BY ORDER OF THE
SECRETARY OF THE AIR FORCE

AIR FORCE INSTRUCTION 32-1043

30 MARCH 2012

Civil Engineering

MANAGING, OPERATING, AND MAINTAINING AIRCRAFT ARRESTING SYSTEMS

COMPLIANCE WITH THIS PUBLICATION IS MANDATORY

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This instruction implements Air Force Policy Directive (AFPD) 32-10, *Installations and Facilities.* It gives procedures for managing, installing, maintaining, and operating United States Air Force (USAF) aircraft arresting systems (AAS). This publication applies to all USAF, Air Force Reserve Command (AFRC), and the Air National Guard (ANG) units and personnel. Refer recommended changes and questions about this publication to the office of primary responsibility (OPR) using Air Force Form 847, *Recommendation for Change of Publication*; route AF Form 847s from the field through appropriate chain of command. Ensure that all records created as a result of processes prescribed in this publication are maintained in accordance with Air Force manual (AFMAN) 33-363, *Management of Records*, and disposed of in accordance with the Air Force Records Information Management System (AFRIMS) Records Disposition Schedule (RDS) located at **https://www.my.af.mil/afrims/afrims/afrims/rims.cfm**. This publication may be supplemented at any level, but all direct supplements must be routed to the OPR of this publication for coordination prior to certification and approval. Waivers to this instruction are expressly limited to those situations in which the siting criteria described in paragraph 1.2.8 of this instruction cannot be met. Process such requests for waiver in accordance with Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design*. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this instruction does not imply endorsement by the Air Force.

SUMMARY OF CHANGES

This document is substantially revised and must be completely reviewed. This revision provides instructions to report USAF aircraft engagements via a web-based program (paragraph 1.2.2); clarifies that minimum qualification requirements for operating and maintaining AAS also apply to contractors (paragraph 1.2.4); clarifies that system deficiencies may be corrected in ways other than replacement (paragraph 1.2.13); adds requirement to initiate projects to correct discrepant shoulder slopes (paragraph 1.3.2.6); emphasizes the need to obtain waivers before modifying arresting systems -prescribes configuration (paragraph 1.3.3.1); updates terms used; changes engagement reporting instructions; exempts overrun systems from effective pendant height (EPH) readings and records; adds requirement to comply with Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-10, *Civil Engineering*, for personal protective equipment (PPE); changed to reflect that Air Force Materiel Command (AFMC) is responsible for development of new requirements, oversight of initial production, and consignment of new systems (paragraph 1.4); updates provisions to agree with T.O. 35E8-2-5-1, *Operation and Maintenance Instructions – Aircraft Arresting System Model BAK-12*, on the policy for sling-shot removal of aircraft from AAS cables; adds cable inspection requirements for swaged-end terminals, textile brake AAS, and expedient trim pad anchoring systems (paragraph 2.2.2); limits the critical area of pavement 60 meters (200 feet) in each direction from the cable to the center 23 meters (75 feet) of the runway vice the off-center engagement capability of the system; clarifies system certification requirements and encourages reduced certification engagement speeds to preclude inadvertent damage to aircraft when performing these tasks; eliminates the requirement to certify with an aircraft after hydraulic component replacement (paragraph 2.3.1); specifically excludes system certification inspections for initial installations; changes the description for on-grade shelter requirements for BAK-12 from "frangible" to "airfield friendly”; clarifies that AAS warning markings and arresting gear marker signs are not used in overruns; requires structures installed in shoulder areas comply with new large aircraft wheel load requirements; requires marking and lighting as requirements for temporary systems unless waived at the appropriate level; revised to agree with UFC 3-260-01 for arresting system shelter design;; adds minimum offset distance for tie-downs from pavement joints; adds paragraph 3.7, Standard BAK-12 System Set-Up; changes the 80% to 90% rule for cable length to a minimum length of 80% cross-runway span updates installation instructions for UHMW panels. All organizational addresses and office symbols have also been updated.

Chapter 1

RESPONSIBILITIES

1.1. Headquarters USAF and Field Operating Agencies.

1.1.1. The Civil Engineer, Headquarters USAF (USAF/A7C), develops maintenance policy and oversees execution of the USAF aircraft arresting system (AAS) program. See AFPD 32-10.

1.1.2. The Air Force Civil Engineer Support Agency, Engineer Support Branch (AFCESA/CEOA), provides technical guidance for all phases of AAS programs. It also validates requirements for new systems and helps resolve technical issues.

1.1.3. The HQ USAF Deputy Chief of Staff for Operations, Plans and Requirements (USAF/A3/5) develops operational policy and oversees execution.

1.1.4. The Air Force Flight Standards Agency (AFFSA) provides technical support to the Air Staff on operational issues relating to installation, maintenance, and use of these systems. It also helps plan, develop, review, and recommend standards for siting, installing, operating, and maintaining AAS.

1.2. MAJCOM. The MAJCOM civil engineer (A7) representative manages AAS programs and enforces Air Force policy and guidance. The representative must also perform the following tasks.

1.2.1. The *Aircraft Arresting Systems Report* (RCS: HAF-ILE [AR] 7150) must be accomplished according to the guidelines provided in Attachment 4. Submit the report any time the location or configuration of an AAS for any runway is changed. Submit the report to:

AFCESA/CEOA
139 Barnes Drive Suite 1
Tyndall AFB, Fl 32403
AFCESA.CEO3333@tyndall.af.mil (E-mail submissions are encouraged.) Also provide a courtesy copy to the MAJCOM Director of Operations.

1.2.2. Submit (or ensure that each installation submits) an *Aircraft Arrestment Report* (RCS: HAF-ILE [M&AR] 8403) as soon as possible after an engagement or missed engagement. The report must be filed at **https://wwwmil.afcesa.af.mil/Directorate/CES/Civil/airfield/aasee_entry.asp** (use **http://wwwmil.afcesa.af.mil/Directorate/CES/Civil/airfield/aasee_entry.asp** pending an update to the host server security certificate). **Note:** Do not submit the report during periods of inactivity or emergency. The report must be submitted for each engagement or attempted engagement (see Attachment 1, *Glossary of References and Supporting Information*, for the definition of a missed engagement). In the event the Website is down for any reason, fill in the online report and print (rather than submit) to Adobe® Acrobat®, or copy and paste the completed form into another program such as Microsoft® PowerPoint or Word. The report can then be sent to the appropriate personnel (e.g., base civil engineer [BCE], MAJCOM, airfield manager, Warner Robins Air Logistics Center [WR-ALC], AFCESA) via e-mail or hard copy.

1.2.3. Include the absorber serial numbers (if applicable) in the "remarks" section of the report. **Note:** Do not submit classified information. Discontinue reporting during emergency conditions but maintain records for later submission.

1.2.4. The MAJCOM/A7 ensures BCEs comply with the designation and certification of personnel as tasked in paragraph 1.3, that all personnel engaged in AAS activities meet the same minimum requirements for the tasks assigned them, and that Air Force contracts for the performance of maintenance operations duties include similar standards of competency for support employees through reference to this instruction and other appropriate Air Force guidance within the support contracts.

1.2.5. Submit waiver requests to Warner Robins Air Logistics Center (WR-ALC) if deviation from the 35E8-series technical orders (T.O.) is required at installation level. Send T.O. waiver requests to:

WR-ALC/GRV
460 Richard Ray Blvd, Suite 200
Robins AFB, GA 31098-1813
642CBSG.Workflow@robins.af.mil (E-mail waiver requests are encouraged.)

1.2.6. Establish a record of dates when all arresting systems under the MAJCOM authority last underwent an overhaul that included a brake change.

1.2.7. Develop an overhaul plan and schedule that prevents unnecessary runway closures and waiver requests and provide a copy of the schedule to the Ground Support Equipment Division at WR-ALC (642 CBSG/GBEB) so they have indicators of the need for spares. Include all systems within the MAJCOM, even those designated as war reserve materiel, such as the mobile aircraft arresting system (MAAS).

1.2.7.1. If the plan requires the WR-ALC depot to perform overhauls, send the depot a copy of a proposed schedule at least two years before the anticipated due date.

1.2.7.2. Provide WR-ALC with updates at least once a year but no more than once every six months.

1.2.8. Review all new AAS project installation drawings for functional and technical correctness before contract award (or start of the project if accomplished in-house). All projects must comply with siting criteria in this instruction, Unified Facilities Criteria (UFC) 3-260-01, *Airfield and Heliport Planning and Design*, the applicable 35E8-series T.O.s, and the typical installation drawings for the specific system. In cases where criteria cannot be met, a waiver must be established according to UFC 3-260-01 and/or the applicable T.O., as appropriate.

1.2.9. Coordinate Air Force Equipment Management System (AFEMS) requests (formerly AF Form 601, *Equipment Action Request*), which authorize new systems, with the directorate of operations.

1.2.10. Communicate with all other MAJCOMs that have a flying mission before decommissioning any arresting system. MAJCOMs with flying missions include any activity that uses the installation in question as a possible divert facility during exercises or contingencies. This does not apply to bases within United States Air Forces in Europe (USAFE) and Pacific Air Forces (PACAF). Follow MAJCOM procedure for Notices To Airmen (NOTAM) and updates to Department of Defense (DOD) Flight Information Publications (FLIP).

1.2.11. If an arresting system is decommissioned and removed and no longer needed within the MAJCOM, contact WR-ALC for disposition instructions.

1.2.12. Coordinate with the MAJCOM Director of Operations (MAJCOM/A3) and flying units to ensure certification engagements are conducted according to paragraph 2.3.

1.2.13. Ensure that systems that do not comply with the requirements of this instruction or the applicable T.O. are programmed for corrective action or replacement.

1.3. Base Civil Engineers.

1.3.1. The BCE must ensure that personnel engaged in AAS operation and maintenance (O&M) activities meet the minimum requirements shown below for the associated tasks. This includes personnel under contract to perform maintenance.

1.3.1.1. To perform an after-arrestment inspection and certify an AAS back in service after arrestment, personnel must be task-certified power production 5-level (or higher skill level) journeyman, or the civilian WG-5378 equivalent.

1.3.1.2. To perform maintenance on an AAS, personnel must be task-certified power production 3-level (or higher skill level) apprentice or the civilian WG-5378 equivalent.

1.3.1.3. Personnel other than power production (AFSC 3E0X2) or civilian equivalent (WG-5378) that augment power production personnel to perform daily inspections or assist during engagements must be specifically designated by the BCE in writing, and must be certified annually by the designated lead power production technician or the civilian equivalent.

1.3.1.4. For new installations or for cases where major civil works have been accomplished that may affect system alignment, a task-certified power production 7-level technician or the civilian WG-5378 equivalent must certify the system ready for use.

1.3.2. BCEs also approve AFEMS requests and work with representatives from operations (A3) and safety (SE) to:

1.3.2.1. Recommend that additional systems be installed to meet new or revised mission requirements (see Attachment 3).

1.3.2.2. Recommend to the MAJCOM to decommission systems no longer needed to support the mission (see Attachment 3).

1.3.2.3. Request that airfield management update the Department of Defense Flight Information Publications (DOD FLIP) before removing any system from service.

1.3.2.4. Determine siting requirements for new systems and obtain MAJCOM/A3 and SE coordination for nonstandard and midfield installations. Ensure that airfield management reviews and coordinates on the proposed siting of any new systems.

1.3.2.5. Determine annually if nonstandard arresting system installations can continue in use without compromising operational efficiency and safety. Non-standard installations are installations that do not comply with the siting and grading requirements given in this instruction and UFC 3-260-01.

1.3.2.6. Initiate projects to replace two-roller edge sheaves and two-roller fairlead beams with three-roller edge sheaves or fairlead beams to eliminate the longitudinal wheel abutment these devices create along the runway shoulder. Also initiate projects to correct shoulder grades that do not meet the 1V:30H or flatter requirement (paragraph 3.3.2.2 and UFC 3-260-01, Table 3.2, Item 5, "Longitudinal Shoulder Grades").

1.3.2.7. Comply with all other provisions within this instruction.

1.3.3. The BCE's representative (power production AAS maintenance section supervisor) must accomplish the following items:

1.3.3.1. Request and obtain waivers from WR-ALC through the MAJCOM/A7 representative when compliance with the 35E8-series T.O.s is not practical and before making any modifications to the equipment that do not comply with the T.O. configuration.

1.3.3.2. Submit AFEMS requests through appropriate channels to obtain authorization for new arresting systems.

1.3.3.3. Ensure that installation, operation, and maintenance actions comply with all criteria listed in this instruction, the typical installation drawings, MAJCOM and local instructions, and the appropriate 35E8-series T.O.

1.3.3.4. Conduct inspections according to 35E8-series T.O. work cards and maintain an accurate historical log and maintenance records for each assigned AAS. Locally developed forms and logs are authorized.

1.3.3.5. Develop and implement local procedures and instructions in writing to clearly delineate responsibilities of all personnel engaged in AAS activities during and after normal duty hours. These instructions must clearly define the different responsibilities of power production and firefighters involved during emergencies, and should address coordination with other work centers involved during operations, such as snow and ice control. They must include procedures to clear aircraft from the runway and inspect and reset the system immediately after each engagement. The BCE must approve the operating instruction. A signed copy must be forwarded to the MAJCOM representative and another maintained in the power production section. These instructions must be reviewed annually for needed changes and updates. When updated, a copy must be provided to the MAJCOM AAS representative within 10 days of approval and publication.

1.3.3.6. Submit all requested information to the MAJCOM for inclusion in the *Aircraft Arresting Systems Report* as described in paragraph 1.2.1.

1.3.3.7. Submit aircraft engagement information at **https://wwwmil.afcesa.af.mil/Directorate/CES/Civil/airfield/aasee_entry.asp**. Include supplemental information as directed by the MAJCOM. Also file reports for all missed engagement attempts. (See Attachment 1 for the definition of a missed engagement.) Reports should be sent as soon as possible after the engagement. Electronic submittals are authorized and encouraged. **Note:** Do not submit the report during periods of inactivity or emergency. The report must be submitted for each engagement or attempted engagement. In the event the Website is down for any reason, fill in the online form and print (rather than submit) to Adobe® Acrobat®, or copy and paste the completed form into another program such as Microsoft® PowerPoint or Word. The report can then be sent to the appropriate personnel via e-mail or hard copy.

1.3.3.8. Develop local procedures and lesson plans to thoroughly train all civil engineering personnel (including non-power production personnel) who use, operate, or maintain an arresting system to the appropriate task level in the 3E0X2 career field education and training plan (CFETP), and ensure that all personnel are task-certified for their assigned duties. Document training and certification of civilian employees on AF Form 971, *Supervisor's Employee Brief*, and other training records, as appropriate.

1.3.3.8.1. Provide training for non-power production personnel at not less than quarterly intervals to ensure all personnel are trained on their duties at least once every 12 months. Maintain a record for each training class that identifies the instructor and all trainees in attendance.

1.3.3.8.2. Provide a copy of the record to the trainee's regular duty section for their use.

1.3.3.9. Report all deficiencies discovered with arresting systems and components to base supply according to T.O. 00-35D-54, *USAF Material Deficiency Reporting, Investigation, and Resolution*.

1.3.3.10. Establish and maintain a record of the effective pendant height (EPH) according to Attachment 6 for each hook-cable arresting system installed on the runway or in a displaced threshold area (except retractable cable systems such as BAK-14 or Type H). EPH records are not required for emergency systems installed in overruns. In accordance with Attachment 6, notify the Airfield Manager if the EPH falls to less than 38 millimeters (1.5 inches).

1.3.3.11. Ensure that systems that do not comply with the requirements of this instruction or the applicable T.O. are programmed for corrective action or replacement.

1.3.3.12. Ensure that copies of applicable AAS T.O.s and work cards, Air Force instructions, MAJCOM supplements or instructions, and local instructions are maintained in the work center and are available for all personnel engaged in arresting systems activities.

1.3.3.13. Ensure that all non-power production personnel engaged in daily AAS activities are certified in their training record and the qualification level is documented. Qualifications must be reviewed and updated on an annual basis. Document each individual's AF Form 623, *Individual Training Record Folder***.**

1.3.3.14. Establish and maintain a "special level" (on-hand supply) of critical replacement items for AAS. Examples of items that should be maintained at special levels include (but are not limited to) purchase tapes, tape connectors, pendants, control valves, shuttle valves, special fittings, brake sets or kits, and replacement modules for textile brake arresting systems.

1.3.3.15. Ensure personnel engaged in AAS operations use appropriate personal protective equipment per Air Force Occupational Safety and Health Standard (AFOSHSTD) 91-10, *Civil Engineering*.

1.4. HQ Air Force Materiel Command (AFMC). AFMC manages engineering development of new requirements and oversees initial production. Once the initial production quantity is complete, responsibility for item management, engineering, and procurement support is consigned to the appropriate ALC, presently Warner Robins ALC (WR-ALC).

1.4.1. WR-ALC provides logistic and engineering support and item management for these systems and components. WR-ALC is also responsible for the following:

1.4.1.1. Procure systems and oversight of spare parts standards.

1.4.1.2. Provide technical assistance, configuration control, and consultation on maintenance, product improvement, modifications, testing, inspections, and installation of all arresting systems in the Air Force inventory.

1.4.1.3. Compile and document all information from the aircraft arrestment reports to ensure availability of the data for analysis of specific system performance and use.

Chapter 2

OPERATION, MAINTENANCE, CERTIFICATION, AND INSPECTION

2.1. General Information.

2.1.1. This chapter provides basic information on inspection, maintenance, certification, operation, maintenance records, and deficiency reporting for AAS. Information contained in this chapter is intended to be general in nature. Specific technical information may be found in the applicable 35E8-series T.O.s.

2.1.2. T.O.s for BAK-12 and BAK-13 provide alternate procedures for removing an aircraft from the cable after engagement. These alternate procedures are commonly referred to as a "slingshot" removal of the aircraft. Potential for aircraft damage is high when using these methods; therefore, use these procedures only during contingencies or in-flight emergencies that require rapid removal of an aircraft from a cable. The procedure must be approved by the installation commander before being used for routine disengagement of aircraft during local exercises or scheduled testing of the arresting system (e.g., certification).

2.2. Inspection and General Maintenance.

2.2.1. Inspections must be performed in accordance with the applicable T.O., information contained within this instruction, and the 35E8-series work cards.

2.2.2. In-service pendant cables must be inspected daily and after each engagement. Use cable inspection criteria from BAK-12 or BAK-13 T.O.s for textile brake AAS. Also, for all AAS cables (pendants), measure and record the swaged end cable insertion depth measurement in the maintenance records before placing any arresting system cross-runway pendant in service (see Figure 2.1). Do not install cables with swaged end depth measurement greater than 63 millimeters (2.5 inches). Also, mark the cable at the swaged end connectors with paint or some other means of permanent marking so that any movement of the swaged end will be evident. After each engagement, inspect the swaged end for movement or measure the swaged end depth again and compare it with the initial measurement recorded in the maintenance records. Remove cables from service that show any change in the swaged end position on the cable and file a product quality deficiency report including item serial number. Spare pendants should be stored indoors.

2.2.2.1. Expedient trim pad anchoring systems can be installed using K-M anchoring components from the MAAS. Use USAF ETL 06-4, *Expedient Trim Pad Anchoring Systems*, to install and inspect expedient trim anchors. Use the following guidance for cable inspection and disposition if AAS pendants are used to restrain the aircraft during trim operations.

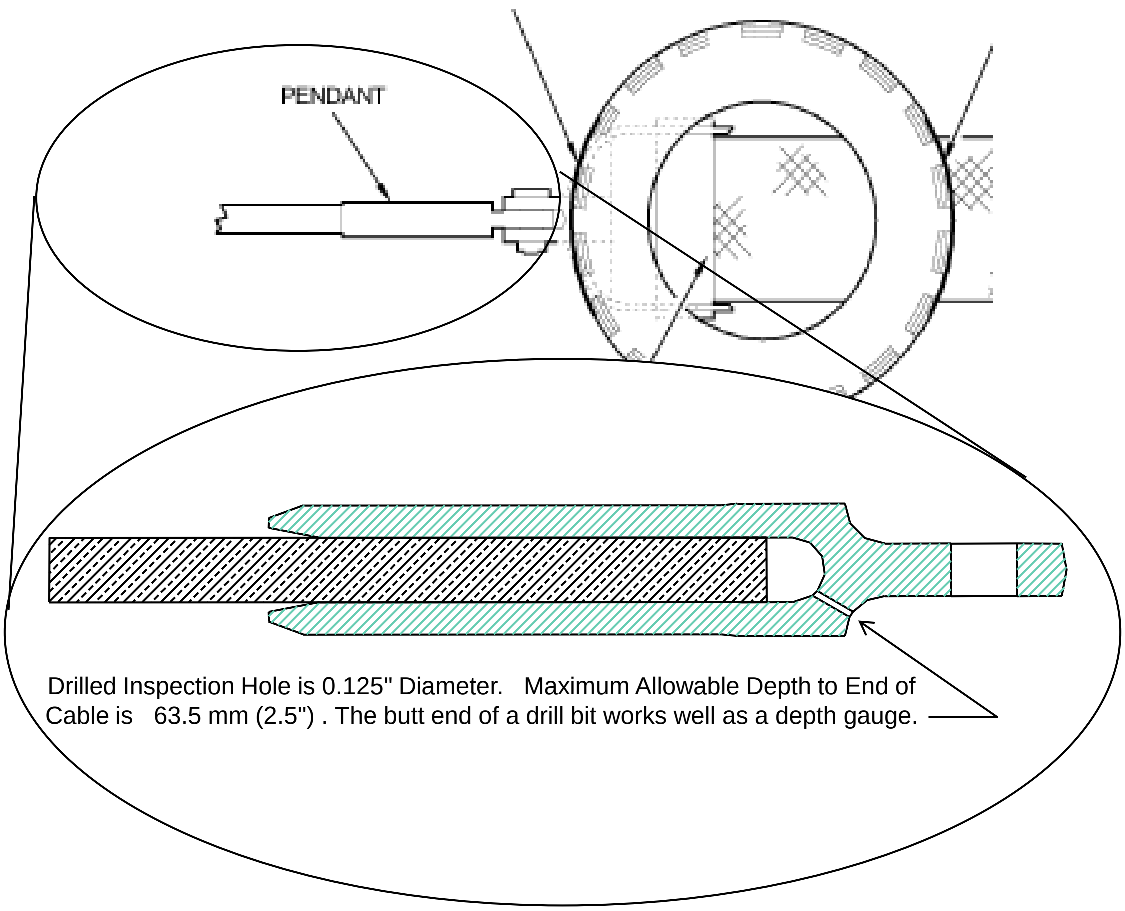
2.2.2.2. Cables used with the expedient trim pad setup shall be kept separate from cables used for aircraft engagements, and shall only be used for trim operations (e.g., cables used for trim operations shall not be used for aircraft engagements, and cables that have been used for engagements shall not be used for trim operations).

2.2.2.3. Develop a use and inspection log for each new cable and record the date and pertinent details of each trim operation in the log. Maintain the log for the life of the cable. There is no limit to the number of trim operations that can be performed with a single cable within a 36-month period; however, all cables will be removed from service 36 months after their initial installation date unless they fail to meet the requirements stated below.

2.2.2.4. Before installing any cable, measure and record the swaged end cable insertion depth as prescribed above in paragraph 2.2.2. Also, inspect the cable in accordance with instructions in T.O. 35E8-2-5-1, *Operation and Maintenance Instructions – Aircraft Arresting System Model BAK-12*. Do not install cables with defects identified in the T.O. or if the insertion depth measurement exceeds 63 millimeters (2.5 inches).

2.2.2.5. After each trim pad operation, inspect the cable in accordance with instructions in T.O. 35E8-2-5-1. Also, measure and record the swaged end cable insertion depth for each end, or inspect for swaged end movement if the swaged end position has been marked as described in paragraph 2.2.2 above. Remove the cable from service if it fails to meet the inspection requirements of T.O. 35E8-2-5-1 or shows any change in the swaged end position on the cable.

Figure 2.1. Pendant Swaged End Depth Measurement.



2.2.3. Crop exposed tape between the runway edge sheave (fairlead beam) and the tape connector on BAK-9 and BAK-12 systems every six months. Crop the tape between the absorber base and the tape connector every six months on expeditionary systems if a tape tube is not used. Reverse (end-for-end) tapes on all systems every 24 months. No nylon tapes should be retained in service longer than 48 months or if usage exceeds the maximum allowable for engagements and pull-outs or tape stack height in the applicable 35E8-series T.O. Due to the negative effects of ultraviolet (UV) light on nylon, every effort must be made to protect tapes from direct sunlight. For this reason, all spare nylon tapes must be stored indoors.

2.2.4. For MA-1A, a new webbing assembly must be installed after each engagement. See T.O. 35E8-2-2-1, *Operation and Service Instructions - Runway Overrun Barrier, Types MA-1 and MA-1A Runway Overrun Barrier*, Section 1, for details. Also, inspect pendant cables and replace if conditions are indicated.

2.2.5. The center 23 meters (75 feet) of pavement extending out for 60 meters (200 feet) on both the approach and departure sides of the arresting system pendant are critical areas. Protruding objects, excessive paint build-up, excessive joint sealant material, warped sacrificial panels, and undulating surfaces are detrimental to successful tailhook engagements and are not allowed. This area of the runway must be visually inspected at least monthly for indications of the above noted conditions. Suspect areas, such as pavement cracks and joints, and panels beneath the cable must be inspected more closely. Increased attention will be necessary after each freeze-thaw cycle.

2.2.5.1. Problem areas must be immediately identified to the installation pavements engineer for a more thorough inspection and corrective action. The airfield manager must also be notified so that NOTAMs, local NOTAMs, and aircrew briefings can be issued to highlight the potential problem pending corrective action.

2.2.5.2. Perform more detailed inspections of suspect areas with a 4-meter (12-foot) straightedge. Begin on the runway centerline and check the pavement in the immediate area of the cable for high spots, depressions, or other undulations. Perform the inspection out to a point beyond the first transverse pavement joint on rigid pavements or for approximately 3 meters (10 feet) past the suspect area, or for a minimum longitudinal distance of 6 meters (20 feet), whichever is greater. Repeat this procedure within 1 meter (3 feet) on both sides of the runway centerline, and then at not more than 2-meter (6-foot) intervals across the runway, for a total distance of 11.5 meters (37.5 feet) on either side of the runway centerline. Grind flush any high spots exceeding 3 millimeters (0.125 inch). Report depressions exceeding 3 millimeters (0.125 inch) in depth to the installation pavements engineer for corrective action.

2.3. System Certification.

2.3.1. All Air Force arresting gear (excluding MA-1A, E-5, BAK-15, textile brake, and soft ground arrestor systems) that have not been engaged at a speed sufficient to exercise the hydraulic system within the past 12 months must be certified by an aircraft engagement. The recommended minimum speed for certification engagement is 75 knots regardless of aircraft weight. For BAK-12 and MAAS, aircraft speeds reported at less than 75 knots are also acceptable as long as the hydraulic system is exercised. To qualify as a valid certification engagement, each hydraulic selector valve must shuttle from static pressure to pump pressure. Certification engagements will be made toward the center of the runway. This may require the aircraft starting position to be in the overrun area. This requirement also applies to initial system installations and after a brake change or absorber overhaul. It does not apply to War Reserve Materiel systems in storage.

2.3.2. If extenuating circumstances prevent certification by engagement, a certification inspection must be performed or the system must be removed from service. The certification inspection must be performed by a MAJCOM-designated representative. For annual certification requirements, the inspection must be accomplished on or before the anniversary of the last system engagement. The inspection must include (but is not limited to) all requirements in Section 5 of the applicable 35E8-series T.O. The period between aircraft engagements must not exceed 24 months. Assigned installation maintenance personnel may not perform the inspection. Certification inspections cannot be substituted for initial installation certification engagements. **Note**: The installation commander has the authority to direct that new system installations are placed in service or those overdue for certification are kept in service for critical missions. If such an order is given, it must be documented in the maintenance records and the MAJCOM representative notified immediately.

2.3.3. Maintenance crews will also be evaluated during certification engagements. The following factors will be considered:

2.3.3.1. Evaluate crew proficiency in disconnecting the aircraft and returning the system to service.

2.3.3.2. Evaluate adequacy of maintenance records and data.

2.3.3.3. Evaluate availability of necessary tools, spare parts, and equipment.

2.3.4. Responsibility for assuring that certification is accomplished according to this instruction rests with the host command. Base personnel must provide an information copy of each record of certification engagement or certification inspection report to airfield management for their file. Records of certifications will also be maintained in accordance with paragraph 2.6.

2.4. Operation.

2.4.1. Disconnect and remove unidirectional barrier nets and pendant cables located in overruns on the approach end of the runway. Also disconnect and remove BAK-9 cables located on the runway on the approach end. Full-size net systems such as the BAK-15 may remain in place in the overrun in the down position; however, the energy absorbers must be disconnected and the BCE's designated representative must inform the airfield manager and the MAJCOM/A3 and SE when the net will be left in place. Do this to publicize the potential hazard to aircrew.

2.4.1.1. If environmental conditions require frequent system configuration changes (runway changes) for MA-1A or MA-1A modified net systems, E-5, BAK-9, or textile brake systems, the nets and cables may be left in place on the approach end of the runway to avoid excessive runway downtime and/or excessive wear from abrasion; however, the non-standard configuration must first be recommended by the installation commander and approved by the MAJCOM/A3, SE, and A7.

2.4.1.2. Additionally, for all unidirectional systems (MA-1A, E-5, BAK-15, and MB 60.9.9.C), the energy absorbers must be disconnected from the engaging device(s) before operations commence in the opposite direction (toward the unidirectional system).

2.4.1.3. For MB 60.9.9.C textile brake systems, after the cable is disconnected from the yoke on both ends, the 31.75-millimeter (1.25-inch) -diameter cable should be secured to the eye-loop of each Tirfor anchor plate or to an added anchor point to prevent movement due to jet blast. Use standard 10-millimeter (0.375-inch) -diameter, three-strand nylon rope (NSN 4020-00-968-1356) like that used for cable tie-downs.

2.4.2. Maintain BAK-12 and BAK-13 operational arresting systems in the ready position on the approach and departure ends of the runway unless the installation commander directs otherwise. Barriers and hook cables may be removed from the overrun and runway during snow and ice removal operations, but coordinate removal with airfield management first and return the barriers and hook cables to operational status as soon as possible.

2.4.2.1. The BAK-14 and the Type H hook cable support systems were not designed to operate in the up position with repeated aircraft rollovers. Repeated high-speed rollovers will damage the system components, reduce system reliability, increase the chance of a missed engagement, and increase maintenance costs.

2.4.2.2. Low-speed taxi rollovers must also be kept to a minimum to prevent degradation of system performance. If the AAS is not required to stop the aircraft, air traffic control (ATC) should lower the BAK-14 or Type H prior to rollover.

2.4.3. When performing duties associated with AAS and barriers in the airfield environment, it will be necessary to communicate with ATC, ground control, fire emergency services, and airfield management by two-way radio. Follow local procedures established within the airfield operating instruction (AOI) and the base airfield driving regulations and program. General terms to be used for radio communication are provided in AFI 13-204, Volume 3, *Airfield Operations Procedures and Programs*, AFI 13-213, *Airfield Driving*, and Federal Aviation Administration (FAA) Order JO 7110.65T, *Air Traffic Control*, *Pilot/Controller Glossary*. The most common terms for use and their definitions are provided in paragraphs 2.4.3.1.1 through 2.4.3.1.7. Attachment 1 also provides definitions for the various terms that relate specifically to the airfield and airfield operational areas, including the method used to designate the in-use runway.

2.4.3.1. Common phrases used in radio communication and their meanings are provided below. The phrase "clear" must not be used when communicating with tower personnel.

2.4.3.1.1. “Acknowledge” — Request that you have received and understand the message.

2.4.3.1.2. “Affirmative” — Yes.

2.4.3.1.3. “Negative” — No.

2.4.3.1.4. “Say Again” — Request to repeat the message.

2.4.3.1.5. “Roger” — I have received and understand the last transmission.

2.4.3.1.6. “Hold Short” — Do not proceed per the tower’s instructions.

2.4.3.1.7. “Wilco” — I have received and will comply with your message.

2.4.3.2. There is no standard phraseology for reporting system status to ATC; however, use “operational” and “not operational,” and “in-service” and “out of service” consistently when reporting status to the airfield authority. These terms are easy-to-understand descriptions of airfield systems. The specific terms selected for each installation should be specified within the local AOI.

2.4.3.3. When communicating the location of an AAS on the active runway, use the active runway designation and refer to the system in question by approach, midfield, or departure end cable, or approach or departure end barrier. In this case, it is important to differentiate between cables and barriers. BAK-12, BAK-13, and BAK-14 systems are cable systems, not barriers. Net systems such as MA-1A and BAK-15 systems are barriers. See the definition of terms in Attachment 1. The active runway (the runway in use) is identified by the numeric designation of the approach end of the runway. For example, for Runway 12/30, the active runway would be "Runway 12" when aircraft are taking off from or landing toward the end of Runway 12, or are on a 120-degree compass heading.

2.5. Standard Hand Signals. Standard hand signals for use between AAS crewmembers and aircrew members are provided in AFI 11-218, *Aircraft Operations and Movement on the Ground*. Standard hand signals for use between AAS crewmembers are shown in Figure 2.2 through Figure 2.5.

Figure 2.2. Standard Hand Signals for Rewind Operations.

POINT MAN TO PILOT

MOVE AHEAD

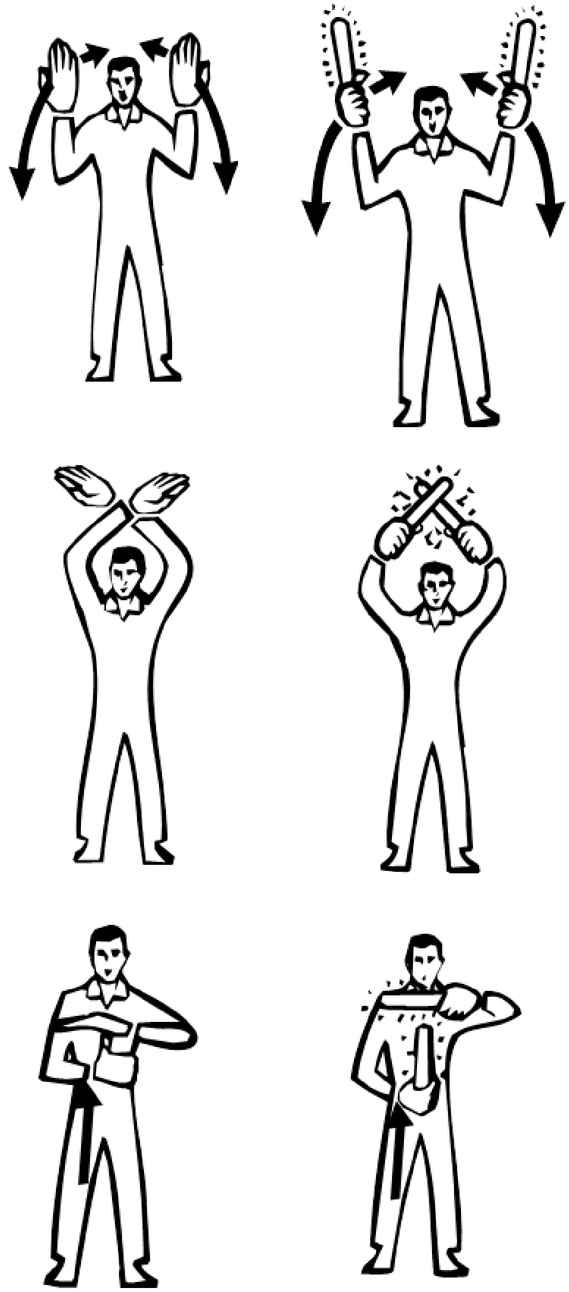
ARMS A LITTLE ASIDE, PALMS FACING BACKWARDS AND REPEATEDLY MOVED UPWARD BACKWARD FROM SHOULDER HEIGHT.

STOP

ARMS CROSSED ABOVE THE HEAD, PALMS FACING FORWARD.

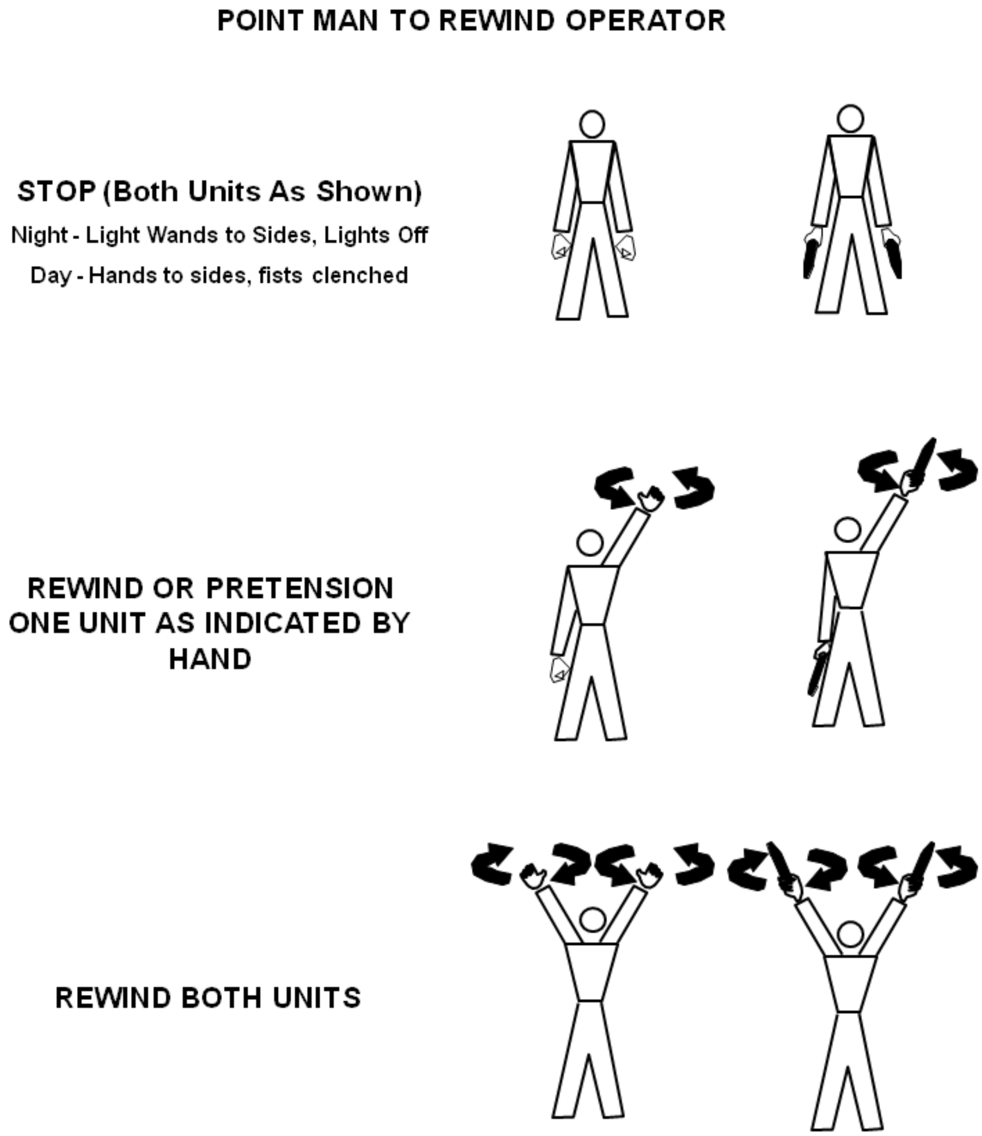
UP TAILHOOK

RIGHT FIST, THUMB EXTENDED UPWARD, RAISED SUDDENLY TO MEET HORIZONTAL PALM OF LEFT HAND.



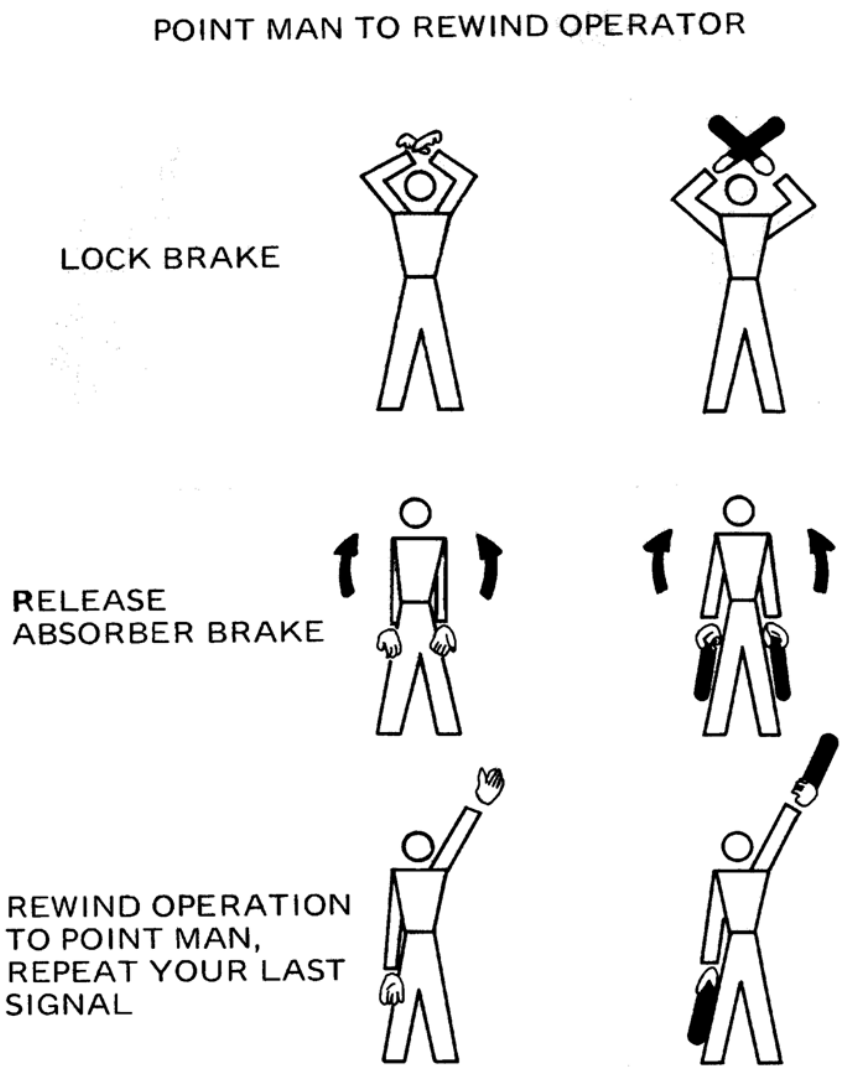
(Figure continued on next page.)

Figure 2.3. Standard Hand Signals for Rewind Operations (Continued).



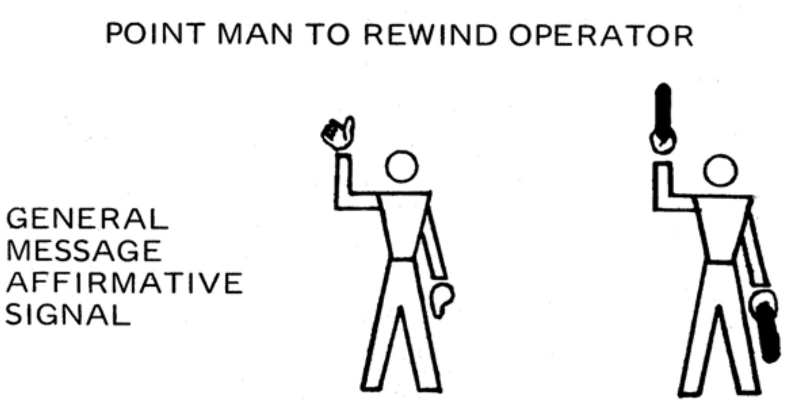
(Figure continued on next page.)

Figure 2.4. Standard Hand Signals for Rewind Operations (Continued).



(Figure continued on next page.)

Figure 2.5. Standard Hand Signals for Rewind Operations (Continued).



2.6. Maintenance Records. The following records will be maintained on each AAS for the overhaul service life of the system and returned to the overhaul facility when the system is changed out. This includes War Reserve Materiel systems in storage and systems designated for training use only, as applicable.

2.6.1. Daily inspections.

2.6.2. Weekly inspections.

2.6.3. Monthly inspections.

2.6.4. Tape data (date installed, contract number, manufacturer, and usage data).

2.6.5. Cable replacement data (date installed and contract number).

2.6.6. Semi-annual inspections.

2.6.7. Qualification and task certification of personnel.

2.6.8. System certifications and certification inspections.

2.6.9. Brake type, date installed, and number of engagements on BAK-12, MAAS, and BAK-9.

2.6.10. Aircraft engagement reports.

2.7. Deficiency Reporting. Deficiency reporting will be accomplished according to T.O. 00-35D-54.

Chapter 3

OBTAINING NEW SYSTEMS, SITING, AND INSTALLATION REQUIREMENTS

3.1. Obtaining New Systems.

3.1.1. Identify new system requirements to the MAJCOM and AFCESA, in turn, at least two years in advance, or as soon as new requirements are known, to allow sufficient lead-time for budgeting, contracting actions, manufacturing, and delivery.

3.1.2. The BCE's representative processes new requirements received from the operations group commander or air expeditionary group commander by first coordinating with the MAJCOM functional manager for AAS. The MAJCOM functional manager coordinates the new requirement with the MAJCOM A3O, SEF, and A7O, and responds to the installation's request. Once MAJCOM endorsement is received, the installation representative submits an AFEMS request to the base equipment management office (BEMO).

3.1.3. Semiannually, the MAJCOM AAS representative must identify all new requirements to AFCESA/CEO during the call for new requirements.

3.1.4. AFCESA/CEO validates the new requirements with WR-ALC for budgeting and procurement.

3.1.5. Upon approval of the AFEMS request, installation-level personnel should requisition the system and any other components not included in the government-supplied equipment (GSE) kit, such as the pendant.

3.2. Siting New Systems.

3.2.1. **General Information.** AAS and overrun barriers are installed in several configurations. Typically, overrun barriers (nets) and emergency arrestors such as MA-1A, BAK-15, E-5 chain gear, textile brake, or soft ground arrestor systems are installed as redundant systems for emergency recovery only. As such, they are installed in the overrun area of the runway. Operational arresting systems, such as BAK-12, are usually installed between the runway thresholds. This is necessary to allow pilots to touch down on the normal landing surface and stabilize the tailhook before engagement. Fairlead beams or runway edge sheaves (to direct the purchase tape path) are installed on the runway shoulders to allow the energy absorber to be installed outside the mandatory zone of frangibility (at least 84 meters [275 feet] away from the runway centerline). Support ramps are constructed to lead up to exposed vertical surfaces of fairlead beams and tape tubes to allow an aircraft to roll over them smoothly. Arresting gear that is installed on grade must have an "airfield friendly" structure built over it to protect the equipment from environmental degradation. The design should be in compliance with typical installation drawings 67F2011A or 67F2012A, as applicable, this instruction, the applicable 35E8-series T.O., and the requirements detailed within UFC 3-260-01 (Chapter 3 and Section 13). Do not install any arresting system where the runout will conflict with any other arresting system or any obstacle such as elevated airfield lights or signs. In cases where criteria cannot be met, a waiver must be established according to UFC 3-260-01 and/or the applicable T.O., as appropriate.

3.2.2. **Siting Operational Systems.** The large rectangular pavement markings (fixed distance markings) located 300 meters (1000 feet) from the threshold represent the ideal aim point for pilots on approach to landing. Other visual landing aids, such as the visual glide slope indicator system, cue the pilot to touch down approximately 300 meters (1000 feet) from the threshold. This ensures a minimum threshold crossing height of at least 11 meters (35 feet). Since stabilizing the tailhook after touchdown requires a distance of 150 to 240 meters (500 to 800 feet), the best location for an arresting system that accommodates approach end engagements is 450 to 540 meters (1500 to 1800 feet) from the threshold. Runways used extensively during instrument meteorological conditions may require that the system be sited as much as 670 meters (2200 feet) from the threshold; however, if aircraft that are not compatible with trampling of the pendant must operate on the same runway, the installation commander may shift the installation site as close to the threshold as possible, but not closer than the distance that will allow an unobstructed runout with a standard BAK-12 system set-up (see paragraph 3.7 and T.O. 35E8-2-5-1). It is critical that the runout area for an aircraft engaging the system from either direction not conflict with other AAS or equipment such as threshold or runway end light fixtures. Other operating scenarios, such as northern tier locations with heavy snow or ice accumulation, may dictate that you place an additional system at the midpoint of the runway. The installation commander must approve midfield siting after coordinating the plan with the host MAJCOM/A3, SE, and A7.

3.2.3. **Siting Emergency Systems.** Locate unidirectional arresting systems and barriers (nets) in the overrun area of the runway. The energy-absorbing device dictates the distance from the threshold because of the need to accommodate full system runout. Do not locate unidirectional systems or net barriers closer than 11 meters (35 feet) from the threshold of the runway. **Note:** Runway threshold markings begin 6 meters (20 feet) inboard of the full-strength pavement; therefore, do not install a unidirectional system within 17 meters (55 feet) of the threshold markings. Do not mark AAS warning markings on the pavement in overruns, or install arresting gear marker (AGM) lighted signs in the overrun to identify the locations of these systems. Installation of these markings and signs might cause a pilot to attempt an approach end engagement with the system.

3.3. Installation Requirements.

3.3.1. Comply with the following standards when locating, configuring, installing, or repairing an arresting system. BCEs must get the installation commander's approval and coordinate with MAJCOM/A3, SE, and A7 before deviating from these standards. A waiver to UFC 3-260-01 or the applicable 35E8-series T.O. will be required if these standards cannot be met.

3.3.2. The BCE's designated representative determines the configuration and location of arresting systems in cooperation with representatives from A3 and SE. Design must conform to the criteria in Section 3 of the appropriate 35E8-series T.O., the typical installation drawings, the requirements in this instruction, and UFC 3-260-01. In cases where criteria cannot be met, a waiver must be established according to UFC 3-260-01 and/or the applicable T.O., as appropriate.

3.3.2.1. Locate all energy absorbers below grade or at least 84 meters (275 feet) from the runway centerline. (**Exceptions:** MA-1A and E-5 ship's anchor chains and textile brake modules may be located along the runway overrun shoulders. Bi-directional textile brake modules may be located either along the overrun or runway shoulders.) Provide paved transitions and buried crushed stone ramps around the arresting system components and a paved service road to the site from the runway, as well as a location other than the runway. Pit-type installations may be sited closer to the runway as long as they meet the minimum split-distance required; however, all above-grade appurtenances must be frangible, the transition to the pit cover must meet runway shoulder grade allowances given in Chapter 3 of UFC 3-260-01, and the pit cover and door must be designed to support wheel loads in accordance with UFC 3-260-01, Chapter 3, paragraph 3.9, "Shoulders."

3.3.2.2. Where fairlead beams, edge sheaves, and tape tubes project above the grade of the existing runway shoulders, provide suitable fill materials and compaction next to or over these components to a finished grade of 1V:30H or flatter. Tape tubes must be steel or ductile iron. Tape tubes of other materials must be programmed for replacement and inspected monthly for signs of damage or degradation. For new installations, select tape tubes that are capable of supporting wheel loads in accordance with UFC 3-260-01, Chapter 3, Paragraph 3.9, "Shoulders."

3.3.2.3. Provide obstruction marking and lighting and arresting system location marking and lighting according to the provisions of AFI 32-1042, *Standards for Marking Airfields,* and UFC 3-535-01, *Visual Air Navigation Systems.* This requirement also applies to temporary installations for construction or air shows unless waived by the appropriate authority. See UFC 3-260-01, Appendix B, Section 1.

3.3.2.4. Protective shelters constructed for on-grade installations must be constructed from lightweight framing materials and sheathing using connections that will allow the structure to break away or collapse if struck by an aircraft wing. See UFC 3-260-01, Appendix B, Section 13, paragraph 13-2.20.1. Provide shelters with a removable roof or end wall, or a door opening to facilitate major maintenance or replacement of the equipment. Also provide proper ventilation and windows that will allow the operator to view the runway and tape sweep areas in both directions. See Typical Installation Drawing 67F2011A, Sheet 2, Note 3.

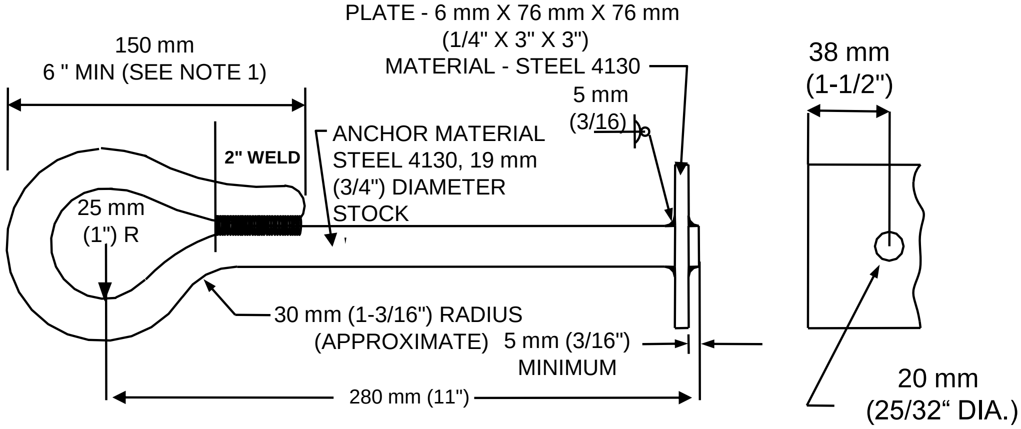
3.3.2.5. The 60 meters (200 feet) of pavement on both the approach and departure sides of the arresting system pendant within the center 23 meters (75 feet) of the runway are critical areas. **Exception:** For 46-meter (150-foot) -wide runways with BAK-14 systems, the critical area is limited to the off-center engagement capability for the BAK-14 system, which is the center 18 meters (60 feet) of runway pavement. For wider runways, the critical area is the center 23 meters (75 feet) of runway pavement for BAK-14 or any other model AAS, regardless of the stated off-center engagement capability. Within this critical area, protruding objects, excessive paint build-up, and undulating surfaces are detrimental to successful tailhook engagements and are not allowable. The maximum permissible longitudinal surface deviation in this area is ±3 millimeters (±0.125 inch) in 4 meters (12 feet). This does not apply to the channels in grooved pavement surfaces. The prohibition on changes in pavement type does not apply to emergency arresting system cables located in overruns because overruns are constructed of asphaltic pavement and the first 305 meters (1,000 feet) of runways are constructed from portland cement concrete (PCC). Grooves to improve surface drainage and surface friction characteristics are not permitted within 3 meters (10 feet) of arresting system cables. Changes in pavement type or an interface between rigid and flexible pavements are not permitted within 60 meters (200 feet) of arresting system cables in the center 23 meters (75 feet) of the runway. This does not apply to emergency systems located within overruns, sacrificial panels installed beneath cables, or to PCC anchor blocks installed for anchoring tie-downs in flexible pavement systems. These are not considered a change in pavement type. Rigid inlays must not be used as a surface repair material beneath the cable in flexible runway systems. This type repair causes high hook-skip potential when the flexible pavement consolidates, exposing the leading edge of the rigid pavement. However, rigid pavement must be used as a foundation under sacrificial panels installed beneath AAS cables in both rigid and flexible pavement systems. In these cases, no part of the rigid foundation can be used as a top-wearing surface.

3.3.2.6. Install cable tie-down anchors for operational systems (systems located between the runway thresholds) to limit cable bounce and potential aircraft damage during aircraft rollover. Install eight anchors for F-16, C-17, and C-130 operating bases and four anchors at all other locations. When using the MAAS or other expeditionary cable systems for other than an air show or a short-term construction project, add cable tie-downs to the runway to prevent aircraft damage during aircraft roll-over and engagements. This also applies at forward locations but may have to be postponed until time and materials are available to accomplish the work. Install anchors at 6-meter (20-foot) intervals centered on the runway width for four-point tie-downs, or at 3-meter (10-foot) intervals centered on the runway width for eight-point tie-downs. For rigid pavements, it is desirable that all anchor locations be offset at least 600 millimeters (24 inches) from pavement joints. The minimum offset from pavement joints for anchor locations is 300 millimeters (12 inches). If sacrificial panels will be installed, see Attachment 8 for anchor spacing. See Figures 3.1 through 3.3, 3.5, and 3.6 for cable tie-down anchor installation. Any of the three styles of anchors may be used for flexible or rigid runway pavements but the anchor block detail shown in Figure 3.6 is specifically designed for flexible pavement systems.

3.3.2.6.1. Secure the cable to the anchors with a length of 10-millimeter (0.375-inch) -diameter, three-strand nylon rope (NSN 4020-00-968-1356) approximately 1200 millimeters (48 inches) long (2200 kilograms [5,000 pounds] maximum breaking strength). The rope must be fastened to the anchor with a simple overhand knot then tied to the cable with a square knot.

3.3.2.6.2. Tie a simple overhand knot as close to the square knot as possible with the remaining rope. This will prevent the square knot from becoming loose. See Figures 3.3 and 3.4.

Figure 3.1. Cable Tie-down Anchor.



NOTE:

This area must be cadmium plated and conform to spec QQ-P-416 Class 1, Type 1.

Figure 3.2. Cable Tie-down Anchor Installation.

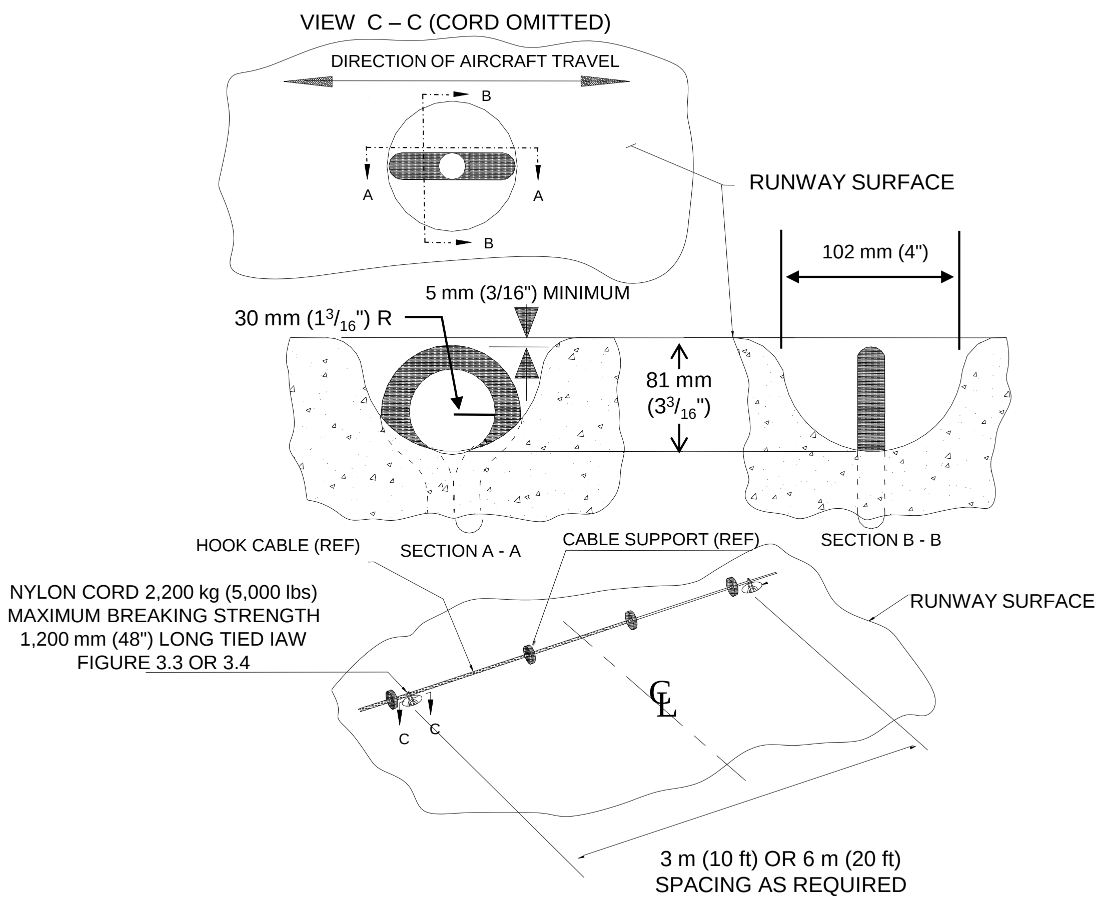
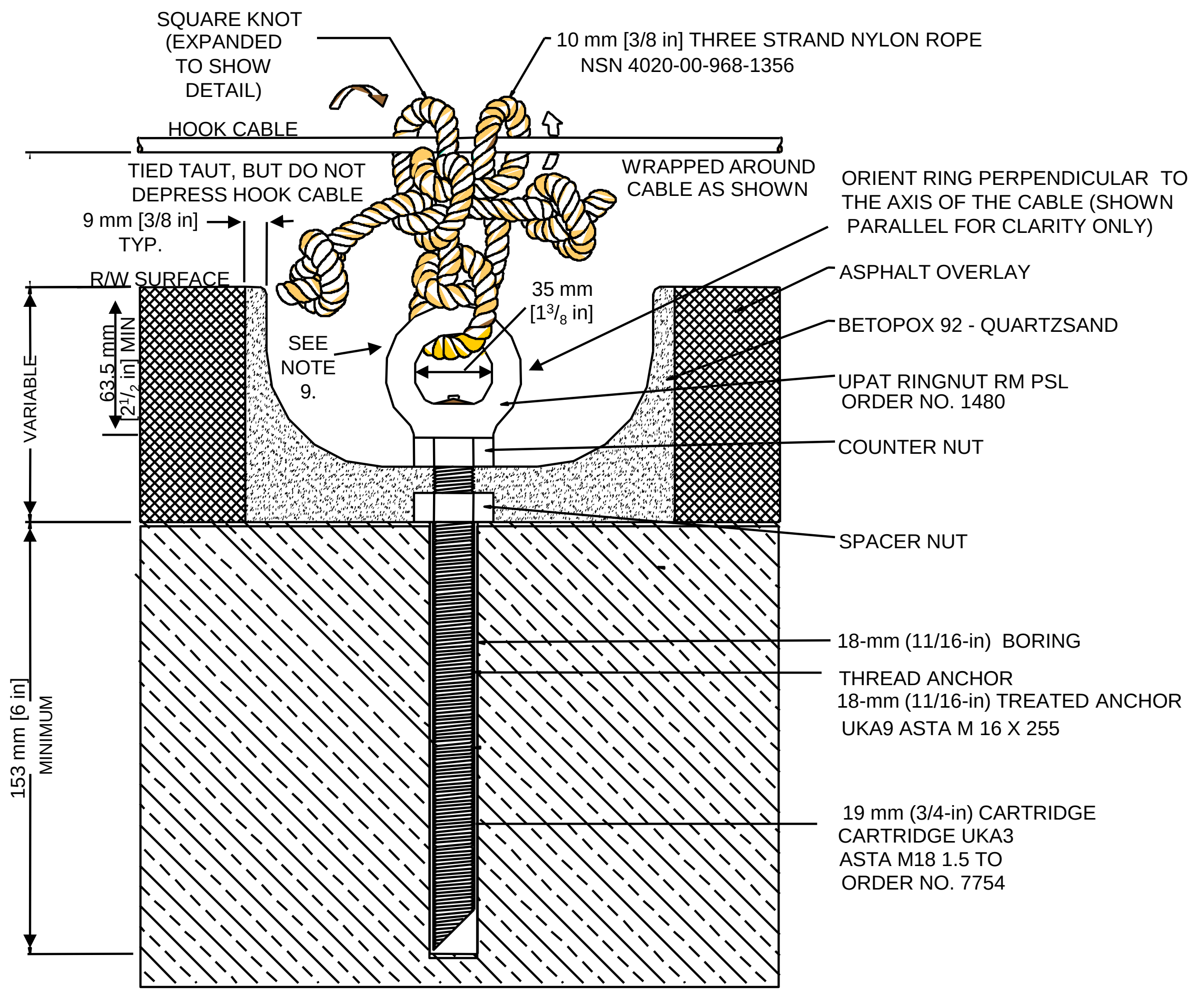


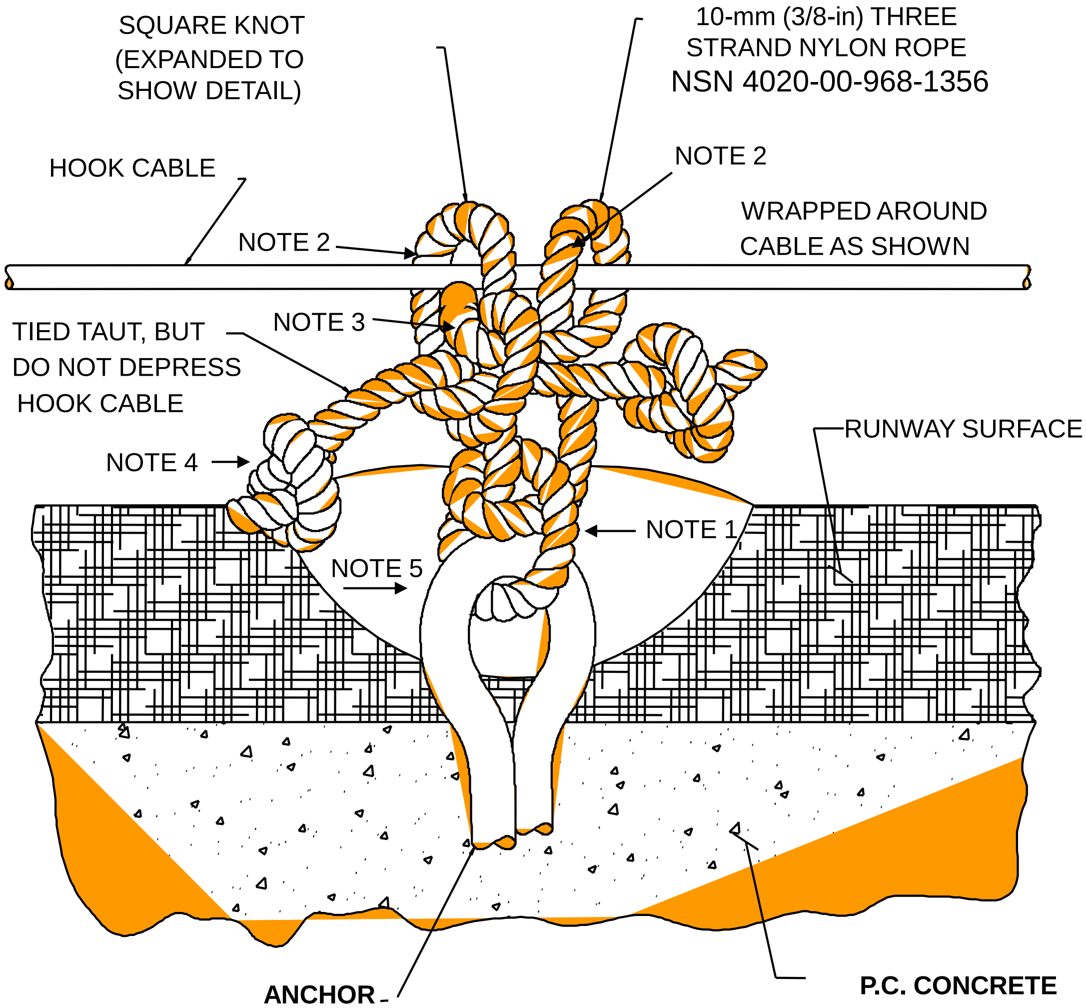
Figure 3.3. Alternate Cable Tie-down Anchor Installation.



NOTES:

1. See paragraph 3.3.2.6 on cable tie-downs and locations for number and placement of tie-downs.
2. Tie-down ropes will be approximately 1,200 millimeters (48 inches) long.
3. Ring nut shall be perpendicular to pendant cable.
4. Minimum anchor insertion into Portland cement concrete shall be 153 millimeters (6 inches).
5. Tie-down anchor bowl shall not exceed 127 millimeters (5 inches) in diameter.
6. Ring nut shall be tightened to full thread depth and locked to the anchor with a thread locking compound.
7. Threaded anchors shall be set with an impact type drilling machine.
8. Do not place anchors within 300 millimeters (1 foot) of rigid pavement joints.
9. Top of ring nut shall be recessed approximately 12 millimeters (0.5 inch) below the runway surface.

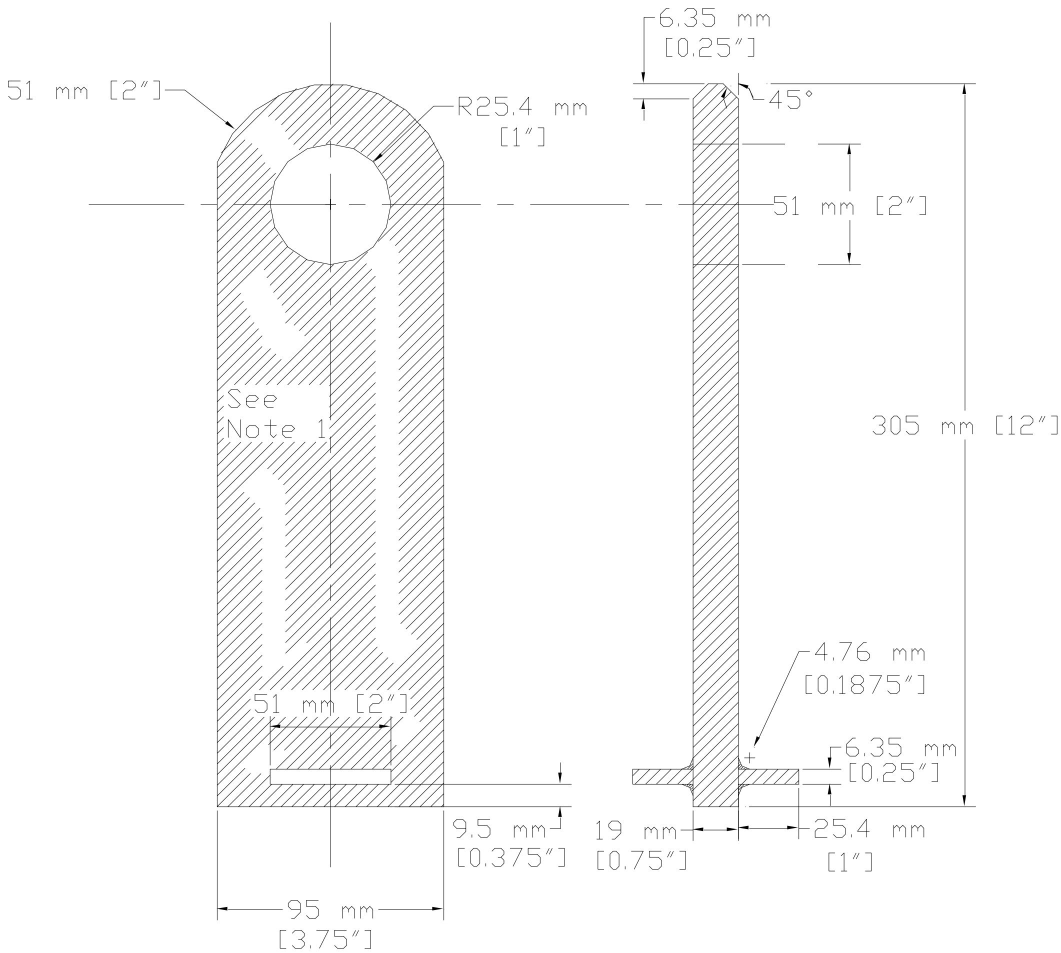
Figure 3.4. Securing Cable with Tie-down Rope.



NOTES:

1. Tie one half of a square knot on the anchor.
2. One end of the rope comes over the cable on the long side of the runway. The other end of the rope comes over the cable from the threshold side.
3. After the ropes are looped over the cable, tie a square knot underneath the cable.
4. Tie knots in ends of rope as close as possible to square knot.
5. Orient ring perpendicular to the axis of the cable. Shown parallel for clarity only.

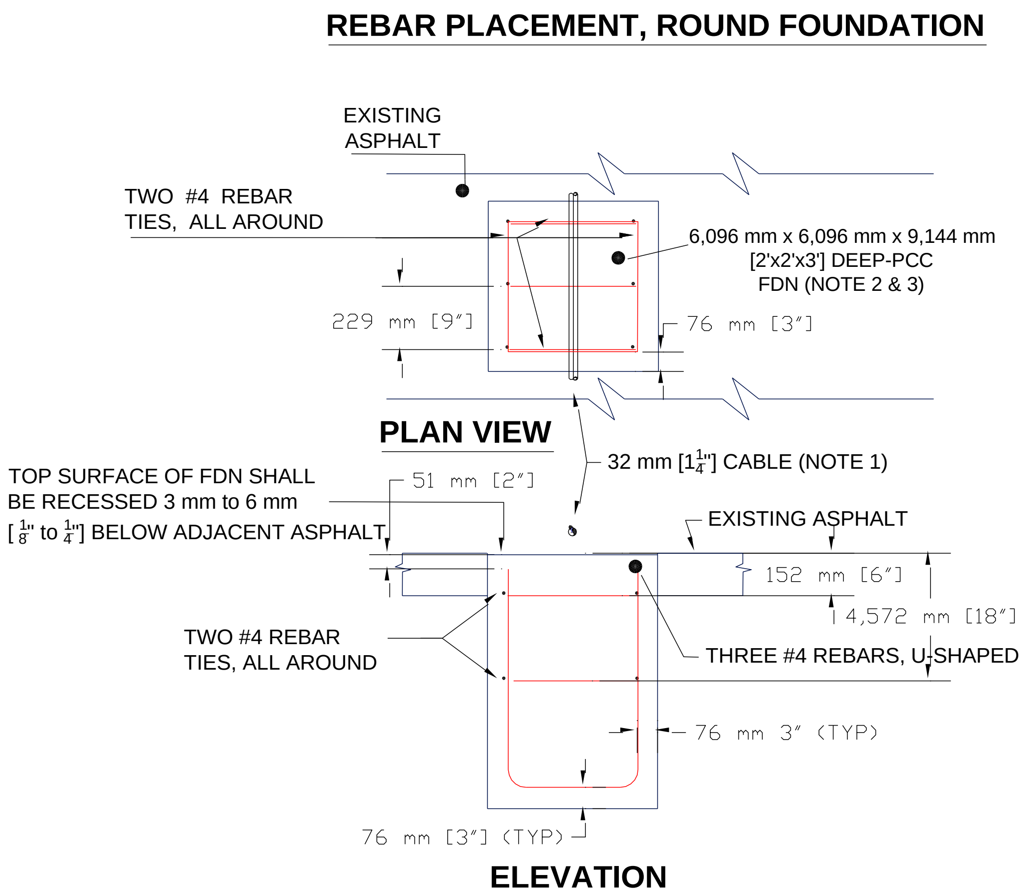
Figure 3.5. Locally Manufactured Cable Tie-down Anchor.



NOTES:

1. Anchor stock is ASTM A36 steel, 19 mm [0.75"] by 95 mm [3.75"].
2. Anti-pull-out wings are 6.35 mm [0.250"] by 51 mm [2"] by 25.4 mm [1"] ASTM 36 flat bar with 4.76 mm [0.187"] fillet weld all around.
3. Chamfer top edges of anchor radius 6.35 mm [0.250"] at 45°.
4. Remove sharp edges from 52 mm [2"] diameter through hole.
5. Coat with cold galvanized coating or two-part epoxy paint suitable for marine applications.
6. Orient anchor with the hole aligned parallel with the cable.

Figure 3.6. Cable Tie-down Anchor Block for Flexible Pavement System.



NOTES:

1. CENTER FOUNDATION UNDER CABLE.
2. LOCATE ANCHOR IN CENTER OF FOUNDATION.
3. CUT ASPHALT AS REQUIRED TO EXCAVATE FOR, AND PLACE PORTLAND CEMENT CONCRETE FOUNDATION. FOUNDATION MAY BE ROUND (711 mm [28"] DIAMETER) TO ALLOW USE OF AUGER FOR EXCAVATION.

3.3.2.7. The BCE's AAS representative will review the construction drawings and contract specifications at the 35 percent and 65 percent completion stages and approve at the 90 percent design completion phase. Other entities with a stake in the project, such as SE and A3 at base and MAJCOM levels, should also be asked to review the project drawings and contract specifications. The BCE's representative also ensures that installation contracts stipulate:

3.3.2.7.1. The construction superintendent, project engineer, or other authority experienced in installing arresting systems is onsite during construction and installation of each system.

3.3.2.7.2. The contractor corrects any deficiencies in the installation until at least two pullouts of the purchase tape are accomplished in each direction of intended operation and the contracting officer officially accepts the system.

3.4. Grandfathered Systems. On-grade BAK-12 systems installed before 1 July 1977 that are sited at least 76.2 meters (250 feet) from the runway centerline do not have to be relocated to meet the minimum setback requirement of 84 meters (275 feet) from the runway centerline; however, all systems equipped with 2-roller edge sheaves or 2-roller fairlead beams must be programmed for retrofit with 3-roller fairlead beams or edge sheaves to eliminate the longitudinal wheel abutment along the runway shoulder. Replacement foundations must be constructed as described in paragraphs 3.3.2.1, 3.3.2.2, and Typical Installation Drawings 67F2011A or 67F2012A to comply with the 1V:30H (3.3 percent) maximum slope requirement along the runway shoulder (see UFC 3-260-01, Table 3.2).

3.5. Installing Systems at Jointly Used Airports.

3.5.1. The FAA acts for and on behalf of the DOD Service component in operating arresting systems installed at jointly used civil airports for the primary use of US military aircraft.

3.5.2. Site arresting systems on civil airports jointly used by civil and military aircraft according to FAA Advisory Circular (AC) 150/5220-9, *Aircraft Arresting Systems on Civil Airports.*

3.5.3. To install an arresting system at a jointly used civil airport, the installation commander must first notify the airport manager (or authority) of the need. If the airport manager agrees, the installation commander submits the plan with sketches or drawings to the Air Force liaison officer at the FAA regional office. Refer any disagreement between the responsible officials to the next higher level within the chain of command.

3.5.4. If construction involves a lease agreement that does not allow placing additional structures on the leased premises, contact the MAJCOM.

3.5.5. Third-party claims presented for damage, injury, or death resulting from FAA operation of the system for military aircraft or from the Air Force or Air National Guard maintenance of the system may be the responsibility of the Air Force. Process such claims under the appropriate Air Force regulatory guidance (AFI 51-502, *Personnel and Government Recovery Claims*).

3.5.6. The FAA is responsible for claims presented for damage resulting from FAA operation of the system for civil aircraft; therefore, separate agreements between DOD and FAA concerning liability for such damage are not necessary.

3.5.7. The MAJCOM negotiates the operational agreement with FAA for a jointly used civil airport. The MAJCOM may delegate this authority to the installation commander. The agreement describes FAA functions and responsibilities concerning the remote-control operation of arresting systems by FAA air traffic controllers. See Attachment 5 for a sample letter of agreement.

3.6. Military Rights Agreements for Foreign Locations and Use by Non-US Government Aircraft.

3.6.1. Install these systems under the military rights agreement with the host government. The installation commander coordinates any separate agreements required with the local US diplomatic representative and negotiates the agreement with the host nation. If the parties are unable to agree, refer the issue to the MAJCOM.

3.6.2. In an emergency, the pilot of a non-US Government aircraft may request and use arresting systems at Air Force bases and jointly used airports within the continental US (CONUS) and overseas.

3.7. Standard BAK-12 System Set-Up. For any of the three installation methods described within T.O. 35E8-2-5-1, site selection should be made to accommodate a standard system configuration. A standard system configuration includes a 365-meter (1200-foot) runout, synchronization pressure of 7584.233 kilopascals (kPa) (1100 pounds per square inch [psi]), and a 32-millimeter (1.25-inch) -diameter pendant supported by 152-millimeter (6-inch) -diameter support disks (donuts). Once the site has been selected and the system installed, the *Aircraft Arresting Systems Report* (RCS: HAL-ILE [AR] 7150) is submitted in accordance with paragraphs 1.2.1 and 1.3.3.6 and a copy is provided to the airfield manager. Information pertaining to location with respect to runway thresholds and runout must be published within the DOD FLIP. Once this has been reported and published, any change to the standard configuration (system runout, synchronization pressure, pendant cable diameter, or donut size) must not be made without written authorization from the installation commander and the MAJCOM civil engineer.

LOREN M. RENO, Lt General, USAF
DCS/Installations, Logistics & Mission Support

Attachment 1

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T.O. 35E8-2-10-1, *Operation and Maintenance Instructions, Arresting Systems, Aircraft, Mobile*, 1 Sep 2009

T.O. 35E8-2-13-1, *Operation, Service, Overhaul with Illustrated Parts Breakdown Textile Brake and Hook Cable Aircraft Arresting System, Type MB60.9.9.C*, 1 Apr 2008

T.O. 35E8-2-14-1, *Operation and Service, Overhaul Instructions, Illustrated Parts Breakdown for Textile Brake and Hook Cable Aircraft Arresting System, Type MB100.10.C*, 1 Mar 2008

UFC 3-260-01, *Airfield and Heliport Planning and Design*, 17 Nov 2008, **http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4**

UFC 3-535-01, *Visual Air Navigation Facilities*, 17 Nov 2005, **http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4**

Prescribed Forms

None.

Adopted Forms:

AF Form 623, *Individual Training Record Folder*

AF Form 971, *Supervisor's Employee Brief*

Abbreviations and Acronyms

642 CBSG/GBEB—642d Combat Sustainment Group

A7—Directorate of Installations and Mission Support

AAS—Aircraft Arresting System

AC—Advisory Circular (FAA)

AF—Air Force (as used on forms)

AFCESA—Air Force Civil Engineer Support Agency

AFCESA/CEO—AFCESA Operations and Programs Support Division

AFCESA/CEOA—AFCESA Engineer Support Branch

AFEMS—Air Force Equipment Management System

AFFSA—Air Force Flight Standards Agency

AFI—Air Force Instruction

AFMAN—Air Force Manual

AFMC—Air Force Materiel Command

AFOSHSTD—Air Force Office of Safety and Health Standard

AFPD—Air Force Policy Directive

AFSC—Air Force Specialty Code

AGM—Arresting Gear Marker

ALC—Air Logistics Center

AOI—Airfield Operating Instruction

AR—As Required (used in report control symbols)

ASTM—American Society for Testing and Materials

ATC—Air Traffic Control

BCE—Base Civil Engineer

BEMO—Base Equipment Management Office

CE—Civil Engineer

CENTAF—US Central Command Air Forces

CFETP—Career Field Education and Training Plan

CFR—Code of Federal Regulation

CONUS—Continental United States

DO—Operations

DOD—Department of Defense

EMAS—Engineered Materials Arresting Systems

EPH—Effective Pendant Height

ETL—Engineering Technical Letter

FAA—Federal Aviation Administration

FAR—Federal Aviation Regulation

FLIP—Flight Information Publications

ft—Foot

ft-lb—Foot-Pound

g/cm—Gram per Centimeter

gal—Gallon

GSE—Government-Supplied Equipment

HQ ACC—Headquarters Air Combat Command

ICAO—International Civil Aviation Organization

kg—Kilogram

kPa—Kilopascal

L—Liter

lb—Pound

lb ft—Pound Foot

LF—Linear Foot

M & AR—Monthly and As Required (used in report control symbols)

MAAS—Mobile Aircraft Arresting System

MAJCOM—Major Command

MAJCOM/A3—Major Command Directorate of Operations

MAJCOM/SE—Major Command Directorate of Safety

m—Meter

mm—Millimeter

N·m—Newton Meter

NOTAM—Notice to Airmen

NSN—National Stock Number

O&M—Operation and Maintenance

OPR—Office of Primary Responsibility

ORM—Operational Risk Management

PACAF—Pacific Air Forces

PPE—Personal Protective Equipment

psi—Pound per Square Inch

RCS HAF-ILE—Report Control Symbol - Headquarters Air Force - Civil Engineer

RDS—Records Disposition Schedule

SE—Safety

T.O.—Technical Order

UFC—Unified Facilities Criteria

UHMW—Ultra-High-Molecular-Weight

UNC—Unified National Coarse (Thread Pitch)

US—United States

USAF/A7C—The Air Force Civil Engineer

USAF/A3—HQ USAF Deputy Chief of Staff for Operations, Plans and Requirements

USAFE—United States Air Forces in Europe

USAF—United States Air Force

UV—Ultraviolet

WG—Wage Grade

WR-ALC—Warner Robins Air Logistics Center

Terms

Active Runway—Any runway or runways currently being used for takeoff or landing. When multiple runways are used, they are all considered active runways.

Aircraft Arresting Barrier—A device, not dependent on an aircraft arresting hook, used to stop an aircraft by absorbing its forward momentum in an emergency landing or aborted takeoff. (Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms*)

Aircraft Arresting Cable—The part of an aircraft arresting system (AAS) that spans the runway surface or flight deck landing area and is engaged by the aircraft arresting hook. (Joint Publication 1-02) (Also see "Pendant.")

Aircraft Arresting Complex—An airfield layout comprising one or more arresting systems.

Aircraft Arresting System (AAS)—A series of components used to engage and absorb the forward momentum of a routine or emergency landing or an aborted takeoff. (Joint Publication 1-02)

Arrestment-Capable Aircraft—An aircraft whose flight manual specifies arrestment procedures.

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.

Effective Pendant Height (EPH)—The vertical distance in inches from the underside of the pendant cable to a projected surface representing undamaged runway surface.

Energy Absorber—The component of the arresting system that dissipates the kinetic energy of the arrested aircraft.

Location Identification—A description identifying the location of arresting systems by the approach or departure end, runway designation, and position in hundreds of meters/feet from the threshold. For example, the location identification extended runout BAK-12 at +457.2 meters (+1500 feet) on approach runway 36 indicates a 365.7-meter (1200-foot) runout BAK-12 located 457.2 meters (1500 feet) beyond the threshold of runway 36.

Missed Engagement—Any unsuccessful attempt to engage an AAS hook cable with a successfully deployed aircraft tailhook.

Mobile Aircraft Arresting System (MAAS)—A self-contained, trailer-mounted BAK-12 AAS that accommodates rapid installation during contingencies.

Movement Area (USAF/FAA)—The runways, taxiways, and other areas of an airport/heliport used for taxiing/hover taxiing, air taxiing, take-off, and landing of aircraft, exclusive of loading ramps and parking areas. At airports/heliports with a tower, specific approval for entry onto the movement area must be obtained from ATC. For USAF, the movement area is determined by the airfield operations flight commander and defined in the installation airfield operations and airfield driving instructions in accordance with AFI 13-204V3, *Airfield Operations Procedures and Programs*, and AFI 13-213, *Airfield Driving*.

Movement Area (ICAO)—That part of an airport used for the take-off, landing and taxiing of aircraft, consisting of the maneuvering area and the apron(s).

Overrun (USAF)—An area beyond the take-off runway designated by the airport authorities as able to support an airplane during an aborted take-off. The FAA/ICAO term for this is "stopway." UFC 3-260-01 identifies this area as one that prevents serious damage to aircraft that overrun or undershoot the runway.

Pendant—The part of an AAS that spans the runway surface or flight deck landing area and is engaged by the aircraft arresting hook.

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 as fully operational.)

Stopway (FAA/ICAO)—An area beyond the take-off runway designated by the airport authorities as able to support an airplane during an aborted take-off. The USAF term for this is "overrun."

Attachment 2

TYPES OF USAF AIRCRAFT ARRESTING SYSTEMS

A2.1. General Information. Aircraft arresting systems (AAS) 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 Type H that raise the pendant to the battery position or retract it below the runway surface. Energy-absorbing devices are ship's anchor chains, rotary friction brakes (such as the BAK-9 and BAK-12), or rotary hydraulic systems (such as the BAK-13), tearing strap modules such as textile brake systems, and soft ground systems such as the Engineered Material Arresting System (EMAS). Tables A2.1 and A2.2 below show the leading particulars for USAF energy-absorbing systems.

Table A2.1. 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 lb	40,000 lb	50,000 lb	100,000 lb	50,000 lb	40,000 lb
Energy Capacity (ft-lb)	55×10^6	65×10^6	85×10^6	170×10^6	85×10^6	40×10^6
Nominal Runout	950 ft	950 ft	1,200 ft	1,200 ft	950 ft	990 ft
Tape Strength	65,000 lb	105,000 lb	105,000 lb	105,000 lb	130,000 lb	105,000 lb
Cable Strength	84,000 lb	130,000 lb	130,000 lb	130,000 lb	129,000 lb	130,000 lb
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 AAS. 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 1200-foot runout in the 31-stake, PCC, or set-back anchoring schemes have the same technical characteristics as a 66-inch BAK-12.

Table A2.2. USAF Textile Brake Aircraft Arresting System Leading Particulars*.

System Type	MB 60.9.9.C	MB 100.10C
Cable diameter/strength	1.25 inches/130,000 lb	1.25 inches/130,000 lb
Stage 1 runout (length of available braking force)	551 feet	N/A
Energy capacity stage 1 (ft-lb)	26×10^6	N/A
Total system energy capacity (ft-lb)	52×10^6	44×10^6
System runout (total length of available braking force)	1000 feet	889 feet
Energy capacity calculated at 160 knots. **Note:** Twelve percent 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.		

A2.2. Types of USAF Systems.

A2.2.1. **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 A2.1). 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 A2.3 (or Chart 1-1 of T.O. 35E8-2-2-1) will result in a runout greater than 305 meters (1000 feet) or cable failure. Most MA-1A systems employ ship's 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 ship's 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 A2.2. 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 A2.1. MA-1A Barrier.

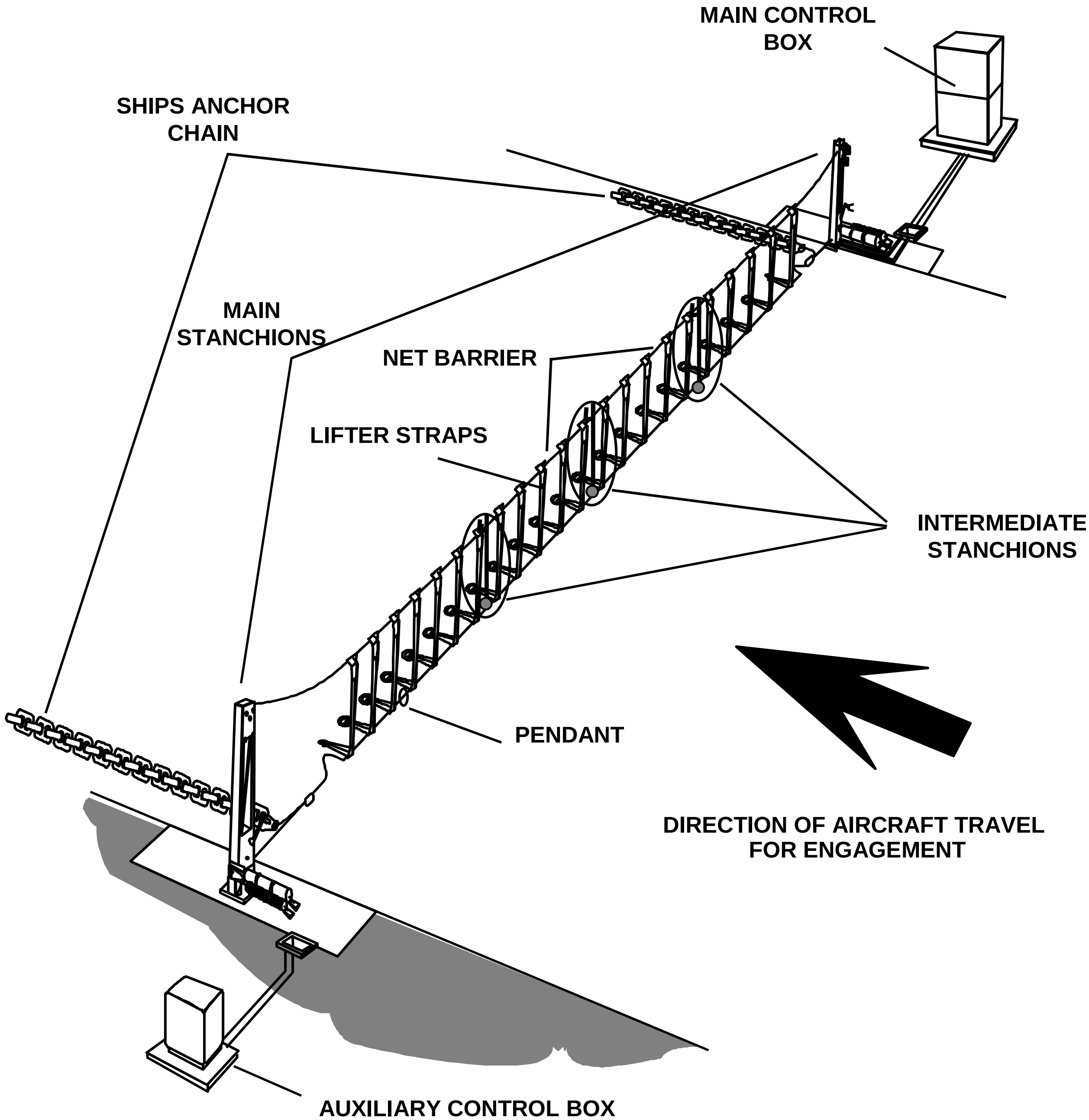


Figure A2.2. MA-1A Modified Barrier With Hook Cable Interconnect.

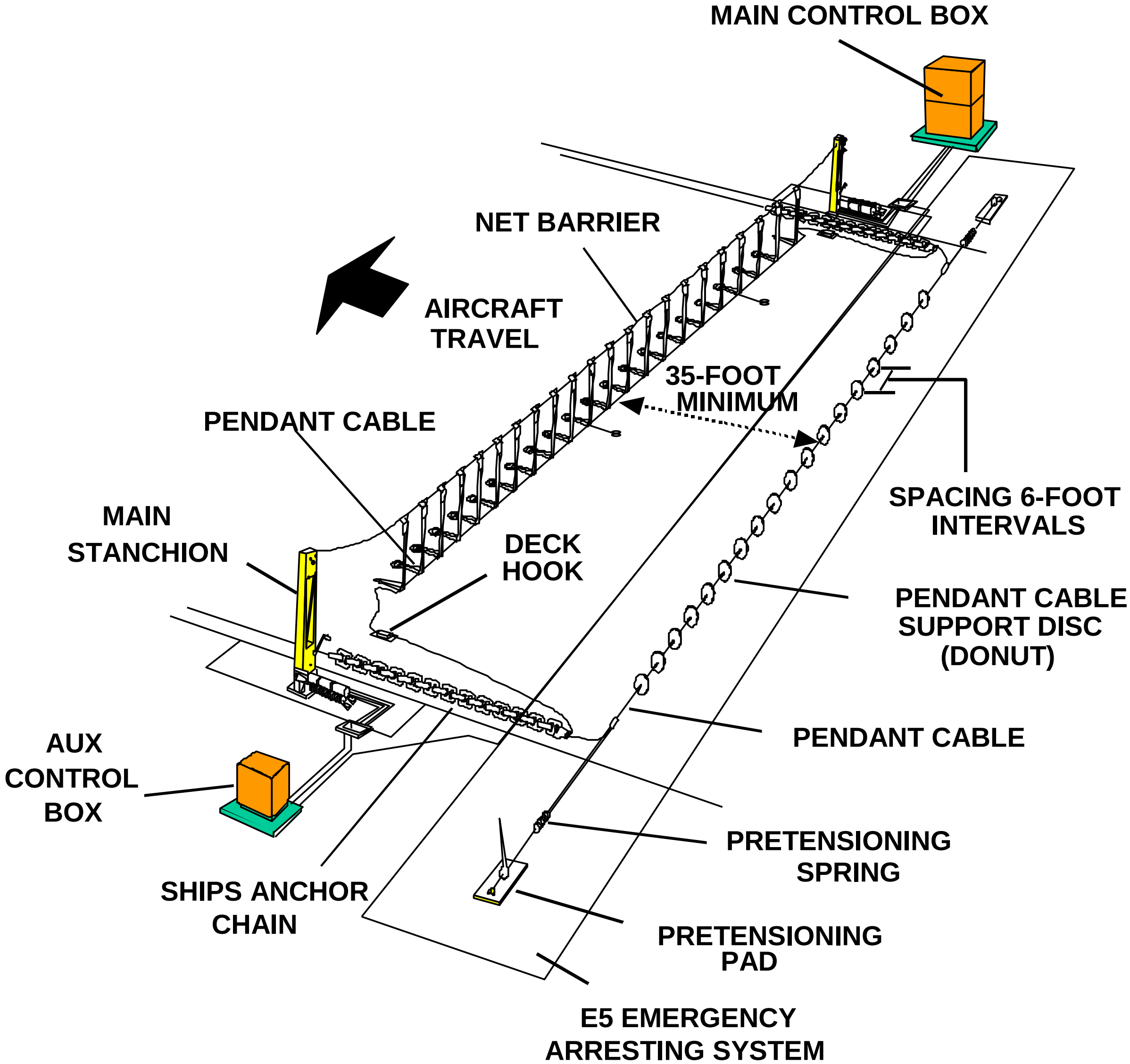
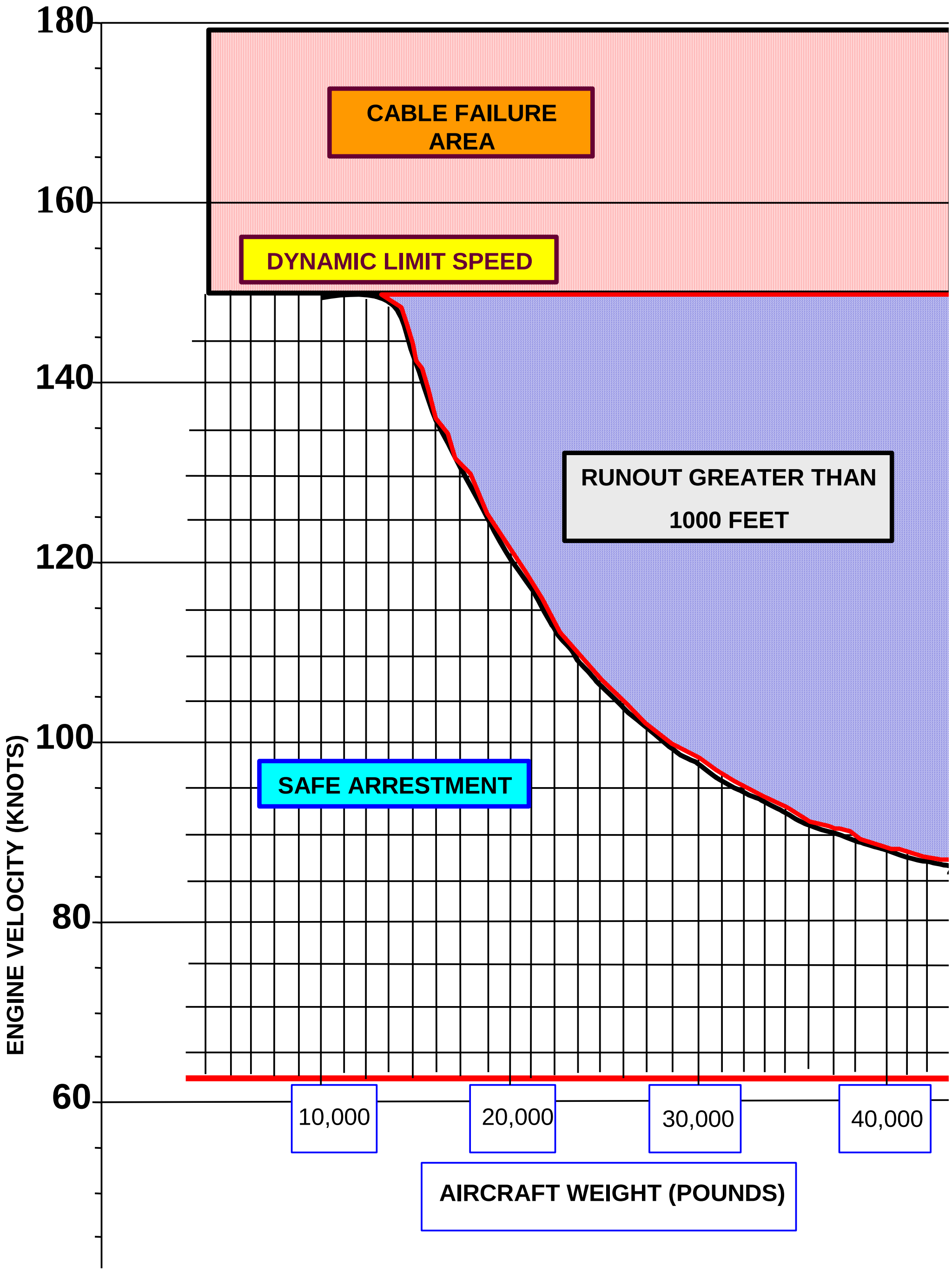
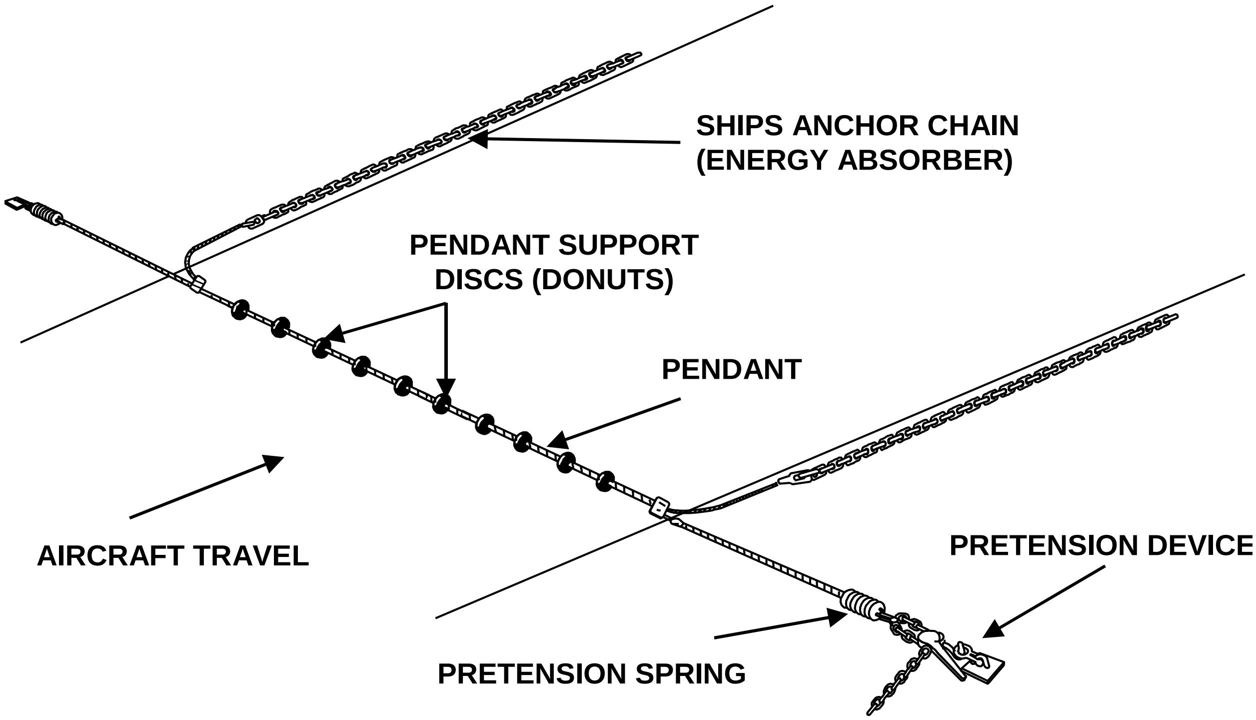


Figure A2.3. Speed and Weight Chart for Chain Gear.



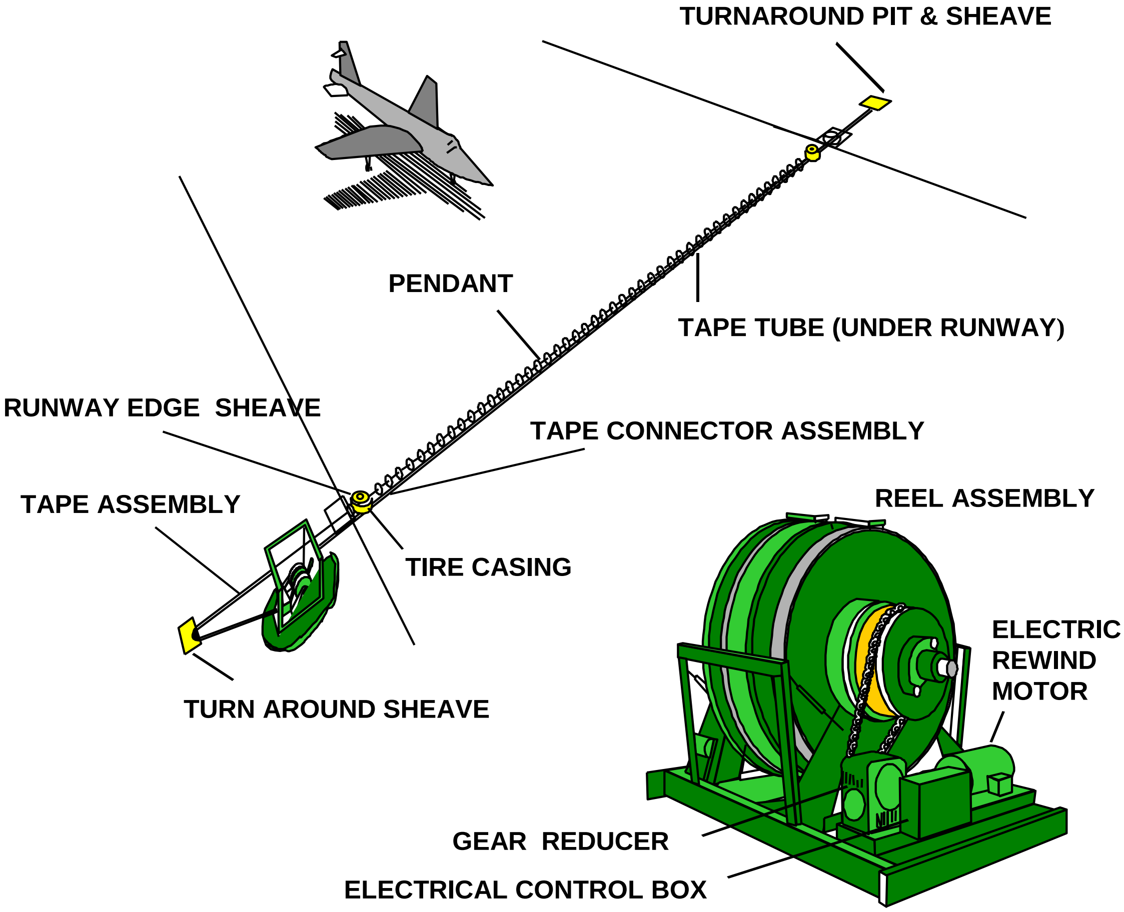
A2.2.2. **E-5.** This unidirectional emergency arresting system is a US Navy design and designation. Much like the MA-1A, this system uses several shots of ship's anchor chain as the energy absorber but these systems are never connected with a barrier (net). For the Navy or Marine Corps, these systems can have from one to four 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, New Jersey. For USAF, these systems use only one pendant and are sited and maintained as MA-1A. They are designated as an E-5 (Figure A2.4).

Figure A2.4. E-5 Hook Cable Arresting System.



A2.2.3. **BAK-9.** The BAK-9 (Figure A2.5) is an obsolete bi-directional emergency arresting system. It consisted of a single energy absorber that employed two 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 one 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 A2.5. BAK-9 Aircraft Arresting System.



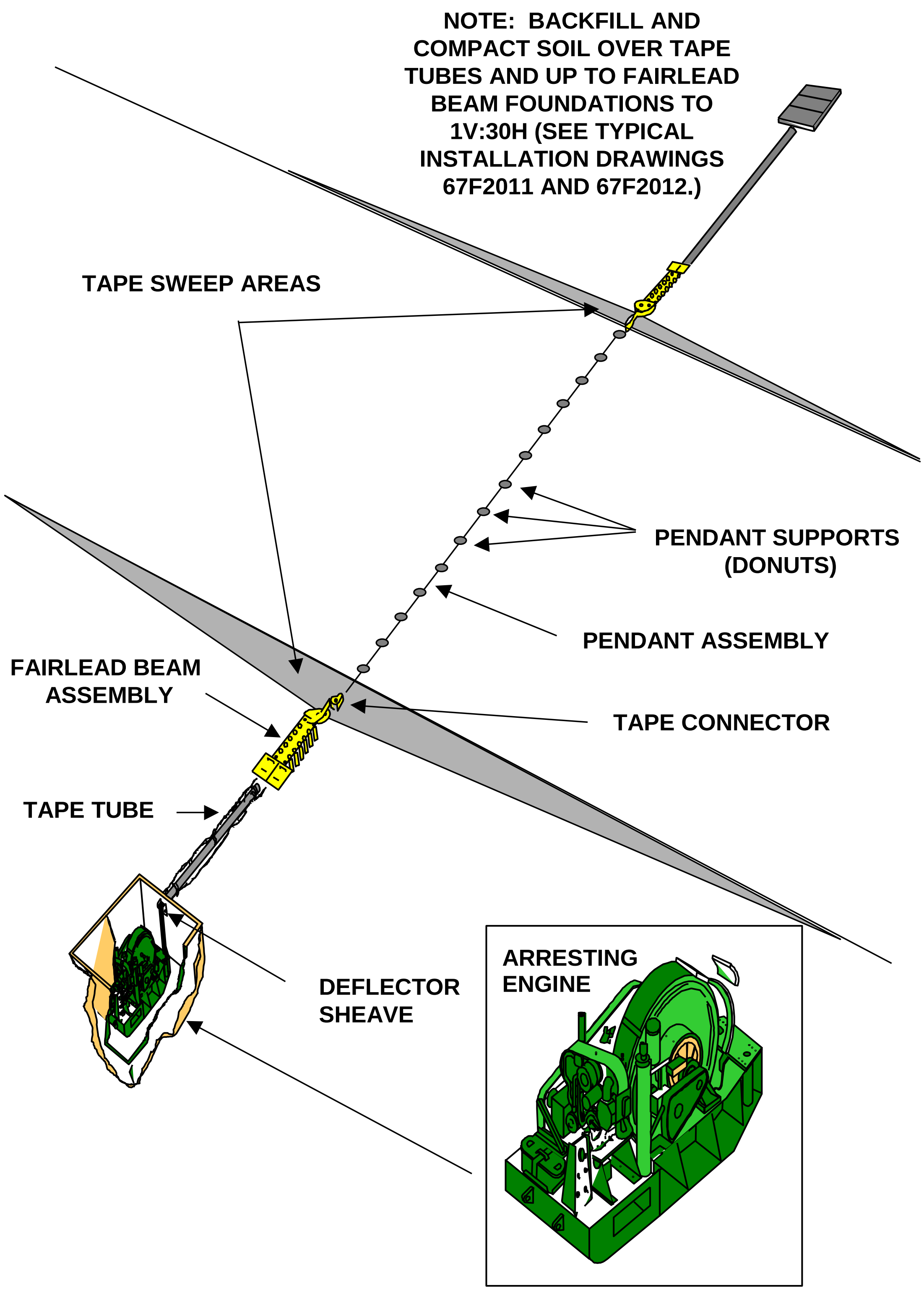
A2.2.4. **BAK-12.** The BAK-12 (Figure A2.6) is the standard USAF operational AAS. This bi-directional system employs two energy absorbers. Each absorber consists of two multi-disc rotary friction brakes mounted on either side of the purchase-tape reel on a common shaft. The energy absorbers are located 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 edge 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 one 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. Siting and grading requirements are in Section 3 of T.O. 35E8-2-5-1. Typical Installation Drawings for pit-type installations (drawing number 67F2012A) and permanent surface type installations (drawing number 67F2011A) are available from AFCESA/CEO and 642 CBSG/GBEB.

A2.2.4.1. 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. The energy absorbers have been retrofitted 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 (1200 feet) plus the length of the aircraft for maximum runout. The 72-inch reel systems are special-purpose systems configured for 610 meters (2000 feet) of runout.

A2.2.4.2. The standard BAK-12 is configured for cross-runway separations of up to 61 meters (200 feet) (distance between fairlead beams or edge 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. 35E8-2-5-1 and T.O. 35E8-2-5-4, *Illustrated Parts Breakdown – Aircraft Arresting System Model BAK-12*, to identify the part number for the correct replacement cam and installation procedures. Also select a pendant length of at least 80 percent of the distance between the fairlead beams to avoid adverse cable dynamics. Selected cable length should be at least 2 meters (6 feet) less than the total span between runway edge sheaves. This will allow sufficient exposed tape on each side of the runway (at least 0.6 meter [2 feet]), as well as an off-set between the runway centerline and the center point of the cable, to further reduce cable dynamics by disrupting parity in the kink wave caused by the engagement.

A2.2.4.3. 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 four 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 (2000 feet) of runout. Special tape connectors and edge sheaves are needed for these installations. For details of these components and other special considerations, see Section VIII of T.O. 35E8-2-5-1.

Figure A2.6. BAK-12 Aircraft Arresting System.

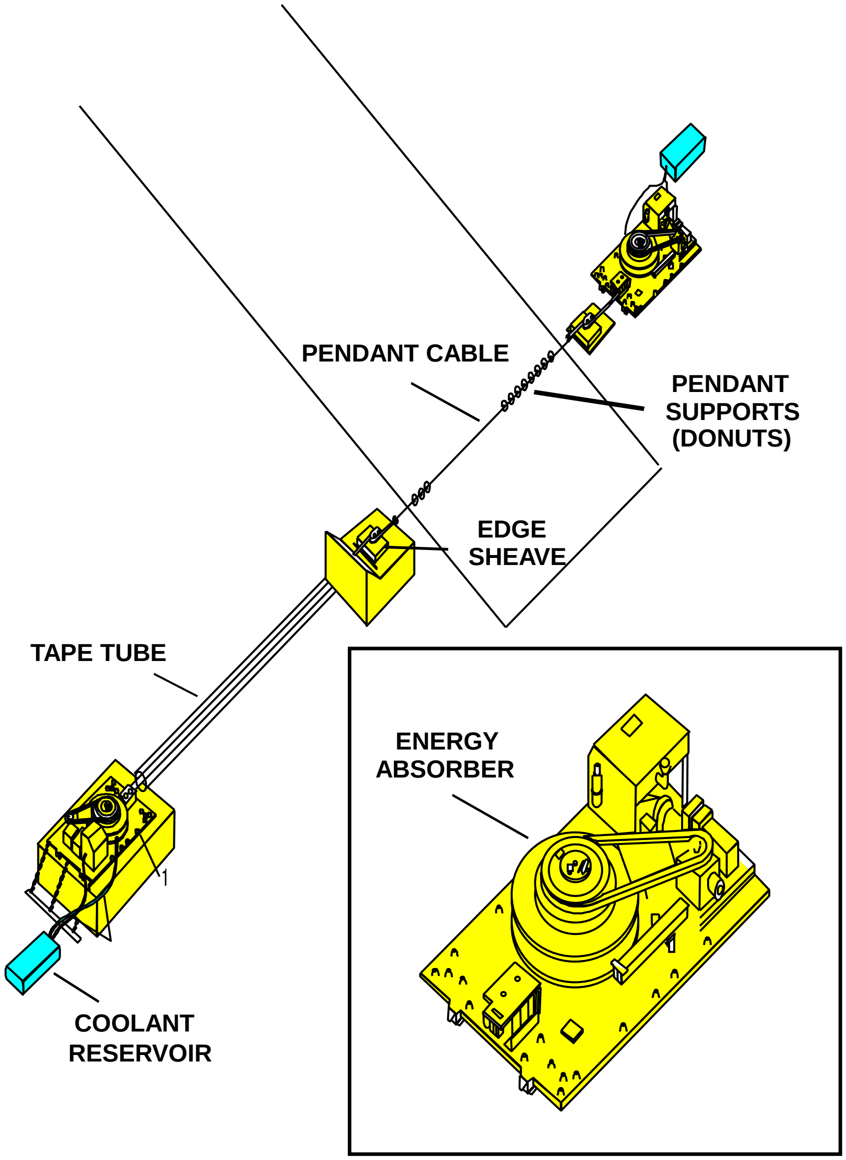


A2.2.5. **BAK-13.** The BAK-13 (Figure A2.7) is a bidirectional AAS. It employs two velocity-sensitive energy absorbers installed on opposite sides of the runway, interconnected by nylon purchase tapes and a 32-millimeter (1.25-inch) disc-supported pendant. The energy absorbers are made from a steel weldment base incorporating 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.

A2.2.5.1. 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 cycling of this system.

A2.2.5.2. 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 semi-permanent 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.

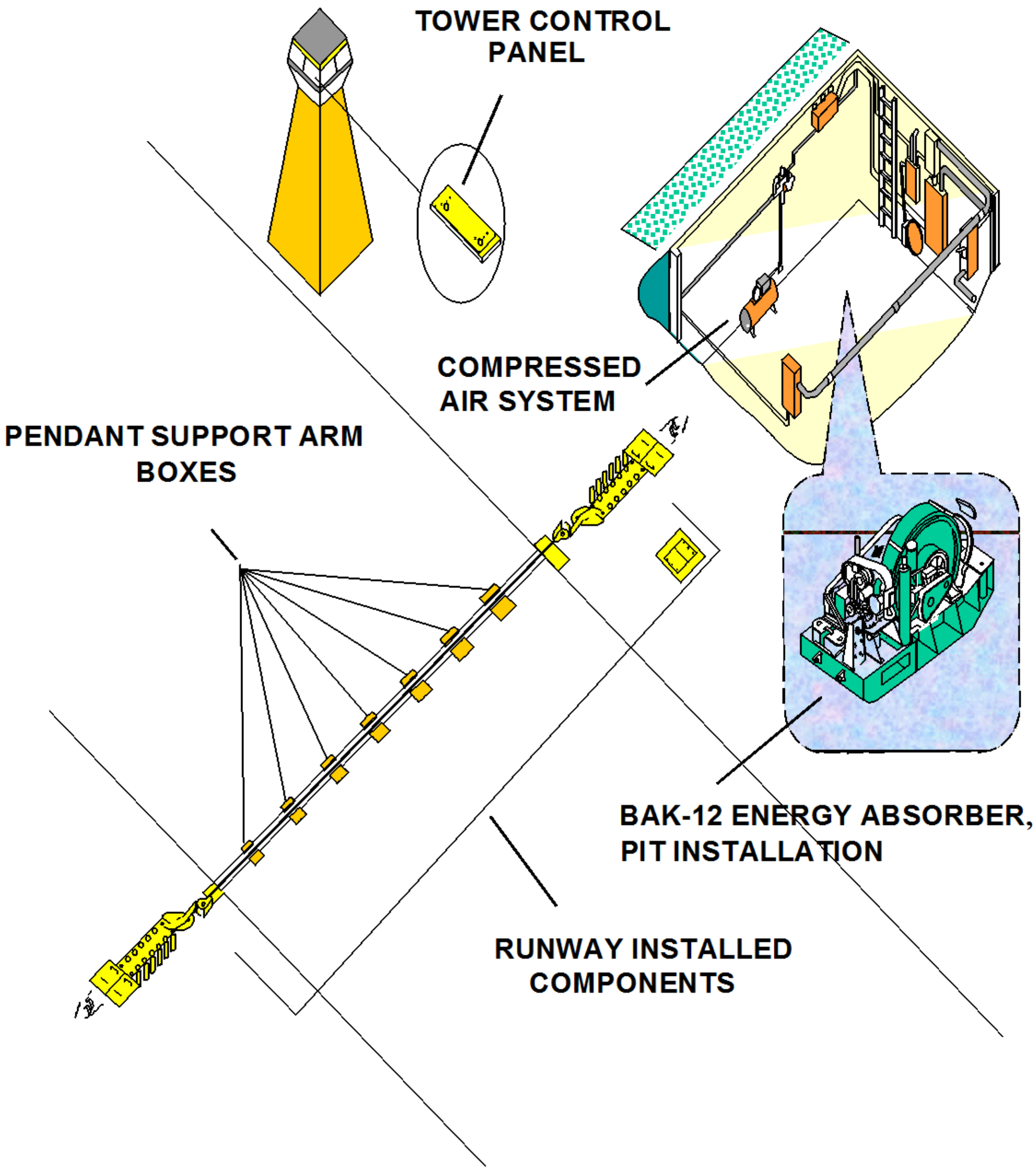
Figure A2.7. BAK-13 Aircraft Arresting System.



A2.2.6. **BAK-14 and Type H Hook Cable Support Systems.**

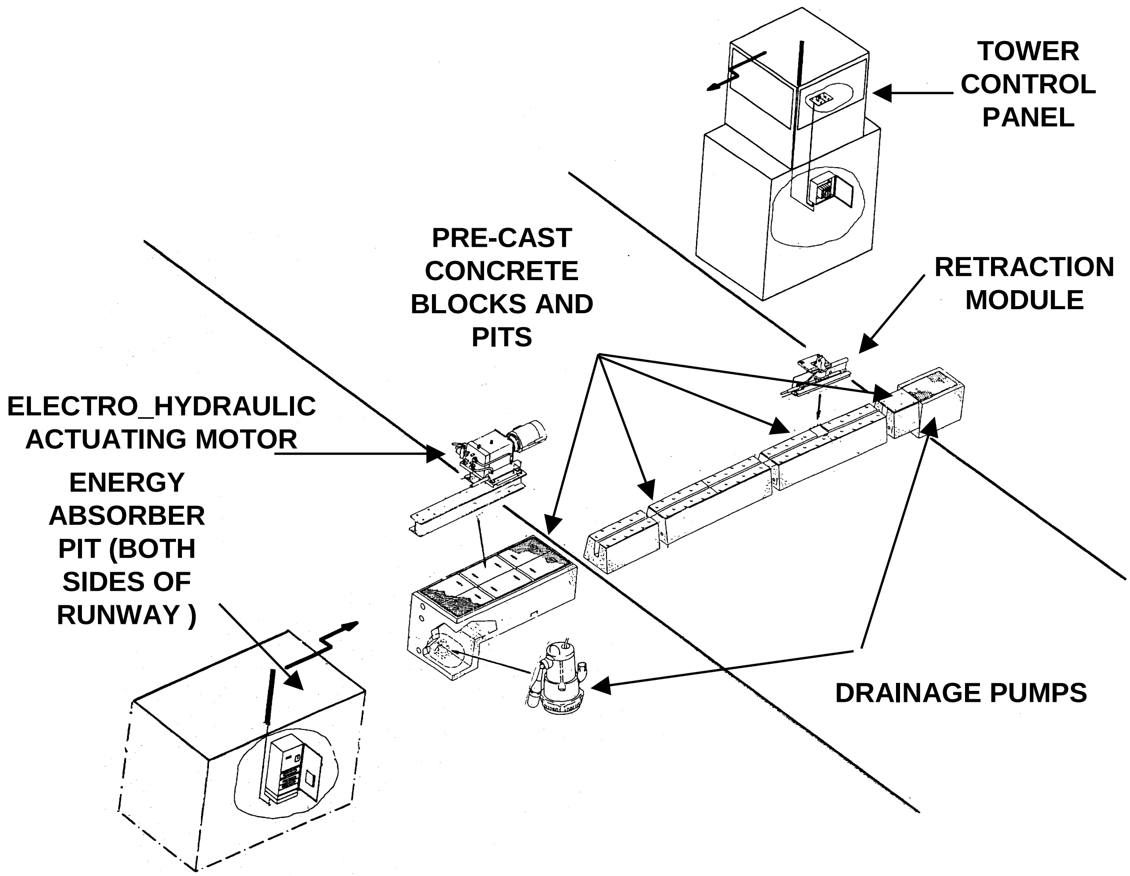
A2.2.6.1. The BAK-14 hook cable support system (Figure A2.8) is a bidirectional hook cable (pendant) support system used in conjunction with the BAK-12, BAK-13, or a comparable arresting system to engage and safely stop a hook-equipped aircraft. It provides the means to support the pendant at least 51 millimeters (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 45-, 200-, and 90-meter (150-, 200-, and 300-foot) -wide runways, but the system can be ordered 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. The site and utility considerations for installation are in T.O. 35E8-2-8-1, *Operation, Maintenance, and Installation Instructions with Illustrated Parts Breakdown, Hook Cable Support System, Model BAK-14.*

Figure A2.8. BAK-14 Cable Support System.



A2.2.6.2. The Type H hook cable support system (Figure A2.9) 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 51 millimeters (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 typically consists of 14 to 18 (depending on runway width) retraction modules 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 located in a concrete pit on one side of the runway. Detailed information (i.e., description, operation, maintenance, IPL), are provided in Aerazur Technical Manual 256-722, *Type H45-200 Retractable Hook Cable System*. Installation drawings are available from the manufacturer.

Figure A2.9. Type H Hook Cable Support System.

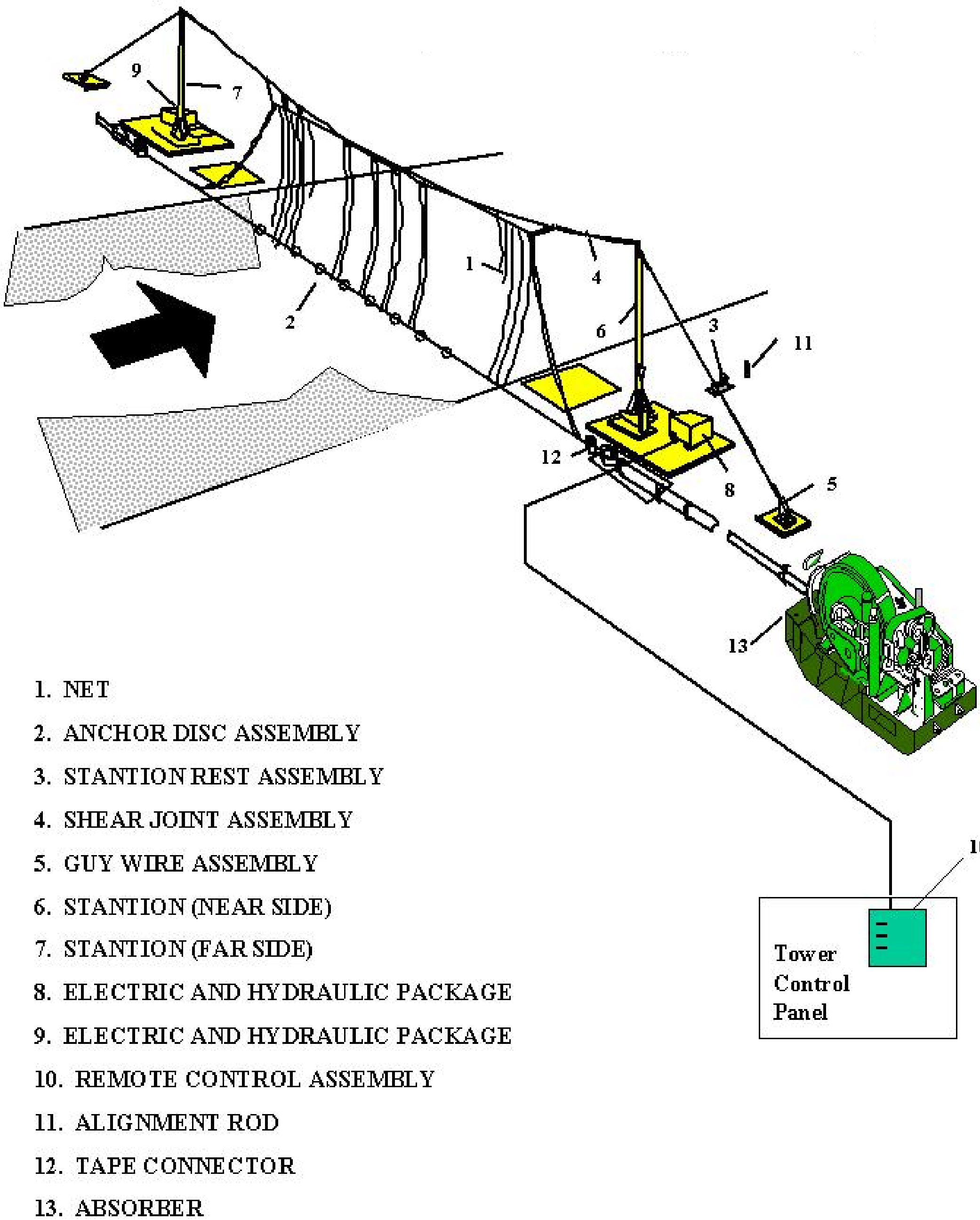


A2.2.7. **BAK-15 (61QSII).** The BAK-15 aircraft arresting barrier consists of a pair of electro-hydraulically powered steel masts that provide support and remote-controlled movement for a unidirectional nylon net barrier (Figure A2.10). The masts are installed on opposite sides of the runway overrun on concrete foundations. The ATC tower contains a remote-control panel which can be hard-wired but most commonly is radio-controlled.

A2.2.7.1. 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.

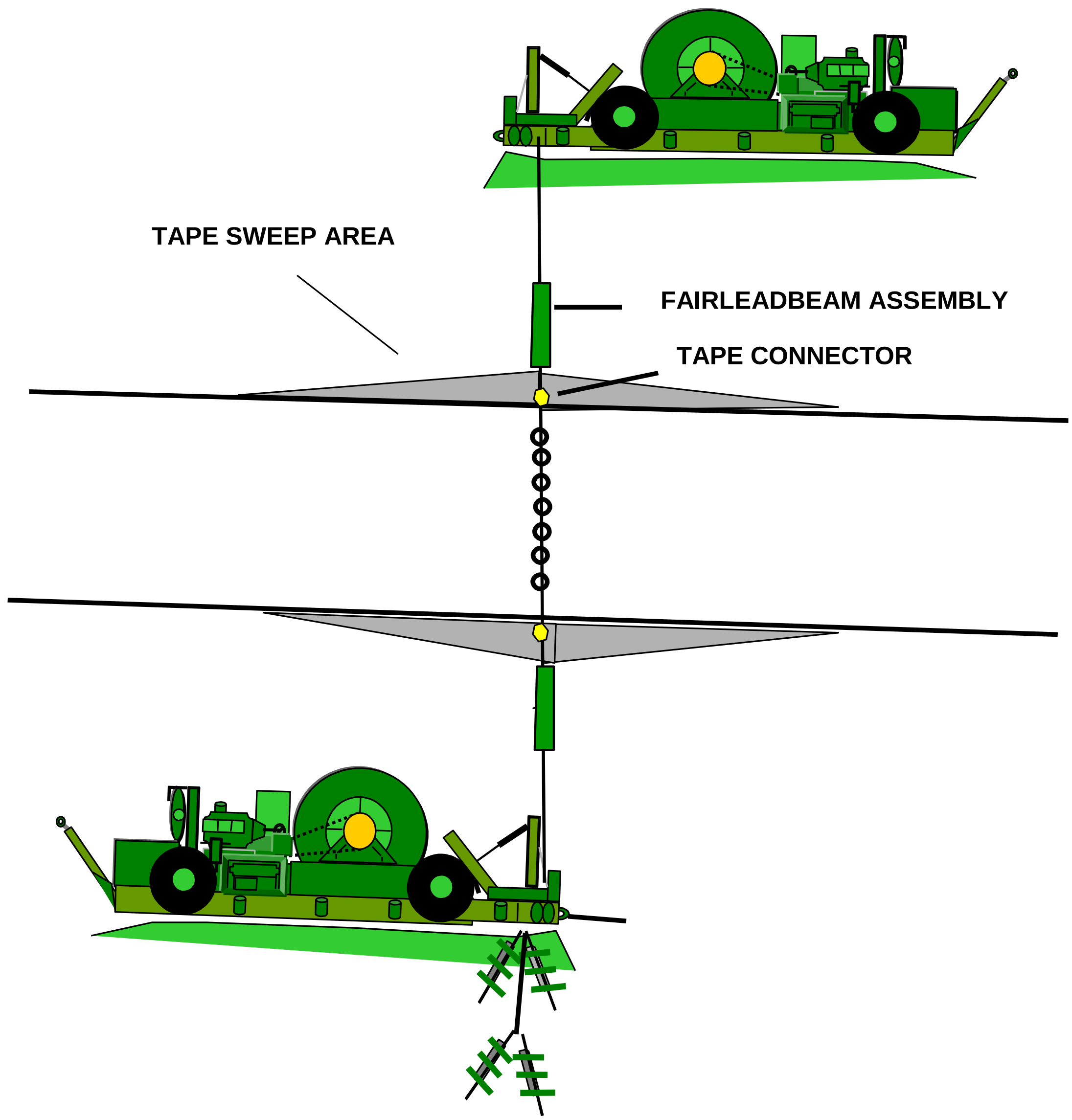
A2.2.7.2. The system can be complemented with a standard disc-supported pendant to accommodate tailhook engagements through interconnect configuration hardware similar to that used for the MA-1A Modified. The hook cable interconnect kit is designated as the 62 NI (net interconnect). System operation and maintenance instructions are in T.O. 35E8-2-9-2, *Maintenance and Operation Instructions, Quick Erect Stanchion System, Models 61QS and 61QSII*. Obtain installation drawings from the manufacturer through the procuring activity at the time of procurement.

Figure A2.10. BAK-15 Net Barrier (Pictured with BAK-12 Absorbers, BAK-15/12).



A2.2.8. **Mobile Aircraft Arresting System (MAAS).** The MAAS (Figure A2.11) is essentially a BAK-12 AAS 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 this 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). For detailed instructions on this system, refer to T.O. 35E8-2-10-1, *Operation and Maintenance Instructions, Arresting Systems, Aircraft, Mobile*.

Figure A2.11. Mobile Aircraft Arresting System (MAAS) in Set-Back Configuration.



A2.2.9. **MAAS Upgrades.** The MAAS can be upgraded to accommodate bi-directional engagements with the full capacity of a standard BAK-12 AAS (Table A2.1). 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 (1200 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 A2.11). For detailed information, see T.O. 35E8-2-10-1, Section VIII, Difference Data Sheets.

A2.2.10. **Textile Brake.** This modular arresting system is primarily intended as an emergency back-up system for standard operational systems. It is composed 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 two-stage unidirectional configuration (Figure A2.12) or as a single-stage bi-directional system (Figure A2.13). See Table A2.2 and T.O. 35E8-2-13-1, *Operation, Service, Overhaul W/IPB Textile Brake and Hook Cable Aircraft Arresting System, Type MB 60.9.9.C*, for information on the model MB 60.9.9.C. For information on the MB 100.10.C, see Table A2.2 and T.O. 35E8-2-14-1, *Operation and Service, Overhaul Instructions, IPB for Textile Brake and Hook Cable Aircraft Arresting System, Model MB 100.10.C*.

A2.2.10.1. The advantages of the two-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 tailhook-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.

A2.2.10.2. 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 A2.12. Textile Brake, Model MB.60.9.9.C.

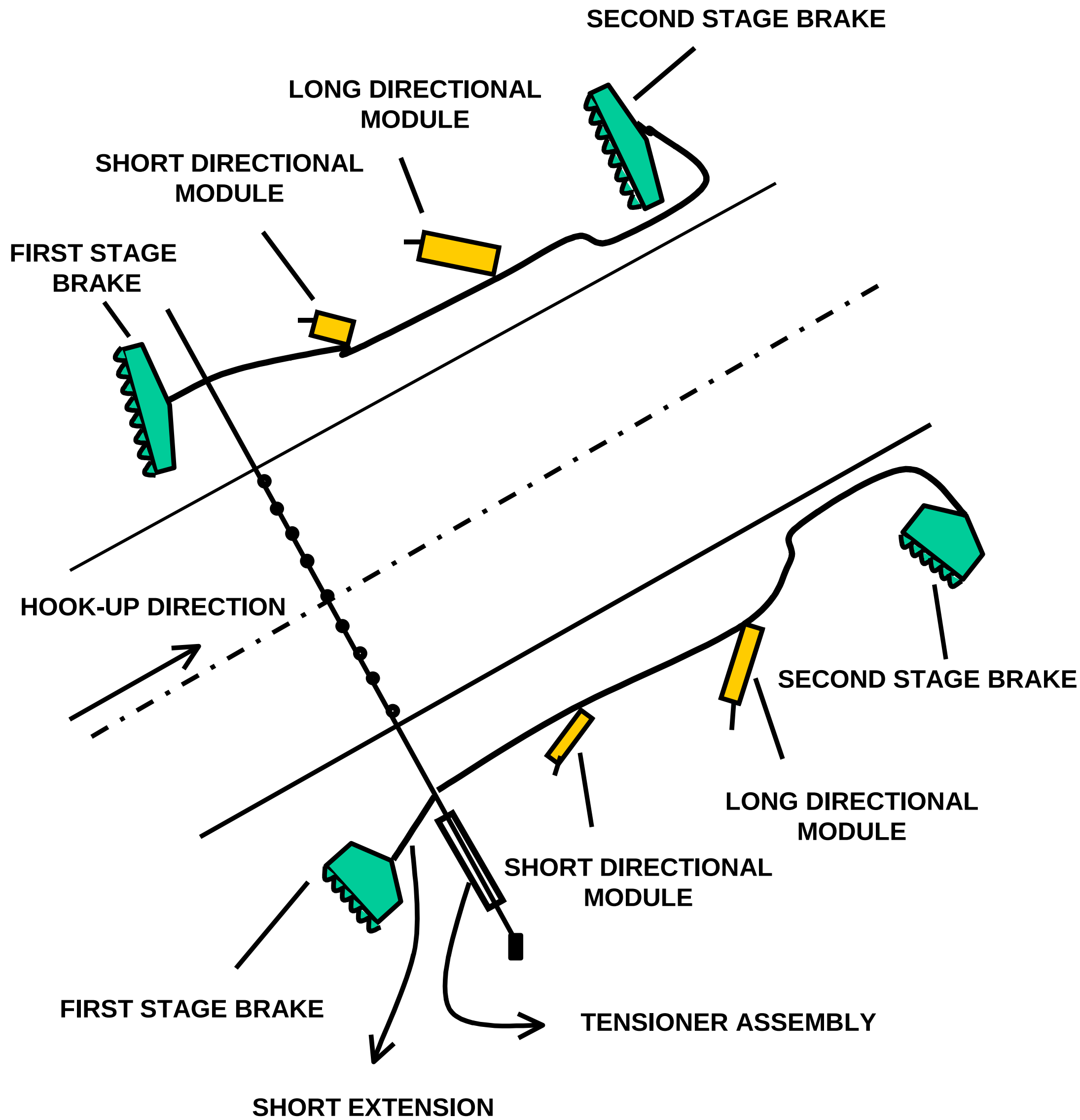
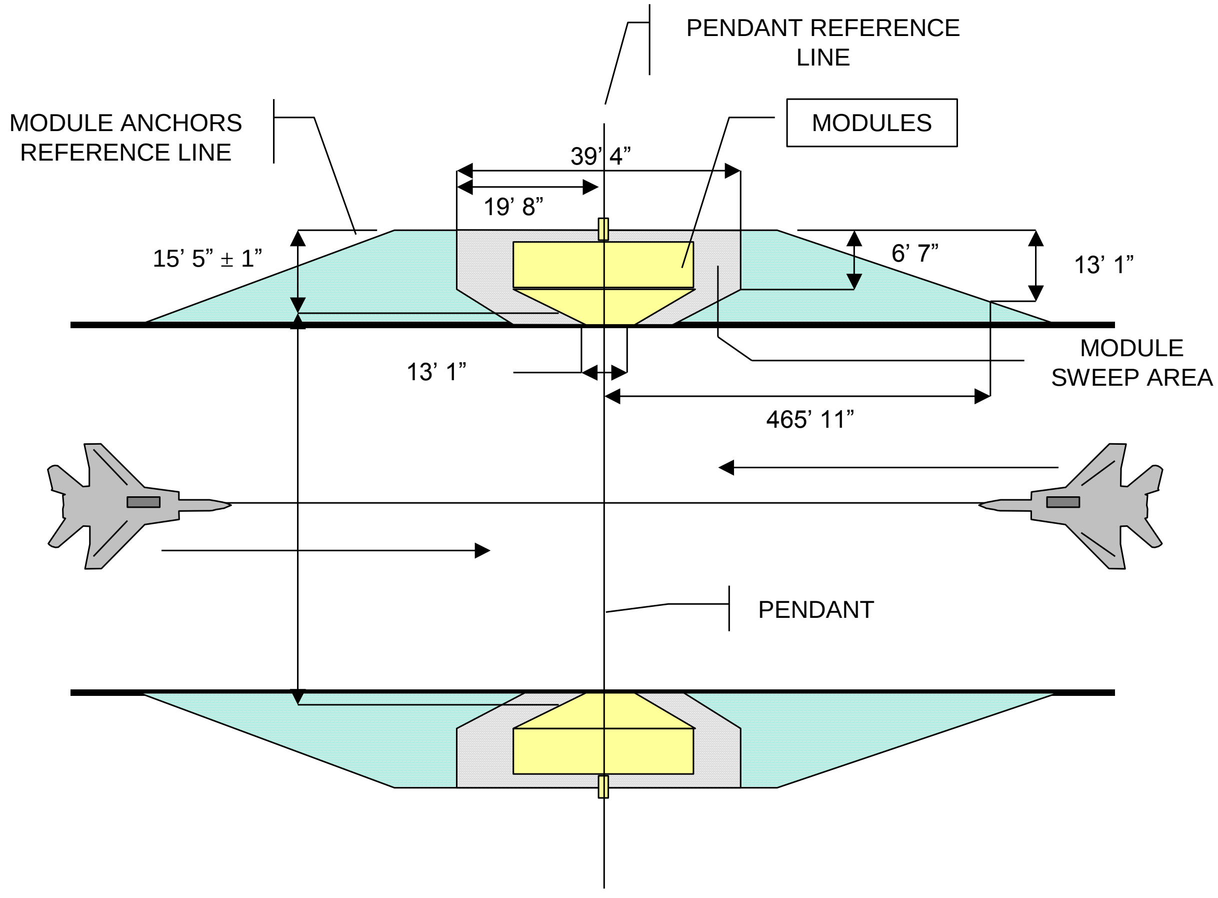
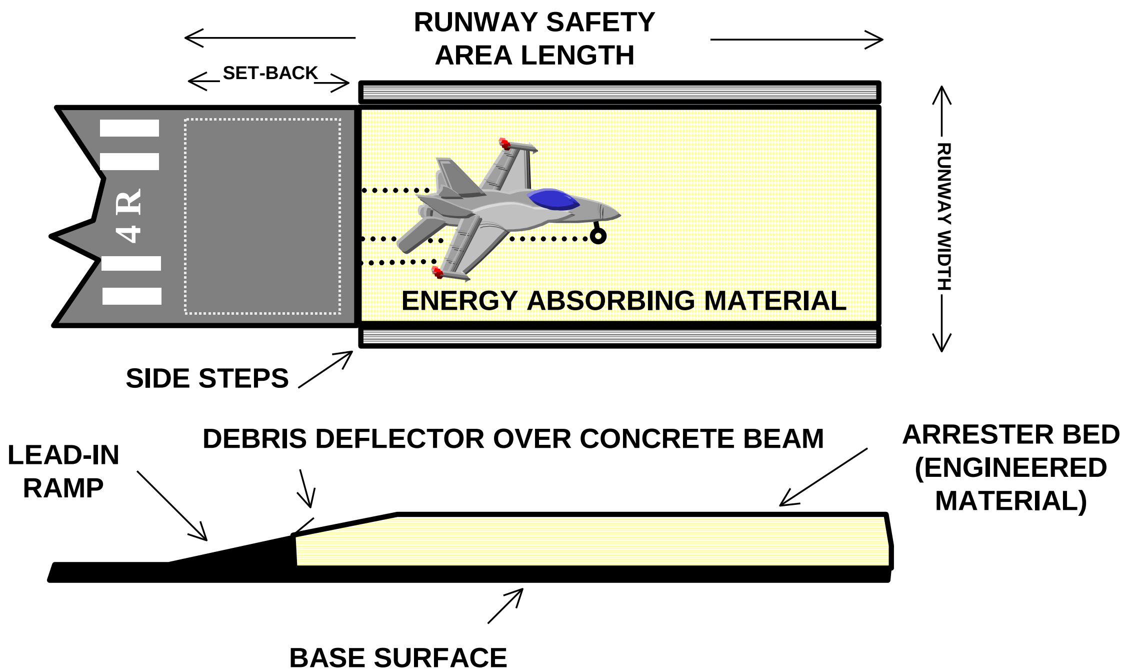


Figure A2.13. Textile Brake, Model MB.



A2.2.11. **Soft Ground Type AAS.** 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 strength 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 A2.14 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 A2.14. Typical Soft Ground Aircraft Arrestor System.



Attachment 3

TYPICAL ARRESTING SYSTEM AND BARRIER CONFIGURATIONS, AND DECOMMISSIONING

A3.1. Configurations. The primary mission aircraft dictates the total number, type, and location of AAS required. The owning MAJCOM of the tailhook-equipped aircraft (or aircraft compatible with net barrier systems) can determine through operational risk management (ORM), runway configuration, proximity to other airfields, and other factors, that the typical configuration of both a runway and overrun system may not be required. Use the following examples for guidance:

A3.1.1. A runway intended primarily for operating tactical or training tailhook-equipped aircraft should typically have an emergency system in each overrun and an operational system at each end of the runway for redundant capability. For some locations at forward operating bases or where snow and ice accumulation warrants, however, two operational systems may be necessary for each runway end and a midfield installation may be needed as well.

A3.1.2. Runways that are prime divert facilities for bases operating tactical or training tailhook-equipped aircraft should typically have an emergency system in each overrun and an operational system on each end of the primary runway.

A3.1.3. Bases that are occasional hosts to arrestment-capable transient aircraft should have an emergency system installed in each overrun of the primary runway or an operational system on each end of the primary runway.

A3.2. Decommissioning. If the mission aircraft assigned to an installation does not require an arresting system complex and removal will not have an impact on other USAF activities, consider decommissioning; however, first follow coordination procedures in Chapter 1.

Attachment 4

SAMPLE FORMAT FOR THE AIRCRAFT ARRESTING SYSTEMS REPORT [RCS: HAF-ILE (AR) 7150]

A4.1. Reporting Guidelines.

A4.1.1. DOD needs an accurate accounting of all AAS to determine worldwide operational capabilities. BCE representatives must ensure that the status and locations of their arresting systems are correct in the DOD FLIP. Report changes in the arresting system array promptly so that others can validate and publish the correction. Report all information in inch-pound units.

A4.1.2. Submit arresting system information to AFCESA at the following address:

AFCESA/CEOA
139 Barnes Drive, Suite 1
Tyndall AFB FL 32403-5319
AFCESA.CEO3333@tyndall.af.mil (E-mail submissions are encouraged.)

A4.2. Report Contents.

A4.2.1. Submit the following information, along with a diagram similar to the diagram in Figure A4.1:

A4.2.1.1. Base name.

A4.2.1.2. MAJCOM or sponsor.

A4.2.1.3. Runway designations.

A4.2.1.4. System type (see Attachment 2).

A4.2.1.5. Length of runway to the nearest 100 feet (threshold to threshold).

A4.2.1.6. Width of runway, in feet.

A4.2.1.7. Length of overrun, in feet (threshold to end of overrun).

A4.2.1.8. Longitudinal location of the arresting system with respect to the threshold, in feet (for example, "plus (+)950" indicates that the system is 950 feet from the threshold on the runway; "minus (-)35" indicates that the system is 35 feet from the threshold into the overrun).

A4.2.2. Describe the arresting system installation characteristics for each system indicated on the airfield scheme using the following notations**:**

A4.2.2.1. AG—above ground.

A4.2.2.2. BG—below ground.

A4.2.2.3. EX1—expeditionary system (BAK-12).

A4.2.2.4. EX2—expeditionary system (MAAS).

A4.2.2.5. IC—barrier interconnected with a hook cable.

A4.2.2.6. RR—remote radio control.

A4.2.2.7. RH—remote hard-wired control.

A4.2.2.8. MO—manually operated barrier net (raised and lowered).

A4.2.2.9. Z—owned by another service, country, or agency.

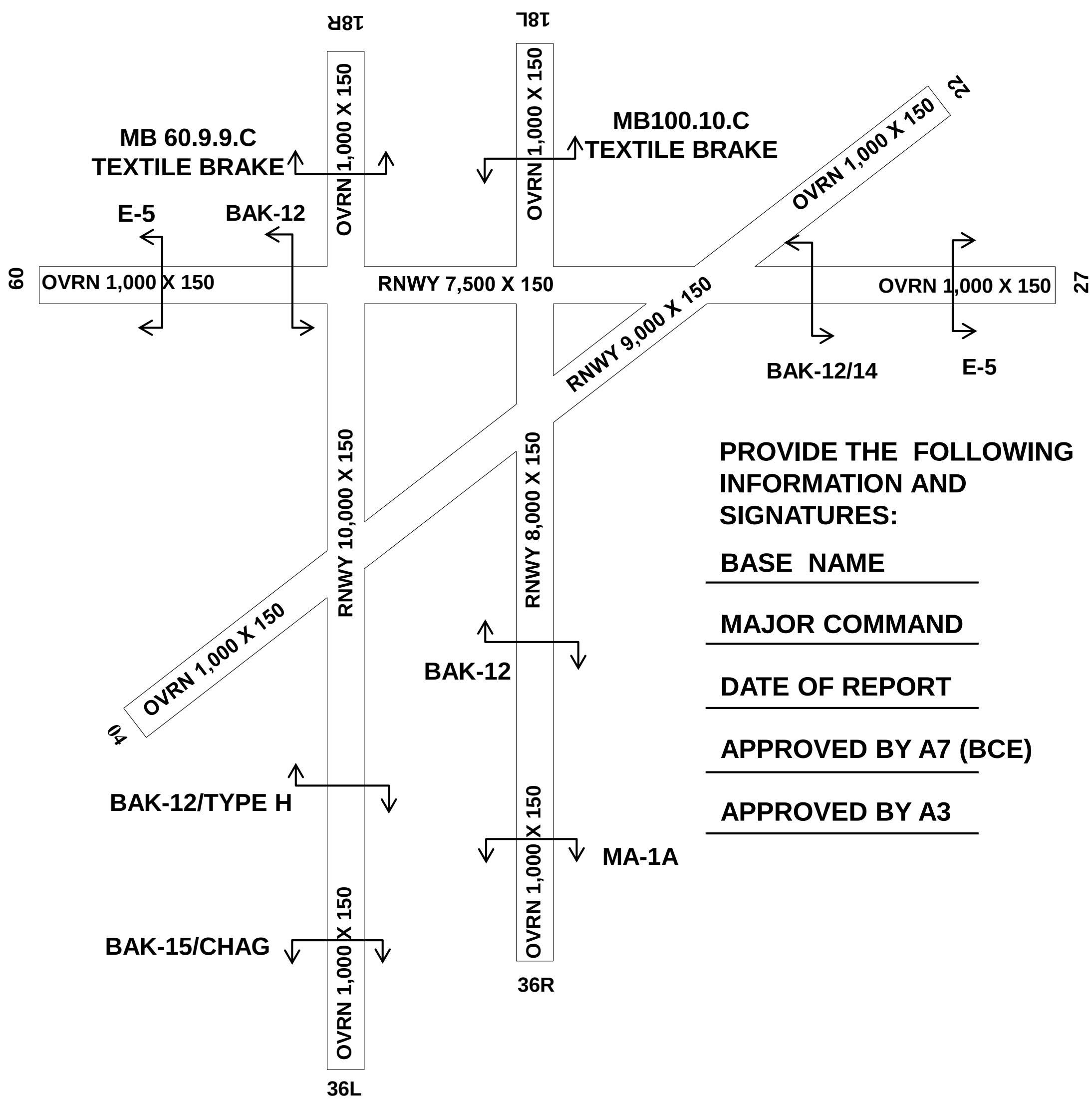
A4.2.2.10. O—out of service, inoperative.

A4.2.2.11. SR—950-foot runout.

A4.2.2.12. ER—1200-foot runout.

A4.2.2.13. NSR—nonstandard runout (indicate runout in feet following code entry).

Figure A4.1. Sample Airfield Diagram for Aircraft Arresting Systems Report.



NOTES:

1. Indicate runway and overrun lengths and widths for all runways as shown above.
2. Indicate runway designations as shown above.
3. Indicate arresting system locations as shown above.
4. Include remarks describing any non-standard configurations or conditions (attach additional sheets as necessary).

Attachment 5

SAMPLE LETTER OF AGREEMENT WITH THE FEDERAL AVIATION ADMINISTRATION (FAA)

AGREEMENT: The [FAA office and address] and [designated MAJCOM] agree to the following provisions for the operation and use of aircraft arresting equipment installed on [designated runway, airport name, and address].

General Provisions:

This agreement describes FAA functions and responsibilities concerning the remote-control operation of arresting systems by FAA air traffic controllers. It governs the use of arresting barriers and hook cable arresting systems for military aircraft and, in an emergency, at pilot request for civil aircraft.

The conditions and procedures described in this agreement become effective when it is signed and dated by the parties and the tower chief receives written notice from the installation commander that one of the following conditions exists:

> The arresting system has been accepted from the contractor and is commissioned and fully operational.
>
> The arresting system is available for emergency use only. If the arresting system has not been accepted from the contractor, this notification must come with a written statement from the contractor authorizing emergency use of the system and waiving any claim against the FAA for damage to the system as the result of such use.
>
> A NOTAM has been issued specifying one of the above conditions. Before receiving the letter from the installation commander, the military crew deenergizes the tower arresting system controls and the chief controller labels them "Inoperative." Tower personnel may not energize the controls under any circumstances.

Automatic arresting systems may be installed on the runway or in the overrun. Control tower personnel raise or lower the barrier or hook cable through a remote-control panel in the control tower.

Air traffic controllers operate the tower arresting system controls at the request of:

> The pilot of any military aircraft (regardless of the Service concerned, type of aircraft, or nature of the operation).
>
> The pilot of a civil aircraft in an emergency, when in commission or emergency use status as described above.
>
> A mobile control unit, the airfield manager, or a designated representative.

The military crew originates NOTAMs covering operational or outage status of a barrier or hook cable. During a NOTAM outage for repair or maintenance, tower personnel operate the controls, provided that the outage NOTAM contains the statement "available for emergency use" and the tower possesses a copy. Otherwise, the military crew deenergizes the tower controls and the chief controller labels them "Inoperative." In this event, tower personnel may not energize the controls under any circumstances.

During NOTAM outages due to failure of controls or when tower personnel advise of malfunction of the system, the military crew at the system site has full and final responsibility for operating the arresting device. The arresting system crew maintains a listening watch on air and ground frequencies and has transmitting and receiving capability with the tower on the ground control frequency keeping personnel informed of the position of the system.

Operations:

Typically, all military aircraft take off and land toward an operational arresting system in the "ready" configuration. The pilot asks the control tower operator to raise or lower the barrier or hook cable. For example, the pilot says "Duluth Tower, Joy 32 on base, gear down and locked, raise cable."

For normal landings, the request involves the approach-end cable.

For normal takeoffs, the request involves the departure-end barrier and cable.

When tower personnel receive a request to raise or lower the barrier or cable, they must inform the pilot of the intended barrier or cable position as part of takeoff or landing information. For example, they say "Joy 32 cleared for takeoff, barrier indicates up."

The pilot may request barrier or cable operating status at any time.

The barrier and cable controls are in the down position except when pilots or other authorized personnel request that either or both be raised.

Tower personnel raise the departure-end barrier and both approach- and departure-end cables for known or suspected radio failure landing by any military arrestment-capable aircraft. Activate the arresting system even if you doubt the aircraft's ability to engage the system.

The standard phraseology for emergency requests to raise the barrier is "barrier, barrier, barrier." The standard phraseology for emergency requests to raise the cable is "cable, cable, cable."

Tower personnel start normal crash procedures when an aircraft engages the barrier or cable if these procedures are not in progress.

When there is a malfunction of the barrier, hook cable mechanism, or remote control system, the tower personnel notify airfield management immediately.

Executed at ______________________________	Dated ____________________________________
For the FAA	For the Air Force
______________________________ (Signed)	______________________________ (Signed)
______________________________ (Title)	______________________________ (Title)

Attachment 6

EFFECTIVE PENDANT HEIGHT (EPH)

A6.1. General.

A6.1.1. Pendant discs must have proper pavement support to ensure adequate clearance between the underside of the pendant cable and the runway surface. Adequate clearance increases the probability that the aircraft tailhook will successfully engage with the arresting system pendant cable. The term for this clearance is the EPH.

A6.1.2. The EPH is the vertical distance (in millimeters or inches) from the underside of the pendant to a projected surface representing the original runway surface. The EPH for an undamaged or ungrooved runway surface is approximately 60 millimeters (2.38 inches) for a 32-millimeter (1.25-inch) pendant cable and 64 millimeters (2.5 inches) for a 25-millimeter (1-inch) cable.

A6.2. EPH Measurements. Measure the EPH along the center third of the runway width at 3-meter (10-foot) intervals or less using an EPH-measuring tool (see Figure A6.1). Manufacture the tool locally for use by the power production shop.

A6.2.1. Start measuring when you notice pavement erosion or grooving and repeat measurements at least monthly. As the EPH approaches 38 millimeters (1.5 inches), take and record measurements daily.

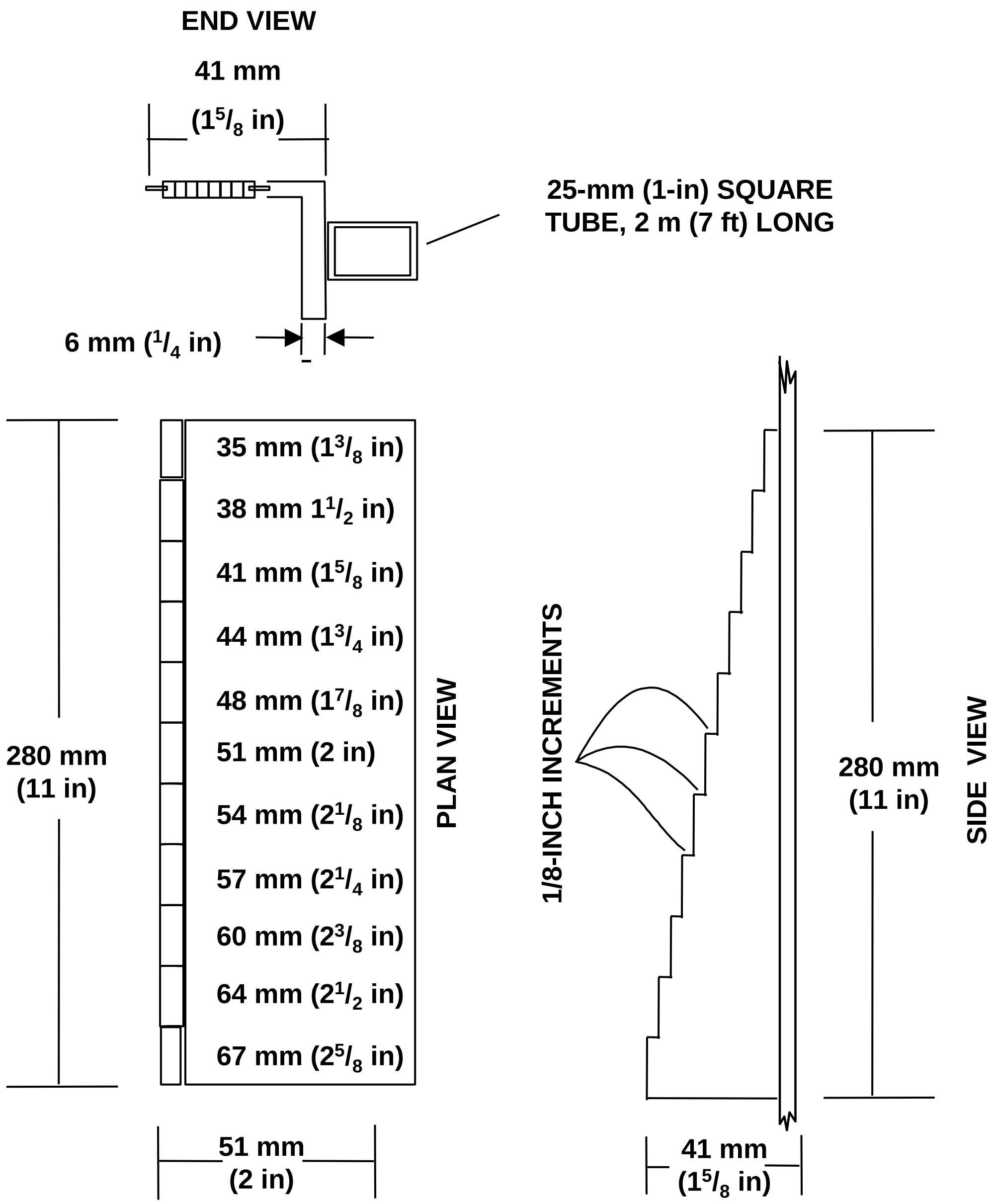
A6.2.2. Record EPH measurements in the arresting system maintenance log, using a sketch to demonstrate the EPH values and the distance to the location where the measurement was taken. Indicate the distance to the left and right of the runway centerline facing the runway approach.

A6.2.3. Arresting system maintenance personnel must notify the MAJCOM representative when EPH measurements become necessary. Provide status reports as changes to the EPH occur.

A6.3. Pavement Repairs. Arrange for pavement repairs when any EPH measurement drops to 44 millimeters (1.75 inches) or less. Make the repair before the lowest EPH drops below 38 millimeters (1.5 inches). Perform emergency repairs (permanent or temporary) when any EPH measurement is less than 38 millimeters (1.5 inches).

A6.4. Notification of Reduced Engagement Reliability. When the EPH falls to less than 38 millimeters (1.5 inches), ask the airfield manager to issue an airfield advisory notifying pilots of the reduced arresting system reliability.

Figure A6.1. Effective Pendant Height Measuring Tool.



EPH MEASURING TOOL CONSTRUCTED FROM 51-mm (2-in) ANGLE STOCK

(NOT TO SCALE)

Attachment 7

OBTAINING A TEMPORARY ARRESTING SYSTEM

A7.1. Continental United States (CONUS) Locations. For CONUS locations, submit requests for temporary use of expeditionary AAS to Headquarters Air Combat Command (HQ ACC) at least two months before the system must be in place and operational. (Air National Guard units request support through the Air National Guard Civil Engineer Technical Support Center [NGB/A7OC], Minot, ND). Typically, HQ ACC only considers requests to support CONUS locations. Coordinate overseas requirements through the appropriate MAJCOM (AFCENT, PACAF, or USAFE). Give the following information in all requests:

A7.1.1. Number of systems needed.

A7.1.2. Reason the systems are needed (including type of aircraft).

A7.1.3. Geographic location of the requirement.

A7.1.4. Date the systems need to be operational.

A7.1.5. Date the systems can be removed.

A7.1.6. Point of contact and telephone number.

A7.2. Operations and Maintenance Personnel. In the request, specify the intended source and the number of qualified personnel who will operate and maintain the expeditionary system at the site. Qualified personnel must attend the systems during all hours of intended operation.

A7.3. Funding Source. The requesting activity must provide a fund citation to cover all costs associated with supporting the expeditionary installation. Include costs for:

A7.3.1. Shipment of the equipment.

A7.3.2. Temporary duty.

A7.3.3. Expendable materials.

A7.3.4. Repair or replacement of damaged items.

A7.3.5. Installation of equipment.

A7.4. Where to Send Requests. Send the information to the appropriate MAJCOM at the appropriate address below (e-mail requests are encouraged):

ACC/A7OI 129 Andrews Street Langley AFB, VA 23665-2769	USCENTAF/A7O 524 Shaw Drive Shaw AFB, SC 29152-5029	NGB/A7OC 3430 2nd St NE Minot, ND 58703-0527
USAFE/A7OI Unit 3050 Box 10 APO AE 09094-3050	PACAF/A7OO 25 E Street Hickam AFB, HI 96853-5412	

A7.5. Processing Time. The appropriate MAJCOM evaluates each request on the basis of availability of personnel, equipment, and priority. It approves or disapproves requests within 10 working days.

Attachment 8

INSTALLATION OF ULTRA-HIGH-MOLECULAR-WEIGHT (UHMW) POLYETHYLENE PANELS UNDER AIRCRAFT ARRESTING SYSTEM CABLES (CONUS, ALASKA, HAWAII AND INSTALLATIONS IN US TERRITORIES)

A8.1. Purpose. This attachment provides instructions for installation of UHMW polyethylene panels under AAS cables. It includes panel specifications and installation and inspection guidelines.

A8.2. Application. Requirements of this attachment are mandatory for new construction of UHMW panel installations. Designers should also consider thickened slabs under UHMW panels for new construction to ensure adequate runway pavement strength and sufficient anchoring depth for studs and tie-downs are provided. Installation of UHMW panels is the preferred method of repair for existing pavements; other repair options may be justified based on economy or mission.

A8.3. Specific Requirements. AAS cables impact underlying pavement, eroding grooves in the pavement; the pendant support disks (donuts) supporting the cable sink into the grooves, lowering the cable. When the EPH is below 38 millimeters (1.5 inches) the aircraft tailhook may miss the cable. These areas must be repaired to maintain a uniform pavement surface and the proper EPH to ensure reliability of the arresting system.

A8.4. Criteria for Repairs:

A8.4.1. Materials must; (1) install easily, and; (2) not warp or erode.

A8.4.2. Method must be cost-effective.

A8.5. Background and Best Practices.

A8.5.1. **Bonded Partial-Depth Inlays.** The Air Force has used numerous cementitious, epoxy, and polyurethane-based materials under arresting system cables. Performance varies from satisfactory to very poor, even with the same material. Most of these repairs have been costly and/or eroded quickly.

A8.5.2. **Preformed Panels.** The Air Force has tested non-UHMW preformed panels with only limited success—panels warp and their edges protrude above the adjacent runway pavement, causing the aircraft tailhook to skip over the cable. It has been established that in cases where preformed panels are the best repair option, UHMW panels should be specified. Further, it is absolutely critical to keep panels flush with, or, preferably, slightly recessed (1.6 to 3.2 millimeters [0.0625 to 0.125 inch]) below the adjacent pavement surface. Thermal compatibility of the panel material, the anchoring system, and the adjacent pavement is extremely important; if possible, plan to install the panels and sealant during average temperatures to allow for optimum sealant placement. If the panels are placed in cold weather the joints will tend to close completely in hot weather. If placed in hot weather the joints will tend to be too wide during cold weather. It is desirable to use light-gray colored panels to help minimize thermal expansion and contraction (see preferred panel colors in Figure A8.1).

Figure A8.1. Preferred Panel Colors from Federal Standard 595, Colors Used in Government Procurement.

36173		Low solar absorbent gray #17
36231		Gray #23 (36231 replacement of MIL-MIL-DTL-700, Formula 20L)
36270		Low solar absorbent gray #27 (also with anti-stain properties)
36307		Gray #30 (Bulkhead gray)
36373		Low solar absorbent gray #37 (Light gray, color#26373)
36492		Gray #49 (Gull or pearl gray)

A8.5.2.1. When considering the installation of UHMW panels it is important to verify thickness of the existing pavement. The panels must be anchored in a solid concrete bed. A typical anchor stud is 245 millimeters (9.625 inches) long and the receiving slot is drilled slightly deeper. A minimum slab thickness of 280 millimeters (11 inches) is recommended to properly anchor the panels.

A8.5.2.2. If the existing concrete is not thick enough you must replace it with adequate thickness concrete prior to UHMW panel installation or select alternative repair methods.

A8.5.3. **Installation in Flexible Pavement Systems.** For installation in asphalt pavement, saw-cut and remove a minimum 635-millimeter (25-inch) -wide section of the asphalt as well as the underlying materials to a depth of 915 millimeters (3 feet). Backfill the bottom of the trench with a well-graded crushed stone material and compact to a 305-millimeter (12-inch) thickness in 150-millimeter (6-inch) lifts then pour the concrete foundation (approximately 570 millimeters [22.5 inches] thick) for panel installation. Care must be taken to ensure that the concrete foundation is finished level enough and at the proper depth for panel installation. Once the concrete is cured, proceed with installing and anchoring the panels as outlined in this attachment. This is a repair procedure for an existing asphalt pavement. If installing UHMW panels in conjunction with construction of new pavement (or reconstruction of an existing pavement), the design may differ; however, the above procedure is recommended.

A8.6. Technical Specifications for UHMW Polyethylene Panels.

A8.6.1. **Referenced Documents.** ASTM Standards:

A8.6.1.1. ASTM C886, *Standard Test Method for Scleroscope Hardness Testing of Carbon and Graphite Materials*

A8.6.1.2. D256-06ae1, *Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics*, Test Method A.

A8.6.1.3. D638-08, *Standard Test Method for Tensile Properties of Plastics*.

A8.6.1.4. D696-08, *Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between –°C and 30 °C with a Vitreous Silica Dilatometer*.

A8.6.1.5. D1505-03, *Standard Test Method for Density of Plastics by the Density-Gradient Technique*.

A8.6.1.6. D3028, *Standard Test Method for Kinetic Coefficient of Friction of Plastic Solids* (Discontinued 2000).

A8.6.1.7. D2240-05, *Standard Test Method for Rubber Property—Durometer Hardness*.

A8.6.1.8. Federal Standard 595, *Colors Used in Government Procurement*.

A8.6.2. **Panel Dimensions and Anchor Stud Locations.**

A8.6.2.1. **Panel Dimensions.** Tolerance on panel length and width will be ±3.2 millimeters (±0.125 inch). Panel thickness will be no greater than 38.1 millimeters (1.5 inches) or less than 36.5 millimeters (1.4375 inches).

A8.6.2.2. **Anchor Stud Hole Locations and Dimensions.** Each full-sized panel will have six anchor stud holes centered 102 millimeters (4 inches) from the edge of the panel. Each partial-sized panel will have four anchor stud holes centered 102 millimeters (4 inches) from the edge of the panel. The anchor stud hole will be 25.4 millimeters (1 inch) for the through hole and 51 millimeters (2 inches) for the countersink hole. The countersink hole will be 22 millimeters (0.875 inch) deep with square shoulders for a flat washer to lie firmly against. Figure A8.2 shows dimensions and drilling details. Tolerances on dimensions for locations and diameters of anchor holes will be ±1.6 millimeters (±0.0625 inch).

A8.6.3. **Holes for Cable Tie-down Anchors.** The agency ordering panels will specify if cable tie-down anchor holes are required and the number of panels that will be furnished with cable tie-down anchor holes. The cable tie-down anchor hole will be 102 millimeters (4 inches) in diameter and drilled completely through the panel. Cable tie-down anchor holes will be located in the center of the panel. The location of the cable tie-down anchor hole is shown in Figure A8.2. The number of tie-down anchors required should be provided by the MAJCOM AAS engineer. Cable tie-downs will not be located closer than 305 millimeters (12 inches) from existing pavement joints. Partial-sized panels will not receive holes for cable tie-down anchors.

A8.7. Material.

A8.7.1. The panels will be fabricated from virgin and/or recycled UHMW polyethylene and will be black in color and UV-stabilized. An antistatic additive will be added to the UHMW polyethylene.

A8.7.2. The UHMW polyethylene must meet the physical requirements of Table A8.1.

Table A8.1. Physical Requirements of UHMW Polyethylene.

Property	Test Method	Requirement
Density	ASTM D1505	0.92–0.94 g/cm
Tensile elongation at break	ASTM D638	300–400 percent
Tensile yield strength	ASTM D638	2800–4000 psi
Shore hardness "D"	ASTM C886	60–70
Coefficient of friction	ASTM D3028	0.2
Izod impact strength	ASTM D256, Method A (see Note)	>20 ft-lb/inch
Note: The test specimens must have two opposing 15-degree notches.		

A8.8. Guidelines for Panel Sizing and Preparation.

A8.8.1. **Panel Dimensions.** Uncut panel stock is 1220 millimeters (48 inches) wide by 3048 millimeters (10 feet) long by 38 millimeters (1.5 inches) thick. Typically, at least five panels can be cut from the 3048-millimeter (10-foot) -long stock with minimal waste. Determine whether a partial or full runway width installation is desired then size, or order panels sized, to avoid material waste.

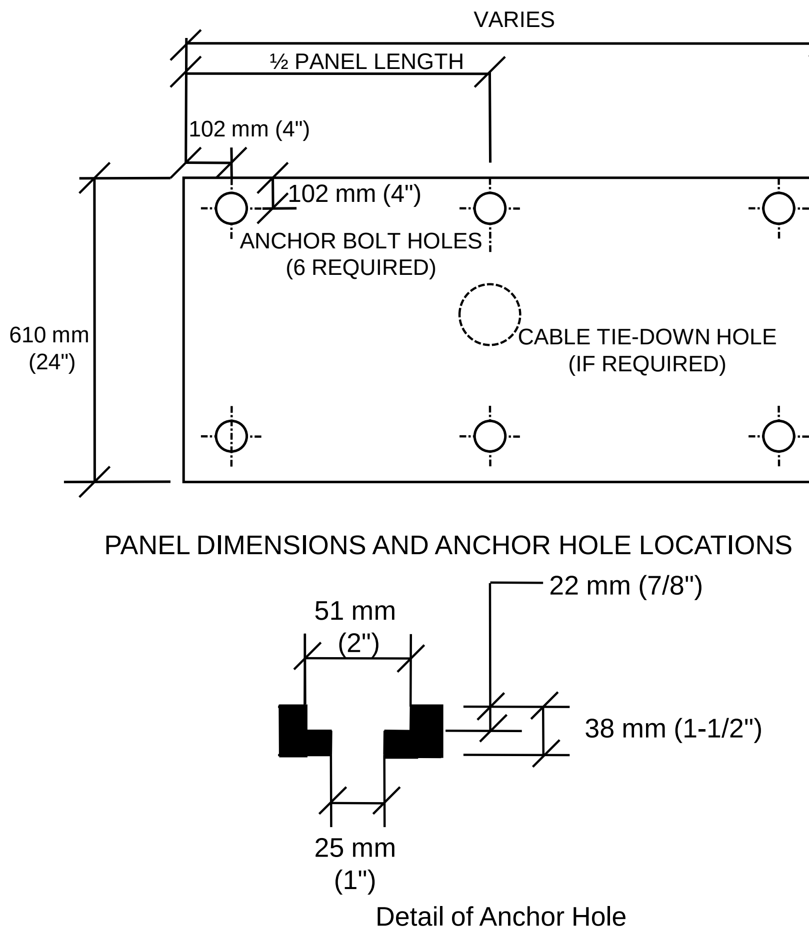
A8.8.2. **Length.** Cut panels to allow joints between panels to line up with runway pavement joints. For runways with slabs sized in 1524-millimeter (5-foot) increments, such as those having 6-meter (20-foot) longitudinal paving lane joint spacing, panels should be 1207 millimeters (3 feet, 11.5 inches) long. Panels may be shorter but must never exceed 1219 millimeters (4 feet). Recommended joint space between panels is 13 millimeters (0.5 inch). In all cases, particularly at oversea installations, the existing slab sizes should be verified before ordering materials and the panels should be sized so the joints between panels line up with the existing pavement joints. Panels should never straddle pavement joints and should not be positioned in a way that would allow the anchor studs to fall in existing pavement joints.

A8.8.3. **Width.** To reduce panel warping and damage to joints from cable impact, panels should be a nominal 610 millimeters (24 inches) wide for all installations.

A8.8.4. **Thickness.** Panel thickness should not be less than 36.5 millimeters (1.4375 inches) nor more than 38.1 millimeters (1.5 inches).

A8.8.5. **Panel Finishing.** The panel supplier should pre-drill holes in panels (for anchor stud installation) in accordance with Figure A8.2.

Figure A8.2. Panel Dimensions and Anchor and Tie-down Locations.



A8.8.6. **Cable Tie-downs.** The MAJCOM AAS engineer will specify the required number and spacing of tie-down anchors. Predrill an appropriate number of panels with 102-millimeter (4-inch) -diameter holes to allow tie-down anchor installation. Tie-down anchors should be located in the center of full-size panels.

A8.9. Guidelines for Pavement Preparation and UHMW Panel Installation.

A8.9.1. **General Procedures.** The procedure to install UHMW panels under arresting system cables involves the following major steps:

A8.9.1.1. Prepare the receiving slot.

A8.9.1.2. Place a cementitious setting bed.

A8.9.1.3. Install the UHMW panels.

A8.9.1.4. Install panel anchor studs.

A8.9.1.5. Install new cable tie-down anchors.

A8.9.1.6. Seal the joints.

A8.9.2. **Prepare Receiving Slot.**

A8.9.2.1. **Remove Concrete.** The dimensions of the area of concrete removed depend upon the number of panels installed. For example, for a runway with 3.8-meter (12.5-foot) slabs, each full panel is 1076 millimeters (42.375 inches) long by 610 millimeters (24 inches) wide, and partial panels are 530 millimeters (20.875 inches) long and 610 millimeters (24 inches) wide, with 13-millimeter (0.5-inch) gaps between panels. Therefore, for a 22.86-meter (75-foot) -long inlay of 18 full panels and six partial panels across the runway (11.4 meters [37.5 feet]) on each side of the runway centerline, the saw cut area must be:

A8.9.2.1.1. 22.87 meters (75 feet, 0.5 inch) long.

A8.9.2.1.2. 635 millimeters (25 inches) wide.

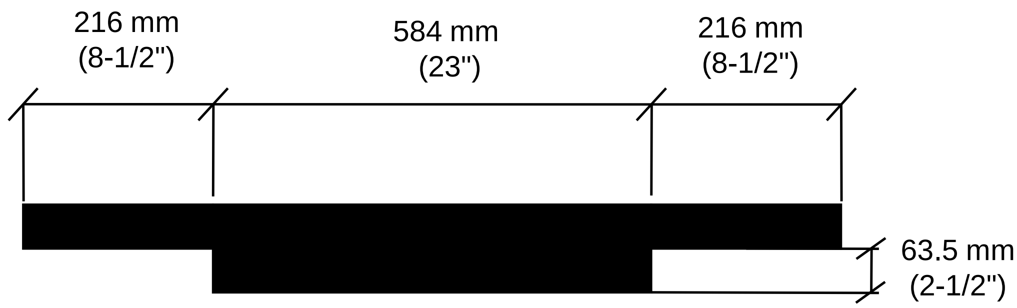
A8.9.2.1.3. At least 64 millimeters (2.5 inches) deep.

A8.9.2.1.4. An installation extending completely across a 46-meter (150-foot) -wide runway requires 36 full panels and 12 partial panels. **Note:** For partial-runway-width installations, provide a means of drainage for the receiving slot to prevent damage from trapped water or dirt that may enter at leaks in the joint seals. Several saw cuts made to run from the ends of the inlay to the shoulders and cut at the same depth as the receiving slot will typically suffice.

A8.9.2.2. **Perimeter Cuts.** Perimeter saw cuts must be 76 millimeters (3 inches) deep and overlap at least 76 millimeters (3 inches) to ensure that corners are perfectly square when pavement is removed. Remove all loose, unsound concrete within the area. Additional saw cuts inside the perimeter will make removing the concrete easier (using chipping hammers) and result in a more uniform concrete profile.

A8.9.2.3. **Inspect Receiving Slot Following Concrete Removal.** With a notched board (Figure A8.3), check the depth of the concrete within the recessed setting bed. Use a chipping hammer to remove any portions less than 64 millimeters (2.5 inches) from the surface of the adjacent pavement then visually check the concrete, sound it with a steel rod to identify any unsound portions, and remove all unsound concrete.

Figure A8.3. Notched Board Used to Check the Receiving Slot.



A8.9.2.4. **Remove Existing Tie-down Anchors.** Cut existing AAS cable tie-down anchors flush with the bottom of the concrete substrate before placing the setting bed.

A8.9.2.5. **Clean Concrete Substrate.** Upon removal of concrete from the slot, it is important to adequately clean the slot to ensure the new setting bed material will adhere to the substrate. Particular care should be taken to remove the laitance from the smooth faces of the sawcut walls; sandblast or use wire brushes, followed by compressed air.

A8.9.3. **Place a Setting Bed.** Place a cementitious setting bed under the panels and allow the bed to cure before drilling and anchoring the panel anchor studs. Use ordinary PCC at airfield strength (34,474 kPa [5,000 psi] compression/4,482 kPa [650 psi] flexural strength in 28 days) when several hours' cure time is available.

A8.9.3.1. As a suggested mix, use:

A8.9.3.1.1. A lean seven-bag mix with 10-millimeter (0.375-inch) maximum size aggregate.

A8.9.3.1.2. Water-to-cement ratio not to exceed 0.3:1.

A8.9.3.1.3. Plasticizer admixture.

A8.9.3.1.4. Substitute fly ash for -50 sieve size sand as required.

A8.9.3.1.5. This mixture will allow drilling within 18 to 24 hours. For short-cure-time applications, a prepackaged material such as Rapid Set® Concrete Mix is satisfactory. Rapid Set Concrete Mix is packaged in 27-kilogram (60-pound) bags that yield approximately 0.014 cubic meters (0.5 cubic foot) of concrete when mixed with water (refer to Table A8.3 for ordering information). Placing a small test sample in a disposable pail the same depth as the setting bed may also serve as a helpful tool in determining adequate cure time for drilling operations.

A8.9.3.2. **Mixing Equipment Placement.** Position two mechanical mortar or concrete mixers approximately 6 meters (20 feet) from the prepared inlay near the center of the runway. Transport mixed mortar in a wheelbarrow. Mortar mixers are preferred. Depending upon the type of material used, drum mixers may not agitate the material enough to produce the desired workability when the recommended amount of water is used.

A8.9.3.2.1. **Mixing and Placing Procedure for Rapid Set Concrete Mix.**

A8.9.3.2.1.1. Place 2.8 to 3.8 liters (3 to 4 quarts) of water in the mixer. In hot climates, using cold water can extend the setting time of the mix. In cold climates, using hot water and heating the substrate may shorten the setting time.

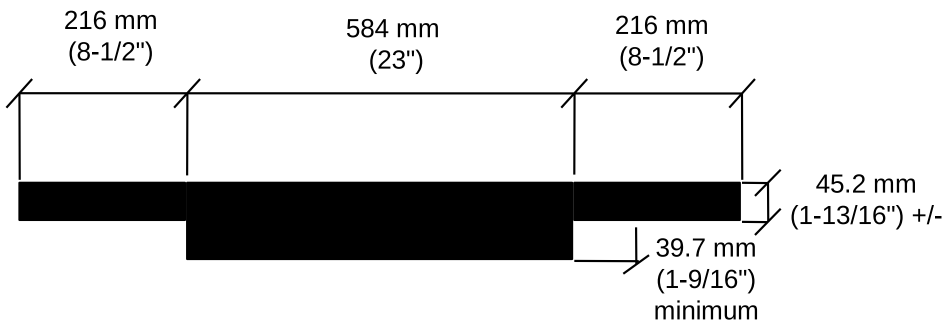
A8.9.3.2.1.2. Add one bag of Rapid Set Concrete Mix and mix for two to three minutes. Note that this mix "wets" slowly. Do not add more water until the full mixing time has elapsed. Over-wetting will weaken the final mix. Place the material within 10 minutes after mixing. If temperature is above freezing, wet the substrate first. If below freezing, do not wet the substrate.

A8.9.3.3. **Finishing.** Finish the material from the center of the bed to the edges to achieve proper bonding along the side walls of the excavation.

A8.9.3.4. **Curing.** After initial set, when the surface becomes hard to the touch, fog- or spray-mist-cure with water for one hour. Do not add an excessive amount of water. Over-wetting will weaken the setting bed.

A8.9.4. **Leveling the Setting Bed.** Mechanically vibrate or jitterbug the concrete before screeding to consolidate the mass. Even simple hand-tamping with a garden rake greatly reduces the percent of voids in the mix. Level the concrete to the proper depth in the setting bed using a notched screed board (Figure A8.4). Strike the screed periodically to ensure proper depth and uniform surface. The 39.7-millimeter (1.5625-inch) depth of the screed board is based upon a panel thickness of 38 millimeters (1.5 inches). Measure the actual thickness of each panel upon delivery to ensure they are all the same thickness and to establish the required screed dimensions. The setting bed must be level and of the proper depth to correctly support the panels. A properly placed setting bed will help avoid a lot of aggravating manual labor. A setting bed that is not level or is placed at an improper depth requires excessive grinding of the pavement and/or shims, or may require grinding of the adjacent pavement surfaces. Shims should be used as a last resort, not planned into the job. When required, the shim stock should be a nonferrous metal and should be sized to provide full surface support for the panel, not just point support at the anchor locations.

Figure A8.4. Notched Screed.



A8.9.5. **Joints.** Extend existing pavement joints through the setting bed by saw-cutting or using an expansion board. The saw cut should be a single blade-width and extend completely through the setting bed. Expansion boards must be set the full depth of the setting bed.

A8.9.6. **Install UHMW Panels.** Install panels in accordance with the following:

A8.9.6.1. Allow the setting bed to harden (approximately 4 hours, depending on the type bed used) to the minimum strength that allows drilling without spalling the concrete.

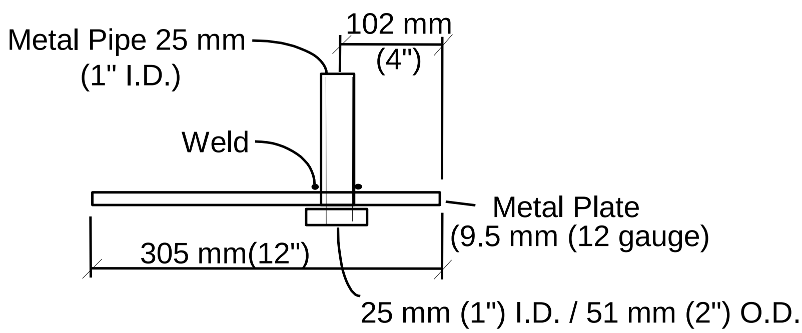
A8.9.6.2. Lay the panels in place and inspect to ensure that the top surface of the panel is at least 1.6 millimeters (0.0625 inch) lower than the adjacent pavement surface. Grind the bedding material or panel edges as necessary so that the panel surface is slightly recessed (1.6 to 3.2 millimeters [0.0625 to 0.125 inch]) below the adjacent pavement surface. Panel height is especially critical in the center half of the runway.

A8.9.6.3. Set spacing between panels using a 13-millimeter (0.5-inch) -thick board and secure all panels in place with wood wedges (minimum four sets per panel) to prevent panels shifting during drilling of anchor stud holes. UHMW panels contract and expand greatly with temperature changes. The panels should be placed and anchored at the medium temperature for the given location to allow for movement either way with temperature changes.

A8.9.7. **Install Panel Anchor Studs.** (For a list of required tools and equipment, see Table A8.2.)

A8.9.7.1. **Drill Holes.** Position the locally fabricated alignment tool (Figure A8.5) over each predrilled hole in the panel and drill 22-millimeter (0.875-inch) -diameter holes in the setting bed. Not all anchor studs are consistent in length as ordered, so check actual anchor stud lengths and drill to accommodate the longest stud. The depth of the hole is critical—if it is not deep enough, the stud will protrude above the panel surface and require excessive grinding; if it is too deep, the adhesive capsule will be positioned below the stud and not provide adequate coverage. Use a drill-mounted depth gage rod or mark a position on the drill bit shaft the length of the stud plus the depth of the alignment tool to ensure proper hole depth when drilling.

Figure A8.5. Alignment Tool (Anchor Drill Guide).



A8.9.7.2. **Clean Drilled Holes.** Thoroughly clean debris from the drilled hole with a round wire brush and compressed air. A 9- to 13-millimeter (0.375- to 0.5-inch) -diameter tube attached to the compressed air line is necessary to remove all fines from the holes. Insert tubing to the bottom of the hole to ensure all particles are removed.

A8.9.7.3. **Install Anchor Studs.** Install each anchor stud as described below. To avoid work stoppage while the adhesive cures, have at least 12 cap nuts available for setting anchors.

A8.9.7.3.1. Insert an adhesive capsule into each hole with the rounded end facing the bottom of the hole. Screw a cap nut (or other manufacturer-provided adapter) onto the end of the anchor bolt and attach the unit to a heavy-duty drill (or rotary impact hammer). Insert a flat washer onto the threaded stud just below the adapter, or position the washer over the panel hole inside the countersink. Drive the anchor stud slowly to the end of the hole and continue slowly rotating the stud in the hole for approximately 15 seconds to mix the adhesive and work it up the anchor. Once the anchor stud is in position, do not disturb it until the adhesive is cured. Allow the adhesive to cure (approximately one hour or as recommended by the manufacturer) to the point where the cap nut can be removed without disturbing the stud position.

A8.9.7.3.2. Remove cap nut and flat washer; seal around stud with silicone sealant; reinsert flat washer; and attach lock washer and nut to top of anchor stud.

A8.9.7.3.3. Allow adhesive to fully cure according to the manufacturer's instructions and then torque the nuts to 81 newton meters (N·m) (60 pound feet [lb ft]).

A8.9.7.3.4. Grind off any portion of a stud that protrudes above the panel surface.

A8.9.8. **Installing New Cable Tie-down Anchors.** The MAJCOM AAS engineer will prescribe the number and spacing of cable tie-down anchors required. Each cable tie-down anchor hole will be located in the center of the appropriate installed panel. When installing cable tie-downs, ensure the top of the tie-down is at least 5 millimeters (0.1875 inch) (recommend 13 millimeters [0.5 inch]) below the final panel surface height. Depending on the location of existing runway pavement joints in relation to the runway centerline and the longitudinal joint spacing, UHMW panels may be installed with a panel joint or panel center falling on the runway centerline. Figures A8.5 through A8.9 depict recommended cable anchor tie-down locations when installing standard full-sized and partial panels in various slab sizes. The partial panels are required to permit acceptable tie-down spacing and to avoid overlapping joints in the existing slabs. For installation in slabs sized other than those shown, consult the MAJCOM AAS engineer. Use eight-point tie-down configurations for F-16 and C-130 aircraft operations; use four-point configurations for all other aircraft operations.

Figure A8.6. Cable Tie-down Locations for Panels Placed on 3.8-Meter (12.5-Foot) Slabs.

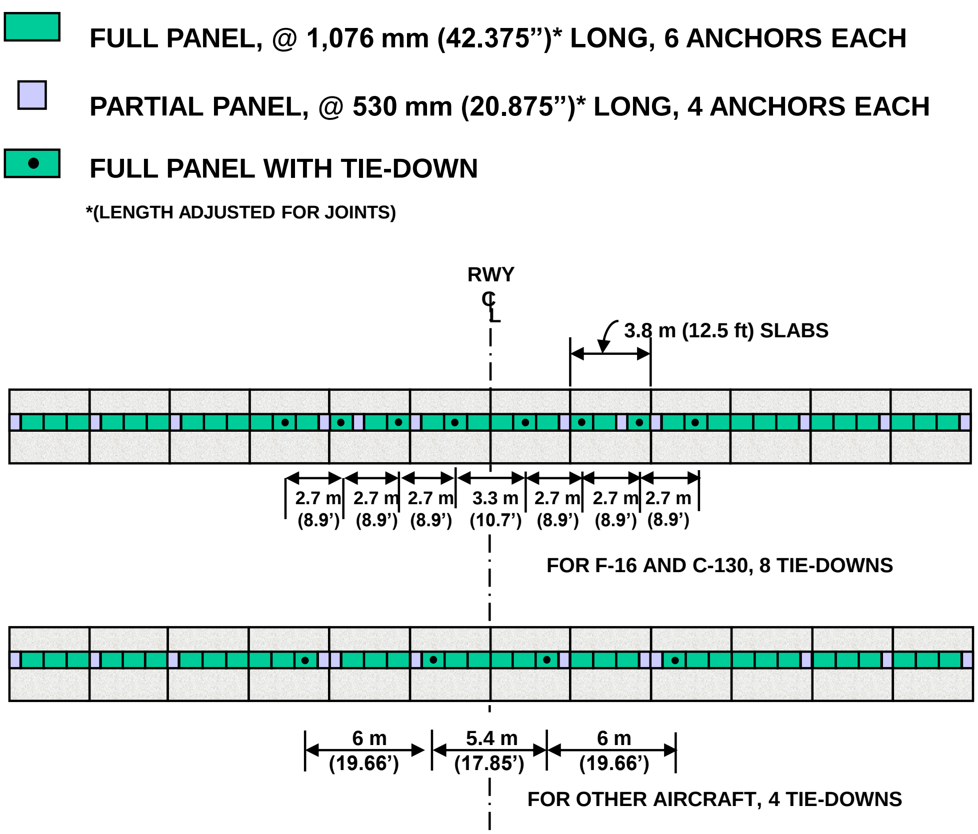


Figure A8.7. Cable Tie-down Locations for Panels Placed on 4.6-Meter (15-Foot) Slabs.

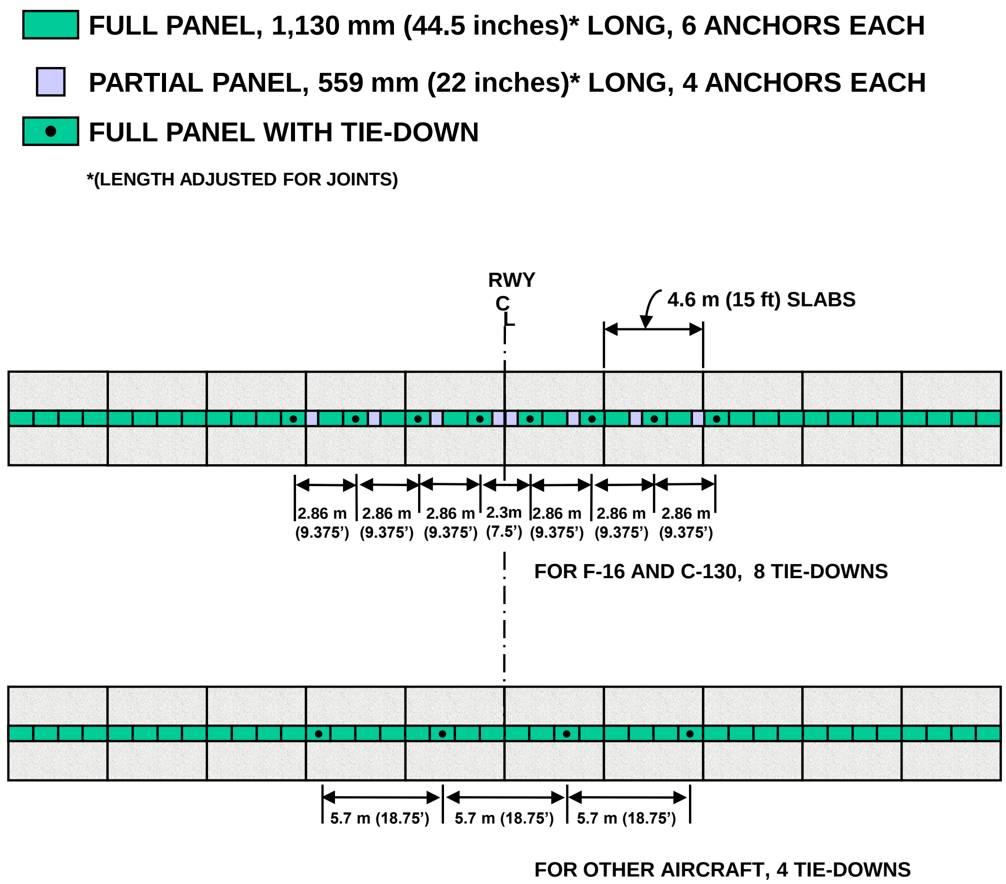


Figure A8.8. Cable Tie-down Locations for Panels Placed on 5.7-Meter (18.75-Foot) Slabs.

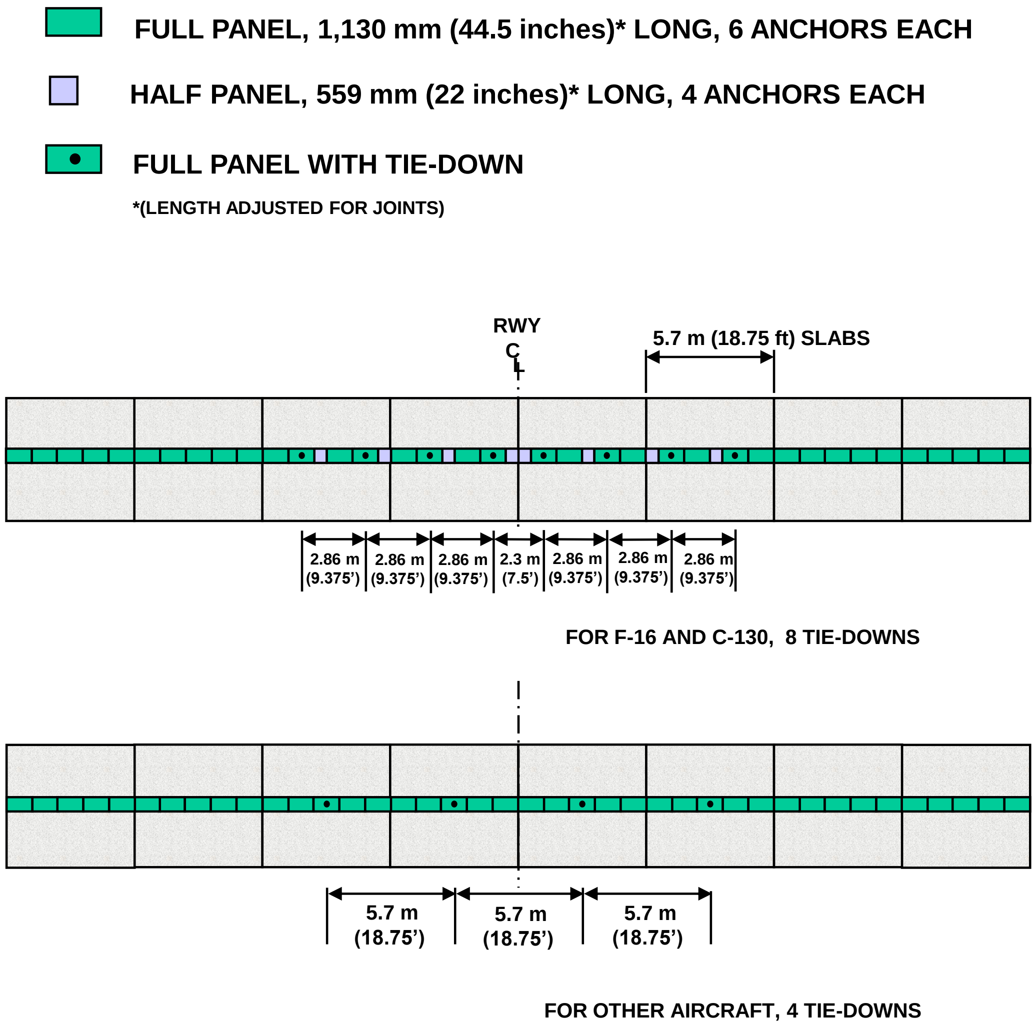
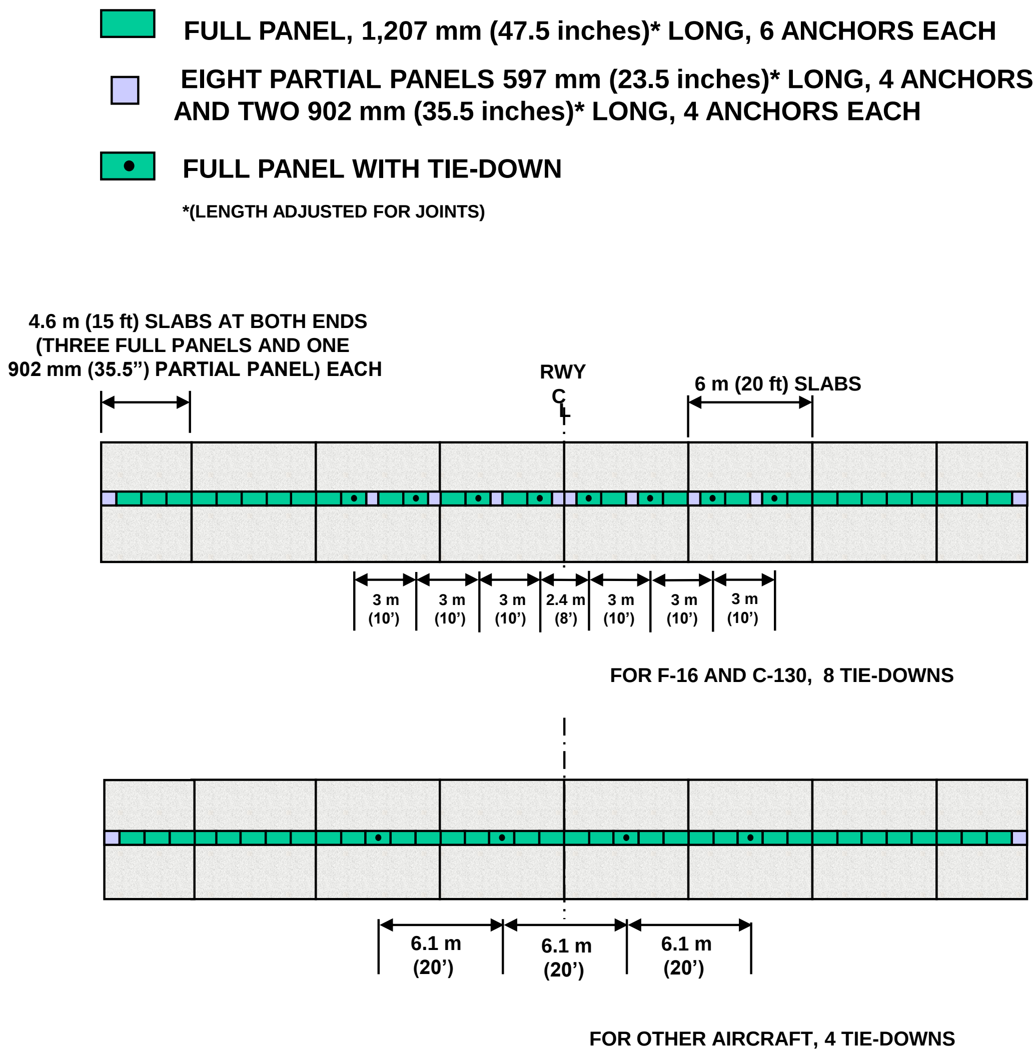
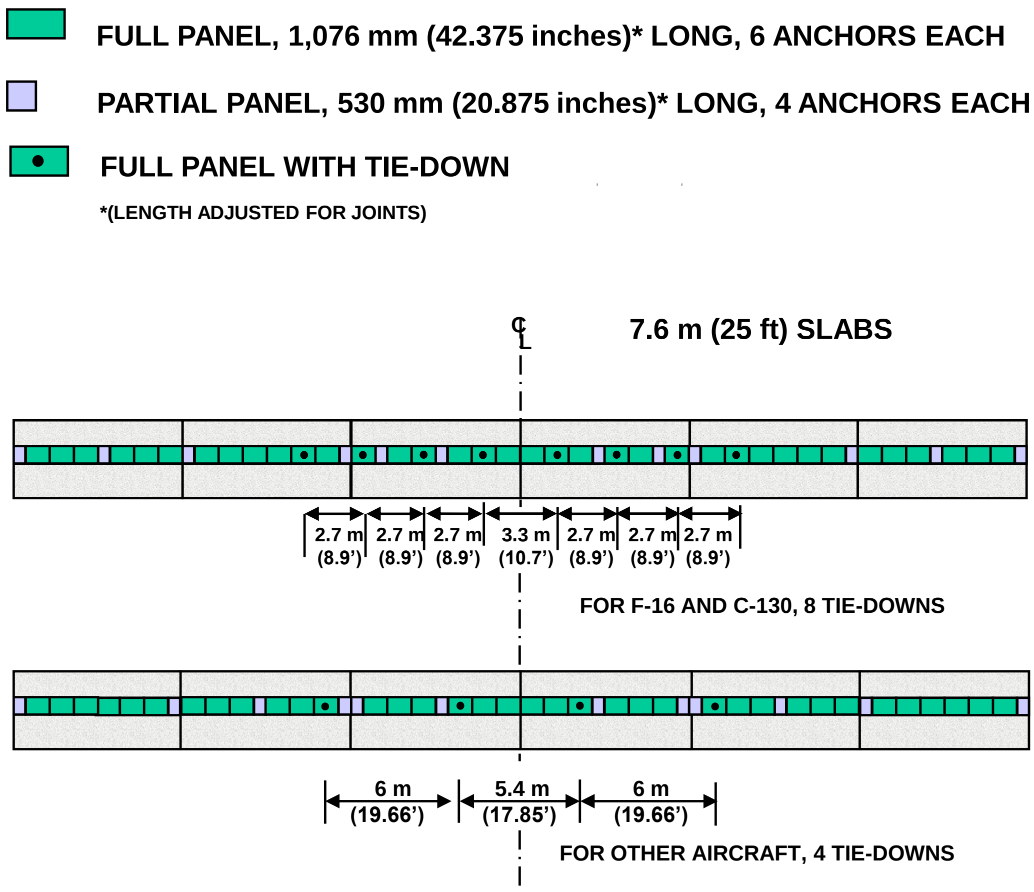


Figure A8.9. Cable Tie-down Locations for Panels Placed on 6-Meter (20-Foot) Slabs.





A8.9.9. **Sealing Joints.**

A8.9.9.1. Apply joint sealant in spacing between and around panel edges, recessed 6.35 millimeters (0.25 inch) below the panel top surface. Joint sealants do not adhere well to UHMW panels and joints should be inspected frequently. Silicone sealants should be used in lieu of hot-pour asphalt or tar sealants. Silicone sealants are suitable for climates with wide temperature ranges and develop a low elastic modulus which allows good extension and compression recovery; this is important due to the contraction and expansion properties of the panels.

A8.9.9.1.1. The size of the backer rod is also complicated due to the expansion properties of the panels. The spaces between panels should be noted while the panels are in their contracted state to prevent installing undersized backer rods that allow the sealant to flow underneath.

A8.9.9.1.2. A non-shrinkable, non-absorbent, highly compressible foam backer rod should be used, sized to span the maximum expected gap but placed at the medium temperature and set at a depth to ensure a proper shape factor is created for the sealant reservoir.

A8.9.9.2. Joints should be resealed just prior to onset of cold weather to prevent moisture accumulation and freezing below panels. Freezing below panels may result in panel failure, anchor failure, or excessive panel warping.

A8.10. Guidelines for Inspection. Installations should establish formal procedures to ensure satisfactory performance of UHMW panels. UHMW panels should be inspected daily and monthly for effects of aircraft traffic and thermal movement (expansion/contraction/warping) in accordance with the following.

A8.10.1. **Daily Inspection.** Panel inspection should be added to the daily arresting system inspection by power production personnel. Visually check for panel buckling, warping, and surface variations.

A8.10.2. **Weekly Inspection.** Check for panel buckling, warping, and surface variations by placing a steel straightedge on top of each panel parallel to the runway centerline at:

A8.10.2.1. Each joint between panels.

A8.10.2.2. At least two locations within each panel.

A8.10.2.3. Any other location that appears raised or irregular.

A8.10.2.4. The straightedge must be long enough to overlap the pavement on each side of the panel by a minimum of 305 millimeters (12 inches). Immediately report raised edges or high spots exceeding 3.2 millimeters (0.125 inch) above the plane of the adjacent runway to the installation pavements engineer and to the MAJCOM AAS engineer for further evaluation. Take color photographs to document findings.

A8.10.3. **Monthly Inspection.** The installation pavements engineer should participate once each month in the daily inspections with the power production personnel. Record all panel conditions, including (but not limited to):

A8.10.3.1. Erosion/EPH.

A8.10.3.2. Distresses.

A8.10.3.3. Warping/curling.

A8.10.3.4. Soundness.

A8.10.3.5. Delamination.

A8.10.3.6. Anchor stud effectiveness. Note that anchor stud nuts may be over-torqued if tightened repeatedly. Consider using a thread-locking or seizing compound such as Loctite® products on nuts that continually loosen. Report any significant deterioration or problem to the MAJCOM immediately for further evaluation.

A8.10.3.7. Joint seal performance.

A8.10.3.8. Spalling.

Table A8.2. Typical Tools and Equipment for Installation.

Quantity	Unit	Description
1	each	Concrete saw, self-propelled
1	each	Hand-held portable saw
2	each	Saw blades
1	each	Water distributor

Quantity	Unit	Description
50	LF	Expansion board, asphalt impregnated, 102 mm x 13 mm (4 in. x 0.5 in.)
3	each	Mortar mixer, 4 cubic feet (two for use, one spare)
1	each	Sandblast unit for air compressor
3	each	Jackhammer, 40 kg (90 lb), with chisel and spade bits
1	each	Heavy-duty disc-type electric grinder
2	each	5 L (1.25 gal) containers for mixing water
3	each	Electric generators (1 per drill)
3	tons	Pea gravel (clean, washed gravel, 9 mm [0.375 inch])
150	bags	Rapid Set Concrete Mix repair material
4	buckets	5 gal size, for measuring aggregate
1	board	Notched screed, 51 mm x 102 mm x 1 m (2 inches x 4 inches x 40 inches)
1	board	Notched depth gauge, 51 mm x 102 mm x 1 m (2 inches x 4 inches x 40 inches)
30	panels	UHMW polyethylene, 610 millimeters (24 inches) wide, 1,511 millimeters (59.5 inches) long, 38 mm (1.5 inches) thick, predrilled with six 25-millimeter (1-inch) -diameter anchor holes and 51-millimeter (2-inch) -diameter countersinks
192	each	Anchor studs, 19 millimeter (0.75 inch) diameter, 245 millimeters (9.65 inches) long, fully threaded, with nuts, flat washers and vinyl ester resin vials (six per panel plus spares)
12 (min)	each	Cap nuts, 19 millimeter (0.75 inch), 10 UNC
2	each	Magnesium floats
1	pair	Vice grips for cap nut removal
1	each	Screwdriver to help with cap nut removal
1	each	Concrete vibrator, small size
2	each	Steel trowels
4	each	Shovels, square point
1	each	Electric drill, 13-millimeter (0.5-inch) drive
1	each	Torque wrench to apply 81 N·m (60 lb ft) torque
1	each	TYMCO airfield sweeper
1	each	Air compressor
1	each	Front end loader
2	each	Dump trucks
2	each	Wheelbarrow, 4 cubic foot

Quantity	Unit	Description
2	each	Knives
1	each	Pickup truck
2	each	Hammer
2	each	Steel chisel, hand-held
1	each	Joint seal kettle with SS-S-1401 joint seal. **Note:** Silicone joint seal is also recommended and preferred. A recommended silicone joint seal is Dow Corning® 890-SL in 0.8-liter (29-ounce) tubes (96 tubes required) and a caulking gun for 0.8-liter (29-ounce) caulk tubes.
3	each	Electric impact drill (Hilti HE72 or equivalent) with 22-mm (0.875-inch) -diameter by 530-mm (21-inch) -long masonry bits.
1	each	Gooseneck wrecking bar, 1220 mm (4 feet) long, minimum
1	each	Pick for debris breakout and removal
2	each	Wire brushes for slot cleaning
1	each	Roll of heavy cloth or plastic tape for marking drill bits for drilling depth
2	each	Alignment tools for drilling holes vertically
As req'd		Wood wedges to secure panels in position, minimum eight tapered wood wedges per panel
As req'd		Safety equipment including, but not limited to, dust masks, goggles, ear protectors, work gloves, and safety shoes *Ensure an eye wash is available.
As req'd		Wood spacers, approximately 13 mm (0.5 inch) thick by 102 mm (4 inches) by 76 mm (3 inches), used to maintain spacing between panels during panel installation
As req'd		String line, spray paint, straightedge board, and a 30-meter (100-foot) tape to measure and mark for saw cuts

Table A8.3. Material Cost and Suggested Sources of Supply.

Quantity	Item	Suggested Source	Cost
30 each	UHMW polyethylene panels, predrilled with six counter-sunk anchor holes	Röchling Engineered Plastics http://www.roechling-plastics.us/ or Ultra Poly http://www.ultrapoly.com/	$16,900

Quantity	Item	Suggested Source	Cost
192 each	Anchor studs, 19 mm (0.75 inch) diameter, 245 mm (9.65 inches) long, full-threaded (Hilti PN 068660) with vinyl ester bonding vials (Hilti PN 256702), nuts, and flat washers (Hilti HVA Adhesive Anchor System with HEA 19-mm [0.75-inch] capsule and HAS 19-mm [0.75-inch] rod)	Hilti Fastening Systems http://www.us.hilti.com/ or Williams Form Engineering Corporation http://www.williamsform.com/	$2,662
4 each	Drive sockets (PN 65279)	Hilti Fastening Systems	$74
4 each	Drive socket shafts (setting tool, square drive): SDS Max Connector, P/N 32221 or SDS Top Connector, P/N 332169		 $484 $299
4 each	Masonry drill bits, 22 mm (0.875 inch) diameter, 530 mm (21 inches) long	Hilti Fastening Systems	$650
25 each	Cap nuts, 19 mm (0.75 inch) diameter, 10 UNC (P/N 91855A036)	McMaster-Carr http://www.mcmaster.com/	$163
150 bags	Rapid Set Concrete Mix	CTS Products www.ctscement.com or www.rapidset.com/rs Midwestern Regional Office 1211 South 6th Street St. Charles, IL 60174 Phone: (312) 773-4949 1-800-929-3030	$4,550
96 tubes	Silicone joint seal (Dow Corning 890-SL)	The Fred R. Hiller Company http://www.fredhiller.com/	$3,250
Note: Costs do not include shipping. Suggested vendors are provided to assist in locating sources. The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this instruction does not imply endorsement by the Air Force.			

A8.11. Typical Schedule of Events for Installing Eight Panels. See Table A8.4 for an example of a typical schedule of events for installing eight panels.

Table A8.4. Typical Schedule of Events (Installing Eight Panels).

Date	Times	Event Description
24 Jun	1800–2200	Perimeter saw cutting, Runway 33. Crew size: 2 men. Saw cuts 76 millimeters (3 inches) deep.
25 Jun	1500–1745	Excavation starts on Runway 33 inlay. Crew size: 9 men. Concrete removed using three 40-kilogram (90-pound) jackhammers and one cold milling cutter drum on a Bobcat 843 skid-steer loader. Debris loaded into dump truck using front-end loader. Large rubble removed by hand and shovel; small debris removed using the suction wand of the airfield sweeper.
25 Jun	1745–1915	Excavation complete. Slot cleaned with high-pressure air. Substrate sounded and delaminated (unsound, hollow) material removed. Approximate final slot size: 30 meters (100 feet) long by 635 millimeters (25 inches) wide by 76 millimeters (3 inches) deep. Notched depth gauge board used to check depth in the center 12.2 meter (40 foot) area where panels will be installed.
25 Jun	1915–2000	Final slot inspection. Loose hollow-sounding areas removed with jackhammer and pick. (Hand-held hammer and steel chisel may also be used.) Slot side walls cleaned with wire brushes. Slot cleaned and dried with high-pressure air.
25 Jun	2000–2230	Mixing and placing of setting bed begins. Both concrete mixers used. Ten-person crew used. No bonding agent used or needed. Notched board used to keep setting bed at the correct level below the surrounding pavement surface.
25 Jun	2030–2242	Curing compound applied periodically as the setting bed is placed.
25 Jun	2242–2300	Cleanup accomplished and runway cleared. Approximately 90 bags of mortar placed.
26 Jun	0855–1030	Joints and cracks saw-cut through the mortar patches, both flush and recessed patch areas. Hand-held portable saw used for recessed setting bed cracks/joints and self-propelled pavement saw used for flush patches.
26 Jun	1015–1045	Panel placement begins. Panels positioned and tightly wedged into place using wood spacers and wood shims (wedges). Panels as ordered for the job have predrilled bolt holes.
26 Jun	1050–1130	Drilling bolt holes begins. Three heavy-duty electric impact drills (two Hilti HE72, one Milwaukee) used and work well. Three minutes drilling time per hole required. Portable drill alignment tool used to keep drill bit positioned vertically to start hole. Drill bits marked with tape to control hole depth. Long slender tube inserted completely to bottom of bolt holes delivers compressed air to thoroughly clean holes. Recommended wire brushing of holes is not accomplished.

Date	Times	Event Description
26 Jun	1130–1345	Panel anchor studs set in position using electric drill with adapter attachment. Anchor studs anchored into pavement with adhesive capsule inserted before inserting anchor stud in hole. Installation of anchors is delayed during first hour while new adapter is fabricated locally for anchor installation. After first adapter is tried and proven, two more adapters are fabricated. Anchor stud installation then progresses rapidly with most anchor studs installed in last hour. Applying oil on ends of studs aids adapter removal after stud installation.
26 Jun	1340–1400	Shims removed. Site cleaned with compressed air to remove all particles before sealing around panels with joint sealant.
26 Jun	1710–1730	Studs torqued to 81 N·m (60 lb ft) with torque wrenches. All studs torqued adequately but several stud ends protrude above panel surface.
26 Jun	1810–1820	High studs ground down flush with surface using a heavy-duty disc-type electric grinder.
26 Jun	1720–1820	Sealant applied to joints around panels using kettle with hot-applied, single-component, non-jet-fuel-resistant sealant (SS-S-1401). Job complete.
26 Jun	1820–1830	Final inspection and job site cleanup completed.

A8.12. Contact Point for Assistance. If you need assistance with installation of these type panels, contact AFCESA/CEOA.