



Designation: E1930-02

Standard Test Method for Designation: E 1930 - 07

Standard Practice for Examination of Liquid-Filled Atmospheric and Low-Pressure Metal Storage Tanks Using Acoustic Emission¹

This standard is issued under the fixed designation E 1930; 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 ~~test method~~ practice covers guidelines for acoustic emission (AE) examinations of new and in-service aboveground storage tanks of the type used for storage of liquids.

1.2 This ~~test method~~ practice will detect acoustic emission in areas of sensor coverage that are stressed during the course of the examination. For flat-bottom tanks these areas will generally include the sidewalls (and roof if pressure is applied above the liquid level). The examination may not detect flaws on the bottom of flat-bottom tanks unless sensors are located on the bottom.

1.3 This ~~test method~~ practice may require that the tank experience a load that is greater than that encountered in normal use. The normal contents of the tank can usually be used for applying this load.

1.4 This ~~test method~~ practice is not valid for tanks that will be operated at a pressure greater than the examination pressure.

1.5 It is not necessary to drain or clean the tank before performing this examination.

1.6 This ~~test method~~ practice applies to tanks made of carbon steel, stainless steel, aluminum and other metals.

1.7 This ~~test method~~ practice may also detect defects in tank linings (for example, high-bulk, phenolics and other brittle materials).

1.8 AE measurements are used to detect and localize emission sources. Other NDT methods may be used to confirm the nature and significance of the AE indications (s). Procedures for other NDT techniques are beyond the scope of this ~~test method~~ practice.

1.9 Examination liquid must be above its freezing temperature and below its boiling temperature.

1.10 Superimposed internal or external pressures must not exceed design pressure.

1.11 Leaks may be found during the course of this examination but their detection is not the intention of this ~~test method~~ practice.

1.12 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.13 *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.* Specific precautionary statements are given in Section 8.

2. Referenced Documents

2.1 ASTM Standards:²

~~E 543 Practice for Evaluating Agencies that Perform Nondestructive Evaluation~~ Specification for Agencies Performing Nondestructive Testing

~~E 650 Guide to Mounting Piezoelectric AE Sensors~~² Guide for Mounting Piezoelectric Acoustic Emission Sensors

E 976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response

~~E 1316 Terminology for Nondestructive Examinations~~² Terminology for Nondestructive Examinations

E 2374 Guide for Acoustic Emission System Performance Verification

¹This test method is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.04 on Acoustic Emission Method.

Current edition approved July 10, 2002. Published September 2002. Originally published as E1930-97. Last previous edition E1930-97.

²This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.04 on Acoustic Emission Method.

Current edition approved Dec. 1, 2007. Published December 2007. Originally approved in 1997. Last previous edition approved in 2002 as E1930 - 02.

³For 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, Vol 03.03, volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 *ANSI/ASNT Standard:*

Recommended Practice ASNT SNT-TC-1A for Qualification and Certification of Nondestructive Testing Personnel³
ANSI/ASNT CP-189 Standard for Qualification and Certification of NDT Personnel³

2.3 *ASME Standard:*

Section V, Article 12, Boiler & Pressure Vessel Code ⁴

2.4 *AIA Document:*

NAS-410 Certification and Qualification of Nondestructive Testing Personnel⁵

3. Terminology

3.1 *Definitions:*

3.1.1 This ~~test method~~practice makes use of definitions provided in Terminology E 1316. Definitions for terms that do not appear in Terminology E 1316 are given below.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *AE activity*—the presence of acoustic emission during an examination. It is normally measured by one or more AE parameters such as number of hits, events, signal strength or AE counts. A source is considered active if its AE activity consistently increases with increasing load.

3.2.2 *maximum operating pressure*—largest pressure within the tank during the six-month period prior to AE examination. This pressure involves the maximum liquid contents level, the range of temperature experienced during operation, superimposed hydrostatic or pneumatic pressure, or both, and any overload or upset conditions which may have occurred.

3.2.3 *signal strength*—the measured area of the rectified AE signal.

4. ~~Summary of Test Method~~ Summary of Practice

4.1 *General*—This ~~test method~~practice consists of subjecting storage tanks to increasing stress while monitoring with sensors that are sensitive to acoustic emission (transient stress waves) caused by growing flaws. The instrumentation and techniques for sensing and analyzing AE are described herein.

4.2 *Loading*—~~The test method~~—This practice requires stressing the tank. Stressing can be accomplished by filling the tank with its normal contents or with an alternative liquid and in some cases applying a superimposed hydrostatic or pneumatic pressure, or both.

4.3 *Report*—The report documents results of the AE examination and other important information. The report also provides recommendations for follow-up NDT examinations at specific locations.

5. Significance and Use

5.1 *General*—This procedure is used for evaluation of the structural integrity of atmospheric storage tanks. The AE method can detect flaws which are in locations that are stressed during pressurization. Such locations include the tank wall, welds attaching pads to the tank, nozzle attachments, and welds attaching circumferential stiffeners to the tank. Among the potential sources of acoustic emission are:

5.1.1 In both parent metal and weld associated regions:

5.1.1.1 Cracks,

5.1.1.2 The effect of corrosion, including cracking of corrosion products or local yielding,

5.1.1.3 Stress corrosion cracking,

5.1.1.4 Certain physical changes, including yielding and dislocations,

5.1.1.5 Embrittlement, and

5.1.1.6 Pits and gouges.

5.1.2 In weld associated regions:

5.1.2.1 Incomplete fusion,

5.1.2.2 Lack of penetration,

5.1.2.3 Undercuts, and

5.1.2.4 Voids and porosity.

5.1.2.5 Inclusions:

5.1.2.6 Contamination.

5.1.3 In parent metal:

² Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

³ Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, <http://www.asnt.org>.

⁴ Available from American Society of Mechanical Engineers, 345 E. 47th Street, New York, NY 10017.

⁴ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁵ Available from Aerospace Industries Association of America, Inc., 1250 Eye St., NW, Washington, DC 20005.

⁵ Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, <http://www.aia-aerospace.org>.

- 5.1.3.1 Laminations.
- 5.1.4 In brittle linings:
 - 5.1.4.1 Cracks,
 - 5.1.4.2 Chips, and
 - 5.1.4.3 Inclusions.

NOTE 1—Not all of these sources are typically encountered in field examination, some are detected under laboratory conditions.

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5.2 Accuracy of the results from this practice can be influenced by factors related to setup and calibration of instrumentation, background noise, material properties and characteristics of an examined structure.

5.3 The outcome of this practice is to determine if the tank is suitable for service or if follow-up NDT is needed before that determination can be made.

5.4 Unstressed Areas—Flaws in unstressed areas and passive flaws (those that are structurally insignificant under the applied load) will not generate AE. Such locations can include the roof and certain welds associated with platforms, ladders, and stairways.

5-3

5.5 Passive Flaws (in Stressed Areas)—Some flaws in stressed areas might not generate acoustic emission during stressing. This usually means that the flaw has a higher stress tolerance than the examination stress.

5-4

5.6 Filling—Filling proceeds at rates which minimize AE activity caused by fluid flow and which allow vessel deformation to be in equilibrium with applied load. Hold periods are used throughout the filling schedule to evaluate AE activity produced by the loaded structure in the absence of fill noise.

5-5

5.7 Follow-up—Sources detected by AE should be examined using other NDT methods.

5-6

5.8 Background Noise—Excess background noise may distort AE data or render them useless. Users must be aware of common sources of background noise: high fill rate (measurable flow noise), mechanical contact (impact, friction, fretting) with the tank by objects, electromagnetic interference (EMI) (motors, welders, overhead cranes) and radio frequency interference (RFI) (broadcasting facilities, walkie talkies), leaks at pipe or hose connections, leaks in the tank bottom or walls, airborne particles, insects, or rain drops, heaters, spargers, agitators, level detectors and other components inside the tank, chemical reactions occurring inside the tank, and hydrodynamic movement of gas bubbles. This test method practice should not be used if background noise cannot be eliminated or controlled.

6. Basis of Application

6.1 Personnel Qualification

6.1.1 If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189

6.1 The following items are subject to contractual agreement between the parties using or referencing this practice.

6.2 Personnel Qualifications

6.2.1 If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS-410, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

6-1-2

6.2.2 Training and Examination—In addition, it is required that personnel performing acoustic emission examination of storage tanks attend a dedicated training course on the subject and pass a written examination. The training course shall include the following topics:

- 6.12.2.1 Storage tank construction and terminology,
- 6.12.2.2 Failure mechanisms of metal and metal fabricated systems,
- 6.12.2.3 Case histories of metal vessels examined with acoustic emission,
- 6.12.2.4 Storage tank examination procedures, including loading requirements,
- 6.12.2.5 Data collection and interpretation, and
- 6.12.2.6 Examination report and permanent record requirements.

6.2.3 Qualification of Nondestructive Agencies—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E 543. The applicable edition of Practice E 543 shall be specified in the contractual agreement.

6.3 Timing of Examination

6.3.1 This test method may be used on new tanks, erected, in place or tanks which have been in service.

6.4 Timing of Examination—This practice may be used on new tanks, erected, in place or tanks that have been in service.

~~6.4.1~~ ~~The~~ ~~The~~ extent of examination shall be in accordance with 1.2, 1.6, 1.7 and 1.11 unless otherwise specified.

6.5

~~6.5.1~~ ~~Reporting~~ ~~Reporting~~ criteria for the examination results shall be in accordance with 10.11 unless otherwise specified.

6.5.2 ~~1~~ Non-mandatory acceptance criteria are described in ~~Appendix~~ Appendix X2.

6.6

~~6.6.1~~ ~~Reexamination~~ ~~Reexamination~~ of repaired/reworked items is not addressed in this standard and if required shall be specified in the contractual agreement.

7. Apparatus

7.1 Essential features of the apparatus required for this examination method are provided in Fig. 1. Full specifications are in Annex A1.

7.2 AE sensors are used to detect stress waves produced by flaws. Sensors must be held in contact with the vessel wall to ensure adequate acoustic coupling. Sensors may be held in place with magnets, adhesive tape, or other mechanical means.

7.3 A preamplifier may be enclosed in the sensor housing or in a separate enclosure. If a separate preamplifier is used, cable length between sensor and preamplifier should not exceed 6 ft (1.83 m). Longer cables may cause unacceptable signal attenuation and increase the likelihood of EMI and RFI.

7.4 Signal cable length (that is, cable between preamplifier and signal processor) should not exceed 500 ft (152.4 m). For longer cable lengths signal repeaters may be required to minimize signal attenuation.

7.5 Signals shall be processed with computerized systems with independent channels that filter, measure, and convert analog information into digital form for display and permanent storage. A signal processor must have sufficient speed and capacity to process data independently from all sensors simultaneously. A printer should be used to provide hard copies of examination results.

7.6 A video monitor should display processed data in various formats. Display format may be selected by the equipment operator.

7.7 A data storage device, such as a floppy disc, may be used to provide data for replay or for archives.

7.8 Hard copy capability should be available from a graphics/line printer or equivalent device.

8. Safety Precautions

8.1 Ambient temperature should not be below the ductile-brittle transition temperature of the pressure vessel construction material.

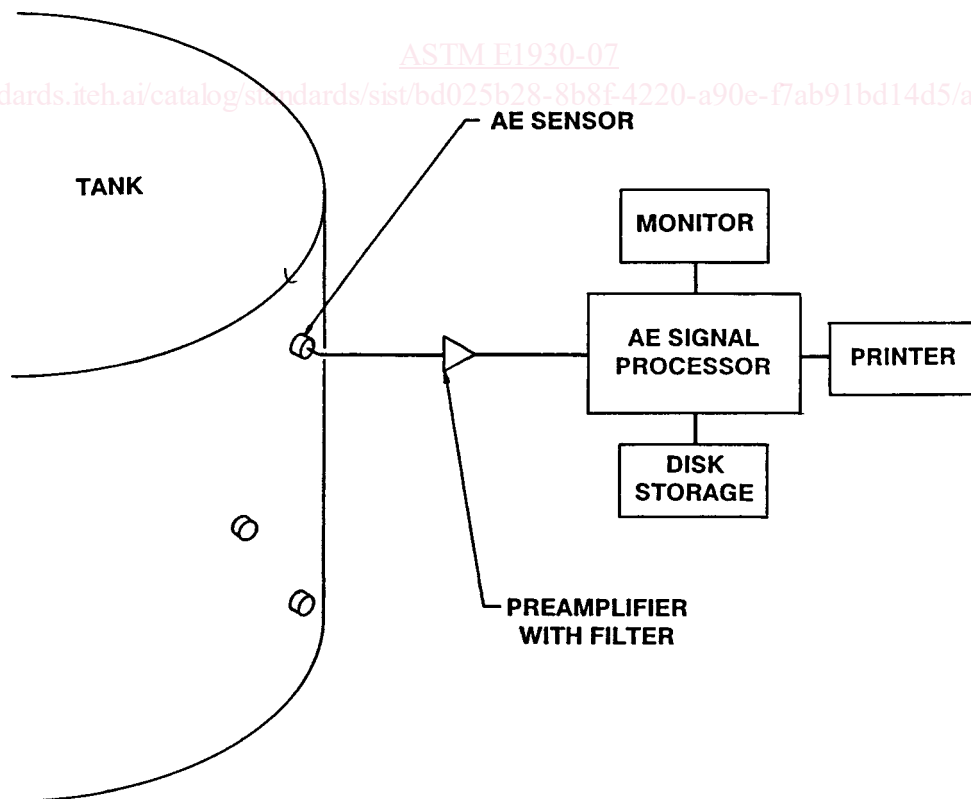


FIG. 1 Features of the Apparatus

9. Standardization and Performance Verification

9.1 Annual standardization and verification of AE sensors, preamplifiers (if applicable), signal processor and AE electronic waveform generator shall be performed. Equipment should be adjusted so that it conforms to equipment manufacturer's specifications. Instruments used for standardizations must have current accuracy certification that is traceable to the National Institute for Standards Technology.

9.2 Routine electronic evaluations must be performed at any time there is concern about signal processor performance. An AE signal generator should be used in making evaluations. Each signal processor channel must respond with peak amplitude reading within ± 2 dB of the AE signal generator output.

9.3 System performance verification must be conducted immediately before each examination and should be repeated afterward.

Refer to E2374.

9.3.1 A performance verification uses a mechanical device to induce stress waves into the vessel wall at a specified distance from each sensor. Induced stress waves stimulate a sensor in a manner similar to emission from a flaw. Performance verification checks the performance of the entire system (including couplant) (see E2374).

9.3.2 Pencil lead breaks, in accordance with Guide E 976, shall be used to verify system performance. Lead breaks will be at least 4 in. (10.16 cm) from the sensor. The average peak amplitude shall not vary more than ± 4 dB from the average of all sensors.

9.3.3 When computed location (See 10.8.7.3) is used, adjacent sensors shall detect lead break signals at amplitudes exceeding the examination threshold. The location accuracy shall be verified to be within 5 % of the sensor spacing.

9.4 *Functional Verification*—A simple functional verification used to insure that all channels are operational, makes use of a spring-loaded center punch before and after examination. To avoid damage to the tank wall, the center punch shall be made on a stiffener ring, or with a $\frac{1}{8}$ in. (3.2 mm) minimum thickness backup plate between the center punch and tank wall. Multiple center punch sites might be needed to cover the entire examination range. Center-punch impacts shall be made at a distance from sensors such that the peak amplitude measured by the sensor/channel combination does not exceed 90 dB (0 dB = one μ v at preamplifier input). Before or during the examination, repair or replace channels that do not respond. After the examination, report channels that do not respond to the punch or have low sensitivity.

10. Procedure

10.1 *Examination Preliminary*—Prior to setting up the examination instruments, the examiner shall be furnished with the following information:

10.1.1 A specification of materials in the tank under examination, including information on linings or internal coatings.

10.1.2 A tank drawing with sufficient detail to establish the dimensions, nozzle locations and material thickness.

10.1.3 Information on operating conditions for the 6 month period prior to AE examination. This information should include the type of liquid contained, maximum liquid contents level, the operating range of temperature, superimposed hydrostatic or pneumatic pressure, or both, and any overload or upset conditions that may have occurred.

10.2 *AE Examination Pressure*—The AE examination pressure depends on whether the AE examination is being performed in conjunction with the hydrostatic proof examination of a new tank, or whether the AE examination is performed on an in-service storage tank. Table 1 describes AE examination pressure to meet the requirements of this examination procedure.

10.3 *Tank Stressing*— Make arrangements to expedite the stressing of the tank at a rate consistent with the requirements of 10.9.4 and Table 1. Tanks will normally be stressed by hydrostatic head pressure plus superimposed hydrostatic or pneumatic pressure, or both. For some in-service tanks it may be appropriate to stress using a combination of hydrostatic head pressure plus

TABLE 1 Storage Tank AE Examination Pressure

NOTE 1—If an alternative fluid with a specific gravity lower than the operating fluid is used, the required AE examination load may be achieved by filling to the maximum level and applying an additional superimposed hydrostatic or pneumatic pressure, or both, to achieve the 5 % overload.

NOTE 2—If an alternative fluid with a specific gravity higher than the operating fluid is used, the maximum fill level shall achieve the 5 % overload at the bottom of the tank, and must be at least equal to the maximum operating pressure.

NOTE 3—In some cases, due to physical limitations, it may not be possible to fill 5 % above the maximum operating level. In such cases a 2 % overload is acceptable. An overload less than 2 % is not acceptable per this procedure.

NOTE 4—Repaired tanks are examined with the same examination pressure as described above.

	Examination Performed	AE Examination Pressure
A.	New tank hydrostatic proof tested as specified by governing codes, Standards, or other regulations.	Fill to maximum design level and apply superimposed hydrostatic and/or pneumatic pressure above the liquid level as required by governing Code, test methods or other regulations.
B.	New tank with no hydrostatic test required.	Fill to maximum design level and apply superimposed hydrostatic or pneumatic pressure, or both, to achieve maximum design pressure. If design pressure is not available, apply maximum operating pressure.
C.	In-service tank with operating and superimposed pressure < 0.22 psig	Fill to maximum operating level plus 5 %. Apply normal superimposed hydrostatic or pneumatic pressure, or both.
D.	In-service tank with operating and superimposed pressure 0.22 to 5.0 psig	Fill to maximum operating level plus 5 %. Apply maximum operating superimposed hydrostatic or pneumatic pressure, or both, that the tank has seen during the previous six months.
E.	In-service tank with operating and superimposed pressure > 5.0 psig	Fill to maximum operating level plus 5 %. Apply maximum operating superimposed hydrostatic or pneumatic pressure, or both, that the tank has seen during the previous six months plus 0.5 psig.

superimposed hydrostatic or pneumatic pressure, or both, plus elevated temperature. For such situations, the examiner and user must be in agreement on the thermal changes that will result in the desired stress change. During tank stressing, it is particularly important to fill through a submerged nozzle to minimize noise from liquid splashing, etc., that could invalidate data taken during filling. Additionally, the following should be considered in planning for an AE examination.

10.3.1 *Fill Time Required*—When scheduling AE examination of large storage tanks it is important that the tank owner provide the examiner with an estimate of the time interval necessary to fill the tank as required by the appropriate sequence described in either 10.9.4.1 or 10.9.4.2. This estimate should be based on the availability of fluid to fill the tank and flow rate of the filling fluid during examination.

10.3.2 *Level Measurement*—Make arrangements to monitor the fill level throughout the AE examination. In most instances existing measuring systems can be used. If a fluid with a specific gravity different from that of the normal process fluid is used during AE examination, restandardization of the level instrumentation may be required for accurate level measurement.

10.3.3 *Start and Stop Filling*—Make provisions to start and stop filling as required for load hold periods. The tank owner shall review these provisions with the AE examiner, making him aware of unavoidable circumstances such as line flushing which may be required when flow stops.

10.3.4 *Hold Time Tolerance*—Shall be -0, +2 min.

10.3.5 *On-Line Examination*—When existing storage tanks are examined on-line, the tank owner shall make the AE examiner aware of circumstances that could affect AE data acquisition. Such circumstances may include existence of steam or gas spargers inside the tank, agitators or submerged pumps, motion of solids suspended in the liquid, chemical reactions, or the inability to accomplish submerged filling.

10.3.6 *New Atmospheric Tanks*—A new tank will normally be AE examined during hydrostatic proof examination as specified by governing codes or standards. Examine a new tank in its operating position and supported in a manner consistent with good installation practice.

10.3.7 *In-Service Tanks*—In-service tanks will normally be AE examined over the pressure range of 75 or less to 100 % of AE examination pressure. The pressure range shall include both the liquid contents and any superimposed pressure.

10.4 *Safety*—All safety requirements unique to the examination location shall be met.

10.4.1 Examiners shall wear protective clothing and equipment that is normally required in the area in which the examination is being conducted.

10.4.2 A fire permit may be needed to allow use of the electronic instrumentation.

10.4.3 Take precautions to prevent overflowing of tanks. Consideration shall be given to the consequences of fluid spillage.

10.4.4 Take special safety precautions during gas or pneumatic examinations, and the examiner shall determine that it is safe to conduct the examination. Such precautions may include the use of safety valves, a rapid-release valve, and supplemental acoustic emission monitoring during pressurization. Such monitoring shall be separate from the acoustic emission monitoring defined under this procedure and shall provide a real time warning of impending failure. Terminate pressurization and unload the vessel if the acoustic emission characteristics described in paragraph T-1244.3.3 of Article 12, Section V, of the ASME Boiler and Pressure Vessel Code are observed.

10.4.4.1 *Examination Termination*—Departure from a linear count or signal strength ~~vs.~~ versus load relationship should signal caution. If the AE count or signal strength rate increases rapidly with load, the vessel shall be unloaded and either the examination terminated or the source of the emission determined and the safety of continued examination evaluated. A rapidly (exponentially) increasing count rate or signal strength may indicate uncontrolled, continuing damage indicative of impending failure.)

10.4.4.2 Bolted and screwed connections such as manway covers, valves, and blind flanges are a particular concern. These shall be inspected prior to examination to ensure that bolts and other attachment components are in place, adequate for the examination pressure, properly torqued, not seriously corroded, or otherwise deteriorated.

10.4.5 Provide proper venting when draining tanks after completing AE examination. This is necessary to prevent excessive vacuum loading.

10.4.6 Exercise care to avoid the consequence of sudden and unexpected premature release of relief valves and safety vents. This is particularly important when examining tanks containing potentially hazardous fluids.

10.5 *Environmental*—For ambient temperatures below 32°F (0°C) take care to eliminate ice buildup that can cause emissions during vessel loading.

10.6 *Background Noise*—It is important to capture valid emissions during monitoring periods. To accomplish this, background noise must be at a minimum. Sources of background noise are discussed in 5-6-5.8

10.6.1 The examiner shall review the stressing techniques and identify all potential sources of extraneous acoustic noises due to loading.

10.6.2 Field experience has shown that care should be exercised in dealing with electrical background noise sources, for example, electromagnetic interference (EMI) is usually due to motors, switch gear, solenoids, and the like. EMI can also be caused by a bad power supply, particularly an inadequate ground. Radio frequency interference (RFI) can be distinguished from EMI with an oscilloscope or correlation plot. Control both RFI and EMI by using shielded sensors and narrow band filters. Power source EMI can be controlled with a constant voltage supply unit.