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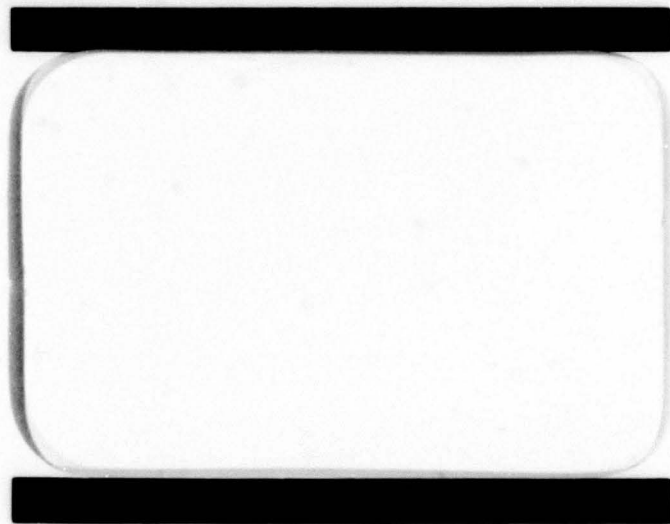
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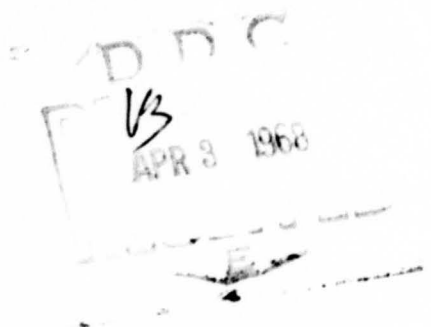
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FINAL REPORT

SEPARATION LATCH TEST

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CLASP

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375-1-64/352

REFERENCES

**Test Plan for Atlas Separation
System Static Latch Test**

GDA-APZ-64-022
Dated 2 April 1964

**Test Procedure for Atlas Separation
System Static Latch Test**

27-B3403-P-1

**Final Test Report on Separation
Latch Tests**

27-B-3403

1.0

INTRODUCTION

This report is herein presented as a portion of the Computer, Launch and Separation Problem (CLASP) Program. Reports for the other phases of the program are not covered, except as necessary to define the subject herein.)

Project CLASP was an extensive investigation of "E" and "F" Series Atlas Missile System failures in order to analyze, isolate and define the critical areas associated with staging, guidance and other problems that may have been defined and to devise and prepare design fixes to correct the problems.

An investigation of possible problem areas in the staging of Atlas "E" and "F" missiles was conducted as a portion of the program in order to determine the mode of failure of 71E, 6F, and 136F. The failure of the three missiles was directly attributed to loss of sustainer hydraulic pressure after initiation of staging.

The separation latch system functions at time of staging. A malfunction of one or more latches could contribute to collision of booster with missile fuel tank or a time delay which could induce loads into the structure that would contribute to a failure mechanism.

An investigation of Engineering Drawing tolerances, manufacturing methods and Inspection reports indicated several possible failure mechanisms could exist.

The separation latch test plan was formulated to test the known conditions as part of the component test portion of the CLASP Program.

2.0

SUMMARY:

2.1

TEST FIXTURE

Four latch assemblies and tank straps were installed on the fixture. The associated tubing and fittings were made to production length and configuration.

A 3000 PSIG Helium supply and a Conax Valve for pressurization was installed to simulate actual missile configuration.

The straps were mounted on a draw bar and latches were mounted on a frame which approximated the spring constant of the missile booster. The capability to apply preloads to latch and strap assembly as well as calculated flight load was provided for.

The straps were instrumented with strain gauges to measure tension loads. A load cell on the strap draw bar was used to measure flight load applied.

Zero time for all separation sequence tests was established as the signal voltage to fire the Conax Valve. Oscilligraph recorders and visual gauges were used to record all data.

Data recorded for all tests were Release time, Release Pressure and total load.

The limitation of the test stand was its inability to transfer load from one latch to another in the event of failure. For static tests planned this was not a critical limitation.

2.2

TESTS PERFORMED:

- A. LATCH PRE-LOAD CHECKOUT. Four separate mechanics were used to adjust the preloads in the latch assemblies. Standard production tools were used and Technical Order procedures were followed. Each adjustment was recorded per the test plan.

The results showed a wide variation in preloads due to operator technique. To facilitate testing a minimum, mean and maximum preload was calculated.

- B. OPERATIONAL SEQUENCE TEST. To define the effect of standard adjustment methods on latch performance a production line mechanic was used to adjust latch preloads per T.O. instructions. The calculated flight loads were applied and a separation sequence was performed.

2.0

Continued

All latches opened within .004 seconds of each other. The average time was .019 seconds and a maximum of 1800 PSIG. The results were within specified allowances and indicated the preload variation did not affect the system performance.

- C. A SERIES OF OPERATIONAL SEQUENCE TESTS were completed using minimum, mean and maximum preloads established from adjustment checkout results. The first two tests were run with nominal calculated flight loads applied. Maximum total load was 9270 lbs.

The next two tests were with 1.5 factor on flight loads. This was to simulate maximum conditions during staging. The maximum total load on one latch was 10405 lbs.

The test results for all runs showed no significant change in performance of the separation latch system.

On the last test a failure of two latch piston cover plate attachments allowed the pistons to be ejected from their housings. The other two latch piston cover plates remained intact, though they were deformed.

Since the latch separation system normally only performs once at missile staging and these had operated four times under severe loading it was felt that this was not a failure mechanism.

- D. To assure reliability and to investigate the failure further a series of special tests were performed. Two aluminum cover plates were replaced with steel cover plates, to measure relative deflections and performance. Ten maintenance cycles were performed. A GN_2 pumping unit used in the factory provided pressurization. 3000PSIG was applied slowly and held for five minutes each time. After ten cycles were completed, two separation sequences were performed. The aluminum plates deflected and deformed. The steel plates did not deform. No failure occurred.

It was found that attaching screws were changed from AN to NAS by Engineering direction on production articles.

To assure reliability of the old hardware, aluminum cover plates (type AN screws, were installed on all latches.

2.0

Continued

- E. Upon inspection of a production latch assembly Q.C. found the latch arm radius was not per print. This caused a compressive load and made the latch difficult to engage. A second random specimen was found to be similar and had been rejected at the test stand.

In addition to the hardware and cover plate, the effect of this condition on separation latch performance was included. The two specimens were mounted in the fixture with two nominal specimens. Ten maintenance pressurization cycles were completed. Maximum loading was applied and the separation sequence was performed. The test was repeated again. No abnormal results were found in either test. The out of tolerance specimens operated within specified time allowances. The aluminum covers deformed but no failures occurred.

- F. LINE RESTRICTIONS of 80% and 50% were orificed into system tubing to simulate crimped lines. The latch system was loaded to nominal condition and the Separation sequence was performed.

No abnormal results were recorded. The system functioned within specified allowances.

- G. MECHANICAL PROBLEMS TEST. To determine the effect of having the latch shear plates installed improper, each of the four latches were used to build in various possible shear plate interferences. The latch system was loaded to nominal condition and the separation sequence was performed. No abnormal results were recorded. The system functioned within specified allowance, The shear plates were driven out of interference by the latch arm in each case.

- H. LATCH TOLERANCE BUILD UP. To determine the effect of a possible bottoming of latch piston before latch arm is free an interference of .016 was created in two latches. The other two latches were used as comparisons.

The latch system was loaded to nominal condition and the separation sequence was performed. No abnormal results were recorded, the system operated within specified allowances.

2.0

Continued

CONCLUSIONS:

The nominal Helium supply pressure is 2600-2800 PSIG at staging sequence time. The nominal unlatch time required is $.020 \pm .010$ seconds as defined by design and test parameters.

None of the test conditions imposed required more than 2200 PSIG or longer than $.024 \pm .004$, seconds time to unlatch. The separation latch system performed within acceptable tolerance.

It was concluded that the latch system is adequate for all known loadings and will perform even under adverse tolerance conditions.

RECOMMENDATIONS:

No further testing of the separation latch system is deemed necessary.

As an improvement type effort the cover plate and its attachment could be studied for possible re-design.

For future tests at Point Loma the cover plates should be replaced with steel plates to preclude failure of the cover plate. The repeated function of latches during drop tests will cause the cover plate failure.

As a second approach cover plates should be changed after each test.

The separation latch system will be instrumented during Point Loma testing at the same discreet points, the data collected should be co-related to static test data.

3.0 TEST SET UP:

3.1 Four latch assemblies and sustainer tank straps were procured from production facility. The tubing for Helium supply was made to production configuration including sizes, fittings, bends and lengths. All connections were torqued per 27-82049 tubing drawing. A one cubic foot - 3000 PSIG Helium bottle supply source and a Conax manifold for control was installed.

The fixture was designed to allow preloading of latch and strap. The spring constant of the booster in the latch area was simulated to allow the pre-load to act similar to the missile configuration, applying a compressive load to structure and Station 1133 ring.

The latch strap hook slot was strain gauged to record the tension load applied by the preload and the flight loads.

The strap was mounted to a draw bar which simulated station 1133 ring. This bar was attached to a load cell and Hydraulic ram. Flight loads were applied by the pulling force of the hydraulic ram simulating a tension load which is additive to the preload. This load is reacted by the latch hook and tends to relieve compression at the 1133 station.

To measure pressure in latch piston at release a transducer was installed at each latch inlet port. The load cells, strain gauges and pressures both Helium supply and release pressure were recorded on oscillograph. Load cells and strain gauges were also read on visual meters for adjustment monitoring.

The Conax valve squibs used for all tests were specimens that had exceeded shelf life. (This did not effect test results).

Each latch and strap assembly was a separate unit. All four latch assemblies were tied to a common pressure source. The capability to transfer load in case of failure was not included.

In all tests different conditions of adjustment loads and test tolerances could be applied to the four samples independantly and comparative data recorded.

A complete description of the set up and illustrations of the test stand are included in the Test Laboratory report 27B3493.

3.0

Continued

The flight loads used were calculated to simulate the same loading as is planned for the Point Loma test program. A severe condition of 1.5 times the calculated values was included for maximum loading during the test series.

Zero time for all tests was the voltage signal to the Conax valve.

DISCUSSION:

The test setup as designed and fabricated functioned very well. The limitation of not being capable of transferring loads from latch to latch did not effect test data or results.

The instrumentation and recorders provided accurate results in most cases. The fixture setup allowed inclusion of all test parameters without compromising test results.

In conclusion the test set up is considered adequate to duplicate static conditions required for test.

4.0 TEST PROGRAM:4.1 LATCH PRELOAD CHECK OUT

Objective: Determine the variation in pre-loads applied due to different personnel and use of standard adjustment tools and procedures. Calculate a minimum, mean and maximum preload that can be expected, for use in test sequence.

Define any problem which may exist the present methods and tools.

Test Set up: The standard tool gauges and technical manual procedure were provided. One man from the missile assembly line was brought in two Engineering Mechanics and one engineer were also utilized.

Each man made a pre-load adjustment to the four latches and each adjustment was recorded. This provided sixteen data points.

Test Results: The applied preloads varied when different people made the adjustment. The difference on each latch was not repeatable.

The following is a table of minimum - maximum preload range established for each latch.

	Q-1	Q-2	Q-3	Q-4
MAx.	8720	7075	7400	8830
Min.	4325	5075	4475	3050
<hr/>				
Range	2395	2000	2925	3780

It was noted that each latch had a minor difference in contact point with strap. The line of action also varied. This contributed to the variations found more than the operator technique.

Interference of the latch arm with its strap was noted. This latch could not be engaged. It was removed prior to test pre-load applications.

A minimum (3050 lb), mean (5500 lb) and maximum (7000lb) test preload was established for further tests. The loads selected provided a range which could be used for comparison.

4.0 CONTINUED

CONCLUSIONS:

Preload tools were adequate. Operator efficiency can cause variations. The largest contribution to variations is the line of action of the latch assembly and its relative location to the strap connection due to tolerances.

Subsequent tests showed that the latch hook line contact with strap slot edge yields the strap edge. This tends to even out the preload.

4.2 OPERATIONAL TEST:

Objective: Establish the basic operating characteristics of the separation latch system when standard production preload adjustment methods are used and nominal calculated flight loads are applied.

Test Set up: A production line mechanic adjusted the four latches using standard tools and Technical Order procedure. Calculated flight loads were applied in accordance with test plan. Loads were recorded prior to separation sequence. The separation sequence was performed. Release time, pressure and loads were recorded.

Test Result: All latches released, visual observation revealed no problems. The data was reviewed and is tabulated below.

Quad	Total Load Lbs	Pre load	Release Time Seconds	Release Pressure PSIG	Supply Pressure PSIG
1	7035	(Min)	0.020	1575	2800
2	5790	(Mean)	0.018	1200	
3	7690	(Max.)	0.0197	11575	
4	8220	(Mean)	0.0217	1800	

The time differential from first to last latch release was .004 seconds.

CONCLUSIONS:

The system functioned within acceptable tolerances. The release pressures were below safe limits. The .004 time span is comparable to previous test data.

4.0 Continued

The variation in preload settings due to operator technique and latch line of contact did not cause any significant problems or time delays.

This test established the normal latch system performance to be used for comparison with subsequent tests.

4.3 SEPARATION SEQUENCE TESTS

Objectives: Define operational characteristics and determine possible failure modes of the latch system with minimum, mean and maximum preloads applied. Tests conditions to include two separation sequences with nominal calculated flight loads applied and two separation sequences with 1.5 nominal calculated flight loads applied to determine affect of maximum calculated loads on the system's performance.

Test Set Up: The four latches designated Quad 1 thru Quad 4 were preloaded by measuring load applied during adjustment with the strap strain gauge meter. The flight loads were applied by the Hydraulic ram and measured from the load cell meter.

The total load was read on the strap strain gauge meter. The separation sequence was performed. The following data was recorded.

Quad	Total Load Lbs	Release Time Seconds	Release Pressure PSIG	Supply Pressure PSIG
Q1	4375	.018	1320	2600
Q2	7285	.018	1500	
Q3	9270	.021	1850	
Q4	7315	.021	1810	

The time differential from first to last latch release was .003 seconds.

The system was readjusted, pressurized and the test was ran again. No significant change in performance was noted.

The second series of separation sequence tests used the same test set up. The calculated flight load times 1.5 factor was applied.

4.0

Continued

The separation sequence was performed. Release time, pressure and load were recorded.

Tabulated below is the comparative data from both runs:

Quad	Quad 1		Quad 2		Quad 3		Quad 4	
	1	2	1	2	1	2	1	2
Total Load lb.	5039	5039	8177	8177	10405	10405	8222	8222
Rel. Time-Sec.	.015	.0185	.016	.021	.015	.027*	.015	.0245*
Rel. Press PSIG	1300	1300	1350	1600	1700	2100*	1500	2000*

* Cover plate attaching hardware failed and actuator piston was ejected.

TEST RESULTS:

The first run at maximum loading showed no significant change from normal operation. No problems were recorded.

The second run was completed and all latches released. The Quad 3 and 4 pistons were ejected when the aluminum cover plates on the piston housings failed. The attaching screws were severed.

Even with the failure the separation sequence was completed within acceptable limits.

CONCLUSIONS:

The separation latch system will function adequately even when maximum calculated flight loads are applied.

The failure of the coverplate and its attachments were caused by fatigue due to excessive staging sequence loading cycles. Special tests were set up to assure the reliability of the system.

4.0 CONTINUED

4.4 SPECIAL TEST-COVER PLATE RELIABILITY:

Objectives: To determine the deflection rate of the aluminum plates and the resulting effect on its attachment hardware versus steel cover plate deflection.

Perform tests to assure that the system was reliable after being actuated several times during installation and maintenance prior to actuation at staging. Test Set up: two standard aluminum cover plates and two, one/eight thick 4130 steel cover plates were installed using NAS Screws. A gaseous nitrogen supply pumping unit was connected to the manifold of the separation latch supply system. The same unit is used during factory maintenance. Dial indicators were installed to measure deflections in one aluminum cover plate and one steel cover plate.

Using the GN₂ pumping unit ten actuations of the release pistons were accomplished, per standard practice, 3000 PSIG was applied slowly and held for five minutes for each actuation. Deflections were recorded.

Upon completion of the ten cycles the GN₂ supply was disconnected. The Helium source was reconnected. The supply pressure was set at 3000 PSIG. The latches were adjusted to minimum, maximum and mean preloads and 1.5 flight loads were applied.

The separation sequence was performed. Release time, pressure and loads were recorded. The system was set up again and adjusted in the same manner. A second separation sequence was performed.

Test results: The maintenance cycles showed .005 deflection of aluminum and .002 deflection of the steel when 3000 PSIG was applied. Both indicators returned to zero after each cycle. No permanent set occurred.

The separation sequence tests showed that the aluminum deflected .02 on the first actuation and .040 on the second actuation. The steel deflection was very minor. No failure occurred.

The release times and pressures were within acceptable limits.

CONCLUSIONS:

No significant difference in performance was noted. Further study of the problem indicated that tests 4.0 should be run to verify all configuration problems.

4.0 CONTINUED

4.5 SPECIAL TEST - HARDWARE TOLERANCES AND COVER PLATE:

Tolerance Problem: The latch arm part number 27-45403-9 had a .56 Rad. instead of the .09 rad. called out on the print. This variance caused the latch to require excessive force to engage. This interfered with the latch strap.

Another latch assembly was rejected at the test stand because it would not engage using normal installation techniques.

An investigation of the problem was initiated. It was found that the detail machine planning did not include final machining of the 109 radius. This allowed a variance. Latches on assembled missiles had this variance.

It was found that NAS 1100 screws had replaced AN 500 screws called out on Engineering drawing. This was done by Engineering Standards direction. Since some latches in the field may have AN 500 screws securing the cover plate the condition was included in the test.

Test Objectives: Determine the capability of AN 500 screws to retain the piston cover plate. Determine the effect of the tolerance on the function of the separation system under maximum calculated flight loading.

Test Set up: The two out of tolerance specimens were mounted in the test fixture. The other two latches were used for comparison during tests. Extreme force was required to engage the out of tolerance latches. The latches all had aluminum cover plates and AN 500 attaching screws installed. Dial indicators were mounted on all four latch cover plates to indicate deflections when latches were pressurized. Ten maintenance pressurization cycles were completed at 3000 PSI.

The latches were adjusted and flight loads applied. The separation sequence was performed. Release time, pressure and cover plate deflections were recorded.

The system was set up again and the separation sequence was performed. Release time, pressure and cover plate deflections recorded.

Test Results: No significant variation in performance was noted in either test. The cover plates deformed progressively but did not fail.

4.0

CONTINUED

The available data is tabulated below for both runs.

QUAD. RUN	QUAD I *		QUAD II*		QUAD III*		QUAD IV°	
	1	2	1	2	1	2	1	2
Total Load Lbs	9405	9405	7422	7422	7077	7077	5889	5889
Rel.Time Sec.	021	026	.022	.016	.019	.015	.020	.016
Rel.Press. PSIG	1950	1980	1920	1500	1500	1300	1425	1350
Supply Press PSig	3000 PSIG He							

- * Out of tolerance latch installed
- ▲ Nominal tolerance specimen
- ° Loose tolerance specimen.

CONCLUSIONS:

The AN 500 screws are adequate. The tolerances did not effect the performance of the system. No rework of latches now installed is necessary.

RECOMMENDATIONS:

As an improvement the use of steel cover plates could be studied however, the results of these tests indicate that a design change is not necessary.

4.0 CONTINUED

4.6 PRESSURIZATION LINE RESTRICTIONS:

Objective: Determine the operating characteristics of the separation latch system if one line has an obstruction or crimp in it.

Test Set up: Installed on 80% flow restriction in latch supply line Quad 1. Installed a 50% flow restriction in latch supply line Quad 4. This provided a restriction in each separate branch line of the system.

All latches were adjusted to the mean preload value and nominal flight loads were applied.

The separation sequence was performed. Release time, pressure and loads were recorded.

Test Results: No change in performance was recorded in either latch.

Conclusion: The separation system will function normally with an extreme obstruction in the line.

In view of the results no further runs were made. One more planned run was cancelled.

4.7 MECHANICAL INTERFERENCE:

Objectives: Several inspection reports investigated showed that the latch shear plate could be improperly installed. IR 906704 from the 136F archives was one of those.

Determine the effect of various possible interferences on the operating characteristics of the separation latch system.

Test Set Up: The shear plate on each of the four latch assemblies was installed to provide possible interferences.

Q-1	.10 interference horizontally
Q-2	Retainer pin installed backwards
Q-3	Leg of shear plate bent to cover latch arm.
Q-4	Shear plate sprung to Jam in piston area.

The latches were adjusted to the mean preload and flight loads were applied. The separation sequence was performed. Release time, pressure and loads recorded.

4.0

CONTINUED

Test Results: In each case the performance of the latch release and pressure required did not change significantly. The system performed within allowable tolerances.

Conclusion: Shear plate interferences will not cause a latch system failure.

4.8

LATCH TOLERANCE BUILD UP:

Objective: Determined the effect of an interference of the actuator piston and the latch arm at time of separation. This would be due to the piston stroke bottoming prior to clearing the edge of the latch arm. The cause of interference would be due to possible tolerance build up.

Test Set Up: Removed two latches from the test fixture. Shims were installed to limit the piston stroke so that a .018 interference was obtained. The latch could be latched by hand but once latched would not release with hand tools used.

Both latches were reinstalled. The four latches were adjusted to the mean preload and nominal flight loads were applied. The separation sequence was performed. Release time, pressure and load was recorded.

The system was set up again and the sequence performed a second time.

Test Results: No change in normal performance was recorded in either latch. Visual inspection showed that the force of the latch arm extruded the latch arm edge past the point of interference.

The data collected for both runs was relatively the same.

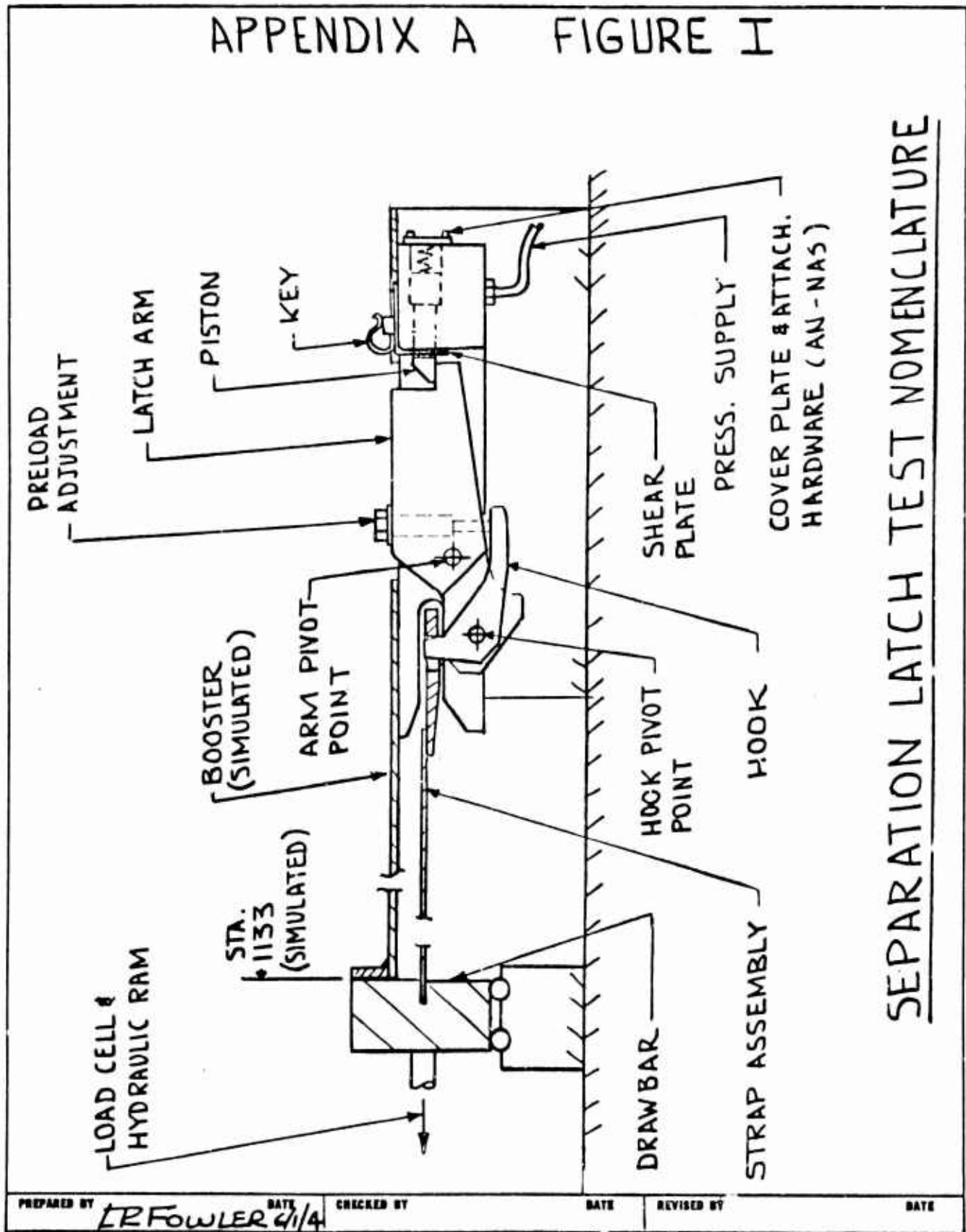
The results are tabulated below:

Run	QUAD 1		QUAD 2		QUAD 3		QUAD 4	
	1	2	1	2	1	2	1	2
Tot. Load	6825	6825	7385	7285	7770	7770	7315	7315
Rel Time	.0235	.023	.0182	.017	.021	.018	---	.018
Rel. Pres	1845	1815	1410	1425	1700	1605	---	1515

* Invalid

Conclusions: The force of the latch arm will overcome any possible interference.

APPENDIX A FIGURE I



SEPARATION LATCH TEST NOMENCLATURE

PREPARED BY LR FOWLER DATE 4/1/4 CHECKED BY _____ DATE _____ REVISED BY _____ DATE _____

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