Appendix 3.6

Marine Emissions

Marine Emissions

Ocean Terminal

1. There are two parking spaces for cruises in the Ocean Terminal. It is observed from the site survey that one berth is used almost exclusively for the berthing of A 40,000-ton ship. The other berth is periodically used by a 70,000-ton ship. The emissions from the ocean passenger cruise depend on their fuels type, the performance of their engines and the hotelling time.

2. The 40,000-ton ship operates in day trip mode parking at the berth from 08:00 to 20:00. The parking mode for the 70,000-ton ship is irregular and assumed 24 hours for 7 days per week parking at the berth for conservative approach. Only the auxiliary engines and auxiliary boilers operate for the berthing mode. The basic information of the two ocean passenger cruise ships are summarized in **Table 1**.

Table 1 Auxiliary Engine and Auxiliary Boiler Information of Ocean Going Vessels (OGV)

Information	Units	The 40,000-ton ship	The 70,000-ton ship
No. of Chimney	-	4	4
Height of the Chimney (1)	mPD	50	50
Hotelling Activity(2)	Hours	12	24
No. of Auxiliary Engine(3)	-	4	5
Name of Auxiliary Engine(3) (4)	-	Wartsila 6R32D	Wartsila W12V46
Power of Auxiliary Engine (4)	kw	2220	11700
Total Power of Auxiliary Engine	kw	8880	58500
Speed(4)	rpm	720	514
Aux Engine/Main Engine Ratio(4)	%	-	16
Auxiliary Engine Power	kw	-	9360
Load Factor of Auxiliary Engine for berthing(5)	%	41.6%	41.6%
No. of Auxiliary Boiler	-	2	2
Name of Auxiliary Boiler (4)	-	Alfa Laval Mission OS	SUNROD CPH-8-2
Power of Auxiliary Boiler for berthing(6)	kw	1000	1000

1. Visual Estimation
2. The hotelling activity of the 70,000-ton ship is irregular while the berthing period of The 40,000-ton ship is from 8:00 to 20:00 which refers to http://www.starcruises.com/media/206207/SPC0005_tariff_1112_EN_intl.pdf
3. The auxiliary engine of the legend of the Sea is not available. The number of auxiliary engine for the 70,000-ton ship is assumed to be 4. The ratio of the Auxiliary engine to main engine is applied to estimate the power of the auxiliary engine.
   http://zh.scribd.com/doc35255987/wartsila-Vasa-32-Project-Guide
   Wartsila- Project guide Wartsila 46 2007

4. http://exchange.dnv.com/exchange/main.aspx?extool+vessel&subview=machinerysummary&vesselid=156
5. Table3-13 Estimated average vessel ratio of auxiliary engines / main engines by ship type - EMEP/EEA Emission Inventory Guidebook
6. Table 3-23 Adapted Auxiliary Boiler Energy Defaults (kw) for OGV – Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory

3. Nitrogen dioxide (NO_2) and Respirable Suspended particulates (RSP (PM10)) are the main pollutants from the ocean passenger cruise. The emission information from the two types of OGVs is summarized in **Table 2**. Both of The 40,000-ton ship and the 70,000-ton ship use the fuel of diesel with density of 832 g/l and heating value of 43 kJ/l.

Table 2 Emission Information of OGV

Parameter		Units	The 40,000-ton ship	The 70,000-ton ship
Emission Factor (Aux Engines)	NO_x (1)	g/kwh	12.07	12.91
	PM10 (2)	g/kwh	1.61	1.18
Emissions per day (Auxiliary Engines) (3)	NO_x	g	535098	1206703
	PM10	g	71494	150717
Emission Factor (Aux Boiler) (4)	NO_x	g/kwh	2.1	2.1
	PM10	g/kwh	0.8	0.8
Emissions per day (Auxiliary Boiler) (3)	NO_x	g	25200	50400
	PM10	g	9600	19200
Total Emissions (Hoteling only) (5)	NO_x	g/s	12.97	14.55
	PM10	g/s	1.88	1.97

1. NOx Emission = 4.5 * (speed of engines in units of rpm)^(-0.2)
http://www.dnv.com/binaries/marpol%20brochure_tcm4-383718.pdf
2. Table 2-16: Auxiliary Engine Emission Factor, g/kWh- USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories
Assume worst case so SSD (slow speed diesel) engines with RO (residual oil) fuel type
3. Emission per day = emission factor * total power * load factor * hoteling activity
4. Section 2.1 USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories
5. Total emission = [emission (Auxiliary engines) + emission (boider)] / Hoteling time

4. The air flow for The 40,000-ton ship and the 70,000-ton ship are 2.364 and 2.49 kg/s respectively with load factor of 42% which are obtain from linear fitting the air flow for various load factors (see **Table 3**).

Table 3 Air flow for Auxiliary Engines of OVGs in various load factors (1)

Load Factor	Unit	Exhaust gas flow	
		The 40,000-ton ship	The 70,000-ton ship
100%	kg/s	4.7	5
85%	kg/s	4.1	4.3
75%	kg/s	3.7	3.9
50%	kg/s	2.7	2.8
42% (2)	kg/s	2.364	2.49

1. http://zh.scribd.com/doc35255987/wartsila-Vasa-32-Project-Guide
2. Linear Fitting results:
   Air flow (The 40,000-ton ship) = 4*load factor +0.7;
   Air flow (The 70,000-ton ship) = 4.2162* load factor +0.7378.

5. By ideal gas law, the exhaust flows are 3.01 and 3.17 m^3/s for The 40,000-ton ship and The 70,000-ton ship respectively. The detail calculations are shown in **Table 4**.

Table 4 Exhaust Air flow of OGVs

Parameter	Unit	OGV	
		The 40,000-ton ship	The 70,000-ton ship
Exhaust Air flow	kg/s	2.364	2.49
Molecular Weight of Air(1)	g/mole	28.97	28.97
Molecular weight of Fuel C14H30	g/mole	198.4	198.4
Total Mole Exhaust	mole/s	81.9	86.3
Standard Pressure	kPa	101.3	101.3
Exhausted Temperature(2)	K	448.2	448.2
Exhaust Air flow(3)	m^3	3.01	3.17
Exhaust Diameter(4)	m	0.6	0.6
Exhaust velocity(5)	m/s	10.65	11.22

1. The moles of air flow are assumed to be the same as the air components of the standard atmosphere. http://www.engineeringtoolbox.com/molecular-mass-air-d_679.html
2. http://www.steamesteem.com/?boilers/exhaust-gas-boilers;
3. Obtained by ideal gas law, PV=nRT
4. http://www.scribd.com/doc/35255987/Wartsila-Vasa-32-Project-Guide
5. Exhaust velocity = exhaust air flow / ((exhaust diameter /2)^2 *pi)

6. The USEPA approved model ISCST3 is used to model the gaseous emission from the two cruises and will be modelled as "Point" source. Since only the terminal is located within the Study Area, emission from marine movement for the cruises is not considered in this assessment.

7. The emission parameters of the OGVs with berthing mode are summarized in the **Table 5**:

Table 5 Emission parameters of the OGVs

Parameter		Unit	The 40,000-ton ship	The 70,000-ton ship
Coordinates	East	-	835175.41	835170.51
	North		817276.31	817393.30
No. of Stack(1)		-	4	4
Berthing period		Hour	08:00-20:00	Whole day
Exhausted Temperature		K	448.2	448.2
Height of Stack		mPD	50	50
Exhaust Diameter		m	0.6	0.6

Parameter		Unit	The 40,000-ton ship	The 70,000-ton ship
Exhaust velocity		m/s	10.65	11.22
Emission Rate for each stack[2]	NO_X	g/s	3.24	3.64
	RSP	g/s	0.47	0.49

1. Four engines so 4 exhaust stacks
2. Emission rates of each stack = the total emission (listed in Table 2) / the numbers of stacks.

HK China Ferry Terminal

8. Eight berths are available in the HK China Ferry Terminal for serving the ferry from Macau and China Pearl River Delta China (hereafter called as China). The emissions from the ferries with berth mode are adopted to be point source while the emissions from the ferries with cruise mode are adopted to be area source.

9. The ferry schedules are the same from Monday to Sunday and shown in **Table 6**. Each vessel is assumed to hotel the berth for half hour for each routine.

Table 6 Schedules of Fast Ferries from Macau and China [1]

Hour	Vessels			Hour	Vessels		
	China	Macau	Total		China	Macau	Total
00	0	0	0	**12**	1	2	3
01	0	0	0	**13**	4	3	7
02	0	0	0	**14**	1	2	3
03	0	0	0	**15**	6	2	8
04	0	0	0	**16**	3	2	5
05	0	0	0	**17**	1	2	3
06	0	0	0	**18**	5	2	7
07	3	2	5	**19**	4	2	6
08	11	3	14	**20**	1	2	3
09	3	3	6	**21**	0	2	2
10	5	3	8	**22**	0	1	1
11	3	3	6	**23**	0	0	0

1. http://www.barcaferry.com/index_c.htm

10. Based on the Study on Marine Vessels Emission, the fast ferries from Macau and CHINA only operate the auxiliary engines with load factor of 45% when the vessel are berthing near the piers. The auxiliary engine types of the fast ferries from Macau are not available and assumed to be the same as the type of the ferries from China ferry. The average values of the parameters of the auxiliary engine are used for modeling. The information of auxiliary engine is shown in **Table 7**.

Table 7 Information of Auxiliary Engines for Fast Ferries[1]

Parameters	Unit	Fast Ferry
Number of Engine[2]	-	2
Power of Engine[2]	kw	96.9
Total Power	m	194

Parameters	Unit	Fast Ferry
Speed(2)	RPM	1500
Displacement (3)	m^3	0.007
	CID(4)	425.5
Volumetric Efficiency(5)	-	3
Intake Airflow per engine (6)	CFM	554
Manifold Flow per engine(7)	CFM	1395.2
	m^3/s	0.66
Manifold Temperature(5)	K	537.8
Exhaust Temperature(8)	K	547.3
Total Exhaust Flow (9)	m^3/s	0.67

1. The auxiliary engines refers to other similarly type
   http://www.kohlerpower.com/onlinecatalog/pdf/g5210.pdf
   http://www.china-dieselgenerator.com/product.php?name=150kw_generator
   http://www.cat.com/cda/files/256118/7/LEHE5521-01.pdf
   http://www.powertechengines.com/MQP-DataSheets/MQP150IV_Rev_0.pdf
   http://www.kohlerpower.com/onlinecatalog/pdf/g5205.pdf
   http://www.china-dieselgenerator.com/product.php?name=50kw_generator
   http://www.generac.com/SpecSheets/0184480SBY.pdf
   http://westgenerator.com/index.cfm/linkservid/BE7D7807-5056-B35E-2CD78C8CEB28D932/showMeta/0/
   http://www.cmdmarine.com/Products/Recreational%20Inboard/QSM11/fr20049.pdf
   http://www.bigge.com/crane-charts/crawler-crane-charts/Kobelco-7250-2F_spec.pdf
   http://www.bigge.com/crane-charts/crawler-crane-charts/Link-Belt-LS278H-Specifications.pdf
   http://www.bigge.com/crane-charts/crawler-crane-charts/CK2500-II.pdf
   http://www.bigge.com/crane-charts/crawler-crane-charts/HC230-LC.pdf
2. Average from the different type of ferries auxiliary engines
   http://www.barcaferry.com/index_c.htm
3. The displacement of the auxiliary engine is not available, reasonable estimation based on interpolation from other similar type of engine
4. $0.007\ m^3 * 39.37^3 = 425.5$ CID
5. http://www.asia.donaldson.com/en/exhaust/support/datalibrary/1053747.pdf
6. Intake Airflow = Engine Size (CID) * Engine Speed (RPM)/3456*Volumetric efficiency
7. Manifold Flow = (900+460)/540*Intake Airflow (CFM)
8. Type A Ship with 46% load factor Table 7, "AE measurement results during periods with steady-state engine load operation, Cooper D.A., 2000 Exhaust emissions from high speed passenger ferries Atmospheric Environment 35 (2001) 4189–4200"
9. Total Exhaust flow = $Flow_{Mani} / T_{Mani} * T_{Exhaust}$ *number of engines

11. There is no chimney emission for those types of ferry and the gas exhaust is from two horizontal stacks at the stern near sea level. Emission from the eight berths will be modelled as "Point" source by the ISCST3. Effective efflux velocity to account for horizontal plume is assumed to be 0.001 m/s based on "AERMOD Implementation Guide" (March 19, 2009) issued by USEPA. Exhaust height is assumed to be 1.3 mPD. The exhaust diameter is calculated from the total exhaust air flow divided by the above effective efflux velocity. The parameters are summarized in **Table 8.**

Table 8 Exhaust Parameter for Fast Ferries with Berth Mode

Coordinates	-	835044.77	817788.12
		835096.67	817795.28
		835153.94	817806.02

		835246.64 835274.11 835202.23 835146.71 835097.62	817940.13 817791.10 817780.00 817768.89 817754.87
Exhausted Temperature	K	448.2	
Height of Stack	mPD	1.3	
Effective efflux velocity(1)	m/s	0.001	
Exhaust Diameter(2)	m	29.24	

1. "Aermod Implementation Guide" (March 19, 2009) issued by USEPA
2. Exhaust diameter =2* (total exhaust flow / π)^(1/2)

12. The emission factors and emission rates for one auxiliary engine are listed in **Table 9**.

Table 9 Emission Information for one Berthing Ferry

Emission Factor(1) (Auxiliary Engine)	NO_X	g/kwh	10
	RSP	g/kwh	0.31
Emission Rate(2)	NO_X	g/s	0.24
	RSP	g/s	0.01

1. Table 4-17 ME and AE emission Factors (g/kWh) for Macau and China Ferry– Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory
2. The emission rate = emission factor * total power * load factor * hotelling activity(0.5hr)

13. The emission rate for each pollutant at each hour is calculated based on the vessels operational schedule, which is the sum of the emission rates from all the vessels hotelling at that hour divided by eight (total number of berth). The emission rates at each hour are shown in **Table 10**:

Table 10 Hourly Emission Rates of the Fast Ferries

Hour	**Vessels**	**NOx**	**RSP**	**Hour**	**Vessels**	**NOx**	**RSP**
		g/s	**g/s**			**g/s**	**g/s**
00	0	0	0	**12**	3	0.363	0.011
01	0	0	0	**13**	6	0.848	0.026
02	0	0	0	**14**	3	0.363	0.011
03	0	0	0	**15**	5	0.969	0.030
04	0	0	0	**16**	4	0.606	0.019
05	0	0	0	**17**	4	0.363	0.011
06	0	0	0	**18**	8	0.848	0.026
07	5	0.606	0.019	**19**	4	0.727	0.023
08	9	1.696	0.053	**20**	3	0.363	0.011
09	5	0.727	0.023	**21**	4	0.242	0.008
10	5	0.969	0.030	**22**	1	0.121	0.004
11	5	0.727	0.023	**23**	0	0	0

14. Emissions for the China ferry and Macau ferry with cruising mode are considered separated due to their route and main engine types are difference.

The cruise speed limit in Victoria harbor is 10 knots while the maximum cruise speeds are 45 knots and 32 knots for Macau ferries and China ferries respectively. Under a conservative assumption, the load factors of the engines are estimated as the ratio of actual cruise speed to the maximum cruise speed. Therefore, the load factor of the ferries with 10 knots cruise speed are 22.2% (10/45 = 0.222) and 31.3% (10/32 = 0.313). The main engine information of China and Macau ferry are shown in **Table 11**.

Table 11 Information of Main Engines for Fast Ferries

Parameters	Unit	Macau	China
Maximum Designed Cruise Speed(1)	knots	45	32
Victoria Harbour Cruise Speed Limit(2)	knots	10	10
Load Factor (Main Engines)-Cruise(3)	%	0.222	0.313
Total maximum Engine Power(4)	kW	9280	5490
Engine Speed(1)	RPM	2000	2000

1. http://www.barcaferry.com/index_c.htm
2. http://www.mardep.gov.hk/en/publication/pressrel/pr2k0629.html
3. Load factor = actual cruise speed / maximum cruise speed
4. Statement 4.2.7 and 4.2.8 in "The Hong Kong University of Science & Technology: Study on Marine Vessels Emission inventory"

15. The cruising emission information is summarized in **Table 12**.

Table 12 Cruise Emission information for Fast Ferry

Parameters		Units	Macau	China
Emission Factor(1) (Main Engine)	NO_X	g/kwh	9.8	
	RSP	g/kwh	0.31	
Emission Rate(2) (Main Engine)	NO_X	g/s	5.61	4.67
	RSP	g/s	0.18	0.15
Emission Rate(3) (Auxiliary Engine)	NO_X	g/s	0	0.24
	RSP	g/s	0	0.01
Total Emission Cruise (4)	NO_X	g/s	5.61	7.74
	RSP	g/s	0.18	0.18

1. The NO_x emission factor is based on the emission limit stated in MARPOL 73/78 Annex VI Regulation for the prevention of Air Pollution from Ships while the emission factor of RSP is based on Table 4-17 ME and AE emission Factors (g/kWh) for Macau and PRD Ferry– Institute for the Environment, The Hong Kong University of Science & Technology: Study on Marine Vessels Emission Inventory
2. The emission rate = emission factor * total power * load factor
3. All power of the Macau ferries are provided by the main engines during cruising.
4. Total emission = emission from main engine + emission from auxiliary engine

16. 30 m is applied to be the route width for variation in the actual vessel rout. The actual cruising speed of the ferries within harbor is 14 knot. The average area source is calculated by the instantaneous emission rate (g/s) multiplied the cruise time within the studying area and then divided by the total cruising area. The area emission information is shown in **Table 13**.

Table 13 Exhaust Parameter for Fast Ferries with Cruise Mode

Route Coordinates Macau	–	833886.00 817401.67 834934.04 817757.43
Route Length - Macau	m	1106.78
Total Area - Macau	m^2	33203.3
Cruise Time in the Study Area – Macau	hr	0.06
Route Coordinates - China	–	833730.57 818678.97 833726.13 817628.84 833886.00 817401.67 834934.04 817757.43
Route Length – China	m	2434.70
Total Area - China	m^2	73041.02
Cruise Time in the Study Area – China	hr	0.13

17. Each route shown in **Table 6** is used to be two ferry trips along the ferry route, one for form China or Macau and one for form Kowloon. The cruise area source information are listed in the **Table 14** and **Table 15** for Macau ferry and China Ferry:

Table 14 Area Emissions Source(1) for Fast Ferry - Macau

Hour	Vessels	NOx	RSP	Hour	Vessels	NOx	RSP
		g/m^2s	g/m^2s			g/m^2s	g/m^2s
00	0	0	0	**12**	4	4.042E-05	1.278E-06
01	0	0	0	**13**	6	6.062E-05	1.918E-06
02	0	0	0	**14**	4	4.042E-05	1.278E-06
03	0	0	0	**15**	4	4.042E-05	1.278E-06
04	0	0	0	**16**	4	4.042E-05	1.278E-06
05	0	0	0	**17**	4	4.042E-05	1.278E-06
06	0	0	0	**18**	4	4.042E-05	1.278E-06
07	4	4.042E-05	1.278E-06	**19**	10	1.010E-05	3.196E-06
08	6	6.062E-05	1.918E-06	**20**	4	4.042E-05	1.278E-06
09	6	6.062E-05	1.918E-06	**21**	4	4.042E-05	1.278E-06
10	6	6.062E-05	1.918E-06	**22**	2	2.021E-05	6.392E-07
11	6	6.062E-05	1.918E-06	**23**	0	0	0

1. Area emission (g/m^2s) = emission rate (g/s) * cruise time (hr) * Number of vessel / total area (m^2)

Table 15 Area Emissions Source(1) for Fast Ferry - China

Hour	Vessels	NOx	RSP	Hour	Vessels	NOx	RSP
		g/m^2s	g/m^2s			g/m^2s	g/m^2s
00	0	0	0	**12**	2	1.768E-05	5.588E-07
01	0	0	0	**13**	8	7.074E-05	2.235E-06
02	0	0	0	**14**	2	1.768E-05	5.588E-07
03	0	0	0	**15**	12	1.061E-04	3.353E-06
04	0	0	0	**16**	6	5.305E-05	1.677E-06
05	0	0	0	**17**	2	1.768E-05	5.588E-07
06	0	0	0	**18**	10	8.842E-05	2.794E-06
07	6	5.305E-05	1.677E-06	**19**	2	1.768E-05	5.588E-07
08	22	1.945E-04	6.147E-06	**20**	2	1.768E-05	5.588E-07

09	6	5.305E-05	1.677E-06	**21**	0	0	0
10	10	8.842E-05	2.794E-06	**22**	0	0	0
11	6	5.305E-05	1.677E-06	**23**	0	0	0

1. Area emission (g/ m^2s) = emission rate (g/s) * cruise time (hr) * Number of vessel / total area (m^2)

Derrick Lighter Barges in the New Yau Ma Tei Typhoon Shelter (NYMTTS)

18. The New Yau Ma Tei Public Cargo Working area (NYPCWA) is mainly used for loading and unloading cargo using derrick lighter barges. The shoreline length is approximately 1,250 meters. The Merchant Shipping (Local Vessels) (Typhoon Shelters) Regulation – Chapter 548E stated that the maximum allowed local vessels length in the typhoon shelter is 50 meters. Considering 5 meters needed for manoeuvring purposes, the maximum number of instantly operating vessels was 20 vessels (the shoreline length divided by vessel and manoeuvring length). The operation period is from 7:00 am to 9:00 pm daily. Since the derrick lighters operate near 5 minutes in an operation sequence with a period of 20 minutes, 25% is adopted as an activity factor for hourly emission estimate.

19. The vessel information for derrick lighter barge is summarized in the **Table 16**.

Table 16 Vessel Information for Derrick lighter Barges

Coordinates	-	834350.61	818456.45
		834379.32	818492.61
		834401.41	818533.03
		834432.32	818571.31
		834461.03	818613.85
		834489.75	818658.52
		834505.20	818726.58
		834505.20	818786.14
		834505.20	818847.82
		834505.20	818913.76
		834507.41	818969.06
		834503.00	819017.98
		834503.00	819077.54
		834505.20	819158.36
		834500.79	819220.05
		834503.00	819281.73
		834503.00	819364.68
		834503.00	819437.00
		834498.58	819502.94
		834505.20	819564.62
Activity Time	hr	14 (07:00 – 21: 00)	
Lifting Capacity(1)	tones	250	
Power of Main Engine(2)	kw	314.6	
Load Factor(3)	%	50%	
Activity	%	25%	
Exhaust Temperature(4)	K	811.28	
Exhaust Flow Rate(4)	m^3/s	0.9752	
Effective Efflux Velocity(5)	m/s	0.001	

Exhaust Diameter[6]	m	35.24
Exhaust Height[7]	m	8.7

1. http://www.globalsecurity.org/military/systems/ship/bd.htm
2. Proportional estimation from 100-tonnes derrick lighter www.globalsecurity.org/military/systems/ship/bd.htm
3. The maximum theoretical loading factor of 43% for gantry cranes "Starcrest Consulting Group, LLC, 2009, Rubber Tired Gantry (RTG) Grane Load Factor Study. Poulsbo: Starcrest Consulting Group, LLC." A conservative loading factor of 50% is used for all the barges.
4. The exhaust temperature is averaged from 7 types of engines while exhaust volume are interpolated from other engines.
   http://www.kohlerpower.com/onlinecatalog/pdf/g5210.pdf
   http://www.china-dieselgenerator.com/product.php?name=150kw_generator
   http://www.cat.com/cda/files/256118/7/LEHE5521-01.pdf
   http://www.powertechengines.com/MQP-DataSheets/MQP150IV_Rev_0.pdf
   http://www.kohlerpower.com/onlinecatalog/pdf/g5205.pdf
   http://www.china-dieselgenerator.com/product.php?name=50kw_generator
   http://www.generac.com/SpecSheets/0184480SBY.pdf
   http://westgenerator.com/index.cfm/linkservid/BE7D7807-5056-B35E-2CD78C8CEB28D932/showMeta/0/
   http://www.cmdmarine.com/Products/Recreational%20Inboard/QSM11/fr20049.pdf
5. The exhaust diameter is calculated from the total exhaust air flow divided by the above effective efflux velocity.
6. Effective efflux velocity to account for horizontal plume is assumed to be 0.001 m/s based on "Aermod Implementation Guide" (March 19, 2009) issued by USEPA.
7. Exhaust height is approximated to be three times of shipping containers.

20. The main emissions pollutants are NO_2 and RSP. The emission factors are estimated from USEPA AP 42 Chapter 3.3 Gasoline and Diesel Industrial Engines and emission rate are based on USEPA current Methodologies in Preparing Mobile Source port-Related emission inventories. The emission information is summarized in **Table 17**.

Table 17 Emission Information for Derrick lighter Barges

Emission Factor (main and auxiliary engines)	NO_X[1,2]	g/kwh	6.40
	RSP[1,2]	g/kwh	0.20
Emission[3]	NO_X	g	3523
	RSP	g	110
Total Emissions rate (per barge)[4]	NO_X	g/s	0.0699
	RSP	g/s	0.0022

1. The 10,000 hours has been assumed to be the operating life and therefore average fleet age of the engine on the barges is conservatively assumed to be 10 years.
   http://www.emergencypower.com/
   http://www.boatsafe.com/nauticalknowhow/enginelife.htm
2. Based on the assumption of the life time of the engines, all of them would be produced after year 2001 and belong to Tier 2 in Table 1 225 <= kW <450 stated in http://www.dieselnet.com/standards/us/nonroad.php
3. Emission = emission factor * engine power * load factor * activity time * Number of engine Section 2.1 USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories
4. Emission rate = emission factor (g/kWh) * load factor * engine capacity (kw) * number of engines / 3600 (s/hr)

Tug- movements in NYMTTS

21. According to the estimation in the Environmental Impact Assessment for West Kowloon Culture District, there are 130 small craft movement in NYMTTS both entering and leaving. The operation schedule of tugs are assumed to be the same as NYPCWA, from 7:00 am to 9:00 pm (total 14 hours) and thus 9.3 tug movements per hour is estimated.

22. The route information is shown in **Table 18**. The emissions from the tugs movement are identified as area sources. Due to the variation of the actual vessel rout, a width of 30 m is applied. In **Table 18**, the total area is calculated by total distance of rout multiplied the width.

Table 18 Exhaust Parameter for Tugs Movement Emission

Route coordinate	-	833918.63 818537.51 834090.28 818434.66 834223.51 818447.52 834396.70 818666.12 834405.57 819039.05 834405.57 819564.62 834016.33 819564.62
Distance of Each Segment	m	200.00 133.84 278.89 373.01 525.60 389.24
Total distance of Route	m	2151
Total Area	m^2	64529

23. In NYMTTS, there are mainly three types of tugs and their information is summarized in **Table 19**.

Table 19 Vessel Information for Tugs

Parameters	Unit	Average from 3 Types of Tugs(1)
Average Cruising Speed(2)	knot	8.0
	km /hr	14.8
Cruise time (3)	hr	0.08
Number of Engine(4)	-	2
Power of Engine(4)	kw	696
Total displacement(4)	m^3	37.7
Fuel Consumption(4)	l/hr	188.4
	g/kWh	225.3
Load Factor(5)	%	31%
Diesel Density(6)	g/l	832
Diesel sulphur content(6)	ppm	5000
Exhaust Temperature(6)	K	421.7
Total Exhaust flow(total) (6)	m^3/s	2.3

1. http://www.maritimesales.com/AT11.htm, http://www.maritimesales.com/AT13.htm and http://www.maritimesales.com/AT15.htm
2. http://www.barcaferry.com/index_c.htm
3. cruise time = total distance of route / average cruising time
4. https://marine.cummins.com/marine/public/home
5. Table 3-4: Load Factors for harbor Craft (Port of Los angeles and long Beach) – USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories
6. Para. 4. Legislative Council panel on Environmental Affairs, Controlling emission from vessels (21 December 2011)

24. The key pollutants from tugs operated in NYMTTS are NO_2 and RSP. The emission factor of NO_x is based on the engine data sheet of the maritime sales information. While the emission factor of RSP is based on USEPA methodology and the correct factor had been applied. The emission factors and emission rates are summarized in **Table 20**.

Table 20 Emission Information for Tugs

Emission Factor	NO_X(1)	g/kwh	8.55
	RSP(2)	g/kwh	0.33
Emission Rate(3)	NO_X	g/s	1.02
	RSP	g/s	0.04

1. Averaged from three engine NOx emissions which are based on the engines data sheet from maritime sales information (https://marine.cummins.com/marine/public/home).
2. RSP emission = 0.3 * 1.09 where 0.3 is the RSP emission factor with sulphur content of 0.31% listed in Table 3-5 of "Harbour Craft Emission Factors - USEPA: Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories" assuming the engine type as category 1, < 3.5 l/cylinder displacement, Tier 1; 1.09 is the correction factor for sulphur content of 0.5% based on table 4.8 in "Fuel Correction Factors – Starcrest: Puget Sound Maritime Air emission inventory (April 2007)"
3. Emission rate = emission factor (g/kWh) * load factor * engine capacity (kw) * number of engines / 3600 (s/hr)

25. The average emission in each hour from area sources are calculated from the emission rate (g/s) which is listed in **Table 20** times the cruise time ratio of one hour and divided by the total rout area. 24 hour area source emissions rates are listed in **Table 21**.

Table 21 Area emission Sources for Tugs (1)

Hour	Vessels	NOx	RSP	Hour	Vessels	NOx	RSP
		g/ m^{2}s	g/ m^{2}s			g/ m^{2}s	g/ m^{2}s
00	0	0	0	**12**	9.3	2.14E-5	8.18E-7
01	0	0	0	**13**	9.3	2.14E-5	8.18E-7
02	0	0	0	**14**	9.3	2.14E-5	8.18E-7
03	0	0	0	**15**	9.3	2.14E-5	8.18E-7
04	0	0	0	**16**	9.3	2.14E-5	8.18E-7
05	0	0	0	**17**	9.3	2.14E-5	8.18E-7
06	0	0	0	**18**	9.3	2.14E-5	8.18E-7
07	9.3	2.14E-5	8.18E-7	**19**	9.3	2.14E-5	8.18E-7
08	9.3	2.14E-5	8.18E-7	**20**	9.3	2.14E-5	8.18E-7
09	9.3	2.14E-5	8.18E-7	**21**	0	0	0
10	9.3	2.14E-5	8.18E-7	**22**	0	0	0
11	9.3	2.14E-5	8.18E-7	**23**	0	0	0

1. Area emission (g/ m^{2}s) = emission rate (g/s) * cruise time (hr) * Number of vessel / total area (m^2)