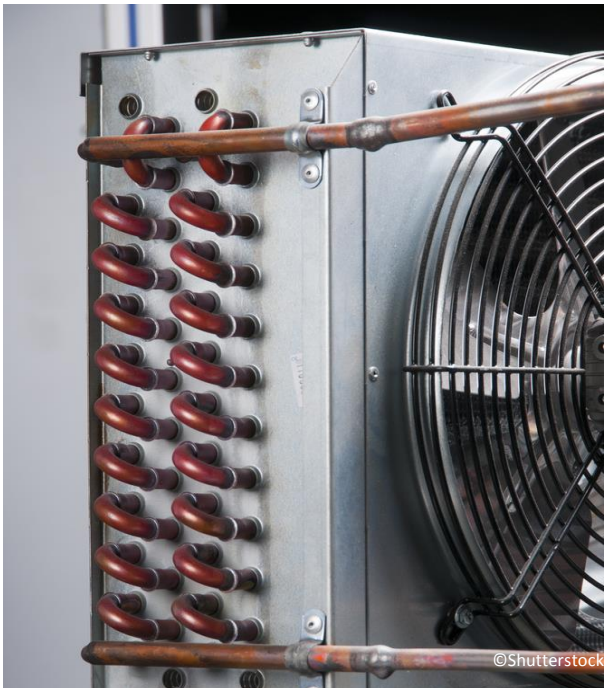
Refrigerant Blends: Calculating Ozone Depleting Potentials

INTRODUCTION

The number of single component refrigerants with different thermodynamic properties suitable for different types of equipment is limited. Growing demand for refrigeration and air-conditioning with diversified applications has led to a continued search for suitable refrigerant blends. A number of such blends have been developed by mixing two or more single component refrigerants in different proportions. The resulting blend, has entirely different properties from that of its components.

While it is common to use the term '*blends'* in the context of the Montreal Protocol, it is important to note that the term '*mixtures'* is also used to describe refrigerants which are comprised of more than one component. The terminology '*mixtures'* is specifically used in the World Customs Organization classification Harmonized Commodity Description and Coding System, also known as the Harmonized System (i.e. HS codes).



TYPES OF REFRIGERANT BLEND

A refrigerant blend or mixture of refrigerants is made up of two or more single component refrigerants. These blends can be of two types: 'Azeotropic' and 'Zeotropic'

Azeotropic blends

These blends behave like a single component refrigerant, in that they boil and condense at a constant temperature at a given pressure. In the ASHRAE refrigerant designation, these blends are assigned numbers (or ASHRAE codes) in the 500 series, e,g R-509A.

Zeotropic blends

These blends boil and condense through a range of temperatures at a given pressure. This range of temperatures is called the 'temperature glide'. Zeotropic blends are assigned ASHRAE codes in the 400 series, e.g R-401A, R-406A, etc.

ODP

ODP values are used to provide a simple way to compare the relative ability of various ODS to destroy stratospheric ozone. ODP is defined as "*the integrated change in total ozone per unit mass emission of a specific ozone-depleting substance relative to the integrated change in total ozone per unit mass emission of CFC-11"* (WMO, 1995), i.e. the ratio of global loss of ozone due to a given substance and global loss of ozone due to CFC-11 of the same mass.

CFC-11 or trichlorofluoromethane is taken as the reference substance and is assigned an ODP value of 1. It is against this standard that all other ODPs are calculated.

ODP values for common HCFCs and CFCs

Substance	ODP value ('reporting' value)
HCFC-22	0.055
HCFC-123	0.02
HCFC-124	0.022
HCFC-142b	0.065
HCFC-225ca	0.025
HCFC-225cb	0.033
CFC-11	1
CFC-12	1
CFC-113	0.8
CFC-115	0.6

N.B. ODP values for all HFCs are = 0

CALCULATION OF ODP OF BLENDS

As refrigerant blends are formed simply by mixing two or more single component refrigerants, the ODP of a refrigerant blend is the mass-weighted average of ODPs of individual components in the blend. That is, to calculate the ODP of a blend, one simply adds the ODPs of the individual components in proportion to their mass.

The ODP of blends are therefore calculated as follows:

ODP of Blend	=	Proportion by % mass of component **A** x ODP of **A**	+	Proportion by % mass of component **B** x ODP of **B**	+	Proportion by % mass of component **C** x ODP of **C**

Example: R-401A

R-401A is a blend composed of **53%** HCFC-22, **13%** HFC-152a and **34%** HCFC-124 (mass %). The ODP value for HCFC-22 is 0.055, for HFC-152a is zero (a non-ODS) and for HCFC-124 is 0.022.

ODP of Blend (R-401A)	=	Proportion by mass of **HCFC-22** x ODP of **HCFC-22**	+	Proportion by mass of **HFC-152a** x ODP of **HFC-152a**	+	Proportion by mass of **HCFC-124** x ODP of **HCFC-124**
	=	**0.53 (53%)** x 0.055	+	**0.13 (13%)** x 0.0	+	**0.34 (34%)** x 0.022
	=	0.029	+	0.0	+	0.007
	=	0.036				

SOME EXAMPLE BLEND ODPs

ASHRAE designation	Composition, substances*	Composition (Mass %)	ODP of components†	Blend ODP
Zeotropic Refrigerant Blends				
R-401A	HCFC-22/HFC-152a/HCFC-124	53/13/34	0.055/0/0.022	0.036
R-402A	HFC-125/HC-290/HCFC-22	60/2/38	0/0/0.055	0.021
R-403A	HC-290/HCFC-22/PFC-218	5/75/20	0/0.055/0	0.041
R-406A	HCFC-22/HC-600a/HCFC-142b	55/4/41	0.055/0/0.065	0.057
R-408A	HFC-125/HFC-143a/HCFC-22	7/46/47	0/0/0.055	0.026
R-409A	HCFC-22/HCFC-124/HCFC-142b	60/25/15	0.055/0.022/0.065	0.048
R-411A	HC-1270/HCFC-22/HFC-152a	1.5/87.5/11	0/0.055/0	0.048
R-412A	HCFC-22/PFC-218/HCFC-142b	70/5/25	0.055/0/0.065	0.054
R-414B	HCFC-22/HCFC-124/HC-600a/HCFC-142b	50.0/39.0/1.5/9.5	0.055/0.022/0/0.065	0.042
R-416A	HFC-134a/HCFC-124/HC-600	59.0/39.5/1.5	0/0.022/0	0.009
R-418A	HC-290/HCFC-22/HFC-152a	1.5/96.0/2.5	0/0.055/0	0.053
Azeotropic Refrigerant Blends				
R-504	HFC-32/CFC-115	48.2/51.8	0/0.6	0.311
R-509A	HCFC-22/PFC-218	44.0/56.0	0.055/0	0.024

Notes

** HCFC = hydrochlorofluorocarbon, HFC = hydrofluorocarbon, PFC = perfluorocarbon, HC = hydrocarbon*

† ODP values are based the Montreal Protocol treaty text, available in the Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer (Annexes A, B, C and E). This includes more information and tables of ODP values to be used for the Montreal Protocol:

http://ozone.unep.org/en/handbook-montreal-protocol-substances-deplete-ozone-layer/5

In the context of the Montreal Protocol, these values are to be used for reporting and calculating the ODPs of blends, even though more recent ODP values are available.

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