

**IMAGE LOW ENERGY NEUTRAL ATOM
(LENA) INSTRUMENT THERMAL
CONTROL**

February 1999

**Michael K. Choi
Code 545
NASA Goddard Space Flight Center
Greenbelt, MD 20771**

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1. Introduction

LENA is a scientific instrument on the IMAGE spacecraft. It consists of the LENA main box and the C&DH. The LENA main box includes the optics housing assembly, collimator housing assembly, electronics mounting plates, two micro-channel plate (MCP) power supplies, two collimator power supplies, an optics power supply, and a time-of-flight (TOF) electronics.

2. Thermal Design

2.1 Desired Temperature

The desired temperature for the LENA main box is 10°C maximum during the normal operating mode after 2 years, due to the high voltage power supplies.

2.2 Thermal Mounting Details

The LENA main box is thermally isolated from the IMAGE spacecraft internal thermal environment. It is mounted to and conductively isolated from the spacecraft equipment shelf through G-10 washers between its eight mounting feet and the equipment shelf.

The LENA C&DH is thermally coupled to the IMAGE spacecraft internal thermal environment. It is mounted to the equipment deck through its mounting feet. The mounting interface thermal conductance is enhanced by a RTV thermal conductive filler.

2.3 Thermal Finishes

The exterior surfaces of the LENA main box housing inside the IMAGE spacecraft have the Dow 9 black coating. The exterior of the electronics boxes mounted on the LENA main box housing is bare aluminum. The LENA main box is radiatively isolated from the IMAGE spacecraft interior by multi-layer insulation (MLI) thermal blankets. The coating on the outer cover of the MLI is vacuum deposited aluminum (VDA). The exterior surfaces of the collimator nose piece outside the spacecraft have the Goddard Space Flight Center conductive composite coating (ITO/SiO_x/Al₂O₃/Ag), which has a low solar absorptance and a rather high emittance, and is electrically very conductive. The solar absorptance at the beginning of life is 0.08, and the hemispherical emittance is 0.66. The interior surfaces of the collimator nose piece has black nickel as the coating. The cables are also insulated with MLI thermal blankets to minimize the heat conduction from the spacecraft to the LENA main box.

Both the exterior and interior surfaces of the C&DH housing are black to enhance heat radiation.

2.4 Survival Heaters

There are three zones of Minco kapton film heaters bonded to the exterior of the LENA main box housing to prevent it from falling below -40°C in the non-operating or survival mode. Each heater zone consists of three heaters in parallel, and two Elmwood mechanical thermostats in series. The total heater capacity is 10 W at 28 V. The heaters are unpowered during the normal operating mode.

3. Thermal Conductance between LENA and Equipment Shelf

The conduction coupling between the LENA main box and the spacecraft equipment shelf is approximately $0.1\text{ W}/^{\circ}\text{C}$. The radiation coupling between the LENA main box and the spacecraft interior is negligible.

Using a RTV thermal conductive filler to enhance the interface conductance, the conduction coupling between the LENA C&DH and the spacecraft equipment shelf is approximately $10\text{ W}/^{\circ}\text{C}$. The radiation coupling between the C&DH and the spacecraft interior is approximately 54 in^2 .

4. Heat Extraction Paths

During the normal operating mode, heat dissipated by the electronics on the LENA main box is conducted to the radiating surfaces of the collimator nosepiece. Heat is also conducted from the equipment shelf to the LENA main box through the G-10 washers and screws at the mounting feet. Heat dissipated by the C&DH is conducted to the equipment shelf through the mounting interface, and radiated from the exterior of the housing to the spacecraft interior.

5. Method of Verifying Interface Temperature

A flight temperature sensor on the equipment shelf, close to the mounting feet of the LENA main box and C&DH, monitors the mounting interface temperature in flight and in the spacecraft level thermal balance and thermal vacuum test.

6. Thermal Analysis

6.1 Thermal Model

Thermal analysis of the LENA instrument is performed by using SINDA and TRASYS. The thermal mathematical model of the LENA instrument has 135 nodes.

6.2 Description of Hot Spots

There is no hot spot on the LENA main box. The maximum flight temperature prediction in the worst hot case is 10°C. Also, the LENA main box is thermally isolated from the spacecraft. Therefore, the spacecraft does not see any hot spots on the LENA main box. In the normal operating mode, the maximum flight temperature prediction of the C&DH in the worst hot case is less than 40°C. This is the hottest temperature that the spacecraft sees.

6.3 Description of Cold Spots

The LENA main box is significantly cooler than the spacecraft interior. In the worst cold case, the minimum flight temperature prediction is -32°C. However, it is thermally isolated from the spacecraft. Therefore, the thermal effect of the cold spots on the spacecraft is negligible. The C&DH is thermally coupled to the spacecraft interior. During the normal operating mode, the C&DH is warmer than the equipment shelf. During the non-operating mode, the temperature of the C&DH is the same as the equipment shelf.