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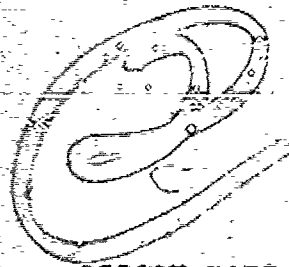
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REPORT NATF-EN-1136

PERFORMANCE OF THE DUAL BAK-12 AIRCRAFT  
ARRESTING SYSTEM WITH MODULAR HARDWARE  
WITH DEADLOADS AND AIRCRAFT

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Seventy-four deadload arrestments were conducted using BAK-12/E32A Aircraft-Arresting System(s) in the Single-System, Dual-System, Single-Mode, and Dual-Mode configurations. Tests were conducted to determine the feasibility of incorporating modular hardware on a Dual BAK-12/E32A Aircraft Arresting System which would enable the system to arrest all present United States Air Force hook-equipped aircraft. Baseline data was first generated for Single and Dual BAK-12/E32A Arresting-System configurations. This data served to		

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provide a valid comparison with data obtained from arrestments conducted into a Dual BAK-12/E32A Arresting System with modular hardware installed.

Fourteen A-4 aircraft arrestments were conducted into a Single BAK-12 Aircraft Arresting System and nine A-4 aircraft arrestments were conducted into a Dual BAK-12 Aircraft Arresting System configured for Dual-Mode operations. The results obtained from these tests served as a comparative basis for similar arrestments conducted into the Dual BAK-12 Arresting System configured for Single-Mode operations.

Sixty-seven aircraft arrestments were conducted into a Dual BAK-12/E32A Aircraft Arresting System configured for Single-Mode operations to determine aircraft performance. The results of aircraft performance derived from this program will be used in the compilation of information necessary to establish an Aircraft Recovery Bulletin.

During all test events, the modular hardware functioned as designed by reducing the maximum aircraft-hook axial loads that occur in the frictional region of the arrestments. Maximum aircraft-hook axial loads that occurred in the dynamic region of the arrestments were reduced by conducting engagements at a nominal 10 feet to port or starboard of the centerline of the hook cable.

The complete results and recommendations for both deadload and aircraft tests are presented in this report.



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## I INTRODUCTION

### A. BACKGROUND

1. With the advent of heavy gross-weight hook-equipped fighter aircraft in the USAF (*United States Air Force*), the weight spectrum is so broad that the energy capacity of any existing single arresting system is not sufficient to accommodate the full energy requirements of all arrested landings. For example, arrestments of a 120,000-pound aircraft at a speed of 160 knots require an arresting system with an energy capacity of approximately 136 million foot-pounds, which is significantly greater than that of a single BAK-12/E32A system (hereinafter referred to as BAK-12).

2. With the use of high-strength aircraft arresting-hook cables, it is entirely feasible to use two BAK-12 systems to arrest heavyweight aircraft. A Dual BAK-12 System was tested at the Flight Test Center at the Edwards Air Force Base; the results of those tests validated the feasibility of the dual concept.

3. The strength of various aircraft arresting hooks is generally proportional to the weight of the aircraft. Therefore, the higher aircraft-hook axial load generated from a larger-diameter aircraft arresting-hook cable and the high inertial load and high braking force generated by the Dual System will present no critical problems for heavyweight aircraft. These same loads, however, may exceed the strength limit of hooks on lightweight aircraft. It becomes necessary, therefore, to provide some means of accommodating the lightweight fighter aircraft. This can be accomplished by providing a method which utilizes the braking force of only one of the BAK-12 systems.

### B. FORWARD

1. The NAVAIRENGCEN (*Naval Air Engineering Center*) was contracted by the USAF to design and manufacture component hardware which could be installed on a Dual BAK-12 Aircraft-Arresting System. The system should then be capable of arresting all USAF hook-equipped aircraft. Upon receipt of the test equipment, the NAVAIRTESTFAC (*Naval Air Test Facility*) was authorized by reference (a) to conduct a test program to evaluate the NAVAIRENGCEN design modification when installed on a Dual BAK-12 Aircraft-Arresting System.

Ref: (a) Naval Air Engineering Center Project Order No. 3-4015, Subj: Evaluation of the Dual BAK-12 Arresting-System Modular Hardware (12 September 1972), and Modification No. 1 to Project Order No. 3-4015 (10 August 1973)

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2. The test program consisted of two phases, as follows:

a. Phase I: ON- and OFF-CENTER arrestments of various weight deadloads were conducted at the RSTS (*Recovery Systems Track Site*) No. 4 with the system installed on a 225-foot arresting-sheave span to obtain base-line performance data for the Single and the Dual BAK-12 (1,200-foot runout) Aircraft-Arresting Systems configured for different modes of operation.

b. Phase II: ON- and OFF-CENTER arrestments of various weight aircraft were conducted on the NAVAIRTESTFAC runway with the system installed on a 225-foot arresting-sheave span to obtain aircraft performance data.

## II INSTALLATION

A. GENERAL: All tests were conducted with the system installed as shown in Figure 1. The aircraft-arresting system was installed on a 225-foot arresting-sheave span with a 30-foot split distance measured from the centerline of the inboard arresting sheave to the centerline of the deflector sheave. The nylon purchase elements were connected to the hook cable with purchase-element connectors and adapters. Tensiometers were installed to record purchase-element tension for units Port 1 and Starboard 1 for both deadload and aircraft tests.

### B. BOLTED INSTALLATION (DEADLOAD TESTS)

1. In order to expedite the installation at RSTS No. 4, the Dual Arresting System was installed on the UMP (*Universal Mounting Pad*) (see Figure 2). This type of installation enables the arresting system to be installed on grade with accurate alignment and true perpendicular arrestments can be accomplished.

2. Each of four BAK-12 energy absorbers was secured to the UMP (12WF58 beam assemblies) with eight 1.125-inch-diameter high-strength bolts inserted through the existing anchor holes on the absorber bases.

3. The arresting-sheave assemblies consisted of one left-hand and one right-hand arresting sheave, PN 52-W-2252-1 and 52-W-2080-1, respectively, mounted on a common baseplate (see Figure 3). Eight mounting holes on each sheave base were fitted with one-inch-long steel bushings (1.125-inch outer diameter x 0.999-inch inner diameter). The arresting sheaves were then fastened to the baseplates with through bolts (1-8UNC-2A, 100,000 UTS (minimum)) that were torqued to 140 to 160 foot-pounds. These bolts replace bolts, PN 52-B-3728, (1-8UNC threaded portion with a 1.062 +0.005-inch shoulder diameter), which in standard installations secure the arresting-sheave assemblies which have 1.125 +0.0156-inch-diameter mounting holes.

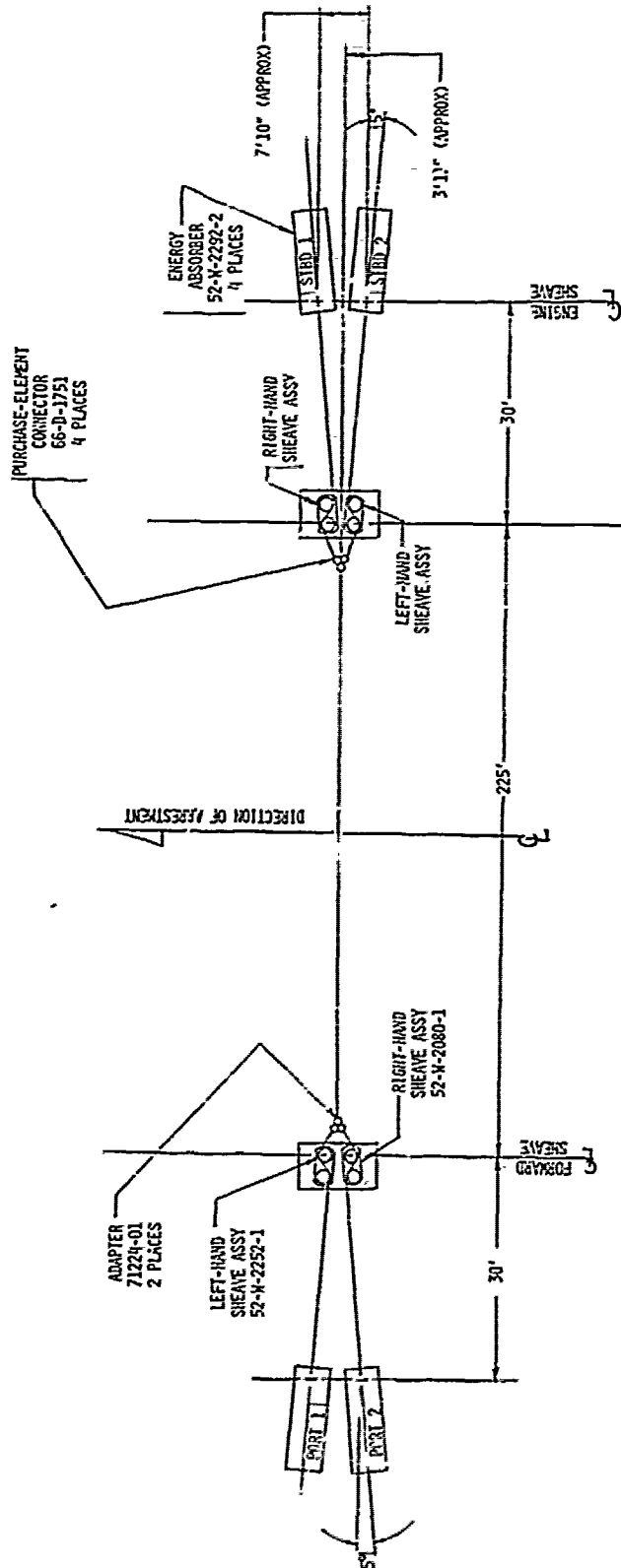


Figure 1 - General Arrangement of the Dual BAK-12 Arresting System

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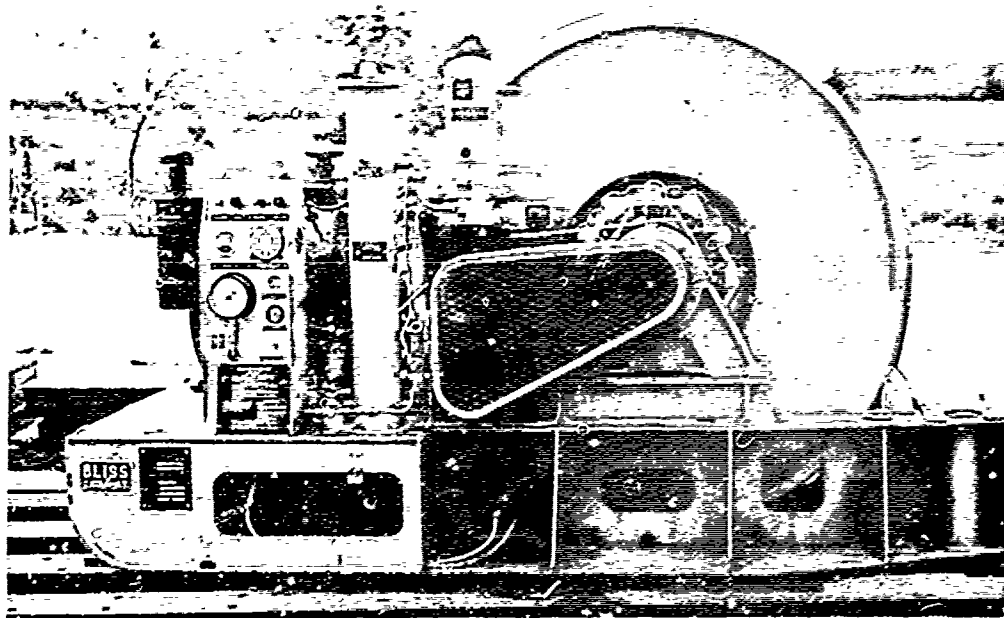
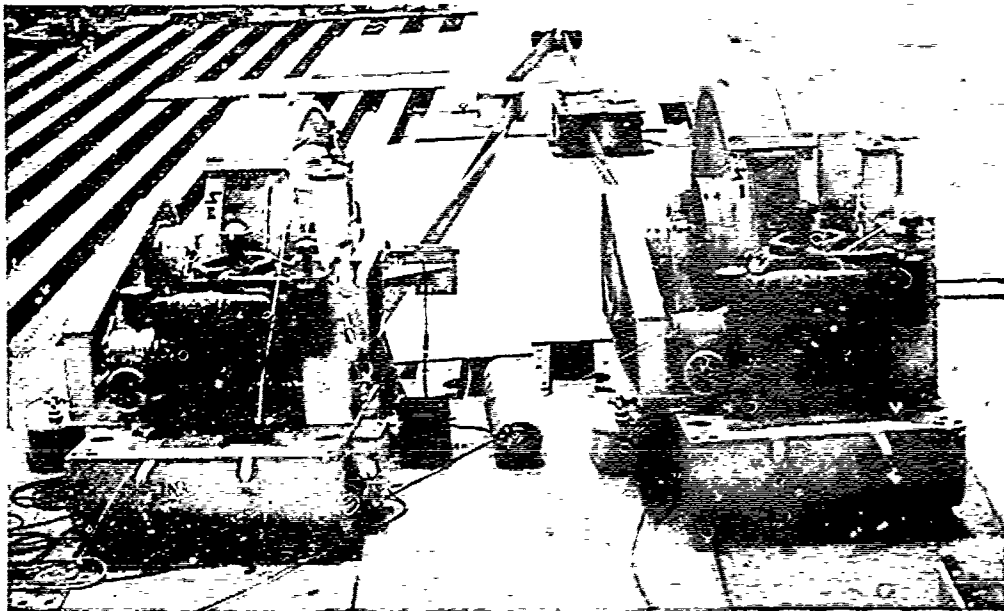


Figure 2 - Dual BAK-12 Arresting System Bolted Installation for Deadload Testing

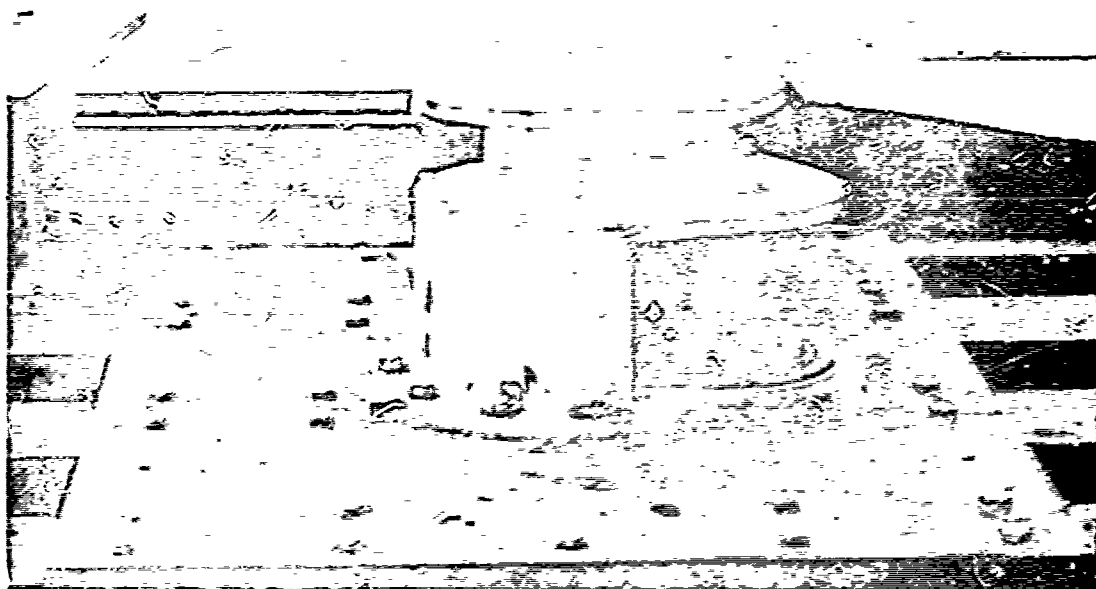


Figure 3 - Dual BAK-12 Arresting System Deck-Sheave Assembly Installation

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4. After the arresting sheaves were shimmed and bolted to the base plates, shear blocks were welded in place (see Figure 4).

5. The arresting-sheave base plates were secured to the UMP by thirty-six one-inch-diameter through bolts.

### C. EXPEDITIONARY INSTALLATION (AIRCRAFT TESTS)

1. Dimensional restraints for the installation of the BAK-12 Arresting System for aircraft tests at the NAVAIRTESTFAC runway were identical to those shown in Figure 1. For these tests an expeditionary-type installation was used.

2. The arresting-sheave assemblies were installed on the same base plate used for the deadload tests. The base plate was modified to accept cruciform stakes and earth anchors (Figures 5 and 6).

3. Each of the four arresting-system energy absorbers was secured to a 5-foot-wide x 13.5-foot-long x 1-inch-thick steel plate by eight 1.125-inch-diameter through bolts which were inserted through the existing mounting holes in the absorber base. The absorber base plates were secured with earth anchors and cruciform stakes as shown in Figures 7 and 8.

4. The runway configuration was installed with a relative 2% slope between the arresting-sheave assemblies and the energy absorbers.

5. Arresting engines, designated Port 2 and Starboard 2, had to be connected electrically. This was accomplished by burying a shielded four-conductor cable in a transverse runway expansion joint to a depth of approximately four inches.

6. No deadmen were used for this installation.

## III GENERAL DESCRIPTION OF DUAL BAK-12 SYSTEM

A. PURPOSE: As aircraft have grown faster and heavier, it has become necessary to provide land-based emergency arresting systems of greater capacity to absorb the greatly increased weight and speed of the aircraft. From this need has grown the Dual BAK-12 Arresting System concept. The Dual BAK-12 Arresting System with its increased absorbing capacity can safely arrest all types of heavyweight hook-equipped aircraft. The increase in system inertia and higher braking forces generated by the Dual BAK-12 System impose a severe penalty on the maximum permissible engaging speed for lightweight aircraft. In order to upgrade the Dual BAK-12 System for use to arrest lightweight aircraft, a modification to two BAK-12 units would, when actuated, prevent hydraulic pressure from acting on the brake assemblies thereby reducing the total braking force when arrestments are made into the Dual BAK-12.



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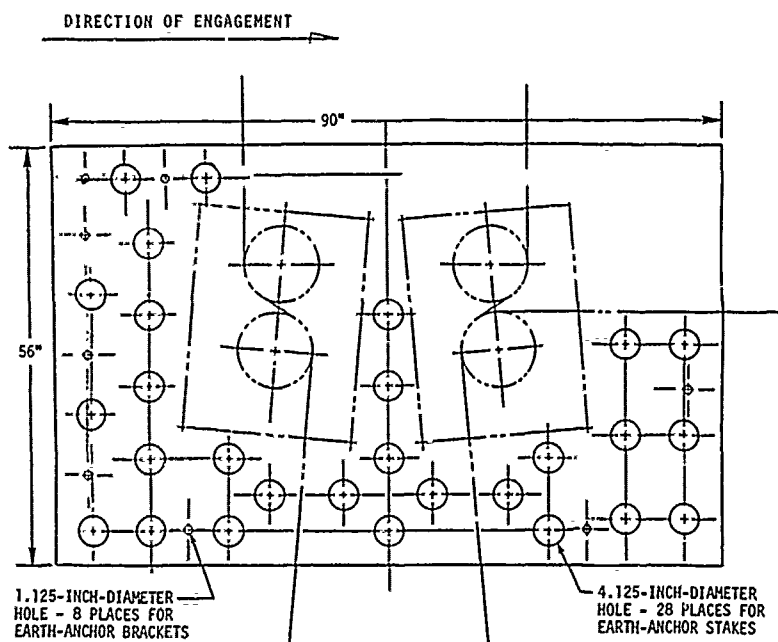


Figure 5 - Dual BAK-12 Arresting-System Detail Expeditionary Deck-Sheave Base Plate

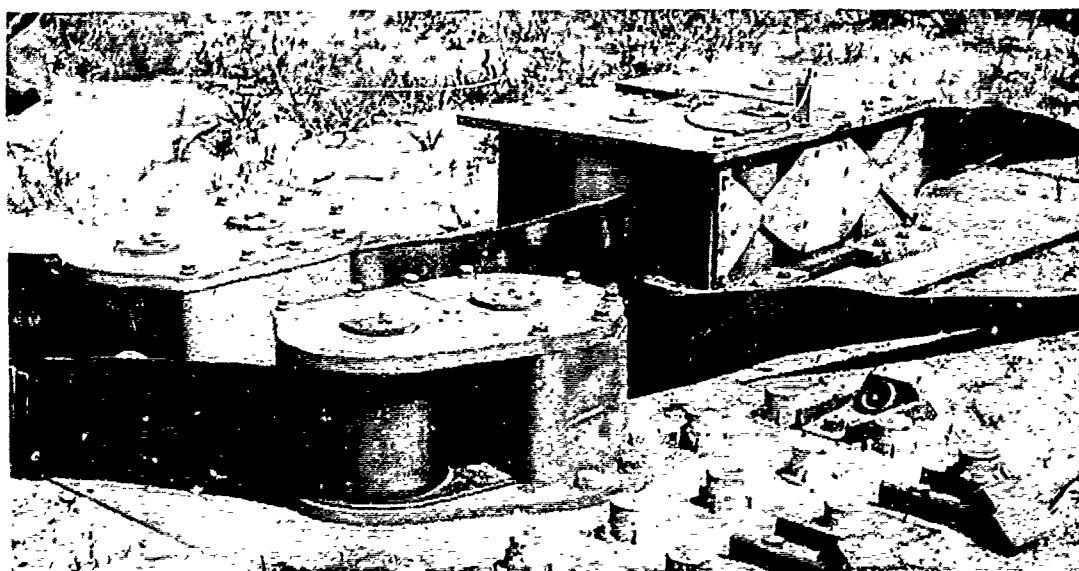


Figure 6 - Dual BAK-12 Arresting System Expeditionary Installation of Deck Sheave

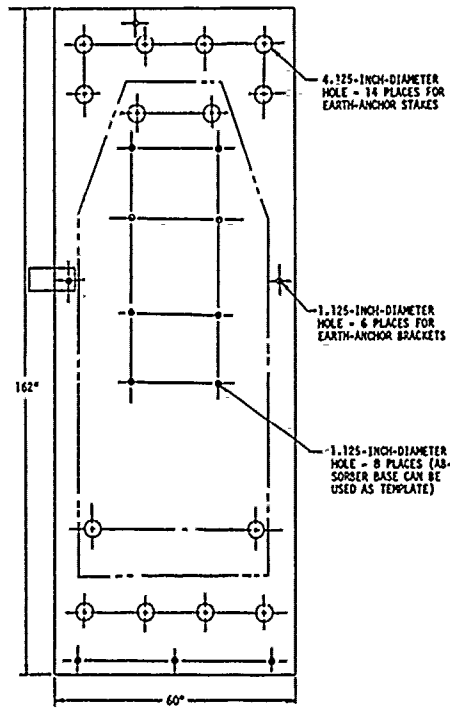


Figure 7 - Dual BAK-12 Arresting System  
Absorber Base-Plate Detail

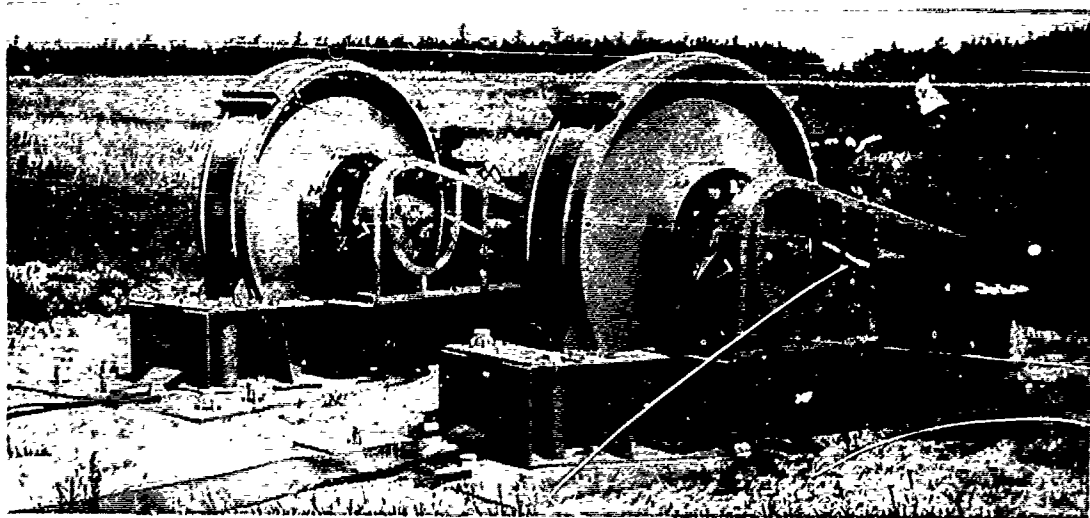


Figure 8 - Dual BAK-12 Arresting System Expeditionary Absorber  
Installation

B. DESCRIPTION (AIRCRAFT ARRESTMENT ENERGY ABSORBERS)

1. The aircraft arresting-system configurations used for this test program are categorized as Single-System BAK-12, Dual-System BAK-12, Dual BAK-12 in the Single Mode, and Dual BAK-12 in the Dual Mode. For the purpose of clarity and brevity, the following terminology will be used throughout this report. Figure 9 displays the braking characteristics of the arresting-system configurations defined below.

a. Single System: A BAK-12 Aircraft Arresting System comprised of two standard arresting-system units (one on each side of the runway) connected by a single 190-foot-long by 1-1/4-inch diameter aircraft arresting-hook cable.

b. Dual System: A Dual BAK-12 Aircraft Arresting System comprised of four standard arresting-system units (two on each side of the runway) connected by a single 190-foot-long by 1-1/4-inch diameter hook cable.

c. Modular Hardware: Equipment (consisting of suitable valves, tubings, electrical junction boxes and wiring, and a tower control panel) which is easily installed as a package on a Dual BAK-12 aircraft arresting hydraulic system. When actuated, the system will prevent hydraulic pressure from acting on the brake assemblies of one of the BAK-12 systems. When Dual BAK-12 capability is required the equipment can be isolated and system performance will not be degraded.

d. Single Mode: A Dual BAK-12 Aircraft Arresting System comprised of two standard and two modified arresting-system units (one standard and one modified unit on each side of the runway) connected by a single 190-foot-long by 1-1/4-inch-diameter hook cable. The modified units are installed with modular hardware which prevents hydraulic pressure generated during an arrestment from acting on the brake assemblies.

e. Dual Mode: A Dual BAK-12 Aircraft Arresting System comprised of two standard and two modified arresting-system units (one standard and one modified unit on each side of the runway) connected by a single 190-foot-long by 1-1/4-inch-diameter hook cable. Although the modified units are installed with modular hardware, the hydraulic system performs identically to a Dual System in that the hydraulic pressure generated during the arrestment acts on the brake assemblies on all units.

2. Each of the four energy absorbers used for these tests is classified as a 1,200-foot-runout, 50,000-pound-weight-setting BAK-12 synchronized according to Figure 5-21 and paragraph 5-38 of reference (b) for an arresting-sheave span of up to 200 feet. The hydraulic system, on units designated Port 2 and Starboard 2 in Figure 1, modified to

Ref: (b) Technical Manual, Operation and Maintenance Instructions (T.O. 35E8-2-5-1) for Aircraft Arresting System Model BAK-12/E32A dated 1 Aug 1972

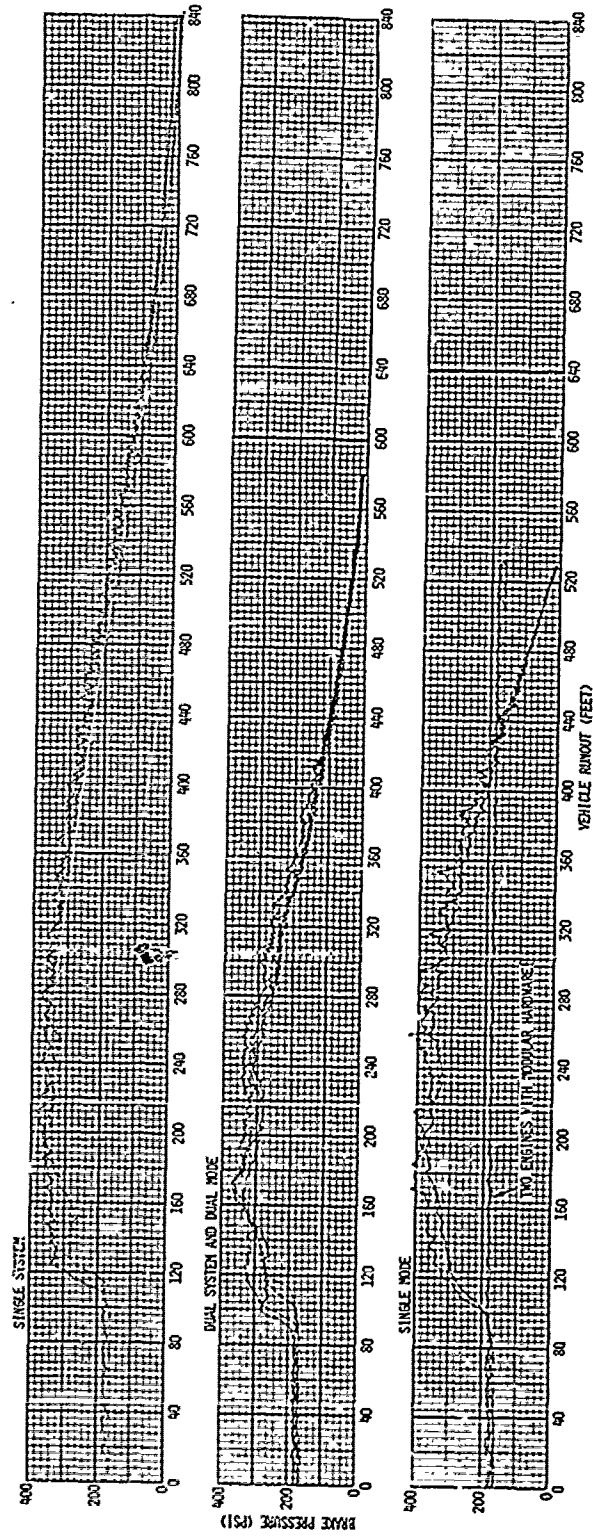


Figure 9 - Braking Characteristics of Single-System, Dual-System, Dual-Mode, and Single-Mode Configurations

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include the modular hardware, was hydrostatically tested in accordance with Appendix A - Hydrostatic Test of Piping on Modified BAK-12 Aircraft Engines. Except for the Single-System configuration, all arrestments were conducted with four energy absorbers, two each on either side of the runway.

3. With the arresting systems in the battery position, the tail hook of the aircraft engages the supported hook cable. The hook cable is connected to purchase elements which, when payed out, impart rotation to the purchase-element reel shaft. The hydraulic pump output is programmed by the cam-actuated valve to control pressure to each of two arresting-system brakes. The brake torque creates a purchase-element tension which slows and eventually stops the aircraft.

4. The aircraft is then disengaged from the hook cable and the purchase elements are rewound on the reels for the next arrestment.

### C. PRINCIPLE OF OPERATION

1. BAK-12 HYDRAULIC SYSTEM: The hydraulic system, Figure 10, is a velocity/position-sensitive control system which is powered by a reel-driven pump. The hydraulic pressure is regulated with a cam-actuated control valve. The system provides the capability of a wide range of weight settings with one basic cam contour. A weight-setting needle valve is installed downstream of the control valve in the hydraulic return line. A vernier scale affixed to the barrel can be preset to any number of orifice sizes and serves to modify the pressures monitored by the control valve; thus, high- and low-weight settings can be accomplished. A static pressure system is used to apply a pressure to the brakes so that tension can be maintained on the purchase elements and hook cable in the battery position. The system consists of an accumulator, a fluid-replenishing hand pump, and a reservoir which is common to the main hydraulic system. The static pressure system is linked to the main hydraulic system by a shuttle valve which also serves to "lock out" the static pressure once the main hydraulic-system pressure overcomes the preset static pressure. Once the shuttle valve locks out the static pressure, the valve will remain in that position until manually reset.

2. BAK-12 HYDRAULIC SYSTEM WITH MODULAR HARDWARE: The hydraulic system on the engines that have the modular hardware is identical to a standard system with the exception of suitable valves, tubing, and fittings used as a bypass during Single-Mode operations (Figures 11 and 12).

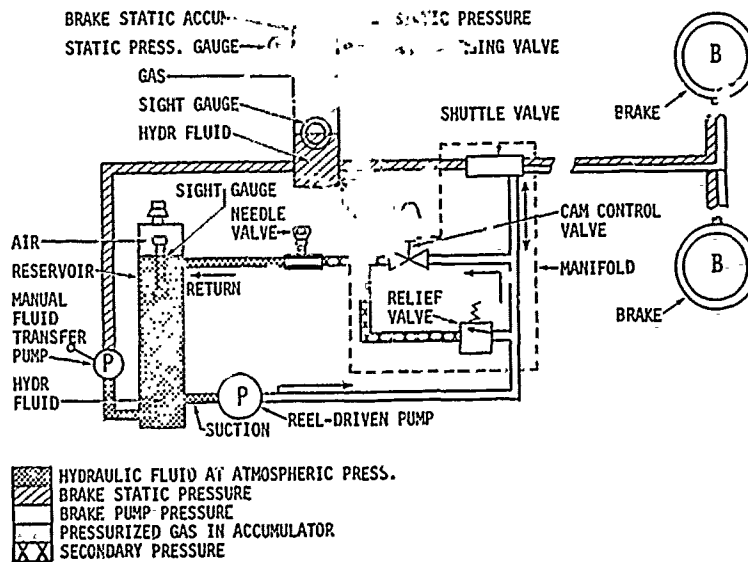


Figure 10 - Schematic of the Hydraulic System of the Dual BAK-12 Arresting System

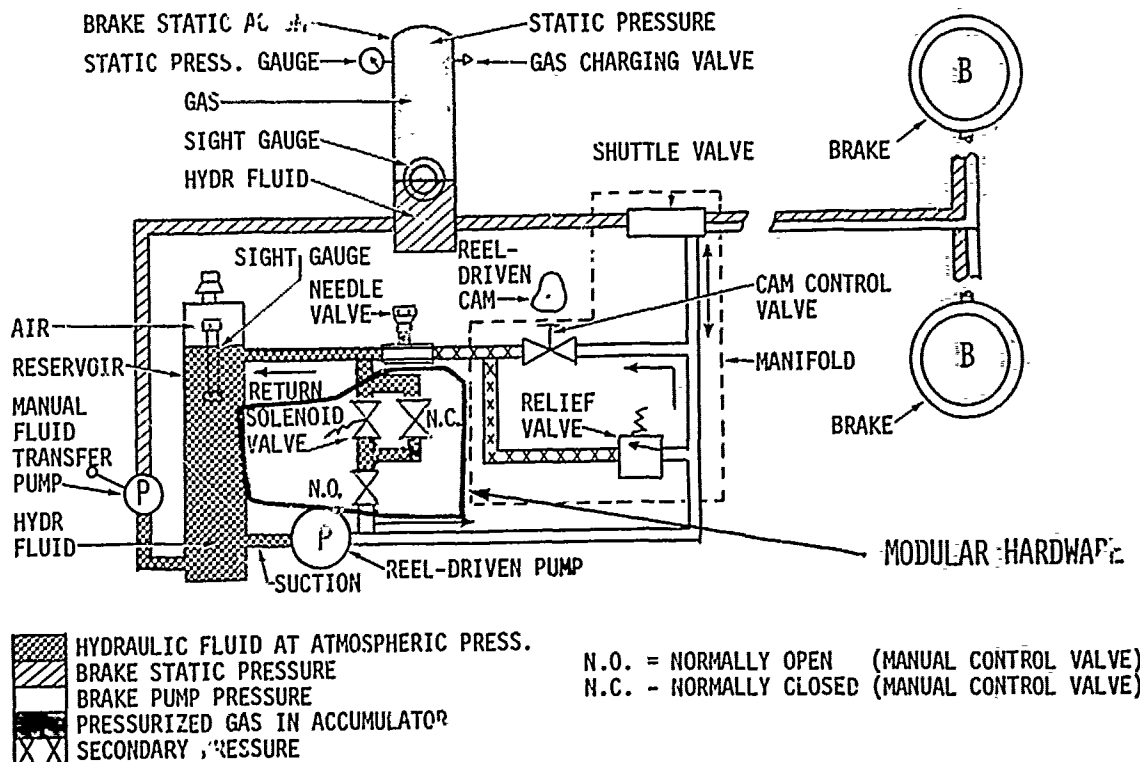


Figure 11 - Schematic of the Modular-Hardware Hydraulic System of the Dual BAK-12 Arresting System

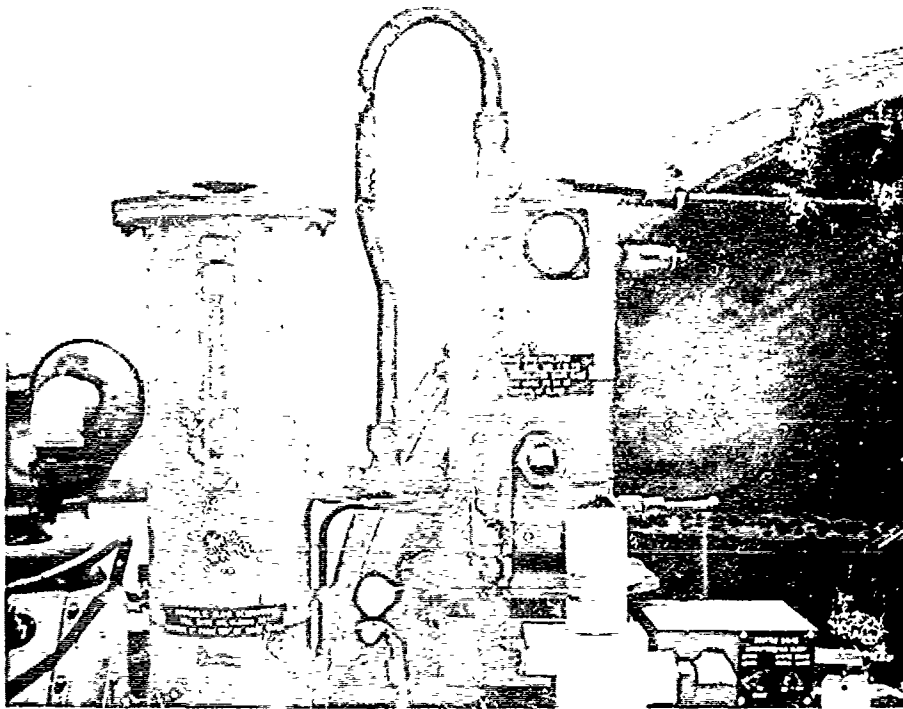


Figure 12 - Modular Hardware Hydraulic System Bypass of the Dual BAK-12 Arresting System

a. Single-Mode Operations: When the arresting system is in the Single-Mode configuration, the valves, tubing, and fittings are used to divert hydraulic-pump output from the energy-absorber brakes and to return the output to the reservoir. Actuation of this bypass can be achieved electrically, from the control panel, Figure 13, or manually from the deck edge, Figure 14. The engines with the modular hardware will supply only static pressure to the brakes throughout the entire arrestment. Because the shuttle valve on the energy absorbers with the modular hardware does not sense any hydraulic-pump pressure when arrestments are conducted in the Single Mode, the spool of the shuttle valve will remain in the ON position (static pressure acting on brake assemblies). Manual selection to the OFF position is necessary prior to retraction in order to relieve the static brake pressure from acting on the brake assemblies.

b. Dual-Mode Operations: When the bypass is closed, the hydraulic-system operation is identical to that of a standard hydraulic system.

3. The two aircraft arresting-system units designated Port 1 and Starboard 1 in Figure 1 have standard BAK-12 hydraulic systems. The two aircraft arresting-system units designated Port 2 and Starboard 2 in Figure 1 have BAK-12 hydraulic systems modified to accept the modular hardware.

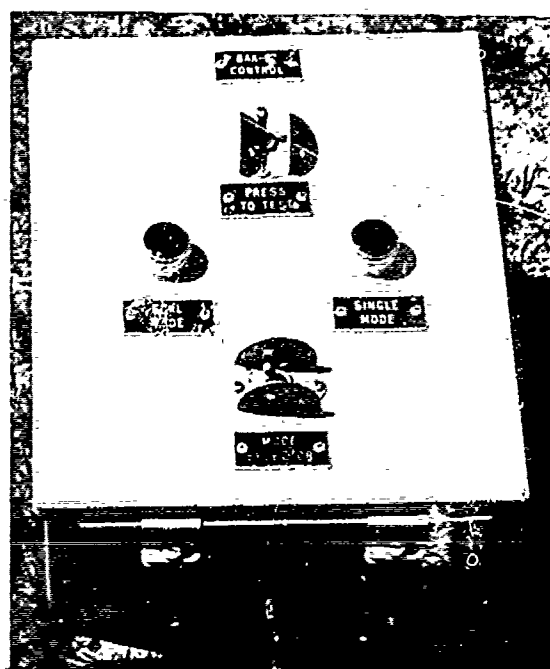


Figure 13 - Dual BAK-12 Arresting System Control Panel

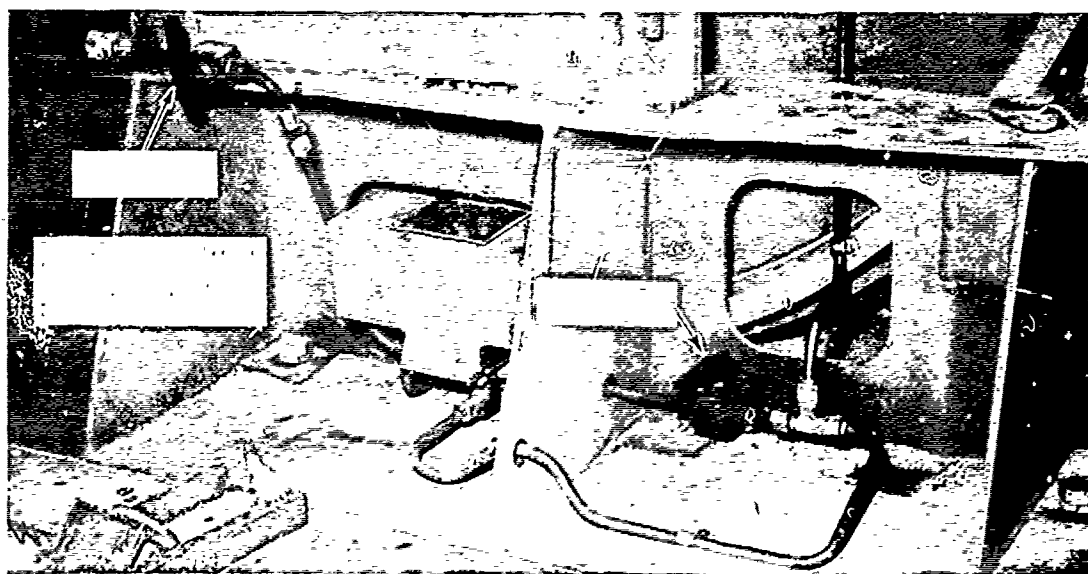


Figure 14 - Dual BAK-12 Arresting System Manual Hydraulic Control Valve

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#### IV TEST PROCEDURE

A. TEST OUTLINE: The test program was divided into a deadload program, Phase I, and an aircraft program, Phase II. Tabulated results of deadload and aircraft testing are presented in Appendix B.

1. Phase I was conducted in three parts:

a. PART I: 16,000-pound deadload arrestments were conducted ON-CENTER with the BAK-12 configured in the Single System, Dual System, and the Single Mode to obtain baseline performance for the three configurations.

b. PART II: 16,000-pound deadload arrestments were conducted ON-CENTER and 3 feet OFF-CENTER with the BAK-12 configured in the Single System and Single and Dual Mode to investigate the effect of 1) reducing the static brake pressure, 2) increasing the connector mass, and 3) engaging the hook cable 3 feet OFF-CENTER.

c. PART III: 16,000- and 35,000-pound deadload arrestments were conducted ON-CENTER, 3 feet OFF-CENTER, and 11-1/2 feet OFF-CENTER with the BAK-12 configured in the Single and Dual Mode to determine the effect of engaging the aircraft arresting-hook cable OFF-CENTER. 90,000-pound deadload arrestments were conducted ON-CENTER in the Dual Mode to determine system performance with high-energy engagements and to demonstrate Mode selection with either the tower control panel or the manual control valves.

2. Phase II arrestments were conducted with A-4, F-4, and A-3 aircraft ON-CENTER and 11-1/2 feet and 30 feet OFF-CENTER with the system configured for Single Mode operations to obtain aircraft performance data. A-4 aircraft arrestments were conducted 11-1/2 feet OFF-CENTER with the arresting system configured in the Single System and Dual Mode to compare results with similar arrestments conducted with the Single Mode configuration.

#### B. DEADLOAD TESTING

1. All deadload tests were conducted at RSTS No. 4. Simulated aircraft arrestments were attained by guiding a weighted vehicle along 7,400 feet of track at which point the vehicle left the rail system and engaged the hook cable with an A-3 aircraft hook assembly which was attached to the vehicle. The deadloads were ballasted to simulate appropriate aircraft weights. Each deadload was propelled by a four-wheel jet car powered by either J48 or J79 engines. The jet car was arrested by a system of trailing friction brakes which engaged a thickened section of track rail at the end of the launch stroke. By proper selection of the initial jet-car thrust setting or by incorporating an electro-mechanical speed control, aircraft arrested energy levels can be simulated.

2. Once the deadload engaged the hook cable, directional and run-out performance of the vehicle was determined solely by the arresting system.

3. Arrestments of deadloads weighing 16,000, 35,000 and 90,000 pounds were conducted at engaging speeds ranging from 79 to 167 knots.

C. AIRCRAFT TESTING: All aircraft tests were conducted on a 200-foot-wide by 12,000-foot-long runway. All arrestments were of the roll-in type and were conducted on a runway heading of 300 degrees.

D. INSTRUMENTATION: All parameters that were measured were recorded either by visual observation or by frequency-division multiplexing methods on magnetic tape. The data was permanently recorded on magnetic tape. An oscillograph was used to provide quick-look data immediately after each test event. The quick-look data allowed immediate data review in order to determine that all parameters were being recorded and that purchase-element tensions and hook axial loads were not exceeding specified limits. It was also used for preliminary data reduction until computer plots of the data were received. The following parameters were recorded:

<u>Parameters Measured</u>	<u>Means of Measurement</u>	<u>Accurate Within (<math>\pm</math>)</u>	<u>Frequency Response (Hz)</u>
<u>Arresting System (Port and Starboard)</u>			
Purchase-element tensions	3-sheave tensiometer	5%	100
Purchase-element reel revolutions	Magnetic coil	5%	NA
Brake pressures	Pressure transducer	3%	NA
Reel RPM	Rotary tachometer	5%	NA
Deflector-sheave revolutions	Magnetic coil	5%	NA
<u>Deadload</u>			
Engaging Speed	Magnetic coil	2 Kn	NA
Wheel revolutions	Magnetic coil	5%	NA
Hook axial load	Strain gauge	5%	60
Longitudinal deceleration	Accelerometer	5%	20
Instant of engagement	Break wire	NA	NA
Deadload stop	Reed switch	NA	NA
Runout	Painted deck marks	10 Ft	NA
NA = not applicable			

(continued)

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<u>Parameters Measured</u>	<u>Means of Measurement</u>	<u>Accurate Within (<math>\pm</math>)</u>	<u>Frequency Response (Hz)</u>
<u>Aircraft</u>			
Engaging Speed	Magnetic coil	2 Kn	NA
Wheel revolutions	Magnetic coil	5%	NA
Hook axial load	Strain gauge	5%	60
Longitudinal deceleration	Accelerometer	5%	20
Engine RPM	Aircraft tachometer generator	5%	20
Runout	Painted deck marks	10 Ft	NA

NA = Not applicable.

In addition to the above arresting-system instrumentation, an indicator switch was wired to the mode-selection switch in the power control panel to indicate arresting-system mode.

#### E. PHOTOGRAPHIC COVERAGE

##### 1. DEADLOAD

a. Still photographs of the arresting-system installation were taken.

b. Four high-speed motion-picture cameras (500 frames per second) were required for selected arrestments to record any purchase-element slip.

c. A high-speed motion-picture camera (500 frames per second) was positioned at each of two deck sheaves to photograph the interaction between purchase elements and deck sheaves.

##### 2. AIRCRAFT

a. Aircraft-mounted high-speed motion-picture coverage (200 frames per second) of the hook cable/hook pickup was used to determine the exact engaging point.

b. High-speed motion-picture coverage (500 frames per second) of the hook cable/hook interaction was used to check on possible aircraft damage from hook-cable dynamics. This coverage was eliminated once it was ascertained that damage would not occur.

c. High-speed motion-picture coverage (500 frames per second) of the absorber engines was used to determine if any over-spin of the purchase-element stack was present when arrestments were conducted into the Single Mode. This coverage was continued throughout the test program.

d. Still photographs of the arresting-system installation, modular installation, tower control panel installation, and equipment failures were taken.

#### F. DATA PRESENTATION

1. The maximum arresting-hook axial loads were plotted versus engaging speed for each configuration. The least-squares method was used to reduce the individual data points to mean curves utilizing the following load equation:

$$\text{Mean load (pounds)} = aV^b \text{ (knots).}$$

Constants a and b were determined from the test data using the least-squares method.

2. In Figure 27, presented on page 38, the solid curves are the mean or regression loads and the dashed curves are the upper one-sigma deviations from the mean curves, indicating the extent of the load scatter. The engaging-speed limit is derived at the point at which the upper one-sigma curve is intersected by the established aircraft arresting-hook axial-load limit of the aircraft. Theoretically, the probability of realizing a load of less than one-sigma is 0.84, and a load of more than one-sigma is 0.16.

V TEST RESULTS AND DISCUSSION

A. PHASE I DEADLOAD TESTING

1. Part I

a. The first 28 deadload arrestments of the test program comprise Part I of Phase I and were conducted with nitrogen in the static accumulator pressurized to 175 psi. Baseline data of arrestments into the Single-System, Dual-System, and Single Mode configurations of the arresting system is presented in Figure 15. The results from thirteen ON-CENTER arrestments conducted with a 16,000-pound deadload comprise the data for the test points represented by the regression curve in Figure 15 for a Single System.

b. Eleven ON-CENTER arrestments were conducted with a Dual System and four arrestments were conducted into the Single-Mode configuration. The test data showing the maximum deadload-hook axial loading for Dual-System and Single-Mode configurations is represented by the appropriate symbols in Figure 15. The maximum deadload-hook axial load occurred in the dynamic region for 13 of the 15 arrestments and in the frictional region during two arrestments. The occurrence of maximum deadload-hook axial loading in the frictional region of the arrestment is believed to be a result of the hook cable not being positioned ON-CENTER during these two arrestments and therefore is not included in the data presentation for the Single-Mode and Dual-System regression curve because the results of these tests were intended to show aircraft arresting-system inertial effects.

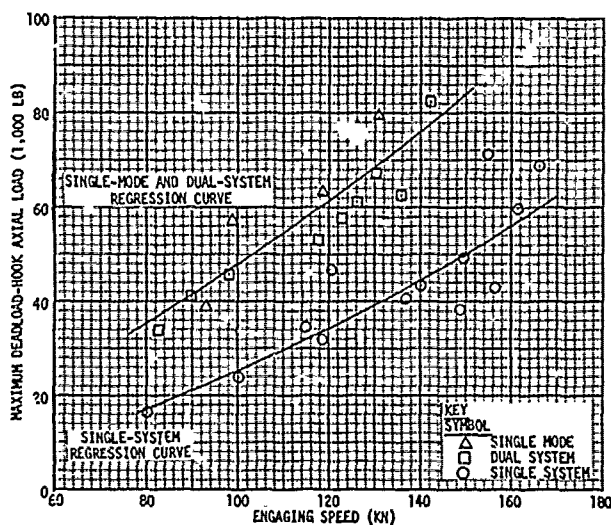


Figure 15 - Baseline Regression Curves of 16,000-Pound Deadload Arrestments Conducted ON-CENTER with Single and Dual Systems and Single Mode

c. No significant difference exists in the maximum deadload-hook axial loads when ON-CENTER arrestments are conducted into either the Single-Mode or Dual-System configurations. Maximum deadload-hook axial loads that occurred in the dynamic region of an arrestment were proportional to the engaging speed, hook-cable density, purchase-element connector mass, and system inertia. The limited number of arrestments conducted into the Single Mode, normal scatter in maximum deadload-hook axial loading associated with tape purchase-element type arresting systems, and the probability of engaging the hook cable exactly ON-CENTER account for the slight variation in results obtained from Single-Mode and Dual-System tests. For these reasons, one regression curve is plotted to present maximum deadload-hook axial loading for both Single-Mode and Dual-System ON-CENTER performance with a 16,000-pound deadload. The regression curves plotted in Figure 15 will serve as a baseline for comparing results obtained when a 16,000-pound deadload is arrested by the BAK-12 Arresting System in other configurations.

d. Figure 16 presents representative runout histories of deadload-hook axial loads of ON-CENTER 16,000-pound deadload arrestments conducted into the Single-Mode configuration and the Dual System.

e. Baseline performance, represented by the regression curve in Figure 15, for the Single System shows an approximate 45% reduction in maximum deadload-hook axial loading when compared to the baseline performance represented by the regression curve for the Single-Mode and Dual-System configurations. The maximum deadload-hook axial loads occur in the dynamic region for ON-CENTER arrestments conducted with the 16,000-pound deadload for Single Mode and Single and Dual Systems. For this reason, the reduction in maximum deadload-hook axial loading, when arrestments are conducted ON-CENTER into the Single System, is a result of reduced system inertia.

## 2. PART II

a. Part II is comprised of 16,000-pound deadload arrestments conducted to investigate: (1) the effect of reducing the pressure in the static accumulator, (2) the effect of making OFF-CENTER engagements into a Single System, and (3) the effect of increasing purchase-element connector mass.

b. Figures 17A and 17B present regression curves for ON-CENTER 16,000-pound deadload arrestments conducted into the Single Mode and Single System, respectively, with nitrogen in the static accumulator pressurized to 175 psi. The data for these curves was obtained during tests conducted during Part I testing. Three arrestments were conducted into a Single-Mode configuration--two arrestments with nitrogen in the static accumulator pressurized to 75 psi and one arrestment with nitrogen in the static accumulator pressurized to 175 psi in one System. During this test, there was no charge in the accumulator of the System with the modular hardware. In addition, three arrestments were conducted into a Single System with nitrogen in the static accumulator pressurized to 75 psi. Reducing the pressure in the static accumulators, during the limited number of tests conducted, appeared to have little or no effect on the arresting-system performance compared to similar arrestments conducted with 175 psi of static charge.

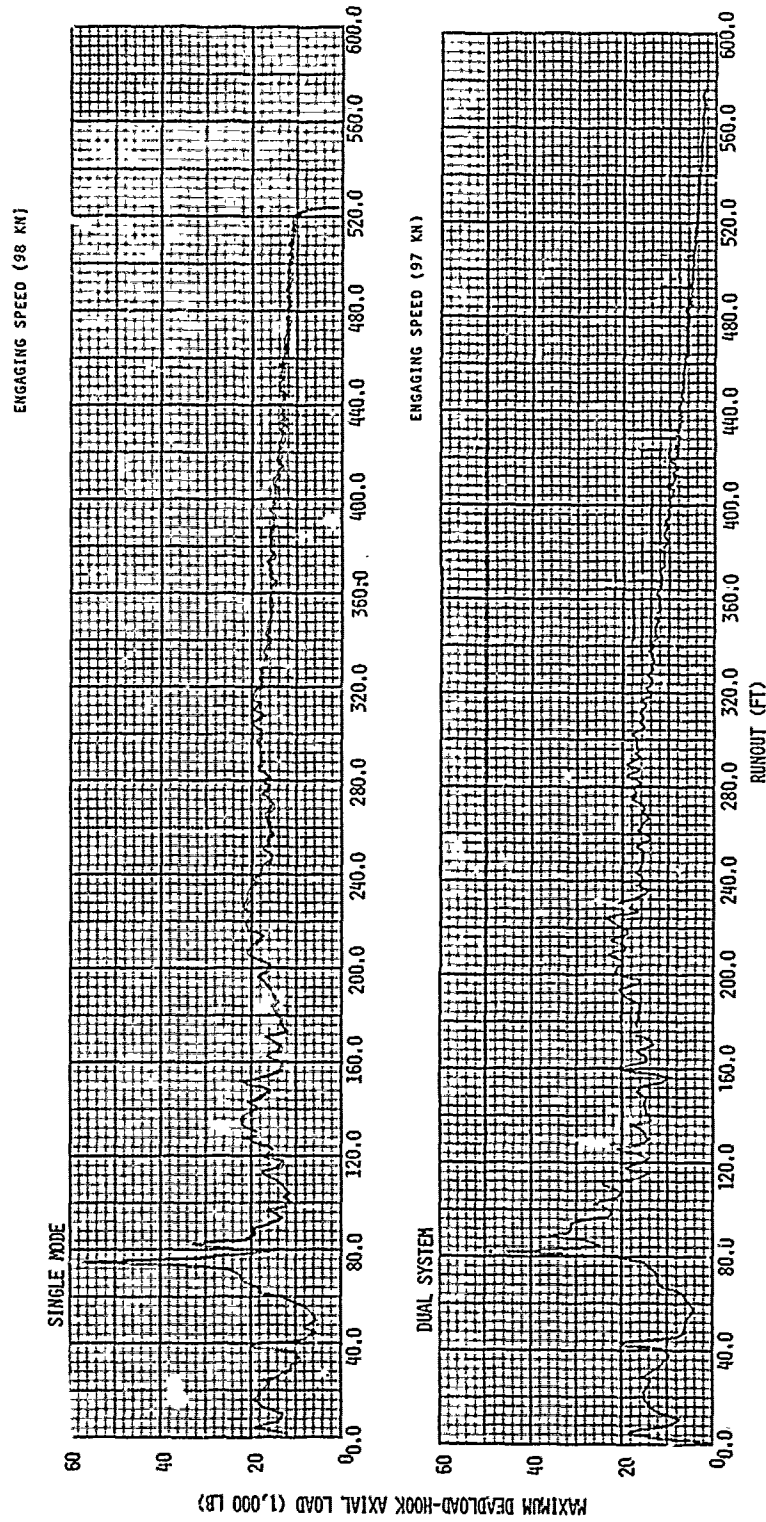


Figure 16 - Runout Histories of Deadload-Hook Axial Loads of ON-CENTER 16,000-Pound Deadload Arrestments

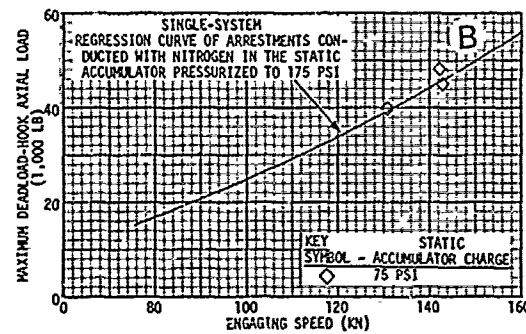
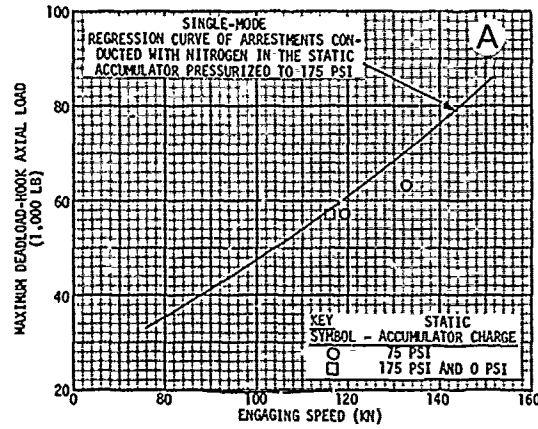


Figure 17 - Comparison of Effects of Reducing Static Accumulator Charge from 175 psi on 16,000-Pound Deadload Arrestments Conducted ON-CENTER into a Single Mode and a Single System

c. The results generated from six 16,000-pound deadload arrestments conducted three feet OFF-CENTER into a Single System comprise the data for the regression curve for baseline performance for this configuration. The ON-CENTER regression curve was reproduced from Figure 15. Both curves are presented in Figure 18. No significant difference exists in maximum deadload-hook axial loading when arrestments are conducted ON-CENTER or 3 feet OFF-CENTER into a Single System.

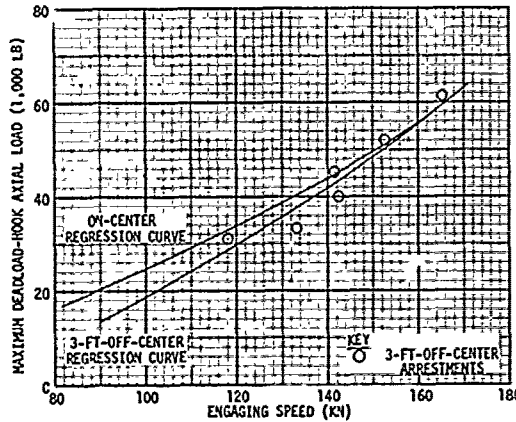


Figure 18 - Baseline Regression Curves for ON-CENTER and 3-foot-OFF-CENTER Arrestments Conducted into a Single System

d. Four arrestments were conducted into a Single System configured with heavy mass connectors. Two arrestments were conducted ON-CENTER and two arrestments were conducted three feet OFF-CENTER. The purchase-element-connector mass was increased by 59 pounds on both the port and starboard purchase-element connectors. The increase in mass was accomplished by adding a second purchase-element connector and adapter to each terminal. The increase in weight simulates the purchase-element-connector mass when conducting arrestments into the Dual System and Single or Dual Mode. Because of the limited test data and the normal scatter in maximum deadload-hook axial loading associated with the dynamic portion of the arrestment, no definite effect was observed from these tests though the data indicated the tendency of an increase in the maximum deadload-hook axial loads when arrestments were conducted with heavyweight connectors.

3. PART III

a. This phase of deadload testing was conducted to determine the effect of positioning the hook cable OFF-CENTER. The investigation was conducted to show the effect of timing the reflected port and starboard kink waves so that they would reach the deadload hook out-of-phase, thereby reducing maximum dynamic deadload-hook axial loads.

b. Four 16,000-pound deadload arrestments were conducted into a Single Mode; two arrestments were conducted ON-CENTER and two arrestments were conducted 3 feet OFF-CENTER. The results of these tests are displayed by the appropriate symbols in Figure 19A. Because of the limited test data, no regression curve is plotted for these results.

c. Figure 19B shows the comparison of 16,000-pound deadload arrestments conducted ON-CENTER and 3 feet OFF-CENTER into a Dual Mode configuration. The results from four 16,000-pound deadload arrestments comprise the data for the 3-foot-OFF-CENTER regression curve plotted in Figure 19B. The ON-CENTER regression curve displayed in Figure 19B was reproduced from Figure 15.

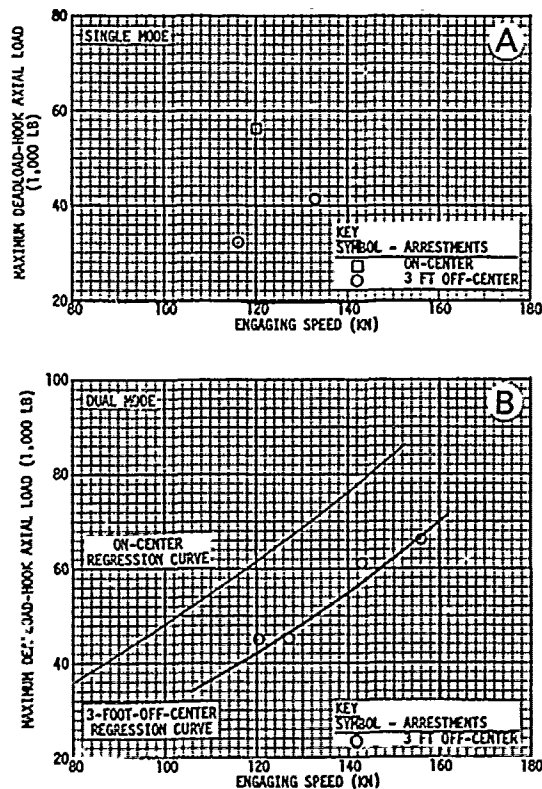


Figure 19 - Regression Curves Showing Comparison Between ON-CENTER and 3-Foot OFF-CENTER Arrestments of a 16,000-Pound Deadload into a Single Mode and a Dual Mode

A significant reduction in maximum deadload-hook axial loading resulted when conducting 3-foot-OFF-CENTER arrestments into the Single and Dual Mode. When 3-foot-OFF-CENTER arrestments were conducted with the 16,000-pound deadload, the reflected kink waves reached the deadload hook out-of-phase thereby reducing the dynamic deadload-hook axial loadings which were the maximum loads recorded throughout the arrestments.

d. Testing was continued with the Dual-Mode configuration using a 35,000-pound deadload to determine the effect of OFF-CENTER engagements and to demonstrate the need for modular hardware. The data in Figure 20 compares the effect of positioning the hook cable 3 feet OFF-CENTER with comparable ON-CENTER arrestments. The maximum deadload-hook axial load recorded during the three arrestments conducted ON-CENTER occurred in the dynamic portion of the arrestment. When the two arrestments were conducted 3 feet OFF-CENTER, dynamic loading was reduced but the frictional loading approached the dynamic loading of the ON-CENTER arrestments. For this reason, only a slight reduction in the maximum deadload-hook axial load occurred.

e. To further investigate the effects of OFF-CENTER engagements with the arresting system configured in the Dual Mode, the hook cable was positioned 11-1/2 feet OFF-CENTER. This is the maximum OFF-CENTER distance that can be accomplished with an ON-CENTER installation by positioning a 190-foot-long hook cable on a 225-foot arresting-sheave span. Arrestments of a 35,000-pound deadload were conducted into the Dual Mode. The regression curve for this data is shown in Figures 20 and 21. The data in Figure 20, when compared to the data for 3-foot-OFF-CENTER engagements, shows that no reduction in maximum deadload-hook axial load occurred during 11-1/2-foot-OFF-CENTER engagements. The maximum load for all of the above OFF-CENTER engagements occurred in the frictional region of the arrestments.

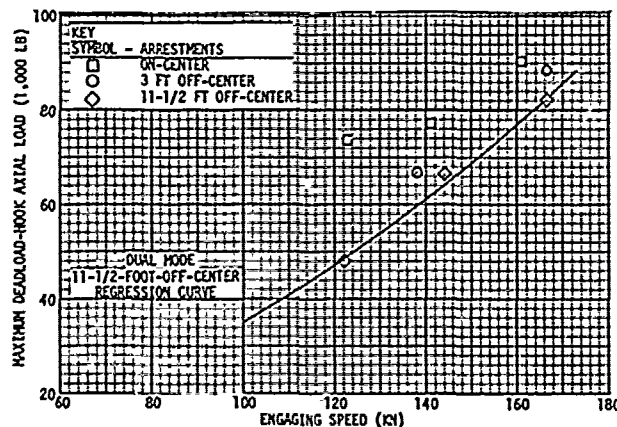


Figure 20 - Regression Curve Showing Comparison Between ON-CENTER and OFF-CENTER 35,000-Pound Deadload Arrestments Conducted into the Dual Mode

f. Figure 21 compares 35,000-pound deadload arrestments conducted 11-1/2 feet OFF-CENTER into a Single- and a Dual-Mode System. Data for the Single-Mode regression curve was obtained from the results of three deadload arrestments. A substantial reduction in maximum deadload-hook axial loading occurred when the arresting system was configured in the Single Mode. The maximum deadload-hook axial loads occurred in the frictional region for all 35,000-pound arrestments conducted 11-1/2 feet OFF-CENTER. When arrestments were conducted into the Single-Mode System, the frictional loading was reduced significantly because of the modular hardware.

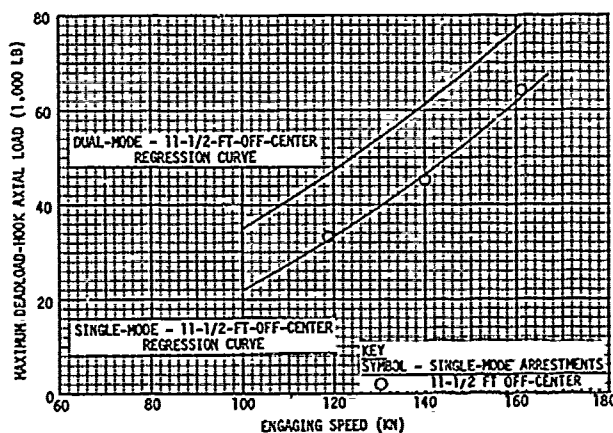


Figure 21 - Regression Curves Showing Comparison of 11-1/2-Foot-OFF-CENTER 35,000-Pound Deadload Arrestments Conducted into the Single and Dual Modes

g. Figure 22 compares representative runout histories of deadload-hook axial loads of two similar arrestments conducted 11-1/2 feet OFF-CENTER (in the Single Mode and Dual Mode). Both arrestments were conducted with a 35,000-pound deadload. Though dynamic loading is approximately the same, a substantial reduction in maximum deadload-hook axial loading resulted during Single-Mode operations.

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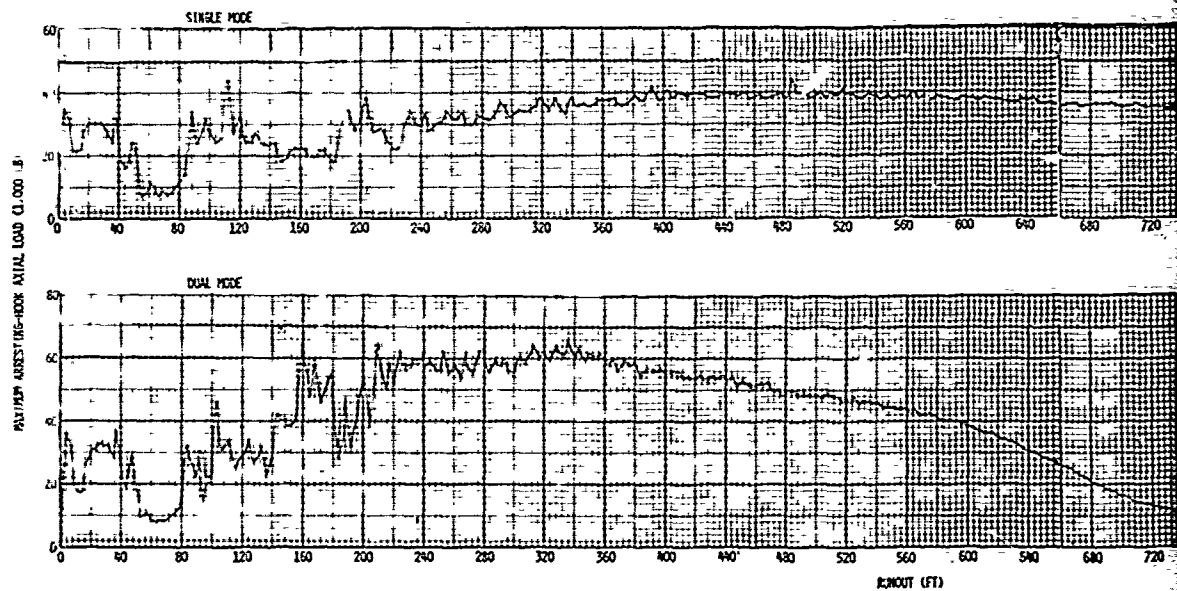
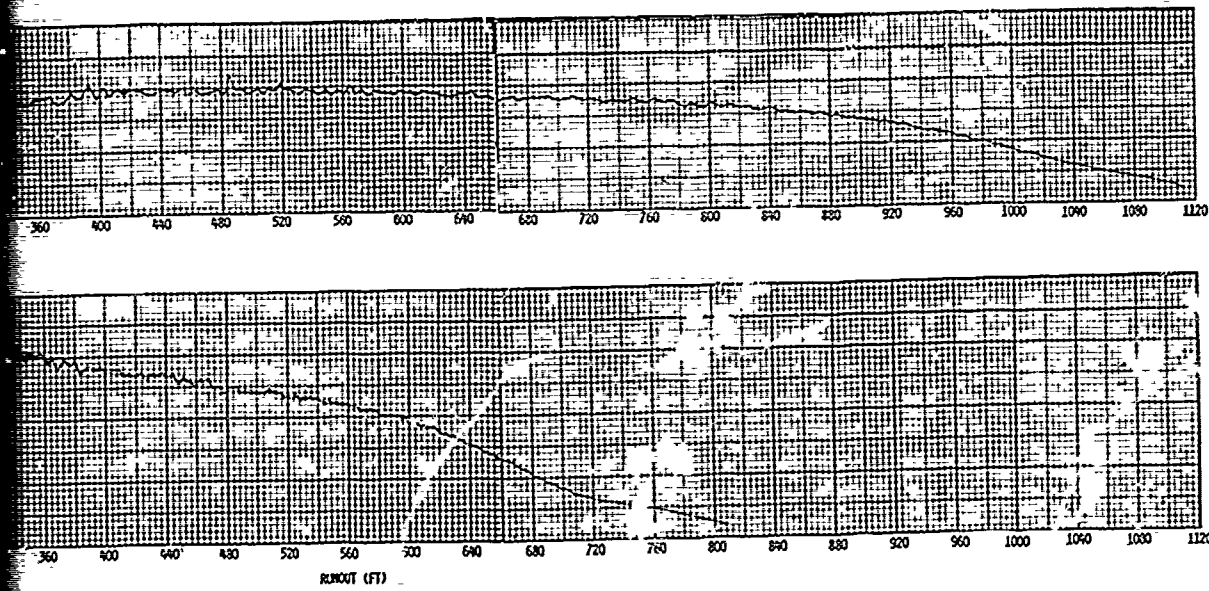


Figure 22 - Comparison of Representative Runout Histories of Arrestments Conducted 11-1/2 Feet OFF-CENTER of the Dual Mode

2



of Representative Runout Histories of Deadload-Hook Axial Loads  
ments Conducted 11-1/2 Feet OFF-CENTER into the Single Mode and  
the Dual Mode

h. Six 90,000-pound deadload arrestments were conducted to determine Dual Mode performance and to demonstrate that mode selection can be obtained either electrically from the tower control panel or manually from the control valves located on the aircraft arresting system. Figure 23 displays the regression curve obtained from data acquired from six arrestments conducted with a 90,000-pound deadload and the aircraft arresting system configured in the Dual Mode. All arrestments were conducted ON-CENTER. Three arrestments were conducted with electrical selection of the system in the Dual Mode and three arrestments were conducted with manual selection of the system in the Dual Mode.

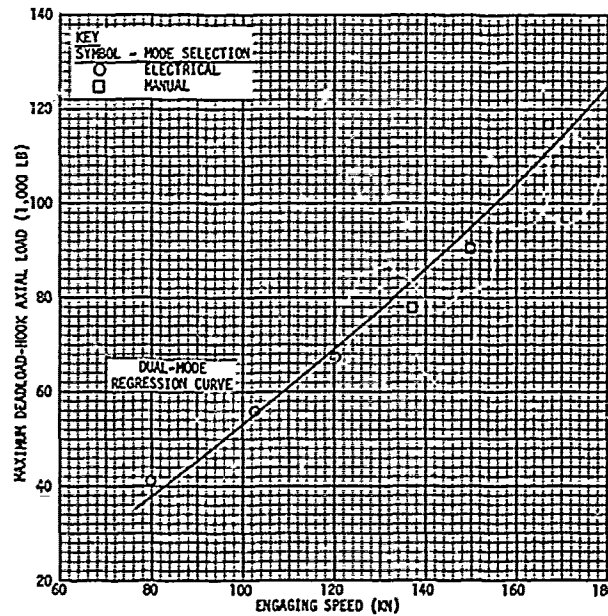


Figure 23 - Regression Curve for 90,000-Pound Deadload ON-CENTER Arrestments Conducted into the Dual Mode

B. PHASE II - AIRCRAFT TESTING

1. All aircraft arrestments were conducted with nitrogen in the static accumulator pressurized to 175 psi. During all aircraft arrestments conducted with the arresting system configured for Single-Mode operations, no problems were encountered with the aircraft hook hanging up in the aircraft arresting-hook cable at the conclusion of the arrestment. All aircraft had sufficient rollback to dislodge the hook from the cable because during Single-Mode arrestments; static pressure acts on the friction brakes on the units with the modular hardware components throughout the entire aircraft runout thus providing sufficient purchase-element elongation at the end of the arrestment to roll back the aircraft. During Single-System and Dual-Mode arrestments conducted with the A-4 aircraft, the aircraft arresting hook did not dislodge from the hook cable. The hook was dislodged from the hook cable by inducing aircraft rollback by retracting the BAK-12 System approximately 25 feet. All arrestments were conducted with dry purchase elements. Dual BAK-12 Arresting System discrepancies which resulted during aircraft testing are reported in Appendix C.

2. Figure 24 presents regression curves of maximum aircraft arresting-hook axial-load data from all A-4 aircraft tests. The A-4 aircraft gross weight ranged from 14,700 to 12,600 pounds.

The results derived from eighteen 11-1/2-foot-OFF-CENTER arrestments (nine arrestments conducted into the Single System and nine conducted into the Dual Mode) comprise the data for the Single-System and Dual-Mode regression curves. Single-Mode regression curves are presented for 12 ON-CENTER arrestments, eight 11-1/2-foot-OFF-CENTER arrestments, and seven 30-foot-OFF-CENTER arrestments.

3. The effect of reducing maximum aircraft-hook axial loads by engaging the aircraft arresting-hook cable OFF-CENTER was confirmed by comparing ON-CENTER and 11-1/2-foot-OFF-CENTER arrestments conducted into the Single Mode. A comparison of the ON-CENTER regression curve with the 11-1/2-foot-OFF-CENTER regression curve for the Single-Mode configuration presented in Figure 24 shows an approximate 35% decrease in maximum aircraft-hook axial load when arrestments were conducted 11-1/2 feet OFF-CENTER. Because maximum aircraft-hook axial loads occur in the dynamic region when conducting ON-CENTER arrestments with lightweight aircraft, a shift in engaging position to either port or starboard of the aircraft arresting-hook cable centerline will cause the reflected kink wave to return to the hook cable out-of-phase, thereby reducing the maximum aircraft-hook axial load.

4. By comparing the curves for Single-Mode and Single-System 11-1/2-foot-OFF-CENTER engagements presented in Figure 24, there is an approximate 6,000-pound increase in the maximum aircraft-hook axial load when arrestments are conducted into the Single Mode. The increase in the maximum aircraft-hook axial loading, when arrestments are conducted with the Single-Mode configuration 11-1/2 feet OFF-CENTER, is attributed to an increase in system braking force due to static brake pressure and also, an increase in inertia.

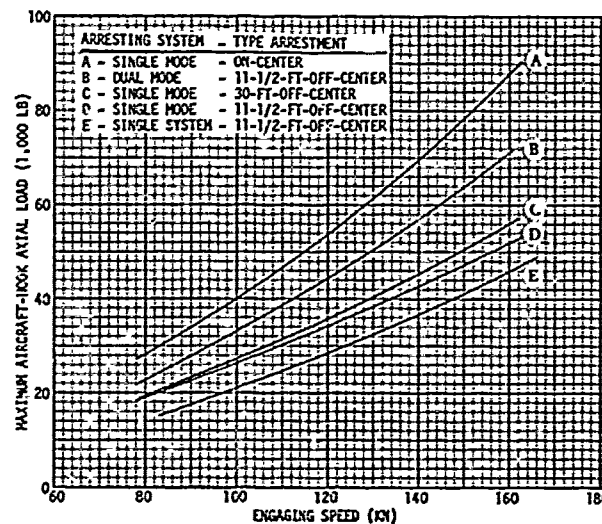


Figure 24 - Regression Curves for A-4 Aircraft (14,700 - 12,500 Lb) Arrestments into the Single System, Dual Mode, and Single Mode

5. Seven A-4 aircraft arrestments were conducted 30 feet OFF-CENTER with the system configured in the Single Mode. No significant difference resulted from 30-foot-OFF-CENTER arrestments when compared to similar 11-1/2-foot-OFF-CENTER arrestments. Results of OFF-CENTER arrestments of the A-4 aircraft into the Single Mode are presented as a single regression curve and one-sigma standard-deviation curve in Figure 27 on page 38. No adverse aircraft swerve occurred when making A-4 aircraft arrestments up to 30 feet OFF-CENTER.

6. Nine A-4 arrestments were conducted 11-1/2 feet OFF-CENTER with the system configured in the Dual Mode. The results of the tests are presented by the appropriate regression curve in Figure 24. Tests were conducted to show a comparison between Single- and Dual-Mode performance when arrestments were conducted 11-1/2 feet OFF-CENTER. An approximate 25% reduction in maximum aircraft-hook axial loading resulted when arrestments were conducted into the Single Mode at an engaging speed of 140 knots.

7. A total of fifteen A-3 aircraft arrestments was conducted with the system configured in the Single Mode. Aircraft gross weight ranged from 52,000 to 46,500 pounds. All arrestments were conducted with the aircraft engines set at IDLE thrust prior to engaging the hook cable and the engines remained at this setting throughout each arrestment. A regression curve of all aircraft-hook axial-load data from the A-3 aircraft arrestments is presented in Figure 25.

a. Ten A-3 aircraft arrestments were conducted into the Single Mode - six arrestments were conducted 11-1/2 feet OFF-CENTER and four arrestments were conducted ON-CENTER. The maximum aircraft-hook axial loads are represented by the appropriate regression curves in Figure 25. No significant difference in maximum aircraft-hook axial loading resulted between ON-CENTER and 11-1/2-foot-OFF-CENTER arrestments. Maximum aircraft-hook axial loads occurred in the dynamic region for three out of four ON-CENTER and five out of six 11-1/2-foot-OFF-CENTER arrestments conducted with the A-3 aircraft.

b. Five A-3 aircraft arrestments were conducted 30 feet OFF-CENTER and the results are represented by the appropriate regression curve in Figure 25. Maximum aircraft-hook axial loads were reduced when arrestments were conducted 30 feet OFF-CENTER. The maximum aircraft-hook axial load occurred in the dynamic region for all arrestments. No adverse aircraft swerve occurred when making A-3 aircraft arrestments up to 30 feet OFF-CENTER.

8. The maximum runout recorded for any A-3 aircraft arrestment conducted into the Single Mode was 1,150 feet. This maximum recorded runout occurred during a 136-knot 30-foot-OFF-CENTER arrestment.

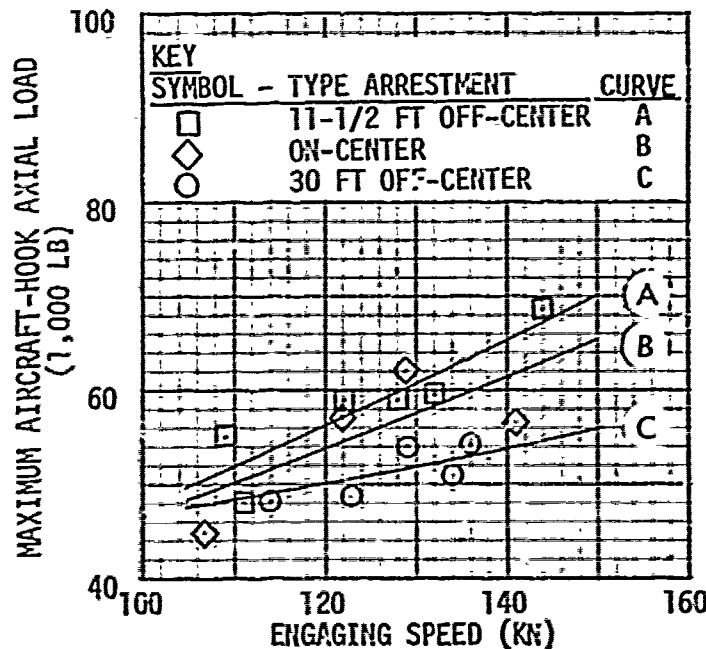


Figure 25 - Regression Curves of A-3 Aircraft (52,000 - 46,500 Lb) ON-CENTER and OFF-CENTER Arrestments Conducted into a Single Mode

9. A total of fifteen F-4 arrestments was conducted ON-CENTER, 11-1/2 feet OFF-CENTER, and 30 feet OFF-CENTER into a Single-Mode configuration. Aircraft gross weight ranged from 38,000 to 35,000 pounds. Figure 26 presents the regression curves obtained from four ON-CENTER, seven 11-1/2-foot-OFF-CENTER, and four 30-foot-OFF-CENTER arrestments. Maximum aircraft-hook axial loading occurred in the dynamic region for ON-CENTER arrestments and in the frictional region for 11-1/2- and 30-foot-OFF-CENTER arrestments. Maximum aircraft-hook axial loads were substantially reduced when arrestments were conducted 11-1/2 feet OFF-CENTER, compared to similar ON-CENTER arrestments.

10. No aircraft swerve was encountered when making 30-foot-OFF-CENTER arrestments with the F-4 aircraft. The aircraft remained stable throughout the arrestment and final OFF-CENTER positions were within ten feet of the initial position.

11. The maximum runout recorded for any F-4 aircraft arrestment conducted into the Single-Mode configuration was 985 feet. This maximum recorded runout occurred during a 143-knot, 11-1/2-foot-OFF-CENTER arrestment.

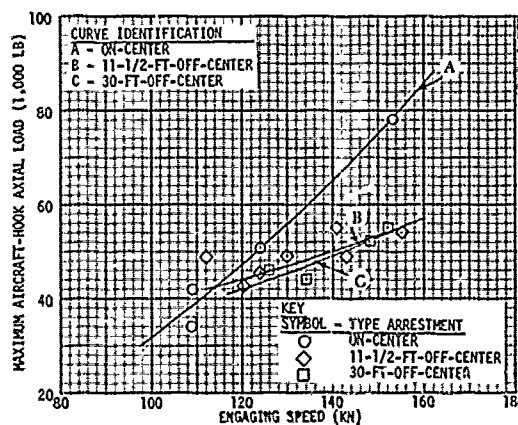


Figure 26 - Regression Curves of F-4 Aircraft (38,000 - 35,000 Lb) Arrestments into the Single Mode

No significant difference exists in maximum aircraft-hook axial loading when arrestments were conducted either 11-1/2 or 30 feet OFF-CENTER. OFF-CENTER results with the F-4 aircraft into the Single Mode are presented as a single regression curve and one-sigma standard-deviation curve in Figure 27 on the following page.

12. Based on A-4, F-4, and A-3 aircraft tests, all aircraft arrestments with a gross weight of up to 52,000 pounds should be conducted with the Dual BAK-12 Aircraft Arresting System configured for Single-Mode operations. Performance curves for OFF-CENTER Single-Mode arrestments with A-4, F-4, and A-3 aircraft are presented in Figure 27.

13. The A-4 and F-4 regression curves and the one-sigma standard deviation curves displayed in Figure 27 are comprised from data generated from 11-1/2-foot- and 30-foot-OFF-CENTER arrestments with the respective aircraft.

14. The regression curve and the one-sigma standard-deviation curve for the A-3 maximum aircraft-hook axial loading presented in Figure 27 are comprised from data generated from 11-1/2-foot-OFF-CENTER arrestments only. Maximum aircraft-hook axial loads resulting from 30-foot-OFF-CENTER arrestments conducted with the A-3 aircraft produced lower loading when compared to similar 11-1/2-foot-OFF-CENTER arrestments. For this reason, the A-3 aircraft performance curves presented in Figure 27 reflect only A-3 arrestments conducted 11-1/2 feet OFF-CENTER.

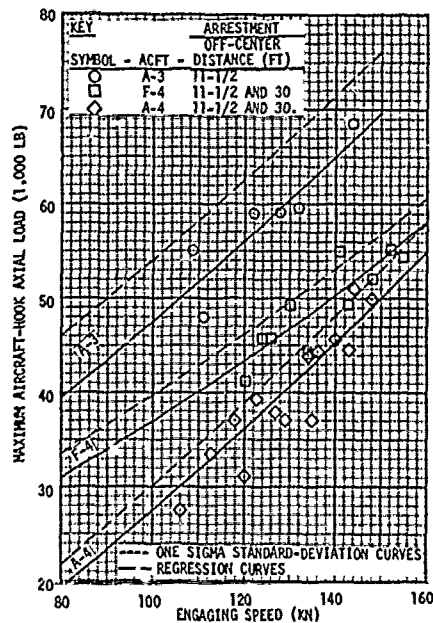


Figure 27 - Regression Curves and One-Sigma Regression Curves for A-4, A-3, and F-4 Aircraft Conducted OFF-CENTER into the Single Mode

## VI CONCLUSIONS

A. No significant difference exists in the maximum deadload-hook axial loads when 16,000-pound deadload arrestments are conducted ON-CENTER into either the Single Mode or the Dual System. (Paragraphs VA1b and VA1c)

B. 16,000-pound deadload arrestments conducted ON-CENTER into the Single System produced an approximate 45% reduction in maximum deadload-hook axial loading when compared to similar Single-Mode and Dual-System arrestments. (Paragraph VA1d)

C. Reducing the pressure in the static accumulators during a limited number of Single-Mode and Single-System arrestments had little or no effect on the arresting-system performance. (Paragraph VA2b)

D. No significant difference exists in maximum deadload-hook axial loading when 16,000-pound deadload arrestments are conducted ON-CENTER or 3 feet OFF-CENTER into a Single System. (Paragraph VA2c)

E. No definite effect in maximum deadload-hook axial loading was observed during Single-System arrestments conducted with heavyweight connectors. (Paragraph VA2d)

F. A significant reduction in maximum deadload-hook axial loading resulted when 16,000-pound deadload arrestments were conducted 3 feet OFF-CENTER into the Single and Dual Mode when compared to similar ON-CENTER arrestments. (Paragraphs VA3b and VA3c)

G. Maximum deadload-hook axial loads were not reduced substantially when 35,000-pound deadload arrestments were conducted 3 feet OFF-CENTER into the Dual Mode, compared to similar ON-CENTER arrestments. (Paragraph VA3d)

H. A substantial reduction in maximum deadload-hook axial loads occurred when 35,000-pound deadload arrestments were conducted 11-1/2 feet OFF-CENTER into the Single Mode, compared to similar arrestments conducted into the Dual Mode. (Paragraph VA3f)

I. Arrestments conducted with modular hardware incorporated in the arresting system resulted in reduced maximum deadload-hook axial loads that occur in the frictional region of an arrestment when the system was configured for Single-Mode operations. (Paragraph VA3f)

J. A-4, F-4, and A-3 aircraft had sufficient rollback to dislodge the aircraft arresting hook from the hook cable during all Single-Mode arrestments. (Paragraph VB1)

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K. Maximum aircraft-hook axial loads for the A-4 and F-4 aircraft were reduced by engaging the aircraft arresting-hook cable 11-1/2 feet OFF-CENTER, compared to similar ON-CENTER arrestments. (Paragraphs VB3 and VB9)

L. No aircraft swerve was encountered when making 30-foot-OFF-CENTER arrestments with the A-4, F-4, or A-3 aircraft. (Paragraphs VB5, VB7b, and VB10)

M. The data contained herein will enable the Naval Air Engineering Center to prepare a family of performance curves for arrestments of aircraft with gross weights up to 60,000 pounds into the Air Force Dual BAK-12 equipped with modular hardware and set for Single-Mode operations. (Paragraphs VB12, VB13, and VB14)

## VII RECOMMENDATIONS

A. Incorporate modular hardware on all Dual BAK-12 Arresting Systems in service.

B. When the arresting system is set for Single-Mode operations, conduct all engagements 10 to 30 feet OFF-CENTER in order to maintain maximum arresting-system capability.

C. The Naval Air Engineering Center should prepare and submit to the United States Air Force a family of performance curves for arrestments of aircraft with gross weights up to 60,000 pounds into the Air Force Dual BAK-12 equipped with modular hardware and set for Single-Mode operations.

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### VIII REFERENCES

- (a) Naval Air Engineering Center Project Order No. 3-4015, Subj: Evaluation of the Dual BAK-12 Arresting-Gear Modular Hardware (12 September 1972), and Modification No. 1 to P.O. 3-4015 (10 August 1973)
- (b) Technical Manual, Operation and Maintenance Instructions (T.O. 35E8-2-5-1) for Aircraft Arresting System Model BAK-12/E32A dated 1 August 1972

## APPENDIX A - PROCEDURE FOR HYDROSTATIC TEST OF MODULAR HYDRAULIC COMPONENTS

The following procedure is required to insure that the modified piping is completely subjected to a pressure test. This Appendix enumerates the steps required on each modified engine prior to connecting the engines together electrically.

1. With the arresting engine in the synchronizing configuration (see paragraph 5-38 of Technical Manual, Operation and Maintenance Instructions - T.O. 35E8-2-5-1 - for Aircraft Arresting System Model BAK-12/E32A dated 1 August 1972), rotate the cam approximately 230 degrees by manually rotating the cam drive sprocket (on the gear reducer). The valve, NAEC PN 422350, labelled with tag "A" must remain open; valve, NAEC PN 422350, labelled with tag "B", must be open.
2. With the rewind engine operating at 2,500  $\pm$ 100 RPM, rotate the cam sprocket so that the cam approaches the 270 degree mark. The brake pressure will approach 2,000 PSIG.
3. Repeat steps 1 and 2 a minimum of three times or as often as required to visually check that no leaks are present in the modified piping system.
4. Return valve, NAEC PN 422350, labelled with tag "B" to the closed position.
5. Return rewind system to operational configuration.
6. Return the cam to zero position and replace the cam reducer-sprocket drive chain.

APPENDIX B - TABULATED DATA OF BAK-12 DEADLOAD AND AIRCRAFT TESTS

Event No. Proj/Site	Deadload					Arresting System								Deadload Arrestment Runout (Ft)	
	Weight (Lb)	Engag- ing Speed (Kn)	Engaging Position (Ft)	Hook Axial Load (1,000 Lb)	Long. Decel (G)	Config or Mode	Purchase- Element Tension (1,000 Lb)		Static Pressure (PSI)	Brake Pressure (PSI)					
							Port 1	Stbd 1		Port		Stbd			
1	6012	16,000	120.3	ON-CTR	46.1	2.45	Single System	19.0	25.5	175	465	-	510	-	868
2	6014	"	137.0	"	40.0	2.23	"	18.0	19.0	"	500	-	520	-	910
3	6015	"	156.6	"	42.5	2.67	"	25.5	25.0	"	655	-	690	-	899
4	6016	"	166.3	"	68.1	3.38	"	27.4	25.4	"	640	-	750	-	945
5	6017	"	161.8	"	59.5	3.28	"	25.7	25.7	"	680	-	705	-	888
6	6018	"	140.3	"	42.7	2.27	"	21.7	21.1	"	530	-	570	-	851
7	6019	"	149.5	"	37.5	2.13	"	23.6	24.0	"	570	-	560	-	900
8	6020	"	100.3	"	23.2	1.43	"	15.5	16.5	"	255	-	305	-	795
9	6021	"	118.9	"	31.0	1.71	"	18.5	19.2	"	365	-	380	-	840
10	6022	"	79.8	"	15.5	1.03	"	11.8	12.2	"	175	-	220	-	531
11	6023	"	114.7	"	34.0	1.75	"	17.8	17.1	"	355	-	370	-	806
12	6024	"	149.5	"	48.5	2.50	"	25.1	25.1	"	660	-	630	-	866
13	6025	"	155.0	"	71.3	3.37	"	28.7	27.9	"	650	-	625	-	893
14	6026	"	97.9	"	45.5	2.30	Dual System	13.5	17.5	"	240	290	310	295	576
15	6027	"	89.7	"	41.5	2.17	"	16.1	14.0	"	200	236	225	210	570
16	6028	"	82.5	"	33.6	1.77	"	12.5	9.8	"	175	200	175	175	404
17	6029	"	114.3	"	39.8	2.31	"	15.0	13.4	"	315	320	360	345	599
18	6030	"	130.4	"	67.4	3.33	"	17.0	17.0	"	390	380	435	425	620
19	6031	"	135.8	"	62.5	3.53	"	19.9	17.7	"	415	450	511	415	611
20	6032	"	142.3	"	82.5	4.00	"	19.3	18.1	"	460	465	520	485	612
21	6033	"	126.0	"	60.8	2.85	"	17.3	15.2	"	390	385	420	405	599
22	6034	"	123.3	"	57.7	2.92	"	15.6	15.0	"	390	380	420	370	585
23	7035	"	117.5	"	53.0	2.84	"	14.5	13.8	"	340	350	370	370	579
24	6036	"	134.5	"	56.4	3.07	"	17.8	17.3	"	475	430	475	435	563
25	6040	"	92.8	"	38.5	2.10	Single Mode	13.9	16.1	"	190	175	240	175	488
26	6041	"	98.7	"	57.0	2.64	"	15.5	12.2	"	220	175	240	175	524
27	6042	"	118.4	"	63.0	3.01	"	15.3	15.1	"	320	175	365	175	575
28	6043	"	131.0	"	78.8	3.60	"	16.7	17.2	"	405	175	420	175	615
29	6044	"	119.8	"	56.0	2.65	"	14.0	13.9	75	350	80	400	75	675
30	6045	"	132.7	"	63.2	3.01	"	17.1	16.5	"	400	150	460	120	820
31	6046	"	117.9	"	56.2	2.73	"	15.5	14.7	175/0*	330	100	365	80	806
32	6047	"	117.9	3 Port	31.9	1.80	"	13.3	13.7	75	380	120	400	75	715
33	6048	"	132.7	"	41.5	2.36	"	16.6	16.5	"	460	160	510	125	820
34	6049	"	118.4	"	30.8	1.65	Single System	16.6	17.1	"	395	-	450	-	825
35	6050	"	133.3	"	33.0	1.66	"	20.6	20.9	"	545	-	530	-	875
36	6051†	"	117.5	"	33.0	1.81	"	15.2	16.5	"	420	-	465	-	835
37	6052†	"	132.7	"	49.2	2.39	"	20.0	20.4	"	550	-	560	-	845
38	6053†	"	114.	ON-CTR	36.2	1.96	"	16.0	16.0	"	400	-	445	-	740
39	6054†	"	132.	"	52.0	2.58	"	19.2	20.1	"	540	-	540	-	785
40	6055	"	142.3	"	48.0	2.50	"	22.6	22.4	"	590	-	640	-	910
41	6056	"	131.6	"	40.1	2.19	"	19.9	19.4	"	525	-	560	-	945
42	6057	"	143.0	"	45.0	2.36	"	21.9	22.1	"	620	-	630	-	950
43	6058	"	142.3	3 Port	39.8	1.89	"	21.8	22.0	"	585	-	640	-	840
44	6059	"	141.0	"	44.3	2.08	"	20.7	22.5	175	550	-	611	-	937
45	6060	"	152.6	"	51.4	2.53	"	24.4	25.4	75	611	-	723	-	860
46	6061	"	165.4	"	61.2	2.92	"	27.7	28.9	"	750	-	851	-	825
47	6062	"	120.8	"	44.65	2.42	Dual Mode	15.18	15.23	175	336	329	381	358	680
48	6063	"	133.9	"	44.3	2.50	"	17.0	17.9	"	404	406	439	404	716
49	6064	"	143.0	"	60.37	3.28	"	18.1	19.1	"	502	438	522	460	736
50	6065	"	155.8	"	65.5	3.54	"	20.9	20.7	"	526	537	632	544	580
51	6066	35,000	118.9	"	NR	NR	"	13.6	13.7	"	451	434	497	455	NR
52	6067	"	138.3	"	67.1	1.72	"	19.3	17.7	"	623	519	638	552	827
53	6068	"	165.3	"	88.6	2.39	"	23.5	23.1	"	799	692	841	780	912
54	6069	"	120.8	"	68.6	1.61	Single Mode	14.5	18.6	"	455	175	505	175	808
55	6070	"	141.0	"	69.3	1.56	"	18.3	18.6	"	582	175	664	175	933
56	6071	"	163.6	"	70.7	1.94	"	22.8	23.0	"	817	230	933	175	NR
57	6072	"	123.3	ON-CTR	73.7	1.69	Dual Mode	14.4	16.5	"	421	390	501	476	1040
58	6073	"	141.0	"	77.1	1.74	"	18.4	18.6	"	562	566	681	562	910
59	6074	"	161.3	"	90.1	2.13	"	22.8	22.7	"	741	741	794	778	965
60	6075	"	117.0	3 Port	46.5	1.26	Single Mode	14.8	15.8	"	420	175	505	175	820
61	6076	"	118.4	11.5 Port	33.2	.948	"	15.0	15.8	75	442	106	508	116	1100
62	6077	"	139.6	"	44.3	1.22	"	17.6	18.6	"	589	187	653	156	1112
63	6078	"	160.9	"	63.7	1.86	"	22.0	21.8	"	812	254	900	212	NR
64	6079	"	121.3	"	47.7	1.50	Dual Mode	15.3	14.6	"	465	435	524	471	1023
65	6080	"	143.7	"	66.1	1.82	"	19.0	17.8	"	669	574	686	628	808
66	6081	"	165.3	"	81.8	2.17	"	24.2	21.3	"	826	824	879	844	892
67	6082	"	121.8	"	29.2	.825	Single System	19.7	19.2	175	598	-	607	-	1085
68	6083	"	141.6	"	41.6	1.00	"	23.6	23.8	"	729	-	767	-	1164
69	6084	90,000	79.8	ON-CTR	41.3	.63	Dual Mode	10.0	12.6	"	265	259	343	281	760
70	6085	"	102.8	"	55.6	.69	"	15.7	15.4	"	456	419	514	451	950
71	6086	"	120.3	"	67.2	.65	"	16.0	17.3	"	597	559	633	566	1090
72	6087	"	137.0	"	78.0	.97	"	17.3	23.0	"	674	723	774	705	1072
73	6088	"	149.5	"	90.2	1.1	"	19.8	26.2	"	771	835	924	836	1127
74	6089	"	167.0	"	117.3	1.35	"	26.3	33.9	"	935	1032	1072	941	1294

NR = Not recorded.

\* 175-psi static pressure on port 1 and stbd 1, 0-psi static pressure on port 2 and stbd 2.

† With 2 adapters (PN 71224-01), and 2 extra purchase-element connectors.

Event No. Proj	Site	Date	Type	Aircraft				Arresting System							Aircraft Arrestment Runout (Ft)			
				Weight (Lb)	Engaging Speed (Kn)	Engaging Position (Ft)		Hook Axial Load (1,000 Lb)	Long. Decel (G)	Config or Mode	Purchase- Element Tension (1,000 Lb)		Static Pressure (PSI)	Brake Pressure (PSI)				
						Target	Actual				Port 1	Stbd 1		Port 1		Port 2	Stbd 1	Stbd 2
1	31,915	7-16-74	A-4	14,700	102	0	0	42.9	2.8	Single	12.6	13.0	175	319	175	331	175	460
2	31,916	"	"	14,300	115	"	"	50.7	3.4	Mode	12.8	14.8	"	332	"	462	"	490
3	31,917	"	"	13,700	116	"	0.5 P	45.9	3.0	"	13.3	14.3	"	380	"	427	"	"
4	31,918	"	"	14,500	117	"	"	51.5	3.3	"	15.2	14.5	"	373	"	424	"	"
5	31,919	"	"	14,100	120	"	"	53.4	3.5	"	14.6	14.5	"	387	"	424	"	"
6	31,920	"	"	13,700	125	"	1.5 P	52.1	3.2	"	15.9	16.4	"	427	"	479	"	510
7	32,029	9-12-74	"	14,400	NR	"	0	NR	NR	"	NR	NR	"	NR	"	NR	"	490
8	32,030	"	"	13,200	NR	"	1.0 S	NR	NR	"	NR	NR	"	NR	"	NR	"	480
9	32,031	9-17-74	"	14,400	122	"	0.5 S	59.2	3.1	"	15.2	15.4	"	463	"	484	"	550
10	32,032	"	"	14,000	127	"	0	57.4	3.1	"	15.0	15.4	"	483	"	548	"	505
11	32,033	"	"	13,600	126	"	1.0 S	58.2	3.2	"	16.2	17.5	"	462	"	492	"	490
12	32,034	"	"	13,200	129	"	0	61.2	3.5	"	15.5	15.5	"	475	"	532	"	"
13	32,035	"	"	12,800	132	"	0.5 S	69.7	4.0	"	16.9	16.7	"	494	"	554	"	495
14	32,035	"	"	12,699	135	"	0.5 S	62.9	3.9	"	18.1	16.2	"	485	"	557	"	490
15	32,037	"	"	14,400	118	11.5 P	"	37.1	2.1	"	14.3	15.0	"	425	"	453	"	570
16	32,038	"	"	13,800	120	"	"	31.1	2.1	"	15.2	14.5	"	416	"	457	"	530
17	32,039	"	"	13,600	127	"	12.0 P	37.9	2.5	"	16.9	15.7	"	462	"	513	"	"
18	32,049	"	"	13,100	135	"	11.5 P	37.2	2.5	"	16.7	17.5	"	499	"	538	"	540
19	32,041	9-18-74	"	14,500	134	"	10.5 P	44.2	2.6	"	16.5	16.1	"	522	"	604	"	545
20	32,042	"	"	14,200	140	"	11.5 P	45.6	2.9	"	16.7	17.4	"	540	"	619	"	540
21	32,043	"	"	14,000	143	"	12.0 P	44.3	3.0	"	17.9	17.5	"	599	"	658	"	550
22	32,044	"	"	13,600	148	"	11.5 P	49.8	3.3	"	18.7	18.3	"	604	"	677	"	595
23	32,045	"	"	13,200	116	"	"	38.9	2.7	Dual	13.5	12.9	"	379	401	411	433	490
24	32,046	9-19-74	"	14,400	126	"	12.5 P	51.2	3.2	Mode	15.4	15.1	"	471	475	544	475	530
25	32,047	"	"	13,800	132	"	12.0 P	60.3	3.9	"	15.1	15.1	"	489	503	529	554	510
26	32,048	"	"	14,400	132	"	"	50.9	3.7	"	17.4	15.4	"	485	498	494	530	520
27	32,049	"	"	14,100	137	"	12.5 P	57.2	3.7	"	16.4	16.0	"	508	519	537	554	"
28	32,050	"	"	13,900	141	"	12.0 P	59.2	3.6	"	16.9	18.6	"	535	534	554	600	505
29	32,051	"	"	13,500	147	"	11.5 P	57.7	4.4	"	17.9	18.5	"	559	558	598	606	510
30	32,052	"	"	13,200	152	"	12.0 P	62.1	4.6	"	19.6	18.2	"	601	592	636	651	525
31	32,053	"	"	12,900	112	"	11.5 P	33.9	2.4	"	14.3	14.2	"	354	364	378	408	500
32	32,054	"	"	12,600	106	23.0 P	23.0 P	27.4	1.9	Single	13.5	13.5	"	358	175	354	175	510
33	32,055	"	"	14,400	98	30.0 P	30.0 P	29.1	1.6	Mode	14.5	13.2	"	335	"	352	"	525
34	32,056	"	"	14,200	113	"	"	33.5	1.9	"	14.5	14.7	"	413	"	418	"	535
35	32,057	"	"	13,800	123	"	31.0 P	39.3	2.4	"	14.6	15.4	"	458	"	458	"	540
36	32,053	"	"	13,600	129	"	28.0 P	37.1	2.4	"	15.9	16.1	"	504	"	501	"	560
37	32,059	"	"	13,200	136	"	"	44.5	2.6	"	17.1	16.8	"	565	"	561	"	580
38	32,060	"	"	13,000	144	"	30.0 P	51.2	3.3	"	18.9	18.3	"	613	"	610	"	"
39	32,164	2-3-75	"	14,000	NR	11.5 P	12.0 P	NR	NR	Single	NR	NR	"	NR	NA	NR	NA	850
40	32,165	2-4-75	"	14,100	NR	"	11.5 P	NR	NR	System	NR	NR	"	NR	NA	NR	NA	750
41	32,166	"	"	13,800	NR	"	9.0 P	NR	NR	"	NR	NR	"	NR	NA	NR	NA	"
42	32,414	3-26-75	"	13,800	110	"	12.5 P	23.1	1.5	"	16.8	15.4	"	463	NA	489	NA	700
43	32,415	"	"	14,400	110	"	17.0 P	22.8	1.4	"	17.7	16.3	"	487	NA	488	NA	730
44	32,416	"	"	14,000	123	"	11.5 P	33.8	2.8	"	21.8	20.5	"	611	NA	642	NA	690
45	36,000	7-7-75	"	14,100	NR	"	10.0 P	NR	NR	"	NR	NR	"	NR	NA	NR	NA	NR
46	36,001	7-8-75	"	14,200	NR	"	7.0 P	NR	NR	"	NR	NR	"	NR	NA	NR	NA	820
47	36,002	"	"	13,900	127	"	10.0 P	29.2	2.2	"	18.7	20.0	"	561	NA	603	NA	875
48	36,003	"	"	14,300	139	"	13.0 P	37.4	2.0	"	21.6	21.7	"	681	NA	639	NA	860
49	36,004	"	"	14,000	134	"	10.0 P	30.2	1.7	"	19.2	19.6	"	552	NA	620	NA	855
50	36,005	"	"	13,600	138	"	10.5 P	29.9	1.9	"	22.3	21.3	"	586	NA	626	NA	850
51	36,006	"	"	13,100	148	"	9.0 P	50.3	3.3	"	22.2	21.7	"	705	NA	715	NA	"
52	36,007	"	"	11,900	151	"	16.5 P	44.1	2.9	"	21.8	23.6	"	710	NA	744	NA	830
53	36,139	9-15-75	F-4	37,000	112	"	11.5 P	48.7	1.1	Single	20.1	21.9	"	503	175	520	175	760
54	36,140	"	"	36,600	120	"	"	42.3	1.0	Mode	16.4	17.4	"	654	"	666	"	830
55	36,142	9-16-75	"	38,000	124	"	12.0 P	45.7	1.2	"	18.8	17.8	"	796	"	757	"	NR
56	36,143	"	"	37,400	130	"	11.5 P	49.1	1.3	"	18.5	21.6	"	795	"	795	"	NR
57	36,144	"	"	36,800	141	"	11.0 P	55.0	1.5	"	20.0	20.8	"	896	"	878	"	NR
58*	36,354	10-2-75	A-3	52,000	109	"	11.5 P	54.8	1.3	"	14.2	14.6	"	569	590*	591	"	NR
59*	36,305	"	"	51,200	122	"	12.0 P	58.7	1.3	"	13.7	21.0	"	553	683*	903	"	NR
60	36,306	"	"	50,800	128	"	11.5 P	58.8	1.1	"	18.5	20.5	"	819	175	835	"	NR
61	36,337	10-2-75	A-3	50,000	132	11.5 P	10.5 P	59.4	1.3	Single	19.1	21.0	175	858	175	884	175	1000
62	36,338	10-3-75	"	50,800	144	"	13.0 P	68.3	1.5	Mode	25.9	29.1	"	1035	"	1034	"	1140
63	36,339	"	"	50,400	107	"	0	44.7	1.1	"	14.7	14.4	"	586	"	626	"	1025
64	36,310	"	"	49,400	129	"	"	61.9	1.4	"	17.1	19.3	"	787	"	881	"	1070
65	36,311	"	"	48,700	141	"	"	56.6	1.2	"	19.2	22.2	"	925	"	956	"	1120
66	36,389	10-14-75	"	50,000	106	30.0 P	28.0 P	NR	NR	"	13.7	18.4	"	583	"	590	"	950
67	36,390	"	"	49,500	125	"	"	NR	NR	"	13.5	18.9	"	766	"	730	"	1050
68	36,391	"	"	51,000	107	"	"	48.1	0.7	"	13.8	14.2	"	596	"	574	"	1000
69	36,392	"	"	50,600	129	"	"	53.9	1.0	"	18.5	17.5	"	868	"	756	"	1120
70	36,393	"	"	50,000	136	"	27.0 P	53.8	1.0	"	20.0	19.6	"	925	"	820	"	1150
71	36,394	"	"	49,600	111	11.5 P	11.5 P	48.2	0.9	"	14.5	14.5	"	581	"	597	"	1010
72	36,395	10-15-75	"	52,200	105	0	2.0 P	NR	NR	"	NR	NR	"	NR	"	NR	"	950
73	36,396	"	"	51,600	134	30.0 P	23.0 P	50.6	1.0	"	17.5	18.8	"	735	"	790	"	1120
74	36,397	"	"	47,500	123	"	29.0 P	43.4	1.1	"	14.9	17.2	"	689	"	715	"	1035
75	36,398	"	"	46,500	122	"	0	57.7	1.3	"	16.9	16.2	"	670	"	734	"	NR
76	36,496	1-28-76	F-4	37,500	95	"	1.0 P	88.9†	2.8	"	19.1	17.5	"	448	"	423	"	705
77	36,437	"	"	36,800	109	"	"	41.7	1.4	"	13.1	14.5	"	541	"	563	"	755
78**	36,498	"	"	36,500	129	NR	NR	NR	NR	"	NR	NR	"	NR	"	NR	"	NR
79	36,499	1-23-76	"	35,700	109	"	0	33.8	1.6	"	11.6	13.9	"	555	"	578	"	765
80	36,500	"	"	37,300	124	"	1.0 S	50.5	1.6	"	14.6	14.8	"	680	"	715	"	815
81**	36,501	"	"	35,600	134	NR	NR	NR	NR	"	NR	NR	"	NR	"	NR	"	NR
82	36,502	"	"	35,500	153	0	0	73.1	2.2	"	20.5	22.8	"	1052	"	1065	"	975
83**	36,503	"	"															

APPENDIX C - NAVAIRTESTFAC DISCREPANCY REPORTS APPLICABLE TO THE  
BAK-12 ARRESTING SYSTEM.

NAVAIRTESTFAC Blue Sheet		NAVAIRENGCEN	
No. and Date	Discrepancy and Action Taken	Date	Action/Reply
BAK-12-1 30 Jul 1974	Rain can drip in through muffler and settle in manifold causing extensive damage to retract engine. <u>Action Taken:</u> Removed muffler, inserted 90° elbow and nipple, and reattached muffler.	6 Aug 1974	Copy sent to J. Shields (Air Force). SAMMA has cognizance of this equipment.
BAK-12-2 30 Jul 1974	52-D-338 rewind clutch hub failed during retract. Hub should be fabricated from steel rather than brittle cast material. <u>Action Taken:</u> Replacement hub ordered from SAAMA. Three remaining hubs removed for dye-penetrant inspection.	6 Aug 1974	Same as above.
BAK-12-3 8 Oct 1974	Second 52-D-338 rewind clutch hub failed during retract. Hub should be fabricated from steel rather than brittle cast material. <u>Action Taken:</u> Spare hub inspected, magnafluxed, and installed.		None.
BAK-12-4 8 Oct 1974	Raised metal keeper on 66-D-1751 tape connector deforms and allows pendant pin to rotate. Keeper should be strengthened or enlarged. <u>Action Taken:</u> Connectors are inspected following each arrestment.		None.
BAK-12-5 8 Oct 1974	Crack developed in 65-D-1751 tape connector. Connectors should be redesigned if similar failures occur at other stations. <u>Action Taken:</u> Connector was replaced.		None.
BAK-12-6 11 Feb 1975	Third 52-D-338 hub rewind clutch failed during retract. Hub should be fabricated from steel rather than brittle cast material. <u>Action Taken:</u> Spare hub installed.	9 Apr 1975	Reply/Action from San Antonio Air Logistics Center, Kelly Air Force Base, Texas: <u>Discrepancy reported has been investigated and corrective action taken as follows:</u> a. Drawing 52-D-338 revised to require hub fabrication from steel. This will affect hubs procured for use with BAK-12 systems using clutch-type rewind systems. b. On new pin drive rewind system using a steel weldment, hub is being furnished with all new BAK-12 systems and will be used on attrition basis to replace all pin drive hubs now in service.

DISTRIBUTION

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