

The Importance of Flatness and Levelness in Battery Room Floors

Introduction: Optimizing Battery Extractor Systems With Flat Floors

Flooring is an important consideration when planning a battery charging room. A safe and efficient battery room requires appropriately level surfaces, and appropriate construction practices can help to meet all building codes and federal regulations while ensuring reliable operation for battery handling equipment. Flooring in areas designated for charging, changing, or maintaining forklift batteries must meet strict technical requirements in order to provide the safest travel for lift trucks and battery changers.

In some cases, forklift battery handling areas will present builders with unique structural challenges. Floors that support battery handling systems will need to withstand forces not encountered in other parts of the facility, such as:

- The tremendous weight of forklift batteries, lift truck fleets, battery extractors, charging equipment, and other battery handling systems.
- Exposure to corrosive battery electrolyte or pure sulfuric acid.
- Consistent, back-and-forth travel of battery changing vehicles.
- Impact from dropped batteries and, in rare cases, battery explosions.

Two major characteristics determine the suitability of floors for battery room application: flatness and levelness. "Flatness" is defined as the floor's similarity to a true, geometric plane. "Levelness" describes a concrete slab's degree of tilt, with greater similarity to a perfect horizontal line equaling greater levelness.

In addition to meeting certain OSHA and American Concrete Institute (ACI) standards, suitably flat and level high-capacity flooring with an acid resistant surface is necessary to protect battery changing equipment from uneven operation or excessive tilt that, over time, can bend tracks and wear components down quickly.

This article will present some of the effects of uneven floors on forklift battery handling systems, examine the importance of flat, level floors, and provide details on the most up-to-date measurement systems engineers can use to ensure that floors are well within established limits. It will also briefly consider the importance of weight limits and acid-resistant surfaces for the ideal battery room floor.

Why Flat and Level Floors are Necessary for Battery Handling Equipment

Operator-board battery extractors travel along defined paths to access battery stands. Efficient travel depends on an even surface, and a flat, level floor can prevent the following problems:

1. Uneven floors create excessive lean. When the vehicle is at rest, this lean is called "static lean," which becomes more serious the higher vehicles lift. Vehicle travel causes "dynamic lean," which, at a sample speed of 10 feet per second, can triple or quadruple the total lean distance according to a report published in trade journal Concrete International.

At certain heights, an imperfection in the floor can even cause battery extraction vehicles to lean into racks. Travel at any speed increases this effect, with faster travel resulting in more extreme leaning.

Likewise, greater differences in elevation from the left wheels to the right translate into more dramatic static lean distances. Level floors prevent this potentially serious issue by keeping all four wheels at an equal elevation. Exceptionally flat and level BHS Battery Room Floors allow battery changers to travel at their full speeds, without any danger of excessive static lean caused by imperfect flooring.
2. Pitted or damaged flooring will slow the movement of battery handling vehicles, limiting productivity and reducing the efficiency of the operation as a whole. In order to provide stability, battery extractors travel without shock absorbers, so imperfections in the floor transmit vibrations directly to the operator control platform.

Not only do battery extractor operators drive more slowly over bumpy floors, but excess vibration can lead to lower back pain and other injuries. A 2010 study in the journal Ergonomics reveals that injury risks increase with more exposure to whole body vibration, such as that

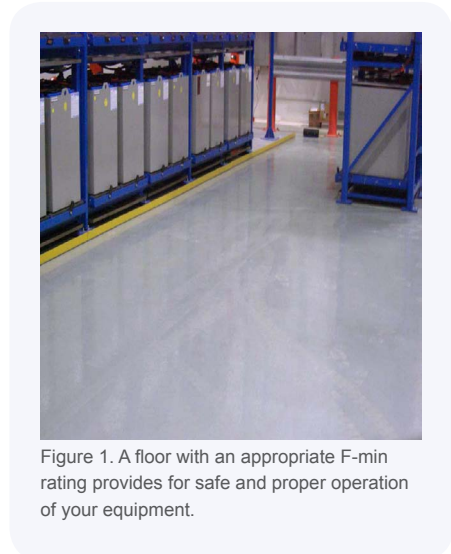


Figure 1. A floor with an appropriate F-min rating provides for safe and proper operation of your equipment.

caused by pitted flooring along vehicle travel paths.

- Without sufficient flatness and levelness, floors cause a consistently higher level of wear on the components of battery handling equipment. Excess operational stress on battery changers causes more frequent maintenance and replacement of parts, which can lead to equipment downtime and lost revenue.

The Concrete International report states that the vibration caused by a bumpy floor is particularly harmful for wheel and axle bearings, extension mechanisms bushings, and any slip-fit part within industrial vehicles.

In order to prevent the damaging effects of uneven floors in the battery room, it is important to meet manufacturers' flatness and levelness specifications. These specifications will be given in terms of an F-min number, which combines measurements of flatness and levelness into a single descriptive rating. Before looking at the implications of different F-min numbers, we will discuss how these numbers are measured and why they are an important factor to keep in mind when planning a battery room.

Measuring the Flatness and Levelness of Floors With F-min Numbers

Before Allen Face developed his methods of measuring flatness and levelness for concrete floors, industrial flooring contractors measured concrete with a straightedge, applying the standard that the floor could not deviate from level by more than $\frac{1}{8}$ inch for every 10 feet.

This traditional method did not sufficiently control for flatness, and had limited power over elevation differences; the result was that narrow-aisle lift trucks were sometimes unable to travel on their designated paths due to excessive static lean. In other cases, lift trucks had to travel so slowly over rough or bumpy patches of floor that operational efficiency was seriously undermined.

In January of 1980, the Edward W. Face Company published Allen Face's formal F-min system, which defines a floor's suitability to defined traffic areas with a series of specific measurements. An F-min number combines ratings along four metrics, as depicted in the following table:

Components of the F-min Rating	
Longitudinal Levelness	Longitudinal Flatness
Transverse Levelness	Transverse Flatness

Figure 2. Factors used to generate an F-min Rating for floors. Source: Concrete Construction

For hard-axle vehicles with predetermined wheel arrangements and travel paths, complying with specified F-min ratings limits motion that can damage equipment, including:

- Sideways tilt
- Front-to-back tilt
- Angular velocity
- Angular acceleration

Eliminating these movements from battery changing vehicles helps to realize full returns on investment in battery handling equipment. With regular loads of a ton or more, operator-aboard battery extractors require the smoothest travel path possible. Floors that meet F-min requirements allow these devices to operate at peak-efficiency, with reduced maintenance and downtime.

Since its publication, the F-min system has been adopted by many authorities in the construction field. The American Concrete Institute describes specifications for defined traffic floors in two publications: ACI 117-06 "Specifications for Tolerances for Concrete Construction and Materials and Commentary" and ACI 302.1 R-04 "Concrete Floor and Slab Construction." Because the F-min system is proprietary, however, it has yet to be officially adopted by the ACI.

BHS Battery Room Floors meet or exceed F-min ratings along defined traffic paths, such as battery extractor travel lines. This provides added assurance for the long-term operation of battery extractors and allows for a more efficient — and therefore more productive — battery room.

Planning a Better Battery Room Floor

OSHA Standard 1926.441(a)(4)
Floors shall be of acid resistant construction unless protected from acid accumulations.

Figure 4. 29 CFR 1926.441(a)(4)

Flatness and levelness are only two criteria that make up the ideal battery room floor. In addition to meeting F-min targets, floors must also have sufficient compressive strength and a durable, acid-resistant surface.

The OSHA standards for the construction industry require floors in battery charging areas to be acid-resistant to prevent damage in the case of electrolyte spills.

An epoxy topcoat can prevent damage to flooring materials even if a serious acid spill occurs (of course, battery rooms must also be well-furnished with spill kits and neutralizing agents, such as BHS AcidSorb).

Considering Differences Between F-min Ratings and F-numbers

There is an important distinction between F-min ratings and the similarly-named F-numbers system. The difference depends on projected floor usage; builders first determine whether a floor will be designated as "random traffic" or "defined traffic." In a random traffic floor, vehicles move in all directions. Vehicles in defined traffic areas will only move along predetermined paths.

Two numbers — one describing flatness, and the other levelness — are used when evaluating random traffic floors. These are F-numbers. The single F-min rating is used to specify the high degree of flatness and levelness required for defined traffic floors.

The two systems use different methods to take measurements, as well. Levelness and flatness in random floors is measured at points along a grid, while defined traffic floors measure these characteristics along the projected vehicle wheel path.

Figure 3. Source: Concrete International

Weight limits are also particularly important in planning battery room floors. BHS battery room floors have a compressive strength of more than ten thousand pounds per square inch, well above standard requirements. Figure 5 shows a sample of commonly consulted specifications for concrete floors:

Authority	Minimum Specified Compressive Strength
New York City Building Code (2008)	2,500 - 3,500 psi
U.S. Department of Defense	4,000 - 5,000 psi
American Concrete Institute	4,000 psi or higher for superflat flooring

Figure 5. Sample compressive strength specifications for various floors. Sources: *New York City Building Code, U.S. Department of Defense, American Concrete Institute.*

Of course, compressive strength is not the only measure of durability for industrial flooring. As industry publication *The Construction Specifier* points out, using concrete with excessively high compressive strength ratings can increase shrinkage, which leads to curling.

BHS Battery Room Floors avoid this problem by applying four levels of flooring to existing concrete slabs, achieving optimal compressive and flexural strength without introducing cracks or curling. Technicians grind uneven patches to establish targeted F-min ratings.

With a six-step process that includes repeated F-min measurements, BHS ensures a durable floor for safe, reliable battery changing operations for years to come.

Conclusion: Reducing Costs With Flat, Level Floors in Forklift Battery Changing Areas

Even putting aside the possibility of equipment damage and personal injury caused by uneven floors in the battery room, the simple fact is that flat and level floors translate into very real efficiency gains. Facilities that do not meet manufacturers' F-min ratings for battery room floors suffer from reduced productivity.

Exact rates of loss will vary from facility to facility, but industry journal *Material Handling & Logistics* reports that the typical warehouse aisle requires corrective grinding along 10 percent of its floor in order to meet F-min ratings considered "superflat." The journal estimates a 1.5 second delay for each imperfection a vehicle must pass over.

Applying these figures to the average forklift battery charging area, battery extractors would lose productivity at a rate of 15 seconds for every 100 feet traveled. With this level of inefficiency, every battery change will incur added costs in wages and lift truck down time.

It is far more cost-effective to invest in a battery room floor with high ratings for flatness, levelness, compressive strength, and a durable, acid-resistant surface layer. BHS Battery Room Floors provide these benefits, meeting all specifications for optimal battery extractor travel, and operations that use these surfaces will enjoy improved productivity and enhanced equipment durability over time.

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