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RDT&E PROJECT NO. 1M643324D58406

USATECOM PROJECT NO. 7-3-0239-07

YPG REPORT 9001

ENGINEERING TEST (DESERT) OF EFFLUENT FUEL TESTER, TOTAMITOR, 50 GPM AND 400 GPM

FINAL REPORT

BY

L. D. POWELL

JANUARY 1969

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YUMA PROVING GROUND

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

AMSTE-GE

29 APR 1969

SUBJECT: Final Reports of Engineering and Service Tests of Effluent Fuel Tester, USATECOM Project Nos. 7-3-0239-07/09

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

1. References.

a. Final Report of Integrated Engineering and Service Test of Fuel Tester, Effluent, RDT&E Project No. 1D643324D58810, USATECOM Project No. 7-3-0239-06 with USATECOM letter to AMC, 6 May 1968.

b. Final Report of Engineering Test (Desert) of Effluent Fuel Tester, Totamiter, 50 GPM and 400 GPM, USATECOM Project No. 7-3-0239-07, January 1969, YPG. (Inclosure 1)

c. Final Report of Integrated Engineering and Service Test of Effluent Fuel Tester, USATECOM Project No. 7-3-0239-09, March 1969, USAGETA. (Inclosure 2)

2. Approval Statement. Subject reports are approved.

3. Background of Test. The effluent fuel tester consists of a group of components which provide a means of monitoring the effluent fuel stream from a filter/separator to assure that fuel is not contaminated with water or solids. Testing was conducted on a 50 GPM size unit and a 400 GPM size unit at each test site.

a. An integrated engineering and service test (arctic winter) was conducted by the U. S. Army Arctic Test Center from 12 December 1967 to 24 March 1968. The results of this test were forwarded by reference 1a. In view of the results of the more extensive tests which are discussed herein, the USATECOM position concerning suitability for use in the arctic is hereby withdrawn.

b. An engineering test (desert) was conducted by Yuma Proving Ground from 27 May 1968 through 6 December 1968 (reference 1b).

c. An integrated engineering and service test (intermediate climate) was conducted by the U. S. Army General Equipment Test Activity from February 1968 through February 1969 (reference 1c).

4. Test Results.

a. The equipment, as tested, failed to meet essential requirements of the approved military characteristics as follows:

(1) The effluent tester was not sufficiently accurate in registering the presence of injurious amounts of contaminants as evidenced by a wide variance between meter readings and actual contamination (Tables 1 and 3 and graph 1, Appendix I, reference 1b).

(2) The tester failed to detect contaminants automatically and continuously as evidenced by two failures of the amplifier at high ambient temperatures (paragraph 2.4.4, reference 1b).

(3) The tester was not adequately resistant to rusting. The steel conduit between the photocell and the conduit box on both testers rusted (paragraph 2.4.4c, reference 1b).

(4) The tester failed to meet the criteria regarding operation in the desert environment as defined in AR 705-15, Change 1, as evidenced by two failures of the amplifier (paragraph 2.4.4a, reference 1b).

(5) The tester was not of one size. Two sizes (50 and 400 GPM capacities) were furnished; two sizes were necessary for detecting the wide range of flow rates.

(6) The tester was not sufficiently rugged as evidenced by chart recorder failures (paragraph 2.5.4d, reference 1c).

b. An analysis of the final reports reveals that seven deficiencies and six shortcomings remain.

(1) Deficiencies:

(a) The amplifier at an ambient temperature of 113°F would activate the contaminant warning bell and caused the fuel flow to be shut off even though there was no contaminant present in the test system (Appendix III, reference 1b).

(b) When the ambient temperature was higher than 105°F, the amplifier when activated by the contaminant simulator button being depressed would close the control but would not allow the control valve to reopen when the simulator button was released (Appendix III, reference 1b).

(c) Fuel leakage from the contaminant simulator button when it is depressed creates a safety hazard (paragraph 5a(1) below)).

(d) The amplifier contaminant meter readings were inaccurate (paragraph 5a(2) below)).

(e) The recorder door was not adequately sealed to prevent damage to the recorder when exposed to rain (paragraph 5a(3) below)).

(f) The draft technical manual was not clear or accurate (paragraph 5a(4) below)).

(g) The test item lacked the sensitivity required for detecting solid contaminants (paragraphs 2.4.2 and 2.4.5, reference 1c).

(2) Shortcomings:

(a) Repair parts and required special tools were not furnished with the test items (paragraph 2.2.4, reference 1c).

(b) A second power supply battery was required to permit uninterrupted operation during frequent required recharging (paragraphs 2.4.11 and 2.5.4, reference 1c).

(c) The dial indicator/chart recorder scale divisions are too large for accurate reading (paragraphs 1.4c(3) and 2.4.2.4, reference 1c)).

(d) Internal corrosion of the flow shut-off valve solenoid caused failure of the flow shut-off sytem (paragraph 2.6.3, reference 1c).

(e) The socket head cap screws on the lamp holder were inaccessible with available tools (cap screws should be compatible with the available hex-head wrench) (paragraph 2.6.3d, reference 1c).

(f) The chart recorder failed once on each of the testers. They were replaced by the developer and the cause of failure was not determined (paragraph 2.6.3e, reference 1c).

5. Comments.

a. The following problems reported in final reports, references 1b and 1c, have been reclassified as follows:

(1) Leakage of fuel from the contaminant simulator button was reported as a shortcoming (paragraph 2, Appendix III, reference 1b). Since leakage of fuel presents a potential safety hazard, it is reclassified as a deficiency.

(2) There was a wide variance between amplifier contaminant meter readings and actual contamination introduced for test purposes (paragraph 2.4.5, charts 1 and 3, Appendix I, reference 1b). This condition is reclassified as a deficiency because the meter indicated much higher contamination than the actual amount.

(3) The recorder door was not adequately sealed. Thus, rain could enter the recorder and cause it to become nonoperational. This is reclassified as a deficiency (paragraph 2.4.4b, reference 1b).

(4) The draft technical manual was not clear or accurate (paragraph 2.5.4, reference 1b and paragraphs 2.7, 2.9, 2.10 and 2.11, Appendix III, reference 1c). This is reclassified as a deficiency. Satisfactory maintenance could not be performed with the furnished manual.

(5) The test item was not of one size capacity as specified in the military characteristics and reported in paragraph 1.1, Appendix III, reference 1c. This is classified as neither a deficiency nor shortcoming since the concept of the two sizes did not adversely affect usage.

(6) Two shortcomings reported in paragraphs 2.1 and 2.2, Appendix III, reference 1c, relate to desired characteristics and are therefore not considered to be shortcomings because they do not adversely affect the performance of the item.

b. The demonstrated reliability of the test item under intermediate climatic conditions was at least 90 per cent at 90 per cent confidence level based on 532 test hours, a mission time of 15 hours and one failure. The reliability of the items tested to detect contamination accurately and stop flow is considered to be inadequate (paragraphs 2.4.2 and 2.4.5, reference 1c). Although reliability was not determined for desert conditions because of limited test time, reliability is considered to be unsatisfactory because of the amplifier failures encountered (Appendix III, reference 1b).

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SUBJECT: Final Reports of Engineering and Service Tests of Effluent Fuel Tester, USATECOM Project Nos. 7-3-0239-07/09

6. Conclusions.

a. The items, as tested, and the draft technical manual are unsuitable for Army use.

b. The maintainability of the effluent testers was unsatisfactory because of the inadequacies in the draft technical manuals as reported in paragraph 2.5.4, reference 1b and Appendix III, reference 1c. Maintainability should be adequate when the draft technical manuals have been corrected and improved as recommended herein.

7. Recommendations.

a. All deficiencies and as many as possible of the shortcomings identified in paragraphs 4b(1) and (2) above be corrected.

b. Two effluent testers (of each size) corrected as recommended herein be furnished to USATECOM for check test.

c. Corrected and improved maintenance packages be furnished for test concurrent with the check test.

FOR THE COMMANDER:

WILLIAM H. HUBBARD
Colonel, GS
Deputy Chief of Staff

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RDTE PROJECT NO. 1M643324D58406

USATECOM PROJECT NO. 7-3-0239-07

ENGINEERING TEST (DESERT) OF EFFLUENT FUEL TESTER, TOTAMITOR, 50 GPM AND 400 GPM

TEST REPORT

BY

L. D. POWELL

JANUARY 1969

YUMA PROVING GROUND
YUMA, ARIZONA

ABSTRACT

The desert engineering test of the Effluent Fuel Tester, Totamitor, (EFTT), 50 and 400 gallons per minute rated capacities, was conducted by and at Yuma Proving Ground from 27 May 1968 through 6 December 1968.

The purpose of the test was to determine the ability of the EFTT's to meet the approved military characteristics in the desert environment.

The amplifier failed to function at ambient temperatures above 105°F when the amplifier is resting on the ground and is not shaded.

The EFTT's warn of minute quantities of contamination; however, correlation between meter readings and actual contamination is very poor.

It was concluded that the EFTT's did not meet the approved military characteristics for operation in a desert environment.

It was recommended that the amplifier components be investigated for possible replacement with parts less susceptible to high temperatures; that repair parts, support equipment and special tools be furnished with each EFTT; that the pickup head electrical conduit be of stainless steel or aluminum; and that the test items, after redesign, and the maintenance package, after updating, be resubmitted for test.

FOREWORD

Yuma Proving Ground was responsible for preparation of the test plan, test execution, and preparation of the test report.

TABLE OF CONTENTS

SECTION 1. INTRODUCTION

1.1 BACKGROUND

A requirement currently exists for monitoring the purity of fuel delivered into fuel tanks of aircraft, combat tanks, various military vehicles and other types of fuel-burning equipment as it is dispensed under field conditions. A means for purity monitoring is desirable for ground vehicles and equipment, and it is mandatory for aircraft because contaminated fuel contributes to engine malfunctions, increases the risk and hazards of accidents, and increases the maintenance requirements for fuel-using items. Therefore, in order to provide a means of detecting harmful contaminants in petroleum products, it has been deemed necessary that a detecting device be employed at POL distribution points in the Field Army and in the Communication Zone. This device should be used in pipeheads, hoseline terminals, refueling tanker vehicles and other delivery media when petroleum is transferred to consuming units and vehicles. Consequently, it is desirable that such a device be a simple, lightweight, portable, inexpensive item of equipment that can be readily installed in fuel dispensing equipment or used separately to determine continuously if the dispersed petroleum products are sufficiently free from water and harmful solid contaminants. It is desirable that the device terminate the flow of fuel automatically when an unacceptable level of contamination has been registered (manual control optional). The tester may be employed at POL distribution points by Quartermaster Petroleum Distribution units, petroleum delivery agencies and combat and administrative units.

Since no satisfactory equipment was available in the U.S. Army system to perform this function, three types of POL effluent testers were selected from the commercial market for evaluation: Two go-no-go gages and a totamitor. Most of the work to date has been directed toward developing suitable means to analyze the effluent product in order to reduce and control contaminants. During the same time, work has progressed under contract to determine whether the various additives used commerically in fuels have the effect of being treated as contaminants by the instruments. Informal results received from U.S. Army Natick Laboratories indicate that additives present no problem.

Because of deficiencies found while testing the go-no-go gages, these items were reported "not suitable for use by the U.S. Army."

The engineering and service tests were initiated in November 1964. The components of the totamitor are commercial items and no carrying cases or wiring harness was provided. Thus, testing was suspended and was rescheduled for October 1965. Testing was again rescheduled for October 1967 due to failure to receive a safety release. The U.S. Army Test and Evaluation Command issued a safety release for resumption of all tests in November 1967.

1.2 DESCRIPTION OF MATERIEL

The Effluent Fuel Tester, Totamitor, (EFTT) is a device designed to instantanecusly measure and record the level of contamination present in any transparent liquid. The unit utilizes the scattered light principle, scanning the liquid at full flow rate. A light source and photocell arrangement detects the scattered light reflected from solid or immiscible liquid particles of contaminant. The signal produced is amplified for operation of an alarm, a direct-reading meter, a recorder and a solenoid actuated flow valve to stop the fuel flow. Two EFTT's were furnished for testing. one with a 50 gallons per minute (gpm) rated capacity, the other with a 400 gpm rated capacity.

1.3 OBJECTIVE

To determine the ability of the EFTT's to meet the approved military characteristics under a desert environment.

1.4 SUMMARY OF RESULTS

a. During testing at Yuma Proving Ground the Effluent Fuel Tester Totamitor, 50 gpm unit (EFTT 50) accumulated 37 hours and the 400 gpm unit (EFTT 400) accumulated 146 hours of testing (Para. 2.4.3).

b. During testing, two deficiencies and one shortcoming were reported (App III).

c. Malfunctions of the amplifier occurred due to extreme high temperatures (Para. 2.4.4).

d. Leakage of fuel occurred around the detector head simulator button due to deterioration of the O-ring (Para. 2.3.4).

e. Rusting of the steel electrical conduit on the detector heads occurred (Para. 2.4.5).

f. The EFTT's detected and warned of minute quantities of fuel contamination; however, correlation between meter readings and actual contamination was very poor (Para. 2.4.5).

g. The reaction time of 4.5 seconds between contamination detection and fuel shutdown allows considerable contaminated fuel to bypass the detector head (Para. 2.3.5).

h. The maintenance package (Draft Technical Manual) was not updated, and was not clear nor accurate (Para. 2.5.4).

i. No repair parts or special tools and equipment were furnished (Para. 2.2.4).

1.5 CONCLUSIONS

The EFTT's did not meet the approved military characteristics for operation in a desert environment (Para. 1.4c, e, f, g).

1.6 RECOMMENDATIONS

a. The amplifier components be investigated for possible replacement with parts less susceptible to high temperatures.

b. Repair parts, support equipment and special tools be furnished with each EFTT.

c. The detector head electrical conduit be of stainless steel or aluminum to prevent rusting.

d. The test items, after redesign, and the maintenance package, after updating, be resubmitted for test.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

The Effluent Fuel Testers, Toaritor, 50 gpm and 400 gpm (EFTT 50 and EFTT 400) were received at Yuma Proving Ground (YPG) on 14 June 1966. Environmental testing under desert conditions was scheduled for the summer of 1967; however, all testing was suspended by direction of the U.S. Army Test and Evaluation Command (USATECOM) on 11 May 1967 for reasons of safety (Ref e, App IV). Testing at YPG was rescheduled for the summer of 1968 when the safety release was issued by USATECOM on 8 November 1967 Ref f, App IV).

Revisions to the test items at YPG to meet the safety requirements were made by personnel from the U.S. Army Mobility Equipment Research and Development Center (USAMERDC) during January and May 1968.

Testing of the EFTT's began on 27 May 1968 and was completed on 16 December 1968.

A meteorological summary covering the test period is included in Appendix I.

Testing at YPG differed from the test plan (Ref b, App IV) for the following reasons:

a. The test plan published in August 1964, covered testing of test items fabricated by two different manufacturers rather than one.

b. The existing pumping facilities at YPG were not adaptable or available for testing the EFTT's.

c. The YPG assignment was changed from an engineering and service test to an engineering test, desert.

2.2 INITIAL TECHNICAL INSPECTION AND PREPARATION FOR TESTING

2.2.1 Objectives

a. To determine weights and dimensions of the test item.

b. To insure that the test items were in proper condition for testing.

c. To calibrate the instrument and control assemblies.

d. To install instrumentation for measuring fuel temperatures and pressures, and for obtaining fuel samples.

e. To install the EFTT components, contamination devices filter/separators, and flow meters in closed loop piping systems.

2.2.2 Criteria

a. TECP 700-700, Material Test Procedures; MTP 9-2-298, Fuel Monitoring and Purity Devices (Para. 6.1 through 6.1.4).

b. Reference f, Appendix IV.

c. Reference d, Appendix IV (para. 2-1 through 2-4 and 3-13 through 3-15).

d. Reference c, Appendix IV (Para. 11d).

2.2.3 Method

The test items when received were packaged in two cartons, one carton for each of the two sizes of EFTT. The weights and dimensions of these packed cartons were determined.

The test items were removed from their cartons and were visually inspected for shipping damages, missing parts and to determine their general conditions. Weights and dimensions of the test item components were determined and a parts list was made.

Wiring harnesses enclosed in safety conduit (1/2-inch galvanized pipe, 30 feet long) were made and assembled. Safety conduit (5/16-inch tubing) was fabricated and installed on the pickup heads (junction box to photocell adapter).

The instrument and control panel assemblies were connected to a fully charged model 6TN, 12-volt battery and to their respective pickup heads and control valves. The pickup heads were filled with clean referee grade gasoline, MIL-G-3056B. The EFTT's were turned on and the calibration of the amplifier sensitivity and alarm setting was checked and/or adjusted.

A sample of the same fuel was contaminated with an unmeasured quantity of water and was poured into the EFTT 50 pickup head to check for contamination warning.

Pressure gages, thermocouples and sampling cocks were installed.

The voltage drop of the two wires from the amplifier to photocell of the pickup head of the EFTT 400 was measured.

Two closed loop piping systems were assembled with an EFTT installed in each.

2.2.4 Results

The dimensions and weights of the EFTT 50 and EFTT 400 packed, as received, were as follows:

	Packaged Dimensions (in.)	Packaged Weight (lb)	Components Weight (lb)
EFTT 400	20.5 x 35.0 x 40.5	224	122
EFTT 50	20.0 x 28.5 x 46.0	185	59

Inspection of the EFTT components disclosed no shipping damage; general condition was good. No repair parts, light bulbs, gaskets, recorder paper, etc, were received. The calibrated scale used to read the record after paper had been removed from the recorder was not received.

The socket head cap screws holding the lamp holder to pickup head body require a special Allen wrench (short end ground off to approximately 1/2-inch length) for removal. No wrench was received with the EFTT's; one was supplied by USAMERDC personnel.

To meet the requirements of the safety release, safety conduit and connectors were installed by USAMERDC personnel. Photographs of these components are presented in Figures 2, 4, 5, 6, and 7, Appendix II.

Minor adjustments for amplifier sensitivity were required.

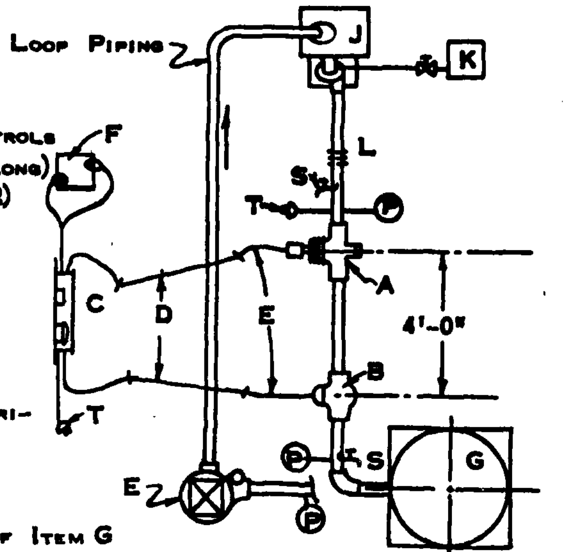
The EFTT 50 indicator meter indicated contamination and the alarm sounded with contaminated fuel in the pickup head and with the tester energized.

The EFTT 50 and EFTT 400 contaminate meters both indicated 50 parts per million (ppm) contamination when the simulator buttons were depressed.

The voltage drop of the two wires from amplifier to the photocell of the pickup head of the EFTT 400 was found to be 0.2 vdc each with photocell energized using 12 vdc power applied to the amplifier. The electrical resistance of these two wires was also measured and was found to be 0.1838 ohms (circuit A) and 0.1828 ohms (circuit B). Figures 1 and 2 show the components of the closed loop piping system and location of instrumentation.

Legend:

1. EFTT 50
   - A – Pickup Head
   - B – Control Valve
   - C – Instruments and Controls
   - D – Conduit (2) (30-feet long)
   - E – Conduit Connectors (2)
2. Support Equipment
   - F – Battery, 6TN, 12volt
   - G – Filter/Separator, 50 gpm
   - J – Tanker, Semitrailer, 5000-gallon, M131 A5C, with GED Centrifugal Pump
   - K – Contaminant Device (water and solids)
   - L – Alternate Position of Item G for Original Cleanup of Fuel
3. Instrumentation
   - P – Pressure Gage
   - S – Sampling Cock
   - T – Thermocouple



Note: All loop piping 2" except inlet and outlet of G which is 1½" diameter.

FIGURE 1. LAYOUT EFTT 50 IN CLOSED LOOP PIPING SYSTEM.

Legend:

1. EFTT 400
   - A – Pickup Head
   - B – Control Valve
   - C – Instruments and Controls
   - D – Conduit (2)(30-feet long)
   - E – Conduit Connectors (2)
2. Support and Other Test Items
   - F – Battery, 6TN, 12volt
   - G – Filter Separator 350 gpm
   - H – Flowmeter, 600 gpm
   - J – Pump, 2-inch Centrifugal, GED, 125 gpm
   - K – Contaminant Supply
3. Instrumentation
   - P – Pressure Gage
   - S – Sampling Cock
   - T – Thermocouple

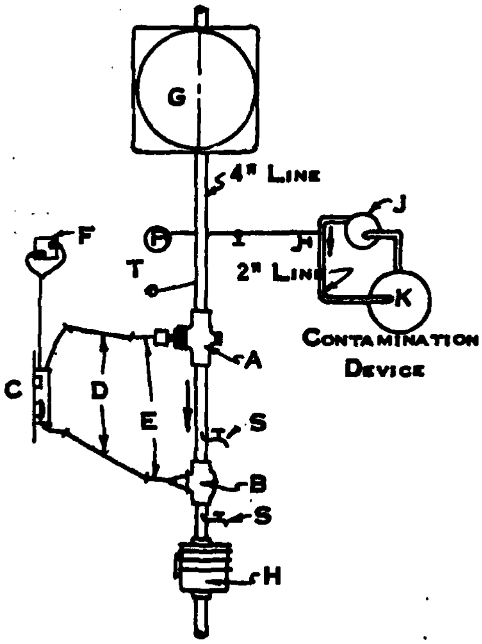


FIGURE 2. LAYOUT EFTT 400 WITH SECTIONS OF CLOSED LOOP PIPING SYSTEM.

2.2.5 Analysis

The EFTT 50 and EFTT 400 were considered to be in suitable condition for testing after correction of safety hazards, and after making minor adjustments.

2.3 OPERATING CHARACTERISTICS

2.3.1 Objectives

a. To determine the ease with which the test items can be operated.

b. To determine the operating characteristics of the test items.

2.3.2 Criteria (Ref c, App IV)

a. Paragraph 8a(1). Essential. The fuel tester shall be reliable, simple to operate, and sufficiently accurate to register presence of injurious amounts of contamination.

b. Paragraph 8a(3). Essential. The fuel tester shall provide a warning device to alert operating personnel when fuel contamination reaches an unacceptable level and/or when any free water is present.

c. Paragraph 8b(1). Desired. A visual warning device shall be incorporated to permit operating personnel to determine whether filtering and coalescing elements of the filter/separators require replacement.

d. Paragraph 8b(2). Desired. The fuel tester shall automatically terminate the flow of fuel when the presence of an intolerable amount of contamination is registered.

2.3.3 Method

This portion of the testing, as well as performance and accuracy testing (Para. 2.4), was conducted using different operating personnel for each test item.

The EFTT 50 was tested using 600 gallons of DF-1 winter grade diesel fuel, Federal Specification VV-F-800. A fuel sample was taken from the tanker prior to start of this test phase. Fuel was first pumped by and from the storage tanker through the filter/separator in its alternate position (Fig. 1) to clean existing contaminates from the fuel. This fuel cleanup run was continued for 8 hours (23,500 gallons of fuel pumped). Fuel was then pumped for an additional 7 hours (21,000 gallons of fuel pumped) with the filter/separator placed downstream from the EFTT 50 and with the actuation of the pickup head simulator button approximately two times per hour.

The EFTT 400 was tested using gasoline, Military Specification MIL-G-3056B. It was installed in a line downstream from a 350 gpm filter/separator (Fig. 2). Water contamination was injected into the EFTT 400 during this phase.

2.3.4 Results

The EFTT's were easy to operate; however, the recorder paper adjustment was not adequately explained in the Draft Technical Manual (DTM). The EFTT's detected contamination when fuel was known to be contaminated. An audible warning sounded when contaminated fuel passed but a visual warning is not included other than the recorder-stylus movement recorded on paper. The EFTT's terminated fuel flow whenever contamination was detected.

The EFTT 50 test fuel analysis of sample taken prior to start of test is contained in Table 1, Appendix I. This fuel was cleaned from an indicator meter reading of 8 ppm to a reading of 0 ppm with the cleanup filter/separator in its alternate position.

After the test fuel was cleaned and the filter/separator was moved downstream from the EFTT 50, a fuel drip occurred each time the contaminate simulator button of the pickup head was depressed (App III).

It was found during this portion of EFTT 50 testing that air trapped in the flowing fuel caused the contaminate meter to register 8 to 10 ppm, the contaminate warning to sound and the fuel flow to be terminated. Tightening of the pump inlet connections and the addition of a valve downstream from the EFTT 50 and filter/separator to increase fuel pressure eliminated this trouble.

Both units caused fuel flow shutdown 4.5 seconds after activating the contaminate simulator button.

The EFTT 400 test fuel analysis of sample taken prior to test is contained in Table 2, Appendix I. Water contamination caused the audible alarm to sound and fuel flow to be stopped.

2.3.5 Analysis

The EFTT's detect minute quantities of free water or solid contaminates, sound an audible alarm to warn of contamination and shut down fuel flow 4.5 seconds after contaminates pass the photocell of the pickup head. This delay in shutdown would allow approximately 3.8 gallons of contaminated fuel to pass through the pickup head at a 50-gpm flow rate, or approximately 30 gallons at a 400-gpm flow rate.

Any air entrapped in the fuel will also cause EFTT actuation.

A visual warning is not included.

The fuel drip from the pickup head simulator button was not repaired as no replacement O-rings were available. Leakage of high volatility fuel would create a safety hazard. Leakage of DF-1 fuel was not considered too dangerous for test conditions.

2.4 PERFORMANCE AND ACCURACY

2.4.1 Objective

To determine whether the fuel tester automatically and continuously detects contamination to a degree of accuracy sufficient to register the presence of contamination by water and solids larger than 5 microns in size when used in the desert environment.

2.4.2 Criteria (Ref c, App IV)

a. Paragraph 8a(1). Essential. The fuel teste shall be reliable, simple to operate, and sufficiently accurate to register presence of injurious amounts of contamination.

b. Paragraph 8a(2). Essential. The fuel tester shall automatically and continuously detect contamination particles and indicate that the water content does not exceed unacceptable amounts specified by the current military specification for filter/separators.

c. Paragraph 8a(3). Essential. The fuel tester shall provide a warning device to alert operating personnel when fuel contamination reaches an unacceptable level and/or when any free water is present.

d. Paragraph 8b(2). Desired. The fuel tester shall automatically terminate the flow of fuel when the presence of an intolerable amount of contamination is registered.

e. Paragraph 9f(1). Essential. The fuel tester shall be designed for use under field conditions and shall have all-weather capability to include extreme hot and cold climates. It shall conform insofar as practicable to the requirements of Paragraph 7, AR 705-15, 14 August 19[illegible].

f. Paragraph 9f(2). Essential. The fuel tester shall incorporate materials and provisions that provide maximum resistance to the detrimental effects of fungi, humidity, rain, snow, and extremes of dust and dirt.

2.4.3 Method

The same fuel and test setup as described in Paragraph 2.3.3 were used. Indicator meter readings were taken simultaneously with each fuel sample to check correlation of meter readings with fuel analysis.

The EFTT 50 was operated intermittently and at flow rates of 12, 25, and 50 gpm for a total of 22 hours. Approximately 65,000 gallons of fuel were pumped.

Solids contaminate (red iron oxide, Fe_2O_3) and 25 gallons of the test fuel were hand stirred in a 55-gallon drum and this mixture was gravity fed into the pump inlet (Fig. 1). Fuel samples were taken from this drum and from the pickup head inlet and outlet during contaminate injection. Fuel samples were also taken at the pickup head inlet during cleanup of the Fe_2O_3 from the test fuel.

Water contamination was gravity fed into the pump inlet using a burette. Samples were taken from the pickup head inlet only during water injection.

Water content of fuel samples was obtained by the semiquantitative (up to 20% error) method of phosphorescence standards using an Aqua/tector analyzer manufactured by Driaire, Inc, East Norwalk, Connecticut. This instrument detects only free water. Fuel samples were taken at above 130°F fuel temperature but were analyzed at room temperature of approximately 80°F.

The EFTT 400 was operated intermittently at a flow rate of 350 gpm for a total of 146 hours. Approximately 3,060,000 gallons of fuel were pumped.

Solids contaminate (red iron oxide Fe_2O_3) and water contaminate were independently mixed with test fuel and hand stirred in a 55-gallon drum. This mixture was pumped with a secondary centrifugal pump into the pickup head inlet line (Fig. 2). Fuel samples were taken from the pickup head outlet.

Water content of fuel samples was determined using the Karl Fischer reagent method.

2.4.4 Results

a. EFTT 50

The fuel analysis summary (Table 1, App I) shows contaminate content, percent transmittance, and indicator meter readings.

When the simulator button on the pickup head was depressed and then released with the amplifier range knob set at 50 ppm and with ambient temperatures of 105 to 110°F, the control valve would close and would fail to reopen when the simulator button was released. This amplifier failure occurred twice. The amplifier was on the ground and was not shaded (App III). At an ambient temperature of 105°F, temperatures of the unshaded amplifier and of the fuel were 120 and 116°F, respectively. At an ambient temperature of 110°F, the amplifier and fuel temperatures were 130 and 134°F, respectively. With the amplifier range knob set at 100 ppm, at an indicator meter reading of 29 ppm (Fe_2O_3 being injected) and at an ambient temperature of 113°F, the control valve closed unexpectedly. The amplifier was on the ground and was shaded at the time of this failure. Temperature inside the amplifier was 120°F and fuel temperature was 143°F (App III). The amplifier from the EFTT 400 was installed to replace the EFTT 50 amplifier and the failures above recurred.

Cooling the amplifier by artificial means (air-conditioner) restored operation; however, the same failures occurred when the amplifier heated up again.

Pressure drop through the pickup head (control valve and 6 feet of 2-inch flexible suction hose, with 50-gpm flow rate and 50- to 60-psig line pressure) was approximately 5 psi.

b. EFTT 400

Chemical analysis of fuel water content of the samples taken is plotted against indicator meter readings and included in Graph 1, Appendix I. Solids content and meter readings are included as Table 3, Appendix I.

Failures of the EFTT 400 amplifier due to heat were reported by operators. Since the EFTT 400 was not instrumented for temperatures, these failures could not be documented.

It was noted that the recorder hinged door was not se ed and is, therefore, subject to water damage.

c. General

The steel conduit from the detector head photocell to the conduit box rusted on both detector heads.

2.4.5 Analysis

The amplifier failed to meet the criteria regarding operation in the desert environment.

The detector head conduits failed to meet the criteria because of rusting.

The amplifier indicator meter indicated much higher than the actual amount of contamination in most instances. Correlation between meter readings and actual contamination was very poor.

The amplifier indicator meter of the EFTT 50 is in ppm-water; the EFTT 400 is in ppm only.

2.5 MAINTENANCE PACKAGE EVALUATION

2.5.1 Objective

To insure that the maintenance package (Ref e, App IV) was complete, accurate, and understandable.

2.5.2 Criteria (Ref c, App IV, Para. 11e)

A maintenance package shall be furnished in accordance with Paragraph 3, AR 750-6, 10 June 1957.

2.5.3 Method

The DTM was the only Maintenance Package element supplied. The manufacturer's booklet (Ref h, App IV) was also furnished. Both of these documents were used during testing of the EFTT's.

2.5.4 Results

Seven typographical errors were noted.

Numerous cases of inconsistent naming of parts and unclear and incomplete instructions were encountered as follows:

a. "Quick disconnect connection," Paragraphs 1-3b, 2-4c, 1-5b, and Figure 2-3, is actually a Kamlock fitting.

b. Paragraph 1-5a is not clear as to pickup head and valve ends.

c. Figure 2-1 shows inlet and outlet ends of pickup head; however, actual valve has no arrow indicating direction of fuel flow and it was assumed that flow in either direction was permissible.

d. Figure 2-2 indicates that the amplifier should be located preferably under 20 feet from pickup head. This has been changed to 30 feet minimum.

e. Paragraph 2-12 states that "the Totamitor indicates the amplifier should be protected and shielded from extreme heat in excess of +125°F." It is not known if the temperature quoted is ambient air temperature or temperature inside the amplifier. Also, the words "The Totamitor indicates" are unclear.

f. It is not clear in several instances whether the EFTT 50 or the EFTT 400 is being described, e.g. Paragraph 3-8.

g. Figure 3-1, Step 1, states "disconnect copper tubing..." This should read "steel tubing" since use of copper tubing was discontinued. Also, when removing the photocell adapter, care should be exercised not to remove the window assembly at the same time (Fig. D-1 of DTM).

h. Paragraph 3-12 and Figure 3-3 should be combined into one figure (using new photograph) and referenced back to Figure 3-1.

i. More and better photographs and instructions regarding recorder adjustment should be furnished (Ref Para. 3-20 of DTM). More consistent part nomenclature of recorder parts and indication of their locations should be used.

j. Paragraph 3-24 reads in part "When the solenoid is de-energized, the main valve opens." To this should be added " and with 5 psig pressure at the valve inlet."

2.5.5 Analysis

The DTM was partially revised in December 1966 (last publication); however, some of the photographs and instructions require updating. A more uniform part nomenclature would also clarify the manual.

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SECTION 3. APPENDICES

APPENDIX I. TEST DATA

TABLE 1. Fuel Analysis Summary, EFTT 50

DF-1 winter grade diesel fuel, Federal Specification VV-F-800.

								Off-Test Fuel	
1. Date (1968)	2. Sample No.	3. Water Content (ppm, by volume)	4. Solids Content, Fe_2O_3 unless noted (mg/liter)	5. PH Value	6. Kinematic Viscosity (CS/SSU @ 100°F)	7. Trans-mittance (%)	8. Sample Taken From**	9. Indicator Meter Reading (ppm)	10. Solids Content, Calculated (ppm by weight)
19 Aug*	68-748	0.0	7.9 (Rust)	5.5	1.76	-	A	8	-
29 Aug	68-756	0.0	176.0	-	-	-	B	-	216.5
	68-757	0.0	30.8	-	-	-	C	>100	37.9
	68-758	0.0	30.4	-	-	50	D	>100	37.4
	68-760	0.0	1.4	-	-	97	D	72	1.722
	68-761	0.0	>0.2	-	-	98.5	D	41	>0.25
	68-762	0.0	0.2	-	-	99	D	30	0.25
1 Sep	68-775	0.0	0.1	-	-	100	D	8	0.12
3 Sep	68-768	0.0	0.4	-	-	99.5	D	18	0.49
	68-770	0.0	0.4	-	-	99.5	D	23	0.49
	68-773	0.0	<0.1	-	-	99.5	D	12	<0.12
4 Sep	68-781	>20	-	-	-	-	D	50	-
	68-783	>20	-	-	-	-	D	20	-
	68-785	>20	-	-	-	-	D	15	-
	68-787	>20	-	-	-	-	D	10	-
	68-789	>20	-	-	-	-	D	5	-

*Fuel from tanker prior to start of testing.

**A - Tanker; B - Contamination container; C - Detector head outlet; D - Detector head inlet.

NOTE: Data contained in columns 3 through 7 per laboratory analysis. Apparatus for obtaining surface tension, water separometer index, or WSIM not available at YPG.

TABLE 2. Fuel Analysis Summary, EFTT 400

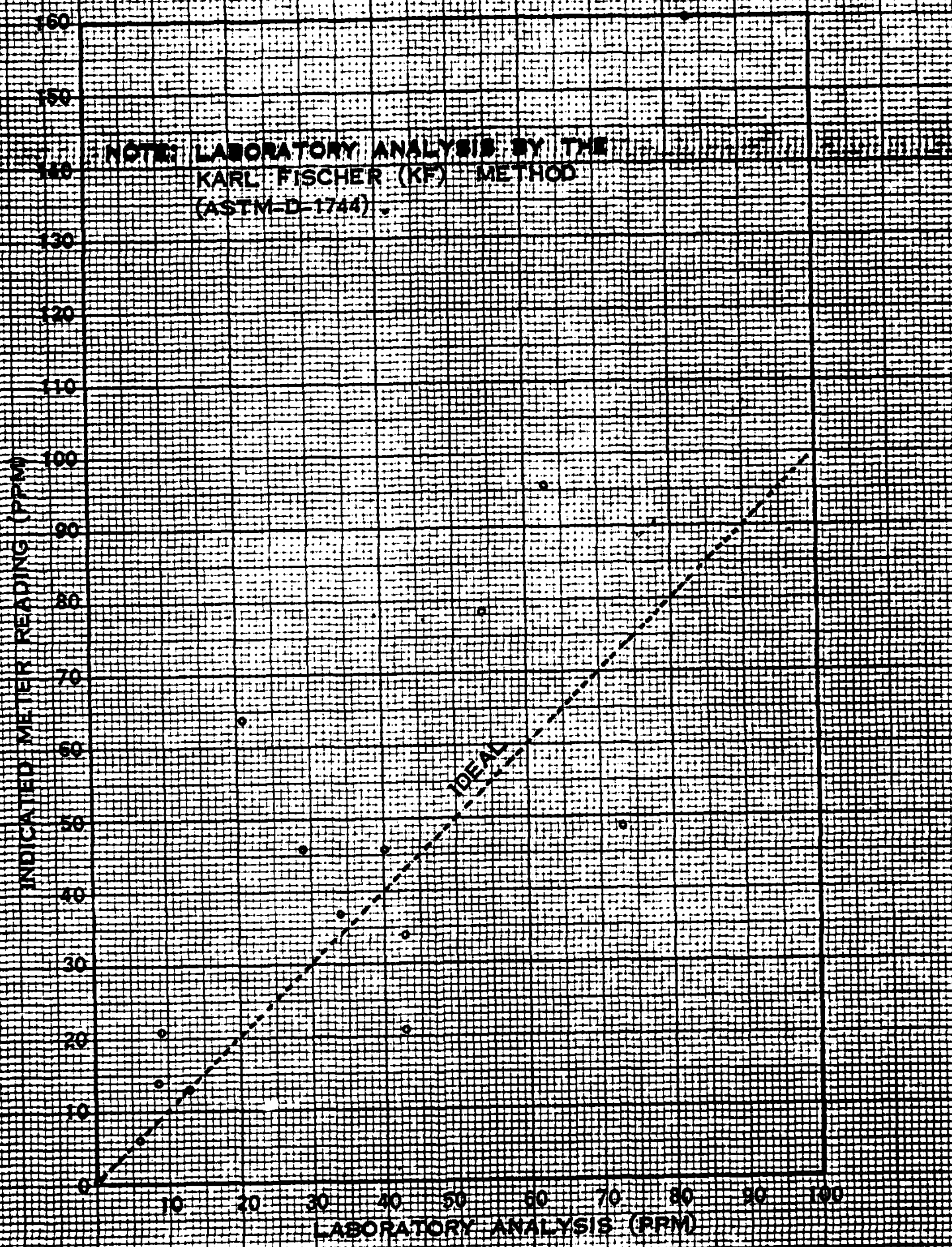
Gasoline, Referee Grade, MIL-G-3056B (MOGAS). Prior to start of testing.

Date: 1 May 1968
Sample No.: 68-352

API Gravity (°)	53.5	Recovery (%)	98.5
Rvp (psig)	3.9	Residue (%)	1.0
Distillation (°F)		Loss (%)	0.5
IBP	118	Temp for V/L of 10:1 (°F)	175.6
5%	155	Octane rating (motor)	84.8
10%	168	Octane rating (research)	92.1
50%	238	Existent Gum (mg/100 ml) washed	3.6
90%	343		
95%	371	Existent Gum (mg/100 ml)	5.2
EP	405	Aromatics (%)	40.3
		Olefins (%)	9.0

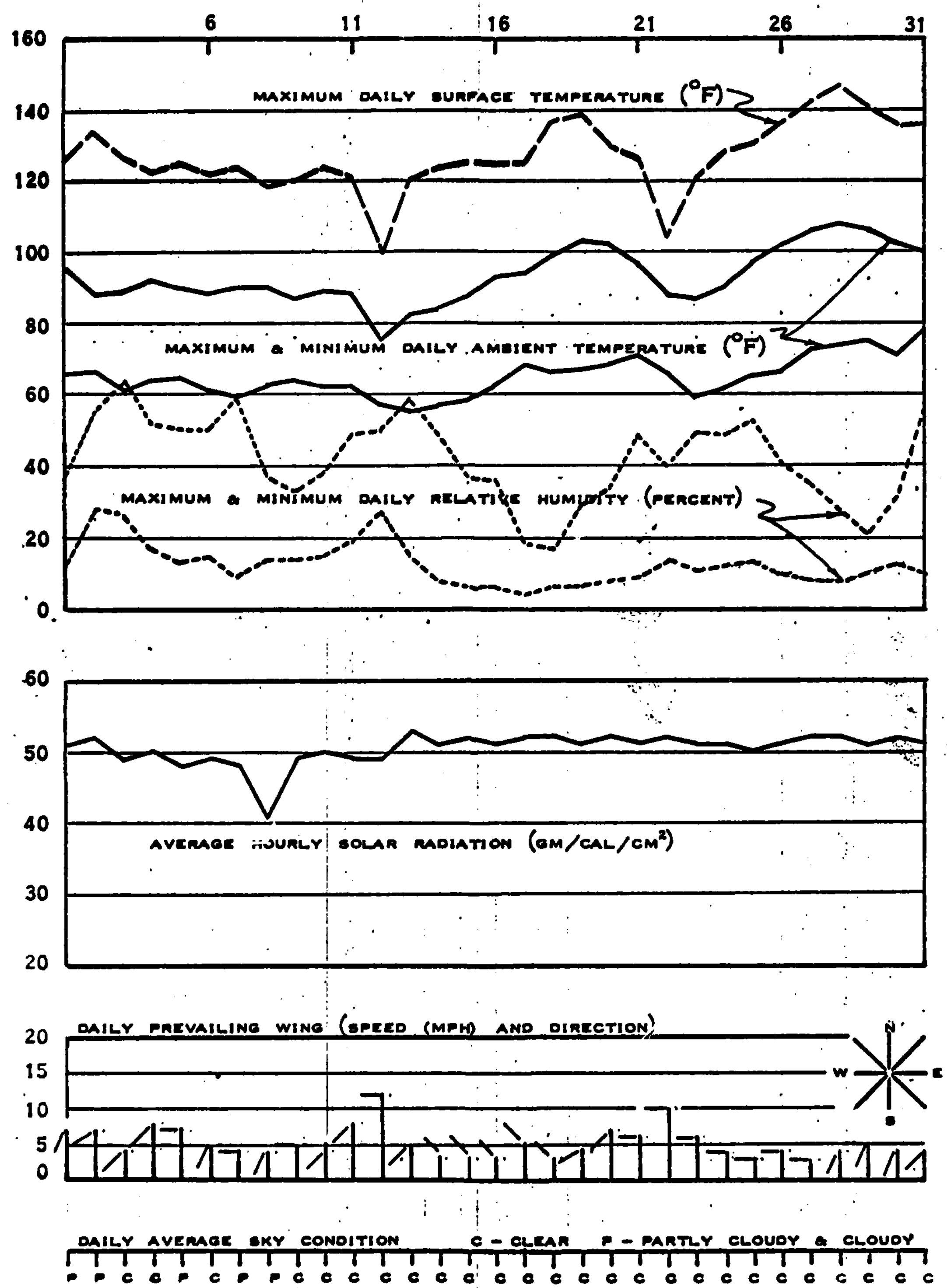
TABLE 3. Analysis of MOGAS Contaminated with Red Iron Oxide (Fe_2O_3), EFTT 400 (ppm by weight)

Sample No.	Lab Analysis (mg/liter)	Calculated (ppm)	Indicator Meter Reading (ppm)
1	0.90	1.2	17
2	1.76	2.3	31
3	3.69	4.8	41
4	3.09	4.1	53
5	4.89	6.4	67
6	10.50	13.8	87
7	0.90	1.2	12
8	2.42	3.1	26
9	3.40	4.5	45
10	7.27	9.6	62
11	0.27	0.4	0
12	0.65	0.9	0

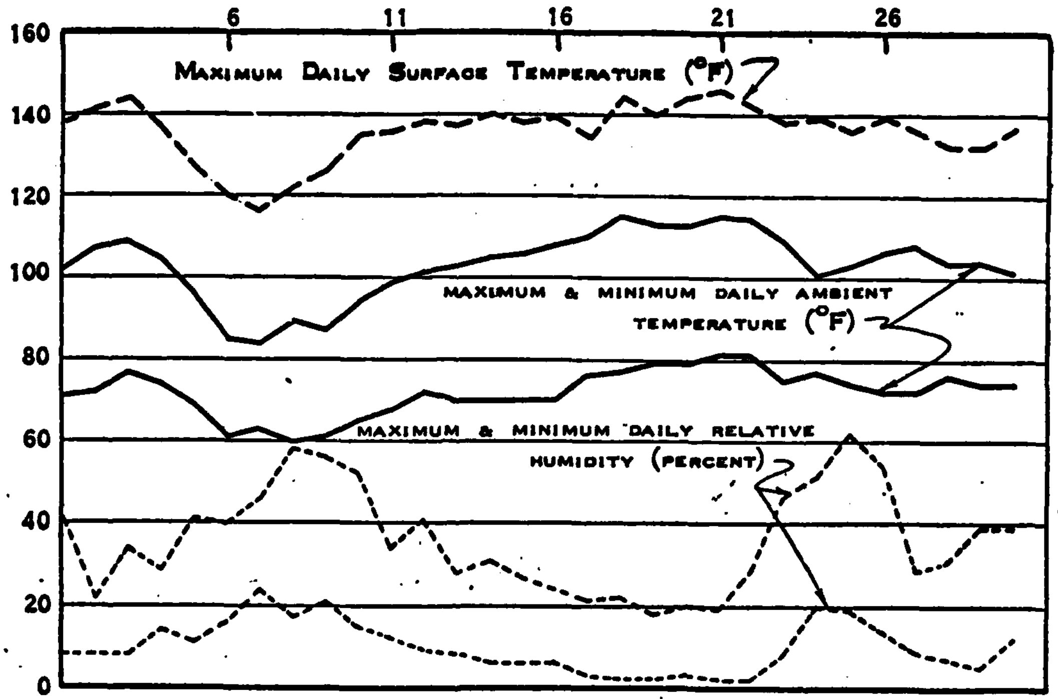


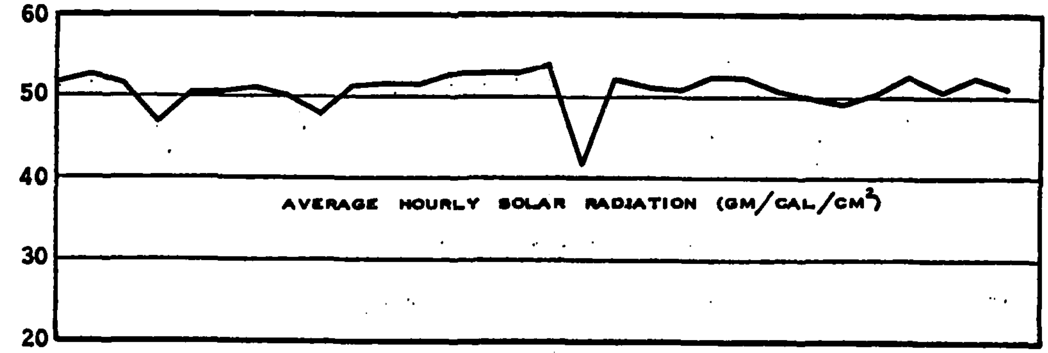
GRAPH 1. EFTT 400 MOGAS CONTAMINATED WITH WATER.

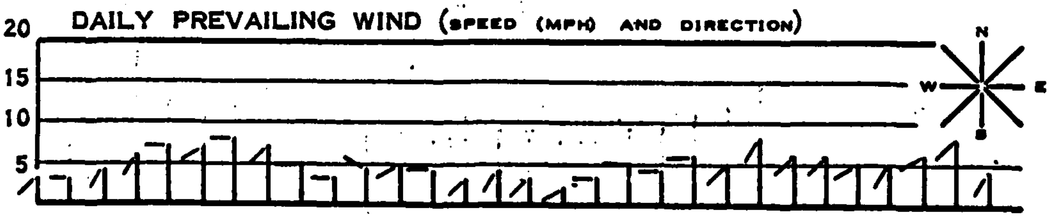
YUMA PROVING GROUND, YUMA, ARIZONA
METEOROLOGICAL SUMMARY FOR MAY 1968

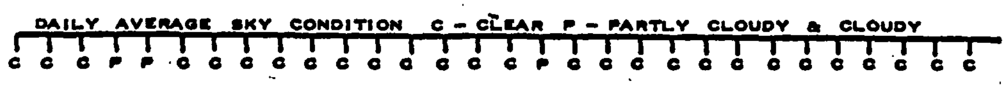


YUMA PROVING GROUND, YUMA, ARIZONA
METEOROLOGICAL SUMMARY FOR JUNE 1968

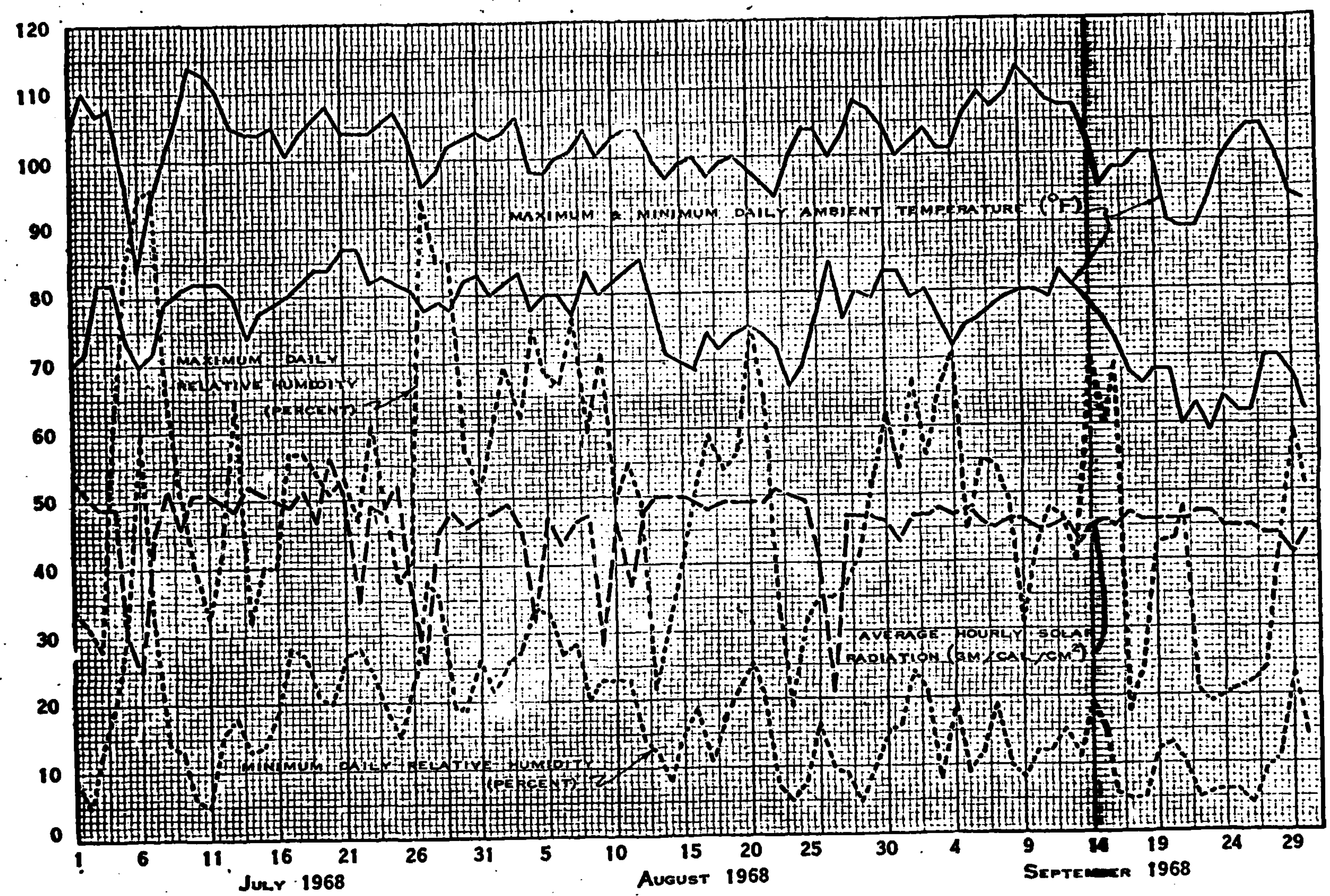








(Ambient Temperature, Relative Humidity and Solar Radiation)
Yuma Proving Ground
Yuma, Arizona



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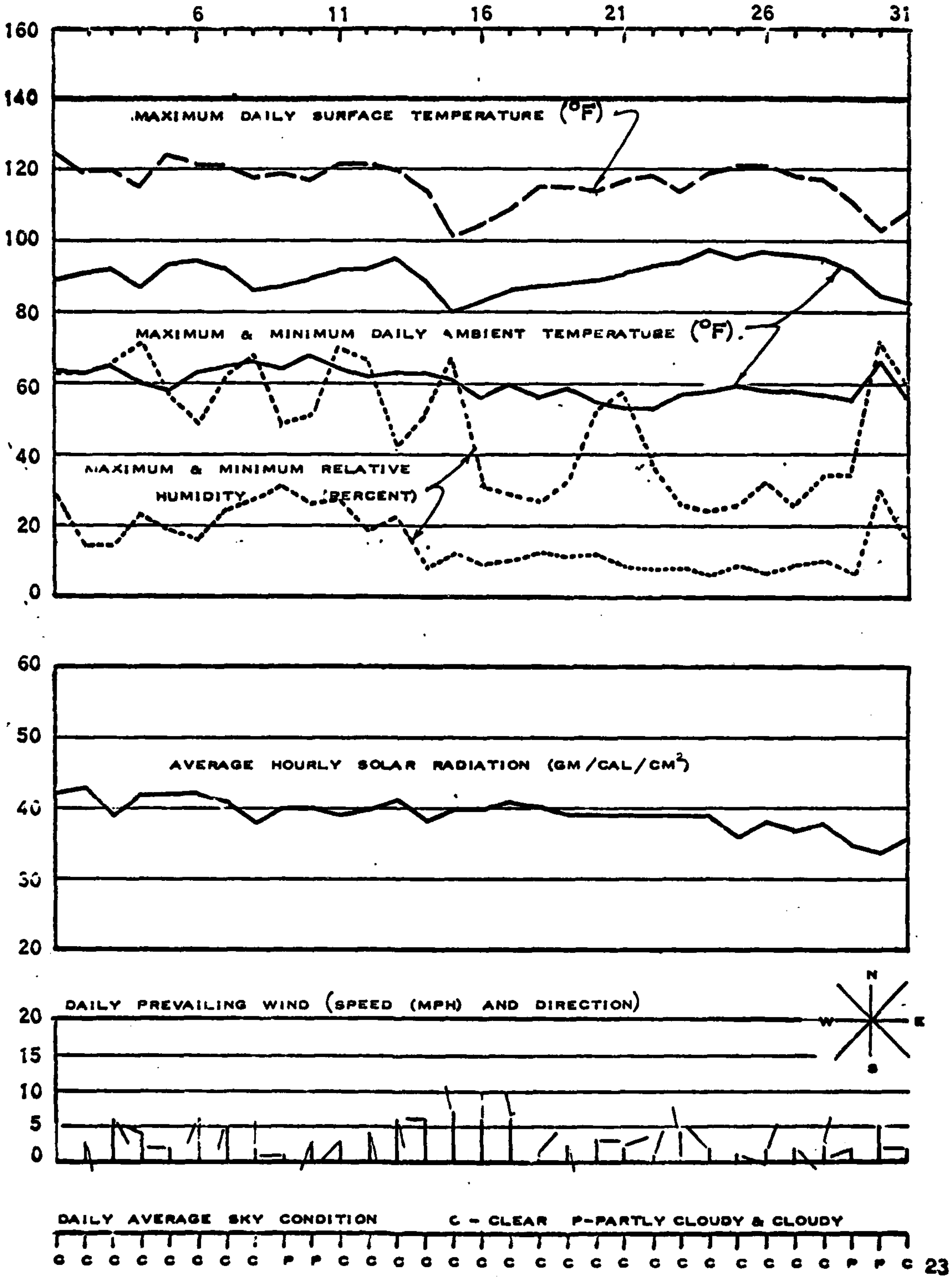
YUMA PROVING GROUND, YUMA, ARIZONA
METEOROLOGICAL SUMMARY FOR OCTOBER 1968



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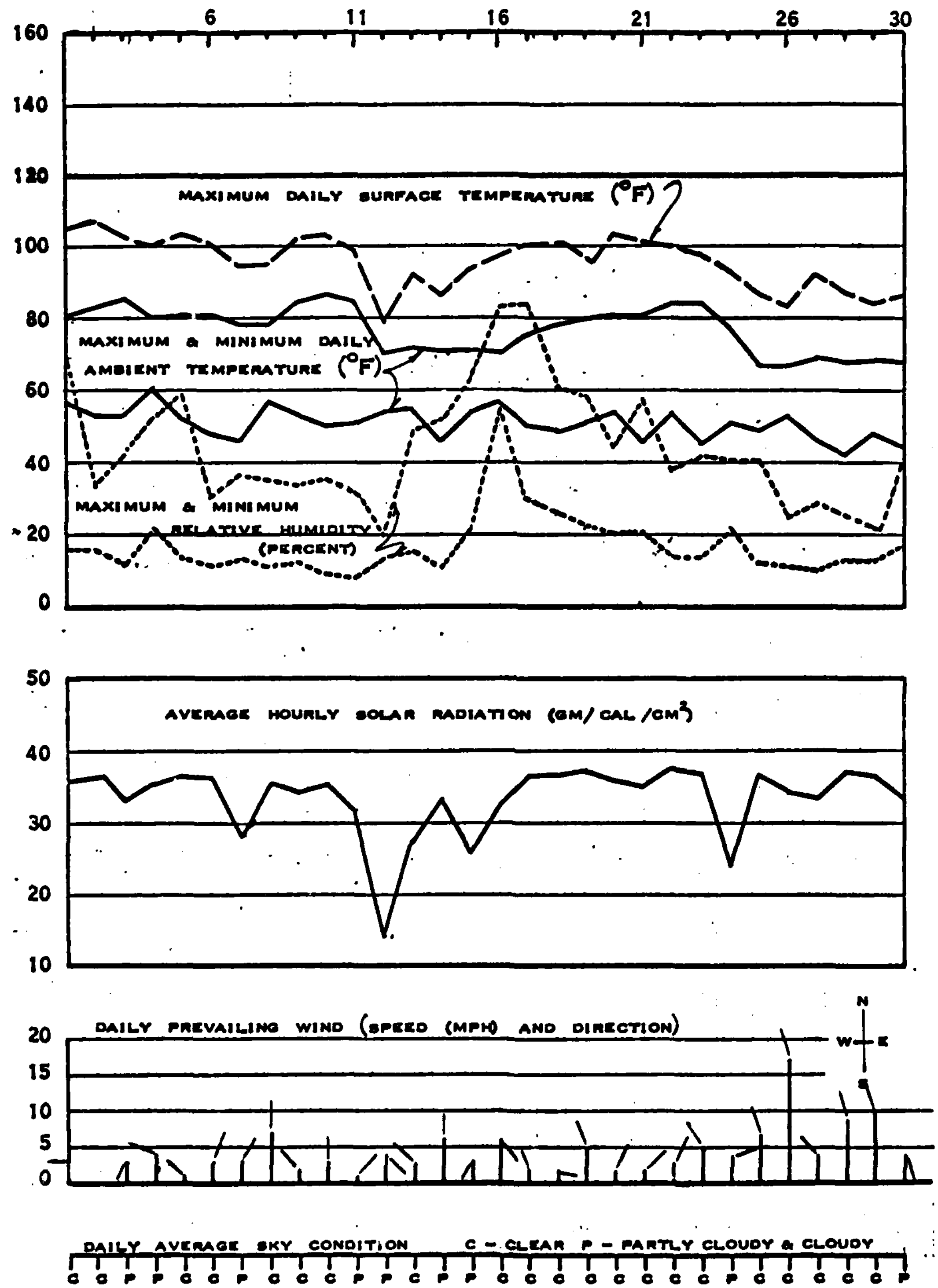
METEOROLOGICAL SUMMARY FOR NOVEMBER 1968



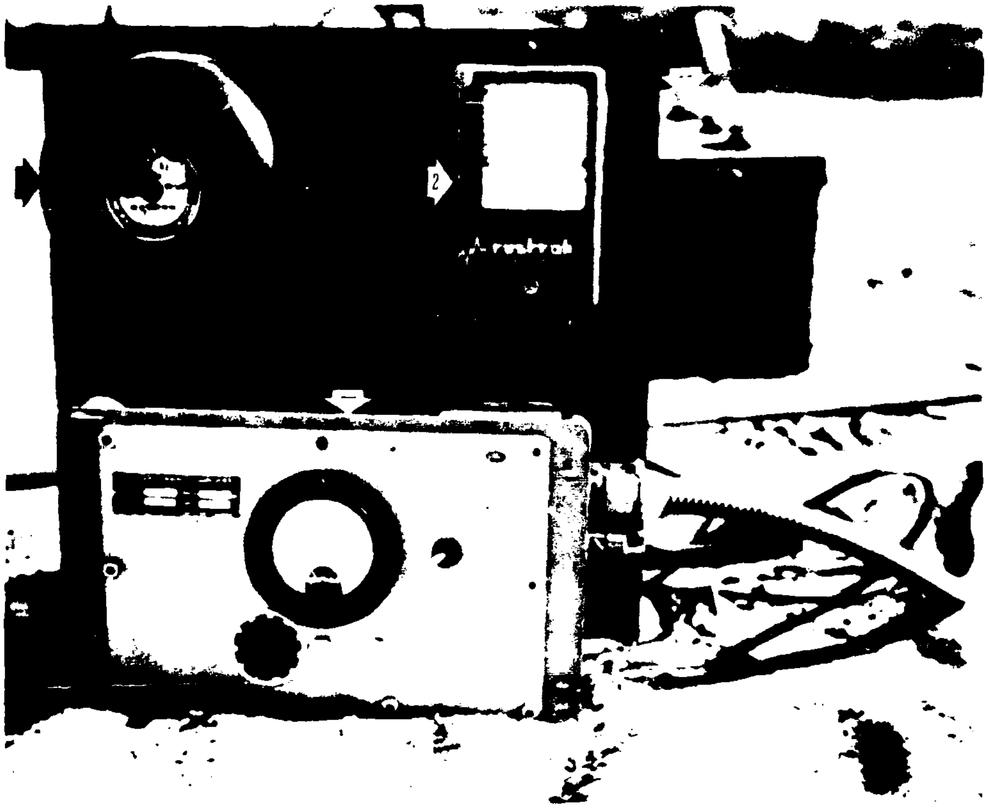


FIGURE 1. Controls and instruments installed on EFTT 50. Identical items used on EFTT 400. 1. Amplifier. 2. Recorder. 3. Alarm. 4. Battery.

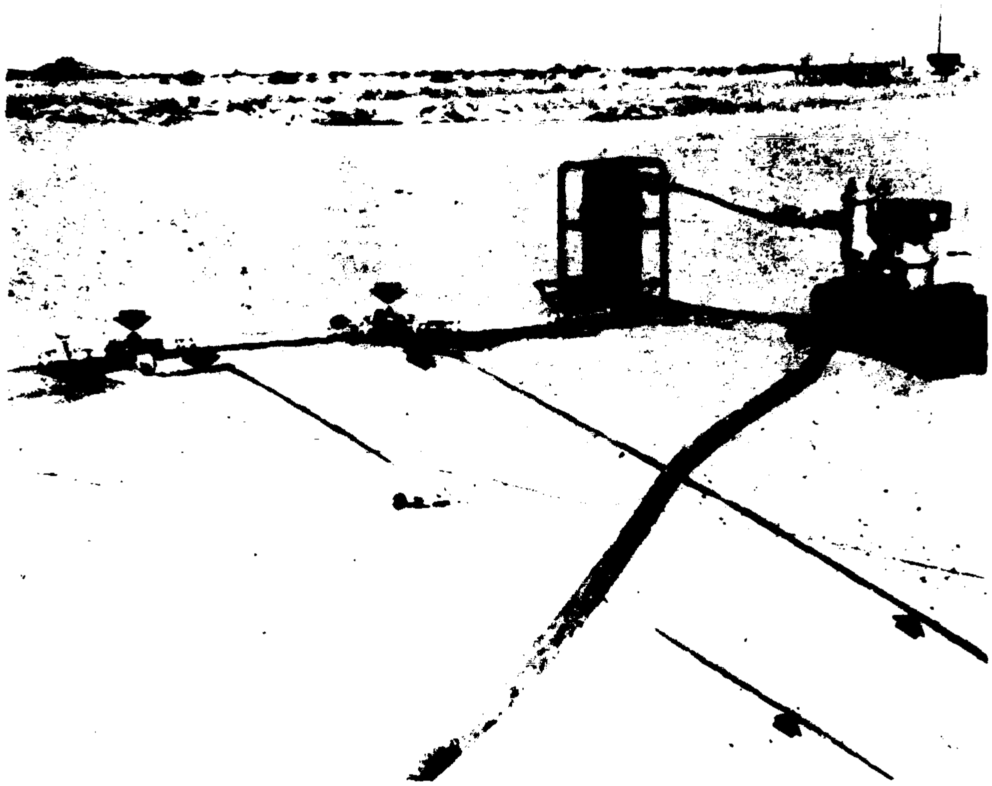


FIGURE 2. EFTT 50 components in closed loop piping system. 1. Pickup head. 2. Control valve. 3. Conduit. 4. Conduit connectors.

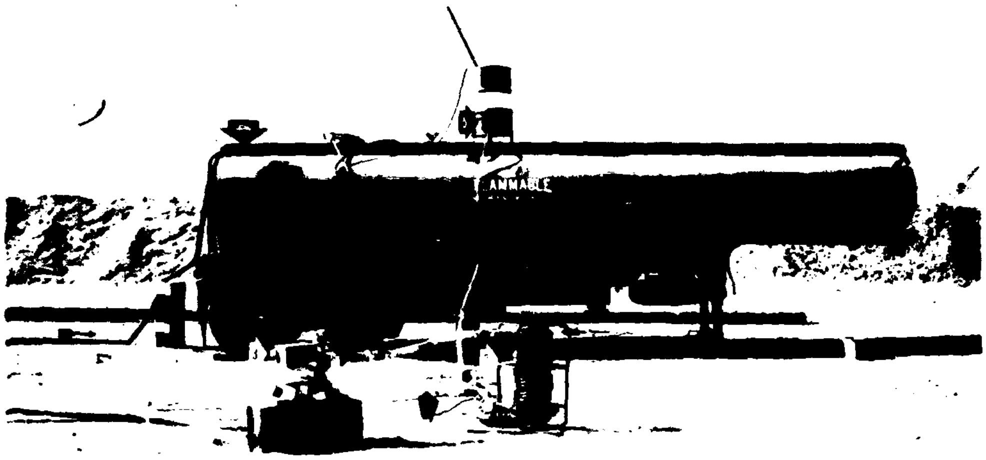


FIGURE 3. EFTT 50 test setup. 1. EFTT 50. 2. Filter/separator. 3. Flow meter. 4. Fuel tanker. 5. Contaminant barrel.

FIGURE 4. EFTT 400 test setup. 1. Detector head. 2. Control valve. 3. Flow meter. 4. Conduit. 5. Controls and instruments.

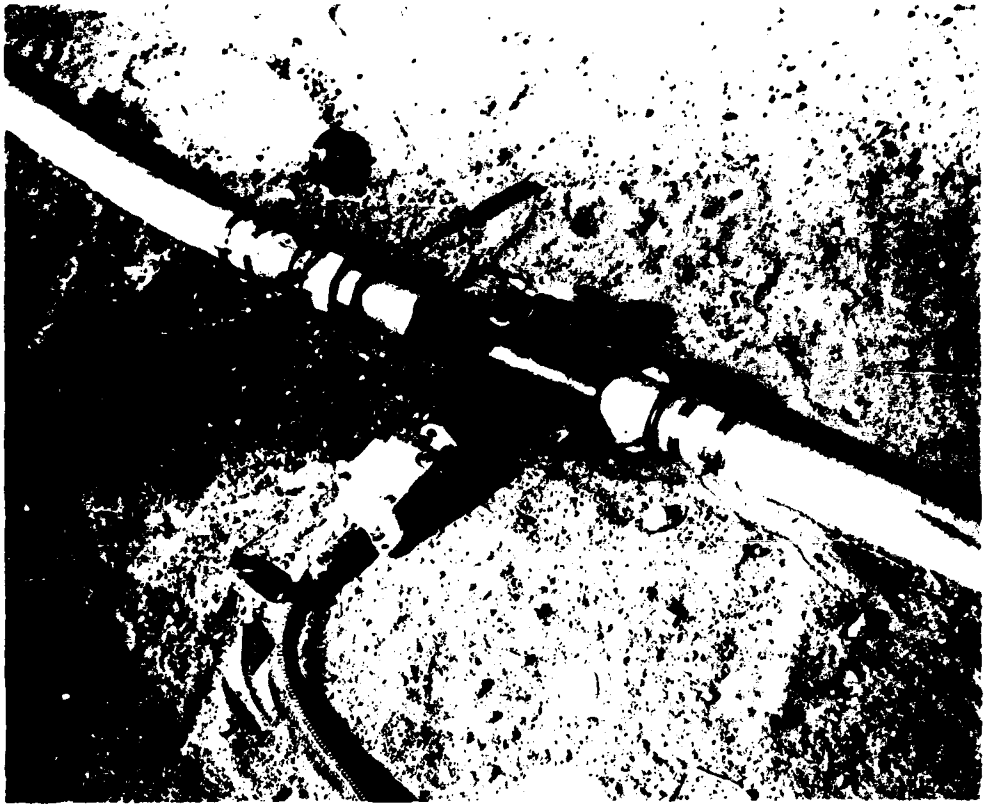


FIGURE 5. EFTT 50 pickup head installed. 1. Pickup head. 2. Steel conduit tube (junction box to photocell adapter). 3. Conduit connector.

FIGURE 6. EFTT 50 control valve installed. 1. Control valve. 2. Conduit connector

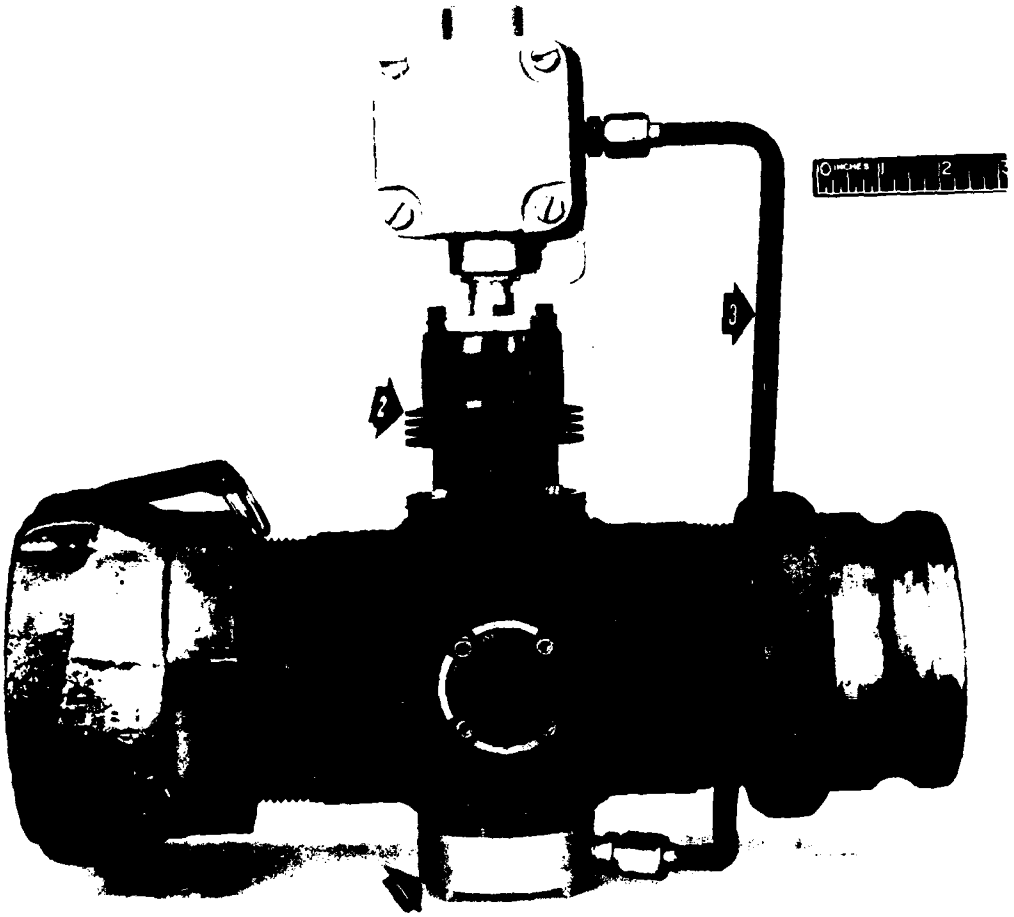


FIGURE 7. EFTT 400 pickup head. 1. Photocell adapter. 2. **Lamp adapter**
3. Steel Conduit tube.

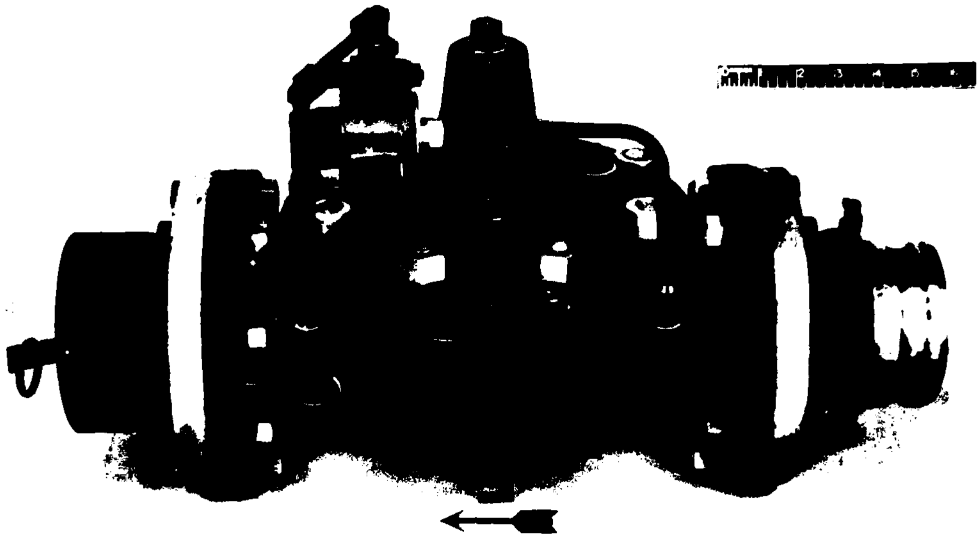


FIGURE 8. EFTT 400 control valve (arrow shows flow **direction**).

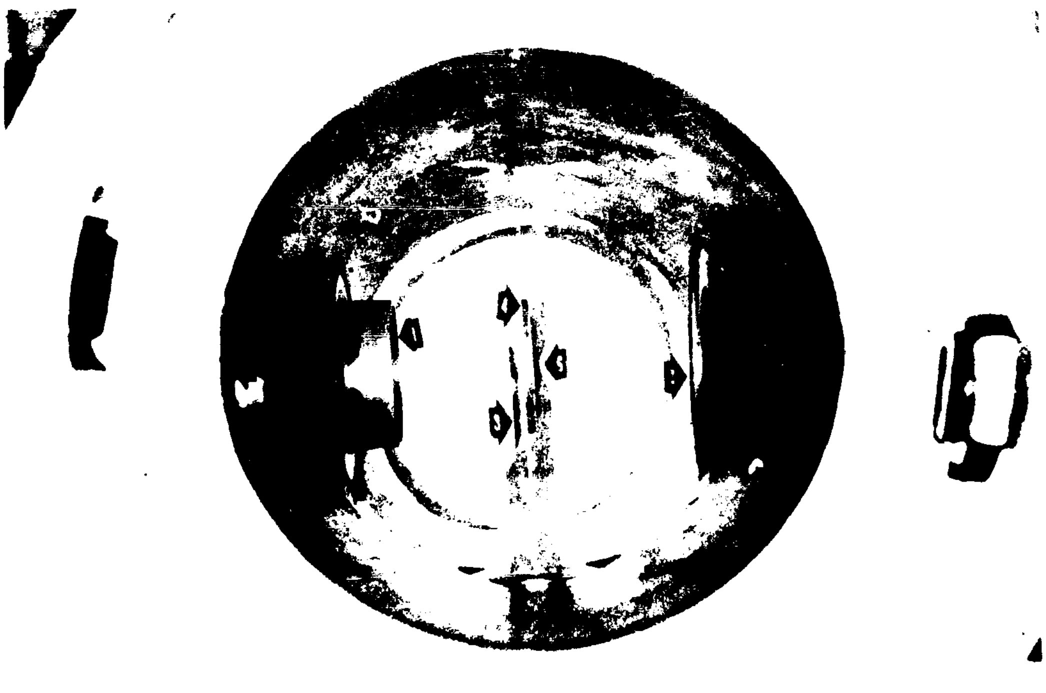


FIGURE 9. View inside EFTT 400 pickup head (from outlet **end). 1. Photocell.**
2. Lamp opening. 3. Simulator slide. 4. **Light shield.**
5. Simulation port (open only when simulator **button is depressed).**

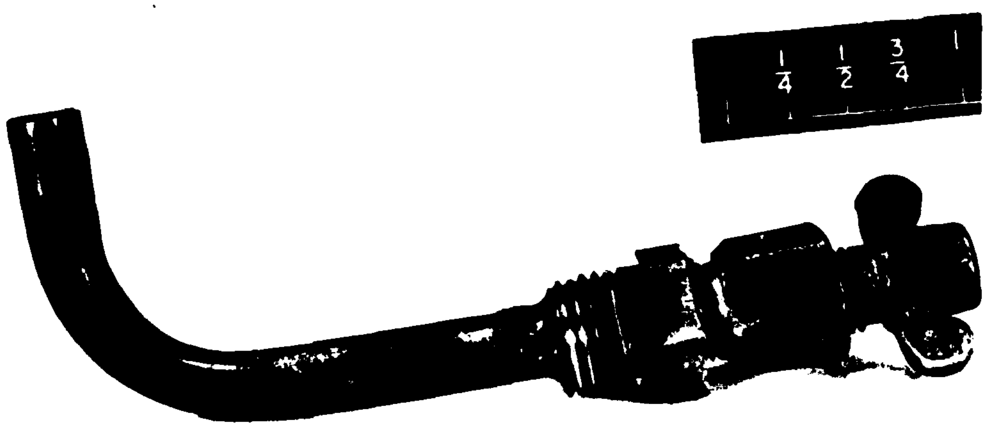


FIGURE 10. Sampling valve (instrumentation).

APPENDIX III. DEFICIENCIES AND SHORTCOMINGS

1. Deficiencies

Deficiency	Suggested Corrective Action	Remarks
Contaminate warning sounded and fuel flow shut down at an ambient air temperature of 113°F. Amplifier case, internal air temperature, 120°F. Fuel temperature, 143°F.	Use amplifier components which will operate satisfactorily at higher temperatures.	DTM is not explicit in describing maximum ambient temperature limits. AR 705-15, Change 1, specifies 120°F ambient air temperature (EPR L5-2).
The control valve would not reopen when contaminate simulator button was depressed and then released at ambient air temperature of 105°F. Ppm indicator meter functioned properly during this failure.	Same as above	Cooling the amplifier by artificial means restored operation. Components functioned properly at lower ambient temperatures. Also same remark as above (EPR L5-3).

2. Shortcomings

Shortcoming		
Fuel dripped from the contaminate simulator button when button was depressed.	Replace O-ring (packing, preformed, 1/4-in. OD, 1/16 in. thick (08189) 204592).	No replacement parts were furnished with the EFTT's

NOTE: This shortcoming could be a safety hazard and would have been considered a deficiency if the EFTT's had been of recent production. The EFTT's were stored indoors at YPG from June 1966 until July 1968, and outdoors at YPG from 12 July 1968 through 29 August 1968. Seals, gaskets, packings, etc., deteriorate rapidly when stored in the hot-dry desert environment.

APPENDIX IV. REFERENCES

a. Letter, AMSTE-GE, subject "Test Directive ... USATECOM Project No. 7-3-0239-06/07/08/09 ... Fuel Tester Effluent", 30 June 1965.

b. Letter, STEYP-TAD, Headquarters, Yuma Proving Ground, 31 August 1964, subject "Plan of Test for Engineering and Service Test of Fuel Tester, Effluent, August 1964, USATECOM Project No. 7-3-0239-04."

c. Approved Military Characteristics, Effluent Fuel Tester, approved QMCTC No. 2, 28 March 1962.

d. Letter, AMSME-MTP, subject "Draft Technical Manual for Totamitor, 50 GPM, TSN 4930-BOO-0019, and 400 GPM, TSN 4390-BOO-0020, DTM 5-4390-207-12" 21 December 1966.

e. Letter, AMSTE-GE, subject "Effluent Fuel Tester, 50 and 400 GPM, Bowser Totamitor, RDTE Project No. 1M643324D58406" 11 May 1967.

f. Letter, AMSTE-GE, subject "Safety Release ... USATECOM Project, No. 7-3-0239-06/07/09, Engineering, Service and Environmental Tests of Fuel Tester, Effluent, 50/400 GPM, Bowser Totamitor, RDTE Project No. 1M643324D58406", 8 November 1967.

g. Military Specification MIL-F-8901A, subject "Filter/separators, Aviation and Motor Fuel, Ground and Shipboard use, Performance Requirements and Test Procedures for", 11 June 1963.

h. Booklet "Description, Installation, Operation and Maintenance of the Model 861F Totamitor" by Manufacturer: Bowser, Inc., Bowser-Briggs Filtration Division, Cookeville, Tenn., Form 926474, (no date).

Unclassified
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13. ABSTRACT

The desert engineering test of the Effluent Fuel Tester, Totamitor, (EFTT) 50 and 400 gallons per minute rated capacities, was conducted by and at Yuma Proving Ground from 27 May 1968 through 6 December 1968.

The purpose of the test was to determine the ability of the EFTT's to meet the approved military characteristics in the desert environment.

The amplifier fails to function at ambient temperatures above 105°F when the amplifier is resting on the ground and is not shaded.

The EFTT's warn of minute quantities of contamination; however, correlation between meter readings and actual contamination is very poor.

It was concluded that the EFTT's did not meet the approved military characteristics for operation in a desert environment.

It was recommended that the amplifier components be investigated for possible replacement with parts less susceptible to high temperatures; that repair parts, support equipment and special tools be furnished with each EFTT; that the pickup head electrical conduit be of stainless steel or aluminum; and that the test items, after redesign, and the maintenance package, after updating, be resubmitted for test.

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Fuel Tester, 50 gpm Fuel Tester, 400 gpm Effluent Fuel Tester, 50 gpm Effluent Fuel Tester, 400 gpm Totamitor, Fuel Tester, 50 gpm Totamitor, Fuel Tester, 400 gpm						

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