00-6 Chemical Abstracts	
	Service Registry Number	
EINECS number:	404-080-1 (European Inventory	
	of Existing Chemical	
	Substances)	
trade name(s):	AlliedSignal Genetron(R) 141b	5A33
	Asahi Glass Asahiklin AK-141b	
	DuPont HCFC-141b	MSDS
	Elf Atochem Forane(R) 141b	MSDS
	ICI Arcton(R) 141b	MSDS
	LaRoche Chemicals R-141b	
	Pennwalt Isotron(R) 141b	
	ZCIRI Kehua (PRC) HCFC-141b	
historical name(s):	Allied Corp refrigerant 2	
	DuPont Freon(R) 141b	5868
ARI container color / Pantone number:	none, use light green grey/413	6601

**PHYSICAL**

· properties -----		
	molar mass:	116.9490232 g/mol (0.257828 lb/mol) 8820
	normal freezing/melting/triple point:	-103.3 °C (-153.9 °F) 8401
· normal boiling point -----		
	temperature:	32.0 °C (89.7 °F) 8401
	density, saturated liquid:	1220 kg/m3 (76.17 lb/cf) 8401
	density, saturated vapor:	4.85 kg/m3 (0.303 lb/cf) 8401
	specific volume, saturated liquid:	0.820 L/kg (0.0131 cf/lb) 8401

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

specific volume, saturated vapor:	206.2 L/kg (3.3024 cf/lb)	8401
heat of vaporization:	223.0 kJ/kg (95.9 Btu/lb)	8401
velocity of sound, saturated liquid:	797 m/s (2616 ft/s)	8401
velocity of sound, saturated vapor:	150 m/s (492 ft/s)	8401
viscosity, saturated liquid:	378 $\mu\text{Pa}\cdot\text{s}$ (0.378 cp)	8401
viscosity, saturated vapor:	9.45 $\mu\text{Pa}\cdot\text{s}$ (0.00945 cp)	8401
thermal conductivity, liquid:	0.0920 W/m $\cdot$ K (0.0532 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, vapor:	0.0099 W/m $\cdot$ K (0.0057 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· normal pressure, 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
density, liquid:	1244 kg/m <sup>3</sup> (10.38 lb/gal)	8401
· normal pressure, 21.1 $^{\circ}$ C (70 $^{\circ}$ F) ---		
density, liquid:	1242 kg/m <sup>3</sup> (10.36 lb/gal)	8401
· 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
pressure, saturated vapor:	65.0 kPa (9.43 psia)	8401
density, saturated liquid:	1244 kg/m <sup>3</sup> (77.66 lb/cf)	8401
density, saturated vapor:	3.21 kg/m <sup>3</sup> (0.200 lb/cf)	8401
specific volume, saturated liquid:	0.804 L/kg (0.0129 cf/lb)	8401
specific volume, saturated vapor:	311.7 L/kg (4.9933 cf/lb)	8401
velocity of sound, saturated liquid:	841 m/s (2760 ft/s)	8401
velocity of sound, saturated vapor:	149 m/s (487 ft/s)	8401
viscosity, saturated liquid:	432 $\mu\text{Pa}\cdot\text{s}$ (0.432 cp)	8401
viscosity, saturated vapor:	9.1 $\mu\text{Pa}\cdot\text{s}$ (0.0091 cp)	8401
thermal conductivity, saturated liquid:	0.0958 W/m $\cdot$ K (0.0554 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, saturated vapor:	0.00930 W/m $\cdot$ K (0.00537 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· 60 $^{\circ}$ C (140 $^{\circ}$ F) -----		
pressure, saturated vapor:	246 kPa (35.7 psia)	8401
heat of vaporization:	208.9 kJ/kg (89.8 Btu/lb)	8401
· critical point -----		
temperature:	204.2 $^{\circ}$ C (399.6 $^{\circ}$ F)	8401
pressure:	4250 kPa (616.4 psia)	8401
density:	460 kg/m <sup>3</sup> (28.7 lb/cf)	8401
specific volume:	2.17 L/kg (0.0348 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{\text{atm}}$ ):	9.2 yr	9501
average stratospheric lifetime ( $\tau_{\text{str}}$ ):	76 yr	5508
ODP (ozone depletion potential):	0.086 (model-derived relative to R 11)	9501
	0.1 (semi-empirical relative to R 11)	9501
	0.11 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	700 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.0905 $\pm$ 0.0065 relative to R 11 for infinite integration period	5964
	0.15 relative to R 11 for infinite integration period	4511
	0.16 relative to R 11 for infinite integration period	5B15

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601

NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 2-0-1	MSDS
	Elf Atochem: 1-1-1	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 1-0-1	MSDS
	DuPont: 2-1-0	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
· long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	500 ppm v/v TWA for 8 hr/day	4B87
	and 40 hr/wk	
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	2,600 ppm v/v (preliminary	
	value under review, based on	
	draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 10 min: 50,000 ppm	5980
	(fatal concentration by	
	inhalation for half of test	
	animals)	
	rat, 4 hr: 61,647 ppm (fatal	5995
	concentration by inhalation	
	for half of test animals)	
dermal LD50 (lethal dosage, 50%):	rabbit: >2,000 mg/kg (fatal	5A80
	dose by skin contact for half	
	of test animals)	
	rat, 0/10: >2,000 mg/kg (fatal	6460
	dose by skin contact for half	
	of test animals)	
oral LD50 (lethal dosage, 50%):	rat, 0/10: >5,000 mg/kg (fatal	5988
	dose by ingestion for half of	
	test animals)	
cardiac sensitization (CS) EC50:	dog, 10 min: 20,000 ppm v/v	6684
	(effective concentration in	
	half of test animals)	
cardiac sensitization threshold/LOEL:	dog, 10 min, 1/10: 5,200 ppm	6467
	v/v (lowest observed effect	
	level in test animals)	
	dog, 10 min, 1/4: 9,000 ppm	5C63
	v/v (lowest observed effect	
	level in test animals)	
	dog, 10 min, 1/6: 20,000 ppm	7206
	v/v (lowest observed effect	
	level in test animals)	
	monkey, 10 min, 1/1: 3,000 ppm	5C63
	v/v (lowest observed effect	
	level in test animals)	
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/10: 2,600 ppm	6467
	v/v (no observed effect level	
	in test animals)	
	dog, 10 min, 0/6: 10,000 ppm	7206
	v/v (no observed effect level	
	in test animals)	
anesthetic/CNS effect EC50:	mouse, 10 min: 25,000 ppm v/v	5980
	(effective concentration in	
	half of test animals)	
anesthetic/CNS effect LOEL:	rat, 4-hr: 29,000 ppm v/v	65A4
	(lowest observed effect level	
	in ALC or LC50 studies)	
anesthetic/CNS effect NOEL:	rat, 6-hr, 0/10: 11,096 ppm	6463

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



	v/v (no observed effect level in ALC or LC50 studies)	
· flammability -----		
LFL-UFL (flammability limits in air):	5.8-17.7 % v/v	5B15
	7.2-18.0 % v/v	2525
	7.3-16.0 % v/v	4511
	7.4-15.5 % v/v	0521
	7.6-17.7 % v/v	5A33
	DuPont: 6.4-15.1 % v/v	MSDS
heat of combustion (by ASHRAE 34-92):	8.6 MJ/kg (3697 Btu/lb)	2318
flash point:	CC, DuPont: none	MSDS
	TCC, Elf Atochem: none	MSDS
	TCC, ICI: >82 °C (>180 °F)	MSDS
	none	5A30
autoignition temperature:	550 °C (1022 °F)	5A30
	Dupont: 530 °C (986 °F)	MSDS
autodecomposition temperature:	AlliedSignal: >250°C (>482°F)	MSDS
· detection -----		
appearance:	clear, colorless liquid	5A33
odor:	faint ethereal odor	5A33

**PRODUCTION**

first commercial use as a refrigerant:	blowing agent: December 1990	
last year production allowed:	2029 in developed countries under the Montreal Protocol	8C01



## R-142a

```

----- REFRIGERANT DATA SUMMARY -----
R-142a      1-chloro-1,2-difluoroethane      see
HCFC        CHClFCH2F                      CAS number 338-64-7      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-142a; R142a; R 142a
                 HCFC-142a
                 fluorochemical 142a; FC 142a
chemical name (by IUPAC convention): 1-chloro-1,2-difluoroethane
alternative chemical names/formulae: ethane, 1-chloro-1,2-difluoro-
                                     CH2FCHClF; CH2F-CHClF
                                     not recommended:
                                     CClFHCFH2; CClFH-CFH2
                                     CFH2CClFH; CFH2-CClFH
                                     CHClFCH2F; CHClF-CH2F
empirical formula: C2H3ClF2
CAS number:       338-64-7 Chemical Abstracts
                  Service Registry Number
historical name(s): Allied Corp refrigerant 106

```

**PHYSICAL**

```

· properties -----
molar mass: 100.4947264 g/mol (0.221553      8820
             lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): <0.001 (model-derived relative 5782
to R 11)
0.07 (0.008-0.07) (estimate      6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

last year production allowed: 2029 in developed countries      8C01
under the Montreal Protocol

```

## R-142b

## ----- REFRIGERANT DATA SUMMARY -----

R-142b	1-chloro-1,1-difluoroethane		see
HCFC	CH3CClF2	CAS number 75-68-3	RDB#

**COMMON USE(S)**

blend component for refrigerants 406A, 409A, 409B, 412A, 414A, 412B, and others; degradation product of fluorochemical 141b; foam blowing agent; intermediate in the manufacture of fluorinated products

**IDENTIFIERS**

common name(s):	R-142b; R142b; R 142b	
	HCFC-142b	
	CDFE	3866
	fluorocarbon 142b	
	fluorochemical 142b; FC 142b	
	halocarbon 142b	
	halochemical 142b	
chemical name (by IUPAC convention):	1-chloro-1,1-difluoroethane	
alternative chemical names/formulae:	2-chloro-2,2-difluoroethane	
	ethane, 1-chloro-1,1-difluoro-	
	difluorochloroethane	
	difluoromonochloroethane	
	alphachloroethylidene fluoride	
	CH3CClF2; CH3-CClF2	
	not recommended:	
	CClF2CH3; CClF2-CH3	
	CF2ClCH3; CF2Cl-CH3	
	CH3CF2Cl; CH3-CF2Cl	
empirical formula:	C2H3ClF2	
CAS number:	75-68-3 Chemical Abstracts	
	Service Registry Number	
Beilstein registry number:	1731584	
EINECS number:	200-891-8 (European Inventory	
	of Existing Chemical	
	Substances)	
NIOSH RTECS number:	KH7650000 (Registry of Toxic	
	Effects of Chemical	
	Substances)	
trade name(s):	AlliedSignal Genetron(R) 142b	MSDS
	Asahi Glass Asahiklin AK-142b	
	Ausimont Meforex(R) 142b	
	Daikin Daiflon(R) 142b	
	DuPont HCFC-142b	MSDS
	Elf Atochem Forane(R) 142b	MSDS
historical name(s):	Allied Corp refrigerant 101	3975
	DuPont Freon(R) 142b	5869
	Elf Atochem Isotron(R) 142b	MSDS
	Pennwalt Isotron(R) 142b	
ARI container color / Pantone number:	none, use light green grey/413	6601
	with red / 185 band	

**PHYSICAL**

· properties -----

molar mass:	100.4947264 g/mol (0.221553 lb/mol)	8820
normal freezing/melting/triple point:	-131.1 °C (-204.1 °F)	8401
· normal boiling point -----		
temperature:	-9.0 °C (15.8 °F)	8401
density, saturated liquid:	1192 kg/m <sup>3</sup> (74.40 lb/cf)	8401
density, saturated vapor:	4.85 kg/m <sup>3</sup> (0.303 lb/cf)	8401
specific volume, saturated liquid:	0.839 L/kg (0.0134 cf/lb)	8401
specific volume, saturated vapor:	206.4 L/kg (3.3056 cf/lb)	8401
heat of vaporization:	222.7 kJ/kg (95.8 Btu/lb)	8401
velocity of sound, saturated liquid:	769 m/s (2523 ft/s)	8401
velocity of sound, saturated vapor:	151 m/s (497 ft/s)	8401
viscosity, saturated liquid:	354 µPa·s (0.354 cp)	8401
viscosity, saturated vapor:	8.74 µPa·s (0.00874 cp)	8401
thermal conductivity, liquid:	0.0943 W/m·K (0.0545 Btu/hr·ft <sup>2</sup> °F)	8401
thermal conductivity, vapor:	0.0093 W/m·K (0.0054 Btu/hr·ft <sup>2</sup> °F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	4.303 kg/m <sup>3</sup> (0.2686 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ----		
density, vapor:	4.285 kg/m <sup>3</sup> (0.2675 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	288.0 kPa (41.77 psia)	4801
density, saturated liquid:	1125 kg/m <sup>3</sup> (70.22 lb/cf)	8401
density, saturated vapor:	13.01 kg/m <sup>3</sup> (0.812 lb/cf)	8401
specific volume, saturated liquid:	0.889 L/kg (0.0142 cf/lb)	8401
specific volume, saturated vapor:	76.9 L/kg (1.2314 cf/lb)	8401
velocity of sound, saturated liquid:	653 m/s (2142 ft/s)	8401
velocity of sound, saturated vapor:	153 m/s (502 ft/s)	8401
viscosity, saturated liquid:	252 µPa·s (0.252 cp)	8401
viscosity, saturated vapor:	9.7 µPa·s (0.0097 cp)	8401
thermal conductivity, saturated liquid:	0.0832 W/m·K (0.0481 Btu/hr·ft <sup>2</sup> °F)	8401
thermal conductivity, saturated vapor:	0.01117 W/m·K (0.00646 Btu/hr·ft <sup>2</sup> °F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	879 kPa (127.5 psia)	8401
heat of vaporization:	175.5 kJ/kg (75.4 Btu/lb)	8401
· critical point -----		
temperature:	137.1 °C (278.8 °F)	8401
pressure:	4123 kPa (598.0 psia)	8401
density:	435 kg/m <sup>3</sup> (27.2 lb/cf)	8401
specific volume:	2.21 L/kg (0.0354 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	18.5 yr	9501
average stratospheric lifetime (τ <sub>str</sub> ):	220 yr	5508
ODP (ozone depletion potential):	0.043 (model-derived relative to R 11)	9501
	0.066 (semi-empirical relative to R 11)	9501
	0.065 (estimate used for the Montreal Protocol)	6904
GWP (global warming potential):	2300 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.36 relative to R 11 for infinite integration period	4511
	0.365 ±0.025 relative to R 11	5964

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	for infinite integration period	
	0.43 relative to R 11 for infinite integration period	4136
photochemical reactivity (grnd level):	0.5 relative to methane	4511
<b>SAFETY</b>		
· classification -----		
safety group (ASHRAE Standard 34):	A2	8601
NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 2-4-0	MSDS
	Ausimont: 2-4-0	MSDS
	Elf Atochem: 2-4-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 2-4-0	MSDS
	DuPont: 1-4-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	7101
· long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	4B89
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	7101
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	17,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
AIHA ERPG-3 (life-threatening):	25,000 ppm v/v for 1 hr	9503
AIHA ERPG-2 (injurious or impairing):	15,000 ppm v/v for 1 hr	9503
AIHA ERPG-1 (odor or mild effects):	10,000 ppm v/v for 1 hr	9503
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 30 min: 500,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5147
	rat, 4 hr, (2-4)/6: 128,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
	rat, 6 hr, 20%: 400,000 ppm (lowest exposure tested with one or more deaths by inhalation)	59A8
	rat, 16 hr 0/10 day 1: 100,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5147
cardiac sensitization (CS) EC50:	dog, 10 min: 73,000 ppm v/v (effective concentration in half of test animals)	6684
cardiac sensitization threshold/LOEL:	dog, 5 min, 5/12: 50,000 ppm v/v (lowest observed effect level in test animals)	5644
cardiac sensitization (CS) NOEL:	dog, 5 min, 0/6: 25,000 ppm v/v (no observed effect level in test animals)	5644

anesthetic/CNS effect EC50:	mouse, 10 min: 250,000 ppm v/v	5980
	(effective concentration in half of test animals)	
anesthetic/CNS effect LOEL:	rat, 30 min: 150,000 ppm v/v	5147
	(lowest observed effect level in test animals)	
• flammability -----		
LFL-UFL (flammability limits in air):	6.7-14.9 % v/v	4511
	6.9-17.0 % v/v	0525
	7.1-18.6 % v/v	3A58
	7.2-18.2 % v/v	2525
	9.0-14.8 % v/v	4136
	AlliedSignal: 8.0-15.4 % v/v	MSDS
	Ausimont: 6.2-18 % v/v	MSDS
	DuPont: 6-15 % v/v	MSDS
	Elf Atochem: 6.9-15.5 % v/v	MSDS
LFL-UFL (with spark ignition):	8.0-14.3 % v/v	3A58
LFL-UFL (with hot-wire ignition):	8.2-14.7 % v/v	3A58
LFL (with hot-wire ignition):	7.8 % v/v	0525
heat of combustion (by ASHRAE 34-92):	9.8 MJ/kg (4213 Btu/lb)	2318
flash point:	none	3A58
autoignition temperature:	632 °C (1170 °F)	3A58
• detection -----		
appearance:	colorless gas	3A58
odor:	nearly odorless to slight ethereal odor	4B89
<b>PRODUCTION</b>		
last year production allowed:	2029 in developed countries under the Montreal Protocol	8C01





infinite integration period

**SAFETY**

· flammability -----  
LFL-UFL (flammability limits in air): 5.8-24.4 % v/v 2525  
heat of combustion (by ASHRAE 34-92): 10.9 MJ/kg (4694 Btu/lb) 4785

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01



temperature:	-47.2 °C (-53.0 °F)	8401
density, saturated liquid:	1168 kg/m <sup>3</sup> (72.90 lb/cf)	8401
density, saturated vapor:	4.76 kg/m <sup>3</sup> (0.297 lb/cf)	8401
specific volume, saturated liquid:	0.856 L/kg (0.0137 cf/lb)	8401
specific volume, saturated vapor:	210.1 L/kg (3.3652 cf/lb)	8401
heat of vaporization:	227.1 kJ/kg (97.6 Btu/lb)	8401
velocity of sound, saturated liquid:	776 m/s (2547 ft/s)	8401
velocity of sound, saturated vapor:	155 m/s (508 ft/s)	8401
viscosity, saturated liquid:	284 µPa·s (0.284 cp)	8401
viscosity, saturated vapor:	8.36 µPa·s (0.00836 cp)	8401
thermal conductivity, liquid:	0.1013 W/m·K (0.0585 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, vapor:	0.0090 W/m·K (0.0052 Btu/hr·ft <sup>2</sup> ·°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	3.558 kg/m <sup>3</sup> (0.2221 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	3.543 kg/m <sup>3</sup> (0.2212 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	1105.7 kPa (160.37 psia)	8401
density, saturated liquid:	951 kg/m <sup>3</sup> (59.38 lb/cf)	8401
density, saturated vapor:	49.83 kg/m <sup>3</sup> (3.110 lb/cf)	8401
specific volume, saturated liquid:	1.050 L/kg (0.0168 cf/lb)	8401
specific volume, saturated vapor:	20.1 L/kg (0.3215 cf/lb)	8401
velocity of sound, saturated liquid:	438 m/s (1436 ft/s)	8401
velocity of sound, saturated vapor:	147 m/s (482 ft/s)	8401
viscosity, saturated liquid:	123 µPa·s (0.123 cp)	8401
viscosity, saturated vapor:	11.3 µPa·s (0.0113 cp)	8401
thermal conductivity, saturated liquid:	0.0724 W/m·K (0.0419 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, saturated vapor:	0.01583 W/m·K (0.00915 Btu/hr·ft <sup>2</sup> ·°F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	2874 kPa (416.9 psia)	8401
heat of vaporization:	94.8 kJ/kg (40.8 Btu/lb)	8401
· critical point -----		
temperature:	72.9 °C (163.2 °F)	8401
pressure:	3776 kPa (547.7 psia)	8401
density:	433 kg/m <sup>3</sup> (27.0 lb/cf)	8401
specific volume:	2.31 L/kg (0.0370 cf/lb)	8401
<b>ENVIRONMENTAL</b>		
average atmospheric lifetime (τ <sub>atm</sub> ):	53.5 yr	9501
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	3B12
GWP (global warming potential):	5400 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.74 ±0.02 relative to R 11 for infinite integration period	5964
	0.97 relative to R 11 for infinite integration period	DW
	1.1 relative to R 11 for infinite integration period	4511
photochemical reactivity (grnd level):	0.2 relative to methane	4511
<b>SAFETY</b>		
· classification -----		
safety group (ASHRAE Standard 34):	A2	8601

NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 2-1-1	MSDS
	Ausimont: 2-4-0	MSDS
	Elf Atochem: 2-4-0	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 1-1-1	MSDS
	DuPont: 1-4-0	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
· long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	1,000 ppm v/v TWA for 8 hr/day	5C16
	and 40 hr/wk	
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	18,000 ppm v/v (preliminary	
	value under review, based on	
	draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr, 0/10: ≥591,000 ppm	7450
	(lowest exposure tested with	
	one or more deaths by	
	inhalation)	
cardiac sensitization (CS) EC50:	dog, 10 min: ~310,000 ppm v/v	6684
	(effective concentration in	
	half of test animals)	
cardiac sensitization threshold/LOEL:	dog, 10 min, 2/5: 300,000 ppm	5C26
	v/v (lowest observed effect	
	level in test animals)	
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/6: 250,000 ppm	6597
	v/v (no observed effect level	
	in test animals)	
anesthetic/CNS effect EC50:	mouse, 10 min: 500,000-600,000	5980
	ppm v/v (effective	
	concentration in half of test	
	animals)	
anesthetic/CNS effect LOEL:	rat, 4 hr, 0/10: >591,000 ppm	7450
	v/v (lowest observed effect	
	level in ALC or LC50 studies)	
· flammability -----		
LFL-UFL (flammability limits in air):	13-17.4 % v/v	5C16
	7.0-19.0 % v/v	2525
	7.4-18.8 % v/v	4785
	DuPont: 7.7-17.4 % v/v	MSDS
	Elf Atochem: 7.1-16.1 % v/v	MSDS
	Solvay: 7.1-16.1 % v/v	MSDS
heat of combustion (by ASHRAE 34-92):	10.3 MJ/kg (4428 Btu/lb)	2318
flash point:	AlSig: gas, not applicable	MSDS
	DuPont: -90 °C (-130 °F)	MSDS
autoignition temperature:	750 °C (1382 °F)	3960
	AlliedSignal: >750°C (>1382°F)	MSDS
autodecomposition temperature:	Elf Atochem: >427 °C (>800 °F)	MSDS
· detection -----		
appearance:	DuPont: clear, colorless	MSDS
odor:	AlliedSignal: faint ethereal	MSDS
	Daikin: faint sweet odor	MSDS
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01

## R-E143

```

----- REFRIGERANT DATA SUMMARY -----
R-E143      fluoromethyl difluoromethyl ether      see
HFE         CH2F-O-CHF2                            CAS number 461-63-2      RDB#
-----

```

**COMMON USE(S)**

candidate alternative for refrigerant 12

**IDENTIFIERS**

```

common name(s):  R-E143; RE143; R E143
                  HFE-E143; HFOC-E143
                  fluorochemical E143; FC E143
                  fluoroether E143; E-143
                  halochemical E143
alternative chemical names/formulae:  fluoromethyl difluoromethyl
                                      ether
                                      difluoromethyl fluoromethyl
                                      ether
                                      difluoromethoxy fluoromethane
                                      fluoromethoxy difluoromethane
                                      CH2FOCHF2; CH2F-O-CHF2
not recommended:
                  CF2HOCFH2; CFH2-O-CFH2
                  CFH2OCF2H; CFH2-O-CF2H
                  CHF2OCH2F; CHF2-O-CH2F
empirical formula:  C2H3F3O
CAS number:        461-63-2 Chemical Abstracts
                  Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass: 100.0398296 g/mol (0.220550 8820
lb/mol)
· critical point -----
temperature: 106.1 °C (223.0 °F) 3407

```

**ENVIRONMENTAL**

```

average tropospheric lifetime (τtrop): 0.3-0.7 yr 5829
ODP (ozone depletion potential): 0.000 (model-derived relative
to R 11)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: unrestricted 8C01

```

## R-E143a

## ----- REFRIGERANT DATA SUMMARY -----

R-E143a	methyl trifluoromethyl ether		see
HFE	CH <sub>3</sub> -O-CF <sub>3</sub>	CAS number 421-14-7	RDB#

**COMMON USE(S)**

candidate alternative for refrigerant 12

**IDENTIFIERS**

common name(s):	R-E143a; RE143a; R E143a HFE-143a; HFOC-E143a fluorochemical E143a; FC E143a fluoroether E143a; E-143a halochemical E143a	
alternative chemical names/formulae:	methyl trifluoromethyl ether	3728
	methyl F-methyl ether	3728
	trifluoromethyl methyl ether	3728
	F-methyl methyl ether	3728
	CH <sub>3</sub> O-CF <sub>3</sub> ; CH <sub>3</sub> -O-CF <sub>3</sub>	3728
	not recommended:	3728
	CF <sub>3</sub> OCH <sub>3</sub> ; CF <sub>3</sub> -O-CH <sub>3</sub>	3728
	F <sub>3</sub> COCH <sub>3</sub> ; F <sub>3</sub> C-O-CH <sub>3</sub>	3728
	H <sub>3</sub> COCF <sub>3</sub> ; H <sub>3</sub> C-O-CF <sub>3</sub>	3728
empirical formula:	C <sub>2</sub> H <sub>3</sub> F <sub>3</sub> O	
CAS number:	421-14-7 Chemical Abstracts Service Registry Number	

**PHYSICAL**

· properties -----		
	molar mass:	100.0398296 g/mol (0.220550 lb/mol) 8820
	normal freezing/melting/triple point:	-149.0 °C (-236.2 °F) 3728
· normal boiling point -----		
	temperature:	-23.8 °C (-10.8 °F) 3728
		-23.8 °C (-10.8 °F) 2255
		-24.1 °C (-11.4 °F) 2834
· critical point -----		
	temperature:	104.9 °C (220.8 °F) 3728
	pressure:	3588 kPa (520.4 psia) 3728
	density:	439 kg/m <sup>3</sup> (27.4 lb/cf)
	specific volume:	2.28 L/kg (0.0365 cf/lb)

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	5.7 yr	9501
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	970 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.107 relative to R 11 for infinite integration period	4890

**SAFETY**

· classification -----		
	safety group (ASHRAE Standard 34):	none (no application pending) 8601

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

· acute (short-term) toxicity -----  
ALC (approximate lethal concentration: rat, 4 hr: 7,500 ppm (lowest 7B15  
exposure tested with one or  
more deaths by inhalation)

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01

## R-150

```

----- REFRIGERANT DATA SUMMARY -----
R-150      1,2-dichloroethane      see
HCC        CH2ClCH2Cl             CAS number 107-06-2      RDB#
-----

```

**COMMON USE(S)**

gasoline additive; ingredient in fumigant insecticides; component in chemical degreasing mixtures; constituent of rubber cement and other adhesives; chemical intermediate

**IDENTIFIERS**

```

common name(s):  R-150; R150; R 150
                  HCC-150
                  1,2-DCE
                  Dutch liquid; Dutch oil
                  halochemical 150
chemical name (by IUPAC convention): 1,2-dichloroethane
alternative chemical names/formulae: ethane, 1,2-dichloro-
                                      1,2-bichloroethane
                                      sym-dichloroethane
                                      symmetrical dichloroethane
                                      a,β-dichloroethane
                                      alpha beta dichloroethane      7744
                                      ethane dichloride
                                      glycol dichloride
                                      CClH2CClH2; CClH2-CClH2
                                      not recommended:
                                      CH2ClCH2Cl; CH2Cl-CH2Cl
empirical formula: C2H4Cl2
CAS number:       107-06-2 Chemical Abstracts
                  Service Registry Number
EINECS number:   203-458-1 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number: KI0525000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
historical name(s): "dichloroethylene"
                   "ethylene chloride"      7744
                   "ethylene dichloride"; EDC 7744
                   "glycol dichloride"; GDC 7744

```

**PHYSICAL**

```

· properties -----
molar mass: 98.95856 g/mol (0.218166      8820
             lb/mol)
normal freezing/melting/triple point: -35.3 °C (-31.5 °F)      7601
                                         -35.6 °C (-32.1 °F)      3903
· normal boiling point -----
temperature: 83.3 °C (181.9 °F)          3903
             83.5 °C (182.3 °F)          7601
· 20 °C (68 °F) -----
density, saturated liquid: 1253 kg/m3 (78.22 lb/cf)      7601
· critical point -----

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



temperature: 288.0 °C (550.4 °F) 7601

**ENVIRONMENTAL**

ODP (ozone depletion potential): <0.001 (model-derived relative 5782 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 IARC/CIRC human carcinogenicity group: 2B, possibly carcinogenic 8802  
 NIOSH caution: potential occupational carcinogen (limit exposures to lowest feasible) 5204  
 ACGIH carcinogenicity category: A4, not classifiable as a human carcinogen 9504  
 DFG carcinogenicity class: IIIA2: carcinogenic in animals 5561  
 · occupational exposure warnings -----  
 substance under study: ACGIH 8810  
 · short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 50 ppm v/v (potential occupational carcinogen) 5204  
 NIOSH SCP IDLH (immediately dangerous: 1,000 ppm v/v for 30 min (SCP excluded potential carcinogenic effects) 3903  
 NIOSH STEL (short-term exposure limit): 2 ppm v/v TWA for 15 min 5204  
 · occupational exposure limit -----  
 OSHA PEL-C (exposure ceiling): 100 ppm v/v (must not exceed) 3904  
 OSHA acceptable maximum peak: 200 ppm for 5 min in 3 hr 3904  
 (peak allowed over ceiling for specified interval)  
 · long-term occupational limit -----  
 OSHA PEL (permissible exposure limit): 50 ppm v/v TWA for 8 hr/day and 40 hr/wk 3904  
 NIOSH REL (recommended exposure limit): 1 ppm v/v TWA for 10 hr/day and 40 hr/wk 5204  
 ACGIH TLV-TWA (time-weighted average): 10 ppm v/v TWA for 8 hr/day and 40 hr/wk 9504  
 · flammability -----  
 LFL-UFL (flammability limits in air): 6.2-16 % v/v 3903  
 flash point: 13 °C (56 °F) 3903

## R-150a

```

----- REFRIERANT DATA SUMMARY -----
R-150a      1,1-dichloroethane      see
HCC         CH3CHCl2                CAS number 75-34-3      RDB#
-----

```

**COMMON USE(S)**

solvent for extraction and degreasing; chemical intermediate

**IDENTIFIERS**

```

common name(s):  R-150a; R150a; R 150a
                  HCC-150a
                  halochemical 150a
chemical name (by IUPAC convention): 1,1-dichloroethane
alternative chemical names/formulae: ethane, 1,1-dichloro-
                                     asymmetrical dichloroethane
                                     ethylidene chloride          7744
                                     1,1-ethylidene dichloride
                                     CH3CHCl2; CH3-CHCl2
not recommended:
                  CC12HCH3; CC12H-CH3
                  CH3CC12H; CH3-CC12H
                  CHCl2CH3; CHCl2-CH3
empirical formula: C2H4Cl2
CAS number:       75-34-3 Chemical Abstracts
                  Service Registry Number
NIOSH RTECS number: KI0175000 (Registry of Toxic
                  Effects of Chemical
                  Substances)

```

**PHYSICAL**

```

· properties -----
molar mass: 98.95856 g/mol (0.218166      8820
             lb/mol)
normal freezing/melting/triple point: -96.7 °C (-142.1 °F)      7601
                                     -97.2 °C (-143.0 °F)      3903
· normal boiling point -----
temperature: 57.3 °C (135.1 °F)          7601
· 20 °C (68 °F) -----
density, saturated liquid: 1174 kg/m3 (73.29 lb/cf)      7601
· critical point -----
temperature: 250.0 °C (482.0 °F)        7601

```

**ENVIRONMENTAL**

ODP (ozone depletion potential): <0.001 (model-derived relative 5782 to R 11)

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34): none (no application pending) 8601
  ACGIH carcinogenicity category:  A4, not classifiable as a      9504
                                     human carcinogen
· occupational exposure warnings -----
  NIOSH caution:  chemical similar to carcinogen 5204
· short-term occupational limit -----

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

NIOSH IDLH (immediately dangerous):	3,000 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	4,000 ppm v/v for 30 min	3903
• occupational exposure limit -----		
MAK (maximum workplace concentration):	II, 1: 200 ppm v/v avg for 30 min	5561
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk	3903
NIOSH REL (recommendd exposure limit):	100 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	100 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	7101
• acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr: 26,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
• flammability -----		
LFL-UFL (flammability limits in air):	5.4-11.4 % v/v	5204
flash point:	-17 °C (2 °F)	5204





## R-152

```

----- REFRIGERANT DATA SUMMARY -----
R-152      1,2-difluoroethane
HFC        CH2FCH2F                      CAS number 624-72-6
                                                see
                                                RDB#
-----

```

**COMMON USE(S)**

under limited consideration as an alternative or blend component for centrifugal chillers and as a refrigerant in high-temperature heat pumps, constrained by concerns with acute toxicity at concentrations as low as 25 ppm (see RDB2411)

**IDENTIFIERS**

```

common name(s):  R-152; R152; R 152
                  HFC-152
                  fluorocarbon 152
                  fluorochemical 152; FC 152
                  halocarbon 152
chemical name (by IUPAC convention):  1,2-difluoroethane
alternative chemical names/formulae:  ethane, 1,2-difluoro-
                                      CH2FCH2F; CH2F-CH2F
not recommended:
    CFH2CFH2; CFH2-CFH2
    H2FCCH2F; H2FC-CH2F
empirical formula:  C2H4F2
CAS number:        624-72-6 Chemical Abstracts
                  Service Registry Number
historical name(s):  Allied Corp refrigerant 105
ARI container color / Pantone number:  none, use light green grey/413 6601
                                      with red / 185 band

```

**PHYSICAL**

```

· properties -----
molar mass:  66.0499664 g/mol (0.145615      8820
              lb/mol)
· normal boiling point -----
temperature:  30.7 °C (87.2 °F)              1136
· critical point -----
temperature:  107.5 °C (225.5 °F)           7601

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (τatm):  0.5 yr      9501
ODP (ozone depletion potential):  0.000 (model-derived relative
to R 11)
GWP (global warming potential):  43 relative to CO2 for 100 yr  9501
integration

```

**SAFETY**

```

· flammability -----
LFL-UFL (flammability limits in air):  3.6-21.8 % v/v      2525
heat of combustion (by ASHRAE 34-92):  17.7 MJ/kg (7607 Btu/lb)  4785

```

**PRODUCTION**

```

last year production allowed:  unrestricted      8C01

```



· properties -----		
	molar mass:	66.0499664 g/mol (0.145615 lb/mol) 8820
	normal freezing/melting/triple point:	-118.6 °C (-181.5 °F) 8401
· normal boiling point -----		
	temperature:	-24.0 °C (-11.2 °F) 8401
	density, saturated liquid:	1011 kg/m <sup>3</sup> (63.13 lb/cf) 8401
	density, saturated vapor:	3.38 kg/m <sup>3</sup> (0.211 lb/cf) 8401
	specific volume, saturated liquid:	0.989 L/kg (0.0158 cf/lb) 8401
	specific volume, saturated vapor:	296.2 L/kg (4.7450 cf/lb) 8401
	heat of vaporization:	329.9 kJ/kg (141.8 Btu/lb) 8401
	velocity of sound, saturated liquid:	889 m/s (2918 ft/s) 8401
	velocity of sound, saturated vapor:	185 m/s (608 ft/s) 8401
	viscosity, saturated liquid:	301 µPa·s (0.301 cp) 8401
	viscosity, saturated vapor:	8.44 µPa·s (0.00844 cp) 8401
	thermal conductivity, liquid:	0.1202 W/m·K (0.0694 Btu/hr·ft°F) 8401
	thermal conductivity, vapor:	0.0094 W/m·K (0.0054 Btu/hr·ft°F) 8401
· normal pressure, 20 °C (68 °F) -----		
	density, vapor:	2.810 kg/m <sup>3</sup> (0.1754 lb/cf) 8401
· normal pressure, 21.1 °C (70 °F) ---		
	density, vapor:	2.799 kg/m <sup>3</sup> (0.1747 lb/cf) 8401
· 20 °C (68 °F) -----		
	pressure, saturated vapor:	512.9 kPa (74.39 psia) 8401
	density, saturated liquid:	912 kg/m <sup>3</sup> (56.93 lb/cf) 8401
	density, saturated vapor:	15.91 kg/m <sup>3</sup> (0.993 lb/cf) 8401
	specific volume, saturated liquid:	1.097 L/kg (0.0176 cf/lb) 8401
	specific volume, saturated vapor:	62.9 L/kg (1.0068 cf/lb) 8401
	velocity of sound, saturated liquid:	673 m/s (2208 ft/s) 8401
	velocity of sound, saturated vapor:	186 m/s (611 ft/s) 8401
	viscosity, saturated liquid:	172 µPa·s (0.172 cp) 8401
	viscosity, saturated vapor:	10.1 µPa·s (0.0101 cp) 8401
	thermal conductivity, saturated liquid:	0.1002 W/m·K (0.0579 Btu/hr·ft°F) 8401
	thermal conductivity, saturated vapor:	0.01424 W/m·K (0.00823 Btu/hr·ft°F) 8401
· 60 °C (140 °F) -----		
	pressure, saturated vapor:	1501 kPa (217.7 psia) 8401
	heat of vaporization:	229.4 kJ/kg (98.6 Btu/lb) 8401
· critical point -----		
	temperature:	113.2 °C (235.7 °F) 9125
		113.3 °C (235.9 °F) 4121
	pressure:	4515 kPa (654.8 psia) 4121
		4517 kPa (655.1 psia) 4B09
	density:	368 kg/m <sup>3</sup> (23.0 lb/cf) 4B09
		369 kg/m <sup>3</sup> (23.0 lb/cf) 9125
	specific volume:	2.72 L/kg (0.0435 cf/lb) 4B09

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	1.5 ±0.4 yr	6695
average stratospheric lifetime ( $\tau_{str}$ ):	61 yr	5508
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	3B12
GWP (global warming potential):	190 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.0295 ±0.0035 relative to R 11 for infinite integration period	5964

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



## Refrigerant Database

photochemical reactivity (grnd level): 4.8 relative to methane 4511

**SAFETY**

- classification -----
  - safety group (ASHRAE Standard 34): A2 8601
  - NFPA 704 degrees of hazard (H-F-R-S): Elf Atochem: 2-4-0 MSDS
  - health-flammability-reactivity [-special]: 0=no, 4=severe
  - NPCA HMIS hazard ratings (H-F-R): DuPont: 1-4-1 MSDS
  - health-flammability-reactivity 0=insignificant, 4=extreme
- long-term occupational limit -----
  - AIHA WEEL (workplace envl exp limit): 1,000 ppm v/v TWA for 8 hr/day 4B90 and 40 hr/wk
- emergency exposure limit -----
  - Refrigerant Concentration Limit (RCL): 9,800 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)
- acute (short-term) toxicity -----
  - LC50 (lethal concentration, 50%): rat, 4 hr: >437,500 ppm (fatal concentration by inhalation for half of test animals) 5C85
- ALC (approximate lethal concentration): rat, 30 min: 500,000 ppm 5147 (lowest exposure tested with one or more deaths by inhalation)
- rat, 4 hr, 1/6: 383,000 ppm 5C85 (lowest exposure tested with one or more deaths by inhalation)
- oral LD50 (lethal dosage, 50%): rat: >1,500 mg/kg (fatal dose by ingestion for half of test animals) 5C84
- cardiac sensitization threshold/LOEL: dog, 5 min, 3/12: 150,000 ppm v/v (lowest observed effect level in test animals) 5644
- cardiac sensitization (CS) NOEL: dog, 5 min, 0/12: 50,000 ppm v/v (no observed effect level in test animals) 5644
- anesthetic/CNS effect LOEL: rat, 30 min: 200,000 ppm v/v (lowest observed effect level in test animals) 5147
- anesthetic/CNS effect NOEL: rat, 30 min: 100,000 ppm v/v (no observed effect level in test animals) 5147
- flammability -----
  - LFL-UFL (flammability limits in air): 3.9-16.9 % v/v 4511
  - 4.5-19.8 % v/v 4785
  - 4.8-20.2 % v/v 2525
  - AlliedSignal: 3.7-18.0 % v/v MSDS
  - Daikin: 4.0-19.6 % v/v MSDS
  - Elf Atochem: 3.1-16.9 % v/v MSDS
  - Elf Atochem: 3.7-18.0 % v/v CSDS
  - LFL-UFL (flammability limits, 95 °C): 3.8-21.4 % v/v 2525
  - LFL-UFL (with spark ignition): 4.5-19.8 % v/v 2525
  - LFL-UFL (with hot-wire ignition): 4.8-18.8 % v/v 2525
  - heat of combustion (by ASHRAE 34-92): 16.9 MJ/kg (7266 Btu/lb) 2318
  - 17.4 MJ/kg (7472 Btu/lb) 4785
  - flash point: TOC: <-50 °C (<-58 °F) 4B90

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

autoignition temperature:	455 °C (851 °F)	3960
autodecomposition temperature:	DuPont: 454 °C (849 °F)	MSDS
· detection -----		
appearance:	colorless gas	4B90
odor:	slight ethereal odor	4B90
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01

## Refrigerant Database

## R-E152

```

----- REFRIERANT DATA SUMMARY -----
R-E152      fluoromethoxy-fluoromethane      see
HFE         CH2F-O-CH2F                      CAS number 462-51-1      RDB#
-----

```

**COMMON USE(S)**

candidate alternative refrigerant as a single-compound refrigerant,  
constrained by flammability and instability, or as a blend component

**IDENTIFIERS**

```

common name(s):  R-E152; RE152; R E152
                 HFE-E152; HFOC-E152
                 fluorochemical E152; FC E152
                 fluoroether E152; E-152
                 halochemical E152
chemical name (by IUPAC convention):  fluoromethoxy-fluoromethane
alternative chemical names/formulae:  methane, fluoromethoxy-fluoro-
                                     bis(fluoromethyl) ether
                                     CH2FOCH2F; CH2F-O-CH2F
not recommended:
                 CFH2OCFH2; CFH2-O-CFH2
empirical formula:  C2H4F2O
CAS number:        462-51-1 Chemical Abstracts
                 Service Registry Number
ARI container color / Pantone number:  none, use light green grey/413 6601
                                     with red / 185 band

```

**PHYSICAL**

```

· properties -----
molar mass:      82.0493664 g/mol (0.180888      8820
                 lb/mol)
· normal boiling point -----
temperature:     33.0 °C (91.4 °F)              7B15

```

**ENVIRONMENTAL**

```

average tropospheric lifetime (τtrop):  0.2-0.3 yr      5829
ODP (ozone depletion potential):        0.000 (model-derived relative
to R 11)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):      none (no application pending)  8601
· flammability -----
LFL-UFL (flammability limits in air):    probably flammable            7B15

```

**PRODUCTION**

```

first commercial use as a refrigerant:   not known to be commercialized
last year production allowed:            unrestricted                  8C01

```

## R-E152a

```

----- REFRI GERANT DATA SUMMARY -----
R-E152a      methoxy-difluoromethane      see
HFE          CH3-O-CHF2                    CAS number 359-15-9      RDB#
-----

```

**COMMON USE(S)**

candidate refrigerant or refrigerant blend component constrained by flammability and instability

**IDENTIFIERS**

```

common name(s):  R-E152a; RE152a; R E152a
                  HFE-E152a; HFOC-E152a
                  fluorochemical E152a; FC E152a
                  fluoroether E152a; E-152a
                  halochemical E152a
chemical name (by IUPAC convention):  methoxy-difluoromethane
alternative chemical names/formulae:  difluoromethoxy-methane
                                      difluoromethyl methyl ether
                                      1,1-difluorodimethyl ether
                                      methyl difluoromethyl ether
                                      CH3OCHF2; CH3-O-CHF2
not recommended:
  CF2HOCH3; CF2H-O-CH3
  CH3OCF2H; CH3-O-CF2H
  CHF2OCH3; CHF2-O-CH3
empirical formula:  C2H4F2O
CAS number:         359-15-9 Chemical Abstracts
                   Service Registry Number
ARI container color / Pantone number:  none, use light green grey/413 6601
                                       with red / 185 band

```

**PHYSICAL**

```

· properties -----
molar mass:  82.0493664 g/mol (0.180888      8820
              lb/mol)

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (τatm):  2.0 yr      5442
average tropospheric lifetime (τtrop): 0.1 yr      5829
ODP (ozone depletion potential):      0.000 (model-derived relative
                                       to R 11)
                                       0.000 (model-derived relative
                                       to R 11)
GWP (global warming potential):       110 relative to CO2 for 100 yr 5442
                                       integration

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending) 8601
· flammability -----
  LFL-UFL (flammability limits in air): probably flammable      7B15

```

**PRODUCTION**

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01

## R-160

```

----- REFRIERANT DATA SUMMARY -----
R-160      chloroethane      see
HCC        CH3CH2Cl          CAS number 75-00-3      RDB#
-----

```

**COMMON USE(S)**

transport refrigeration in railway cars from the 1870s through 1920s;  
 domestic refrigerators, sometimes in blends with refrigerant 160B1,  
 in the 1900s through 1930s; formerly used as a topical anesthetic

**IDENTIFIERS**

```

common name(s):  R-160; R160; R 160
                  HCC-160
                  chlorene
                  halochemical 160
chemical name (by IUPAC convention): chloroethane
alternative chemical names/formulae: 1-chloroethane
                                       ethane, chloro-
                                       ethane, 1-chloro-
                                       monochloroethane
                                       chloroethyl          7744
                                       ethyl chloride
                                       CH3CH2Cl; CH3-CH2Cl
not recommended:
  CC1H2CH3; CC1H2-CH3
  CH2ClCH3; CH2Cl-CH3
  H3CCH2Cl; H3C-CH2Cl
empirical formula: C2H5Cl
CAS number:       75-00-3 Chemical Abstracts
                  Service Registry Number
Beilstein registry number: 1730751
EINECS number:    200-830-5 (European Inventory
of Existing Chemical
Substances)
Merck Index (volume-number): 11-3740
NIOSH RTECS number: KH7525000 (Registry of Toxic
Effects of Chemical
Substances)
historical name(s): aetheylis          7744
                   aetheylis chloridum 7744
                   ether chloratus     7744
                   ether chloridum     7744
                   ether hydrochloric  7744
                   ether muriatic      7744
                   hydrochloric ether  5204
                   muriatic ether     5204
                   Chelen              7744
                   Kelene              7744
                   Railway and Stationary Refrig-
                   erating Company Clothel(R) 2113
ARI container color / Pantone number: none, use light green grey/413 6601
                                       with red / 185 band

```

**PHYSICAL**

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

· properties -----		
	molar mass:	64.51380 g/mol (0.142229 lb/mol) 8820
	normal freezing/melting/triple point:	-138.3 °C (-216.9 °F) 1136
		-138.9 °C (-218.0 °F) 5204
· normal boiling point -----		
	temperature:	12.2 °C (54.0 °F) 5204
		12.4 °C (54.3 °F) 2318
		13.1 °C (55.6 °F) 7601
· critical point -----		
	temperature:	186.6 °C (367.9 °F) 2318
		187.2 °C (369.0 °F) 7601
		187.3 °C (369.1 °F) 9318
	pressure:	5240 kPa (760.0 psia) 2318
		5270 kPa (764.4 psia) 9318
	density:	330 kg/m3 (20.6 lb/cf) 1136
	specific volume:	3.03 L/kg (0.0485 cf/lb) 1136

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	<1 yr	2318
ODP (ozone depletion potential):	0.02 (model-derived relative to R 11)	9318
	<0.001 (model-derived relative to R 11)	5782

**SAFETY**

· classification -----		
	safety group (ASHRAE Standard 34):	none (no application pending) 8601
	NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-4-0 MSDS
		health-flammability-reactivity [-special]: 0=no, 4=severe
	NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-4-0 MSDS
		health-flammability-reactivity 0=insignificant, 4=extreme
	UL Comparative Hazard to Life Group:	between 4 and 5 in absence of flame or hot objects 4B64
	ACGIH carcinogenicity category:	A3, animal carcinogen 9504
	DFG carcinogenicity class:	IIIB: suspect, to be evaluated 5561
· occupational exposure warnings -----		
	NIOSH caution:	chemical similar to carcinogen 5204
	ACGIH caution:	cutaneous absorption potential 9504
· short-term occupational limit -----		
	NIOSH IDLH (immediately dangerous):	3,800 ppm v/v based on 10% of LEL 5204
	NIOSH SCP IDLH (immediately dangerous):	20,000 ppm v/v for 30 min 3903
· long-term occupational limit -----		
	OSHA PEL (permissible exposure limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk 3904
	ACGIH TLV-TWA (time-weighted average):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk 9504
· acute (short-term) toxicity -----		
	LC50 (lethal concentration, 50%):	rat, 2 hr, BOC Gases: 60,000 ppm (fatal concentration by inhalation for half of test animals) MSDS
· flammability -----		
	LFL-UFL (flammability limits in air):	3.8-15.4 % v/v 3903
	LFL (lower flammability limit in air):	3.6 % v/v 2318
	heat of combustion (by ASHRAE 34-92):	20.6 MJ/kg (8856 Btu/lb) 2318

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

flash point:	-50 °C (-58 °F) for liquid	5204
	not applicable for gas	3903
autoignition temperature:	519 °C (966 °F)	4B64
autodecomposition temperature:	BOC Gases: 519 °C (966 °F)	MSDS
· detection -----		
appearance:	colorless gas or liquid	5204
odor:	pungent ether-like odor	5204
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1870 by C. C. Palmer	2113
	before 1924 Utility Compressor	6104



## R-160B1

```

----- REFRIGERANT DATA SUMMARY -----
R-160B1      bromoethane
HBC          CH3CH2Br          CAS number 74-96-4          see
                                           RDB#
-----

```

**COMMON USE(S)**

blend component with refrigerant 160 in domestic refrigerators in the 1900s and 1910s; limited use in early commercial refrigeration, but displaced in the late 1930s and 1940s due to high toxicity (subsequently also identified as a carcinogen); chemical intermediate

**IDENTIFIERS**

```

common name(s):  R-160B1; R160B1; R 160B1
                  HBC-160B1
                  halochemical 160B1
                  halon 2001
chemical name (by IUPAC convention):  bromoethane
alternative chemical names/formulae:  1-bromoethane
                                      ethane, bromo-
                                      ethyl bromide
                                      monobromoethane
                                      CH3CH2Br; CH3-CH2Br
not recommended:
  BrH2CCH3; BrH2C-CH3
  CBrH2CH3; CBrH2-CH3
  CH2BrCH3; CH2Br-CH3
  CH3CBrH2; CH3-CBrH2
empirical formula:  C2H5Br
CAS number:        74-96-4 Chemical Abstracts
                  Service Registry Number
Beilstein registry number:  1209224
EINECS number:      200-825-8 (European Inventory
                  of Existing Chemical
                  Substances)
Merck Index (volume-number):  12-3819
NIOSH RTECS number:  KH6475000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
historical name(s):  bromic ether          7744
                    hydrobromic ether    7744
ARI container color / Pantone number:  none, use light green grey/413 6601
                                      with red / 185 band

```

**PHYSICAL**

```

· properties -----
molar mass:      108.96510 g/mol (0.240227      8820
                  lb/mol)
normal freezing/melting/triple point:  -118.9 °C (-182.0 °F)      3903
· normal boiling point -----
temperature:     38.0 °C (100.4 °F)            4B64

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

UL Comparative Hazard to Life Group:	4(b) in absence of flame or hot objects	4B64
IARC/CIRC human carcinogenicity group:	3, not classifiable	8802
ACGIH carcinogenicity category:	A3, animal carcinogen	9504
DFG carcinogenicity class:	IIIA2: carcinogenic in animals	5561
• occupational exposure warnings -----		
NIOSH caution:	PEL of 200 ppm inadequate	5204
	STEL of 250 ppm inadequate	5204
ACGIH caution:	cutaneous absorption potential	9504
substance under study:	ACGIH	8810
• short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	2,000 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	3,500 ppm v/v for 30 min	3903
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	200 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
ACGIH TLV-TWA (time-weighted average):	5 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
• flammability -----		
LFL-UFL (flammability limits in air):	6.0-11.0 % v/v	4B64
	6.8-8.0 % v/v	3903
flash point:	< -15.6 °C (<4 °F)	3903
autoignition temperature:	511 °C (952 °F)	4B64
• detection -----		
appearance:	colorless to yellow liquid	5204
odor:	ether-like odor	5204
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1932 by Brown-Boveri Company	4147



safety group (ASHRAE Standard 34):	none (no application pending)	8601
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration:	rat, 4 hr: 256,000 ppm (lowest	5643
	exposure tested with one or	
	more deaths by inhalation)	
· flammability -----		
LFL-UFL (flammability limits in air):	3.8-18.0 % v/v	2525
LFL-UFL (with spark ignition):	14.2-43.7 % v/v	2525
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01



## R-170 (ethane)

## ----- REFRIGERANT DATA SUMMARY -----

R-170	ethane		see
HC	CH3CH3	CAS number 74-84-0	RDB#

**COMMON USE(S)**

low stage of cascade refrigeration systems for extremely low temperature industrial systems, primarily in the metal and chemical industries; use is constrained by flammability even though R-170 offers comparatively high system capacities at very low temperatures

**IDENTIFIERS**

common name(s):	R-170; R170; R 170
	HC-170
	bimethyl
	dimethyl
	hydrocarbon 170
	n-C2; n-C2H6
chemical name (by IUPAC convention):	ethane
alternative chemical names/formulae:	methyl methane
	methylmethane
	ethyl hydride
	CH3CH3; CH3-CH3
	not recommended: (CH3)2
empirical formula:	C2H6
CAS number:	74-84-0 Chemical Abstracts
	Service Registry Number
Beilstein registry number:	1730716
EINECS number:	200-814-8 (European Inventory
	of Existing Chemical
	Substances)
Merck Index (volume-number):	12-3767
NIOSH RTECS number:	KH3800000 (Registry of Toxic
	Effects of Chemical
	Substances)
ARI container color / Pantone number:	none, use light green grey/413 6601
	with red / 185 band

**PHYSICAL**

· properties -----		
	molar mass:	30.06904 g/mol (0.066291 lb/mol) 8820
normal freezing/melting/triple point:		-182.8 °C (-297.0 °F) 8401
· normal boiling point -----		
	temperature:	-88.6 °C (-127.5 °F) 8401
	density, saturated liquid:	544 kg/m3 (33.96 lb/cf) 8401
	density, saturated vapor:	2.05 kg/m3 (0.128 lb/cf) 8401
	specific volume, saturated liquid:	1.838 L/kg (0.0294 cf/lb) 8401
	specific volume, saturated vapor:	487.0 L/kg (7.8007 cf/lb) 8401
	heat of vaporization:	489.5 kJ/kg (210.4 Btu/lb) 8401
velocity of sound, saturated liquid:		1313 m/s (4308 ft/s) 8401
velocity of sound, saturated vapor:		249 m/s (815 ft/s) 8401
	viscosity, saturated liquid:	162 µPa·s (0.162 cp) 8401
	viscosity, saturated vapor:	5.86 µPa·s (0.00586 cp) 8401

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

thermal conductivity, liquid:	0.1931 W/m·K (0.1116 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, vapor:	0.0102 W/m·K (0.0059 Btu/hr·ft <sup>2</sup> ·°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	1.260 kg/m <sup>3</sup> (0.0787 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	1.255 kg/m <sup>3</sup> (0.0784 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	3766.0 kPa (546.21 psia)	8401
density, saturated liquid:	339 kg/m <sup>3</sup> (21.18 lb/cf)	8401
density, saturated vapor:	86.39 kg/m <sup>3</sup> (5.393 lb/cf)	8401
specific volume, saturated liquid:	2.947 L/kg (0.0472 cf/lb)	8401
specific volume, saturated vapor:	11.6 L/kg (0.1854 cf/lb)	8401
velocity of sound, saturated liquid:	371 m/s (1219 ft/s)	8401
velocity of sound, saturated vapor:	211 m/s (693 ft/s)	8401
viscosity, saturated liquid:	41 µPa·s (0.041 cp)	8401
viscosity, saturated vapor:	11.6 µPa·s (0.0116 cp)	8401
thermal conductivity, saturated liquid:	0.0958 W/m·K (0.0554 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, saturated vapor:	0.03795 W/m·K (0.02193 Btu/hr·ft <sup>2</sup> ·°F)	8401
· critical point -----		
temperature:	32.2 °C (89.9 °F)	8401
pressure:	4872 kPa (706.6 psia)	8401
density:	207 kg/m <sup>3</sup> (12.9 lb/cf)	8401
specific volume:	4.84 L/kg (0.0775 cf/lb)	8401

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	unknown, but very low: ~20 relative to CO <sub>2</sub> for 100 yr integration	
photochemical reactivity (grnd level):	37 relative to methane	4511

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A3	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 0-4-0 Texaco: 1-4-0	MSDS MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 0-4-0 Texaco: 1-4-0	MSDS MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	5(b) in absence of flame or hot objects	4B64
· occupational exposure warnings -----		
ACGIH caution:	simple asphyxiant	9504
· long-term occupational limit -----		
exposure limit consistent to OSHA PEL:	Exxon: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk Pennzoil, C1-C4 assumed: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk Phillips: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS MSDS MSDS

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

· acute (short-term) toxicity -----  
 ALC (approximate lethal concentration: rat, 4 hr, 0/10: >24,838 ppm 7623  
 (lowest exposure tested with  
 one or more deaths by  
 inhalation)  
 cardiac sensitization (CS) EC50: dog 10min 2/4: 100,000-250,000 6192  
 ppm v/v (effective  
 concentration in half of test  
 animals)

· flammability -----  
 LFL-UFL (flammability limits in air): 3.2-12.45 % v/v 6290  
 3.3-10.6 % v/v 0036  
 BOC Gases: 3.0-12.4 % v/v MSDS  
 Exxon: 3.0-12.5 % v/v MSDS  
 Phillips: 2.9-13.0 % v/v MSDS  
 Texaco: 2.9-13.0 % v/v MSDS  
 Union Carbide: 3.2-12.5 % v/v MSDS  
 flash point: -135 °C (-211 °F) 6290  
 CC, Exxon: -152 °C (-242 °F) MSDS  
 autoignition temperature: 510 °C (950 °F) 4B64  
 BOC Gases: 472 °C (882 °F) MSDS  
 Exxon: 515 °C (959 °F) MSDS  
 Texaco: 515 °C (959 °F) MSDS

· detection -----  
 appearance: Phillips: colorless MSDS  
 odor: Union Carbide: odorless MSDS

**PRODUCTION**  
 last year production allowed: unrestricted 8C01





temperature:	128.8 °C (263.8 °F)	1136
pressure:	5321 kPa (771.8 psia)	1136
density:	369 kg/m <sup>3</sup> (23.0 lb/cf)	1136
specific volume:	2.71 L/kg (0.0434 cf/lb)	1136

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	0.015 yr	9501
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	<1 relative to CO <sub>2</sub> for 100 yr integration	9501

**SAFETY**

• classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
NFPA 704 degrees of hazard (H-F-R-S):	DuPont: 2-4-1	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	DuPont: 1-4-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
• occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	5561
• long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	4B84
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 4 hr, DuPont: 164,000 ppm (fatal concentration by inhalation for half of test animals)	MSDS
cardiac sensitization threshold/LOEL:	dog, 5 min, 2/12: 200,000 ppm v/v (lowest observed effect level in test animals)	5644
cardiac sensitization (CS) NOEL:	dog, 5 min, 0/6: 100,000 ppm v/v (no observed effect level in test animals)	5644
• flammability -----		
LFL-UFL (flammability limits in air):	3.3-18.0 % v/v	6210
	3.3-21.3 % v/v	2525
	DuPont: 3.4-18.0 % v/v	MSDS
flash point:	TOC, DuPont: -41 °C (-42 °F)	MSDS
autoignition temperature:	DuPont: 350 °C (662 °F)	MSDS
• detection -----		
appearance:	DuPont: clear, colorless	MSDS
odor:	DuPont: slight ethereal	MSDS

**PRODUCTION**

first commercial use as a refrigerant:	1863 or earlier by C. Tellier	2115
last year production allowed:	not known to be commercialized unrestricted	8C01



## R-212

```

----- REFRI GERANT DATA SUMMARY -----
R-212      hexachlorodifluoropropane      see
CFC        C3Cl6F2                        CAS number 3182-26-1      RDB#
-----

IDENTIFIERS

          common name(s):  R-212; R212; R 212
                           CFC-212
  chemical name (by IUPAC convention):  hexachlorodifluoropropane
  alternative chemical names/formulae:  propane, hexachlorodifluoro-
        empirical formula:  C3Cl6F2
        CAS number:        3182-26-1 Chemical Abstracts
                           Service Registry Number
  ARI container color / Pantone number:  none, use light green grey/413 6601

PHYSICAL
· properties -----
          molar mass:      286.7451064 g/mol (0.632165      8820
                           lb/mol)

ENVIRONMENTAL
          ODP (ozone depletion potential):  1.0 (estimate used for the      6904
                           Montreal Protocol)

SAFETY
· classification -----
          safety group (ASHRAE Standard 34):  none (no application pending)  8601

PRODUCTION
          last year production allowed:      1995 in developed countries      8C01
                           under the Montreal Protocol

```







## R-216

----- REFRIGERANT DATA SUMMARY -----  
 R-216            dichlorohexafluoropropane            see  
 CFC             C3Cl2F6                                    RDB#  
 -----

**COMMON USE(S)**

see individual isomers; promoted as refrigerants in the 1960s, but  
 not accepted (see RDB 2304)

**IDENTIFIERS**

   common name(s): R-216; R216; R 216  
    CFC-216  
    fluorochemical 216; FC 216  
 chemical name (by IUPAC convention): dichlorohexafluoropropane  
 alternative chemical names/formulae: propane, dichlorohexafluoro-  
    empirical formula: C3Cl2F6  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----  
    molar mass: 220.9279192 g/mol (0.487063    8820  
    lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 1.0 (estimate used for the    6904  
 Montreal Protocol)

**PRODUCTION**

last year production allowed: 1995 in developed countries    8C01  
 under the Montreal Protocol





## R-216ba

```

----- REFRIERANT DATA SUMMARY -----
R-216ba      1,2-dichloro-1,1,2,3,3,3-hexafluoropropane      see
CFC          CClF2CClFCClF3          CAS number 661-97-2      RDB#
-----

```

**COMMON USE(S)**

considered as an azeotropic blend component with refrigerant 11 to improve pressure lift capabilities and discharge temperatures (may be protected by U.S. patent 4,687,588)

**IDENTIFIERS**

```

common name(s):  R-216ba; R216ba; R 216ba
                  CFC-216ba
                  fluorochemical 216ba; FC 216ba
                  halochemical 216ba
chemical name (by IUPAC convention): 1,2-dichloro-1,1,2,3,3,3-
                                       hexafluoropropane
alternative chemical names/formulae: 1,2-dichlorohexafluoropropane
                                       propane, 1,2-dichloro-
                                       1,1,2,3,3,3-hexafluoro-
                                       methylpyrrolidone
empirical formula: C3Cl2F6
CAS number:        661-97-2 Chemical Abstracts
                   Service Registry Number
Beilstein registry number: 1758819
EINECS number:      211-551-3 (European Inventory
of Existing Chemical
Substances)
NIOSH RTECS number: UY5790000 (Registry of Toxic
Effects of Chemical
Substances)
ARI container color / Pantone number: none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass: 220.9279192 g/mol (0.487063      8820
lb/mol)
· normal boiling point -----
temperature: 34.8 °C (94.6 °F)              3A39

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: 1995 in developed countries      8C01
under the Montreal Protocol

```

## R-216ca

```

----- REFRIGERANT DATA SUMMARY -----
R-216ca      1,3-dichloro-1,1,2,2,3,3-hexafluoropropane      see
CFC          CClF2CF2CClF2          CAS number 662-01-1      RDB#
-----

```

**COMMON USE(S)**

considered as an azeotropic blend component with refrigerant 11 to improve pressure lift capabilities and discharge temperatures (may be protected by U.S. patent 4,687,588)

**IDENTIFIERS**

```

common name(s):  R-216ca; R216ca; R 216ca
                  CFC-216ca
                  "R-216"
                  fluorochemical 216ca; FC 216ca
                  halochemical 216ca
chemical name (by IUPAC convention):  1,1-dichloro-1,1,2,2,3,3-
                                        hexafluoropropane
alternative chemical names/formulae:  1,3-dichlorohexafluoropropane
                                        propane, 1,1-dichloro-
                                        1,1,2,2,3,3-hexafluoro-
empirical formula:  C3Cl2F6
CAS number:         662-01-1 Chemical Abstracts
                    Service Registry Number
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass: 220.9279192 g/mol (0.487063      8820
             lb/mol)
normal freezing/melting/triple point:  -125.4 °C (-193.7 °F)      3208
· normal boiling point -----
temperature: 35.7 °C (96.2 °F)      3208
heat of vaporization: 117.4 kJ/kg (50.5 Btu/lb)      0036
· critical point -----
temperature: 180.0 °C (356.0 °F)      3208
pressure: 2754 kPa (399.4 psia)      3208
density: 574 kg/m3 (35.9 lb/cf)      3208
specific volume: 1.74 L/kg (0.0279 cf/lb)      3208

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)      8601
· flammability -----
  LFL-UFL (flammability limits in air):  none (nonflammable as tested)      3208

```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized
last year production allowed: 1995 in developed countries      8C01
                               under the Montreal Protocol

```





## R-CE216ca1

----- REFRIGERANT DATA SUMMARY -----  
 R-CE216ca1 hexafluoro-oxetane see  
 FE -CF2-CF2-O-CF2- CAS number 425-80-1 RDB#  
 -----

**COMMON USE(S)**

candidate alternative or blend component for centrifugal chillers and  
 for refrigerant 12

**IDENTIFIERS**

common name(s): R-CE216ca1; RCE216ca1;  
 R CE216ca1  
 FE-CE216ca1; FOC-CE216ca1  
 E-C216ca1; E-C216  
 "R-CE216"; RCE216"; "R CE216"  
 alternative chemical names/formulae: hexafluoro-oxetane  
 perfluoro-oxetane  
 fluoro-oxetane, F-oxetane  
 -CF2CF2OCF2-; -CF2-CF2-O-CF2-  
 not recommended:  
 -CF2CF2CF2O-; -CF2-CF2-CF2-O-  
 empirical formula: C3F6O  
 CAS number: 425-80-1 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 166.0219192 g/mol (0.366016 8820  
 lb/mol)  
 normal freezing/melting/triple point: -117.0 °C (-178.6 °F) 3728  
 · normal boiling point -----  
 temperature: -28.4 °C (-19.1 °F) 2255  
 -29.2 °C (-20.5 °F) 7B15  
 · critical point -----  
 temperature: 88.4 °C (191.1 °F) 2411  
 88.7 °C (191.7 °F) 2478  
 pressure: 3030 kPa (439.5 psia) 3728

**ENVIRONMENTAL**

average tropospheric lifetime ( $\tau_{\text{trop}}$ ): >330 yr 5551  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · flammability -----  
 LFL-UFL (flammability limits in air): probably nonflammable 7B15

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: unrestricted 8C01

## Refrigerant Database

## R-CE216ca12

```

----- REFRIGERANT DATA SUMMARY -----
R-CE216ca12  hexafluorodioxetane                see
FE           -CF2-O-CF2-O-CF2-                  RDB#
-----

```

**COMMON USE(S)**

candidate refrigerant or blend component to replace refrigerant 12

**IDENTIFIERS**

```

common name(s):  R-CE216ca12; RCE216ca12;
                  R CE216ca12
                  FE-CE216ca12; FOC-CE216ca12
                  E-216ca12; E-C216ca; E-C216
                  "R-CE216"; "R-CEE216"
alternative chemical names/formulae: hexafluoro-dioxetane
                                      perfluoro-dioxetane
                                      fluoro-dioxetane, F-dioxetane
                                      -CF2-O-CF2-O-CF2-
                                      -CF2OCF2OCF2-
                                      not recommended:
                                      -CF2-CF2-O-CF2-O-
                                      -CF2CF2OCF2O-
empirical formula: C3F6O2

```

**PHYSICAL**

```

· properties -----
      molar mass: 166.0219192 g/mol (0.366016 8820
                  lb/mol)
· normal boiling point -----
      temperature: -22.1 °C (-7.8 °F) 3407
                  -22.1 °C (-7.8 °F) 2255
· critical point -----
      temperature: 90.0 °C (194.0 °F) 3407
                  94.9 °C (202.9 °F) 2255

```

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

```

· classification -----
      safety group (ASHRAE Standard 34): none (no application pending) 8601
· flammability -----
      LFL-UFL (flammability limits in air): probably nonflammable 7B15

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed:         unrestricted 8C01

```







## R-217ba11

----- REFRIGERANT DATA SUMMARY -----  
 R-217ba11 1,1,1,2,3,3,3-heptafluoro-2-iodopropane see  
 FIC CF3CFICF3 CAS number 677-69-0 RDB#  
 -----

**COMMON USE(S)**

under consideration as a blend component for alternatives to  
 refrigerants 11, 113, and 123

**IDENTIFIERS**

common name(s): R-217ba11; R217ba11; R 217ba11  
 FIC-217ba11  
 fluorochemical 217ba11;  
 FC 217ba11  
 halochemical 217ba11  
 "R-217ea11"; "R217ea11";  
 "FIC-217ea11" (ETEC proposal)  
 "R-217I1"; "R217I1"; "R 217I1" 3A52  
 "FIC-217I1" (Lankford/Nimitz) 3A52

chemical name (by IUPAC convention): 1,1,1,2,3,3,3-heptafluoro-2-  
 iodopropane

alternative chemical names/formulae: heptafluoro-2-iodopropane  
 propane, 1,1,1,2,3,3,3-  
 heptafluoro-2-iodo-  
 2-iodoheptafluoropropane  
 heptafluoroisopropyl iodide  
 perfluoroisopropyl iodide  
 CF3CFICF3; CF3-CFI-CF3  
 not recommended:  
 CF3CIFCF3; CF3-CIF-CF3  
 CFI(CF3)2; CIF(CF3)2  
 FIC(CF3)2

empirical formula: C3F7I  
 CAS number: 677-69-0 Chemical Abstracts  
 Service Registry Number  
 EINECS number: 211-643-3 (European Inventory  
 of Existing Chemical  
 Substances)

ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----  
 molar mass: 295.9253924 g/mol (0.652404 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: 38.0 °C (100.4 °F) 3A52  
 40.0 °C (104.0 °F) 3A52

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized

last year production allowed: unrestricted

8C01



## R-217ca11

```

----- REFRIGERANT DATA SUMMARY -----
R-217ca11    1,1,2,2,3,3,3-heptafluoro-1-iodopropane    see
FIC          CF3CF2CF2I                                CAS number 754-34-7    RDB#
-----

```

**COMMON USE(S)**

under consideration as a blend component for alternatives to refrigerants 11, 113, and 123; under consideration as a fire suppressant

**IDENTIFIERS**

```

common name(s):  R-217ca11; R217ca11; R 217ca11
                  FIC-217ca11
                  fluorochemical 217ca11;
                  FC 217ca11
                  halochemical 217ca11
                  halon 37001
                  "R-2171b11"; "R2171b11";
                  "FIC-2171b11" (ETEC proposal)
                  "R-217jb11"; R217jb11";          3A52
                  "FIC-217jb11"(Lanford/Nimitz)    3A52

chemical name (by IUPAC convention): 1,1,2,2,3,3,3-heptafluoro-1-
                                      iodopropane

alternative chemical names/formulae: heptafluoro-1-iodopropane
                                      propane, 1,1,2,2,3,3,3-
                                      heptafluoro-1-iodo-
                                      heptafluoro-n-propyl iodide
                                      heptafluoropropyl iodide
                                      perfluoro-n-propyl iodide
                                      1-C3F7I          7C32
                                      CF3CF2CF2I; CF3-CF2-CF2I
                                      not recommended:
                                      CF2ICF2CF3; CF2I-CF2-CF3
                                      CF3CF2CIF2; CF3-CF2-CIF2
                                      CIF2CF2CF3; CIF2-CF2-CF3

empirical formula: C3F7I
CAS number:       754-34-7 Chemical Abstracts
                  Service Registry Number
Bellstein registry number: 1758822
EINECS number:    212-045-5 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number: T23930000 (Registry of Toxic
                  Effects of Chemical
                  Substances)

ARI container color / Pantone number: none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass: 295.9253924 g/mol (0.652404    8820
             lb/mol)

· normal boiling point -----
temperature: 40.0 °C (104.0 °F)          3A52
             41.0 °C (105.8 °F)          3A52

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

**ENVIRONMENTAL**

average atmospheric lifetime (tatm):	2 days; <0.01 yr	7C32
ODP (ozone depletion potential):	≤0.0025 (model-derived relative to R 11)	7C32
GWP (global warming potential):	<2 relative to CO2 for 100 yr integration	7C32

**SAFETY**

· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 2 hr: >250,000 ppm (fatal concentration by inhalation for half of test animals)	4831

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01



density, saturated liquid:	1611 kg/m <sup>3</sup> (100.55 lb/cf)	8814
density, saturated vapor:	10.20 kg/m <sup>3</sup> (0.637 lb/cf)	8814
specific volume, saturated liquid:	0.621 L/kg (0.0099 cf/lb)	8814
specific volume, saturated vapor:	98.1 L/kg (1.5708 cf/lb)	8814
heat of vaporization:	105.3 kJ/kg (45.3 Btu/lb)	3331
	106.5 kJ/kg (45.8 Btu/lb)	8814
velocity of sound, saturated liquid:	542 m/s (1777 ft/s)	8814
velocity of sound, saturated vapor:	101 m/s (332 ft/s)	8814
viscosity, saturated liquid:	317 $\mu$ Pa·s (0.317 cp)	8814
viscosity, saturated vapor:	9.80 $\mu$ Pa·s (0.00980 cp)	8814
thermal conductivity, liquid:	0.0556 W/m·K (0.0321 Btu/hr·ft <sup>2</sup> ·°F)	8814
thermal conductivity, vapor:	0.0091 W/m·K (0.0052 Btu/hr·ft <sup>2</sup> ·°F)	8814
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	7.996 kg/m <sup>3</sup> (0.4992 lb/cf)	8814
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	7.963 kg/m <sup>3</sup> (0.4971 lb/cf)	8814
· 20 °C (68 °F) -----		
pressure, saturated vapor:	758.5 kPa (110.01 psia)	8814
density, saturated liquid:	1354 kg/m <sup>3</sup> (84.51 lb/cf)	8814
density, saturated vapor:	73.45 kg/m <sup>3</sup> (4.585 lb/cf)	8814
specific volume, saturated liquid:	0.739 L/kg (0.0118 cf/lb)	8814
specific volume, saturated vapor:	13.6 L/kg (0.2181 cf/lb)	8814
velocity of sound, saturated vapor:	307 m/s (1008 ft/s)	8814
	95 m/s (312 ft/s)	8814
viscosity, saturated liquid:	142 $\mu$ Pa·s (0.142 cp)	8814
viscosity, saturated vapor:	12.3 $\mu$ Pa·s (0.0123 cp)	8814
thermal conductivity, saturated liquid:	0.0424 W/m·K (0.0245 Btu/hr·ft <sup>2</sup> ·°F)	8814
thermal conductivity, saturated vapor:	0.01336 W/m·K (0.00772 Btu/hr·ft <sup>2</sup> ·°F)	8814
· 60 °C (140 °F) -----		
pressure, saturated vapor:	2021 kPa (293.2 psia)	8814
heat of vaporization:	45.2 kJ/kg (19.4 Btu/lb)	8401
· critical point -----		
temperature:	71.9 °C (161.4 °F)	8814
pressure:	2680 kPa (388.7 psia)	8814
density:	627 kg/m <sup>3</sup> (39.1 lb/cf)	7713
	628 kg/m <sup>3</sup> (39.2 lb/cf)	8814
specific volume:	1.59 L/kg (0.0255 cf/lb)	8814

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	2600 yr	6694
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	8600 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	40.9 relative to R 11 for infinite integration period	DW

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	3M: 1-0-0	MSDS
	BOC Gases: 1-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	3M: 0-0-0	MSDS



## Refrigerant Database

BOC Gases: 1-0-0 MSDS  
health-flammability-reactivity  
0=insignificant, 4=extreme

· long-term occupational limit -----  
exposure limit consistent to OSHA PEL: Rhône-Poulenc: 1,000 ppm v/v 1tr  
TWA for 8 hr/day and 40 hr/wk

· emergency exposure limit -----  
Refrigerant Concentration Limit (RCL): 69,000 ppm v/v (preliminary  
value under review, based on  
draft ASHRAE 34aa)

· acute (short-term) toxicity -----  
LC50 (lethal concentration, 50%): rat, 1 hr, 0/10: >800,000 ppm 5C79  
(fatal concentration by  
inhalation for half of test  
animals)  
rat, 4 hr: >110,000 ppm (fatal 65F8  
concentration by inhalation  
for half of test animals)  
rat, 10 day: >113,000 ppm 5C79  
(fatal concentration by  
inhalation for half of test  
animals)

cardiac sensitization (CS) EC50: dog, 10 min: >400,000 ppm v/v 6684  
(effective concentration in  
half of test animals)

cardiac sensitization threshold/LOEL: dog, 2/8: 400,000 ppm v/v 65F9  
(lowest observed effect level  
in test animals)

cardiac sensitization (CS) NOEL: dog, 0/6: 300,000 ppm v/v (no 65F9  
observed effect level in test  
animals)

anesthetic/CNS effect LOEL: rat, 1 hr, ?/10: 780,000 ppm 5C79  
v/v (lowest observed effect  
level in test animals)

anesthetic/CNS effect NOEL: rat, 10 day, 0/20: 113,000 ppm 5C79  
v/v (no observed effect level  
in test animals)

· flammability -----  
LFL-UFL (flammability limits in air): none (nonflammable as tested) 2525  
flash point: BOC Gases: none MSDS  
autoignition temperature: BOC Gases: none MSDS

· detection -----  
appearance: Rhône-Poulenc: colorless MSDS  
odor: BNFL Fluorochemicals: odorless MSDS  
BOC Gases: faintly sweet odor MSDS

**PRODUCTION**

last year production allowed: unrestricted 8C01





## R-220da

```

----- REFRIGERANT DATA SUMMARY -----
R-220da      1,1,1,2,3,3,3-heptachloropropane      see
HCC          CCl3CHClCCl3                          CAS number 3849-33-0      RDB#
-----

```

**IDENTIFIERS**

```

                common name(s):  R-220da; R220da; R 220da
                                HCC-220da
chemical name (by IUPAC convention):  1,1,1,2,3,3,3-
                                heptachloropropane
alternative chemical names/formulae:  propane, 1,1,1,2,3,3,3-
                                heptachloro-
                                empirical formula:  C3HCl7
                                CAS number: 3849-33-0 Chemical Abstracts
                                Service Registry Number

```

**PHYSICAL**

```

· properties -----
                                molar mass: 285.20894 g/mol (0.628778      8820
                                lb/mol)

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)  8601

```



## R-225ba

----- REFRIGERANT DATA SUMMARY -----  
 R-225ba      2,3-dichloro-1,1,1,2,3-pentafluoropropane      see  
 HCFC      CHClFCClFCF3      CAS number 422-48-0      RDB#  
 -----

**IDENTIFIERS**

common name(s): R-225ba; R225ba; R 225ba  
 HCFC-225ba  
 empirical formula: C3HCl2F5  
 CAS number: 422-48-0 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
    molar mass: 202.9374560 g/mol (0.447401      8820  
    lb/mol)  
 normal freezing/melting/triple point: -132.7 °C (-206.9 °F)      3408  
 · normal boiling point -----  
    temperature: 51.9 °C (125.4 °F)      3408  
    heat of vaporization: 144.8 kJ/kg (62.3 Btu/lb)      3408  
 · critical point -----  
    temperature: 212.9 °C (415.2 °F)      3408  
    pressure: 3070 kPa (445.3 psia)      3408  
    density: 586 kg/m3 (36.6 lb/cf)      3408  
    specific volume: 1.71 L/kg (0.0273 cf/lb)      3408

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.07 (0.02-0.07) (estimate      6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending)      8601

**PRODUCTION**

last year production allowed: 2029 in developed countries      8C01  
 under the Montreal Protocol

## R-225ca

```

----- REFRIGERANT DATA SUMMARY -----
R-225ca      3,3-dichloro-1,1,1,2,2-pentafluoropropane      see
HCFC         CHCl2CF2CF3          CAS number 422-56-0      RDB#
-----

```

**COMMON USE(S)**

under consideration as an alternative for chlorofluorocarbon 113 as an industrial cleaning solvent, particularly for electronic circuit boards

**IDENTIFIERS**

```

common name(s):  R-225ca; R225ca; R 225ca
                 HCFC-225ca
chemical name (by IUPAC convention):  3,3-dichloro-1,1,1,2,2-
                                     pentafluoropropane
alternative chemical names/formulae:  propane, 3,3-dichloro-
                                     1,1,1,2,2-pentafluoro-
empirical formula:  C3HCl2F5
CAS number:        422-56-0 Chemical Abstracts
                  Service Registry Number
EINECS number:    207-016-9 (European Inventory
                  of Existing Chemical
                  Substances)

```

**PHYSICAL**

```

· properties -----
molar mass:      202.9374560 g/mol (0.447401      8820
                 lb/mol)
normal freezing/melting/triple point:  -94.0 °C (-137.2 °F)      PCRL
· normal boiling point -----
temperature:     51.1 °C (124.0 °F)      PCRL

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (τatm):  2.1 ±0.7 yr      6695
average stratospheric lifetime (τstr): 60 yr      5508
ODP (ozone depletion potential):      0.017 (model-derived relative 9501
to R 11)
0.025 (semi-empirical relative 9501
to R 11)
0.025 (estimate used for the 6904
Montreal Protocol)
GWP (global warming potential):      170 relative to CO2 for 100 yr 4B13
integration
180 relative to CO2 for 100 yr 9501
integration
HGWP (halocarbon GWP):               0.02 relative to R 11 for      DW
infinite integration period

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending) 8601
· long-term occupational limit -----
exposure limit consistent to OSHA PEL: AlliedSignal PEL: 10 ppm v/v

```

TWA for 8 hr/day and 40 hr/wk  
 Tech Spray PEL: 25 ppm v/v TWA MSDS  
 for 8 hr/day and 40 hr/wk

• acute (short-term) toxicity -----

LC50 (lethal concentration, 50%):	rat, 4 hr: 37,000 ppm (fatal concentration by inhalation for half of test animals)	4A66
dermal LD50 (lethal dosage, 50%):	>2,000 mg/kg (fatal dose by skin contact for half of test animals)	5C39
oral LD50 (lethal dosage, 50%):	>5,000 mg/kg (fatal dose by ingestion for half of test animals)	4A66
anesthetic concentration:	rat: >5,000 ppm v/v	5C39

**PRODUCTION**

last year production allowed:	2029 in developed countries under the Montreal Protocol	8C01
-------------------------------	---	------



## R-225cb

```

----- REFRIGERANT DATA SUMMARY -----
R-225cb      1,3-dichloro-1,1,2,2,3-pentafluoropropane      see
HCFC         CHClFCF2CClF2          CAS number 507-55-1      RDB#
-----

```

**COMMON USE(S)**

under consideration as an alternative for chlorofluorocarbon 113 as an industrial cleaning solvent, particularly for electronic circuit boards

**IDENTIFIERS**

```

common name(s):  R-225cb; R225cb; R 225cb
                  HCFC-225cb
chemical name (by IUPAC convention):  1,3-dichloro-1,1,2,2,3-
                                       pentafluoropropane
alternative chemical names/formulae:  propane, 1,3-dichloro-
                                       1,1,2,2,3-pentafluoro-
empirical formula:  C3HCl2F5
CAS number:         507-55-1 Chemical Abstracts
                   Service Registry Number
EINECS number:     208-076-9 (European Inventory
                   of Existing Chemical
                   Substances)

```

**PHYSICAL**

```

· properties -----
molar mass:      202.9374560 g/mol (0.447401      8820
                  lb/mol)
normal freezing/melting/triple point:  -97.0 °C (-142.6 °F)      PCRL
· normal boiling point -----
temperature:     56.1 °C (133.0 °F)              PCRL

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (τatm):  6.2 ±2.2 yr      6695
average stratospheric lifetime (τstr): 130 yr          5508
ODP (ozone depletion potential):      0.017 (model-derived relative 9501
                                       to R 11)
                                       0.03 (semi-empirical relative 9501
                                       to R 11)
                                       0.033 (estimate used for the 6904
                                       Montreal Protocol)
GWP (global warming potential):       620 relative to CO2 for 100 yr 9501
                                       integration
HGWP (halocarbon GWP):                0.09 relative to R 11 for      DW
                                       infinite integration period

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):    none (no application pending) 8601
· long-term occupational limit -----
exposure limit consistent to OSHA PEL: AlliedSignal PEL: 200 ppm v/v
                                       TWA for 8 hr/day and 40 hr/wk
                                       Tech Spray PEL: 250 ppm v/v      MSDS

```







## R-226ba

```

----- REFRIGERANT DATA SUMMARY -----
R-226ba      2-chloro-1,1,1,2,3,3-hexafluoropropane      see
HCFC         CHF2CClFCF3          CAS number 51346-64-6      RDB#
-----

```

**IDENTIFIERS**

```

              common name(s):  R-226ba; R226ba; R 226ba
                                HCFC-226ba
chemical name (by IUPAC convention): 2-chloro-1,1,1,2,3,3-
                                hexafluoropropane
alternative chemical names/formulae: propane, 2-chloro-1,1,1,2,3,3-
                                hexafluoro-
                                empirical formula: C3HClF6
                                CAS number: 51346-64-6 Chemical Abstracts
                                Service Registry Number

```

**PHYSICAL**

```

· properties -----
              molar mass: 186.4831592 g/mol (0.411125      8820
                                lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.10 (0.02-0.10) (estimate      6904
                                used for the Montreal
                                Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```



## R-226cb

```

----- REFRIGERANT DATA SUMMARY -----
R-226cb      1-chloro-1,1,2,2,3,3-hexafluoropropane      see
HCFC         CHF2CF2CClF2          CAS number 422-55-9      RDB#
-----

```

**IDENTIFIERS**

```

                common name(s):  R-226cb; R226cb; R 226cb
                                HCFC-226cb
chemical name (by IUPAC convention):  1-chloro-1,1,2,2,3,3-
                                hexafluoropropane
alternative chemical names/formulae:  propane, 1-chloro-1,1,2,2,3,3-
                                hexafluoro-
                empirical formula:  C3HClF6
                CAS number:        422-55-9 Chemical Abstracts
                                Service Registry Number

```

**PHYSICAL**

```

· properties -----
                molar mass:      186.4831592 g/mol (0.411125      8820
                                lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential):  0.10 (0.02-0.10) (estimate      6904
                                used for the Montreal
                                Protocol)

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)  8601
· acute (short-term) toxicity -----
ALC (approximate lethal concentration):  mouse, 10 min: 200,000 ppm      5169
                                (lowest exposure tested with
                                one or more deaths by
                                inhalation)
                anesthetic concentration:  mouse, 10 min: 100,000 ppm v/v 5169

```

## R-226da

```

----- REFRIGERANT DATA SUMMARY -----
R-226da      2-chloro-1,1,1,3,3,3-hexafluoropropane      see
HCFC         CF3CHClCF3          CAS number 431-87-8      RDB#
-----

```

**IDENTIFIERS**

```

common name(s): R-226da; R226da; HCFC-226da
chemical name (by IUPAC convention): 2-chloro-1,1,1,3,3,3-
hexafluoropropane
alternative chemical names/formulae: propane, 2-chloro-1,1,1,3,3,3-
hexafluoro-
CF3CHClCF3; CF3-CHCl-CF3
not recommended:
CF3CClHCF3; CF3-CClH-CF3
empirical formula: C3HClF6
CAS number: 431-87-8 Chemical Abstracts
Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass: 186.4831592 g/mol (0.411125      8820
lb/mol)
normal freezing/melting/triple point: -119.6 °C (-183.3 °F)      3408
· normal boiling point -----
temperature: 14.1 °C (57.4 °F)      3408
heat of vaporization: 132.2 kJ/kg (56.8 Btu/lb)      3408
· critical point -----
temperature: 158.2 °C (316.8 °F)      3408
pressure: 3020 kPa (438.0 psia)      3408
density: 591 kg/m3 (36.9 lb/cf)      3408
specific volume: 1.69 L/kg (0.0271 cf/lb)      3408

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.10 (0.02-0.10) (estimate      6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending)      8601

```









	ppm v/v (no observed effect level in test animals)	
	mouse, 12 min, 0/6: 120,000	6B51
	ppm v/v (no observed effect level in test animals)	
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2A06
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01



temperature:	-15.6 °C (3.9 °F)	8401
density, saturated liquid:	1541 kg/m <sup>3</sup> (96.21 lb/cf)	8401
density, saturated vapor:	8.47 kg/m <sup>3</sup> (0.528 lb/cf)	8401
specific volume, saturated liquid:	0.649 L/kg (0.0104 cf/lb)	8401
specific volume, saturated vapor:	118.1 L/kg (1.8923 cf/lb)	8401
heat of vaporization:	135.9 kJ/kg (58.4 Btu/lb)	8401
velocity of sound, saturated liquid:	552 m/s (1811 ft/s)	8401
velocity of sound, saturated vapor:	111 m/s (365 ft/s)	8401
viscosity, saturated liquid:	441 µPa·s (0.441 cp)	8401
viscosity, saturated vapor:	9.83 µPa·s (0.00983 cp)	8401
thermal conductivity, liquid:	0.0641 W/m·K (0.0370 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, vapor:	0.0098 W/m·K (0.0057 Btu/hr·ft <sup>2</sup> ·°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	7.284 kg/m <sup>3</sup> (0.4547 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	7.253 kg/m <sup>3</sup> (0.4528 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	388.8 kPa (56.39 psia)	8401
density, saturated liquid:	1407 kg/m <sup>3</sup> (87.83 lb/cf)	8401
density, saturated vapor:	31.04 kg/m <sup>3</sup> (1.938 lb/cf)	8401
specific volume, saturated liquid:	0.711 L/kg (0.0114 cf/lb)	8401
specific volume, saturated vapor:	32.2 L/kg (0.5161 cf/lb)	8401
velocity of sound, saturated liquid:	417 m/s (1368 ft/s)	8401
velocity of sound, saturated vapor:	110 m/s (361 ft/s)	8401
viscosity, saturated liquid:	262 µPa·s (0.262 cp)	8401
viscosity, saturated vapor:	11.2 µPa·s (0.0112 cp)	8401
thermal conductivity, saturated liquid:	0.0546 W/m·K (0.0315 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, saturated vapor:	0.01228 W/m·K (0.00710 Btu/hr·ft <sup>2</sup> ·°F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	1182 kPa (171.5 psia)	8401
heat of vaporization:	86.9 kJ/kg (37.4 Btu/lb)	8401
· critical point -----		
temperature:	102.8 °C (217.0 °F)	7713
pressure:	2980 kPa (432.2 psia)	8401
density:	580 kg/m <sup>3</sup> (36.2 lb/cf)	3408
specific volume:	1.72 L/kg (0.0276 cf/lb)	3408

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	36.5 ±7.3 yr	6695
average tropospheric lifetime ( $\tau_{trop}$ ):	40 yr	5804
	estimated: 63-72 yr	8312
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	3800 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.69 relative to R 11 for infinite integration period	8101

**SAFETY**

· long-term occupational limit -----		
exposure limit consistent to OSHA PEL:	Hoechst internal guide: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	mfr
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	40,000 ppm v/v (preliminary	

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

value under review, based on  
draft ASHRAE 34aa)

- acute (short-term) toxicity -----  
 LC50 (lethal concentration, 50%): rat, 4 hr, 0%: >110,000 ppm 7116  
 (fatal concentration by  
 inhalation for half of test  
 animals)  
 rat, 4 hr: >800,000 ppm (fatal 5526  
 concentration by inhalation  
 for half of test animals)
- cardiac sensitization (CS) EC50: dog, 30 min: 140,000 ppm v/v 65F2  
 (effective concentration in  
 half of test animals)
- cardiac sensitization threshold/LOEL: dog, 30 min, ?/10: 105,000 ppm 65F2  
 v/v (lowest observed effect  
 level in test animals)
- cardiac sensitization (CS) NOEL: dog, 30 min, 0/10: 90,000 ppm 65F2  
 v/v (no observed effect level  
 in test animals)
- anesthetic/CNS effect LOEL: dog, 1 hr, ?/4: 150,000 ppm 7116  
 v/v (lowest observed effect  
 level in ALC or LC50 studies)  
 rat, 4 hr: 110,000 ppm v/v 7116  
 (lowest observed effect level  
 in ALC or LC50 studies)
- anesthetic/CNS effect NOEL: dog, 1 hr, 0/4: 50,000 ppm v/v 7116  
 (no observed effect level in  
 ALC or LC50 studies)
- flammability -----  
 LFL-UFL (flammability limits in air): none (nonflammable as tested) 3726  
 heat of combustion (by ASHRAE 34-92): 3.3 MJ/kg (1398 Btu/lb) 4785  
 flash point: Great Lakes: nonflammable gas MSDS
- detection -----  
 appearance: Great Lakes: colorless gas MSDS  
 odor: Great Lakes: odorless MSDS  
 Hoechst: ether-like MSDS

**PRODUCTION**

- first commercial use as a refrigerant: January 1996
- last year production allowed: unrestricted 8C01

## R-234

----- REFRIGERANT DATA SUMMARY -----  
 R-234            dichlorotetrafluoropropane            see  
 HCFC            C3H2Cl2F4            CAS number 127564-83-4            RDB#  
 -----

**COMMON USE(S)**

see individual isomers

**IDENTIFIERS**

                  common name(s): R-234; R234; R 234  
   HCFC-234  
                   empirical formula: C3H2Cl2F4  
                   CAS number: 127564-83-4 Chemical Abstracts  
   Service Registry Number

**PHYSICAL**

· properties -----  
   molar mass: 184.9469928 g/mol (0.407738    8820  
   lb/mol)

**ENVIRONMENTAL**

          ODP (ozone depletion potential): 0.28 (0.01-0.28) (estimate    6904  
   used for the Montreal  
   Protocol)



## R-234cb

```

----- REFRIGERANT DATA SUMMARY -----
R-234cb      1,1-dichloro-2,2,3,3-tetrafluoropropane      see
HCFC         CHCl2CF2CHF2          CAS number 4071-01-6      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-234cb; R234cb; R 234cb
                 HCFC-234cb
chemical name (by IUPAC convention):  1,1-dichloro-2,2,3,3-
                                     tetrafluoropropane
alternative chemical names/formulae:  propane, 1,1-dichloro-2,2,3,3-
                                     tetrafluoro-
empirical formula:  C3H2Cl2F4
CAS number:        4071-01-6 Chemical Abstracts
                  Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass:  184.9469928 g/mol (0.407738      8820
              lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential):  0.28 (0.01-0.28) (estimate      6904
                                   used for the Montreal
                                   Protocol)

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)  8601
· acute (short-term) toxicity -----
ALC (approximate lethal concentration):  mouse, 10 min: 20,000 ppm      5169
                                           (lowest exposure tested with
                                           one or more deaths by
                                           inhalation)
anesthetic concentration:  mouse, 10 min: 5,000 ppm v/v      5169

```

## R-234da

```

----- REFRIERANT DATA SUMMARY -----
R-234da      2,3-dichloro-1,1,1,3-tetrafluoropropane      see
HCFC         CHClFCHClCF3          CAS number 146916-90-7      RDB#
-----

```

**IDENTIFIERS**

```

common name(s): R-234da; R234da; R 234da
                HCFC-234da
chemical name (by IUPAC convention): 2,3-dichloro-1,1,1,3-
                tetrafluoropropane
alternative chemical names/formulae: propane, 2,3-dichloro-1,1,1,3-
                tetrafluoro-
empirical formula: C3H2Cl2F4
CAS number: 146916-90-7 Chemical Abstracts
                Service Registry Number

```

**PHYSICAL**

```

· properties -----
                molar mass: 184.9469928 g/mol (0.407738      8820
                lb/mol)
normal freezing/melting/triple point: -98.0 °C (-144.4 °F)      3408
· normal boiling point -----
                temperature: 70.1 °C (158.2 °F)      3408
                heat of vaporization: 171.5 kJ/kg (73.7 Btu/lb)      3408
· critical point -----
                temperature: 242.5 °C (468.5 °F)      3408

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.28 (0.01-0.28) (estimate      6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

## R-235

----- REFRIERANT DATA SUMMARY -----  
 R-235 chloropentafluoropropane see  
 HCFC C3H2CLF5 CAS number 108662-83-5 RDB#  
 -----

**COMMON USE(S)**

see individual isomers

**IDENTIFIERS**

common name(s): R-235; R235; R 235  
 HCFC-235  
 fluorochemical 235; FC 235  
 halocarbon 235  
 halochemical 235  
 chemical name (by IUPAC convention): chloropentafluoropropane  
 alternative chemical names/formulae: propane, chloropentafluoro-  
 empirical formula: C3H2ClF5  
 CAS number: 108622-83-5 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----

molar mass: 168.4926960 g/mol (0.371463 8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.52 (0.03-0.52) (estimate 6904  
 used for the Montreal  
 Protocol)

## R-235ba

----- REFRIGERANT DATA SUMMARY -----  
 R-235ba      2-chloro-1,1,2,3,3-pentafluoropropane      see  
 HCFC      CHF2CClFCHF2      CAS number 144429-90-3      RDB#  
 -----

**IDENTIFIERS**

common name(s): R-235ba; R235ba; R 235ba  
 HCFC-235ba  
 fluorochemical 235ba; FC 235ba  
 halocarbon 235ba  
 halochemical 235ba  
 chemical name (by IUPAC convention): 2-chloro-1,1,2,3,3-  
 pentafluoropropane  
 alternative chemical names/formulae: propane, 2-chloro-1,1,2,3,3-  
 pentafluoro-  
 CHF2CClFCHF2; CHF2-CClF-CHF2  
 not recommended:  
 CF2HCClFCF2H; CF2H-CClF-CF2H  
 CF2HCFC1CF2H; CF2H-CFCl-CF2H  
 CHF2CFClCHF2; CHF2-CFCl-CHF2  
 empirical formula: C3H2ClF5  
 CAS number: 144429-90-3 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 168.4926960 g/mol (0.371463      8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.52 (0.03-0.52) (estimate      6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending)      8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: 2029 in developed countries      8C01  
 under the Montreal Protocol

## R-235ca

```

----- REFRI GERANT DATA SUMMARY -----
R-235ca      1-chloro-1,2,2,3,3-pentafluoropropane      see
HCFC         CHClFCF2CHF2          CAS number 679-99-2      RDB#
-----

```

**COMMON USE(S)**

under limited consideration as a refrigerant in high-temperature heat pumps; constrained by ozone depletion potential

**IDENTIFIERS**

```

common name(s):  R-235ca; R235ca; R 235ca
                  HCFC-235ca
                  fluorochemical 235ca; FC 235ca
                  halocarbon 235ca
                  halochemical 235ca
chemical name (by IUPAC convention): 1-chloro-1,2,2,3,3-
                                       pentafluoropropane
alternative chemical names/formulae: propane, 1-chloro-1,2,2,3,3-
                                       pentafluoro-
                                       CHClFCF2CHF2; CHClF-CF2-CHF2
                                       not recommended:
                                       CF2HCF2CClFH; CF2H-CF2-CClFH
                                       CF2HCF2CFC1H; CF2H-CF2-CFC1H
                                       CHF2CF2CHClF; CHF2-CF2-CHClF
                                       CHF2CF2CHFCl; CHF2-CF2-CFHCl
empirical formula: C3H2ClF5
CAS number:       679-99-2 Chemical Abstracts
                  Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass: 168.4926960 g/mol (0.371463      8820
              lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.52 (0.03-0.52) (estimate      6904
                                   used for the Montreal
                                   Protocol)

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34): none (no application pending) 8601
· acute (short-term) toxicity -----
ALC (approximate lethal concentration: mouse, 10 min: 30,000 ppm      5169
                                       (lowest exposure tested with
                                       one or more deaths by
                                       inhalation)
anesthetic concentration: mouse, 10 min: 25,000 ppm v/v      5169

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed:         2029 in developed countries      8C01
                                       under the Montreal Protocol

```

## R-235cb

----- REFRIGERANT DATA SUMMARY -----  
 R-235cb      3-chloro-1,1,1,2,2-pentafluoropropane      see  
 HCFC      CH<sub>2</sub>ClCF<sub>2</sub>CF<sub>3</sub>      CAS number 422-02-6      RDB#  
 -----

## IDENTIFIERS

common name(s): R-235cb; R235cb; R-235cb  
 HCFC-235cb  
 fluorochemical 235cb; FC 235cb  
 halocarbon 235cb  
 halochemical 235cb  
 chemical name (by IUPAC convention): 3-chloro-1,1,1,2,2-  
 pentafluoropropane  
 alternative chemical names/formulae: propane, 3-chloro-1,1,1,2,2-  
 pentafluoro-  
 1,1,1,2,2-pentafluoropropyl  
 propyl  
 2,2,3,3,3-pentafluoropropyl      5939  
 propyl  
 CH<sub>2</sub>ClCF<sub>2</sub>CF<sub>3</sub>; CH<sub>2</sub>Cl-CF<sub>2</sub>-CF<sub>3</sub>  
 not recommended:  
 CClH<sub>2</sub>CF<sub>2</sub>CF<sub>3</sub>; CClH<sub>2</sub>-CF<sub>2</sub>-CF<sub>3</sub>  
 CF<sub>3</sub>CF<sub>2</sub>CClH<sub>2</sub>; CF<sub>3</sub>-CF<sub>2</sub>-CClH<sub>2</sub>  
 CF<sub>3</sub>CF<sub>2</sub>CH<sub>2</sub>Cl; CF<sub>3</sub>-CF<sub>2</sub>-CH<sub>2</sub>Cl  
 empirical formula: C<sub>3</sub>H<sub>2</sub>ClF<sub>5</sub>  
 CAS number: 422-02-6 Chemical Abstracts  
 Service Registry Number

## PHYSICAL

· properties -----  
 molar mass: 168.4926960 g/mol (0.371463      8820  
 lb/mol)  
 normal freezing/melting/triple point: -85.0 °C (-121.0 °F)      3408  
 · normal boiling point -----  
 temperature: 28.1 °C (82.6 °F)      3408  
 heat of vaporization: 163.8 kJ/kg (70.4 Btu/lb)      3408  
 · critical point -----  
 temperature: 170.3 °C (338.5 °F)      3408  
 pressure: 3080 kPa (446.7 psia)      3408  
 density: 550 kg/m<sup>3</sup> (34.3 lb/cf)      3408  
 specific volume: 1.82 L/kg (0.0291 cf/lb)      3408

## ENVIRONMENTAL

ODP (ozone depletion potential): 0.52 (0.03-0.52) (estimate      6904  
 used for the Montreal  
 Protocol)

## SAFETY

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending)      8601

## PRODUCTION

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: 2029 in developed countries      8C01

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

under the Montreal Protocol

## R-235cc

----- REFRIERANT DATA SUMMARY -----  
 R-235cc      1-chloro-1,1,2,2,3-pentafluoropropane      see  
 HCFC      CH2FCF2CClF2      CAS number 677-55-4      RDB#  
 -----

**IDENTIFIERS**

common name(s): R-235cc; R235cc; R 235cc  
 HCFC-235cc  
 fluorochemical 235cc; FC 235cc  
 halocarbon 235cc  
 halochemical 235cc  
 alternative chemical names/formulae: CH2FCF2CClF2; CH2F-CF2-CClF2  
 not recommended:  
 CFH2CF2CClF2; CFH2-CF2-CClF2  
 CFH2CF2CF2Cl; CFH2-CF2-CF2Cl  
 CH2FCF2CF2Cl; CH2F-CF2-CF2Cl  
 empirical formula: C3H2ClF5  
 CAS number: 677-55-4 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 168.4926960 g/mol (0.371463      8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.52 (0.03-0.52) (estimate      6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending)      8601  
 · acute (short-term) toxicity -----  
 ALC (approximate lethal concentration): mouse, 10 min: 150,000 ppm      5169  
 (lowest exposure tested with  
 one or more deaths by  
 inhalation)  
 anesthetic concentration: mouse, 10 min: 100,000 ppm v/v      5169

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: 2029 in developed countries      8C01  
 under the Montreal Protocol



## R-235da

```

----- REFRI GERANT DATA SUMMARY -----
R-235da      2-chloro-1,1,3,3,3-pentafluoropropane      see
HCFE        CHF2CHClCF3                                  RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-235da; R235da; R 235da
                  HCFC-235da
                  fluorochemical 235da; FC 235da
                  halocarbon 235da
                  halochemical 235da
chemical name (by IUPAC convention): 2-chloro-1,1,3,3,3-
                                       pentafluoropropane
alternative chemical names/formulae: propane, 2-chloro-1,1,3,3,3-
                                       pentafluoro-
                                       CHF2CHClCF3; CHF2-CHCl-CF3
                                       not recommended:
                                       CF2HCClHCF3; CF2H-CClH-CF3
                                       CF3CClHCF2H; CF3-CClH-CF2H
                                       CF3CHClCHF2; CF3-CHCl-CHF2
empirical formula: C3H2ClF5

```

**PHYSICAL**

```

· properties -----
molar mass: 168.4926960 g/mol (0.371463 8820
             lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.52 (0.03-0.52) (estimate 6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: 2029 in developed countries 8C01
under the Montreal Protocol

```

## R-235fa

----- REFRIGERANT DATA SUMMARY -----  
 R-235fa      1-chloro-1,1,3,3,3-pentafluoropropane      see  
 HCFC      CClF<sub>2</sub>CH<sub>2</sub>CF<sub>3</sub>      CAS number 460-92-4      RDB#  
 -----

**IDENTIFIERS**

common name(s): R-235fa; R235fa; R 235fa  
 HCFC-235fa  
 fluorochemical 235fa; FC 235fa  
 halocarbon 235fa  
 halochemical 235fa  
 chemical name (by IUPAC convention): 1-chloro-1,1,3,3,3-  
 pentafluoropropane  
 alternative chemical names/formulae: propane, 1-chloro-1,1,3,3,3-  
 pentafluoro-  
 CClF<sub>2</sub>CH<sub>2</sub>CF<sub>3</sub>; CClF<sub>2</sub>-CH<sub>2</sub>-CF<sub>3</sub>  
 not recommended:  
 CF<sub>3</sub>CH<sub>2</sub>CClF<sub>2</sub>; CF<sub>3</sub>-CH<sub>2</sub>-CClF<sub>2</sub>  
 CF<sub>3</sub>CH<sub>2</sub>CF<sub>2</sub>Cl; CF<sub>3</sub>-CH<sub>2</sub>-CF<sub>2</sub>Cl  
 CF<sub>2</sub>ClCH<sub>2</sub>CF<sub>3</sub>; CF<sub>2</sub>Cl-CH<sub>2</sub>-CF<sub>3</sub>  
 empirical formula: C<sub>3</sub>H<sub>2</sub>ClF<sub>5</sub>  
 CAS number: 460-92-4 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 168.4926960 g/mol (0.371463      8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.52 (0.03-0.52) (estimate      6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending)      8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: 2029 in developed countries      8C01  
 under the Montreal Protocol









last year production allowed: unrestricted

8C01

## R-236ea

```

----- REFRIGERANT DATA SUMMARY -----
R-236ea      1,1,1,2,3,3-hexafluoropropane      see
HFC          CHF2CHF3          CAS number 431-63-0      RDB#
-----

```

**COMMON USE(S)**

considered (circa 1990-1996) as an alternative for refrigerant 114, both alone and as a blend component; also considered as a foam-blowing agent

**IDENTIFIERS**

```

common name(s):  R-236ea; R236ea; R 236ea
                 HFC-236ea
                 fluorochemical 236ea; FC 236ea
                 halochemical 236ea
chemical name (by IUPAC convention):  1,1,1,2,3,3-hexafluoropropane
alternative chemical names/formulae:  propane, 1,1,1,2,3,3-
                                     hexafluoro-
                                     CHF2CHF3; CHF2-CHF-CF3
not recommended:
                 CF2HCFHCF3; CF2H-CFH-CF3
                 CF3CFHCF2H; CF3-CFH-CF2H
                 CF3CHFCHF2; CF3-CHF-CHF2
empirical formula:  C3H2F6
CAS number:        431-63-0 Chemical Abstracts
                  Service Registry Number
EINECS number:    207-076-6 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number:  TZ3986666 (Registry of Toxic
                  Effects of Chemical
                  Substances)
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:      152.0383992 g/mol (0.335187      8820
                 lb/mol)
normal freezing/melting/triple point:  -146.1 °C (-231.0 °F)      3403
· normal boiling point -----
temperature:     6.2 °C (43.2 °F)      8401
density, saturated liquid:  1483 kg/m3 (92.56 lb/cf)      8401
density, saturated vapor:   6.95 kg/m3 (0.434 lb/cf)      8401
specific volume, saturated liquid:  0.674 L/kg (0.0108 cf/lb)      8401
specific volume, saturated vapor:   143.9 L/kg (2.3044 cf/lb)      8401
heat of vaporization:       165.2 kJ/kg (71.0 Btu/lb)      8401
velocity of sound, saturated liquid:  622 m/s (2042 ft/s)      8401
velocity of sound, saturated vapor:  123 m/s (404 ft/s)      8401
viscosity, saturated vapor:   10.23 µPa·s (0.01023 cp)      8401
viscosity, saturated liquid:  375 µPa·s (0.375 cp)      8401
thermal conductivity, liquid:  0.0757 W/m·K (0.0438      8401
                 Btu/hr·ft°F)
thermal conductivity, vapor:  0.0114 W/m·K (0.0066      8401
                 Btu/hr·ft°F)

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



· normal pressure, 20 °C (68 °F) -----		
density, vapor:	6.568 kg/m <sup>3</sup> (0.4100 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	6.539 kg/m <sup>3</sup> (0.4082 lb/cf)	8401
· 20 °C (68 °F) -----		
density, saturated liquid:	1440 kg/m <sup>3</sup> (89.91 lb/cf)	8401
density, saturated vapor:	11.51 kg/m <sup>3</sup> (0.718 lb/cf)	8401
specific volume, saturated liquid:	0.694 L/kg (0.0111 cf/lb)	8401
specific volume, saturated vapor:	86.9 L/kg (1.3921 cf/lb)	8401
velocity of sound, saturated liquid:	573 m/s (1880 ft/s)	8401
velocity of sound, saturated vapor:	124 m/s (406 ft/s)	8401
viscosity, saturated liquid:	315 µPa·s (0.315 cp)	8401
viscosity, saturated vapor:	10.7 µPa·s (0.0107 cp)	8401
thermal conductivity, saturatd liquid:	0.0717 W/m·K (0.0414 Btu/hr·ft°F)	8401
thermal conductivity, saturated vapor:	0.01230 W/m·K (0.00711 Btu/hr·ft°F)	8401
· 60 °C (140 °F) -----		
heat of vaporization:	134.9 kJ/kg (58.0 Btu/lb)	8401
· critical point -----		
temperature:	139.3 °C (282.7 °F)	8401
pressure:	3502 kPa (507.9 psia)	8401
density:	563 kg/m <sup>3</sup> (35.1 lb/cf)	8401
specific volume:	1.78 L/kg (0.0285 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	8.1 yr	9501
average tropospheric lifetime (τ <sub>trop</sub> ):	7.2 yr	5804
	estimated: 9-10 yr	8312
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	1000 relative to CO <sub>2</sub> for 100 yr integration	9501

**SAFETY**

· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	4 hr, rat: >85,000 ppm (lowest exposure tested with one or more deaths by inhalation)	6803
anesthetic/CNS effect LOEL:	rat, 4 hr: 24,000 ppm v/v (lowest observed effect level in ALC or LC50 studies)	6803
anesthetic/CNS effect NOEL:	rat, 4 hr: 14,000 ppm v/v (no observed effect level in ALC or LC50 studies)	6803
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	4785
heat of combustion (by ASHRAE 34-92):	5.4 MJ/kg (2337 Btu/lb)	4785

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-236fa

----- REFRIGERANT DATA SUMMARY -----  
 R-236fa 1,1,1,3,3,3-hexafluoropropane see  
 HFC CF3CH2CF3 CAS number 690-39-1 RDB#  
 -----

**COMMON USE(S)**

alternative for refrigerant 114, primarily for aftermarket use to retrofit centrifugal chillers on surface ships and in nuclear power plants; under consideration for use in heat-recovery chillers, high temperature and industrial heat pumps, and high condensing temperature air-conditioners; fire suppressant (e.g., DuPont Chemicals FE-36); semiconductor manufacturing

**IDENTIFIERS**

common name(s): R-236fa; R236fa; R 236fa  
 HFC-236fa  
 not recommended: HFA-236fa  
 fluorocarbon 236fa  
 fluorochemical 236fa; FC 236fa  
 halocarbon 236fa  
 halochemical 236fa  
 hexafluoropropane  
 hydrofluorocarbon 236fa  
 chemical name (by IUPAC convention): 1,1,1,3,3,3-hexafluoropropane  
 alternative chemical names/formulae: propane, 1,1,1,3,3,3-  
 hexafluoro-  
 bis(trifluoromethyl)methane  
 bistrifluoromethylmethane  
 2,2-dihydroperfluoropropane  
 CF3CH2CF3; CF3-CH2-CF3  
 empirical formula: C3H2F6  
 CAS number: 690-39-1 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: TZ4043332 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): 3M(TM) HFG-3236 MSDS  
 3M(TM) HFG-3236fa 6B05  
 AlliedSignal Genetron(R) 236fa MSDS  
 DuPont Suva(R) 236fa MSDS  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

properties -----  
 molar mass: 152.0383992 g/mol (0.335187 8820  
 lb/mol)  
 normal freezing/melting/triple point: -93.6 °C (-136.5 °F) 8401  
 normal boiling point -----  
 temperature: -1.4 °C (29.4 °F) 8401  
 density, saturated liquid: 1445 kg/m3 (90.19 lb/cf) 8401  
 density, saturated vapor: 7.14 kg/m3 (0.446 lb/cf) 8401  
 specific volume, saturated liquid: 0.692 L/kg (0.0111 cf/lb) 8401  
 specific volume, saturated vapor: 140.0 L/kg (2.2423 cf/lb) 8401  
 heat of vaporization: 160.3 kJ/kg (68.9 Btu/lb) 8401

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

velocity of sound, saturated liquid:	624 m/s (2048 ft/s)	8401
velocity of sound, saturated vapor:	122 m/s (399 ft/s)	8401
viscosity, saturated liquid:	356 $\mu\text{Pa}\cdot\text{s}$ (0.356 cp)	8401
viscosity, saturated vapor:	9.96 $\mu\text{Pa}\cdot\text{s}$ (0.00996 cp)	8401
thermal conductivity, liquid:	0.0724 W/m $\cdot$ K (0.0418 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, vapor:	0.0106 W/m $\cdot$ K (0.0061 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· normal pressure, 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
density, vapor:	6.542 kg/m <sup>3</sup> (0.4084 lb/cf)	8401
· normal pressure, 21.1 $^{\circ}$ C (70 $^{\circ}$ F) ---		
density, vapor:	6.514 kg/m <sup>3</sup> (0.4066 lb/cf)	8401
· 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
pressure, saturated vapor:	229.6 kPa (33.31 psia)	6B05
density, saturated liquid:	1376 kg/m <sup>3</sup> (85.93 lb/cf)	8401
density, saturated vapor:	15.58 kg/m <sup>3</sup> (0.973 lb/cf)	8401
specific volume, saturated liquid:	0.727 L/kg (0.0116 cf/lb)	8401
specific volume, saturated vapor:	64.2 L/kg (1.0278 cf/lb)	8401
velocity of sound, saturated liquid:	545 m/s (1789 ft/s)	8401
velocity of sound, saturated vapor:	122 m/s (400 ft/s)	8401
viscosity, saturated liquid:	270 $\mu\text{Pa}\cdot\text{s}$ (0.270 cp)	8401
viscosity, saturated vapor:	10.7 $\mu\text{Pa}\cdot\text{s}$ (0.0107 cp)	8401
thermal conductivity, saturated liquid:	0.0662 W/m $\cdot$ K (0.0382 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, saturated vapor:	0.01198 W/m $\cdot$ K (0.00692 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· 60 $^{\circ}$ C (140 $^{\circ}$ F) -----		
pressure, saturated vapor:	765 kPa (110.9 psia)	8401
heat of vaporization:	122.6 kJ/kg (52.7 Btu/lb)	8401
· critical point -----		
temperature:	124.9 $^{\circ}$ C (256.9 $^{\circ}$ F)	7714
pressure:	3200 kPa (464.1 psia)	8401
density:	551 kg/m <sup>3</sup> (34.4 lb/cf)	8401
specific volume:	1.81 L/kg (0.0291 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{\text{atm}}$ ):	226 yr	9501
average tropospheric lifetime ( $\tau_{\text{trop}}$ ):	estimated: 77-218 yr	8312
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	9400 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	3.79 relative to R 11 for infinite integration period	8101
	4.2 relative to R 11 for infinite integration period	6B05

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A1	34e
NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 2-0-0 health-flammability-reactivity [-special]: 0=no, 4=severe	MSDS
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 2-0-0 DuPont: 1-0-1 health-flammability-reactivity 0=insignificant, 4=extreme	MSDS MSDS
· long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	1,000 ppm v/v TWA for 8 hr/day	8612

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

and 40 hr/wk

exposure limit consistent to OSHA PEL: DuPont AEL: 1,000 ppm v/v TWA MSDS  
for 8 hr/day and 40 hr/wk

• emergency exposure limit -----  
Refrigerant Concentration Limit (RCL): 55,000 ppm v/v (preliminary  
value under review, based on  
draft ASHRAE 34aa)

• acute (short-term) toxicity -----  
LC50 (lethal concentration, 50%): mouse, 10 min: 440,000 ppm 5980  
(fatal concentration by  
inhalation for half of test  
animals)  
rat, 4 hr: >457,000 ppm (fatal 6A94  
concentration by inhalation  
for half of test animals)

cardiac sensitization (CS) EC50: dog, 10 min, 3/6: 200,000 ppm 65A5  
v/v (effective concentration  
in half of test animals)

cardiac sensitization threshold/LOEL: dog, 10 min, 2/6: 150,000 ppm 65A5  
v/v (lowest observed effect  
level in test animals)

cardiac sensitization (CS) NOEL: dog, 10 min, 0/6: 100,000 ppm 65A5  
v/v (no observed effect level  
in test animals)

anesthetic/CNS effect EC50: mouse, 10 min: 110,000 ppm v/v 5980  
(effective concentration in  
half of test animals)

anesthetic/CNS effect LOEL: rat, 4 hr: 189,000 ppm v/v 6803  
(lowest observed effect level  
in ALC or LC50 studies)

anesthetic/CNS effect NOEL: rat, 4 hr: 134,000 ppm v/v (no 6803  
observed effect level in ALC  
or LC50 studies)

• flammability -----  
LFL-UFL (flammability limits in air): none (nonflammable as tested) 6B05  
flash point: 3M: none MSDS  
autodecomposition temperature: AlliedSignal: >250°C (>482°F) MSDS

• detection -----  
appearance: DuPont: colorless MSDS  
odor: 3M: faint ethereal MSDS

**PRODUCTION**

first commercial use as a refrigerant: October 1996  
last year production allowed: unrestricted 8C01

## R-E236ea1

----- REFRIGERANT DATA SUMMARY -----  
 R-E236ea1 2-(difluoromethoxy)-1,1,1,2-tetrafluoroethane see  
 HFE CHF2-O-CHF-CF3 RDB#  
 -----

**COMMON USE(S)**

candidate replacement for refrigerant 114 in centrifugal chillers

**IDENTIFIERS**

common name(s): R-E236ea1; RE236ea1; R E236ea1  
 HFE-E236ea1; HFOC-E236ea1  
 FC E236ea1  
 fluorochemical E236ea1  
 fluoroether E236ea1; E-236ea1  
 halochemical E236ea1  
 chemical name (by IUPAC convention): 2-(difluoromethoxy)-1,1,2,2-  
 tetrafluoroethane  
 alternative chemical names/formulae: 1,1,1,2-tetrafluoroethyl-  
 3,3-difluoromethyl ether  
 1,2,2,2-tetrafluoroethyl-  
 difluoromethyl ether  
 CHF2OCHF3; CHF2-O-CHF-CF3  
 not recommended:  
 CF3CHFOCHF2; CF3-CHF-O-CHF2  
 empirical formula: C3H2F6O

**PHYSICAL**

· properties -----  
 molar mass: 168.0377992 g/mol (0.370460 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: 23.2 °C (73.8 °F) 7B15  
 23.3 °C (74.0 °F) 8317  
 29.0 °C (84.2 °F) 7733

**ENVIRONMENTAL**

average atmospheric lifetime (tatm): 5.8 yr 9501  
 average tropospheric lifetime (ttrop): estimated: 3-9 yr 8312  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)  
 GWP (global warming potential): 960 relative to CO2 for 100 yr 9501  
 integration  
 HGWP (halocarbon GWP): 0.13 relative to R 11 for 8317  
 infinite integration period

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · flammability -----  
 LFL-UFL (flammability limits in air): nonflammable 7733

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized

last year production allowed: unrestricted

8C01



## R-242

----- REFRIGERANT DATA SUMMARY -----  
 R-242            trichlorodifluoropropane            see  
 HCFC            C3H3Cl3F2                                        RDB#  
 -----

**COMMON USE(S)**

see individual isomers

**IDENTIFIERS**

common name(s): R-242; R242; R 242  
 HCFC-242  
 fluorocarbon 242  
 fluorochemical 242; FC 242  
 halocarbon 242  
 halochemical 242  
 hydrochlorofluorocarbon 242  
 empirical formula: C3H3Cl3F2

**PHYSICAL**

· properties -----

molar mass: 183.4108264 g/mol (0.404352    8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.13 (0.005-0.13) (estimate    6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34): none (no application pending) 8601





## R-243da

----- REFRIGERANT DATA SUMMARY -----  
 R-243da 1,2-dichloro-1,3,3-trifluoropropane see  
 HCFC CHClFCHClCHF2 RDB#  
 -----

**IDENTIFIERS**

common name(s): R-243da; R243da; R 243da  
 HCFC-243da  
 fluorocarbon 243da  
 fluorochemical 243da; FC 243da  
 halocaron 243da  
 halochemical 243da  
 hydrochlorofluorocarbon 243da  
 chemical name (by IUPAC convention): 1,2-dichloro-1,3,3-  
 trifluoropropane  
 alternative chemical names/formulae: propane, 1,2-dichloro-1,3,3-  
 trifluoro-  
 CClHFCClHCF2H; CClHF-CClH-CF2H  
 not recommended:  
 CClFH-CClH-CF2H  
 CClFHCClHCF2H  
 CHF2-CHCl-CHClF  
 CHF2CHClCHClF  
 empirical formula: C3H3Cl2F3

**PHYSICAL**

· properties -----  
 molar mass: 166.9565296 g/mol (0.368076 8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.12 (0.007-0.12) (estimate 6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized

## R-243db

```

----- REFRIERANT DATA SUMMARY -----
R-243db      2,3-dichloro-1,1,1-trifluoropropane      see
HCFC         CH2ClCHClCF3          CAS number 338-75-0      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-243db; R243db; R 243db
                  HCFC-243db
                  fluorocarbon 243db
                  fluorochemical 243db; FC 243db
                  halocarbon 243db
                  halochemical 243db
                  hydrochlorofluorocarbon 243db
chemical name (by IUPAC convention):  2,3-dichloro-1,1,1-
                                       trifluoropropane
alternative chemical names/formulae:  propane, 2,3-dichloro-1,1,1-
                                       trifluoro-
                                       CH2ClCHClCF3; CH2Cl-CHCl-CF3
not recommended:
                                       CClH2CClHCF3; CClH2-CClH-CF3
                                       CF3CClHCClH2; CF3-CClH-CClH2
                                       CF3CHClCH2Cl; CF3-CHCl-CH2Cl
empirical formula:  C3H3Cl2F3
CAS number:         338-75-0 Chemical Abstracts
                   Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass: 166.9565296 g/mol (0.368076 lb/mol)      8820
normal freezing/melting/triple point: -71.6 °C (-96.9 °F)      3408
· normal boiling point -----
temperature: 75.5 °C (167.9 °F)      5980
              76.7 °C (170.1 °F)      3408
heat of vaporization: 185.0 kJ/kg (79.5 Btu/lb)      3408
· critical point -----
temperature: 251.9 °C (485.4 °F)      3408

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.12 (0.007-0.12) (estimate used for the Montreal Protocol)      6904

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending)      8601
· acute (short-term) toxicity -----
LC50 (lethal concentration, 50%): mouse, 10 min: 22,000 ppm      5980
                                   (fatal concentration by
                                   inhalation for half of test
                                   animals)
anesthetic/CNS effect EC50: mouse, 10 min: 4,000-5,000 ppm      5980
                              v/v (effective concentration
                              in half of test animals)

```

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: 2029 in developed countries 8C01  
under the Montreal Protocol

## Refrigerant Database

## R-244

----- REFRIGERANT DATA SUMMARY -----  
 R-244 chlorotetrafluoropropane see  
 HCFC C3H3ClF4 RDB#  
 -----

**COMMON USE(S)**

see individual isomers

**IDENTIFIERS**

common name(s): R-244; R244; R 244  
 HCFC-244  
 fluorochemical 244; FC 244  
 halochemical 244  
 chemical name (by IUPAC convention): chlorotetrafluoropropane  
 propane, chlorotetrafluoro-  
 empirical formula: C3H3ClF4

**PHYSICAL**

· properties -----  
 molar mass: 150.5022328 g/mol (0.331801 8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.14 (0.009-0.14) (estimate 6904  
 used for the Montreal  
 Protocol)

## R-244ca

## ----- REFRIGERANT DATA SUMMARY -----

R-244ca	3-chloro-1,1,2,2-tetrafluoropropane	see
HCFC	CH <sub>2</sub> ClCF <sub>2</sub> CHF <sub>2</sub>	RDB#
	CAS number 679-85-6	----

**COMMON USE(S)**

limited consideration as a refrigerant in high-temperature heat pumps; constrained by ozone depletion potential

**IDENTIFIERS**

common name(s): R-244ca; R244ca; R 244ca  
 HCFC-244ca  
 fluorochemical 244ca; FC 244ca  
 halochemical 244ca

chemical name (by IUPAC convention): 3-chloro-1,1,2,2-tetrafluoropropane

alternative chemical names/formulae: propane, 3-chloro-1,1,2,2-tetrafluoro-  
 CH<sub>2</sub>ClCF<sub>2</sub>CHF<sub>2</sub>; CH<sub>2</sub>Cl-CF<sub>2</sub>-CHF<sub>2</sub>  
 not recommended:  
 CClH<sub>2</sub>CF<sub>2</sub>CF<sub>2</sub>H; CClH<sub>2</sub>-CF<sub>2</sub>-CF<sub>2</sub>H  
 CF<sub>2</sub>HCF<sub>2</sub>CClH<sub>2</sub>; CF<sub>2</sub>H-CF<sub>2</sub>-CClH<sub>2</sub>  
 CHF<sub>2</sub>CF<sub>2</sub>CH<sub>2</sub>Cl; CHF<sub>2</sub>-CF<sub>2</sub>-CH<sub>2</sub>Cl

empirical formula: C<sub>3</sub>H<sub>3</sub>ClF<sub>4</sub>  
 CAS number: 679-85-6 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----

molar mass:	150.5022328 g/mol (0.331801 lb/mol)	8820
normal freezing/melting/triple point:	-101.8 °C (-151.2 °F)	3408
· normal boiling point -----	temperature: 54.8 °C (130.6 °F)	3408
	heat of vaporization: 206.6 kJ/kg (88.8 Btu/lb)	3408
· critical point -----	temperature: 221.0 °C (429.8 °F)	3408
	pressure: 3710 kPa (538.1 psia)	3408
	density: 525 kg/m <sup>3</sup> (32.8 lb/cf)	3408
	specific volume: 1.90 L/kg (0.0305 cf/lb)	3408

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.14 (0.009-0.14) (estimate used for the Montreal Protocol) 6904

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized

last year production allowed: 2029 in developed countries 8C01  
 under the Montreal Protocol



## R-245ca

```

----- REFRIERANT DATA SUMMARY -----
R-245ca      1,1,2,2,3-pentafluoropropane      see
HFC          CH2FCF2CHF2                        CAS number 679-86-7      RDB#
-----

```

**COMMON USE (S)**

under primary consideration as an alternative for refrigerants 11 and 123, constrained by marginal flammability; under consideration as a foam blowing agent

**IDENTIFIERS**

```

common name(s):  R-245ca; R245ca; R 245ca
                  HFC-245ca
                  fluorocarbon 245ca
                  fluorochemical 245ca; FC 245ca
                  halocarbon 245ca
                  halochemical 245ca
                  hydrofluorocarbon 245ca
chemical name (by IUPAC convention): 1,1,2,2,3-pentafluoropropane
alternative chemical names/formulae: propane,
                                      1,1,2,2,3-pentafluoro-
                                      CH2FCF2CHF2; CH2F-CF2-CHF2
not recommended:
                  CF2HCF2CFH2; CF2H-CF2-CFH2
                  CFH2CF2CF2H; CFH2-CF2-CF2H
                  CHF2CF2CH2F; CHF2-CF2-CH2F
                  FCH2CF2CHF2; FCH2-CF2-CHF2
empirical formula: C3H3F5
CAS number:       679-86-7 Chemical Abstracts
                  Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass: 134.047936 g/mol (0.295525      8820
             lb/mol)
normal freezing/melting/triple point: -73.4 °C (-100.1 °F)      3301
· normal boiling point -----
temperature: 25.1 °C (77.2 °F)              8401
density, saturated liquid: 1386 kg/m3 (86.53 lb/cf)      8401
density, saturated vapor: 5.74 kg/m3 (0.358 lb/cf)       8401
specific volume, saturated liquid: 0.722 L/kg (0.0116 cf/lb) 8401
specific volume, saturated vapor: 174.3 L/kg (2.7922 cf/lb) 8401
heat of vaporization: 201.0 kJ/kg (86.4 Btu/lb)           8401
velocity of sound, saturated liquid: 655 m/s (2150 ft/s) 8401
velocity of sound, saturated vapor: 136 m/s (446 ft/s)   8401
viscosity, saturated vapor: 10.16 µPa·s (0.01016 cp)     8401
viscosity, saturated liquid: 542 µPa·s (0.542 cp)       8401
thermal conductivity, liquid: 0.0873 W/m·K (0.0505      8401
                               Btu/hr·ft°F)
thermal conductivity, vapor: 0.0123 W/m·K (0.0071      8401
                               Btu/hr·ft°F)
· normal pressure, 20 °C (68 °F) -----
density, liquid: 1399 kg/m3 (11.67 lb/gal)                8401
· normal pressure, 21.1 °C (70 °F) ---

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



	density, liquid:	1396 kg/m <sup>3</sup> (11.65 lb/gal)	8401
• 20 °C (68 °F) -----			
	pressure, saturated vapor:	82.9 kPa (12.02 psia)	8401
	density, saturated liquid:	1399 kg/m <sup>3</sup> (87.32 lb/cf)	8401
	density, saturated vapor:	4.75 kg/m <sup>3</sup> (0.296 lb/cf)	8401
	specific volume, saturated liquid:	0.715 L/kg (0.0115 cf/lb)	8401
	specific volume, saturated vapor:	210.7 L/kg (3.3744 cf/lb)	8401
	velocity of sound, saturated liquid:	674 m/s (2210 ft/s)	8401
	velocity of sound, saturated vapor:	135 m/s (444 ft/s)	8401
	viscosity, saturated liquid:	584 µPa·s (0.584 cp)	8401
	viscosity, saturated vapor:	10.0 µPa·s (0.0100 cp)	8401
	thermal conductivity, saturatd liquid:	0.0889 W/m·K (0.0513 Btu/hr·ft°F)	8401
	thermal conductivity, saturated vapor:	0.01187 W/m·K (0.00686 Btu/hr·ft°F)	8401
• 60 °C (140 °F) -----			
	pressure, saturated vapor:	327 kPa (47.5 psia)	8401
	heat of vaporization:	180.6 kJ/kg (77.6 Btu/lb)	8401
• critical point -----			
	temperature:	174.4 °C (346.0 °F)	7714
	pressure:	3935 kPa (570.7 psia)	8401
	density:	524 kg/m <sup>3</sup> (32.7 lb/cf)	7714
	specific volume:	1.91 L/kg (0.0306 cf/lb)	7714

**ENVIRONMENTAL**

	average atmospheric lifetime (τ <sub>atm</sub> ):	6.6 ±2.3 yr	6695
	average tropospheric lifetime (τ <sub>trop</sub> ):	6.3 yr	5804
		estimated: 1.3-3 yr	8312
	ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
	GWP (global warming potential):	720 relative to CO <sub>2</sub> for 100 yr integration	9501
	HGWP (halocarbon GWP):	0.13 relative to R 11 for infinite integration period	8101

**SAFETY**

• classification -----			
	safety group (ASHRAE Standard 34):	none (no application pending)	8601
• acute (short-term) toxicity -----			
	LCLo (lethal concentration, lowest):	rat, 4 hr: >993 ppm (fatal concentration by inhalation for even one test animal)	5805
• flammability -----			
	LFL-UFL (flammability limits in air):	7.1-14.8 % v/v	4785
		8.3-12.8 % v/v	5B15
		none (nonflammable as tested)	2A01
	heat of combustion (by ASHRAE 34-92):	7.1 MJ/kg (3052 Btu/lb)	6501
		8.4 MJ/kg (3616 Btu/lb)	4785
	flash point:	none	5B15

**PRODUCTION**

	first commercial use as a refrigerant:	not known to be commercialized	
	last year production allowed:	unrestricted	8C01

## R-245cb

## ----- REFRIGERANT DATA SUMMARY -----

R-245cb	1,1,1,2,2-pentafluoropropane	see
HFC	CH3CF2CF3	RDB#
	CAS number 1814-88-6	-----

**COMMON USE(S)**

considered as a candidate, as a single compound and as a blend component, to replace refrigerant 123; also considered as a blowing agent

**IDENTIFIERS**

common name(s): R-245cb; R245cb; R 245cb  
 HFC-245cb  
 fluorocarbon 245cb  
 fluorochemical 245cb; FC 245cb  
 halocarbon 245cb  
 halochemical 245cb  
 hydrofluorocarbon 245cb

chemical name (by IUPAC convention): 1,1,1,2,2-pentafluoropropane  
 alternative chemical names/formulae: propane,  
 1,1,1,2,2-pentafluoro-  
 CH3CF2CF3; CH3-CF2-CF3  
 not recommended:  
 CF3CF2CH3; CF3-CF2-CH3

empirical formula: C3H3F5  
 CAS number: 1814-88-6 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

• properties -----

molar mass:	134.047936 g/mol (0.295525 lb/mol)	8820
normal freezing/melting/triple point:	-81.1 °C (-114.0 °F)	3408
• normal boiling point -----	temperature: -18.0 °C (-0.5 °F)	8215
	heat of vaporization: 176.1 kJ/kg (75.7 Btu/lb)	3408
• 20 °C (68 °F) -----	pressure, saturated vapor: 395.5 kPa (57.36 psia)	4101
	397.6 kPa (57.67 psia)	2506
	density, saturated liquid: 1195 kg/m3 (74.57 lb/cf)	2506
	density, saturated vapor: 25.04 kg/m3 (1.563 lb/cf)	4101
• 60 °C (140 °F) -----	pressure, saturated vapor: 1167 kPa (169.3 psia)	4101
• critical point -----	temperature: 107.2 °C (225.0 °F)	7713
	pressure: 3137 kPa (455.0 psia)	2506
	3148 kPa (456.6 psia)	8215
	3264 kPa (473.4 psia)	3408
	density: 499 kg/m3 (31.1 lb/cf)	7713
	499 kg/m3 (31.2 lb/cf)	3408
	specific volume: 2.00 L/kg (0.0321 cf/lb)	3408
	2.04 L/kg (0.0326 cf/lb)	2506

**ENVIRONMENTAL**

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

average atmospheric lifetime ( $\tau_{atm}$ ):	1.8 yr	3627
average tropospheric lifetime ( $\tau_{trop}$ ):	estimated: 7 yr	8312
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01



## R-245eb

```

----- REFRIERANT DATA SUMMARY -----
R-245eb      1,1,1,2,3-pentafluoropropane      see
HFC          CH2FCHFCF3                          CAS number 431-31-2      RDB#
-----

```

**COMMON USE(S)**

under limited consideration as an alternative for refrigerants 11 and 123; under consideration as a foam blowing agent

**IDENTIFIERS**

```

common name(s):  R-245eb; R245eb; R 245eb
                 HFC-245eb
                 fluorocarbon 245eb
                 fluorochemical 245eb; FC 245eb
                 halocarbon 245eb
                 halochemical 245eb
                 hydrofluorocarbon 245eb
chemical name (by IUPAC convention):  1,1,1,2,3-pentafluoropropane
alternative chemical names/formulae:  propane, 1,1,1,2,3-
                                     pentafluoro-
                                     CH2FCHFCF3; CH2F-CHF-CF3
not recommended:
                 CF3CFHCFH2; CF3-CFH-CFH2
                 CF3CHFCH2F; CF3-CHF-CH2F
                 CFH2CFHCF3; CFH2-CFH-CF3
empirical formula:  C3H3F5
CAS number:        431-31-2 Chemical Abstracts
                  Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass:      134.047936 g/mol (0.295525      8820
                 lb/mol)
normal freezing/melting/triple point:  -126.7 °C (-196.1 °F)      8211
· normal boiling point -----
temperature:     20.0 °C (68.0 °F)              7837
                 22.7 °C (72.9 °F)              5B15
· 20 °C (68 °F) -----
density, saturated liquid:  1380 kg/m3 (86.15 lb/cf)      5B15

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (τatm):  3.6 yr      8101
                                     6 yr      5442
ODP (ozone depletion potential):      0.000 (model-derived relative
to R 11)
GWP (global warming potential):      350 relative to CO2 for 100 yr      8101
integration
HGWP (halocarbon GWP):               0.08 relative to R 11 for      8101
infinite integration period
0.12 relative to R 11 for            5B15
infinite integration period

```

**SAFETY**

```

· classification -----

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

safety group (ASHRAE Standard 34): none (no application pending) 8601  
· flammability -----  
LFL-UFL (flammability limits in air): 9.6-10.7 % v/v 5B15

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01



· normal boiling point -----		
temperature:	14.9 °C (58.8 °F)	8401
	15.1 °C (59.2 °F)	8324
density, saturated liquid:	1366 kg/m <sup>3</sup> (85.26 lb/cf)	8401
density, saturated vapor:	5.92 kg/m <sup>3</sup> (0.370 lb/cf)	8401
specific volume, saturated liquid:	0.732 L/kg (0.0117 cf/lb)	8401
specific volume, saturated vapor:	16.9 L/kg (0.2705 cf/lb)	8401
heat of vaporization:	196.7 kJ/kg (84.6 Btu/lb)	8401
velocity of sound, saturated liquid:	715 m/s (2346 ft/s)	8401
velocity of sound, saturated vapor:	134 m/s (439 ft/s)	8401
viscosity, saturated liquid:	464 µPa·s (0.464 cp)	8401
viscosity, saturated vapor:	9.99 µPa·s (0.00999 cp)	8401
thermal conductivity, liquid:	0.0841 W/m·K (0.0486 Btu/hr·ft <sup>2</sup> °F)	8401
thermal conductivity, vapor:	0.0117 W/m·K (0.0067 Btu/hr·ft <sup>2</sup> °F)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	123.8 kPa (17.96 psia)	8401
density, saturated liquid:	1352 kg/m <sup>3</sup> (84.42 lb/cf)	8401
density, saturated vapor:	7.16 kg/m <sup>3</sup> (0.447 lb/cf)	8401
specific volume, saturated liquid:	0.740 L/kg (0.0118 cf/lb)	8401
specific volume, saturated vapor:	14.0 L/kg (0.2238 cf/lb)	8401
velocity of sound, saturated liquid:	693 m/s (2272 ft/s)	8401
velocity of sound, saturated vapor:	134 m/s (441 ft/s)	8401
viscosity, saturated liquid:	432 µPa·s (0.432 cp)	8401
viscosity, saturated vapor:	10.2 µPa·s (0.0102 cp)	8401
thermal conductivity, saturated liquid:	0.0826 W/m·K (0.0477 Btu/hr·ft <sup>2</sup> °F)	8401
thermal conductivity, saturated vapor:	0.01208 W/m·K (0.00698 Btu/hr·ft <sup>2</sup> °F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	464 kPa (67.2 psia)	8401
heat of vaporization:	168.4 kJ/kg (72.4 Btu/lb)	8401
· critical point -----		
temperature:	154.1 °C (309.3 °F)	7714
pressure:	3640 kPa (527.9 psia)	8401
	4433 kPa (643.0 psia)	8324
density:	517 kg/m <sup>3</sup> (32.3 lb/cf)	7714
specific volume:	1.93 L/kg (0.0310 cf/lb)	7714

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	7.6 yr	9709
	8.4 yr	8323
	8.8 yr	5442
average tropospheric lifetime ( $\tau_{trop}$ ):	8.6 yr	5805
	estimated: 7-11 yr	8312
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	760 relative to CO <sub>2</sub> for 100 yr	9709
	integration	
	820 relative to CO <sub>2</sub> for 100 yr	8101
	integration	
	990 relative to CO <sub>2</sub> for 100 yr	ETF
	integration	
HGWP (halocarbon GWP):	0.18 relative to R 11 for	8101
	infinite integration period	
	0.24 relative to R 11 for	5B15
	infinite integration period	



## Refrigerant Database

## SAFETY

• classification -----  
   safety group (ASHRAE Standard 34): none (application pending)  
   A1 provisional recommended 34h  
   NFPA 704 degrees of hazard (H-F-R-S): AlliedSignal: 2-0-1 MSDS  
   health-flammability-reactivity  
   [-special]: 0=no, 4=severe  
   NPCA HMIS hazard ratings (H-F-R): AlliedSignal: 2-0-1 MSDS  
   health-flammability-reactivity  
   0=insignificant, 4=extreme

• long-term occupational limit -----  
   exposure limit consistent to OSHA PEL: AlliedSignal provisional: 500 MSDS  
   ppm v/v TWA for 8 hr/day and  
   40 hr/wk  
   exposure limit: AIHA WEEL under consideration

• emergency exposure limit -----  
   Refrigerant Concentration Limit (RCL): 34,000 ppm v/v (preliminary  
   value under review, based on  
   draft ASHRAE 34aa)

• acute (short-term) toxicity -----  
   ALC (approximate lethal concentration: mouse, 4 hr, 0/10: >101,300 9707  
   ppm (lowest exposure tested  
   with one or more deaths by  
   inhalation)  
   rat, 4 hr, 0/10: >203,000 ppm 7111  
   (lowest exposure tested with  
   one or more deaths by  
   inhalation)  
                   dermal LD50 (lethal dosage, 50%): rabbit: >2,600 mg/kg (fatal 7113  
   dose by skin contact for half  
   of test animals)  
   cardiac sensitization threshold/LOEL: dog, 10 min, 1/4: 44,000 ppm 9707  
   v/v (lowest observed effect  
   level in test animals)  
                   cardiac sensitization (CS) NOEL: dog, 10 min, 0/4: 34,100 ppm 9707  
   v/v (no observed effect level  
   in test animals)  
                   anesthetic/CNS effect LOEL: mouse, 4 hr, 10/10: 101,300 9707  
   ppm v/v (lowest observed  
   effect level in ALC or LC50  
   studies)  
   rat, 4 hr, 10/10: 143,000 ppm 7111  
   v/v (lowest observed effect  
   level in ALC or LC50 studies)  
                   anesthetic/CNS effect NOEL: rat, 4 hr, 0/10: 116,000 ppm 7115  
   v/v (no observed effect level  
   in ALC or LC50 studies)

• flammability -----  
   LFL-UFL (flammability limits in air): none (not flammable as tested) 6B20  
   none (not flammable as tested) 7114  
   heat of combustion (by ASHRAE 34-92): 6.1 MJ/kg (2618 Btu/lb) UL  
   flash point: none 6B20  
   autoignition temperature: 704 °C (1299 °F) UL  
   AlliedSignal: 412 °C (774 °F) MSDS  
   for 500 and 160 ml flasks MSDS  
   autodecomposition temperature: AlliedSignal: >250°C (>482°F) MSDS  
   former UL Classification: practically nonflammable UL  
   (withdrawn for revision of the  
   classification system,

category SBQT2)

· detection -----

appearance:	AlliedSignal: colorless	MSDS
	volatile liquid	
odor:	AlliedSignal: faint ethereal	MSDS
	and sweetish odor	MSDS

**PRODUCTION**

first commercial use as a refrigerant:	projected: 2001-2003	
last year production allowed:	unrestricted	8C01

## R-E245ca2

```

----- REFRIERANT DATA SUMMARY -----
R-E245ca2    1-(difluoromethoxy)-1,1,2-trifluoroethane    see
HFE          CH2F-CF2-O-CHF2                               RDB#
-----

```

**COMMON USE(S)**

candidate refrigerant for high temperature applications; candidate for use as a foam blowing agent

**IDENTIFIERS**

```

common name(s):  R-E245ca2; RE245ca2; R E245ca2
                  HFE-E245ca2; HFOC-E245ca2
                  FC E245ca2
                  fluorochemical E245ca2
                  fluoroether E245ca2; E-245ca2
                  halochemical E245ca2
chemical name (by IUPAC convention):  1-(difluoromethoxy)-1,1,2-
                                       trifluoroethane
alternative chemical names/formulae:  ethane, 1-(difluoromethoxy)-
                                       1,1,2-trifluoro-
                                       CH2FCF2OCHF2; CH2F-CF2-O-CHF2
not recommended:
                                       CF2HOCF2CFH2; CF2H-O-CF2-CFH2
                                       CFH2CF2OCF2H; CFH2-CF2-O-CF2H
                                       CHF2OCF2CH2F; CHF2-O-CF2-CH2F
empirical formula:  C3H3F5O

```

**PHYSICAL**

```

· properties -----
      molar mass:  150.0473360 g/mol (0.330798    8820
                  lb/mol)
· normal boiling point -----
      temperature:  43.1 °C (109.5 °F)           8703
· critical point -----
      temperature:  188.9 °C (372.0 °F)         8703
      pressure:    3538 kPa (513.1 psia)        8703
      density:     533 kg/m3 (33.3 lb/cf)       8703
      specific volume:  1.88 L/kg (0.0301 cf/lb) 8703

```

**ENVIRONMENTAL**

```

average tropospheric lifetime (τtrop):  estimated: 3-10 yr    8312
ODP (ozone depletion potential):        0.000 (model-derived relative
to R 11)

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending) 8601

```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized
last year production allowed:           unrestricted    8C01

```

## R-E245cb1

----- REFRIGERANT DATA SUMMARY -----  
 R-E245cb1 1-methoxy-1,1,2,2,2-pentafluoroethane see  
 HFE CH3-O-CF2-CF3 CAS number 22410-44-2 RDB#  
 -----

**COMMON USE(S)**

candidate replacement for refrigerant 114 in centrifugal chillers  
 either as a single compound or as a blend component

This candidate refrigerant is one of three hydrofluoroethers  
 identified as promising by the Research Institute of Innovative  
 Technology for the Earth (RITE) in Japan.

**IDENTIFIERS**

common name(s): R-E245cb1; RE245cb1; R E245cb1  
 HFE-E245cb1; HFOC-E245cb1  
 FC E245cb1  
 fluorochemical E245cb1  
 fluoroether E245cb1; E-245cb1  
 halochemical E245cb1  
 "R-E245mc"; "HFE-245mc" 8321  
 chemical name (by IUPAC convention): 1-(methoxy)-1,1,2,2,2-  
 pentafluoroethane  
 alternative chemical names/formulae: 2-(methoxy)-1,1,1,2,2-  
 pentafluoroethane  
 ethane, 1-(methoxy)-1,1,2,2,2-  
 pentafluoro-  
 methoxypentafluoroethane  
 methoxy-pentafluoroethane  
 methyl F-ethyl ether  
 methyl pentafluoroethyl ether  
 pentafluoroethyl methyl ether  
 CH3OCF2CF3; CH3-O-CF2-CF3  
 not recommended:  
 CF3CF2OCH3; CF3-CF2-O-CH3  
 empirical formula: C3H3F5O  
 CAS number: 22410-44-2 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 150.0473360 g/mol (0.330798 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: 5.6 °C (42.1 °F) 5B02  
 heat of vaporization: 169.7 kJ/kg (73.0 Btu/lb) 7108  
 · 20 °C (68 °F) -----  
 density, saturated liquid: 1185 kg/m3 (73.98 lb/cf) 8323  
 · critical point -----  
 temperature: 133.7 °C (272.6 °F) 8321  
 pressure: 2886 kPa (418.6 psia) 8321  
 2887 kPa (418.7 psia) 5B02  
 density: 499 kg/m3 (31.2 lb/cf) 8321

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	1.2 yr	9501
average tropospheric lifetime ( $\tau_{trop}$ ):	estimated: 0.8-0.9 yr	8312
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	8323
GWP (global warming potential):	160 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.13 relative to R 11 for infinite integration period	8317

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
· flammability -----		
LFL-UFL (flammability limits in air):	nonflammable	7733
flash point:	nonflammable	7108

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-E245fa1

## ----- REFRIGERANT DATA SUMMARY -----

R-E245fa1	2-(difluoromethoxy)-1,1,1-trifluoroethane	see
HFE	CHF2-O-CH2-CF3	CAS number 1885-48-9
		RDB#

**COMMON USE(S)**

considered as a replacement for refrigerants 11 and 123 in centrifugal chillers, but found to react autocatalytically with glass to produce high pressure, hydrogen fluoride, and 2,2,2-trifluoroethyl ether (a convulsant); reaction with glass is accelerated by air (oxygen) and peroxide; also found to be unstable with fibrous-glass motor materials

**IDENTIFIERS**

common name(s):	R-E245fa1; RE245fa1; R E245fa1 HFE-E245fa1; HFOC-E245fa1 FC E245fa1 fluorochemical E245fa1 fluoroether E245fa1; E-245fa1 halochemical E245fa1 incorrectly: "R-E245fa2"; "HFE-245fa2"	9501
chemical name (by IUPAC convention):	2-(difluoromethoxy)- 1,1,1-trifluoroethane	
alternative chemical names/formulae:	ethane, 2-(difluoromethoxy)- 1,1,1-trifluoro- 2,2,2-trifluoroethyl difluoromethyl ether difluoromethyl 2,2,2-trifluoroethyl ether CHF2OCH2CF3; CHF2-O-CH2-CF3 not recommended: CF2HOCH2CF3; CF2H-O-CH2-CF3 CF3CH2OCF2H; CF3-CH2-O-CF2H CF3CH2OCHF2; CF3-CH2-O-CHF2	
empirical formula:	C3H3F5O	
CAS number:	1885-48-9 Chemical Abstracts Service Registry Number	
EINECS number:	413-830-7 (European Inventory of Existing Chemical Substances)	

**PHYSICAL**

· properties -----		
	molar mass:	150.0473360 g/mol (0.330798 lb/mol) 8820
· normal boiling point -----		
	temperature:	26.1 °C (79.0 °F) 3626 29.0 °C (84.2 °F) 8317 29.2 °C (84.5 °F) 3626
· critical point -----		
	temperature:	170.9 °C (339.6 °F) 7713
	pressure:	3420 kPa (496.0 psia) 8254
	density:	516 kg/m3 (32.2 lb/cf) 7713

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ):	4.4 yr	9501
average tropospheric lifetime ( $\tau_{trop}$ ):	estimated: 0.7-1.6 yr	8312
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	570 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.15 relative to R 11 for infinite integration period	8713

**SAFETY**

· classification -----		
· safety group (ASHRAE Standard 34):	none (no application pending)	8601
· acute (short-term) toxicity -----		
anesthetic/CNS effect LOEL:	100,000 ppm v/v (lowest observed effect level in test animals)	7461

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-E245fa2

----- REFRIGERANT DATA SUMMARY -----  
 R-E245fa2 2-(trifluoromethoxy)-1,1-difluoroethane see  
 HFE CHF2-CH2-O-CF3 CAS number 84011-15-4 RDB#  
 -----

**COMMON USE(S)**

candidate replacement for refrigerants 11 and 123 in centrifugal chillers

**IDENTIFIERS**

common name(s): R-E245fa2; RE245fa2; R E245fa2  
 HFE-E245fa2  
 FC E245fa2  
 fluorochemical E245fa2  
 fluoroether E245fa2; E-245fa2  
 halochemical E245fa2  
 chemical name (by IUPAC convention): 2-(trifluoromethoxy)-1,1-difluoroethane  
 alternative chemical names/formulae: ethane, 2-(trifluoromethoxy)-1,1-difluoroethane  
 difluoromethoxytrifluoroethane  
 CHF2CH2OCF3; CHF2-CH2-O-CF3  
 not recommended:  
 CF2HCH2OCF3; CF2H-CH2-O-CF3  
 CF3OCH2CF2H; CF3-O-CH2-CF2H  
 CF3OCH2CHF2; CF3-O-CH2-CHF2  
 empirical formula: C3H3F5O  
 CAS number: 84011-15-4 Chemical Abstracts Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 150.0473360 g/mol (0.330798 8820 lb/mol)

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ): 2.2 yr 9501  
 average tropospheric lifetime ( $\tau_{trop}$ ): estimated: 0.9-2 yr 8312  
 ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)  
 GWP (global warming potential): 280 relative to CO2 for 100 yr 9501 integration

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: unrestricted 8C01









## R-253

----- REFRIGERANT DATA SUMMARY -----  
 R-253 chlorotrifluoropropane see  
 HCFC C3H4ClF3 RDB#  
 -----

**COMMON USE(S)**

see individual isomers

**IDENTIFIERS**

common name(s): R-253; R253; R 253  
 HCFC-253  
 fluorocarbon 253  
 fluorochemical 253; FC 253  
 halocarbon 253  
 halochemical 253  
 hydrochlorofluorocarbon 253  
 empirical formula: C3H4Cl2F2

**PHYSICAL**

· properties -----  
 molar mass: 132.5117696 g/mol (0.292138 8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.03 (0.003-0.03) (estimate 6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601







· classification -----  
safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01









## R-254fb

## ----- REFRIGERANT DATA SUMMARY -----

R-254fb	1,1,1,3-tetrafluoropropane		see
HFC	CH2F-CH2-CF3	CAS number 460-36-6	RDB#

-----

**COMMON USE(S)**

candidate replacement, as a single-compound refrigerant and as a blend component, for refrigerants 11, 113, and 123

**IDENTIFIERS**

common name(s):	R-254fb; R254fb; R 254fb HFC-254fb fluorocarbon 254fb fluorochemical 254fb; FC 254fb halocarbon 254fb halochemical 254fb hydrofluorocarbon 254fb
chemical name (by IUPAC convention):	1,1,1,3-tetrafluoropropane
alternative chemical names/formulae:	propane, 1,1,1,3-tetrafluoro- CH2FCH2CF3; CH2F-CH2-CF3 not recommended: CF3CH2CFH2; CF3-CH2-CFH2 CF3CH2CH2F; CF3-CH2-CH2F CFH2CH2CF3; CFH2-CH2-CF3
empirical formula:	C3H4F4
CAS number:	460-36-6 Chemical Abstracts Service Registry Number

**PHYSICAL**

· properties -----		
	molar mass:	116.0574728 g/mol (0.255863 lb/mol) 8820
	normal freezing/melting/triple point:	-112.8 °C (-171.0 °F) 8211
· normal boiling point -----		
	temperature:	29.4 °C (84.9 °F) 7837
	heat of vaporization:	245.0 kJ/kg (105.3 Btu/lb) 8211
· critical point -----		
	temperature:	181.9 °C (359.4 °F) 8211
	pressure:	3934 kPa (570.6 psia) 8211
	density:	470 kg/m3 (29.3 lb/cf) 8211
	specific volume:	2.13 L/kg (0.0341 cf/lb) 8211

**ENVIRONMENTAL**

average tropospheric lifetime ( $\tau_{\text{trop}}$ ):	estimated: 2-8 yr	8312
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

## R-E254cb1

```

----- REFRIGERANT DATA SUMMARY -----
R-E254cb1    1-(methoxy)-1,1,2,2-tetrafluoroethane    see
HFE          CH3-O-CF2-CHF2                               RDB#
-----

```

**COMMON USE(S)**

considered as a replacement for refrigerants 11, 113, and 123 in centrifugal chillers, but constrained by toxicity and flammability; candidate for use as a foam blowing agent

**IDENTIFIERS**

```

common name(s):  R-E254cb1; RE254cb1; R E254cb1
                 HFE-E254cb1; HFOC-E254cb1
                 FC E254cb1
                 fluorochemical E254cb1
                 fluoroether E254cb1; E-254cb1
                 halochemical E254cb1
                 incorrectly:
                 "R-E254cb2"; "HFE-254cb2"          9501
chemical name (by IUPAC convention):  1-(methoxy)-1,1,2,2-
                                       tetrafluoroethane
alternative chemical names/formulae:  ethane, 1-(methoxy)-1,1,2,2-
                                       tetrafluoro-
                                       CH3OCF2CHF2; CH3-O-CF2-CHF2
                                       not recommended:
                                       CF2HCF2OCH3; CF2H-CF2-O-CH3
                                       CH3OCF2CF2H; CH3-O-CF2-CF2H
                                       CHF2CF2OCH3; CHF2-CF2-O-CH3
empirical formula:  C3H4F4O

```

**PHYSICAL**

```

· properties -----
molar mass:  132.0568728 g/mol (0.291136      8820
              lb/mol)
· normal boiling point -----
temperature:  35.0 °C (95.0 °F)                7733
              36.5 °C (97.7 °F)                7461
              37.2 °C (99.0 °F)                8323

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (τatm):  0.22 yr          9501
                                       0.49 yr          8317
average tropospheric lifetime (τtrop): estimated: 0.4-0.5 yr      8312
ODP (ozone depletion potential):      0.000 (model-derived relative
                                       to R 11)
GWP (global warming potential):       25 relative to CO2 for 100 yr  9501
                                       integration
HGWP (halocarbon GWP):                0.01 relative to R 11 for      8713
                                       infinite integration period

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):    none (no application pending)  8601

```





## R-261

## ----- REFRIGERANT DATA SUMMARY -----

R-261	dichlorofluoropropane	see
HCFC	C3H5Cl2F	RDB#

-----

**COMMON USE(S)**

see individual isomers

**IDENTIFIERS**

common name(s):	R-261; R261; R 261
	HCFC-261
	fluorocarbon 261
	fluorochemical 261; FC 261
	halocarbon 261
	halochemical 261
	hydrochlorofluorocarbon 261
empirical formula:	C3H5Cl2F

**PHYSICAL**

· properties -----

molar mass:	130.9756032 g/mol (0.288752 lb/mol)	8820
-------------	-------------------------------------	------

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.02 (0.002-0.02) (estimate used for the Montreal Protocol)	6904
----------------------------------	---	------

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34):	none (no application pending)	8601
------------------------------------	-------------------------------	------



## R-261ba

```

----- REFRIGERANT DATA SUMMARY -----
R-261ba      1,2-dichloro-2-fluoropropane      see
HCFC         CH3CClFCH2Cl                               RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-261ba; R261ba; R 261ba
                  HCFC-261ba
                  fluorocarbon FC 261ba
                  fluorochemical 261ba; FC 261ba
                  halocarbon 261ba
                  halochemical 261ba
                  hydrochlorofluorocarbon 261ba
alternative chemical names/formulae: CH3CClFCH2Cl; CH3-CClF-CH2Cl
not recommended:
                  CH3CClFCClH2; CH3-CClF-CClH2
                  CH3CFClCH2Cl; CH3-CFCl-CH2Cl
                  CClH2CClFCH3; CClH2-CClF-CH3
                  CClH2CFClCH3; CClH2-CFCl-CH3
                  CH2ClCClFCH3; CH2Cl-CClF-CH3
                  CH2ClCFClCH3; CH2Cl-CFCl-CH3
                  CH3CClFCClH2; CH3-CClF-CClH2
                  CH3CFClCClH2; CH3-CFCl-CClH2
empirical formula: C3H5Cl2F

```

**PHYSICAL**

```

· properties -----
molar mass: 130.9756032 g/mol (0.288752 8820
lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.02 (0.002-0.02) (estimate 6904
used for the Montreal
Protocol)

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34): none (no application pending) 8601
· flammability -----
  LFL-UFL (flammability limits in air): probably flammable

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: 2029 in developed countries 8C01
under the Montreal Protocol

```

## R-262

----- REFRIGERANT DATA SUMMARY -----  
 R-262            chlorodifluoropropane            see  
 HCFC            C3H5ClF2                                        RDB#  
 -----

**COMMON USE(S)**

see individual isomers

**IDENTIFIERS**

common name(s): R-262; R262; R 262  
 HCFC-262  
 fluorocarbon 262  
 fluorochemical 262; FC 262  
 halocarbon 262  
 halochemical 262  
 hydrochlorofluorocarbon 262  
 empirical formula: C3H5ClF2

**PHYSICAL**

· properties -----

molar mass: 114.5213064 g/mol (0.252476    8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.02 (0.002-0.02) (estimate    6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34): none (no application pending) 8601











## R-263fb

```

----- REFRIERANT DATA SUMMARY -----
R-263fb      1,1,1-trifluoropropane      see
HFC          CH3CH2CF3                    CAS number 421-07-8      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-263fb; R263fb; R 263fb
                  HFC-263fb
                  fluorocarbon 263fb
                  fluorochemical 263fb; FC 263fb
                  halocarbon 263fb
                  halochemical 263fb
                  hydrofluorocarbon 263fb
chemical name (by IUPAC convention): 1,1,1-trifluoropropane
alternative chemical names/formulae: propane, 1,1,1-trifluoro-
                                      CH3CH2CF3; CH3-CH2-CF3
                                      not recommended:
                                      CF3CH2CH3; CF3-CH2-CH3
empirical formula: C3H5F3
CAS number:       421-07-8 Chemical Abstracts
                  Service Registry Number
EINECS number:   207-002-2 (European Inventory
                  of Existing Chemical
                  Substances)

```

**PHYSICAL**

```

· properties -----
molar mass: 98.0670096 g/mol (0.216201      8820
             lb/mol)
normal freezing/melting/triple point: -148.0 °C (-234.4 °F)      PCR
· normal boiling point -----
temperature: -12.5 °C (9.5 °F)             PCR
             -13.0 °C (8.6 °F)             5346

```

**ENVIRONMENTAL**

```

average tropospheric lifetime (τtrop): estimated: 1.4-9 yr      8312
ODP (ozone depletion potential): 0.000 (model-derived relative
to R 11)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601
· acute (short-term) toxicity -----
anesthetic/CNS effect EC50: mouse, 10 min: 500,000 ppm v/v 5980
(effective concentration in
half of test animals)
· flammability -----
LFL-UFL (flammability limits in air): probably flammable

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: unrestricted      8C01

```









## R-271

----- REFRI GERANT DATA SUMMARY -----  
 R-271 chlorofluoropropane see  
 HCFC C3H6ClF RDB#  
 -----

**COMMON USE (S)**

see individual isomers

**IDENTIFIERS**

common name(s): R-271; R271; R 271  
 HCFC-271  
 fluorocarbon 271  
 fluorochemical 271; FC 271  
 halocarbon 271  
 halochemical 271  
 hydrochlorofluorocarbon 271  
 empirical formula: C3H6ClF

**PHYSICAL**

· properties -----

molar mass: 96.5308432 g/mol (0.212814 8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.03 (0.001-0.03) (estimate 6904  
 used for the Montreal  
 Protocol)

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34): none (no application pending) 8601



**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34): none (no application pending) 8601
  NFPA 704 degrees of hazard (H-F-R-S): BOC Gases: 1-4-0          MSDS
                                         health-flammability-reactivity
                                         [-special]: 0=no, 4=severe
  NPCA HMIS hazard ratings (H-F-R): BOC Gases: 1-4-0          MSDS
                                         health-flammability-reactivity
                                         0=insignificant, 4=extreme

· flammability -----
  LFL-UFL (flammability limits in air): 2.4-10.4 % v/v          2A06

· detection -----
  appearance: BOC Gases: colorless          MSDS
  odor:       BOC Gases: odorless          MSDS

```



















## R-290 (propane)

```

----- REFRIGERANT DATA SUMMARY -----
R-290      propane
HC         CH3CH2CH3
                                CAS number 74-98-6
                                                see
                                                RDB#
                                                -----

```

**COMMON USE(S)**

blend component for alternatives to refrigerants 12, 22, and 502 including 402A, 402B, 403A, and 403B; limited use in industrial refrigeration; primary use is as a fuel as a principal component of liquified petroleum gas (LPG); feedstock for organic synthesis of other compounds; thermobulb fill for temperature and pressure control sensors; selective solvent for removal of asphaltic components from high-boiling fractions of crude oil

Natural propane contains approximately 96% actual propane and 4% other hydrocarbons and contaminants. Some commercial grades of propane include 0-50 ppm v/v odorants such as methyl mercaptan and thiopane.

**IDENTIFIERS**

```

common name(s):  R-290; R290; R 290
                  HC-290
                  bottled gas
                  hydrocarbon 290
                  n-C3; n-C3H8
                  n-propane; normal-propane
chemical name (by IUPAC convention): propane
alternative chemical names/formulae: dimethyl methane
                                      dimethylmethane; CH2(CH3)2
                                      propyl hydride
                                      CH3CH2CH3; CH3-CH2-CH3
empirical formula: C3H8
CAS number:       74-98-6 Chemical Abstracts
                  Service Registry Number
EINECS number:   200-827-9 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number: TX2275000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
trade name(s):   Calor Gas (UK) CARE 40
                  Ecozone BV (NL) Ecoool-PRO
ARI container color / Pantone number: none, use light green grey/413 6601
                                      with red / 185 band

```

**PHYSICAL**

```

· properties -----
molar mass: 44.09562 g/mol (0.097214 lb/mol) 8820
normal freezing/melting/triple point: -187.3 °C (-305.1 °F) 8401
· normal boiling point -----
temperature: -42.1 °C (-43.8 °F) 8401
density, saturated liquid: 581 kg/m3 (36.29 lb/cf) 8401
density, saturated vapor: 2.42 kg/m3 (0.151 lb/cf) 8401

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

specific volume, saturated liquid:	1.721 L/kg (0.0276 cf/lb)	8401
specific volume, saturated vapor:	413.4 L/kg (6.6225 cf/lb)	8401
heat of vaporization:	425.4 kJ/kg (182.9 Btu/lb)	8401
velocity of sound, saturated liquid:	1158 m/s (3800 ft/s)	8401
velocity of sound, saturated vapor:	218 m/s (716 ft/s)	8401
viscosity, saturated liquid:	197 $\mu\text{Pa}\cdot\text{s}$ (0.197 cp)	8401
viscosity, saturated vapor:	6.47 $\mu\text{Pa}\cdot\text{s}$ (0.00647 cp)	8401
thermal conductivity, liquid:	0.1294 W/m $\cdot$ K (0.0747 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, vapor:	0.0114 W/m $\cdot$ K (0.0066 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· normal pressure, 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
density, vapor:	1.865 kg/m <sup>3</sup> (0.1164 lb/cf)	8401
· normal pressure, 21.1 $^{\circ}$ C (70 $^{\circ}$ F) ---		
density, vapor:	1.858 kg/m <sup>3</sup> (0.1160 lb/cf)	8401
· 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
pressure, saturated vapor:	836.2 kPa (121.29 psia)	8401
density, saturated liquid:	500 kg/m <sup>3</sup> (31.23 lb/cf)	8401
density, saturated vapor:	18.10 kg/m <sup>3</sup> (1.130 lb/cf)	8401
specific volume, saturated liquid:	1.999 L/kg (0.0320 cf/lb)	8401
specific volume, saturated vapor:	55.2 L/kg (0.8850 cf/lb)	8401
velocity of sound, saturated liquid:	754 m/s (2473 ft/s)	8401
velocity of sound, saturated vapor:	217 m/s (711 ft/s)	8401
viscosity, saturated liquid:	102 $\mu\text{Pa}\cdot\text{s}$ (0.102 cp)	8401
viscosity, saturated vapor:	8.5 $\mu\text{Pa}\cdot\text{s}$ (0.0085 cp)	8401
thermal conductivity, saturatd liquid:	0.0954 W/m $\cdot$ K (0.0551 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, saturated vapor:	0.01838 W/m $\cdot$ K (0.01062 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· 60 $^{\circ}$ C (140 $^{\circ}$ F) -----		
pressure, saturated vapor:	2116 kPa (306.9 psia)	8401
heat of vaporization:	258.4 kJ/kg (111.1 Btu/lb)	8401
· critical point -----		
temperature:	96.7 $^{\circ}$ C (206.1 $^{\circ}$ F)	7713
pressure:	4248 kPa (616.1 psia)	8401
density:	221 kg/m <sup>3</sup> (13.8 lb/cf)	7713
specific volume:	4.54 L/kg (0.0726 cf/lb)	7713

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	unknown, but very low: ~20 relative to CO <sub>2</sub> for 100 yr integration	
HGWP (halocarbon GWP):	~0 relative to R 11 for infinite integration period	
photochemical reactivity (grnd level):	220 relative to methane	4511

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A3	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-4-0	MSDS
	Texaco: 1-4-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-4-0	MSDS
	Texaco: 1-4-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	



## Refrigerant Database

UL Comparative Hazard to Life Group:	5(b) in absence of flame or hot objects	4B64
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	2,100 ppm v/v based on 10% of LEL	5204
NIOSH SCP IDLH (immediately dangerous:	20,000 ppm v/v for 30 min	3903
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	5561
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	1,000 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	2,500 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
exposure limit consistent to OSHA PEL:	Exxon: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
	Texaco: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
	being examined for changes	7101
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	5,300 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 15 min: >800,000 ppm (fatal concentration by inhalation for half of test animals)	6110
ALC (approximate lethal concentration:	rat, 4 hr, 0/10: >12,190 ppm (lowest exposure tested with one or more deaths by inhalation)	7624
cardiac sensitization (CS) EC50:	dog, 5 min: 180,000 ppm v/v (effective concentration in half of test animals)	6110
cardiac sensitization threshold/LOEL:	dog, 5 min, 2/12: 100,000 ppm v/v (lowest observed effect level in test animals)	5644
cardiac sensitization (CS) NOEL:	dog, 10 min, 0/6: 50,000 ppm v/v (no observed effect level in test animals)	5644
anesthetic/CNS effect EC50:	rat, 10min: depressant 280,000 ppm v/v (effective concentration in half of test animals)	6110
· flammability -----		
LFL-UFL (flammability limits in air):	2.1-9.5 % v/v	5204
	2.1-9.6 % v/v	2525
	2.37-9.5 % v/v	6290
	BOC Gases: 2.2-9.5 % v/v	MSDS
	Ecozone: 2.0-10.0 % v/v	mfr
	Texaco: 2.3-9.5 % v/v	MSDS
heat of combustion (by ASHRAE 34-92):	50.3 MJ/kg (21625 Btu/lb)	2318
flash point:	-105 °C (-157 °F)	4906
	BOC Gases: -104 °C (-156 °F)	MSDS
	Exxon: -17.8 °C (0 °F)	MSDS

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

autoignition temperature:	450 °C (842 °F)	5608
	466 °C (871 °F)	4B64
	510 °C (950 °F)	4904
	BOC Gases: 480 °C (896 °F)	MSDS
	Texaco: 468 °C (874 °F)	MSDS
autodecomposition temperature:	650 °C (1202 °F)	6569
• detection -----		
appearance:	colorless	5608
odor:	pure R-290 is odorless	5167
odor sensing, lower threshold:	with usual contaminants 20,000 ppm v/v	5167
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01



## R-C316

```

----- REFRIGERANT DATA SUMMARY -----
R-C316      1,2-dichloro-1,2,3,3,4,4-hexafluorocyclobutane      see
CFC         -CClF-CClF-CF2-CF2-          CAS number 356-18-3      RDB#
-----

```

**COMMON USE(S)**

considered as a specialty solvent in the early 1950s

**IDENTIFIERS**

```

common name(s):  R-C316; RC316; R C316
                  CFC-C316
                  fluorochemical C316; FC C316
                  halochemical C316
chemical name (by IUPAC convention):  1,2-dichloro-1,2,3,3,4,4-
                                       hexafluorocyclobutane
alternative chemical names/formulae:  cyclobutane, 1,2-dichloro-
                                       1,2,3,3,4,4-hexafluoro-
empirical formula:  C4Cl2F6
CAS number:         356-18-3 Chemical Abstracts
                   Service Registry Number
Beilstein registry number:  1909267
EINECS number:         206-599-7 (European Inventory
                           of Existing Chemical
                           Substances)
NIOSH RTECS number:  GU1760000 (Registry of Toxic
                           Effects of Chemical
                           Substances)
historical name(s):  DuPont FCD-589      7737

```

**PHYSICAL**

```

· properties -----
molar mass:  232.9386192 g/mol (0.513542      8820
              lb/mol)
normal freezing/melting/triple point:  -15.1 °C (4.8 °F)      7601
· normal boiling point -----
temperature:  59.5 °C (139.1 °F)      1136

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)  8601
· acute (short-term) toxicity -----
ALC (approximate lethal concentration:  rat, 6 hr, 0/10: >10,000 ppm      7737
                                         (lowest exposure tested with
                                         one or more deaths by
                                         inhalation)

```

## R-C317

----- REFRIGERANT DATA SUMMARY -----  
 R-C317 chloroheptafluorocyclobutane see  
 CFC -CClF-CF2-CF2-CF2- CAS number 377-41-3 RDB#  
 -----

**COMMON USE(S)**

considered as a specialty solvent in the early 1950s

**IDENTIFIERS**

common name(s): R-C317; RC317; R C317  
 CFC-C317  
 fluorochemical C317; FC C317  
 halochemical C317  
 alternative chemical names/formulae: -CClF-CF2-CF2-CF2-  
 -CClFCF2CF2CF2-  
 c-CClF-CF2-CF2-CF2-  
 cyclo-CClF-CF2-CF2-CF2-  
 not recommended:  
 -CF2-CF2-CF2-CClF-  
 -CF2CF2CF2CClF-  
 cyclic C4ClF7; -CClF(CF2)3-  
 empirical formula: C4ClF7  
 CAS number: 377-41-3 Chemical Abstracts  
 Service Registry Number  
 historical name(s): DuPont FCD-590 7737

**PHYSICAL**

· properties -----  
 molar mass: 216.4843224 g/mol (0.477266 8820  
 lb/mol)  
 normal freezing/melting/triple point: -39.1 °C (-38.4 °F) 7601  
 · normal boiling point -----  
 temperature: 25.6 °C (78.1 °F) 7601

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · acute (short-term) toxicity -----  
 ALC (approximate lethal concentration): rat, 6 hr, 0/10: >10,000 ppm 7737  
 (lowest exposure tested with  
 one or more deaths by  
 inhalation)

## R-318

## ----- REFRIGERANT DATA SUMMARY -----

R-318	dichlorooctafluorobutane		see
CFC	CCl <sub>2</sub> F <sub>8</sub>	CAS number 355-24-8	RDB#

**COMMON USE(S)**

see individual isomers

**IDENTIFIERS**

common name(s): R-318; R318; R 318  
 CFC-318  
 chlorofluorocarbon 318  
 fluorocarbon 318  
 fluorochemical 318; FC 318  
 halocarbon 318  
 halochemical 318  
 halon 482

chemical name (by IUPAC convention): dichlorooctafluorobutane  
 alternative chemical names/formulae: butane, dichlorooctafluoro-  
 empirical formula: C<sub>4</sub>Cl<sub>2</sub>F<sub>8</sub>  
 CAS number: 355-24-8 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 270.9354256 g/mol (0.597310 8820  
 lb/mol)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

last year production allowed: unrestricted (but vulnerable) 8C01

## R-318lcc

```

----- REFRIGERANT DATA SUMMARY -----
R-318lcc      1,4-dichloro-1,1,2,2,3,3,4,4-octafluorobutane      see
CFC           CClF2CF2CF2CClF2          CAS number 355-24-8      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-318lcc; R318lcc; R 318lcc
                  CFC-318lcc
                  FC 318lcc
                  chlorofluorocarbon 318lcc
                  fluorocarbon 318lcc
                  fluorochemical 318lcc
                  halocarbon 318lcc
                  halochemical 318lcc
                  halon 482
                  "R-318lcc1"; "CFC-318lcc1"
chemical name (by IUPAC convention): 1,4-dichloro-1,1,2,2,3,3,4,4-
butane
alternative chemical names/formulae: butane, 1,4-dichloro-
1,1,2,2,3,3,4,4-octafluoro-
CClF2-CF2-CF2-CClF2
CClF2CF2CF2CClF2
not recommended:
CF2Cl-CF2-CF2-CF2Cl
CF2ClCF2CF2CF2Cl
CClF2(CF2)2CClF2
CClF2-(CF2)2-CClF2
CF2Cl(CF2)2CF2Cl
CF2Cl-(CF2)2-CF2Cl
empirical formula: C4Cl2F8
CAS number: 355-24-8 Chemical Abstracts
Service Registry Number
ARI container color / Pantone number: none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass: 270.9354256 g/mol (0.597310 8820
lb/mol)

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: unrestricted (but vulnerable) 8C01
in developed countries under
the Montreal Protocol

```

## R-318mbb

## ----- REFRIGERANT DATA SUMMARY -----

R-318mbb	2,3-dichloro-1,1,1,2,3,4,4,4-octafluorobutane	see
CFC	CF3CClFCClFCF3	RDB#
	CAS number 355-20-4	----

**IDENTIFIERS**

common name(s): R-318mbb; R318mbb; R 318mbb  
 CFC-318mbb  
 FC 318mbb  
 chlorofluorocarbon 318mbb  
 fluorocarbon 318mbb  
 fluorochemical 318mbb  
 halocarbon 318mbb  
 halochemical 318mbb  
 "R-318mbbm"; "CFC-318mbbm"

chemical name (by IUPAC convention): 2,3-dichloro-1,1,1,2,3,4,4,4-butane

alternative chemical names/formulae: butane, 2,3-dichloro-1,1,1,2,3,4,4,4-octafluoro-CF3-CClF-CClF-CF3  
 CF3CClFCClFCF3  
 not recommended:  
 CF3-CFCl-CFCl-CF3  
 CF3CFClCFClCF3  
 CF3(CFCl)2CF3  
 CF3-(CFCl)2-CF3

empirical formula: C4Cl2F8  
 CAS number: 355-20-4 Chemical Abstracts Service Registry Number  
 Beilstein registry number: 1777520  
 EINECS number: 206-578-2 (European Inventory of Existing Chemical Substances)

ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----

molar mass:	270.9354256 g/mol (0.597310 lb/mol)	8820
normal freezing/melting/triple point:	-68.0 °C (-90.4 °F)	PCRL
· normal boiling point -----	temperature: 62.5 °C (144.5 °F)	PCRL

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34):	none (no application pending)	8601
------------------------------------	-------------------------------	------

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted (but vulnerable) in developed countries under the Montreal Protocol	8C01





Hoechst Frigen(R) C318

ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----

molar mass:	200.0300256 g/mol (0.440991 lb/mol)	8820
normal freezing/melting/triple point:	-39.8 °C (-39.6 °F)	8401
· normal boiling point -----		
temperature:	-6.0 °C (21.2 °F)	8401
density, saturated liquid:	1615 kg/m3 (100.83 lb/cf)	8401
density, saturated vapor:	9.54 kg/m3 (0.596 lb/cf)	8401
specific volume, saturated liquid:	0.619 L/kg (0.0099 cf/lb)	8401
specific volume, saturated vapor:	104.8 L/kg (1.6788 cf/lb)	8401
heat of vaporization:	116.8 kJ/kg (50.2 Btu/lb)	8401
velocity of sound, saturated liquid:	553 m/s (1814 ft/s)	8401
velocity of sound, saturated vapor:	104 m/s (342 ft/s)	8401
viscosity, saturated vapor:	10.22 µPa·s (0.01022 cp)	8401
viscosity, saturated liquid:	341 µPa·s (0.341 cp)	8401
thermal conductivity, liquid:	0.0567 W/m·K (0.0328 Btu/hr·ft°F)	8401
thermal conductivity, vapor:	0.0102 W/m·K (0.0059 Btu/hr·ft°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	8.588 kg/m3 (0.5362 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	8.552 kg/m3 (0.5339 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	265.5 kPa (38.51 psia)	8401
density, saturated liquid:	1518 kg/m3 (94.78 lb/cf)	8401
density, saturated vapor:	23.93 kg/m3 (1.494 lb/cf)	8401
specific volume, saturated liquid:	0.659 L/kg (0.0106 cf/lb)	8401
specific volume, saturated vapor:	41.8 L/kg (0.6695 cf/lb)	8401
velocity of sound, saturated liquid:	456 m/s (1495 ft/s)	8401
velocity of sound, saturated vapor:	104 m/s (342 ft/s)	8401
viscosity, saturated liquid:	243 µPa·s (0.243 cp)	8401
viscosity, saturated vapor:	11.2 µPa·s (0.0112 cp)	8401
thermal conductivity, saturated liquid:	0.0512 W/m·K (0.0296 Btu/hr·ft°F)	8401
thermal conductivity, saturated vapor:	0.01191 W/m·K (0.00688 Btu/hr·ft°F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	839 kPa (121.7 psia)	8401
heat of vaporization:	86.0 kJ/kg (37.0 Btu/lb)	8401
· critical point -----		
temperature:	115.2 °C (239.4 °F)	8401
pressure:	2778 kPa (402.9 psia)	8401
density:	620 kg/m3 (38.7 lb/cf)	8401
specific volume:	1.61 L/kg (0.0258 cf/lb)	8401

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	3200 yr	6694
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	11,200 relative to CO <sub>2</sub> for 100 yr integration	9501

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34):	none (application pending) A1 proposed 20Jun99	34c
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 0-0-0 health-flammability-reactivity [-special]: 0=no, 4=severe	MSDS
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 0-0-0 DuPont: 1-0-1 health-flammability-reactivity 0=insignificant, 4=extreme	MSDS MSDS
UL Comparative Hazard to Life Group:	6 by estimate (not tested) in absence of flame or hot objects	5906
· long-term occupational limit ----- exposure limit consistent to OSHA PEL:	DuPont AEL: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
· emergency exposure limit ----- Refrigerant Concentration Limit (RCL):	69,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· acute (short-term) toxicity ----- LC50 (lethal concentration, 50%):	rat, 4 hr: >800,000 ppm (fatal concentration by inhalation for half of test animals)	5169
ALC (approximate lethal concentration):	rat, 4 hr, 0/6: >800,000 ppm (lowest exposure tested with one or more deaths by inhalation)	7216
LCLo (lethal concentration, lowest):	mouse, 2 hr, BOC Gases: 780,000 ppm (fatal concentration by inhalation for even one test animal)	MSDS
cardiac sensitization (CS) EC50:	dog, 5 min: 250,000-500,000 ppm v/v (effective concentration in half of test animals)	5644
cardiac sensitization threshold/LOEL:	dog, 5 min, 1/12: 100,000 ppm v/v (lowest observed effect level in test animals)	5644
anesthetic/CNS effect EC50:	mouse, 10 min, 0/6: >800,000 ppm v/v (effective concentration in half of test animals)	5A25
anesthetic/CNS effect NOEL:	rat, 4 hr, 0/6: 800,000 ppm v/v (no observed effect level in ALC or LC50 studies)	7216
· flammability ----- LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
flash point:	BOC Gases: none TOC, DuPont: will not burn	MSDS MSDS
autoignition temperature:	BOC Gases: none	MSDS
· detection ----- appearance:	DuPont: clear colorless gas	MSDS
odor:	BOC Gases: odorless DuPont: none Liquid Carbonic: slightly ethereal	MSDS MSDS MSDS MSDS
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1961	5C39

last year production allowed: unrestricted

8C01

## R-CE318ccc1

----- REFRIGERANT DATA SUMMARY -----  
 R-CE318ccc1 octafluoro-oxetane see  
 FE -CF2-CF2-CF2-O-CF2- RDB#  
 -----

**IDENTIFIERS**

common name(s): R-CE318ccc1; RCE318ccc1;  
 R CE318ccc1  
 FE-CE318ccc1; FOC-CE318ccc1  
 E-C318ccc1; E-CE318  
 FC CE318ccc1  
 fluorochemical CE318ccc1  
 fluoroether CE318ccc1  
 alternative chemical names/formulae: octafluoro-oxetane  
 -CF2-CF2-CF2-O-CF2-  
 -CF2CF2CF2OCF2-  
 not recommended:  
 -CF2-CF2-CF2-CF2-O-  
 -CF2CF2CF2CF2O-  
 empirical formula: C4F8O

**PHYSICAL**

· properties -----  
 molar mass: 216.0294256 g/mol (0.476263 8820  
 lb/mol)  
 normal freezing/melting/triple point: -86.1 °C (-123.1 °F) 4445  
 · normal boiling point -----  
 temperature: -0.7 °C (30.7 °F) 4445  
 · critical point -----  
 temperature: 126.8 °C (260.2 °F) 4445  
 pressure: 2694 kPa (390.7 psia) 4445

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: unrestricted 8C01

## R-31-10

----- REFRIGERANT DATA SUMMARY -----  
 R-31-10      decafluorobutane      see  
 FC            CF3CF2CF2CF3                      CAS number 355-25-9      RDB#  
 -----

**COMMON USE(S)**

fire suppressant for flooding systems (e.g., 3M CEA-410); solvent for precision cleaning

**IDENTIFIERS**

common name(s): R-31-10; R31-10; R 31-10  
 R-31-10mcc; R31-10mcc  
 FC-31-10, FC-31-10mcc  
 "PFC-31-10", "PFC-3-1-10",  
 "R-3-1-10", "3-1-10", "31-10",  
 "R-3110", "HFC-3110", "PFC-3110"  
 fluorocarbon 31-10  
 fluorochemical 31-10; FC 31-10  
 halon 4-10  
 perfluorocarbon 31-10  
 chemical name (by IUPAC convention): decafluorobutane  
 alternative chemical names/formulae: perfluorobutane  
 butane, decafluoro-  
 decafluoro-n-butane  
 perfluoro-n-butane  
 CF3CF2CF2CF3; CF3-CF2-CF2-CF3  
 CF3(CF2)2CF3; CF3-(CF2)2-CF3  
 empirical formula: C4F10  
 CAS number: 355-25-9 Chemical Abstracts  
 Service Registry Number  
 EINECS number: 206-580-3 (European Inventory  
 of Existing Chemical  
 Substances)  
 trade name(s): 3M Performance Fluid PF-5040

**PHYSICAL**

· properties -----  
    molar mass: 238.026832 g/mol (0.524759      8820  
    lb/mol)  
 normal freezing/melting/triple point: -128.0 °C (-198.4 °F)      CRC  
    -84.5 °C (-120.1 °F)      LPCR  
 · normal boiling point -----  
    temperature: -2.0 °C (28.4 °F)      LPCR  
    4.0 °C (39.1 °F)      CRC

**ENVIRONMENTAL**

average atmospheric lifetime (τ<sub>atm</sub>): 2600 yr      6694  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)  
 GWP (global warming potential): 8600 relative to CO<sub>2</sub> for 100      9501  
    yr integration  
 HGWP (halocarbon GWP): 41.7 relative to R 11 for      DW  
    infinite integration period

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr: >800,000 ppm	5526
	(lowest exposure tested with one or more deaths by inhalation)	
cardiac sensitization (CS) EC50:	dog, 10 min: >400,000 ppm v/v	6684
	(effective concentration in half of test animals)	
cardiac sensitization (CS) NOEL:	400,000 ppm v/v (no observed effect level in test animals)	5526
· flammability -----		
LFL-UFL (flammability limits in air):	Lancaster-PCR: nonflammable	LPCR
flash point:	Lancaster-PCR: none	LPCR

**PRODUCTION**

first commercial use as a refrigerant:	circa 1995	
last year production allowed:	unrestricted	8C01







## R-C336

## ----- REFRIGERANT DATA SUMMARY -----

R-C336	hexafluorocyclobutane	see
HFC	isomers of C <sub>4</sub> H <sub>2</sub> F <sub>6</sub>	RDB#

**IDENTIFIERS**

common name(s):	R-C336; RC336; R C336 FC-C336
chemical name (by IUPAC convention):	hexafluorocyclobutane
alternative chemical names/formulae:	cyclobutane, hexafluoro-
empirical formula:	C <sub>4</sub> H <sub>2</sub> F <sub>6</sub>

**PHYSICAL**

· properties -----		
	molar mass:	164.0490992 g/mol (0.361666 lb/mol) 8820

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)
----------------------------------	--

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601

**PRODUCTION**

last year production allowed:	unrestricted	8C01
-------------------------------	--------------	------

## R-C336ccc

----- REFRIGERANT DATA SUMMARY -----  
 R-C336ccc 1,1,2,2,3,3-hexafluorocyclobutane see  
 HFC -CH2-CF2-CF2-CF2- RDB#  
 -----

**IDENTIFIERS**

common name(s): R-C336ccc; RC336ccc; R C336ccc  
 FC-C336ccc  
 "R-C336cccf"; "HFC-C336cccf"  
 FC C336ccc  
 fluorochemical C336ccc  
 halochemical C336ccc  
 chemical name (by IUPAC convention): 1,1,2,2,3,2-  
 hexafluorocyclobutane  
 alternative chemical names/formulae: cyclobutane, 1,1,2,2,3,2-  
 hexafluoro-  
 -CH2-CF2-CF2-CF2-  
 -CH2CF2CF2CF2-  
 c-CH2-CF2-CF2-CF2-  
 cyclo-CH2-CF2-CF2-CF2-  
 not recommended:  
 -CF2-CF2-CF2-CH2-  
 -CF2-(CF2)3-  
 empirical formula: C4H2F6

**PHYSICAL**

· properties -----  
 molar mass: 164.0490992 g/mol (0.361666 8820  
 lb/mol)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: unrestricted 8C01

## R-C336cce

```

----- REFRIERANT DATA SUMMARY -----
R-C336cce    1,1,2,2,3,4-hexafluorocyclobutane    see
HFC          -CHF-CHF-CF2-CF2-                      RDB#
-----

```

**COMMON USE (S)**

normal boiling point temperature is high for refrigerant use; under consideration as a foam blowing agent

Note: Both cis and trans forms occur for this isomer.

**IDENTIFIERS**

```

common name(s):  R-C336cce; RC336cce; R C336cce
                  FC-C336cce
                  "R-C336ccee"; "HFC-C336ccee"
                  FC C336cce
                  fluorochemical C336cce
                  halochemical C336cce
chemical name (by IUPAC convention):  1,1,2,2,3,4-
                                       hexafluorocyclobutane
alternative chemical names/formulae:  cyclobutane, 1,1,2,2,3,4-
                                       hexafluoro-
                                       -CHF-CF2-CHF-CF2-
                                       -CHF2CF2CHF2-
                                       c-CHF-CF2-CHF-CF2-
                                       cyclo-CHF-CF2-CHF-CF2-
                                       not recommended:
                                       -CF2-CFH-CF2-CFH-
                                       -CF2-CHF-CF2-CHF-
                                       -CFH-CF2-CFH-CF2-
empirical formula:  C4H2F6

```

**PHYSICAL**

```

· properties -----
      molar mass:  164.0490992 g/mol (0.361666    8820
                  lb/mol)
· normal boiling point -----
      temperature:  40-50 °C (104-122 °F) ?      7733

```

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)  8601
· flammability -----
  LFL-UFL (flammability limits in air):  flammable                    7733

```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized
last year production allowed:           unrestricted                    8C01

```



last year production allowed: unrestricted

8C01



## R-329mcc

## ----- REFRIGERANT DATA SUMMARY -----

R-329mcc	1,1,1,2,2,3,3,4,4-nonafluorobutane	see
HFC	CHF2CF2CF2CF3	CAS number 375-17-7 RDB#

**COMMON USE(S)**

candidate replacement for refrigerants 11, 113, and 123 in centrifugal chillers

**IDENTIFIERS**

common name(s): R-329mcc; R329mcc; R 329mcc  
 HFC-329mcc  
 FC 329mcc  
 fluorochemical 329mcc  
 halochemical 329mcc  
 "R-329mccp"; "HFC-329mccp"  
 Beyerlein: R-329ccb; R329ccb; 3408  
 R 329ccb; HFC-329ccb 3408  
 Corr et al.: R-329cca; 7733  
 R329cca; R 329cca; HFC-329cca 7733

chemical name (by IUPAC convention): 1,1,1,2,2,3,3,4,4-nonafluorobutane

alternative chemical names/formulae: butane, 1,1,1,2,2,3,3,4,4-nonafluoro-  
 CHF2-CF2-CF2-CF3  
 CHF2CF2CF2CF3  
 not recommended:  
 CF2H-CF2-CF2-CF3  
 CF2HCF2CF2CF3  
 CF3-CF2-CF2-CF2H  
 CF3-CF2-CF2-CHF2  
 CF3CF2CF2CF2H  
 CF3CF2CF2CHF2  
 CF3(CF2)2CF2H  
 CF3(CF2)2CHF2  
 CF3-(CF2)2-CF2H  
 CF3-(CF2)2-CHF2

empirical formula: C4HF9  
 CAS number: 375-17-7 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----

molar mass:	220.0363688 g/mol (0.485097 lb/mol)	8820
normal freezing/melting/triple point:	-122.3 °C (-188.1 °F)	3408
· normal boiling point -----	temperature: 15.1 °C (59.2 °F)	3408
	heat of vaporization: 121.5 kJ/kg (52.2 Btu/lb)	3408
· critical point -----	temperature: 140.2 °C (284.4 °F)	3408
	pressure: 2390 kPa (346.6 psia)	3408
	density: 600 kg/m3 (37.5 lb/cf)	3408
	specific volume: 1.67 L/kg (0.0267 cf/lb)	3408

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · flammability -----  
 LFL-UFL (flammability limits in air): nonflammable 7733

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: unrestricted 8C01



**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01





## R-338mcc

```

----- REFRIGERANT DATA SUMMARY -----
R-338mcc      1,1,1,2,2,3,3,4-octafluorobutane      see
HFC           CH2FCF2CF2CF3          CAS number 662-35-1      RDB#
-----

```

**COMMON USE(S)**

under consideration as a blend component in replacements for refrigerants 11 and 123, including the azeotrope R-245ca/338mcc

**IDENTIFIERS**

```

common name(s):  R-338mcc; R338mcc; R 338mcc
                 HFC-338mcc
                 FC 338mcc
                 fluorochemical 338mcc
                 halochemical 338mcc
                 "R-338mccq"; "HFC-338mccq"
                 Beyerlein: "R-338ccb";          3408
                 "R338ccb"; "HFC-338ccb"        3408

chemical name (by IUPAC convention):  1,1,1,2,2,3,3,4-
                                     octafluorobutane

alternative chemical names/formulae:  butane, 1,1,1,2,2,3,3,4-
                                     octafluoro-
                                     CH2F-CF2-CF2-CF3
                                     CH2FCF2CF2CF3
                                     not recommended:
                                     CF3-CF2-CF2-CFH2
                                     CF3-CF2-CF2-CH2F
                                     CF3CF2CF2CFH2
                                     CF3CF2CF2CH2F
                                     CFH2-CF2-CF2-CF3
                                     CFH2CF2CF2CF3
                                     CF3(CF2)2CFH2
                                     CF3(CF2)2CH2F
                                     CF3-(CF2)2-CFH2
                                     CF3-(CF2)2-CH2F
                                     CFH2(CF2)2CF3
                                     CFH2-(CF2)2-CF3
                                     CH2F(CF2)2CF3
                                     CH2F-(CF2)2-CF3

empirical formula:  C4H2F8
CAS number:        662-35-1 Chemical Abstracts
                  Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass: 202.0459056 g/mol (0.445435      8820
             lb/mol)
normal freezing/melting/triple point: -119.4 °C (-182.9 °F)      3408
· normal boiling point -----
temperature: 27.8 °C (82.0 °F)              3A39
heat of vaporization: 130.5 kJ/kg (56.1 Btu/lb)      3408
· critical point -----
temperature: 158.8 °C (317.8 °F)            8212
pressure: 2726 kPa (395.3 psia)            8212

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

density: 572 kg/m3 (35.7 lb/cf) 8210  
specific volume: 1.75 L/kg (0.0280 cf/lb) 8210

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
to R 11)

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01











· flammability -----  
LFL-UFL (flammability limits in air): nonflammable 7733

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01



safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01

## R-C344ccd

```

----- REFRIERANT DATA SUMMARY -----
R-C344ccd      3-chloro-1,1,2,2-tetrafluorocyclobutane      see
HCFC           -CH2-CHCl-CF2-CF2-                          RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-C344ccd; RC344ccd; R C344ccd
                 HCFC-C344ccd
                 "R-C344ccdf"; "HCFC-C344ccdf"
                 FC C344ccd
                 fluorochemical C344ccd
                 halochemical C344ccd
chemical name (by IUPAC convention): 3-chloro-1,1,2,2-
alternative chemical names/formulae: tetrafluorocyclobutane
                                     cyclobutane, 3-chloro-
                                     1,1,2,2-tetrafluoro-
                                     -CH2-CHCl-CF2-CF2-
                                     -CH2CHClCF2CF2-
                                     c-CH2-CHCl-CF2-CF2-
                                     cyclo-CH2-CHCl-CF2-CF2-
not recommended:
                 -CF2-CF2-CClH-CH2-
                 -(CF2)2-CClH-CH2-
                 -CH2-CHCl-(CF2)2-
empirical formula: C4H3ClF4

```

**PHYSICAL**

```

· properties -----
molar mass: 162.5129328 g/mol (0.358280 8820
lb/mol)
· normal boiling point -----
temperature: 74.0 °C (165.2 °F) 7601

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601
· flammability -----
LFL-UFL (flammability limits in air): probably nonflammable

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: unrestricted (but vulnerable) 8C01

```





## Refrigerant Database

## R-347mcc

```

----- REFRIGERANT DATA SUMMARY -----
R-347mcc      1,1,1,2,2,3,3-heptafluorobutane      see
HFC           CH3CF2CF2CF3                          CAS number 662-00-0      RDB#
-----

```

**COMMON USE(S)**

candidate replacement for refrigerants 11, 113, and 123 in centrifugal chillers

**IDENTIFIERS**

```

common name(s):  R-347mcc; R347mcc; R 347mcc
                  HFC-347mcc
                  FC 347mcc
                  fluorochemical 347mcc
                  halochemical 347mcc
chemical name (by IUPAC convention):  1,1,1,2,2,3,3-
                                       heptafluorobutane
alternative chemical names/formulae:  butane, 1,1,1,2,2,3,3-
                                       heptafluoro-
                                       CH3CF2CF2CF3; CH3-CF2-CF2-CF3
not recommended:
   CH3(CF2)2CF3; CH3-(CF2)2-CF3
   CF3(CF2)2CH3; CF3-(CF2)2-CH3
   CF3CF2CF2CH3; CF3-CF2-CF2-CH3
empirical formula:  C4H3F7
CAS number:        662-00-0 Chemical Abstracts
                  Service Registry Number

```

**PHYSICAL**

```

· properties -----
      molar mass:  184.0554424 g/mol (0.405773      8820
                  lb/mol)
normal freezing/melting/triple point:  -124.9 °C (-192.8 °F)      3408
· normal boiling point -----
      temperature:  15.1 °C (59.2 °F)              3408
      heat of vaporization:  140.4 kJ/kg (60.4 Btu/lb)      3408
· critical point -----
      temperature:  144.2 °C (291.6 °F)            3408
      pressure:     2570 kPa (372.7 psia)           3408
      density:      532 kg/m3 (33.2 lb/cf)          3408
      specific volume:  1.88 L/kg (0.0301 cf/lb)     3408

```

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34):  none (no application pending)  8601

```

**PRODUCTION**

```

first commercial use as a refrigerant:  not known to be commercialized
last year production allowed:           unrestricted                    8C01

```



first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01

## R-E347mcc3

----- REFRIGERANT DATA SUMMARY -----  
 R-E347mcc3 1-(methoxy)-1,1,2,2,3,3,3-heptafluoropropane see  
 HFE CH3-O-CF2-CF2-CF3 RDB#  
 -----

**COMMON USE(S)**

under consideration as foam blowing agent

This chemical is one of three hydrofluoroethers identified as promising by the Research Institute of Innovative Technology for the Earth (RITE) in Japan.

**IDENTIFIERS**

common name(s): R-E347mcc3; RE347mcc3;  
 R E347mcc3  
 HFE-E347mcc3; HFOC-E347mcc3  
 FC E347mcc3; E-347mcc3  
 fluorochemical E347mcc3  
 fluoroether E347mcc3  
 halochemical E347mcc3  
 "R-E347mccs3"; "HFE-E347mccs3"  
 "R-E347mcc"; "HFE-347mcc" 8323  
 chemical name (by IUPAC convention): 1-(methoxy)-1,1,2,2,3,3,3-  
 heptafluoropropane  
 alternative chemical names/formulae: methoxy-heptafluoropropane  
 propane, 1-(methoxy)-  
 1,1,2,2,3,3,3-heptafluoro-  
 1-methoxy-heptafluoropropane  
 CH3-O-CF2-CF2-CF3  
 CH3OCF2CF2CF3  
 not recommended:  
 CF3(CF2)2OCH3  
 CF3-(CF2)2-O-CH3  
 CF3-CF2-CF2-O-CH3  
 CF3CF2CF2OCH3  
 CH3-O-(CF2)2-CF3  
 CH3O(CF2)2CF3  
 empirical formula: C4H3F7O

**PHYSICAL**

· properties -----  
 molar mass: 200.0548424 g/mol (0.441045 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: 33.0 °C (91.4 °F) 7733  
 34.2 °C (93.5 °F) 5B02  
 heat of vaporization: 142.3 kJ/kg (61.2 Btu/lb) 7108  
 · 20 °C (68 °F) -----  
 density, saturated liquid: 1330 kg/m3 (83.03 lb/cf) 8323  
 · critical point -----  
 temperature: 164.6 °C (328.2 °F) 5B02  
 pressure: 2481 kPa (359.8 psia) 5B02

**ENVIRONMENTAL**

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

average atmospheric lifetime ( $\tau_{atm}$ ):	1.3 yr	9501
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	8323
GWP (global warming potential):	140 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.11 relative to R 11 for infinite integration period	8317

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
· acute (short-term) toxicity -----		
oral LD50 (lethal dosage, 50%):	>2,000 mg/kg (fatal dose by ingestion for half of test animals)	7108
· flammability -----		
LFL-UFL (flammability limits in air):	nonflammable	7733
flash point:	nonflammable	7108

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-E347mmy1

----- REFRIGERANT DATA SUMMARY -----  
 R-E347mmy1 2-(methoxy)-1,1,1,2,3,3,3-heptafluoropropane see  
 HFE CF3-CF(OCH3)-CF3 RDB#  
 -----

**COMMON USE(S)**

candidate replacement for refrigerants 11, 113, and 123 in centrifugal chillers either alone or as a blend component; candidate for use as a foam blowing agent

This chemical is one of three hydrofluoroethers identified as promising by the Research Institute of Innovative Technology for the Earth (RITE) in Japan.

Note: The designation convention of ANSI/ASHRAE Standard 34-1997 does not fully accommodate this compound. It is identified in this database as shown, following common industry extensions, to facilitate information retrieval.

**IDENTIFIERS**

common name(s): R-E347mmy1; RE347mmy1;  
 R E347mmy1  
 HFE-E347mmy1; HFOC-E347mmy1  
 FC E347mmy1; E-347mmy1  
 fluorochemical E347mmy1  
 fluoroether E347mmy1  
 halochemical E347mmy1  
 "R-E347mmys1"; "HFE-E347mmys1"  
 "R-E347mmy"; "HFE-347mmy" 8323  
 chemical name (by IUPAC convention): 2-(methoxy)-1,1,1,2,3,3,3-heptafluoropropane  
 alternative chemical names/formulae: 2-(methoxy)-heptafluoropropane  
 propane, 2-(methoxy)-  
 1,1,1,2,3,3,3-heptafluoro-  
 propane, 2-(methoxy)-  
 heptafluoro-  
 CF3-CF(OCH3)-CF3  
 CF3CF(OCH3)CF3  
 CF3-C(OCH3)F-CF3  
 CF3C(OCH3)FCF3  
 not recommended:  
 (CF3)2CFOCH3; (CF3)2CF-O-CH3  
 CF(CF3)2OCH3; CF(CF3)2-O-CH3  
 CH3OCF(CF3)2; CH3-O-CF(CF3)2  
 FC(CF3)2OCH3; FC(CF3)2-O-CH3  
 empirical formula: C4H3F7O

**PHYSICAL**

· properties -----  
 molar mass: 200.0548424 g/mol (0.441045 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: 29.4 °C (84.8 °F) 5B02  
 heat of vaporization: 139.3 kJ/kg (59.9 Btu/lb) 5B02

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

· 20 °C (68 °F) -----  
     density, saturated liquid: 1380 kg/m3 (86.15 lb/cf) 8323  
 · critical point -----  
     temperature: 160.2 °C (320.3 °F) 8317  
     pressure: 2553 kPa (370.3 psia) 5B02

**ENVIRONMENTAL**

average atmospheric lifetime (tatm): 3.5 yr 9501  
 ODP (ozone depletion potential): 0.000 (model-derived relative 8323  
     to R 11)  
 GWP (global warming potential): 340 relative to CO2 for 100 yr 9501  
     integration  
 HGWP (halocarbon GWP): 0.08 relative to R 11 for 8317  
     infinite integration period

**SAFETY**

· classification -----  
     safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · flammability -----  
     flash point: nonflammable 7108

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: unrestricted 8C01

## R-E347pce2

```

----- REFRIGERANT DATA SUMMARY -----
R-E347pce2  1,1,2,2,3,4,4-heptafluoro-3-oxabutane      see
HFE         CHF2-CHF-O-CF2-CHF2                        RDB#
-----
    
```

**COMMON USE(S)**

candidate refrigerant for high-temperature applications; candidate replacement for fluorochemicals 11 and 141b as a foam blowing agent

**IDENTIFIERS**

```

common name(s):  R-E347pce2; RE347pce2;
                  R E347pce2
                  HFE-E347pce2; HFOC-E347pce2
                  "R-E347pcep2"; "HFE-E347pcep2"
                  FC E347pce2; E-347pce2
                  fluorochemical E347pce2
                  fluoroether E347pce2
                  halochemical E347pce2
chemical name (by IUPAC convention): 1,1,2,2,3,4,4-heptafluoro-
                                        -3-oxabutane
alternative chemical names/formulae: CHF2-CHF-O-CF2-CHF2
                                        CHF2CHFOCF2CHF2
not recommended:
                  CF2H-CFH-O-CF2-CF2H
                  CF2HCFHOCF2CF2H
                  CF2H-CF2-O-CHF-CF2H
                  CF2HCF2OCHF2CF2H
                  CHF2-CF2-O-CHF-CHF2
                  CHF2CF2OCHFCHF2
empirical formula: C4H3F7O
    
```

**PHYSICAL**

```

· properties -----
molar mass: 200.0548424 g/mol (0.441045 8820
             lb/mol)
· normal boiling point -----
temperature: 62.0 °C (143.6 °F) 6B51
    
```

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34): none (no application pending) 8601
· acute (short-term) toxicity -----
  anesthetic/CNS effect LOEL: mouse, 3min, 1/1: 23,000 ppm 6B51
                               v/v (lowest observed effect
                               level in test animals)
    
```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed:          unrestricted 8C01
    
```







## Refrigerant Database

## R-356mcf

```

----- REFRIERANT DATA SUMMARY -----
R-356mcf      1,1,1,2,2,4-hexafluorobutane      see
HFC           CH2FCH2CF2CF3                          RDB#
-----

```

**COMMON USE(S)**

under consideration as a solvent

Note: AlliedSignal announced suspension of its development activity for this compound in May 1995.

**IDENTIFIERS**

```

common name(s):  R-356mcf; R356mcf; R 356mcf
                 HFC-356mcf; HFC-356-qfc
                 FC 356mcf
                 fluorochemical 356mcf
                 halochemical 356mcf
                 "R-356mcfq"; "HFC-356mcfq"
chemical name (by IUPAC convention): 1,1,1,2,2,4-hexafluorobutane
alternative chemical names/formulae:  butane, 1,1,1,2,2,4-
                                     hexafluoro-
                                     CH2FCH2CF2CF3
                                     CH2F-CH2-CF2-CF3
not recommended:
                 CF3-CF2-CH2-CFH2
                 CF3-CF2-CH2-CH2F
                 CF3CF2CH2CFH2
                 CF3CF2CH2CH2F
                 CFH2-CH2-CF2-CF3
                 CFH2CH2CF2CF3
empirical formula: C4H4F6

```

**PHYSICAL**

```

· properties -----
molar mass: 166.0649792 g/mol (0.366111 8820
lb/mol)

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.000 (model-derived relative
to R 11)
GWP (global warming potential): low relative to CO2 for 100 yr
integration

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed: unrestricted 8C01

```





**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
last year production allowed: unrestricted 8C01

## R-356mmz

```

----- REFRIGERANT DATA SUMMARY -----
R-356mmz      2-(methyl)-1,1,1,3,3,3-hexafluoropropane      see
HFC           CF3CH(CH3)CF3          CAS number 382-09-2      RDB#
-----

```

**COMMON USE(S)**

candidate replacement for refrigerants 11, 113, and 123

**IDENTIFIERS**

```

common name(s):  R-356mmz; R356mmz; R 356mmz
                 HFC-356mmz
                 FC 356mtm
                 fluorochemical 356mmz
                 halochemical 356mmz
                 "R-356mmzs"; "HFC-356mmzs"
                 Beyerlein et al.: "R-356mms"; 8211
                 "HFC-356mmz" 8211

chemical name (by IUPAC convention): 2-(methyl)-1,1,1,3,3,3-
hexafluoropropane
alternative chemical names/formulae: propane, 1,1,1,3,3,3-
hexafluoro-2-(methyl)-
propane, 2-(methyl)-
1,1,1,3,3,3-hexafluoro
1,1,1,3,3,3-hexafluoro-
2-methylpropane
CF3CH(CH3)CF3; CF3-CH(CH3)-CF3
not recommended:
CF3-C(CH3)H-CF3
CF3C(CH3)HCF3
CH3C(CF3)2H; CH3-C(CF3)2H
CH3CH(CF3)2; CH3-CH(CF3)2

empirical formula: C4H4F6
CAS number: 382-09-2 Chemical Abstracts
Service Registry Number

```

**PHYSICAL**

```

· properties -----
molar mass: 166.0649792 g/mol (0.366111 8820
lb/mol)
normal freezing/melting/triple point: -138.9 °C (-218.0 °F) 8211
· normal boiling point -----
temperature: 21.3 °C (70.3 °F) 8211
heat of vaporization: 159.4 kJ/kg (68.5 Btu/lb) 8211
· critical point -----
temperature: 158.8 °C (317.8 °F) 8211
pressure: 2852 kPa (413.6 psia) 8211
density: 511 kg/m3 (31.9 lb/cf) 8211
specific volume: 1.96 L/kg (0.0313 cf/lb) 8211

```

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**PRODUCTION**

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01





## R-365mfc

```

----- REFRIERANT DATA SUMMARY -----
R-365mfc      1,1,1,3,3-pentafluorobutane      see
HFC           CH3CF2CH2CF3                      CAS number 406-58-6      RDB#
-----

```

**COMMON USE(S)**

under consideration (circa 1998) as a blend component to replace refrigerants 11 and 123 in chillers, as a blend component in high-glide blends, and as a refrigerant in high-temperature heat pumps; under consideration (since 1994) as a foam blowing agent to replace fluorochemical 141b

**IDENTIFIERS**

```

common name(s):  R-365mfc; R365mfc; R 365mfc
                 HFC-365mfc
                 FC 365mfc
                 fluorochemical 365mfc
                 halochemical 365mfc
                 "R-365mfcs"; "HFC-365mfcs"
chemical name (by IUPAC convention):  1,1,1,3,3-pentafluorobutane
alternative chemical names/formulae:  butane, 1,1,1,3,3-pentafluoro-
                                     CH3CF2CH2CF3, CH3-CF2-CH2-CF3
                                     not recommended:
                                     CF3CH2CF2CH3, CF3-CH2-CF2-CH3
empirical formula:  C4H5F5
CAS number:        406-58-6 Chemical Abstracts
                  Service Registry Number

```

**PHYSICAL**

```

· properties -----
      molar mass:  148.0745160 g/mol (0.326448      8820
                  lb/mol)
· normal boiling point -----
      temperature:  40.2 °C (104.4 °F)              8808
      heat of vaporization:  176.9 kJ/kg (76.1 Btu/lb)  8808
· 20 °C (68 °F) -----
      pressure, saturated vapor:  4700.0 kPa (681.68 psia)  8808
      density, saturated liquid:  1230 kg/m3 (76.79 lb/cf)  5B15
· critical point -----
      temperature:  187.7 °C (369.9 °F)              mfr
      pressure:     2754 kPa (399.4 psia)              mfr

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (tatm):  10.2 yr          9501
ODP (ozone depletion potential):  0.000 (model-derived relative
to R 11)
GWP (global warming potential):  910 relative to CO2 for 100 yr 9501
integration
HGWP (halocarbon GWP):  0.19 relative to R 11 for      8101
infinite integration period

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)  8601

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

· acute (short-term) toxicity -----  
 LC50 (lethal concentration, 50%): 4 hr: >100,000 ppm (fatal 8809  
 concentration by inhalation  
 for half of test animals)  
 anesthetic/CNS effect EC50: mouse, 10 min: 50,000 ppm v/v 5980  
 (effective concentration in  
 half of test animals)

· flammability -----  
 LFL-UFL (flammability limits in air): 3.5-9.0 % v/v 8808  
 LFL (lower flammability limit in air): 3.4 % v/v 5B15  
 flash point: -25 °C (-13 °F) 5B15

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized  
 projected: 2002  
 last year production allowed: unrestricted 8C01

## R-C390 (cyclobutane)

```

----- REFRIGERANT DATA SUMMARY -----
R-C390      cyclobutane                      see
HC          -CH2-CH2-CH2-CH2-              RDB#
-----

```

**COMMON USE(S)**

use is constrained by flammability concerns

**IDENTIFIERS**

```

                common name(s): R-C390; RC390; R C390; HC-C390
chemical name (by IUPAC convention): cyclobutane
alternative chemical names/formulae: tetramethylene
                                     -CH2-CH2-CH2-CH2-
                                     -CH2CH2CH2CH2-
                                     c-CH2-CH2-CH2-CH2-
                                     cyclo-CH2-CH2-CH2-CH2-
                                     not recommended: -(CH2)4-
                empirical formula: C4H8
ARI container color / Pantone number: none, use light green grey/413 6601
                                     with red / 185 band

```

**PHYSICAL**

```

· properties -----
                molar mass: 56.10632 g/mol (0.123693      8820
                                     lb/mol)
normal freezing/melting/triple point: -50.0 °C (-58.0 °F)      CRC
· normal boiling point -----
                temperature: 12.5 °C (54.5 °F)              7837

```

**ENVIRONMENTAL**

```

ODP (ozone depletion potential): 0.000 (model-derived relative
to R 11)
GWP (global warming potential): unknown, but very low: ~20
relative to CO2 for 100 yr
integration

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34): none (no application pending) 8601
· acute (short-term) toxicity -----
  cardiac sensitization threshold/LOEL: dog 10min 2/2: 100,000-250,000 6192
                                     ppm v/v (lowest observed
                                     effect level in test animals)
· flammability -----
  LFL-UFL (flammability limits in air): expected to be very flammable

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed:          unrestricted          8C01

```

## R-43-10meec

----- REFRIGERANT DATA SUMMARY -----  
 unassigned 1,1,1,2,2,3,4,5,5,5-decafluoropentane see  
 HFC CF3CHFCHFCF2CF3 CAS number 142347-08-9 RDB#  
 -----

**COMMON USE(S)**

under consideration to replace refrigerants 11 and 123 in  
 low-pressure, centrifugal chillers; under consideration as a blowing  
 agent; solvent (e.g., DuPont Vertrel(R) XF)

**IDENTIFIERS**

common name(s): R-43-10meec, R43-10meec,  
 R 43-10meec  
 HFC-43-10meec  
 "4-3-10mee", "R-4-3-10mee",  
 "43-10mee", "4310mee", "4310",  
 "R-43-10mee", "R-4310mee"  
 halon 5-10, halon 5-10meec  
 chemical name (by IUPAC convention): 1,1,1,2,2,3,4,5,5,5-  
 decafluoropentane  
 alternative chemical names/formulae: pentane, 1,1,1,2,2,3,4,5,5,5-  
 decafluoro-  
 CF3CHFCHFCF2CF3  
 CF3-(CHF)2-CF2-CF3  
 CF3-CHF-CHF-CF2-CF3  
 not recommended:  
 CF3CF2CHFCHFCF3  
 CF3-CF2-(CHF)2-CF3  
 CF3-CF2-CHF-CHF-CF3  
 empirical formula: C5H2F10  
 CAS number: 142347-08-8 Chemical Abstracts  
 Service Registry Number

**PHYSICAL**

· properties -----  
 molar mass: 252.053412 g/mol (0.555683 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: 47.0 °C (116.6 °F) 7733

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ): 17.1  $\pm$ 6 yr 6695  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)  
 GWP (global warming potential): 1700 relative to CO2 for 100 9501  
 yr integration  
 HGWP (halocarbon GWP): 0.29 relative to R 11 for 8101  
 infinite integration period

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · occupational exposure limit -----  
 exposure limit consistent OSHA PEL-C: DuPont AEL-Ceiling: 400 ppm

· long-term occupational limit ----- exposure limit consistent to OSHA PEL:	v/v (must not exceed) DuPont AEL: 200 ppm v/v TWA for 8 hr/day and 40 hr/wk	
· acute (short-term) toxicity ----- anesthetic concentration:	after convulsions: 2,000 ppm v/v	6452
· flammability ----- LFL-UFL (flammability limits in air):	nonflammable	7733
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-41-12mccc

----- REFRIGERANT DATA SUMMARY -----  
 unassigned dodecafluoropentane see  
 FC CF3CF2CF2CF2CF3 CAS number 678-26-2 RDB#  
 -----

**COMMON USE(S)**

solvent for precision cleaning

**IDENTIFIERS**

common name(s): R-41-12; R41-12; R 41-12  
 R-41-12mccc; R41-12mccc  
 FC-41-12; FC-41-12mccc  
 "PFC-41-12"  
 "R-4-1-12"; "4-1-12"; "41-12";  
 "R-4112"; "HFC-4112"; "PFC-4112"  
 fluorochemical 41-12; FC 41-12  
 halon 5-12  
 chemical name (by IUPAC convention): dodecafluoropentane  
 alternative chemical names/formulae: n-perfluoropentane  
 perfluoropentane  
 pentane, dodecafluoro-  
 CF3-CF2-CF2-CF2-CF3  
 CF3CF2CF2CF2CF3  
 CF3(CF2)3CF3; CF3-(CF2)3-CF3  
 empirical formula: C5F12  
 CAS number: 678-26-2 Chemical Abstracts  
 Service Registry Number  
 trade name(s): 3M Performance Fluid PF-5050

**PHYSICAL**

· properties -----  
 molar mass: 288.0343384 g/mol (0.635007 8820  
 lb/mol)  
 normal freezing/melting/triple point: -30.5 °C (-22.9 °F) CRC  
 · normal boiling point -----  
 temperature: 57.7 °C (135.9 °F) CRC

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ): 4100 yr 6694  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)  
 GWP (global warming potential): 8900 relative to CO2 for 100 9501  
 yr integration  
 HGWP (halocarbon GWP): 68.3 relative to R 11 for DW  
 infinite integration period

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

first commercial use as a refrigerant: circa 1995  
 last year production allowed: unrestricted 8C01

## R-51-14mcccc

----- REFRIGERANT DATA SUMMARY -----  
 unassigned tetradecafluorohexane see  
 FC CF3CF2CF2CF2CF2CF3 CAS number 355-42-0 RDB#  
 -----

**COMMON USE(S)**

heat transfer fluid; fire suppressant for streaming systems (e.g., 3M Company "CEA-614"); solvent for precision cleaning

**IDENTIFIERS**

common name(s): R-51-14; R51-14; R 51-14  
 R-51-14mcccc; R51-14mcccc  
 FC-51-14, FC-51-14mcccc  
 "PFC-51-14"  
 "R-5-1-14", "5-1-14", "5114",  
 "R-5114", "FC-5114", "PFC-5114"  
 PFH  
 halon 6-14  
 chemical name (by IUPAC convention): tetradecafluorohexane  
 alternative chemical names/formulae: n-perfluorohexane  
 perfluorohexane  
 hexane, tetradecafluoro-  
 hexane, perfluoro-  
 CF3CF2CF2CF2CF2CF3  
 CF3-CF2-CF2-CF2-CF2-CF3  
 CF3(CF2)4CF3; CF3-(CF2)4-CF3  
 empirical formula: C6F14  
 CAS number: 355-42-0 Chemical Abstracts  
 Service Registry Number  
 also reported as 86508-42-1 6B50  
 Chemical Abstracts Service  
 Registry Number  
 trade name(s): 3M Performance Fluid PF-5060  
 BNFL Flutec(R) PP1

**PHYSICAL**

· properties -----  
 molar mass: 338.0418448 g/mol (0.745255 8820  
 lb/mol)  
 normal freezing/melting/triple point: -87.1 °C (-124.8 °F) CRC  
 · normal boiling point -----  
 temperature: 57.1 °C (134.8 °F) CRC

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ): 3200 yr 6694  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)  
 GWP (global warming potential): 9000 relative to CO2 for 100 9501  
 yr integration

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · acute (short-term) toxicity -----



LC50 (lethal concentration, 50%): rat, 4 hr: >800,000 ppm (fatal concentration by inhalation for half of test animals) 5526

ALC (approximate lethal concentration: mouse, 30 min, 0/3: >120,000 ppm (lowest exposure tested with one or more deaths by inhalation) 6B51

cardiac sensitization (CS) EC50: dog, 10 min: >170,000 ppm v/v (effective concentration in half of test animals) 6684

cardiac sensitization (CS) NOEL: >400,000 ppm v/v (no observed effect level in test animals) 5526

anesthetic/CNS effect NOEL: mouse, 30 min, 0/3: 120,000 ppm v/v (no observed effect level in test animals) 6B51

· detection -----

appearance: BNFL: clear, colorless liquid MSDS

odor: BNFL: odorless MSDS

**PRODUCTION**

first commercial use as a refrigerant: circa 1995

last year production allowed: unrestricted 8C01

## R-600 (butane)

```

----- REFRIGERANT DATA SUMMARY -----
R-600      n-butane      see
HC         CH3-CH2-CH2-CH3  CAS number 106-97-8  RDB#
-----

```

**COMMON USE(S)**

blend component with fluorocarbons and other hydrocarbons as alternatives to refrigerants 12 and 500, among them refrigerants 416A and others; refrigerant in hydraulic refrigeration systems; use is constrained by flammability concerns; primary uses are as a fuel, aerosol propellant, and feedstock for solvents, rubbers, and plastics

**IDENTIFIERS**

```

common name(s):  R-600; R600; R 600
                  HC-600
                  "R-3-11-0" (in Russia)
                  hydrocarbon 600
                  n-C4; n-C4H10
                  n-butane; normal-butane

chemical name (by IUPAC convention):  butane
alternative chemical names/formulae:  1-butane
                                      diethyl
                                      ethyl-ethyl
                                      methylethylmethane
                                      butyl hydride
                                      CH3CH2CH2CH3; CH3-CH2-CH2-CH3;
                                      CH3(CH2)2CH3; CH3-(CH2)2-CH3

empirical formula:  C4H10
CAS number:         106-97-8 Chemical Abstracts
                   Service Registry Number
NIOSH RTECS number:  EJ4200000 (Registry of Toxic
                   Effects of Chemical
                   Substances)

ARI container color / Pantone number:  none, use light green grey/413 6601
                                      with red / 185 band

```

**PHYSICAL**

```

· properties -----
      molar mass:  58.12220 g/mol (0.128138      8820
                  lb/mol)
normal freezing/melting/triple point:  -138.3 °C (-216.9 °F)      3209
· normal boiling point -----
      temperature:  -0.5 °C (31.0 °F)          8401
heat of vaporization:  385.8 kJ/kg (165.9 Btu/lb)  8401
· normal pressure, 20 °C (68 °F) -----
      density, vapor:  2.496 kg/m3 (0.1558 lb/cf)  8401
· normal pressure, 21.1 °C (70 °F) ---
      density, vapor:  2.486 kg/m3 (0.1552 lb/cf)  8401
· 20 °C (68 °F) -----
      pressure, saturated vapor:  208.1 kPa (30.18 psia)  8401
      density, saturated liquid:  578 kg/m3 (36.11 lb/cf)  8401
      density, saturated vapor:  5.33 kg/m3 (0.333 lb/cf)  8401
specific volume, saturated liquid:  1.729 L/kg (0.0277 cf/lb)  8401
specific volume, saturated vapor:  187.8 L/kg (3.0075 cf/lb)  8401

```

velocity of sound, saturated liquid:	923 m/s (3029 ft/s)	8401
velocity of sound, saturated vapor:	202 m/s (663 ft/s)	8401
viscosity, saturated liquid:	167 $\mu\text{Pa}\cdot\text{s}$ (0.167 cp)	8401
viscosity, saturated vapor:	7.5 $\mu\text{Pa}\cdot\text{s}$ (0.0075 cp)	8401
thermal conductivity, saturated liquid:	0.1089 W/m $\cdot$ K (0.0629 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, saturated vapor:	0.01584 W/m $\cdot$ K (0.00915 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· 60 $^{\circ}$ C (140 $^{\circ}$ F) -----		
pressure, saturated vapor:	639 kPa (92.7 psia)	8401
heat of vaporization:	320.8 kJ/kg (137.9 Btu/lb)	8401
· critical point -----		
temperature:	152.0 $^{\circ}$ C (305.6 $^{\circ}$ F)	8401
pressure:	3796 kPa (550.6 psia)	8401
density:	228 kg/m <sup>3</sup> (14.2 lb/cf)	8401
specific volume:	4.38 L/kg (0.0702 cf/lb)	0036

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	unknown, but very low: ~20 relative to CO <sub>2</sub> for 100 yr integration	
HGWP (halocarbon GWP):	~0 relative to R 11 for infinite integration period	
photochemical reactivity (grnd level):	320 relative to methane	4511

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A3	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-4-0 health-flammability-reactivity [-special]: 0=no, 4=severe	MSDS
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-4-0 health-flammability-reactivity 0=insignificant, 4=extreme	MSDS
UL Comparative Hazard to Life Group:	5(b) in absence of flame or hot objects	4B64
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	5561
· long-term occupational limit -----		
NIOSH REL (recommndd exposure limit):	800 ppm v/v TWA for 10 hr/day and 40 hr/wk	5204
ACGIH TLV-TWA (time-weighted average):	800 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk being examined for changes	5561 7101
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 2 hr: 281,000 ppm (fatal concentration by inhalation for half of test animals)	5363
	rat, 4 hr: 272,000 ppm (fatal concentration by inhalation for half of test animals)	5363
cardiac sensitization threshold/LOEL:	anesthetized dog: 5,000 ppm v/v (lowest observed effect)	6290

	level in test animals)	
	dog 10min 2/2: 100,000-250,000 ppm v/v (lowest observed effect level in test animals)	6192
anesthetic concentration:	mouse, 1 min: 220,000 ppm v/v	6197
	mouse, 25 min: 130,000 ppm v/v	6197
anesthetic/CNS effect LOEL:	human, 10 min: 100,000 ppm v/v (lowest observed effect level)	6290
anesthetic/CNS effect NOEL:	18,600 ppm v/v (no observed effect level in test animals)	6290
• flammability -----		
LFL-UFL (flammability limits in air):	1.5-10.1 % v/v	2525
	1.6-8.4 % v/v	5204
	BOC Gases: 1.8-8.4 % v/v	MSDS
	Exxon: 1.9-8.5 % v/v	MSDS
	Phillips: 1.9-8.5 % v/v	MSDS
heat of combustion (by ASHRAE 34-92):	49.5 MJ/kg (21281 Btu/lb)	2318
flash point:	CC, BOC Gases: -73.9 °C (-101 °F)	MSDS
	CC, Exxon: -60 °C (-76 °F)	MSDS
	not applicable for gas	5204
autoignition temperature:	430 °C (806 °F)	4B64
	510 °C (950 °F)	4906
	BOC Gases: 420 °C (788 °F)	MSDS
	Exxon: 405 °C (761 °F)	MSDS
autodecomposition temperature:	BOC Gases: 435 °C (815 °F)	MSDS
• detection -----		
appearance:	Exxon: colorless gas	MSDS
odor:	BOC Gases: odorless	MSDS
	Exxon: faint disagreeable odor	MSDS
	Phillips: none	MSDS
odor sensing, lower threshold:	50,000 ppm v/v	6290
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01

## R-600a (isobutane)

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----- REFRIERANT DATA SUMMARY -----
R-600a      isobutane
HC          CH(CH3)2-CH3
                                CAS number 75-28-5
                                                see
                                                RDB#
-----

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**COMMON USE(S)**

used in small refrigeration systems including household refrigerators in the 1920s and early 1930s; re-emerged in the 1990s as a blend component with fluorocarbons and other hydrocarbons as alternatives to refrigerants 12 and 500, among them refrigerants 406A, 413A, 414A, 414B, and others; fuel; blend component for aerosol propellants; feedstock for petrochemicals

**IDENTIFIERS**

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common name(s):  R-600a; R600a; R 600a
                 HC-600a
                 hydrocarbon 600a
                 i-C4; i-C4H10
                 iso-C4; iso-C4H10
chemical name (by IUPAC convention):  isobutane
alternative chemical names/formulae:  propane, 2-methyl-
                                     isomethylpropane
                                     methylpropane, iso
                                     2-methylpropane, (CH3)2CH-CH3
                                     trimethylmethane, CH(CH3)3
                                     CH3CH(CH3)CH3, CH3-CH(CH3)-CH3
empirical formula:  C4H10
CAS number:        75-28-5 Chemical Abstracts
                  Service Registry Number
NIOSH RTECS number:  TZ4300000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
trade name(s):     Calor Gas (UK) CARE 10
                  Diversified CPC Aeron A-31
                  Ecozone BV (NL) Ecoool-ISO
historical name(s):  "R-601" (nonstandard number)  2113
                  "R601" (nonstandard number)    2113
                  Copeland Products Freezol     2113
ARI container color / Pantone number:  none, use light green grey/413 6601
                                     with red / 185 band

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**PHYSICAL**

```

· properties -----
molar mass: 58.12220 g/mol (0.128138 lb/mol) 8820
normal freezing/melting/triple point: -159.6 °C (-255.3 °F) 8401
· normal boiling point -----
temperature: -11.6 °C (11.1 °F) 8401
density, saturated liquid: 594 kg/m3 (37.06 lb/cf) 8401
density, saturated vapor: 2.83 kg/m3 (0.176 lb/cf) 8401
specific volume, saturated liquid: 1.685 L/kg (0.0270 cf/lb) 8401
specific volume, saturated vapor: 353.7 L/kg (5.6664 cf/lb) 8401
heat of vaporization: 366.7 kJ/kg (157.6 Btu/lb) 8401
velocity of sound, saturated liquid: 1008 m/s (3308 ft/s) 8401

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SEE DATA LIMITATIONS AND NOTES ON PAGE 2

velocity of sound, saturated vapor:	197 m/s (645 ft/s)	8401
viscosity, saturated liquid:	228 $\mu\text{Pa}\cdot\text{s}$ (0.228 cp)	8401
viscosity, saturated vapor:	6.64 $\mu\text{Pa}\cdot\text{s}$ (0.00664 cp)	8401
thermal conductivity, liquid:	0.1121 W/m $\cdot$ K (0.0648 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, vapor:	0.0126 W/m $\cdot$ K (0.0073 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· normal pressure, 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
density, vapor:	2.485 kg/m <sup>3</sup> (0.1551 lb/cf)	8401
· normal pressure, 21.1 $^{\circ}$ C (70 $^{\circ}$ F) ---		
density, vapor:	2.475 kg/m <sup>3</sup> (0.1545 lb/cf)	8401
· 20 $^{\circ}$ C (68 $^{\circ}$ F) -----		
pressure, saturated vapor:	301.8 kPa (43.77 psia)	8401
density, saturated liquid:	557 kg/m <sup>3</sup> (34.77 lb/cf)	8401
density, saturated vapor:	7.90 kg/m <sup>3</sup> (0.493 lb/cf)	8401
specific volume, saturated liquid:	1.796 L/kg (0.0288 cf/lb)	8401
specific volume, saturated vapor:	126.6 L/kg (2.0284 cf/lb)	8401
velocity of sound, saturated liquid:	838 m/s (2749 ft/s)	8401
velocity of sound, saturated vapor:	198 m/s (651 ft/s)	8401
viscosity, saturated liquid:	160 $\mu\text{Pa}\cdot\text{s}$ (0.160 cp)	8401
viscosity, saturated vapor:	7.6 $\mu\text{Pa}\cdot\text{s}$ (0.0076 cp)	8401
thermal conductivity, saturated liquid:	0.0978 W/m $\cdot$ K (0.0565 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
thermal conductivity, saturated vapor:	0.02110 W/m $\cdot$ K (0.01219 Btu/hr $\cdot$ ft $^{\circ}$ F)	8401
· 60 $^{\circ}$ C (140 $^{\circ}$ F) -----		
pressure, saturated vapor:	868 kPa (125.9 psia)	8401
heat of vaporization:	285.2 kJ/kg (122.6 Btu/lb)	8401
· critical point -----		
temperature:	134.7 $^{\circ}$ C (274.5 $^{\circ}$ F)	8401
pressure:	3640 kPa (527.9 psia)	8401
density:	224 kg/m <sup>3</sup> (14.0 lb/cf)	8401
specific volume:	4.46 L/kg (0.0714 cf/lb)	8401

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)
GWP (global warming potential):	unknown, but very low: ~20 relative to CO <sub>2</sub> for 100 yr integration
HGWP (halocarbon GWP):	~0 relative to R 11 for infinite integration period

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A3	8601
NFPA 704 degrees of hazard (H-F-R-S):	Matheson: 1-4-0	MSDS
	Pennzoil: 0-4-0	MSDS
	Texaco: 1-4-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	Texaco: 1-4-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	5(b) in absence of flame or hot objects	0036
· short-term occupational limit -----		
recommended short-term exposure limit:	Rhône-Poulenc: 750 ppm(10 min)	MSDS
· occupational exposure limit -----		

MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	5561
• long-term occupational limit -----		
NIOSH REL (recommended exposure limit):	800 ppm v/v TWA for 10 hr/day and 40 hr/wk	5204
exposure limit consistent to OSHA PEL:	Pennzoil, C1-C4 assumed: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	
	Rhône-Poulenc OES: 600 ppm v/v TWA for 8 hr/day and 40 hr/wk	
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
	being examined for changes	7101
• emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	4,300 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 2 hr: 520,000 ppm (fatal concentration by inhalation for half of test animals)	6569
	rat, 15 min: 570,000 ppm (fatal concentration by inhalation for half of test animals)	6110
cardiac sensitization (CS) EC50:	dog, 5 min: 70,000 ppm v/v (effective concentration in half of test animals)	6110
cardiac sensitization threshold/LOEL:	dog, 5 min, 4/12: 50,000 ppm v/v (lowest observed effect level in test animals)	5644
cardiac sensitization (CS) NOEL:	dog, 5 min, 0/12: 25,000 ppm v/v (no observed effect level in test animals)	5644
anesthetic/CNS effect EC50:	rat, 10 min: stimulant 200,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic concentration:	dog, 10 min: 450,000 ppm v/v	6197
	mouse, 17 min: 200,000 ppm v/v	6197
	mouse, 60 min: 150,000 ppm v/v	6197
anesthetic/CNS effect NOEL:	human, 8 hr, 0/8: 1,000 ppm v/v (no observed effect level)	5364
• flammability -----		
LFL-UFL (flammability limits in air):	1.7-9.7 % v/v	2525
	Ecozone: 1-8.5 % v/v	mfr
	Pennzoil: 1.8-8.5 % v/v	MSDS
	Phillips: 1.8-8.4 % v/v	MSDS
	Texaco: 1.8-8.4 % v/v	MSDS
heat of combustion (by ASHRAE 34-92):	49.4 MJ/kg (21238 Btu/lb)	2318
flash point:	-83 °C (-117 °F)	6290
	Matheson CC: -88 °C (-126 °F)	MSDS
	Pennzoil: -83 °C (-117 °F)	MSDS
	Phillips: -83 °C (-117 °F)	MSDS
	Texaco: -118 °C (-181 °F)	MSDS
	not applicable for gas	5204
autoignition temperature:	530 °C (986 °F)	4906
	Pennzoil: 462.2 °C (864 °F)	MSDS
	Rhône-Poulenc: 420 °C (788 °F)	MSDS

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

former UL Classification:	Texaco: 460.0 °C (860 °F)	MSDS
	flammable (withdrawn for	UL
	revision of the classification	
	system, category SBQT2)	
· detection -----		
appearance:	Phillips: colorless	MSDS
odor:	Matheson: slight petroleum	MSDS
	Phillips: none	MSDS
	Rhône-Poulenc: virtually	MSDS
	odorless	MSDS
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1920s by E Copeland, H Edwards	2113
	1923 by J DeRemer	6104
	1923 by Savage Arms Company	6104
last year production allowed:	unrestricted	8C01





· 60 °C (140 °F) -----  
     pressure, saturated vapor: 215 kPa (31.1 psia) 4101  
 · critical point -----  
     temperature: 196.4 °C (385.4 °F) 4101  
     pressure: 3360 kPa (487.3 psia) 4101

**ENVIRONMENTAL**

average atmospheric lifetime (tatm): "few days": <<1 yr 5C94  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
     to R 11)  
 GWP (global warming potential): 11 relative to CO2 for 100 yr 5C94  
     integration

**SAFETY**

· classification -----  
     NFPA 704 degrees of hazard (H-F-R-S): BOC Gases: 1-4-0 MSDS  
     Phillips: 1-4-0 MSDS  
     Texaco: 2-4-0 MSDS  
     health-flammability-reactivity  
     [-special]: 0=no, 4=severe  
     NPCA HMIS hazard ratings (H-F-R): BOC Gases: 1-4-0 MSDS  
     Texaco: 3-4-0 MSDS  
     health-flammability-reactivity  
     0=insignificant, 4=extreme  
 · short-term occupational limit -----  
     NIOSH IDLH (immediately dangerous): 1,500 ppm v/v based on 10% of 5204  
     LEL  
     NIOSH SCP IDLH (immediately dangerous: 15,000 ppm v/v for 30 min 3903  
     (based on 100% of LEL)  
 · occupational exposure limit -----  
     NIOSH REL-C (exposure ceiling): 610 ppm v/v for 15 min (must 3903  
     not exceed)  
     MAK (maximum workplace concentration): IV: 2,000 ppm v/v momentary 60 5561  
     min  
 · long-term occupational limit -----  
     OSHA PEL (permissible exposure limit): 1,000 ppm v/v TWA for 8 hr/day 3904  
     and 40 hr/wk  
     NIOSH REL (recommended exposure limit): 120 ppm v/v TWA for 10 hr/day 3903  
     and 40 hr/wk  
     ACGIH TLV-TWA (time-weighted average): 600 ppm v/v TWA for 8 hr/day 9504  
     and 40 hr/wk  
     exposure limit consistent to OSHA PEL: DuPont AEL: 600 ppm v/v TWA MSDS  
     for 8 hr/day and 40 hr/wk  
     MAK (maximum workplace concentration): 1,000 ppm v/v TWA for 8 hr/day 5561  
     40 (or 42) hr/wk  
     being examined for changes 7101  
 · acute (short-term) toxicity -----  
     LC50 (lethal concentration, 50%): rat, 4 hr: 11,260 ppm (fatal 6B40  
     concentration by inhalation  
     for half of test animals)  
     LCLo (lethal concentration, lowest): human: 130,000 ppm (published 6290  
     fatal concentration to one or  
     more humans)  
     dermal LD50 (lethal dosage, 50%): rabbit, Texaco: >3,000 mg/kg MSDS  
     (fatal dose by skin contact  
     for half of test animals)  
     oral LD50 (lethal dosage, 50%): rat, Texaco: 500-2,000 mg/kg MSDS  
     (fatal dose by ingestion for  
     half of test animals)

## Refrigerant Database

anesthetic concentration:	mouse, 1.3 min: 90,000 ppm v/v	6197
	mouse, 10 min: 70,000 ppm v/v	6197
· flammability -----		
LFL-UFL (flammability limits in air):	1.5-7.8 % v/v	3903
	Phillips: 1.4-8.3 % v/v	MSDS
flash point:	-40 °C (-40 °F)	5C94
	-49 °C (-57 °F)	3903
autoignition temperature:	284 °C (544 °F)	4906
· detection -----		
appearance:	Phillips: colorless liquid	MSDS
odor:	BOC Gases: mild paraffinic	MSDS
	Texaco: gasoline odor	MSDS

**PRODUCTION**

last year production allowed:	unrestricted	8C01
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pressure: 3371 kPa (488.9 psia) 4101

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

• classification -----  
 NFPA 704 degrees of hazard (H-F-R-S): Exxon: 1-4-0 MSDS  
 NPCA HMIS hazard ratings (H-F-R): Texaco: 2-4-0 MSDS  
 health-flammability-reactivity  
 0=insignificant, 4=extreme

• short-term occupational limit -----  
 exposure limit consistent OSHA STEL: Exxon: 750 ppm v/v TWA for 15 min MSDS

• occupational exposure limit -----  
 MAK (maximum workplace concentration): IV: 2,000 ppm v/v momentary 60 5561 min

• long-term occupational limit -----  
 ACGIH TLV-TWA (time-weighted average): 600 ppm v/v TWA for 8 hr/day 9504  
 and 40 hr/wk  
 exposure limit consistent to OSHA PEL: Exxon: 600 ppm v/v TWA for 8 MSDS  
 hr/day and 40 hr/wk  
 MAK (maximum workplace concentration): 1,000 ppm v/v TWA for 8 hr/day 5561  
 40 (or 42) hr/wk  
 being examined for changes 7101

• acute (short-term) toxicity -----  
 dermal LD50 (lethal dosage, 50%): rabbit, Texaco: >3,000 mg/kg MSDS  
 (fatal dose by skin contact  
 for half of test animals)  
 oral LD50 (lethal dosage, 50%): rat, Texaco: 3,000-5,000 mg/kg MSDS  
 (fatal dose by ingestion for  
 half of test animals)  
 cardiac sensitization (CS) EC50: dog, 10 min: 70,000-80,000 ppm 6684  
 v/v (effective concentration  
 in half of test animals)  
 cardiac sensitization threshold/LOEL: dog 10min 3/3: 150,000-900,000 6192  
 ppm v/v (lowest observed  
 effect level in test animals)

• flammability -----  
 LFL-UFL (flammability limits in air): DuPont: 1.4-8.3 % v/v MSDS  
 Exxon: 1.0-7.8 % v/v MSDS  
 Phillisp: 1.4-8.3 % v/v MSDS  
 Texaco: 1.4-7.6 % v/v MSDS  
 flash point: -51 °C (-60 °F) 6290  
 TCC, Exxon: -17.8 °C (0 °F) MSDS  
 autoignition temperature: DuPont: 420 °C (788 °F) MSDS  
 Exxon: 219 °C (426 °F) MSDS  
 Texaco: 420 °C (788 °F) MSDS

• detection -----  
 appearance: Phillips: colorless liquid MSDS  
 odor: Texaco: gasoline odor MSDS

**PRODUCTION**

last year production allowed: unrestricted 8C01

## R-601b (neopentane)

## ----- REFRIGERANT DATA SUMMARY -----

R-601b	neopentane		see
HC	(CH <sub>3</sub> ) <sub>4</sub> C	CAS number 463-82-1	RDB#

-----

**COMMON USE(S)**

refrigerant use is limited by flammability concerns; under consideration as a blowing agent for insulation

Note: No number designation has been assigned to this compound in ASHRAE Standard 34; the number indicated would be a logical assignment based on this Standard

**IDENTIFIERS**

common name(s):	R-601b; R601b; R 601b HC-601b neo-C5; neo-C5H12
chemical name (by IUPAC convention):	neopentane
alternative chemical names/formulae:	2,2-dimethylpropane tert-pentane tetramethylmethane, C(CH <sub>3</sub> ) <sub>4</sub> CH <sub>3</sub> -C(CH <sub>3</sub> ) <sub>2</sub> -CH <sub>3</sub>
empirical formula:	C <sub>5</sub> H <sub>12</sub>
CAS number:	463-82-1 Chemical Abstracts Service Registry Number
ARI container color / Pantone number:	none, use light green grey/413 6601 with red / 185 band

**PHYSICAL**

· properties -----		
	molar mass:	72.14878 g/mol (0.159061 lb/mol) 8820
	normal freezing/melting/triple point:	-16.5 °C (2.2 °F) 6290
· normal boiling point -----	temperature:	9.5 °C (49.1 °F) 6290
· critical point -----	temperature:	160.6 °C (321.1 °F)
	pressure:	3202 kPa (464.4 psia)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary 60 min	5561
· long-term occupational limit -----		
ACGIH TLV-TWA (time-weighted average):	600 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
· flammability -----	being examined for changes	7101

LFL-UFL (flammability limits in air):	1.4-8.3 % v/v	6290
flash point:	-7 °C (20 °F)	6290

**PRODUCTION**

last year production allowed:	unrestricted	8C01
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## R-602 (hexane)

## ----- REFRIGERANT DATA SUMMARY -----

R-602	n-hexane		see
HC	CH3CH2CH2CH2CH2CH3	CAS number 110-54-3	RDB#
			----

**COMMON USE(S)**

under consideration as a flushing agent or component; use is limited by flammability and toxicity concerns

Note: No number designation has been assigned to this compound in ASHRAE Standard 34; the number indicated would be a logical assignment based on this Standard. Commercial hexane typically contains 65-80% n-hexane, 10-20% methylcyclopentane, 3-10% isohexane, 3-10% 3-methylpentane, and <0.01% benzene.

**IDENTIFIERS**

common name(s):	R-602; R602; R 602 HC-602 hydrocarbon 602 n-C6; n-C6H14 n-hexane; normal-hexane
chemical name (by IUPAC convention):	hexane
alternative chemical names/formulae:	hexyl hydride CH3CH2CH2CH2CH2CH3 CH3(CH2)4CH3; CH3-(CH2)4-CH3 CH3-CH2-CH2-CH2-CH2-CH3
empirical formula:	C6H14
CAS number:	110-54-3 Chemical Abstracts Service Registry Number
Beilstein registry number:	1730733
EINECS number:	203-777-6 (European Inventory of Existing Chemical Substances)
Merck Index (volume-number):	12-4729
NIOSH RTECS number:	MN9275000 (Registry of Toxic Effects of Chemical Substances)
ARI container color / Pantone number:	none, use light green grey/413 6601 with red / 185 band

**PHYSICAL**

· properties -----		
	molar mass:	86.175360 g/mol (0.189984 lb/mol) 8820
	normal freezing/melting/triple point:	-139.4 °C (-218.9 °F) 3903 -95.3 °C (-139.6 °F) 6290
· normal boiling point -----	temperature:	68.7 °C (155.7 °F) 6290
· critical point -----	temperature:	234.4 °C (453.8 °F) 7809
	pressure:	2970 kPa (430.8 psia) 7809

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative



to R 11)

**SAFETY**

• classification -----  
 NFPA 704 degrees of hazard (H-F-R-S): BOC Gases: 1-3-0 MSDS  
 Phillips: 1-3-0 MSDS  
 health-flammability-reactivity  
 [-special]: 0=no, 4=severe  
 NPCA HMIS hazard ratings (H-F-R): BOC Gases: 1-3-0 MSDS  
 health-flammability-reactivity  
 0=insignificant, 4=extreme

• occupational exposure warnings -----  
 ACGIH caution: cutaneous absorption potential 9504

• short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 1,100 ppm v/v based on 10% of 5204  
 LEL  
 NIOSH SCP IDLH (immediately dangerous): 5,000 ppm v/v for 30 min 3903

• long-term occupational limit -----  
 OSHA PEL (permissible exposure limit): 500 ppm v/v TWA for 8 hr/day 3904  
 and 40 hr/wk  
 NIOSH REL (recommendd exposure limit): 50 ppm v/v TWA for 10 hr/day 3903  
 and 40 hr/wk  
 ACGIH TLV-TWA (time-weighted average): 50 ppm v/v TWA for 8 hr/day 9504  
 and 40 hr/wk  
 exposure limit consistent to OSHA PEL: Exxon: 100 ppm v/v TWA for 8 MSDS  
 hr/day and 40 hr/wk  
 MAK (maximum workplace concentration): 50 ppm v/v TWA for 8 hr/day 40 5561  
 (or 42) hr/wk  
 being examined for changes 7101

• acute (short-term) toxicity -----  
 dermal LD50 (lethal dosage, 50%): rabbit, Texaco: 1,000-3,000 MSDS  
 mg/kg (fatal dose by skin  
 contact for half of test  
 animals)  
 oral LD50 (lethal dosage, 50%): rat, Texaco: >5,000 mg/kg MSDS  
 (fatal dose by ingestion for  
 half of test animals)

• flammability -----  
 LFL-UFL (flammability limits in air): 1.1-7.5 % v/v 3903  
 1.2-7.8 % v/v 6290  
 BOC Gases: 1.7-7.7 % v/v MSDS  
 Exxon: 1.0-7.5 % v/v MSDS  
 flash point: -22 °C (-7 °F) 3903  
 autoignition temperature: Exxon: >260 °C (>500 °F) MSDS

• detection -----  
 appearance: Exxon: clear, colorless liquid MSDS  
 odor: BOC Gases: mild solvent odor MSDS  
 Texaco: gasoline odor MSDS

**PRODUCTION**

last year production allowed: unrestricted 8C01











oral ALD (approximate lethal dose):	more deaths by inhalation)	
	rat, 0/10: >5,000 mg/kg (fatal 7629	
	dose by ingestion for one or	
	more test animals)	
• flammability -----		
LFL-UFL (flammability limits in air):	1.2-6.7 % v/v	6290
flash point:	-4 °C (24 °F)	6290
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01

## R-610 (ether)

----- REFRIGERANT DATA SUMMARY -----  
 R-610 diethyl ether see  
 HE CH<sub>3</sub>-CH<sub>2</sub>-O-CH<sub>2</sub>-CH<sub>3</sub> CAS number 60-29-7 RDB#  
 -----

**COMMON USE(S)**

used in 1834 in the first practical refrigerating machine;  
 consideration constrained by anesthetic effects and flammability

**IDENTIFIERS**

common name(s): R-610; R610; R 610  
 HE-610  
 ether  
 alternative chemical names/formulae: bis(ethyl) ether  
 diethylether, diethyl ether  
 diethyl oxide  
 (C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>-O, C<sub>2</sub>H<sub>5</sub>-O-C<sub>2</sub>H<sub>5</sub>  
 empirical formula: C<sub>4</sub>H<sub>10</sub>O; (C<sub>2</sub>H<sub>5</sub>)<sub>2</sub>-O  
 CAS number: 60-29-7 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: KI5775000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 historical name(s): ethyl ether, ethyl oxide 2113  
 solvent ether, sulfuric ether 2113  
 ARI container color / Pantone number: none, use light green grey/413 6601  
 with red / 185 band

**PHYSICAL**

· properties -----  
 molar mass: 74.1215 g/mol (0.163410 8820  
 lb/mol)  
 normal freezing/melting/triple point: -116.3 °C (-177.3 °F) 1136  
 · normal boiling point -----  
 temperature: 34.6 °C (94.3 °F) 1136  
 · critical point -----  
 temperature: 214.0 °C (417.2 °F) 1136  
 pressure: 5999 kPa (870.0 psia) 1136  
 density: 348 kg/m<sup>3</sup> (21.8 lb/cf) 1136  
 specific volume: 2.87 L/kg (0.0460 cf/lb) 1136

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · occupational exposure warnings -----  
 NIOSH caution: PEL of 400 ppm inadequate 5204  
 STEL of 500 ppm inadequate 5204  
 · short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 1,900 ppm v/v based on 10% of 5204  
 LEL



## Refrigerant Database

NIOSH SCP IDLH (immediately dangerous: (based on 100% of LEL)	19,000 ppm v/v for 30 min	3903
ACGIH TLV-STEL (short-term exp limit): · occupational exposure limit -----	500 ppm v/v TWA for 15 min	9504
MAK (maximum workplace concentration): · long-term occupational limit -----	II, 1: 800 ppm v/v avg for 30 min	5561
OSHA PEL (permissible exposure limit):	400 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
ACGIH TLV-TWA (time-weighted average):	400 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	400 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk being examined for changes	5561 7101
· acute (short-term) toxicity ----- LC50 (lethal concentration, 50%):	mouse, 10 min: 112,000 ppm (fatal concentration by inhalation for half of test animals)	5980
anesthetic/CNS effect EC50:	mouse, 10 min: 32,000 ppm v/v (effective concentration in half of test animals)	5980
· flammability ----- LFL-UFL (flammability limits in air):	1.9-16.0 % v/v	3903
flash point:	-45 °C (-49 °F)	3903
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1834 by J. Perkins, associates	2113
last year production allowed:	unrestricted	8C01

## R-611 (methyl formate)

----- REFRIGERANT DATA SUMMARY -----  
 R-611 methyl formate see  
 HE HCOOCH3 CAS number 107-31-3 RDB#  
 -----

**COMMON USE(S)**

formerly used in refrigerators from approximately 1932-1934,  
 replacing and in turn replaced by refrigerant 764 (sulfur dioxide);  
 use was complicated by low chemical stability and flammability

**IDENTIFIERS**

common name(s): R-611; R611; R 611  
 HE-611  
 "H-Cooch" (from HCOOCH3)  
 alternative chemical names/formulae: formic acid methyl ester  
 methyl methanoate  
 HCO-O-CH3, HCO2CH3  
 empirical formula: C2H4O2  
 CAS number: 107-31-3 Chemical Abstracts  
 Service Registry Number  
 EINECS number: 203-481-7 (European Inventory  
 of Existing Chemical  
 Substances)  
 NIOSH RTECS number: LQ8925000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 ARI container color / Pantone number: none, use light green grey/413 6601  
 with red / 185 band

**PHYSICAL**

· properties -----  
 molar mass: 60.05196 g/mol (0.132392 8820  
 lb/mol)  
 normal freezing/melting/triple point: -98.9 °C (-146.0 °F) 0036  
 · normal boiling point -----  
 temperature: 31.8 °C (89.2 °F) 0036  
 heat of vaporization: 468.5 kJ/kg (201.4 Btu/lb) 0036  
 · critical point -----  
 temperature: 214.0 °C (417.2 °F) 0036  
 pressure: 5994 kPa (869.4 psia) 0036  
 density: 349 kg/m3 (21.8 lb/cf) 0036  
 specific volume: 2.87 L/kg (0.0459 cf/lb) 0036

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): B2 8601  
 UL Comparative Hazard to Life Group: 3 in absence of flame or hot 4B64  
 objects  
 DFG pregnancy risk group: C (no risk fear below MAK/BAT) 7101  
 · short-term occupational limit -----

## Refrigerant Database

NIOSH IDLH (immediately dangerous):	4,500 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	5,000 ppm v/v for 30 min	3903
NIOSH STEL (short-term exposure limit):	150 ppm v/v TWA for 15 min	3903
ACGIH TLV-STEL (short-term exp limit):	150 ppm v/v TWA for 15 min	9504
• occupational exposure limit -----		
MAK (maximum workplace concentration):	I: 200 ppm v/v momentary for 5 min	5561
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommndd exposure limit):	100 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	50 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	7101
• acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	guinea pig, 20 min: 50,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5340
oral LD50 (lethal dosage, 50%):	rabbit: 1,622 mg/kg (fatal dose by ingestion for half of test animals)	5340
anesthetic/CNS effect NOEL:	human, 1 min: 1,500 ppm v/v (no observed effect level)	5340
• flammability -----		
LFL-UFL (flammability limits in air):	4.5-20.0 % v/v	0036
	4.5-23 % v/v	3903
	5.1-23.8 % v/v	2525
flash point:	-19 °C (-2 °F)	3903
autoignition temperature:	456 °C (853 °F)	4B64
• detection -----		
appearance:	colorless liquid	5340
odor:	pleasant odor	5340
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1933 by General Electric	2113
last year production allowed:	unrestricted	8C01



## Refrigerant Database

	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 3-4-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	100 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	100 ppm v/v for 30 min	3903
ACGIH TLV-STEL (short-term exp limit):	15 ppm v/v TWA for 15 min	9504
· occupational exposure limit -----		
MAK (maximum workplace concentration):	V: 20 ppm v/v momentary for 10 min	7101
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	10 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	10 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	5 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	10 ppm v/v TWA for 8 hr/day (or 42) hr/wk	5561
	being examined for changes	7101
· emergency exposure limit -----		
AIHA ERPG-3 (life-threatening):	500 ppm v/v for 1 hr	4B77
AIHA ERPG-2 (injurious or impairing):	100 ppm v/v for 1 hr	4B77
AIHA ERPG-1 (odor or mild effects):	10 ppm v/v for 1 hr	4B77
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 1 hr, BOC Gases: 5,000 ppm (fatal concentration by inhalation for half of test animals)	MSDS
	rat, 2½ hr, BOC Gases: 448 ppm (fatal concentration by inhalation for half of test animals)	MSDS
oral LD50 (lethal dosage, 50%):	rat, BOC Gases: 100-200 mg/kg (fatal dose by ingestion for half of test animals)	MSDS
oral ALD (approximate lethal dose):	rat, BOC Gases: 2,500 mg/kg (fatal dose by ingestion for one or more test animals)	MSDS
· flammability -----		
LFL-UFL (flammability limits in air):	4.9-20.7 % v/v	3903
flash point:	-10 °C (14 °F)	5204
autoignition temperature:	CC, BOC Gases: 0 °C (32 °F)	MSDS
	BOC Gases: 430 °C (806 °F)	MSDS
· detection -----		
appearance:	BOC Gases: colorless	MSDS
odor:	BOC Gases: strong fishy	MSDS
	BOC Gases: ammonia-like odor	MSDS
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1860s by A. Muhl	2113
	1860s by C. Tellier	2113
last year production allowed:	unrestricted	8C01

## R-631 (ethylamine)

----- REFRIGERANT DATA SUMMARY -----  
 R-631 aminoethane see  
 HNC CH3-CH2(NH2) CAS number 75-04-7 RDB#  
 -----

**COMMON USE(S)**

phased out due to flammability and toxicity

**IDENTIFIERS**

common name(s): R-631; R631; R 631  
 HNC-631; HCN-631  
 chemical name (by IUPAC convention): aminoethane  
 alternative chemical names/formulae: ethylamine; ethyl amine  
 monoethylamine  
 CH3-CH2(NH2); CH3CH2(NH2)  
 amine C2; C2H5NH2  
 empirical formula: C2H7N  
 CAS number: 75-04-7 Chemical Abstracts  
 Service Registry Number  
 EINECS number: 200-834-7 (European Inventory  
 of Existing Chemical  
 Substances)  
 NIOSH RTECS number: KH2100000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 ARI container color / Pantone number: none, use light green grey/413 6601  
 with red / 185 band

**PHYSICAL**

· properties -----  
 molar mass: 45.08372 g/mol (0.099393 8820  
 lb/mol)  
 normal freezing/melting/triple point: -80.6 °C (-113.1 °F) 3A79  
 -81.1 °C (-114.0 °F) 3903  
 · normal boiling point -----  
 temperature: 16.6 °C (61.9 °F) 3A79  
 heat of vaporization: 600.8 kJ/kg (258.3 Btu/lb) 0036  
 · 20 °C (68 °F) -----  
 pressure, saturated vapor: 113.0 kPa (16.39 psia) 7101  
 · critical point -----  
 temperature: 183.0 °C (361.4 °F) 3A79  
 pressure: 5619 kPa (815.0 psia) 3A79

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 · occupational exposure warnings -----  
 ACGIH caution: cutaneous absorption potential 9504  
 · short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 600 ppm v/v 5204

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

NIOSH SCP IDLH (immediately dangerous:	4,000 ppm v/v for 30 min	3903
ACGIH TLV-STEL (short-term exp limit):	15 ppm v/v TWA for 15 min	9504
· occupational exposure limit -----		
MAK (maximum workplace concentration):	V: 10 ppm v/v momentary for 10 min	7101
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	10 ppm v/v TWA for 8 hr/day and 40 hr/wk	3903
NIOSH REL (recommendd exposure limit):	10 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	5 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	5 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	7101
· flammability -----		
LFL-UFL (flammability limits in air):	3.5-14.0 % v/v	3903
flash point:	-17 °C (1 °F)	3903
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1860s by C. Tellier	2113
last year production allowed:	unrestricted	8C01

## R-631a (dimethylamine)

## ----- REFRIGERANT DATA SUMMARY -----

R-631a	dimethylamine		see
HNC	(CH <sub>3</sub> ) <sub>2</sub> -NH	CAS number 124-40-3	RDB#

-----

**COMMON USE(S)**

use is limited by flammability and toxicity concerns

Note: No number designation has been assigned to this compound in ASHRAE Standard 34; the number indicated would be a logical assignment based on this Standard.

**IDENTIFIERS**

common name(s):	R-631a; R631a; R 631a HNC-631a; HCN-631a DMA
chemical name (by IUPAC convention):	dimethylamine
alternative chemical names/formulae:	dimethylamine anhydrous N-methylmethanamine (CH <sub>3</sub> ) <sub>2</sub> NH; (CH <sub>3</sub> ) <sub>2</sub> -NH
not recommended:	HN(CH <sub>3</sub> ) <sub>2</sub> ; HN-(CH <sub>3</sub> ) <sub>2</sub> NH(CH <sub>3</sub> ) <sub>2</sub> ; NH-(CH <sub>3</sub> ) <sub>2</sub>
empirical formula:	C <sub>2</sub> H <sub>7</sub> N
CAS number:	124-40-3 Chemical Abstracts Service Registry Number
Beilstein registry number:	605257
EINECS number:	204-697-4 (European Inventory of Existing Chemical Substances)
NIOSH RTECS number:	IP8750000 (Registry of Toxic Effects of Chemical Substances)
ARI container color / Pantone number:	none, use light green grey/413 6601 with red / 185 band

**PHYSICAL**

· properties -----		
	molar mass:	45.08372 g/mol (0.099393 lb/mol) 8820
	normal freezing/melting/triple point:	-92.2 °C (-134.0 °F) 5204
· normal boiling point -----	temperature:	6.7 °C (44.0 °F) 5204

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

· classification -----		
	safety group (ASHRAE Standard 34):	none (no application pending) 8601
	NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 3-4-0 MSDS
		health-flammability-reactivity [-special]: 0=no, 4=severe

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



## Refrigerant Database

NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 3-4-0	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
ACGIH carcinogenicity category:	A4, not classifiable as a	9504
	human carcinogen	
DFG pregnancy risk group:	IIc (no pregnancy risk class)	7101
• short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	500 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	2,000 ppm v/v for 30 min	3903
ACGIH TLV-STEL (short-term exp limit):	15 ppm v/v TWA for 15 min	9504
• occupational exposure limit -----		
MAK (maximum workplace concentration):	V: 4 ppm v/v momentary for 10	7101
	min	
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	10 ppm v/v TWA for 8 hr/day	3904
	and 40 hr/wk	
ACGIH TLV-TWA (time-weighted average):	5 ppm v/v TWA for 8 hr/day and	9504
	40 hr/wk	
MAK (maximum workplace concentration):	2 ppm v/v TWA for 8 hr/day 40	7101..
	(or 42) hr/wk	
• emergency exposure limit -----		
AIHA ERPG-3 (life-threatening):	500 ppm v/v for 1 hr	9503
AIHA ERPG-2 (injurious or impairing):	100 ppm v/v for 1 hr	9503
AIHA ERPG-1 (odor or mild effects):	1 ppm v/v for 1 hr	9503
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 6 hr, BOC Gases: 2,430	MSDS
	ppm (fatal concentration by	
	inhalation for half of test	
	animals)	
	rat, ? hr, BOC Gases: 4,000	MSDS
	ppm (fatal concentration by	
	inhalation for half of test	
	animals)	
oral LD50 (lethal dosage, 50%):	rat, BOC Gases: 698 mg/kg	MSDS
	(fatal dose by ingestion for	
	half of test animals)	
• flammability -----		
LFL-UFL (flammability limits in air):	2.8-14.4 % v/v	5204
flash point:	-7 °C (20 °F)	5204
	CC, BOC Gases: -50 °C (-58 °F)	MSDS
autodecomposition temperature:	BOC Gases: 400 °C (752 °F)	MSDS
• detection -----		
appearance:	colorless	5204
odor:	weak ammonia- or fish-like	5204

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-702 (hydrogen)

```

----- REFRIERANT DATA SUMMARY -----
R-702      hydrogen (25/75 mixture of para-/ortho-hydrogen)      see
inorganic  H2                                                    CAS number 1333-74-0      RDB#
-----

```

**COMMON USE(S)**

component of air (0.5 ppm in dry atmospheric air)

**IDENTIFIERS**

```

common name(s):  R-702; R702; R 702
chemical name (by IUPAC convention):  hydrogen
alternative chemical names/formulae:  normal hydrogen; n-hydrogen
                                         H2; n-H2
CAS number:      1333-74-0 Chemical Abstracts
                  Service Registry Number
NIOSH RTECS number:  MW8900000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
ARI container color / Pantone number:  none, use light green grey/413 6601
                                         with red / 185 band

```

**PHYSICAL**

```

· properties -----
molar mass:      2.01588 g/mol (0.004444      8820
                  lb/mol)
normal freezing/melting/triple point:  -259.3 °C (-434.8 °F)      3208
· normal boiling point -----
temperature:      -252.9 °C (-423.2 °F)      3208
heat of vaporization:  733.1 kJ/kg (315.2 Btu/lb)      3208
· critical point -----
temperature:      -239.9 °C (-399.8 °F)      0036
pressure:         1315 kPa (190.7 psia)      0036
density:          30 kg/m3 (1.9 lb/cf)      0036
specific volume:  33.21 L/kg (0.5320 cf/lb)      0036

```

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  A3      8601
NFPA 704 degrees of hazard (H-F-R-S):  BOC Gases: 0-4-0      MSDS
health-flammability-reactivity
[-special]: 0=no, 4=severe
NPCA HMIS hazard ratings (H-F-R):  BOC Gases: 0-4-0      MSDS
health-flammability-reactivity
0=insignificant, 4=extreme
· occupational exposure warnings -----
ACGIH caution:  simple asphyxiant      9504
· flammability -----
LFL-UFL (flammability limits in air):  4.0-75.0 % v/v      4908
                                         4.1-74.0 % v/v      3208
                                         BOC Gases: 4.0-74.5 % v/v      MSDS

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

autoignition temperature: BOC Gases: >570 °C (>1058 °F) MSDS  
· detection -----  
appearance: BOC Gases: colorless MSDS  
odor: BOC Gases: odorless MSDS

**PRODUCTION**

last year production allowed: unrestricted 8C01



## R-704 (helium)

----- REFRIGERANT DATA SUMMARY -----  
 R-704 helium see  
 inorganic He CAS number 7440-59-7 RDB#  
 -----

**COMMON USE(S)**

potential use in Stirling cycle and thermoacoustic refrigeration  
 machines; component of air (5.24 ±0.004 % in dry atmospheric air)

**IDENTIFIERS**

common name(s): R-704; R704; R 704  
 helium-4  
 chemical name (by IUPAC convention): helium  
 alternative chemical names/formulae: He  
 CAS number: 7440-59-7 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: MH6520000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----  
 molar mass: 4.002602 g/mol (0.008824 8820  
 lb/mol)  
 normal freezing/melting/triple point: none 0036  
 · normal boiling point -----  
 temperature: -268.9 °C (-452.0 °F) 0036  
 heat of vaporization: 20.9 kJ/kg (9.0 Btu/lb) 3208  
 · critical point -----  
 temperature: -267.9 °C (-450.2 °F) 0036  
 pressure: 229 kPa (33.2 psia) 0036  
 density: 69 kg/m<sup>3</sup> (4.3 lb/cf) 0036  
 specific volume: 14.43 L/kg (0.2311 cf/lb) 0036

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): A1 8601  
 NFPA 704 degrees of hazard (H-F-R-S): BOC Gases: 0-0-0 MSDS  
 health-flammability-reactivity  
 [-special]: 0=no, 4=severe  
 NPCA HMIS hazard ratings (H-F-R): BOC Gases: 0-0-0 MSDS  
 health-flammability-reactivity  
 0=insignificant, 4=extreme  
 · occupational exposure warnings -----  
 ACGIH caution: simple asphyxiant 9504  
 · flammability -----  
 LFL-UFL (flammability limits in air): none (nonflammable as tested) 3208  
 flash point: BOC Gases: none MSDS  
 autoignition temperature: BOC Gases: none MSDS

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



## R-717 (ammonia)

```

----- REFRIGERANT DATA SUMMARY -----
R-717      ammonia      see
inorganic  NH3          CAS number 7664-41-7  RDB#
-----

```

**COMMON USE(S)**

chillers, widely used in industrial refrigeration; wide use as a fertilizer; intermediate to manufacture synthetic fibers, plastics, and explosives; cleaning solvent; ammonia is found in water, soil, and air - it is a natural decomposition product of decaying manure, plants, and animals

**IDENTIFIERS**

```

common name(s):  R-717; R717; R 717
                  anhydrous ammonia
                  nitro-sil
chemical name (by IUPAC convention): ammonia
alternative chemical names/formulae: NH3; less commonly H3N
CAS number:      7664-41-7 Chemical Abstracts
                  Service Registry Number
NIOSH RTECS number: BO0875000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
historical name(s): spirit of hartshorn      5C46
ARI container color / Pantone number: none, use light green grey/413 6601
                  with red / 185 band

```

**PHYSICAL**

```

· properties -----
molar mass:      17.03056 g/mol (0.037546      8820
                  lb/mol)
normal freezing/melting/triple point: -77.7 °C (-107.8 °F)      8401
· normal boiling point -----
temperature:     -33.3 °C (-28.0 °F)      8401
density, saturated liquid: 682 kg/m3 (42.57 lb/cf)      8401
density, saturated vapor:  0.89 kg/m3 (0.056 lb/cf)      8401
specific volume, saturated liquid: 1.466 L/kg (0.0235 cf/lb)      8401
specific volume, saturated vapor:  1242.2 L/kg (19.8981 cf/lb)      8401
heat of vaporization: 1369.5 kJ/kg (588.8 Btu/lb)      8401
velocity of sound, saturated liquid: 1768 m/s (5801 ft/s)      8401
velocity of sound, saturated vapor:  386 m/s (1267 ft/s)      8401
viscosity, saturated liquid: 255 µPa·s (0.255 cp)      8401
viscosity, saturated vapor:  8.05 µPa·s (0.00805 cp)      8401
thermal conductivity, liquid: 0.6666 W/m·K (0.3851      8401
                  Btu/hr·ft·°F)
thermal conductivity, vapor: 0.0210 W/m·K (0.0121      8401
                  Btu/hr·ft·°F)
· normal pressure, 20 °C (68 °F) -----
density, vapor: 0.716 kg/m3 (0.0447 lb/cf)      8401
· normal pressure, 21.1 °C (70 °F) ---
density, vapor: 0.713 kg/m3 (0.0445 lb/cf)      8401
· 20 °C (68 °F) -----
pressure, saturated vapor: 857.5 kPa (124.37 psia)      8401
density, saturated liquid: 610 kg/m3 (38.09 lb/cf)      8401

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

density, saturated vapor:	6.70 kg/m <sup>3</sup> (0.418 lb/cf)	8401
specific volume, saturated liquid:	1.639 L/kg (0.0263 cf/lb)	8401
specific volume, saturated vapor:	149.2 L/kg (2.3900 cf/lb)	8401
velocity of sound, saturated liquid:	1385 m/s (4542 ft/s)	8401
velocity of sound, saturated vapor:	405 m/s (1328 ft/s)	8401
viscosity, saturated liquid:	138 µPa·s (0.138 cp)	8401
viscosity, saturated vapor:	9.7 µPa·s (0.0097 cp)	8401
thermal conductivity, saturatd liquid:	0.4999 W/m·K (0.2888 Btu/hr·ft°F)	8401
thermal conductivity, saturated vapor:	0.02552 W/m·K (0.01474 Btu/hr·ft°F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	2616 kPa (379.4 psia)	8401
heat of vaporization:	997.3 kJ/kg (428.8 Btu/lb)	8401
· critical point -----		
temperature:	132.3 °C (270.1 °F)	8401
pressure:	11333 kPa (1643.7 psia)	8401
	11336 kPa (1644.2 psia)	9701
density:	225 kg/m <sup>3</sup> (14.0 lb/cf)	8401
	235 kg/m <sup>3</sup> (14.7 lb/cf)	9701
specific volume:	4.26 L/kg (0.0682 cf/lb)	9701
	4.44 L/kg (0.0712 cf/lb)	8401

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)
GWP (global warming potential):	unknown, but very low: <1 relative to CO <sub>2</sub> for 100 yr integration

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	B2	8601
NFPA 704 degrees of hazard (H-F-R-S):	ARI recommendation: 3-1-0	3A15
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 3-1-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	2 in absence of flame or hot objects	4B64
DFG pregnancy risk group:	C (no risk fear below MAK/BAT)	7101
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	300 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	500 ppm v/v for 30 min	3903
OSHA STEL (short-term exposure limit):	50 ppm v/v TWA for 15 min (set in 1989, but vacated in 1992)	5204
NIOSH STEL (short-term exposur limit):	35 ppm v/v TWA for 15 min	3903
ACGIH TLV-STEL (short-term exp limit):	35 ppm v/v TWA for 15 min	9504
recommended short-term exposure limit:	DuPont EEL: 500 ppm (≤10 min)	MSDS
	DuPont EEL: 300 ppm (10-60min)	MSDS
	DuPont EEL: 500 ppm (ceiling)	MSDS
· occupational exposure limit -----		
MAK (maximum workplace concentration):	I: 40 ppm v/v momentary for 5 min	7101
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	50 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	25 ppm v/v TWA for 10 hr/day	3903

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



## Refrigerant Database

	and 40 hr/wk	
ACGIH TLV-TWA (time-weighted average):	25 ppm v/v TWA for 8 hr/day	9504
exposure limit consistent to OSHA PEL:	DuPont AEL: 25 ppm v/v TWA for MSDS 8 hr/day and 40 hr/wk	
MAK (maximum workplace concentration):	20 ppm v/v TWA for 8 hr/day 40	7101
	(or 42) hr/wk	
· emergency exposure limit -----		
NRC EEGL (emergency exposure level):	1 hr: 100 ppm v/v ceiling	5154
	guidance level for single	
	emergency exposures	
	24 hr: 100 ppm v/v ceiling	5154
	guidance level for single	
	emergency exposures	
Refrigerant Concentration Limit (RCL):	300 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
AIHA ERPG-3 (life-threatening):	1,000 ppm v/v for 1 hr	4B76
AIHA ERPG-2 (injurious or impairing):	200 ppm v/v for 1 hr	4B76
AIHA ERPG-1 (odor or mild effects):	25 ppm v/v for 1 hr	4B76
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 30 min: 23,472 ppm (fatal	6278
	concentration by inhalation	
	for half of test animals)	
	rat, 1 hr: 7,338 ppm (fatal	6230
	concentration by inhalation	
	for half of test animals)	
	rat, 1 hr: 7,338-11,590 ppm	5340
	(fatal concentration by	
	inhalation for half of test	
	animals)	
	rat, 1 hr: 11,342 ppm (fatal	6229
	concentration by inhalation	
	for half of test animals)	
	rat, 1 hr: 16,600 ppm (fatal	5152
	concentration by inhalation	
	for half of test animals)	
	rat, 4 hr: 2,000 ppm (fatal	5643
	concentration by inhalation	
	for half of test animals)	
	rat, 4 hr: 4,067 ppm (fatal	5151
	concentration by inhalation	
	for half of test animals)	
LCL50 (lowest published LC50 value):	rat, 1 hr: 6,586 ppm	1106
LCLo (lethal concentration, lowest):	human, 5 min: 5,000 ppm	72A3
	(published fatal concentration	
	to one or more humans)	
oral LD50 (lethal dosage, 50%):	rat, using NH4OH: 350 mg/kg	6267
	(fatal dose by ingestion for	
	half of test animals)	
respiratory RD50 (response dose 50%):	mouse, 30 min: 303 ppm v/v	6249
	(50% decrease in respiratory	
	rate in test animals)	
· flammability -----		
LFL-UFL (flammability limits in air):	15-16 - 25-28 % v/v	3635
	15-28 % v/v	4908
	16-25 % v/v	4757
	16-25 % v/v	5C46
	at 100% RH: 15.95-26.55 % v/v	6350
	in dry air: 15.15-27.35 % v/v	4B60

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	match ignition: 14.8-33.4 %	2525
	v/v	
LFL (with spark ignition):	15.1 % v/v	2525
LFL (with hot-wire ignition):	15.1 % v/v	2525
heat of combustion (by ASHRAE 34-92):	22.5 MJ/kg (9673 Btu/lb)	2318
flash point:	none (nonflammable as tested)	3903
autoignition temperature:	651 °C (1204 °F)	4757
	BOC Gases: 690 °C (1274 °F)	MSDS
autodecomposition temperature:	DuPont: 400-500 °C (842-932°F)	MSDS
· detection -----		
appearance:	colorless	5C46
odor:	penetrating and pungent odor	5C46
odor sensing, lower threshold:	5-50 ppm v/v	3635
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1859 by F. Carre (absorption)	2115
	1869 by C. Linde (compression)	2113
last year production allowed:	unrestricted	8C01



**SAFETY**

· classification -----  
  safety group (ASHRAE Standard 34): A1 8601  
· flammability -----  
  LFL-UFL (flammability limits in air): none (nonflammable as tested)

**PRODUCTION**

first commercial use as a refrigerant: 11th century BC, prehistoric 5C49  
  1755 by W. Cullen 2115  
  ~1912 by M LeBlanc using a 4147  
  centrifugal compressor  
last year production allowed: unrestricted 8C01



## R-728 (nitrogen)

## ----- REFRIGERANT DATA SUMMARY -----

R-728	nitrogen		see
inorganic	N2	CAS number 7727-37-9	RDB#

**COMMON USE(S)**

inert gas for soldering, brazing, and leak detection of refrigerant piping; component of air (78.084 ±0.004 %, 780,840 ppm, in dry atmospheric air); fire suppressant

**IDENTIFIERS**

common name(s):	R-728; R728; R 728
chemical name (by IUPAC convention):	nitrogen
alternative chemical names/formulae:	N2
CAS number:	7727-37-9 Chemical Abstracts Service Registry Number
NIOSH RTECS number:	QW970000 (Registry of Toxic Effects of Chemical Substances)
ARI container color / Pantone number:	none, use light green grey/413 6601

**PHYSICAL**

· properties -----		
	molar mass:	28.01348 g/mol (0.061759 lb/mol) 8820
	normal freezing/melting/triple point:	-210.0 °C (-346.0 °F) 0036
· normal boiling point -----		
	temperature:	-198.8 °C (-325.8 °F) 0036
	heat of vaporization:	199.3 kJ/kg (85.7 Btu/lb) 3208
· normal pressure, 21.1 °C (70 °F) ---		
	density, vapor:	1.153 kg/m3 (0.0720 lb/cf) MSDS
· critical point -----		
	temperature:	-146.9 °C (-232.4 °F) 0036
	pressure:	34 kPa (4.9 psia) 0036
	density:	315 kg/m3 (19.6 lb/cf) 0036
	specific volume:	3.18 L/kg (0.0509 cf/lb) 0036

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

· classification -----		
	safety group (ASHRAE Standard 34):	A1 8601
	NFPA 704 degrees of hazard (H-F-R-S):	Amerex: 1-0-0 MSDS
		health-flammability-reactivity [-special]: 0=no, 4=severe
	NPCA HMIS hazard ratings (H-F-R):	Amerex: 1-0-0 MSDS
		health-flammability-reactivity 0=insignificant, 4=extreme
· occupational exposure warnings -----		
	ACGIH caution:	simple asphyxiant 9504
· flammability -----		
	LFL-UFL (flammability limits in air):	none (nonflammable as tested) 3208

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

**PRODUCTION**

last year production allowed: unrestricted

8C01







appearance: BOC Gases: colorless MSDS  
odor: BOC Gases: odorless MSDS

**PRODUCTION**

last year production allowed: unrestricted 8C01



odor: BOC Gases: odorless MSDS

**PRODUCTION**

last year production allowed: unrestricted 8C01

## R-744 (carbon dioxide)

```

----- REFRIGERANT DATA SUMMARY -----
R-744      carbon dioxide      see
inorganic  CO2                  CAS number 124-38-9      RDB#
-----

```

**COMMON USE(S)**

industrial refrigerant, first used in 1866 and still in use;  
 component of air (0.033 ±0.001 %, 330 ppm, in dry atmospheric air);  
 frozen carbon dioxide (dry ice) is used as a coolant for temporary  
 storage at refrigerated conditions; propellant; fire suppressant;  
 carbonation of beverages

**IDENTIFIERS**

```

common name(s):  R-744; R744; R 744
                  carbon dioxide; "carbon oxide"
                  dry ice (when frozen)
chemical name (by IUPAC convention):  carbon dioxide
alternative chemical names/formulae:  CO2
CAS number:      124-38-9 Chemical Abstracts
                  Service Registry Number
EINECS number:   204-696-9 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number:  FF6400000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
trade name(s):    Khladon 744
historical name(s):  carbonic acid anhydride
                  carbonic acid gas      2113
                  carbonic anhydride     2113
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass: 44.0095 g/mol (0.097024      8820
              lb/mol)
normal freezing/melting/triple point: -56.6 °C (-69.8 °F)      3209
· normal boiling point -----
  temperature: -78.4 °C (-109.1 °F)      8401
heat of vaporization: 572.9 kJ/kg (246.3 Btu/lb)      3208
· normal pressure, 20 °C (68 °F) -----
  density, vapor: 1.839 kg/m3 (0.1148 lb/cf)      8401
· normal pressure, 21.1 °C (70 °F) ----
  density, vapor: 1.832 kg/m3 (0.1144 lb/cf)      8401
· 20 °C (68 °F) -----
  pressure, saturated vapor: 5721.6 kPa (829.85 psia)      8401
  density, saturated liquid: 774 kg/m3 (48.33 lb/cf)      8401
  density, saturated vapor: 192.32 kg/m3 (12.006 lb/cf)      8401
  specific volume, saturated liquid: 1.292 L/kg (0.0207 cf/lb)      8401
  specific volume, saturated vapor: 5.2 L/kg (0.0833 cf/lb)      8401
  velocity of sound, saturated liquid: 341 m/s (1119 ft/s)      8401
  velocity of sound, saturated vapor: 198 m/s (649 ft/s)      8401
  viscosity, saturated liquid: 67 µPa·s (0.067 cp)      8401
  viscosity, saturated vapor: 17.3 µPa·s (0.0173 cp)      8401

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

thermal conductivity, saturated liquid:	0.0712 W/m·K (0.0412 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, saturated vapor:	0.01894 W/m·K (0.01094 Btu/hr·ft <sup>2</sup> ·°F)	8401
· critical point -----		
temperature:	31.1 °C (87.9 °F)	3209
pressure:	7384 kPa (1071.0 psia)	8401
density:	469 kg/m <sup>3</sup> (29.2 lb/cf)	8401
specific volume:	2.13 L/kg (0.0342 cf/lb)	8401
<b>ENVIRONMENTAL</b>		
average atmospheric lifetime (τ <sub>atm</sub> ):	variable: >50 yr	6694
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	1 relative to CO <sub>2</sub> for 100 yr integration	9501
HGWP (halocarbon GWP):	0.00076 relative to R 11 for infinite integration period	6307
<b>SAFETY</b>		
· classification -----		
safety group (ASHRAE Standard 34):	A1	8601
NFPA 704 degrees of hazard (H-F-R-S):	ARI recommendation: 2-0-0	3A15
	Amerex: 1-0-0	MSDS
	BOC Gases: 1-0-0	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	Amerex: 1-0-0	MSDS
	BOC Gases: 1-0-0	MSDS
	DuPont: 1-0-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	5(a) in absence of flame or hot objects	4B64
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	40,000 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	50,000 ppm v/v for 30 min	3903
NIOSH STEL (short-term exposure limit):	30,000 ppm v/v TWA for 15 min	3903
ACGIH TLV-STEEL (short-term exp limit):	30,000 ppm v/v TWA for 15 min	9504
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 10000 ppm v/v momentary 60 min	5561
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	5,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommended exposure limit):	5,000 ppm v/v TWA for 10 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	5,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	5,000 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk being examined for changes	5561 7101
· emergency exposure limit -----		
Refrigerant Concentration Limit (RCL):	40,000 ppm v/v (preliminary value under review, based on draft ASHRAE 34aa)	
· acute (short-term) toxicity -----		
LCLo (lethal concentration, lowest):	human, 5 min: 90,000 ppm (published fatal concentration)	6283

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## Refrigerant Database

· flammability -----	to one or more humans)	
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
flash point:	none (nonflammable as tested)	3903
autoignition temperature:	BOC Gases: none	MSDS
autodecomposition temperature:	BOC Gases: 1700 °C (3092 °F)	MSDS
· detection -----		
appearance:	colorless	6280
odor:	odorless	5141
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1869 by T. S. C. Lowe	2113
last year production allowed:	unrestricted	8C01







## R-746 (nitrogen dioxide)

```
----- REFRIGERANT DATA SUMMARY -----
R-746      nitrogen dioxide      see
inorganic  NO2                  CAS number 10102-44-0      RDB#
-----
```

**IDENTIFIERS**

```

common name(s): R-746; R746; R 746
alternative chemical names/formulae: nitrogen dioxide
                                       nitrogen oxide
                                       nitrogen peroxide
                                       dinitrogen tetroxide
                                       nitrogen tetroxide, NTO
CAS number: 10102-44-0 Chemical Abstracts
Service Registry Number
NIOSH RTECS number: QW9800000 (Registry of Toxic
Effects of Chemical
Substances)
```

**PHYSICAL**

```

· properties -----
molar mass: 46.00554 g/mol (0.101425      8820
lb/mol)
normal freezing/melting/triple point: -9.4 °C (15.1 °F)      3903
· normal boiling point -----
temperature: 21.1 °C (70.0 °F)      3903
```

**ENVIRONMENTAL**

```
ODP (ozone depletion potential): 0.000 (model-derived relative
to R 11)
```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34): none (no application pending) 8601
NFPA 704 degrees of hazard (H-F-R-S): BOC Gases: 3-0-0      MSDS
health-flammability-reactivity
[-special]: 0=no, 4=severe
NPCA HMIS hazard ratings (H-F-R): BOC Gases: 3-0-0      MSDS
health-flammability-reactivity
0=insignificant, 4=extreme
ACGIH carcinogenicity category: A4, not classifiable as a      9504
human carcinogen
· occupational exposure warnings -----
substance under study: ACGIH      8810
· short-term occupational limit -----
NIOSH IDLH (immediately dangerous): 20 ppm v/v      5204
NIOSH SCP IDLH (immediately dangerous): 50 ppm v/v for 30 min      3903
NIOSH STEL (short-term exposure limit): 1 ppm v/v TWA for 15 min      3903
ACGIH TLV-STEL (short-term exposure limit): 5 ppm v/v TWA for 15 min      9504
· occupational exposure limit -----
OSHA PEL-C (exposure ceiling): 5 ppm v/v (must not exceed)      3904
MAK (maximum workplace concentration): I: 10 ppm v/v momentary for 5      5561
min
· long-term occupational limit -----
ACGIH TLV-TWA (time-weighted average): 3 ppm v/v TWA for 8 hr/day and      9504
```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	40 hr/wk	
MAK (maximum workplace concentration):	5 ppm v/v TWA for 8 hr/day 40	5561
	(or 42) hr/wk	
	being examined for changes	7101
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 30 min: 258 mg/m3 = 135	6278
	ppm (fatal concentration by	
	inhalation for half of test	
	animals)	
	rat, 4 hr, BOC Gases: 88 ppm	MSDS
	(fatal concentration by	
	inhalation for half of test	
	animals)	
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
	flash point: none (nonflammable as tested)	3903
	autoignition temperature: BOC Gases: none	MSDS
· detection -----		
	appearance: BOC Gases: reddish-brown gas	MSDS
	BOC Gases: yellow-brown liquid	MSDS
	odor: BOC Gases: acrid, suffocating	MSDS
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01

## R-748 (ozone)

## ----- REFRIGERANT DATA SUMMARY -----

R-748	ozone		see
inorganic	O3	CAS number 10028-15-6	RDB#
			----

**COMMON USE(S)**

not used as a refrigerant

stratospheric ozone absorbs harmful ultraviolet B (UV-B) radiation (part of sunlight); chlorine- and bromine-containing refrigerants are being phased out to protect the stratospheric ozone layer

although not flammable, ozone is a powerful oxidizer that attacks many materials, both organic and inorganic

**IDENTIFIERS**

common name(s):	R-748; R748; R 748
	odd oxygen
	triatomic oxygen
chemical name (by IUPAC convention):	ozone
alternative chemical names/formulae:	O3
	CAS number: 10028-15-6 Chemical Abstracts
	Service Registry Number
NIOSH RTECS number:	RS8225000 (Registry of Toxic
	Effects of Chemical
	Substances)

**PHYSICAL**

· properties -----		
	molar mass:	47.9982 g/mol (0.105818 lb/mol) 8820
	normal freezing/melting/triple point:	-192.8 °C (-315.0 °F) 3903
· normal boiling point -----		
	temperature:	-111.7 °C (-169.1 °F) 3903
· critical point -----		
	temperature:	-12.1 °C (10.2 °F) CRC
	pressure:	5532 kPa (802.4 psia) CRC
	density:	437 kg/m3 (27.3 lb/cf) CRC
	specific volume:	2.29 L/kg (0.0367 cf/lb) CRC

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)
----------------------------------	--

**SAFETY**

· classification -----		
	safety group (ASHRAE Standard 34):	none (no application pending) 8601
	ACGIH carcinogenicity category:	A4, not classifiable as a human carcinogen 9504
· occupational exposure warnings -----		
	substance under study:	ACGIH 8810
· short-term occupational limit -----		
	NIOSH IDLH (immediately dangerous):	5 ppm v/v 5204
	NIOSH SCP IDLH (immediately dangerous):	10 ppm v/v for 30 min 3903

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

Refrigerant Database

- occupational exposure limit -----
  - NIOSH REL-C (exposure ceiling): 0.1 ppm v/v (must not exceed) 3903
  - MAK (maximum workplace concentration): I: 0.2 ppm v/v momentary for 5 5561 min
  
- long-term occupational limit -----
  - OSHA PEL (permissible exposure limit): 0.1 ppm v/v TWA for 8 hr/day 3904 and 40 hr/wk
  - ACGIH TLV-TWA (time-weighted average):
    - light work, 0.10 ppm v/v 9504
    - TWA for 8 hr/day and 40 hr/wk moderate work, 0.08 ppm v/v 9504
    - TWA for 8 hr/day and 40 hr/wk heavy work, 0.05 ppm v/v 9504
    - TWA for 8 hr/day and 40 hr/wk
  - MAK (maximum workplace concentration):
    - 0.2 ppm v/v TWA for ≤2 hr 9504
    - 0.1 ppm v/v TWA for 8 hr/day 5561
    - 40 (or 42) hr/wk
  
- emergency exposure limit -----
  - NRC EEGL (emergency exposure level):
    - 1 hr: 1 ppm v/v ceiling 7413
    - guidance level for single emergency exposures
    - 24 hr: 0.1 ppm v/v ceiling 7413
    - guidance level for single emergency exposures
  
- special-purpose exposure control ---
  - NRC CEGL (continuous exposure level):
    - 90 day: 0.02 ppm v/v ceiling 7413
    - guidance for prolonged exposure in closed environments
  
- flammability -----
  - LFL-UFL (flammability limits in air): none (nonflammable as tested) 3903
  - flash point: none (nonflammable as tested) 3903
  
- detection -----
  - appearance: bluish gas or blue liquid 7413
  - odor: characteristic 7413
  
- PRODUCTION**
  - last year production allowed: unrestricted 8C01

## R-764 (sulfur dioxide)

## ----- REFRIGERANT DATA SUMMARY -----

R-764	sulfur dioxide		see
inorganic	SO2	CAS number 7446-09-5	RDB#

**COMMON USE(S)**

one of the earliest refrigerants in commercial and industrial refrigeration, first introduced in 1875 and still in use, though not commonly; widely used in refrigerators from 1911 to 1936 and less commonly into the 1940s; displaced because of its high toxicity and sharp odor, temporarily by refrigerants 40 and 611 in the late 1920s and early 1930s and eventually by refrigerant 12 in the mid-1930s through the 1940s; environmental pollutant resulting from burning of materials containing sulfur

**IDENTIFIERS**

common name(s):	R-764; R764; R 764	
chemical name (by IUPAC convention):	sulfur dioxide	
alternative chemical names/formulae:	sulfur oxide	
	SO2	
	not recommended: O2S	
CAS number:	7446-09-5	Chemical Abstracts Service Registry Number
EINECS number:	231-195-2	(European Inventory of Existing Chemical Substances)
Merck Index (volume-number):	11-8950	
NIOSH RTECS number:	WS4550000	(Registry of Toxic Effects of Chemical Substances)
historical name(s):	anhydrous sulphurous acid	2113
	anhydrous sulphurous oxide	2113
	bisulfite	
	sulfurous oxide	
	sulphurous anhydride	2113

**PHYSICAL**

· properties -----		
	molar mass:	64.0648 g/mol (0.141239 lb/mol) 8820
	normal freezing/melting/triple point:	-75.5 °C (-103.9 °F) 0036
· normal boiling point -----		
	temperature:	-10.0 °C (14.0 °F) 0036
	heat of vaporization:	388.6 kJ/kg (167.1 Btu/lb) 0036
· critical point -----		
	temperature:	157.5 °C (315.5 °F) 0036
	pressure:	7875 kPa (1142.2 psia) 0036
	density:	524 kg/m3 (32.7 lb/cf) 0036
	specific volume:	1.91 L/kg (0.0306 cf/lb) 0036

**ENVIRONMENTAL**

ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)
----------------------------------	--

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	B1	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 3-0-0	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 3-0-1	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	1 in absence of flame or hot	4B64
	objects	
ACGIH carcinogenicity category:	A4, not classifiable as a	9504
	human carcinogen	
· occupational exposure warnings -----		
substance under study:	ACGIH	8810
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	100 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	100 ppm v/v for 30 min	3903
NIOSH STEL (short-term exposure limit):	5 ppm v/v TWA for 15 min	3903
ACGIH TLV-STEEL (short-term exposure limit):	5 ppm v/v TWA for 15 min	9504
· occupational exposure limit -----		
MAK (maximum workplace concentration):	I: 4 ppm v/v momentary for 5	5561
	min	
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	5 ppm v/v TWA for 8 hr/day and	3904
	40 hr/wk	
NIOSH REL (recommended exposure limit):	2 ppm v/v TWA for 10 hr/day	3903
	and 40 hr/wk	
ACGIH TLV-TWA (time-weighted average):	2 ppm v/v TWA for 8 hr/day and	9504
	40 hr/wk	
MAK (maximum workplace concentration):	2 ppm v/v TWA for 8 hr/day 40	5561
	(or 42) hr/wk	
	being examined for changes	7101
· emergency exposure limit -----		
NRC EEGL (emergency exposure level):	10 min: 30 ppm v/v ceiling	7214
	guidance level for single	
	emergency exposures	
	30 min: 20 ppm v/v ceiling	7214
	guidance level for single	
	emergency exposures	
	60 min: 10 ppm v/v ceiling	7214
	guidance level for single	
	emergency exposures	
	24 hr: 5 ppm v/v ceiling	7214
	guidance level for single	
	emergency exposures	
AIHA ERPG-3 (life-threatening):	15 ppm v/v for 1 hr	4B78
AIHA ERPG-2 (injurious or impairing):	3 ppm v/v for 1 hr	4B78
AIHA ERPG-1 (odor or mild effects):	0.3 ppm v/v for 1 hr	4B78
· special-purpose exposure control ---		
NRC CEGL (continuous exposure level):	90 day: 1 ppm v/v ceiling	7214
	guidance for prolonged	
	exposure in closed	
	environments	
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 1 hr: 2,520 ppm (fatal	5340
	concentration by inhalation	
	for half of test animals)	
respiratory RD50 (response dose 50%):	mouse: 117 ppm v/v (50%	6279

	decrease in respiratory rate in test animals)	
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	0036
flash point:	none (nonflammable as tested)	3903
autoignition temperature:	>750 °C (>1382 °F)	5906
	BOC Gases: none	MSDS
· detection -----		
appearance:	colorless	7414
odor:	BOC Gases: highly irritating	MSDS
	BOC Gases: pungent	MSDS
	strong suffocating odor	7414
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	~1875 by R. Pictet	2113
last year production allowed:	unrestricted	8C01



## R-771 (nitrogen trifluoride)

```

----- REFRIERANT DATA SUMMARY -----
R-771      nitrogen trifluoride      see
inorganic  NF3                      CAS number 7783-54-2      RDB#
-----

```

**COMMON USE(S)**

considered as a refrigerant for ultra-low temperature refrigeration; use is constrained by toxicity concerns and by reactivity with other materials in fires, above 1,000 °C (1,832 °F)

**IDENTIFIERS**

```

common name(s):  R-771; R771; R 771
chemical name (by IUPAC convention):  nitrogen trifluoride
alternative chemical names/formulae:  nitrogen fluoride
                                       trifluoroamine
                                       perfluoroammonia
                                       trifluoroammonia
                                       NF3
                                       not recommended: F3N
CAS number:      7783-54-2 Chemical Abstracts
                  Service Registry Number
NIOSH RTECS number:  QX1925000 (Registry of Toxic
                       Effects of Chemical
                       Substances)
ARI container color / Pantone number:  none, use light green grey/413 6601

```

**PHYSICAL**

```

· properties -----
molar mass:      71.0019496 g/mol (0.156533      8820
                  lb/mol)
normal freezing/melting/triple point:  -206.7 °C (-340.0 °F)      5204
· normal boiling point -----
temperature:     -128.9 °C (-200.0 °F)      5204

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (τatm):  740 yr      9501
GWP (global warming potential):      10,800 relative to CO2 for 100 yr      9501
integration

```

**SAFETY**

```

· classification -----
safety group (ASHRAE Standard 34):  none (no application pending)      8601
NFPA 704 degrees of hazard (H-F-R-S):  BOC Gases: 3-0-0      MSDS
health-flammability-reactivity
[-special]: 0=no, 4=severe
NPCA HMIS hazard ratings (H-F-R):  BOC Gases: 3-0-0      MSDS
health-flammability-reactivity
0=insignificant, 4=extreme
· short-term occupational limit -----
NIOSH IDLH (immediately dangerous):  1,000 ppm v/v      5204
NIOSH SCP IDLH (immediately dangerous:  2,000 ppm v/v for 30 min      3903
· long-term occupational limit -----
OSHA PEL (permissible exposure limit):  10 ppm v/v TWA for 8 hr/day      3904
and 40 hr/wk

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

ACGIH TLV-TWA (time-weighted average):	10 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
· acute (short-term) toxicity ----- LC50 (lethal concentration, 50%):	rat, 1 hr, BOC Gases: 6,700 ppm (fatal concentration by inhalation for half of test animals)	MSDS
· flammability ----- LFL-UFL (flammability limits in air):	none (nonflammable as tested)	5204
flash point:	BOC Gases: none	MSDS
autoignition temperature:	BOC Gases: none	MSDS
· detection -----		
appearance:	colorless gas	5204
odor:	moldy odor	5204

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01







(fatal concentration by  
inhalation for half of test  
animals)

· flammability -----		
LFL-UFL (flammability limits in air):	BOC Gases: nonflammable	MSDS
flash point:	Voltaix: nonflammable	MSDS
autoignition temperature:	BOC Gases: none	MSDS
· detection -----		
appearance:	BOC Gases: colorless gas	MSDS
odor:	BOC Gases: sharp, irritating	MSDS
	Voltaix: pungent	MSDS

**PRODUCTION**

first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01

## R-7131 (xenon)

----- REFRIERANT DATA SUMMARY -----  
 R-7131 xenon see  
 inorganic Xe CAS number 7440-63-3 RDB#  
 -----

**COMMON USE(S)**

being investigated as as a single-compound refrigerant and as a blend component for thermoacoustic refrigeration; not known to be used as a commercial refrigerant; vapor-compression-cycle applications would be limited to ultra-low temperatures and would be constrained by high costs, due to its rarity, and the narrow range between the normal melting and boiling points, and high toxicity of most of its compounds

**IDENTIFIERS**

common name(s): R-7131; R7131; R 7131 9406  
 chemical name (by IUPAC convention): xenon  
 alternative chemical names/formulae: Xe  
 CAS number: 7440-63-3 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: ZE1280000 (Registry of Toxic  
 Effects of Chemical  
 Substances)

**PHYSICAL**

· properties -----  
 molar mass: 131.29 g/mol (0.289445 lb/mol) 8820  
 normal freezing/melting/triple point: -111.9 °C (-169.4 °F)  
 · normal boiling point -----  
 temperature: -107.1 °C (-160.8 °F)

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 NFPA 704 degrees of hazard (H-F-R-S): BOC Gases: 0-0-0 MSDS  
 health-flammability-reactivity  
 [-special]: 0=no, 4=severe  
 NPCA HMIS hazard ratings (H-F-R): BOC Gases: 0-0-0 MSDS  
 health-flammability-reactivity  
 0=insignificant, 4=extreme  
 · flammability -----  
 LFL-UFL (flammability limits in air): BOC Gases: none, nonflammable MSDS  
 flash point: BOC Gases: none MSDS  
 autoignition temperature: BOC Gases: none MSDS  
 · detection -----  
 appearance: BOC Gases: colorless gas MSDS  
 odor: BOC Gases: odorless MSDS

**PRODUCTION**

first commercial use as a refrigerant: not known to be commercialized

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

last year production allowed: unrestricted

8C01



## R-7146 (sulfur hexafluoride)

----- REFRIGERANT DATA SUMMARY -----  
 R-7146 sulfur hexafluoride see  
 inorganic SF6 CAS number 2551-62-4 RDB#  
 -----

**COMMON USE(S)**

experimental use in the 1930's both as a single compound and blend component; dielectric fluid in high-voltage power applications including circuit breakers, switchgear, transformers, coaxial cables, waveguides, capacitors, and others; used in magnesium production, as a tracer gas, in chemical lasers, in shock absorbers, in loud speakers, and other applications

**IDENTIFIERS**

common name(s): R-7146; R7146; R 7146 9406  
 chemical name (by IUPAC convention): sulfur hexafluoride  
 alternative chemical names/formulae: sulfur fluoride  
 sulfur perfluoride  
 SF6  
 not recommended: F6S  
 CAS number: 2551-62-4 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: WS4900000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): NIPK (Russia) Elegas 7930  
 NIPK (Russia) Elegaz 7930

**PHYSICAL**

· properties -----  
 molar mass: 146.0564192 g/mol (0.321999 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: -63.5 °C (-82.4 °F) 7809  
 -63.8 °C (-82.8 °F) 1136  
 · normal pressure, 21.1 °C (70 °F) ---  
 density, vapor: 6.139 kg/m3 (0.3832 lb/cf) 5A35  
 · critical point -----  
 temperature: 45.6 °C (114.0 °F) 5A40  
 pressure: 3761 kPa (545.5 psia) 1136  
 density: 735 kg/m3 (45.9 lb/cf) 1136  
 specific volume: 1.36 L/kg (0.0217 cf/lb) 5A40

**ENVIRONMENTAL**

average atmospheric lifetime (τ<sub>atm</sub>): 3200 yr 6694  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)  
 GWP (global warming potential): 22,200 relative to CO<sub>2</sub> for 100 9501  
 yr integration  
 HGWP (halocarbon GWP): 173 relative to R 11 for DW  
 infinite integration period

**SAFETY**

· classification -----

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

safety group (ASHRAE Standard 34):	none (no application pending)	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 2-0-0	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 0-0-0	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
· occupational exposure warnings -----		
NIOSH caution:	may contain highly toxic	5204
	sulfur pentafluoride impurity	
· occupational exposure limit -----		
MAK (maximum workplace concentration):	IV: 2,000 ppm v/v momentary	60 5561
	min	
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	1,000 ppm v/v TWA for 8 hr/day	3904
	and 40 hr/wk	
NIOSH REL (recommendd exposure limit):	1,000 ppm v/v TWA for 10	5204
	hr/day and 40 hr/wk	
ACGIH TLV-TWA (time-weighted average):	1,000 ppm v/v TWA for 8 hr/day	9504
	and 40 hr/wk	
MAK (maximum workplace concentration):	1,000 ppm v/v TWA for 8 hr/day	5561
	40 (or 42) hr/wk	
	being examined for changes	7101
· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 2 hr: >800,000 ppm (fatal	5169
	concentration by inhalation	
	for half of test animals)	
LD50 (lethal dosage, 50%):	intravenous,rabbit,AlSig: 5790	MSDS
	mg/kg (fatal dose for half of	
	test animals)	
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	2525
	flash point:	none (nonflammable as tested)
	autoignition temperature:	BOC Gases: none
	autodecomposition temperature:	BOC Gases: 204 °C (400 °F)
· detection -----		
	appearance:	colorless gas
	odor:	odorless
		5A35
		5A35
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01



**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
IARC/CIRC human carcinogenicity group:	2A, probably carcinogenic	8802
NIOSH caution:	potential occupational	3903
	carcinogen (limit exposures to lowest feasible)	
ACGIH carcinogenicity category:	A3, animal carcinogen	9504
DFG carcinogenicity class:	IIIB: suspect, to be evaluated	5561
DFG pregnancy risk group:	C (no risk fear below MAK/BAT)	7101
· short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	150 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	500 ppm v/v for 30 min	3903
ACGIH TLV-STEL (short-term exp limit):	100 ppm v/v TWA for 15 min	9504
· occupational exposure limit -----		
OSHA PEL-C (exposure ceiling):	200 ppm v/v (must not exceed)	3904
OSHA acceptable maximum peak:	300 ppm for 5 min in 3 hr	3904
	(peak allowed over ceiling for specified interval)	
MAK (maximum workplace concentration):	II, 1: 100 ppm v/v avg for 30 min	5561
· long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
ACGIH TLV-TWA (time-weighted average):	25 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	50 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	5561
	being examined for changes	7101
· emergency exposure limit -----		
AIHA ERPG-3 (life-threatening):	1,000 ppm v/v for 1 hr	9503
AIHA ERPG-2 (injurious or impairing):	200 ppm v/v for 1 hr	9503
AIHA ERPG-1 (odor or mild effects):	100 ppm v/v for 1 hr	9503
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	4 hr: 5,200 ppm (lowest exposure tested with one or more deaths by inhalation)	6452
	rat, 4 hr: 4,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
	dog, 10 min, 0/12: 10,400 ppm v/v (no observed effect level in test animals)	65A0
	anesthetic concentration:	
	11 min: 3,400 ppm v/v	6452
· flammability -----		
LFL-UFL (flammability limits in air):	none (nonflammable as tested)	3903
flash point:	none (nonflammable as tested)	3903

**PRODUCTION**

    last year production allowed: unrestricted (short lifetime) 8C01











## Refrigerant Database

safety group (ASHRAE Standard 34):	none (no application pending)	8601
NFPA 704 degrees of hazard (H-F-R-S):	AlliedSignal: 4-4-0	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	AlliedSignal: 4-4-0	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
• long-term occupational limit -----		
AIHA WEEL (workplace envl exp limit):	5 ppm v/v TWA for 8 hr/day and 40 hr/wk	4B85
exposure limit consistent to OSHA PEL:	AlliedSignal PEL: 5 ppm v/v	
	TWA for 8 hr/day and 40 hr/wk	
• emergency exposure limit -----		
AIHA ERPG-3 (life-threatening):	300 ppm v/v for 1 hr	4B81
AIHA ERPG-2 (injurious or impairing):	100 ppm v/v for 1 hr	4B81
AIHA ERPG-1 (odor or mild effects):	20 ppm v/v for 1 hr	4B81
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 4 hr, AlliedSignal: 1,000 ppm (fatal concentration by inhalation for half of test animals)	MSDS
	rat, 4 hr: 1,000 ppm (fatal concentration by inhalation for half of test animals)	5169
	rat, 4 hr: 4,000 ppm (fatal concentration by inhalation for half of test animals)	5643
anesthetic/CNS effect LOEL:	mouse, 1 min: 480,000 ppm v/v (lowest observed effect level in test animals)	5939
• flammability -----		
LFL-UFL (flammability limits in air):	14.2-43.7 % v/v	4B10
autodecomposition temperature:	AlliedSignal: >250°C (>482°F)	MSDS
• detection -----		
appearance:	colorless gas	4B10
odor:	faint ethereal	4B10





ACGIH carcinogenicity category:	A5, not suspected as a human carcinogen	9504
DFG carcinogenicity class:	IIIA1: carcinogenic in humans	7101
• short-term occupational limit -----		
NIOSH IDLH (immediately dangerous):	1,000 ppm v/v	5204
NIOSH SCP IDLH (immediately dangerous):	1,000 ppm v/v for 30 min	3903
ACGIH TLV-STEL (short-term exp limit):	100 ppm v/v TWA for 15 min	9504
• occupational exposure limit -----		
OSHA PEL-C (exposure ceiling):	200 ppm v/v (must not exceed)	3904
OSHA acceptable maximum peak:	300 ppm for 5 min in 2 hr (peak allowed over ceiling for specified interval)	3904
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	100 ppm v/v TWA for 8 hr/day and 40 hr/wk	3904
NIOSH REL (recommendd exposure limit):	25 ppm v/v TWA for 10 hr/day and 40 hr/wk	5204
ACGIH TLV-TWA (time-weighted average):	50 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
• emergency exposure limit -----		
AIHA ERPG-3 (life-threatening):	5,000 ppm v/v for 1 hr	9503
AIHA ERPG-2 (injurious or impairing):	500 ppm v/v for 1 hr	9503
AIHA ERPG-1 (odor or mild effects):	100 ppm v/v for 1 hr	9503
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 15 min: >68,000 ppm (fatal concentration by inhalation for half of test animals)	6110
ALC (approximate lethal concentration):	4 hr: 5,000 ppm (lowest exposure tested with one or more deaths by inhalation)	6452
	rat, 4 hr: 8,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
cardiac sensitization (CS) EC50:	dog, 5 min: 7,000 ppm v/v (effective concentration in half of test animals)	6110
cardiac sensitization threshold/LOEL:	dog, 10 min, 1/12: 4,500 ppm v/v (lowest observed effect level in test animals)	65A0
anesthetic/CNS effect EC50:	rat, 10 min: depressant 4,000 ppm v/v (effective concentration in half of test animals)	6110
anesthetic concentration:	human, 2 hr: 1,000 ppm v/v	6452
• flammability -----		
LFL-UFL (flammability limits in air):	8-10.5 % v/v	3903
LFL (lower flammability limit in air):	8.3 % v/v	5A33
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1925 by W. H. Carrier	4147
last year production allowed:	unrestricted (short lifetime)	8C01















	min	
· long-term occupational limit -----		
ACGIH TLV-TWA (time-weighted average):	200 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	200 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk being examined for changes	7101 7101
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat: 32,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
oral LD50 (lethal dosage, 50%):	rat: 770 mg/kg (fatal dose by ingestion for half of test animals)	5340
· flammability -----		
LFL-UFL (flammability limits in air):	5.6-11.4 % v/v 5.6-12.8 % v/v	0036 3903
flash point:	2.2-3.9 °C (36-29 °F)	5204
autoignition temperature:	458 °C (856 °F)	4B64
· detection -----		
appearance:	colorless liquid	5340
odor:	slightly acrid, chloroform- like odor	5340
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	1922 by W. H. Carrier	4147

## R-1130a

```

----- REFRIERANT DATA SUMMARY -----
R-1130a      1,1-dichlororoethene      see
HCC          CH2=CCl2                  CAS number 75-35-4      RDB#
-----

```

**COMMON USE(S)**

intermediate in production of polymeric plastics for films and coatings; uses constrained by potential carcinogenicity

**IDENTIFIERS**

```

common name(s):  R-1130a; R1130a; R 1130a
                  HCC-1130a
chemical name (by IUPAC convention):  1,1-dichloroethene
alternative chemical names/formulae:  1,1-dichloroethylene; 1,1-DCE
ethene, 1,1-dichloro-
asym-dichloroethylene
asymmetrical dichloroethylene
dichloroacetylene
ethylidene chloride
vinylidene chloride
vinylidene dichloride; VDC
CH2=CCl2; CH2CCl2
empirical formula:  C2H2Cl2
CAS number:        75-35-4 Chemical Abstracts
                  Service Registry Number
EINECS number:     200-864-0 (European Inventory
of Existing Chemical
Substances)
NIOSH RTECS number:  KV9275000 (Registry of Toxic
Effects of Chemical
Substances)

```

**PHYSICAL**

```

· properties -----
molar mass:      96.94268 g/mol (0.213722      8820
                  lb/mol)
normal freezing/melting/triple point:  -122.1 °C (-187.8 °F)      2250
· normal boiling point -----
temperature:     31.6 °C (88.9 °F)            2250
                  37.0 °C (98.6 °F)            7601
· critical point -----
temperature:     230.1 °C (446.2 °F)          2250
pressure:       7080 kPa (1026.9 psia)        2250
density:        530 kg/m3 (33.1 lb/cf)        2250
specific volume: 1.89 L/kg (0.0302 cf/lb)     2250

```

**SAFETY**

```

· classification -----
NIOSH caution:   potential occupational      3903
                  carcinogen (limit exposures to
                  lowest feasible)
ACGIH carcinogenicity category:  A4, not classifiable as a      9504
                  human carcinogen
DFG carcinogenicity class:      IIIB: suspect, to be evaluated 7101

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	being examined for changes	7101
DFG pregnancy risk group:	C (no risk fear below MAK/BAT)	7101
• occupational exposure limit -----		
MAK (maximum workplace concentration):	II, 1: 4 ppm v/v avg for 30 min	7101
• long-term occupational limit -----		
ACGIH TLV-TWA (time-weighted average):	5 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
MAK (maximum workplace concentration):	2 ppm v/v TWA for 8 hr/day 40 (or 42) hr/wk	7101
• emergency exposure limit -----		
NRC EEGL (emergency exposure level):	24 hr: 10 ppm v/v ceiling guidance level for single emergency exposures	7414
• special-purpose exposure control ---		
NRC CEGL (continuous exposure level):	90 day: 0.15 ppm v/v ceiling guidance for prolonged exposure in closed environments	7214
• acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr: 32,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5643
• flammability -----		
LFL-UFL (flammability limits in air):	6.5-15.5 % v/v	2250
flash point:	-10 °C (14 °F)	7214
	-19 °C (-2 °F)	5204
	-23 °C (-9 °F)	2250
• detection -----		
appearance:	colorless	7414
odor:	mild sweet odor	7414

## R-1130c

```

----- REFRI GERANT DATA SUMMARY -----
R-1130c      cis-1,2-dichloroethene      see
HCC          CHCl=CHCl                   RDB#
          CAS number 156-59-2
-----

```

**IDENTIFIERS**

```

          common name(s):  R-1130c; R1130c; R 1130c
                          HCC-1130c
alternative chemical names/formulae:  cis-1,2-dichloroethylene
                                      cis-acetylene dichloride
                                      Z-1,2-dichloroethene
                                      CHCl=CHCl; CHClCHCl; (CHCl)2
empirical formula:          C2H2Cl2
CAS number:                156-59-2 Chemical Abstracts
                          Service Registry Number
EINECS number:            205-859-7 (European Inventory
                          of Existing Chemical
                          Substances)
NIOSH RTECS number:      KV9420000 (Registry of Toxic
                          Effects of Chemical
                          Substances)

```

**PHYSICAL**

```

· properties -----
          molar mass:  96.94268 g/mol (0.213722      8820
                          lb/mol)
normal freezing/melting/triple point:  -80.5 °C (-112.9 °F)      7601
· normal boiling point -----
          temperature: 60.3 °C (140.5 °F)          7601
· critical point -----
          temperature: 234.1 °C (453.4 °F)        2250
          pressure:   5191 kPa (752.9 psia)        2250
          density:    452 kg/m3 (28.2 lb/cf)       2250
          specific volume: 2.21 L/kg (0.0354 cf/lb) 2250

```

**SAFETY**

```

· long-term occupational limit -----
  ACGIH TLV-TWA (time-weighted average): 200 ppm v/v TWA for 8 hr/day 9504
                                          and 40 hr/wk
· acute (short-term) toxicity -----
  ALC (approximate lethal concentration): rat, 4 hr: >8,000 and <16,000 5340
                                          ppm (lowest exposure tested
                                          with one or more deaths by
                                          inhalation)
          anesthetic/CNS effect LOEL:  rat, 8 min: 16,000 ppm v/v      5340
                                          (lowest observed effect level
                                          in ALC or LC50 studies)
· flammability -----
  LFL-UFL (flammability limits in air):  3.3-15.0 % v/v          2250
          flash point: 6 °C (43 °F)          2250
· detection -----
          appearance:  colorless liquid          5340

```

## Refrigerant Database

## R-1130t

```

----- REFRIGERANT DATA SUMMARY -----
R-1130t      trans-1,2-dichloroethene      see
HCC          CHCl=CHCl              CAS number 156-60-5      RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-1130t; R1130t; R 1130t
                 HCC-1130t
                 dioform
alternative chemical names/formulae:  trans-1,2-dichloroethylene
                                     trans-acetylene dichloride
                                     E-1,2-dichloroethene
                                     acetylene dichloride
                                     CHCl=CHCl; CHClCHCl; (CHCl)2
empirical formula:  C2H2Cl2
CAS number:        156-60-5 Chemical Abstracts
                  Service Registry Number
EINECS number:    205-860-2 (European Inventory
                  of Existing Chemical
                  Substances)
NIOSH RTECS number:  KV9400000 (Registry of Toxic
                  Effects of Chemical
                  Substances)

```

**PHYSICAL**

```

· properties -----
molar mass:      96.94268 g/mol (0.213722      8820
                 lb/mol)
normal freezing/melting/triple point:  -50.0 °C (-58.0 °F)      7601
· normal boiling point -----
temperature:     47.5 °C (117.5 °F)           7601
· critical point -----
temperature:     234.1 °C (453.4 °F)         2250
pressure:        5190 kPa (752.7 psia)       2250
density:         452 kg/m3 (28.2 lb/cf)      2250
specific volume: 2.21 L/kg (0.0354 cf/lb)    2250

```

**SAFETY**

```

· long-term occupational limit -----
ACGIH TLV-TWA (time-weighted average): 200 ppm v/v TWA for 8 hr/day      9504
and 40 hr/wk
· acute (short-term) toxicity -----
LC50 (lethal concentration, 50%):  mouse, 6 hr: 21,723 ppm (fatal      5340
concentration by inhalation
for half of test animals)
ALC (approximate lethal concentration):  rat, 4 hr: ~ >4,000 and <8,000      5340
ppm (lowest exposure tested
with one or more deaths by
inhalation)
oral LD50 (lethal dosage, 50%):  rat: 1,275 mg/kg (fatal dose      5340
by ingestion for half of test
animals)
· flammability -----
LFL-UFL (flammability limits in air):  9.7-12.8 % v/v           2250

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

· detection -----	flash point: 2 °C (36 °F)	2250
	appearance: colorless liquid	5340





## R-1131a

----- REFRIGERANT DATA SUMMARY -----  
 R-1131a      1-chloro-1-fluoroethene      see  
 HCFC      CH<sub>2</sub>=CClF      CAS number 2317-91-1      RDB#  
 -----

**COMMON USE(S)**

decomposition product of refrigerant (and blowing agent) 141b; not known to be used commercially

**IDENTIFIERS**

common name(s): R-1131a; R1131a; R 1131a  
 HCFC-1131a  
 chlorofluoroethene  
 chemical name (by IUPAC convention): 1-chloro-1-fluoroethene  
 alternative chemical names/formulae: ethene, 1-chloro-1-fluoro-  
 1-chloro-1-fluoroethylene  
 CH<sub>2</sub>=CClF; CH<sub>2</sub>CClF  
 empirical formula: C<sub>2</sub>H<sub>2</sub>ClF  
 CAS number: 2317-91-1 Chemical Abstracts  
 Service Registry Number  
 EINECS number: 219-027-6 (European Inventory  
 of Existing Chemical  
 Substances)  
 historical name(s): Allied Corp refrigerant 51

**PHYSICAL**

· properties -----  
    molar mass: 80.4883832 g/mol (0.177447      8820  
    lb/mol)  
 normal freezing/melting/triple point: -169.0 °C (-272.2 °F)      1136  
 · normal boiling point -----  
    temperature: -24.0 °C (-11.2 °F)      1136  
    -25.0 °C (-13.0 °F)      7601

**SAFETY**

· classification -----  
     safety group (ASHRAE Standard 34): none (no application pending)      8601  
 · long-term occupational limit -----  
 exposure limit consistent to OSHA PEL: AlliedSignal PEL: 10 ppm v/v  
    TWA for 8 hr/day and 40 hr/wk  
 · flammability -----  
 LFL-UFL (flammability limits in air): flammable      LPCR





## Refrigerant Database

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)  
 GWP (global warming potential): 1.7 relative to CO2 for 100 yr 7849 integration

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601  
 ACGIH carcinogenicity category: A4, not classifiable as a human carcinogen 9504  
     DFG carcinogenicity class: IIIIB: suspect, to be evaluated 5561

· occupational exposure limit -----  
 NIOSH REL-C (exposure ceiling): 5 ppm v/v (must not exceed) 5204

· long-term occupational limit -----  
 NIOSH REL (recommended exposure limit): 1 ppm v/v TWA for 10 hr/day and 40 hr/wk 5204  
 ACGIH TLV-TWA (time-weighted average): 500 ppm v/v TWA for 8 hr/day and 40 hr/wk 9504  
 exposure limit consistent to OSHA PEL: Solvay SAEL: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk 7849  
 being examined for changes 7101

MAK (maximum workplace concentration):  
 · acute (short-term) toxicity -----  
 ALC (approximate lethal concentration: rat, 30 min: >800,000 ppm (lowest exposure tested with one or more deaths by inhalation) 5147  
     rat, 4 hr: 128,000 ppm (lowest exposure tested with one or more deaths by inhalation) 5643

    anesthetic/CNS effect LOEL: rat, 30 min: 400,000 ppm v/v (lowest observed effect level in test animals) 5147  
     anesthetic/CNS effect NOEL: rat, 30 min: 300,000 ppm v/v (no observed effect level in test animals) 5147

· flammability -----  
 LFL-UFL (flammability limits in air): 4.7-25.1 % v/v 7849  
     5.5-21.3 % v/v 5204  
     flash point: not applicable for gas 5204

**PRODUCTION**

last year production allowed: unrestricted 8C01

## R-1140

## ----- REFRIGERANT DATA SUMMARY -----

R-1140	chloroethene		see
HCC	CH <sub>2</sub> =CHCl	CAS number 75-01-4	RDB#

-----

**COMMON USE(S)**

consideration impeded by carcinogenicity and flammability; also impeded by chlorine content and consequent restrictions to protect the stratospheric ozone layer; intermediate to manufacture polymers

**IDENTIFIERS**

common name(s):	R-1140; R1140; R 1140 HCC-1140
chemical name (by IUPAC convention):	chloroethene
alternative chemical names/formulae:	1-chloroethene ethene, chloro- ethene, 1-chloro- ethylene, 1-chloro- ethylene monochloride vinyl C monomer, VCM vinyl chloride monomer, VCM vinyl chloride, VC 1-chloroethylene chloroethylene monochloroethene monochloroethylene CH <sub>2</sub> =CHCl; CH <sub>2</sub> CHCl
empirical formula:	C <sub>2</sub> H <sub>3</sub> Cl
CAS number:	75-01-4 Chemical Abstracts Service Registry Number
EINECS number:	200-831-0 (European Inventory of Existing Chemical Substances)
NIOSH RTECS number:	KU9625000 (Registry of Toxic Effects of Chemical Substances)
ARI container color / Pantone number:	none, use light green grey/413 6601 with red / 185 band

**PHYSICAL**

· properties -----		
	molar mass:	62.49792 g/mol (0.137784 lb/mol) 8820
	normal freezing/melting/triple point:	-155.7 °C (-248.3 °F) 4A73 -159.7 °C (-255.5 °F) 7601 -160.0 °C (-256.0 °F) 3903
· normal boiling point -----		
	temperature:	-13.9 °C (7.0 °F) 7601
· 20 °C (68 °F) -----		
	pressure, saturated vapor:	344.0 kPa (49.89 psia) 4A73

**SAFETY**

· classification -----		
	safety group (ASHRAE Standard 34):	none (no application pending) 9710

## Refrigerant Database

UL Comparative Hazard to Life Group:	4-5 by estimate (not UL test) in absence of flame or hot objects	5854
IARC/CIRC human carcinogenicity group:	1, carcinogenic to humans	8802
NIOSH caution:	potential occupational carcinogen (limit exposures to lowest feasible)	3903
ACGIH carcinogenicity category:	A1, confirmed human carcinogen	9504
DFG carcinogenicity class:	IIIA1: carcinogenic in humans	7101
• occupational exposure limit -----		
OSHA PEL-C (exposure ceiling):	5 ppm v/v for 15 min (must not exceed)	3903
• long-term occupational limit -----		
OSHA PEL (permissible exposure limit):	1 ppm v/v TWA for 8 hr/day and 40 hr/wk	3903
ACGIH TLV-TWA (time-weighted average):	1 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 15 min: 180,000 ppm (fatal concentration by inhalation for half of test animals)	6110
cardiac sensitization (CS) EC50:	dog, 5 min: 50,000 ppm v/v (effective concentration in half of test animals)	6109
cardiac sensitization threshold/LOEL:	dog, 5 min, 6/12: 50,000 ppm v/v (lowest observed effect level in test animals)	5644
cardiac sensitization (CS) NOEL:	dog, 5 min, 0/12: 25,000 ppm v/v (no observed effect level in test animals)	5644
anesthetic/CNS effect EC50:	rat, 10 min: depressant 38,000 ppm v/v (effective concentration in half of test animals)	6110
• flammability -----		
LFL-UFL (flammability limits in air):	3.6-33.0 % v/v	3903
flash point:	-78 °C (-108 °F)	4A73
autoignition temperature:	472 °C (882 °F)	4A73
• detection -----		
appearance:	colorless gas	4A73
odor:	sweet odor	4A73
odor sensing, lower threshold:	3,000 ppm v/v	4A73







· acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	rat, 4 hr: 800,000 ppm (fatal concentration by inhalation for half of test animals)	7601
ALC (approximate lethal concentration:	rat, 30 min: ≥800,000 ppm (lowest exposure tested with one or more deaths by inhalation)	5147
anesthetic/CNS effect LOEL:	rat, 30 min: 300,000 ppm v/v (lowest observed effect level in test animals)	5147
anesthetic/CNS effect NOEL:	rat, 30 min: 200,000 ppm v/v (no observed effect level in test animals)	5147
· flammability -----		
LFL-UFL (flammability limits in air):	2.6-21.7 % v/v	5204
flash point:	not applicable for gas	5204
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01

## R-1150 (ethylene)

----- REFRIERANT DATA SUMMARY -----  
 R-1150 ethene see  
 HC CH2=CH2 CAS number 74-85-1 RDB#  
 -----

**COMMON USE(S)**

extremely low temperature refrigeration, generally in the lowest stage of a multistage, cascaded system; fruit and vegetable ripening agent; important chemical intermediate to manufacture other chemicals, petrochemicals, polymers, and resins; surgical anesthetic

**IDENTIFIERS**

common name(s): R-1150; R1150; R 1150  
 HC-1150  
 bicarburetted hydrogen  
 ethylene HP  
 chemical name (by IUPAC convention): ethene  
 alternative chemical names/formulae: ethylene  
 acetene  
 CH2=CH2; CH2CH2; (CH2)2  
 empirical formula: C2H4  
 CAS number: 74-85-1 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: KU5340000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 historical name(s): acetine  
 elayl  
 elefant gas; olefant gas  
 etherin  
 ARI container color / Pantone number: none, use light green grey/413 6601  
 with red / 185 band

**PHYSICAL**

· properties -----  
 molar mass: 28.05316 g/mol (0.061847 8820  
 lb/mol)  
 normal freezing/melting/triple point: -169.1 °C (-272.5 °F) 6290  
 · normal boiling point -----  
 temperature: -103.7 °C (-154.7 °F) 0036  
 -109.4 °C (-165.0 °F) MSDS  
 heat of vaporization: 480.6 kJ/kg (206.6 Btu/lb) 3208  
 · critical point -----  
 temperature: 9.3 °C (48.7 °F) 0036  
 pressure: 5114 kPa (741.7 psia) 0036  
 density: 229 kg/m3 (14.3 lb/cf) 0036  
 specific volume: 4.37 L/kg (0.0700 cf/lb) 0036

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· classification -----

safety group (ASHRAE Standard 34):	A3	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 0-4-0	MSDS
	Phillips: 1-4-2	MSDS
	health-flammability-reactivity	
	[-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 0-4-0	MSDS
	health-flammability-reactivity	
	0=insignificant, 4=extreme	
UL Comparative Hazard to Life Group:	5(b) in absence of flame or	0036
	hot objects	
IARC/CIRC human carcinogenicity group:	3, not classifiable	8802
ACGIH carcinogenicity category:	A4, not classifiable as a	9504
	human carcinogen	
DFG carcinogenicity class:	IIIB: suspect, to be evaluated	5561
· occupational exposure warnings -----		
	ACGIH caution: simple asphyxiant	9504
· long-term occupational limit -----		
exposure limit consistent to OSHA PEL:	Exxon: 1,000 ppm v/v TWA for 8	MSDS
	hr/day and 40 hr/wk	
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 3 hr: >900,000 ppm	65B9
	(lowest exposure tested with	
	one or more deaths by	
	inhalation)	
cardiac sensitization (CS) NOEL:	dog 10 min 0/12: 100000-250000	6192
	ppm v/v (no observed effect	
	level in test animals)	
anesthetic/CNS effect LOEL:	rat, 18-20 min, 1/1: 900,000	65B9
	ppm v/v (lowest observed	
	effect level in test animals)	
anesthetic/CNS effect NOEL:	25,000 ppm v/v (no observed	6290
	effect level in test animals)	
· flammability -----		
LFL-UFL (flammability limits in air):	2.7-36 % v/v	6290
	3.0-25.0 % v/v	0036
	BOC Gases: 3.1-32 % v/v	MSDS
	DuPont: 2.7-36.0 % v/v	MSDS
	Exxon: 2.3-32.4 % v/v	MSDS
	Phillips: 2.7-28.6 % v/v	MSDS
	Texaco: 2.7-35.0 % v/v	MSDS
flash point:	-136 °C (-213 °F)	6290
autoignition temperature:	BOC Gases: 520 °C (968 °F)	MSDS
	Dupont: 490 °C (914 °F)	MSDS
	Exxon: 450 °C (842 °F)	MSDS
	Texaco: 490 °C (914 °F)	MSDS
· detection -----		
appearance:	colorless	6290
odor:	faintly sweet odor	6290
odor sensing, lower threshold:	DuPont: 400 ppm v/v	MSDS



normal freezing/melting/triple point:	-156.2 °C (-249.2 °F)	1136
• normal boiling point -----		
temperature:	-29.4 °C (-20.9 °F)	CRC
• 20 °C (68 °F) -----		
pressure, saturated vapor:	653.5 kPa (94.78 psia)	mfr
• critical point -----		
temperature:	94.9 °C (202.7 °F)	mfr
pressure:	2900 kPa (420.6 psia)	mfr
specific volume:	1.79 L/kg (0.0286 cf/lb)	mfr

**ENVIRONMENTAL**

average atmospheric lifetime (τ <sub>atm</sub> ):	5.8 days, 0.02 yr	7C31
ODP (ozone depletion potential):	0.000 (model-derived relative to R 11)	
GWP (global warming potential):	1.6 ±1.6 relative to CO <sub>2</sub> for 100 yr integration	7C31

**SAFETY**

• classification -----		
safety group (ASHRAE Standard 34):	none (no application pending)	8601
NFPA 704 degrees of hazard (H-F-R-S):	BOC Gases: 1-0-0	MSDS
	TACIP: 1-0-1	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 1-0-0	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
• occupational exposure warnings -----		
substance under study:	ACGIH	8810
• emergency exposure limit -----		
AIHA ERPG-3 (life-threatening):	500 ppm v/v for 1 hr	9503
AIHA ERPG-2 (injurious or impairing):	50 ppm v/v for 1 hr	9503
AIHA ERPG-1 (odor or mild effects):	10 ppm v/v for 1 hr	9503
• acute (short-term) toxicity -----		
LC50 (lethal concentration, 50%):	mouse, 4 hr, TACIP: 750 ppm (fatal concentration by inhalation for half of test animals)	MSDS
	rat, 4 hr: 3,000 ppm (fatal concentration by inhalation for half of test animals)	5169
• flammability -----		
LFL-UFL (flammability limits in air):	BOC Gases: none	MSDS
	TACIP: none	MSDS
flash point:	BOC Gases: none	MSDS
autoignition temperature:	BOC Gases: none	MSDS

**PRODUCTION**

last year production allowed:	unrestricted	8C01
-------------------------------	--------------	------













## R-1270 (propylene)

```

----- REFRIGERANT DATA SUMMARY -----
R-1270      propene
HC          CH3CH=CH2
              CAS number 115-07-1
              see
              RDB#
              -----

```

**COMMON USE(S)**

component of refrigerants 411A and 411B; very limited use as an industrial refrigerant; further use as a single-compound refrigerant is constrained by its flammability; aerosol propellant, alone or as a blend component; widely used feedstock to produce plastics, alcohols, gasoline, synthetic rubbers, and other chemical products; considered as an anesthetic agent in the 1920s, but not widely used due to depression of the heart function

Revision of the safety classification for this refrigerant was proposed on 1998.01.18. The revision is subject to a review and approval procedure; assignment will not occur until published in an addendum or revision to ANSI/ASHRAE Standard 34-1997.

**IDENTIFIERS**

```

common name(s):  R-1270; R1270; R 1270
                  HC-1270
                  hydrocarbon 1270
alternative chemical names/formulae: propene; propylene
                                      1-propene; 1-propylene
                                      methylethene
                                      methylethylene
                                      CH3CH=CH2; CH3-CH=CH2
not recommended:
                  CH2=CHCH3; CH2=CH-CH3
                  CH3CHCH2; H3CCH=CH2;
                  H3C-CH=CH2; H3CCH=CH2
empirical formula: C3H6
CAS number:      115-07-1 Chemical Abstracts
                  Service Registry Number
NIOSH RTECS number: UC6740000 (Registry of Toxic
                  Effects of Chemical
                  Substances)
ARI container color / Pantone number: none, use light green grey/413 6601
                                      with red / 185 band

```

**PHYSICAL**

```

· properties -----
molar mass:      42.07974 g/mol (0.092770      8820
                  lb/mol)
normal freezing/melting/triple point: -185.2 °C (-301.4 °F)      8401
· normal boiling point -----
temperature:     -47.7 °C (-53.8 °F)          8401
density, saturated liquid: 609 kg/m3 (38.02 lb/cf)      8401
density, saturated vapor:  2.36 kg/m3 (0.147 lb/cf)      8401
specific volume, saturated liquid: 1.642 L/kg (0.0263 cf/lb)      8401
specific volume, saturated vapor:  424.2 L/kg (6.7944 cf/lb)      8401
heat of vaporization: 439.2 kJ/kg (188.8 Btu/lb)      8401
velocity of sound, saturated liquid: 1169 m/s (3835 ft/s)      8401

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

velocity of sound, saturated vapor:	224 m/s (735 ft/s)	8401
viscosity, saturated liquid:	244 $\mu\text{Pa}\cdot\text{s}$ (0.244 cp)	8401
viscosity, saturated vapor:	5.84 $\mu\text{Pa}\cdot\text{s}$ (0.00584 cp)	8401
thermal conductivity, liquid:	0.1573 W/m·K (0.0909 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, vapor:	0.0104 W/m·K (0.0060 Btu/hr·ft <sup>2</sup> ·°F)	8401
· normal pressure, 20 °C (68 °F) -----		
density, vapor:	1.776 kg/m <sup>3</sup> (0.1109 lb/cf)	8401
· normal pressure, 21.1 °C (70 °F) ---		
density, vapor:	1.769 kg/m <sup>3</sup> (0.1104 lb/cf)	8401
· 20 °C (68 °F) -----		
pressure, saturated vapor:	1019.9 kPa (147.92 psia)	8401
density, saturated liquid:	513 kg/m <sup>3</sup> (32.03 lb/cf)	8401
density, saturated vapor:	21.44 kg/m <sup>3</sup> (1.338 lb/cf)	8401
specific volume, saturated liquid:	1.949 L/kg (0.0312 cf/lb)	8401
specific volume, saturated vapor:	46.6 L/kg (0.7471 cf/lb)	8401
velocity of sound, saturated liquid:	727 m/s (2387 ft/s)	8401
velocity of sound, saturated vapor:	223 m/s (730 ft/s)	8401
viscosity, saturated liquid:	106 $\mu\text{Pa}\cdot\text{s}$ (0.106 cp)	8401
viscosity, saturated vapor:	7.7 $\mu\text{Pa}\cdot\text{s}$ (0.0077 cp)	8401
thermal conductivity, saturated liquid:	0.1113 W/m·K (0.0643 Btu/hr·ft <sup>2</sup> ·°F)	8401
thermal conductivity, saturated vapor:	0.08639 W/m·K (0.04991 Btu/hr·ft <sup>2</sup> ·°F)	8401
· 60 °C (140 °F) -----		
pressure, saturated vapor:	2533 kPa (367.3 psia)	8401
heat of vaporization:	249.7 kJ/kg (107.3 Btu/lb)	8401
· critical point -----		
temperature:	92.4 °C (198.4 °F)	8401
pressure:	4665 kPa (676.6 psia)	8401
density:	223 kg/m <sup>3</sup> (13.9 lb/cf)	8401
specific volume:	4.48 L/kg (0.0717 cf/lb)	8401

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative to R 11)

**SAFETY**

· classification -----		
safety group (ASHRAE Standard 34):	A3	8601
	B3 (revision) proposed 18Jan98	34i
NFPA 704 degrees of hazard (H-F-R-S):	Ashland: 1-4-1	MSDS
	BOC Gases: 1-4-1	MSDS
	DuPont: 1-4-1	MSDS
	Phillips: 1-4-1	MSDS
	Texaco: 1-4-1	MSDS
	health-flammability-reactivity [-special]: 0=no, 4=severe	
NPCA HMIS hazard ratings (H-F-R):	BOC Gases: 0-4-0	MSDS
	DuPont: 0-4-2	MSDS
	Texaco: 1-4-1	MSDS
	health-flammability-reactivity 0=insignificant, 4=extreme	
IARC/CIRC human carcinogenicity group:	3, not classifiable	2428
ACGIH carcinogenicity category:	A4, not classifiable as a human carcinogen	9504
DFG carcinogenicity class:	being examined for new entry	7101
· occupational exposure warnings -----		

ACGIH caution:	simple asphyxiant	9504
· long-term occupational limit ----- exposure limit consistent to OSHA PEL:	Exxon: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk Greencool: 375 ppm v/v TWA for 8 hr/day and 40 hr/wk Phillips: 1,000 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS MSDS
· acute (short-term) toxicity ----- ALC (approximate lethal concentration):	rat, 2 hr, ?/? : 650,000 ppm (lowest exposure tested with one or more deaths by inhalation) rat, 6 hr, 0/? : >400,000 ppm (lowest exposure tested with one or more deaths by inhalation)	65B9 65B9
cardiac sensitization threshold/LOEL:	dog 10min 2/2: 100,000-250,000 ppm v/v (lowest observed effect level in test animals)	6192
anesthetic concentration:	human, 2.25 min: 64,000 ppm v/v	6A64
anesthetic/CNS effect LOEL:	rat, 15-20 min, 1/1: 400,000 ppm v/v (lowest observed effect level in test animals)	65B9
· flammability ----- LFL-UFL (flammability limits in air):	2.0-11.0 % v/v	6290
flash point:	-108 °C (-162 °F) Ashland: -40 °C (-40 °F)	6290 MSDS
autoignition temperature:	DuPont: 460 °C (860 °F) Exxon: 458 °C (856 °F) Texaco: 497 °C (927 °F)	MSDS MSDS MSDS
· detection ----- appearance:	colorless	6290
odor:	BOC Gases: mild olefinic odor Phillips: mild, sour odor Texaco: odorless practically odorless	MSDS MSDS MSDS 6290
odor sensing, lower threshold:	DuPont: 10-60 ppm v/v	MSDS
<b>PRODUCTION</b>		
last year production allowed:	unrestricted	8C01

## R-C1314

```

----- REFRIERANT DATA SUMMARY -----
R-C1314      3,4-dichloro-1,1,2,2-tetrafluorocyclobutene      see
CFC          -CCl=CCl-CF2-CF2-                                   RDB#
-----

```

**IDENTIFIERS**

```

common name(s):  R-C1314; RC1314; R C1314
                  CFC-C1314
                  fluorochemical C1314; FC C1314
                  halochemical C1314
chemical name (by IUPAC convention): 3,4-dichloro-1,1,2,2-
alternative chemical names/formulae: tetrafluorocyclobutene
                                     cyclobutene, 3,4-dichloro-
                                     1,1,2,2-tetrafluoro-
                                     -CCl=CCl-CF2-CF2-
                                     -CCl=CClCF2CF2-
                                     c-CCl=CCl-CF2-CF2-
                                     cyclo-CCl=CCl-CF2-CF2-
                                     not recommended:
                                     -CCl=CCl-(CF2)2-
empirical formula: C4Cl2F4

```

**PHYSICAL**

```

· properties -----
molar mass: 194.9418128 g/mol (0.429773 8820
             lb/mol)
normal freezing/melting/triple point: -43.4 °C (-46.1 °F) 7601
· normal boiling point -----
temperature: 67.1 °C (152.8 °F) 7601
· 25 °C (77 °F) -----
density, saturated liquid: 2 kg/m3 (0.10 lb/cf) 7601

```

**SAFETY**

```

· classification -----
  safety group (ASHRAE Standard 34): none (no application pending) 8601
· flammability -----
  LFL-UFL (flammability limits in air): probably nonflammable

```

**PRODUCTION**

```

first commercial use as a refrigerant: not known to be commercialized
last year production allowed:         unrestricted (but vulnerable) 8C01

```





	(fatal concentration by inhalation for half of test animals)	
anesthetic/CNS effect EC50:	mouse, 30 min: 47,000 ppm v/v	6165
	(effective concentration in half of test animals)	
• flammability -----		
LFL-UFL (flammability limits in air):	expected to be nonflammable	
<b>PRODUCTION</b>		
first commercial use as a refrigerant:	not known to be commercialized	
last year production allowed:	unrestricted	8C01





## R-1390 (butylene)

```

----- REFRIGERANT DATA SUMMARY -----
R-1390      1-butene
HC          CH3CH2CH=CH2
CAS number 106-98-9
see
RDB#
-----

```

**COMMON USE(S)**

use constrained by high flammability

**IDENTIFIERS**

common name(s): R-1390; R1390; R 1390  
 HC-1390  
 alpha-butylene  
 butene  
 butylene  
 ethylethylene  
 hydrocarbon 1390

chemical name (by IUPAC convention): 1-butene

alternative chemical names/formulae:

n-butene  
 1-butylene  
 n-butylene  
 methylpropene  
 methylpropylene  
 CH3CH2CH=CH2; CH3-CH2-CH=CH2  
 not recommended:  
 CH2=CHCH2CH3; CH2=CH-CH2-CH3

empirical formula: C4H8

CAS number: 106-98-9 Chemical Abstracts  
 Service Registry Number

Beilstein registry number: 1098262

EINECS number: 203-449-2 (European Inventory  
 of Existing Chemical  
 Substances)

Merck Index (volume-number): 12-1548

**PHYSICAL**

· properties -----

molar mass: 56.10632 g/mol (0.123693 8820  
 lb/mol)

normal freezing/melting/triple point: -185.3 °C (-301.5 °F) CRC

· normal boiling point -----

temperature: -6.3 °C (20.7 °F) CRC

**ENVIRONMENTAL**

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

**SAFETY**

· flammability -----

LFL-UFL (flammability limits in air): highly flammable

flash point: -80 °C (-112 °F) PCRL

**PRODUCTION**

last year production allowed: unrestricted 8C01

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

## acetone

----- REFRIERANT DATA SUMMARY -----  
 unassigned acetone see  
 organic CH3COCH3 CAS number 67-64-1 RDB#  
 -----

**COMMON USE(S)**

under consideration as a high-boiling, blend component in  
 vapor-compression machines with solution circuits; occurs naturally  
 in plants and animals; widely used industrial solvent; chemical  
 intermediate

**IDENTIFIERS**

common name(s): acetone  
 alternative chemical names/formulae: 2-propanone  
 dimethyl ketone  
 dimethyl ketal  
 ketone propane; ketopropane  
 CH3COCH3; CH3-CO-CH3; C(CH3)2O  
 empirical formula: C3H6O  
 CAS number: 67-64-1 Chemical Abstracts  
 Service Registry Number  
 Beilstein registry number: 635680  
 EINECS number: 200-662-2 (European Inventory  
 of Existing Chemical  
 Substances)  
 Merck Index (volume-number): 12-64  
 NIOSH RTECS number: AL3150000 (Registry of Toxic  
 Effects of Chemical  
 Substances)

**PHYSICAL**

· properties -----  
 molar mass: 58.07914 g/mol (0.128043 8820  
 lb/mol)  
 normal freezing/melting/triple point: -95.3 °C (-139.6 °F) 7413  
 -95.6 °C (-140.1 °F) 3903  
 · normal boiling point -----  
 temperature: 56.1 °C (133.0 °F) 3903

**SAFETY**

· classification -----  
 ACGIH carcinogenicity category: A4, not classifiable as a 9504  
 human carcinogen  
 DFG pregnancy risk group: IIc (no pregnancy risk class) 7101  
 · short-term occupational limit -----  
 NIOSH IDLH (immediately dangerous): 2,500 ppm v/v based on 10% of 5204  
 LEL  
 NIOSH SCP IDLH (immediately dangerous: 20,000 ppm v/v for 30 min 3903  
 ACGIH TLV-STEL (short-term exp limit): 750 ppm v/v TWA for 15 min 9504  
 · occupational exposure limit -----  
 MAK (maximum workplace concentration): I: 1000 ppm v/v momentary 5 7101  
 min  
 · long-term occupational limit -----  
 OSHA PEL (permissible exposure limit): 1,000 ppm v/v TWA for 8 hr/day 3904

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

	and 40 hr/wk	
NIOSH REL (recommndd exposure limit):	250 ppm v/v TWA for 10 hr/day	3903
	and 40 hr/wk	
ACGIH TLV-TWA (time-weighted average):	500 ppm v/v TWA for 8 hr/day	9504
	and 40 hr/wk	
MAK (maximum workplace concentration):	500 ppm v/v TWA for 8 hr/day	7101
	40 (or 42) hr/wk	
• emergency exposure limit -----		
NRC EEGL (emergency exposure level):	1 hr: 8,500 ppm v/v ceiling	7413
	guidance level for single	
	emergency exposures	
	24 hr: 1,000 ppm v/v ceiling	7413
	guidance level for single	
	emergency exposures	
• special-purpose exposure control ---		
NRC CEGL (continuous exposure level):	90 day: 200 ppm v/v ceiling	7413
	guidance for prolonged	
	exposure in closed	
	environments	
• acute (short-term) toxicity -----		
respiratory RD50 (response dose 50%):	mouse: 77,516 ppm v/v (50%	6279
	decrease in respiratory rate	
	in test animals)	
• flammability -----		
LFL-UFL (flammability limits in air):	2.5-12.8 % v/v	5204
	flash point:	
	-18 °C (0 °F)	3903
	0 °C (32 °F)	7413
	0 °C (32 °F)	7413
	autoignition temperature:	
	538 °C (1000 °F)	4B64
• detection -----		
	appearance: colorless liquid	7413
	odor: pungent odor	7413

## cyclopentane

```

----- REFRIERANT DATA SUMMARY -----
unassigned   cyclopentane           see
HC           -(CH2)5-                          RDB#
                               CAS number 287-92-3
-----

```

**COMMON USE(S)**

under consideration as a blowing agent for insulation, constrained by flammability and global warming concerns

**IDENTIFIERS**

```

common name(s):  incorrectly: "R-C41-10"
                 incorrectly: "HC-C41-10"
chemical name (by IUPAC convention):  cyclopentane
alternative chemical names/formulae:  pentamethylene
                                     -(CH2)5-
                                     -CH2-CH2-CH2-CH2-CH2-
empirical formula:  C5H10; c-C5
CAS number:        287-92-3 Chemical Abstracts
                  Service Registry Number
Beilstein registry number:  1900195
EINECS number:      206-016-6 (European Inventory
of Existing Chemical
Substances)
Merck Index (volume-number):  12-2809
NIOSH RTECS number:  GY2390000 (Registry of Toxic
Effects of Chemical
Substances)

```

**PHYSICAL**

```

· properties -----
molar mass:  70.13290 g/mol (0.154617 lb/mol)      8820
normal freezing/melting/triple point:  -93.9 °C (-137.0 °F)      5204
· normal boiling point -----
temperature:  49.3 °C (120.7 °F)      9843
              49.4 °C (121.0 °F)      5204
· 20 °C (68 °F) -----
pressure, saturated vapor:  33.8 kPa (4.90 psia)      5C94
density, saturated liquid:  750 kg/m3 (46.82 lb/cf)      6B40
· critical point -----
temperature:  238.6 °C (461.5 °F)      4906
pressure:    4510 kPa (654.1 psia)      4906

```

**ENVIRONMENTAL**

```

average atmospheric lifetime (tatm):  "few days": <<1 yr      5C94
ODP (ozone depletion potential):  0.000 (model-derived relative
to R 11)
GWP (global warming potential):  11 relative to CO2 for 100 yr
integration      5C94

```

**SAFETY**

```

· long-term occupational limit -----
NIOSH REL (recommendd exposure limit):  600 ppm v/v TWA for 10 hr/day
and 40 hr/wk      5204

```

SEE DATA LIMITATIONS AND NOTES ON PAGE 2

ACGIH TLV-TWA (time-weighted average):	600 ppm v/v TWA for 8 hr/day and 40 hr/wk	9504
exposure limit consistent to OSHA PEL:	Exxon: 400 ppm v/v TWA for 8 hr/day and 40 hr/wk	MSDS
· acute (short-term) toxicity -----		
ALC (approximate lethal concentration):	rat, 4 hr, 0/10: >11,260 ppm (lowest exposure tested with one or more deaths by inhalation)	7627
oral ALD (approximate lethal dose):	rat, 0/10: >5,000 mg/kg (fatal dose by ingestion for one or more test animals)	7627
cardiac sensitization threshold/LOEL:	dog 10min 2/3: 150,000-900,000 ppm v/v (lowest observed effect level in test animals)	6192
· flammability -----		
LFL-UFL (flammability limits in air):	1.1-8.7 % v/v 1.4-9.4 % v/v	5204 6B40
flash point:	-37 °C (-35 °F) -7 °C (20 °F)	5204 4906
Exxon: <-30 °C (< -22 °F)		MSDS
Phillips, TCC: -37 °C (-35 °F)		MSDS
autoignition temperature:	380 °C (716 °F)	4906
· detection -----		
appearance:	Exxon: clear, colorless liquid colorless liquid	MSDS 5204
odor:	Phillips: mild	MSDS



## difluoromethyl-bis(trifluoromethyl) amine

----- REFRIGERANT DATA SUMMARY -----  
 unassigned difluoromethyl-bis(trifluoromethyl) amine see  
 HFNC NCHF2(CF3)2 RDB#  
 -----

**COMMON USE(S)**

under consideration as a replacement for refrigerant 114

**IDENTIFIERS**

chemical name (by IUPAC convention): difluoromethyl-  
 bis(trifluoromethyl)amine  
 alternative chemical names/formulae: amine, difluoromethyl-  
 bis(trifluoromethyl)-  
 NCHF2(CF3)2  
 not recommended:  
 N(CF3)2CHF2  
 CF2H(CF3)2N; (CF3)2CF2HN  
 CF2HN(CF3)2; (CF3)2NCF2H  
 CHF2(CF3)2N; (CF3)2CHF2N  
 CHF2N(CF3)2; (CF3)2NCHF2  
 empirical formula: C3HF8N  
 ARI container color / Pantone number: none, use light green grey/413 6601

**PHYSICAL**

· properties -----  
 molar mass: 203.0340056 g/mol (0.447613 8820  
 lb/mol)  
 · normal boiling point -----  
 temperature: 7.5 °C (45.5 °F) 8703  
 · critical point -----  
 temperature: 131.8 °C (269.2 °F) 8703  
 pressure: 2727 kPa (395.5 psia) 8703  
 density: 591 kg/m3 (36.9 lb/cf) 8703  
 specific volume: 1.69 L/kg (0.0271 cf/lb) 8703

**ENVIRONMENTAL**

average atmospheric lifetime ( $\tau_{atm}$ ): 2.2 yr 8317  
 ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)  
 HGWP (halocarbon GWP): 0.01 relative to R 11 for 8317  
 infinite integration period

**SAFETY**

· classification -----  
 safety group (ASHRAE Standard 34): none (no application pending) 8601

**PRODUCTION**

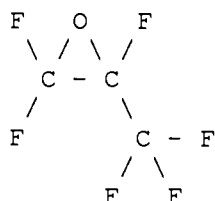
first commercial use as a refrigerant: not known to be commercialized  
 last year production allowed: unrestricted 8C01

## hexafluoropropene oxide

----- REFRIGERANT DATA SUMMARY -----  
 unassigned hexafluoropropene oxide see  
 HFE C3F6O CAS number 428-59-1 RDB#  
 -----

**COMMON USE(S)**

candidate for medium temperature refrigeration constrained by toxicity

**MOLECULAR STRUCTURE****IDENTIFIERS**

common name(s): HFPO  
 chemical name (by IUPAC convention): 1,2-epoxy-1,1,2,3,3,3-hexafluoropropane  
 alternative chemical names/formulae: oxirane,  
 trifluoro(trifluoromethyl)-  
 2-(trifluoromethyl)-  
 perfluoropropene oxide  
 trifluorooxirane  
 hexafluoro-1,2-epoxypropane  
 hexafluoro-1,2-epoxypropene  
 hexafluoroepoxypropane  
 hexafluoropropene epoxide  
 hexafluoropropene oxide  
 hexafluoropropylene oxide  
 perfluoro(methyloxirane)  
 perfluoropropylene oxide  
 propylene oxide hexafluoride  
 trifluoro(trifluoromethyl)-  
 oxirane  
 -CF3OC(CF3)-  
 empirical formula: C3F6O  
 CAS number: 428-59-1 Chemical Abstracts  
 Service Registry Number  
 Beilstein registry number: 110835  
 EINECS number: 207-050-4 (European Inventory  
 of Existing Chemical  
 Substances)  
 NIOSH RTECS number: TZ3400000 (Registry of Toxic  
 Effects of Chemical  
 Substances)

**PHYSICAL**

properties -----  
 molar mass: 166.0219192 g/mol (0.366016 8820  
 lb/mol)  
 normal freezing/melting/triple point: -129.0 °C (-200.2 °F) Akro

SEE DATA LIMITATIONS AND NOTES ON PAGE 2



## isobutene

----- REFRIGERANT DATA SUMMARY -----  
 unassigned isobutene see  
 HC CH<sub>2</sub>=C(CH<sub>3</sub>)<sub>2</sub> CAS number 115-11-7 RDB#  
 -----

## IDENTIFIERS

common name(s): isobutene  
 isobutylene  
 chemical name (by IUPAC convention): 2-methylpropene  
 alternative chemical names/formulae: 2-methyl-1-propene  
 1-propene, 2-methyl-  
 1,1-dimethylethylene  
 iso-C<sub>4</sub>H<sub>8</sub>  
 isopropylidenemethylene  
 (CH<sub>3</sub>)<sub>2</sub>C=CH<sub>2</sub>  
 CH<sub>2</sub>=C(CH<sub>3</sub>)<sub>2</sub>  
 not recommended:  
 CH<sub>2</sub>=CCH<sub>3</sub>CH<sub>3</sub>  
 empirical formula: C<sub>4</sub>H<sub>8</sub>  
 CAS number: 115-11-7 Chemical Abstracts  
 Service Registry Number  
 NIOSH RTECS number: UD0890000 (Registry of Toxic  
 Effects of Chemical  
 Substances)  
 trade name(s): BOC Gases: isobutylene MSDS  
 ARI container color / Pantone number: none, use light green grey/413 6601  
 with red / 185 band

## PHYSICAL

· properties -----  
 molar mass: 56.10632 g/mol (0.123693 8820  
 lb/mol)  
 normal freezing/melting/triple point: -140.8 °C (-221.4 °F) 8913  
 · normal boiling point -----  
 temperature: -6.9 °C (19.6 °F) 8913

## ENVIRONMENTAL

ODP (ozone depletion potential): 0.000 (model-derived relative  
 to R 11)

## SAFETY

· long-term occupational limit -----  
 exposure limit consistent to OSHA PEL: Phillips: 1,000 ppm v/v TWA MSDS  
 for 8 hr/day and 40 hr/wk  
 · flammability -----  
 LFL-UFL (flammability limits in air): Phillips: 1.8-9.6 MSDS  
 flash point: CC, BOC Gases: -76 °C (-105 °F) MSDS  
 Phillips: -76 °C (-105 °F) MSDS  
 autoignition temperature: BOC Gases: 465 °C (869 °F) MSDS  
 · detection -----  
 appearance: BOC Gases: colorless gas MSDS  
 odor: BOC Gases: unpleasant order MSDS  
 similar to burning coal MSDS

**PRODUCTION**

first commercial use as a refrigerant:	1891	2113
last year production allowed:	unrestricted	8C01





SEE DATA LIMITATIONS AND NOTES ON PAGE 2





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