Cleanroom FDR

Introduction

The Spartnik cleanroom was constructed for the assembly and integration of the Spartnik satellite and its subsystems. The solar arrays on the exterior of the satellite require a cleanroom environment to avoid contamination. There may also be primary payload systems on the launch vehicle, such as the optical systems, that are sensitive to contamination. In such cases, the assembly of Spartnik in a cleanroom environment will be required to qualify for a launch.

Cleanroom Research

A portion of the Engineering Building's room 236 was chosen as the site for the cleanroom. The site was chosen due to the availability of air conditioning vents, power, and compressed air. Research into the type and class of cleanroom needed was conducted, including Internet searches, tours of the high-bays in which satellites are assembled and tested at Lockheed Martin, and the expertise of Carl Strombom from Hewlett Packard.

The Internet searches yielded several contacts with manufacturers of portable cleanrooms. Portable cleanrooms are modular systems and come complete with the frame, laminar-flow hoods, and vinyl sheets for the walls. The modular design allows for flexibility according to the specific application. The cost of portable cleanrooms is reasonable by industry standards, but high with respect to the Spartnik budget.

The tours of high-bays at Lockheed Martin yielded an understanding of the environment in which satellites are assembled in industry. The high-bays were between class 100,000 and class 10,000 cleanrooms. The class refers to the number of particles per cubic foot present in the air of the room. According to information from the web-site of Clean Air Solutions, a cleanroom consulting firm, a class 10,000 cleanroom requires HEPA filters across 20% of the total ceiling

of the room and 36 to 72 complete air changes in the room per hour. A class 100,000 cleanroom requires 10% coverage of HEPA filters across the cleanroom ceiling and 24 to 36 air changes per hour. To maintain this classification, lab coats, paper booties, and shower caps must be worn inside the room. People create the majority of contamination in the room.

Carl Strombom, from Hewlett-Packard, provided the majority of advice and information regarding the design and construction of the cleanroom. Carl also arranged for the donation of three laminar-flow hoods from Hewlett Packard. He came to San Jose State for a tour of the facilities, and based on what he saw, provided advice for building the cleanroom. The design advice provided allowed for simple, economical construction and maintenance of the cleanroom.

The hoods will take in air from outside the cleanroom, filter it, and force it into the room. The clean air introduced into the room will create a pressure differential between the inside of the cleanroom and the surrounding environment. This pressure differential will help to keep the room clean. As the air is drawn in by the hoods, it will flow over the tables and onto the floor. The walls will be constructed such that there is a gap between the bottom of the vinyl curtain and the floor. The air will flow out through the gap, sweeping the particles, which have been carried to the floor by the airflow, out of the room. The hoods can either be mounted from the ceiling from threaded rods, or mounted on top of C-frames. The C-frame option was chosen because it does not require any modification to the structure of the building. The walls of the cleanroom can be made out of either a wooden frame or a metal frame draped with plastic sheeting. If a wooden frame is used, any wood exposed to the inside of the room must be covered with plastic to prevent wood particles from contaminating the room. The most important issue in maintaining the cleanroom will be proper cleaning. Procedures were written for working within the cleanroom and for periodic maintenance.

Jim Currier, owner of Flowstar Corporation in Gilroy, a cleanroom consulting firm and fabricator, donated three C-frames on which to support the laminar flow hoods. The C-frames were custom made for the hoods, as were work tables. Employees of Flowstar installed the C-frames into room 236 in March 1999.

Design Requirements

According to (the book we got the table out of for the presentation, the cleanroom requirements for different assemblies pertaining to Spartnik are as follows:

General spacecraft assembly requires a cleanroom environment of class 100,000. Electronic assembly requires a class 10,000 cleanroom, and optical assembly is the most restrictive, requiring class 100. Mechanical assembly is not controlled.

Design Analysis

The hoods, mounted on C-frames, are arranged so that they form an "L" shape. A wall made of 2x4 lumber and plastic sheeting will connect the ends of the "L," creating a triangular-shaped room. An experiment was conducted to model the airflow from the hoods and across the cleanroom. This modeling was used to determine the final shape and dimensions of the room to minimize pockets of standing air in the room. Dry ice was used to visualize the airflow during regular operation of the cleanroom, and plastic sheeting without the wooden frame was used to simulate the walls. The dry ice was set under the laminar-flow hoods while they were running, and the airflow patterns were videotaped. The air has a tendency to flow under the worktables and escape from the cleanroom. This is undesirable because the air needs to flow across the entire cleanroom floor to ensure proper particle evacuation. The solution is to seal the back of the C-frames so that no air can escape, and install fans under the worktables to encourage the air to flow across the room. The original triangular-shaped design will work well for the room.

Final Design Summary

The final design is as follows:

Three laminar-flow hoods are mounted on C-frames, and arranged in an “L” shape. The worktables under the hoods provide 60 square feet of class 100 working area. The rest of the room will be class 1000. This is more than adequate for the requirements. The general shape of the room will be triangular, with fans mounted under the worktables to encourage the airflow across the room. The walls will be framed with 2x4 lumber, covered with plastic sheeting and constructed such that there is a gap between the bottom of the vinyl curtain and the floor.

Pending Projects

- The walls around the cleanroom still need to be built
- After the room is built, the cleanliness needs to be verified with a particle counter.
- If the room is not within the cleanroom spec, a ceiling may have to be added.