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AMCMS Code No. 4750.74.4682.H.K2
USATECOM Project No. 7-EG-175-036-002
Report No. APG-MT-3277

FINAL REPORT ON

INITIAL PRODUCTION TEST

OF

AIR CONDITIONER, 36,000 BTU/HR, 60-HZ,

SINGLE-PACKAGE

BY

VICTOR W. MORAWSKI, JR.

JULY 1969

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ABERDEEN PROVING GROUND

ABERDEEN PROVING GROUND, MARYLAND

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DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY T[illegible] AND EVALUATION COMMAND
ABERDEEN PROVING [illegible]OUND, MARYLAND 21005

AMSTE-CF

15 AUG 1969

SUBJECT: Final Report on Initial Production Test of Air Conditioner, 36,000 BTU/HR, 60-HZ, Single-Package, USATECOM Project No 7-EG-175-036-002

Commanding General
U. S. Army Materiel Command
ATTN: AMCMR-C
Washington, D.C. 20315

1. General Statement. The subject final report is approved except as noted herein.

2. Background of Test.

a. The test item is a single-package, base-mounted unit designed to operate on 208-volt, 60-cycle, 3-phase power. The unit has a rated cooling capacity of 36,000 BTU/HR. The air conditioner is a self-contained, air-cooled, electric-motor-driven unit containing a hermetically sealed compressor, evaporator, condenser, and other associated components.

b. The test was conducted at Aberdeen Proving Ground during the period 24 February to 13 June 1969. The purpose was to determine compliance with the initial production specifications and suitability for release.

3. Test Results.

a. The item met criteria for initial inspection and operation, cooling-capacity, high-temperature, short term endurance, rain, and maintenance subtests. The measured total net cooling capacity was found to exceed the minimum specified requirements (36,000 BTU/HR) by 6870 BTU/HR.

b. Test results show the equipment has two deficiencies and one shortcoming as follows:

(1) Inadequate resistance to vibration stress of the high pressure refrigerant tubing (deficiency). During vibration of the test unit in

the longitudinal axis, the weld, connecting the discharge service valve to the high pressure line, fractured. The fracture occurred during the 25-HZ resonant dwell at a 1.5-g input level and resulted in a complete loss of the unit's refrigerant charge.

2) Correction of motor contactors in a humid environment (deficiency). The test unit failed to meet the humidity test objectives as a result of the contactors and armatures of the evaporator fan motor contactor, condenser fan motor contactor, and compressor motor contactor becoming heavily rusted, and seriously impaired the equipment's operational capability.

3) Inadequate resistance to vibration stress of the air filter retaining bracket (shortcoming). During vibration in the vertical axis, a corner spot weld on the right air filter retaining bracket broke. The break occurred during the 16-HZ resonant dwell at a 1.5-g input level. Examination of the broken spot weld on the filter retaining bracket showed the weld was not properly made. Neither the thickness nor the coverage of the weld met specifications.

c. Review of TM 5-4120-259-15 indicated the contents to be adequate for the various levels of maintenance.

d. No special tools or equipment were required for servicing or repair operations of the air conditioner.

4. Conclusions. The subject air conditioner is unsuitable for release.

5. Recommendations.

a. Correct the two deficiencies and, if feasible, the shortcoming.

b. Submit a modified test sample for retest under vibration and humidity environments.

FOR THE COMMANDER:

WILLIAM H. HUBBARD
Colonel, GS
Deputy Chief of Staff

1 Incl
Final Rept 7-EG-175-036-002

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USATECOM PROJECT NO. 7-EG-175-036-002

INITIAL PRODUCTION TEST OF AIR CONDITIONER, 36,000 BTU/HR, 60-HZ, SINGLE-PACKAGE

FINAL REPORT

BY

VICTOR W. MORAWSKI, JR.

JULY 1969

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND
21005

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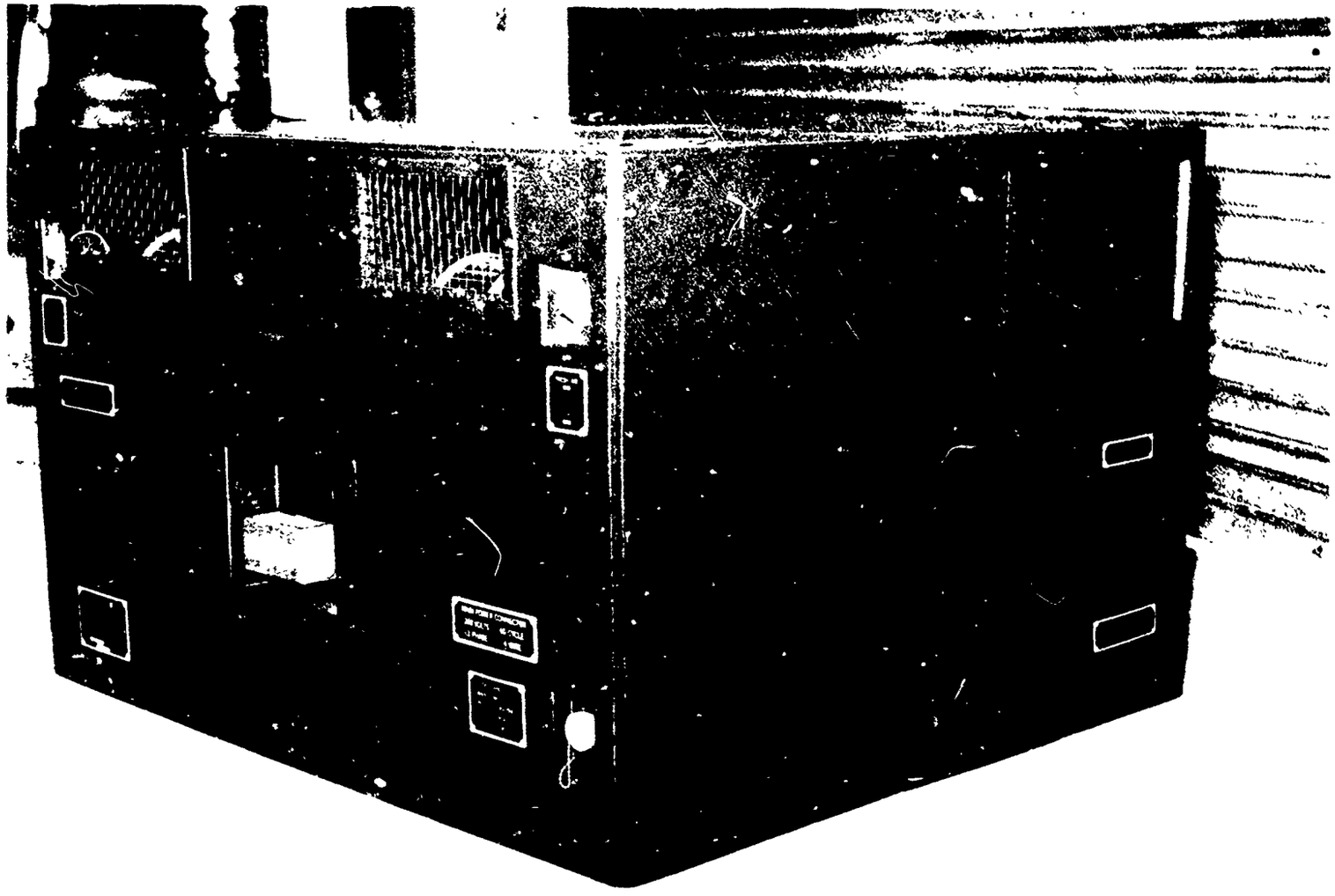
ABSTRACT

This report summarizes the initial production test of the 36,000 Btu/hr, single-package air conditioner conducted at Aberdeen Proving Ground from 24 February to 13 June 1969. The purpose of the test was to determine conformance of the air conditioner to required performance characteristics. The results show that a fractured refrigerant line weld, a broken filter retaining spot weld, and a broken compressor motor-winding terminal wire resulted from laboratory vibrations. Also, heavy rusting of the stators and armatures of all motor contactors resulted from exposure to humidity. It is concluded that the air conditioner met the test objectives with the exceptions noted.

FOREWORD

Materiel Test Directorate was responsible for conducting the test and preparing the test report.



Frontispiece. Air Conditioner, Single-Package, 36,000 Btu/Hr.

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

USATECOM PROJECT NO. 7-EG-175-036-002

FINAL REPORT ON INITIAL PRODUCTION TEST OF AIR CONDITIONER, 36,000 BTU/HR, 60-HZ, SINGLE-PACKAGE

24 FEBRUARY TO 13 JUNE 1969

SECTION I. INTRODUCTION

1.1 BACKGROUND

Aberdeen Proving Ground (APG) was directed by letter from the US Army Test and Evaluation Command (USATECOM) (Appendix IV) to conduct the tests requested by the US Army Mobility Equipment Command (USAMECOM) and additional tests recommended by the Materiel Test Directorate (MTD) to insure compliance with the provisions of AMCR 700-34. Additional tests recommended by MTD were the cooling-capacity, high-temperature, rain, humidity, and vibration tests. In January 1969 two air conditioners (Nos. 6703174 and 6703193) were received at APG for the initial production test.

Because of extensive damage to unit No. 6703174, encountered during the vibration test, an additional unit (No. 6703365) was received at APG in support of the test.

1.2 DESCRIPTION OF MATERIEL

The air conditioner (Frontispiece) is rated at 36,000 Btu/hr cooling capacity. The unit is a single-package, base-mounted unit weighing 515 pounds. The dimensions are 28 inches high, 42 inches wide, and 36 inches deep. The unit is designed to operate on 208-volt, 60-cycle, 3-phase power.

The air conditioner is a self-contained, air-cooled, electric-motor-driven unit containing a hermetically-sealed compressor, evaporator, condenser, and other associated components. Air movement through the condenser and evaporator is provided by dual centrifugal fans affixed to separate motors.

The unit contains three operating controls: a mode selector switch for off, cooling, and ventilating; two damper controls; and a thermostat control. Temperature regulation in the cooling mode is achieved by cycling of a solenoid valve by the return air thermostat (the compressor and condenser and evaporator fans run continuously). The unit is equipped with permanent type filters to filter both the return and ventilated air.

1.3 TEST OBJECTIVE

The objective of this test was to determine if the air conditioner met the requirements for tests outlined in paragraphs 4.7.2.18, 4.7.2.19, and 4.7.2.21 of MIL-A-52435A(ME) and additional tests (cooling-capacity, high-temperature, rain, humidity, and vibration) recommended by MTD.

1.4 SUMMARY OF RESULTS

1.4.1 Initial Inspection and Operational Test

All units were in satisfactory condition and displayed satisfactory performance when received for test.

1.4.2 Cooling-Capacity Test

The total net cooling capacity of the test item exceeded the minimum specified requirement by 6870 Btu/hr.

1.4.3 High-Temperature Test

At +120°F, the compressor thermal time delay relay operated as required, repeating an 8-second response time throughout ten unit starts made.

1.4.4 Rain Test

Throughout the rain test the unit successfully prevented any water build-up or flooding of components. The unit displayed satisfactory operating characteristics during the exposure and showed no evidence of leaks uncharacteristic to its design.

1.4.5 Humidity Test

During 240 hours exposure to humidity, the stators and armatures of the evaporator fan motor contactor, condenser fan motor contactor, and compressor motor contactor became heavily rusted. This caused the contactors to chatter badly when energized. Although the evaporator and condenser fan motors operated under the chattering contactor conditions, the compressor was found to labor and eminate thumping tones.

After the contactors were disassembled and the rust removed, operation of the unit was found to be satisfactory.

Although light rust was found on several screws, nuts, and washers, it was not considered detrimental to the performance or maintainability of the test item.

1.4.6 Laboratory Vibration Test

The test item satisfactorily withstood the applied vibrations except for the following:

a. During vibration in the longitudinal axis the weld, connecting the discharge service valve to the high-pressure line, fractured. The fracture occurred during the 25-Hz resonant dwell at a 1.5-g input level and resulted in a complete loss of the units refrigerant charge.

b. During vibration in the vertical axis a corner spot weld of the right air filter retaining bracket broke. The break occurred during the 16-Hz resonant dwell at a 1.5-g input level. Inspection showed that the weld had been poorly made.

c. The compressor was found to be inoperable following the vibration test. Investigation revealed that an electrical wire, inside the compressor, was broken at the flag connector on the compressor hermetic terminals. Since three identical units, containing the same model compressor, had previously undergone the vibration test at APG without a compressor failure of this type, the incident was considered a random failure.

1.4.7 Short Term Endurance Test

The test item demonstrated satisfactory performance throughout the 50-hour endurance test run.

1.4.8 Maintenance Test

The maintenance literature was found to contain adequate instructions for the various levels of maintenance.

No special tools or equipment were required for servicing or repair of the air conditioner.

1.5 CONCLUSIONS

It is concluded that the air conditioner met the test objectives of all the tests except for the following:

a. The unit failed to meet the humidity test objective as a result of the stators and armatures of the evaporator fan motor contactor, condenser fan motor contactor, and compressor motor contractor becoming heavily rusted (ref par. 2.5.4).

b. The unit failed to meet the vibration test objective as a result of: 1) the fractured weld, connecting the service valve to the high pressure line, and 2) the broken corner spot weld of the right air filter retaining bracket (ref par. 2.6.4).

1.6 RECOMMENDATIONS

Not applicable.

SECTION 2. DETAILS OF TEST

2.1 INITIAL INSPECTION AND OPERATIONAL TEST

2.1.1 Objective

The objective was to determine if the air conditioner was in satisfactory condition and completely operational before starting subsequent tests.

2.1.2 Criteria

Any one of the following shall constitute failure of this test:

a. Missing or damaged components.

b. Abnormal operation.

c. Low refrigerant charge.

d. Air temperature drop less than 20°F between evaporator inlet and outlet.

e. Unit not bypassing with thermostat set to maximum temperature.

f. Current drawn in the cooling cycle more than 27 amperes (average of three phases).

2.1.3 Method

This test was conducted on unit Nos. 6703174, 6703193, and 6703365:

The units were inspected for missing or damaged components.

Sheet metal ducts were installed on the evaporator return air inlets and evaporator openings. Each duct was 24 inches long and of the same cross-sectional dimension as the respective opening. Two thermocouples were placed in each duct. The thermocouples were located 18 inches from the air conditioner openings and were equally spaced over the cross section of the ducts to give average intake and discharge air temperatures. With power connected to the unit through a test console, the unit was operated for 2 hours in the cooling mode of operation. During the 2-hour operating period proper operation of the unit's controls and performance characteristics were determined.

2.1.4 Results

Inspection showed the units to be complete and undamaged.

Each unit operated as required for each setting of the mode selector switch and thermostat control.

There was no evidence of abnormal unit operation or refrigerant leaks.

Operational characteristics of each unit were as presented in Table 2.1-I.

Table 2.1-I. Operational Characteristics

Characteristic	Unit No. 6705174	6705195	6705365
Input, volts	208	208	208
Current drawn, amperes (average of three phases)	19.5	18.8	19.5
Power drawn, kw	6.2	6.1	6.2
Left evaporator intake temperature, °F	78	83	78
Right evaporator intake temperature, °F	78	83	78
Left evaporator discharge temperature, °F	48	55	49
Right evaporator discharge temperature, °F	47	56	49
Condenser intake temperature, °F	79	83	78
Left condenser discharge temperature, °F	100	102	99
Right condenser discharge temperature, °F	100	102	98
Refrigerant suction pressure, psig	59	59	61
Refrigerant discharge pressure, psig	200	200	200
Refrigerant sight glass	Clear	Clear	Clear
Compressor thermal relay delay, sec	9	11	8

2.1.5 Analysis

The air conditioner met the initial inspection and operational test criteria.

The air temperature drop between the evaporator inlet and outlet of each unit exceeded the minimum requirements by at least 7°F.

The maximum current drawn in the cooling mode of operation averaged 7.7 amperes lower than the allowable limit.

2.2 COOLING-CAPACITY TEST

2.2.1 Objective

The objective was to determine if the test item would provide its rated cooling capacity.

2.2.2 Criterion

The unit will have a total (sensible plus latent) cooling capacity of 36,000 Btu/hr with the air entering the condenser at +120°F (dry bulb) and the air entering the evaporator at +90°F (dry bulb) and +75°F (wet bulb).

2.2.3 Method

This test was conducted on unit No. 6703193.

The capacity test was conducted by Electrical Testing Laboratories, Inc., New York, N.Y., in accordance with ASHRAE Standard 37-60, Method of Testing for Rating Unitary Air Conditioning Equipment.

The test item was installed in a psychrometric test chamber and properly instrumented. The test item was installed flush with the "indoor" - barrier wall of the chamber, the fresh-air damper was fully closed, and the thermostat set at maximum cooling. The capacity of the evaporator and condenser sides was measured by the air enthalpy method while the above criterion conditions were maintained.

2.2.4 Results

The measured total net cooling capacity was 42,870 Btu/hr.

The data obtained from the capacity test are contained in the reference (Appendix V).

2.2.5 Analysis

The test item met the cooling capacity test criterion.

The total net cooling capacity of the test item exceeded the minimum specified requirement by 6870 Btu/hr.

2.3 HIGH-TEMPERATURE TEST

2.3.1 Objective

The objective was to determine if the compressor thermal time delay relay operated satisfactorily at +120°F.

2.3.2 Criterion

Inability of time delay relay to energize the compressor within prescribed limits (5 to 15 seconds after turn-on) shall constitute failure of this test.

2.3.3 Method

This test was conducted on unit No. 6703565.

The air conditioner was placed in a climatic test chamber and stored at +120°F for 14 hours.

Remaining at +120°F, the test item was energized in the cooling mode and allowed to remain energized until the thermal time delay relay energized the compressor motor. The elapsed time from initial turn-on until the relay energized the compressor motor was clocked using a stop watch. This timing procedure was repeated at 10-minute intervals for a total of ten unit starts.

2.3.4 Results

The thermal time delay relay was found to energize the compressor motor 8 seconds after turn-on. The 8-second response time was repeated throughout the ten starts that were made.

2.3.5 Analysis

The test item met the high-temperature test criterion.

2.4 RAIN TEST

2.4.1 Objective

The objective was to determine if the air conditioner was capable of being stored and operated under 4 ± 1 inches per hour simulated rainfall without detrimental effects.

2.4.2 Criterion

The unit shall perform satisfactorily under applicable rain storage and operating climatic conditions established by AR 705, C1, 14 October 1963.

2.4.3 Method

This test was conducted on unit No. 6703365.

The unit was tested in two phases; a storage test and an operational test. Throughout both test phases a fixture producing a simulated rainfall of 4-1/2 inches per hour was used.

For the open storage test, the top and each side of the unit was exposed for 30 minutes. Following each exposure an inspection for water penetration and adequate drainage was made.

For the operational test, ducts were attached to the evaporator return air inlets to prevent any water penetration through the inlets. A plywood shield was affixed around the entire front edge of the unit and caulked to prevent water from getting to the front of the unit. The top, sides, and back of the unit were then exposed to the simulated rainfall for 2 hours while the unit was operated in the cooling mode. During this exposure the unit was observed for evidence of abnormal operation and for evidence of water penetration to the front of the unit.

2.4.4 Results

Examination of the unit, after the storage test, showed that water entering the unit had settled to the bottoms of the condenser and upper evaporator condensate trays and was drained free of the unit via the drain hole. There was no evidence of water build-up or flooding of components.

Examination of the unit, during and after the operational test phase, showed that water penetration was confined to the condenser compartment. There was no evidence of water entering the evaporator compartment of the unit. Operation of the unit throughout the 2-hour exposure was satisfactory.

2.4.5 Analysis

The test item met the rain test criterion.

2.5 HUMIDITY TEST

2.5.1 Objective

The objective was to determine if operation of the test item was adversely affected from exposure to a warm, highly humid condition such as encountered in the tropics.

2.5.2 Criteria

Failure to meet any one of the following requirements shall constitute failure of this test:

a. Unit shall perform satisfactorily following exposure to high-humidity environment.

b. All components shall be adequately treated, plated, or painted to resist rust and corrosion which may affect the units operational characteristics.

2.5.3 Method

This test was conducted on unit No. 6703565.

The test item was placed in a standard humidity test chamber. The chamber temperature and relative humidity were slowly raised to +155°F and 95% respectively, over a period of 2 hours. This condition was maintained for 6 hours. The chamber temperature was then gradually reduced to +80°F over a period of 16 hours; the relative humidity was maintained at 95%.

This cycle was conducted ten times for a total exposure of 240 hours.

At the conclusion of the 240-hour exposure, the test item was removed from the chamber and a detailed inspection was made. In addition, the test item was given an operational test. All controls were checked and any evidence of improper unit operation was noted.

2.5.4 Results

Inspection of the unit, following exposure to humidity, revealed no adverse effects. Although light rust was found on several screws, nuts, and washers, it was not considered detrimental to the performance or maintainability of the test item.

Operation of the unit showed the evaporator fan motor contactor, condenser fan motor contactor, and compressor motor contactor to be chattering badly. Although the evaporator and condenser fan motors operated under the chattering contractor conditions, the compressor was found to labor and eminate thumping tones.

Investigation showed the stator and armature of each contactor to be heavily rusted. After the contactors were disassembled and the rust removed, operation of the unit was found to be satisfactory. Post-humidity operational characteristics are presented in Table 2.5-I.

Table 2.5-I. Post-Humidity Operational Characteristics

Characteristics	Unit No. 6703365
Input, volts	208
Current drawn, amperes (average of three phases)	19.6
Power drawn, kw	6.2
Left evaporator intake temperature, °F	78
Right evaporator intake temperature, °F	78
Left evaporator discharge temperature, °F	45
Right evaporator discharge temperature, °F	45
Condenser intake temperature, °F	79
Left condenser discharge temperature, °F	103
Right condenser discharge temperature, °F	103
Refrigerant suction pressure, psig	60
Refrigerant discharge pressure, psig	210
Refrigerant sight glass	Clear
Compressor thermal relay delay, sec	8

2.5.5 Analysis

The test item failed to meet the humidity test criteria as a result of the malfunctioning motor contactors.

The contactors presently used should be replaced with contactors that are impervious to moisture.

2.6 LABORATORY VIBRATION TEST

2.6.1 Objective

The objective was to determine if the air conditioner could withstand, without damage, simulated vibrations associated with 2500 miles of truck and semitrailer transportation.

2.6.2 Criterion

The unit shall be designed and constructed to withstand, without damage, transportation in military vehicles.

2.6.3 Method

This test was first conducted on unit No. 6703174 with the top and two side-cover panels removed to facilitate observance of the various internal components during test. Because of extensive damages encountered during this test, it was resolved that the cover panels were a major factor in contributing over-all support and strength to the frame structural members of the unit. This test was therefore considered invalid. The vibration test was then repeated on unit No. 6703365 with all cover panels in place.

The test item was mounted by its base with seven 1/4"-28 bolts on an aluminum plate as shown on page I-4. For vibration through the transverse and longitudinal axes, the plate was bolted to the slip table and driven by the C150 electrodynamic vibration exciter in the horizontal plane as shown on page I-4. For vibration through the vertical axis, the plate with the air conditioner was bolted on top of the large table on the C150 exciter as shown on page I-4.

Calibrated, piezoelectric accelerometers were mounted in the direction of the applied force on various components of the unit to measure the responses to the programmed input as monitored at each of the four corners of the air conditioner. Pages I-5 through I-12 show the accelerometer locations. All acceleration data were recorded on a visicorder. The air conditioner was tested at the prevailing ambient room temperature.

The laboratory test in each axis simulated the vibration environment associated with 2500 miles of truck and semitrailer transportation as outlined in Figure 1 of TECP 700-700, Interim Pamphlet 70-73. The test schedule per axis was as follows:

a. Cycling Phase. The air conditioner was cycled from 5.5 to 200 Hz at 1.5-g input at a sweep rate of 5.05 minutes, minimum to maximum frequency. The accelerometer responses were recorded during the first sweep through the frequency spectrum and from these recorded responses, the approximate resonant frequencies were determined and then pinpointed. The total cycling time was dependent upon the total time spent at resonance dwell and is given on page I-1.

b. Resonance Dwell. The unit was subjected to a 6.25-minute dwell at each resonant frequency (not exceeding four per axis) at the input specified for that frequency in the cycling phase. Page I-1 lists the number of resonances and the total dwell time.

The test item was inspected following each resonant dwell and at the completion of the cycling in each axis.

2.6.4 Results

Throughout the vibration test the air conditioner incurred the following damage:

a. During vibration in the longitudinal axis the weld, connecting the discharge service valve to the high-pressure line, fractured. The fracture occurred during the 25-Hz resonant dwell at a 1.5-g input level and resulted in a complete loss of the units refrigerant charge.

b. During vibration in the vertical axis a corner spot weld of the right air filter retaining bracket broke. The break occurred during the 16-Hz resonant dwell at a 1.5-g input level. Inspection showed that the weld had been poorly made.

c. The compressor was found to be inoperable following the vibration test. An electrical continuity checkout revealed one open compressor motor winding. Upon direction from USAMECOM, this compressor was replaced with the compressor contained in unit No. 6703174 for the running of the post-vibration operational checkout.

A chronological list of damage is contained on page I-2 and pages I-13 and I-14 contain pictorial coverage of the damage.

The input amplification factors at the resonant frequencies for the various accelerometer locations are tabulated on page I-3.

Operational characteristics of the test item after the vibration test are presented in Table 2.6-I.

Table 2.6-1. Post-Vibration Operational Characteristics

Characteristic	Unit No. 6703365
Input, volts	208
Current drawn, amperes (average of three phases)	19.3
Power drawn, kw	6.2
Left evaporator intake temperature, °F	76
Right evaporator intake temperature, °F	75
Left evaporator discharge temperature, °F	43
Right evaporator discharge temperature, °F	43
Condenser intake temperature, °F	80
Left condenser discharge temperature, °F	100
Right condenser discharge temperature, °F	99
Refrigerant suction pressure, psig	59
Refrigerant discharge pressure, psig	210
Refrigerant sight glass	Clear
Compressor thermal relay delay, sec	.8

2.6.5 Analysis

The test item failed to meet the vibration test criterion as a result of:

a. The fractured weld, connecting the service valve to the high pressure line.

b. The broken corner spot weld of the right air filter retaining bracket.

c. The inoperable compressor.

The fractured weld at the high-pressure line was caused by excessive stress at the weld. The tubing connecting the service valve to the high-pressure line is a straight run 2-inch line permitting minimal flexing. Since the same failure occurred during vibration of unit No. 6703174, the straight run tubing configuration appears to be inadequate. An appropriate length of tubing should be incorporated to permit an S or U bend tube run between these points thereby increasing the flexing limits and in turn decreasing the stress at the welded joint.

Examination of the broken spot weld on the filter retaining bracket showed the weld to be poorly made. Neither the thickness nor the coverage of the weld were uniform. Closer quality control measures are needed.

The inoperable compressor was sent to Fort Belvoir, Virginia for investigation. The investigation revealed that a wire, inside the compressor, was broken at the flag connector on the compressor hermetic terminals. Since three identical units, containing the same model compressor, had previously undergone the vibration test at APG without a compressor failure of this type, the incident was considered a random failure.

2.7 SHORT TERM ENDURANCE TEST

2.7.1 Objective

The objective was to determine if the test item would operate satisfactorily for 50 hours without incurring damage.

2.7.2 Criteria

Any one of the following shall constitute failure of this test:

a. Failure of any component or fracture or breakdown of any material.

b. Evidence of refrigerant leakage.

c. Need for servicing, other than filter cleaning, of the air conditioner during operation.

d. Abnormal operation.

e. Air temperature difference less than 20°F between evaporator inlet and outlet.

f. Low refrigerant charge.

g. Current drawn on cooling cycle more than 27 amperes (average of three phases).

2.7.3 Method

This test was conducted on unit Nos. 6703365 and 6703193.

The test was conducted in a shop area using the sheet metal ducts and thermocouples in the manner described in paragraph 2.1.3. With power connected to the test item through a test console, the test item was operated for 50 hours in the cooling mode in cyclic operation of 50 minutes on and 10 minutes off. Cyclic operation was controlled by

an electric timer which operated a contactor relay that was placed in the power line of the test item. During the 50-hour operating period, the operational requirements were checked periodically in the following specified manner:

a. Observed the refrigerant sight glass to ascertain that the unit remained fully charged.

b. Observed the test item for evidence of abnormal operations.

c. Monitored evaporator intake- and discharge-air temperature to ascertain that the intake-to-discharge temperature drop was at least 20°F.

d. Monitored input power parameters to ascertain that the current drawn in the cooling mode was less than 27 amperes (average of three phases).

2.7.4 Results

The test items demonstrated satisfactory performance throughout the 50-hour endurance test run.

Operational characteristics recorded at the completion of the test run are presented in Table 2.7-I.

Table 2.7-I. Operational Characteristics

Characteristic	Unit No. 6703365	Unit No. 6703193
Input, volts	208	208
Current drawn, amperes (average of three phases)	19.3	19.8
Power drawn, kw	6.2	6.2
Left evaporator intake temperature, °F	80	74
Right evaporator intake temperature, °F	80	73
Left evaporator discharge temperature, °F	46	48
Right evaporator discharge temperature, °F	46	48
Condenser intake temperature, °F	80	80
Left condenser discharge temperature, °F	106	96
Right condenser discharge temperature, °F	105	102
Refrigerant suction pressure, psig	63	60
Refrigerant discharge pressure, psig	226	232
Refrigerant sight glass	Clear	Clear
Compressor thermal relay delay, sec	8	11

2.7.5 Analysis

The test item met the short term endurance test criteria.

2.8 MAINTENANCE TEST

2.8.1 Objectives

The objectives were:

a. To determine if the technical literature was adequate for maintaining the test item.

b. To determine if special tools are required to perform maintenance.

2.8.2 Criteria

Criteria were as follows:

a. Maintenance literature shall contain adequate instructions and guidance for organizational, direct, and general support maintenance.

b. Special tools or equipment shall not be required for maintenance of the unit.

2.8.3 Method

A cursory review of TM 5-4120-259-15 was made to determine adequacy of instructions for the various levels of maintenance.

Throughout the test program the need for applications of special tools was determined during performance of maintenance on an "as required" basis. The need for special tools to service the components not requiring maintenance during the test program was determined by visual examination.

2.8.4 Results

Review of TM 5-4120-259-15 showed the contents to be adequate for the various levels of maintenance.

No special tools or equipment were required for servicing or repair operations of the air conditioner.

2.8.5 Analysis

The test item met the maintenance test criteria.

SECTION 3. APPENDICES

APPENDIX I - TEST DATA

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

CYCLING AND RESONANCE DWELL TIMES

Axis	Number of Resonances	Total Dwell* Time - Min.	Total Cycling Time - Min.
Transverse	3	18.75	18.75
Longitudinal	3	18.75	18.75
Vertical	4	25	12.5

* Based on 6.25 minutes per resonance.

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

CHRONOLOGICAL LIST OF DAMAGE

Axis	Event	Time Duration Min.	Total Elapsed Time Per Axis Min.	Inspection Results	PAGE
Transverse	Cycle 5.5 to 7 Hz at 1.0 inch, D.A., input and 7 to 200 Hz at 1.5g input (resonance search conducted during this)	18.75	18.75	No damage	
	Resonant dwell, 143 Hz at 1.5 g	6.25	25	Rear screws in main off-on switch loose - tightened	
	Resonant dwell - 74 Hz at 1.5g	6.25	31.25	No damage	
	Resonant dwell - 46 Hz at 1.5 g	6.25	37.5	High pressure switch loose - tightened.	
Longitudinal	Cycle as above	12.50	12.5	No damage	
	Cycle as above	6.25	18.75	No damage	
	Resonant dwell - 112 Hz at 1.5 g	6.25	25	No damage	
	Resonant dwell - 40 Hz at 1.5 g	6.25	31.25	No damage	
	Resonant dwell - 25 Hz at 1.5 g	6.25	37.5	Liquid service line cracked where joins large line. Freon escaping.	I-14
Vertical	Cycle as above	12.5	12.5	No damage	
	Resonant dwell - 116 Hz at 1.5 g	6.25	18.75	No damage	
	Resonant dwell - 107 Hz at 1.5 g	6.25	25	No damage	
	Resonant dwell - 86 Hz at 1.5 g	6.25	31.25	No damage	
	Resonant dwell - 16 Hz at 1.5 g	6.25	37.5	Spot weld on one corner of filter in top broken - bad weld.	I-13

Operational checkout at end of test revealed that the compressor was inoperable.

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

RESONANT FREQUENCIES AND INPUT AMPLIFICATION FACTORS

Axis	Resonant Frequency - Hz	Input g ±10%	Input Amplification Factors at Accelerometer Locations					
			1	2	3	4	5	6
Transverse	143	1.5	0	0	0	5.4	1.2	0
	74	1.5	1.9	1.1	0	4.4	15.9	0
	46	1.5	0	4.4	1.1	5.8	2.5	5.4
Longitudinal	112	1.5	0	1.4	0	5.3	4.2	1.5
	40	1.5	7.0	1.0	1.3	1.2	5.1	0
	25	1.5	2.1	4.4	4.3	0	4.1	5.2
Vertical	116	1.5	0	0	1.6	5.7	0	3.6
	107	1.5	1.4	0	1.3	1.3	1.6	6.8
	86	1.5	4.1	0	0	3.2	2.4	2.1
	16	1.5	0	0	3.7	0	2.1	0

$$\text{Input Amplification Factor} = \frac{\text{Response G Value}}{\text{Input G Value}}$$

Accelerometer locations are given on pages I-5 through I-12.

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

TEST SETUPS

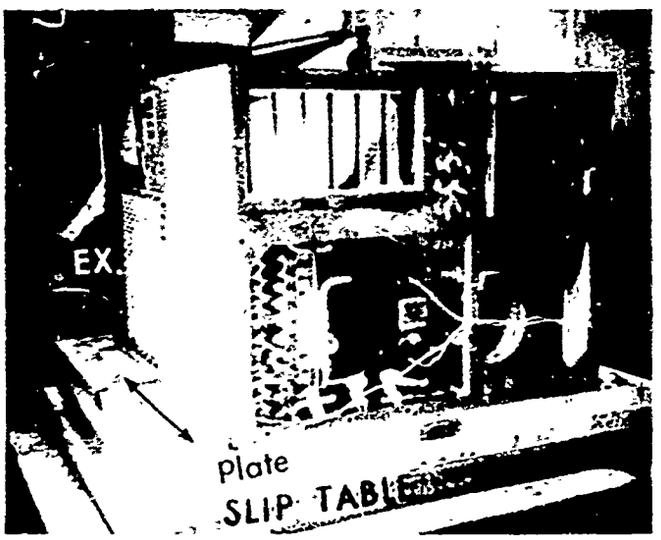
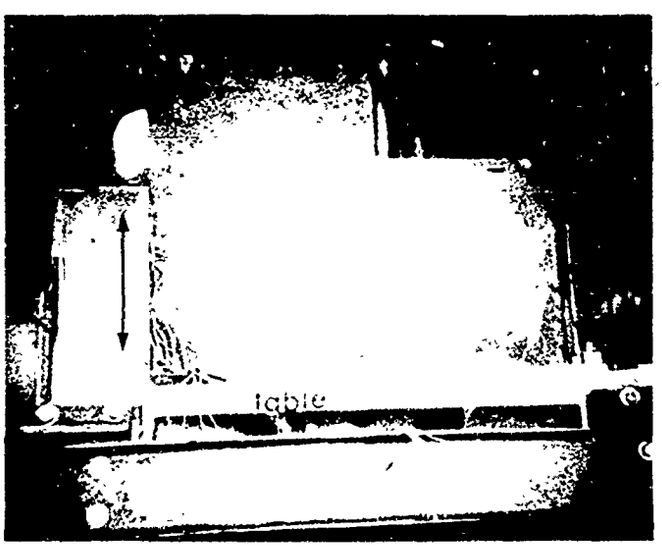


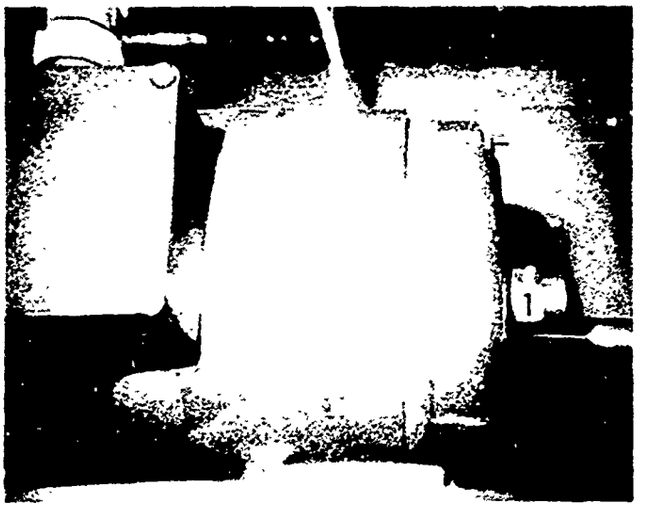
Photo shows setup in transverse axis. The unit was bolted to an aluminum plate which in turn was bolted to the slip table driven by the C150 exciter (Ex.). The arrow indicates the axis of the applied force. For longitudinal axis, the plate was turned 90°.

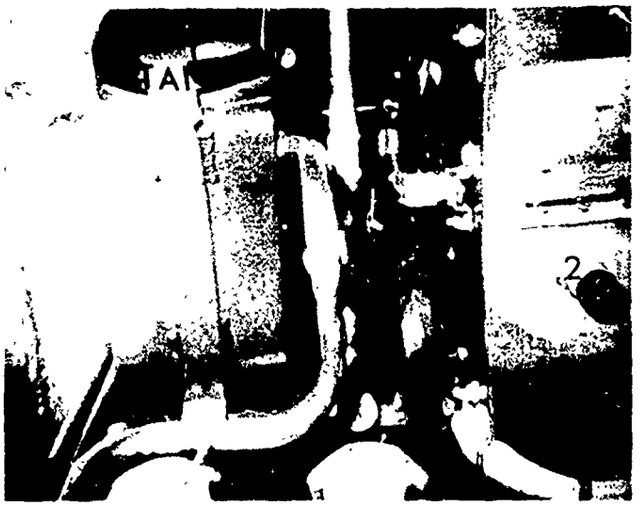


Setup in vertical axis. The plate with the air conditioner was bolted to the C150 table. The arrow indicates the axis of the applied force.

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

ACCELEROMETER LOCATIONS - TRANSVERSE AXIS

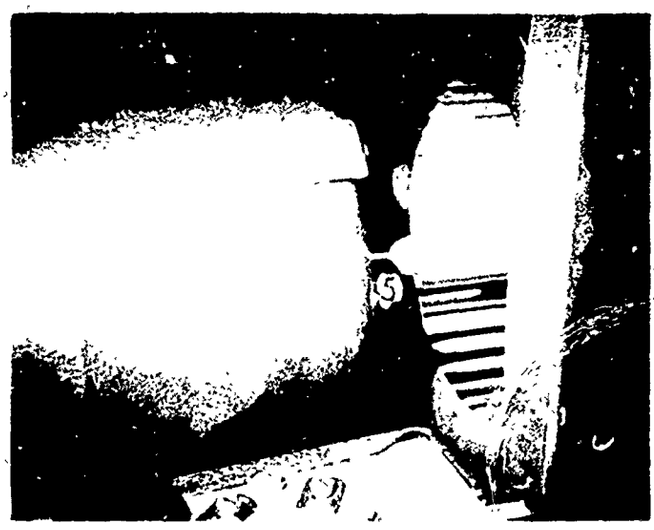




Accelerometer No.	Location
1	Evaporator Blower Motor (Upper Motor)
2	Main Off-On Switch Assembly
3	Liquid Storage Tank - Not shown in lower photo but on opposite side of tank.

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

ACCELEROMETER LOCATION - TRANSVERSE AXIS



Accelerometer No.	Location
4	Compressor
5	Condensor Blower Motor (Lower Motor)

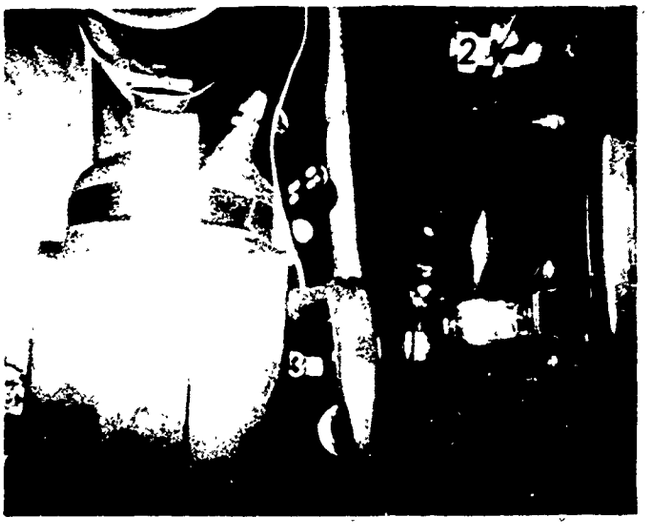
LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

ACCELEROMETER LOCATION - TRANSVERSE AXIS

Accelerometer No. 6 on High Pressure Safety Switch

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

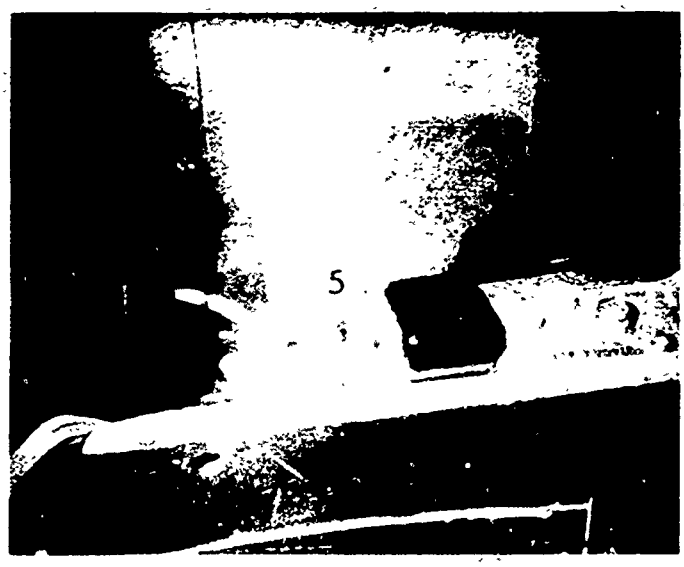
ACCELEROMETER LOCATIONS - LONGITUDINAL AXIS



Accelerometer No.	Location
1	Evaporator Blower Motor (Upper Motor)
2	Main Off-On Switch Assembly
3	Liquid Storage Tank

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

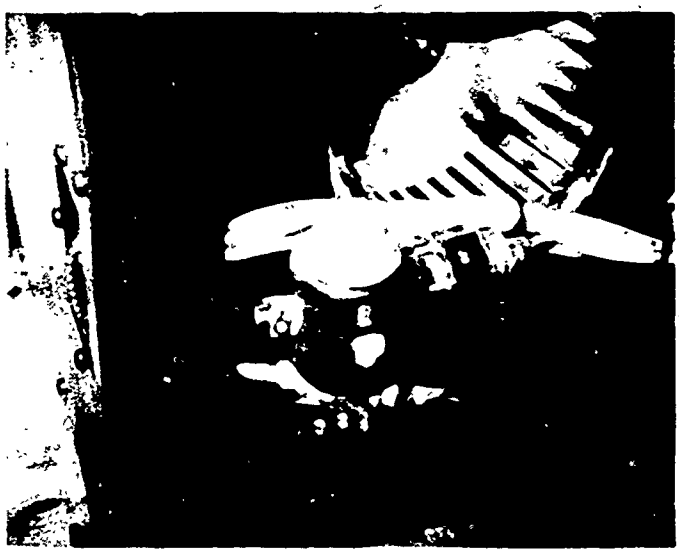
ACCELEROMETER LOCATION - LONGITUDINAL AXIS



Accelerometer No.	Location
4	Compressor
5	Condensor Blower Motor (Lower Motor)

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

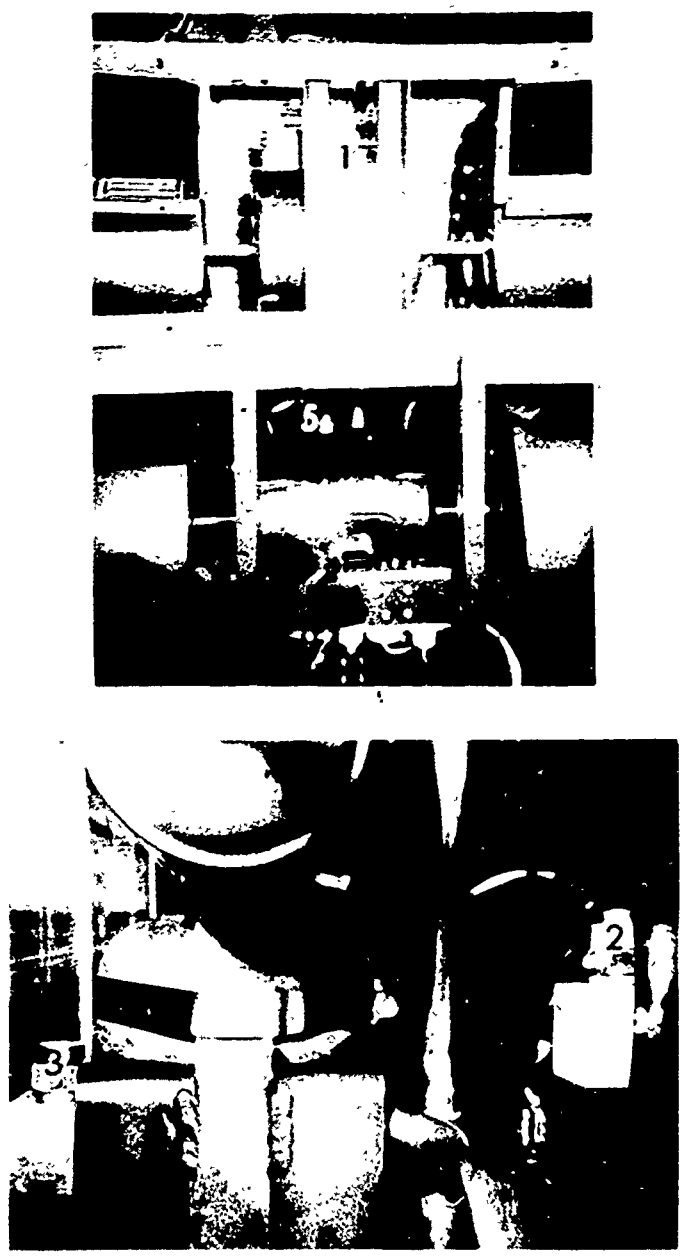
ACCELEROMETER LOCATIONS - LONGITUDINAL AXIS



Accelerometer No. 6 was Located on the High Pressure Safety Switch

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

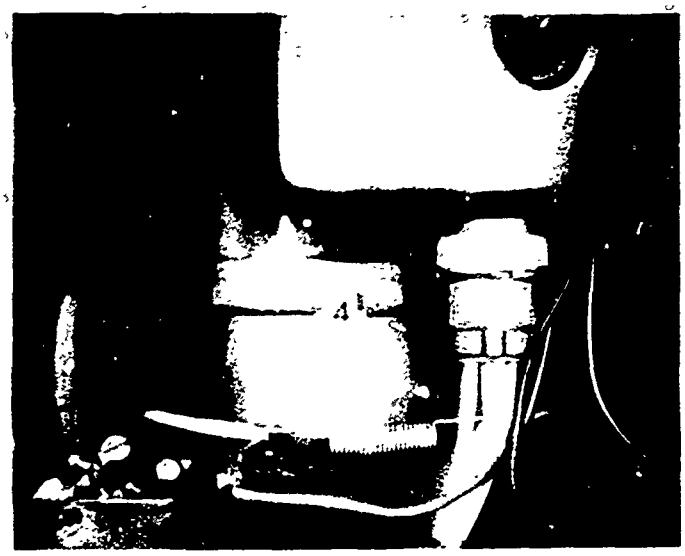
ACCELEROMETER LOCATIONS - VERTICAL AXIS

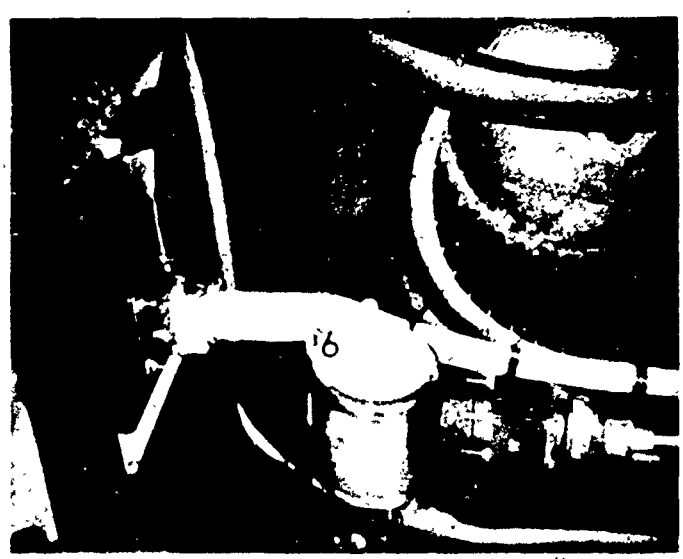


Accelerometer No.	Location
1	Evaporator Blower Motor (upper motor)
2	Main Off-On Switch Assembly
3	Liquid Storage Tank
5	Condensor Blower Motor (lower motor)

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

ACCELEROMETER LOCATIONS - VERTICAL AXIS

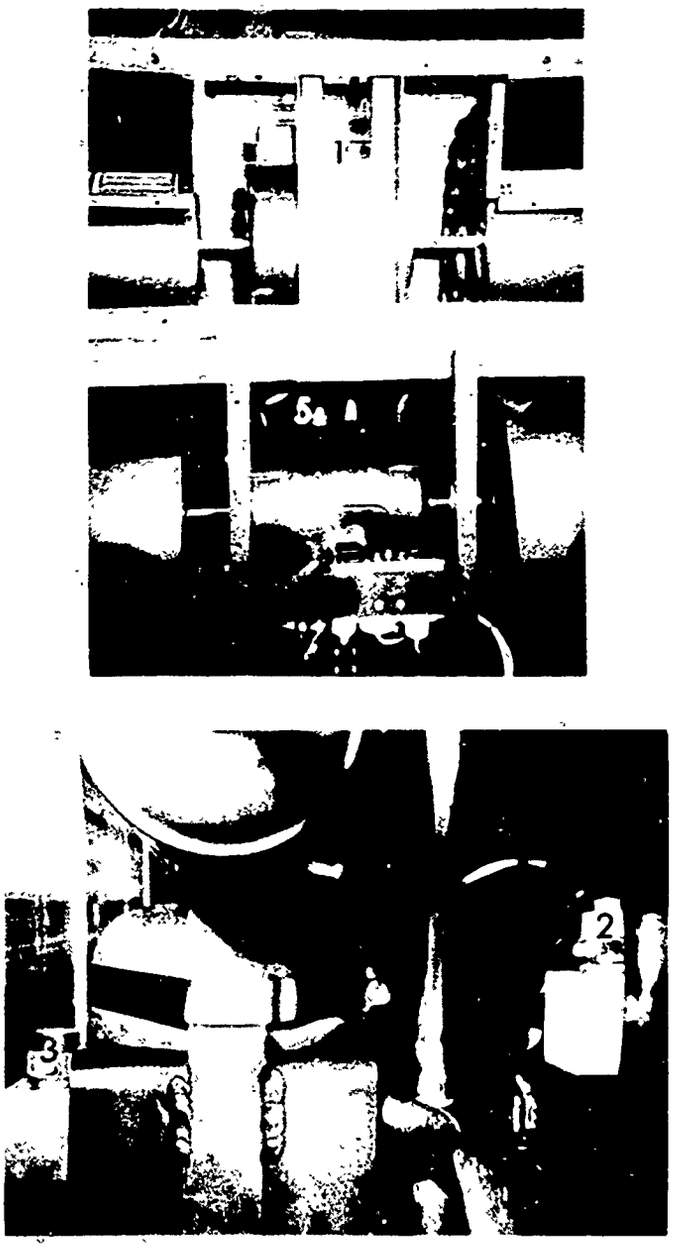




Accelerometer No.	Location
4	Compressor
6	High Pressure Safety Switch

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

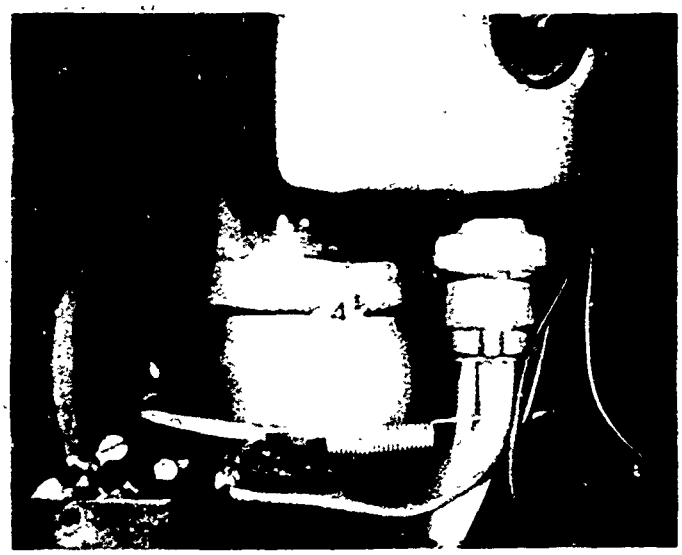
ACCELEROMETER LOCATIONS - VERTICAL AXIS

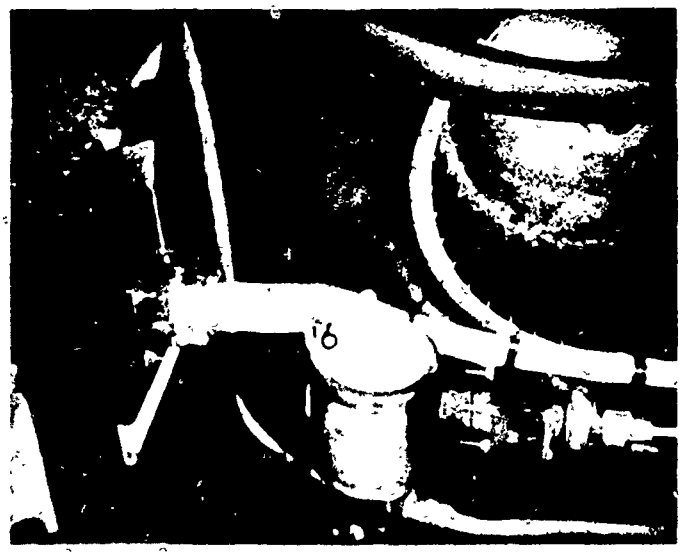


Accelerometer No.	Location
1	Evaporator Blower Motor (upper motor)
2	Main Off-On Switch Assembly
3	Liquid Storage Tank
5	Condensor Blower Motor (lower motor)

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

ACCELEROMETER LOCATIONS - VERTICAL AXIS

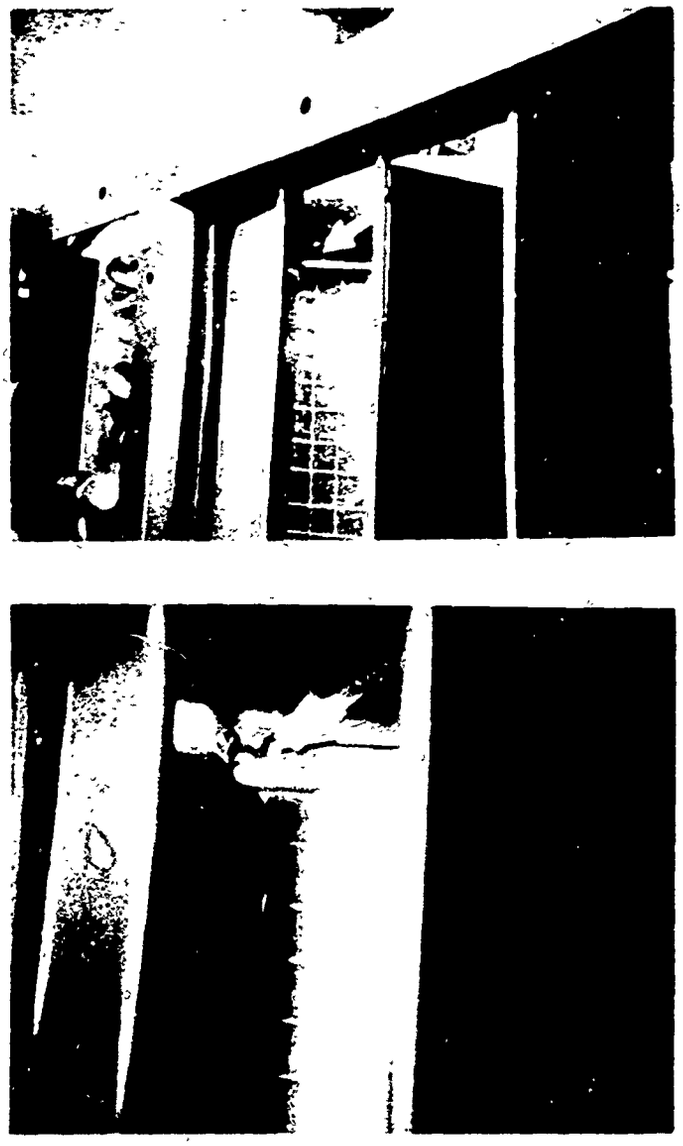




Accelerometer No.	Location
4	Compressor
6	High Pressure Safety Switch

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

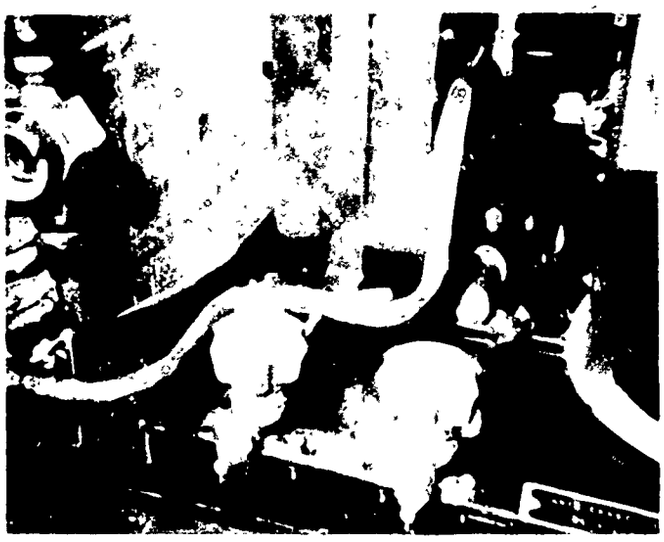
DAMAGE OCCURRING IN VERTICAL AXIS



Arrow identifies spot weld that broken in upper corner of filter.

LABORATORY SIMULATED TRANSPORTATION VIBRATION TEST OF AIR CONDITIONER, 36,000 BTU/HR

DAMAGE OCCURING IN LONGITUDINAL AXIS



Arrow indicates the crack in the liquid service line where it joins into large copper line.

Requirement	Source	Finding	Reported in Par. No.
The test item shall be undamaged and completely operational when received for test.	Assumed requirement	Satisfactory. All units were in satisfactory condition and operated as required.	2.1.4
Unit shall produce an air temperature drop of at least 20°F between evaporator inlet and outlet.	Par. 4.7.2.19 of MIL-A-52435A	Satisfactory. All units produced temperature drops in excess of the minimum allowable limit.	2.1.4
Current drawn in the cooling cycle shall not exceed 27 amperes (average of three phases).	Par. 4.7.2.19 of MIL-A-52435A	Satisfactory. The maximum current drawn, under the conditions operated, was 19.8 amperes.	2.7.4
Unit shall have a minimum total net cooling capacity of 36,000 Btu/hr.	Assumed requirement	Satisfactory. The capacity of the unit was 42,870 Btu/hr.	2.2.4
The time delay relay, when operating at an ambient temperature of +120°F, shall energize the compressor within 5 to 15 seconds after turn-on.	Par. 3.12 of MIL-A-52435A	Satisfactory. The relay energized the compressor 8 seconds after turn-on.	2.3.4
Unit shall perform satisfactorily under applicable rain storage and operating climatic conditions established by AR 705, C1.	Assumed requirement.	Satisfactory.	2.4.4
Unit shall perform satisfactorily following exposure to high-humidity environment. Also, components shall be adequately treated, plated or painted to resist rust and corrosion which may affect the units operational characteristics.	Assumed requirement	Unsatisfactory. The evaporator fan motor contactor, condenser fan motor contactor, and compressor motor contactor malfunctioned as a result of heavy rusting of the contactor armatures and stators during exposure to humidity.	2.5.4

Requirement	Source	Finding	Reported in Par. No.
The unit shall be designed and constructed to withstand, without damage, transportation in military vehicles.	Assumed requirement	Unsatisfactory. The weld, connecting the service valve to the high-pressure line, fractured; the corner spot weld of the right air filter retaining bracket broke; and a broken electrical wire inside the compressor rendered the compressor inoperable.	2.6.4
The unit shall operate satisfactorily for 50 hours without incurring damage.		Satisfactory.	2.7.4
Maintenance literature shall contain adequate instructions and guidance for organizational, direct, and general support maintenance.	Assumed requirement	Satisfactory.	2.8.4
Special tools or equipment shall not be required for maintenance of the unit.	Assumed requirement	Satisfactory. No special tools or equipment were required.	2.8.4

APPENDIX III - DEFICIENCIES AND SHORTCOMINGS

1. Deficiencies

Deficiency	Suggested Corrective Action	Remarks
The stators and armatures of the evaporator fan motor contactor, condenser fan motor contactor, and compressor motor contactor became heavily rusted. This caused the contactors to chatter badly when energized (ref par. 2.5.4).	Replace the contactors presently used with contactors that are impervious to moisture.	Rusting of the contactors was discovered after 240 hours exposure to humidity.
The weld, connecting the discharge service valve to the high-pressure line, fractured during vibration in the longitudinal axis (ref par. 2.6.4).	Incorporate a longer length of tubing to connect the service valve to the high-pressure line allowing enough tubing to permit an S or U bend tube run between these points.	The fracture occurred during the 25-Hz resonant dwell at a 1.5-g input level and resulted in a complete loss of the units refrigerant charge.

2. Shortcomings

Shortcoming	Suggested Corrective Action	Remarks
A corner spot weld of the right air filter retaining bracket broke during vibration in the vertical axis (ref par. 2.6.4).	Greater quality control measures in the welding of the bracket.	The broken weld occurred during the 16-Hz resonant dwell at a 1.5-g input level.

3. Random Failures

Random Failure	Remarks
One of the compressor motor-winding terminal wires broke during vibration of the unit (ref par. 2.6.4).	The compressor was inoperative after the unit was subjected to vibration. The broken terminal wire was found during investigation of the inoperable compressor at USAMERCD, Fort Belvoir, Virginia.

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-GE
7-3-0028-08

29 DEC 1967

SUBJECT: Test Directive, USATECOM Project No. 7-3-0028-08, Initial Production Test of Air Conditioner, Base Mounted, Air Cooled, 208V, 3 Phase, 60 HZ, AC, Single Package, 36,000 BTU/HR, Contract No. DAAK01-67-C-0628

TO: Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-CO-P
Aberdeen Proving Ground, Md. 21005

1. References.

a. Letter, AMSME-QX, U. S. Army Mobility Equipment Command, 3 October 1967, subject: "Request for Time and Cost Estimate for Air Conditioner, Base Mounted, Air Cooled, 208V, 3 Phase, 60 HZ, AC, Single Package, 36,000 BTU/HR," inclosure 1.

b. Letter, AMSTE-GE, U. S. Army Test and Evaluation Command, 27 December 1967, subject: "Request for Time and Cost Estimate for IPT of Air Conditioner, Base Mounted, Air Cooled, 208V, 3 Phase, 60 HZ, AC, Single Package, 36,000 BTU/HR."

c. AMC Regulation 700-34.

2. Background.

See reference 1a.

3. Description of Materiel.

See paragraph 3.1 of inclosure 2 to reference 1a.

4. Test Objectives.

a. To verify the adequacy and quality of subject air conditioner manufactured according to the production drawings and of the mass production process.

AMSTE-CF 2 DEC 1967

SUBJECT: Test Directive, USATECOM Project No. 7-3-0028-08, Initial Production Test of Air Conditioner, Base Mounted, Air Cooled, 208V, 3 Phase, 60 HZ, AC, Single Package, 36,000 BTU/HR, Contract No. DAAK01-67-C-C628

b. To determine suitability of subject air conditioner for issue in accordance with AMCR 700-34.

5. Responsibilities.

a. Commanding Officer, Aberdeen Proving Ground, will:

(1) Schedule subject test in accordance with the plan presented in reference 1a, expanded to include the additional test phases needed to determine suitability for issue in accordance with the requirements of AMCR 700-34, as presented in reference 1b. The determination as to suitability for issue is understood to include evaluation of the maintenance package with special attention to the adequacy of manuals and any special tools required.

(2) Conduct the test in accordance with the plan outlined in 5a(1) above as soon as the test item(s) and funds have been made available. Expected delivery date is August 1968.

(3) Submit reports as follows:

(a) EPR's will be prepared and submitted in accordance with existing regulations. Distribution of the EPR's will be as indicated in paragraph 12, reference 1a, and to this headquarters.

(b) An interim and a final report will be submitted to this headquarters for approval. A TWX report based on the approved interim report will be sent to U. S. Army Mobility Equipment Command by this headquarters. The balance of the distribution of the interim and final reports to addressees listed in paragraph 12, reference 1a, will be effected when so directed further by this headquarters.

(4) Dispose of the test item(s) in accordance with the desires of U. S. Army Mobility Equipment Command.

b. Commanding General, U. S. Army Mobility Equipment Command, is expected to:

(1) Make available at Aberdeen Proving Ground the test item(s) to be tested.

(2) Fund for the test.

(3) Provide Aberdeen Proving Ground with instructions for disposing of the test item after test.

6. Coordination.

Not used.

7. Special Instructions.

a. Subject project number will be referenced in all related correspondence.

b. Attached for your information and retention, inclosure 2, is copy of STE Form 1028 used for entering this task in TSMS.

c. Test priority is 2 and item is in support of Southeast Asia.

d. Repair parts support will be as indicated in paragraph 9, reference 1a.

e. Request U. S. Army Mobility Equipment Command be notified upon delivery at Aberdeen Proving Ground of the test item(s).

f. Technical support may be obtained by contacting Mr. Don Fulk, AUTOVON 693-2145.

8. Test Plans and Reports.

a. Test Plan. The test plan outlined in paragraph 5a(1) above is considered adequate for determining the test objectives.

b. Test Reports. Deadline dates for submission to this headquarters for approval of the interim and final reports are as follows:

Interim Report - 7 October 1968
Final Report - 31 October 1968

9. Security.

Unclassified.

FOR THE COMMANDER:

2 Incl
as

JAMES O. DAULTON
Colonel, GS
Dir, General Equipment
Testing Directorate

AMSTE-GE

SUBJECT: Test Directive, USATECOM Project No. 7-3-0028-08, Initial Production Test of Air Conditioner, Base Mounted, Air Cooled, 208V, 3 Phase, 60 HZ, AC, Single Package, 36,000 BTU/HR, Contract No. DAAK01-67-C-0628

Copy furnished:
CG, USAMECOM
ATTN: AMSME-QX
CG, USCONARC
ATTN: ATIT-RD-MD
CG, USACDC (3cys)
ATTN: CDC LnO USATECOM
CO, USACDCMA

APPENDIX V - REFERENCE

Electrical Testing Laboratories, Inc. Report No. 407862, 14 April 1969, Cooling-Capacity Test of Air Conditioner, FSN 4120-935-5348, Serial No. 6703193.

APPENDIX VI - DISTRIBUTION LIST

USATECOM PROJECT NO. 7-EG-175-036-002

Addressee	Final Report
Commanding General US Army Test and Evaluation Command Aberdeen Proving Ground, Maryland 21005 ATTN: AMSTE-GE	12
Commanding General US Army Materiel Command Washington, D.C. 20315 ATTN: AMCRD-GP	5*
AMCRM-MEP	5*
AMCRD-R	1
AMCRD-ET	1
AMCMA-VS	1
AMCQA-E	1
AMCMR-CP	1
AMCSF	1
Commanding General US Continental Army Command Fort Monroe, Virginia 23351 ATTN: ATIT-RD-MD	4
Commanding General US Army Combat Developments Command Aberdeen Proving Ground, Maryland 21005 ATTN: USACDC LnO (USATECOM)	12
Commanding General US Army Mobility Equipment Command 4300 Goodfellow Boulevard St. Louis, Missouri 63120 ATTN: AMSME-QRT	8
Commanding Officer US Army Logistics Doctrine Systems and Readiness Agency New Cumberland Depot, P.O. Box 2947 Harrisburg, Pennsylvania 17105 ATTN: LDSRA-ME	1

*Distribution denoted by an asterisk (*) will be made from those copies forwarded to Headquarters, USATECOM.

Addressee	Final Report
Chief of Research and Development Department of Army Washington, D.C. 20310 ATTN: CRDME-1	7
Assistant Chief of Staff, Force Development Dept of Army System Staff Officers (DASSO) Washington, D.C. 20310	1
President US Army Maintenance Board Fort Knox, Kentucky 40121	1
Commander Hq, Defense Documentation Center for Scientific and Technical Information Cameron Station Alexandria, Virginia 22313 ATTN: Document Service Center	20
Commanding Officer Aberdeen Proving Ground Aberdeen Proving Ground, Maryland 21005 ATTN: STEAP-TL	1
US Marine Corps Liaison Officer US Army Test and Evaluation Command Aberdeen Proving Ground, Maryland 21005	1
Commanding Officer US Army Mobility Equipment Research and Development Center Fort Belvoir, Virginia 22060 ATTN: SMEFB-RDE-O	4

Secondary distribution is controlled by US Army Mobility Equipment Command, ATTN: AMSME-QRT.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Materiel Test Directorate Aberdeen Proving Ground, Maryland 21005	Unclassified
	2b. GROUP

3. REPORT TITLE

INITIAL PRODUCTION TEST OF AIR CONDITIONER, 36,000 BUT/HR, 60-HZ, SINGLE-PACKAGE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report - 24 February to 13 June 1969

5. AUTHOR(S) (First name, middle initial, last name)

Victor W. Morawski, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1969	49	1

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
AMCMS Code No. 4750.74.4682.M.K2 b. PROJECT NO. USATECOM Project No. 7-EG-175-036-002 c. d.	APG-MT-3277 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

This document may be further distributed by any holder only with specific prior approval of Commanding General, US Army Mobility Equipment Command, ATTN: AMSME-QRT.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
None	USAMECOM

13. ABSTRACT

This report summarizes the initial production test of the 36,000 Btu/hr, single-package air conditioner conducted at Aberdeen Proving Ground from 24 February to 13 June 1969. The purpose of the test was to determine conformance of the air conditioner to required performance characteristics. The results show that a fractured refrigerant line weld, a broken filter retaining spot weld, and a broken compressor motor-winding terminal wire resulted from laboratory vibrations. Also, heavy rusting of the stators and armatures of all motor contactors resulted from exposure to humidity. It is concluded that the air conditioner met the test objectives with the exceptions noted.

DD FORM 1 NOV 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Air conditioner Single package 36,000 Btu/hr Electric-motor-driven 208 volt 60 hertz						