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MILITARY STANDARD

AIRCREW STATION ALERTING SYSTEMS



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FOREWORD

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.
2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 53), Naval Air Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.
3. The scope of MIL-STD-411D, Aircrew Station Signals, was limited to the technology base of 1974. Requirements were specified for the location, arrangement and presentation of dedicated, transilluminated signals. Limited guidance was given for verbal and nonverbal auditory signals, and the presentation of visual alerting signals on other than dedicated transilluminated displays.
4. Revision E to MIL-STD-411 was prepared under the auspices of the tri-service and industry Aircrew Station Standardization Panel (ASSP). The document has been updated to reflect current technologies and methods of presenting alerting messages to the aircrew. Guidance has been added and requirements established for electronic displays and night vision imaging system compatibility. Many of these requirements are based in the aircrew station alerting systems utilized in the U.S. Army's OH-58D and the U.S. Air Force's HH-60 and C-17 aircraft, as well as inputs obtained during review cycles. Requirements for the specific location and arrangement of dedicated transilluminated signals has been transferred to MIL-STD-203 Aircrew Station Controls and Displays; Location, Arrangement and Actuation of, for Fixed Wing Aircraft or MIL-STD-250, Aircrew Station Controls and Displays for Rotary Wing Aircraft.
5. The auditory warning signal portion of MIL-STD-411 is the subject of a separate ASSP committee. The results of their revision will be consolidated with this document when they become available.

CONTENTS

<u>PARAGRAPH</u>	<u>PAGE</u>
1. PURPOSE, SCOPE AND APPLICABILITY.....	1
1.1 Purpose.....	1
1.2 Scope.....	1
1.3 Applicability.....	1
2. APPLICABLE DOCUMENTS.....	1
2.1 Government documents.....	1
2.1.1 Specifications, standards and handbooks.....	1
2.2 Order of precedence.....	2
3. DEFINITIONS.....	3
3.1 Alert signal.....	3
3.2 Annunciator.....	3
3.3 Audio signal.....	3
3.3.1 Audio warning/master warning signal.....	3
3.3.2 Audio caution/master caution signal.....	3
3.3.3 Tone.....	3
3.3.4 Voice message.....	3
3.4 Contrast and contrast ratio.....	3
3.5 Display.....	3
3.5.1 Dedicated alert display.....	3
3.5.2 Integrated display.....	3
3.5.3 Transilluminated display.....	3
3.6 Flag.....	3
3.7 Indicator.....	3
3.8 Tactile signal.....	4
3.9 Visual signal.....	4
3.9.1 Warning signal.....	4
3.9.2 Master warning signal.....	4
3.9.3 Caution signal.....	4
3.9.4 Master caution signal.....	4
3.9.5 Advisory signal.....	4
3.9.6 Annunciator assembly.....	4
3.9.7 Legend signal.....	4
3.9.8 Nonlegend signal.....	4
4. GENERAL REQUIREMENTS.....	5
4.1 Functional requirements.....	5
4.2 Design criteria and presentation of signals.....	5
4.2.1 Luminance contrast and levels.....	5
4.2.2 Selection of signals.....	5
4.2.3 Presentation of signals.....	5
4.3 General systems characteristics.....	5
4.3.1 Legends.....	5
4.3.2 Color.....	5
4.3.3 Luminance and contrast.....	6

CONTENTS

<u>PARAGRAPH</u>		<u>PAGE</u>
4.3.3.1	Transilluminated displays.....	6
4.3.3.2	Electronic displays.....	6
4.3.4	Lettering.....	6
4.3.5	Visual signal flash rate.....	6
4.3.6	Test systems.....	6
4.3.7	Alerting signals.....	6
4.3.8	Cancellation of master warning/caution signal.....	6
4.4	Night vision imaging system (NVIS) compatibility.....	7
5.	DETAILED REQUIREMENTS.....	8
5.1	Dedicated signal assemblies.....	8
5.1.1	Readability in sunlight.....	8
5.1.2	Location and arrangement of signals.....	8
5.1.3	Warning signals.....	8
5.1.3.1	Color.....	8
5.1.3.2	Legend.....	8
5.1.3.3	Luminance.....	8
5.1.3.4	Presentation.....	9
5.1.3.5	Master warning signal reset.....	9
5.1.3.6	Wheels warning legend (C/STOL aircraft).....	9
5.1.3.7	Wheels warning legend (VTOL aircraft).....	9
5.1.4	Caution signals.....	9
5.1.4.1	Color.....	9
5.1.4.2	Legend.....	9
5.1.4.3	Luminance.....	10
5.1.4.4	Presentation.....	10
5.1.4.5	Master caution signal reset.....	10
5.1.5	Advisory signals.....	10
5.1.5.1	Color.....	10
5.1.5.2	Legend.....	11
5.1.5.3	Luminance.....	11
5.1.5.4	Presentation.....	11
5.2	Integrated alert displays.....	11
5.2.1	Benefit.....	11
5.2.2	Display type.....	11
5.2.3	Number and location of displays.....	11
5.2.4	Message presentation.....	12
5.2.4.1	Warning messages.....	12
5.2.4.2	Caution messages.....	12
5.2.4.3	Advisory messages.....	12
5.2.5	Message format.....	12
5.2.5.1	Syntax.....	12
5.2.5.2	Prioritization.....	12
5.2.5.3	Overflow memory.....	12
5.2.5.4	Color coding.....	13
5.2.5.5	Minimum message duration.....	13
5.2.6	Options and control.....	13
5.2.6.1	Message prioritization.....	13

CONTENTS

<u>PARAGRAPH</u>		<u>PAGE</u>
5.2.6.2	Inhibit logic.....	13
5.2.6.3	Storage and recall.....	13
5.2.7	Display luminance and contrast.....	14
5.2.8	Display size.....	14
5.2.9	Character dimensions.....	14
5.2.10	Maintenance record.....	14
5.2.11	Test requirements.....	14
5.3	Audio warning signals.....	14
5.3.1	Master warning signals.....	14
5.3.2	Bail-out signal.....	15
5.3.3	Wheels-up signal.....	15
5.3.4	Audio angle of attack/airspeed/stall warning signal....	15
5.3.5	Nuclear radiation danger signal.....	16
5.3.6	Verbal audio warning signals.....	16
5.3.7	Other verbal audio signals.....	16
5.4	Mechanical visual signals.....	16
5.4.1	Color.....	17
5.4.2	Markings.....	17
5.4.3	Luminance.....	17
5.4.3.1	Flags.....	17
5.4.3.2	Indicators.....	17
5.5	Tactual signals.....	17
6.	NOTES.....	18
6.1	Intended use.....	18
6.2	Issue of DoDISS.....	18
6.3	Subject term (keyword) listing.....	18
6.4	International interest.....	18
6.5	Changes from previous issue.....	18
6.6	Use of metric units.....	18
 <u>FIGURES</u>		
1.	Legend presentation.....	19

1. PURPOSE, SCOPE AND APPLICABILITY

1.1 Purpose. The purpose of this standard is to establish uniform requirements and provide functional design criteria for an effective aircrew station alerting system. The use of new technology is encouraged where it can be demonstrated that the use of the technology will result in shorter aircrew response times and more effective aircrew action subsequent to presentation of the alert.

1.2 Scope. This standard covers the requirements for aircrew station alerting systems including general functions; operational logic; information content of messages; and physical characteristics of the alerting system's visual, auditory, and tactual signals.

1.3 Applicability. The requirements specified herein apply to all aircrew station alerting systems in aircraft acquired by the Department of Defense.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this standard 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 (see 6.2).

SPECIFICATIONS

MILITARY

- MIL-S-9320 - Signal Warning Audible for Headset, Type MA-1
- MIL-M-18012 - Markings for Aircrew Station Displays, Design and Configuration of
- MIL-C-25050 - Colors, Aeronautical Lights, and Lighting Equipment, General Requirements for
- MIL-L-25467 - Lighting, Integral, Aircraft Instrument, General Specification for
- MIL-L-27160 - Lighting, Instrument, Integral, White, General Specification for
- MIL-L-85762 - Lighting, Aircraft, Interior, Night Vision Imaging System (NVIS) Compatible

STANDARDS

FEDERAL

- FED-STD-376 - Preferred Metric Units for General Use
by the Federal Government

MILITARY

- MIL-STD-203 - Aircrew Station Controls and Displays:
Location, Arrangement and Actuation of,
for Fixed Wing Aircraft
- MIL-STD-250 - Aircrew Station Controls and Displays
for Rotary Wing Aircraft
- MIL-STD-783 - Legends for Use in Aircrew Stations
and on Airborne Equipment
- MIL-STD-1333 - Aircrew Station Geometry for Military Aircraft
- MIL-STD-1472 - Human Engineering Design Criteria for
Military Systems, Equipment and Facilities

(Unless otherwise indicated copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg 4D, 700 Robbins Ave., Philadelphia, PA 19111-5094.)

2.2 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 Alert signal. A signal which alerts the aircrew to the existence of a warning, caution, or advisory condition.

3.2 Annunciator. A cueing device which is activated only when required to provide status or condition information of a warning, caution, or advisory nature to the aircrew. An annunciator may be any mechanically, electrically, or electronically driven device used to produce an audio, visual, or tactual cue, verbal message, or any similar alerting signal.

3.3 Audio signal. A signal which is heard rather than seen or felt.

3.3.1 Audio warning/master warning signal. An audible signal which indicates the existence of a particular hazardous condition requiring immediate corrective action.

3.3.2 Audio caution/master caution signal. An audible signal which indicates the existence of a particular impending dangerous condition requiring attention, but not necessarily immediate action.

3.3.3 Tone. A sound with definable regularity of oscillation or no oscillation (steady tone).

3.3.4 Voice message. An audio signal with a verbal communication format.

3.4 Contrast and contrast ratio. For the purposes of this standard, contrast is defined as:

$$C = \frac{L(T) - L(B)}{L(B)}$$

where L(T) is the total luminance (image plus background) and L(B) is the luminance of the background portion. Contrast ratio defined as L(T)/L(B) and is one more than the contrast.

3.5 Display. A device which presents information to one or more aircrew members via one or more of the senses.

3.5.1 Dedicated alert display. A display whose sole purpose is to present alert signals.

3.5.2 Integrated display. A display which can operate in several modes or functions, one of which is the presentation of alert signals.

3.5.3 Transilluminated display. A display in which the light passes from behind the display surface through translucent portions.

3.6 Flag. A visual mechanical or electromechanical device used to show a change in the status of an indicator, instrument, or its associated system.

3.7 Indicator. A display device, usually mechanical or electromechanical, which indicates discrete conditions or status of a system.

3.8 Tactual signal. A signal which is felt rather than seen or heard.

3.9 Visual signal. A signal which is seen rather than heard or felt.

3.9.1 Warning signal. A visual signal which indicates the existence of a hazardous condition requiring immediate action to prevent loss of life, equipment damage, or abortion of the mission.

3.9.2 Master warning signal. A visual signal which indicates that one or more warning signals is energized.

3.9.3 Caution signal. A visual signal which indicates the existence of a condition requiring immediate attention but not immediate action.

3.9.4 Master caution signal. A visual signal which indicates that one or more caution signals is energized.

3.9.5 Advisory signal. A visual signal which indicates a safe or normal configuration, condition of performance, or operation of essential equipment or attracts attention and imparts information for routine action purposes.

3.9.6 Annunciator assembly. A grouped assembly of two or more warning, caution, or advisory legend signals arranged categorically or functionally.

3.9.7 Legend signal. A visual signal which has alphanumeric characters or symbols.

3.9.8 Nonlegend signal. A visual signal which has no alphanumeric characters or symbols.

4. GENERAL REQUIREMENTS

4.1 Functional requirements. The design of an effective alerting system should:

(a) Not provide audible and visible caution and warning alerts when all systems are operating normally.

(b) Reduce aircrew information assimilation and memory demands.

(c) Minimize the time required for the aircrew to detect and to assess failure conditions, and to initiate corrective actions.

(d) Provide visual alerts which can be detected and understood easily under high altitude, high ambient light, and critical (i.e., high-G, high workload, high stress, low light level) conditions.

(e) Facilitate alerting system standardization.

(f) Provide for alerting system growth capability in a form that does not necessitate additional system components.

4.2 Design criteria and presentation of signals.

4.2.1 Luminance contrast and levels. Visual signals shall be presented and located to provide effective luminance contrast and to minimize the effects of excessive ambient light. At any location, the signals shall have sufficient luminance and contrast to be fully readable and easily recognizable in a 10,000 footcandle (fc) lighting environment.

4.2.2 Selection of signals. The selection of signals (e.g., visual versus audio) should be in accordance with MIL-STD-1472. Specific signals shall be provided to furnish the aircrew all information for operation and maintenance functions as required by the acquiring activity. Conditions which fall into the warning, caution or advisory category shall be based on the aircraft's subsystems, its roles and missions and the aircrew's information requirements.

4.2.3 Presentation of signals. Presentation of signals shall be in accordance with acquiring activity approved specifications. Signals shall not be actuated by transient, erroneous, or random sensor signals.

4.3 General system characteristics.

4.3.1 Legends. Legends shall be in accordance with MIL-STD-783.

4.3.2 Color. Unless otherwise specified, all colors specified herein shall be in accordance with MIL-C-25050. The color coding of electronic displays shall be in accordance with 5.2.5.4. For electronic color displays, chromaticity shall be in accordance with system specification and shall ensure discriminability of the alert message.

4.3.3 Luminance and contrast.

4.3.3.1 Transilluminated displays. The luminance level of dedicated transilluminated signals and legends shall be in accordance with 5.1.3.3, 5.1.4.3, and 5.1.5.3 as applicable, and shall be measured by averaging the readings within small sub-areas of the signal or legend. Readings on an illuminated letter which is a portion of a word or legend, may be averaged if a minimum of three readings taken on separate locations on each letter make up the average luminance. Warning light signal utilizing opaque letters and a translucent background may be divided into a minimum of five approximately equal subareas for determination of luminance compliance. Each subarea (containing at least three separate readings, which may be averaged) shall individually meet the luminance requirements. All legends shall be capable of being read in bright sunlight. The average contrast ratio of any lighted legend to the background shall be 2.0 minimum when the display is subjected to ambient illumination of 10,000 foot candles at $5,000 \pm 500$ degrees Kelvin color temperature. The contrast ratio of any unlighted legend to the background shall be less than 0.1 for any legends which are slightly visible.

4.3.3.2 Electronic displays. The luminance and contrast of electronic displays shall be in accordance with 5.2.7.

4.3.4 Lettering. All characters shall be upper case except on integrated displays, on which lower case characters may be used. All letters and numbers on dedicated signal assemblies shall conform to the requirements of MIL-M-18012. Letters and numbers on electronic displays should conform to the general requirements of MIL-STD-1472. Character dimensions shall be in accordance with 5.2.9.

4.3.5 Visual signal flash rate. Flashing presentations should be avoided; however, where they are required for their alerting value, they shall have a flash rate between three to five hertz. The "ON" time shall be approximately equal to the "OFF" time. No more than two flash rates shall be used. Where two flash rates are used, the second rate shall be one to two hertz. Flashing presentations which could be simultaneously active should have synchronized flashes.

4.3.6 Test systems. A single test switch shall be provided for testing all dedicated displays and, where possible, all subsystem circuitry within a crew station. A test switch is not necessary if the function is automated within an integrated alert display. Blank displays, provided for a growth capability, on the annunciator assembly shall also be included as part of the test circuitry.

4.3.7 Alerting signals. The system should be designed to minimize the effects of undetected, false, or nuisance alerts, or any condition which would cause a crewman to perceive an alert signal to be energized when it is not.

4.3.8 Cancellation of master warning/caution signal. The master warning /master caution signal shall remain "ON" until it is cancelled by the crewman or cancelled automatically when the problem has been corrected. Audio portions of alerting signals shall be automatically cancelled within ten seconds if not previously cancelled by a crewmember. Upon cancellation, the master warning/caution signal shall reset automatically to be able to annunciate new alerting situations.

4.4 Night vision imaging system (NVIS) compatibility. When night vision imaging system (NVIS) compatibility is specified by the acquiring activity, the alerting system shall be in accordance with MIL-L-85762. Compensatory means of attention getting (e.g., auditory or flashing) may be required to augment the visual signal.

5. DETAILED REQUIREMENTS

5.1 Dedicated signal assemblies.

5.1.1 Readability in sunlight. The legend on light signals, when energized, shall be readable in a 10,000 fc environment with the source illumination striking the face of the display at an angle of incidence of 90 degrees. When not energized, the legend shall not be perceptible in the presence of high ambient illumination.

5.1.2 Location and arrangement of signals. The location and arrangement of dedicated warning, caution and advisory signals shall be in accordance with MIL-STD-203 and MIL-STD-250. Warning signals shall be installed within the pilot's 30-degree (total included angle) forward cone of vision. When space is limited or the required number of warning signals is excessive, warning signals may be grouped outside of the pilot's 30-degree forward cone of vision. In these cases, a master warning signal shall be installed within the pilot's 30-degree forward cone of vision. Additionally, the master caution signal shall be located within the pilot's 30-degree forward cone of vision.

5.1.3 Warning signals. When required, legend warning and master warning signals shall be used in all aircrew stations. A master warning signal, when required, shall be energized simultaneously with any individual warning signal.

5.1.3.1 Color. Except where NVIS compatibility is required, the color of the warning signals shall be aviation red. Where NVIS compatibility is required, the color of the warning signals shall meet the requirements of MIL-L-85762.

5.1.3.2 Legend. Except when NVIS compatibility is required, the warning legend, when energized, shall be opaque on a translucent background as shown in Figure 1. When NVIS compatibility is required, the legend, when energized, shall be translucent on an opaque background. The character height of the legend shall subtend a viewing angle of not less than 20 minutes of arc when measured from the aft most point of the design eye line, as defined in MIL-STD-1333. The character proportions shall be in accordance with MIL-M-18012. The minimum horizontal separation between two legends shall be two times the width of the widest character. The minimum vertical separation between two legends shall be two character heights. The minimum vertical separation between two lines in the same legend shall be one-half the height of a character.

5.1.3.3 Luminance. The luminance of light signals shall be not less than 150 footlamberts (fL) at the point of entry of the light source when the signals are operated at rated voltage. Not less than two lamps, operated in parallel, shall be employed for each incandescent and light emitting diode type legend warning light. When installed in the flight aircrew station and unless otherwise specified by the acquiring activity, lights shall automatically be dimmed to 15 ± 3 fL when the pilot's primary interior light control is "ON". The design shall preclude inadvertent dimming during daylight conditions. When installed in other aircrew stations, the warning lights shall automatically be dimmed to 15 ± 3 fL when the operator's primary light control is "ON". Except when NVIS are being used within a crew station, the dimmed warning lights shall automatically reset to full bright when any of the following conditions exist:

- (a) Main aircraft power is turned off.

- (b) Pilot's primary light control is off.
- (c) High intensity lights are energized.

When an NVIS compatible lighting mode is selected, the dimmed warning lights shall not reset to full bright when any of the above conditions exist, but shall remain at their NVIS compatible level. When an NVIS compatible lighting mode is being used within a crew station, the lighting circuit logic shall preclude the system from obtaining a luminance level which will degrade external vision or NVIS performance.

5.1.3.4 Presentation. Warning signal presentation in the cockpit shall be steady "ON". An exception to the steady "ON" presentation is the Wheels Warning Legend which must attract the aircrew's attention during a critical mission phase (see 5.1.3.6 and 5.1.3.7). When installed in other aircrew stations, the warning signal presentation may be flashed as specified in 4.3.5.

5.1.3.5 Master warning signal reset. The master warning signal shall have a push-to-reset or voice reset capability which deenergizes the master warning signal while the applicable warning signal remains "ON".

5.1.3.6 Wheels warning legend (C/STOL aircraft). A "WHEELS" legend indicator, when specified by the acquiring activity, shall be installed and connected so that it flashes whenever the following conditions exist simultaneously:

- (a) The aircraft is in a landing configuration, as specified by the acquiring activity and,

- (b) The landing gear is not down and locked.

A time delay, sufficient to allow the landing gear to be fully extended, shall be installed in the wheels warning system to eliminate the nuisance activation and flashing of the "WHEELS" legend.

5.1.3.7 Wheels warning legend (VTOL aircraft). A "WHEELS" legend indicator, when specified by the acquiring activity, shall be installed on VTOL aircraft equipped with retractable landing gear. The indicator shall be connected so that it flashes whenever the airspeed and collective pitch (or other combination of functions approved by the acquiring activity) indicate that the VTOL is configured for landing and the landing gear are not down and locked. A time delay, sufficient to allow the landing gear to be fully extended, shall be installed in the wheels warning system to eliminate the nuisance activation and flashing of the "WHEELS" legend.

5.1.4 Caution signals. When required, legend caution and master caution signals shall be used in all aircrew stations. The master caution signal shall be energized simultaneously with any individual caution signal.

5.1.4.1 Color. Except where NVIS compatibility is required, the color of the caution signals shall be aviation yellow. Where NVIS compatibility is required, the color of the caution signals shall meet the requirements of MIL-L-85762.

5.1.4.2 Legend. When illuminated, the legend shall be translucent on an opaque background as shown in Figure 1. The character height of the legend shall

subtend a viewing angle of not less than 20 minutes of arc when measured from the aft most point of the design eye line, as defined in MIL-STD-1333. Character proportions shall be in accordance with MIL-M-18012. The minimum horizontal separation between two legends shall be two times the width of the widest character. The minimum vertical separation between two legends shall be two character heights. The minimum vertical separation between two lines in the same legend shall be one-half the height of a character.

5.1.4.3 Luminance. The luminance of the light signals shall be not less than 150 fL when the signals are operated at rated voltage at the point of entry of the light source. No less than two lamps, operating in parallel, shall be employed for each incandescent and light emitting diode type legend caution light. When installed in the flight aircrew station, the master caution signal shall be dimmed to 15 ± 3 fL and the caution signals shall be automatically reduced to $1 \pm .50$ fL when the pilot's primary interior light control is "ON". Caution signals shall be capable of being dimmed to a luminance of 0.1 fL when NVIS compatibility is required. The design shall preclude inadvertent dimming during daylight conditions. When installed in other aircrew stations, the caution signals shall automatically be dimmed to 15 ± 3 fL when the operator's primary panel light control is "ON". Except when NVIS are being used within a crew station, the dimmed caution signals shall be automatically reset to full bright when any of the following conditions exist:

- (a) Main aircraft power is turned off.
- (b) Pilot's primary light control is off.
- (c) High intensity lights are energized.

When an NVIS compatible lighting mode is being used within a crew station, the lighting circuit logic shall preclude the system from obtaining a luminance level which will degrade external vision or NVIS performance.

5.1.4.4 Presentation. The master caution signal shall have a steady "ON" light presentation unless a flashing presentation is approved by the acquiring activity. All other caution signals shall have a steady "ON" light presentation.

5.1.4.5 Master caution signal reset. The master caution signal shall have a push-to-reset or voice reset capability which deenergizes the master caution signal while the applicable caution signal remains "ON".

5.1.5 Advisory signals. The use of advisory signals in the cockpit area shall be minimized to avoid unnecessary distraction of the aircrew and to minimize those factors which deteriorate night vision capability of the crew. They shall not be used where other methods, such as switch labeling, mechanical visual signals, etc., may be employed. Advisory signals may be either of the legend or nonlegend type. If a nonlegend signal is employed, a readily identifiable legend shall be provided adjacent to, and preferably above, the signal.

5.1.5.1 Color. Except where NVIS compatibility is required, the color of advisory signals in the cockpit shall be aviation green. In other crew stations, advisory signals may be aviation green, aviation blue, or aviation white. The use of blue or white advisory lights should be avoided wherever dark adaptation must be maintained. For NVIS compatibility, the color of advisory lights in all compartments shall be NVIS green A or NVIS green B, as specified in MIL-L-85762.

5.1.5.2 Legend. Legend type advisory signals installed in the crew station shall employ translucent legends on an opaque background as shown in Figure 1. The character height of the legend shall subtend a viewing angle of no less than 20 minutes of arc when measured from the aft most point of the design eye line, as defined in MIL-STD-1333. Character proportions shall be in accordance with MIL-M-18012. The minimum horizontal separation between two legends shall be two times the width of the widest character. The minimum vertical separation between two legends shall be two character heights. The minimum vertical separation between two lines in the same legend shall be one-half the height of a character.

5.1.5.3 Luminance. The luminance of the signals shall not be less than 150 fL when the signals are operated at rated voltage at the point of entry of the light source. In the crew station, advisory signals shall automatically be dimmed to $1 \pm .50$ fL when the pilot's primary interior light control is "ON". Advisory signals shall be capable of being dimmed to a luminance of 0.1 fL when NVIS compatibility is required. The design shall preclude inadvertent dimming during daylight conditions. In other aircrew stations, advisory signal luminance may be greater than $1 \pm .50$ fL when ambient conditions so dictate. Except when NVIS are being used within a crew station, the dimmed signals shall automatically reset to full rated when any of the following conditions exist:

- (a) Main aircraft power control is turned off.
- (b) Pilot's primary light control is off.
- (c) High intensity lights are energized.

When an NVIS compatible lighting mode is being used within a crew station, the lighting circuit logic shall preclude the system from obtaining a luminance level which will degrade external vision or NVIS performance.

5.1.5.4 Presentation. Advisory signal presentation shall be steady "ON", unless otherwise specified by the acquiring activity.

5.2 Integrated alert displays.

5.2.1 Benefit. The benefit of an integrated alert display for the presentation of warning, caution, and advisory messages is that it allows a single location for message presentation. It can present a concise alphanumeric message for each alerting situation, information about the alert urgency level, recommended corrective actions, and feedback to the crew when faults are corrected.

5.2.2 Display type. Display types may include cathode ray tube (CRT), plasma, thin film electroluminescent, liquid crystal, or any other medium. The requirements herein apply to any type display. The presentation medium used for the information display is left to the discretion of the airframe manufacturer and the acquiring activity.

5.2.3 Number and location of displays. The number of displays shall be based upon the informational requirements of the aircrew and the reliability of the displays. All warning, caution and advisory messages shall be presented within the operator's 30-degree (total included angle) forward cone of vision, on a single display surface, insofar as practical. If more than one display is present at a crew station, the display farthest to the left should display all warning, caution, and advisory messages. Warning, caution, and advisory messages may be presented on a head-up display only with acquiring activity approval. The location of the display(s) and the viewing angle(s) should be such that the

readability is not degraded, even in illumination up to 10,000 fc through the aircraft windows. If interactive control functions are included with the display, they shall be within the anthropometric reach of the operator using them, as constrained by the crew station installation for the particular air vehicle involved. MIL-STD-1472 requirements for control and display integration, and for the specific display under consideration shall be met.

5.2.4 Message presentation. The presentation of warning, caution and advisory messages shall be as specified herein. Alternative means of communicating warning, caution or advisory messages that take advantage of integrated interactive technologies may be used when approved by the acquiring activity.

5.2.4.1 Warning messages. The presentation of warning messages shall have precedence over caution and advisory messages and routine display information. What constitutes routine display information will be dependent on the aircraft's role, mission, and flight phase and shall be approved by the acquiring activity. Whenever one or more warning conditions are present, the message(s) shall appear in a location dedicated for the presentation of warning messages. The dedicated location may be at the top or bottom of the display. The warning message location may blank out any display symbology or video, except that which has been determined to be flight critical, when presenting a message. Only the appropriate active warning message(s) shall appear; however, the location for presenting the warning messages shall be large enough to present as many messages as there are warnings within the system. Warning messages shall remain presented until the causative condition has been corrected.

5.2.4.2 Caution messages. The presentation of caution messages shall have precedence over advisory messages and routine display information. Caution messages shall remain presented until either the causative condition has been corrected or the operator takes an action to store the message in overflow memory for later recall as required in paragraph 5.2.5.3.

5.2.4.3 Advisory messages. The presentation of advisory messages shall have precedence over routine display information. Advisory messages shall be presented until either the causative condition no longer exists or the operator takes an action to store the message in overflow memory for later recall as required in paragraph 5.2.5.3.

5.2.5 Message format.

5.2.5.1 Syntax. Warning, caution and advisory messages shall concisely convey the nature of the problem and the specific subsystem or location. A standard syntax is desirable for all messages, but shall be subordinate to a clear statement of the problem if not appropriate.

5.2.5.2 Prioritization. Messages should be grouped by urgency level. Warnings shall be presented at the top of the annunciator area of the display (which may be at the top or bottom of the display), with cautions and advisories following in that order. The acquiring activity shall approve any scheme for ordering alert messages (in order of occurrence, in order of priority, etc.) within urgency levels.

5.2.5.3 Overflow memory. A system to display messages stored in overflow memory shall be used when the number of active messages exceeds the capacity of

the display. If there are more messages than there is space to display them all, an indication shall be provided to the operator that additional alerts exist. Any overflow messages shall be stored and a capability shall be provided to recall/scroll through alerts so stored. If a new alert condition arises:

(a) The new message shall be placed with messages of equal criticality.

(b) If room does not exist on the display, a message of lower criticality shall be replaced. The replaced message shall be moved into overflow. If no lower criticality message exists, a message of equal criticality must be moved into overflow.

(c) Messages placed in overflow shall be grouped with messages of equal criticality.

5.2.5.4 Color coding. When color is used to provide a unique and easily distinguishable coding method for all three alerting categories, red shall be reserved for warning messages, yellow shall be reserved for caution messages, and a third color (green preferred with blue and white as non-flightdeck options) shall be used to represent advisory level messages. The chromaticity of the third color shall be significantly different from the chromaticities of the red and yellow signals. All three selected colors must be different enough from the background color so that symbols and words are easily readable.

5.2.5.5 Minimum message duration. It is possible for a warning or caution condition to exist for such a short period of time that a crew member may not have a chance to identify the condition, even though the condition has been cured or otherwise ended. Therefore, a minimum message display time of three seconds is required for all warning and caution messages.

5.2.6 Options and control.

5.2.6.1 Message prioritization. As a minimum, messages shall be prioritized by urgency level. A prioritization scheme which is flight phase adaptive should be incorporated in the alerting system. Aircraft configuration variations and exceptions shall be considered in tailoring a scheme to specific aircraft.

5.2.6.2 Inhibit logic. An inhibit logic may be incorporated in the alerting system. Depending on system specifics, "on ground" conditions may inhibit certain caution messages as well as inhibiting caution messages during an "ENGINE OUT" warning condition. The inhibit scheme should be flight phase related, (i.e., non-critical messages should be inhibited during critical phases of flight, during high workload periods, and during multiple failure situations). Any specific methodology for applying an inhibit logic shall be evaluated and approved by the acquiring activity prior to implementation.

5.2.6.3 Storage and recall. If specified by the acquiring activity, a capability shall be provided to enable the crew to store and recall caution and advisory level messages. The display shall provide an indication of the quantity and type of messages that are in memory. Both selective and total storage and recall capabilities should be provided.

5.2.7 Display luminance and contrast. Displays shall follow the general guidelines of MIL-STD-1472. For monochrome displays luminance and contrast shall be in accordance with the system specification and shall be such that alert messages are easily readable from the design eye position, as defined in MIL-STD-1333, in any ambient light condition. The minimum display luminance shall not be less than 1.5 fL to prevent the dimming of the display to such a level that would make alert messages unreadable. For color displays luminance contrast shall be in accordance with the system specification and shall ensure discriminability of the alert message from the background.

5.2.8 Display size. Specific aircraft design characteristics shall determine the minimum number of message lines to be displayed, taking into account the need to have characters large enough to be legible to crewmembers seated in their normal flight positions. If legends are abbreviated, the display shall be wide enough so that any message will fit on one line.

5.2.9 Character dimensions. The alphanumeric character dimensions and spacing shall be selected for speed and accuracy of interpretation and follow the general guidelines of MIL-STD-1472. The height of symbols and characters shall subtend a viewing angle of no less than 20 minutes of arc when measured from the design eye position, as defined in MIL-STD-1333. Character dimensions and fonts shall be evaluated and approved by the acquiring activity prior to implementation.

5.2.10 Maintenance record. A capability shall be provided to have all warning and caution messages recorded in non-volatile memory for maintenance purposes. None of the advisory messages shall be stored for maintenance purposes. Because several warning and caution conditions will normally be present prior to the start of the engine, the storage of warning and caution conditions in a non-volatile memory shall be inhibited while the "on ground" conditions exist. If any of these conditions are still present when the "on ground" condition no longer exists, they shall be recorded in non-volatile memory for maintenance records. The memory shall be capable of being cleared by maintenance personnel when the existing record is no longer required.

5.2.11 Test requirements. The capability to test all integrated display characters and functions shall be provided.

5.3 Audio warning signals. Audio warning signals, when used, shall conform to the requirements specified herein, and to MIL-STD-1472 requirements for audio displays.

5.3.1 Master warning signals. A nonverbal audio master warning signal shall produce an output with the following frequency and interruption rates:

(a) Fundamental audio output frequency shall sweep from 700 Hz to 1,700 Hz in 0.85 second.

(b) Interruption interval shall be 0.12 second.

The cycle shall be repeated until the signal generator is deenergized.

5.3.2 Bail-out signal. The audio bail-out signal for use in troop carriers, cargo transport, and all other multicrew aircraft shall be a bell. The bell shall strike at a continuous rate of 5 ± 1 beats per second and shall be audible during flight to all aircrew members and passengers.

5.3.3 Wheels-up signal. When a nonverbal audio wheels-up signal is used, it shall have the following tone and conform to the requirements of MIL-S-9320:

- (a) Frequency - 250 ± 50 Hz.
- (b) Fundamental tone interrupted at 5 ± 1 Hz.
- (c) 50 ± 10 percent on-off cycle.

5.3.4 Audio angle of attack/airspeed/stall warning signal. When a nonverbal audio signal is used for presenting angle of attack/airspeed/stall warning information, referenced to a selected angle of attack/airspeed/stall speed, it shall be as specified in Table I. The discrete position at which the chopped signal commences on either side of the "correct" signal shall be readily adjustable.

TABLE I. AUDIO ANGLE OF ATTACK/AIRSPEED/STALL WARNING SIGNAL

<u>Angle of Attack</u>	<u>Airspeed</u>	<u>Tone Signal</u>
Low	Fast	1,600 Hz tone interrupted at a rate of 1 to 10 Hz, the rate increasing linearly with decreasing angle of attack/increasing airspeed.
Safe Low	Safe Fast	900 Hz steady tone, plus 1,600 Hz tone interrupted at a rate of zero to 1 Hz, the rate increasing linearly with decreasing angle of attack/increasing airspeed.
Correct	Correct	900 Hz steady tone.
Safe High	Safe Slow	900 Hz steady tone, plus 400 Hz tone interrupted at a rate of zero to 1 Hz, the rate increasing linearly with increasing angle of attack/decreasing airspeed.
High	Slow	400 Hz tone interrupted at a rate of 1 to 10 Hz, the rate increasing linearly with increasing angle of attack/decreasing airspeed.

5.3.5 Nuclear radiation danger signal. When a nonverbal audio nuclear radiation danger signal is used, it shall consist of the following tones:

(a) Square wave 500 ± 10 Hz

(b) Square wave 400 ± 10 Hz

The two tones shall be presented alternately, each being heard for 0.30 ± 0.05 seconds. The change from one tone to the other shall be accomplished in 0.02 seconds or faster. The output of the signal generator shall be such that the tones reaching the operator's ear shall have an overall sound pressure level of 95 ± 3 db.

5.3.6 Verbal audio warning signals. Verbal warning signals shall be audible signals in verbal form indicating the existence of a hazardous or imminent catastrophic condition requiring immediate action and shall only be used to complement red warning or other critical visual signals. The verbal warning signals shall be presented at levels which will insure operator reception under noise conditions in the specific aircraft. There shall be provision for overriding and resetting the signals. The signal, when activated, shall always start at the beginning of the message and shall continue to be presented until either:

(a) The causative condition is corrected.

(b) A warning of higher priority is presented.

(c) The signal is silenced by manual actuation of the override switch.

The structure for verbal warnings shall be:

(a) General heading (i.e., the system or service involved).

(b) Specific subsystem or location.

(c) Nature of emergency.

MIL-STD-1472 requirements for verbal warning signals shall be met.

5.3.7 Other verbal audio signals. Where applicable, the specific requirements in 5.3.6 shall apply to other verbal audio signal assemblies.

5.4 Mechanical visual signals. The criticality of the mechanical visual signal and the informational requirements of the aircrew shall be used to determine if the onset of the mechanical signal will activate the master warning/master caution signal. When mechanical visual signals are used, the requirements of MIL-STD-1472 for a given type of signal device shall be met.

5.4.1 Color. Mechanical visual signals shall have white markings on a black background unless otherwise specified by the acquiring activity.

5.4.2 Markings. Mechanical visual signals shall be marked with a legend or symbol which is descriptive of the information being given.

5.4.3 Luminance.

5.4.3.1 Flags. The markings on flags shall be as luminous as the markings on the indicator or display in which they are mounted.

5.4.3.2 Indicators. Indicator luminance shall be in accordance with MIL-L-25467 for red lighted instruments or MIL-L-27160 for white lighted instruments.

5.5 Tactile signals. If tactile signals are used, they should be of such amplitude as to be detected by the part of the body being stimulated, and should be delivered by an apparatus that will always be in contact with the body. Tactile signals shall also be coded such that they could not be misconstrued as a normal vibration of the equipment or crew station. Any use of tactile signals in aircrew stations must have prior approval by the acquiring activity.

6. NOTES

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

6.1 Intended use. This standard is intended for use during the design and development of aircrew station alerting systems for military aircraft.

6.2 Issue of DoDISS. When this standard is used in acquisition, the applicable issue of the DoDISS must be cited in the solicitation (see 2.1.1).

6.3 Subject term (keyword) listing.

Advisory	Legends
Annunciator	Luminance
Auditory	Indicator
Caution	Presentation
Color	Signal
Contrast	Tactile
Flag	Visual
	Warning

6.4 International interest. Certain provisions of this standard are the subject of international standardization agreements (ASCC Air Standard 10/30 and NATO STANAG 3370). When change notice, revision, or cancellation of this standard is proposed that 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.

6.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

6.6 Use of metric units. When metric units are preferred, conversion to metric units shall be performed and conform to the practices of FED-STD-376. If metric units are utilized, conformance to all of the requirements of this standard shall be maintained. The following conversion factors are applicable to this standard.

Footlamberts (fL) x 3.427 = candela per meter² (cd/m²)

Footcandles (fc) x 10.764 = lux (lx)

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

Preparing Activity:
Navy - AS
(Project No. 15GP - 0086)

**MASTER
CAUTION**

TRANSLUCENT AVIATION
YELLOW LETTERS AND
OPAQUE BACKGROUND

CAUTION

**MASTER
WARNING**

TRANSLUCENT AVIATION
RED BACKGROUND AND
OPAQUE LETTERS

WARNING

TRANSLUCENT AVIATION GREEN,
BLUE, OR WHITE LETTERS AND
OPAQUE BACKGROUND

ADVISORY

FIGURE 1. LEGEND PRESENTATION.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
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I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER
MIL-STD-411E

2. DOCUMENT DATE (YYMMDD)
01 MARCH 1991

3. DOCUMENT TITLE

AIRCREW STATION ALERTING SYSTEMS

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)

b. ORGANIZATION

c. ADDRESS (Include Zip Code)

d. TELEPHONE (Include Area Code)
(1) Commercial
(2) AUTOVON
(if applicable)

7. DATE SUBMITTED
(YYMMDD)

8. PREPARING ACTIVITY

a. NAME
COMMANDING OFFICER
NAEC, SESD CODE 53

b. TELEPHONE (Include Area Code)
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