

Submitted for recognition as an American National Standard

Airborne Windshear Systems

FOREWORD

Changes in this reaffirm are format/editorial only.

1. SCOPE:

This document recommends criteria for Airborne Windshear Systems, including operational objectives, characteristics, and functional requirements.

The recommendations of the document apply to transport aircraft, and describe the operational objectives of windshear alerting systems, situational displays, guidance systems, and avoidance/detection systems.

2. REFERENCES:

2.1 Applicable Documents:

This document should be used in conjunction with the ARP4102 Core Document. The following documents may also be applicable:

- a. SAE S-7 ARP4102/4 Flight Deck Alerting System
- b. SAE S-7 ARP4102/7 Electronic Displays

2.2 Definitions:

2.2.1 Airborne Windshear System: System or systems which alert(s) the crew of the presence of windshear either before or after the phenomenon is encountered, and/or aid in avoidance of or escape from the hazard. The following types of systems may be integrated or independent:

2.2.1.1 Reactive Alerting System: A system which senses and identifies the presence of windshear AFTER the phenomenon is encountered.

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- 2.2.1.2 Short Range Predictive Alerting System: A system which senses and identifies windshear SHORTLY BEFORE an encounter, such that pilot action may precede the encounter.
- 2.2.1.3 Long Range Predictive Alerting System: A system which senses and identifies windshear FAR ENOUGH IN ADVANCE of a possible encounter to allow the crew to consider maneuvering away from the hazard. Such a system shall include display(s) to assist the crew with identification of the hazardous area.
- 2.2.1.4 Airborne Windshear Flight Guidance System: A system which provides the crew with flight guidance to improve recovery probability in a windshear encounter.
- 2.2.1.5 Airborne Windshear AutoFlight Recovery System: A system which integrates or couples the autopilot and the autothrottle systems of the aircraft with an Airborne Windshear Flight Guidance System.
- 2.2.2 Functions/Features of Airborne Windshear Systems:
 - 2.2.2.1 False Alert: An alert which occurs when the design windshear threshold conditions do not exist.
 - 2.2.2.2 Windshear Advisory: An alert which is set at a windshear level requiring crew awareness and may require crew action. (Advisory Condition, Level One, ARP4102/4)
 - 2.2.2.3 Windshear Caution: An alert which is set at a windshear level requiring immediate crew awareness and subsequent corrective action. (Abnormal Condition, Level Two, ARP4102/4)
 - 2.2.2.4 Windshear Warning: An alert which is set at a windshear level requiring immediate corrective action by the crew. (Emergency Condition, Level Three, ARP4102/4)

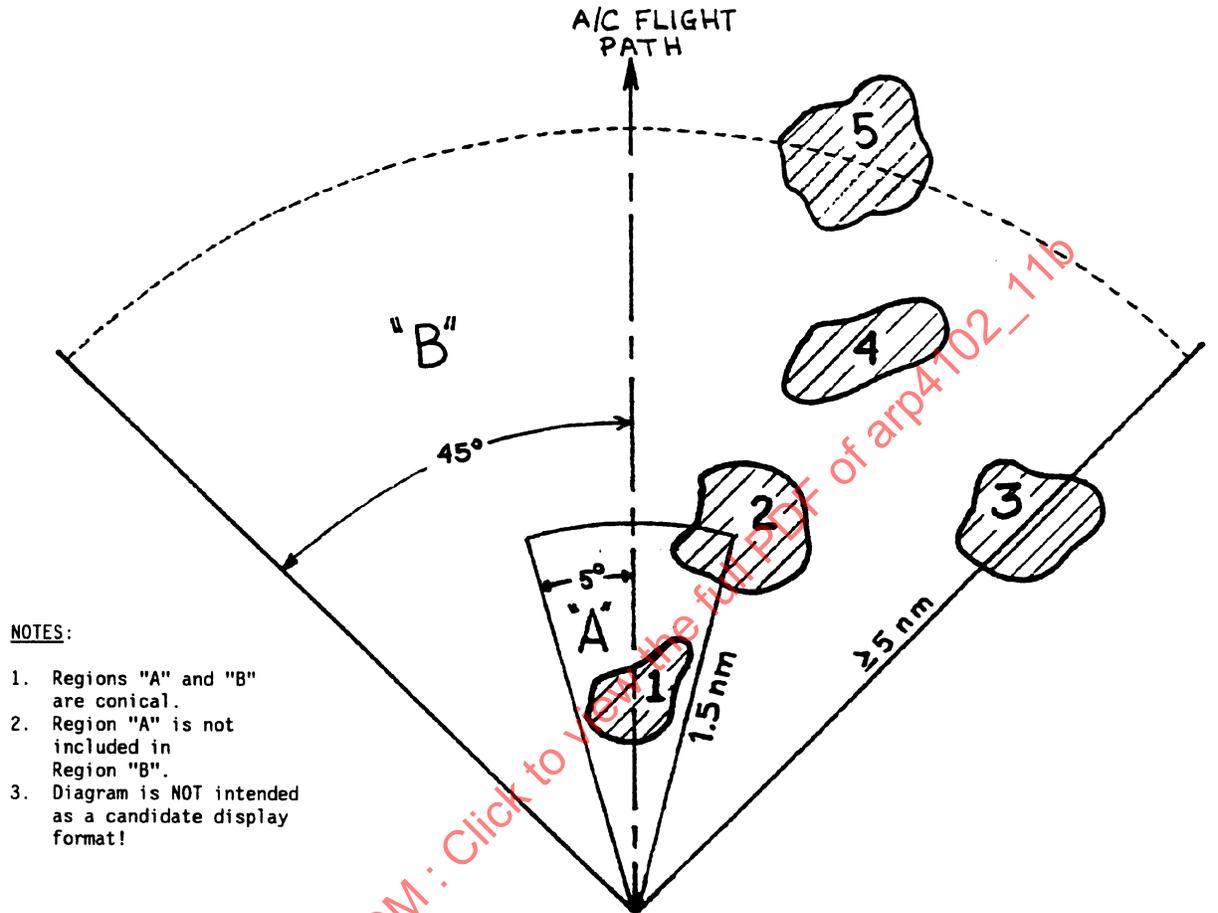
3. OPERATIONAL REQUIREMENTS:

(Refer to Figure 1)

3.1 General:

- 3.1.1 Windshear Alert Threshold (in the energy loss sense) should be the lesser of:
 - a. A windshear of 2.86 knots/s (0.15 "g") increasing tailwind component (or decreasing headwind), or
 - b. the equivalent energy loss rate due to vertical downdraft (0.15 x airspeed), or

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NOTES:

1. Regions "A" and "B" are conical.
2. Region "A" is not included in Region "B".
3. Diagram is NOT intended as a candidate display format!

WINDSHEAR LOCATION:	at A/C (Reactive Energy Gain)	at A/C (Reactive, Energy Loss)	Region "A" (e.g.: 1 or 2)	Region "B" (NOT impinging on "A") (e.g.: 3, 4, or 5)
Alert Level: (ref 4102/4)	2 (Abnormal)	3 (Emergency)	3 (Emergency)	1 (Advisory)
Audio Alert:	ATTENSON	"Windshear"	"Windshear Ahead"	ATTENSON only
Visual Alert				
Display Location:	Alerting Sys. Panel (e.g. EICAS) and PFD	Alerting Sys. Panel and PFD	Alerting Sys. Panel and PFD	Alerting Sys. Panel only
Nomenclature:	WINDSHEAR	WINDSHEAR	WINDSHEAR AHEAD or W/S AHEAD	WINDSHEAR AHEAD or W/S AHEAD
Color:	Amber	Red	Red	Amber

FIGURE 1 - ARP4102/11 - Windshear Alerts and Displays

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3.1.1 (Continued):

- c. any combination of a) and b) such that:

$$0.15 = (1/\text{airspeed}) W_v + (1/g) W_h \quad (\text{Eq. 1})$$

where:

W_v = vertical wind speed

W_h = horizontal wind acceleration

g = gravitational acceleration

filtered for normal turbulence and maneuvering flight (including biasing due to other sensed phenomena, e.g., ambient temperature) or,

- d. Upon critical degradation of performance capability (less than level flight) for existing atmospheric conditions and aircraft configuration.

Incorporation of wind correction factor and filtering as described in c) above is desirable.

3.1.2 Windshear Advisory:

- 3.1.2.1 A Windshear Advisory shall provide an alert of detected shear ahead of the aircraft exceeding the same threshold magnitudes as those defined by 3.1.1 a) through c).
- 3.1.2.2 Windshear Advisories shall continue for a finite time unless superseded by a Warning or Caution Alert, then cease if the conditions which initiated the alert no longer exist.
- 3.1.2.3 Windshear Advisories shall include ATTENSON.
- 3.1.2.4 Windshear Advisories apply only to a Long Range Predictive Alerting System.

3.1.3 Windshear Caution:

- 3.1.3.1 A Windshear Caution shall provide an alert of increasing performance shear exceeding the same threshold magnitudes as those defined by 3.1.1 a) through c) (opposite sign for increasing performance).
- 3.1.3.2 Windshear Cautions shall continue for a finite time unless superseded by a Warning Alert, then cease if the conditions which initiated the alert no longer exist.
- 3.1.3.3 Windshear Cautions pertain only to Reactive Alerting Systems.

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3.1.4 Windshear Warning:

3.1.4.1 A Windshear Warning shall activate for measured shear exceeding the threshold defined by 3.1.1.

3.1.4.2 Windshear Warnings shall cease when adverse conditions no longer exist. Adverse conditions include, but are not limited to, the conditions which initiate the alert. Additional criteria, such as attainment of a minimum altitude or a finite timespan (e.g., 30 s), may be applicable to the cessation of alerts. See Section 6 for aural, visual, and voice alerts.

3.1.4.3 Windshear Warnings apply only to Reactive and Short Range Predictive Alerting Systems.

3.2 Reactive Alerting System:

3.2.1 The system shall function in initial climb, approach and go-around after approach. Alerts during takeoff roll including rotation are desirable only if the system incorporates adequate protection against runway overruns.

3.2.2 The system shall function below approximately 1000 ft AGL, and should function below 2500 ft AGL.

3.2.3 The computed severity of a windshear encounter should include the rate of energy change from the horizontal and/or vertical winds of a shear, in whatever combination they appear.

3.2.4 The probability of a false alert shall be 10^{-4} per flight hour or less.

3.2.5 The probability of an unannounced failure shall be 10^{-5} per flight hour or less.

3.2.6 The system should function independently of Airborne Windshear Flight Guidance System or Airborne Windshear AutoFlight Recovery System.

3.3 Short and Long Range Predictive Systems:

3.3.1 General:

3.3.1.1 Systems shall be able to detect windshear in both dry and wet meteorological conditions.

3.3.1.2 Probabilities of false alerts and unannounced failures shall be the same as those for Reactive Alerting System (see 3.2).

3.3.1.3 System(s) should complement the functions of Reactive Alerting System.

3.3.1.4 Systems shall be inhibited below 100 ft AGL on approach.

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3.3.2 Short Range Predictive System:

- 3.3.2.1 The system shall function below approximately 1500 ft AGL, and should function below 2500 ft AGL.
- 3.3.2.2 The system should detect hazardous areas up to 1.5 nautical miles ahead even in heavy rain, up to two inches per hour (red radar return, 50 dBZ), and within five degrees of the track and flight path angle (ten degree cone), even with worst case drift angles.
- 3.3.2.3 The system shall issue a Windshear Warning which conforms to 3.1.1 and 3.1.2 for threshold and cessation.
- 3.3.2.4 If the system can also identify hazards beyond 1.5 miles in the absence of a Long Range Predictive Alerting System and its display, it shall issue an Advisory Alert for detected events conforming to 3.1.4.
- 3.3.2.5 The system should interface with Airborne Windshear Flight Guidance and/or Airborne Windshear AutoFlight Recovery systems, although automatic mode switching is not recommended.

3.3.3 Long Range Predictive System:

- 3.3.3.1 The system shall function below approximately 2500 ft AGL.
- 3.3.3.2 The system shall detect windshear within at least five nautical miles of the aircraft with intervening rain up to 0.5 inches per hour (typical yellow/red threshold for weather radar, 40 dBZ), and within 45 degrees of the aircraft longitudinal axis (90 degree cone), including the capability to display the position with respect to the aircraft, and relative intensity of hazards.
- 3.3.3.3 The system shall issue a Windshear Advisory upon detection of windshear greater than 1.5 nautical miles from the aircraft, or outside the ten degree cone specified in 3.3.2.2 for detected events conforming to 3.1.4.
- 3.3.3.4 Display of sensor data may be selected by pilot action or automatically. Pilot workload necessary to effect display of the most immediate and significant hazard zone shall be minimized.
- 3.3.3.5 The system shall not interface with Airborne Windshear Flight Guidance or Airborne Windshear AutoFlight Recovery systems for windshear greater than 1.5 nautical miles from the aircraft.
- 3.3.3.6 The system shall conform to the requirements of the Short Range Predictive Alerting System for events detected within 1.5 nautical miles of the aircraft. Displays should remain active.

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3.4 Airborne Windshear Flight Guidance System and AutoFlight Recovery System:

- 3.4.1 Systems should utilize the available kinetic and potential energy of the aircraft. If terrain contact is a consideration, recovery guidance should provide commands to take advantage of all usable aircraft energy.
- 3.4.2 Systems should take account of factors such as height above the ground, vertical speed, shear severity, general aircraft aerodynamic characteristics, rate of performance degradation, and aircraft limitations.
- 3.4.3 For each aircraft type in which these systems are installed, adequate controllability shall be demonstrated within the envelope of the system commands.
- 3.4.4 Systems shall provide guidance commands which are found to be reasonable in piloted evaluations. Such commands shall be compatible with manual techniques trained in the event of system failure.
- 3.4.5 The probability of misleading guidance commands shall be 10^{-5} per flight hour or less.
- 3.4.6 A Windshear Warning shall accompany presentation of Windshear Flight Guidance or activation of Windshear Auto Flight Recovery permitted under 3.4.9 or 3.4.10. Suitable mode annunciation shall be provided and any conflicting mode annunciation shall be withdrawn.
- 3.4.7 During approach, selection of Windshear Flight Guidance and/or Windshear Auto Recovery shall be accomplished by manual activation of the TOGA mode.
- 3.4.8 Manual de-selection of Windshear Flight Guidance and Windshear Auto Recovery mode shall be possible by means other than the TOGA switches.
- 3.4.9 Flight Director Presentations of Windshear Flight Guidance:
 - 3.4.9.1 During takeoff (after liftoff) and climb phases, or during go-around, Windshear Flight Guidance shall be automatically presented, regardless of the previous status or mode of the guidance display (autopilot OFF).
 - 3.4.9.2 Windshear Flight Guidance shall be displayed on the PFD/ADI flight director, and Head Up Display if installed and normally capable of flight guidance presentations.
 - 3.4.9.3 Systems should, if applicable, inhibit or override flight director pitch limits without exceeding aircraft performance limitations.
 - 3.4.9.4 Failure of the Windshear Flight Guidance System should remove any Windshear Flight Guidance information from the flight director, and disengage the Windshear AutoFlight Recovery System.

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3.4.9.5 In the absence of a Windshear AutoFlight Recovery System, manual autopilot disconnection should precede presentation of Windshear Flight Guidance (if the autopilot is engaged).

3.4.10 Automatic Flight System Modes:

3.4.10.1 Any Windshear AutoFlight Recovery System shall interface with both the autopilot and autothrottle systems when activated.

3.4.10.2 Following a Windshear Warning, a Windshear AutoFlight Recovery System should operate only if the autopilot and autothrottle were engaged prior to the alert.

3.4.10.3 When the autopilot is engaged following takeoff, or in the autopilot go-around mode, Windshear AutoFlight Recovery should activate without further pilot action.

3.4.10.4 Failure of the Windshear AutoFlight Recovery System should disengage any automatic systems associated with the failed system or failed portion of the system.

3.4.10.5 Failure of either the autopilot or autothrottle should preclude selection of Windshear AutoFlight Recovery, or should deselect Windshear AutoFlight Recovery if already active.

3.4.10.6 When active, the Windshear AutoFlight Recovery System shall command maximum thrust until subsequent pilot action is taken.

4. NUMBER NOT USED:

5. NUMBER NOT USED:

6. DISPLAYS:

(NOTE: Refer to Reference Documents for visual alerting requirements associated with alerting levels specified in this document.)

6.1 General:

6.1.1 Displays should contain the word "windshear" or suitable unambiguous acronym.

6.1.2 Alerts shall be coordinated and presented through a single set of indicators and aural output installations, regardless of origin from a Reactive Alerting System or one of the Predictive options. When provided, such alerts shall be integrated through the Flight Deck Alerting System.

6.1.3 Where alerting is prioritized in presentation, or where simultaneous aural annunciation could occur, sequencing shall be implemented assuring windshear alerts are presented or annunciated first.

6.1.4 Display of Windshear Warning shall not be readily cancellable by the pilot.