AEROSPACE RECOMMENDED PRACTICE

ARP1538™	REV. C
Issued 1978-04 Revised 2007-10 Reaffirmed 2019-04 Stabilized 2022-07 Superseding ARP1538B	

Arresting Hook Installation, Land-Based Aircraft

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

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1. SCOPE

This SAE Aerospace Recommended Practice (ARP) covers the recommended criteria and performance requirements for the design and installation of land-based aircraft emergency and operational arresting hooks for use on runway arresting systems. Design criteria for fully operational hooks and for carrier-based aircraft hook installations are contained in specification MIL-A-18717.

2. REFERENCES

2.1 Applicable Documents

MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-203	Aircrew Station Controls and Displays: Location, Arrangement and Actuation of, For Fixed Wing Aircraft
MIL-A-8860	Airplane Strength and Rigidity, General Specification For
MIL-A-8863	Airplane Strength and Rigidity Ground Loads for Navy Acquired Airplanes
MIL-A-8867	Airplane Strength and Rigidity Ground Tests
ASME-Y14.100	Engineering Drawing Practices
ASME-Y14.24	Types and Applications of Engineering Drawings
ASME-Y14.35M	Revision of Engineering Drawings and Associated Lists
ASME-14.34M	Associated Lists

2.2 Definitions[1]

ARRESTING HOOK: The hook assembly, commonly referred to as the tail hook, is usually mounted on the aircraft for purposes of engaging arresting gear mounted on the deck or runway for deceleration (arrestment) of the aircraft. “The hook assembly consists of the shank (usually a V, Y or “stinger” arrangement) and a hook point, usually detachable. The arresting hook installation usually consists of the hook assembly, the holddown (dashpot, snubber), the holddown accumulator and pressure gauge(s), the extend/retract actuator (sometimes combined with the dashpot), the centering spring or similar device, the uplatch mechanism, the cockpit controls, and any related linkages, mechanisms, and fairings.”

ARRESTING SYSTEM: (shipboard and field) Also known as arresting gear, this refers to any gear or apparatus designed to decelerate (arrest) the aircraft in its motion either all or part of such gear being external to the aircraft being arrested; specifically, any such apparatus used (i.e., in carrier landings) to arrest airplanes in the landing roll. “Arresting gear in the commonest form comprises a wire rope (arresting wire, arresting cable, cross deck pendant), or the like, stretched across the deck or runway in the path of the aircraft and which engages the airplane arresting hook; and energy-absorbing devices (arresting engine). In lieu of the wire rope/arresting hook system, a webbing assembly is sometimes used to engage the airframe and/or the landing gear, usually in emergency circumstances.”

CABLE: Wire rope (arresting wire, arresting cable, cross deck pendant) used as component of the ground arresting gear or system.

EMERGENCY HOOK: An emergency arresting hook is usually designed for a very limited number of engagements where it would be deployed only in an emergency such as a loss of brakes during landing or rejected takeoff or on extremely slippery runways where loss of the aircraft is imminent. Under these circumstances, it may be permissible to allow minor structural damage to the aircraft.

OPERATIONAL HOOK: An operational arresting hook is designed to accept a significant number of engagements without any damage to the arresting hook system or airframe. This type of arresting hook would be used for short runway landings in conjunction with a mobile arresting system; for assisting in stopping the aircraft at airfields where extreme weather and/or short field lengths require repeated arrested landings; and for emergency stops.

3. REQUIREMENTS

3.1 Materials

Materials should be as specified in military specifications or industry standards. When materials used are not covered by military specifications, etc., they should be completely defined in detail specifications or documents furnished by the contractor.

3.1.1 Protective Treatment

When materials are used for components of the installation that are subject to deterioration when exposed to environmental conditions likely to occur during service usage, they should be protected against such deterioration in a manner that will in no way prevent compliance with the intended design performance.

3.1.2 Selection of Specifications and Standards

Specifications and standards describing necessary systems, commodities, materials, and processes should be selected in accordance with applicable industry and military specifications. Parts, materials, or processes that are not covered by these documents should be completely described in the manufacturer's documents or detail specifications.

[1] Definitions taken directly from AIR1489 dated April 1977.

3.2 Design

3.2.1 Function

a. The arresting hook installation should be designed and constructed to successfully engage a runway arresting system cable and decelerate the aircraft to a stop.

b. The particular runway arresting system and its characteristics, for which the aircraft arresting hook installation is to be designed, should be prescribed by the procuring activity. In the event that such a designation is not made, it should be assumed that the installation is designed for use with a BAK-13 system (Figure 1).

3.2.2 Extension and Retraction

a. The arresting hook should be capable of being extended either prior to or after landing touchdown and during the takeoff ground roll. Unless the using organization requires the operational capability for approach-end engagements, the emergency arrestment system should not be designed for in-flight engagements.

b. There is no requirement for retraction of an emergency arresting hook in flight since the installation is intended for emergency use only. A means should be provided from the cockpit for the hook to clear the cable, enabling the aircraft to taxi off the active runway.

c. The emergency arresting hook should be capable of being retracted and locked manually on the ground without the use of special tools.

d. Operational arresting hooks should be capable of being retracted and locked from the cockpit.

e. All arresting hooks should include provisions to preclude accidental release of the retracted hook.

3.2.3 Loads

a. The arresting hook system should be designed to withstand the loads resulting from engagement during aborted takeoff and emergency landings. Operational hooks should be capable of operational landing arrestments as prescribed by the procuring activity. The engagement velocities and maximum aircraft weights should be as defined in MIL-A-8860 and/or in the detail aircraft performance specification. The hook loads should be determined from the characteristics of the particular arresting system or systems as identified by the procuring agency, but the procuring agency must confirm the applicability of the arresting system data used. The BAK-13 Arresting System is often used for preliminary design efforts if nothing is known about the system(s) to be engaged (Reference Figure 1 (Note: Loads in Figure 1 for aircraft weighing less than 30,000 lb, should follow the 30,000 lb curve. Test data indicates that below 20,000 to 30,000 lb cable dynamic loads dominate and are primarily a function of velocity.)).

b. It is assumed that the arresting gear is engaged after landing impact has been completed and the aircraft is supported to the extent possible by the nose and main landing gears. At the time of engagement, varying lift characteristics of different aircraft may result in gear loads and strut extensions significantly different than those at static conditions. Required hook geometry should take into account these differences if present.

c. Side loads should be those components derived from the maximum tail hook load obtained, applied at angle of ±20° from the aircraft centerline in a horizontal plane.

3.2.3.1 Life

a. An emergency tail hook is usually designed for a very limited number of engagements where it would be deployed only in an emergency such as a loss of brakes during landing or rejected takeoff or on extremely slippery runways where loss of the aircraft is imminent. Under these circumstances, it may be permissible to allow minor structural damage to the aircraft.

   Although an emergency tail hook may only be required to have a one engagement life, the number of aircraft arrestments required to complete the Operating Tests (4.3.3) may drive the number of cycles for design life. Some emergency hooks in service, although "one-shot" hooks, were designed to withstand 10 test cycle operational engagements at Edwards Air Force Base.

b. An operational tail hook is designed to accept a significant number of engagements without any damage to the tail hook system or airframe. This type of tail hook would be used for short runway landings in conjunction with a mobile arresting system; for assisting in stopping the aircraft at airfields where extreme weather and/or short field lengths require repeated arrested landings; and for emergency stops. Consideration of the airframe structural design should be made to accept the repeated high tail hook loads for the life of the aircraft without failure. The life of the hook point is limited and provision for easy replacement should be included. In addition, the hook point radius should be designed to minimize wear/damage on the arresting cable. The operational life in terms of the number of engagements should be specified by the procuring activity.

3.2.4 Geometry

The arresting hook geometry (see Figure 2) should be such that the following parameters are satisfied.

a. The arresting hook attach point should be located such that the arresting force does not cause directional instability during the arrestment.

b. The arresting hook should be located so that the arresting force causes the minimum practical increase in nose gear vertical reaction.The aft arresting force should not cause the nose wheel(s) to be lifted from the runway during any portion of the arrestment.

d. The arresting hook length and down stop should allow positive contact of the hook point on the runway at a maximum nose down condition (Line N, Figure 2).

e. The arresting hook point should be so located when up and locked that the point clears the runway by minimum of 14 inches at the maximum tail down landing attitude with the aft struts and tires compressed to the design sinking speed deflection as shown in Figure 2, Line (T). If this is incompatible with the aircraft basic design, suitable guards should be installed that will prevent inadvertent engagement under these conditions.

f. For other than laterally rigid ("V" type) hooks, the hook should be free to swing laterally not less than 20° each side of center to allow alignment during an off center or yawed engagement. A centering device should be provided to maintain the hook parallel to the vertical projection of the aircraft centerline prior to cable engagement and lateral damping.

g. The in-flight maximum down angular position of the hook should be 80° or less when measured relative to the airplane landing approach line (A) or to the airplane maximum tail down line (T) (see Figure 2), whichever is critical.

h. The arresting hook should be positioned to ensure engagement after the cable has been displaced by the nose gear and/or main gear and/or tail bumper where applicable.

i. The arresting hook geometry should minimize the likelihood of unplanned in-flight engagement.

j. The arresting hook geometry should prevent cable strikes on the airframe during cable engagement and runout.

3.2.4.1 Definition of Ground Lines

Static Ground Line S – The ground line with the aircraft at rest, in the basic mission take-off configuration.

Design Landing Ground Line L – The ground line related to aircraft centerline at the aircraft landing attitude for the design landing configuration (as defined in the detail aircraft specification) with the shock struts and tires deflected to the corresponding landing loads.

Landing Approach Line A – A theoretical line determined by increasing the angle of the line L by vectorially adding the design landing speed (V) less the maximum design headwind (V_W) to the design sinking speed (V_V), as shown in Figure 2.

Maximum Tail Down Ground Line T – The maximum tail down attitude possible, limited by either aircraft structure or the tail bumper (if installed) compressed to maximum working stroke. The shock struts compressed and tires deflected corresponding to design landing loads.

Maximum Nose Down Ground Line N – The maximum nose down ground line caused by any of the following:

a. Brake drag of 0.31 times the main gear reaction for the weight and C.G. location causing the most nose down attitude, with the strut and tire deflections as appropriate for the applied brake load and weight.

b. A flat nose strut and a flat nose tire for the weight and C.G. location causing the most nose down attitude with main strut and tire deflections as appropriate for the weight.

c. Brake drag of 0.31 times the main gear reaction for the minimum landing weight and appropriate C.G. with the shock struts and tires serviced at aircraft maximum gross weight and with strut and tire deflections as appropriate for the minimum landing weight and applied brake load.

d. A flat nose strut and a flat nose tire for the minimum landing weight with the main struts and tires serviced at aircraft maximum gross weight and with main struts and tire deflections as appropriate for the minimum landing weight.

3.2.5 Components

Design of the various components of the installation should comply with the following requirements.

a. The hook point contour should be configured as shown in Figure 3 unless otherwise directed by the procuring activity. Hook point design should eliminate the possibility of double wire pick-up.

b. The hook point should be easily removable from the shank to allow for replacement in the field. The attachment should not be loosened or damaged by the normal wear expected during engagement with the runway. The design should preclude incorrect attachment of the hook point.

c. A force should be provided to lower and maintain the hook extended against air loads equivalent to the gear down placard speed. This force may or may not be from the same source as the "hold down" moment.

d. The hook should be fully extended and stabilized ready for arrestment within 2 s after the cockpit release control has been actuated.

e. A "hold down" moment about the hook attach point should be provided to load the hook point against the runway. The following minimum values of hold down moment at various hook positions should be provided; and should result in a force not less than 100 lb at the hook point measured perpendicular to the hook shank.

Hook on runway, aircraft in 3 point attitude
M = I/15 in lb

Hook full up
M = I/15 in lb

where:

I = weight moment of inertia of hook about the pivot point in pound-inches squared

If pneumatic pressure is used to provide the extension and hold down moment, a pressure gauge that can be readily observed during normal pre-flight should be incorporated. Any pneumatic pressure system should be designed to provide proper load when subjected to the required extreme changes in temperature between servicing and actual use, including servicing tolerances.

f. An energy-absorbing device to prevent hook bounce should be provided. The device should limit hook bounce to 2-1/4 inches when rolling over runway discontinuities and slab mismatch irregularities of up to 1/4 inch during the subject rollout. The ability of the energy-absorbing device to limit hook bounce to the extent required to ensure positive cable engagement on runway roughness anticipated in service should be verified by aircraft test. The energy-absorbing device should be designed to allow changing the damping level without major redesign if required. The energy absorber should incorporate a load relief device that will allow the necessary rapid movement of the hook during cable engagement without overloading the hook assembly or back-up structure. The energy absorber may be eliminated if analytical and operational test data can be presented indicating that the hook can be made stable by other means. This data should be approved by the procuring activity prior to release for manufacture of the first article.

g. An uplock mechanism should be provided to retain the arresting hook in the up position during all required aircraft flight and landing conditions and that releases the hook upon command of the pilot. The cockpit controls should be located in accordance with the requirements of MIL-STD-203. A manually operated mechanical system independent of the proper function of any other aircraft system is desired. A powered system would be acceptable provided the source of operating force is not adversely affected by the failure of any single airplane power source. The uplock should be readily released and reset from the ground without special tools.

h. A suitable removable ground safety lock with appropriate flag should be provided to prevent accidental actuation of the uplock. The ground safety lock should be able to withstand all actuation loads.

i. A means should be provided in the cockpit that indicates when the arresting hook is in the proper position for cable engagement.

j. If necessary, an up-stop bumper or energy absorber should be provided to prevent damage to the aircraft during overshoot of the hook from initial cable engagement or from cable wave loads during runout. The device should prevent the hook from causing any damage to the aircraft structure or internal equipment under the most adverse required cable engagement.

k. A down–stop that limits the maximum down position of the hook as described in 3.2.4g is required. The down–stop should function properly after hook release with or without airload present.

l. The hook should be smooth and clear of obstructions as shown on Figure 3. The hook shank should be torsionally stable, preferably utilizing a closed section.

m. The hook point cable groove radius should have a metal spray coating to prevent excessive cable wear and cable welding. The specific process to be used should be coordinated with the procuring activity.

3.3 Drawings

3.3.1 Preliminary drawings showing the following items should be submitted to the procuring activity for approval in accordance with the aircraft data submittal requirements document:

a. A profile, plan and front view drawing of the aircraft with an envelope of extreme center of gravity locations shown. The hook should be shown at full down, full up, and at pertinent intermediate positions. The various ground lines as required in 3.2.4 and Figure 2 should be shown.

b. A preliminary installation drawing showing the hook point, shank, uplock assembly, snubber, attach fittings and other significant pieces of hardware. Intended materials, heat treatments, and finish processes should be indicated for major structural components.

c. A schematic of the uplock release and indication system.

d. All logic diagrams.

3.4 Interchangeability

All parts having the same manufacturer's part number should be functionally and dimensionally interchangeable. ASME drawing requirements should govern changes in the manufacturer's part number.

3.5 Performance

The arresting installation should be capable of satisfactorily completing the ground, flight, and inspection tests specified in Section 4.

3.6 Marking

Assemblies and components should be identified in accordance with MIL-STD-130.

3.7 Workmanship

The components should be uniform in quality and free from irregularities or defects that could adversely affect performance, reliability, or durability.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility

Unless otherwise specified in the procurement document, the contractor is responsible for the inspection requirements under the surveillance of the procuring activity. Records of tests performed should be kept complete and available to the procuring activity.

4.2 Classification of Tests

Tests are classified as:

a. Preproduction – Preproduction tests are those tests required on initial installations to prove the suitability and integrity of the basic design of the installation.

b. Quality Assurance – Quality assurance tests are those tests required on each component or assembly to prove and maintain the quality of the installation and its components on a production basis.

4.3 Preproduction Tests

4.3.1 Structural Static Tests

The contractor should conduct structural static tests on the arresting hook installation as prescribed in MIL-A-008867, except that of repeated load tests. Repeated load test requirements, if any, will be specified by the procuring activity.

4.3.2 Development Tests – Runway

The contractor should conduct a series of runway taxi tests to determine that the hook system is stable and the hook point will not bounce over the cable during the actual arresting tests. An actual test aircraft may be used or a substitute moving vehicle capable of simulating the required runway speeds, aircraft weights, main gear spacing, and wheel-to-hook point distance that duplicates that of the actual airplane may be used. Data would be recorded to determine height of hook bounce and magnitude of bounce loads incurred at various velocities.

4.3.3 Operating Tests

It is recommended that a series of actual complete airplane arrestments be conducted to prove the adequacy of the complete design to meet the intended performance requirements. The test program, as a minimum, should determine the following parameters:

4.3.3.1 Maximum hook load and cable load as a function of aircraft weight and contact velocity for on-center engagements and for off-center engagements up to 20% of the cable span.

4.3.3.2 Maximum allowable engagement velocity for on-center and off-center engagements as a function of aircraft weight.

4.3.3.3 Proper function of the complete installation and detail components during above tests.

4.3.3.4 Type of aircraft damage incurred from cable contact and hook overshoot for various types of engagements. Determine the inspection procedures necessary for service aircraft after various types of engagements.