

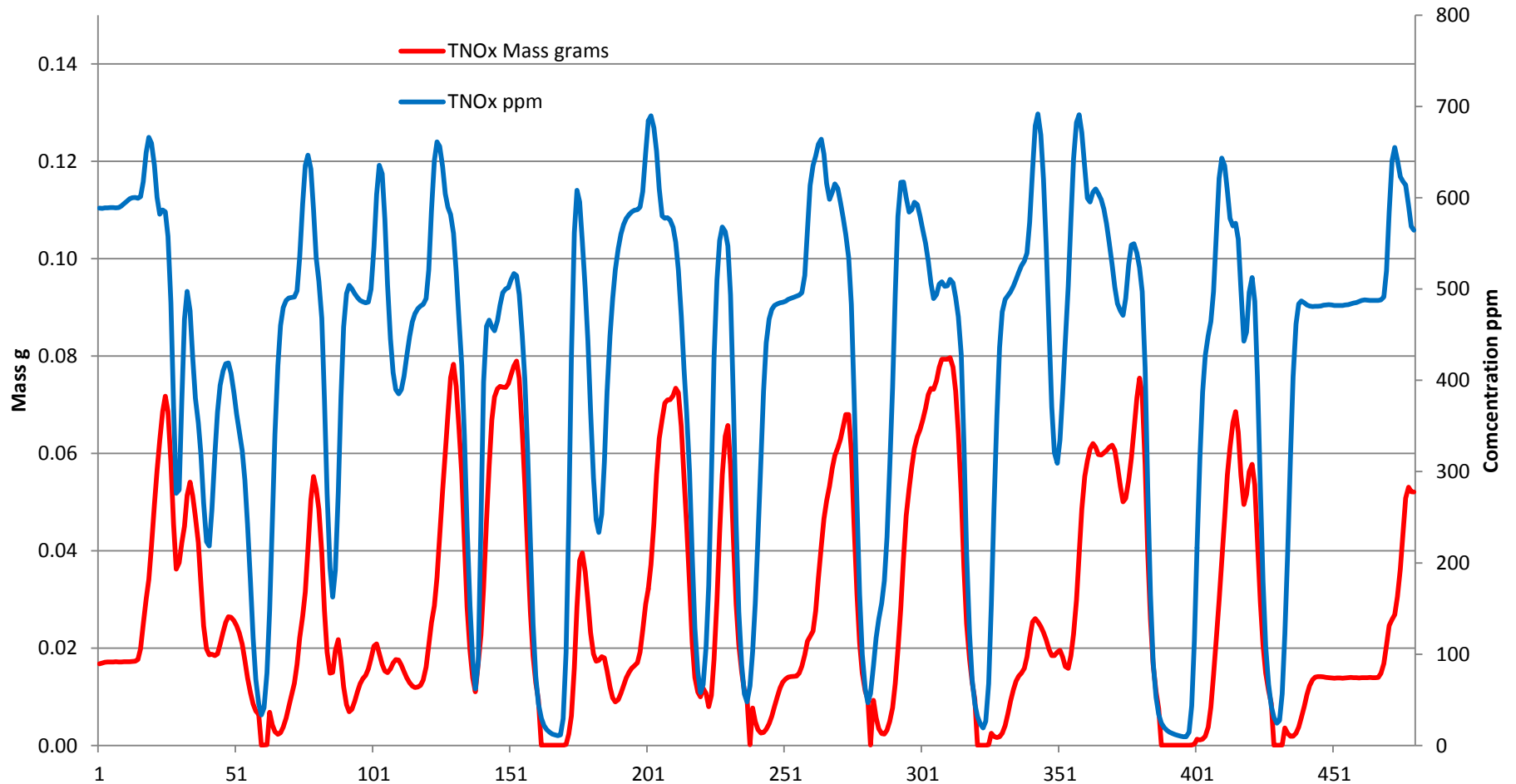
NOx & Fuel Consumption Measurement Options



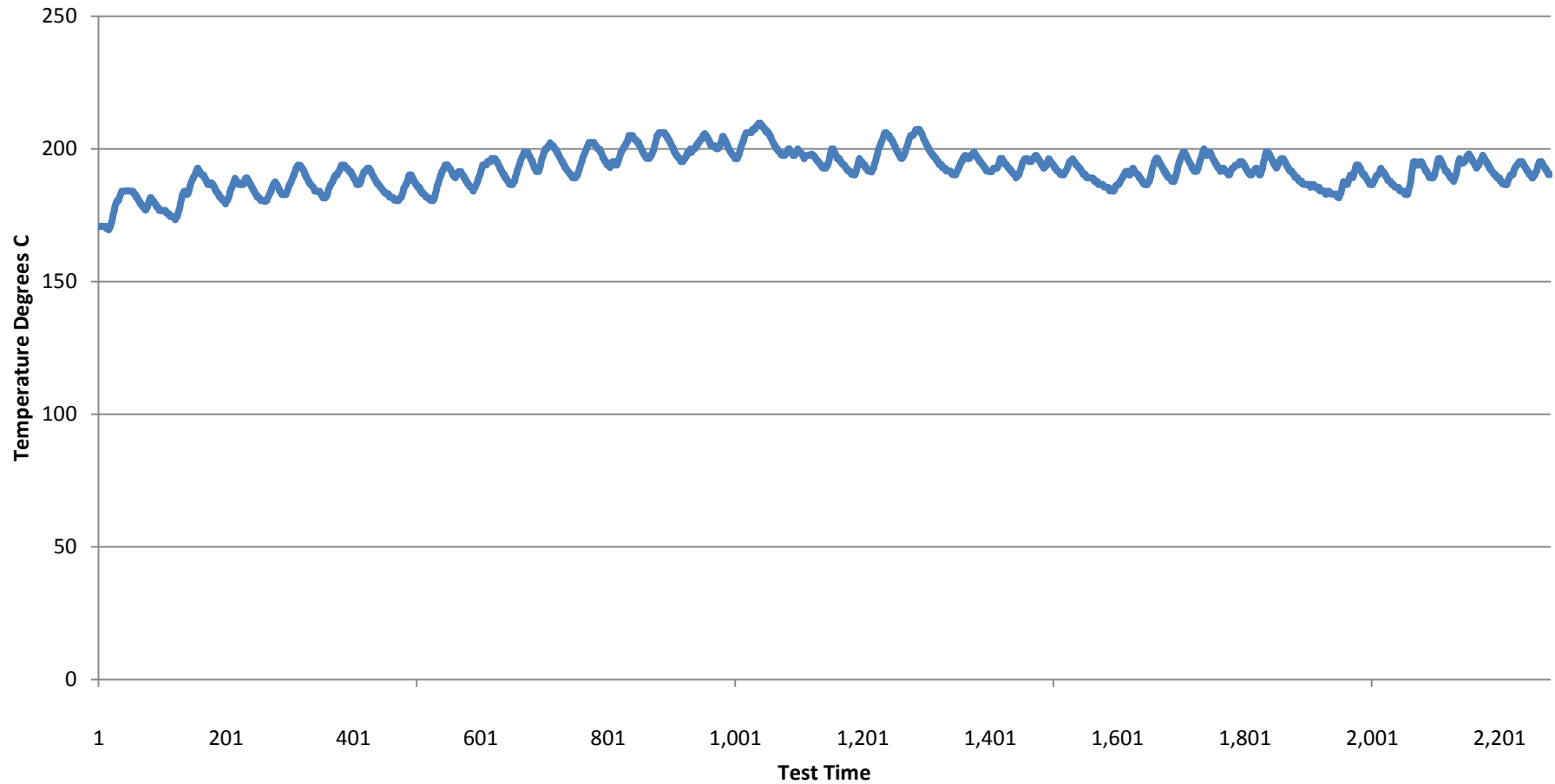
Executive Summary

- Millbrook is an established proving ground and automotive test business, formerly part of GM.
- Under new ownership and making significant investments.
- Integrated
 - vehicle engineering;
 - powertrain, system and whole vehicle testing; and
 - specialist vehicle conversions, including powertrain changes.
- Centre for events and high technology businesses.
- Millbrook is known for high levels of customer service, responsiveness and value for money.

Real World NOx Emissions



Engine Out Exhaust Temperature



Exhaust Gas & Fuel Consumption Measurements

- MOT measurements
- Laboratory measurements
- Portable measurements
- NOx Sensors
- Fuel Consumption
- Appropriate driving conditions / cycles

MOT Testing

- Idle test
- No load
- Diesel Opacity test



Laboratory Testing

Vehicle Emissions Laboratory

- Chassis dynamometer
- VCA Certified to Euro 6
- Highly Refined Test Procedures
 - Increased accuracy
 - ISO 17025 accreditation



Variable Temperature Emissions Chamber

- Chassis dynamometer
- Meets Federal and European specifications
- Inertia simulation up to 20,000kg



Laboratory Testing



- Highly accurate
- Separate measurements of NO and NO₂ possible
- Very repeatable
- Tight control on variables
- Quickest option
- Real world and legislative drive cycles
- Fuel consumption & NOx in real time
- Most expensive method of testing

PEMS Equipment



Testing on Public Roads with PEMS

- Vehicle in its working environment
- Real time NOx and fuel consumption
- NOx species possible in real time pre and post after-treatment
- High level of disturbance
- Variable ambient conditions
- Variable payload
- Ancillary loading not constant

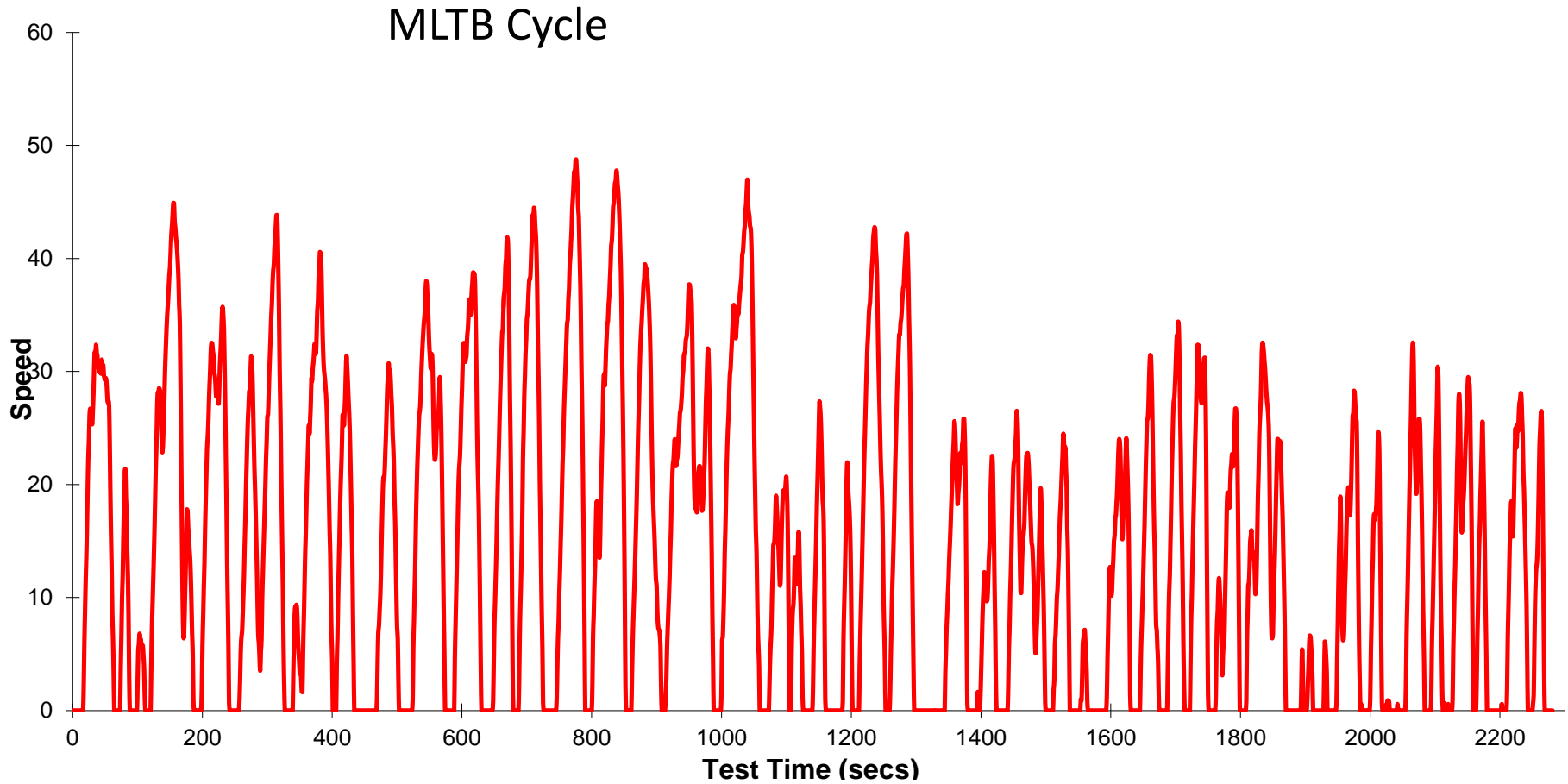
- Increased control and accuracy by testing on test tracks

On Board NOx sensors

- Vehicle in its working environment
- Real time NOx monitoring
- Pre and post aftertreatment
- Real time conversion monitoring
- Does not speciate the Nox to NO & NO₂
- Measures concentration so exhaust volume measurement required



Representative Drive Cycles

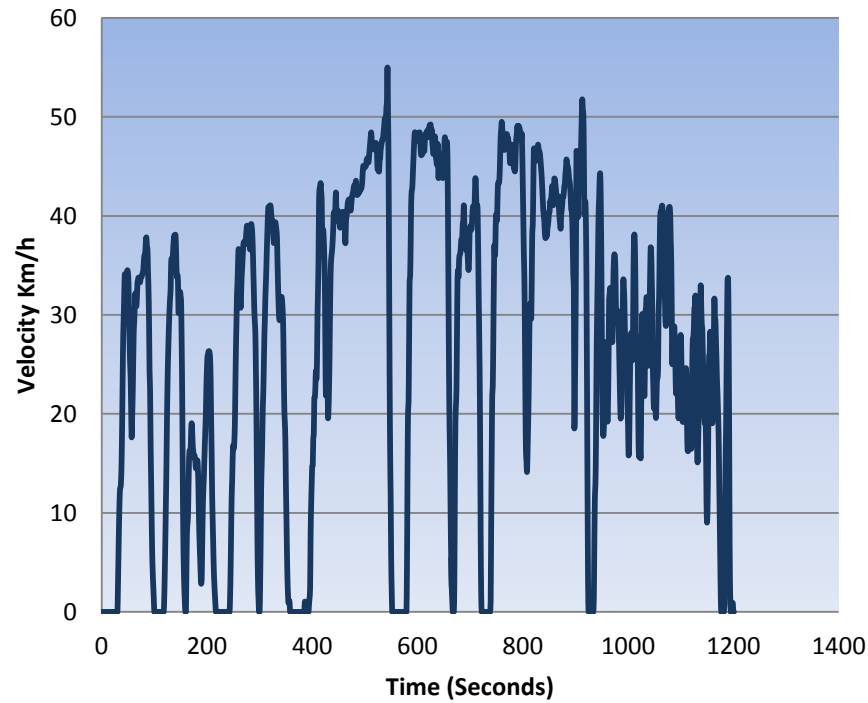


Repeatability

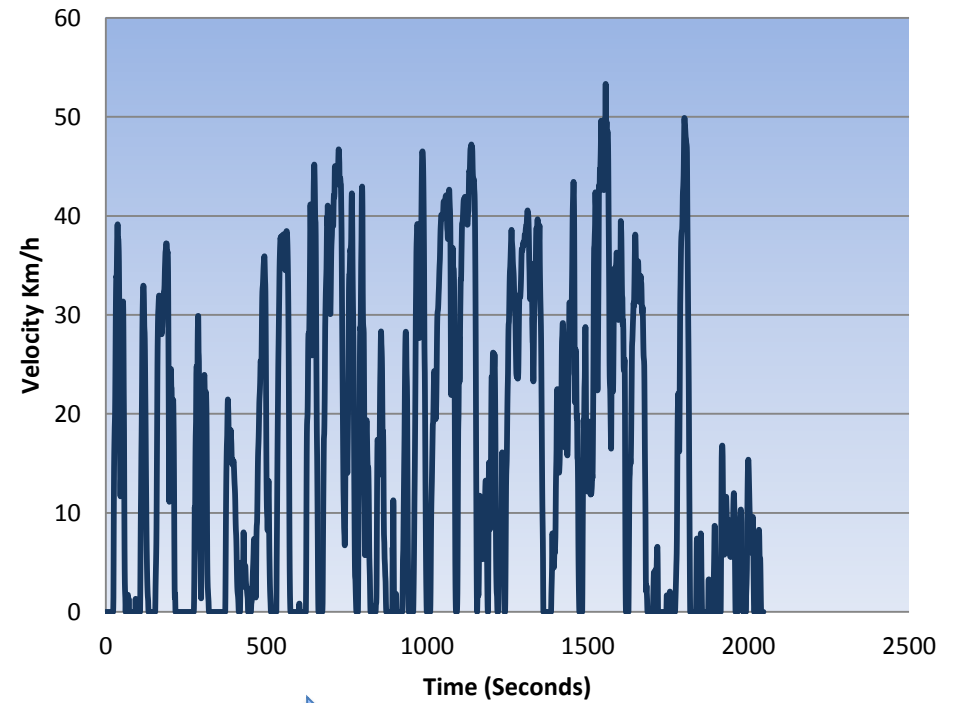
Test No.ML02012814		06-Feb-13						Fuel Cons
Odo	6473	UNITS	HC	CO	NOx	CO2	PM	(Carb Bal)
Phase 1	Outer London	g/km	0.083	0.031	4.828	768.9	0.045	29.04
Phase 2	Inner London	g/km	0.129	0.218	8.179	1035.4	0.077	39.11
Combined result		g/km	0.096	0.083	5.765	843.5	0.054	litres/100km
								31.86
Test No.ML02012815		06-Feb-13						Fuel Cons
Odo	6484	UNITS	HC	CO	NOx	CO2	PM	(Carb Bal)
Phase 1	Outer London	g/km	0.145	0.101	3.447	762.6	0.047	28.80
Phase 2	Inner London	g/km	0.240	0.255	6.928	1031.3	0.079	38.96
Combined result		g/km	0.172	0.144	4.423	837.9	0.056	litres/100km
								31.65
Test No.ML02012816		06-Feb-13						Fuel Cons
Odo	6494	UNITS	HC	CO	NOx	CO2	PM	(Carb Bal)
Phase 1	Outer London	g/km	0.153	0.103	4.696	763.1	0.043	28.82
Phase 2	Inner London	g/km	0.210	0.293	6.992	1026.7	0.084	38.79
Combined result		g/km	0.169	0.156	5.342	837.2	0.054	litres/100km
								31.62
Average of Combined Tests (g/km)			0.146	0.128	5.176	839.5	0.055	31.71
Standard Deviation/Mean x100			24.12	24.88	10.82	0.33	1.68	0.33

Drive cycle comparisons

Urban Free Flow



Urban AM-Peak



NOx +100% CO₂ +50%

Fuel Consumption

- Brim to Brim
- CAN data
- Carbon Balance
- Fuel Flow meters



All Measurements

- Independently taken
- Traceable measurements
- Measurement equipment calibrated
- Repeatable

- Recommend NO_x species (NO and NO₂) measured separately.

- Really depends what you want to achieve and be able to say.

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