STANAG 1008
Edition 7

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Chairman MAS under the authority vested in him by the NATO Military Committee.

2. No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

DEFINITIONS

4. Ratification is "The declaration by which a nation formally accepts the content of this Standardization Agreement".

5. Implementation is "The fulfilment by a nation of its obligations under this Standardization Agreement".

6. Reservation is "The stated qualification by a nation which describes that part of this Standardization Agreement which it cannot implement or can implement only with limitations".

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

7. Page iii gives the details of ratification and implementation of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions. Page iv (and subsequent) gives details of reservations and proprietary rights that have been stated.

N A T O U N C L A S S I F I E D

AC/141(IEG/6)SG/4-D/26
(STANAG 1008)
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NAVY

NATO STANDARDIZATION AGREEMENT (STANAG)

CHARACTERISTICS OF SHIPBOARD ELECTRICAL POWER SYSTEMS IN WARSHIPS OF THE NORTH ATLANTIC TREATY NAVIES

Annex A: National specifications of member countries

Related Documents: References in Annex A.
IEC Publication 50 - International Electrotechnical Vocabulary
IEC Publication 60-2 - High Voltage Test Techniqu
IEC 445 - Identification of apparatus terminals and general rules for a uniform system of terminal marking using an alphanumeric notation

AIM

1. The aim of this agreement is to provide for operational compatibility between warships of North Atlantic Treaty Navies and assist in simplifying problems associated with international procurement of future electrical equipment, through specifying mutually acceptable and agreed to shipboard electrical power supply system characteristics.

AGREEMENT

2. Participating nations agree that in new construction warships the ship service power supply system will accord with the characteristics as specified in the relevant section of this STANAG.

DEFINITIONS

3. The following definitions are to be used for the purpose of this agreement only. Other terms used in this agreement and which are not defined herein are as defined in IEC Publication 50.

(a) General Definitions

1. User equipment — Any system or equipment which uses electric power from power supplies covered by this STANAG.

2.	Ships Service Power Supply System	The principal distribution system to user equipment (excluding electric propulsion systems), including generation, cables, switchboards, protective devices, convertors, transformers and regulators up to the power supply interface.
3.	Power Supply Interface	For user equipment contained within a single enclosure, the terminals in the equipment to which the cables from the distribution system are connected. For user equipment consisting of interconnected independent enclosures, the terminals, designated by mutual agreement between the power supply design authority and the user, at which the provisions of this STANAG apply.
4.	Unearthed Electrical System	An unearthed system is one which can continue to perform normally if one line conductor becomes solidly earthed.
5.	Limited Break Supply	A power supply, provided by one or two or more independent power sources, incorporating automatic means for detecting failure of the power source and for transferring the user equipment load to another power source within a specified time delay.
6.	No-Break Supply	A limited break supply for which the transfer time is zero and the supply characteristics are continuously held within specified limits. In a special case a no-break supply may be specified to have a limited time duration for the alternate source.
7.	Pulsed Load	A pulsed load is a random or cyclic load that imposes varying power requirements on the system; for example, Sonar or Radar.

(b) Voltage (all a.c. voltages are root mean square (rms) and all d.c. voltages are mean values unless otherwise indicated in the text. All tolerances are expressed in percentage of the nominal user voltage).

1. Nominal User Voltage — Nominal user voltage is the designated line to line voltage at the power supply interface (as defined in paragraph 3.(a).3.

2. User Voltage Tolerance — User voltage tolerance is the maximum permitted departure from nominal user voltage during shipboard operations, excluding transients and modulation.

User voltage tolerance includes variations caused by the environment (temperature, humidity, vibration, inclination).

3. Line Voltage Unbalance Tolerance — The line voltage unbalance tolerance is the permitted difference between the highest and lowest line-to-line voltages.

4. Voltage Modulation — Voltage Modulation is the permitted periodic variation of the user voltage, such as might be caused by regularly or randomly repeated pulsed loading. For the purposes of definition the periodicity of voltage modulation is considered to be longer than one cycle time on an a.c. system and less than 10 seconds.

Voltage Modulation (%) =

$$\frac{(E_{max}-E_{min}) \times 100}{2 \times E_{nominal}}$$

(Voltages in this formula to be all rms values, all peak values or all mean d.c. values - Fig. 1 and Fig. 2.)

5.	Voltage Transient Tolerance	A voltage transient (excluding voltage spikes) is a sudden change in voltage which goes outside the user voltage tolerance limits and returns to and remains inside these limits within a specified recovery time (longer than 1 millisecond) after the initiation of the disturbance. The voltage transient tolerance is in addition to the user voltage tolerance limits.
6.	Voltage Transient Recovery Time	Voltage transient recovery time is the time elapsed from initiation of the disturbance until the voltage recovers and remains within the user voltage tolerance limits.
7.	Voltage Spike	A voltage spike is a voltage change of very short (less than 1 millisecond) duration. The standard lightning impulse shown in Fig. 3 is the characteristic voltage spike used for test purposes.
8.	Voltage Waveform	
	(i) Harmonic Content	A function obtained by subtracting the Fundamental Wave from a non sinusoidal periodic function.
	(ii) Total Harmonic Distortion	The total harmonic distortion of a voltage wave is the ratio of the rms value of the harmonic content to the rms value of the fundamental, expressed in percent.
	(iii) Harmonic Components	Development terms in the Fourier series for a periodic function.
	(iv) Individual Harmonic	The value of the individual harmonic of a voltage wave is the ratio of the rms value of the individual harmonic component (ex fundamental) to the rms value of the fundamental expressed in percent.

(v) Deviation Factor — The deviation factor of a voltage waveform is the maximum difference between corresponding ordinates of the wave and an equivalent sine wave (same rms value and frequency and having a phase relationship such as to make the difference as small as possible) expressed as a percent of the maximum ordinate of the equivalent sine wave of the same voltage and of such a phase relationship as to make this difference as small as possible.

(vi) Ripple Voltage — The alternating voltage component of the uni-directional voltage from a direct current power supply. The frequency of the ripple voltage is always greater than or equal to the input power supply frequency.

(c) Frequency (all frequencies are expressed in Hertz and all tolerances are expressed in percentage of the nominal frequency).

1. Nominal Frequency — The nominal frequency is the designated frequency in Hertz of the alternating current system.

2. Frequency Tolerance — Frequency tolerance is the maximum permitted departure from nominal frequency during normal operation, excluding transient and frequency modulation. This includes variations such as those caused by the environment (temperature, humidity, vibration, inclination).

3. Frequency Modulation

Frequency modulation is the permitted periodic variation of the frequency such as might be caused by regularly or randomly repeated loading. For purposes of definition the periodicity of Frequency Modulation is considered to be longer than one cycle time and less than 10 seconds.

Frequency Modulation % =

$$\frac{(F_{max}-F_{min}) \times 100}{2 \times F_{nominal}}$$

(see Fig.1)

4. Frequency Transient Tolerance

A frequency transient is a sudden change in frequency which goes outside the frequency tolerance limits and returns to and remains inside these limits within a specified recovery time after the initiation of the disturbance. The frequency transient tolerance is in addition to the frequency tolerance limits.

5. Frequency Transient Recovery Time

Frequency transient recovery time is the time elapsed from initiation of the disturbance until the frequency recovers and remains within the frequency tolerance limits.

GENERAL

4. This agreement is divided into two parts - Part I - User Information and Constraints and Part II - Characteristics of Standard Electrical Power Supplies. The section covering user information and constraints contains guidance on certain aspects of power systems in Warships and on restrictions that would be typically imposed on user equipment to ensure compatibility with power systems and to minimise interference with other user equipment. Three types of power supplies, operating at 60Hz, 400Hz, and D.C. are specified in the section detailing characteristics and it should be noted that not all these supplies may be present in a particular ship.

PART I - USER INFORMATION AND CONSTRAINTS

5. General

(a) Three types of power supplies operating at 60Hz, 400Hz and D.C. are specified in STANAG 1008, and it should be noted that not all of these supplies may be present in any one particular ship. Generally, provided a ship's design does not principally embody aircraft practice (e.g. Hovercraft), then 440V, 60Hz, 3-phase power will form the ship's main power supply system. D.C. and 400Hz supplies of limited capacity may be made available either from the ship's system (if installed) or derived locally and dedicated to a particular equipment.

(b) User equipment shall be designed for 60Hz to avoid installing conversion equipment in the ship. Where there are overriding equipment design features demanding a high frequency, then the preferred frequency is 400Hz.

(c) All loads of 5KVA and above should be 3-phase and supplied at 440 volts, 60Hz.

(d) Where practicable, all equipment rated at less than 5KVA should also be supplied at 440 volts, 60Hz, 3-phase. Where this is either undesirable or not practicable, the following shall be the order of preference:

1. 440 volts, 60Hz, 1-phase, 2 wire;

2. 115 volts, 60Hz, 3-phase, 3 wire;

3. 115 volts, 60Hz, 1-phase, 2 wire.

(e) Equipment conditioning devices, e.g. anti-condensation heaters should be designed for connection to 115 volt supplies.

6. Earthing

(a) The ships supply systems covered by this STANAG are un-earthed and user equipment must not introduce direct or indirect connections between supply lines and earth except for electro-magnetic interference suppression, surge suppression, or for occasional test or maintenance purposes (see paragraph 13(c)). Where earthed circuits are considered essential, then the equipment must be isolated from the ship's supply system e.g. using transformers or motor generator sets.

(b) Designers should note that the potential of individual phase voltages to earth will vary and are not necessarily equal:

1. Each line to earth may be subjected to full system voltage;

2. Voltage spikes up to 2.5kV amplitude may be experienced between a line and earth;

3. Full phase voltage may occur between earth and any artificially created neutral point;

4. Voltage waveform to earth may contain appreciable triple harmonic distortion;

5. AC lines may carry DC voltage levels of 300 volts to earth;

6. Earth faults on directly coupled (i.e. not transformer isolated) DC systems may be reflected and rotated around each phase of the AC system at harmonic frequencies equivalent to the rectifier pulse number.

7. Limited Break and No-Break Supplies. Limited break supplies are only provided to user equipment designated as being vital to the safety of the ship or essential for its mission. For such supplies, time for which power is interrupted will be typically greater than 0.1 but less than 30 seconds. For user equipment requiring no-break power the preferred approach is for the user to provide the source of power and the power conditioning equipment required to maintain power to the equipment during loss of ship's power.

8. Non-Standard Supplies. The provison of non-standard supplies will be strongly resisted and requests for such supplies shall be notified to the relevant power supply design authority at an early stage of the design. Approval is to be obtained before entering into any commitment.

9. Load Unbalance. If a three-phase load is composed of single-phase loads or three-phase loads or both single-phase and three-phase loads, the resulting difference between the highest and lowest line currents under normal operating conditions should not exceed 5% of the arithmetic sum of the three line currents.

10. Waveform Distortion. User Equipment Specifications, or early consultation with the power supply design authority, should ensure that the consuming equipment will not cause distortion in the voltage waveform of the power supply to levels sufficient to exceed the voltage waveform tolerances of the power supply system. This would normally be achieved by designing equipment to draw alternating current that is closely sinusoidal. If non-sinusoidal current demand is essential, the effects on the power supply system shall be minimised by:

(a) Provision of filters in the consuming equipment or sub system;

(b) Other suitable means, such as higher number of input phases to transformer rectifier equipment;

(c) Consultation with the power supply design authority if the limit of the specified values will be exceeded.

The above applies particularly to equipment employing electronic switches operating once, or more than once, per cycle of the power supply voltage.

11. Pulsed Loads. User equipment which demands frequent or regularly repeated kilowatt or kilovoltampere input shall have such demands restricted in relation to the normal generating capacity of the system, to avoid exceeding the specified system modulation tolerances for frequency and voltage. This will be achieved by:

(a) Limiting the rating of pulse load equipment;

(b) Provision of kinetic or electrical energy storage and re-emission;

(c) Early consultation with the power supply design authority;

(d) Other suitable means.

12. Voltage Spikes. The amplitude and waveform of voltage spikes will vary greatly, dependent on circuit parameters. On AC systems, line-to-line and line-to-earth spikes are unlikely to exceed 2500V in amplitude. A standard lightning impulse, as defined in IEC Publication 60-2 High Voltage Test Techniques-Part 2 - Test Procedures (Section IV) with a crest (peak) level as given in Section 6 of this document is recommended for test purposes. (See Fig.3.)

13. Design Constraints. The following illustrate the principles which are both necessary and sensible to avoid one user creating disturbances which adversely affect other users. Equipment conforming to the following specific constraints will normally be acceptable for all ships of the NATO navies. Equipment designers should, as early as possible, notify the ship power system design authority if their equipment exceeds these design constraints.

(a) The peak (crest) value of any inrush/starting current on a circuit is normally to be less than 10 x its full load rms current except for 60Hz transformers where 25 x rated full load rms current is acceptable. Furthermore, 440 volt motor starting currents are to be limited as follows:

Motor Starting Current (% of Generator)	Generator Size (Amps, rated current)
50	< 800
45	800 to 1600
40	> 1600

(b) Protection devices for the equipment are to prevent imposition of faults beyond the capacity of power supply system.

(c) The aggregate value of any capacitance connected between any one 440V line and earth at the agreed power supply interface when looking into the equipment should be limited. If the value exceeds 0.1uF for 60Hz and 0.02uF for 400Hz the power supply design authority is to be informed. Moreover, a maximum value of 1uF is not to be exceeded without the approval of the power supply design authority.

(d) The operation of user equipment should have the minimum harmonic distortion effect on the electrical power system. The operation of user equipment incorporating electronic power convertors or power controllers of the following ratings should not cause individual harmonic line currents to be generated that are greater than 3% of the units full rated load fundamental current between 2nd and 32nd harmonic.

Frequency of Power Source		Rating of Unit
60	-	1KVA or more
400	-	0.2KVA or more other than single-phase, 115 volt source
400	-	2 amperes or more on a single-phase 115 volt source.

Additionally, currents with frequencies from the 32nd harmonic through to 20KHz should not exceed 100/n percent of the units rated full load fundamental current where 'n' is the harmonic multiple number. Units with power ratings less than those specified above should be current amplitude limited such that no individual harmonic line current from the 2nd harmonic through to 20KHz exceeds a magnitude of 100/n percent of the units rated full load fundamental current.

(e) The cycle period for semi conductor controlled AC resistance loads, e.g. space heating, must be as long as possible. The power system design authority should ensure that as few heaters as possible are simultaneously switched. Minimum cycle periods for various heater sizes are shown in Fig. 6.

(f) Pulsed loads should not exceed the limits specified on Fig. 7 since that will cause voltage and frequency modulations exceeding the limits of the power supply standard. If such a load cannot be avoided the power supply design authority is to be consulted so that corrective action can be determined.

(g) Where more than one ship supply input to any user equipment is provided then:

1. Paralleling of the AC system at user equipment is expressly forbidden;

2. Paralleling after a DC conversion stage is only permitted with transformer isolation on the AC input.

PART II - CHARACTERISTICS OF STANDARD ELECTRICAL POWER SUPPLIES

14. Phase Sequence. Terminals of electrical power supplies should be designated in accordance with IEC 445 by using an alphanumeric notation.

15. Characteristics of Standard 60Hz Supplies

Voltage	Nominal User Voltage	440V or 115V
	User voltage tolerances	
	a. average of three line-to-line voltages (1) - see note A.	± 5 %
	b. any one line-to-line voltage including a. above and line voltage unbalance tolerance.	± 7 %
	Voltage Modulation (2)	2 %
	Line voltage unbalance tolerance (3)	3 %
	Voltage transient tolerance - see note B	± 16 %
	Voltage transient recovery time	2 seconds
	Voltage spike (peak value)	2.5 kV
Waveform	Total harmonic distortion	5 %
	Individual Harmonic	3 %
	Deviation Factor	5%
Frequency	Nominal Frequency	60Hz
	Frequency tolerance (4) - see note C	± 3 %
	Frequency Modulation (5) - see note C	0.5 %
	Frequency transient tolerance (6) - see note C	± 4 %
	Frequency transient recovery time	2 seconds

Note A Except under transient or fault conditions the maximum departure from nominal user voltage, due to the combined effects of (1), (2), (3) will not exceed ± 6% for average of three line-to-line voltages; ± 8% for any one line-to-line voltage.

Note B Except under fault conditions the maximum excursion due to the combined effects of transients and (1), (2), (3) above will not exceed ± 20% for the average of three line-to-line voltages; ± 22% for any one line-to-line voltage. Excursions of this order will only occur infrequently, which means not more than 10 times in a period of 24 hours. (See Fig. 4 for the voltage transient envelope.)

Note C Except under fault conditions the maximum departure from 60Hz resulting from (4), (5) and (6) above will not exceed 5.5%.

16. Characteristics of Standard 400Hz Supplies

Voltage	Nominal User Voltage User Voltage tolerances : a. Average of 3 line to line voltages (1) See Note A. b. Any one line to line voltage including a. above and line voltage unbalance tolerance - see Note A Voltage Modulation (2) Line Voltage unbalance tolerance (3) Voltage transient tolerance - see Note B Voltage transient recovery time Voltage spike (peak value)	440V or 115V ± 5 % ± 7 % 2 % 3 % ± 16 % 2 seconds 2.5 Kv
Waveform	Total harmonic distortion Individual Harmonic Deviation Factor	5 % 3 % 5%
Frequency	Nominal Frequency Frequency tolerance (4) - See Note C. Frequency modulation (5) - See Note C. Frequency transient tolerance (6) - See Note C. Frequency transient recovery time	400Hz ± 5 % 0.5% ± 4 % 2 seconds

Note A Except under transient or fault conditions the maximum departure from nominal user voltage due to the combined effects of (1), (2) and (3) will not exceed ±6% for average of three line-to-line voltages; ± 8% for any one line-to-line voltage.

Note B Except under fault conditions the maximum excursion due to the combined effects of transients and (1), (2) and (3) above will not exceed ± 20% for the average of three line-to-line voltages; ± 22% for any one line-to-line voltage. Excursions of this order will only occur infrequently which means not more than 10 times in a period of 24 hours. (See Fig. 4 for the voltage transient envelope.)

Note C Except under fault conditions the maximum departure from 400Hz resulting from (4), (5) and (6) above will not exceed 6.5%.

17. Characteristics of Standard Low Voltage DC Supplies

Nominal User Voltage	24/28V
User voltage limits (see Note C)	
a. Normal	22-29V
b. Emergency - See Note A	18-29V
c. Abnormal - See Note B	18-32V
Voltage Modulation (See Fig 2)	2%
Ripple peak to peak (See Fig 2)	2.5V
Voltage Transient	
Upper Limit	35V
Lower Limit	18V
Voltage spike (peak value)	600V
Voltage Transient recovery time (See fig 5)	2 seconds

Note A Emergency is the condition existing when the battery charger has ceased to function.

Note B Abnormal is the condition existing when, through fault or other reasons, the battery is at top of charge. This is a rare condition for which equipment designated as vital must maintain its operational efficiency without deterioration for periods of at least 2 hours.

Note C Voltage modulation and ripple variations are additional to nominal user voltage and transient limits.

CHARACTERISTICS OF OTHER ELECTRICAL POWER SUPPLIES

18. The voltage and frequencies of supplies not covered previously which may be available in warships is tabled below. If an equipment requires such supplies then reference should be made to clause 5.4 and to NATO countries national specifications listed in Annex A.

Alternating Current

(a) 115V, 400Hz, single-phase, 2 wire for Analogue Data Transmission;

(b) 200/115V, 400Hz, 3-phase, 4 wire.

Where 200/115V, 400Hz supplies are provided for aircraft type equipment, these should conform to the characteristic listed under paragraph 16.

IMPLEMENTATION OF THE AGREEMENT

19. This STANAG is considered to be implemented when national specifications ensure that new construction warships provide electrical power supplies with characteristics in accordance with this agreement.

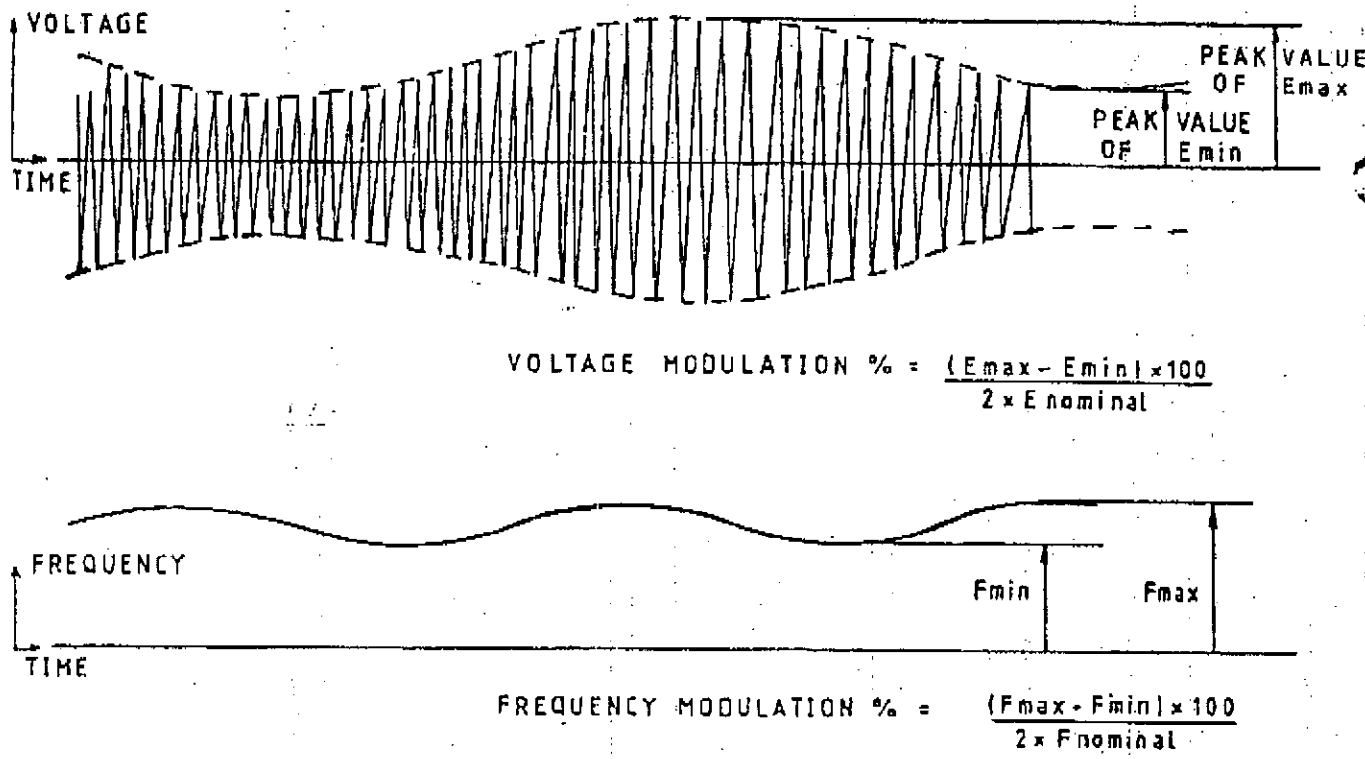

FIG 1 - A.C. SYSTEMS - VOLTAGE & FREQUENCY MODULATION

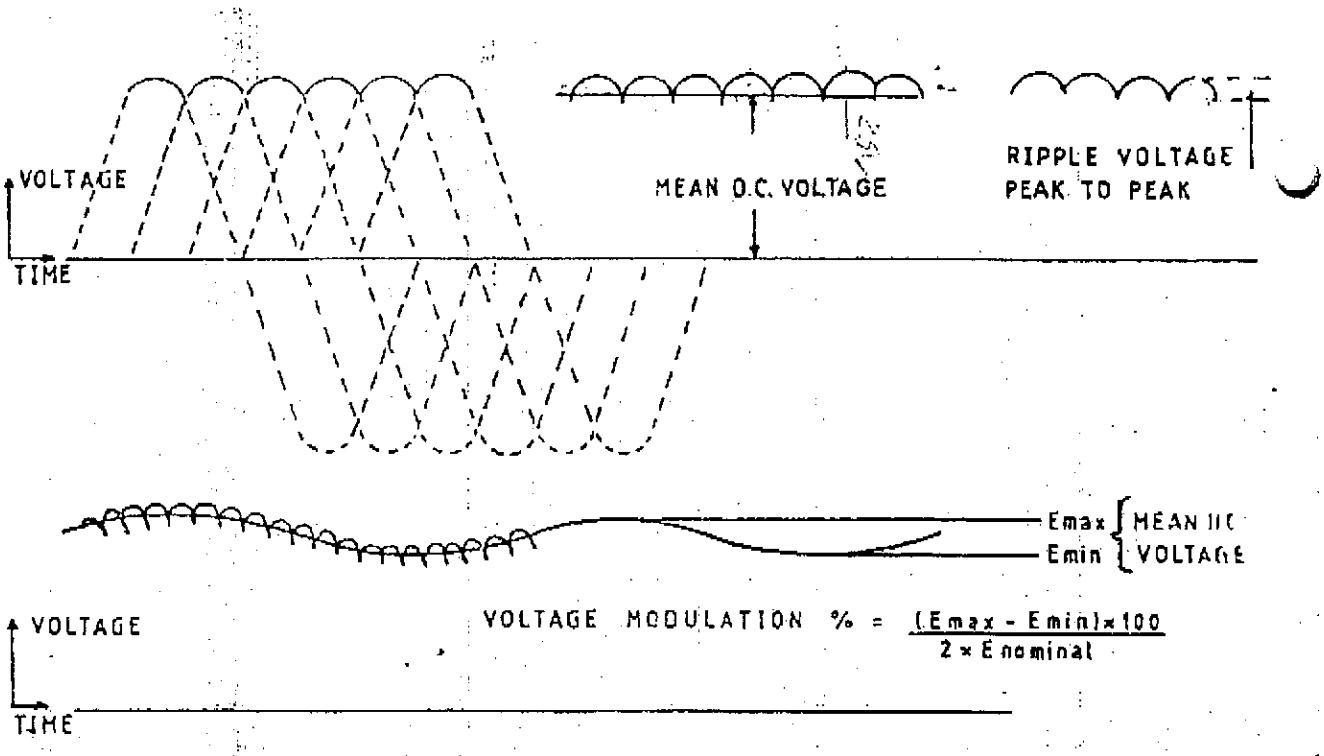

FIG 2 - VOLTAGE MODULATION & RIPPLE

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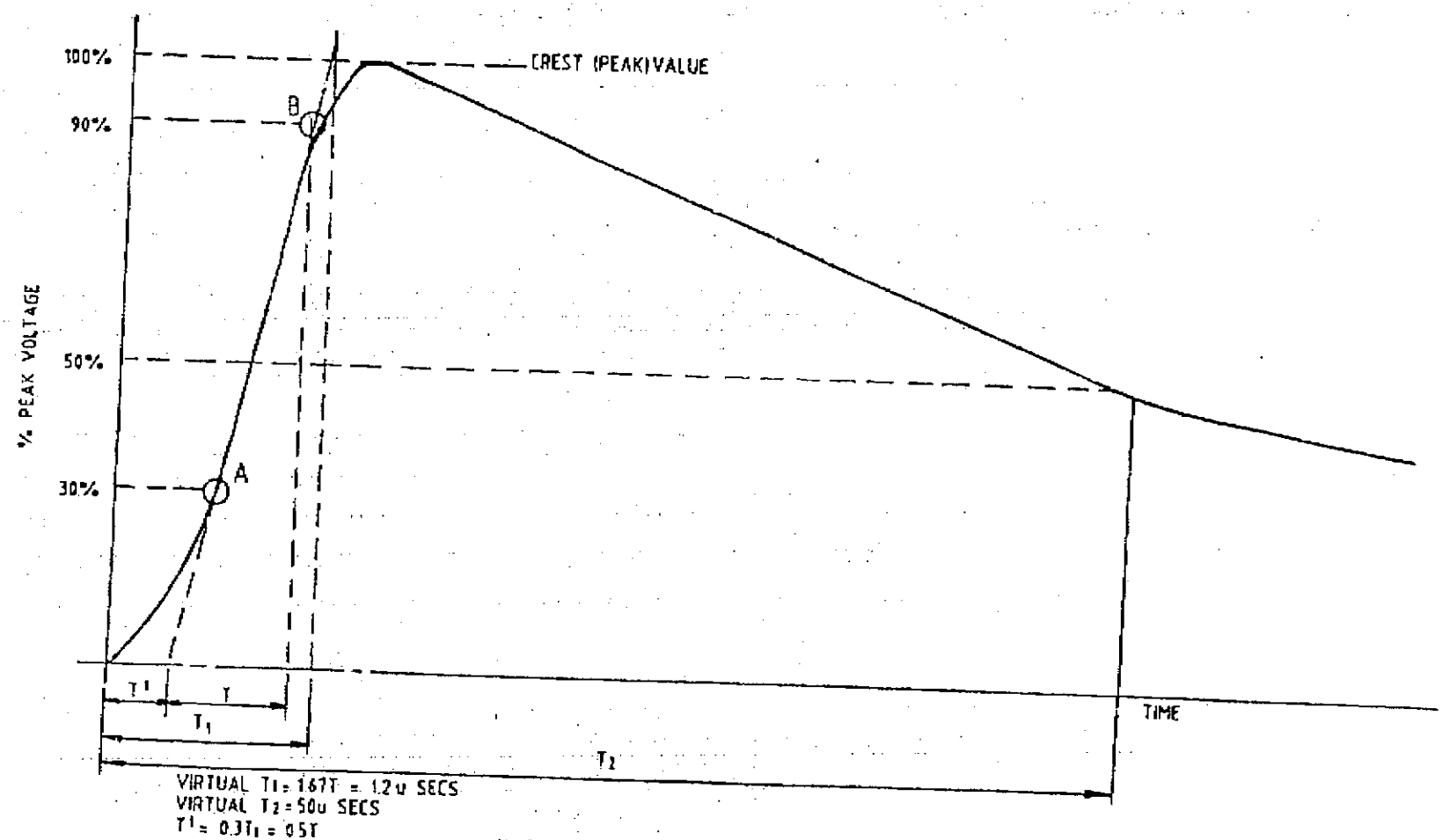
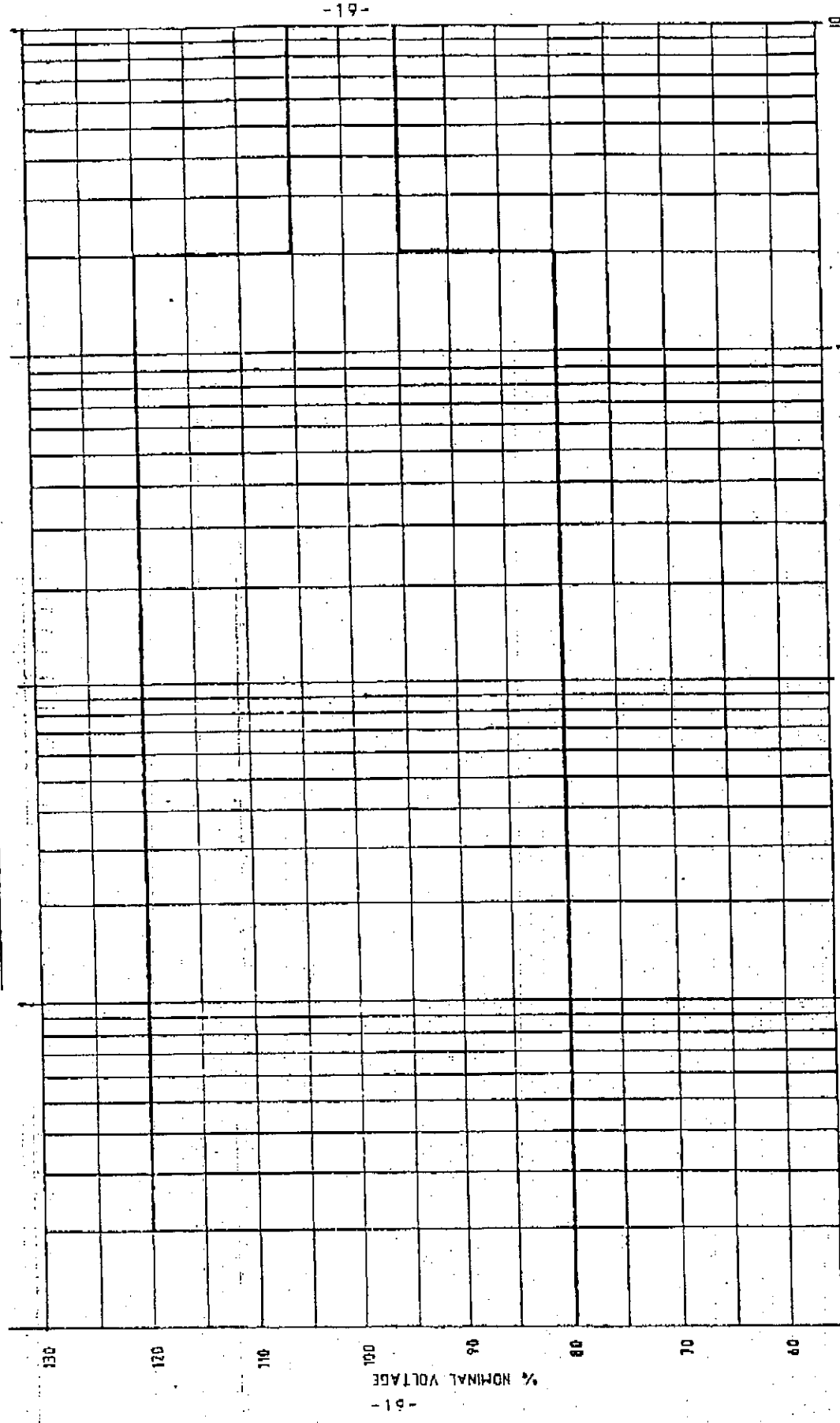
FIG. 3 VOLTAGE SPIKE TEST WAVEFORM

(IN ACCORDANCE WITH I.E.C. 60-2, FIG 2. FULL LIGHTNING IMPULSE)



-18-

FIG. 4 VOLTAGE CHARACTERISTICS OF 60Hz & 400Hz SUPPLIES



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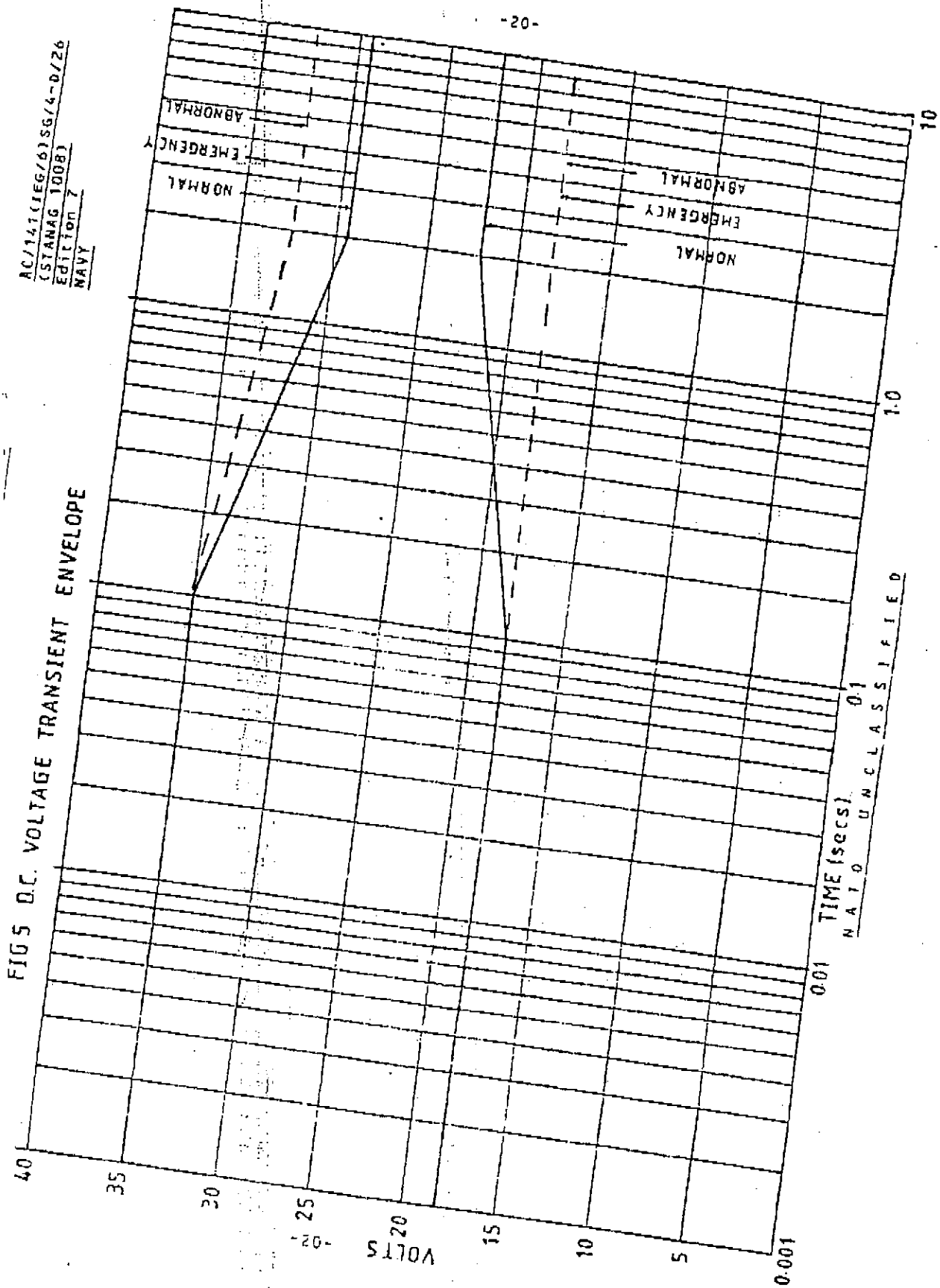
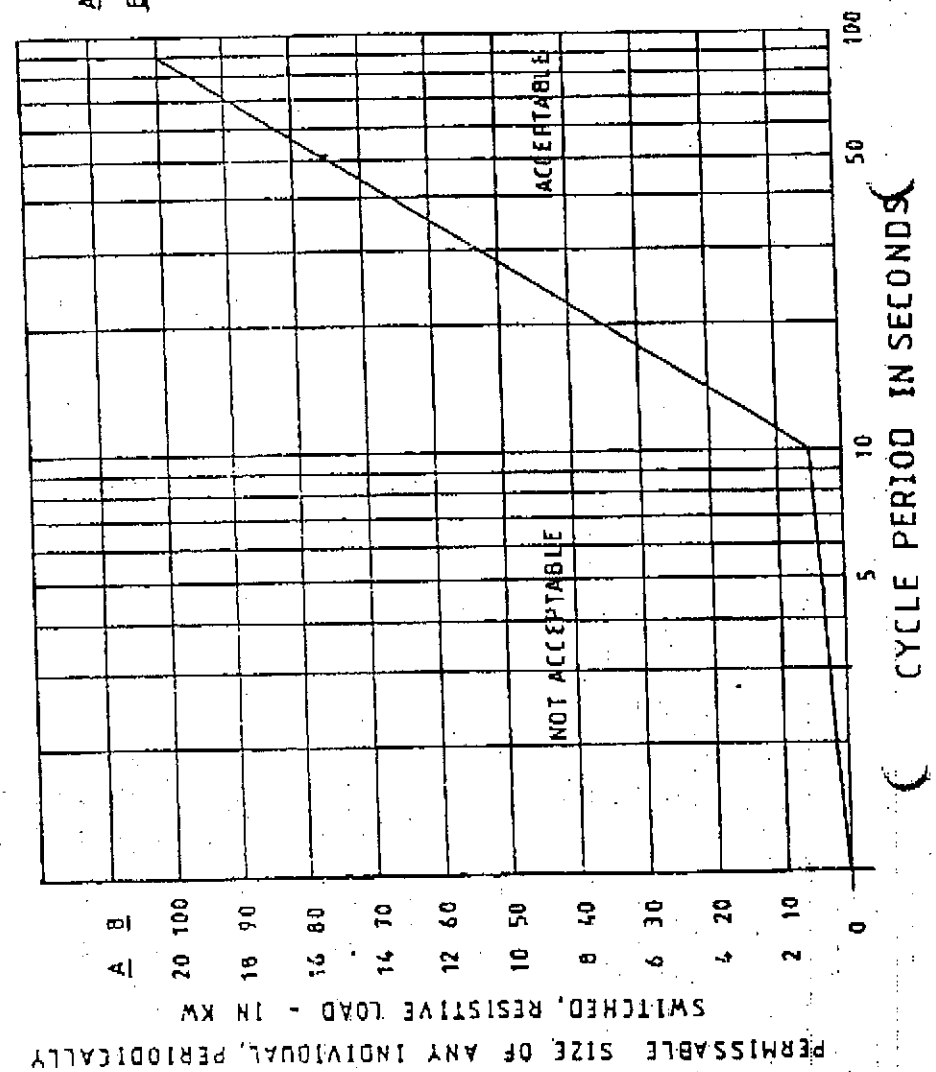


FIG 5 D.C. VOLTAGE TRANSIENT ENVELOPE

NATO UNCLASSIFIED

FIG 6


A-FOR SHIPS ≤ 1000 TONNES
B-FOR SHIPS 4-6000 TONNES
(EXTRAPOLATE FOR INTERMEDIATE SIZES)
ACCEPTABLE
NOT ACCEPTABLE
CYCLE PERIOD IN SECONDS
0
2
4
6
8
10
12
14
16
18
20
A
B
10
20
30
40
50
60
70
80
90
100
5
50
100
PERMISSABLE SIZE OF ANY INDIVIDUAL, PERIODICALLY SWITCHED, RESISTIVE LOAD - IN KW