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Minimum Performance Standards – Airborne Ground Proximity Warning Equipment

RTCA DO-161A
Revised May 27, 1976

Prepared by:
SC-128

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F O R E W O R D

This Document was prepared by Special Committee 128 of the Radio Technical Commission for Aeronautics (RTCA). It was approved by RTCA on May 27, 1976.

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I N T R O D U C T I O N

This Document sets forth Minimum Performance Standards for Airborne Ground Proximity Warning Equipment.

This revision of DO-161 includes Changes 1 and 2 to that Document, and also includes further changes that were suggested by operational experience. The Environmental Tests in this Document have been modified to reflect the requirements of RTCA Document DO-160, "Environmental Conditions and Test Procedures for Airborne Electronic/ Electrical Equipment and Instruments".

Compliance with these standards by manufacturers and users is recommended as a means of assuring that the equipment will satisfactorily perform its intended function under all conditions normally encountered in routine aeronautical operations.

In any application of these minimum performance standards, due allowance should be made, where necessary, for equipments in current use which meet the intent of the standards contained herein.

It is recognized that any regulatory application of these standards is the responsibility of governmental agencies.

Inasmuch as the measured values of equipment performance characteristics may be a function of the method of measurement, standard test conditions and methods of test are also recommended in this Document.

The word "equipment" as used herein includes all of the components or units necessary (as determined by the equipment manufacturer) for the equipment to properly perform its intended function. For example, an Airborne Ground Proximity Warning "equipment" may include cockpit controls, an indicator, a computer unit, aural warning generator, a barometric rate computer, a shock mount, etc. In the case of this example, all of the foregoing components or units comprise the "equipment". It should not be inferred from this example, however, that every "equipment" will necessarily include all of the foregoing components. This will depend on the design used by the "equipment" manufacturer. The "equipment" need not include other sensor systems for which separate standards are applicable, e.g. Radio Altimeter.

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1.0 GENERAL STANDARDS

1.1 Purpose of Equipment

Ground Proximity Warning Equipment is an aid to aircrew for determining the imminent occurrence of inadvertent contact with the ground. It is intended to supplement flight instrument data from which this situation may be determined, annunciating the onset of the condition caused by excessive rate of descent, excessive closure rate to terrain, negative climb rate or altitude loss after take-off, flight into terrain when not in landing configuration and excessive downward deviation from an ILS glide slope.

1.2 Operation of Controls

The operation of controls intended for use during flight, in all possible combinations and sequences, shall not result in a condition whose presence or continuation would be detrimental to the continued performance of the equipment.

1.3 Accessibility of Controls

Controls which are not normally adjusted in flight shall not be readily accessible to flight personnel.

1.4 Effects of Tests

Unless otherwise provided, the application of the specified tests shall produce no subsequently discernible condition which would be detrimental to the continued performance of the equipment.

1.5 Modes of Operation

Ground Proximity Warning equipment shall provide indications of imminent inadvertent contact with the ground in the following modes of aircraft operation as further defined by this Minimum Performance Standard:

1. Excessive Rates of Descent
2. Excessive Closure Rate to Terrain
3. Negative Climb Rate or Altitude Loss After Take-Off
4. Flight Into Terrain When Not in Landing Configuration
5. Excessive Downward Deviation From an ILS Glide Slope

1.6 Warning and Alert Indications

Distinctive aural and visual warning must be provided for Modes 1 through 4. A separate distinctive aural alert must be provided for Mode 5.

1.6.1 Aural Warning/Alert

The aural warning for Modes 1 through 4 shall consist of the sound "Whoop-Whoop", followed by either "Pull-up" or "Terrain" (or other acceptable annunciation) repeated until the hazardous condition no longer exists. The warning may be provided by the GPW equipment itself or an auxiliary warning unit which is activated by the GPW equipment.

The aural alert for Mode 5 shall consist of the annunication "Glide Slope" (or other acceptable phrase) repeated until the condition responsible for the alert no longer exists or the alert is inhibited.

1.6.2 Visual Warning Characteristics (Modes 1 through 4)

The visual warning provided for Modes 1 through 4 shall be distinctive under all normal lighting conditions and commensurate with other cockpit warnings.

1.6.3 Emergency/Planned Abnormal Deactivation

Means to deactivate the warning indications (Modes 1 through 4) may be provided, and means to deactivate the alert indication (Mode 5) must be provided for flight crew use in planned abnormal or emergency conditions.

1.7 False Warnings

To enhance pilot confidence, the equipment shall be designed to minimize false warnings, including those attributable to sensor input signal variations caused by aircraft power line voltage variations and interruptions.

1.8 Failure Monitoring and Self-Test

Failure monitoring and/or self-test shall be used to provide indication of equipment condition.

2.0 MINIMUM PERFORMANCE STANDARDS UNDER STANDARD TEST CONDITIONS

The test procedures, applicable to a determination of the performance of Ground Proximity Warning equipment under standard test conditions, are set forth in Appendix "B" of this Document. Test procedures which provide equivalent information may be used.

2.1 Envelopes of Conditions for Warning

2.1.1 Excessive Rates of Descent With Respect To Terrain (Mode 1)

Warnings shall be provided by the equipment when, regardless of landing gear and flap position inputs, the combination of barometric altitude sink rate and height above terrain is within the envelope(s) for Mode 1 selected from the envelopes prescribed for this mode in Appendix A.

2.1.2 Excessive Closure Rate To Terrain (Mode 2)

Warnings shall be provided by the equipment when the combination of the rate of change in height above the terrain and the height above the terrain is within the applicable portion of envelope prescribed for Modes 2A and 2B in Appendix A.

2.1.3 Negative Climb Rate (Mode 3A) OR Altitude Loss (Mode 3B) Before Acquiring 700 Feet Terrain Clearance After Take-Off or Missed Approach

Warnings shall be provided by the equipment when the combination of barometric altitude sink rate and height above terrain is within the envelope prescribed for Mode 3A in Appendix A, OR when the combination of barometric altitude loss and height above terrain is within the envelope prescribed for Mode 3B in Appendix A, regardless of landing gear position and with flaps not in landing configuration. Optionally, the warning may be provided for all landing gear and flap configurations except both gear and flaps in the landing configuration.

2.1.4 Flight Into Terrain With Less Than 500 Feet Terrain Clearance and Not in Landing Configuration (Mode 4)

Warnings shall be provided by the equipment when the combination of barometric altitude rate of change and the height above the terrain is within the applicable portion of the envelope(s) for Mode 4 selected from those prescribed for this mode in Appendix A. The warnings for the portion of each envelope labelled "gear other than landing configuration" shall be provided only when this portion of the envelope is entered from above with the landing gear configured other than for landing. There should be no warnings if the pilot changes the landing gear configuration from landing to not landing after entering this portion of the envelope with the gear configured for landing, unless descent continues into the portion of the envelope labelled "gear and/or flaps other than in landing configuration". 1/ If the aircraft ascends above 1000 feet after the pilot changed the gear configuration from landing to not landing while in the "gear other than landing" part of the envelope, and before entering the "gear and/or flaps other than in landing configuration" part of the envelope, the warning mode described for the "gear other than landing configuration" part of the envelope shall be rearmed. Warnings shall be provided if the aircraft reenters this portion of the envelope with the gear configured other than for landing.

Warnings shall be provided for the "gear and/or flaps other than in landing configuration" portion of the envelope when a configuration other than for landing has been selected for either flaps or landing gear or both.

1/ If the optional Mode 3/Mode 4 logic is used (see Appendix A, page 8, 9 and 10) the equipment will revert to Mode 3 after a 2 to 3 second delay.

2.2 Automatic Mode Selection

The equipment shall be designed to accomplish automatically any mode selection from aircraft take-off to landing without action by the flight crew, as indicated in Appendices A and B.

2.3 Characteristics of Warning Indications (Modes 1 through 4)

2.3.1 Aural Warning Characteristics

The aural warning for Modes 1 through 4 consists of the sound "Whoop-Whoop", followed by either "Pull-up" or "Terrain" (or other acceptable annunciation) repeated until the hazardous condition no longer exists. It is not necessary for any warning cycle ("Whoop-Whoop" plus voice annunciation) to be completed following the termination of a hazardous condition. "Whoop-Whoop" is described as a tone sweep from 400 Hz ±10% to 800 Hz ±10% at a period of 0.3 seconds ±20% and with increasing amplitude of 9dB ±3dB. The complete cycle of two tone sweeps plus voice annunciation should take 1.4 seconds ±20%, with the cycle repeated immediately. The gain may be automatically reduced after three complete warning cycles to a lower, but discernable, level.

2.3.1.1 Speaker Output Level

The voice warning signal shall have an output level of at least 2W RMS.

2.3.1.2 Headset Output Level

If provided, the headset voice warning signal shall have an output level of at least 50 mW.

2.3.2 Visual Warning

The visual warning for Modes 1 through 4 shall be red and include, in distinctive letters, the letters GPWS (or other acceptable legend).

2.4 Deactivation Control

The control for deactivation of the warning

indications under planned abnormal or emergency conditions shall be a circuit breaker. Alternatively a switch which is protected from inadvertant crew operation may be used. Such a switch shall provide obvious indication it has been operated.

2.5 Failure Monitor and/or Self-Test 1/

The failure monitor and/or self-test functions shall provide highly reliable indications of equipment condition. They shall include power input, aural alert and warning outputs, visual warning output and input validity signals. Manufacturers may elect to provide, or users to use, either or both failure monitoring or self-test.

2.5.1 Failure Monitor

If a failure monitor is elected as the exclusive alternative for equipment condition testing, the indicator(s) shall be provided on the flight deck.

2.5.2 Self-Test

If self-test is used, it shall provide indication(s) of equipment condition on the flight deck.

2.5.3 Failure Monitor and Self-Test

If both failure monitoring and self-test are provided, the failure monitor indicator(s) need not be located on the flight deck.

2.6 Glide Slope Deviation Alerting (Mode 5)

2.6.1 Envelope of Conditions For Alerting

An alert shall be provided when the combination of deviation below an ILS glide slope and the height above terrain is within the envelope for Mode 5 prescribed in Appendix A.

1/ Definitions: Self-Test - an aircrew-initiated test of the equipment; Failure Monitor - an automatic test function within the equipment.

2.6.2 Deactivation

It shall be possible for the flight crew to deactivate Mode 5. The control provided for this purpose shall be separate from any control provided to deactivate Modes 1 through 4. The Mode 1 through 4 deactivation control, however, may also deactivate Mode 5.

2.6.3 Reactivation

If Mode 5 is deactivated by the pilot, it shall be automatically reactivated for the next approach.

2.6.4 Arming/Disarming

Mode 5 shall be armed when the landing gear is selected to the landing position and disarmed either when the flaps are retracted from the landing position or the landing gear is selected to the non-landing position.

2.6.5 Glide Slope Mode Alert

The glide slope deviation alert shall consist of the aural annunication "Glide Slope" (or other acceptable annunciation) repeated until the condition responsible for the alert no longer exists or the alert is inhibited. An aural warning related to GPWS Modes 1 through 4 shall take precedence over this alert.

The equipment may provide a constant alert repetition rate and audio output level, or one or both of these quantities may increase as the below glide slope deviation increases and/or the terrain clearance decreases. In the former case the alert shall be repeated at least once every three seconds. The audio output power levels may take on any value between 0 and 6dB below those values specified for the Modes 1 through 4 aural warning in paragraphs 2.3.1.1 and 2.3.1.2.

If the repetition rate/audio output level is/are varied with terrain clearance/glide

slope deviation, the alert should be repeated once every seven seconds (nominal) at 1000 feet terrain clearance and the audio levels be discernable to the pilot. As the terrain clearance decreases and/or the glide slope deviation increases, the alert rate should increase to a maximum of once every 0.7 seconds and the audio output power levels to the maximum of those values specified for the Modes 1 through 4 aural warning in paragraphs 2.3.1.1 and 2.3.1.2.

3.0 MINIMUM PERFORMANCE STANDARDS UNDER ENVIRONMENTAL TEST CONDITIONS 1/

Unless otherwise specified, the test procedures applicable to a determination of the performance of equipment under environmental test conditions shall be those set forth in RTCA Document D0-160, "Environmental Conditions and Test Procedures for Airborne Electronic/Electrical Equipment and Instruments".

3.1 Temperature and Altitude Tests

3.1.1 Low Operating Temperature Test

When the equipment is subjected to this test:

(a) All mechanical devices shall operate satisfactorily.

(b) The requirements of Paragraph 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning and 2.5 Failure Monitor and/or Self-Test shall be met.

3.1.2 High Operating Temperature Tests

(a) When subjected to the High Short-Time Operating Temperature, the equipment shall operate both electrically and mechanically.

(b) When the equipment is operated at the High Operating Temperature:

(1) All mechanical devices shall operate satisfactorily;

1/ It will be noted that some of the performance parameters addressed in the paragraphs of Section 2.0, Minimum Performance Standards Under Standard Test Conditions, are not enumerated in the several specific environmental tests contained in this section. This is so because engineering judgment and experience has indicated that these particular performance parameters are not susceptible to certain of these environmental conditions and that the level of performance specified in 2.0 will, therefore, not be measurably degraded by exposure to these particular environmental conditions.

(2) The requirements of Paragraph 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning and 2.5 Failure Monitor and/or Self-Test shall be met.

3.1.3 Altitude Test

When the equipment is subjected to this test:

(a) The requirements of Paragraph 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

(b) All mechanical devices shall operate satisfactorily.

3.1.4 Decompression Test (When Required)

When the equipment has been subjected to this test:

(a) All mechanical devices shall operate satisfactorily.

(b) The requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.1.5 Overpressure Test (When Required)

When the equipment has been subjected to this test:

(a) All mechanical devices shall operate satisfactorily.

(b) The requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.2 Temperature Variation Test

When the equipment is subjected to this test, the requirement of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.3 Humidity Test

(a) After subjection to humidity and within 15 minutes after primary power is applied:

(1) The appropriate requirements of Paragraph 2.5, Failure Monitor and/or Self-Test shall be met.

(2) All mechanical devices shall operate satisfactorily.

(b) After subjection to humidity and within four hours from the time primary power is applied the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.4 Shock Tests

(a) Following the application of the Operational Shocks:

(1) The requirements of Paragraph 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

(2) All mechanical devices shall operate satisfactorily.

(b) Following the application of the Crash Safety Shocks, the equipment under test shall have remained in its mounting, and no parts of the equipment or its mounting shall have become detached and free of the equipment or of the shock table. 1/

3.5 Vibration Test

When subjected to this test, the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions, 2.5 Failure Monitor and/or Self-Test shall be met.

1/ The application of this test may result in damage to the equipment under test. Therefore, it may be conducted after the other tests are completed. Paragraph 1.4 does not apply.

3.6 Explosion Test (When Required)

During the application of this test, the equipment shall not cause detonation of the explosive mixture within the test chamber.

3.7 Waterproofness (Drip Proof) Test (When Required)

After subjection to this test, the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.8 Hydraulic Fluid Test (When Required)

After subjection to this test, the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.9 Sand and Dust Test (When Required)

After subjection to this test, all mechanical devices shall operate satisfactorily.

3.10 Fungus Resistance Test (When Required)

After subjection to this test, the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.11 Salt Spray Test (When Required)

After subjection to this test, the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.12 Magnetic Effect Test

Determine and record the magnetic effect of the equipment.

3.13 Power Input Test

When subjected to the applicable power input conditions defined in Paragraphs 16.3.1, 16.3.2, 16.3.3, 16.3.4 and 16.3.5 of Document DO-160:

(a) The requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning, 2.3.1, Aural Warning Characteristics, and 2.6.5 Glide Slope Mode Alert shall be met.

(b) All mechanical devices shall operate satisfactorily.

(c) There shall be no nuisance warnings.

Exceptions to the above are as follows:

(1) When subjected to the applicable power inputs conditions specified in Paragraphs 16.3.3.1, B2 or 16.3.3.1, C2 and 16.3.4.1, B2, of Document DO-160 the equipment shall start and continue to operate electrically and mechanically. Degradation of performance is tolerable but there shall be no nuisance warnings.

(2) When subjected to the test defined in Paragraph 16.3.4.2 of Document DO-160 (DC operated equipment) the equipment shall produce no evidence of the presence of fire or smoke. 1/

3.14 Voltage Spike Conducted Test

When subjected to this test, equipment declared to Category A shall meet the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning and 2.5 Failure Monitoring and/or Self-Test. There shall be no false warnings.

DC powered equipment declared to Category B shall:

(a) Following the application of Intermittent Transients, meet the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning and 2.5 Failure Warning and/or Self-Test.

1/ The application of this test may result in damage to the equipment under test. Therefore, it may be conducted after the other tests are completed. Paragraph 1.4 does not apply.

(b) Output no nuisance warnings during the application of Repetitive Transient.

AC powered equipment declared to Category B shall output no nuisance warnings.

3.15 Audio-Frequency Conducted Susceptibility Test

When the equipment is subjected to this test, the requirements of Paragraph 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.16 Induced Signal Susceptibility Test

When the equipment is subjected to the tests for Magnetic Fields Induced into the Equipment, Magnetic Fields Induced into Interconnecting Cables, Electric Fields Induced into Interconnecting Cables and Spikes Induced into Interconnecting Cables, the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.17 Radio-Frequency Susceptibility Test (Radiated and Conducted)

When the equipment is subject to these tests, the requirements of Paragraphs 2.1 (Modes 1-4) and 2.6.1 (Mode 5), Envelopes of Conditions for Warning shall be met.

3.18 Emission of Radio Frequency Energy Test

Determine the levels of emissions of radio frequency energy from the equipment in accordance with the requirements of this test.

M E M B E R S H I P

Special Committee 128

MINIMUM PERFORMANCE STANDARDS - AIRBORNE GROUND PROXIMITY WARNING EQUIPMENT

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A P P E N D I X A

ENVELOPES OF CONDITIONS FOR WARNING

FOR

AIRBORNE GROUND PROXIMITY WARNING EQUIPMENT

NOTE: THE CURVES OF APPENDIX A SPECIFY THE PERFORMANCE REQUIRED OF THE GROUND PROXIMITY WARNING EQUIPMENT ON THE BENCH WHEN IT IS SUPPLIED WITH LABORATORY-SOURCE INPUTS OF BAROMETRIC DATA, RADIO HEIGHT DATA AND GLIDE SLOPE DEVIATION, AND TESTED USING THE PROCEDURES OF APPENDIX B OR THEIR EQUIVALENTS.

IF THESE CURVES ARE USED AS REFERENCES FOR STABILIZED DESCENT-RATE FLIGHT TESTS OF THE EQUIPMENT AN ADDITIONAL TOLERANCE BAND BELOW THE LOWER TOLERANCE LIMIT OF EACH BENCH TEST CURVE IS NECESSARY TO ACCOMMODATE THE INTEGRATION OF THE EQUIPMENT INTO THE AIRCRAFT. FIVE PERCENT OF NOMINAL CURVE VALUES HAS BEEN USED FOR THIS ADDITIONAL TOLERANCE BAND.

SMOOTHING OF THE INPUT DATA IS NECESSARY IN THE GROUND PROXIMITY WARNING EQUIPMENT TO MINIMIZE NUISANCE WARNINGS. THE TEST PROCEDURES OF APPENDIX B SPECIFY CONSTANT RATE INPUTS, AND ARE DESIGNED TO ENSURE THAT DELAYS TO WARNING ONSET RESULTING FROM SUCH SMOOTHING ARE NOT SUCH THAT THE EQUIPMENT FAILS TO PROVIDE WARNINGS BEFORE THE LOWER TOLERANCE LIMITS OF THE WARNING ENVELOPES ARE REACHED. THE CURVES OF APPENDIX A ARE NOT APPLICABLE TO INCREASING RATES, AND ADDITIONAL DELAYS TO WARNING ONSET WILL BE EXPERIENCED IF INCREASING RATES ARE USED.

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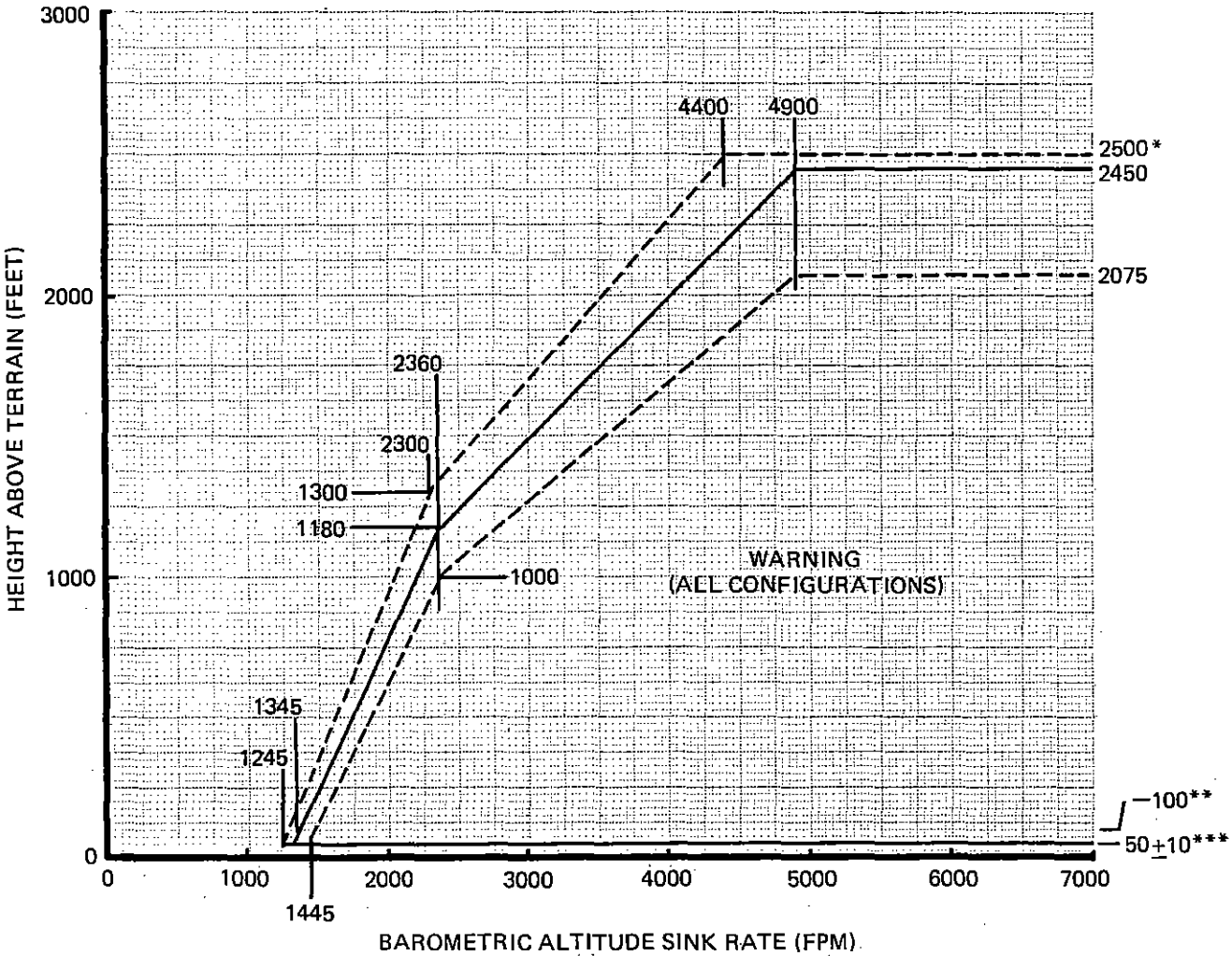
MODE 1, ENVELOPE 1
EXCESSIVE RATE OF DESCENT WITH RESPECT TO TERRAIN



Solid lines are nominal values.

Dashed lines indicate tolerance limits.

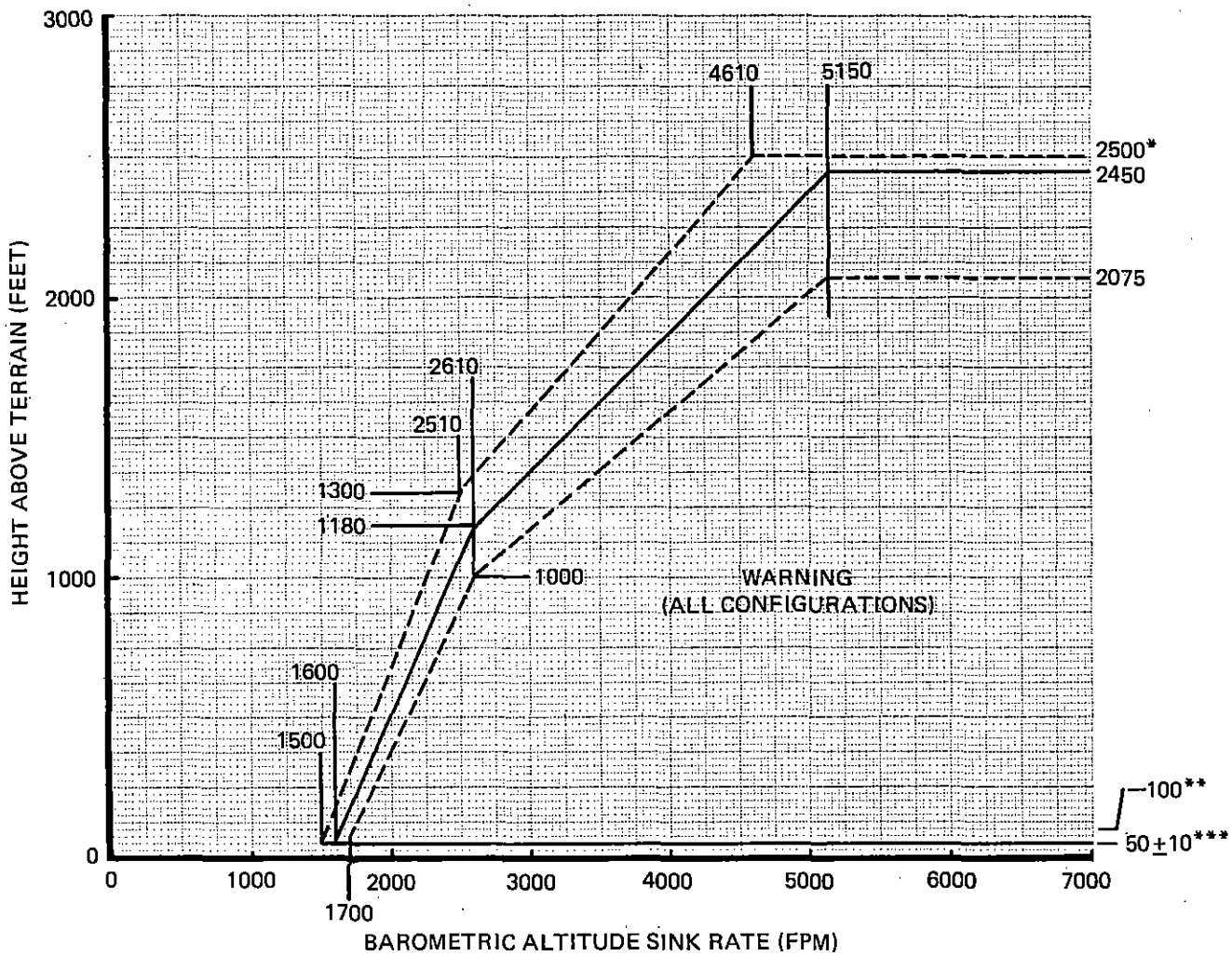
* Positive cutoff necessary at 2500 feet. (Recognize that radio altimeter reads 2500 feet (or more) at all heights greater than 2500 feet.)

** Maximum ascending arming height.

*** Descent inhibit height.

MODE 1 IS FUNCTIONAL AT ALL TIMES.

MODE 1, ENVELOPE 2
EXCESSIVE RATE OF DESCENT WITH RESPECT TO TERRAIN



Solid lines are nominal values.

Dashed lines indicate tolerance limits.

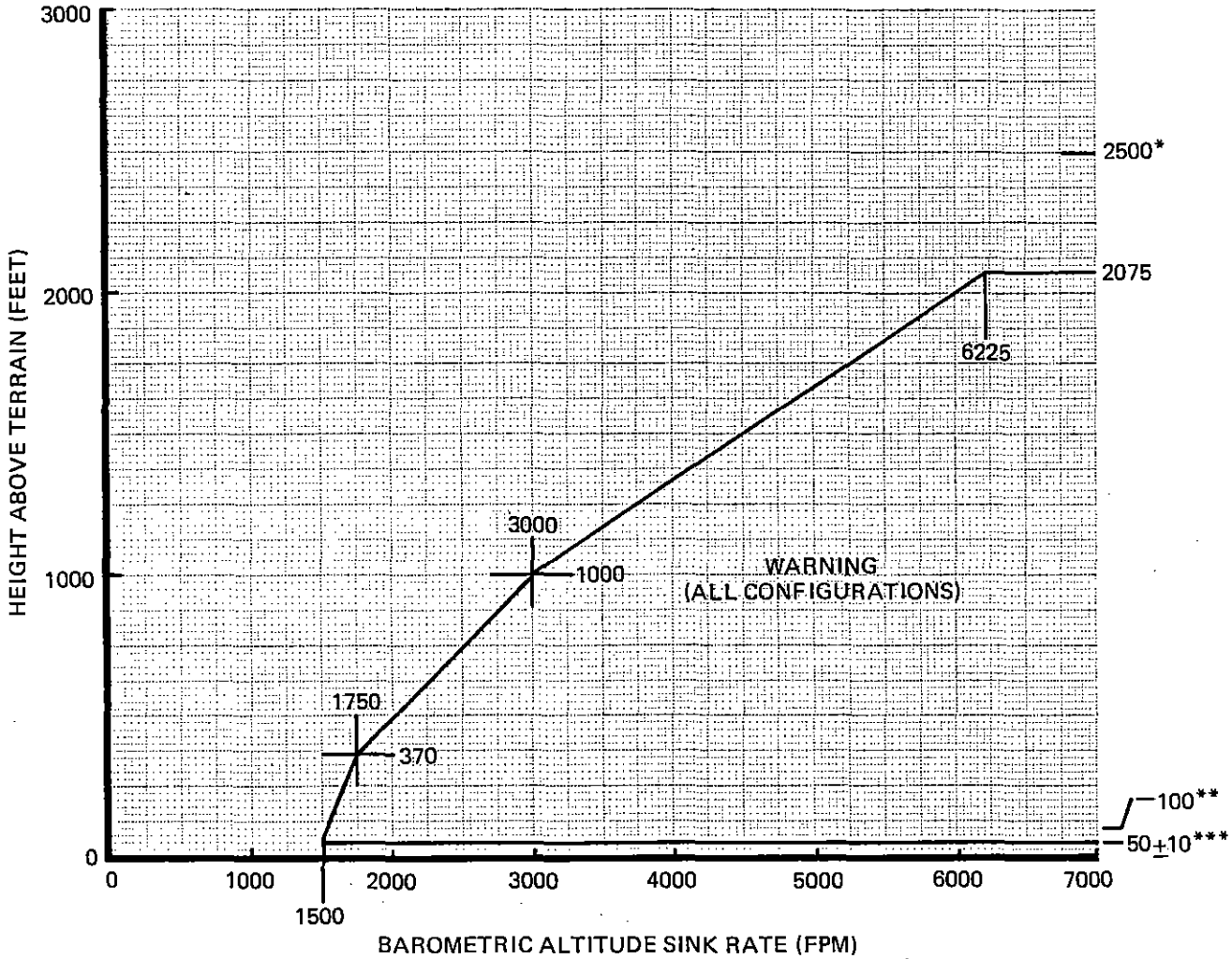
* Positive cutoff necessary at 2500 feet. (Recognize that radio altimeter reads 2500 feet (or more) at all heights greater than 2500 feet.)

** Maximum ascending arming height.

*** Descent inhibit height.

MODE 1 IS FUNCTIONAL AT ALL TIMES.

MODE 1, ENVELOPE 3
EXCESSIVE RATE OF DESCENT WITH RESPECT TO TERRAIN



Solid line is lower tolerance limit. Manufacturer shall declare selected position for nominal above this line and compute upper tolerance limit similar to that for Mode 1, Envelopes 1 and 2 (recognizing the need to minimize nuisance warnings) before applying test procedure T-1 of appendix B.

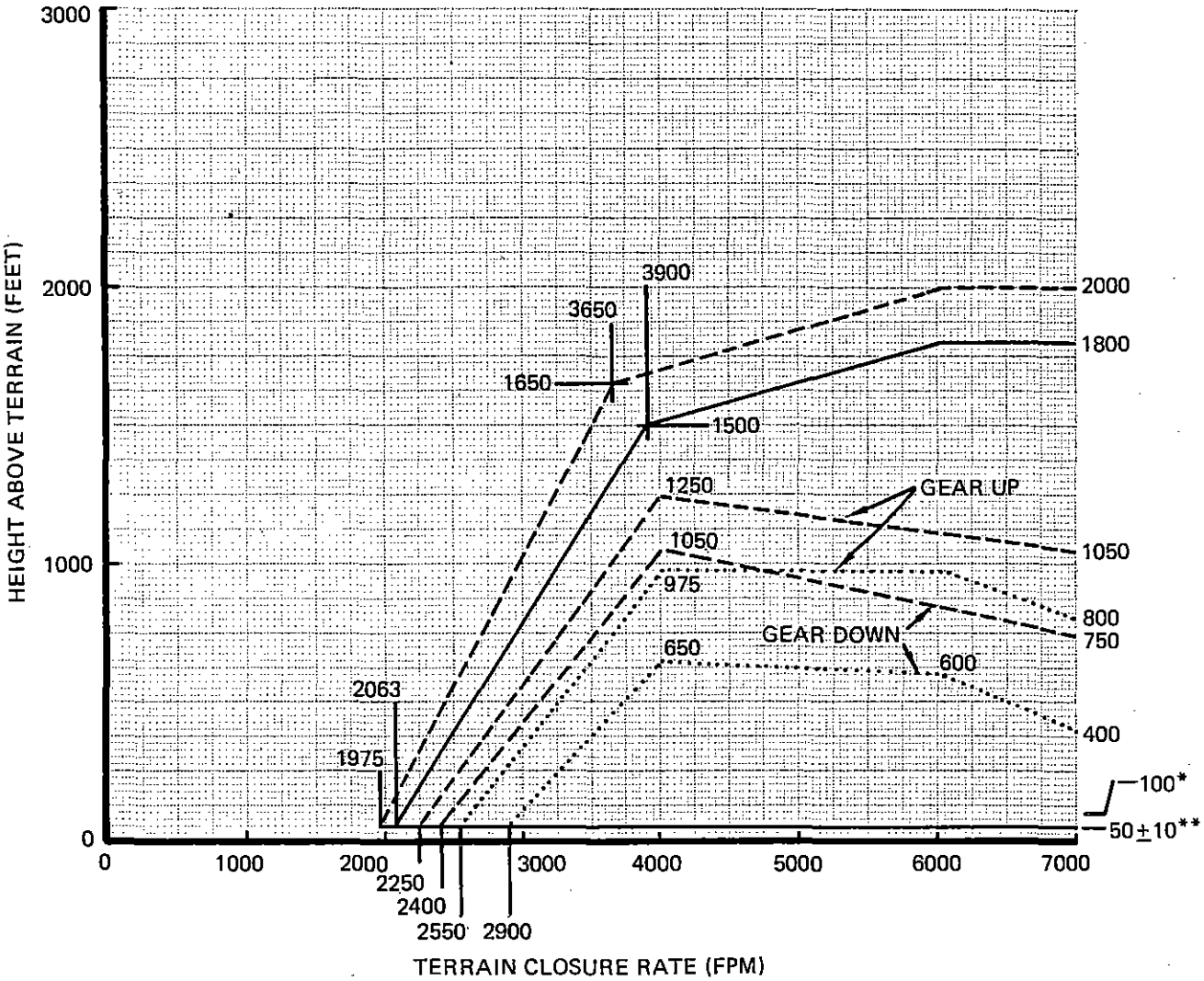
* Radio altimeter cutoff height.

** Maximum ascending arming height.

*** Descent inhibit height.

MODE 1 IS FUNCTIONAL AT ALL TIMES.

MODE 2A
EXCESSIVE CLOSURE RATE TO TERRAIN
(Flaps Not in Landing Configuration)



Solid lines are nominal values.

Dashed lines indicate tolerance limits when initiating test from 2450 feet.

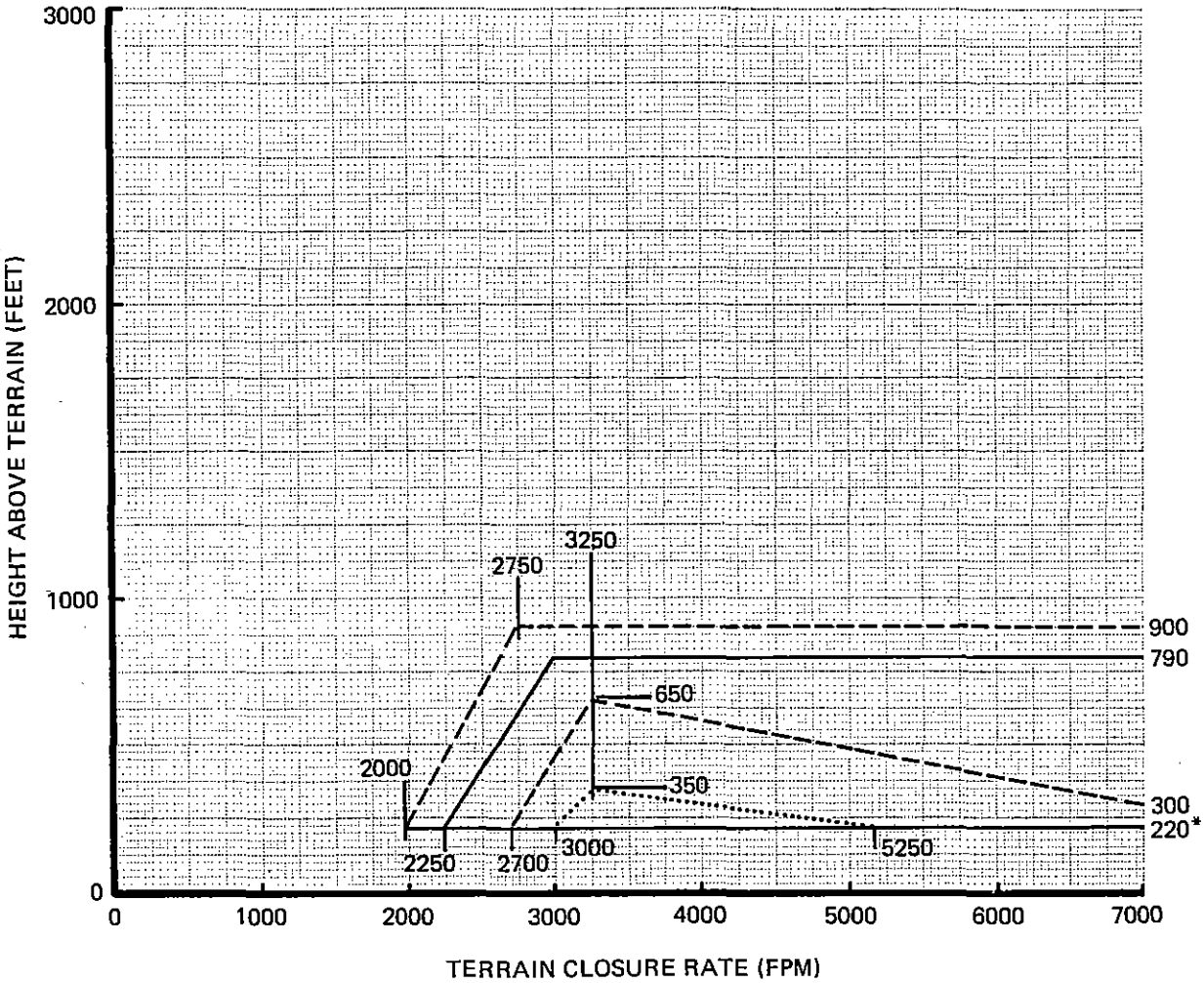
Dotted lines indicate tolerance limits when initiating test from the nominal envelope.

* Maximum ascending arming height.

** Descent inhibit height.

MODE 2A IS FUNCTIONAL AT ALL TIMES FLAPS ARE NOT IN LANDING CONFIGURATION

MODE 2B
EXCESSIVE CLOSURE RATE TO TERRAIN
(Landing Configuration)



Solid lines are nominal values.

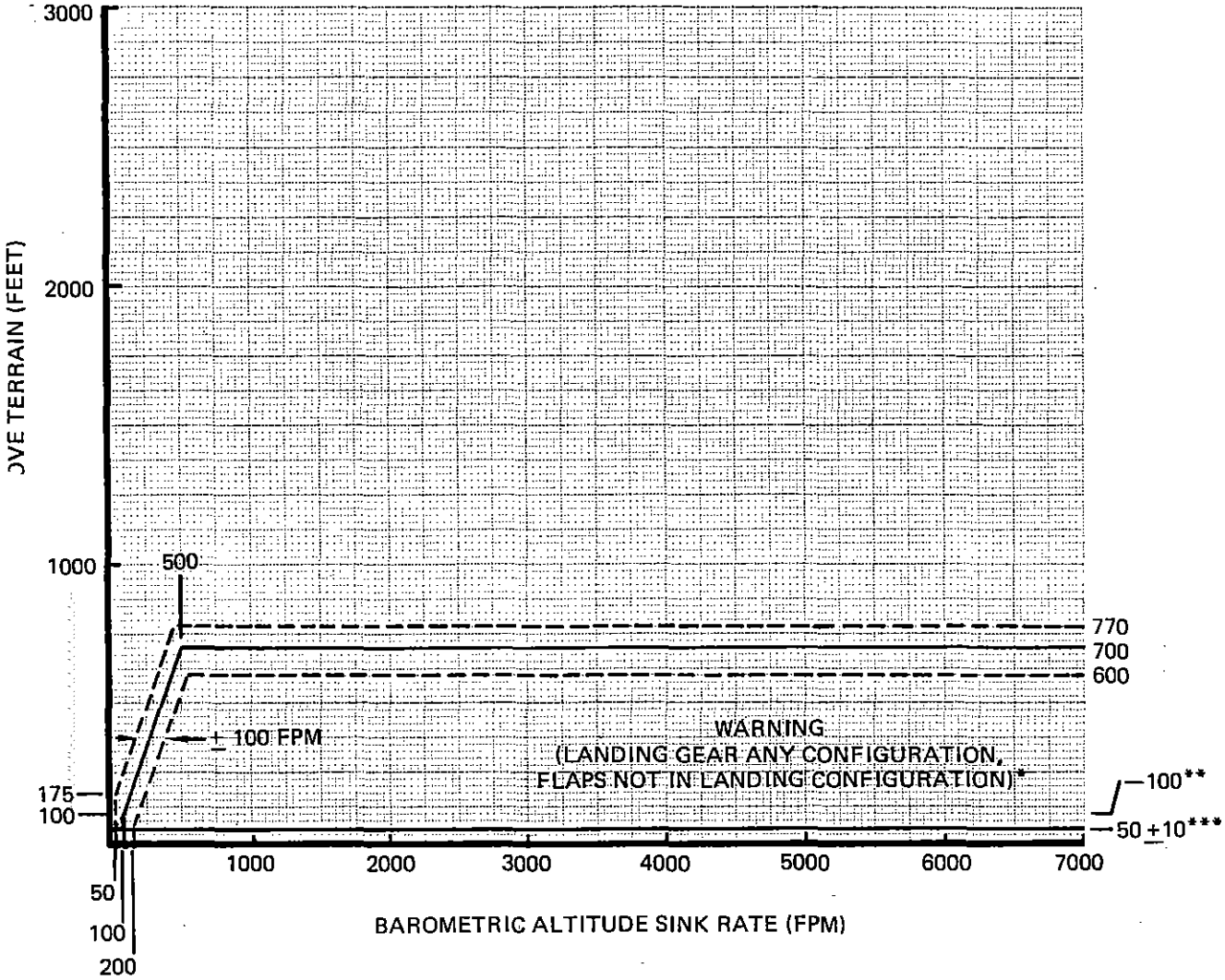
Dashed lines indicate tolerance limits when initiating test from 2450 feet.

Dotted lines indicate tolerance limits when initiating test from 1500 feet.

* Maximum inhibit height.

MODE 2B IS FUNCTIONAL AT ALL TIMES FLAPS ARE IN LANDING CONFIGURATION AND IRRESPECTIVE OF LANDING GEAR POSITION.

MODE 3A
NEGATIVE CLIMB (SINK) RATE BEFORE ACQUIRING 700 FEET TERRAIN CLEARANCE AFTER TAKEOFF OR MISSED APPROACH



Solid lines are nominal values.

Dashed lines indicate tolerance limits.

* Optionally, all configurations except gear and flaps in landing configuration.

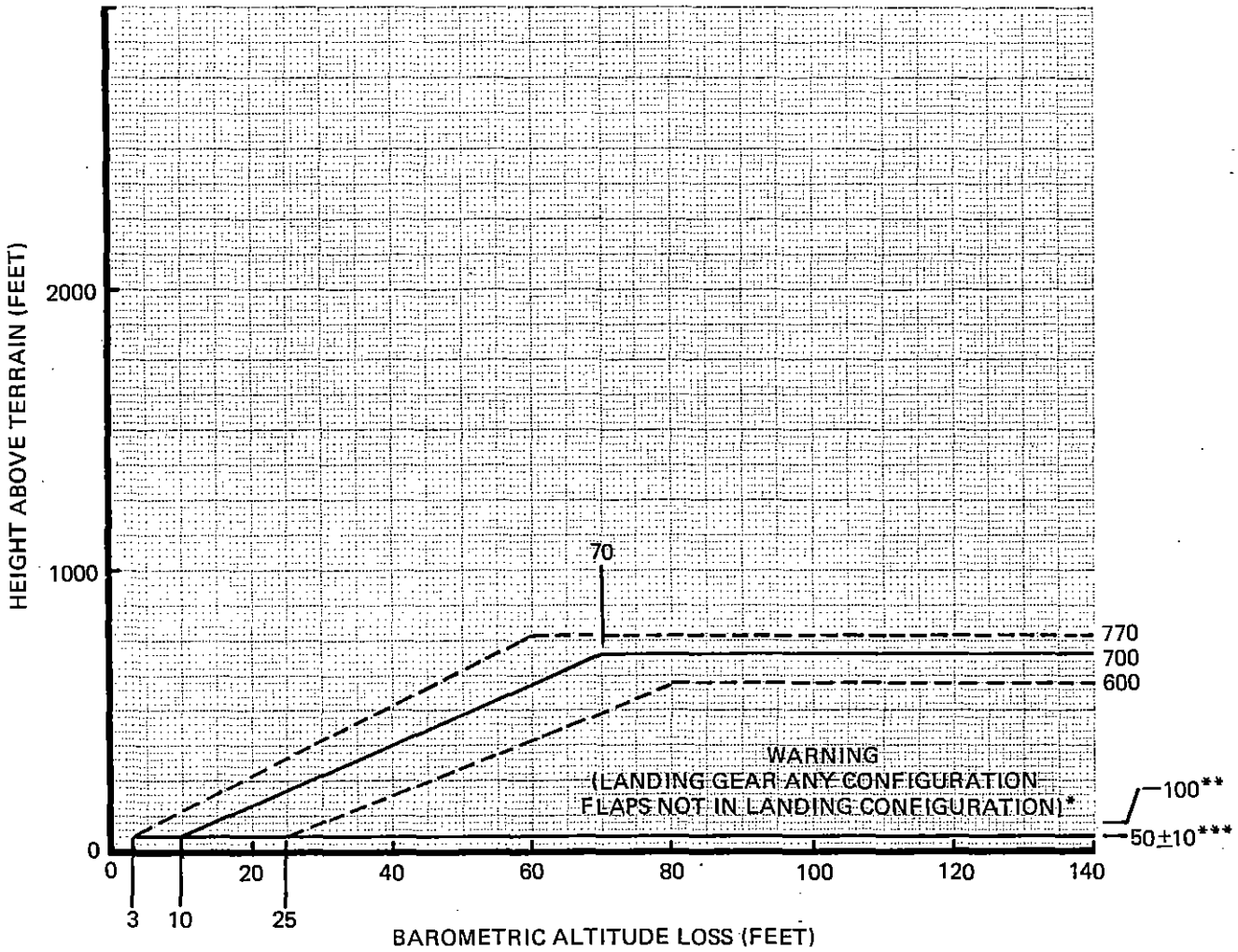
** Maximum ascending arming height.

*** Descent inhibit height.

MODE 3A IS FUNCTIONAL DURING TAKEOFF OR MISSED APPROACH WHEN MODE 4 IS DISABLED.

TRANSITION TO MODE 4 BETWEEN 600 AND 770 FEET.

MODE 3B
ACCUMULATED ALTITUDE LOSS BEFORE ACQUIRING 700 FEET TERRAIN CLEARANCE AFTER TAKEOFF OR MISSED APPROACH



Solid lines are nominal values.

Dashed lines indicate tolerance limits.

* Optionally, all confiugrations except gear and flaps in landing configuration.

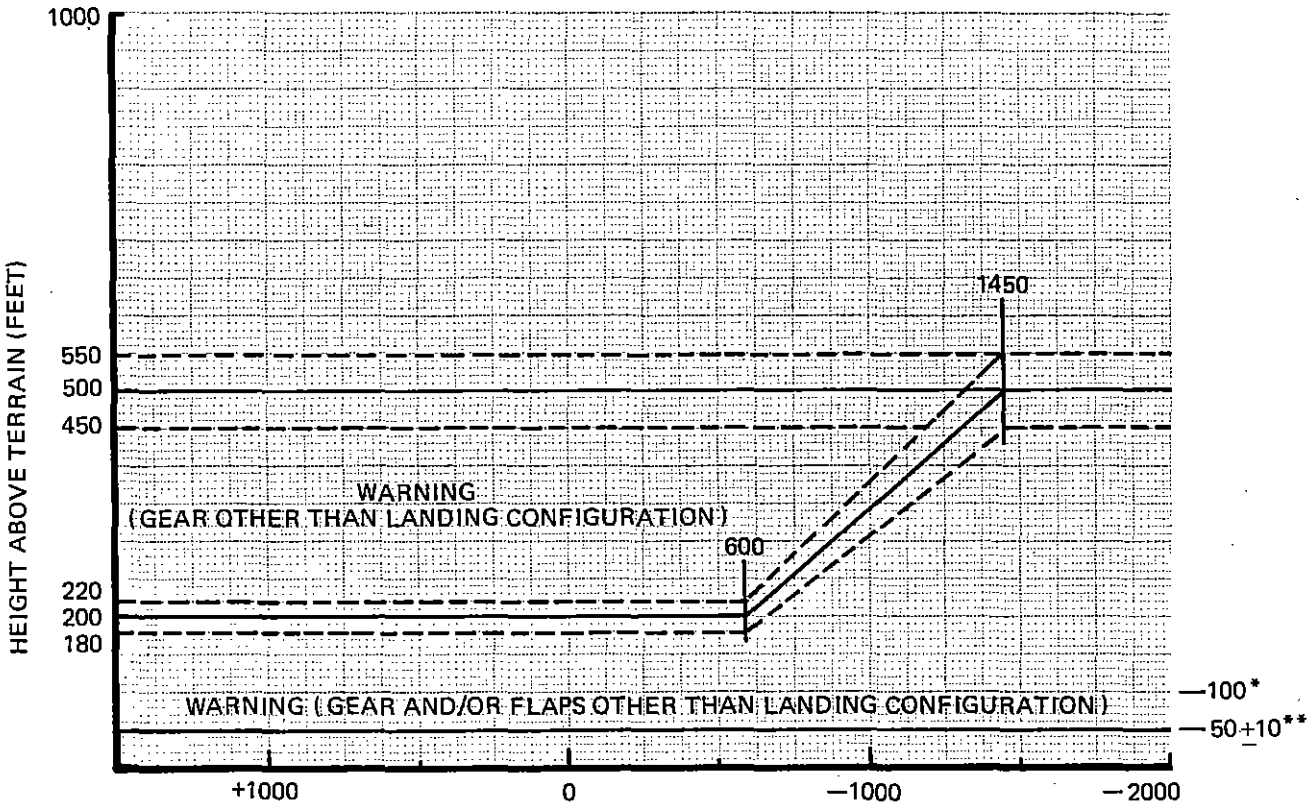
** Maximum ascending arming height.

*** Descent inhibit height.

MODE 3B IS FUNCTIONAL DURING TAKEOFF OR MISSED APPROACH WHEN MODE 4 IS DISABLED.

TRANSITION TO MODE 4 BETWEEN 600 AND 770 FEET.

MODE 4, ENVELOPE 1
FLIGHT INTO TERRAIN WITH LESS THAN 500 FEET TERRAIN CLEARANCE AND NOT IN LANDING CONFIGURATION



Solid lines are nominal values.

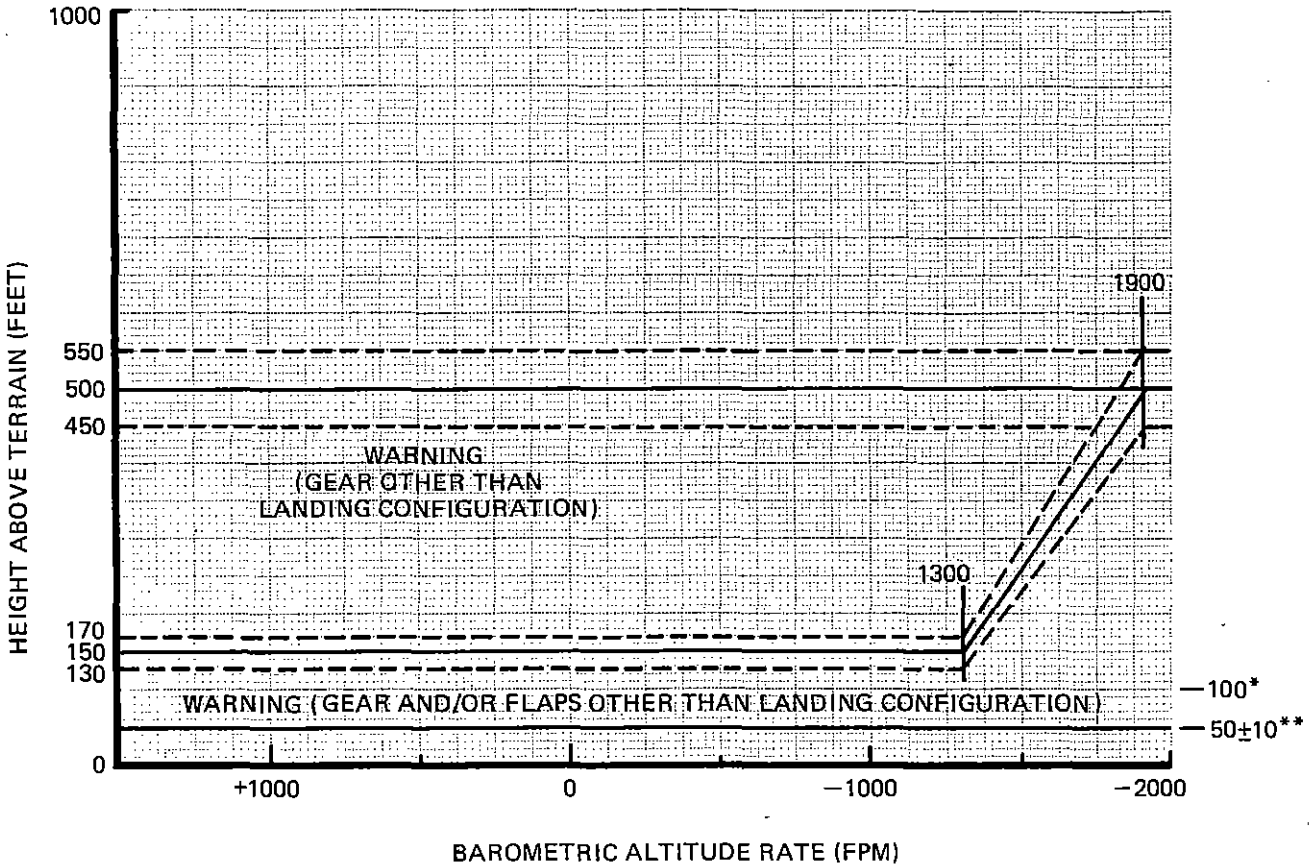
Dashed lines indicate tolerance limits.

AUTOMATIC TRANSFER FROM MODE 4 TO MODE 3 MUST OCCUR WITHIN 2 TO 3 SECONDS UPON CHANGING AIRCRAFT CONFIGURATION WITHIN AREA BOUNDED BY GEAR AND/OR FLAPS OTHER THAN LANDING CONFIGURATION ENVELOPE WHEN EXECUTING MISSED APPROACH. ABOVE THIS BOUNDARY AIRCRAFT CONFIGURATION CHANGE SHALL NOT CAUSE TRANSFER OUT OF MODE 4. OPTIONALLY, AUTOMATIC TRANSFER FROM MODE 4 TO MODE 3 MAY OCCUR WITHIN 2 TO 3 SECONDS UPON CHANGING AIRCRAFT CONFIGURATION WITHIN AREA BOUNDED BY GEAR AND/OR FLAPS OTHER THAN LANDING CONFIGURATION ENVELOPE AND GEAR OTHER THAN LANDING CONFIGURATION ENVELOPE WHEN EXECUTING MISSED APPROACH. ABOVE 500 ± 50 FEET AIRCRAFT CONFIGURATION CHANGE SHALL NOT CAUSE TRANSFER OUT OF MODE 4.

* Maximum ascending arming height.

** Descent inhibit height.

MODE 4, ENVELOPE 2
FLIGHT INTO TERRAIN WITH LESS THAN 500 FEET TERRAIN CLEARANCE AND NOT IN LANDING CONFIGURATION



Solid lines are nominal values.

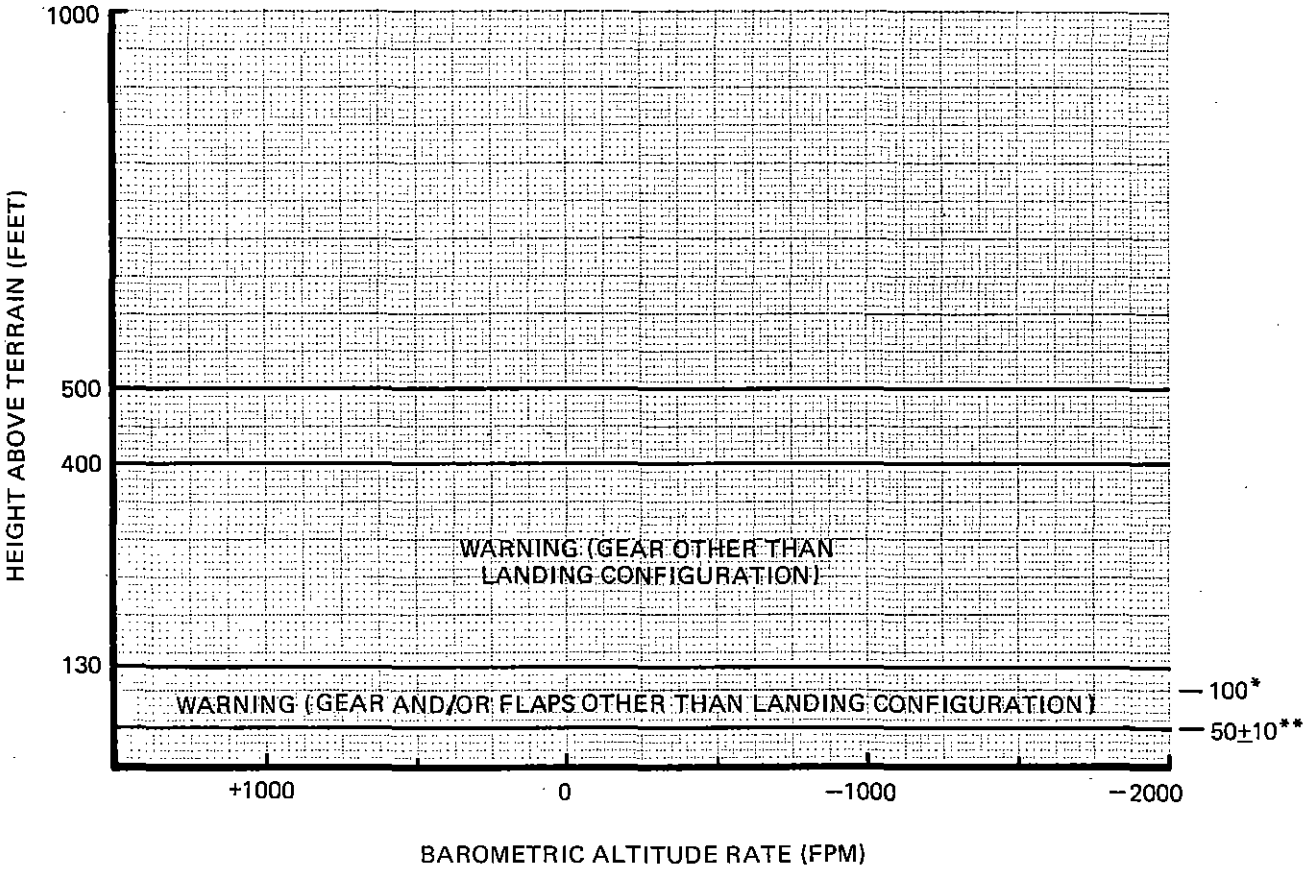
Dashed lines indicate tolerance limits.

AUTOMATIC TRANSFER FROM MODE 4 TO MODE 3 MUST OCCUR WITHIN 2 TO 3 SECONDS UPON CHANGING AIRCRAFT CONFIGURATION WITHIN AREA BOUNDED BY GEAR AND/OR FLAPS OTHER THAN LANDING CONFIGURATION ENVELOPE WHEN EXECUTING MISSED APPROACH. ABOVE THIS BOUNDARY AIRCRAFT CONFIGURATION CHANGE SHALL NOT CAUSE TRANSFER OUT OF MODE 4. OPTIONALLY, AUTOMATIC TRANSFER FROM MODE 4 TO MODE 3 MAY OCCUR WITHIN 2 TO 3 SECONDS UPON CHANGING AIRCRAFT CONFIGURATION WITHIN AREA BOUNDED BY GEAR AND/OR FLAPS OTHER THAN LANDING CONFIGURATION ENVELOPE AND GEAR OTHER THAN LANDING CONFIGURATION ENVELOPE WHEN EXECUTING MISSED APPROACH. ABOVE 500 ±50 FEET, AIRCRAFT CONFIGURATION CHANGE SHALL NOT CAUSE TRANSFER OUT OF MODE 4.

*Maximum ascending arming height.

**Descent inhibit height.

MODE 4, ENVELOPE 3
FLIGHT INTO TERRAIN WITH LESS THAN 500 FEET TERRAIN CLEARANCE AND NOT IN LANDING CONFIGURATION



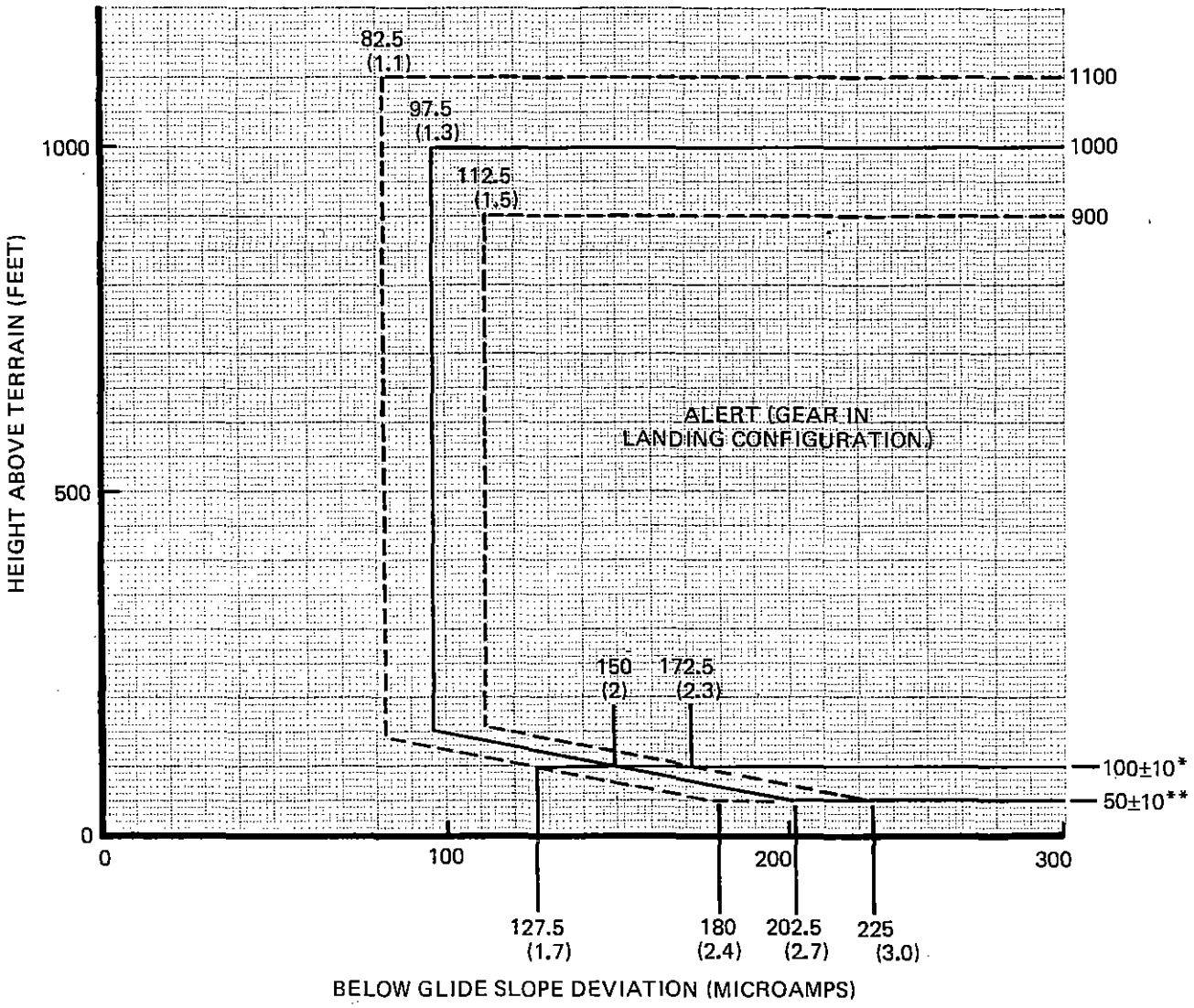
Horizontal lines at 130 and 400 feet height above terrain are lower tolerance limits. Manufacturer shall declare selected positions for nominals above these lines and compute upper tolerance limits similar to those for Mode 4 Envelopes 1 and 2 (recognizing the need to minimize nuisance warnings) before applying test procedure T-4 of Appendix B.

AUTOMATIC TRANSFER FROM MODE 4 TO MODE 3 MUST OCCUR WITHIN 2 TO 3 SECONDS UPON CHANGING AIRCRAFT CONFIGURATION WITHIN AREA BOUNDED BY GEAR AND/OR FLAPS OTHER THAN LANDING CONFIGURATION ENVELOPE WHEN EXECUTING MISSED APPROACH. ABOVE THIS BOUNDARY AIRCRAFT CONFIGURATION CHANGE SHALL NOT CAUSE TRANSFER OUT OF MODE 4. OPTIONALLY, AUTOMATIC TRANSFER FROM MODE 4 TO MODE 3 MAY OCCUR WITHIN 2 OR 3 SECONDS UPON CHANGING AIRCRAFT CONFIGURATION WITHIN AREA BOUNDED BY GEAR AND/OR FLAPS OTHER THAN LANDING CONFIGURATION ENVELOPE AND GEAR OTHER THAN LANDING CONFIGURATION ENVELOPE WHEN EXECUTING MISSED APPROACH. ABOVE 500±50 FEET, AIRCRAFT CONFIGURATION CHANGE SHALL NOT CAUSE TRANSFER OUT OF MODE 4.

*Maximum ascending arming height.

**Descent inhibit height.

MODE 5
GLIDE SLOPE DEVIATION ALERTING



Solid lines are nominal values.

Dashed lines indicate tolerance limits.

Deviation in "Dots" shown in parenthesis.

*Automatic inhibit height upper limit.

**Automatic inhibit height lower limit.

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A P P E N D I X B

TEST PROCEDURES

FOR

AIRBORNE GROUND PROXIMITY WARNING EQUIPMENT

NOTE: THE TEST PROCEDURES SET FORTH IN PART II OF THIS APPENDIX ARE SATISFACTORY FOR USE IN DETERMINING THE PERFORMANCE OF AIRBORNE GROUND PROXIMITY WARNING EQUIPMENT. TEST PROCEDURES WHICH PROVIDE EQUIVALENT INFORMATION MAY BE USED.

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PART I

DEFINITIONS OF TERMS AND CONDITIONS OF TEST

The following definitions of terms and conditions of test are applicable to the test procedures specified herein:

A. Power Input Voltage - Direct Current

Unless otherwise specified, when the Ground Proximity Warning equipment is designed for operation from a direct current power source, all measurements shall be conducted with the voltage input to the equipment adjusted to 27.5 V, ±2% for 24-28 V equipment. The input voltage shall be measured at the equipment power input terminals.

B. Power Input Voltage - Alternating Current

Unless otherwise specified, when the equipment is designed for operation from an alternating current power source, all tests shall be conducted with the power input voltage adjusted to design voltage ±2%. In the case of equipment designed for operation from a power source of essentially constant frequency (e.g., 400 Hz), the input frequency shall be adjusted to design frequency ±2%. In the case of equipment designed for operation from a power source of variable frequency (e.g., 350 to 1000 Hz), tests shall be conducted with the input frequency adjusted to within 5% of a selected frequency within the range for which the equipment is designed.

C. Adjustment of Equipment

The circuits of the equipment under test shall be properly aligned and otherwise adjusted in accordance with the manufacturer's recommended practices, prior to the application of the specified tests.

D. Test Instrument Precautions

Due precautions shall be taken during the conduct of the tests to prevent the introduction of errors resulting from the improper sensor system

simulators, oscilloscopes and other test instruments.

E. Ambient Conditions

Unless otherwise specified, all tests shall be conducted under conditions of ambient room temperature, pressure, and humidity. However, the room temperature shall be not lower than 10°C.

F. Warm-up Period

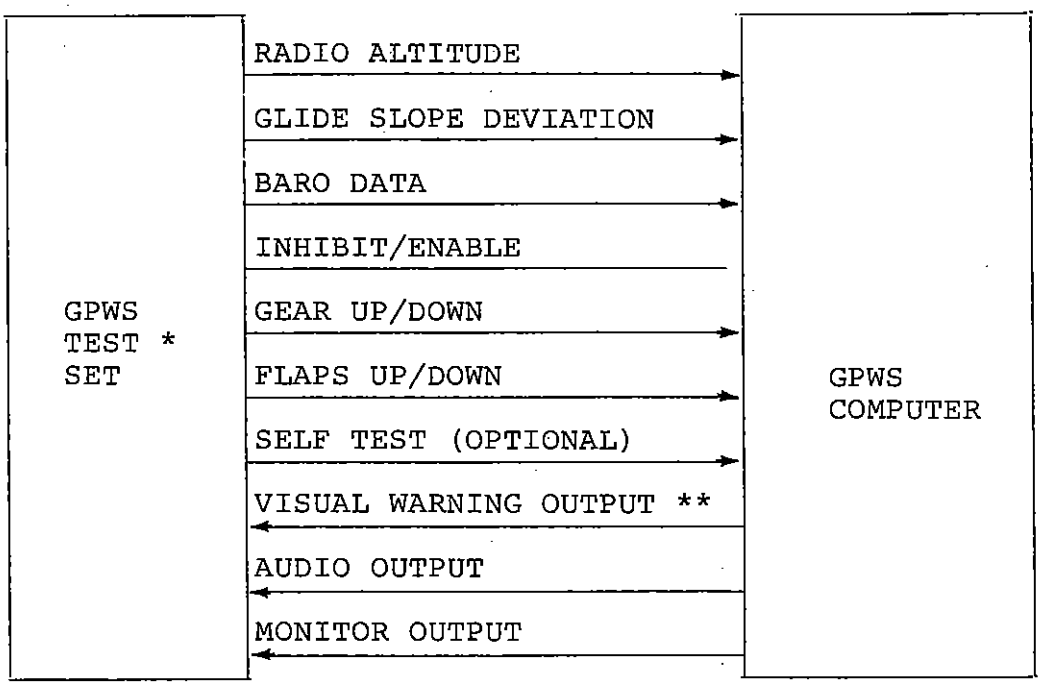
Unless otherwise specified, all tests shall be conducted after a warm-up period of not less than 15 minutes.

G. Connected Loads

Unless otherwise specified, all tests shall be performed with the equipment connected to loads having the impedance value for which it is designed.

H. Special Purpose Test Set

The Special Purpose Ground Proximity Warning equipment test set shown in Figure 1 may be used to facilitate testing. Equivalent test sets or arrangements of discrete test equipment may be used.



*SUNDSTRAND - P/N 951-0090-001
BENDIX - CPT-83A
COLLINS - 971T-1
EDO - GPW 1501TD
LITTON - MODEL GPWS-STC
IDC - 28400-001

** MODES 1 THROUGH 4 ONLY

FIG. 1 SPECIAL PURPOSE GROUND PROXIMITY WARNING TEST EQUIPMENT

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PART II

DETAILED TEST PROCEDURES

General

Special purpose Ground Proximity Warning System (GPWS) test equipment described in Part 1, or equivalent, is used for all test procedures. For all tests T-1 through T-4 at least two points shall be established for each segment of each warning envelope.

T-1 MODE 1

The initial test altitude shall be 2600 feet height above terrain. Attach GPWS test equipment, Figure 1, and determine that warning outputs are provided within the envelope(s) for Mode 1 selected from those set forth for this mode in Appendix A. Each measurement shall be made with a selected barometric altimeter sink rate and the corresponding rate of decrease of height above the terrain. The warning outputs shall occur at an altitude within the limits prescribed by the dashed lines for Mode 1 in Appendix A. Demonstrate that Mode 1 is functional with the gear and flaps in the landing configuration.

T-2 MODE 2

Attach GPWS test equipment, Figure 1, and determine that warning outputs are provided within the envelopes specified by Modes 2A and 2B, Appendix A, for each of the applicable aircraft configurations. Demonstrate that Mode 2A is functional at heights within Mode 4 envelope.

MODE 2A

(a) Apply a uniformly decreasing rate of change of the height above terrain signal starting from a height of 2450 feet. The warning outputs occur within the limits prescribed by the dashed lines for Mode 2A in Appendix A for each of the two applicable aircraft configurations.

(b) Apply a uniformly decreasing rate of change of the height above terrain signal starting from the nominal warning envelope. The warning outputs shall occur within the limits prescribed by the dotted lines for Mode 2A in Appendix A for each of the two applicable aircraft configurations.

MODE 2B

(a) Apply a uniformly decreasing rate of change of the height above terrain signal starting from a height of 2450 feet. The warning outputs shall occur at a height not lower than the limits prescribed by the dashed lines for Mode 2B in Appendix A.

(b) Apply a uniformly decreasing rate of change of the height above terrain signal starting from a height of 1500 feet. The warning outputs shall occur at a height not lower than the limits prescribed by the dotted lines for Mode 2B in Appendix A.

T-3 MODE 3A

(a) Attach GPWS test equipment, Figure 1, and determine that warning outputs are provided within the envelope specified by Mode 3A, Appendix A. Starting with an initial height above terrain of less than 600 feet, apply a constant barometric altitude sink rate and the corresponding rate of decrease of height above terrain. The warning outputs shall occur at a height within the limits prescribed by the dashed lines of Mode 3A in Appendix A. The terrain height shall be increased to 770 feet and the barometric altitude sink rate increased to 1000 feet per minute to verify that the mode is inhibited. The height above terrain shall then be reduced to verify that the Mode 4 envelope is armed. The maximum ascending arming height shall be verified by

increasing the height signal to 100 feet and then providing a barometric altitude sink rate signal of 200 feet/ minute.

MODE 3B

(b) Attach GPWS test equipment, Figure 1, and determine that warning outputs are provided within the envelope specified by Mode 3B, Appendix A. Starting with an initial height above terrain of less than 600 feet, set the test equipment to generate an altitude loss using either a sink rate of 300 feet/minute and time, or altitude directly. The warning outputs shall occur within the limits prescribed by the dashed lines of Mode 3B in Appendix A. The terrain height shall be increased to 770 feet and the barometric altitude sink rate increased to 1000 feet/per minute or equivalent altitude loss of 100 feet to verify that the mode is inhibited. The height above terrain shall then be reduced to verify that the Mode 4 envelope is armed. The maximum ascending arming height shall be verified by increasing the radio height signal to 100 feet, and then providing a barometric altitude sink rate signal of 200 feet/minute or an altitude loss in excess of 30 feet.

T-4 MODE 4

(a) Attach GPWS test equipment, Figure 1, and determine that warning outputs are provided within the envelope(s) for Mode 4, selected from those set forth for this Mode in Appendix A for each of the applicable aircraft configurations. Apply a constant barometric altitude rate and the selected rate of decrease of height above terrain signal starting from a height of 1000 feet. The warning outputs shall occur within the limits prescribed by the dashed lines for Mode 4 in Appendix A for each of the applicable aircraft configurations.

(b) Attach GPWS test equipment, Figure 1, and set the barometric altitude rate signal to zero rate. With gear selected in landing configuration, and flaps set in other than landing configuration, apply a terrain height signal of 300 feet. Select gear not in landing configuration and verify that no warning occurs. Change the terrain height signal to 1000 feet to rearm Mode 4, then lower the height signal to 300 feet. Verify that warning occurs. Select landing gear in landing gear configuration and verify that the warnings cease. Apply a sink rate of 1000 feet/minute and verify that Mode 4 provides warnings. Where the optional Mode 3/Mode 4 changeover logic is used (see paragraph 2.1.4 and Appendix A pages 8, 9, and 10), verify that the application of the 1000 feet/minute sink rate causes Mode 3A to provide warnings, or apply a barometric altitude loss of 90 feet and verify that Mode 3B provides warnings.

(c) Attach GPWS test equipment, Figure 1, and set the barometric altitude rate signal to zero rate. With gear and flaps selected in landing configuration, apply a terrain height signal of 100 feet. Select flaps not in landing configuration and verify that no warnings occur. Apply a sink rate of 500 feet/minute to verify that Mode 3A provides warnings, or a barometric altitude loss of 40 feet to verity that Mode 3B provides warnings.

T-5 Inhibit Altitude Test

Attach GPWS test equipment, Figure 1, and adjust height above terrain to a value less than the inhibit height. Determine that the GPW function is inhibited in each mode.

T-6 Audio Output Test

Connect dummy loads of the correct values for maximum power transfer from the GPWS to

both the speaker and headset audio output terminals.

(a) MODES 1-4

Apply suitable values of height above terrain and barometric altitude rate signal inputs from the GPWS test equipment, Figure 1, to the GPWS such that it produces warnings. (Alternative methods of causing the GPWS to produce warnings, such as self-test activation, are acceptable.) Record from an oscilloscope, connected across each of the dummy loads in turn, the voltage waveforms of one complete cycle ("Whoop-Whoop" plus command) of the warning. Calculate from these waveforms the powers developed in each of the loads. The resulting values shall be greater than the minima specified in paragraphs 2.3.1.1 and 2.3.1.2. Check also the frequency and amplitude variations of the "Whoop" parts of the waveform and ensure their compliance with the requirements of paragraph 2.3.1.

(b) MODE 5

Apply suitable values of height above terrain and glide slope deviation signal inputs from the test equipment to the GPWS such that it produces alerts. For equipment that provides fixed alert repetition rate and audio power output levels, record from an oscilloscope, connected across each of the dummy loads in turn, the voltage waveform of one complete cycle of the alert. Note also the alert repetition rate. Calculate from the waveforms the powers developed in each of the loads. The resulting values shall be greater than the minima specified in paragraph 2.6.5. The alert repetition rate shall be as specified in paragraph 2.6.5 also.

For equipment that provides varying alert repetition rate and/or audio power output levels (see paragraph 2.6.5)

repeat the above procedure a sufficent number of times within the Mode 5 warning envelope of Appendix A to demonstrate that the relevant requirements of paragraph 2.6.5 are met.

T-7 MODE 5

Attach GPWS equipment, Figure 1, and arm Mode 5, including selecting the landing gear to the landing configuration.

(a) Set the test equipment height above terrain signal to 1200 feet and increase the deviation below glide slope signal from zero to 300 μA (4 dots) and verify that no alert occurs.

Set the test equipment height above terrain signal to 100 feet and two values between 200 feet and 900 feet. Verify that, in each case, the alert is provided as specified by Mode 5, Appendix A.

(b) Verify that the alert specified in the envelope defined for Mode 5 in Appendix A is inhibited by the momentary closure of a switch.

(c) While in the alert mode specified for Mode 5 in Appendix A, verify that Mode 5 is deactivated by changing either the landing gear or the flaps from a landing configuration to a non-landing configuration.

(d) Means to rearm Mode 5 shall be demonstrated.