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TO APOLLO SATURN UNIT FABRICATION

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The extreme sensitivity of critical parts in the Apollo/Saturn Instrument Unit (IU) has demanded unique clean room techniques by International Business Machines Corporation.

IBM, through its Federal Systems Division facility at Huntsville, Alabama, is prime contractor to NASA for the fabrication, assembly and checkout of 27 flight model Instrument Units.

Designed by NASA's Marshall Space Flight Center and associated contractors, including IBM, the IU is the nerve center for both Up-rated Saturn I and Saturn V launch vehicles. All IU parts are vital to a successful mission because the three-foot high, 21.7-foot diameter ring contains the advanced electronic and electrical equipment needed to guide, navigate and control the vehicle from liftoff to Apollo spacecraft separation.

Of the six major subsystems -- structure, guidance, flight control, environmental, instrumentation and electrical -- the environmental and guidance systems' parts must be super-cleaned to qualify for a man-rated space vehicle. Particles in this equipment so small that they would be missed by the eye could cause serious flight problems. For instance,

a particle no larger than 20 microns (that is smaller than the diameter of a human hair) in the gas bearing supply for the IU's guidance system could cause a drastic navigational error.

For inspection and preliminary assembly work, a regular Class IV clean room -- where the temperature is always 72 degrees, plus or minus one degree, the relative humidity is 40 percent, plus or minus five percent, and the particle count is constantly monitored so that it does not climb dangerously -- has been built at IBM's Huntsville facility. But getting the cleaned parts assembled to the IU structure while maintaining Class IV requirements caused a problem. The IU's size prevented bringing it into the clean room, so the clean room was brought to the IU.

Mobile Clean Room

A downdraft mobile unit designed and built by Envirco of Albuquerque was selected by MSFC for the job. The room is big. It has to be to do the job. Nearly 12 feet high, 13 feet long, and 9 feet wide, it has a five-horse power motor, belt-driven blower, which drives 8,110 cubic feet of air downward at a speed of 100 feet per minute.

The motor, which is the heaviest part of the room, is centered on top. With the weight distributed among the four supporting legs, whenever the room is moved, there is little chance of a tipping problem.

Placement of the legs is interesting. Two are positioned at the center, while the other two are at the back end. This allows 50 percent of the power area to extend over the IU interference-free. Thus, the unit can be positioned with all four legs outside the IU while enough clean

air washes down both sides during assembly operations.

The room is fitted with a clear vinyl curtain, 15 mils thick. This completely surrounds the filters and has several vertical thistle fastener-type openings. Arranged in this fashion, the portion of the IU ring that is being worked on can be covered while the remainder extends through the openings in the normal high-bay assembly area. These slight openings cause no great problem because the inside pressure, which is kept at 0.1 to 0.2 inches of water, simply forces contaminated air out.

The curtain drops to about one foot from the floor, and with the high rate of downward air flow the possibility of contamination seeping underneath is negligible.

Other room details include four fluorescent lights, heavy duty casters on the legs for easy movement, a pre-filter which is a microtron, woven-dacron type CHP filter with an efficiency rating of 45 percent as measured by the National Bureau of Standards Dust Spot Test Method. There is a final filter rated at 99.97 percent efficient in the .03 micron range. Twelve filters (modules) are required to fill the upper frame, and these measure 2 feet by 4 feet by 6 inches. The room weighs approximately 3,500 pounds.

Operation

When cleaned parts are to be assembled to the IU's cylindrical, aluminum honeycomb structure, the portable clean room is positioned, Padding, or other protection, is used to prevent the legs from touching the IU structure, and the leg casters are secured to prevent movement.

Before the blower is started, the floor underneath the room, and

the adjacent work area, is vacuumed to remove loose dirt. Two other precautions against accidental contamination are taken: the blower is started fifteen minutes before any packaged part is delivered, assuring a steady, uninterrupted downward flow of air when work begins; and work is never performed within one foot of the bottom, or within 14 inches of the sides.

Quality Control

When the room is in operation, quality control technicians make particle counts at least once a day inside the portable clean room. This particle count cannot exceed the Class IV requirements as measured at a minimum of one-foot above the bottom of the curtain.

Temperature and humidity requirements are controlled by monitoring the outside environment. The high-bay assembly area meets Class I clean room requirements, sufficient to perform work within the portable area. Cleaned parts moved from the permanent clean room are never exposed longer than necessary, and are kept packaged until ready for installation.

Maintenance

Prefilter media are checked twice each week to determine replacement needs. The absolute (99.97 percent efficient) filters are protected by use of the prefilter, and are expected to last several years. A further check is made by using a magna-helic gauge located near the "Start" button, which is outside the curtain. This gauge indicates the pressure passing through the filters; if it exceeds 1.5 inches water the absolute filters need changing. An indication of the success of the pre-filters is

demonstrated by the fact that the absolute filters have not required changing in the two years the room has been operating.

Employees follow normal clean room regulations. For example, each employee working in the room takes a four-hour clean room indoctrination course; smocks and caps, which are packaged in plastic bags when not in use, are worn by technicians and this clothing is not used outside of the clean room area, nor is it worn to and from the regular clean room. Finally, visitors are kept out. Any monitoring necessary is done by observing the work through the clear vinyl curtain, and no one is permitted to enter or leave the room while parts are exposed.

Conclusion

Three units are in use, and each one has given satisfactory service for the two-year period. The design and construction make them portable about the 300-foot-long assembly area, giving the facility a Class IV clean room capability when required.

