Designation: D8251 – 23

Standard Practice for Determining Compressor Oil Carryover in Compressed Natural Gas Used as a Natural Gas Motor Vehicle Fuel[1]

This standard is issued under the fixed designation D8251; 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 standard practice is intended for gravimetric determination of compressor oil carryover as aerosols using either a coalescing filter method or sorbent tube method.

1.2 The method using coalescing filters is applicable to analysis of compressor or lube oil carryover as a liquid and is intended for long term monitoring of a compressed natural gas (CNG) dispenser system.

1.3 The method using a sorbent tube is applicable to analysis of compressor or lube oil carryover as a vapor and liquid in CNG dispenser systems present at 1 mg/kg to 500 mg/kg in a sample volume of 0.2 m^3 to 0.6 m^3. This method is applicable to a measurement intended to replicate the filling of a vehicle.

1.4 This standard shall be applicable to natural gas, biogas, or renewable natural gas (RNG) that is compressed for use as a fuel for internal combustion engines in motor vehicles.

1.5 This standard shall be applicable to natural gas, biogas, or renewable natural gas when they have been blended with hydrogen and have been compressed for use as a fuel for internal combustion engines in motor vehicles.

1.6 The user shall determine if the volumetric measuring elements of the dispensing system are adjusted for the composition of gaseous fuel blends being delivered and those volumetric measuring elements correctly calculate the volume of fuel delivered. The users shall apply appropriate correction factors if necessary.

1.7 *Units*—The values stated in SI units are to be regarded as standard.

1.8 Mention of trade names or organizations in this standard does not constitute endorsement or recommendation. Other manufacturers of equipment or equipment models can be used.

1.9 *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.*

1.10 *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]

D1070 Test Methods for Relative Density of Gaseous Fuels

D3588 Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels

D4150 Terminology Relating to Gaseous Fuels

E617 Specification for Laboratory Weights and Precision Mass Standards

2.2 *ISO Standard:*[3]

ISO 15970:2008 Natural gas—Measurement of properties—Volumetric properties: density, pressure, temperature, and compression factor

3. Terminology

3.1 For definitions of terms used D03 Gaseous Fuels standards, refer to Terminology D4150.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *natural gas vehicle (NGV), n*—vehicle designed to operate on compressed natural gas (CNG), liquefied natural gas (LNG), or renewable natural gas (RNG).

4. Summary of Practice

4.1 This practice describes construction of an apparatus for collecting compressor oil contained in CNG as well as a procedure for collecting and gravimetrically measuring compressor oil in CNG.

[1] This practice is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.06 on Analysis of Constituents in Gaseous Fuels.

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[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 International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

5. Significance and Use

5.1 Uncontrolled oil carryover from lubricated natural gas compressors can adversely affect natural gas vehicle (NGV) performance. In some instances, small amounts of oil will accumulate in vehicle pressure regulators and slow their response. It can also affect other components of the engine fueling system. Erratic engine performance, under fueling, or engine shutdown can occur. Such incidents have been reported by operators of NGV fueling stations and vehicles.

5.2 There is some vaporization of the lubrication (lube) oil that occurs due to compression of the gas. The oil vapor in CNG can be collected using a sorbent tube and quantified. Along with quantification of lube oil, this procedure can collect solids present in the gas.

5.3 These methods do not separate any solids including siloxane from the compressor oil carryover or vapor.

5.4 This practice can be applied to other gaseous samples requiring determination of compressor oil carryover provided the user's data quality objectives are satisfied.

6. Materials

6.1 *Filter Method:*

6.1.1 Filter test assembly (Fig. 1).

6.1.1.1 Coalescing filter elements 0.1 micron.

6.1.1.2 Coalescing filter housings without auto drain feature.

NOTE 1—The filter selected should not be affected by the solvent used to wash it. The filters used should be verified that any binder material is not soluble in the solvent.

6.1.2 Cleaned and pre-weighed glass jars for liquids.

6.1.3 Two glass jars (100 mL) for filter elements.

6.1.4 Solvent: Petroleum ether or Acetone; certified ACS grade.

6.1.5 O-rings for filter housings, compatible with selected solvent.

6.1.6 Gloves compatible with the solvent(s) used.

6.1.7 Safety glasses.

6.1.8 Oven capable of maintaining a temperature of 250 °C ± 1 °C.

6.1.9 Analytical balance with a minimum capacity of 200 g at a minimum resolution of 0.1 mg.

6.1.10 Tongs.

6.2 *Tube Method:*

6.2.1 Stainless steel tubing, 316.

6.2.2 Sampling apparatus as per Fig. 2.

6.2.3 Chromosorb® P NAW, 60/80 mesh or equivalent.

6.2.4 Glass wool.

6.2.5 Analytical balance with a minimum capacity of 200 g at a minimum resolution of 0.1 mg.

6.2.6 Oven capable of maintaining a temperature of 250 °C ± 1 °C.

6.2.7 Dessicator.

6.2.8 Dessicant.

6.2.9 Gloves compatible with the solvent used and/or tongs.

6.2.10 Acetone, Certified ACS Grade.

6.2.11 Plastic bags.

6.2.12 Stainless steel needle valve.

6.2.13 Particulate filter, 0.5 micron (as needed).

6.2.14 Drying tube (as needed).

6.2.15 Hydrocarbon filter (as needed).

6.2.16 Compressed nitrogen. Purity consisting of total hydrocarbons less than 0.5 ppm(v) and water less than 1 ppm(v).

7. Hazards

7.1 CNG is a highly flammable gas. Care should be taken to avoid hazards associated with gas leaks during sampling. Redundant safety measures such as gas leak monitors are recommended to ensure that potentially combustible gas mixtures do not come in contact with any ignition sources.

7.2 Improper handling of CNG can result in fire and/or explosion.

7.3 Rapid release CNG can result in asphyxiation.

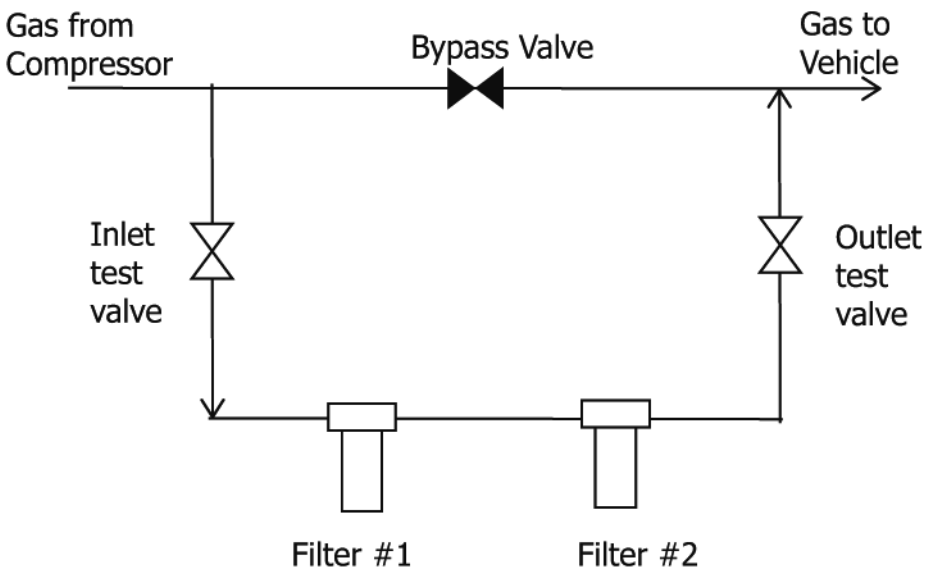
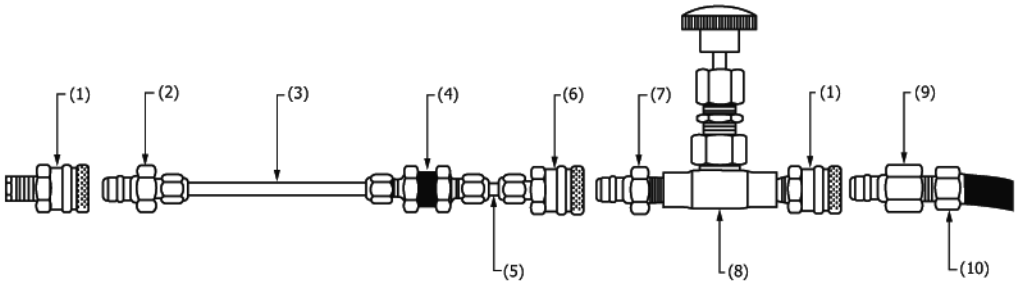


FIG. 1 Filter Test Assembly



Number	Swagelok® Number	Description
(1)	SS-QF4-B-4PM	1/4" MPT Quick Connect Body (2)
(2)	SS-QF4-S-400	1/4" Swagelok® Quick Connect Stem
(3)		6" long × 1/4" O.D × 0 035" wall Seamless Tube
(4)	SS-4FWS-0 5	In-line Filter, 0 5 micron
(5)	SS-401-PC	1/4" Port Connector
(6)	SS-QF4-B-400	1/4" Swagelok® Quick Connect Body
(7)	SS-QF4-S-4PM	1/4" MPT Quick Connect Stem
(8)	SS-31RF4	1/4" FPT Metering Valve
(9)	SS-QF4-S-4PF	1/4" FPT Quick Connect Stem

NOTE 1—Source: Czachorski, M. & Kina, R., 1998. Validation Testing of a Gravimetric Method to Measure CNG Compressor Oil Carryover, Illinois: Institute of Gas Technology. (GRI-98/0228)

FIG. 2 Compressor Oil Carryover Sampling Apparatus

8. Procedure

8.1 *Filter Method:*

8.1.1 *Cleaning and Pre-weighing Glass Jar:*

8.1.1.1 When handling the glass jar, always wear gloves. Several glass jars may be cleaned and weighed at one time. The jars are labelled with the pre-weight on the jar lids and stored until needed.

8.1.1.2 Wipe the outside of a 100 mL glass jar with a soft, clean cloth. Attach a label to the jar lid.

8.1.1.3 Remove the lid and place the jar in an oven at 82 °C ± 1 °C for one hour.

8.1.1.4 Remove the jar from oven. Place it in a desiccator and allow it to cool to room temperature.

8.1.1.5 Weigh the jar to the nearest 0.1 mg (lid off). Record the weight on the jar label.

NOTE 2—When removed from the desiccator, the jar should be weighed as soon as possible to minimize weight gain due to moisture from the air.

8.1.2 *Cleaning and Pre-weighing Filter Element:*

NOTE 3—Filter elements used for testing are rinsed initially with either petroleum ether or acetone to remove oils. Wear gloves and use tongs when handling the filter elements. The filters are stored in glass jars labelled with the jar tare-weight until needed.

8.1.2.1 Submerge filter elements in a beaker of solvent. Let them soak for 1 min to 2 min.

8.1.2.2 Place filter elements on a glass tray. Place them under a hood to allow ether to evaporate. Depending on the filter size this can be 3 h or more.

8.1.2.3 Once the solvent has evaporated, place the filters in an oven at 82 °C ±1 °C for 4 h.

8.1.2.4 Place filters in a desiccator and allow to cool to room temperature. Remove and immediately (see Note 2) weigh each filter to the nearest 0.1 mg.

8.1.2.5 Place filters in a clean glass jar. Label the jar with the filter tare-weight.

8.1.3 *Filter Housing Installation:*

8.1.3.1 The filter housings must be rated for the CNG fueling pressure. For example, a CNG fueling pressure of 24 800 kPag (3600 psig) requires a filter housing rating of at least 27 700 kPag (4000 psig). All tubing and valves, in this case, must be rated for 34 600 kPag (5000 psig). Ball valves may be used for the inlet, outlet, and bypass test valves. Needle valves must be used for the drain valves. Installation of the test assembly is usually done by the NGV station operator.

8.1.3.2 Install the test assembly shown in Fig. 1 downstream of all coalescing filters in the system, and as close to the dispenser as possible (Note 4). Make sure the filter housings are installed correctly (flow direction is specified by filter manufacturer). The size of the tubing should be the same as the size used near the installation location.

NOTE 4—Make sure that the test assembly is installed in a location where the entire volume of compressed gas, as recorded by the meter, passes through the filter housings. One exception is discharge side once-through dryers where the test assembly is installed between the coalescing filter and dryer cartridges on one side of the dryer. In this case it is assumed that half of the total volume of gas passes through each side of the dryer.

8.1.3.3 Check the test assembly for leaks. Repair any leaks.

8.1.3.4 Label the filter housings as filter #1 and #2 in the direction of the gas flow.

8.1.3.5 Close both inlet and outlet valves to the test assembly and open the bypass valve.

8.1.4 *Filter Installation:*

8.1.4.1 Make sure the bypass valve is open, and the inlet and outlet test valves are closed. Purge out any pressure in the filter housings by slowly opening the drain valves.

8.1.4.2 Remove both filter housings. They should loosen without using a wrench. If not, use a wrench on the bottom of the housing to loosen.

8.1.4.3 Using tongs, install a filter element in each housing. Record the date of installation, location, and filter # on the label of each filter element jar, and in a data sheet.

8.1.4.4 Record the meter reading, compressor hours (if available), filter #'s, and tare-weights in the data sheet.

8.1.4.5 Make sure the O-rings (if applicable) are in place and tighten the filter housings and drain valves.

8.1.4.6 Slowly, open the inlet test valve all the way. Caution, if a valve is opened too fast, filter elements may be damaged.

8.1.4.7 Slowly open the outlet test valve all the way.

8.1.4.8 Check for leaks.

8.1.4.9 Close the bypass valve shut.

8.1.5 *Filter Removal:*

8.1.5.1 Be sure to wear gloves and safety glasses. The filter change out interval must be pre-determined to insure accurate test results. The change out interval is dependent on the station throughput and the amount of oil carryover from the compressor. Change out of filters should be conducted when the first filter is saturated with oil. There may be some oil accumulated in the first filter housing, however, the elements should be changed before oil begins to accumulate in the second filter housing (before the second filter is saturated). If the oil carryover rate is very low, saturation of the filters may not occur for several weeks. In this case, the filter elements may be changed prior to saturation.

8.1.5.2 Open the bypass valve and close the inlet and outlet test valves.

8.1.5.3 Position a pre-weighed glass jar at the outlet of drain valve #1. Slowly open the drain valve and collect any liquids in the glass jar. Let all the gas purge out of the drain valve. Leave the drain valve open.

NOTE 5—Be very careful, as there may be for example 24 800 kPag (3600 psig) in the filter housings.

8.1.5.4 Position a pre-weighed glass jar (can be combined in same jar as in 8.1.5.3) under drain valve #2. Slowly open and collect any liquids in the jar. There should be no pressure remaining in the system. Record the collection date and location on the label.

8.1.5.5 Remove both filter housings. They should loosen without using a wrench. If not, use a wrench on the bottom of the housing to loosen.

8.1.5.6 Check both filter elements. If liquids were collected in both filter housings, then both filter elements have been saturated. In this case, the change-out interval must be shortened. Follow the procedure described below for removal of the filters. If liquids were found in filter #1 but not filter #2, the change-out interval is satisfactory. Follow the procedure below for removal of the filters. If both filter elements appear dry, do no change elements. Skip to step 8.1.5.10. In this case, the change-out interval will need to be lengthened.

8.1.5.7 Wearing gloves, remove filter element #1, and place it in the original jar labelled filter #1. Record the removal date on the label.

8.1.5.8 Wearing gloves, remove filter element #2, and place it in the original jar labelled filter #2. Record the removal date on the label.

8.1.5.9 Hold the glass jar, with any liquid collected, under each filter housing, rinse the inside of the housing with solvent until clean. Place the lid on the jar.

8.1.5.10 If additional testing is needed, install a new filter element in each housing. Record the date of installation, location, and filter # on the label of each filter element jar. Record the filter # for each element on a new data sheet.

NOTE 6—If further testing is not needed, do not install new filter elements. Replace O-rings and close the inlet and outlet test valves. Open the bypass valve.

8.1.6 Record the meter reading, compressor hours (if available), glass jar tare-weight, and removal date in the data sheet.

8.1.6.1 Determine the density of the gas being sampled by direct measurement or by using an accepted density for the gas being supplied. Density shall be determined under the same conditions as fuel metering device.

8.1.6.2 Volumetric meter readings shall be converted into kilograms of gas delivered using the appropriate gaseous fuel densities at metered conditions.

8.1.7 Replace the O-rings on each filter housing. Tighten the filter housing and drain valves. Slowly, open the inlet test valve all the way (if the valve is opened too fast, filter elements may be damaged).

8.1.7.1 Slowly open the outlet test valve all the way.

8.1.7.2 Check for leaks.

8.1.7.3 Close the bypass valve all the way.

8.1.8 *Post-Weight Determination of Filter Elements and Liquids:*

8.1.8.1 When handling filter elements, use tongs. When handling glass jars, wear gloves.

8.1.8.2 Remove the lid from the glass jar containing the collected liquid and place the glass jar under a hood overnight to evaporate off the solvent. Weigh the jar to the nearest 0.1 mg. If the weight fluctuates by more than 0.1 mg, put it back in a hood for 2 additional hours, and re-weigh it, repeat this process until 2 consecutive weights differ by less than 1 mg.

8.1.8.3 Remove the lid from each jar containing a filter element. Place the jars, and filter elements (elements should be on a petri dish) in an oven at 82 °C ± 1 °C for at least 3 h to 4 h.

8.1.8.4 Remove jars and filter elements from the oven. Place these items in a desiccator and allow them to cool to room temperature.

8.1.8.5 Weigh each filter element and glass jars (lid off) as soon as possible (see Note 2). Record post-weights in the data sheet.

8.2 *Tube Method:*

8.2.1 *Gravimetric Sampling Apparatus Construction*—A schematic of the sampling apparatus and parts list is presented in Fig. 2. All parts are constructed from 316 stainless steel; excepting the fueling hose.

8.2.2 *Sampling Device Construction and Assembly:*

8.2.2.1 Cut one stainless steel tubing between 15 cm.