Supporting Information

Emissions of PCDD/Fs, PCBs, and PAHs from a Modern Diesel Engine Equipped with Catalyzed Emission Control Systems

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36 Pages
2 Figures
31 Tables

Table S1. Test Fuel Properties

test method	result
Net Heat of Combustion, ASTM D3338-92 (MJ/kg)	42.86
Density @ 15.5 ºC (g/cm^3), ASTM D4052	0.8519
Cetane Number, ASTM D613	44.1
Cetane Index, ASTM D976	44.4
Olefins, by FIA, ASTM D1319-93 (% Vol.)	0.8
Aromatics, by FIA, ASTM D1319-93 (% Vol.)	29.7
Sulfur, ASTM D2622 (ppm mass)	8.2
Carbon, ASTM D5291 (% mass)	87.05
Distillation Properties, ASTM D86	
IBP (ºC):	177
10 % (ºC):	205
50 % (ºC):	243
90 % (ºC):	295
End Point (ºC):	322
Residue Diesel (mL):	0.9
Recovery:	98.6%

Table S2. Catalyst Properties

catalyst type	cell density (cpsi)	wall thickness (mil)	volume (L)	zeolite type	PGM[a] ratio[b]	PGM[a] loading (g/L)
DOC	400	4	4.25		4.4:1:0	1.3
CDPF	200	12	11.5		1:0:0	0.19
FeZ SCR	300	5	12.75	Fe-Y-exchanged		
ASC for FeZ SCR	300	5	4.25		1:0:0	0.18
CuZ SCR	300	5	12.75	Cu-Y-exchanged		
ASC for CuZ SCR	300	5	4.25		1:0:0	0.18

[a]PGM stands for Platinum Group Metals which consists of platinum, palladium, and rhodium.
[b]PGM ratio is defined as Pt:Pd:Rh.

Table S3. Emission Results for a Selection of Test Configurations

test configuration	NOx (g/hp-hr)	HC (g/hp-hr)	CO (g/hp-hr)	PM (g/hp-hr)
SS Engine Out	1.66	0.06	0.40	
SS DOC+CDPF	1.40	0.00	0.02	
T DOC+CDPF	1.81	0.07	0.04	0.002
T DOC+CDPF+CuZ SCR+ASC+urea	0.08	0.06	0.04	0.002

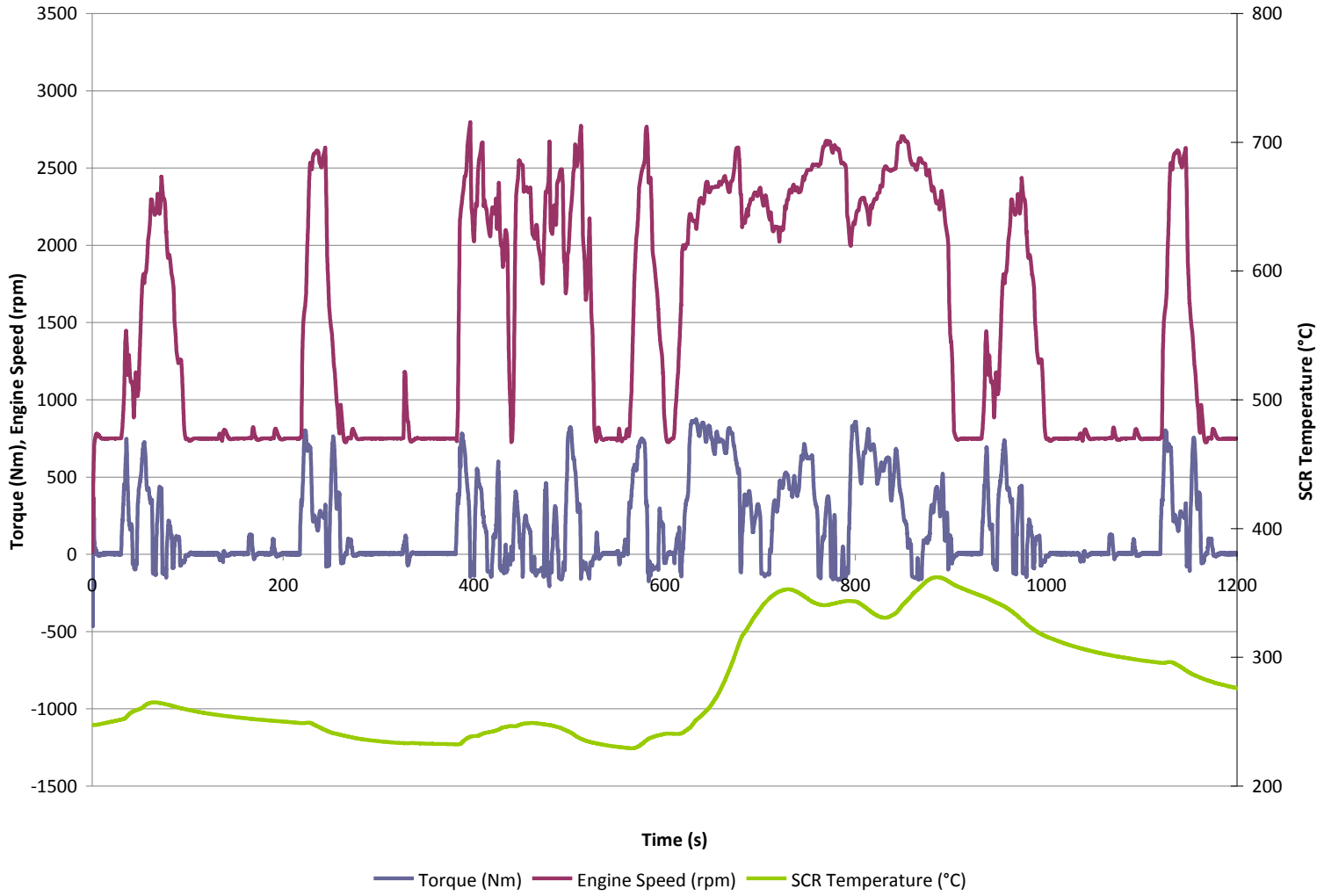

Figure S1. Engine speed and torque along with SCR catalyst temperature over the hot start HDDE-FTP.

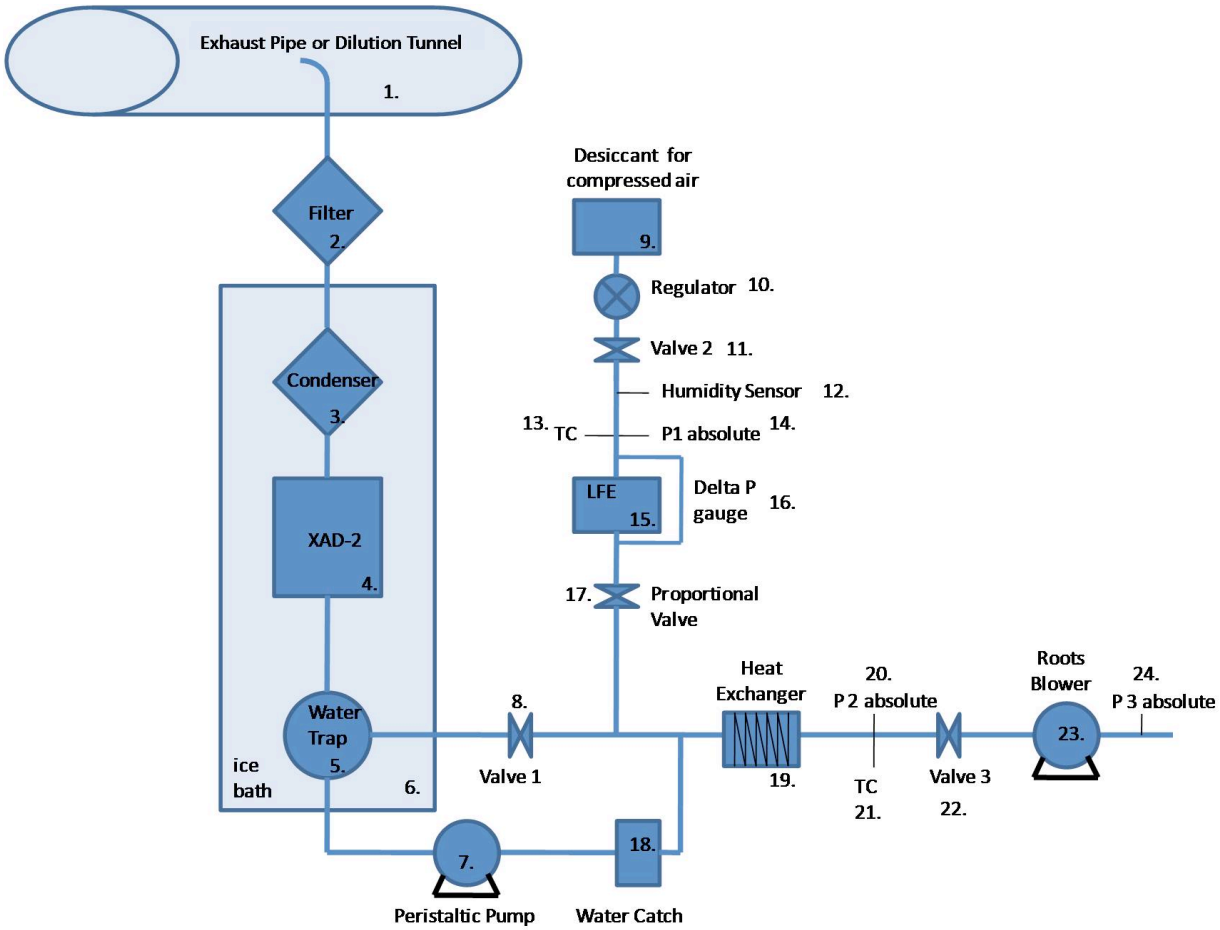

Figure S2. Schematic of the sampling system used in this test program. A description is given below for each of the numbered components:

1. Exhaust pipe or dilution tunnel: The point at which the raw or diluted exhaust sample is extracted.
2. Heated filter: Collects particulate matter from exhaust, heated to 191 ±11°C, constructed from titanium.
3. Condenser coil: Used to rapidly cool the exhaust sample, constructed from titanium.
4. Holder for XAD-2 resin, constructed from nickel.
5. Water Trap: Collects the water that condenses out of the exhaust, constructed from 316-stainless steel.
6. Ice bath: Used to cool the exhaust gas to 5 °C before it reaches the XAD-2.
7. Peristaltic pump: Used to remove water from the water trap.
8. Valve: Closes off the sample train from the rest of the system.
9. Desiccant: Removes water, oil and particles from house supplied compressed air.
10. Regulator: Used to set the desired pressure of air at the LFE inlet.
11. Valve: Used to perform leak check.
12. Humidity sensor: Used to verify that all of the water is removed from the compressed air.
13. Temperature sensor: Used for calculation of make up air flow rate.

14. Pressure sensor: Used for calculation of make up air flow rate.
15. Laminar Flow Element: Used to measure make up air flow rate.
16. Differential pressure sensor: Used for calculation of make up air flow rate.
17. Proportional valve: Used to control the make up air flow rate.
18. Water catch: Used to collect water removed from exhaust.
19. Heat exchanger: increases the gas temperature to ambient to simplify the flow calculations for the total flow.
20. Pressure sensor: Used for calculation of total flow rate.
21. Thermocouple: Used for calculation of total flow rate.
22. Valve: Used to perform leak check.
23. Roots Blower: Used to control and measure total flow rate.
24. Pressure Sensor: Used for calculation of total flow rate.

Table S4. List of Isotopically Labeled PCDD/F Standards Used for Sample Analysis

PCDD/F	
Surrogate Standards	Alternate Standards
$^{37}Cl_4$-2,3,7,8-TCDD	$^{13}C_{12}$-1,3,6,8-Tetrachlorodibenzo-p-dioxin
$^{13}C_{12}$-1,2,3,4,7-PeCDD	$^{13}C_{12}$-1,3,6,8-Tetrachlorodibenzofuran
$^{13}C_{12}$-1,2,3,4,6-PeCDF	
$^{13}C_{12}$-1,2,3,4,6,9-HxCDF	Recovery Standards
$^{13}C_{12}$-1,2,3,4,6,8,9-HpCDF	$^{13}C_{12}$-1,2,3,4-Tetrachlorodibenzo-p-dioxin
	$^{13}C_{12}$-1,2,3,4,6,7-Hexachlorodibenzo-p-dioxin
Internal Standards	$^{13}C_{12}$-1,2,3,4-Tetrachlorodibenzofuran
$^{13}C_{12}$-2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	
$^{13}C_{12}$-1,2,3,7,8-Pentachlorodibenzo-p-dioxin (PeCDD)	
$^{13}C_{12}$-1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	
$^{13}C_{12}$-1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin (HxCDD)	
$^{13}C_{12}$-1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin (HxCDD)	
$^{13}C_{12}$-1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD)	
$^{13}C_{12}$-Octachlorodibenzo-p-dioxin (OCDD)	
$^{13}C_{12}$-2,3,7,8-Tetrachlorodibenzofuran (TCDF)	
$^{13}C_{12}$-1,2,3,7,8-Pentachlorodibenzofuran (PeCDF)	
$^{13}C_{12}$-2,3,4,7,8-Pentachlorodibenzofuran (PeCDF)	
$^{13}C_{12}$-1,2,3,4,7,8-Hexachlorodibenzofuran (HxCDF)	
$^{13}C_{12}$-1,2,3,6,7,8-Hexachlorodibenzofuran (HxCDF)	
$^{13}C_{12}$-1,2,3,7,8,9-Hexachlorodibenzofuran (HxCDF)	
$^{13}C_{12}$-2,3,4,6,7,8-Hexachlorodibenzofuran (HxCDF)	
$^{13}C_{12}$-1,2,3,4,6,7,8-Heptachlorodibenzofuran (HpCDF)	
$^{13}C_{12}$-1,2,3,4,7,8,9-Heptachlorodibenzofuran (HpCDF)	
$^{13}C_{12}$-Octachlorodibenzofuran (OCDF)	

Table S5. List of Isotopically Labeled PCB Standards Used for Sample Analysis

PCB	
Internal Standards	Surrogate Standards
$^{13}C_{12}$-2-Monochlorobiphenyl (PCB-1)	$^{13}C_{12}$-2,4,4'-Trichlorobiphenyl (PCB-28)
$^{13}C_{12}$- 4-Monochlorobiphenyl (PCB-3)	$^{13}C_{12}$-2,3,3',5,5'-Pentachlorobiphenyl (PCB-111)
$^{13}C_{12}$-2,2'-Dichlorobiphenyl (PCB-4)	$^{13}C_{12}$-2,2',3,3',5,5',6-Heptachlorobiphenyl (PCB-178)
$^{13}C_{12}$-4,4'-Dichlorobiphenyl (PCB-15)	
$^{13}C_{12}$-2,2',6-Trichlorobiphenyl (PCB-19)	Alternate Standards
$^{13}C_{12}$-3,4,4'-Trichlorobiphenyl (PCB-37)	none
$^{13}C_{12}$-2,2',6,6'-Tetrachlorobiphenyl (PCB-54)	
$^{13}C_{12}$-3,3',4,4'-Tetrachlorobiphenyl (PCB-77)	Recovery Standards
$^{13}C_{12}$-3,4,4',5-Tetrachlorobiphenyl (PCB-81)	$^{13}C_{12}$-2,5- Dichlorobiphenyl (PCB-9)
$^{13}C_{12}$-2,2',4,6,6'-Pentachlorobiphenyl (PCB-104)	$^{13}C_{12}$-2,2',5,5'-Tetrachlorobiphenyl (PCB-52)
$^{13}C_{12}$-2,3,3',4,4'-Pentachlorobiphenyl (PCB-105)	$^{13}C_{12}$-2,2',4,5,5'-Pentachlorobiphenyl (PCB-101)
$^{13}C_{12}$-2,3,4,4',5-Pentachlorobiphenyl (PCB-114)	$^{13}C_{12}$-2,2',3,4,4',5'-Hexachlorobiphenyl (PCB-138)
$^{13}C_{12}$-2,3,4,4',5-Pentachlorobiphenyl (PCB-115)	$^{13}C_{12}$-2,2',3,3',4,4',5,5'-Octachlorobiphenyl (PCB-194)
$^{13}C_{12}$-2,3',4,4',5-Pentachlorobiphenyl (PCB-118)	
$^{13}C_{12}$-2',3,4,4',5-Pentachlorobiphenyl (PCB-123)	
$^{13}C_{12}$-3,3',4,4',5-Pentachlorobiphenyl (PCB-126)	
$^{13}C_{12}$-2,2',4,4',6,6'-Hexachlorobiphenyl (PCB-155)	
$^{13}C_{12}$-2,3,3',4,4',5-Hexachlorobiphenyl (PCB-156)	
$^{13}C_{12}$-2,3,3',4,4',5'-Hexachlorobiphenyl (PCB-157)	
$^{13}C_{12}$-2,3',4,4',5,5'-Hexachlorobiphenyl (PCB-167)	
$^{13}C_{12}$-3,3',4,4',5,5'-Hexachlorobiphenyl (PCB-169)	
$^{13}C_{12}$-2,2',3,3',4,4',5- Heptachlorobiphenyl (PCB-170)	
$^{13}C_{12}$-2,2',3,4,4',5,5'- Heptachlorobiphenyl (PCB-180)	
$^{13}C_{12}$-2,3,3',4,4',5,5'- Heptachlorobiphenyl (PCB-189)	

$^{13}C_{12}$-2,2',3,3',5,5',6,6'-Octachlorobiphenyl (PCB-202)

$^{13}C_{12}$-2,3,3',4,4',5,5',6-Octachlorobiphenyl (PCB-205)

$^{13}C_{12}$-2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (PCB-206)

$^{13}C_{12}$-2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (PCB-208)

$^{13}C_{12}$-2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (PCB-209)

Table S6. List of Isotopically Labeled PAH Standards Used for Sample Analysis

PAH	
Surrogate Standards	Alternate Standards
d_{10}-Fluorene	d_{10}-Anthracene
d_{14}-Terphenyl	
	Recovery Standards
Internal Standards	d_{10}-2-Methylnaphthalene
$^{13}C_6$-Naphthalene	d_{10}-Acenaphthene
$^{13}C_6$-2-Methylnaphthalene	d_{10}-Pyrene
$^{13}C_6$-Acenaphthylene	d_{12}-Benzo(a)Pyrene
$^{13}C_6$-Acenaphthene	
$^{13}C_6$-Fluorene	
$^{13}C_6$-Phenanthrene	
$^{13}C_6$-Anthracene	
$^{13}C_6$-Fluoranthene	
$^{13}C_3$-Pyrene	
$^{13}C_6$-Benzo(a)anthracene	
$^{13}C_6$-Benzo(b)fluoranthene	
$^{13}C_6$-Benzo(k)fluoranthene	
$^{13}C_4$-Benzo(a)pyrene	
$^{13}C_4$-Benzo(e)Pyrene	
d_{12}-Perylene	
$^{13}C_6$-Ideno(1,2,3-c,d)pyrene	
$^{13}C_6$-Dibenz(a,h)anthracene	
$^{13}C_{12}$-Benzo(g,h,i)perylene	
$^{13}C_x$-Chrysene	

Note Regarding the Averaging of Reported Emission Factors and Detection Limits (Tables S7 – S31)

The following describes how the PCDD/F, PCB, and PAH emission factors and detection limits were averaged for the different test configurations (Note, all EMPCs were reported as detects for these test results). The same methodology applies for determination of the standard deviation as well:

Test Configurations without a DOC+CDPF

For testing without a DOC+CDPF where exhaust dilution was utilized, the filters had to be extracted separately from the PUF/XAD-2/rinsate. For these test results, emissions above the detection limit were summed for an individual test (filter result + PUF/XAD-2/rinsate result) for each individual congener. If a given congener emission result was reported as a non-detect for both the PM and PUF/XAD-2/rinsate, the higher of the two non-detect results was reported, as the summing of two non-detects would have artificially elevated the detection limit. For instances where a given congener emission resulted in a non-detect for the PM result and was above the detection limit for the PUF/XAD-2/rinsate (or vice versa), each result was reported. These individual test results for emissions above the detection limit and non-detects were grouped and averaged to create emission and non-detect results for the given congener. Where a non-detect is reported as "-", all individual tests reported results as a detect for that congener. Where a standard deviation is reported as "-", only one value was reported as the detect or non-detect. The average values for the 2,3,7,8-substituted CDD/F congeners and 2005 WHO PCB congeners were then used to calculate I-TEQ and 2005 WHO TEQ respectively with non-detects reported as 0, 0.5*DL, and DL

Test Configurations with a DOC+CDPF

For testing with a DOC+CDPF where exhaust dilution was not utilized, the filters were extracted with the PUF/XAD-2/rinsate. For these test results, emissions above the detection limit were averaged across all of the tests for each individual congener. For instances where a given congener emission resulted in a non-detect, the non-detects were averaged across all of the tests for each individual congener. Where a non-detect is reported as "-", all individual tests reported results as a detect for that congener. Where a standard deviation is reported as "-", only one value was reported as the detect or non-detect. The average values for the 2,3,7,8-substituted CDD/F congeners and 2005 WHO PCB congeners were then used to calculate I-TEQ and 2005 WHO TEQ respectively with non-detects reported as 0, 0.5*DL, and DL.

Table S7. PCDD/F Emission Factor Results in I-TEQ pg/L and pg/m^3, ND = 0 and EMPC = EMPC

	pg/L			pg/m^3		
test configuration	range of I-TEQ	average I-TEQ	± 95% C.I.	range of I-TEQ	average I-TEQ	± 95% C.I.
SS engine out	0.75 – 4.42	1.89	0.72	0.04 – 0.21	0.09	0.03
SS CuZ SCR HT	0.55 – 4.73	1.60	1.02	0.02 – 0.16	0.07	0.04
SS CuZ SCR LT	0.49 – 4.54	2.55	2.15	0.02 – 0.21	0.12	0.1
SS FeZ SCR	1.85 – 3.80	2.78	1.06	0.09 – 0.18	0.12	0.05
SS DOC+CDPF	0.30 – 3.46	1.23	1.66	0.01 – 0.17	0.06	0.08
T DOC+CDPF+CuZ SCR+ASC+urea	0.04 – 3.18	1.28	1.61	0.0 – 0.13	0.05	0.06
T DOC+CDPF+FeZ SCR+ASC+urea	0.04 – 0.58	0.36	0.32	0.01 – 0.02	0.01	0.01
T DOC+CDPF	0.0 – 0.49	0.21	0.30	0.0 – 0.02	0.01	0.01
T DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl	0.04 – 0.35	0.17	0.13	0.0 – 0.01	0.01	0.01
Tunnel Blank	0.0 – 0.85	0.30	0.55	0.0 – 0.01	0.003	0.005
Field Blank	0.0 – 0.57	0.09	0.05	0.0 – 0.03	0.004	0.002

Table S8. Average PCDD/F Emissions in pg/L fuel consumed – 2,3,7,8-substituted Congeners and Homologues by Class for Steady-state Tests, EMPC=EMPC

	concentration									
	engine out (n=14)		CuZ SCR HT (n=9)		CuZ SCR LT (n=5)		FeZ SCR (n=5)		DOC+CDPF (n=5)	
	pg/L		pg/L		pg/L		pg/L		pg/L	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	ND	-	ND	-	ND	-	ND	-	0.08	0.15
1,2,3,7,8-PeCDD	ND	-	ND	-	ND	-	ND	-	0.20	0.22
1,2,3,4,7,8-HxCDD	ND	-	ND	-	ND	-	ND	-	0.07	-
1,2,3,6,7,8-HxCDD	ND	-	ND	-	ND	-	ND	-	0.06	-
1,2,3,7,8,9-HxCDD	ND	-	ND	-	ND	-	ND	-	ND	-
1,2,3,4,6,7,8-HpCDD	2.46	2.32	2.97	3.68	3.48	6.08	0.70	0.65	0.34	0.09
OCDD	10.15	5.36	22.20	31.87	13.47	4.91	3.70	2.79	0.66	0.06
2,3,7,8-TCDF	7.98	2.02	8.05	3.59	6.38	1.65	0.23	0.51	1.47	2.04
1,2,3,7,8-PeCDF	0.40	0.67	1.09	1.63	ND	-	0.27	0.37	0.99	1.22
2,3,4,7,8-PeCDF	0.91	1.26	0.83	1.35	3.53	3.46	5.19	1.38	1.41	1.37
1,2,3,4,7,8-HxCDF	1.61	2.39	1.37	1.18	ND	-	0.78	0.72	0.41	0.32
1,2,3,6,7,8-HxCDF	0.71	1.39	0.51	0.78	ND	-	0.46	0.65	0.43	0.31
2,3,4,6,7,8-HxCDF	0.96	1.28	0.49	0.77	0.92	2.05	ND	-	0.45	0.40
1,2,3,7,8,9-HxCDF	0.17	0.64	0.14	0.42	ND	-	ND	-	ND	-
1,2,3,4,6,7,8-HpCDF	20.70	48.17	2.57	2.46	0.81	1.80	1.25	1.05	0.54	0.21
1,2,3,4,7,8,9-HpCDF	0.21	0.78	ND	-	ND	-	ND	-	0.17	0.08
OCDF	23.25	49.09	1.53	4.60	1.31	2.94	0.97	1.33	0.35	0.08
Total TCDDs	6.90	3.99	10.70	7.18	ND	-	33.63	49.24	227.26	184.03
Total PeCDD	ND	-	ND	-	ND	-	2.43	5.43	7.12	3.34
Total HxCDD	ND	-	0.18	0.55	ND	-	1.65	1.91	0.75	0.91
Total HpCDD	5.24	5.62	9.46	12.04	7.72	10.66	1.97	1.18	0.66	0.21
Total TCDF	259.72	54.78	344.00	117.80	177.17	17.79	95.32	28.70	433.55	252.63
Total PeCDF	42.39	105.13	23.96	21.45	6.18	1.37	14.48	6.56	22.49	16.43
Total HxCDF	6.37	8.33	4.62	4.63	2.12	4.75	3.35	4.84	4.83	3.85
Total HpCDF	21.75	47.81	2.94	2.93	0.81	1.80	0.90	0.84	1.15	0.60
ITEF TEQ (ND=0)	1.89	1.25	1.60	1.32	2.55	1.73	2.78	0.85	1.23	1.33
ITEF TEQ (ND=DL/2)	4.85	3.09	6.62	3.08	6.80	1.17	4.44	0.71	1.48	1.27
ITEF TEQ (ND=DL)	7.81	5.08	11.63	6.12	11.04	1.33	6.09	0.99	1.72	1.20

Table S9. Average PCDD/F Detection Limits in pg/L fuel consumed – 2,3,7,8-substituted Congeners and Homologues by Class for Steady-state Tests

	detection limit									
	engine out (n=14)		CuZ SCR HT (n=9)		CuZ SCR LT (n=5)		FeZ SCR (n=5)		DOC+CDPF (n=5)	
	pg/L		pg/L		pg/L		pg/L		pg/L	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	1.41	0.76	3.12	1.14	2.95	0.45	1.31	0.31	0.21	0.03
1,2,3,7,8-PeCDD	2.75	1.68	4.23	1.58	3.15	0.30	1.25	0.32	0.23	0.07
1,2,3,4,7,8-HxCDD	3.67	1.69	4.96	2.60	4.37	0.47	1.38	0.37	0.23	0.03
1,2,3,6,7,8-HxCDD	3.76	1.67	4.85	2.70	4.52	0.42	1.38	0.37	0.23	0.02
1,2,3,7,8,9-HxCDD	4.11	1.86	5.49	3.21	4.73	0.46	1.61	0.43	0.26	0.02
1,2,3,4,6,7,8-HpCDD	2.90	1.90	4.46	2.26	4.40	0.87	1.66	0.45	0.29	-
OCDD	4.21	2.63	8.88	4.80	6.88	0.80	3.02	1.03	0.50	0.01
2,3,7,8-TCDF	1.33	0.59	2.83	1.69	2.38	0.40	0.95	0.28	0.17	-
1,2,3,7,8-PeCDF	2.11	1.35	3.06	1.22	2.31	0.17	0.79	0.22	0.12	-
2,3,4,7,8-PeCDF	1.83	1.01	3.10	1.10	2.04	0.45	0.84	0.04	-	-
1,2,3,4,7,8-HxCDF	1.81	0.70	2.64	2.15	2.63	0.36	0.71	0.26	0.14	-
1,2,3,6,7,8-HxCDF	1.89	1.05	2.42	1.89	2.56	0.20	0.71	0.24	0.12	-
2,3,4,6,7,8-HxCDF	1.78	0.61	2.52	2.00	2.64	0.19	0.83	0.25	0.13	-
1,2,3,7,8,9-HxCDF	2.65	1.37	3.97	3.54	3.22	0.32	1.17	0.37	0.23	0.03
1,2,3,4,6,7,8-HpCDF	2.71	2.35	2.26	2.11	2.69	0.57	0.96	0.11	-	-
1,2,3,4,7,8,9-HpCDF	4.01	3.55	3.82	2.68	3.90	1.00	1.30	0.34	0.27	0.02
OCDF	4.03	4.13	8.27	4.29	5.45	1.30	2.27	0.77	0.55	-
Total TCDDs	1.41	0.60	2.52	0.68	2.95	0.45	0.79	-	-	-
Total PeCDD	2.85	1.66	4.23	1.58	3.15	0.30	1.20	0.34	-	-
Total HxCDD	3.84	1.74	5.09	2.84	4.52	0.43	1.41	0.47	0.37	0.16
Total HpCDD	2.61	1.92	4.85	2.16	4.40	0.87	1.66	0.45	0.29	-
Total TCDF	-	-	-	-	-	-	-	-	-	-
Total PeCDF	2.64	1.50	2.76	0.92	2.04	0.37	-	-	-	-
Total HxCDF	1.91	0.75	3.24	2.29	2.73	0.23	0.84	0.23	-	-
Total HpCDF	3.18	2.80	2.89	2.46	3.19	0.78	1.33	0.25	0.36	-

Table S10. Average PCDD/F Emissions in pg/L fuel consumed – 2,3,7,8-substituted Congeners and Homologues by Class for Transient Tests, EMPC=EMPC, n=5 for each configuration

	concentration							
	DOC+CDPF+CuZ SCR+ASC+urea		DOC+CDPF+FeZ SCR+ASC+urea		DOC+CDPF		DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl	
	pg/L		pg/L		pg/L		pg/L	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	ND	-	ND	-	ND	-	ND	-
1,2,3,7,8-PeCDD	ND	-	ND	-	ND	-	ND	-
1,2,3,4,7,8-HxCDD	ND	-	ND	-	ND	-	ND	-
1,2,3,6,7,8-HxCDD	ND	-	ND	-	ND	-	ND	-
1,2,3,7,8,9-HxCDD	ND	-	ND	-	0.20	-	ND	-
1,2,3,4,6,7,8-HpCDD	5.02	2.27	1.46	1.01	1.24	1.48	2.01	0.24
OCDD	33.48	8.17	8.36	4.87	4.46	0.81	6.06	0.74
2,3,7,8-TCDF	0.24	-	ND	-	ND	-	ND	-
1,2,3,7,8-PeCDF	0.51	0.22	ND	-	ND	-	ND	-
2,3,4,7,8-PeCDF	1.56	1.31	0.60	0.22	0.30	0.17	ND	-
1,2,3,4,7,8-HxCDF	1.06	1.08	0.16	-	ND	-	0.79	0.45
1,2,3,6,7,8-HxCDF	1.17	1.00	ND	-	ND	-	0.31	0.18
2,3,4,6,7,8-HxCDF	0.86	0.98	ND	-	ND	-	ND	-
1,2,3,7,8,9-HxCDF	ND	-	ND	-	ND	-	ND	-
1,2,3,4,6,7,8-HpCDF	4.77	4.32	1.26	0.70	1.44	0.49	2.44	0.94
1,2,3,4,7,8,9-HpCDF	0.28	-	ND	-	ND	-	ND	-
OCDF	8.33	5.04	5.19	3.37	3.39	1.41	4.55	2.35
Total TCDDs	1.01	1.21	ND	-	ND	-	0.45	0.31
Total PeCDD	ND	-	0.37	-	ND	-	0.91	0.19
Total HxCDD	1.35	-	ND	-	0.20	-	ND	-
Total HpCDD	9.27	4.03	2.10	1.94	1.58	1.36	3.48	1.03
Total TCDF	7.70	12.44	ND	-	0.44	0.58	0.66	1.65
Total PeCDF	8.95	12.38	0.60	0.22	0.30	0.17	0.11	-
Total HxCDF	8.94	14.91	0.31	-	ND	-	1.92	1.58
Total HpCDF	8.74	7.40	1.26	0.70	1.44	0.49	2.78	1.63
ITEF TEQ (ND=0)	1.28	1.30	0.36	0.26	0.21	0.24	0.17	0.11
ITEF TEQ (ND=DL/2)	2.85	1.13	2.55	1.59	2.05	0.85	1.18	0.17
ITEF TEQ (ND=DL)	4.41	1.10	4.74	3.33	3.90	1.82	2.20	0.27

Table S11. Average PCDD/F Detection Limits in pg/L fuel consumed – 2,3,7,8-substituted Congeners and Homologues by Class for Transient Tests, n=5 for each configuration

	detection limit							
	DOC+CDPF+CuZ SCR+ASC+urea		DOC+CDPF+FeZ SCR+ASC+urea		DOC+CDPF		DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl	
	pg/L		pg/L		pg/L		pg/L	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	1.19	0.34	1.72	1.47	1.31	0.71	0.77	0.10
1,2,3,7,8-PeCDD	1.29	0.30	1.71	1.43	1.43	0.77	0.80	0.18
1,2,3,4,7,8-HxCDD	1.37	0.33	1.53	1.19	1.48	0.70	0.79	0.09
1,2,3,6,7,8-HxCDD	1.34	0.34	1.54	1.18	1.45	0.73	0.83	0.09
1,2,3,7,8,9-HxCDD	1.38	0.34	1.77	1.28	1.86	0.70	0.94	0.10
1,2,3,4,6,7,8-HpCDD	-	-	3.42	2.56	1.52	0.24	-	-
OCDD	-	-	-	-	7.02	-	-	-
2,3,7,8-TCDF	0.76	0.16	1.01	0.76	0.85	0.42	0.48	0.04
1,2,3,7,8-PeCDF	0.95	0.22	0.95	0.63	1.02	0.52	0.59	0.07
2,3,4,7,8-PeCDF	0.76	0.03	1.30	1.00	1.20	0.61	0.55	0.06
1,2,3,4,7,8-HxCDF	0.98	0.16	1.04	0.88	0.91	0.39	0.48	-
1,2,3,6,7,8-HxCDF	0.87	0.14	0.94	0.75	0.86	0.42	0.61	0.10
2,3,4,6,7,8-HxCDF	0.89	0.08	1.04	0.95	0.88	0.47	0.62	0.09
1,2,3,7,8,9-HxCDF	1.03	0.20	1.42	1.29	1.22	0.54	0.79	0.15
1,2,3,4,6,7,8-HpCDF	-	-	2.01	1.68	2.18	-	-	-
1,2,3,4,7,8,9-HpCDF	1.27	0.17	1.92	1.67	1.60	0.94	0.81	0.11
OCDF	-	-	1.78	-	6.25	-	-	-
Total TCDDs	1.34	0.30	1.71	1.48	1.31	0.71	0.77	0.14
Total PeCDD	1.29	0.30	1.92	1.56	1.43	0.77	0.67	0.04
Total HxCDD	1.44	0.32	1.60	1.20	1.72	0.67	0.85	0.09
Total HpCDD	-	-	3.42	2.56	1.52	0.24	-	-
Total TCDF	0.75	0.06	1.01	0.76	1.02	0.46	0.50	0.04
Total PeCDF	0.79	0.02	1.32	1.01	1.23	0.57	0.55	0.06
Total HxCDF	0.91	0.09	1.18	1.04	0.95	0.45	0.54	-
Total HpCDF	-	-	2.50	2.07	2.62	-	-	-

Table S12. Average PCDD/F and PCB Tunnel Blank Results in pg/L fuel consumed – 2,3,7,8-substituted Congeners and Homologues by Class (PCDD/F) and 2005 WHO Congeners and Homologues by Class (PCB), EMPC=EMPC, n=5

	concentration pg/L		detection limit pg/L	
compound	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	ND	-	1.84	0.09
1,2,3,7,8-PeCDD	ND	-	1.74	0.31
1,2,3,4,7,8-HxCDD	ND	-	1.75	0.15
1,2,3,6,7,8-HxCDD	ND	-	1.89	0.18
1,2,3,7,8,9-HxCDD	ND	-	1.91	0.22
1,2,3,4,6,7,8-HpCDD	ND	-	1.89	0.27
OCDD	1.51	-	3.67	0.32
2,3,7,8-TCDF	ND	-	0.94	0.07
1,2,3,7,8-PeCDF	ND	-	0.92	0.07
2,3,4,7,8-PeCDF	0.64	0.16	0.89	0.04
1,2,3,4,7,8-HxCDF	ND	-	1.04	0.15
1,2,3,6,7,8-HxCDF	ND	-	0.94	0.15
2,3,4,6,7,8-HxCDF	ND	-	0.98	0.12
1,2,3,7,8,9-HxCDF	ND	-	1.44	0.27
1,2,3,4,6,7,8-HpCDF	ND	-	1.10	0.19
1,2,3,4,7,8,9-HpCDF	ND	-	1.41	0.16
OCDF	ND	-	2.93	0.33
Total TCDDs	3.02	7.5	62.77	105.4
Total PeCDD	ND	-	1.86	0.41
Total HxCDD	ND	-	1.84	0.18
Total HpCDD	ND	-	1.89	0.27
Total TCDF	9.40	9.2	-	-
Total PeCDF	0.64	0.16	0.92	0.05
Total HxCDF	ND	-	1.08	0.16
Total HpCDF	ND	-	1.25	0.17
ITEF TEQ (ND=0)	0.32	0.46		
ITEF TEQ (ND=DL/2)	2.49	0.26		
ITEF TEQ (ND=DL)	4.67	0.20		

	concentration pg/L		detection limit pg/L	
compound	average	standard deviation	average	standard deviation
PCB-77	34.3	9.3	-	-
PCB-81	ND	-	2.70	0.49
PCB-105	201.1	68.7	-	-
PCB-114	18.6	6.3	-	-
PCB-118	729.1	239.7	-	-
PCB-123	12.4	4.3	4.16	-
PCB-126	ND	-	3.56	0.49
PCB-156/157	39.5	11.2	-	-
PCB-167	18.0	4.2	-	-
PCB-169	ND	-	2.76	0.30
PCB-189	3.0	0.55	1.72	-
Total Mono-CBs	1,225	457.3	-	-
Total Di-CBs	7,309	3,331	-	-
Total Tri-CBs	10,993	5,613	-	-
Total Tetra-CBs	23,667	18,127	-	-
Total Penta-CBs	14,817	5,323	-	-
Total Hexa-CBs	6,151	1,943	-	-
Total Hepta-CBs	1,816	481.6	-	-
Total Octa-CBs	362.9	86.0	-	-
Total Nona-CBs	63.1	18.3	-	-
PCB-209	8.0	5.6	3.56	-
WHO 2005 TEQ (ND=0)	0.03	0.01		
WHO 2005 TEQ (ND=DL/2)	0.25	0.03		
WHO 2005 TEQ (ND=DL)	0.47	0.05		

Table S13. PCB Emission Factor Results in I-TEQ pg/L and pg/m^3, ND = 0 and EMPC = EMPC

	pg/L			pg/m^3		
test configuration	range of I-TEQ	average I-TEQ	± 95% C.I.	range of I-TEQ	average I-TEQ	± 95% C.I.
SS engine out	0.02 – 0.12	0.05	0.02	0.0011 – 0.0059	0.0003	0.0001
SS CuZ SCR HT	0.03 – 0.24	0.10	0.05	0.0014 – 0.0082	0.0041	0.0017
SS CuZ SCR LT	4.19 – 29.34	15.21	12.37	0.19 – 1.33	0.69	0.56
SS FeZ SCR	0.02 – 0.05	0.04	0.02	0.0011 – 0.0032	0.002	0.001
SS DOC+CDPF	0.001 – 0.003	0.00	0.00	0.0001 – 0.0002	0.0001	0.00005
T DOC+CDPF+CuZ SCR+ASC+urea	0.01 – 0.02	0.02	0.01	0.0003 – 0.0010	0.0006	0.0003
T DOC+CDPF+FeZ SCR+ASC+urea	0.01 – 0.03	0.02	0.08	0.0 – 0.0011	0.0007	0.0005
T DOC+CDPF	0.01 – 0.02	0.01	0.00	0.0003 – 0.0006	0.0004	0.0002
T DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl	0.09 – 0.39	0.22	0.15	0.0036 – 0.0162	0.0092	0.0062
Tunnel Blank	0.02 – 0.05	0.032	0.013	0.0002 – 0.0004	0.0003	0.0001
Field Blank	0.0 – 0.01	0.003	0.001	0.0 – 0.0005	0.0002	0.0001

Table S14. Average PCB Emissions in pg/L fuel consumed – 2005 WHO Congeners and Homologues by Class for Steady-state Tests, EMPC=EMPC

	concentration									
	engine out (n=17)		CuZ SCR HT (n=9)		CuZ SCR LT (n=5)		FeZ SCR (n=5)		DOC+CDPF (n=5)	
	pg/L		pg/L		pg/L		pg/L		pg/L	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
PCB-77	23.3	29.4	66.3	88.0	273.3	93.6	61.4	20.9	2.9	2.8
PCB-81	ND	-	ND	-	85.3	45.6	ND	-	ND	-
PCB-105	430.2	452.9	971.2	540.3	1130	827.7	334.3	157.5	13.7	4.9
PCB-114	ND	-	ND	-	147.4	100.7	20.1	7.3	0.4	-
PCB-118	1255	502.1	1998	1,227	3408	3,146	858.8	324.2	36.1	10.3
PCB-123	ND	-	ND	-	146.8	78.1	8.5	11.7	13.5	5.0
PCB-126	ND	-	ND	-	98.8	83.1	ND	-	ND	-
PCB-156/157	ND	-	95.1	207.0	349.8	145.3	41.1	14.9	5.0	2.6
PCB-167	ND	-	ND	-	161.9	84.5	15.4	10.2	3.1	2.0
PCB-169	ND	-	ND	-	170.5	57.8	ND	-	ND	-
PCB-189	ND	-	ND	-	140.2	39.9	ND	-	ND	-
Total Mono-CBs	1,664	2,509	61,803	17,596	36,825	7,306	1645	642.0	142.8	113.0
Total Di-CBs	31,646	90,527	12,061	4,440	16,314	10,069	7,626	3,290	2,151	705.2
Total Tri-CBs	10,218	6,994	18,017	7,088	23,859	17,082	11,122	3,385	6,248	1,497
Total Tetra-CBs	96,796	135,509	164,598	193,800	122,638	83,942	36,256	22,078	290,355	73,062
Total Penta-CBs	20,121	11,417	28,126	15,218	57,384	61,160	14,959	3,169	1,451	447.7
Total Hexa-CBs	10,173	7,516	11,205	7,378	26,396	25,116	5,655	1,226	511.3	124.9
Total Hepta-CBs	2,796	3,401	2,645	1,371	7,590	6,518	1,859	531.2	299.2	153.3
Total Octa-CBs	221.2	880.3	125.6	191.3	1,397	951.9	324.1	127.9	27.8	15.2
Total Nona-CBs	18.8	77.5	ND	-	338.3	153.8	34.2	35.8	ND	-
PCB-209	ND	-	ND	-	192.8	51.4	1.6	3.6	ND	-
WHO 2005 TEQ (ND=0)	0.05	-	0.10	0.1	15.2	10.0	0.04	-	0.002	0.001
WHO 2005 TEQ (ND=DL/2)	24.5	5.5	8.8	3.6	17.9	8.4	2.5	0.6	0.06	0.03
WHO 2005 TEQ (ND=DL)	48.9	11.0	17.46	7.2	20.7	7.0	4.86	1.1	0.12	0.05

Table S15. Average PCB Detection Limits in pg/L fuel consumed – 2005 WHO Congeners and Homologues by Class for Steady-state Tests

	detection limit									
	engine out (n=14)		CuZ SCR HT (n=9)		CuZ SCR LT (n=5)		FeZ SCR (n=5)		DOC+CDPF (n=5)	
	pg/L		pg/L		pg/L		pg/L		pg/L	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
PCB-77	453.8	119.1	200.8	43.2	-	-	30.5	4.9	2.9	1.0
PCB-81	401.2	79.1	210.6	54.5	61.0	43.4	31.3	4.2	2.6	0.62
PCB-105	291.5	160.2	14.1	-	-	-	-	-	-	-
PCB-114	228.4	120.9	110.2	49.3	14.4	5.0	38.6	9.3	0.8	0.22
PCB-118	114.6	-	-	-	-	-	-	-	-	-
PCB-123	245.3	133.9	117.3	52.9	16.4	-	40.7	9.4	-	-
PCB-126	350.2	80.1	115.0	65.2	39.7	16.2	33.8	5.7	1.2	0.30
PCB-156/157	494.9	136.0	162.2	90.7	-	-	60.9	21.2	-	-
PCB-167	398.2	124.3	165.4	56.9	31.8	-	41.9	13.3	1.1	-
PCB-169	454.9	127.5	191.9	61.6	48.7	-	47.4	15.9	1.6	0.75
PCB-189	238.5	77.3	87.3	30.8	33.4	-	30.0	8.3	1.1	0.39
Total Mono-CBs	1029	146.5	-	-	-	-	-	-	-	-
Total Di-CBs	-	-	-	-	-	-	-	-	-	-
Total Tri-CBs	-	-	-	-	-	-	-	-	-	-
Total Tetra-CBs	-	-	-	-	-	-	-	-	-	-
Total Penta-CBs	-	-	-	-	-	-	-	-	-	-
Total Hexa-CBs	-	-	-	-	-	-	-	-	-	-
Total Hepta-CBs	53.5	2.0	50.5	-	-	-	-	-	-	-
Total Octa-CBs	283.0	166.2	83.6	59.0	-	-	53.4	15.8	-	-
Total Nona-CBs	331.5	159.6	200.9	67.8	23.6	-	61.2	13.2	2.9	0.65
PCB-209	323.8	134.3	211.4	63.8	13.5	-	54.9	9.9	1.0	0.22

Table S16. Average PCB Emissions in pg/L fuel consumed – 2005 WHO Congeners and Homologues by Class for Transient Tests, EMPC=EMPC, n=5 for each configuration

	concentration							
	DOC+CDPF+CuZ SCR+ASC+urea		DOC+CDPF+FeZ SCR+ASC+urea		DOC+CDPF		DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl	
	pg/L		pg/L		pg/L		pg/L	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
PCB-77	12.3	7.6	14.1	3.5	13.0	1.2	13.8	3.9
PCB-81	ND	-	ND	-	ND	-	0.30	-
PCB-105	106.5	44.7	117.3	39.0	80.2	27.3	81.7	24.2
PCB-114	5.6	3.2	6.8	6.6	2.9	1.6	6.6	2.1
PCB-118	313.1	117.9	331.4	193.3	196.2	63.7	221.6	92.3
PCB-123	3.4	2.1	5.2	4.1	0.79	-	4.5	1.7
PCB-126	ND	-	ND	-	ND	-	1.0	0.59
PCB-156/157	32.0	10.2	26.3	2.8	25.9	7.3	28.3	7.1
PCB-167	10.8	5.6	8.4	1.1	9.9	3.7	11.6	3.0
PCB-169	ND	-	ND	-	ND	-	3.70	0.78
PCB-189	1.8	1.5	ND	-	ND	-	3.4	0.81
Total Mono-CBs	7,552	15,651	261.6	254.2	187.3	75.9	829.5	412.5
Total Di-CBs	40,855	86,735	2,232	1,953	2,000	915.0	2,120	544.1
Total Tri-CBs	52,501	111,721	3,364	3,035	2,324	1,335	2,162	1,400
Total Tetra-CBs	11,027	17,937	5,578	6,930	2,829	1,424	2,514	1,386
Total Penta-CBs	2,554	949.3	4,507	4,970	1,858	788.9	2,069	1,266
Total Hexa-CBs	1,940	525.8	2,158	1,090	1,606	571.1	1,833	667.1
Total Hepta-CBs	1,033	265.6	889.2	63.6	877.2	232.8	1,075	325.4
Total Octa-CBs	271.7	118.5	182.7	8.4	143.5	39.4	273.5	50.5
Total Nona-CBs	27.6	20.5	12.8	6.7	13.3	2.4	22.6	8.1
PCB-209	3.6	3.9	1.53	-	4.12	3.3	5.9	1.3
WHO 2005 TEQ (ND=0)	0.02	0.01	0.02	0.01	0.01	0.003	0.22	0.12
WHO 2005 TEQ (ND=DL/2)	0.39	0.35	0.26	0.16	0.23	0.08	0.27	0.10
WHO 2005 TEQ (ND=DL)	0.77	0.70	0.50	0.31	0.45	0.15	0.32	0.08

Table S17. Average PCB Detection Limits in pg/L fuel consumed – 2005 WHO Congeners and Homologues by Class for Transient Tests, n=5 for each configuration

	detection limit							
	DOC+CDPF+CuZ SCR+ASC+urea		DOC+CDPF+FeZ SCR+ASC+urea		DOC+CDPF		DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl	
	pg/L		pg/L		pg/L		pg/L	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
PCB-77	35.1	-	-	-	-	-	-	-
PCB-81	9.9	12.9	2.7	2.10	2.4	0.54	1.6	0.31
PCB-105	-	-	-	-	-	-	-	-
PCB-114	8.8	7.5	7.1	-	3.1	0.55	-	-
PCB-118	-	-	-	-	-	-	-	-
PCB-123	9.2	8.2	7.1	-	2.7	0.45	-	-
PCB-126	5.5	4.7	3.6	2.21	3.1	1.12	1.01	0.27
PCB-156/157	-	-	-	-	-	-	-	-
PCB-167	18.7	-	7.9	-	-	-	-	-
PCB-169	6.4	7.4	4.1	3.15	4.2	1.30	-	-
PCB-189	7.8	8.2	3.2	2.26	2.2	0.77	-	-
Total Mono-CBs	-	-	-	-	-	-	-	-
Total Di-CBs	-	-	-	-	-	-	-	-
Total Tri-CBs	-	-	-	-	-	-	-	-
Total Tetra-CBs	-	-	-	-	-	-	-	-
Total Penta-CBs	-	-	-	-	-	-	-	-
Total Hexa-CBs	-	-	-	-	-	-	-	-
Total Hepta-CBs	-	-	-	-	-	-	-	-
Total Octa-CBs	-	-	-	-	-	-	-	-
Total Nona-CBs	33.8	-	11.3	-	-	-	-	-
PCB-209	-	-	5.1	-	3.3	1.01	-	-

Table S18. PAH Emission Factor Results for Steady-state Engine Out and CuZ SCR HT Tests

	concentration							
	SS engine out (n=17)				SS CuZ SCR HT (n=9)			
	ng/L		ng/m^3		ng/L		ng/m^3	
analyte	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
Naphthalene	1,084,405	398,586	52,283	19,137	1,299,934	78,195	55,590	6,829
2-Methylnaphthalene	815,442	250,816	39,338	12,204	410,175	141,400	16,946	3,511
Acenaphthylene	67,988	6,108	3,275	284.5	32,966	8,773	1,373	174.2
Acenaphthene	18,605	5,535	896.9	266.1	2,475	839.6	102.5	21.3
Fluorene	68,149	27,840	3,281	1,339	16,737	6,890	686.6	176.7
Phenanthrene	186,268	25,928	8,989	1,363	210,057	33,673	8,872	852.6
Anthracene	14,707	2,111	708.4	99.4	4,017	1,674	164.6	45.2
Fluoranthene	10,345	1,555	498.7	77.2	8,497	1,003	360.1	27.2
Pyrene	22,980	5,249	1,107	252.1	5,778	1,238	243.6	37.3
Benzo(a)Anthracene	1,214	100.4	58.5	5.1	493.2	42.7	21.2	3.9
Chrysene	1,299	148.4	62.6	7.1	734.4	41.6	31.3	3.1
Benzo(b)Fluoranthene	699.7	176.8	33.6	8.1	600.7	55.8	25.9	4.9
Benzo(k)Fluoranthene	261.1	87.7	12.5	4.0	182.6	30.2	7.9	1.9
Benzo(e)Pyrene	589.9	68.2	28.4	2.9	302.1	27.5	13.0	2.5
Benzo(a)Pyrene	586.6	108.0	28.2	4.8	404.1	59.5	17.5	4.0
Perylene	108.1	10.9	5.2	0.5	59.4	11.8	2.6	0.8
Indeno(1,2,3-c,d)Pyrene	509.1	330.4	24.5	15.7	540.9	190.3	23.5	10.0
Dibenzo(a,h)Anthracene	88.3	61.2	4.2	2.9	72.0	10.4	3.1	0.7
Benzo(g,h,i)Perylene	846.1	979.5	40.5	46.2	658.5	226.8	28.9	12.3

Table S19. PAH Emission Factor Results for Steady-state CuZ SCR LT and FeZ SCR Tests

	concentration							
	SS CuZ SCR LT (n=5)				SS FeZ SCR (n=5)			
	ng/L		ng/m^3		ng/L		ng/m^3	
analyte	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
Naphthalene	2,399,417	271,776	109,326	12,777	13,732	4,233	619.9	231.1
2-Methylnaphthalene	630,964	84,075	28,742	3,841	6,610	1,433	297.9	85.1
Acenaphthylene	43,746	6,013	1,993	277.2	1,105	124.0	49.7	10.1
Acenaphthene	3,698	2,422	168.1	109.3	249.3	81.3	11.1	4.0
Fluorene	20,472	4,775	932.8	218.8	586.4	147.0	26.1	7.0
Phenanthrene	361,051	35,615	16,444	1,590	3,295	711.2	145.7	27.6
Anthracene	8,667	2,043	395.0	94.0	275.9	23.3	12.4	2.4
Fluoranthene	13,959	1,753	635.7	78.4	640.7	74.0	28.8	5.5
Pyrene	10,369	2,197	472.1	98.9	790.9	98.8	35.5	6.7
Benzo(a)Anthracene	803.8	133.7	36.6	5.9	350.5	47.4	15.7	3.0
Chrysene	1,099	163.1	50.0	7.3	323.9	45.0	14.5	2.7
Benzo(b)Fluoranthene	547.3	87.7	24.9	4.0	567.1	199.6	25.3	9.7
Benzo(k)Fluoranthene	202.7	19.5	9.2	0.9	185.0	65.1	8.2	2.9
Benzo(e)Pyrene	386.0	67.7	17.6	3.0	299.3	112.3	13.2	5.1
Benzo(a)Pyrene	435.9	59.7	19.8	2.6	553.9	229.5	23.6	6.1
Perylene	80.0	12.4	3.6	0.5	120.6	40.4	5.3	1.4
Indeno(1,2,3-c,d)Pyrene	498.6	38.7	22.7	1.7	337.3	230.0	13.4	3.8
Dibenzo(a,h)Anthracene	73.2	7.1	3.3	0.3	71.7	43.3	2.9	0.7
Benzo(g,h,i)Perylene	797.8	159.3	36.3	7.0	569.3	395.3	22.6	7.2

Table S20. PAH Emission Factor Results for Steady-state DOC+CDPF and Tunnel Blank Tests

	concentration							
	SS DOC+CDPF (n=5)				tunnel blank (n=5)			
	ng/L		ng/m^3		ng/L		ng/m^3	
analyte	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
Naphthalene	1,644	1,836	81.3	91.8	44.3	10.7	63.9	14.4
2-Methylnaphthalene	76.8	58.2	3.8	2.9	22.3	3.8	32.2	4.8
Acenaphthylene	3.4	4.3	0.2	0.2	0.083	0.01	0.1	0.02
Acenaphthene	2.9	0.2	0.1	0.009	2.3	1.0	3.3	1.5
Fluorene	13.3	2.3	0.7	0.12	3.3	1.4	4.8	2.1
Phenanthrene	78.8	59.8	3.9	3.0	7.9	3.4	11.4	5.2
Anthracene	2.8	2.4	0.1	0.12	0.080	0.02	0.1	0.03
Fluoranthene	15.9	6.0	0.8	0.3	1.004	0.2	1.4	0.2
Pyrene	10.8	5.1	0.5	0.2	0.344	0.1	0.5	0.10
Benzo(a)Anthracene	0.9	1.1	0.05	0.05	0.008	0.003	0.012	0.004
Chrysene	0.8	0.9	0.04	0.04	0.014	0.003	0.021	0.005
Benzo(b)Fluoranthene	2.3	3.5	0.1	0.2	0.017	0.005	0.024	0.007
Benzo(k)Fluoranthene	0.9	1.6	0.04	0.08	0.006	0.002	0.009	0.003
Benzo(e)Pyrene	1.5	1.8	0.1	0.09	0.011	0.003	0.016	0.004
Benzo(a)Pyrene	0.4	0.8	0.02	0.04	0.007	0.002	0.010	0.003
Perylene	0.1	0.2	0.004	0.01	0.011	0.01	0.016	0.013
Indeno(1,2,3-c,d)Pyrene	1.0	1.6	0.05	0.1	0.008	0.002	0.012	0.003
Dibenzo(a,h)Anthracene	0.2	0.3	0.01	0.02	ND	-	ND	-
Benzo(g,h,i)Perylene	1.6	1.8	0.1	0.1	0.012	0.003	0.018	0.004

Table S21. PAH Emission Factor Results for Transient DOC+CDPF+CuZ SCR+ASC+urea and DOC+CDPF+FeZ SCR+ASC+urea Tests

	concentration							
	FTP DOC+CDPF+CuZ SCR+ASC+urea (n=5)				FTP DOC+CDPF+FeZ SCR+ASC+urea (n=5)			
	ng/L		ng/m^3		ng/L		ng/m^3	
analyte	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
Naphthalene	846.5	207.5	34.1	8.1	2,323	1,503	95.6	62.2
2-Methylnaphthalene	171.3	41.5	6.9	1.7	522.1	549.2	21.4	22.4
Acenaphthylene	5.7	0.9	0.2	0.04	8.6	11.3	0.4	0.5
Acenaphthene	23.1	1.4	0.9	0.1	31.2	7.7	1.3	0.3
Fluorene	59.3	19.9	2.4	0.8	61.8	24.7	2.5	1.0
Phenanthrene	223.8	34.7	9.0	1.4	220.9	66.8	9.1	2.7
Anthracene	9.5	5.0	0.4	0.2	7.8	9.4	0.3	0.4
Fluoranthene	52.4	5.9	2.1	0.3	52.9	13.3	2.2	0.6
Pyrene	60.9	47.9	2.5	1.9	34.0	11.7	1.4	0.5
Benzo(a)Anthracene	1.4	0.4	0.1	0.02	1.6	1.8	0.1	0.07
Chrysene	2.5	0.9	0.1	0.04	1.5	0.3	0.1	0.01
Benzo(b)Fluoranthene	3.0	1.0	0.1	0.04	2.2	1.0	0.1	0.04
Benzo(k)Fluoranthene	0.8	0.2	0.03	0.007	0.6	0.3	0.02	0.01
Benzo(e)Pyrene	2.1	0.9	0.1	0.04	1.3	0.3	0.1	0.01
Benzo(a)Pyrene	0.8	0.3	0.03	0.01	0.4	0.2	0.02	0.01
Perylene	0.4	0.1	0.02	0.004	0.1	0.1	0.004	0.004
Indeno(1,2,3-c,d)Pyrene	0.9	0.3	0.04	0.01	0.5	0.3	0.02	0.01
Dibenzo(a,h)Anthracene	ND	-	ND	-	ND	-	ND	-
Benzo(g,h,i)Perylene	1.7	0.6	0.1	0.02	0.9	0.5	0.04	0.02

Table S22. PAH Emission Factor Results for Transient DOC+CDPF and DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl Tests

	concentration							
	FTP DOC+CDPF (n=5)				FTP DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl (n=5)			
	ng/L		ng/m^3		ng/L		ng/m^3	
analyte	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
Naphthalene	2,103	503.2	85.9	20.8	1,487	2,468	61.2	101.7
2-Methylnaphthalene	556.1	270.4	22.8	11.2	535.9	847.8	22.0	34.9
Acenaphthylene	5.7	1.6	0.2	0.06	6.3	7.5	0.3	0.3
Acenaphthene	28.0	11.9	1.1	0.5	33.1	23.3	1.4	1.0
Fluorene	65.3	30.9	2.7	1.3	59.7	32.0	2.5	1.3
Phenanthrene	251.5	74.7	10.3	3.1	195.3	69.1	8.0	2.9
Anthracene	5.5	1.8	0.2	0.07	7.1	2.3	0.3	0.09
Fluoranthene	55.9	11.1	2.3	0.5	48.3	11.2	2.0	0.5
Pyrene	40.1	26.6	1.6	1.1	29.6	8.1	1.2	0.3
Benzo(a)Anthracene	0.9	0.2	0.04	0.009	1.2	1.3	0.05	0.05
Chrysene	2.6	0.5	0.1	0.02	1.9	1.2	0.1	0.05
Benzo(b)Fluoranthene	3.0	0.4	0.1	0.02	2.9	2.5	0.1	0.10
Benzo(k)Fluoranthene	1.0	0.2	0.04	0.006	1.3	1.2	0.1	0.05
Benzo(e)Pyrene	2.0	0.2	0.1	0.01	1.8	1.4	0.1	0.06
Benzo(a)Pyrene	0.8	0.5	0.03	0.02	1.1	1.4	0.05	0.06
Perylene	0.2	0.2	0.01	0.01	0.9	1.5	0.04	0.06
Indeno(1,2,3-c,d)Pyrene	1.0	0.6	0.04	0.02	1.3	1.4	0.1	0.06
Dibenzo(a,h)Anthracene	0.1	0.1	0.002	0.005	0.2	0.3	0.01	0.01
Benzo(g,h,i)Perylene	2.3	0.9	0.1	0.04	1.9	1.5	0.1	0.1

Table S23. Average PCDD/F Emissions in pg/m^3 – 2,3,7,8-substituted Congeners and Homologues by Class for Steady-state Tests, EMPC=EMPC

	concentration									
	engine out (n=14) pg/m^3		CuZ SCR HT (n=9) pg/m^3		CuZ SCR LT (n=5) pg/m^3		FeZ SCR (n=5) pg/m^3		DOC+CDPF (n=5) pg/m^3	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	ND	-	ND	-	ND	-	ND	-	0.004	0.01
1,2,3,7,8-PeCDD	ND	-	ND	-	ND	-	ND	-	0.01	0.01
1,2,3,4,7,8-HxCDD	ND	-	ND	-	ND	-	ND	-	0.01	-
1,2,3,6,7,8-HxCDD	ND	-	ND	-	ND	-	ND	-	0.01	-
1,2,3,7,8,9-HxCDD	ND	-	ND	-	ND	-	ND	-	ND	ND
1,2,3,4,6,7,8-HpCDD	0.12	0.11	0.12	0.13	0.16	0.28	0.03	0.03	0.02	0.004
OCDD	0.49	0.26	0.87	1.08	0.61	0.23	0.17	0.14	0.03	0.003
2,3,7,8-TCDF	0.38	0.10	0.33	0.10	0.29	0.08	0.01	0.02	0.07	0.10
1,2,3,7,8-PeCDF	0.02	0.03	0.04	0.06	ND	-	0.01	0.02	0.05	0.06
2,3,4,7,8-PeCDF	0.04	0.06	0.03	0.05	0.16	0.16	0.23	0.07	0.07	0.07
1,2,3,4,7,8-HxCDF	0.08	0.11	0.06	0.05	ND	-	0.04	0.04	0.02	0.02
1,2,3,6,7,8-HxCDF	0.03	0.07	0.02	0.03	ND	0.00	0.02	0.03	0.02	0.02
2,3,4,6,7,8-HxCDF	0.05	0.06	0.02	0.03	0.04	0.09	ND	-	0.02	0.02
1,2,3,7,8,9-HxCDF	0.01	0.03	0.01	0.02	ND	-	ND	-	ND	-
1,2,3,4,6,7,8-HpCDF	1.00	2.31	0.10	0.09	0.04	0.08	0.06	0.05	0.03	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.04	ND	-	ND	-	ND	-	0.01	0.004
OCDF	1.12	2.36	0.05	0.16	0.06	0.13	0.05	0.07	0.02	0.004
Total TCDDs	0.33	0.19	0.44	0.28	ND	-	1.60	2.40	11.21	9.14
Total PeCDD	ND	-	ND	-	ND	-	0.12	0.26	0.35	0.17
Total HxCDD	ND	-	0.01	0.03	ND	-	0.07	0.09	0.04	0.05
Total HpCDD	0.25	0.27	0.37	0.41	0.35	0.49	0.09	0.05	0.03	0.01
Total TCDF	12.48	2.49	14.31	3.13	8.07	0.81	4.35	1.69	21.36	12.68
Total PeCDF	2.06	5.14	0.95	0.70	0.28	0.06	0.66	0.34	1.11	0.82
Total HxCDF	0.31	0.40	0.19	0.18	0.10	0.22	0.15	0.24	0.24	0.19
Total HpCDF	1.05	2.30	0.12	0.11	0.04	0.08	0.04	0.04	0.06	0.03
ITEF TEQ (ND=0)	0.09	0.06	0.07	0.05	0.12	0.08	0.12	0.04	0.06	0.07
ITEF TEQ (ND=DL/2)	0.24	0.15	0.28	0.11	0.31	0.05	0.20	0.06	0.07	0.06
ITEF TEQ (ND=DL)	0.38	0.25	0.49	0.23	0.50	0.06	0.28	0.09	0.08	0.06

Table S24. Average PCDD/F Detection Limits in pg/m^3 – 2,3,7,8-substituted Congeners and Homologues by Class for Steady-state Tests

	detection limit									
	engine out (n=14) pg/m^3		CuZ SCR HT (n=9) pg/m^3		CuZ SCR LT (n=5) pg/m^3		FeZ SCR (n=5) pg/m^3		DOC+CDPF (n=5) pg/m^3	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	0.07	0.04	0.13	0.04	0.13	0.02	0.06	0.02	0.01	0.002
1,2,3,7,8-PeCDD	0.13	0.08	0.18	0.06	0.14	0.01	0.06	0.02	0.01	0.004
1,2,3,4,7,8-HxCDD	0.18	0.08	0.21	0.10	0.20	0.02	0.06	0.03	0.01	0.002
1,2,3,6,7,8-HxCDD	0.18	0.08	0.20	0.11	0.21	0.02	0.06	0.03	0.01	0.001
1,2,3,7,8,9-HxCDD	0.20	0.09	0.23	0.13	0.22	0.02	0.07	0.03	0.01	0.001
1,2,3,4,6,7,8-HpCDD	0.14	0.09	0.19	0.10	0.20	0.04	0.08	0.03	0.01	-
OCDD	0.20	0.13	0.37	0.19	0.31	0.04	0.14	0.07	0.02	0.001
2,3,7,8-TCDF	0.06	0.03	0.12	0.06	0.11	0.02	0.04	0.02	0.01	-
1,2,3,7,8-PeCDF	0.10	0.06	0.13	0.04	0.11	0.01	0.04	0.01	0.01	-
2,3,4,7,8-PeCDF	0.09	0.05	0.13	0.04	0.09	0.02	0.04	0.002	-	-
1,2,3,4,7,8-HxCDF	0.09	0.03	0.11	0.10	0.12	0.02	0.03	0.02	0.01	-
1,2,3,6,7,8-HxCDF	0.09	0.05	0.10	0.09	0.12	0.01	0.03	0.02	0.01	-
2,3,4,6,7,8-HxCDF	0.09	0.03	0.11	0.09	0.12	0.01	0.04	0.02	0.01	-
1,2,3,7,8,9-HxCDF	0.13	0.07	0.17	0.16	0.15	0.02	0.05	0.02	0.01	0.002
1,2,3,4,6,7,8-HpCDF	0.13	0.11	0.10	0.08	0.12	0.03	0.04	0.02	-	-
1,2,3,4,7,8,9-HpCDF	0.19	0.17	0.16	0.10	0.18	0.04	0.06	0.02	0.01	0.001
OCDF	0.20	0.20	0.36	0.21	0.25	0.06	0.10	0.05	0.03	-
Total TCDDs	0.07	0.03	0.10	0.03	0.13	0.02	0.04	-	-	-
Total PeCDD	0.14	0.08	0.18	0.06	0.14	0.01	0.06	0.03	-	-
Total HxCDD	0.19	0.08	0.21	0.11	0.21	0.02	0.06	0.03	0.02	0.008
Total HpCDD	0.13	0.09	0.21	0.10	0.20	0.04	0.08	0.03	0.01	-
Total TCDF	-	-	-	-	-	-	-	-	-	-
Total PeCDF	0.13	0.07	0.12	0.03	0.09	0.02	-	-	-	-
Total HxCDF	0.09	0.04	0.14	0.11	0.12	0.01	0.04	0.02	-	-
Total HpCDF	0.15	0.13	0.12	0.10	0.15	0.03	0.06	0.02	0.02	-

Table S25. Average PCDD/F Emissions in pg/m^3 – 2,3,7,8-substituted Congeners and Homologues by Class for Transient Tests, EMPC=EMPC, n=5 for each configuration

	concentration							
	DOC+CDPF+CuZ SCR+ASC+urea pg/m^3		DOC+CDPF+FeZ SCR+ASC+urea pg/m^3		DOC+CDPF pg/m^3		DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl pg/m^3	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	ND	-	ND	-	ND	-	ND	-
1,2,3,7,8-PeCDD	ND	-	ND	-	ND	-	ND	-
1,2,3,4,7,8-HxCDD	ND	-	ND	-	ND	-	ND	-
1,2,3,6,7,8-HxCDD	ND	-	ND	-	ND	-	ND	-
1,2,3,7,8,9-HxCDD	ND	-	ND	-	0.01	-	ND	-
1,2,3,4,6,7,8-HpCDD	0.20	0.09	0.06	0.04	0.05	0.06	0.08	0.01
OCDD	1.35	0.34	0.34	0.20	0.18	0.03	0.25	0.03
2,3,7,8-TCDF	0.01	-	ND	-	ND	-	ND	-
1,2,3,7,8-PeCDF	0.02	0.01	ND	-	ND	-	ND	-
2,3,4,7,8-PeCDF	0.06	0.05	0.02	0.009	0.01	0.01	ND	-
1,2,3,4,7,8-HxCDF	0.04	0.04	0.01	-	ND	-	0.03	0.02
1,2,3,6,7,8-HxCDF	0.05	0.04	ND	-	ND	-	0.01	0.01
2,3,4,6,7,8-HxCDF	0.03	0.04	ND	-	ND	-	ND	-
1,2,3,7,8,9-HxCDF	ND	-	ND	-	ND	-	ND	-
1,2,3,4,6,7,8-HpCDF	0.19	0.18	0.05	0.03	0.06	0.02	0.10	0.04
1,2,3,4,7,8,9-HpCDF	0.01	-	ND	-	ND	-	ND	-
OCDF	0.34	0.21	0.21	0.14	0.14	0.06	0.19	0.10
Total TCDDs	0.04	0.05	ND	-	ND	-	0.02	0.01
Total PeCDD	ND	-	0.02	-	ND	-	0.04	0.01
Total HxCDD	0.06	-	ND	-	0.01	-	ND	-
Total HpCDD	0.38	0.17	0.09	0.08	0.06	0.06	0.14	0.04
Total TCDF	0.31	0.49	ND	-	0.02	0.02	0.03	0.07
Total PeCDF	0.36	0.49	0.02	0.009	0.01	0.01	0.005	-
Total HxCDF	0.36	0.59	0.01	-	ND	-	0.08	0.06
Total HpCDF	0.35	0.30	0.05	0.03	0.06	0.02	0.11	0.07
ITEF TEQ (ND=0)	0.05	0.05	0.01	0.01	0.01	0.01	0.01	0.004
ITEF TEQ (ND=DL/2)	0.11	0.05	0.10	0.07	0.08	0.03	0.05	0.01
ITEF TEQ (ND=DL)	0.18	0.04	0.20	0.14	0.16	0.07	0.09	0.01

Table S26. Average PCDD/F Detection Limits in pg/m^3 – 2,3,7,8-substituted Congeners and Homologues by Class for Transient Tests, n=5 for each configuration

	detection limit							
	DOC+CDPF+CuZ SCR+ASC+urea pg/m^3		DOC+CDPF+FeZ SCR+ASC+urea pg/m^3		DOC+CDPF pg/m^3		DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl pg/m^3	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	0.05	0.01	0.07	0.06	0.05	0.03	0.03	0.004
1,2,3,7,8-PeCDD	0.05	0.01	0.07	0.06	0.06	0.03	0.03	0.007
1,2,3,4,7,8-HxCDD	0.06	0.01	0.06	0.05	0.06	0.03	0.03	0.003
1,2,3,6,7,8-HxCDD	0.05	0.01	0.06	0.05	0.06	0.03	0.03	0.003
1,2,3,7,8,9-HxCDD	0.06	0.01	0.07	0.05	0.08	0.03	0.04	0.004
1,2,3,4,6,7,8-HpCDD	-	-	0.14	0.11	0.06	0.01	-	-
OCDD	-	-	-	-	0.29	-	-	-
2,3,7,8-TCDF	0.03	0.01	0.04	0.03	0.03	0.02	0.02	0.001
1,2,3,7,8-PeCDF	0.04	0.01	0.04	0.03	0.04	0.02	0.02	0.003
2,3,4,7,8-PeCDF	0.03	0.001	0.05	0.04	0.05	0.02	0.02	0.003
1,2,3,4,7,8-HxCDF	0.04	0.01	0.04	0.04	0.04	0.02	0.02	-
1,2,3,6,7,8-HxCDF	0.04	0.01	0.04	0.03	0.04	0.02	0.03	0.004
2,3,4,6,7,8-HxCDF	0.04	0.004	0.04	0.04	0.04	0.02	0.03	0.004
1,2,3,7,8,9-HxCDF	0.04	0.01	0.06	0.05	0.05	0.02	0.03	0.006
1,2,3,4,6,7,8-HpCDF	-	-	0.08	0.07	0.09	-	-	-
1,2,3,4,7,8,9-HpCDF	0.05	0.01	0.08	0.07	0.07	0.04	0.03	0.005
OCDF	-	-	0.07	-	0.26	-	-	-
Total TCDDs	0.05	0.01	0.07	0.06	0.05	0.03	0.03	0.006
Total PeCDD	0.05	0.01	0.08	0.06	0.06	0.03	0.03	0.002
Total HxCDD	0.06	0.01	0.07	0.05	0.07	0.03	0.03	0.003
Total HpCDD	-	-	0.14	0.11	0.06	0.01	-	-
Total TCDF	0.03	0.002	0.04	0.03	0.04	0.02	0.02	0.001
Total PeCDF	0.03	0.001	0.05	0.04	0.05	0.02	0.02	0.002
Total HxCDF	0.04	0.004	0.05	0.04	0.04	0.02	0.02	-
Total HpCDF	-	-	0.10	0.09	0.11	-	-	-

Table S27. Average PCB Emissions in pg/m^3 – 2005 WHO Congeners and Homologues by Class for Steady-state Tests, EMPC=EMPC

	concentration									
	engine out (n=14) pg/m^3		CuZ SCR HT (n=9) pg/m^3		CuZ SCR LT (n=5) pg/m^3		FeZ SCR (n=5) pg/m^3		DOC+CDPF (n=5) pg/m^3	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
PCB-77	1.1	1.4	2.6	3.1	12.4	4.2	2.8	1.2	0.1	0.14
PCB-81	ND	-	ND	-	3.9	2.1	ND	-	ND	-
PCB-105	20.8	22.1	41.2	22.0	51.3	37.4	14.6	6.8	0.7	0.25
PCB-114	ND	-	ND	-	6.7	4.5	0.90	0.37	0.02	-
PCB-118	60.5	24.5	82.7	42.0	154.8	142.1	38.0	15.0	1.8	0.52
PCB-123	ND	-	ND	-	6.7	3.5	0.32	0.48	0.7	0.25
PCB-126	ND	-	ND	-	4.5	3.8	ND	-	ND	-
PCB-156/157	ND	-	4.1	9.3	15.9	6.5	1.8	0.73	0.2	0.13
PCB-167	ND	-	ND	-	7.4	3.8	0.66	0.45	0.2	0.10
PCB-169	ND	-	ND	-	7.8	2.6	ND	-	ND	-
PCB-189	ND	-	ND	-	6.4	1.8	ND	-	ND	-
Total Mono-CBs	80.6	121.8	2680	916.7	1676	321.0	73.3	31.4	7.0	5.6
Total Di-CBs	1,535	4,401	510.5	190.2	741.6	454.1	338.4	157.0	105.7	35.1
Total Tri-CBs	493.7	339.5	750.4	250.7	1,084	770.6	494.7	162.5	307.1	75.7
Total Tetra-CBs	4,643	6,487	6,566	7,180	5,589	3,840	1,618	1,134	14,278	3,722
Total Penta-CBs	970.5	556.1	1152	461.3	2606	2,765	666.4	155.7	71.3	22.4
Total Hexa-CBs	490.8	364.6	464.8	254.1	1199	1,135	251.8	59.2	25.1	6.3
Total Hepta-CBs	135.2	164.2	111.2	48.6	344.7	294.4	82.3	23.9	14.7	7.6
Total Octa-CBs	10.7	42.4	5.1	7.2	63.5	43.0	14.3	6.1	1.4	0.75
Total Nona-CBs	0.91	3.7	ND	-	15.4	6.9	1.3	1.4	ND	-
PCB-209	ND	-	ND	-	8.8	2.3	0.08	0.18	ND	-
WHO 2005 TEQ (ND=0)	0.003	-	0.004	-	0.69	0.45	0.002	-	0.0001	0.00004
WHO 2005 TEQ (ND=DL/2)	1.2	0.27	0.36	0.11	0.82	0.38	0.11	-	0.003	0.001
WHO 2005 TEQ (ND=DL)	2.4	0.53	0.72	0.21	0.94	0.31	0.21	-	0.006	0.003

Table S28. Average PCB Detection Limits in pg/m^3 – 2005 WHO Congeners and Homologues by Class for Steady-state Tests

	detection limit									
	engine out (n=14) pg/m^3		CuZ SCR HT (n=9) pg/m^3		CuZ SCR LT (n=5) pg/m^3		FeZ SCR (n=5) pg/m^3		DOC+CDPF (n=5) pg/m^3	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
PCB-77	21.8	5.5	8.8	1.7	-	-	1.4	0.22	0.14	0.05
PCB-81	19.3	3.8	8.9	1.9	2.8	2.0	1.4	0.27	0.13	0.03
PCB-105	14.1	7.8	0.55	-	-	-	-	-	-	-
PCB-114	11.0	5.9	4.6	1.8	0.65	0.22	1.7	0.18	0.04	0.01
PCB-118	5.5	-	-	-	-	-	-	-	-	-
PCB-123	11.8	6.5	4.9	1.9	0.74	-	1.8	0.20	-	-
PCB-126	16.9	3.9	4.7	2.0	1.8	0.74	1.5	0.22	0.06	0.01
PCB-156/157	23.8	6.4	6.9	3.5	-	-	2.6	0.27	-	-
PCB-167	19.2	5.8	7.0	2.0	1.4	-	1.8	0.28	0.05	-
PCB-169	21.9	6.0	8.0	1.8	2.2	-	2.0	0.16	0.08	0.04
PCB-189	11.5	3.8	3.6	1.0	1.5	-	1.3	0.19	0.05	0.02
Total Mono-CBs	50.0	6.9	-	-	-	-	-	-	-	-
Total Di-CBs	-	-	-	-	-	-	-	-	-	-
Total Tri-CBs	-	-	-	-	-	-	-	-	-	-
Total Tetra-CBs	-	-	-	-	-	-	-	-	-	-
Total Penta-CBs	-	-	-	-	-	-	-	-	-	-
Total Hexa-CBs	-	-	-	-	-	-	-	-	-	-
Total Hepta-CBs	2.5	0.08	2.3	-	-	-	-	-	-	-
Total Octa-CBs	13.6	8.0	3.6	2.6	-	-	2.1	0.22	-	-
Total Nona-CBs	16.0	7.8	8.6	3.2	1.1	-	2.7	0.44	0.14	0.03
PCB-209	15.7	6.6	9.0	3.0	0.61	-	2.5	0.58	0.05	0.01

Table S29. Average PCB Emissions in pg/m^3 – 2005 WHO Congeners and Homologues by Class for Transient Tests, EMPC=EMPC, n=5 for each configuration

	concentration							
	DOC+CDPF+CuZ SCR+ASC+urea pg/m^3		DOC+CDPF+FeZ SCR+ASC+urea pg/m^3		DOC+CDPF pg/m^3		DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl pg/m^3	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
PCB-77	0.50	0.3	0.58	0.14	0.53	0.05	0.56	0.16
PCB-81	ND	-	ND	-	ND	-	0.01	-
PCB-105	4.3	1.9	4.8	1.6	3.3	1.1	3.4	1.00
PCB-114	0.23	0.13	0.28	0.27	0.12	0.07	0.27	0.09
PCB-118	12.7	4.9	13.6	7.8	8.0	2.6	9.1	3.8
PCB-123	0.14	0.09	0.21	0.16	0.03	-	0.19	0.07
PCB-126	ND	-	ND	-	ND	-	0.04	0.02
PCB-156/157	1.3	0.43	1.1	0.12	1.1	0.30	1.2	0.29
PCB-167	0.43	0.23	0.35	0.04	0.41	0.15	0.48	0.12
PCB-169	ND	-	ND	-	ND	-	0.15	0.03
PCB-189	0.07	0.06	ND	-	ND	-	0.14	0.03
Total Mono-CBs	304.0	629.4	10.7	10.3	7.7	3.1	34.0	17.0
Total Di-CBs	1,644	3,488	91.5	79.4	81.8	37.5	87.1	22.5
Total Tri-CBs	2,113	4,493	137.9	123.5	94.9	54.5	88.8	57.6
Total Tetra-CBs	444.6	721.0	228.3	282.4	115.5	58.1	103.3	57.2
Total Penta-CBs	103.4	38.9	184.6	202.4	75.9	32.3	85.0	52.3
Total Hexa-CBs	78.5	21.8	88.6	44.1	65.6	23.5	75.3	27.6
Total Hepta-CBs	41.8	10.8	36.6	2.4	35.9	9.6	44.2	13.5
Total Octa-CBs	11.0	4.8	7.5	0.35	5.9	1.6	11.2	2.1
Total Nona-CBs	1.1	0.82	0.53	0.28	0.54	0.10	0.93	0.34
PCB-209	0.15	0.16	0.06	-	0.17	0.14	0.24	0.05
WHO 2005 TEQ (ND=0)	0.001	0.0003	0.001	0.0003	0.0004	0.0001	0.01	0.01
WHO 2005 TEQ (ND=DL/2)	0.02	0.01	0.01	0.01	0.01	0.003	0.01	0.004
WHO 2005 TEQ (ND=DL)	0.03	0.03	0.02	0.01	0.02	0.01	0.01	0.003

Table S30. Average PCB Detection Limits in pg/m^3 – 2005 WHO Congeners and Homologues by Class for Transient Tests, n=5 for each configuration

	detection limit							
	DOC+CDPF+CuZ SCR+ASC+urea pg/m^3		DOC+CDPF+FeZ SCR+ASC+urea pg/m^3		DOC+CDPF pg/m^3		DOC+CDPF+CuZ SCR+ASC+urea, 10 ppm Cl pg/m^3	
compound	average	standard deviation	average	standard deviation	average	standard deviation	average	standard deviation
PCB-77	1.4	-	-	-	-	-	-	-
PCB-81	0.40	0.53	0.11	0.09	0.10	0.02	0.07	0.01
PCB-105	-	-	-	-	-	-	-	-
PCB-114	0.36	0.31	0.29	-	0.12	0.02	-	-
PCB-118	-	-	-	-	-	-	-	-
PCB-123	0.38	0.33	0.29	-	0.11	0.02	-	-
PCB-126	0.22	0.19	0.15	0.09	0.13	0.05	0.04	0.01
PCB-156/157	-	-	-	-	-	-	-	-
PCB-167	0.76	-	0.33	-	-	-	-	-
PCB-169	0.26	0.30	0.17	0.13	0.17	0.05	-	-
PCB-189	0.32	0.34	0.13	0.09	0.09	0.03	-	-
Total Mono-CBs	-	-	-	-	-	-	-	-
Total Di-CBs	-	-	-	-	-	-	-	-
Total Tri-CBs	-	-	-	-	-	-	-	-
Total Tetra-CBs	-	-	-	-	-	-	-	-
Total Penta-CBs	-	-	-	-	-	-	-	-
Total Hexa-CBs	-	-	-	-	-	-	-	-
Total Hepta-CBs	-	-	-	-	-	-	-	-
Total Octa-CBs	-	-	-	-	-	-	-	-
Total Nona-CBs	1.38	-	0.46	-	-	-	-	-
PCB-209	-	-	0.21	-	0.13	0.04	-	-

Table S31. Average PCDD/F and PCB Tunnel Blank Results in pg/m^3 – 2,3,7,8-substituted Congeners and Homologues by Class (PCDD/F) and 2005 WHO Congeners and Homologues by Class (PCB), EMPC=EMPC, n=5

	concentration pg/m^3		detection limit pg/m^3	
compound	average	standard deviation	average	standard deviation
2,3,7,8-TCDD	ND	-	0.02	0.001
1,2,3,7,8-PeCDD	ND	-	0.02	0.003
1,2,3,4,7,8-HxCDD	ND	-	0.02	0.001
1,2,3,6,7,8-HxCDD	ND	-	0.02	0.002
1,2,3,7,8,9-HxCDD	ND	-	0.02	0.002
1,2,3,4,6,7,8-HpCDD	ND	-	0.02	0.002
OCDD	0.01	-	0.03	0.003
2,3,7,8-TCDF	ND	-	0.01	0.001
1,2,3,7,8-PeCDF	ND	-	0.01	0.001
2,3,4,7,8-PeCDF	0.01	0.001	0.01	0.0003
1,2,3,4,7,8-HxCDF	ND	-	0.01	0.001
1,2,3,6,7,8-HxCDF	ND	-	0.01	0.001
2,3,4,6,7,8-HxCDF	ND	-	0.01	0.001
1,2,3,7,8,9-HxCDF	ND	-	0.01	0.002
1,2,3,4,6,7,8-HpCDF	ND	-	0.01	0.002
1,2,3,4,7,8,9-HpCDF	ND	-	0.01	0.001
OCDF	ND	-	0.03	0.003
Total TCDDs	0.03	0.07	0.54	0.91
Total PeCDD	ND	-	0.02	0.004
Total HxCDD	ND	-	0.02	0.002
Total HpCDD	ND	-	0.02	0.002
Total TCDF	0.08	0.08	-	-
Total PeCDF	0.01	0.001	0.01	0.0004
Total HxCDF	ND	-	0.01	0.001
Total HpCDF	ND	-	0.01	0.001
ITEF TEQ (ND=0)	0.003	0.004		
ITEF TEQ (ND=DL/2)	0.02	0.002		
ITEF TEQ (ND=DL)	0.04	0.002		

	concentration pg/m^3		detection limit pg/m^3	
compound	average	standard deviation	average	standard deviation
PCB-77	0.30	0.08	-	-
PCB-81	ND	-	0.02	0.004
PCB-105	1.74	0.60	-	-
PCB-114	0.16	0.05	-	-
PCB-118	6.32	2.1	-	-
PCB-123	0.11	0.04	0.04	-
PCB-126	ND	-	0.03	0.004
PCB-156/157	0.34	0.10	-	-
PCB-167	0.16	0.04	-	-
PCB-169	ND	-	0.02	0.003
PCB-189	0.03	0.005	0.01	-
Total Mono-CBs	10.62	4.0	-	-
Total Di-CBs	63.34	28.9	-	-
Total Tri-CBs	95.27	48.6	-	-
Total Tetra-CBs	205.1	157.1	-	-
Total Penta-CBs	128.4	46.1	-	-
Total Hexa-CBs	53.30	16.8	-	-
Total Hepta-CBs	15.73	4.2	-	-
Total Octa-CBs	3.14	0.75	-	-
Total Nona-CBs	0.55	0.16	-	-
PCB-209	0.07	0.05	0.03	-
WHO 2005 TEQ (ND=0)	0.03	0.0001		
WHO 2005 TEQ (ND=DL/2)	0.25	0.0002		
WHO 2005 TEQ (ND=DL)	0.47	0.0005		