VLBA Electronics Memo No. 46

CTI Model 21/22 Cryogenic Refrigerator
Progress Report

- Summary -

Recent CTI Model 21/22 Cryogenic systems have demonstrated poor quality and high premature failure rate. Earlier CTI refrigerators, particularly a unit operating at Mojave Base Station, have shown excellent performance and durability. BFEC's Cryogenic Component Section (CCS) has been working with CTI to rectify this discrepancy.

A partial solution, developed by BFEC/CCS, to the problem of premature failure is the substitution of a polymer bearing material (Envex) for the carbon in the bushings supporting the displacer drive rod. Studies show before 3000 hours, carbon bushings had wear between .003 to .005-inch, while Envex-treated bushings had only .0005-inch wear after greater than 6000 hours.

The four field units and one life test unit have accumulated 30,000+ hours of operation.

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April 1985

To: Dr. Tom Clark/NASA Crustal Dynamics Project

From: R. A. Kriss/RF & Microwave Development Office

1.0 Introduction

CTI Model 21 and Model 22 Cryogenic Refrigerators have been in use in the VLBI/CDP for approximately eighteen months, cooling dual band S- and X-band LNA front end systems. This report encompasses the hours of operation of these refrigerators, the problems encountered, fixes applied to resolve the problems, and testing results.

2.0 Hours of Operation

At present there are four LNA systems operating at field locations in Alaska, Hawaii, Florida and Massachusetts, and one is undergoing life test at the BFEC Cryogenics Laboratory in Columbia, Maryland. The following table outlines the total hours of operation of each of the systems to date:

LNA-01	Coldhead S/N 1H33007	Haystack, Massachusetts	-----
LNA-02	Coldhead S/N 1H33013	Kauai, Hawaii	3000+
LNA-03	Coldhead S/N 1H32994	Fairbanks, Alaska	3000+
LNA-04	Coldhead S/N 11D43254	Richmond, Florida	-----
Life Test	Coldhead S/N 1H32999	BFEC, Columbia, Maryland	8000+
Prototype		Mojave, Goldstone, CA	$\sim$ 15,000

3.0 Failures

Three cold heads and three compressors were noted to be defective. All three compressors and one of the cold heads were returned to the manufacturer for replacement. The other two cold heads were repaired at BFEC and subsequently returned to service.

3.1 Compressor Failures

Two of the compressor failures were due to locked rotors, one occurring at initial turn on after receipt from the manufacturer, and one at the completion of initial test run. The third was a field failure with less than 1000 hours of running time.

3.2 Cold Head Failures

A. Cold Head S/N 11D43254

Problems: Cold solder joints on motor stator winding; metal filings and carbon dust in motor and valve housing due to broken yoke shaft bushing and misalignment of rotating parts.

Action: BFEC Cryogenics Laboratory repaired and tested the unit.

B. Cold Head S/N 11G43335

Problem: Ratcheting on initial turn on.

Action: Unit returned to manufacturer.

C. Cold Head S/N 1H33007

Problem: Field failure, drive motor failure.

Action: Motor replaced by manufacturer. BFEC Cryogenics Laboratory repaired and tested the cold head.

3.3 Corrective Action for Field Failures

All field failures of cold heads will be corrected by the replacement of the cold head assembly and the failed unit returned to the BFEC Cryogenics Component Section (CCS) for repairs.

Any compressor failures will be handled in a similar manner, by unit exchange and the failed unit returned to BFEC/CCS for repair and disposition as required.

4.0 Quality Control

In maintaining a high standard of quality control, the following operations are performed on each cryogenic refrigerator:

All cold heads are run/tested upon receipt from manufacturer.

All units are disassembled for close examinations.

Yoke shafts are polished.

Upper yoke bushings are pressed further into housing to prevent yoke shaft end entry into yoke drive bushing.

All unit's parts are thoroughly cleaned.

All unit's are reassembled, then purged and pressurized with 99.999% pure helium.

Units are cooled and run for 250 hours while temperature is monitored. This test run serves to indicate any infant mortality.

The helium compressors are run for approximately 800 hours and cycled on/off numerous times. (Infant failures generally occur before 1000 hours of operation).

5.0 Improvements

In addition to the above actions taken to ensure quality control, the BFEC CCS also makes several improvements to the units. These include:

Polishing the yoke drive shaft to a finish of 25 microns.

Replacing the carbon yoke shaft bushings with a self-lubricating polymer (Envex) material and line ream to a 0.0005-inch fit to the yoke drive rod. This is done upon failure of the carbon bushings.

Replacing the Scotch yoke guide buttons with Envex material versus the Micarda material. This is done when the bushings are replaced.

6.0 Status of LNA S/N 02

LNA S/N 02 has been cycled through the system. The cold head, S/N 1H33013 had greater than 3000 hours running time. The carbon yoke drive rod bushings were badly worn and grey dust was dispersed throughout the cold

head valve body assembly. The first stage seal was worn very thin in one area, primarily due to suspected misalignment of yoke drive rod bushings.

The following corrective maintenance actions were taken on the unit:

Carbon bushings replaced with Envex material and line reamed to fit yoke drive rod.

Yoke drive rod polished.

All shaft seals and O-rings replaced.

New displacer seals installed.

Yoke guide buttons replaced with Envex material.

7.0 Status of Life Test LNA

Cold head S/N 1H32999, mounted in an instrumented test dewar, has been running since mid-January 1984 and has accumulated 8000 hours of operation. This unit is also used as an engineering model for modifications and changes in types of materials used in the components of the cold heads.

Life Test history to date is as follows:

$\underline{\sim}$ 1900 Hours

Problems: Bushing wear and grey dust build-up on displacers.

Actions: Unit cleaned, carbon bushings replaced with Envex material, and displacer seals replaced (overhaul).

$\underline{\sim}$ 3500 Hours

Problem: Poor vacuum.

Actions: Unit rough pumped and recooled.

$\underline{\sim}$ 5200 Hours

Problems: Ratcheting and poor vacuum. Displacers had droplets of water on them when cold head was removed from cylinder.

Actions: Entire unit cleaned, replaced all "O"-Rings and seals, including first and second stage displacer seals, displacers cleaned and placed under hard vacuum of less than 10 microns for 24 hours (overhaul).

Notes: Close inspection showed minimum wear on Envex yoke drive rod bushings (~ 0.0005-inch). Cause of water on displacers has not yet been determined.

~ 5250 Hours

Problem: Unusual squeek.

Action: Lubricated Scotch yoke guide buttons.

~ 5650 Hours

Problems: Squeeking continued (determined to be Micarda yoke buttons), water on displacers.

Actions: Changed yoke buttons to Envex material, displacers desicated at 100°C with hard vacuum, vacuum pumped compressor and helium lines to less than 10μ for ~ 18 hours.

Note: Yoke drive bushings still show minimum wear.

~ 7500 Hours

Problem: Poor vacuum

Action: Unit rough pumped and recooled.

8.0 Mojave Base Station

The Mojave Base STation has a C.T.I. Model 21 Cross Head in use that has been operating troublefree since June of 1983, with an accumulated run-time of approximately 15K hours. This unit has not been opened since its initial cooldown and has operated constantly, except for receiver maintenance periods, at normal cold temperature. No problems have been experienced in subsequent cooldown attempts. The compressor absorber had been changed at 13K hours and only once was it necessary to add helium gas to the system.

Despite its excellent performance, however, this system is believed to be the exception and not the rule for reliability of the Model 21 refrigerators. Furthermore, because this unit has reached (even surpassed) its life expectancy, failure is anticipated at any time.

9.0 Conferences with C.T.I. Cryogenics

Bendix Cryogenics Section personnel have been in close contact with C.T.I. Cryogenics, manufacturer of cryogenics components, via memorandums and on-site conferences dealing with product quality control. It is believed that the rejection and failure rate of recent refrigerator units is excessively high and that the overall quality has deteriorated from past experiences (reference sections 2.0 and 7.0 of this report).

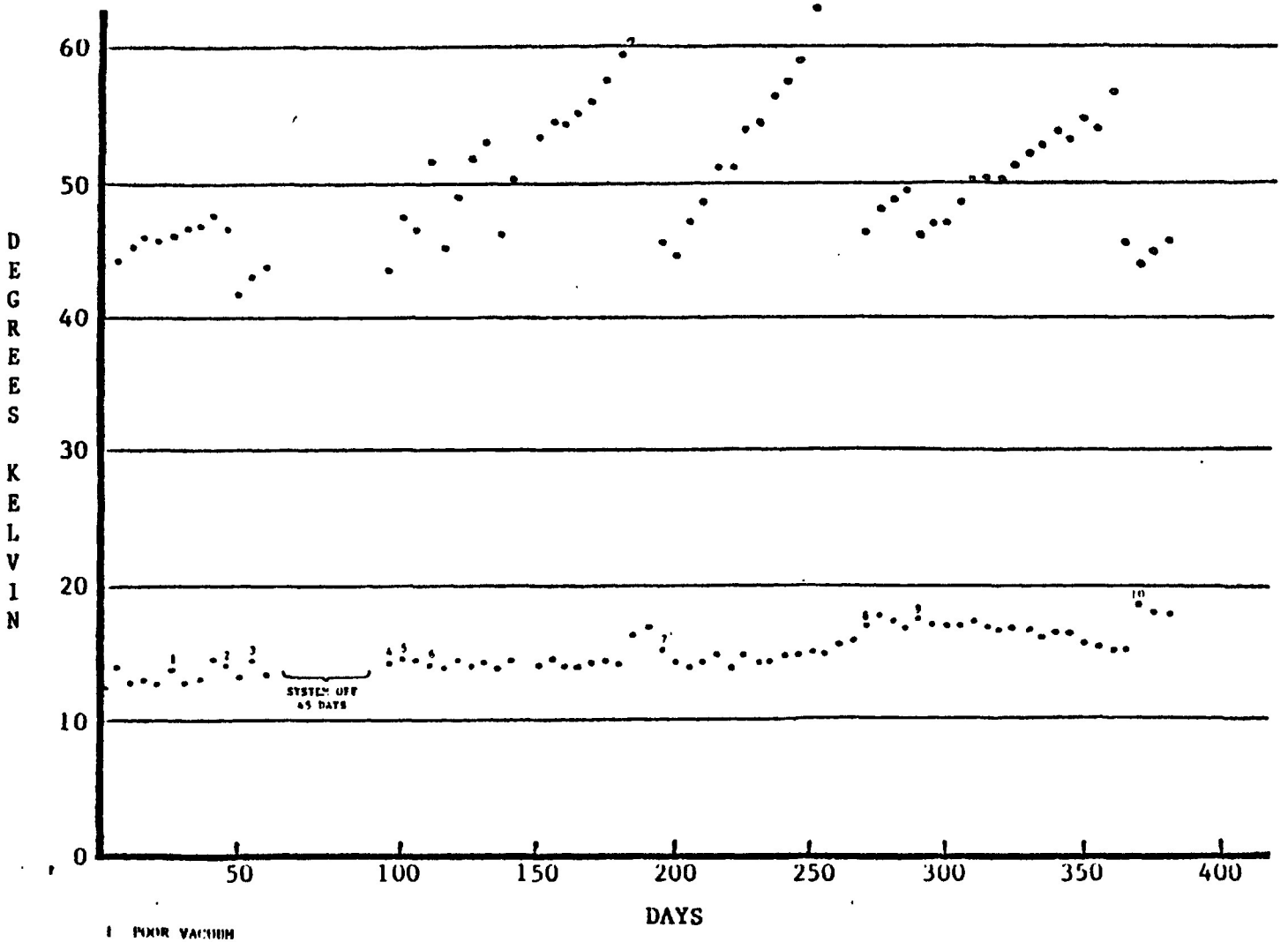
As a result of this interchange, the manufacturer has noted the problem areas and has instigated an investigation into finding solutions for correcting the problems.

R. A. Kriss BFEC/Cryogenics Components Section

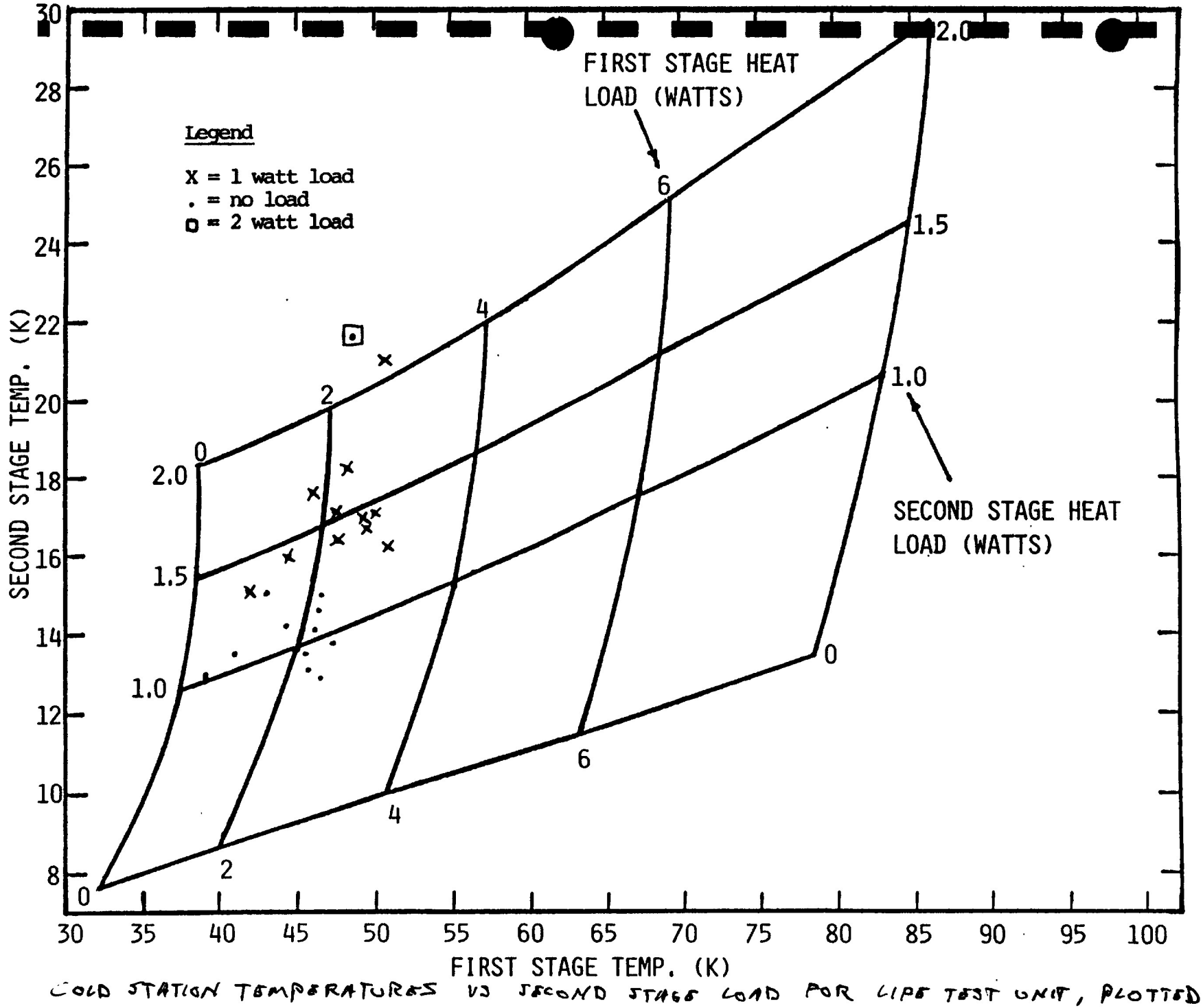
C. Moore RF & Microwave Systems Group

DAILY TEMPERATURE READINGS OF LIFE TEST REFRIGERATOR

IN DEGREES KELVIN



1 POOR VACUUM
2 COMPRESSOR CHANGE
3 COMPRESSOR CHANGE
4 COMPRESSOR CHANGE
5 RESTART
6 NEW BUSHINGS & SEALS
7 POOR VACUUM
8 POOR VACUUM, RATCHETING (NEW SEALS)
9 NEW BUTTONS
10 RESTART



COLD STATION TEMPERATURES VS SECOND STAGE LOAD FOR LIFE TEST UNIT, PLOTTED ON TYPICAL REFRIGERATION CAPACITY OF THE MODEL 22C CRYODYNE(R) CRYOCOOLER (60 HERTZ)