ALMA Memo 356

22 March 2001

Reliability of Nanonics Dualobe Connectors

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Miniature connectors manufactured by Nanonics Corporation (http://www.nanonics.com/dualobe.html) are being used on ALMA mixers in development at NRAO's Central Development Lab. These "Dualobe" connectors have been selected for a number of spacecraft programs, which affirms their reliability. Connector pin damage from misalignment during connection, which occurred on previous NRAO mixer bias connectors, is minimized because the plastic insulator must be engaged before the pins contact their receptacles

This report provides reliability information obtained from Nanonics for their Dualobe connectors. A section summarizing a visit to Ball Aerospace, who is using hundreds of these Nanonics connectors, is also included.

Programs Using Nanonics Connectors

The Nanonics Dualobe connectors have contact spacings of just 0.63 mm (0.025") and are being used on a number of large spacecraft, such as the:

- Hubble Space Telescope,
- Space Infrared Telescope Facility (SIRTF),
- Mu Space Engineering Spacecraft (Muses-CN), and
- Gamma Ray Large Area Space Telescope (GLAST).

These connectors are also installed on a number of US military aircraft (F-22, F-18) and according to the manufacturer "many other classified space programs".

One of the most demanding applications of this connector occurs on NASA's SIRTF spacecraft, because that spacecraft's cryostat operates at 1.4K and 5.5K, and of course reliability is paramount. Details are provided below about how the connector is used on SIRTF.

Reliability Specifications

Nanonics claims their connectors comply with the following specifications:

- US military specification MIL-C-85327 (*Performance Specification: Connectors, Electrical, Rectangular, Microminiature, Polarized Shell, General Specification For*).
- NASA SP-R-0022 (*General Specification, Vacuum Stability Requirements of Polymeric Material for Spacecraft Application)*
- US Defense Supply Center (Columbus, OH, USA) DSCC 94031 to 94046
- NASA Workmanship Standards NHB-5300.4

The US MIL standard extensively covers most connector characteristics that are relevant to ALMA, but that standard's temperature range is only –55C to 125C, which does not include cryogenic temperatures. Nanonics contracted with the commercial testing firm Trace Laboratories to perform cryogenic thermal shock tests of the connector by dipping it in liquid nitrogen. Trace Laboratories continuously monitored the relative contact resistance with a data logger and there was no evidence of open circuits or resistance increases during thermal shock testing of three connectors.

The following table summarizes the significant reliability characteristics and provides references for Nanonics Dualobe connectors.

Selected Reliability Characteristics of Nanonics Dualobe Connectors		
Characteristic	**Reference**	**Details**
Durability	MIL-PRF-83513D[1] Para 3.5.14	500 mating/unmating cycles while maintaining contact resistance specs and mating/unmating force specs.
Contact Resistance	MIL-PRF-83513D Para 3.5.6	30 mΩ
Low-Signal Level Contact Resistance	MIL-PRF-83513D Para 3.5.19	32 mΩ
Temperature Cycling (Thermal Shock)	Trace Laboratories' report "Formal Test Report for Cryogenic Testing of LCP Vectra Molded Connectors" dated 1999-02-12	Dip testing in liquid nitrogen while monitoring contact resistance.
Vacuum Outgassing	NASA SP-R-0022A[2]	Max volatile condensable material content < 0.1% Total mass loss < 1%

Report on Trip to SIRTF Spacecraft Assembly Plant

On Saturday, 17 Feb 2001, a visit was made to Ball Aerospace in Boulder, Colorado, USA, to discuss their experience with Nanonics Dualobe connectors. Ball is building the Dewar and instrument package for SIRTF (http://www.ball.com/aerospace/sirtf_ball.html) which is an infrared telescope observatory whose instrumentation will be cooled to 1.4K using superfluid Helium. Ball has selected Nanonics' Dualobe connectors for most of the critical connections in the Dewar on SIRTF. That spacecraft uses about 450 Dualobe connectors to route about 1600 wires.

The contact at Ball was Bill Burmester, who is experienced with all the wiring between the SIRTF spacecraft bus and the Dewar. The author is indebted to Dr. Burmester for giving a tour of the SIRTF program on a Saturday morning and for promptly replying to numerous e-mails.

SIRTF is now undergoing rigorous in-plant testing, and there have been only 2 anomalies in the 1600 wires routed to the instrument package on SIRTF. No failure analysis was performed on these anomalies because the failed signal lines are not required during the mission. These failed lines carry temperature

[1] US MIL-PRF-83513D is at http://www.dscc.dla.mil/Programs/MilSpec/ListDocs.asp?BasicDoc=MIL-PRF-83513
[2] NASA SP-R-0022A is apparently unavailable to the general public, see http://128.158.165.63/TSL/restricted/restricteddetail.htm?id=090033d780045ca0

monitoring signals, and the failure could have just as likely occurred in the sensors, or in other types of connectors that also carry the sensor signals.

Burmester gives a few recommendations when using Nanonics' Dualobe connectors:

1. Only use metal backshell connectors. - Do not use the plastic versions.
2. Do not have any screws in the connectors when mating - insert screws later - or leave the screws out and stake (glue) the connectors.
3. Have specific people trained to mate and unmate the connectors.
4. Inspect all connectors before each mating with magnification and strong illumination
5. Develop a pin and socket straightening technique

To secure the connectors at bulkheads, Ball machined aluminum rectangular shrouds with ears that bolt to the bulkhead. The connectors reside in a channel in the shroud and are secured to it with setscrews mounted in threaded holes in the shroud. On SIRTF, Nanonics Dualobe connectors are used at thermal interfaces, but not for vacuum interfaces, because they are not rated for that service.

SIRTF required numerous cables with two layers of shielding over 40 AWG twisted pairs made from manganin and phosphor bronze wire. Phosphor bronze is used only for high current carrying lines because it has less resistance, but poorer thermal resistance, than manganin. Some of these shielded cables, manufactured by Tayco Engineering (http://www.taycoeng.com/proc.htm) developed high resistances between the outer shield and connector shroud that had to be repaired manually by soldering a wire from the outer shield to the metal shroud.

Burmester recommends against using the surface mount type of Nanonics connectors that attach directly to PC boards. Ball attempted to use those on the NICMOS spacecraft but the force necessary for mating and unmating fractured the solder at the surface mount pads. Ball ultimately replaced the Nanonics' PC connectors with the Nanonics' connectors with wire pigtails.

Although the connector is designed to prevent pin damage when one attempts to mate the connectors at an angle, pin damage can occasionally occur. Connector damage is usually a result of trying to mate connectors where a few sockets are misaligned with the pins. Hence, Burmester recommends building a simple tool from a cannibalized connector to repair damaged pins.

Figure 1 shows the Tayco-manufactured cables with Nanonics' Dualobe connectors at each end mating near the lower cryostat section on SIRTF. These cables are double shielded and are incredibly rugged, although the price for such robustness is some loss of bending flexibility.

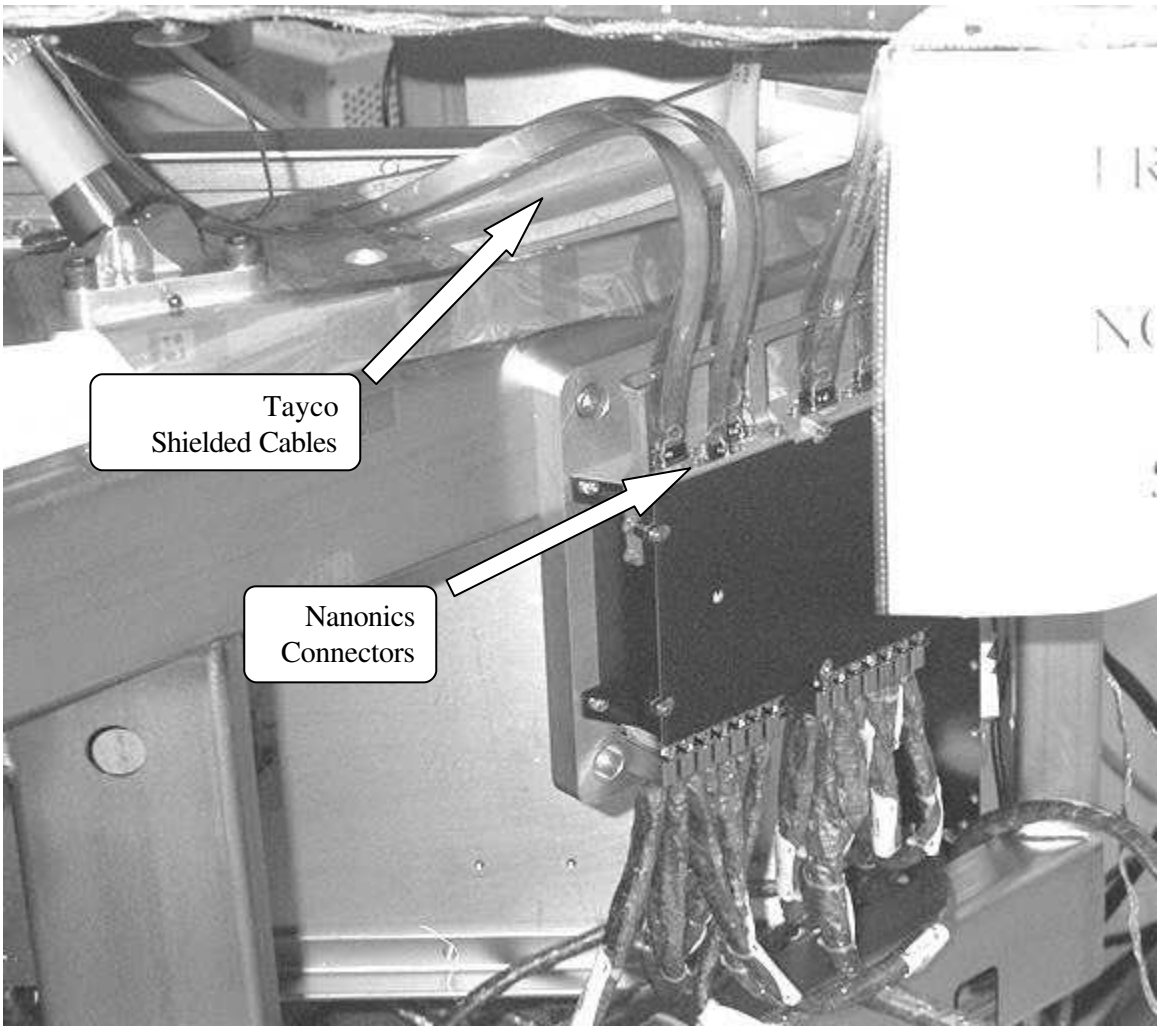

Figure 1 Nanonics Dualobe connectors attached to shielded twisted pair cables