

PAPER • OPEN ACCESS

## The Research of Reliability of CX-1B-5 Connectors Coupling in ALT process of spacecraft

To cite this article: Wei Zhang *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **563** 032027

View the [article online](#) for updates and enhancements.

You may also like

- [Thermal performance of a flat polymer heat pipe heat spreader under high acceleration](#)  
Christopher Oshman, Qian Li, Li-Anne Liew et al.
- [Flat flexible polymer heat pipes](#)  
Christopher Oshman, Qian Li, Li-Anne Liew et al.
- [Design of a 3D-printed liquid lithium divertor target plate and its interaction with high-density plasma](#)  
Congcong YUAN, , Zongbiao YE et al.



**ECS** The Electrochemical Society  
Advancing solid state & electrochemical science & technology

**247th ECS Meeting**  
Montréal, Canada  
May 18-22, 2025  
*Palais des Congrès de Montréal*

**Showcase your science!**

**Abstract submission deadline extended: December 20**

**ECS UNITED**

# The Research of Reliability of CX-1B-5 Connectors Coupling in AIT process of spacecraft

Wei Zhang<sup>1</sup>, Dongmei Wang<sup>1</sup>, Peirong Zhao<sup>1</sup>, Xilong Xie<sup>1</sup> and Na Zuo<sup>1</sup>

<sup>1</sup>Beijing Institute of Spacecraft Environment Engineering, Beijing Engineering Research Center of the Intelligent Assembly Technology and Equipment for Aerospace Product, Beijing, China

Corresponding author e-mail: zhangwei308308@163.com

**Abstract.** This paper reviews the applications of CX-1B-5 connectors in assembly and integration process of spacecraft. Wire breakage near the solder joint is the common phenomenon of the connection failure, through fracture morphology and fault tree analysis, tensile force after repeated bending which is a key factor leads to the fatigue fracture. Because the bending of the wire at the root of the solder joint is unavoidable, wire insulation thickening method and anti-wicking tools are used to improve the reliability of CX-1B-5 connectors coupling, with the test showing the bending fatigue resistance improved by 110% by using anti-wicking tools.

## 1. Introduction

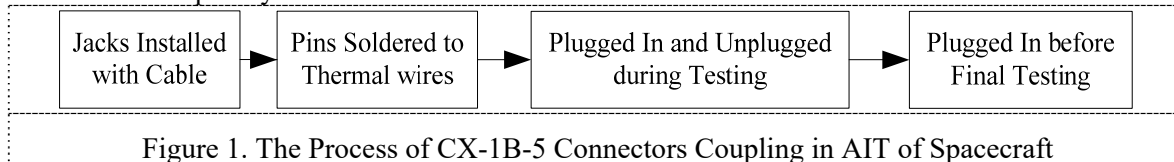
There are a large number of electrical connector plug operations in assembly and integration process of spacecraft. There are many types of electrical connectors, but multi-core electrical connectors are the main ones. In order to facilitate the telemetry signal test, the CX-1B-5 connector which is a kind of single core electrical connector<sup>[1]</sup> is often used to control the turn-on and turn-off of telemetry signals. With the frequent use of the CX-1B-5 connector and the frequent plugging and unplugging operations, the problem of connection failure occurs, which affects the quality and production of spacecraft. The ESA standard ECSS-Q-ST-70-08C<sup>[2]</sup> defines the technical requirements and quality assurance provisions, it mentions that anti-wicking tools can be used for pre-tinning the stranded wires to improve manual soldering reliability which is critical to spacecraft, however, in the actual spacecraft assembly process, anti-wicking tools has not been used yet. Huang bo carries out the fatigue life prediction for laser soldering joints of Micro-USB electrical connectors under heat acceleration test<sup>[3]</sup>. Microscopic metallographic analysis has become a routine analytical tool<sup>[4-6]</sup>. This paper reviews the applications of CX-1B-5 connectors in assembly and integration process of spacecraft. Aimed at the Reliability of CX-1B-5 connectors coupling in assembly and integration process of spacecraft, process improvement of CX-1B-5 connectors coupling is studied. Through fracture morphology and fault tree analysis, wire insulation thickening method and anti-wicking tools are used to improve the reliability of CX-1B-5 connectors coupling.

## 2. The Applications of CX-1B-5 Connectors in AIT Process of Spacecraft

CX-1 connector is produced by Guizhou aerospace electrical appliance corporation. It belongs to single-core pinhole electrical connector, the material is QSn4-3 tin bronze and the surface is gold plated. It contains many types of connectors, and CX-1B-5 connector is a soldered extension electrical connector which is commonly used on spacecraft. CX-1B-5 connector jacks are soldered to cable on

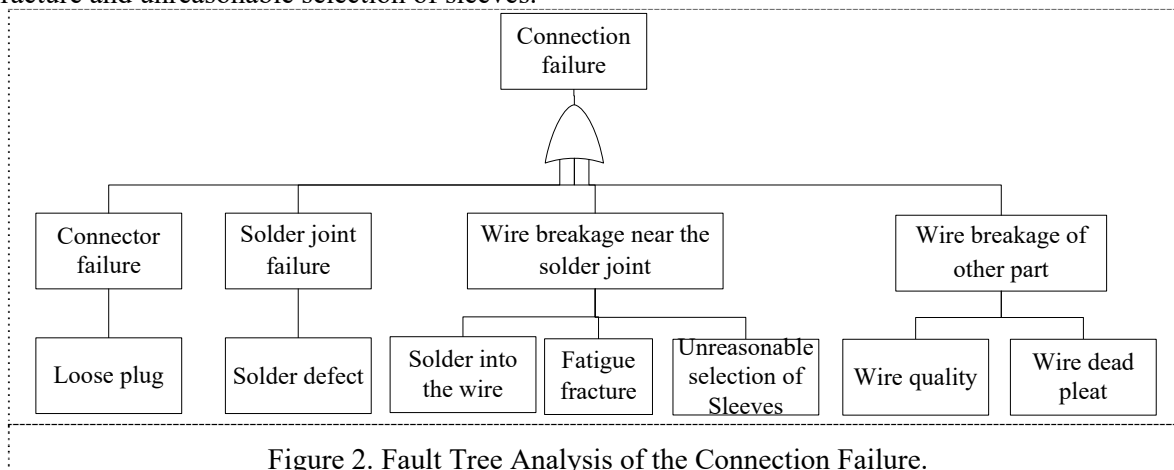


the spacecraft corresponding to the thermistor and the heating circuit, and the wire of the thermistor and heating circuit are soldered to the CX-1B-5 connector pins. The CX-1B-5 connectors will all be temporarily fixed before plugging in, and the process of the CX-1B-5 connectors coupling in AIT of spacecraft is shown as Figure 1, the CX-1B-5 connectors need to be plugged in and unplugged several times during the testing of spacecraft because some devices or structural panels needs to be disassembled frequently.



### 3. Disconnection Failure Analysis of CX-1B-5 Connector

In recent years, many connection failure of the thermistor have occurred during the testing of spacecraft. Due to the thick wire diameter of the heating circuit conductor, there is no accident of breakage. The thermistor wires mainly use thin wires of 28 and 26 wire gauges because of spacecraft weight reduction requirements. The fault tree analysis is shown in Figure 2, the CX-1B-5 connectors are locked by a spring and a limiting hole, so it is difficult to see the phenomenon of loose plugging, the connector failure is denied; through the on-site inspection of the accident, the disconnected parts are all at the root of the solder joint, so the main reason is in three aspects, solder into the wire, fatigue fracture and unreasonable selection of sleeves.



The fracture morphology of failed part was observed by a scanning electron microscope JSM-6010LA. The chief character of fracture is fatigue striation and dimple, through check the fracture morphology of the broken part of the root of the failed part, the failure mode can be determined. The striation and dimple characteristic of failed part is shown in Figure 3~5, the edge part is a fatigue strip and the middle part is a dimple, It can be preliminarily considered that the solder joint breaks after being bent many times and finally receives a certain direction of pulling. When the connector is soldered to the wire, the wire needs to be tinned, and the tin-stained part is about 0.5mm away from the end of the insulation layer, but the tin material creeps along the wire when it is hot-melted. As a result, some tin may enter the wire insulation, and the thermal stress reduces the toughness of the wire near the solder joint.

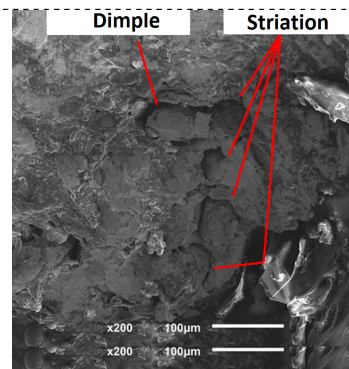


Figure 3. Striation and Dimple Characteristic of Failed Part

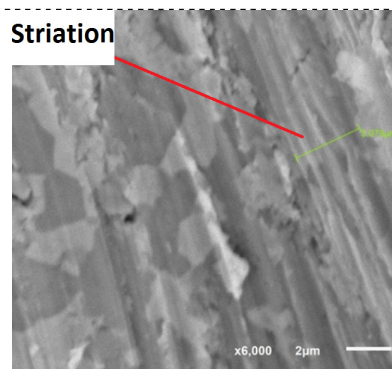


Figure 4. Enlarged photo of Striation Characteristic

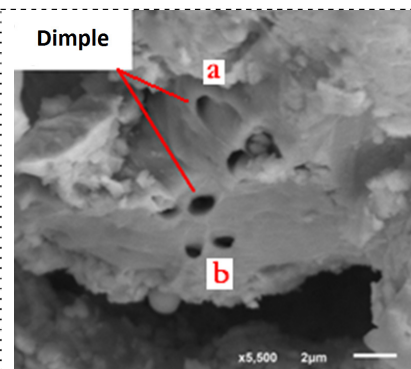


Figure 5. Enlarged photo of Dimple Characteristic

#### 4. Improvement of CX-1B-5 Connectors Coupling Process

Wire breakage near the solder joint is the common phenomenon of the connection failure, through fracture morphology and fault tree analysis method, tensile force after repeated bending which is a key factor leads to the fatigue fracture. In the process of plugging and unplugging the connectors, or in the process of tidying up the wires, the bending of the wire at the root of the solder joint is unavoidable, so process improvement is necessary to improve the reliability of CX-1B-5 connectors coupling.

##### 4.1. Improvement of Heat-shrinkable Sleeves

The thermistor wires mainly use wires of C55/0812-28 because of spacecraft weight reduction requirements, and the maximum outer diameter of such a wire containing insulation is 0.94mm. Double heat-shrinkable sleeves are installed on the solder joint after soldering the CX-1B-5 connectors with wires, the heat-shrinkable sleeves are made of polyethylene and have many specifications, such as RSG1.2/0.6, RSG1.6/0.8, RSG 2.0/1.0, RSG2.4/1.2. The inner heat-shrinkable sleeve used previously is RSG 2.0/1.0, so the sleeve cannot tighten the wire after heat shrinking, there are two ways to solve the problem, one way is using high shrinkage ratio sleeves, and another way is improving the selection of sleeves. Wire insulation thickening method is used to enhance the mechanical bend properties of the wire root, which is shown in Figure 6. The RSG1.2/0.6 heat-shrinkable sleeve is installed outside the wire before soldering the CX-1B-5 connectors.

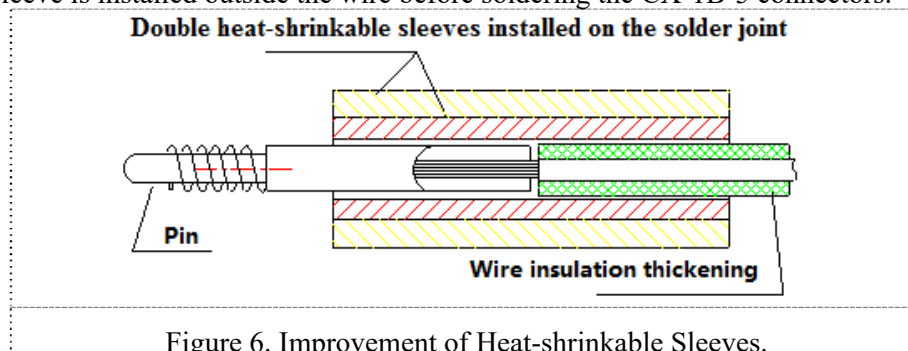


Figure 6. Improvement of Heat-shrinkable Sleeves.

##### 4.2. Improvement of soldering Process

To enhance the toughness of the wire near the solder joint after soldering the CX-1B-5 connector, Anti-wicking tools is used for pre-tinning the wires. The Anti-wicking tools and it's working condition is shown in Figure 7~8. When the connector is tinned, the tin material creeps along the wire when it is hot-melted, and cannot enter the wire insulation due to tool blocking. A test was designed to verify the

effect after using the tool, and the heat-shrinkable sleeves are not installed to facilitate analysis of the effect of the tool on soldering performance.



Figure 7. The Anti-wicking tool.

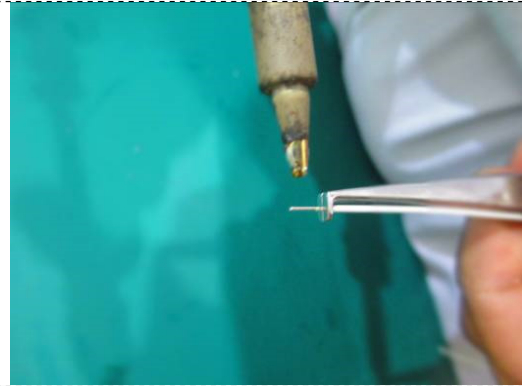


Figure 8. Working Condition

Figure 5. The Anti-wicking tool and it's Working Condition.

The test conditions are set as follows: the CX-1B-5 connectors are vertical clamped by hand vise, the wire is 270mm, and the tail of the wire is tied with a weight of 382g. The weight is used for pendulum movement, as shown in Figure 9~10, the angle is 30 degrees, manually swing the weight block along the fixed pendulum movement path, the number of bends recorded as one time as a pendulum back and forth. If the wire breaks during the process, record the number of bends before breaking.

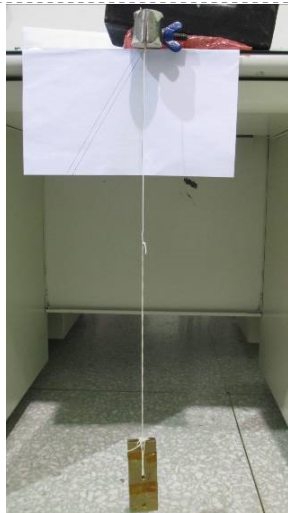


Figure 9. Pendulum Movement Test Photo.

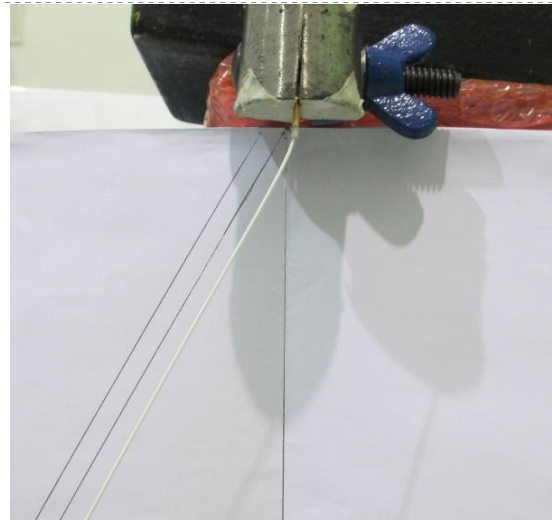


Figure 10. Enlarged View

10 test samples are operated by the same operators, the first 5 samples did not use anti-wicking tools, the last 5 samples use the anti-wicking tools, wire type is C55/0812-26, and the connectors are CX-1B-5 connector jacks. The test sample before and after fracture is shown in Figure 11~12, the fracture is the root of the soldered wire, where the ductility of the wire is low and the fatigue resistance is poor. The test data is shown in Table 1. The average number of bends before improvement is 7.6, and the average number of bends after improvement is 16.2, so the bending fatigue resistance improved by 110%.





Figure 11. The Test Sample before Fracture.



Figure 12. The Test Sample after Fracture.

Table 1. Comparison of the number of bends before the wire breaks.

| Sample Number | The number of bends before the wire breaks | Working condition  |
|---------------|--|--------------------|
| Sample1       | 10   | Before improvement |
| Sample2       | 7  | Before improvement |
| Sample3       | 6  | Before improvement |
| Sample4       | 8  | Before improvement |
| Sample5       | 7  | Before improvement |
| Sample6       | 23   | After improvement  |
| Sample7       | 16   | After improvement  |
| Sample8       | 16   | After improvement  |
| Sample9       | 12   | After improvement  |
| Sample10      | 14   | After improvement  |

## 5. Conclusion

This paper mainly analyzes the reasons for the failure of CX-1B-5 connector coupling during the spacecraft assembly process. Wire breakage near the solder joint is the common phenomenon of the connection failure. Through fracture morphology and fault tree analysis, tensile force after repeated bending is a key factor which leads to the fatigue fracture. Because the bending of the wire at the root of the solder joint is unavoidable, wire insulation thickening method and anti-wicking tools are used to improve the reliability of CX-1B-5 connectors coupling, with the test showing the bending fatigue resistance improved by 110% by using anti-wicking tools.

## References

- [1] Handbook of connector comprehensive selection, Guizhou aerospace electrical appliance corporation
- [2] ECSS-Q-ST-70-08C-2009, Manual soldering of high-reliability electrical connections;
- [3] Huang bo, LI Xun-bo, ZENG Zhi, Thermal Fatigue Life Prediction for Laser Soldering Joints of Electrical Connectors, ISTIC EI PKU, 2016, 46(6)
- [4] Jiang-ping YU, Xi-yan ZHANG, Yang SHU, Li TAN and Rui-sen YINE, evolution characteristics of microstructure and properties in AZ31 alloy during high cycle fatigue processes, Transactions of Nonferrous Metals Society of China, 2017, 27(7)
- [5] ZHANG Zi-yu, XIAO Bing, LIU Si-xing, DUAN Duan-zhi, Brazing mechanism and surface crack characteristics of diamond wire saw, The Chinese Journal of Nonferrous Metals, 2018, 28(2)
- [6] WANG Jing, WANG Yong, Interface Characteristics and Fracture Behavior of Al/Ti Dissimilar Metal TIG Welded-brazed Joints, Hot Working Technology, 2016, 45(21)