U.S. CONSUMER PRODUCT SAFETY COMMISSION
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Subject: CPSC Staff Proposal for Determining Carbon Monoxide Emissions from Portable Generators in a Reduced Oxygen Environment Using the Dilution Chamber Method.

Dear Dr. Dunn:

U.S. Consumer Product Safety Commission ("CPSC", "Commission") staff proposes a new test method to the UL 2201 Carbon Monoxide Task Group, the dilution chamber method, to determine carbon monoxide ("CO") emissions from portable generators under reduced oxygen conditions. [a] CPSC staff has worked with the task group to consider several test methods that have been developed to determine the CO emissions from portable generators in a reduced oxygen environment. These test methods include the test described in NIST TN 1834 Appendix B[1] and the dilution tunnel method.[2] After evaluation of these methods, critical issues were identified by the task group. Some of the issues identified involve complexity of testing, infrastructure cost, repeatability, and application to varying portable generator configurations. The dilution chamber method was developed to address these concerns.

The information provided in the appendix describes the proposed dilution chamber test fixture and method. This method uses a control volume around the portable generator and dilutes the oxygen by flowing nitrogen into the volume. The exhaust from the generator does not accumulate in the chamber but is ducted directly out of the engine to a Constant Volume Sampling (CVS) system for analysis. Air flow through the chamber is created by the intake flow of the engine. The dilution chamber method accommodates a variety of generator configurations because this method does not require a physical connection to the engine intake. For fuel injected engines using narrow band oxygen sensors, this method provides the same oxygen concentration to the air reference on the oxygen sensor that is provided to the engine intake. Oxygen levels can be precisely adjusted through a range of 20.9 percent to 16.0 percent. This method also uses a CVS system for emissions analysis, which is currently a common method for engine emissions analysis, according to task group input.

[a] These comments are those of CPSC staff, and they have not been reviewed or approved by, and may not necessarily reflect the views of, the Commission.

CPSC staff is confident that the dilution chamber test method can provide a simple and repeatable procedure to determine the CO emissions from portable generators in a reduced oxygen environment. This proposal offers a potential solution to finding a suitable test method when evaluating portable generators to a new low CO emission performance requirement. Thank you for your consideration and the opportunity to improve the safety of portable generators.

Sincerely,

Matthew J. Brookman

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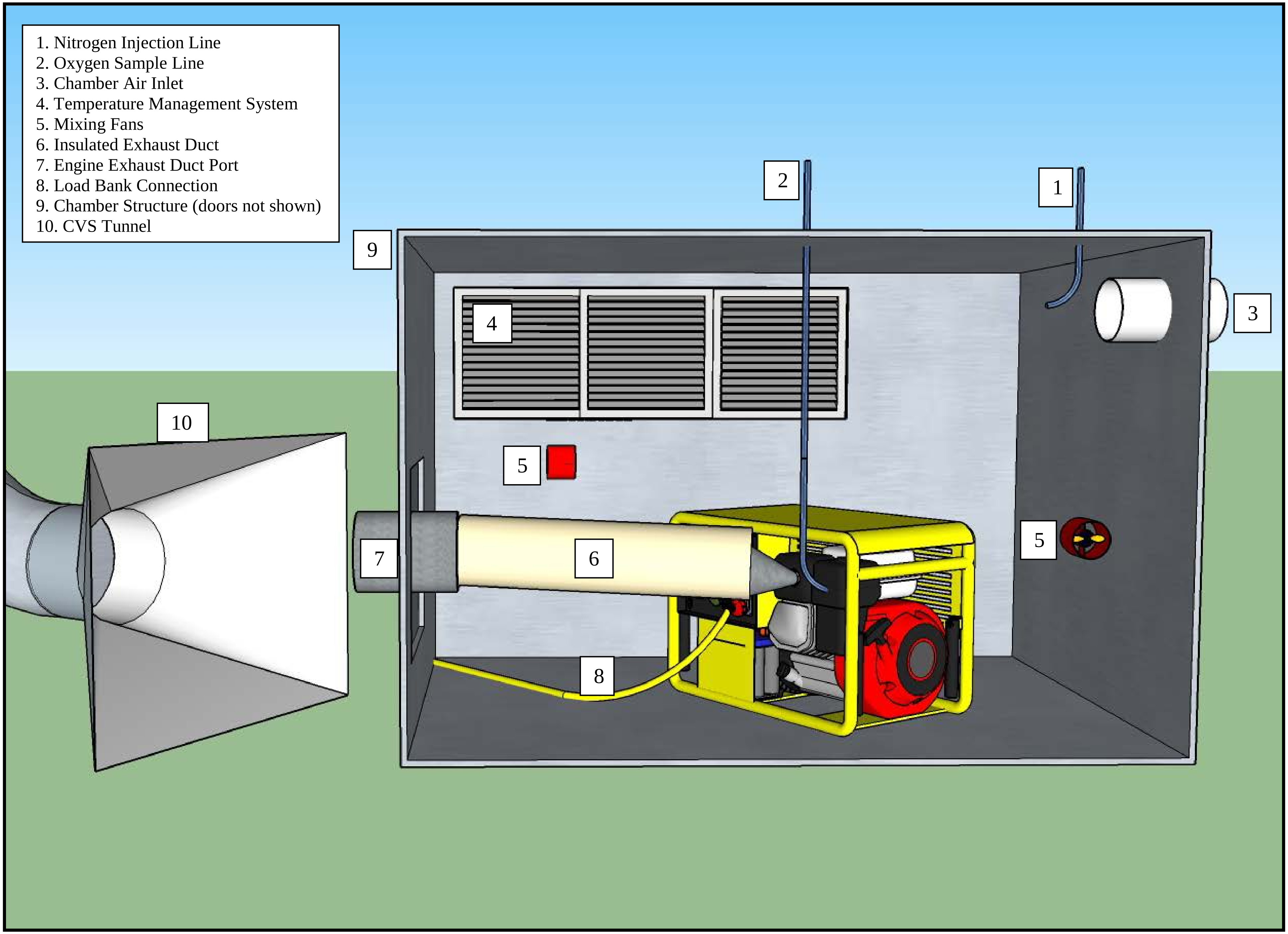
References

1. S. J. Emmerich, A. K. Persily, *Development of a Test Method to Determine Carbon Monoxide Emission Rates from Portable Generators* (NIST Technical Note 1834), June 2014 (available online http://www.cpsc.gov/Global/Research-and-Statistics/Technical-Reports/Home/Portable-Generators/NISTReportDevelopmentofaTestMethodtoDetermineCarbonMonoxideEmissionRatesfromPortableGenerators-NISTTechnicalNote1834.pdf).

2. M. Brookman, J. Buyer, *Draft Test Method for UL2201 Task Group for Determining the CO Emission Rate of Portable Generators*, U.S. Consumer Product Safety Commission, Bethesda, MD, February 2015.(available online at http://www.cpsc.gov/Global/Regulations-Laws-and-Standards/Voluntary-Standards/Portable-Generators/Draft-Test-Method-for-Determining-the-CO-Emission-Rate-of-Portable-Generators.pdf).

Appendix A: Dilution Chamber Test Method for Determining Portable Generator CO Emissions in a Reduced Oxygen Environment (Schematic)



Dilution Chamber Test System:

1. **Nitrogen Injection Line:** The nitrogen injection line provides a variable flow of nitrogen to the chamber volume. A precision valve or flow controller will provide the necessary adjustment capabilities for nitrogen flow. Flows up to 4 scfm with a line pressure of 100 psi were used successfully for a generator nominally rated at 5 kW to reduce oxygen levels to below 16.0 percent.
2. **Oxygen Sample Line:** The oxygen sample line measures the oxygen concentration near the intake of the engine.
3. **Chamber Air Inlet:** The chamber air inlet is of sufficient size to prevent the development of a significant pressure differential between chamber environment and its surroundings. It is also positioned to promote mixing and a steady oxygen concentration at the intake of the engine. For reference, a 6-inch diameter inlet duct was used successfully for a generator nominally rated at 5 kW. A pressure measurement device can be used to evaluate the pressure differential.
4. **Temperature Management System:** The temperature management system regulates the temperature in the chamber to within the normal expected operating environment of the generator. A cooling system capable of removing approximately 8 kW was used successfully for a generator nominally rated at 5 kW. The cooling was acceptable; however, a 10 kW cooling system would provide more confidence in cooling capability and less temperature rise for a generator of this size.
5. **Mixing Fans:** Mixing fans are used to ensure proper mixing and a steady oxygen concentration at the intake of the engine.
6. **Insulated Exhaust Duct:** The insulated exhaust duct is well sealed to ensure that all of the exhaust from the engine is ported directly out of the chamber to the CVS tunnel. The duct is flexible to minimize mechanical stresses on the exhaust assembly and is of sufficient diameter to have no effect on the normal backpressure present in the test engines exhaust assembly. It is well insulated to reduce heat loads within the chamber.
7. **Engine Exhaust Duct Port:** The exhaust duct port directs the engine emissions into the collection hood of the CVS tunnel. It is designed to exhaust to the open environment surrounding the dilution chamber while ensuring full capture of the exhaust by the CVS tunnel. The port should be designed to limit heat transfer to the dilution chamber walls if high temperature sensitive materials are used to construct the dilution chamber structure.
8. **Load Bank Connection:** The load bank connection is routed safely through the chamber wall and to the generator.
9. **Chamber Structure:** The chamber structure is a box of approximately 100 cubic feet, constructed of materials capable of withstanding high temperatures. A structure built of Oriented Strand Board (OSB) wood was used successfully with all edges sealed. The exhaust duct port was mounted through a sheet of .065 inch sheet metal approximately 18 inches x 18 inches to minimize heat transfer to the wood and dampen vibrations transferred through the exhaust duct. One wall of the chamber consists of doors that seal the chamber well when closed. Penetrations through the chamber walls should be sealed. Windows may be added to provide visibility of the chamber environment during testing. Braces or other means of mechanically affixing the generator in the chamber may be needed to limit movement of the generator assembly due to vibration.
10. **CVS Tunnel:** The engine exhaust duct port on the side of the dilution chamber is positioned in the center of the CVS tunnel hood. Background samples for CVS system calculations are taken from the environment surrounding the dilution chamber.

Dilution Chamber Test Method:

1. Warm the engine to operating temperature.
2. Precondition the room to cool the chamber surfaces. This will assist with temperature management and maintaining chamber temperature to below 100 °F.
3. Apply the test load at ambient oxygen levels (~20.9 %) with chamber doors open. Turn on the mixing fans and seal the chamber when the target load is achieved.
4. Flow nitrogen into the chamber and reduce the oxygen concentration to 17.0 % ± 0.1 %.
5. Measure emissions for 3 minutes. Record temperature and CO concentration within the chamber. The CO concentration is measured in the chamber to evaluate the integrity of the exhaust duct and port. Low levels of CO within the chamber are acceptable (< 200 ppm), but if levels increase significantly, the exhaust duct may not be sealed or may have failed.
6. Remove the load from the generator, and restore the oxygen concentration to ambient (20.9 %). This can be achieved quickly by partially opening a chamber door to ventilate the space.
7. Test the next load by repeating steps 3-6.