Basic Noise and Emissions

NOISE AND EMISSIONS MODELING – BASIC CALCUATIONS

A. Key Formulas

Noise (DNL) DNL at specified location due to specified aircraft = 10 log (N/T♦ [10^(Si/10)] Eq. 1

where the summation is over all segments in the aircraft movement, and
Si = SEL value on segment i
T = number of seconds in a day (86400)
N = [number of daytime events + (10 * number of nighttime events)] for the specified aircraft

Emissions Total mass = Neng♦ (Ti * Fi * Ei) Eq. 2

where the summation is over all segments in the aircraft movement, and
Neng = number of engines on the aircraft
Ti = time that aircraft spends on segment i
Fi = fuel-consumption rate per engine during segment i
Ei = pollutant production per unit of fuel consumed

B. Population Data

		Location of Population		
		x (feet)	y (feet)	z (feet)
ID	Population			
A1	100	25000	0	0

C. Aircraft State Data

		Location of End of Each Segment				
Aircraft State	Segment	x (feet)	y (feet)	z (feet)	Thrust (lbs)	Time (min)
	Taxi Out	0	0	0	8000	16
	Takeoff	6300	0	1000	46000	0.7
	Climb	25000	0	3000	40000	2.2
	Approach (part 1)	25000	0	3000	16000	2
	Approach (part 2)	6300	0	0	16000	2
	Taxi In	-10000	0	0	8000	10
	Initial and final positions:	-10000	0	0		

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D. Noise Data (SEL values as function of distance and thrust setting)

					Distance from Aircraft (ft)									
					200	400	630	1000	2000	4000	6300	10000	16000	25000
Aircraft	Engine	rofile Typ	Mode	Thrust (lbs)										
747-400	PW4056	Std	App (or Taxi)	8000	103.6	99.1	95.8	92.3	86.6	80.1	75.3	70.5	65.6	60.9
	PW4056	Std	App	16000	105.5	100.7	97.1	93.3	87.2	80.6	76	71.2	66.4	61.8
	PW4056	Std	Dep	26000	106.3	102	98.6	95	89	82.8	78.5	73.8	69.1	64.7
	PW4056	Std	Dep	32000	107.4	103.3	100.1	96.7	91	84.9	80.7	76.1	71.5	67.1
	PW4056	Std	Dep	40000	109	105.2	102.3	99.2	94	88.2	84.1	79.7	75.1	70.8
	PW4056	Std	Dep	46000	111.1	107.4	104.6	101.7	96.7	91.2	87.3	82.9	78.5	74.2

E. Emissions Data

				----------Fuel Flow----------				**----------EI NOx----------**			
Aircraft	Engine	ID	No. Engines	**Takeoff**	**Climb**	**App**	**Taxi**	**Takeoff**	**Climb**	**App**	**Taxi**
				----------kg/sec----------				**----------g/kg----------**			
747-400	PW4056	1PW042	4	2.342	1.93	0.658	0.208	28.1	22.9	11.6	4.8

F. Simplifying Assumptions

1. Assume the aircraft produces the same noise field in all directions. This means that the SEL level depends only on distance.
2. Assume that the distance to the population location is measured at the end of each segment.
3. Assume that linear interpolation between SEL values as a function of distance is appropriate.

G. Questions

1. What is the DNL at location A1 due to one 747-400 daytime departure?

a. The SEL is determined by the taxi or departure portions of the noise-power-distance data given in section D.
Linear interpolation is used here for simplicity. Also for simplicity, we are not calculating the aircraft noise at altitudes above 3000 feet.

	Distance (f	Thrust (lb)	SEL (dB)
Taxi Out	25000	8000	60.9
Takeoff	18727	46000	77.19723431

Climb	3000	40000	91.1

b. Once the SEL values are determined, they are combined using Equation 1 in section A.

Resulting DNL (dB) 41.91215199

2. What is the DNL at location A1 due to one 747-400 daytime arrival?

a. The same methods are applied as above, but the approach and taxi portions of the noise-power-distance data is used.

	Distance (f	Thrust (lb)	SEL (dB)
Approach (part 1)	3000	16000	83.9
Approach (part 2)	18700	16000	65.02
Taxi In	35000	8000	55.67777778

Resulting DNL (dB) 34.5971596

3. What is the total NOx emission due to one 747-400 departure?

a. Equation 2 is applied using the appropriate times, fuel rates, and emissions rates per unit fuel (emission index).
Limiting the calculation to that part of the trajectory below 3000 feet is not unusual in analysis of local air quality due to mixing effects in the atmosphere.

	Neng	Time (min)	Fuel (kg/sec)	Em. Rate (g/kg)	NOx (g)
Taxi Out	4	16	0.208	4.8	3833.9
Takeoff	4	0.7	2.342	28.1	11056
Climb	4	2.2	1.93	22.9	23336

Total NOx (g) 38226

4. What is the total NOx emission due to one 747-400 arrival?

a. The same methods as used in problem 3 are applied.

	Neng	Time (min)	Fuel (kg/sec)	Em. Rate (g/kg)	NOx (g)
Approach (part 1)	4	2	0.658	11.6	3663.7
Approach (part 2)	4	2	0.658	11.6	3663.7
Taxi In	4	10	0.208	4.8	2396.2

Total NOx (g) 9723.6