Refrigerant Blends: Calculating Global Warming 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.

GWP

Global warming potential (GWP) is a measure which enables comparisons of the global warming effects of different gases. It compares the amount of heat trapped by a certain mass of a gas to the amount of heat trapped by a similar mass of carbon dioxide over a specific period of time. Carbon dioxide was chosen by the Intergovernmental Panel on Climate Change (IPCC) as the reference gas and its GWP is taken as 1.

Following the 2016 Kigali Amendment, the Montreal Protocol has adopted standard 'reporting values' for GWPs of HFCs[1] and selected HCFCs and CFCs which have been incorporated into the text of the Protocol (in Annexes A, C and F).

GWP values for some common refrigerants

Substance	GWP value
CFC-12	10 900
HCFC-22	1810
HCFC-124	609
HCFC-142b	2310
HFC-143a	4470
HFC-152a	124
HFC-23	14 800
HFC-32	675
HFC-125	3500
HFC-134a	1430
HFC-1234ze(E)	<1
HFC-1234yf	<1
R-290 (Propane)	5

CALCULATION OF GWP OF BLENDS

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

The GWP of blends are therefore calculated as follows:

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

Example: R-401A

R-401A is a blend composed of **53%** HCFC-22, **13%** HFC-152a and **34%** HCFC-124 (mass %). The GWP value for HCFC-22 is 1810, for HFC-152a is 124 and for HCFC-124 is 609.

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 1810	+	**0.13 (13%)** x 124	+	**0.34 (34%)** x 609
	=	959.3	+	16.1	+	207.1
	=	1182.5 (rounded to 1180)				

SOME EXAMPLE BLEND GWPs

ASHRAE designation	Composition, substances*	Composition (Mass %)	GWP of components†	Blend GWP
Zeotropic Refrigerant Blends				
R-401A	HCFC-22/HFC-152a/HCFC-124	53/13/34	1810/124/609	1180
R-404A	HFC-125/HFC-143a/HFC-134a	44/52/4	3500/4470/1430	3920
R-407A	HFC-32/HFC-125/HFC-134a	20/40/40	675/3500/1430	2110
R-407C	HFC-32/HFC-125/HFC-134a	23/25/52	675/3500/1430	1770
R-407F	HFC-32/HFC-125/HFC-134a	30/30/40	675/3500/1430	1820
R-410A	HFC-32/HFC-125	50/50	675/3500	2090
R-417A	HFC-125/HFC-134a/HC-600	46.6/50/3.4	3500/1430/4	2350
R-444B	HFC-32/HFC-1234ze(E)/HFC-152a	41.5/48.5/10	675/1/124	290
R-446A	HFC-32/HFC-1234ze(E)/HC-600	68/29/3	675/1/4	460
R-449A	HFC-134a/HFC-125/HFC-1234yf/HFC-32	26/25/25/24	1430/3500/1/675	1410
R-452A	HFC-1234yf/HFC-32/HFC-125	30/11/59	1/675/3500	2140
Azeotropic Refrigerant Blends				
R-507A	HFC-125/HFC-143a	50/50	3500/4470	3990
R-513A	HFC-1234yf/HFC-134a	56/44	1/1430	630

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

Notes

The GWP values for HCFCs, HFCs and CFCs used in this factsheet (including to calculate blend GWPs) are taken from the Montreal Protocol Annex A, C and F. All other values are from the *2014 Scientific Assessment of Ozone Depletion, World Meteorological Organization (100 year time horizon values).*

[1] Hydrofluoroolefins (HFOs) are a new class of unsaturated HFC refrigerants which have lower GWPs and shorter atmospheric lifetimes when compared to other HFCs. HFOs are not included as substances to be phased down in the Kigali Amendment.

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