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AIR TRAFFIC CONTROL TRAINING SERIES

EQUIPMENT

ARRESTING SYSTEMS

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AT-G-02

FOREWORD

PURPOSE: This publication is for use in the training of USAF air traffic controllers and is not intended to replace, substitute for, or supersede official regulations, procedures, or directives.

SANDRA SERAFIN, Col, USAF
Director of Airfield Operations

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SUMMARY OF CHANGES

#4 Terms relating to Aircraft Arresting systems updated
#5-25 Updated all paragraphs to reflect current arresting system configurations and new systems.
#5-25 Detailed barrier figures added.

TERMS RELATING TO AIRCRAFT ARRESTING SYSTEMS

The unique terms used in this manual as well as the referenced documents are described below.

Aircraft Arresting System (AAS): A series of components used to engage an aircraft and absorb the forward momentum of an emergency landing or an aborted take off.

Arresting Barrier: A device, not dependent on an aircraft hook, used to engage an aircraft and absorb the forward momentum of an emergency landing or an aborted take off.

Aircraft Arresting Cable: That part of an aircraft arresting gear which spans the runway surface or flight deck landing area and is engaged by the aircraft arresting hook. This component is also commonly referred to as the pendant, hook cable, cable or wire.

Aircraft Arresting Complex: An airfield layout comprised of one or more arresting systems.

Arrestment Capable Aircraft: An aircraft which has arrestment procedures published in its flight manual.

Cycle Time: A measure of the time between the engagement of an aircraft and the point at which the arresting system is capable of another engagement. Systems will not be considered back in service until declared so by the cognizant maintenance activity.

Emergency Arresting System (EAS): An arresting system normally installed in the overrun area of the runway which is used to prevent loss of life and damage to aircraft during an aborted take-off or landing.

Energy Absorber: The component of the arresting system through which the kinetic energy of the arrested aircraft is dissipated.

Location Identification: The location of an arresting system within the arresting system complex is identified by stating whether it is located on the approach, mid field, or departure end of any particular runway designation and its position described in hundreds of feet with respect to the threshold. E.G. Extended runout BAK-l 2 at + 1,300 on approach runway 36. This indicates the 1,200 foot runout BAK-12 is located 1,300 feet beyond the threshold of runway 30.

Operational Arresting System (OAS): A rapid cycle, bidirectional arresting system designed for use on a daily basis to enhance the tactical mission and avert emergencies created by meteorological conditions, short or slick runways, and known or suspected aircraft malfunctions.

Reset Time: The time required to ready the arresting system for another engagement niter aircraft release. (This does not include the time required to disengage the aircraft from the AAS.)

NOTE: This manual was created using excerpts from AFI 32-1043. For more detailed information on aircraft arresting systems, barriers, and the operation of these systems, refer to AFI 32-1043 and the appropriate 35E8-series Technical Orders referenced in this guide.

TYPES OF USAF AIRCRAFT ARRESTING SYSTEMS

1. General Information. Aircraft arresting systems consist of engaging devices and energy absorbers. Engaging devices are net barriers such as MA-1A and BAK-15, disc-supported pendants (hook cables), and cable support systems such as BAK-14 and the Aerazur Type H, that raise the pendant to the battery position or retract it below the runway surface. Energy absorbing devices are ships' anchor chains, rotary friction brakes (such as the BAK-9 and BAK-12), or rotary hydraulic systems (such as the BAK-13). Tables 1-1 and 1-2 below show the leading particulars for USAF energy absorbing systems.

Table 1-1. USAF Aircraft Arresting System Energy Absorber Leading Particulars (except Textile Brake)*.

System Type	BAK-9	BAK-12 60-Inch Reel	BAK-12 66-Inch Reel	Dual BAK-12 66-Inch Reel	BAK-13	MAAS 990-Foot Runout***
Nominal Aircraft Weight	40,000 lbs	40,000 lbs	50,000 lbs	100,000 lbs	50,000 lbs	40,000 lbs
Energy Capacity (Ft Lbs)	55×10^6	65×10^6	85×10^6	170×10^6	85×10^6	40×10^6
Nominal Runout	950'	950'	1,200'	1,200'	950'	990'
Tape Strength	65,000 lbs	105,000 lbs	105,000 lbs	105,000 lbs	130,000 lbs	105,000 lbs
Cable Strength	84,000 lbs	130,000 lbs	130,000 lbs	130,000 lbs	129,000 lbs	130,000 lbs
Maximum Speed**	180 knots	180 knots	180 knots	180 knots	180 knots	150 knots

* The operating characteristics given in this table are described in inch-pound units as reported by the original equipment manufacturers.
** 190 knots is the dynamic limit for steel cables used in aircraft arresting systems. Random failures will occur at 190 knots and above; therefore, 180 knots is established as the working limit for cable-engagement systems.
*** MAAS configured for 1,200 feet runout in the 31-stake, Portland Cement Concrete, or set-back anchoring schemes have the same technical characteristics as a 66" BAK-12.

Table 1-2. USAF Textile Brake Aircraft Arresting System Leading Particulars*.

System Type	MB 60.9.9.C	MB 100.10C	MB 100.12.C**
Cable Diameter/Strength	1.25 inches/ 130,000 lbs	1.25 inches/ 130,000 lbs	1.25 inches/ 130,000 lbs
STAGE 1 Runout (Length of available braking force)	551 feet	N/A	N/A
Energy Capacity Stage 1 (Ft Lbs)	26 X 10^6	N/A	N/A
Total System Energy Capacity (Ft Lbs)	52 X 10^6	44 X 10^6	52 X 10^6
System Runout (Total length of available braking force)	1000 feet	889 feet	889 feet

Energy Capacity calculated at 160 knots.

NOTE: 12% increase in Energy Capacity when using a net.

* The operating characteristics given in this table are described in inch-pound units as reported by the original equipment manufacturers.

** The MB 100.12C can produce hook loads that exceed the working limit for pre Block 40 F-16 aircraft. Therefore, it should not be used at installations that host this model aircraft (mission, tenant, or transient support). Block 40 model F-16 and later are fully compatible with the MB100.12 Textile Brake Arresting System.

2. Types of USAF Systems.

2.1. MA-1A. The MA-1A emergency arresting system consists of a net barrier and cable system designed to engage the main landing gear of an aircraft (Figure 2-1). Because it is a unidirectional system, it must always be installed in the overrun area. Aircraft engaging this system above the speed and weight limits provided in Figure 2-3 (or Chart 1-1 of T.O. 35E8-2-2-1) will result in a runout greater than 305 meters (1,000 feet), or cable failure. Most MA-1A systems employ ships' anchor chains as the energy absorber. These systems require a runout area of at least 259 meters (850 feet) plus the length of the aircraft. The chains lie on either side of the runway overrun, beginning at the barrier location and running in the direction of aircraft travel; however, some MA-1A systems use a BAK-9 instead of a ships' anchor chain as the energy absorber. These systems require a runout area of at least 290 meters (950 feet) plus the length of the aircraft. This configuration is an MA-1A/BAK-9. The MA-1A may also be complemented with a hook-cable interconnect to accommodate hook engagement. This arrangement is shown in Figure 2-2. The MA-1A is not currently in production as a system. Do not consider it for new installations

unless you can salvage the necessary equipment from another facility. Obtain further technical information on this system from T.O. 35E8-2-2-1.

Figure 2-1. MA-1A Barrier.

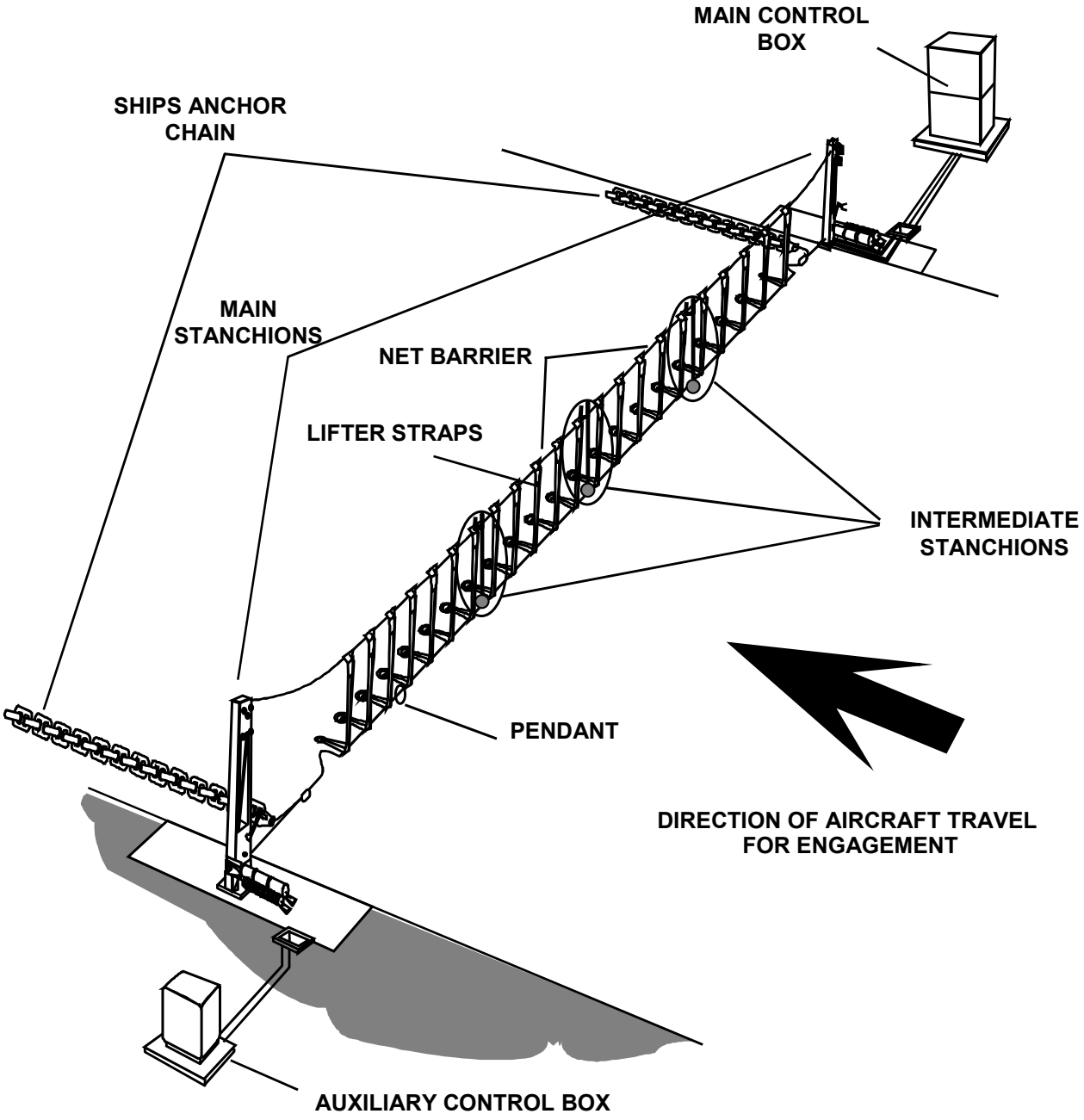


Figure 2-2. MA-1A Modified Barrier With Hook Cable Interconnect.

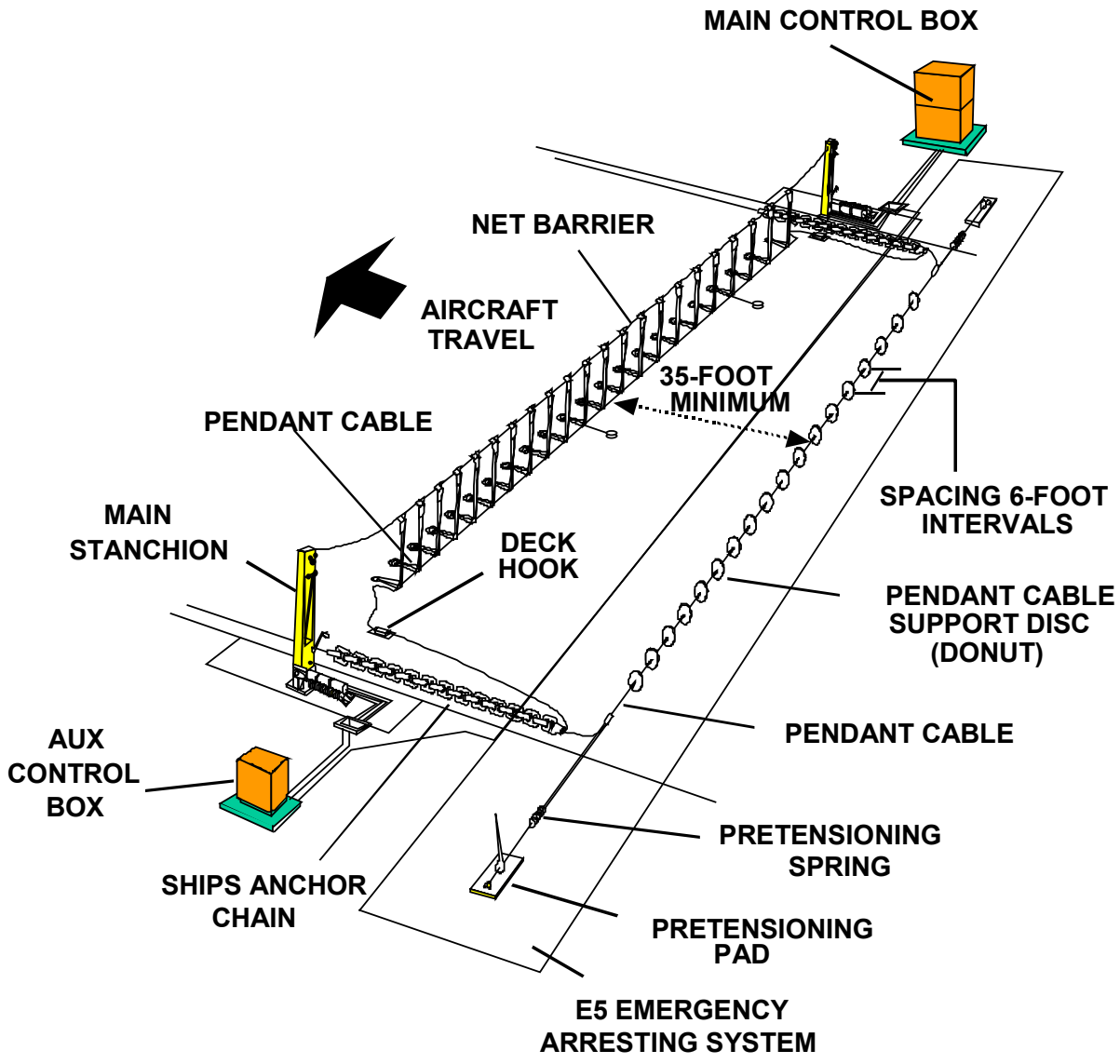
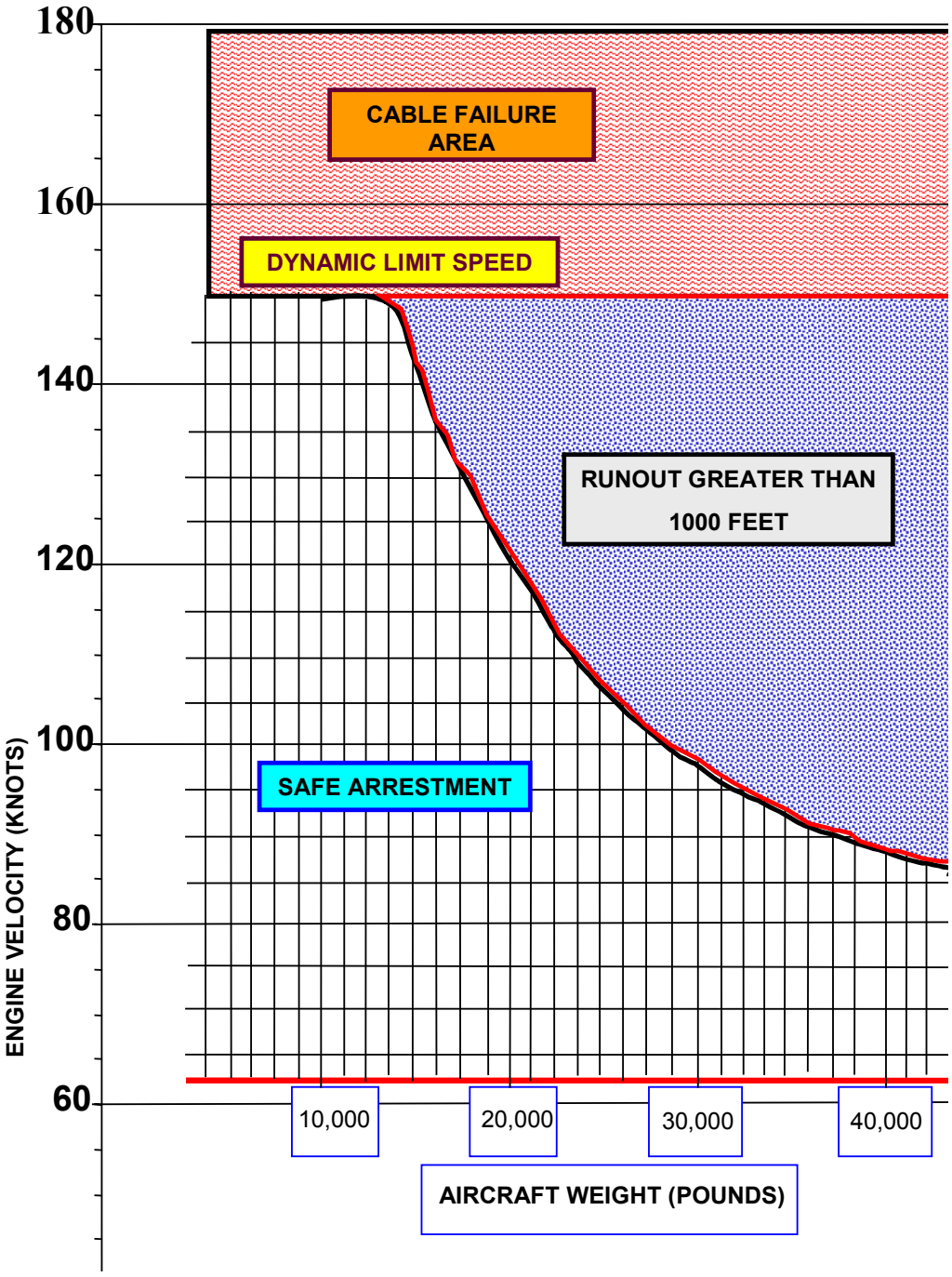


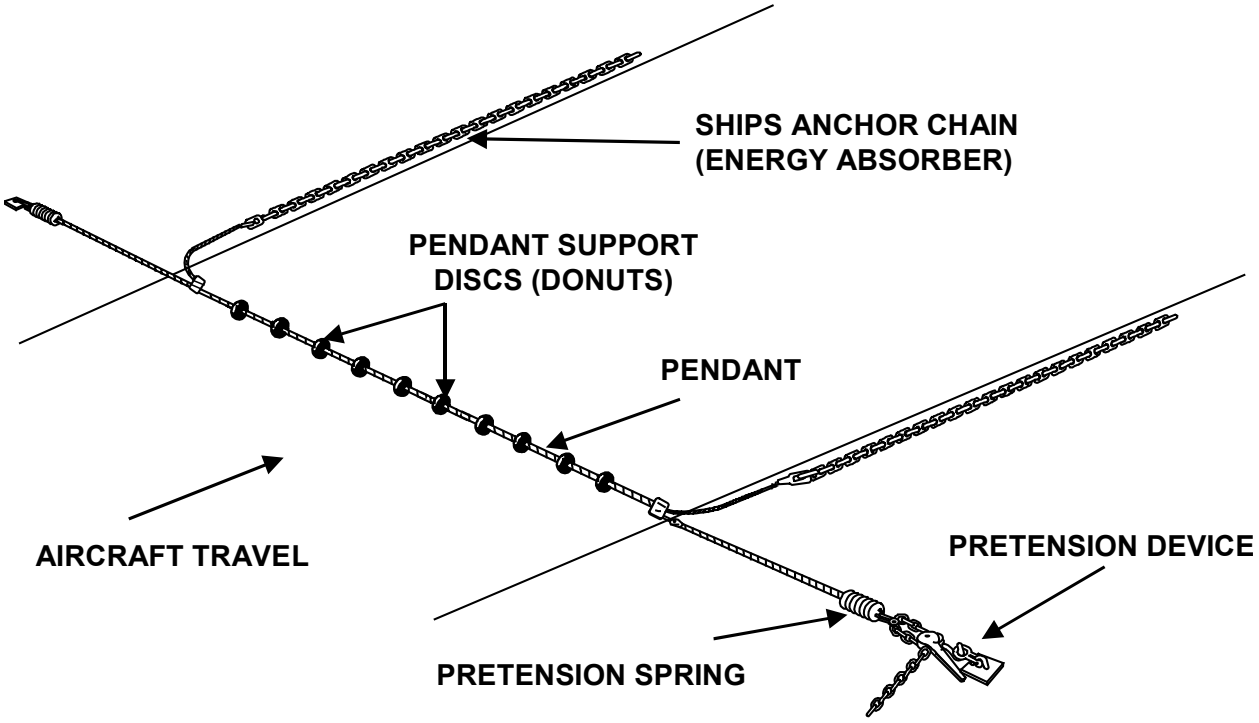
Figure 2-3. Speed and Weight Chart for Chain Gear.



2.2.2. E-5. This unidirectional emergency arresting system is a US Navy design and designation. Much like the MA-1A, this system uses several shots of ships' anchor chain as the energy absorber, but these systems are never connected with a barrier (net). For the Navy or Marine Corps, these systems can have from 1 to 4 disc-supported hook cables, with designations of E-5 and E-5 Mod 1 through E-5 Mod 3. Obtain further technical information on the Navy configuration of this

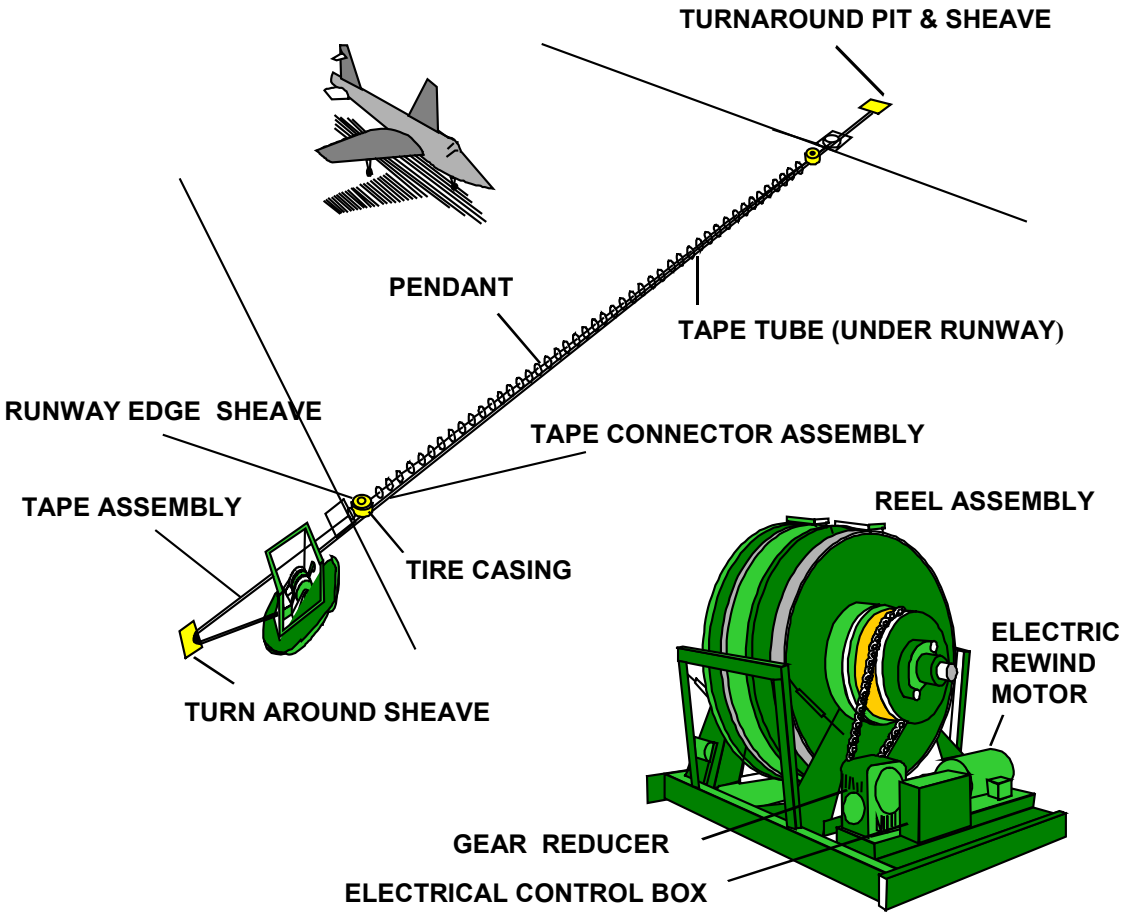
system from the Naval Air Warfare Center, Lakehurst, NJ. For USAF, these systems use only 1 pendant and are sited and maintained as MA-1A. They are designated as an E-5 (Figure 2-4).

Figure 2-4. E-5 Hook Cable Arresting System.



2.2.3. BAK-9. The BAK-9 (Figure 2-5) is an obsolete bi-directional emergency arresting system. It consisted of 1 energy absorber that employed 2 rotary friction brakes and purchase-tape reels mounted on a common shaft. The reels were mechanically connected at the midpoint by a third brake that acted as a clutch. This allowed each reel to turn at different speeds during off-center engagements and helped steer the aircraft toward the center of the runway. The energy absorber for these systems was installed below grade on 1 side of the runway and the purchase tape was routed to the opposite side of the runway through deflector sheaves and duct. The other purchase tape (near side) was routed to a turnaround sheave located in a pit sited to allow both purchase tapes to be of equal length. The BAK-9 is not currently in production as a system and should not be considered as a suitable system for a new requirement. Obtain further technical information on this system from T.O. 35E8-2-4-1, *Aircraft Arresting Gear, Model BAK-9.*

Figure 2-5. BAK-9 Aircraft Arresting System.



2.2.4. BAK-12. The BAK-12 (Figure 2-6) is the standard USAF operational aircraft arresting system. This bi-directional system employs 2 energy absorbers. Each absorber consists of 2 multi-disc rotary friction brakes mounted on either side of the purchase-tape reel on a common shaft. The energy absorbers are located on opposite sides of the runway, connected to a 32-millimeter (1.25-inch) disc-supported pendant by the purchase tape. Ideally, the energy absorbers should be in a below-grade pit with a minimum split distance of 15.24 meters (50 feet). (Split distance is a measurement taken between the lead-on sheave of the fairlead beam or deck sheave, and the energy absorber.) Split distances of up to 91 meters (300 feet) are acceptable for all BAK-12 installations. You may also install BAK-12 systems above grade in one of two configurations, the selection depending upon site conditions and operational requirements. These are the expeditionary installation for periods of up to 1 year, and the semi-permanent installation, well-suited for long term use and typically selected when site conditions will not allow a pit-type installation. Note: BAK-12s are installed as either permanent (in pit), semi permanent (above ground) or expeditionary (above ground using dead-man anchors and stakes). The expeditionary BAK-12 is a MAAS without wheels and the MAAS is a

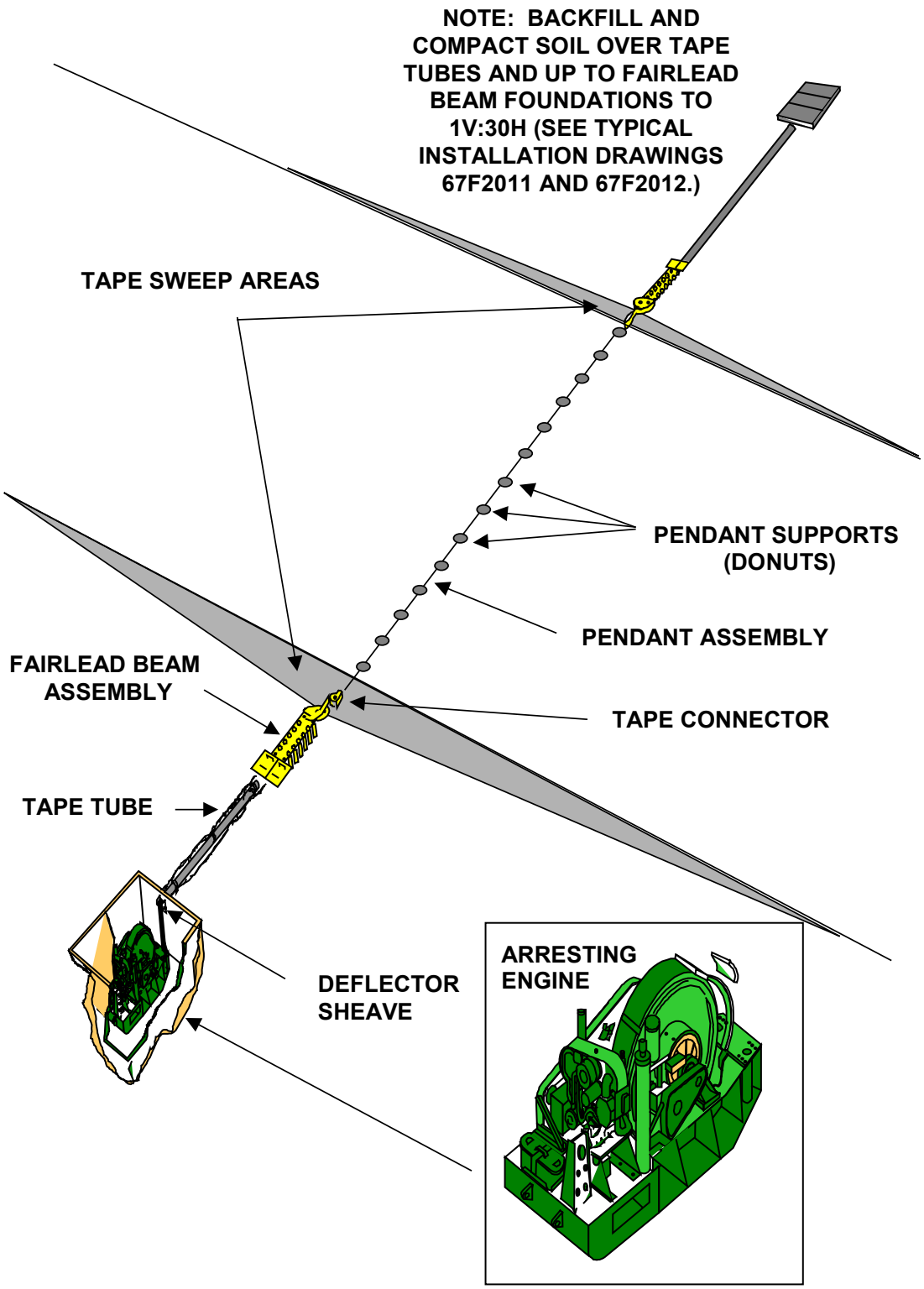
BAK-12 on a trailer. They are all BAK-12s. The expeditionary BAK-12 is simple a standard BAK-12 installed using dead-man anchors and stakes instead of being anchored with anchor bolts to concrete. These configurations are commonly used during expeditionary or displaced threshold operations. Sighting and grading requirements are in section 3 of USAF T.O. 35E8-2-5-1, *BAK-12*.

2.2.4.1. Originally, BAK-12 energy absorbers were fitted with a 60-inch purchase-tape storage reel. This design allowed the maximum energy expected to be imparted during an aircraft engagement to dissipate within a runout of 290 meters (950 feet) plus the length of the aircraft. Designers have since improved the BAK-12 to meet increased demands of heavier and faster aircraft. They retrofitted the energy absorbers with larger 66-inch or 72-inch tape storage reels to accommodate increased runout, thus increasing the total energy capacity of the system. Although some BAK-12 systems have 60-inch tape storage reels, new and upgraded BAK-12 systems (part numbers 52-W-2291-801, 52-W-2291-801A, 52-W-2291-901, and 52-W-2291-901A) have 66-inch reels. These systems require 366 meters (1,200 feet) plus the length of the aircraft for maximum runout. The 72-inch reel systems are special-purpose systems configured for 610 meters (2,000 feet) of runout.

2.2.4.2. The standard BAK-12 is configured for cross-runway separations of up to 61 meters (200 feet) (distance between fairlead beams or deck sheaves). For installations with cross-runway spans exceeding 61 meters (200 feet), replace the BAK-12 control valve cam to accommodate full runout of the system. Refer to T.O.s 35E8-2-5-1 and 35E8-2-5-4 to identify the part number for the correct replacement cam and installation procedures. Also, select a pendant length of between 80 and 90 percent of the distance between the fairlead beams to avoid adverse cable dynamics.

2.2.4.3. Dual BAK-12 systems are special-purpose installations configured to accommodate high-energy engagements of aircraft ranging from 27,200 to 63,500 kilograms (60,000 to 140,000 pounds). These configurations consist of 4 BAK-12 energy absorbers arranged in pairs on either side of the runway. The energy absorbers may be standard BAK-12s or be equipped with 72-inch diameter tape storage reels to accommodate 610 meters (2,000 feet) of runout.

Figure 2-6. BAK-12 Aircraft Arresting System.

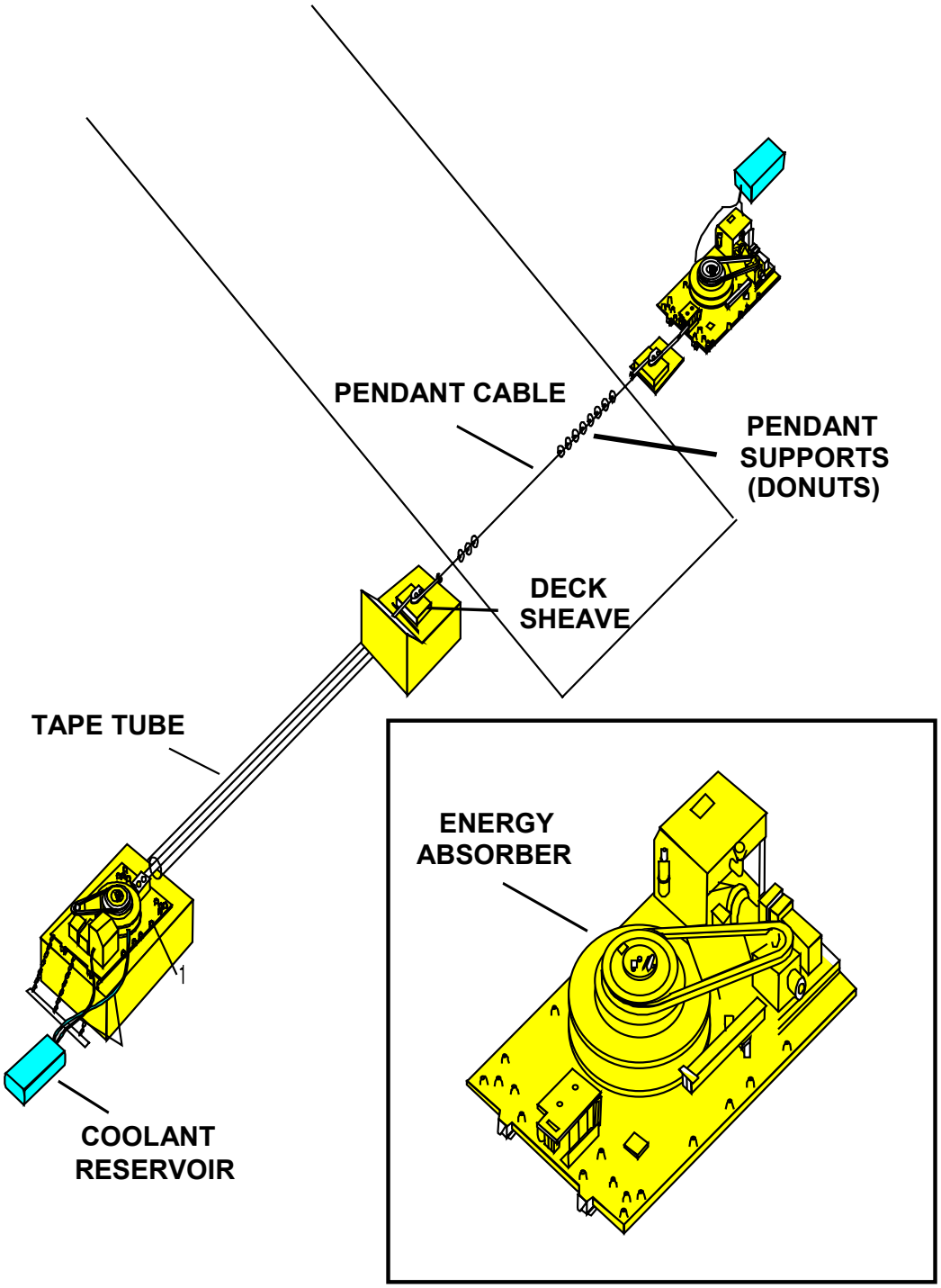


2.2.5. BAK-13. The BAK-13 (Figure 2-7) is a bidirectional aircraft arresting system. It employs 2 velocity-sensitive energy absorbers installed on opposite sides of the runway, interconnected by nylon purchase tapes and a 32-millimeter (1.25-inch) disc-supported pendant. The energy absorbers are made from a steel weldment base that incorporates a tape-storage reel mounted on a vertical shaft and a vaned rotor assembly enclosed within a vaned stator assembly (also called a tub) that contains a water and glycol mixture. A rewind engine, transmission assembly, and an operator control panel are also included along with necessary hydraulic system components.

2.2.5.1. The energy imparted during an aircraft arrestment converts to heat through the turbulence developed by rotation of the vaned rotor within the vaned stator. An external cooling reservoir permits rapid cycle of this system.

2.2.5.2. Siting and grading requirements are provided in section 3 of T.O. 35E8-2-7-11, *Operation and Maintenance Instructions, Aircraft Arresting System, Type BAK-13A/F48A*. The site requirements are essentially the same as for the BAK-12; however, the low-profile units may be located as close as 46 meters (150 feet) from the runway edge if installed in a semipermanent configuration. These systems require 290 meters (950 feet) plus the length of the aircraft for maximum runout. The BAK-13 is not currently in production as a system. It should not be considered as a suitable system for a new requirement due to the potentially high hook loads generated during engagement.

Figure 2-7. BAK-13 Aircraft Arresting System.



2.2.6. BAK-14 and Type H Hook cable Support Systems.

2.2.6.1. The BAK-14 hook cable support system (Figure 2-8) is a bidirectional hook cable (pendant) support system used in conjunction with the BAK-12, BAK-13, or a comparable arresting system to engage and safely stop a hook-equipped aircraft. It provides the means to support the pendant at least 2 inches above the runway surface while giving ATC the means to lower the pendant below the surface of the runway to prevent damage to low-undercarriage aircraft, the pendant, and the pavement below the pendant during trampling. These systems can accommodate 150, 200, and 300 foot-wide runways, but you order the system to suit the specific application. The control side BAK-12 pit or protective shelter and foundation must be expanded to house the compressed air and control systems needed to operate this supplemental system.

2.2.6.2. The Type H hook cable support system (Figure 2-9) is a bi-directional hook cable support system that can be used in conjunction with any type of energy-absorbing device. It provides a means to raise a cable at least 2 inches above a runway surface or lower it below the runway surface in less than 1.5 seconds. It can be supplied to accommodate runway widths of 46, 60, and 90 meters (150, 200, and 300 feet). A radio remote control system provides ATC the means to operate the system and to monitor its operational status. It mainly consists of Retraction Modules (from 14 to 18, depending on runway width) installed into pre-cast concrete blocks across the runway, and connected together by metallic rods, to form a rigid loop. This loop is actuated by an electro-hydraulic motor that is located in a concrete pit on one side of the runway.

Figure 2-8. BAK-14 Cable Support System.

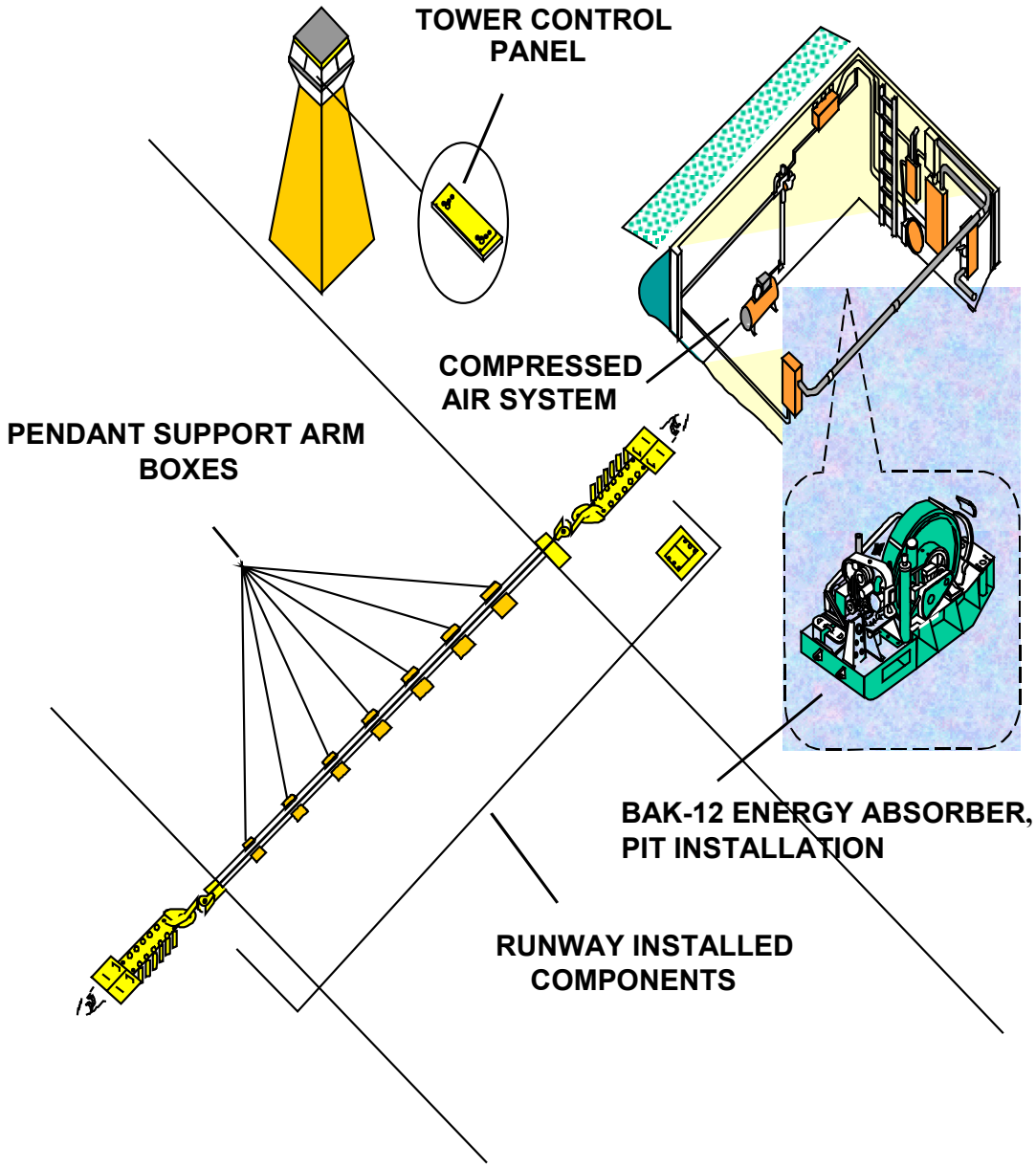
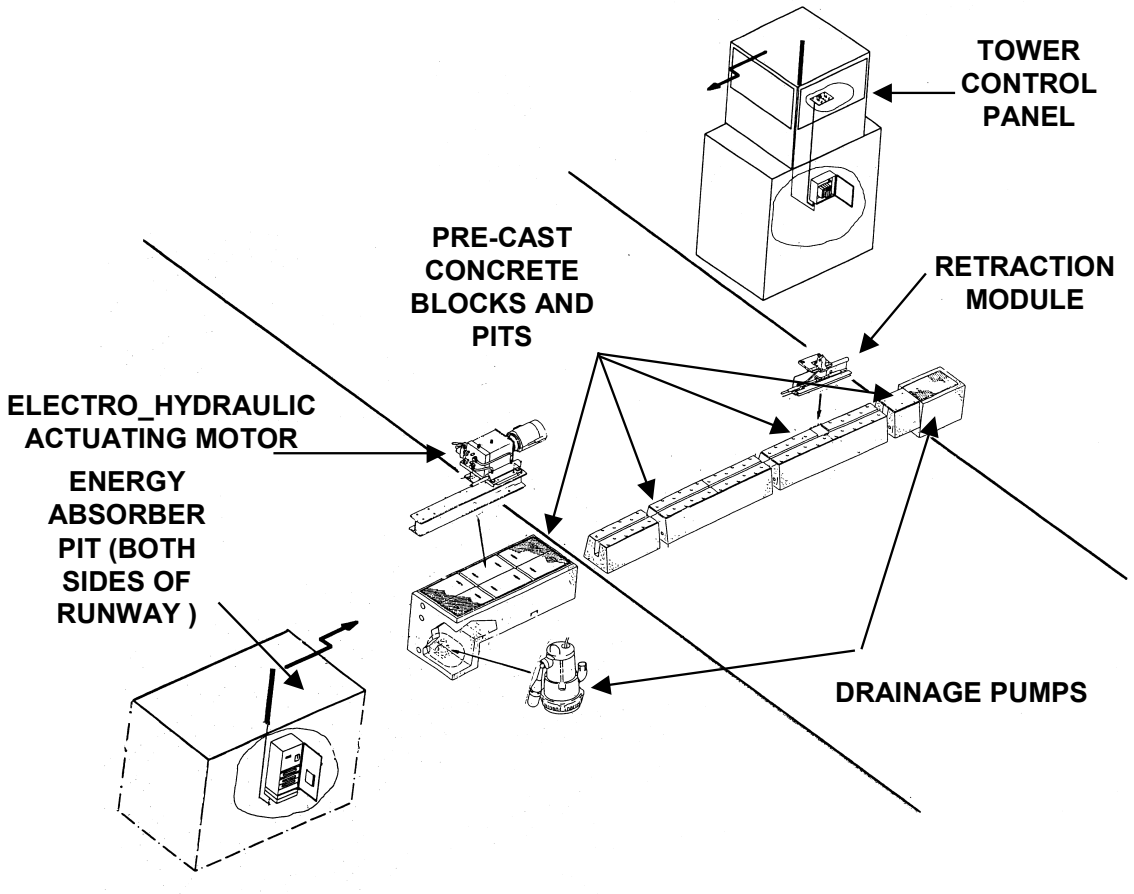


Figure 2-9. Type H Hook Cable Support System.

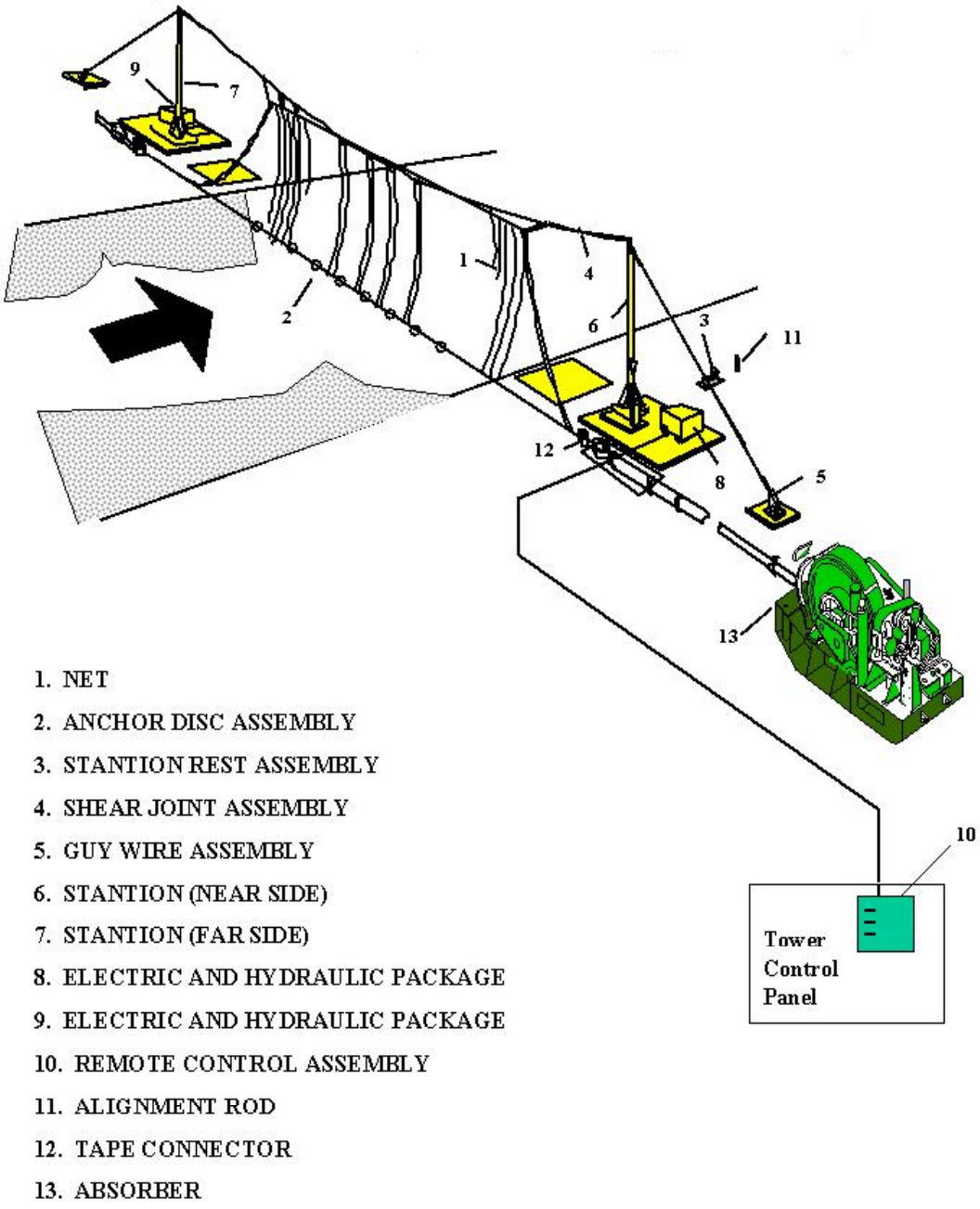


2.2.7. BAK-15 (61QSII). The BAK-15 aircraft arresting barrier consists of a pair of electro hydraulically powered steel masts that provide support and remote-controlled movement for a unidirectional nylon net barrier (Figure 2-10). The masts are installed on opposite sides of the runway overrun on concrete foundations. The ATC tower contains a remote-control panel, which can be hard-wired but most commonly is radio controlled.

2.2.7.1. The barrier must be augmented with an energy-absorbing device such as a ship's anchor chain, BAK-12, or Textile Brake. During an aircraft engagement, shear links in the net suspension straps separate by the force of the aircraft engaging the net. The net then envelops the aircraft and seats on the leading edge of the wings, transferring the forward momentum of the aircraft to the energy-absorbing device.

2.2.7.2. You can complement the system with a standard disc-supported pendant to accommodate tail hook engagements through interconnect configuration hardware similar to that used for the MA-1A Modified. The hook cable interconnect kit is designated as the 62 NI (net interconnect).

Figure 2-10. BAK-15 Net Barrier (Pictured with BAK-12 Absorbers, BAK-15/12).

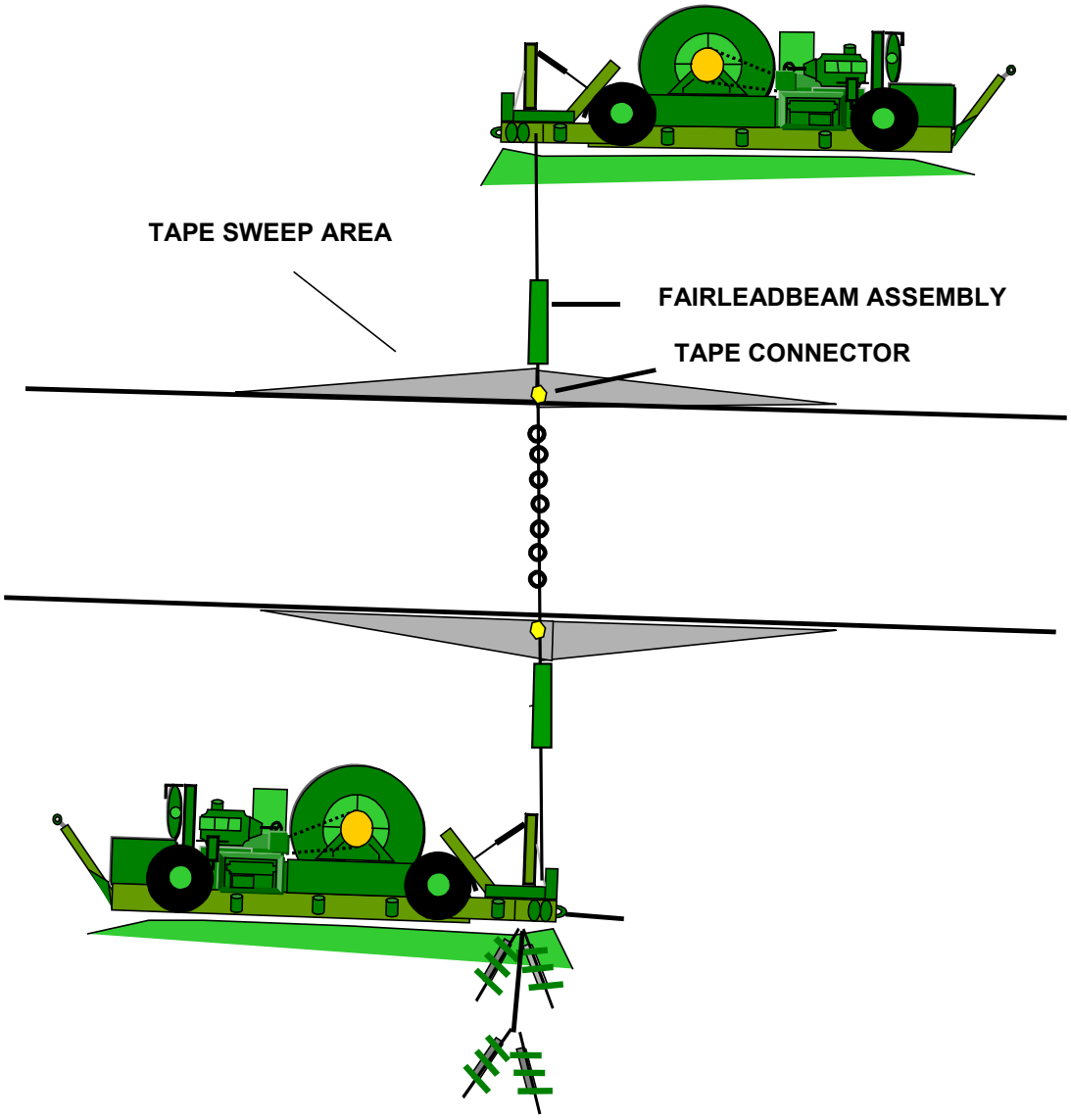


1. NET
2. ANCHOR DISC ASSEMBLY
3. STANTION REST ASSEMBLY
4. SHEAR JOINT ASSEMBLY
5. GUY WIRE ASSEMBLY
6. STANTION (NEAR SIDE)
7. STANTION (FAR SIDE)
8. ELECTRIC AND HYDRAULIC PACKAGE
9. ELECTRIC AND HYDRAULIC PACKAGE
10. REMOTE CONTROL ASSEMBLY
11. ALIGNMENT ROD
12. TAPE CONNECTOR
13. ABSORBER

2.2.8. Mobile Aircraft Arresting System (MAAS). The MAAS (Figure 2-11) is essentially a BAK-12 aircraft arresting system mobilized through installation on a specially developed trailer. It is configured for a maximum aircraft runout of 302 meters (990 feet). This system was initially developed and tested to accommodate recovery of fighter aircraft returning to a battle-damaged airfield. Such cases require rapid deployment and installation, and may require that only the minimum essential anchoring hardware be installed to accommodate the

above scenario. When installed for this purpose, the MAAS is installed using a 19-stake anchoring scheme. This configuration is limited to unidirectional engagement capability with a maximum aircraft weight and speed of 18,144 kilograms (40,000 pounds) at 150 knots (Table A2.1).

Figure 2-11. Mobile Aircraft Arresting System (MAAS) in Set-Back Configuration.



2.2.9. The MAAS can be upgraded to accommodate bi-directional engagements with the full capacity of a standard BAK-12 aircraft arresting system (Table 2-1). This is accomplished by increasing the total number of cruciform stakes used to anchor the system from 19 to 31, extending the runout to 366 meters (1,200 feet), and synchronizing the system for higher brake pressure. The system may also be installed in a set-back

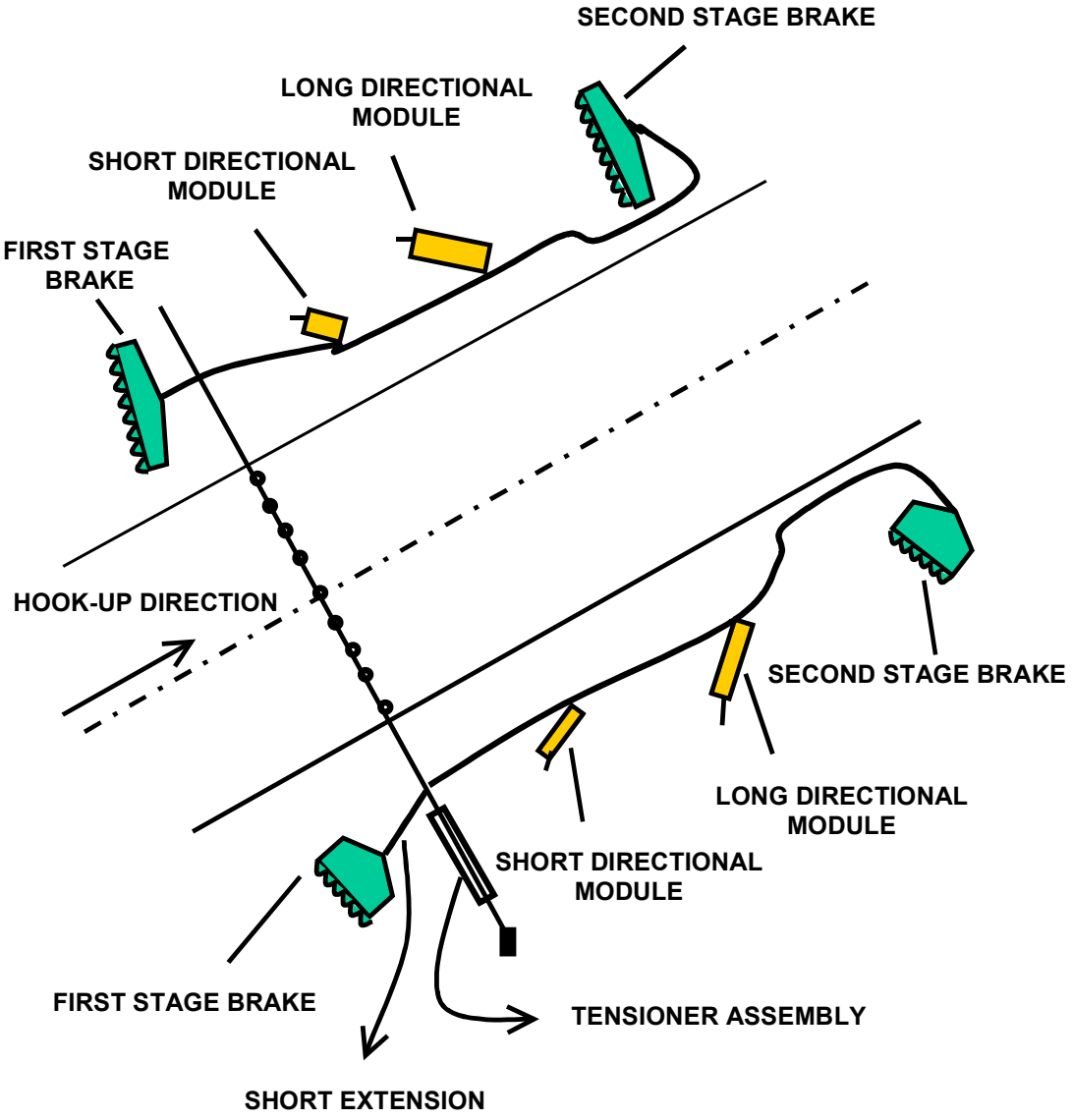
configuration to accommodate wide body aircraft operations through use of a fairlead beam (Figure A2.10).

2.2.10. Textile Brake. This modular arresting system is primarily intended as an emergency back up system for standard operational systems. It is comprised of multiple modules arranged in equal numbers on both sides of the overrun that contain specially woven textile tearing straps to absorb the kinetic energy generated during an engagement. One end of each module is anchored to the ground and the other end is connected to a tensioned cable positioned across the runway. The system is available in a 2-stage unidirectional configuration (Figure 2-13) or as a single stage bi-directional system (Figure 2-13). See Table 2-2 and T.O. 35E8-2-13-1, *Textile Brake and Hook Cable Aircraft Arresting System, Type MB50.9.9.C,* for information on the model MB 60.9.9.C. For information on the MB 100.10.C and MB 100.12.C, see Table A2.2 and Aerazur Technical Manuals 256-721, *Textile Brake and Hook Cable Aircraft Arresting System, Model MB 100.10.C,* and 256-726, *Textile Brake and Hook Cable Aircraft Arresting System, Model MB 100.12.C.* Note that the MB 100.12.C can produce hook loads that exceed the working limit for pre Block 40 F-16 aircraft; therefore, it should not be used at installations that host this model aircraft (mission, tenant, or transient support). Block 40 model F-16 and later, are fully compatible with the MB100.12 Textile Brake Arresting System.

2.2.10.1. The advantages of the 2-stage system (MB 60.9.9.C) over the MB 100.10.C bi-directional system are higher system capacity and lower costs for reconfiguration after low energy engagements. The modules in a stage (breaking line) are expended upon aircraft engagement and must be replaced; however, a life cycle analysis indicates system costs are approximately 50 percent of the life cycle cost for a BAK-12 installed in the overrun area of a runway due to the low number of engagements that occur there. These systems are designed for tail-hook equipped fighter aircraft, but can also be complemented with a net barrier such as the BAK-15 or a net/cable interconnect system. They may also be configured for expeditionary or temporary installations.

2.2.10.2. If the bi-directional version of the Textile Brake arresting system is installed on the operational runway surface due to a non-standard length overrun, the Arresting Gear Marker (AGM) signs should be blanked when viewed from the approach. This is because the system is a low energy capacity system (compared with BAK-12 or BAK-13), and is not intended for approach end engagements.

Figure 2.12. Textile Brake, Model MB.60.9.9.C.



2.2.11. Soft-Ground Type Aircraft Arresting Systems. The Engineered Material Arresting System (EMAS) is an FAA-approved soft-ground system normally used for civil airports to mitigate short safety areas (less than 305 meters [1,000 feet] long) at runway ends. The system is constructed of cellular foam concrete of specific strengths and thickness to decelerate an aircraft that overruns the runway through rolling resistance. The design for each system is aircraft specific, based upon the type of aircraft that will use the runway. FAA AC 150/5220-22, *Engineered Materials Arresting Systems (EMAS) for Aircraft Overruns*, provides the design basis. It is intended for use where it is impractical to obtain the standard 305-meter (1000-foot) safety area and other alternatives are not feasible. See Figure 2-14 for layout of a typical soft ground type system. For purposes of

design, the soft ground arrestor system can be considered fixed by function and frangible since it is designed to fail at a specific impact load; therefore, a soft ground system is not considered an obstruction under Federal Aviation Regulation (FAR) 14 Code of Federal Regulation (CFR) Part 77, *Objects Affecting Navigable Airspace*. Soft ground systems are located beyond the end of the runway, centered on the extended runway centerline. They will usually begin at some distance from the end of the runway to avoid damage due to jet blast or short landings. This distance will vary depending on the available area and the specific system design.

Figure 2-13. Textile Brake, Model MB.100.10.C.

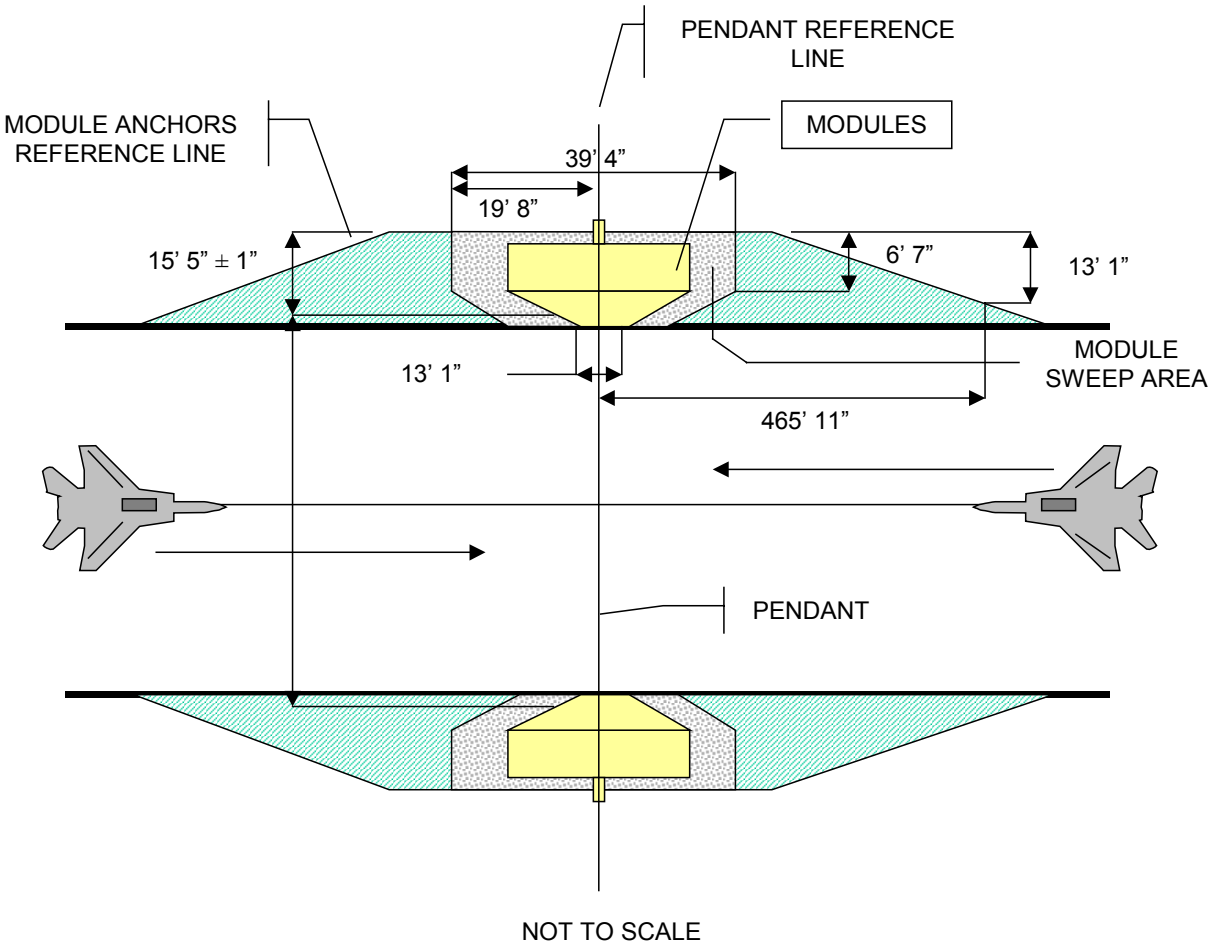


Figure 2-14. Typical Soft Ground Aircraft Arrestor System.