

Cleanroom Gowning or How to Dress in the Cleanroom

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Before embarking on missions in space, NASA spacecraft and rovers are assembled in special facilities called cleanrooms. Cleanrooms are designed to be pristine. Cleanroom conditions control particulate, molecular, and biological contamination of hardware destined for exploration beyond Earth.

People who work in the cleanroom and the activities performed there are the primary sources of contamination that can find its way into the cleanroom. People naturally shed particles, including skin cells, hair and respiratory droplets. Clothing also sheds particles and fibers when people move through the airflow in the room. As a result, cleanrooms require special dress considerations, known as cleanroom gowning. Gowning is critical to maintaining a clean hardware assembly environment by containing many shedding human and clothing-based particles.

In addition to proper gowning, there are a number of requirements and restrictions regarding personal items and attire in cleanrooms. For example, wearing make-up is prohibited. Open-toe shoes are not allowed, even under shoe covers; all footwear should be fully enclosed. Workers should remove outer layers such as sweaters, as well as removing clothing that might be particularly likely to shed particles like sweaters or glitter.

For spacecraft with missions that target Jupiter and its moons, Mars, and Enceladus, where there is the possibility of past or present life, planetary protection requires that workers wear full cleanroom garments. These include head coverings, coveralls, and shoe covers and are colloquially known as bunny suits. Workers wear these garments over street clothes to prevent contaminants such as clothing particles and hair and skin cells from entering and the cleanroom and potentially transferring to the sensitive spaceflight hardware. People must wear

cleanroom garments at all times in the cleanroom. Most suits are made from non-particle generating, anti-static white fabric such as Tyvek® and workers should change their suits daily to maintain optimum cleanliness levels. The ensemble includes a disposable hair cover, face mask, a hood that covers the entire head and neck, coveralls, disposable shoe covers, and cleanroom boots to wear over shoes and shoe covers. It's essential to glove hands, and in some cleanrooms, the gauntlet of the glove is taped to the sleeve of the overall to prevent slippage, which could expose a

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wrist or bare arm during cleanroom activities. Gloves are replaced upon entry to the cleanroom, when they get dirty or are solvent cleaned throughout the assembly process. Maintaining clean gloves minimizes the direct transfer of particulates around the cleanroom. Gloves may also be worn in multiple layers, which allows the outer glove to be removed when it becomes dirty to expose a clean glove underneath. All gowning and degowning take place in the anteroom or change room. There are special procedures for gowning and gown removal when entering or exiting the cleanroom.

Personnel who work in the cleanrooms receive specialized training and certifications on how to suit up. The gowning process starts by putting on

disposable shoe covers over street shoes. Some cleanrooms have a special shoe cleaner that brushes and vacuums the outer surfaces of the street shoes before putting on shoe covers. Once inside the change room, gowning proceeds from the top down. A disposable hair cover and beard/face covering come next, and it's crucial to contain all hair under the hair cover. A cleanroom hood cover is put on over the disposable hair cover. Next come the coveralls, and it is crucial to take great care to keep the coveralls from touching the floor during gowning. The coveralls are carefully pulled over the legs, the arms are inserted in the sleeves, and the head cover is tucked into the coveralls' neck before zipping and closing the suit. Next, cleanroom boots are put on over the disposable shoe covers and adjusted for a snug fit. If electrostatic discharge (ESD) wrist straps are required, the wrist strap is worn under the cuff of the coverall cuff and gauntlet. The last item of clothing is the gloves. Some cleanrooms include air showers, and suited workers must walk through the air shower before entering the cleanroom. Whenever the worker leaves the cleanroom, the individual goes back into the change room to remove all cleanroom garments in the reverse order as the gowning process.



Applied Physics Laboratory (APL) engineers gowned and working on the upper cylinder of the Europa Clipper Spacecraft. Cleanroom garments include head and face covers, coverall, boots and gloves (photo provided by APL, used with permission)

Once fully garmented, individuals cannot pull down their face masks or remove any part of the cleanroom garments while working in the cleanroom. When wearing multiple layers of gloves, additional pairs go over the first upon entering the cleanroom. These extra pairs can be changed as needed when the outer glove layer is contaminated. For example, if someone touches the floor with their glove or takes a phone call, the top set of gloves should be removed and replaced.

Cleanroom garments can be hot and uncomfortable, but they are essential for maintaining biological cleanliness for many cleanroom purposes, including planetary protection. Many other industries use cleanroom garments, including medical suppliers and the semiconductor industry. For planetary protection, suits and gloves provide a barrier between humans that build spacecraft and the flight hardware.



APL's planetary protection laboratory is located inside the hardware assembly cleanroom complex. All analysts are required to wear cleanroom suits to perform their lab work. (photo provided by APL, used with permission)

In addition to gowning, other protocols in cleanrooms ensure the hardware stays as clean as possible. Although a cleanroom can be busy, the number of people allowed in the room at any one time is controlled and monitored. The operational requirements of wearing a suit require that everyone is always aware of their physical actions and activities and mindful of any actions that might compromise cleanliness requirements in the cleanroom.