Appendix 6.4

Detailed Calculation of Cruise Emission

Detailed Calculation of Cruise Emission

Super Sub-Panamax - Wasa Queen/Sub-Panamax - Costa Allegra

E/hr=Power x LF x EF
Propulsion Engine:

Propulsion Engine power (19,200kW) = 19200 kW
Load Factor=(4/21.5)^3 or minimum of 2% [1] : 2%

	Emission Factor in g/kWh [2]	E.F. Adjustment Factors at Low Loads	Emission Rate in kg/hr
NO_x	14	4.63	24.89
SO_2	11.1	1	4.26
CO	1.1	10	4.224
PM10	1.14	7.29	3.191

Maneuvering
Auxiliary Engine:

Auxiliary Power = (0.278*19200 kW) 5337.6 kW
Load Factor [3] = 0.8

Using Residual Oil

	Emission Factor in g/kWh [4]	Emission Rate in kg/hr
NO_x	14.7	62.77
SO_2	11.1	47.40
CO	1.1	4.697
PM10	1.14	4.868

Idling
Auxiliary Engine:

Auxiliary Power = (0.278*19200kW) 5337.6
Load Factor [3] = 0.64

	Emission Factor in g/kWh [4]	Emission Rate in kg/hr
NO_x	14.7	50.22
SO_2	11.1	37.92
CO	1.1	3.758
PM10	1.14	3.894

Boiler

consumption rate 0.0125 tonne/hr

	Fuel Emission Factor in kg/tonne [5]	Emission Rate in kg/hr
NO_x	12.3	0.15
SO_2	54	0.68
CO	4.6	0.058
PM10	1.3	0.016

Total Emission

	Emission Rate(kg/hr)	
	Maneuvering	Hotelling
NOx	87.8148	50.3699
SO2	52.3353	38.5933
CO	8.9786	3.8152
PM10	8.0754	3.9106

Emission Rate	Maneuvering (15mins)	Hotelling (30mins)	Hotelling (60mins)
NO_2 (g/s) [6]	1.2197E+00	1.3992E+00	2.7983E+00
SO_2 (g/s) [7]	5.1151E+00	7.5440E+00	1.5088E+01
PM10 (g/s) [7]	7.8926E-01	7.6441E-01	1.5288E+00

Notes:
(1) Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting for USEPA.
(2) Table 2-8 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting
(3) Table 2-7 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting
(4) Table 2-10 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting
(5) Table 2-11 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting
(6) NO_2/NO_x ratio of 20% has been assumed in the calculation.
(7) Correction factor of 1.41 for average 3.8% fuel sulphur content was applied.

Detailed Calculation of Cruise Emission

Panamax - Queen Elizabeth II

E/hr=Power x LF x EF
Propulsion Engine:

Propulsion Engine power (2x44MW)= 88000 kW
Load Factor=(4/21.5)^3 or minimum of 2% [1] : 2%

	Emission Factor in g/kWh [2]	Emission Rate in kg/hr
NO_x	14	24.64
SO_2	11.1	19.54
CO	1.1	1.936
PM10	1.14	2.006

Maneuvering
Auxiliary Engine:

Auxiliary Power (=9.5MW/0.64) = 14843.75 kW
Load Factor [3] = 0.8

Using Residual Oil

	Emission Factor in g/kWh [4]	Emission Rate in kg/hr
NO_x	14.7	174.56
SO_2	11.1	131.81
CO	1.1	13.063
PM10	1.14	13.538

Idling
Auxiliary Engine:

Auxiliary Power (=9.5MW/0.64) = 14843.75 kW
Load Factor [3] = 0.64

	Emission Factor in g/kWh [4]	Emission Rate in kg/hr
NO_x	14.7	139.65
SO_2	11.1	105.45
CO	1.1	10.450
PM10	1.14	10.830

Boiler

consumption rate : 0.0125 tonne/hr

	Fuel Emission Factor in kg/tonne [5]	Emission Rate in kg/hr
NO_x	12.3	0.15
SO_2	54	0.68
CO	4.6	0.058
PM10	1.3	0.016

Total Emission

	Emission Rate(kg/hr)	
	Maneuvering	Hotelling
NO_x	199.3563	139.8038
SO_2	152.0235	106.1250
CO	15.0560	10.5075
PM10	15.5602	10.8463

Emission Rate	Maneuvering (15mins)	Hotelling (30mins)	Hotelling (60mins)
NO_2 (g/s) [6]	2.7688E+00	3.8834E+00	7.7669E+00
SO_2 (g/s) [7]	1.4858E+01	2.0745E+01	4.1489E+01
PM10 (g/s) [7]	1.5208E+00	2.1202E+00	4.2403E+00

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(5) Table 2-11 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF
(6) NO_2/NO_x ratio of 20% has been assumed in the calculation.
(7) Correction factor of 1.41 for average 3.8% fuel sulphur content was applied.

Detailed Calculation of Cruise Emission

Post-Panamax/Super Post-Panamax - Queen Mary II

E/hr=Power x LF x EF
Propulsion Engine:

Propulsion Engine power (4x21.5MW)= 86000 kW
Load Factor=(4/21.5)^3 or minimum of 2% [1] 2%

	Emission Factor in g/kWh [2]	Emission Rate in kg/hr
NO_x	14	24.08
SO_2	11.1	19.09
CO	1.1	1.892
PM10	1.14	1.961

Maneuvering
Auxiliary Engine:

Auxiliary Power (=9.5MW/0.64) = 14843.75 kW
Load Factor [3] = 0.8

Using Residual Oil

	Emission Factor in g/kWh [4]	Emission Rate in kg/hr
NO_x	14.7	174.6
SO_2	11.1	131.8
CO	1.1	13.06
PM10	1.14	13.54

Idling
Auxiliary Engine:

Auxiliary Power (=9.5MW/0.64) = 14843.75 kW
Load Factor [3] = 0.64

	Emission Factor in g/kWh [4]	Emission Rate in kg/hr
NO_x	14.7	139.7
SO_2	11.1	105.5
CO	1.1	10.45
PM10	1.14	10.83

Boiler

consumption rate = 0.0125 tonne/hr

	Fuel Emission Factor in kg/tonne [5]	Emission Rate in kg/hr
NO_x	12.3	0.1538
SO_2	54	0.6750
CO	4.6	0.0575
PM10	1.3	0.0163

Total Emission

	Emission Rate(kg/hr)		AQO	Ratio (AQO/emission rate) [6]	
	Maneuvering	Hotelling		Maneuvering	Hotelling
NOx	198.7963	139.8038	150	0.27	0.19
SO2	151.5795	106.1250	350	0.61	0.43
CO	15.0120	10.5075	10000	0.0015	0.0011
PM10	15.5146	10.8463	180	0.12	0.08

Emission Rate	Maneuvering (15mins)	Hotelling (30mins)	Hotelling (60mins)
NO_2 (g/s) [6]	2.7611E+00	3.8834E+00	7.7669E+00
SO_2 (g/s) [7]	1.4815E+01	2.0745E+01	4.1489E+01
PM10 (g/s) [7]	1.5163E+00	2.1202E+00	4.2403E+00

Notes:
(1) Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting for USEPA.
(2) Table 2-8 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting for USEPA.
(3) Table 2-7 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting for USEPA.
(4) Table 2-10 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting for USEPA.
(5) Table 2-11 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting for USEPA.
(6) NO_2/NO_x ratio of 20% has been assumed in the calculation.
(7) Correction factor of 1.41 for average 3.8% fuel sulphur content was applied.

Detailed Calculation of Cruise Emission

Tugboat

Propulsion Engine:

Propulsion Engine power = 1532 kW
Load Factor for Harbor Craft [1] = 31%

	Emission Factor in g/kWh [2]	Emission Rate in kg/hr
NO_x	13.2	6.27
SO_2	0.63	0.30
CO	1.1	0.522
PM10	0.72	0.342

Auxiliary Engine:

Propulsion Engine power = 82 kW
Load Factor for Harbor Craft [1] = 31%

	Emission Factor in g/kWh [2]	Emission Rate in kg/hr
NO_x	13.2	0.34
SO_2	0.63	0.02
CO	1.1	0.028
PM10	0.72	0.018

Total Emission

	Emission Rate(kg/hr)
NO_x	6.6045
SO_2	0.3152
CO	0.5504
PM10	0.3602

	Emission Rate (g/s), 15 mins
NO_2 (g/s) [3]	9.1729E-02
SO_2 (g/s) [4]	5.5454E-02
PM10 (g/s) [4]	6.3376E-02

Notes:
(1) Table 2-14 Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consulting
(2) Table 2-16 of Current Methodologies and Best Practices in Preparing Port Emission Inventories, Final Report, January 2006 prepared by ICF Consultir
(3) NO_2/NO_x ratio of 20% has been assumed in the calculation.
(4) Correction factor of 2.53 for average 3.8% fuel sulphur content was applied.