CombiSec

Proposal of unified cargo securing principles for road and combined transport trains



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PREFACE

In the autumn of 2007 a pre study was performed to examine the need of a project to investigate the possibilities to unify the principles for cargo securing in Cargo Transport Units (CTUs) such as trailers, containers and swap bodies for road and combined transport on rail. The conclusion of this study was that a unification of the principles was regarded as very important and it was decided to start the CombiSec project. The project has been financed by the National Swedish Rail Administration and the Swedish Road Administration, present the Swedish Transport Administration, within the Virtual Research and Demonstration Centre "Swedish Intermodal Research Centre", Sir-C.

A large number of Swedish companies and organisations have contributed to the founding of the project by their own work, see list of contributing companies in section 2.4 below. All financiers have been invited to the project meetings for the project that have been held during the project period, and the attendance in the meetings has been large or even very large. Erik Andersson from IKEA has been the chairman during the project meetings. All participants have been very active in the project work and eager to see a result of the work.

Within the project extensive shunting tests with Cargo Transport Units (trailers, containers and swap bodies) have been carried out as well as a large number of test transports. In the tests the cargo transport units have contained different types of cargoes.

We wish to thank all involved for valuable contribution and help during the project period.

Höganäs, 2011-02-24
MariTerm AB

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SUMMARY

The principles for cargo securing in Cargo Transport Units (CTUs) differs completely between the current rules and regulations for road and sea transports on one hand and rail transports on the other. This is not a favourable circumstance for combined transports, especially considering that:

- the UIC Loading Guidelines can not be complied with in a steadily increasing fraction of the European fleet of CTUs, and
- combined transports on rail are part of transports chains that normally starts with a road transport with CTUs that in principle always are loaded and secured by personnel at industries and terminals familiar with road transports only

Thus, the research project "*CombiSec – Proposal of unified cargo securing principles for road and combined transport trains*" aims to identify cargo securing methods that are in accordance with valid road regulations and that could provide a sufficient and acceptable level of cargo securing during combined transports by rail. This identification has been carried out in three steps:

1. Theoretic analysis and comparison of current regulations for road and rail transports
2. Shunting tests with a wide range of common cargo types
3. Test transports with a wide range of common cargo types

The CombiSec project has been financed by the National Swedish Rail Administration and the Swedish Road Administration and by the work of a very large number of industry partners which has participated in the project.

In practice, the securing of the goods in CTUs is normally done according to the principles used for road transport. If blocking is not possible, which is the case in most curtainsiders and open flat bed trailers, top-over lashings are by far the most commonly used method for cargo securing. However, generally the UIC (International Union of Railways) Loading Guidelines disqualifies indirect fastenings (top-over lashings) from being used to prevent sideways sliding.

Through the analysis of regulations performed within the project it has been concluded that:

- The UIC Loading Guidelines offers no relevant method for securing several types of common cargoes in standard curtainsider trailers or open flat bed trailers.
- The CEN method for "combined transport –rail" requires copious amounts of lashings to be used in most cases, and can thus not be recommended as a suitable method.

Within the project, shunting tests were performed in accordance with UIC Loading Guidelines with 19 cargo transport units supplied by the projects industry representatives.

The cargo securing fulfilled the road regulations in 13 of the 19 units only. None of the units were in compliance with the instructions in the UIC Loading Guidelines. Despite this, cargo movements in the longitudinal direction were very limited, and it could be concluded that it is sufficient to secure cargo in cargo transport units for combined road/rail transports according to the road regulations as long as shunting is carried out at the prescribed maximum speed of 4 km/h.

During the project, the securing of a wide range of cargoes was documented during test transports of more than 100 units. The selection of units where carried out by two different principles:

1. Multiple units with identical cargo units were documented by industry representatives in the project, throughout the whole transport chain on selected relations.

2. Random units where selected at rail terminals and documented prior to and after the rail haulage.

For each unit the cargo type and properties, type and classification of the cargo transport unit as well as the means of cargo securing were recorded. The original position of the cargo was marked on the platform floor and any movement was noted upon arrival at the destination.

The following main conclusions have been reached based on the results of the test transports:

- In most inspected units, no signs of significant accelerations in any direction could be detected except in some units in one and the same train, which probably was exposed to large shunting speeds.

- There were no indications of significant accelerations in the transverse direction in any of the inspected units.

- There is a significant wandering effect for unlashed cargo during intermodal transports by rail due to vibrations. The movement of the cargo occurred randomly.

- The curtain sides of XL trailers have in these test transports proved to be able to safely contain the cargo within the unit without showing any noticeable deflection, even when the cargo was unlashed.

- Indirect lashings (top-over lashings) may be used to safely secure cargo during rail transports.

- In all cases, when properly applied, the securing principles for cargo securing during road transports may serve as safe guidelines also for combined transports by rail.

Recommendations

Based on the findings in the CombiSec project and the conclusions above the principles set out in the "***European Best Practice Guidelines on Cargo Securing for Road Transport"*** is sufficient also for combined rail transports. It is thus recommended that the UIC Loading

Guidelines are complemented with the inclusion of these principles. It is, however, important to bear in mind that a design acceleration in longitudinal direction of 0,5 g (about 5 m/s^2) is based on shunting speeds of maximum 4 km/h.

To avoid that cargo moves uncontrolled due to vibrations during the rail part of the transports it is recommended that special requirements are provided for cargo securing arrangements to avoid such movements.

If the UIC Loading Guidelines are complemented according to these recommendations it is also recommended to approach CEN/TC 168 to get the basic design accelerations for combined rail transports altered to be in line with the accelerations for road transports. This is important not to jeopardize the future increase of combined rail transports as the cargo securing standard EN 12195-1 (2010) might be used to form the bases for a future cargo securing directive within the European Community.

SAMMANFATTNING

Principerna för lastsäkring i lastbärare (Cargo Transport Units, CTUs) är enligt gällande regelverk helt olika för väg- och sjötransport respektive järnvägstransport. Detta förhållande är inte en gynnsam förutsättning för kombitrafiken, särskilt inte med tanke på att:

- UIC Loading Guidelines inte är anpassad efter den stadigt ökande andelen av lastbärare i Europa, samt att
- kombinerade transporter på järnväg är en del av en transportkedja som oftast börjar med en vägtransport med lastbärare som i princip alltid lastas och säkras av personal på industrier och terminaler som endast är bekant med landsvägens regler

Syftet med forskningsprojektet "*CombiSec – Proposal of unified cargo securing principles for road and combined transport trains*" är därför att undersöka om en godtagbar säkerhetsnivå kan åstadkommas med de av vägmyndigheterna fastställda lastsäkringsprinciperna även vid transport av gods i kombienheter på järnväg. Studien har utförts i tre olika steg:

1. Teoretisk analys och jämförelse mellan gällande regler för väg- och järnvägstransport
2. Rangerprov med ett stort urval av vanliga godstyper
3. Testtransporter med ett stort urval av vanliga godstyper

Kombisäkring har finansierats av Banverket och Vägverket, nuvarande Trafikverket, samt av ett stort antal medverkande representanter från näringslivet i form av deltagande på projektmöten, hjälp vid utförande av de praktiska proven samt tillhandahållande av bl a lastbärare och provmaterial.

I normalfallet lastas och säkras gods i lastbärare, CTUs, enligt landsvägens principer. Om det inte är möjligt att förstänga, vilket det vanligtvis inte är i gardinenheter och på öppna flak, är överfallssurrning den överlägset mest använda säkringsmetoden. Problemet är att UIC (Internationella järnvägsunionen) Loading Guidelines inte tillåter användning av nedbindning (överfallssurrning) för att förhindra att gods glider i sidled.

Analysen och jämförelsen av de olika regelverken har gett följande slutsatser:

- UIC Loading Guidelines erbjuder ingen relevant metod för säkring av vanligt gods varken i trailers eller på öppna flak och växelflak
- CEN-metoden (enligt europastandarden EN 12195-1:2010) för kombinerade transporter på järnväg kräver ofta enorma mängder surrningar, och kan därför inte rekommenderas som en lämpligt metod

Rangerproven genomfördes med 19 enheter som var lastade med diverse gods, allt tillhanda-hållet av de i projektet medverkande företagen. Proven utfördes i enlighet med instruktionerna i UIC Loading Guidelines. Lastsäkringen uppfyllde landsvägsreglerna i endast 13 av 19 enheter och inte i någon enhet var godset säkrat i enlighet med instruktionerna i UIC Loading

Guidelines. Trots detta var rörelserna i längdled mycket begränsade och det har därför kunnat fastställas att det är tillräckligt att lastsäkra enligt landsvägens krav också vid kombinerade transporter på järnväg så länge rangering sker inom föreskriven hastighet 4 km/h.

I projektet genomfördes även testtransporter med en stor mängd olika godsslag lastade i över 100 enheter. Urvalet av enheter gjordes enligt följande två kriterier:

1. Åtskilliga enheter med identiskt gods, tillhandahållna av i projektet medverkande företag, följdes och dokumenterades genom hela transportkedjan

2. Slumpvis utvalda enheter vid järnvägsterminaler som dokumenterades såväl före som efter järnvägstransporten

För varje enhet antecknades godstyp och dess dimensioner, typ och klassifikation av lastbärare samt hur godset var lastsäkrat. Placeringen av godset markerades på flaket och all rörelse av godset noterades vid ankomst till varje destination.

Baserat på resultatet av testtransporterna har följande huvudslutsatser kunnat dras:

- Inga tecken på markanta accelerationsnivåer i någon riktning kunde noteras med undantag av i några enheter i ett och samma tåg som troligen utsattes för höga islaghastigheter i samband med växling

- Inga tecken på markanta accelerationsnivåer i sidled i någon av enheterna

- Det finns en markant vandringseffekt hos osurrat gods vid kombitransport på järnväg på grund av vibrationer. Vandringen sker slumpmässigt i enheterna.

- Sidorna i XL-enheter har under testtransporterna visat att godset transporteras säkert i enheterna, utan att sidorna buktar ut, även under järnvägstransport, trots att godset var osurrat

- Nedbindning (överfallssurrning) bör få användas som säkringsmetod i kombienheter under järnvägstransport

- Landsvägens lastsäkringsprinciperna, rätt använda, bör i alla lägen kunna användas som säkra riktlinjer även vid kombitransport på järnväg

Rekommendationer

Baserat på resultatet av projektet och ovanstående slutsatser borde således principerna för lastsäkring för landsvägstransport så som de beskrivs i *”European Best Practice Guidelines on Cargo Securing for Road Transport”* även kunna användas vid kombitransport på järnväg. Rekommendationerna till UICs lastsäkringskommitté är därför att göra ett tillägg till UIC Loading Guidelines med hänvisning till dessa principer. Dock är det viktigt att komma ihåg att accelerationskravet i längdled på 0,5 g (ca 5 m/s^2) vid rangering är baserat på en islagshastighet på max 4 km/h.

För att undvika att gods rör sig okontrollerat på grund av vibrationer under järnvägs-transporten rekommenderas att speciella krav på lastsäkringen sätts upp för att upphäva denna effekt.

Om UIC Loading Guidelines kompletteras med ovanstående rekommendationer är det vidare lämpligt att kontakta CEN/TC 168 för att få accelerationskraven för kombitransport på järnväg ändrade till att bli i linje med landsvägens krav. Detta är viktigt för att inte äventyra en framtida ökning av kombitransport på järnväg då lastsäkringsstandarden EN 12195-1:2010 kan komma att användas som underlag för ett eventuellt framtida lastsäkringsdirektiv inom EU.

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1. INTRODUCTION

The principles for cargo securing in Cargo Transport Units (CTUs) such as trailers, containers and swap bodies suitable for combined transport are according to current rules and guidelines completely different for road and rail. This circumstance is not a favourable condition for combined transports, especially since the UIC Loading Guidelines can not be complied with in a steadily increasing fraction of the European fleet of CTUs. If it would be possible to show that the road regulations are sufficient for cargo securing in CTUs also on rail, very much would be gained.

The research project "*CombiSec – Proposal of unified cargo securing principles for road and combined transport trains*" aims to identify cargo securing methods that are in accordance with valid road regulations and that could provide a sufficient and acceptable level of cargo securing during combined transports by rail. This identification has been carried out in three steps:

1. Theoretic analysis and comparison of current regulations for road and rail transports
2. Shunting tests with a wide range of common cargo types
3. Test transports with a wide range of common cargo types

Based on these analysis and practical tests, a proposal has been prepared on unified principles for cargo securing in cargo transport units during combined transports.

1.1 Background

Transportation of CTUs (trailers, containers and swap bodies) is part of a road, sea and/or rail transport. The units are loaded and secured by personnel at industries and terminals that are mainly used to road transports and they have very little or no experience at all of rail transports. The securing of the goods in CTUs is thus mainly done according to the principles used for road transport. If blocking is not possible, which is the case in most curtainsiders, top-over lashings are by far the most commonly used method for cargo securing.

According to the international guidelines for railway transport, UIC (International Union of Railways) Loading Guidelines, it is, however, not permitted to prevent cargo from moving sideways with indirect fastenings (top-over lashings) only during rail transport. In addition to indirect fastening there has to be a second security barrier, primarily some kind of blocking. Indirect fastening may only be used with the purpose to reduce the sliding distance for sliding cargo.

Many of the arrangements for securing cargo during rail transport allow the goods to slide in longitudinal direction, which is dangerous and completely forbidden during road and sea transports.

The problem with completely different principles for cargo securing for transport by road and rail is especially obvious for curtainsiders. The curtain side in the majority of units used today

is according to the European Standard EN 12642 regarded as a weather protection only and is not to be considered as being part of any cargo securing arrangement, for more details see chapter 5. In this type of CTUs friction and indirect fastenings is the only way to prevent sideway movements of the cargo in reality.

As the number of curtainsiders (trailers and swap bodies) is steadily increasing, the international guidelines for rail transports therefore disqualify an ever increasing portion of the cargo transport units that are available for transport by rail. This may lead to a drastically decrease in the attraction of goods to combined transports on rail. Even if the curtainsiders will be constructed according to the XL-code of the revised standard EN 12642, with strengthened sides, it is a question if the allowed deflection of up to 300 mm, when exposed to the design loads, can be accepted for cargo securing during rail transport.

Coordination of the principles and regulations for cargo securing on road and in combined transport trains must be regarded as an extremely urgent matter to make it easier for transport of goods in CTUs in combined transport trains. It would be natural to have the same principles for cargo securing in all parts of the transport chain.

Even if the situation described above is not considered by many as troublesome at present, as there are few inspections carried out to ensure that the UIC Loading Guidelines are observed, it is unsatisfactory that regulations and normal practice differs radically from each other. If an incident or accident would happen in a combined transport train there is an obvious risk that the authorities with immediate effect decide to apply current regulations independently of the reason for the accident.

1.2 Purpose and scope of the work

The purpose of the CombiSec project has been to examine if the cargo securing methods stated in the road regulations give an acceptable safety level also for rail transport, by applying standard UIC testing procedures.

The purpose has also been to investigate if the design forces for road transports are sufficient for cargo in combined transport trains as well or which modifications that have to be done.

As indirect fastening is one of the most common cargo securing principles on road, this project has in particular studied if this method can be used also in combined transport trains.

In the project the suitability of curtainsiders built according the European standard 12642 XL for rail transports has also been studied.

According to the railway guidelines shunting tests as well as test transports have to be carried out to verify if a securing arrangement is safe for rail transport. Thus a large number of practical tests have been carried out within the project with different types of goods.

1.3 Expected result

Based on the result of this project a proposal on unified cargo securing principles for road and combined transport trains will be presented for national authorities as well as for the Cargo Securing Committee of the International Union of Railways (UIC). The goal is that a chapter is included in the UIC Loading Guidelines containing information on which typical cargo securing arrangements in CTUs used for road transports that can be accepted also for rail transports.

1.4 Contribution of participating companies

Within the CombiSec project numerous of practical tests in the form of shunting tests and test transports have been carried out. Without invaluable contribution and help from the participating companies, these activities had not been possible. To give an idea of the extent of the engagement in the project a list of contribution besides participation in the project meetings is given below.

1.4.1 Shunting tests

For the shunting tests 19 CTUs loaded on railway wagons for combined transports, were shunted at speeds and directions according to the instructions for shunting tests in the UIC Loading Guidelines. The 19 units used in the tests were supplied and transported by the following companies:

Type of cargo	Supplier	Type of CTU	Carrier
Square-sawn timber	Södra Timber	Trailer	van Dieren
Paper reels	Billerud	Container	Port of Norrköping, Maersk, Green Cargo
Paper reels	Korsnäs	Trailer	LKW Walter, CargoNet
Bags on pallets	Borealis	Trailer	DSV
Octabins	Borealis	Trailer	DSV
Liner reels	Peterson Linerboard	Trailer	DHL, CargoNet
Mixed cargo	IKEA	Trailer	Nor-Cargo
Lying concrete elements	Betong o smide	Trailer	K.E. Palms åkeri
Standing concrete elements	Betong o smide	Trailer	K.E. Palms åkeri
Barrels on pallets	Akzo Nobel	Trailer	N-TEX
Paper pallets	Stora Enso Fors	Swap body	Hangartner
Cable drums	ABB	Trailer	DB Schenker
Single drum vibratory roller	Dynapac	Trailer	DSV
Steel pipes	Ovako Steel	Trailer	Hangartner, CargoNet
Truck cabin	Scania	Trailer	Ewals Cargo

Type of cargo	Supplier	Type of CTU	Carrier
Palletised cargo	DHL	Trailer	DHL
Steel coils	Outokumpu	Trailer	Nils Hanssons Åkeri
Steel sheet metal	Outokumpu	Trailer	Nils Hanssons Åkeri
Paper pulp	Södra Cell	Swap body	Norfolkline

The tests were carried out at the CargoNet Combi Terminal in Malmö 2009-10-01--02 and CargoNet supplied the required handling equipment as well as the tracks for the tests. Green Cargo supported with locomotive, wagons as well as with personnel for the shunting operation and registration. In addition DB Schenker provided two empty trailers to be used as conference room, coffee bar and office during the two days testing.

The following 30 persons were attending the tests:

Person	Company
Bengt Månsson	Norfolkline
Carl-Erik Silow	IKEA Svenska AB
Christer Nilsson	Green Cargo AB
Erik Andersson	IKEA Svenska AB
Hans Josefsson	Dynapac Compaction Equipment AB
Izidor Bobek	Borealis AB
Jan Olofsson	DHL
Jan-Olof Bengtsson	Nils Hanssons åkeri AB
Kenneth Falkeling	ABB AB
Kenneth Petersen	Eurotrucking
Lars-Olof Trulsson	ABB AB
Magnus Berg-Labor	CargoNet AB
Marko Vartiainen	Borealis AB
Mats Nilsson	CargoNet AB
Mats Olsson	Outokumpu Stainless AB
Mikael Engström	Ewals Cargo AB
Mikael Nessroth	Green Cargo AB
Mikael Pellrud	Hangartner
Mike Barry	Maersk A/S
Olle Bernstaf	DHL
Peter Andersson	MariTerm AB
Peter Gundel	DB Schenker
Petra Hugoson	MariTerm AB
Ronny Nilsson	DSV Road AB
Stanley Öberg	Green Cargo AB
Stefan Andersson	ABB AB
Sven Sökjer-Petersen	MariTerm AB
Thomas Frej	CargoNet AB
Toni Steiner	LKW Walter
Ulf Nilsson	Green Cargo AB

The tests are in detail documented in chapter 3 below.

1.4.2 Test transports

Test transports, where the applicability for rail transports of different stowage and securing methods normally used for road transports have been performed within the project by industry representatives as listed in the table below:

Company	Hauler	Cargo	CTU	Relation
Korsnäs	Maersk	Paper reels	Container	Gävle (SE) – Gothenburg (SE)
DHL		General cargo	Trailer	Helsingborg (SE) – Paris (FR)
Volvo Cars	Green Cargo	Steel racks (cars)	Trailer	Olofström (SE) – Gent (BE)
Södra Cell	Norfolkline	Pulp	Swap body	Mörrum (SE) – Turino (IT)
Ikea	Bring	General cargo	Trailer	Älmhult (SE) – Oslo (NO)
Scania	Ewals Cargo	Truck cabins	Trailer	Oskarshamn (SE) – Zwolle (NL)
Outokumpu	DSV	Steel coils	Trailer	Avesta (SE) – Azay sur Cher (FR)
Peterson Linerboard	DHL	Paper reels	Trailer	Trondheim (NO) – Oslo (NO) – Malmö (SE)



Inspection of containers with paper reels in the Port of Gothenburg by representatives from Korsnäs, Gävle Hamn, Maersk and Geodis Wilson.

In addition to the above mentioned test transports about 60 units were checked during transport between the combi terminals in Stockholm (Årsta) and Malmö.

2. DIFFERENCE IN ROAD AND RAIL REGULATIONS

In this chapter, brief descriptions of the road and rail regulations are given and a comparison of required securing arrangements for some types of goods is made based on the different regulations.

2.1 UIC Loading Guidelines

The current version of the UIC Loading Guidelines is valid from 1 January 1999 for train speeds up to and including 120 km/h. The Loading Guidelines are divided into four Volumes;

- Volume 1 – Principles
- Volume 2 – Goods
- Volume 3 – Line categories and
- Volume 4 – List of profile numbers for special consignments

Volume 2 – Goods, contains loading methods for specific types of goods, which either correspond directly to the principles set out in Volume 1 or have been derived from practical testing. Other methods of loading and load securing are permitted providing they meet the provisions in Volume 1.

In the introduction to Volume 1 it is mentioned that the following accelerations, expressed in *g*, should be taken into account during a combined transport on railway:

	Forward	**Backward**	**Sideways**	
			Horizontally	**Simultaneously upward**
Combined transport, railway	1.0	1.0	0.5	0.7

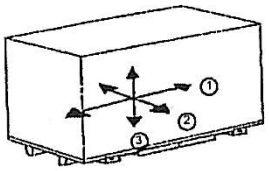
The loading methods described in Volume 2 for specific types of goods are, however, based on specific principles or are derived from practical testing. As was shown in the report on the research project **jvgRASLA** (Equipment for Rational Securing of Cargo on Railway Wagons, *http://www.mariterm/hoganas/rapporter.html*), most cargo securing arrangements for rail transports can only withstand fractions of the general acceleration requirements.

In the information sheets found in the introduction to Volume 2 the following general guidelines are given on sheet 0.5 regarding Intermodal Transport Units (CTUs: Containers, swap bodies, semi-trailers and road trains):

Goods

Goods loaded in intermodal transport units

Stresses arising during transit/accelerations

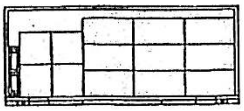


① lengthways (forwards and backwards) up to 1 g
② crosswise up to 0.5 g ($g = 9.81\ m/s^2$)
③ Vertically-acting vibrations can encourage the displacement of the goods during transit.

Condition of the transport units

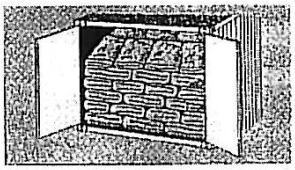
- floor should be clean
- side walls, longitudinal members, battens and sheets should be whole and in good condition
- locking systems of sliding doors and walls should be in proper working order

Method of loading



- goods should be loaded in compact formation over the whole loading surface (without intermediate spaces) or individually secured
- bulk goods should be spread evenly and compactly over the whole wagon floor
- the outside dimensions of the vehicles, containers and swap bodies should not be exceeded
- the load should be uniformly distributed
- stacking is only permitted if the bottom layer covers the whole of the loading surface
- neither the goods nor the method of loading must exert stresses on the transport unit liable to cause a risk to operations

Securing

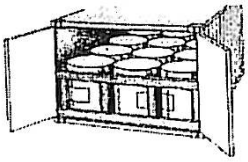


To form stable loads, identical elements or stacks should be bound together, for example using fastenings or plastic film. Loose sacks should be stacked in a criss-cross formation or inclined inwards.
Goods that are liable to being blown off are to be secured against falling/being blown off.
Goods that are not in contact with fixed sides or walls must be secured, for example with:



- direct or indirect fastenings
- props or bracing
- air cushions / padding
- pallets or planks positioned vertically
- friction-enhancing inserts.

The built-in securing devices should preferably be used to secure the load.
Bracing should be arranged such that the pressure exerted by the load is spread over as large a surface as possible. Bracing struts on the end doors or walls should cover the full width of the load, if possible set against the corner mountings.



Securing goods using sheets, hoops, longitudinal members or battens only is not sufficient.

Goods should be secured against tipping using frames, struts or fastenings to approx. 3/4 of their height if the bearing surface is not at least
- 6/10 in the longitudinal direction,
- 5/10 in the transverse direction of the height.

Cylindrically-shaped goods should be scotched to prevent them from rolling

However, when it comes to securing of different types of goods also these general guidelines are overridden by the specific instructions for each type of goods in the rest of Volume 2.

The loading and securing methods for specific types of goods in Volume 2 are set out in one left-hand and one right-hand column where the right-handed column apply to, among others, wagons used in combined transport trains with containers, swap bodies, semi-trailers and lorries, where appropriate with trailers. Text printed across the full width of the page is valid in all cases.

In Volume 1 of the UIC Loading Guidelines it is prescribed that goods that are not in contact with fixed sides or walls must be secured, for example with top-over lashings (indirect fastenings). However, in the detailed load examples in Volume 2 very few cases are shown with top-over lashings only, for goods in ordinary goods wagons as well as for goods in CTUs. In addition to the top-over lashings, some kind of blocking by walls, drop sides, stanchions, bracings, chocks, battens etc is required in most cases. Thus it is not permissible to secure cargo loaded in curtainsiders of L-type (without strong sides) with top-over lashings only.

Even though the loading and securing examples for different types of goods are valid also for goods in CTUs it is in the introduction of each example indicated for which type of wagons the example is valid i.e. “wagons with walls, sides or stanchions (E…, K…, L…, R…, S…)”. It is nowhere indicated for which types of CTUs the example is valid and thus it is not informed if, for example a drop sided trailer, is permitted in an example with the above description.

Many of the examples in Volume 2 show securing arrangements that allow sliding of the goods in longitudinal direction. Such securing arrangements are perfect for rail transports to overcome the shunting chocks. Sliding of the goods in longitudinal direction is however considered to be very dangerous in road transport and thus not allowed. Never the less such arrangements are shown in the examples also for the securing in CTUs.

2.2 European Best Practice Guidelines on cargo securing for road transport

According to the introduction of the European Best Practice Guidelines on cargo securing for road transport (EU BPG) the cargo should be secured either according to the IMO/ILO/UN ECE or the CEN method in cross border operations; both methods should be recognised by the controlling authorities for International Transport, leaving to the haulier or the loader the choice of which method to apply. Some Member States could however impose one of the two methods or specific rules for transports on their roads.

According to the EU BPG, practical tests are not required for cargo securing arrangements as long as the number of lashings is decided according to either the IMO or the CEN method described in section 8.6 or 8.7 of the document.

2.3 The IMO method for road transport

The IMO method is based on the IMO Model Course 3.18 including the IMO Quick Lashing Guides. The lashing guide for road transport describes different lashing methods, for example blocking, top-over lashing (indirect fastening), loop lashing, spring lashing and direct lashing, which all are designed according to the accelerations to be expected during road transport.

The design accelerations expressed in *g* during road transport according to the IMO method are as follows:

	Forward	Backward	Sideways	Simultaneously downward
Road transport, IMO method	1.0	0.5	0.5	1.0

The aim with the CombiSec project is to investigate if cargo secured according to these accelerations also is safe for rail transports or to find out which additional precautions that have to be taken.

The number of top-over lashings to prevent sliding is in the IMO-method calculated according to the following formulas:

Forward/backward: $n = (C_x - \mu_s \times C_z) \times m \times g / (2 \times \mu_s \times \sin\alpha \times F_T)$
Sideways: $n = (C_y - \mu_s \times C_z) \times m \times g / (2 \times \mu_s \times \sin\alpha \times F_T)$

The number of spring lashings is calculated by the following formula:

Forward/backward: $n = (C_x - \mu_d \times C_z) \times m \times g / (2 \times LC\ (\mu_d \times \sin\alpha + \cos\alpha))$

where

n = *Required number of lashings*
C_x = *Longitudinal acceleration factor*
C_y = *Transverse acceleration factor*
C_z = *Vertical acceleration factor*
m = *Cargo weight in ton*
μ_s = *Static friction coefficient*
μ_d = *Dynamic friction coefficient, normally 0.7 × μ_s*
α = *Angle between the horizontal plane and the lashing in degrees*
g = *Gravity acceleration 9.81 m/s^2*
F_T = *Pretension in the lashing in kN*
LC = *Lashing capacity of the lashing in kN*

2.4 The CEN method for combined transport on railway

Corresponding design accelerations expressed in *g* during combined transport on railway according to the European standard 12195-1:2010 – the CEN method are as follows:

Securing	Forward/backward		Sideways	Downward	
	Sliding	Tilting		Sliding	Tilting
Forward/backward	1.0	0.6	-	1.0	1.0
Sideways	-	-	0.5	0.7	1.0

The differences in the design accelerations for sliding between road transport and combined transport for road/railway according to the CEN method is in longitudinal direction especially

backwards as well as downward simultaneously with the accelerations sideways. For tilting there are also differences.

The number of top-over lashings to prevent sliding is in the CEN-method calculated according to the following formulas:

Forward/backward: $\mathbf{n = (C_x - \mu \times C_z) \times m \times g \times f_s / (2 \times \mu \times \sin\alpha \times F_T)}$
Sideways: $\mathbf{n = (C_y - \mu \times C_z) \times m \times g \times f_s / (2 \times \mu \times \sin\alpha \times F_T)}$

The number of spring lashings is calculated by the following formula:

Forward/backward: $\mathbf{n = (C_x - \mu \times f_\mu \times C_z) \times m \times g / (2 \times LC\ (\mu \times f_\mu \times \sin\alpha + \cos\alpha))}$

In addition to the parameters explained in section 3.3 the following parameters are used in these formulas:

μ = *Friction factor to be taken from the standard or as 0,925 × μ_s*
f_s = *Safety factor 1.1 in all directions during rail transport (1.25 forward is applied for road transport only)*
f_μ = *Friction factor 0.75*

2.5 Comparison between the road and rail regulations

In this section the difference in required number of lashings is shown for the following regulations and guidelines:

- UIC Loading Guidelines, combined transport - rail
- IMO-method, road transport
- CEN-method, combined transport - rail

The following types of goods are taken as example:

- Example 1 - Particle boards on curtainsided L-type trailers
- Example 2 - I-beams on curtainsided L-type trailers
- Example 3 - Paper reels loaded eye-to-sky in box and curtainsided L-type trailers
- Example 4 - Concrete elements on open flat bed trailers

The acceleration backward is 0.5 *g* for road transport. The corresponding acceleration is 1.0 *g* according to the UIC Loading Guidelines and the CEN method for rail transport. This discrepancy makes a big different for the dimensioning of cargo securing arrangements in backward direction.

In addition, the reduced downward force acting simultaneously with the sideways forces, according to the UIC Loading Guidelines and the CEN method, means that the pressure from the cargo against the surface is smaller during rail transport than during road transport. Thus top-over lashings (indirect fastening) are considered much less efficient during railway than during road transport.

2.5.1 Example 1 - Particle boards

In this example particle boards are loaded in three sections and three layers with a total weight of 24 ton in a curtainsided L-type trailer (no strong side) but with a strong headboard.



Securing according to the UIC Loading Guidelines

The following instructions are found in the UIC Loading Guidelines 2.9:

Loading guidelines 2.9

Plywood slabs, hardboard

Single wagons and groups of wagons	Wagons in block trains and combined transport

Type of goods

Plywood and hardboard slabs coated or uncoated, bound into packages

① Height of packages
– for smooth-coated slabs approx. 60 cm,
– for uncoated slabs approx. 100 cm.

② Bindings with edge protection at intervals of approx. 1 metre, at least 2 bindings per package length (breaking strength at least 14 kN).

Wagons

Wagons with wooden floor and if possible locking partition walls (H..., Li..., Rils, Si..., T...)

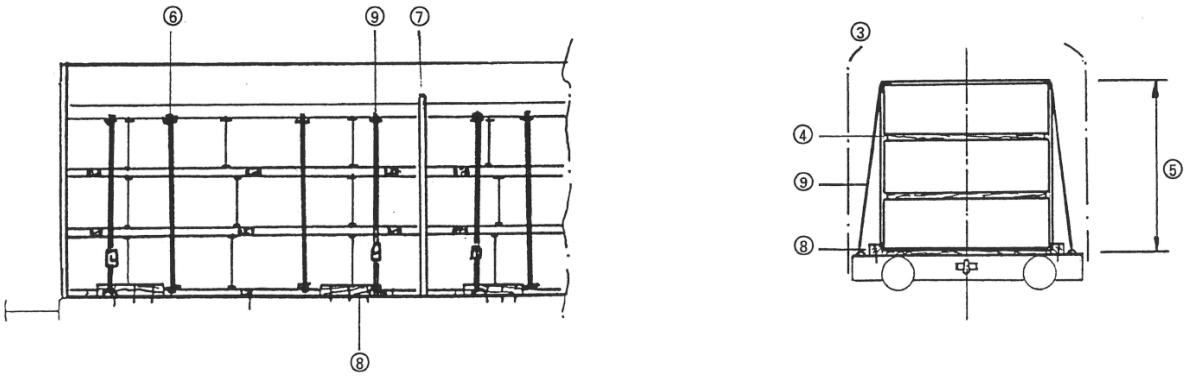
Method of loading

③ Packages should be laid on wooden timbers in one or several tiers.

④ Timbers and bolsters should be made of soft wood
– of rectangular cross-section and resting on the broader face,
– of one piece or a maximum of three overlapping pieces covering the full width of the load unit

⑤ Stack heights should not exceed 180 cm for smooth-coated slabs.

⑥ Stacks should be bound together with at least 2 bindings with edge protection (breaking strength of bindings at least 22 kN).



Securing

– lengthways in the wagon:

⑦ • by locking partition walls **or**
• by filling in the intermediate space (e.g. with wooden cross-bracing)

– crossways in the wagon

⑧ • by timbers nailed in place, at least 2 per stack on each side
Timbers should be at least 5 cm thick with an effective height of at least 3 cm; number of nails of 5 mm diameter in the timbers on each side: 1 nail / 1.500 kg **or**

⑨ • by at least 2 indirect fastenings per stack with tensioning devices and edge protection (breaking strength of bindings at least 40 kN)

Additional indications

Distribution of load: see sheet 0.1

1.1.2000

It can thus be concluded that 24 ton of particle boards in three section and three layers may be secured sideways with 6 top-over (indirect fastenings) with a breaking strength of 40 kN. It shall be noted that the required pretension in the lashings is not stated.

As can be seen in the right column of the instruction above no securing (7) is required in longitudinal direction for combined transport.

It can also be seen that this instruction is valid for wagon types H..., Li…, Rils, Si… and T….

It is not mentioned for which types of CTUs it is valid, and it is thus not known if the arrangement is allowed in a curtainsider of L-type or not.

Securing according to the IMO-method for road transport

It is assumed that normal web lashings are used for the securing and the following parameter values are used in the equations in section 3.3 to calculate the required number of top-over lashings to prevent sliding sideways and backwards:

C_x = *0.5 backwards*
C_y = *0.5*
C_z = *1.0*
m = *24 ton*
μ_s = *assumed to be 0.35*
α = *90 degrees*
g = *9.81 m/s*^{2}
F_T = *4 kN*

This gives the following required number of top-over lashings to prevent sliding in different directions:

Direction	Number of top-over lashings
Forward	0 (blocked)
Backward	13
Sideways	13

13 typical top-over web lashings with a pretension of 4 kN are thus required to prevent the 24 ton particle boards from sliding sideways and backward.

Securing according to the CEN-method for combined transport - rail

The following parameter values are used in the equations in section 3.4 to calculate the required number of top-over web lashings to prevent sliding sideways and backwards:

C_x = 1.0 backwards
C_y = 0.5
C_z = 1.0 during backward sliding and 0.7 during sideways sliding
m = 24 ton
μ_s = Assumed to be 0.35
$\mu = 0.925 \times \mu_s = 0.324$
α = 90 degrees
$g = 9.81\ m/s^2$
F_T = 4 kN
LC = 16 kN
f_s = Safety factor 1.1
f_μ = Friction factor 0.75

This gives the following required number of top-over lashings to prevent sliding in different directions:

Direction	Number of top-over lashings
Forward	0 (blocked)
Backward	68*
Sideways	28

* *Alternatively 28 top-over lashings + 5 spring lashings*

68 top-over web lashing with a pretension of 4 kN are thus required to prevent the 24 ton particle boards from sliding backwards, alternatively 28 top-over lashings in combination with 5 spring lashings with LC 16 kN.

2.5.2 Example 2 - I-beams

In this example I-beams are loaded, according to the photos below, in two layers with a total weight of 24 ton in a curtainsided trailer of L-type (no strong side) but with a strong headboard.





Securing according to the UIC Loading Guidelines

The following instructions are found in the UIC Loading Guidelines 1.6.1:

Loading guidelines 1.6.1

Sections (ungreased)

Single wagons and groups of wagons	Wagons in block trains and combined transport Wagons with long-stroke shock absorbers

Type of goods

① Steel sections (EN 10079) in bulk or

② bound into packages, with one binding every 3 m and a minimum of 2 bindings. Bindings should be approx. 30 cm from the ends of the packages. Breaking strength of bindings at least 1,400 daN. Synthetic or woven straps with edge protection

Wagons

Wagons with walls, sides or stanchions and wooden floor (E ..., K..., L..., R..., S..., T...)

Method of loading

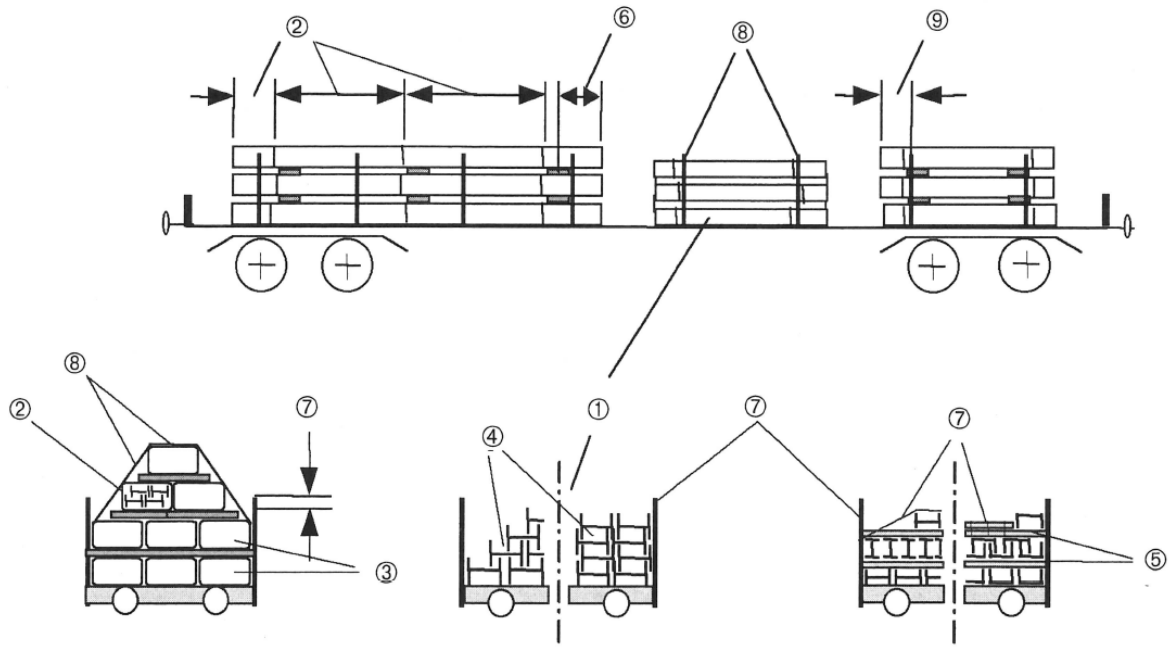
Sections and packages should be loaded directly onto the wagon floor, on bolsters or wooden timbers

③ – in one or more tiers;

④ – stacked one on top of another, where possible across the whole width of the wagon.

⑤ Wooden timbers and supports
– of square or rectangular cross-section, resting on the broader face;
– of one piece or a maximum of 3 overlapping pieces (at least 4 cm thick) covering the full width of the load or load unit.

⑥ Sections and packages should project beyond the cross-timbers by at least 50 cm.



Securing

Steel sections and packages should be secured directly by the walls, sides or stanchions (distance ≤ 10 cm). If the distance is greater than 10 cm (breaking strength of bindings at least 1,400 daN) steel sections should be bound together.

⑦ Effective height of the walls, sides or stanchions at least 10 cm
– intermediate space **filled with pieces of wood (nailed in place) or**
– joined together or bound (with edge protection) to the underlying parts of the load. Number of bindings: 1 for every 6 m length, at least 2 per stack (breaking strength at least 1,400 daN).
No additional bindings for sections resting on the edges.

⑧ Sections and packages on top of the load and extending beyond the top of the stanchions by more than 10 cm are bound together and to the underlying part of the load; one binding per 6 m length, at least 2 bindings per stack (breaking strength at least 1,400 daN), synthetic or woven straps with edge protection, distance of bindings from edge of load at least 50 cm.

⑨ When held by only 2 stanchions, sections and packages should extend beyond the stanchions by at least
50 cm | 30 cm

Additional indications

Distribution of load, see sheet 0.1
By virtue of point 5.5.3 of RIV Appendix II, Section 1, it is possible to dispense with clearances from the front walls/sides when the goods are not vulnerable to impact.

1.7.2005

In these guidelines it is mentioned that the I-beams shall be blocked sideways by walls, sides or stanchions as well as joined together with bindings with minimum break load of 14 kN. I-beams are thus not possible to transport in a curtainsided trailer of L-type in combined transport according to the UIC Loading Guidelines. Note that beams above the stanchions may be secured by one round-turn lashing per 6 m length, at least 2 bindings per stack and with bindings with breaking strength at least 14 kN.

Securing according to the IMO-method for road transport

The I-beams are assumed to be block stowed against the headboard, which thus prevents forward sliding. If “normal” web lashings are used, the following parameter values shall be used in the equations in section 3.3 to calculate the required number of top-over lashings to prevent sliding sideways and backwards:

C_x = 0.5 backwards
C_y = 0.5
C_z = 1.0
m = 24 ton
μ_s = assumed to be 0.40
α = 90 degrees
g = 9.81 m/s^2
F_T = 4 kN

This gives the following required number of top-over lashings to prevent sliding in different directions:

Direction	Number of top-over lashings
Forward	0 (blocked)
Backward	8
Sideways	8

8 top-over web lashing with a pretension of 4 kN are thus required to prevent the 24 ton I-beams from sliding in any direction.

Securing according to the CEN-method for combined transport - rail

The following parameter values are used in the equations in section 3.4 to calculate the required number of top-over web lashings to prevent sliding sideways and backwards:

C_x = 1.0 backwards
C_y = 0.5
C_z = 1.0 during backward sliding and 0.7 during sideways sliding
m = 24 ton
μ_s = Assumed to be 0.40
μ = 0.925 × μ_s = 0.37
α = 90 degrees
g = 9.81 m/s^2
F_T = 4 kN
LC = 16 kN
f_s = Safety factor 1.1
f_μ = Friction factor 0.75

This gives the following required number of top-over lashings to prevent sliding in different directions:

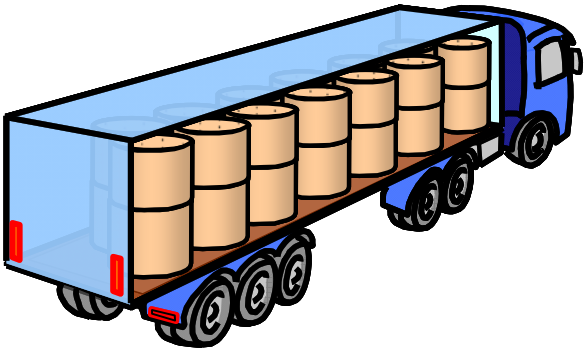
Direction	Number of top-over lashings
Forward	0 (blocked)
Backward	56*
Sideways	22

** Alternatively 22 top-over lashings + 5 spring lashings*

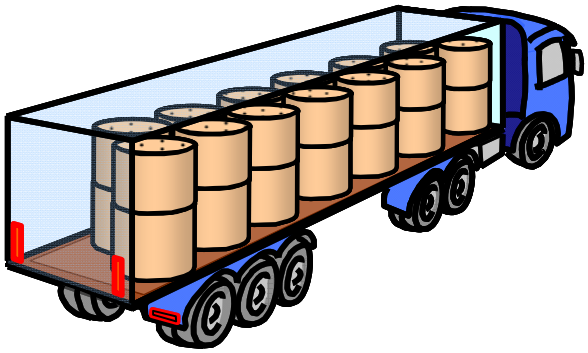
56 top-over web lashings with a pretension of 4 kN are thus required to prevent the 24 ton I-beams from sliding backwards, alternatively 22 top-over lashings in combination with 5 spring lashings with LC 16 kN.

2.5.3 Example 3 - Paper reels loaded eye-to-sky in box or curtainsided trailers

In this example paper reels with a diameter of 140 cm are loaded eye-to-sky in a zigzag pattern in two layers and 13 sections according to the sketches below. The total weight is 21.5 ton. The reels are placed on friction mats with a measured static friction $\mu_s = 0.67$. Either box trailers or curtainsiders are used for the transport.



A) Box trailer of XL-type



B) Curtainsided trailer of L-type with strong headboard

Securing according to the UIC Loading Guidelines

The following instructions are found in the UIC Loading Guidelines 4.1.3:

Loading guidelines 4.1.3

Rolls of paper loaded upright ("eye-to-sky")

Single wagons and groups of wagons	Wagons in block trains and combined transport Wagons with long-stroke shock absorbers

Type of goods

Rolls of paper

Wagons

Wagons with sliding walls and fixed end walls (H..., Li..., Si...)

Method of loading

① Rolls should be loaded "upright" in one or more tiers. They should if possible cover the whole loading surface. When loaded in several tiers, rolls should be placed exactly one on top of another.

– when loaded without intermediate spacing, the diameter of the rolls must be at least 5/10 of their

② height. Otherwise, roll diameter must be at least

7/10	6/10

of roll height.

– rolls should be arranged as follows in the wagon

③ • in a single line one behind the other (roll axis placed along the wagon longitudinal centreline),

• in two staggered lines (symmetrical about the wagon longitudinal centreline),

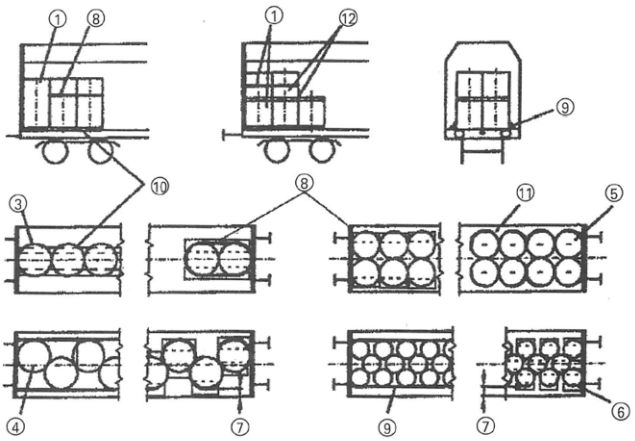
④ • in two lines, with the rolls one behind another,

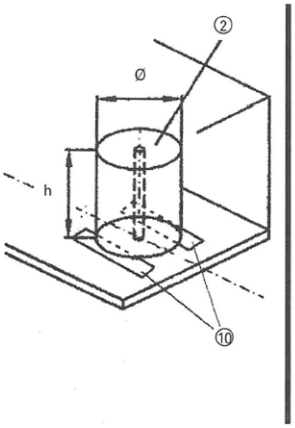
⑤ • in three staggered lines (in groups of 5 rolls),

⑥ – upright and in contact with the end walls, with space left in the middle of the wagon

⑦ – if arranged according to ④ or ⑥, rolls should be formed into fixed groups crossways in the wagon or else the load should be at least 10 cm clear of the sliding walls.

– there should be no contact with the sloping part of the roof.





Securing

– lengthways in the wagon

⑧ by the end walls, able to slide if appropriate. Rolls whose diameter is less than

7/10 | 6/10

of their height should be bound together and prevented from moving.
Breaking strength of bindings: at least 1000 daN.

– crossways in the wagon

⑨
- by guide-rails[1] that are an integral part of the wagon or are fixed, for example, to existing battens **or**
- by wooden guide-pieces approx. 5 cm high. Number of nails per side : 1 nail/2000 kg with at least 2 nails per guide-piece **or**
- by cradles resting against the sliding walls (corrugated cardboard, several layers thick, wooden laths) to fill up the space across the wagon **or**

⑩ using friction-enhancing inserts, 2 parallel strips laid lengthways under each roll, with a μ value of at least 0.7 and a minimum width of 15 cm. The friction coefficient, resistance to deformation and average resistance to dirt shall be guaranteed by the manufacturer **or**

⑪ sliding walls: if loaded as shown in ⑤ , loading without friction-enhancing inserts is possible providing the lateral clearance to the sliding wall is ≤ 10 cm and the height of the paper rolls is no greater than the vertical part of the sliding wall.

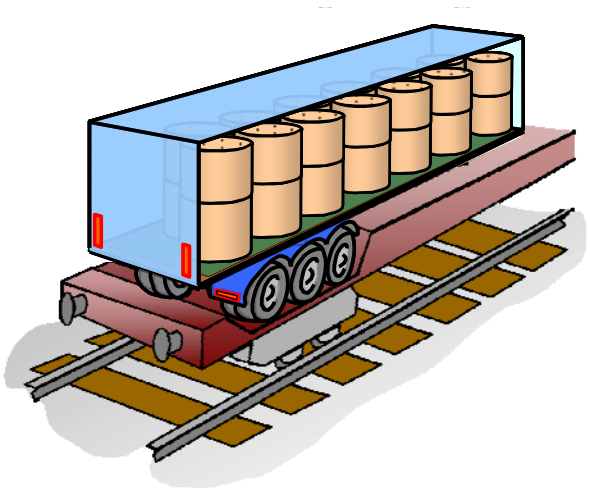
⑫ If the rolls are stacked, friction inserts should be placed between each tier.

Additional indications

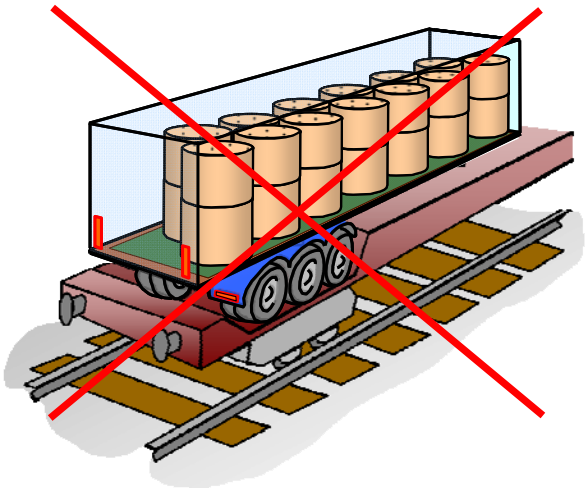
Distribution of load: see sheet 0.1

1) For example, profiled tubes of height ≥ 50 mm; the upper edge facing the goods should be rounded off to avoid causing damage.

1.1.2004

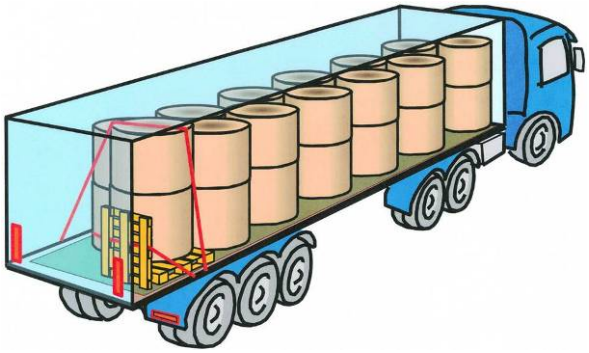


According to the guidelines in instruction 4.1.3 it is allowed to transport the paper reels unlashed in a box trailer as long as the reels fill out the entire length of the unit.



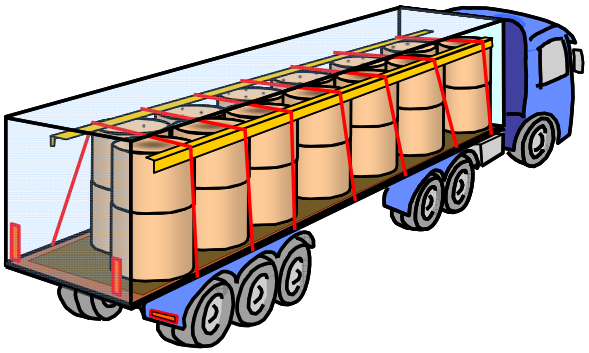
It is however not allowed to transport paper reels in combined transport - rail according to the UIC Loading Guidelines in a curtainsided trailer independent if it is of L- or XL-type.

Securing according to the IMO-method for road transport



In a box trailer of XL-type no lashings are required unless something to prevent backward movement if the distance to the rear doors is too large.

With a static friction of 0.67 there is no sliding risk of the reels. With a diameter of 140 cm there is also no tipping risk as long as the stowage height is below 280 cm. In a curtainsided trailer of L-type at least one top-over lashing shall be used per 4 ton cargo to prevent wandering. In this case long edge beams and 7 top-over web lashings are proposed according to the sketch to the right.



Securing according to the CEN-method for combined transport - rail

In box trailers of XL-type there is no need for lashings also according to the CEN-method. In curtainsided trailers of L-type with a strong headboard the following parameter values are used in the equations in section 3.4 to calculate the required number of top-over web lashings to prevent sliding sideways and backwards:

C_x = 1.0 backwards
C_y = 0.5
C_z = 1.0 during backward sliding and 0.7 during sideways sliding
m = 21.5 ton
μ_s = 0.67
$\mu = 0.925 \times \mu_s = 0.62$
α = 90 degrees
$g = 9.81\ m/s^2$
F_T = 4 kN
f_s = Safety factor 1.1

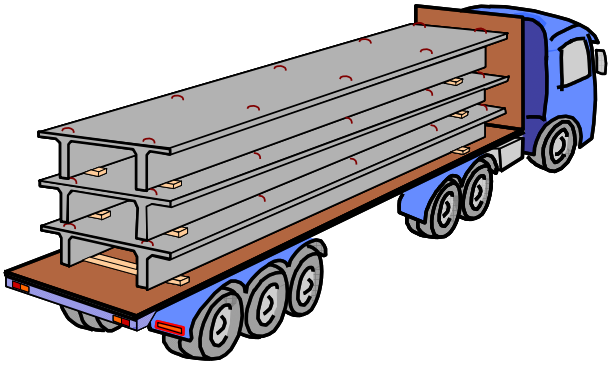
This gives the following required number of top-over lashings to prevent sliding in different directions:

Direction	Number of top-over lashings
Forward	0 (blocked)
Backward	18
Sideways	4

Long edge beams and 18 top-over web lashing with a pretension of 4 kN are thus required to prevent the 21.5 ton paper reels from sliding backwards.

2.5.4 Example 4 - Concrete elements

In this example concrete elements are loaded in three layers on open flat bed trailers. Due to the weight distribution it is not possible to block stow the elements against the headboard, and they are thus loaded according to the figure below.



Securing according to the UIC Loading Guidelines

The following instructions are found in the UIC Loading Guidelines 6.1.1:

Loading guidelines 6.1.1

Blocks of stone (worked)

Single wagons and groups of wagons	Wagons in block trains and combined transport

Type of goods

Blocks of stone (worked)

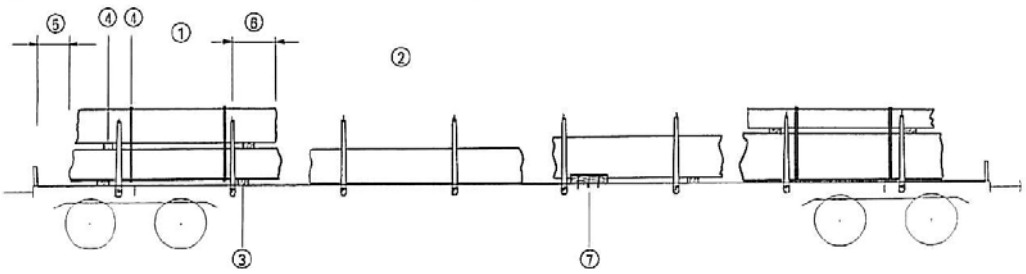
Wagons

Wagons with walls, sides or stanchions and wooden floor (E..., K..., L..., R..., S...)

Method of loading

① Blocks should be loaded in one or two tiers, lying flat, and wherever possible spread over the whole loading surface, with or without intermediate space.
② – with their broadest surface to the wagon floor or
③ – lying in a stable position on softwood timbers (1 to 4 cm thick).
④ Stacked blocks of stone should be separated by cross-timbers, plaited straw or thick ropes/cables and bound together at least twice into load units (breaking strength of fastenings at least 14 kN).
⑤ Minimum clearance

smooth bearing surface	50 cm	0 cm
rough bearing surface	30 cm	0 cm



Securing

Blocks should be secured by the wagon walls, sides or at least 2 stanchions.

⑥ – when secured by only 2 stanchions, blocks should extend lengthways beyond the stanchion centre by at least

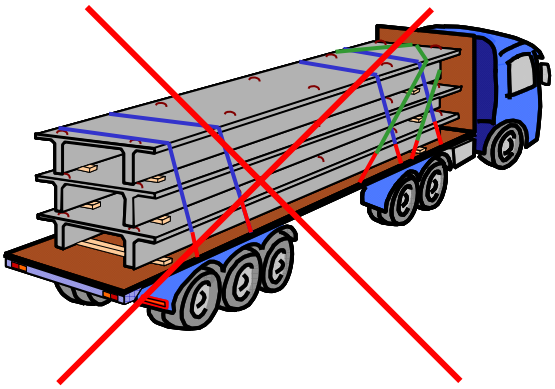
(smooth bearing surface)	50 cm	30 cm
(rough bearing surface)	30 cm	20 cm

⑦ – by guide-pieces when ⑥ is not complied with or when the blocks of stone are more than 10 cm away from the walls, sides or stanchions
- guide-pieces should be at least 5 cm thick with an effective height of at least 3 cm
- total number of nails of 5 mm diameter along each side: 1 nail / 1,500 kg, and at least 2 nails per guide-piece.

Blocks [1] which are not directly secured laterally by the wagon walls, sides or stanchions must be laterally secured with guide-pieces.

Additional indications

Distribution of load: see sheet 0.1



As the elements have to be secured against walls, sides or at least 2 stanchions it is not allowed to transport the elements on open flat bead trailers according to the UIC Loading Guidelines.

Securing according to the IMO-method for road transport

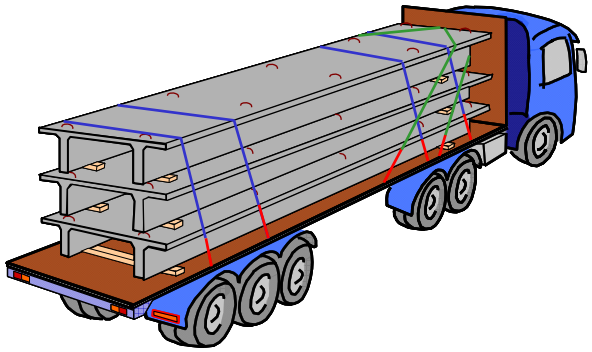
The concrete elements with a total weight of 32 ton are assumed to be secured by chain lashings with a pretension of 10 kN and a LC of 40 kN. The following parameter values are used in the equations in section 3.3 to calculate the required number of top-over lashings to prevent sliding in any direction:

C_x = *1.0 forward and 0.5 backwards*
C_y = *0.5*
C_z = *1.0*
m = *32 ton*
μ_s = *0.60*
α = *90 degrees*
g = *9.81 m/s*^{2}
F_T = *10 kN*
LC = 40 kN

This gives the following required number of top-over lashings to prevent sliding in different directions:

Direction	Number of top-over lashings
Forward	11*
Backward	4**
Sideways	4**

* *Alternatively 4 top-over lashings and 2 spring lashings forward*
** *Due to risk of wandering sideways and backwards*



11 top-over chain lashings with a pretension of 10 kN are thus required to prevent the 32 ton concrete elements from sliding in any direction. Alternatively 4 top-over lashings and 2 spring lashings with LC 40 kN in forward direction are required according to the figure.

Securing according to the CEN-method for combined transport - rail

The following parameter values are used in the equations in section 3.4 to calculate the required number of top-over lashings to prevent sliding in any direction:

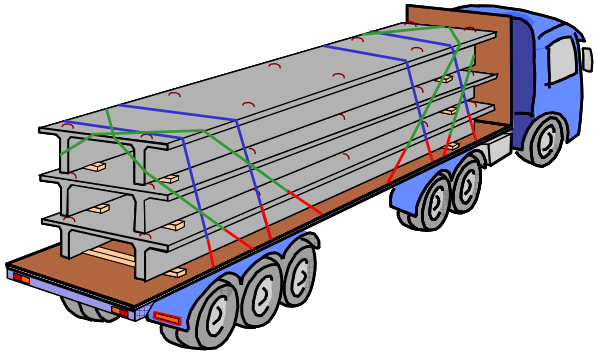
C_x = 1.0 forward and backward
C_y = 0.5
C_z = 1.0 during longitudinal sliding and 0.7 during sideways sliding
m = 32 ton
μ_s = 0.6
$\mu = 0.925 \times \mu_s = 0.55$
α = 90 degrees
$g = 9.81\ m/s^2$
F_T = 10 kN
LC = 40 kN
f_s = Safety factor 1.1
f_μ = 0.75

This gives the following required number of top-over lashings to prevent sliding in different directions:

Direction	Number of top-over lashings
Forward	14*
Backward	14*
Sideways	4

* *Alternatively 4 top-over lashings and 2 spring lashings*

in each direction



14 top-over chain lashings with a pretension of 10 kN are thus required to prevent the 32 ton concrete elements from sliding in any direction. Alternatively 4 top-over lashings and 2 spring lashings in each direction with LC 40 kN are used as shown in this figure.

2.6 Conclusions from the comparison

According to the calculations in the section above the following number of lashings are required in the different loading examples according to the different rules and guidelines:

Example	Required number of lashings		
	UIC Loading Guidelines - rail	**IMO method - road**	**CEN method - rail**
1 – Particle boards	6 top-over lashings	13 top-over lashings	68 top-over lashings alternatively 28 top-over and 5 spring lashings
2 – I-beams	Not allowed Beams above the stanchions may be secured by one round-turn lashing per 6 m	8 top-over lashings	56 top-over lashings alternatively 22 top-over and 5 spring lashings
3 – Paper reels	Not allowed	7 top-over lashings	18 top-over lashings
4 – Concrete elements	Not allowed	11 top-over lashings alternatively 4 top-over and 2 spring lashings forward	14 top-over lashings alternatively 4 top-over and 2 spring lashings in each direction

In the table above it can be seen that the goods in several of the examples above can not be transported in combined transport – rail in curtainsided trailers or open flat bed trailers.

It is of great interest to note that in example 1, where top-over lashings (indirect fastenings) are allowed, the required number of lashings is much less according to the UIC Loading Guidelines than according to the road regulations. It is also noted that according to the UIC Loading Guidelines no securing arrangement is required to prevent sliding in longitudinal direction for this type of goods.

It can also be noted that the CEN method for combined transport – rail gives an enormous amount of lashings in most cases.

3. SHUNTING TESTS

3.1 Introduction

Within the research project "CombiSec - Coordination of cargo securing principles for road and combined transport trains" shunting tests were carried out in Malmö 2009-10-01 -- 02.

The principles for cargo securing in cargo transport units suitable for combined transport are according to current regulations completely different for road/sea on one hand and rail on the other. This circumstance is not a favorable condition for combined transports by rail. If it would be possible to show that valid road regulations are sufficient also for cargo securing on combined transport on rail, very much would be gained. The project aims to prepare a proposal on unified principles for cargo securing in cargo transport units for combined road/sea and rail transports.

The shunting tests described in this report are the first part of a series of tests performed within this project. The different sets of tests will be documented in separate reports and will be compiled and referred to in the final report for this research project.

For this particular test, 19 units loaded on wagons for combined transports, were shunted at speeds and directions according to the instructions for shunting tests in UIC Loading Guidelines, see below. The 19 units used in the tests were supplied and transported by the following companies:

Type of cargo	Supplier	Type of CTU	Carrier
Square-sawn timber	Södra Timber	Trailer	van Dieren
Paper reels	Billerud	Container	Port of Norrköping, Maersk, Green Cargo
Paper reels	Korsnäs	Trailer	LKW Walter, CargoNet
Bags on pallets	Borealis	Trailer	DSV
Octabins	Borealis	Trailer	DSV
Liner reels	Peterson Linerboard	Trailer	DHL, CargoNet
Mixed cargo	IKEA	Trailer	Nor-Cargo
Lying concrete elements	Betong o smide	Trailer	K.E. Palms åkeri
Standing concrete elements	Betong o smide	Trailer	K.E. Palms åkeri
Barrels on pallets	Akzo Nobel	Trailer	N-TEX
Paper pallets	Stora Enso Fors	Swap body	Hangartner
Cable drums	ABB	Trailer	DB Schenker
Single drum vibratory roller	Dynapac	Trailer	DSV
Steel pipes	Ovako Steel	Trailer	Hangartner, CargoNet
Truck cabin	Scania	Trailer	Ewals Cargo
Palletised cargo	DHL	Trailer	DHL
Steel coils	Outokumpu	Trailer	Nils Hanssons Åkeri

Steel sheet metal	Outokumpu	Trailer	Nils Hanssons Åkeri
Paper pulp	Södra Cell	Swap body	Norfolkline

The aims of these impact tests were:

- to measure accelerations experienced in the units during shunting in speeds according to the prescribed instructions of shunting tests in the UIC Loading Guidelines
- to examine if the cargo securing principles established by the road authorities and thus the design forces for road transport in rearward direction are sufficient for cargo in combined transport trains

Accelerometers were used to record the shocks. These provided several values for the accelerations during each shock, enabling the plotting of a timeline history graph.

The following 30 persons were attending the tests:

Bengt Månsson	Norfolkline
Carl-Erik Silow	IKEA Svenska AB
Christer Nilsson	Green Cargo AB
Erik Andersson	IKEA Svenska AB
Hans Josefsson	Dynapac Compaction Equipment AB
Izidor Bobek	Borealis AB
Jan Olofsson	DHL
Jan-Olof Bengtsson	Nils Hanssons åkeri AB
Kenneth Falkeling	ABB AB
Kenneth Petersen	Eurotrucking
Lars-Olof Trulsson	ABB AB
Magnus Berg-Labor	CargoNet AB
Marko Vartiainen	Borealis AB
Mats Nilsson	CargoNet AB
Mats Olsson	Outokumpu Stainless AB
Mikael Engström	Ewals Cargo AB
Mikael Nessroth	Green Cargo AB
Mikael Pellrud	Hangartner
Mike Barry	Maersk A/S
Olle Bernstaf	DHL
Peter Andersson	MariTerm AB
Peter Gundel	DB Schenker
Petra Hugoson	MariTerm AB
Ronny Nilsson	DSV Road AB
Stanley Öberg	Green Cargo AB
Stefan Andersson	ABB AB
Sven Sökjer-Petersen	MariTerm AB
Thomas Frej	CargoNet AB
Toni Steiner	LKW Walter
Ulf Nilsson	Green Cargo AB

Many thanks to all involved for valuable contribution and help during the shunting tests.

3.2 Summary

The shunting tests carried out in Malmö in October 2009 comprised shunting of 19 units; 16 trailers, two swap bodies and one container, loaded on wagons for combined transport. The tests were carried out according to the instructions for impact tests in the UIC Loading Guidelines.

The test data received from the accelerometers indicates that, if performing impacts within the stipulated speed ranges 3 - 4 km/h, the acceleration 0.5 g (4.9 m/s^2) will not be exceeded in longitudinal direction. This result clearly demonstrates that it is sufficient for the cargo in cargo transport units for combined road/rail transports to be secured according to the road regulations in longitudinal direction.

Although the cargo securing in six of the 19 units was designed for accelerations lower than 0.5 g, the cargo did not move in longitudinal direction as long as the shunting speed was within the prescribed limits.

The cargo securing did not fulfil the instructions in the UIC Loading Guidelines in none of the 19 units. The fact that this regulation was not fulfilled in any of the units shows that other securing techniques are used by road operators.

The shunting tests were performed to examine movements in longitudinal direction during shunting. However, four of the 19 units were transported by combined road/rail transport to Malmö which enabled to also examine movements sideways in these units. There had been movement in one of these four units only. The cause of the movement must have been the vibrations and that the cargo had not been 100% compact stowed. The movement could in no way be regarded as causing any danger to the rail safety. Additional tests to examine the behaviour in transverse direction of the cargo in combined transport units during rail transport have been carried out.

The main conclusion of the shunting tests:

- The tests have shown that, in longitudinal direction, it is sufficient to secure cargo in cargo transport units for combined road/rail transports according to the road regulations as long as shunting is carried out in the prescribed speed max 4 km/h.

3.3 Test method

The different cargo transport units were loaded on wagons for combined transport and are, according to the methods described in the UIC Loading Guidelines, see below, to be subjected to two impacts in the same direction at speeds of 3 - 4 km/h. Some of the units were unfortunately shunted at higher impact speeds than prescribed.

UIC Loading Guidelines for impact tests

The following guidelines for impact tests can be found in the UIC Loading Guidelines, Section 1, Principles, Table 4.

Impact test for loading methods and loose fastenings

1 Purpose

The purpose of these tests is to check whether the loading methods used and loose fastenings stand up to the longitudinal stresses exerted during railway operating.

2 Test conditions

2.1 Impact wagon

The wagon shall be

- a high-sided open bogie wagon,
- fitted with Category A sided buffers in accordance with **UIC Leaflet 526-1**,
- loaded to a total mass of 80 t, preferably with bulk goods,
- kept stationary on flat straight track in the unbraked position by means of stop blocks positioned at a distance of approximately one metre.

2.2 Wagon loaded according to the method requiring testing

The wagon must be:

- loaded as far as possible to maximum capacity (part load: insufficient), in order to limit investment in means of fastening,
- fitted in principle with Categories A and B side buffers, in accordance with **UIC Leaflets 526-1** or **526-2**.

The results of tests carried out with wagons with buffers in accordance with **UIC Leaflet 526-1**, Category C, or **UIC Leaflet 526-3** may not be transposed to wagons fitted with conventional buffers (**UIC Leaflet 526-1**, Categories A and B, and **UIC Leaflet 526-2**).

The floor of the wagon shall be

- clean,
- free from any load debris, fastenings, snow or ice.

The state of the floor (eg. wet or dry) must be stated in the report.

2.3 Position of the impact wagon

For testing purposes, the impact wagon may also impact the wagon loaded according to the method which is being tested.

2.4 Impact programme

2.4.1 full wagons fly or gravity shunted

2 impacts in the same direction,

- 1st impact at 5-7 km/h
- 2nd impact at 8-9 km/h

followed, without any adjustment of the load fastenings, by

- counter-shock at 8-9 km/h.

The need to carry out a counter-shock must be assessed on the basis of the results of the two previous impacts with account taken, where appropriate, of the features of the goods carried and loading type.

2.4.2 full wagons not fly or gravity shunted (block trains)

2 impacts in the same direction, both at 3-4 km/h.

2.5 Measurement of impact speeds

- section measured preferably to be marked with primer caps,
- end of the section situated approximately 10 m from the buffers on the impact wagon,
- measurement by means of a chronometer and conversion using the «time/impact speed» concordance table and the tolerance ranges given under Point 5,
- in order to avoid involuntary impacts, i.e., at speeds outside the range of values given under Point 2.4, placing of a stop block to act as an emergency brake between the section measured and the impact wagon. Removal if the tolerance range is respected.

It is also possible to apply more sophisticated measurement techniques.

3 Analysis of results

After the impact programme has been carried out in accordance with Point 2.4

- operating safety must be preserved
- the fastenings, wagon gear and load must be free of damage.

In the case of loads likely to move about freely in the lengthwise direction across the wagon, the analysis will focus on the distance covered by the load during the second impact.

The result of the test must be recorded in accordance with Point 7 of Specimen 1.

4 Dangerous goods (RID)

For the purposes of impact tests, RID goods are assimilated to other transported goods. Other conditions which apply are set out in the RID under the section headed «Regulations relating to the various Classes».

5 Conversion table

Impact speed						
	section measured					
km/h	5 m	6 m	7 m	8 m	9 m	10 m
	second					
3	6.00	7.20	8.40	9.60	10.80	12.00
4	4.50	5.40	6.30	7.20	8.10	9.00
5	3.60	4.32	5.04	5.76	6.48	7.20
7	2.57	3.09	3.60	4.11	4.63	5.14
8	2.25	2.70	3.15	3.60	4.05	4.50
9	2.00	2.40	2.80	3.20	3.60	4.00

3.4 Wagons and engine used during tests

The impact wagon (8474 9853 0421) used in the tests was a bogie wagon with Category A 105 mm stroke buffers loaded with gravel to a total mass of 80 ton.



The impact wagon



The buffers on the impact wagon

The test wagon (3174 4955 0795) used for 18 of the 19 units was also a bogie wagon with Category A 105 mm stroke buffers.



The used test wagon 1



The buffers on the test wagon 1

A second test wagon (3385 4506 7484) was used for one unit, the mega-trailer from Ewals Cargo containing a truck cabin from Scania. This wagon was a Hupac-wagon T5 with buffers marked 150-IG-R2750.



The used test wagon 2



The buffers on the test wagon 2

The engine (T44 263) used in the tests was a diesel electrical engine belonging to Green Cargo.

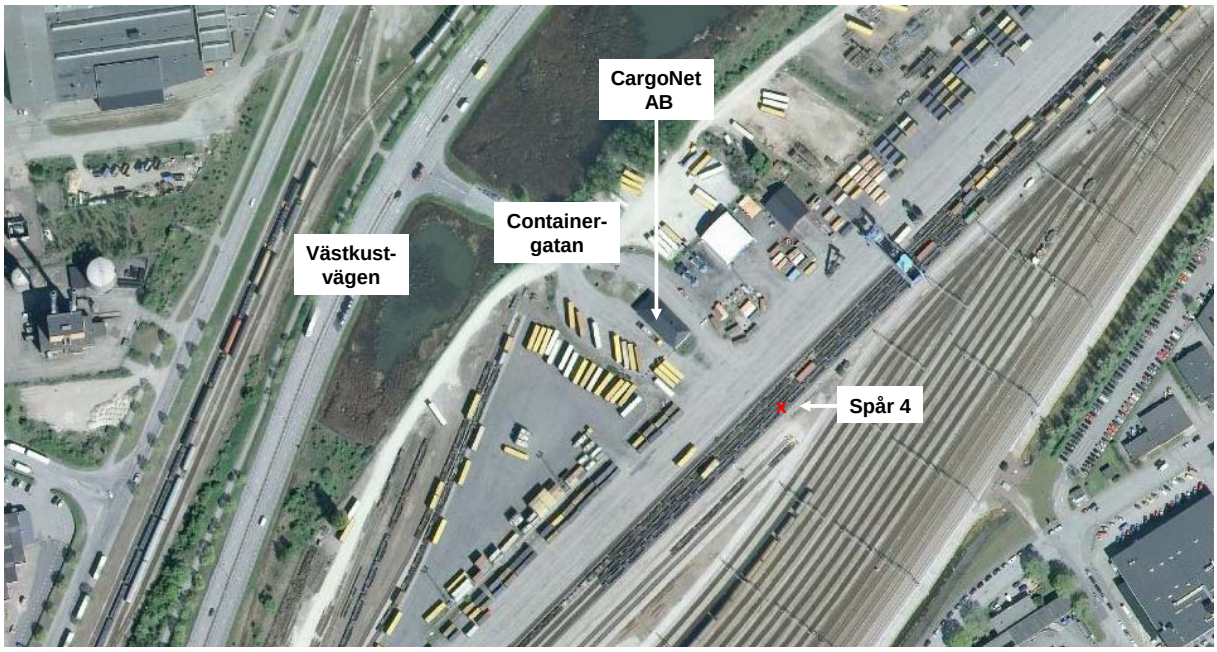




The used engine

3.5 Test conditions

The tests were carried out on track number 4 of the CargoNet AB Malmö Kombiterminal, see the map below.



The weather during the shunting tests was cloudy with sunny as well as rainy intervals and the temperature was about +13°C. A gale was blowing during Thursday but on Friday the wind had calmed down.

The speed of the test wagons was measured by taking the time with a stopwatch between two positions, a distance of 8 meters marked by chalk and with primer caps. In order to avoid impacts of speeds outside the range a stop block was put on the track to act as an emergency brake.



The distance was marked with primer caps



Christer Nilsson, GreenCargo, measured the time with a stopwatch and looked after the stop block

Before the tests a project meeting was held in a trailer supplied by DB Schenker and it was placed beside the test track, track number 4.

This trailer was also used for recreation and coffee room during the test period.



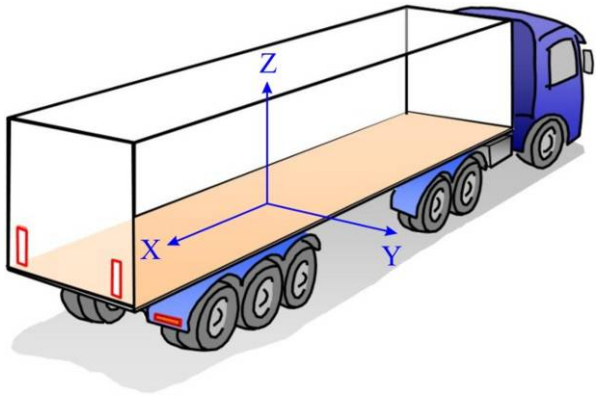

The trailer supplied by DB Schenker worked as a conference room as well as recreation and coffee room

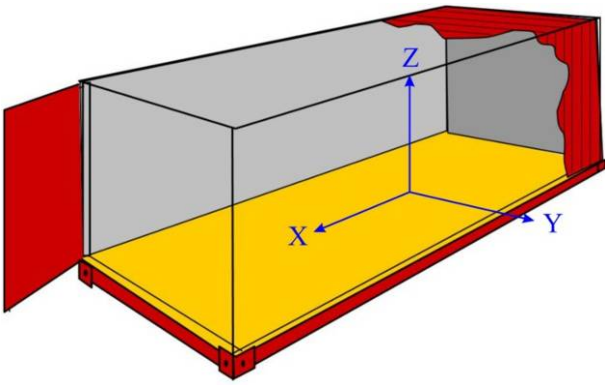
From test number 13 it was found that the air pressure of the suspension system in all trailers was to be released before the shunting tests. It is mentioned for each test if the air in the air suspensions was released or if it was unknown.

3.6 Shock recording equipment

During the measurements two accelerometers where mounted on the floor of the loaded cargo transport units. The acceleration data along three axes were recorded continuously throughout the measurement campaign. The equipment used is described below.

The definition of the axis along which accelerations were recorded, are illustrated in the figures below.





X *LONGITUDINALLY* *Positive direction rearwards, towards the doors*

Y *SIDEWAYS* *positive direction to the right*

Z *VERTICALLY* *Positive direction upwards*

The values of the accelerations that are presented in this report are taken in relation to the state of equilibrium at rest, i.e. the static gravity accelerations has been subtracted from the Z-axis.
Apart from accelerations, the position of the cargo transport units was recorded with a GPS receiver approximately every second, which allows the velocity of the unit to be determined.

3.6.1 The measurement equipment

The computer and most of the measurement equipment used along with its power supply where placed in a wooden, purpose built box. The acceleration sensors where mounted on the units floors with screws and the GPS receiver where fastened on the outside of the unit by a magnet.

The major components of the equipment used are described below. The accelerometers with auxiliary equipment were rented from KTH in Stockholm.

Portable lap top

Model: Acer 5200A
Storage capacity: 14 GB



Data acquisition board

One piece of data acquisition board, model *DataAquisition DT9816*, with the following characteristics:

- USB connection
- 6 analogue channels
- 12 bits sampling
- Simultaneous sampling of analogue channels
- Range: +/- 5 volt



The data points where collected and recorded with a purpose designed MATLAB script at a sampling frequency of 1500 Hz.

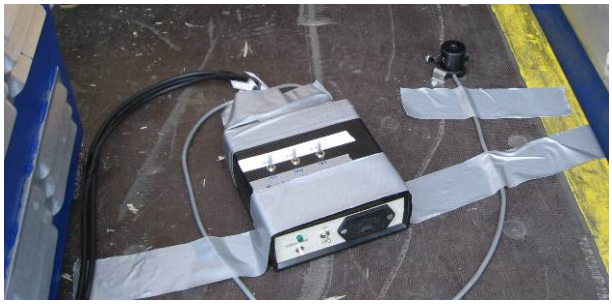
Acceleration sensors



Amount: 2 pcs
Type: BURR Brown, 3-axliga
Range: appr. ± 50 m/s^2
Sensitivity: appr. 25 mV / m/s^2

The sensors were screwed to the floor of the units at the rear end, one at each side.

Power supply for the sensors



The sensors were driven by a 9 volt battery.

Low pass filter

- 4 channels with break frequency 370 Hz.
- 2 channels with break frequency 500 Hz.

Battery



Voltage: 12 Volt
Capacity: 17 Ah

The battery was used to power the computer and the low pass filters.

GPS receiver

The GPS receiver was placed outside the cargo transport units and connected to the computer which registered the position of the unit every second.




One of the accelerometers inside one of the units



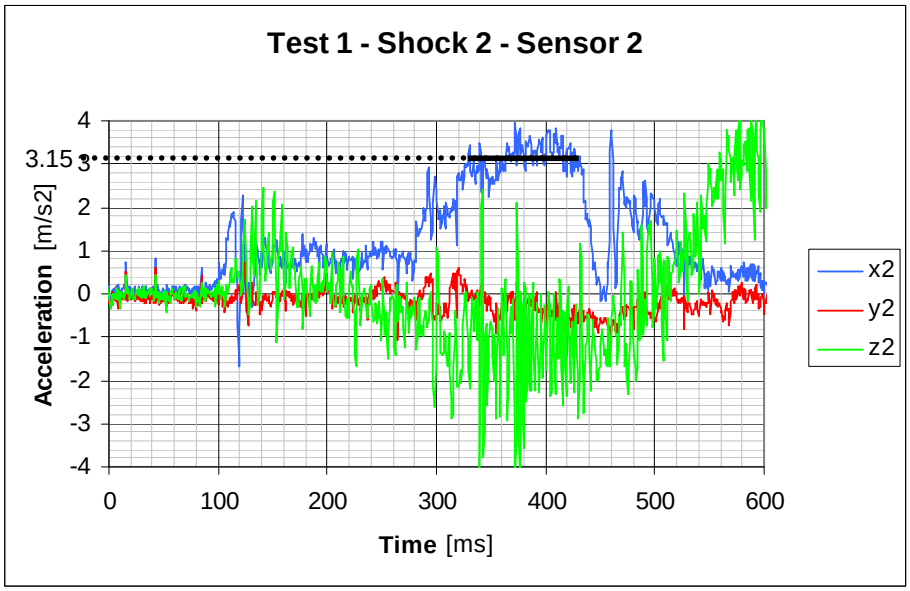

The accelerometers were fixed to the floor of the cargo transport units

Acceleration data

The measured accelerations are presented in diagrams with the accelerations and time in m/s^2 and ms according to the diagram below. The given acceleration data in the tables shown in the descriptions for the different tests below are the mean value for the actual shock during 1/10 of a second (100 ms). This because of the time for which the forces, to be taken into account according to the UIC Loading Guidelines, are to be exerted approximate 1/10 second.

The mean acceleration values given in the tables are presented in m/s^2 as well as in g. The data for each measured shock is inserted in an Excel file and the mean value is calculated on the basis of respective Excel file.

The mean acceleration value for shock 2 and sensor 2 in test 1 in the diagram below is calculated to be 3.15 m/s^2 (0.32 g) and is estimated to be between 330 – 430 ms.



The acceleration diagram for shock and sensor 2 in test 1

3.7 Comparison between cargo securing regulations

The objective of the CombiSec project is to facilitate the cargo securing for combined road/railway transports. Below a short summary of the differences in the regulations for road and rail is presented.

A comparison has been made for the following regulations:

- UIC Loading Guidelines, railway transport (combined transport)
- IMO method, road transport
- CEN method (EN 12195-1), road transport
- CEN method (EN 12195-1), railway transport (combined transport)

The accelerations below expressed in *g* are to be used when dimensioning cargo securing arrangements to prevent cargo from **sliding** forward, backward and sideways during road and railway transport. For **tilting** somewhat other accelerations are to be used.

TRANSPORT	Forward	Backward	Simul-taneously downwards	Sideways	Simul-taneously downwards
Railway (combi), UIC Loading Guidelines	1.0	1.0	0.7	0.5	0.7
Road, IMO method	1.0	0.5	1.0	0.5	1.0
Road, EN 12195-1	1.0/0.8	0.5	1.0	0.5	1.0
Railway (combi), EN 12195-1	1.0 *	1.0 *	1.0	0.5	0.7

** The acceleration in longitudinal direction used for tilting is 0.6.*

As can be seen in the table above the acceleration backward for road transport according to the IMO and CEN method is 0.5 *g* and the corresponding acceleration according to the UIC Loading Guidelines and the CEN method for rail is 1.0 *g*. This variation makes a big different for the dimensioning of the cargo securing in backward direction.

The downward force, acting simultaneously with the sideways forces according to the CEN method for rail, means that the pressure from the cargo against the surface is smaller during rail transport than during road transport. This fact makes a top-over lashing (indirect fastening) less efficient during railway transport.

The regulations also differ from each other in other aspects when calculating required number of top-over lashings. The cargo securing principles according to UIC Loading Guidelines are based on experiences and practical tests only. For the IMO and CEN 12195-1 (2010) methods the formulas in section 3.4 above are used.

3.8 Results of the shunting tests

Below the result of the shunting tests with the 19 units is shown.

3.8.1 Test 1 – Packaged square-sawn timber from Södra Timber in a trailer

The first test was with square-sawn timber from Södra Timber in a trailer from van Dieren. This unit arrived from Långasjö outside Emmaboda in Småland by road and there had been no movement among the timber during this transport.

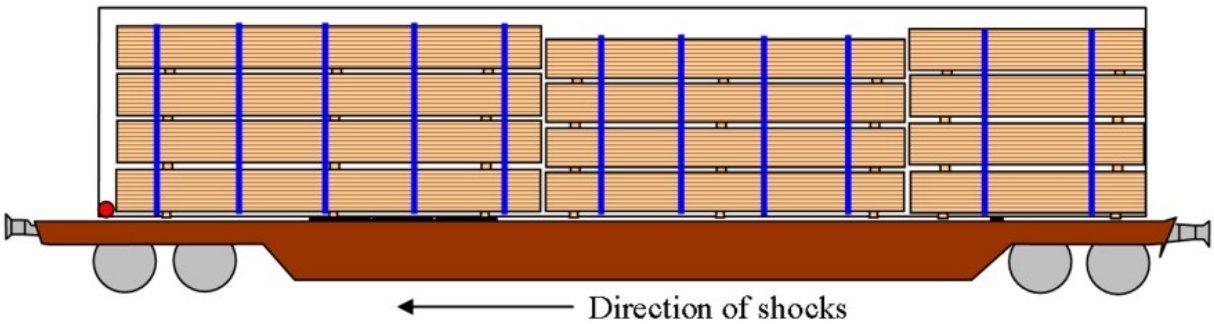
The following information is available:

Unit:	Trailer, curtainsided
Unit number:	OJ-74-DX
State of the floor:	Plyfa, dry and quite clean
Net weight:	24 100 kg
Load pattern:	28 packages loaded in 4 layers and 3 - 4 sections, battens between each layer
Friction:	0.35 (according to tests carried out in Höganäs 2007-04-10 -- 12)
Securing:	11 top-over lashings, LC 1 600 kg, S_{TF} 400 kg and 3 centre stanchions
Air suspensions:	It was not registered if the air was released or not





The unit loaded with timber packages



Loading and securing of the square-sawn timber. Note that the other row consists of 4 sections

Required cargo securing

The timber was blocked in forward direction and sideways by the centre stanchions. According to calculations the static friction is 0.35 and the 11 top-over lashings will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by the headboard		
Backward		0.48	0.43	0.43
Sideways		Blocked by centre stanchions		

Extract of UIC Loading Guidelines:

Loading guidelines 2.2.2

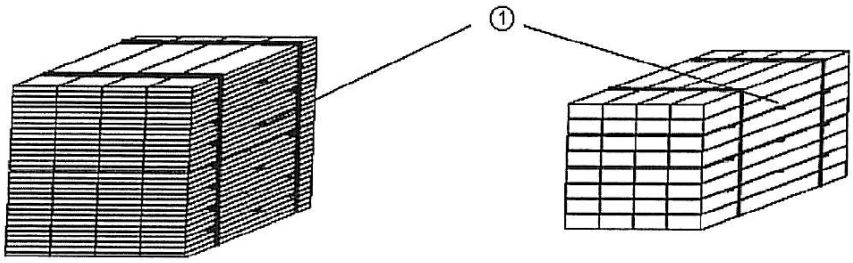
Square-sawn timber, trimmed and bound in packages

Single wagons and groups of wagons	Wagons in block trains and combined transport Wagons with long-stroke absorbers

Type of goods

① Square-sawn timber, trimmed and bound into compact packages[1] of rectangular cross-section and, where appropriate, intermediate timbers inserted, with or without packaging. When intermediate timbers are bound into the packages their maximum thickness shall be 1.5 cm and they shall not be inserted between every layer.

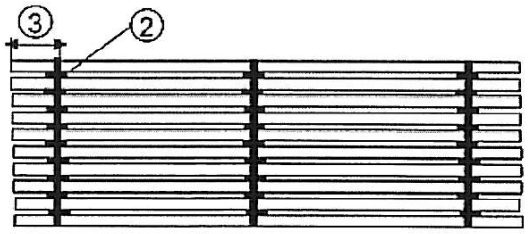
Depending on the thickness of the square-sawn timbers the intermediate timbers shall be bound into every second layer at most.



Packages up to 4.5 m long shall be equipped with 2 fastenings and with one additional fastening for every additional 1.5 m length or partial length.

② When drying timbers are used inside packages at least 3 fastenings shall be used, with one additional fastening for every additional 1.5 m length/partial length. The fastenings shall be bound over the drying timbers or in the immediate vicinity.

③ External fastenings shall be positioned a minimum of 30 cm from package ends.



The breaking strength of fastenings used for tangent traction for rough-sawn and planed timber shall be 700 daN and 1000 daN respectively, where the the fastening point in case of use of PET straps must ensure at least 80 % of the breaking strength for tangent traction. Minimum pre-stressed force: 300 daN.
Steel wire and PP straps may not be used.

Wagons

a) rough-sawn timber

- Flat wagons with stanchions and wooden floor or integrated bolsters or friction materials, with or without sides, with or without mechanically sheeted hood
- Wagons with sliding walls or metal roofs

b) planed timber

Flat wagons with high end walls, stanchions and wooden floors Wagons with sliding walls or metal roofs	Flat wagons with stanchions and wooden floors, with or without sides, with or without mechanically sheeted hoods

[1] Packages that are not compactly bound should only be carried in wagons with end walls or mechanically sheeted hoods

01.04.2009

Method of loading

Timber packages should be loaded side by side and one behind another. Packages with the same dimensions should where possible be arranged side by side and one on top of another or, where appropriate, individual packages may be placed in the middle of the top tier on underlying packages of equal height. Packages of unequal length should be loaded as compactly as possible.

Stacks of planed timber must be loaded without gaps and must not project lengthways beyond the end walls

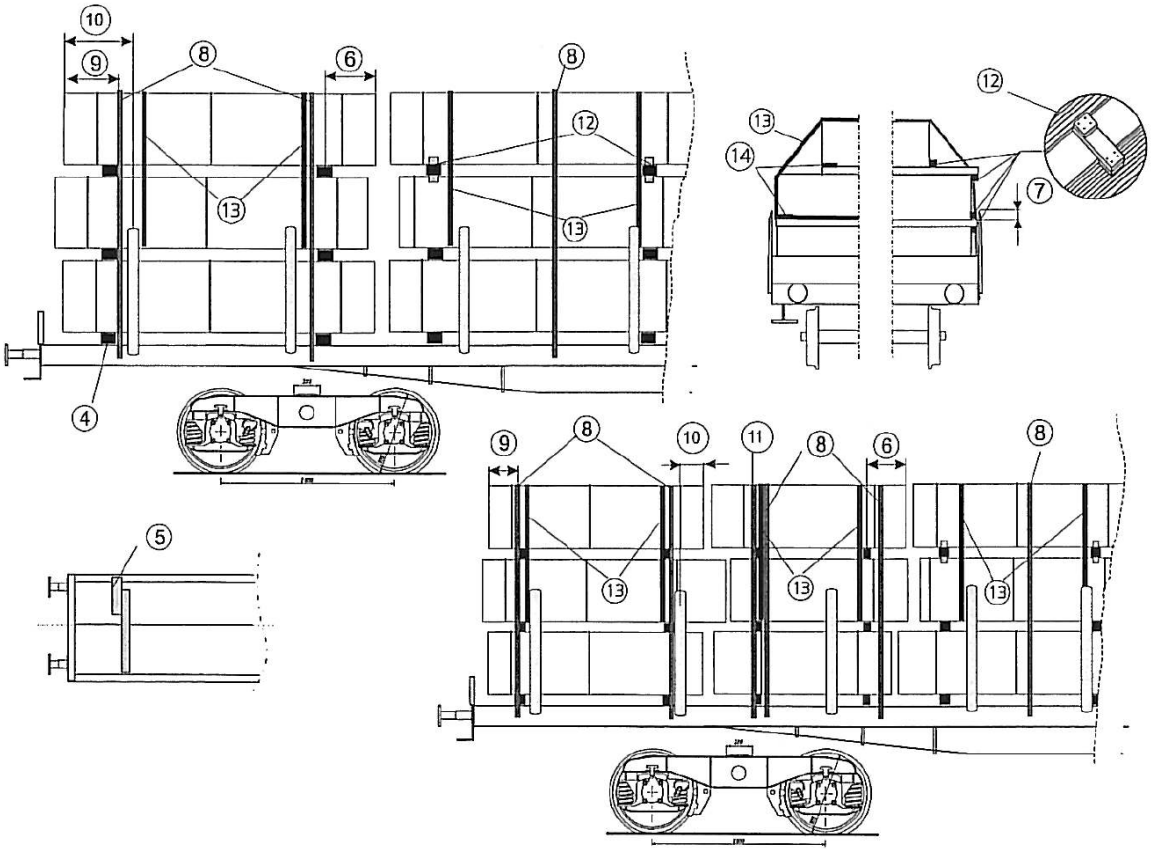
Loading

④ – Packages should rest on bolsters, timbers or intermediate timbers of one piece and spanning the full width of the wagon, even when using bound-in timbers.

⑤ – Timbers/intermediate timbers - of rectangular cross-section and lying on their broader face[1] - may be made up of several pieces of the same thickness, overlapping at the sides; where this is the case, however, the number of pieces of wood must be no greater than the number of packages lying side by side

– Timbers/intermediate timbers made up of several superimposed layers must be properly bound together and span the whole width of the wagon at once.

⑥ Timbers/intermediate timbers between packages should be vertically aligned where possible and placed around 50 cm from the packages ends



[1] Timbers of square cross-section (at least 6 x 6 cm) are accepted provided all the edges of the wood used are sharp, except in case of bound-in timbers.

01.04.2009

Securing

Packages of unequal length should be secured down each longitudinal side of the wagon as sh⑦ in ⑬ to

Stacks should be

⑦ - secured by the sides[3)] and/or stanchions[3)] or by the end walls and the sliding walls / hoods[1] effective height of the sides or stanchions must be at least 10 cm

⑧ - rough-sawn timber: secured by at least 2 fastenings (minimum breaking strength 1,000 daN)
or
- by one indirect fastening with a tensioning device placed in the middle of the package (breaking strength min. 4,000 daN)
- planed timber: secured by at least 2 indirect fastenings (minimum breaking strength 4,000 daN)

⑨ Indirect fastenings should be made at least 30 cm from the end of stacks and pulled tight

⑩ When secured by only two stanchions the packages should extend lengthways beyond the stanchion centres by at least

30 cm 20 cm

⑪ - in the absence of a pair of stanchions or if ® is not complied with, secured by an extra indirect fastening.

Individual packages on the upper tier and adjacent packages if © is not complied with should be

⑫ – secured on each longitudinal side using two scotches nailed on top and bottom with one nail (Ø 5 mm) per 2000 kg of load and at least 2 per scotch or

⑬ – bound twice () with the tiers arranged below and secured by the stanchions, breaking strength of fastening, including fastening point, at least 700 daN in tangent traction, minimum pre-stressed force 300 daN. Metal wires, steel strips (on open wagons) and PP straps may not be used.

In case of use of smooth timbers or intermediate timbers and/or packaging ($\mu < 0.3$) packages which are placed on such timbers or intermediate timbers shall be additionally secured by friction inserts placed at the ends of the packages.. 14) (Approx. dimensions: 150 x 80 x min. 3mm, $\mu = 0.7$)

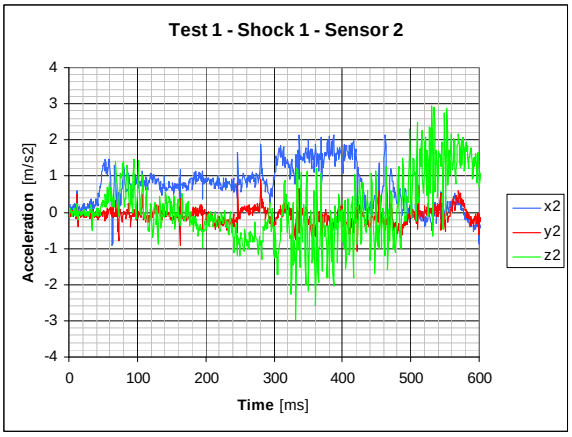
Additional indications

Distribution of load, loading gauge, indirect fastening and partition wall loadings see sheets 0.1,0.2, 0.6, 0.7 and 100.1.

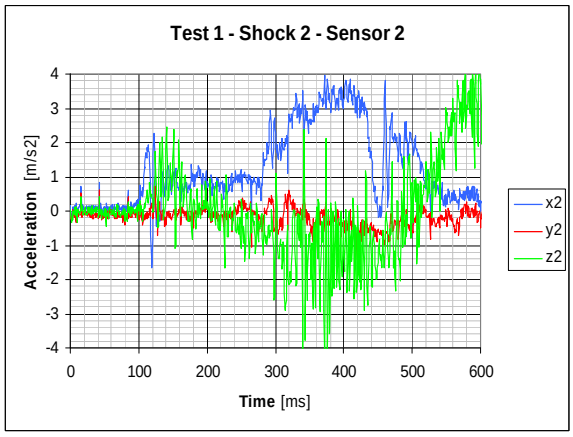
The square-sawn timber should be “secured by the sides and/or stanchions …” which it’s not. Thus the securing in this unit is not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch of loading and securing above. The equipment produced the following results:



Measured accelerations in m/s^2 during shock 1



Measured accelerations in m/s^2 during shock 2

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of timber** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	3.57	1.53	0.15	None	None
2	4.32	3.15	0.32	None	None

There was no movement among the timber during none of the shocks.





There was no measured dislocation of the timber

3.8.2 Test 2 – Paper reels from Billerud in a container

Test number 2 was with paper reels from Billerud in a container from Maersk. This unit arrived by combined transport train from the Port of Norrköping and with help from Green Cargo. Minor movements were registered among the stacks after the transport to Malmö which probably was the cause of slackened lashings in the rear end of the container.

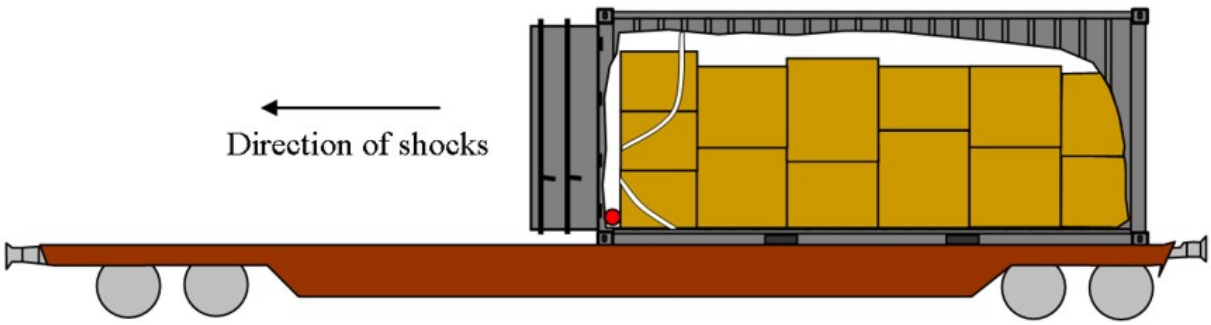
The following information is available:

Unit:	Container
Unit number:	MSKU 541916-6
State of the floor:	Wooden floor, dry and clean
Net weight:	15 562 kg
Load pattern:	26 reels in 2 rows and 2 - 3 layers
Friction:	0.44 (according to tests carried out in Skärblacka 1997-10-20)
Securing:	No free space sideways. Secured by two slack “one way lashings” in a cross to prevent the reels from moving rearwards.





The container loaded with paper reels from Billerud



Approximate load pattern for the paper reels from Billerud

Required cargo securing

The paper reels were blocked both forward and sideways. According to calculations the static friction is 0.44 and the arrangement will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by the container end wall		
Backward		0.40	0.40	0.40
Sideways		Blocked by the container side walls		

Extract from UIC Loading Guidelines:

Rolls of paper loaded upright ("eye-to-sky")

Single wagons and groups of wagons | Wagons in block trains and combined transport
Wagons with long-stroke shock absorbers

Type of goods

Rolls of paper

Wagons

Wagons with sliding walls and fixed end walls (H..., Li..., Si...)

7/10 | 6/10

of roll height.

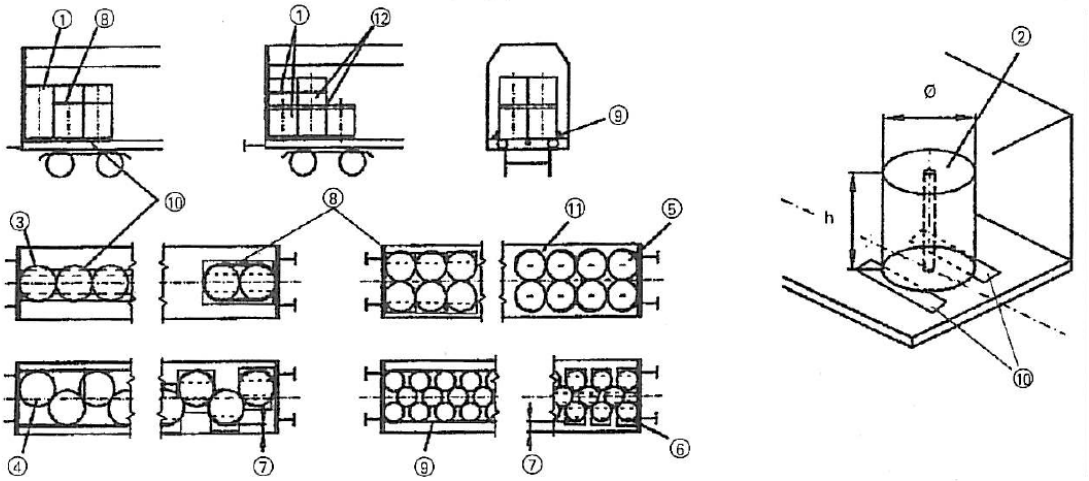
– rolls should be arranged as follows in the wagon

③ • in a single line one behind the other (roll axis placed along the wagon longitudinal centreline),
• in two staggered lines (symmetrical about the wagon longitudinal centreline),
④ • in two lines, with the rolls one behind another,
⑤ • in three staggered lines (in groups of 5 rolls),

⑥ – upright and in contact with the end walls, with space left in the middle of the wagon

⑦ – if arranged according to ④ or ⑥, rolls should be formed into fixed groups crossways in the wagon or else the load should be at least 10 cm clear of the sliding walls.

– there should be no contact with the sloping part of the roof.



Securing

– lengthways in the wagon

⑧ by the end walls, able to slide if appropriate. Rolls whose diameter is less than

7/10 | 6/10

of their height should be bound together and prevented from moving.
Breaking strength of bindings: at least 1000 daN.

– crossways in the wagon

⑨ • by guide-rails[1] that are an integral part of the wagon or are fixed, for example, to existing battens **or**
• by wooden guide-pieces approx. 5 cm high. Number of nails per side : 1 nail/2000 kg with at least 2 nails per guide-piece **or**
• by cradles resting against the sliding walls (corrugated cardboard, several layers thick, wooden laths) to fill up the space across the wagon **or**

⑩ using friction-enhancing inserts, 2 parallel strips laid lengthways under each roll, with a μ value of at least 0.7 and a minimum width of 15 cm. The friction coefficient, resistance to deformation and average resistance to dirt shall be guaranteed by the manufacturer **or**

⑪ sliding walls: if loaded as shown in ⑤ , loading without friction-enhancing inserts is possible providing the lateral clearance to the sliding wall is ≤ 10 cm and the height of the paper rolls is no greater than the vertical part of the sliding wall.

⑫ If the rolls are stacked, friction inserts should be placed between each tier.

Additional indications
Distribution of load: see sheet 0.1

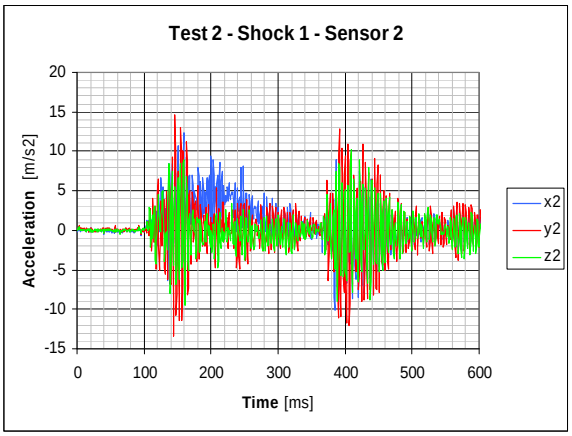
1) For example, profiled tubes of height ≥ 50 mm; the upper edge facing the goods should be rounded off to avoid causing damage.

1.1.2004

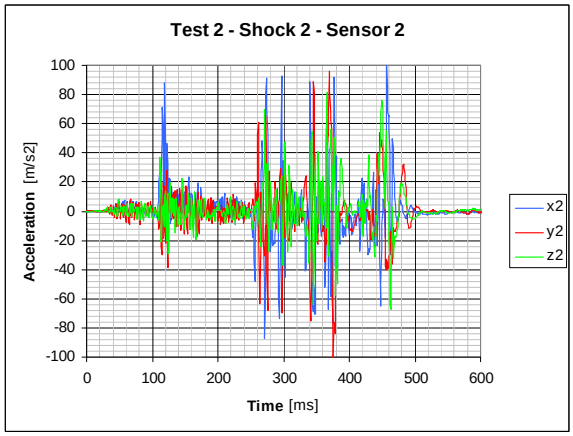
The paper reels should be loaded in contact with the end walls, with space left in the middle of the unit. This is not an acceptable stowage of paper reels in containers and the loading and securing of the reels in this unit is not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch of approximate load pattern above. The equipment produced the following results:



Measured accelerations in m/s2 during shock 1



Measured accelerations in m/s2 during shock 2

Please note that the two diagrams above are presented in different scales.

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of reels** [mm] *Distance moved during shock*	*Accumulated moved distance*
1 *	3.92	3.25	0.33	20 - 30	20 - 30
2 **	5.35	(8.52)	(0.87)	150	170 – 180

* *The lashings were tightened*
** *The lashings broke and the accelerometers were hit by the reels*

The dislocations were of whole stacks and there was no movement between the reels during none of the shocks.
The second shock was performed with much too high speed. This caused large movements among the stacks of reels and the stacks were sliding all way to the accelerometers, which registered very large accelerations when they were hit by the reels. As can be seen from the

right diagram above accelerations up to 100 m/s^2 were measured. The accelerometers broke down and could not be used for some of the coming tests until they were repaired.

The reels should not have moved during the first chock as the horizontal acceleration was lower than the static friction. The reason for the movement could be the vertical accelerations (vibrations) that have decreased the friction effect of the non top-over lashed reels.



The lashings were tightened during the first shock



The lashings broke during the second shock





The movement of the stacks of reels during the second shock damaged the accelerometers

On the return voyage of the paper reels from Billerud to Norrköping there was an incident. Information about this can be found in section 9, “Incident on return voyage”.

3.8.3 Test 3 – Paper reels from Korsnäs in a trailer

The third test was with paper reels from Korsnäs in a trailer from LKW Walter. This unit arrived from Gävle by road and combined transport train with help from CargoNet. There had been no movement among the reels during this transport.

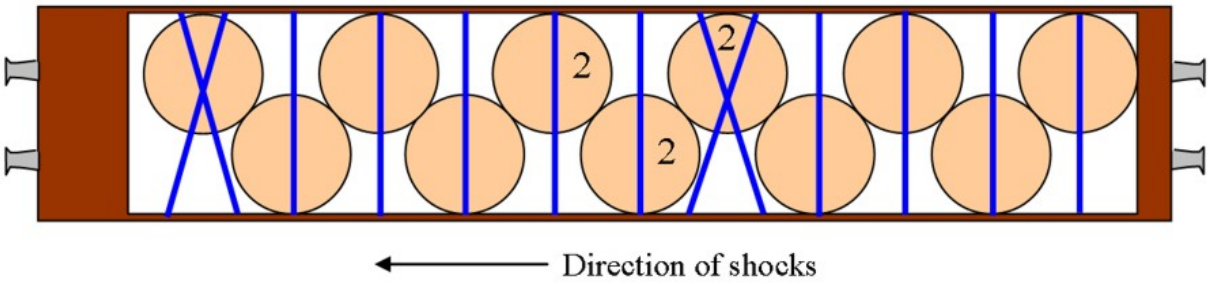
The following information is available:

Unit:	Trailer, curtainsided
Unit number:	HRDKU752

State of the floor:	Plyfa, dry and clean
Net weight:	26 476 kg
Dimension:	Diameter: 1500 mm, Width: 1500 mm
Load pattern:	14 reels in 11 sections in zig-zag, double layers for the three sections 5, 6 and 7
Friction:	0.7 (according to internal tests within Korsnäs)
Securing:	1 top-over lashing per section, 2 top-over lashings in a cross on the last section and on the forward double stacked section
Air suspensions:	It was not registered if the air was released or not



The trailer loaded with paper reels from Korsnäs



Loading and securing of the paper reels from Korsnäs seen from above

Required cargo securing

The paper reels were blocked in forward direction. According to calculations the static friction is 0.7 and the 13 top-over lashings will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by the headboard		
Backward		0.93	0.85	0.85
Sideways		1.36	1.29	1.14

The instruction in UIC Loading Guidelines for rolls of paper loaded upright is inserted under test 2 above. The securing of the reels from Korsnäs is not in compliance with the UIC Loading Guidelines neither lengthways nor crossways in the trailer.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of reels** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	4.72	-	-	None	None
2	4.63	-	-	None	None

There was no movement among the reels during none of the shocks.

No acceleration data was measured in this unit due to the broken accelerometers.



There was no dislocation among the paper reels from Korsnäs during none of the shocks

3.8.4 Test 4 – Bags on pallets from Borealis in a trailer

Test number four was with bags on pallets from Borealis in a trailer from DSV. This unit arrived from Stenungsund by road and there was no movement among the pallets during this transport.

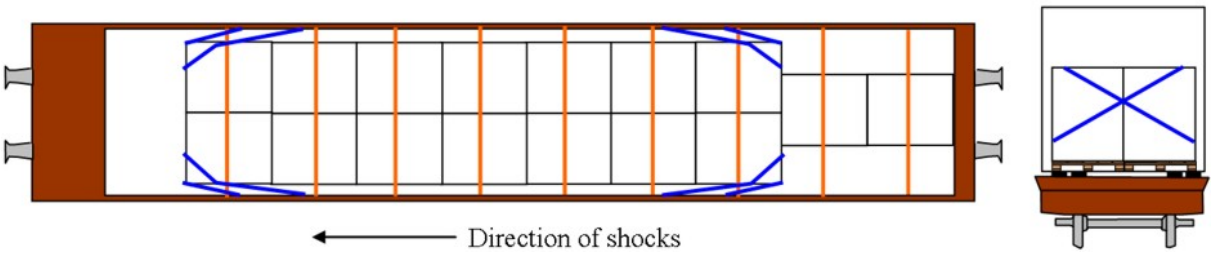
The following information is available:

Unit: Trailer

Unit number:	DSV 370850
State of the floor:	Plyfa, dry and clean
Net weight:	22 ton
Load pattern:	16 pallets in 9 sections; single pallets in the first two sections and two rows in the 7 rear sections
Friction:	0.5 (wood on plyfa)
Securing:	1 top-over lashing per section, 2 spring lashings on the first and last section of the double rows, LC 1 600 kg, S_{TF} 400 kg
Air suspensions:	It was not registered if the air was released or not



The trailer loaded with bags on pallets from Borealis



Loading and securing of the bags on pallets from Borealis seen from above and from behind

Required cargo securing

The two single pallets were blocked in forward direction. According to calculations the static friction is 0.5 and the 9 top-over lashings and the 2 spring lashings to prevent movement backwards will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not available according to below	Blocked by the headboard		
Backward		0.75	0.73	0.73
Sideways		0.65	0.59	0.45

Extract from UIC Loading Guidelines:

Formation of palletised load units

Type of goods

Cases, sacks, building materials, stone, slabs, paper, cardboard, casks, drums, products loaded on semi-pallets, fruit and vegetables in boxes or crates, etc.

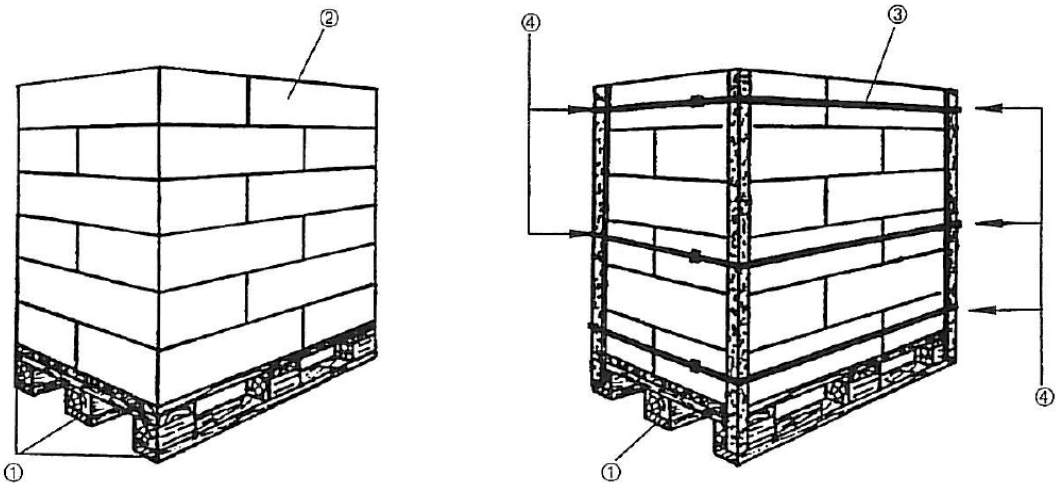
Loaded on

Flat pallets made of wood, plastic, pressboard, etc.

① – with feet / bearers designed and fastened to ensure they will not tip up or break off

Method of loading

② Goods should be arranged on the pallet in stable and compact manner, with sides flush with the pallet edges (avoid offset or projecting goods)
– in interlocking layers (e.g. crates)
– stacked in criss-cross formation (e.g. sacks)



Securing

Cohesion of load unit increased by

③ – using steel strip, textile or synthetic bands (breaking strength 700 daN minimum) to encircle the load vertically and/or horizontally

④ – horizontal encircling bands for easily displaced goods with edge protection bound to the load, one to be placed
- round the lower tier
- one around the middle and
- 1 one towards the top of the load unit

– the application of shrunk or stretched plastic sheeting of sufficient thickness (min 150 µm) is permitted (should also cover the pallet feet)

– use of
- inserts made from friction-enhancing material between individual layers or
- special adhesives or
- corner pieces.

1.7.2005

The instructions for palletised load units above only describe the securing of the cargo to the pallet. No instructions are available for securing of the pallets to the cargo transport unit.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	Speed	Acceleration		Measured dislocation of pallets [mm]	
	[km/h]	[m/s^2]	[g]	*Distance moved during shock*	*Accumulated moved distance*
1	4.10	-	-	None	None
2	4.59	-	-	None	None

There was no movement among the pallets after none of the shocks.

No acceleration data was measured in this test as the accelerations were still not repaired.



There was no measured dislocation among the cargo

3.8.5 Test 5 – Octabins from Borealis in a trailer

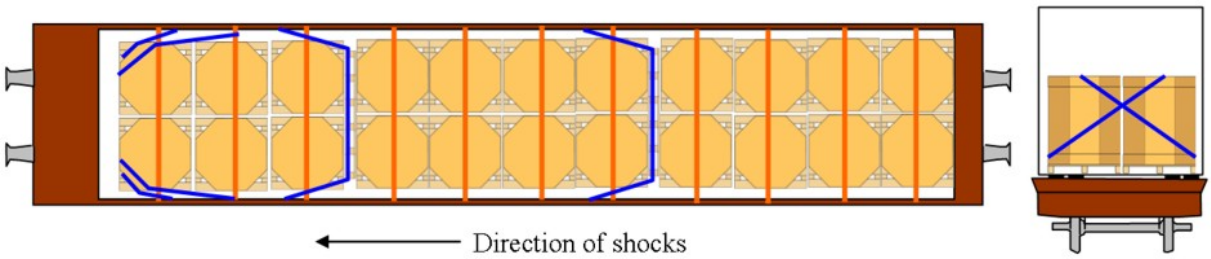
Test number five was with octabins from Borealis in a trailer from DSV. This unit arrived from Stenungsund by road and there was no movement among the octabins during the transport to Malmö.

The following information is available:

Unit:	Trailer, curtain sided
Unit number:	DFDS 8022
State of the floor:	Plyfa, dry and clean
Net weight:	22 ton
Load pattern:	22 octabins in two rows and 11 sections
Friction:	0.5 (wood on plyfa)
Securing:	1 top-over lashing per section, 2 spring lashings on the last section to prevent movement backwards, empty pallets and 1 spring lashing after section 4 and 8 to prevent movement in forward direction, LC 1 600 kg, S_{TF} 400 kg
Air suspensions:	It was not registered if the air was released or not



The trailer loaded with octabins from Borealis



Loading and securing of the octabins from Borealis seen from above and from behind

Required cargo securing

The octabins were blocked in forward direction. According to calculations the static friction is 0.5 and the 11 top-over lashings plus the two spring lashings preventing movement backwards will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not available, see below	Blocked by the headboard		
Backward		0.78	0.76	0.76
Sideways		0.70	0.63	0.49

No instructions for securing of octabins are available in UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to 2 shocks. Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed**	**Acceleration**		**Measured dislocation of octabins** [mm]	
	[km/h]	[m/s^2]	[g]	*Distance moved during shock*	*Accumulated moved distance*
1	4.07	-	-	None	None
2	5.01	-	-	None	None

There was no movement among the octabins on pallets during none of the shocks.

No acceleration data was measured in this test.



There was no measured dislocation among the cargo

3.8.6 Test 6 – Liner reels from Peterson Linerboard in a trailer

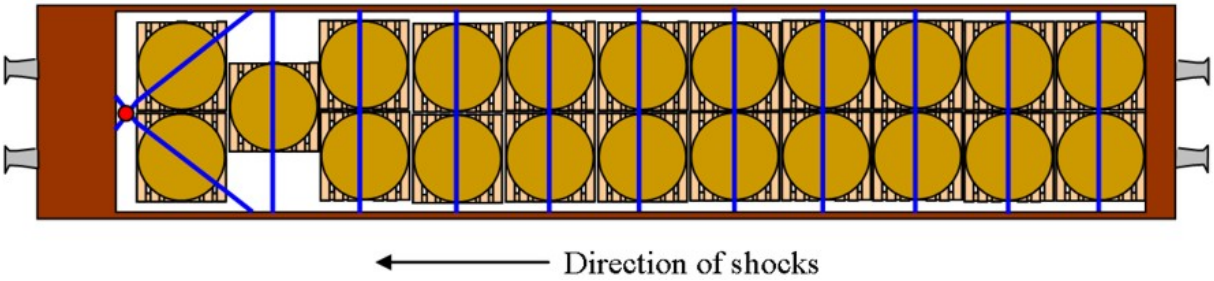
The sixth test was with liner reels from Peterson Linerboard in a trailer from DHL. This unit arrived from Trondheim by road and combined transport train with help from CargoNet. There had been no movement among the reels during this transport. The reels were shrink filmed and placed on pallets.

The following information is available:

Unit:	Trailer, cover/stake type with drop sides
Unit number:	DHL 1211
State of the floor:	Plyfa, dry and quite clean
Net weight:	24 716 kg
Dimension:	Diameter: 1200 mm, Width: 1500 mm
Load pattern:	21 pallets with liner reels in 6 or 7 layers, 11 sections with a single pallet in the second last section
Friction:	0.3 (shrink filmed reels on wooden pallets)
Securing:	1 top-over lashing per section, 2 top-over lashings in a cross on the last section
Air suspensions:	It was not registered if the air was released or not



The trailer loaded with liner reels from Peterson Linerboard



Loading and securing of the liner reels from Peterson Linerboard seen from above

Required cargo securing

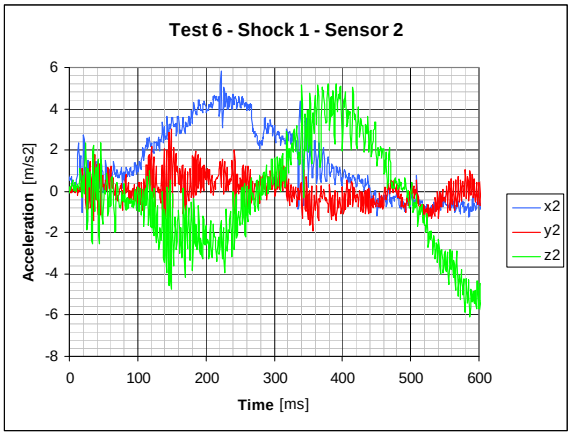
The liner reels were blocked in forward direction. According to calculations the static friction is 0.3 and the 12 top-over lashings will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not available, see below	Blocked by the headboard		
Backward		0.42	0.38	0.38
Sideways		0.39	0.36	0.27

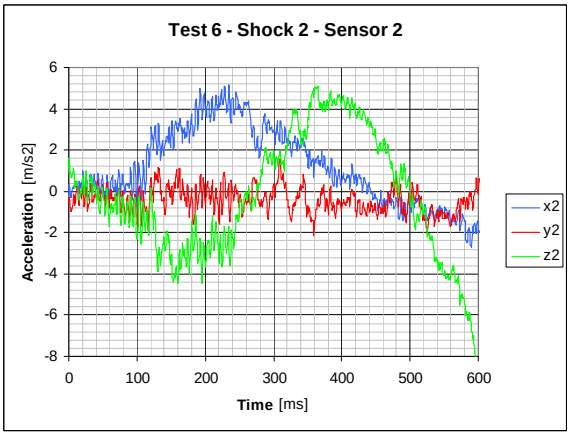
Instructions for securing of paper reels loaded on pallets are not available in the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The accelerometers were now back in use and the position of the recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s^2 during shock 1



Measured accelerations in m/s^2 during shock 2

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of reels** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	4.43	4.12	0.42	None	None
2	4.64	3.90	0.40	None	None

There was no movement among the liner reels during none of the shocks.





There was no measured dislocation among the liner reels from Peterson Linerboard

3.8.7 Test 7 – Mixed cargo from IKEA in a trailer

Test number 7 was with mixed cargo from IKEA in a trailer from Nor-Cargo. This unit arrived from Älmhult in Småland by road. The cardboard boxes in the rear end of the trailer seemed to have moved a bit on the pallets during the road transport to Malmö.

The following information is available:

Unit:	XL-trailer
Unit number:	OY7652
State of the floor:	Plyfa, dry and a little gravelly
Net weight:	11 490 kg
Load pattern:	72 pallets of mixed cargo (carpets, plates, cardboard boxes etc); 50 EU pallets, 6 IKEA-pallets and 16 ½ pallets loaded in several sections
Friction:	0.5 (wooden pallets on plyfa and use of friction boards)
Securing:	No lashings were used in this unit. The cargo was stowed tightly against the headboard and backwards and from side to side. There was 7 - 8 cm free space between the rear section of pallets and the doors.
Air suspensions:	It was not registered if the air was released or not




The unit loaded with mixed cargo from IKEA




The cardboard boxes had moved a bit on the pallets during the transport to Malmö

Required cargo securing

The mixed cargo was blocked in all directions.

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not available, see below	Blocked by the headboard		
Backward		Blocked by the doors of the trailer		
Sideways		Blocked by the sides in the XL-trailer		

There are no instructions for mixed cargo available in the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of pallets** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	4.61	-	-	5	5
2	4.43	-	-	50	55

During the first shock there were movements between the pallets and the plyfa floor of ½ cm and very small movements between the cardboard boxes. During the second shock there were movements of approximately 5 cm between all layers in the rear section and the cargo moved rearwards against the doors.





The pallets as well as the cardboard boxes on the pallets moved against the doors during the second shock

Since there was no free space in the trailer the accelerometers were not used during this test.

3.8.8 Test 8 – Laying concrete elements from Betong o Smide on an open trailer

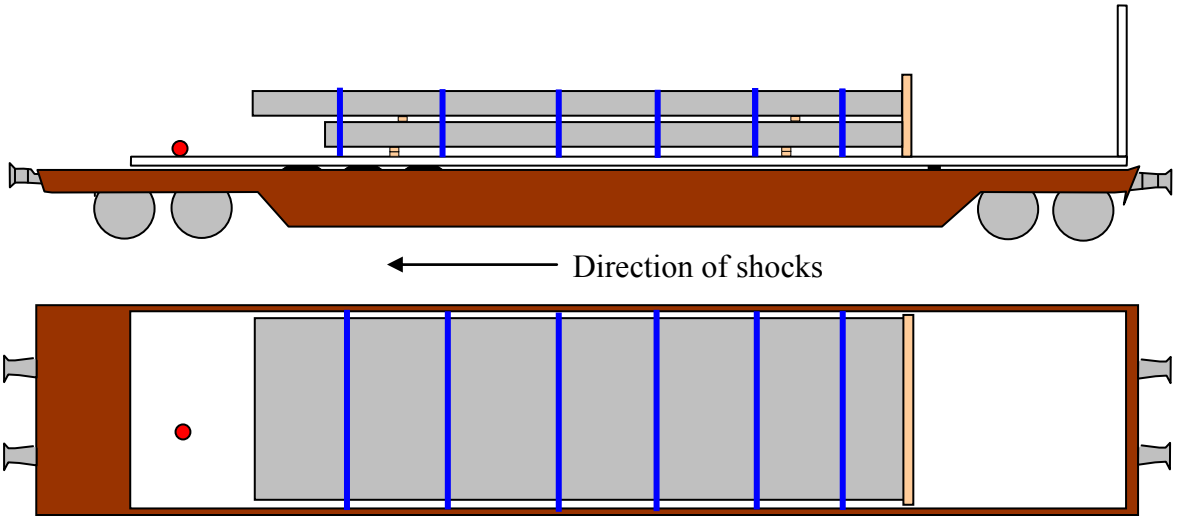
Test number 8 was with lying concrete elements from Betong o Smide i Trelleborg AB on an open trailer from K.E. Palms Åkeri. This unit arrived from Trelleborg by road and there had been no movement during this transport.

The following information is available:

Unit:	Open trailer
Unit number:	WXP 111
State of the floor:	Plyfa, dry and clean
Net weight:	18 730 kg
Load pattern:	Two lying concrete elements in two layers; the lower element weighed 8 870 kg and the upper 9 860 kg
Friction:	0.5 (wooden cross bars on plyfa)
Securing:	Blocking in forward direction by a constructed headboard, 6 top-over lashings with LC 1 600 kg, S_{TF} 400 kg
Air suspensions:	It was not registered if the air was released or not




The trailer loaded with lying concrete elements from Betong o Smide



Loading and securing of the lying elements from Betong o Smide seen from the side and from above

Required cargo securing

The elements were blocked in forward direction. According to calculations the static friction is 0.5 and the securing arrangement will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by a constructed headboard		
Backward		0.63	0.57	0.57
Sideways		0.63	0.57	0.43

Extract from UIC Loading Guidelines:

Loading guidelines 6.1.1

Blocks of stone (worked)

Single wagons and groups of wagons	Wagons in block trains and combined transport

Type of goods

Blocks of stone (worked)

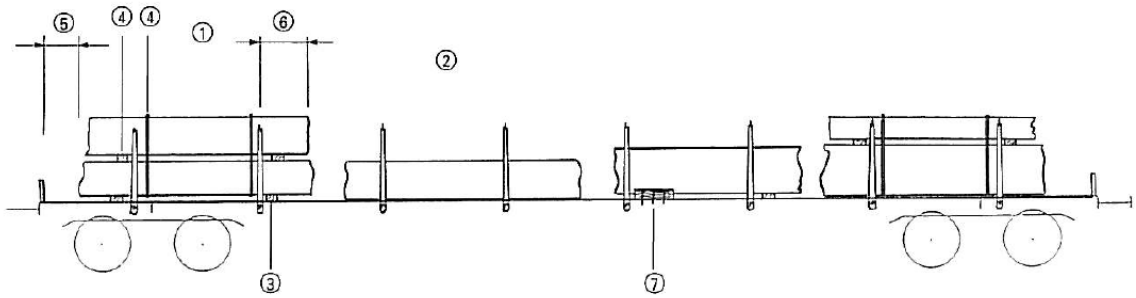
Wagons

Wagons with walls, sides or stanchions and wooden floor (E..., K..., L..., R..., S...)

Method of loading

① Blocks should be loaded in one or two tiers, lying flat, and wherever possible spread over the whole loading surface, with or without intermediate space.
② – with their broadest surface to the wagon floor or
③ – lying in a stable position on softwood timbers (1 to 4 cm thick).
④ Stacked blocks of stone should be separated by cross-timbers, plaited straw or thick ropes/cables and bound together at least twice into load units (breaking strength of fastenings at least 14 kN).
⑤ Minimum clearance

smooth bearing surface	50 cm	0 cm
rough bearing surface	30 cm	0 cm



Securing

Blocks should be secured by the wagon walls, sides or at least 2 stanchions.

⑥ – when secured by only 2 stanchions, blocks should extend lengthways beyond the stanchion centre by at least

(smooth bearing surface)	50 cm	30 cm
(rough bearing surface)	30 cm	20 cm

⑦ – by guide-pieces when ⑥ is not complied with or when the blocks of stone are more than 10 cm away from the walls, sides or stanchions
- guide-pieces should be at least 5 cm thick with an effective height of at least 3 cm
- total number of nails of 5 mm diameter along each side: 1 nail / 1,500 kg, and at least 2 nails per guide-piece.

Blocks [1] which are not directly secured laterally by the wagon walls, sides or stanchions must be laterally secured with guide-pieces.

Additional indications

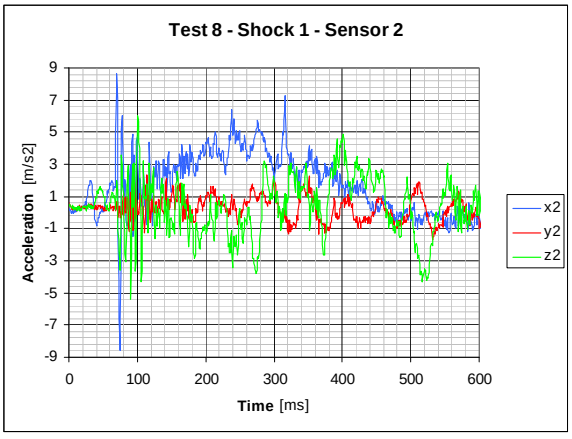
Distribution of load: see sheet 0.1

1) Except blocks with rough bearing surface

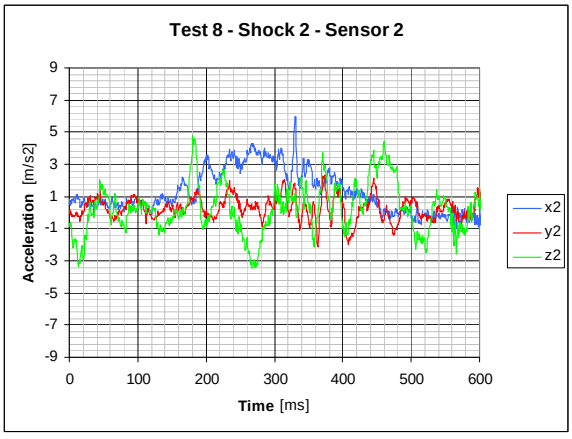
The securing of the lying elements is not in compliance with the UIC Loading Guidelines. The elements should be secured by the wagon walls, sides or at least 2 stanchions, which they were not.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s² during shock 1



Measured accelerations in m/s² during shock 2

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed**	**Acceleration**		**Measured dislocation of elements** [mm]	
	[km/h]	[m/s^2]	[g]	*Distance moved during shock*	*Accumulated moved distance*
1	4.21	4.07	0.41	None	None
2	4.03	3.32	0.34	None	None

There was no movement among the lying elements during none of the shocks.



There was no measured dislocation of the lying elements

3.8.9 Test 9 – Standing concrete elements from Betong o Smide on an open trailer

The ninth test was with standing concrete elements (walls) from Betong o Smide i Trelleborg AB on an open trailer from K.E. Palms Åkeri. This unit arrived from Trelleborg by road and there had been no movement during this transport.

The following information is available:

Unit:	Open trailer
Unit number:	WUW 746
State of the floor:	Plyfa, dry and clean
Net weight:	19 280 kg
Load pattern:	Two walls leaning against each other
Friction:	0.4 (steel on plyfa for ⅔ of the wedges) and 0.7 (smooth concrete on wood for ⅓ of the wedges)
Securing:	Loaded on a trestle (inclined around 10°) with 6 wedges (3 per side), blocked in forward direction by a constructed headboard, 6 top-over lashings and 1 spring lashing to prevent movement backwards, LC 2 000 kg, S_{TF} 400 kg, rubber underneath one of the three pair of wedges (the ones in the middle)
Air suspensions:	It was not registered if the air was released or not



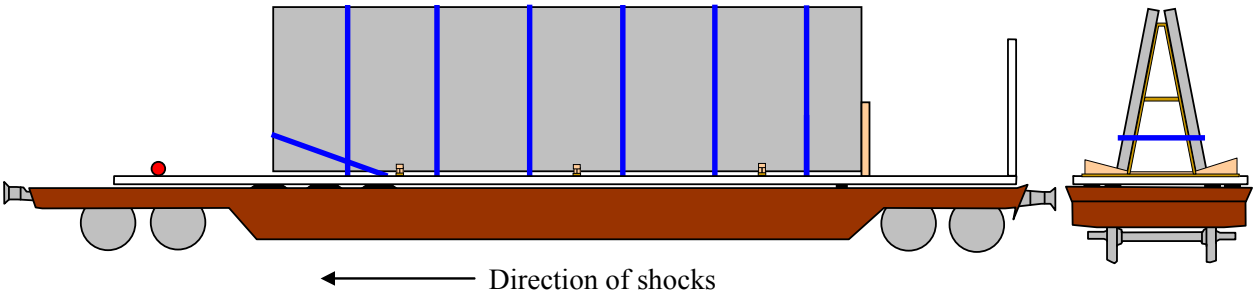


The trailer loaded with concrete walls from Betong o Smide





The spring lashing to prevent movement backwards and one of the six wedges



Loading and securing of the walls from Betong o Smide seen from the side and from behind

Required cargo securing

The walls were blocked in forward direction. According to calculations the static friction is 0.4 respectively 0.7 and the securing arrangement will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by a constructed headboard		
Backward		0.64	0.63	0.63
Sideways		0.63	0.57	0.43

Extract from UIC Loading Guidelines:

Loading guidelines 6.2

Stone and concrete slabs (sliding method of loading)

Single wagons and groups of wagons | Wagons in block trains and combined transport
Wagons with long-stroke absorbers

Type of goods

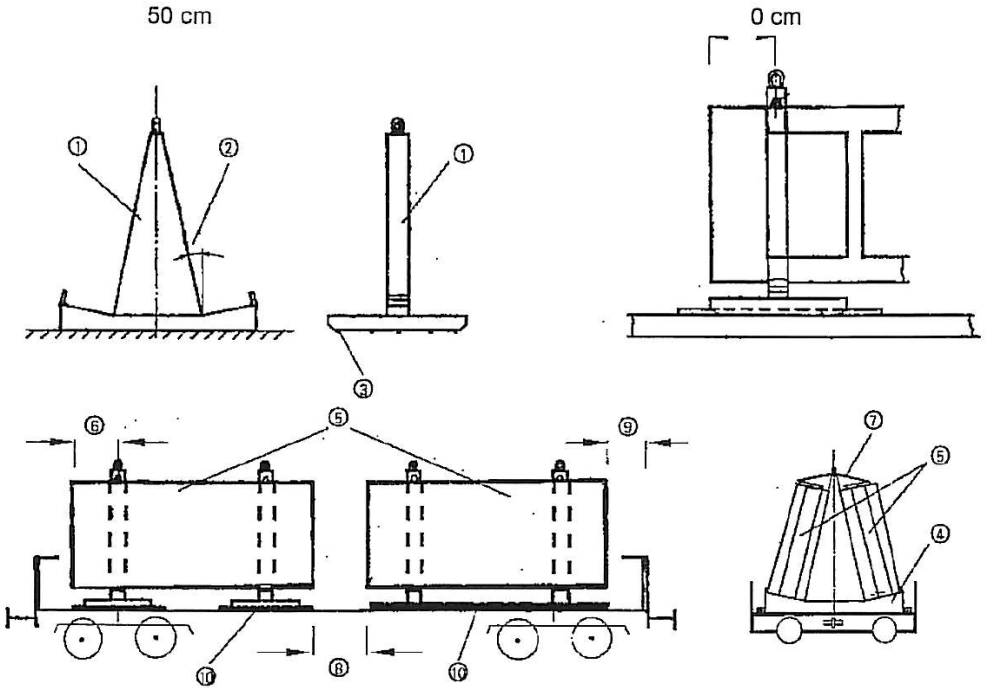
① – Stone and concrete slabs on A-frame steel trestles
② – trestle bearing surface inclined at an angle of at least 12°
③ – trestle skids should be obliquely positioned, with small spikes or weld beads under the skids,
about 3 mm high and perpendicular to the direction of sliding

Wagons

Wagons with walls, sides or stanchions and a wooden floor

Method of loading

④ Trestles should be loaded lengthwise
⑤ The same number of slabs of similar dimensions should be placed standing on either side of the
⑥ trestle.
Slabs should extend beyond the trestle by around 50 cm at either end
⑦ Each stack should be directly fastened to the trestles at least twice (breaking strength of fastening at least 1,000 daN).
⑧ Several load units may be placed one behind another at intervals of at least 50 cm as
⑨ appropriate.
Minimum clearance



Securing

⑩ The trestles should be secured laterally using guide-pieces
– guide-pieces at least 5 cm thick with an effective height of at least 3 cm
– total number of nails of 5 mm diameter along each side: 1 nail / 1,500 kg load weight, with at least 2 nails per guide-piece.

Additional indications

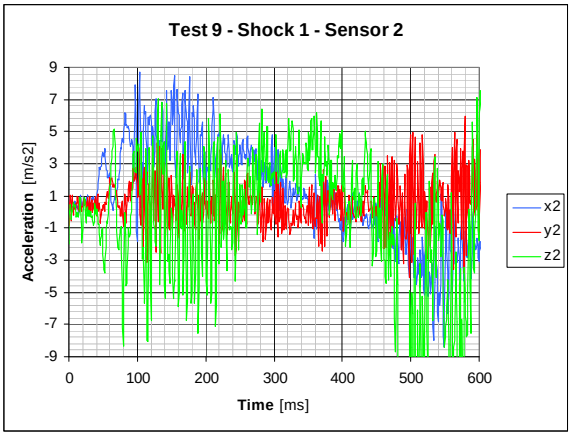
Distribution of load: see sheet 0.1

01.04.2009

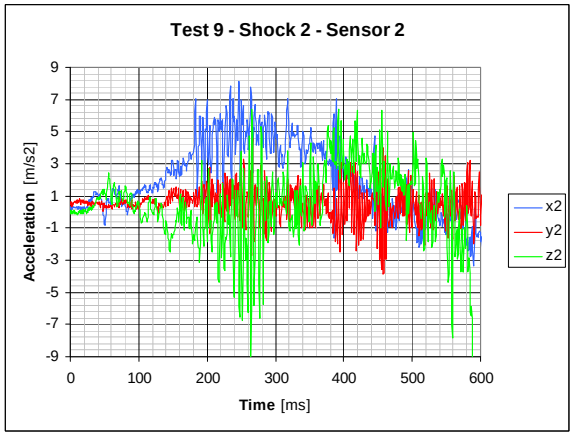
The instruction above demands that the walls are secured by using guide-pieces which they are not. Thus, the securing in this test is not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s² during shock 1



Measured accelerations in m/s² during shock 2

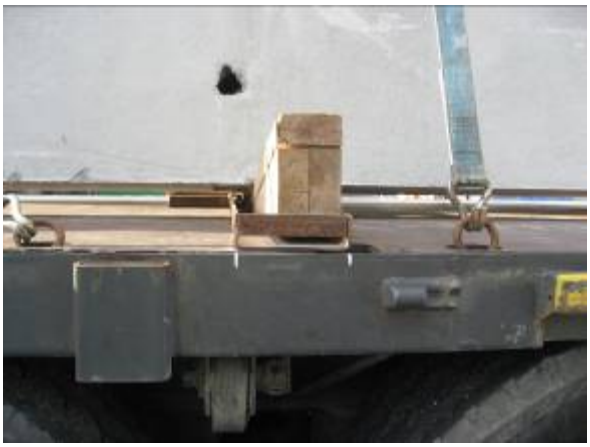
Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed**	**Acceleration**		**Measured dislocation of walls** [mm]	
	[km/h]	[m/s²]	[g]	*Distance moved during shock*	*Accumulated moved distance*
1	4.10	4.70	0.48	None	None
2	4.78	4.72	0.48	None	None

No movement of the walls were observed during none of the shocks.



Installation of the accelerometer equipment



The walls did not move during the shocks

3.8.10 Test 10 – Barrels on pallets from Akzo Nobel in a trailer

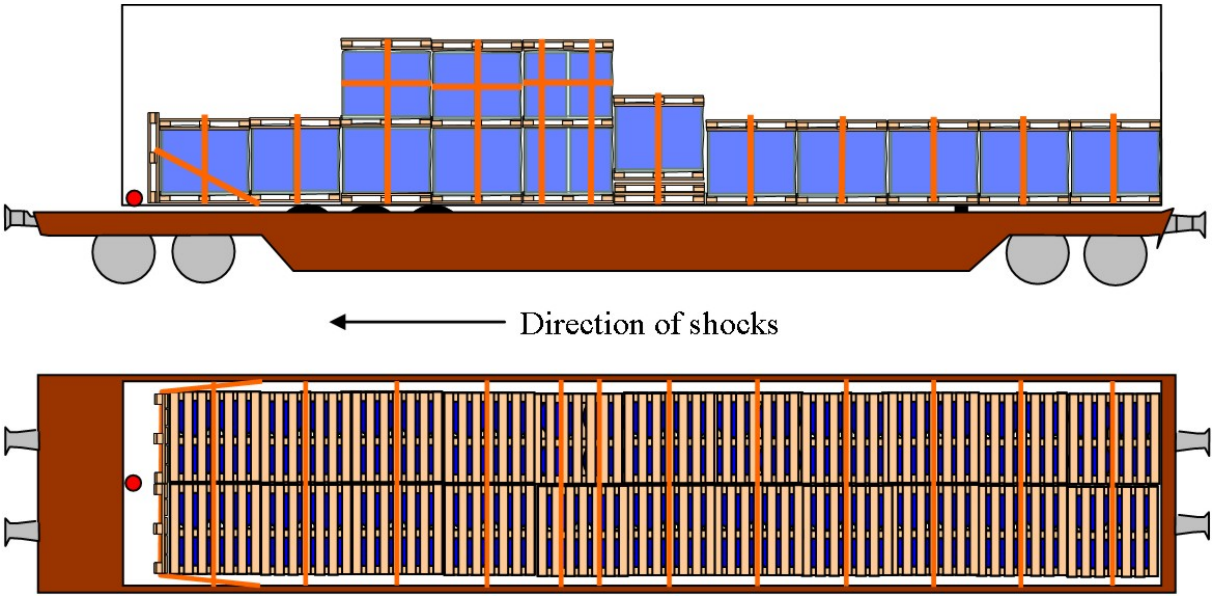
The tenth test was with barrels on pallets from Akzo Nobel in a trailer from N-TEX. This unit arrived from Stenungsund by road and there had been no movement of the barrels or the pallets during this transport.

The following information is available:

Unit:	Trailer, curtainsided
Unit number:	NTEX 1855
State of the floor:	Plyfa, dry and clean
Net weight:	22 400 kg
Dimension:	Diameter: 1500 mm, Width: 1500 mm
Load pattern:	28 pallets, 4 barrels á 200 kg per pallet, 6 sections in one layer in the front, 3 sections in double layer in the middle and 2 sections in one layer in the rear end
Friction:	0.5 (wooden pallets on plyfa, the coefficient of friction between barrels and wood is 0.55 according to tests carried out in Alby 1991-07-02)
Securing:	1 top-over lashing per section, 1 extra top-over lashing on the forward section of double layers, 1 spring lashing to prevent movement backwards, round turn lashings on the pallets in the second layer, 2 extra pallets under section 6 (in front of sections with double layers), empty pallets on top of every pallet with barrels as well as in the rear to keep the spring lashing in place
Air suspensions:	It was not registered if the air was released or not



The trailer loaded with barrels from Akzo Nobel



Loading and securing of the barrels from Akzo Nobel seen from the side and from above

Required cargo securing

The barrels on pallets were blocked in forward direction. According to calculations the static friction is 0.5 and the securing arrangement will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by a constructed headboard		
Backward		0.68	0.66	0.66
Sideways		0.63	0.57	0.43

The accelerations sideways in the table above are calculated for the sections of double layers.

Extract from UIC Loading Guidelines:

Loading guidelines 10.1

Barrels

Single wagons and groups of wagons	Wagons in block trains and combined transport

Type of goods
Barrels

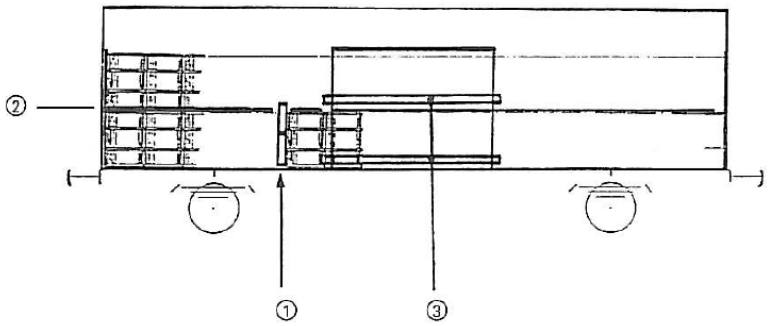
Wagons
Wagons with walls or sides (E..., G..., K..., Re...)

Method of loading

① Barrels should be loaded upright and in compact formation over the whole loading surface, with intermediate space filled in.

② When barrels are loaded in 2 tiers (only on E and G wagons), the tiers should be separated using panels (e.g. wooden panels).

When loading barrels of different dimensions, barrels of similar dimensions should be grouped together and separated (e.g. using wooden panels).



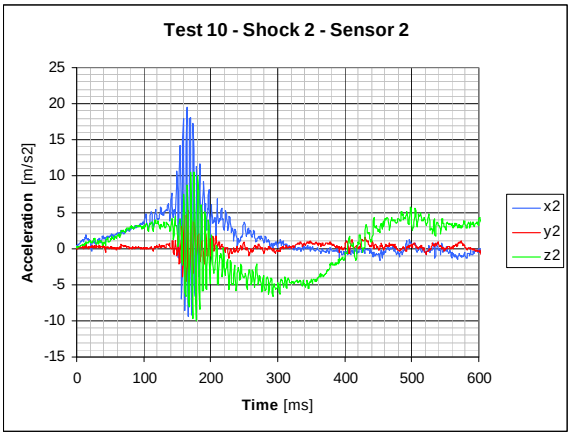
Securing

③ By the walls and sides. In the vicinity of the side doors additional measures are used to ensure stability: barrels bound together into groups (breakings strength of bindings: at least 10 kN) friction-enhancing inserts or timber scotches used.
Scotches should be secured on each side with one 5 mm diameter nail per 1,500 kg load weight, and at least 2 nails per scotch.

The barrels should be secured by walls and sides which is not the case in an ordinary curtainsided trailer and the securing is not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results during shock 2:



Measured accelerations in m/s^2 during shock 2

No acceleration data was available for shock 1.

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of barrels** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	4.29	-	-	None	None
2	4.58	4.74	0.48	None	None

No movement of the barrels or pallets were noticed during none of the shocks.



Position of one of the accelerometer sensors



The barrels/pallets didn't move during the shocks

3.8.11 Test 11 – Paper pallets from Stora Enso Fors in a swap body

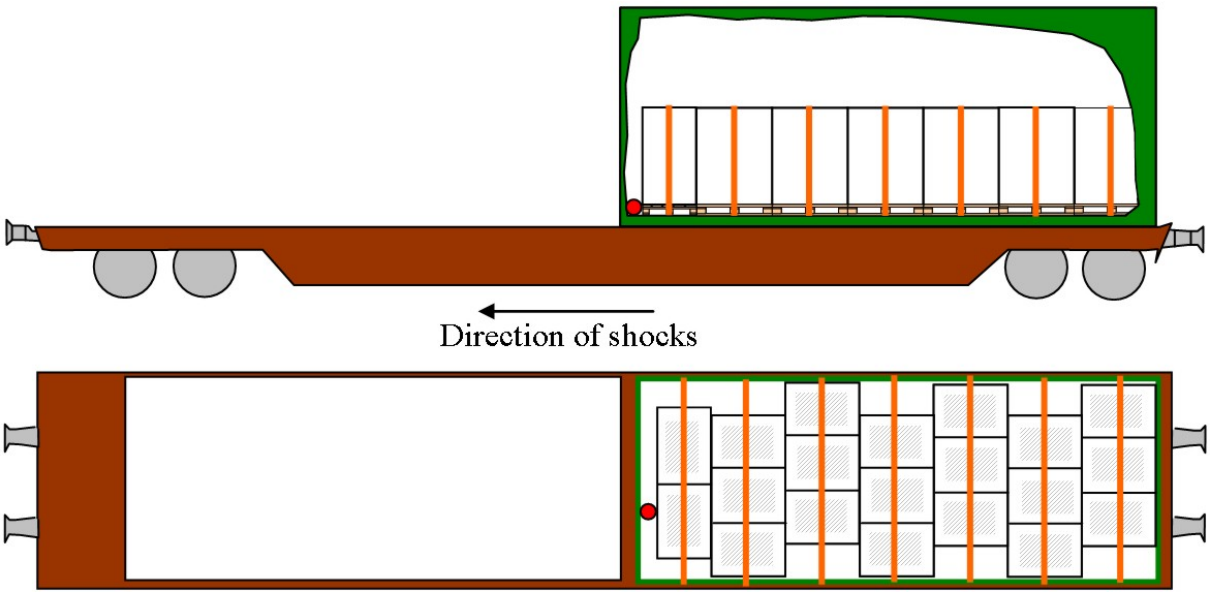
Test number eleven was with paper pallets from Stora Enso Fors in a swap body from Hangartner. This unit arrived from Trelleborg by road and there had been no movement among the pallets during this road transport.

The following information is available:

Unit:	Swap body, cover/stake type with drop sides
Unit number:	HT 3803
State of the floor:	Plyfa, dry and clean
Net weight:	Approximately 10 700 kg, ~535 kg per pallet
Dimension:	Diameter: 1500 mm, Width: 1500 mm
Load pattern:	20 pallets in 7 sections; 6 sections with 3 pallets stowed in longitudinal direction in the swap body and the last section with 2 pallets in transverse direction of the swap body
Friction:	0.5 (wooden pallets on plyfa)
Securing:	1 top-over lashing per section, well tensioned, LC 1 600 kg, S_{TF} 400



The swap body loaded with paper pallets from Stora Enso Fors



Loading and securing of the paper pallets from Stora Enso Fors seen from the side and from above

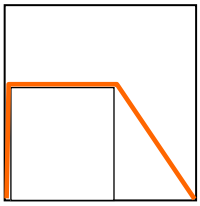
Required cargo securing

The paper pallets were blocked in forward direction. According to calculations the static friction is 0.5 and the securing arrangement will manage to withstand the following accelerations, expressed in g:

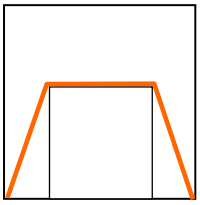
	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not available, see below	Blocked by a constructed headboard		
Backward		0.74	0.67	0.67
Sideways		0.74	0.67	0.53

Instructions for securing of paper pallets are not available in UIC Loading Guidelines.

Please note that it is not recommended to load and secure the paper pallets as in this unit. From a general point of view cargo are to be loaded in the middle of the unit. If the cargo should move sideways the lashing would become slacker if the cargo is placed to the side than if it is placed in the middle. The accelerations above are calculated with one angle in 90° and one in 60° according to the sketch below to the left.



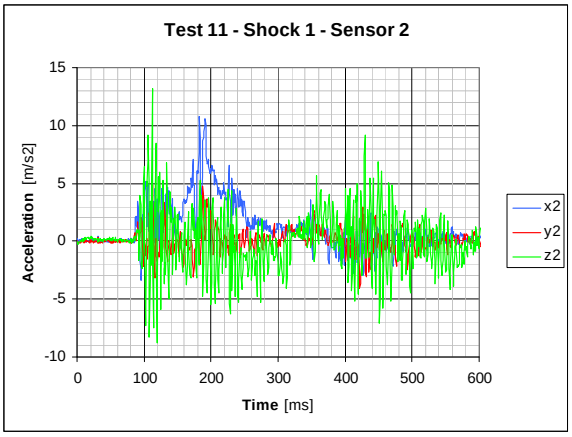
Not recommended loading and securing of cargo



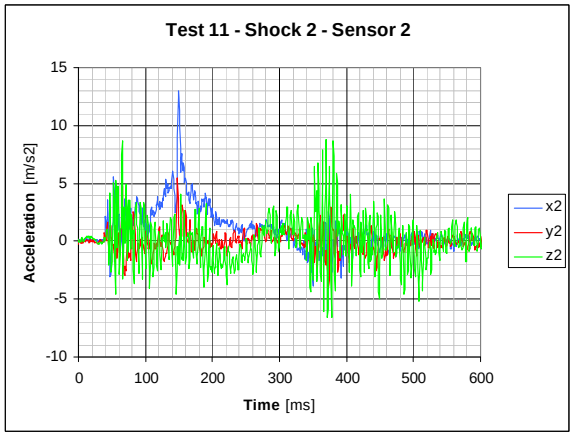
Instead the cargo should be loaded in the middle of the unit

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s^2 during shock 1



Measured accelerations in m/s^2 during shock 2

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	Speed	Acceleration		Measured dislocation of pallets [mm]	
	[km/h]	[m/s^2]	[g]	*Distance moved during shock*	*Accumulated moved distance*
1	4.18	4.59	0.47	None	None
2	3.86	3.97	0.40	None	None

There was no movement among the pallets during none of the shocks.



Position of the accelerometer equipment



The pallets didn't move during the shocks

3.8.12 Test 12 – Cable drums from ABB in a trailer

Test number twelve was with two cable drums from ABB in a trailer from DB Schenker. This unit arrived from Karlskrona by road and there had been no movement of the drums during this transport.

The following information is available:

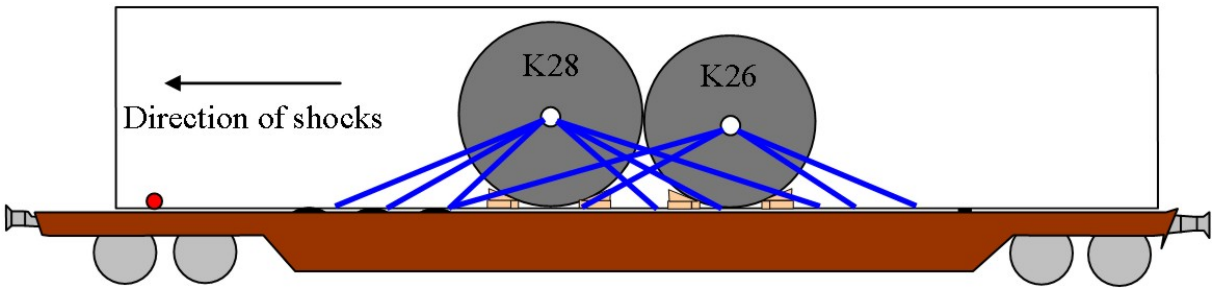
Unit:	Trailer, curtainsided
Unit number:	CURT 103
State of the floor:	Plyfa, dry and quite clean
Net weight:	Totally 14 535 kg (8 440 plus 6 095 kg)
Load pattern:	2 cable drums with diameter 2 800 mm (K28) respectively 2 600 mm (K26)
Friction:	0.5 (wooden pallets on plyfa)
Securing:	The drums were loaded in cradles made of wood.
	During test 1: Spring lashings; 2 to prevent movement forward and 2 to prevent movement backwards on the front drum and 3 to prevent movement forward and 3 to prevent movement backwards on the rear drum
	During test 2 and 3: Spring lashings; 2 to prevent movement forward and 1 to prevent movement backwards on

the front drum and 3 to prevent movement forward and 2 to prevent movement backwards on the rear drum;
LC 1 600 kg, S_{TF} 400 kg

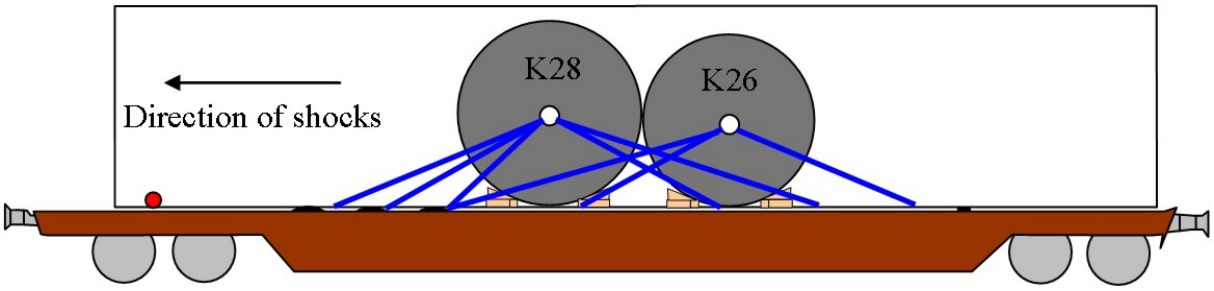
Air suspensions: It was not registered if the air was released or not



The trailer loaded with cable drums from ABB



Loading and securing of the cable drums from ABB during test 1 seen from the side



Loading and securing of the cable drums from ABB during test 2 and 3 seen from the side

Required cargo securing

According to calculations the static friction is 0.5 and the spring lashings (used during test 2 and 3) and the cradles will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not available,	1.42	1.42	1.42

Backward	see below	0.99	0.99	0.99
Sideways		0.66	0.60	0.46

Extract from UIC Loading Guidelines:

Loading guidelines 20.2

Cable drums

Single wagons and groups of wagons	Wagons in block trains and combined transport

Type of goods

Cable drums, loaded "on the roll" (eye-to-side)

Wagons

Wagons with walls, sides or stanchions and wooden floor (E..., K..., R..., S..., U..., L...)

Method of loading

Cable drums should be loaded

① – on timbers or

② – on wedged scotches

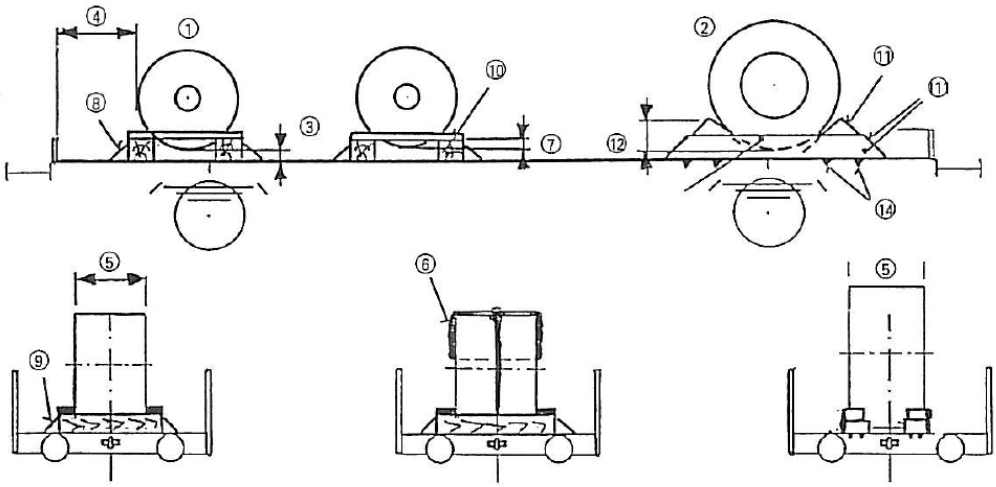
③ – clearance from floor 2 to 3 cm.

④ – clearances to end walls or ends at least

50 cm	10 cm

⑤ – drum width should be at least 5/10 of drum diameter, for wagons without walls at least 7/10.

⑥ – narrower drums should be secured against tipping, for example by being tied together. Bindings should have a breaking strength of at least 40 kN.



Securing

Drums weighing up to a maximum of 7 t should secured with timbers

– Cross-timbers

⑦
- effective height at least 1/8 of the drum diameter,
- timber width at least equal to height,
- in each running direction

⑧
- secured on the outside with at least 2 wooden scotches (scotch height approx. 2/3 of timber height)
- scotches should be fastened with a total of

1 nail / 500 kg	1 nail / 2,000 kg

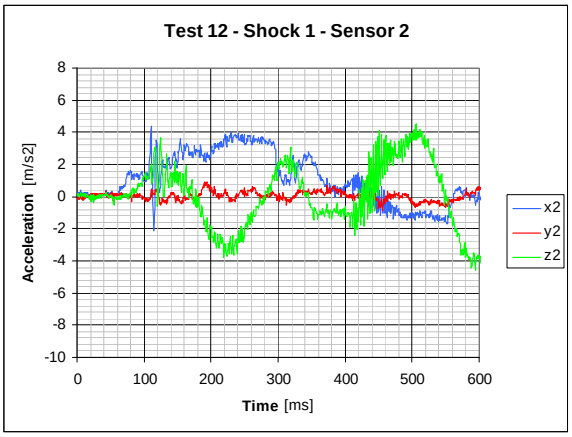
but at least 2 nails per scotch

⑨ ▪ secured laterally with scotches
▪▪ scotches should be fastened on each side with a total of 1 nail per 1,500 kg load weight, but at least 2 nails
⑩ – Supporting pieces
▪ minimum cross-section 5 x 15 cm
▪ fastened at each end with at least 4 nails
– nails at least 5 mm in diameter with penetration of at least 40 mm
⑪ Drums weighing up to a maximum of 20 t should be secured with 2 wedged scotches.
⑫ – effective height of scotches at least 1/8 of drum diameter, scotch width at least 2/3 of scotch height.
⑬ – scotches should be covered on three sides with steel sheeting at least 6 mm thick.
⑭ – sheet on underside of scotches should have 8 steel spikes (2x4), 10 - 15 mm long.
⑮ – drums are prevented from lateral movement by resting against the lateral sheeting.

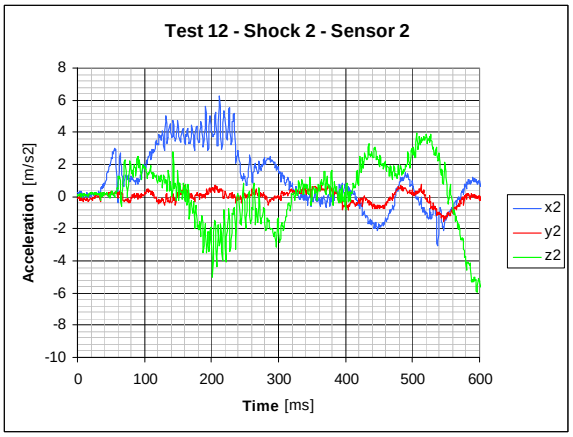
The instruction for cable drums loaded with the eye to the side is valid for drums weighing up to a maximum of 7 ton. The K28 drum from ABB weighed 8.44 ton and instruction for this drum is therefore not available in UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

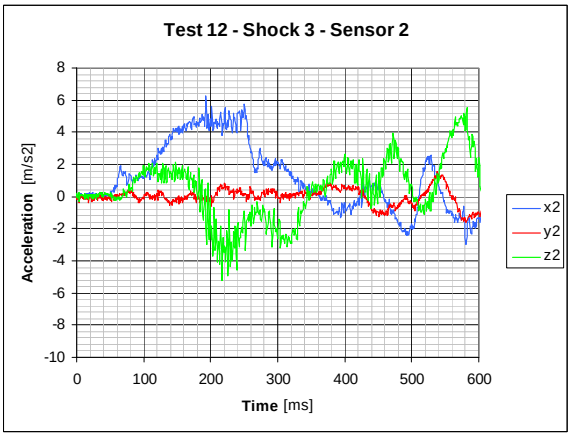
The wagon was subjected to three shocks; shock 2 and 3 with reduced number of lashings. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s^2 during shock 1



Measured accelerations in m/s^2 during shock 2



Measured accelerations in m/s^2 during shock 3

The three shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of cable drums** [mm] *Distance moved during shock*	*Accumulated moved Distance*
1	3.81	3.38	0.34	None	None
2	3.96	4.06	0.41	None	None
3	4.30	4.64	0.47	None	None

There was no movement of the drums during neither of the shocks.



The drums didn't move during none of the shocks

3.8.13 Test 13 – Single drum vibratory roller from Dynapac in a trailer

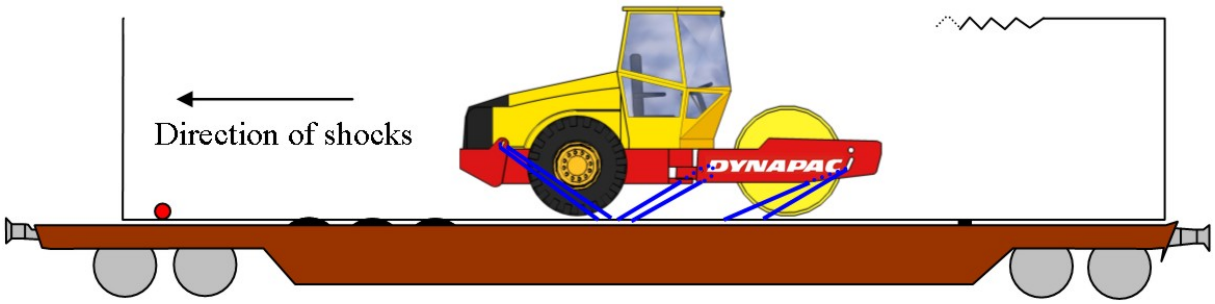
The 13th test was with a single drum vibratory roller of model CA402 from Dynapac in a trailer from DSV. This unit arrived from Karlskrona by road and there had been no movement of the roller during the transport.

The following information is available:

Unit:	Trailer, curtainsided
Unit number:	DSV 770175
State of the floor:	Plyfa, dry and clean
Net weight:	16 320 kg
Load pattern:	A single drum vibratory roller of model CA402
Friction:	At least 0.6 (rubber on plyfa)
Securing:	Rubber friction pads are placed between the drum and the platform, 6 double straight lashings (3 per side), LC 2 500 ton, S_{TF} 300 kg
Air suspensions:	The air was released



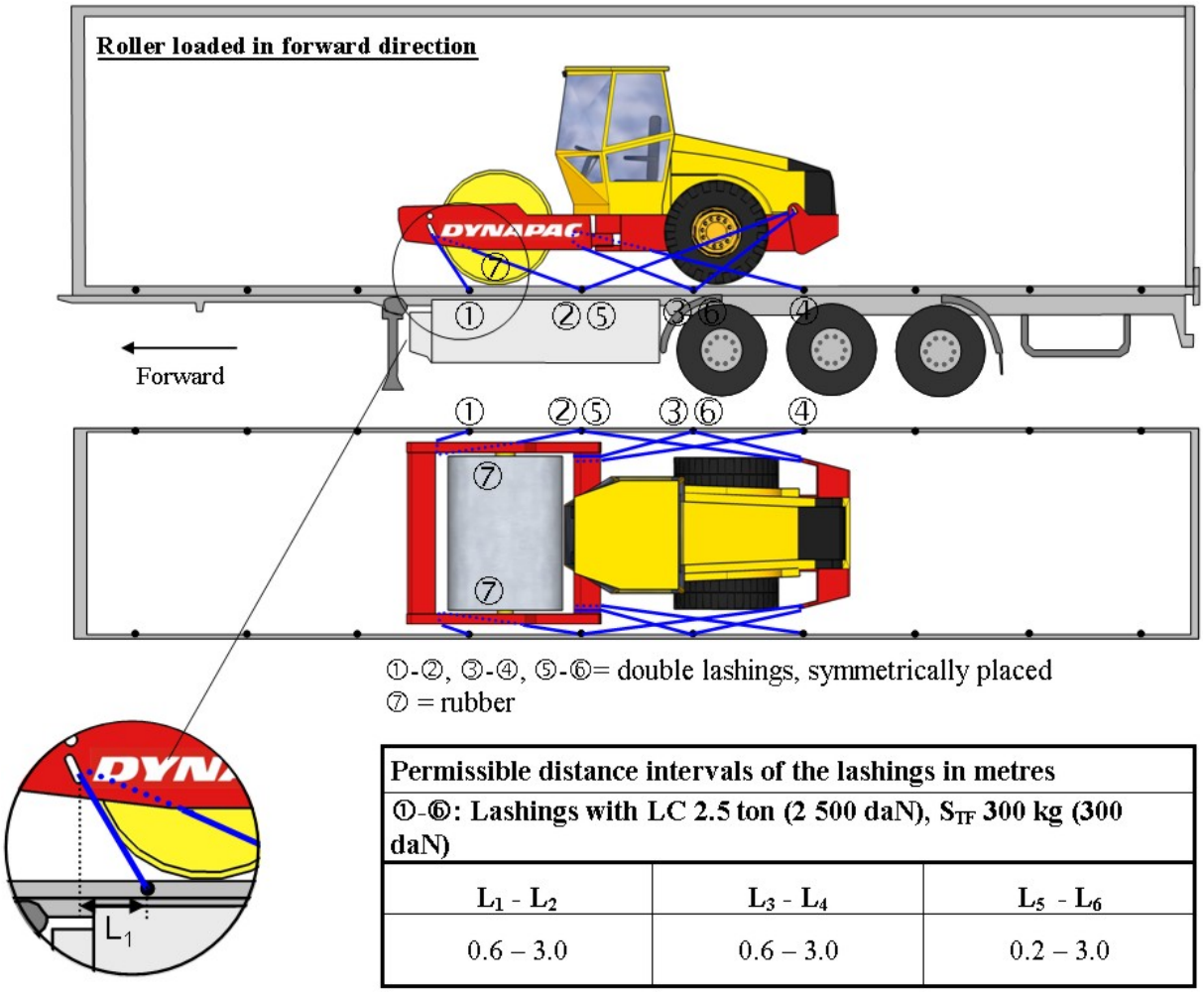

The single drum vibratory roller from Dynapac loaded on the trailer



Loading and securing of the single drum vibratory roller from Dynapac seen from the side

Required cargo securing

A cargo securing certificate for transport on road is available for this type of machinery and the principles and calculations in the certificate fulfil both the IMO and the CEN method for road transport. The certificate gives the permissible distance intervals of each lashing in metres for lashings with lashing capacity (LC) 1 700 kg. When using lashings with LC 2 500 kg the following intervals is allowed:



Permissible distance intervals of the lashings in metres		
①-⑥: Lashings with LC 2.5 ton (2 500 daN), S_{TF} 300 kg (300 daN)		
L_1 - L_2	L_3 - L_4	L_5 - L_6
0.6 – 3.0	0.6 – 3.0	0.2 – 3.0

***L_1** is the distance between the lashing point on the platform and the projected point, laterally at a right angle towards the edge of the platform from the lashing point on the roller, for lashing 1. The relationships for **L_2 - L_6** for lashing 2 - 6 are the same.*

The distance intervals for the roller in the test was L_1 = 1.25 m, L_2 = 2.0 m, L_3 - L_4 ≈ 1.6 m and L_5 - L_6 ≈ 0.9 m.

The lashing points in the trailer have LC at least 2 ton and LC in the calculations is therefore limited to 2 ton.

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	0.94	0.94	0.94
Backward		0.88	0.88	0.88
Sideways		0.66	0.66	0.54

Extract from UIC Loading Guidelines:

Vehicles and machinery on wheels or caterpillar tracks, secured with fastenings

Single wagons and groups of wagons	Wagons in block trains and combined transport Wagons with long-stroke shock-absorbers

Type of goods

Motor cars, lorries, trailers, diggers, bulldozers, cranes
- vehicle canopies or bonnets should be closed and secured
- aerials should be retracted, detached or folded back
- engines should be secured against spontaneously starting up
- tyres inflated to normal service pressure

Wagons

Wagons with wooden floors (K..., L..., R..., S...)

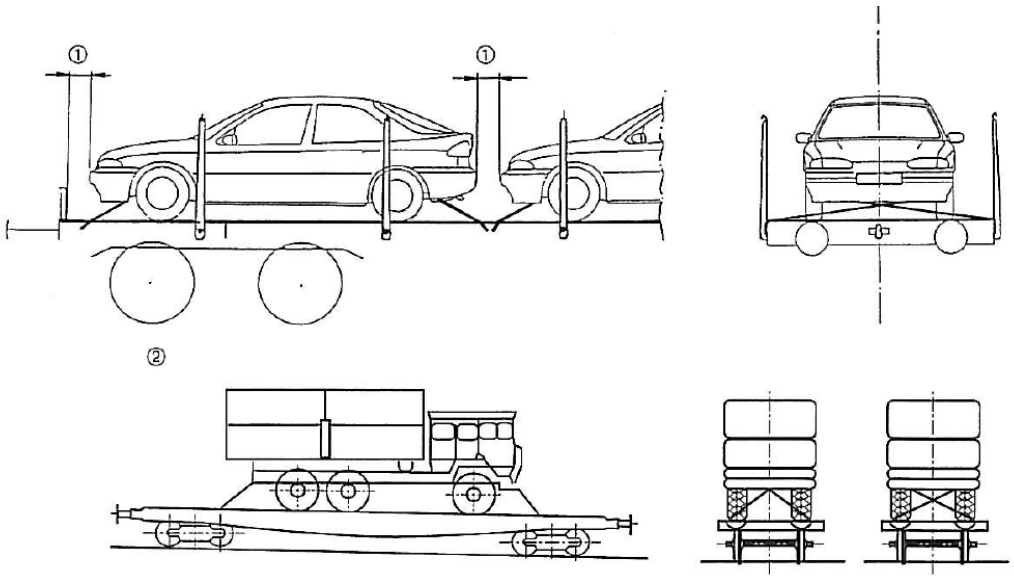
Method of loading

Vehicles and machinery should be loaded lengthways in the wagon

① Minimum clearances to the fixed parts of the wagon and between vehicles

20 cm*	10 cm*

* take account of extra space needed for fastenings



1.7.2005

Securing

② Vehicles and machinery should be secured as follows
- two fastenings, taut and independent of one another, to be applied to each end of vehicles and machinery, effective both lengthways and crossways
- hand-brakes on and lowest gear engaged or gears blocked; vehicles that cannot be secured in any of these ways should also be scotched (see Loading guidelines 7.1)

For the strength of the fastenings used, consult the following tables:

Vehicle weight up to:		Breaking strength *) of fastenings	Breaking strength *) of fastenings
Wheeled vehicles	Caterpillar vehicles		
3 t	5 t	4000 daN	2000 daN
8 t	10 t	8000 daN	4000 daN
15 t	25 t	12500 daN	8000 daN
30 t	50 t	20000 daN	12500 daN
40 t	60 t	32000 daN	20000 daN

* Bands and load securing straps used as slings are considered to have twice the breaking strength as in straight pull.

For vehicles of up to 3 t, fastenings made of wire (diameter of at least 4 mm) may be used.

Each fastening must comprise

4 wires of 4 mm diameter each	2 wires of 4 mm diameter each

Sliding, swinging or turning parts (such as crane booms, lifting devices, counterweights or cabs of vehicles and machinery) shall be mechanically secured or lashed down so they are unable to move during transit (breaking strength of bindings min. 1000 daN, for crane booms min. 4000 daN).

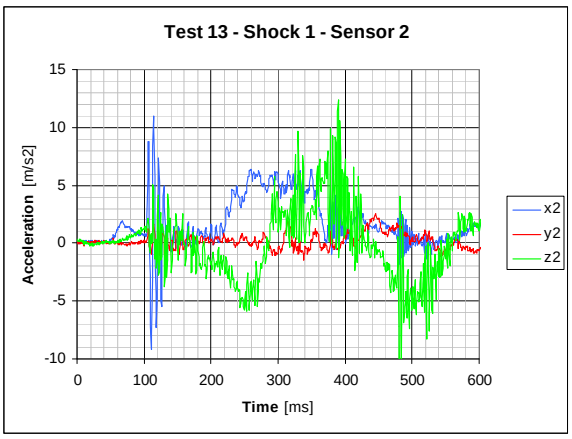
The draw-bars of uncoupled trailers must be indirectly fastened (breaking strength of bindings min. 1000 daN).

1.1.2004

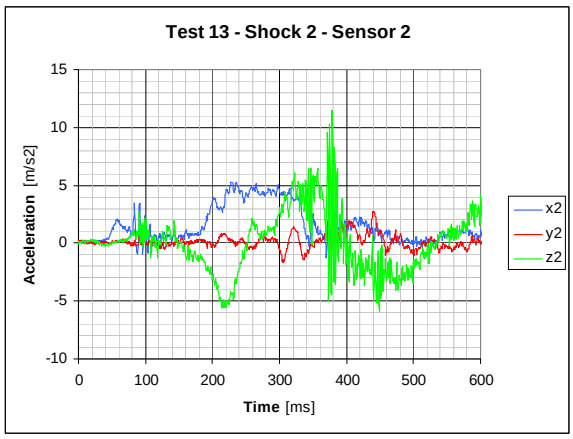
According to UIC Loading Guidelines the roller are to be secured as follows; “two fastenings, taut and independent of one another, to be applied to each end of vehicles and machinery, effective both lengthways and crossways”. The breaking strength, MBL, of the fastenings should be at least 12 500 daN (12.5 ton). This is not fulfilled and thus the securing of the roller is not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s^2 during shock 1



Measured accelerations in m/s^2 during shock 2

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of vibratory roller** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	4.36	5.26	0.54	5 mm	5 mm
2	4.06	4.44	0.45	None	5 mm

The roller moved approximately 5 mm during the first and nothing during the second shock.



The vibratory roller moved approximately 5 mm during shock 1 and nothing during shock 2

3.8.14 Test 14 – Steel pipes from Ovako Steel in a trailer

Test number 14 was with steel pipes from Ovako Steel in a trailer from Hangartner. This unit arrived from Hofors to Gävle by road and from Gävle to Malmö by combined transport train with help from CargoNet. There had been no movement among the steel pipes during the transport.

The following information is available:

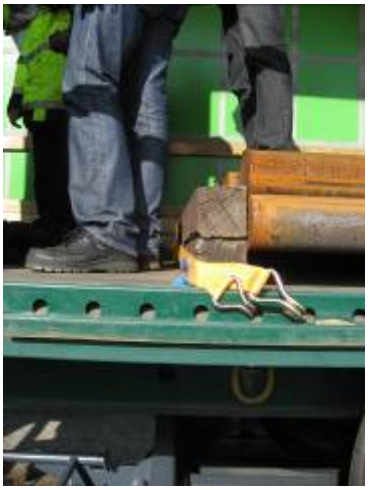
Unit:	Trailer, curtainsided
Unit number:	HT 8333
State of the floor:	Plyfa, dry and clean
Net weight:	27 390 kg
Load pattern:	8 bundles in one layer
Friction:	0.5 (according to tests carried out in Hofors 2008-09-03)
Securing:	Blocked in forward direction, secured with 9 top-over lashings, timber in 2 layers to block the pipes in rearward direction together with 2 spring lashings (of which one had become slack), LC 1 300 kg, S_{TF} 400 kg
Air suspensions:	The air was released before the third shock




The trailer loaded with steel pipes from Ovako Steel




Blocking of steel pipes in forward direction

Blocking with timber and two spring lashings (of which one was slack) to prevent movement backwards

Required cargo securing

According to calculations the static friction is 0.5 and the 9 top-over lashings and one spring lashing in 0° will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by a constructed headboard		
Backward		0.54	0.53	0.53
Sideways		0.63	0.58	0.44

Extract from UIC Loading Guidelines:

Loading guidelines 1.4.7

Steel pipes, rods and polygonal profiles in bundles

Single wagons and groups of wagons | Wagons in block trains and combined transport
Wagons with long-stroke absorbers

Type of goods

Steel pipes, rods and polygonal profiles bound into bundles.
Number of bindings according to diameter, length and weight of bundle; one binding per 3 m of bundle length, at least 2 bindings per bundle. Distance of bindings from bundle ends: 30 cm approx.
Breaking strength[1] of binding min. 1400 daN, binding pulled tight to be effective
Synthetic straps and woven strips should only be used on sharp edges with edge protection.

Wagons

Wagons with stanchions and end boards.

Method of loading

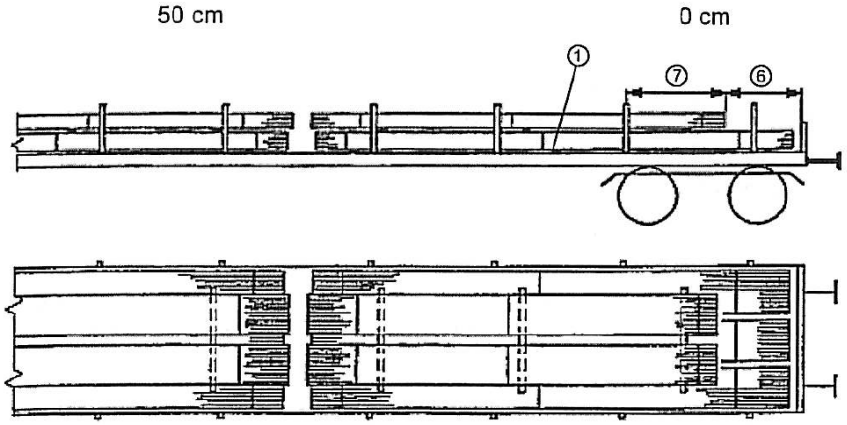
① Bundles loaded side by side directly onto the wagon floor, on bolsters or on wooden timbers.

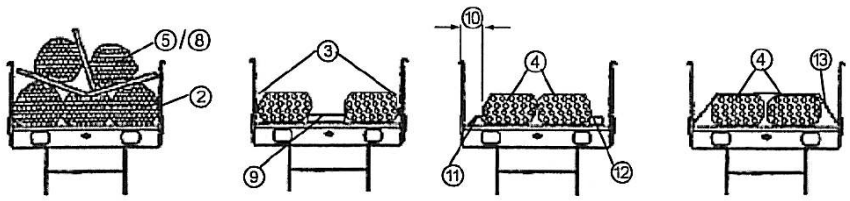
② ③ Timbers should be soft wood, of rectangular cross-section and resting on the broader face.
On the bottom layer, bundles are in contact with the stanchions or

④ loaded in the centre in case of single-layer loading which does not take up the full width

⑤ available
On the upper layer, bundles are dovetailed. To facilitate transhipment, they may be separated using inserted timbers placed either at an angle or vertically.

⑥ Clearances for bundles above the wagon end boards, minimum:





[1] Breaking strength when subject to traction in a straight line = 2 x permissible traction force

01.04.2009

Securing

⑦ - by side stanchions (bottom layer); when secured by only 2 stanchions on each side, the load must extend lengthways beyond the centre of the stanchions by at least:

50 cm	30 cm

⑧ - by the dovetailing arrangement (upper layer).

⑨ For loading in accordance with ③: empty spaces shall be filled with timber and fixed with nails. Minimum height of timber pieces: 5cm.

⑩ For loading in accordance with ④

Where direct support is provided by walls, sides or stanchions (lateral distance ≤ 10 cm) no additional securing is required,
with lateral securing where lateral distance is > 10cm.

⑪ - by scotches. Scotch dimensions: Min. height 12cm, min width 8 cm, scotch angle approx. 35°. Number of nails in the scotches, on each side of the load: 1 nail per 1500 kg of load mass, with at least two nails per scotch, or

⑫ - by guide-pieces nailed in place. Minimum height 5cm, secured to the wagon floor with 1 nail per 1,500 kg of load mass, at least 2 nails per guide-piece. Nail diameter min. 5 mm; threaded nail min. 4.2 mm, depth of penetration into wagon floor min. 40 mm, or

⑬ - by indirect fastenings in the form of synthetic or woven straps, should only be used on sharp edges with edge protection (breaking strength[2] min. 2800 daN), 1 indirect fastening per 3 m bundle length , at least 2 per stack.

Additional indications

Distribution of load: see sheet 0.1; indirect fastenings see sheet 0.7

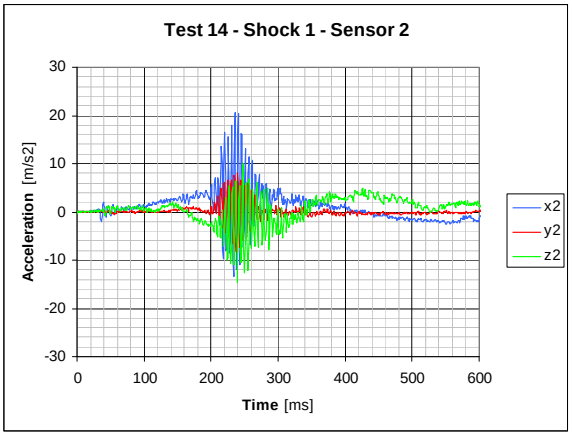
[2] Breaking strength when subject to traction in a straight line = 2 x permissible traction force

01.07.2006

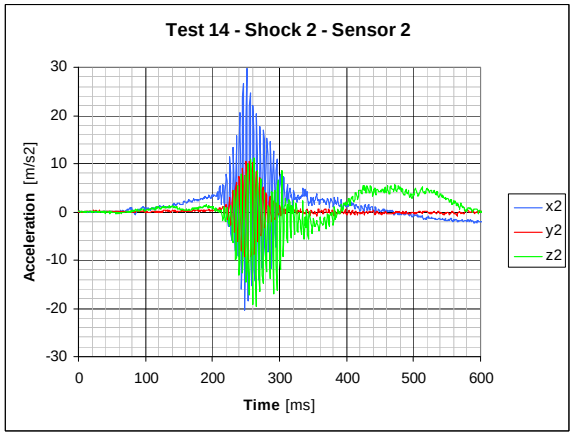
The steel pipes should be secured by side stanchions and the securing in this unit is therefore not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

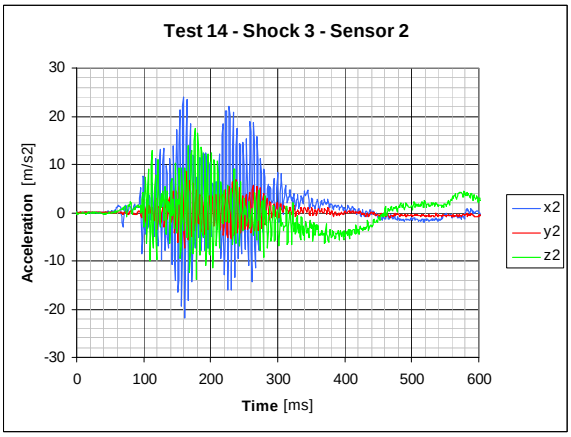
The wagon was subjected to three shocks. The shock recording equipment was positioned at the rear end of the trailer. The equipment produced the following results:



Measured accelerations in m/s^2 during shock 1



Measured accelerations in m/s^2 during shock 2



Measured accelerations in m/s^2 during shock 3

The three shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed**	**Acceleration**		**Measured dislocation of steel pipes** [mm]	
	[km/h]	[m/s^2]	[g]	*Distance moved during shock*	*Accumulated moved Distance*
1	3.92	3.39	0.35	None	None
2	4.17	3.37	0.38	None	None
3 *	3.89	1.47	0.15	None	None

** The air pressure in the trailer was released*

There was no movement among the steel pipes during none of the shocks. Before the third shock the air in the air suspensions was released.

3.8.15 Test 15 – Truck cabin from Scania in a MEGA trailer

Test number 15 was with a truck cabin from Scania in a megatrailer from Ewals cargo. This unit arrived from Oskarshamn by road and there had been no movement of the cabin during this transport. The truck cabin was re-secured because of incorrect securing during the road transport to Malmö.

The wagon used in the other tests didn't work for this mega-trailer. Instead a T5 wagon with the following marking was used: HUPAC-08-SVT 150-1g-R2750, 09, 0038, see below.





The special wagon used in the test with the truck cabin

The following information about this unit is available:

Unit:	Mega-trailer, curtainsided
Unit number:	CCH 7241
State of the floor:	Plyfa, dry and clean
Net weight:	400 kg, 550 kg including the rack
Load pattern:	A truck cabin loaded in the middle of the trailer
Friction:	0.45 (according to practical tests performed at Scania in Oskarshamn 2001-12-18)
Securing:	2 spring lashings; 1 to prevent movement in forward direction and 1 to prevent movement backwards, LC 1 700 kg, S_{TF} 200 kg
Air suspensions:	The air was released

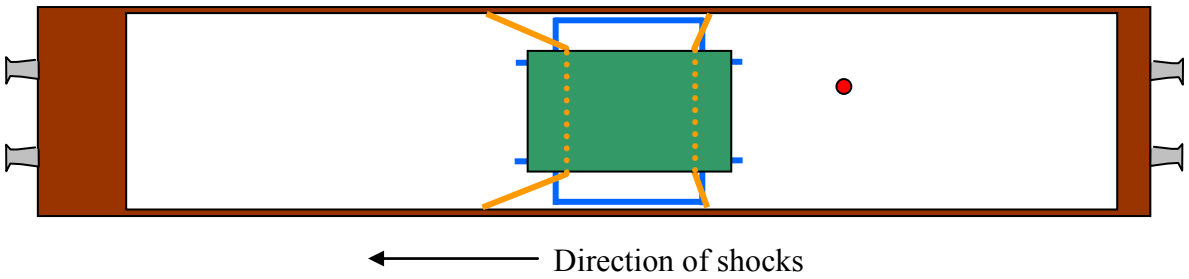



The trailer loaded with the truck cabin




Secured by two spring lashings, one to prevent movement in forward direction and one to prevent movement in rearward direction

The lashing hook in the picture above to the right, for the lashing to prevent movement in rearward direction, was turned downwards after the first shock.



Loading and securing of the truck cabin from Scania seen from above

Required cargo securing

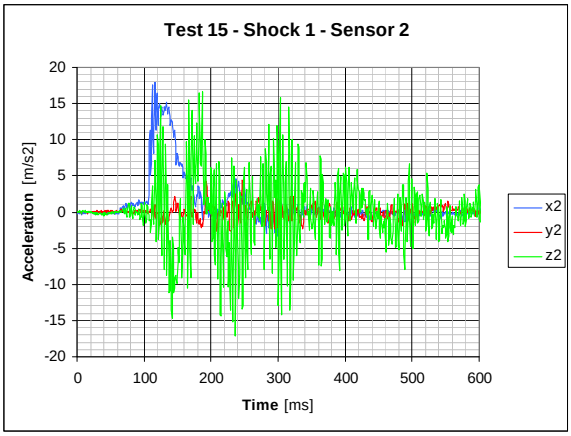
According to calculations the static friction is 0.45 and the two spring lashings will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not available according to below	3.21	3.20	3.20
Backward		1.29	1.29	1.29
Sideways		1.69	1.49	1.40

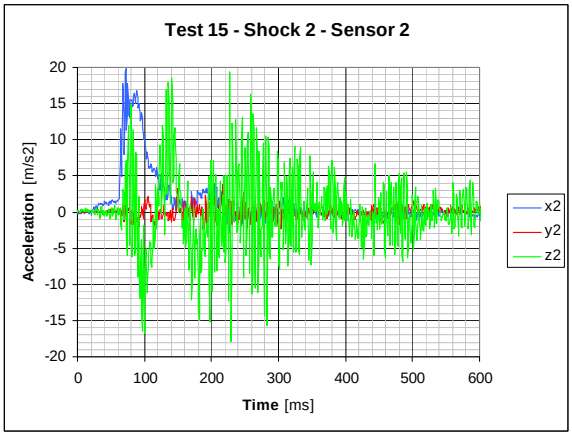
There are no instructions for securing of truck cabins available in UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s^2 during shock 1



Measured accelerations in m/s^2 during shock 2

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of truck cabin** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	3.69	6.94	0.71	10 – 15*	10 – 15
2	3.98	7.28	0.74	3	13 - 18

** The cabin truck turned a little*

The cabin truck turned a little during the first shock and moved some during the second shock.




Movement of the truck cabin after the two shocks

According to the calculations above the truck cabin should have managed to withstand the actual accelerations arisen during the shocks. The movements may probably be explained by the incorrect direction of the spring lashing to prevent movements in rearward direction. This lashing should have been drawn in forward direction instead of straight sideways, see the picture below. To get full effect of a spring lashing there will always be a small movement of the cargo due to elongation of the web lashing.



The spring lashing to prevent movements in rearward direction was drawn straight sideways instead of in forward direction



Position of the accelerometer equipment

3.8.16 Test 16 – Palletised cargo from DHL (Gambro Lundia AB actually) in a trailer

The 16th test was with palletised cargo from Gambro Lundia AB through DHL in a trailer from DHL. This unit arrived from Trelleborg by road and there had been no movement among the pallets during this transport.

The following information about this unit is available:

Unit:	Trailer, curtainsided
Unit number:	DHL 14520
State of the floor:	Plyfa, dry and quite clean

Net weight:	20 394 kg
Load pattern:	66 plasticized pallets in 11 sections, 6 pallets in two layers per section
Friction:	0.5 (wooden pallets on plyfa) and 0.3 (wooden pallets on shrink film)
Securing:	1 top-over lashing per section and 2 spring lashings on the last section to prevent movement backwards, some of the lashings were slack and some knotted, LC 1 700 kg, S_{TF} 170 kg, air bags were used between the two rear sections
Air suspensions:	The air was released





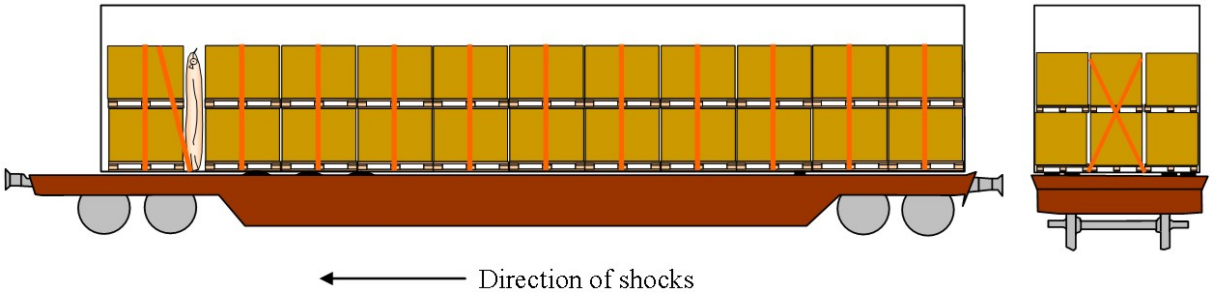
The trailer loaded with palletised cargo





The pallets were secured with one top-over lashing per section, two spring lashings on the rear section and air bags between the two rear sections.

As mentioned above some of the lashings were slack and some knotted. The air bags had lost their pressure due to leaking and did therefore not have the intended effect.



Loading and securing of the palletised cargo from DHL seen from the side and from behind

Required cargo securing

The pallets were blocked in forward direction. The two spring lashings on the rear section only secure the row in the middle and as the air bags were empty, these lashings are disregarded.

According to calculations the static friction is 0.5 and 0.3 and 11 top-over lashings will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not available, see below	Blocked by the headboard		
Backward		0.41	0.37	0.37
Sideways		0.41	0.37	0.29

The accelerations in the table above is calculated for the upper layer for the reason that the coefficient of friction is lower between the wooden pallets and the shrink film than between the wooden pallets and the plyfa.

There are no instructions for securing of palletised cargo available in UIC Loading Guidelines. For details, see instruction and comments below test number 4.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of pallets** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	3.43	-	-	3*	3*
2	4.38	-	-	10*	13*

** Movement of the upper layer*

The pallets in the upper layer moved a little during both the first and the second shock.

.



The lower layer didn't move during none of the shocks

The upper layer moved a little during both shocks

Since there was no free space in the trailer the accelerometer equipment wasn't used during this test.

3.8.17 Test 17 – Steel coils from Outokumpu in a trailer

Test number 17 was with steel coils from Outokumpu in a trailer from Nils Hanssons Åkeri. This unit arrived from Ljungbyhed by road and there had been no movement among the coils during this transport.

The following information about this unit is available:

Unit:	Trailer, cover/stake type with drop sides
Unit number:	TBT 115
State of the floor:	Plyfa, dry and quite clean
Net weight:	21 455 kg
Load pattern:	3 plasticized coils in cradles made of wood, ~ 7 ton per coil
Friction:	0.3 (according to practical tests performed at Outokumpu in Avesta 2008-03-12 -- 14)
Securing:	Cradles of wood, 2 loop lashing pairs per coil, stanchions and 1 spring lashing with help of an empty pallet to prevent movement forward and 1 spring lashing with help of an empty pallet to prevent movement backwards, empty pallets between the coils, LC 1 600 kg, S_{TF} 400 kg
Air suspensions:	The air was released




The trailer loaded with steel coils

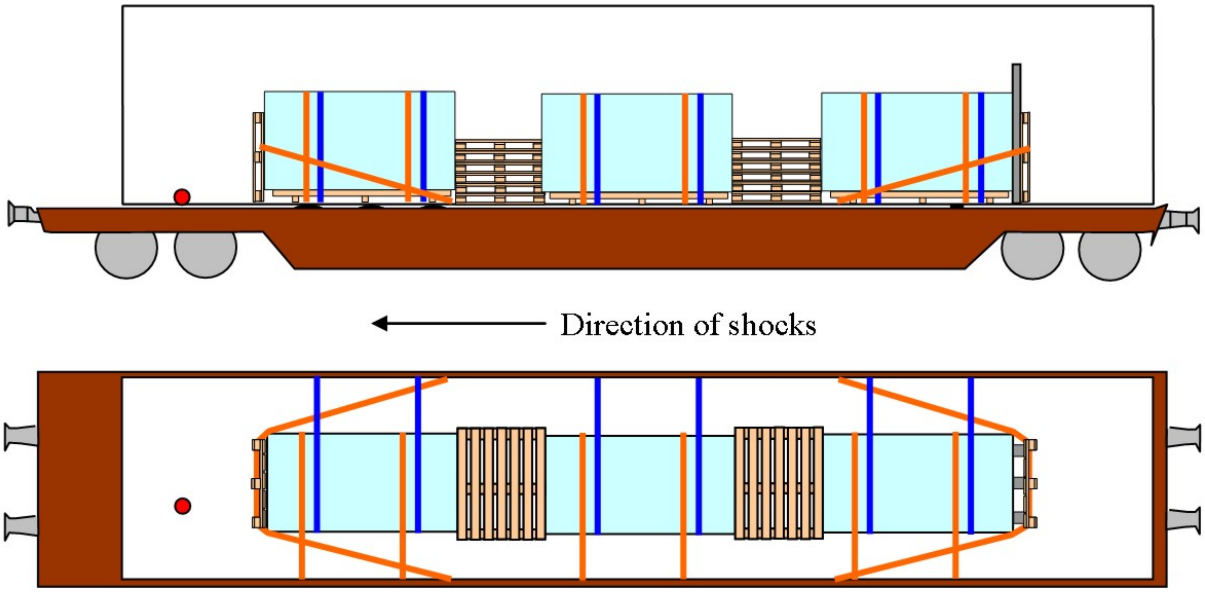


The stanchions, empty pallet and spring lashing for securing in forward direction



The coils were placed in cradles made of wood

The coils were loaded in cradles made of wood and six empty pallets in height were placed between the coils. The spring lashings were secured with help of empty pallets both in forward and rearward direction. Stanchions were also used for securing in forward direction.



Loading and securing of the steel coils from Outokumpu seen from the side and from above

Required cargo securing

The coils were blocked in forward direction. According to calculations the static friction is 0.3 and the six loop lashing pairs and the spring lashing to prevent movement backwards will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by stanchions and a spring lashing		
Backward		0.37	0.37	0.37
Sideways		1.06	1.05	0.99

In the calculations for the accelerations backwards the six loop lashings are considered as six top-over lashings with the angle between the lashings and the platform bed of 45°.

Extract from UIC Loading Guidelines:

Loading guidelines 1.3.1

Coiled sheet (greased or ungreased)

Single wagons and groups of wagons	Wagons in block trains and combined transport Wagons with long-stroke shock-absorbers

Type of goods

Coiled sheet, loaded on the roll, with a maximum weight (individually or per group) of 7 t.

① – each coil bound twice around the circumference,
② – greased metal sheets should also be bound 3 times through the mandrel hole,
③ – several coils bound together 4 times through the mandrel hole.

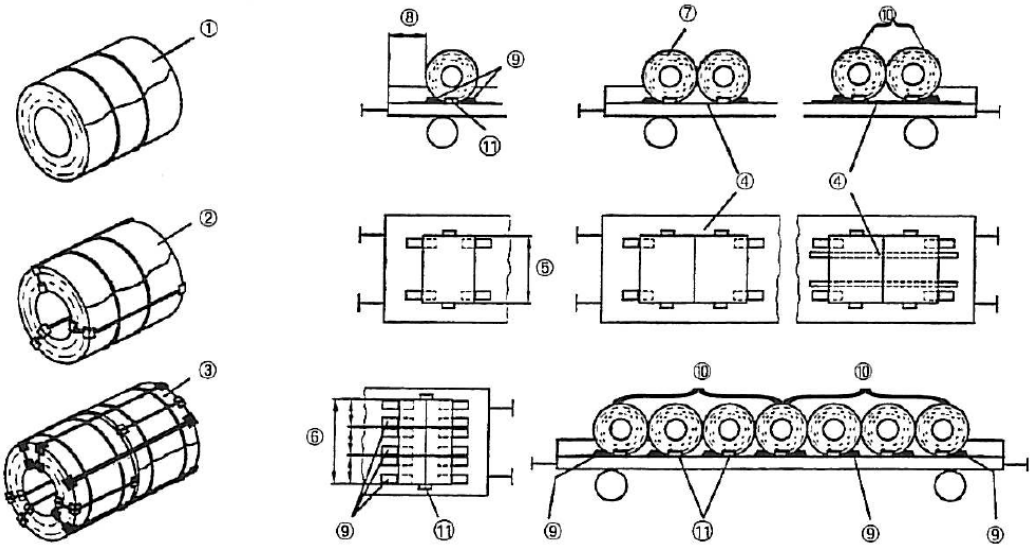
Type of binding : steel strip with a breaking strength of at least 14 kN for binding individual rolls and at least 20 kN for binding together several coils.

Wagons

Wagons with walls or sides and wooden floor (K..., Li..., Re..., H..., Si..., T....).

Method of loading

④ – Coiled sheet loaded directly onto the wagon floor or on softwood timbers laid lengthways in the wagon (cross-section of approx. 5 x 12 cm) resting on the broader face
⑤ – individually, when the width is at least 5/10 of the diameter,
⑥ – side by side and bound into one unit when the width of each individual coil is at least 1/3 of the diameter and the total width of each unit is at least 7/10 of the diameter,
⑦ – in groups, one behind the other (touching) ; for loads in excess of 7 t, separate groups should be formed,
⑧ – clearance : at least 50 cm..



Securing

⑨ – lengthways in the wagon
each coil – even when several coils are bound to form one unit – shall be secured on either side by at least 2 scotches in each running direction.

⑩ Groups (max. 7 t) as shown in the diagram
Scotch dimensions : minimum height 12 cm, minimum breadth 12 cm, angle of slope approx. 35°.
Number of nails in the scotches on each side (total).

1 nail / 500 kg of load	1 nail / 2,000 kg of load

⑪ – across the wagon
each coil shall be secured with stop scotches at least 5 cm thick and with at least 3 cm effective height.
Number of nails in scotches on each side (total) : 1 nail / 1,500 kg. At least 2 nails per scotch.

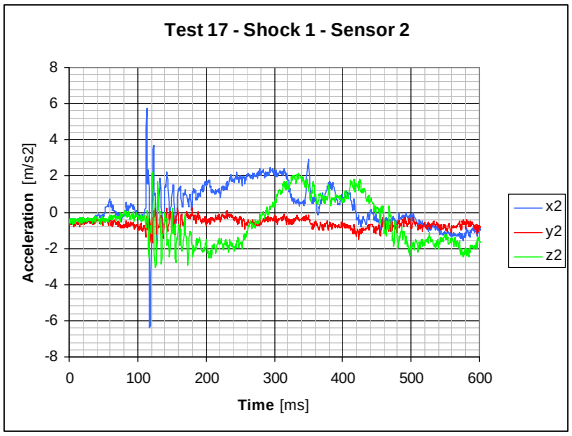
Additional indications
Distribution of load : see sheet 0.1.

1.10.2001

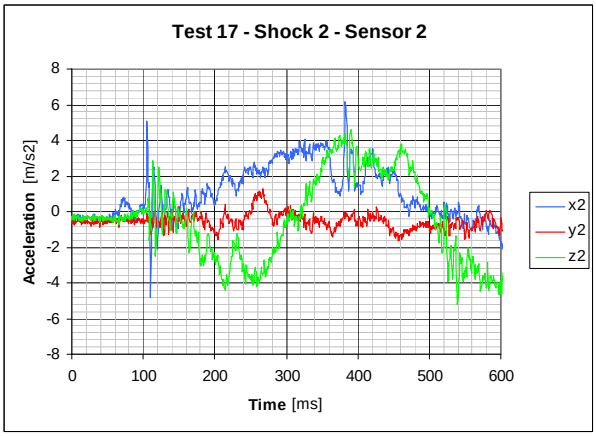
The instruction in UIC Loading Guidelines is valid for coils weighing up to 7 ton. The total weight of the three coils is 21 455 kg, just more than 7 ton each. The coils should be secured by scotches lengthways as well as across the wagon. The actual securing does not fulfil the instruction above and is therefore not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s² during shock 1



Measured accelerations in m/s² during shock 2

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s²]	[g]	**Measured dislocation of steel coils** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	3.32	1.94	0.20	None	None
2	4.21	3.17	0.32	None	None

There was no observed movement among the steel coils during none of the shocks.

3.8.18 Test 18 – Steel sheet metal and steel coil from Outokumpu in a trailer

Test number 18 was with steel sheet metal and a steel coil from Outokumpu in a trailer from Nils Hanssons Åkeri. This unit arrived from Ljungbyhed by road and there had been no movement during this transport.

The following information about this unit is available:

Unit:	Trailer cover/stake type with drop sides
Unit number:	AYW 103
State of the floor:	Plyfa, dry and clean
Net weight:	22 382 kg of which the coil weighs 10 000 kg
Load pattern:	Steel sheet material in 3 or 4 layers in 4 sections, a plasticized steel coil stowed in the middle
Friction:	0.4 between stacked steel sheet metal and 0.3 between a plasticized coil in a cradle made of wood (according to practical tests performed at Outokumpu in Avesta 2008-03-12 -- 14)
Securing:	3 top-over lashings per section of steel sheet metal, battens between each layer of steel sheet metal, cradle of wood for the coil, 4 false loop lashings on the coil, H-frames between the coil and section 3 and between section 3 and 4
Air suspensions:	The air was released





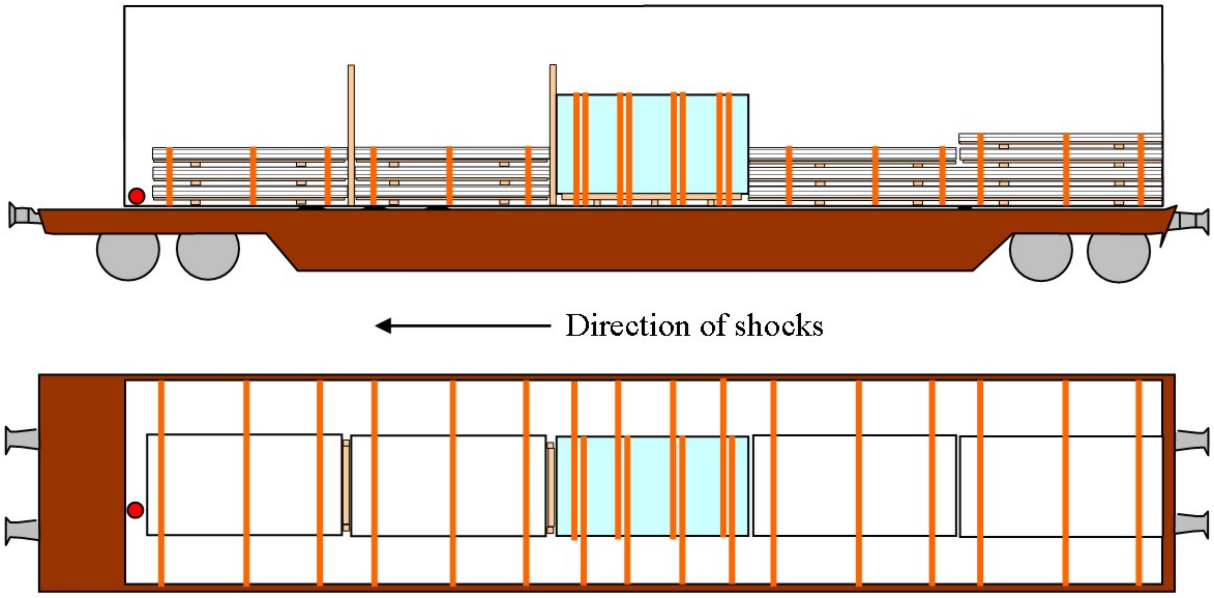
The trailer loaded with steel sheet metal and a steel coil from Outokumpu



The coil was secured with 4 false loop lashings



Each section of steel sheet metal was secured with 3 top-over lashings



Loading and securing of the steel sheet metal and the steel coil from Outokumpu seen from the side and from above

Required cargo securing

The steel sheet metal and the steel coil were blocked in forward direction. According to calculations the static friction is 0.4 and 0.3 and the 12 top-over lashings on the steel sheet metal (with the approximate angle between the lashing and the platform of 45°) and the 4 false loop lashings on the steel coil (assumed to be 4 top-over lashings with the angle 45° between the lashing and the platform) will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	Blocked by the headboard		
Backward		0.50	0.45	0.45
Sideways		0.62 / 0.37	0.56 / 0.34	0.45 / 0.25

The accelerations sideways are calculated for both the steel sheet metal and the steel coil in the following order: steel sheet metal / steel coil.

Extract of UIC Loading Guidelines:

Loading guidelines 1.2.2

Steel sheet in packages on bound-in timbers placed crossways, able to slide

Single wagons and groups of wagons	Wagons in block trains and combined transport Wagons with long-stroke shock-absorbers

Type of goods

① Packages of steel sheet on grooved timbers, bound-in crossways.

② Height of packages
- max. 75 cm with U-shaped edge protection or closed steel sheet packing,
- max. 50 cm without edge protection or packing.

③ Packages should be bound crossways with steel strip (breaking strength at least 1,400 daN) at intervals of approx. 1 metre and at least 3 bindings for packages ≤ 3 m. Synthetic straps should only be used with edge protection.
If the 1 m spacing cannot be observed when binding the packages together, the missing bindings should be compensated for by additional fastenings on the stacks ⑧

Wagons

Wagons with wooden floor (K.., Li.., R.., E.., G.., H.., Si.., T..)

Method of loading

④ Packages of the same length and width in up to 6 tiers and a stacked height of 1.25 m, though no higher than the width of the packages. Goods spread evenly over the wagon floor insofar as possible (in compliance with ⑦). The difference in height between two adjacent stacks must be less than the height of one package. Between the individual packages, use friction inserts or non-slip packaging (μ min. 0.7).

⑤ Smaller individual packages on the top of the stack.

⑥ Stacks loaded lengthways in the wagon on skids made from hard fibre panel (rough side facing down) or from other suitable material. The number, width and thickness of the skids must be such that the bound-in wooden timbers do not touch the wagon floor (at least 3, spread regularly beneath the stack, min. width 15 cm).

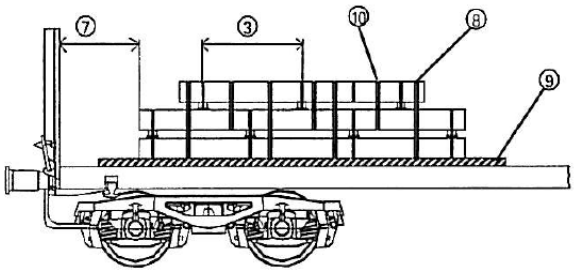
⑦ Clearances to be left at the wagon ends :

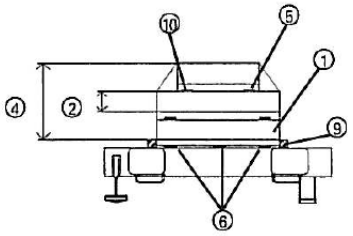
at least 50 cm	0 cm

⑧ Stacks bound together crossways
with **woven straps** with edge protection, min. breaking strength 2,500 daN (straight pull) :
- at least 3 bindings for stacks of length ≤ 3 m,
- at least 4 bindings for stacks of length > 3 m.

or

with **steel strip**, min. breaking strength 2,000 daN
- at least 3 bindings for stacks of length ≤ 3 m,
- at least 3 bindings for stacks of length > 3 m + 1 binding every additional 2 m.





Securing

– **Lengthways** in the wagon
Stacks loaded with possibility of sliding
– **Across** the wagon
⑨ Secured with guide-pieces, min. height 5 cm, min. working height 3 cm. Fixed to the wagon floor with 1 nail per 1,500 kg of load and at least 2 nails per guide-piece. Nails should have a min. diameter of 5 mm and penetrate at least 40 mm into the wagon floor.
⑩ Smaller packages on the top of the stack secured with
– friction inserts (μ min. 0.7) and
– fastenings to join them to the package below (for number of bindings and their arrangement see ⑧).

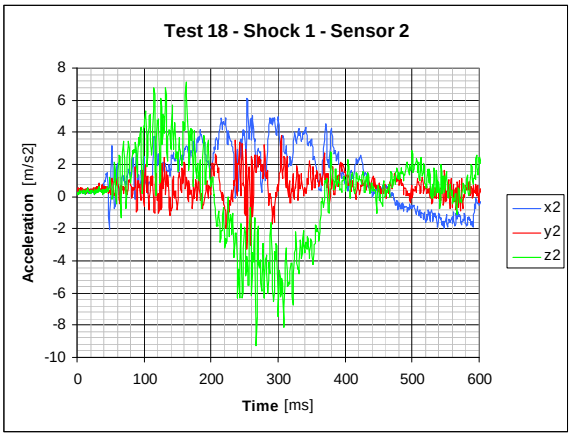
Additional indications
Distribution of load : see sheet 0.1.

1.10.2004

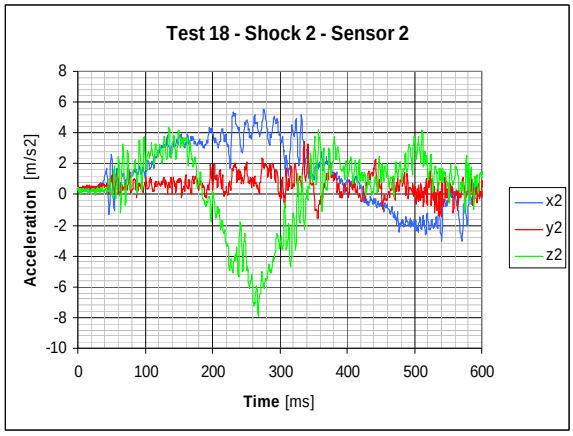
According to test number 17 it can be established that for a coil weight of 10 ton there are no instructions in the UIC Loading Guidelines. The steel sheet metal should be secured with guide-pieces across the trailer and the securing of the steel sheet is also not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s² during shock 1



Measured accelerations in m/s² during shock 2

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s²]	[g]	**Measured dislocation of sheet and coils** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	4.21	3.34	0.34	None	None
2	4.33	4.08	0.42	None	None

There was no observed movement among the steel material during none of the shocks.




No movement of the steel material was observed after none of the shocks

3.8.19 Test 19 – Paper pulp from Södra Cell in a swap body

The 19th and final test was with paper pulp from Södra Cell in a swap body from Norfolkline. This unit arrived from Mörrum by road and there had been no movement among the pulp during this transport.

The following information about this unit is available:

Unit:	Swap body, cover/stake type with drop sides
Unit number:	NFL 2953
State of the floor:	Plyfa, dry and clean
Net weight:	14 000 kg
Load pattern:	7 sections (units) á 2 000 kg; 8 pulp bales in 2 rows and 4 layers in each section
Friction:	0.45 (according to practical tests performed at Södra Cell in Mörrum 1998-03-17)
Securing:	1 top-over lashing per section on sections in the middle (section 2, 3, 4, 5 and 6) and 1 spring lashing on the front as well as on the rear section, LC 1 700 kg, S_{TF} 350 kg



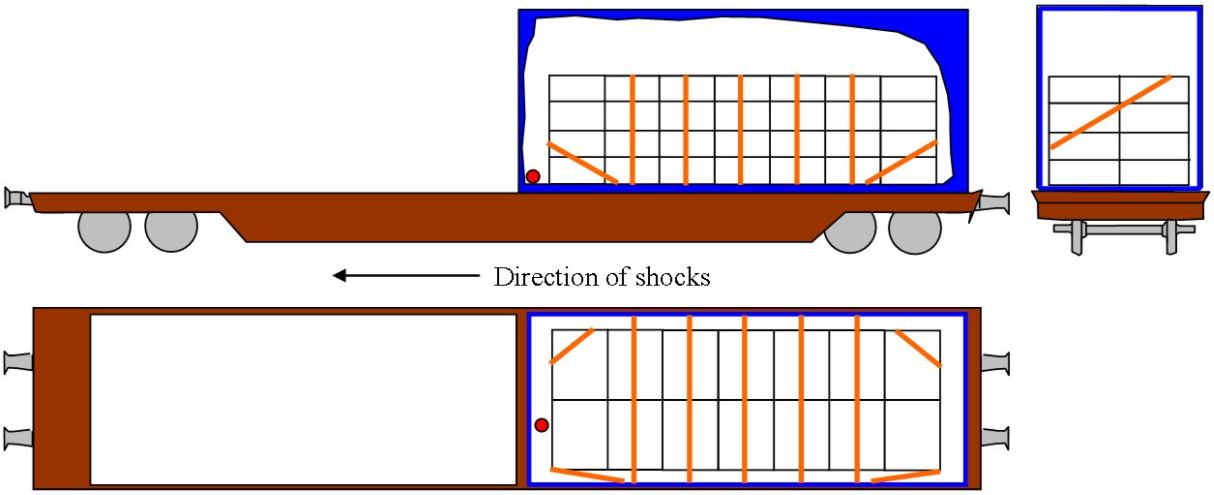

The swap body loaded with paper pulp from Södra Cell



The spring lashing on the rear section



The pulp bales in sections 2-6 were secured with one top-over lashing per section



Loading and securing of the paper pulp from Södra Cell seen from the side, from above and from behind

Required cargo securing

According to calculations the static friction is and the five top-over lashings and the two spring lashings will manage to withstand the following accelerations, expressed in g:

	UIC Loading Guidelines	IMO road	EN 12195-1 road	EN 12195-1 railway (combined)
Forward	Not accepted according to below	0.64	0.60	0.60
Backward		0.64	0.60	0.60
Sideways		0.58	0.53	0.40

Extract from UIC Loading Guidelines:

Wood pulp in bales (in units)

Single wagons and groups of wagons	Wagons in block trains and combined transport

Type of goods

Wood pulp in bales, bound lengthwise and crosswise with bands

① – 6 or 8 bales should be bound together to form a single load unit, no higher than 190 cm (breaking strength of the bindings at least 7 kN)

Wagons

Wagons with sides or stanchions (K..., La..., R..., S...)

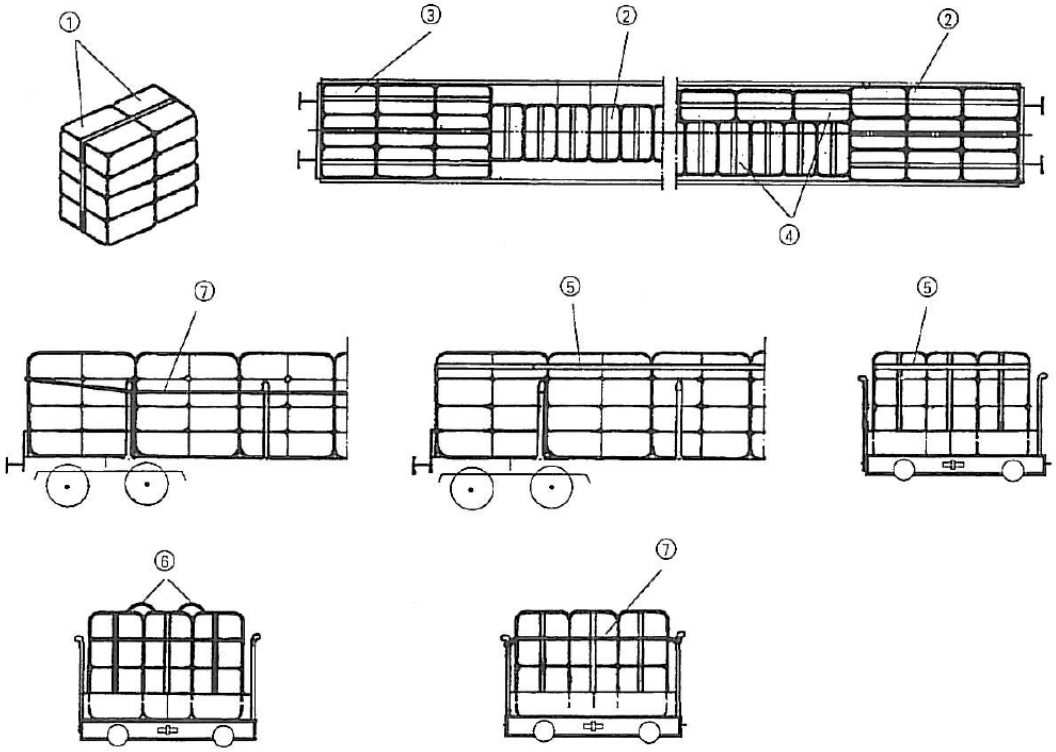
Method of loading

Load units should be

② – spread evenly and without gaps over the full loading surface

③ – at the ends, at least one row end-on (lengthwise)

④ – placed lengthwise or crosswise in the wagon



Securing

⑤ The upper bales in a unit should be encircled with a band secured against slipping off.

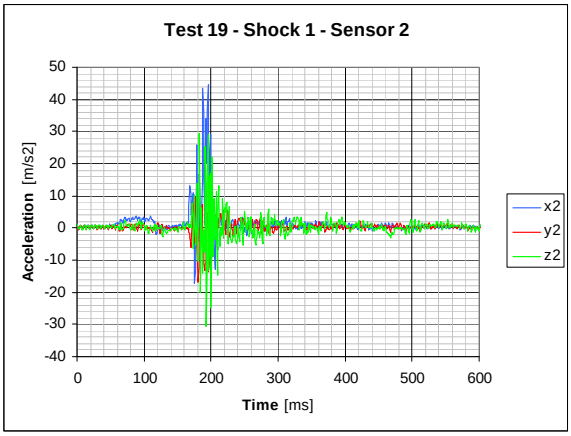
⑥ Adjacent load units should be bound together or

⑦ stanchions should be tied together horizontally in the top third, transverse fastening at each stanchion (e.g. looped). Breaking strength of binding must be at least 10 kN.

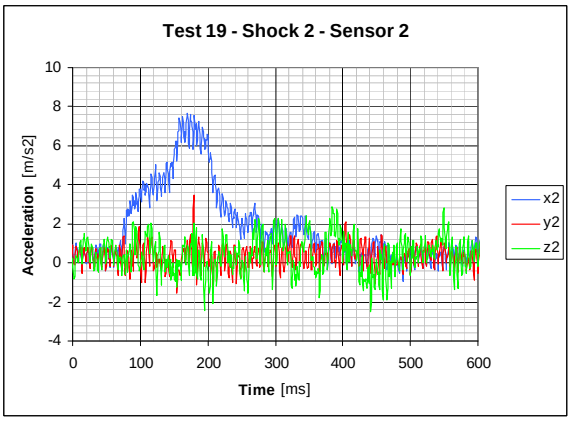
According to UIC Loading Guidelines the units should be loaded “at the ends, at least one row end-on (lengthways)”. The units in this swap body were not stowed against the end walls and the securing was thus not in compliance with the UIC Loading Guidelines.

Recorded speed, accelerations and dislocation during the shocks

The wagon was subjected to two shocks. The position of the shock recording equipment is marked in the sketch above. The equipment produced the following results:



Measured accelerations in m/s^2 during shock 1



Measured accelerations in m/s^2 during shock 2

Please note that the diagrams above are presented in different scales.

Both shocks were produced by letting the wagon hit the impact wagon with the following results:

Shock	**Speed** [km/h]	**Acceleration** [m/s^2]	[g]	**Measured dislocation of pulp bales** [mm] *Distance moved during shock*	*Accumulated moved distance*
1	3.85	4.77	0.49	None	None
2	4.36	5.46	0.56	None	None

There was no observed movement among the pulp bales during none of the shocks.



No movement of the paper pulp bales was observed after none of the shocks

3.9 Summary of the results of the shunting tests

Test no	Cargo transport unit	Type of cargo	Weight (ton)	Air suspension	Shock 1			Shock 2			Shock 3			Cargo securing backwards *		
					Speed (km/h)	Acc (g)	Move-ment (mm)	Speed (km/h)	Acc (g)	Move-ment (mm)	Speed (km/h)	Acc (g)	Move-ment (mm)	IMO	EN road	EN rail
1	Trailer	Square-sawn timber	24.1	Airpressure unknown	3.57	0.15	-	4.32	0.32	-	-	-	-	0.48	0.43	0.43
2	Container	Paper reels	15.562	-	3.92	0.33	20 - 30	5.35	0.87	150	-	-	-	0.40	0.40	0.40
3	Trailer	Paper reels	26.476	Airpressure unknown	4.72	-	-	4.63	-	-	-	-	-	0.93	0.85	0.85
4	Trailer	Bags on pallets	22	Airpressure unknown	4.10	-	-	4.59	-	-	-	-	-	0.75	0.73	0.73
5	Trailer	Octabins	22	Airpressure unknown	4.07	-	-	5.01	-	-	-	-	-	0.78	0.76	0.76
6	Trailer	Liner reels	24.716	Airpressure unknown	4.43	0.42	-	4.64	0.40	-	-	-	-	0.42	0.38	0.38
7	Trailer	Mixed cargo	11.49	Airpressure unknown	4.61	-	5	4.43	-	50	-	-	-	0.40	0.40	0.40
8	Trailer	Lying concrete elements	18.73	Airpressure unknown	4.21	0.41	-	4.03	0.34	-	-	-	-	0.63	0.57	0.57
9	Trailer	Standing con-crete elements	19.28	Airpressure unknown	4.10	0.48	-	4.78	0.48	-	-	-	-	0.64	0.63	0.63
10	Trailer	Barrels on pallets	22.4	Airpressure unknown	4.29	-	-	4.58	0.48	-	-	-	-	0.68	0.66	0.66
11	Swap body	Paper pallets	10.7	-	4.18	0.47	-	3.86	0.40	-	-	-	-	0.74	0.67	0.67
12	Trailer	Cable drums	14.535	Airpressure unknown	3.81	0.34	-	3.96	0.41	-	4.30	0.47	-	0.99	0.99	0.99
13	Trailer	Vibratory roller	16.32	Airpressure released	4.36	0.54	5	4.06	0.45	-	-	-	-	0.88	0.88	0.88
14	Trailer	Steel pipes	27.39	Airpressure released (shock 3)	3.92	0.35	-	4.17	0.38	-	3.89	0.15	-	0.54	0.53	0.53
15	Trailer	Truck cabin	0.55	Airpressure released	3.69	0.71	10 - 15	3.98	0.74	3	-	-	-	1.29	1.29	1.29
16	Trailer	Palletised cargo	20.394	Airpressure released	3.43	-	3	4.38	-	10	-	-	-	0.41	0.37	0.37
17	Trailer	Steel coils	21.455	Airpressure released	3.32	0.20	-	4.21	0.32	-	-	-	-	0.37	0.37	0.37
18	Trailer	Steel sheet metal	22.382	Airpressure released	4.21	0.34	-	4.33	0.42	-	-	-	-	0.50	0.45	0.45
19	Swap body	Paper pulp	14	-	3.85	0.49	-	4.36	0.56	-	-	-	-	0.64	0.60	0.60

* *None of the cargo securing arrangements were in compliance with the UIC Loading Guidelines.*

3.10 Incident on return voyage

The Maersk container loaded with paper reels from Billerud returned from Malmö to Norrköping via Hallsberg some days after the shunting tests. The container was transported by rail on behalf of Green Cargo.

When the container arrived to Norrköping there were visible damages of the container doors. The only explanation for the origin of these damages is that the container has been shunted at much too high speed which caused the reels to crash against the doors. Considering that the container was shunted in almost 5.5 km/h in the tests (3 - 4 km/h allowed only) this shunting must have been performed in even higher speed to cause that kind of damages to the container doors.



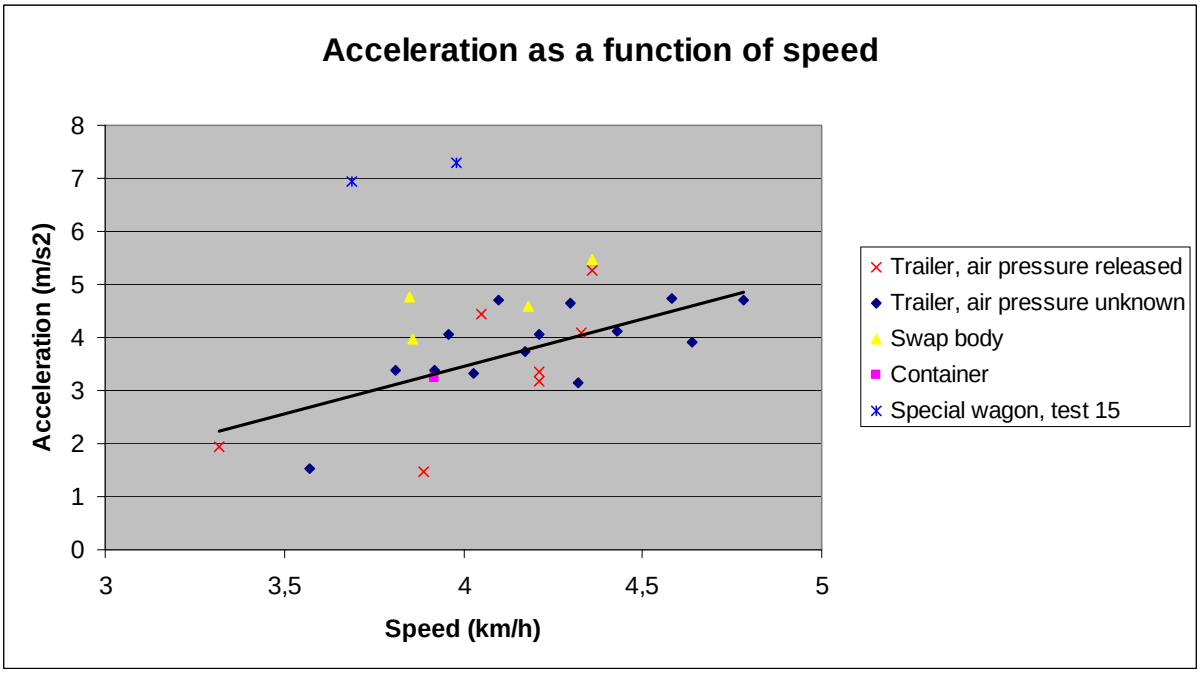
The reels had crashed against the container doors



The container doors were demolished by the paper reels

3.11 Conclusions

The results of the shunting tests are summarized by plotting the mean acceleration values in m/s^2 during 0.1 seconds (100 ms) as a function of the shunting speed in km/h. For those of the tests where the accelerometers were out of order have of course not been possible to plot. The tests have been divided into the following categories; trailer; with air pressure released and unknown if the air pressure was released or not, swap body, container and the trailer with the special wagon in test 15. The following diagram is obtained:



The mean acceleration values plotted as function of speed

The diagram shows that the test data received from the accelerometers indicates that, if performing impacts within the stipulated speed ranges 3 - 4 km/h, the acceleration 0.5 g (4.9 m/s^2) will not be exceeded in longitudinal direction. Please note that the data from the second shock in test 2 (speed 5.35 km/h, acceleration 0.87 g) with the container is not plotted above. This result gives an obvious assignment that it is sufficient for the cargo in cargo transport units for combined road/rail transports to be secured according to the road regulations in longitudinal direction.

Although the cargo securing in six of the 19 units was designed for accelerations lower than 0.5 g, the cargo did not move in longitudinal direction as long as the shunting speed was within the prescribed limits.

From the diagram above it may also be concluded that there seems to be no difference in the relation between the acceleration and speed if the air pressure in the suspensions of a trailer is released or not. Though, the accelerations in the swap bodies are somewhat higher than in the trailers as these types of units are more rigidly fixed to the wagon.

The results for the unit loaded with a truck cabin from Scania in a MEGA-trailer from Ewals Cargo (test 15) in the diagram above differs from all the other units. The cause of this is probably that this unit was loaded with 550 kg only. According to the instructions for shunting tests in the UIC Loading Guidelines the test wagon should be “loaded as far as possible to maximum capacity (part load: insufficient)”. The test wagon should also be fitted with category A or B buffers. The buffers of this wagon are suspected to be of category A but this has not been confirmed.

There were movements among the cargo in five of the 19 units during the shunting tests. In 3 of these; the trailers loaded with a roller (test 13), with a truck cabin (test 15) and with cardboard boxes on pallets (test 16), the observed movements were very small only. In the

other two units; the container loaded with paper reels from Billerud (test 2) and the mixed cargo from IKEA in a trailer (test 7), the cargo was loaded without any lashings and the speed was higher than the prescribed 3 - 4 km/h.

The unlashed cargo in test 2 and 7 should not have moved during the shocks as the horizontal accelerations were lower than the static friction. The reason for the movements could be that the vertical accelerations (vibrations), z2 in the acceleration diagrams, have decreased the friction effect of the unlashed cargo. This shows that if the coefficient of friction is 0.5 or higher the cargo should be secured against wandering and if it is lower than 0.5 the cargo has to be secured by lashings or blocking in longitudinal direction.

From the acceleration diagrams shown in the descriptions for the different tests above it may be noted that there, in spite of about same mean acceleration values, are much higher peaks for the units in test 2, 11, 15 and 19 than for the other units. These peaks may be explained by the rigidity of the securing of containers and swap bodies to the wagons compared to the securing of trailers as well as of the limited weight of the truck cabin in test 15.

The cargo securing did not fulfil the instructions in the UIC Loading Guidelines in none of the 19 units. The fact that this regulation was not fulfilled in any of the units shows that other securing techniques are used by road operators than assumed by the rail authorities.

The incident on the return voyage of the container loaded with paper reels from Billerud shows that cargo transport units in combined rail may not be hump flied before better shunting techniques is developed.

The shunting tests were performed to examine movements in longitudinal direction during shunting. Though, four of the 19 units were transported by combined road/rail transport to Malmö (test 2, 3, 6 and 14) which enabled to also examine movements sideways in these units. There had been movement in one of these four units only. This unit was the container loaded with paper reels from Billerud. The cause of the movement must have been the vibrations and that the reels had not been 100% compactly stowed. The movement could in no way be regarded as causing any danger to the rail safety. Additional test transports to examine the behaviour in transverse direction of the cargo in combined transport units have been carried out and is described in chapter 4 of this report.

4. Test transports

Further to the shunting tests, test transports have been carried out within the project, where the loading and securing of different types of cargoes in CTUs were documented prior to and after a combined rail transport on different relations.

In the test transports that are documented in this chapter, the loading and securing of the different cargoes where performed in accordance with the applicable road regulations, i.e. the IMO Quick Lashing Guides which is referred to in section 8.6 in the *European Best Practice Guidelines on Cargo Securing for Road Transport*.

4.1 Documentation principles

The selection of units for studying as test transports where carried out by two different principles:

1. Multiple units with identical cargo units were documented by industry representatives in the project, throughout the whole transport chain on selected relations.

2. Random units where selected at rail terminals and documented prior to and after the rail haulage.

For each unit the cargo type and properties, type and classification of the cargo transport unit as well as the means of cargo securing were recorded. The original position of the cargo was marked on the platform floor and any movement was noted upon arrival at the destination.

In addition to a written protocol, each unit was also documented by photos taken prior to and after the completed transport. An example test transport protocol is amended as Appendix A to this report.

4.2 Test transports carried out by industry representatives

The test transports conducted within the project by industry representatives are listed in the table below:

Company	Hauler	Cargo	CTU	Relation
Korsnäs	Maersk	Paper reels	Container	Gävle (SE) – Gothenburg (SE)
DHL		General cargo	Trailer	Helsingborg (SE) – Paris (FR)
Volvo Cars	Green Cargo	Steel racks (cars)	Trailer	Olofström (SE) – Gent (BE)
Södra Cell	Norfolkline	Pulp	Swap body	Mörrum (SE) – Turino (IT)
Ikea	Bring	General cargo	Trailer	Älmhult (SE) –

Company	Hauler	Cargo	CTU	Relation
				Oslo (NO)
Scania	Ewals Cargo	Truck cabins	Trailer	Oskarshamn (SE) – Zwolle (NL)
Outokumpu	DSV	Steel coils	Trailer	Avesta (SE) – Azay sur Cher (FR)
Peterson Linerboard	DHL	Paper reels	Trailer	Trondheim (NO) – Oslo (NO) – Malmö (SE)

For each relation above, the aim was to document the transport of approximately 10 units, which has not been possible for all of the cargo types. The results from each series of test transports are presented in separate subchapters below.

4.2.1 Test transports from Korsnäs, Gävle

Two sets of containers with 5 containers each were loaded with paper reels and transported with train from Gävle to the port of Gothenburg on the 29th and 30th of Mars 2010 respectively.

The following transport route was used:

- By road: Korsnäs, Gävle (SE) – Port of Gävle (SE) Appr. 10 km
- By rail: Port of Gävle (SE) – Port of Gothenburg (SE) Appr. 600 km

The paper reels were block stowed in zig-zag patterns in one or two layers. All reels were originally stowed a few centimetres from the sides of the containers.



MSKU 137324-1



FRLU 861519 7

The reels were placed on carton blocks. Carton blocks had also been used to block the reels against the left container door. Their original position had been marked with crayons on the floor and on the sides of the container. In order to check the rotation of the reels, matching lines had also been drawn on top of some reels.
The notes taken in Gothenburg for each container are listed with the photos below.

Containers departed 2010-06-29

The five containers in this shipment contained 12 reels each, which were partially stacked in two layers and had the following approximate dimensions:

- Width: 1250 mm
- Diameter: 1500 mm
- Weight: 1800 kg

The movements of the reels in these containers are noted under the photos below.

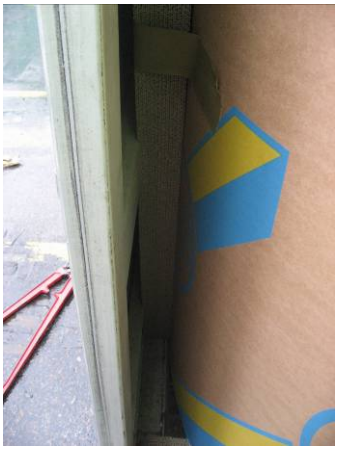




MSKU 137 324-1

No noticeable movements where recorded.





MSKU 890 942-3

The outermost reel had moved some 5 cm against the door, squeezing the carton block. It had also moved approximately 2 cm towards the right hand side.





MSKU 982 270-8

All reels had moved approximately 1 cm against the doors (the carton block had been slightly squeezed). No rotational movements were noted.



MSKU 095 834-0

All reels had moved towards the front end gable and possibly rotated some degrees. Shaving damages where noted. The reels had also moved towards the sides.



MSKU 873 389-0

All reels had moved approximately 1 cm against the doors. The carton blocks underneath the reels had moved with the reels.

Containers departed 2010-06-30

The five containers in this shipment contained 9 reels each, which were stowed in one layer only and had the following approximate dimensions:

- Width: 1500 mm
- Diameter: 1500 mm
- Weight: 2000 kg

For records of movements, see photos below.




FRLU 861 519-7

No noticeable movements where recorded.




MSKU 611 984-3

The outermost reel had moved appr. 2 cm against the door and 2 cm towards the right hand side.
Second last reel had moved up against the right hand side wall.
The carton blocks underneath the reels had moved with the reels.




MSKU 630 598-0

No noticeable movements where recorded.




MSKU 673 588-9
The outermost reel had moved approximately 1 cm forward. The reel had moved on the carton blocks.




MSKU 650 190-0
No movement of the outermost reel was noted.
The 3rd reel from the doors had moved up against the side.

The block stowage of the reels allowed for some minor dislocations, but in no case the container or the reels were damaged. In some containers, no movement whatsoever was detected even though the reels were free to move some centimetres.

It can be concluded that reels may safely be block stowed in containers as described above, without risking damages to either the container or the cargo during intermodal transports by rail.

4.2.2 Test transports from DHL, Helsingborg

The stowage and securing of the cargo in two trailers were documented during loading in the DHL terminal in Helsingborg on the 13th of April 2010. However, only one of these was eventually inspected at arrival in Paris, France, and thus only the result from one trailer is presented below.

The following transport route was used:

- By road: DHL, Helsingborg (SE) – Port of Helsingborg (SE) Appr. 10 km
- By rail: Port of Helsingborg (SE) – Paris (FR) Appr. 1300 km
- By road: Distribution, Paris (FR)

The trailer was a curtainsided trailer with plyfa floor **not** build to the EN 12642-XL standard.

The cargo consisted of general cargo, block stowed against the head board and, in most cases, from side to side. The total weight of the cargo was 9.5 ton.

The original positions of the cargo items were marked on the floor with crayons.

Most sections of cargo were secured with one top-over lashing, most of which was marked with STF 400 daN. In total 10 top-over lashings were used. In some cases, empty pallets were used to block off void spaces. The stowage and securing of each section of cargo at departure and arrival is presented in the photos below, along with notes taken on the stowage, securing and movement of the cargo.



Section 1 (Departure)



Section 1 (Arrival)

The pallets in the 1st section had a weight of approximately 600 kg each and were secured with 2 top-over lashings. No movement was detected.



Section 2 (Departure)

This section was secured by one top-over lashing. No movement was detected.



Section 3 & 4 (Departure)



Section 3 (Arrival)

Section 3 was secured by one top-over lashing, while section 4 was unlashed. No movement was detected.



Section 4 & 5 (Departure)

The machinery part at the top of section 5 was bolted to the pallet.



Section 5 (Departure)



Section 5 (Arrival)

The sturdy pallets with wooden rims in section 5 were secured with one top-over lashing. No movement of the cargo was detected.



Section 6 (Departure)



Section 6 (Arrival)

Section 6 was secured with one top-over lashing. No movement of the cargo was detected.



Section 7 & 8 (Departure)



Section 7 & 8 (Arrival)

Sections 7 and 8 were secured by one top-over lashing. No movement was detected for any of the sections.



Section 9 (Departure)



Section 9 (Arrival)

The parcel was probably damaged during handling or stepped on during unloading, as no other cargo unit in the vicinity had moved.



Section 10 (Departure)



Section 10 & 11 (Arrival)

Section 10 was secured by one top-over lashing, and despite the voids between the pallets, the lashing remained tight through out the transport and the cargo didn't move.



Section 11 (Departure)

The tyres and pallets in section 11 were secured with one top-over lashing. During the transport the carton boxes on the bottom pallet collapsed and the upper pallet fell rearwards and the lashing of the tyres fell off (see picture below).



Last sections (Departure)



Last sections (Arrival)

In most sections, no movement of the cargo whatsoever where noticed. The only position where the cargo moved where in section 11, where the bottom boxes collapsed and allowed the lashing to become loose and the upper pallet to fall backwards.

Since the cargo was stowed on wooden pallets it can be assumed that the static friction was approximately μ=0.5, and lashings are needed only to prevent the cargo from wandering during road transports.

It could be concluded that the general cargo secured according to the road regulations in this trailer with soft curtain sides did not move significantly during the rail transport.

4.2.3 Test transports from Volvo Cars, Olofström

The stowage and securing of car chassis in steel racks in trailers were documented during loading at Volvo Cars facilities in Olofström, Sweden. The trailers were then inspected upon arrival at the facilities in Gent, Belgium.

The following transport route was used:

- By road: Olofström (SE) – Alvesta (SE) Appr. 100 km
- By rail: Alvesta (SE) – Gent (BE) Appr. 1200 km
- By road: Gent (BE) – Gent (BE) Appr. 10 km

A total of 11 trailers were inspected during a period from 8th of April to 10th of May 2010.

The racks were loaded into non XL curtainsided trailers with plyfa floor. Each load consisted of 16 racks, stowed in 4 sections, each with two rows and two layers. The total weight of the cargo was 8 928 kg per trailer. The racks were intended to be block stowed against the headboard, but in many cases there were minor voids between the units in the longitudinal directions.

In most trailers, the racks had been secured with one spring lashing at the rear end only. However, in the last 3 trailers 4 spring lashings, one on each section, had been used. Considering a static friction coefficient of μ=0.4 and that the racks had been block stowed against the headboard, both cargo securing methods are in compliance with the road regulations in the forward and rearward direction. Since the curtainsider trailers were not built to the EN 12 642-XL standard, each section should have been secured against sideways movement. Spring lashings are primarily intended for preventing forward or rearward movement, and none of the trailers complied with the road regulations for cargo securing. The most adequate method according to the road regulations would have been to secure each section consisting of four racks with one top-over lashing with a pretension of 400 daN.

Trailer nr	Departure	Arrival	Securing
5013	2010-04-08	2010-04-12	1 spring lashing at the rear end
5004	2010-04-08	2010-04-12	1 spring lashing at the rear end
5003	2010-04-10	2010-04-12	1 spring lashing at the rear end
5006	2010-04-10	2010-04-12	1 spring lashing at the rear end
5014	2010-04-12	2010-04-15	None
5002	2010-04-13	2010-04-15	1 spring lashing at the rear end

Trailer nr	Departure	Arrival	Securing
5011	2010-04-13	2010-04-15	1 spring lashing at the rear end
5004	2010-05-05	2010-05-07	4 spring lashings, one on each section
5006	2010-05-06	2010-05-10	4 spring lashings, one on each section
5007	2010-05-06	2010-05-10	4 spring lashings, one on each section

Results for racks secured with 1 spring lashing and the unlashed racks

Trailer nr	Comments	
5013	Rack 066	Rear positioned, moved 2-3 cm sideways
5004	Rack 045	Positioned in the middle, moved sideways, sticking over the edge of the platform floor a bit
5003	Rack 043 Rack 004	Positioned in the middle, stuck out over the edge of the trailer floor. Moved sideways 3-5 cm Moved sideways a bit
5006	Racks 103 -211	Positioned in the middle, moved sideways, sticking out over the edge of the platform floor.
5014	Rack 193 Rack 011	Rear positioned, not lashed!!!, moved a bit towards side. Positioned in the middle, moved sideways at least 5 cm, stuck out over the edge. (rack 011 putting pressure on side stanchion) ***Extra note: <u>None</u> of the racks were lashed!!***
5002	Rack 039 Rack 273 Rack 215	Rear position, moved a bit both lengthwise and towards side In the middle, moved sideways a bit Front position, not lashed, moved sideways at least 5 cm, stuck over the edge of the platform floor
5011	Rack 051 Rack 258 Rack 261	Front position, not lashed! In the middle, moved sideways 3 cm Rear position, lashed but moved a bit towards the side



5004 *(Departure, 2010-04-08)*
The racks closest to the rear end were secured with one spring lashing.



5004 *(Arrival, 2010-04-12)*
The racks had moved sideways all the way towards the trailers curtain side, so that it was sticking out over the edge of the platform floor.



***5003** (Departure, 2010-04-10)*



***5003** (Arrival, 2010-04-12)*
Rack sticking out over the edge of the platform floor.



***5002** (Departure, 2010-04-13)*
Racks at rear secured with a spring lashing with a very unfavourable angle to prevent sideways movement.



***5002** (Arrival, 2010-04-15)*
Rack sticking out over the edge of the platform floor.

In most sections, slight movement (a few cm) of the racks towards the side had been noticed, even on the last section where spring lashings had been used. In some cases the angle of the spring lashing was very unfavourable for preventing sideways movement (see image of trailer no. 5002 above). But even with more favourable angles, motions were noted. If the racks are not stowed very tight against the headboard, they will move forward slightly and the lashing will become less tensioned, thereby loosing its ability to prevent sideways movement by pressing the racks against the flooring.

Despite the motions, the cargo never threatened to protrude through the sides of the trailer, nor was any record made of any trailer having a bulging curtain due to movement of the cargo.

Results for racks secured with 4 spring lashing

Trailer nr	Comments	
5004	Rack 139	2 cm out of position in forward direction, 1.5 cm out of position towards the side
	Rack 090	Moved a bit out of position towards the side
	Rack 901	Moved out of position towards the side (not possible to measure, line not to be seen)
	Rack 082	Moved out of position towards the side appr. 1 cm
5006	Rack 158	1.5 cm out of position in forward direction, 1.5 cm out of position towards the side.
	Rack 275	Appr. 1 cm out of position towards the side
		Other racks were still in position
		Lashings were applied over all top racks.
5007		No movements of the cargo found



5007 *(Departure, 2010-05-06)*
All sections were secured with one spring lashing each.



5007 *(Arrival, 2010-05-10)*
This was the only trailer in which no movement of the cargo was recorded.

Just as in the previously sent trailers, where the racks had been secured with one spring lashing only, the lashings lost their effect in the sideways direction since the racks moved slightly against the headboard.

In the last trailer however, the racks were properly stowed against the headboard, and the securing was in compliance with the principles of the road regulations. In this trailer the cargo did not move. It can thus be concluded that it is possible (and safe) to use this securing method in both road and rail transports.

The following conclusions can be reached from the test transports from Volvo Cars:

- There is a considerable wandering effect for unsecured rigid cargoes during rail transport.
- It is more efficient to prevent wandering in the sideways direction by using top-over lashings than to use spring lashings.
- For spring lashings to have the desired effect, it is necessary to achieve a tight stow, all the way in the longitudinal direction.
- In no case the racks had moved outside the extreme width of the trailer even though they were unlashed and the sides consisted of soft curtains of non XL class.

4.2.4 Test transports from Södra Cell, Mörrum

The stowage and securing of pulp packages in swap bodies were documented during loading at Södra Cell's facilities in Mörrum, Sweden. The swap bodies were then inspected upon arrival at Ahlstrom Turin SPA in Italy.

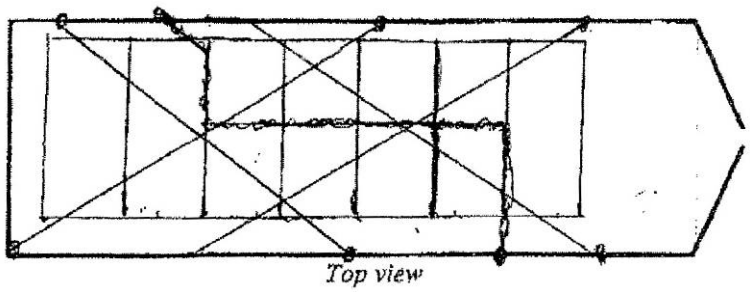
The following transport route was used:

- By road: Mörrum (SE) – Malmö (SE) Appr. 150 km
- By rail: Malmö (SE) – Busto Arizio (IT) Appr. 1500 km
- By road: Busto Arizio (IT) – Mathi Canavese (Turin) (IT) Appr. 150 km

A total of 10 swap bodies were inspected in a shipment that departed on 26th March and arrived on 1st April 2010. Each swap body had cover/stake sides and plyfa floor and contained between 6 and 8 pulp packages width the following dimensions:

- Length: 0.9 meter
- Width: 1.6 meter
- Height: 1.7 meter
- Weight: 2.0 ton each

The packages were loaded free standing in the middle of each swap body and were primarily secured with one top-over lashing with a pre-tension of 400 kg each. In two cases however, the packages were secured by lashings that had been applied in order to act both as spring lashings and as top-over lashings, as illustrated in the figure below.



Securing pattern in units 2579 and 2606.

The original positions of the packages were marked on the floor with crayons. The number of packages and the number of lashings in each swap body is given in the table below.

Swap body	Number of pulp packages	Lashings
2968	8	8, top-over
2806	6	6, top-over
1621	7	7, top-over
1660	7	7, top-over
2946	6	6, top-over
2962	8	8, top-over
2579	7	5 top/cross lashings
2606	7	5 top/cross lashings
2867	7	7, top-over
2818	7	7, top-over

No significant movement was found in any of the units at arrival.

According to tests performed in 1998, the friction between pulp packages and plyfa is μ=0.4. This means that the top-over lashing securing arrangements may withstand a horizontal force of 0.55 g (5.5 m/s^2). Thus, this arrangement is proficient in sideways and rearwards directions during road transport, but not in the forward direction.



2968, Departure



2968, Arrival



2806, Departure



2968, Arrival



2806, Departure

Pulp packages secured with top-over lashings.



2806, Arrival

The packages were stowed in the centre of the swap body, leaving approximately half a meter void at each side.



2621, Departure

In most swap bodies, a significant void was also left towards the front and rear end gables.



2621, Arrival



2621, Departure



2621, Arrival



2946, Departure

The original position of the packages was marked with crayon on the swap body floor.



2946, Arrival



2962, Departure



2962, Arrival



2579, Departure



2579, Arrival



2606, Departure



2606, Arrival

In this unit the packages had been secured with crossed top-over lashings.



2818, Departure



2867, Arrival

Also in this unit the packages had been secured with crossed top-over lashings.

Since no movement in any direction was found in any of the units, it can be concluded that pulp packages that are properly secured with top-over lashings according to the road regulations may as well be safely sent by combined rail transport.

4.2.5 Test transports from IKEA, Älmhult

The stowage and securing of general cargo (home furniture) in XL curtainsider trailers were documented during loading at IKEAs facilities in Älmhult, Sweden. The trailers were then inspected upon arrival at the IKEA warehouse in Oslo, Norway.

The following transport route was used:

- By road: IKEA, Älmhult (SE) – CargoNet, Älmhult (SE) Appr. 1 km
- By rail: Älmhult (SE) – CargoNet, Oslo (NO) Appr. 550 km
- By road: CargoNet, Oslo (NO) – IKEA , Oslo (NO) Appr. 5 km

A total of 11 trailers were inspected during a period from 3rd through 31st of May 2010. However, only 4 of these were caught for inspection upon arrival.

The cargoes were more or less block stowed against the headboard, back doors and the sides of the trailer. No lashings were used but friction boards were inserted between the different layers of the cargo to obtain a static friction of about 0.5. Since all trailers were XL curtain-siders, the stowage and securing was mostly in compliance with the road regulations. In some cases however, the cargo was not block stowed as tightly as would have been desired, leaving voids of several decimetres to either side. Although high enough friction to prevent sideways sliding was ensured, this would potentially allow the cargo to wander considerable distances towards either side.



Trailer 1 (Departure, 2010-05-03)



Trailer 1 (Arrival, 2010-05-05)

The pallets were tightly block stowed between the strong curtain sides, which showed no deflection upon arrival.





Trailer 1 (Departure, 2010-05-03) ***Trailer 1 (Arrival, 2010-05-05)***

Movement of the pallets were checked upon arrival against crayon marks at the floor of the trailers.





Trailer 2 (Departure, 2010-05-04) ***Trailer 2 (Arrival, 2010-05-05)***

In case the bottom pallets didn't have the same width as the trailer, friction boards were used to support the upper pallets.





Trailer 2 (Departure, 2010-05-04) ***Trailer 2 (Arrival, 2010-05-05)***

Even in cases were proper block stowage had not been achieved, no significant movement was noted.



Trailer 9 (Departure, 2010-05-25)



Trailer 9 (Arrival, 2010-05-27)



Trailer 9 (Departure, 2010-05-25)



Trailer 9 (Arrival, 2010-05-27)

In case the bottom pallets didn't have the same width as the trailer, friction boards were used to support the upper pallets.



Trailer 11 (Departure, 2010-05-27)



Trailer 11 (Arrival, 2010-05-29)



Trailer 11 (Departure, 2010-05-27)



Trailer 11 (Arrival, 2010-05-29)

Most significantly, it can be seen that the side walls of these XL trailers have provided sufficient support for this type of cargo, without complementary lashings.

As seen in trailer 2 above, the bottom pallets don't have to be stowed tightly between the side walls, as long as there is sufficient friction towards the floor beneath them and towards the full width pallets above them. However, in such cases, support from underneath must be provided for the upper pallets over their full width by the use of boards, to prevent them from tipping over.

Furthermore, the lack of significant wandering, which have been seen for other cargoes not held down by lashings in these test transports, may be explained by higher friction and, for cargoes stowed in upper layers, by the dampening effect of the cargoes underneath.

Neither significant movements, nor any damages to the cargo or the trailers were noted in any unit that was part of the test. However, in other units on the same route, when the pallets have not been stowed sufficiently tight or loaded on top of narrower pallets, they have collapsed or toppled over, see example below.



Trailer arriving 2010-05-31 illustrating the need for tight stowage and proper support of the feet of the pallets.

4.2.6 Test transports from Scania Cabs, Oskarshamn

The stowage and securing of cabs in trailers were documented during loading at Scania Cab facilities in Oskarshamn, Sweden. The trailers were then inspected upon arrival at Scania Netherlands BV in Zwolle.

The following transport route was used:

- By road: Oskarshamn (SE) – Nässjö (SE) Appr. 170 km
- By rail: Nässjö (SE) – Herne (DE) Appr. 1000 km
- By road: Herne (DE) – Zwolle (NL) Appr. 170 km

A total of 11 trailers with 5 cabs each were followed during a period from 29th April to 12th May 2010. Each trailer was loaded with approximately 7 tonnes of cargo. The cabs were mounted on steel racks which were secured to the trailer with top-over lashings in accordance with a previously issued cargo securing certificate for road transports.



Lashing arrangement for cabs on steel racks, validated though practical tests.

All trailers were curtainsiders with plyfa floor, built in accordance with the EN 12642 XL standard.

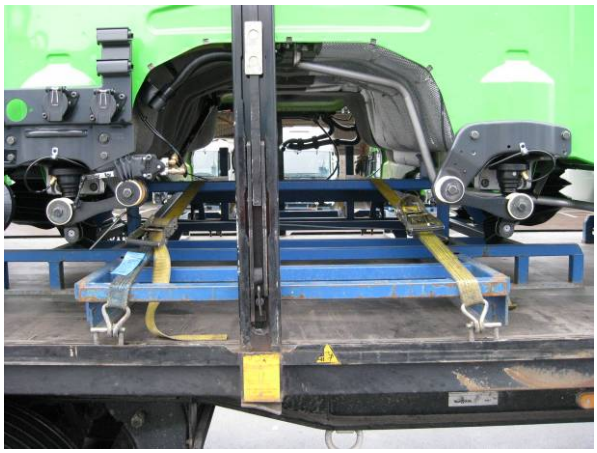
The original positions of the racks were marked on the floor with crayons. No movements of the cargo where noted in any of the trailers upon arrival in Zwolle.



Trailer CCH-7249, Departure



Trailer CCH-7249, Departure



Trailer CCH-7268, Departure



Trailer CCH-7268, Arrival



Trailer CCH-8828, Departure



Trailer CCH-8828, Arrival



Trailer CCH-8856, Departure



Trailer CCH-8856, Departure



Trailer CCH-8902, Departure



Trailer CCH-8956, Departure



Trailer CCH-7260, Departure



Trailer CCH-7283, Departure



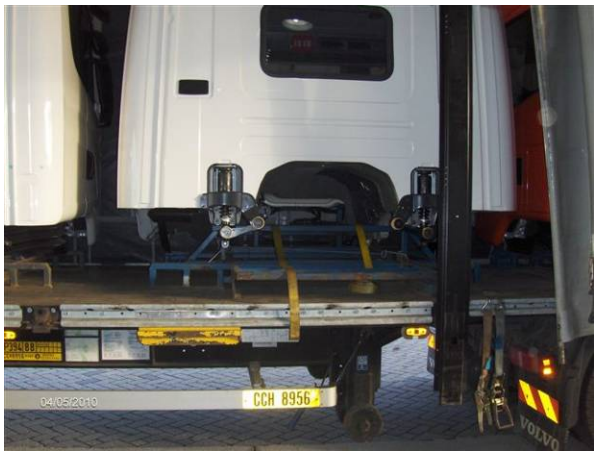
Trailer CCH-7295, Departure



Trailer CCH-9520F, Departure



Trailer CCH-9542F, Departure



Trailer CCH-9542F, Arrival

Since no movement of the cargo were noted during the test transports, it can be concluded that the lashing arrangement that has been certified for road transports by practical tests, may safely be used during combined rail transports as well.

4.2.7 Test transport from Outokumpu, Avesta

The stowage and securing of steel coils in one trailer was documented during loading at Outokumpu's facilities in Avesta, Sweden. The trailer was then inspected upon arrival at Outokumpu SAS in Azay sur Cher, France. The test transport was performed during 18th through 25th of October 2010.

The following transport route was used:

- By road: Avesta (SE) – Eskilstuna (SE) Appr. 120 km
- By rail: Eskilstuna (SE) – Malmö (SE) Appr. 600 km
- By rail: Malmö (SE) – Duisburg (DE) Appr. 700 km
- By road: Duisburg (DE) – Azay sur Cher (FR) Appr. 760 km

In Malmö the trailer was shifted to another wagon.

The trailer was loaded with 3 stainless steel coils in wooden cradles, each with the following dimensions:

- Weight: 7.7 ton
- Length: 2.0 ton
- Diameter: 0.99 m
- Height (incl. wood cradle): 1.09 m

The coils were blocked by stanchions in the forward direction and secured by four top-over lashings with tension force 400 daN each. The lashings were all applied with an angle of approximately 45º towards the trailer floor. Additionally, the coils were secured to the cradles by four plastic straps each. The trailer had a plyfa floor.



Securing arrangement for Steel coils from Outokumpu.

Practical tests performed at Outokumpu´s facilities during 12th through 14th March 2008 showed that the static friction between the stretch film, in which the coils where wrapped, and sawn wood is $\mu = 0.33$. Considering the angle of the lashings and assuming a tension of 100 daN in each of the plastic straps, the coils are secured against a horizontal acceleration of 4.5 m/s^2 (0.46 g) in the rearwards direction. This is slightly less than what is required by road regulations.

The original positions of the coils were marked on the floor with crayons. No movements of the cargo were noted in the trailer upon arrival in Azay sur Cher.



Coils being secured prior to the test transport.



Coils at arrival in Azay sur Cher. The crayon marking shows that the coils have remained in there original position.

Since no movement of the cargo was noted during the test transport, the following conclusions may be drawn:

- The securing of the coils, which was just slightly insufficient of withstanding the rearwards forces prescribed by road regulations, was indeed sufficient for the combined transport by rail.

- The acceleration experienced by the coils in the rearwards direction during the transport, could not have exceeded by far the theoretical maximum acceleration for the securing arrangement, which has been calculated as 4.5 m/s^2.

4.2.8 Test transports from Peterson Linerboard, Trondheim

The stowage and securing of paper reels, in one DHL XL curtainsided trailer was documented during loading at Peterson Linerboard in Trondheim on the 8th of November 2010. The trailer was inspected upon arrival at CargoNet, both in Oslo/Alnabru Norway and in Malmö Sweden.

The following transport route was used:

- By road: Trondheim (NO) – Trondheim (NO) Appr. 10 km
- By rail Trondheim (NO) – Oslo/Alnabru (NO) Appr. 490 km
- By rail: Oslo/Alnabru (NO) – Malmö (SE) Appr. 560 km

The 38 paper reels were stowed in a two layer zig-zag pattern, against the headboard and the sides of the trailer. In the rear there was some space between the reels and the back door. The last reel in the pattern was therefore secured by one top-over lashing, but all other reels were secured by the curtains of the trailer only. The total weight of the cargo was 24 550 kg.

- Width: 1 400 mm
- Height: 762 mm
- Weight: 646 kg each

Paper reels after loading in Trondheim - before departure.

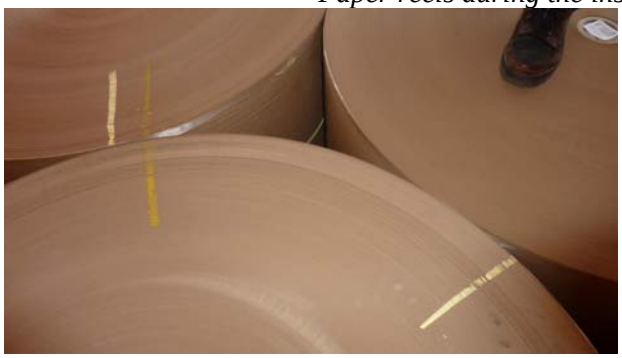


Loading pattern



Lashing over the last paper reel in the pattern

Paper reels during the inspection in Oslo /Alnabru.



Rotation



Overview

Paper reels during the inspection in Malmö.



Overview



Rotation

Curtainsides during the inspection in Malmö



Right side



Left side

The reels were placed directly on the trailer plyfa floor, with no other material between. The original positions of each reel had been marked on the floor with crayons in order to check the presence of wandering. A matching line had also been drawn between the reels, on top, in order to check the rotation.

The results from the inspections are shown in the table below

Paper reel nr.	Rotation Oslo - Malmö	Rotation Trondheim-Malmö	Paper reel nr.	Movement Trondheim - Malmö
4/3	15 cm C	50 cm C	3	2 cm R
6/4	2 cm C	-	4	4 cm R B
5/6	-	-	5 upper	5 cm R (measured from lower)
7/8	30 cm A	50 cm A	5 lower	5 cm R
9/11	5 cm C	-	7	-
9/10	2 cm A	30 cm A	8	4 cm L F
11/10	5 cm C	-	9	4 cm R F
11/12	10 cm C	2 cm A	10	-
13/12	3 cm C	-	11	3 cm R F
15/14	-	-	12	-
15/16	-	-	15	1 cm L
17/18	5 cm C	70 cm C		
19/20	5 cm A	30 cm A		
20/21	-	7 cm A		

Definitions: A = Anticlockwise, C = Clockwise, F = Forward, B = Backward, L= Left, R= Right, - = no rotation or movement

Conclusion

The test transport has shown that the movements of the paper reels in the trailer have occurred randomly, caused by vibrations and lateral forces. There is no sign of significant and individual chocks since no major impact can be seen among the cargo. Some paper reels have, however, moved in a transverse direction in such a way that they have been kept in place by the XL-classed curtainside of the trailer. In these cases the curtain has shown to be strong enough to work as a sufficient securing device, without displacing outside the original trailer dimensions. This can be seen in the pictures above, showing the curtainsides during the inspection in Malmö.

4.3 Test transports carried out between rail terminals

The stowage, position and securing of cargo in about 60 randomly selected cargo transport units were inspected and documented prior to and after a combined transport on rail between Malmö and Stockholm and vice versa.

The inspections were carried out by two teams at the combi terminals in Malmö and Årsta, Stockholm during the period from 27th to 30th September 2010. The distance between the two terminals is approximately 600 km.

Units in three departures from each terminal were inspected. In five out of the six departures, very small movements of the cargo were seen, even for unsecured cargo. However, in close to all the units on one train, significant movements were seen in one direction, indicating significant accelerations probably from shunting. No significant sideways movements were noted in any of the units in this train.

The inspected units included both trailers and swap bodies. The trailers were of box, cover/stake and curtainsider type. The swap bodies were of box and cover/stake type.

The pictures below represent a few examples from the inspected units.

Malmö – Årsta 2010-09-27



Block stowed general cargo in a cover/stake type trailer at departure (left) and arrival (right). Despite the improper spacing between cargo units and walls, no cargo had moved at arrival.



Steel pipes insufficiently secured by a few top-over lashings with unfavourable angle. At arrival (right) the steel pipes had not shifted in any direction.

Årsta – Malmö 2010-09-27



Steel racks in a box type trailer with aluminium flooring. The racks had been secured with a top-over lashing and remained perfectly in place throughout the transport.



Pallets in a box type trailer with aluminium flooring at departure (left) and arrival (right).

Malmö – Årsta 2010-09-28




Steel pipes in a curtainsider trailer at departure (left) and arrival (right). The pipes had been secured with top-over lashings. The trailer was a curtainsider type non XL-classed.




Octabins in a curtainsider trailer, block stowed between the sides and secured rearwards with a spring lashing. The octabins stood on wooden pallets which had been placed on rubber mats.

Årsta – Malmö 2010-09-28

During this transport there was a locomotive break down and the train went out of schedule quite significantly. Upon arrival in Malmö several hours delayed the cargo in most units had shifted a short distance in the same longitudinal direction, indicating that the train had been shunted more heavily than normally probably due to the stressed situation with the delayed train.




Pallets with bread which was tightly stowed in a non XL curtainsider trailer and not secured by any other mean than blocking. The total weight of the cargo was 14 ton. Due to the tight stowage, the pallet had not shifted towards the head board or rear door, nor did the curtain side show any deflection.




General cargo in a box type trailer which had been secured in the rearwards direction by two portable stanchions. At arrival (right) the stanchions had been pushed towards the doors as the cargo shifted rearwards.







The general cargo in this box type 20' swap body had been secured in the longitudinal direction by means of lashings attached in a straight angle to the lashing rails at the side of the unit. At arrival (right) it was noted that the cargo had shifted in the longitudinal direction and the lashing rail was damaged. Lashing rails are not designed to take up forces perpendicular to the walls.




The two smaller pallets in this swap body had been block stowed against the headboard. The larger pallet had been stowed with voids in all directions but secured with one top-over lashing. None of the pallets had shifted during transport.

Malmö – Årsta 2010-09-29




This curtainsider trailer was loaded with 36 pallets with wooden boards. The total cargo weight was 30 ton. The pallets had been secured with 12 top-over lashings. The cargo did not shift during transport and the curtain side showed no deflection upon arrival (right)




Each of the steel racks with cardboard boxes in this cover/stake trailer had been secured with a top-over lashing. No movements of the cargo where noted upon arrival (right).

Årsta – Malmö 2010-09-29




General cargo in a box type trailer prior to departure (left) and at arrival (right). None of the pallets shifted during transport despite not being secured in the longitudinal direction.





The 12 sawn timber packages in this trailer were secured with 15 top-over lashings and centre stanchions. The total weight of the packages was approximately 25 ton. The lashings had only been tensioned to about 100 – 200 daN each. The cargo did not shift during transport.

Conclusions

From the test transports between Malmö and Årsta, Stockholm, and vice versa, it can be concluded that the accelerations that acts on cargo transport units in combined transports are normally very small, in all directions. Some tests were also made with loose lashing equipment placed on the floor in empty trailers and upon arrival the equipment had move just a few centimetres due to vibrations.

In some cases however, significant accelerations, especially in the longitudinal direction, may occur if the train is shunted in excessive speeds. In such cases, improperly secured cargo may shift. In one of the six test transports, damages to cargo as well as to the cargo transport units were seen. It was however concluded that simple cargo securing measures at least satisfying the principles for cargo securing during road transports, including top-over lashings, may prevent shifting of the cargo if significant accelerations occur.

In no case there were any signs of cargo pressing against the unit sides in such a way that the sides deflected, not even where curtainsided units had been used.

4.4 Conclusions of the test transports

The following conclusions have been reached based on the results of the test transports:

- In most inspected units, no signs of significant accelerations in any direction could be detected. Most movements occurred randomly and many due to vibrations during the transport.

- However, shifting of the cargo in the same longitudinal direction in close to all units on one train inspected during the test transports between the rail terminals, showed

that excessive accelerations and cargo movement may occur if the trains are shunted in excessive speeds.

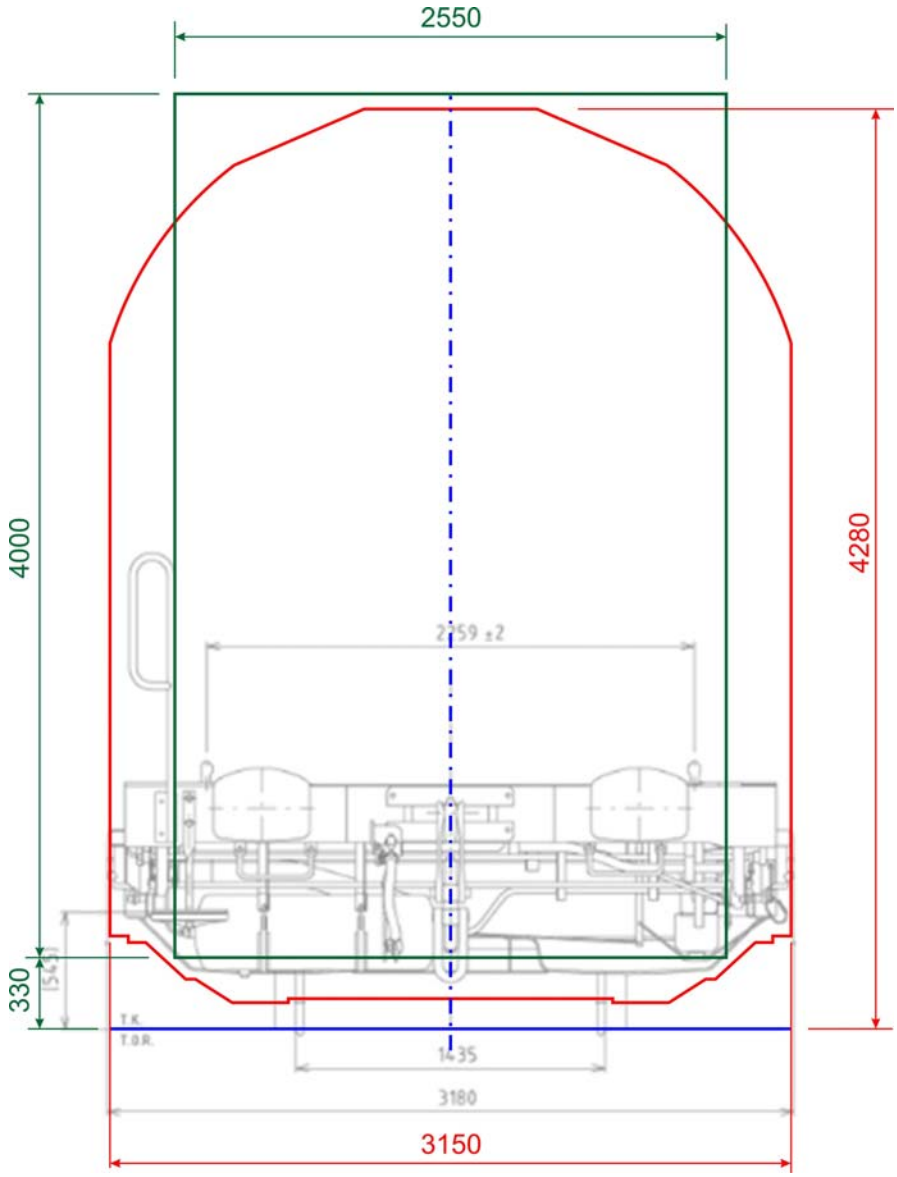
- There were no indications of significant accelerations in the transverse direction in any of the inspected units.
- There is a significant wandering effect for unlashed cargo during intermodal transports by rail.
- High friction and dampening from softer cargoes underneath, as well as top-over lashings, may serve to reduce the wandering effect significantly.
- Paper reels may safely be block stowed in containers during combined rail transports without risking damages to the reels or the containers.
- The curtain sides of XL trailers have in the test transports proved to be able to safely contain the cargo within the unit without showing any noticeable deflection, even when the cargo was inadequately lashed or even unlashed.
- Tight stowage must be achieved in the longitudinal direction, if blocking is combined with direct lashings.
- Indirect lashings (top-over lashings) may be used to safely secure cargo during rail transports.
- In all cases, when properly applied, the securing principles for cargo securing during road transports may serve as safe guidelines also for combined transports by rail.

5. SUITABILITY OF XL-CLASSED CURTAINSIDERS FOR RAIL TRANSPORT

Within the CombiSec project it has been investigated whether a curtainside built according the European standard EN 12642 Code XL can be used for cargo securing during rail transport in the same way as during road transport.

According to the test norms in the standard the sides in a XL-classed unit shall withstand a transverse force of 40% of the payload uniformly distributed over the full length of the side and from the floor up to 75% of the height of the side. During the test the side may not deflect more than 300 mm and after the test the side shall show no permanent deformations.

A deflection of 300 mm is a test requirement only and not an acceptable limit of cargo motion during transport even if the clearance between the vehicle sides and the UIC profile allows for a deflection of 300 mm on either side apart from the uppermost corner, as can be seen in the figure below.





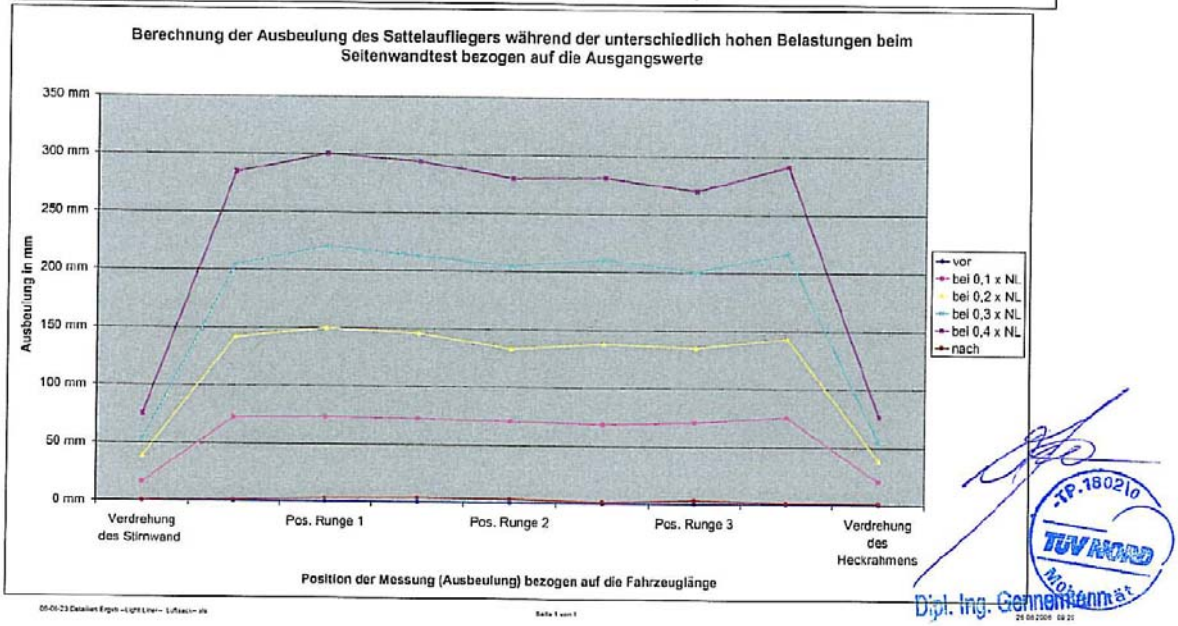
From this photo of a curtainside loaded to 40% of the vehicle's payload it can be seen that the maximum deflection is at about half the height of the side and the upper corner is deflecting much less.

The table and diagram below show that at loadings of the side below 40% of the payload the deflection is considerably reduced. At a loading of 10% (0.1 × NL) the deflection at the most deflected point of the side is about 75 mm only.

berechnete Testwerte

Mess Abstand unten errechnet (Ausbeulung) in mm	Verdrehung des Stirnwand		Pos. Runge 1		Pos. Runge 2		Pos. Runge 3		Verdrehung des Heckrahmens
vor	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm
bei 0,1 x NL	16 mm	72 mm	73 mm	72 mm	70 mm	68 mm	70 mm	75 mm	20 mm
bei 0,2 x NL	39 mm	142 mm	150 mm	146 mm	133 mm	138 mm	135 mm	143 mm	38 mm
bei 0,3 x NL	53 mm	204 mm	220 mm	212 mm	204 mm	210 mm	200 mm	216 mm	54 mm
bei 0,4 x NL	75 mm	284 mm	300 mm	294 mm	280 mm	281 mm	270 mm	291 mm	76 mm
nach	0 mm	1 mm	3 mm	4 mm	3 mm	1 mm	3 mm	1 mm	1 mm

Ergebnis:	Anforderungen der prEN 12642 Code XL wurden erfüllt!



It has not been possible, during the project time, to obtain test results showing the deflection of the upper corner when the curtainside is loaded to different percentage of the vehicle's payload.

From the test transports carried out within the project it has been concluded that the transverse forces during rail transport is limited. The same conclusion was drawn in chapter 5 of the report "*Equipment for Rational Securing of Cargo on Railway Wagons*". The report can be found at the following link:

http://www.mariterm.se/hoganas/download/jvgRASLA%20Rapport%20-%20webutgåva2.pdf

Large transverse forces may occur during shunting in excessive speeds if the cargo due to its shape or loading pattern is pushed outwards when exposed to large longitudinal forces. If a train has been shunted and if it can not be guaranteed that the shunting speed has been within the prescribed limits, its units must be inspected before the train is allowed to depart in rail traffic. Units on which a side is bulging out, independently if the bulge is in a curtainsider or a cover stake body type, must be stopped from further transport on rail in the same way as for road transport.

The largest cargo movements during rail transport have in the past been experienced among liner reels. Due to this, a test transport was carried out, after permission from the rail authorities within the CombiSec project, by such paper reels unlashed in a XL-classed curtainsided vehicle from Trondheim in Norway, via Alnabru in Oslo, to Malmö in Sweden, a distance of more than 1000 km. The reels moved in all directions and rotated considerably due to vibrations, but there was no tendency at all that the reels should press out the curtainsides of the vehicle.

5.1 Conclusions

Based on the tests carried out within the CombiSec project it can be concluded that curtain sides could safetly be used for cargo securing during rail transports in the same way as for road transports.

If wagons loaded by cargo transport units have been shunted they must, however, be inspected before they are allowed to be sent out on the tracks in rail traffic if it can not be guaranteed that the shunting speed has been within maximum prescribed speed. Units, on which a side is bulging out, independently if the bulge is found on a curtainsider or a cover stake body type, must be stopped for further transport on rail in the same way as for road transport.

6. CONCLUSIONS AND RECOMMENDATIONS

Within the CombiSec project the following have been investigated and tested:

- Differences in road and rail regulations
- Required cargo securing in longitudinal direction through shunting tests
- Required cargo securing in transverse direction through test transports
- Suitability of XL-classed curtainsided vehicles for rail transport

Based on these investigations and tests the conclusions and recommendations below have been reached.

6.1 Conclusions

6.1.1 Differences in road and rail regulations

The required number of lashings has been calculated for four different loading examples (see chapter 2) according to:

- The UIC Loading Guidelines
- IMO-method for road transport
- CEN-method for rail transport

Example	Required number of lashings		
	UIC Loading Guidelines - rail	IMO method - road	CEN method - rail
1 – Particle boards	6 top-over lashings	13 top-over lashings	68 top-over lashings alternatively 28 top-over and 5 spring lashings
2 – I-beams	Not allowed Beams above the stanchions may be secured by one round-turn lashing per 6 m	8 top-over lashings	56 top-over lashings alternatively 22 top-over and 5 spring lashings
3 – Paper reels	Not allowed	7 top-over lashings	18 top-over lashings
4 – Concrete elements	Not allowed	11 top-over lashings alternatively 4 top-over and 2 spring lashings forward	14 top-over lashings alternatively 4 top-over and 2 spring lashings in each direction

The calculations are valid for curtainsided vehicles with strong headboards but with non XL-classed sides. From the table above it can be seen that the goods in three of the four examples

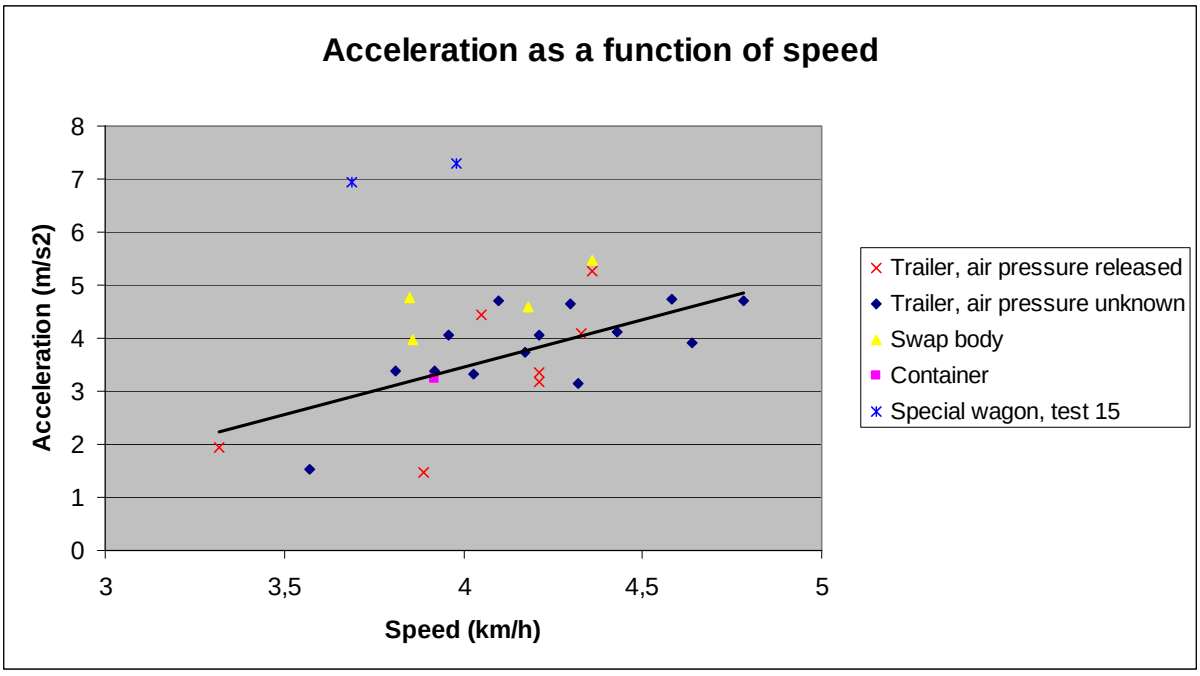
can not be transported in combined transport by rail in curtainsided trailers or open flat bed trailers according to the UIC Loading Guidelines.

Interestingly, in example 1, where top-over lashings (indirect fastenings) are allowed, the required number of lashings is much less according to the UIC Loading Guidelines than according to the road regulations. It is also noted that according to the UIC Loading Guidelines no securing arrangement is required to prevent sliding in longitudinal direction for this type of goods.

It can also be noted that the design method in the European standard 12195-1 (2010) for combined transport by rail prescribes a huge amount of lashings to be used in most cases.

6.1.2 Required cargo securing in longitudinal direction

The results of the shunting tests carried out within the project are summarized in the diagram below where the mean acceleration values in m/s^2 during 0.1 seconds (100 ms) are plotted as a function of the shunting speed in km/h. The tests have been divided into the following categories; trailer; with air pressure released and unknown if the air pressure was released or not, swap body, container and the trailer with the special wagon in test 15.



The mean acceleration values plotted as function of speed

The diagram shows that the test data received from the accelerometers indicates that, if performing impacts within the stipulated speed range 3 - 4 km/h, the acceleration 0.5 g (4.9 m/s^2) will not be exceeded in longitudinal direction. Please note that the data from the second shock in test 2 (speed 5.35 km/h, acceleration 0.87 g) with the container is not plotted above. This result clearly shows that it is sufficient for the cargo in cargo transport units for combined road/rail transports to be designed for longitudinal accelerations according to the road regulations, which stipulates 0.8 g forward and 0.5 g backward.

Although the cargo securing in six of the 19 tested units was designed for accelerations lower than 0.5 g, the cargo did not move in longitudinal direction as long as the shunting speed was within the prescribed limits.

From the diagram above it can also be concluded that there seems to be no difference in the relation between the acceleration and speed if the air pressure in the suspensions of a trailer is released or not. However, the accelerations in the swap bodies are somewhat higher than in the trailers as these types of units are more rigidly fixed to the wagons.

The results for the unit loaded with a truck cabin from Scania in a MEGA-trailer from Ewals Cargo (test 15) in the diagram above differs from all the other units. The cause of this is probably that this unit was loaded with 550 kg only. According to the instructions for shunting tests in the UIC Loading Guidelines the test wagon should be "loaded as far as possible to maximum capacity (part load: insufficient)". The test wagon should also be fitted with category A or B buffers. The type of buffers of the wagon used for test 15 was unknown.

There were movements among the cargo in five of the 19 units during the shunting tests. In three of these; the trailers loaded with a roller (test 13), with a truck cabin (test 15) and with cardboard boxes on pallets (test 16), the observed movements were very small only. In the other two units; the container loaded with paper reels from Billerud (test 2) and the mixed cargo from IKEA in a trailer (test 7), the cargo was loaded without any lashings and the speed was higher than the prescribed 3 - 4 km/h.

The unlashed cargo in test 2 and 7 should not have moved during the shocks as the horizontal accelerations were lower than the static friction. The reason for the movements could be that the vertical accelerations (vibrations) decreased the friction effect of the unlashed cargo. This shows that if the coefficient of friction is 0.5 or higher the cargo should be secured against wandering and if it is lower than 0.5 the cargo has to be secured by lashings or blocking in longitudinal direction.

The cargo securing did not fulfil the instructions in the UIC Loading Guidelines in none of the 19 units, a fact that shows that other securing techniques are used by road operators than assumed by the rail authorities.

On the return trip of the container loaded with paper reels from Billerud, the paper had damaged the doors probably due to a heavy shunting at one of the shunting yards in or between Malmö and Norrköping. This incident shows that cargo transport units in combined rail may not be hump and fly shunted before better shunting techniques are developed.

6.1.3 Required cargo securing in transverse direction

The following conclusions have been reached based on the results of the test transports:

- In most inspected units, no signs of significant accelerations in any direction could be detected. Most movements occurred randomly and many due to vibrations during the transport.

- However, shifting of the cargo in the same longitudinal direction in close to all units on one train inspected during the test transports between rail terminals, showed that excessive accelerations and cargo movement may occur if the trains are shunted in excessive speeds.

- There were no indications of significant accelerations in the transverse direction in any of the inspected units.

- There is a significant wandering effect for unlashed cargo during intermodal transports by rail.

- High friction and dampening from softer cargoes underneath, as well as top-over lashings, may serve to reduce the wandering effect significantly.

- Paper reels may safely be block stowed in containers during combined rail transports without risking damages to the reels or the containers.

- The curtain sides of XL trailers have in the test transports proved to be able to safely contain the cargo within the unit without showing any noticeable deflection, even when the cargo was inadequately lashed or even unlashed.

- Tight stowage must be achieved in the longitudinal direction, if blocking is combined with direct lashings.

- Indirect lashings (top-over lashings) may be used to safely secure cargo during rail transports.

- In all cases, when properly applied, the securing principles for cargo securing during road transports may serve as safe guidelines also for combined transports by rail.

6.1.4 Suitability of XL-classed curtainsides for cargo securing

Based on the tests carried out within the project it can be concluded that curtain sides could be used for cargo securing during rail transports in the same way as for road transports. If the cargo due to too heavy shunting, inadequate cargo securing or of any other reason has moved too much inside a vehicle, independently if it is in a curtainsider or a cover stake body type, and the cargo is pressing out any of the sides of the vehicle, it should be stopped from further transports both on rail and on road.

6.2 Recommendations

As have been pointed out in this report combined rail transports are part of a transport chain that includes other modes of transport and cargo securing in and on cargo transport units (containers, trailers, swap bodies and vehicles) are carried out by people used to road transports. The UIC Loading Guidelines are in most cases totally unknown to people carrying out cargo securing in cargo transport units. Thus, it is strongly recommended that the UIC

Loading Guidelines for cargo securing in cargo transport units are adjusted to the principles for cargo securing valid for road transport.

Based on the findings in the CombiSec project and the conclusions above the principles set out in the "***European Best Practice Guidelines on Cargo Securing for Road Transport"*** is sufficient also for combined rail transports. It is thus recommended that the UIC Loading Guidelines are complemented accordingly. It is, however, important to bear in mind that a design acceleration in longitudinal direction of 0,5 g (about 5 m/s^2) is based on shunting speeds of maximum 4 km/h.

To avoid that cargo moves uncontrolled due to vibrations during the rail part of the transports it is recommended that special requirements are set up that securing arrangements should not only prevent cargo motions due to acceleration forces but also due to vibrations as these are more severe during rail than during road transport.

If the UIC Loading Guidelines are complemented according to these recommendations it is also recommended to approach CEN/TC 168 to get the basic design accelerations for combined rail transports altered to be in line with the accelerations for road transports. This is important not to jeopardize the future for combined rail transports as the cargo securing standard EN 12195-1 (2010) might be used to form the bases for a future cargo securing directive within the European Community.

APPENDIX A – EXAMPLE TEST TRANSPORT PROTOCOLS

Kombisäkring **TRAILER** **MariTerm AB**

Form for documenting intermodal test transports

Procedure:

1. Fill in items 1 – 5 in this form prior to departure (electronically or manually on printout).
2. Mark cargo positions in the trailer with chalk
3. Take photos of cargo and cargo securing equipment
4. Send a copy of the form to the recipient
5. Send a copy of the form plus photos and cargo list if available to MariTerm AB (Sven.Petersen@mariterm.se / Fax: +46 (0) 42 33 31 02)
6. Fill in item 6 -7 in this form upon arrival at the receiver
7. Take photos of cargo and cargo securing equipment
8. Send a copy of the form plus photos to MariTerm AB (Sven.Petersen@mariterm.se / Fax: +46 (0) 42 33 31 02)

Part to be filled in by the shipper

1. Shipper

Company: _____

Departure (trailer): *Date:* _____ *Time* _____

Contact person: *Name:* _____

Phone: _____ *Email:* _____

2. Cargo

Description of cargo: _____

Number of pieces: _____ *pcs*

Dimensions *Length* _____ *m* *Width* _____ *m*

Height _____ *m*

Weight: *Total:* _____ *ton*

Please enclose a cargo list to this form if available

3. Trailer

Reg no.: _____

Type: ❑ *Box type* ❑ *Cover/stake* ❑ *Curtainsider*

XL Trailer ❑ *Yes* ❑ *No*

Floor: ❑ *Plyfa (plywood)* ❑ *Groove aluminium* ❑ *Other:* _____

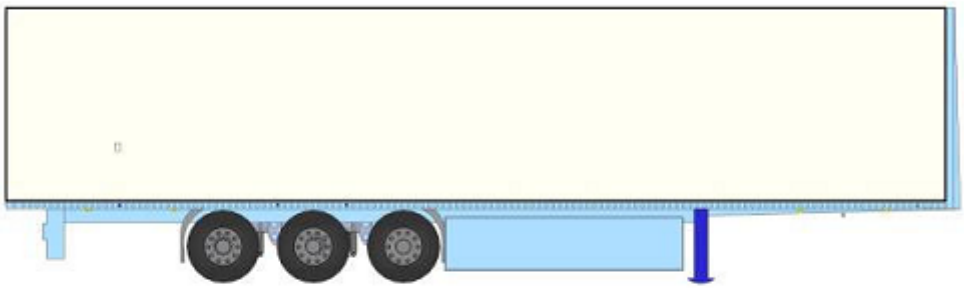
Inner dimensions: *Length:* _____ *13.6 m* *Width:* _____ *2.48 m*

Height: _____ *2.80 m*

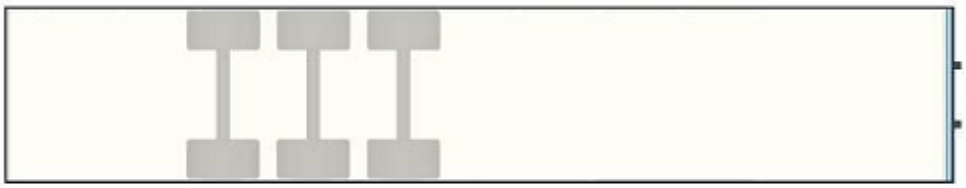
Page 1 of 3

4. Load Pattern and Cargo Securing arrangement

Sketch



Side view



Top view

Cargo Securing equipment

Lashings



Top-over lashings: _____ pcs



Loop lashings: _____pcs



Spring lashings, forward:_____pcs



Spring lashings (rearward) ___pcs

❑ *Photo of marking tag (or LC = _____ daN, STF = _____ daN)*

Friction material: _____

Dunnage bags: *Pieces:_____ pcs*

Blocking equipment (Stanchions, wedges or other): _____

_____

5. Transport route

Description of transport route and it's modes of transport:

_____

_____

_____

_____

_____

_____

Part to be filled in by the receiver

6. Receiver

Company: _____

Address: *City:* _____ *Country:* _____

Arrival (trailer): *Date:* _____ *Time* _____

Contact person: *Name:* _____

Phone: _____ *Email:* _____

7. Cargo dislocations

Note any dislocations of the cargo:

_____

_____

_____

_____

_____

_____