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Post-Field Evaluation of DEEP/ Noranda Diesel Particulate Filters

Mahe Gangal, Brent Rubeli, David A. Young,
Vince Feres (NRCan-CANMET) and
Sean McGinn (Noranda)

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Project Objective

Bench testing of diesel particulate filters for exhaust emissions under controlled laboratory conditions after 18 months in operation at Brunswick mine.

Diesel Particulate Filters Tested

- ECS - Ceramic filter with base metal catalyst (after 4053 hours in operation)
- DCL – SiC filter with precious metal catalyst (after 4261 hours in operation)
- Oberland Mangold – Wound fibre cartridges with fuel borne catalyst - Octimax 4804 (after 2898 hours in operation)
- ECS - Octel, filter trap could not be tested

Test Plan

Engine: DDEC S60, 11.1 L, 325hp @ 2100 rpm
Intermediate speed at 1260 rpm

Fuel: CGSB-3.16, Mining Diesel Fuel
Sulphur = 275 ppm

Test Method: ISO 8178-1

Test Cycles: Mine test (6 modes) and ISO 8178-C1 (4 modes)

Baseline: Engine only (without DPFs)

Filters: Cleaned with compressed air

Fuel Additive: Octimax 4804 used with Oberland filter only

Mine Test Cycles

1. FTC - Full torque converter stall (1950 rpm)
2. FH - Full hydraulic stall (1650 rpm)
3. HI - High idle speed, no load (2225 rpm)
4. LI - Low idle speed, no load (600 rpm)
5. Free snap acceleration - no load (sets of 3)
6. Loaded snap acceleration - full torque converter stall (sets of 3)

Measurements – O_2, CO, NO, NO_2, PAS/DC

ISO 8178-C1 (4 Modes)

Mode #1	Rated speed, 100% load
Mode #3	Rated speed, 50% load
Mode #5	Intermediate speed, 100% load
Mode #7	Intermediate speed, 50% load

Measurements – O_2, CO, CO_2, NO, N_2O, NOx, SO_2, HC, DPM, PAS/DC

ECS Filter

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DCL Filter

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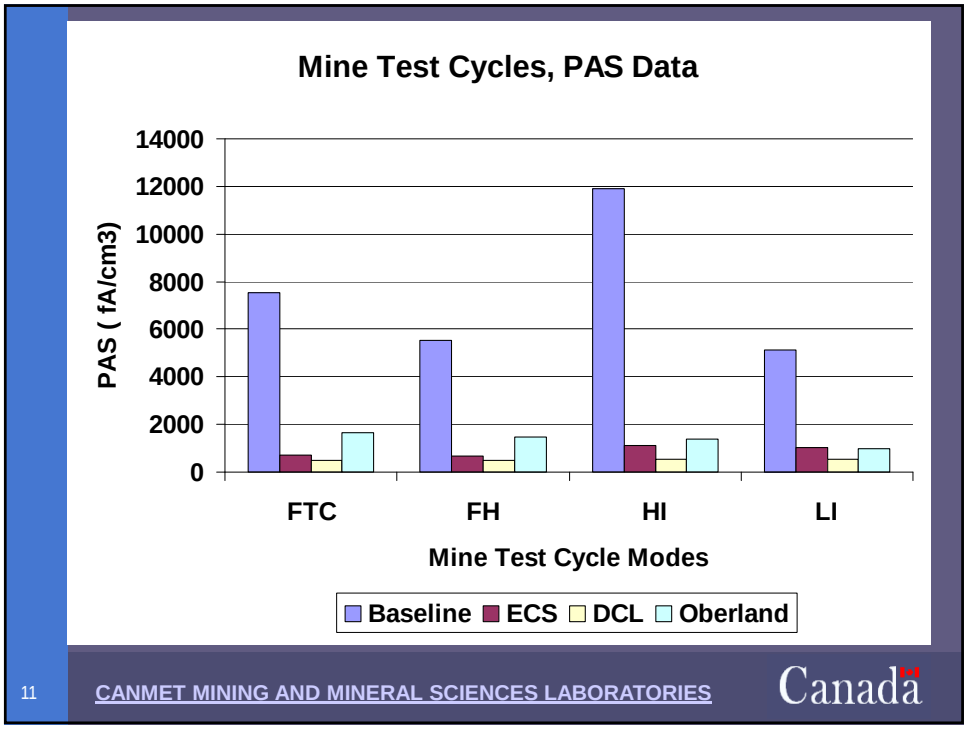
Oberland Mangold Filter

Results

- Mine Test Cycle (6 modes)
  - Photoelectric Aerosol Sensor (PAS)
  - Filter efficiency based on PAS/EC
- ISO 8178-C1 (4 modes)
  - CO, HC, NO, NO_2, DPM
  - Filter efficiency based on DPM mass & PAS/EC


Mine Test Cycles, PAS Data
14000
12000
10000
8000
6000
4000
2000
0
PAS (fA/cm3)
FTC
FH
HI
LI
Mine Test Cycle Modes
Baseline
ECS
DCL
Oberland
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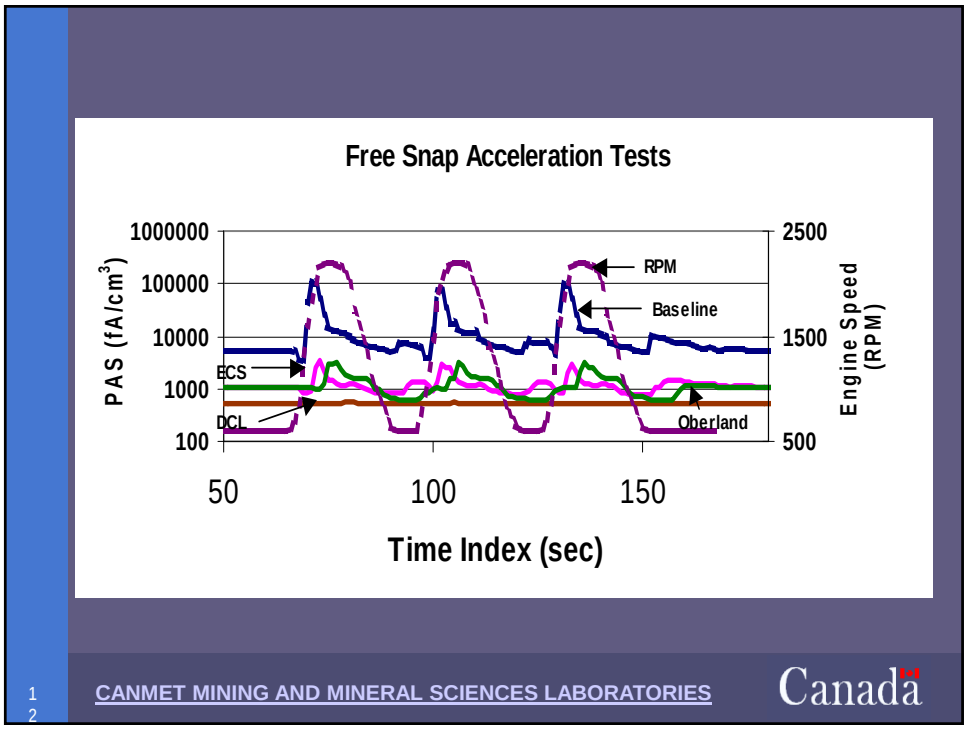
Free Snap Acceleration Tests
1000000
100000
10000
1000
100
PAS (fA/cm3)
2500
1500
500
Engine Speed (RPM)
RPM
Baseline
ECS
DCL
Oberland
50
100
150
Time Index (sec)
12
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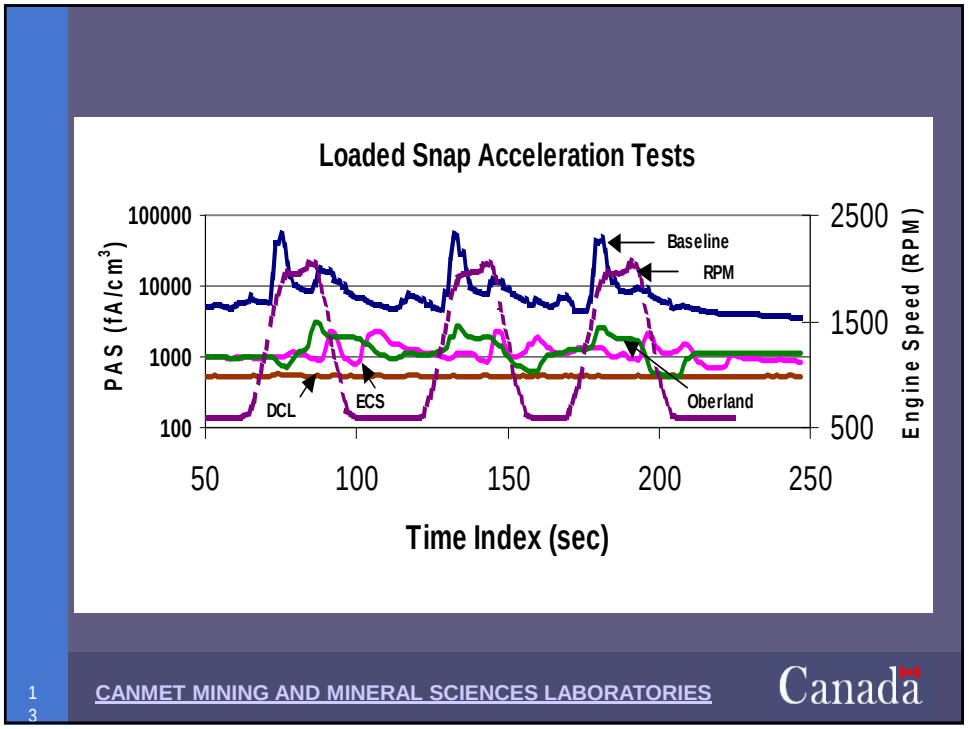

Filter Efficiency – ECS (Mine Test Cycles)

Mode -->	FTC	FH	HI	LI	Snap Accel.	
					free	loaded
Speed (rpm)	1950	1650	2225	600	transient	
Load (%)	100	100	idle	idle	cycle	
PAS/EC (%)	91	88	91	80	91	88

Filter Efficiency – DCL (Mine Test Cycles)

Mode -->	FTC	FH	HI	LI	Snap Accel.	
					free	loaded
Speed (rpm)	1950	1650	2225	600	transient	
Load (%)	100	100	idle	idle	cycle	
PAS/EC (%)	93	91	96	90	96	95

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Filter Efficiency - Oberland (Mine Test Cycles)

Mode -->	FTC	FH	HI	LI	Snap Accel.	
					free	loaded
Speed (rpm)	1950	1650	2225	600	transient	
Load (%)	100	100	idle	idle	cycle	
PAS/EC (%)	78	74	88	81	92	87

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4-Mode Cycle
Baseline Engine Data

ISO 8178-C1 Mode # ->	1	3	5	7
Speed (rpm)	2100	2100	1260	1260
Load (%)	100%	50%	100%	50%
Torque (lb.ft)	820	409	1077	538
Power (hp)	328	164	258	129
Fuel (lb/hr)	117	63	86	44
Exhaust Gas Temp.(^{0}C)	405	335	501	410

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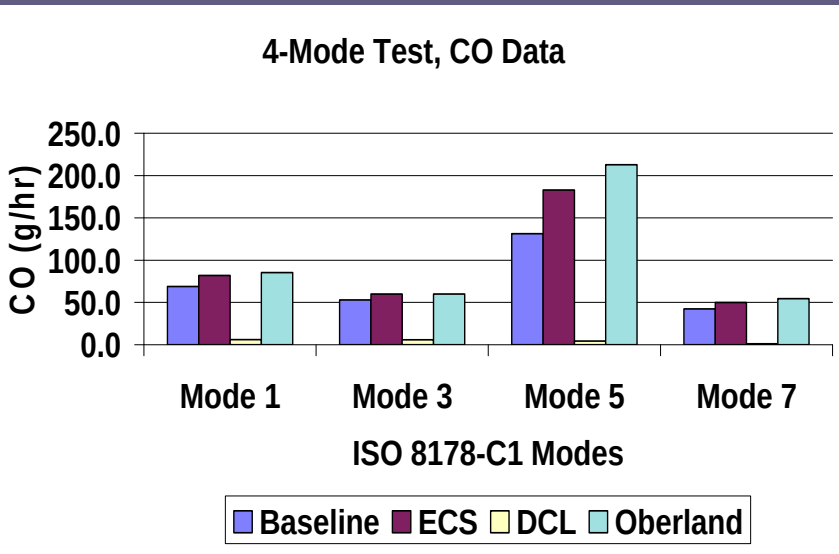

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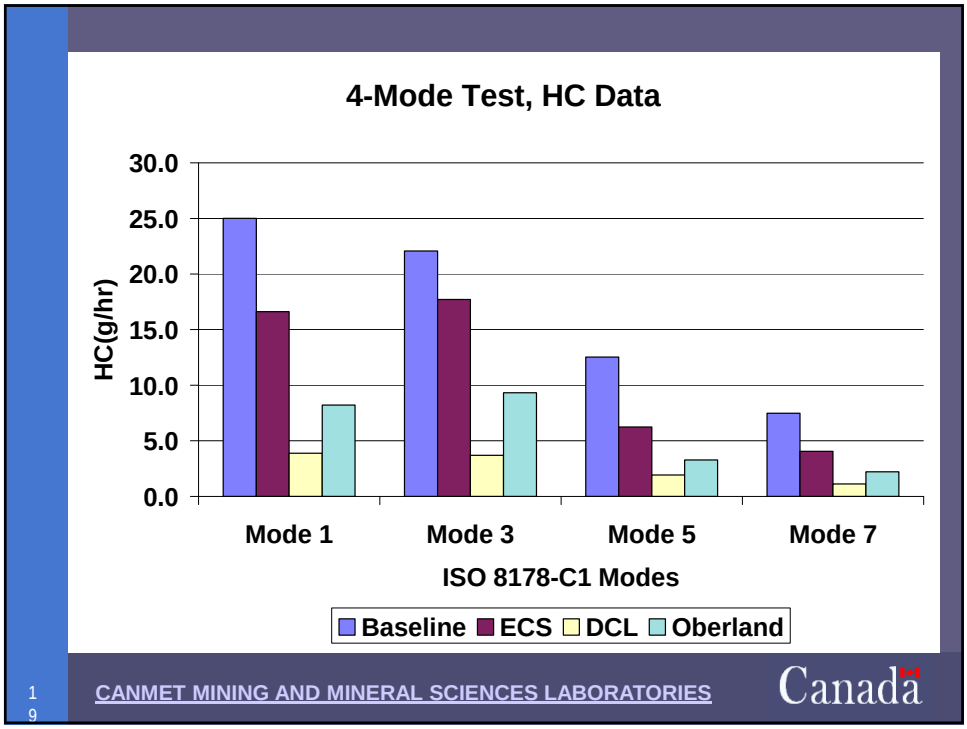
4-Mode Test, HC Data
30.0
25.0
20.0
15.0
10.0
5.0
0.0
HC(g/hr)
Mode 1
Mode 3
Mode 5
Mode 7
ISO 8178-C1 Modes
Baseline
ECS
DCL
Oberland
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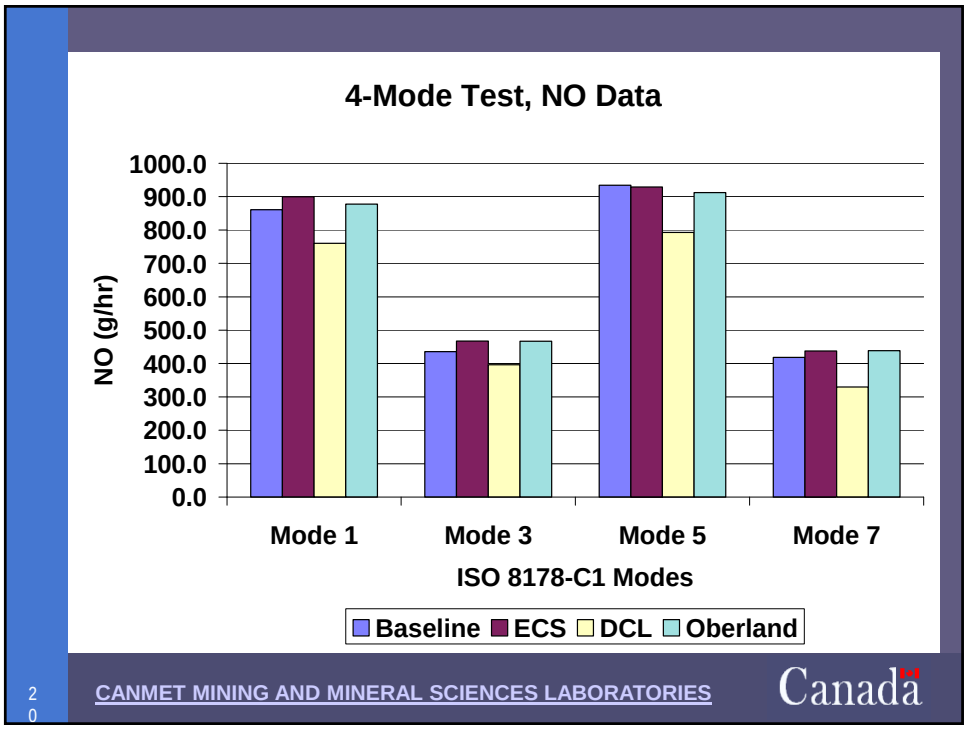
4-Mode Test, NO Data
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
NO (g/hr)
Mode 1
Mode 3
Mode 5
Mode 7
ISO 8178-C1 Modes
Baseline
ECS
DCL
Oberland
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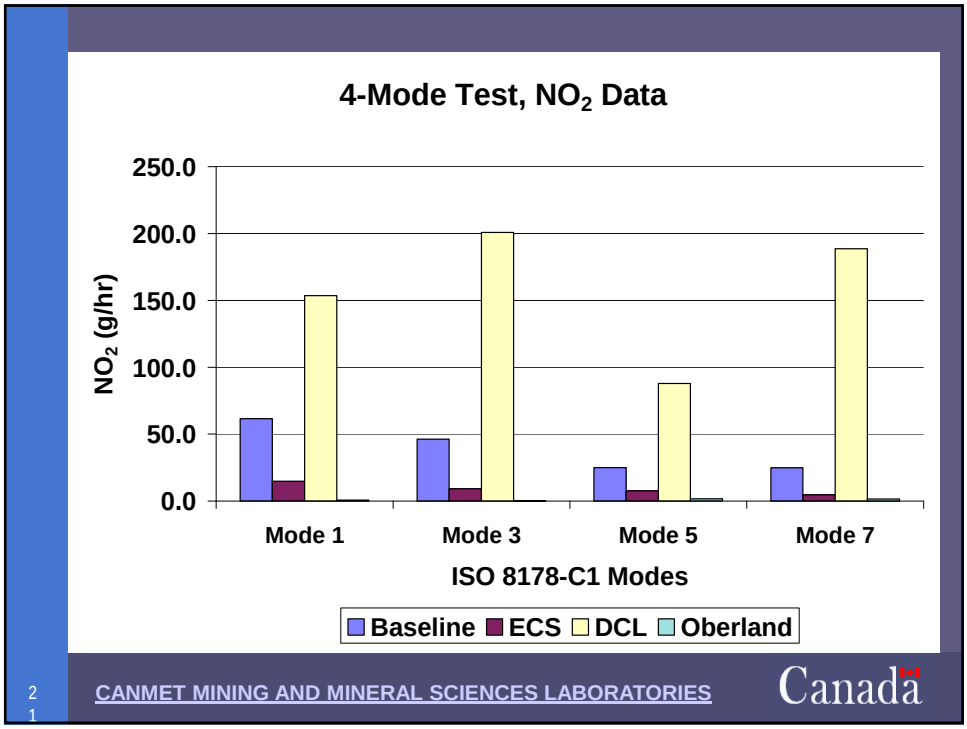
4-Mode Test, NO2 Data
250.0
200.0
150.0
100.0
50.0
0.0
NO2 (g/hr)
Mode 1
Mode 3
Mode 5
Mode 7
ISO 8178-C1 Modes
Baseline
ECS
DCL
Oberland
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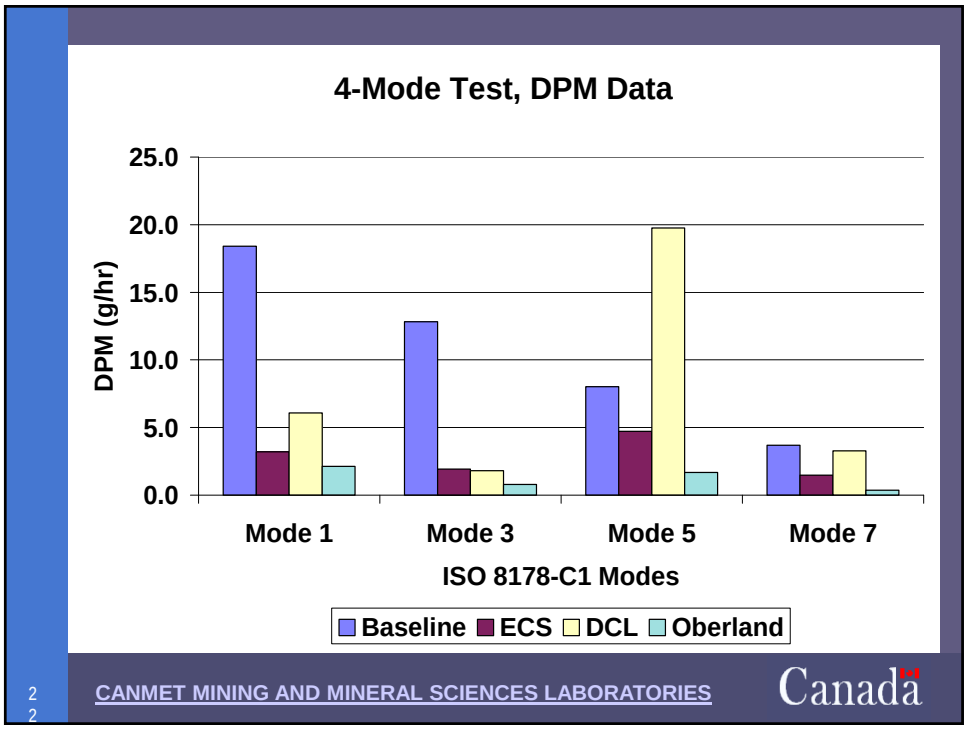
4-Mode Test, DPM Data
25.0
20.0
15.0
10.0
5.0
0.0
DPM (g/hr)
Mode 1
Mode 3
Mode 5
Mode 7
ISO 8178-C1 Modes
Baseline
ECS
DCL
Oberland
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Filter Efficiency – ECS (ISO 8178-C1, 4 Modes)

ISO 8178-C1 Mode # ->	1	3	5	7
DPM Based (%)	83	85	41	60
PAS/EC Based (%)	99	92	93	94
Inlet Gas Temp. (^{0}C)	371	321	464	376
Filter dp (in. H_2O)	15	7	6	2

Filter Efficiency – DCL (ISO 8178-C1, 4 Modes)

ISO 8178-C1 Mode # ->	1	3	5	7
DPM Based (%)	67	86	-146	11
PAS/EC Based (%)	93	96	94	96
Inlet Gas Temp. (^{0}C)	393	324	476	393
Filter dp (in. H_2O)	15	6	5	2

Filter Efficiency – Oberland (ISO 8178-C1, 4 Modes)

ISO 8178-C1 Mode # ->	1	3	5	7
DPM Based (%)	88	94	79	90
PAS/EC Based (%)	82	87	84	91
Inlet Gas Temp. (^{0}C)	396	328	488	403
Filter dp (in. H_2O)	17	7	6	3

Questions?