DRAFT PROTOCOL FOR TESTING AND VERIFYING THE PERFORMANCE OF ENGINE AND VEHICLE AFTER-MARKET TECHNOLOGIES

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1.0 INTRODUCTION

There are a number of technologies and products which claim to reduce engine emissions and fuel consumption. These technologies and products include fuel additives, catalysts, engine modifications, auxiliary power systems and other devices. In some cases, the performance claims for these technologies and products are not supported by adequate data. Sometimes the end result is that the variables which cause the claimed reduction in emissions and fuel use are not documented, and thus the underlying basis for the performance of the technology is unclear. To establish market credibility, technology proponents need to base their performance claims on test data which are reproducible and verifiable.

To address this issue, ETV Canada, with support from Environment Canada and the Ontario Research and Commercialization Program (ORCP), convened a series of meetings to determine the expectations of stakeholders with respect to testing and verifying the performance of engine/vehicle after-market technologies.

The first meeting in March 2007, involved a group of qualified experts from recognized testing organizations. The focus was to help determine how vehicle/engine technologies and products should be tested, the level of testing needed and other requirements. Participants included the Emissions Research and Measurement Division (ERMD) of Environment Canada, the Prairie Agricultural Machinery Institute (PAMI) and Bodycote Materials Testing Canada Inc. These organizations have extensive knowledge and experience in testing engine emissions/fuel use reduction technologies and verifying performance, as well as in the development of testing protocols.

This was followed by a meeting with a number of municipal fleet managers in April 2007 to obtain their feedback and suggestions regarding the criteria and procedures that should be used for testing and verifying the performance of engine and vehicle after-market devices. These first two meetings produced a discussion document to support future engagement of stakeholders in establishing acceptable environmental performance criteria and relevant test methods for vehicle and engine related technologies which claim to reduce emissions and/or fuel use.

The third meeting which took place in May 2007 involved ETV Canada, fleet managers and engine/vehicle after-market technology proponents. The focus was to review and discuss the results of the previous two meetings. It helped to determine the requirements of vendors and their expectations with respect to engine/vehicle after-market technology testing and verification.

The results of this series of meetings were presented at the Annual Meeting of the Canadian Association of Municipal Fleet Managers (CAMFM) on May 31, 2007. At the same time, the "Draft protocol for Testing and Verifying the Performance of Engine and Vehicle After-Market Technologies" was presented and subsequently endorsed by CAMFM.

It is recognized that a standardized set of appropriate test methods would be a major step in ensuring a level playing field for fair testing of technologies and products which claim to reduce the environmental impacts of vehicles in Canada. This will also assist fleet managers and

government agencies establishing performance criteria and corresponding test methods for technologies that reduce mobile source emissions.

As a follow-up to these consultations, ETV Canada has indicated its willingness to take the lead in preparing three specific proposals for funding support:

1. To share the results of this series of consultations with other vehicle fleets associations within Canada - This would help establish performance-based criteria to assist the members of these associations in selecting specific technologies that can reduce mobile source emissions. It could also involve the establishment of a focal point, with sufficient funding, to help bring parties together and to encourage information sharing through regular updates and web postings on the ETV Canada website.

2. To implement a demonstration project targeting the screening, testing and verification of up to 10 vehicle/engine after-market technologies – This would be undertaken in conjunction with the Canadian Association of Municipal Fleet Managers (CAMFM) and possibly other vehicle fleet associations. It would involve close cooperation with vehicle fleet managers, technology providers and other stakeholders.

3. To support harmonization with U.S. EPA - The U.S. EPA and Environment Canada have separate but similar Environmental Technology Verification (ETV) programs, which can assist in establishing performance criteria for various pollution control technologies for fleet vehicles. Both countries recognize that mobile emissions sources contribute to poor air quality in border regions. Working together can help local governments and fleet managers throughout North America select the appropriate technologies to reduce emissions and improve fuel use efficiency.

Each of the above proposed initiatives would be responsive to Canadian objectives for the protection and improvement of air quality and would support efforts to address mobile source emissions.

2.0 SCOPE OF ISSUES

The main objective of the ETV Canada Program is to address the overall environmental impacts of technologies, and to ensure a clear understanding of the environmental performance of these technologies as determined by well-defined testing and verification protocols. This objective is central to the concept of Environmental *Performance* Verification (EPV).

Comprehensive environmental performance verification of technologies based on comprehensive systemic criteria, such as Life Cycle Assessment, can be very expensive and difficult to implement. It is therefore important to acknowledge from the outset, the scope and limitations of any performance verification exercise. This includes recognition of the reality that verification can only be applied against quantifiable performance criteria (or things that can be measured).

Furthermore, although the ETV Canada process can help fleet managers better decide on the suitability of particular technologies for their fleets, performance verification is only one of the factors which contribute to the purchasing decision.

Other key issues for consideration include:

- The need for caution to ensure that innovative solutions are not foreclosed due to onerous, or inappropriate, testing requirements.
- The variety of operational applications for a technology based on different end-use requirements and duty cycles (for example, fire trucks may be used a couple of times per day, whilst buses may be used for 12 to 14 hours per day)
- The need to assess whether engine warranties would be valid if a particular technology is used.
- Technology reliability over the long-term – even if verified, the technology could break down
- Durability testing of vehicles (for example, based on 500 hour or 1000 hour tests)
- The importance of internationally harmonized approaches in this area (for example, through Environment Canada with the US EPA ETV Program).
- The need for a fuller assessment of the impact of the overall technology system on the environment (for example, the overall life cycle impacts and benefits of ethanol).
- The benefits of an “Energy Star” type method for classifying the energy efficiency of classes of technologies and where they fit in terms of energy use
- Recognition that fuel savings can also occur from effective management of the fleet as a whole.
- The need for a weighting system which could be used by Fleet Managers when assessing the key operational factors and performance criteria central to their engine/vehicle after-market technology purchasing decisions.

In addition to the key issues listed above, additional insights were provided by technology proponents at the third stakeholder meeting. Some of these are highlighted below:

- An estimated 80% of vehicles on the road are out-of-warranty, representing a large target group for engine/vehicle after-market technologies. Both technology proponents and fleet managers agree on the need to "screen out" engine/vehicle after-market technologies that have no environmental benefits thus allowing technologies that produce measurable benefits to be more easily recognized for their value.
- The importance of a transparent verification process was emphasized. Various engine/vehicle after-market technology proponents mentioned that they wanted clarification on the purchasing requirements of fleet managers. In response to this, one fleet manager confirmed that his organization would only be considering purchase of products with ETV Canada verification.
- The differences between verification and certification needs to be recognized. Certification is potentially onerous as it could involve certification of devices for many different engines/vehicles rather than just one.
- To address the inconsistencies which currently exist across North America, it was noted that harmonization with the US ETV program should be encouraged. It was noted progression towards harmonization with the US ETV Program will require a commitment from the federal government. Strengthening the ETV Canada Program is seen to have greater benefits relative to funding ad-hoc engine/vehicle focussed projects across the country.
- The diversity of the fleets operated by fleet managers was identified as an important consideration, particularly with regards to the high costs of testing specific segments of the fleet. For example, it was noted that ETV Canada had already worked with City of Toronto on the development and use of a testing protocol specifically for street-sweepers. Given that specific test protocols may be necessary in some cases, it is important to clarify the "full" procedure up-front, prior to spending money for testing and verification.
- Minimising the effect of the fuel type on the test runs is essential. Therefore to make test results more reliable, only one type of fuel (i.e., standard fuel) should be used.
- There was discussion about whether or not both positive and negative verifications should be publicly released by ETV Canada. It was noted that the USEPA ETV program makes public both positive and negative verifications (i.e. engine/vehicle after-market technologies that do or do not show environmental benefits from the testing). It was agreed that ETV Canada should also follow a similar route, even though ETV Canada currently does not make public verifications of technologies that do not show a positive environmental benefit.
- It was seen as useful to maintain an ongoing, open dialogue on this important topic. It was noted that a focal point is needed with sufficient funding to help bring parties together and to encourage information sharing through regular updates and web postings on the ETV Canada website.
- A key point raised was the need for political support to encourage greater acceptance of independent third-party verification of technologies. It was noted that political support for such a program is more likely to occur if a broad range of stakeholders were to make their views known.

3.0 PROPOSED FIVE-STEP PROCESS

As a result of discussion on the above issues with technical experts and fleet managers, a 5–step process has been proposed:

(1) Initial pre-screening of the proponent's technology application

(2) Engine/vehicle after-market technology testing to verify performance in accordance with the testing procedure recommended by the technical experts

(3) Verification

(4) Cost Benefit Analysis

(5) Pilot testing of the technology within the fleet (this step could also entail additional verification and cost benefit analysis).

3.1 Technology Pre-screening

Objective:

The focus of pre-screening is to determine whether an engine/vehicle after-market device or technology meets certain basic criteria prior to proceeding with testing and verification. It was noted that successful technologies at the screening stage could well attract financial support from investors.

Proposed Approach:

a) ETV Canada and the three ETV Canada recognized vehicle emissions test laboratories already provide preliminarily screening of engine/vehicle after-market technology devices. For example, initial scientific and data reviews are undertaken to determine if it is in the best interests of technology proponents to proceed with testing their technologies. An addition to the current screening process could be for the three test laboratories to consult with each other and, if necessary, additional external testing experts, to ensure a better understanding of the fundamental scientific principles which form the basis of these technologies.

b) One approach to pre-screening would be to request a preliminary technical review of the proponent's documentation by a qualified expert prior to full testing of the technology for verification purposes in accordance with the requirements specified by ETV Canada. Such a preliminary review could be undertaken by a qualified member of the Society of Automotive Engineers (SAE). Related to this, it was pointed out that the Canadian Environmental Technology Advancement Centres (CETACs) currently provide a range of support services to technology proponents, including early-stage technical review and business mentorship. For example, the Ontario Centre for Environmental Technology Advancement (OCETA) has established the Environmental Technology Demonstration Assessment Program (ETDAP), which for a modest fee, provides an analysis and report on the market potential and testing requirements for a proponent's technology.

c) Another option would be initial screening of technologies using short cycle lower-cost dynamometer testing. Such screening tests could be performed back-to-back on hot-start dynamometers, instead of using the more expensive cold start tests required for verification. While this may be valid for light duty vehicles, most aftermarket products claim to require a period of on-road driving (service accumulation) in order to see the benefits. For heavy duty vehicles, most of the testing is already hot start and without the service accumulation can be accomplished in a fairly short period of time.

d) Some after-market devices may need to be tested using technology-specific test methods which may be different than those specified under currently accepted testing protocols. Similarly, there may be certain operating variables that may make it desirable to consider testing under different conditions. These possibilities might occur, for example, as new performance criteria are identified and/or as new operating systems are implemented. Consequently, it is conceivable that after-market device proponents may approach ETV Canada with technology performance claims that cannot be adequately tested under currently accepted testing protocols. Recognizing that the Canadian ETV Program requires that the technology testing protocols and technology-specific test methods used for verification must be acceptable to the designated verification entities, ETV Canada will, as the need arises and on a case-by-case basis, facilitate a technical review with the relevant testing and verification experts in order to understand the need, if any, to modify or develop new testing protocols and, where possible, make a determination of their acceptability. Great care should be taken to not design test programs that only evaluate a product in a very narrow operating regime and without the proper QA controls in place.

Important Points:

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(a) A preliminary evaluation of existing studies examining the target technology and the theoretical basis should be the first step. An energy balance will be one of the tools used in that evaluation along with any previous work conducted by qualified researchers using recognized protocols

(b) It is recommended that additional testing be performed, where necessary, on issues such as durability and whether the technology would affect engine warranties, as well as the toxicity of fuel additives.

(c) Durability of the device under specific operating conditions needs to be considered when screening engine/vehicle after-market technologies. Therefore, pre-screening should include consideration of climatic effects and the cost issues associated with the maintenance of the technology under extreme conditions (i.e., the potential for temperature variation from -40°C to up to +40°C). It is also suggested that 24-hour salt spray testing should be requested to help ensure the suitability of technologies given the realities of Canadian climate conditions. (The Environment Canada ERMD test lab can simulate -25ºC to 40ºC and the National Research Council has facilities that can go to -40ºC.)

(d) The screening process should include information on whether the device of fuel additive will impact the engine manufacturer's warranty.

(e) Toxicity testing related to additive technologies could be based on the additive alone, or on the likely components produced in the exhaust pipe. A minimum requirement would be the submission of Material Safety Data Sheets (MSDS) as required under the Workplace Hazardous Materials Information System (WHMIS).

(f) A sound manufacturing process is essential for producing high quality engine/vehicle after-market technologies. Pre-screening on the basis of manufacturing process soundness is therefore advised.

(g) It is important to be aware that some technology proponents and product promoters do not understand the vehicle and engine testing methodologies and assume that a "lab" test cannot simulate "real" world conditions.

3.2 Testing of the technology under controlled laboratory conditions

Objective:

The focus of testing under controlled laboratory conditions is to determine with 95% statistical significance, the changes in the fuel use and/or emissions of engine/vehicle after-market technologies (and heating rates of anti-idling devices).

Proposed Approach:

(a) It was agreed that at least 3 tests without the after-market device, followed by the same 3 tests with the after-market device fitted would be the minimum acceptable in laboratory dynamometer testing to meet the requirements of ETV Canada to demonstrate statistical significance at a confidence level of 95%

(b) With regards to the choice of hot or cold cycles for laboratory based dynamometer testing, after-market technology proponents need to have understanding of their technology to determine if it is more effective on fuel use and emissions reductions on cold start engines, or on engines that are hot. This information will help in determining the costs of running the tests, as cold cycles can only be run less frequently due to the need for the engines to cool after testing. A series of preliminary steady-state tests could be performed first using less expensive (repeated) hot cycle testing to optimize or confirm optimal performance. The after-market technology could subsequently be tested on the cold and hot cycles. As previously noted, while this may be valid for light duty vehicles, most aftermarket products claim to require a period of on-road driving (service accumulation) in order to see the benefits. Also, for heavy duty vehicles, most of the testing is already hot start and without the service accumulation can be accomplished in a fairly short period of time.

(c) Auxiliary power technologies, such as cab and engine heating technologies for idling reduction would not necessarily require dynamometer testing. But emissions and fuel consumption testing for engine heating technologies should be performed in a test facility equipped with a temperature controlled 'environmental chamber'.

(d) Information on basic requirements for testing to produce verifiable data for ETV Canada is provided in Appendix 1. Currently accepted test methods are provided in Appendix 2.

Important Points:

(a) With regards to variability in dynamometer test data produced by the three laboratories, up to 5% variability might be expected, partly due to changes in temperature and humidity in the dynamometer test areas but also as a result of engine ECM learning, driver variability, in the case of chassis testing, and vehicle preparation variability. It should be noted however that data from test to test for fuel consumption should be less than 2% but for some exhaust emissions tests can be as high as 15%. With natural gas fuelled vehicles this variability can be even higher. This is part of the reason why the number of test runs for each after-market technology needs to be a minimum of three runs without the engine after-market technology fitted, and three runs under the same conditions, with the after-market technology fitted.

(b) Very low exhaust emission rates for HC and NOx will normally result in high percentage changes from test to test. A Bin 5 certified vehicle must have HC and NOx emissions of less than 0.075 and 0.04 grams/mile. Often a vehicle will produce 0.01 gm/mile on one test and 0.02 gm/mile on the next for a percentage change of 100%.

(c) The potential level of experimental error that might arise in testing vehicles on a dynamometer is analyte specific, with variability for:

- Total Hydrocarbons = 15%
- Carbon dioxide = 1.5%
- NOx = 4-8%
- CO = 10 -15%.

This information is important to determine what level of screening of technologies could be based on measurement errors such as these. In addition, dynamometer testing typically should be able to detect a 2% change in fuel use, although not on big trucks.

(d) A statistical analysis of the results at a 95% confidence level will objectively determine if there is in fact a change from the baseline results to the product results. It is important to note that if the difference between two sample means is determined to be not statistically significant, no percentage difference is reported as those two means are deemed to be equivalent. This will go a long way in preventing misinterpretation of results.

(e) Although the end result of verification might be fuel use and emissions reductions under specific conditions, other important issues would still need to be addressed such as

durability testing, the effects of additives on engine warranties and the need for additive toxicity testing.

(f) Even if an engine after-market device reduces fuel use and emissions in the short-term, its abilities to produce such results in the long term may change. As a result durability testing would be valuable for verifying performance. However, due to the difficulty in observing the test vehicle outside of laboratory controlled conditions, a preferred method might be to drive on the road under known conditions under the direction of the testing agency in order to accumulate vehicle hours with the after-market technology installed and operating. Longer runs, such as 500-hour or 1000-hour testing, could be performed on a durability test cell. On-road deterioration factor testing could be used but would not be considered as reliable as in-lab testing (due to the lack of control of testing conditions and other variables). In addition, it should be noted that the lack of well documented deterioration factor testing can invalidate engine warranties.

(g) As previously noted, a preliminary evaluation of existing studies examining the target technology and the theoretical basis should be the first step. An energy balance will be one of the tools used in that evaluation along with any previous work conducted by qualified researchers using recognized protocols.

(h) It is important to recognize the large range of drive cycles for dynamometers (varying by temperature of test, type of vehicle – whether truck or light duty vehicle, highway test/urban test cycles etc) that vendors need to decide upon as most applicable for their technology. This needs to be linked to the specific information requirements of the Fleet Managers. For example, it was mentioned that 500km testing of trucks was not necessarily appropriate for assessing fuel use of high fuel use stop-start vehicles such as garbage collection trucks used by cities.

3.3 Verification

Objective:

The objective of verification is third party expert evaluation of the technology and the independent third party testing. The complete formal application to verification is reviewed based on a General Verification Protocol.

Proposed Approach:

(a) ETV Canada provides an independent mechanism for the verification of performance claims. In order for ETV Canada to accept a performance claim for verification, the technology should be commercially available, comply with health and safety standards, have environmental benefits and be based on scientifically sound and engineering principles. The vendor submits all of the necessary supporting documentation for review by a qualified ETV Canada Verification Entity (VE). The VE is an impartial third party accredited laboratory or qualified specialist in the area.

(b) The performance claim(s) must be supported by third party data generated by an independent laboratory or testing organization accredited under the conformity assessment process of the Standards Council of Canada or equivalent.

(c) The organizations and individuals participating in the testing and verification (e.g., testing organization, analytical laboratories, verification entity) must be clearly specified. A list of participating organizations and/or personnel and a brief statement identifying each participant's role in planning, implementation and assessment activities must be prepared. Participants include the following:

Vendor - The vendor should provide a detailed description of the system including a systematic diagram of the process, operations and maintenance (O&M) manuals and the supporting references to the selected testing organization to ensure a full understanding of the technology. It is the vendor's responsibility to select the testing organization and analytical laboratory from a list of qualified candidates and to provide the appropriate test site to perform verification testing. Prior to the testing, the owner should work with the testing organization on details about the testing procedures and the key elements of the tests and sampling procedures. The vendor should also provide all related equipment and facilities to carry out the demonstration. The equipment should be in good condition to minimize experimental errors.

Testing Organization - ETV Canada verification requires an independent, unbiased testing organization to oversee the testing. The testing organization should prepare an individual test plan using guidelines and requirements provided in the "ETV Canada engine/vehicle after-market technologies – Test Guidance Document" (to be developed). It is the testing organization's responsibility to operate and maintain the technology in accordance with the vendor's O & M manual. Upon completion of the test, the testing organization must prepare and submit a testing report along with the test data to the technology vendor.

Analytical Laboratory - The selected laboratory must be a qualified laboratory accredited by the Standard Council of Canada (SCC), Canadian Association for Environmental Analytical Laboratories (CAEAL) or equivalent to provide assurance of the quality of the analytical results. The laboratory must also have related experience with similar projects and a currently approved Quality Assurance (QA) and Quality Control (QC) plan. It is the laboratory's responsibility to apply and execute the appropriate analytical procedures which meet general accepted principles of good laboratory practice and quality control. Appropriate laboratory equipment must be provided for sample analysis. Records of analytical procedures and sample and data chains of custody must be maintained throughout the process. The laboratories recognized by ETV Canada for testing and verifying engine/vehicle after-market devices are appended.

Site Owner - The owner of the facility where the testing will take place must be identified in the test plan, as well as any particular responsibilities assigned to the owner or the testing team members.

Verification Entity - To perform the specific technology verifications, ETV Canada engages the services of independent technical experts within qualified organizations which have the expertise and credibility to verify the test data provided by independent testing organizations against the performance claims in question. These independent verification experts are called "Verification Entities" or VEs under the Canadian Environmental Technology Verification Program.

Important Points:

(a) ETV Canada operates the Canadian ETV Program on behalf of the Government of Canada. ETV Canada is part of a not-for-profit organization, the Ontario Centre for Environmental Technology Advancement (OCETA), which has the license from the responsible Canadian Government Department, Environment Canada, to operate the Canadian ETV Program. Through this arrangement, ETV Canada has the authority to verify technologies on behalf of Environment Canada.

(b) When a technology is verified by ETV Canada a license agreement is signed between ETV Canada and the company, which is considered a legal contract valid for three years (with the option of subsequent renewal every 3 years).

(c) Additional information on environmental performance benchmarking and verification is provided in Appendix 3. Currently recognized Canadian vehicle/engine emissions testing and verification centres are listed in Appendix 4.

3.4 Cost Benefit Analysis:

Objective:

The objective of cost benefit analysis is to ensure that a spectrum of considerations which include the environmental cost, and social impacts and benefits are assessed.

It should be noted that this is NOT a component of the verification, but is likely to be included by the Fleet Managers as a requirement for purchasing any engine/vehicle after-market technology.

Proposed Approach:

a) In addition to pre-screening, the need to undertake Cost Benefit Analysis (CBA) is considered to be an important decision-making requirement for fleet managers. This is often done by the finance department in some municipalities. It could also be performed by a qualified CBA expert, however the content and scope of the review would need to be decided.

b) Recognizing the limitations of quantitative verification, it may be necessary to weight the performance claim components. This would mean that a technology could be assessed

(e.g. on a scale from one to ten) by a potential fleet manager or purchasing agent based on a number of key performance attributes (i.e., cost, environmental impact, etc.). Examples might include consideration of emissions of greenhouse gases and criteria air contaminants, measured from emissions tests and, utilizing a structured method, incorporated into a Cost Benefit Analysis.

Important Points:

a) There are a number of issues related to CBA. To illustrate, while the reduced air quality impacts of using natural gas for vehicles is a clear benefit, maintenance of these vehicles is very high. Also to be balanced into the purchasing equation is the public view that natural-gas fuelled vehicles are more favorable.
b) Another example is the purchasing decision for ice resurfacer vehicles based on emissions of propane powered vehicles compared to battery powered vehicles. The battery type (acid versus gel battery) is also an important factor.

3.5 Pilot Testing Within the Fleet

Objective:

To determine the performance characteristics of the technology under operational conditions. This is a possible next step for technology purchasers such as fleet managers, whereby they would install or use the engine/vehicle after-market technology on their fleet to assess technology issues (e.g. maintenance etc) in greater depth.

Important Points:

(a) Although it is agreed that dynamometer testing should be the first verification step after pre-screening, there is lack of consensus about which, if any, on-road tests would be best suited for verification (and hence the usefulness of on-road tests to purchasers such as fleet managers). It was suggested that Society of Automotive Engineers (SAE) type tests should be used to avoid “reinventing the wheel” on which on-road test results could be verifiable.
(b) On-road testing and the use of portable emissions measurement systems are discussed further in Section 4.
(c) This step could also include verification of test results, as well as additional cost benefit analysis.

4.0 OTHER IMPORTANT CONSIDERATIONS:

4.1 On Road Testing

Although this is NOT currently considered to be a component of the verification, it is possible for vendors to perform approved tests that could enhance the information provided by dynamometer testing. This may or may not be required by fleet managers as a requirement for purchasing any engine/vehicle after-market technology. Depending on the design of the on-road testing, it may be appropriate to undertake additional verification.

The high variability of on-road testing and the need for 3rd party testing for all on-road tests is an issue. Important for all testing performed on engine/vehicle after-market devices, is the need for a full report and complete data sets from the testing organization. Data summaries are not sufficient for verification. This is especially important for road tests, given that the sources of variability are considerable. Factors such as fuel type, tire pressure and climatic conditions are likely to cause errors in on-road testing of after-market devices and technologies.
On-road testing can have a variability of 4-15%, and therefore would need a much greater attention to detail in terms of independent test agents observing all testing and noting sources of error, as well as variables that would affect results (such as air temperature and pressure). Clearly a larger sample size (of tests) is needed if on-road testing is used.

The need for third party testing of emissions and fuel use from vehicles was emphasized to make on-road testing more credible. Ultimately, the testing must be tailored to meet the needs of the specific location and vehicle applications.

For verification purposes, laboratory dynamometer testing should be performed before on-road testing. The applicable SAE on-road testing procedures must be adhered to during any on-road testing. These are:

1. SAEJ1264 Oct86, Joint RCCC/SAE Fuel Consumption Test Procedure
2. SAE J1321 Oct86, Joint TMC/SAE Fuel Consumption Test Procedure Type II
3. SAE J1526 Oct86, Joint TMC/SAE Fuel Consumption Test Procedure Type III
4. SAE J1082 Oct02, Fuel Economy Measurement Road Test Procedure

The following basic rules must be applied to these procedures to ensure valid test results:

1. A single test is inconclusive. A single test result may be an indicator. Test results must be repeatable to have validity.
2. The more variables controlled, the more conclusive the results.
3. All test procedures are accurate within prescribed limits. If the component, system or vehicle being tested by a given procedure shows a degree of improvement which is equal to or less than the accuracy limit of the procedure, an additional number of tests is inconclusive.

4.2 Portable Emissions Measurement Systems (PEMS)

There is interest in the use of Portable Emissions Measurement Systems (PEMS) for testing to verification of engine/vehicle after-market technologies. This was suggested as providing more real world quantification of emissions and fuel use from vehicles. It was noted that PEMS are being used by the EPA for on-road tests.

The importance of trading credits for greenhouse gas emissions reduction was also raised as an important potential verification outcome. PEMS could be the way to help attain credits for such emissions reductions. It was emphasized that emissions measurements for greenhouse gas credits trading is additional to the need to verify fuel use savings from engine/vehicle after-market technologies.

The need for side by side calibration of and use of the PEMS system during dynamometer testing was also raised. This would permit the use of the calibrated PEMS system for later on-road verification tests. It was mentioned that PEMS could offer more testing cycles for the same cost or less than dynamometer testing. It was also mentioned that on–road tests may show higher emissions reduction and fuel use savings.

As stated above the need for third party testing of emissions and fuel use from vehicles was emphasized to make on-road testing more credible. Ultimately, the testing must be tailored to meet the needs of the specific location and vehicle applications.

4.3 Technology Demonstrations

Technology demonstration projects, whereby a number of vehicle technologies could be tested, might be a potential future route for the verification program. Furthermore, engine/vehicle after-market technologies could be compared under the same program to determine which are best.
Testing of technologies under a demonstration program could be funded in part by the technology proponents and municipalities. The Green Municipal Fund could be a source of funding for demonstrating and implementing fuel efficiency and emissions reduction technologies. The provincial and federal governments might also be approached.

For on-road testing, a minimum of 6 test runs on a vehicle without the engine after-market device fitted, and 6 of the same test runs on the vehicle with the engine after-market technology fitted, should be required.

4.4 Integration with E3 Fleets

Assessment under a Green Fleet Rating program could offer benefits to fleet managers. This could include a snapshot of sections of a vehicle fleet, or all of a fleet so as to compare baseline performance with later or future performance to determine improvements in the fleet. It could also include future savings reviews, for example for the purchase of newer cleaner vehicles and the resulting reduction in maintenance compared to keeping older vehicles. The end result of a Green Fleet assessment would show cost benefits and environmental benefits.

The Green Fleet assessment can also be used to compare one fleet with another and help spot outliers of technologies which do not show the level of fuel use (for example) that a fleet manager would like to see for such technologies. Part of the analysis performed by a Green Fleet assessment is vehicle downtime, as well as the impact on vehicle resale values.

The Green Fleet process is based on the LEED (Leadership in Energy and Environmental Design) system. Green Fleet uses a LEED accredited auditor for their Green Fleet assessments. ETV Canada verified technologies may be helpful solutions for fleets. A Green Fleet Rating program could be used to identify problems in a fleet, and ETV Canada verified technologies could be applied to help solve the problems.

4.5 Disclaimer

ETV Canada verifications result in the successful graduate being awarded a verification certificate and report containing a detailed performance claim. Without hindering the usefulness of verifications, the statement of limitations must state the scope of testing, including what was and was not covered by testing the product or device. The performance claim for engine/vehicle after-market devices must (especially if there is a question about the device performing similarly on other engines/vehicles) include mention of the specific engine and/or vehicle tested, test fuel, engine cycle, test location, and operating parameters used. The potential purchaser of an after-market device verified under the ETV Canada program must then determine for themselves the applicability of the after-market device to their own vehicle(s) and particular operating conditions. The verification certificate/report disclaimer should also indicate that the verification does not cover end-of-life issues.

Appendix 1:

Basic Requirements for Testing to Produce Verifiable Data for the Canadian ETV Program

APPENDIX 1: BASIC REQUIREMENTS FOR TESTING TO PRODUCE VERIFIABLE DATA FOR THE CANADIAN ETV PROGRAM

1 Basic Parameters to be measured:

- Regulated emissions (Hydrocarbons, Carbon Monoxide, Nitrogen Oxides, Carbon Dioxide, Particulates)
- Fuel Consumption

Note: Additional unregulated emissions would be optional

2 Drive cycles to be considered:

- Urban Driving Dynamometer Schedule
- Highway Fuel Consumption Test
- USO6 test
- Cold CO test
- SCO3 test
- Evaporative test
- Steady State AVL8 mode for Heavy Duty
- FTP Heavy Duty Transient on road according to CFR Part 86
- Off road Transient Tier IV

Note: It is recommended that consideration of other drive cycles be reviewed by the test agent and verification entity.

3 Types of dynamometer testing to be used:

- Chassis dynamometer
- Engine Dynamometer

Note: Testing using additional facilities or equipment would be optimal

4 Number of test runs:

At least 6 tests by an accredited laboratory - 3 tests without the after-market device, followed by the same 3 tests with the after-market device - to meet the requirements of ETV Canada to demonstrate 95% statistical significance.

5 Other:

Auxiliary power technologies, such as cab and engine heating technologies for idling reduction, would not necessarily require dynamometer testing. But emissions and fuel consumption testing for engine heating technologies should be performed in a test facility equipped with a temperature controlled ‘environmental chamber’.

Appendix 2:

Preliminary List of Emissions Test Methods Currently Acceptable for Verification Purposes

APPENDIX 2: PRELIMINARY LIST OF EMISSIONS TEST METHODS CURRENTLY ACCEPTABLE FOR VERIFICATION PURPOSES

The Federal Test Procedure (FTP) is used in both Canada and the US for new vehicle testing. The FTP test involves new vehicle models being driven by a trained driver on a chassis dynamometer in a laboratory and is useable for both emissions and fuel economy calculations in both the 'city test' and 'highway tests'. Fuel consumption is calculated using the carbon balance method which correlates the amount of carbon compounds emitted during the testing with the fuel properties. This method is used throughout the world by governments and industry to determine fuel consumption of vehicles and engines.

It is important to note that the FTP uses a standardized fuel. A modified FTP procedure that deviates in some of the vehicle preparation aspects, is often used for research purposes to study fuels and technologies. Also of importance is that the same test parameters and drive cycles are used for both the baseline or OEM test configurations and the modified vehicle configuration. This helps ensure consistent methods in different labs, and therefore a known test procedure for ETV Canada verifications. (Transport Canada 2007).

A list of accepted test methods in the US and internationally, and in some cases used as standard methods in Canada, are listed below:

For light-duty vehicles:

FTP 72 test (CFR 40): This chassis dynamometer test simulates an urban route and is a transient test cycle for cars and light duty trucks. It is intended to simulate a cycle with frequent stops.

FTP 75 test: Derived from FTP 72, this is a transient test cycle for cars and light duty trucks and is used for emission certification of light duty trucks and cars in the USA.

SFTP US06 test: This is a supplemental FTP procedure used to simulate aggressive highway driving.

SFTP SCO3 test: This is a supplemental FTP procedure that simulates emissions associated with air conditioning unit use.

New York City Cycle test: This is an Environmental Protection Agency (EPA) test to simulate low speed city driving.

Highway Fuel Economy (HWFET) test: This EPA test is for fuel economy determination.

California Unified Cycle (UC, LA92) test: This is the California UC dynamometer driving schedule.

IM240 test: This is the Inspection and Maintenance driving cycle used for emission measurements from in-use vehicles.

Standard Road Cycle (SRC) and Standard Bench Cycle (SBC) test: These are dynamometer and engine bench tests for emissions durability determination.

For heavy-duty engines (Engine Dynamometer):

FTP Transient: This test is for heavy-duty truck and bus engines, and the test cycle includes segments simulating urban and freeway driving. In the USA it is used for heavy-duty diesel engine certification.

AVL 8-Mode Heavy-Duty Cycle test: This is a steady state test designed by AVL to produce results for emissions test closely correlating with those measured over the US FTP Transient test.

Constant-Speed, Variable-Load (CSVL) test: This test was developed by the EPA for constant speed engines, but not adopted in emissions regulations.

CTA test: This is the Chicago Transit Authority engine cycle test

For heavy-duty vehicles (on Chassis Dynamometer):

Urban Dynamometer Driving Schedule (UDDS) test: This is the EPA transient chassis dynamometer for heavy-duty vehicles.

Central Business District test: This is a transient chassis dynamometer test cycle for heavy-duty vehicles

Business Arterial Commuter test: This is also known as the Transit Coach Operating Duty Cycle and is a composite heavy-duty vehicle's fuel economy cycle.

City Suburban Cycle and Route (CSC) test: This is a chassis dynamometer test for heavy-duty vehicles.

New York Composite test: This is a transient chassis dynamometer test for heavy-duty vehicles.

New York Bus (NYBus) test: This is a transient chassis dynamometer test for urban transit buses.

Manhattan Bus Cycle: This is a transient chassis dynamometer test for urban transit buses.

Orange County Bus Cycle: This is a chassis dynamometer test cycle for transit buses developed by West Virginia University.

WVU 5–Peak: This is a 5-speed chassis dynamometer test cycle for heavy-duty trucks developed by the West Virginia University.

International standards used in Canada:

ISO 8178: Several steady-state modes compose this method. It is used for selected non-road engine applications in the US and Europe.

References:

Dieselnet.com (2007) Emissions Test Cycles http://www.dieselnet.com/standards/cycles (Website Accessed March 2007)

Transport Canada (2007) (website accessed Feb 2007) Fuel Consumption Program: Vehicle Testing. Federal Test Procedure.
http://www.tc.gc.ca/programs/environment/fuelpgm/testing/menu.htm

Modified from Dieselnet.com (2007)

Appendix 3:

Background Information on

Environmental Performance Verification

APPENDIX 3: BACKGROUND INFORMATION ON ENVIRONMENTAL PERFORMANCE VERIFICATION

Environmental performance verification is a proven assessment mechanism for determining technology performance with a high level of reliability. It is based on stakeholder engagement to identify acceptable performance criteria and the use of scientific and statistically valid protocols for verifying performance. The process helps ensure that technology performance is measured and reported clearly, in a transparent manner, thereby facilitating the implementation of sustainable technology solutions and process improvements that meet the objectives of key stakeholders.

Performance benchmarking and verification can be applied at multiple levels to address decision-making needs:

- At the first level, early in the decision-making process, performance benchmarking can be used to identify achievable targets or standards upon which verifiable performance criteria can be based. This typically requires motivated stakeholders with a specific sectoral or issue focus.
- At the second level, once acceptable performance criteria have been identified, the benchmarking process can serve as an effective screening and assessment tool. At this point the goal is to identify and screen suitable technologies through comprehensive assessment based on established criteria and recognized technical protocols.
- The principal goal at the third level of performance benchmarking and verification is to determine actual technology performance through comprehensive testing based on relevant technical protocols and sound statistical analysis. At this level performance testing and verification is built into implementation, as part of technology demonstration, thus ensuring a greater level of confidence in the performance results than might otherwise occur.

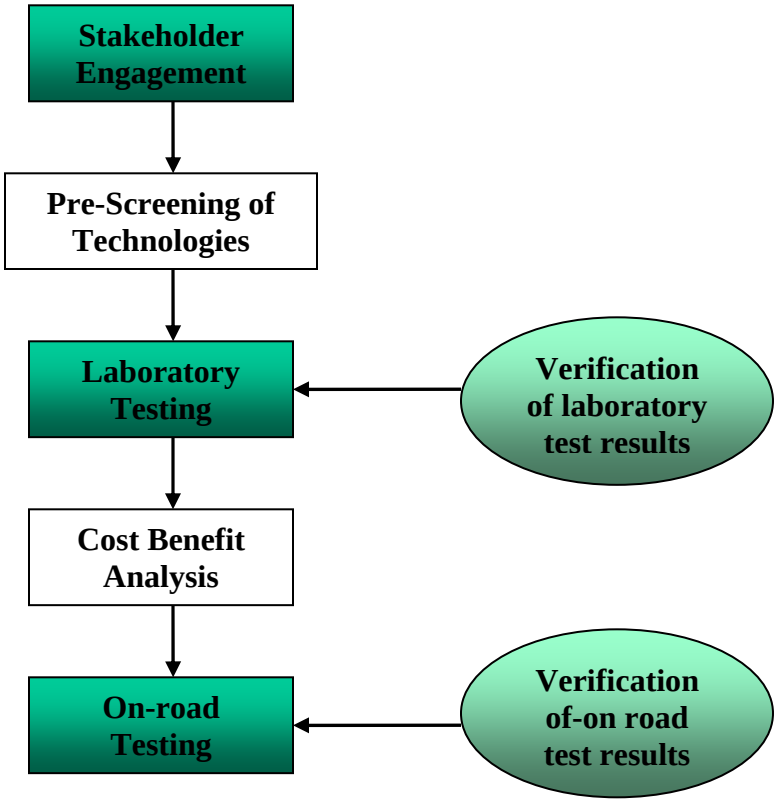
The information produced through performance benchmarking and verification can be reported in a credible manner and used to accelerate the development, implementation and deployment of sustainable technology solutions. This information can be used to support continuous learning and subsequent performance improvements. Also, by working with financial institutions and funding agencies on characterizing and quantifying risk, performance benchmarking and verification can help bring confidence to investors and facilitate the mobilization of financial resources and responsible investment.

Other related potential benefits include:

- Establishing appropriate institutional mechanisms through which technology performance can be evaluated
- Strengthening core capacity within existing scientific and technical organizations to independently assess and evaluate technology options
- Avoiding duplication by linking to existing support systems and initiatives and facilitating the engagement and involvement of key stakeholders
- Contributing to a culture of innovation by integrating the core elements of capacity-building, information and knowledge management, and nurturing an enabling environment for the development and deployment of innovative technologies.

The following diagram outlines the performance benchmarking-verification process that can be used to address decision-making needs.

Figure 1: Performance Benchmarking –Verification Process



Appendix 4:

Canadian Vehicle/Engine Emissions

Testing and Verification Centers

APPENDIX 4: CANADIAN VEHICLE/ENGINE EMISSIONS TESTING AND VERIFICATION CENTERS

- **Emissions Research and Measurement Division, Environmental Science and Technology Centre:**
  Fred Hendren (Chief)
  http://www.etc-cte.ec.gc.ca/organization/ermd/ermd_summary_e.html
  613 990 5859
  Fred.hendren@ec.gc.ca

- **Bodycote Materials Testing Canada Inc. Mississauga:**
  Mehboob Sumar (Business Development Manager, Engine Technologies Engineering and Transportation Division)
  www.na.bodycote-mt.com
  905 822 4111 x 654
  Sumar.m@bodycote.ca

- **Prairie Agricultural Machinery Institute, Manitoba: Mechanical Testing Division:**
  Harvey Chorney (Vice President, Manitoba Operations)
  http://www.pami.ca/mechanical_testing.htm
  204 239 5445
  hchorney@pami.ca

Additional accredited laboratories can potentially be used in the US with prior approval from ETV Canada.