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MILITARY STANDARD

AIRCRAFT ELECTRIC POWER CHARACTERISTICS

FSC MISC

DEPARTMENT OF DEFENSE
Washington, DC 20301

AIRCRAFT ELECTRIC POWER CHARACTERISTICS

MIL-STD-704D

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2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commanding Officer, Naval Air Engineering Center, Engineering Specifications and Standards Department (Code 93), Lakehurst, New Jersey 08733 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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*1. SCOPE

This standard establishes requirements for conducted electric power characteristics on aircraft at the interface between the electric power system and the input to electric utilization equipment.

1.1 Purpose. The purpose of this standard is to insure compatibility between aircraft electric systems or ground support electric systems and airborne utilization equipment.

*2. REFERENCED DOCUMENTS

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

* SPECIFICATION

* MILITARY

* MIL-E-6051 Electromagnetic Compatibility Requirements, Systems

* (Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. DEFINITIONS

3.1 AC voltage. The term ac voltage refers to the gross, root mean square (rms) phase to neutral value unless otherwise designated.

3.2 Crest factor. The crest factor of the ac voltage waveform is defined as the ratio of the peak to the rms value.

3.3 Distortion. AC distortion is the rms value of the ac waveform exclusive of the fundamental. AC distortion includes the components resulting from amplitude modulation as well as harmonic and non-harmonic components. In a dc system, distortion is the rms of the superimposed alternating voltage.

3.3.1 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 average dc voltage.

3.3.2 Distortion spectrum. The distortion spectrum quantifies ac distortion and 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 ac waveform.

* 3.4 Emergency operation. The emergency operation is that condition of the electric system whereby a limited electric source, independent of the main generation equipment, is used to power a selected, reduced complement of distribution and utilization equipment.

* 3.5 Frequency. Frequency is equal to the reciprocal of the alternation period of the ac voltage. The unit of frequency is the number of alternations per second of the ac voltage and is designated hertz (Hz).

3.5.1 Frequency drift. Frequency drift is the slow and random variation of the controlled frequency level within steady state limits due to such influences as environmental effects and aging.

3.5.1.1 Frequency drift rate. The frequency drift rate is the time rate of frequency change due to frequency drift.

* 3.5.2 Steady state frequency deviation. Steady state frequency deviation is defined as difference between maximum and minimum values of 1/T, where T is the period of one alternation of the fundamental of the phase voltage. The reciprocal of the interval at which 1/T values repeat is defined as the frequency deviation change rate.

3.5.3 Frequency transient. The frequency transient is the locus of values defined by the reciprocals of sequential alternation periods of the ac voltage, in instances when the frequency departs from the steady-state value.

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

3.6 Normal operation. Normal operation is that condition wherein the electric system is operating as intended in the absence of any fault or malfunction which degrades performance below established requirements. It includes all system functions required by all phases of aircraft operation except during the electrical starting of the propulsion engines when required. Normal operating conditions include switching of utilization equipment, engine speed changes, synchronizing and paralleling of power sources, and operation from external ground power. Although transfer operation as defined herein is a normal characteristic of most electric systems, it is treated as a separate operating condition in this standard because of the power interruption which it usually produces.

3.7 Abnormal operation. Abnormal operation is that condition of the electric system wherein a malfunction or failure in the aircraft electric system has taken place and the protective devices of the aircraft electric system are operating to remove the malfunction or failure from the remainder of the system before the limits for abnormal operation are exceeded.

* 3.8 Ripple amplitude. The ripple amplitude is the maximum value of the difference between the average and the instantaneous values of a pulsating unidirectional wave.

3.9 Starting operation. The electric starting operation is that condition of the aircraft electric system, which occurs during the electric starting of the propulsion engines of certain aircraft. This condition results in power characteristics that exceed the limits for normal operation, due to the aircraft high electric starting load.

3.10 Steady state. A steady state condition of the characteristics is one in which the characteristic shows only negligible change throughout an arbitrarily long period of time.

3.11 Transfer operation. The transfer operation is that condition of the electric system which takes place when a transfer is taking place between power sources, including transfers from or to external power sources.

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

* 3.12.1 Utilization equipment terminals. Utilization equipment terminals are the terminals through which the electric power system is connected to the utilization equipment. Power interconnections within the utilization equipment or equipment system are excluded.

3.13 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 or dc level crossings of their instantaneous values traced in the negative to positive direction.

3.14 Voltage unbalance. Voltage unbalance is defined as the maximum difference among phase voltage magnitudes at the utilization equipment terminals.

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

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 the electric power characteristics as specified in this standard at the utilization equipment terminals during all operations of the power system including operations from externally supplied power sources but excluding periods of electrical starting of the propulsion engines.

4.2 Aircraft utilization equipment requirements.

4.2.1 Normal operation. When supplied electric power characteristics as stated herein for normal operation, each utilization equipment shall provide the full performance required by its specification.

4.2.2 Abnormal or transfer operation. When supplied electric power characteristics as stated herein for abnormal or transfer operation, each utilization equipment:

a. shall be permitted a degradation or loss of function unless required otherwise by its specification, and

b. shall not produce a damaging or unsafe condition, and

c. shall automatically recover full specified performance when the electric power characteristics are restored to the normal operation limits herein.

4.2.3 Starting operation or emergency operation. When the detail specification for the utilization equipment requires operation during starting operation or emergency operation, then the utilization equipment shall provide the full performance required by its detail specification when supplied electric power characteristics as stated herein for starting operation or emergency operation.

4.2.4 Partial power failure. The failure of one or more phases of ac power or the loss of power to any input terminals of equipment which require ac and dc power shall not result in an unsafe condition.

4.2.5 AC phase power utilization. Loads greater than 0.5 KVA utilizing ac power shall be configured to utilize 3-phase steady state balanced power within the limits of Figure 1. Single phase power shall be used only on a line-to-neutral basis.

* 4.3 External power source requirement. The external electric power source shall provide the electrical power characteristics as specified in this standard at the power input connections of the aircraft electric utilization equipment during all operations from external power with the steady state voltage drop between the aircraft external power receptacle and the aircraft utilization equipment terminals as follows:

(1) AC feeder voltage drop of 0 to 5 volts.
(2) DC feeder voltage drop of 0 to 2 volts.

5. DETAIL REQUIREMENTS

5.1 Transfer performance characteristics. Under conditions of bus or power source transfers, voltage shall be between zero volts and normal electric system operation characteristics for no longer than 50 milliseconds.

5.2 AC power characteristics.

5.2.1 Type system. AC power characteristics are those of a single-phase or three-phase wye-connected neutral or ground return system having a nominal voltage of 115/200 volts and a nominal frequency of 400 Hz. The only alternate standard is a nominal 230/400 volts when specifically authorized. The voltage magnitude limits for the 115/200 volts standard shall apply proportionally to the 230/400 volts standard. The power characteristics specified herein can take place on each phase independent of other phases unless otherwise specified.

5.2.2 Phase sequence. The phase sequence shall be A-B-C corresponding to aircraft wire designations, see Figure 2.

5.2.3 AC normal operation characteristics.

5.2.3.1 AC steady state characteristics. The ac steady state characteristics shall be in accordance with Table I.

5.2.3.2 AC transient characteristics.

5.2.3.2.1 AC voltage transients. The ac voltage transients shall be within the limits of Figure 5.

5.2.3.2.2 AC frequency transient.

5.2.3.2.2.1 Transient limits. The ac frequency transients shall be within the limits of Figure 6.

5.2.4 AC abnormal operation characteristics.

5.2.4.1 AC overvoltage and undervoltage. The ac overvoltage and undervoltage values shall be within the limits of Figure 7.

5.2.4.2 AC overfrequency and underfrequency. The ac overfrequency and underfrequency values shall be within the limits of Figure 8.

5.2.5 AC emergency operation. All aircraft electric power characteristics in ac emergency operation shall be the same as for normal operation except for steady state voltage and steady state frequency.

5.2.5.1 AC emergency steady state voltage. The ac steady state voltage in the emergency operation shall be within 104 to 122 volts.

5.2.5.2 AC emergency steady state frequency. The ac steady state frequency in the emergency operation shall be within 360 to 440 hertz.

5.3 DC power characteristics.

5.3.1 Type system. DC power characteristics are those of a direct current, two-wire or ground return system having a nominal voltage of 28 volts. The only alternative standard is a nominal 270 volts when specifically authorized.

5.3.2 DC normal operation characteristics. The dc normal operation characteristics shall be in accordance with Table II.

5.3.3 DC abnormal operation characteristics.

5.3.3.1 28 volts system. The dc overvoltage and undervoltage values for the 28 volts (nominal) dc system shall be within the limits of Figure 12.

5.3.3.2 270 volts system. The dc overvoltage and undervoltage values for the 270 volts (nominal) dc system shall be within the limits of Figure 13.

5.3.4 DC emergency or steady state voltage.

5.3.4.1 28 volts (nominal) dc system. The dc steady state voltage in the emergency operation shall be within 16.0 to 29.0 volts.

5.3.4.2 270 volts (nominal) dc system. The dc steady state voltage in the emergency operation shall be within 240 to 290 volts.

5.3.5 DC electric starting operation. The dc voltage in electric starting operation shall be within 12.0 to 29.0 volts.

6. NOTES

The material in this section is not a mandatory part of this standard.

6.1 Supersession data. This issue of MIL-STD-704D 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 equipment. 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 international standardization agreements: NATO STANAG 3456 and ASCC Air Standard 12/10. 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. The margins of this revision are marked with an asterisk to indicate where changes (additions, modifications, corrections, deletions) from the previous revision were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous revision .

Custodians:
Army - AV
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Reviewer activities:
Navy - YD, EC, SH
Army - CR, ER, MI, TE

User activities:
Navy - MC

Preparing activity:
Navy - AS
(Project No. MISC-0B92)

Table I.

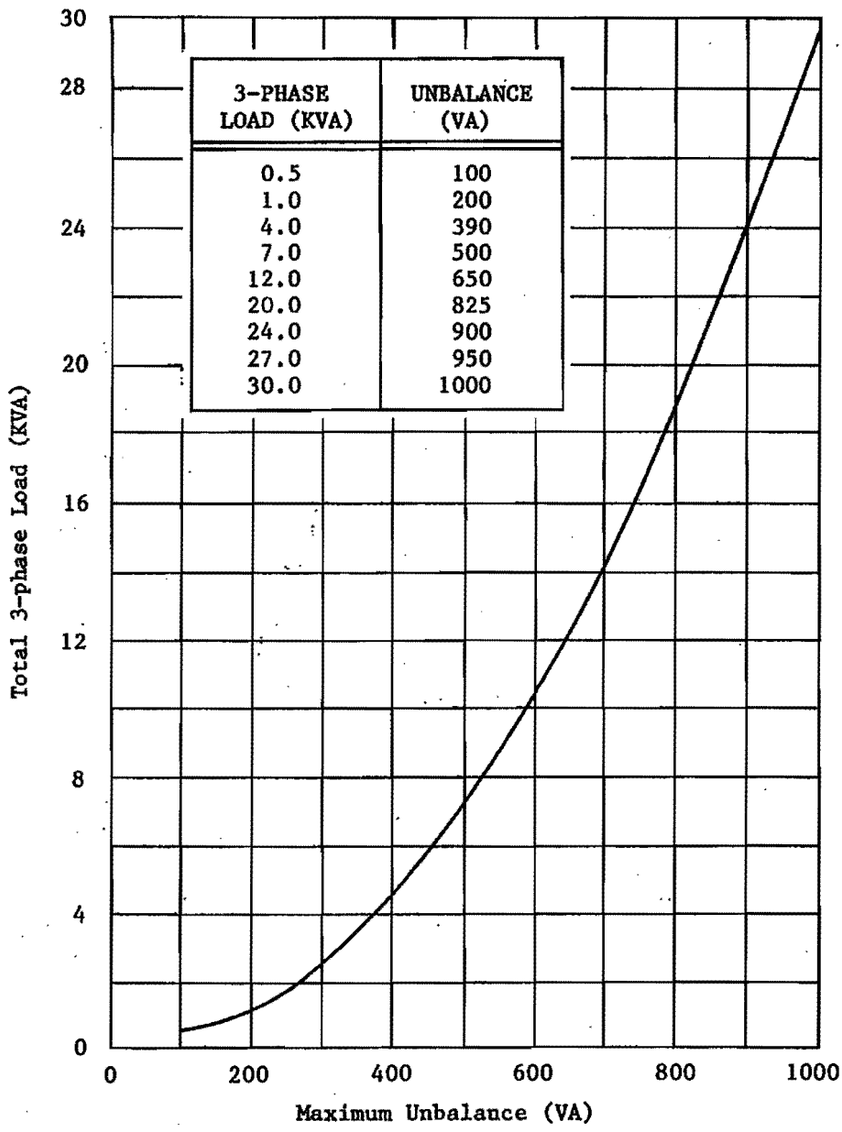
AC Normal Operation Steady State Characteristics (See 5.2.3.1)

Characteristics	Limits
Voltage	108.0 to 118.0 volts
Voltage unbalance	3 volts maximum
Voltage phase difference	116° to 124°
Waveform distortion factor	0.05 maximum
Waveform distortion spectrum	Figure 3
Crest factor	1.31 to 1.51
DC component	+0.10 to -0.10 volts
Frequency	393 to 407 hertz
Frequency deviation	Figure 4
Frequency drift rate	15 hertz per minute maximum

Table II.

DC Normal Operation Characteristics (See 5.3.2)

Characteristics	Limits	
	28 volts (nominal) DC system	270 volts (nominal) DC system
Steady state voltage	22.0 to 29.0 volts	250 to 280 volts
Distortion factor	0.035 maximum	0.008 maximum
Distortion spectrum	Figure 9	Figure 9
Ripple amplitude	1.5 volts maximum	6.0 volts maximum
Voltage transient	Figure 10	Figure 11



3-PHASE LOAD (KVA)	UNBALANCE (VA)
0.5	100
1.0	200
4.0	390
7.0	500
12.0	650
20.0	825
24.0	900
27.0	950
30.0	1000

Figure 1. Unbalance Limits for 3-Phase Utilization Equipment (See 4.2.5)

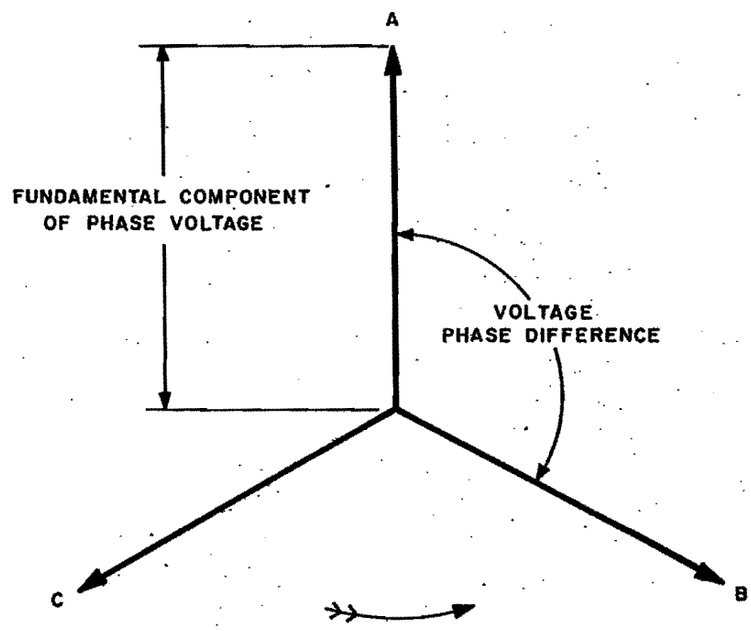


Figure 2. Phasor Diagram Showing Required Phase Sequence Relationship (See 5.2.2)

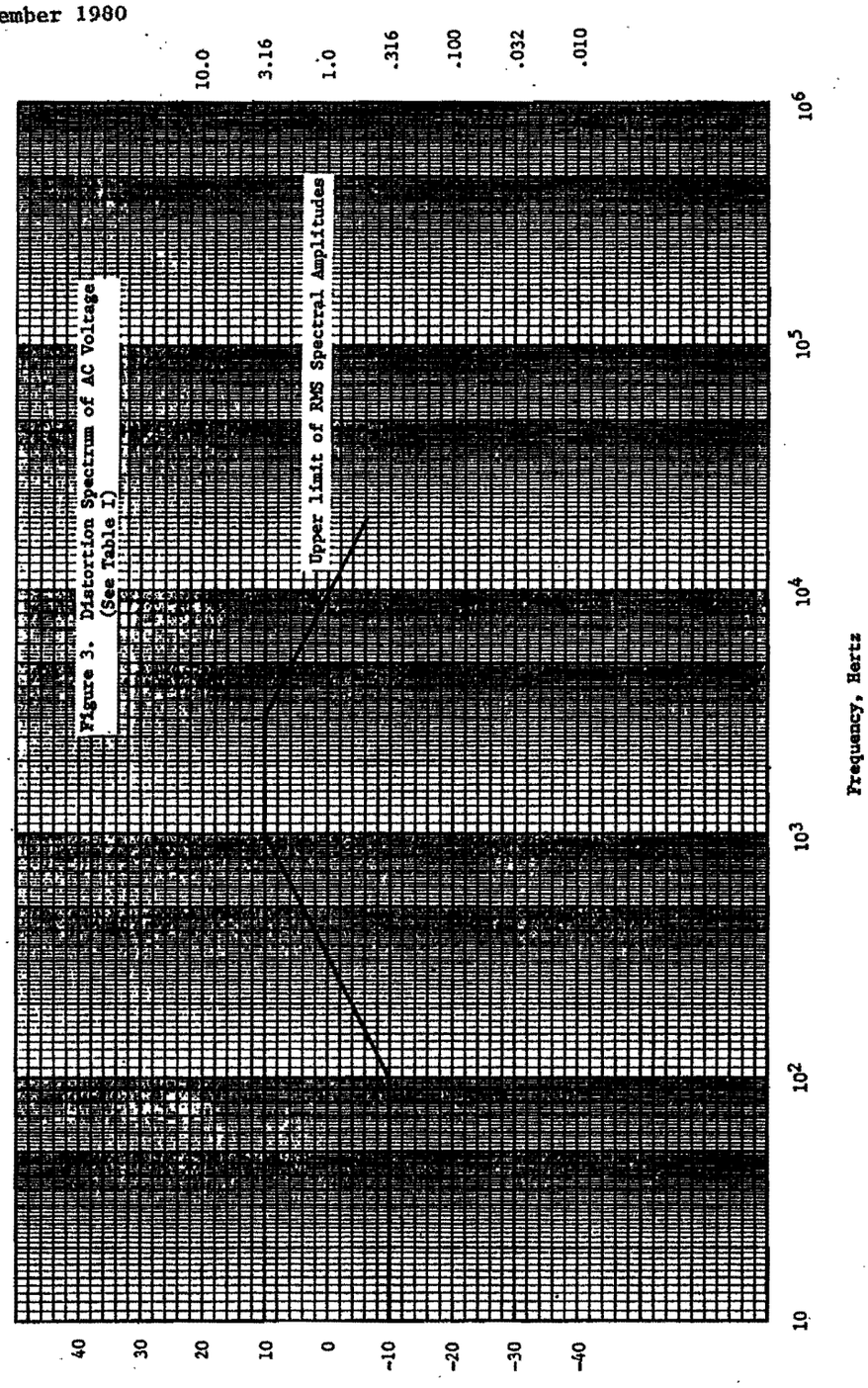


Figure 3. Distortion Spectrum of AC Voltage (See Table I)

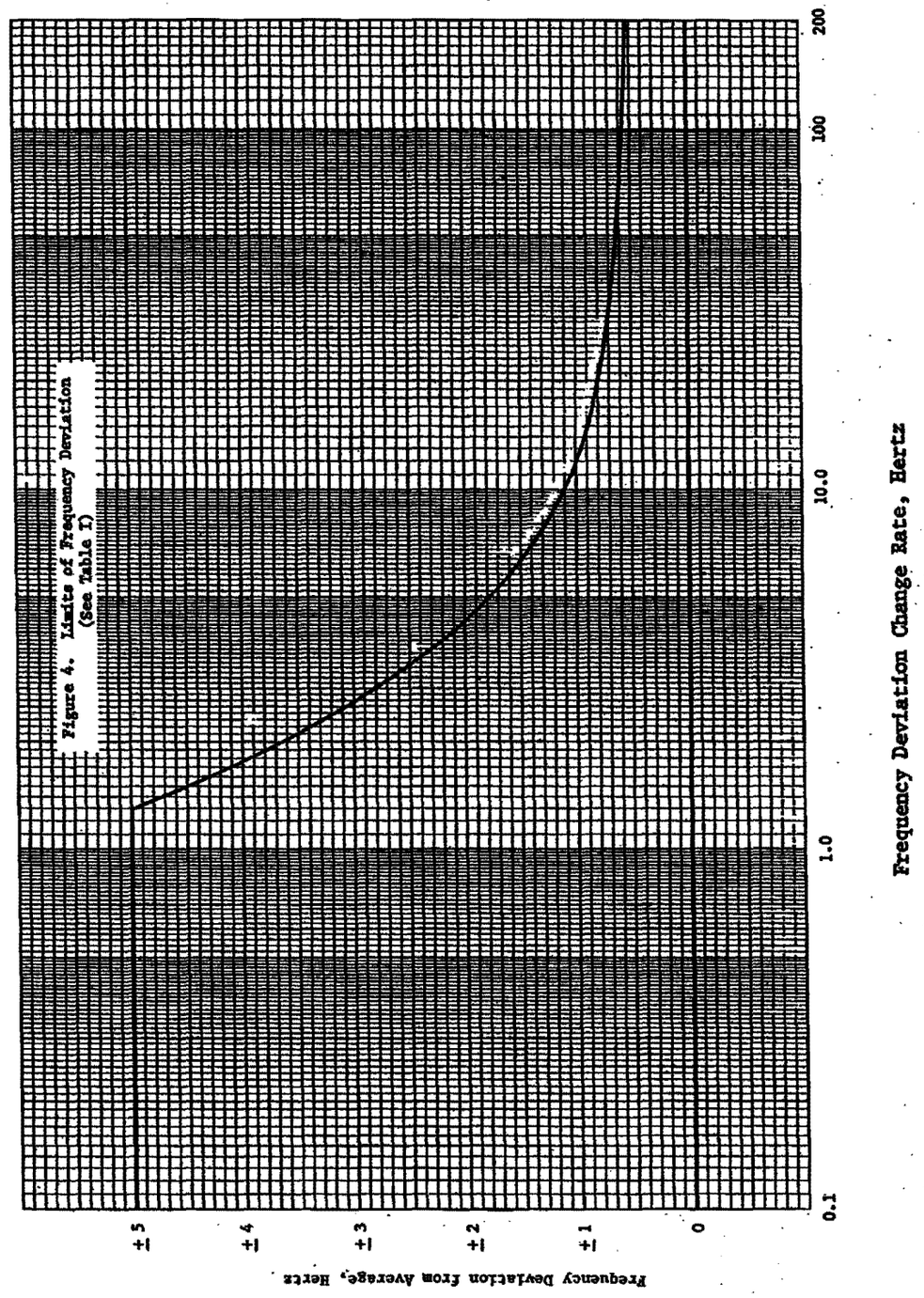


Figure 4. Limits of Frequency Deviation (See Table I)

*

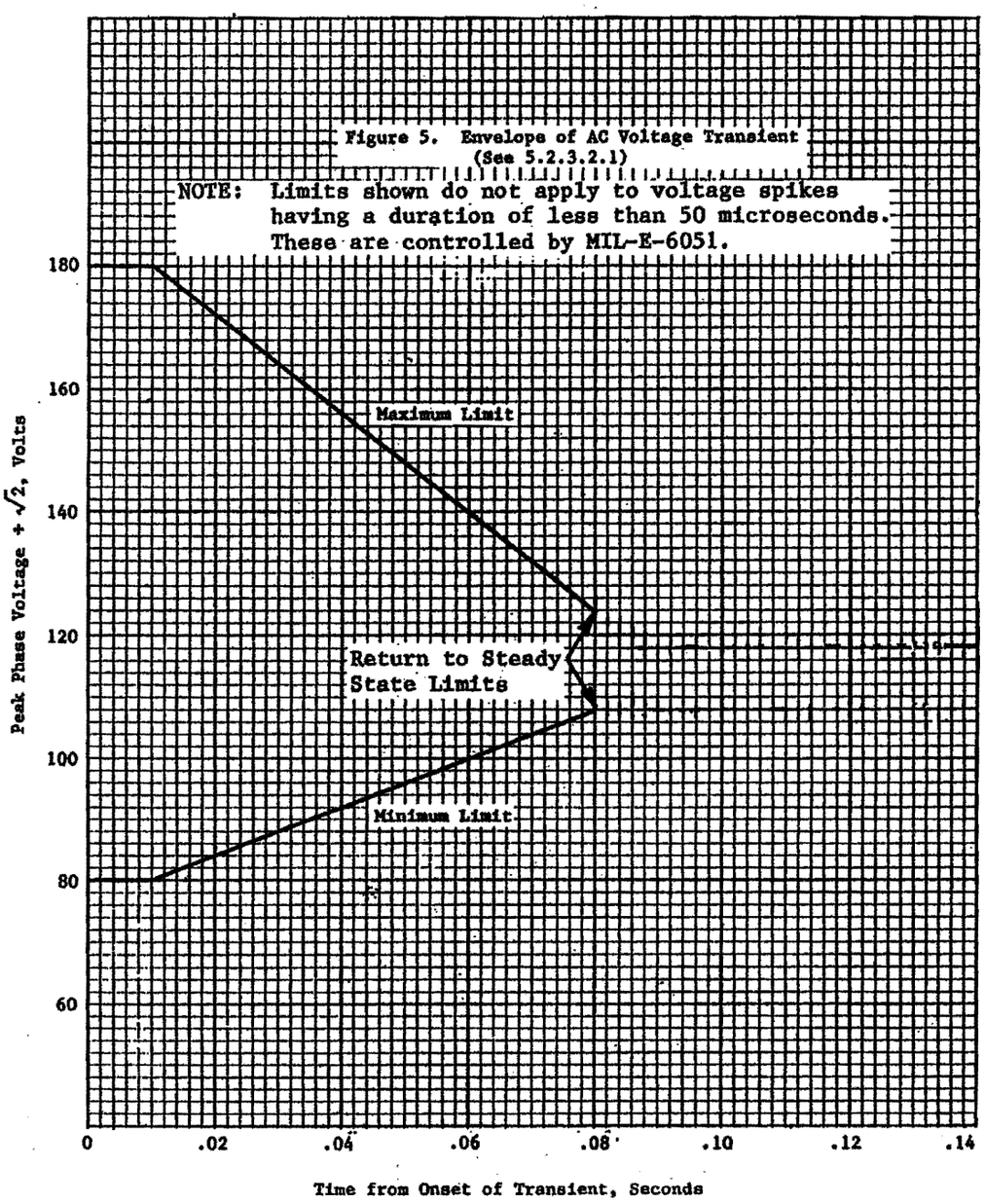


Figure 5. Envelope of AC Voltage Transient (See 5.2.3.2.1)

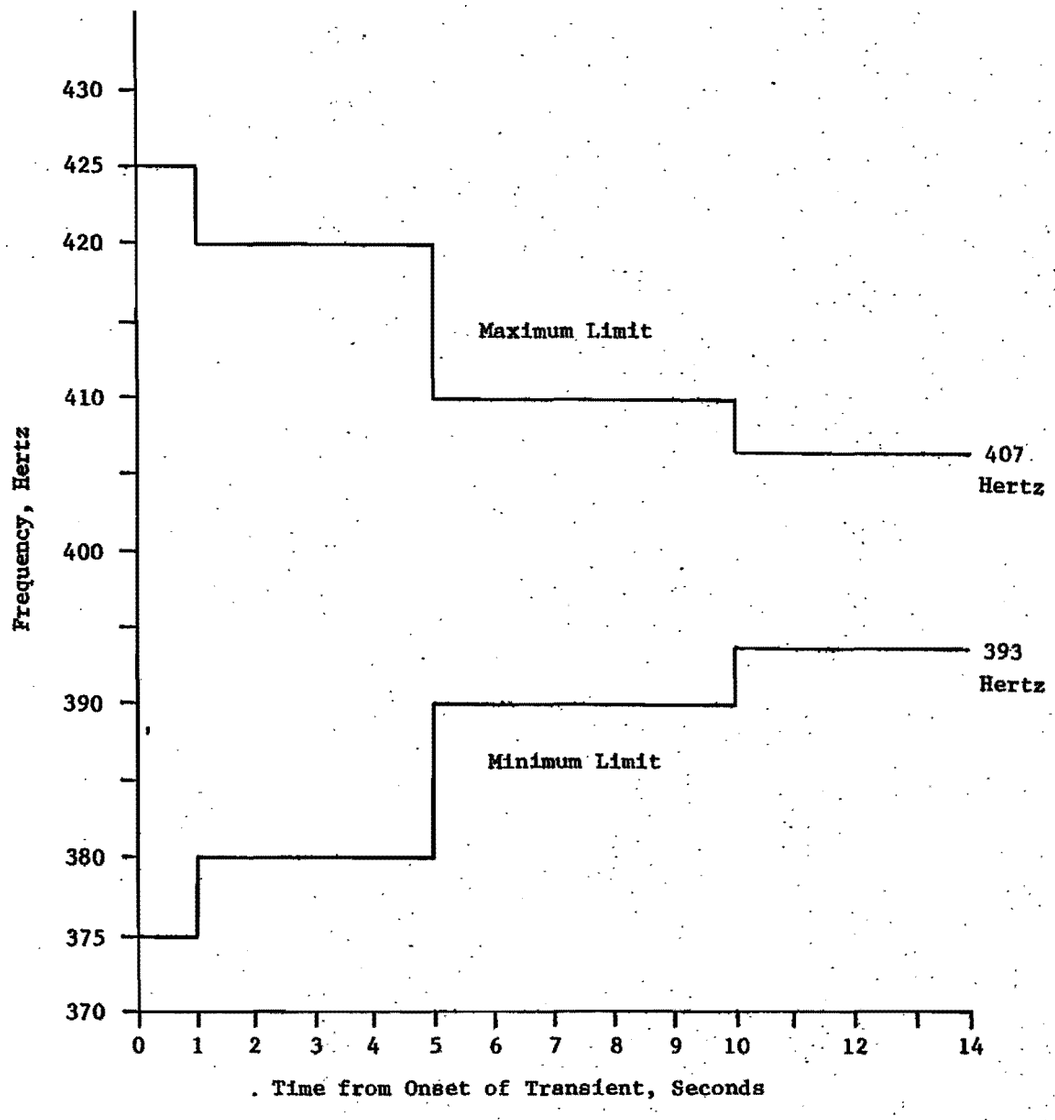


Figure 6. Envelope of AC Frequency Transient
(See 5.2.3.2.2.1)

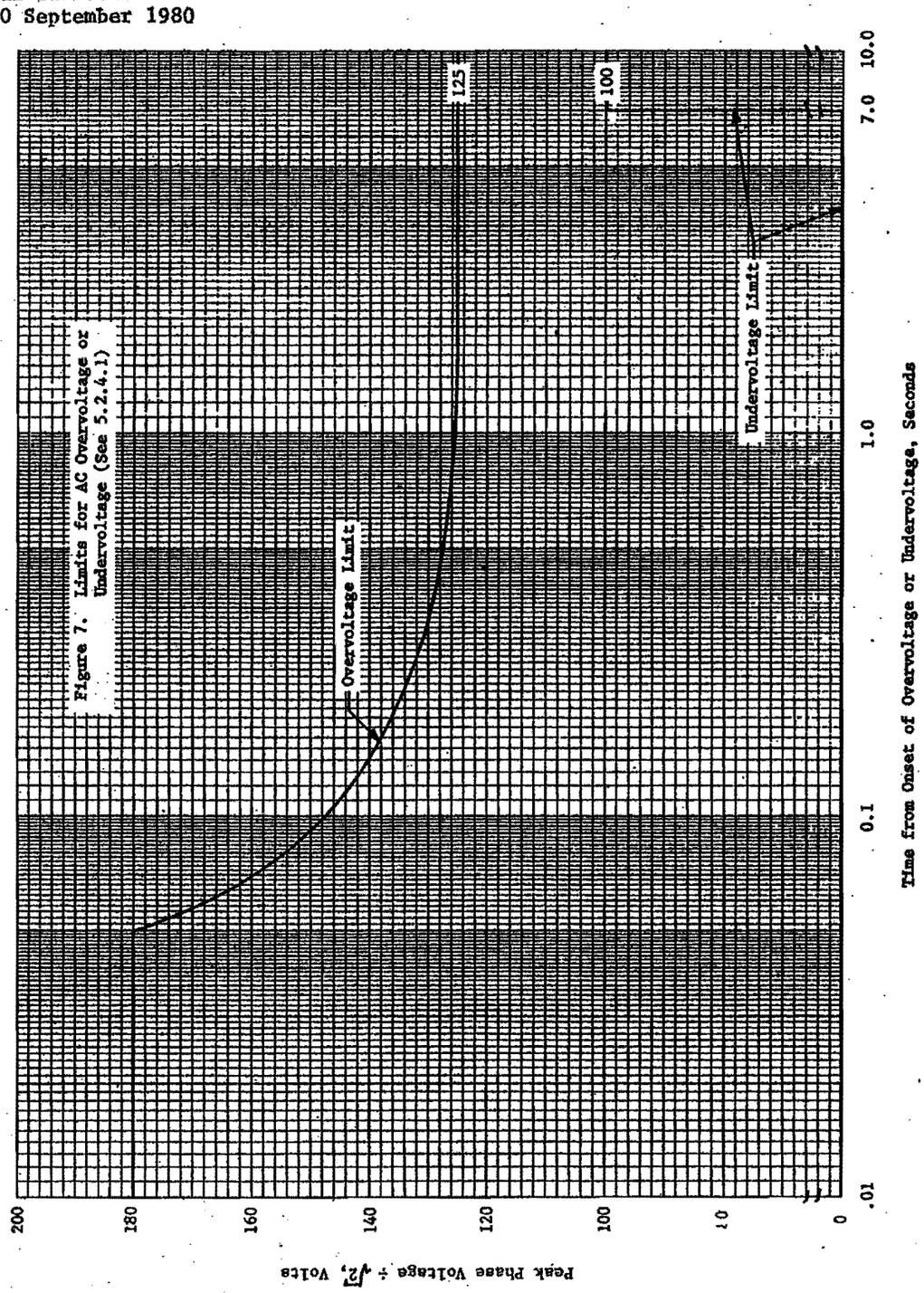


Figure 7. Limits for AC Overvoltage or Undervoltage (See 5.2.4.1)

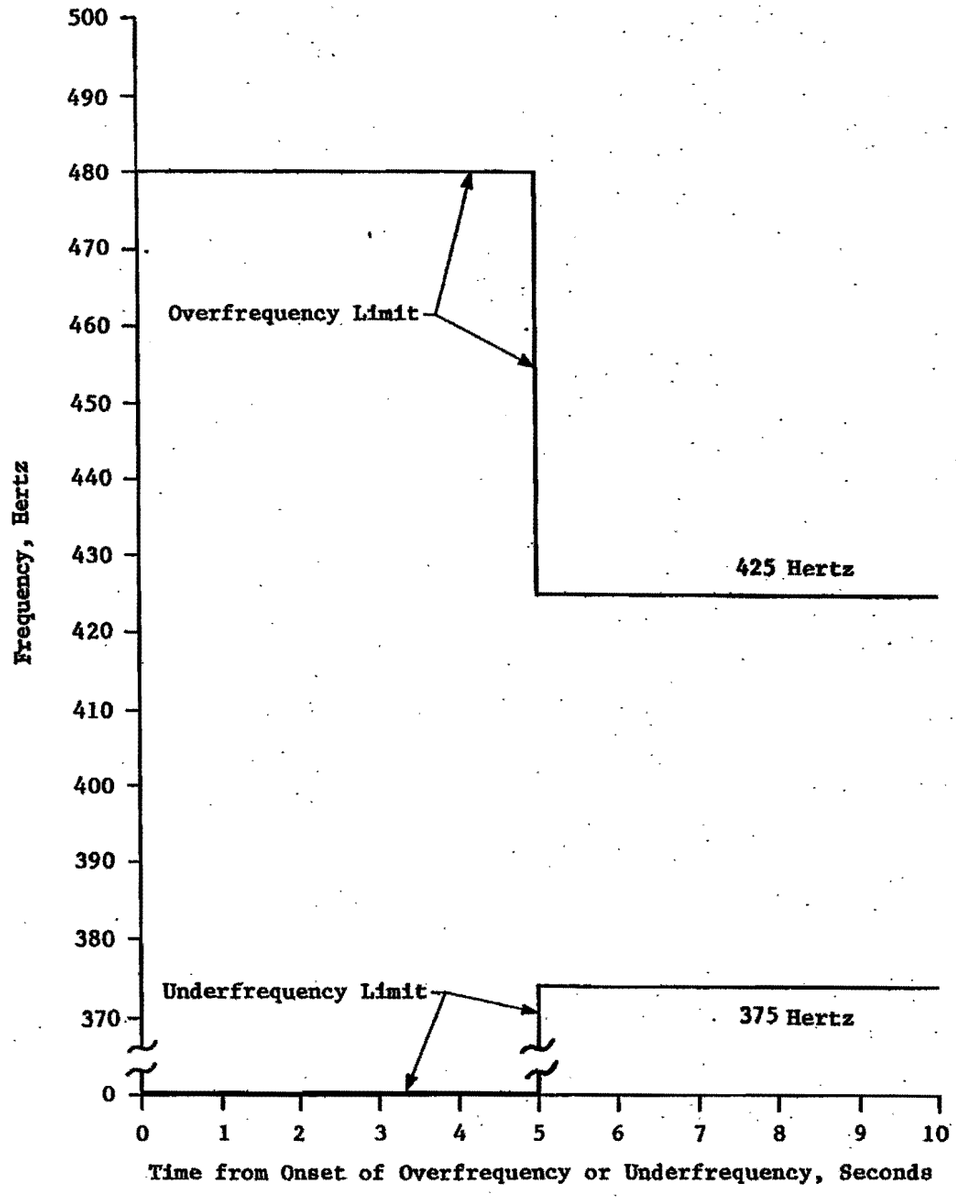


Figure 8. Limits for AC Overfrequency or Underfrequency (See 5.2.4.2)

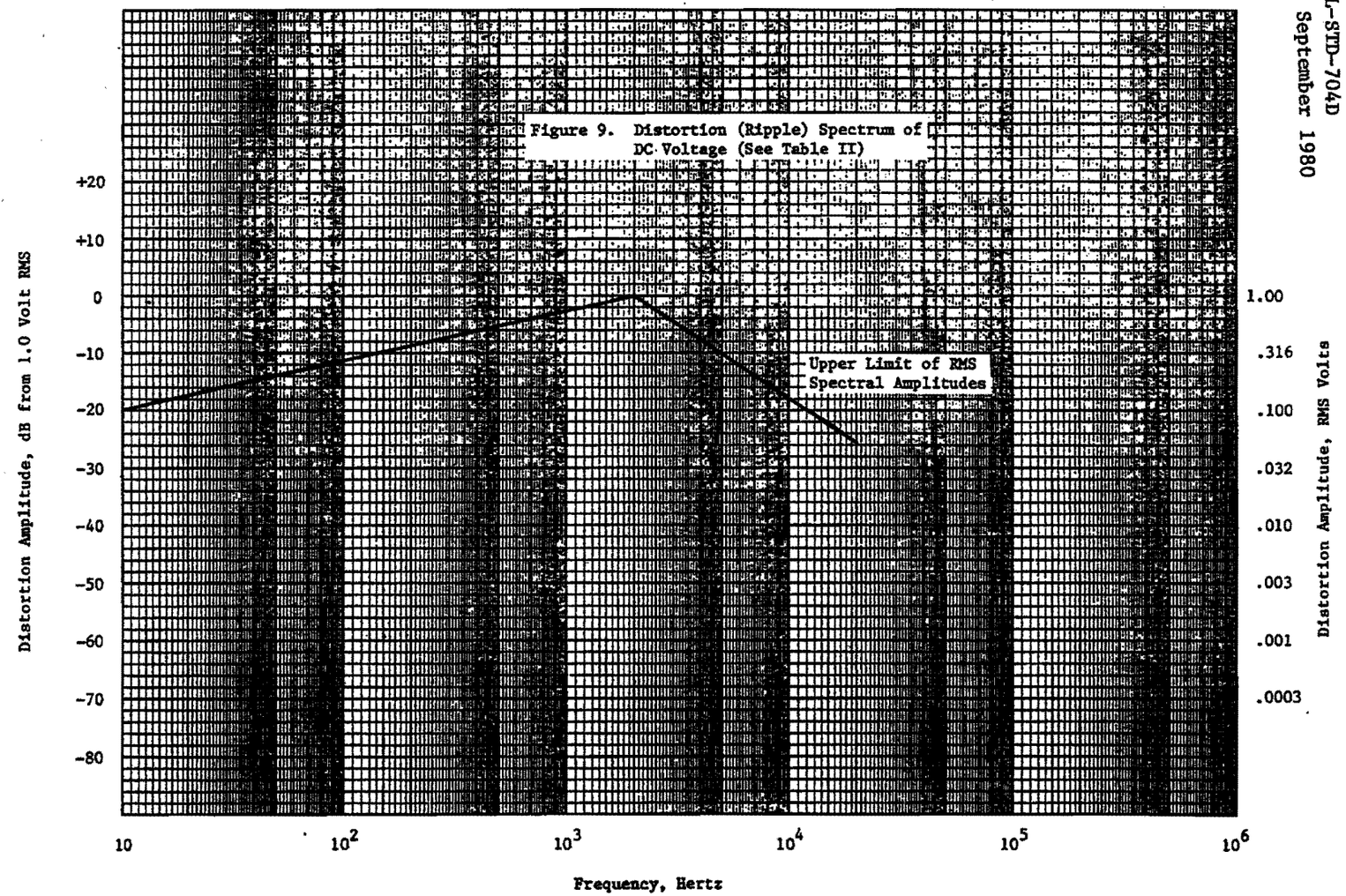


Figure 9. Distortion (Ripple) Spectrum of DC Voltage (See Table II)

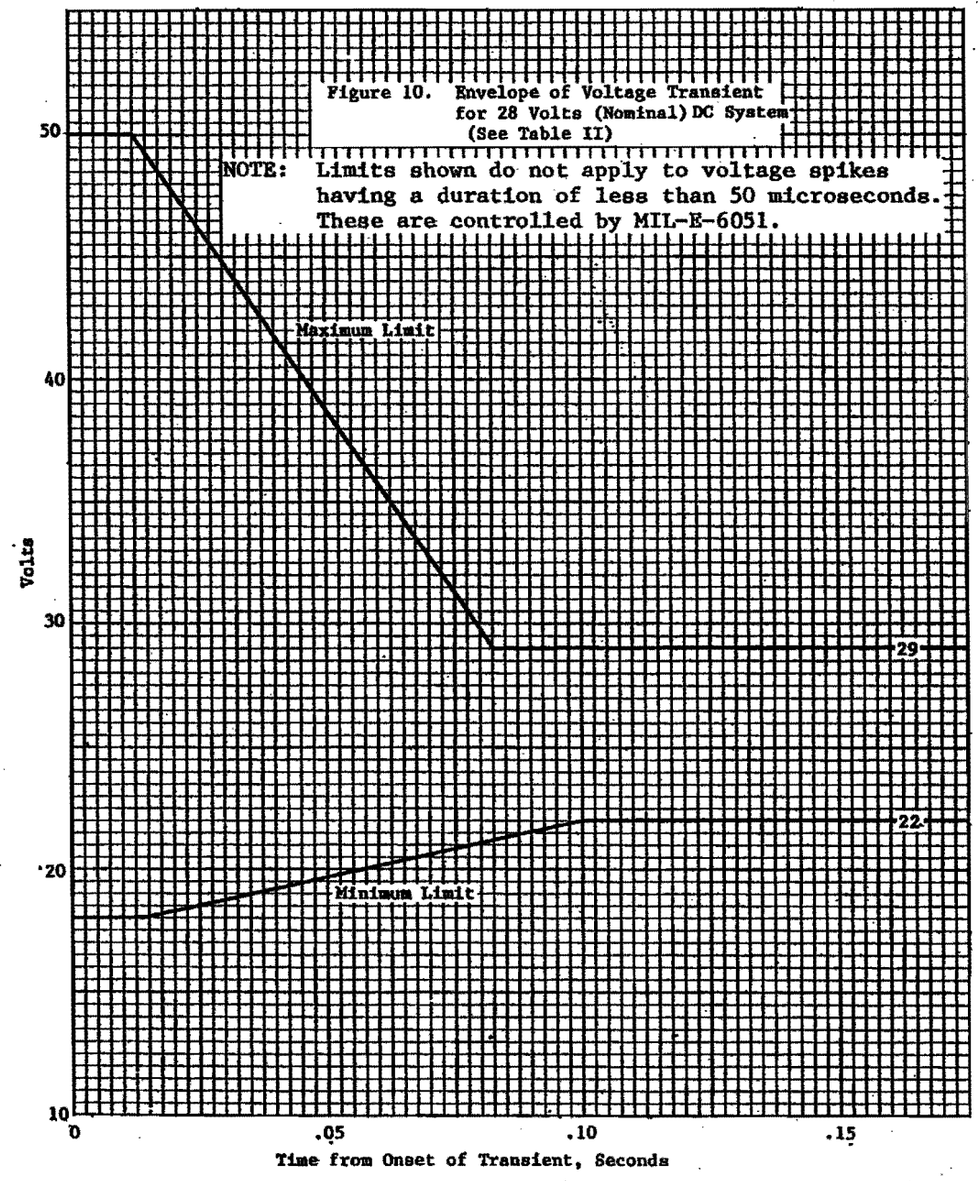


Figure 10. Envelope of Voltage Transient for 28 Volts (Nominal) DC System (See Table II)

* NOTE: Limits shown do not apply to voltage spikes having a duration of less than 50 microseconds. These are controlled by MIL-E-6051.

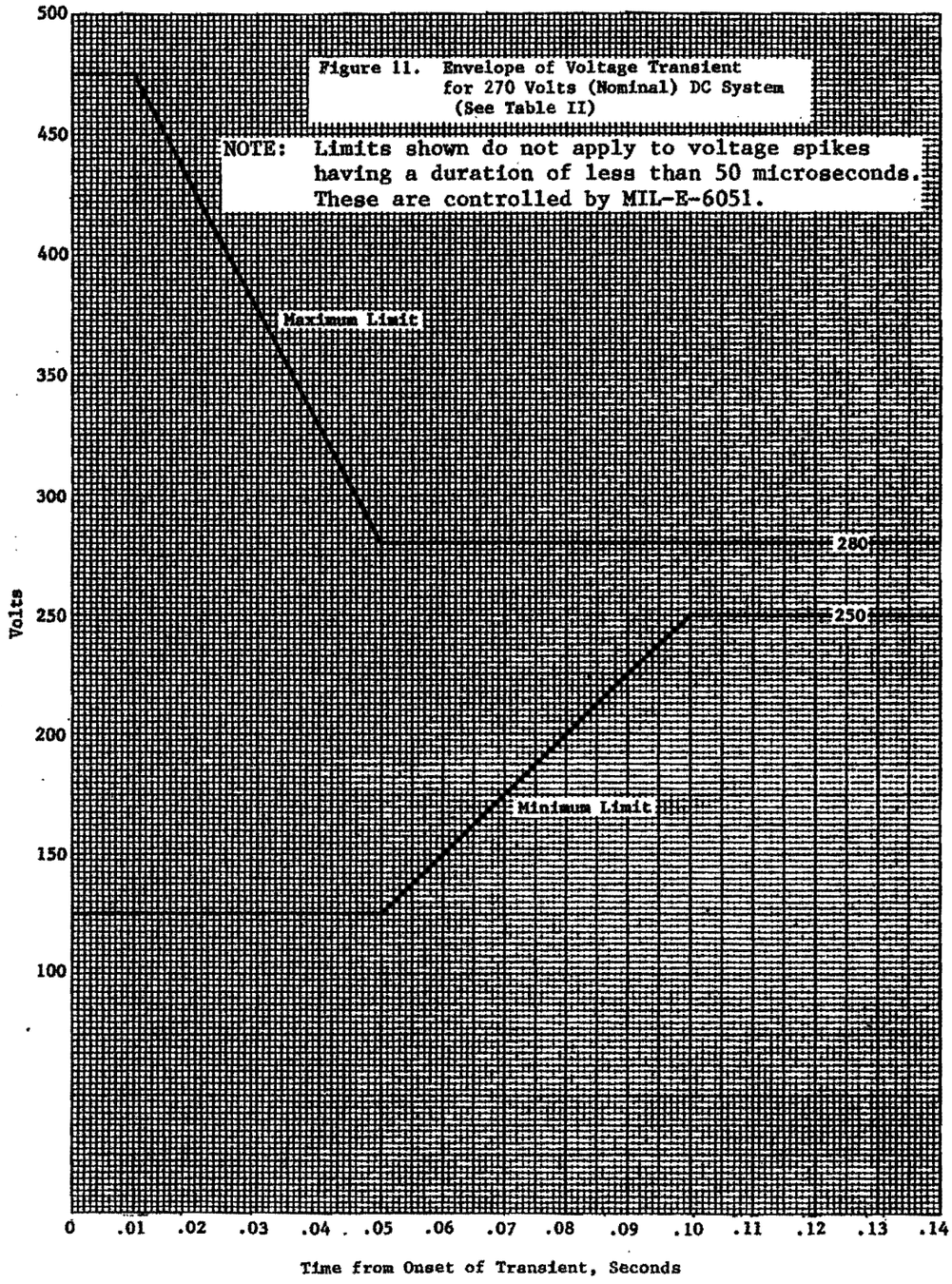


Figure 11. Envelope of Voltage Transient for 270 Volts (Nominal) DC System (See Table II)

* NOTE: Limits shown do not apply to voltage spikes having a duration of less than 50 microseconds. These are controlled by MIL-E-6051.

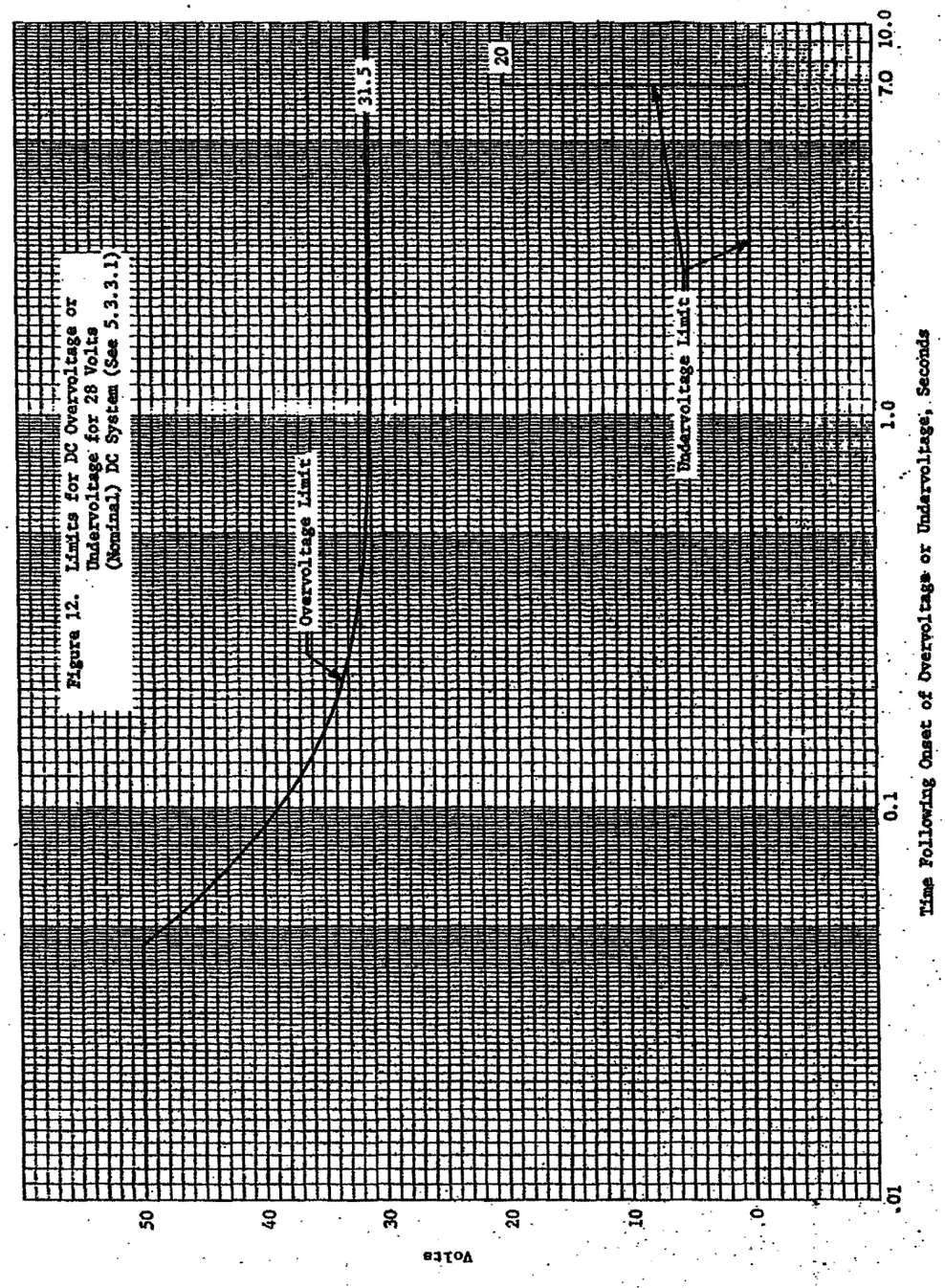


Figure 12. Limits for DC Overvoltage or Undervoltage for 28 Volts (Nominal) DC System (See 5.3.3.1)

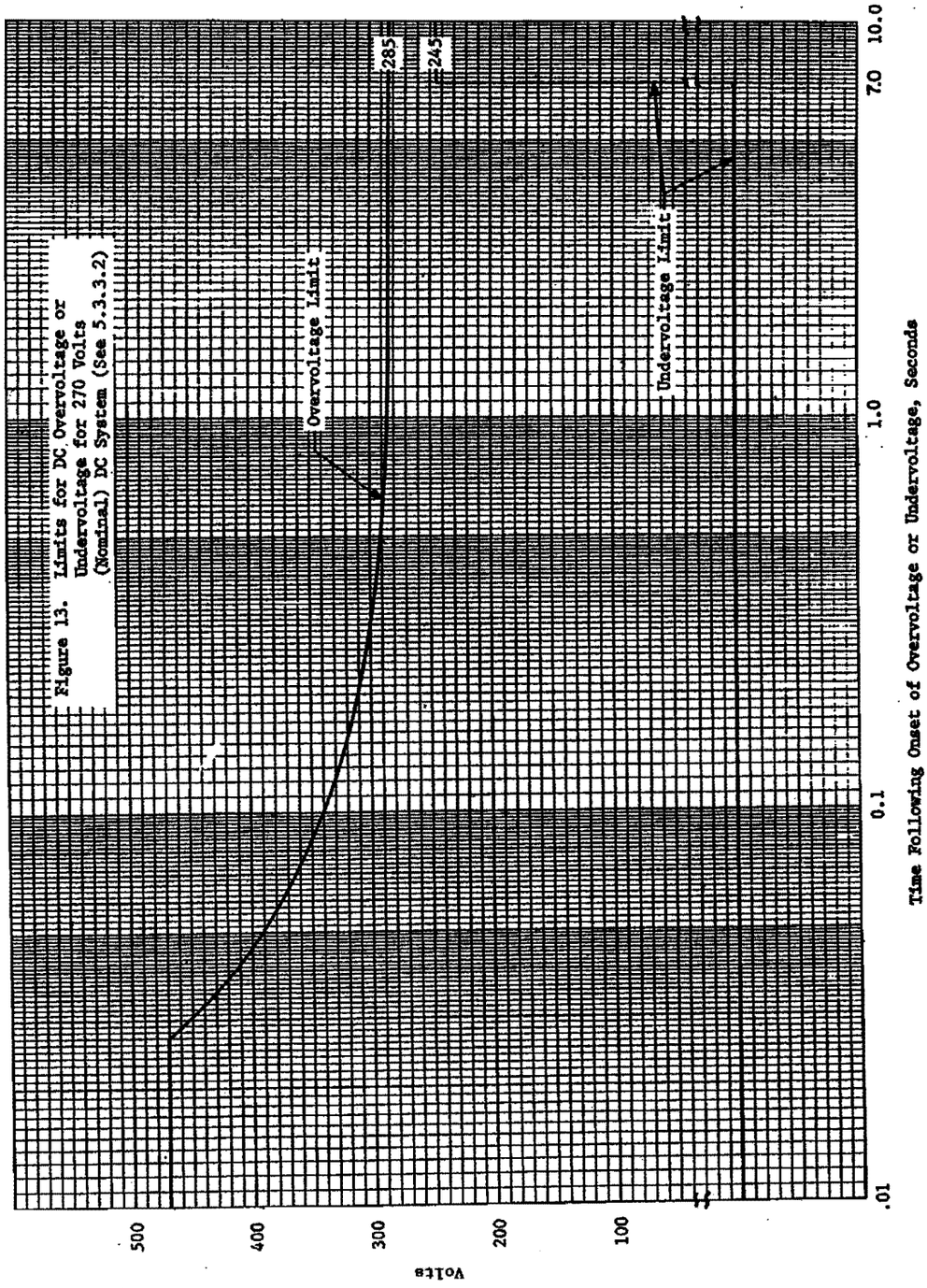


Figure 13. Limits for DC Overvoltage or Undervoltage for 270 Volts (Nominal) DC System (See 5.3.3.2)

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