

An aerial photograph of a Boeing 757 aircraft on a runway. The aircraft is white with blue accents and the number '757' on the tail. The runway is paved with yellow markings. The background shows a grassy area.

MINIMIZING THE IMPACT OF RUNWAY ARRESTING SYSTEMS

ON COMMERCIAL AIRPLANE OPERATIONS

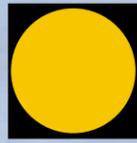
Many airports throughout the world have joint commercial-military operations. Runways at these airports often are equipped with arresting gear systems for tactical military aircraft to use for landing. These systems pose a potential damage and safety hazard to commercial airplanes that use the same runways. Airports and airlines can take steps to help ensure safe commercial operations under such circumstances. Measures include writing airport procedures specifically for commercial airplane operations, modifying existing arresting systems, reducing declared landing and takeoff distances, and increasing inspections of airplanes with nosegear spray and gravel deflectors.

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f the nearly 36,000 airports around the world that are classified as civil, military, or joint-use, approximately 3,800 are used for scheduled commercial service. Worldwide, an estimated 2,000 aircraft arresting systems are installed at facilities in 64 countries. The highest concentration of these systems is on military runways or where the military is a major tenant of a commercial airport. Commercial operators mainly encounter these systems at joint commercial-military airports or when operating charters to military airfields. If the nosegear spray and gravel deflectors used on some commercial airplanes come in contact with the arresting systems, the deflectors could shatter, creating foreign object debris (FOD). In extreme cases, the FOD could damage a critical airplane system.

To help minimize the impact of runway arresting systems on commercial operations, airlines need to know the following:

1. Types of aircraft arresting systems.
2. Operational concerns for airlines.
3. Measures to help ensure safe commercial operations.

1 TYPES OF AIRCRAFT ARRESTING SYSTEMS

The three basic types of aircraft arresting systems are barriers, cables, and engineered materials arresting systems (EMAS). The first two systems are primarily military systems used for tactical aircraft, such as fighter and attack jets. The third system recently has been developed and is used at commercial airports that do not have sufficient safety areas at the end of the runway. (See “U.S. and International Aircraft Arresting Systems” on p. 31.)

Aircraft arresting barriers.

These devices, which do not depend on arresting hooks on aircraft, stop an aircraft by absorbing its forward momentum in a landing or aborted takeoff overrun. These systems are most commonly net devices (fig. 1), but they also include older devices that catch the main gear struts. The barriers typically are located in the overrun of the runway, are unidirectional, and can have collocated or interconnected arresting cables as part of their configuration.

They sometimes are used for special purposes, such as stopping the space shuttle.

Aircraft arresting cables.

Arresting cables span the runway surface and are engaged by the aircraft arresting gear hook (fig. 2). Cables are typically 1 to 1 1/4 in (2.5 to 3.2 cm) in diameter and suspended 1 1/2 to 3 in (3.8 to 7.6 cm) above the pavement surface by rubber donuts 6 in (15.2 cm) in diameter. Used primarily by aircraft built in the United States and Europe, arresting cables have been used by the military since the late 1920s on aircraft carriers and for land-based runways.

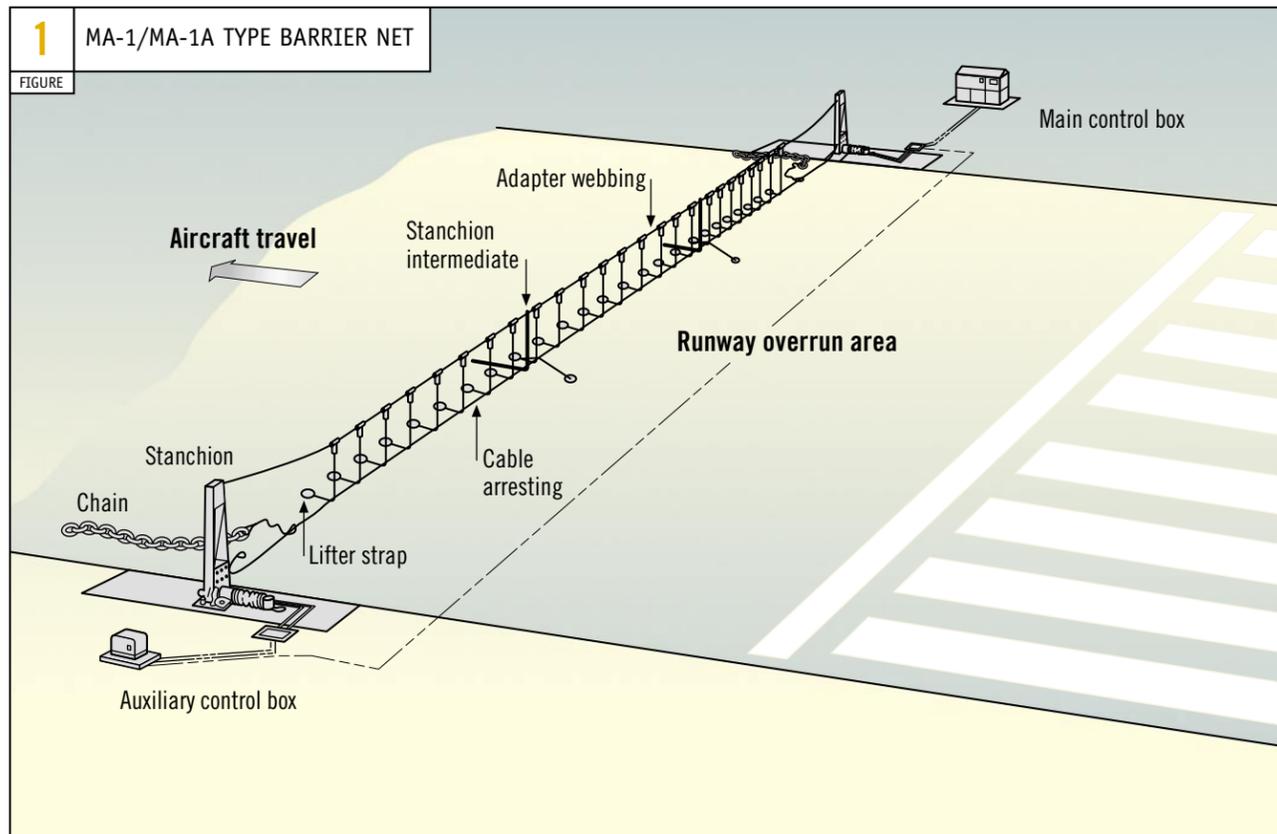
Three main factors determine where cables are located on runways: the direction of engagement (unidirectional or bidirectional); the runout of the system, which is the distance from the cable to the point at which the aircraft stops (typically 950 to 1,200 ft, or 290 to 360 m); and whether the system is typically used under visual meteorological conditions or instrument meteorological conditions. Figure 3 shows the typical locations for

arresting-cable installations. An aircraft operating on runway 10R would use the cable at the far end for both landing and aborted takeoff unless the aircraft had an emergency, at which point the arresting gear nearest the approach end of the runway would be used.

The installation criteria for cable systems on commercial runways are identified in the U.S. Federal Aviation Administration (FAA) Advisory Circular AC 150/5220-9, *Aircraft Arresting Systems for Joint Civil/Military Airports*. The location of the cable is marked on the runway by a series of reflective discs 10 ft (3 m) in diameter painted “identification yellow.” These discs are laid out with 30 ft (9.1 m) between centers and extend the full width of the runway (fig. 2). (See *location identification* in “Common Terms” on p. 30.)

Engineered materials arresting systems (EMAS).

EMAS, which are constructed of high-energy-absorbing materials of selected strength, are located in the safety area,



or overrun, of the runway. They are designed to crush under the weight of commercial airplanes as they exert deceleration forces on the landing gear. These systems do not affect the normal landing and takeoff of airplanes. More information concerning EMAS is in FAA Advisory Circular AC 150/5220-22, *Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns*.

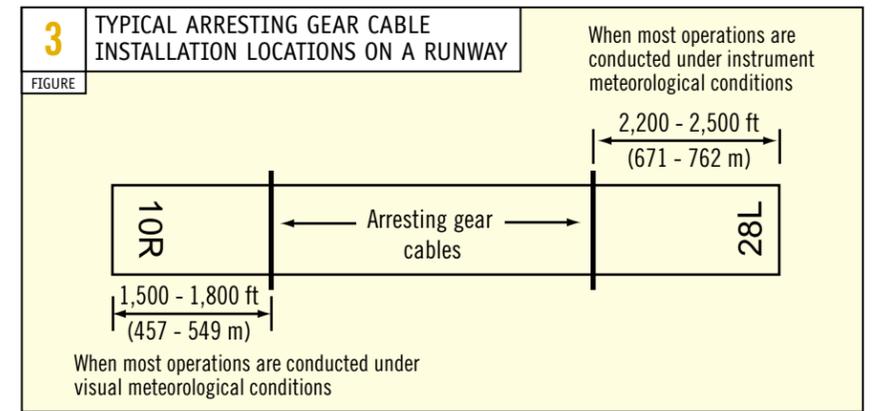
2 OPERATIONAL CONCERNS FOR AIRLINES

Airlines have numerous concerns about operating commercial airplanes on runways with aircraft arresting systems. These include airplane nosegear interference, trampling of the arresting cable, adjustments to declared distances, dealing with arresting barriers, runway availability, airplane maintenance, and unintentionally engaging arresting systems.

Nosegear interference.

Some commercial airplanes have unique nosegear devices to deflect either spray or foreign objects. A 737-200 that operates on gravel runways has a nosegear gravel-deflector unit with a ground clearance of 3 1/2 to 6 in (8.9 to 15.2 cm) (fig. 4). The MD-80, MD-90, and 717 airplanes are equipped with a combination nosegear spray-FOD deflector for normal operations (fig. 5). The ground clearance of this deflector is 3/4 to 1 1/2 in (1.9 to 3.8 cm). A few DC-9-50 airplanes also use the same nosegear deflector for additional FOD protection. Because most arresting cables are 1 to 1 1/4 in (2.5 to 3.2 cm) in diameter and suspended by rubber donuts 6 in (15.2 cm) in diameter, nosegear deflectors are at risk of being damaged if a donut is struck.

Normal procedure is for the rubber donuts to be approximately 6 ft (1.8 m) apart, starting 3 ft (0.91 m) from the runway centerline on runways 200 ft (61 m) or less in width. For runways wider than 200 ft (61 m), the donuts are placed 8 ft (2.4 m) apart. To minimize potential damage to the nosegear deflectors, airplanes with such attachments should slow-taxi over the cable, avoiding the donuts. If the nosegear spray deflector is damaged and



removed, in accordance with the minimum equipment list, the airplane is limited to operating on dry runways until the deflector is replaced.

Trampling of the arresting cable.

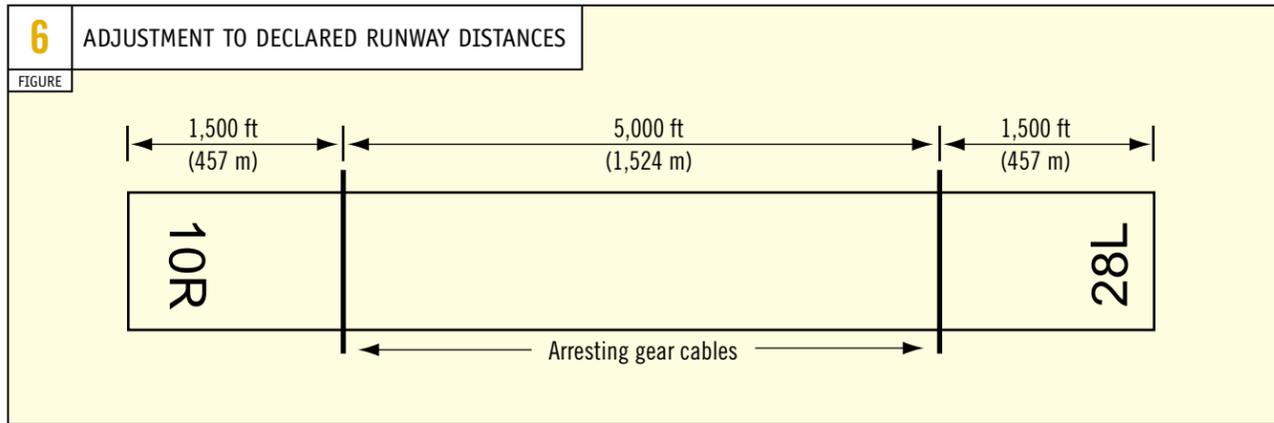
If an operator considers the trampling, or rolling over, of a cable to be too rough on the airplane, the donuts that elevate the arresting cable above the runway surface can be moved to the sides of the runway during commercial operations. This allows the cable to rest directly on the pavement surface, minimizing the bump effect on the airplane.

It is important to note that the cable must be kept under tension, whether lying on the pavement or elevated by the donuts. Otherwise, the cable could be lifted by the airplane landing gear and contact the bottom of the fuselage or antennae located on the lower fuselage. (See *rigged and down*, *rigged and up*, and *out of battery* in "Common Terms" on p. 30.)

Adjustments to declared distances.

Some airlines that operate on runways with arresting cables have reduced the available runway length by the distance from the operational end of the runway, or threshold, to the cable. For example, an 8,000-ft (2,438-m) runway could be reduced to 5,000 ft (1,524 m) of usable runway length for each of the following declared distances: takeoff distance available, takeoff runway available (TORA), accelerate stop distance available, and landing distance available (fig. 6).

If the distance between the threshold and the cable is not used, however, the remaining runway substantially reduces the available payload on a 737-800 and MD-83 operation, based on the conditions of a standard day, optimal flap setting, zero wind, no obstacles, and zero slope (table 1). This method may be usable for a short-haul flight, but it is not a preferred long-term solution.



Dealing with arresting barriers.

Nets are typically located in the over-run area near the runway threshold. If the net is in the raised position at the departure end, it should be treated as an obstruction that has to be cleared by 35 ft in accordance with the FAA federal aviation regulations and an adjustment made to the TORA. There are rare situations in which a net has been located in the actual runway. In these cases, provided the net lies flat on the runway and is under tension, it can be rolled over. If the net is bunched and lying on top of the runway, the airplane should not cross it.

Runway availability.

A commercial airplane following a military aircraft could experience a delay in landing if the military aircraft engages the arresting gear. The flight crew of the commercial airplane should expect to execute a missed approach while the military aircraft is removed and the arresting gear reset. Typical cycle times for arresting gear can vary from 3 to 10 minutes depending on the type of system. (See *cycle time* and *reset time* in “Common Terms” on p. 30.)

Airplane maintenance.

If the flight crew believes the airplane nosegear has contacted one of the hard rubber donuts supporting an arresting-gear cable, a visual inspection of the nosegear spray deflector should be conducted to verify whether it has been damaged. A similar visual inspection would apply if the flight crew

1 EXAMPLE OF REDUCED RUNWAY LENGTHS ON WEIGHT

TABLE

Airplane	Airfield length ft (m)	Takeoff weight lb (kg)	Weight loss lb (kg)
737-800	8,000 (2,438)	174,000 (78,926)	—
	5,000 (1,524)	140,300 (63,640)	33,700 (15,286)
MD-83	8,000 (2,438)	159,700 (72,440)	—
	5,000 (1,524)	131,300 (59,558)	28,400 (12,882)

thought that the cable had made contact with the belly of the airplane. For airlines that routinely operate on runways with arresting-gear cables, additional visual inspections may be conducted depending on the type of arresting systems installed and to what extent the airplane interacts with the system.

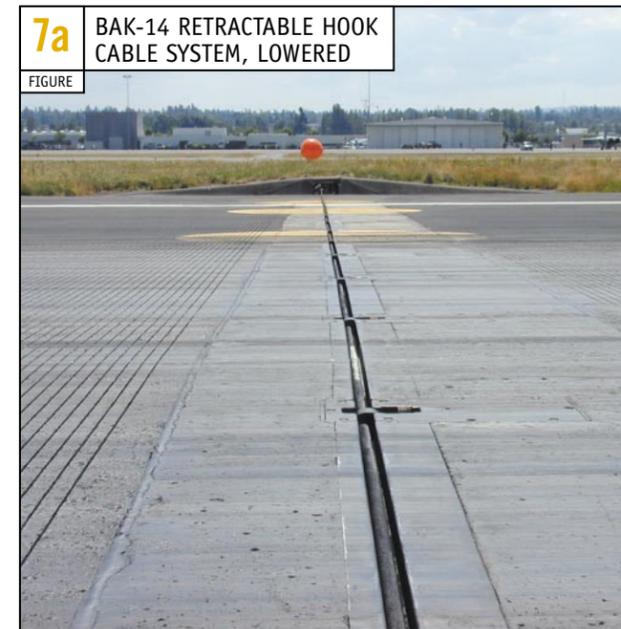
Unintentionally engaging arresting systems.

Occurrences of commercial airplanes being engaged or tangled in arresting cables are rare. In the 1970s, a DC-10 had a rejected takeoff during a flight test. In this case, the fuse plugs on the leading tires on one main landing gear had deflated, and during the takeoff roll the arresting cable was snagged, causing the airplane to stop.

In 1995, an MD-88 was starting its takeoff roll when the nose landing gear snagged the arresting gear, bringing the airplane to a halt. It was inspected with no damage found and dispatched shortly thereafter.

3 MEASURES TO HELP ENSURE SAFE COMMERCIAL OPERATIONS

The key to dealing with the presence of arresting cables on runways is coordination among the airline operator, the airport operator, and the agency having control of the arresting system. Educating the various parties on the operational needs of commercial airplanes can alleviate many limitations. Six ways to minimize the impact of arresting systems located on runways used by commercial airplanes are shown in the following list.



- If the airport has parallel runways, normally only one of the two runways has the arresting systems installed. Consider limiting commercial operations to the runway without the arresting systems.
- Coordinate the permanent removal of the arresting systems. The military aircraft using the runways may no longer need the arresting gear; the gear, or at least the cable, could be removed. (See *derigged* in “Common Terms” on p. 30.)
- Install a system to raise and lower the arresting cable flush into a track on the runway (fig. 7). This modification, referred to as BAK-14, takes an existing arresting cable and allows the air traffic control tower to remotely raise the arresting cable for military operations and lower it into a track flush-mounted on the runway for commercial operations. At the majority of joint-use airports in the United States, this modification has been made to the standard BAK-9/12/13 systems that previously were supported by the rubber donuts. (See *BAK* in “Common Terms” on p. 30.)

- Although not considered an optimal solution, the runway length can be reduced. This is feasible if the runway is of sufficient length that the mission of the airplane can be achieved on the usable runway distance between arresting gears installed at each end of the runway. At a minimum, operators may consider reducing only the distance from the approach end of the runway to the gear.
- Operators may wish to increase the frequency of maintenance inspection of the nosegear and lower fuselage areas for airplanes that routinely operate over arresting-gear cables.

- Disconnect the cable and lay it on the side of the runway during periods of commercial operations (fig. 8). This is a workable solution provided the scheduled commercial operations do not interfere with the flight schedule of the military aircraft. Or slide the rubber donuts to the edge of the runway so that the cable lies flat on the pavement but is still under tension. The airplane then can roll over the top of the cable.



SUMMARY

Commercial airplanes can safely use runways with aircraft arresting systems. Safe operation requires planning by, and coordination among, commercial airplane operators, airport authorities, and the agencies that control the arresting systems.

COMMON TERMS

Arresting-Gear Cable Status:

- **derigged** — The cable is removed from the runway surface and is not an operational concern.
- **rigged and down** — The cable is under tension across the runway but not elevated off the surface by use of rubber donuts (BAK-9/12) or rubber elevation arms (BAK-14 mod).
- **rigged and up** — Also referred to as the gear being “in battery.” Means that the cable is under tension across the runway and elevated off the surface by use of rubber donuts (BAK-9/12/13) or rubber elevation arms (BAK-14 mod).

- **out of battery** (slack cable) — The cable is extended across the runway but is not under tension.
- BAK** — U.S. designation for a barrier arresting system. Non-U.S. arresting systems carry other designations. (See “U.S. and International Aircraft Arresting Systems” on p. 31.)
- cycle time** — A measure of time between engagement of an aircraft and the point when the arresting system is certified fully operational and ready for another engagement.
- location identification** — A description identifying the location of arresting systems by the approach

or departure end, runway designation, and position in hundreds of feet from the threshold. For example, the location identification “extended runout BAK-12 at +1,500 on approach runway 36” indicates a 1,200-ft runout BAK-12 arresting system located 1,500 ft beyond the threshold of runway 36.

reset time — The time required to ready the arresting system for another engagement after aircraft release. (This does not include time to disengage the aircraft from the arresting system but does include the time required to inspect and certify the system fully operational.)

U.S. AND INTERNATIONAL AIRCRAFT ARRESTING SYSTEMS

TAIL HOOK SYSTEMS

Bidirectional

- BAK-6** Water squeezer
- BAK-9** Rotary friction brake
- BAK-12** Rotary friction brake

There are three types of installation for the BAK-12 system:

- **Standard BAK-12** — 950-ft runout, 1-in cable, and 40,000-lb weight setting.
- **Extended BAK-12** — 1,200-ft runout, 1-1/4-in cable, and 50,000-lb weight setting.
- **Dual BAK-12** — Two energy absorbers on each side of the runway connected to a single cable; runout varies.

MAAS Essentially a BAK-12 system mobilized on a specially developed trailer. Basic system has 990-ft runout and is equivalent to standard BAK-12. MAAS may be modified to accommodate different configurations equivalent to various BAK-12 systems.

- BAK-13** Rotary hydraulic
- E28** Rotary hydraulic (water brake)
- M21** Rotary hydraulic (water brake) mobile

Unidirectional

E5/E5-1/E5-3 Chain type. Rated by chain weight and length. The rating is used to determine the maximum aircraft engaging speed. A dry rating applies to a stabilized surface (dry or wet), while a wet rating takes into account the amount (if any) of wet overrun that is not capable of withstanding the aircraft weight.

Foreign cable

- 34B-1A, 1B, 1C** Rotary hydraulic (water brake)
- 44B-2E, 2F, 2H, 2I, 2L, 3A, 3H, 3L, 4C, 4E, 4H** Rotary hydraulic (water brake)
- 500S, 500S-4, 500S-6** Rotary friction
- 500S-8 (TAG)** Rotary friction (trans-arresting gear)
- 500S-8** Rotary friction
- 1300** Rotary hydraulic (water brake)
- 2800** Rotary hydraulic (water brake)
- AAE-64** Rotary hydraulic (water brake)
- BEFAB 8:3, 20:4, 56:2** Pneumatic disc brake
- DUALBAK-12** Rotary friction
- E5-1, E5-2, E5-3** Chain
- E6** Chain
- E15, E27** Rotary friction
- E28** Rotary hydraulic (water brake)
- M21** Rotary hydraulic (water brake) mobile
- MAG I thru MAG X** Rotary hydraulic (mobile arresting gear)
- PAAG** Portable aircraft arresting gear (British)
- UNKAGEAR** Unknown type of energy absorber

MAIN STRUT OR WING ENGAGEMENT SYSTEMS

Unidirectional

- MA-LA** Web barrier between stanchions attached to a chain energy absorber. Designed primarily for main strut engagement, but tests reveal successful hook backup capability.
- MA-LA modified or MA-1A/E-5** Web barrier between adjustable stanchions combined with a hook pickup cable and chain energy absorber.
- MA-1A/BAK-9 or MA-1A/BAK-12** Web barrier between adjustable stanchions combined with a hook pickup cable and a mechanical energy absorber (bidirectional on request).
- BAK-15** Web barrier between stanchions attached to an energy absorber (water squeezer, rotary friction, chain). Designed for wing engagement.
- BAK-15 (NI)** Web barrier between stanchions interconnected with a hook pickup cable and energy absorber. System is called BAK-15 with Net Interconnect (NI).
- BEFAB 6:3*** Description not available (N/A)
- BEFAB 12:3*** N/A
- BEFAB 21:2** N/A
- BEFAB 24:4**** N/A
- RAF MK-6** N/A
- RAF MK-12A** All nylon net
- RAF TYPE A** N/A
- RAF TYPE B** N/A (net only; may be attached to energy absorber from any arresting gear)
- SAFE-BAR (Safe-land barrier)** N/A (engage with closed canopy)
- 61QSII** Barricade net system
- 62NI** Net barrier with hook cable interconnect
- 63PI** Dual-cable interconnect for hook engagement
- A30** Aerazur 30-element net (F30)
- A40** Aerazur 40-element net (F40)
- HOOK CABLE** Unspecified type of tail hook engagement
- HP-NET** Adec high-performance net
- J-BAR** Generic barrier (non-hook cable) engagement
- MA-1** Net barrier main gear cable engagement
- NET** Unspecified type of net engagement
- UNK** Unknown

DEVICES USED WITH SOME AIRCRAFT ARRESTING SYSTEMS

- BAK-11** Pop-up engaging device with a mechanical energy absorber (BAK-9, BAK-12) to engage main struts
- BAK-14** A device that raises a hook cable out of a slot in the runway surface and is remotely positioned for engagement by the tower on request

* May alternatively be fitted with a cable
** Cable attached

SOURCE: THE U.S. DEPARTMENT OF DEFENSE (DOD) EN ROUTE SUPPLEMENT, A DOD FLIGHT INFORMATION PUBLICATION (FLIP) PRODUCED AND DISTRIBUTED BY THE NATIONAL IMAGERY AND MAPPING AGENCY (NIMA).