

White Paper

How Aero-Casters Can Work Perfectly Even On Imperfect Floors



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AeroGo

Innovative Load Moving Solutions

Aero-Casters can work perfectly even with imperfect surfaces, with the right preparation.

Here's how: Aero-Casters offer numerous advantages over other methods of moving extremely heavy loads; but because they require the floor or surface to meet certain conditions, many would-be users assume the casters won't work with their floor. Not true! It's far easier than you think to prep your surface for use with Aero-Casters. With the right remediation tactics, they can work beautifully even with "impossible" surfaces. This paper will break down your options for prepping your floor for use with Aero-Casters, organized by surface type and condition.



2998 Ton Yacht Moved on Air Bearings in a Shipyard.

Aero-Casters can work perfectly even with imperfect floors, with the right remediation tactics.

What's your floor type or condition?									
Floor type or Condition:	Remediation options:								For more information, see:
	Thin Overlay	Steel Plate	Sealant	Top Coat	Tape	Special Casters	Filler	Other	
Antiskid	✓	✓		✓				✓	Rough Surfaces, p.14
Asphalt	✓			✓				✓	Rough Surfaces, p.14
Concrete	✓		✓	✓				✓	Concrete Surfaces, p.5
Cracks	✓	✓			✓	✓	✓		Cracks, Expansion Joints and Small Gaps, p.9
Elevated Platform		✓				✓			Minimal Load-Bearing Capacity, p.11
Expansion Joints	✓	✓			✓	✓	✓		Cracks, Expansion Joints and Small Gaps, p.9
Gaps (Small)	✓	✓			✓	✓	✓		Cracks, Expansion Joints and Small Gaps, p.9
Gaps (Large)	✓	✓					✓		Gaps, p.12
Mezzanine		✓				✓			Minimal Load-Bearing Capacity, p.11
Minimal Load-Bearing		✓				✓			Minimal Load-Bearing Capacity, p.11
Porous Surface	✓		✓	✓				✓	Porous Surfaces, p.13
Raised Flooring		✓				✓			Minimal Load-Bearing Capacity, p.11
Ramps								✓	Sloping Surfaces, p.15
Rough Surface Texture	✓	✓	✓	✓				✓	Rough Surfaces, p.14
Sloped Floors								✓	Sloping Surfaces, p.15
Steps and Projections						✓		✓	Steps and Projections, p.12
T-Slots		✓				✓			Gaps, p.12
Unevenness or Undulations in Floor	✓	✓				✓			Uneven Flooring, p.16
Wood Floors		✓				✓			Wooden floors, p.17

Aero-Casters are an amazing way to move heavy loads. They work with far more surfaces than you may realize, with many different remedies available.

Aero-Casters – also known as air casters, air bearings, air cushions, air pads, air skates, etc. – provide optimum movement compared to wheels, in the right environment. They allow enormously heavy loads to float on a thin membrane of air, and furthermore to distribute the load much more evenly than other transport methods, including skates, wheels, and fork lifts.

Thus, Aero-Casters can protect delicate floors and equipment while making it easy to precisely align and easily move heavy loads without powered equipment (see the table below for a comparison between air casters and wheel casters). Aero-Casters have been proven to work perfectly moving loads from 500 lbs. to 5,000+ tons on a variety of surfaces.

However, air casters require a certain level of continuous air pressure to operate. The specifics vary based on the floor surface and conditions, which can have an enormous impact on the effectiveness of the Aero-Casters.

Since the thickness of the air film is only .003” to .005” (the thickness of a business card), the quality and condition of the operating surface is the most important aspect of any Aero-Caster application. A perfect surface reduces the amount of air required for flotation and ensures continuous, smooth movement.

Successful Aero-Caster operation requires a smooth, nonporous surface – a clean, “slick” material. In general, polished plate glass is used as the standard reference; this surface requires the least amount of air for flotation of a given load. In other words, it maximizes load carrying capability with the least amount of air.

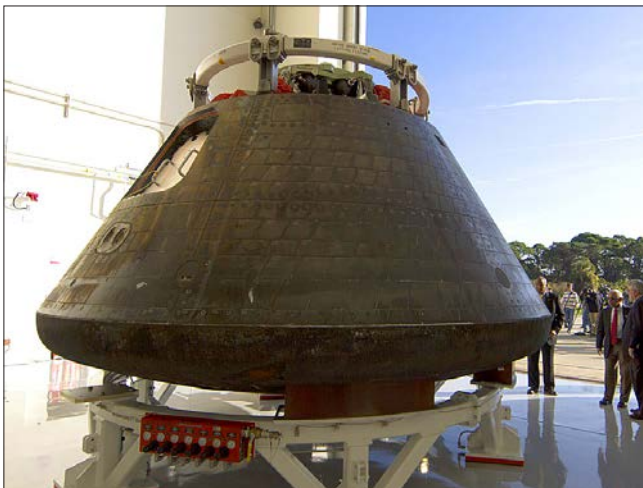
Air Casters	Wheel Casters
Require only 5-25 lbs. of force for one person to move 5,000 lbs.	Require 300 lbs. of force for one person to move 5,000 lbs.
Floor wear and tear is near zero due to reduced friction.	Can create floor grooves and peeling from point loading.
No noise, no dust, no friction, no static.	Wheels can squeak and create marks, cuts, friction, and static.
Easy, accurate and immediate positioning in all directions.	Resist directional changes.
No vibration or jarring.	Pits and bumps in the floor transfer to and through wheels.

Other examples of preferred floor surfaces include:

1. Coated concrete surface (coated with epoxy material to fill in peaks and valleys)
2. Concrete (Index 2 – smooth, steel-troweled and sealed with light reflecting non-porous penetrating surface sealant.)
3. Steel or Aluminum plate (no rust, oil, mill scale, burrs)
4. Varnished hardwood floors (e.g., gymnasiums)
5. Linoleum (non-embossed)
6. Vinyl tile (non-embossed)
7. Formica

However, the operating surface does NOT have to be perfect. Few are; and there are many, many different remedies available for almost any type of surface.

This paper will discuss specific techniques that can be used to enable almost any surface type or condition to work with air casters.



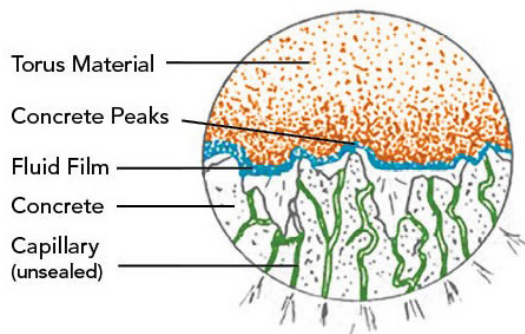
Concrete Surfaces

Aero-Casters will function well on machine steel troweled surfaces which conform to the construction specifications covered in the American concrete institute standards 301 and 302, which require a $\frac{1}{4}$ " in 10' finish surface tolerance.

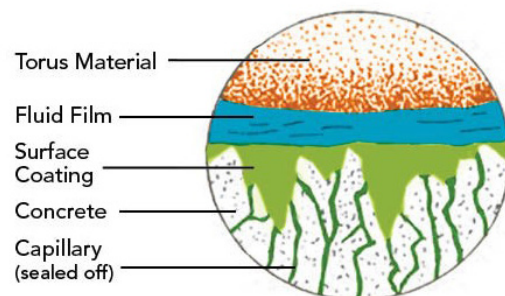
Fortunately, licensed contractors routinely conform to these standards. Sealed, steel-troweled smooth concrete offers a very good air film surface that falls short only of sheet or plate steel, glass, smooth vinyl tile, and similar surfaces.

However, not all concrete surfaces match those specifications; these may require some form of preparation for use with Aero Casters. When a concrete floor hasn't been sealed, the pressurized air in the Aero-Casters escapes through the porosity of the concrete. In other words, unsealed concrete acts like a sponge to absorb air. This is easy to detect by pouring a small cup of water on the floor. Water will bead on a sealed floor but soak into an unsealed one.

When this happens, the Caster may be unable to hold the necessary air pressure to float the load or the air requirements may be excessive.



Poor surface: Untreated Rough Concrete



Good Surface: Coated Concrete

Permanent Option 1: Concrete sealant

Concrete, the most common industrial floor, can be easily made non-porous by applying commercial sealants.

Commercial sealants should be applied to the concrete surface in a manner, time schedule and temperature range as prescribed by the sealant manufacturer. Use a penetrating sealer (look specifically for the word “penetrating” on the sealer product).

Since this solution is permanent, it is wise to apply the sealer to a small test area and operate a loaded AeroGo product before coating the entire facility with the product. Variations in concretes and the presence of hardeners in the surface can affect how the sealer adheres and penetrates.

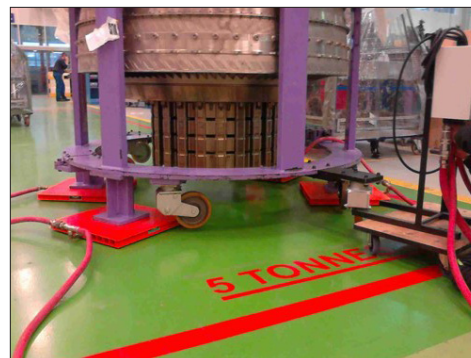
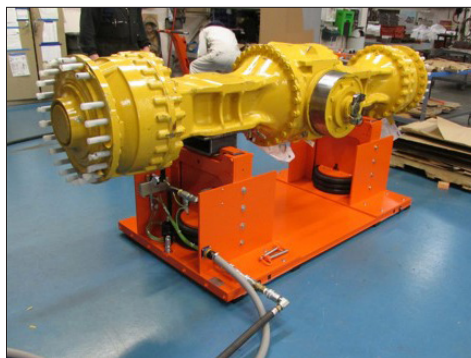
Permanent Option 2: Concrete top coating

A top coating seals porous concrete while simultaneously improving surface smoothness. The function of the concrete top coating is to fill the ‘valleys’ in the top surface of the concrete and provide a durable smooth, light reflective, wear- and weather-resistant operating plane.

Commercial, solvent-less, epoxy-based coating(s) should be applied to the concrete surface in a manner and time schedule as specified by the coating manufacturer.

Depending on the floor finish and coating, additional applications and/or surface grinding may be required.

Ensure the surface is clean, and, as with sealant, always apply the top coating to a smaller test area before coating the entire facility with the product.



Temporary Option: Overlay

Any clean, uncorroded “slick” surface material strong enough to bridge surface irregularities without being damaged by the air pressure load of the Aero-Casters would be suitable as a temporary surface overlay. Thickness of material depends upon its stiffness, underlying roughness, and air pressure load.

Examples of suggested overlay materials are:

- Aluminum (sheet or interlocking planks)
- Smooth, galvanized sheet metal
- Hot rolled steel (no rust, oil, mill scale or burrs)
- Painted steel (avoid urethane paints)
- Vinyl linoleum
- Mylar
- Sealed or smooth painted plywood
- Standard plywood with vinyl or metal overlay

Overlays should be equal to or less than 0.020”, if they are not tapered at the edges. Overlays greater than 0.020” should have runway edges beveled to a 1:20 slope. Ensure that the edges are free of burrs or sharp corners that might wear, cut or tear the fabric of the Aero-Casters.

Whenever possible, tape the joints of the overlays, and with lightweight sheet metal, tape the leading edge of the sheet metal so the Aero-Caster does not bulldoze the sheet metal out of the way.

Also, for overlays greater than 0.020” thick, use vinyl “T” extrusion to seal butt joints of plywood panels or metal plates on construction and expansion joints. Duct tape applied to the underside of the gap may be used to secure the overlays in alignment.

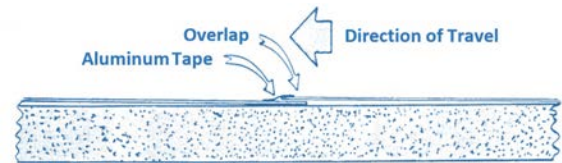


Linoleum Overlay



Aluminum Overlay

Overlap edges by shingling in the direction of travel so that the Aero-Casters step down from one sheet to the next (see image below). Further, arrange sheets such that the Aero-Casters cross the fewest number of joints.



Care should be taken where several sheets of overlay material run together at odd angles, such as in turning corners. Aero-Casters should not travel the length of a joint; indeed, joints should be infrequent and “stack” heights reduced.

Sheets should be wider than the Aero-Casters in use (typically three times wider).



Cracks, Expansion Joints and Small Gaps

Hairline cracks cause few problems, unless the available air supply volume is marginal, but larger cracks and expansion joints should be addressed to prevent air losses. In general, the same surface treatments described for cracks will also apply to expansion joints. Construction joints should be avoided wherever possible; but if inescapable, such joints should be treated to prevent a shift – where air losses can occur – between adjacent surfaces. Like cracks, expansion joints can be filled, taped, or covered with an overlay (usually 20-gauge sheet metal).

Temporary option: Aluminum tape

Taping can be a quick method for overcoming smaller floor defects for short-term use of Aero-Caster floated loads. This works well for smaller cracks, joints or holes – in either single or multiple layers. Aluminum tape can also be used on overlays to address any small gaps.

Temporary option: Overlay

Overlay creates a smooth, sealed operating surface path for Aero-Casters by covering unsealed surfaces, steps and gaps, and drain holes. For example, AeroGo high-density polyethylene (HDPE) geo-membrane easily rolls over the travel path to cover small gaps, cracks, and joints while eliminating the need to tape seams as with smaller sized sheets. For more information about overlays, refer to “[Concrete Surfaces](#)” section.

Permanent option: Load-bearing filler

In situations that may call for a permanent solution, fill in the cracks or expansion joints with a permanent filling like an epoxy or urethane – the latter is preferable because it’s flexible and less breakable. Make sure the filling is flush with the adjoining surface. The finished surface must be smooth and continuously bonded to the crack/joint walls to prevent air losses.

The filler must flex with temperature and operating changes, and must provide minimum surface planarity interruption consistent with fluid film operational



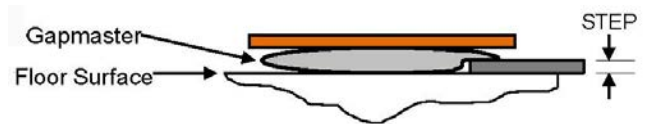
requirements. If all air passages are not sealed, air may escape during operation and/or put upward pressure on other joint areas. Thus, the filler must be applied securely so that it resists both down and up air forces.

In some cases, it may not be possible to achieve complete surface continuity with filler material alone. A slightly convex profile is fine, but a concave profile should be remediated (see the "[Uneven Flooring](#)" section for more information).

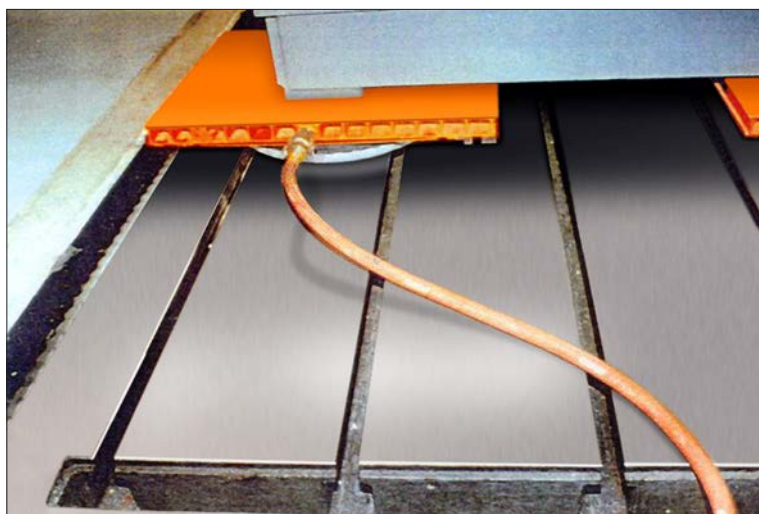
Clean the cracks free of all loose materials, then epoxy fill smooth and flush with adjoining surface.

Permanent option: Gapmaster™ Aero-Casters

It may also be possible to use Gapmaster™ Aero-Casters without having to repair the floor. Gapmaster™ Aero-Casters are designed to provide smooth movement of loads over gaps and steps up to 1" in floor surfaces. Gapmaster™ Aero-Casters utilize the same principle behind regular Aero-Casters, but a flexible perforated membrane encloses the Gapmaster™ Aero-Casters in order to meter the rate of airflow. When the Gapmaster™ meets a gap, this membrane prevents the rapid outflow of air. Similarly, when the Gapmaster™ meets a step in the floor, it can accommodate changes in floor height since it is actually floating over the surface on a nearly frictionless cushion of air 0.003" to 0.005" thick.



Note: drawing not to scale.



Gapmaster Aero-Casters Traverse Gaps and Steps.

Minimal Load-Bearing Capacity

It is reasonable to be concerned about the force applied to a floor when using Aero-Casters. All potential operating surfaces are the upper surface of a floor of some type, and all floors have load limits regarding allowable weight distribution over an area.

Some floors may have low load-bearing capacities. These include mezzanines, cleanrooms, elevated platforms, floors above ground level, ship decks, wood, etc.

Fortunately, this situation highlights one of the competitive advantages of Aero-Casters compared to rollers and wheels. A typical Hilman-style machine roller, fork lift or wheeled vehicle can transmit pressures well over 1,000 psi. Aero-Casters, by contrast, typically transmit pressures in the two to 50 psi range.



Permanent option: More Aero-Casters

It's also possible to lower the pressure on the floor by using more Aero-Casters to bring the load down to just a few pounds per square inch, since Aero-Casters can spread out the load very efficiently. This often works well in cleanrooms with raised floors, for example.

Depending on the specific scenario, this remediation technique may be used either in place of or in addition to using a load-bearing overlay.

Temporary option: Load-bearing overlay

Self-supporting overlay must be used. Quarter inch (1/4" or 5mm) steel plate, butt-welded, has sufficient strength for many conditions. Supplementary supports may be necessary for proper load distribution.

Lay the sheet steel across the path to be traveled and spot weld, then use aluminum tape across the seam.

Gaps

Some gaps – like drains, railroad tracks, utility troughs, etc. – exceed the size of ordinary cracks and expansion joints and require special treatment. Such gaps must be avoided entirely or brought up to the smoothness, non-porosity, and continuity needed for proper operation.

Temporary option: Thin overlay

In general, large gaps can be filled with Plaster of Paris, wet sand or any other load-bearing material and then overlaid with thin, rollable overlay.

Temporary option: Load-bearing overlay

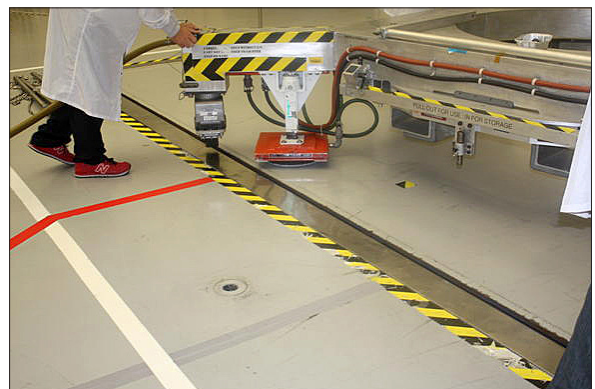
Alternatively, it may be possible to use self-supporting overlay alone. Quarter inch (1/4" or 5mm) steel plate, butt-welded and ground has sufficient strength for many conditions, though supplementary supports may still be necessary for proper load distribution.

Steps and Projections

Blend steps by grinding to slope angle of 1:20 or greater. Steps should not exceed local planarity height limits noted in the "[Uneven Flooring](#)" section. Blended areas should be sealed. Special Aero-Casters, like Gapmasters™ and High Lifts, may also help with steps.

Grind projections flush with adjacent concrete, or blend as with steps. Like steps, projections should not exceed the local planarity height limits. See the "[Uneven Flooring](#)" section for more information.

Areas should be sealed, and it's advisable to add a radius to corners; it's easier for the air casters to go over a round surface than a sharp edge.



Porous Surfaces

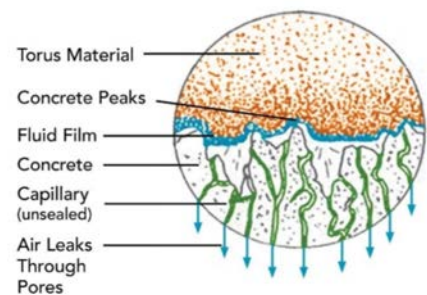
Porous surfaces act like a sponge to absorb air. Materials like unsealed concrete, plywood, blacktop, etc. will absorb air, preventing the formation of a proper operating film under the Aero-Caster and thus grounding the load.

Concrete, the most common industrial floor, can be easily made non-porous by applying a commercial sealant or top coating. Please see the "[Concrete Surfaces](#)" section for more information.

Temporary option: Overlay

Other porous surfaces can be mitigated with a temporary surface overlay.

- For surfaces with full load-bearing capacity, it is possible to use a thin overlay like 24-gauge sheet metal (galvanized steel or aluminum), vinyl linoleum (non-embossed), or 14-mil plastic.
- For surfaces with minimal load-bearing capacity, the overlay must be able to support the load, such as $\frac{1}{4}$ " steel plate butt-welded and ground.



Rough Surfaces

The texture of the surface can also affect the effectiveness of the Aero-Casters. An asphalt highway is typically flat and level but far from smooth. Similarly, while machine-troweled concrete is typically smooth, hand-troweled is not.

Optimal Aero-Caster operation requires smooth-to-touch surfaces, not just flat and level. In fact, local smoothness of the operating surface is perhaps the single most important factor relating to compliant fluid film operation. The film of air between the torus bag and the operating surface is in the range of .003" to .005" thick, and rough surfaces with peaks and valleys that are greater than this thickness will penetrate the film, causing drag and undue wear on the Air-Caster bag.

Permanent option: Top coating to fill the 'valleys' in the top surface of the flooring.

A top coating seals porous concrete while simultaneously improving surface smoothness. A top coating can provide a durable, smooth, light reflective, wear and weather-resistant operating plane. For example, a commercial, solvent-less, epoxy-based coating(s) can be applied to an appropriate surface.

Temporary option: Overlay

Any clean, uncorroded "slick" surface material strong enough to bridge surface irregularities without being damaged by the air pressure load of the Aero-Casters would be suitable as a temporary surface overlay.

The necessary thickness of the material depends upon its stiffness, underlying roughness, and air pressure load. Please see the "[Concrete Surfaces](#)" section for more information.



Sloping Surfaces

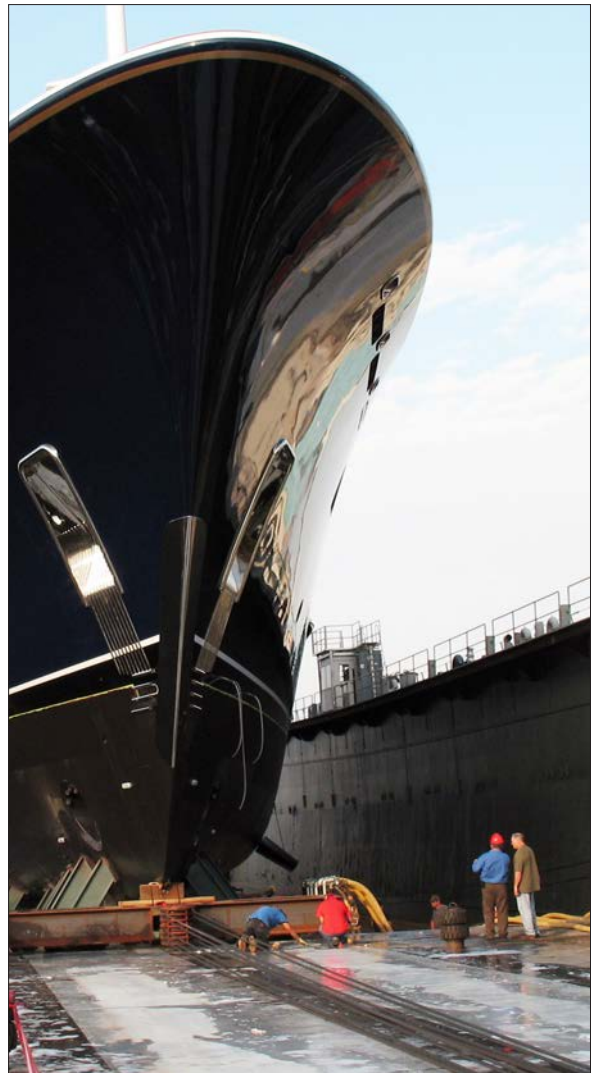
The finished surface should not slope from a flat overall plane greater than 0.1%, or a ¼" in 10'0" slope (or less). Aero-Casters can operate on ramps and sloped floors, but slopes create two critical issues that must be addressed early in any application.

1. One is the force of gravity and safety. When the Aero-Caster floats, friction is virtually eliminated, and the load must be secured; or you will have an immediate safety problem moving downhill.
2. The second issue is that sloped floors that require uphill movement drastically increase the pushing force required. Uphill takes more pushing force regardless of whether a load is on air bearings or anything else.

So, the importance of levelness relates solely to the frictionless nature of a load floating on fluid film. When actual levelness exceeds desired levelness, loads will tend to drift toward a lower level and require anti-drift restraints like guidewheels.

On a decline, the load must be secured. On an incline, drives, chains, wire or rope should be used to avoid slippage.

Changes of elevation connected by ramps require that the areas of transition leading onto and off the ramp be rounded to present a more gradual, continuous operating path. Care should be taken to avoid "high centering" a load at the top and bottom of a ramp.



Uneven Flooring

Thankfully, a floor does not have to be dead flat, given that most floors are not.

For example, many concrete floors are assembled out of large square pieces with expansion joints between them. These pieces are individually troweled from the center, leaving the centers low and the edges high. This creates an undulating effect; as you move across such a floor, it's like traversing waves that could potentially affect the use of Aero-Casters.

A normal floor is considered to have a $\frac{1}{4}$ " in 10'0" slope, or less. In actual operation, Aero-Casters can conform to variation (convex or concave) of approximately one-fourth of their lift height across their effective lift diameter.

For example, a 21" air bearing will traverse a crown with a rise of about $9/32$ " (7.14 mm) within about 19" (480 mm). In fact, performance on both convex and concave surfaces is excellent at loads up to maximum ratings for all Aero-Caster sizes.

The overall planarity of the finished top concrete surface may deviate (X) from a true plane. The local planarity of the finished top concrete surface may be within (Y) in any 10 feet as determined by a 10-foot straight edge when placed on the surface. The Aero-Caster size and tolerances are as follows:

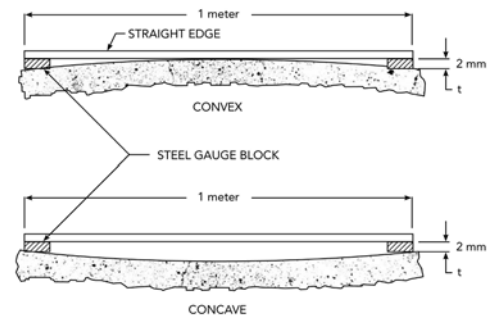
Aero-Caster Diameter	X-Plane	Y-Plane
60" TO 36"	+/-1/4"	+/-1/4"
27" TO 21"	+/-3/16"	+/-3/16"
15" TO 8"	+/-1/8"	+/-1/8"

Permanent option: High-lift Aero-Casters

Simply using larger air casters may work, because they have more lift height. If that's not sufficient, High-lift Aero-Casters are a type of air caster that lifts even higher than normal. High-lifts allow users to navigate undulations in the floor easily as steps.

Notably, they can also provide some application advantages for issues other than the floor. For example, if you need to go beneath a unit and pick up something that's a bit high, you can lift higher with high lifts.

Finally, Gapmaster™ Aero-Casters also provide higher lift.



Aero-Casters flex up to $\frac{1}{4}$ of their rated effective lift height to absorb undulations in the floor.

Wooden Floors

Wooden floors can pose several problems. They can be even more porous than concrete: just as unsealed concrete can absorb air to prevent the formation of a proper operating film under the Aero-Caster, so can untreated wood surfaces. They can also easily impose gaps and/or steps between planks. Worse, many wood floors lack the load-bearing capacity of concrete.

Temporary option: More Aero-Casters

If the primary issue is the load-bearing capacity of the floor, it may also be possible to lower the pressure on the floor by using more Aero-Casters to bring the load down to just a few pounds per square inch. This often works well with raised floors, for example.

Permanent option: Gapmaster™

Gapmaster™ Aero-Casters are specially designed with a flexible perforated membrane that meters the rate of airflow. When the Gapmaster™ Aero-Caster meets a gap, this membrane prevents a rapid outflow of air. Similarly, Gapmaster™ can accommodate steps in the floor, such as between wood planks, because it is floating over the surface on a nearly frictionless cushion of air 0.003" to 0.005" thick.

As a result, Gapmaster™ Aero-Casters are ideal for movement and position over wood floors, including theatrical and performing arts center applications. In fact, Gapmaster™ was originally developed for the entertainment industry to move stage sets and theater seating.

Permanent option: Load-bearing overlay

Self-supporting overlay must be used. Quarter inch (1/4" or 5mm) steel plate, butt-welded and ground has sufficient strength for many conditions. Supplementary supports may be necessary for proper load distribution. Lay the sheet steel across the path to be traveled and spot weld, then use aluminum tape across the seam.

Aero-Casters can conquer even “impossible” surfaces by using the kinds of mitigation techniques discussed in this paper.

The floor types and conditions considered in this paper reflect only the most *common* applications. Aero-Casters can work – and have – even in more unusual circumstances with otherwise seemingly impossible surfaces.

Aero-Casters have moved a 2,998-ton, 300-foot large luxury yacht about 300 yards from the shipyard where it was constructed, down to the water. The project owner built a runway out of smooth concrete down to the dry dock; we used Aero-Casters to move the vessel there, from which it was launched into the water.



Aero-Casters have moved entire sections of stands in professional sports stadiums – such as Aloha Stadium in Hawaii and a stadium in Singapore – allowing the property owners to easily change the configuration to accommodate different sports.

Aero-Casters have moved a megaton generator down a public road and over railroad tracks into a warehouse facility for storage. The 200-ton generator could not be transported by truck as it exceeded the allowable load limits of the road. Not only did the Aero-Casters enable the project owner to move the generator, it shortened the amount of time it would otherwise take – even when traversing multiple sub-optimal surface conditions.

The question is not, “Can Aero-Casters work with my floor?” because the answer is almost always “yes.” It’s only a question of how.

If this paper has not addressed *your* situation, please visit www.AeroGo.com or email us at info@aerogo.com. We can help you figure out how to best address your needs.

About

AeroGo manufactures innovative load moving equipment, utilizing wheels and hovercraft technology, that move heavy, awkward, or delicate loads in factories.

Companies large and small find benefit from our worldwide dealer network, experienced product specialists, and skilled engineers. They will work with you to find a load moving solution that is safe, efficient and cost-effective, as your valuable loads are carried through the manufacturing process.

From our Standard Product offerings to our highly customized Engineered Systems, AeroGo has an innovative solution for your load moving need.

- Solutions Focused
- Team Approach
- Engineering Expertise
- Lean Manufacturing
- ISO Compliant



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