BIMA cryogenics

(Dick Plambeck, 18jan2007)

Normal operation. Monitor from the antennas > 6-meter > receivers multiple> cryo rtd page.

sensor	what is it?	normal range
stage1	outer dewar radiation shield temp	40 - 80 K
stage2	inner dewar radiation shield temp	11 - 18 K
stage3	coldest refrigerator stage temp	2.8 - 4.5 K
stage4	3mm mixer block temp	3.2 - 5.0 K
stage5	1mm mixer block temp	3.2 - 5.0 K
heater3v	voltage to mixer block heaters	0 V (normally off)
heater3ma	(mislabeled as mA, should be mW) power to mixer block heaters	0 mW (normally off)
inlet	inlet air temp for compressor	10-35 C
disch	gas discharge temp	40-90 C
exch	heat exchanger temp	15-40 C
sump	oil sump temperature	20-50 C
supply	helium supply pressure	245-290 psi
return	helium return pressure	30-70 psi

Troubleshooting.

symptom	problem	action
dewar warming up (stage1,2,3 temperatures all warmer than normal, and increasing)	compressor has tripped off (supply and return pressures nearly equal, gas discharge temperature low)	restart compressor (see below)
	compressor is running, but cold head is not	restart cold head (see below)
	low helium pressure (supply < 200 psi, return < 50 psi)	add helium at manifold, look for leak
	low pressure differential (supply < 220, return > 80)	replace compressor or cold head
dewar stage3 warmer than normal (> 4.5 K) but stage1 and stage2 are OK	mixer block heaters are on (heater3V > 0)	turn off heaters
	cold head running at fast speed (stage3 ~ 5K)	switch speed controller from fast to slow
	contaminant buildup in cold head, or bad stage 3 seal	(1) defrost cycle; (2) partial wamup flushing procedure; (3) rebuild cold head
dewar stage2 temperature high (> 20 K), but stage1 and stage2 are OK	bad stage2 seal	rebuild cold head, replace seal

dewar stage1 temperature high (>80 C), but stage2 and stage3 are OK	bad dewar vacuum (outer dewar shell exceptionally cold, or frost-covered)	pump out dewar with vacuum pump, look for leak
	bad stage1 seal	rebuild cold head, replace seal
	low helium pressure	add helium at manifold, look for leak
compressor won't start or trips off within seconds	bad 3-phase switch	replace switch
	compressor too cold (sump < 15 C)	make sure sump heater switch is on
	missing phase	look for burned wiring at plug or inside electrical box
	breaker tripped in breaker box (note: 2 min time delay!)	check breaker in electrical panel (far side of platform from compressor)
compressor starts, but gas discharge temp climbs rapidly (to > 100 C), compressor trips off in a few minutes	compressor too cold or hasn't been run in a long time	disconnect helium lines, run with bypass tube for ~30 minutes until compressor warms up
	internal fan not working	replace fan motor
cold head won't operate fast or slow	bad cold head pwr switch on compressor	replace switch
cold head operates on fast but not slow speed	bad speed controller	replace speed controller
cold head fibrillates (loud clattering sound)	blown fuse on rear of compressor's electrical box	check fuses, replace as necessary (temporary fix – will probably blow again)
	displacers or scotch yoke too tight, motor stalls	rebuild cold head, making sure that displacers can center themselves
cold head operates in wrong direction (CCW as viewed through sight glass) on fast speed; OK on slow speed	3-phase power has wrong phase	interchange any 2 wires (except GND!) in the compressor's electrical plug
return pressure unusually high (100 psi or higher)	broken reed valve in compressor	replace compressor
	leaky inlet valve in cold head	repair the cold head
helium leak	loose Teflon valve seats on large manifold valves (cold weather)	tighten the valve seat nut under the black handle
	cracked flex line (usually near one end)	search for leak with Snoop or leak detector; replace faulty flex line

Cooldown from ambient temperature.

- Normally it is not necessary to repump the dewar with a vauum pump, unless the dewar was opened.
- Check helium pressures on the gauges on the right-hand wall of the receiver cabin. With neither compressor nor cold head running, the static pressure should be approximately 250 psi. Add helium (only ultra high purity, grade 5.0) if necessary.
- On the platform, open the lid to the compressor hut, set the speed controller switch to 'fast-cooldown,' turn on the helium compressor. In the receiver cabin, open the large black valves on the right hand cabin wall, turn on the cold head power switch.
- If the compressor trips off in a few minutes (most likely in cold weather), it may be necessary to go through the 'priming' procedure: remove the helium lines from the back of the compressor, install U-shaped priming tube, operate compressor for about half an hour to warm up the oil, then reinstall normal helium lines and try again.
- The dewar requires about 5 hours to cool. After the temperatures bottom out – typically stage1 is at 40-50 K, stage 2 at 11-14 K, stage3 at 5 K – flip the speed controller switch to 'slow-normal.' This slows down the refrigerator cycle from 60 Hz/72 rpm to 25 Hz/30 rpm. Within minutes the stage3 temperature should drop below 3.5 K.

Adding helium.

- Use only ultra high purity, grade 5.0 helium.
- In the receiver cabin, remove the brass cap from the charging fitting on either the supply or return side of the manifold on the right-hand cabin wall.
- Crack open the valves on the gas cylinder and pressure regulator; flush helium through the yellow charging hose for 10 or 20 seconds, then attach the hose to the charging fitting.
- Open the small black valve to allow helium into the manifold.
- Target pressures: 250 psi supply and return if the compressor is not running; 280-300 psi supply if the compressor is running and the dewar is warm; 250-270 psi if the compressor is running and stage3 is at 4 K.
- Close valves when finished, replace brass cap on charging fitting. Be certain to close the main valve on the helium cylinder tightly, since the pressure regulator tends to leak.

Simple defrost procedure.

After several months of operation the stage3 temperature typically creeps up because contaminants freeze out at the cold end of the refrigerator. If the stage3 temperature is 4-5 K, the following 'defrost' procedure can sometimes help. It takes about 10 minutes and can be done remotely.

- ssh control@bimaX // log onto antenna computer as control.
- bimaRx heater3=12 // turn on mixer block heaters.

- Wait 5 to 10 minutes. The refrigerator continues to run, but stage3 temperature increases to 7K, stages 4 and 5 to 12-17 K.
- bimaRx heater3=0 // turn off heaters.
- Ideally, stage3 will cool to lower temperature than before (doesn't always work).

Partial warmup decontamination procedure.

If the simple defrost doesn't lower the stage3 temperature, a more thorough defrost may be in order. This will take several hours.

- Close the large black valves on the helium manifold, sealing off the cold head from the compressor – this will keep contaminants from migrating back to the compressor.
- Turn off the cold head with the switch in the receiver cabin; allow the helium compressor to keep running.
- (Optional) Connect rapid warmup heater supply to the dewar (4-pin Bendix connector). Turn on the stage2 heater. This greatly speeds up the defrost process.
- Turn on the stage3 heaters using the simple defrost commands.
- Wait until stage3 is 35-50 K; if the rapid warmup heater is used, this will take only a few minutes, and stage2 will be at 100 K or so.
- Turn off all heaters.
- Attach helium bottle to the charging fitting on the supply side of the manifold, after flushing out the yellow charging hose.
- Turn on the cold head, open the small black valve on the supply side of the manifold, and crack open the small black valve on the return side of the manifold. Helium will flow from the gas cylinder through the cold head, and escape from the return fitting. Do this for 20-30 seconds. This will flush contaminants out of the cold head.
- Close black valve on return side, pressurize the cold head to 250 psi; then close supply valve. Open the large black valves to the compressor and begin cooling down again.

Background information – basic description.

The dewar on each 6-m telescopes is cooled by a 3-stage cryocooler. This is a CTI 1020 cold head modified by the addition of a 3rd stage in Berkeley. SIS mixers and feed horns are connected to the 3rd stage, at about 3.5 K. IF amplifiers and an inner radiation shield are connected to the 2nd stage, at about 12 K. An outer radiation shield is cooled by the 1st stage, at about 40-80 K.

The cold head in the dewar expands helium from about 280 to about 50 psi. A helium compressor (CTI 1020R) on the azimuth platform supplies the compressed gas stream. The compressor is mounted inside an insulated 'hut' with a variable speed ventilation fan. The fan sucks outdoor air through louvers at one end of the hut and exhaust the air out the other side. When the inlet air temperature drops below about 50 F, a fan controller (Phase-On) reduces the fan speed to idle, and the louvers swing shut (unless, alas, the wind blows them open again). Heater tapes, enabled by a switch and an inline thermoswitch, are wrapped on the compressor and oil sump to keep the compressor warm in extremely cold weather. Another thermoswitch prevents the compressor from starting if the oil sump temperature is below 15 C.

Flexible helium lines carry the supply and return helium lines over the elevation wrap into the receiver cabin. Self-sealing Aeroquip fittings are used on all helium lines.

A speed controller is used to slow down the cold head from its normal cycle frequency of 72 rpm to 30 rpm. At 72 rpm the stage3 temperature bottoms out at about 5 K. Slowing the cycle frequency reduces the stage3 temperature to about 3.5 K.