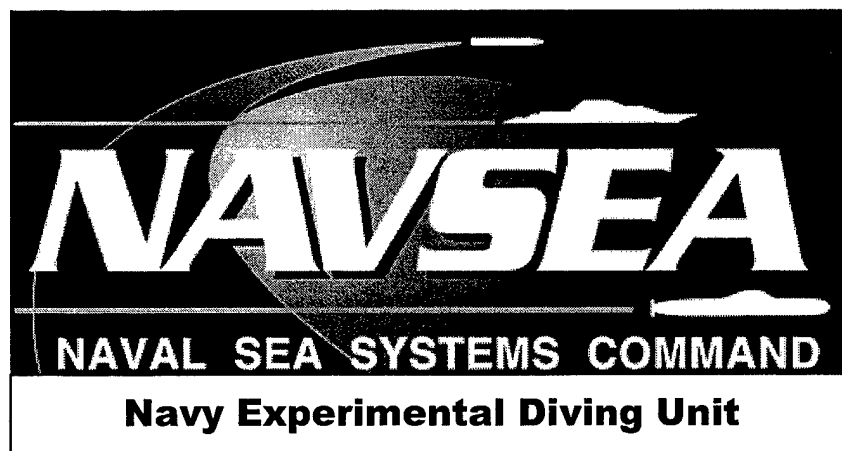


Navy Experimental Diving Unit  
321 Bullfinch Rd.  
Panama City, FL 32407-7015

TA98-030  
NEDU TR# 12-01  
October 2001



NAVSEA 00C5 DESIGNED GROUND FAULT  
INTERRUPTER FIRST ARTICLE OF PRODUCTION MODEL  
TEST AND EVALUATION

Author: JERRY D. PELTON, NEDU 0352

<Unclassified>  
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# NAVXDIVINGUINST 3965.1D

UNCLASSIFIED  
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE					
1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited		
2b. DECLASSIFICATION/DOWNGRADING AUTHORITY					
4. PERFORMING ORGANIZATION REPORT NUMBER (S) NEDU Technical Report No. 12-01			5. MONITORING ORGANIZATION REPORT NUMBER (S)		
6a. NAME OF PERFORMING ORGANIZATION Navy Experimental Diving Unit		6b. OFFICE SYMBOL (If Applicable)	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and ZIP Code) 321 Bullfinch Road, Panama City, FL 32407-7015			7b. ADDRESS (City, State, and Zip Code)		
8a. NAME OF FUNDING SPONSORING ORGANIZATION Naval Sea Systems Command		8b. OFFICE SYMBOL (If Applicable) 00C	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code) 2531 Jefferson Davis Highway, Arlington, VA 22242-5160			10. SOURCE OF FUNDING NUMBERS N0002400WR01028		
		PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO. 98-030	WORK UNIT ACCESSION NO.
11. TITLE NAVSEA 00C5 DESIGNED GROUND FAULT INTERRUPTER, FIRST ARTICLE OF PRODUCTION MODEL TEST AND EVALUATION (Unclassified)					
12. PERSONAL AUTHOR (S) JERRY D. PELTON					
13a. TYPE OF REPORT Technical Report		13b. TIME COVERED FROM 2001 TO 2001		14. DATE OF REPORT (Year, Month, Day) 2001, 09, 25	15. PAGE COUNT 10
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and Identify by block number)		
FIELD	GROUP	SUB-GROUP			
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This test and evaluation covers the final version of a Navy-designed portable ground fault interrupter. Testing included manual and drawings review, bench testing, and environmental testing. The first article of the production version was tested in accordance with the sections of MIL-STD-810E that present conditions under which this equipment will be operated. The result of this testing and evaluation is a recommendation for Authorized for Navy Use status.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED X SAME AS RPT. DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION Unclassified		
22a. NAME OF RESPONSIBLE INDIVIDUAL NEDU Librarian		22b. TELEPHONE (Include Area Code) 904-230-3100		22c. OFFICE SYMBOL	

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# **NAVSEA 00C5 DESIGNED GROUND FAULT INTERRUPTER FIRST ARTICLE OF PRODUCTION MODEL TEST AND EVALUATION**

## **ABSTRACT**

This test and evaluation covers the final version of a Navy-designed portable ground fault interrupter. Testing included manual and drawings review, bench testing, and environmental testing. The first article of the production version was tested in accordance with the sections of MIL-STD-810E that present conditions under which this equipment will be operated. The result of this testing and evaluation is a recommendation for Authorized for Navy Use status.

## **INTRODUCTION**

Extensive market research determined that none of the commercial portable ground fault interrupters (GFI) met Navy requirements. Therefore, Naval Sea Systems Command (NAVSEA 00C5) set out to design a system that would meet these requirements and that would subsequently be built under contract for use by Navy diving commands. The Navy Experimental Diving Unit (NEDU) was tasked to review the design, test breadboard equipment and prototype versions, and finally test the first article of the production version.

## **METHODS**

### **GENERAL**

#### Phase 1

- (a) The test plan was written by Battelle Memorial Institute, Columbus, OH, and comments and recommendations were returned to NAVSEA 00C5. A second test plan, approved by the Commanding Officer of NEDU, was also submitted for review by NAVSEA 00C5, which combined both test plans into one and approved it.
- (b) The breadboard version of the Navy design was built by NAVSEA 00C5 and shipped to NEDU for testing. During testing, problems were found and corrected by both NEDU and the designer. The breadboard version was finalized, and the design for prototype versions was submitted by NAVSEA 00C5.

## Phase 2

- (a) Prototype versions were completed and shipped to NEDU for testing. NEDU bench tested two units and contracted with the Naval Coastal Systems Station (CSS), Panama City, FL, to conduct environmental testing per the test plan, which was in accordance with MIL-STD-810E.
- (b) Both prototype units failed portions of the environmental testing and were shipped back to NAVSEA 00C5 for modifications.
- (c) When modifications were made, the units were returned to NEDU and testing was restarted from the beginning.
- (d) The order of the second series of testing was changed: the rain test was conducted first, to determine if leakage problems had been solved, and the low and high temperature operational tests were then conducted to meet personnel schedules.

## Phase 3

- (a) The first article of production was completed and shipped to NEDU for testing. NEDU conducted limited bench testing to ensure that the unit had not suffered any damage in shipping. NAVSEA 00C5 had extensive bench testing conducted by an outside source.
- (b) CSS was again contracted to conduct environmental testing per the test plan, which was in accordance with MIL-STD-810E.
- (c) CSS completed its testing (see enclosure 1 for details).

## **EXPERIMENTAL DESIGN AND ANALYSIS**

The objective of this task was to test and evaluate a GFI designed to meet Navy requirements. This equipment must provide a high level of electrical safety to operators of portable electrical devices in and around water.

Test Parameters

(a) Bench testing was conducted to confirm that trip times and leakage trip points were within specifications: times less than 20 milliseconds (ms) with a leakage of 10 milliamps (mA) to ground. These tests were conducted with utility power and simulated shipboard power. Testing was conducted on each line lead five times and the average of the trip times was taken for the overall value. The NEDU-designed GFI Tester provided input power and introduced the fault current through the built-in decade resistance box; each line lead was tested according to its voltage level above reference ground. The following tables show results from these tests:

Table 1.  
GROUND FAULT INTERRUPTER (GFI)  
TEST DATA REPORT

EQUIPMENT TYPE AND MANUFACTURER: <u>NAVY-DESIGNED GFI</u>			
SERIAL NUMBER : <u>GFI-01</u> TEST DATE: <u>07/09/2001</u> Arrival Test			
APPLIED VOLTAGE	CIRCUIT OPEN<20ms		COMMENTS
	PASS	FAIL	
L1 – L2 = 115 VAC	PASS		
L1 – GRD. = 2.63 VAC	PASS		Fault = 263 Ω for 10mA
L2 – GRD. = 111.8 VAC	PASS		Fault = 11,180 Ω for 10mA
ADDITIONAL COMMENTS: Five test were conducted on each leg.			
L1 average = 9.26 ms			
L2 average = 7.76 ms			

TEST EQUIPMENT USED:

TYPE	MANUFACTURER	SERIAL NUMBER	CAL. DUE DATE
Multimeter	Hewlett Packard Model 34401A	US36077584	10/2002
Oscilloscope	Tektronix Model 5730 A	B033497	08/2002
GFI Tester	NEDU (Prototype)	Case #38080	N/A

Table 2.  
GROUND FAULT INTERRUPTER (GFI)  
TEST DATA REPORT

EQUIPMENT TYPE AND MANUFACTURER: <u>NAVY-DESIGNED GFI</u>			
SERIAL NUMBER : <u>GFI-01</u> TEST DATE: <u>08/03/2001</u> Post-environmental test			
APPLIED VOLTAGE	CIRCUIT OPEN<20ms		COMMENTS
	PASS	FAIL	
L1 – L2 = 115 VAC	PASS		
L1 – GRD. = 2.94 VAC	PASS		Fault = 294 Ω for 10mA
L2 – GRD. = 113.2 VAC	PASS		Fault = 11,320 Ω for 10mA
ADDITIONAL COMMENTS: Five tests were conducted on each leg.			
L1 average = 8.52ms			
L2 average = 7.72 ms			

TEST EQUIPMENT USED:

TYPE	MANUFACTURER	SERIAL NUMBER	CAL. DUE DATE
Multimeter	Hewlett Packard Model 34401A	US36077584	10/2002
Oscilloscope	Tektronix Model 5730 A	B033497	08/2002
GFI Tester	NEDU (Prototype)	Case #38080	N/A

(b) Resistive and inductive overload tests were not conducted on this unit, since NAVSEA 00C5 had an independent test lab conduct this testing on all of the production units.

(c) Environmental Testing was conducted per MIL-STD-810E:

- High temperature operational: +48°C (118.4°F) for 48 hours.
- Vibration method, 514.4, Category 1, without shipping container.
- Rain: Place the GFI unit in the test area in the upright, operational position, with the required input and output wiring connected. Operate the unit during the test, and manually or automatically trip it a minimum of once every 20 minutes during the test. Expose the unit to an overlapping spray pattern with the nozzles placed 19 inches from the test surface. The droplets are to be

approximately 2 to 4.5 mm and are sprayed at a minimum pressure of 40 psig. Expose the unit to this environment for a minimum of 40 minutes for each exposed face.

- Low temperature operational: Place the unit in the operational position, within the temperature chamber. Set the chamber temperature to  $-31\text{ }^{\circ}\text{C}$  ( $-23.8\text{ }^{\circ}\text{F}$ ), and maintain the unit at that temperature for a minimum of 8 hours. During the test, trip the unit with the internal tripping circuit. Trip and reset the unit a minimum of once per hour throughout the test.
- Low temperature/transit drop test. This test combines the effects from low temperature storage with those from potential for being dropped during transit. Place the unit within a temperature chamber and maintain it at  $-31\text{ }^{\circ}\text{C}$  ( $-23.8\text{ }^{\circ}\text{F}$ ) for a minimum of 24 hours.

## **EQUIPMENT AND INSTRUMENTATION**

### Bench Testing

- GFI Tester (NEDU Device)
- Digital Volt Meter- HP-34401A
- Oscilloscope – Tektronix Model TH5730A

### Environmental Testing (Enclosure 1)

- Test chambers (hot and cold)
- Vibration table
- Spray nozzle array (rain test)

## **PROCEDURES**

### Bench Testing

Bench testing was conducted in accordance with NAVXDIVINGU Instruction 3960.3 (see Tables 1 & 2).

### Ergonomics Evaluation

The production unit was evaluated for the ease of operation it allowed, the visibility of its nametags, and the ability of its users to hear or view alarms. Also evaluated were the ease of its repairs and its troubleshooting with the drawings and the user's manual provided.

### Environmental Testing

Environmental testing was conducted per MIL-STD-810E (see enclosure 1, CSS report ELPR-2001-901 for details)



## RESULTS

### TESTING OF THE FIRST ARTICLE PRODUCTION VERSION

#### Bench Testing

- Average ground fault trip times on the production unit were less than 20 ms at 10-mA leakage.
- Ground fault interruption testing, using the NEDU procedure, was conducted before starting the environmental testing (see Table 1). The built-in test circuit was used upon completion of each phase of the environmental testing.
- After the final environmental test, the unit was tested via the built-in test circuit and the NEDU procedure. The unit was found to be fully operational (see Table 2).

#### Ergonomic Evaluation

- All switches were easy to operate.
- All name tags were easy to read under normal lighting conditions and were acceptable in low light conditions.
- Audible alarms could be heard under normal working conditions with background noise levels below 85 dBA.
- Visual alarms could be seen under normal and low light levels; however, they may be difficult to see in bright sunlight. This does not pose a problem if operators check the unit before starting a dive.
- The covers on the receptacles have retainer chains that tend to break and allow the covers to be misplaced. This will need close attention. Also, in order for the unit to be rain-splashproof, the proper mating plugs must be used. These should be provided with the units when they are issued. Receptacles not in use must have covers and these covers must be screwed on tightly.

#### Environmental Testing

- The environmental testing was conducted by Coastal Systems Station, Dahlgren Division, Naval Surface Warfare Center. Details of this testing are included in its report, ELPR-2001-901, dated 4 September, 2001 (see enclosure 1).

## DISCUSSION

This equipment is designed to increase safety while portable electrical equipment is used in or around water. During the testing of the breadboard and prototype GFI, design changes were made to improve the performance and reliability of the design. The design is very complex and will require trained technicians to maintain it. Operators/users of this equipment must be advised about its proper operation/use and its limitations: GFIs do not provide protection past any transformers.

## **CONCLUSIONS**

This equipment is a complex design and must be properly maintained; care must be given to the source input power. The type of equipment to be powered by this GFI must be considered, and operators must have a good working knowledge of how the equipment operates and must be aware of its limitations. Since this GFI design has passed all required testing, it is recommended for Authorized for Navy Use (ANU) status.

DAHLGREN DIVISION  
NAVAL SURFACE WARFARE CENTER  
Panama City, FL 32405



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ELPR – 2001 – 901

# **Environmental Testing of a Portable Electrical Ground Fault Interrupt Unit**

JEFFREY W. BLANKENSHIP  
COASTAL ENGINEERING, TEST, AND EVALUATION DEPARTMENT

4 September 2001

**ENCLOSURE (1)**

**Results Of Environmental Testing Of  
A  
Portable Electrical Ground Fault Interrupt (GFI) Unit**

**1.0 Background**

Coastal Systems Station (CSS), Code E31, was requested by the Navy Experimental Diving Unit (NEDU) to perform environmental testing on a portable Electrical Ground Fault Interrupt (GFI) Unit. This design was previously tested at CSS in 1999 and 2000 as part of the developmental effort. The tests performed during this test series were considered the First Article Tests for the GFI design. The tests were performed at the CSS Environmental Test Facility during July and August, 2001. This report provides the results of the environmental tests performed.

**2.0 Description of Equipment**

The GFI unit provides a ground fault circuit when using portable electric equipment aboard ships. The unit can be plugged into any 110 Volt, single phase receptacle and provides a total of four 110V output receptacles. The unit has a test switch used to test the GFI circuitry by providing a "trip" condition for both the "low" and "high" sides of the receptacles. In addition, a reset switch is provided to reset the unit after the test is performed or if the unit experiences a ground fault condition. There are also LED's which provide indications as to the current state of the unit. Only one unit was available for testing.

**3.0 Functional Performance**

At the beginning and at the end of the environmental testing program, operational performance was verified by NEDU. The results of these tests are beyond the scope of this report. During the environmental test program, a quick measure of performance was made by: toggling the "test" switch; verifying that the power was removed to the receptacles; "resetting" the unit; and verifying that the power was restored. This test was performed by Code E31 personnel, as needed, throughout the testing program.

**4.0 Testing Program**

Based on the testing done previously, it was determined that the following tests would be performed:

High Temperature Operation  
Low Temperature Operation  
Vibration  
Rain

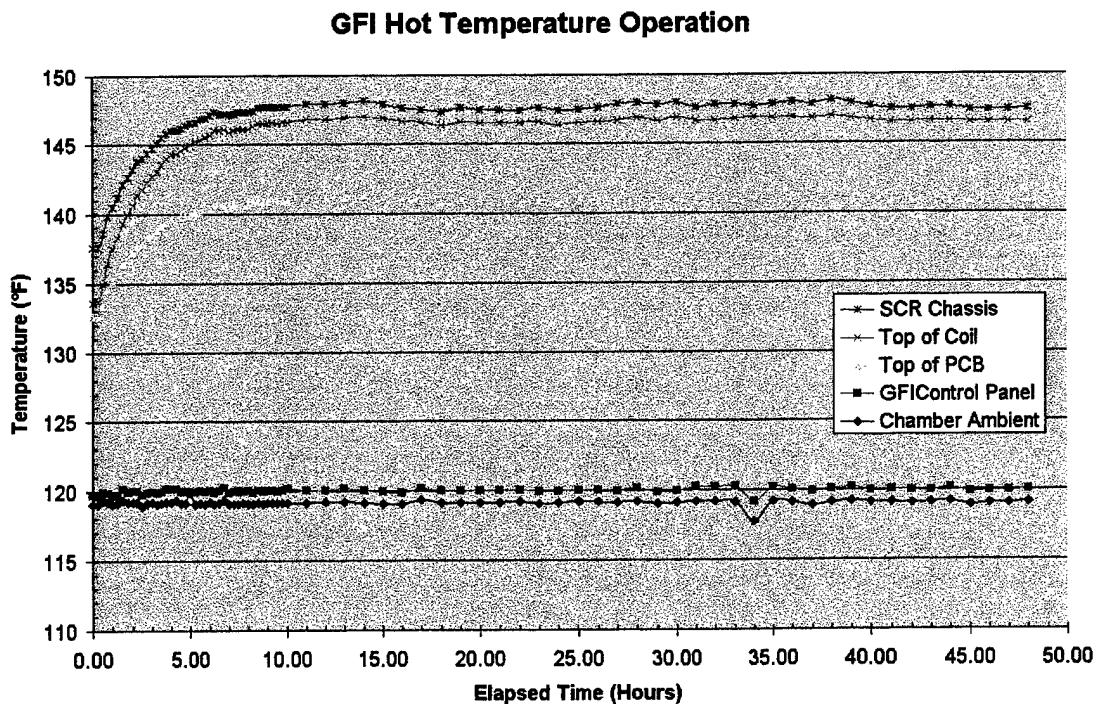
The test plan used was the same as used for the previous series of tests. The only exception was that the Drop tests were not performed during this test series. A copy of the revised test plan is included as Appendix A. The test plan also provides a detailed description of each test performed, with the specific environmental conditions for each. Where applicable, the tests followed the recommendations made in MIL-STD-810E. The tests were performed in the order listed.

All the tests performed required that the unit be operational throughout the environmental exposure. The unit was connected to the facility power at convenient locations for the test performed. For all the tests, except the rain test, a 600 watt load (4, 150 watt lamps) was electrically connected to the GFI unit. These lamps were used to verify system performance throughout the testing program. Since proper mating connectors for the GFI receptacles were not available for the testing, no load was applied to the unit during the rain test.

## 5.0 Test Results

### 5.1 High Temperature Operation

The unit was placed into a temperature chamber and instrumented with thermocouples. The thermocouples were located as follows: external near the LED and switch panel; on top of the circuit board; under the circuit board, over the coil; and on the SCR chassis. Figure 1 shows the temperature profiles obtained during the testing.

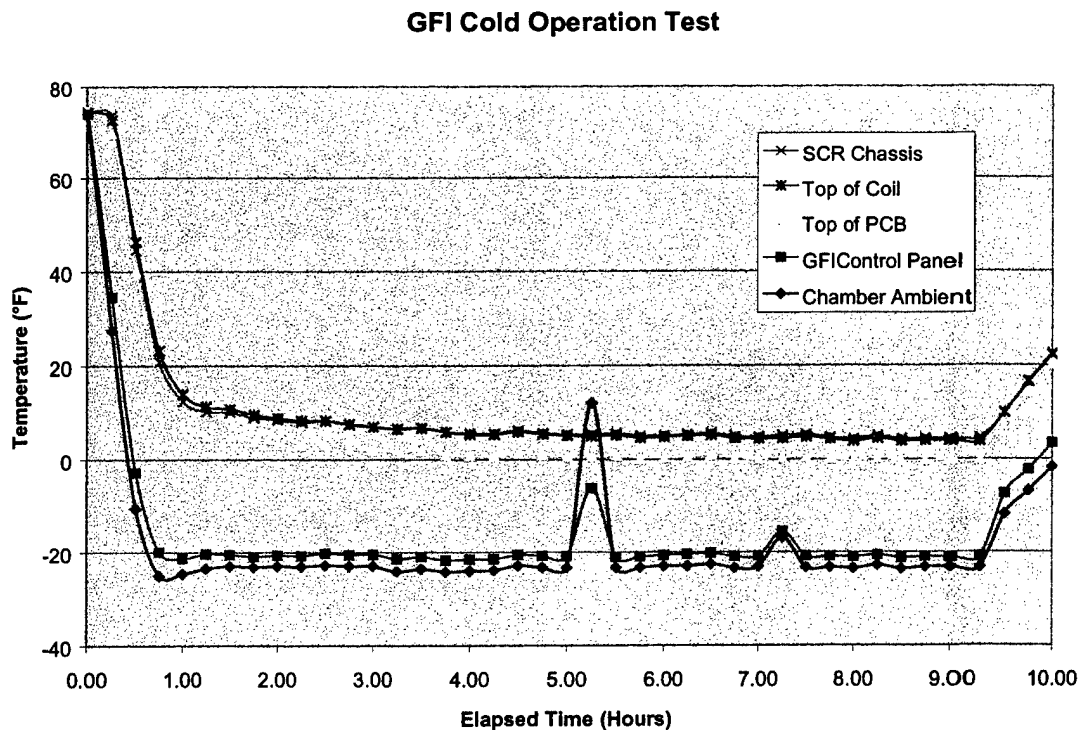


**FIGURE 1:** Temperature Profiles for the GFI Unit During Hot Operation Test

The testing was begun on July 11, 2001. The unit was preconditioned to 119 °F and maintained for approximately 2 hours prior to starting the test. Once the unit was preconditioned, the GFI was powered and the operational test was started by manually toggling the “TEST” switch alternately between the “LOW” and “HIGH” positions. The “RESET” switch was manually depressed to reset the unit. This test was repeated approximately once each hour throughout the testing. The Hot Operation test was completed with no anomalies noted.

## 5.2 Low Temperature Operation

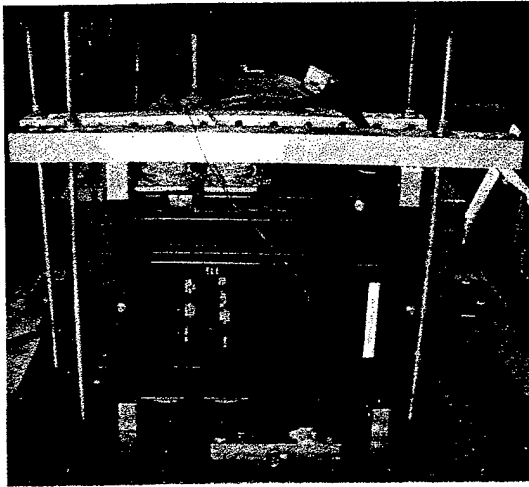
As with the High Temperature Operation Test, the unit was placed into the temperature chamber and instrumented with thermocouples. The sensor locations were identical to the previous test. The testing was begun on July 18, 2001. The unit was powered immediately upon starting the chamber. However the operational performance checks were not started for approximately 1 hour. The operational performance test was performed the same as for the High Temperature Operation. This test was performed for a total of 8 hours. Figure 2 shows the temperature profile for the unit during this test. The test was completed with no anomalies noted.



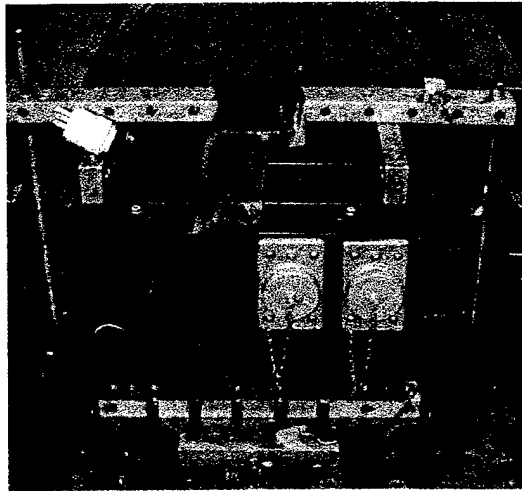
**FIGURE 2:** Temperature Profile During Cold Operation Test

### 5.3 Vibration

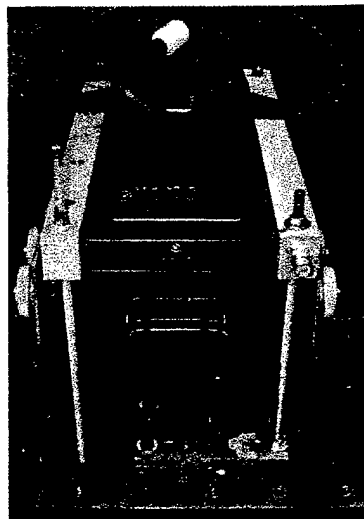
The vibration test was started on July 23, 2001 and completed on July 24, 2001. The unit was subjected to the random vibration environment for one hour in each of three mutually perpendicular directions. The three directions chosen were defined as follows: (1) Vertical – perpendicular to the face or LED panel, (2) Longitudinal – perpendicular to the GFI handles, and (3) Transverse – perpendicular to the receptacles. Figure 3 shows the unit ready for testing in each axis.



(a)



(b)

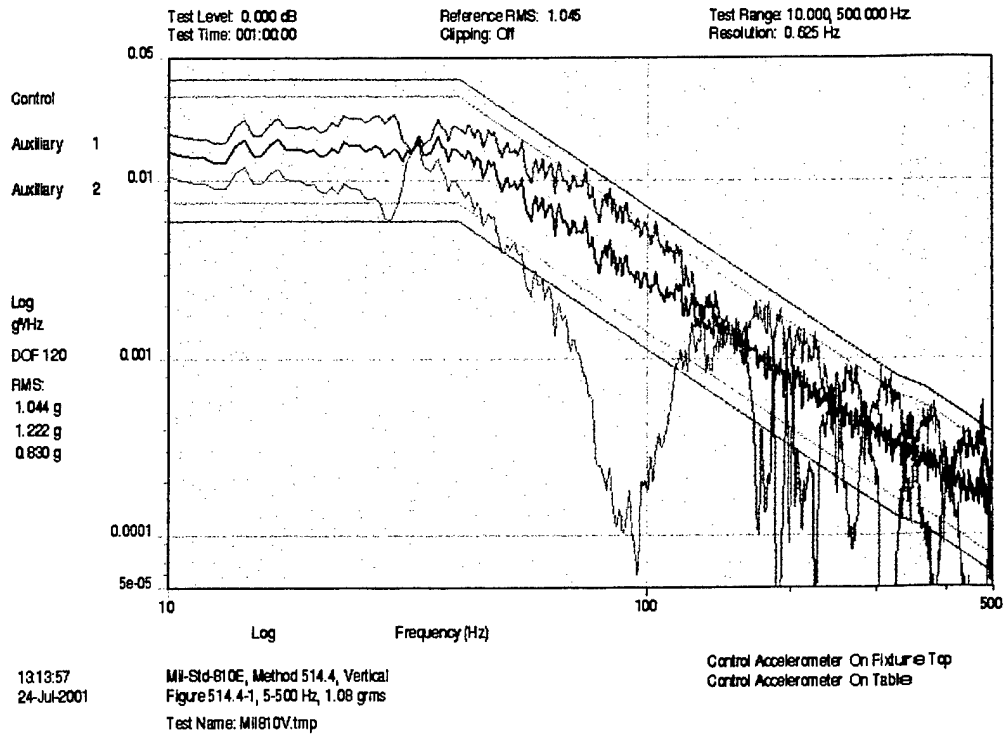


(c)

**FIGURE 3: GFI Mounted to vibration table for testing**  
(a) Vertical (b) Transverse (c) Vertical

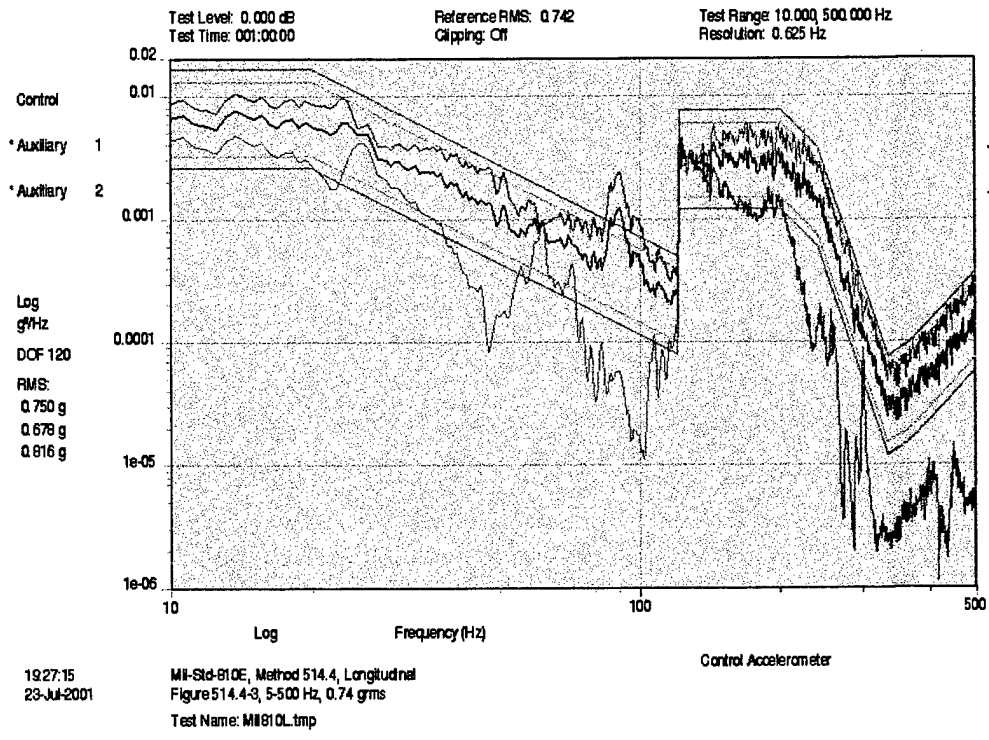
The test was performed using the levels recommended by MIL-STD-810E, Method 514.4, Category 1, Basic Transportation. The recommended test profiles for the vertical and longitudinal directions were used for testing. The recommended transverse profile was not used. Since the orientation of the unit in the X-Y plane is arbitrary during shipment and operation, it was decided to use the test profile which provided the higher overall grms level for testing in the X-Y plane. Therefore the test profile as defined by Figure 514.4-3 in MIL-STD-810E (Longitudinal) was used for both the longitudinal and transverse directions. The test profile as defined by MIL-STD-810E, Figure 514.4-1 (Vertical) was used for the vertical direction.

Two accelerometers were used for control of the test. One accelerometer was located on the vibration table and one accelerometer was located on top of one of the tie down bars. The accelerometer locations for the vertical direction can be seen in Figure 3. Figure 4 shows the typical responses observed for testing in all three directions. For all plots the center trace is the average of the two accelerometers. The blue (lower) trace is the accelerometer on the table and the green (upper) is on the top of the fixture.

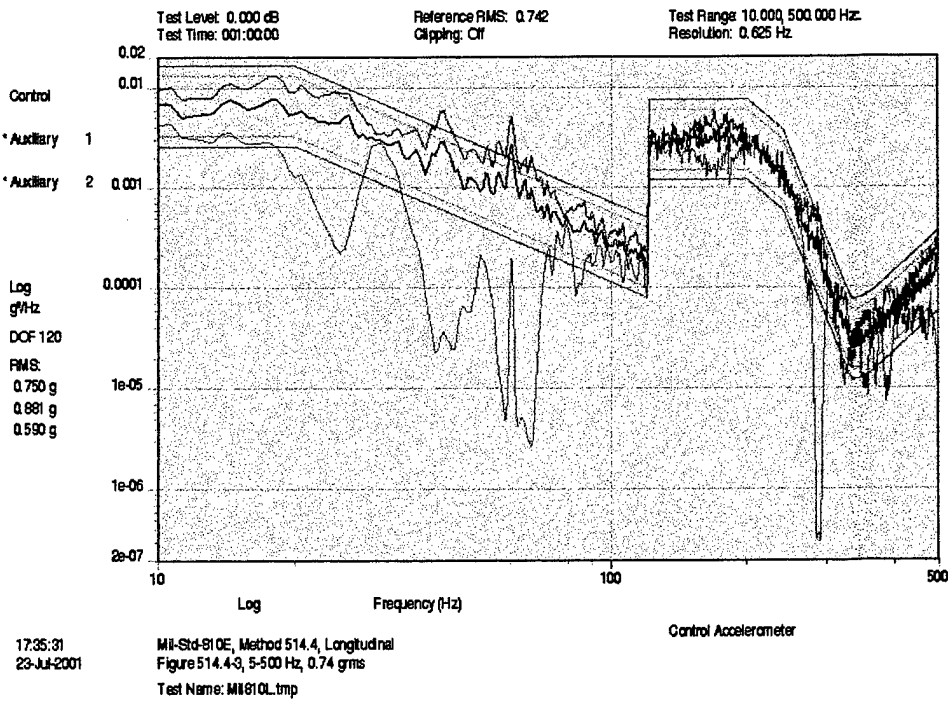


**FIGURE 4A:** Typical vibration test profile showing difference between the two control accelerometers for the Vertical Direction





**FIGURE 4B:** Typical vibration test profile showing difference between the two control accelerometers for the Longitudinal Direction



**FIGURE 4C:** Typical vibration test profile showing difference between the two control accelerometers for the Transverse Direction

The vibration test was performed with the unit in the non-operational state. The unit was tested in all three directions and was then opened and visually inspected for damage. No anomalies were noted. Once no physical damage was observed, the unit was powered and functionally tested. The unit performed as expected with no problems observed.

#### 5.4 Rain

The rain test was performed on August 1, 2001. The unit was subjected to a total of 120 minutes of testing in 3 orientations. In the first orientation, the spray was predominantly projected onto the top surface of the unit. In the second orientation, the spray was directed towards the outlets on one side. The third orientation, the spray was directed towards the outlets on the opposite side and where the power cable penetrated the housing. Figure 5 shows the unit under test with the spray predominantly on the top.

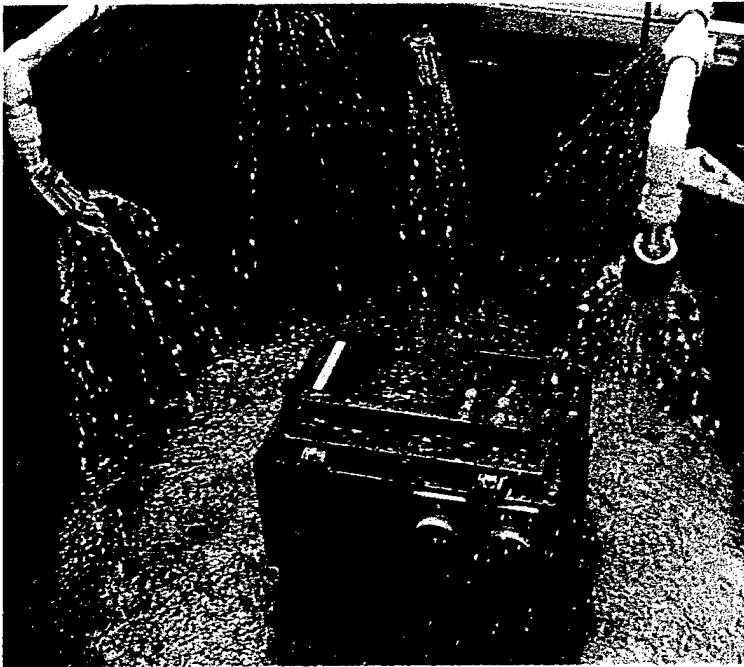


FIGURE 6: GFI Unit During the Rain Test

The unit was powered during the test with no load applied. Since no waterproof mating connectors for the receptacles were available, it was decided to perform the test with no load applied, with all the receptacle caps in place. During the test at approximately 1 hour intervals, the unit was functionally tested. The unit was “tripped” and reset for both the “high” and “low” conditions. The unit functioned as expected throughout the test. At the completion of rain testing in all orientations, the unit was opened to investigate the possibility of water intrusion. Upon opening, it was discovered

that approximately 2 oz of water was inside the unit. Further investigation revealed that the water entered through one of the receptacles. It was determined that although the seal cap was "hand" tight, that it had leaked.. The cap was again tightened by hand, ensuring that the seal had adequately compressed. The test was repeated for one hour with the spray predominately on the top. Post test inspection revealed no signs of water intrusion. Throughout the test, no anomalies in performance were observed.

## **6.0 Conclusions and Recommendations**

The testing was completed with no testing anomalies observed. With the exception of the rain test, no performance anomalies were observed. The water intrusion observed during the rain test was easily solved by insuring compression of the seals in the caps. It is therefore recommended that the operating procedures for the unit reflect the need to verify that the caps are properly secured (i.e. seal fully compressed) during foul weather operation.

**APPENDIX A**

**TEST PLAN**

**Test Plan  
for Environmental Testing of the  
Portable Ground Fault Interrupt Prototype Units**

**Background**

E31 was tasked to provide a test plan for performing Environmental tests for the Portable Ground Fault Interrupt (GFI) units. A meeting was held on Thursday 30 September, 1999 to discuss the desired test program. At that meeting E31 was provided with a list of recommended tests. E31 was tasked to determine the feasibility of performing the tests at CSS, the cost of performing these tests, and any additional test recommendations.

E31 personnel took this information and compiled a recommended testing program. This was submitted to NEDU for evaluation. The basic set of recommendations were incorporated into a required testing program. Based on the discussions, the following is a list of the required tests to be performed:

High Temperature Operation  
Low Temperature Operation  
Vibration  
Rain

The test procedures for each of these tests are based on recommended procedures found in MIL-STD-810E. The following provides a more detailed description of each environment and will be used at the planned testing for this program.

**Functional testing**

The units will be functionally tested between each test environment. The test consists of measuring the time from a ground fault condition until the unit power is removed. This test will be performed by NEDU personnel.

**High Temperature Operation**

This test is based on the requirements of MIL-STD-810E, Method 501.3, Procedure 2. The maximum temperature for this test shall be +48 °C. The unit will be placed in a chamber that is preconditioned to the desired temperature level. Once the unit has stabilized in its operational state, the GFI will be "tripped" manually to the HIGH and LOW trip conditions

The unit will be maintained in the temperature chamber for a total of 48 hours. During this 48 hour period, the GFI will be "tripped" and "reset" a minimum of once every hour.

## **Low Temperature Operation**

The unit will be exposed to the Low Temperature Operation test as specified in MIL-STD-810E, Method 502.3, Procedure II. The unit will be placed, in the operational condition within the temperature chamber. The chamber temperature will be lowered to  $-31\text{ }^{\circ}\text{C}$  stabilized. Once the unit has stabilized, it will be maintained at that temperature for a minimum of 8 hours. During the test, the unit will manually "tripped" and reset as with the High Temperature Operation test. The unit will be "tripped" and reset a minimum of once per hour throughout the test.

## **Vibration**

The vibration test is based on the Transportation Vibration, Common Carrier requirements as specified in MIL-STD-810E, Method 514.4, Category 1, Basic Transportation. The unit, in its shipping and storage container, will be securely mounted to the vibration equipment. The test will be conducted in three mutually perpendicular axes. The test conducted will conform to the specific requirement for each axis as shown in MIL-STD-810E, Figures 514.4-1, 514.4-2, and 514.4-3. The unit will be subjected to the vibration for 60 minutes in each axis for a total test time of 3 hours.

## **Rain**

The rain test is based on the Watertightness Test as specified in MIL-STD-810E, Method 506.3, Procedure III. The GFI will be placed in the test chamber in the upright, operational position, with the required input and output wiring connected. The unit will be operating during the test, and will be manually "tripped" a minimum of once every 20 minutes during the test. The item will be exposed to an overlapping spray pattern where the nozzles are placed 19 inches from the test surface. The droplets will be approximately 2 to 4.5 mm and sprayed at a minimum pressure of 40 psig. The item will be exposed to this environment for a minimum of 40 minutes for each exposed face.

**APPENDIX B**  
**TEST DATA SHEETS**

**HIGH TEMPERATURE OPERATION  
DATA SHEET**

DATE:        Start: 7/11/01

Completed: 7/13/01

**1. TEST EQUIPMENT:**

Temperature Chamber:	WEBBER Model WF64-100+300 Serial Number: 7894
Temperature Controller:	WATLOW Series 922 Serial Number: 50985
Data Logger:	OMEGA Model OM501-C Serial Number: 48RA263 (M813)

**2. THERMOCOUPLE LOCATIONS**

**EXTERNAL:**

Next to the Unit in chamber air  
On top of Unit, by the LED's

**INTERNAL**

Top Center of the circuit board  
Under Circuit board, above the main coil  
On the SCR heat sink chassis

**3. PERFORMANCE DATA**

See attached chart for "trip" times during the test. The temperatures were logged on a hard copy every 15 minutes throughout the 48 hour test. These log records are not included with this data sheet, but are maintained by CSS. A 600 watt load (4, 150 watt lamps) was applied throughout the test

**4. RESULTS/COMMENTS**

Unit completed this test with no anomalies observed.



### Hot Temperature Operation Performance Data Log

Temperature Operation Data Log Sheet				
Date	TIME	Unit 1		Comments
		Low	High	
07/11/2001	14:15	Π	Π	Test Started
	15:15	Π	Π	
	15:45	Π	Π	
	16:15	Π	Π	
	17:45	Π	Π	
	18:15	Π	Π	
	19:30	Π	Π	
	20:15	Π	Π	
	21:15	Π	Π	
	22:15	Π	Π	
	23:15	Π	Π	
07/12/2001	0:15	Π	Π	
	1:15	Π	Π	
	2:15	Π	Π	
	3:15	Π	Π	
	4:00	Π	Π	
	5:00	Π	Π	
	5:45	Π	Π	
	7:00	Π	Π	
	8:00	Π	Π	
	9:00	Π	Π	
	10:00	Π	Π	
	11:00	Π	Π	
	12:00	Π	Π	
	13:00	Π	Π	
	14:00	Π	Π	
	15:00	Π	Π	
	15:45	Π	Π	
	16:50	Π	Π	
	18:10	Π	Π	
	19:10	Π	Π	
	20:00	Π	Π	
	21:00	Π	Π	
	22:00	Π	Π	
	23:00	Π	Π	

Temperature Operation Data Log Sheet				
Date	TIME	Unit 1		Comments
		Low	High	
07/13/2001	0:00	Π	Π	
	1:15	Π	Π	
	2:00	Π	Π	
	3:00	Π	Π	
	4:00	Π	Π	
	5:00	Π	Π	
	6:00	Π	Π	
	7:00	Π	Π	
	8:00	Π	Π	
	9:00	Π	Π	
	10:00	Π	Π	
	11:00	Π	Π	
	12:00	Π	Π	
	13:00	Π	Π	
	14:00	Π	Π	
	15:00	Π	Π	Test Stopped

LOW TEMPERATURE OPERATION  
DATA SHEET

DATE:           Start: 7/18/01

Completed: 7/18/01

1. TEST EQUIPMENT:

Temperature Chamber:	WEBBER Model WF64-100+300 Serial Number: 7894
Temperature Controller:	WATLOW Series 922 Serial Number: 50985
Data Logger:	OMEGA Model OM501-C Serial Number: 48RA263 (M813)

2. THERMOCOUPLE LOCATIONS

EXTERNAL:

Next to unit, in chamber air  
On top of Unit, by the LED's

INTERNAL

Top Center of the circuit board  
Under Circuit board, above the main coil  
On the SCR heat sink chassis

3. PERFORMANCE DATA

See attached chart for "trip" times during the test. The temperatures were logged on a hard copy every 15 minutes throughout the 8 hour test. These log records are not included with this data sheet, but are maintained by CSS.

4. RESULTS/COMMENTS

. Unit completed this test with no anomalies observed.

### Cold Temperature Operation Performance Data Log

Cold Temperature Operation Data Log Sheet				
Date	TIME	Unit 1		Comments
		Low	High	
07/13/2001	6:45	Π	Π	Chamber Started
	8:00	Π	Π	
	9:00	Π	Π	
	10:00	Π	Π	
	11:00	O	Π	
	12:00	Π	Π	
	13:00	O	Π	
	14:00	O	Π	
	15:00	O	Π	
	16:00	O	Π	GFI units Turned Off, Chamber turned off

## VIBRATION TEST DATA SHEET

DATE: Start: 7/23/01

Completed: 7/24/01

### 1. TEST EQUIPMENT:

Vibration Table:	UNHOLTZ-DICKIE Model TC208 Shaker Serial Number: 508
Vibration Controller:	SPECTRAL DYNAMICS Model 2552C Serial Number: 7894
Accelerometers:	ENDEVCO Model 2213E, S/N K728 ENDEVCO Model 7201-50, S/N JM84
Charge Amplifier:	KISLTER Model 504E, S/N 731 KISTLER Model 504A, S/N 744
:	

### 2. ACCELEROMETER LOCATIONS

Only two accelerometers were used for this test and both were used for feedback control of the acceleration. One accelerometer was located on the vibration table, near the GFI mounting location. The second accelerometer was located on the tie down bar used on top of the GFI. The average of the two accelerations were used as the method of obtaining the desired acceleration levels. No internal accelerations were measured during this test.

### 3. PERFORMANCE DATA

This test was performed with the unit in the non-operational state. Therefore no performance data was collected during the test.

### 4. RESULTS/COMMENTS

At the completion of 3 directions of testing, the unit was opened and visually inspected for broken wires, loose connections, etc. No anomalies were noted. The unit was powered and the "trip" test was performed. No anomalies were observed.

## RAIN TEST DATA SHEET

DATE: Start: 8/01/01

Completed: 8/02/02

### 1. TEST EQUIPMENT:

The rain test equipment consisted of 5 shower heads arranged in an "H" pattern. A single ¾ inch hose supplied tap water to the heads. This equipment was made by CSS.

### 2. INSTRUMENTATION

No instrumentation was used for this test.

### 3. PERFORMANCE DATA

The unit was successfully "tripped" and "reset" approximately once every hour. However, a log sheet logging the times was not kept and is therefore not available.

### 4. RESULTS/COMMENTS

The unit was tested in 3 orientations for 40 minutes in each direction. At the completion of the test, the unit was opened and visually inspected. Upon opening, it was discovered that the bottom of the unit contained approximately 2 oz of water.

The water intrusion was traced to two of the receptacles. It was discovered that the seal cap was hand tight, but not tight enough to fully engage the seal. The caps were tightened, ensuring that the seals were engaged and compressed. The rain test was repeated for 1 hour with the spray directed on the top and side. At the end of the test, the unit was opened and no water intrusion was observed.

Throughout this test the unit was powered. No system performance anomalies were observed.