Annex V

Major Chemical Formulae and Nomenclature

This annex presents the formulae and nomenclature for halogen-containing species and other species that are referred to in this report (Annex V.1). The nomenclature for refrigerants and refrigerant blends is given in Annex V.2.

V.1 Substances by Groupings

V.1.1 Halogen-Containing Species

V.1.1.1 Inorganic Halogen-Containing Species

Atomic chlorine	Cl
Molecular chlorine	Cl_2
Chlorine monoxide	ClO
Chlorine radicals	ClO_x
Chloroperoxy radical	ClOO
Dichlorine peroxide (ClO dimer)	$(ClO)_2$, Cl_2O_2
Hydrogen chloride (Hydrochloric acid)	HCl
Inorganic chlorine	Cl_y
Antimony pentachloride	$SbCl_5$

Atomic bromine	Br
Molecular bromine	Br_2
Bromine monoxide	BrO
Bromine radicals	BrO_x
Bromine nitrate	$BrONO_2$, $BrNO_3$
Potassium bromide	KBr

Atomic fluorine	F
Molecular fluorine	F_2
Hydrogen fluoride (Hydrofluoric acid)	HF
Sulphur hexafluoride	SF_6
Nitrogen trifluoride	NF_3

Atomic iodine	I
Molecular iodine	I_2

V.1.1.2 Halocarbons

For each halocarbon the following information is given in columns:

- Chemical compound [Number of isomers][1] (or common name)
- Chemical formula
- CAS number[2]
- Chemical name (or alternative name)

V.1.1.2.1 Chlorofluorocarbons (CFCs)

CFC-11	CCl_3F	75-69-4	Trichlorofluoromethane
CFC-12	CCl_2F_2	75-71-8	Dichlorodifluoromethane
CFC-13	$CClF_3$	75-72-9	Chlorotrifluoromethane
CFC-113 [2]	$C_2Cl_3F_3$		Trichlorotrifluoroethane
CFC-113	CCl_2FCClF_2	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane
CFC-113a	CCl_3CF_3	354-58-5	1,1,1-Trichloro-2,2,2-trifluoroethane
CFC-114 [2]	$C_2Cl_2F_4$		Dichlorotetrafluoroethane
CFC-114	$CClF_2CClF_2$	76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane
CFC-114a	CCl_2FCF_3	374-07-2	1,1-Dichloro-1,2,2,2-tetrafluoroethane
CFC-115	$CClF_2CF_3$		Chloropentafluoroethane

V.1.1.2.2 Hydrochlorofluorocarbons (HCFCs)

HCFC-21	$CHCl_2F$	75-43-4	Dichlorofluoromethane
HCFC-22	$CHClF_2$	75-45-6	Chlorodifluoromethane
HCFC-123 [3]	$C_2HCl_2F_3$		Dichlorotrifluoroethane
HCFC-123	$CHCl_2CF_3$	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane
HCFC-123a	$C_2HCl_2F_3$	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane
HCFC-123b	$C_2HCl_2F_3$	812-04-4	1,1-Dichloro-1,2,2-trifluoroethane
HCFC-124 [2]			Chlorotetrafluoroethane
HCFC-124	$CHClFCF_3$	2837-89-0	2-Chloro-1,1,1,2-tetrafluoroethane
HCFC-124a	C_2HClF_4	354-25-6	1-Chloro-1,1,2,2-tetrafluoroethane
HCFC-141b	CH_3CCl_2F	1717-00-6	1,1-Dichloro-1-fluoroethane
HCFC-142b	CH_3CClF_2	75-68-3	1-Chloro-1,1-difluoroethane
HCFC-225ca	$CHCl_2CF_2CF_3$	422-56-0	3,3-Dichloro-1,1,1,2,2-pentafluoropropane
HCFC-225cb	$CHClFCF_2CClF_2$	507-55-1	1,3-Dichloro-1,1,2,2,3-pentafluoropropane

[1] The number of isomers is shown between brackets for figures larger than unity.

[2] The Chemical Abstracts Service (CAS) Registry Number for this substance. The CAS number is an internationally-recognised unique numeric identifier that designates only one chemical substance. The CAS is a division of the American Chemical Society.

V.1.1.2.3 Hydrofluorocarbons (HFCs)

HFC-23		CHF_3	75-46-7	Trifluoromethane
HFC-32		CH_2F_2	75-10-5	Difluoromethane (Methylene fluoride)
HFC-41		CH_3F	593-53-3	Fluoromethane (Methyl fluoride)
HFC-125		CHF_2CF_3	354-33-6	Pentafluoroethane
HFC-134	[2]	$C_2H_2F_4$		Tetrafluoroethane
HFC-134		CHF_2CHF_2	359-35-3	1,1,2,2-Tetrafluoroethane
HFC-134a		CH_2FCF_3	811-97-2	1,1,1,2-Tetrafluoroethane
HFC-143	[2]	$C_2H_3F_3$		Trifluoroethane
HFC-143		CH_2FCHF_2	430-66-0	1,1,2-Trifluoroethane
HFC-143a		CH_3CF_3	420-46-2	1,1,1-Trifluoroethane
HFC-152	[2]	$C_2H_4F_2$		Difluoroethane
HFC-152		CH_2FCH_2F	624-72-6	1,2-Difluoroethane
HFC-152a		CHF_2CH_3	75-37-6	1,1-Difluoroethane
HFC-161		CH_3CH_2F	353-36-6	Monofluoroethane (Ethyl fluoride)
HFC-227	[2]	C_3HF_7		Heptafluoropropane
HFC-227ca		$CF_3CF_2CHF_2$	2252-84-8	1,1,1,2,2,3,3-Heptafluoropropane
HFC-227ca		CF_3CHFCF_3	431-89-0	1,1,1,2,3,3,3-Heptafluoropropane
HFC-236	[4]	$C_3H_2F_6$		Hexafluoropropane
HFC-236ca		$CHF_2CF_2CHF_2$	27070-61-7	1,1,2,2,3,3-Hexafluoropropane
HFC-236cb		$CH_2FCF_2CF_3$	677-56-5	1,1,1,2,2,3-Hexafluoropropane
HFC-236ea		CHF_2CHFCF_3	431-63-0	1,1,1,2,3,3-Hexafluoropropane
HFC-236fa		$CF_3CH_2CF_3$	690-39-1	1,1,1,3,3,3-Hexafluoropropane
HFC-245	[5]	$C_3H_3F_5$		Pentafluoropropane
e.g. HFC-245ce		$CH_2FCF_2CHF_2$	679-86-7	1,1,2,2,3-Pentafluoropropane
HFC-245fa		$CHF_2CH_2CF_3$	460-73-1	1,1,1,3,3-Pentafluoropropane
HFC-365mfc		$CH_3CF_2CH_2CF_3$	406-58-6	1,1,1,3,3-Pentafluorobutane
HFC-c-447ef		c-$C_5H_3F_7$	15290-77-4	Heptafluorocyclopentane

V.1.1.2.4 Halons

Halon-1202	CBr_2F_2	75-61-6	Dibromodifluoromethane
Halon-1211	$CBrClF_2$	353-59-3	Bromochlorodifluoromethane (Chlorodifluorobromomethane), R-12B1
Halon-1301	$CBrF_3$	75-63-8	Bromotrifluoromethane, R-13B1
Halon-2402	$CBrF_2CBrF_2$	124-73-2	1,2-Dibromotetrafluoroethane (1,1,2,2-Tetrafluoro-1,2-dibromoethane, 1,2-Dibromo-1,1,2,2-tetrafluoroethane)

V.1.1.2.5 Perfluorocarbons (PFCs)

PFC-14	CF_4	75-73-0	Tetrafluoromethane (Carbon tetrafluoride)
PFC-116	C_2F_6 (CF_3CF_3)	76-16-4	Perfluoroethane (Hexafluoroethane)
PFC-218	C_3F_8 ($CF_3CF_2CF_3$)	76-19-7	Perfluoropropane (Octafluoropropane)
PFC-318 or PFC-c318	c-C_4F_8 (-$(CF_2)_4$-)	115-25-3	Perfluorocyclobutane (Octafluorocyclobutane)
PFC-3-1-10	C_4F_{10}	355-25-9	Perfluorobutane
PFC-5-1-14	C_6F_{14}	355-42-0	Perfluorohexane
PFC-6-1-16	C_7F_{16}	335-57-9	Perfluoroheptane
PFC-7-1-18	C_8F_{18}	307-34-6	Perfluorooctane

V.1.1.2.6 Fluorinated Ethers

HFE-449s1	$C_5H_3F_9O$		
	$CF_3(CF_2)_3OCH_3$	163702-07-6	Methyl nonafluorobutyl ether
	$(CF_3)_2CFCF_2OCH_3$	163702-08-7	Perfluoroisobutyl methyl ether
HFE-569sf2	$C_6H_5F_9O$		
	$CF_3(CF_2)_3OCH_2CH_3$	163702-05-4	Ethyl perfluorobutyl ether
	$(CF_3)_2CFCF_2OCH_2CH_3$	163702-06-5	Ethyl perfluoroisobutyl ether
HFE-347pcf2	$C_4H_3F_7O$ ($CF_3CH_2OCF_2CHF_2$)		1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl ether

V.1.1.2.7 Chlorocarbons

Carbon tetrachloride	CCl_4	56-23-5	R-10, (Halon 104)
Chloroform	$CHCl_3$	67-66-3	Trichloromethane, R-20
Methylene chloride	CH_2Cl_2	75-09-2	Dichloromethane, R-30, freon 30
Methyl chloride	CH_3Cl	74-87-3	Chloromethane, R-40, freon 40
Trichloroethene	C_2HCl_3 ($CHCl=CCl_2$)	79-01-6	1,1,2-Trichloroethylene, TCE
Perchloroethene	C_2Cl_4 ($CCl_2=CCl_2$)	127-18-4	Perchloroethylene, tetrachloroethene
Ethyl chloride	CH_3CH_2Cl	75-00-3	Chloroethane
Methyl chloroform	CH_3CCl_3	71-55-6	1,1,1-Trichloroethane
Isopropyl chloride	$CH_3CHClCH_3$	75-29-6	2-Chloropropane

V.1.1.2.8 Bromocarbons

Methyl bromide	CH_3Br	74-83-9	Bromomethane (Halon-1001)
Bromoform	$CHBr_3$	75-25-2	Tribromomethane
n-Propyl bromide	$CH_3CH_2CH_2Br$ ($n\text{-}C_3H_7Br$)	106-94-5	1-Bromopropane, n-PB

V.1.1.2.9 Other Halocarbons

FK-5-1-12	$C_6F_{12}O$ $(CF_3CF_2C(O)CF(CF_3)_2)$	756-13-8	Nonafluoro-4- (trifluoromethyl)-3- pentanone
	CH_2BrCl	74-97-5	Bromochloromethane (Halon-1011)
	$C_2HF_3O_2$ (CF_3COOH)	76-05-1	Trifluoroacetic acid (TFA), Perfluoric acid
	COF_2	353-50-4	Carbonyl fluoride, Carbonic difluoride
	C_2F_4O (CF_3COF)	354-34-7	Trifluoroacetyl fluoride
	$C_8HF_{15}O_2$	335-67-1	Perfluorooctanoic acid (FOA), Pentadecafluorooctanoic acid
	CH_2ClI	593-71-5	Chloroiodomethane
	CH_2BrI	557-68-6	Bromoiodomethane
	CF_3I	2314-97-8	Trifluoromethyl iodide, trifluoroiodomethane
	CF_3CF_2I	354-64-3	Iodopentafluoroethane
	$COClF$	353-49-1	Chlorofluorocarbonyl
	CF_3COCl	354-32-5	Trifluoroacetyl chloride
	SF_5CF_3	373-80-8	Trifluoromethylsulphur pentafluoride

V.1.2 Other Species

V.1.2.1 Inorganic Species

Atomic oxygen	O
Atomic oxygen (first excited state)	$O(^1D)$
Molecular oxygen (R-732)	O_2
Ozone	O_3
Odd oxygen (O, $O(^1D)$, O_3) or oxidant (O_3 + NO_2)	O_x

Atomic hydrogen	H
Molecular hydrogen (R-702)	H_2
Hydroxyl radical	OH
Hydroperoxyl radical	HO_2
Water (R-718)	H_2O
Hydrogen peroxide	H_2O_2
Odd hydrogen (H, OH, HO_2, H_2O_2)	HO_x

Atomic sulphur	S
Sulphur dioxide (R-764)	SO_2
Sulfate	SO_4
Sulphuric acid	H_2SO_4
Hydrogen sulfide	H_2S
Sulphur oxides (SO + SO_2 + SO_3)	SO_x

Carbon atom	C
Carbon monoxide	CO
Carbon dioxide (R-744)	CO_2
Sodium bicarbonate	$NaHCO_3$

Atomic nitrogen	N
Molecular nitrogen (R-728)	N_2
Nitrous oxide (R-744A)	N_2O
Nitric oxide	NO
Nitrogen dioxide	NO_2
Nitrogen trioxide, nitrate radical	NO_3
Dinitrogen pentoxide	N_2O_5
Nitrogen oxides (NO + NO_2)	NO_x
Total reactive nitrogen (usually includes NO, NO_2, NO_3, N_2O_5, $ClONO_2$, HNO_4, HNO_3)	NO_y
Amidogen radical	NH_2
Ammonia (R-717)	NH_3
Ammonium	NH_4
Ammonium sulfate	$(NH_4)_2SO_4$
Ammonium nitrate	NH_4NO_3
Ammonium phosphate	$(NH_4)H_2PO_4$
Nitric acid	HNO_3
Hydrogen cyanide	HCN

Helium (R-704)	He
Argon (R-740)	Ar
Radon	Rn

V.1.2.2 Non-Halogenated Hydrocarbons and Other Organic Species

Common or Industrial Designation	Formula	CAS-number	Other Names
Methane	CH_4	74-82-8	R-50
Ethane	C_2H_6 (CH_3CH_3)	74-84-0	R-170
Propane	C_3H_8 ($CH_3CH_2CH_3$)	74-98-6	R-290
Butane	C_4H_{10} ($CH_3CH_2CH_2CH_3$)	106-97-8	R-600, n-Butane
Isobutane	C_4H_{10} ($(CH_3)_2CHCH_3$)	75-28-5	R-600a, i-Butane, 2-Methylpropane
Pentane	C_5H_{12} ($CH_3(CH_2)_3CH_3$)	109-66-0	R-601, n-Pentane
Isopentane	C_5H_{12} ($(CH_3)_2CHCH_2CH_3$)	78-78-4	R-601a, i-Pentane, 2-Methylbutane
Methyl ether	C_2H_6O (CH_3OCH_3)	115-10-6	R-E170, Dimethyl ether
Cyclopropane	c-C_3H_6 (-$(CH_2)_3$-)	75-19-4	C-270
Cyclopentane	c-C_5H_{10} (-$(CH_2)_5$-)	287-92-3	
Ethene	C_2H_4 (CH_2=CH_2)	74-85-1	R-1150, Ethylene
Propene	C_3H_6 (CH_3CH=CH_2)	115-07-1	R-1270, Propylene
Benzene	C_6H_6	71-43-2	
Toluene	C_7H_8	108-88-3	Methylbenzine
Xylene	C_8H_{10}	several isomers	Dimethylbenzene
Trimethylbenzene	C_9H_{12}	several isomers	
Isoprene	C_5H_8	78-79-5	2-Methyl-1,3-butadiene
Ethyl ether	$C_4H_{10}O$ ($CH_3CH_2OCH_2CH_3$)	60-29-7	R-610, Diethyl ether
n-Octanol	$C_8H_{18}O$ ($CH_3(CH_2)_7OH$)	111-87-5	1-Octanol, 1-Octyl alcohol
Methyl formate	$C_2H_4O_2$ ($HCOOCH_3$)	107-31-3	R-611, Formic acid methyl ester
Isopropanol	C_3H_8O ($CH_3CHOHCH_3$)	67-63-0	Isopropyl alcohol
Methyl amine	CH_5N (CH_3NH_2)	74-89-5	R-630
Ethyl amine	C_2H_7N ($CH_3CH_2(NH_2)$)	75-04-7	R-631
Ethyne	C_2H_2 (CH≡CH)	74-86-2	Acetylene
Formaldehyde	CH_2O (HCHO)	50-00-0	Oxomethane, Methylene oxide
Acetone	C_3H_6O (CH_3COCH_3)	67-64-1	2-Propanone, Methyl ketone
Methyl peroxide	CH_4O_2 (CH_3OOH)	3031-73-0	Methyl hydroperoxide
Methyl peroxy radical	CH_3OO		
Acetyl peroxy radical	$CH_3C(O)OO$		
Alkoxy radicals	RO		
Organic peroxy radicals	RO_2		

V.2 Refrigerant Nomenclature

V.2.1 Refrigerant Designations for Compounds

Refrigerant Number	CFC	HCFC	HFC	PFC	HC	Other	Chemical name
10						x	Carbon tetrachloride
11	x						Trichlorofluoromethane
12	x						Dichlorodifluoromethane
12B1						x	Bromochlorodifluoromethane (Halon-1211)
13	x						Chlorotrifluoromethane
13B1						x	Bromotrifluoromethane (Halon-1301)
14				x			Carbon tetrafluoride
20						x	Chloroform
21		x					Dichlorofluoromethane
22		x					Chlorodifluoromethane
23			x				Trifluoromethane
30						x	Dichloromethane (Methylene chloride, Freon 30)
31		x					Chlorofluoromethane
32			x				Difluoromethane (Methylene fluoride)
40						x	Chloromethane (Methyl chloride, Freon 40)
41			x				Fluoromethane (Methyl fluoride)
50					x		Methane
113	x						1,1,2-Trichloro-1,2,2-trifluoroethane
114	x						1,2-Dichloro-1,1,2,2-tetrafluoroethane
115	x						Chloropentafluoroethane
116				x			Hexafluoroethane
123		x					2,2-Dichloro-1,1,1-trifluoroethane
124		x					2-Chloro-1,1,1,2-tetrafluoroethane
125			x				Pentafluoroethane
134a			x				1,1,1,2-Tetrafluoroethane
141b		x					1,1-Dichloro-1-fluoroethane
142b		x					1-chloro-1,1-Difluoroethane
143a			x				1,1,1-Trifluoroethane
152a			x				1,1-Difluoroethane
170					x		Ethane
E170					x		Methyl ether (Dimethyl ether)
218				x			Octafluoropropane
227ea			x				1,1,1,2,3,3,3-Heptafluoropropane
236fa			x				1,1,1,3,3,3-Hexafluoropropane
245fa			x				1,1,1,3,3-Pentafluoropropane
C270					x		Cyclopropane
290					x		Propane
C318					x		Octafluorocyclobutane
600					x		Butane
600a					x		2-Methyl propane (Isobutane)
610					x		Ethyl ether
611					x		Methyl formate
630					x		Methyl amine
631					x		Ethyl amine

Examples:

R-11 is also referred to as CFC-11
R-12B1 ,, Halon-1211
R-22 ,, HCFC-22
R-23 ,, HFC-23
R-116 ,, PFC-116
R-600 ,, HC-600 (or butane)

Refrigerant Number	CFC	HCFC	HFC	PFC	HC	Other	Chemical name
702						x	Hydrogen
704						x	Helium
717						x	Ammonia
718						x	Water
720						x	Neon
728						x	Nitrogen
729						x	Air
732						x	Oxygen
740						x	Argon
744						x	Carbon dioxide
744A						x	Nitrous oxide
764						x	Sulphur dioxide
1132a			x				1,1-Difluoroethene (Vinylidene fluoride)
1150					x		Ethene (Ethylene)
1270					x		Propene (Propylene)

V.2.2 Refrigerant Designations for Blends of Compounds (R-400 and R-500 Blends)

Nominal composition (mass%)

	CFC-12	CFC-13	CFC-114	CFC-115	HCFC-22	HCFC-31	HCFC-124	HCFC-142b	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	PFC-116	PFC-218	PFC-C318	R-E170	HC-290	HC-600	HC-600a	HC-1270
R-400[1]	x%		y%																			
R-401A					53%		34%							13%								
R-401B					61%		28%							11%								
R-401C					33%		52%							15%								
R-402A					38%						60%								2%			
R-402B					60%						38%								2%			
R-403A					75%											20%			5%			
R-403B					56%											39%			5%			
R-404A											44%	4%	52%									
R-405A					45%			5.5%						7%			42.5%					
R-406A					55%			41%													4%	
R-407A										20%	40%	40%										
R-407B										10%	70%	20%										
R-407C										23%	25%	52%										
R-407D										15%	15%	70%										
R-407E										25%	15%	60%										
R-408A					47%						7%		46%									
R-409A					60%		25%	15%														
R-409B					65%		25%	10%														
R-410A										50%	50%											
R-410B										45%	55%											
R-411A					87.5%									11%								1.5%
R-411B					94%									3%								3%
R-412A					70%			25%								5%						
R-413A												88%				9%					3%	
R-414A					51%		28.5%	16.5%													4%	
R-414B					50%		39%	9.5%													1.5%	
R-415A					82%									18%								
R-415B					25%									75%								
R-416A							39.5%					59%								1.5%		
R-417A											46.6%	50%								3.4%		
R-418A					96%									2.5%					1.5%			
R-419A											77%	19%						4%				
R-500	73.8%													26.2%								
R-501	25%				75%																	

[1] R-400 can have various proportions of CFC-12 and CFC-114. The exact composition needs to be specified, e.g. R-400 (60/40).

	CFC-12	CFC-13	CFC-114	CFC-115	HCFC-22	HCFC-31	HCFC-124	HCFC-142b	HFC-23	HFC-32	HFC-125	HFC-134a	HFC-143a	HFC-152a	PFC-116	PFC-218	PFC-C318	R-E170	HC-290	HC-600	HC-600a	HC-1270
R-502				51.2%	48.8%																	
R-503		59.9%							40.1%													
R-504				51.8%						48.2%												
R-505	78%					22%																
R-506			44.9%			55.1%																
R-507A											50%		50%									
R-508A									39%						61%							
R-508B									46%						54%							
R-509A					44%											56%						