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# Center for Night Vision and Electro-Optics

AMSEL-RD-NV-0077

## ENVIRONMENTAL TEST REPORT ON THE CTI-CRYOGENICS 1-WATT INTEGRAL STIRLING COOLER (LONG LIFE HD-1033D)

by

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APRIL 1989

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This final report describes and provides the data on the environmental testing of the CTI-Cryogenics 1-Watt Integral Stirling Cooler (Long Life HD-1033D). The 1-Watt Integral Cooler (HD-1033B/C) is currently used in the M1 FLIR, M60 FLIR, and the Advanced Attack Helicopter FLIR. The long life cooler (clearance seal) improves life of the cooler by approximately two and one half times. $C^2$NVEO evaluated the cooler performance at environmental extremes per the purchase description, PD-0182-001(CR). The cooler successsfully passed all the environmental tests with no failures.

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# TABLE OF CONTENTS

# SECTION I. INTRODUCTION

The US Army CECOM Center for Night Vision and Electro-Optics ($C^2$NVEO) is responsible for developing cryogenic coolers for all infrared imaging systems for the Army. $C^2$NVEO also maintains configuration management control of the forward-looking infrared (FLIR) Common Module coolers used in thermal imagers in fielded Army weapon systems such as: M60A3 and M1 Tanks, Bradley Fighting Vehicle System, tube-launched, optically tracked, wire-guided (TOW) Missile System, and Army Attack Helicopters. Currently, there are over 30,000 coolers in fielded systems and several thousand more are added each year. $C^2$NVEO conducts development programs and monitors contractor internal research and development efforts to improve cooler performance such as reliability, audio noise, power consumption, and output vibration. One of these efforts has been the development of a clearance seal HD-1033 cooler for the potential use in the tank and helicopter FLIRs. This report covers environmental testing performed by $C^2$NVEO on the HD-1033 clearance seal cooler.

The HD-1033 1-Watt Integral Stirling Cooler was originally designed by Texas Instruments in 1974. The cooler requires a 400-hertz (Hz), 117-volt alternating current (vac) power source. The current dynamic seals used on the piston and regenerator of the 1-Watt Integral Cooler are known as *contacting lip seals.* They operate very similar to the compression rings in an automobile engine, in that they rub against the sides of the cylinder. As they rub, they wear out and the particles migrate throughout the cooler. Clearance seals do not rub against the sides of the cylinder and hence do not wear. Compression is maintained by very close tolerances between the regenerator and the coldfinger and the compressor piston and the cylinder. Through the use of clearance seals, the reliability requirement for this cooler has been increased dramatically. The current lip seal 1-Watt Integral Cooler (HD-1033C) has a reliability requirement of 1,000-hour mean-time-to-failure (MTTF), whereas the reliability requirement for the HD-1033D cooler is 2,500-hour MTTF.

Under this test program, CTI-Cryogenics is conducting the life testing on the three units, and the US Army $C^2$NVEO performed the environmental testing on two units.

# SECTION II. DESCRIPTION

The environmental portion of the testing was intended to subject the cooler to a series of demanding tests (high temperature, low temperature, temperature shock, imposed vibration, and mechanical shock) to determine if the cooler could be stored and operated under severe climatic and service conditions without experiencing physical damage or deterioration in performance. Cooler vibration output was also measured as a part of this evaluation and this data was compared to standard 1-Watt Integral data. A brief description of each test is provided in Table 1.

Two coolers, S/N D-0008 and S/N D-0012, were selected to undergo all the environmental tests. Baseline acceptance tests were conducted before, during (where applicable), and after each test to determine whether the coolers had passed each test. Additionally, leak rates were performed before and after each test to determine acceptance.

**Table 1. Tests Descriptions**

| TEST | REQUIREMENT |
|---|---|
| Leak Rate | Less than 2.5 x $10^{-6}$ std cc/sec helium |
| Acceptance Test | |
| —Cooldown | Less than 15 minutes to 80°K |
| —Cooling Capacity | 1.0 watt at 80°K |
| —Input Power | Less than 50 watts |
| Vibration Output | Translational and rotational forces must meet specified limits for each cooler axis |
| Temperature Shock | Rapid temperature changes from –62°C to +95°C every 4 hours for 24 hours total |
| High Temperature | 48-hour soak at +95°C, +71°C operation |
| Low Temperature | 24-hour soak at –62°C, –54°C operation |
| Mechanical Shock | 100g peak amplitude for 11 msec |
| Imposed Vibration | 4 to 5g acceleration over 5 to 500 Hz |
| Restart | After cooling down to 80°K, the cooler must restart within 5 seconds when power is disconnected and reapplied |

# SECTION III. TEST RESULTS

All environmental tests were successfully completed by S/N D-0008 and S/N D-0012. There were no failures, relevant or otherwise, and all tests were completed without incident. In addition to testing the coolers at 117 vac, the coolers were also operated at 108 vac during high and low temperature tests. The coolers successfully restarted and operated at 108 vac. The results of the vibration output testing also met the requirements of the purchase description. It should be noted that for comparison purposes, two HD-1033Cs were subjected to the vibration output tests. This data has been provided in Section IV and Appendices A through G. A brief summary of all the performance tests results are provided in Tables 2 and 3. Section IV and Appendices A through G contain the details of each baseline along with all other pertinent data.

The environmental tests portion of this program has been successfully completed. This testing has demonstrated the ability of the clearance seal 1-Watt Integral Cooler to perform satisfactorily during and following exposure to various environmental conditions as specified in the cooler purchase description and MIL-STD-810.

**Table 2. Environmental Test Results—S/N D-0008**

| TEST | COOLDOWN 80°K (min) | TEMP (°K) WITH HEAT LOAD | POWER (watts) | LEAK RATE scc He/sec |
|---|---|---|---|---|
| Initial Baseline | 11.45 | 74.93 | 41.02 | $7.8 \times 10^{-9}$ |
| Post Mechanical Vibration | 11.65 | 75.47 | 40.80 | $1.2 \times 10^{-8}$ |
| Low Temperature | 7.80 | 67.99 | 35.84 | |
| Post Low Temperature | 11.27 | 73.13 | 40.44 | $1.2 \times 10^{-8}$ |
| Post Temperature Shock | 11.33 | 73.55 | 41.60 | $1.5 \times 10^{-8}$ |
| High Temperature | 14.42 | 68.33 | 45.51 | |
| Post High Temperature | 11.27 | 73.13 | 40.84 | $1.4 \times 10^{-8}$ |
| Post Mechanical Shock | 11.18 | 72.92 | 40.96 | $1.2 \times 10^{-8}$ |

Table 3. Environmental Test Results—S/N D-0012

| TEST | COOLDOWN 80°K (min) | TEMP (°K) WITH HEAT LOAD | POWER (watts) | LEAK RATE scc He/sec |
|---|---|---|---|---|
| Initial Baseline | 11.38 | 72.25 | 41.98 | $2.0 \times 10^{-8}$ |
| Post Mechanical Vibration | 11.27 | 71.16 | 42.54 | $2.6 \times 10^{-8}$ |
| Low Temperature | 8.25 | 67.51 | 37.63 | |
| Post Low Temperature | 11.27 | 70.47 | 42.83 | $2.6 \times 10^{-8}$ |
| Post Temperature Shock | 11.33 | 71.43 | 42.69 | $2.8 \times 10^{-8}$ |
| High Temperature | 14.67 | 68.22 | 47.47 | |
| Post High Temperature | 11.27 | 70.97 | 43.21 | $2.8 \times 10^{-8}$ |
| Post Mechanical Shock | 11.20 | 69.57 | 43.53 | $3.4 \times 10^{-8}$ |

## SECTION IV. APPLICATION TEST DATA

All environmental test data contained in the appendices appears in chronological order of the testing. The vibration output data is provided in Appendix G.

Performance requirements for the HD-1033D cooler include the ability to maintain a 1-watt heat load at 80°K at an ambient temperature of 23°C, cooldown of a 1,440 joule thermal mass from 300°K to 80°K within 15 minutes at 23°C, and operate under steady state conditions with a heat load applied at room temperature with a power consumption of 50 watts or less.

# APPENDIX A
# INITIAL BASELINES

## Initial Baseline—S/N D-0008

```
                 NVEOL CRYOGENIC COOLER LAB

                   CRYOGENIC COOLER DATA

 COOLER: CTI D-0008 -- TC 010               DATE: 16 JUNE 88 08:07
VOLTAGE: 117                                ENGR: HLD
AMBIENT: 23 (C)                         DEWAR COMP: -2.355

   TEST: BASELINE TEST AS RECEIVED FROM CTI

-----------------------------------------------------------------------
    TIME          POWER          CURRENT          KELVIN         LOAD
-----------------------------------------------------------------------
    0.00          94.82           .815            294.57         0.000
    1.00          34.90           .401            267.12         0.000
    2.00          35.16           .403            241.00         0.000
    3.00          35.65           .406            216.70         0.000
    4.00          36.01           .409            195.30         0.000
    5.00          36.53           .412            175.27         0.000
    6.00          37.10           .417            156.49         0.000
    7.00          37.75           .422            139.52         0.000
    8.00          38.42           .426            123.45         0.000
    9.00          39.19           .432            109.23         0.000
    9.70          39.73           .437             99.87         0.000
   10.00          39.93           .438             96.31         0.000
   11.00          40.89           .446             84.69         0.000
   11.45          41.19           .448             79.96         0.000
   12.00          41.64           .452             75.01         0.000
   13.00          42.31           .457             66.88         0.000
   14.00          42.87           .462             60.86         0.000
   15.00          43.26           .465             56.42         0.000
   16.00          43.66           .468             53.46         0.000
   17.00          43.81           .469             51.19         0.000
   18.00          43.90           .471             49.88         0.000
   19.00          43.99           .471             48.97         0.000
   20.00          44.04           .472             48.45         0.000
-----------------------------------------------------------------------
   30.00          41.38           .449             73.70          .999
   40.00          41.02           .44              74.93          .999
***********************************************************************
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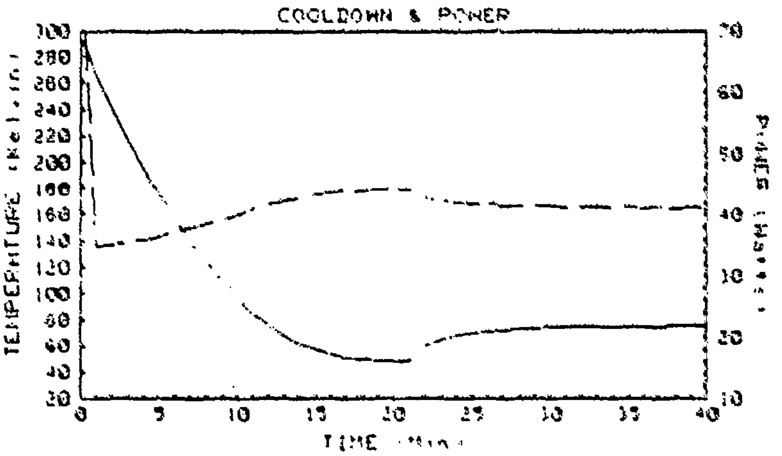


# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0008

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1.02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: $7.8 \times 10^{-9}$ std cc/sec

COMMENTS: As received from CTI.

TEST TECHNICIAN G. Doggett

TEST DATE 13 JUN 88

6.1 Data Summary Sheet

Summary Sheet Acceptance Test Procedure – Army Common Module Cooler 80063 Assembly TBD, CTI P/N 8194001

S/N: D-0008

Purchase Order No.: DAAJ09-87-C-A039

| Reference Paragraph | Requirement | Data |
|---|---|---|
| 4.0 | Test equipment calibration certification is current at time of test. | ✓ Accept |
| 5.1 Step 1 | Verify that cooler burn in was conducted | ✓ Date |
| 5.1 Step 2 | Ambient temperature (23 ± 5°C) | ✓ °C |
| 5.2 Step 1 | Cold Station temperature calibrated for $LN_2$ | ✓ |
| 5.2 Step 2 | Test setup is in accordance with Figure 1 | ✓ Accept |
| 5.2 Step 3 | Test Dewar pressure ($1.0 \times 10^{-5}$ torr minimum). | ✓ Torr |
| 5.2 Step 4 | Verify that the cooling fan is operating. | ✓ OK |
| 5.2 Step 5 | Verify that the strip chart recorder is operating. | ✓ Accept |
| 5.3.1 | <u>Cooldown Test</u> | |
| 5.3.1 Step 3 | Time required for cold station to reach 80K (15 minutes maximum). | 12.02 Minutes |
| 5.3.2 | <u>Cooling Capacity Test</u> | |
| 5.3.2 Step 1 | Heat load adjusted to 1.0 watt minimum | ✓ Check |
| 5.3.2 Step 2 | Temperature of cold station after 30 minutes | 76.6 K |
| 5.3.2 Step 3 | Cooler housing temperature | 35.6 °C |
| | Test ambient temperature | 22.4 °C |
| | Temperature difference (5°C to 15°C) | 13.2 °C |
| 5.3.3 | <u>Input Power Test</u> | |
| 5.3.3 Step 1 | Input voltage to cooler (117 ± VAC) | 117.25 VAC |
| | Input Current to cooler | .44 Amps |
| | Total input power to cooler (50 Watts maximum) | 39.6 Watts |
| | Input frequency to cooler (400 ± 20 Hz) | 400 Hz |
| 5.3.4 | <u>Restart Test (Total of 6 Restarts Completed)</u> | ✓ Accept |
| 5.3.5 | <u>Leak Rate Test</u><br>Leak rate is<br>(Requirement: $2.5 \times 10^{-6}$ cc/sec or less) | $2.4 \times 10^{-8}$ cc/sec |
| 5.4 | <u>Inspection</u><br>Verify that all applicable inspection requirements have been met. | 538 Inspector |

Test Technician ______________ Date 4-15-88

Product Engineer ______________ Date 4/22/88

Quality Control R Mac______________ Date 4/25/88

| SIZE | FSCM NO | DWG NO | REV |
|---|---|---|---|
| A | 31949 | 3864648 | B |
| SCALE | | SHEET 9 | |

## Initial Baseline—S/N D-0012

NVEOL CRYOGENIC COOLER LAB

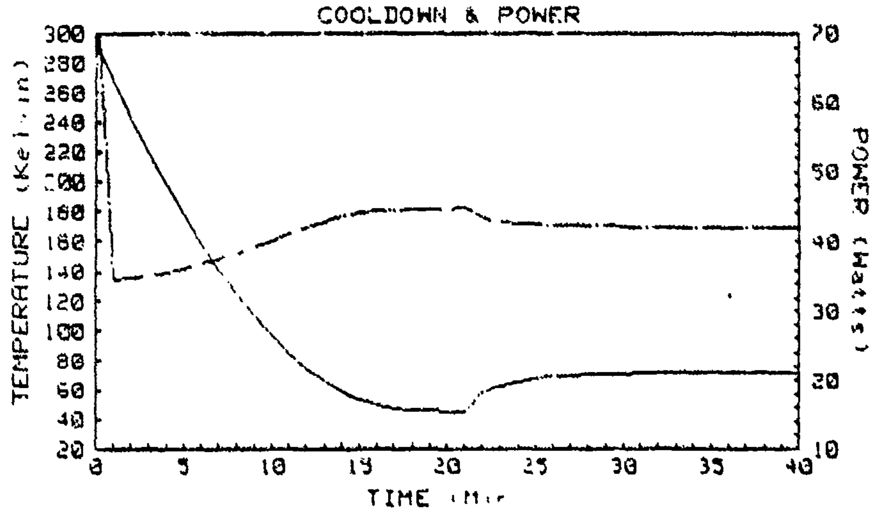
CRYOGENIC COOLER DATA

COOLER: CTI D-0012
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 16 JUNE 88 07:15
ENGR: HLD
DEWAR COMP: -2.24

TEST: BASELINE TEST AS RECEIVED FROM CTI

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 80.80 | .773 | 293.42 | 0.000 |
| 1.00 | 34.52 | .417 | 267.74 | 0.000 |
| 2.00 | 34.83 | .419 | 242.46 | 0.000 |
| 3.00 | 35.18 | .421 | 218.95 | 0.000 |
| 4.00 | 35.70 | .424 | 197.15 | 0.000 |
| 5.00 | 35.19 | .428 | 177.33 | 0.000 |
| 6.00 | 36.89 | .432 | 158.56 | 0.000 |
| 7.00 | 37.55 | .436 | 140.81 | 0.000 |
| 8.00 | 38.37 | .442 | 124.92 | 0.000 |
| 9.00 | 39.25 | .448 | 109.97 | 0.000 |
| 9.73 | 39.88 | .453 | 99.69 | 0.000 |
| 10.00 | 40.14 | .455 | 96.38 | 0.000 |
| 11.00 | 41.11 | .462 | 84.38 | 0.000 |
| 11.38 | 41.39 | .465 | 79.92 | 0.000 |
| 12.00 | 42.01 | .469 | 73.78 | 0.000 |
| 13.00 | 42.88 | .475 | 65.16 | 0.000 |
| 14.00 | 43.49 | .481 | 58.46 | 0.000 |
| 15.00 | 43.99 | .485 | 53.50 | 0.000 |
| 16.00 | 44.36 | .487 | 49.93 | 0.000 |
| 17.00 | 44.47 | .489 | 47.75 | 0.000 |
| 18.00 | 44.57 | .490 | 46.35 | 0.000 |
| 19.00 | 44.65 | .490 | 45.44 | 0.000 |
| 20.00 | 44.72 | .490 | 44.79 | 0.000 |
| 30.00 | 42.06 | .470 | 71.16 | 1.000 |
| 40.00 | 41.98 | .468 | 72.25 | 1.000 |



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0012

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1.02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: $2.0 \times 10^{-8}$ std cc/sec

COMMENTS: As received from CTI.

TEST TECHNICIAN G. Doggett

TEST DATE 13 JUN 88

6.1 Data Summary Sheet    Summary Sheet Acceptance Test Procedure - Army Common Module Cooler 80063 Assembly TBD, CTI P/N 8194001

S/N: D0012    Purchase Order No.: DAAJ09-87-C-A039

| Reference Paragraph | Requirement | Data |
|---|---|---|
| 4.0 | Test equipment calibration certification is current at time of test. | ✓ Accept |
| 5.1 Step 1 | Verify that cooler burn in was conducted | 4-27-88 Date |
| 5.1 Step 2 | Ambient temperature (23 ± 5°C) | 22.7 °C |
| 5.2 Step 1 | Cold Station temperature calibrated for $LN_2$ | ✓ |
| 5.2 Step 2 | Test setup is in accordance with Figure 1 | ✓ Accept |
| 5.2 Step 3 | Test Dewar pressure ($1.0 \times 10^{-5}$ torr minimum). | ✓ Torr |
| 5.2 Step 4 | Verify that the cooling fan is operating. | ✓ OK |
| 5.2 Step 5 | Verify that the strip chart recorder is operating. | ✓ Accept |
| 5.3.1 | <u>Cooldown Test</u> | |
| 5.3.1 Step 3 | Time required for cold station to reach 80K (15 minutes maximum). | 11.61 Minutes |
| 5.3.2 | <u>Cooling Capacity Test</u> | |
| 5.3.2 Step 1 | Heat load adjusted to 1.0 watt minimum | ✓ Check |
| 5.3.2 Step 2 | Temperature of cold station after 30 minutes | 72.6 K |
| 5.3.2 Step 3 | Cooler housing temperature | 34.3 °C |
| | Test ambient temperature | 22.6 °C |
| | Temperature difference (5°C to 15°C) | 11.7 °C |
| 5.3.3 | <u>Input Power Test</u> | |
| 5.3.3 Step 1 | Input voltage to cooler (117 ± VAC) | 117.24 VAC |
| | Input Current to cooler | .470 Amps |
| | Total input power to cooler (50 Watts maximum) | 41.2 Watts |
| | Input frequency to cooler (400 ± 20 Hz) | 400 Hz |
| 5.3.4 | <u>Restart Test (Total of 6 Restarts Completed)</u> | ✓ Accept |
| 5.3.5 | <u>Leak Rate Test</u><br>Leak rate is<br>(Requirement: $2.5 \times 10^{-6}$ cc/sec or less) | $1.0 \times 10^{-7}$ cc/sec |
| 5.4 | <u>Inspection</u><br>Verify that all applicable inspection requirements have been met. | 27 CTI Inspector |

Test Technician    Date 4-29-88

Product Engineer    K. M. 6-3-88    Date 4.29-88

Quality Control    Date 6-6-88

| SIZE | FSCM NO. | DWG NO. | REV |
|---|---|---|---|
| A | 31949 | 3864648 | B |
| SCALE | | SHEET 9 | |

## APPENDIX B
## MECHANICAL VIBRATION
Test Report Dated 6/29/88

# NIGHT VISION

**DEPARTMENT OF THE ARMY**
HEADQUARTERS, US ARMY COMMUNICATIONS-ELECTRONICS COMMAND
CENTER FOR NIGHT VISION & ELECTRO-OPTICS
FORT BELVOIR, VIRGINIA 22060-5677

# TEST REPORT

CRYOGENIC COOLERS
CTI S/N's D0008 AND D0012

## TEST ITEM

Cryogenic Coolers, CTI S/N's D-0008 and D-0012

## TEST SPECIFICATION

PD-0182-000(CR), Figure 4, para 4.7.5

## TEST DESCRIPTION

The coolers were operated for five minutes before beginning. The units were then vibrated for 120 minutes using a sine sweep input from 5-500-5 Hz. There were eight (8) such cycles, each 15 minutes long, with the amplitude spectrum shown on the enclosed curve (Encl).

This was performed on all three axes. Both coolers maintained visible frost on the cold finger during all vibrations.

After completion both units were returned to the Far Infrared Engineering Team, Technical Support Division for evaluation.

David Allingham
DAVID J. ALLINGHAM
Test Coordinator
Support Operations Team
Technical Support Division
Center for Night Vision and
Electro-Optics

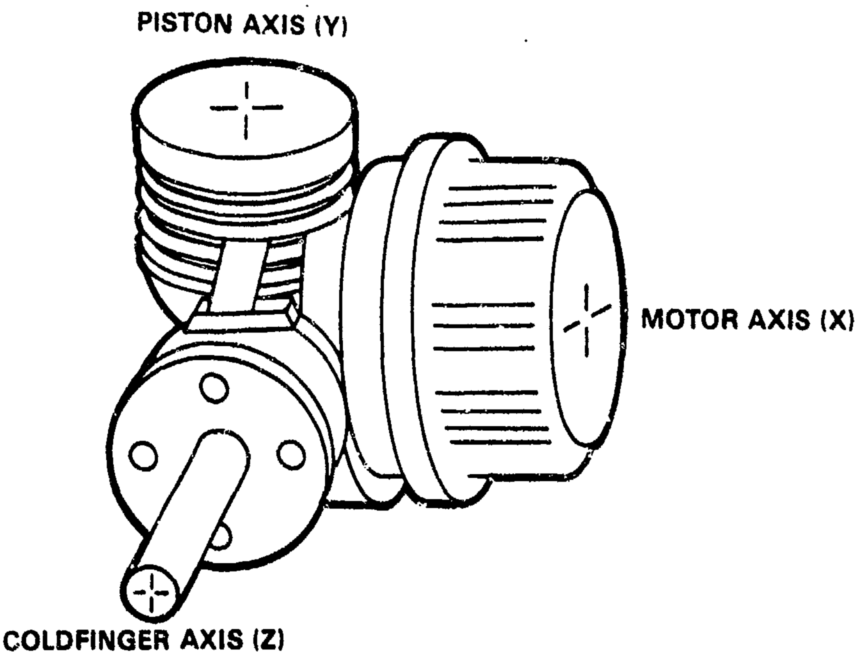
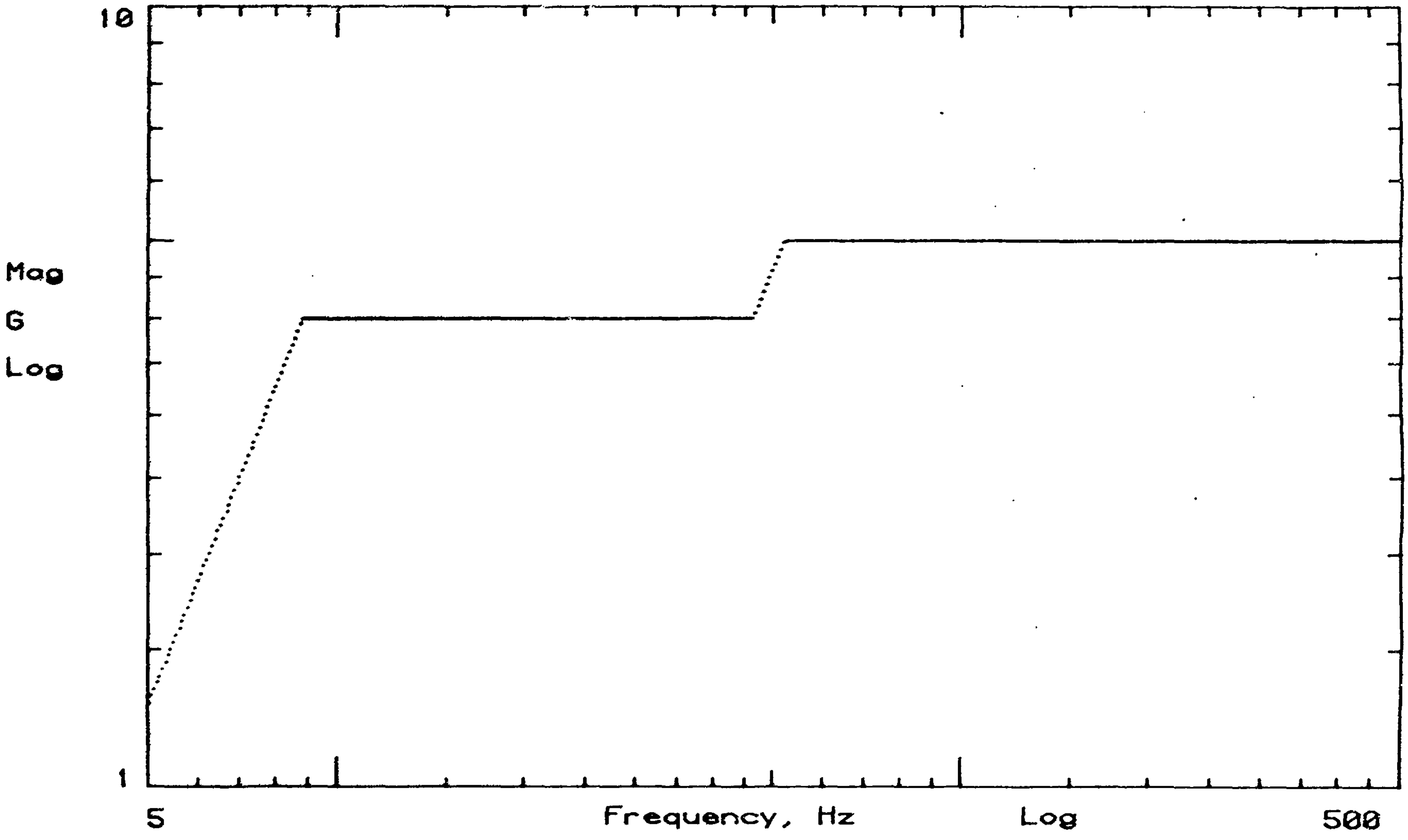


Figure 3. Cooler axes



CRYOGENIC COOLER TEST SPECTRUM
CTIIW SPEC. PD-0182-001(CR)

# MECHANICAL VIBRATION—S/N D-0008

NVEOL CRYOGENIC COOLER LAB

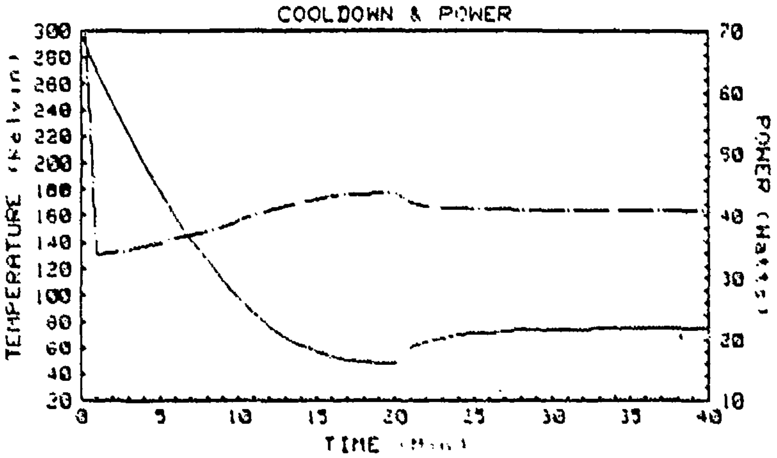
CRYOGENIC COOLER DATA

COOLER: CTI D-0008
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 21 JUNE 88 14:23
ENGR: HLD
DEWAR COMP: -2.355

TEST: PERFORMANCE TEST FOLLOWING MECHANICAL VIBRATION

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 87.04 | .804 | 297.90 | 0.000 |
| 1.00 | 33.81 | .393 | 270.99 | 0.000 |
| 2.00 | 34.08 | .395 | 244.30 | 0.000 |
| 3.00 | 34.52 | .399 | 220.77 | 0.000 |
| 4.00 | 35.07 | .402 | 198.86 | 0.000 |
| 5.00 | 35.67 | .406 | 178.65 | 0.000 |
| 6.00 | 36.42 | .411 | 159.99 | 0.000 |
| 7.00 | 37.05 | .416 | 142.67 | 0.000 |
| 8.00 | 37.62 | .421 | 126.73 | 0.000 |
| 9.00 | 38.36 | .426 | 111.73 | 0.000 |
| 9.88 | 39.19 | .432 | 100.09 | 0.000 |
| 10.00 | 39.26 | .433 | 98.62 | 0.000 |
| 11.00 | 40.17 | .440 | 87.19 | 0.000 |
| 11.65 | 40.67 | .445 | 79.96 | 0.000 |
| 12.00 | 40.90 | .446 | 76.74 | 0.000 |
| 13.00 | 41.63 | .453 | 68.48 | 0.000 |
| 14.00 | 42.28 | .458 | 61.51 | 0.000 |
| 15.00 | 42.79 | .462 | 56.83 | 0.000 |
| 16.00 | 43.21 | .465 | 53.50 | 0.000 |
| 17.00 | 43.51 | .468 | 51.02 | 0.000 |
| 18.00 | 43.63 | .469 | 49.62 | 0.000 |
| 19.00 | 43.73 | .469 | 48.66 | 0.000 |
| 20.00 | 43.73 | .470 | 48.05 | 0.000 |
| 30.00 | 40.96 | .447 | 74.43 | .999 |
| 40.00 | 40.80 | .446 | 75.47 | .999 |



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0008

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1.02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: $1.2 \times 10^{-8}$ std cc/sec

COMMENTS: Post vibration.

TEST TECHNICIAN G. Doggett

TEST DATE 21 JUN 88

# MECHANICAL VIBRATION—S/N D-0012

NVECL CRYOGENIC COOLER LAB

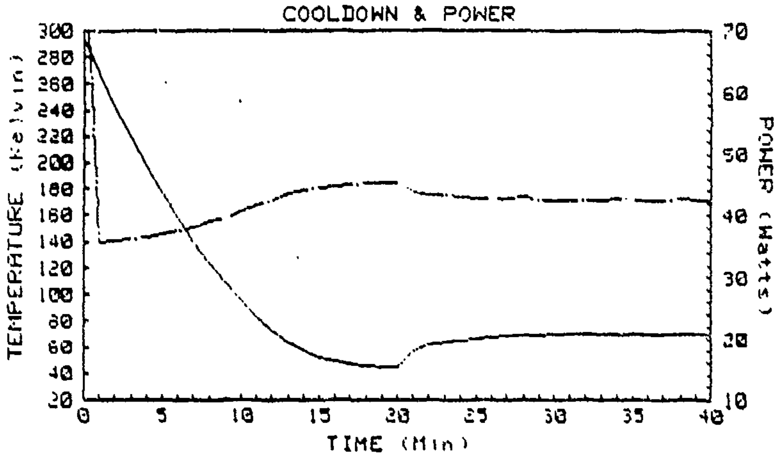
CRYOGENIC COOLER DATA

COOLER: CTI D-0012
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 21 JUNE 88 09:12
ENGR: HLD
DEWAR COMP: -2.24

TEST: PERFORMANCE TEST FOLLOWING MECHANICAL VIBRATION

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 82.34 | .793 | 293.52 | 0.000 |
| 1.00 | 35.77 | .423 | 267.56 | 0.000 |
| 2.00 | 35.80 | .424 | 241.83 | 0.000 |
| 3.00 | 36.10 | .425 | 218.59 | 0.000 |
| 4.00 | 36.51 | .428 | 196.84 | 0.000 |
| 5.00 | 36.90 | .431 | 176.59 | 0.000 |
| 6.00 | 37.36 | .434 | 157.74 | 0.000 |
| 7.00 | 38.04 | .439 | 140.20 | 0.000 |
| 8.00 | 39.05 | .446 | 123.89 | 0.000 |
| 9.00 | 39.68 | .451 | 108.87 | 0.000 |
| 9.65 | 40.25 | .456 | 99.76 | 0.000 |
| 10.00 | 40.61 | .458 | 95.35 | 0.000 |
| 11.00 | 41.62 | .466 | 83.08 | 0.000 |
| 11.27 | 41.88 | .468 | 79.89 | 0.000 |
| 12.00 | 42.47 | .472 | 72.63 | 0.000 |
| 13.00 | 43.49 | .480 | 63.72 | 0.000 |
| 14.00 | 44.11 | .486 | 57.24 | 0.000 |
| 15.00 | 44.64 | .490 | 52.64 | 0.000 |
| 16.00 | 44.91 | .492 | 49.19 | 0.000 |
| 17.00 | 45.25 | .496 | 47.18 | 0.000 |
| 18.00 | 45.33 | .495 | 45.79 | 0.000 |
| 19.00 | 45.49 | .497 | 44.92 | 0.000 |
| 20.00 | 45.40 | .496 | 44.35 | 0.000 |
| 30.00 | 42.50 | .473 | 70.20 | .999 |
| 40.00 | 42.54 | .474 | 71.16 | .999 |



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0012

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1.02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: 2.6 X $10^{-8}$ std cc/sec

COMMENTS: Post vibration.

TEST TECHNICIAN G. Doggett

TEST DATE 17 JUN 88

# APPENDIX C
# LOW TEMPERATURE

## Low Temperature—S/N D-0008

**ENVIRONMENTAL TEST DATA SHEET**

**TEST: LOW TEMPERATURE**
**COOLER: 1-WATT INTEGRAL, 1033D**
**MANUFACTURER:** CTI
**S/N:** D-0008
**DATE OF TEST:** 28 June 88
**TESTED BY:** Jim Shaffer

| PARAMETER | START | END | PASS | FAIL | COMPLY |
|---|---|---|---|---|---|
| PRE-TEST OPERATION | 27<br>1423 | June 88<br>1503 | ✓ | | ✓ |
| 4 HOUR SOAK @-62C | 0915 | 1315 | | | ✓ |
| RAISE TEMP. TO -54C | 1315 | 1330 | | | ✓ |
| STABILIZE @-54C,.5HR | 1330 | 1603 | | | ✓ |
| OPERATION @-54C | 1921 | 2001 | ✓ | | ✓ |
| POST TEST PERFORMANCE | | | | | |
| LEAK RATE | [illegible] | [illegible] | ✓ | | |

NVEOL CRYOGENIC COOLER LAB

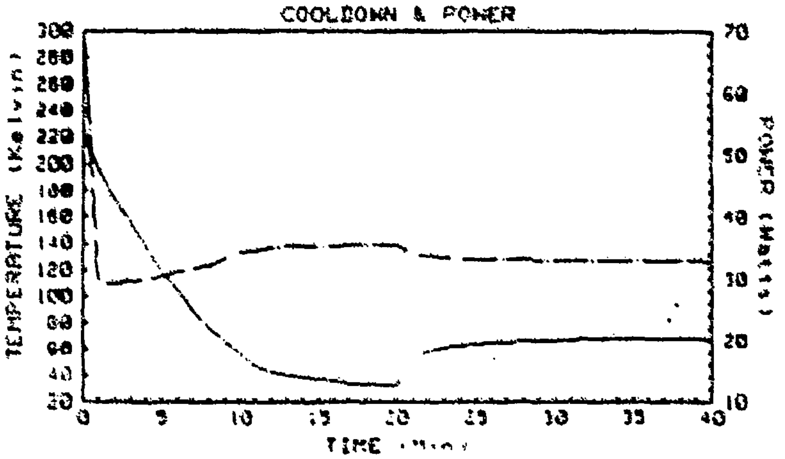
CRYOGENIC COOLER DATA

COOLER: CTI 0-0008
VOLTAGE: 108
AMBIENT: -54 (C)

DATE: 28 JUNE 1988 22:27
ENGR: RNS
DEWAR COMP: -2.355

TEST: BASELINE AT LOW TEMP (108 V)

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 70.37 | .749 | 218.67 | 0.000 |
| 1.00 | 29.19 | .356 | 196.21 | 0.000 |
| 2.00 | 29.18 | .357 | 174.47 | 0.000 |
| 3.00 | 29.40 | .360 | 154.92 | 0.000 |
| 4.00 | 29.93 | .363 | 136.84 | 0.000 |
| 5.00 | 30.30 | .366 | 120.04 | 0.000 |
| 6.00 | 31.08 | .373 | 104.76 | 0.000 |
| 6.32 | 31.10 | .372 | 99.83 | 0.000 |
| 7.00 | 31.63 | .376 | 90.46 | 0.000 |
| 7.80 | 32.19 | .381 | 79.54 | 0.000 |
| 8.00 | 32.33 | .385 | 77.00 | 0.000 |
| 9.00 | 33.15 | .390 | 65.24 | 0.000 |
| 10.00 | 34.30 | .396 | 55.31 | 0.000 |
| 11.00 | 34.59 | .404 | 47.40 | 0.000 |
| 12.00 | 35.15 | .407 | 42.43 | 0.000 |
| 13.00 | 35.20 | .409 | 39.77 | 0.000 |
| 14.00 | 35.37 | .410 | 38.03 | 0.000 |
| 15.00 | 35.49 | .410 | 36.85 | 0.000 |
| 16.00 | 35.50 | .411 | 35.60 | 0.000 |
| 17.00 | 35.55 | .412 | 33.94 | 0.000 |
| 18.00 | 35.63 | .413 | 33.48 | 0.000 |
| 19.00 | 35.67 | .413 | 32.82 | 0.000 |
| 20.00 | 35.68 | .414 | 32.44 | 0.000 |
| 30.00 | 33.07 | .390 | 66.92 | .999 |
| 40.00 | 33.91 | .388 | 67.90 | .999 |



# RESTART TEST

TEST TECH
TEST DATE 28 JUNE 1988

COOLER MANUFACTURER CTI S/N D-0008
DEWAR MANUFACTURER TEST DEWAR S/N TD-010
TEMPERATURE SENSOR LAKE SHORE
AMBIENT TEMPERATURE -54 C

DATA WHEN COLD FINGER REACHES 75K
INPUT VOLTAGE 108 V(AC)
CURRENT 0.413 AMPS
POWER 31.540 WATTS

RESTART TEST

**CYCLE 1**
**OFF 2 SEC** X
**RESTART WITHIN 5 SEC** X YES ___ NO
**TIME REQUIRED TO RESTART** 1 SEC

**CYCLE 2**
**OFF 2 SEC** X
**RESTART WITHIN 5 SEC** X YES ___ NO
**TIME REQUIRED TO RESTART** 1 SEC

**CYCLE 3**
**OFF 2 SEC** X
**RESTART WITHIN 5 SEC** X YES ___ NO
**TIME REQUIRED TO RESTART** 1 SEC

**CYCLE 4**
**OFF 2 SEC** X
**RESTART WITHIN 5 SEC** X YES ___ NO
**TIME REQUIRED TO RESTART** 1 SEC

**CYCLE 5**
**OFF 2 SEC** X
**RESTART WITHIN 5 SEC** X YES ___ NO
**TIME REQUIRED TO RESTART** 1 SEC

**NOTES:**

NVEOL CRYOGENIC COOLER LAB

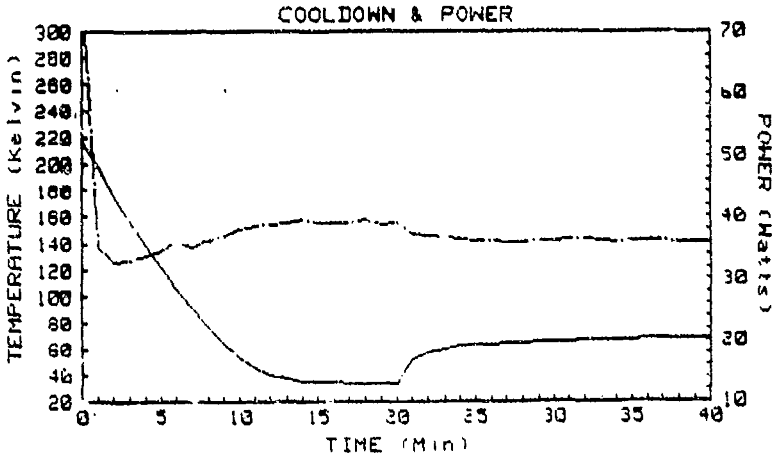
CRYOGENIC COOLER DATA

COOLER: CTI D-0008
VOLTAGE: 117
AMBIENT: -54 (C)

DATE: 28 JUNE 1988 19:21
ENGR: RNS
DEWAR COMP: -2.355

TEST: BASELINE AT LOW TEMP (117 V)

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 80.08 | .793 | 217.27 | 0.000 |
| 1.00 | 35.06 | .407 | 197.36 | 0.000 |
| 2.00 | 32.71 | .391 | 176.25 | 0.000 |
| 3.00 | 33.10 | .399 | 156.92 | 0.000 |
| 4.00 | 33.68 | .406 | 138.70 | 0.000 |
| 5.00 | 34.66 | .410 | 121.91 | 0.000 |
| 6.00 | 36.16 | .407 | 105.78 | 0.000 |
| 6.40 | 35.70 | .403 | 99.69 | 0.000 |
| 7.00 | 35.18 | .408 | 91.16 | 0.000 |
| 7.80 | 36.05 | .417 | 79.66 | 0.000 |
| 8.00 | 36.08 | .415 | 77.30 | 0.000 |
| 9.00 | 36.92 | .422 | 64.17 | 0.000 |
| 10.00 | 36.13 | .430 | 53.42 | 0.000 |
| 11.00 | 38.65 | .433 | 44.87 | 0.000 |
| 12.00 | 38.73 | .438 | 40.00 | 0.000 |
| 13.00 | 39.06 | .438 | 37.20 | 0.000 |
| 14.00 | 39.63 | .436 | 35.38 | 0.000 |
| 15.00 | 39.09 | .440 | 34.28 | 0.000 |
| 16.00 | 39.13 | .442 | 34.24 | 0.000 |
| 17.00 | 38.98 | .438 | 33.77 | 0.000 |
| 13.00 | 39.61 | .439 | 33.46 | 0.000 |
| 19.00 | 38.94 | .437 | 33.25 | 0.000 |
| 20.00 | 38.98 | .437 | 33.14 | 0.000 |
| 30.00 | 36.11 | .415 | 65.81 | .999 |
| 40.00 | 35.84 | .413 | 67.99 | .999 |



# RESTART TEST

TEST TECH
TEST DATE 28 JUNE 1988

COOLER MANUFACTURER CTI S/N D-0008
DEWAR MANUFACTURER TEST DEWAR S/N TD-010
TEMPERATURE SENSOR LAKE SHORE
AMBIENT TEMPERATURE -54 C

DATA WHEN COLD FINGER REACHES 75K
INPUT VOLTAGE 117 V(AC)
CURRENT 0.413 AMPS
POWER 34.168 WATTS

RESTART TEST

CYCLE 1
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 2
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 3
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 4
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 5
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

NOTES:

## NVEOL CRYOGENIC COOLER LAB

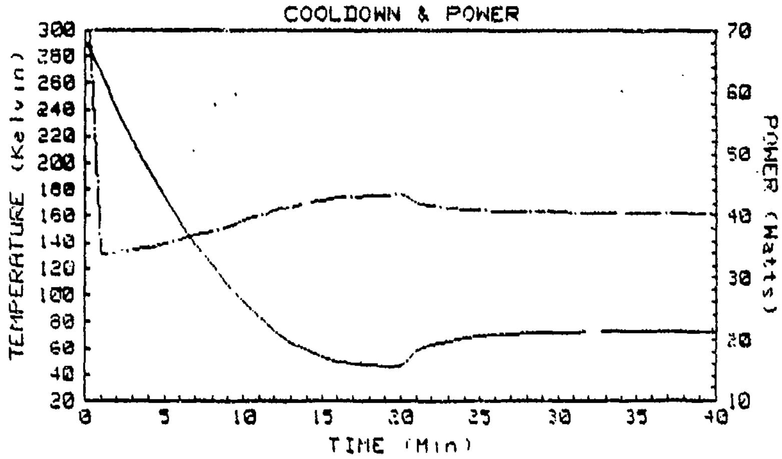
## CRYOGENIC COOLER DATA

COOLER: CTI D-0008
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 29 JUNE 1988 10:15
ENGR: RNS
DEWAR COMP: -2.355

TEST: BASELINE AFTER LOW TEMP TEST

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 83.30 | .806 | 293.00 | 0.000 |
| 1.00 | 33.70 | .393 | 266.49 | 0.000 |
| 2.00 | 34.01 | .395 | 240.06 | 0.000 |
| 3.00 | 34.52 | .398 | 216.45 | 0.000 |
| 4.00 | 34.97 | .402 | 194.57 | 0.000 |
| 5.00 | 35.57 | .405 | 174.75 | 0.000 |
| 6.00 | 36.17 | .410 | 155.88 | 0.000 |
| 7.00 | 36.84 | .415 | 138.81 | 0.000 |
| 8.00 | 37.53 | .420 | 122.68 | 0.000 |
| 9.00 | 38.40 | .427 | 107.87 | 0.000 |
| 9.62 | 38.87 | .431 | 99.69 | 0.000 |
| 10.00 | 39.21 | .433 | 94.80 | 0.000 |
| 11.00 | 40.01 | .439 | 82.81 | 0.000 |
| 11.27 | 40.22 | .441 | 79.85 | 0.000 |
| 12.00 | 40.95 | .4 6 | 72.78 | 0.000 |
| 13.00 | 41.55 | .452 | 64.17 | 0.000 |
| 14.00 | 42.32 | .458 | 57.93 | 0.000 |
| 15.00 | 42.58 | .461 | 53.50 | 0.000 |
| 16.00 | 42.96 | .463 | 50.19 | 0.000 |
| 17.00 | 43.14 | .465 | 48.27 | 0.000 |
| 18.00 | 43.21 | .466 | 47.01 | 0.000 |
| 19.00 | 43.35 | .467 | 46.18 | 0.000 |
| 20.00 | 43.51 | .468 | 45.57 | 0.000 |
| 30.00 | 40.56 | .444 | 72.13 | .999 |
| 40.00 | 40.44 | .443 | 73.13 | .999 |



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0008

COOLDOWN TEST

| | | |
|---|---|---|
| TIME REQUIRED TO REACH 100K | N/A | MINUTES |
| TIME REQUIRED TO REACH 1.02 V | N/A | MINUTES |
| TIME REQUIRED TO REACH 80K | N/A | MINUTES |
| TEMPERATURE AFTER 20 MINUTES | N/A | K |

LEAK RATE: $1.2 \times 10^{-8}$ std cc/sec

COMMENTS: Post low-temperature testing.

TEST TECHNICIAN G. Doggett

TEST DATE 29 JUN 88

# LOW TEMPERATURE—S/N D-0012

ENVIRONMENTAL TEST DATA SHEET

TEST: LOW TEMPERATURE
COOLER: 1-WATT INTEGRAL, 1033D
MANUFACTURER: CTI
S/N: D-0012
DATE OF TEST: 28 June 88
TESTED BY: Jim Shaffer

| PARAMETER | START | END | PASS | FAIL | COMPLY |
|---|---|---|---|---|---|
| PRE-TEST OPERATION | 2[illegible]<br>0912 | ne 88<br>0952 | ✓ | | ✓ |
| 4 HOUR SOAK @-62C | 0915 | 1315 | | | ✓ |
| RAISE TEMP. TO -54C | 1315 | 1330 | | | ✓ |
| STABILIZE @-54C,.5HR | 1330 | 1603 | | | ✓ |
| OPERATION @-54C | 1603 | 1643 | ✓ | | ✓ |
| POST TEST PERFORMANCE | | | ✓ | | ✓ |
| LEAK RATE | | | ✓ | | ✓ |

NVEOL CRYOGENIC COOLER LAB

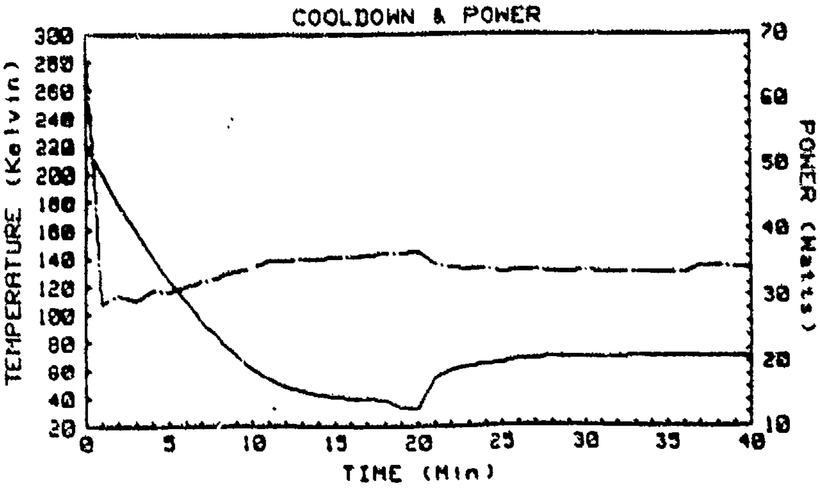
CRYOGENIC COOLER DATA

COOLER: CTI D-0012
VOLTAGE: 108
AMBIENT: -54 (C)

DATE: 28 JUNE 1988 17:17
ENGR: RNS
DEWAR COMP: -2.24

TEST: BASELINE AT LOW TEMP (108 V)

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 67.71 | .711 | 219.38 | 0.000 |
| 1.00 | 28.79 | .372 | 199.52 | 0.000 |
| 2.00 | 30.12 | .374 | 178.86 | 0.000 |
| 3.00 | 29.38 | .373 | 159.49 | 0.000 |
| 4.00 | 30.85 | .384 | 141.84 | 0.000 |
| 5.00 | 30.66 | .384 | 125.14 | 0.000 |
| 6.00 | 31.45 | .387 | 109.79 | 0.000 |
| 6.67 | 32.05 | .391 | 100.02 | 0.000 |
| 7.00 | 32.45 | .392 | 95.46 | 0.000 |
| 8.00 | 32.76 | .400 | 82.46 | 0.000 |
| 8.18 | 33.26 | .403 | 79.96 | 0.000 |
| 9.00 | 33.74 | .412 | 70.81 | 0.000 |
| 10.00 | 34.35 | .412 | 60.65 | 0.000 |
| 11.00 | 35.28 | .420 | 53.14 | 0.000 |
| 12.00 | 35.39 | .422 | 47.53 | 0.000 |
| 13.00 | 35.63 | .425 | 44.22 | 0.000 |
| 14.00 | 35.70 | .426 | 42.26 | 0.000 |
| 15.00 | 35.84 | .426 | 40.86 | 0.000 |
| 16.00 | 35.97 | .426 | 40.19 | 0.000 |
| 17.00 | 36.23 | .431 | 39.47 | 0.000 |
| 18.00 | 36.32 | .428 | 37.99 | 0.000 |
| 19.00 | 36.56 | .430 | 33.94 | 0.000 |
| 20.00 | 36.66 | .432 | 32.37 | 0.000 |
| 30.00 | 33.68 | .404 | 69.48 | .990 |
| 40.00 | 34.43 | .414 | 70.55 | .998 |



# RESTART TEST

TEST TECH
TEST DATE 28 JUNE 1988

COOLER MANUFACTURER CTI S/N D-0012
DEWAR MANUFACTURER TEST DEWAR S/N TD-011
TEMPERATURE SENSOR LAKE SHORE
AMBIENT TEMPERATURE -54 C

DATA WHEN COLD FINGER REACHES 75K
INPUT VOLTAGE 108 V(AC)
CURRENT 0.415 AMPS
POWER 31.692 WATTS

RESTART TEST

CYCLE 1
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 2
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 3
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 4
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 5
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

NOTES:

## NVEOL CRYOGENIC COOLER LAB

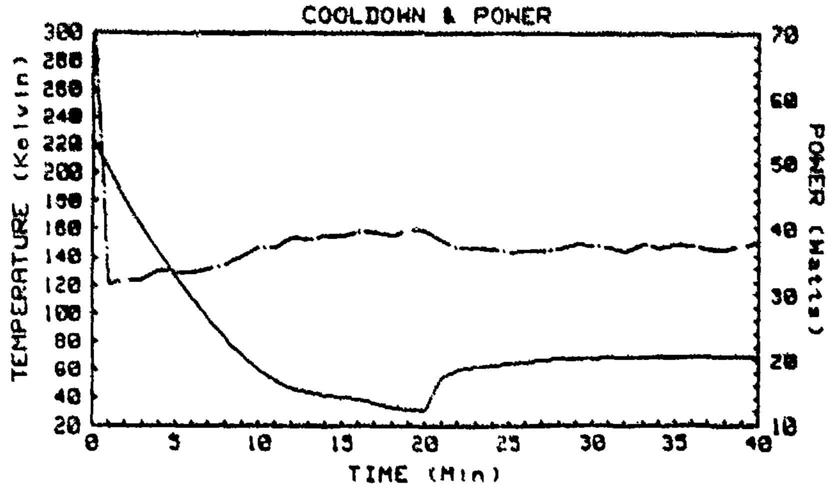
## CRYOGENIC COOLER DATA

COOLER: CTI D-0012
VOLTAGE: 117
AMBIENT: -54 (C)

DATE: 28 JUNE 1988 16:03
ENGR: RNS
DEWAR COMP: -2.24

TEST: BSAELINE AT LOW TEMP (117 V)

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 73.97 | .727 | 221.78 | 0.000 |
| 1.00 | 31.77 | .401 | 200.74 | 0.000 |
| 2.00 | 32.59 | .405 | 180.04 | 0.000 |
| 3.00 | 32.45 | .406 | 161.14 | 0.000 |
| 4.00 | 33.77 | .412 | 143.24 | 0.000 |
| 5.00 | 33.45 | .410 | 126.73 | 0.000 |
| 6.00 | 33.54 | .409 | 110.89 | 0.000 |
| 6.73 | 33.84 | .415 | 99.87 | 0.000 |
| 7.00 | 34.13 | .415 | 96.16 | 0.000 |
| 8.00 | 34.67 | .419 | 82.69 | 0.000 |
| 8.25 | 35.07 | .422 | 79.27 | 0.000 |
| 9.00 | 35.97 | .430 | 70.62 | 0.000 |
| 10.00 | 37.17 | .433 | 60.00 | 0.000 |
| 11.00 | 37.23 | .437 | 51.80 | 0.000 |
| 12.00 | 38.90 | .444 | 46.44 | 0.000 |
| 13.00 | 38.61 | .444 | 43.17 | 0.000 |
| 14.00 | 39.13 | .453 | 41.08 | 0.000 |
| 15.00 | 39.15 | .459 | 40.08 | 0.000 |
| 16.00 | 39.52 | .453 | 38.98 | 0.000 |
| 17.00 | 39.72 | .451 | 36.21 | 0.000 |
| 18.00 | 39.15 | .453 | 32.88 | 0.000 |
| 19.00 | 39.82 | .468 | 31.63 | 0.000 |
| 20.00 | 39.75 | .457 | 31.16 | 0.000 |
| 30.00 | 37.42 | .442 | 68.52 | .998 |
| 40.00 | 37.63 | .437 | 69.51 | .998 |



# RESTART TEST

TEST TECH
TEST DATE 28 JUNE 1988

COOLER MANUFACTURER CTI S/N D-0012
DEWAR MANUFACTURER TEST DEWAR S/N TD-011
TEMPERATURE SENSOR LAKE SHORE
AMBIENT TEMPERATURE -54 C

DATA WHEN COLD FINGER REACHES 75K
INPUT VOLTAGE 117 V(AC)
CURRENT 0.411 AMPS
POWER 34.003 WATTS

RESTART TEST

CYCLE 1
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 2
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 3
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 4
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 5
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

NOTES:

## NVEOL CRYOGENIC COOLER LAB

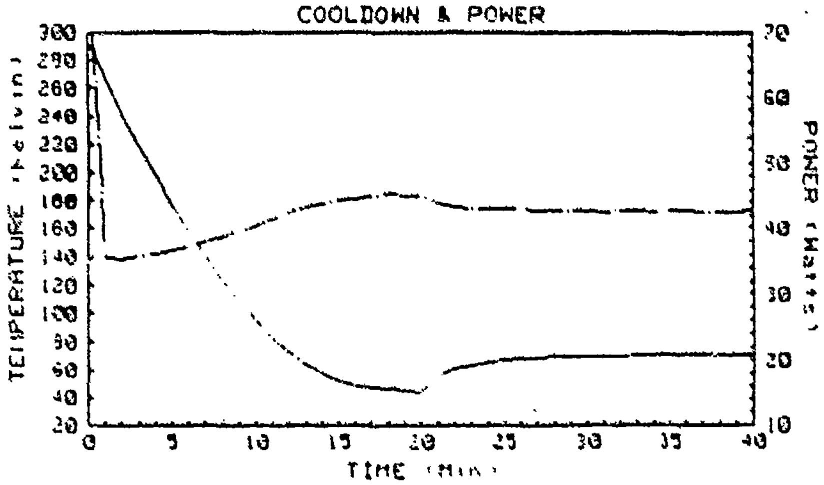
## CRYOGENIC COOLER DATA

COOLER: CTI D-0012
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 29 JUNE 1988 11:07
ENGR: RNS
DEWAR COMP: -2.24

TEST: BASELINE AFTER LOW TEMP TEST

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 81.79 | .789 | 294.15 | 0.000 |
| 1.00 | 35.54 | .423 | 268.29 | 0.000 |
| 2.00 | 35.50 | .423 | 242.39 | 0.000 |
| 3.00 | 35.84 | .426 | 219.06 | 0.000 |
| 4.00 | 36.18 | .427 | 197.39 | 0.000 |
| 5.00 | 36.72 | .431 | 177.01 | 0.000 |
| 6.00 | 37.35 | .434 | 158.24 | 0.000 |
| 7.00 | 38.13 | .440 | 140.52 | 0.000 |
| 8.00 | 38.94 | .446 | 124.08 | 0.000 |
| 9.00 | 39.70 | .451 | 109.23 | 0.000 |
| 9.67 | 40.14 | .455 | 99.83 | 0.000 |
| 10.00 | 40.52 | .457 | 95.50 | 0.000 |
| 11.00 | 41.40 | .464 | 83.04 | 0.000 |
| 11.27 | 41.71 | .466 | 80.04 | 0.000 |
| 12.00 | 42.45 | .473 | 72.63 | 0.000 |
| 13.00 | 43.18 | .478 | 63.64 | 0.000 |
| 14.00 | 43.90 | .484 | 56.95 | 0.000 |
| 15.00 | 44.27 | .487 | 52.06 | 0.000 |
| 16.00 | 44.57 | .490 | 48.88 | 0.000 |
| 17.00 | 45.20 | .494 | 46.79 | 0.000 |
| 18.00 | 45.43 | .498 | 45.44 | 0.000 |
| 19.00 | 45.26 | .495 | 44.52 | 0.000 |
| 20.00 | 45.18 | .495 | 43.91 | 0.000 |
| 30.00 | 42.77 | .475 | 69.48 | .999 |
| 40.00 | 42.83 | .475 | 70.47 | .999 |



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0012

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1.02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: 2.6 X $10^{-8}$ std cc/sec

COMMENTS: Post low-temperature testing.

TEST TECHNICIAN G. Doggett

TEST DATE 29 JUN 88

# APPENDIX D
# TEMPERATURE SHOCK

## Temperature Shock—S/N D-0008

**ENVIRONMENTAL TEST DATA SHEET**

**TEST: TEMPERATURE SHOCK**
**COOLER: 1-WATT INTEGRAL, 1033D**
**MANUFACTURER:** CTI
**S/N:** D-0008
**DATE OF TEST:** 29 JUNE 1988 THROUGH 1 JULY 1988
**TESTED BY:** R. N. SAMUELS
H. G. KLING

| PARAMETER | START | END | PASS | FAIL | COMPLY |
|---|---|---|---|---|---|
| PRE-TEST OPERATION | | | ✓ | | |
| 4 HOURS @+95C | 29 June 88<br>1315 | 1715 | | | ✓ |
| 4 HOURS @-62C | 1715 | 2115 | | | ✓ |
| 4 HOURS @+95C | 2115 | 30 June 88<br>0115 | | | ✓ |
| 4 HOURS @-62C | 0115 | 0515 | | | ✓ |
| 4 HOURS @+95C | 0515 | 0915 | | | ✓ |
| 4 HOURS @-62C | 0915 | 1315 | | | ✓ |
| STABILIZE @+23C | 1315 | 1 July 1988<br>0820 | | | ✓ |
| OPERATION @+23C | 0820 | 0900 | ✓ | | |
| LEAK RATE | 1 July 1988 | | ✓ | | |

NVEOL CRYOGENIC COOLER LAB

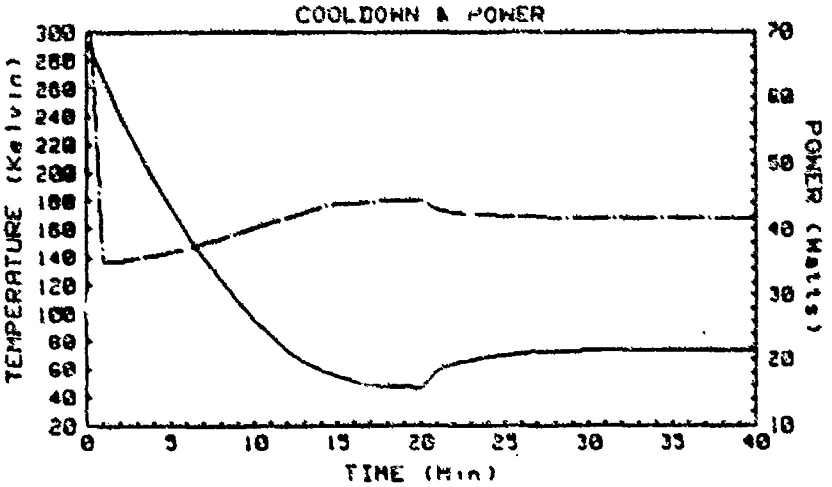
CRYOGENIC COOLER DATA

COOLER: CTI D-0008
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 1 JULY 1988 09:02
ENGR: RNS
DEWAR COMP: -2.355

TEST: POST TEMPERATURE SHOCK BASELINE

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 84.81 | .818 | 293.91 | 0.000 |
| 1.00 | 35.15 | .402 | 267.34 | 0.000 |
| 2.00 | 35.19 | .403 | 241.04 | 0.000 |
| 3.00 | 35.53 | .405 | 217.05 | 0.000 |
| 4.00 | 35.94 | .409 | 195.58 | 0.000 |
| 5.00 | 36.42 | .412 | 175.34 | 0.000 |
| 6.00 | 37.05 | .416 | 156.05 | 0.000 |
| 7.00 | 37.72 | .421 | 139.42 | 0.000 |
| 8.00 | 38.43 | .426 | 123.27 | 0.000 |
| 9.00 | 39.26 | .432 | 108.72 | 0.000 |
| 9.67 | 39.75 | .437 | 99.65 | 0.000 |
| 10.00 | 40.01 | .439 | 95.46 | 0.000 |
| 11.00 | 40.92 | .446 | 83.58 | 0.000 |
| 11.33 | 41.18 | .449 | 79.89 | 0.000 |
| 12.00 | 41.81 | .453 | 73.51 | 0.000 |
| 13.00 | 42.59 | .460 | 64.91 | 0.000 |
| 14.00 | 43.28 | .466 | 58.46 | 0.000 |
| 15.00 | 43.74 | .469 | 53.96 | 0.000 |
| 16.00 | 43.91 | .472 | 50.75 | 0.000 |
| 17.00 | 44.22 | .473 | 48.75 | 0.000 |
| 18.00 | 44.29 | .474 | 47.44 | 0.000 |
| 19.00 | 44.41 | .475 | 46.62 | 0.000 |
| 20.00 | 44.36 | .474 | 46.09 | 0.000 |
| 30.00 | 41.84 | .453 | 72.48 | .999 |
| 40.00 | 41.60 | .451 | 73.55 | .999 |



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0008

COOLDOWN TEST

| | | |
|---|---|---|
| TIME REQUIRED TO REACH 100K | N/A | MINUTES |
| TIME REQUIRED TO REACH 1.02 V | N/A | MINUTES |
| TIME REQUIRED TO REACH 80K | N/A | MINUTES |
| TEMPERATURE AFTER 20 MINUTES | N/A | K |

LEAK RATE: 1.5 X $10^{-8}$ std cc/sec

COMMENTS: Post temperature-shock testing.

TEST TECHNICIAN G. Doggett

TEST DATE 01 JUL 88

# Temperature Shock—S/N D-0012

ENVIRONMENTAL TEST DATA SHEET

TEST: TEMPERATURE SHOCK
COOLER: 1-WATT INTEGRAL, 1033D
MANUFACTURER: CTI
S/N: D-0012
DATE OF TEST: 29 JUNE / 1 JULY 88
TESTED BY: RNS / HGK

| PARAMETER | START | END | PASS | FAIL | COMPLY |
|---|---|---|---|---|---|
| PRE-TEST OPERATION | | | ✓ | | |
| 4 HOURS @+95C | 29 JUNE<br>1315 | 1715 | | | ✓ |
| 4 HOURS @-62C | 1715 | 2115 | | | ✓ |
| 4 HOURS @+95C | 2115 | 0115 | | | ✓ |
| 4 HOURS @-62C | 0115 | 0515 | | | ✓ |
| 4 HOURS @+95C | 0515 | 0915 | | | ✓ |
| 4 HOURS @-62C | 0915 | 1315 | | | ✓ |
| STABILIZE @+23C | 1315 | 1 JULY<br>0820 | | | ✓ |
| OPERATION @+23C | 0820 | 0900 | ✓ | | |
| LEAK RATE | 1 JULY | | ✓ | | |

NVEOL CRYOGENIC COOLER LAB

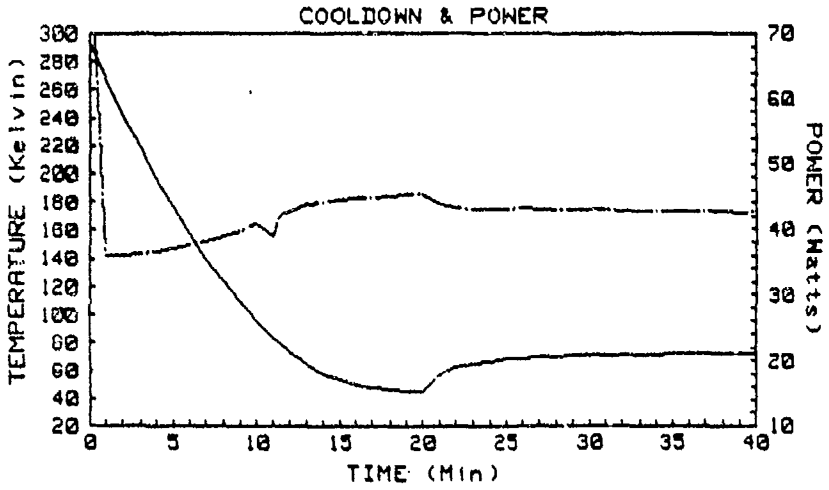
CRYOGENIC COOLER DATA

COOLER: CTI D-0012
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 1 JULY 1980 11:09
ENGR: RNS
DEWAR COMP: -2.24

TEST: POST TEMPERATURE SHOCK BASELINE

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 82.29 | .792 | 293.45 | 0.000 |
| 1.00 | 36.20 | .437 | 267.34 | 0.000 |
| 2.00 | 36.19 | .435 | 241.83 | 0.000 |
| 3.00 | 36.37 | .431 | 218.34 | 0.000 |
| 4.00 | 36.80 | .434 | 196.45 | 0.000 |
| 5.00 | 37.19 | .435 | 176.49 | 0.000 |
| 6.00 | 37.81 | .438 | 157.45 | 0.000 |
| 7.00 | 38.35 | .442 | 140.13 | 0.000 |
| 8.00 | 39.17 | .447 | 123.71 | 0.000 |
| 9.00 | 39.96 | .453 | 108.87 | 0.000 |
| 9.67 | 40.56 | .457 | 99.58 | 0.000 |
| 10.00 | 40.88 | .459 | 95.24 | 0.000 |
| 11.00 | 38.99 | .467 | 83.23 | 0.000 |
| 11.33 | 42.22 | .470 | 79.46 | 0.000 |
| 12.00 | 42.86 | .474 | 72.71 | 0.000 |
| 13.00 | 43.83 | .482 | 64.01 | 0.000 |
| 14.00 | 44.20 | .485 | 57.44 | 0.000 |
| 15.00 | 44.64 | .489 | 52.89 | 0.000 |
| 16.00 | 44.89 | .491 | 49.45 | 0.000 |
| 17.00 | 45.02 | .491 | 47.40 | 0.000 |
| 18.00 | 45.19 | .492 | 46.09 | 0.000 |
| 19.00 | 45.33 | .494 | 45.22 | 0.000 |
| 20.00 | 45.29 | .494 | 44.61 | 0.000 |
| 30.00 | 43.01 | .474 | 70.47 | .999 |
| 40.00 | 42.69 | .472 | 71.43 | .999 |



## ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0012

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1.02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: $2.8 X 10^{-8}$ std cc/sec

COMMENTS: Post temperature-shock testing.

TEST TECHNICIAN G. Doggett

TEST DATE 01 JUL 88

# APPENDIX E
# HIGH TEMPERATURE

## High Temperature—S/N D-0008

ENVIRONMENTAL TEST DATA SHEET

TEST: HIGH TEMPERATURE
COOLER: 1-WATT INTEGRAL, 1033D
MANUFACTURER: CTI
S/N: D0008
DATE OF TEST: 5-8 JULY 88
TESTED BY: JIM SHAFFER

| PARAMETER | START | END | PASS | FAIL | COMPLY |
|---|---|---|---|---|---|
| PRE-TEST OPERATION | | | ✓ | | |
| 48 HOUR SOAK @+95C | 0755<br>5 JULY | 0755<br>7 JULY | | | ✓ |
| LOWER TEMP. TO +71C | 0755<br>7 JULY | 1130<br>7 JULY | | | ✓ |
| STABILIZE @+71C,.5HR | 1130<br>7 JULY | 1528<br>7 JULY | | | ✓ |
| OPERATION @+71C | 1717 | 1757 | ✓ | | |
| POST TEST PERFORMANCE | 0939<br>8 JULY | 1019<br>8 JULY | ✓ | | |
| LEAK RATE | 8 JULY | 8 JULY | ✓ | | |

NVEOL CRYOGENIC COOLER LAB

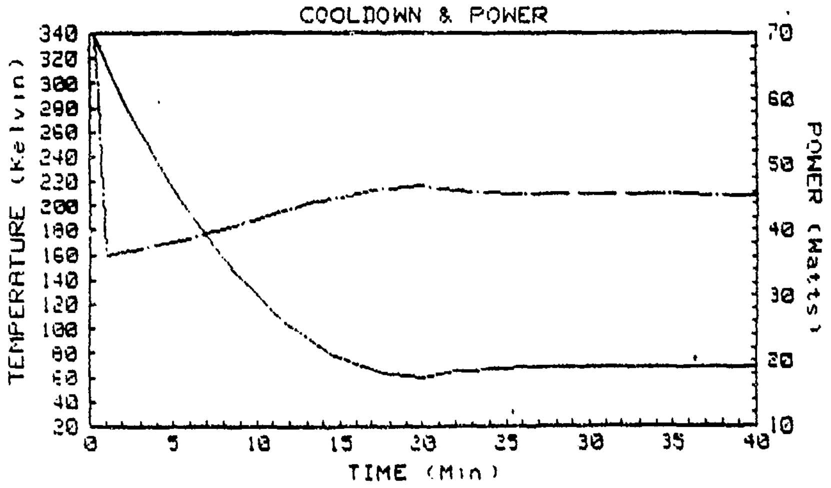
CRYOGENIC COOLER DATA

COOLER: CTI D-0008
VOLTAGE: 117
AMBIENT: 71 (C)

DATE: 7 JULY 1988 17:17
ENGR: RNS
DEWAR COMP: -2.355

TEST: HIGH TEMP BASELINE

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 85.34 | .820 | 345.20 | 0.000 |
| 1.00 | 36.23 | .408 | 315.42 | 0.000 |
| 2.00 | 36.59 | .411 | 286.06 | 0.000 |
| 3.00 | 37.12 | .415 | 260.02 | 0.000 |
| 4.00 | 37.63 | .419 | 235.78 | 0.000 |
| 5.00 | 38.23 | .423 | 213.95 | 0.000 |
| 6.00 | 38.77 | .427 | 193.67 | 0.000 |
| 7.00 | 39.48 | .432 | 174.99 | 0.000 |
| 8.00 | 40.17 | .438 | 157.35 | 0.000 |
| 9.00 | 40.84 | .442 | 141.45 | 0.000 |
| 10.00 | 41.64 | .449 | 127.05 | 0.000 |
| 11.00 | 42.49 | .455 | 113.50 | 0.000 |
| 12.00 | 43.28 | .463 | 101.86 | 0.000 |
| 12.17 | 43.32 | .463 | 100.02 | 0.000 |
| 13.00 | 44.18 | .470 | 91.71 | 0.000 |
| 14.00 | 44.65 | .474 | 83.00 | 0.000 |
| 14.42 | 44.83 | .475 | 79.73 | 0.000 |
| 15.00 | 45.20 | .478 | 75.89 | 0.000 |
| 16.00 | 45.75 | .484 | 70.43 | 0.000 |
| 17.00 | 46.11 | .487 | 66.02 | 0.000 |
| 18.00 | 46.50 | .490 | 62.74 | 0.000 |
| 19.00 | 46.80 | .492 | 60.41 | 0.000 |
| 20.00 | 46.92 | .493 | 58.78 | 0.000 |
| 30.00 | 45.62 | .482 | 68.06 | .500 |
| 40.00 | 45.51 | .481 | 68.33 | .500 |



# RESTART TEST

TEST TECH JKS
TEST DATE 7 JULY 1988

COOLER MANUFACTURER CTI S/N D-0008
DEWAR MANUFACTURER TEST DEWAR S/N TD-010
TEMPERATURE SENSOR LAKE SHORE
AMBIENT TEMPERATURE +71 C

DATA WHEN COLD FINGER REACHES 75K
INPUT VOLTAGE 117 V(AC)
CURRENT 0.476 AMPS
POWER 39.380 WATTS

RESTART TEST

CYCLE 1
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 2
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 3
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 4
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 5
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ____ NO
TIME REQUIRED TO RESTART 1 SEC

NOTES: The cooler dieseled on every test cycle.

## RESTART TEST

TEST TECH JKS
TEST DATE 7 JULY 1988

COOLER MANUFACTURER CTI S/N D-0008
DEWAR MANUFACTURER TEST DEWAR S/N TD-010
TEMPERATURE SENSOR LAKE SHORE
AMBIENT TEMPERATURE +71 C

DATA WHEN COLD FINGER REACHES 75K
INPUT VOLTAGE 108 V(AC)
CURRENT 0.465 AMPS
POWER 35.511 WATTS

RESTART TEST

CYCLE 1
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 2
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 3
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 4
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 5
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

NOTES: The cooler dieseled on cycles 1, 2, 3, & 5.

## NVEOL CRYOGENIC COOLER LAB

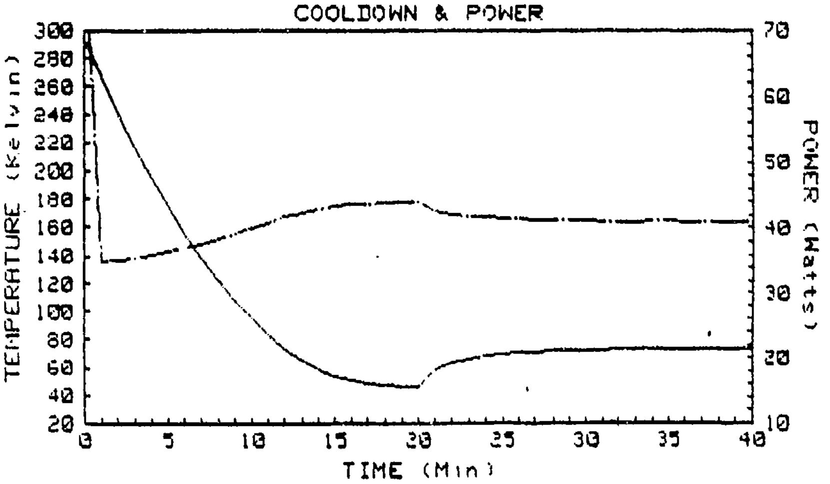
## CRYOGENIC COOLER DATA

COOLER: CTI D-0008
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 8 JULY 1988 09:39
ENGR: RNS
DEWAR COMP: -2.355

TEST: POST HIGH TEMP BASELINE

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 84.27 | .815 | 293.56 | 0.000 |
| 1.00 | 34.83 | .400 | 266.82 | 0.000 |
| 2.00 | 35.14 | .402 | 240.33 | 0.000 |
| 3.00 | 35.48 | .405 | 216.73 | 0.000 |
| 4.00 | 35.92 | .408 | 194.71 | 0.000 |
| 5.00 | 36.38 | .412 | 174.89 | 0.000 |
| 6.00 | 37.05 | .416 | 156.28 | 0.000 |
| 7.00 | 37.60 | .420 | 138.81 | 0.000 |
| 8.00 | 38.40 | .426 | 122.90 | 0.000 |
| 9.00 | 39.18 | .432 | 107.95 | 0.000 |
| 9.60 | 39.72 | .437 | 99.72 | 0.000 |
| 10.00 | 39.95 | .438 | 94.87 | 0.000 |
| 11.00 | 40.75 | .445 | 82.81 | 0.000 |
| 11.27 | 41.04 | .448 | 79.92 | 0.000 |
| 12.00 | 41.67 | .452 | 72.86 | 0.000 |
| 13.00 | 42.30 | .457 | 64.29 | 0.000 |
| 14.00 | 42.84 | .462 | 57.93 | 0.000 |
| 15.00 | 43.25 | .466 | 53.63 | 0.000 |
| 16.00 | 43.49 | .468 | 50.36 | 0.000 |
| 17.00 | 43.64 | .470 | 48.45 | 0.000 |
| 18.00 | 43.76 | .470 | 47.18 | 0.000 |
| 19.00 | 43.82 | .471 | 46.40 | 0.000 |
| 20.00 | 43.93 | .471 | 45.87 | 0.000 |
| 30.00 | 41.08 | .448 | 72.13 | .997 |
| 40.00 | 40.84 | .446 | 73.13 | .997 |


COOLDOWN & POWER

# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0008

COOLDOWN TEST

| | | |
|---|---|---|
| TIME REQUIRED TO REACH 100K | N/A | MINUTES |
| TIME REQUIRED TO REACH 1.02 V | N/A | MINUTES |
| TIME REQUIRED TO REACH 80K | N/A | MINUTES |
| TEMPERATURE AFTER 20 MINUTES | N/A | K |

LEAK RATE: $1.4 \times 10^{-8}$ std cc/sec

COMMENTS: Post high-temperature testing.

TEST TECHNICIAN R. Samuels

TEST DATE 08 JUL 88

# High Temperature— S/N D-0012

ENVIRONMENTAL TEST DATA SHEET

TEST: HIGH TEMPERATURE
COOLER: 1-WATT INTEGRAL, 1033D
MANUFACTURER: CTI
S/N: D-0012
DATE OF TEST: 5-8 JULY 88
TESTED BY: JIM SHAFFER

| PARAMETER | START | END | PASS | FAIL | COMPLY |
|---|---|---|---|---|---|
| PRE-TEST OPERATION | | | ✓ | | |
| 48 HOUR SOAK @+95C | 0755<br>5 JULY | 0755<br>7 JULY | | | ✓ |
| LOWER TEMP. TO +71C | 0755<br>7 JULY | 1130<br>7 JULY | | | ✓ |
| STABILIZE @+71C,.5HR | 1130<br>7 JULY | 1528<br>7 JULY | | | ✓ |
| OPERATION @+71C | 1528 | 1608 | ✓ | | |
| POST TEST PERFORMANCE | 1053<br>8 JULY | 1133<br>8 JULY | ✓ | | |
| LEAK RATE | 8 JULY | 8 JULY | ✓ | | |

# NVEOL CRYOGENIC COOLER LAB

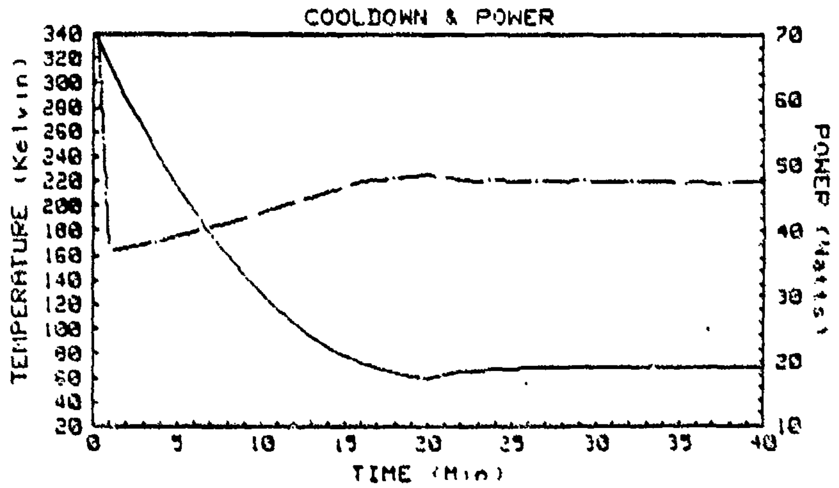
## CRYOGENIC COOLER DATA

COOLER: CTI D-0012
VOLTAGE: 117
AMBIENT: 71 (C)

DATE: 7 JULY 1988 15:28
ENGR: RNS
DEWAR COMP: -2.24

TEST: HIGH TEMP BASELINE

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 82.51 | .792 | 343.83 | 0.000 |
| 1.00 | 37.06 | .434 | 315.66 | 0.000 |
| 2.00 | 37.59 | .436 | 287.67 | 0.000 |
| 3.00 | 38.07 | .440 | 262.36 | 0.000 |
| 4.00 | 38.47 | .443 | 238.67 | 0.000 |
| 5.00 | 39.23 | .447 | 216.55 | 0.000 |
| 6.00 | 39.89 | .452 | 196.49 | 0.000 |
| 7.00 | 40.68 | .457 | 177.67 | 0.000 |
| 8.00 | 41.27 | .461 | 160.46 | 0.000 |
| 9.00 | 41.98 | .467 | 144.24 | 0.000 |
| 10.00 | 42.81 | .473 | 129.52 | 0.000 |
| 11.00 | 43.49 | .478 | 116.18 | 0.000 |
| 12.00 | 44.39 | .484 | 104.32 | 0.000 |
| 12.40 | 44.77 | .487 | 99.91 | 0.000 |
| 13.00 | 45.28 | .492 | 93.95 | 0.000 |
| 14.00 | 46.07 | .498 | 85.04 | 0.000 |
| 14.67 | 46.56 | .502 | 79.73 | 0.000 |
| 15.00 | 46.74 | .504 | 77.43 | 0.000 |
| 16.00 | 47.45 | .509 | 71.88 | 0.000 |
| 17.00 | 47.78 | .511 | 67.53 | 0.000 |
| 18.00 | 48.15 | .515 | 63.72 | 0.000 |
| 19.00 | 48.41 | .517 | 61.31 | 0.000 |
| 20.00 | 48.58 | .519 | 59.47 | 0.000 |
| 30.00 | 47.55 | .510 | 67.91 | .500 |
| 40.00 | 47.47 | .510 | 68.22 | .500 |



## RESTART TEST

TEST TECH JKS
TEST DATE 7 JULY 1988

COOLER MANUFACTURER CTI S/N D-0012
DEWAR MANUFACTURER TEST DEWAR S/N TD-011
TEMPERATURE SENSOR LAKE SHORE
AMBIENT TEMPERATURE +71 C

DATA WHEN COLD FINGER REACHES 75K
- INPUT VOLTAGE 108 V(AC)
- CURRENT 0.491 AMPS
- POWER 37.496 WATTS

RESTART TEST

CYCLE 1
- OFF 2 SEC X
- RESTART WITHIN 5 SEC X YES ___ NO
- TIME REQUIRED TO RESTART 1 SEC

CYCLE 2
- OFF 2 SEC X
- RESTART WITHIN 5 SEC X YES ___ NO
- TIME REQUIRED TO RESTART 1 SEC

CYCLE 3
- OFF 2 SEC X
- RESTART WITHIN 5 SEC X YES ___ NO
- TIME REQUIRED TO RESTART 1 SEC

CYCLE 4
- OFF 2 SEC X
- RESTART WITHIN 5 SEC X YES ___ NO
- TIME REQUIRED TO RESTART 1 SEC

CYCLE 5
- OFF 2 SEC X
- RESTART WITHIN 5 SEC X YES ___ NO
- TIME REQUIRED TO RESTART 1 SEC

NOTES: The cooler dieseled on every test cycle.

# RESTART TEST

TEST TECH JKS
TEST DATE 7 JULY 1988

COOLER MANUFACTURER CTI S/N D-0012
DEWAR MANUFACTURER TEST DEWAR S/N TD-011
TEMPERATURE SENSOR LAKE SHORE
AMBIENT TEMPERATURE +71 C

DATA WHEN COLD FINGER REACHES 75K
INPUT VOLTAGE 108 V(AC)
CURRENT 0.491 AMPS
POWER 37.496 WATTS

RESTART TEST

CYCLE 1
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 2
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 3
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 4
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

CYCLE 5
OFF 2 SEC X
RESTART WITHIN 5 SEC X YES ___ NO
TIME REQUIRED TO RESTART 1 SEC

NOTES: The cooler dieseled on every test cycle.

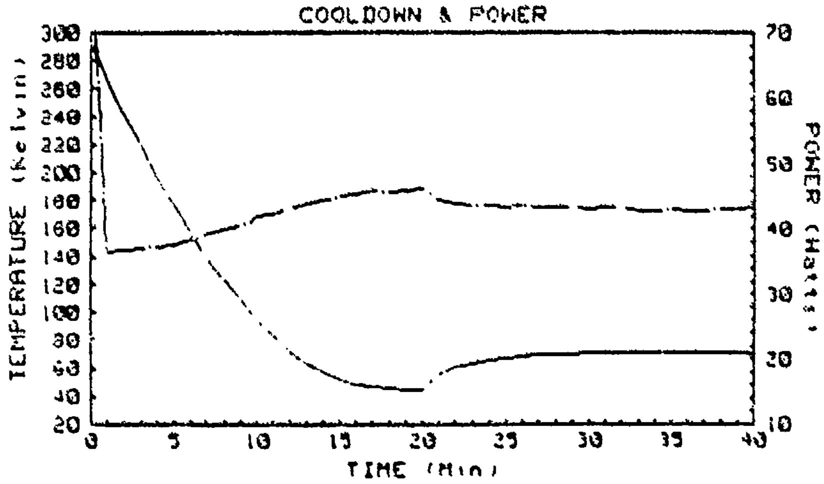
```
                         NVEOL CRYOGENIC COOLER LAB

                           CRYOGENIC COOLER DATA

 COOLER: CTI D-0012                               DATE: 8 JULY 1988 10:53
VOLTAGE: 117                                      ENGR: RNS
AMBIENT: 23 (C)                             DEWAR COMP: -2.24

   TEST: POST HIGH TEMP BASELINE

-----------------------------------------------------------------------------
    TIME          POWER          CURRENT          KELVIN           LOAD
-----------------------------------------------------------------------------
    0.00          81.83           .786            293.03           0.000
    1.00          36.43           .434            267.19           0.000
    2.00          36.77           .436            241.45           0.000
    3.00          37.06           .439            218.24           0.000
    4.00          37.35           .440            196.38           0.000
    5.00          37.53           .441            176.46           0.000
    6.00          38.35           .446            157.35           0.000
    7.00          38.95           .451            139.70           0.000
    8.00          39.78           .457            123.64           0.000
    9.00          40.51           .462            108.57           0.000
    9.67          41.02           .466             99.32           0.000
   10.00          41.91           .472             94.98           0.000
   11.00          42.37           .478             82.89           0.000
   11.27          42.50           .478             79.89           0.000
   12.00          43.06           .482             72.36           0.000
   13.00          43.88           .488             63.68           0.000
   14.00          44.30           .491             56.99           0.000
   15.00          45.11           .498             52.10           0.000
   16.00          45.29           .499             48.92           0.000
   17.00          45.84           .502             46.96           0.000
   18.00          45.65           .501             45.57           0.000
   19.00          45.98           .505             44.65           0.000
   20.00          46.08           .505             44.13           0.000
-----------------------------------------------------------------------------
   30.00          43.10           .484             70.01            .998
   40.00          43.21           .483             70.97            .999
=============================================================================
```



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0012

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1.02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: 2.8 X $10^{-8}$ std cc/sec

COMMENTS: Post high-temperature testing.

TEST TECHNICIAN R. Samuels

TEST DATE 08 JUL 88

# APPENDIX F
# MECHANICAL SHOCK

## Mechanical Shock—S/N D-0008

ENVIRONMENTAL TEST DATA SHEET

TEST: MECHANICAL SHOCK
COOLER: 1-WATT INTEGRAL, 1037D
MANUFACTURER: CTI
S/N: D-0008
DATE OF TEST: 21 JULY 88
TESTED BY: RNS

| PARAMETER | PASS | FAIL | COMPLY |
|---|---|---|---|
| PRE-TEST OPERATION | ✓ | | |
| 12 SHOCKS TOTAL | | | ✓ |
| POST TEST PERFORMANCE | ✓ | | |
| LEAK RATE | | | ✓ |

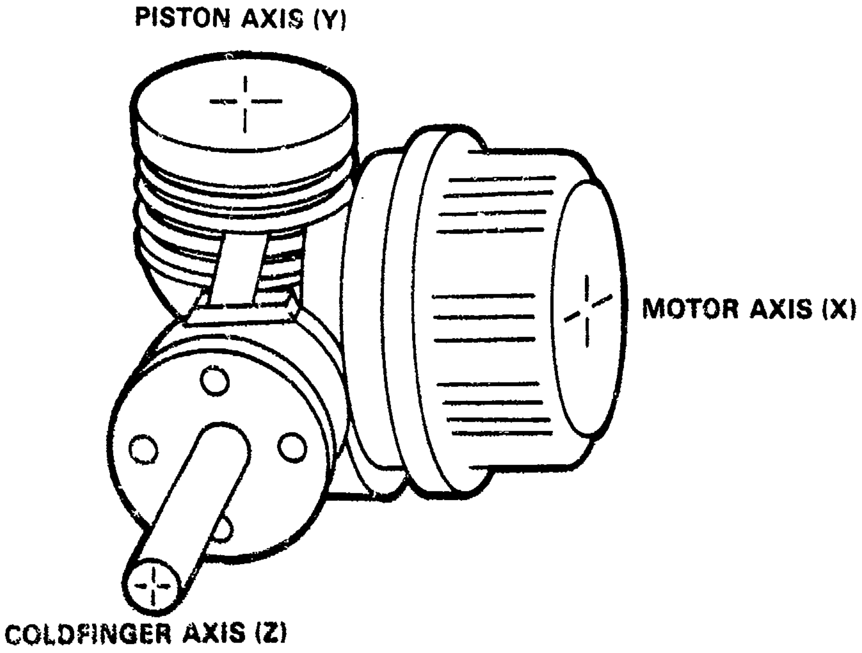
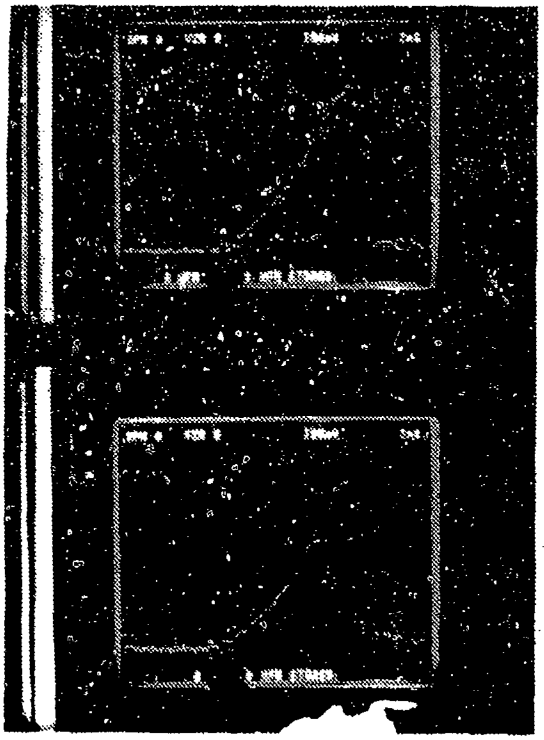
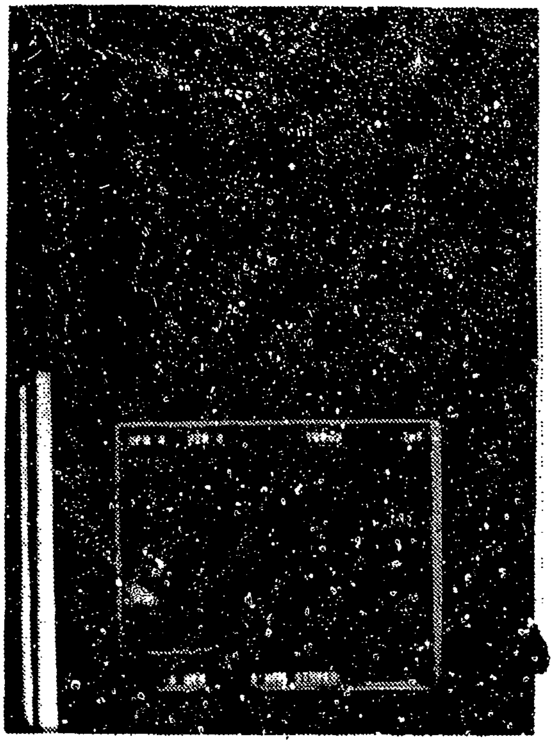


Figure 3. Cooler axes

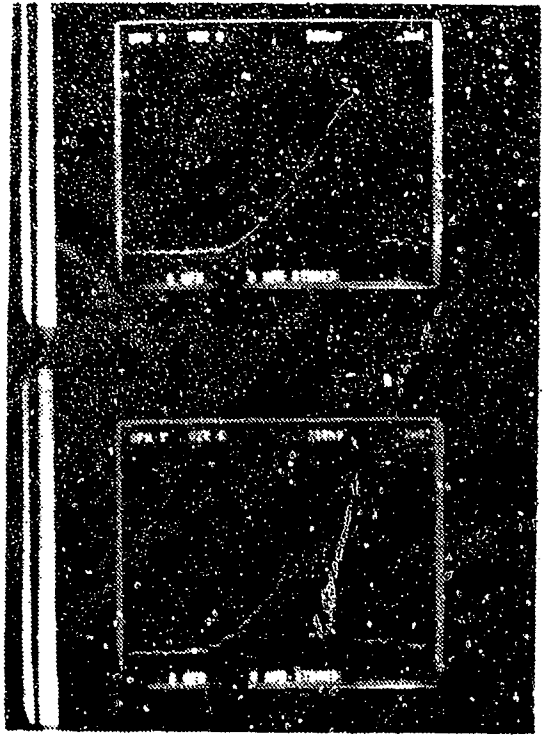


**(+) COLDFINGER AXIS**



**(–) COLDFINGER AXIS***

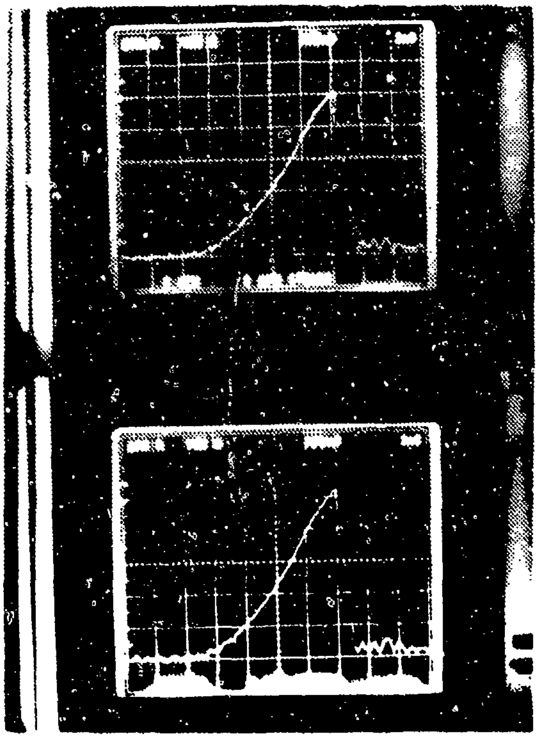
*** First drop data was not recorded due to the failure of the oscilloscope to receive the triggering signal.**



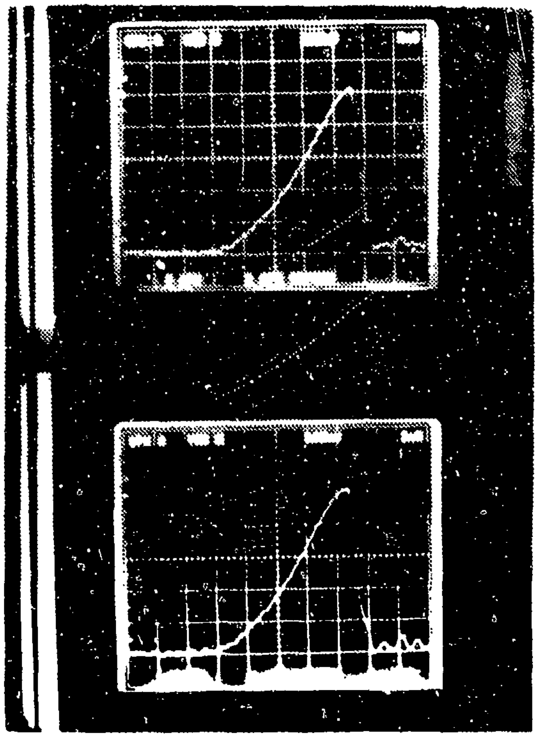
**(+) MOTOR AXIS**

**(–) MOTOR AXIS**

S/N D-0008



(+) PISTON AXIS



(–) PISTON AXIS

## NVEOL CRYOGENIC COOLER LAB

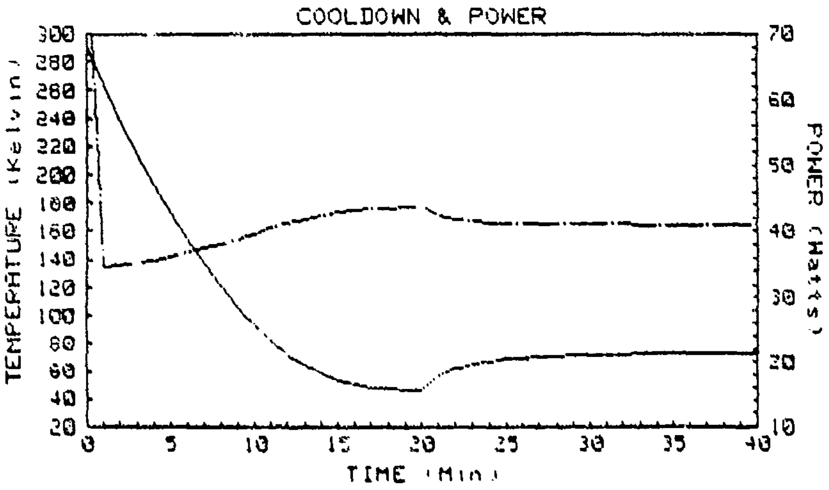
## CRYOGENIC COOLER DATA

COOLER: CTI D-0008 / TD-010
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 21 JULY 88 09:44
ENGR: HLD
DEWAR COMP: -2.355

TEST: PERFORMANCE TEST FOLLOWING MECHANICAL SHOCK

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 83.33 | .808 | 291.31 | 0.000 |
| 1.00 | 34.60 | .399 | 264.47 | 0.000 |
| 2.00 | 34.92 | .401 | 238.38 | 0.000 |
| 3.00 | 35.27 | .404 | 214.20 | 0.000 |
| 4.00 | 35.67 | .407 | 192.63 | 0.000 |
| 5.00 | 36.23 | .411 | 172.46 | 0.000 |
| 6.00 | 36.88 | .415 | 154.03 | 0.000 |
| 7.00 | 37.48 | .420 | 136.81 | 0.000 |
| 8.00 | 38.09 | .425 | 120.91 | 0.000 |
| 9.00 | 38.81 | .430 | 106.66 | 0.000 |
| 9.53 | 39.32 | .434 | 99.54 | 0.000 |
| 10.00 | 39.72 | .437 | 93.66 | 0.000 |
| 11.00 | 40.53 | .444 | 82.18 | 0.000 |
| 11.18 | 40.73 | .445 | 79.99 | 0.000 |
| 12.00 | 41.34 | .451 | 72.23 | 0.000 |
| 13.00 | 42.00 | .456 | 64.07 | 0.000 |
| 14.00 | 42.58 | .462 | 58.06 | 0.000 |
| 15.00 | 43.03 | .465 | 53.53 | 0.000 |
| 16.00 | 43.28 | .467 | 50.66 | 0.000 |
| 17.00 | 43.52 | .469 | 48.31 | 0.000 |
| 18.00 | 43.67 | .470 | 47.01 | 0.000 |
| 19.00 | 43.75 | .471 | 46.09 | 0.000 |
| 20.00 | 43.77 | .471 | 45.48 | 0.000 |
| 30.00 | 41.11 | .449 | 71.89 | .998 |
| 40.00 | 40.96 | .447 | 72.92 | .998 |



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0008

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1.02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: 1.2 X $10^{-8}$ std cc/sec

COMMENTS: Post shock testing.

TEST TECHNICIAN G. Doggett

TEST DATE 22 JUL 88

# Mechanical Shock—S/N D-0012

## ENVIRONMENTAL TEST DATA SHEET

TEST: MECHANICAL SHOCK
COOLER: 1-WATT INTEGRAL, 1033D
MANUFACTURER: CTI
S/N: D-C012
DATE OF TEST: 21 JULY 88
TESTED BY: RNS

| PARAMETER | PASS | FAIL | COMPLY |
|---|---|---|---|
| PRE-TEST OPERATION | ✓ | | |
| 12 SHOCKS TOTAL | | | ✓ |
| POST TEST PERFORMANCE | ✓ | | |
| LEAK RATE | | | ✓ |

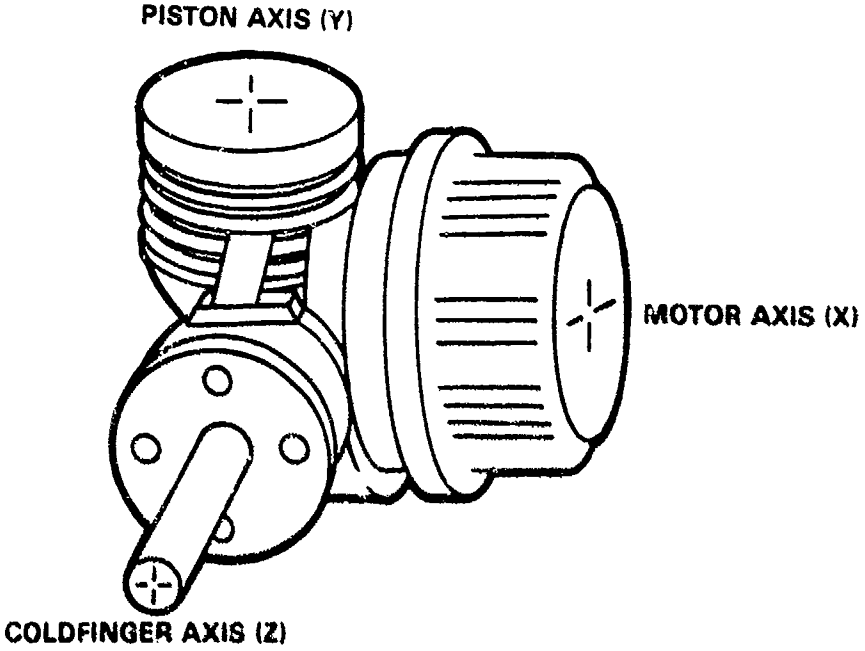
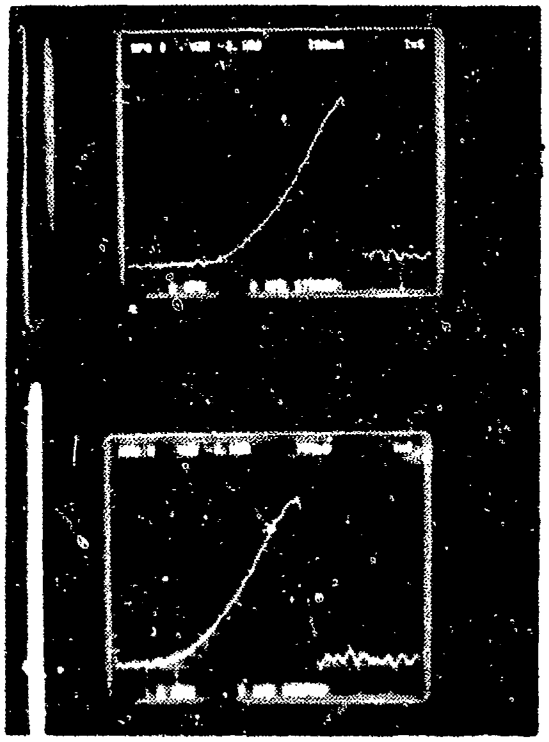
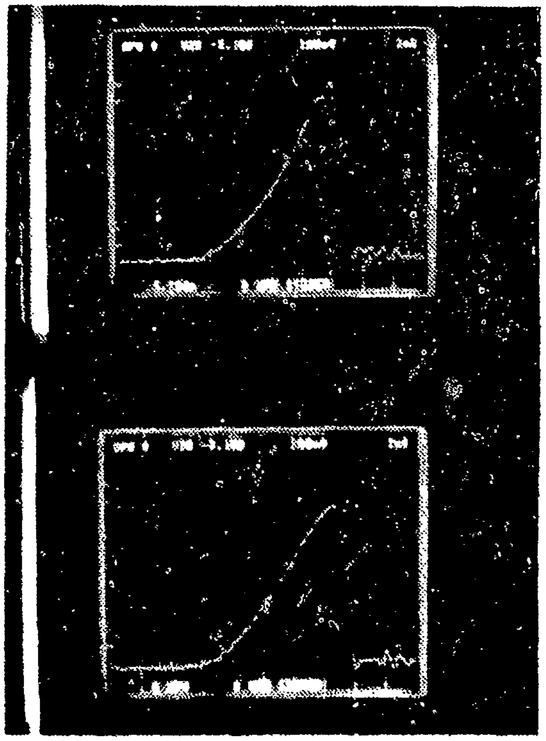


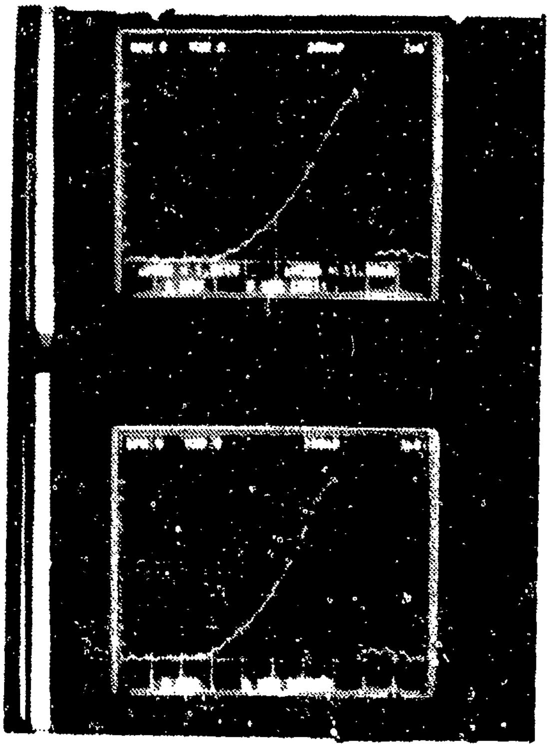
Figure 3. Cooler axes



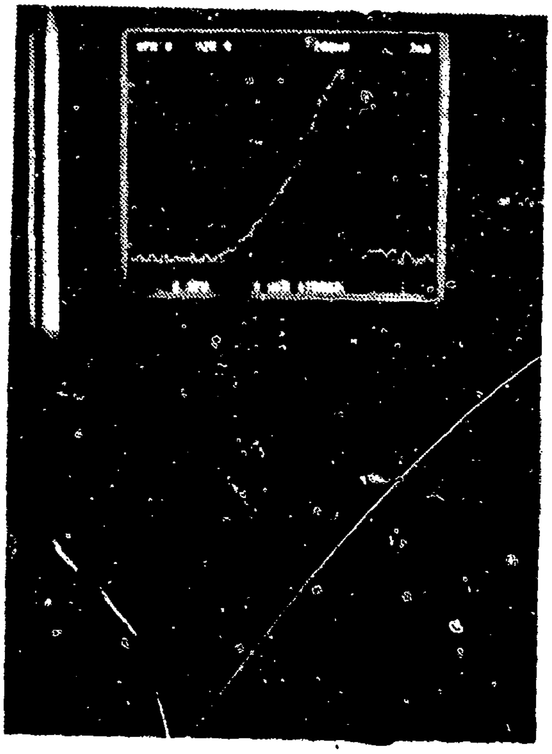
**(+) COLDFINGER AXIS**



**(–) COLDFINGER AXIS**



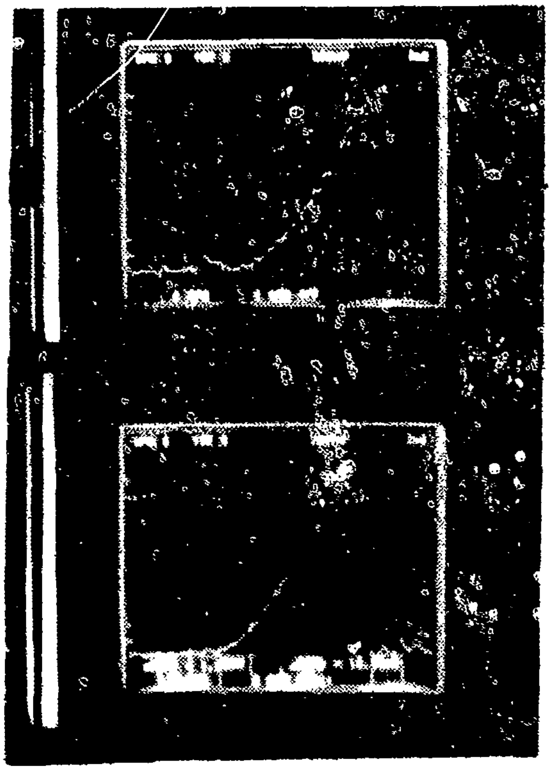
**(+) MOTOR AXIS**



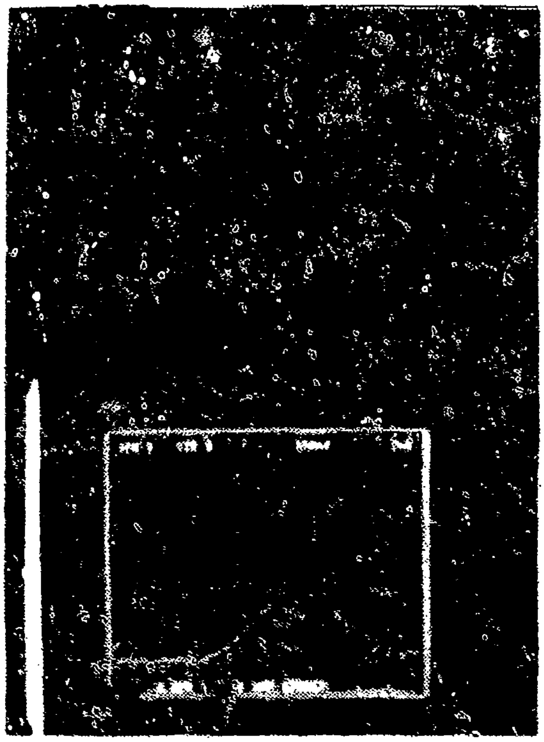
**(–) MOTOR AXIS***

* First drop data was not recorded due to a failure in the camera.

S/N D-0012



(+) PISTON AXIS



(–) PISTON AXIS*

* First drop data was not recorded due to a failure in the camera.

NVEOL CRYOGENIC COOLER LAB

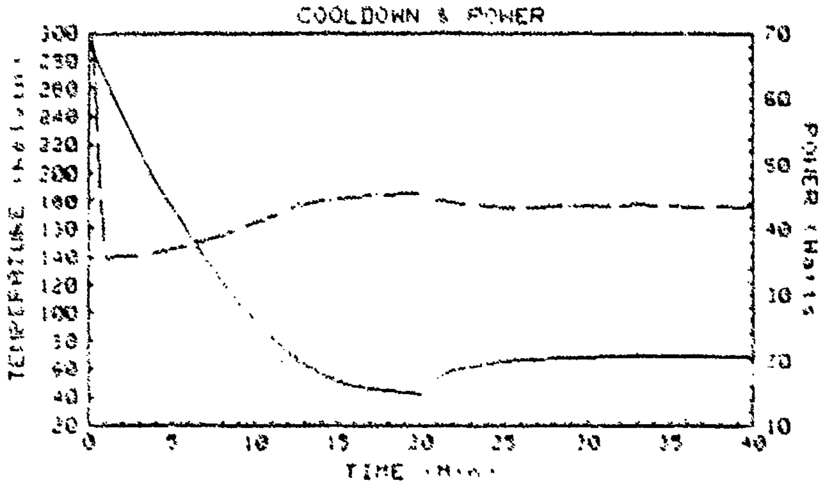
CRYOGENIC COOLER DATA

COOLER: CTI 0-0012
VOLTAGE: 117
AMBIENT: 23 (C)

DATE: 22 JULY 88 07:17
ENGR: HLD
DEWAR COMP: -2.24

TEST: PERFORMANCE TEST FOLLOWING MECHANICAL SHOCK

| TIME | POWER | CURRENT | KELVIN | LOAD |
|---|---|---|---|---|
| 0.00 | 30.90 | .779 | 292.68 | 0.000 |
| 1.00 | 35.67 | .433 | 266.96 | 0.000 |
| 2.00 | 35.90 | .434 | 241.16 | 0.000 |
| 3.00 | 35.94 | .434 | 217.71 | 0.000 |
| 4.00 | 36.40 | .438 | 195.75 | 0.000 |
| 5.00 | 37.05 | .441 | 175.35 | 0.000 |
| 6.00 | 37.60 | .445 | 156.75 | 0.000 |
| 7.00 | 38.26 | .450 | 139.39 | 0.000 |
| 8.00 | 39.15 | .456 | 122.98 | 0.000 |
| 9.00 | 40.05 | .462 | 108.10 | 0.000 |
| 9.60 | 40.59 | .467 | 99.73 | 0.000 |
| 10.00 | 40.92 | .468 | 94.40 | 0.000 |
| 11.00 | 41.88 | .476 | 82.22 | 0.000 |
| 11.20 | 42.10 | .478 | 79.68 | 0.000 |
| 12.00 | 42.91 | .484 | 71.81 | 0.000 |
| 13.00 | 43.80 | .491 | 62.88 | 0.000 |
| 14.00 | 44.45 | .496 | 56.14 | 0.000 |
| 15.00 | 44.93 | .500 | 51.31 | 0.000 |
| 16.00 | 45.23 | .502 | 47.82 | 0.000 |
| 17.00 | 45.42 | .504 | 45.60 | 0.000 |
| 18.00 | 45.55 | .505 | 44.24 | 0.000 |
| 19.00 | 45.61 | .506 | 43.24 | 0.000 |
| 20.00 | 45.73 | .506 | 42.60 | 0.000 |
| 30.00 | 43.65 | .489 | 68.50 | .999 |
| 40.00 | 43.53 | .489 | 69.57 | .999 |



# ACCEPTANCE DATA SHEET

COOLER S/N: CTI D-0012

COOLDOWN TEST

TIME REQUIRED TO REACH 100K N/A MINUTES

TIME REQUIRED TO REACH 1 02 V N/A MINUTES

TIME REQUIRED TO REACH 80K N/A MINUTES

TEMPERATURE AFTER 20 MINUTES N/A K

LEAK RATE: $3.4 \times 10^{-8}$ std cc/sec

COMMENTS: Post shock testing.

TEST TECHNICIAN G. Doggett

TEST DATE 22 JUL 88

# APPENDIX G
# VIBRATION OUTPUT

## Self-Induced Vibration Test of CTI HD-1033D 1-Watt Integral Cooler

Two CTI HD-1033D 1-Watt Integral Coolers were tested to determine their vibration output characteristics and to compare the characteristics with those of two CTI HD-1033C 1-Watt Integral Coolers.

For these tests, each cooler was suspended from the ceiling by a bungy cord arrangement that allowed free rotation about the center of gravity and free translation. The coolers were run for approximately 15 minutes prior to making any measurements. The cooler coldfinger was covered with a stryofoam sleeve—not a detector dewar. For the piston and motor axes, an accelerometer was placed directly on the respective axis to measure the acceleration. The accelerometer for the coldfinger axis measurement was mounted on the coldfinger flange.

The linear acceleration along the coldfinger, motor, and piston axis was determined by measuring the spectrum of the resulting signal with an HP-3561A Dynamic Signal Analyzer. The force along each axis was determined by multiplying the weight of the cooler by the measured acceleration (in g's). In comparing data, the only consistent differences in translational forces between the HD-1033C and the HD-1033D was along the motor axis where the HD-1033C produced less force. This generalization was not very useful considering the sample size. All four coolers were found to be within specifications.

### TRANSLATIONAL FORCE DATA

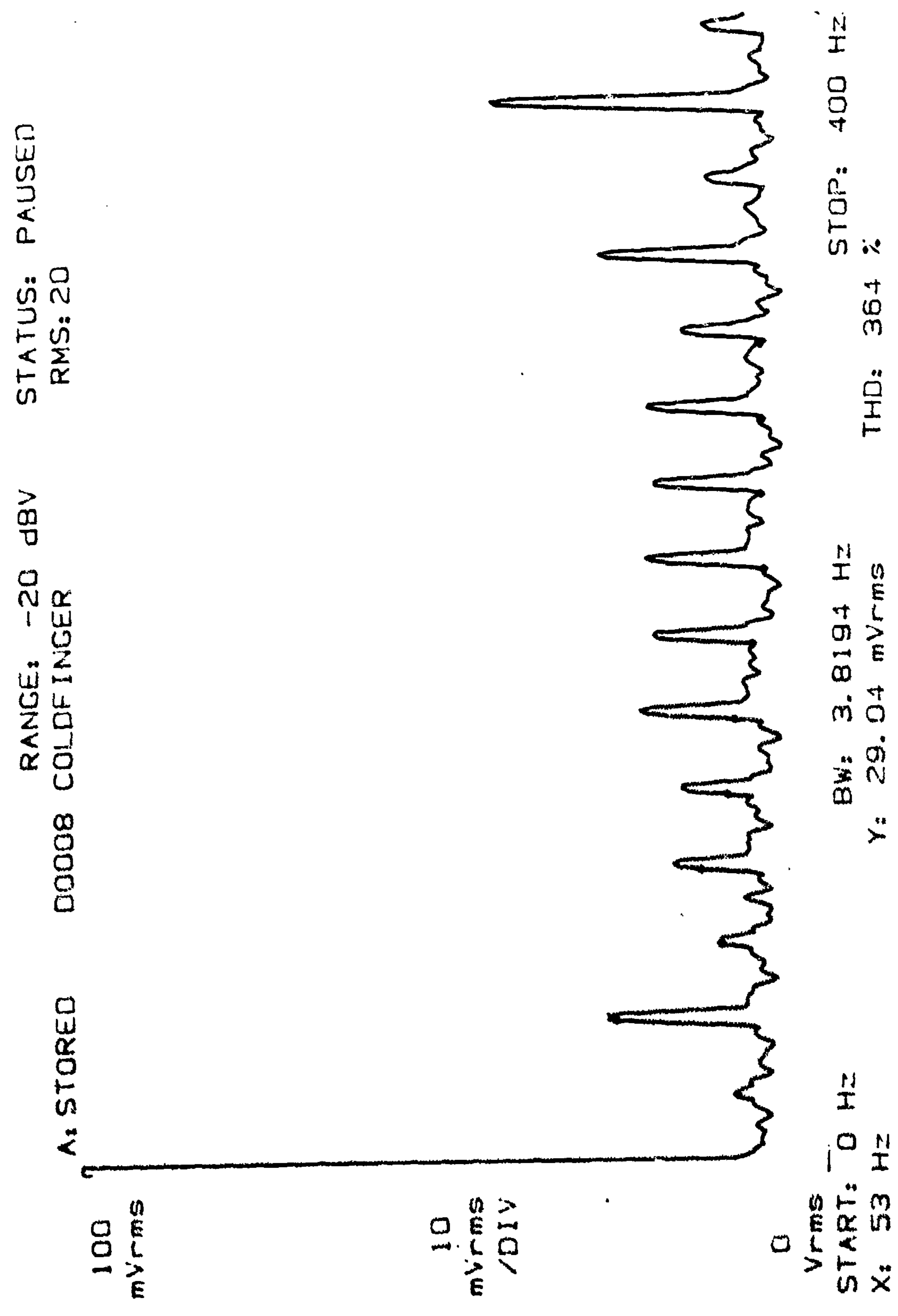
The data plotted on the following pages was collected from an Endevco accelerometer and signal conditioner set to output 1 volt/g. This signal was then input to the HP-3561A Dynamic Signal Analyzer and the frequency spectrum with mVrms amplitude was stored. A 1 mVrms amplitude corresponds to a 1 mgrms acceleration. The translational forces were then calculated using Fpeak = (1.414) x (W) x (grms) where W is equal to the weight of the cooler and grms is the maximum rms value recorded for acceleration at the 26Hz fundamental frequency or any of the next eight harmonics.

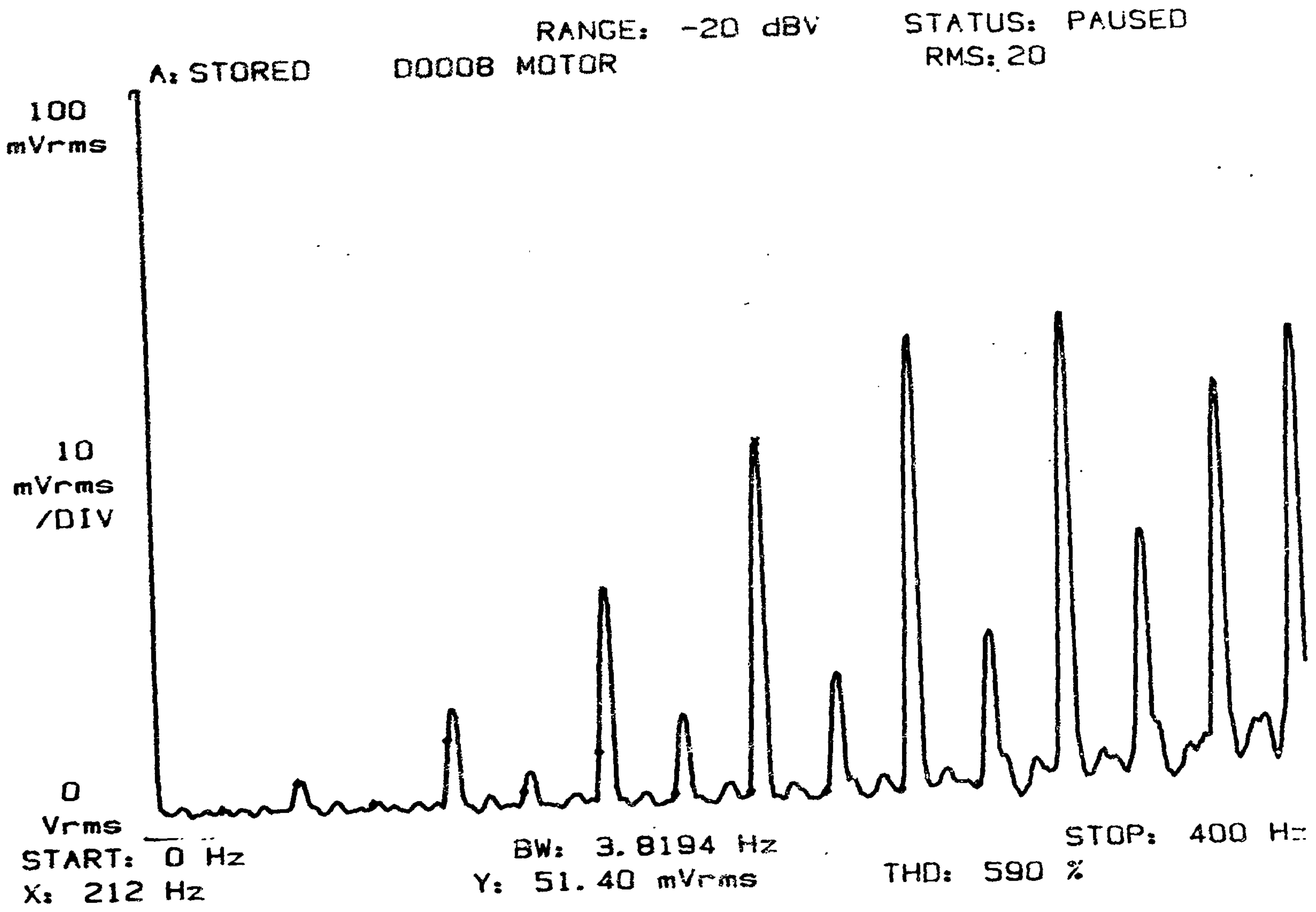
| COOLERS | WEIGHT (pounds) |
|---|---|
| S/N D-0008 | 3.80 |
| S/N D-0012 | 3.77 |
| S/N C7064G | 3.75 |
| S/N C7045G | 3.75 |

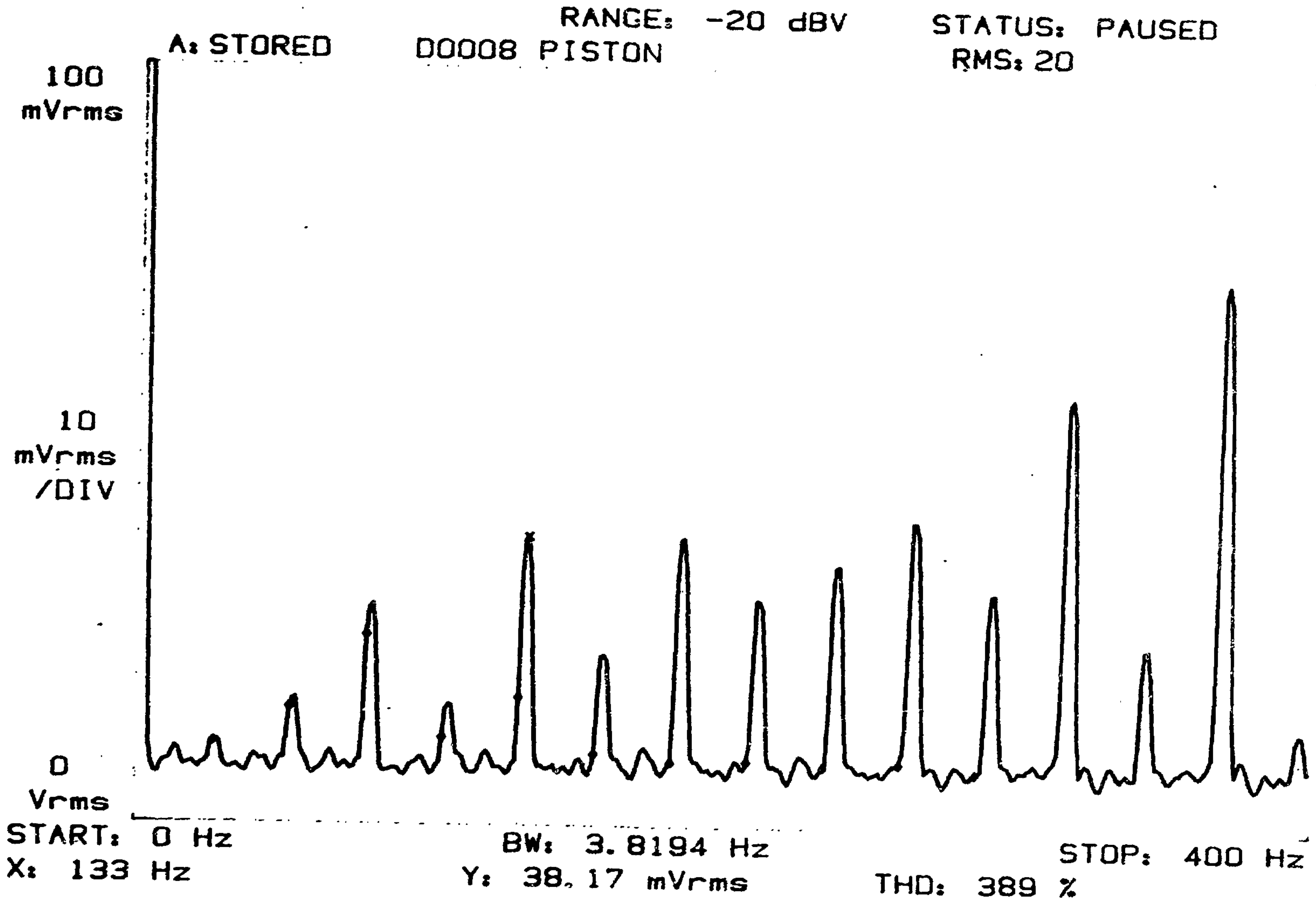
# TRANSLATIONAL FORCE (POUNDS)

| | AXIS | | |
|---|---|---|---|
| **COOLERS** | **Coldfinger** | **Motor** | **Piston** |
| **HD-1033D** | | | |
| S/N D-0008 | 0.16 | 0.27 | 0.20 |
| S/N D-0012 | 0.14 | 0.21 | 0.15 |
| **HD-1033-C** | | | |
| S/N C7064G | 0.18 | 0.10 | 0.21 |
| S/N C7045G | 0.15 | 0.10 | 0.17 |
| **Specification** | 0.35 | 0.50 | 0.35 |

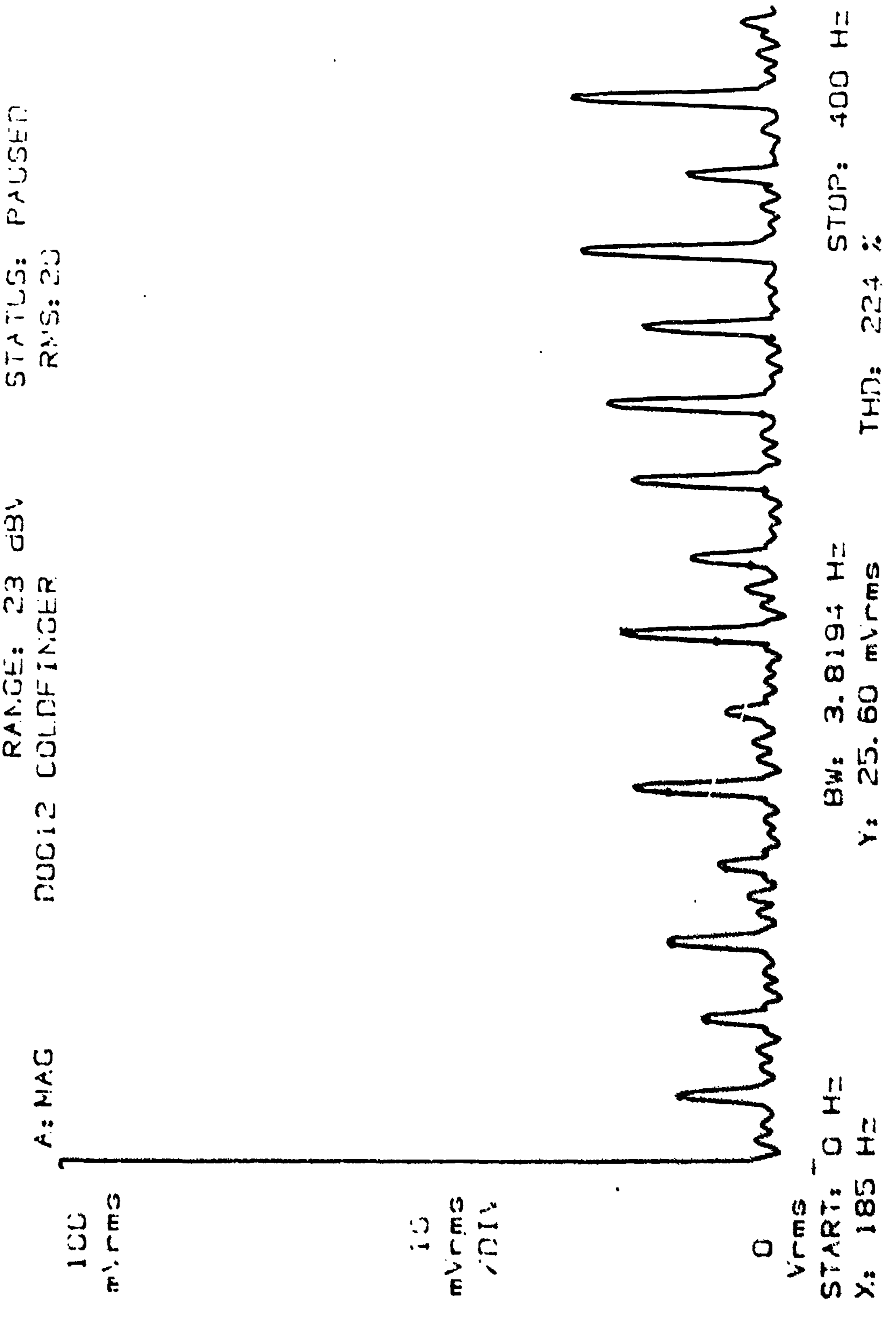
## VIBRATION OUTPUT—S/N D-0008

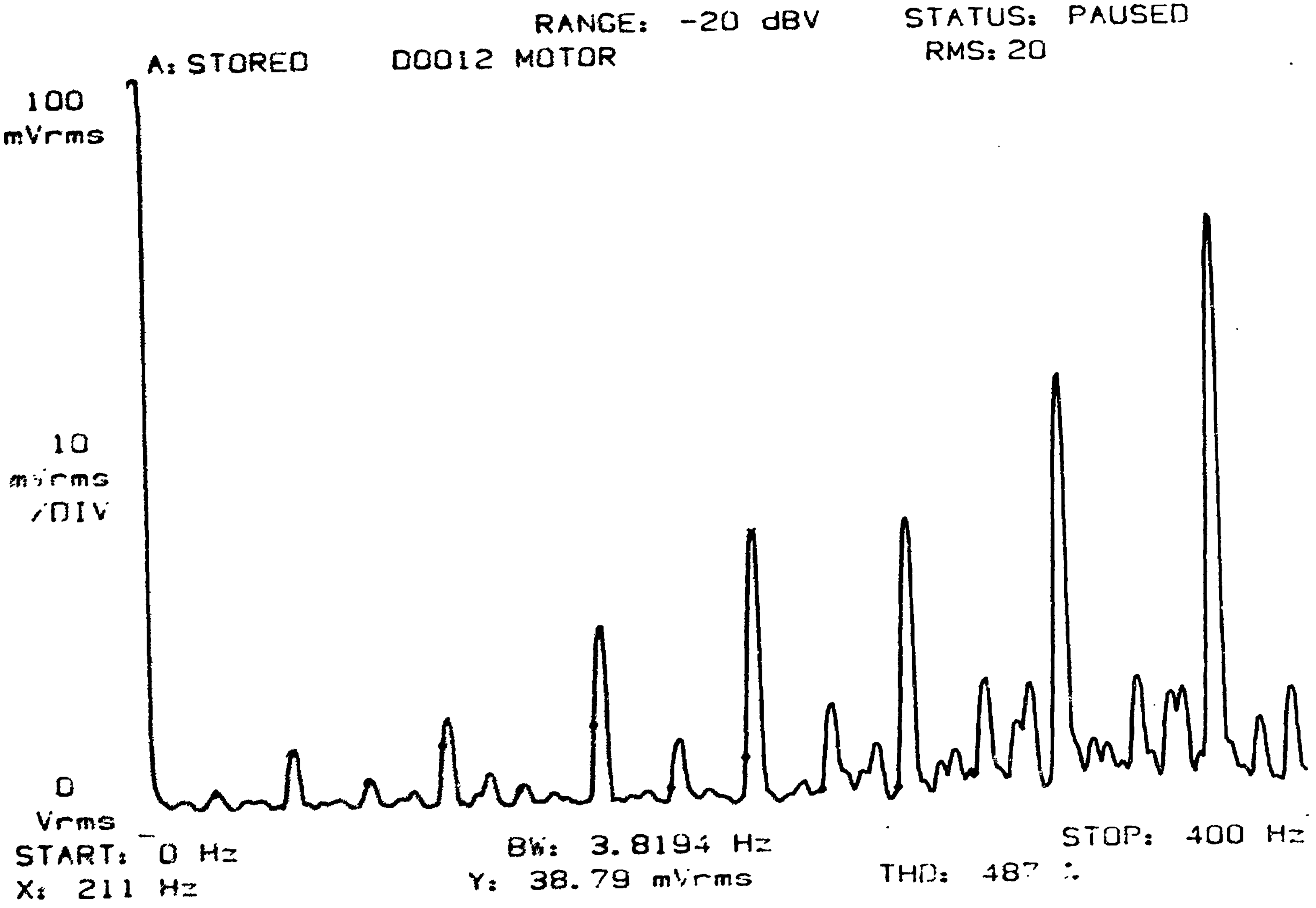


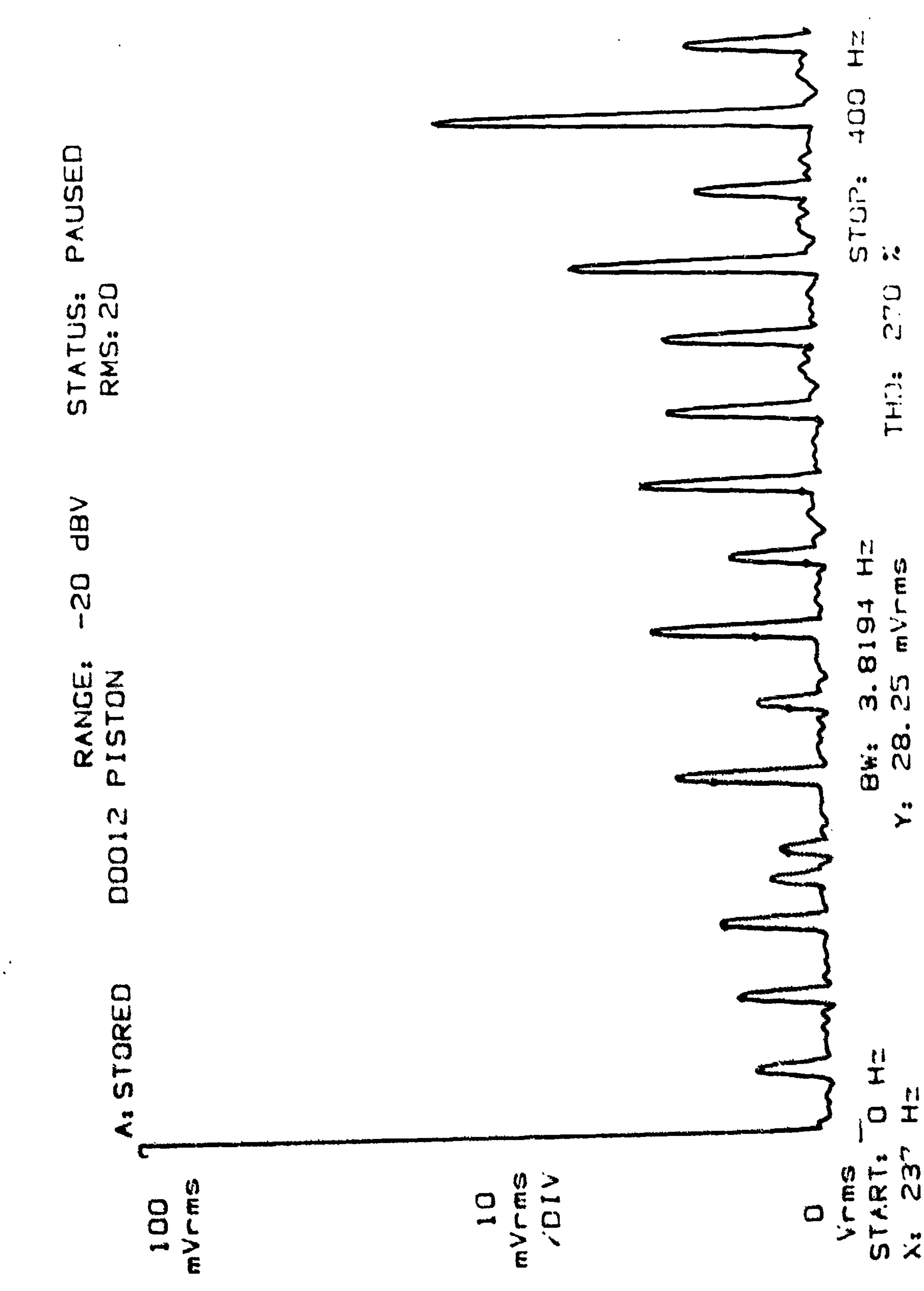

RANGE: -20 dBV
STATUS: PAUSED
A: STORED
D0008 MOTOR
RMS: 20
100
mVrms
10
mVrms
/DIV
0
Vrms
START: 0 Hz
X: 212 Hz
BW: 3.8194 Hz
Y: 51.40 mVrms
STOP: 400 Hz
THD: 590 %


A: STORED
D0008 PISTON
RANGE: -20 dBV
STATUS: PAUSED
RMS: 20
100
mVrms
10
mVrms
/DIV
0
Vrms
START: 0 Hz
X: 133 Hz
BW: 3.8194 Hz
Y: 38.17 mVrms
THD: 389 %
STOP: 400 Hz

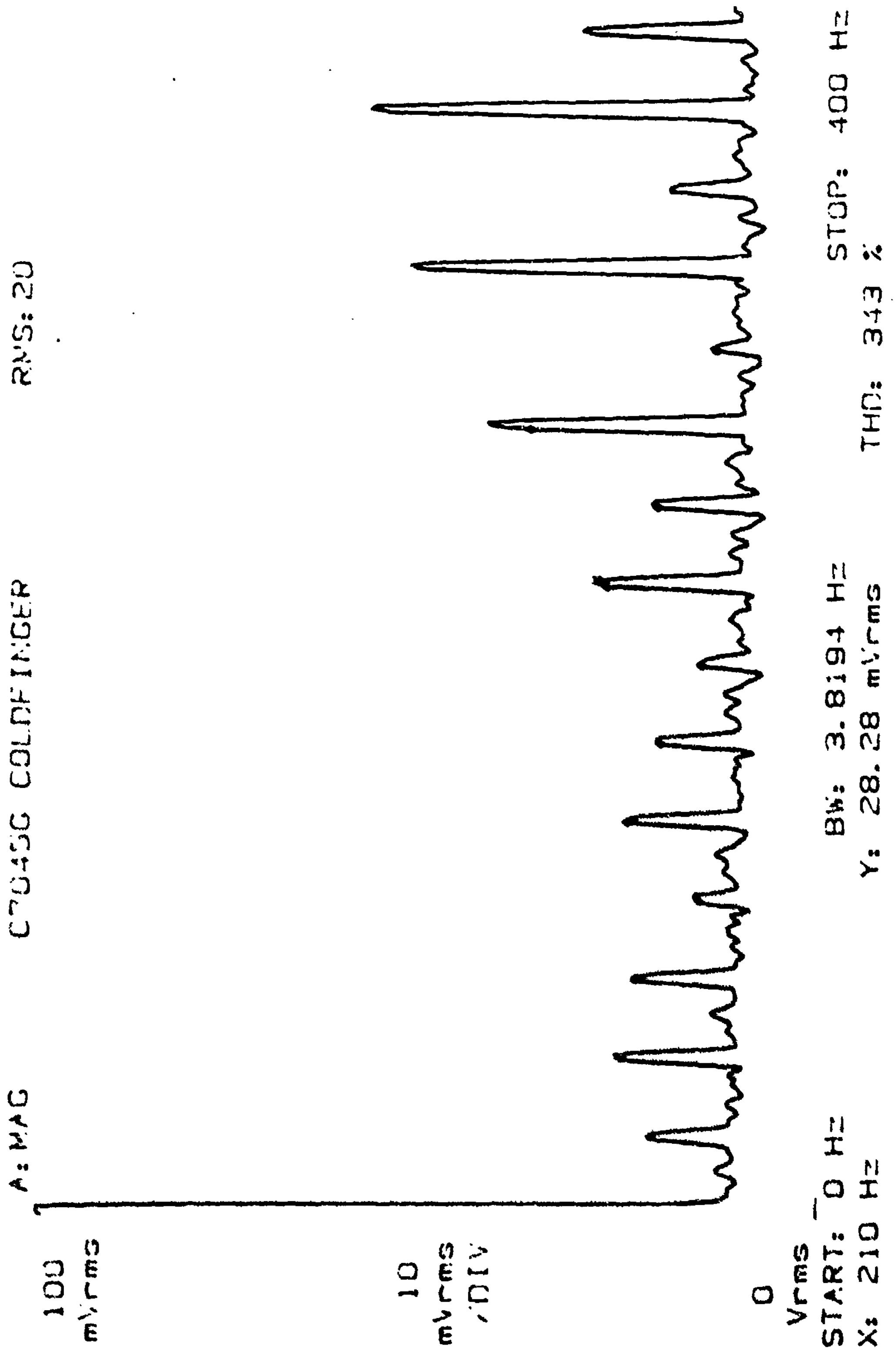
## VIBRATION OUTPUT—S/N D-0012

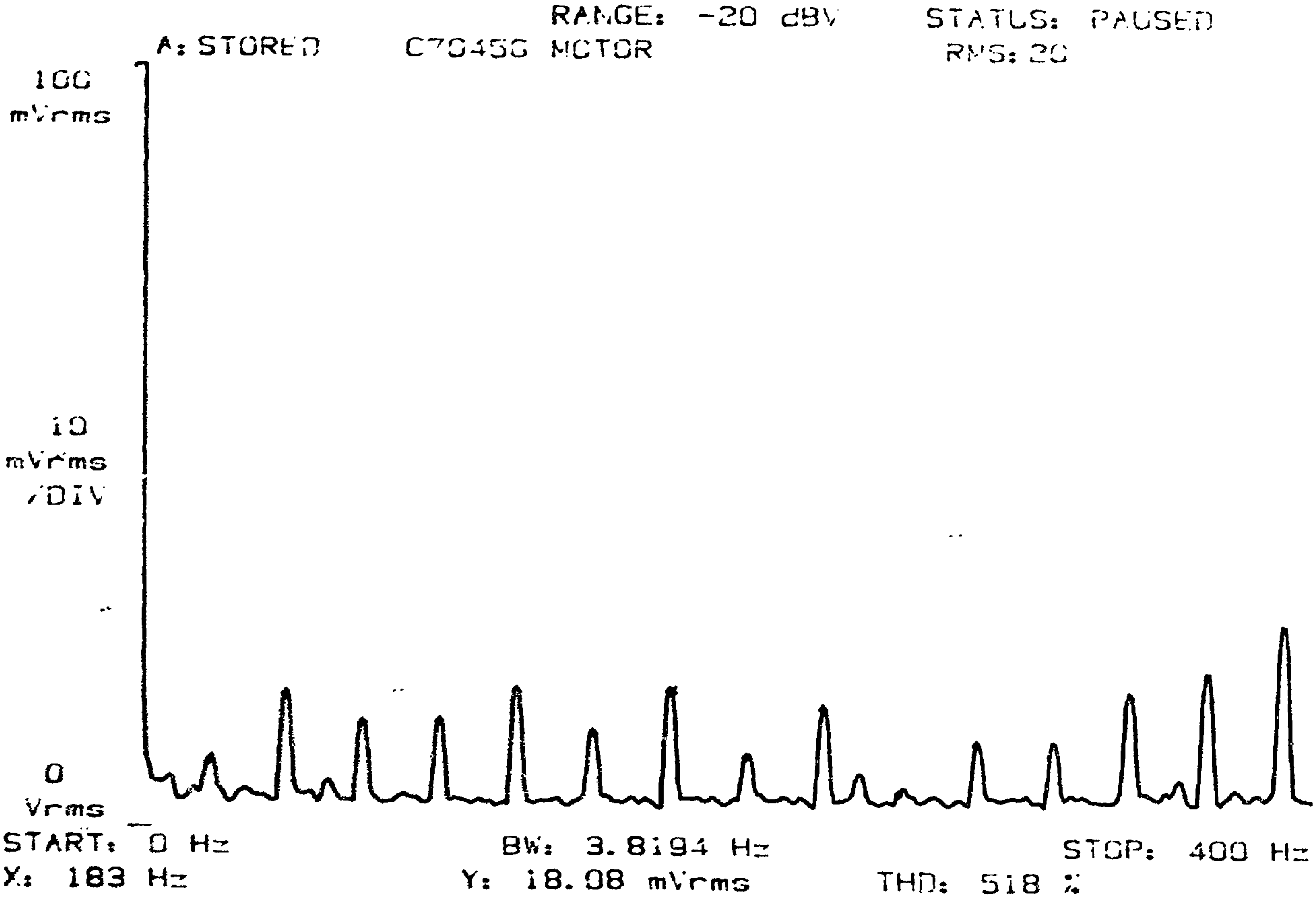


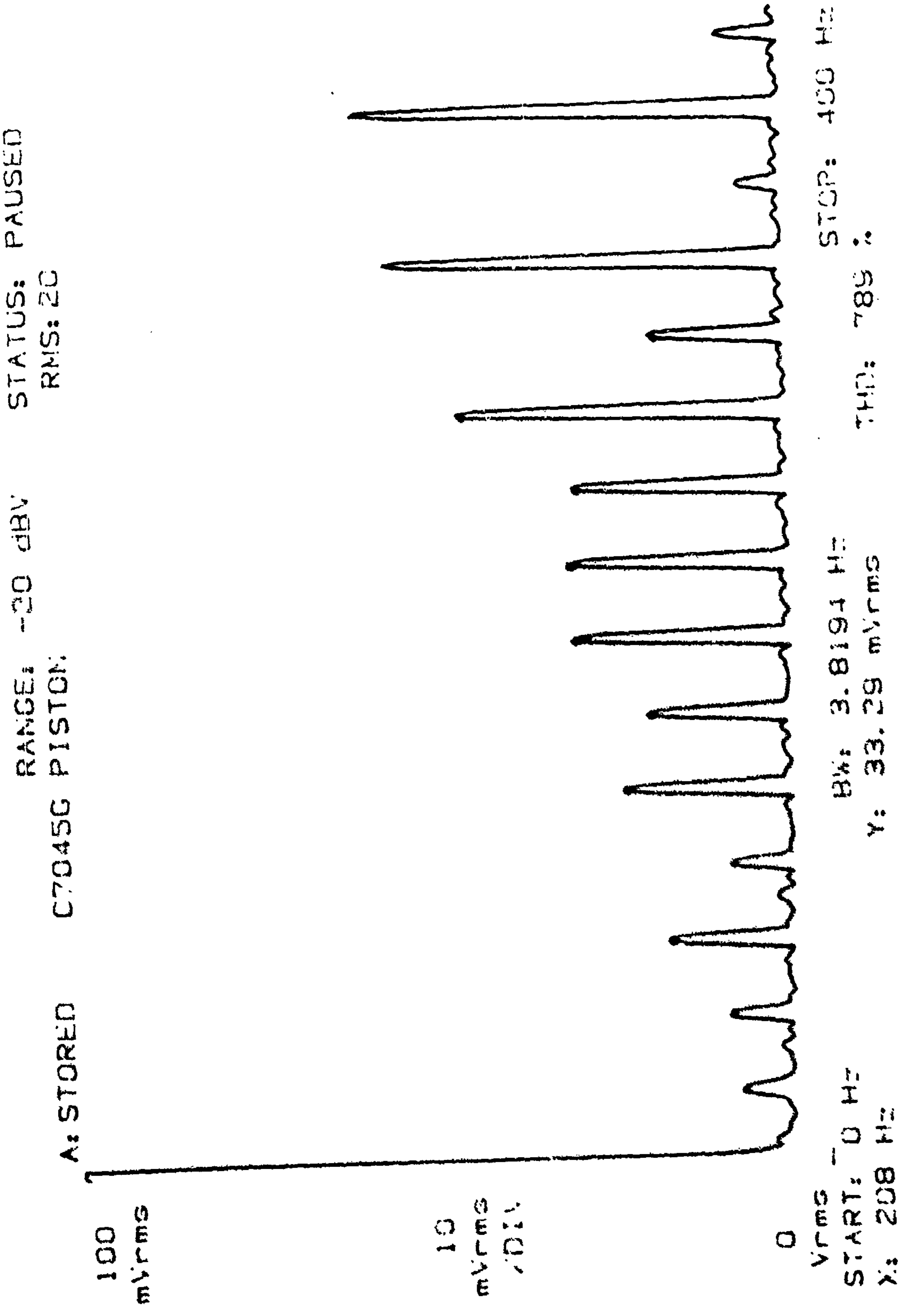

RANGE: -20 dBV
STATUS: PAUSED
A: STORED
D0012 MOTOR
RMS: 20
100
mVrms
10
mVrms
/DIV
0
Vrms
START: 0 Hz
X: 211 Hz
BW: 3.8194 Hz
Y: 38.79 mVrms
THD: 487 %
STOP: 400 Hz


A: STORED
RANGE: -20 dBV
STATUS: PAUSED
00012 PISTON
RMS: 20
100 mVrms
10 mVrms /DIV
0 Vrms
START: 0 Hz
BW: 3.8194 Hz
STOP: 400 Hz
X: 237 Hz
Y: 28.25 mVrms
THD: 270 %

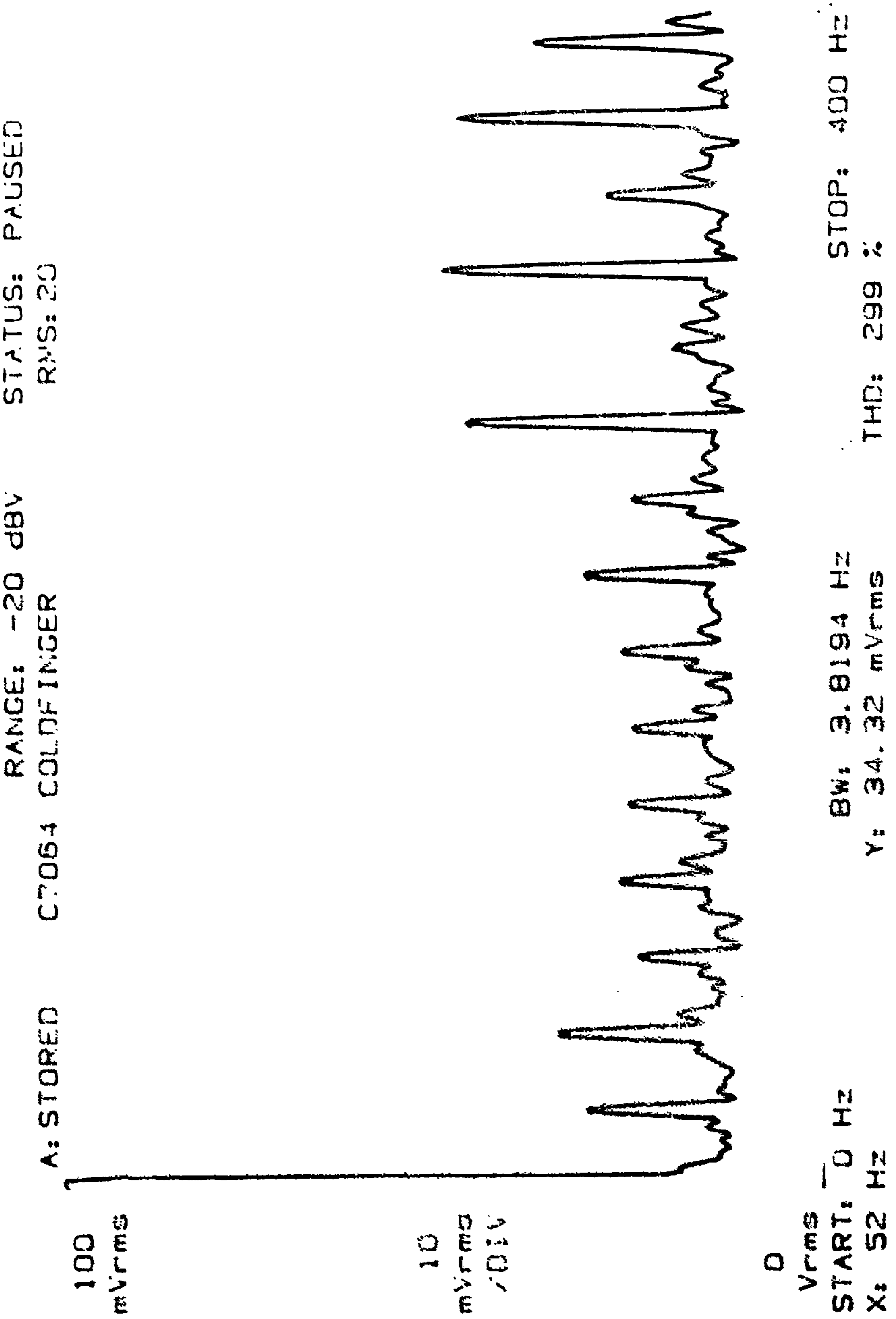
# VIBRATION OUTPUT—S/N C7045G

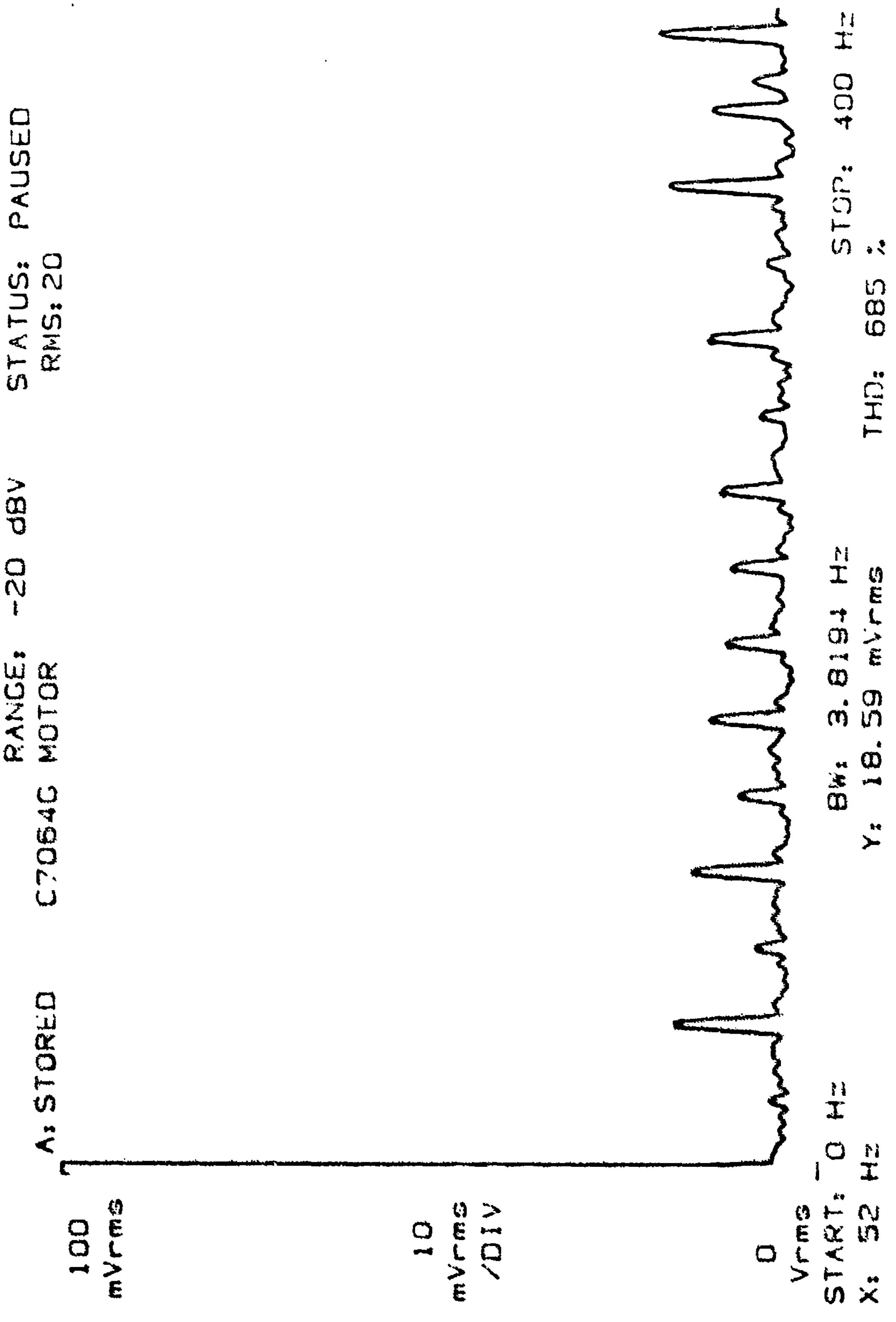


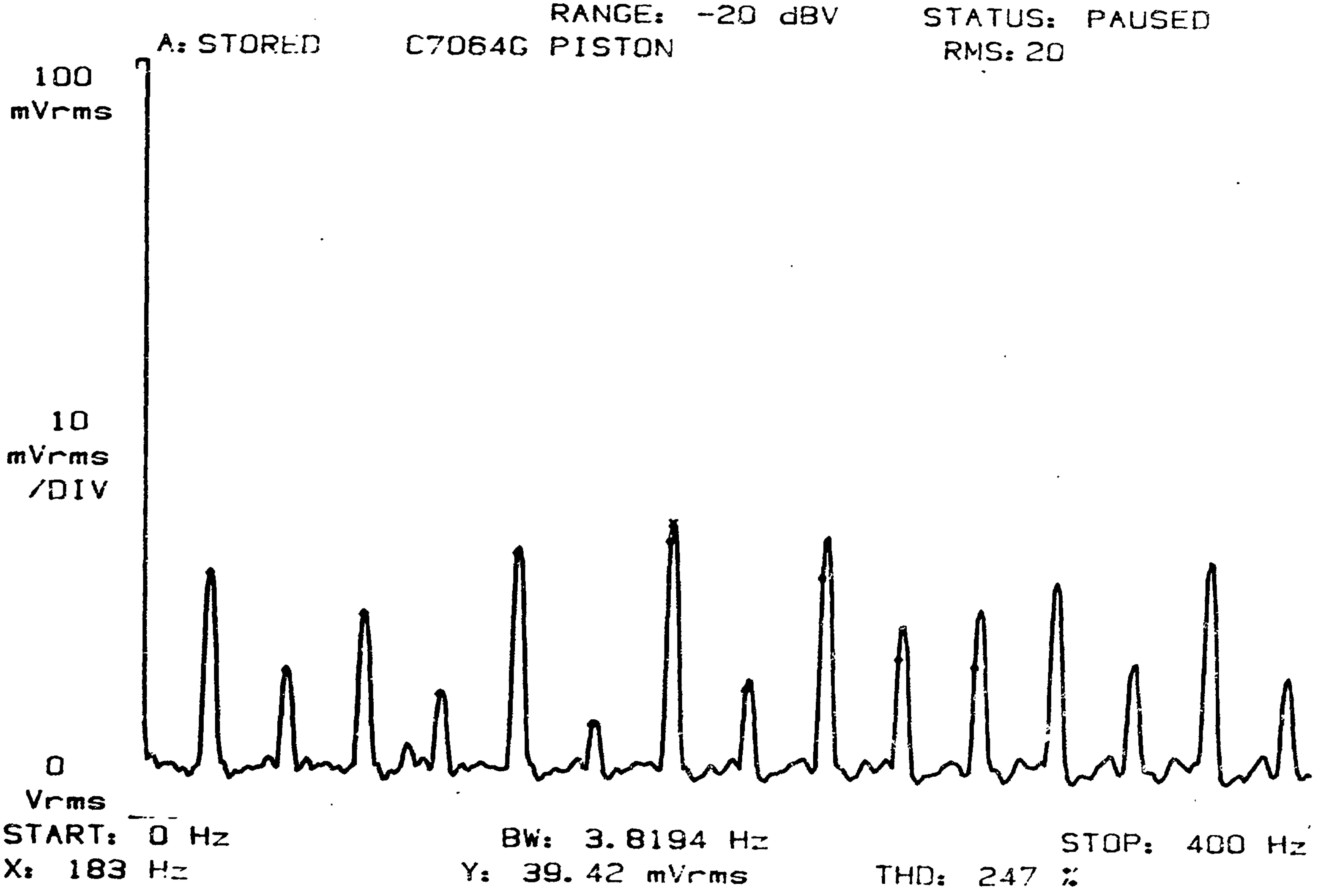

RANGE: -20 dBV
STATUS: PAUSED
A: STORED
C7045G MOTOR
RMS: 20
100 mVrms
10 mVrms /DIV
0 Vrms
START: 0 Hz
BW: 3.8194 Hz
STOP: 400 Hz
X: 183 Hz
Y: 18.08 mVrms
THD: 518 %


A: STORED
RANGE: -20 dBV
STATUS: PAUSED
C7045C PISTON
RMS: 20
100 mVrms
10 mVrms /DIV
0 Vrms
START: 0 Hz
BW: 3.8191 Hz
STOP: 400 Hz
X: 208 Hz
Y: 33.29 mVrms
THD: 789 %

# VIBRATION OUTPUT—S/N C7064G




A: STORED
C7064C MOTOR
RANGE: -20 dBV
STATUS: PAUSED
RMS: 20
100
mVrms
10
mVrms
/DIV
0
Vrms
START: 0 Hz
X: 52 Hz
BW: 3.8194 Hz
Y: 18.59 mVrms
THD: 685 %
STOP: 400 Hz


RANGE: -20 dBV
STATUS: PAUSED
A: STORED
C7064G PISTON
RMS: 20
100
mVrms
10
mVrms
/DIV
0
Vrms
START: 0 Hz
X: 183 Hz
BW: 3.8194 Hz
Y: 39.42 mVrms
STOP: 400 Hz
THD: 247 %

# APPENDIX H
# PURCHASE DESCRIPTION (PD) 0182-001 (CR), 9/26/86

PD-0182-001(CR)
26 September 1986

## PURCHASE DESCRIPTION

## COOLER, CRYOGENIC LONG LIFE, ONE WATT INTEGRAL

This Document May Be Used for a Purchase Description
for This Procurement Only.

APPROVAL:

PROJECT LEADER
COOLER, CRYOGENIC LONG LIFE,
ONE WATT INTEGRAL

CONFIGURATION MANAGER
CECOM CENTER FOR NIGHT
VISION AND ELECTRO-OPTICS CENTER

REVIEWED BY:

H. J. Brugger Jr.
DIRECTOR
CECOM, PA&T DIRECTORATE
ELECT/PMDE DIVISION
NIGHT VISION EOC BRANCH

PD-0182-001 (CR)
26 September 1986

# PURCHASE DESCRIPTION

# COOLER, CRYOGENIC LONG LIFE, ONE WATT INTEGRAL

This Purchase Description is approved for use by USACECOM, Department of the Army and is available for use by all Departments and Agencies of the Department of Defense.

## 1. SCOPE

1.1 Scope. This Purchase Description covers one type of common module; one watt integral cryogenic cooler built with clearance seals.

## 2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this purchase description to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-P-116 - Preservation-Packaging, Methods of
MIL-P-11268 - Parts, Materials, and Processes Used in Electronic Equipment
MIL-E-55585 - Electronic Equipment and Parts, Packaging of

STANDARDS

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-252 - Classification of Visual and Mechanical Defects for Equipment, Electronic, Wired, and Other Devices
MIL-STD-454 - Standard General Requirements for Electronic Equipment
MIL-STD-726 - Packaging Requirement Codes
MIL-STD-810C - Environmental Test Methods

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Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: HQ, USA Communications - Electronics Command and Fort Monmouth, ATTN: AMSEL-ED-TO, Fort Monmouth, NJ 07703 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 5855

DRAWINGS

USA ELECTRONICS R&D COMMAND

| | |
|---|---|
| SM-D-773447 | - Outline Dimension, Cooler, Cryogenic, Mechanical |
| 54490-5004372 | - Cryogenic Heat Load Assembly (1 Watt Integral) |

(Copies of specifications, standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this purchase description to the extent specified herein. Unless otherwise indicated the issue in effect on the date of invitation for bids or request for proposal shall apply.

| | |
|---|---|
| ANSI S1.11-1971 | - Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets |

(Application for copies of ANSI standards should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.)

## 3. REQUIREMENTS

3.1 Description. The Cooler, Cryogenic, Long Life, One Watt Integral, referred to herein as the cooler, is a closed-cycle refrigerator for cooling the infrared detector and interfacing with the Dewar of the infrared Detector-Dewar package in an infrared system. The cooler is identical in performance and external configuration as the HD-1033B/UA and HD-1033C/UA. In system usage they are completely interchangeable.

3.2 Construction. The cooler shall be constructed in accordance with the outline dimension drawing of SM-D-773447 and as specified herein.

3.2.1 Weight. The weight of the cooler shall be 3.7, (+0.2, -0.2) pounds.

3.3 First article. The contractor shall furnish first article assemblies in accordance with 4.3.

3.4 Materials, parts, and processes. Materials, parts, and processes shall be as specified herein and as shown on the applicable drawings. Materials, parts, and processes not specified shall be selected by the contractor in accordance with MIL-P-11268.

3.5 Components. The cooler shall consist of an ac motor-driven, helium-filled compressor with a coldfinger.

3.6 Performance characteristics. The cooler shall meet the performance characteristics specified herein when adequate heat sinking or convective cooling is provided to ensure that any point on the cooler cylinder head shall fall within 5°C to 15°C above ambient air temperature.

3.6.1 Cooling capacity. The cooler with thermal load (copper mass) shall provide the minimum refrigeration capacity at 80 K maximum as shown in Figure 1, curve A.

3.6.2 Cooldown time. The cooldown time to reach a cold tip temperature of 80 K with a 1440, (+25, -0) joule copper thermal mass (in accordance with Drawing 54490-5004372) (from 300 K to 80 K) shall be in accordance with figure 2.

3.6.3 Input power. The total input power to the cooler shall not exceed that shown in figure 3 with 1440, (+25, -0) joule thermal mass and at a coldfinger temperature of 80 (+0, -20) K with the heat load shown in figure 1, curve A as a minimum. The input voltage shall be 117, ±2 volts alternating current (VAC), 400, ±20 hertz (Hz) power source.

3.6.4 Acoustic noise. The cooler noise emission shall not be more than the values listed below, when measured at a distance of 3 feet.

Sound pressure values

| Center frequency (Hz) | Octave band (Hz) | Maximum sound pressure level (dB), reference 0.0002 microbar |
|---|---|---|
| 125 | 87-175 | 45 |
| 250 | 175-350 | 45 |
| 500 | 350-700 | 48 |
| 1000 | 700-1400 | 55 |
| 2000 | 1400-2800 | 60 |
| 4000 | 2800-5600 | 65 |
| 8000 | 5600-11200 | 67 |

3.6.5 Leak rate. The leak rate of the cooler shall not be greater than 2.5 x $10^{-6}$ cubic centimeters per second (cc/sec) helium equivalent at an ambient temperature of +23°C, ±5°C.

3.6.6 Vibration output. The maximum amplitude, at the ambient temperature of +23°C, ±5°C, of the vibrational force induced by the cooler at a frequency of 26, ±4 Hz or any of the next eight harmonics along the compressor piston and coldfinger axes shall not exceed 0.35 pound (semi-amplitude) and shall not exceed 0.5 pound (semi-amplitude) along the motor axis. The maximum amplitude of the torque induced by the cooler about the motor, piston and coldfinger axes at 26, ±4 Hz or any of the next eight harmonics shall not exceed:

a. 4.0 in-oz (semi-amplitude) compressor piston axis
b. 4.0 in-oz (semi-amplitude) coldfinger axis
c. 15.0 in-oz (semi-amplitude) motor axis.

3.6.7 Restart. The cooler shall restart after having cooled to the operating temperture of at least 80K at any ambient from -54°C to +71°C.

3.7 Environmental conditions.

3.7.1 Temperature shock. The cooler shall not be damaged (see 6.3.1) by sudden changes in temperature between -62°C and +95°C.

3.7.2 High temperature. The cooler shall not be damaged by storage to +95°C or operation up to +71°C.

3.7.3 Low temperature. The cooler shall not be damaged by operation to -54°C or storage to -62°C.

3.7.4 Shock. The cooler shall not be damaged by high intensity shocks of 100 g's peak amplitude with 11 milliseconds duration and by bench handling tests.

3.7.5 Vibration. The cooler shall not be damaged by vibration over a frequency spectrum at the specified g levels and amplitudes shown in figure 4.

3.8 Burn-in. Each cooler delivered shall have accumulated a minimum of 12 hours burn-in over the temperature profile in accordance with figure 5.

3.9 Reliability. The cooler shall have a lower mean-time-to failure (MTTF) (See 6.3.3) of at least 2,500 hours.

3.10 Treatment. Unless otherwise specified, the cooler and its components and parts shall be cleaned and treated in accordance with the applicable drawing.

3.11 Nameplates and product marking. Unless otherwise specified, the cooler. parts, components, subassemblies, and assemblies thereof shall be marked for identification and reference designation markings in accordance with the applicable drawing.

3.12 Workmanship. Workmanship shall be in accordance with MIL-STD-454. Requirement 9.

## 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsiblity for inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspections. Inspections shall be classified as follows:

a. First article inspection (see 4.3).
b. Quality conformance inspection (see 4.5).
c. Inspection of packaging (see 4.10).

4.3 First article inspection. Unless otherwise specified in the contract, the first article inspection shall be performed by the contractor.

4.3.1 Inspections. All materials, parts, processes and assemblies shall be examined for conformance to the applicable specification or drawing. Inspections shall be made using MIL-STD-105, General Inspection Level II with a 2.5 percent AQL for mechanical and a 4 percent AQL for visual inspection, except as noted in table I.

TABLE I. Inspections.

| Inspection Requirement | Percent AQL | Requirement paragraph | Inspection criteria |
|---|---|---|---|
| Any part or component missing or damaged | 2.5 | 3.2, 3.4 | MIL-STD-252 |
| Weight not as specified | 2.5 | 3.2.1 | MIL-STD-252 |
| Treatment not as specified | 2.5 1/ | 3.10 | |
| Marking not as specified | 2.5 | 3.11 | |
| Workmanship not as specified | 2.5 | 3.12 | MIL-STD-454 |
| Dimensions not as specified | | 3.2 | SM-D-773447 |

1/ MIL-STD-105, Inspection Level S-3 or objective quality evidence.

4.3.2 Test. Upon successful completion of the inspections specified in 4.3.1. four first article coolers shall be subjected to reliability testing and 2 first article coolers shall be subjected to all other tests listed in table II. Tests may be conducted in any order. Failure of any test shall constitute first article failure.

4.3.3 Disposition of first article samples. First article samples shall not be considered as part of the procurement quantities (see 6.2.f).

TABLE II. First article inspection.

| Inspection | Requirement paragraph | Test paragraph |
|---|---|---|
| Cooling capacity | 3.6.1 | 4.6.1 |
| Cooldown time | 3.6.2 | 4.6.2 |
| Input power | 3.6.3 | 4.6.3 |
| Acoustic noise | 3.6.4 | 4.6.4 |
| Leak rate | 3.6.5 | 4.6.5 |
| Vibration output | 3.6.6 | 4.6.6 |
| Restart | 3.6.7 | 4.6.7 |
| Temperature shock | 3.7.1 | 4.7.1 |
| High temperature | 3.7.2 | 4.7.2 |
| Low temperature | 3.7.3 | 4.7.3 |
| Shock | 3.7.4 | 4.7.4 |
| Vibration | 3.7.5 | 4.7.5 |
| Reliability | 3.9 | 4.9 |

4.4 Inspection procedures for quality assurance provisions. Unless otherwise specified herein, the cooler shall be operated at an ambient temperature of +23°C, ±5°C. Adequate heat sinking or convective cooling shall be provided to ensure that any point on the cooler cylinder head shall fall within 5°C to 15°C above ambient air temperature (see 3.6).

4.5 Quality conformance inspection.

4.5.1 Inspection. Inspection shall be as specified in 4.3.1.

4.5.2 Tests.

4.5.2.1. Burn-in. Burn-in shall be in accordance with 4.8 and shall be performed upon each cooler that has passed the inspection of 4.5.1.

4.5.2.2 Group A inspection. Group A inspection shall be conducted on all coolers which have completed burn-in specified in 4.5.2.1. Group A tests listed in table III may be performed in any order unless otherwise specified. Failure of any test shall be cause for rejection of that unit.

TABLE III. Group A inspection.

| Inspection | Requirement paragraph | Test paragraph |
|---|---|---|
| Cooling capacity | 3.6.1 | 4.6.1 |
| Cooldown time | 3.6.2 | 4.6.2 |
| Input power | 3.6.3 | 4.6.3 |
| Leak rate | 3.6.5 | 4.6.5 |
| Restart | 3.6.7 | 4.6.7 |

4.5.2.3 Group B inspection. Not required.

4.5.2.4 Group C inspection. Group C inspections shall be conducted on coolers selected from units which have passed the tests in 4.5.2.2 (see 6.2.h). The sample(s) shall be tested in accordance with the inspections listed in table IV. Samples shall be selected in accordance with 4.5.2.4.1. Group C tests listed in table IV may be performed in any order.

4.5.2.4.1 Sampling for Group C inspection. One Group C sample shall be randomly selected from the initial delivery quantity and one sample selected from every 150 units thereafter.

TABLE IV. Group C inspection.

| Inspection | Requirement paragraph | Test paragraph |
|---|---|---|
| Acoustic noise | 3.6.4 | 4.6.4 |
| Vibration output | 3.6.6 | 4.6.6 |
| Temperature shock | 3.7.1 | 4.7.1 |
| High temperature | 3.7.2 | 4.7.2 |
| Low temperature | 3.7.3 | 4.7.3 |

4.5.2.4.2 Group C failures. Actions required relative to Group C failures shall be specified in the contract (see 6.2.c.(2)).

4.5.2.4.3 Disposition of Group C samples. Group C samples shall be accepted on contract subsequent to successful Group A retest.

4.5.2.5 Group D inspection. Group D inspections shall be conducted on coolers selected from units which have passed the tests in 4.5.2.2. The samples shall be tested in accordance with 4.9.

4.5.2.5.1 Sampling for Group D inspection. The sample shall be randomly selected from the production quantity such that the results of the test will be obtained prior to delivery of 75 percent of the total quantity.

4.5.2.5.2 Group D Failures. Actions required relative to group D failures shall be specified in the contract (see 6.2.c.(3)).

4.5.2.5.3 Disposition of Group D Samples. Group D samples shall not be considered as part of the procurement quantities (see 6.2.f).

4.6 Test methods.

4.6.1 Cooling capacity. The cooling capacity shall be measured by attaching to the cooler a test Dewar and coldstation. The heat load shall be applied after achieving cooldown. Capacity shall be measured not less than 30 minutes later. The tests of paragraphs 4.6.1, 4.6.2 and 4.6.3 shall be performed using test equipment consisting of the following items to measure cooldown and refrigeration capacity:

1. Test dewar

2. Coldstation

3. Appropriate power supplies and meters

4. High vacuum source

a. The test dewar shall be made of either brass or aluminum with a highly polished surface finish of at least an 8 RMS. The test dewar in conjunction with the high vacuum source shall enclose the coldfinger and coldstation in a vacuum of $1x10^{-5}$ torr or lower.

b. The 1440 joule coldstation shall consist of the following elements as defined on drawing 54490 5004372: copper block, temperature sensor, resistor, thermally conductive epoxy and a clamp screw.

c. The coldstation assembly will have the following characteristics:

   1. The temperature sensor and resistor will be bonded to the copper block with the thermally conductive epoxy.

   2. The thermal energy which must be removed when cooling the coldstation from 300 K to 80 K shall be 1440, (+25. -0) joules. The mass of the coldstation shall be adjusted until it meets this requirement.

3. The resistor in the coldstation shall have a voltage applied to obtain a 1000, (+20, -0) mw thermal load. The applied voltage shall be such that the product of the voltage and the current of the resistor shall equal 1000, (+20, -0) mw.

4. The resistor and temperature sensor shall be connected to a vacuum feedthru by four teflon coated constantan wires. The wires shall be less than six inches in length and the resistance shall be less than one percent of the value of the resistor in the coldstation.

5. The coldstation is clamped to the coldfinger, sufficiently tight to effect good heat transfer without damaging the coldfinger.

6. Good thermal conductivity is assured by applying a metal oxide impregnated silicone thermal joint compound to the end of the coldfinger that is in contact with the coldstation.

7. A radiation shield shall not be used.

4.6.2 Cooldown time. Cooldown time shall be measured using the test Dewar and the copper mass described in 4.6.1. Failure to meet requirements of 3.6.2 shall constitute failure of this test.

4.6.3 Input power. Input power shall be measured at a coldfinger temperature no higher than 80 K. Failure to meet requirements of 3.6.3 shall constitute failure of this test.

4.6.4 Acoustic noise. The cooler shall be set up for operation in an area where the background noise level is at least 5 dB below the sound level to be measured. The cooler shall be operated and sound pressure measurements made with the cooler oriented in 4 positions in the same plane with each position approximately 90 degrees apart. Measurements shall be made with an octave-band analyzer with characteristics which comply with ANSI Specification S1.11-1971. The test shall be performed without using a test Dewar. Failure to meet requirements of 3.6.4 shall constitute failure of this test.

4.6.5 Leak rate. The cooler shall be placed in a bell jar or suitable fixture connected to a helium mass spectrometer. The bell jar or fixture shall be evacuated to establish an inside-out test mode. Operating test shall not be performed during leak rate test. The leakage rate shall be measured at +23°C, ±5°C ambient. Failure to meet requirements of 3.6.5 shall constitute failure of this test.

4.6.6 Vibration output. The cooler shall be turned on for 15 minutes to allow it to reach equilibrium temperature. The cooler shall be vertically suspended such that the fundamental frequency of the cooler is much higher than the natural frequency of the suspension system. The static deflection of this arrangement shall be in excess of 6 inches and critical frequency ($f_{cr}$) of 1.3 Hz approximately. The acceleration along each axis shall be obtained by attaching an accelerometer to the center of the piston and motor faces and to the unit centered on the coldfinger axis. Moments around each axis shall be obtained by attaching two accelerometers (to the motor, piston face or coldfinger face) and coherently subtracting the two signals. This difference divided by the separation distance between the accelerometers yields the angular acceleration. Moment of inertia shall be obtained from the period of a bifilar pendulum containing the cooler. Peak forces are derived from the expression F = MA, where F is the peak force. M is the cooler mass, and A is the measured acceleration at a given frequency. Peak torque is derived from the expression T = I $\alpha$, where T is the peak torque, I is the moment of inertia about the principal axis, and $\alpha$ is the measured angular acceleration for the applicable axis at a given frequency. The test shall be performed without using a test Dewar. Failure to meet requirements of 3.6.6 shall constitute failure of this test.

4.6.7 Restart. The cooler shall be operating at 80K or less in a 23°C + 5°C ambient. The power switch shall be turned off and the cooler motor shall be be at rest. The power switch shall be turned on and the cooler must start within 5 seconds. This test shall be repeated a total of five times. The cooler shall also be tested at -54°C and +71°C using the above procedure during the high and low tests of 4.7. The restart test shall be performed after the cool down and cooling capacity test. Failure to meet the requirement of 3.6.7 shall consitute failure of this test.

4.7 Environmental tests. Unless otherwise specified, the environmental tests shall be performed in accordance with MIL-STD-810. The operating tests required before and after environmental tests shall be those specified in table III. During 4.7.2 and 4.7.3, operating test 4.6.1, 4.6.2 and 4.6.3 shall be performed and must be successfully completed. Operating tests are not required during 4.7.1, 4.7.4 and 4.7.5 except that the unit under test shall have power applied during 4.7.4 (Procedure IV only) and 4.7.5.

4.7.1 Temperature shock. The cooler shall be tested in accordance with MIL-STD-810, Method 503.1, Procedure I except that the temperature of step 2 shall be -62°C and the temperature of step 1 and step 4 shall be +95°C. Failure to meet requirements of 3.7.1 shall constitute failure of this test.

4.7.2 High temperature. The cooler shall be tested in accordance with MIL-STD-810, Method 501.1, Procedure I (see figure 6) except that the temperature of step 2 shall be +95°C. The temperature of steps 4 and 5 shall be +71°C. Failure to meet requirements of 3.7.2 shall constitute failure of this test.

4.7.3 Low temperature. The cooler shall be tested in accordance with MIL-STD-810, Method 502.1, Procedure I (see figure 7) except that the storage temperature of step 2 shall be -62°C and low operating temperature of step 4 shall be -54°C. Failure to meet requirements of 3.7.3 shall constitute failure of this test.

4.7.4 Shock. The cooler shall be tested in accordance with MIL-STD-810, Method 516.2, Procedure IV, figure 516.2-1 (100 g's peak value at 11 milliseconds time duration) and Procedure V. Failure to meet requirements of 3.7.4 shall constitute failure of this test.

4.7.5 Vibration. The cooler shall be tested in accordance with MIL-STD-810, Method 514.2, Procedure VIII except that the curve shown in figure 4 of this specification shall be used in lieu of the MIL-STD-810 curve. The sinusoidal cycle time shall be 120 minutes per axis. The dwell time shall be 1/6 of the cycling time at each resonance. Failure to meet requirements of 3.7.5 shall constitute failure of this test.

4.8 Burn-in. Each cooler shall be subjected to a minimum of 12 hours burn-in in accordance with figure 5. Failure of burn-in shall be defined as failure to pass the inspections listed in table III after burn-in. Any unit which fails and is repaired or is later altered, repaired or reworked, shall be resubjected to burn-in.

4.9 Reliability.

+522

4.9.1 Reliability. The lower MTTF shall be demonstrated using 4 coolers in accordance with the reliability test cycle shown in figure 8. Heat load, input power, cold tip temperature and ambient temperature shall be monitored hourly. Cooldown time shall be measured twice during each cycle of figure 8, at -32°C and +52°C. The tests of paragraph 4.9.1.1 shall be performed at least once prior to and once after the reliability test. The results of all 4.9.1.1 tests shall be used to determine the success or failure of the reliability test.

4.9.1.1 Failure definition. Failure shall be defined by any one of the four criteria below:

a. Inability to achieve the heat load carrying capability in accordance with figure 1, curve C at any ambient measured at 90 K when measured at any point during the 40-hour reliability cycle.

b. Failure to cooldown to 90K in 15 minutes.

c. Failure to meet 55 watts input power when measured at any point during the 40-hour reliability cycle.

d. Failure to meet the leak rate requirement of 3.6.5.

Should a failure occur in one of the four categories above, the hours accumulated since completion of the previously successful test, shall not be included in the accept/reject decision.

4.9.1.2 Accept/Reject decision. The accept/reject decision shall be made by the Government in accordance with the following definition. Four coolers shall be run until 10,000 total "on" hours have been accumulated. A cooler which experiences a relevant failure as determined by the Government shall not be repaired and put back into test. No single unit "on" time shall be less than ½ the average operating time of all units on test and no single unit "on" time shall be greater than 1.25 the average operating time of all units on test.

4.10 Inspection of packaging. Packaging shall be inspected in accordance with MIL-P-116 to determine compliance with requirements of section 5.

## 5. PACKAGING

5.1 Preservation. Preservation shall be as specified in MIL-STD-726, coded as follows:

5.1.1 Level A. 10-1-1-00-NS-X-ED-0-00-A.

5.1.2 Level B. 10-1-1-00-NS-X-ED-0-00-B.

5.2 Packing and marking. Packing and marking shall be in accordance with MIL-E-55665.

## 6. NOTES

6.1 Intended use. The cooler is intended for use in infrared systems.

6.2 Ordering data. Procurement documents should specify the following:

- a. Title, number, and date of this specification.
- b. First article tests are required except for existing suppliers (6.3.2).
    - 1. Time frame for submission of first article test reports when first article tests are required.
    - 2. Time frame for approval of first article test reports when first article tests are required.
- c. Production delivery schedule.
    - 1. Defined in terms of monthly lots.
    - 2. Actions required relative to group C failures (see 4.5.2.4.2).
    - 3. Actions required relative to group D failures (see 4.5.2.5.2).

d. Level A or level B preservation and packaging (the coldfinger is extremely delicate; packaging shall protect it from bending or distortion)(see section 5).

e. MIL-STD-810C shall be used for environmental tests of 4.7.

f. Deliver all first article samples to - Commander. USACECOM, ATTN: AMSEL-NV-EST, Fort Belvoir, VA 22060.

g. Environmental pollution prevention measures are contained in the packaging material specifications referenced herein. Refer to material specification or preparing activity for recommended disposability methods.

h. Group C and Group D inspection monthly sample size to be established based on cumulative totals of concurrent contract.

i. All coolers delivered shall contain port, purge per drawing 5006825 and ball valve screw per drawing 5006823.

6.3 Definitions.

6.3.1 Damage. Breakage, loosening, shifting, evidence of corrosion, or failure of any finish, hardware, connection or component; and any degradation of cooler performance to values less than specified herein.

6.3.2 Existing suppliers. Suppliers who are currently supplying equipment to this specification with a minimum average monthly rate of 10 units per month over the most current 12 month period. If a supplier cannot maintain the minimum monthly average, a first article test (less reliability) performed annually shall sustain the existing supplier's status when performed on 3 units manufactured by the supplier explicitly for this test.

6.3.3 Lower mean time to failure. The term "Lower" is used to define that value which is the least operational capability and/or the maximum operating and support cost burden the Army can tolerate and accept. This distinction is made to aid the system designer in allocating reliability characteristics of the device.

6.4 Design note. New coolers may see the input power increase when tested with a Dewar (0.4 WHL). The input power may increase from 50 w to 53 w at +23°C ambient temperature and from 55 w to 60 w at +71°C ambient temperature.

| | |
|---|---|
| CUSTODIAN: | PREPARING ACTIVITY: |
| Army CR | Army CR |

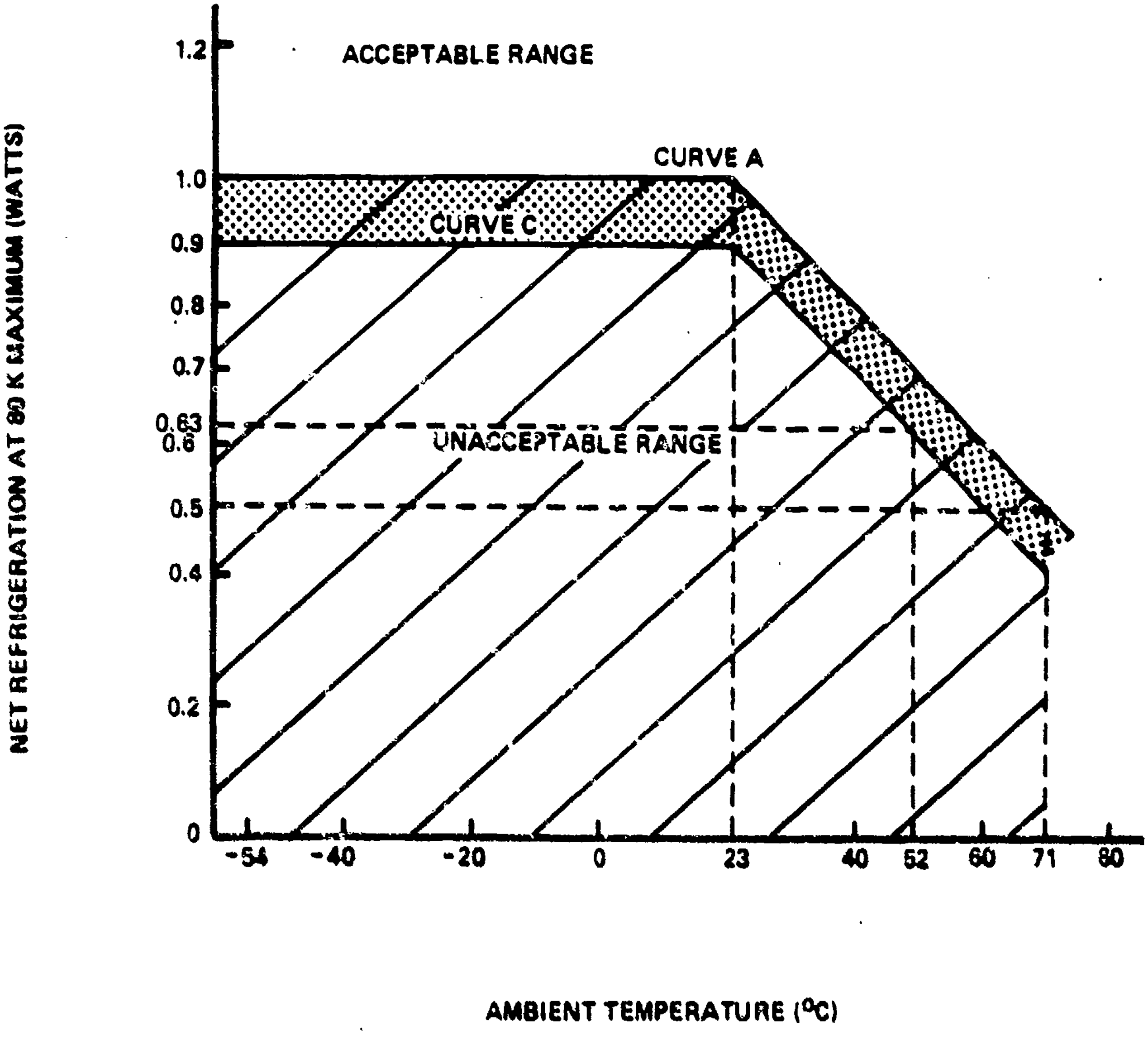


FIGURE 1. Cooling capacity.

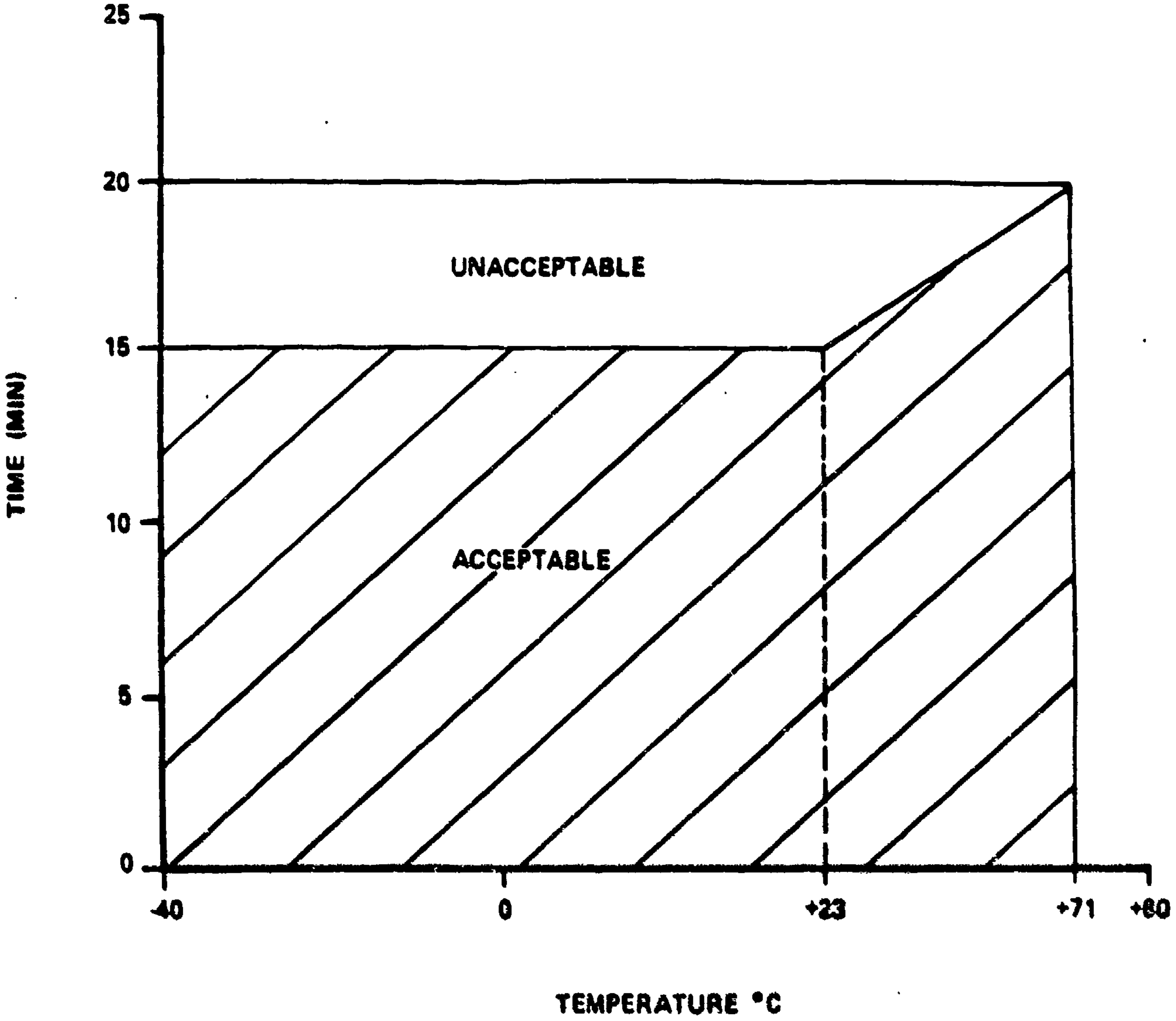


FIGURE 2. Cool down curve.

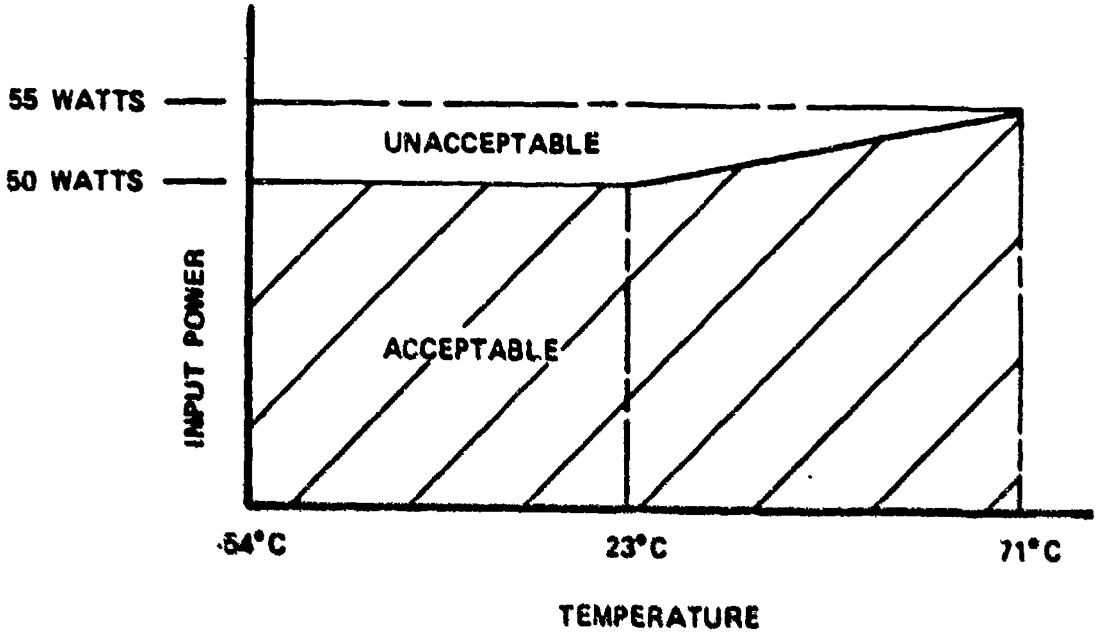


FIGURE 3. Input power with heat load applied.

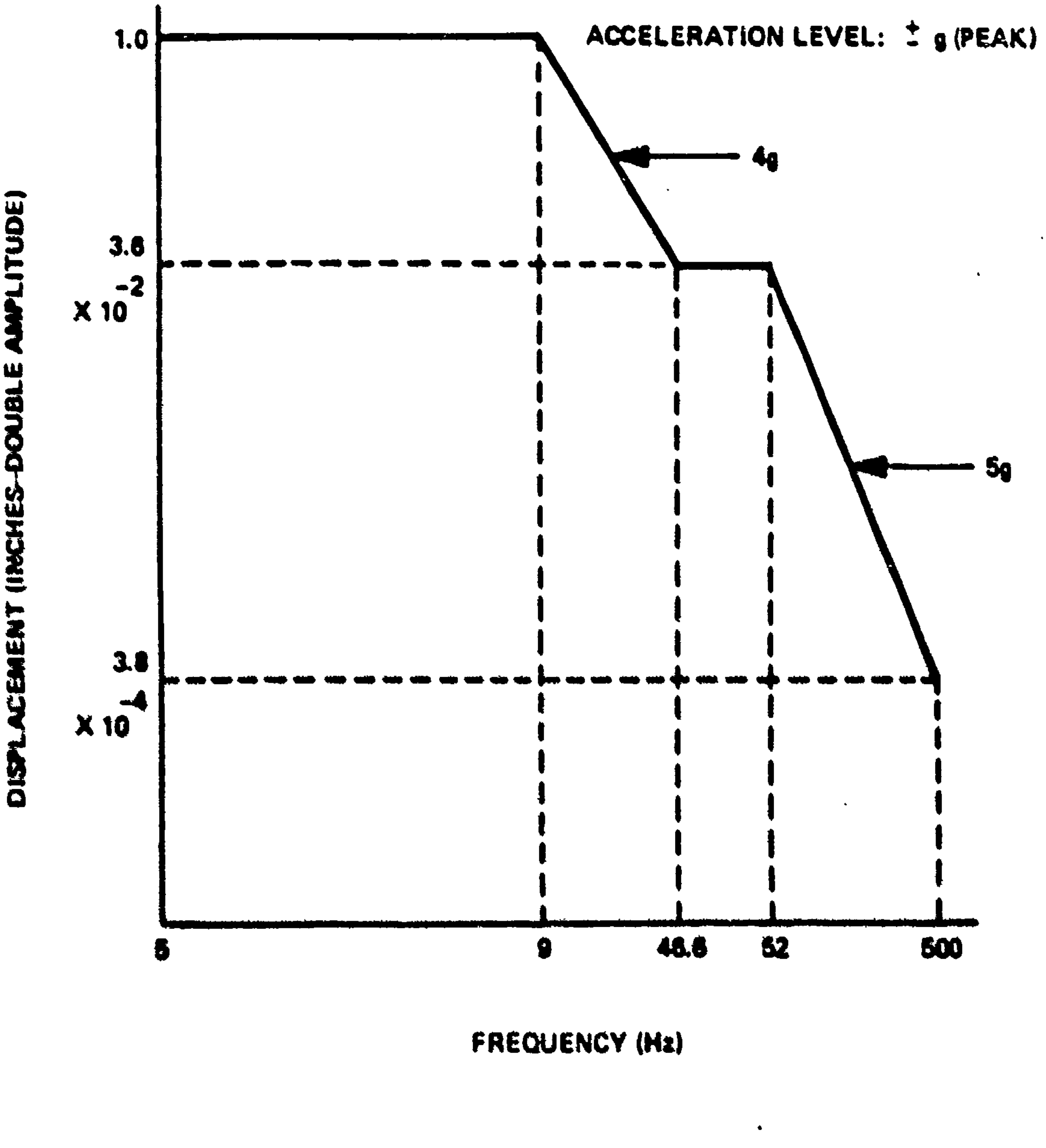
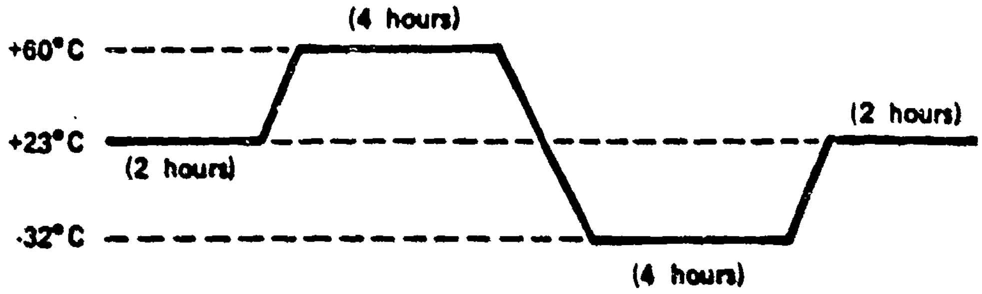
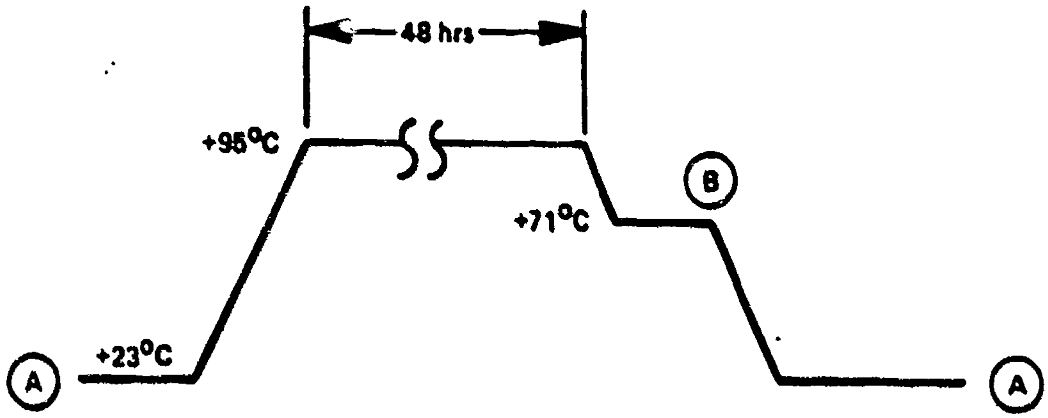


FIGURE 4. VIBRATION TEST PROFILE



1) CHAMBER TEMPERATURE EXTREMES SHALL NOT VARY MORE THAN 5°C PER HOUR.
2) RATE OF CHAMBER TEMPERATURE CHANGE SHALL AVERAGE LESS THAN 5°C PER MINUTE.
3) UNIT OPERATES THROUGH FULL CYCLE.

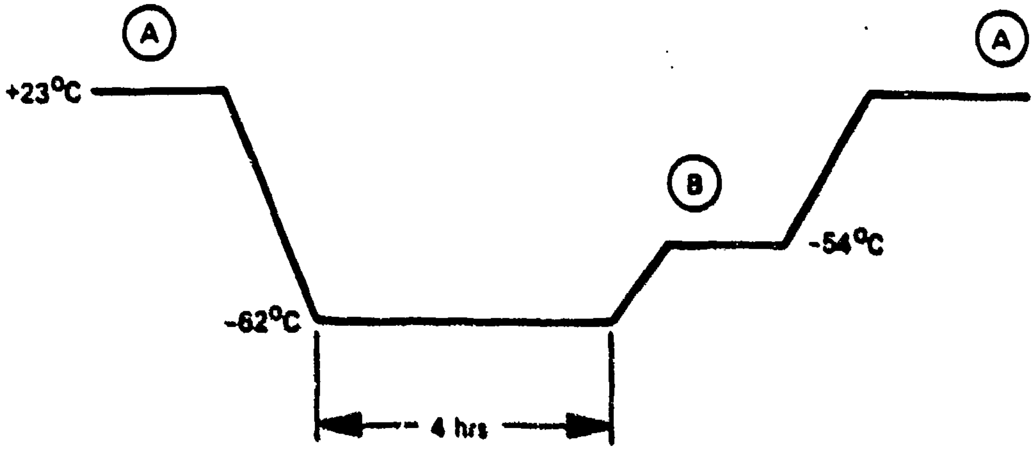
**FIGURE** 5. Burn-in.



Ⓐ GROUP A TESTS (TABLE III) ARE CONDUCTED AT THESE POINTS.

Ⓑ COLDFINGER TEMPERATURE WITH 0.5 WATT APPLIED HEAT LOAD MONITORED AT THIS POINT TO VERIFY ABILITY OF COOLER TO MAINTAIN 80 K TEMPERATURE.

FIGURE 6. HIGH TEMPERATURE TEST PROFILE



Ⓐ GROUP A TESTS (TABLE III) ARE CONDUCTED AT THESE POINTS.

Ⓑ COLDFINGER TEMPERATURE WITH 0.8 WATT APPLIED HEAT LOAD MONITORED AT THIS POINT TO VERIFY ABILITY OF COOLER TO MAINTAIN 80 K TEMPERATURE.

FIGURE 7. LOW TEMPERATURE TEST PROFILE

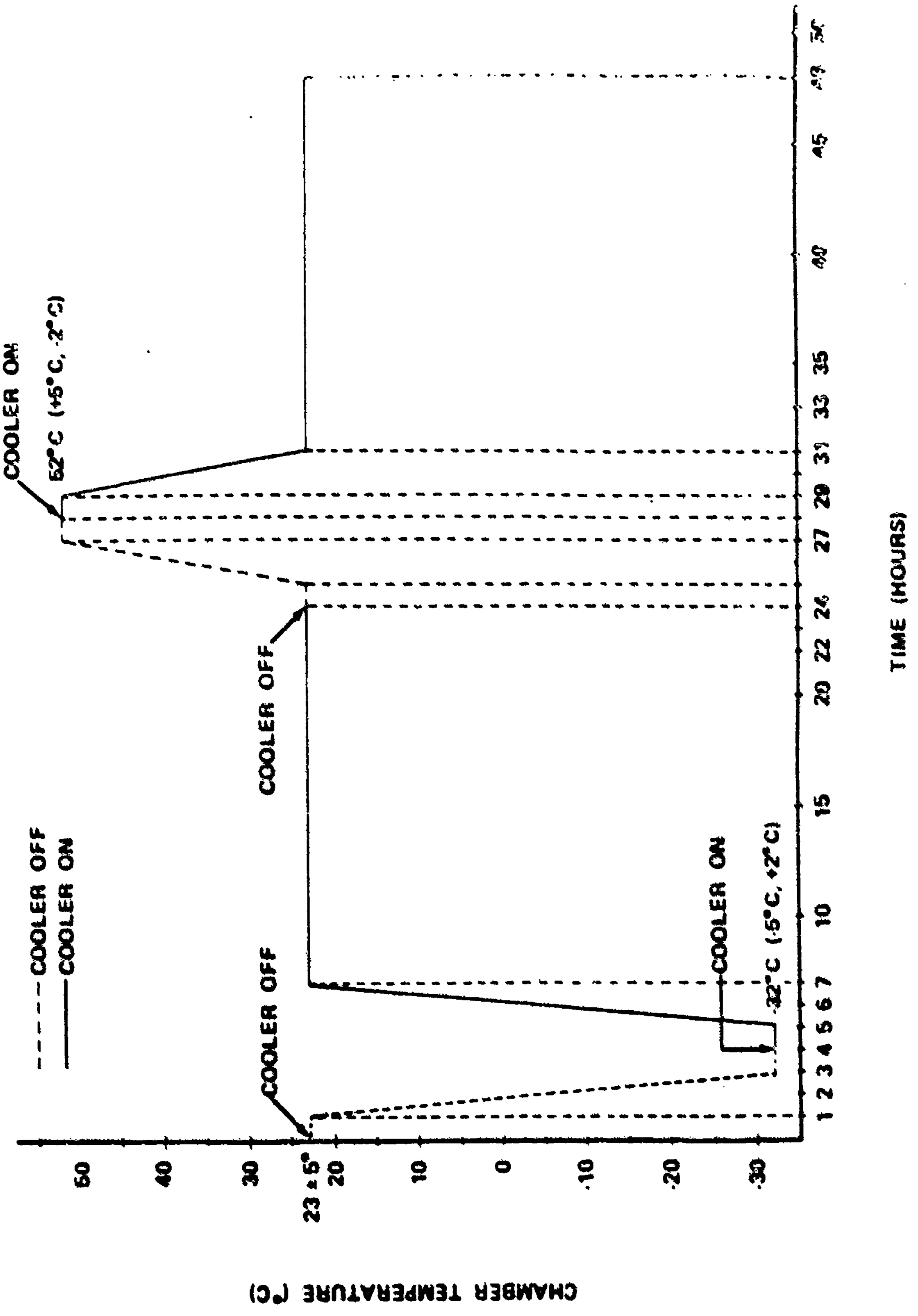


FIGURE H. Reliability Test

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