

# SPACE QUALIFICATION PROCESS FOR THERMOELECTRIC COOLERS

Coherent has the knowledge and experience to ensure the success of your space program's thermal requirements and stands ready to help you in the formulation of your specification and testing requirements.



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Coherent has developed processes and procedures for 35+ years that have been used to design, fabricate and test thermoelectric coolers (TECs) for space applications. The Space Qualification Procedure consists of the following elements:

- TEC design and documentation
- TE material processing
- TEC assembly
- TEC testing

The output of these processes is TECs that fall into three categories:

- **Engineering Units:** Used by the customer to validate thermal performance, develop assembly processes, and confirm fit. Additional testing for space applications is not performed.
- **Flight Units:** These are Engineering Units that have gone thru additional non-destructive testing agreed to by the customer, commonly referred to as Acceptance Testing. These TECs are suitable for flight.
- **Qualification Units:** These are Flight Units that go thru additional life testing that is considered to be destructive testing. The data generated is shared with the customer. The TECs can be delivered to the customer if desired for archival purposes.

## TE Design and Documentation

For all space applications, the design parameters and boundary conditions are carefully discussed with the customer. Coherent then assists in the preparation of the specifications and the Statement of Work. After Coherent is placed under contract, the design and documentation are finalized. Design reviews are conducted to confirm that the customer agrees with the final design according to their expectations.

Space qualified TEC applications can use Commercial Off-The-Shelf (COTS) TECs. For these applications, the customer requirements are evaluated and a COTS recommendation will be made, if appropriate. The COTS parts can go through the same testing as custom designs to become space qualified.

Frequently, custom designs will be required to meet the specific requirements. A custom design will be dedicated to a specific customer and will be 'owned' by the customer. The custom design will be built in our U.S. based facility, and will then go through the testing required to become space qualified.

## TE Material Processing

For Space Applications, Coherent has developed TE material processing procedures with additional inspection steps and a higher level of documentation control as compared to our standard procedures. This documentation system assures tighter control on the processing standards and additional testing on individual lots of materials.

## TEC Assembly

The assembly of custom space Qualified TECs uses specific documentation that tightly controls the assembly process and ensures product traceability. Both solder joints at each element are inspected for proper coverage by confirming that the appropriate solder fillet exists around the base of the element. Additional inspection steps by both the operator and inspector ensure that the TEC fabrication steps are performed properly.

Based on Coherent's 30+ years of experience, we recommend that the TEC be mounted into the customer's package at Coherent. This allows the TEC to be Acceptance and Qualification Tested while experiencing the stresses induced onto the TEC by the package during assembly and testing. The likelihood of downstream failure due to thermal stresses induced by the package onto the TEC during processing by our customer is greatly reduced. Additionally, the mounting of a TEC into a package is typically a difficult step in the integration process. When Coherent mounts the TEC into the package, the customer's handling/processing of the TEC is reduced, and the customer's risk of damaging expensive hardware is reduced. Performing Acceptance testing on mounted TECs reduces program risk. The customer's long term cost and risk is reduced by having the TEC/package mounting performed at Coherent.

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## TEC Testing

TEC testing for Space Qualified Applications typically consists of Acceptance and Qualification Testing. All Acceptance and Qualification test data is recorded and shipped with the TECs to the customer. Copies are retained at Marlow for a minimum of 15 years. Customer and government source inspection can be accommodated as required.

**Acceptance Testing:** Performed on 100% of the units. Since customers' requirements vary from application to application, Acceptance Test sequences also vary. A typical TEC Space Qualification Acceptance Test sequence could be as follows:

- AC Resistance Test
- Insulation Resistance Test
- Thermal Performance Test
- AC Resistance Test
- Thermal Shock Test
- AC Resistance Test
- Burn-In Test (Power Cycle)
- AC Resistance Test
- Final Thermal Performance Test
- Final AC Resistance Test
- Final Insulation Test
- Final Ionics Cleaning

**Qualification Testing:** Usually performed either on a one-time design verification basis or on a lot basis depending on a customer's requirements. These tests are also customized to the customer requirements. Some of the tests can be the same as acceptance testing, but for longer durations. This testing is considered to be destructive. A typical TEC Space Qualification Test sequence could be as follows:

- AC Resistance Test
- Insulation Resistance Test
- Thermal Performance Test (including heat load testing)
- AC Resistance Test
- Thermal Shock Test
- AC Resistance Test
- Power Cycle Test
- AC Resistance Test
- Vibration Test
- AC Resistance Test
- Final Thermal Performance Test (including heat load testing)
- Final AC Resistance Test
- Final Insulation Test

Additional test capabilities include cold start and hot start testing, cooling and heating mode testing, temperature cycling testing and mechanical shock and acceleration.