NAVAIR

DEPARTMENT OF THE NAVY
NAVAL AIR WARFARE CENTER
AIRCRAFT DIVISION
LAKEHURST, NJ 08733-5000

ALRE Test Site Operations Branch
LETTER REPORT

NO.: NAWCADLKE-TR247
Date: 29-Mar-22

From: R. Brennan, ALRE Chief Test Engineer

To: United States Air Force (USAF)

Subject: USAF Smart Arrest Deadload Test Program

Airtask: N/A	**Work Unit:** N/A	**Effort Level:** Normal
Test Dates: 14-May-21 to 11-Aug-21	**Installation Dates:** May-2021	
Test Engineer: M. Schettino	**Location:** NAWCAD Lakehurst, JCTS-3	

Enclosures:

_[redacted]_Photographs [redacted]_Tables [redacted]_Enclosures

_[redacted]_Drawings [redacted]_Curves [redacted]__Figures

[redacted]

Distribution Statement A - Approved for public release; distribution is unlimited

References

REF (1) [redacted]

REF (2) [redacted]

Enclosures

ENC (A) [redacted]

1. Introduction

1.1. The BAK-12 is an emergency arresting gear system that is manufactured by Saffron Engineering (formerly ESCO) and utilized by the United States Air Force (USAF) and other North Atlantic Treaty Organization (NATO) nations. [redacted]. Saffron engineering has produced a digital control system for BAK-12s called Smart Arrest. [redacted]

1.2. The purpose of this program was to determine differences in the performance characteristics of the standard BAK-12 and the new Smart Arrest system and to determine if it is suitable for United States Air Force (USAF) use.

2. Description and Configuration

2.1. Smart Arrest System

The Smart Arrest system that was tested is a modified BAK-12 system. [redacted] The analysis and conclusions in this report only apply to the exact configuration that was tested. The configuration utilized was an [redacted] BAK-12 [redacted] equipped with the new Smart Arrest control system. [redacted] all conclusions and analysis in this report apply to only the May-2021 version and are not applicable to any future systems [redacted]

2.2. Site Configuration

This test was conducted at Jet Car Track Site (JCTS) #3 at Joint Base McGuire Dix Lakehurst (JBMDL) in Lakehurst, NJ. The rails of JCTS #3 were extended to within approximately 20' of the primary Smart Arrest System. A second set of BAK-12 arresting gear was installed as the backup gear for this test. The E28 system typically utilized on JCTS #3 was removed to accommodate the BAK-12 backup gear. Six foot long nylon E28 cable risers were utilized for this effort. [redacted]

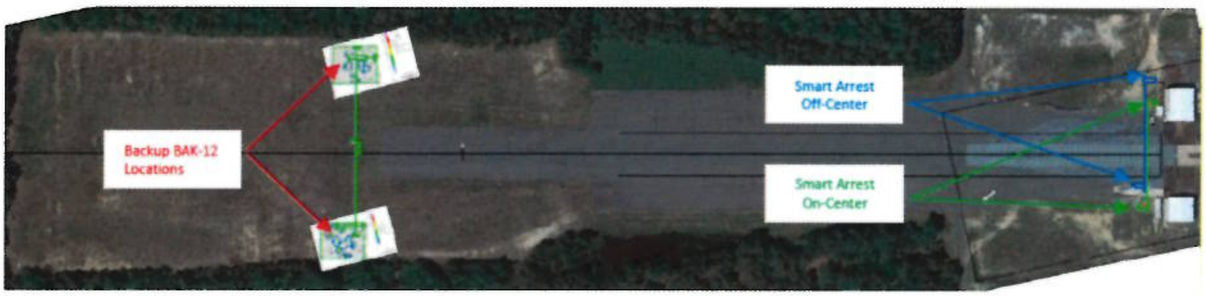

Figure 1: JCTS #3 Site Configuration

2.3. Test Article

The Smart Arrest was installed [redacted]. This test utilized a [redacted] Cross Deck Pendent (CDP) or Arresting Cable with approximately [redacted] of exposed tape on either side for a total sheave to sheave distance of [redacted]. No fairlead beam was utilized for this testing.

2.4. Installation method

The primary on-center Smart Arrest system was installed in existing concrete pads utilizing a deviation of the standard concrete anchor installation, see section 5.6.2 for additional information. The primary off-center Smart Arrest system was installed using a K/M Stake line over concrete / asphalt.

3. Test Procedure

3.1. As Executed Test Matrix

The originally planned test matrix included additional events [redacted] Based on the results of preliminary events and for safety concerns this test matrix was modified during the course of testing. The final as-executed matrix can be seen below. The originally planned matrix can be found in the Test Directive, REF(1).

Smart Arrest / Fixed Orifice				
[redacted]	[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 1: As-Executed Test Matrix

NOTE:

Letters after the Test Event number, such as 40A indicate repeated executions of the same test point. [redacted]

3.2. Additional Safety Mitigations

[redacted]

[redacted]

Anti-rollback gear was utilized due to the high rollback during certain events. This is standard practice for Deadload testing.

4. Instrumentation

The following data was collected during this test. Additional information about data collection can be found in the Test Directive, REF (1).

Parameter Name	Anticipated Data Range	Instrumentation Range	Data Sampling Rate	Do Not Exceed Value	Real/Near Real Time Display	Critical Parameter
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]						

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 2: Instrumentation

5. Test Results, Performance and Analysis

The full dataset collected during this test, [redacted] has been transferred to USAF personnel via digital file transfer and is stored in NAVAIR Test Division archives. A summary of that data can be found [redacted]

The highest energy event that was performed was [redacted]

[redacted]

5.1.1 [redacted]

[redacted]

Figure 2 [redacted]

The above graph shows [redacted] each deadload weight. In general, [redacted]

5.1.2. [redacted]

[redacted]

Figure 3: [redacted]

The above graph show the Smart Arrest system [redacted]

5.1.3. [redacted]

Figure 4: [redacted]

[redacted]

Figure 5: [redacted]

[redacted]

5.1.4. [redacted]

Figure 6: [redacted]

5.1.5. USAF Aircraft Hook Load Limits

[redacted]

Table 3: [redacted]

[redacted] It should be noted that the maximum deadload weight that was tested was [redacted] Below is a summary table of events [redacted]

[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	
[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	
[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	
[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	
[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	

Table 4: [redacted]

5.1.6 [redacted]

The following graphs depict the tape tension and tailhook load against time. Time zero represents the instant the deadload crosses the laser trigger, a fixed point on the rails just before the instant of engagement where the tailhook impacts the arresting cable. Three events where selected to represent "low", "medium" and "high" energy arrestments relative to the range that was executed during this test. [redacted]

	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]

Figure 7: Tape Tension and Hookload vs Time Summary

Hookload and Tape Tension vs Time
Low Energy

[redacted]

Hookload and Tape Tension vs Time
Medium Energy

[redacted]

Hookload and Tape Tension vs Time
High Energy

[redacted]

[redacted]

[redacted]

5.2. Final Off-Center Distance

[redacted]

[redacted]

[redacted]

[redacted]

Above is a graph showing the final off-center position of the deadload after each event, this includes the arrestment and any rollback that occurred. The 0,0 location on the graph corresponds with center of the deck cable prior to the arrestment. Negative values indicate the port (left hand side) and positive values indicate starboard (right hand side). [redacted]

5.2.2. [redacted]

[redacted]

Figure 12: [redacted]

The largest off-center distance was [redacted] This is measured from the center of the Jet Car track.

5.2.3. Smart Arrest [redacted]

Figure 13: [redacted]

[redacted]

Figure 14: [redacted]

The above graphs compare the final off-center distance during on-center arrestments with Smart Arrest and [redacted]. For on-center arrestments there [redacted]

NOTE:

[redacted]

5.3. [redacted]

Runout is the distance the deadload moved along the centerline, it is different than the tape payout statistic that is calculated by the Smart Arrest system, [redacted] Energy is the total energy of the deadload at the start of the engagement, it is calculated based on the weight and engaging speed using E=1/2 MV^2, it is expressed in ft-lbs. The below graph shows calculated energy vs recorded runout.

5.3.1. Calculated Energy vs Runout

[redacted]

5.3.2. Runout Limitation

[redacted]

During the course of testing NAVAIR imposed a runout limitation of [redacted] his limitation applied to both Smart Arrest [redacted] Due to the difficulty of predicting the runout of future events this safety factor was required to safely conduct the test program. A combination of [redacted] were utilized to determine which events would be safe to execute.

5.4. Rollback

Rollback or walk back is the distance the deadload moves in the opposite direction it was traveling after the completion of the arrestment. It is measured from the point the deadload stops moving forward and reaches a velocity of zero to the point it stops moving again in reverse.

[redacted]

Anti-rollback gear is a set piece of equipment used during deadload testing at the JCTS to prevent the deadload from rolling back to great a distance after the completion of the event. Because it rollback distance was a critical parameter for this test it was not initially [redacted] Anti-rollback is installed at a set location in the runout area of the track. If it is installed but not engaged by the deadload it does not affect the rollback distance, if it is engaged by the deadload it invalidates the rollback distance. The table below shows which events the deadload was engaged by the anti-rollback gear. As such those events are not included in the above graph.

[redacted]

5.5. Tape Tension

There is a tape tension limit of [redacted] used by the Smart Arrest system. During the course of testing this limit was never reached.

5.5.1. Smart Arrest On-Center

[redacted]

[redacted]

5.6. Additional Observations

[redacted]

[redacted]

5.6.2. [redacted]

Initially the USAF standard concrete expansion anchors were utilized to install the Smart Arrest system in an existing concrete pad. [redacted]

5.6.3. [redacted]

[redacted]

[redacted]

5.6.4. [redacted]

[redacted]

[redacted]

5.7. Pass / Fail Requirements

[redacted]

5.7.1. [redacted]

[redacted]

[redacted]

Criteria d: [redacted]

Criteria e: [redacted]

Criteria f: [redacted]

Criteria g: [redacted]

Criteria h: [redacted]

Criteria i: [redacted]

Criteria j: [redacted]

Criteria k: [redacted]y due to [redacted]

Criteria l: [redacted]

5.7.2. Performance Criteria

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

6. Conclusions

[redacted]

[redacted]

7. Recommendations

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted]

Robert A. Brennan

NAVAIR ALRE Chief Test Engineer

Enclosure 1 Summarized Test Data

NOTE:

If there are any discrepancies between the summarized data in this enclosure and the full data set in REF (1), the full data should take precedence.

Enclosure 1 Summarized Test Data

[redacted]

Enclosure 1 Summarized Test Data

[redacted]

Enclosure 1 Summarized Test Data

[redacted]