Designation: E 1002 – 96

Standard Test Method for Leaks Using Ultrasonics[1]

This standard is issued under the fixed designation E 1002; 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 *Test Method A, Pressurization*—This test method covers procedures for calibration of ultrasonic instruments, location, and estimated measurements of gas leakage to atmosphere by the airborn ultrasonic technique.[2]

1.2 In general practice this should be limited to leaks producing leakage of 4.5×10^{-7} mol/s (1×10^{-2} std. cm^3/s at 0°C) or more for the pressure method of gas leakage to atmosphere. Refer to Guide E 432 for additional information.

1.3 *Test Method B, Ultrasonic Transmitter*—For object under test not capable of being pressurized but capable of having ultrasonic tone placed/injected into the test area to act as an ultrasonic leak trace source.

1.3.1 This test method is limited to leaks producing leakage of 4.5×10^{-6} mol/s (1×10^{-1} std. cm^3/s at 0°C) or greater.

1.4 The values stated in SI units are to be regarded as the standard.

1.5 *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 consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 432 Guide for Selection of a Leak Testing Method[3]

E 1316 Terminology for Nondestructive Examinations[3]

2.2 *Other Documents:*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing[4]

ANSI/ASNT CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, see Terminology E 1316, Section E.

4. Summary of Test Method

4.1 *Test Method A*—This test method sets minimum requirements for an ultrasonic detector. It provides for calibration of the detector and gives procedures for pressurizing the test object, locating leaks, and estimating the leakage rates.

4.2 *Test Method B*—This test method sets minimum requirements for an ultrasonic detector used in conjunction with an ultrasonic transmitter. It gives procedures for locating leaks using an electronically generated ultrasonic leak tracer source.

5. Personnel Qualification

5.1 It is recommended that personnel performing leak testing attend a dedicated training course on the subject and pass a written examination. The training course should be appropriate for NDT level II qualification according to Recommended Practice No. SNT-TC-1A of the American Society for Nondestructive Testing or ANSI/ASNT Standard CP-189.

6. Significance and Use

6.1 *Test Method A*—This test method is useful for locating and estimating the size of pressurized gas leaks, either as a quality control test or as a field inspection procedure. It is also valuable as a pretest before other more time consuming and more sensitive leak tests are employed. It should not be used exclusively to locate highly toxic or explosive gas leaks.

6.2 *Test Method B*—This test method is useful for locating leaks in systems that are not under pressure or vacuum as either a quality control or a field inspection procedure. It is not useful for estimating the size of a leak. It is also valuable as a pretest before leak tests using pressurized gas methods and more sensitive leak tests are employed.

7. Interferences

7.1 The areas to be tested must be free of oil, grease, paint, and other contaminants that might mask a leak.

7.2 Under certain conditions background noise detected by the instrument can prevent the detection of relevant leakage. This background noise can result from equipment vibration and

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[1] This test method is under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.08 on Leak Testing Method.

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[2] This technique is sometimes called "ultrasonic translation."

[3] *Annual Book of ASTM Standards*, Vol 03.03.

[4] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228 – 0518.

air movement due, for example, to wind, or air-cooled motors, aircraft engines, pneumatic systems, etc.

7.3 Use of earphones is required in areas where the background noise might interfere with hearing the audible output of a speaker.

8. Apparatus

8.1 *Ultrasonic Leak Detection System*:

8.1.1 The system shall consist of an instrument, probes, focusing probe accessory and earphones. (A speaker may or may not be utilized.)

8.1.2 The system shall provide for detection of acoustic energy in the ultrasonic range from 20 000 to 100 000 Hz and shall translate this energy into an audible signal that can be heard by use of earphones or speaker, or both.

8.1.3 The detected energy shall be indicated on a meter readout.

8.2 *Minimum Instrument Requirements*—The instrument shall meet the following requirements:

8.2.1 The detected ultrasonic energy shall be indicated on a meter readout that shall have pointer deflection great enough to exceed normal background fluctuations. The meter indication may have a correlation to decibels.

8.2.2 The audible response shall consist of the down-converted heterodyned ultrasonic signal. This audio signal will be representative of the amplitude or frequency characteristics, or both, of the original ultrasonic signal. Heterodyned signals could allow the operator to discriminate audible background interference as in 7.2.

8.2.3 The instrument shall be equipped with a sensitivity control or gain adjustment, or both, to achieve the conditions of 9.3.3.

8.2.4 The instrument may be equipped with a ten-turn sensitivity control with a three-digit readout.

8.2.5 The internal power supply shall be regulated to provide repeatability of the sensitivity set point to within ±5 % of full scale over the full range of battery condition.

8.2.6 The instrument may include additional features which could enhance leak detection such as frequency controls or meter response selection, or both.

8.3 *Other Apparatus*—Pressure gages, valves, and piping as required.

8.4 *Ultrasonic Transmission*

8.4.1 The system shall consist of an apparatus described in 8.1-8.3 with the addition of an ultrasonic transmitter.

8.4.2 The transmitter shall produce an ultrasound between the frequencies of 38 to 42 kHz.

8.4.3 The output of the transmitter transducer shall be in excess of 100 dB at 1 ft.

8.4.4 The intensity of the output may be adjustable.

8.4.5 The heterodyned signal received by the ultrasonic leak detection system from the ultrasonic transmitter must be easily identified and recognized as the ultrasonic tracer source.

8.4.6 The internal power supply shall be regulated and be sufficient to produce the required output (see 8.4.3).

8.4.7 The transmitter may include additional features that could enhance the leak detection process such as a warble tone transmission and amplitude adjustments.

9. Calibration

9.1 *Calibration/Sensitivity Validation*—The ultrasonic instrument should be calibrated or have the sensitivity validated before each initial use.

9.2 *Calibration/Sensitivity Validation Equipment*—Use the following equipment for calibration of the test system:

NOTE 1—This equipment serves a dual function; either to calibrate the ultrasonic instrument for leakage rate approximation as in 11.3, or to verify the sensitivity for detection and location as in 11.1.

9.2.1 *Leak Standard*, with a preset flow rate of 4.9×10^{-5} mol/s (1.1 std. cm^3/s at 0°C) ± 5 %. The orifice size shall be approximately 0.2 mm (0.008 in.).

9.2.2 *Regulator*, for the nitrogen supply with output pressure and flow gages. The tank pressure gage is optional.

9.3 *Calibration for Air Probe*:

9.3.1 Locate the detection probe a distance of 10.0 m (±0.1 m) from the calibrated leak standard specified in 9.2.1.

9.3.2 Check to see that the detector probe and leak source are aligned to obtain the peak response (see Fig. 1).

9.3.3 Adjust the instrument's meter to a meter reading of 50 % of full scale (±5 %).

9.3.4 Place a sound absorbing barrier in front of the microphone, blocking out the calibrated leak source; the meter reading should zero with a corresponding absence of an audible signal.

9.4 *Recalibration*:

9.4.1 Recheck or validate the sensitivity of the equipment at the beginning of each shift or designated work period interval. This test must be performed at the same sensing frequency as the initial test.

9.4.2 Recheck the equipment when abnormalities are observed in its operation.

9.5 *Ultrasonic Transmitter Method*, should have the sensitivity calibrated or have the generated amplitude validated before each initial use. This could be done by placing the ultrasonic transmitter in a container with a known leak that is equivalent to the leaks that are to be detected.

10. General Considerations

10.1 *Openings*:

10.1.1 Seal all openings using plugs, covers or other suitable materials that can be readily and completely removed after the completion of the test.

10.1.2 Provide a gas inlet by attaching a valve to one of the test covers on all items to be pressurized.

10.2 *Check of Test Parts*:

10.2.1 Examine the part and test equipment before pressure is applied to ensure that it is tight and all appurtenances that should not be subjected to the test pressure have been disconnected or isolated by valves or other suitable means.

10.2.2 Check safe pressure rating to be sure it will not be exceeded during test.

10.3 *Temperature of Vessel and Testing Medium*:

10.3.1 The temperature of the pressurizing gas must not be at a level that would be injurious to the part or its components.

10.3.2 The test gas is dry nitrogen. (Compressed air can contain oil or water droplets which can seal leaks.)

10.4 *Pressure*:

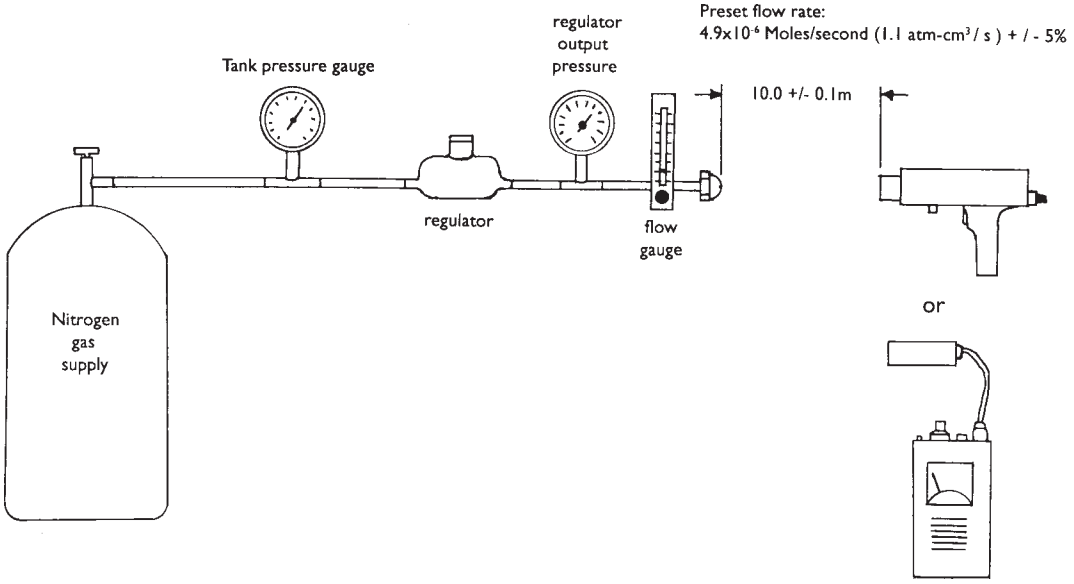

FIG. 1 Calibrated Leak Standard/Sensitivity Validation Equipment

10.4.1 Unless otherwise specified the gage pressure shall be at least 70 kPa (10 psig). Normal safety precautions should be observed when pressurizing the part under test with the gas to avoid test part ruptures.

10.4.2 Gradually increase the pressure in the part to final test pressure.

10.5 *Ultrasonic Transmitter Method*—Inspect test object to be sure it is free of debris and liquids at the test sites.

11. Detection and Location of Pressurized Gas Leaks

11.1 *Detection*:

11.1.1 Set the sensitivity at maximum.

11.1.2 Begin to scan by pointing the probe towards the test area. The procedure is to go from "high sensitivity" to "low sensitivity," reducing the sensitivity as the leak is approached.

11.1.3 Note the fluctuations in meter readings and the volume from the earphones or speaker.

11.1.4 If there is too much ultrasound in the area, reduce the sensitivity and continue to scan.

11.1.5 If it is difficult to isolate the leak due to competing ultrasound, place the focusing probe accessory over the scanning probe. This increases the directional response characteristics of the probe.

11.1.6 Listen for a "rushing" sound while observing the meter.

11.1.7 Follow the ultrasound to the loudest point. The meter will show a higher reading as the leak is approached.

11.2 *Ultrasonic Transmitter Method*—rovide for access of transmitter placement in the test object or provide an inlet pipe conduit fitting to couple with the transmitter allowing it to adequately saturate the test object with ultrasound in such a way as to shield stray ultrasonic leakage into the ultrasonic leak detection side.

11.2.1 All potential interferences shall be cleared away from the test areas either by cleaning or by blowing the areas dry with compressed gas.

11.2.2 *Transmitter Placement*—The transmitters shall be placed to adequately cover the test object with a uniform ultrasound.

11.2.3 Listen for the distinct heterodyned ultrasound produced by the ultrasonic transmitter. This may be a whistle or warbling tone.

11.3 *Location*:

11.3.1 In order to focus on the leak, keep reducing the sensitivity until a leak is located.

11.3.2 *To Confirm a Leak*—Position the scanning probe with or without the rubber focusing extension close to the suspect leak site and move it, slightly back and forth, up and down. If the leak is at this location, the sound and meter readings will both increase and decrease in intensity. This source discrimination technique will eliminate false leak identification due to reflected leak signals from other sites near the suspect leak site.

11.4 *Leakage Rate Approximation*—The leakage rate may be estimated by moving the probe away from the leak to maximum detection distance at the calibrated sensitivity (leakage just indicated by a slight increase in meter indication and sound level over normal background, with the probe pointed to maximize the leak signal intensity). The leak rate can be approximated as follows:

$$LR = 4.9 \times 10^{-6}\ \text{mol/s} \times DDM$$

or

$$LR = 1.1 \times 10^{-2}\ \text{std. cm}^3\text{/s at } 0°C \times DDM$$

where:

LR = leakage rate, and
DDM = detection distance meters.

12. Report

12.1 The following information should be recorded at the time of the measurements and included in the report:

12.1.1 Date tested.

12.1.2 Test conditions such as temperature and pressure.
12.1.3 Location of leak.
12.1.4 Name and model of apparatus used.
12.1.5 Calibration.
12.1.6 Signature of tester.

13. Precision and Bias

13.1 This procedure is based on laboratory results and is believed to represent the best available method. Operational procedures that might affect precision and bias have been defined as closely as appears practicable.

14. Keywords

14.1 leak detection—ultrasonic; leak testing; leakage rate; ultrasonic detector