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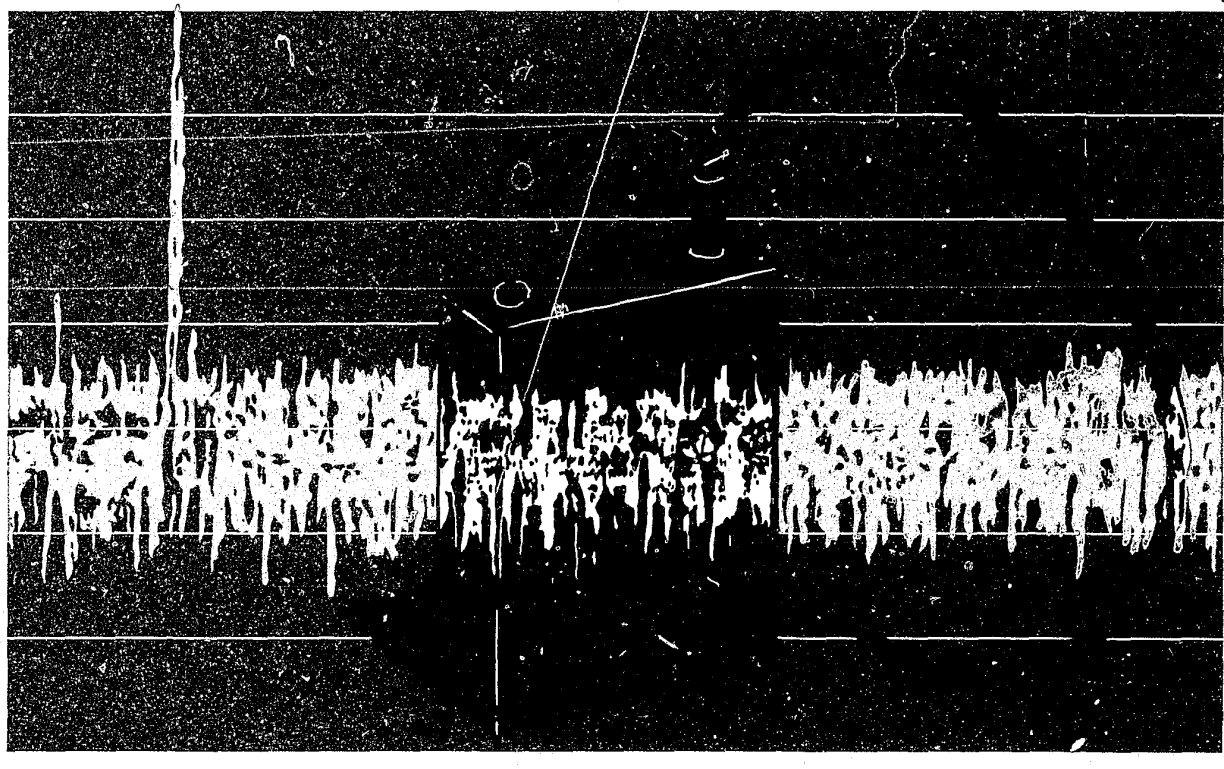

Equipment Performance Report:

Body-Worn FM Transmitters

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Equipment Performance Report: Body-Worn FM Transmitters

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About the Technology Assessment Program

The Technology Assessment Program (TAP) is an applied research project of the National Institute of Justice (NIJ). TAP develops minimum performance standards for law enforcement equipment and tests equipment based on these standards.

To accomplish program tasks, NIJ coordinates the activities of two organizations: the TAP Information Center (TAPIC) and the Law Enforcement Standards Laboratory (LESL) of the National Institute of Standards and Technology (NIST). LESL prepares equipment standards, reports, and guides; TAPIC coordinates the testing of law enforcement equipment by independent laboratories and publishes the test results. LESL, TAPIC, and NIJ support one another in accomplishing TAP's tasks and goals.

TAP's major tasks and goals are:

Coordination of the TAP Advisory Council. Composed of nationally recognized professionals from Federal, State, and local criminal justice agencies, the Advisory Council helps NIJ set priorities for developing new equipment standards and for testing available products.

Coordination of equipment testing. TAPIC develops Requests For Proposals to select testing laboratories, evaluates proposals with assistance from LESL, selects laboratories, and monitors the testing activities.

Compilation and dissemination of test results. TAPIC compiles and analyzes the test results and, after review by NIJ and LESL, publishes the results in TAP bulletins (summaries issued periodically) and in *Equipment Performance Reports* (also published periodically and containing complete testing data on specific equipment).

Dissemination of information. TAP educates the criminal justice community about its resources and services in a number of ways. Staff prepare articles for criminal justice periodicals, develop exhibits, make presentations at major criminal justice conferences, and serve as a clearinghouse of information about equipment and technology.

For more information, or to add your name to TAPIC's mailing list, call 1–800–248–2742 (in Maryland and Metropolitan Washington, D.C., call 1–301–251–5060.)

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Introduction and Summary of Test Results

Body-worn FM transmitters are used in surveillance operations to transmit, to a receiving device, conversation between a suspect and a law enforcement officer. They also provide protection to the person wearing the transmitter. Dependable operation of the transmitter is, therefore, critical to the success of many investigations and to the safety of the people conducting these investigations.

This *Equipment Performance Report* contains the results of testing nine body-worn FM transmitters in accordance with *NIJ Standard-0214.01, Body-Worn FM Transmitters*, January 1990. This report was developed to provide information to law enforcement agencies to aid them in evaluating and selecting suitable equipment.

The standard contains requirements that would ensure that a transmitter passing the tests would be dependable and would provide an intelligible audio signal that results in an acceptable quality voice recording. None of the transmitters met all the requirements of the standard. However, some transmitters met most of the requirements or marginally failed some of the requirements. Users of this report should carefully review the actual test results to arrive at a good understanding of the performance capabilities of each transmitter. The report contains descriptions of how the tests were performed and of the importance of the requirements. Users should review the entire report to determine which equipment best suits their needs.

Results of the testing are summarized in table 1. References are provided in the table to the appropriate paragraph in the Minimum Performance Requirements/ Methods of Testing section of this report. Readers can study the appropriate paragraph for clarification of test results.

When reviewing table 1, be aware that an item in the table may summarize the results of more than one item from the data sheets. For example, the user information requirement includes 17 data items. If only one item was not included, table 1 indicates that the user information is not in compliance with the standard.

Surveillance transmitters used by non-Federal agencies for law enforcement applications must be type-accepted by the Federal Communications Commission (FCC).

If a nonapproved transmitter is used by a non-Federal agency to gather evidence, that evidence may not be admitted into legal proceedings. Without FCC type-acceptance, the transmitter is not a legal transmitting device and its use to gather evidence is not legal. All non-Federal agencies should only use surveillance transmitters that are FCC type-accepted devices under Section 90.19 of the *Code of Federal Regulations*, Chapter 47, Parts 2 and 90. In addition, the agency using the transmitter must obtain an FCC station license before the device can be operated.

Table 2 defines the type-acceptance status of the transmitters evaluated in this test.

Detailed test data are set forth in full under Test Results/ Transmitter Data Sheets later in this report. Please call the TAP Information Center if you have any questions concerning the test results: 1–800–248–2742, or in Maryland and Metropolitan Washington D.C., 1–301–251–5060.

Table 1

Summary of Test Results
Body-Worn FM Transmitters

I = Inconclusive.
C = Complies with standard.
N = Does not comply.

Characteristic	Requirement	Pass									Fail									Total No.		Minimum Performance Paragraph Reference
	Transmitter code no.	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	Pass	Fail	
User information	Complete data										N	N	N	N	N	N	N	N	N	0	9	Paragraph 1
Radio frequency carrier characteristics																						
Carrier output power _____ W specified																						
Nominal voltage _____ W meas.	Specified +3, -0.5 dB	C	C		C	C	C	C	C				N						N	7	2	Paragraph 2A
Nominal voltage +10% _____ W meas.	Nom. meas. ±3.0 dB	C	C	C	C	C	C	C	C	C										9	0	
Nominal voltage -10% _____ W meas.	Nom. meas. ±3.0 dB	C	C	C	C	C	C	C	C	C										9	0	
Nominal voltage -20% _____ W meas.	Nom. meas. ±6.0 dB	C	C	C	C	C	C	C	C	C										9	0	
Carrier frequency 159.2700 MHz																						
Nominal voltage _____ MHz	±0.003%	C	C	C	C	C	C	C	C										N	8	1	Paragraph 2B
Nominal voltage +15% _____ MHz	Specified ±0.003%	C	C	C	C	C	C	C	C										N	8	1	
Nominal voltage -15% _____ MHz	Specified ±0.003%	C	C	C	C	C	C	C	C	C										9	0	
AM hum and noise attenuation	34 dB minimum	C	C	C	C	C	C	C	C	C										9	0	Paragraph 2C
Transmitter efficiency	40% minimum		C	C	C				C		N				N	N	N		N	4	5	Paragraph 2D
Audio frequency modulation characteristics																						Paragraph 3A
Audio frequency harmonic distortion	Maximum of 5%	C	C	C	C		C	C		C					N			N		7	2	
FM hum and noise attenuation	40 dB minimum	C	C			C				C			N	N		N	N	N		4	5	Paragraph 3B
Audio frequency response test	+10.5 +1, -3 dB @ 300 Hz -9.5 +1, -3 dB @ 3.0 kHz 1.0 kHz as reference	C										N	N	N	N	N	N	N	N	1	8	Paragraph 3C
Frequency deviation	±4.05 to 4.95 kHz										N	N	N	N	N	N	N	N	N	0	9	Paragraph 3D
Modulation limiting	±4.05 to 4.95 kHz										N	N	N	N	N	N	N	N	N	0	9	Paragraph 3E
Electromagnetic compatibility																						
Radiated spurious emissions attenuation	43 dB below carrier	C	C	C	C	C	C										N	N	N	6	3	Paragraph 4A
Sideband spectrum attenuation																						
Carrier +10 kHz	25 dB below carrier	C		C	C		C	C	C	C		N			N					7	2	Paragraph 4B
Carrier -10 kHz	25 dB below carrier	C		C	C		C	C	C			N			N				N	6	3	
Carrier +20 kHz	60 dB below carrier	C			C		C	C	C			N	N		N				N	5	4	
Carrier -20 kHz	60 dB below carrier	C			C		C	C	C			N	N		N				N	5	4	
Battery service life	See battery service life results			C	C						I	I			I	N	I	I	I	2	7	Paragraph 5
	Total Number	16	12	13	16	10	14	13	13	8	5	9	8	5	11	7	8	8	13	115	74	

Table 2

Type-Acceptance Status

Manufacturer	Model	FCC type-acceptance number
Dynatech Tactical Communications (DTC)	T70	ELT 55CT70
Household Data Services (HDS)	ATX-101	Application pending
Intelligence Support Group (ISG)	Mini-Pax	G443J4MINI-PAX
Motorola	SP2700061	CC3544
Sherwood Communications Associates Ltd.	Pocket TX	Has not applied for type-acceptance
Spectrum Communications	SCT5-1P	B2Y8QRSCT5-1
Swintek Enterprises, Inc.	Mark 50	WMS-111-50 Not accepted under Section 90.19
Tactical Technologies, Inc.	CST-586	Application pending
Telex Communications, Inc.	WT400	B5D8NJWT-400 Not accepted under Section 90.19

The Test Program

According to the TAP equipment testing program procedures (discussed in Appendix B), TAPIC solicited bids to test body-worn FM transmitters (BWT's) from independent testing laboratories. Dayton T. Brown, Inc., in Bohemia, New York, was selected based on its proposal score.

One of the first steps in the testing procedure involved a review of BWT's that were available to police. After LESL and TAPIC identified which BWT's to include in the testing, TAPIC invited the manufacturers/distributors to provide units for testing. Table 3 identifies the participating manufacturers and the equipment tested.

Staff members from TAPIC, LESL, and the National Institute of Standards and Technology (NIST) Laboratory Accreditation Program attended preliminary testing to ensure that the selected testing laboratory was staffed appropriately, had the correct equipment, and followed the procedures set forth in NIJ Standard-0214.01. For the preliminary test, the laboratory tested one transmitter. After TAP reviewed and approved the preliminary test report, the laboratory tested the remaining equipment.

After completion of the testing, LESL staff members assisted TAPIC in the data analysis and the compilation of results presented in this *Equipment Performance Report.*

Table 3
Body-Worn FM Transmitters Tested

Manufacturer	Transmitter
Dynatech Tactical Communications (DTC)	T70
Household Data Services (HDS)	ATX-101
Intelligence Support Group (ISG)	Mini-Pax
Motorola	SP2700061
Sherwood Communications Associates Ltd.	Pocket TX
Spectrum Communications	SCT5-1P
Swintek Enterprises, Inc.	Mark 50
Tactical Technologies, Inc. (formerly CanCom Industries)	CST-586
Telex Communications, Inc.	WT400

Minimum Performance Requirements/ Methods of Testing

NIJ Standard-0214.01, Body-Worn FM Transmitters, dated January 1990, established requirements and methods for testing body-worn FM transmitters of 3 watts or less used in undercover operations by law enforcement agencies. The following discussion summarizes the specific requirements and briefly describes how compliance is determined. The minimum performance requirements included in this report are for Type II transmitters (150-174 MHz frequency band) only. All of the transmitters that were tested had a carrier frequency of 159.27 MHz. Appendix A describes the purpose of each requirement.

1. User information

NIJ Standard-0214.01 requires the manufacturer or distributor to include information about the transmitter and the batteries supplied with the transmitter. The following items are required for the transmitter: (a) carrier output power; (b) carrier frequency; (c) transmit current; (d) AM hum and noise attenuation; (e) transmitter efficiency; (f) audiofrequency harmonic distortion; (g) FM hum and noise attenuation; (h) frequency deviation; (i) radiated spurious emission attenuation; (j) ±10 kHz sideband spectrum attenuation; (k) ±20 kHz sideband spectrum attenuation; (l) battery voltage; (m) audio input signal for rated system deviation; and (n) audio input impedance. Additionally, a nominal value for the service life for each battery shall be included in the user information. The labeling on the battery shall include: (a) nominal voltage; (b) battery type and model; (c) rated capacity; (d) indication of polarity; (e) indication if battery is rechargeable; (f) month and year of manufacture.

Compliance is determined by examining the user information provided and the battery provided and/or specified by the manufacturer to determine if all the items required by the standard are included in the equipment documentation or on the battery.

2. Radio frequency carrier tests

A. Output power tests. The antenna is replaced by a power meter and a standard load. A variable power supply is substituted for the battery, and the transmitter output power is measured with the supply voltage at nominal, nominal +10%, nominal -10%, and nominal -20%. The transmitter is operated without modulation for these measurements.

Compliance is determined by verifying that:

1. The output power with the input voltage at nominal is within +3, -0.5 dB of the nominal output power.

2. The output power with the input voltage at nominal +10% and nominal -10% is within ±3 dB of the measured output power with the input voltage at nominal.

3. The output power with the input voltage at nominal -20% is within ±6 dB of the measured output power with the input voltage at nominal.

B. Carrier frequency stability test. The antenna is replaced by a sampler, a frequency counter, and a standard load. A variable power supply is substituted for the battery, and the carrier frequency of the transmitter is measured with the supply voltage at nominal, nominal +15%, and nominal -15%. The transmitter is operated without modulation for these measurements.

Compliance is determined by verifying the measurements are within ±0.003% of the nominal carrier frequency.

C. AM hum and noise level test. The antenna is replaced by a sampler, a linear peak-carrier responsive AM detector, and a standard load. With the input voltage at nominal and the audio input connected to a standard input load, the transmitter is operated without modulation. First, the dc voltage across the AM detector's load resistor is measured using a high impedance dc volt meter. Next, the peak ac voltage is measured with an oscilloscope. The AM hum and noise level is then calculated as follows:

$$\text{AM hum and noise level (dB)} = 20 \log_{10} (V_p/V_{dc})$$

where V_p = peak ac voltage,
V_{dc} = dc voltage.

Compliance is determined by verifying that the calculated AM hum and noise attenuation is at least 34 dB.

D. Transmitter efficiency test. The antenna is replaced by a power meter and a standard load. A variable power supply is substituted for the battery and a dc ammeter and a dc voltmeter are connected between the power

supply and the transmitter. With the supply voltage at nominal, the output power and the input current are measured. The transmitter efficiency is calculated as follows:

efficiency (%) = (100 x P_{rf})/(V x A),
where P_{rf} = output power in watts,
V = nominal supply voltage in volts,
A = direct current in amperes.

Compliance is determined by verifying that the calculated value is at least 40%.

3. *Audiofrequency modulation tests*

A. Harmonic distortion test. The audio input of the transmitter is connected to an audio generator. The antenna is removed and replaced by a sampler and a standard load. A test receiver terminated in a standard audio output load is connected to the sampler via a variable attenuator. The audio generator is set to 1 kHz. The transmitter output is processed by the test receiver. Using a distortion analyzer, which removes the 1 kHz tone from the output, the audio signal from the receiver is measured. This is a measurement of all the noise and harmonic components of the output signal.

Compliance is determined by verifying that the harmonic distortion is 5% or less.

B. FM hum and noise level test. The transmitter and test equipment are set up in the same way as in the harmonic distortion test. The audio generator is adjusted to 1 kHz. The audio output voltage of the test receiver is measured using the distortion analyzer as a voltmeter. Then the audio generator is disconnected and a standard audio input load (resistor) is attached to the transmitter's audio input. The audio output voltage of the test receiver is again measured. The FM hum and noise level is calculated as follows:

FM hum and noise level (dB) = 20 $\log_{10}$ (V_1/V_2),
where V_1 = test receiver voltage with 1 kHz tone,
V_2 = test receiver voltage with resistor.

Compliance is determined by verifying that the FM hum and noise level is attenuated by at least 40 dB.

C. Audiofrequency response test. The audio input of the transmitter is connected to an audio generator via an impedance matching network. The output of the transmitter is connected to a sampler and a standard load. A deviation meter is connected to the sampler via a variable attenuator. The audio input is monitored by an audio voltmeter at the transmitter input. Selected audio frequencies from 0.3 to 3 kHz are input to the transmitter and the audio input level maintained at a constant 30% of rated system deviation as observed with the deviation meter. For each test frequency, determine the audio voltmeter reading in decibels relative to the voltmeter reading at 1 kHz. Draw an audiofrequency response characteristics graph from these data.

Compliance is determined by verifying that the audiofrequency response did not vary more than +1, -3 dB from a true 6 dB per octave pre-emphasis characteristic from 0.3 to 3 kHz as referred to the 1 kHz level, with the exception that a 6 dB per octave roll-off from 600 to 300 Hz and 2.5 to 3 kHz may be present.

D. Frequency deviation test. Connect the equipment as in the audiofrequency response test, except remove the impedance matching network. Adjust the audio generator to 1 kHz and increase the audio input level until the maximum frequency deviation is observed. Frequency deviation is measured with the deviation meter.

Compliance is determined by verifying that the maximum frequency deviation is within -4.95 to -4.05 kHz and 4.05 to 4.95 kHz.

E. Modulation limiting test. The equipment is set up as in the frequency deviation test. The audio generator is set to 1 kHz and at a level to produce ±3 kHz system deviation. The audio level is then increased 20 dB and held constant as the input frequency is varied from 0.3 to 3 kHz. The frequency deviation is measured with the deviation meter.

Compliance is determined by verifying that the maximum frequency deviation is within -4.95 to -4.05 kHz and 4.05 to 4.95 kHz.

4. *Electromagnetic compatibility tests*

A. Radiated spurious emission test. The transmitter is placed on a turntable with its antenna vertically extended. A receiving antenna is positioned 10 meters away from the transmitter.[1] The turntable is rotated and the receiving antenna is raised and lowered while in the horizontal and vertical positions until the strongest and largest signal is obtained. This measurement is done for the carrier frequency and any radiated spurious emission from the lowest radio frequency generated by the transmitter to the tenth harmonic of the carrier frequency. The attenuation of each radiated spurious emission is calculated by subtracting the field strength of the emission from the field strength of the carrier frequency, both expressed in dB. Compliance is determined by verifying that the calculated attenuations are at least 43 + $\log_{10}$ (nominal output power in watts) dB.

B. Sideband spectrum test. The audio input of the transmitter is connected to an audio oscillator and the output to a sampler. This sampler is connected to another sampler and a spectrum analyzer via a variable attenuator. The second sampler is connected to a standard output load and a deviation meter via a variable attenuator. Using the variable attenuator connected to the spectrum analyzer, the unmodulated carrier signal is adjusted for a full-scale signal of at least 60 dB above the noise level as displayed on the spectrum analyzer. The spectrum analyzer controls are adjusted so that approximately 50 kHz of transmitter spectrum is centered on the display. A 2.5 kHz frequency is input to the transmitter. The test modulation input level is adjusted to be 16 dB greater than the modulation required to produce ±2.5 kHz deviation at 1 kHz. The amplitudes of the center frequency and the sideband frequencies ±10 kHz and ±20 kHz from the center frequency are measured and expressed in dB. The attenuation of the sideband spectrum is calculated by subtracting the amplitudes of the sideband frequencies from the the amplitude of the center frequency.

Compliance is determined by verifying that the attenuations of the ±10 kHz sideband amplitudes are at least 25 dB and of the ±20 kHz sideband amplitudes are at least 60 dB.

5. *Battery service life test*

The transmitter is equipped with a fully-charged battery(ies). The antenna is removed, and a power meter and a standard load are connected to the antenna output. The transmitter is turned on and the time required for the output power to decrease 3 dB below the nominal output power is recorded.

Compliance is determined by verifying that the measured time is at least 90% of the nominal service life of the battery(ies) as specified by the manufacturer.

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1. This test was performed at the test laboratory with the field strength meter receiving antenna positioned 3 meters away from the transmitter. Limitations within the test facility precluded a 10-meter spacing. This deviation from the test standard did not affect the results of the emissions measurements.

DATA SHEET
DYNATECH T70

Characteristic	Requirement	Result
User information	Complete data	Incomplete*
Radio frequency carrier characteristics		
		Measured watts / Variance (dB)
Carrier output power variance		
Nominal voltage	0.10 W, +3, -0.5 dB	0.103 W 0.128 dB
Nominal voltage +10%	0.103 W ±3 dB	0.129 W 0.977 dB
Nominal voltage -10%	0.103 W ±3 dB	0.078 W -1.207 dB
Nominal voltage -20%	0.103 W ±6 dB	0.056 W -2.646 dB
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.26940 MHz
Nominal voltage +15%	159.27 MHz ±0.003%	159.26970 MHz
Nominal voltage -15%	159.27 MHz ±0.003%	159.26920 MHz
AM hum and noise attenuation	34 dB minimum	49.5 dB
Transmitter efficiency[1]	40% minimum	38.6%* at 6 VDC input 42.9% at 9 VDC input
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion	5% maximum	2.3%
FM hum and noise attenuation	40 dB minimum	45.1 dB
Audiofrequency response test	See graph	See graph
Frequency deviation	4.05 to 4.95 kHz	4.00 kHz*
Modulation limiting		
300 Hz test tone	4.05 to 4.95 kHz	2.50 kHz*
500 Hz test tone	4.05 to 4.95 kHz	3.54 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	4.10 kHz
1500 Hz test tone	4.05 to 4.95 kHz	4.23 kHz
2000 Hz test tone	4.05 to 4.95 kHz	4.38 kHz
2500 Hz test tone	4.05 to 4.95 kHz	4.25 kHz
3000 Hz test tone	4.05 to 4.95 kHz	3.43 kHz*

* Not in compliance with the standard.

Model: DYNATECH T70 *(Continued)*

Characteristic	Requirement	Result
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation[2]		
79.6 MHz	33 dB minimum	56 dB
139 MHz	33 dB minimum	62 dB
179 MHz	33 dB minimum	55 dB
Sideband spectrum attenuation		
+10 kHz sideband	25 dB minimum	34.2 dB
-10 kHz sideband	25 dB minimum	32.8 dB
+20 kHz sideband	60 dB minimum	77.2 dB
-20 kHz sideband	60 dB minimum	81.0 dB
Battery service life[3]	Not specified	2 h

Notes:

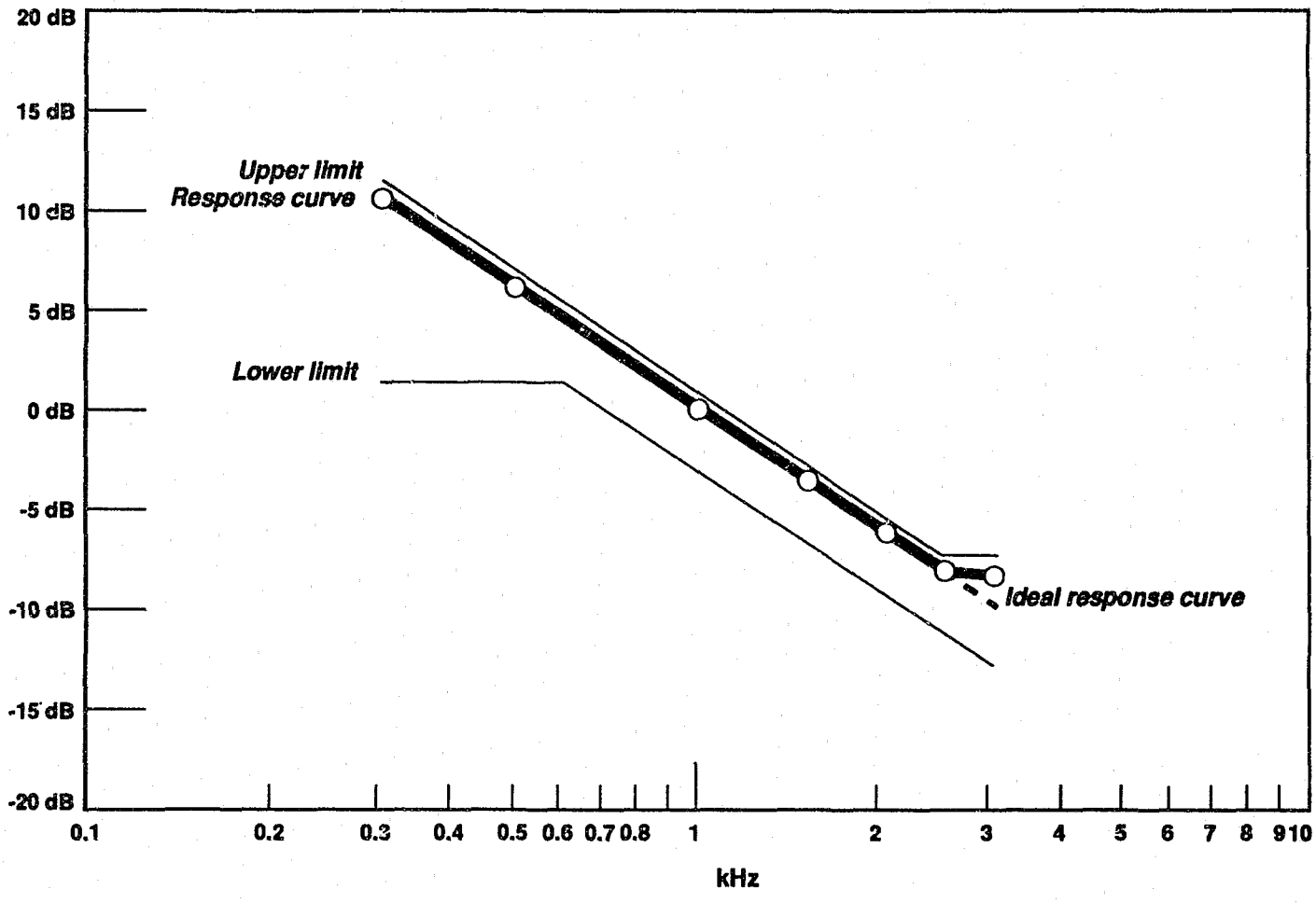
1. Manufacturer specifies operating voltage of 6 VDC, but supplied the optional 9 VDC battery. When the transmitter is operated at 6 VDC, it has a 38.6% efficiency. When the transmitter is operated at 9 VDC, it has a 42.9% efficiency.

2. Radiated spurious emission shall be attenuated a minimum of 43 dB +10 $\log_{10}$ (measured power output in watts) decibels below the field strength of the carrier. For this transmitter, attenuation should be:

$$43 \text{ dB} + 10 \log_{10} (0.103 \text{ W}) = 33 \text{ dB minimum}$$

3. The results are inconclusive since the minimum service life was not specified by the manufacturer.

Audiofrequency Response
DYNATECH T70



Test Results *(Continued)*

DATA SHEET
HDS ATX-101

Characteristic	Requirement	Result
User information	Complete data	Incomplete*
Radio frequency carrier characteristics		
		Measured watts / Variance (dB)
Carrier output power variance		
Nominal voltage	0.25 W +3, -0.5 dB	0.234 W -0.287 dB
Nominal voltage +10%	0.234 W ±3 dB	0.302 W 1.108 dB
Nominal voltage -10%	0.234 W ±3 dB	0.148 W -1.990 dB
Nominal voltage -20%	0.234 W ±6 dB	0.068 W -5.367 dB
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.26875 MHz
Nominal voltage +15%	159.27 MHz ±0.003%	159.26945 MHz
Nominal voltage -15%	159.27 MHz ±0.003%	159.26775 MHz
AM hum and noise attenuation	34 dB minimum	79.6 dB
Transmitter efficiency	40% minimum	51.2%
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion	5% maximum	3.4%
FM hum and noise attenuation	40 dB minimum	48.9 dB
Audiofrequency response test	See graph	See graph*
Frequency deviation[1]	4.05 to 4.95 kHz	2.00 kHz*
Modulation limiting[1]		
300 Hz test tone	4.05 to 4.95 kHz	2.34 kHz*
500 Hz test tone	4.05 to 4.95 kHz	2.20 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	2.23 kHz*
1500 Hz test tone	4.05 to 4.95 kHz	2.32 kHz*
2000 Hz test tone	4.05 to 4.95 kHz	2.40 kHz*
2500 Hz test tone	4.05 to 4.95 kHz	2.43 kHz*
3000 Hz test tone	4.05 to 4.95 kHz	2.53 kHz*
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation[2]		
140 MHz	37 dB minimum	73 dB
325 MHz	37 dB minimum	60 dB
Sideband spectrum attenuation[3]		
+10 kHz sideband	25 dB minimum	40.0 dB*
-10 kHz sideband	25 dB minimum	35.6 dB*
+20 kHz sideband	60 dB minimum	58.0 dB*
-20 kHz sideband	60 dB minimum	67.0 dB*

* Not in compliance with the standard.

Model: HDS ATX-101 *(Continued)*

Characteristic	Requirement	Result
Battery service life[4]	Not specified	1 h, 9 min

Notes:

1. Due to the design of the transmitter, a 60% (±3 kHz) rated system deviation could not be used for this test. Instead a 24% (±1.2 kHz) rated system deviation was used.

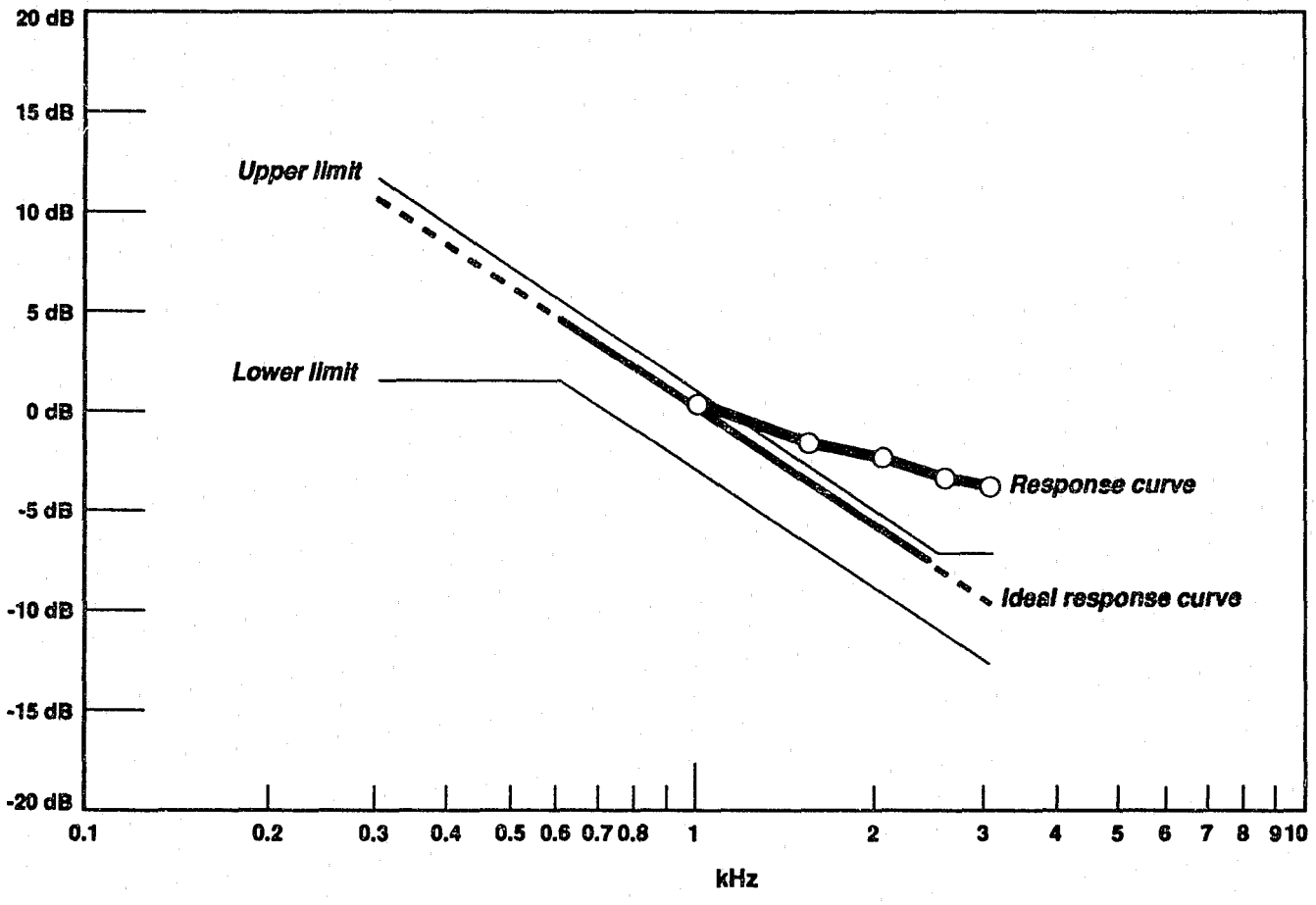
2. Radiated spurious emissions shall be attenuated a minimum of 43 dB +10 $\log_{10}$ (measured power output in watts) decibels below the field strength of the carrier. For this transmitter, attenuation should be:

$$43 \text{ dB} + 10 \log_{10} (0.234 \text{ W}) = 37 \text{ dB}$$

3. With the audio drive adjusted to 16 dB above the setup level, it was not possible to accurately measure the sideband power levels. Instead, the audio drive was adjusted to 6 dB above setup level yielding these results. Based on the fact that the test was performed at 10 dB less than the requirement, the transmitter did not meet the specification.

4. Results are inconclusive since the minimum battery service life was not supplied by the manufacturer.

Audiofrequency Response
HDS ATX-101



NOTE: Deviation could not be set to 1.0 kHz at 0.3 kHz and 0.5 kHz.
Therefore, the audiofrequency response at these frequencies is not shown.

Test Results *(Continued)*

DATA SHEET
ISG MINI-PAX

Characteristic	Requirement	Result
User information	Complete data	Incomplete*
Radio frequency carrier characteristics		
		Measured watts / Variance (dB)
Carrier output power variance		
Nominal voltage	2.00 W +3, -0.5 dB	1.752 W -0.575*
Nominal voltage +10%	1.752 W ±3 dB	2.028 W 0.635
Nominal voltage -10%	1.752 W ±3 dB	1.438 W -0.858
Nominal voltage -20%	1.752 W ±6 dB	1.188 W -1.678
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.27060 MHz
Nominal voltage +15%	159.27 MHz ±0.003%	159.27030 MHz
Nominal voltage -15%	159.27 MHz ±0.003%	159.27030 MHz
AM hum and noise attenuation	34 dB minimum	52.3 dB
Transmitter efficiency	40% minimum	40.4%
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion	5% maximum	2.6%
FM hum and noise attenuation	40 dB minimum	39.1 dB*
Audiofrequency response test	See graph	See graph*
Frequency deviation	4.05 to 4.95 kHz	5.51 kHz*
Modulation limiting		
300 Hz test tone	4.05 to 4.95 kHz	6.20 kHz*
500 Hz test tone	4.05 to 4.95 kHz	6.08 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	5.90 kHz*
1500 Hz test tone	4.05 to 4.95 kHz	5.35 kHz*
2000 Hz test tone	4.05 to 4.95 kHz	4.80 kHz
2500 Hz test tone	4.05 to 4.95 kHz	4.40 kHz
3000 Hz test tone	4.05 to 4.95 kHz	4.04 kHz*
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation[1]		
141 MHz	45 dB minimum	84 dB
318 MHz	45 dB minimum	62 dB
Sideband spectrum attenuation		
+10 kHz sideband	25 dB minimum	29.5 dB
-10 kHz sideband	25 dB minimum	25.5 dB
+20 kHz sideband	60 dB minimum	52.5 dB*
-20 kHz sideband	60 dB minimum	49.0 dB*

* Not in compliance with the standard.

Model: ISG MINI-PAX *(Continued)*

Characteristic	Requirement	Result
Battery service life[2]	90% of 3 h minimum (2 h, 43 min)	3 h, 31 min

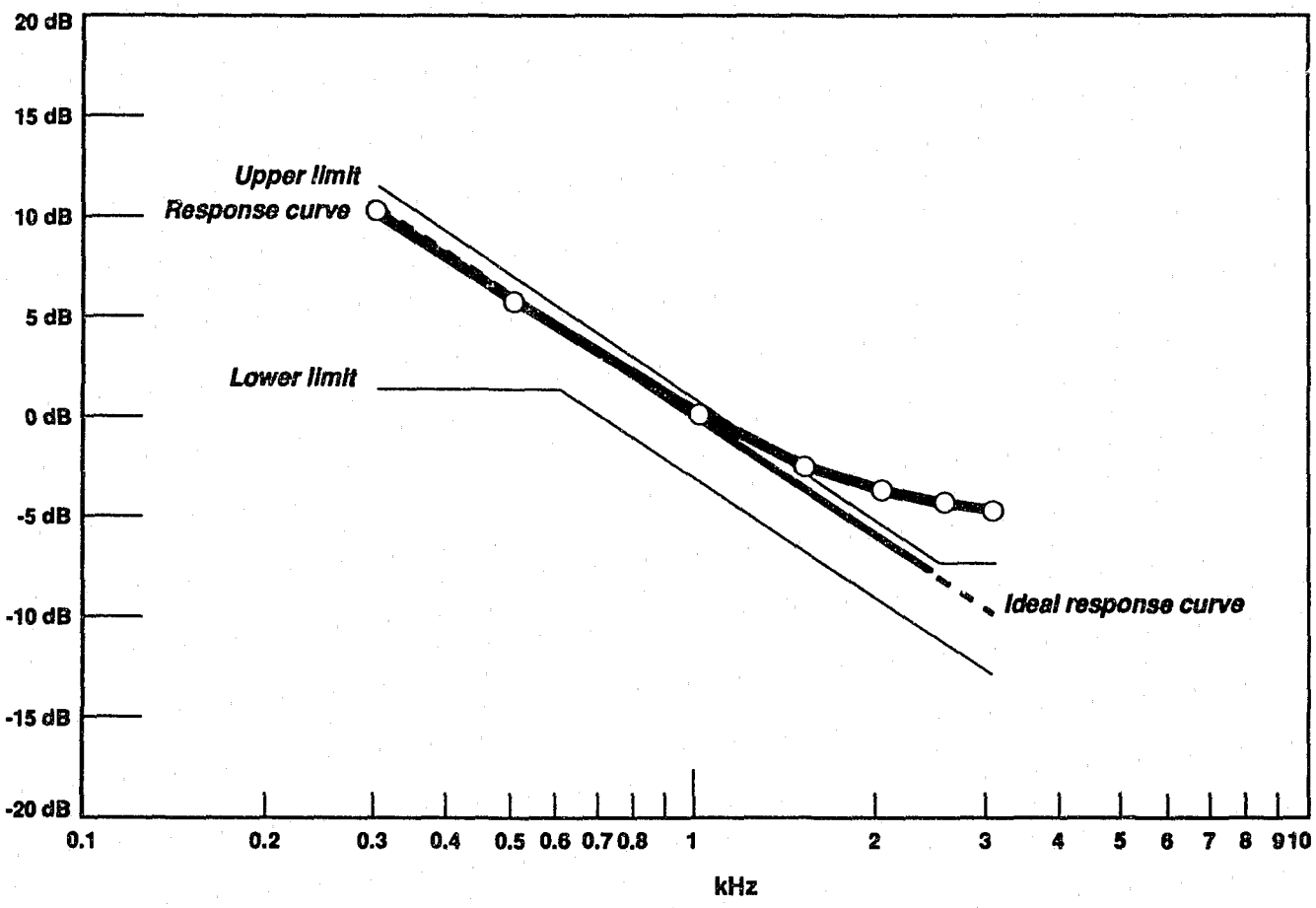
Note:

1. Radiated spurious emissions shall be attenuated a minimum of 43 dB +10 $\log_{10}$ (measured power output in watts) decibels below the field strength of the carrier. For this transmitter, attenuation should be:

$$43 \text{ dB} + 10 \log_{10} (1.752 \text{ W}) = 45 \text{ dB}$$

2. Battery service life specified by the manufacturer, 3 hours at 68 °F.

Audiofrequency Response
ISG MINI-PAX



Test Results *(Continued)*

DATA SHEET
MOTOROLA SP2700061

Characteristic	Requirement	Result
User information	Complete data	Incomplete*
Radio frequency carrier characteristics		
		Measured watts / Variance (dB)
Carrier output power variance		
Nominal voltage	1.01 W +3, -0.5 dB	1.179 W 0.715 dB
Nominal voltage +10%	1.179 W ±3 dB	1.475 W 0.973 dB
Nominal voltage -10%	1.179 W ±3 dB	0.816 W -1.598 dB
Nominal voltage -20%	1.179 W ±6 dB	0.375 W -4.975 dB
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.27075 MHz
Nominal voltage +15%	159.27 MHz ±0.003%	159.27090 MHz
Nominal voltage -15%	159.27 MHz ±0.003%	159.27022 MHz
AM hum and noise attenuation	34 dB minimum	55.1 dB
Transmitter efficiency	40% minimum	51.8%
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion	5% maximum	4.6%
FM hum and noise attenuation	40 dB minimum	33.2 dB*
Audiofrequency response test	See graph	See graph*
Frequency deviation[1]	4.05 to 4.95 kHz	5.00 kHz*
Modulation limiting[1]		
300 Hz test tone	4.05 to 4.95 kHz	5.50 kHz*
500 Hz test tone	4.05 to 4.95 kHz	5.40 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	5.00 kHz*
1500 Hz test tone	4.05 to 4.95 kHz	4.77 kHz
2000 Hz test tone	4.05 to 4.95 kHz	4.50 kHz
2500 Hz test tone	4.05 to 4.95 kHz	4.10 kHz
3000 Hz test tone	4.05 to 4.95 kHz	3.50 kHz*
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation		
30 MHz	43 dB minimum	103 dB
35 MHz	43 dB minimum	67 dB
53 MHz	43 dB minimum	85 dB
61 MHz	43 dB minimum	80 dB
77 MHz	43 dB minimum	89 dB
123 MHz	43 dB minimum	84 dB
141 MHz	43 dB minimum	65 dB
175 MHz	43 dB minimum	63 dB

* Not in compliance with the standard.

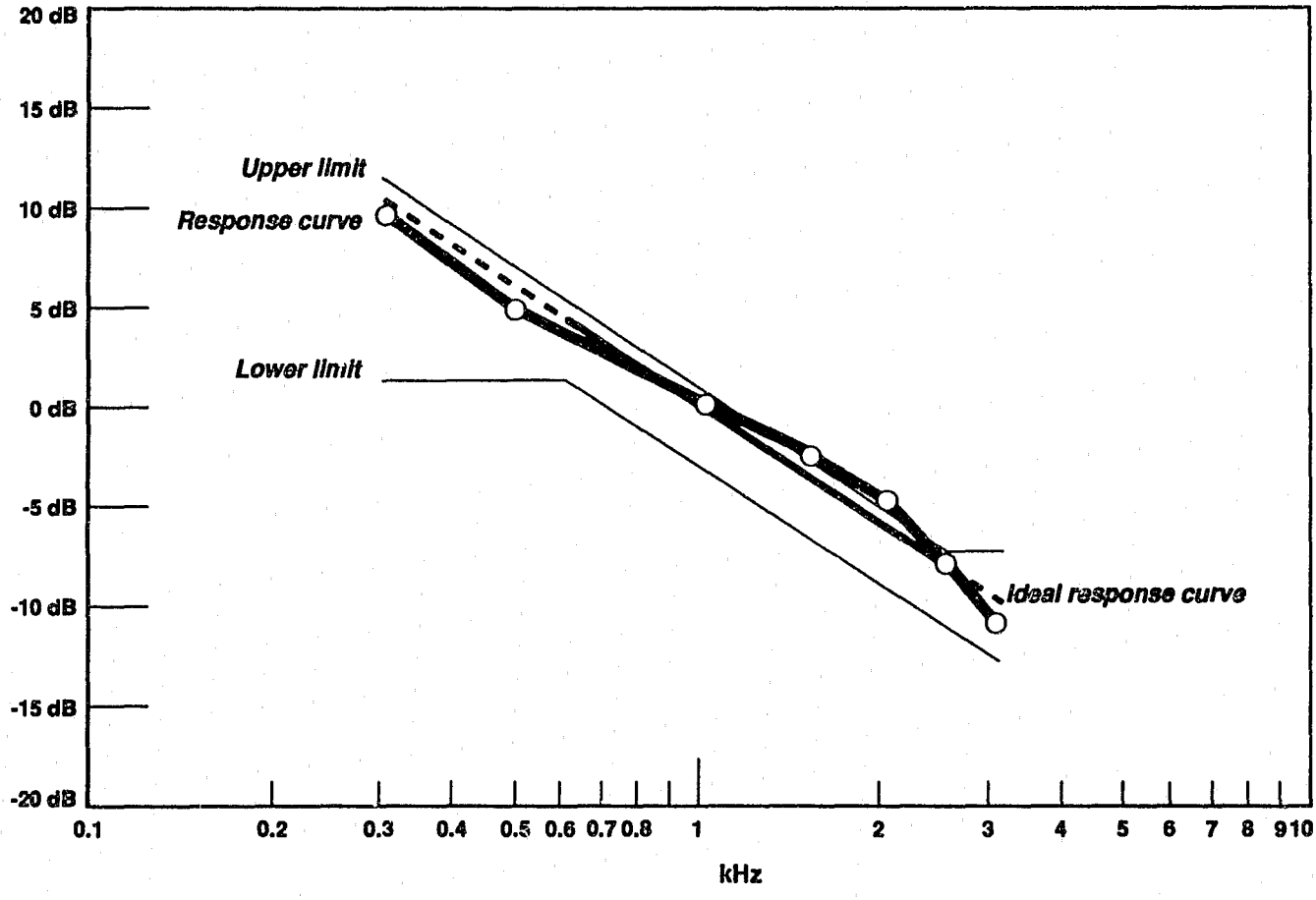
Model: MOTOROLA SP2700061 *(Continued)*

Characteristic	Requirement	Result
177 MHz	43 dB minimum	51 dB
195 MHz	43 dB minimum	69 dB
210 MHz	43 dB minimum	47 dB
320 MHz	43 dB minimum	72 dB
370 MHz	43 dB minimum	69 dB
430 MHz	43 dB minimum	83 dB
670 MHz	43 dB minimum	63 dB
950 MHz	43 dB minimum	50 dB
1000 MHz	43 dB minimum	78 dB
Sideband spectrum attenuation		
+10 kHz sideband	25 dB minimum	31.0 dB
-10 kHz sideband	25 dB minimum	34.0 dB
+20 kHz sideband	60 dB minimum	60.0 dB
-20 kHz sideband	60 dB minimum	60.0 dB
Battery service life	90% of 2 h minimum (1 h, 48 min)	2 h, 8 min

Note:

1. The deviation of this unit is adjustable according to the schematic, but no adjustment was performed.

Audiofrequency Response
MOTOROLA SP2700061



Test Results *(Continued)*

DATA SHEET
SHERWOOD POCKET TX

Characteristic	Requirement	Result
User information	Complete data	Incomplete*
Radio frequency carrier characteristics		
Carrier output power variance		Measured watts / Variance (dB)
Nominal voltage	0.1 W +3, -0.5 dB	0.108 W 0.334 dB
Nominal voltage +10%	0.108 W ±3 dB	0.137 W 1.033 dB
Nominal voltage -10%	0.108 W ±3 dB	0.079 W -1.358 dB
Nominal voltage -20%	0.108 W ±6 dB	0.058 W -2.700 dB
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.27090 MHz
Nominal voltage +15%	159.27 MHz ±0.003%	159.27088 MHz
Nominal voltage -15%	159.27 MHz ±0.003%	159.27041 MHz
AM hum and noise attenuation	34 dB minimum	76.1 dB
Transmitter efficiency	40% minimum	33.5%*
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion[1]	5% maximum	15.0%*
FM hum and noise attenuation	40 dB minimum	40.9 dB
Audiofrequency response test	See graph	See graph*
Frequency deviation	4.05 to 4.95 kHz	8.63 kHz*
Modulation limiting		
300 Hz test tone	4.05 to 4.95 kHz	4.61 kHz
500 Hz test tone	4.05 to 4.95 kHz	6.36 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	8.18 kHz*
1500 Hz test tone	4.05 to 4.95 kHz	8.04 kHz*
2000 Hz test tone	4.05 to 4.95 kHz	7.90 kHz*
2500 Hz test tone	4.05 to 4.95 kHz	7.61 kHz*
3000 Hz test tone	4.05 to 4.95 kHz	7.28 kHz*
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation[2]		
183 MHz	33 dB minimum	65 dB
325 MHz	33 dB minimum	57 dB
480 MHz	33 dB minimum	57 dB

* Not in compliance with the standard.

Model: SHERWOOD POCKET TX *(Continued)*

Characteristic	Requirement	Result
Sideband spectrum attenuation		
+10 kHz sideband	25 dB minimum	23.0 dB*
-10 kHz sideband	25 dB minimum	21.8 dB*
+20 kHz sideband	60 dB minimum	31.0 dB*
-20 kHz sideband	60 dB minimum	33.5 dB*
Battery service life[3]	Not specified	8 h, 8 min

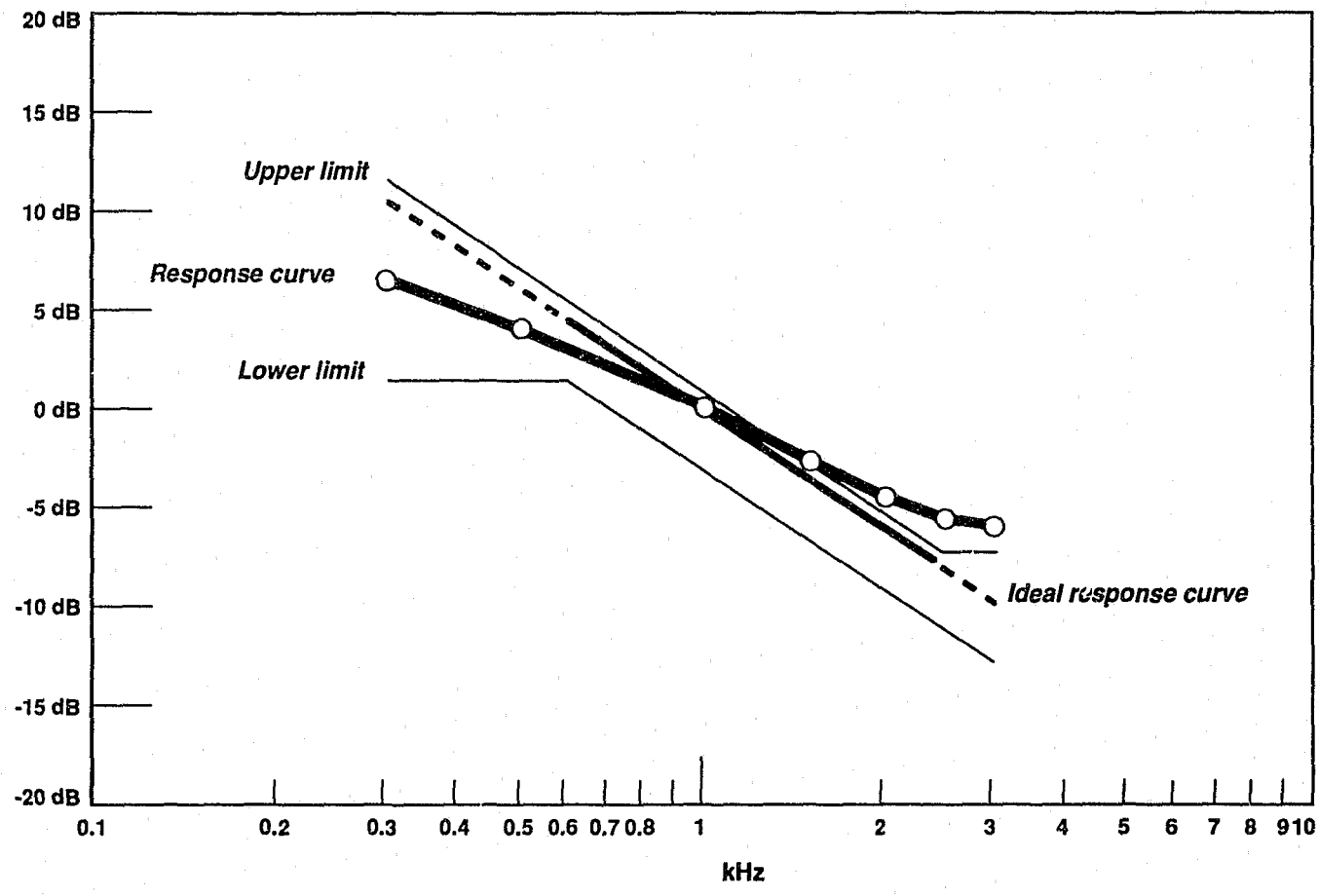
Notes:

1. Audiofrequency test modulation produced only ± 2 kHz deviation due to design of transmitter.
2. Radiated spurious emissions shall be attenuated a minimum of 43 dB +10 $\log_{10}$ (measured power output in watts) decibels below the field strength of the carrier. For this transmitter, attenuation should be:

$$43 \text{ dB} + 10 \log_{10} (0.108 \text{ W}) = 33 \text{ dB}$$

3. The results are inconclusive since the minimum battery service life was not specified by the manufacturer.

Audiofrequency Response
SHERWOOD POCKET TX



Test Results *(Continued)*

DATA SHEET
SPECTRUM SCT5-1P

Characteristic	Requirement	Result
User information	Complete data	Incomplete*
Radio frequency carrier characteristics		
		Measured watts / Variance (dB)
Carrier output power variance		
Nominal voltage	0.25 W +3, -0.5 dB	0.333 W 1.245 dB
Nominal voltage +10%	0.333 W ±3 dB	0.406 W 0.861 dB
Nominal voltage -10%	0.333 W ±3 dB	0.258 W -1.108 dB
Nominal voltage -20%	0.333 W ±6 dB	0.186 W -2.529 dB
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.26985 MHz
Nominal voltage +15%	159.27 MHz ±0.003%	159.27022 MHz
Nominal voltage -15%	159.27 MHz ±0.003%	159.26958 MHz
AM hum and noise attenuation	34 dB minimum	78.1 dB
Transmitter efficiency	40% minimum	30.6%*
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion	5% maximum	2.4%
FM hum and noise attenuation	40 dB minimum	27.4 dB*
Audiofrequency response test	See graph	See graph*
Frequency deviation	4.05 to 4.95 kHz	6.53 kHz*
Modulation limiting		
300 Hz test tone	4.05 to 4.95 kHz	8.26 kHz*
500 Hz test tone	4.05 to 4.95 kHz	6.71 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	5.53 kHz*
1500 Hz test tone	4.05 to 4.95 kHz	5.20 kHz*
2000 Hz test tone	4.05 to 4.95 kHz	5.11 kHz*
2500 Hz test tone	4.05 to 4.95 kHz	5.04 kHz*
3000 Hz test tone	4.05 to 4.95 kHz	4.99 kHz*
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation[1]		
54 MHz	38 dB minimum	81 dB
143 MHz	38 dB minimum	59 dB
173 MHz	38 dB minimum	61 dB
178 MHz	38 dB minimum	59 dB
325 MHz	38 dB minimum	44 dB
660 MHz	38 dB minimum	76 dB

* Not in compliance with the standard.

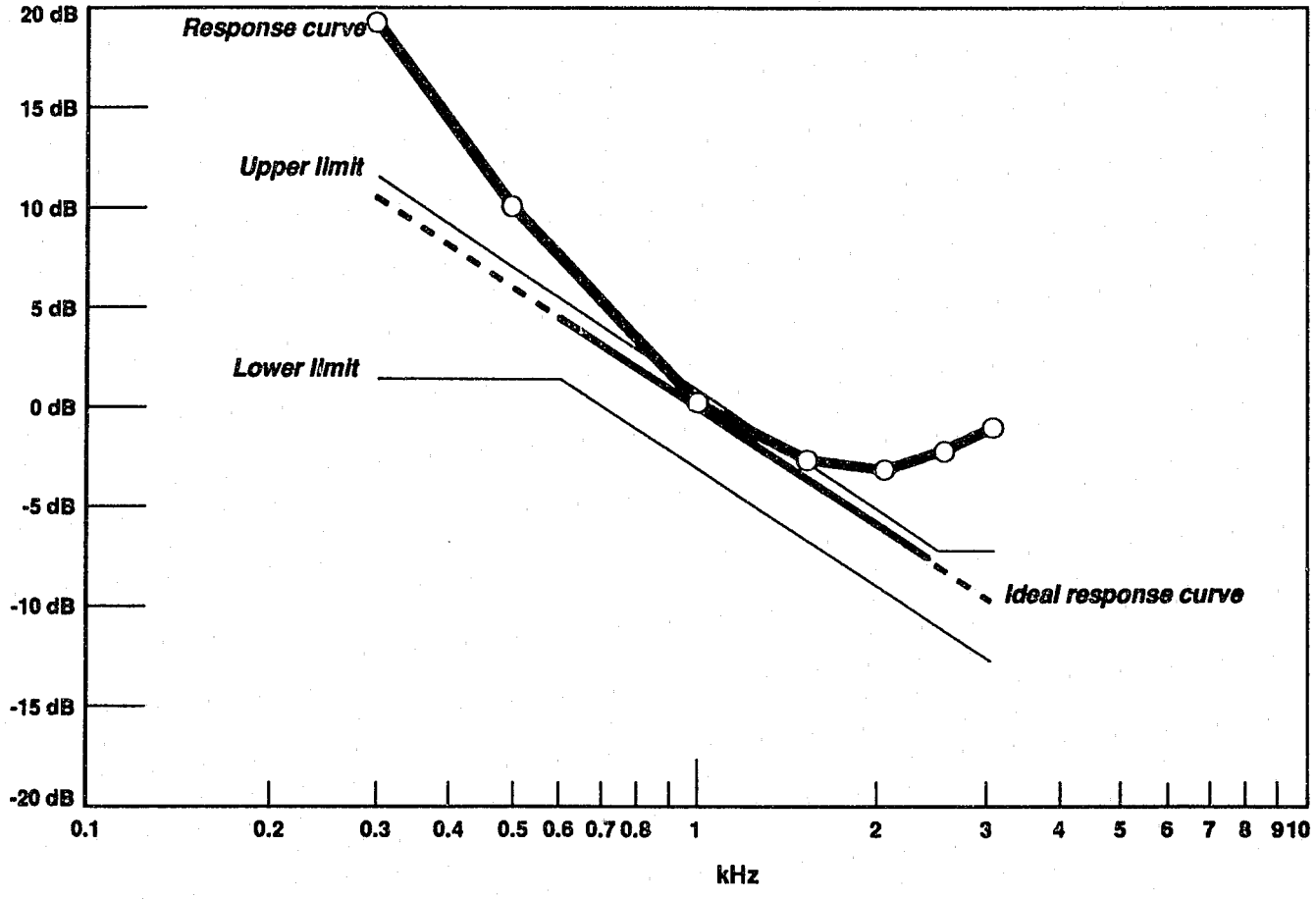
Model: SPECTRUM SCT5-1P *(Continued)*

Characteristic	Requirement	Result
Sideband spectrum attenuation		
+10 kHz sideband	25 dB minimum	30.5 dB
-10 kHz sideband	25 dB minimum	30.5 dB
+20 kHz sideband	60 dB minimum	69.5 dB
-20 kHz sideband	60 dB minimum	65.0 dB
Battery service life	90% of 4.5 h min (4 h, 3 min)	2 h, 25 min*

1. Radiated spurious emissions shall be attenuated a minimum of 43 dB +10 $\log_{10}$ (measured power output in watts) decibels below the field strength of the carrier. For this transmitter, attenuation should be:

$$43 \text{ dB} + 10 \log_{10} (0.333 \text{ W}) = 38 \text{ dB}$$

Audiofrequency Response
SPECTRUM SCT5-1P



Test Results *(Continued)*

DATA SHEET
SWINTEK MARK 50

Characteristic	Requirement	Result
User information	Complete data	Incomplete*
Radio frequency carrier characteristics		
		Measured watts / Variance (dB)
Carrier output power variance		
Nominal voltage	0.5 W +3, -0.5 dB	0.522 W 0.187 dB
Nominal voltage +10%	0.522 W +/-3 dB	0.650 W 0.952 dB
Nominal voltage -10%	0.522 W +/-3 dB	0.430 W -0.842 dB
Nominal voltage -20%	0.522 W +/-6 dB	0.314 W -2.207 dB
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.26987 MHz
Nominal voltage +15%	159.27 MHz ±0.003%	159.26944 MHz
Nominal voltage -15%	159.27 MHz ±0.003%	159.27003 MHz
AM hum and noise attenuation	34 dB minimum	81.3 dB
Transmitter efficiency	40% minimum	31.6%*
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion	5% maximum	2.2%
FM hum and noise attenuation	40 dB minimum	39.8 dB*
Audiofrequency response test	See graph	See graph*
Frequency deviation	4.05 to 4.95 kHz	6.80 kHz*
Modulation limiting		
300 Hz test tone	4.05 to 4.95 kHz	6.77 kHz*
500 Hz test tone	4.05 to 4.95 kHz	6.59 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	6.80 kHz*
1500 Hz test tone	4.05 to 4.95 kHz	7.52 kHz*
2000 Hz test tone	4.05 to 4.95 kHz	8.42 kHz*
2500 Hz test tone	4.05 to 4.95 kHz	8.99 kHz*
3000 Hz test tone	4.05 to 4.95 kHz	9.30 kHz*
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation[1]		
120 MHz	40 dB minimum	71 dB
200 MHz	40 dB minimum	50 dB
240 MHz	40 dB minimum	87 dB
290 MHz	40 dB minimum	68 dB
325 MHz	40 dB minimum	37 dB*
365 MHz	40 dB minimum	74 dB
405 MHz	40 dB minimum	76 dB

* Not in compliance with the standard.

Model: SWINTEK MARK 50 *(Continued)*

Characteristic	Requirement	Result
440 MHz	40 dB minimum	71 dB
480 MHz	40 dB minimum	60 dB
660 MHz	40 dB minimum	75 dB
800 MHz	40 dB minimum	56 dB
Sideband spectrum attenuation		
+10 kHz sideband	25 dB minimum	33.5 dB
-10 kHz sideband	25 dB minimum	34.3 dB
+20 kHz sideband	60 dB minimum	69.5 dB
-20 kHz sideband	60 dB minimum	68.8 dB
Battery service life[2]	Not specified	2 h, 52 min

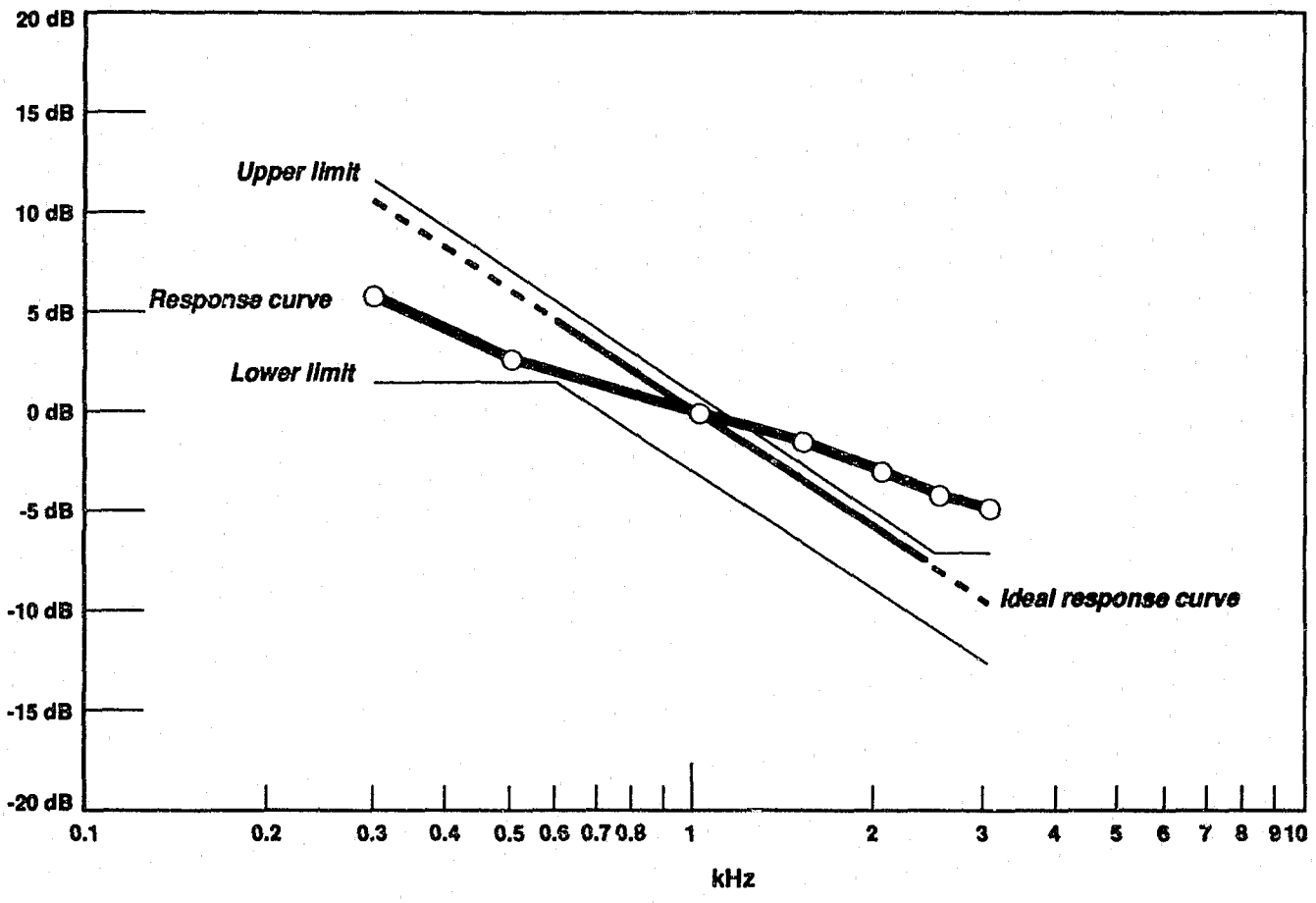
Note:

1. Radiated spurious emissions shall be attenuated a minimum of 43 dB +10 $\log_{10}$ (measured power output in watts) decibels below the field strength of the carrier. For this transmitter, attenuation should be:

$$43 \text{ dB} + 10 \log_{10} (0.522 \text{ W}) = 40 \text{ dB}$$

2. The results are inconclusive since the minimum battery service life was not specified by the manufacturer.

Audiofrequency Response
SWINTEK MARK 50



Test Results *(Continued)*

DATA SHEET
TACTICAL TECHNOLOGIES CST-586

Characteristic	Requirement	Result
User information	Complete data	None supplied*[1]
Radio frequency carrier characteristics		Measured watts / Variance (dB)
Carrier output power variance		
Nominal voltage	1.0 W +3, -0.5 dB	1.282 W +1.079 dB
Nominal voltage +10%	1.282 W ±3 dB	1.345 W +0.208 dB
Nominal voltage -10%	1.282 W ±3 dB	1.011 W -1.031 dB
Nominal voltage -20%	1.282 W ±6 dB	0.769 W -2.220 dB
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.26865 MHz
Nominal voltage +15%	159.27 MHz ±0.003%	159.26857 MHz
Nominal voltage -15%	159.27 MHz ±0.003%	159.26878 MHz
AM hum and noise attenuation	34 dB minimum	78.6 dB
Transmitter efficiency	40% minimum	57.7%
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion	5% maximum	12.0%*
FM hum and noise attenuation	40 dB minimum	7.1 dB*
Audiofrequency response test	See graph	See graph*
Frequency deviation	4.05 to 4.95 kHz	4.97 kHz*
Modulation limiting		
300 Hz test tone	4.05 to 4.95 kHz	4.80 kHz
500 Hz test tone	4.05 to 4.95 kHz	5.14 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	5.34 kHz*
1500 Hz test tone	4.05 to 4.95 kHz	5.53 kHz*
2000 Hz test tone	4.05 to 4.95 kHz	5.60 kHz*
2500 Hz test tone	4.05 to 4.95 kHz	5.59 kHz*
3000 Hz test tone	4.05 to 4.95 kHz	5.56 kHz*
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation		
140 MHz	44 dB minimum	60 dB
180 MHz	44 dB minimum	65 dB
325 MHz	44 dB minimum	40 dB*
485 MHz	44 dB minimum	46 dB

* Not in compliance with the standard.

Model: TACTICAL TECHNOLOGIES CST-586 *(Continued)*

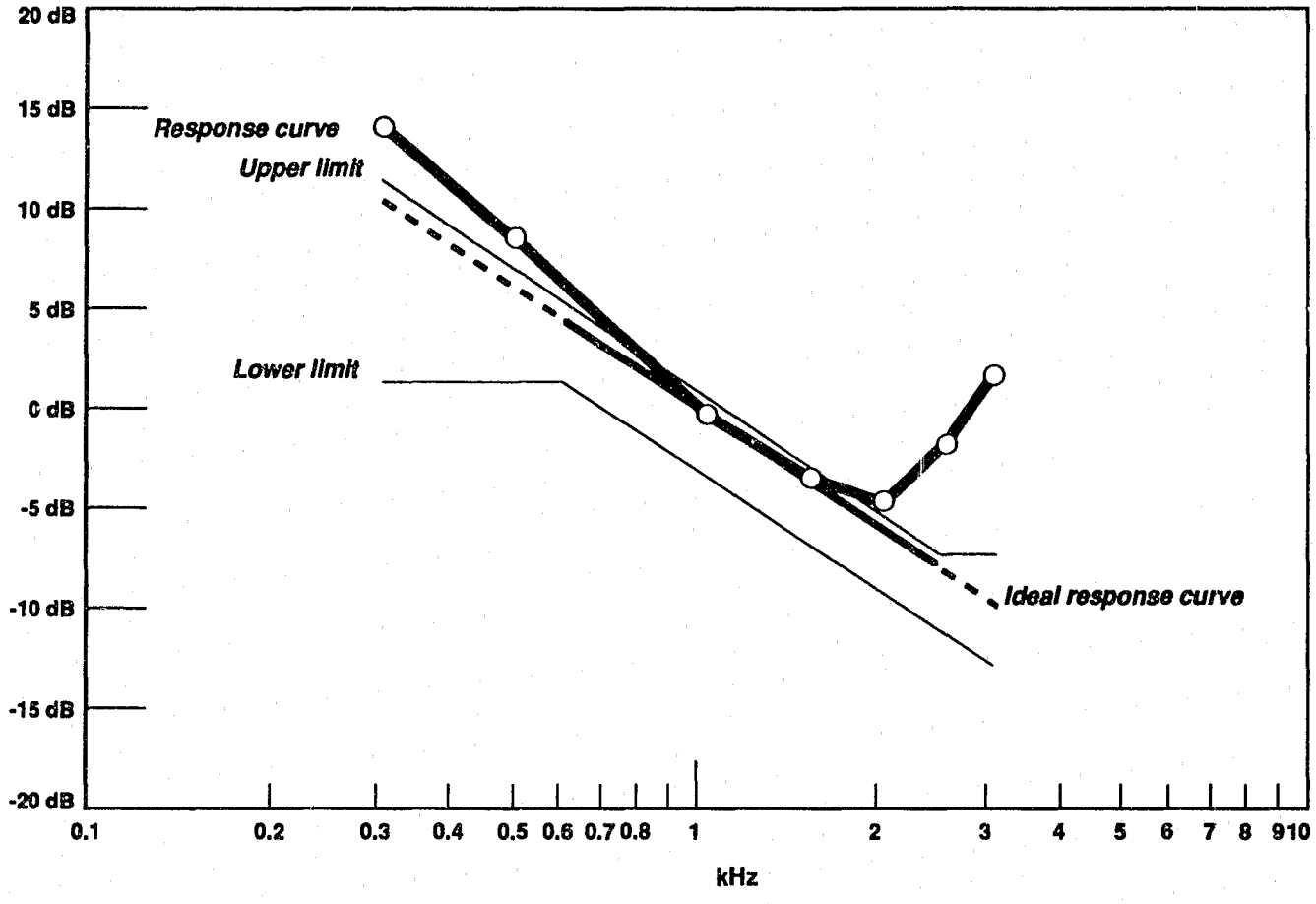
Characteristic	Requirement	Result
Sideband spectrum attenuation		
+10 kHz sideband	25 dB minimum	30.30 dB
-10 kHz sideband	25 dB minimum	28.10 dB
+20 kHz sideband	60 dB minimum	78.00 dB
-20 kHz sideband	60 dB minimum	78.30 dB
Battery service life[2]	Not specified	3 h, 8 min

Notes:

1. User information was not supplied with the transmitter for the test. The information was supplied after the test. See the User Information Summary Sheet for a listing of user information for this transmitter.

2. The results are inconclusive since the minimum service life was not specified by the manufacturer.

Audiofrequency Response
TACTICAL TECHNOLOGIES CST-586



Test Results *(Continued)*

DATA SHEET
TELEX WT400

Characteristic	Requirement	Result
User information	Complete data	Incomplete*
Radio frequency carrier characteristics		
		Measured watts / Variance (dB)
Carrier output power variance		
Nominal voltage	0.05 W +3, -0.5 dB	0.022 W -3.565 dB*
Nominal voltage +10%	0.022 W ±3 dB	0.027 W 0.889 dB
Nominal voltage -10%	0.022 W ±3 dB	0.017 W -1.119 dB
Nominal voltage -20%	0.022 W ±6 dB	0.013 W -2.285 dB
Carrier frequency stability		
Nominal voltage	159.27 MHz ±0.003%	159.27510 MHz*
Nominal voltage +15%	159.27 MHz ±0.003%	159.27700 MHz*
Nominal voltage -15%	159.27 MHz ±0.003%	159.27190 MHz
AM hum and noise attenuation	34 dB minimum	51.1 dB
Transmitter efficiency	40% minimum	5.1%*
Audiofrequency modulation characteristics		
Audiofrequency harmonic distortion	5% maximum	1.8%
FM hum and noise attenuation	40 dB minimum	41.3 dB
Audiofrequency response test	See graph	See graph*
Frequency deviation	4.05 to 4.95 kHz	32.00 kHz*
Modulation limiting		
300 Hz test tone	4.05 to 4.95 kHz	26.54 kHz*
500 Hz test tone	4.05 to 4.95 kHz	26.90 kHz*
1000 Hz test tone	4.05 to 4.95 kHz	28.50 kHz*
1500 Hz test tone	4.05 to 4.95 kHz	30.87 kHz*
2000 Hz test tone	4.05 to 4.95 kHz	33.80 kHz*
2500 Hz test tone	4.05 to 4.95 kHz	37.47 kHz*
3000 Hz test tone	4.05 to 4.95 kHz	43.20 kHz*
Electromagnetic compatibility characteristics		
Radiated spurious emissions attenuation[1]		
140 MHz	26 dB minimum	46 dB
173 MHz	26 dB minimum	55 dB
196 MHz	26 dB minimum	45 dB
215 MHz	26 dB minimum	25 dB*
325 MHz	26 dB minimum	39 dB
804 MHz	26 dB minimum	46 dB

* Not in compliance with the standard.

Model: TELEX WT400 *(Continued)*

Characteristic	Requirement	Result
Sideband spectrum attenuation		
+10 kHz sideband	25 dB minimum	28.0 dB
-10 kHz sideband	25 dB minimum	18.8 dB*
+20 kHz sideband	60 dB minimum	18.3 dB*
-20 kHz sideband	60 dB minimum	22.0 dB*
Battery service life[2]	Not specified	7 h, 54 min

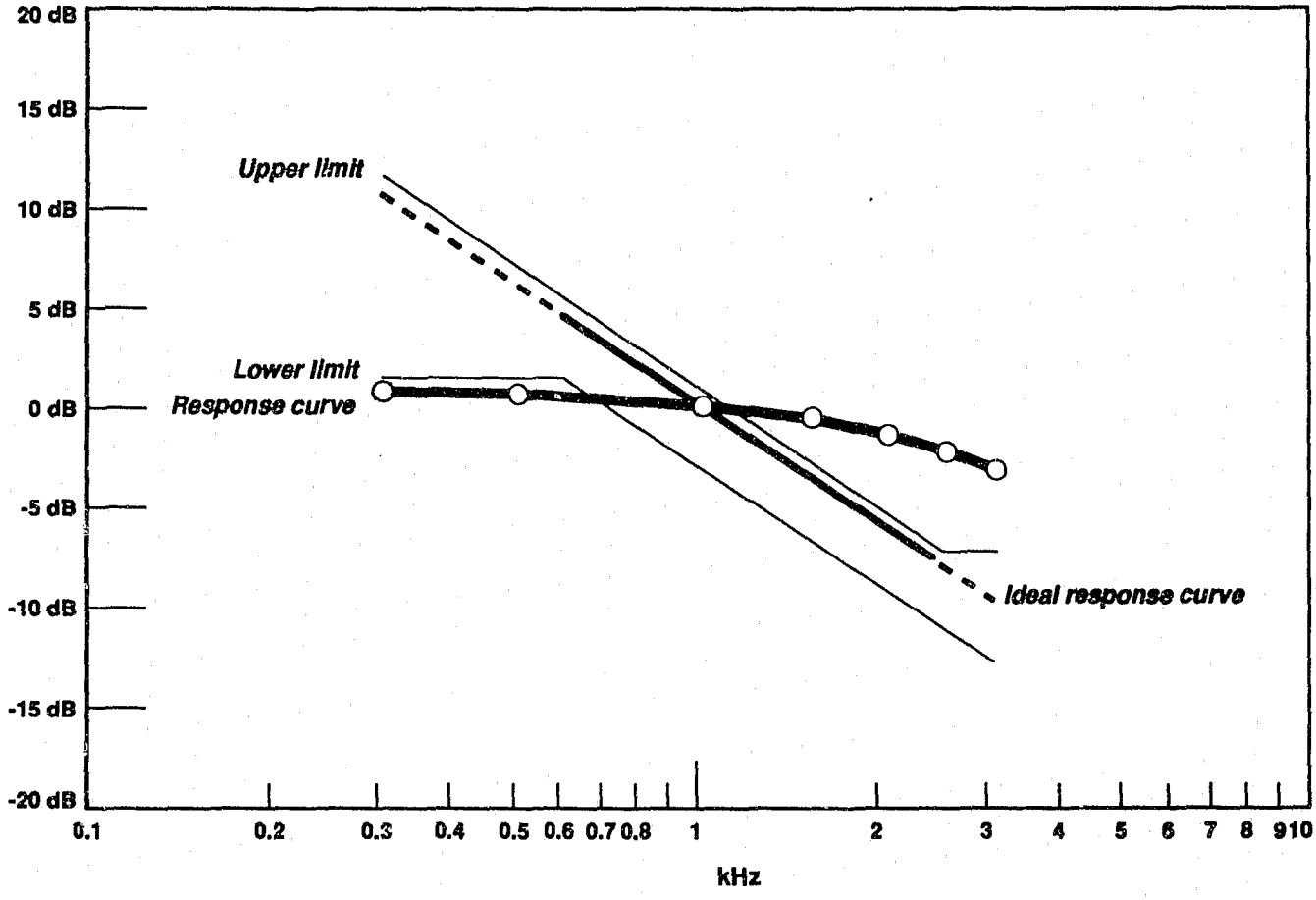
Note:

1. Radiated spurious emissions shall be attenuated a minimum of 43 dB +10 $\log_{10}$ (measured power output in watts) decibels below the field strength of the carrier. For this transmitter, attenuation should be:

$$43 \text{ dB} + 10 \log_{10} (0.022 \text{ W}) = 26 \text{ dB}$$

2. The results are inconclusive since the minimum battery service life was not specified by the manufacturer.

Audiofrequency Response
TELEX WT400



User Information Summary Sheet

Transmitter information	DTC T70	HDS ATX-101	ISG Mini-Pax	Motorola SP2700061	Sherwood Pocket TX	Spectrum SCT5-1P	Swintek Mark 50	Tactical Technologies CST-586	Telex WT400
Carrier output power	C	C	C	C	C	C	C	C	C
Carrier frequency	N	C	C	C	C	C	N	C	C
Transmit current	N	C	N	C	C	N	N	N	C
AM hum and noise attenuation	N	N	N	N	N	N	N	N	N
Transmitter efficiency	N	N	N	N	N	N	N	N	N
Audiofrequency distortion	N	N	N	N	C	N	N	N	N
FM hum and noise attenuation	N	N	N	C	C	N	N	N	N
Frequency deviation	N	C	C	N	C	N	C	N	C
Radiated spurious emissions attenuation	N	C	N	C	C	N	C	N	N
Sideband attenuation (±10 kHz)	N	N	N	N	N	N	N	N	N
Sideband attenuation (±20 kHz)	N	N	N	N	N	N	N	N	N
Battery voltage	C	C	C	N	C	C	C	C	C
Audio input signal for system deviation	N	N	N	N	N	C	N	N	C
Audio input impedance	N	N	N	N	N	C	N	N	C
Battery information									
Service life	N	N	C	C	C	C	C	N	C
Nominal voltage	C	C	C	C	C	C	C	C	C
Battery type and model	C	N	N	C	C	C	C	C	C
Rated capacity Polarity indication Rechange capability indication Month/Year of manufacture	} This information not available for any of the batteries supplied with transmitters.								

C = Complies with standard.
N = Does not comply.

Appendix A: Commentary—NIJ Standard-0214.01

Body-Worn FM Transmitters: NIJ Standard-0214.01, January 1990, established minimum performance requirements for body-worn FM transmitters of 3 watts or less. Each requirement of the standard is discussed in this appendix in terms of the purpose of the requirement. Some of the characteristics specified in the standard are Federal Communications Commission (FCC) requirements. Others were derived from laboratory testing of typical body-worn FM transmitters offered to the law enforcement community. All tolerances are for Type II transmitters.

1. *User information*

The items listed in the user information section include those nominal values necessary to make the required measurements and those useful in the procurement of equipment.

2. *Radio frequency carrier tests*

A. Output power tests. The transmitter's output power shall remain within the following tolerances:

(1) The output power with the supply voltage at nominal shall be within +3, -0.5 dB of the nominal output power.

(2) The output power with the supply voltage at nominal +10% and nominal -10% shall be within ±3 dB of the measured output power with the input voltage at nominal.

(3) The output power with the supply voltage at nominal -20% shall be within +/-6 dB of the measured output power with the input voltage at nominal.

Failure of a transmitter to maintain its output power within these tolerances could affect the reliable operation of the transmitter. This is an FCC requirement.

B. Frequency stability test. The carrier frequency shall remain within ±0.003% of the nominal value at nominal supply voltage, and at nominal supply voltage ±15%. Failure of a transmitter to remain within this tolerance could affect the ability of the receiver to detect the radio transmission and the quality of the audio signal. The requirement is also intended to prevent interference with adjacent channels. This is an FCC requirement.

C. AM hum and noise level. The AM hum and noise level shall be attenuated at least 34 dB below the unmodulated nominal carrier output power level. Failure of a transmitter to meet this requirement could affect the quality of the audio signal.

D. Transmitter efficiency test. The transmitter efficiency shall be at least 40%. This test shows the percentage of input power that is delivered to the antenna. Failure of a transmitter to meet this requirement could affect the distance over which the transmitter could effectively transmit.

3. *Audiofrequency modulation tests*

A. Harmonic distortion test. The maximum audiofrequency harmonic distortion shall be 5%. Audiofrequency distortion is distortion characterized by the appearance of integral multiples of an audiofrequency input signal in the output of the transmitter. Failure of a transmitter to meet this requirement would affect the quality of the audio signal.

B. FM hum and noise level test. The FM hum and noise level shall be attenuated at least 40 dB. FM hum and noise is the frequency modulation present on an unmodulated (no audiofrequency input) carrier. Failure of a transmitter to meet this requirement could affect the quality of the audio signal.

C. Audiofrequency response test. The audiofrequency response shall not vary more than +1, -3 dB from a true 6 dB per octave pre-emphasis characteristic from 0.3 to 3 kHz as referred to a 1 kHz level, with the exception that a 6 dB per octave roll-off from 600 to 300 Hz and from 2.5 to 3 kHz may be present. This test determines the degree of precision with which the frequency deviation of a transmitter responds to a audiofrequency signal level. Failure of a transmitter to meet this requirement would affect the quality of the audio signal.

D. Frequency deviation test. The maximum frequency deviation shall be within ±(4.05 to 4.95) kHz of the carrier frequency. Frequency deviation is the difference between the instantaneous frequency of a modulated carrier (one with an audiofrequency signal input) and the carrier frequency. Laboratory testing found that voice

reproduction was best when the frequency modulation was within these limits.

E. Modulation limiting test. The instantaneous peak and steady state frequency shall be within ±(4.05 to 4.95) kHz of the carrier frequency with a 20 dB increase in audio above the normal audio input level. This test determines the ability of the transmitter to restrict the frequency modulation within the above limits. Failure of a transmitter to meet this requirement would affect the quality of the audio signal.

4. *Electromagnetic compatibility tests*

A. Radiated spurious emissions test. Each radiated spurious emission shall be attenuated a minimum of 43 +10 $\log_{10}$ (nominal output power in watts) dB below the field strength of the carrier. This test determines the ability of the transmitter to attenuate each transmitted frequency that is not intended to be transmitted. The failure of a transmitter to meet this requirement could mean that the transmitter may interfere with other equipment. This is an FCC requirement.

B. Sideband spectrum test. Each sideband frequency ±10 kHz from the carrier frequency shall be attenuated at least 25 dB and each sideband frequency ±20 kHz from the carrier frequency shall be attenuated at least 60 dB from the power level of the carrier frequency. This requirement prevents interference to the channels adjacent to the carrier frequency. This is an FCC requirement.

5. *Battery service life test*

The service life of each battery shall be at least 90% of the nominal service life. Failure of a transmitter and its battery to meet this requirement would reduce the operating time of the unit.

Appendix B: Testing Program Procedures

The National Institute of Justice (NIJ) Technology Assessment Program Advisory Council was originally established to recommend research priorities consistent with the current needs of the law enforcement community. Based on the recommendations of the Advisory Council, NIJ subsequently established a testing program to evaluate equipment in accordance with the performance standards that NIJ issues for voluntary national use and to publish the test results in an NIJ *Equipment Performance Report.*

Each year, the Advisory Council gives NIJ its recommendations for testing equipment. The recommendations are given in priority order according to overall interest and importance to State and local law enforcement agencies. Funding considerations normally limit the scope of testing programs to two items of equipment, which NIJ selects from the Advisory Council recommendations.

The testing program is complex, involving NIJ, the Technology Assessment Program Information Center (TAPIC), the National Institute of Standards and Technology (NIST), and independent testing laboratories. The testing program provides valid, unbiased test results that assist law enforcement agencies in selecting and procuring equipment suitable for their needs. Moreover, the program is structured so that manufacturers can continue to have their products evaluated according to the NIJ standard and the results disseminated to users as new products are tested.

Following the decision to test an item of equipment, TAPIC and the Law Enforcement Standards Laboratory (LESL) of NIST identify manufacturers and models of equipment that are available. The TAPIC staff then invite the manufacturers to participate in the program. After TAPIC identifies the models to be tested, LESL and NIJ assist TAPIC in developing a Request For Proposal (RFP) to solicit bids from independent testing laboratories. The National Voluntary Laboratory Accreditation Program (NVLAP) staff at NIST develop a laboratory questionnaire to screen the testing laboratory capabilities, which is used as part of the RFP. A laboratory that is biased toward a manufacturer or derives a major portion of its income from such a manufacturer is prohibited from bidding on testing. TAPIC normally seeks to award contracts to two independent testing laboratories, one east and one west of the Mississippi River.

When the responses to the RFP are received, LESL, TAPIC, and NVLAP staff evaluate each proposal independently and score it according to the scoring criteria specified in the RFP. A final score is then established, and TAPIC recommends to NIJ the laboratory with the highest score for contract award. For the testing of body-worn FM transmitters, the contract was awarded to a single laboratory, Dayton T. Brown, Inc., in Bohemia, New York, because the limited number of test samples did not warrant the use of two laboratories.

A laboratory awarded a contract is required to demonstrate its competence and ability to properly conduct tests in accordance with the NIJ standard. This is accomplished through an onsite inspection by representatives of TAPIC, LESL, and the NVLAP staff. During the inspection, a single item of equipment is tested, and the staff evaluates all the factors associated with laboratory competence. Once the laboratory has been found fully capable of conducting tests in accordance with the NIJ standard, and its test report found adequate, it becomes a TAPIC-approved independent laboratory for future tests of that item. Should the laboratory not be competent, it is eliminated from the program and another laboratory is awarded a contract and subjected to full evaluation.

The approved laboratory is authorized to proceed with the remaining or "main quantity" testing. Representatives of TAPIC, LESL, and NVLAP may periodically visit the laboratory during the final testing.

After TAPIC has received the final test reports, LESL and TAPIC staff analyze and interpret the results to ensure accuracy and validity. Data are reviewed with the laboratories to resolve any ambiguities prior to preparation of the *Equipment Performance Report.*

Manufacturers are encouraged to have additional items of equipment tested after the *Equipment Performance Report* is published. Such testing must be accomplished according to NIJ standards, by a TAPIC-approved laboratory, and subject to TAPIC administrative controls. TAPIC issues supplements to the *Equipment Performance Report* after such new equipment is tested.

Appendix C: Glossary

Abbreviations

°C	Degree Celsius
dB	Decibel
dBm	Decibel (referenced to 1 milliwatt)
°F	Degree Fahrenheit
h	Hour
Hz	Hertz
KHz	Kilohertz
MHz	Megahertz
min	Minute
ms	Millisecond
mW	Milliwatt
NA	Not applicable
rf	Radio frequency
s	Second
W	Watt

Conversions

dBm	= 10 x log (1,000 x watts)
mW	= $10^{dBm/10}$
°F	= 9/5 (°C) +32

Definitions

AM hum and noise	The amplitude modulation present on an unmodulated carrier.
Audiofrequency harmonic distortion	Nonlinear distortion characterized by the appearance in the output of integral multiples of an audiofrequency input signal.
Audiofrequency response	The degree of precision with which the frequency deviation of a transmitter responds to a designated audiofrequency signal level.
Authorized bandwidth	The maximum width of the band of frequencies specified by the Federal Communications Commission to be occupied by an emission; i.e., 20 kHz for public safety agencies.
Carrier output power	For a transmitter, the radio frequency power available at the antenna terminal when no modulating signal is present.
FM hum and noise	The frequency modulation present on an unmodulated carrier.

Frequency deviation	In frequency modulation, the difference between the instantaneous frequency of a modulated carrier and the unmodulated carrier frequency.
Frequency stability	The ability of a transmitter to maintain an assigned carrier frequency.
Modulation limiting	That action, performed within an FM transmitter, which intentionally restricts the signal to the required spectral limits.
Nominal value	The numerical value of a device characteristic as specified by the manufacturer.
Occupied bandwidth	The width of the frequency band containing those frequencies at which a total of 99 percent of the radiated power appears, extended to include any discrete frequency at which the power is at least 0.25 percent of the total radiated power.
Rated capacity, battery	A designation by the battery manufacturer that indicates the approximate capacity, in ampere-hours or milliampere-hours, at typical discharge rates.
Sampler	A series device that couples energy over a broad frequency range from a transmission line into a third port. The attenuated output signal from the third port has the same waveform as the original signal.
Service life	The length of time that a primary cell (or battery) or a fully charged secondary cell (or battery) will provide satisfactory service under specified conditions.
Sideband spectrum	The emissions generated by a modulated transmitter that are within 250 percent of the authorized bandwidth; i.e., ±25 kHz.
Spurious emission	Any part of the radio frequency output that is not a component of the theoretical output or exceeds the authorized bandwidth.
Transmitter efficiency	The ratio of (1) the rf output power delivered to a standard output load to (2) the dc input power to the transmitter.
Type I transmitter	A transmitter that operates in the 25-50 MHz band.
Type II transmitter	A transmitter that operates in the 150-174 MHz band.
Type III transmitter	A transmitter that operates in the 400-512 MHz band.