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MIL-STD-704E
1 May 1991
SUPERSEDING
MIL-STD-704D
30 September 1980

DEPARTMENT OF DEFENSE INTERFACE STANDARD

AIRCRAFT ELECTRIC POWER CHARACTERISTICS

AMSC N/A FSC GDRQ

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

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Naval Air System Command, ATTN: AIR-53633, Jefferson Davis Highway, Arlington, Virginia 22202, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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TABLES

FIGURES

1. SCOPE

1.1 Purpose. The purpose of this standard is to ensure compatibility between the aircraft electric system, external power, and airborne utilization equipment.

1.2 Scope. This standard defines the requirements and describes the characteristics of aircraft electric power provided at the input terminals of electric utilization equipment. It also establishes the areas of responsibility for aircraft electric system performance.

2. APPLICABLE DOCUMENTS

2.1 Government documents. Copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA, 19111-5094.

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are Department of Defense (DoD) adopted are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS), North Atlantic Treaty Organization (NATO) STANAG 3456 - Aircraft Electrical System Characteristics, cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supercedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Abnormal operation. Abnormal operation occurs when a malfunction or failure in the electric system has taken place and the protective devices of the system are operating to remove the malfunction or failure from the remainder of the system before the limits for abnormal operation are exceeded. The power source may operate in a degraded mode on a continuous basis where the power characteristics supplied to the utilization equipment exceed normal operation limits but remain within the limits for abnormal operation.

3.2 AC voltage. AC voltage is the root mean square (rms) phase to neutral value for each half cycle. Steady state ac voltage is the time average of the rms voltage over

a period not to exceed one second. Peak ac voltage is the maximum absolute value of the instantaneous voltage. The direct current (dc) component of the ac voltage is the average value of the voltage.

3.3 Aircraft electric power systems. An aircraft electric power system consists of a main power source, emergency power source, power conversion equipment, control and protection devices, and an interconnection network (wires, cables, connectors, etc.). The main power is derived from aircraft generators driven by the aircraft propulsion engines. Emergency power is derived from batteries, independent auxiliary power units, ram air or hydraulically driven generators.

3.4 Crest factor. The crest factor is the absolute value of the ratio of the peak to the rms value for each half cycle of the voltage waveform measured over a one second period under steady state conditions.

3.5 DC voltage. Steady state dc voltage is the time average of the instantaneous dc voltage over a period not to exceed one second.

3.6 Distortion. AC distortion is the rms value of the ac waveform exclusive of the fundamental. In a dc system, dc distortion is the rms value of the alternating voltage component on the dc voltage.

3.7 Distortion factor. The ac distortion factor is the ratio of the ac distortion to the rms value of the fundamental component. The dc distortion factor is the ratio of the dc distortion to the dc steady state voltage.

3.8 Distortion spectrum. The distortion spectrum quantifies ac or dc distortion in terms of the amplitude of each frequency component. The distortion spectrum includes the components resulting from amplitude and frequency modulation as well as harmonic and non-harmonic components of the waveform.

3.9 Electric starting operation. Electric starting operation is a specialized case of normal electric system operating conditions where the normal voltage limits may be exceeded due to the high electric demand. The voltage limits for normal operation may be exceeded during the following starting conditions:

(a) An electric start of the propulsion engine.

(b) A battery start of an auxiliary power unit.

3.10 Emergency operation. Emergency operation occurs following the loss of the main generating equipment when a limited electric source, independent of the main system, is used to power a reduced complement of distribution and utilization equipment selected to maintain flight and personnel safety.

3.11 External power source. The external power source refers to the ground or shipboard power source used to provide power to the aircraft's electrical distribution system.

3.12 Frequency. Frequency is the reciprocal of the period of the ac voltage. The unit of frequency is designated hertz (Hz). Steady state frequency is the time average of the frequency over a period not to exceed one second.

3.13 Frequency modulation. Frequency modulation is the difference between the maximum and minimum frequency values that occur in a one minute period during steady state operating conditions. Frequency modulation is a measure of the stability of the power source's frequency regulation (in Hz).

3.14 Load unbalance. Load unbalance for a three-phase load is the difference between the highest and lowest phase loads.

3.15 Normal operation. Normal operation occurs when the system is operating as intended in the absence of any fault or malfunction which degrades performance beyond established requirements. It includes all system functions required for aircraft operation except during the electric starting of propulsion engines and the battery start of an auxiliary power unit. Normal operation includes switching of utilization equipment, prime mover speed changes, synchronizing and paralleling of power sources, and operation from external power sources. Although transfer operation as defined herein is a normal function, it is treated separately in this standard because of the power interruption which it may produce. Conducted switching spikes, which are excursions of the instantaneous voltage not exceeding 50 microseconds, shall be considered normal operation characteristics.

3.16 Overfrequency and underfrequency. Overfrequency and underfrequency are those frequencies which exceed the transient limits for normal operation and are limited by the action of protective devices.

3.17 Overvoltage and undervoltage. Overvoltage and undervoltage are those voltages which exceed the transient limits for normal operation and are limited by the action of protective devices.

3.18 Point of regulation. The point of regulation (POR) is that point at which a power source senses and regulates the system voltage. The POR shall be at the input terminals of the line contactor connecting the power system to the load bus.

3.19 Ripple. Ripple is the variation of voltage about the steady state dc voltage during steady state electric system operation. Sources of ripple may include, but are not limited to, voltage regulation stability of the dc power source, commutation/rectification within the dc power source, and load variations within utilization equipment. Ripple amplitude is the maximum absolute value of the difference between the steady state and the instantaneous dc voltage.

3.20 Steady state. Steady state is that condition in which the characteristics remain within the limits for normal operation steady state characteristics throughout an arbitrarily long period of time. Steady state conditions may include lesser transients.

3.21 Transfer operation. Transfer operation occurs when the electric system transfers between power sources, including transfers from or to external power sources.

3.22 Transient. A transient is a changing value of a characteristic that usually occurs as a result of normal disturbances such as electric load change and engine speed change. A transient may also occur as a result of a momentary power interruption or an abnormal disturbance such as fault clearing. Transients that do not exceed the steady state limits are defined as lesser transients. Transients that exceed the steady state limits but remain within the specified normal transient limits are defined as normal transients. Transients that exceed normal transients limits as a result of an abnormal disturbance and eventually return to steady state limits are defined as abnormal transients.

3.23 Utilization equipment. Utilization equipment is that equipment which receives power from the electric power system.

3.24 Utilization equipment terminals. Utilization equipment terminals provide the interface with the electric power system. Power interconnections within the utilization equipment or equipment system are excluded.

3.25 Voltage modulation. Voltage modulation is the variation of ac voltage during steady state ac electric system operation. Sources of voltage modulation may include, but are not limited to, voltage regulation stability of the ac power source, generator speed variations, and load variations within utilization equipment. Voltage modulation amplitude is the difference between the maximum and minimum ac voltage values that occur in a one second period during steady state operating conditions.

3.26 Voltage phase difference. The voltage phase difference is the difference in electrical degrees between the fundamental components of any two phase voltages taken at consecutive zero crossings traced in the negative to positive direction.

3.27 Voltage unbalance. Voltage unbalance is defined as the maximum difference between rms phase voltage amplitudes at the utilization equipment terminals.

4. GENERAL REQUIREMENTS

4.1 Aircraft electric power system requirements.

4.1.1 Aircraft electric power system performance. The aircraft electric power system shall provide electric power having the characteristics specified in this standard at the utilization equipment terminals during all operations of the power system.

4.1.2 Generated power characteristics. The characteristics of generated power measured at the POR shall be within the limits specified in the appropriate detail generator specification. It is the responsibility of the airframe manufacturer/modifier to provide the distribution and protection network to the terminals of the utilization equipment while maintaining the power characteristics specified in this standard.

4.1.3 Protective devices. Protective devices shall function independently of control and regulation equipment.

4.2 Aircraft utilization equipment requirements.

4.2.1 Power compatibility. Utilization equipment must be compatible with the power characteristics specified herein. Utilization equipment shall not require electric power of better quality than specified herein. Utilization equipment shall also be compatible with the applicable aircraft specification requirements for control of electromagnetic interference and voltage spikes induced by lightning, electromagnetic pulses and power switching. Electromagnetic interference and voltage spikes are not covered by this standard.

4.2.2 Operation. When supplied electric power having characteristics specified herein, aircraft utilization equipment shall provide the level of performance required by its detail specification for each operating condition. Operation of utilization equipment shall not cause the power characteristics at its terminals to exceed the limits specified herein. Utilization equipment operation under any electric system operating condition shall not have an adverse effect on or cause malfunction of the electric system.

4.2.2.1 Normal operation. Utilization equipment shall provide the level of performance specified in its detail specification.

4.2.2.2 Abnormal operation. Detail specifications for utilization equipment may require a level of performance during abnormal operation. Utilization equipment which is permitted a degradation or loss of performance during abnormal operation shall not suffer damage or cause an unsafe condition and shall automatically resume specified performance when normal operating characteristics are restored.

4.2.2.3 Transfer operation. Utilization equipment may not be required to operate under the transfer condition unless a level of performance is specified by its detail specification. Utilization equipment shall automatically resume specified performance when normal operating characteristics are resumed.

4.2.2.4 Emergency operation. Utilization equipment shall provide the level of performance specified in its detail specification when such performance is essential for flight or safety.

4.2.2.5 Starting operation. Utilization equipment shall provide the level of performance specified in its detail specification when such performance is essential during the starting operation.

4.2.3 Power failure. The loss of power (ac or dc) or the loss of one or more phases of ac power to any utilization equipment terminal shall not result in an unsafe condition or damage to utilization equipment.

4.2.4 AC power utilization. Utilization equipment that requires more than 0.5 kilovoltamperes (KVA) of ac power shall be configured to utilize three-phase steady state balanced power. Load unbalance of individual utilization equipment shall be within the limits of figure 1. The load unbalance of utilization equipment whose total load is

greater than 30 KVA shall be no greater than 3.33 percent of its total three-phase load. Single-phase ac power shall be used only on a line-to-neutral basis. AC power shall not be half-wave rectified.

4.3 External power source requirement. External electric power sources shall supply power having the characteristics specified in this standard at the power input terminals of the aircraft electric utilization equipment. In order to allow for steady state voltage drop between the aircraft external power receptacle and the aircraft utilization equipment terminals, the voltage at the external power receptacle shall be as follows:

(a) AC system 113 to 118 volts.

(b) 28 VDC system 24 to 29 volts.

(c) 270 VDC system 260 to 280 volts.

4.4 North Atlantic Treaty Organization (NATO) procurements. Equipment or subsystems procured by the DoD in support of NATO shall comply with the applicable requirements of this standard and applicable NATO standardization agreements (STANAGS). The NATO STANAGS are not to be waived or modified unless specific authority has been granted by the procuring activity.

4.5 Test requirements. Equipment testing is required to demonstrate utilization equipment compatibility with the electric power characteristics of this standard. Utilization equipment test requirements shall be in accordance with the equipment detail specification. Aircraft testing is required to demonstrate that the aircraft electric system power characteristics are within the limits of this standard throughout all operating conditions of the aircraft and its utilization equipment. Aircraft test requirements shall be in accordance with the aircraft detail specification.

5. DETAIL REQUIREMENTS

5.1 Transfer operation characteristics. Under conditions of bus or power source transfers, voltage and frequency shall not vary between zero and normal operating limits for longer than 50 milliseconds. A normal transient may occur upon completion of the transfer.

5.2 AC power characteristics.

5.2.1 Type system. AC power characteristics are those of a single-phase or three-phase wye-connected grounded neutral system having a nominal voltage of 115/200 volts. The waveform is a sine wave having nominal frequency of 400 Hz. The only alternate standard is a nominal 230/400 volts

when specifically authorized. The voltage amplitude limits for the 115/200 volts standard shall apply proportionally to the 230/400 volts standard. The power characteristics specified herein are applicable to each phase.

5.2.2 Phase sequence. The phase sequence shall be A-B-C and aircraft wiring and equipment terminals shall be marked accordingly. Generator terminals shall be marked T_1-T_2-T_3 corresponding to A-B-C, respectively. The phase sequence shall be counterclockwise (positive) as shown in figure 2.

5.2.3 Normal operation. Normal operation characteristics shall be in accordance with table I.

5.2.4 Abnormal operation. The overvoltage and undervoltage values shall be within the limits of figure 6. The overfrequency and underfrequency values shall be within the limits of figure 7.

5.2.5 Emergency operation. All power characteristics in emergency operation shall be the same as normal operation.

5.3 DC power characteristics.

5.3.1 Type system. DC power characteristics are those of a direct current, two-wire or negative ground return system having a nominal voltage of 270 volts or 28 volts.

5.3.2 270 volts dc system

5.3.2.1 Normal operation. Normal operation characteristics shall be in accordance with table II.

5.3.2.2 Abnormal operation. Overvoltage and undervoltage values shall be within the limits of figure 12.

5.3.2.3 Emergency operation. All power characteristics in emergency operation shall be the same as normal operation.

5.3.3 28 volts dc system.

5.3.3.1 Normal operation. Normal operation characteristics shall be in accordance with table II.

5.3.3.2 Abnormal operation. Overvoltage and undervoltage values shall be within the limits of figure 11.

5.3.3.3 Emergency operation. The dc steady state voltage in emergency operation shall be between 18 and 29 volts.

5.3.3.4 Electric starting. The dc voltage in electric starting operation shall be between 12 and 29 volts. Electric starting of an auxiliary power unit (other than battery starts) is a normal operating function and is not included under this condition.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Supersession data. This issue of MIL-STD-704 supersedes all previous issues of MIL-STD-704 for new designs. Previous issues of MIL-STD-704 remain in effect to cover the procurement of previously designed utilization equipment or new utilization equipment designed for use with previously designed aircraft electric power systems. Copies of previous issues shall be retained as needed, and will no longer be stocked by the Government.

6.2 International standardization agreement. Certain provisions of this standard are subject to the international standardization agreement NATO STANAG 3456. When change notice, revision or cancellation of this standard is proposed that 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.

6.3 Changes from the previous issue. This document has undergone extensive revision and reorganization. Most paragraphs have been changed from the previous issue. Bidders and contractors are cautioned that a thorough review of the entire document is required.

6.4 Application of this standard in utilization equipment specifications. Utilization equipment specifications should include a statement that "This equipment shall utilize electric power in accordance with MIL-STD-704 and shall be in accordance with the utilization equipment requirements of MIL-STD-704." The equipment specification should also specify the type of electric power to be utilized and the detailed performance required during normal, abnormal, emergency, starting and transfer operation of the electric system. The electric power characteristics specified herein are minimum requirements for utilization equipment. Therefore, specifications for utilization equipment that require greater operating margins should include specific electric power characteristic operating ranges that exceed those stated herein. Utilization equipment specifications should never specify operating ranges that are narrower than those specified herein nor waive compatibility with the electric power characteristics

specified herein, since that could result in failure of the equipment to perform as required. Utilization equipment specifications should also include requirements that reduce the likelihood of the equipment having an adverse effect on the electric power characteristics provided by the electric system. High inrush current, low lagging power factor, high peak power to average power ratio, high current ripple amplitude, and current distortion are some characteristics of utilization equipment that can adversely affect the electric system by degrading electric power characteristics or increasing capacity requirements. Minimizing these undesirable utilization equipment characteristics involves tradeoffs with weight, cost and reliability that are specific to each type of equipment and should be addressed in the utilization equipment specification.

6.5 Precedence. Continuous reproduction of the figures may result in the distortion of the curves. Tables and equations on the figures take precedence.

TABLE I. AC normal operation characteristics

Steady state characteristics	Limits
Steady state voltage	108.0 to 118.0 volts, rms
Voltage unbalance	3.0 volts, rms maximum
Voltage modulation	2.5 volts, rms maximum
Voltage phase difference	116° to 124°
Distortion factor	0.05 maximum
Distortion spectrum	Figure 3
Crest factor	1.31 to 1.51
DC component	+0.10 to -0.10 volts
Steady state frequency	393 to 407 Hz
Frequency modulation	4 Hz
Transient characteristics	**Limits**
Peak voltage	271.8 volts, rms maximum
Voltage transient	Figure 4
Frequency transient	Figure 5

TABLE II. DC normal operation characteristics

Steady state characteristics	Limits	
	28 volts DC system	270 volts DC system
Steady state voltage Distortion factor Distortion spectrum Ripple amplitude	22.0 to 29.0 volts 0.035 maximum Figure 8 1.5 volts maximum	250.0 to 280.0 volts 0.015 maximum Figure 13 6.0 volts maximum
Transient characteristics	**Limits**	
	28 volt DC system	270 volts DC system
Voltage transient	Figure 9	Figure 10

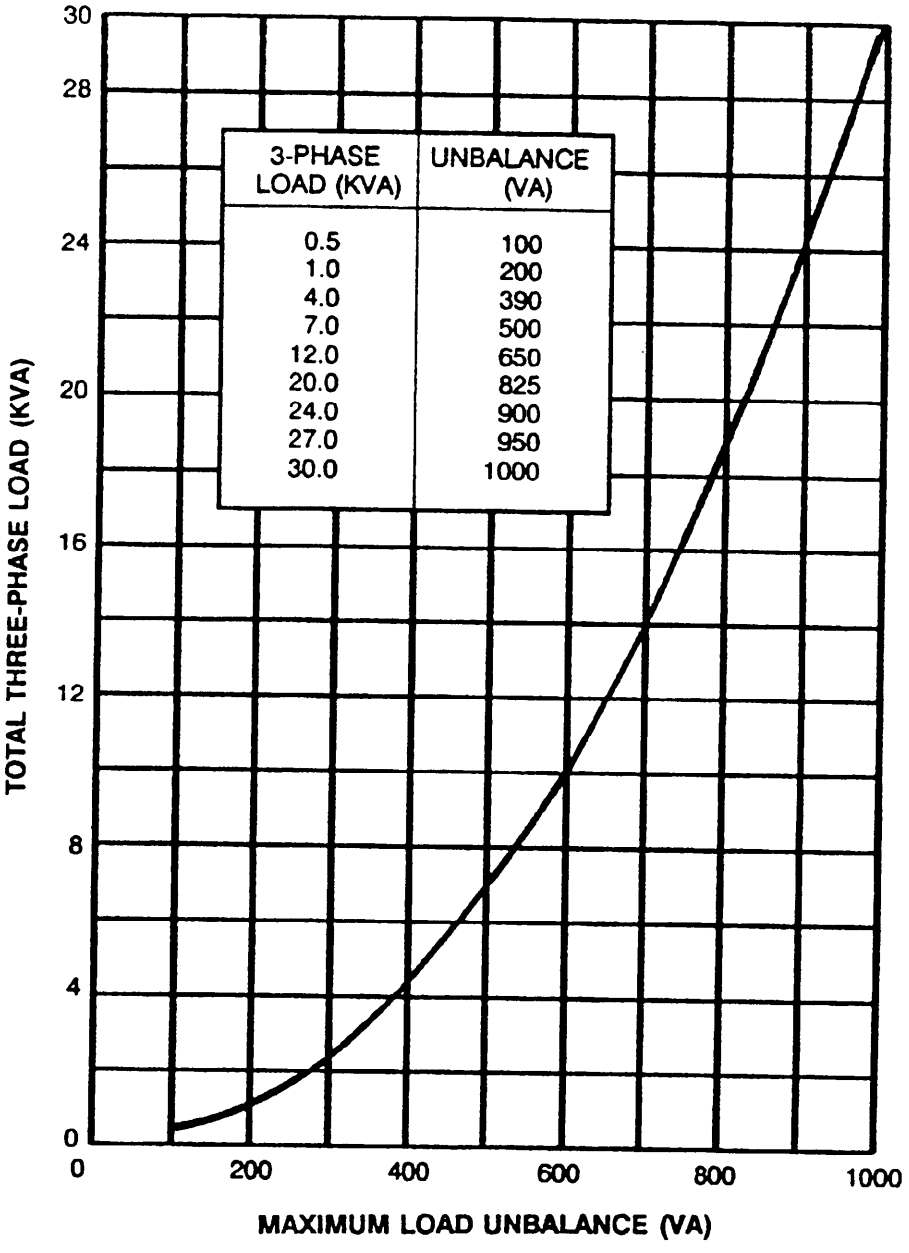

FIGURE 1. Load unbalance limits for three-phase utilization equipment.

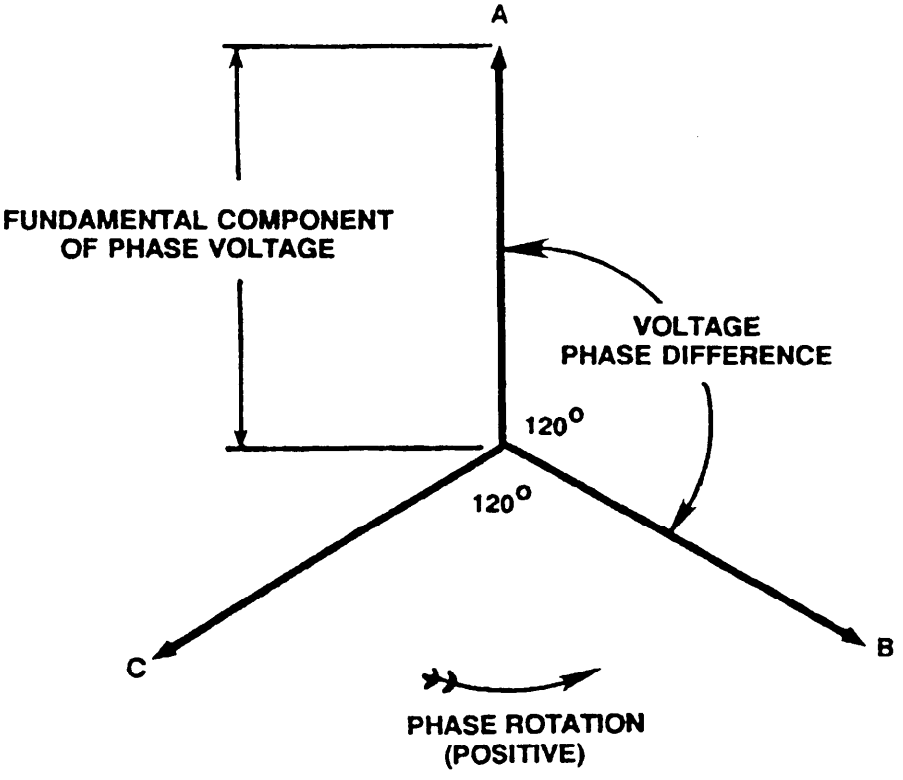

FIGURE 2. Phasor diagram showing required phase sequence relationship.

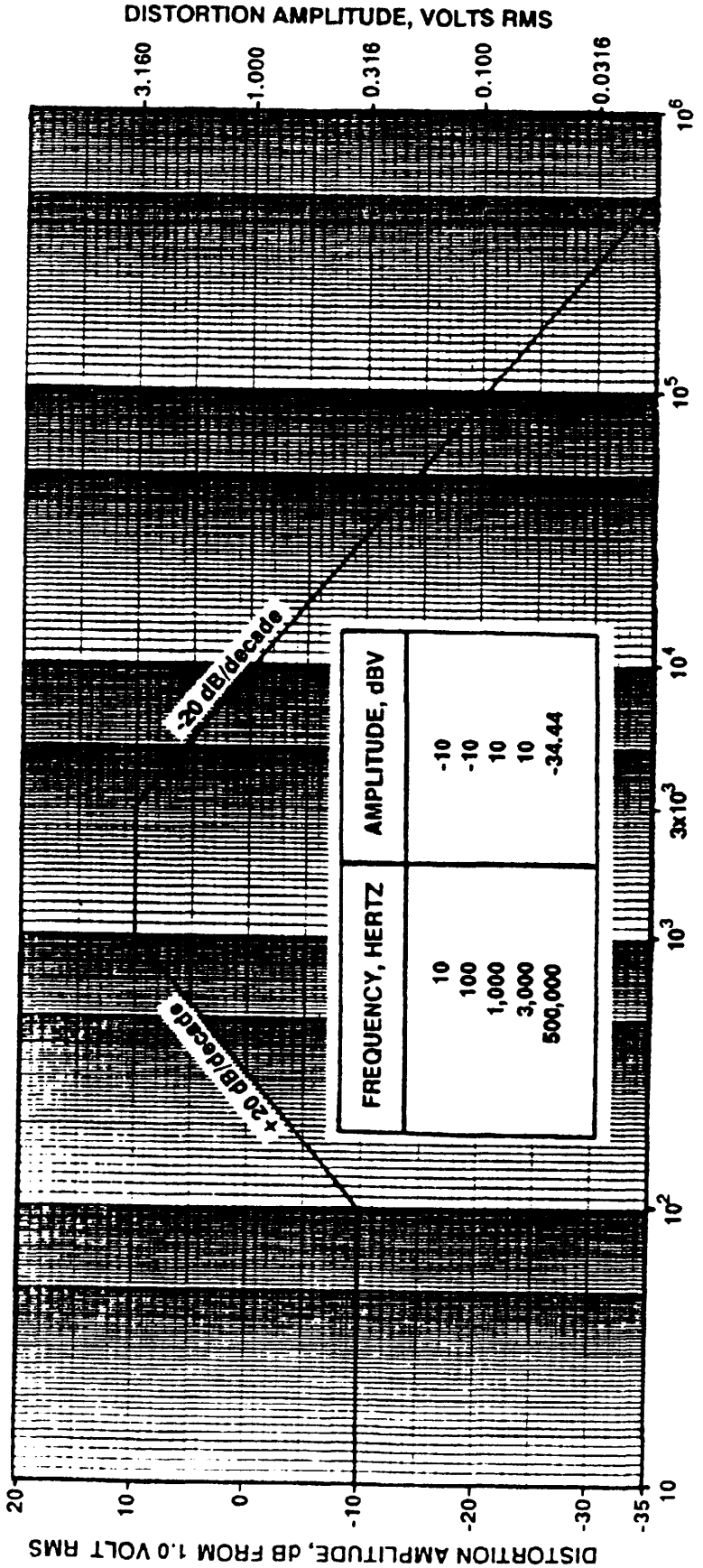

FIGURE 3. Maximum distortion spectrum of AC voltage.

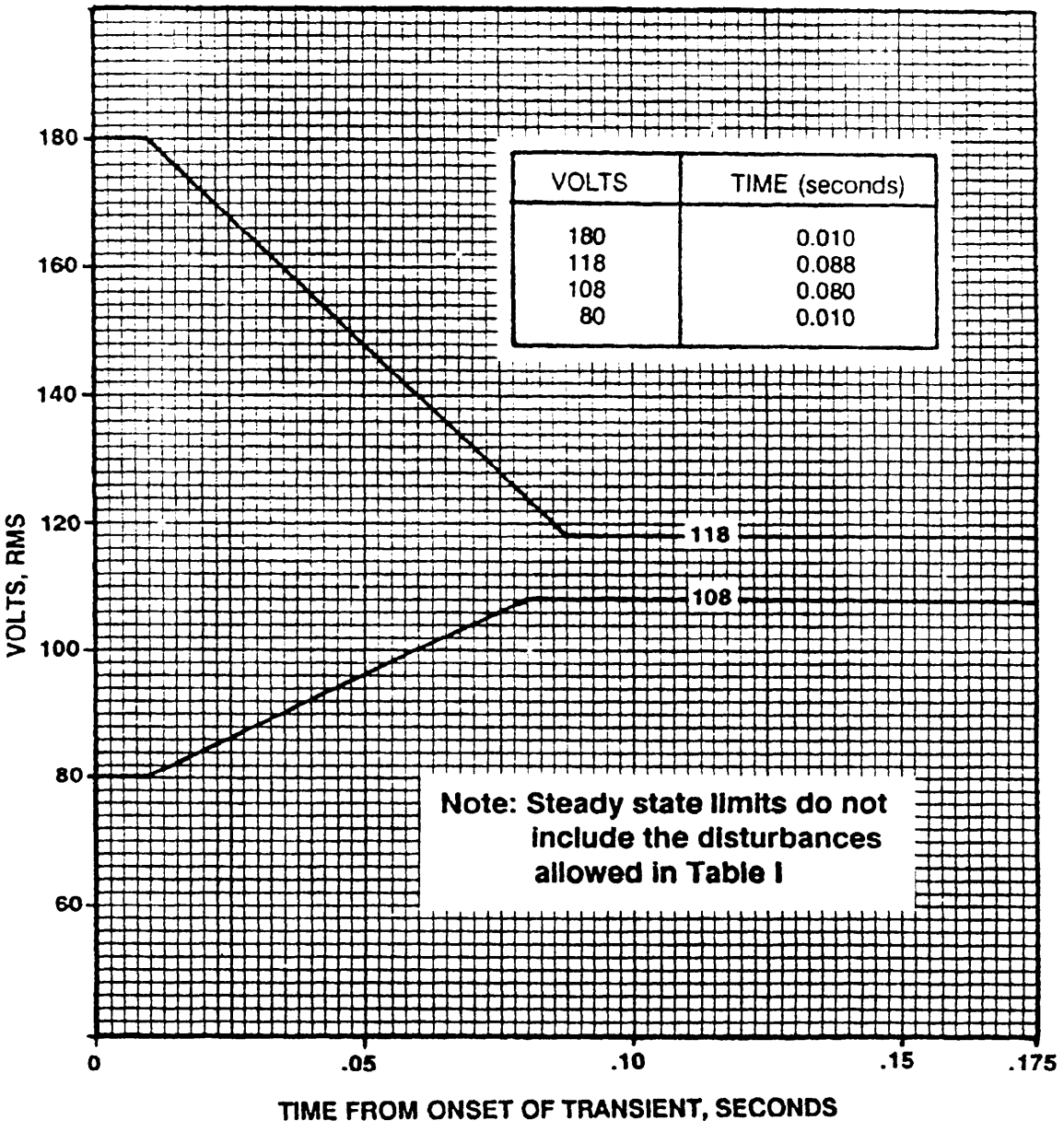

FIGURE 4. Envelope of normal AC voltage transient.

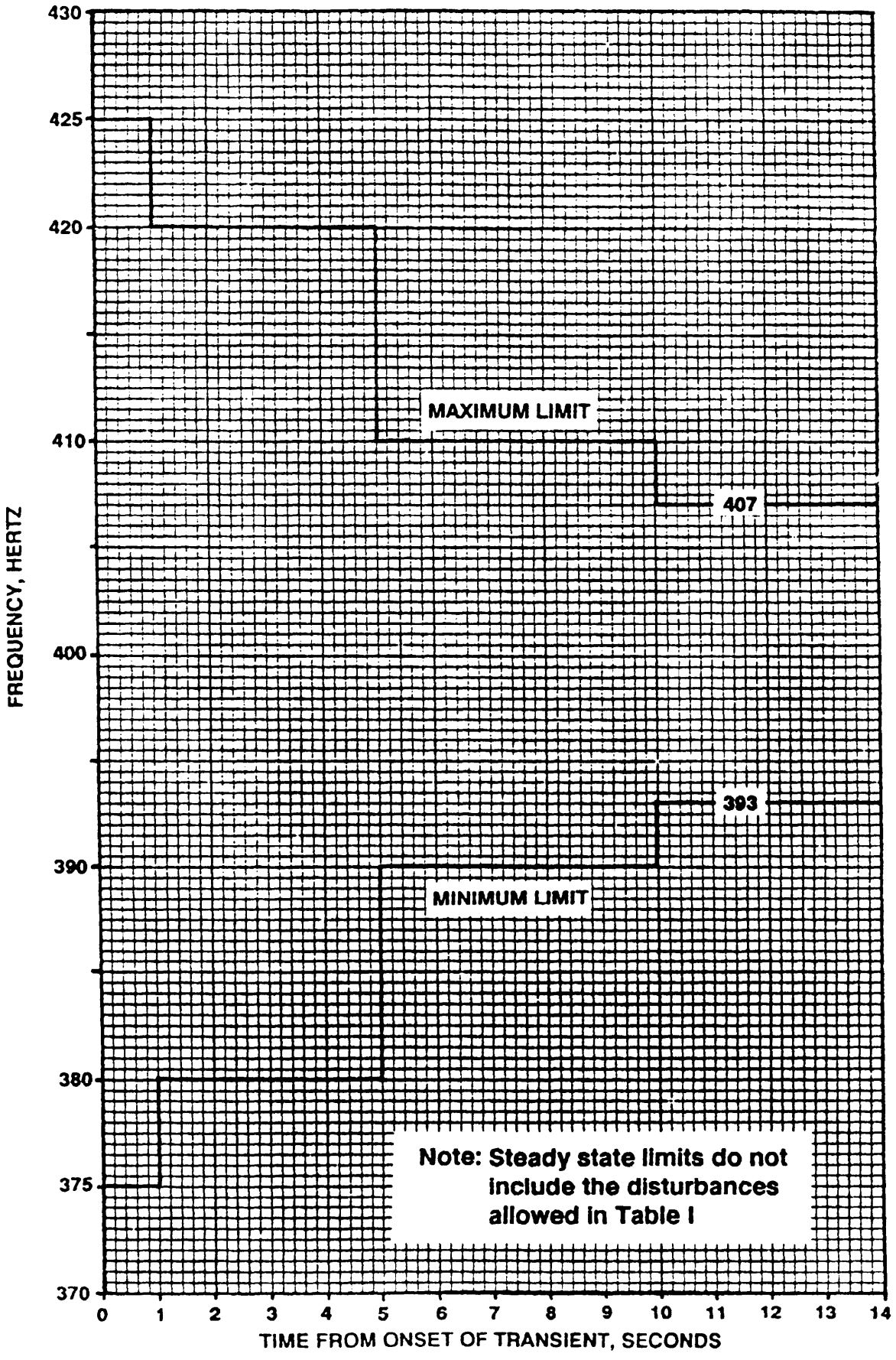

FIGURE 5. Envelope of normal AC frequency transient.

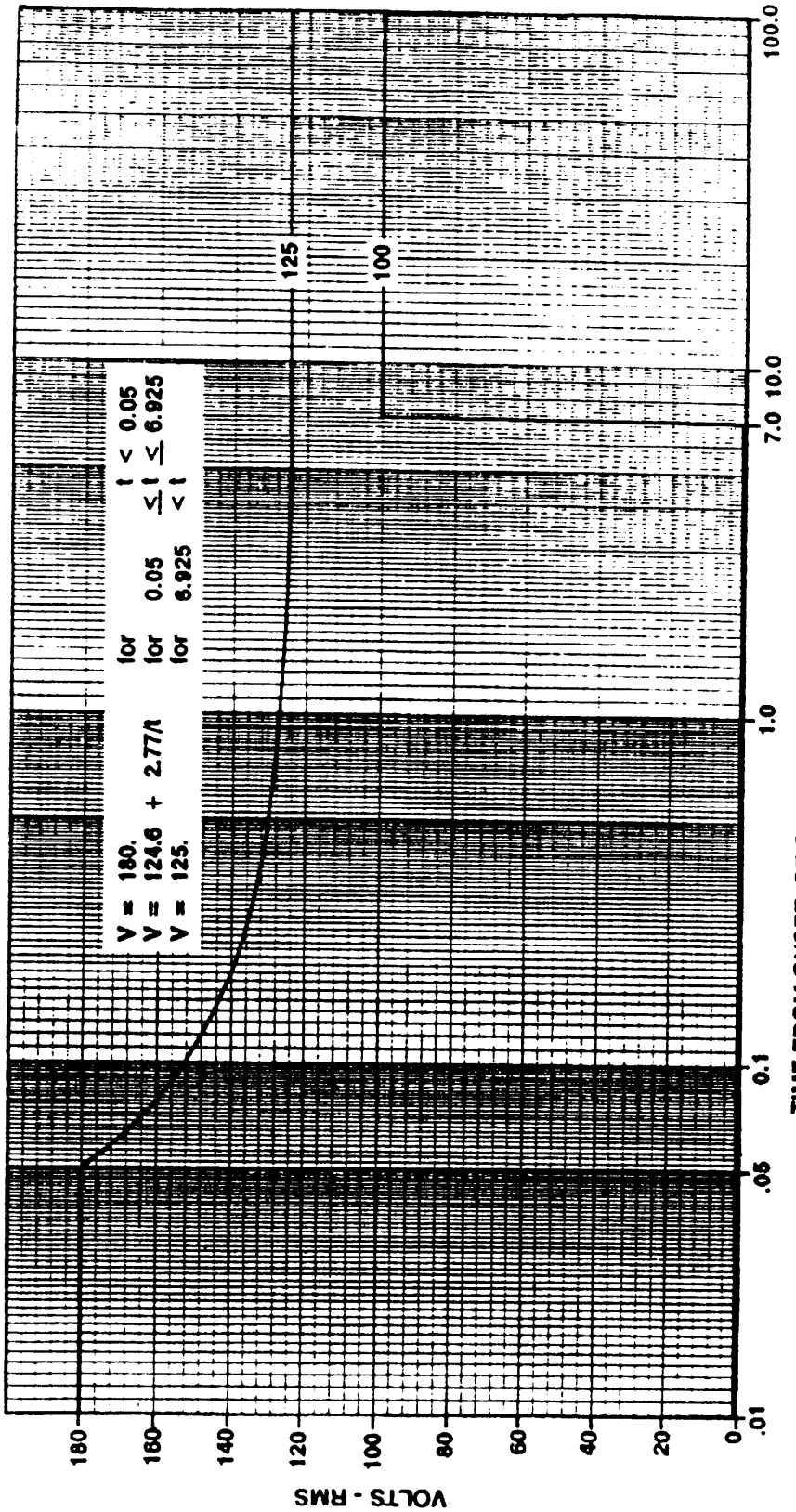

FIGURE 6. Limits for AC overvoltage or undervoltage.

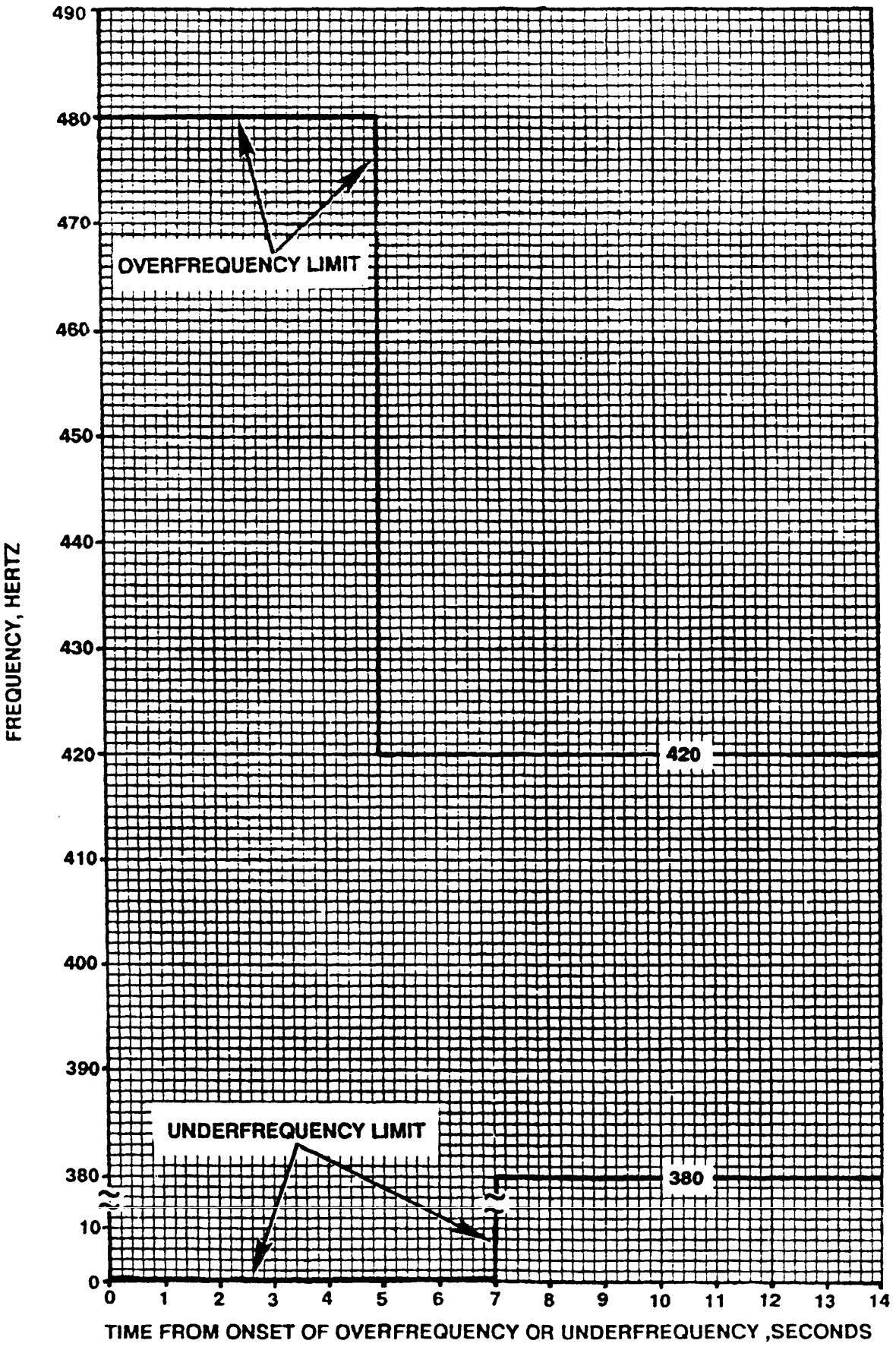

FIGURE 7. Limits for AC overfrequency or underfrequency.

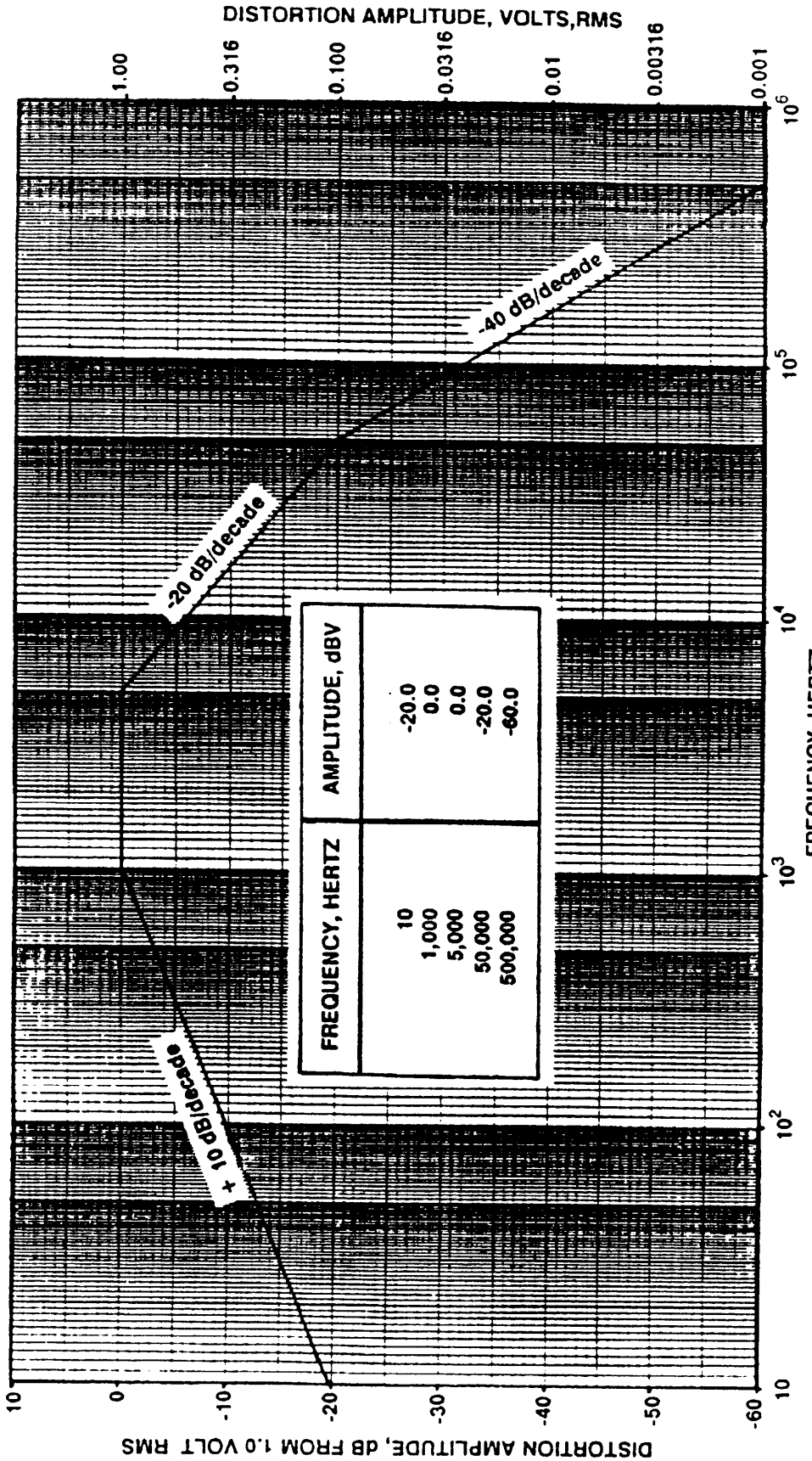

FIGURE 8. Maximum distortion spectrum for 28 volts DC system.

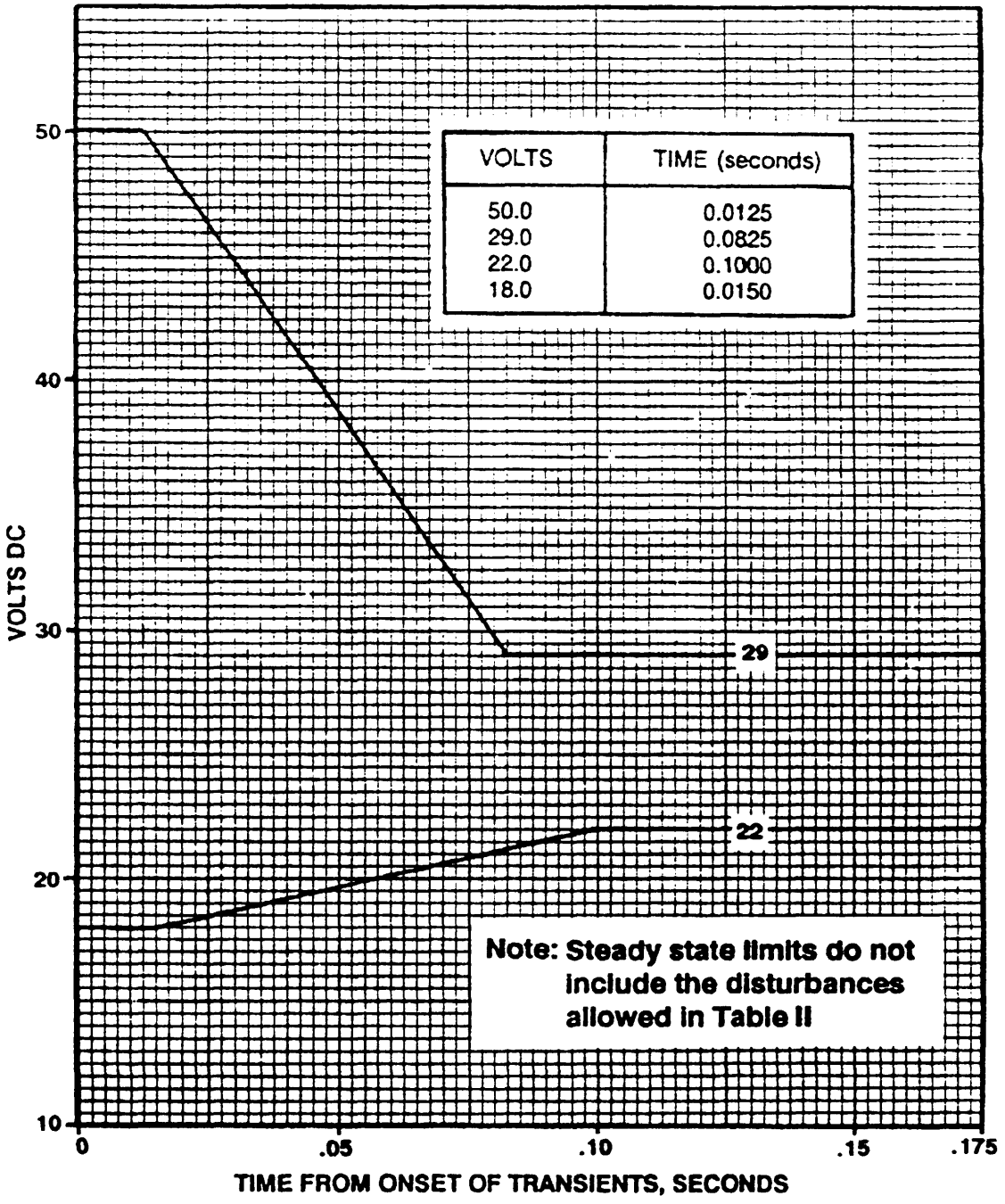

FIGURE 9. Envelope of normal voltage transient for 28 volts DC system.

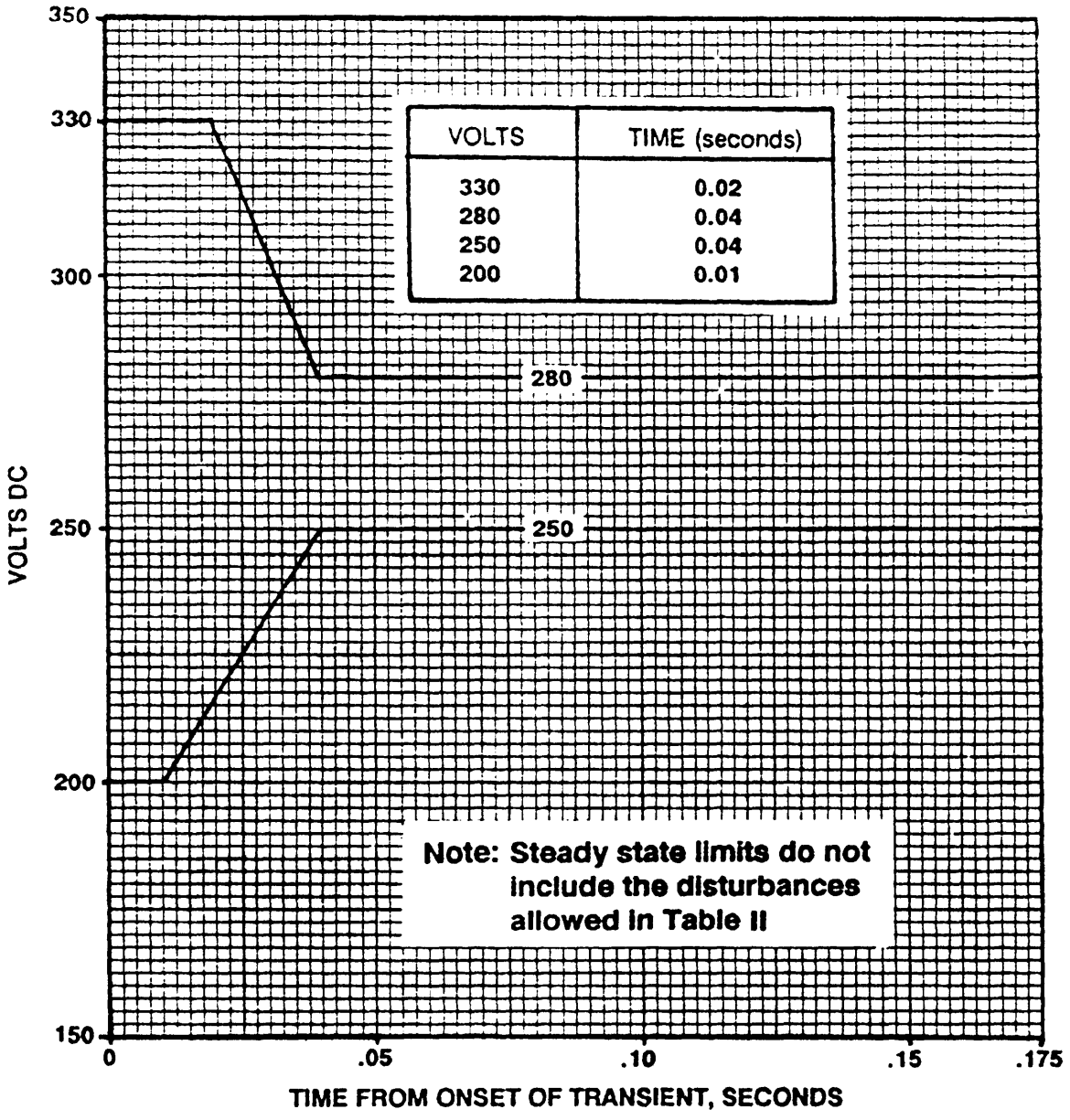

FIGURE 10. Envelope of normal voltage transient for 270 volts DC system.

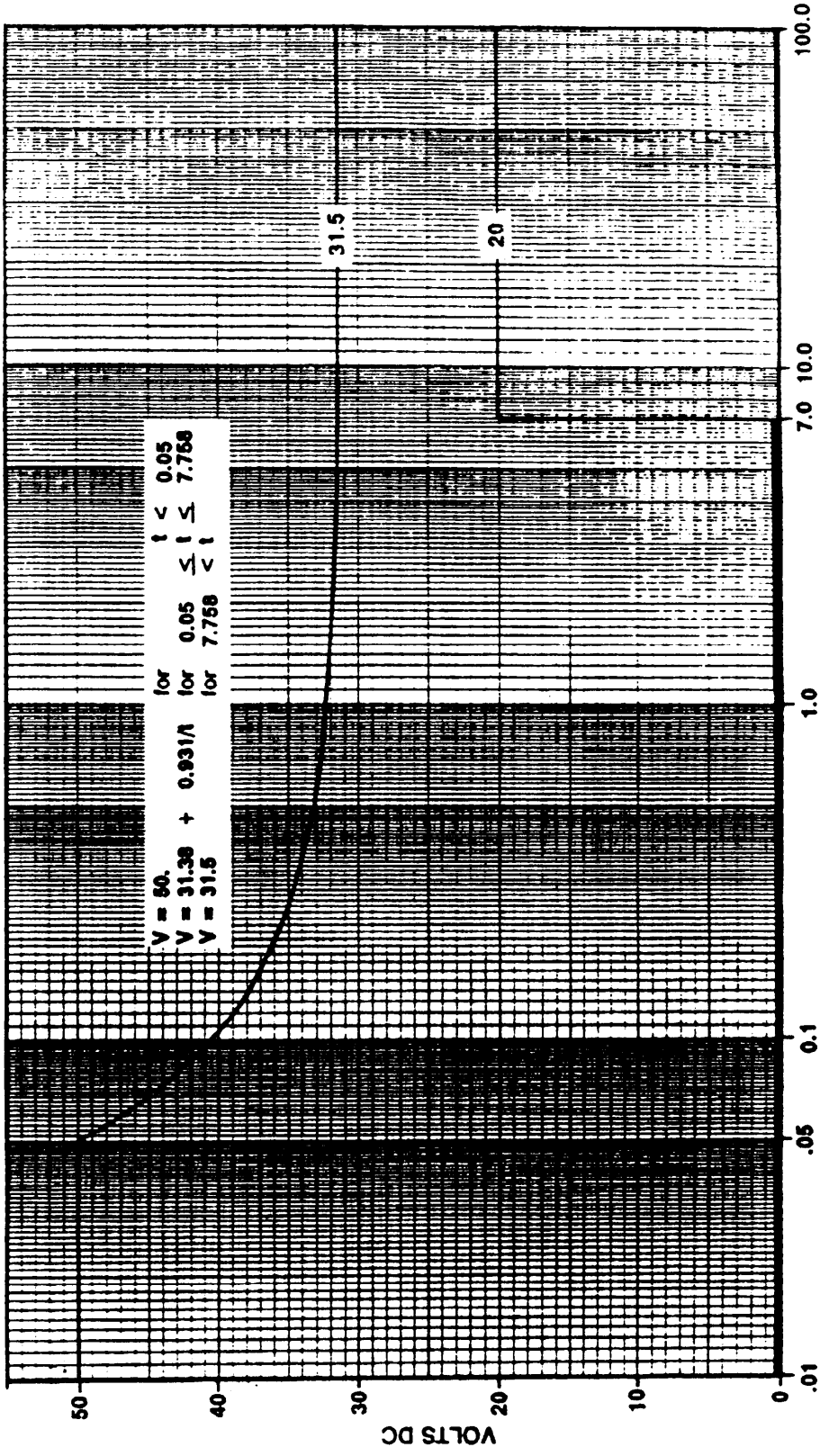

FIGURE 11. Limits for DC overvoltage or undervoltage for 28 volts DC system.

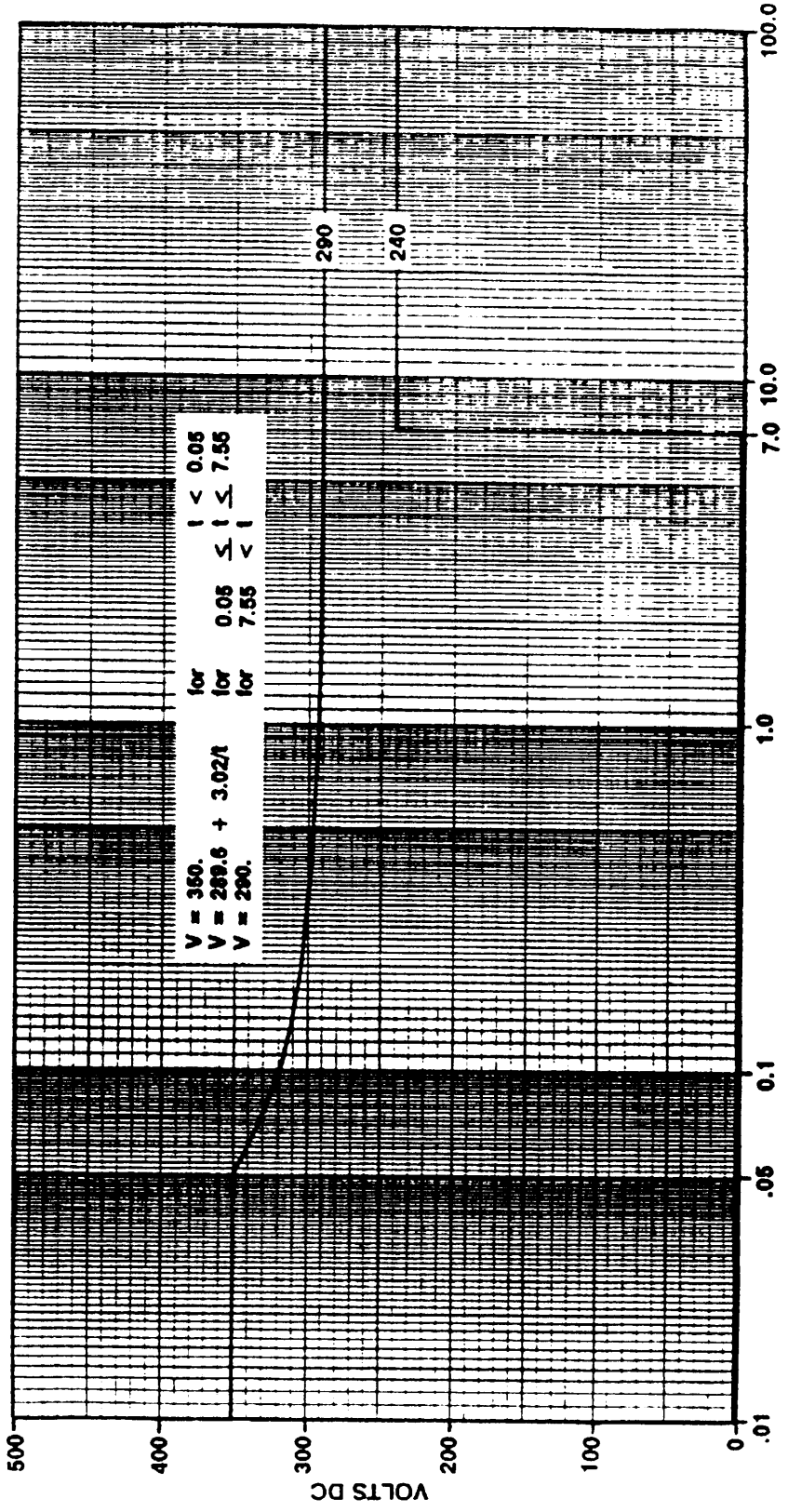

FIGURE 12. Limits for DC overvoltage or undervoltage for 270 volts DC system.

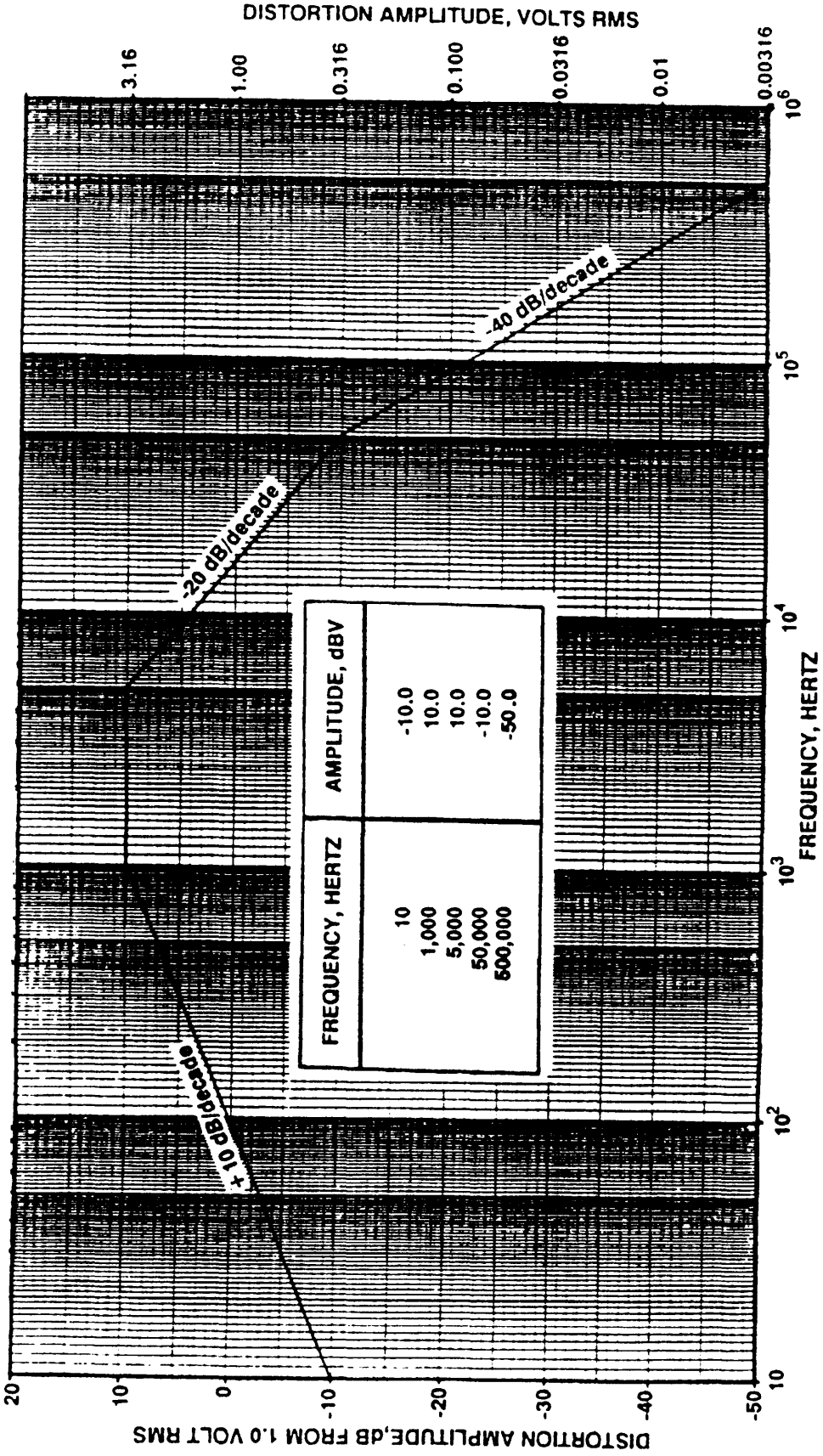

FIGURE 13. Maximum distortion spectrum for 270 volts DC system.

Custodians:
Army - AV
Navy - AS
Air Force - 11

Preparing Activity:
Navy - AS

Review Activities
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Navy - YD, EC, SH
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1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-STD- 704E	AIRCRAFT ELECTRIC POWER CHARACTERISTICS

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
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	☐ USER
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ MANUFACTURER
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a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

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