Designation: E2292 – 21

Standard Guide for Field Investigation of Carbon Monoxide Poisoning Incidents[1]

This standard is issued under the fixed designation E2292; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers collection and preservation of information and physical evidence related to incidents involving the poisoning of individuals by carbon monoxide.

1.2 This guide is not intended to address the medical effects of carbon monoxide exposure.

1.3 This guide is not intended to be a guide for investigating carbon monoxide poisoning caused by hostile fires, or contamination in closed air systems or confined spaces. Guidance on the investigation of carbon monoxide poisonings related to fire can be found in NFPA 921.

1.4 This guide is not intended for an investigation where equipment is removed from the incident site and conducted in a more controlled setting.

1.5 This guide is intended to be used by a wide range of investigators, including first responders, appliance technicians and engineers.

1.6 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E860 Practice for Examining And Preparing Items That Are Or May Become Involved In Criminal or Civil Litigation
E1459 Guide for Physical Evidence Labeling and Related Documentation
E2713 Guide to Forensic Engineering

2.2 *NFPA Standards:*[3]
NFPA 54 National Fuel Gas Code
NFPA 921 Guide for Fire and Explosion Investigations

2.3 *UL Standard:*[4]
UL 2034 Single and Multiple Station Carbon Monoxide Alarms

2.4 *IFGC Publication:*[5]
IFGC International Fuel Gas Code

3. Significance and Use

3.1 This guide is intended for use by individuals who investigate incidents involving carbon monoxide poisoning. If this guide is followed, the cause for the carbon monoxide poisoning incident may be determined, and corrective action may be identified to prevent future incidents.

3.2 When attempting to identify the source of carbon monoxide, consider that it is produced at some level in virtually every fuel-burning engine, boiler, furnace, burner, stove or fire. All carbon-based fuels (for example, gasoline, diesel fuel, natural gas, propane, coal, wood, paper products, plastics) produce carbon monoxide as a result of incomplete combustion. When there is insufficient air for complete combustion, carbon monoxide can become a major product of combustion. In properly-operating fuel-fired combustion appliances (for example, residential furnaces and water heaters), the level of carbon monoxide produced may be as little as a hundred parts per million or less (that is, 0.01 %). In those same appliances, malfunctions can potentially result in significantly higher carbon monoxide concentrations (10 000 ppm to

[1] This practice is under the jurisdiction of ASTM Committee E58 on Forensic Engineering and is the direct responsibility of Subcommittee E58.05 on Industrial Processes.

Current edition approved July 1, 2021. Published July 2021. Originally approved in 2003. Last previous edition approved in 2014 as E2292 – 14. DOI: 10.1520/E2292-21.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[4] Available from Underwriters Laboratories (UL), 2600 N.W. Lake Rd., Camas, WA 98607-8542, http://www.ul.com.

[5] Available from International Code Council (ICC), 500 New Jersey Ave., NW, 6th Floor, Washington, DC 20001, http://www.iccsafe.org.

100 000 ppm, or higher). Properly-operating internal combustion engines may also generate carbon monoxide concentrations on the order of 10 000 ppm or higher.

3.3 Be aware of the effects of carbon monoxide on humans and pets. Carbon monoxide acts as a central nervous system depressant. With increasing dosage (combination of concentration and time of exposure) symptoms may include headache, dizziness, weakness, upset stomach, vomiting, chest pain, and confusion, and may lead to death. Carbon monoxide is especially hazardous because it is colorless and odorless, providing no warning of its presence. When inhaled, carbon monoxide binds with hemoglobin in the blood, creating carboxyhemoglobin (COHb). The affinity of carbon monoxide for hemoglobin is approximately 200 times greater than the affinity of oxygen for hemoglobin. Therefore, the blood can accumulate dangerous levels of COHb, depriving the body of oxygen.

3.4 Since there is the potential for investigators to become victims of elevated carbon monoxide levels themselves, extreme care should be taken to assure the safety of investigators and anyone else at risk of continuing carbon monoxide exposure. Carbon monoxide monitoring and measurement equipment is required to ensure life safety of those present, as well as to determine the cause of the problem and its solution.

4. Equipment

4.1 The following is a listing of basic measurement equipment that may be useful in diagnosing a carbon monoxide problem and determining the source, cause, and validating corrective actions:

4.1.1 *Electronic Carbon Monoxide Monitor*—A properly calibrated direct reading electronic monitor having a range of 0 to 1000 or 2000 ppm (that is, 0.1 to 0.2 %) is preferred in that its output provides almost instantaneous concentration data, and it therefore has the capability to warn the investigator if carbon monoxide levels are reaching dangerous concentrations. The carbon monoxide monitor may also be used to survey different areas of a building to locate the area of highest concentration, helping to identify the source. Monitors with data logging capabilities are preferred to assist in assessments of dosage.

4.1.2 *Carbon Monoxide Alarms (compliant with UL 2034)*—These alarms may be used as warning devices (see Section 5). Alarms with digital readouts should not be used as primary investigative monitors since their range is typically limited to ~100 ppm (that is, 0.01 %).

4.1.3 *Combustion Gas Analyzer*—Because malfunctioning combustion equipment is sometimes found to be the source of excessive carbon monoxide, portable gas analyzers are useful to check the combustion products produced by fuel burning equipment. These instruments indicate carbon monoxide as well as other exhaust gases. Combustion gas analyzers are used to determine whether the combustion equipment is operating within its normal limits for carbon monoxide in the exhaust. A measurement range up to 10 % carbon monoxide (100 000 ppm) may be required.

4.1.4 *Manometer*, or equivalent instrument, capable of determining positive and negative pressures in the combustion air supply, exhaust stack, and inside the living space while fuel burning equipment is operating.

4.1.5 *Ventilation Equipment*—A fan, blower, or similar device should be available to provide air movement in the space around equipment between tests to lower the carbon monoxide level to the baseline. Monitor the carbon monoxide level in the area before running each test.

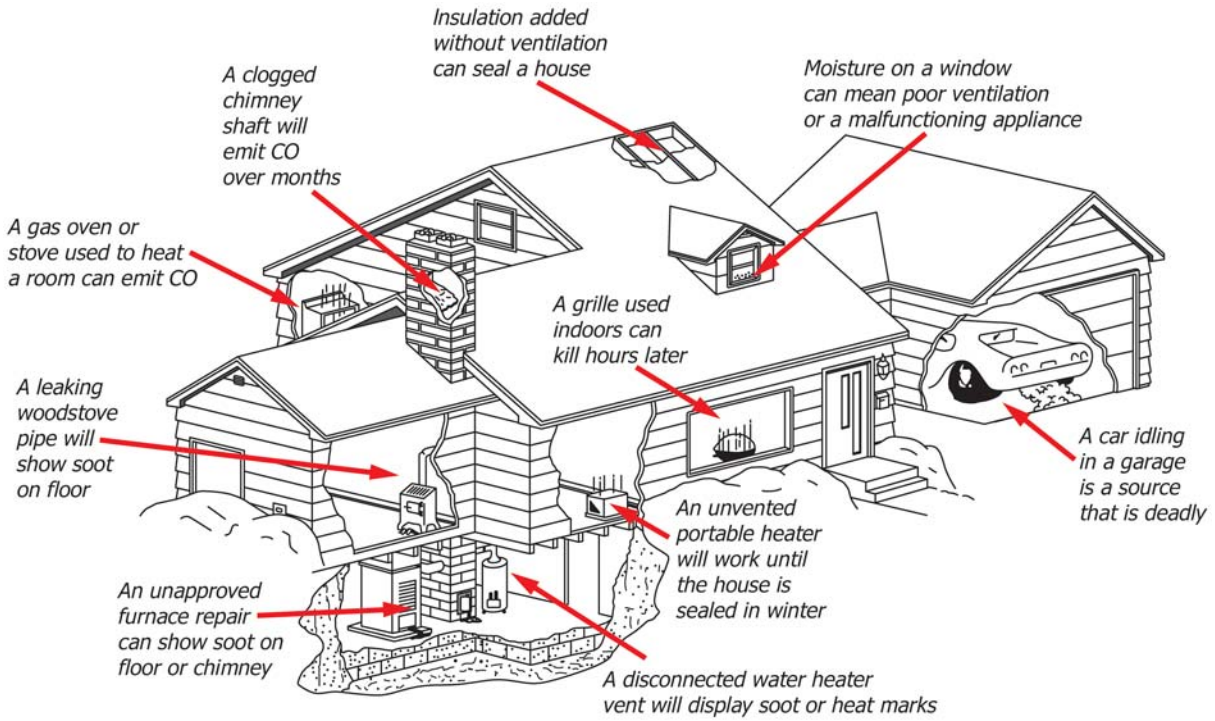

FIG. 1 Common Locations of Carbon Monoxide Build-Up

4.1.6 *SCBA (self contained breathing apparatus)* may be used if entering a highly contaminated area while conducting tests.

4.1.7 All indicating equipment should be calibrated at least annually or in accordance with the manufacturer's recommendations, and checked prior to each use. The equipment may be checked against a standard reference gas. Selection of calibration gas concentrations should reflect both low and high range for gas measurement equipment.

5. Safety

5.1 Entering spaces and testing of equipment suspected of causing carbon monoxide poisoning may yield definitive results that cannot be obtained any other way. Testing of equipment that may have injured individuals, however, is a potentially dangerous undertaking, in that the investigator runs the risk of becoming exposed to carbon monoxide being produced by improperly functioning equipment.

5.2 Safe testing procedures are of the utmost importance. Before any testing is undertaken, a safety officer should be identified. The safety officer's responsibilities are to protect the safety and health of the investigator and any individuals who may be affected by the testing.

5.3 Stable communications should be assured between the site and emergency service providers.

5.4 Audible carbon monoxide alarms, compliant with UL 2034, may be used as warning devices to warn participants of hazardous conditions. Such alarms are not substitutes for carbon monoxide monitors or analyzers, which may be worn on-person and can be configured to alert the user at different thresholds.

5.5 Until its safe operation has been verified, the minimum number of participants should be in the space where a piece of equipment is being tested for carbon monoxide output that the potentially interested parties will agree upon. Those persons inside should remain within sight of the safety officer or another individual capable of rescuing that individual from the space. SCBAs may be used if necessary.

5.6 All testing should be discussed in detail with all individuals involved in the testing, prior to the beginning of any test. A written test protocol may be advisable, as discussed in 6.11 below.

5.7 Permissible levels of carbon monoxide concentration depend on the time of exposure. The U.S. Environmental Protection Agency (EPA) advises a threshold of 50 ppm averaged over 8 hours. Higher concentrations or longer exposures at lower levels, or both, are also hazardous.

6. Procedure

6.1 *Scene Security*—If the carbon monoxide concentration is elevated in the area, the first priority is to evacuate the scene and prevent further injuries or loss of life.

6.1.1 After evacuation, the scene should be secured. If possible, field measurements of carbon monoxide levels in various locations around the scene should be taken.

6.1.2 The fuel supply to the scene should be turned off. This may require the switching off of internal combustion engines, or the closing of valves for gaseous or liquid fuels.

6.2 Notify individuals who have been identified as potentially having an interest in the testing of the time that the tests are going to take place. Prior to the testing, provide each of these individuals a copy of the testing protocol developed for their information and comment. For additional guidance on notification, see Guide E2713, E860, and NFPA 921 at 7.10 and 12.3.5. The advice of legal counsel may be advisable.

6.2.1 Such individuals may include the property owner, representatives of the victim(s), equipment manufacturers, fuel suppliers, equipment service personnel, law enforcement officers, code enforcement officers, and the insurance carrier for any of the parties listed above.

6.2.2 Keep a record of individuals who have been notified of the proposed testing.

6.2.3 Notification of other interested parties may not be necessary if the investigation is going to be limited to observations that do not change the condition of any of the structures or equipment.

6.3 *Documentary Information*—The following information may be of interest; not all of the information ultimately obtained will be available at the time of the initial field investigation. Nevertheless, the collection process should begin as soon as practical.

6.3.1 Emergency phone line recordings and medical records, particularly those that describe the blood gas analysis of the victims.

6.3.2 Obtain statements as early as possible from all individuals associated with the incident.

6.3.2.1 Determine if the occupants (including small animals) have exhibited prior signs of carbon monoxide exposure; for example, flu like symptoms.

6.3.2.2 First responders' test protocols and data.

6.3.2.3 First responders' actions to correct defects or remove carbon monoxide sources.

6.3.3 Weather data prior to and at the time of the incident; wind speed and direction, temperature, precipitation (snow, rain).

6.3.4 Altitude of the site if over 2000 ft; see NFPA 54 regarding high altitude installations.

6.3.5 Maintenance/service records for any fuel burning equipment, including maintenance contracts.

6.3.6 Equipment manuals or other related information regarding operation, service, maintenance, and input ratings.

6.3.7 Activities prior to the incident that may have affected the fuel sources, fuel burning equipment or ventilation of combustion products.

6.3.8 Information about the status of carbon monoxide alarms and monitoring systems.

6.3.9 Layout of the rooms and their dimensions. If the structure contains more than one heating appliance, indicate which appliances service each room.

6.3.10 Heating, ventilation, and air conditioning (HVAC) system configurations and settings. For structures, this may include thermostat setpoint, supply duct locations, and louver