METRIC
MIL-STD-1275B
20 November 1997
SUPERSEDING
MIL-STD-1275A(AT)
17 September 1976

DEPARTMENT OF DEFENSE
INTERFACE STANDARD

CHARACTERISTICS OF 28 VOLT DC ELECTRICAL SYSTEMS IN MILITARY VEHICLES

AMSC N/A FSC 2920
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FOREWORD

1. This standard is approved for use by all departments and agencies of the Department of Defense.

2. The intent of this document is to provide a standard limiting voltage characteristics of 28 volt direct current (dc) electric circuits on military vehicles.

3. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-E/BLUE, Warren, MI 48397-5000, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

CONTENTS

PARAGRAPH		PAGE
	FOREWORD	ii
1.	SCOPE	1
1.1	Scope	1
2.	APPLICABLE DOCUMENTS	1
2.1	General	1
2.2	Government documents	1
2.2.1	Specifications, standards, and handbooks	1
2.3	Order of precedence	1
3.	DEFINITIONS	2
3.1	General	2
3.1.1	Vehicle power supply system	2
3.1.2	Fault	2
3.1.3	Transients	2
3.1.3.1	Surge	2
3.1.3.2	Spike	2
3.1.4	Steady-state	2
3.1.5	Recovery time	2
3.1.6	Ripple	4
3.1.7	Starting disturbances	5
4.	GENERAL REQUIREMENTS	6
4.1	Temperature conditions	6
4.2	Circuit characteristics point of measurement	6
4.3	Equipment compatibility	6
4.4	Polarity	6
5.	DETAILED REQUIREMENTS	6
5.1	Fault free condition	6
5.1.1	Electromagnetic interference	6
5.1.2	Combined generator-battery power supply	6
5.1.2.1	Steady-state voltage	6
5.1.2.2	Ripple	6
5.1.2.3	Surges	6
5.1.2.4	Spikes	7
5.1.2.5	Starting disturbances	8
5.1.2.5.1	Initial engagement surges	9
5.1.2.5.2	Cranking level	9

CONTENTS

PARAGRAPH		PAGE
5.1.3	Battery only condition	9
5.1.3.1	Steady-state voltage	9
5.1.3.2	Ripple	9
5.1.3.3	Surges	9
5.1.3.4	Spikes	9
5.1.3.5	Starting disturbances	9
5.1.3.5.1	Initial engagement surges	9
5.1.3.5.2	Cranking level	9
5.2	Single fault condition	9
5.2.1	Steady-state voltage	9
5.2.2	Ripple	9
5.2.3	Surges	9
5.2.4	Spikes	11
5.3	Compatibility of power supply system and utilization equipment	11
5.4	Test methods	12
5.4.1	Vehicle electrical system.	12
5.4.2	Vehicle equipment.	12
5.4.2.1	General.	12
5.4.2.2	Spikes exported from equipment.	12
5.4.2.3	Spikes exported into equipment.	15
5.4.2.4	Voltage surges imported into equipment.	15
6.	NOTES	16
6.1	Intended use	16
6.2	Subject term (key word) listing	16
6.3	International interest	16

FIGURES

1.	Illustrative surge with recovery time	3
2.	Enlarged view of ripple.	4
3.	Starting disturbances	5
4.	Loci of surges fault free condition	7
5.	Loci of spikes fault free condition.	8
6.	Loci of surges single fault condition	10
7.	Loci of spikes single fault condition	11
8.	Exported spike test circuit (all equipment)	13
9.	Exported spike test circuit (equipment with remote switch)	13
10.	Imported spike test circuit	14
11.	Imported surge test circuit	14

1. SCOPE

1.1 Scope. This standard covers the limits of transient voltage characteristics and steady state limits of the 28 volt (V) direct current (dc) electric power circuits of military vehicles.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4 and 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirement documents cited in sections 3, 4 and 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-461 - Electromagnetic Interference Characteristics Requirements for Equipment.

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

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, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 General. For the purposes of this standard, the following definitions should apply.

3.1.1 Vehicle power supply system. The generating equipment, storage batteries and distribution equipment normally fitted to the vehicle comprise the power supply system. Power is supplied from this system to the utilization equipment.

3.1.2 Fault. A fault is any malfunction or misoperation of the power supply system or utilization equipment. An unserviceable battery is a single fault. Any non-standard switching sequence is a single fault. A single fault is a relatively common occurrence. A multi-fault occurs rarely (e.g. failure of the battery connection occurring in conjunction with a generator voltage regulator failure).

3.1.3 Transients. Transients are the changing conditions of a characteristic. These usually go beyond the steady-state limits and return to and remain within the steady-state limits within a specified time period. The transient may take the form of either a surge or a spike.

3.1.3.1 Surge. A surge is a variation from the controlled steady-state level of a characteristic, resulting from the inherent regulation of the electric power supply system and remedial action by the regulator, except for battery only operation. Surge may also occur due to the application of loads in the battery only condition.

3.1.3.2 Spike. A spike is a high frequency oscillatory variation from the controlled steady-state level of a characteristic. It results from very high frequency currents of complex wave form produced when reactive loads are switched. An individual spike generally lasts less than 50 micro-seconds but may take up to one millisecond to decay to the steady-state level.

3.1.4 Steady-state. The condition in which circuit values remain essentially constant, occurring after all initial transients or fluctuating conditions have subsided. It is also definitive of the condition where, during normal system operation, only inherent or natural changes occur; (i.e., no fault occurs and no deliberate change is made to any part of the system).

3.1.5 Recovery time. The interval between the time a characteristic deviates from the steady-state limits and the time it returns and remains within the same range (see figure 1).

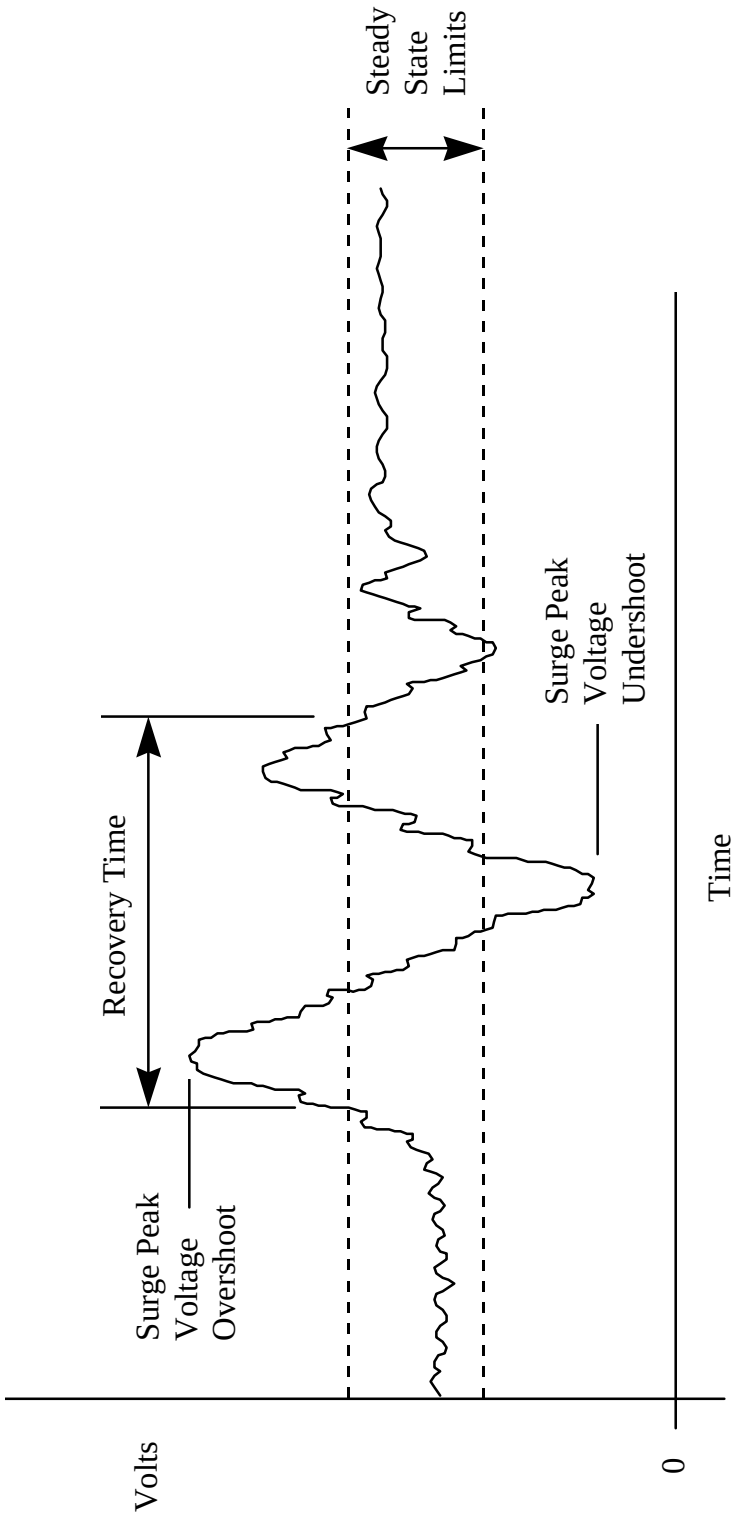


FIGURE1. Illustrative surge with recovery time

3.1.6 Ripple. The regular or irregular variations, or both, of voltage about a fixed dc voltage level during steady-state operation of a dc system. The upper and lower limits of the oscillations are called “upper peak or ripple voltage” and “lower peak of ripple voltage”, respectively (see figure 2).

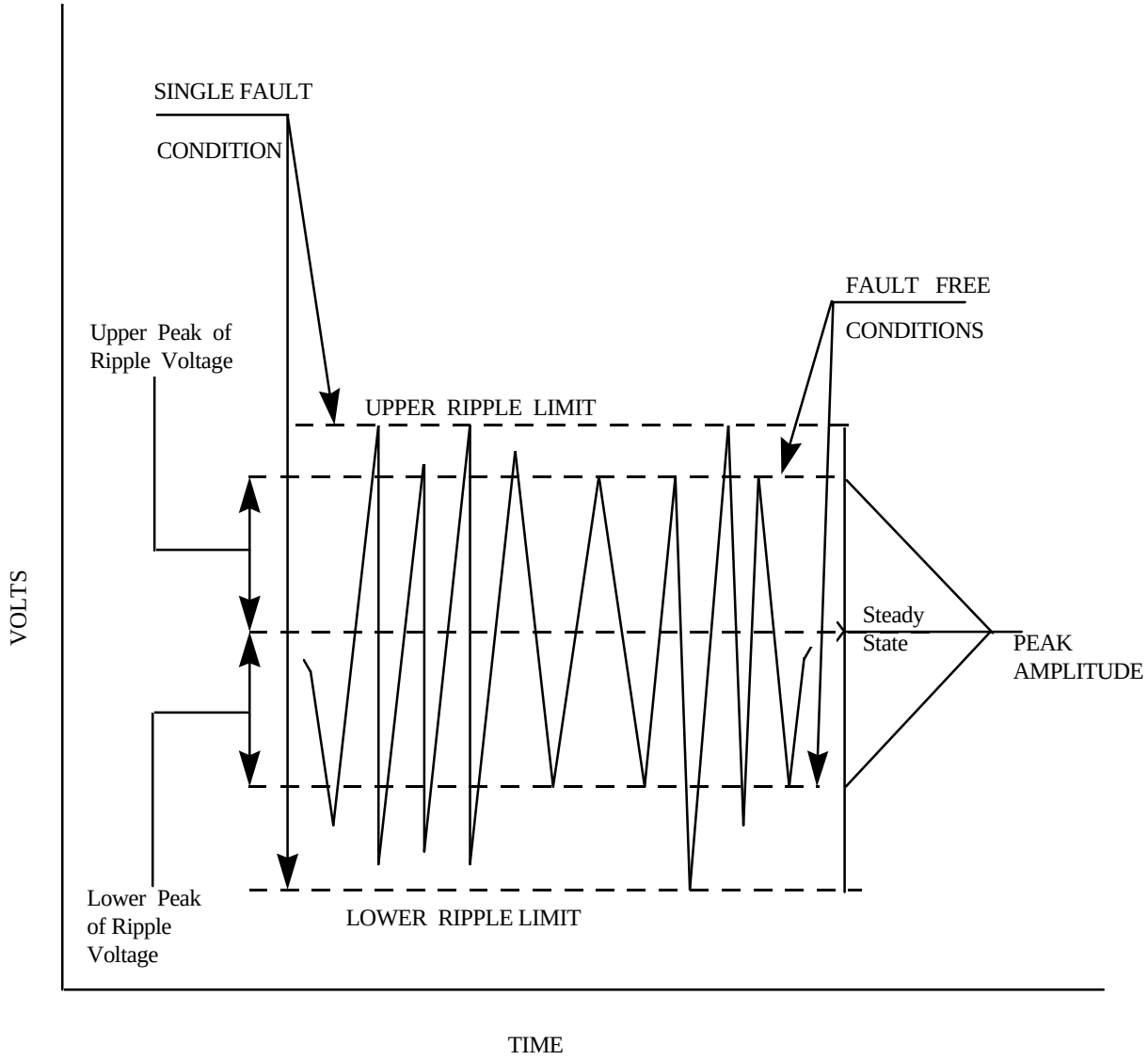


FIGURE 2. Enlarged view of ripple.

3.1.7 Starting disturbances. These are undervoltage variations from the steady-state level and are caused by engine starter engagement and cranking. A typical profile showing “Initial Engagement Surge” (IES) and “Cranking Level” is given in figure 3. The duration of the initial engagement surge is measured from the distant at which it departs from the steady-state value to the instant at which it reaches and remains at the cranking level. The cranking level lasts from the end of the initial engagement surge until the starter is disengaged.

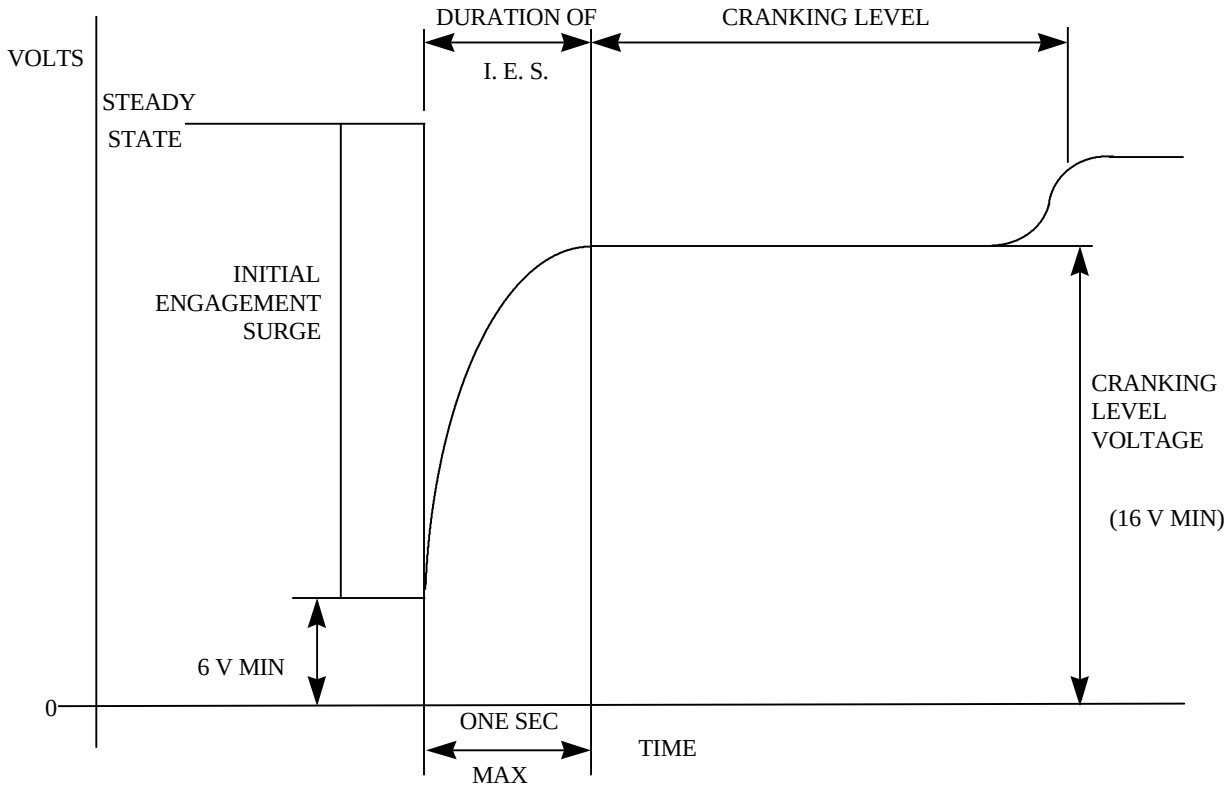


FIGURE 3
STARTING DISTURBANCES

FIGURE 3. Starting disturbances.

4. GENERAL REQUIREMENTS

4.1 Temperature conditions. The limits stated in circuit characteristics shall be determined at the extremes of 52 degrees Celsius (°C) and -32°C.

4.2 Circuit characteristics point of measurement. These characteristics apply at the utilization equipment terminals.

4.3 Equipment compatibility. All electrical equipment shall be able to withstand spikes of up to ±250 V amplitude. Equipment shall provide protection against polarity reversal as a result of slave starting or other improper connection.

4.4 Polarity. The negative of the dc power supply shall be grounded to the vehicle metal structure and this ground shall normally be considered the second conductor of the circuit. When required a supplementary ground wire may be used.

5. DETAIL METHODS

5.1 Fault free condition.

5.1.1 Electromagnetic interference. The equipment of the vehicle power supply system and the utilization equipment shall meet the requirements of MIL-STD-461 for conducted emissions and susceptibility as applicable for the vehicle and type of equipment.

5.1.2 Combined generator-battery power supply.

5.1.2.1 Steady-state voltage. Circuit steady-state voltage shall be between 25 and 30 V.

5.1.2.2 Ripple. The upper and lower peaks of ripple voltage (see figure 2) shall each be less than 2 V. The frequency components of the ripple shall be within the range 50 Hertz (Hz) to 200 kilohertz (kHz).

5.1.2.3 Surges. All surges resulting from system operation shall fall within the loci shown in figure 4.

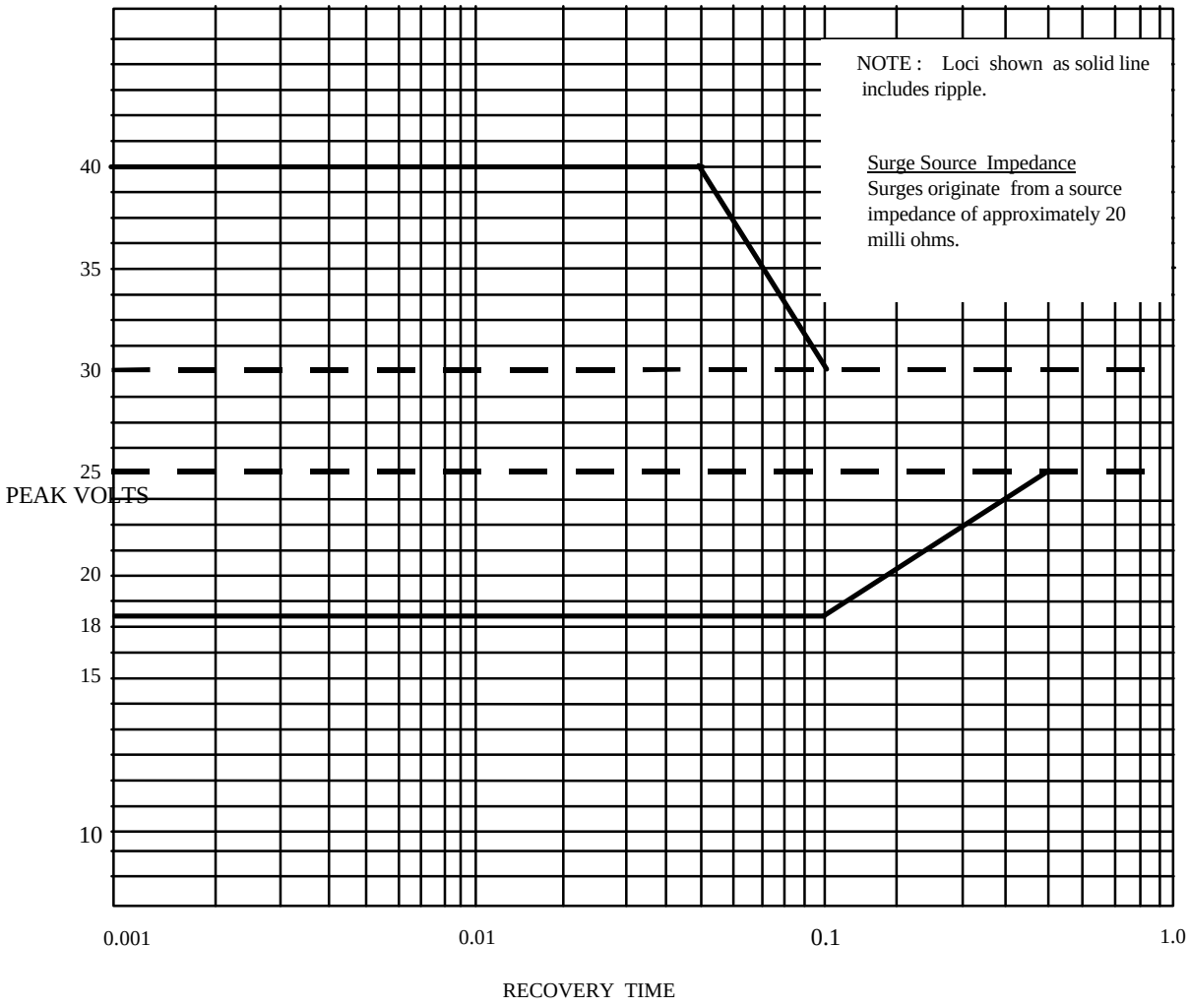


FIGURE 4. Loci of surges fault free condition.

5.1.2.4 Spikes. All spikes resulting from system operation shall fall within the loci shown in figure 5.

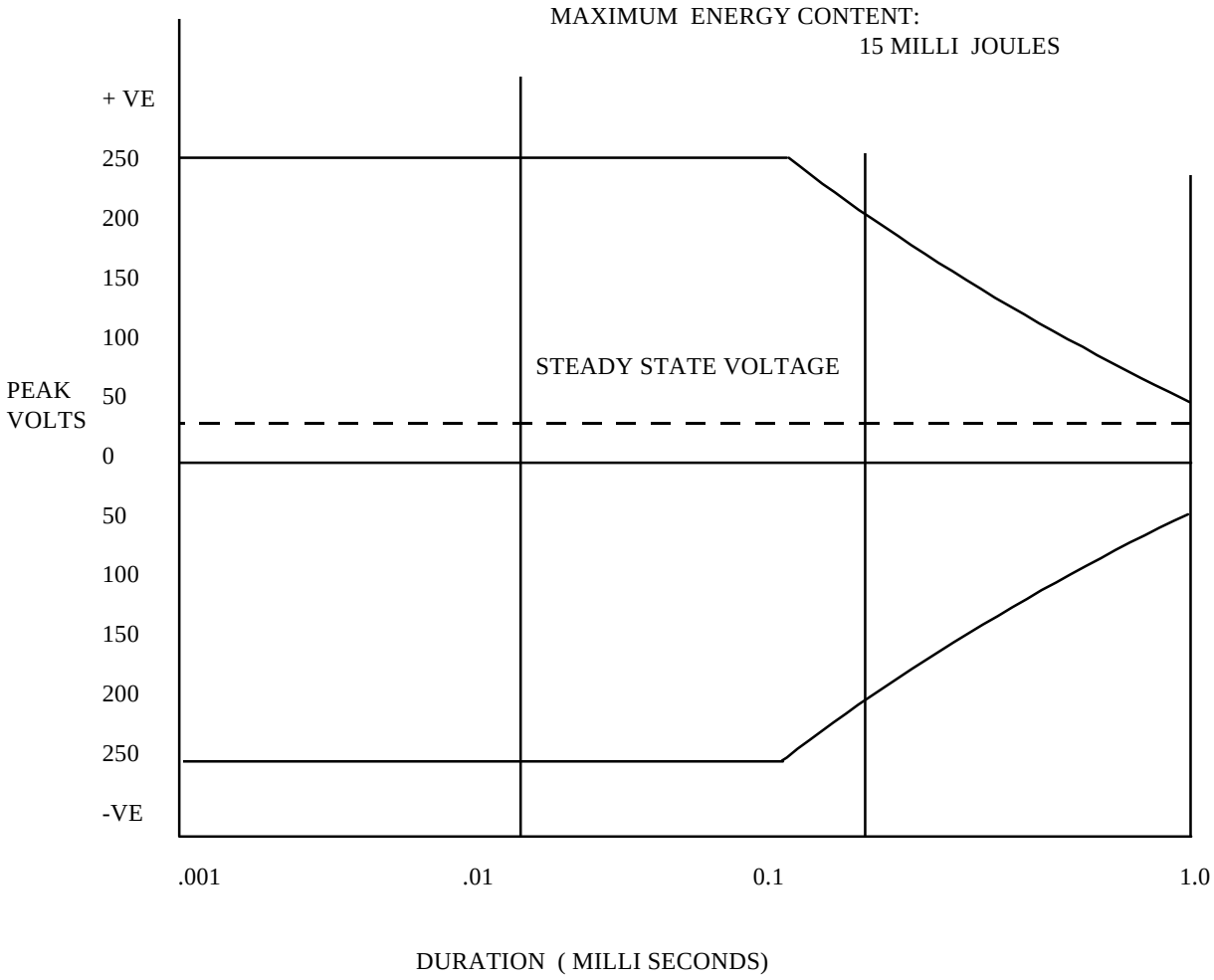


FIGURE 5. Loci of spikes fault free condition.

5.1.2.5 Starting disturbances. Fully charged battery shall be used (battery drawing less than 5 amperes (A) from a 28 V charging source with electrolyte temperature between 27°C and 38°C).

5.1.2.5.1 Initial engagement surges. During this disturbance, the voltage shall not be below 6 V and the duration shall not exceed 1 second.

5.1.2.5.2 Cranking level. The steady voltage during cranking shall not be below 16 V (no more than 3 cranking attempts of 30 seconds each with 2 minute cranking level pauses between attempts). This characteristic applies to starting the second engine of a multi-engine vehicle, or slave starting another vehicle.

5.1.3 Battery only condition.

5.1.3.1 Steady-state voltage. Circuit steady-state voltage shall be between 20 and 27 V.

5.1.3.2 Ripple. The upper and lower peaks of ripple (see figure 2) shall each be less than 2 V. The frequency components of the ripple shall be within the range of 50 Hz to 200 kHz.

5.1.3.3 Surges. Any switching action resulting in a surge which takes the voltage outside steady-state limits will be considered as a fault condition for the duration of the excursion.

5.1.3.4 Spikes. All spikes resulting from system operation shall fall within the loci shown in figure 6.

5.1.3.5 Starting disturbances. Fully charged battery shall be used (battery drawing less than 5 A from a 28 V charging source with electrolyte temperature between 27°C and 38°C.)

5.1.3.5.1 Initial engagement surges. During this disturbance the voltage shall not fall below 6 V and the duration shall not exceed 1 second.

5.1.3.5.2 Cranking level. The steady voltage during cranking shall not be below 16 V (no more than 3 cranking attempts of 30 seconds each with 2 minute cranking level pauses between attempts).

5.2 Single fault condition. Vehicle system operates with generator only (i.e., no battery).

5.2.1 Steady-state voltage. The voltage shall be greater than 23 V and less than 33 V.

5.2.2 Ripple. The upper and lower peaks of ripple voltage (see figure 2) shall each be less than 7 V. The frequency components of the ripple shall be within the range 50 Hz to 200 kHz.

5.2.3 Surges. All surges resulting from system operation shall fall within the loci shown in figure 6. (A lower steady-state limit of 23 V shall be used to establish the recovery time of negative-going surges.)

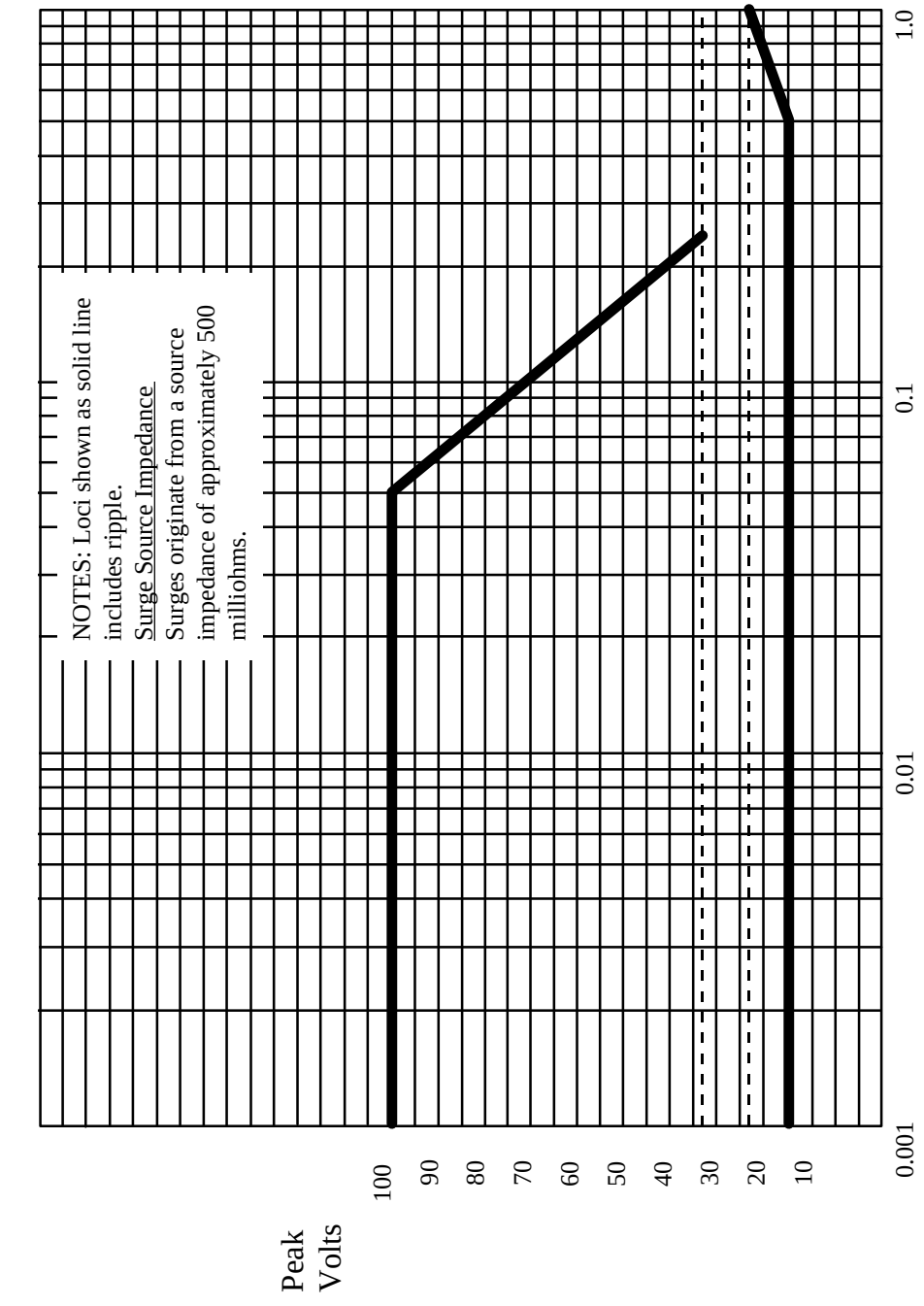


FIGURE 6. Loci of surges single fault condition

5.2.4 Spikes. All spikes resulting from system operation shall fall within the loci shown in figure 7.

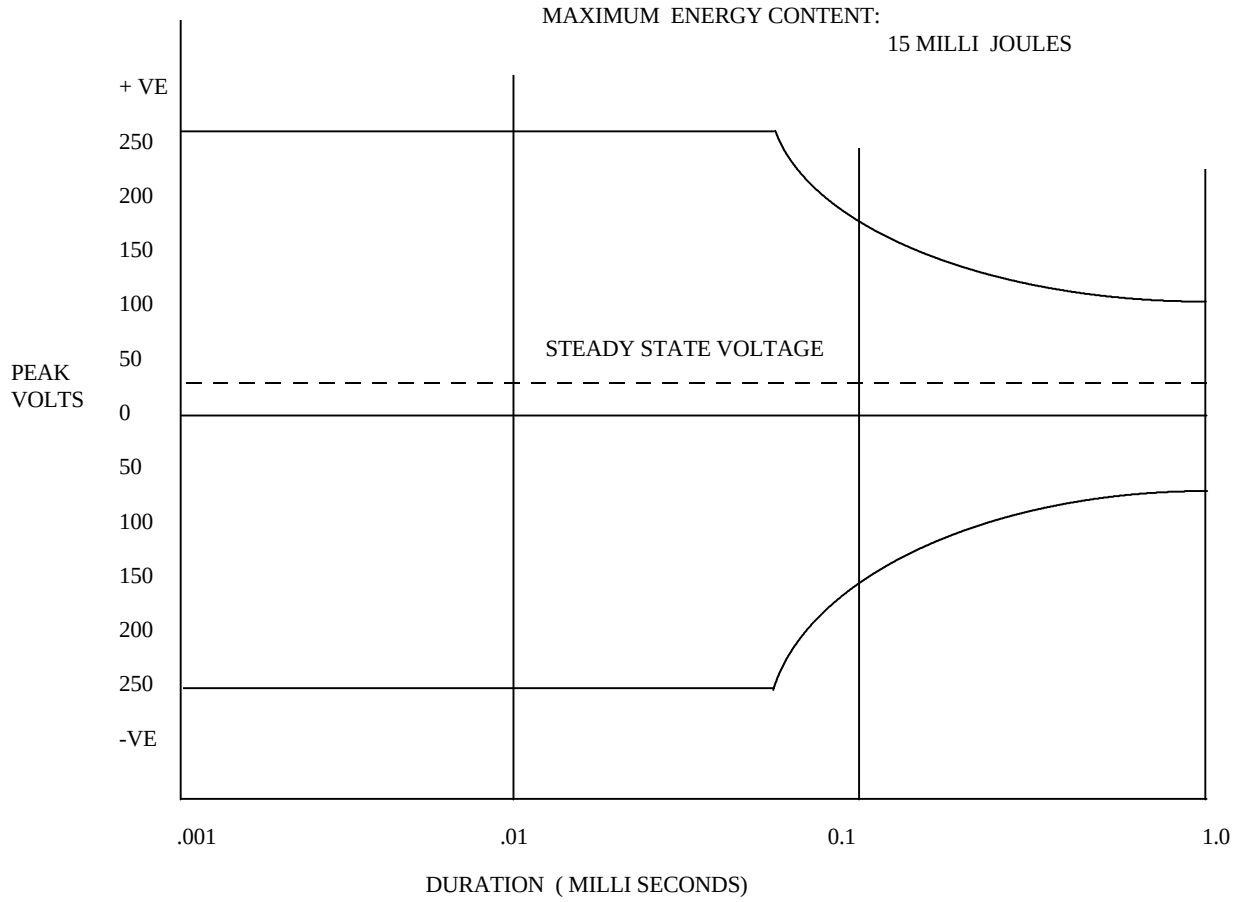


FIGURE 7. Loci of spikes single fault condition.

5.3 Compatibility of power supply system and utilization equipment. It is the responsibility of the appropriate authority to specify how the equipment shall function during and after the disturbances quoted in the detailed requirements. There shall be no influence by utilization equipment which would cause the electrical system to depart from the limits specified in the detailed requirements. In a multi-fault condition the output voltage is a function of generator speed and can be higher than 100 Vdc or equal to zero (0).

5.4 Test methods.

5.4.1 Vehicle electrical system. Measuring equipment and test procedures shall have the following minimum standards:

a. Ripple.
   (1) Measuring equipment. Oscilloscope or portable recorder having an input impedance of not less than 0.1 megohm and a bandwidth of not less than 30 megahertz (MHz).
   (2) Test procedure. Operate vehicle in fault-free and single-fault modes.
b. Spikes.
   (1) Measuring equipment. (Same as for ripple measurement.)
   (2) Test procedure. For test purposes, voltage spikes shall be produced by inductive load switching including, as a minimum, blowing the horn, operating the bilge pumps, (if any), starting and stopping the engine and rotating the turret (if any).
c. Surges.
   (1) Measuring equipment. (Same as for ripple measurement.)
   (2) Test procedure. Same as for spike test with the addition of the following: Voltage surges shall also be produced by load switching from 10 percent to 85 percent and 85 percent to 10 percent of system current rating. In small systems (e.g., 25 and 40 A) where it is impossible to achieve a minimum of 10 percent load, the minimum load shall be used.

5.4.2 Vehicle equipment.

5.4.2.1 General. It is the responsibility of the appropriate authority to specify the following:

a. Which of the following tests, if any, shall be applied to the equipment to determine whether it is compatible with an electrical system whose characteristics are defined in this standard.
b. How the equipment shall function during and after these tests.
c. The electrical and environmental conditions under which these tests are carried out.

5.4.2.2 Spikes exported from equipment. Using the test circuit shown in figure 8 the equipment shall be operated over its specified range of functions. Any switching operation capable of producing spikes shall be repeated a sufficient number of times to give a reasonable probability that the maximum spike voltage is recorded (say 20 operations). In addition, where the power supply to the equipment is normally provided via an independent vehicle mounted switch, the test shall be repeated using this switch connected as shown in figure 9.

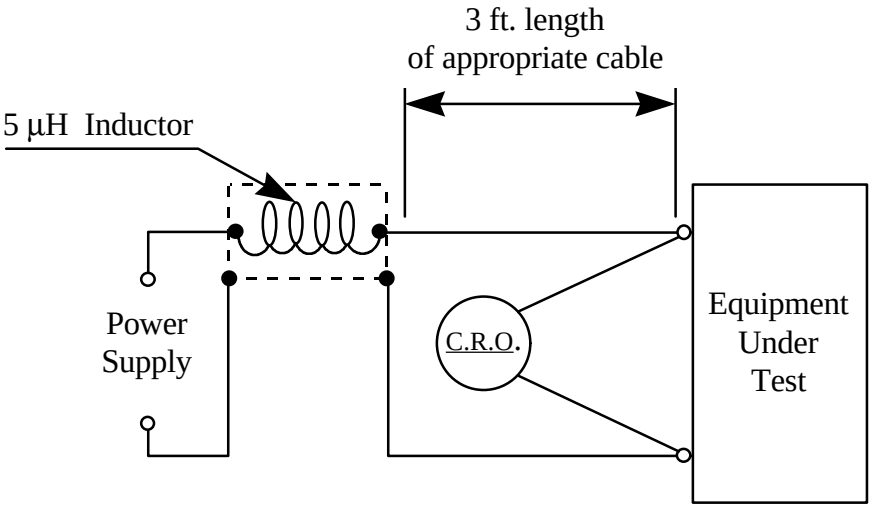


FIGURE 8. Exported spike test circuit (all equipment).

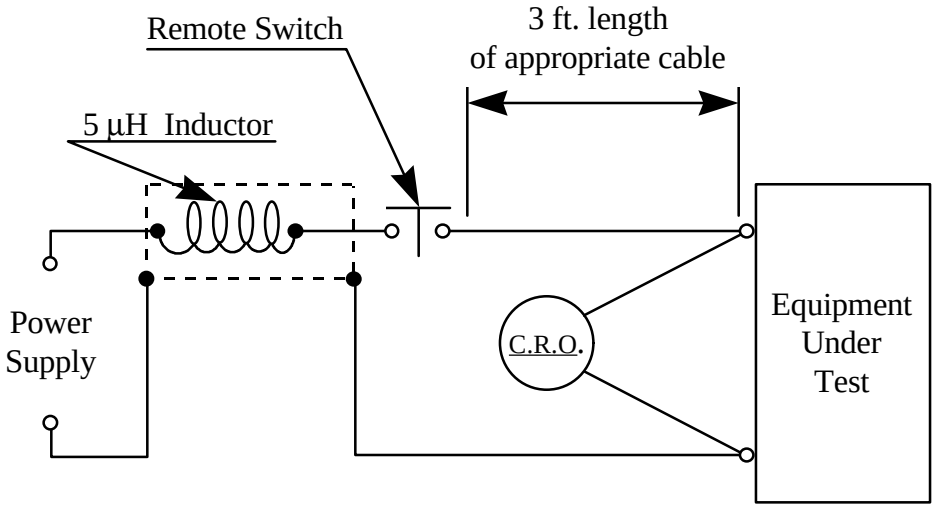


FIGURE 9. Exported spike test circuit (equipment with remote switch).

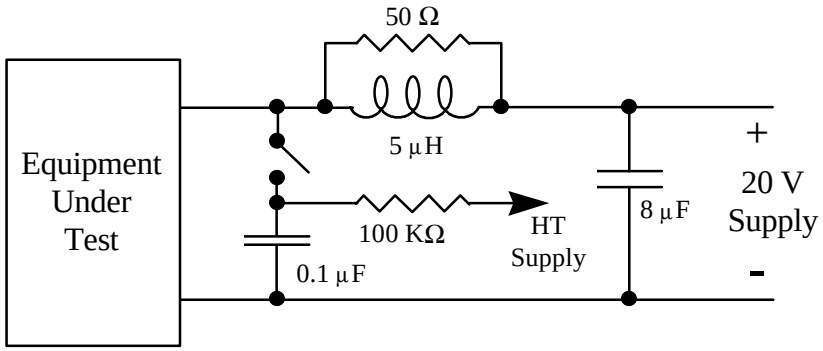
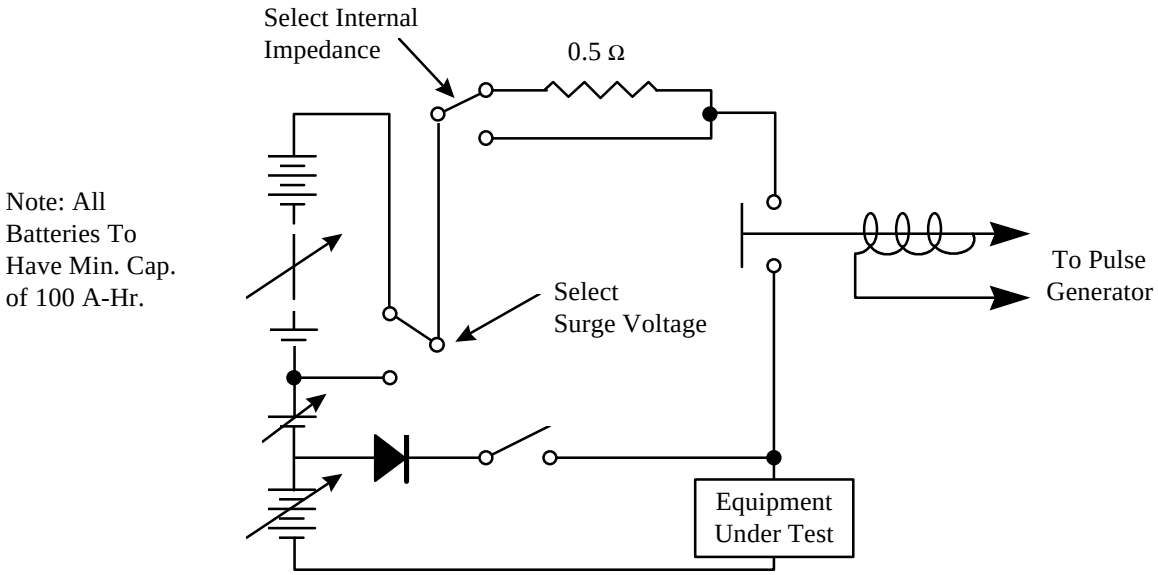


FIGURE 10. Imported spike test circuit.



NOTE: Pulse Generator Produces A Train Of Five
50 m. Sec Pulses At One Sec Intervals.

FIGURE 11. Imported surge test circuit.

No spike voltage recorded during these tests shall exceed ±250 V. No spike or combination of spikes arising from a single event, shall have an energy content exceeding 15 millijoules. (Method of measuring energy content to be specified later.)

5.4.2.3 Spikes imported into equipment.

a. An acceptable circuit is shown in figure 10. The 5 μH coil and 50Ω resistor provide a stabilized source impedance with a frequency characteristic typical of that of a vehicle power supply circuit. The energy for the spike is stored in the 0.1 μF capacitor charged from a high voltage dc source through 100 kilohm resistor. When the switch is closed, a voltage step is produced, followed by a damped sinusoidal oscillation. The reset time of the voltage step is largely determined by the inductance of the series circuit of the capacitor and switch. To obtain the specified short risetime the inductance must be kept to a low value by the use of suitable components. A feed-through capacitor and a coaxial mounted mercury-wetted reed switch together with short coaxial cables for the connecting leads are suggested. The peak amplitude of the spike is controlled by the dc charging voltage.
b. For these tests, simulated voltage spikes shall be applied to the equipment while it is operating at nominal voltage. The test spike shall have an amplitude of 250 V, a risetime not exceeding 50 nanoseconds, a frequency of oscillation greater than 100 kHz and less than 500 kHz and an energy content of not less than 15 millijoules. Measuring equipment specified in 5.4.1 shall be used to monitor the spike voltage.
c. Tests shall be carried out with both polarities of spike voltage. The number of applications of spikes will depend upon the equipment under test. However, a minimum of fifty 250 V spikes of each polarity shall be applied at one second intervals. The voltage spikes so imposed shall not cause any damage nor affect the normal operation of the equipment.

5.4.2.4 Voltage surges imported into equipment.

a. For these tests, simulated voltage surges shall be applied to the equipment while it is operating at nominal voltage. The vehicle electrical system shall be represented in both the fault-free and the single fault conditions. An acceptable circuit is shown in figure 11.
b. To simulate a voltage surge in the fault-free condition, a surge of ±40 V total amplitude lasting for 50 milliseconds from a source impedance of 20 milliohms shall be applied. Both before and after each surge the nominal supply voltage shall be maintained. This test shall be applied five times at intervals of 1 second. The equipment shall continue to operate normally throughout these tests without damage to any components.

c. To simulate a voltage surge in the single fault condition, a surge of ±100 V total amplitude lasting for 50 milliseconds from a source impedance of 500 milliohms shall be applied. Both before and after each surge the nominal supply voltage shall be maintained. This test shall be applied five times at intervals of 1 second. The equipment shall function as specified.
d. The voltage surges specified in b and c shall have the amplitude stated before connection of the equipment. The voltage shall be sensibly constant during the surge. The rise and fall times shall be approximately 1 milliseconds

6. NOTES

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

6.1 Intended use. The purpose of this document is to provide for compatibility between vehicular electric power supply and utilization equipment by confining electric power characteristics within definitive limits and restricting the requirements imposed on the electric power by the utilization equipment.

6.2 Subject term (key word) listing.

Electromagnetic interference
Polarity
Recovery time
Ripple
Single fault
Spike
Starting disturbance
Surge

6.3 International interest. Certain provisions of this standard are the subject of international standardization agreement QSTAG-307. When change notice, revision, or cancellation of this standard is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

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