

**Microphonic Response Criteria for Non-communications
Devices**

TSG Standard No. 8

October 1994

PREFACE

The Telephone Security Group prepared this standard (TSG). The charter members of the TSG are: Department of the Air Force, Department of the Army, Central Intelligence Agency, Defense Intelligence Agency, Department of Energy, Federal Bureau of Investigation, Department of the Navy, National Security Agency, U.S. Secret Service, and Department of State.

The TSG is the primary technical and policy resource in the US Intelligence Community for all aspects of the technical surveillance countermeasures (TSCM) program involving telephone systems. The TSG standards contain guidance for providing on-hook security to telephone systems in areas where sensitive government information is discussed. Implementation of TSG standards neither prevents the application of more stringent requirements nor satisfies the requirements of other security programs such as TEMPEST, COMSEC, or OPSEC.

TSG Standard 1 is an introduction to telephone security that provides general information about the TSG standards.

1. Purpose

TSG Standard 8 specifies the procedures and minimum audio security performance required to obtain TSG approval for installation in sensitive discussion areas, of devices other than communications equipment that cannot initiate off-hook connectivity service.

2. Applicability

This standard applies only to devices intended for connection to a telephone network that cannot originate an off-hook request for connectivity service. Such devices include, but are not limited to, disconnectors, isolators, interfaces, and Caller ID. See the Glossary for additional requirements for disconnects and isolators.

3. Definitions

A glossary of terms is provided in this standard.

4. Documentation and Certification Requirements

4.1 The manufacturer must submit a letter of application for TSG approval, signed by an authorized company official that identifies the proposed product and certifies it to comply with all the requirements of this standard. Documentation of all claims relating to the requirements is mandatory. Each requirement must be specifically addressed and an explanation of how the device has been determined to comply with that requirement must be provided.

4.2 The manufacturer must provide an electrical description of the device containing the following:

4.2.1 Complete theory of operation including descriptions of the interface connection

4.2.2 Block diagrams including complete descriptions of signals between functional blocks

4.2.3 Schematic diagrams and circuit descriptions

4.2.4 Component listing

4.2.5 Installation and maintenance manual

4.2.6 Any supplementary information requested by the government in order to complete the evaluation of the application

4.2.7 Documents identified as containing proprietary information will be used to evaluate and confirm the necessary conditions only. All proprietary information will be treated with strict confidentiality

4.3 The below listed documentation is necessary to support field tests and inspections and must be provided by the manufacturer. These documents will be distributed to field inspection teams for use during on-site testing. The information provided for this purpose should be non-proprietary.

4.3.1 Component layout diagrams; include location and function of test points

4.3.2 Instructions for assembly and disassembly of the device

4.3.3 Photographs showing all circuit boards and assemblies

4.3.4 Complete theory of operation including descriptions of the interface connection

5. Specifications

5.1 The proposed device must be certified by the manufacturer to comply with all the requirements of this standard. Documentation of all claims relating to the requirements is required. Each requirement must be specifically addressed and an explanation of how the device has been determined to comply with that requirement must be provided.

5.2 Some of the requirements specified below are annotated "**TEST REPORT REQUIRED.**" For these requirements, at least one production specimen of the device must be tested and shown to be in full compliance. All delivered items must be exactly identical to the specimen(s) used for these tests. Paragraph 5.3 (following) provides a listing of information that must be included in these test reports. The various required tests may be documented in a single consolidated test report or as separate individual reports.

5.3 Format for Required Test Reports

5.3.1 Abstract

5.3.2 Objectives of tests

5.3.3 List of test equipment used

5.3.4 Test equipment configuration used for each test

5.4 Test data and conclusions

5.4.1 If requested, the loan of a production specimen, and whatever ancillary equipment is required for it to be operational, must be provided to allow independent testing and technical evaluation to verify the asserted compliance with the specifications.

5.4.2 Technical supplements numbers 1 and 2 are included to provide background information and guidance for performing the tests required to document compliance with these specifications.

6. Required Performance

6.1 Intrinsic On-hook Microphonics. The microphonic sound-pressure-response criteria specified in this section applies to all acoustic signals in the frequency range 100Hz - 15kHz.

6.2 The RMS voltage limits in Table 1 below placed on the microphonic sound-pressure-response levels (MSPRL), at the terminating impedance indicated, in response to a two Pascal tone, apply to all the wires and connections that can be used to connect the device to any entity that is not a part of the device. Their ground-referenced and pair-wise differential sound-pressure-response voltages must all conform to the specifications.

Terminating Impedance (Z)	MSPRL Allowed to a 2 Pa Tone (V_m)
$Z < 50\Omega$	$V_m = 30\text{nv}$
$50\Omega \leq Z < 1\text{K}\Omega$	$V_m = 75\text{nv}$
$1\text{K}\Omega \leq Z < 10\text{K}\Omega$	$V_m = 150\text{nv}$
$10\text{K}\Omega \leq Z < 100\text{K}\Omega$	$V_m = 500\text{nv}$
$100\text{K}\Omega \leq Z < 1\text{M}\Omega$	$V_m = 1\mu\text{v}$
$1\text{M}\Omega \leq Z$	$V_m = 3\mu\text{v}$

Table 1

6.3 All required non-microphonic characteristics must be sustained independent of all environmental stimuli; including acoustic and electromagnetic fields, voltages, or commands that could be impressed upon the mounting cord or power supply wires.

6.4 The device must comply with the limits placed on microphonic sound-pressure-response levels and microphonic sound-pressure-response carrier modulation for all of the following configurations:

6.4.1 Disconnected from the telephone lines with no power applied.

6.4.2 Disconnected from the telephone lines but fully powered and operationally ready.

6.4.3 Connected to the telephone lines, fully powered, and operationally ready.

6.5 The open-circuit, non-terminated, microphonic sound-pressure-response levels on any of the devices' external wires and metallic connections must not exceed 0.5 microvolt RMS per Pascal.

TEST REPORT REQUIRED.

6.6 The microphonic sound-pressure-response levels on the telephone lines at their point of attachment to the device must not exceed 0.5 microvolt RMS per Pascal. **TEST REPORT REQUIRED.**

6.7 The sound-pressure response on all telecommunications-medium that either leave the device or are used to convey information between modules of the device must conform to the requirement and applies both to the intentional telecommunications channels and to any fortuitous vectors that might exist.

6.7.1 When the telecommunications medium are measurable in volts, the modulations of carrier and subcarrier levels due to microphonic sound-pressure response must not exceed 0.5 microvolt RMS per Pascal. **TEST REPORT REQUIRED.**

6.7.2 The following requirements apply to all telecommunications medium that are not measurable in volts.

6.7.2.1 The microphonic sound-pressure-response levels at these points must not exceed 0.5-microvolt RMS per Pascal. The voltage levels will be measured at the transmission-medium drive point of the final-stage electrical drivers for the carriers and subcarriers.

TEST REPORT REQUIRED.

6.7.3 The following specifications apply to every carrier and subcarrier frequency and to its final-stage electrical driver current:

6.7.3.1 The sum of the upward and downward modulation factors for any amplitude modulations due to microphonic sound-pressure responses of the carriers and subcarriers must not exceed -180dB per Pascal. **TEST REPORT REQUIRED.**

6.7.3.2 For carrier and subcarrier frequencies that are less than 100MHz:

6.7.3.2.1 If f_a represents the frequency of an acoustic test signal that is incident on the device, $f_{c,d}$ represents the frequency produced by the deviation to a carrier (or subcarrier) frequency caused by a microphonic sound-pressure response to that acoustic test signal, $f_{c,o}$ represents the carrier frequency when no sound is present, and $f_{c,d}/f_{c,d} - f_{d,o}/f_{c,o}$. Then the amplitude level of $f_{c,d}$ must not exceed -180dB per Pascal with respect to $f_{c,o}$ for all $f_{c,d}$ such that $f_{c,d} \leq 3f_a/4$.

TEST REPORT REQUIRED.

6.7.3.3 For carrier-phase-shifts due to microphonic sound-pressure-response effects on a telecommunications medium's transmission properties: The total angular deviation over the entire transmission path, relative to transmission of the carrier with no sound present, must not exceed 0/09 radians per Pascal.

TEST REPORT REQUIRED.

6.8 If the device is computerized, or is a part of a computerized telephone system, it is not permissible for any software or firmware change to cause the device to become microphonic.

6.8.1 The required non-microphonic characteristics must be achieved independently of all software and firmware contained within the device.

6.8.2 No change in the device's software or firmware can have any effect on its performance in the microphonic sound-pressure level tests.

6.9 Resistance to Modification

6.9.1 The ideal condition for on-line audio security is when the device in question cannot by any means be caused to produce microphonic audio. For any real equipment, however, there is always the possibility that accidental or deliberate modifications to an otherwise approved device could cause it to become microphonic. The following measures must be applied to reduce this possibility to an acceptable level.

6.9.2 The design and construction of the device must not facilitate any modification, which could cause it to pass audio or become microphonic while on-hook.

6.9.3 The device's internal components must be situated so that the normal isolation of intrinsic microphonic transducers cannot be easily or inconspicuously bypassed.

6.9.4 There must be no unnecessary or spare wires leaving the device.

7. Verifiable Security

7.1 With the cover removed, the internal layout must present critical components and connections in clear view. The layout must facilitate inspection to such a degree that any added conductors or implanted components would be found immediately.

7.2 On-hook audio security is compromised when a microphonic element becomes connected to or transfers audio to the external wires. Therefore, components and circuit traces, which are connected to electro-acoustic transducers or microphonic elements, must not be located adjacent to components or circuit traces which connect to external wires or telecommunications media.

7.3 To support the above inspection requirement, there must be no unnecessarily enclosed spaces that prevent inspection.

7.4 The internal component layout of the device must facilitate countermeasures inspection to find potentially compromising modifications.

7.5 The construction of the device must provide a means for the physical, electrical, and software/firmware, if present, inspection at any time: before, during, or after installation. All security related

characteristics must be verifiable by physical inspection, electrical measurement, and/or software/firmware (if present) verification.

7.6 The device must be capable of sustaining repeated disassembly without physical damage or deterioration occurring.

7.7 Production changes and modifications or repairs to existing telephone instruments must not diminish compliance with these specifications.

TECHNICAL SUPPLEMENT NO. 1

8. Sound-Pressure-Response Level Measurement Requirements

8.1 The purpose for testing microphonic behavior is not to identify or study individual microphonic components, but to measure the level of microphonic response for the whole device. With respect to microphonics, the device is considered as if it were an elemental microphone. When excited by a sound-pressure field, its microphonic response produces signal voltages at its external wires that are a function of the sound-pressure level.

8.2 The pressure-response level of a microphone is the ratio of voltage output to sound-pressure level (SPL) input. The voltage measurement is generally specified as an open-circuit measurement. For purposes of this specification, the internal loading on the wires being tested may be taken into consideration in configuring the voltage measuring equipment. The test equipment input resistance must equal or exceed the on-hook terminating impedance inside the telephone. Regardless of the actual internal terminating impedance, test equipment impedance in excess of 100,000 ohms is neither required nor prohibited. The minimum allowed impedances for various conditions are:

TERMINATING IMPEDANCE INSIDE TELEPHONE	MINIMUM ALLOWED IMPEDANCE FOR TEST EQUIPMENT
Z 100,000	Z
Z 100,000	100,000

Table 2

8.3 The specified on-hook microphonic performance is required over the frequency range 100Hz - 15kHz. The actual testing to demonstrate compliance with these specifications may be conducted by measurements taken either at discrete frequencies or with a continuous frequency sweep over the required range. The continuous frequency sweep is preferred.

8.4 If discrete frequencies are used, below 400Hz the measurements may be made at intervals not to exceed one-half octave; above 400Hz the frequency intervals are not to exceed one-third octave.

8.5 A response of 0.5 microvolt/pascal is the maximum sound pressure response that is allowed for any device for which this specification is applicable.

8.6 When the response is measured in microvolts and the SPL in pascals, the pressure-response level is obtained by dividing the output voltage by the input SPL and the allowed limit is:

$$\text{microvolts} - \text{pascals} \leq 0.5$$

8.7 When decibels are used to express both the SPL and response voltage, the pressure-response level may be obtained by subtracting the input SPL [dB] from the output voltage [dB]. If the voltage is measured in dB above one microvolt and the SPL in dB above 20 micropascals, the maximum allowed pressure-response level becomes -100dB.

$$\text{dB(V)} - \text{dB (SPL)} \leq -100\text{dB}$$

8.8 The device may be tested at any convenient SPL provided that accurate voltage measurements can be accomplished with the necessary resolution. Compliance with these requirements can normally be accomplished using an input SPL of 100dB or greater, at two pascals. Lower sound-pressure levels require the ability to perform calibrated audio frequency voltage measurements of less than one microvolt. Examples of the maximum allowed response voltages for various test SPL values are shown in Table 3.

MAXIMUM ALLOWED RESPONSE			
DB (SPL) ^{*TEST} SPL	Pascals	(μ V)	db V
60	0.02	0.01	-40
70	0.063	0.03	-30
80	0.2	0.1	-20
90	0.63	0.3	-10
94	1	0.5	-6
100	2	1	0
110	6.3	3	10

*[dB(SPL) = dB above 20micropascals]

Table 3

8.9 The ground-referenced voltage must be measured at every wire and terminal whose purpose is to provide an external connection to the device.

8.10 All differential voltage for all pair-wise combinations of the device's external wires and terminals must be measured.

8.11 The equivalent impedance (from 100Hz -15kHz) combining all the terminations, devices, and test equipment connected to the particular wire/wire or wire/ground combination being tested must comply with Table 1.

TECHNICAL SUPPLEMENT NO. 2

9. Sound-Pressure-Response Modulation Measurements Requirements

9.1 These sound-pressure-response measurements are to assure that the subject device will not be unduly susceptible to unintentional modulation of its proper communications processes by normal conversational speech that takes place in its vicinity. The normal operation of many devices requires that they transmit information between physically separated locations by means of electrical or optical waveforms. Under certain conditions of design, construction, or use, these waveforms may also become modulated by the sound-pressure variations caused by human speech. Depending upon the types of carriers employed, and the types of fortuitous mechanisms that produce the sound-pressure responses, any of several modulations to which a device might be susceptible are amplitude modulation, frequency modulation, phase modulation, pulse-position-modulation, and pulse-width-modulation. The carrier may receive the inadvertent modulation in the driver electronics or in the transmission medium through, which it is propagated.

9.1.1 The device may be tested at any convenient SPL provided that accurate measurements can be accomplished with the necessary resolution. Compliance with these requirements can normally be accomplished using an input SPL of 100dB (2 Pascals) or greater. Lower sound-pressure levels require the ability to perform calibrated audio frequency measurements at very low levels.

9.2 All telecommunications media that use wireline conductors are measurable in volts.

9.3 Antenna radiated RF carriers (including those propagated through wave guides) are measurable in volts at the output port of the transmitter (the final-stage electric driver), prior to their conversion to radiated electromagnetic fields by the antenna.

9.4 The electric voltage and/or current of a fiber-optic light source is measurable at the input terminal of the optical transducer.

9.5 An amplitude-modulated signal has an upward modulation factor given by:

$$m_u = \frac{E_{\max} - E}{E}$$

and/or a downward modulation factor given by:

$$m_d = \frac{E - E_{\min}}{E}$$

Where E is the peak-amplitude of the unmodulated carrier, E_{\max} is the maximum peak-amplitude of the modulated carrier, and E_{\min} is the minimum peak-amplitude of the modulated carrier. The specification applies to sum of m_u and m_d and requires that:

$$M = m_u + m_d = \frac{E_{\max} - E_{\min}}{E} \leq 180 \text{ dB /pascal}$$

For an incident sound-pressure level of 100dB (ref 20 pa) the maximum permissible value for M is -90dB.

9.6 For fiber-optic systems, interferometry may be used to observe the microphonic sound-pressure-response phase shift. If, the time-invariant zero modulation (no sound) phase difference between the transmission path under test and the reference path used to produce the interference effect is $2n$ where n may be any integer ≥ 0 . Then, the interference effect of the maximum allowed carrier-phase-shift on the light intensity will be a downward modulation factor of 0.002.

GLOSSARY

ANNUNCIATOR -- A device for producing an audible or visual signal to announce an incoming call.

DISCONNECT -- A non-communications device, which prevents or allows audio or data, from reaching a telephone network or STE, through the use of a temporary, switchable metallic path. To qualify as a disconnect for purposes of this standard, the device must possess all of the following properties:

1. The device must insert a break within the telecommunications medium that exists between the STE and the telephone network.
2. The device must prevent all communications from the STE except when the STE is off-hook.
3. The device must prevent all communications to the STE except when the STE is either off-hook or audibly annunciating an incoming call.
4. The device must provide a temporary link, only when the STE is off-hook, across the break that has been interposed in the normal conduction path. This temporary link must be entirely under the control of the on-hook/off-hook state of the STE.
5. The device may generate, or may require another device to generate, the audible or visual annunciation of an incoming call.

ELECTRO-ACOUSTIC TRANSDUCER -- A component or element, which either converts electrical signals to acoustic signals or acoustic signals to electrical signals.

ISOLATOR -- A non-communications device which prevents or allows audio or data, from reaching a telephone network, or from reaching STE, through the use of a temporary, switchable path. This path must be either a light conductor, such as fiber optics, or semi-conductor(s).

1. An isolator must meet the same requirements as a disconnect above.
2. If an isolator is intended to meet EMI or TEMPEST requirements, it must have at least a four inch optically coupled path.

MICROPHONE -- A component among whose intended functions include performing as an electro-acoustic transducer to produce an electrical analog output from an audio-frequency sound pressure waveform input.

MICROPHONIC -- A term used to identify any component, regardless of its intended functions, that exhibits electro-acoustic transducer behavior to produce an electrical analog output from an audio-frequency sound pressure waveform input. Capacitors and transformers, if physically large enough, can be microphonic.

MODEM -- A non-communications interface device that modulates and demodulates information.

NON-COMMUNICATIONS DEVICE -- Any equipment that cannot request off-hook connectivity service from a telephone network. These devices include, but are not limited to: Caller ID, disconnect, isolator, and interfaces such as modems. Modems integrated into other equipment, such as faxes and computers, are still considered non-communications devices because they are still an interface.

OFF-HOOK -- An active or in-use state of STE connected to a telephone network, that is either actively initiating a request for connectivity service to other STE, or that is already connected to other STE.

ON-HOOK -- An inactive state of STE connected to a telephone network in which connectivity service is not being requested. STE cannot be on-hook while it is off-hook.

SOUND-PRESSURE-RESPONSE LEVEL -- The SOUND-PRESSURE-RESPONSE LEVEL of a microphone is the ratio of voltage output to sound-pressure level input.

SOUND-PRESSURE-RESPONSE MODULATION -- The degree of change in a measurable property of a telecommunications medium, or carrier signal on that medium, that is produced in response to a unit-value sound pressure level.

STE (SUBSCRIBER TERMINAL EQUIPMENT) -- The communications equipment connected to a telephone network that has the capability of going off-hook, for which a subscriber normally pays a service charge to provide connectivity to other STE. The equipment may be comprised of, but not limited to: A telephone, fax, computer, or teleconferencing system.

SWITCHED NETWORK -- An assembly of member subscriber terminals, control facilities, and intercommunication facilities, which can establish and maintain a communications link between any two of the member terminals.

TELECOMMUNICATIONS MEDIUM -- Any medium by which information is conveyed from one STE to another without transporting physical matter. The medium may be comprised of, but not limited to wire, fiber optics, light, or radio frequencies.

TELEPHONE NETWORK -- A network system of voice grade channels that provides off-hook links between the calling and called STE, only for the duration of the call. It recognizes when connectivity service is requested, identifies the number dialed, and annunciates the incoming call.