MIL-STD-461
31 JULY 1967

SUPERSEDING
(SEE FORWARD)

MILITARY STANDARD

LECTROMAGNETIC INTERFERENCE CHARACTERISTICS REQUIREMENTS FOR EQUIPMENT

DEPARTMENT OF DEFENSE

WASHINGTON, D.C. 20360

Electromagnetic Interference
Characteristics Requirements for Equipment

MIL-STD-461

1. This standard is mandatory for use by all Departments and Agencies of the Department of Defense.

2. Recommended corrections, additions, or deletions should be addressed to Commander, Naval Ship Systems Command, Department of the Navy, Washington, D. C. 20360, with carbon copies to the departmental custodians.

FOREWORD

In the past, the Army, Navy, and Air Force have used a number of general-purpose interference specifications and standards for equipments and subsystems used with shipboard, submarine, aerospace, and ground systems. In general, these specifications were similar but many of the individual requirements and test methods were stated differently and had minor variations. Contractors had the problem of analyzing each of these differences to determine whether requirements were, in fact, the same or different. Since thousands of manufacturers did this every time a specification was changed, it became very costly and time consuming.

The purpose of this standard is to provide military interference control requirements in a coordinated document.

The standards and specifications superseded by this document are as follows:

Coordinated Documents

MIL-I-6181
MIL-S-10379
MIL-S-12348
MIL-I-43121

Single Service Documents

Army	Navy	Air Force
MIL-E-55301(E)	MIL-I-16910	MIL-STD-826
	MIL-I-17623	MIL-I-26600
	NFEC-SPEC-50Y	

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ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS

REQUIREMENTS FOR EQUIPMENT

1. SCOPE

1.1 Scope.-This standard covers the requirements and test limits for the measurement and determination of the electromagnetic interference characteristics (emission and susceptibility) of electronic, electrical and electromechanical equipment. The requirements shall be applied for general or multi-Service procurements (for example, items that are purchased for use by any Service in any installation or location) and to single-Service procurements, as specified in the individual equipment specification or the contract or order.

1.1.1 The requirements specified in this standard are established to:

(a) Insure that interference control is considered and incorporated into the design of an equipment.
(b) Enable compatible operation of the equipment in a complex electromagnetic environment.

1.1.2 This standard shall be used in conjunction with MIL-STD-463 and MIL-STD-462.

1.2 Units.-This standard requires use of the International System of Units as specified in MIL-STD-463.

2. REFERENCED DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein:

SPECIFICATIONS

MILITARY
MIL-C-45662 - Calibration of Standards.

STANDARDS

MILITARY
MIL-STD-462 - Electromagnetic Interference Characteristics, Measurement of
MIL-STD-463 - Definitions and System of Units, Electromagnetic Interference Technology.
MIL-STD-831 - Test Reports, Preparation of

DRAWINGS

MILITARY
62J4040 - Antenna, Conical Logarithmic Spiral, 200 to 1000 MHz
62J4041 - Antenna, Conical Logarithmic Spiral, 1 to 10 GHz
ES-DL-201090 - Antenna, Microwave, 12 to 40 GHz, Detail Assembly.
ES-F-201286 - Biconical Antenna, Details and Assembly.

(Copies of these drawings may be obtained from the departmental custodians of this standard.)

2.2 Other Publications.-The documents referenced below form a part of this standard to the extent specified herein. Unless otherwise specified in the individual equipment specification, the issues of these documents in effect on date-of-invitation for bids or requests for proposals shall apply.

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. (SAE)
SAE-ARP-936-Ten Microfarad Capacitor
SAE-ARP-958-Measurement of Antenna Factors
SAE-J551-Measurement of Vehicle Radio Interference (30 to 400 MC)

(Copies may be obtained from the Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York, New York 10017.)

3. DEFINITIONS The terms used in this standard are defined in MIL-STD-463.

4. GENERAL REQUIREMENTS

4.1 Application of Standard.-The requirements of this standard shall be applied to electronic, electrical and electromechanical equipment as indicated hereinafter:

4.1.1 Equipment.-The requirements of this standard shall be applied to units or equipments that are intended to operate as individual items. Individual equipment classes are defined in Table I. A guide for the application of each test requirement for the particular equipment class is shown in Table II.

4.1.2 Government Furnished Equipment.-Equipment furnished by the Government to a contractor may, unless the test data is furnished by the Government, require testing by the contractor for conformance to the equipment item class and limit requirements. Application of suppression measures to meet the requirements shall be detailed in the control plan.

4.1.3 Commercial Off-the-Shelf Equipment.-

4.1.3.1 When commercial off-the-shelf equipment is selected by the contractor all applicable tests required by this standard shall be performed and the test data submitted to the procuring activity to determine the EMI/EMC suitability in the end-item configuration. The EMI/EMC suitability shall be covered in the control plan (see 4.2).

4.1.3.2 When C-E equipment certified to FAA Technical Standard Orders (Part 5.1.4(a) and (b)) are used with, or become part of any military equipment configuration, the requirements in 4.1.3.1 apply.

4.1.4 Class I equipment identical to Government furnished model (GFM).-Class I equipments required to conform to the performance and design characteristics of a government furnished procurement model previously certified to superseded EMI standards or specification shall be tested in accordance with the requirements of this standard and shall satisfy either of the following conditions:

(a) Full conformance with the requirements of this standard
(b) If the test sample fails to conform to the requirements of this standard, the government furnished procurement model shall also be tested, and the test data submitted to the procuring activity in accordance with the requirements of this standard.

4.1.5 Other EMI Requirements.-

4.1.5.1 If an equipment has met the EMI requirements of activities not using this standard, that data may be submitted for evaluation by the procuring activity as evidence of meeting equivalent portions of this standard.

4.1.5.2 All equipments, other than class I equipment, produced by a manufacturer which are identical to those previously produced by the same manufacturer, tested in accordance with this standard, found satisfactory and accepted shall require minimal testing to ascertain conformance with this standard. A copy of the previous test report, Government letter of compliance, or reference thereto, shall be forwarded with the new test report for comparison and evaluation.

4.1.6 Short-Duration Interference.-Short duration interference is not exempt from the requirements of this standard, unless specifically indicated in the individual equipment specification.

4.2 Interference Control Plan.-The interference control plan shall be a detailed plan outlining the interference control or reduction program, the engineering design procedures and proposed techniques that will be used to determine conformance with the requirements of this standard and that will enable the equipment to perform its operational function without interference from its parts and subassemblies. Approval of the control plan and compliance thereto does not relieve the contractor of the responsibility of meeting the applicable requirements of this standard. Technically justifiable deviations which are being, or are to be formally processed through contractual channels may be included in the control plan.

4.2.1 Contents.-The control plan shall contain but not be limited to the following major categories:

Table I – Classes of Equipment

Class No.	Description
I	Communication-Electronic (C-E) Equipment Any item, including subassemblies and parts, serving functionally in electromagnetically generating, transmitting, conveying, acquiring, receiving, storing, processing or utilizing information in the broadest sense. Sub classes are:
IA	Receivers Using Antennas
IB	Transmitters Using Antennas
IC	Non-Antenna C-E Equipment (such as computers, power supplies, digital equipment, wire terminal, image interpretation facilities, photographic processing equipment and other electronic devices working in conjunction with classes IA and IB).
ID	Electrical and electronic equipment and instruments which would affect mission success or safety if degraded or malfunctioned by internally generated interference or susceptibility to external fields and voltages.
II	Non-Communication Equipment, Specific subclasses are:
IIA	Non Communication-Electronic Equipment - Equipment in which rf energy is intentionally generated for other than information or control purposes. Examples are ultrasonic equipment, medical diathermy equipment, induction heaters, rf stabilized arc-welders and rf power supplies.
IIB	Electrical Equipment - Some examples are electric motors, handtools, office and kitchen equipment, laundry and repair shop equipment, electric fork lift trucks and lithographic processing equipment.
IIC	Accessories for Vehicles and Engines - Electrically and mechanically driven and engine electrical accessories such as gauges, fuel pumps, regulators, windshield wipers, turret motors, magnetos and generators, when tested off of the vehicle or engine. Applicable only to accessories for use on items of classes IIIA and IIIB.
III	Vehicles, Engine-Driven Equipment
IIIA	Tactical Vehicles.–Included are: armored and tracked vehicles, off-the-road cargo and personnel carriers, assault and landing craft, amphibious vehicles, patrol boats, mobile railway and maintenance-of-way equipment, and all other vehicles intended for installation of tactical C-E equipment.
IIIB	Engine Generators.–Those not exceeding 60 kVA, or 500 volts a.c. or d.c., and supplying power to, or closely associate with, C-E equipment.
IIIC	Special Purpose Vehicles and Engine-Driven Equipment - Those intended for use in critical communication areas such as air-fields, missile sites, forward areas, or in support of tactical operations. Examples are fire engines, aircraft service vehicles, pumps, blowers, and bulldozers and other construction equipment, harbor tugs, floating repair shops, self-propelled barges, and fork-lift trucks (engine-driven).
IIID	Administrative Vehicles.–Those of basically civilian character, not intended for use in tactical areas or in critical areas covered by class IIIC, and not intended for installation of communication equipment. Examples are sedans, and other material handling equipment, whether engine-driven or electrically driven.
IV	Overhead Power Lines

Table II – Test Requirements Applicable to Equipment Classes

	Equipment Class												Description of Test Method	Notes
	IA	IB	IC	ID	IIA (8)	IIB	IIC	IIIA	IIIB	IIIC	IIID (13)	IV		
CE01	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	30 Hz to 20 kHz, Power Leads	(9)
CE02	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	0.03 to 20 kHz, Control and Signal Leads	
CE03	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	0.02 to 50 MHz, Power Leads	(6, 11)
CE04	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	0.02 to 50 MHz, Control and Signal Leads	
CE05	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	30 Hz to 50 MHz, Inverse Filter Method	(4)
CE06	Y	Y	N	N	N	N	N	N	N	N	N	N	10 kHz to 12.4 GHz, Antenna Terminal	
CS01	Y	Y	Y	Y	N	N	N	N	N	N	N	N	0.03 to 50 kHz, Power Leads	
CS02	Y	Y	Y	Y	N	N	N	N	N	N	N	N	0.05 to 400 MHz, Power Leads	
CS03	Y	N	Y	N	N	N	N	N	N	N	N	N	30 Hz to 10 GHz, Intermodulation	
CS04	Y	N	Y	N	N	N	N	N	N	N	N	N	30 Hz to 10 GHz, Rej. of Undes. Sig. (2-Sig Gen Method)	(7)
CS05	Y	N	Y	N	N	N	N	N	N	N	N	N	30 Hz to 10 GHz, Cross - Modulation	
CS06	Y	Y	Y	Y	N	N	N	N	N	N	N	N	Spike, Power Leads	
(T) CS07	Y	N	Y	N	N	N	N	N	N	N	N	N	Squelch Circuits	
CS08	Y	N	Y	N	N	N	N	N	N	N	N	N	30 Hz to 10 GHz, Rej. of Undes Sig. (1-Sig Gen Method)	(7)
RE01	Y	Y	Y	N	Y	Y	N	N	N	N	N	N	0.03 to 30 kHz, Magnetic Field	(5)
RE02	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	14 kHz to 10 GHz, Electric Field	(2, 12)
RE03	N	Y	N	N	N	N	N	N	N	N	N	N	10 kHz to 40 GHz, Spurious and Harmonics, Radiated Technique	(3)
(T) RE04	Y	Y	Y	N	Y	Y	N	N	N	N	N	N	0.02 to 50 kHz, Magnetic Field	(5)
RE05	N	N	N	N	N	N	N	Y	Y	Y	N	N	150 kHz to 1 GHz Vehicles and Engine-Driven Equipment	(10)
RE06	N	N	N	N	N	N	N	N	N	N	N	Y	Overhead Power Line Test	
RS01	Y	Y	Y	Y	N	N	N	N	N	N	N	N	0.03 to 30 kHz, Magnetic Field	(5)
RS02	Y	Y	Y	Y	N	N	N	N	N	N	N	N	Magnetic Induction Field	
RS03	Y	Y	Y	Y	N	N	N	N	N	N	N	N	14 kHz to 10 GHz, Electric Field	(2)
(T) RS04	Y	Y	Y	Y	N	N	N	N	N	N	N	N	14 kHz to 30 MHz	(2)

Y = Test shall be performed as described in MIL-STD-462 or the approved test plan.
N = Test does not have to be performed, unless required by the test plan.

ıes for Table II:

(1) The test methods in MIL-STD-462 are designated by a series of numbers as shown hereinafter:

C = Conducted
R = Radiated
E = Emission
S = Susceptibility
"--" = Numerical order of test from 01 to 99.
T = New or Modified Test Procedure Included for Trial use, or as required by the procuring activity.

(2) Unless otherwise indicated in the test procedure or approved test plan, radiated emission tests in the frequency range of 25 to 200 MHz shall be performed alternately on the vertical and horizontal electric field with the biconical antenna and radiated susceptibility tests in the frequency range of 20 to 200 MHz shall be performed alternately on the vertical and horizontal electric fields with the biconical antenna.

(3) RE03 shall be performed when the operating frequency of the test sample is greater than 1.24 GHz, when the average power of the test sample is greater than 5 kW, or when the test sample's antenna is an integral part of the transmitter and cannot be replaced by a suitable dummy load.

(4) Test method (CE05) may be submitted to the command or agency concerned for approval in the test plan, in lieu of CE01, CE02, CE03, or CE04 when the signal to be measured is generated by a single shot event or at repetition rates of less than 5 pps.

(5) These tests (RE01, (T) RE04 and RS01) shall be performed on equipment operating at frequencies up to 30 MHz. Equipment operating at higher frequencies are exempt from testing.

(6) For classes IIB, IIC, IIIA and IIIB perform the test over the frequency range of 150 kHz to 50 MHz. For class IIIB only, remove the 10 microfarad feed-through capacitor.

(7) Perform either CS04 or CS08, as approved in the test plan.

(8) Shall conform to F.C.C. Regulations, Part 15 or Part 18 as applicable. In addition, the applicable requirements of this standard shall be met, unless otherwise specified in the individual equipment specification.

(9) Class IIA shall be tested from 14 kHz to 20 kHz with this test procedure (CE01). However, when required by the individual equipment specification, the test shall be performed from 1 kHz to 20 kHz.

(10) For class IIIC items, this test is not required above 400 MHz.

(11) Electric hand tools (which fall under class IIB) shall be tested from 150 kHz to 30 MHz.

(12) Class IIB items, except electric hand tools, shall be tested from 150 kHz to 400 MHz. Electric hand tools shall be tested from 150 kHz to 30 MHz. Class IIC items shall be tested from 150 kHz to 1000 MHz.

(13) Class IIID items shall comply with the requirements of SAE J551.

4.2.1.1 Management Controls.-Specific organizational responsibilities, lines of authority and control, and the implementation plan, including milestones to be used by the contractor shall be included in the interference control plan. The section shall also include a definition of responsibility for associate contractor equipments, government furnished equipments and sub-contractor vendor items as required by 4.1.2 and 4.1.3.

4.2.1.2 Frequency Management.-Frequency management shall be employed and shall consist of minimizing emission spectrum and receiver bandwidths and controlling oscillator frequencies, pulse rise times, harmonics, sidebands and the duty cycle.

4.2.1.3 EMI Mechanical Design.-The materials and construction methods selected for design shall provide an inherent attenuation to electromagnetic emanations and susceptibilities which will enable the equipment to meet the requirements of this standard without compromising other mechanical requirements of the individual equipment specification. The control plan shall describe the material and construction used and criteria for this selection. Specific data to be included are as follows:

(a) Type of metals, casting, finishes and hardware employed in the design.
(b) Type of construction, such as compartmentizing, filter mounting and isolation of other parts, dimensions of access ports, windows and ventilation ports, type and characteristics of filtering used on openings including such items as ventilation ports, access hatches, windows, meter faces and control shafts, and type and attenuation characteristics of rf gaskets used on all internal and external mating surfaces.

4.2.1.4 Electrical/Electronic Wiring Design.-The control plan shall include a description of the proposed electrical/electronic wiring designs. Cables shall be separated and routed to minimize electromagnetic interference and susceptibility.

4.2.1.5 Electrical/Electronic Circuit Design.-This section shall fully describe the EMI suppression techniques which will be applied to all parts and circuitry whether capable of generating undesirable emanations or suspected of being susceptible to the fields and voltage levels specified in this standard. The specifically required design data shall include but not be limited to the following:

(a) Choice of parts and circuitry, the criteria for use of standard parts and circuitry, and bonding and grounding techniques.
(b) Justification of selected filter characteristics including type and attenuation, technical reasons for selecting types of filters (for example, absorptive vs. non-absorptive filters) and specific circuit applications.
(c) Part location and separation based on orientation of EM fields for reduction of emissions, susceptibility or both.
(d) Discussion indicating valid technical reasons for selection of pulse shape. The pulse shapes to be considered shall include, but are not limited to the following:

(1) Binomial
(2) Raised Cosine
(3) Triangular
(4) Rectangular

4.2.1.6 Analysis.-Prediction or analysis techniques employed to determine adequacy of contractor's conclusions shall be included. Specific aspects of the mechanical, electrical and electronic design to be included are as follows:

(a) Adequacy of mechanical construction, and an analysis of the shielding afforded by the proposed designs over the specified frequency range and energy level.
(b) Complete frequency matrix of all frequencies associated with receivers and transmitters, expected spurious responses of receivers at input signal levels and frequency range(s) specified in this standard, and expected spurious outputs of items such as transmitters, local oscillators and frequency synthesizers.
(c) Worst case analysis (Fourier) of multivibrators, switching (single and repetitive) and logic circuits, clock signals and strobe signals.

(d) Analysis of circuitry, subassemblies and total equipment, including cabling and loads for:

(1) The prediction of susceptibility to internally and externally generated fields and voltages, whether below or above the limits imposed by this standard.

(2) The prediction of emissions, whether below or above the limits imposed by this standard.

4.2.1.7 R&D Testing.-Discussions of proposed testing program during development construction stages is required. Listing of instrumentation facilities and responsible EMI/EMC design engineering personnel shall be included in the control plan.

4.3 EMI/EMC Test Plan.-The test plan shall detail the means of implementation and application of the test procedures to be performed to verify compliance with the applicable EMI/EMC requirements of this standard. Approval of the test plan shall precede the start of formal testing. The test plan shall include but need not be limited to the following:

(a) Nomenclature, serial numbers and general characteristics of test equipment (for example, transfer impedance of current probes and effective length of antennas).
(b) Methods and dates of last calibration of interference measuring equipment and calculations to show expected accuracy of each.
(c) Dummy loads, filters, dummy antennas, signal samplers, and similar items to be used and their description (for example, VSWR, isolation and loss) in the frequency range of interest. In addition, a tabular or graphical plot of the complex impedance at selected test frequencies of all reactive loads used shall be included.
(d) Readout and detector functions to be used in measuring equipment, where applicable.
(e) Nomenclature, description and modes of operation of the test sample.
(f) Control settings, monitored points and sequence of operation of test sample during the tests.
(g) Description and rf ambient profile of test site (open space or shielded enclosure).
(h) Detailed step-by-step test procedures and test setups, with maximum use of photographs, drawings and diagrams.
(i) Test frequencies based on the frequency matrix developed in the control plan, and modulations, and computations to indicate frequencies at which extraneous outputs, susceptibilities and intermodulation products may be expected.
(j) Expected overall accuracy of measurements.
(k) Personnel required, both designated Government representatives and the contractor.
(l) Considerations and regulations regarding the operation of test sample and measuring equipment in open areas (for example, FCC or FAA regulation).

4.4 Test Report Format

4.4.1 Format.-The format of the test report shall be specified in MIL-STD-831 with the modifications given hereinafter:

4.4.1.1 Cover Page.-A cover page is required.

4.4.1.2 Appendices.-A separate appendix shall be utilized for each test required by this standard. Each appendix shall include the applicable test procedure, data sheets, graphs, illustrations and photographs. The log sheets shall be included in a separate appendix which will be last. Definitions of specialized terms or word usage shall be included in another appendix.

4.4.2 Content.-The test report shall contain the factual data given hereinafter in accordance with the format requirements of this standard and MIL-STD-831. If technical support data required for the interference test report is published in other documents required by the contract or order, it may be included in the interference report by reference. The report shall include the data required hereinafter. However, if these data are contained in the approved test plan, the test plan shall be included as an appendix.

(a) Nomenclatures of interference measuring equipment.
(b) Serial numbers of interference measuring equipment.
(c) Date of last calibration of interference measuring equipment.
(d) Scanning speed used to drive interference measuring equipment.

(e) Descriptions of procedures used (methods of loading and triggering and operation and control settings for test sample).
(f) Measured line voltages to test sample.
(g) Frequencies and methods of selection of frequencies if different from test plan.
(h) Type of emission or susceptibility measured and its source.
(i) Measured level of emission or susceptibility at each frequency and accuracy of measured values.
(j) Applicable limit at each frequency.
(k) Graphs showing items (i) and (j).
(l) Photographs or diagrams of the test setup and test sample with identification.
(m) Sample calculations showing how equivalent meter reading was calculated.
(n) Graphs showing x-y recording of equivalent meter reading.
(o) Description and size of shielded enclosure.
(p) Ground plane used, if test is not performed in shielded enclosures.
(q) Description of open space area, if used.
(r) Ambient rf profile of test site and ambient levels with each detector function energized and at each test frequency.
(s) Methods and criteria for monitoring for degradation of performance.
(t) Explanation of special terms and abbreviations used in the report.
(u) Settings of test samples control functions during the tests.
(v) Ground plane d.c. bonding resistance.
(w) Identification of suppression devices using schematics, performance data and drawings, except where these data are in other documents required of the contractor.
(x) Transfer impedance of current probes.

4.4.3 Interservice Data Exchange Program.–Reports submitted for the Interservice Data Exchange Program (IDEP) may conform to any applicable special requirement.

5. MEASURING EQUIPMENT.–This section describes the test equipment used in the test methods contained in MIL-STD-462. Apparatus used primarily for a particular test will be described under that test.

5.1 Electromagnetic Interference Instruments.–

5.1.1 Table III will list measuring instruments accepted for use with this standard. The approval criteria will be forthcoming in a future revision.

5.1.2 In the interim, those EMI instruments which are capable of measuring the parameters of this standard may be used, when approved by the procuring activity for the specific procurement in question.

5.2 Test Antennas.–The following antennas shall be used for performing radiated emission and susceptibility measurements. Antenna factors shall be measured in accordance with SAE ARP-958.

5.2.1 30 Hz to 30 kHz

(a) For magnetic field emission measurements, a 5-1/4-inch diameter loop having 36 turns of 7-41 Litz wire (AT-205/URM-6 or equal) shall be used.
(b) For radiating magnetic fields during susceptibility measurements, the loop shown on Figure 1 shall be used.

5.2.2 14 kHz to 25 MHz

(a) For emission measurements, a 41-inch rod antenna (electrical length = 0.5 meter) and an appropriate matching network, as required, with a square counterpoise whose sides measure at least 60 cm shall be used.
(b) For radiating fields up to 1 Volt/meter, the 41-inch rod antenna and appropriate matching networks may be used. When fields greater than 1 Volt/meter are required, the antenna and general procedure shall be described in the test plan.

5.2.3 20 to 200 MHz

(a) Emission measurements in the frequency range of 25 to 200 MHz shall be performed using the biconical antenna constructed in accordance with Drawing ES-F-201286. The antenna factors for the biconical antenna are shown on Figure 2.

Table III–Approved Measuring Equipment

(The approval criteria will be forthcoming in a future revision).

(b) Fields for susceptibility measurements shall be radiated from 20 to 200 MHz using the biconical antenna referenced in 5.2.3.a.

5.2.4 200 to 1000 MHz.–Emission and susceptibility measurements (except for harmonic and spurious outputs in the open field) shall be performed using the conical logarithmic spiral antenna constructed in accordance with Drawing 62J4040. The antenna factors are shown on Figure 3.

5.2.5 One to 10 GHz.–Emission and susceptibility measurements (except for harmonics and spurious outputs in the open field) shall be performed using the conical logarithmic spiral antenna constructed in accordance with Drawing 62J4041. The antenna factor is shown on Figure 4.

5.2.6 200 MHz to 40 GHz.–Harmonic and spurious output measurements shall be performed with the following antennas:

(a) 200 to 1000 MHz – Cavity-back spiral antenna, AEL Model ASN-1232 or equal.
(b) 1 to 12 GHz –
  (1) Cavity-backed spiral antenna, AEL Model ASN-116 or equal
  (2) AEL Model ASN-1242 or equal (cavity-backed spiral antenna mounted in a 3-foot dish).
(c) 12 to 40 GHz – (Drawing ES-DL-201090)
  (1) 12 to 18 GHz – Horn antenna feeding an 18 inch diameter dish.
  (2) 18 to 26 GHz – Horn antenna feeding a 12-inch diameter dish.
  (3) 26 to 40 GHz – Horn antenna feeding a 12-inch diameter dish.

5.2.6.1 Characteristics and construction data for the above antennas are shown in Figures 5 through 11 and table IV, and Drawing ES-DL-201090, respectively.

5.3 Current Probes.–Any current probe capable of measuring to the limits specified herein may be used. The transfer impedance of the probe shall be included in the test plan and the test report.

5.4 Impulse Generators.–Impulse generators used shall conform to following requirements:

(a) Calibrated in terms of output to a 50-ohm load.
(b) Spectrum shall be flat ±2 dB over its frequency range.
(c) Amplitude accuracy shall be ±2 dB.

5.5 Signal Sources.–Any commercially available signal source, power amplifier and general purpose amplifier capable of supplying the necessary modulated and unmodulated power required to develop the susceptibility levels specified herein may be used, provided the following requirements are met:

(a) Frequency Accuracy.–Frequency accuracy shall be within ±2 percent.
(b) Harmonic Content.–Harmonics and spurious outputs shall be not more than -30 dB as related to the fundamental power.

5.5.1 Susceptibility Signals.–Susceptibility signals shall have characteristics (for example, amplitude, type, degree, and frequency and waveform of modulation) which will have the maximum effect on the test sample.

5.6 Ten Microfarad Capacitors.–The 10 μf capacitors shall conform to the requirements of SAE-ARP-936.

5.7 Calibration

5.7.1 Measuring instruments and accessories used in determining compliance with the requirements of this standard shall be calibrated under an approved program in accordance with MIL-C-45662.

5.7.2 Calibration of measurement equipment and accessories, impulse generators, and other equipment shall be verified (spot checked) at any time upon request of witnessing officials or authorized representatives of the procuring activity.

Table IV–Calculated Beamwidth and Gain
Cavity Backed Spiral Antenna Mounted in a 3 Foot Dish (1 to 12 GHz)

Frequency GHZ	Calculated Beamwidth (degrees)	Gain (dB)
1.0	23.0	11.0
1.5	15.2	14.5
2.0	11.4	17.0
2.5	9.2	19.0
3.0	7.6	20.5
3.5	6.5	22.0
4.0	5.8	23.0
4.5	5.0	24.0
5.0	4.6	25.0
5.5	4.2	26.0
6.0	3.8	26.5
6.5	3.5	27.2
7.0	3.3	28.0
7.5	3.0	28.5
8.0	2.8	29.0
8.5	2.7	29.8
9.0	2.6	30.0
9.5	2.4	30.5
10.0	2.3	31.0
10.5	2.2	31.5
11.0	2.1	32.0
11.5	2.0	32.5
12.0	2.0	33.0

5.8 Accuracy of Measurements.–All measurements made in accordance with this standard shall have the following accuracies, unless otherwise specified in a particular test:

5.8.1 Frequency accuracy shall be ± 2 percent.

5.8.2 Amplitude accuracy shall be ± 2 dB.

6. LIMITS.–This section contains the limits applicable to the tests required by Section 4 of this standard. An equipment emitting both broadband and narrowband signals at the same frequency shall meet both requirements.

6.1 Limits for CE01, CE02 and CE05.–Electromagnetic emissions in the frequency range of 30 Hz to 20 kHz shall not appear on power leads, control leads, signal leads and interconnecting cables between parts, sources and loads of an equipment in excess of the values shown on Figures 12 and 13. Intentional transmissions of electrical energy by conduction on their intended leads, at their specified power levels, and within their necessary information bandwidths are exempt from the requirements of this standard.

6.2 Limits for CE03, CE04 and CE05.-Electromagnetic emissions in the frequency range of 20 kHz to 50 MHz shall not appear on power leads, control leads, signal leads and interconnecting cables between parts, sources and loads of an equipment, except hand tools, in excess of the values shown on Figures 14 and 15. Intentional transmissions of electrical energy by conduction on their intended leads, at their specified power levels, and within their necessary information bandwidths are exempt from the requirements of this standard. The limit for electric hand tools shall be as specifically indicated on Figure 14 (for Electric Hand Tools).

6.3 Limits for CE06.-No conducted emissions in the frequency range under test shall appear at the test sample's antenna terminals in excess of the following:

6.3.1 Receivers.-

(a) 34 dBμV into a matched load for narrowband emissions.
(b) 40 dBμV/MHz for broadband emissions.

6.3.2 Transmitters (Key-up mode.).-

(a) 34 dBμV for narrowband emissions.
(b) 40 dBμV/Mhz for broadband emissions.

6.3.3 Harmonics and all other spurious emissions shall have absolute peak powers not exceeding those shown on Figure 16. This limit does not apply within either the test sample's designed emission bandwidth or ±5 percent of f_o, as defined on the test plan.

6.4 Limit for CS01.-The performance characteristics of class I equipment shall not be degraded beyond the tolerances given in the individual equipment specification or approved test plan, in the frequency range of 30 Hz to 50 kHz, when subjected to electromagnetic energy injected on its power leads equal to or less than the values shown on Figure 17.

6.4.1 The requirements for this test are also met if the test voltages cannot be generated by 50-watts dissipated into a 0.5 ohm load.

6.5 Limit for CS02.-The performance characteristics of class I equipment shall not be degraded beyond the tolerances given in the individual equipment specification or approved test plan, in the frequency range of 50 kHz to 400 MHz, when subjected to 1 volt from a 50-ohm source applied to the equipment power input terminals (excluding power cable).

6.5.1 When a one watt source of 50-ohm impedance cannot develop the required voltage at the test sample power input terminals (excluding power cable) and the test sample is not susceptible to the output of this signal source, then the equipment may be considered non-susceptible.

6.6 Limits for CS03.-Intermodulation products from two signals shall not be present in the frequency range of 30 Hz to 10 GHz when:

(a) Signal generator one is set 66 dB above the level obtained to produce the standard reference output as specified in method CS03 of MIL-STD-462.
(b) Signal generator two is set 66 dB above the level obtained to produce the standard reference output as specified in method CS03 of MIL-STD-462.

6.7 Limits for CS04 and CS08.-The test sample shall not exhibit any undesired responses when subjected to the test signal shown on Figure 18.

6.8 Limit for CS05.-The test sample shall not exhibit, due to cross-modulation, any malfunction, degradation of performance or deviation from specified indication beyond the tolerances given in the individual equipment specification or approved test plan when subjected to the following level:

(a) Signal generator 2: 66 dB above the level required to obtain the standard reference output.

6.9 Limit for CS06.-The test sample shall not exhibit any malfunction, degradation of performance or deviation from specified indication beyond the tolerances given in the test sample's individual equipment

specification or approved test plan when the spike shown on Figure 19 is applied to the a.c. or d.c. power input lines of the test sample.

6.10 Limits for (T) CS07.-

6.10.1 Test 1.-Squelch circuits shall not open when the output of a 50-ohm impedance impulse generator, set at 90 dBμV/MHz, is applied and matched to the input terminals of the test sample.

6.10.2 Test 2.-The squelch circuit shall not open when two signals are applied at the input of the test sample. One signal shall be an unmodulated rf signal at f_o whose amplitude is 2/3 of the rf voltage used to adjust the squelch threshold. The second signal is an impulse signal of 50 dBμV/MHz.

6.11 Limit for RE01.-Magnetic field emissions in the frequency range of 30 Hz to 30 kHz shall not be generated and radiated in excess of the values shown in the "Acceptable Radiation" portion as shown on Figure 20.

6.12 Limits for RE02.-

6.12.1 Narrowband E-field emissions in the frequency range of 14 kHz to 10 GHz shall not be generated and radiated in excess of the values shown in Figure 21.

6.12.2 Broadband E-field emissions except from electric hand tools in the required frequency range shall not be generated and radiated in excess of the values shown on Figure 22. The limit for electric hand tools shall be as specifically indicated on Figure 22.

6.12.3 In the frequency range of 25 to 200 MHz, the limit shall be met for both horizontally and vertically polarized waves, except for electric hand tools. For these tools the limits apply only to vertically polarized waves.

6.13 Limit for RE03.-Harmonics and all other spurious emissions requiring measurement by the radiated technique shall have absolute peak power not exceeding those shown on Figure 16. The limit does not apply within either the test sample's designed emission bandwidth or ±5 percent of f_o, as defined in the test plan.

6.14 Limit for (T) RE04.-Magnetic field emissions in the frequency range of 20 Hz to 50 kHz shall not be generated and radiated in excess of the values shown on Figure 23.

6.15 Limit for RE05.-Broadband emissions in the frequency range of 0.15 to 1000 MHz shall not be generated and radiated in excess of the values shown on Figure 22 for classes IIIA and IIIB items. The limit for class IIIC items in the applicable frequency range of 0.15 to 400 MHz shall be relaxed by 20 dB.

6.16 Limit for RE06.-Radiated electromagnetic emissions from overhead power lines shall not exceed the values shown on Figure 24 for the applicable weather condition.

6.17 Limit for RS01.-The test sample shall not exhibit any malfunction, degradation of performance or deviation from specified indications beyond the tolerances specified in the individual equipment specification, in the frequency range of 30 Hz to 30 kHz, when subjected to the magnetic fields shown in the "Acceptable Susceptibility" portion of Figure 20.

6.18 Limit for RS02 and (T) RS04.-The test sample shall not exhibit any malfunction, degradation of performance, or deviation from specified indication beyond tolerances given in the individual equipment specification or approved test plan when subjected to the following fields:

(a) Power Frequency Test.-20 Amperes applied to the test wire at the power frequency(ies).
(b) Spike Test.-The same spike shape shown in Figure 19 where E = 100 volts across 5 ohms applied to the test wire.

6.19 Limit for RS03.-No malfunction, degradation of performance or deviation from specified indication beyond tolerances given in the individual equipment specification or approved test plan shall occur in the frequency range from 14 kHz to 10 GHz when the test sample is subjected to a radiated field: 1 Volt/meter.

7. NOTES

7.1 International Standardization Agreements.-

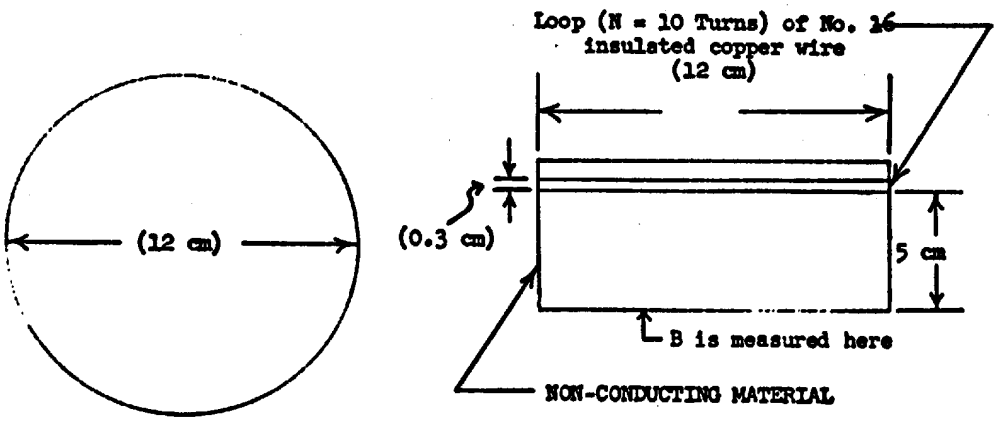
Certain provisions of this standard are subject to international standardization agreements STANAG 3456 and STANAG 3516. When amendment, revision or cancellation of this standard is proposed which will affect or violate the international agreement concerned, the preparing activity will take appropriate reconciliation action through international standardization channels, including departmental offices, if required.

Custodians:
Army - EL
Navy - SH
Air Force - 11

Review Activities:
Army - EL, MI, AV
Navy - SH, OS, AS
Air Force - 11, 13, 14, 15, 17, 19, 67, 68, 69, 70, 71, 79, 80, 82, 83, 84

User Activities:
Army - AT, ME, WC, GL, CE, MD
Navy - MC

Preparing Activity
Navy - SH
(Project MISC-0350)



NOTE 1: $B = 5 \times 10^{-5} \frac{\text{Tesla}}{\text{Amp}}$ at 5 cm from wire turns.

NOTE 2: LOOP SELF RESONANT FREQUENCY SHALL BE GREATER THAN 100 kHz.

Figure 1 - Loop used for radiating magnetic fields.

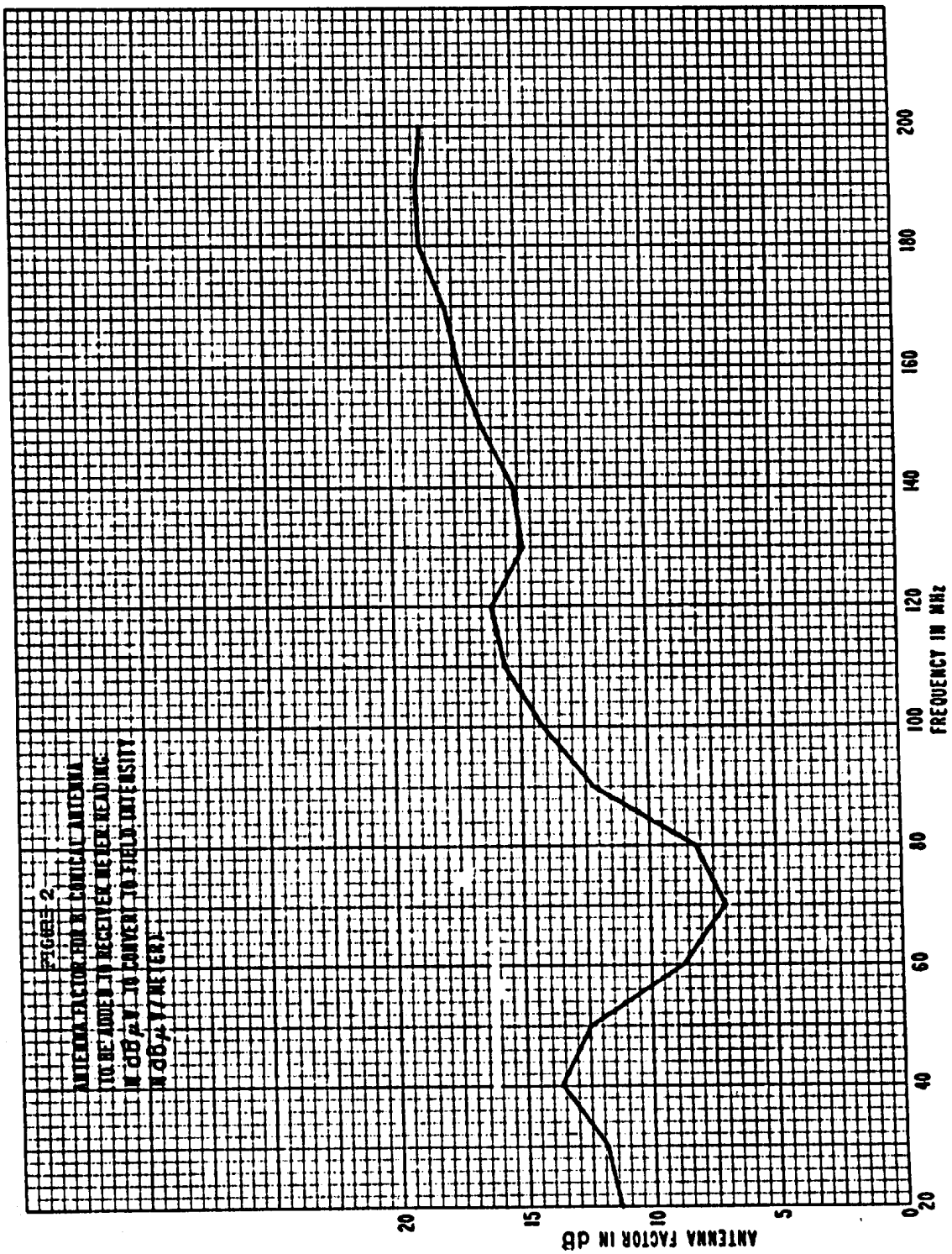


FIGURE 2
ANTENNA FACTOR FOR A CONICAL ANTENNA
TO BE ADDED TO RECEIVER METER READING
IN dB μV TO CONVERT TO FIELD INTENSITY
IN dB μV/METER
ANTENNA FACTOR IN dB
0
5
10
15
20
20
40
60
80
100
120
140
160
180
200
FREQUENCY IN MHz

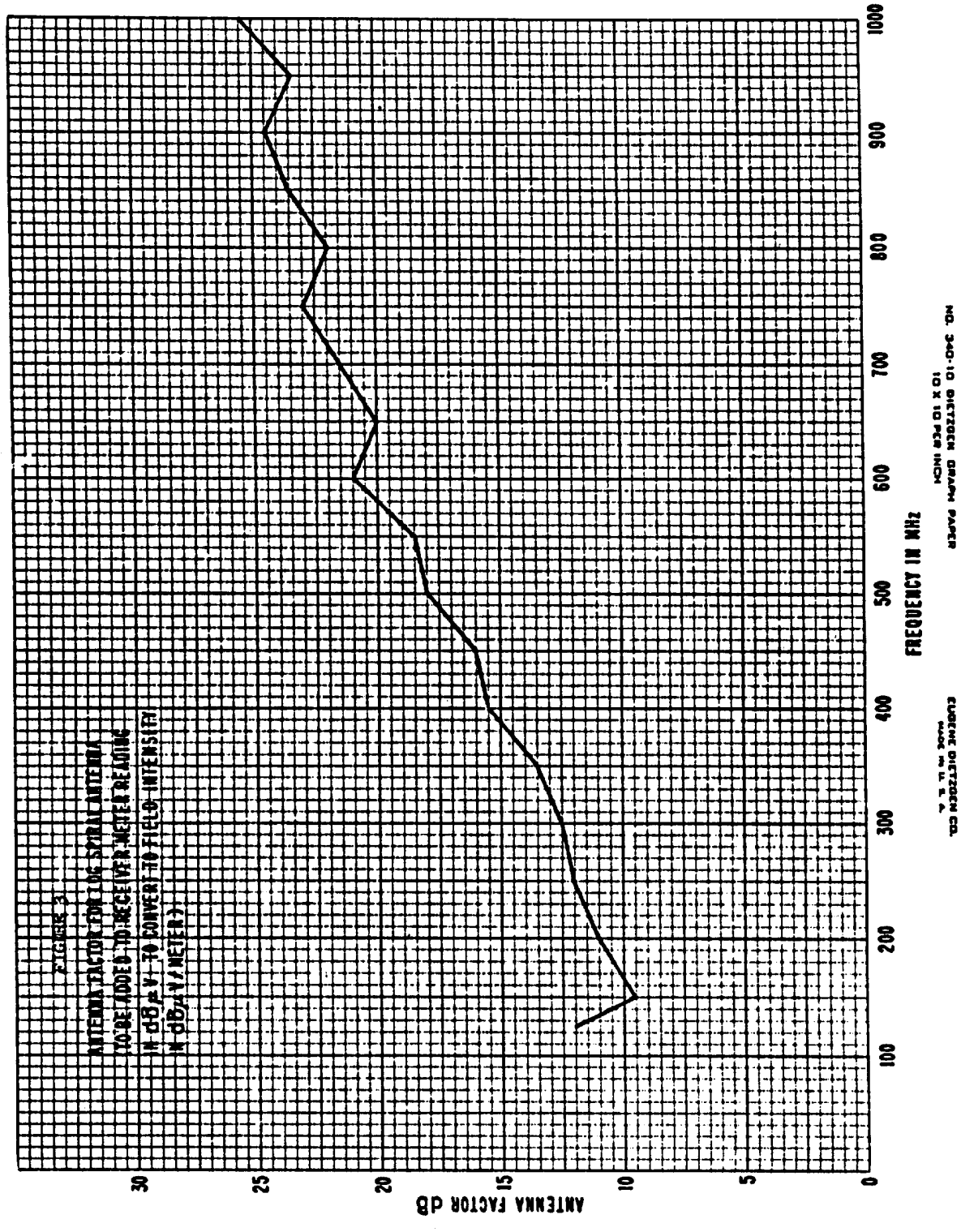


FIGURE 3
ANTENNA FACTOR FOR LOG SPIRAL ANTENNA
TO BE ADDED TO RECEIVER METER READING
IN dBμV TO CONVERT TO FIELD INTENSITY
IN dBμV/METER)
ANTENNA FACTOR dB
30
25
20
15
10
5
0
100
200
300
400
500
600
700
800
900
1000
FREQUENCY IN MHz
NO. 340-10 DIETZGEN GRAPH PAPER
10 X 10 TO THE INCH
EUGENE DIETZGEN CO.
MADE IN U. S. A.

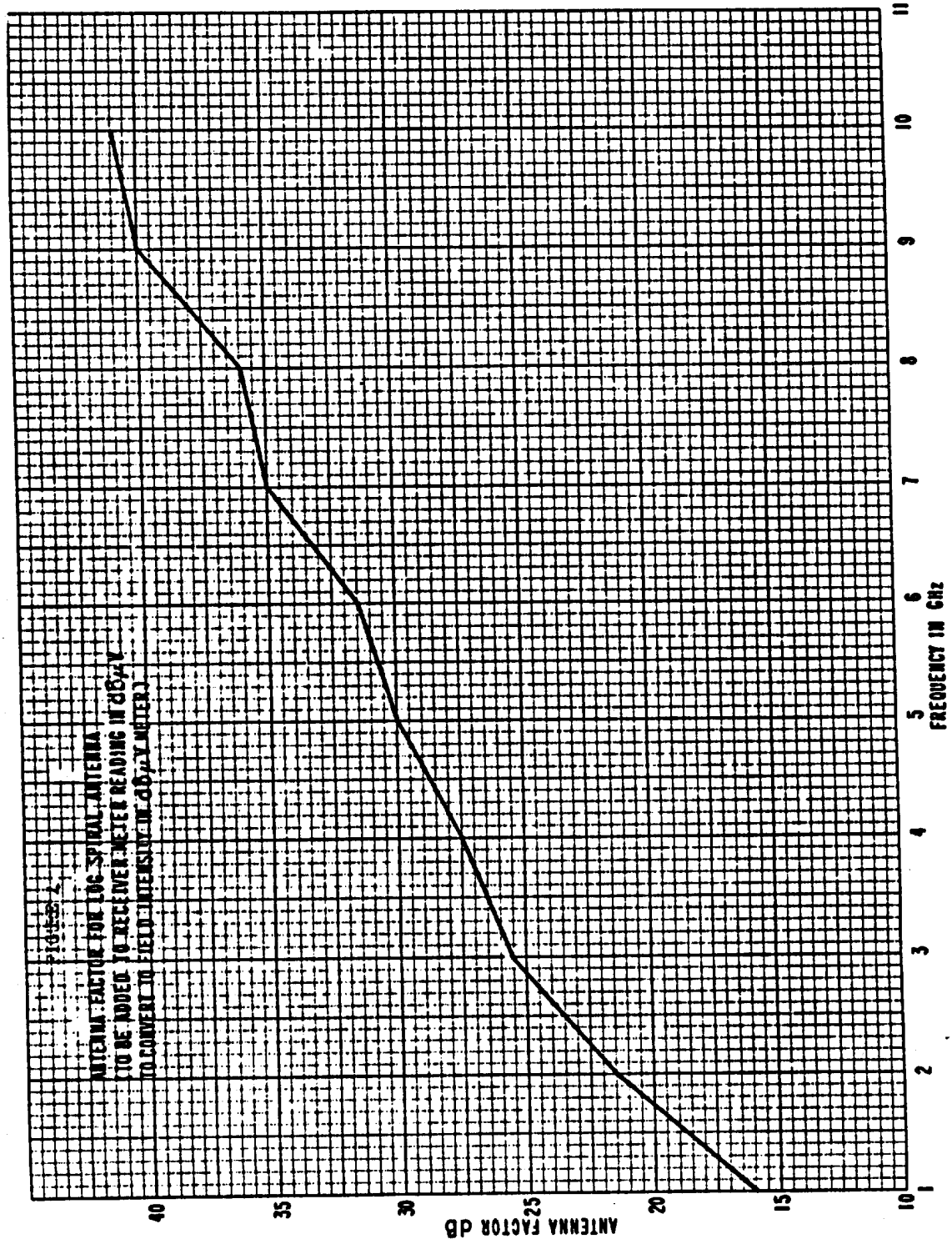


FIGURE 4.
ANTENNA FACTOR FOR LOG SPIRAL ANTENNA
(TO BE ADDED TO RECEIVER METER READING IN dBμV
TO CONVERT TO FIELD INTENSITY IN dBμV/METER)

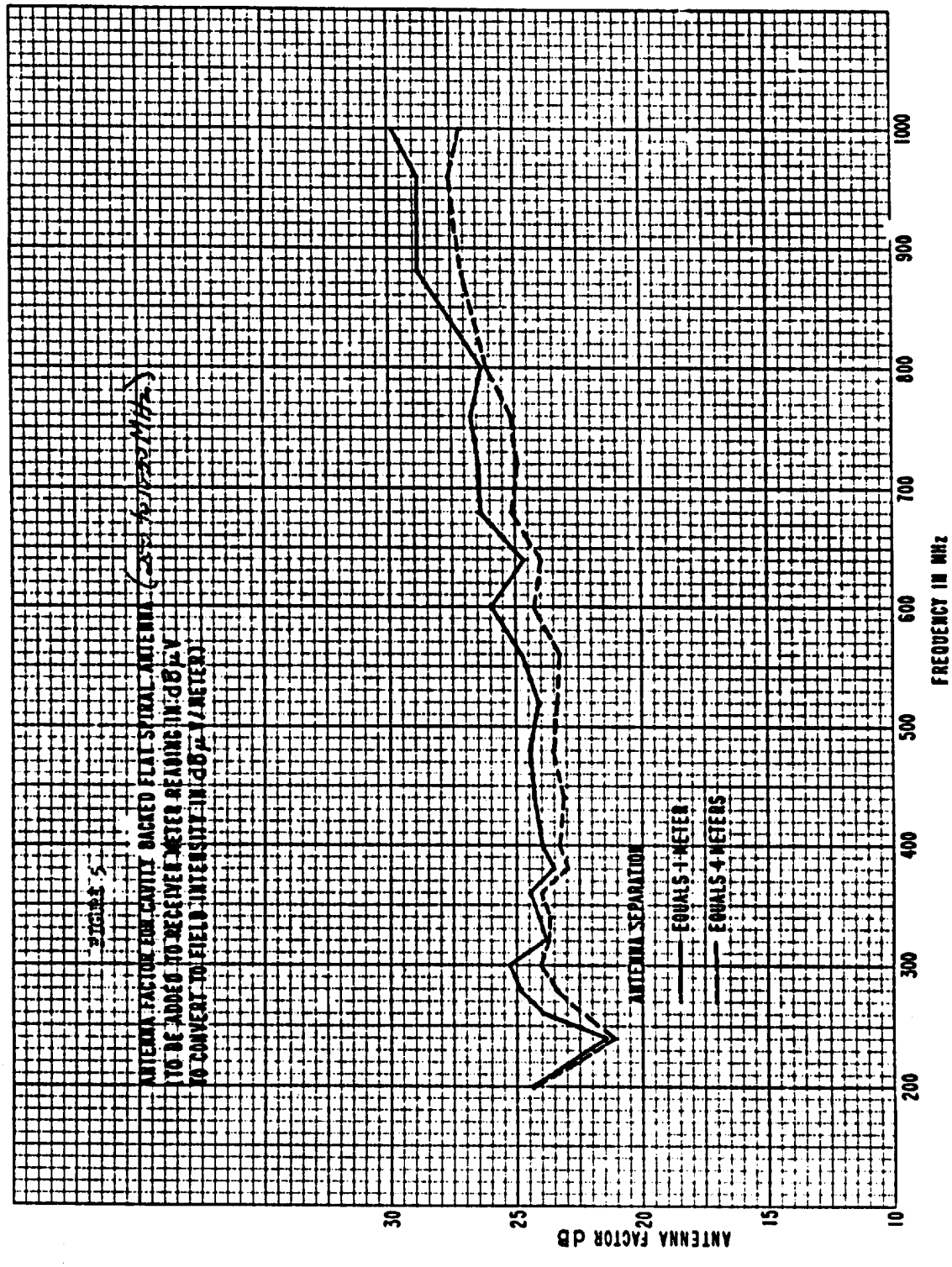

ANTENNA FACTOR FOR CAVITY BACKED FLAT SPIRAL ANTENNA (25 to 1000 MHz)
(TO BE ADDED TO RECEIVER METER READING IN dBμV
TO CONVERT TO FIELD INTENSITY IN dBμV/METER)
ANTENNA SEPARATION
EQUALS 1 METER
EQUALS 4 METERS
ANTENNA FACTOR dB
30
25
20
15
10
200
300
400
500
600
700
800
900
1000
FREQUENCY IN MHz

FIGURE 5

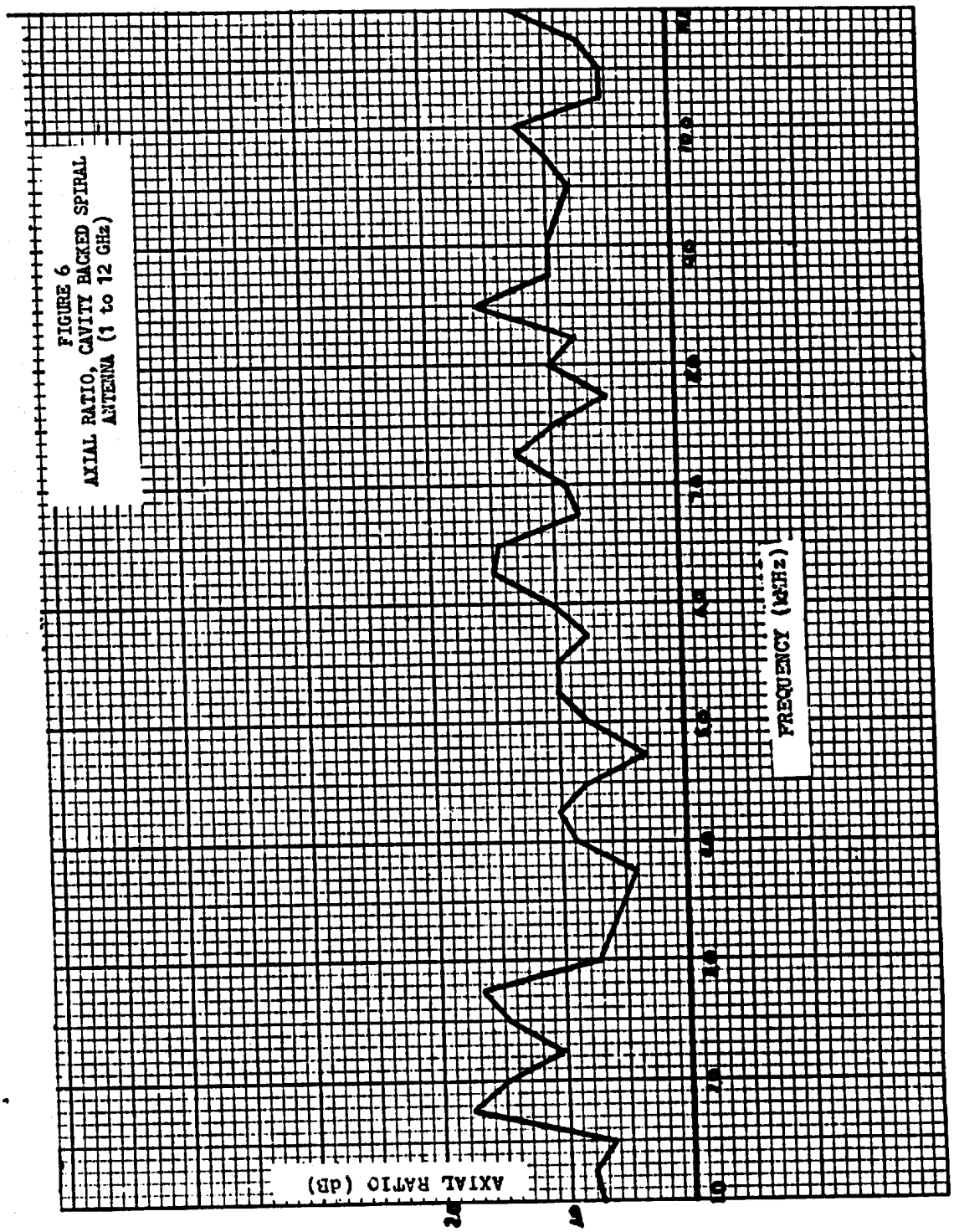


FIGURE 6
AXIAL RATIO, CAVITY BACKED SPIRAL ANTENNA (1 to 12 GHz)

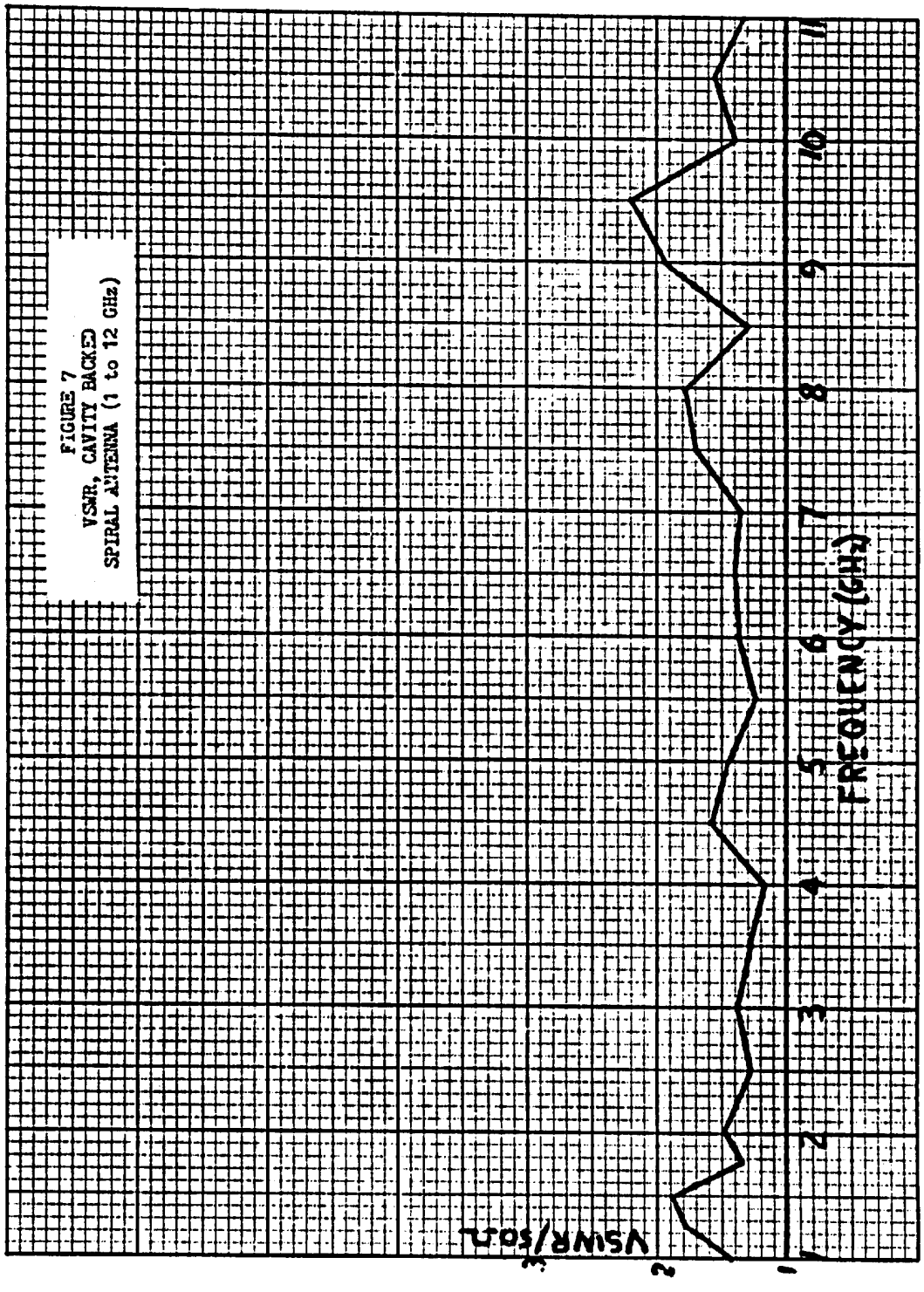


FIGURE 7
VSWR, CAVITY BACKED
SPIRAL ANTENNA (1 to 12 GHz)

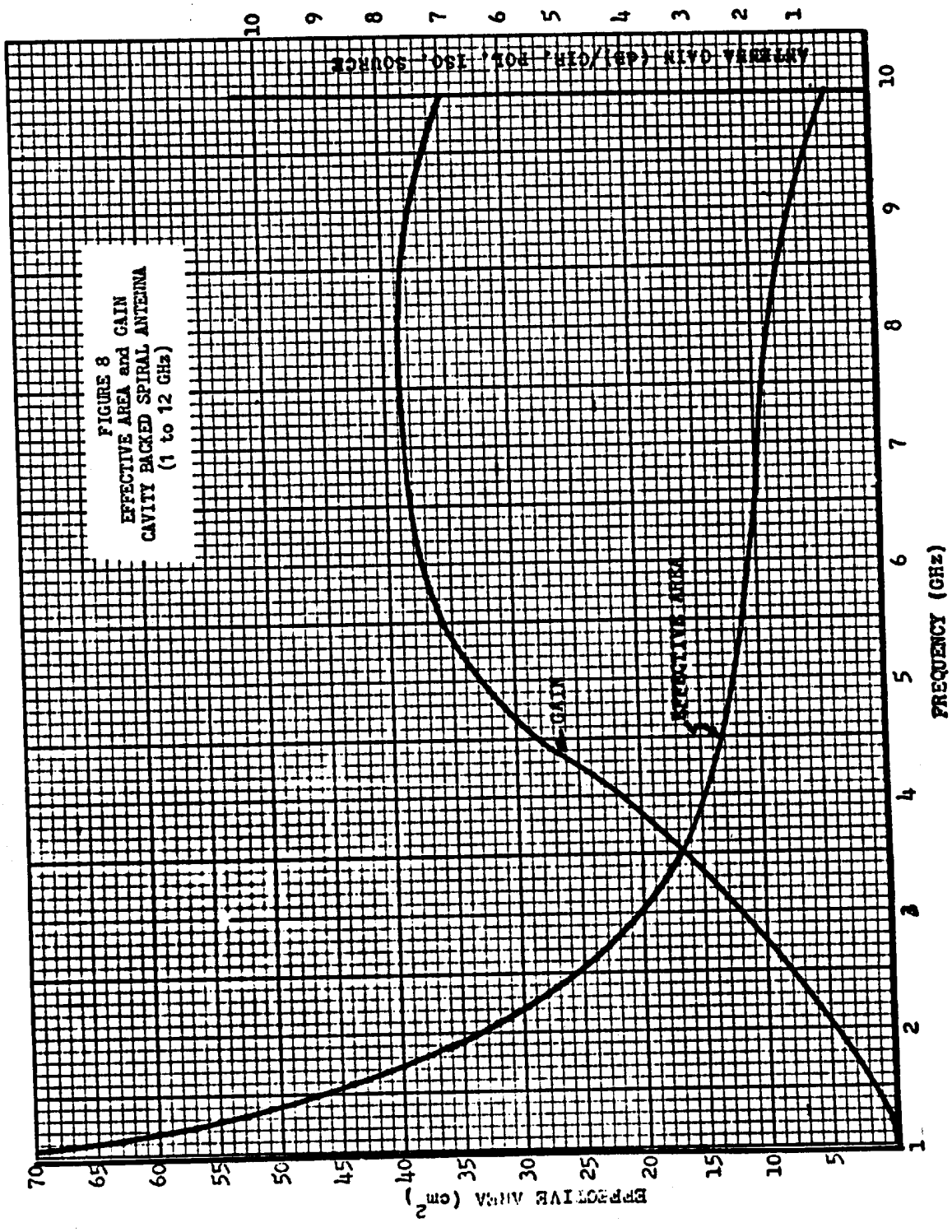


FIGURE 8
EFFECTIVE AREA and GAIN
CAVITY BACKED SPIRAL ANTENNA
(1 to 12 GHz)

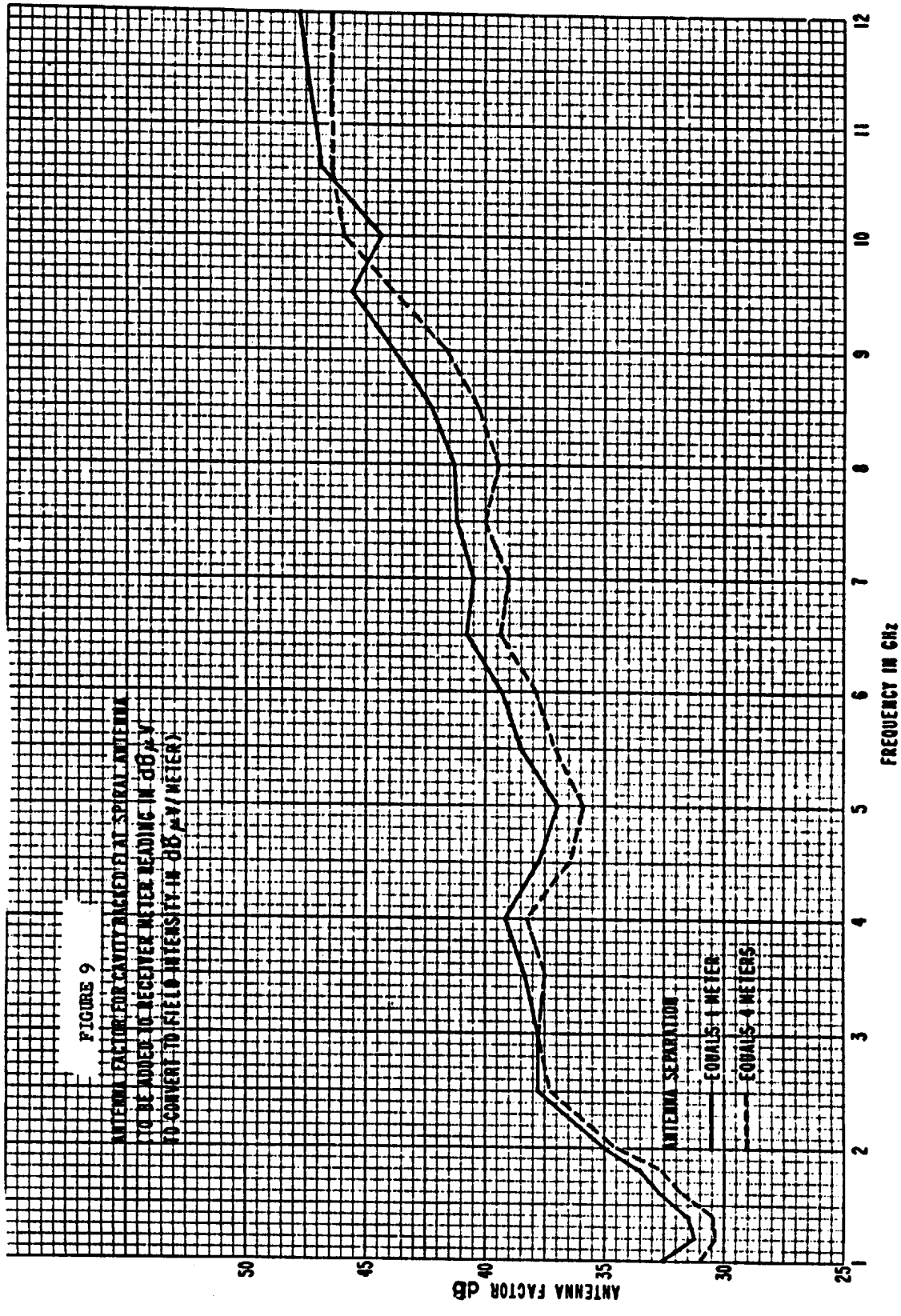


FIGURE 9
ANTENNA FACTOR FOR CAVITY BACKED FLAT SPIRAL ANTENNA
(TO BE ADDED TO RECEIVER METER READING IN dBμV
TO CONVERT TO FIELD INTENSITY IN dBμV/METER)

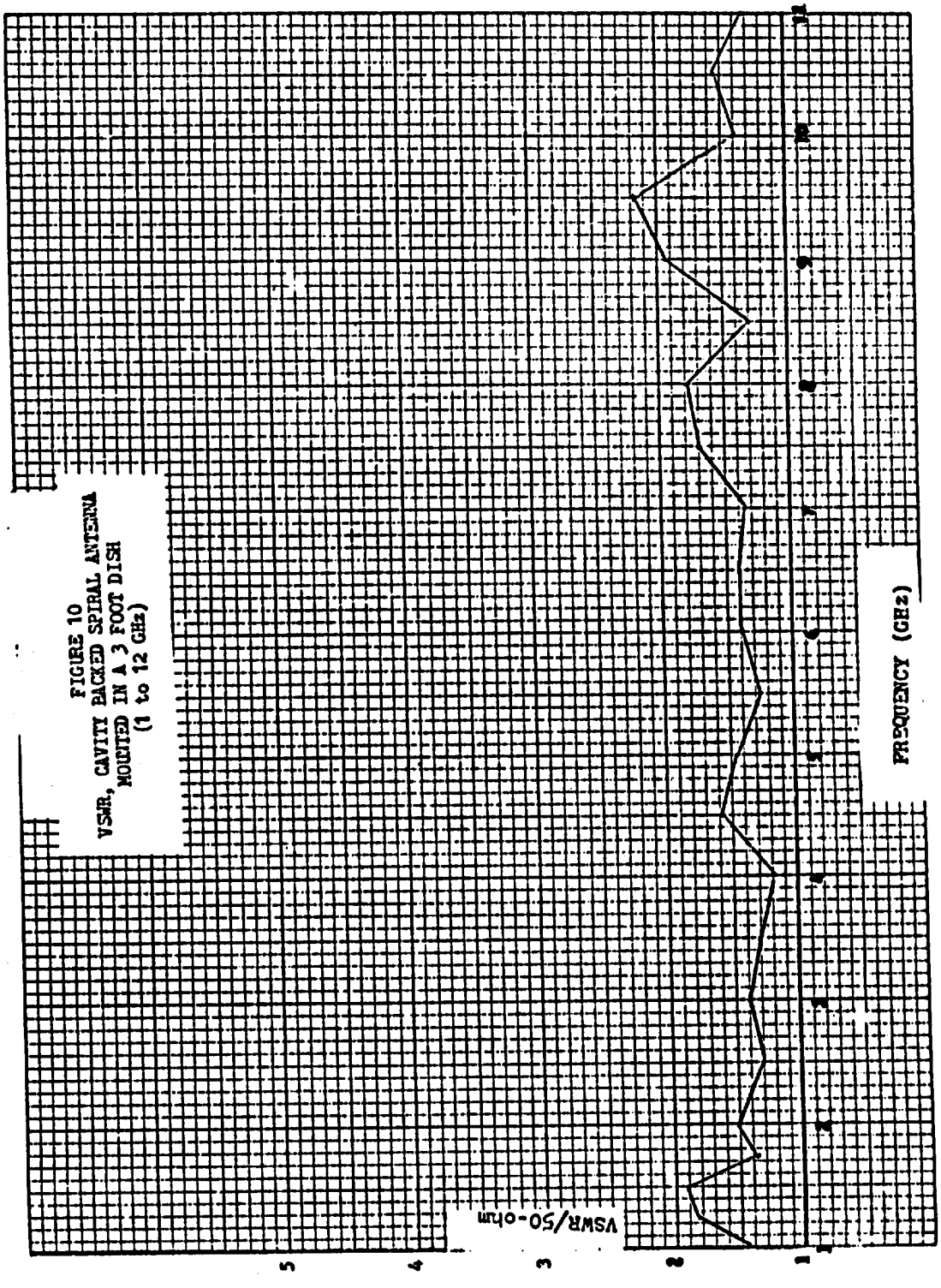


FIGURE 10
VSWR, CAVITY BACKED SPIRAL ANTENNA
MOUNTED IN A 3 FOOT DISH
(1 to 12 GHz)

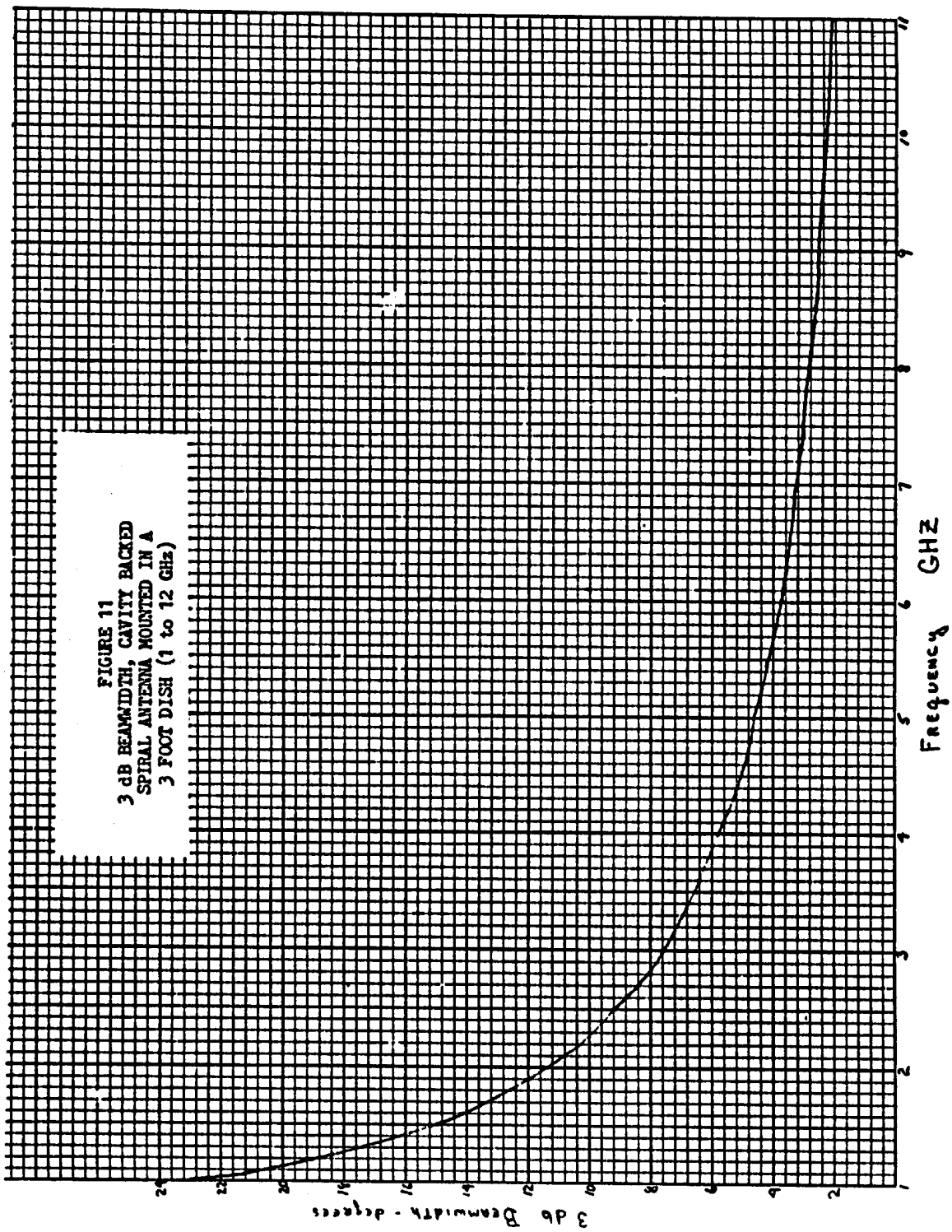


FIGURE 11
3 dB BEAMWIDTH, CAVITY BACKED
SPIRAL ANTENNA MOUNTED IN A
3 FOOT DISH (1 to 12 GHz)

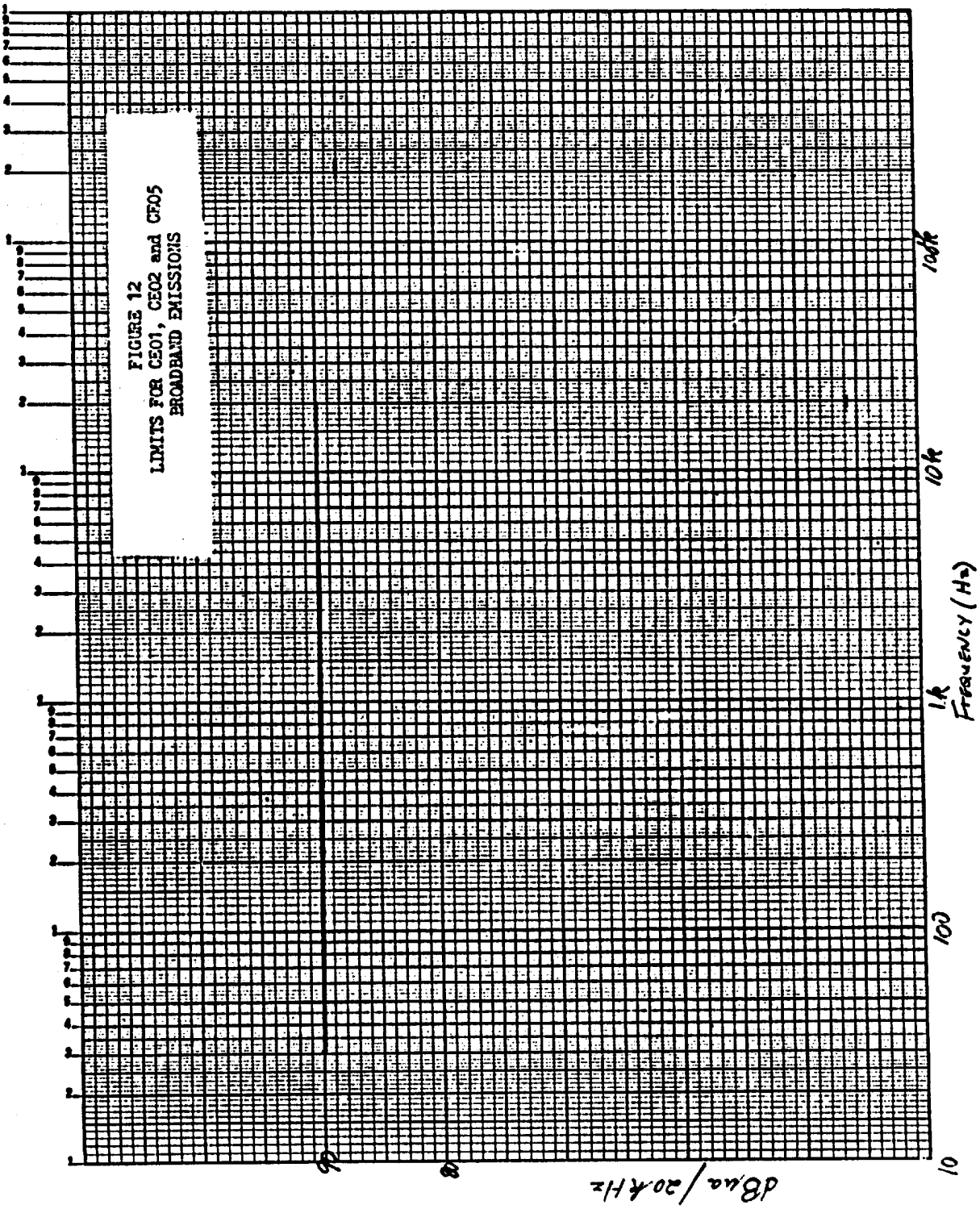


FIGURE 12
LIMITS FOR CE01, CE02 and CF05
BROADBAND EMISSIONS

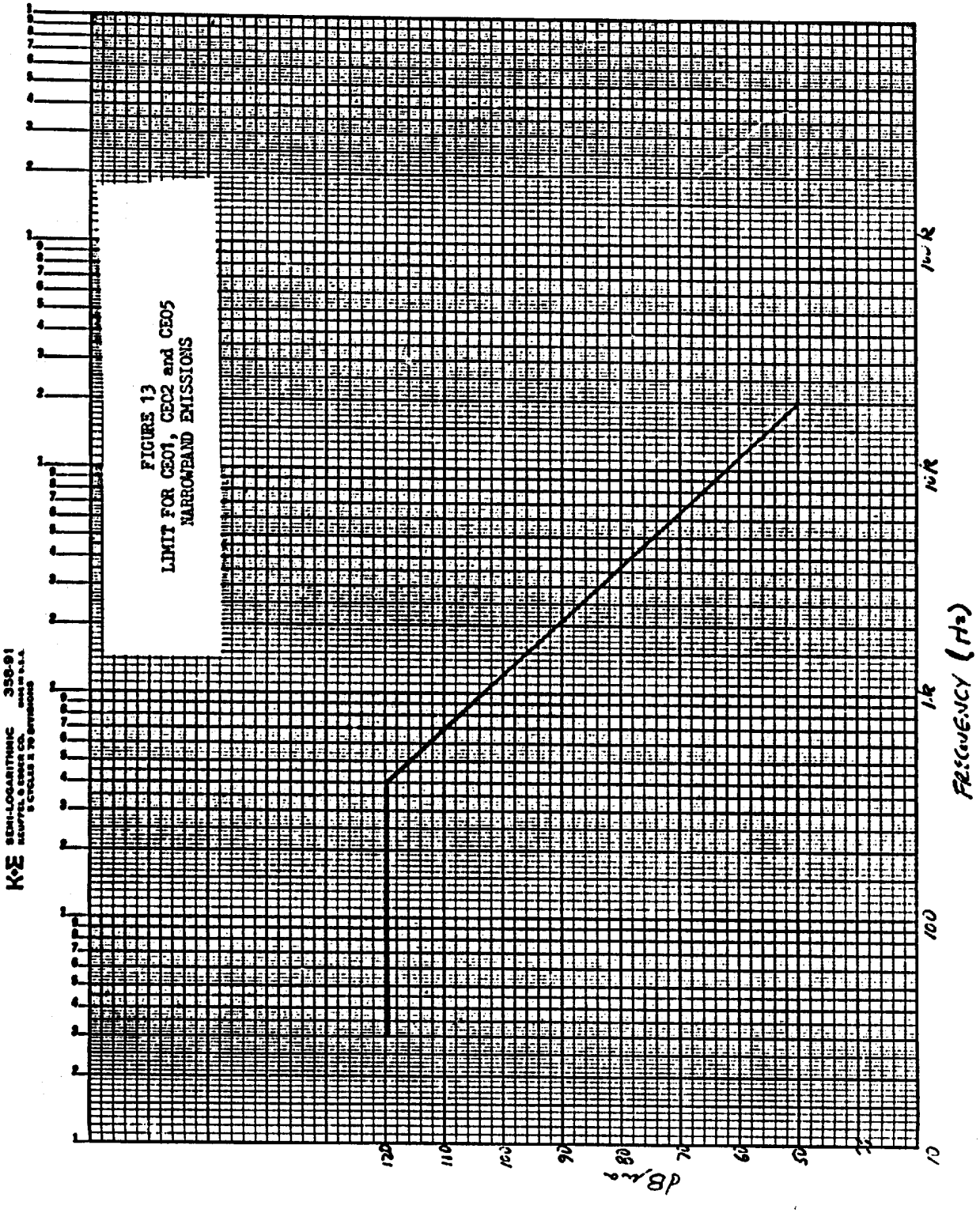


FIGURE 13
LIMIT FOR CE01, CE02 and CE05
NARROWBAND EMISSIONS

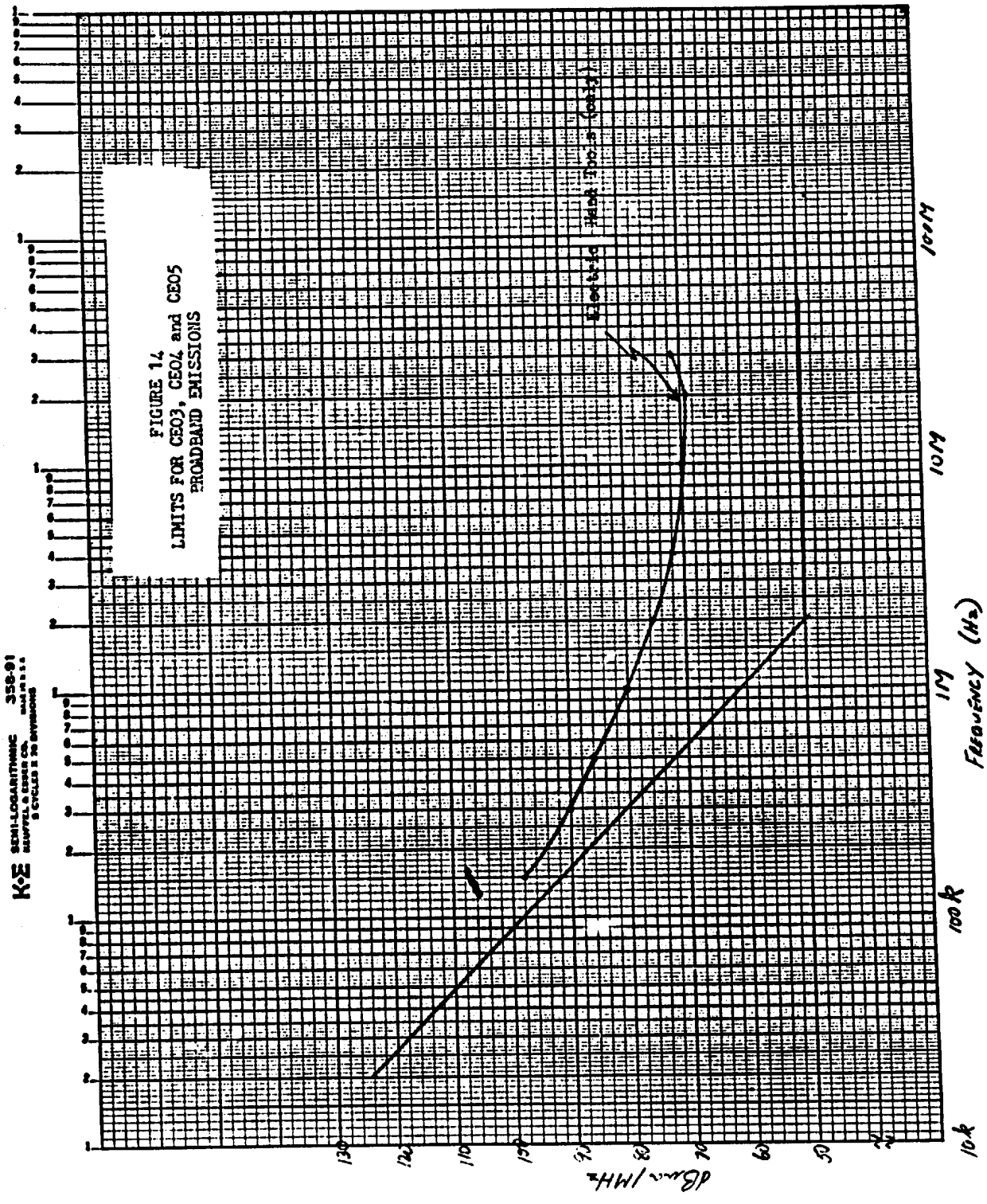


FIGURE 14
LIMITS FOR CE03, CE04 and CE05
BROADBAND EMISSIONS

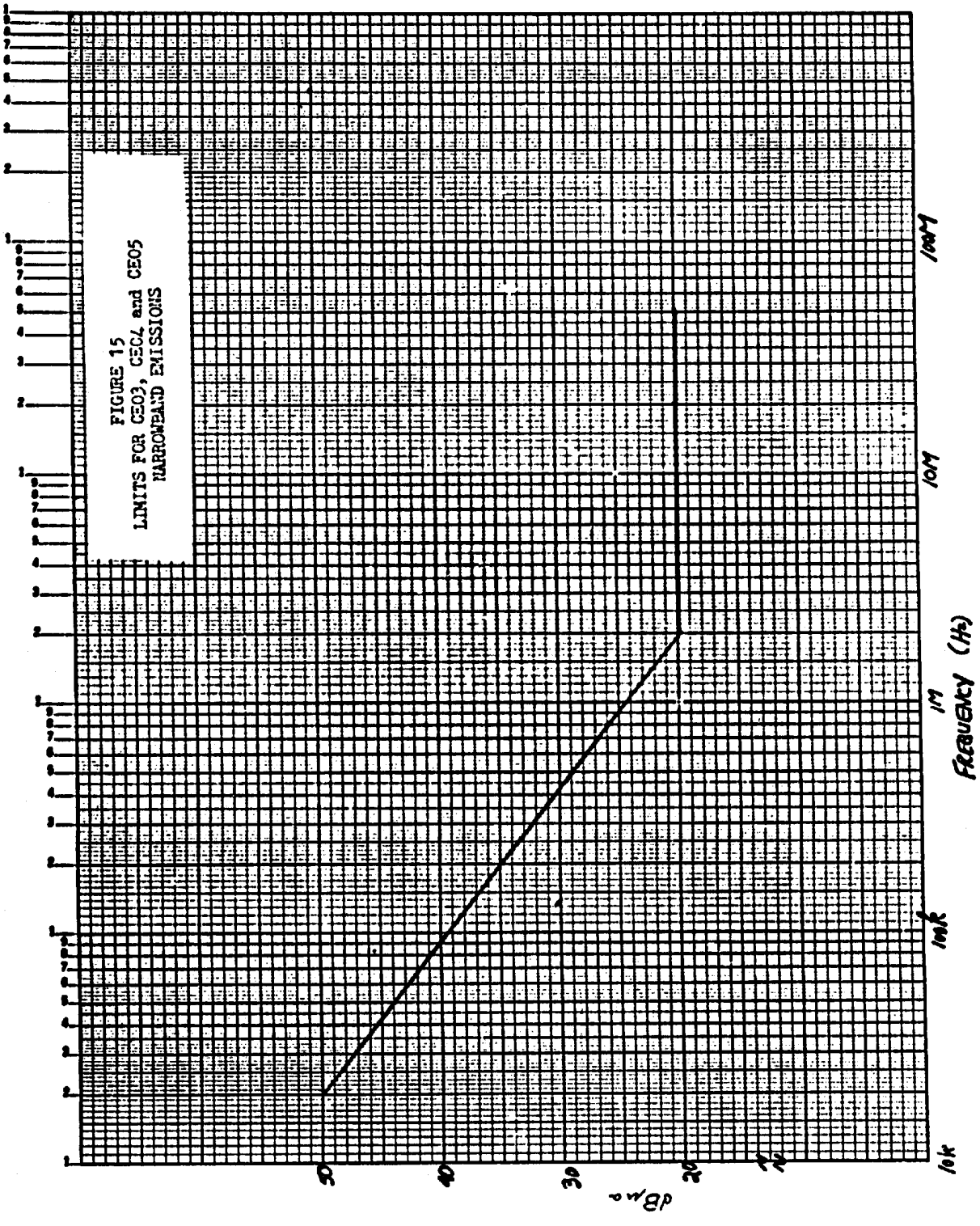


FIGURE 15
LIMITS FOR CE03, CE04 and CE05
NARROWBAND EMISSIONS

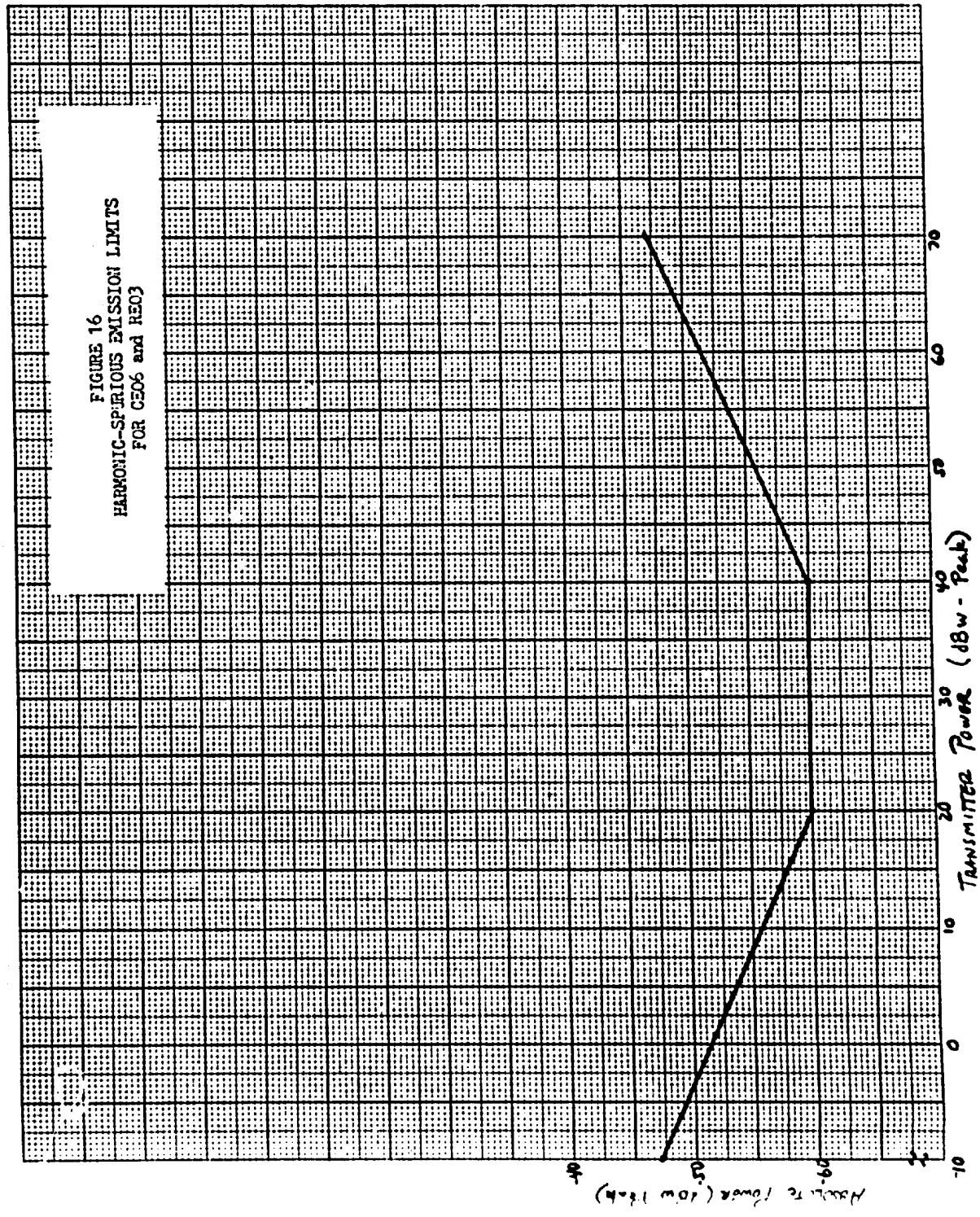


FIGURE 16
HARMONIC-SPURIOUS EMISSION LIMITS
FOR CE06 and RE03

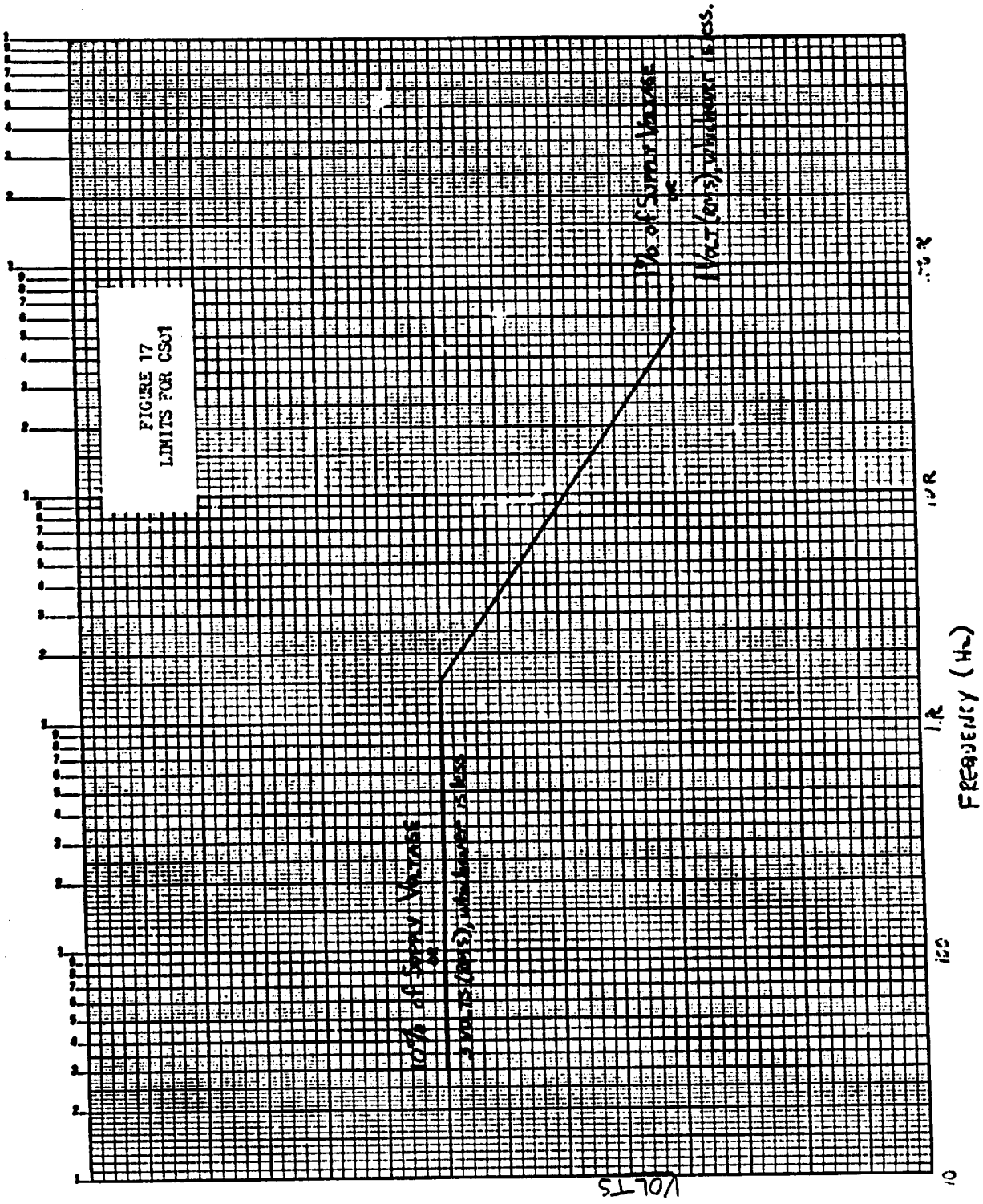
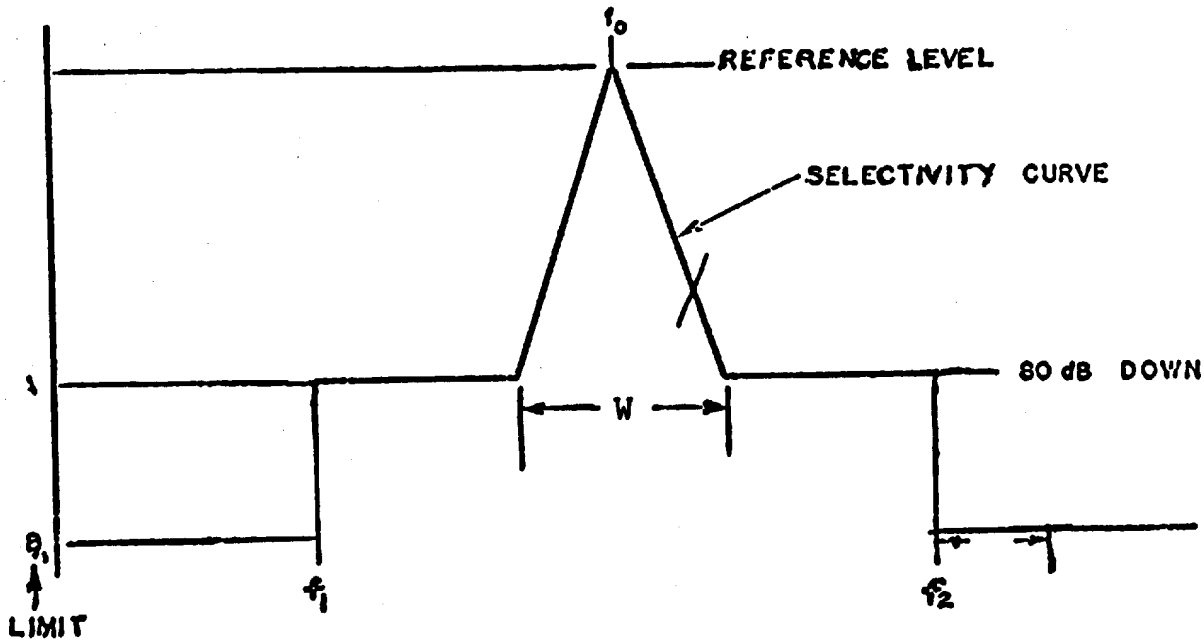


FIGURE 17
LIMITS FOR CS01



f_o = Any frequency between f_1 and f_2.
f_1 = Lowest tunable frequency of each tuning band.
f_2 = Highest tunable or desired frequency of each tuning band.
W = Bandwidth at 80 dB down on selectivity curve as defined in the test sample technical requirements or the control plan.

Limits:

1. Limit at "A" is 80 dB above input voltage required for standard reference output. The exact value shall be determined by measurement of the reference level and the 80 dB down points.
2. Limit "B" is an input signal = OdbmW.

Figure 18 - Limits for CS04 and CS08

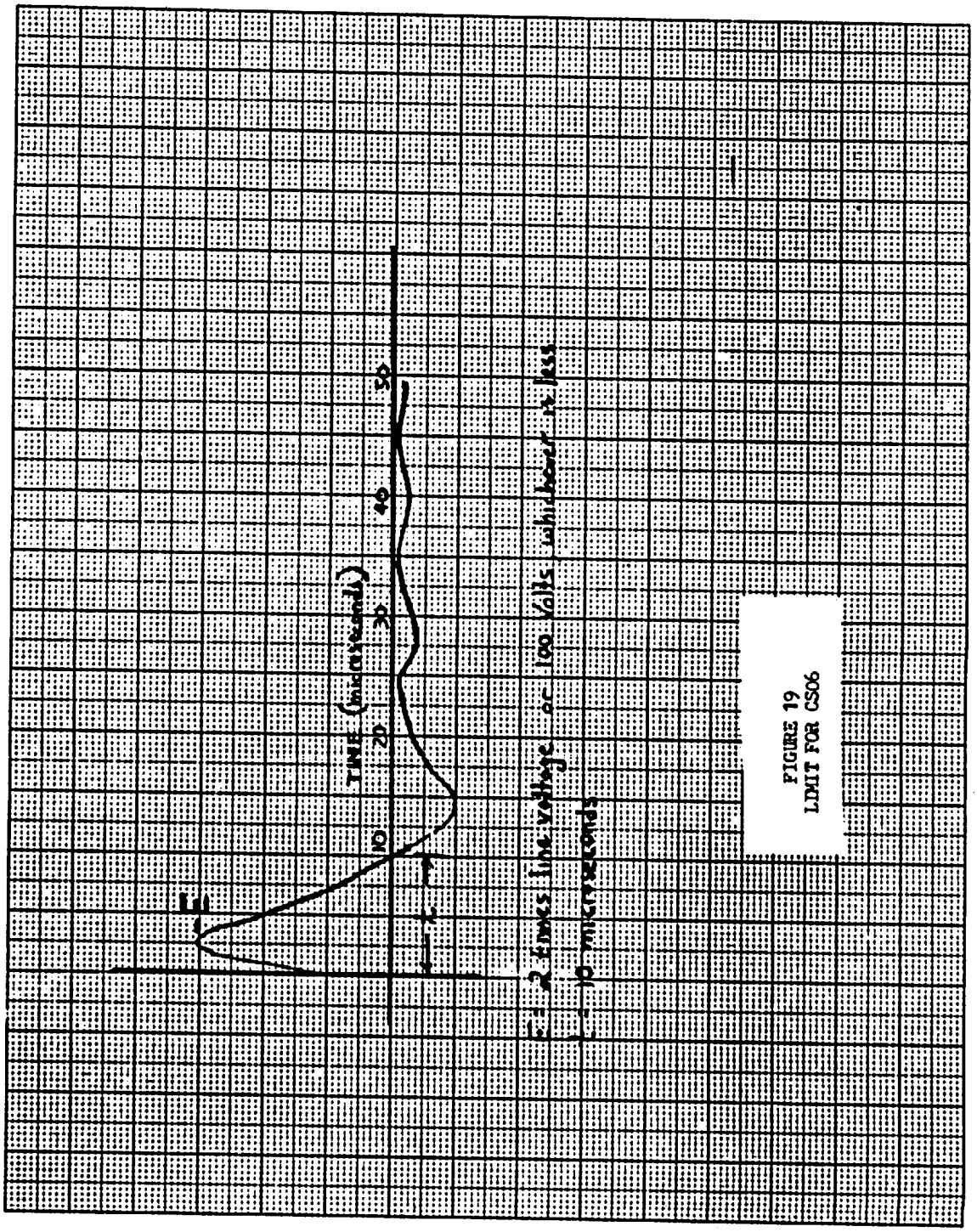


FIGURE 19
LIMIT FOR CS06

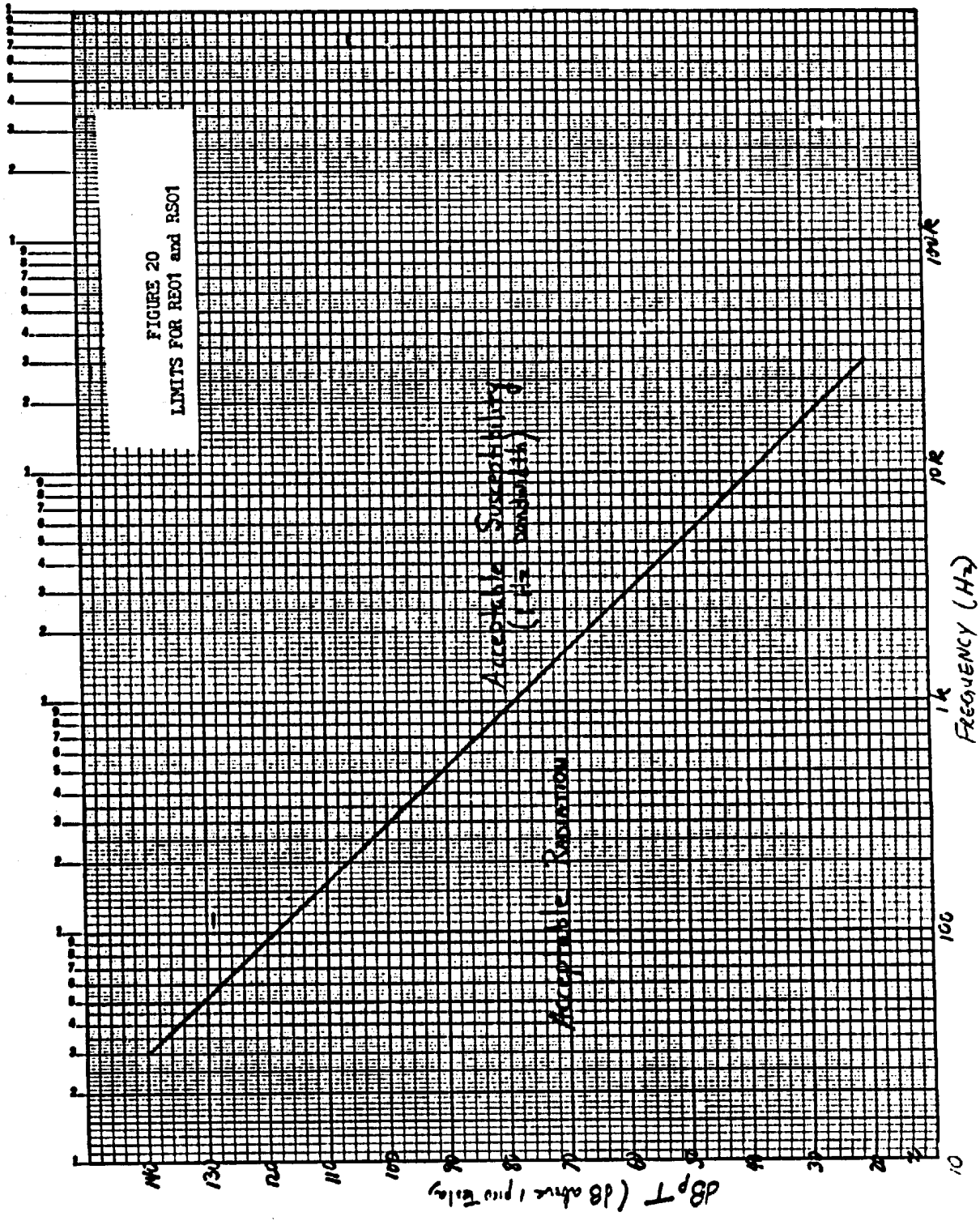


FIGURE 20
LIMITS FOR RE01 and RS01

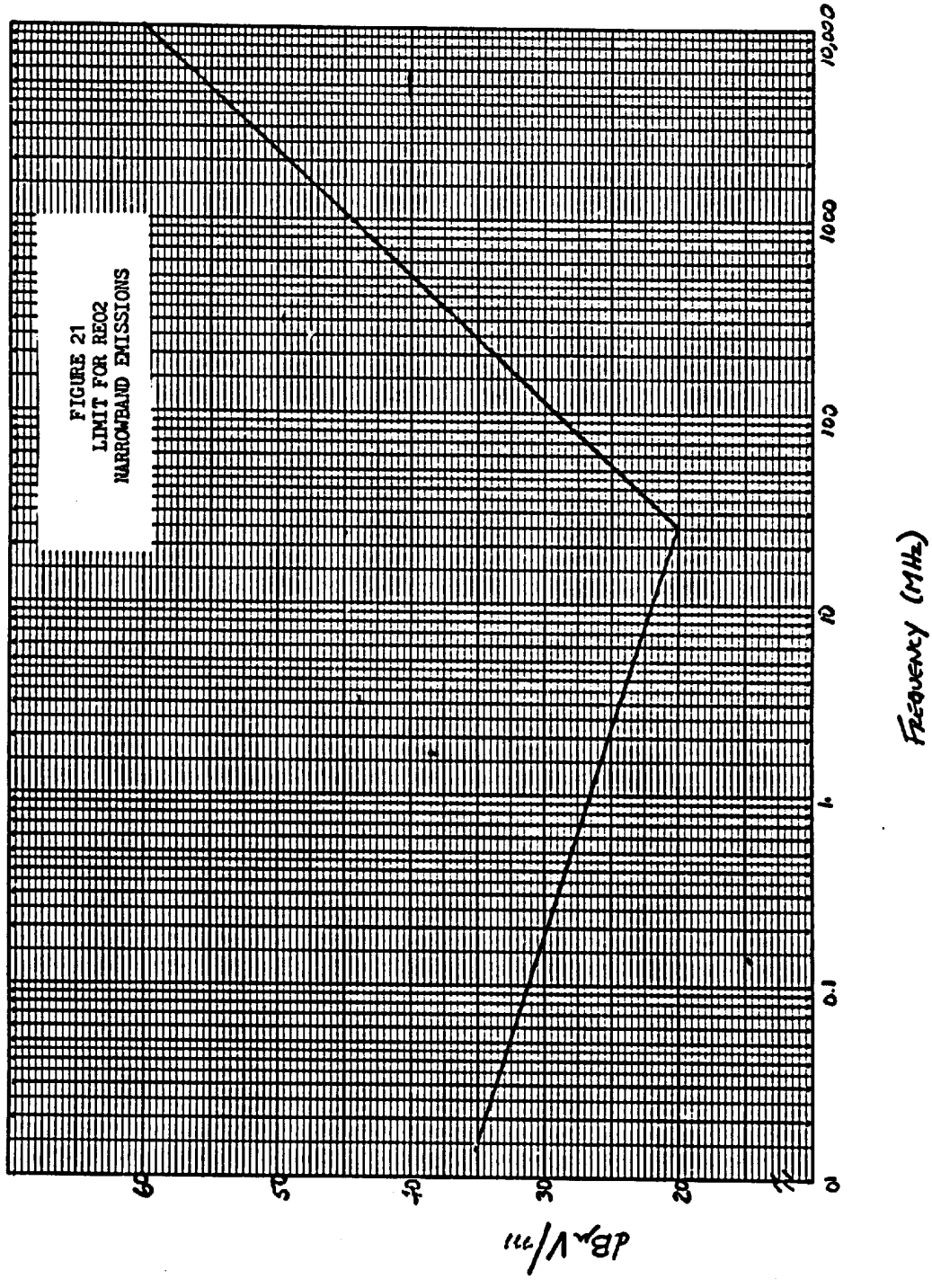


FIGURE 21
LIMIT FOR RE02
NARROWBAND EMISSIONS

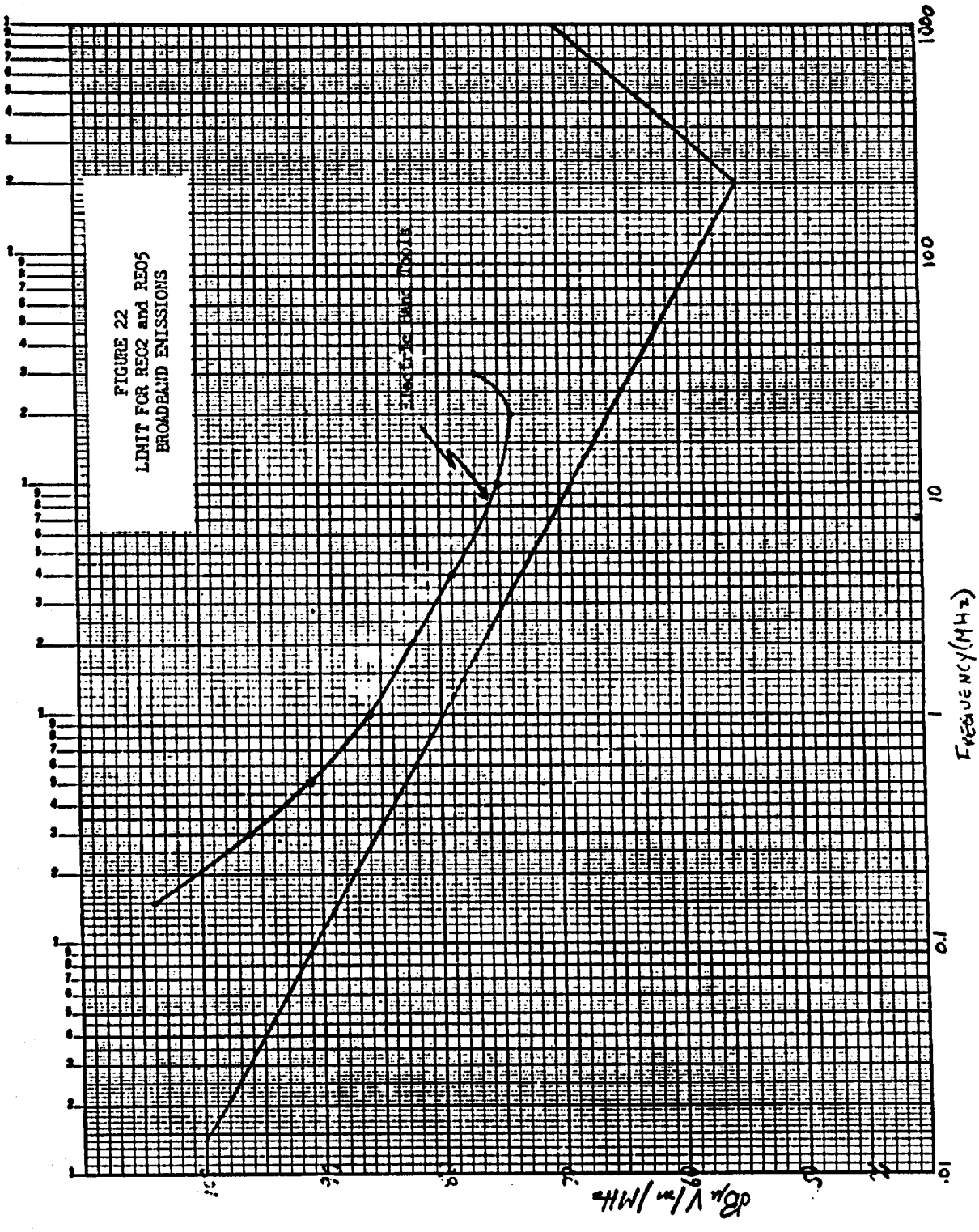


FIGURE 22
LIMIT FOR REC2 and RE05
BROADBAND EMISSIONS

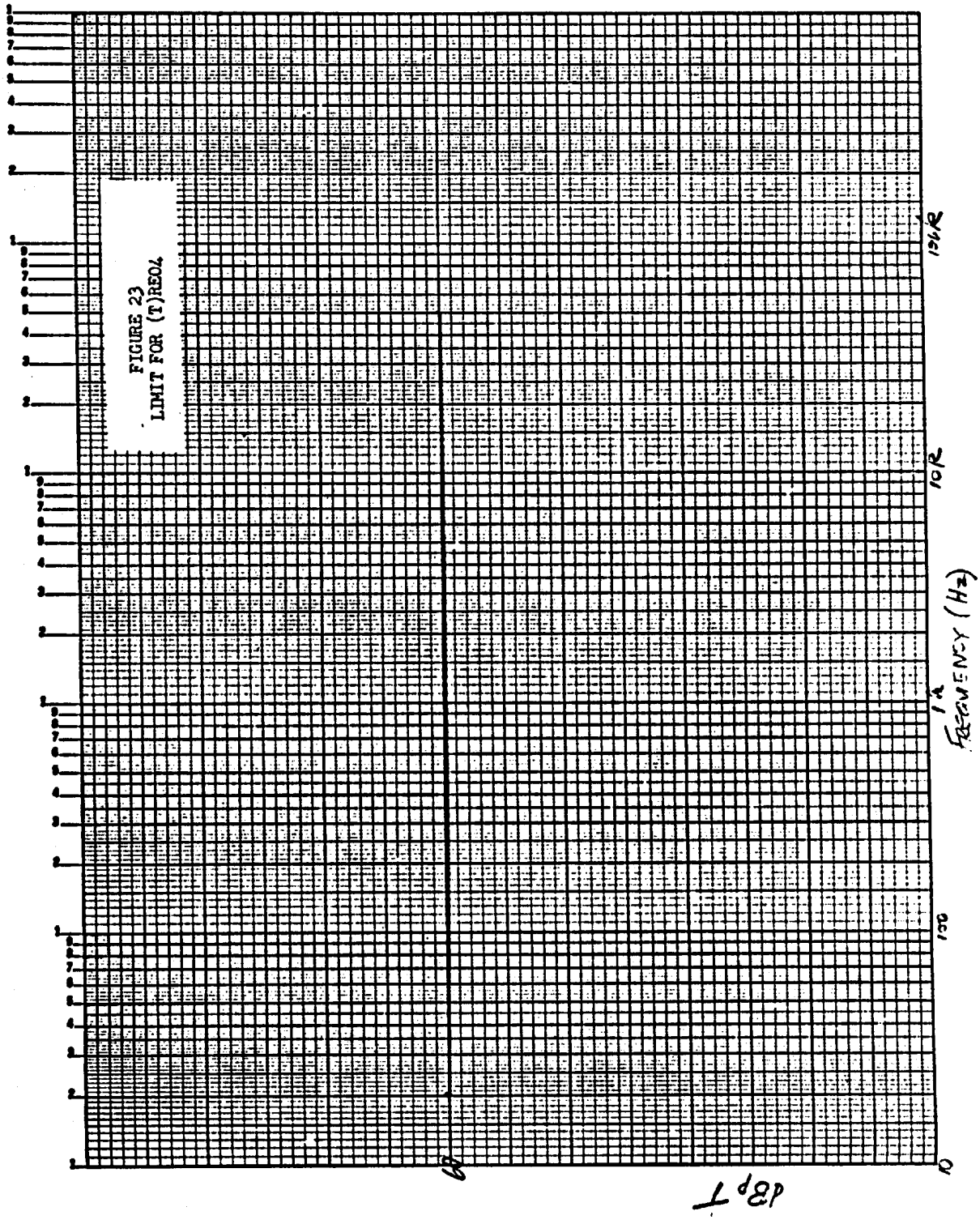


FIGURE 23
LIMIT FOR (T)RE04

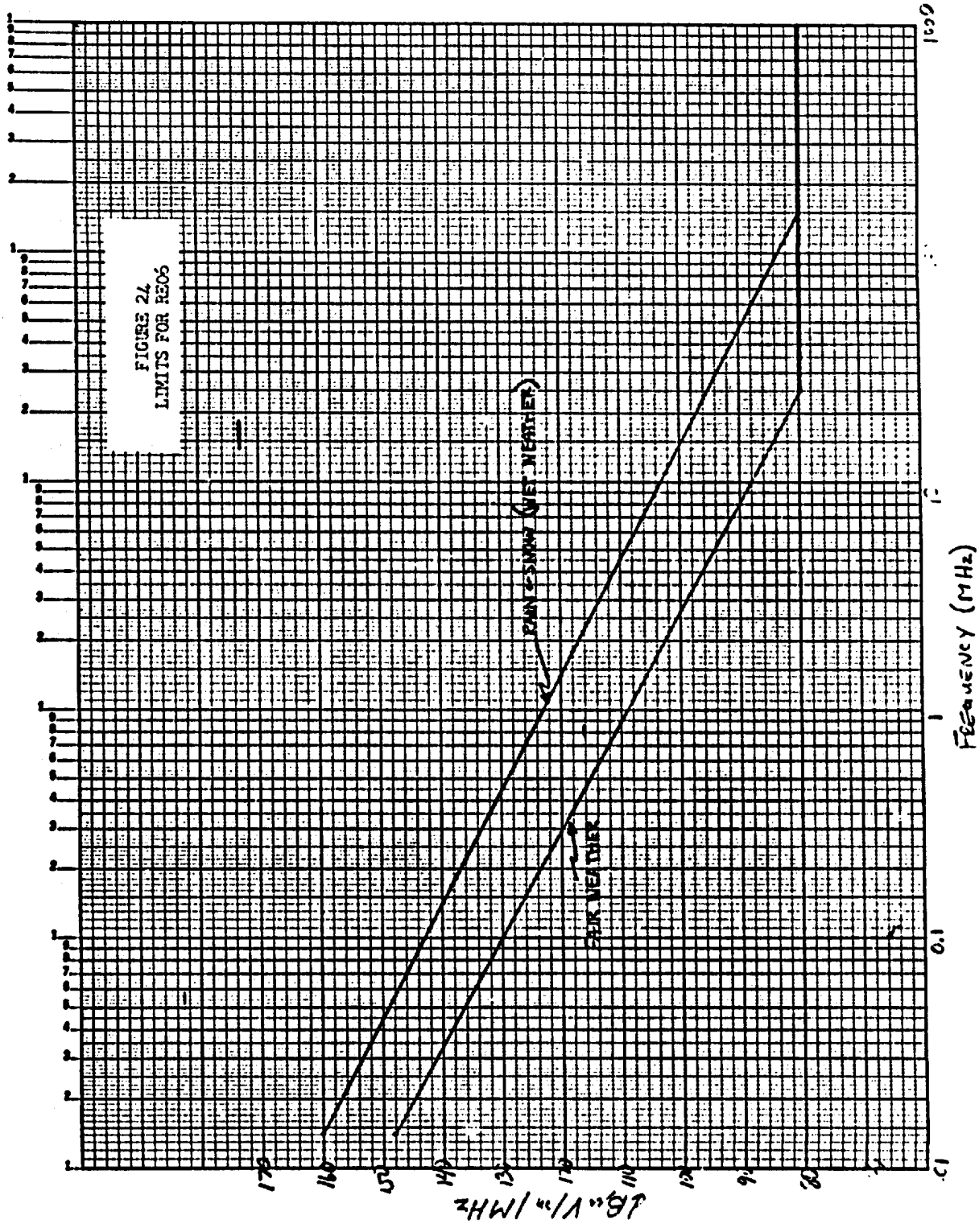


FIGURE 24
LIMITS FOR RE06