Handheld Advisory Circular Update

Louise Speitel

Fire Safety Branch
FAA Wm. J. Hughes Technical Center
Atlantic City International Airport, NJ 08405

International Aircraft Systems Fire Protection Working Group
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Federal Aviation Administration

Dos and Don’ts

- FAA Aircraft Certification Service has advised the FAA Fire Safety Team that the Advisory Circular AC 20-42D is considered in the process of rulemaking.
- We cannot release a draft version or discuss the AC because ex parte communication of pending rulemaking is not permitted.
- We can discuss recent data on handheld agents that was not available when the task group was working on the draft AC.

Outline

- **Updated Data:**
  - **Halon 1211:** Remove Max Safe W/V Selector Curves for Ventilated Compartments
  - **HCFC Blend B:** Add Max Safe W/V Data for Ventilated and Nonventilated Compartments
  - **Halocarbon Blends:** Provide Max Safe W/V Calculation Method.

- **Methods:**
  - PBPK Modeling of HCFC-123 for Human Exposures to LOAEL Concentrations. Do not exceed Target Arterial Concentrations
  - Maximum Safe W/V Guidance for Blends

PBPK Modeling Approach

- **LOAEL**
  - Lowest observable adverse effect level for a group of dogs exposed to a chemical **(%V/V)**
- **Standard FAA-accepted PBPK methodology:** is described in

  Allen Vinegar, Gary W. Jepson, Mark Cisneros, Reva Rubenstein, William J. Brock, "Setting Safe Acute Exposure Limits for Halon Replacement Chemicals using Physiologically Based Pharmocokinetic Modeling", *InhalationToxicology. 12, pp. 751-763, 2000.*

- **Human PBPK Model**
  - Describes the uptake, distribution, metabolism, and elimination of inhaled halocarbons in the human body.
  - This PBPK model includes a respiratory-tract region and a pulmonary exchange area
  - **Partition Coefficients:**
    - Liver
    - Fat
    - Lung
    - Gut
    - Slowly perfused tissues
    - Rapidly perfused tissues

PBPK Modeling Approach (cont.)

- **Human PBPK Model (cont)**
  - **Monte Carlo Method:**
    - ❖ Monte Carlo simulations describe the effect of interindividual variability on the output of PBPK models : 2 standard deviations.
    - ❖ Accounts for **97.5%** of the simulated population
  - **Target arterial Concentration:**
    - ❖ Out of a group of dogs exposed to each chemical at the LOAEL gas concentration, the lowest measured 5-min arterial concentration was taken as the target arterial concentration for use in modeling human exposure.
    - ❖ Target arterial concentration: same for dogs and humans

Halon 1211 PBPK-Based Maximum Safe W/V

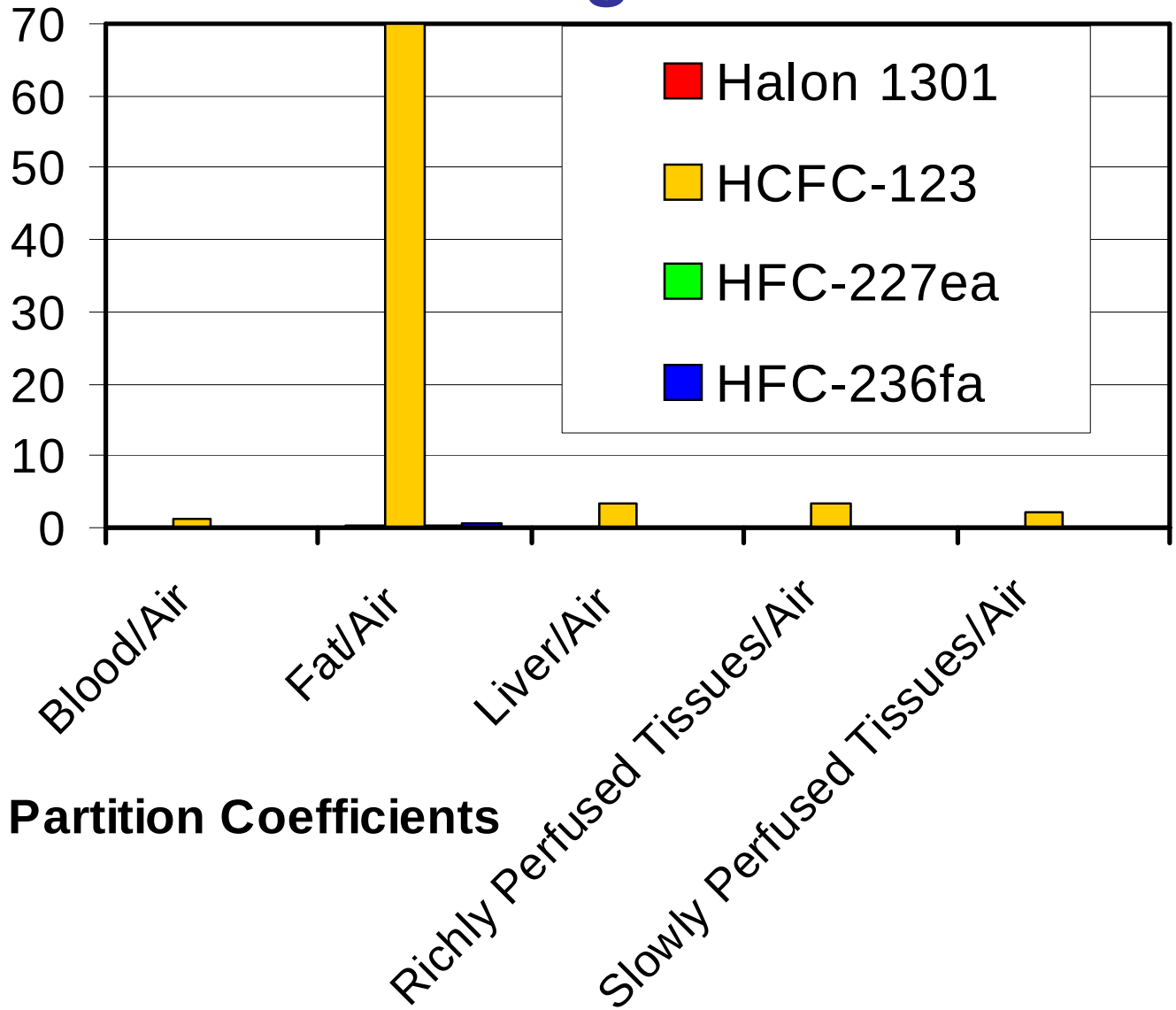
- **Halon 1211 PBPK Modeling Efforts don't meet requirements:**
  - Al Vinegar's Halon1211 PBPK modeling articles:
    - Early work and a precurser to the more robust modeling efforts that followed.
    - There is no measured dog arterial blood concentration at the NOAEL cardiac sensitization (CS) concentration.
    - The human PBPK model was run at the LOAEL 1% gas concentration to simulate arterial blood concentrations to establish the "target" CS threshold blood level of Halon 1211.
  - We can not locate references for the partition coefficients
  - A Monte Carlo sort was not used: Clearly stated

- **Solution:**
  - Use NOAEL concentration in place of the maximum safe human exposure concentration to calculate the Maximum Safe W/V
  - In the absence of an acceptable PBPK solution, one can not develop selector curves for the maximum safe W/V for ventilated aircraft compartments.

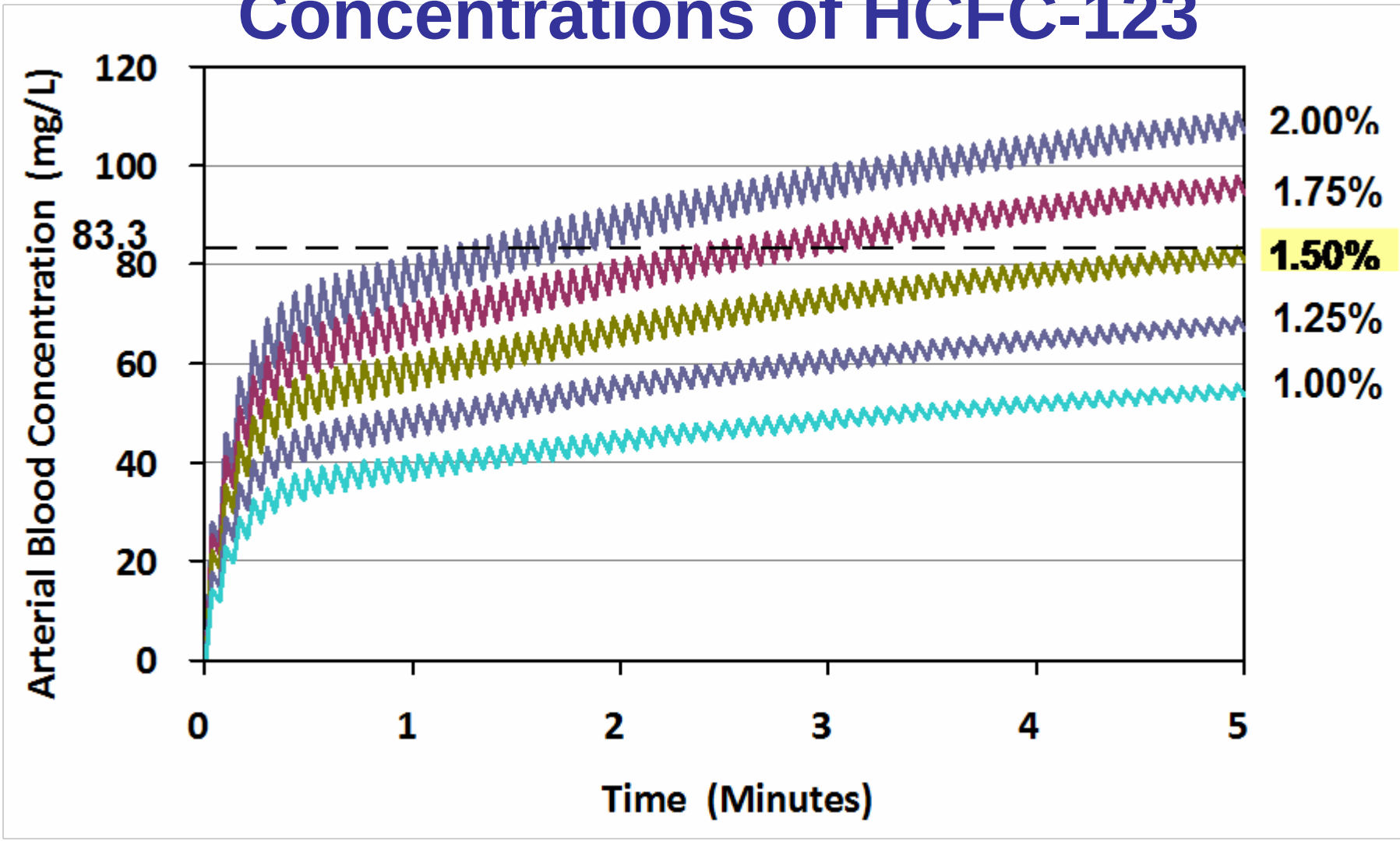
HCFC-123 PBPK-Based Maximum Safe W/V

- **Data presented for HCFC Blend B to obtain the target 5 minute concentration is in review.**
- **HCFC-Blend B data not yet accepted by the FAA**
- **Data is presented in following slides:**

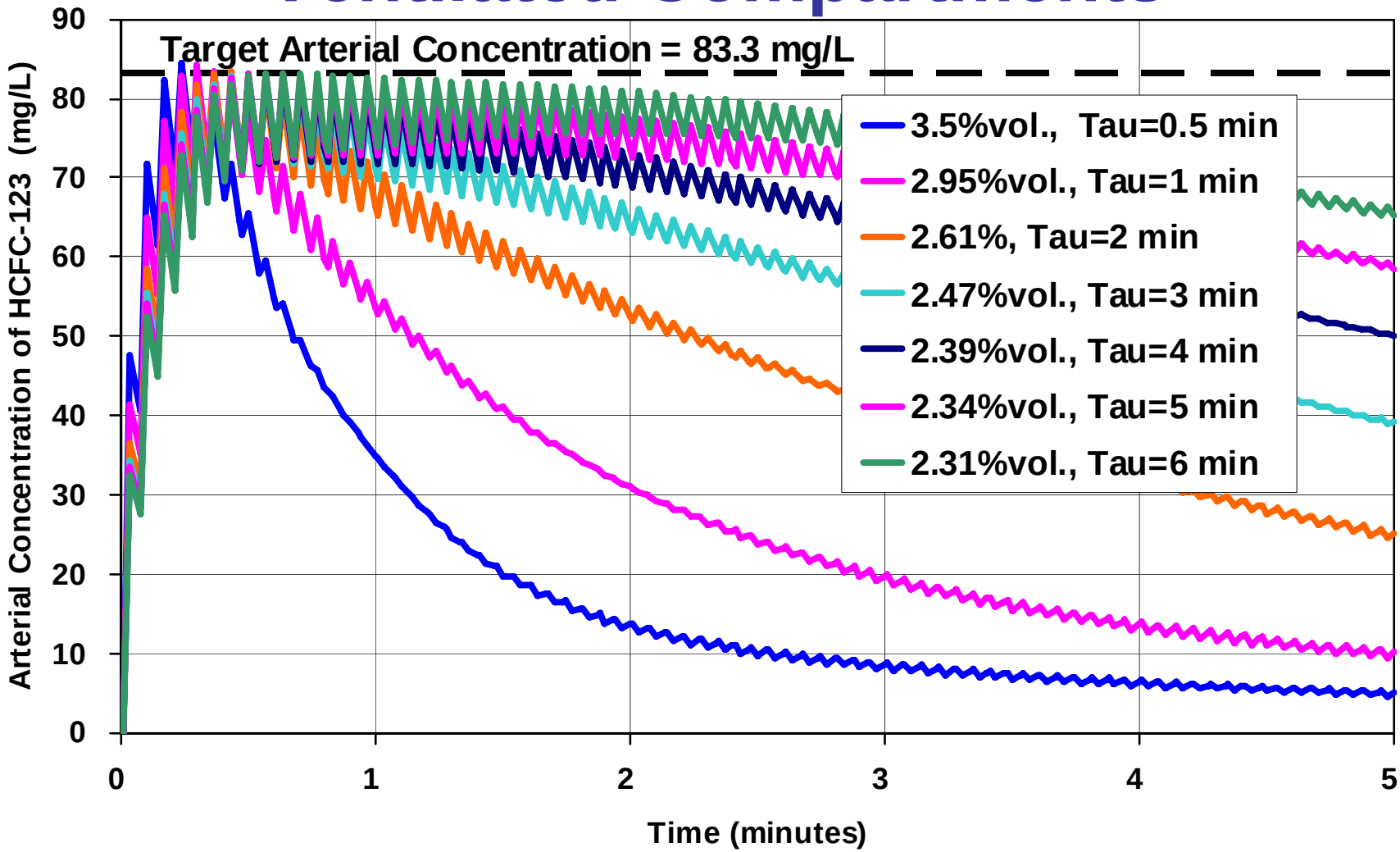
PBPK Modeling of Halocarbons



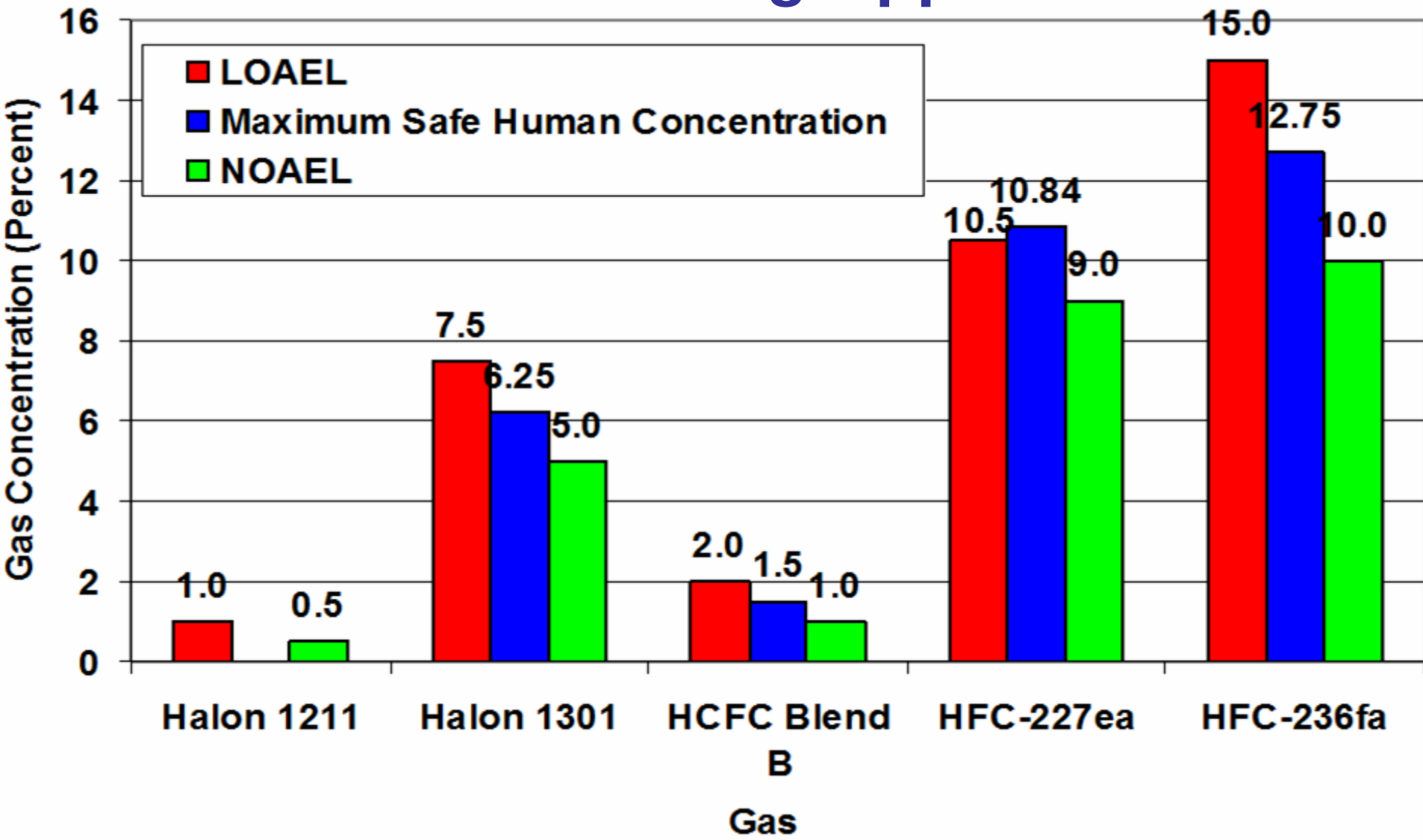
PBPK Modeling + 2SD of Constant Concentrations of HCFC-123



PBPK Modeling of HCFC 123: Ventilated Compartments



PBPK Modeling Approach



Maximum Safe Exposure Concentrations No Ventilation

Agent	NOAEL (%v/v)	Max Safe 5 Minute Human Exposure Concentration (%v/v)	C_{Safe} (%v/v)
HCFC Blend B	1.0	1.50	1.50
HFC-227ea	9.0	10.84	10.84
HFC-236fa	10.0	12.75	12.75
Halon 1211	0.5	N/A	0.5
Halon 1301	5.0	6.25	6.25

Maximum Safe W/V: No Ventillation

Agent	Maximum Safe W/V (lbs/ft^3)					
	Sea Level (For info only)	Pressurized Aircraft (8k ft. CPA)	Non-Pressurized Aircraft			
			12.5k ft.	14k ft.	18k ft.	25k ft.
HCFC Blend B	0.00586	0.00435	0.00367	0.00345	0.00294	0.00218
HFC-227ea	0.0551	0.0409	0.0344	0.0324	0.0275	0.0205
HFC-236fa	0.0595	0.0442	0.0371	0.0349	0.0297	0.0221
Halon 1211	0.00224	0.00166	0.00139	0.00131	0.00112	0.000829
Halon 1301	0.0260	0.0193	0.0162	0.0153	0.0130	0.00968

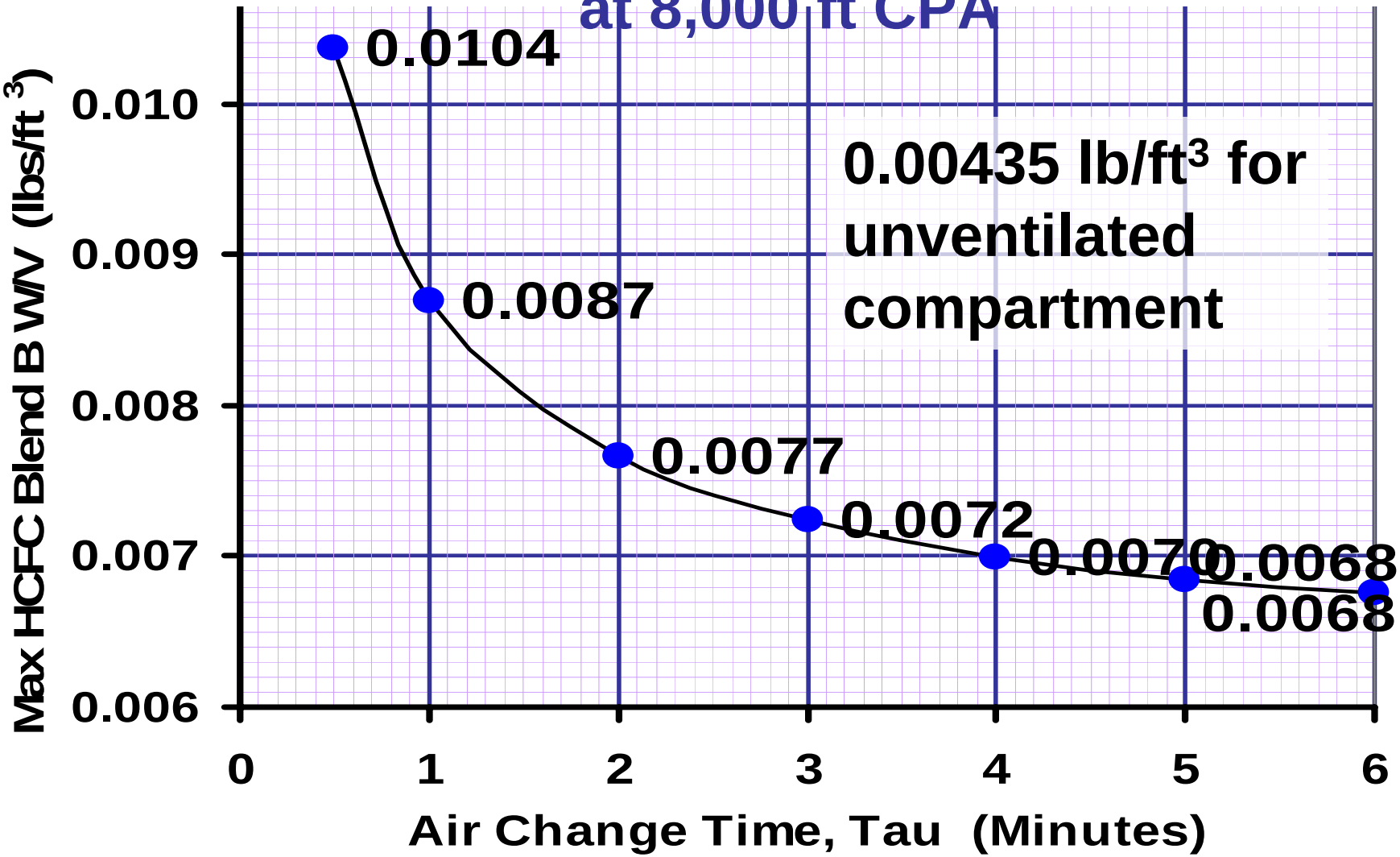
Minimum Safe Compartment Volumes No Ventilation

Agent	Agent Weight (lbs)	Minimum Safe Volume For One 5 B:C Extinguisher (ft^3)					
		Sea Level (for info only)	Pressurized Aircraft	Non-Pressurized Aircraft			
			8,000 ft CPA	12,500 ft	14,000 ft	18,000 ft	25,000 ft
HCFC Blend B	5.5	938	1264	1499	1593	1870	2525
HFC-227ea	5.5	99.8	135	160	170	200	269
HFC-236fa	4.75	79.8	107	128	136	159	214
Halon 1211	2.5	1116	1502	1790	1908	2232	3016
Halon 1301	5.0	192	258	308	327	385	517

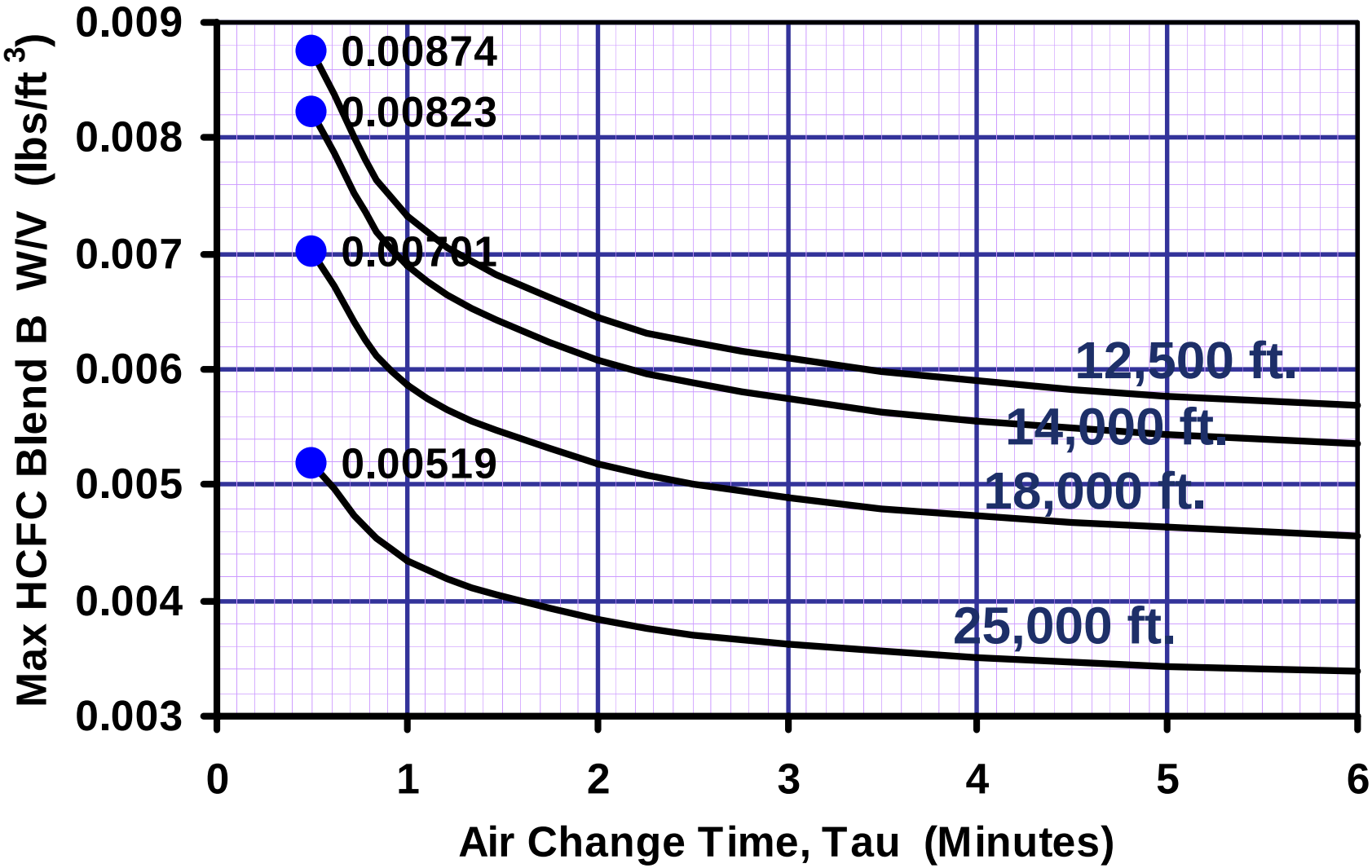
Number of 5 B:C Extinguishers That Can be Safely Installed at 8,000 ft CPA

Aircraft	Volume (ft^3)	Max No. Seats	Halon 1211		Halon 1301	HCFC Blend B	HFC-236fa	HFC-227ea
			AC 20-42C and U.S. UL1093	AC 20-42D	AC 20-42D	AC 20-42D	AC 20-42D	AC 20-42D
C 152	77	2	0.3	**0.05**	0.3	**0.06**	0.7	0.5
C 210C	140	6	0.5	**0.09**	0.5	**0.1**	1.3	1.0
C 421B	217	10	0.7	**0.1**	0.8	**0.2**	2.0	1.5
S76	204	14	0.7	**0.1**	0.8	**0.2**	1.9	1.5
CRJ200	2015	50	6.5	**1.3**	7.8	**1.6**	19	15
B727-10	5,333	131	17	**3.5**	21	**4.2**	50	38
B767-200	11,265	255	36	**7.5**	43	**8.9**	105	80
B747	27,899	500	90	**18**	108	**22**	260	198

Maximum Safe HCFC Blend B W/V at 8,000 ft CPA



Maximum HCFC Blend B W/V



Halocarbon Blends

The maximum safe W/V for a blend can be calculated from the maximum safe W/V of halocarbon A and the maximum safe W/V of halocarbon B as follows:

$$\left(\frac{W_{A+B}}{V}\right)_{Safe} = \chi_A \times \left(\frac{W_A}{V}\right)_{Safe} + \chi_B \times \left(\frac{W_B}{V}\right)_{Safe}$$

where $\chi_A + \chi_B = 1$

and $\chi_A = \frac{n_A}{n_A + n_B} \qquad \chi_B = \frac{n_B}{n_A + n_B}$

and $n_A = \frac{m_A}{MW_A} \qquad n_B = \frac{m_B}{MW_B}$

ENVIRONMENTAL PROPERTIES

Agent	Formula	ODP	GWP (100 years)	Atmospheric Lifetime (yrs)
Halon 1211	$CBrClF_2$	5.1	1300	11
Halon 1301	$CBrF_3$	16	7140	65
HCFC-123	$CHCl_2CF_3$	0.012	120	1.4
HFC-227ea	CF_3CHFCF_3	0.0	3800	36.5
HFC-236fa	$CF_3CH_2CF_3$	0.0	9400	226