CAMBUSTION

Pressure drop characteristics of soot generated by a DPG and a Euro IV, 2 litre diesel engine

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Introduction

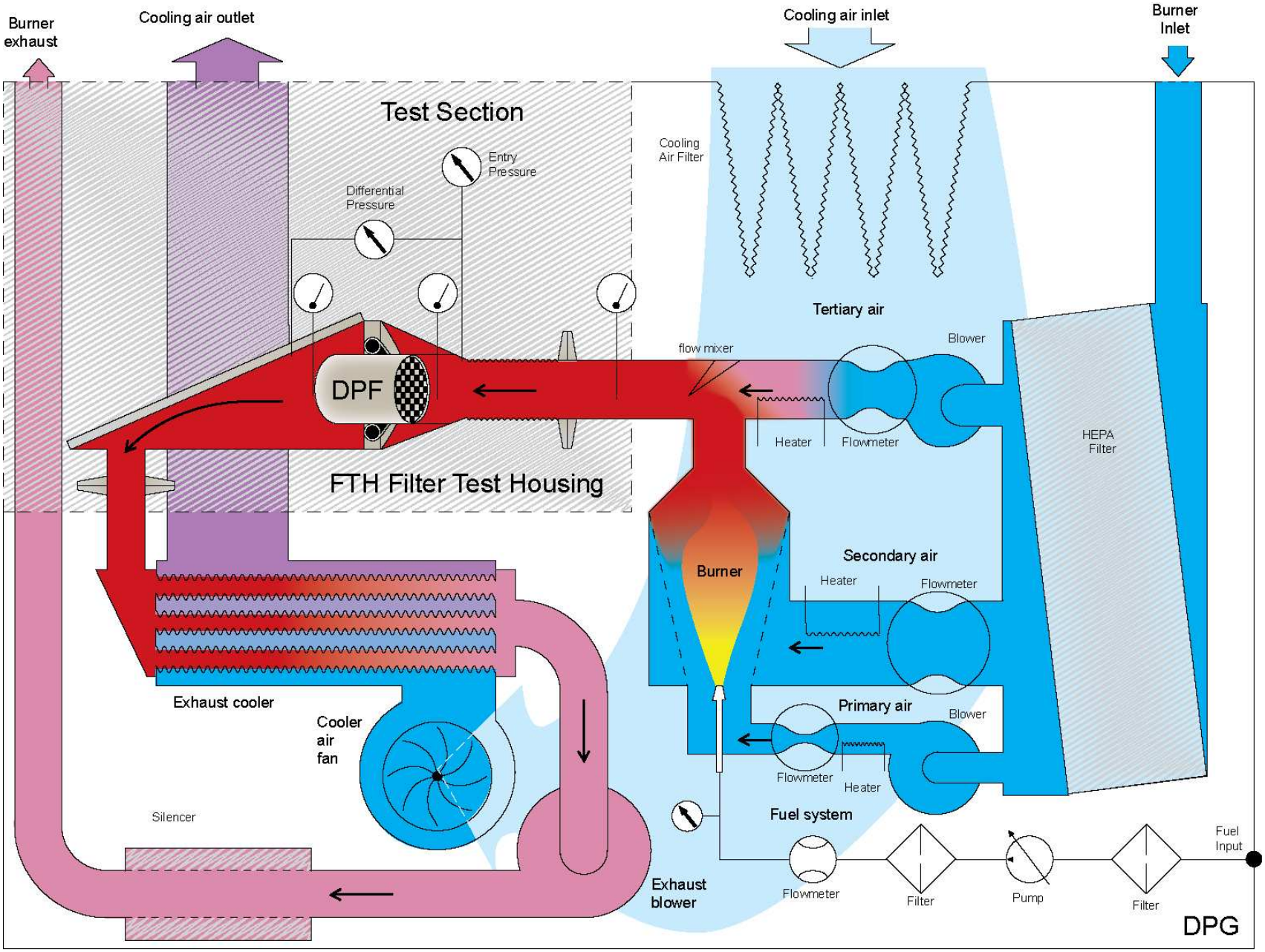
- The DPG is part of the Cambustion DPF Testing System which tests Diesel Particulate Filters for
  - Backpressure vs soot load
  - Regeneration characteristics
  - Filtration efficiency (with a soot monitoring system)
- This is done by loading filters with soot generated in a Diesel burner, at flows and temperatures similar to engine conditions.
- This work compares the backpressure produced by the soot from the DPG burner with that from and engine.
- Effects causing variability in the backpressure associated with
  - Engine cold starts
  - High flow conditions

  were measured in these tests and are discussed.

The Cambustion DPG

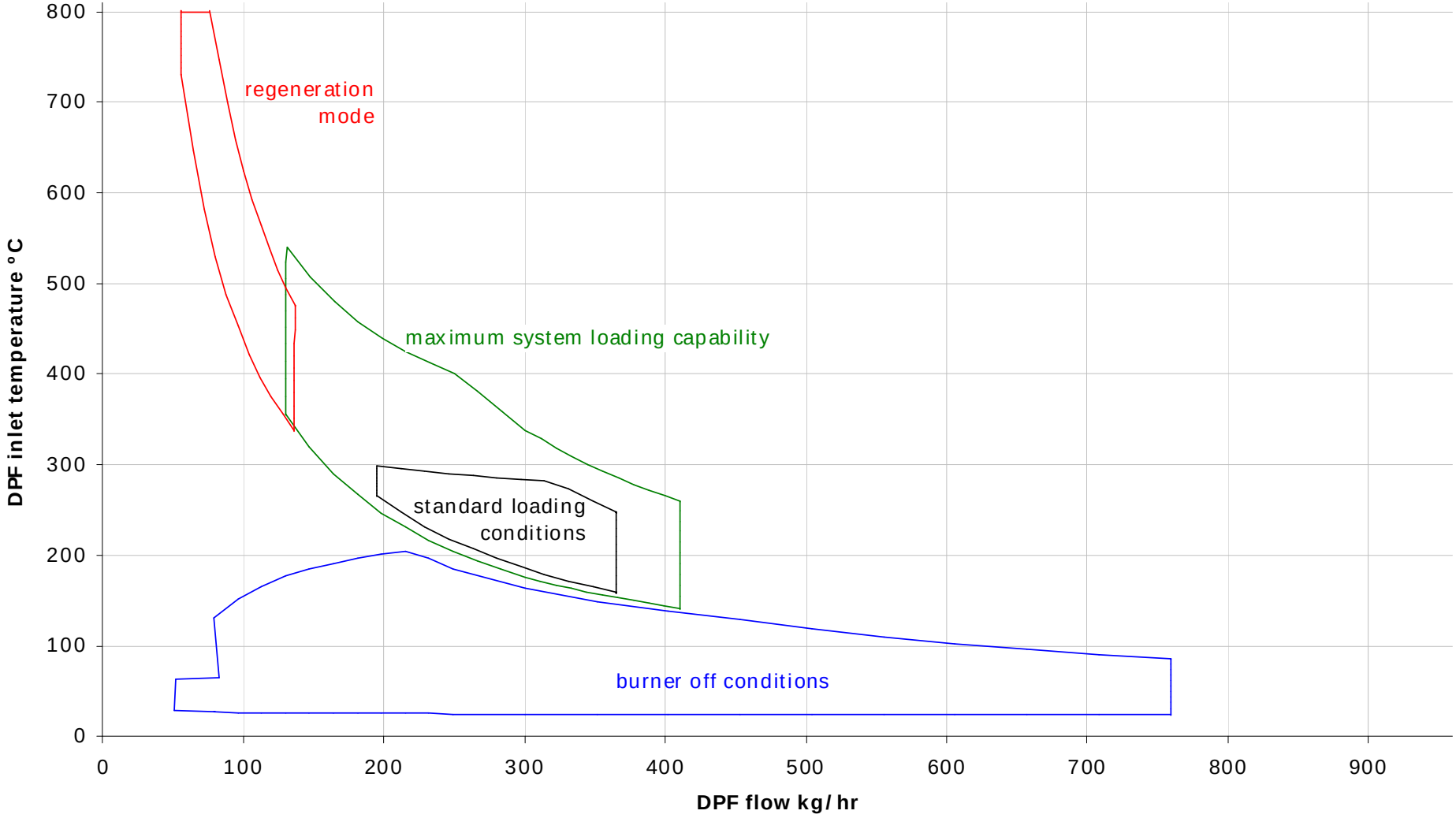
- More repeatable and rapid testing of DPGs than engine tests
- Burner conditions unaffected by DPF backpressure
- Automated, unattended testing except for loading & weighing the filter.

DPG Schematic



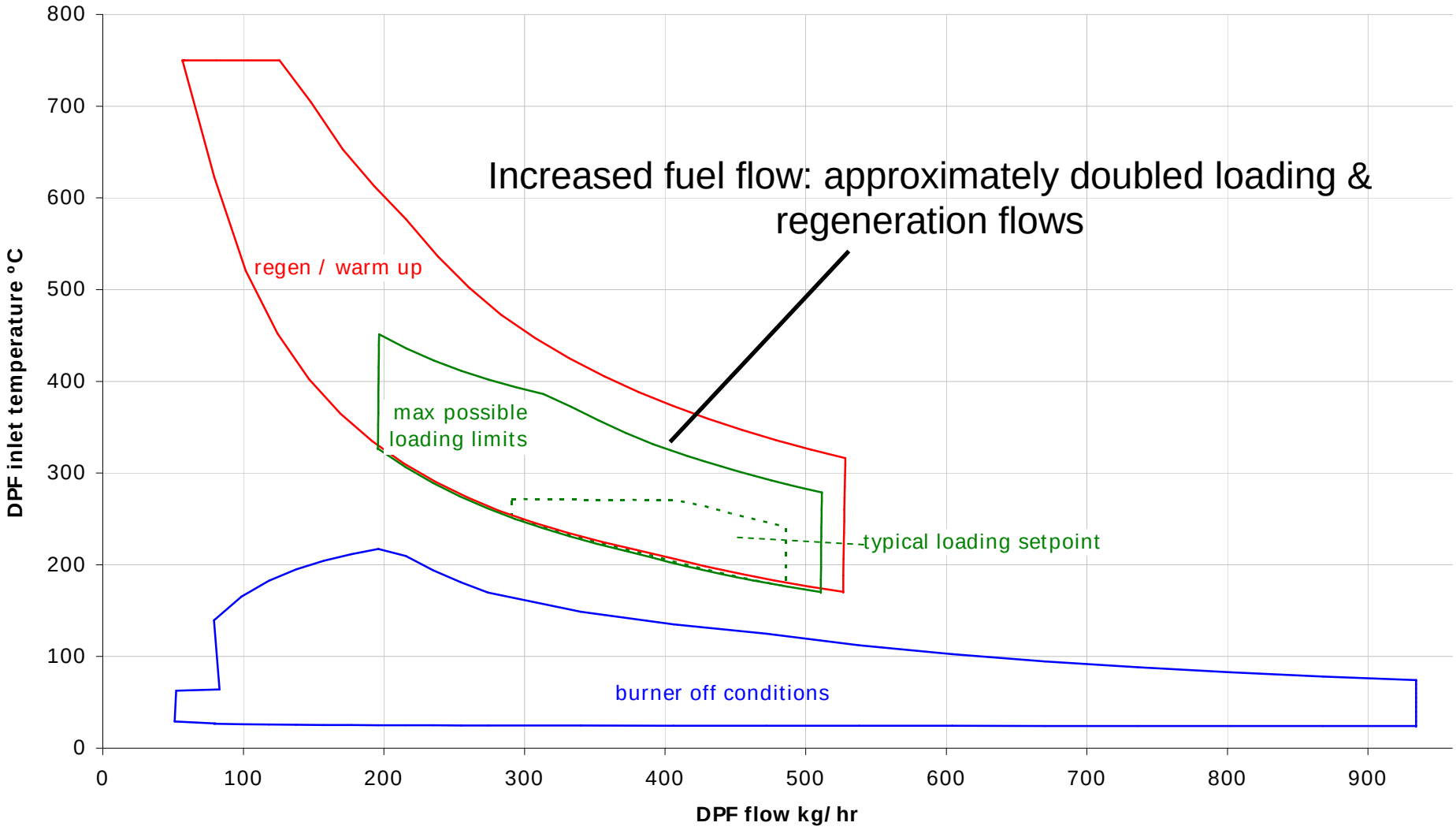
DPG Flow – Temperature Capability
Standard LD version

DPG - LD Operating Temperature : Flow Rate Capability



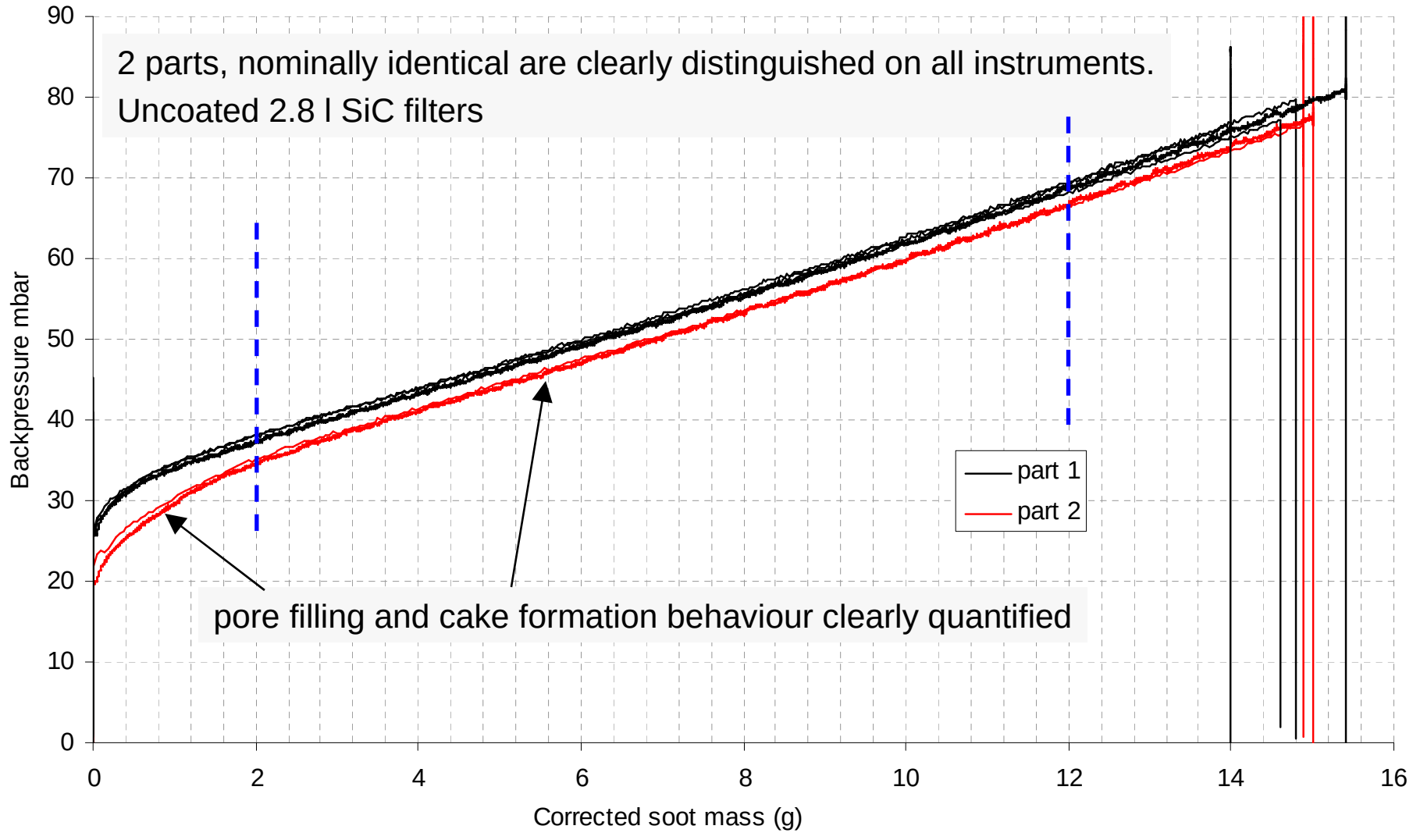
DPG Flow – Temperature Capability
New MD Version

DPG - Medium Duty Operating Temperature : Flow Rate Capability

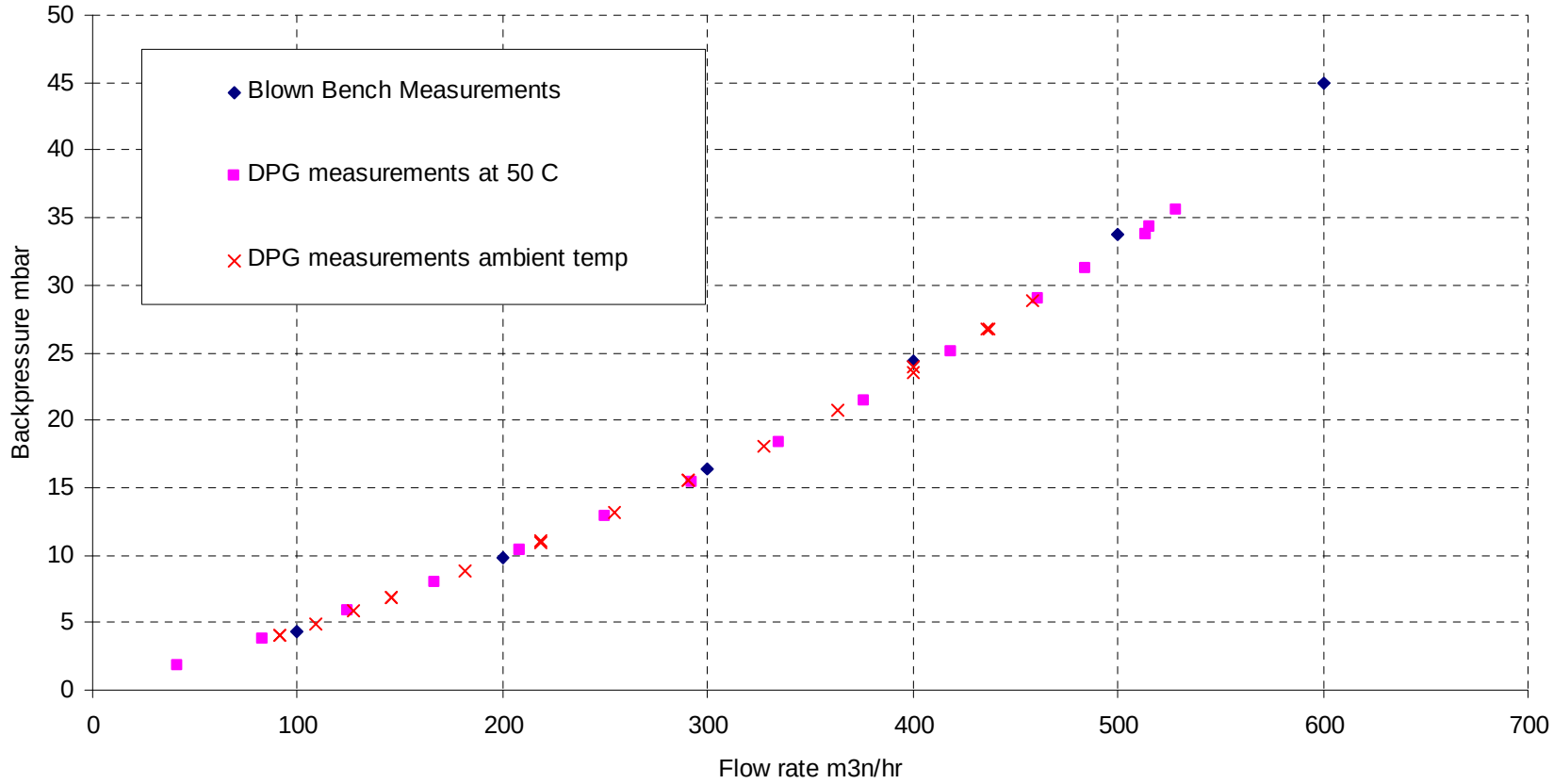


DPG Application for Dp vs Soot Mass Testing

Instrument : instrument repeatability



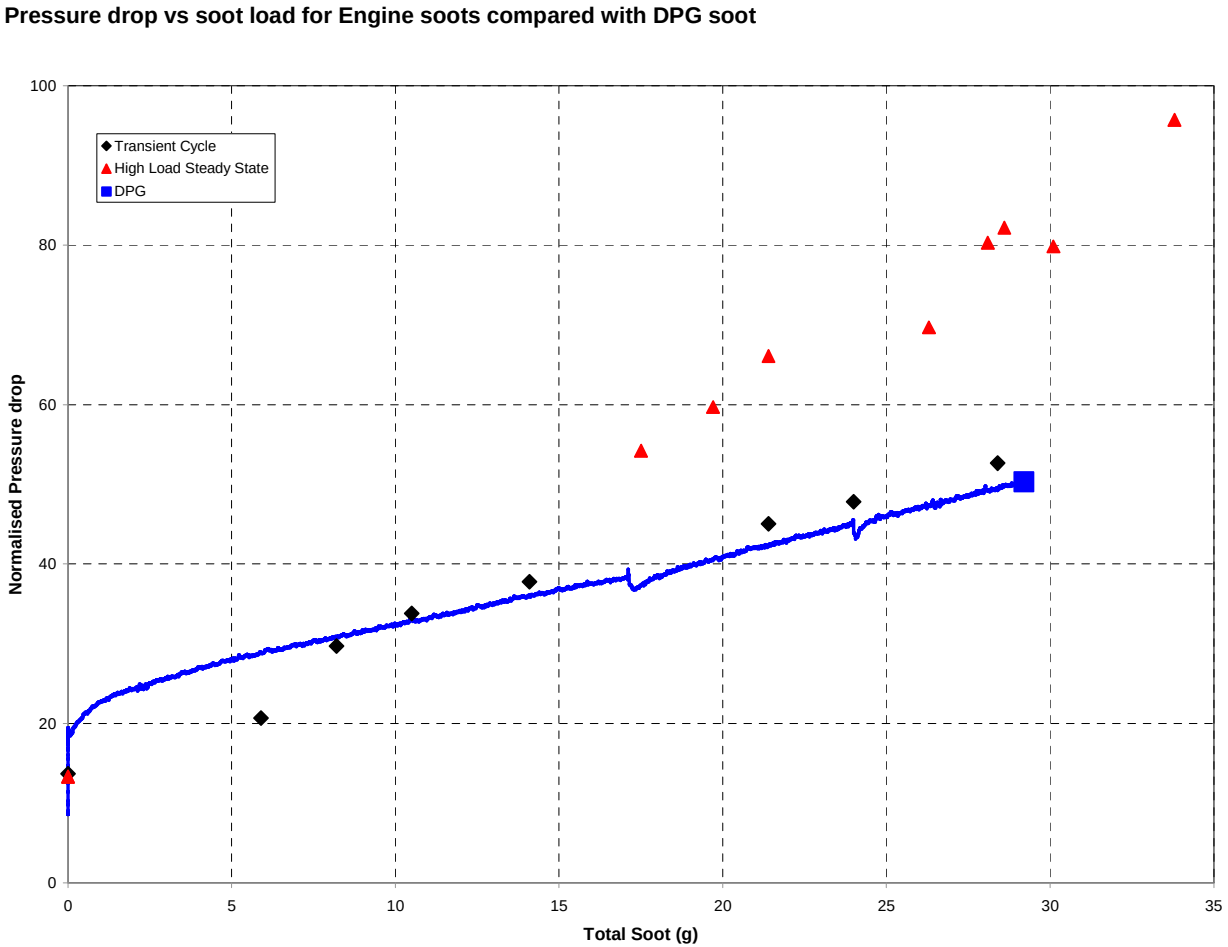
DPG Flow Sweep Testing



- DPG measures backpressure vs flow up to ~ 600 m^3/h
- For comparison with engine results, Reynolds number should be the same
  - Cold flow test at a **lower** flow rate than the engine!
  - This keeps the balance of viscous & inertial pressure drops the same.

Previous Engine Correlation Work

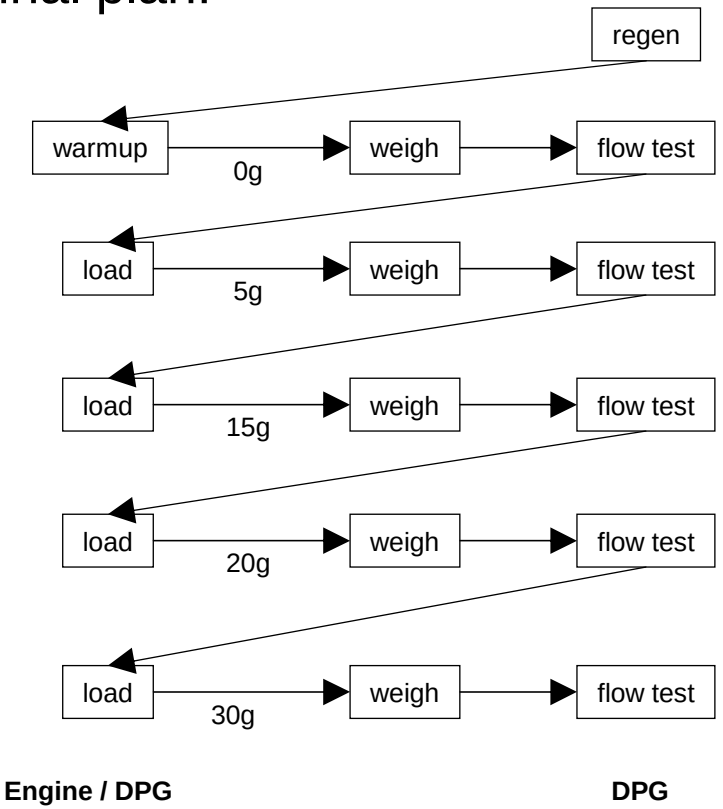
T Hands et al, DEER 2007:



- Difference between cycle & steady state engine soot
- Engine soot backpressure measured on engine: less accurate
- Other private data also shows significant variation between engines

New Test Programme

- DPF canned for easy connection to engine
- Load on engine or DPG.
- Cold flow test at 0g, 5g, 15g, 20g & 30g on DPG
  - Improved accuracy compared with engine backpressure measurement due to accurate & stable temperature and flow
- Original plan:



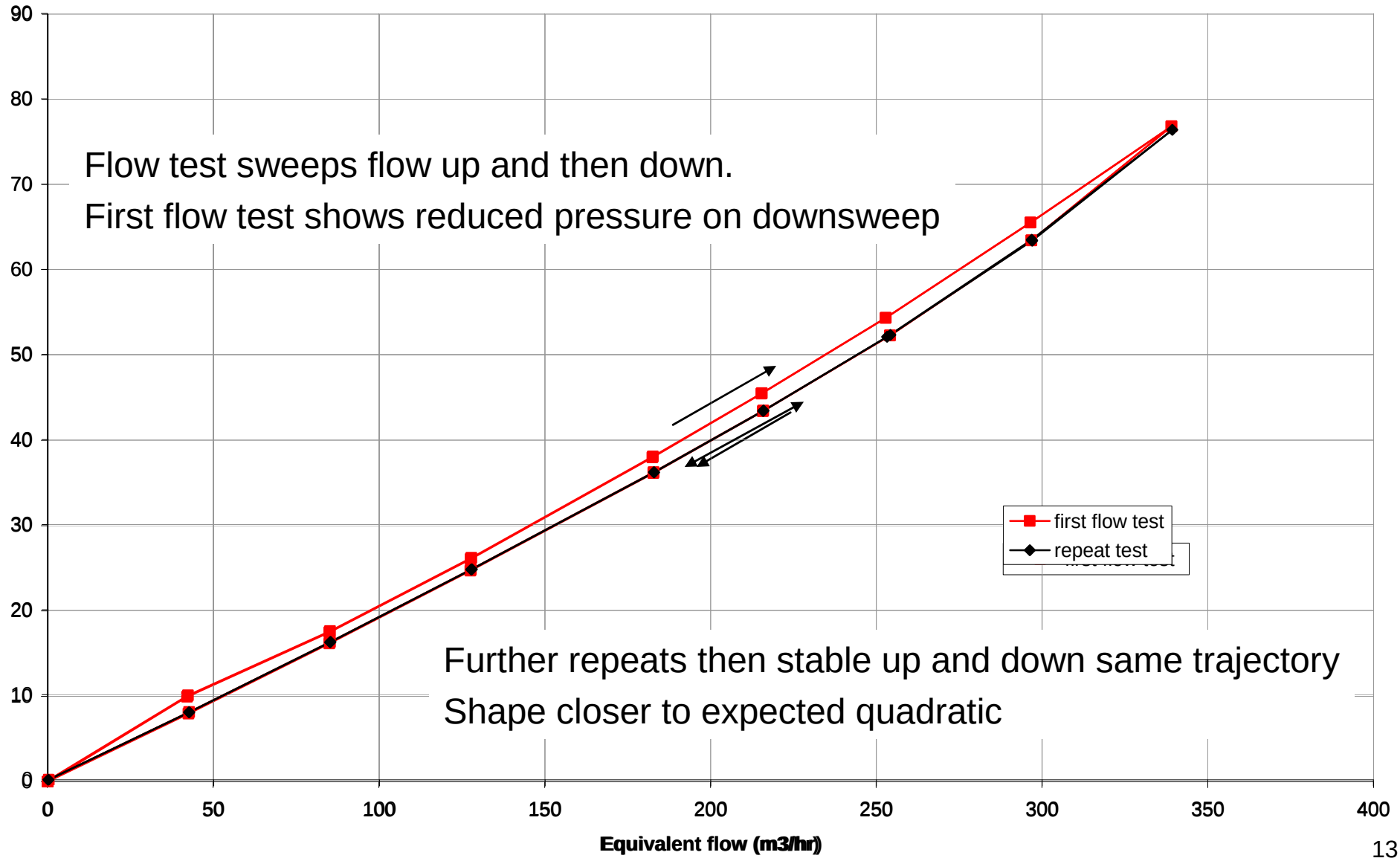
Engine Details

- 2l Common rail Diesel engine
- Stage 4 emissions compliant
- Mounted on dynamic dyno
  - Comparisons made with cycle soot
- Fitted with Diesel Oxidation Catalyst upstream of DPF
  - In this test programme, the DPG testing was **not** fitted with the DOC. This is to simulate best the application of the DPG for testing filters which are then used with an upstream DOC, currently the majority application.
  - For single brick systems, the engine soot would differ mainly via higher levels of volatile components.
- All tests performed on the same DPF:
  - 5.66” dia x 10” 4.1 l
  - Uncatalysed SiC.

Soot Loading Conditions

- Engine – 3 conditions used
  - NEDC – approx 3g/h for this engine
  - ‘Rural’ drive cycle – 6g/h
  - Steady state accelerated soot loading (modified engine operating points) – 10g/h
- DPG
  - All tests at approx 10 g/h setpoint

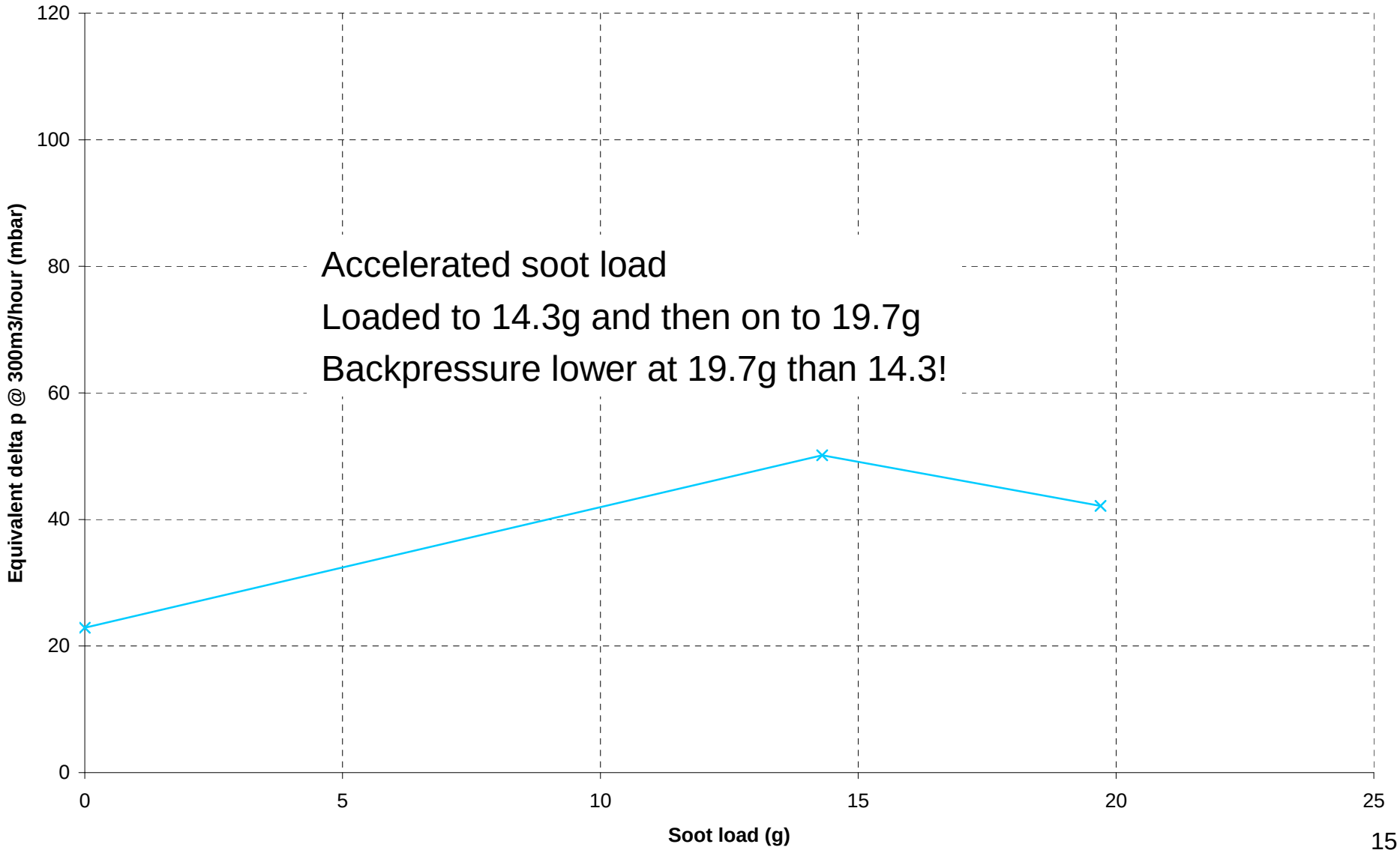
Effect 1: Backpressure ‘Relaxation’ in flow test 27g load



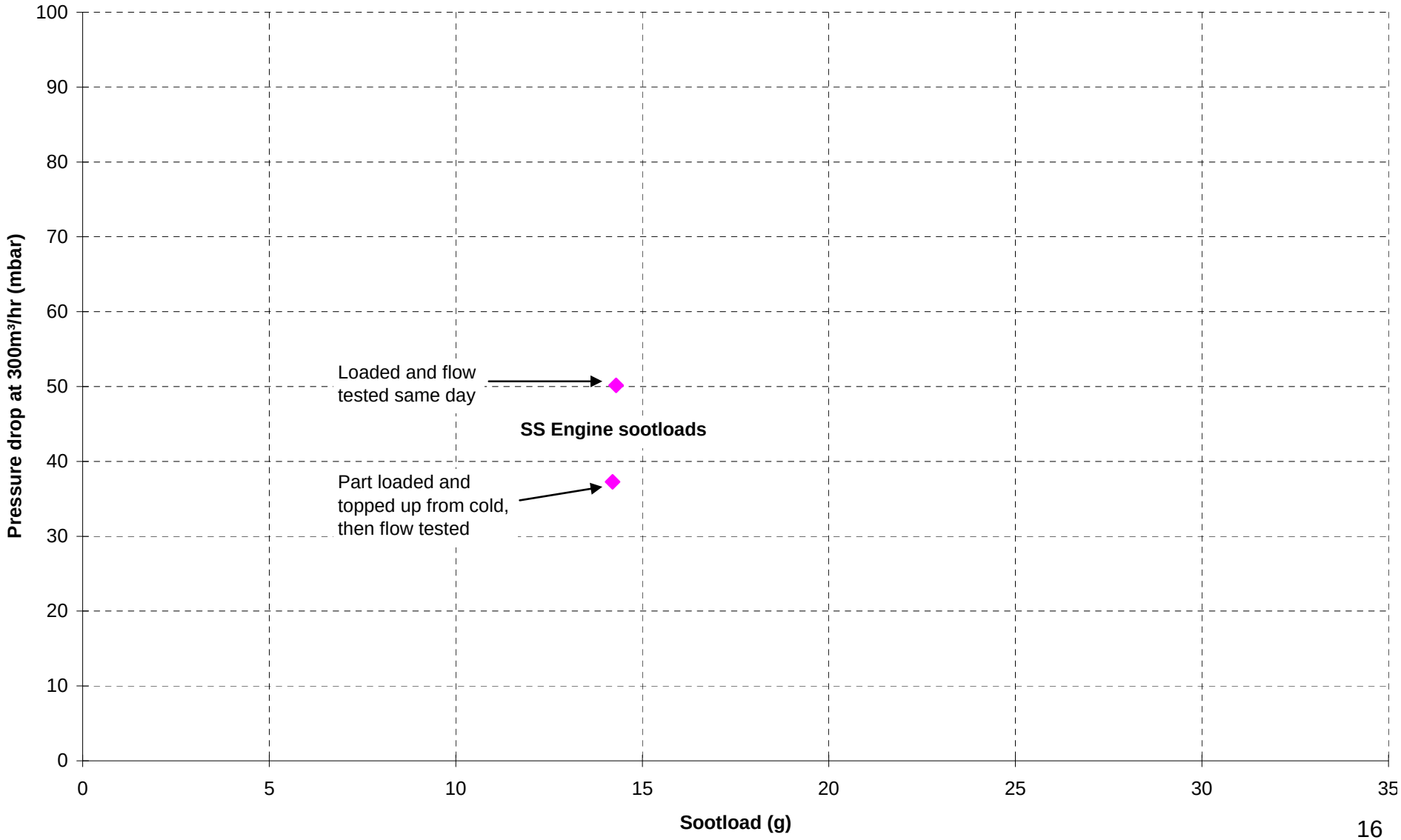
High Flow Relaxation Conclusions

- Deposited soot is disturbed by high flow conditions
- Once relaxation has occurred, soot is then stable.
- Flow tests all repeated twice in this work, and data quoted from repeat.

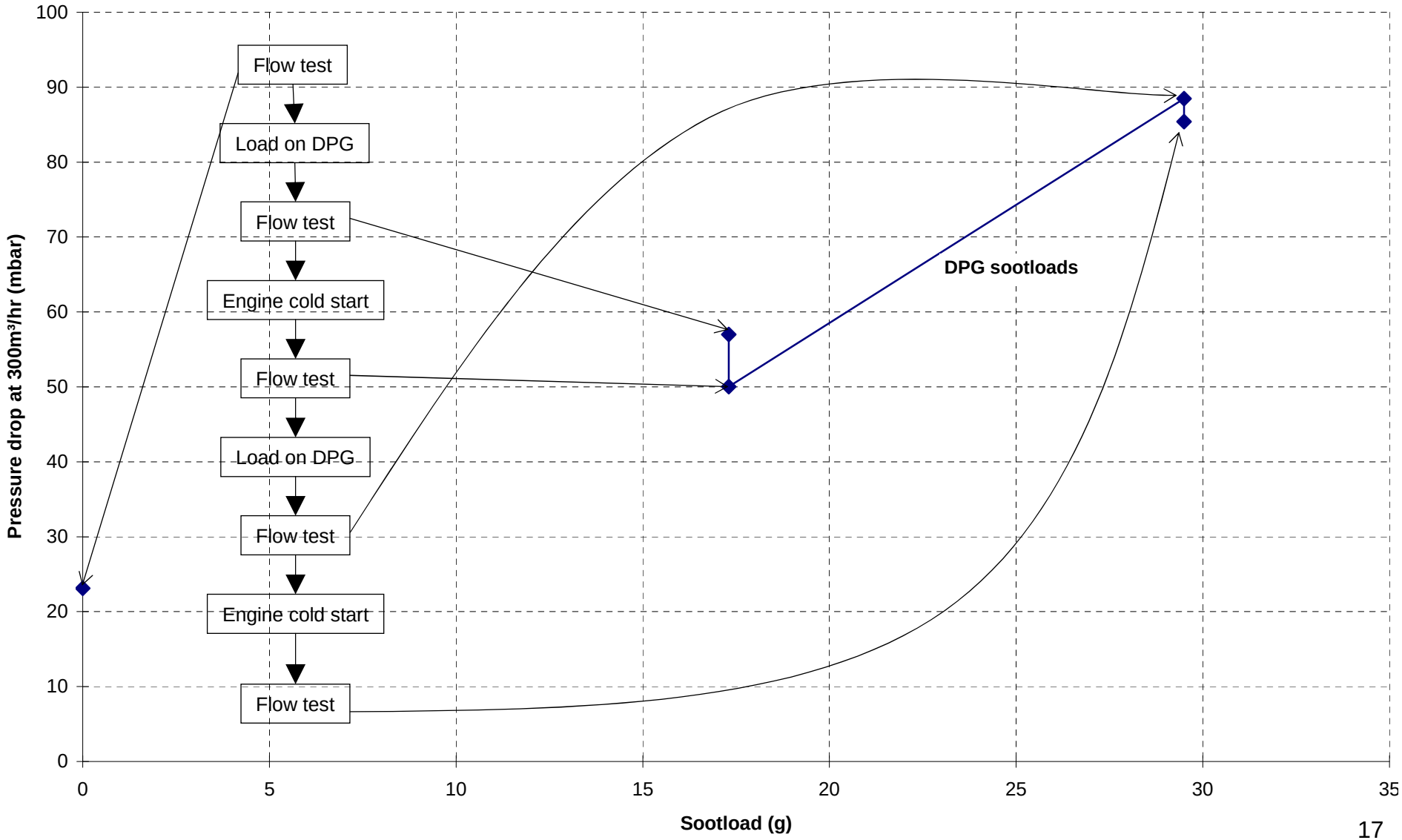
Backpressure reduction in multistage loading (1)



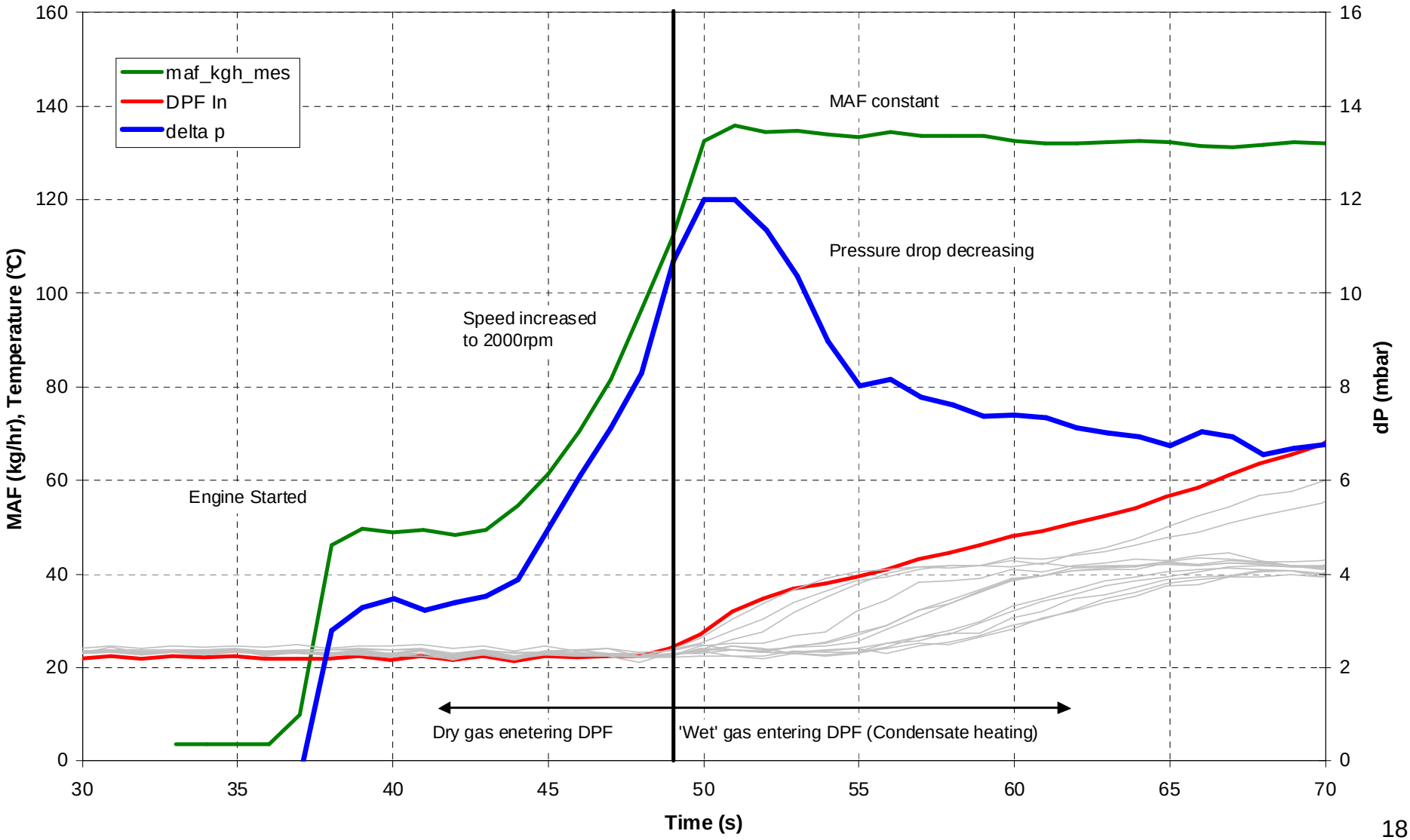
Backpressure Reduction In multistage loading (2)



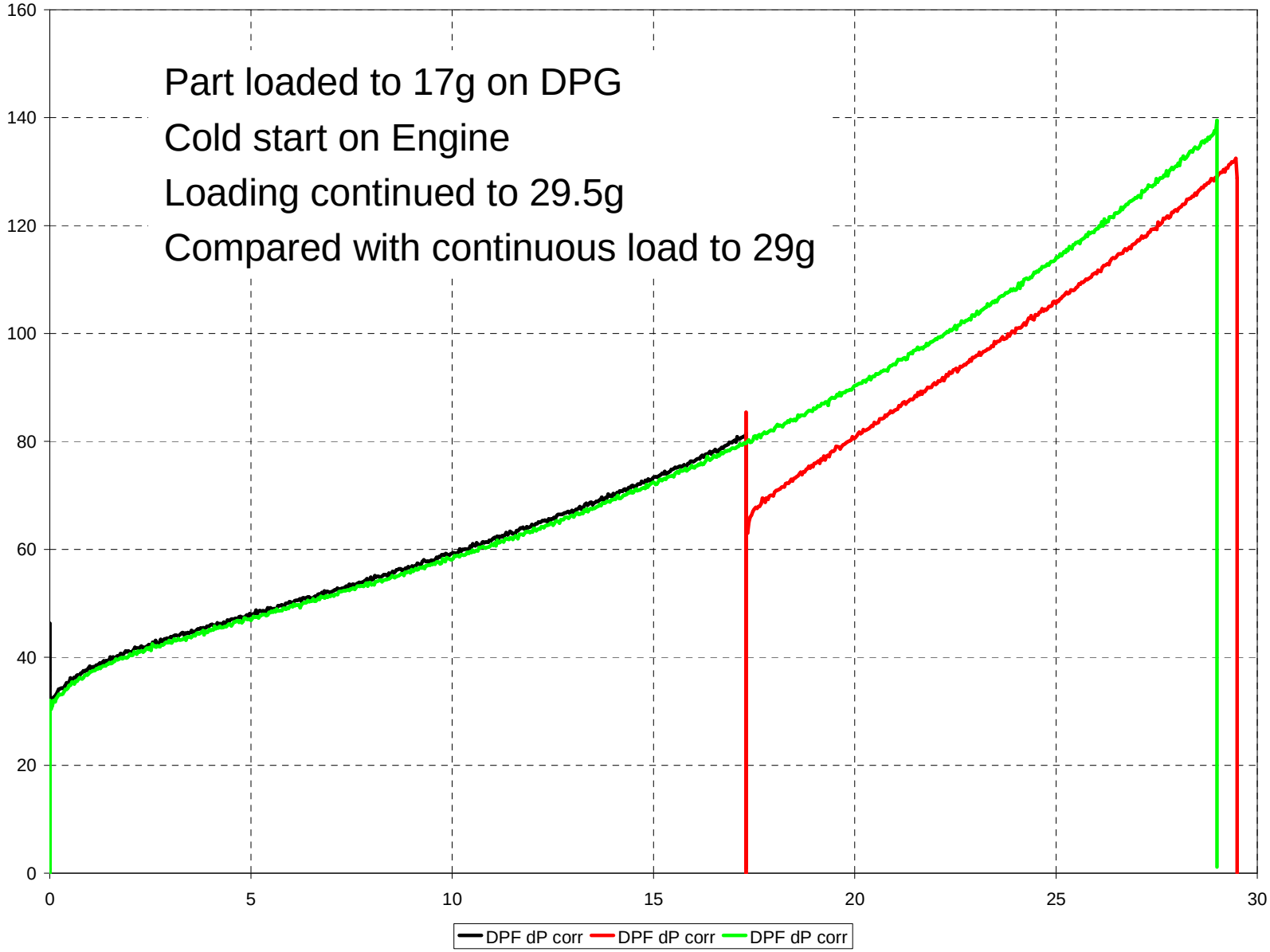
DPG soot subjected to cold start on engine



Cold Restart Backpressure Reduction



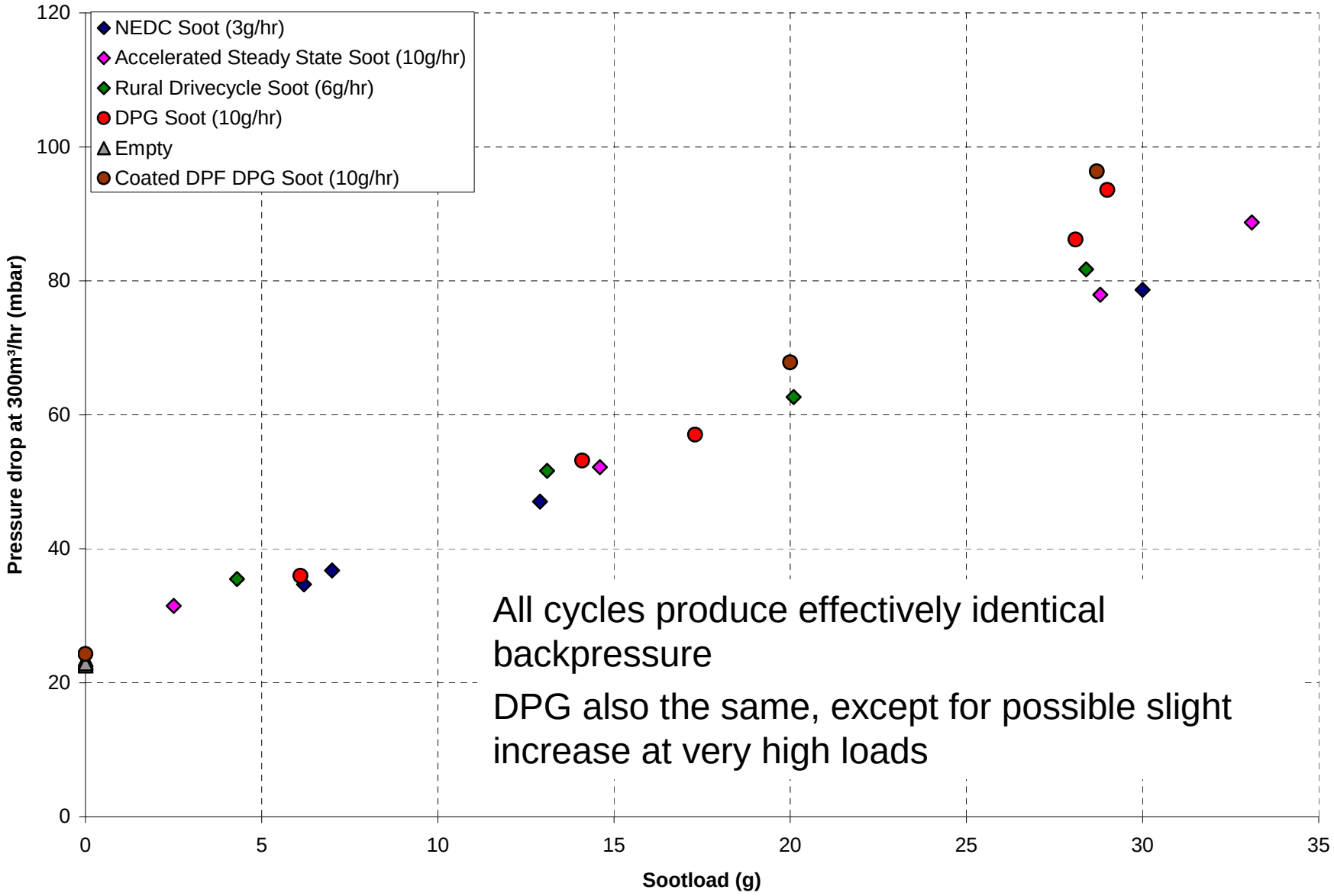
Recovery of Reduced Backpressure



Effect of Cold Start - summary

- Regardless of soot type, engine cold start appears to cause reduction in backpressure
- Does not occur with restart in loading on DPG
- Reduction in backpressure is visible in real time during engine start
- Possibly connected with condensation & re-evaporation of water from soot cake, damaging the structure.
- Reduction in backpressure not fully recovered with further loading.
- All engine loaded data in the comparison is therefore loaded directly from zero to the final weight.
  - Significant increase in the amount of testing required.

Backpressure vs Soot Load Engine & DPG



All cycles produce effectively identical backpressure

DPG also the same, except for possible slight increase at very high loads

Conclusions

- Significant effects on backpressure measurement noted in this work:
  - Relaxation of soot at high flow rates
  - Permanent reduction in backpressure by engine cold start
- With these effects avoided, all engine cycles produced very similar backpressure vs soot load.
- DPG soot also behaves the same as engine soot.
- Inconsistent with earlier experience
  - Previous tests did not carefully avoid effects above
  - Increased variability in engine rather than DPG tests
  - Different behaviour of different engines.

Further Work

- There is scope for further work:
  - Variation in soot behaviour between different engines.
  - Effect of different filter types (catalysed, materials)
  - Investigation of effects at very high loads
  - Comparison of regeneration behaviour of engine & DPG soot – ongoing.

Acknowledgements

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