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CRaTER
Thermal-Vacuum
Test Procedure

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Preface

Revision 01 is being released for general comment. The actual procedures for installing the instrument in the T/V chamber and running the thermal balance part of the procedure are more to be regarded as placeholders than finished products.

1 Introduction

The flight hardware for the Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instrument on the Lunar Reconnaissance Orbiter (LRO) is composed of a single assembly incorporating both radiation detector and all associated power, command, data processing, and telemetry electronics.

1.1 Activity Description

This procedure will provide a demonstration that

- the hardware meets its performance requirements within allowable tolerance when subjected to a thermal-vacuum environment representative of extreme operating conditions in flight;
- the hardware meets its performance requirements after being subjected to multiple thermal cycles in a vacuum environment;
- the thermal model faithfully represents the actual flight instrument.

Demonstration of hardware performance during the test is accomplished by use of the CRaTER Short Form (32-06003.02) and Long Form (32-06003.01) Functional Tests.

A graphical timeline of the activities described here is given by the TV Temperature Profile (32-06005.0101)

1.2 Test Item Description

Six silicon particle detectors (labeled D1, D3, D5 for the “thin” 140um units; D2, D4, D6 for the “thick” 1000um units) are arranged in a stack with intermediate cylinders of Tissue Equivalent Plastic (TEP). When used in coincidence, these detectors form a crude telescope with a 35 degree field-of-view. Charge collected by each detector is separately amplified, filtered, and converted by an A/D converter. The six values of deposited charge form a hextuple of 12-bit values that comprise the primary science data for a single event. The FPGA packs a series of these hextuples into a CCSDS primary science telemetry packet for transmission to the spacecraft data system. Similarly, secondary science information (*e.g.*: rejected event rates) and analog housekeeping values are packed by the FPGA into their own CCSDS telemetry packets. All telemetry is transmitted on a MIL-STD-1553 data bus.

Similarly, all instrument commands are received from the spacecraft *via* the 1553 bus.

Six instrument temperatures are read out through the normal flight telemetry stream:

- telescope – this is a good representation of the TEP and detector temperatures
- analog board – the analog board has no point heat sources
- digital board – this is the temperature of the case of the hottest component (the 1553 transceiver)
- DC-DC converter – the case temperature of the hotter of the two converters
- bulkhead – the wall separating the electronics box from the telescope volume
- prt reference – located on the bulkhead adjacent to the above sensor

Note that the “prt reference” is normally read out by the spacecraft telemetry system; only in the stand-alone instrument test configuration is it read out in the instrument telemetry stream. The location of these sensors is shown in Appendix B.

1.3 Support Item Description

1.3.1 Thermal-Vacuum Chamber

The Thermal-Vacuum Chamber is a 2' x 2' x 2' chamber made of stainless steel. All walls are electropolished. The chamber baseplate is 3/8" thick copper, gold plated with temperature limits of -120C to +125C. The door gasket and baseplate feedthrough seals are viton. All other seals are conflat with copper gaskets. The vacuum system consists of a 4.5" OD Leybold turbo pump backed by a Tribudine dry rotary vane roughing pump.

1.3.2 TQCM

A Thermoelectric Quartz Crystal Microbalance (TQCM) is provided to assess the cleanliness of the instrument.

1.3.3 Radiation Source

A ⁶⁰Co gamma ray source is used to stimulate the thick detectors during parts of the Long Form Functional tests.

1.3.4 Spacecraft Simulator

The spacecraft simulator is composed of a single-board-computer (SBC) married to a MIL-STD-1553 bus controller. The SBC is programmed to interrogate the instrument on a fixed cadence, retrieving up to 25 primary science packets per second, 1 secondary science packet per second, and 1 housekeeping packet per second. (Once integrated with the LRO spacecraft, the housekeeping packets are retrieved only once every 16 seconds, but the packets are available from the instrument at the higher rate, since the instrument runs at a one second cadence.)

1.3.5 28VDC Power Supply

A standard laboratory DC power supply, adjustable over the range of 27 to 35 VDC, 0.5 amperes maximum, is required to power the instrument.

1.3.6 Data Logger for Chamber Environment

The Chamber Data Logger acquires low time resolution data about chamber temperatures and pressure.

1.3.7 Computer Workstation

To support the monitoring of environment variables from the data logger in addition to the command and data interface to the instrument via the spacecraft simulator, a computer workstation is required. This workstation is also responsible for logging all data into standard LRO-format data files. Our software will run on UNIX, Mac, or Windows operating systems which support UDP network connections to the spacecraft simulator and data logger and have both Perl and TCL/Tk available to run the scripts.

2 Requirements

2.1 Verification Plan

This Procedure supports the Instrument Performance and Environmental Verification Plan (32-01206).

2.2 Temperature Limits – Thermal Balance

The test temperature requirements for Thermal Balance are taken from Table 2-1 of the LRO Thermal System Specification, 431-SPEC-000091, Rev C. These are not based on flight predicts of the internal reference temperatures but on the specified limits on the spacecraft side of the interface – in this case the plate to which the instrument under test is mounted.

- Hot balance: +25 C
- Cold balance: -30 C

2.3 Temperature Limits – Thermal Cycling

The test temperature requirements for Thermal Cycling are taken from Table 6-3 of the CRaTER Thermal ICD, 431-ICD-000118. In this case we refer to the temperature at the (internal) reference location.

- Hot Survival +50 C
- Hot Qualification +40 C
- Hot Operating +30 C
- Cold Operating -30 C
- Cold Qualification -40 C
- Cold Survival -40 C

2.4 Temperature Tolerance

The tolerance on all test temperatures is $\pm 2\text{C}$.

2.5 Temperature Slew Rates

Thermal slews will be commanded to occur at a rate of 0.5C/min.

2.6 Required Items

- Thermal-vacuum chamber
- TQCM
- ⁶⁰Co radiation source
- Chamber data logger
- Spacecraft Simulator
- 28VDC Adjustable Power Supply
- Flight CRaTER Instrument

2.7 Documents to be on Hand

- 32-03002.02 T/V Chamber Wiring Diagram
- 32-06003.01 Instrument Long Form Functional Test Procedure (4 copies)
- 32-06003.02 Instrument Short Form Functional Test Procedure (12 copies)
- 32-06003.05 Vacuum Pumpdown and Venting Procedure
- 32-06003.06 Instrument GN2 Purge Procedure

3 Configuration

3.1 General Constraints

Electrostatic Discharge (ESD) protection procedures per MIT 99-01003 shall be observed.

Connector mating/demating procedures per MIT 99-03002 shall be observed. Any connections made directly to the unit under test shall be noted in the mate/demate log.

Only qualified personnel may install/remove the radiation source to/from the chamber. The activity level of the unshielded source is comparable to natural background at a distance of 1 foot.

The flight instrument shall be maintained in a clean environment per MIT 32-01203. In addition the thermal-vacuum chamber must be verified clean (using the TQCM) prior to installation of the instrument in the chamber.

The laboratory power supply shall be operated only within the range of 27 to 35 VDC.

A three-digit, calibrated digital voltmeter shall be used for the initial setup of the input power. No other calibrated equipment is required.

3.2 Nomenclature

The Electrical Ground Support Equipment (EGSE) consists of a 28 VDC power supply, a Ballard Technologies single board computer with 1553 interface (the spacecraft simulator), the Chamber Data Logger, a computer workstation, and associated cabling.

The **chamber baseplate** is thermally isolated from the chamber walls and temperature controlled by a combination of heaters and LN₂. The **interface plate** provides a hole pattern equivalent to the spacecraft mechanical interface. It is hard mounted to the chamber baseplate (and thus should follow the control temperature closely); the instrument and blanket are, in turn, mounted on the interface plate.

3.3 Test Configuration

The flight instrument with a representative thermal blanket is configured for test inside the thermal-vacuum chamber located at MIT Building NE80 with connections made through the chamber wall to the laboratory power supply and spacecraft simulator. (The thermal blanket is optional if only thermal cycling is to be performed.)

3.4 Hazardous Commands

It is not permissible to turn on the detector bias supply in partial vacuum environments where the pressure is between 525 torr (10K feet altitude nominal) and 10^{-3} torr.

3.5 Instrument Purge

The instrument should be purged prior to returning the instrument to storage after testing; see the Instrument GN2 Purge Procedure (32-06003.06). Nominal completion of this procedure will result in that happening as part of the chamber vent cycle.

4 Procedures -- Initialization

Space is provided for the recording of information of particular significance in the conduct of this test. Where a value simply needs to be verified, as opposed to recorded, a simple check mark \checkmark will suffice. In addition the Test Conductor may redline the procedure to more accurately document the actual flow of events, both routine and anomalous. An example of this would be that the Thermal Balance dwells are done on only one flight unit and hence skipped on the alternate unit.

The pages of this section will be attached to the Test Report that is filed for each instrument on which this activity is conducted. That is also true of the as-run copies of the Short and Long Form Test Procedures. The telemetry data stream generated by the spacecraft simulator and chamber data logger is an integral part of the Test Report; that data is archived on crater.bu.edu.

4.1 Identification of Equipment and Personnel

Flight Instrument, 32-10000 S/N _____

Spacecraft Simulator, 32-80201 S/N _____

Principal Test Conductor _____

Other Test Conductors _____

QA Representative: _____

Other Individuals: _____

4.2 Data Logging

The general intent is to log the instrument and chamber data continuously for the duration of this test procedure. Since standard archive process date-stamps the file names, and every CCSDS data packet is time-tagged, we can, after the fact, stitch together a continuous archival record. The important point for the test conductor is not to terminate a data log archive at the conclusion of any short or long form functional test, but simply to let it run. (At maximum event rate we generated < about 1GB/day.)

4.3 Baseline Chamber Cleanliness

At some time prior to this test the chamber must be subjected to a “dry run” before the instrument and its thermal blanket are installed. With the interface plate held at +35C and the TQCM held at –20C, an empty-chamber cleanliness level must be established.

TQCM Drift	Date of Test	Initial

4.4 Install Instrument in Chamber

4.4.1 Install Instrument on Interface Plate

All operations to be performed in clean bench, wearing ESD-safe clean gloves. ESD precautions must be met.

1. Mount the CRaTER assembly onto Interface Plate.
2. Secure to Interface Plate with clean 10-32 x .75” min SHCS. Torque to 28 in lbs.
3. Connect vacuum interface cable (1553, 1 Hz clock, power) to the instrument.
4. Remove vent plug at the purge inlet.
5. Remove vent cover at the purge outlet.
6. Install Thermal Blanket.
7. Bag assembly with NMD-clean bag material. Seal with ESD-safe tape.
8. Place on assembly transport cart and go to T/V chamber

Date	Time	Initial

4.4.2 Install Interface Plate in Chamber

ESD precautions must be met. Clean room attire shall worn: ESD-safe clean gloves, ESD clean room smock, ESD wrist strap, hair net must be worn.

1. Open chamber door and clean interface surface with dry clean Alpha 10 wipe.
2. Ensure wires, cables and hardware are not in the way to install the Interface Plate. One screw should be left in place in the rear, center of the copper plate. This is for ease of installing and aligning the Interface Plate
3. (Two people may be required to install assembly.) Remove clean bagging material from unit. Maintain in tacked for future use.
4. Lift unit into chamber as far as possible so as to minimize the sliding of the Interface Plate on the copper plate. Align the slot in the Interface Plate to the center, rear screw.
5. Loosely install the right side at the 5 (five) mounting locations with ¼-20 x 1”L SHCS (clean). Secure the left side at the 5 (five) mounting locations with ¼-20 x 1 ¼”L SHCS (clean). Torque to 20 in-lbs TBR.
6. Mate cable from the instrument to the feed-thru connector labeled CRaTER.

7. Mount RTD #7 near the front of the Interface Plate. Secure with aluminized Kapton tape. Mount RTD # 8 in another convenient location and secure with aluminized Kapton tape. Test RTDs by gently touching with hands and watch for temperature rise.
8. Visually inspect inside of chamber to ensure no wires are pinched.

Date	Time	Initial

4.5 Check out the EGSE

Connect the external 1553, 1Hz clock, and 28VDC power cables to the Spacecraft Simulator and run a Short Form Functional to demonstrate basic aliveness. **In addition to a normal Short Form, check out the alternate 1553 connection. The instrument should be left in a powered down state.**

Pass/Fail	Instr. State	Date	Time	Initial
	Off?			

Connect the external cables to the Chamber Data Logger and verify that all environmental channels and the TQCM monitor are functioning properly.

Time	Initial

4.6 Pump Down the Chamber

Following the Vacuum Pumpdown Procedure, 32-06003.05, pump down the chamber. Continue on to the next step when the pressure is less than 5×10^{-5} torr.

Date	Time	Initial

4.7 Initial Outgassing Period

Command the chamber baseplate to 35C. Continue on to the next step when the pressure is again less than 5×10^{-5} torr.

Date	Time	Initial

4.8 **Baseline Long Form Functional Test**

Command the chamber baseplate to 0C.

Wait for the Instrument Reference Temperature to reach between -2 and +2C; then run a full Long Form Functional Test, 32-06003.01. (The internal reference temperature will rise slightly in the course of this test as the instrument stabilizes thermally; we'll use this information later as we aim for particular operating temperatures.) The Long Form will leave the instrument unpowered.

Pass/Fail	Instr. State	Tbaseplate	Tref	Time	Initial
	Off?				

Tref – Tbaseplate: _____

4.9 **General Instrument Monitoring**

As the instrument operates more or less continuously during this test, the test conductor must monitor the data to assure that nothing untoward – or even unusual – is happening between the benchmark test events. In particular both instrument and facility data should be monitored carefully during temperature transitions.

5 Procedures – Temperature Dwells

5.1 Hot Survival Dwell

Command the chamber baseplate to +50C – this and all subsequent control temperature changes are to be commanded at a slew rate of 0.5C/minute -- and wait for the Instrument Reference Temperature to reach a minimum of +48C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Dwell at this temperature for a minimum of 4 hours; the instrument remains unpowered.

Date	Time	Initial

If the Thermal Balance dwells are not being performed on this unit, proceed directly to section 5.4 .

5.3 Cold Thermal Balance

Command the chamber baseplate to -30C. (For the balance tests, the interface plate temperature, not the instrument reference temperature, is the controlling requirement.)

Date	Time	Initial

When the interface plate first reaches its target temperature (it is not necessary to wait for the whole instrument to stabilize), run a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. Running?	Time	Initial

At 30 minute intervals record the instrument temperature data. Balance is achieved when, after a minimum of 5 hours, there is no change in any of the six instrument temperatures of more than 0.5 degree C in the previous 3 hours.

Time	Telescope	Analog	Digital	Converter	Bulkhead	PRT	Interface Plate

Turn off the instrument by executing para 4.8 *Clean Up and Shut Down* of the SFF.

Time	Initial

5.4 Hot Dwell #1 – Hot Turn On/Long Form

Command the chamber baseplate to +40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach the range or +38 to +42C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 2 hours with the instrument un-powered; then perform a Long Form Functional. The instrument should be powered off at the end of this procedure.

Pass/Fail	Instr. State	Time	Initial
	Off?		

Since the Long Form takes longer than 4 hours to complete, we can simply go on.

5.5 Cold Dwell #1 – Cold Turn On/Long Form

Command the chamber baseplate to -40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach the range or -38 to -42C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 2 hours with the instrument un-powered; then perform a Long Form Functional, stopping before para 4.16 *Clean Up and Shut Down*. When finished leave the instrument running in the state defined by para 4.7 *Check Detector Noise Levels* of the Short Form Functional.

Pass/Fail	Instr. State	Time	Initial
	On?		

Since the Long Form takes longer than 4 hours to complete, we can simply go on.

5.6 Hot Dwell #2

Command the chamber baseplate to +40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach a minimum of +38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.7 Cold Dwell #2

Command the chamber baseplate to -40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to fall below -38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.8 Hot Dwell #3

Command the chamber baseplate to +40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach a minimum of +38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.9 Cold Dwell #3

Command the chamber baseplate to -40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to fall below -38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.10 Hot Dwell #4

Command the chamber baseplate to +40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach a minimum of +38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.11 Cold Dwell #4

Command the chamber baseplate to -40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to fall below -38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.12 Hot Dwell #5

Command the chamber baseplate to +40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach a minimum of +38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.13 Cold Dwell #5

Command the chamber baseplate to -40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to fall below -38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.14 Hot Dwell #6

Command the chamber baseplate to +40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach a minimum of +38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.15 Cold Dwell #6

Command the chamber baseplate to -40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to fall below -38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.16 Hot Dwell #7

Command the chamber baseplate to +40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach a minimum of +38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.17 Cold Dwell #7

Command the chamber baseplate to -40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to fall below -38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.18 Hot Dwell #8

Command the chamber baseplate to +40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach a minimum of +38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

5.19 Cold Dwell #8

Command the chamber baseplate to -40C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to fall below -38C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.)

Time	Initial

Now wait for (a minimum of) 4 hours with the instrument operating; then perform a Short Form Functional, stopping at the conclusion of para 4.7 *Check Detector Noise Levels*. This will leave the instrument running in its nominal on-orbit condition.

Pass/Fail	Instr. State	Time	Initial
	On?		

6 Procedures – Wrap-up

6.1 *Baseline Long Form Functional*

Command the chamber baseplate to 0C.

Date	Time	Initial

Wait for the Instrument Reference Temperature to reach the range or -2 to +2C. (If the Reference Temperature fails to follow the baseplate temperature closely, some control adjustment to the baseplate temperature may be necessary.) Run a Long Form Functional, but leave the instrument in the state defined by the conclusion of para 4.7 *Check Detector Noise Levels* of the Short Form Functional.

Pass/Fail	Instr. State	Time	Initial
	On?		

6.2 *Cleanliness Monitor*

Command the chamber baseplate to +35C

Date	Time	Initial

Turn on the TQCM (per Appendix A), setting the cooling loop to +10C and the sensor head to -20C. Record the TQCM readings every hour (for at least five hours) until the Contamination Engineer sees that a satisfactory evaluation of the instrument cleanliness has been achieved.

Nominal Hours	Time	TQCM (Hz)	f Change (Hz/Hr)	Bulkhead (C)	Sensor (C)
0					
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

CC Engineer	Date	Time	Initial

6.3 Power off Instrument

Power off the instrument following para 4.8 *Clean Up and Shut Down* of the Short Form Functional.

Date	Time	Initial

6.4 Power off TQCM

Raise the temperature of the sensor to +30C. After the sensor has stabilized, turn off the TQCM.

Time	Initial

6.5 Power off Thermal Control of the Chamber Baseplate

Remove power from the chamber baseplate, leaving it drift at approximately +35C.

Time	Initial

6.6 Vent the Thermal-Vacuum Chamber

Vent the thermal-vacuum following the procedure of 32-06003.05.

Time	Initial

6.7 Remove Instrument from Chamber

6.7.1 Remove Interface Plate from Chamber

Wearing ESD safe clean room garment, wrist strap and gloves:

1. Verify that the EGSE has been powered down.
2. Place Yellow dust cap over the TQCM.
3. Disconnect connector from the instrument cable to the chamber feed thru cable. Remove RTDs 7 and 8 from Interface Plate.
4. Loosen and remove the hardware securing the Interface Plate to the copper plate.
5. Place NMD bag on stainless steel cart and place cart near chamber.
6. Remove the Interface Plate and Instrument from chamber and place on the stainless steel cart and NMD bag. Seal bag over the assembly and transport to the test area.
7. Remove the Interface Plate Perform a wipe test on the chamber door by applying ethyl alcohol to a clean alpha 10 wipe and inspect for smudging and smearing on the chamber door surface. Also inspect wipe for any discoloration.

Date	Time	Initial

6.7.2 Remove Instrument from Interface Plate

Wearing ESD safe clean room garment, wrist strap and gloves:

1. Unbag assembly, keeping bag in tact for future use.
2. Remove retaining clips holding the blanket in place on the standoffs. Remove one screw holding the blanket on the bottom part of the telescope.
3. Place Blanket in a clean bag for future use.
4. Disconnect vacuum test cable connections J1 and J2 from to the connector savers. Unscrew J3 and J4 1553 connectors.
5. Loosen and remove 10-32 hardware that secures CRaTER to the Interface Plate.
6. Lift CRaTER Assembly off of Interface Plate

Date	Time	Initial

7 In Case of Test Failure

7.1 Chamber Anomalies

In case of electrical power failure you must perform the steps in Section 2.5 of the Vacuum Pumpdown and Venting Procedure document. Note that the TQCM will have to be shut off if the chamber pressure rises above 1×10^{-5} torr. The instrument should also be powered down if the pressure rises above this value. (The instrument bias supply does not like partial vacuum; normal atmospheric conditions are fine.)

7.2 Workstation Anomalies

Note that if the power is cycled to the Spacecraft Simulator, any current invocations of CHouse, CCmd, *etc.* will have to be closed and the programs restarted. (Each application program makes a specific request to the Simulator for a data feed, and these requests do not persist over a power cycle.)

If you have trouble logging in as “jennyg”, an alternative might be to log in as your own persona, and then enter the command

```
source /nfs/acis/a1/crater/etc/config
```

which should allow you to proceed with the CHouse, CCmd, *etc.* commands.

Most other workstation problems will probably require the assistance of a guru.

7.3 Spacecraft Simulator

The spacecraft simulator starts the CRAter 1553 server (omniserver) and packet distribution program (pdist) automatically upon power-on boot. A healthy Ethernet connection is indicated by the blinking green status light on the front of the OmniBusBox.

The 1553 server defaults to using the A side 1553 bus (only) on power up. The server can be commanded (button on lower left of the workstation command window) to use the B side. All command and telemetry will operate normally in this mode, and all test procedures may be run in this condition without modification.

The spacecraft simulator also generates the 1 Hz tick. This signal may be commanded ON/OFF by a button on the lower left of the workstation command window (it will be ON by default on power up.)

Lacking success, there is little more the casual user can do but recheck the cables and cycle the power.

7.4 General Procedure Errors

A time stamp is generated by the spacecraft simulator once per second, converted into LRO-standard Mission Elapsed Time and sent to the Instrument in a 1553 data packet. That time stamp is then attached to each CCSDS telemetry packet returned by the Instrument. The GSE displays unpack those MET timestamps and convert them back into standard wall-clock format. The end result: if the GSE time displays are incrementing once per second, the entire end-to-end command-instrument-telemetry system is working. And, if not, there is no sense in proceeding on until that problem is solved.

7.5 Independence

Each dwell or balance in this procedure is really an independent test and, as such, can be executed separately from the rest if a procedural or GSE failure causes an interruption. One must only be careful that the final conditions of the previous test (*e.g.*: instrument power off) are met when picking up a test sequence in the middle.

A true test failure, on the other hand, will require that – after failure resolution – the test sequence is restarted from the beginning. Even here, however, the thermal balance, thermal cycling, and cleanliness monitoring are still separate entities, combined in this one procedure merely as a matter of convenience.

Appendix A -- TQCM Instructions

The Thermoelectric Quartz Crystal Microbalance (TQCM) provides an indication of the cleanliness level of the hardware in the Thermal-Vacuum chamber. It produces frequency data for the relative beat frequency of 2 crystals within the sensor head. This frequency increases with contamination deposition onto the surface of the exposed crystal surface.

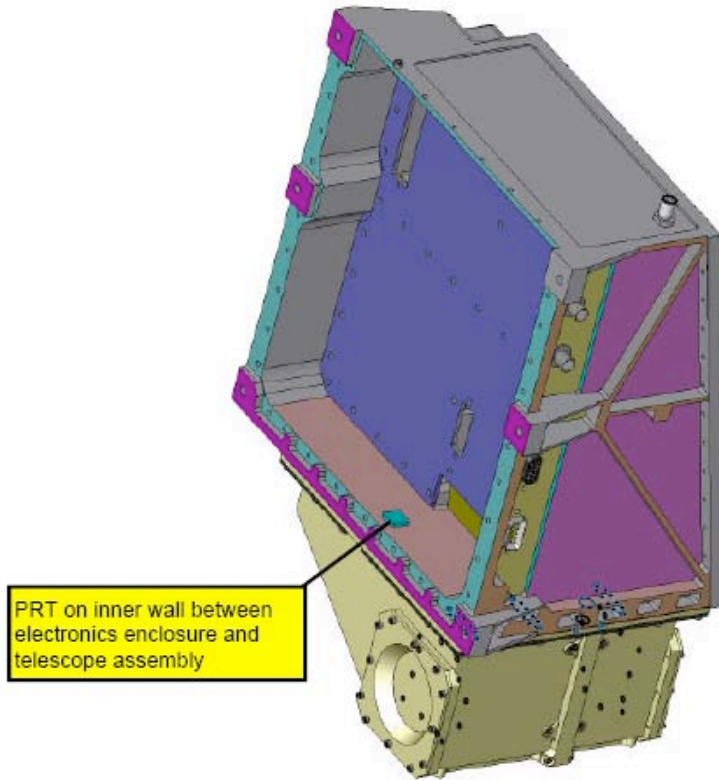
There are two temperatures which are adjustable for the TQCM, that of the sensor and that of the cooling loop. The sensor temperature is set by a dial on the controller box. Running the sensor colder than the instrument under test causes the contamination to migrate to the sensing crystal surface. The sensor must be turned off during non-vacuum operating conditions and kept warmer than +10C to avoid the risk of forming condensation and subsequent icing of the crystal.

The TQCM cooling loop temperature is controlled +10C during sensor operation.

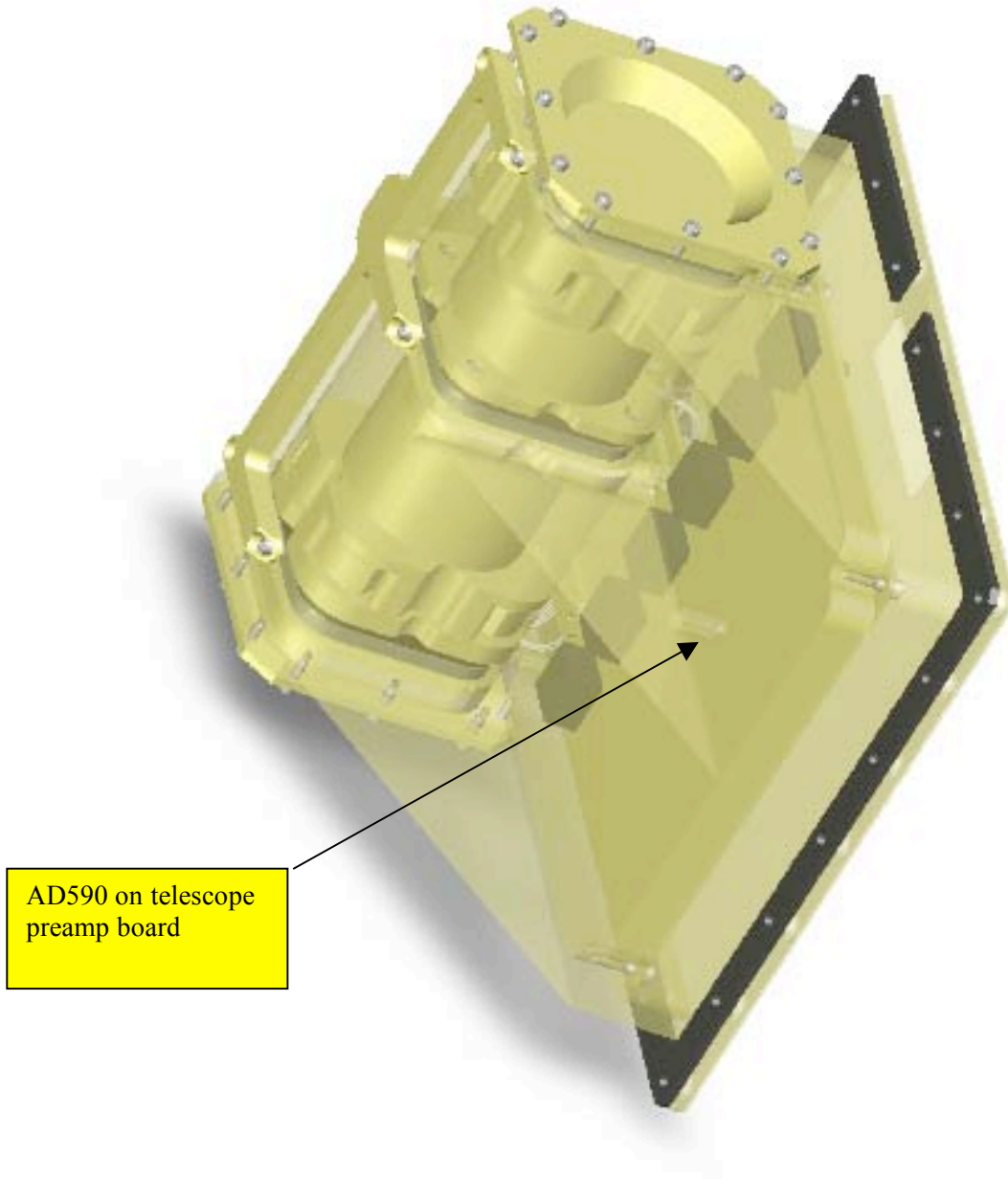
The TQCM requires a heat-cleaning cycle when its frequency exceeds 3,000 Hz. During heat-cleaning, raise the sensor temperature to 100C for approximately 30 minutes. Do not be alarmed if the frequency drops to 0 during cleaning. It should reappear within the 30 minutes. Upon completion of the heat cycle, reset the TQCM sensor temperature to its pre-cleaning level

Appendix B – Temp Monitor Locations

Referenece Location

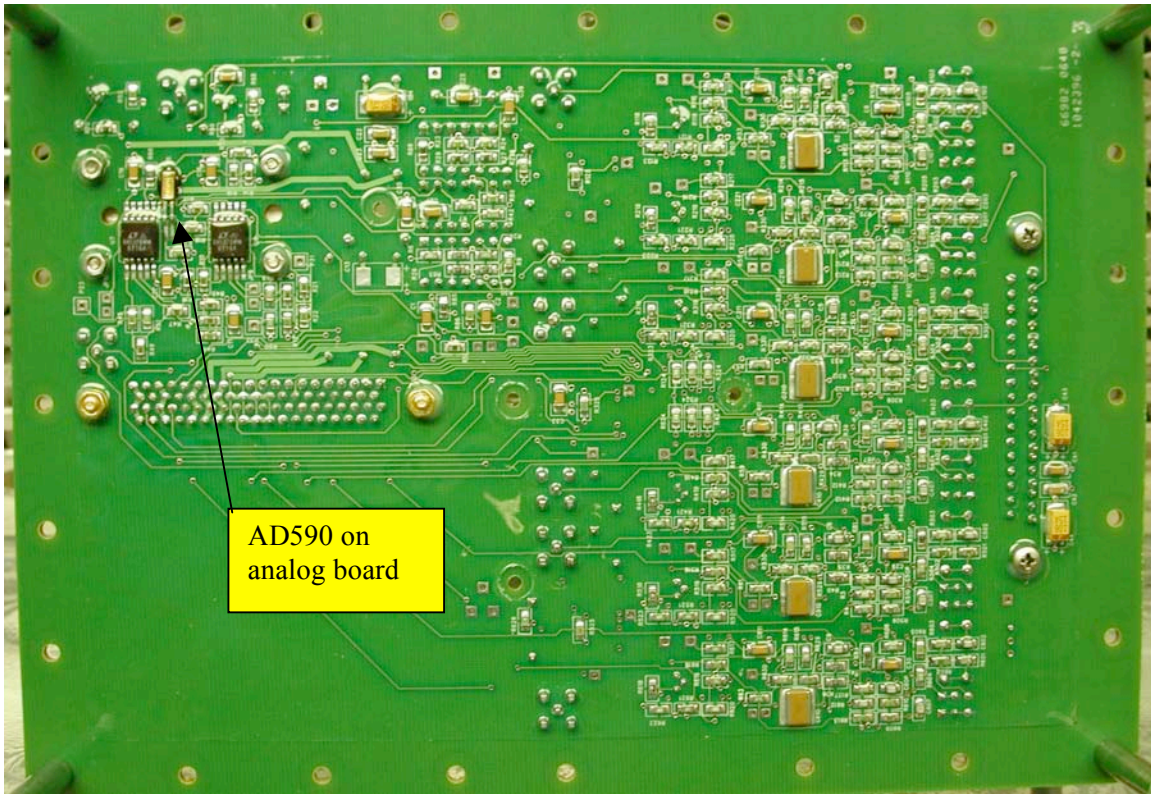


Telescope

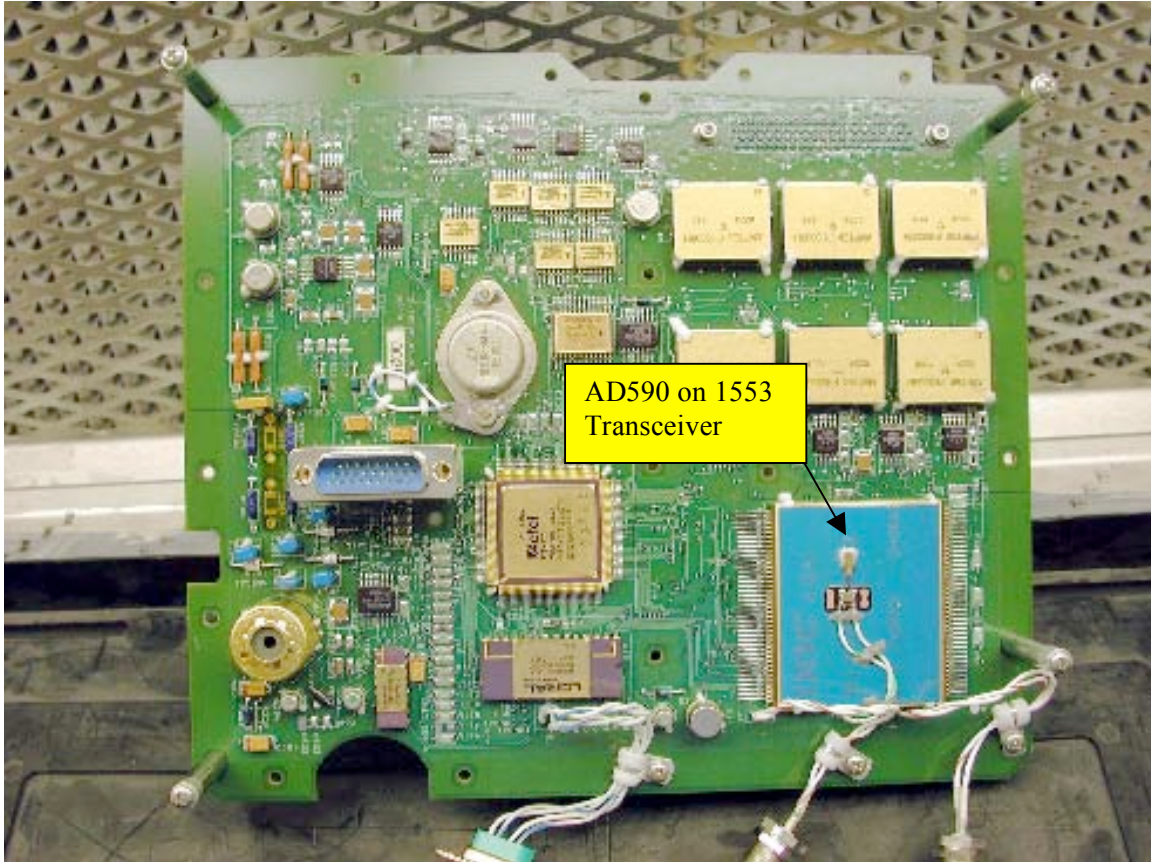


AD590 on telescope
preamp board

Analog Board



Digital Board



Power Converter

