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Cleanrooms

Air Caster Technology in the Cleanroom Environment

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An air-powered solution has become the preferred material handling system for cleanrooms because it prevents damage to expensive flooring and ensures nearly frictionless, vibration-free movement.

Semiconductor operations need to meticulously protect their machinery from vibration, shock loads and particulates, which can cause potentially ruinous damage to invaluable equipment. These understandable concerns explain why the semiconductor industry has such stringent requirements for handling and transport of equipment used in its cleanrooms.

From wafer probers weighing more than 4,000-pounds to 20,000-pound

lithography equipment, these extremely heavy delicate, and often unwieldy machines can be prohibitively difficult to navigate through environments that often include tight corridors and raised floors with limited load support—all while keeping equipment protected and safe. So how can these manufacturers not only maintain facility cleanliness when moving heavy machinery and still manage the sensitive equipment that populates these cleanrooms?

For an optimal load moving solution, many facilities turn to air casters. Their specific features are designed to eliminate nearly all material handling challenges in a cleanroom environment.

The composition of air casters

Air casters are donut-shaped bags that attach to an aluminum structure or load module while an air hose connects the standard compressed air supply (Figure 2). As the bags inflate, excess air leaks beneath them and forms a nearly frictionless, 0.003-inch to 0.005-inch film of air. The load then literally floats on the ultrathin air cushion. At that point, air casters work much like the puck on an air hockey table or a hovercraft, rendering the load easy to move in any direction.

Consider the experience of one semiconductor manufacturer that needed to repeatedly move a wafer prober with a chiller unit (Figure 1) inside its cleanroom across vinyl composition tile (VCT), a move that required overcoming several challenges, including:

- **Weight.** The entire unit weighed nearly 5,000-pounds.
- **Fragility.** The equipment contained delicate components sensitive to shock.
- **Unwieldiness.** The weight was distributed unevenly across the machine.



Figure 1. A 4800 lb. test cell wafer prober is moved 30-40 feet, four times a day, on an air caster pallet over VCT flooring.



can easily arrange component modules for assembly by pushing them together and attaching them without requiring cranes or other load-movers. Indeed, cranes come with their own limitations. It would be impossible to use a crane to move machinery from a loading dock to the final destination through hallways, loading doors, and 90 degree corners.

The advantage of built-in lifting and lowering mechanisms

Air casters can also move equipment in and out of service as often as needed during the day with only an operator, a spotter, and a source of plant air. But how can the two users place the load onto the air caster?

If the operation involves a wheeled vehicle, rollers or other conventional method, getting the machine loaded becomes a project of its own. Operators will have to jack the machine up; slide the cart, vehicle or platform underneath, lower the jacks to place it onto the rollers, move it into place and, finally, jack it up again to pull out the rollers before setting it down. These are non-issues with air casters, which are self-loading and form a lift transport. Users insert the air caster underneath the

Figure 2. With the machine's wheel placed on the aluminum square housing the air caster, weight is efficiently redistributed, alleviating any issue with floor point loads on raised floors.

- Damage potential. Load movement could harm a delicate floor; in fact, most traditional material handling solutions would damage the VCT.
- Frequent moves. The operation required as many as four moves a day without disrupting production.

These challenges are compounded when the facility is a cleanroom. To meet that environment's stringent standards, the manufacturer determined air casters were the best option.

The advantage of human power for moving heavy loads

With air casters, a single operator can move very heavy loads, although larger moves require more operators and spotters. Moving typical processing equipment, for instance, requires a single person to push and a spotter to guide the operation. With a friction coefficient of less than 1-percent, the air caster requires only 5- to 25-pounds of force to move a 5,000-pound load (Figure 3). By contrast, other common alternatives in cleanrooms, such as vehicles or platforms with wheels or rollers, require significant amounts of force for load movement and hand steering. A similar 5,000-pound load on wheels pushed by hand would take 300-pounds of force and perhaps more if the wheeled conveyance must pass over a surface with gaps or steps.

The advantage of superb maneuverability

Space is always at a premium in

cleanroom environments, where costs per square foot can be some of the most expensive. Operators will most likely have to move equipment down narrow hallways, around 90-degree corners and through load doors from the loading dock. Indeed, one semiconductor producer had to move a 4,000-pound inspection tool from the shipping and receiving dock to the work area through three sets of double-doors and into a joint chamber with the rest of the tool. Thanks to air casters, the move, which was completed successfully, required only two people.

That's why material handling solutions must minimize the space



Figure 3. It only takes 5-25 pounds of force for a single operator to move up to 5,000 lbs. on air casters.

required for the move—a situation tailor-made for air casters, which sit within the footprint of the equipment to be moved and can turn omnidirectionally at a push, including rotating in place. That becomes critical if modules must be joined to assemble larger machines. An operator with a spotter

machine and turn on the compressed air supply. The casters put the equipment into a floating condition, lift the load slightly off the floor then deflate and gently lower it to the ground when the move is completed.

Notably, air casters lift the load by only 2- to 2.5-inches, compared with a

5- to 10-inch lift required for wheeled casters. That low profile offers a load-lifting advantage, which proved beneficial for another semiconductor manufacturer moving a variety of processing equipment. The company had kept its cleanroom intentionally small (relatively low ceilings and doorways with low headroom) creating an environment ideal for minimizing the total volume of space to be kept clean but increasing the difficulty for moving large machinery. The limited volume, however, proved to be no problem for air casters that easily fit the facility profile.

The advantage of floor surface protection

Returning to the wafer prober example, the manufacturer had also invested in special raised vinyl composition tile (VCT)

flooring that had to be protected from damage. The air caster exerted low local contact pressure, with total floor loading around 25-psi to avoid damaging the tiles (Figure 1). Compare that to the usual 1,000- to 2,000-psi of wheeled casters, which concentrate load at a limited number of points of contact.

Different types of flooring represent different challenges. Cleanroom floors are often composed of raised panels with limited weight-supporting capabilities. If the load handling mechanism doesn't share a heavy load equally and/or lacks a built in suspension system, system overload is inevitable and it is likely to damage to individual panels.

Consider moving a theoretical machine weighing 4,000-pounds via a wheeled solution over panels unable to support more than 1,000-pounds each.

With a four-wheel load mover, one wheel is likely to lift off the floor at some point, perhaps while passing over a slight area of unevenness or a gap. In that moment, the other three wheels suddenly shift from supporting 1,000-pounds each to more than 1,300-pounds, which overload the floor panels.

Adding wheels can potentially complicate this situation. Without a suspension system, it is impossible for



Figure 4. Heavy machines floating on air casters do not pose any risk of damaging epoxy floors.

wheels to evenly distribute a load to a floor, particularly when panels are not perfectly flat. Load-sharing capability is mandatory, especially for machinery whose weight isn't evenly distributed. That is precisely what air casters are designed to control.

Because they lift the load on a film of air, they automatically share the load so that none of the four panels are subject to more than 1,000-pounds each. This simultaneously prevents operators from overloading any individual point and reduces or even eliminates the risk of tipping an unbalanced load.

Clean moves and vibration protection

It is not just the floor that is potentially breakable. Semiconductor machinery, no matter how large, can be surprisingly delicate and sensitive

to vibration and shock, much like the silicon wafers they produce. Wheeled casters that move this machinery over a floor with gaps and steps may well transmit vibration and shock loads to the machine. Too intense a shock during movement will likely damage the equipment's fragile internal components. With air casters, the inflated bag acts as a large air spring, isolating the load from vibration and shock, protecting both the floor below and the machine above.

Air casters ensure clean moves

Air casters offer the features needed to resolve nearly all material handling challenges inherent in a cleanroom environment. Indeed, an air-powered solution has become the preferred material handling system for cleanrooms because it prevents damage to expensive flooring and

ensures nearly frictionless, vibration-free movement to preserve delicate, precision-calibrated machinery. In short, air casters are the best option for keeping cleanrooms pristine while moving heavy loads. Semiconductor cleanroom operators have some difficult choices when deciding how to move their delicate, heavy machinery, but one option clearly and easily floats to the top of the list: air casters.

About the Author

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