GSE - Sample Calculation for NO_x Emission

Total GSE Emission per GSE type = GSE Emission of arrival phase + GSE Emission of stands movement phase[1] + GSE Emission of departure phase
GSE Emission of different phase = Emission of operation mode + Emission of idling mode
Emission of operation mode = Engine Power (hp) x Load factor of Operation Mode x Operation Time (hr) x Emission Index (g/hphr) x Deterioration Factor
Emission of idling mode = Engine Power (hp) x Load factor of Idling Mode x Idling Time (hr) x Emission Index (g/hphr) x Deterioration Factor
Deterioration Factor = 1 + A x (age/lifespan)^B [2]

Note:
[1] GSE emission of stands movement only applicable to aircraft tractor
[2] Deterioration Factor - DF coefficient is extracted from NONROOD2005 database and the equation is referenced from Page 6-39 of User's Guide for the Final NONROAD2005 Model

Emission from GSE for Airbus A330-200 (HXML17N30 on 1 Jan 2013) (3RS Scenario)[3]
Note:
[3] The calculation steps for 2RS Scenario is the same as 3RS. Only sample calculations for 3RS are provided for demonstration purpose.

Basic Information of the GSE

GSE	Average Age of GSE (yr) [4]	Horse Power of GSE equipment (hp) [4]	Load Factor (Operation) (%) [4]	Load Factor (Idling) (%) [5]	Average Lifespan (yr) [6]	Engine Type [4]
Aircraft Tractor	11	670	85	25	14	Diesel
Baggage Tractor	8	48	55	25	13	Diesel
Belt Loader	6	49	50	25	11	Diesel
Cargo Loader	10	120	50	25	11	Diesel
Catering Truck	10	210	53	25	10	Diesel
Hydrant Truck	10	235	70	25	10	Diesel
Lavatory Truck	12	260	25	25	13	Diesel
Fuel Truck	14	235	25	25	14	Diesel
Passenger Stands	9	48	57	25	10	Diesel

Note:
[4] The information is based on the response (weighted average for age and horse power/ average for load factor (operation)) from the GSE operator. If no information is available, the default value of the EDMS v5.1.4.1 is used instead.
[5] The idling load factor of 25% is given by the operator. If the operation load factor is smaller than 25% , the idling load factor is assumed same as the operation load factor.
[6] The average lifespan is based on the default value of the EDMS v5.1.4.1.

Operation detail

GSE	Time-in-mode (hr)					
	Arrival (Operation) [6]	Arrival (Idling) [6]	Departure (Operation) [6]	Departure (Idling) [6]	Stands Movement (Operation) [7]	Stands Movement (idling) [7]
Aircraft Tractor	0.00	0.00	0.08	0.25	0.30	0.50
Baggage Tractor	1.25	0.00	1.53	0.00	0.00	0.00
Belt Loader	0.53	0.00	0.83	0.00	0.00	0.00
Cargo Loader	0.53	0.20	1.13	0.28	0.00	0.00
Catering Truck	1.27	0.00	0.00	0.00	0.00	0.00
Hydrant Truck	0.00	0.00	0.12	0.00	0.00	0.00
Lavatory Truck	0.17	0.00	0.00	0.00	0.00	0.00
Fuel Truck	0.00	0.00	0.77	0.00	0.00	0.00
Passenger Stands	0.00	0.00	0.00	0.00	0.00	0.00

Note:
[6] The time-in-mode is based on the site survey.
[7] The stand movement time (operation/idling) is based on the TAAM Model. The idling time is equal to the number of movement multiply the idling time per movement (15 minutes/movement).

Emission Indices

GSE	NO_x Emission Index (g/hphr)	DF Coefficient [8][9]		
		A	b	DF
Aircraft Tractor	0.280000	0.008	1.000	1.006
Baggage Tractor	3.000000	0.008	1.000	1.005
Belt Loader	3.000000	0.008	1.000	1.004
Cargo Loader	0.280000	0.008	1.000	1.007
Catering Truck	0.280000	0.008	1.000	1.008
Hydrant Truck	0.280000	0.008	1.000	1.008
Lavatory Truck	0.280000	0.008	1.000	1.007
Fuel Truck	0.280000	0.008	1.000	1.008
Passenger Stands	3.000000	0.008	1.000	1.007

Note:
[8] The emission index and DF coefficient (except SO_2) are extracted from NONROOD2005 database based on the manufacture year, horse power and fuel type.
[9] The emission index for SO_2 is extracted from EDMS 5.1.4.1 and the deterioration is already considered in the EDMS model.

=(Sum of Emission during Departure, Arrival and Stand Movement) x Busy Day Ratio

Emission

GSE	Emission During Arrival (kg)	Emission During Departure (kg)	Emission During Stand Movement (kg)	Busy Day Ratio	Total Emission (kg)
	NO_x	NO_x	NO_x		NO_x
Aircraft Tractor	0.00	0.03	0.07	0.9353	0.09
Baggage Tractor	0.10	0.12	0.00	0.9353	0.21
Belt Loader	0.04	0.06	0.00	0.9353	0.09
Cargo Loader	0.01	0.02	0.00	0.9353	0.03
Catering Truck	0.04	0.00	0.00	0.9353	0.04
Hydrant Truck	0.00	0.01	0.00	0.9353	0.01
Lavatory Truck	0.00	0.00	0.00	0.9353	0.00
Fuel Truck	0.00	0.01	0.00	0.9353	0.01
Passenger Stands	0.00	0.00	0.00	0.9353	0.00
				Total LTO Emission	0.48

Emission on Road (3RS Scenario)

GSE	Estimated on road time at 2031 (hour) [10]	Horse Power (hp)	Load Factor (%)	NOx Emission Index (g/hphr)	DF Coefficient [11][12]			2031 Annual NO_x Emission (kg)
					A	b	DF	
Aircraft Tractor	Nil	670	85	0.280000	0.008	1.000	1.006	Nil
Baggage Tractor	408705	48	55	3.000000	0.008	1.000	1.005	32,529
Belt Loader	Nil	49	50	3.000000	0.008	1.000	1.004	Nil
Cargo Loader	Nil	120	50	0.280000	0.008	1.000	1.007	Nil
Catering Truck	558036	210	53	0.280000	0.008	1.000	1.008	17,530
Hydrant Truck	29933	235	70	0.280000	0.008	1.000	1.008	1,390
Lavatory Truck	41951	260	25	0.280000	0.008	1.000	1.007	769
Fuel Truck [13]	N/A	235	25	0.280000	0.008	1.000	1.008	N/A
Passenger Stands	4029	48	57	3.000000	0.008	1.000	1.007	333
							Total On Road Emission	52,551

Note:
[10] The estimated on-road time at 2031 is calculated from projected total operating time at Year 2031 based on ATM minus at-stand operating time of GSE.
As the vehicles usage is assumed growing with the same rate as ATM. The ATM in 2011 is 326702 and estimated ATM in 2031 is 620000, so a scale up factor of 1.8978 is applied on the estimation of total operating time in 2031.
[11] The emission index and DF coefficient (except SO_2) are extracted from NONROOD2005 database based on the manufacture year, horse power and fuel type.
[12] The emission index for SO_2 is extracted from EDMS 5.1.4.1 and the deterioration is already considered in the EDMS model.
[13] The emission of fuel truck on road will be counted as non-GSE emission due to insufficient information.

Emission on Road (2RS Scenario)

GSE	Estimated on road time at 2031 (hour) [14]	Horse Power (hp)	Load Factor (%)	NOx Emission Index (g/hphr)	DF Coefficient [15][16]			2031 Annual NO_x Emission (kg)
					A	b	DF	
Aircraft Tractor	Nil	670	85	0.280000	0.008	1.000	1.006	Nil
Baggage Tractor	264530	48	55	3.000000	0.008	1.000	1.005	21,054
Belt Loader	Nil	49	50	3.000000	0.008	1.000	1.004	Nil
Cargo Loader	Nil	120	50	0.280000	0.008	1.000	1.007	Nil
Catering Truck	363531	210	53	0.280000	0.008	1.000	1.008	11,420
Hydrant Truck	20277	235	70	0.280000	0.008	1.000	1.008	941
Lavatory Truck	28418	260	25	0.280000	0.008	1.000	1.007	521
Fuel Truck [17]	N/A	235	25	0.280000	0.008	1.000	1.008	N/A
Passenger Stands	2729	48	57	3.000000	0.008	1.000	1.007	226
							Total On Road Emission	34,162

Note:
[14] The estimated on-road time at 2031 is calculated from projected total operating time at Year 2031 based on ATM minus at-stand operating time of GSE.
As the vehicles usage is assumed growing with the same rate as ATM. The ATM in 2011 is 326702 and estimated ATM in 2031 is 420000, so a scale up factor of 1.2856 is applied on the estimation of total operating time in 2031.
[15] The emission index and DF coefficient (except SO_2) are extracted from NONROOD2005 database based on the manufacture year, horse power and fuel type.
[16] The emission index for SO_2 is extracted from EDMS 5.1.4.1 and the deterioration is already considered in the EDMS model.
[17] The emission of fuel truck on road will be counted as non-GSE emission due to insufficient information.