	FEDERATION EUROPEENNE DE LA MANUTENTION Section IX SERIES LIFTING EQUIPMENT	**FEM 9.832**
	Basis of calculations for S/R machines, tolerances, deformations and clearances in automatic small parts warehouses (not silo design)	08.2001 (E)

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Available in German (D), English (E) and French (F)

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1 Introduction and Aims

In automatic small parts warehouses items are mainly stored by means of load carriers or load make-up accessories, such as boxes, storage trays and cases. Storage and retrieval is automatically achieved by a Storage and Retrievel (refered to as S/R in the continuing text) machine. Load handling devices operate with lift, pull or grabbing mechanisms. The racks are designed as single or multi-location systems. Their functionality depends on a number of system components. The interrelation of tolerances and deformations during operation requires sufficient clearance between moving loads or unit loads and fixed system components.

The aim of this document is to show the relation of the individual system components in respect of tolerances and deformations. Permissible practical tolerances and deformations shall be listed for typical system solutions. The aim is that the values for individual system components will result in clearly defined levels of responsibility in the event of interface problems.

Due to the tolerances and deformations quantified in this document as well as the additional data for tolerances, wear and deformation of the S/R machine and the load make-up accessories, calculations for clearances and entry clearances must be made. The method used is described in section 7.

The aim of this document is to determine the admissible deformations and tolerances in order to optimise the factors relating to the economical dimensioning, manufacturing and assembly required for the safe functioning of the overall system.

2 Scope

This document applies to automatic small parts warehouses (not silo design) with S/R machines which travel on a floor mounted rail and are stabilized by an upper guide rail. The storage locations in the rack must be filled as evenly as possible (random storage).

If there is to be a deviation from this guideline in a specific instance, clear arrangements must be made and evidence of functionality of the overall system in any given operating system produced, taking normal wear into account.

3 Definitions

Coordinate positioning: Positioning of the S/R machine using global coordinates.

Positioning via the Teach-in Process: Teach-in processes rely on calculating the position coordinates by means of an initial control of all storage locations. The actual coordinates calculated are stored in the control system and can be reproduced. Through permanent control points the system can monitor and correct itself where possible. Depending on the warehouse configuration the Teach-in Process can require considerable effort in calculating the individual coordinates.

Location fine positioning: Basic positioning of the S/R machine using global coordinates, followed by rack fine positioning via additional sensors for the X and/or Y coordinates. The greater accuracy this achieves is accompanied by a loss in performance.

System level: Plane without tolerances in XY direction, XZ direction and YZ direction, defined by clearly marked points or straight lines.

Tolerance: The permissiblle maximum deviation from nominal dimension, resulting from manufacture and assembly.

Deformation: Deviation from the basic position due to the effect of forces.

Clearance: The required nominal distance between fixed and moving parts and which, all individual tolerances and deformations considered, prevent collisions.

Entry Clearance: Clearance between the load handling device and the load make-up accessory or rack structure.

Rack compartment clearance: Clearance between respective unit loads and the rack structure.

Aisle clearance: Clearance between the outer most edge of the S/R machine and the outer most edge of the rack or the unit load and clearances at the rear of the stored unit load.

System axes: A fixed straight line between 2 points in the X direction (aisle length direction), Y direction (aisle vertical direction) and Z direction (aisle lateral direction).

Auxiliary level: Vertical or horizontal level without tolerances.

4 Factors of Influence

A common height plane as well as common horizontal axes shall normally be defined for all components by the persons responsible for the construction. These shall be marked clearly and permanently, and shall act as reference points for the project-related datum planes and axes.

When calculating the internal measurements of the building the negative effects of deformations and tolerances must be taken into account.

Persons responsible for the construction must be able to demonstrate its suitability for use and thus define the conditions (forces, tolerance, admissible deformations and clearances).

The constructors and sub-contractors shall ensure that individual components (e.g. floor slabs, racks, S/R machines) have sufficient capacity for the agreed loads and maintain the defined tolerances and deformations.

Tolerances and possible deformations will result from the following operating components of an automatic small parts warehouse:

- surface/foundations behaviour under load
- floor slab (manufacturing accuracy and behaviour under load)
- floor rail
- guide rail
- load make-up accessories incl. load
- profile check
- storage location
- S/R machine
- rack structure

In contrast to high bay storage where pallets are mainly used, automatic small parts stores are characterised by a wide range of solutions for load handling devices on S/R machines and load make-up accessories. The following types of load handling device can be used:

I. Telescopic tables (used with lifting mechanism)

II. Mechanical insertion/extraction (pulling device) at the front of the load make up accessory

III. Lateral grabbing / pushing devices

IV. Belt or conveyor pulling devices

V. All other types: All requirements must be agreed by the contract parties.

Plastic containers, metal containers, trays, rigid plattens (e.g. wooden plattens), cardboard boxes etc. can be used as unit loads or load make-up accessories. As a rule, any given load make-up accessory will require a particular load handling device. The properties of these system components may require different clearances.

In the racking structure, different supporting beams are used for the loads. Typical solutions include:

- lateral supporting angles on beams between each load make-up accessory (single location storage);
- beams with support bearers embedded, i.e. several loads between the stands (multi-location storage).

The S/R machines can be fitted with different positioning control systems. Depending on the system, the following may be used:

- pure coordinate positioning in X and Y directions
- location fine positioning in X and/or Y direction
- positioning via Teach-in process

NOTE: The selection of the location system (e.g. location fine positioning, Teach-in Process) will greatly affect the clearances/entry clearances, pepending on the positioning system certain factors of influence will not come into play (or at least to a much lesser extent) when calculating the clearances/entry clearances.

4.1 Surface / Foundations

It is assumed that the foundations for the length of the entire floor slab are the same.

This is the responsibility of the constructing owner or civil engineer.

4.2 Floor Slab

There are two types of floor slab

a) Rigid floor slabs which lie fully flat on the surface.

b) Deflection-resistant floor slabs which lie on supports or against walls, such as ceilings in buildings or floor slabs on piles.

The manufacturing tolerances listed in section 4.2.1 (warping, sloping, uneveness) apply to floor slabs. For type b) slabs, depending on each case, specific agreement must be reached relating primarily to the behaviour of the slab in the unladen state and under increasing load condition during the filling of the store. If necessary, instructions on how to fill the warehouse should be drawn up.

The constructing owner or civil engineer is responsible for the capacity, rigidity and flatness of the floor slab.

4.2.1 Floor slab manufacturing tolerance

Manufacturing tolerance is the flatness of the surface on which the rack structure and the floor rail are to be assembled. The following values must be maintained when the floor slab is not under load:

The following admissible tolerances result from a horizontal auxiliary plane:

- up to 50 m floor slab length: ± 10 mm
- over 50 m floor slab length: ± 15 mm

Where packing plates are used under the base plates of the rack uprights, any slope of the floor slab in the area of the rack upright feet must not lead to eccentric loading of the packing plates. The concrete surface must be flat.