

Fifteenth Plenary meeting of the Working Group On Off-Cycle Emissions 10 and 11 October 2006, Ann Arbor, Michigan, USA.

The Chairperson welcomed all of the attendees to the meeting and expressed his thanks to EMA for sponsoring the lunchtime meals and coffee service for both the Plenary and Editorial meetings.

Agenda Item 1

- A. The draft agenda was amended to include a presentation by OICA under Item 3.
- B. The draft agenda was reviewed and approved by the plenary group, a copy of the final Agenda is attached to these minutes.

Agenda Item 2

- A. The members did not have any comments on the minutes of the Fourteenth Plenary Meeting ("14th") at this time. If the Chairperson or Secretary do not receive any comments in the next two weeks, the minutes will be considered final and will be submitted to the GRPE Secretary for posting as an informal document.

Agenda Item 3

- A. The European Commission ("EC") stated that it has financed a joint project between TNO and DG Enterprise to evaluate the WNTE Control Zone using EURO certified vehicles and studying European driving behaviors. The draft report was provided to DG Enterprise a few weeks ago, but it is not yet finalized. The draft Executive Summary was circulated to the OCE group prior to this meeting. TNO, as project lead, will present a brief summary of the results of the study. Once the report is finalized, it will be circulated to the group.

Presentation by TNO. The project reviewed data collected from in use tests conducted using Portable Emission Measurement Systems (PEMS) to determine if the current WNTE control zone would cover driving conditions or engine operation in the EU. Originally the project focused on evaluating the WNTE control zone concept in the EU, but then the scope of the project expanded at the request of the European Commission (EC) to review alternative approaches.

The presentation discussed the ambient conditions encountered during the evaluation. It was determined that very high altitude is not of great concern in the EU, since the majority of the countries are primarily located at points below 1680 meters. The weather conditions do pose issues, and the data taken from the various weather stations show that the average temperatures are less than in those prescribed in the draft GTR without the use of emission correction factors. The data from the weather stations was only used to look at average temperatures and did not include information on traffic conditions. The average temperature was the average from all of the weather stations, the majority of which were located at altitudes less than 200 meters. EMA asked if ozone was the primary focus of the study, because if this is the case, they should concentrate on summer temperatures more than year round temperatures. The Chairperson stated if the TNO study only looked at ozone, the EMA comment is valid, but this is not the case with the draft GTR because it covers all gaseous components. The EC stated that ozone was a key concern, but cold temperatures are also of concern.

The data showed that in the EU, the vehicles operate only about 20% of the time in the WNTE control zone. Data was also presented which showed that by increasing the WNTE control zone boundaries, it may be possible to eliminate the use of correction factors, which would simplify EU type approval. The Chairperson asked what the EC's perspective was regarding the use of emission correction factors for temperature and humidity and why is this outside the scope of the study?

TNO stated that it is not possible to cover all possible driving conditions in the EU as contemplated by the current draft GTR. The WNTE control zone needs to be drastically

increased to cover all possible EU driving conditions. In the study, if the WNTE control zone is widened slightly, 65% of EU driving conditions are covered. The project is just highlighting proposals for the European Commission to consider, it is not for the project contractors to decide which path the working group will pursue. Correction factors were left outside of the study, because TNO was not asked to include correction factors in the analysis. The current GTR has correction factors and manufacturers have some flexibility on which correction factors they can use, so in the EU there is risk associated with this, because multiple type approval authorities could result in different correction factors being applied. The Chairperson asked if the concern is that the emission correction factors for temperature and humidity are not specified or is it the fundamental issue of having correction factors? The EC stated it would like to see a system in place that is simple, robust, transparent and without a lot of discretion. The current GTR with the allowance for emission correction factors for specified ranges of temperature and humidity does not fit well with the EU ambient conditions, and the Commissions concern with the use of unspecified correction factors, so there is a need for specificity in the correction factors that can be used. The TNO study is to see how the WNTE control zone fit EU conditions. There is too much uncertainty as to how correction factors will be used. Canada stated that perhaps, due to the varying conditions in the EU, there may be a lot of reliance on the use of correction factors, and perhaps that is why they want some certainty as to how will the correction factors will be used and applied. TNO believes that correction factors increase emission levels and this may also be an issue. The Chairperson asked if any data exists to tie the WNTE control zone effectiveness more directly to heavy-duty vehicle operations rather than to weather stations? The Chairperson stated that in January 2005, the US EPA gave a presentation to the OCE Plenary Group which showed for the US the relationship between ambient temperature and vehicle kilometers traveled by a certain type of heavy-duty vehicle and were able to tag it to the local weather station. The EC stated that this analysis can be done but the problem when doing this type of study is the high cost and the difficulty to find a good set of data for the EU 25, in that you may end up with a mix in quality of data because the data sets are so different.

TNO described the OCE data analysis approaches and the methodology used to calculate results. The EURO III engines and the EURO V engine, which were optimized for the EU steady-state cycle, were evaluated. The results were calculated for each individual truck and miles traveled and driving conditions were also evaluated. For the EU situation, the WNTE control zone concept, with a 30 second sampling period does not cover low loads and low engine speeds, since they usually occur under transient conditions and are excluded when the 30 second sampling rule is applied. The current WNTE control zone is thus problematic if a regulator is interested in covering a broader area of driving conditions. The WNTE control zone approach is more suited to motorway driving. Under urban driving conditions, only 22% of the total time traveled is covered by the control zone and only 33% of NO_x emissions and 28% of PM emissions were covered. OICA asked what type of data was TNO requested to generate, because there is existing data on vehicles which transport goods. EMA asked if TNO looked at the WNTE control zone in combination with the WHDC and WNTE, because it seems much of the area that is missing is covered by the WHDC. TNO did look to see how well WHDC is covered by the WNTE control zone, but it was difficult to come to a conclusion because it will depend on how the off-cycle emission monitoring is going to be used. The Chairperson asked what definition of the control zone TNO used: the definition of the control zone in the US EPA regulations or the GTR draft definition. TNO stated that they used the latest definition of the WNTE control zone in the GTR draft. TNO also looked at the impact of modifications to the WNTE control zone concept. One such approach involved keeping the size of the zone the same, but reducing the sampling period to 10 seconds rather than 30 seconds. This resulted in improved results resulting in 45% of driving time being covered. They also looked to enlarge the control area by reducing torque and power limits of the WNTE control zone in order to increase the size of the zone as well as decreasing the sampling period to 10 seconds. There were still concerns with this approach, in that while more of the vehicle operation is included, but still the highly transient operation was not covered. In addition, therefore there is a risk that a good engine with short emission peaks won't comply with the regulation.

An alternative approach studied by TNO was the “work window” approach. This approach covers the complete driving range of the vehicle. Emission and engine power data are averaged over time periods and the cumulative positive engine power amounts to a value. This approach has an advantage in that periods of low engine load operation have a smaller influence on the overall averaged emissions. A third approach studied was the “CO2 specific” approach. This involves relating the total emissions during the total driving time to the total CO2 emissions. The CO2 specific emissions would then be compared with the limit values based on the emission limits specified in a regulation. TNO observed that when either the “work window” or the “CO2 specific” approach, on the order of 99% of NOx and PM emissions are subject to the off-cycle requirement. A key feature of these two approaches are that all relevant operating conditions are covered by the off-cycle test, and can be classified as an emission events. The advantage of the CO2 approach is that no “tricks” are needed. Even at idle and low loads it is possible to have accurate CO2 emissions measurement. The CO2 specific approach is a more robust method of measuring emissions. Emissions are also less sensitive to ambient conditions. The expert from TNO stated they currently had no explanation for this, but it is an interesting observation. If the CO2 specific method is used for on-vehicle in-use conformity work, it has the advantage that power and engine speed information are not needed from the engine’s ECM. TNO also believes it will be less sensitive to portable emission measurement system (PEMS) flow measurement errors.

OICA asked why there is such a dramatic change between 30 second and 10 second sampling events when looking at the WNTC control zone. TNO stated that the data becomes more scattered. The shorter the average timing the greater the difference is. 30 seconds is a good stable measurement but it prevents the measurement of emissions during most transient operation. OICA wanted to know why so much emphasis was placed on transients’ in-use. TNO stated they are not putting emphasis on urban driving conditions. They don’t want a detection method to detect just the short emission spikes but rather a method that allows the short spikes but which also detects strategies. EMA asked what the impact on the CO2 specific method would be if you have new fuel economy technologies. TNO stated that with the CO2 specific approach you determine a fixed compliance factor based on the type approval values. There is no punishment for improving the engine, but when you have brake specific emissions you can optimize for fuel economy strategies.

TNO summarized by saying that all the approaches have advantages and disadvantages. The WNTC control zone specified in the draft GTR only covers 30% of EU heavy duty emission. Urban and rural driving are not well covered and TNO believes this does not add any value to the existing type approval test.

OICA stated that when they discuss ambient conditions, industry presented some information on the status in the EU. A two step approach was discussed which was developed by Professor Samaras. This information has to be considered in view of the TNO presentation. The OICA presentation looked at vehicle miles driven, similar to the US approach; therefore there is a need to look at this.

OICA also stated that a lot of the TNO presentation deals with PEMS and in-use which is not within the scope of the OCE working group. Therefore they still need to have additional discussion on how this can be used within the work of the OCE group which is type approval.

The Chairperson stated that the mandate of the group is to consider how the GTR will address off-cycle emissions. In the last two years we have looked at a two step approach, a prohibition against defeat devices as covered in the definitions and the WNTC control zone. Thus he does not see how the TNO recommendations are contrary to the group’s mandate, and the information regarding in-use PEMS testing is clearly relevant and within the scope of the groups mandate.

OICA stated that in the current EU directives there are provisions dealing with off-cycle emissions and there will be in-use conformance requirements based on PEMS. If manufacturers are able to meet the off-cycle provisions during the type approval process, they will meet them in-use. They have to be linked but they do not have to be identical. The EC stated that so far, they have been looking at the two hand in hand: type approval and applying them to in-use, so there is a need to understand the in-use side of off-cycle emission as well.

OICA stated that some of the TNO conclusions apply only to in-use and should not be part of this groups consideration. TNO agrees that the parts which apply to the use of PEMS can just be in-use.

The Chairperson asked why TNO came to the conclusion that if the current draft WNTE approach is pursued, why in TNO's opinion there would be little value added to the existing type-approval process. TNO felt that it would be good if off-cycle represents real world conditions but if the WNTE control zone only covers 30% it is not sufficient. Canada asked what the OCE groups objective is? Off-cycle does not represent typical in-use driving conditions, but the WHDC is aimed at looking at the typical driving conditions, it maybe okay that it is not addressing all driving conditions.

The Chairperson observed with respect to TNO's work on a Euro V vehicle that it is difficult to take too much away from a single vehicle, which does not have to meet too many additional provisions. 2007 is the first model year that all the US EPA certified heavy-duty diesel engines will have to meet US NTE. Last year in Chicago, EPA presented data to the OCE plenary group regarding an NTE compliant vehicle from the east coast of the US to the city of Denver and back and collected on-vehicle emissions and performance data. It was certified to the US 2004 standards, which includes the US FTP, the US NTE and the EURO 13 mode test cycle. When EPA looked at the total emissions of the vehicle it met the FTP standard, even when operating in the NTE. It never exceeded the NTE emission limit except for a few samples out of 1000s. Therefore, as a result of the combination of the certification test cycles and the NTE, the vehicle in-use was emitting on average at the NOx standard it was certified to. The US EPA does not look at the NTE in isolation; all of the certification requirements in total are important, and no single test covers all of the operation.

The EC stated that from a EURO perspective have more urban driving conditions, therefore not sure this would address those conditions. This is becoming a big issue in the EU. So the question is will the draft GTR address this or will there be residual issues which will need to be addressed separately.

Canada stated that the objective should not be to have 100% of the engine's in-use emissions monitored. The OCE gtr should compliment the WHTC, not override or replace it. If there is a specific application, where no events are being recorded, there may be a need to have a different method for that type of engine or vehicle application.

The Chairperson stated that he does not agree with the statement that a WNTE would have no additional value to a laboratory-based certification or type approval test. In the US, the NTE has consistently proven to be is a very powerful tool for control emissions. The NTE has resulted in a strong incentive to ensure that the emission standards are being met in-use, and the NTE has allowed EPA to perform in-use, on vehicle emissions testing which the US did not have before. With regard to the issue temperature and humidity-based emission correction factors, the chairperson agrees that ensuring a level playing field is important. The EC stated that the situation in the EU is unique in that there are 27 type approval authorities, not one; therefore, there is a need for transparency. The Chairperson asked the hypothetical question - if the OCE group were to undertake a robust testing program and develop specific correction factors which all manufacturers must use, would this address the concerns expressed by the EC? The EC stated that they are not opposed to the use of correction factors, but specification of the correction factors is important.

EMA stated that the development of universal correction factors makes sense because the alternative may be for the manufacturers to develop separate factors for each region. In addition, if we were to develop universal factors a manufacturer could use them to adjust the emissions for the engine to a specific condition not just to the end of a range. The Chairperson stated that in the late 1990s for US EPA, the manufacturers were allowed to pool data to come up with universal correction factors. OICA stated that the problem with universal correction factors is that they will always be behind the technology level, since this regulation will apply to future technology and we don't know what that will be, therefore we are only able to come up with them after the fact. It will not be easy to come up with universal correction factors, but perhaps we can come up with some general rules for correction factors, based on existing information. The Chairperson stated that there is no prohibition from going back to amend the GTR in the future to add or update correction factors, in response to future control technology.

The EC asked how the group felt about changing the size of the ambient conditions during which the WNTe applies and no temperature or humidity correction factors applied, rather than relying on correction factors? EMA believes that significant changes to the current GTR with respect to ambient conditions and the use of correction factors would likely change the overall stringency of the GTR and must be considered in that light, this includes the potential elimination of correction factors as suggested by the EC. EMA supports the inclusion of uniform correction factors in GTR which would be used by all manufacturers.

The Chairperson stated that the issue WNTe sampling period difference between a 30 second and a 10 second sampling period, may not add much value, if the purpose is to identify a defeat strategy. The Chairperson asked if any members could think of an engine or vehicle control strategy where the engine is able to recognize if it is in the zone and knows in advance how long it will be in the zone – how could the engine predict the future behavior of the driver, and therefore employ a defeat strategy for 29 seconds, but than stop for samples longer than 30 seconds? Is there an advantage to making a 10 second event from the objective of ensuring that engines are not equipped with a defeat strategy? TNO believes that such a strategy may be possible because in the future, it may be possible for on-vehicle navigation systems to optimize the engine and vehicle system if they know the future vehicle driving route, though it is true the system does not know how the driver will respond or what the traffic conditions will be. TNO feels that a 10 second or a 30 second sample is not that different, only with a 10 second sample the WNTe events will be broader but not sure there is a big advantage. TNO believes that while a 30 second sample may work well in the US, it does not work well for the EU, though a 10 second sample may not be good for the EU either. Therefore the robustness of the approach may not improve.

Regarding the presentation and the report from TNO, OICA stated that we need to know the driving conditions the results were based on, was it on a motorway, was it rural, or was it urban. We need all of the information to make a determination also need to know how often you get such high results. OICA stated that they need to know all of this before an alternative proposal to the WNTe can be fully discussed.

The Netherlands stated that the focus of off-cycle is to see what defeat strategies manufacturers can use, which allow compliance with the test cycle, but which may beat the cycle in the real world. There is a need to try to eliminate those elements where manufacturers can beat the cycle, but also have to develop a level playing field for manufacturers in type approval. There is no objection to giving a manufacturer the ability to design the engine as they need to, so long as we have a robust test cycle and way to control off-cycle emissions.

The EC stated that the next steps in the contract with TNO was for the EC to provide observations on the draft TNO report, and they hope to have a finalized report by early November. The draft report offered more questions than solutions. It did raise awareness how the EC wants to proceed with the GTR especially in-use and it has highlighted elements which

require further consideration for the GTR and also in the EU. Some member states feel if the GTR is finalized in its current format, it may not fully address off-cycle issues in the EU. The report is not viewed as a solution, but as highlighting the issues.

The Netherlands stated that we need to make the report available on a broad scale and have time to reflect on it. The technical elements and the political elements need to be discussed and it will take time to consider all of this.

The Chairperson raised concerns that some of the statements in the draft report regarding PEMS systems and the measurement of PM on vehicles are contrary to work performed in the US, and US EPA would like to see if something can be done in the draft TNO report to recognize the PM PEMS work which is being done in the US. The EC stated that TNO will also need to look at the PEMS work in the EU.

The Chairperson asked what the EU implementation year may be for heavy-duty vehicles which would be subject to the OCE GTR? If the OCE group goes down a path to develop an alternative OCE compliance mechanism, how long will the process take to turn it into a GTR? The EC stated that the entry into force ideally will be with EURO VI, but there is no specific requirement to introduce an OCE GTR at a particular stage. The EC stated that if more time is needed in order to have a robust GTR, the EC would support taking more time. From the EC's perspective, one of the alternative OCE approaches discussed by TNO could possibly add two years to the GTR development, depending on what is proposed and how. The time frame for EURO VI is on the order of 2012/2013, though timing can be adjusted if necessary.

The Chairperson stated that it is too early to speculate what the timing in the US will be. If we stay on the current path of WHDC, WHTC and OCE GTR at the earliest 2013, but this is just speculation at the US EPA staff level, and in the US such changes could only be considered through a formal notice and comment rulemaking. The Chairperson stated that if the OCE group were to further develop an OCE other than the WNTE, there is a lot of momentum behind the NTE in the US, and it is unclear what the new approach could mean in the US. If the US supported the development of an alternative approach to off-cycle emission control, it is unclear how that would impact the recently completed regulation in the US which defines a manufacturer-run, in-use, on-vehicle emissions testing program, which is built around the US NTE. World-wide, major engine and vehicle manufacturers are already working to develop the technology to comply with the US 2010 heavy-duty standards which includes the US NTE. These manufacturers will expect stability in the regulations. US EPA has not discussed what this may mean with EMA. In addition, the Chairperson stated that the NTE is also included in the Tier 4 nonroad diesel regulation which begins to be phased in starting in 2011. US EPA had proposed a work based approach for the Tier 4 nonroad regulation, but manufacturers supported the on-highway NTE approach. It is not clear to the US EPA what would be the implications on the Tier 4 nonroad diesel standards if the highway diesel program in the US were to move from the NTE to a substantially different approach. There is also the issue of money and resources and a new rulemaking requires the US EPA to give adequate lead time, therefore it is hard to speculate. From the US perspective, all of these issues are important when considering an alternative to the WNTE approach.

- B. **Presentation by EPA.** Mr. Bob Giannelli from the US EPA gave a presentation regarding portable PM measurement work. At the last plenary meeting, the US EPA was asked to provide an update on the work that is being conducted in the US regarding onboard PM measurement. Currently, in the US, there is a manufacturer run in-use testing program which is in the pilot phase through 2006. Heavy-duty diesel engine manufactures select a sample of engines every year, which are in actual customer vehicles, and the manufacturer is responsible to perform on-the-road emissions testing of the engines. The NTE is the method used for compliance testing.

For the development of in-use testing equipment for both gaseous and PM, US EPA is working with a Dodge ram truck with a Cummins diesel engine. The standards for measurement are ISO 16183 and 40 CFR Part 1065. PM measurement involves a proportional sampling system, time resolved mass scale. The scale must be for on-board measurement. The sampling system was developed by EPA and Sensors Inc.

QCM is a quartz crystal microbalance with is able to determine PM mass directly from the frequency of measurement. This is a highly sensitive mass measurement technique. Kansas City was the site of the first large scale use of a single head QCM with an initial version of the MPS, but it was not on board a vehicle. Kansas City was selected because it is representative of driving conditions in the US.

A truck was recently driven from Ann Arbor to San Diego, a distance of approximately 5000 miles. The MPS performed without problems. The control software to collect the PM mass data during the NTE events worked.

US EPA will be continuing its analysis of the EPA test cell data and will evaluate a new MPS which has been recently delivered. They will consider all PM loss mechanisms and will follow-up with engine test cell evaluation of the MPS and the 8 head QCM. SWRI is conducting the study of the MPS and the 8 head QCM. Preliminary conclusions find that the MPS operates under varied ambient conditions. MPS and QCM PM mass losses need further quantification.

OICA asked if the PM loss mechanism is related to measurement procedure. EPA states that both as mass is being deposited it is being evaporated off therefore need to understand this, so an independent evaluation will be done.

OICA asked if the QCM is going to be the only method allowed in the US or will other methods be permitted with respect to on vehicle in-use measurement. The Chairperson stated that in the WHTC there are equipment equivalency provisions, and nearly identical provisions are allowed today by EPA, therefore, if an alternative PM PEMS meets the equivalency requirements it can be used. All other systems that meet the equivalency provisions would be considered acceptable. One of the other elements of the manufacturer run in-use testing is once gaseous on-board PEMS were available, the industry and US EPA agreed to a joint test program between EPA, EMA and ARB. This program includes side-by-side comparison of the available gaseous PEMS systems along with laboratory-based measurements to develop in-use measurement allowances for the PEMS systems which are then applied in-use during the enforceable program. This agreed upon test program includes a detailed test matrix and a data analysis process which is being used to develop the in-use measurement allowances for gaseous emissions. EPA will go through a similar program for PM PEMS measurement to determine how close the PEMS systems are to the lab measurements. The gaseous measurement allowance determination process is nearly complete, but the PM program is 1 to 2 years away.

- C. **Presentation by OICA.** At the 14th OCE meeting, OICA was asked to come up with WNTE factors at this meeting for CO and HC and they presented the factors at this meeting based on how the factors for NOx and PM were previously developed.

Agenda Item 5

- A. The Chairperson stated that in the 1998 Agreement, Contracting Parties are required to provide periodic updates regarding the progress of GTR development to AC3. He proposed to modify the presentation made in June 2006 at the 52nd GRPE meeting, and have the have US give a short status update at the AC3 meeting in November. If the group does decide to gown down a different path, AC3 should have some advance notice and we can see if there is a reaction to this.

Canada asked if we want the presentation to be a progress report or will we be seeking guidance from AC3.

The Chairperson said the presentation will give some background information on the key concepts and issues, but not too much detail on the alternative approaches because we do not yet know what will happen with respect to the possible exploration of alternative approaches. When this working group gets to the appropriate point, we will need to decide if we are empowered to decide on an alternative approach or if guidance from either GRPE or AC3 is needed. The EC stated that he believes we should be able to get this guidance before AC3. The EC suggested that perhaps we can develop some options for GTR progress if we decide to follow an alternative path, if we know we are following an alternative path.

Agenda Item 6

The Chairperson stated that the next plenary and editorial meetings will take place in Geneva, Switzerland, at the Palais des Nation on Wednesday, 10 January 2007 starting at 14:30 h..

Joanna Vardas, Secretariat
Dated November 27, 2006

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