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Fifth plenary meeting of the Working Group On Off-Cycle Emissions 11 September 2003, Windsor, Canada

Meeting Minutes

Agenda Item 1

A. Jane Armstrong, the Chairperson of the Off-Cycle Emissions Working Group, commenced the proceedings by reviewing the draft agenda that was circulated prior to the meeting.
B. The Agenda for the Fifth Plenary Meeting was approved by the membership.
C. The minutes of the Fourth Plenary Meeting ("4th") were adopted by the membership.

Agenda Items 2 and 3

A. Introduction

Engine Manufacturers Association (EMA) re-presented the material from the 4th, having incorporated the new working definition for Emission Control System, which was adopted at the 4th and also having changed "Base Emission Control System" to "Base Emission Control Strategy" so that it is consistent with the other definitions.

EMA's goal in developing the new definitions is to make them more accurately reflect the way AECSs and DSs are viewed today by the US EPA. The primary concern is to distinguish between an AECS and a BECS, where a BECS encompasses the engine's normal operating controls and an AECS modifies the BECS under particular circumstances. EMA believes that the manner in which regulators have to look at these strategies is different than the way in which they were viewed before requiring a distinction be made between a BECS and an AECS.

EMA recommended eliminating the definition for Irrational Emission Control Device, because there is no true distinction between it and the definition for Defeat Device.

B. Element of Design

EMA accepts the new working definition. A suggestion was made to change the word "engine" as used in these definitions to "engine system", which includes the engine proper, but also any after treatment system(s). The US EPA indicated that the concept of "engine system" is captured in the current definition. Environment Canada added that the WWH-OBD working group has developed a definition for "engine system" and perhaps this definition could be adopted in this working group. The Chairperson proposed that we call it an "engine system" so that there is consistency between GTRs.

The US EPA indicated that the emission control system consists of a long and comprehensive list of elements, where many subsystems can be present, for example EGR control within a system and asked if consideration can be given to further breaking down sub-point (a) to list other elements, because there is a potential to have subassemblies and/or components which may be of concern, thus elaborating on the word "system" and breaking it down into all subsystems.

EMA believes that Element of Design is viewed by manufacturers as being broad, but would not object to the inclusion of subassemblies. EMA further stated that the definitions have to be as broad as possible to include all elements that an engine designer may consider in designing an engine system.

The Chairperson asked the working group how a subsystem is thought of, is it hardware, is it logic and also asked how specific does the working group want the definitions to be?

C. Emission Control Strategy
EMA indicated that perhaps the definition for Emission Control Strategy will satisfy the US EPA's concern with not having subsystems listed in the Element of Design definition. The US EPA concurred that the two definitions cover the intent of the regulations and thus, was satisfied with the working definition for Element of Design.

The Chairperson noted that in the previous version of the EMA definition, it was referred to as an Emission Control System and in this definition the word "System" is changed to "Strategy". EMA indicated that the word was changed to be consistent with the other definitions, but has not objection to the use of the word "System".

The Chairperson asked if "Strategy" in this instance encompasses a hardware component, because she wants to ensure that both hardware and software elements are covered. The UK indicated that the word "Strategy" is less firm, more vague, whereas "System" encompasses things that are more tangible. The US EPA added that "System" does come into play under the Element of Design definition and if the working group is going to use Element of Design as a key term, it may be worth elaborating on the system components.

D. Base Emission Control Strategy
EMA stated that this definition is intended to encompass the default emission control system, as opposed to an AECS, which is activated under certain conditions. The problem with the working definitions is that they could result in a literal interpretation where all BECS are AECS and even defeat devices. An example of this is a base strategy of an injection timing map, which is defined as a function of speed and load. On any given element of table you are going to select a timing; if you advance the timing, there will be more NOx, if you retard the timing, there will be more PM, CO, HC, thus reducing the effectiveness of one or more emission constituents, perhaps on a portion of the map that is not represented in test cycle. Therefore, the way you fill in the timing map for the may be considered a defeat strategy.

The US EPA asked if it is the intent of a BECS to comply with emission standards and if so, should such a statement be added to the proposed definition. EMA indicated that both the BECS and the AECS (as defined by EMA) are intended to comply with the standards and added that manufacturers have to be able to use both types of strategies.

The US EPA stated when using a strategy where the engine gravitates away from the BECS and there is a corresponding reduced effectiveness of the emission control system; this is traditionally considered an AECS. EMA indicated that this modulation is part of emission control.

The Chairperson read the working definition for AECS to illustrate how the EMA definition differs from the working definition, and explained that the working definition encompasses BECS. The Chairperson also stated that this is perhaps an obsolete definition because is does not represent how current technology engines work. Therefore, if the working group accepts the EMA logic, the group will have to throw away the working definition for AECS and adopt split definitions for BECS and AECS.

German UBA asked EMA to provide an example of BECS and AECS. An example of a BECS can be an injection timing map that provides a schedule of operation over the speed and load, this is always in effect unless a peculiar set of conditions are met that cause the AECS to activated, causing a deviation from the timing map, an offset in timing under peculiar circumstances. For example, under cold conditions the AECS will activate and the timing will be advanced to control white smoke emissions.

E. Defeat Strategy

EMA stated that this definition is similar to the working definition for defeat strategy. It includes strategies that are not normally prohibited, such as elements of the timing table that are included in the test cycle, strategies for vehicle protection which may allow the timing to be modified in response to an over heat condition and/or cold operation strategies, which are accepted in the USA due to climatic necessary. The engine warm-up strategy is used to protect the engine, but also to control smoke and hydrocarbons at the time of engine warm-up.

The US EPA clarified that warm-up and cold ambient strategies are not automatically excluded in the US, and wants to ensure that the definitions reflect that the strategy is used as needed for the protection of the engine, and thus wants regulators to retain the ability to scrutinize the strategy to see how much modulation is occurring. The US EPA has some concern about including "warm-up" with the cold start exclusion, because this is a gray area and it implies the "warm-up" strategy is an automatic pass, with no opportunity for review. Various levels of protection can be provided, but they may still warrant review. Cold start is an infrequent occurrence; therefore it is an automatic pass. The US EPA asked if "warm-up" could be taken out of this grouping.

The US EPA also asked why there was a need for cold start, warm-up and cold ambient exclusions. EMA stated that very hot conditions, which need to be protected for fall under engine protection, but with cold conditions, it is not always clear how to protect for this, as there may some degradation of the engine.

The US EPA asked that if there is both a cold start and warm-up test procedure would the exclusion then fall under bullet point 1 of the definition? EMA stated that a cold start test begins at a specific test point and what manufacturers are protecting against in bullet point 3 are for strategies which are used at temperatures below this point.

The US EPA suggested that perhaps there is a need for different levels of strategies, some of which have an automatic pass, and others which will be subject to review. Environment Canada supported the US EPA position concurring that the proposed definition does not give the regulators discretion. OICA suggested that to avoid misunderstanding, perhaps it is possible to have a separate list of approved AECDs, therefore simplifying the definition. EMA responded that the problem is in determining what is approved and what is not approved. The US EPA stated that in their review, what distinguishes an approved AECS versus an unapproved AECS is if the AECS does not reduce the effectiveness of the emission control system.

Environment Canada expressed concern about there being so much information in the definition, and perhaps it may be prudent to have a simpler definition in conjunction with a regulatory requirement that sets out what is allowed.

German UBA expressed concern with the use of words such as "protecting the engine from damage", the primary concern being that this can be liberally interpreted and that there may be other solutions for protecting the engine that are not harmful to the environment.

The UK agreed with German UBA's point, but from a regulator's point of view does not know how this determination can be made, especially in the European Union where there are many different regulators.

The US EPA stated that they use what is "reasonable", but then a decision has to be made as to what is "reasonable", for example, if technology is available from other manufacturers, or being used in other applications. Adding language such as "reasonable" and "temporarily" is a good idea, but also need to have balance in the definitions.

EMA stated that one concern that manufacturers have today is the fact that a manufacturer selects a design path early in the process and has a defined package together at the time the material is submitted for certification, at the same time other manufacturers are doing the same thing, and what they have to certify may be very different from what others have to certify. As a result, manufacturers do not always apply the same criteria when using an AECS, so it becomes very frustrating at the time of certification because one manufacturer's strategies are being compared with strategies used by other manufacturers, and manufacturers cannot know what other manufacturers are doing. It is very important that some objective criteria be established early in the process, which manufacturers will have to meet to ensure that at the time of certification, certificates will be granted. Manufacturers sometimes find that what is acceptable this year may not necessarily be acceptable next year, because other manufacturers may have raised the bar in terms of what is acceptable, which is very frustrating especially when you are preparing for the start of production and the approval hangs in the balance.

The Chairperson asked if manufactures have defined these objective criteria. EMA stated that the US EPA reviews the applications and informs manufacturers what is acceptable, so perhaps the criteria are already established by the agency.

The Chairperson asked if the situation in the EU is the same? The UK indicated that the level of review/discussions, which take place in the US, do not happen in the EU. Furthermore, technical services are in competition with one another and local manufacturers have relationships with the local technical service. OICA added that even though there is competition between type approval authorities, once an approval is granted it can be used for the whole production period of that particular engine model, until there is a change to the Directive, but in the US manufacturers have to submit carryover applications every year and the playing field may change from year to year. The US EPA stated that the intention of carryover year applications is that they are not to be subject to the same scrutiny as in the first year, but the past few years have been an anomaly, and the use of new technologies makes the applications subject to more review. It is the US EPA's intention to have carryover strategies approved without review.

EMA feels it is important that the DS definition include bullet point 4, which is not in the working definition. For example, engines that operate at higher altitudes have advanced timing to control emissions, but at the same time are also reducing the control of NOx emissions, modify timing to control black smoke. The tradeoffs are an effective and reasonable approach and have been approved by US EPA in the past. Furthermore, if this bullet point is acceptable to the working group, then manufactures could consider eliminating bullet point 3.

The US EPA stated that all tradeoffs being made today are because of technical limitations and in the absence of the tradeoff; one or both pollutants would be exceeded. The US EPA also stated that it wants to avoid indiscriminate tradeoffs. Today there are tradeoffs, which are based in physics, and there is nothing available in diesel technology to prevent this, so it is acceptable.

German UBA stated that this issue of tradeoffs might become a political issue. In the EU, for example, PM emissions are a priority, so there may be a tradeoff the industry prefers to utilize, but this may be contrary to political intentions.

The UK wanted to know if this trade-off provision would include CO_2 and also wanted to know how many BECSs there are and what distinguishes them from AECSs. EMA responded to by stating that in the US manufacturers generally first think of the constituents which are regulated in the US, but looking at the global market, it may have an impact on CO_2. With respect to the number of BECSs, EMA stated that when considering a family of ratings, there could be a BECS for each rating in a family, but

some engines may have access to multiple ratings, and each rating would be certified and comply with the regulations. A BECS can consist of a set of maps which are controlling the engine under most conditions, and there could be several elements to the strategy; the inner working relationship of the maps can be the base, normal operation.

The UK responded stating if the base strategy is the output of a number of strategies and different conditions will result in how the strategies are used, an engine can have all the maps available at all times, especially if a vehicle is equipped with a function that can select the best strategies for the conditions the vehicle is operating under, so how would this be viewed, as a BECS or an AECS. The UK expressed concern about reduced effectiveness, for example, if an engine has three timing maps which all meet the standards, but one that is less effective than the others, would this be considered an AECS. EMA stated if the ratings are bundled in a family this means they should have similar emission levels, within tolerances, though the situation described by the UK may be possible, but cannot see how. Manufacturers recognize that each rating must fully comply with the emission requirements. If you have a line haul and a waste hauler, you cannot have these ratings in the same family under the current US EPA regulations, because they would not meet the criteria for establishing a family of ratings.

The US EPA wants a concrete way to distinguish between a BECS and an AECS. Would it help manufacturers if a BECS is what is designed to comply, and an AECS is intended to modulate from the BECS and if you have reduced control as a result of the AECS, you have to go through the DS defn. EMA stated that depending on how comprehensive the certification test, there may be elements of a BECS that are not used on test and if a manufacturer just designed the map to meet the finite number of modes in the Euro test, for example, a BECS could just focus on these points. A BECS is designed to provide compliance over the tests procedures and also a proportionate level of control over a portion of the map that is not covered by the test.

The Chairperson asked how a BECS is defined under the NTE? EMA responded stating that it will be defined the same as it is here.

The Chairperson asked under what ambient conditions would a BECS operate? EMA was not able to say at this time, due to the use of aftertreatment systems, and even if the conditions are met, it does not necessarily mean that an engine is operating in the Base map.

The US EPA asked EMA what it meant by use of the word “discriminates” (last point in DS defn). EMA indicated that this is a prime example of trying to conform to the EU steady state test cycle, and once you move off a mode, for a fuel economy strategy, you go to a swiss cheese map. This should not be permitted, but if you move to a strategy which is between points which meet the MAEL requirements, then this should be okay. Different systems come into play depending if a BECS and an AECS is used.

The Chairperson asked the group if the DS definition includes the word “temporarily”, as the working definition does, will the EMA proposal be more acceptable.

The UK stated that the group has to be careful when using words such as “temporarily” and “reasonable”, because we have to know how to define temporary and reasonable.
German UBA stated that in the EMA proposed definition, it is not clear if an AECS is used temporarily. EMA indicated that the word temporarily was intentionally deleted because some engines may have a need to utilize a strategy permanently through its useful life (for example in Denver, where there are extreme cold conditions). German UBA asked if in some cases an engine has a permanent combination of a BECS and an AECS under extreme conditions, does the engine comply with type approval requirements. EMA responded that the engine would comply, because the manufacturer has to fully disclose

this in the certification process and the regulatory authority will have to make a judgment on compliance.

The Chairperson asked if there are altitude and temperature conditions that are beyond current Japanese and European rules, where an AECS will be used all the time?

The US EPA asked if there is any benefit in making a distinction between a "Base Map" and a "Base Strategy"? EMA responded by stating that a BECS incorporates more than maps, it also incorporates algorithms that control these maps. The Chairperson stated that authorities do no want to undermine their ability to regulate engines, but also want to entertain industry's definitions.

The Chairperson asked if the Virtual Engine, discussed at the Second and Fourth Plenary meetings is an AECS?

OICA stated that under the Virtual Engine concept an engine may have one set of hardware, and may also have multiple ratings with different ways to use that set of hardware, multiple BECS and each rating having its own modulating AECS. Engine switching strategies have to be considered; when a failure occurs which enables an automatic switch to another certified engine rating, the ratings will either be certified under one family or multiple families therefore, you are switching between certified ratings, so there is no harm to the environment.

The UK sees a circumstance in the future where the engine will not toggle between ratings, but an intelligent system will be in place which will recognize the conditions and select the best features from multiple ratings available, not necessarily all of the features of a single rating.

The Chairperson asked it this would be an intelligent truck, a rating change or a more subtle change? The UK stated that today we do not know what this would be, because there is no clear direction as to what is technologically possible; it may not be map to map, but parts of various maps working together. EMA stated that depending on how this is implemented it may be an AECS or a BECS. The US EPA stated that regulators do see some of this today, where different controls are used based on the conditions and strategies are used to move between modes in order to comply with the standards. The US EPA stated that if a manufacturer can demonstrate that this complies with the regulations, the US EPA would view these as a set of base maps.

The Chairperson stated that the US EPA would take the EMA proposal and make some modifications to it to see if the requested changes to the working definitions can be accommodated, and will circulate it to the other regulatory authorities for comment. The definitions will be discussed further at the next meeting. The Chairperson stated that in principle, this is a good set of definitions and perhaps the working group will be able to work with it.

Agenda Item 4

A presentation was made by Mr. Stefan Rodt of the German Federal Environmental Agency (German UBA), on off-cycle emissions.

Recent studies indicate that the actual reduction rates of new engine designs in actual operation are most likely to fall behind earlier assumptions. Electronic injection systems in heavy-duty commercial vehicles, introduced as part of the EURO II technology, allow different injection strategies to be used in the various ranges of the engine map. Recent studies have shown that EURO II engines are deliberately optimized outside of the speeds driven in the type approval testing cycle to improve the specific consumption (cycle bypass). In return, this leads to a considerable increase in NOx emissions

The conclusion of the materials presented stated how to get off cycle emissions under control, because politically speaking, the intention of updating emission legislation and reducing emission standards is to enable an overall emission level to be attained, it is industry's obligation to comply with this intention, not to search for "loopholes" or freedom of interpretation of the regulation to increase emissions above the desired level, test cycles can never be perfect, either regarding how well they represent real life operation or to protect against cycle by pass or cycle beating.

Therefore, emission requirements must not be limited to a test cycle and a defined control area, but be extended to cover all possible operating conditions engines must comply with emission requirements in any randomly selected mode of operation, under almost all ambient conditions which may occur in real life. The definition of DS and IRCS become less important if a not-to-exceed concept and clear definition of boundary conditions including ambient conditions is in place. Manufacturers will have to provide full disclosure at the time of certification on the operation and effect on emissions from the use of any devices or control strategies, as well as having the manufacturer sign a declaration that no DS or IRCS is applied which violates either the legal provisions or the basic intent of the regulation, and that the engine complies with the not-to-exceed. Finally, in-use compliance testing is more important than type approval certification, this will enable the verification of compliance with the not to exceed requirements at randomly selected modes of operation.

Some concern was raised with certain data that were presented in the material, showing that the EURO III compliant engine shows more off cycle emissions than the EURO II engines. EMA indicated that this information does not make sense, because the EURO II cycle had its weaknesses and those weaknesses were remedied with the EURO III cycle, and the introduction of mystery points. OICA also stated that the figures shown are very rough preliminary figures and not the final figures, so they cannot be given too much weight at this time, until the final figures are presented. The UK stated that the Artemis group put some data together, which included engines that were not subject to the amendment to the Directive for EURO III, so could the data in these materials be artificial especially if not taken from the EURO III engines subject to the revisions to the Directive Mr. Rodt stated that it is possible that the data are preliminary. Mr. Rodt also stated that they are still waiting for more data and engine maps, and will do on board measurement to finalize the data. OICA stated that in the official DACH report, the difference between the EURO III and the EURO II engines is 20% not 67%.

Agenda Item 5

The Chairperson asked the US EPA if incorporating the NTE into the regulation accomplished what the agency intended? The US EPA stated that this is a question to which they do not have an absolute answer, as it is only now with the 2004 compliant engines that the scope of the NTE can be appreciated. Preliminary data show that with MY 1998 compliant engines the NTE works. The US EPA feels that the right program is in place, but has to be confirmed with in-use testing and it will be more challenging with the 2004 and 2007 standards. EMA stated that for many manufacturers, the challenge in engine development was directed towards meeting the NTE, so it has already had an impact on how engines are designed.

The US EPA stated that for the past year the agency has been looking at the 2004 compliant engines and is seeing the same level of compliance with the 1998 engines. Generally the NTE is doing what it was intended to do, and the scrutiny of the AECD descriptions will lessen as the agency gains more data and develops a comfort level with the data. Manufacturers are taking great strides to be cognizant of AECDs and to reduce how frequently they are being used.

The Chairperson asked if this levels the playing field between manufacturers. EMA stated that some manufacturers had to comply with the consent decree, whereas others did not, so the playing field was not level, but as there is more clarity in the regulations, they should be applied more consistently and there should be a more level playing field.

OICA stated that in the EU, manufacturers have been successful in accomplishing the intent of the Directives without an NTE. This is a limited solution and it does not cover the full range of engine use.

The Chairperson asked what type of global NTE, which may not necessarily look like the US EPA NTE, could be considered? Is it proper to start with a zone and carve outs? The US EPA stated that in 2007, the carve outs change, there are no PM carve outs because PM filters will be used. Carve outs were based on the state of the art engines at the time NTE was negotiated, thus with PM filters, it becomes a different scenario.

German UBA asked if there are any plans to extend the control area downward. The US EPA stated that currently, there is no plan to extend the control area, but cannot rule it out, but the agency does not want to extend the control area significantly below peak torque because there may be problems with drivability. The FTP does regulate this area and the strategies are subject to scrutiny. The Chairperson stated that if the working group has some measure of the engine activity in this area, we can figure out what the expectation of manufacturers is in this area. OICA stated that the control area should cover most of the normal load operation of the engine. The US EPA stated that with the number of carve out provisions, the general purpose is to recognize the limitations of engine technology and to not hold engine manufacturers responsible for glitches in the engine operation which have a nominal effect on emissions. Looking for a level of proportional control, so what is done over the test cycles is also done outside of the test cycles.

The Chairperson asked how the global NTE would operate in a EU or Japanese context. OICA stated that the EU would be launching a research program on in-use emissions as they have recognized the problem, but do not know the time frame. The Japanese stated that they will try to have a response at the next meeting.

The Chairperson stated that in terms of the working group's activities, the applicability of a global NTE is in the future but, how will this be applied in multiple jurisdictions? The UK stated that the problem in EU is that member states will apply in-use testing requirements on their own. The Chairperson stated that an in-service compliance mechanism may help make this easier, so it does not matter whom the type approval authority is, if there is an in-service compliance mechanism.

The UK stated that enforcement becomes a problem, the fear being that manufacturers are not doing things correctly. A need exists to link the relationship between the vehicle (enforcement) and engine (type approval). Need to have a way that the vehicle will not be able to recognize that it is being scrutinized, to be sure that the right cycle is used while being measured.

Going back to a comment from the 4th, whereby the Chairperson stated that having an NTE will limit the scrutiny on applications for certification, manufacturers have found that it has been the US EPA's policy to hold manufacturers to strategies that are not defeat strategies and this may not go away with the NTE.

The US EPA stated that in 2007 this may/will not be the case. With NTE compliance, the agency has the flexibility today, though there is an NTE in place, to use strategies which take the engine out of compliance, but which are okay as long as a determination is made that it is still within the NTE limit. EMA stated that in the 2010 timeframe, engines strategies will be such that most of the time the engine will operate in this range, so will

this engine be acceptable? The US EPA responded that it would be acceptable if the NTE requirements were met. The US EPA did not scrutinize manufacturers who utilized multiple timing maps, and made the NTE compliance statement. EMA stated that manufacturers are still being questioned on AECDs, even when within the NTE limit.

German UBA suggested that if the goal is to establish a global NTE, the principles shall also be transferable to passenger cars and motorcycles, starting from the whole engine map and then deciding where the carve outs should be, adding that once we have the NTE, definitions become less important.

Agenda Item 6 (other business)

No other business was discussed.

Agenda Item 7 (next steps)

The Chairperson asked what will the group present in terms of a GTR? We have definitions, a transient test procedure, a stationary test procedure with random points, or if we continue to have a problem with definitions, do we have an NTE, describe a control area, and ambient conditions over which the NTE applies.

Agenda Item 8 (summary and conclusion)

The next plenary meeting of the Off-Cycle Working Group will be held on January 12, 2004 from 14:30 to 17:30 at the Palais Des Nations, Geneva, Switzerland. A draft agenda and any working and informal documents will be circulated to the membership prior to the meeting.

Dated this 11th day of September, 2003

Joanna Vardas, Secretariat