# Surface regularity of industrial floors – a review of TR34 2003

In this, the second of two articles, floor flatness specifications for *Defined Movement Areas* in warehouses are discussed. In *Defined Movement Areas*, Mechanical Handling Equipment (MHE) uses fixed paths in very narrow aisles (VNA) and is usually associated with high-level storage racking (see Figure 1).

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This is the second of a two-part article by Tony Hulett on surface regularity of industrial floors. The first part appeared in the January issue[2].

In the Third Edition of TR34 *Concrete industrial ground floors*[1], TR34-2003, an alternative method under development was introduced as Appendix C and the rationale behind this is explained here. As in last month's article[2], the development of modern floor surveying methods for regularity in the USA and UK are described.

## Defined movement – measurement techniques

The origins of modern measurement techniques were in the USA. In 1976, the Face Floor Profileograph was first demonstrated at the World of Concrete exhibition. Sam and Allen Face, recognising the impracticality of using straight edges on large areas of floor, devised this machine to replicate the wheel configuration and movement of MHE. It remains in use in the same format today, as shown in Figure 2, and is described in Appendix C of TR34 -2003.

A profileograph is a motorised level sensing instrument. As it traverses the floor surface, differential measurements are taken between predetermined pairs of points. Differential graphs are produced, which can then be further differentiated with respect to forward movement to determine rates of change. The profileograph, as used in the USA and in Appendix C, has two sensors measuring transverse and longitudinal elevational differences. This configuration replicates a truck wheel configuration precisely.

Although the current Face Profileograph is the same as originally conceived in 1976, different configurations were tried in the intervening years both in the USA and the UK. One was the addition of sensors to measure flatness in each outer wheel track over 300mm. In the USA this was discontinued as the additional data provided was not found to add significantly to the assessment of truck performance made from the original two sensors.

This adaptation was tried in the UK, followed by a further modification that removed the longitudinal sensor measuring front to rear elevational differences. Thus, the control of the commonly used centre wheel track was lost. This ultimately resulted in the profileograph described in TR34 that is used today (see Figure 3).

It should be emphasised that profileographs do not produce a true profile of the floor. In theory, data can be accumulated to create a true profile and some equipment is apparently supplied with software for this purpose. However, there are potential limitations on accuracy due to accumulated errors.


(Photo: FACE Consultants.)

Figure 1: Mechanical Handling Equipment (MHE) uses fixed paths in very narrow aisles.

## Defined movement – data analysis

In the UK, survey data is summarised and limit values applied to the 95 percentile and an overall limit. This approach also applies to Appendix C in TR34 -2003. In the USA, a single absolute limit is applied. This difference in approach is considered here.

On defined movement surveys, every part of the aisle is measured with analogue or digital profileographs. These instruments typically gather data at 50mm intervals and thus surveys provide data effectively on 100% of the measurable points. Analysis based on sample data is not therefore applicable and it could be argued that only one limit is required. This would lead to a simpler and, on the face of it, a more appropriate system, provided that any prescribed single limit adequately reflects the performance required. However, it is not that simple.

It has always been assumed that there is normal distribution of data from aisle measurements. Analysis of data from surveys suggests that this assumption holds good for initial surveys of aisles that have just been constructed. However, once remedial grinding takes place to deal with irregularity, the distribution of data can change significantly, with proportionately greater numbers of higher readings in the resulting total population of data. This leads to an overall poorer regularity of floor than would be the case if remediation had not been required.

This suggests that there is a requirement to have more than a single limiting value and that a measurement of characteristic quality should be included. In principle, this is achieved by the existing 95% value but in practice, this fails when remedial work is carried out, as remediation is more often than not to the 100% limit. This leaves the floor user disadvantaged as the 100% limit is one and a half times the 95% limit. It also disadvantages the contractor who gets it right first time to the benefit of the contractor who corrects

**Table 1: Classifications for MHE lift heights**

| MHE lift height | Appendix C classification | Original classification |
|---|---|---|
| Over 13m | DM 1 | Superflat |
| 8 to 13m | DM 2 | Category 1 |
| Up to 13m | DM 3 | Category 2 |

Figure 2: The Face floor profileograph.

Figure 3: The modified profileograph.

only the exceptional errors.

### Defined movement – classifications

The classifications for MHE lift heights for TR34 Appendix C and the basic TR34 are given in Table 1.

There is much uncertainty about using Appendix C, including a perception that it adopts tighter tolerances. This is not correct. Transverse measurements have not changed from those first prescribed in the second edition of TR34[3] in 1994. However, there is the additional requirement to control the contours of the floor along the aisles, typically over distances of 2m. The tolerances for this additional measurement are less onerous than the transverse measurements.

### TR34 Appendix C in use

Although the use of Appendix C as an alternative to controlling surface regularity has so far been limited, a pattern is beginning to emerge which suggests that like for like, in terms of classifications, floors are complying to the suggested requirements of Appendix C in much the same way as for the original TR34 specification and at comparable costs. Thus, DM 1 (Superflat) floors tend to be constructed using long strip methods, while DM 2 (Category 1) and DM 3 (Category 2) floors are usually built using large area pour techniques.

The Fédération Européene de la Manutention (FEM), the European umbrella body of The British Industrial Truck Association (BITA), is developing floor surface regularity standards that will eventually be adopted by all truck manufacturers. Early discussions indicate that there will be a requirement to take into account the front to rear elevation of the truck in defined movement. Research is underway at the Technical University of Munich to better quantify the relationship between MHE performance and these floor tolerances.

### Concluding remarks

Profileograph methods for measuring defined movement paths have given good service, both in the UK and the USA, and are likely to be adopted in European Standards. Appendix C of TR34 -2003 has been tabled for discussion at FEM. It has been acknowledged that this method of survey has the benefits of compatibility with a well-established American system.


**References:**

1. THE CONCRETE SOCIETY. Technical Report 34, Third edition. *Concrete industrial ground floors – a guide to their design and construction*. Camberley, 2003. 105pp.
2. HULETT, T. Surface regularity of industrial floors – a review of TR34 – 2003, *CONCRETE*, Vol. 39, No 1, Jan 2005, pp.34–35.
3. THE CONCRETE SOCIETY. Technical Report 34, Second edition. *Concrete industrial ground floors – a guide to their design and construction.* Camberley, 1994. 170pp.