SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

SAE AS5402

Issued 2001-08

Design and Performance Criteria Aircraft Crash Axes

1. SCOPE:

This SAE Aerospace Standard (AS) provides design criteria and performance tests for crash axes intended for use by aircraft crew members to assist in evacuation, extrication, fire fighting, or other emergency activities.

1.1 Purpose:

The purpose of this AS is to assure minimum standards of functionality and performance for crash axes carried aboard aircraft for use by crew members in emergency situations.

As a minimum, the crash ax design shall facilitate assisting crew members performance of the following emergency functions:

- Prying open jammed flight deck/other emergency exits (e.g., sliding windows, plug hatches, flight deck entry doors, cabin doors, etc).
- Prying open jammed or locked access panels.
- Penetrating bulkheads or panels to permit application of fire extinguishing agent.
- Penetrating aircraft skin, bulkheads or panels when the airplane is on the ground to permit ventilation of fire and for clean air to breathe.
- Chopping holes in side windows to permit or assist in extrication, to permit application of fire extinguishing agent, and/or to permit ventilation.
- Penetrating inadvertently inflated devices (e.g., lift rafts, etc.).

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1.2 Introduction:

In the preparation of this document, consideration has been given to the performance of existing equipment as well as recommendations of flight crew associations, aircraft operators, aircraft manufacturers, and emergency equipment manufacturers. The primary goal of this AS is to ensure that future crash axes will perform adequately in emergency situations.

1.3 Alternative Designs:

The specifications and test methods provided herein anticipate a traditional "crash ax" configuration with the striking head at one end of a handle and other features including a pike, wedge and pry bar. The striking force is applied perpendicular to the major axis of the handle. These specifications are not intended to limit the design to this traditional configuration. Other alternative designs having a different configuration or other features may be evaluated and determined to meet this Aerospace Standard. In evaluating the alternative designs, it shall be demonstrated that the design offers at least an equivalent level of utility and effectiveness in satisfying the functional performance of ARP5403 on crash axes, as well as the functional tests of Section 5 of this Aerospace Standard. This evaluation shall consider the flight deck and cabin emergencies anticipated by each of the specific design features, and it shall ensure that ease of stowage and emergency use in a confined flight deck space is not compromised.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and 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.

2.1.1 FAA Publications: Available from the United States Government Printing Office (GPO). Order online at www.access.gpo.gov/su_docs.

14 CFR Part 25	Airworthiness Standards: Transport Category Airplanes §25.853
14 CFR Part 91	General Operating and Flight Rules §91.513(e)
14 CFR Part 121	Operating Requirements: Domestic, Flag, and Supplemental Operations §121.309(e)
14 CFR Part 125	Certification and Operations: Airplanes having a seating capacity of 20 or more passengers or a maximum payload capacity of 6000 pounds or more §125.207(a)
14 CFR Part 135	Operating Requirements: Commuter and On-Demand Operations §135.177(a)

2.1.2 ASTM Publications: Available from ASTM, 100 Barr Harbor, West Conshohocken, PA 19428-2959.

ASTM E 1842-96 Standard Test Method for Macro-Rockwell Hardness Testing of Metallic Materials

2.1.3 RTCA Publications: Available from RTCA Inc., 1140 Connecticut Avenue, NW, Suite 1020, Washington, DC 20036.

RTCA DO-160D Environmental Conditions and Test Procedures for Airborne Equipment, July 29, 1997

2.1.4 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AIR5401 Aircraft Crash Axes
ARP5403 Aircraft Crash Axes

2.1.5 Ergonomics, How to Design for Ease & Efficiency, Kroemer, Karl; Kroemer, Henrike; Kroemer-Elbert, Katrin; Prentice Hall International Series in Industrial & Systems Engineering, 1994

2.2 Definitions:

2.2.1 CRASH AX: A hand tool to aid aircraft crew members in emergencies. The hand tool is to assist crew members in penetrating aircraft materials and for prying, twisting and cutting jammed items that are impeding the crews' responding to an emergency.

2.2.2 AX BLADE: The ax blade is the part of the crash ax used to cut or chop through materials such as interior paneling, fuselage skin, electrical wires, etc. The blade is part of the ax head.

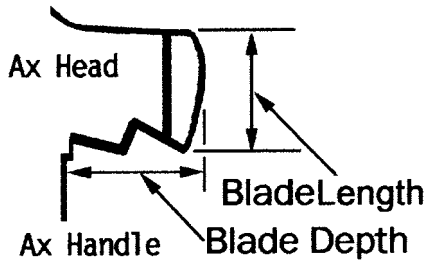


FIGURE 1

2.2.3 PIKE: The pike is the part of the crash ax used to make small openings through materials such as interior paneling, fuselage skin, doors, etc. The pike is typically part of the ax head.

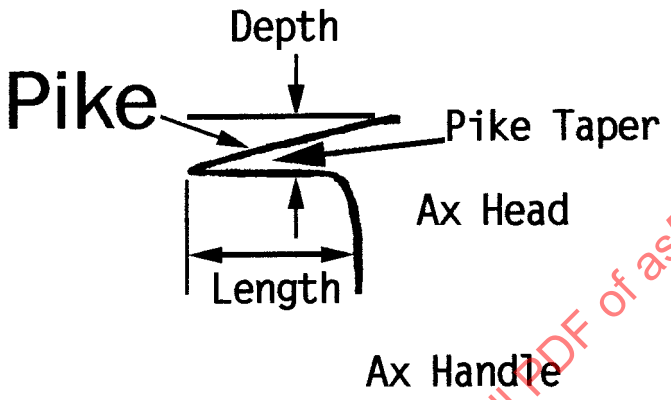


FIGURE 2

2.2.4 WEDGE: The wedge is the part of the crash ax used to widen gaps and/or facilitate a prying action (such as prying a door jammed in its frame). A handle of sufficient length attached to the wedge is necessary in order to use the tool as a lever.

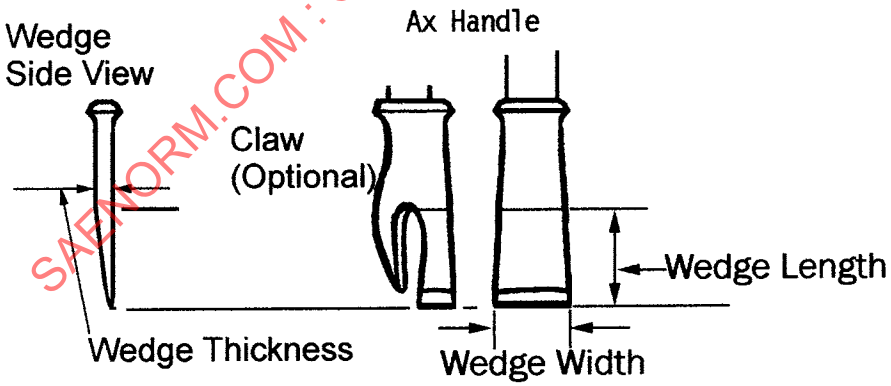


FIGURE 3

2.2.5 HANDLE: The handle is the part of the crash ax which facilitates the tool's carriage and use as both a striking implement and/or as a pry bar. It shall provide sufficient space for a user's hands, allowing a proper grip in order to use the components of the crash ax.

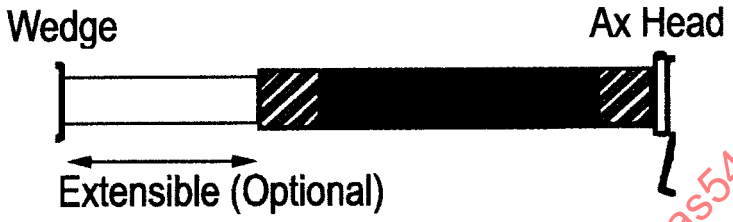


FIGURE 4

NOTE: The illustrations included in 2.2.1 through 2.2.4 are not intended to be design or configuration limiting.

3. FUNCTIONAL REQUIREMENTS:

3.1 Minimum Features:

The crash ax shall include (but not be limited to) the following functional design features which conform to testing requirements specified in Section 5.

3.1.1 Ax blade for cutting.

3.1.2 Pike for penetrating.

3.1.3 Wedge (with associated handle) for prying and twisting.

3.1.4 Handle to provide:

a. A grip to facilitate one-handed use of the tool by way of either hand, and

b. A lever-arm of sufficient length to allow application of leverage and/or torque as required by the functions listed in 3.1.1, 3.1.2, and 3.1.3 and as tested in Section 5. The handle may be of fixed length or may be extendible/retractable to facilitate increasing leverage, stowage, and/or other usage considerations.

3.2 Ax Supplementation:

It is preferred that one multifunction tool be provided to perform the functions in 3.1.1 through 3.1.4. However, where axes perform all specified functions, with the exception of those associated with prying, a supplemental pry bar shall be supplied to augment the existing ax so that the combination of tools meets the minimum standards herein.

4. GENERAL REQUIREMENTS:

Refer to 2.2.1 through 2.2.4 for measurement methods. Dimensions specified in 4.1.1 through 4.1.4 are nominal and are provided for design guidance.

4.1 Overall Size:

The overall length in either the extended or retracted mode shall be in a range from 30.48 to 76.2 cm (12 to 30 in).

4.1.1 Ax Blade:

4.1.1.1 Length: The blade length shall be in a range from 5.08 to 10.16 cm (2 to 4 in) long.

4.1.1.2 Depth: The blade shall be able to penetrate at least 5.08 cm (2 in) into a surface before the handle contacts the surface.

4.1.2 Pike:

4.1.2.1 Length: The pike length shall be in a range from 5.08 to 8.25 cm (2 to 3.25 in) long.

4.1.2.2 The pike depth at its deepest point shall be in a range from 1.78 to 2.54 cm (0.7 to 1 in) deep.

4.1.2.3 The pike thickness shall be in a range from 0.76 to 2.29 cm (0.3 to 0.9 in).

4.1.2.4 The pike taper shall be no more than 0.27 cm thickness per cm length (inches thickness per inch length) and no less than 0.13 cm thickness per cm length (inches thickness per inch length), in at least one dimension (thickness or depth). Expressed as an angle, the pike shall have a point that converges at an angle between 15 and 30 degrees.

4.1.3 Wedge:

4.1.3.1 The wedge shall be tapered. The wedge length shall be in a range from 6.35 to 10.16 cm (2.5 to 4 in).

4.1.3.2 The wedge width shall be in a range from 1.27 to 5.08 cm (0.5 to 2 in) wide (lateral to ax handle, in plane of blade).

4.1.3.3 The wedge point shall have a radius of not more than 1 mm (0.039 in) and a taper within the following range. The wedge thickness shall be no less than 1 mm (0.039 in) nor more than 3.2 mm (0.125 in), measured at 2.5 mm (0.1 in) from the wedge point. The wedge shall not be thicker than 5.08 cm (2 in) at its thickest point.

4.1.4 Handle:

4.1.4.1 Grip Size: Handle grip diameter shall be in a range from 3 to 5 cm (1.18 to 1.96 in). The handles shall have a grip area large enough for two hands (20 cm (7.87 in) minimum length). See the ergonomic reference in 2.1.5 for supporting documentation.

4.1.4.2 Handle Length: The handle length shall be in a range from 20.32 to 45.72 cm (8 to 18 in). If the handle is extendible, it shall lock in both the fully extended and fully retracted positions.

4.2 Weight:

The ax shall weigh not less than 1.13 kg (2.5 lb) nor no more than 4.54 kg (10 lb). The center of gravity of the ax shall be located between the head of the ax and the midpoint of the tool when used in the normal striking mode.

4.3 Durability and Reliability:

The crash ax shall be designed to meet the following requirements:

4.3.1 All functional areas with the exception of the handle/grip shall be constructed of maintenance free metal or alloy material complying with Section 6.

4.3.2 The handle/grip shall be constructed of maintenance free materials complying with Section 6.

4.3.3 All materials used, except those used for markings, shall be self-extinguishing when tested in accordance with applicable requirements of FAR 25.853.

4.3.4 The handle/grip shall not conduct electricity as confirmed by tests conducted in accordance with Section 6.

4.4 Color:

The ax shall be colored to enhance its visibility in emergency lighting conditions. The handle insulation should have retroreflective material at the top and bottom of the handle to increase its visibility under conditions of low visibility.

5. TEST PROCEDURES - FUNCTIONAL:

5.1 Format for Detailed Test Information:

- INTENT - Explanation of the reason for the test
- FIXTURE - Design of the standard test fixture (includes reference diagram)
- METHOD - Procedure to follow in evaluating the tool (includes reference diagram)
- PASS/FAIL CRITERIA - Criteria used to evaluate test results

5.1.1 The following tests are designed with the assumption that the ax user approaches an immovable assembly and an attempt is made to use the ax on the assembly. The user is simulated by a mechanical force application. The ax user is assumed to be a 95th percentile male. An additional 50% force is included to provide an overload capacity.

NOTE: The weight of a 95th percentile male plus a 50% overload factor = 149 kg (336 lb) (see 2.1.5).

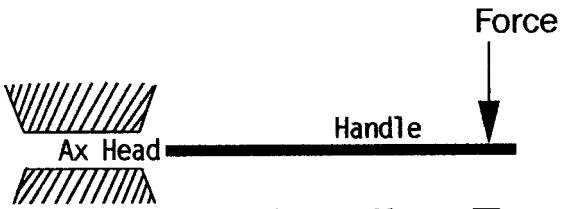
5.1.2 The tests that follow address the ability of the ax to survive loading on the various components of the ax, specifically the blade, pike, wedge, and handle.

5.2 Handle Test Details:

5.2.1 Head Fixed - Bending of Handle (in plane of handle and perpendicular to ax head):

- INTENT - This test is intended to ensure that the handle and the head/handle joint will not fail under loading conditions typical of those experienced in operation. The test models a situation in which the head is fixed between two immovable objects and a 149 kg (336 lb) force is applied onto the end of the handle (in the fully extended position, if applicable).

- FIXTURE - The fixture for this test is an immovable assembly with a slot large enough for the entire ax head to fit in so that the handle will be within 10 degrees of horizontal when at rest, supported only by the fit of the ax head into the slot.



Handle Bending Test

FIGURE 5

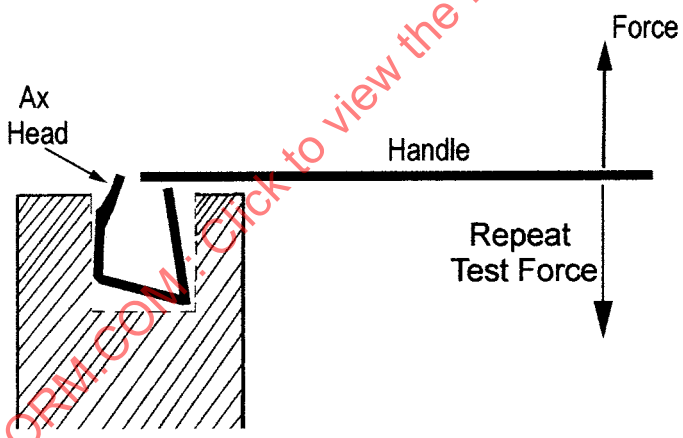
5.2.1 (Continued):

- METHOD - With the ax head in the fixture, apply a 149 kg (336 lb) force to the ax handle at an application rate (0.5 to 1.25 cm/s (0.2 to 0.5 in/s)). The force shall be applied not more than 7.6 cm (3 in) from the end of the ax handle (fully extended, if applicable).

- PASS/FAIL CRITERIA - The handle shall not break or separate from the ax head during the test. The handle shall not deflect more than 10% of its length at the maximum load. The handle shall not retain a permanent deformation after the force is removed.

5.2.2 Head Fixed - Bending of Handle (in plane of handle and parallel to ax head):

- INTENT - This test is intended to ensure that the handle and head/handle joint will not fail under loading conditions typical of those experienced in operation, in a plane of the ax blade, pike and handle. The test models a situation in which the head is fixed between two immovable objects and a 149 kg (336 lb) force is applied onto the end of the handle (in the fully extended position, if applicable).



Handle Bending Test, Head Fixed

FIGURE 6

- FIXTURE - A slot in an immovable assembly to receive the ax blade which is locked in place to limit its movement during the test.

- METHOD - With the ax head in the fixture, apply a 149 kg (336 lb) force to the ax handle in a plane perpendicular to the handle (in its undeflected position) and parallel to the ax blade at an application rate of 0.5 to 1.25 cm/s (0.2 to 0.5 in/s). The force shall be applied not more than 7.6 cm (3 in) from the end of the ax handle (fully extended, if applicable).

- Repeat the test with the same force applied at the same point in the opposite direction.

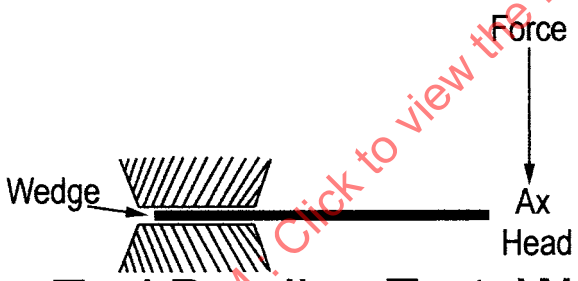
5.2.2 (Continued):

- PASS/FAIL CRITERIA - The handle shall not break or separate from the ax head during the test. The handle shall not deflect more than 10% of its length at the maximum load. The handle shall not retain a permanent deformation after the force is removed.

5.2.3 Pry Tool Bending (Wedge Fixed): Bending of ax handle or pry tool handle in prying action (in plane of handle and perpendicular to ax head).

- INTENT - This test is intended to ensure that the handle will not fail under loading conditions typical of those experienced in operation as a pry tool. The test models a situation in which the wedge is fixed between two immovable objects and a 149 kg (336 lb) force is applied onto the end of the handle (in the fully extended position, if applicable).

- FIXTURE - The fixture for this test is an immovable assembly with a slot large enough for the wedge to fit in so that the handle will be within 10 degrees of horizontal when supported only by the wedge in the slot. No more than 10% of the handle should be in the fixture slot.



Pry Tool Bending Test, Wedge Fixed

FIGURE 7

- METHOD - With the wedge in the fixture, apply a 149 kg (336 lb) force to the ax handle at an application rate of 0.5 to 1.25 cm/s (0.2 to 0.5 in/s). The force shall be applied not more than 7.6 cm (3 in) from the end of the ax head (handle fully extended, if applicable).

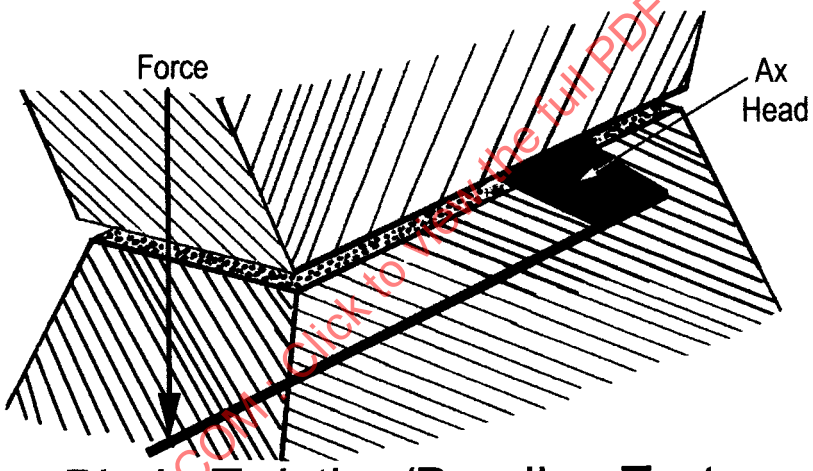
- PASS/FAIL CRITERIA - The handle shall not break or separate from the wedge during the test. The handle shall not deflect more than 10% of its length at the maximum load. The handle shall not retain a permanent deformation after the force is removed.

5.3 Blade Test Details:

5.3.1 Blade - Twisting/Bending: Blade fixed, handle pivoted with force perpendicular to handle and blade.

- INTENT - This test is intended to ensure that the blade will not fail under loading conditions typical of those experienced in operation. The test models a situation in which a 149 kg (336 lb) force is applied onto the handle while the ax blade is in a fixed slot.

- FIXTURE - The fixture for this test is an immovable assembly with a slot large enough to accept 50 to 90% of the ax blade, so that the handle will be within 10 degrees of horizontal when at rest, supported only by the fit of the ax blade into the slot.



Blade Twisting/Bending Test

FIGURE 8

- METHOD - With the ax blade in the fixture, apply a 149 kg (336 lb) force to the ax handle at an application rate of 0.5 to 1.25 cm/s (0.2 to 0.5 in/s). The force shall be applied not more than 7.6 cm (3 in) from the end of the ax handle (handle fully extended, if applicable).

- PASS/FAIL CRITERIA - The blade and/or handle shall not break during the test. The handle shall not deflect more than 10% of its length at the maximum load. The blade and/or the handle shall not retain a permanent deformation after the force is removed. The blade shall not separate from the handle during the test.

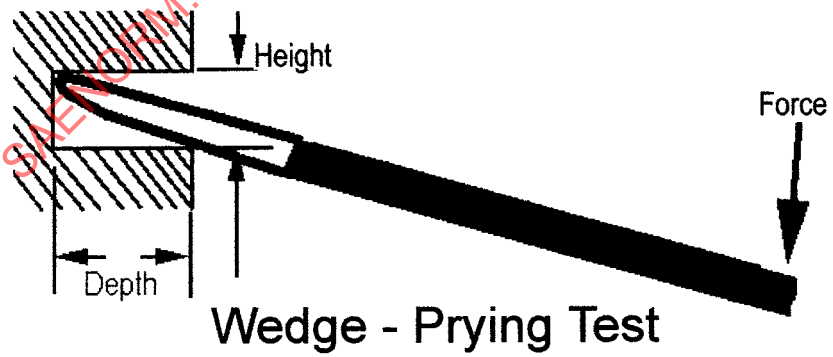
5.3.2 Blade - Hardness:

- INTENT - This test is intended to ensure that the material used for the blade will not fracture or be so malleable that, in use, it cannot maintain integrity to perform the function of cutting aircraft structure.
- FIXTURE - Use the standard ASTM test fixture for material Rockwell hardness testing (see 2.1.2).
- HARDNESS - Use the standard ASTM test method for material Rockwell hardness testing.
- PASS/FAIL CRITERIA - The hardness value shall be between 38 and 42 Rockwell-C hardness.

5.4 Wedge Test Details:

5.4.1 Wedge - Prying Test:

- INTENT - This test is intended to ensure that the wedge and wedge/handle will not fail under loading conditions typical of those experienced in operation. The test models a situation in which the wedge is inserted into an immovable recess to a specified depth, fixed in that position, and a 149 kg (336 lb) force is applied onto the end of the handle (in the fully extended position, if applicable) to simulate a prying action.
- FIXTURE - The fixture is an immovable assembly with a rectangular recessed section that is 2.54 cm (1 in) in depth and 1.9 cm (0.75 in) in height and of sufficient width to accept any pry tool presented for testing.



Wedge - Prying Test

FIGURE 9