Business Helicopter - Sample Calculation for NO_x Emission

Helicopter Emission = Emission of Approach Mode + Emission of Taxi-in Mode + Emission of Taxi-out Mode + Emission of Take-off Mode +Emission of Cruising Mode
Emission of Each Mode = Time-in-mode (s) X Fuel Flow Rate (kg/s) X Emission Index (g/kg fuel) X Number of Engine

Table 1: Daily Operation Profile of One BAC Helicopter Flight [1][2][3]

	Hourly LTO per day in month of											
	January	February	March	April	May	June	July	August	September	October	November	December
Hour 01	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 02	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 04	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 05	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 06	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 07	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 08	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 09	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 10	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 11	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 12	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 13	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 14	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 15	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 16	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 17	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 18	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 19	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 20	0.0027	0.0030	0.0027	0.0028	0.0027	0.0028	0.0027	0.0027	0.0028	0.0027	0.0028	0.0027
Hour 21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hour 24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note
[1] BAC mentioned that the total helicopter LTO is 2-3 per month without fixed flight schedule. Each helicopter flight will be divided into operation profile to incorporate the effect of meteorological condition on helicopter emission.
[2] According to the website of the operator, the BAC helicopter service is available from 08:30 to sunset. It is assumed that the BAC Helicopter Service is operated from Hour 09 to Hour 20, inclusively (total 12 hours per day), for emission calculation.
[3] Hourly LTO = 1 / (Number of operation hour per day X Number of operation day of that month)

Calculation Sample of One Macau BAC Helicopter Flight

Table 2: Corrected Time-in-mode[4]

Day	Hour	Mixing Height	Unadjusted TIM (min)				Adjusted TIM (min)					
			Approach	Taxi-in	Taxi-out	Take off	Approach	Taxi-in	Taxi-out	Take off	Cruising (Departure)	Cruising (Approach)
:	:	:	:	:	:	:	:	:	:	:	:	:
9-Feb-31	19	467.0	5.50	2.00	2.00	3.00	0.92	2.00	2.00	1.50	1.84	1.84
9-Feb-31	20	491.4	5.50	2.00	2.00	3.00	0.92	2.00	2.00	1.50	1.84	1.84
:	:	:	:	:	:	:	:	:	:	:	:	:
2-Mar-31	09	331.1	5.50	2.00	2.00	3.00	0.92	2.00	2.00	1.50	1.84	1.84
2-Mar-31	10	427.7	5.50	2.00	2.00	3.00	0.92	2.00	2.00	1.50	1.84	1.84
:	:	:	:	:	:	:	:	:	:	:	:	:

Since Mixing Height > Cruising Height (152.4 m), Corrected TIM = 5.50 x (152.4/914.4) = 0.92 min

Note
[4] The detail correction method of TIM is shown in Appendix 5.3.2-3.

Table 3: Adjusted Fuel Flow of Eurocopter AS355N Twin Squirrel

Date	Time	Adjusted Fuel Flow (kg/s) [5]				
		Approach	Taxi-in	Taxi-out	Take off	Cruising
:	:	:	:	:	:	:
9-Feb-31	19	0.0232	0.0099	0.0117	0.0313	0.0313
9-Feb-31	20	0.0233	0.0100	0.0117	0.0315	0.0314
:	:	:	:	:	:	:
2-Mar-31	09	0.0235	0.0100	0.0118	0.0317	0.0316
2-Mar-31	10	0.0230	0.0098	0.0116	0.0311	0.0310
:	:	:	:	:	:	:

Note
[5] The Adjusted Fuel Flow is derived from EDMS with correction of meteorological data of corresponding hour by creating a user-created helicopter with fuel flow provided from FOCA

Table 4: Adjusted NO_x Emission Factor of Eurocopter AS355N Twin Squirrel

Date	Time	Adjusted NO_x Emission Factor (g/kg fuel)[6]				
		Approach	Taxi-in	Taxi-out	Take off	Cruising
:	:	:	:	:	:	:
9-Feb-31	19	3.3145	1.0482	1.2687	4.9848	4.9848
9-Feb-31	20	3.3085	1.0463	1.2664	4.9758	4.9758
:	:	:	:	:	:	:
2-Mar-31	09	3.3111	1.0472	1.2674	4.9797	4.9797
2-Mar-31	10	3.2571	1.0301	1.2467	4.8985	4.8985
:	:	:	:	:	:	:

Note
[6] The Adjusted NOx Emission Factor is derived from EDMS with correction of meteorological data of corresponding hour by creating a user-created helicopter with NOx Emission Factor provided from FOCA

Table 5: NO_x Emission of Eurocopter AS355N Twin Squirrel

Date	Time	NO_x Emission of One Macau Flight (g)					Corrected NO_x Emission of One Macau Flight (g)					
		Approach	Taxi-in	Taxi-out	Take off	Cruising	Approach	Taxi-in	Taxi-out	Take off	Cruising	Total
:	:	:	:	:	:	:	:	:	:	:	:	:
9-Feb-31	19	8.46	2.50	3.55	28.10	68.71	0.0252	0.0074	0.0106	0.0836	0.2045	0.3313
9-Feb-31	20	8.49	2.50	3.56	28.20	68.95	0.0253	0.0075	0.0106	0.0839	0.2052	0.3324
:	:	:	:	:	:	:	:	:	:	:	:	:
2-Mar-31	09	8.55	2.52	3.59	28.41	69.47	0.0230	0.0068	0.0096	0.0764	0.1867	0.3025
2-Mar-31	10	8.25	2.43	3.46	27.41	67.00	0.0222	0.0065	0.0093	0.0737	0.1801	0.2918
:	:	:	:	:	:	:	:	:	:	:	:	:

Emission of Approach Mode = Time-in-mode X Fuel Flow Rate X Emission Index
X Number of Engine (=2 for Eurocopter AS355N Twin Squirrel) X Hourly Emission Correction Factor