

EMFAC-HK Vehicle Emission Model

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What is EMFAC-HK

- * Computer model written in Intel FORTRAN which is adapted from EMFAC model developed by California Air Resources Board (CARB)
- * Calculates emission factors (g/km) for a “Fleet Average Vehicle” and total emissions (tonnes/hr, tonnes/day)
- * Used for petrol, diesel, LPG on-road vehicles
- * Calculates Emissions for All HK Vehicle Classes
- * Exhaust and Evaporative Hydrocarbon Emissions (HC)
- * Exhaust Carbon Monoxide (CO)
- * Exhaust Nitrogen Oxides (NO_x)
- * Exhaust PM

Vehicle Classification Chart

V3.x Index	Vehicle Class Description	Gross Vehicle Weight (tonnes)
1	Private Cars	ALL
2	Taxi	ALL
3	Light Goods Vehicles (<=2.5t)	<=2.5t
4	Light Goods Vehicles (2.5-3.5t)	>2.5-3.5t
5	Light Goods Vehicles (3.5-5.5t)	>3.5-5.5t
6	Medium & Heavy Goods Vehicles (5.5-15t)	>5.5-15t
7	Medium & Heavy Goods Vehicles (>=15t)	>15t
8	Public Light Buses	ALL
9	Private Light Buses (<=3.5t)	<=3.5t
10	Private Light Buses (>3.5t)	>3.5t
11	Non-franchised Buses (<6.4t)	<=6.36t
12	Non-franchised Buses (6.4-15t)	>6.36-15t
13	Non-franchised Buses (>15t)	>15t
14	Single Deck Franchised Buses	ALL
15	Double Deck Franchised Buses	ALL
16	Motor Cycles	ALL

What Can the Model Do?

- * Analytical Tool that can be applied for local and regional Air Quality Planning
- * Can be used to estimate emission impacts from:
 - * Future Vehicle Fleets
 - * Diesel/Alternate Fuel Use
 - * Vehicle Speeds
 - * Ambient Temperature
 - * Fuel properties – Reid vapor pressure (RVP)/Oxygen content/Sulfur content
 - * Air Conditioning
 - * Cold Starts
 - * Inspection/Maintenance Programs
 - * New Vehicle Standards
 - * Other Strategies
 - * Evaporative Controls

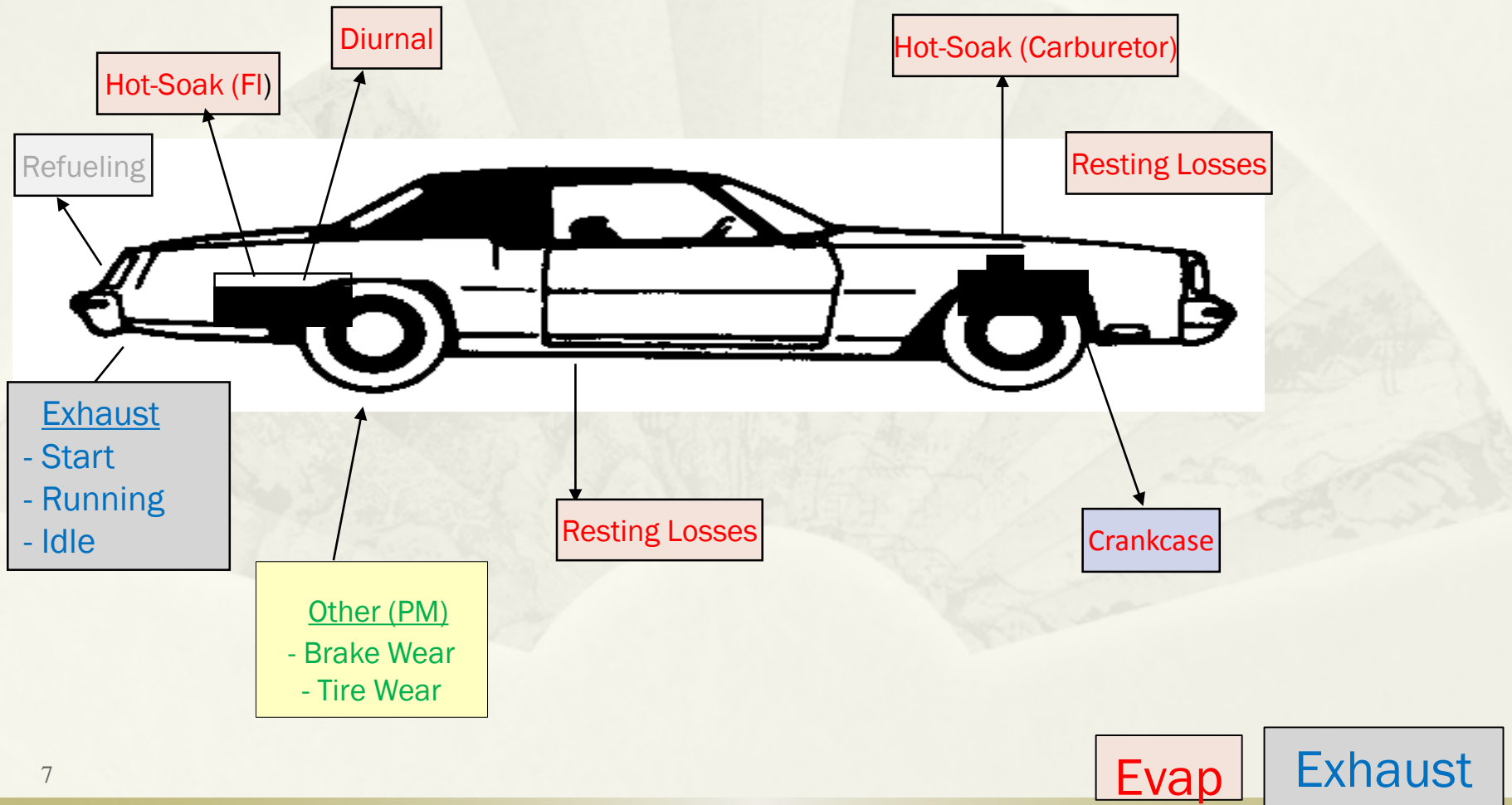
Uses of Model

- * Project Specific Vehicle emissions impact
- * Territory-wide Inventories and Control Strategy Analysis
- * Conformity Demonstrations
- * Area-wide Inventories
- * New Regulation Development
- * Local/fleet-specific analyses
- * Impact on local roadways/intersections
- * Setting up of Roadway Network Speed Limits

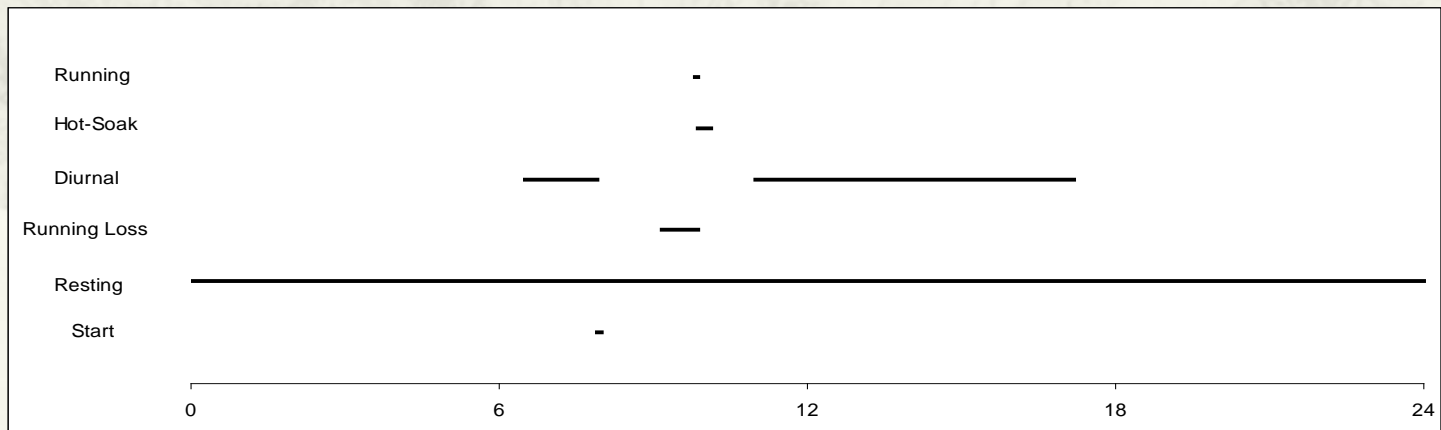
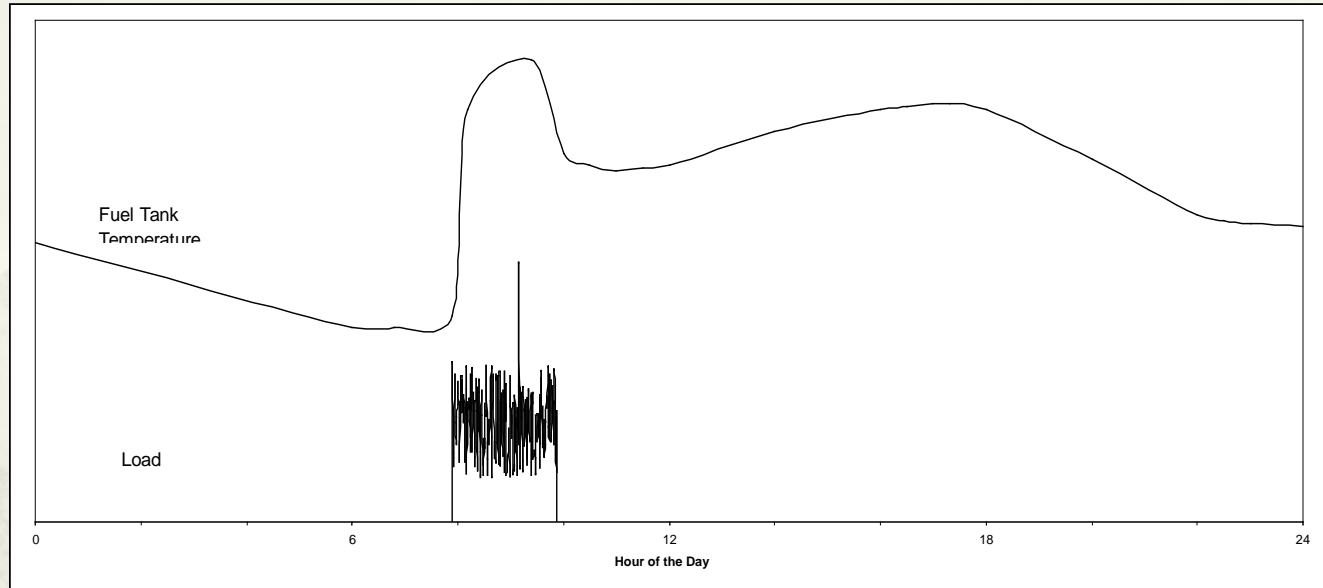
Vehicle Emissions Data Used for Development of Model

- * Hong Kong PEMS and activity data
- * Vehicles tested in real Hong Kong conditions
- * Estimates made for new vehicles and as they age
- * Changes in emissions for temperatures, fuel analysis, cold start conditions, mileage, etc.
- * Vehicles of various technologies tested in as use state
- * Developed emission relationships
- * Remote Sensing data can be used to characterize (e.g. Emission Regime fractions)

Emissions Processes



When Do Emissions Occur?





Calculation Methodology/Structure

Main Calculations

Primary Groups

- Technology/Emission Standards - Many groups
Emissions Regime - Super/High/Normal
Emissions Type - Start/Running/Evap(with different processes)

2-Step Process

- Emission Factor Calculations
- Activity Matrices

Examples of Technology Groups

Vehicle Class	Fuel Type	Vehicle Emission Standards	Tech Group Index
PC	Diesel	pre-Euro	170
PC	Diesel	pre-Euro Traps Retrofitted	171
PC	Diesel	pre-Euro DOC Retrofitted	172
PC	Diesel	Euro I	173
PC	Diesel	Euro IV	176
PC	Diesel	Euro V - SCR	175
PC	Diesel	Euro V - DPF & SCR	174
PC	Diesel	Euro VI	177
PC	Petrol	pre-ULP	1
PC	Petrol	Unleaded Petrol Vehicles	8
PC	Petrol	Euro I	10
PC	Petrol	Euro II	13
PC	Petrol	Euro III	23
PC	Petrol	Euro IV	24
PC	Petrol	Euro V & VI	29

Vehicle Class	Fuel Type	Vehicle Emission Standards	Tech Group Index
HGV8	Diesel	pre-Euro	153
HGV8	Diesel	pre-Euro DOC Retrofitted	155
HGV8	Diesel	Euro I	154
HGV8	Diesel	Euro II	157
HGV8	Diesel	Euro III	159
HGV8	Diesel	Euro IV	160
HGV8	Diesel	Euro IV - DPF	163
HGV8	Diesel	Euro IV - SCR	164
HGV8	Diesel	Euro V	161
HGV8	Diesel	Euro V - DPF	165
HGV8	Diesel	Euro V - SCR	166
HGV8	Diesel	Euro VI	162

Loop over all SCENARIOS in input file

Loop over all AREAS in scenario

Call Area_Average for activity

Calculate activity for all GAs

For area-average case, calculate weighted-average activity for area

Loop over all VEHICLE CLASSES in scenario

Loop over all AGES allowed by scenario and calendar year

Age and calendar year specify MODEL YEAR.

Loop over EXHAUST TECH GROUPS

Calculate exhaust BERs

Running, start, and idle basic emission rates

Calculate I/M benefit

Calculate exhaust correction factors

Calculate and accumulate tons [Burden mode]

Write tech-group report detail [Burden mode]

Loop over EVAP TECH GROUPS

For six evap processes...

Calculate evap BERs

Calculate I/M benefit

Calculate evap correction factors

Calculate and accumulate tons [Burden mode]

Write tech-group report detail [Burden mode]

Write model year and speed report detail [Burden mode]

Calculate and accumulate grams [Emfac mode]

Write vehicle class and speed report detail [Burden mode]

Write vehicle class report [Emfac mode]

Write area and speed report detail [Burden mode]

Write area-based report(s) [Burden mode]

Write area-based report(s) [Emfac mode]

Exhaust Calculations

- * For Each Calendar Year and Vehicle Class
 - * Calculate emissions (each Pollutant) for each Age- three primary steps
 - * Estimate Exhaust emissions
 - * Estimate impact of Inspection program
 - * Use correction factors to model local situation
 - * Combine emissions for all Ages

Exhaust Calculations

Exhaust subroutine

- * Each age is associated with a particular Model year
- * In each model year there are few technology groups assigned
- * For each technology groups
 - * Estimate emitter category Regime Fraction
 - * Estimate emitter category Regime Emissions

Emitter Category- Regime Fractions

- * For each age and vehicle class the odometer is assigned
- * Regime Size Calculated for Super, High, and Normal Emitters
- * Regime Size is calculated as (data in Reg_Size):

$$\text{RegSize} = \textit{func} (\text{Odometer})$$

Regime growth rates developed based on local data

Exhaust Calculations

Emitter Category Emissions

* For Each Myr, Age, Tech group :

Stored within
EMFAC-HK

$$E_{\text{emit_cat}} = E_{\text{zero}} + \text{Det_rate} * \text{Odo}$$

$$E_{\text{emit_cat}} = \textit{func} (\text{poll, mode, tech group, reg})$$

Vehicles Used for Updating the EMFAC-HK Model

Vehicle Class	Fuel Type	Emission Standard							Total
		Pre-Euro	Euro I	Euro II	Euro III	Euro IV	Euro V	Euro VI	
Cars	Petrol			3	7	21	11	2	44
Taxis	LPG			11	5	12	11		39
Public light buses	Diesel				3	1			4
	LPG				6	4			10
Private light buses	Diesel		1	1	3	1			6
Light goods vehicles <= 5.5t	Diesel	5	4	12	23	18	23	2	87
	Petrol					4			4
Heavy goods vehicles > 5.5t	Diesel	4	1	4	19	13	22	2	65
Single Deck Coaches	Diesel			2	9	19	25		55
Double Deck Franchised Buses	Diesel			4	2		6	6	18
Total		9	6	37	77	93	98	12	332

Euro III & IV Diesel Vehicles Used for Updating the EMFAC-HK Model

Vehicle Class	Euro III						Euro IV				
	NIL	DOC	DOC & EGR	DPF	EGR	DPF & SCR	DOC & EGR	POC & DOC, EGR	DPF & EGR	SCR	SCR & DOC/EGR
Public light buses		3							1		
Private light buses		1	2						1		
Light goods vehicles <= 5.5t		4	16		3		9	4	5		
Heavy goods vehicles > 5.5t	5	5	6		3		6	2	3		2
Single Deck Coaches	2		6		1		3		4	10	2
Double Deck Franchised Buses #	1			2		2					
Total	8	13	30	2	7	2	18	6	14	10	4

#Two double deck franchised buses have been tested with different configurations.

Euro V & VI Diesel Vehicles

Used for Updating the EMFAC-HK Model

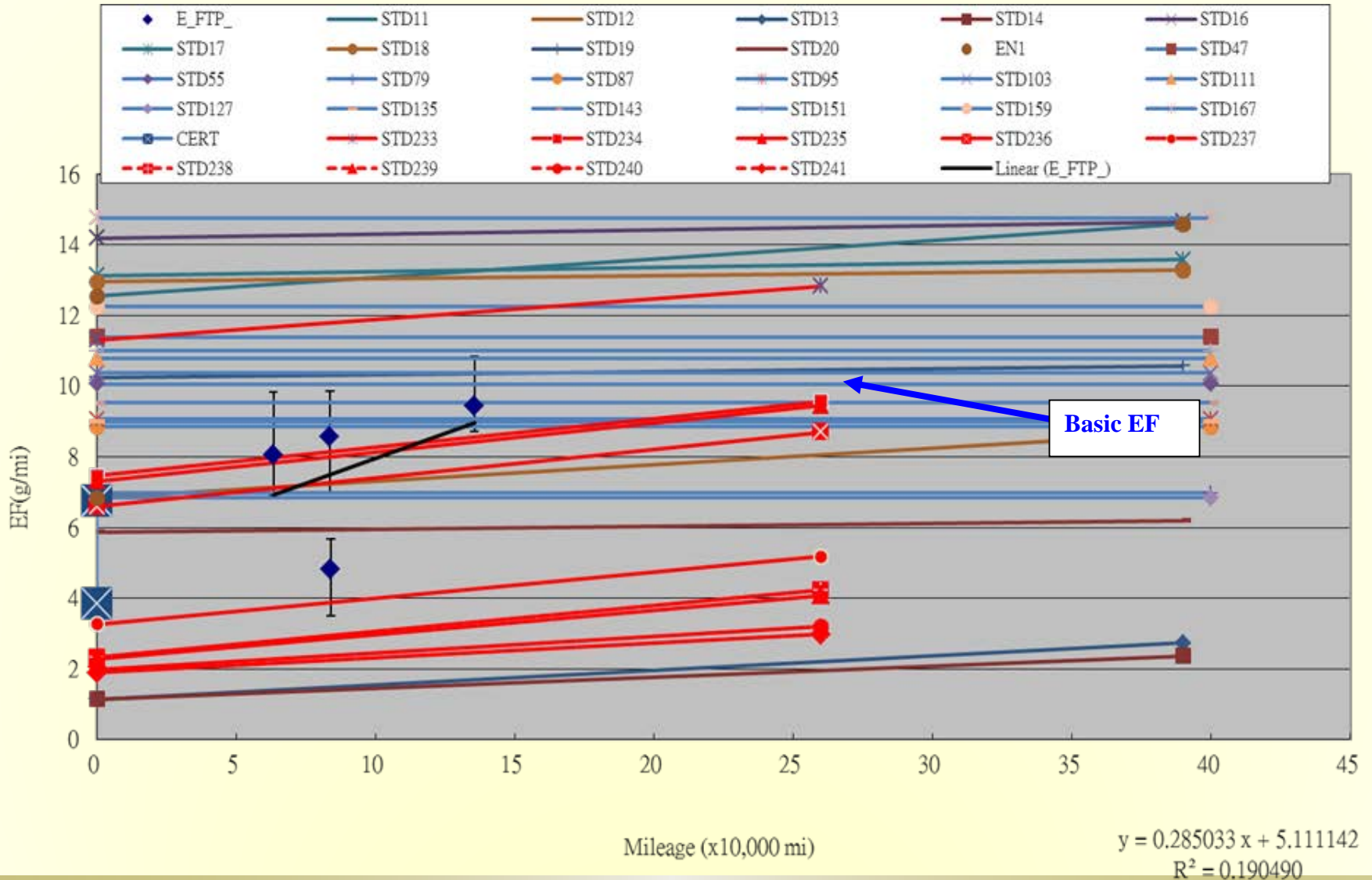
Vehicle Class	Euro V					Euro VI	
	DOC & EGR	DPF & EGR	SCR & DOC/EGR	DPF, EGR & SCR	SCR	DPF & SCR	DPF, EGR & SCR
Light goods vehicles <= 5.5t		21		2			2
Heavy goods vehicles > 5.5t	1	19	1	1		1	1
Single Deck Coaches	4	11			10		
Double Deck Franchised Buses					6		6
Total	5	51	1	3	16	1	9

Zero Mile Emission Factors (ZMEF) and (Deterioration Rates (DR)

- * Calculated emission factors (EF) at 1-minute and 8-minute averages of PEMS data of each vehicle (used mainly 8-minute average);
- * For each Tech Group, estimated the ZMEF and DR by median of EFs of vehicles at average speed between 25 km/hr and 35 km/hr.
- * For Speed Correction Factors, conducted statistical analysis on the ratios of median emission factors (in g/km) for all 8-km/hr average speed bins over basic emission rates obtained from ZMEF & DR by linear regression model.

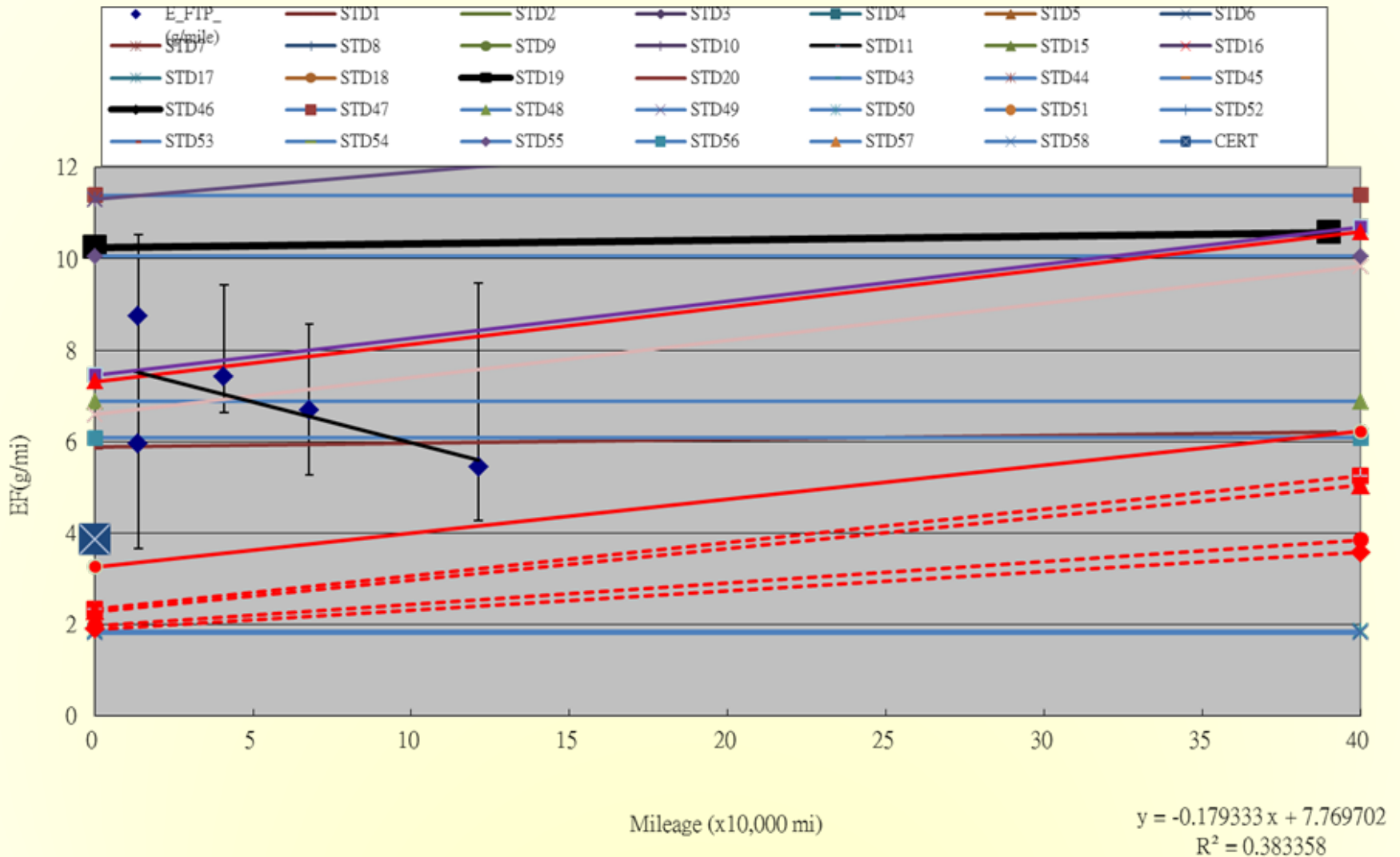
NOx emission factors for Euro IV SCR Heavy Goods Vehicles > 15t and Non-Franchised Bus > 15t

EMFAC2014 Diesel HHDT 2008 for these vehicle classes is used.



NOx emission factors for Euro V SCR Non Franchised Buses > 15t

Average is taken from measurements result



Regime Growth Rates

- Regime Growth Rates represent the fractions of different “regimes” of emitters by tech group, pollutant and mileage.
- Three regimes – Normal, High and Super, are assumed for the following cases:
 - For PM: diesel vehicles equipped with DPF except PC; and
 - For NO_x/VOC/CO: LPG and petrol vehicles.

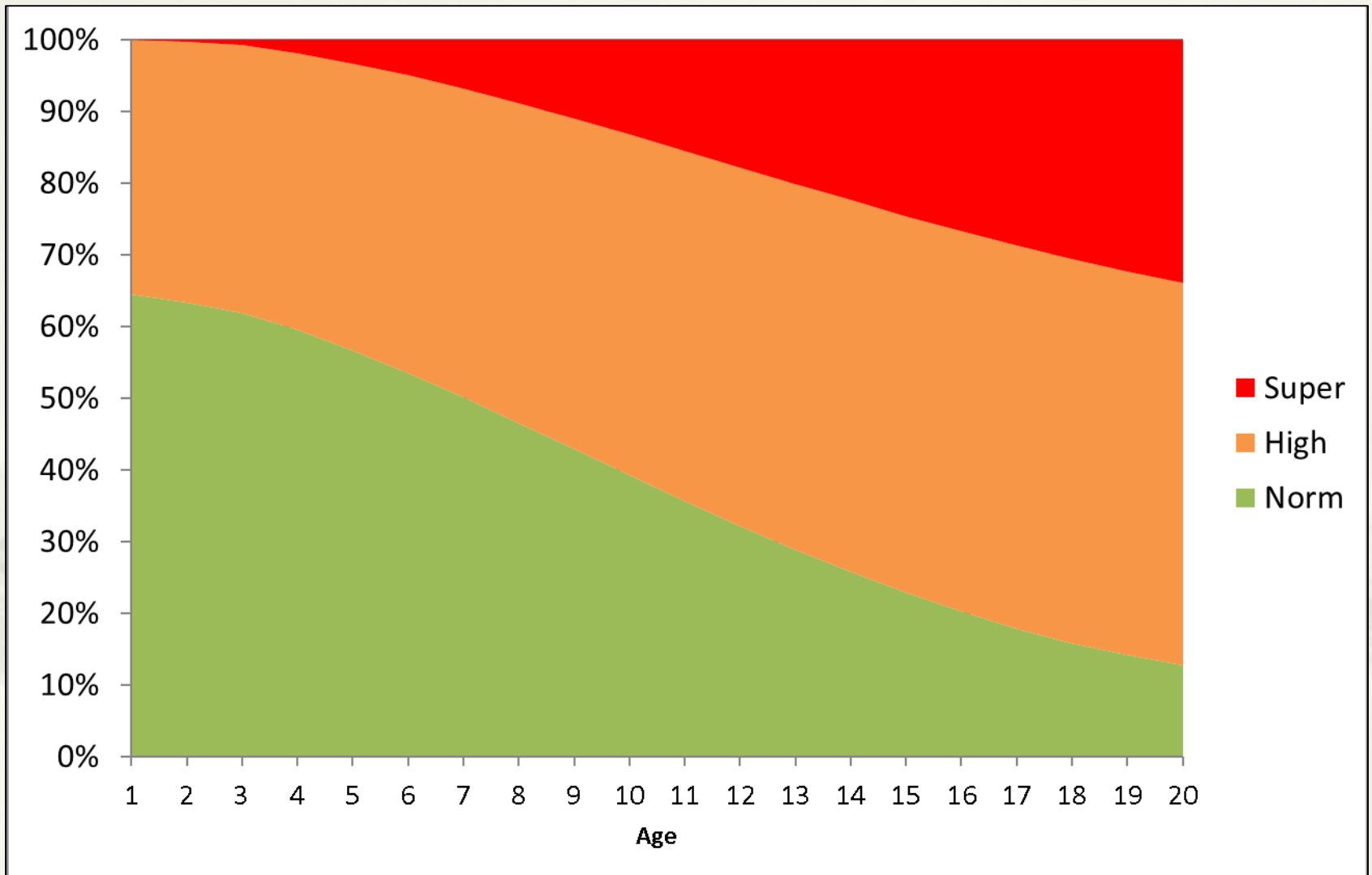
All other cases only have two regimes.

Regime Growth Rates

- Regimes fractions estimations are based on:
 - Data from smoky vehicle programme, for diesel vehicles#;
 - remote sensing data, for Petrol & LPG vehicles.

#For diesel light goods vehicles $\leq 3.5t$, super regime is estimated based on measurement data of abnormally high emission of a particular brand.

LPG Taxi NOx Regime Growth Rates



Exhaust Emissions

Tech Group/ Model Year Emissions
For Each Pollutant – Before I/M

$$E_{\text{tech_group}} = E_{\text{super}} * \text{RegSize}_{\text{super}} \\ + E_{\text{high}} * \text{RegSize}_{\text{high}} \\ + E_{\text{normal}} * \text{RegSize}_{\text{normal}}$$

$$E_{\text{model_year}} = \sum E_{\text{tech_group}}(\text{my}, \text{tg}) * \text{Tech_Frac}(\text{my})$$

Exhaust I/M calculations

- * I/M only causes the regime size fractions to change
- * EMFAC-HK already built-in existing I&M (remoting sensing) benefits by applying fitted measurement data to regime growth rates for petrol and LPG vehicles.
- * Emissions changes are caused as vehicles go from super and high emitting regimes to normal emitting regime

Vehicle Mileage Surveys

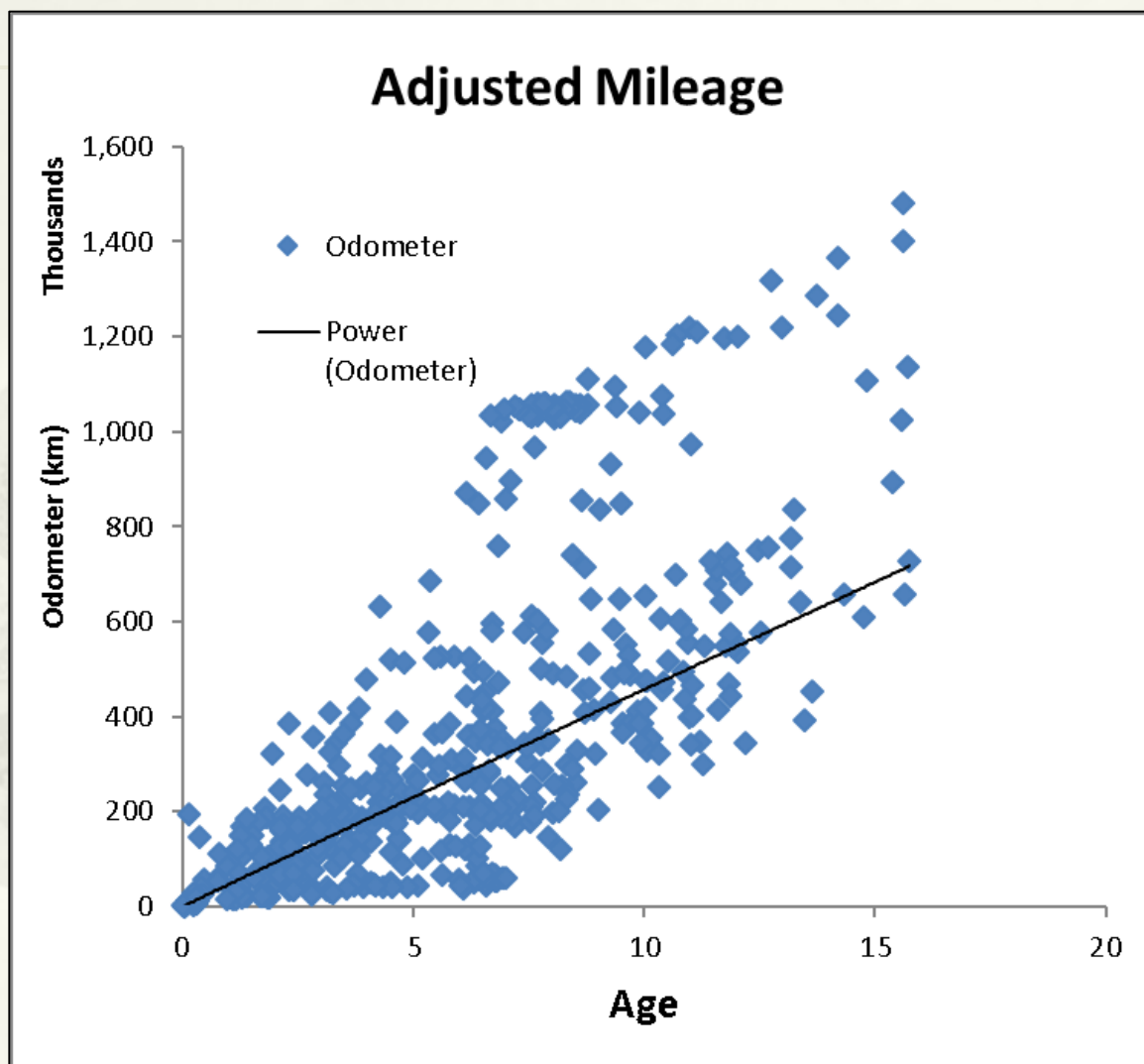
The sources included:

- Surveys conducted at petrol filling stations, car parks, and vehicle examination centres.
- Data provided by franchised bus companies.

Analysis:

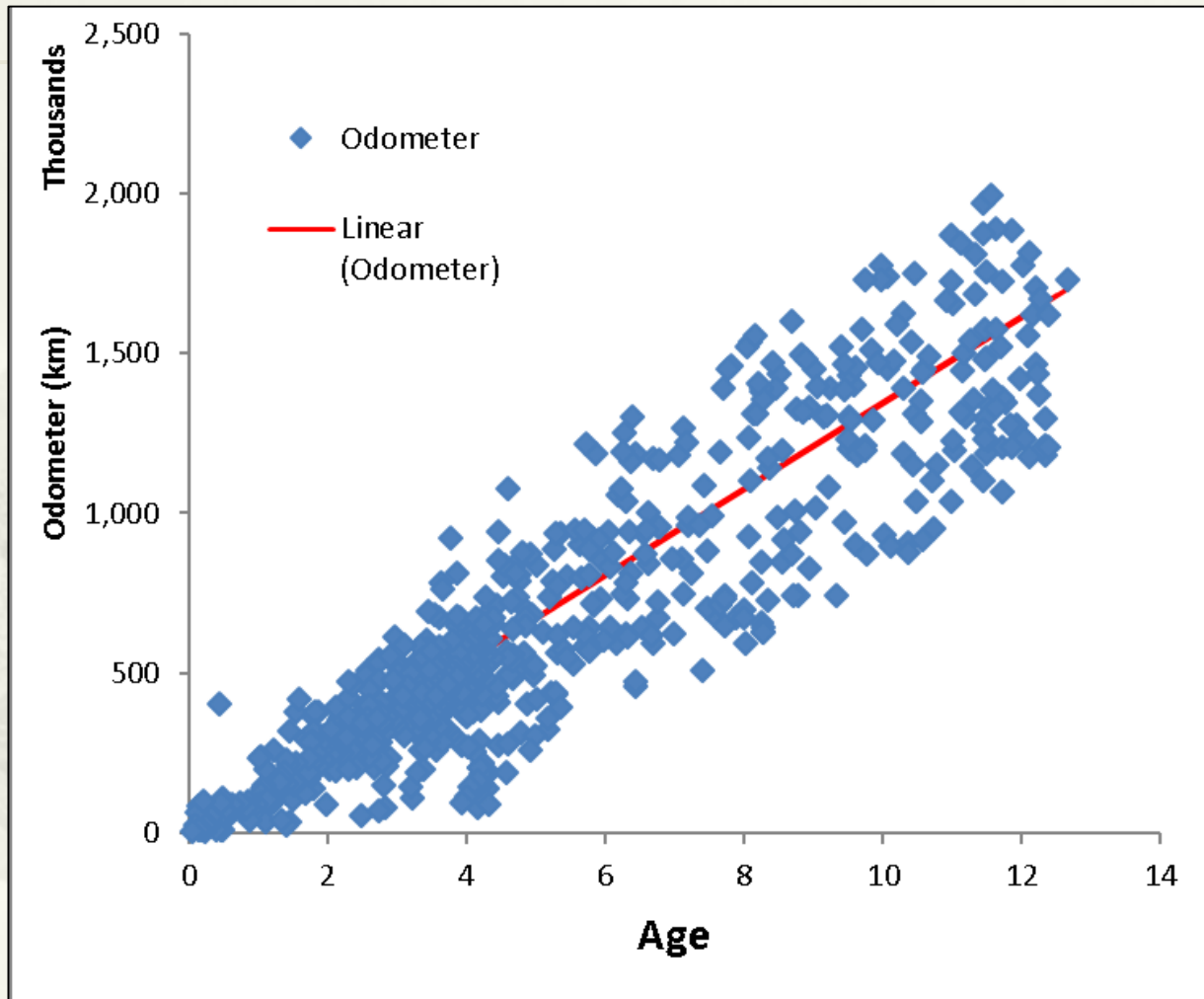
- Screen out those with too low mileage for certain age for commercial vehicles.
- Establish a odometer-age relationship by fitting the data.

Distribution of Odometer Reading vs. Age for Non-Franchised Buses > 6.4t



#Combined data from 2004-2005, 2012-2013 Surveys. Similar result were obtained in later surveys.

Distribution of Odometer Reading vs. Age for Taxi



#Combined data from 2004-2005, 2012-2013 Surveys. Similar result were obtained in later surveys.

Forecast of Vehicle Population

- EMFAC uses the population of a specific model of vehicles for consecutive calendar years to derive a variation curve of the percentage of vehicles sold still remain in the fleet after a specified amount of time has elapsed – retention rate. The curve is then used to forecast vehicle population.
- Retention rates are used in EMFAC for both forecasting to future calendar years and back-casting for those years where vehicle registration information is unavailable.
- The above methodology is to model the natural replacement of vehicles.

Forecast from One year to the Next:

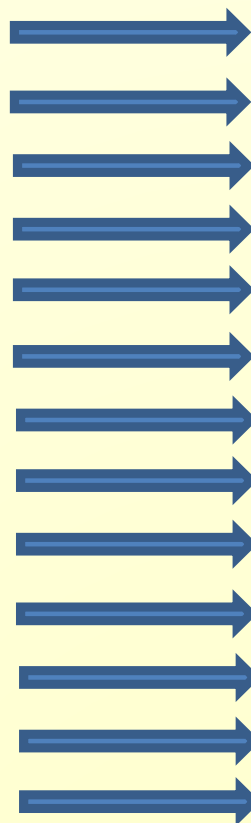
new sales are essentially determined by growth rates and survivors

Model Year

2018
2017
2016
2015
2014
2013
2012
2011
2010
2009
2008
2007
2006
2005
...

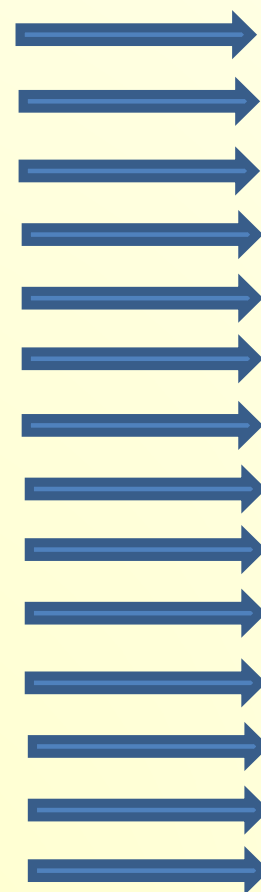
Calendar Year
2016
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
...

Retention Rates

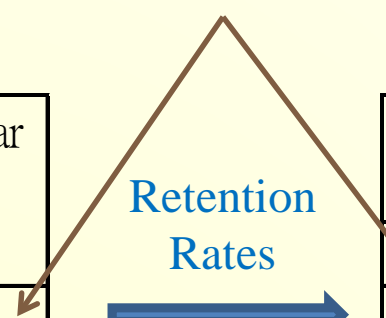


Calendar Year
2017
new sales
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
...

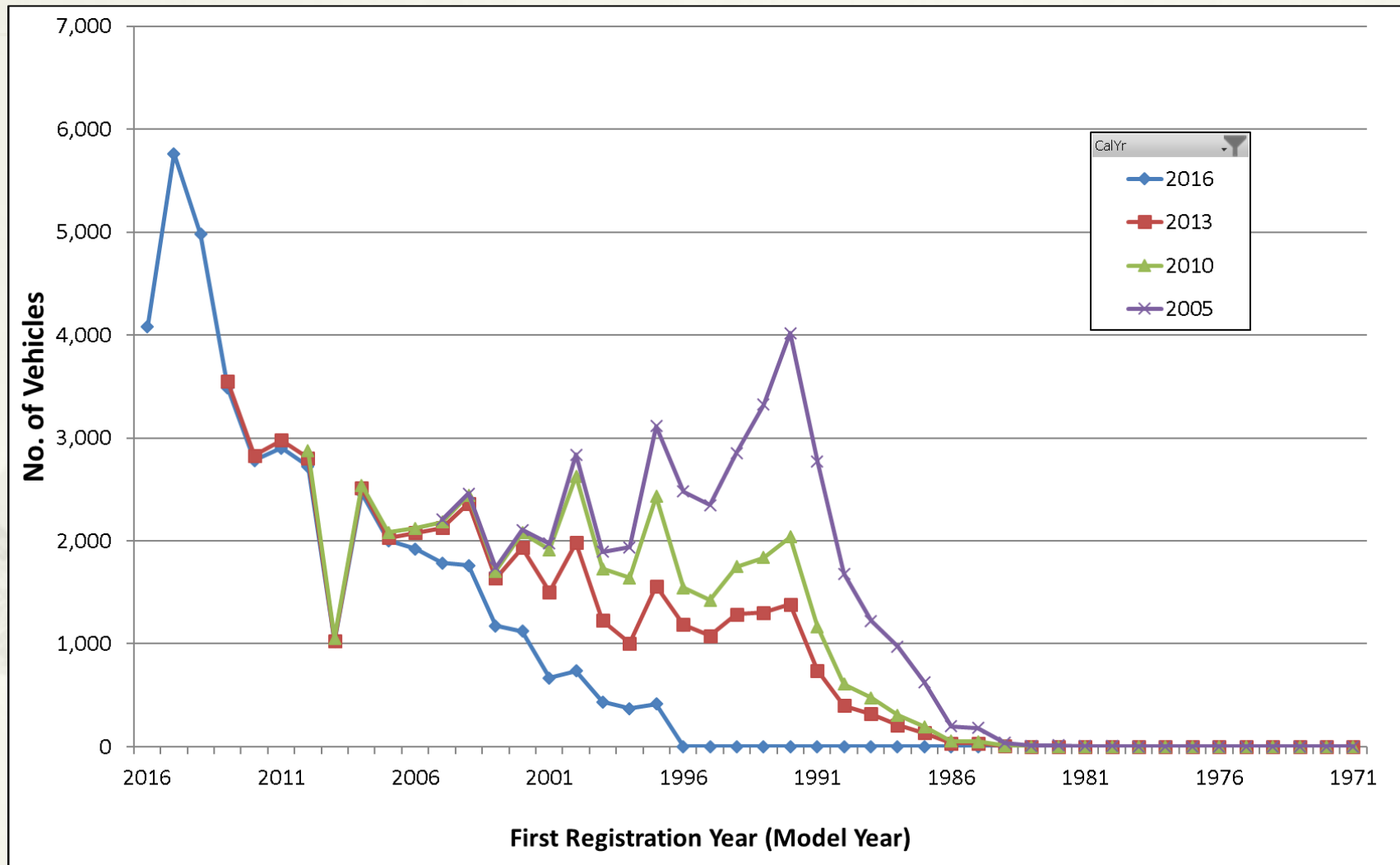
Retention Rates



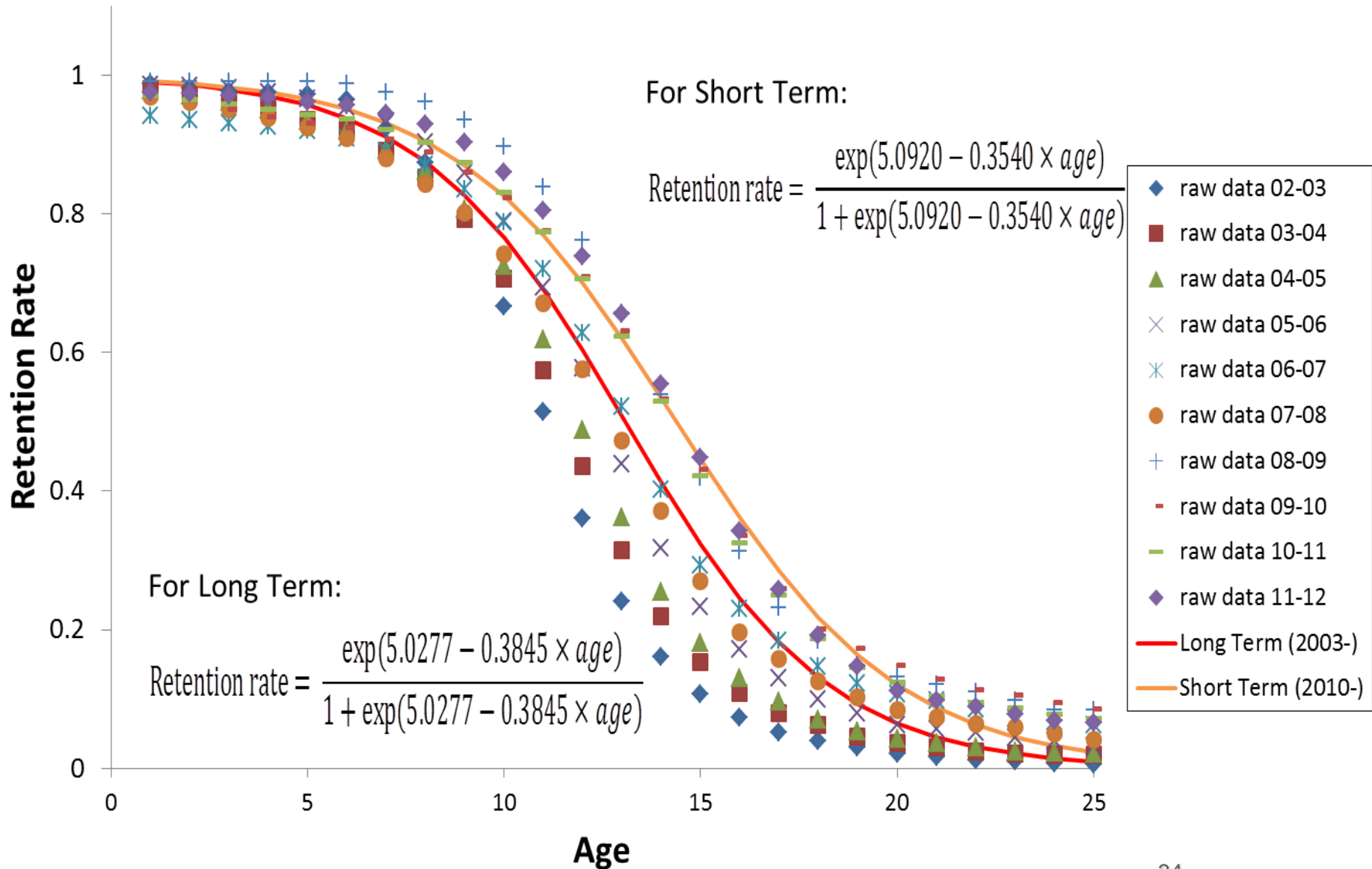
Calendar Year
2018
new sales
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
XXX
...



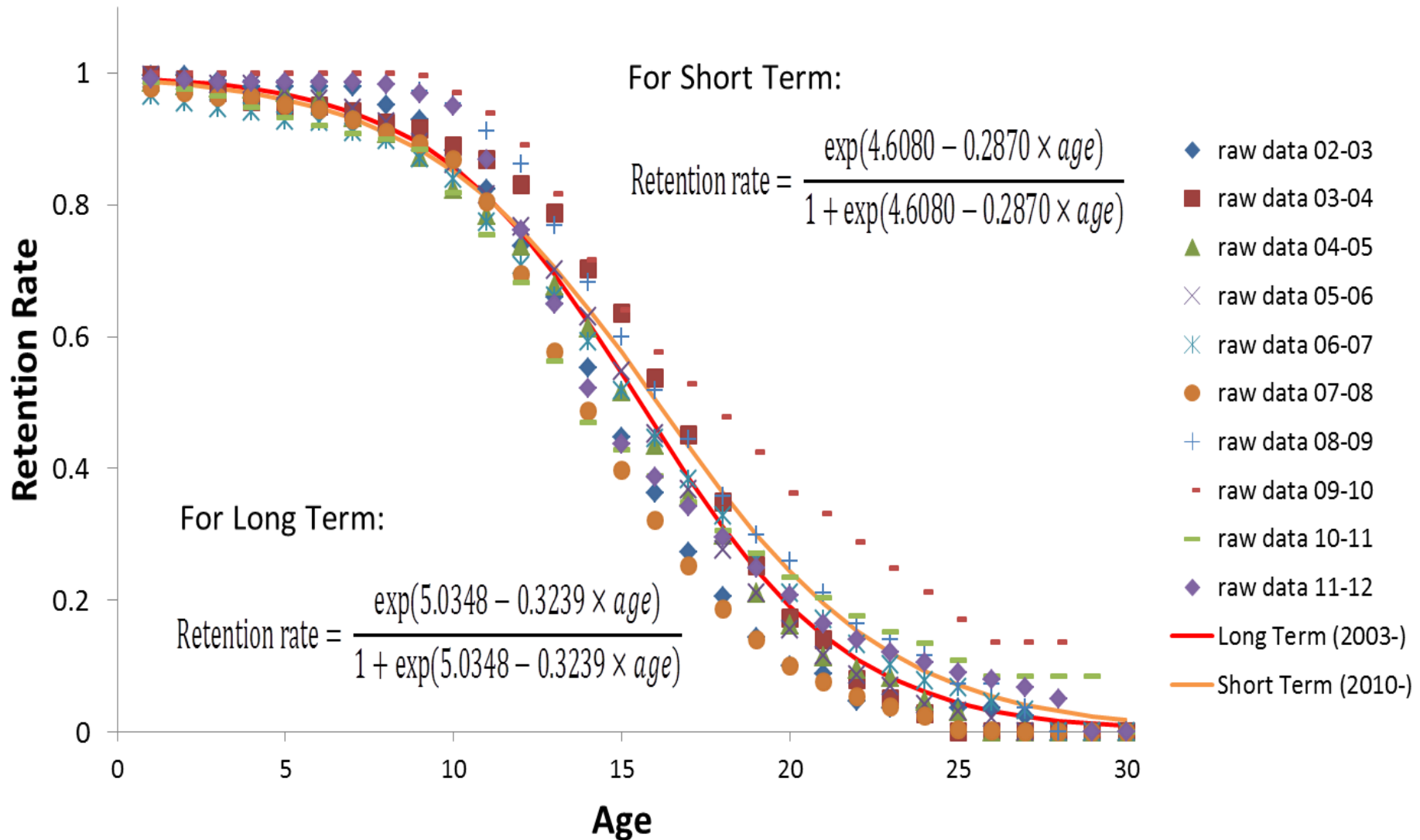
Distribution of Goods Vehicles > 15 t Population vs. 1st Reg. Year



Retention Rates for Private Cars



Retention Rates for Heavy-duty Goods Vehicles



EMFAC-HK Population Growth Rates from TD

The growth rates for PC, MC and goods vehicles were estimated based on the TD's latest inputs.

For other vehicle classes, the following assumptions were made:

- As the numbers of franchised buses, public light buses and taxis are regulated by TD, their growth rates are assumed to be zero.
- For non-franchised buses and private light buses, as there is no information predicting the future trend, their growth rates are assumed to be zero.

Exhaust Correction Factors

- * Calculate each of the correction factors
 - * Call ExhCF_Speed()
 - * Call ExhCF_Temperature()
 - * Call ExhCF_NOx()
 - * Call ExhCF_AC()
 - * Call ExhCF_Fuel()
 - * Call ExhCF_HighIdle()
 - * ! Combine them into AllCF
- * Call ExhCF_Finalize()

Speed Correction Factor

Speed correction Factors are calculated by speed bin.

For each speed bin, [VKT fraction] is multiplied by the corresponding speed correction factor

Example:

$$\begin{aligned} \text{SCFactor}(\text{Speed}) = & \text{SCF\%Coefs}(1) * (\text{Speed} - \text{SAdj}) \\ & + \text{SCF\%Coefs}(2) * (\text{Speed} - \text{SAdj})^{**2} \\ & + \text{SCF\%Coefs}(3) * (\text{Speed} - \text{SAdj})^{**3} \\ & + \text{SCF\%Coefs}(4) * (\text{Speed} - \text{SAdj})^{**4} \end{aligned}$$

$$\text{AvgSCF} = \text{Sum over bins} \{ \text{VKT Fraction Spent in each bin} * \text{SCFactors}(\text{Speed}) \}$$

Calculation of Speed Correction Factors

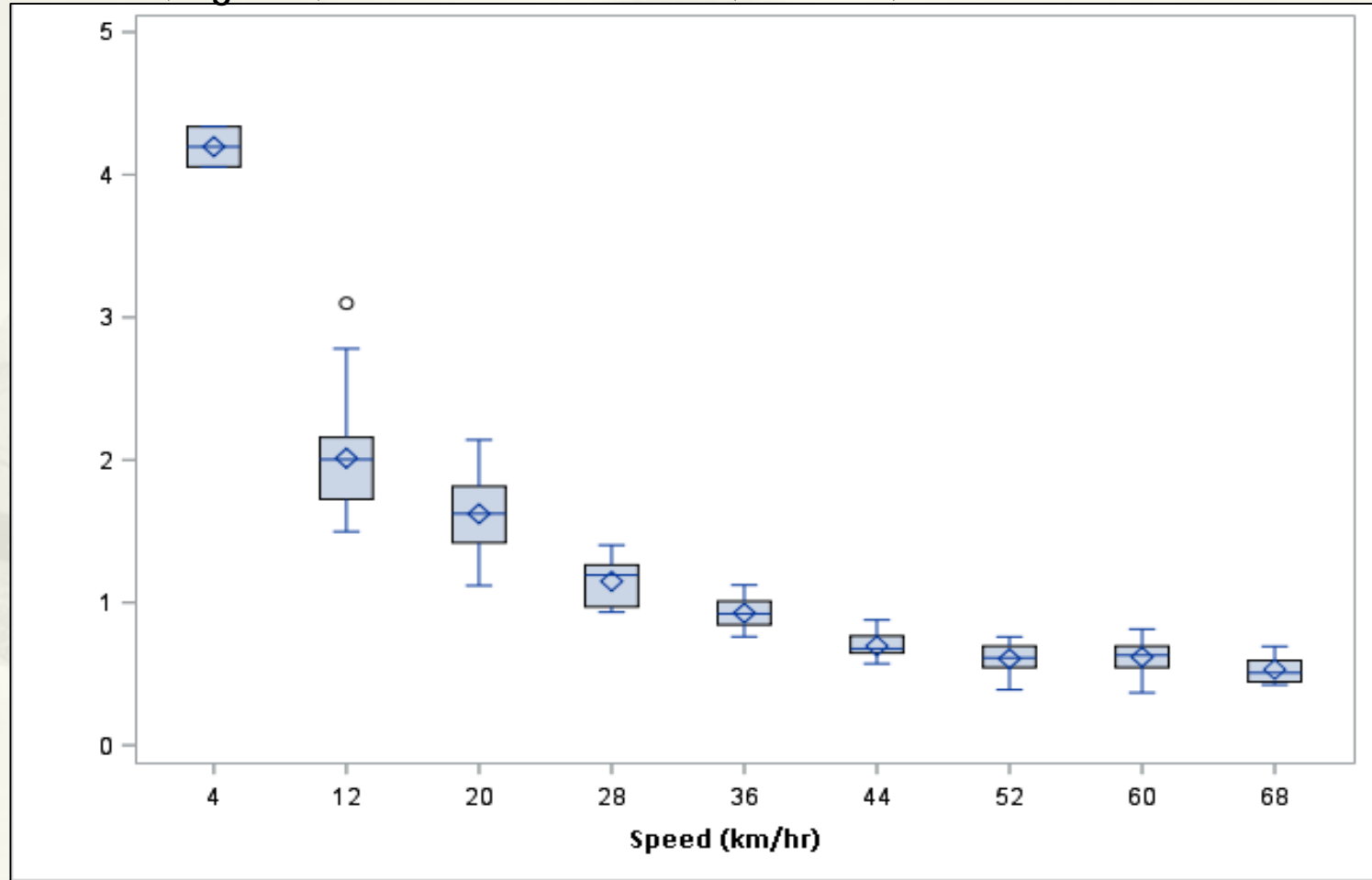
$$\text{SCF}_{\text{speed}} = \frac{\text{Emissions}_{\text{speed}}}{\text{Emission}_{\text{speed}=30\text{km/hr}}}$$

SCF is used:

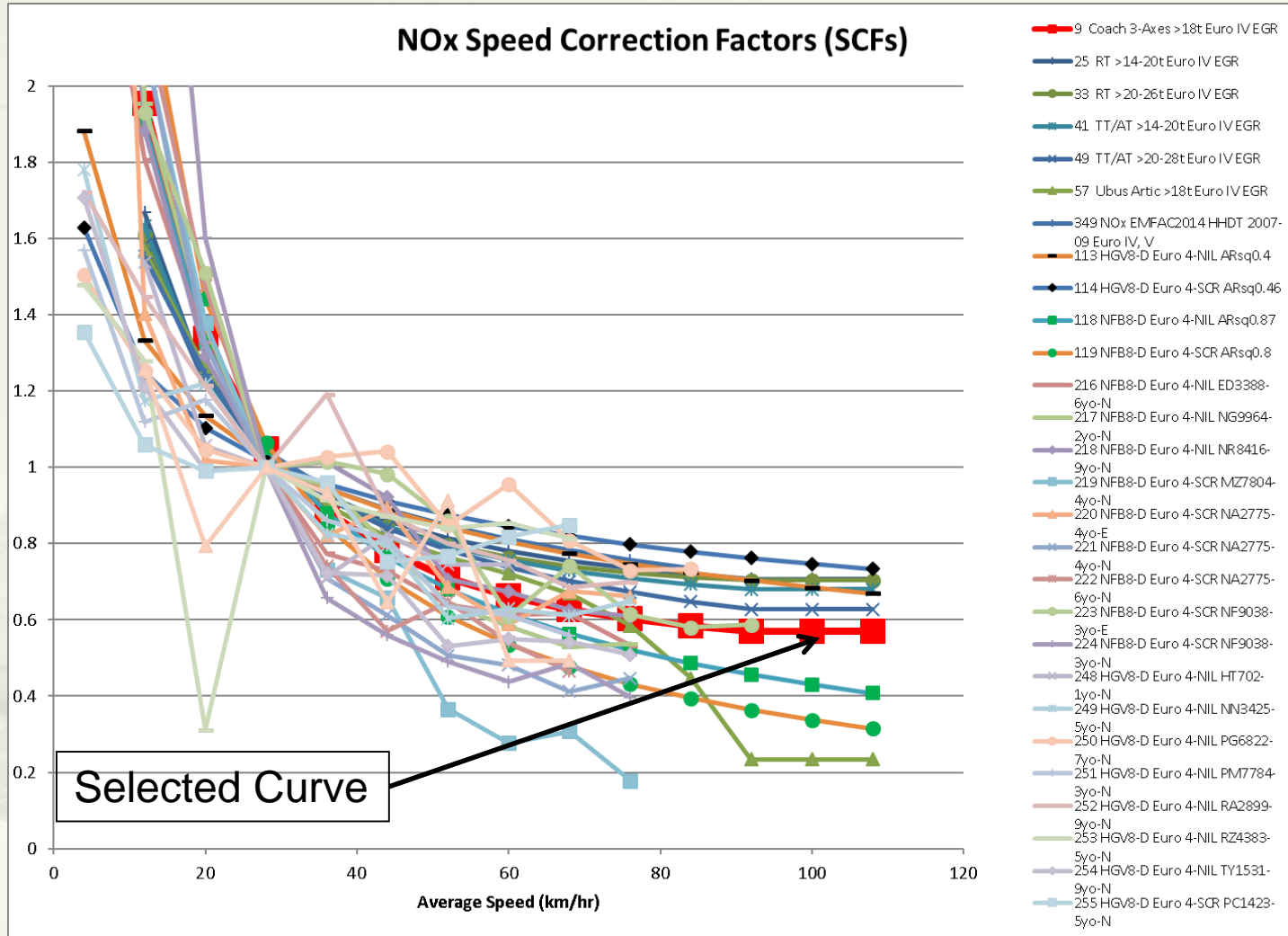
- in Burden mode with Speed Fraction for emission estimation.
- in EMFAC mode to get the matrices of EF by speed

SCF Example: An Euro III Franchised Bus: 8-minute average NO_x emission factors

KUXXXX; Age=10; Euro III Franchised Bus; No-SCR; 8-min interval



NOx Speed Correction Factor: Euro IV Heavy Goods Vehicles, Non-Franchised Buses >15t and Single-Deck Franchised Buses with SCR



#The SCF curve will be flattened for speed > 60km/hr

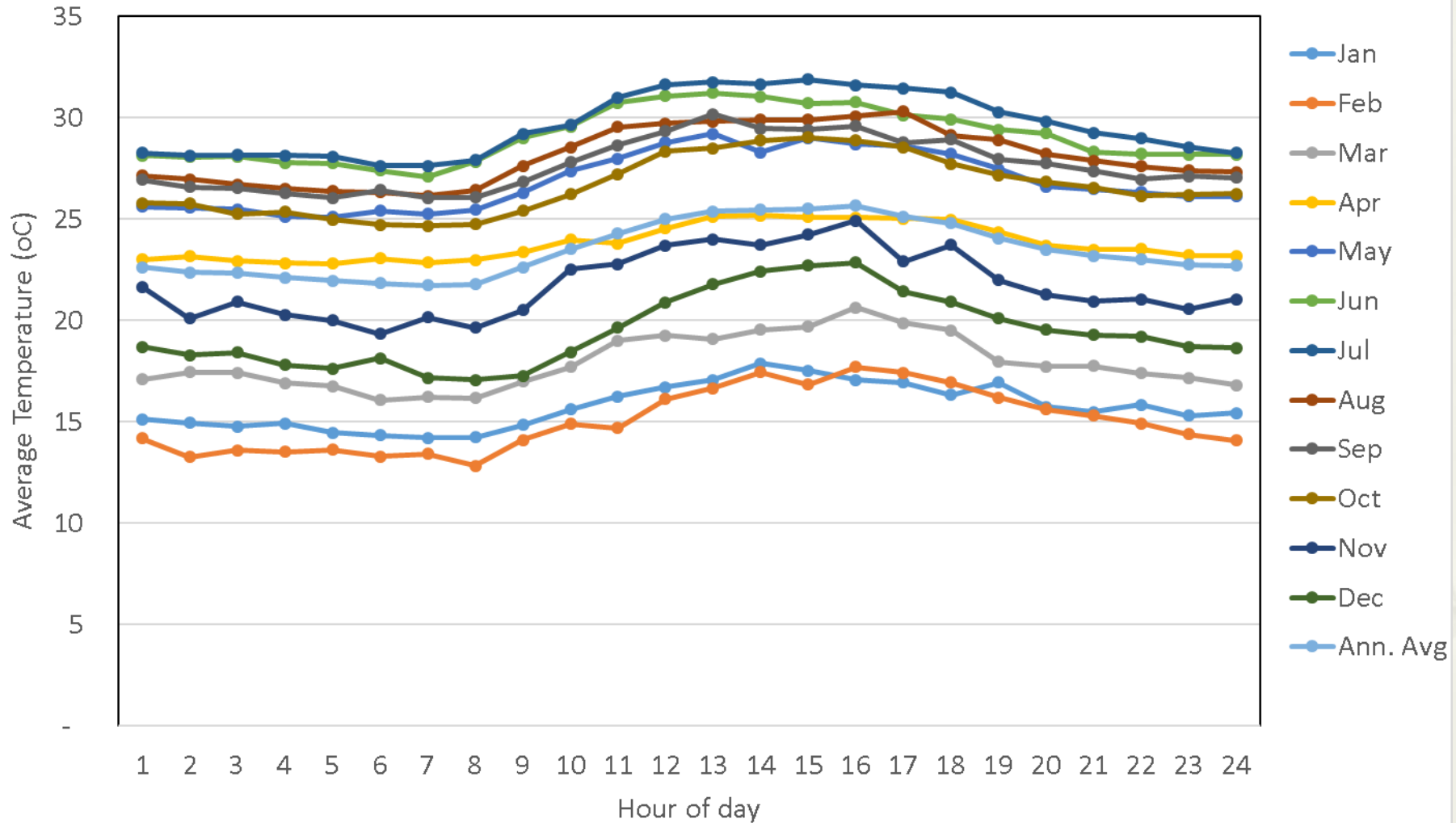
Temperature Correction Factor

- Temperature correction based on the temperature for area and hour
- For example, equation for vehicles with 3-way catalyst is :

$$TCF = 1 + A * (TEMP-75) + B * (TEMP-75)**2 + C * (TEMP-75)**3$$

, where Coefficients A, B ,C are dependent on Pollutant, driving mode, and tech group.

Monthly Average Temperature by Hour in 2016



Humidity for NOx

The basic form of the correction factor is as follows:

$$\text{RHUM_CF} = \frac{(1 + (\text{M_MANOS} * (\text{Ht} - \text{Hs}))) * (1 + (\text{M_CLASS} * (\text{H} - \text{Hs})))}{1 + \text{M_CLASS} * (\text{Ht} - \text{Hs})}$$

where:

RHUM_CF = humidity correction factor (ratio)

M_MANOS = -0.0047, a constant derived by Manos et al (1972) in "Effect of Laboratory Conditions on Exhaust Emissions"

Ht = tech group specific base humidity (grains/lb) (different for Light and Heavy vehicles, stored in RHCData.for)

Hs = 75 grains/lb, standard humidity

M_CLASS = tech group specific humidity correction factor constant (different for DSL and Petrol, stored in RHCData.for)

H = scenario humidity to which correction is to be performed (grains/lb)

Absolute Humidity

$$H = RH * (A + B * T + C * T^{**2} + D * T^{**3})$$

where:

H = scenario humidity (grains/lb)

T = scenario temperature (deg F)

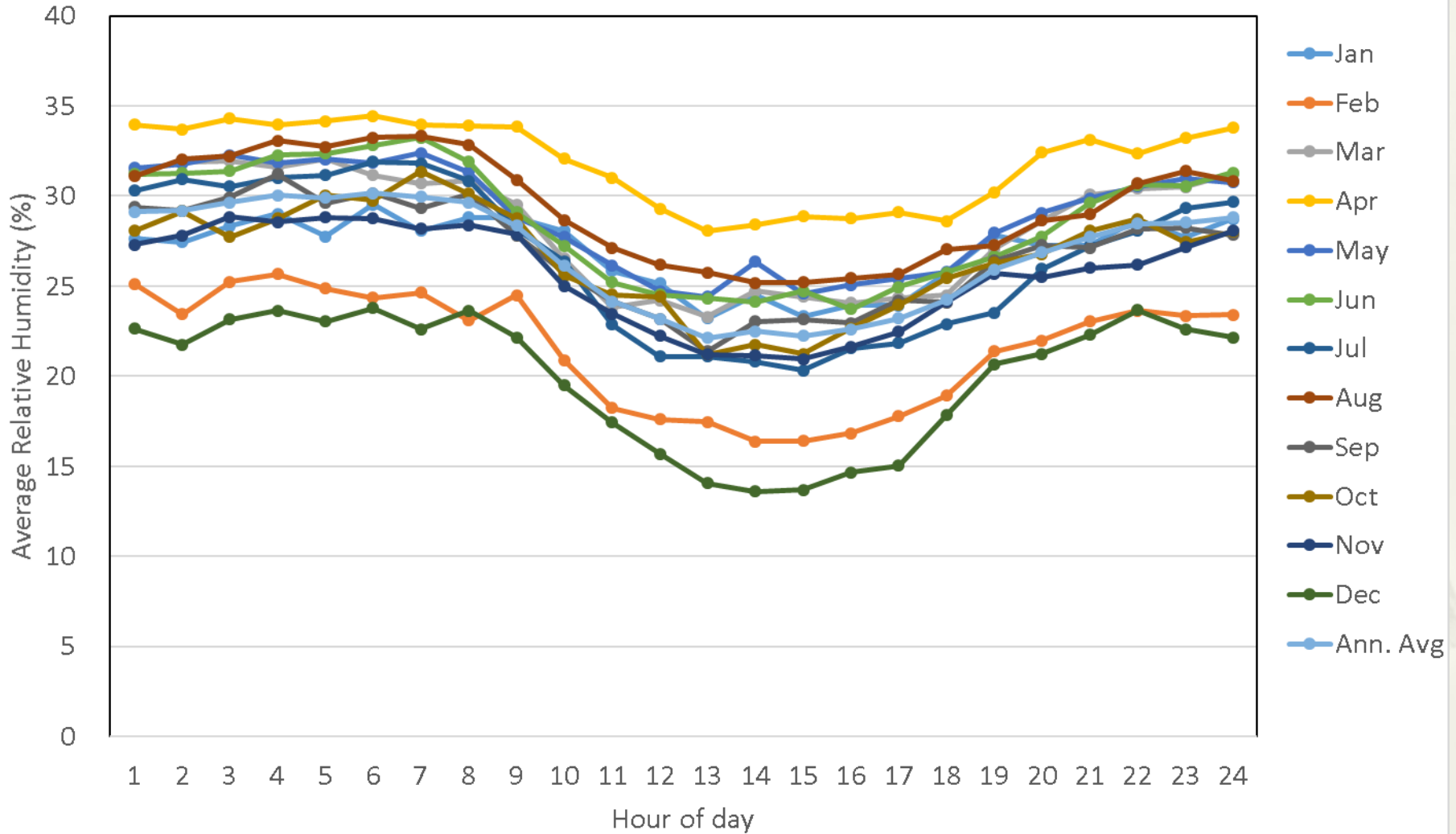
A = -0.09132

B = 0.01594

C = -0.00029

D = 4.37E-06

Monthly Average Relative Humidity by Hour in 2016



AC Correction

$$\text{ACCF} = (\text{ACon}) * (m * \text{BER} + C) + (1 - \text{ACon}) * \text{BER}$$

where:

ACCF = base emission rate adjusted for A/C usage

ACon = air conditioning activity factor

m = slope of regression equation

BER = base emission rate

C = constant from regression equation

AC On Fraction

$$AC_{on} = AC_{frac} * AC_{func} * COM_{Pon}$$

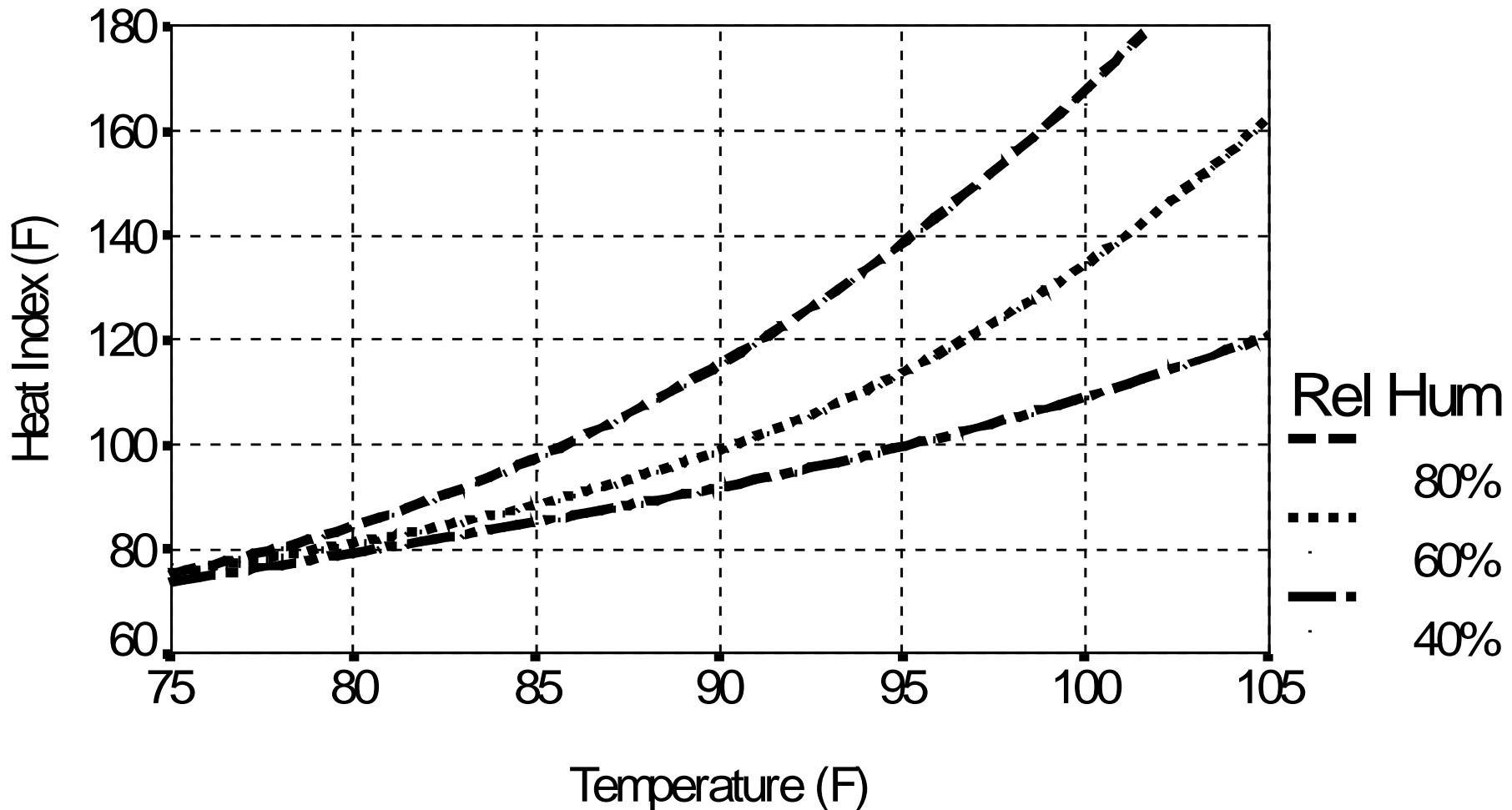
where:

AC_{frac} = Fraction of vehicles equipped with A/C units

AC_{func} = Fraction of A/C units functional

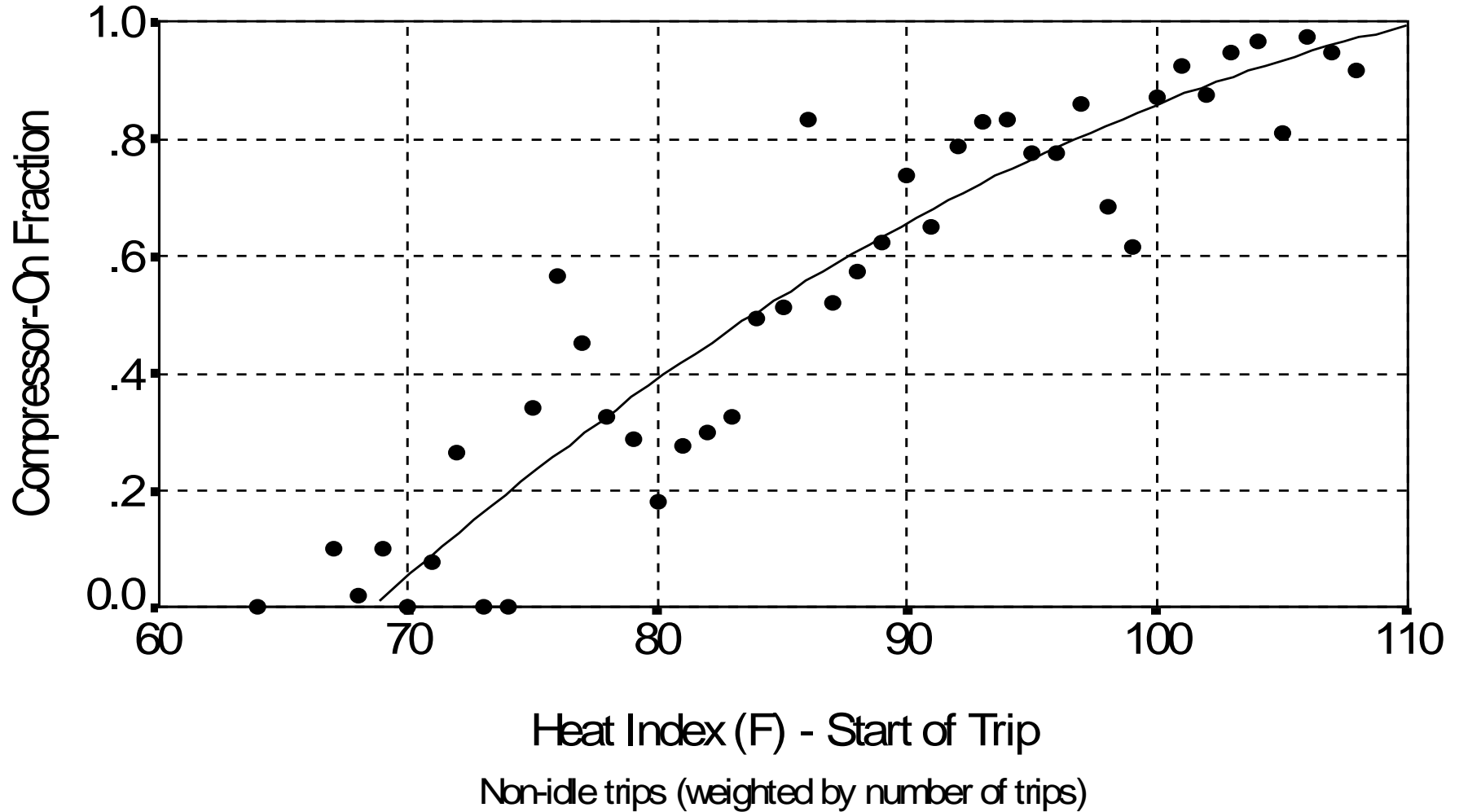
COM_{Pon} = Factor representing compressor activity as a function of temperature and humidity.

Temperature, Humidity, and Heat Index



Note: Heat Index values based on shady conditions

Compressor-On vs. Heat Index



Fuel Correction Factors

- * Correction factors are dependent on
 - * Driving mode
 - * Pollutant
 - * Season
 - * Fuel regulation (via model year)
 - * Tech group

Burden Calculations

- * Emission Rate $E_{\text{model_year}}$ for pollutant
- * Correction Factors (CF)
- * Activity (Population, VMT, Starts)
- * Calculate for both No_I/M and Post I/M
- * Estimate Tonnes/year :

$$E_{\text{model_year}} * \text{ALL_CF} * \text{Activity}$$

Loop over all SCENARIOS in input file

Loop over all AREAS in scenario

Call Area_Average for activity

Calculate activity for all GAs

For area-average case, calculate weighted-average activity for area

Loop over all VEHICLE CLASSES in scenario

Loop over all AGES allowed by scenario and calendar year

Age and calendar year specify MODEL YEAR.

Loop over EXHAUST TECH GROUPS

Calculate exhaust BERs

Running, start, and idle basic emission rates

Calculate I/M benefit

Calculate exhaust correction factors

Calculate and accumulate tons [Burden mode]

Write tech-group report detail [Burden mode]

Loop over EVAP TECH GROUPS

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Calculate and accumulate grams [Emfac mode]

Write vehicle class and speed report detail [Burden mode]

Write vehicle class report [Emfac mode]

Write area and speed report detail [Burden mode]

Write area-based report(s) [Burden mode]

Write area-based report(s) [Emfac mode]

Evaporative Emissions

- * Evap calculations are done for a specific combination of:
 - * Calendar year,
 - * Area,
 - * Vehicle class,
 - * Vehicle age, and
 - * Evap technology group.
- * Evap emissions are calculated for six distinct emissions processes:
 - * Hot soak
 - * Running losses
 - * Partial-day resting losses
 - * Multi-day resting losses
 - * Partial-day diurnal losses
 - * Multi-day diurnal losses
- * There are three emitter class regimes defined in the model:
 - * Normal
 - * Moderate
 - * High

Hot Soak Emissions

Basic Emission Rates are calculated for each emitter regime as:

Type of Equation Based on Tech Group		Age	Odometer
	Linear	1	2
	Exponential	3	4

Emissions Calculations:

$$EF_{N,M,H} = EF_0 + Det * \begin{bmatrix} \text{Age} \\ \text{or} \\ \text{Odo} \end{bmatrix}$$

or

$$= \exp \left(EF_0 + Det \begin{bmatrix} \text{Age} \\ \text{or} \\ \text{Odo} \end{bmatrix} \right)$$

Running Loss Emissions

Emission rates for running loss emissions are calculated by the use of the following equation:

$$\begin{aligned} EF_{(N,M,H)} &= Zm \\ &+ DR * Odo \\ &+ RL_Age * Age \end{aligned}$$

A correction factor is calculated for use later which accounts for increased running loss due to longer trips. This factor is calculated as:

$$\begin{aligned} RL_TOF &= RL_TIME * TIME_ON_{[a1]} \\ Evap_EF &= EF_{(N,M,H)} + RL_TOF \end{aligned}$$

Partial Day Resting Losses

Stored in :

Partial day results:	Rest_BER(1,::,::)
Single day results:	Rest_BER(2,::,::)
Multiple day results:	Rest_BER(3,::,::)

Next, the BER is calculated as a function of temperature T. For normal and moderate emitters, between 55F and 65F the emissions relationship is linear:

$$\text{Rest_BER_All} = (T-55) * EF_4 * \text{RVP_CF}$$

Beyond 65°F, the equation form used is a polynomial in temperature:

$$\text{Rest_BER_All} = [EF_0 + EF_1 * T + EF_2 * T^2 + EF_3 * T^3] * \text{RVP_CF}$$

Where:

$$\text{Numerator} = A + B * (T+15) + C * \text{RVP} + D * (T+15) * \text{RVP}$$

$$\text{Denominator} = A + B * (T+15) + C * 9.0 + D * (T+15) * 9.0$$

$$\text{RVP_CF} = \text{Numerator/Denominator}$$

The Coefficients A, B, C, and D are stored in Array EVAP_TCF, which is the file TCF_Data.for

Multiple Day Resting Losses

Multiple day resting losses are calculated by scaling the partial day BERs with a multi-day factor selected based on the tech group:

$$\text{Rest_BER_All}_2 = \text{Rest_BER_All}_1 * \text{MD_Factor}_2$$

$$\text{Rest_BER_All}_3 = \text{Rest_BER_All}_1 * \text{MD_Factor}_3$$

Partial Day Diurnal Emissions

Stored in :

Partial day results:	Drnl_BER(1,::,::)
Single day results:	Drnl_BER(2,::,::)
Multiple day results:	Drnl_BER(3,::,::)

Diurnal emission factors are a function of primary temperature and RVP. In the EVAP subroutine an additive emission factor is estimated as follows and another multiplicative emission factor is applied in Burden.

Drnl_BER = F (T)
= Additive in Evap Subroutine
= Multiplicative in Burden

Drnl_CF = CF₀ + CF₁ * (T + 15)
+ CF₂ * RVP
+ CF₃ * (Temp + 15) * RVP

Drnl_BER(1) = A + B * Temp
+ C * Temp²
+ D * Temp³ + Dirnl_CF

Diurnal losses only occur when temperature is rising.

Diurnal emission factors are stored for each vehicle age, emitter category, and tech group.

Multiple Day Diurnal Emissions

Multiple day diurnal losses are calculated by scaling the partial day BERs with a multi-day factor selected based on the tech group:

$$\text{Drnl_BER_All}_2 = \text{Drnl_BER_All}_1 * \text{MD_Factor}_2$$

$$\text{Drnl_BER_All}_3 = \text{Drnl_BER_All}_1 * \text{MD_Factor}_3$$

Evap Correction Factors

Hot Soak Correction

Temperature and RVP correction: The hot soak corrections for temperature and RVP are based on “correcting” temperature from 75F to actual and “correcting” RVP from 9.0psi to actual, using the following equation form:

$$\text{HS_RVP_TEMP_CF} = \frac{\exp(A + B * (T - 75) + C * (Rvp - 9))}{\exp(A + B * (75 - 75) + C * (9 - 9))}$$

Estimate the number of soak events in time periods that are below 40 minutes (5 periods, periods are 0-5, 6-10, 11-20, 21-30, 31-40 (with mean of 35), 41-50, 51-60, 61-120 etc.)

Run_Frac allows us to discount the hot soak emissions which follow very short trips (4 minutes or less).

$$\text{Run Frac} = \left[\frac{\text{Sum of Trips which are greater than 5 minutes}}{\text{Sum of all trips}} \right]$$

$$P = [C_1 * [C_2t + C_3t^2 + C_4t^3 + C_5t^4]/C_6/100]$$

F = frequency of trips with this time-off period at this hour

Where t is the length of the time-off period from TIME_OFF, C₁ to C₆ are constants specific to the emitter regime, and F is evaluated from array TIME_OFF_FREQ.

$$\text{Partial_Soak factor} = \text{Sum}(P * F) / \text{Sum}(F)$$

The function result is the combination of the two corrections:

$$\text{HS_BER_TO_GM_PER_HR} = \text{Run_Frac} * \text{Partial_Soak}$$

The final hot soak correction factor is the combination of temperature and RVP correction and basis conversion:

$$\text{CF} = \text{HS_RVP_TEMP_CF} * \text{HS_BER_TO_GM_PER_HR}$$

Running Loss Correction

$$RL_{CF} = \frac{A + Time_On * (B * RVP * Temp + C + RVP + D * Temp)}{E + F * TIME_ON}$$

RL_{CF} are only valid for Time_On values < 60 minutes

Evap EF () =

$$\sum_{TIMEON} RL_TOF * RL_{cf} * TIME_ON_FREQ$$

Time ON Matrix

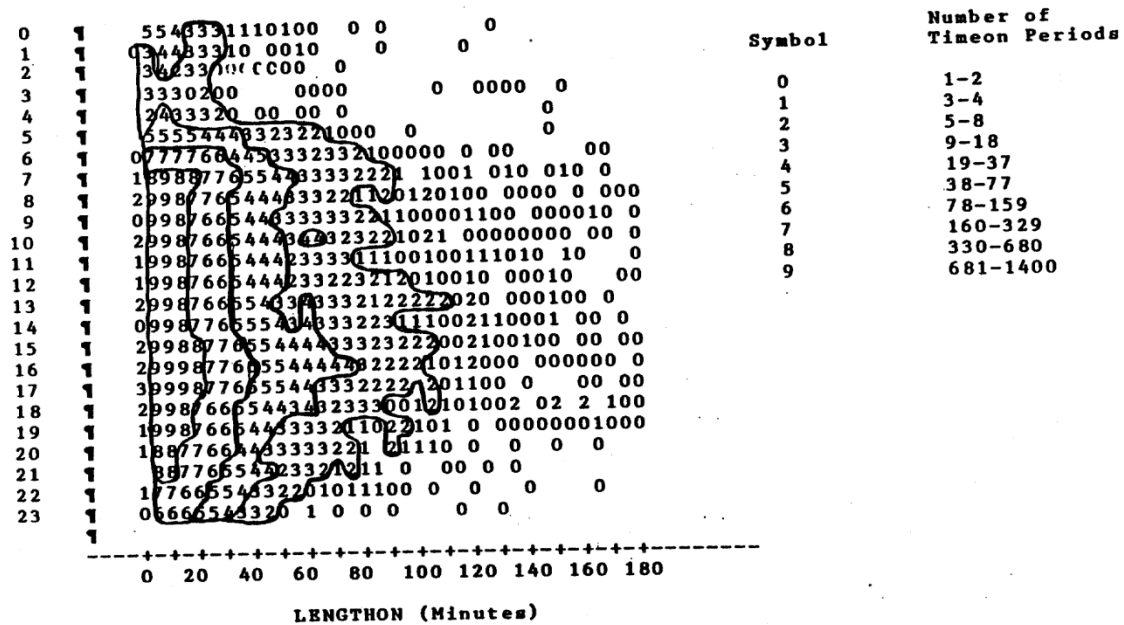


Figure 6-11. Frequency Distributions of Timeon Periods (Monday-Friday)

Diurnal and Resting Loss Corrections

The four resting and diurnal loss processes are not corrected any further for RVP and Temperature, the corrections are include in the raw BER:

Partial day resting loss CF	=	1.0
Multi-Day Resting Loss CF	=	1.0
Partial Day Diurnal CF	=	1.0
Multi-Day Diurnal CF	=	1.0

$$\text{Evap EF} = \text{Rest_BER} (1,2,3) * \text{Activity} (\text{AT_Rest}(1,2,3))$$

$$\text{Evap EF} = \text{Diurnal_BER} (1,2,3) * \text{Activity} (\text{AT_Rest}(1,2,3))$$

Partial – Index 1

Multiple – Sum of 2 and 3

Time OFF (AT_Rest) Matrix

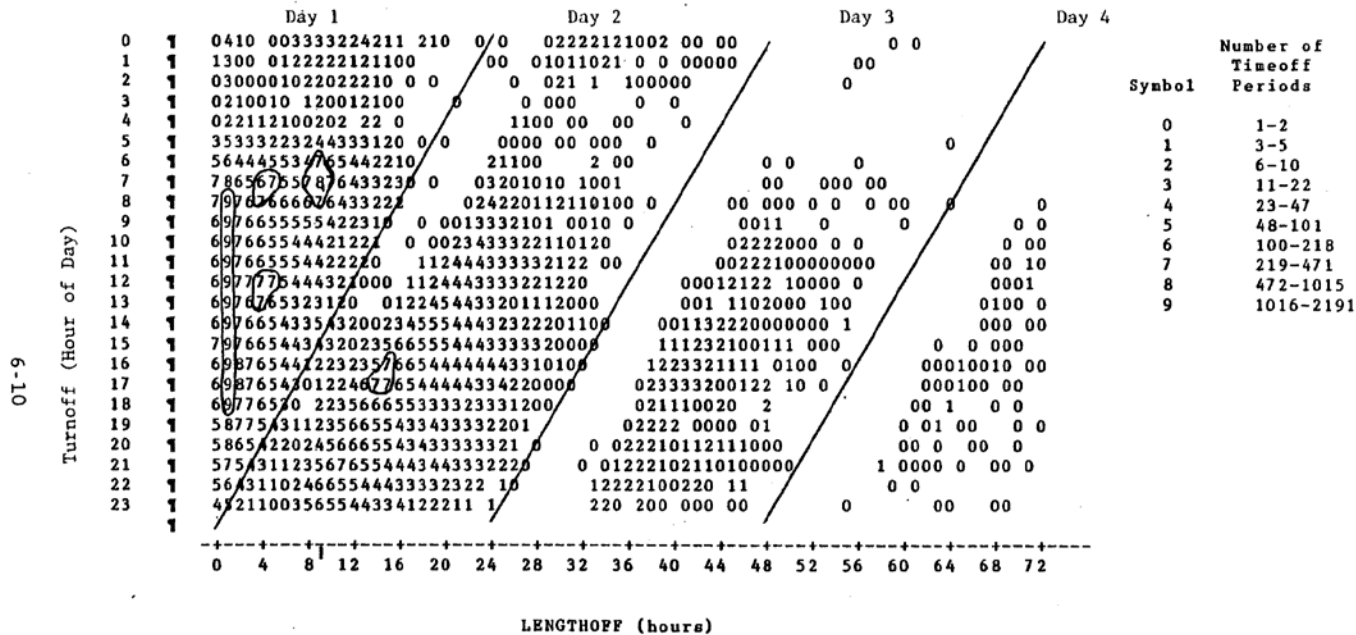


Figure 6-3. Frequency Distribution of Timeoff Periods (Monday-Friday)

Thank you!