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Guideline:

Vehicle Restraining Devices:

Safety and Performance

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Foreword

This publication is only for guidance and gives an overview regarding the assessment of the Safety and Performance of Vehicle Restraining Devices. It shall not be considered as a binding interpretation of the existing legal framework. It neither claims to cover any aspect of the matter, nor does it reflect all legal aspects in detail. It is not meant to, and cannot, replace own knowledge of the pertaining directives, laws and regulations. Furthermore the specific characteristics of the individual products and the various possible applications have to be taken into account. This is why, apart from the assessments and procedures addressed in this guide, many other scenarios may apply. Manufacturer's instructions and manuals must always be respected.

It is intended to provide useful information and guidance for owners, users, designers, purchasers and/or specifiers of material handling equipment or systems. It is advisory only and should only be regarded as a simple tool that its intended audience may or may not choose to follow, adopt, modify, or reject. The following information does not constitute a comprehensive safety program, cannot guard against pitfalls in operating, selecting and purchasing such a system, and should not be relied upon as such. Such a program should be developed, and an independent adviser should be consulted in doing so.

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Disclaimer of liability

This Guidance Note is based on specifications, procedures and other information that have been collected by the FEM from its members. They represent what is, as far as FEM is aware, the best available data at the time of publication on the instruction and use of the equipment concerned in the general conditions described and are intended to provide guidance for such use.

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1. **Scope and purpose**

This document defines safety, performance, and use recommendations with regard to the application of vehicle restraining devices. The purpose of this document is to provide a uniform means of comparison, improve user confidence and knowledge, and define safety aspects of vehicle restraining devices.

Health and safety requirements will define which vehicle restraint device should be selected depending on the risk assessment and /or local conditions.

A vehicle restraining device is designed to minimize the risks arising from movement of the transport vehicle away from the loading area. The different types of vehicle restraining devices within the scope of this document are classified according to their function.

2 **Documents for Reference**

The following documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

For powered vehicle restraints – Machine directive 2006/42/EC

EN 349, Safety of machinery — Minimum gaps to avoid crushing of parts of the human body

EN 982, Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics

EN 983, Safety of machinery — Safety requirements for fluid power systems and their

components — Pneumatics

EN 1398:2009 Dock levellers — Safety requirements

EN 60204-1:2006, Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005, modified)

EN 60529:1991, Degrees of protection provided by enclosures (IP code) (IEC 60529:1989)

EN 60947-4-1, Low-voltage switchgear and control gear — Part 4-1: Contactors and motor-starters; Electromechanical contactors and motor-starters (IEC 60947-4-1:2000)

EN 60947-4-2, Low-voltage switchgear and control gear — Part 4-2: Contactors and motor-starters — AC semiconductor motor controllers and starters (IEC 60947-4-2:1999)

EN ISO 12100-1:2003, Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology (ISO 12100-1:2003)

EN ISO 12100-2:2003, Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles (ISO 12100-2:2003)

EN ISO 13849-1:2008, Safety of machinery — Safety related parts of control systems — Part 1: General principles for design (ISO 13849-1:2006)

EN ISO 13850, Safety of machinery — Emergency stop — Principles for design (ISO 13850:2006)

ISO 11228-1, Ergonomics — Manual handling — Part 1: Lifting and carrying

ISO 11228-2, Ergonomics — Manual handling — Part 2: Pushing and pulling

FEM document 11.003, Guidance on safety on/around a vehicle loading area

3 Definitions

3.1 Dock

See “Loading dock”

3.2 Dock leveller

A device affixed to a dock structure to form a bridge between the dock structure and a transport vehicle, thus allowing movement of industrial vehicles between the transport vehicle and the dock structure.

3.3 Drive-away

The event of a transport vehicle departing the loading area before it is allowed to do so.

3.4 Driveway

The surface where the transport vehicle is parked.

The driveway surface is typically made of concrete, asphalt or gravel.

3.5 Industrial vehicle

Fork lift trucks, powered or non-powered pallet jacks, or any other form of vehicles used to load or unload material on a transport vehicle

- 3.6 Lip**
The extension member on the transport vehicle end of a dock leveller which supports the dock leveller on the transport vehicle bed and provides a smooth transition to the transport vehicle bed.
- 3.7 Loading area**
An area where goods are moved to and from a transport vehicle, this could be at the same level as the driveway, or raised above it.
- 3.8 Loading dock**
A building area or structure where goods are moved to and from a transport vehicle, elevated above the driveway.
- 3.9 Operating personnel**
A person or persons engaging in the process of loading and/or unloading transport vehicles whereby the activities may include the operation of industrial vehicles, dock levelers, vehicle restraints, dock doors, etc.
- 3.10 Owner**
Owner, lessee, person, or organization controlling the building, loading area or dock in which a vehicle restraining device is used.
- 3.11 Roll away**
Movement of a transport vehicle not caused by forces associated with loading/unloading equipment
- 3.12 Traffic Light/s**
Coloured lights to communicate the status of the loading operation to the dock operator and to the driver of the transport vehicle.
- Typically one set of lights is visible to the dock operator to indicate whether the vehicle restraint is engaged, and another set of lights is visible to the transport vehicle driver to indicate whether it is safe to pull the transport vehicle away from the dock.
- 3.13 Transport vehicle**
A cargo-carrying vehicle (e.g., a truck, semi-trailer or trailer).
- 3.14 Vehicle creep**
The movement of a transport vehicle away from the loading area caused by forces associated with loading/unloading equipment
- 3.15 Vehicle restraining device**
A device designed to prevent the movement of a transport vehicle away from a loading area.

4 Safety Assessment

A safety assessment of the conditions prevailing must be undertaken for the appropriate class of vehicle restraining device to be selected.

5 Safety recommendations

5.1 Calculations, loads and forces

The vehicle restraining device must be calculated with the given loads and a safety factor of 1,5 against the material yield stress.

5.1.1 CLASS 1:

Any vehicle restraining device which is intended to stop a transport vehicle from **rolling away**.

Rolling away can be caused by, for example, gravity and/or wind and/or manual loading operations. Forces on the transport vehicle are relatively small.

Under normal conditions these horizontal forces are calculated at a maximum of 10 kN. (See annex A)

The vertical load on the vehicle restraining device is the axle load divided by 2, where applicable

5.1.2 CLASS 2:

Any vehicle restraining device which is intended to prevent **vehicle creep**.

Creep protection will be required when transport vehicle movement could create a hazard.

One example is where loading or unloading is done by means of loading equipment fitted with a lip. The movement of a transport vehicle away from the loading area can be caused by forces associated with loading/unloading equipment. Uncontrolled vehicle creep may allow the lip of a dock leveller to become unsupported and create a hazard.

The minimum safe support length of the lip is considered to be 100 mm (EN 1398:2009 7.3.2 n).

Any vehicle restraining device which is intended to prevent loss of support by means of preventing the moving away of the transport vehicle bed from the loading area, must take this into consideration.

Another example could be the forces created when loading or unloading a transport vehicle with a fork lift truck driving on the same surface on which the transport vehicle is situated.

A vehicle restraining device to prevent Creep (Class 2 system), can be calculated for the actual horizontal force (at maximum axle load) that is required to drive over them, which depends on actual wheel size. In normal operating conditions this force is estimated at 35 kN. The dimensions and strength of this device must be such that this pull-out force of 35 kN can be achieved. (See annex A)

The vertical load on the vehicle restraining device is the axle load divided by 2 where applicable.

CLASS 3:

Any vehicle restraining device which is intended to prevent **drive-away**.

Drive-away protection reduces the risk of an inadvertent action of a driver which leads to transport vehicle movement, thus creating a hazard.

Drive-away refers to a transport vehicle departing the loading area before loading or unloading is completed, and may allow the lip of the loading equipment to become unsupported and create a hazard.

The main function of the vehicle restraining device is to make the act of driving away difficult and to alert the driver.

The dimensions and strength of the vehicle restraining device must be such that it can withstand a pull-out force of 115 kN. (See annex A)

The vertical load on the vehicle restraining device is the axle load divided by 2, where applicable.

5.2 Additional recommendations

5.2.1 Moving parts

Consideration must be given to the safety of all personnel who are in the vicinity of any moving parts

5.3 Optional recommendations

5.3.1 Interlock with dock leveller or door controls

The level of safety can be increased when the vehicle restraining device is interlocked with the loading area equipment. For example: The transport vehicle must be restrained before the dock leveller (or door) is released for operation. The vehicle restraining device can only be released with the dock leveller (or door) in the returned (home) position.

5.3.2 Operator / transport vehicle driver information (feedback)

The level of safety can be further increased by an operator and transport vehicle driver information system being installed, such as a traffic light system or more sophisticated system.

6 General Information

An appropriate vehicle restraining device must be selected for the intended application.

In order to meet applicable national laws and/or regulations, manufacturers, importers or suppliers must supply vehicle restraining devices with the essential marking and with written instructions for use including installation, operation, maintenance and inspection in the official language(s) of the country of installation.

Annex A

Calculations of horizontal forces

Applied parameters:

The following calculations assume that no brakes are applied to the transport vehicle.

Transport vehicle weights and dimensions according to EU DIRECTIVE 96/53/EC, Article 1

- Transport vehicle height: 4,0 m (GB: 5.03m / 16')
- Transport vehicle width: 2,6 m
- Transport vehicle length: 18,75 m
- Maximum transport vehicle load: 440 kN
- Maximum transport vehicle axle load on driven axle: 115 kN
- Normal transport vehicle axle load on the non-driven axle, when loaded : 90kN
- Normal transport vehicle axle load on the non-driven axle, when empty: 15 kN
- Wind load: 0,65 kN/m²
- Air resistance factor: 0,01
- Slope of driveway: 2 %
- Coefficient of friction between dry tarmac and rubber which is a maximum of 1,0
- Braking load of forklift truck: 30% of the rated load (See EN 1398:2009 5.1.2.2.5)
- Rated load of dock leveller: 90 kN

Horizontal forces in Class 1:

Frontal wind load: $4 * 2,6 * 0,65 = 6,8$ kN (GB=8.5kN)

Wind friction: $4 * 18,75 * 0,65 * 0,01 = 0,5$ kN per side, 1,0 kN total

The horizontal component of the rolling forces due to the 2 % slope is supposed to be equaled out by the rolling resistance.

The rounded value of this load is a maximum of 10 kN

Horizontal forces in Class 2:

Braking load of forklift truck: $0,3 * 90 = 27$ kN

Frontal wind load: $4 * 2,6 * 0,65 = 6,8$ kN (GB=8.5kN)

Wind friction: $4 * 18,75 * 0,65 * 0,01 = 0,5$ kN per side, 1,0 kN total

The horizontal component of the rolling forces due to the 2 % slope is supposed to be equaled out by the rolling resistance.

The rounded value of this load is a maximum of 35 kN (GB=37kN)

Horizontal forces in Class 3:

The pull-out force is limited by the axle load and the coefficient of friction between dry tarmac and rubber.

With a maximum driven axle load of 115 kN, it is assumed that a transport vehicle can develop a maximum pull-out force of 115 kN.

Influence of the wheel size, restraint height and axle load on the pull-out force.

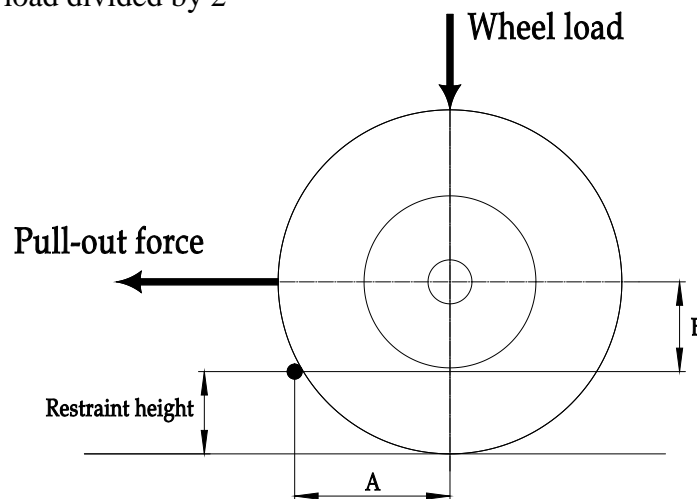
Note:

Values in the tables are theoretical and only to be used as an indication. In practice, values are influenced by (a.o.) deformation of the tire.

Assumptions:

One wheel is blocked by the vehicle restraining device

Wheel load is axle load divided by 2



The wheel will drive over the vehicle restraining device when:

$$\text{Pull-out force} \times B > \text{Wheel load} \times A$$

According to this principle, the next tables are showing the pull-out forces for 3 different common wheel sizes.

	Roll away (class1) exists in these situations
	Vehicle creep (class 2) exists in these situations
	Drive away (class 3) exists in these situations
	Beyond the scope of this Guidance Document

Maximum pull out force in kN for wheel size 385/65-22,5: (Ø1072mm)

Vehicle restraint height in mm	Axle load in kN			
	15	50	90	115
150	7	24	43	55
200	9	31	56	72
250	12	40	71	91
300	15	51	92	117
350	20	68	122	155
400	29	95	172	219
450	46	154	277	354
500	111	371	669	854
550	∞	∞	∞	∞

Maximum pull out force in kN

Maximum pull out force in kN for wheel size 385/55-22,5: (Ø 995mm)

Vehicle restraint height in mm	Axle load in kN				Maximum pull out force in kN
	15	50	90	115	
150	8	26	46	59	
200	10	34	60	77	
250	13	44	79	100	
300	17	58	104	133	
350	24	81	145	185	
400	38	125	225	288	
450	78	261	469	599	
500	∞	∞	∞	∞	
550	∞	∞	∞	∞	

Maximum pull out force in kN for wheel size: 265/55-19.5 (Ø 787mm)

Vehicle restraint height in mm	Axle load in kN				Maximum pull out force in kN
	15	50	90	115	
150	10	32	57	73	
200	13	44	80	102	
250	19	64	115	147	
300	31	102	184	235	
350	67	225	405	517	
400	∞	∞	∞	∞	
450	∞	∞	∞	∞	
500	∞	∞	∞	∞	
550	∞	∞	∞	∞	

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