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Standard Practice for the Toxic Contamination of the Environment in the Operator Enclosure of Self-Propelled Agriculture Vehicles[1]

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1. Scope

1.1 This practice may be used to determine the level of specific harmful airborne contaminants within a vehicle operator enclosure under standardized test conditions. The air exchange rate, air pressure relative to ambient conditions, air temperature, and relative humidity maintained within the enclosure during the test are also determined. Operator-introduced contaminants are not addressed by this practice.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *SAE Standards:*

SAE Air Cleaner Test Code (for Fine Dust)[2]

SAE J1012 Recommended Practice Agricultural Equipment Enclosure Pressurization System Test Procedure[2]

2.2 *NIOSH Standards:*

NIOSH 2549 Method for Xylene (Aromatic Hydrocarbons)[3]

NIOSH 2539 Method for Formaldehyde (Aldehydes)[3]

NIOSH S340 Method for Carbon Monoxide[3]

NIOSH Method for Malathion (Organic Phosphates)[3]

NIOSH Manual of Analytical Methods[3]

2.3 *OSHA Standard:*

OSHA Instruction CPL 2-2.20, Standard Methods for Sampling Air Contaminants[4]

SKC Guide to NIOSH/OSHA Air Sampling Standards[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *aerosols, n*—small droplets of a liquid or particles of solid matter suspended in air, for example, a mist, fog, or smoke.

3.1.2 *air exchange rate, n*—the rate at which the air in a specific space is removed or replaced, or both.

3.1.3 *breathing zone, n*—the zone surrounding and immediately in front of operator's face. Assumed to be directly above front edge of operator's seat and 1.2 m above floor of enclosure.

3.1.4 *closed operator enclosure, n*—a structure for enclosing or enveloping the operator that is sufficiently air-tight to permit modification of the environment within.

3.1.5 *contaminant, n*—an undesirable component in any material or system.

3.1.6 *differential air pressure, n*—difference in the pressure exerted by air at a specific location relative to another selected location.

3.1.7 *dynamic test, n*—a test conducted while the test subject is undergoing specified motion.

3.1.8 *forced air ventilation, n*—air ventilation which is created or aided by a forced movement of air as by a fan or blower.

3.1.9 *gaseous, adj*—existing in the state of a molecular gas (< 0.001 µm particle size); containing no liquid droplets or solid particles.

3.1.10 *mists, n*—cloud-like aggregation of liquid droplets having a diameter of < 20 µm which are temporarily suspended in air.

3.1.11 *operator-introduced contaminant, n*—substance which is introduced by or as a result of actions of the operator (that is, as carried on operator's hands or clothing).

3.1.12 *primary filter (also particulate filter or fresh-air filter), n*—a device used for filtering suspended mists and particulate matter out of intake air.

3.1.13 *rated air flow, n*—rate of flow of air in or through a system specified for designed performance.

3.1.14 *recirculating filter, n*—filter used for filtering the air which is recirculated within the operator enclosure (see *secondary filter*).

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[1] These test methods are under the jurisdiction of ASTM Committee E35 on Pesticides and are the direct responsibility of Subcommittee E35.26 on Safety to Man.

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[2] Available from Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, PA 15096.

[3] Available from National Institute of Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.

[4] Available from Occupational Safety and Health Administration, 219 S. Dearborn, Chicago, IL.

[5] Available from SKC, Inc., 863 Valley View Rd., Eighty Four, PA 15330-9614.

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3.1.15 *secondary filter, n*—filter located in a system where air in the enclosure is refiltered after passing through the primary filter (usually for recirculated air) (see *recirculating filter*).

3.1.16 *self-propelled agricultural vehicle, n*—an agricultural vehicle that has the capability of providing its own motive power.

3.1.17 *seat index point (SIP), n*—reference point relative to the operator's seat as determined by a SIP measurement device.

3.1.18 *static test, n*—a test performed while the test subject is stationary, in a fixed position.

3.1.19 *technical material, n*—the chemically active ingredient of a chemical solution or formulation.

3.1.20 *test media, n*—the materials being used to test the performance of a system.

3.1.21 *threshold limit value (TLV), n*—time-weighted concentration of a material to which most workers can be exposed for 8 h per day over long periods of time without experiencing adverse effects.

3.1.22 *ultra-low volume (ULV), n*—0.45 to 4.5 L per hectare.

4. Summary of Practice

4.1 *Static (Laboratory) Test*—This test involves having the stationary vehicle housed in a sealed and insulated chamber. Air containing standard dust or chemical test media is passed through the chamber at various speeds, temperatures, and humidities, while the vehicle engine and air-filtering or air-conditioning system are operating. Automatic —samplers are positioned inside and outside the operator enclosure to sample the air during the test interval. Analysis of these samples for the test contaminants provides a basis for determining the efficiency of the air-filtering or air-conditioning system for the operator enclosure.

4.2 *Dynamic (Field) Test*—This test involves monitoring the operator enclosure during normal field operations of the vehicle. Air sampling inside and outside the operator enclosure is carried out in a fashion similar to that used in the static test method. Analysis of the test parameters, vehicle speed and direction, ambient atmospheric conditions, operator enclosure environment, properties of the materials involved, sample analytical results, etc., provides a basis for determining the efficiency of the air-filtering or air-conditioning system for the operator enclosure.

5. Significance and Use

5.1 There are concerns about the potential for excessive exposure of the operators of self-propelled agricultural vehicles to toxic agricultural chemicals when transporting or applying these materials, or both. A need exists for suitable procedures for determining the amount of toxic chemical contaminants in the vehicle operator environment when official testing is required.

5.2 The purpose of this practice is to provide a practical, reliable, and reproducible procedure for testing the performance of operator enclosure ventilating or air conditioning systems, or both, relative to the maintenance of safe environmental conditions with regard to toxic material contamination within the enclosure under static (laboratory) or dynamic (field) conditions, or both.

STATIC (LABORATORY) TEST

6. Test Facilities and Apparatus

6.1 *Test Chamber:* For the static test, construct a test chamber as specified as follows:

6.1.1 *Dimensions*—The test chamber shall be large enough to contain the vehicle to be tested with a minimum of 1.0 m clearance on all sides and top of the vehicle being tested.

6.1.2 *Construction*—Insulate and seal the test chamber sufficiently to adequately maintain the physical conditions specified for the tests to be conducted. (While not essential, a turntable is recommended so that vehicle being tested can be quickly repositioned for different tests.)

6.1.3 *Chamber Pressure*—Provide the test chamber with a means for maintaining air pressure specified for the tests to be conducted.

6.1.4 *Heating and Cooling System*, adequate to maintain steady state temperature within the test chamber from 5 to 40 ± 3°C for the duration of each test.

6.1.5 *Humidity Control*—Provide a means which can maintain the relative humidity within the test chamber that is specified for the test being conducted, ranging from 20 to 90% relative humidity ± 5%.

6.1.6 *Air Circulation System*—Equip the test chamber with an air circulation system capable of maintaining uniform air flow within the chamber at the speed and direction specified for the test. The air flow should be from 2 to 18 ± 2 km/h measured 0.5 m above the center of the top of the operator enclosure being tested.

6.1.7 *Vehicle Engine*—Duct the engine air supply into the test chamber. Duct the exhaust gases separately out of the test chamber.

6.1.8 *Test Media Introduction and Removal*:

6.1.8.1 *Introduction*—Provide a means for introducing the test media into the air circulation system and maintaining the concentration throughout the air in the system that is specified for the test being conducted.

6.1.8.2 *Removal*—Provide a means for filtering out or removing test media, or both, from the air in the air circulating system of the test chamber and test vehicle and from the surfaces within the test chamber and of the test vehicle, when tests with a specific test media are completed. Follow chemical manufacturers' decontamination procedures as indicated on the labels of chemicals being used.

6.2 *Instrumentation*:

6.2.1 *Air Flow Meters.*[6]

6.2.2 *Air Pressure Measuring Devices*— Two calibrated barometers (aneroid or mercury type), one for inside the enclosure being tested and one for outside of the enclosure but inside the test chamber. A differential manometer[7] may be substituted for the barometer inside the enclosure.

[6] ALNOR Hood/HVAC Mode/Velometer, or equivalent, available from Fisher Scientific Co.

[7] Fisher Well-Type Manometer No. 11-290, or equivalent, available from Fisher Scientific Co.

6.2.3 *Hygrometer.*[8]

6.2.4 *Thermometers*—The instruments used should give acceptable accuracy from −1 to +51°C.

6.2.5 *Air Samplers:*[9]

6.2.5.1 *Dusts*—See OSHA Instruction CPL 2-2.20.

7. Test Conditions

7.1 *Air Pressure*:

7.1.1 *Interior Air Pressure*—Measure the pressure within the operator enclosure by following SAE J1012.

7.1.2 *Exterior Air Pressure*—Maintain air pressure outside the operator enclosure but within the test chamber at standard atmospheric pressure, ± 3 %.

7.2 *Air Temperature*:

7.2.1 *Low Temperature Test*—Maintain the temperature of the test media (air plus contaminants) within the test chamber at 5 ± 3°C.

7.2.2 *Normal Temperature Test*—Maintain the temperature of the test media within the test chamber at 22 ± 3°C.

7.2.3 *High Temperature Test*—Maintain the temperature of the test media within the test chamber at 40 ± 3°C.

7.3 *Humidity*:

7.3.1 *Low Relative Humidity Test*—Maintain the relative humidity within the test chamber at 10 ± 5 % for this test.

7.3.2 *High Relative Humidity Test*—Maintain the relative humidity within the test chamber at 90 ± 5%.

7.4 *Air Movement*:

7.4.1 *Calm Conditions Test*—Maintain the movement of the test media (air plus contaminants) relative to the operator enclosure within the test chamber at 8 ± 2 km/h toward the front of the enclosure being tested.

7.4.2 *Moderate Wind Conditions Test*— Conduct tests with the test media moving from three directions relative to the operator enclosure being tested (from directly in front from 90° to one side and directly from the rear).

7.4.2.1 *Wind from in Front*—Maintain the movement of the test media within the test chamber at 18 ± 2 km/h from directly in front of the enclosure being tested.

7.4.2.2 *Wind from the Side*—Maintain the movement of the test media within the test chamber at 8 ± 2 km/h from 90° to either side of the enclosure being tested.

7.4.2.3 *Wind from the Rear*—Maintain the movement of the test media within the test chamber at 2 ± 2 km/h from the rear of the enclosure being tested.

7.5 *Air Filtering or Conditioning System*, operated at rated speed (normal operating speed during field operations) ± 5 % for all tests.

7.6 *Vehicle Engine Speed*—Operate the engine of the vehicle of which the operator enclosure is being tested at 70± 5 % of rated engine speed during all static tests.

8. Test Media (See Section 2)

8.1 *Dust*— Table 1 and Table 2.

8.2 *Organic Phosphates*—See NIOSH 5600. Malathion mist and vapor (4 % solution in xylene) in air at 90 µg/m^3 of air (range 80 to 110 µg/m^3 of air).

8.3 *Aromatic Hydrocarbons (Xylene)*— See NIOSH 2549. 435 µg/m^3 (range 218 to 870 µg/m^3 of air).

8.4 *Aldehydes* (*Formaldehyde*)—See NIOSH 2539. OSHA standard concentration 10 ppm (range 4.6 to 19.8 ppm).

8.5 *Carbon Monoxide*—OSHA standard 57 µg/m^3 (range 24.7 to 115.4 µg/m ^{3} of air).

TABLE 1 Chemical Analysis of Test Dust

Chemical	Weight, %
SiO_2	67–69
Fe_2O_3	3–5
Al_2O_3	15–17
CaO	2–4
MgO	0.5–1.5
Total alkalis	3–5
Ignition loss	2–3

TABLE 2 Particle Size Distribution by Weight, %

Size, µm	Fine Grade
0–5	39 ± 2
5–10	18 ± 3
10–20	16 ± 3
20–40	18 ± 3
40–80	9 ± 3
80–200	...

9. Test Procedures

9.1 *Duration of Test*—The normal test period shall be a minimum of 3 h duration for each specific set of conditions under which tests are to be conducted.

9.2 *Sampler Locations*:

9.2.1 Near center of air intake outside of operator enclosure 70 to 120 mm from opening (must be protected from falling droplets), and

9.2.2 At operator's breathing zone inside operator enclosure.

9.2.3 Optional additional samplers may be located at: outside, center, rear of operator enclosure or inside enclosure near air inlet from air conditioning or ventilating system, or both.

9.3 *Sample Collection*—Use sampling methods described in Section 8.

9.4 *Data Recording*—Record conditions (physical and chemical) being measured periodically (at least every 15 min) during each test.

9.5 *Storage and Shipment of Samples*— Use methods described in Section 8.

9.6 *Processing of Samples*—Use methods described in Section 8.

9.7 *Analysis and Evaluation*—Use methods described in Section 8.

DYNAMIC (FIELD) TEST

10. Test Equipment

10.1 *Air Samplers*:

10.1.1 *Airborne Dust*—Equipment described in OSHA Instruction CPL 2-2.20 (Office of Field Coordination Sampling Method for Respirable Dust).

[8] Fisher Direct-Reading Hygrometer No. 11-657, or equivalent, available from Fisher Scientific Co.

[9] RAM-1 Real Time Aerosol Monitor, available from MIE, Inc. 7 Oak Park, Bedford, MA 01730.

10.1.2 *Carbon Monoxide.*[10]

10.1.3 Use existing NIOSH or OSHA standard procedures where applicable.

10.1.4 *Aldehydes*—Equipment described in NIOSH S327 or P&CAM 354.

11. Test Media

11.1 *Dusts*—That fraction of dust encountered during normal field operations which is considered to be respirable. (Particles smaller than 2.5 µm in diameter). This material may consist of soil particles, pollens, and other naturally occurring material, as well as applied agricultural chemicals.

11.2 *Mists*—The airborne mist fraction of the chemicals being applied which are considered to be toxic to man.

11.3 *Vapors*—The vapors present in the air surrounding the vehicle being tested resulting from chemicals that are being applied and are considered to be toxic to man.

12. Test Conditions

12.1 *Wind*—Wind speed should not exceed 16 km/h at the test location at any time during any test.

12.2 *Temperature*—Avoid temperature extremes when conducting field tests. Tests should not be conducted when the temperature is below 2°C or above 43°C.

12.3 *Humidity*—Avoid extremes in relative humidity when conducting field tests. Test should not be conducted when the relative humidity is below 15 % or above 95 %.

13. Test Procedures

13.1 *Vehicle Operation*—Follow normal operating procedures for the particular chemical application which is being conducted.

13.2 *Test Duration*—The length of each test shall be a minimum of 3 h sampling time while applying chemicals in the field. Shut off monitors during interruptions of chemical application. Operator enclosure must remain closed during entire test period.

13.3 *Sampler Locations*—See 9.2.

13.4 *Sampling Techniques*—Use techniques prescribed in static (laboratory) test procedure for each material being checked.

13.5 *Storage and Shipping of Samples*— Use methods prescribed in static (laboratory) test procedure.

13.6 *Processing of Samples*—Use methods prescribed in static (laboratory) test procedure.

13.7 *Analysis and Evaluation*—Use methods prescribed in static (laboratory) test procedure.

14. Report

14.1 *For the static (laboratory) test, include the following information*:

14.1.1 Name of the investigator(s), laboratory address, location of raw data, and dates of initiation and termination of the test.

14.1.2 Detailed description of the test chamber.

14.1.3 Samplers, collection media, and procedures used.

14.1.4 Concentrations of test media outside and inside the operator enclosure during test.

14.1.5 Total amount of test media collected in samplers during each test.

14.2 For the Dynamic (Field) test, include the following:

14.2.1 The location and description of the field used for the test.

14.2.2 Description of spraying operation: Type of crop, height, population, and row spacing of crop.

14.2.3 Specific materials being applied, including application rate and concentration.

14.2.4 Vehicle speed and direction of travel during test.

14.2.5 Ambient atmospheric conditions at test site including: Temperature, relative humidity, atmospheric pressure, wind speed and direction, (to be recorded at least every 15 min).

14.2.6 Average environmental conditions inside operator enclosure including temperature, humidity, and air pressure.

14.2.7 Time and duration of test.

15. Quality Assurance

15.1 Utilize good laboratory practices to ensure the quality and reliability of data developed using these tests (see CFR Title 40 Part 792 and Title 21 Part 58).

16. Precision and Bias

16.1 The precision and bias of this practice will vary depending upon the specific contaminant for which the test is being conducted. The test methods described in the standards listed in Section 2 each include the precision and bias for each specific test. The resultant overall precision will depend upon the care and precision used in collecting and analyzing test samples.

17. Keywords

17.1 agricultural vehicle; field test; pesticide; static test; test chamber

[10] General Electric carbon monoxide dosimeter with support console, or equivalent.

RECOMMENDED READINGS

(**1**) Miller, M. L., A. W. Eissler, and J. W. Ackley *ASAE* Paper No. 79–1009 "Tractor Operator Enclosure Environment During Pesticide Application Operations".

(**2**) "Protective Effect of Operator Enclosure During Application of Plant-Treating Agents" (Translation) by Wilhelm Batel, *In Grundlagen der Landtechnik*, Vol 2, 1983.

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