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MINUTES OF 13TH DECEMBER PMP HEAVY DUTY VALIDATION/ROUND-ROBIN PLANNING MEETING

JRC Investigative Experiment Results

1. JRC presented the preliminary results of their exploratory test work with the Golden Engine. HEPA filters were found to be necessary on all dilution air, and in this case, were able to reduce particle background levels to below 5cm^{-3} . Particulate mass background levels across WHSC cycles were equivalent to around 1-2mg/kWh with (single filter paper) emissions from the Golden Engine at around 2.5 - 4.5mg/kWh with TX40 filters. Substantially lower mass was collected with a Teflo filter, but this may have been influenced by leakage from the filter holder.
2. The two 3010D CPCs contained in the Golden Measurement Systems (Horiba SPCSs) both showed around 10% lower reading than a reference PNC (CPC 3790) when exposed to a dry test aerosol and <1% difference relative to one another. The SPCSs showed a 15% underestimation of the emissions when compared to a reference PNC measuring downstream a thermodenuder. JRC concluded that the difference was due to thermophoretic losses. They explained that the SPCS's were calibrated for gas dilution and to demonstrate compliance with solid particle penetration efficiency requirements rather than for particle concentration reduction factor (the new approach agreed in August 2007).
3. Over a WHTC test the SPCSs agreed within 10% with both sampling from the CVS. Measurements with and without a cyclone showed no significant difference in particle numbers. The effect of a 4m heated line upstream of a SPCS was also negligible (<5%). Sampling from partial flow systems the two SPCSs agreed to within 17%, a similar level of agreement was seen with one SPCS connected to an AVL partial flow sampling system and the other connected to a Sistem PSS partial flow system. It was noted that peak concentrations from the partial flow sampling system during hot start tests were very low, around 100cm^{-3} , making background particle levels a very significant influence on results.
4. Experiments suggested that end of day pre-conditioning should involve 15 minutes at ESC mode 10 followed by 30 minutes at ESC mode 7 to condition the engine and ensure stable DPF soot loading.
5. It was clarified that, for partial flow sampling, use of a cyclone or heating of the system was not required (a residence time at $47^\circ\text{C} \pm 5^\circ\text{C}$ for at least 0.2 seconds prior to the filter face is however required).

6. For full flow sampling a pump will be required to achieve the 90l/min flow rate required for the cyclone cut size. It may be necessary to circulate the pump to Validation exercise laboratories with the measuring systems.

Japanese Round-Robin - Initial Results

7. Mr Yamada gave a presentation of initial results from Japanese Round-Robin testing using a Hino engine with catalysed DPF and the Horiba SPCS measurement system. The Japanese programme will involve testing of this engine at both NTSEL and JARI. Initial testing at NTSEL is now complete.
8. No statistically significant differences were seen between full and partial flow sampling measurements for either PM or particle number.
9. Repeat, hot WHTC testing showed particle number results decreasing with subsequent tests. Discussions suggested that this was probably due to DPF filtration efficiency increasing with increased soot loading from test to test, since the DPF had been regenerated immediately prior to each cold start WHTC test in the cold, hot, hot sequence. As per the PMP light duty test programme, PM appeared insensitive to DPF loading.
10. Comparing full and partial flow particle number results NTSEL reported approximately 10% particle losses in full-flow measurements in cold start tests compared to partial flow results. Matter suggested that this might be due to agglomeration of particles in the transfer line at the higher particle concentrations seen in cold start tests.
11. Cold start particle number results were reported to be around 1000 times higher than hot start results. It was noted that DPF loading was a contributory factor to such a high ratio. EMPA queried whether we could be certain that there was no volatile penetration of the VPR in the cold start tests contributing to such a high ratio. This was generally considered unlikely although a clear conclusion could not be reached from the data presented. Subsequent discussion between JRC and Mr Yamada highlighted that NTSEL's cold start WHTC particle number measurement levels were consistent with those seen at JRC from the Golden Engine.

Heavy Duty Test Protocol

12. The lubricating oil specification for the Validation exercise will be added to the test protocol. Daimler commented that for the lube oil in the Round Robin reference engine should not be changed at each lab. It was agreed that it may be necessary to drain it prior to air freighting of the engine between continents, in which case Daimler will provide details of the lubricant specification.
13. It was confirmed that the test fuel would be RF06 in both Round Robin and Validation exercises. In the case of the Round Robin separate batches of fuel would be used at each lab (in the Validation exercise labs will purchase fuel from a single batch).

14. JRC agreed to circulate a list of information on instrumentation/connectors that would be supplied with the Golden Engine, to assist labs in commissioning the engine. Daimler would do likewise for the Round Robin reference engine.
15. Since no SCR equipped engines were scheduled to be tested it was agreed that the hot start WHTC following 20 minute soak would be deleted from the test matrix. This would be replaced by a WHSC test, eliminating the need for the two days WHSC testing currently at the end of the test matrix.
16. It was clarified that should additional cold start WHTC tests be required at a lab, due to one or more test results being outliers or non valid tests (e.g. engine stall, malfunction during the test), then the pre-conditioning, cold soak and cold test only needed to be repeated and not the full days testing following the cold start test. No more than 2 repeat tests will be required at a lab in the event of non-valid tests or some results being classified as outliers. Statistical criteria defining outlier results will be added to the test protocol.
17. End of day pre-conditioning of 15 minutes at mode 10 and 30 minutes at mode 7 will be added to the test protocol. At the end of testing in each lab a full regeneration of the DPF will be performed by running for 1 hour at full load before sending the engine to the next lab.
18. Pre-conditioning for WHSC tests will be as defined in GTR 4.
19. In the case of Round Robin laboratories, where practical constraints prevent CVS dilution tunnels being left unused between end of day pre-conditioning and the first cold start WHTC of the next day, this should be noted as a possible influence in the results reported. Where this is the case, Round Robin labs should make every effort to limit overnight testing to testing of DPF equipped engines. Validation labs will ensure that there is no overnight use of the CVS.
20. UTAC noted that the 5 minute soak period between cold and hot WHTC's made CO measurement from the bagged sample problematic. Some labs might find it necessary to wait until after the hot start WHTC to sample the cold start WHTC bag. This will mean that the interval between completion of test and sampling of the bag is not strictly within Reg 49 requirements.
21. It was clarified that the use of a cyclone with full flow sampling would be optional within the Round Robin.
22. CVS flow rates should be within the range 60-100 l/min (or equivalent residence times). Flexibility will be allowed on secondary tunnel dilution ratios provided that filter face temperature, velocity and residence time at temperature requirements are met. Partial flow sampling control should be set to reactive not predictive.
23. For the Validation exercise 47mm TX40 filter papers will be used.
24. Particle number sampling equipment specifications will be updated in line with the changes made in ECE/TRANS/WP.29/GRPE/2007/8/Rev.1 (proposal to insert particle number measurement in Regulation 83 for consideration at GRPE 55).
25. Sampling lines should be specified as stainless steel for preference with conductive silicone favoured over TYGON.

26. Full calibration data must be submitted for all particle number measurement systems used in the Validation and Round Robin exercises.
27. OICA requested that Round Robin labs be allowed to take particle number measurements from partial flow sampling systems. It was explained that lack of experience with partial flow particle number sampling necessitated greater guidance and control of this aspect of validating the measurement procedure. This was the reason why it had been clearly set out at previous meetings that partial flow particle number measurement would be limited to the Validation exercise.
28. After some discussion it was agreed that Round Robin labs testing before completion of the Validation exercise, would be allowed to make partial flow particle number measurements in addition to full flow measurements. This will allow any abnormal results due to partial flow operating set-up to be identified and discounted. Round Robin labs testing after completion of the Validation exercise and finalisation of the protocol for partial flow sampling would be allowed the option of making only partial flow measurements if they wished.

VALIDATION & ROUND ROBIN SCHEDULES

29. JRC will have completed testing and be ready to ship the engine by the end of February 2008. The following schedule of test laboratories was agreed. None of the labs had plans to test additional engines.

JRC	To end of February 2008
AVL-MTC	March-April 2008
Ricardo	May-June 2008
UTAC	July-August 2008
Review of data accumulated	September 2008
EMPA	October-November 2008
JRC	December 2008-January 2009

30. The following schedule of Round Robin test labs was agreed subject to confirmation by those labs not present. It was noted that the timing, after the first few labs, was indicative only and that there was a high probability of some slippage.

TUV	April-May 2008
Ricardo	June-August 2008
Volvo	September-October 2008
Japan & Korea	November 2008 - June 2009
JRC	July-August 2009
UTAC	September-October 2009

TNO	November-December 2009
VTT	January-February 2010
Scania	March-April 2010
Environment Canada	June-August 2010
Daimler Chrysler	September 2010

31. Progress and scheduling will be reviewed late in 2009.

32. The chairman closed the meeting and thanked the participants. JRC gave a tour of their heavy duty test cell with the Golden Engine and Golden Measurement Systems installed.

Chris Parkin
PMP Chairman