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SPECIAL REPORT II ON SAFETY-CRITICAL FACTORS RELATING TO HOOKLIFT CONTAINER TRANSPORT

Accident Investigation Board Norway • P.O. Box 213, N-2001 Lillestrøm, Norway • Phone: + 47 63 89 63 00 • Fax: + 47 63 89 63 01
www.aibn.no • post@aibn.no

This report has been translated into English and published by the AIBN to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photos: AIBN

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SUMMARY

Special Report II on safety-critical factors relating to hooklift containers is based on the AIBN's investigations of a total of 15 accidents/incidents involving hooklift container transport between 2009 and 2014. Among other things, the investigation is based on loading tests, interviews with those involved, technical vehicle examinations, documentation reviews and contributions from the authorities, relevant organisations and other players in the production and transport sector.

In the accidents/incidents that the AIBN has investigated, containers have come loose from lorries or trailers (with tilt frames) as a consequence of lateral forces and subsequent vertical loading of the securing system. In some cases, the trailers have overturned. Safety-critical defects have been found on hooklift containers, hooklifts and trailers. The loading tests that were carried out showed that the containers on the lorries/trailers had not been adequately secured.

The investigation has shown that the safety-critical defects are related to weaknesses involving several parties and phases. They include inadequate safety requirements for securing systems on new containers, deficiencies in the transport enterprises' maintenance and inspection procedures, and inadequate follow-up and inspection by public authorities.

In the AIBN's opinion, the Swedish standard SS3021:2014 'Road vehicles – Hooklift frames – Dimensions' should be improved. Most hooklift containers on the Norwegian market are built to this standard. It was revised in 2014, but the standard nonetheless lacks important safety elements, as it only covers dimensions and compatibility. It contains no requirements for the choice of securing system to hold the container in place, for the material quality and strength for the chosen container to be secured to the hooklift system, and no guidance on safe use, maintenance or criteria for testing and inspection.

Furthermore, the AIBN is of the opinion that the transport undertakings and container owners have inadequate procedures for maintenance and inspection of hooklift containers and securing systems. The AIBN points to this being an area that places great demands on the driver in terms of daily self-inspection of the vehicle, and that safety can only be ensured by expedient training and follow-up by the enterprises.

Follow-up and inspection of hooklift container transport by public authorities is also inadequate. This is because the initial approval process does not include hooklift containers and securing systems, and because the annual periodic vehicle inspections do not include the securing systems. Limited attention is given to the condition of containers and container securing systems during the Norwegian Public Roads Administration's roadside inspections relating to the securing of cargo. The Norwegian Labour Inspection Authority has also not prioritised inspections in this area, and the industry is not obliged to submit to any third-party inspection of hooklifts and containers.

The investigation has therefore shown that the safety of hooklift container transport depends on several parties in different phases. The AIBN has been in contact with many parties that, each in their own way, have an opportunity to influence safety. One of the AIBN's sub-goals of the investigation was to make both previous and new findings known to these parties.

The AIBN proposes a total of five safety recommendations as a result of the investigation.

1. INTRODUCTION

1.1 The background to Special Report II on hooklift container transport

Safety-critical factors relating to hooklift container transport were previously discussed in a Special Report published by the AIBN in 2012, Report ROAD 2012/03. In the following that report is referred to as 'AIBN Special Report 2012'. The background to the AIBN's publication of yet another special report on hooklift container transport is that the number of undesirable incidents, and information from public authorities and the industry, show that today, four years later, there is still a potential for improving the safety of this type of transport. The AIBN would have expected the relevant authorities to give higher priority to the safety recommendations in the previous report.

The consequences of a container falling off a moving vehicle or a vehicle rolling over can be fatal. This was clearly demonstrated in the rollover accident with a hooklift container on 12 August 2009 on the E6 road in Trøndelag, in which two people died and one was seriously injured. (AIBN 2011, Report ROAD 2011/03.)

Public authorities, relevant organisations and several big manufacturing and transport industry players have contributed to the AIBN's work on this special report. The AIBN believes that good dialogue with the industry is essential for the AIBN's investigation process and published report to have maximum impact on safety.

The special reports should be seen in conjunction with each other in order to get an overview of the safety problems and and overall risks. It is therefore recommended that AIBN Special Report 2012 should be studied, before reading this report. The summary and conclusions from the AIBN Special Report 2012 are also included in Appendix C to this report.

1.2 Factual basis for the investigation

AIBN Special Report 2012 concerns four accidents. After the publication of the report in 2012, another 11 incidents have been brought to the AIBN's attention, either through monitoring the media or by direct notification to the AIBN. The AIBN has investigated two of these incidents, which are described in Sections 2.1 and 2.2 in this report.

Limited investigations have also been carried out of the remaining nine incidents, with the focus on identifying common safety problems. This part of the factual basis is described in Section 2.3.

This Special Report II is thus based on a total of 15 accidents and incidents involving hooklift containers. Information received from different players in the industry also indicate that the unrecorded figures are high for this type of transport.

2. FACTUAL INFORMATION

2.1 Accident in Skedsmo (Borgen bridge) involving hooklift container vehicle combination

2.1.1 Sequence of events

On 26 November 2014, a heavy goods vehicle on the Rv 22 road in Skedsmo was passing through a roadworks area by Borgen bridge, headed for Lillestrøm. The vehicle combination consisted of a truck and trailer, each carrying a loaded hooklift container.

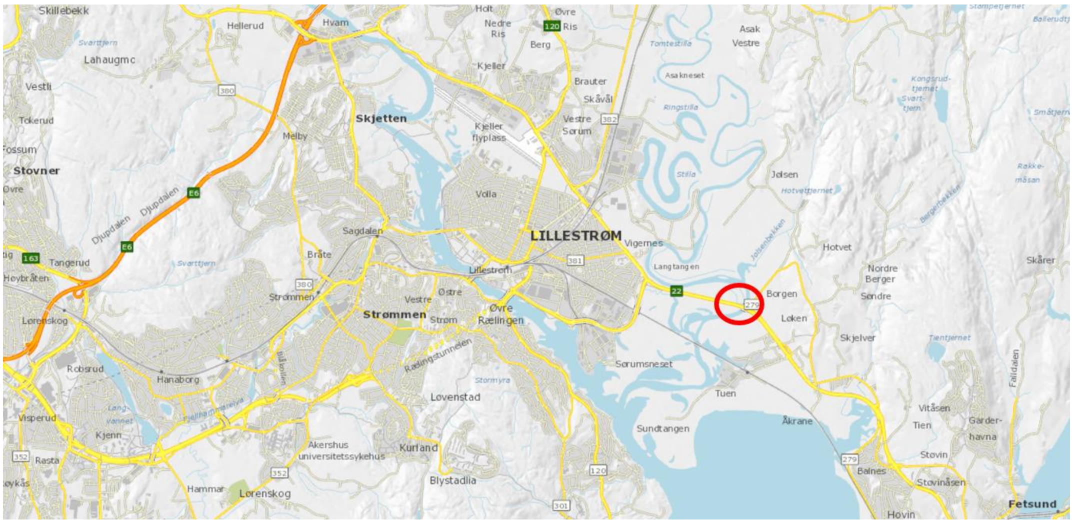


Figure 1: Map showing the incident site. The area in which the accident occurred is marked with a red ring. Map: Road map, NPRA. Illustration: AIBN

The heavy goods vehicle was negotiating an S-curve between the new and the old road. Where it entered the S-curve, there was an elevated connecting section of tarmac between the two roads (see figure 2). As the vehicle left the S-curve, the front securing arrangement for the container on the trailer loosened. The container slid leftwards onto the roadway and came to rest in the opposite lane, at approximately 90 degrees to the lanes. The container crashed into the front of an oncoming passenger car. The driver of the passenger car realised what was happening and drove the car into the ditch. One of the two people in the car was slightly injured.

The accident occurred at 11:34, and the AIBN was notified at 11:58. On receiving the notification, two AIBN representatives were immediately deployed to the scene of the accident.

Figure 2: Schematic drawing of the scene of the accident, photo showing the final position of the container/vehicles and photo providing an overview of the roadworks area. The red arrows show the position/direction from which the photos were taken, and the green arrow shows the elevation in the tarmac. Photos and illustration: AIBN

Tachograph data downloaded after the incident showed that the recorded speed of the heavy goods vehicle as it passed through the S-curve was slightly over 40[1] km/h.

2.1.2 Vehicle and load

The heavy goods vehicle was a 2008 Scania truck towing a 2006 Nor Slep trailer, both registered to Isachsen Maskin AS. In connection with the initial registration in 2006, the manufacturer documented that the trailer met the applicable requirements for load securing equipment laid down in Chapter 45 of the Vehicle Regulations. The trailer was a hooklift trailer with a tilt frame for front loading.

The vehicle combination was examined at the scene of the accident by the AIBN and the NPRA. The NPRA subsequently also examined the vehicle in own inspection premises. The AIBN received the documentation from that inspection. The truck and trailer had a gross vehicle weight of 24.4 tonnes and 16.9 tonnes, respectively, which was within the authorised limits. In its investigation after the accident, the AIBN found that there was insufficient engagement length between the locking system and the container and that there was some slack in the front locks on the container. No further faults or defects were found on the heavy goods vehicle that could have contributed to the accident.

[1] According to the regulations, the maximum permitted total uncertainty margin for such records is +\- 6 km/h.

2.1.2.1 *Locking system and hooklift container on trailer*

Prior to the accident, the trailer had passed its most recent periodic vehicle inspection on 1 April 2014. The load securing mechanism for the container on the trailer consisted of two rear locking devices (stoppers) and four pneumatic locks on the inside of the bottom side rails at the front. The four locks were installed on the trailer's tilt frame, see figure 3. The reason why there are four locks at the front is that the trailer can be adapted to carry containers of different lengths. The two rearmost of the four locks were designed in accordance with SS3021 to engage in the locking holes in the container in question.

After the accident, it was concluded by the NPRA that the mechanism for engagement with the container did not meet the requirements for load securing laid down in Section 3-3 of the Regulations of 25 January 1990 No 92 on the use of vehicles. The NPRA also concluded that there was some slack in the pneumatic locks inside of the bottom side rails, so that the container could be displaced laterally, and that the combined effect of the S-curve and elevation in the roadway at the scene of the accident was to wrench the container from the locks and cause it to fall off the trailer.

When tidying up after the accident, the container was loaded onto the trailer in question by first running it towards the rear until it was stopped by the rear stoppers, and then activating the pneumatic locks. For the locking studs to engage in the locking holes on the inside of the container's bottom side rails, the container had to be pulled slightly forwards. Figure 4 shows how the locking stud has been marked by the container's lateral movements.

Figure 3: The container securing points: four pneumatic locking studs inside of the bottom side rails at the front and two stoppers at the rear. The rearmost locking studs were aligned to the recesses in the container's bottom rails at the time of the accident. The upper left photo shows an implemented measure whereby a chain is used between the container and tilt frame. Photo: AIBN

Figure 4: Marks on the locking stud from the container's lateral movements. Photo: NPRA Illustration: AIBN

The hooklift container was marked BNS Consent. It had been manufactured in 2006, and was 2.7 m high, 7 m long and 2.5 m wide. It had a total volume of 41 m^3 and a specific gravity of 4.17 tonnes. The container was not marked with the standard to which it had been constructed. A distance of 91 cm was measured between the bottom side rails on the hooklift container, where the locking holes were located. This is within the limits prescribed in Swedish Standard SS3021 (see Section 2.7).

The AIBN also took measurements of the trailer's locking system. The distance between the locking studs was measured to be 96.5 cm. When they were pressed together manually, the distance was 95 cm, i.e. a slack of 1.5 cm. The slack and the possibility of a slight lateral displacement of the hooklift container, left a total engagement between the locking studs and the locking holes in the container of approximately 1 cm.

The pneumatic locking system had no additional mechanical locking devices. Nor were any other additional means of securing the containers used.

2.1.3 <u>The driver and the transport company</u>

The driver was 35 years old and employed by a subsidiary of Isachsen Gruppen AS at the time of the accident. He had been given in-house safety training, including in what checks should be carried out of the hooklift container vehicle combination and how to lock the container to the vehicle before setting out. On the day of the accident, the driver had performed such a check before setting out on his journey.

The driver had picked up the hooklift container in Bjørkelangen, approximately 30 km from where the accident occurred, and was headed for Drammen. He stated that when the container was loaded onto the trailer it had to be run to the rearmost position and then pulled forward a little to achieve engagement between the inside locking mechanisms and the bottom side rails on the container. The driver also said that a visual inspection is demanding, since it often has to be carried out in a dark area with the aid of a torch. The front locks are located some way under the hooklift container, and their engagement with the container's bottom side rails is difficult to ascertain.

The driver told the AIBN that he had previously been stopped for roadside inspection by the NPRA without being instructed to use chains for additional securing of the hooklift container to the trailer. He therefore understood the securing to be adequate, as the trailer and locking system had been approved by the NPRA.

According to information provided by the transport company, the company has a service agreement with an authorised dealer's garage and an agreement on trailer inspections. The company also carries out some maintenance in its own garage, primarily on the trailer which is serviced approximately every 15,000 km. Furthermore, the transport company was convinced that the safety of the locking system was one of the checkpoints during annual periodic inspections.

2.1.4 The trailer manufacturer Nor Slep AS

In meetings with Nor Slep AS, the AIBN reported on the slack that was found in the front locking system on the trailer, and asked for any guidelines the company might have on what constitutes acceptable wear from a safety perspective. Nor Slep AS told the AIBN that it had not prepared any wear tolerances and that nobody had ever requested this.

During the AIBN’s work on the Special Report 2012, the AIBN found that some of the trailers from Nor Slep AS have mechanical locking of the pneumatic front locking mechanisms. The AIBN was informed by Nor Slep AS that this was optional equipment and that many customers did not want to pay the extra cost of such equipment. The user manual for hooklift tipper trailers recommends securing the hooklift container with chains at the front.

2.1.5 Road conditions

Because of the roadworks in the area, roadwork signs had been posted and the speed limit reduced to 30 km/h. The speed limit on either side of the roadworks area was 70 km/h.

The work was being carried out to widen the road from two lanes to four lanes. At the point of entry to the temporary S-curve, was an elevated connecting section that sloped at a gradient of 3.5 degrees to either side of the midpoint. The elevated section was 2.25 m wide; see figure 2.

When visiting the site, the AIBN observed that the truck/tractor and trailer in vehicle combinations tilted to opposite sides in the S-curve because of the lateral pendulum movement that was produced when they crossed the elevated section.

2.1.6 Calculations and simulation of the sequence of events

The engineering firm Rekon DA was commissioned by the AIBN to assist in the investigation. Some of the factual information is uncertain, and the results of calculations, simulations and assessments are therefore also uncertain.

Rekon DA's report included the following conclusion concerning the loads on the trailer's locking system as it passed through the S-curve:

> *The vertical load on each of the inside securing points (the lock at the front and the rear stoppers) is estimated to have been approximately 9 kN*
>
> *The horizontal load on each of the securing points is estimated to have been approximately 22 kN*

The whole report from Rekon DA is enclosed in Appendix A.

2.1.7 Implemented measures

2.1.7.1 *Norwegian Public Roads Administration (NPRA)*

The night after the accident, the NPRA milled down the asphalt section that connected the lanes.

2.1.7.2 *Isachsen Gruppen AS*

Following the accident, the company has replaced the pneumatic front locks on the trailer in question. The company has also revised its internal procedures and now requires its drivers to use chains for added safety when securing hooklift containers on trailers.

2.1.7.3 *Nor Slep AS*

The AIBN has been informed that Nor Slep AS has implemented the following changes to improve safety:

- Introduced a reinforced version of the rear stoppers.
- Extended the studs in the front container locks and installed guides.
- Modified the perimeter structure of the tilt frame to prevent the container from sliding off during loading/unloading. This also secures the container from moving sideways while under transportation on the road.
- Developed a hydraulic lock between the tilt frame and the main chassis, to prevent upward movement of the tilt frame when exposed to lateral forces. This solution was an option as from 2015 and became part of the standard delivery in 2016.
- Lashing points on the outside of the main chassis have been provided for the past four years or so.
- The trailer has a board at the front for holding chain. This has been part of the delivery for approximately two years now.
- While this is being written, Nor Slep AS is in the process of adding an extra set of lashing hooks between the front locking system on the inside of the tilt frame. This will improve the securing of short containers (when combined with the lock on the tilt frame).

2.2 Accident involving hooklift container vehicle in Aurland

2.2.1 <u>Sequence of events</u>

At approximately 06:00 on Monday 12 December 2014, a Norwegian-registered heavy goods vehicle set off from Årdalstangen in Sogn og Fjordane County and drove to Fodnes ferry quay, where hooklift containers were loaded onto the truck and trailer. The heavy goods vehicle was headed for Bergen and consisted of a truck and trailer, each carrying a loaded hooklift container. After driving a distance of approximately 40 km, through the Lærdal tunnel and some way along the Aurlandsfjord towards Flåm, (Figure 5), the vehicle overturned and left the roadway in a left curve.

The accident occurred at 07:20 and the AIBN was notified at 14:00 the same day.

Tachometer data indicate that the heavy goods vehicle maintained a speed of 80 km/h during the final 10 seconds before it overturned. The steady speed indicates that the driver was using cruise control at the time of the accident.

Marks at the accident site and on the vehicles indicate that the container on the truck broke loose from the rear securing points and that it pulled the truck with it when it was flung towards the right.

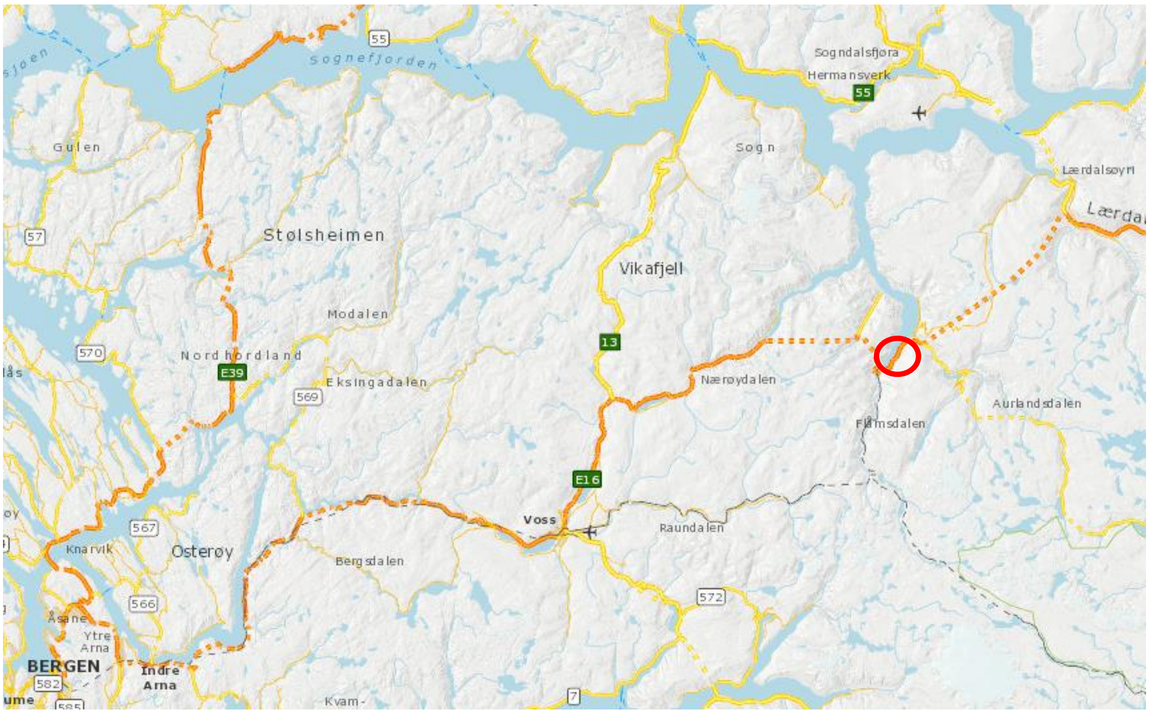


Figure 5: Map showing the incident site. The area in which the accident occurred is marked with a red ring. Map: Road map NPRA. Illustration: AIBN

The truck and trailer crashed through the crash barrier on the right side of the road and continued down a steep slope. They finally came to rest at the edge of the water (Figure 6). The driver's cabin was heavily damaged (Figure 7) in the accident, and the driver died.

The trailer remained coupled to the truck, but the hooklift container on the trailer broke loose as it crashed down the steep slope, and ended up under water.

Figure 6: The truck in its final position. The trailer is still coupled to the truck, but is partially submerged in water. Photo: NPRA

Figure 7: The driver's cabin was heavily damaged in the accident. Photo: The police

2.2.2 Vehicle and load

The truck was leased and used by Sunde Resirk AS. It was a Volvo FH16 truck, first registered on 7 June 2012. Its unladen weight was 13.6 tonnes. The trailer was of the make Nummi, first registered in January 2011. Locking systems for carrying hooklift containers were installed on the truck and trailer.

When the truck was first registered in 2012, Volvo Norge AS had documented that it met the applicable technical requirements in the Regulations on the approval of road vehicles and road vehicle trailers (the Approval Regulations). In connection with the first-time registration, a declaration of conformity from the bodybuilder was produced, documenting that the vehicle's hooklift had been delivered in accordance with the Vehicle Regulations, the chassis manufacturer's guidelines and the Norwegian Labour Inspection Authority's guidelines. Section 45 of the Motor Vehicle Regulations, which concerns load securing equipment, did not apply in 2012 (see Section 2.7). It is the Regulations on the use of vehicles that regulate load securing requirements. The hooklift container was not marked with the standard to which it had been constructed.

After the accident, the NPRA conducted and documented a technical inspection of the heavy goods vehicle. The AIBN received the documentation from that inspection. Both the NPRA documentation and the AIBN's examinations after the accident show that there was little or no engagement between the locking clamps on the truck and the container. No further faults or defects were found on the heavy goods vehicle that could have contributed to the accident.

The heavy goods vehicle was carrying miscellaneous items of scrapped steel. In the accident, the cargo in the hooklift container was spread over a relatively wide area, and some of it ended up in the sea. According to information provided by Sunde Resirk AS, the gross weight of the container on the truck was approximately 12 tonnes. The AIBN does not know the exact weight of the heavy goods vehicle, but there is nothing to indicate that the gross weights exceeded the permitted limits.

2.2.2.1 *Locking system and hooklift container on truck*

Prior to the accident, the truck had passed its most recent periodic vehicle inspection on 11 June 2014. A Multilift hooklift (XR20SL56) was mounted on the truck for lifting, locking and transporting hooklift containers. It had been supplied by Hiab Norway AS.

The container was suspended from the hooklift/lifting arm at the front and was locked by hydraulically operated clamps at the rear. No additional means of securing were used.

The clamps are designed to lock the hooklift container to the truck by holding down the container's bottom side rails during transport. When the AIBN examined the truck after the accident, measurements were taken of the locking system. The measurements are reproduced in figure 8 and show a total distance of 103 cm (99 cm + 4 cm) from the tip of the clamp one side to the neck of the clamp on the opposite side.

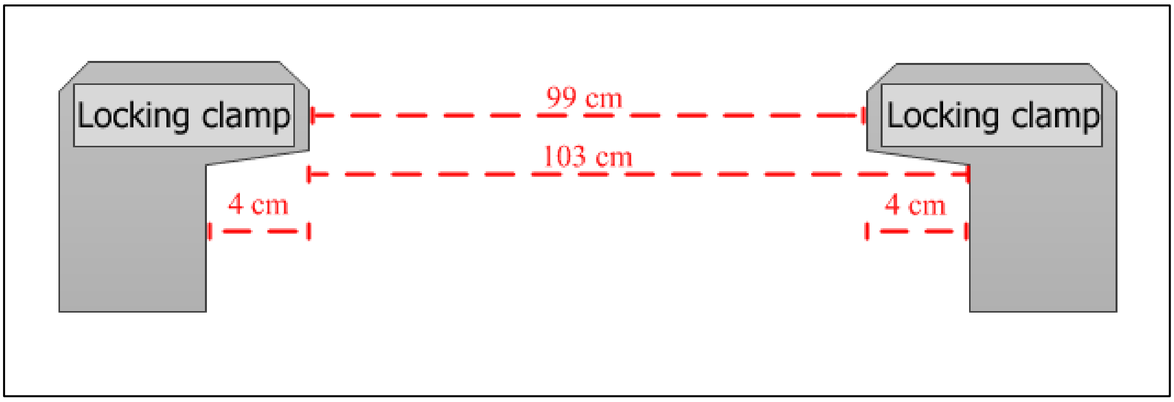


Figure 8: Locking clamps and relevant measurements. Illustration: AIBN

Figure 9 shows the left locking clamp marked by contact with the container's bottom side rail. During the AIBN's examination of the truck, it was not possible to move the locking clamps manually.

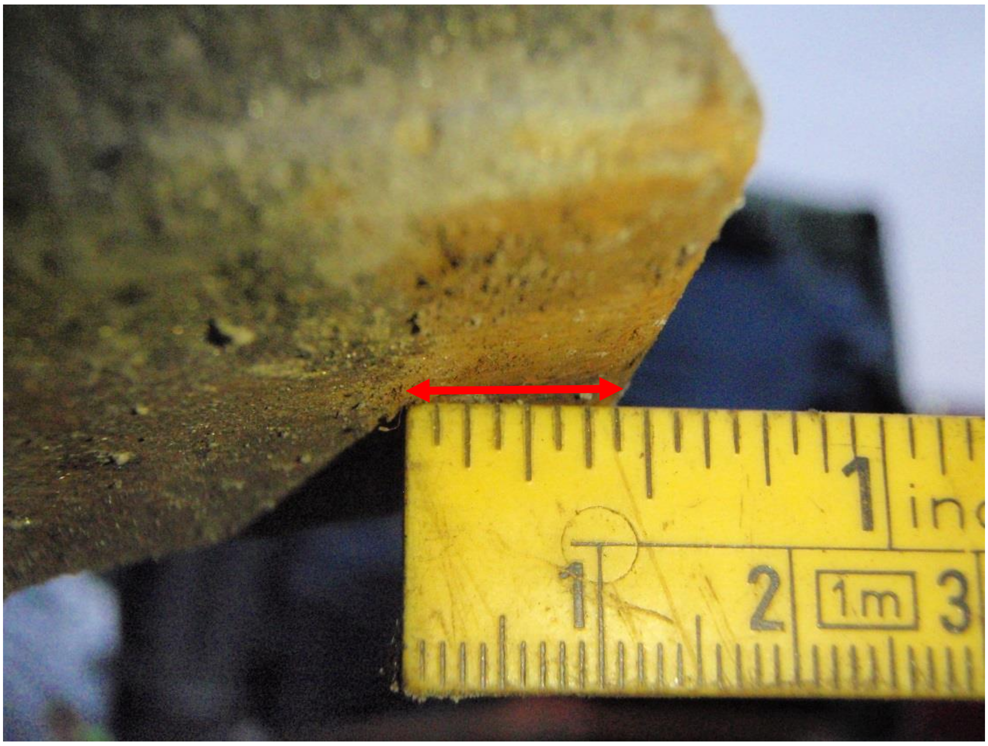


Figure 9: Left locking clamp marked by contact with the container's bottom side rail. The red arrow shows the worn down area. There was slightly more than one centimetre of wear. Photo: NPRA

When the AIBN examined the container after the accident, it appeared to be old and marked by clear cracks that had probably propagated prior to the accident. The container had also sustained some damage and deformation after the accident.

The container bore no manufacturer rating plate. When measured by the AIBN, the container was found to be 6.2 m long, 2.5 m wide and 2.7 m high. Measurements of the container where the clamps are supposed to grip the container, showed a distance of 102 cm between the outer edges of the bottom side rails. Swedish Standard SS3021:2014 requires an external measurement of 1,060. 0/-5 mm.

2.2.3 The driver and the transport company

The driver was 28 years old and had worked as a professional driver for 9 years. He was employed by Årdal Gods og Spedisjon AS on a permanent basis. The company is run by the same management as Sunde Resirk AS.

The driver had completed documented training, including in loading, maintenance and driving of the vehicle combination in question.

2.2.4 The hooklift importer Hiab Norway AS

According to the hooklift importer Hiab Norway AS, the manufacturer Multilift's instruction manual prescribed daily checks of the locking mechanism. The AIBN asked the manufacturer whether limit values exist for what constitutes acceptable wear on the locks before they need to be repaired, and received confirmation that no such limit values have been defined. In the same instruction manual, the manufacturer states that it can provide inside mechanical locking in addition to the hydraulically operated outside locking clamps at the rear of the truck.

Figure 10 shows that the hydraulically operated locking clamp has an engagement length of 23 mm under the least favourable tolerances mentioned in SS3021.

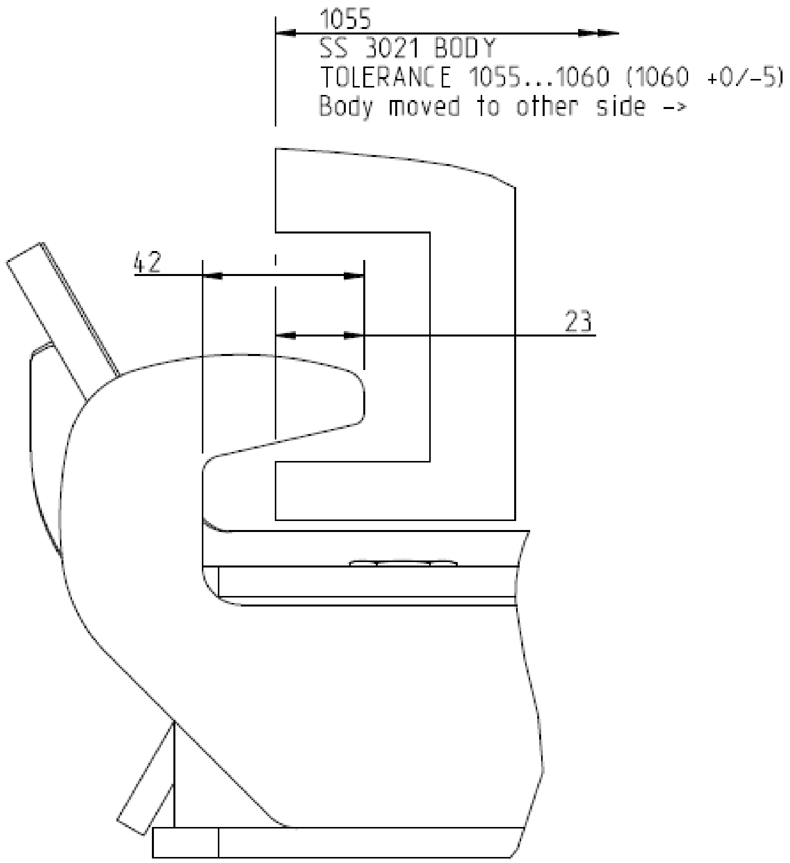


Figure 10: Illustration showing the engagement length and the relationship between the locking mechanism and the container. Source: Hiab Norway AS

2.2.5 Road conditions

The accident occurred on the E16 north-east of Flåm, in a left curve with a curve radius of approximately 175 m. The accident occurred on a humid roadway without snow or ice.

The speed limit at the accident site was 80 km/h. A crash barrier had been erected on the right side of the road. Both the roadway's white edge lines and yellow centreline were profiled. The lines were clearly visible to motorists.

On the left of the road, there was an approximately 3.5–4 m wide flat shoulder of blasted rock and gravel which ended in a rock cutting. The driver's line of sight was somewhat limited because of the rock cutting. Figure 11 shows the curve in which the accident occurred.

Figure 11: The scene of the accident The damage to the road barrier on the right side of the road caused by the vehicle that overturned can be seen in the middle of the photo. The photo was taken at approximately 12:00 on the day of the accident. Photo: The police

2.2.6 Calculations and simulation of the sequence of events

Rekon DA was commissioned by the AIBN to assist in the investigation. Some of the factual information is uncertain, and the results of calculations, simulations and assessments are therefore also uncertain.

The following conclusions were presented in the report from Rekon DA:

> *Point 1(a) of the assignment:*
>
> *If the container was secured against lateral movement only, and not against overturning, it would have overturned at a vehicle speed of 89 km/h.*
> *As a unit, the truck and container would have overturned at a speed of 113 km/h.*
> *This means that neither the container alone nor the whole unit should have overturned at a speed of 80 km/h had the container been secured against sliding sideways.*
> *Our calculations show that it is highly probable that the container broke loose and pulled the truck with it as it tipped.*
>
> *In our calculations, we have chosen to slightly change the curve radius and use slightly different centre of gravity heights for the load in order to illustrate the impact of these factors on the calculated rollover speeds.*
>
> *The results of these calculations are presented in the diagram below.*

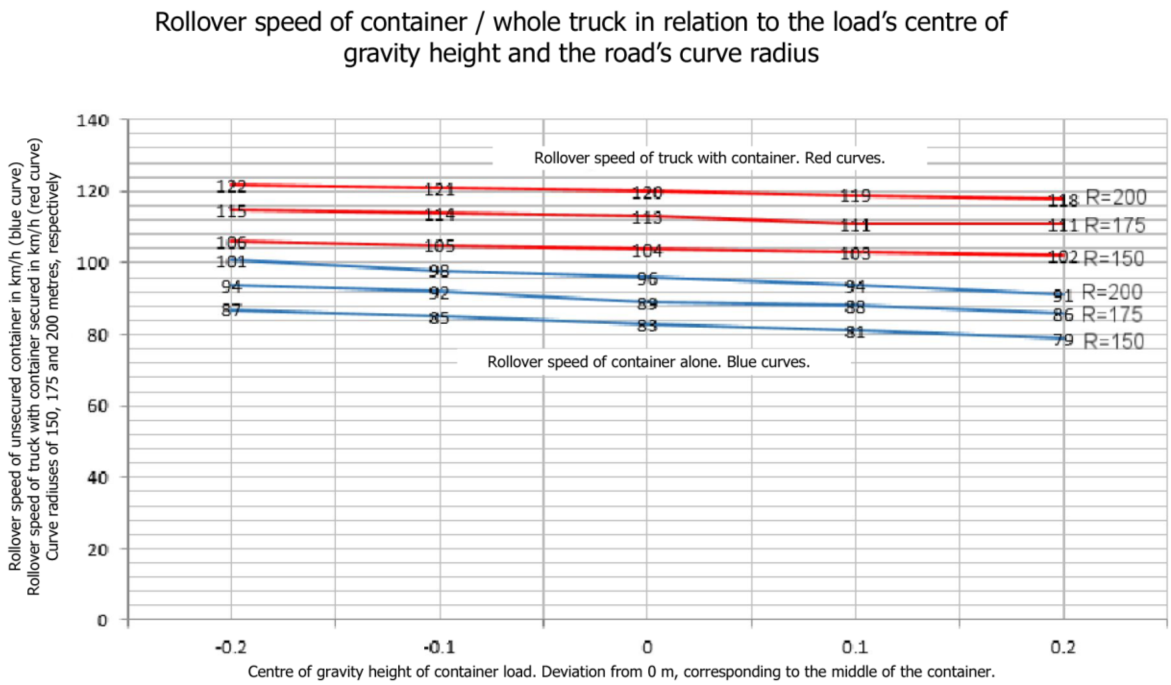


Figure 12: Different rollover speeds for the truck and container as one unit (red curve) and for the container (blue curve). Source: Rekon DA

Point 1(b) of the assignment:

i) Rollover speed of container with relevant load of 8,000 kg:	*89 km/h*
corresponding to a lateral acceleration of:	*0.36 g.*
ii) Rollover speed of container alone without cargo:	*91 km/h*
corresponding to a lateral acceleration of:	*0.38 g.*
iii) Rollover speed of container with maximum permitted load of 20,000 kg:	*89 km/h*
corresponding to a lateral acceleration of:	*0.36 g.*

Point 2 of the assignment:

The horizontal forces acting on the container's securing points are estimated to amount to a total of 34 kN. We have disregarded the frictional forces between the container and the supporting surface.

The vertical upward forces acting on the container's inner locking stud through the curve are estimated to amount to approximately 12 kN. This means that the securing points must withstand a vertical force of 12 kN to prevent the container from tipping.

Point 3 of the assignment:

If the container was loaded to the authorised total weight (total weight: 20,000 kg, cargo: 16,000 kg) with the same centre of gravity height for the cargo as above, the horizontal forces acting on the container's securing points at a lateral acceleration of 0.5 g (the load securing requirement) are estimated to amount to approximately 100 kN. The vertical forces acting on the container's inside anchorage points in the curve are estimated to amount to approximately 42 kN in the upward direction. This *means that the anchorage points must withstand a vertical force of 42 kN to prevent the container from tipping.*

We have disregarded the forces that are supported by the hook at the front.

Point 4 of the assignment:

The vertical downward forces acting on the inside anchorage points on an ISO container that is loaded as in point 3 are estimated to amount to approximately 41 kN. This means that the container will exert this force on the securing points. Hence the ISO container wouldl not tip under a lateral load of 0.5 g. The horizontal forces would be the same as in point 3, i.e. approximately 100 kN.

The whole report from Rekon DA is enclosed in Appendix A.

2.2.7 Implemented measures

2.2.7.1 *The transport company Sunde Resirk AS*

Following the accident, the transport company has installed additional equipment on its hooklift containers for the purpose of improving safety. The trucks have been equipped with an inside mechanical locking mechanism for the container in addition to the outside factory-installed locking mechanism. This is a relatively simple mechanism consisting of a steel plate and four bolts on the inside of the hydraulic locks, see Figure 13 and Figure 14.

Figure 13: Retrofitted plates (black in colour, indicated by the yellow arrows) for mechanical locking of the container to the truck from the inside. The photo shows the plates installed as part of a JOAB hooklift system. Photo: AIBN

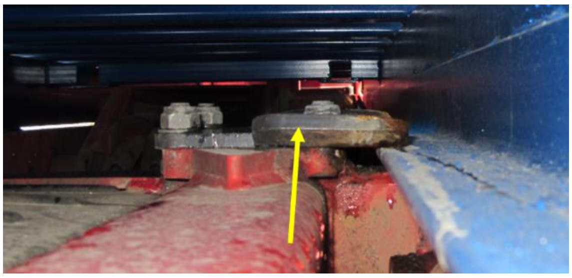


Figure 14: The plates (black/grey/brown, indicated by the yellow arrow) lock the hooklift container (blue) to the hooklift system (red) and the truck. Photo: AIBN

2.2.7.2 *The hooklift importer Hiab Norway AS*

Hiab Norway AS has informed the AIBN that it is working on including mechanical locking at the rear and extra side locking at the front in the product specifications.

2.3 Nine other incidents

Since the publication of the Special Report 2012, the AIBN has received reports of / been notified by the police and/or the NPRA of several incidents related to hooklift container transport. The AIBN's media monitoring system has also brought several undesirable incidents to the AIBN's attention. The AIBN has registered a total of nine other incidents during the period February 2013 to June 2015, in addition to the two incidents mentioned above (ref. Sections 2.1 and 2.2). One of these incidents involved a single truck, while the other eight involved vehicle combinations with tilt frame trailers. In eight of the incidents (including the incident involving a single truck) the container in question was loaded.

The NPRA assisted the police with technical examinations in six of the nine incidents, submitting a report on four of them. The AIBN has received copies of these reports and they have been used as a basis for the AIBN's review of these accidents.

The following information from the nine incidents is of relevance to the safety of hooklift containers:

- In the incident involving a single truck that overturned, the information provided by the NPRA indicates that the truck's and hooklift container's locking systems were built to different standards. Furthermore, the container showed signs of damage and deformation. The findings indicate that there was insufficient engagement between the locking studs and the container's bottom side rails and that this was a contributory cause to the rollover.

- In three of the accidents, the vehicle (trailer) appears to have overturned as one unit, indicating that the container was still firmly secured to the vehicle when it overturned.

- In four of the incidents, the trailer and container were separated in their final position and findings indicated that the container had broken loose under the impact of lateral forces while travelling along the road. There is uncertainty about why the container fell off in these incidents. The findings suggest that the pneumatic locking system at the front of these trailers provided little or no engagement with the container. In one case, the locks did not engage with the container at all. In several of these incidents, indications were also found that the condition (deformation/damage) of the container contributed to there being little or no engagement.

- In the final incident involving a trailer, the causalities remain rather uncertain. It is also not clear whether the incident should be seen as a rollover accident in which the trailer and container tipped as one unit or whether the container came partially loose from a locked position and pulled the trailer with it as it tipped. The container was found to be in poor condition, however.

2.4 Loading tests

In most of the cases that the AIBN is aware of, the hooklift container has broken loose from the rear of a truck or from the front of a trailer with tilt frame. The AIBN wanted to look more closely at the loads to which hooklift containers and vehicle anchorage points are exposed by performing tests on vehicles corresponding to those involved in the Borgen and Aurland accidents. For this purpose it used a vehicle combination with a Multilift (HIAB) hooklift system and a trailer manufactured by Nor Slep AS. The containers used had been subject to third-party inspection by Ophus Kran & Maskin Godkjenning AS in 2015.

When selecting the equipment, it was stressed that both the vehicle combination and containers should meet regulatory and road safety requirements. The vehicle combination was loaded with a cargo of raw wood chips and the truck and trailer were weighed. The gross weight of the truck was 26.4 tonnes (container w/cargo: 13.6 tonnes) while the gross weight of the trailer was 23.1 tonnes (container w/cargo: 17.3 tonnes). The specific weight of the cargo was so high that the containers could not be filled completely.

The AIBN commissioned SP Technical Research Institute of Sweden to prepare, carry out and document loading tests on a vehicle combination with loaded hooklift containers.

As far as possible, the tests were to provide answers to the following questions:

1. Whether the load-bearing part (where the anchorage points were located) would fail to meet the load securing requirements when exposed to increasing lateral loads and whether it would continue to meet the dimensional requirements in SS3021.

2. What happens to the trailer's load-bearing structure including the tilt frame and front locking system if the trailer is exposed to torsional and lateral loads at the same time?

3. What happens to the rear locks on the truck and front locks on the trailer when the locking system is exposed to loads approaching the lateral load securing requirements?

4. In addition to the tests, the AIBN wanted a professional assessment from SP of whether road safety is sufficiently ensured in connection with hooklift container transport, based on the tests and on SP's previous experience.

The tests were conducted at Sessvollmoen Military Facility in Ullensaker in September 2015. They were carried out in close collaboration between the AIBN as client, SP as the executing party and the military which provided equipment, personnel and an area for conducting the tests. Figure 15 shows the parties directly involved in the tests.

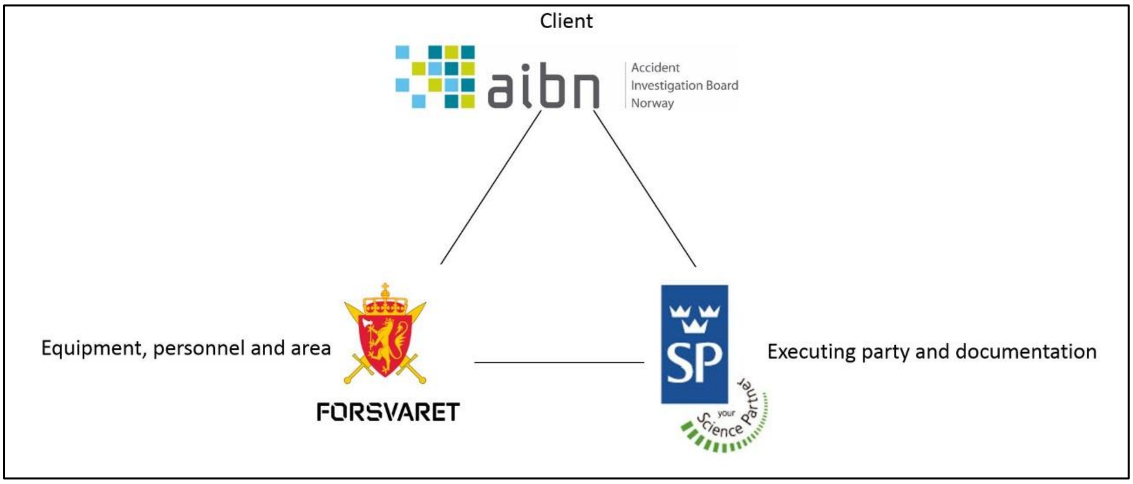


Figure 15: The parties directly involved in the tests. Illustration: AIBN

In addition to the parties mentioned, observers from the Directorate for Public Roads, Hiab Norway AS and Nor Slep AS were also present during the tests.

The test results are described in detail in SP's report in Appendix B. As described in that appendix, SP chose to impose the load at a point corresponding to the centre of gravity on a fully loaded container. In the following, the AIBN will describe SP's most important findings.

Figure 16 shows what happens to the truck when exposed to a lateral load of approximately 0.5 G. As shown in the photo, the hooklift container is lifted, leaving a gap of approximately 12 cm between the load carrier (hooklift system) and the front of the hooklift container. Figure 17 shows the hooklift arm and lift bar before the lateral load was imposed. Figure 18 shows that the hooklift arm moves in the lift bar when exposed to a lateral load of approximately 0.5 G. These are photos from one of the camera points used during the test.

Figure 16: The hooklift container on the truck is lifted approximately 12 cm (see red arrow) at the front when exposed to a lateral load of approximately 0.5 G. Photo: SP

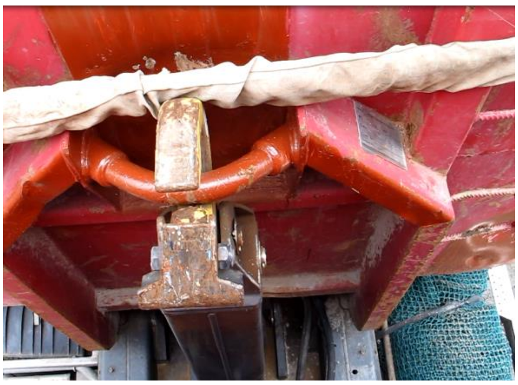


Figure 17: Hooklift arm and lift bar on container without lateral load. Photo: AIBN

Figure 18: Hooklift arm and lift bar on container exposed to a lateral load of approximately 0.5 G. Photo: AIBN

The lateral load on the trailer was removed at 0.38 G to prevent the trailer and container from overturning. We can observe from Table 2 in Appendix B that when the lateral load is increased from 0.30 G to 0.38 G, the gap between the load carrier and the front of the hooklift container increases from 25 mm to more than 150 mm, see figure 19. The hooklift container is held in place by the front locking studs; it is the tilt frame that is lifted from the load carrier.

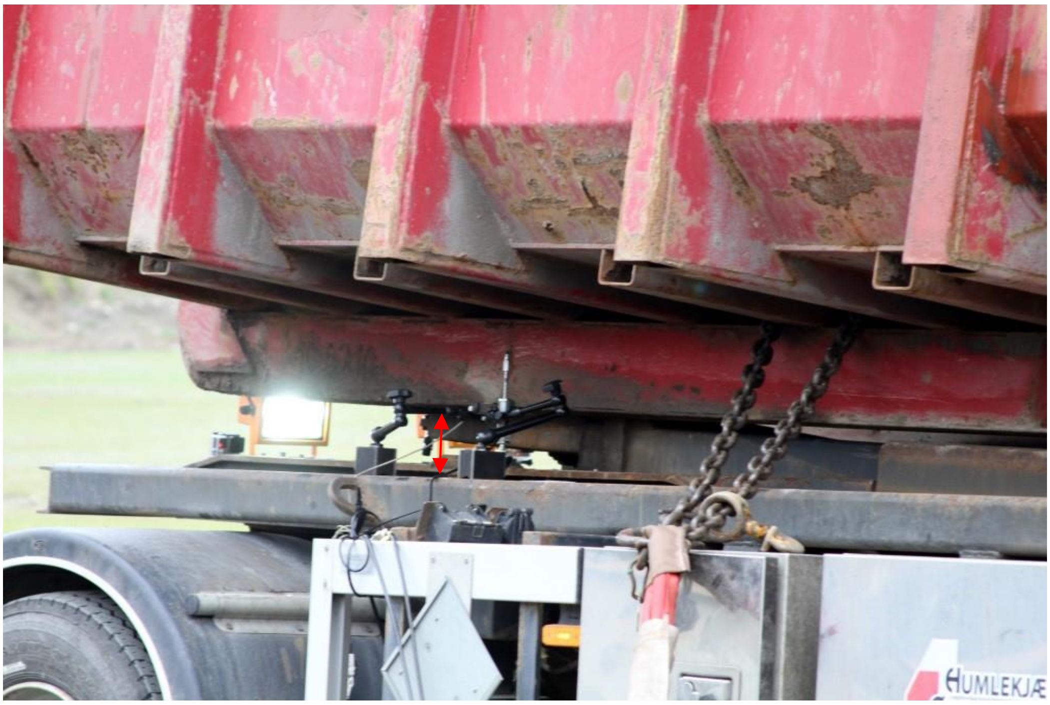


Figure 19: The front of the hooklift container is lifted more than 15 cm (see red arrow) when exposed to a lateral load of 0.38 G. Photo: SP

Important conclusions reproduced from SP's report:

> *The height of the hooklift container on the trailer was so high that trailer and container did not fulfill the requirement for lateral accelerations 0.5 g. The test was stopped when a lateral acceleration of 0.38 was reached because of overturning. The truck managed to withstand 0.5 g but it was obvious that this was maximum. Those facts creates a big risk during road transports and is not fulfilling requirements for load securing on road transport.*
>
> *If the securing devices shall be able to lock into the holes in the bottom rails it is mandatory that they are adapted to each other. Tolerances for the inside distance between the bottom rails are big, +30/-5mm. If the hooklift container is pushed to one side on the load carrier and the difference between load deck and bottom rail is the maximum of what is allowed, there is an obvious risk that the securing devices on the opposite side does not lock properly. As shown in photo 11 the hole intended for securing had been made with a gas burner and looks as it was done in a hast to fit the actual load carrier.*
>
> *The lateral supports that the load deck of the truck was equipped with, see photo 3, is a good solution since it helps both loading operations and gives support sideways during transport. They have no possibility to hinder the container to overturn if the securing devices are not locked on the opposite side of the load deck. Comparing the strength requirements for securing equipment on road transport with ISO 1496 containers with securing devices for hooklift containers*

it is obvious while that the requirements for ISO 1496 containers are high they are lacking for hooklift containers.

2.5 The AIBN's Special Report on safety-critical factors relating to hooklift container transport, published in 2012 (AIBN Special Report 2012)

The AIBN has also previously published a special report on hooklift container transport. That investigation included problems raised by the AIBN in Report ROAD 2011/03 (AIBN 2011) and it revealed the need to address a notification of critical safety issue to the NPRA on 30 June 2011.

The investigation looked into four accidents and pointed out wear, defects and weaknesses in hooklift containers and hooklift systems as well as in trailers. Unfortunate safety issues were also found in the regulatory framework and standards, and related to the supervision, follow-up and use of hooklift containers.

The AIBN proposed six safety recommendations as a result of the investigation. These are reproduced in italics below, together with a description of status concerning follow-up of the recommendations.

2.5.1 Safety recommendation ROAD No 2012/07T

The investigation has shown that most hooklift containers used in Norway are built to Swedish Standard SS3021, but that no harmonised common standard exists. Hooklift containers may therefore be built to varying standards and to accommodate different customer needs. The Accident Investigation Board Norway shares the opinion of the Bodybuilder Industry Association (a member of The Federation of Norwegian Industries) that increased focus on standards and dimensions, together with better marking of hooklift containers could improve the safety of such transport.

The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration, in its capacity as the supervisory authority, implement measures to ensure that hooklift systems and the hooklift containers used with these systems be built to the same standard, or that they be otherwise mutually adapted or safely secured.

This recommendation has not yet been closed, and the AIBN has received the following information on its status as of 19 December 2014:

The NPRA agrees that there is a need to implement measures to take account of the findings documented by the AIBN. As soon as the NPRA's capacity allows, it will appoint an interdisciplinary working group to examine and propose safety improvement measures for this type of transport. A natural part of this work will be to examine regulations, standards, supervision, follow-up etc. This recommendation is covered by the established project mentioned in recommendation 2012/03T. The work will probably not be concluded until sometime in 2015. The matter will remain under observation.

2.5.2 Safety recommendation ROAD No 2012/08T

Under the regulations, hooklift containers are deemed to be part of the load. Neither the Working Environment Act nor the Road Traffic Act or its regulations provide for supervision of such equipment by public authorities. As from 29 April 2009, load securing equipment was no longer listed as an item to be checked during the mandatory periodic vehicle inspections. The Accident Investigation Board Norway believes that systematic follow-up of the condition of hooklift containers (and hooklift systems) constitute an important safety barrier in this type of transport.

The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration collaborate with the Norwegian Labour Inspection Authority to establish systematic follow-up of the condition of hooklift containers, hooklift systems and anchorage points on vehicles.

This recommendation has not yet been closed, and the AIBN has has received the following information on its status as of 19 December 2014:

Reference is made to our comment on Recommendation No 2012/07. It is natural to invite participation from the Norwegian Labour Inspection Authority in a future working group. The matter will remain under observation.

2.5.3 Safety recommendation ROAD No 2012/09T

'Best practice guidelines on cargo securing' are available to private and professional carriers. Locks and fastening devices for hooklift containers are hardly mentioned in these guidelines. It is therefore important for daily checks of the fastenings that the driver has been given good training, has demonstrated technical insight and has been provided with enough time and the right tools for the purpose. In this connection, good procedures can be decisive for the safety of hooklift container transport.

The Accident Investigation Board Norway recommends that the Norwegian Truck Owners' Association (Norges Lastebileier-Forbund – NLF), together with other relevant organisations and businesses as appropriate, implement measures so that daily driver checks in connection with hooklift container transport can improve the level of safety.

The recommendation was closed on the following grounds:

NLF has informed us that they have established procedures for loading, securing and maintenance of hooklift containers as part of its 'Quality and Environment on the Road' management system.

Among other things, the management system describes that a chain shall be used as an additional means of securing the container to the trailer during transport. The procedures do not describe how the containers are to be loaded.

2.6 Suppliers, special interest organisations and public authorities

The following suppliers, special interest organisations and public authorities have contributed information to the AIBN's work on this special report. Together, they are able to influence the safety of hooklift container transport, and one of the AIBN's sub-goals in this investigation has been to draw their attention to both previous and new findings.

2.6.1 The Norwegian Public Roads Administration (NPRA)

The NPRA is an administrative agency that reports to the Ministry of Transport and Communications. Among other things, the agency is responsible for approval and supervision of vehicles and motorists. The NPRA, the Directorate of Public Roads and relevant regions have contributed information about the accidents mentioned in the investigation, participated in meetings with the AIBN and attended the loading tests mentioned in Section 2.4.

2.6.2 The Norwegian Labour Inspection Authority

The Labour Inspection Authority is a government agency that reports to the Ministry of Labour and Social Affairs. The agency is charged with conducting supervisory activities to ensure that enterprises comply with the requirements of the Working Environment Act. The AIBN has been in dialogue with the Labour Inspection Authority and been provided with information of relevance to the investigation.

2.6.3 Hiab Norway AS

Hiab Norway AS supplies goods handling equipment to the road transport sector. Among other things the company supplies Multilift hooklifts to the Norwegian market. The AIBN has held a meeting with the company to obtain information for the investigation. The company was also present during some parts of the loading tests described in Section 2.4.

2.6.4 Nor Slep AS

Nor Slep AS supplies transport equipment and trailers, and manufactures container trailers among other things. The AIBN has held a meeting with the company to obtain information for the investigation. The company was also present during some parts of the loading tests described in Section 2.4.

2.6.5 Norwegian Waste Management and Recycling Association (Avfall Norge)

Avfall Norge is a trade organisation for the waste management and recycling sector in Norway. The AIBN has met with the organisation and obtained contributions to the investigation.

2.6.6 The Federation of Norwegian Industries (Norsk Industri)

Norsk Industri is the biggest national member organisation of the Confederation of Norwegian Business and Industry (NHO), employing 25 % of all full-time equivalents employed by NHO's member enterprises. Norsk Industri ensures that industrial issues are high up on the agenda in the NHO community. The Bodybuilder Industry Association is a member of this organisation. The association is made up of enterprises that manufacture bodies, hooklift systems and cabinets for load carriers, buses, emergency response vehicles and special-purpose vehicles. The AIBN has met with the organisation and obtained contributions to the investigation. As early as in 2006, the Bodybuilder Industry Association sent a letter to the Directorate of Public Roads expressing concern about the safety of hooklift container transport.

2.6.7 Norsk Gjenvinning AS

Norsk Gjenvinning AS is an important recycling and environmental services provider. The AIBN has held a meeting with and communicated with Norsk Gjenvinning AS, and obtained contributions to the investigation. The company also supplied equipment for the loading tests.

2.6.8 Ophus Kran og Maskin Godkjenning AS

Ophus Kran og Maskin Godkjenning AS inspects containers on assignment for Norsk Gjenvinning AS. The company has informed the AIBN that in more than half the cases they find major faults and defects in the anchorage points for the hooklift container. The company has prepared its own set of criteria for what is sufficient to ensure safety. The company considers that important factors with a view to improving safety would be to introduce requirements related to use of materials, locking and grip hole design.

In its capacity as a sub-supplier to Norsk Gjenvinning AS, Ophus Kran og Maskin Godkjenning AS had, in the course of 2015, inspected the hooklift containers used in the loading tests.

2.6.9 BNS Container AS

BNS Container AS is a Scandinavian company offering containers, swap bodies and module solutions for different applications. The AIBN has met with BNS Container AS and obtained contributions to the investigation. The company has also submitted proposals for improving Swedish Standard SS3021.

2.6.10 Other suppliers

The AIBN has also been in contact with other suppliers of both containers and hooklift systems.

2.7 Regulations and guidelines

Act/Regulations	Provisions
Act of 18 June 1965 No 4 (the Road Traffic Act)	Section 23 of the Road Traffic Act imposes the following requirements on the driver and owner of a vehicle: *Before starting to drive, the driver shall make sure that the condition of the vehicle is safe and in accordance with the regulations and that it is loaded safely and in accordance with the regulations. He shall also ensure that the vehicle is in safe condition and safely loaded during use. The owner of a vehicle or the person who is in charge of the vehicle on the owner's behalf, is obliged to make sure that the vehicle is not used if it is not in a safe condition.*
Regulations of 4 October 1994 No 918 on Technical Requirements for and Approval of Motor vehicles, Parts and Equipment (Motor Vehicle Regulations)	Section 45-1 Load-securing equipment, points 2 and 3: *2. On first-time registration of a vehicle that comes under the scope of these provisions, documentation shall be provided on request that the permanently installed securing equipment meets the requirements of these regulations concerning strength and number. The documentation, annotated with the vehicle's chassis identification number, may be based on calculations or tests.* *3. Load carrier.* *The load carrier is the part of the vehicle that is constructed for the transportation of cargo. A load carrier may be an open flatbed, an enclosed cargo space, a tank, horizontal or vertical cargo racks and similar. The load carrier and permanently installed securing equipment shall be anchored to the vehicle in such a way that the fully loaded load carrier is not displaced when the fundamental load securing requirements are met. See the Regulations of 25 January 1990 No 92 on the use of motor vehicles. The load carrier shall be designed in such a way that the cargo can be secured in accordance with these regulations.* According to information from the NPRA, the annulment of Section 45-1 of the Motor Vehicle Regulations meant that, as from 29 April 2009, Section 6.4 'Load-securing equipment' in Annex 1 to the Regulations relating to periodic vehicle inspections is no longer applicable.

	The regulatory framework for load securing is now enshrined in the Regulations on the use of vehicles (Vehicle Use Regulations).
Regulations of 5 July 2012 No 817 on the approval of road vehicles and road vehicle trailers.	These regulations concern, among other things, technical requirements in connection with first time approval of road vehicles and road vehicle trailers in Norway. The regulations entered into force on 15 September 2012. As from 1 November 2014, it became a requirement that, on first-time registration, all trailers in categories O3 and O4, with the exception of trailers with four or more axles, must be equipped with a system for maintaining roll stability and directional stability (RSS, RSP, RSC, TRSP).
Regulations of 25 January 1990 No 92 on the use of motor vehicles	Section 3-3 of these regulations includes rules related to load carriers and securing of same. The load carrier shall be secured to the vehicle so that it can withstand the following when fully loaded: *During transport, the goods on the vehicle shall be secured so that no part of the goods can be displaced or fall off. At minimum, the means of securing shall be capable of withstanding the following forces:* *a) Forward along the vehicle: A force equal to the total weight of the goods.* *b) Rearwards and across the vehicle: A force equal to half the weight of the goods.* *The goods shall be secured by locking, blocking or lashing, or by a combination of these methods. The goods may be otherwise secured if it can be documented by calculations or practical tests that the method used meets the requirements laid down in this section.*
Regulations of 13 May 2009 No 590 on roadside vehicle inspections	These regulations apply to unannounced technical roadside inspections along public roads of vehicles with an authorised total weight exceeding 3,500 kg, of all vehicles registered for 10 persons or more and of trailers, including semi-trailers with an authorised total weight exceeding 3,500 kg. The NPRA's instructions for roadside inspections, dated February 2013, specify a separate checkpoint for damage, incorrect alignment or defective locking of hooklift containers together with swap bodies and ISO container securing points.

	Directive 2014/47/EU will be implemented in the Norwegian regulatory framework by 20 May 2017, and will be effective from 20 May 2018. Among other things, the directive entails changed requirements for the training of inspectors.
Regulations of 13 May 2009 No 591 relating to periodic vehicle inspections	These regulations concern periodic inspection of Norwegian-registered vehicles and requirements imposed on inspection bodies that are to carry out such inspections. The NPRA has informed the AIBN that the permanently installed locks on vehicles for transporting hooklift containers are not included as a checkpoint in connection with roadside inspections. Directive 2014/45/EU will be implemented in the Norwegian regulatory framework by 20 May 2017, and will be effective from 20 May 2018.
Act of 17 December 1982 No 84 on safe containers (Container Act)	The Container Act is administered by the Ministry of Trade and Industry. The act applies to what are known as ISO containers (normally not hooklift containers) and requires that *'Containers must have been inspected and approved by the supervisory authority'*. Among other things the act contains requirements for material strength and locking of the container's four corners.
Act of 17 June 2005 No 62 relating to the working environment, working hours and employment protection etc. (the Working Environment Act)	The Working Environment Act requires that enterprises safeguard employees' health, environment and safety. Regulations of relevance to the AIBN's investigation are listed below. The Working Environment Act and its regulations are administered by the Labour Inspection Authority.
Regulation 6 December 1996 No 1127 relating to systematic health, environment and safety activities in enterprises (Internal Control Regulations).	The Internal Control Regulations require enterprises to engage in systematic and ongoing improvement work relating to health, safety and the environment (HSE). The regulations state that enterprises shall plan, organise, perform and maintain their activities in conformity with requirements laid down in or pursuant to the health, environmental and safety legislation.

Regulations of 20 May 2009 No 544 on machinery (Machinery Regulations)	Under the Machinery Regulations, manufacturers and suppliers are required to ensure that the equipment is CE-marked when the complete hooklift system is mounted on the vehicle. The manufacturer of the actual hooklift submits a manufacturer's declaration which the bodywork manufacturer uses as a supporting document for its CE-marking and declaration of conformity for the hooklift system.
Regulation of 6 December 2011 No 1357 on execution of work, use of work equipment and related technical requirements (Regulations on the Execution of Work)	The purpose of these regulations is to ensure that work is executed and working equipment used in a safe manner, so as to protect the life and health of employees. Sections 11-2, 12-1, 12-2 and 12-3 describe requirements for training in use, maintenance and inspection of working equipment.
Regulation of 6 June 2011 No 1360 on administrative arrangements in the area covered by the Working Environment Act (Regulations on Administrative Arrangements)	These regulations concern the exercise of public authority and administrative arrangements relating to safety training, corporate health service, enterprises of competence and safety representatives. Sections 7-1 and 7-2 concern requirements of certification bodies appointed by the Labour Inspection Authority

2.7.1 Swedish Standard SS3021:2014 'Road Vehicles – Hooklift Frames – Dimensions'

The standard is published by the Swedish Standard Institute (SIS), and was prepared by the Committee for Data Transfer between Chassis Manufacturers and Bodybuilders, SIS/TK214. There are no Norwegian representatives on this committee.

Several other standards are also available for the construction of containers. Examples are DIN 30722, SFS 4417, CHEM (Multilift 2009) NF R17-108 and DIN 15018. In Norway, the sector mainly refers to the Swedish standard, however.

SS3021:2014 does not include any requirements for a locking system between the load carrier (hooklift system) and container, for material quality or for container strength.

The AIBN has been in contact with and received the following clarification of the standard from the chair of the Swedish working group for SS3021:

1. In connection with the preparation of the standard, no assessment was carried out of whether the anchorage points for the container meet the requirement for lateral load securing when the container is filled with a homogeneous cargo to a total weight of up to 25 tonnes.

2. The standard contains a minimum requirement for hydraulic locking at the rear and a hook rod anchorage point at the front.

3. The standard does not provide guidelines on maintenance other than that the container must comply with the dimensions specified in the standard.

4. There are no minimum requirements for engagement length between the locks on the vehicle and the container.

5. The standard does not describe the changes that may be made to the vehicle if the anchorage points on the vehicle are not adapted to the container's securing points. It should be noted that the locks and securing points would be adapted to each other if both truck and container were built to the same standard.

2.8 Securing of hooklift container to vehicle

The AIBN has been in contact with Hiab Norway AS (Multilift), Nor Slep AS and BNS Container AS, since their equipment was used in the two investigated accidents (Aurland, Borgen) and in the conducted loading tests. The AIBN has been provided with documentation related to loads, centre of gravity heights and anchorage points. The AIBN has also requested information from the above-mentioned parties on how much slack and wear is permitted in the locking systems and anchorage points for the load securing requirements to be met.

The AIBN has received two sets of calculations regarding Multilift's outside hydraulic locks, one of which also includes extra locking at the front. Both sets of documentation are based on the ADR load securing requirements for different weights and centre of gravity heights.

One of the sets of documentation shows that when lateral forces reach a given level while a vehicle is passing through a curve, the whole lateral load must be supported by the inside locking stud at the back. This is the same locking method as the one used in the Aurland case and on the truck used in the loading test.

The other set of documentation describes a case where there are two additional front locks on either side. The AIBN has not received any information about slack or wear limits in the permanently installed locks.

Nor Slep AS has also provided the AIBN with various calculations/tests related to the permanently installed locking devices attached to the tilt frame on the trailer. They show how the container is secured to the tilt frame. Use of a chain at the front is recommended to further secure the container. The company believes that the hydraulic lock it has delivered to some of its customers since 2015, and which has become part of the standard delivery in 2016, prevents the tilt frame from being lifted under the impact of lateral loads. Nor Slep AS has not documented any slack or wear limits in the front or rear locking mechanisms.

BNS Container AS has informed the AIBN that the weight limit in SS3021 is 25 tonnes, while their hooklift containers are approved for a total weight of 20 tonnes. The company therefore considers that its containers have a certain safety margin. Hence, BNS has not set limits on / conducted tests to ascertain how great a load their anchorage points are capable of withstanding. The AIBN has been provided with information about a minimum lift bar dimension of 40 mm, but has not received any limit values for slack or wear in the securing points under the container.

2.9 Quality assurance/recalculation of documentation

The AIBN commissioned Rekon DA to assess the documentation from Hiab Norway AS (Multilift), and calculations and tests of individual components received from Nor Slep AS (trailer); see Section 2.8.

After translating ADR requirements into general lateral load securing requirements, 0.5 G in case of the truck, Rekon DA concluded that the documentation from Multilift showed that hydraulic outside locking at the rear only was sufficient to meet the load securing requirements.

It was also concluded that the documentation showed that the securing points (front and rear) on the tilt frame from Nor Slep AS meet the lateral load securing requirement of 0.5 G.

2.10 Prioritisation and implementation of measures by the NPRA

In a letter of 29 January 2016, the Directorate of Public Roads, on behalf of the NPRA, has informed the Ministry of Transport and Communications of its prioritisation and measures for systematic follow-up of the condition of hooklift containers, hooklift systems and securing points. The AIBN has gained access to the letter, which stated the following among other things:

> *The NPRA is working on hooklift container transport solutions. Unfortunately this work has yielded priority to other prioritised tasks for the Ministry of Transport and Communications.*
>
> *Through the Road users and vehicles study programme used in the training of roadside inspectors, the NPRA has increased its focus on issues related to hooklift container transport. At the national inspection workshop in 2015 where all the regions participated, the roadside inspectors were asked, when inspecting load securing, to focus on the securing of hooklift containers.*
>
> *The NPRA plans to meet with the Labour Inspection Authority in the near future to clarify responsibilities related to the condition of hooklift containers. In that connection, we will look at the possibility of introducing rules for (periodic) inspection of hooklift containers.*

The AIBN knows that the NPRA and the Labour Inspection Authority had a first meeting concerning this collaboration in spring 2016.

2.11 Prioritisation and implementation of measures by the Labour Inspection Authority

The following is reproduced from the Labour Inspection Authority's response to the draft report:

> *The Labour Inspection Authority makes reference to the fact that, during the period 2014–2016, we have transport as a national priority area. Transport has been chosen as one of several priority areas because of the sector's challenges related to the occupational working environment. The Labour Inspection Authority's initiative concerns the goods transport and tourist coach segments*

> *because those were the parts of the sector that the parties themselves identified as the segments with the greatest occupational working environment challenges.*
>
> *We would also like to mention that the Labour Inspection Authority participates in a collaboration project with representatives of the Directorate of Public Roads/NPRA, the Directorate of Taxes, Customs and Excise, and the Police. The purpose of the collaboration is to develop more effective and formalised cooperation between different supervisory agencies, including a coordinated inspection strategy for the road transport sector. The plan is for the collaboration to include all types of inspections.*
>
> *The Labour Inspection Authority will initiate collaboration with the Directorate of Public Roads to find a common solution for improving safety on Norwegian roads, including the safety of hooklift container transport. The collaboration aims to clarify the Labour Inspection Authority's and the Directorate of Public Roads' responsibilities related to hooklift container transport and the problems that have been identified in the AIBN's special report.*

As mentioned above, the Labour Inspection Authority and the NPRA have had their first meeting in this collaboration.

3. ANALYSIS

This Special Report is the result of a new, comprehensive investigation into the safety of hooklift container transport. The report is a follow-up to AIBN's first special report on safety-critical factors relating to hooklift container transport, Report ROAD 2012/03 (referred to as 'the AIBN Special Report 2012'), and it confirms previous findings and adds new knowledge. Manufacturers, product suppliers, trade organisations, enterprises and public authorities will all benefit from learning about the results that are presented, as a contribution to the work of improving the safety of hooklift container transport.

The analysis that follows is based on AIBN Special Report 2012, two investigated accidents and nine other incidents/accidents. This means that the analysis is based on investigations into a total of 15 incidents and accidents. In four of these incidents the container broke loose from the locking system at the rear of a truck, while the remaining 11 involved a trailer with a tilt frame. There is thus an essential difference between the two types of incidents. In the following analysis, the AIBN considers both differences and similarities as well as overall problems.

In addition to the incidents and accidents, the AIBN's assessment is based on conducted loading tests, studies of documents and communication with public authorities, organisations, transport companies, drivers and product suppliers.

By way of introduction (Section 3.1), the AIBN discusses safety problems in connection with hooklift container accidents on the basis of investigated incidents and accidents and conducted loading tests. The second part of the analysis (Section 3.2) addresses safety in different phases, from the time of ordering/manufacturing (including Swedish Standard SS3021:2014) through approval, use and maintenance to inspection of the equipment. The final part of the analysis (Section 3.3) presents the AIBN's assessment of the systematic follow-up of safety and of how public authorities, enterprises and special interest organisations ensure transfer of experience.

3.1 Assessment of safety problems

3.1.1 Accident in Skedsmo (Borgen bridge)

The heavy goods vehicle had driven approximately 30 km when the accident occurred in a roadworks warning area where the speed limit had been reduced to 30 km/h. The speed at the time was just over 40 km/h. Just as it was leaving the S-curve, the container broke loose from the trailer and collided with an oncoming passenger car.

The AIBN's investigation showed that there was limited engagement length between the pneumatic locking system at the front and the container that had been loaded onto the trailer. Some slack was also found in the same locks. Additional securing by a chain at the front as recommended by the manufacturer was also not used. Calculations carried out by Rekon DA on assignment for the AIBN showed a vertical load on the front locking system of approximately 9 kN while the vehicle was driving through the S-curve in question. This does not include the additional load resulting from the elevation in the roadway.

The driver has explained that once the hooklift container had been rolled to the rear position on the trailer, it had to be pulled slightly forward again to achieve engagement between the pneumatic locking studs and the container. This is confirmed by the AIBN's investigation. If the driver fails to pull the container slightly forward again, the container can be transported without the locking studs being engaged in the holes in the container. Similar problems have previously been discussed in the AIBN Special Report 2012 and in connection with one of the nine incidents mentioned in Section 2.3.

The AIBN believes that inadequate engagement length and slack in the locks, in combination with negotiating an S-curve with an elevation in the roadway, caused the container to break loose from the front locks and partially fall off the trailer. In the AIBN's opinion, wear in the locking system and hooklift system combined with high standard tolerances (a variation of up to 35 mm in the distance between the inside of the bottom side rails) on the container can lead to little engagement and weak locking, and this constitutes a safety problem.

3.1.2 Accident in Aurland

The heavy goods vehicle drove through a left curve at approximately 80 km/h. When passing through a curve, there is some lateral displacement of the centre of gravity due to the angular moment when the vehicle tilts. In this accident, assuming that the centre of gravity was at the centre of the cargo, these lateral forces meant that the inner (left) locking stud had to support a vertical load of approximately 12 kN (see Section 2.2.6). When the lock was exposed to this vertical load, the container probably broke loose from its locked position, tipped to the right and caused the vehicle to overturn in the roadway.

Measurements carried out after the accident of the container and truck's rear hydraulic locks showed that, had the container moved towards the right until stopped by the locking stud, this would have produced a gap of approximately 1 cm. Judging by the marks on the left locking stud (see figure 9), the AIBN reckons that the engagement length between the left locking stud and the container was approximately 1 cm prior to the accident. After the accident, in which the container was exposed to great torsional forces, the distance between the bottom side rails where the locking clamps are designed to grip the container, was measured to be 102 cm. This is approximately 3 cm less than prescribed in the SS3021:2014 standard.

In the AIBN's opinion, the condition of the container may have caused the load-bearing structure to give way in the curve, so that the engagement length of 1 cm was not sufficient, in addition to the fact that it was possible for the container to move slightly sideways. These factors probably contributed to overturning the truck.

According to calculations carried out by Rekon DA, the truck would probably not have overturned if the container had remained in its locked position through the curve. In figure 12 Rekon DA illustrated the impact of a change in the centre of gravity height on the vehicle's rollover speed when carrying a homogeneous cargo. It is often difficult for the driver to assess the centre of gravity height of the cargo in a container, as the driver is not always present while the container is being loaded. The AIBN is aware that, in many cases, the cargo with the highest specific weight is placed at the top, which also has a negative impact on the centre of gravity height.

It is the AIBN's opinion that, in this accident, the condition of the container and the engagement length of the locking system for the container were inadequate to ensure safety. The AIBN considers this to be a safety problem.

3.1.3 Other incidents

The following assessments are based on the factual information presented in Section 2.3, concerning nine incidents – one involving a single truck and eight involving trailers (vehicle combinations).

Three of these accidents are considered to have been rollover accidents. In one of the latter three cases, the vehicle's roll stability system (RSS)[2] was not programmed to respond. The AIBN has no information about whether RSS was activated in the other two accidents. RSS is an electronic stability system that helps the driver to choose a safe speed for negotiating a curve. The AIBN knows that RSS can also be programmed for containers that were manufactured before 2014, when this became a requirement. The AIBN believes that such systems prevent rollover accidents and recommends that the transport sector take note of this possibility.

In many of the incidents, cracks, deformation and wear were found in the containers, which the AIBN believes had an impact on safety. In the AIBN Special Report 2012, the AIBN addressed a safety recommendation to the NPRA and the Labour Inspection Authority concerning systematic follow-up of the condition of hooklift containers, among other things.

Slack in the locking systems caused by wear was also found in some of the incidents. The AIBN has noted that slack in the locking systems can reduce the engagement length with the container securing points and thus reduce the safety margin. In several cases it was also noted that the container had the possibility of moving sideways, which also reduced the engagement length and safety margin. The AIBN also knows of cases where there was no engagement between the locks and the container. The engagement length between the locks and the container can also be affected by deformation, damage and container design.

Although there have been no fatalities in the above incidents, the AIBN is concerned about the number of such incidents and about the fact that the problems that have been pointed out are still an issue.

3.1.4 Assessment of loading tests

The tests described in Section 2.4 were limited to one vehicle combination. As far as the AIBN is aware, the locking mechanism for securing the container to the vehicles that were used in this vehicle combination is the one that is most commonly used in the market. Although the results cannot be generalised, the AIBN believes that the findings are relevant in order to clarify and understand the loads to which the anchorage points are exposed. Raw wood chips were used in the test, considered by us to constitute a homogeneous mass. The report in Appendix B shows that SP Technical Research Institute of Sweden chose to impose the load at a point corresponding to the centre of gravity on a fully loaded container.

The tests carried out on the truck were stopped at a lateral load corresponding to what the vehicle was required to withstand in accordance with the load-securing requirements,

[2] Roll stability systems (RSS), used to prevent rolling accidents, are also commonly referred to as: Roll Stability Program (RSP), Roll stability Control (RSC) and Trailer Roll Stability Program (TRSP).

while the test on the trailer had to be interrupted before that, to prevent it from overturning. The results showed that the container gave way slightly under the imposition of a lateral load, but that there was no permanent deformation. The AIBN believes that vehicles on the public roads network can also be exposed to corresponding lateral forces in certain situations, and that this can contribute to rollover accidents or that the container breaks loose (see Section 3.2.5).

It was observed that the front of the container on the truck was lifted when lateral loads were imposed; see figure 16. The container on the truck was connected to the hooklift arm at the front (see figure 17) and locked from the outside by two hydraulic locks at the rear. The test showed that the imposition of a gradually increasing lateral load at centre of gravity height caused the locking stud on the opposite side to transfer the full vertical load to the truck's load bearing structure. The front of the container was lifted approximately 12 cm (at a load of 0.5 G). The test showed that, at this point in time, the hooklift arm did not function as a means of securing the load. The AIBN believes that this was because the vertical load is supported at a single point at the rear of the truck and that a torsional moment is produced between the container and the truck's load bearing structure.

The container and tilt frame on the trailer were lifted as one unit at the front when lateral forces were imposed at centre of gravity height on the container. The test was stopped at a lateral acceleration of 0.38 G to avoid overturning the trailer. The container was attached to the tilt frame by two stoppers at the back and two inside pneumatic locks at the front. The tilt frame on the trailer was locked to the main chassis by rear hinges and attached to the tipper cylinder. In the AIBN's view, the reason why the front of the tilt frame was lifted more than 15 cm (when exposed to a load of 0.38 G), was that the vertical load produces a torsional moment in the tilt frame which is transferred to the trailer's load-bearing structure through the tilt frame's rear supports.

SP concluded in its report on the tests that the load securing requirements were not met; see Section 2.4 and Appendix B. The AIBN believes that the records of how the tilt frame was lifted when exposed to lateral loads, together with the other problems that were identified, raise critical safety issues related to the truck and particularly to the trailer.

3.1.5 Assessment of securing of hooklift containers in curves – new equipment

The investigation has shown that, in Multilift hooklift systems on trucks, the full vertical load is supported by one of the rear locking studs when the vehicle is passing through a curve. Such systems are much used by several major suppliers. Because of the great slack between the hooklift hook and the lift bar on the container, the AIBN takes the view that the hooklift hook cannot be seen as a means of load securing. Nor has Multilift in its calculations (see Section 2.8) included the hooklift hook as a means of load securing. The AIBN takes a critical view of the full load being supported at a single point. This can expose the hooklift container to torsional moments that increase with the weight of the cargo and the centre of gravity height when passing through a curve.

Concerning the trailer and tilt frame manufactured by Nor Slep, the company recommends use of chain as an additional means of securing the container at the front. Such a chain was not used in any of the incidents described in this report. The AIBN knows that where a chain is used for securing, it usually secures the container to the tilt frame at the front; see figure 3.

The AIBN's opinion is that in order to prevent the tilt frame from being lifted at the front when the container is exposed to great lateral forces, the extra means of securing must be attached to the load bearing structure (not to the tilt frame). Other solutions are also possible. The AIBN knows that trailers with tilt frame structures are much used, and believes that the same safety issue can potentially arise in comparable equipment. The AIBN takes a positive view of the fact that Nor Slep supplies hydraulic locking of the tilt frame on tipper trailers, but has seen no records of calculations or tests of how this functions in relation to the load-securing requirements.

BNS Container refers to the standard's weight limit of 25 tonnes, and that the company has reduced the weight limit to a total weight of 20 tonnes for its containers. The AIBN has not been provided with any documentation of how much this improves the safety of such transport. Nor has BNS Container provided any documentation of the strength of the anchorage points. The AIBN sees the reduction of the weight limit for containers as a positive initiative, but has not assessed the extent to which this improves safety when driving through curves.

The supplier has provided the AIBN with information about the wear limit for the lift bar, but not about permitted limits for slack and wear in the locking mechanisms or vehicle anchorage points for containers.

3.1.6 Summary of safety problems

In more than half the accidents/incidents that the AIBN has investigated, containers have come loose from the truck (with locking mechanism at the rear) or trailer (with tilt frame) as a consequence of lateral forces and subsequent vertical loading of the locking system.

The Motor Vehicle Regulations no longer contain requirements for load securing equipment, but the provisions of the Vehicle Use Regulations are still applicable. The NPRA has informed the AIBN that the permanently installed locks are not included as a checkpoint in connection with annual periodic inspections.

Several players in the transport sector have informed the AIBN that they believed that first-time registration included inspection of the permanently installed locks, and that the locks were also checked during the annual periodic inspections. It is important that the transport sector take note of the fact that this is not the case and that the players themselves ensure that the products they choose comply with the applicable provisions. They must also ensure that their maintenance systems include inspections to ascertain the condition of the locks.

In the AIBN's view, containers in poor technical condition (cracks, deformations, wear in securing points etc.), slack and worn locking systems on vehicles and wide standard tolerances for container anchorage points contribute to inadequate engagement length and weak locking, so that containers can be displaced and break loose when exposed to loads. Cases have also been found where the locks have not engaged correctly in the container, and where the hooklift system/trailer/container has not been marked with the standard to which it is built. The supplier has provided the AIBN with information about the wear limit for the lift bar, but not about permitted limits for slack and wear in the locking mechanisms or anchorage points on vehicles and hooklift containers.

The loading tests carried out by the AIBN in connection with this investigation clearly show that containers were lifted from the load carrier when exposed to lateral loads below the load securing requirement (see figure 16 and figure 19), and that considerable torsion and movement occurred between the tilt frame and main chassis (trailer). SP concluded that the way in which the container was lifted entails a risk and that the load securing requirements cannot be deemed to have been met. Furthermore, the AIBN has been informed by the Swedish working group for SS3021 that lateral load securing requirements are not covered by the standard. Based on the above-mentioned accidents/incidents and the findings and conclusions from the tests that SP Technical Research Institute of Sweden was commissioned to conduct, the AIBN concludes that the permanently installed solutions for fastening the container to the vehicle do not provide adequate load securing.

The investigation showed that no extra means of securing were used in any of the incidents. There is a gap between the public authorities and users' understanding of the need for extra means of securing, and the AIBN considers this to be a safety problem. In the AIBN's opinion, the public authorities must assess whether the solutions mentioned (hydraulic locking at the rear of the truck and container secured to the tilt frame on the trailer), including the securing points on the hooklift container, are in accordance with the regulatory framework for load securing, and it submits one safety recommendation to the NPRA on this issue.

3.2 Assessment of the safety of hooklift container transport in different phases

The AIBN's investigations show that, in many cases the containers were inadequately secured, and that containers therefore broke loose when exposed to lateral loads. The AIBN believes that the standards and procedures for adequately securing hooklift containers must apply throughout the lifetime of the vehicle and equipment, i.e. the standards and procedures used for building, ordering and production, approval, use, maintenance and inspection by public authorities. The AIBN will discuss potential improvements to safety in the different phases:

3.2.1 Swedish Standard SS3021:2014

The AIBN Special Report 2012 discussed Swedish Standard SS3021:1995 'Road Vehicles – Hooklift Frames – Dimensions' and assessed the dimensions prescribed by the standard. SS3021:2014 was prepared by Swedish manufacturers of trucks and hooklift container systems. Under the Norwegian regulatory framework, the equipment does not have to be built to a specific standard, but SS3021 is still the most commonly used standard for building hooklift containers, and hooklift systems on trucks and trailers.

SS3021 was revised and the revised edition published in 2014. The revised edition concerns the dimensions and compatibility of the hooklift system only. There are still no requirements for the choice of locking system for securing the container, or for the material quality and strength required in the container to adequately secure it to the hooklift system. Hence, it is left up to the manufacturers of the locking systems and containers to define what engagement lengths and systems will adequately lock containers to trucks and trailers during transportation. The revised edition includes two annexes that show how it is possible to secure the container at several points. The AIBN found no such extra securing in any of the investigated incidents.

Furthermore, the standard fails to describe what requirements the bodywork manufacturers should define concerning modification, if any, and maintenance of the container's load-bearing structure. The AIBN is of the opinion that tolerance requirements/limit values, requirements for materials, functional requirements and tolerance limits for wear in hooklift systems and containers should all be part of a common system. The standard should include requirements for marking of containers and hooklift systems; ref. ISO standard(s). In the AIBN's opinion, SS3021:2014 fails to address essential elements of safety.

The AIBN also takes the view that the standard should oblige the manufacturers to document under what conditions the load-securing requirements are met and to provide user manuals describing criteria for what is considered good enough in connection with maintenance and inspection. SP Technical Research Institute of Sweden emphasises that SS3021 lacks requirements for the strength of anchorage points corresponding to those that apply to ISO containers. The sector has expressed a wish to achieve the same level of safety as for ISO containers, which is supported by the AIBN.

The AIBN is therefore of the opinion that several manufacturers must be included in the revision work, see Section 2.6 for more information about these manufacturers. The AIBN submits one safety recommendation to Norsk Industri, together with other special interest organisations and Norwegian suppliers, urging them to use their influence to achieve a revision of the current standard.

3.2.2 Ordering and manufacturing

3.2.2.1 *Design of vehicle hooklift container systems and trailers*

The investigation has shown that, in contrast to vehicles for transporting ISO containers, not all vehicles for transporting hooklift containers have locking systems that adequately secure the container to the vehicle, and that different locking systems are provided by different suppliers. The investigation has also shown that the party placing the order often takes it for granted that the safety of the equipment supplied is good when reference is made to the product being manufactured to the SS3021 standard. The AIBN does not find that a reference to the aforementioned standard provides any guarantee for safe locking of the container, however, as the standard does not prescribe what should be done to ensure that the hooklift system and container function as one common system.

Solutions are available for extra securing at the front of the truck; see the AIBN Special Report 2012. Extra mechanical securing from inside the bottom rails is also available, introduced after the accident in i Aurland; see Section 2.2.7. On trailers, the AIBN has seen examples of mechanical locking of the pneumatic locking mechanism at the front. Manufacturers of trailers for transporting hooklift containers have recently developed a centre lock for the tilt frame. The AIBN has not carried out any tests, modelling, calculations or similar to determine the extent to which safety is improved by use of such solutions.

Extra systems for better locking of the container to the vehicle can prevent or reduce the lifting of the container that was observed in the loading tests carried out during the investigations. The AIBN is aware, however, that several customers do not wish to buy extra equipment over and above what is required by the regulatory framework or the prevailing standards. Such solutions increase the customer's costs in what is already a pressed market. The AIBN therefore sees a need for public authorities, suppliers and the industry to provide good guidance to customers who invest in vehicles with hooklift systems, so that they are provided with some redundancy in container locking systems.

3.2.2.2 *Design of hooklift containers*

Hooklift containers are manufactured in many countries, and the SS3021:2014 standard has relatively wide tolerances for the distance between the bottom side frames. The standard also fails to include any guidelines related to the material quality or material strength of the containers.

There is no official approval procedure for containers, so it is up to the buyers themselves to ensure adequate safety through being well-informed when they place their orders. The AIBN finds that the customer has a difficult task, given that the vehicle's hooklift container system and containers are not subject to more safety criteria and are not seen as one common system.

3.2.3 Approval of new products

3.2.3.1 *Approval of vehicle hooklift container systems and trailers*

New vehicles with hooklift systems included (truck and trailer in the present case) are approved by the NPRA before they may be used on public roads. On first-time registration, there is no requirement for documentation that permanently installed locking systems meet the load-securing requirements; it is only the general load-securing requirements in the Vehicle Use Regulations that apply.

The investigation has shown that many vehicle owners expect and assume that the initial approval by the NPRA includes approval of anchorage points and permanently installed locking mechanisms. The AIBN considers this to be a safety problem, and it is important to make the users aware of the facts.

In the AIBN's opinion it is a demanding task for users and the inspection authorities to assess whether the load securing requirement in the Vehicle Use Regulations is met, given that there is no requirement for documentation in connection with the initial approval. The NPRA should be better at providing information about this safety issue, and should seek to have the technical load securing requirements included in the provisions on first-time registration.

3.2.3.2 *New hooklift containers*

Hooklift containers are not required to be approved by a public authority before they are used. Even if the hooklift container is to be used as an integral part of a CE-marked system (hooklift system on truck or trailer), the container itself is not subject to any specific safety requirements. Nor is there any requirement for the container to be marked with the standard to which it is built. In the AIBN's opinion, this imposes a demanding task on the container buyer, as it is up to the buyer to assess whether it will be safe to use the equipment.

3.2.4 Use and maintenance in transport undertakings

Daily inspection of the vehicle's hooklift system, trailer and hooklift is usually carried out by the driver. Drivers are required to check and assess that the hooklift container is safely secured to the vehicle before setting out on a journey. In the AIBN's opinion, it is important that the authorities clarify whether the most commonly used solutions on the market (see Section 3.1.6) meet the regulatory requirements, so that the carrier has something to go on.

There are many parameters that need to be included in such an inspection and assessment. Among other things, drivers must be aware of any slack in the locking system on the vehicle, any deformations or weaknesses in the container and any possibility of lateral displacement of the container. In some cases, the container also needs to be pulled slightly forward again on the container for the lock to be engaged. The hooklift system on a container includes a lamp inside the driver's cabin to indicate that the container is secured, but that the container has been pulled onto the vehicle and the locks activated does not necessarily mean that there is engagement between the locks and the container. This means that the lamp entails a risk that the driver drives off without the container being adequately secured. It is more difficult to visually inspect the locking of the container to the trailer than to the truck, as the locks on the trailer are hidden by the container once it has been pulled into place.

The AIBN finds the tasks with which the driver is charged, which are also provided for in Section 23 of the Road Traffic Act, to be demanding. Good in-house training is therefore essential, and it should include instruction in, for example, how to assess the need for extra means of securing. Employers must also have systems for maintenance and follow-up to ensure that the vehicles and containers that the drivers are put in charge of are in roadworthy condition.

Many transport undertakings have signed service and maintenance agreements for their vehicles. In the AIBN's opinion this helps to improve safety, as the garages often possess the requisite knowledge and equipment. Nonetheless, the locking system is often not covered by such service agreements and it is also not a checkpoint in the annual periodic inspections. Furthermore, the AIBN has been informed that faults and defects are often found during inspection of containers, including wear, rust and deformations, something that the AIBN also found to be the case during its own examinations.

This supports the AIBN's conclusion that both transport undertakings and container owners need to improve their systems for follow-up and maintenance of containers and locking systems. Such follow-up should include good inspection criteria, such as wear tolerances. As far as the AIBN is aware, no manufacturers of containers, hooklifts or trailers have specified such inspection criteria or wear tolerances for anchorage points in their products. The AIBN does not regard the lift bar as an anchorage point. Nor are such criteria described in SS3021.

3.2.5 Stability of vehicles carrying hooklift containers

This investigation and the investigation documented in the AIBN Special Report 2012 both show that there are challenges involved in hooklift container transport. Transporting hooklift containers on trailers with tilt frames appears to be particularly demanding.

As mentioned in Section 2.4 on loading tests, lateral loads produced a vertical gap between the hooklift container and the trailer chassis. The gap increased to more than 10 cm at lateral loads between 0.3 G and 0.38 G. The AIBN believes that this leads to a slight displacement of the centre of gravity of the cargo, which also has a negative effect on the stability limit. The test that was carried out also showed that the stability limit of the trailer in question was around 0.38 G.

The vehicle combination in the Borgen incident had a registered speed of approximately 40 km/h prior to the incident, and a measured curve radius of approximately 33 metres produces a lateral acceleration of 0.38 G. Based on the tests that were carried out, this is the limit value for when the trailer can overturn, but in this particular case, the container broke loose at the front.

Calculations by Rekon DA concerning the Borgen incident and the Grong accident in 2011 have also shown that there is much uncertainty about the actual centre of gravity height of the container and cargo. The AIBN also knows that the cargo with the highest specific gravity is often placed at the top of the container. This reduces the margins for overturning to below the minimum and gives rise to lateral forces of which the driver may not be aware when driving through a curve. In the AIBN's opinion it is hard for a driver to know at what point the vehicle approaches its stability limit.

The AIBN found that the safety margins against overturning are small during this type of transport. The risk of overturning can also differ somewhat from other types of transport where the centre of gravity height can more easily be determined. The AIBN considers this to be essential information that should be made known, and that the addition of electronic stability systems would have a good effect on safety. In this connection, the AIBN refers *inter alia* to the report on the rollover accident in Svinesund where this was discussed, and asks the transport sector to take note of this. (AIBN 2015, Report ROAD 2015/06.)

3.2.6 Supervision by the authorities

The AIBN is aware that there is no systematic inspection by public authorities of the condition of hooklift containers and anchorage points on vehicles, and this was also discussed in the AIBN Special Report 2012.

According to the Norwegian Labour Inspection's regulations, transport undertakings are obliged to follow up on the condition of their containers and other equipment they own after putting it into use. The Labour Inspection Authority has not prioritised inspection of hooklift bodywork and related equipment. However, in latter years, the supervisory authority has increased its focus on transport inspections, and transportation of goods is identified as a priority focus area.

The NPRA's instructions for roadside inspections, prepared in pursuance of the Roadside Inspection Regulations, state that anchorage points for hooklift containers shall be assessed, and that orders to repair any defects shall be issued where the load-securing requirements in the Vehicle Use Regulations are not met. The AIBN takes a positive view of the NPRA's claim that it has begun to concentrate more on inspecting whether containers on vehicle combinations carrying hooklift containers are secured in accordance with general load-securing requirements. However, it is sometimes difficult to adequately assess the condition of container locks and anchorage points on the container, and whether there has been any lateral displacement of the container, while the container is loaded and in use. In the AIBN's opinion it is very important to provide the NPRA's inspectors with good guidelines in order to optimise the effect of such inspections.

The investigation has also shown that manufacturers/suppliers have not specified any limit values for slack/wear in locks and securing points on containers that can be used as criteria for the inspections. As mentioned above, the AIBN's view is that public authorities must determine whether the load-securing requirements are met, including those that apply to anchorage points on hooklift containers. They must also set guidelines for how to conduct roadside inspections to check whether the load-securing requirements are met.

The NPRA's roadside inspectors are not legally competent to order repairs to defective permanently installed securing equipment on hooklift container vehicles that are not carrying a container. Hence, the AIBN sees little opportunity for the inspection authorities to follow up permanently installed locking equipment in such cases.

The AIBN Special Report 2012 referred to the need for documentation confirming that the units are mutually adapted or properly secured. In safety recommendations ROAD No 2012/07T and 2012/08T, the AIBN recommended that the NPRA, together with the Labour Inspection Authority, should ensure better follow-up of the condition of such equipment and implement measures to ensure that the hooklift systems and hooklift containers used with such systems are built to the same standard.

These recommendations have not yet been closed, and the AIBN considers it a problem that the Motor Vehicle Regulations do not regulate requirements for permanently installed locking equipment. The AIBN also takes the view that the NPRA's inspectors should have the legal competence to follow up those parts of permanently installed locking systems that fall under the scope of the Machinery Regulations administered by the Labour Inspection Authority.

In the AIBN's opinion, a major review is needed of the legal competence of all the inspection authorities to ensure that inspections of hooklift container transport can be carried out consistently and with the focus on safety at all stages. The AIBN therefore submits one safety recommendation to the NPRA on improving the inspection of hooklift container transport, and that this be done in collaboration with the Labour Inspection Authority so as to clarify the division of responsibility.

3.3 Summary and safety developments in hooklift container transport

3.3.1 Manufacturers and suppliers

To varying degrees, the AIBN has conducted preliminary and other investigations of such equipment since 2009. The suppliers have made positive contributions to these investigations.

During the period that has passed since the first investigation involving hooklift container transport, leading manufacturers have made improvements to their products. However, in the AIBN's opinion, requirements for material strength and wear tolerances should be incorporated into SS3021:2014. This is the standard most commonly referred to in connection with sales and deliveries of hooklift containers to the Norwegian market. The

AIBN emphasises that manufacturers and suppliers are also important standard-setters for improving the safety of this type of transport.

3.3.2 Special interest organisations

During the period, there have been meetings and good communication between the AIBN and the trade organisations Norsk Industri and Avfall Norge. These are important organisations whose members include several major undertakings, but they do not cover all transport undertakings that use this type of transport. Previous investigation reports have pointed out the need for good maintenance procedures for hooklift containers and locking systems, as these are often exposed to heavy loads and impacts during their lifetime.

In that connection, the AIBN would advise the special interest organisations to continue to emphasise the importance of good maintenance and training, and to influence and provide guidance on the correct choice of new products with a view to achieving the best possible level of safety.

3.3.3 Transport undertakings

The investigation has shown that undertakings base their internal control and follow-up of locking mechanisms and containers on the expectation that the safety level is adequate when the products are new. Undertakings make reference to their understanding that regular inspection of the equipment is ensured through annual periodic inspections and service agreements. The AIBN is informed, however, that the annual periodic inspections do not cover locking systems, and that these systems are often not covered by service agreements either. Wear and slack in locking systems are often only detected by accident. It is therefore important that the undertakings themselves also have an internal system for detecting weaknesses in hooklift containers.

The investigation showed that insufficient engagement with the container has contributed to incidents and accidents. This can be ascribed to deficiencies in competence, training and internal control procedures.

The AIBN knows that solutions are available for providing more secure anchorage points for containers than those that are generally offered as standard by the manufacturers. The investigation has nonetheless shown that many transport undertakings are unwilling to pay for solutions over and above those that are set out as requirements in regulations or standards.

The AIBN will nevertheless recommend that transport undertakings choose solutions that can contribute to improving safety and that they provide their drivers with training and procedures.

3.3.4 Public authorities

3.3.4.1 *Norwegian Labour Inspection Authority*

The investigation found safety-critical defects on hooklift containers, hooklift systems and trailers. As a supervisory authority, an important function of the Labour Inspection Authority is to insist on proper maintenance and inspection procedures for machinery and work equipment. As pointed out above, it is difficult to detect safety-critical faults and defects. The AIBN is of the opinion that there is a need to systematically follow up hooklift containers, hooklift systems and anchorage points, and that this is an area where the Labour Inspection Authority can bring its influence to bear though its supervisory activities.

The AIBN submits one safety recommendation to the Norwegian Labour Inspection Authority on this point.

3.3.4.2 *Norwegian Public Roads Administration (NPRA)*

The AIBN has been in contact with the NPRA during this investigation, and has noted the agency's initiatives to improve the safety of this type of transport. The AIBN submitted several safety recommendations in 2012 concerning the safety of hooklift container transport, and is aware that the NPRA has implemented measures to improve the inspection of such transport since then, including after the most recent investigation. The AIBN regards this as favourable and necessary if awareness of safety issues related to this type of transport is to be raised.

The investigation also found that the NPRA has assisted the police with technical examinations in connection with several incidents/accidents involving hooklift container transport. The AIBN also notes that, through this work, the NPRA becomes aware of factors that provide much valuable knowledge. The information that is obtained is disseminated and often used locally. However, the AIBN cannot see that the agency, on the basis of this information, has established any form of internal system for reporting and systematic learning.

Seen in light of the NPRA's role as the agency responsible for supervision of road users and vehicles and with sector responsibility for road safety, the AIBN is of the view that the NPRA should increasingly use the knowledge it acquires through assisting the police to implement measures in its own organisation.

The AIBN submits one safety recommendation to the Norwegian Public Roads Administration on this point.

4. CONCLUSION

In 12 of the 15 accidents/incidents involving hooklift container transport investigated by the AIBN in this special investigation, the container broke loose from the truck or trailer (with tilt frame) under the impact of lateral forces acting on the vehicle as it passed through a curve. The AIBN considers three of the incidents to have been rollover accidents.

4.1 Important results of the investigation with a bearing on safety

a) Based on investigations of 15 accidents/incidents in which containers have fallen off or vehicles have overturned, and on the findings and conclusions from a testing assignment carried out by the SP Technical Research Institute of Sweden, the AIBN is of the opinion that the most frequently used solutions for securing hooklift containers to a vehicle do not provide adequate cargo securing to uphold safety when exposed to lateral forces. The AIBN believes that it is important that the authorities clarify whether permanently installed systems for hooklift container transport and securing points on containers are dimensioned and designed so as to provide adequate securing of new and used containers without any additional measures. The investigation has shown that there is a gap between the public authorities' and users' understanding of the need for extra means of securing, and the AIBN considers this to be a safety problem.

b) The SS3021 standard was revised in 2014. The standard covers dimensions and compatibility, but it still does not include any material quality and strength or wear tolerance requirements. Hence, it is left up to the manufacturers of the locking systems and containers to define what engagement lengths and systems will adequately lock the container to the truck and trailer during transportation. Furthermore, the AIBN has been informed by the Swedish working group for SS3021 that lateral load securing requirements are not covered by the standard. The investigation has also shown that manufacturers/suppliers have not specified any limit values for slack/wear in locks and securing points on containers that can be used as criteria for the inspections.

c) Transport enterprises and container owners appear to have inadequate procedures for maintenance and inspection of hooklift containers and securing systems. The AIBN points out that it is a demanding task for the driver to detect slack resulting from wear and poor adaptation, and that safety can only be ensured through good in-house training and follow-up. The Norwegian Labour Inspection Authority has also not prioritised inspections of such equipment, and the industry is not obliged to submit to any third-party inspection of hook-lift systems and containers.

d) The investigation showed that the permanently installed locking systems are not covered by the initial approval, and that the condition of hooklift containers and anchorage points is not subject to systematic inspection by any official body. At the same time, hooklift containers and hooklift systems are only to a limited extent covered by the NPRA's roadside inspections. The Labour Inspection Authority do not often conduct vehicle inspections other than coordinated supervision in collaboration with the NPRA. Hence, permanently installed hooklift systems are normally not subject to inspection by the Labour Inspection Authority.

e) The technical examinations carried out by the NPRA to assist the police after undesirable incidents are not used for systematic learning within the agency.

4.2 Investigation results

4.2.1 Technical factors

a) In many of the incidents, cracks, deformation and wear were found in the containers, which have an impact on safety.

b) Slack and inadequate engagement length in locks are contributory causes why containers break loose from the front locks on containers. The locking devices are designed with wide tolerance limits, and, after some time's use, the risk is further increased by wear.

c) The centre of gravity of the container is displaced laterally when the vehicle passes through a curve, and both the condition of the container and inadequate engagement of the locking studs cause the container to break loose.

d) During the loading tests carried out by the AIBN in this investigation, the container was lifted from the front of the truck when exposed to a lateral load below the load-securing requirement.

e) During the loading tests on the trailer, the container and tilt frame were lifted as one unit at the front when increasing lateral loads were imposed on the container.

f) In certain situations, vehicles on the public roads network can be exposed to lateral forces corresponding to those imposed in the tests, and this can contribute to rollover accidents or the container breaking loose.

g) The vehicle combination in the Borgen incident had a registered speed of approximately 40 km/h prior to the incident in the roadworks warning area, which resulted in a calculated lateral acceleration of 0.38 G. Based on the tests that were carried out, this is the limit value for when the trailer can overturn, but in this particular case, the container broke loose at the front.

4.2.2 Ordering and approval

a) The investigation showed that, in the industry, hooklift containers are often ordered with reference to the SS3021 standard, and this is assumed to mean that the equipment, hooklift system and container are all safe to use during transport. In the AIBN's opinion, however, reference to the aforementioned standard is no guarantee for safe locking of the container.

b) Extra systems for better locking of the container to the vehicle can prevent or reduce the lifting of the container that was observed in the loading tests carried out by the AIBN.

4.2.3 Use and maintenance

a) The tasks to be included in the drivers' daily checks of the vehicle's hooklift system, trailer and hooklift container(s) are demanding.

b) As from 2014, new trailers are required to have a roll stability system (RSS) to help the driver to choose a safe speed for negotiating a curve.

c) The AIBN recommends that the transport undertakings take note of the fact that RSS can also be programmed for containers that were manufactured before this became a requirement in 2014.

d) Locking systems for containers are normally not covered by the service and maintenance agreements that transport undertakings enter into for their vehicles.

e) No manufacturer of containers, hooklifts or trailers for hooklift containers have specified any inspection criteria or wear tolerances for their locking systems. Hence, no criteria are available for how much slack is acceptable in the locking system from a safety perspective.

4.2.4 Inspection and control

a) The investigation showed that undertakings base their internal control and follow-up of locking mechanisms and containers on the expectation that the safety level is adequate when the products are new. The undertakings also assume that the locking systems on vehicles are subject to regular inspection during the annual periodic inspections. The AIBN is informed that the annual periodic inspections do not cover locking systems, and that these systems are often not covered by service agreements either. Wear and slack in locking systems are therefore often only detected by accident.

b) According to the Norwegian Labour Inspection Authority's regulations, transport undertakings are obliged to follow up on the condition of their containers and other equipment they own after putting it into use, but the authority has not specifically prioritised following this up.

c) It is difficult to assess the condition of containers and locking systems, and faults and weaknesses are often not detected during the NPRA's roadside inspections.

4.2.5 Other investigation results

The AIBN would have expected the relevant authorities to give higher priority to the safety recommendations in the previous report. Communication with the authorities, manufacturers and transport undertakings revealed that the organisations, the industry and public authorities were not well enough informed about the content of the AIBN Special Report 2012.

5. SAFETY RECOMMENDATIONS

The investigation of this accident has identified several areas in which the AIBN deems it necessary to submit safety recommendations for the purpose of improving road safety.[3]

The AIBN has previously conducted a study on hooklift container transport (AIBN 2012, Report ROAD 2012/03). The study resulted in tree safety recommendations, two of which have not yet been closed, ROAD No 2012/07T and Road No 2012/08T. The AIBN believes that the issues addressed in these recommendations are still relevant, and makes reference to them.

Safety recommendation ROAD No 2016/08T

Based on investigations of 15 accidents/incidents in which containers have fallen off or vehicles overturned, and findings and conclusions from testing assignments carried out by the SP Technical Research Institute of Sweden, the AIBN is of the opinion that the most frequently used solutions for attaching hooklift containers to a vehicle fail to provide adequate cargo securing. The investigation has shown that there is a gap between the authorities and the users' perception of the need for additional safety measures.

The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration consider whether the cargo securing requirements in the Regulations relating to the use of vehicles are met for new and used hooklift containers by using nothing other than the fixed locking system.

Safety recommendation ROAD No 2016/09T

The AIBN has carried out safety investigations of several accidents involving hooklift container transport since 2009. The investigations show that many of the containers have been inadequately secured, and that containers have therefore come loose when exposed to lateral forces. Most hooklift containers on the Norwegian market are built to the Swedish standard SS3021:2014 'Road vehicles – Hook lift frames – Dimensions'. The standard contains no cargo securing requirements but covers dimensions and compatibility. The AIBN has found the standard lacking in material safety requirements for the strength of materials and securing systems, as well as requirements for guidance on safe use, maintenance and inspection.

The Accident Investigation Board Norway recommends that the Federation of Norwegian Industries, in cooperation with other special interest organisations and suppliers, take the initiative to have standard SS3021:2014 revised to improve safety.

Safety recommendation ROAD No 2016/10T

Investigations of hooklift containers and pertaining securing systems have identified inadequacies in the maintenance and inspection procedures of transport enterprises and owners of containers. The Norwegian Labour Inspection Authority has also not prioritised inspections in this area, and the industry is not obliged to submit to any third-party inspection of hook-lifts and containers. The AIBN believes that this is an area that places great demands on the driver in terms of daily self-inspection of the vehicle, and that safety can only be ensured by expedient training and follow-up by the enterprises.

[3] The investigation report is submitted to the Ministry of Transport and Communications, which will take necessary measures to ensure that due consideration is given to the safety recommendations, cf. the Regulations of 30 June 2005 on Public Investigation and Notification of Traffic Accidents etc. Section 14.

The AIBN sees a need for the Norwegian Labour Inspection Authority to follow up that the relevant enterprises implement such accident prevention activities.

The Accident Investigation Board Norway recommends that the Norwegian Labour Inspection Authority increase its supervision of the transport industry's maintenance and inspection procedures for hooklift containers and securing systems.

Safety recommendation ROAD No 2016/11T

The investigation has shown that there is no systematic official inspection of the condition of hooklift containers and attachment points on the vehicles. There is no requirement permanently attached securing devices on hooklift container vehicles to be documented in connection with initial registration, and this is not a checkpoint in connection with annual periodic vehicle inspections. Weaknesses in hooklift containers and hook-lifts are only identified to a limited extent by the NPRA's roadside inspections when they check cargo securing, and only the Norwegian Labour Inspection Authority is authorised under its regulations to perform inspections of hooklift containers and the vehicles' attachment points. In the AIBN's view, it is important to ensure more comprehensive inspections of hooklift containers and address safety at all levels.

The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration and the Norwegian Labour Inspection Authority coordinate their approval and inspection activities relating to hooklift container transport so as to ensure that safety is addressed overall and in all phases.

Safety recommendation ROAD No 2016/12T

Through its investigations of undesirable incidents involving hooklift container transport, the AIBN has found that the NPRA has assisted the police with technical examinations on several occasions. However, the NPRA lacks a system for reporting and systematic learning based on this information at the national level of the organisation. Seen in light of the NPRA's role as the agency responsible for supervision of road users and vehicles and with sector responsibility for road safety, the AIBN is of the view that the NPRA should increasingly use the knowledge it acquires through assisting the police to implement measures in its own organisation.

The Accident Investigation Board Norway recommends that the Norwegian Public Roads Administration establish an internal system for reporting and systematic learning based on information acquired in connection with assistance assignments for the police.

Accident Investigation Board Norway

Lillestrøm, 11 July 2016

REFERENCES

AIBN (2012). Special Report on safety-critical factors relating to hooklift container transport

AIBN (2011). Report on vehicle combination rollover accident and subsequent collision with passenger car on the E6 road in Grong on 12 August 2009

AIBN (2015). Report on serious road accident on 5 May 2014 at Svinesund

APPENDICES

Appendix A: Report with calculations from Rekon DA

Appendix B: SP's report on loading tests

Appendix C: Summary conclusions from the AIBN Special Report 2012

Ingeniørfirmaet

REKON DA

Report concerning traffic accidents

www.rekon-da.no

This report has been translated into English to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

C.J. Hambros plass 5
NO-0164 OSLO

P.O. Box 2665
NO-0203 OSLO

Org. no 976 480 031

Erik Aanerud
Mobile phone: +47 905 51 945
aanerud@rekon-da.no

Henrik Nesmark
Mobile phone: + 47 900 12 044
nesmark@rekon-da.no

AIBN
P.O. Box 213
NO-2001 Lillestrøm

Oslo, 26 April 2016

Your ref.: **Serious incident at Borgen bridge in Akershus County on 26 November 2014**
Serious accident on the E16 road in Aurland Municipality on 12 December 2014
Our ref.: **EA1245**

With reference to your inquiry concerning the above, we hereby submit our report.

1. Our assignment as described in the assignment letter of 27 July 2015:

Description of requested assignment relating to the incident on county road Rv 22 at Borgen bridge in Akershus County on 26 November 2015

Based on the above description, the AIBN requests calculations and a completion date for the following work:

1. How great are the loads (forces and direction) that the relevant weights would impose on the front and rear anchorage points for the trailer's locking system in the curve where the container broke loose at the front and finally fell off?

Description of requested assignment relating to the accident on the E16 road in Aurland Municipality. The AIBN requests a price offer and completion date for the following assignment:

1. The truck and hooklift container overturned in the roadway. Use relevant weight with homogeneous cargo of the same height as the walls.
    a. What rolled over first when passing through the left curve? Did the container break loose and pull the truck with it, or did the truck and container overturn as one unit?

b. Calculate rollover speed and lateral acceleration for the container alone as if it were not secured against vertical movement at the anchorage points on the following assumptions:
    i. Container with relevant load
    ii. Container without cargo
    iii. Container loaded to maximum permitted load (total weight of 20,000 kg, centre of gravity height as in the case under consideration)

2. How great are the forces (vertical and horizontal) acting on the anchorage points on the truck before the container falls off/slips out of the anchorage points in the relevant case?

3. How great are the loads on the anchorage points if the container is exposed to the lateral load securing requirement when the container is loaded with the maximum permitted load of 20 tonnes (as stated on the manufacturer's rating plate)? A homogeneous cargo of the same height as the container's side walls should be assumed in the calculations.

4. What would have been the load on the anchorage points had they been located at the outer edge of the container and loaded as in point 3, as would have been the case for an ISO container?

2. Calculations relating to the accident at Borgen bridge

In these calculations, we have chosen to use the following values in addition to the data mentioned in the assignment letter:

- Centre of gravity height of container without cargo above the container's supporting surface: 1.365 m
- Centre of gravity height of cargo above the container's supporting surface: 1.455 m
- The stoppers at the rear of the container are assumed to be in the same position in relation to the container cross-section as the front anchorage points.

Simple simulations have been carried out using Scan-Crash to determine the approximate tilt angle of the container in the curve where the container fell off.
In the simulations, an assumed centre of gravity height on the trailer of 0.75 metres, with the supporting surface 1.27 metres above the ground is used for the trailer without cargo combined with a reasonable stiffness in the trailer's suspension. Furthermore, a gradient of 3 degrees is assumed between the roadways, but the roadways are assumed to be horizontal.
The vehicle combination was driven through the roadworks area at a speed of 40 km/h prior to entering the left curve and so that the trailer's centre of gravity describes a curve radius of approximately 33 metres.
The results of the simulations are shown in illustrations 1–3.

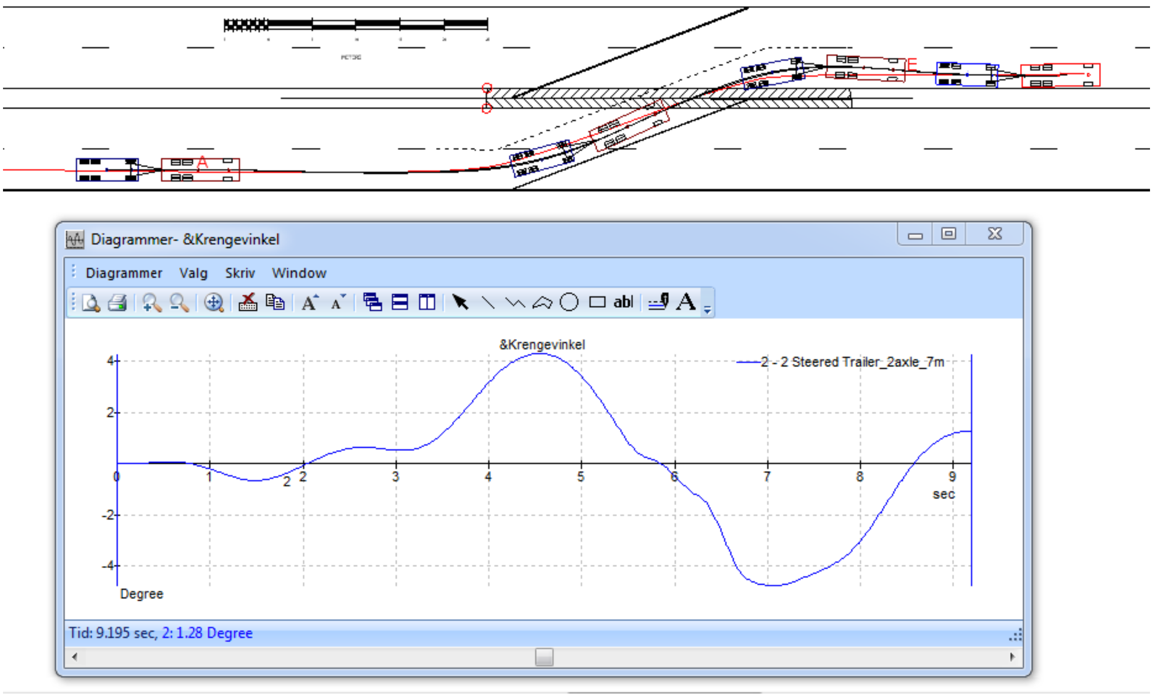


Illustration 1: Shows the start and end position for the simulation. The diagram shows the development of the trailer's tilt angle. The positions for maximum tilt angle to either side are drawn in.

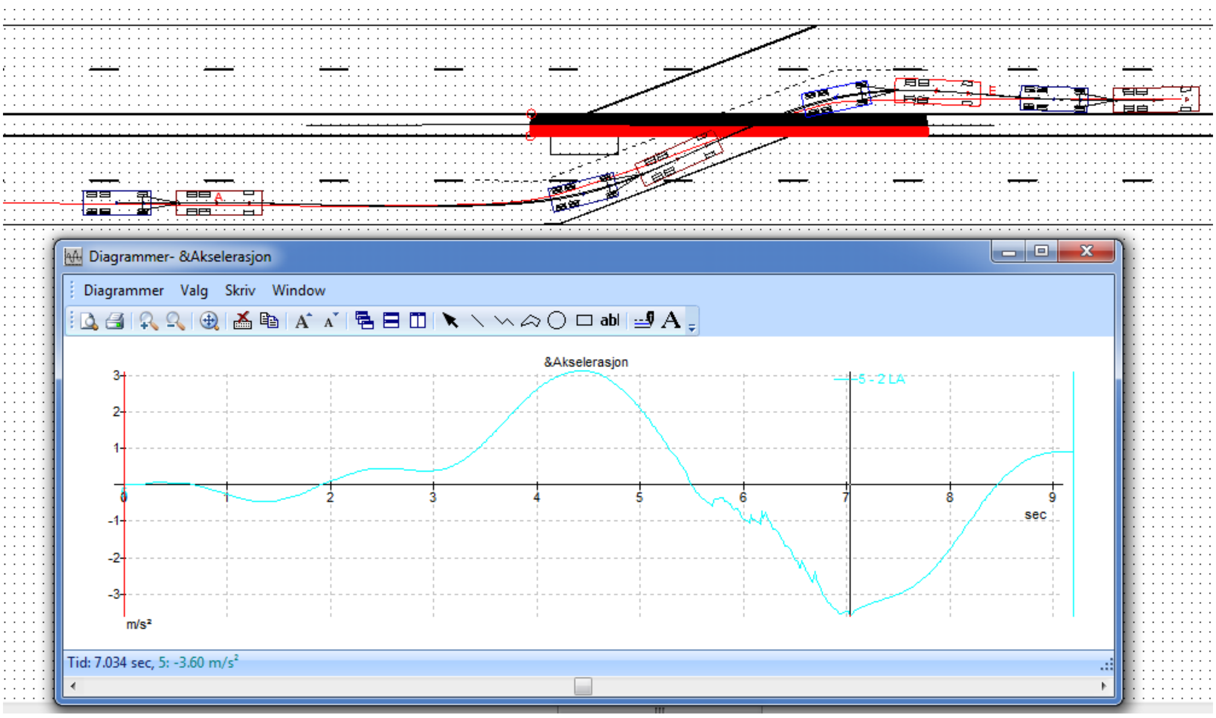


Illustration 2: Shows the start and end position for the simulation. The diagram shows the development of the lateral acceleration at the trailer's centre of gravity. The positions for maximum lateral acceleration to either side are drawn in.

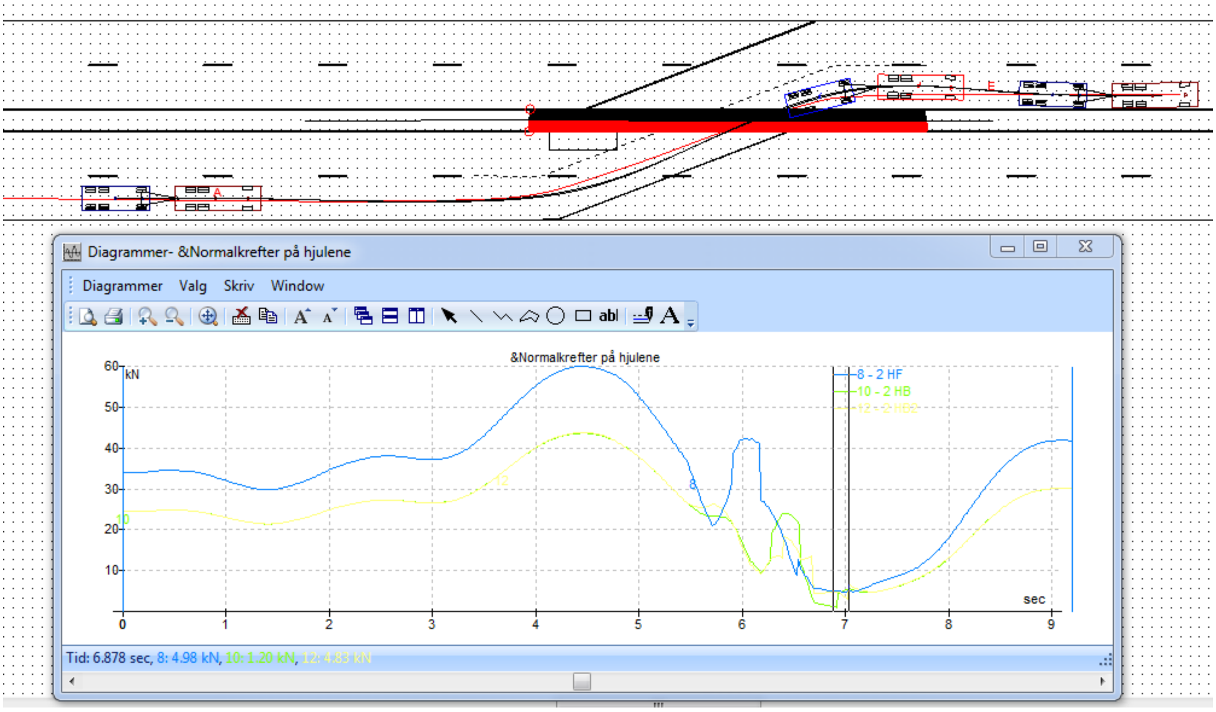


Illustration 3: Shows the start and end position for the simulation. The diagram shows the development of the normal forces acting on the trailer's right wheels. The position for minimum normal forces in the right curve is drawn in.

The simulations show a maximum tilt angle of 4.75 degrees in the right curve before the vehicle combination is brought to the upright position, a maximum lateral acceleration of 3.6 m/s^2 in the same place and that the vertical forces acting on the right wheels are low in the same area.
No acceleration or braking has been reckoned with in the course of these movements. This means that the speed at maximum lateral acceleration in the right curve was approximately 38 km/h.
Use of the above values, including an outward tilt angle of 4.75 degrees, gave the following results:

Point 1 of the assignment:
The vertical load on each of the inside securing points (the lock at the front and the rear stoppers) is estimated to have been approximately 9 kN.
The horizontal load on each of the securing points is estimated to have been approximately 22 kN.

3. Calculations relating to the accident in Aurland

In the calculations, we have chosen to use the following values in addition to the data mentioned in the assignment letter:

- A calculated centre of gravity height of truck with hooklift system of 1.11 metres above the ground based on assumed values as stated in the table below.

Element	Weight (kg)	Centre of gravity height above the ground
Engine, gears	4,000	1.2
Frame	3,300	1.2
Driver’s cabin	2,175	1.5
Wheels, axles	4,200	0.75
Total	13,675	1.11

- A centre of gravity height of the container without cargo of 1.35 metres above the container’s supporting surface
- A centre of gravity height with loaded container of 1.45 metres above the container’s supporting surface
- A container width of 1.02 metres
- A truck wheelbase of 2.10 metres; a truck tipping axis parallel to the truck on the ground 1.05 metres from the middle of the truck.
- Distance from the middle of the truck to the anchorage points for an ISO container: 1.25 metres

The road’s cross slope and the truck’s tilt angle were not taken into account in the calculations.
Simple Scan-Crash simulations using the above values and an assumed reasonable stiffness in the suspension show that the truck would tilt approximately 1.5 degrees through the curve when no cross slope is reckoned with. The cross slope is stated as being 5–6% in the area where the vehicle started to tip (stated in the document ‘20150109 Rapport Ev 16 hp 06 km 2700–3300’ (in Norwegian only) received from Torgeir Bang at the Norwegian Public Roads Administration). This corresponds to approximately 3–3.5 degrees. Hence, the tilting combined with the cross slope means that the rollover speeds will be slightly underestimated when these values are not taken into account.

Use of the above values gave the following results:
Point 1(a) of the assignment:
If the container was secured against lateral movement only, and not against overturning, it would have overturned at a vehicle speed of 89 km/h.
As a unit, the truck and container would have overturned at a speed of 113 km/h.
This means that neither the container alone nor the whole unit should have overturned at a speed of 80 km/h had the container been secured against sliding sideways.
Our calculations show that it is highly probable that the container broke loose and pulled the truck with it as it tipped.

In our calculations, we have chosen to slightly change the curve radius and use slightly different centre of gravity heights for the load in order to illustrate the impact of these factors on the calculated rollover speeds.
The results of these calculations are presented in Illustration 2.

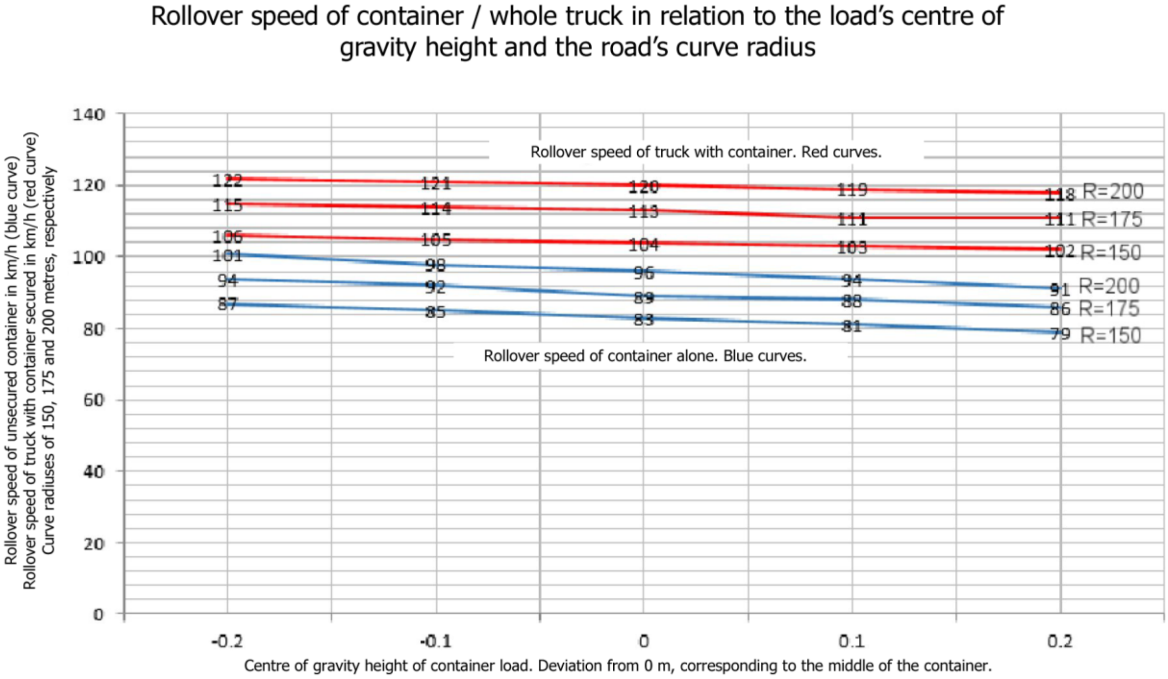


Illustration 4

Point 1(b) of the assignment:

i)	Rollover speed of container with relevant load of 8,000 kg:	89 km/h
	corresponding to a lateral acceleration of	0.36 g
ii)	Rollover speed of container alone without cargo:	91 km/h
	corresponding to a lateral acceleration of	0.38 g
iii)	Rollover speed of container with maximum permitted load of 20,000 kg:	89 km/h
	corresponding to a lateral acceleration of	0.36 g

Point 2 of the assignment:

The horizontal forces acting on the container's securing points are estimated to amount to a total of 34 kN. We have disregarded the frictional forces between the container and the supporting surface.

The vertical downward forces acting on the container's inner locking stud through the curve are estimated to amount to approximately 12 kN.

Point 3 of the assignment:

If the container was loaded to the authorised total weight (total weight: 20,000 kg, cargo: 16,000 kg) with the same centre of gravity height for the cargo as above, the horizontal forces acting on the container's securing points at a lateral acceleration of 0.5 g (the load securing requirement) are estimated to amount to approximately 100 kN. The vertical forces acting on the container's inside anchorage points in the curve are estimated to amount to approximately 42 kN in the upward direction. This means that the anchorage points must withstand a vertical force of 42 kN to prevent the container from tipping. We have disregarded the forces that are supported by the hook at the front.

Point 4 of the assignment:

The vertical forces acting on the inside anchorage points on an ISO container that is loaded as in point 3 are estimated to amount to approximately 41 kN in the downward direction. This means that the container will exert this force on the securing points. Hence the ISO container will not tip under a lateral load of 0.5 g. The horizontal forces will be the same as is in point 3, i.e. approximately 100 kN.

On behalf of the engineering firm **REKON** DA

Erik Aanerud

REPORT

Contact person
Gunnar Kjell
Safety
+46 10 516 52 29
lars.andersson@sp.se

Date 2016-09-28
Reference 5P07533E

SHT Statens Havarikommisjon for Transport
potboks 213
NO-2001 LILLESTRÖM
Norway

Investigation of transports with hooklift containers

This is a translation from report 5P07533 in Swedish language. In case of dispute the Swedish report has preference.

1 Mission

Because of a series of accidents during transports with hooklift containers ("krokcontainer" in Norwegian language) an investigation has been performed with the aim to test the total stability of vehicles and container during road transport and the function of the locking devices on both the truck and the trailer. Practical tests has been performed with truck and trailer subjected to static lateral forces applied in the centre of gravity of filled hooklift containers. The lateral forces have been taken from the European standard EN 12195-1 "Load restraining on road vehicles - Safety – Part 1: Calculation of securing forces".

Accelerations according to EN 12195-1is shown in following table:

Direction	Accelerations koefficient g				
	Longitudinal		Transvers		Vertical down
	Forward	Backward	Sideways	Wagging sideways	
Longitudenal	0,8 [1)]	0,5			1,0
Transvers			0,5	0,5/0,6 [2)]	1,0

1) *In Norway the requirement is 1 g forwards*
2) *0,6 g is recommended when the road surface is uneven and affecting the transport by its inclination.*

The static forces have been applied in steps with the force applied in the center of the gravity of a fully loaded hooklift container, 2525 mm over the road surface. Movements between truck/trailer and the container have been measured in both vertical and horizontal direction during each step of the testing. The test assemblies is shown in photo 1, showing the truck during the testing.

Photo 1. Truck with container. To the right of the container is the strap that is used to apply the lateral force. The other strap is only used to secure the vehicle from tipping.

Another type of test was performed in order to simulate what happens when truck and trailer crosses over a bump in the middle of the road and at the same time takes a turn. The simulation was performed so that one of the front wheels of the trailer was lifted in two steps until a difference in level between the two front wheels were 300 mm. During the test movements between the frame of the trailer and the container were measured.

Finally was the horizontal force needed to make the securing device in the truck to open measured. An attempt to measure the same force in the trailer failed because of the geometry in the device and dirt prohibiting its movements. Dimensions deemed important were measured during those testings.

The tests were performed at Sessvollmoen military camp in Gardemoen. Forces and movements were measured with calibrated loadcells and indicators. Forces were applied with equipment from Sessvollmoen military camp such as winches fixed to heavy wrecker trucks and suitable straps.

2 Description of truck and trailer

SHT supported the tests with truck and trailer together with suitable hooklift containers loaded with wodden chips. It was required that all equipment should be of acceptable standard for road transport.

2.1 Truck with hooklift container

The truck, type Volvo FM 540, reg no. AS 28499, inclusive loaded container had according to the client a total mass of 26 400 kg. The loaded hooklift container was loaded to a total mass of 13630 kg. When loaded on the truck the hooklift container expanded 152 mm behind the frame wheels of the container, see photo 2. The total volume of the hooklift container was 41 m^{3}.

Photo2 . Truck with hooklift container

Photo 3. Loading deck of the truck

Photo 4. Part of the loading deck of the truck with the frame wheels which is supporting the container horizontally

Photo 5. The two external securing hooks in the aft part of the loading deck.

Photo 6. The indicators location when measuring movements between load deck and hooklift container in horizontal and vertical direction.

Photo 7. Marking of the hooklift container used on the truck.

2.2 Trailer and hooklift container

Trailer, reg no LP 5663, inclusive loaded hooklift container had a total mass of 23 120 kg. The loaded container had a mass of 17 270 kg and a volume of 46 m^3. The trailer was equipped with a tilting device.

Photo 8. The load deck of the trailer, observe the four securing devices on the front part of the tilting frame.

Photo 9. Securing device on the front part of the tilting frame

Photo 10. Trailer with hooklift container, observe that the front pair of securing devices do not have any holes to fit into in the container frame. The aft pair fits into holes in the frame of the container.

Photo 11. The hole in the fram of the hooklift container into which the securing devices fitted. Observe that the hole was filled with gravel and dirt.

Photo 12. One of the securing devices fitted inte the tilting frame of the trailer.

Photo 13. The trailer’s two securing fittings at the aft end of the hooklift container.

Photo 14. The aft fittings are secured by a pin prohibiting them from coming out. The pin is secured with an yoke.

Photo 15. Marking of the hooklift container used on the trailer.

3 Result

3.1 Horizontal forces applied in the side of the hooklift container on the truck

A static lateral force was applied in the centre of gravity of a fully loaded container in 90° to the longitudenal direction, see photo 1. The force was increased in 5 steps, 0.1 g in each step, and movements between hooklift container and the truck was measured. Measurments and lateral forces are shown in table 1. The position of the indicators are shown in photo 6. Before any force was applied the indicators were set to zero. Movements given in table 1 after unloading indicates remaining movement. Annex 1 shows force against movement in diagrams.

Table 1

Lateral acceleration G	Force kN	Horisontal movement mm	Vertical movement mm	Observation
0	0	0	0	
0,1	14	0,45	0	
0	0	0,35	0	
0,2	28	1,90	0,2	
0	0	0,35	0	
0,3	42	3,6	16	
0	0	0,35	0	
0,4	56	5,0	20	1)
0	0	0,35	0	
0,5	70	5,0	25	2)
0	0	0,35	0	

1) *The horizontal movement depended on the fact that the hooklift container slided on the load deck until it stopped against the side supports. No remaining deformations could be observed after the tests.*
2) *The aft wheels of the truck was lifted from the ground and any increasing of the* lateral *force was possible see photo 15 and 16. The hooklift container had no contact with the load deck in the front of the container, see photo 17 and 18 .*

Photo 16. At a force level equivalent to 0.5 g were the aft wheels of the truck lifted from the ground.

Photo 17. Force level equivalent to 0.5 g

Photo 18. Force level equivalent to 0.5 g. The front part of the hooklift container has no contact with the load deck of the truck.

Photo 19. Detail from photo 18, the distance between container and load deck was estimated to 120 mm.

3.2 Horizontal forces applied in the side of the hooklift container on the trailer

A static lateral force was applied in the centre of gravity of a fully loaded container in 90° to the longitudenal direction, see photo 1. The force was increased in 5 steps, 0.1 g in each step, and movements between hooklift container and the load deck of the trailer was measured. Measurments and lateral forces are shown in table 2. The position of the indicators were the same as with the truck and are shown in photo 6. Before any force was applied the indicators were set to zero. Movements given in table 2 after unloading indicates remaining movement. Annex 2 shows force against movement in diagrams.

Table 2

Lateral acceleration G	Force kN	Horizontal movement mm	Vertical movement mm	Observation
0	0	0	0	
0,1	20	0,5	2,0	
0	0	0	0	
0,2	40	2,0	12,0	
0	0	0	0	
0,3	60	5,0	25,0	
0	0	0	0	
0,38	75,5	-	>150	1)
0	0	0	0	

1) *The wheels of the* trailer *lost its contact with the ground and further increasing of the lateral force was impossible, see photo 19 and 20 . The hooklift container was still fixed to the tilting frame of the* trailer *but a big distance between container and the load deck of the* trailer *had occurred, see photo 21. After each load step the container returned to the position it had when the test started. This shows that no remaining deformations had occurred during the tests. The distance between the hooklift container and the load deck of the* trailer *was so big that it was not possible to measure.*

Photo 20. The wheels of the trailer lost contact with the ground at a force equivalent to an acceleration of 0,38g.

Photo 21. Force level equivalent to 0,38g.

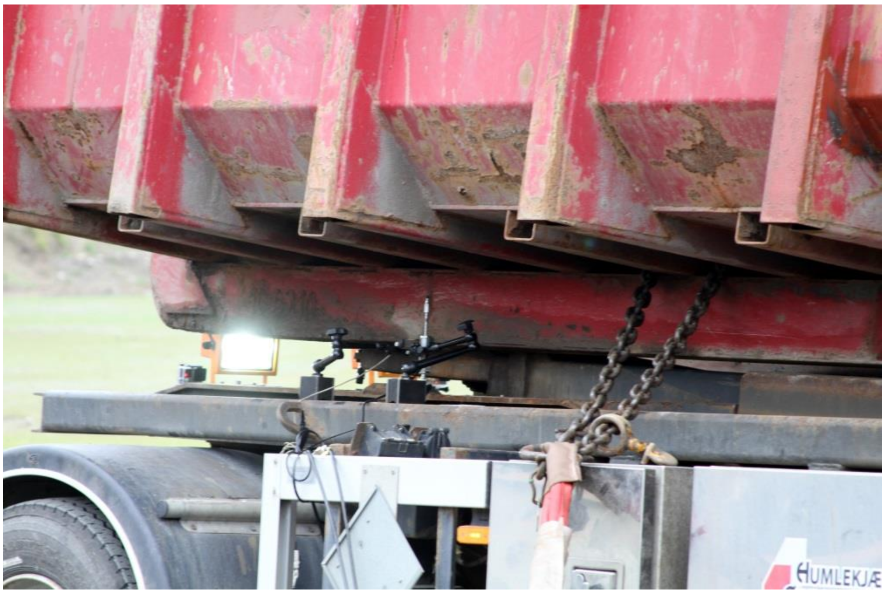


Photo 22. Observe that the hooklift container has left a big distance between its underside and the load deck. It is the tilting device that is holding it on the trailer but the tilting device has no support from the frame in its frontal part and is subjected to a unfavorable angle between tilting device and trailer frame. This angle may make it possible to deform the tilting device and subsequently make the hooklift container slide off the load deck. Observe also that all measuring equipment has lost contact with the container.

3.3 Measuring of horizontal and vertical movements between hooklift container and the load deck of the trailer when the front wheels are positioned in different heights

In order to simulate that the trailer is pulled over a bumb diagonally between two lanes, one of the front wheels was positioned on a horizontal platform, see photo 23. The other front wheel remained in the same height on the ground. With a fork lift truck the wheel positioned on the horizontal platform was lifted until a difference in height between the two front wheels was established. Movements between the hooklift container and the load deck was measured until the difference in height had reached 300 mm. The test was first performed with the securing device fixed to the tilting device and after that another test without the securing devices fixed. The securing device was fixed throughout the tests.

The results are shown in table 3.

Table 3

Frontal securing devices fixed	Difference in height between front wheels mm	Distance between container and load deck mm
Fixed	0	0
	100	0
	200	11
Not fixed	0	0
	100	0
	200	11
	300	27

Photo 23. Lifting of the left front wheel of the trailer in order to simulate a turn over a bumb between two lanes.

3.4 Securing device on truck and trailer

The securing devices on the truck were designed so that they lock the hooklift container by pressing it together from outside around the flange in the bottom rail of the container, see photo 24 and 25. Two chains were fastened in the securing device and a force was applied in horizontal direction and 90° to the longitudinal. Photo 25 and 26 show how the indicators were positioned for measuring of movements. The force was increased and at a force of 43 kN the securing devices were pulled open, see force/movement diagram in annex 3. The main task for the securing device is, according to SPs opinion, to take vertical forces, horizontal forces can be handled by side supports such as frame wheels and supports along the bottom of the container. The force 43 kN is not enough to keep the container on the load deck when subjected to accelerations of 0.5 g sideways.

It was also observed that the hydraulic securing devices on the truck were not able to be moved to their inner position because of dirt in the mechanism, 10 mm remained to move to inner position. This clearly indicates the risk that the securing device can be stuck in their outer position without the driver noticing.

The securing device of the trailer was designed in another way. They were locking in holes in the inside area of the bottom rail of the hooklift container, see photo 8 to 12. The mechanism of these pneumatic securing devices was so dirty that the function was affected. Equipment to measure the force they were able apply to the bottom rail was lacking but a person using an iron-bar level had difficulties to move the locks when pneumatic pressure was released. This shows that also this type of securing devices can easily be fastened in unlocked position. Reduced force can also result making it impossible to lock in the hole of the bottom because of it being filled with dirt and ice.

Photo 24. Measuring of the force when the securing device of the truck opens.

Foto 25. Position of indicator for measuring of the movements of the locking hooks on the right side of the truck.

Photo 26. Position of indicator for measuring of the movements of the locking hooks on the left side of the truck.

3.5 Dimensions

In the standard SS 3021:2014 dimensions and tolerances for hooklift containers are described. An inner distance between the bottom rails is set to 900 mm with the tolerance +30/-5 mm. the outer dimension is set to 1060 mm with the tolerance + 0/-5 mm.

The inner distance between the bottom rails was measured in many different locations on both containers and varied between 917 and 921 mm. The outer distance between the bottom rails were measured to 1059.5 mm except for the container tested on the truck where a distance of 1057.5 mm was found in the position where the securing devices was gripping. This was probably dependt of a cracked weld that was detected in that position after the tests.

All measurements were within the tolerances given in the standard. The generous tolerance for the inner distance between the bottom rails, in total 35 mm require likely that hooklift container and carrier is adapted to each other. If the load carrier is designed to the minimum tolerance and the hooklift container to the maximum it can have the result that when the container has slid to one side of the load deck there is a play of 35 mm in the other side. Will the securing device then still remain in locked position?

The height of the bottom rails was measured to 180 mm and was made of u-beams with a flange dimension of 70 mm.

The outer securing devices on the truck had in open position a gap of 1083 mm and in inner position a gap of 901 mm. This means that they could get a good grip in the two bottom rails of the container since the outer dimension of the bottom rails, measured over the flanges, may vary between 1055 and 1060 mm and was 1057.5 to 1059.5 on the container tested on the truck. They were also not dependent of holes in the bottom rails since they could grip anywhere along the bottom rails.

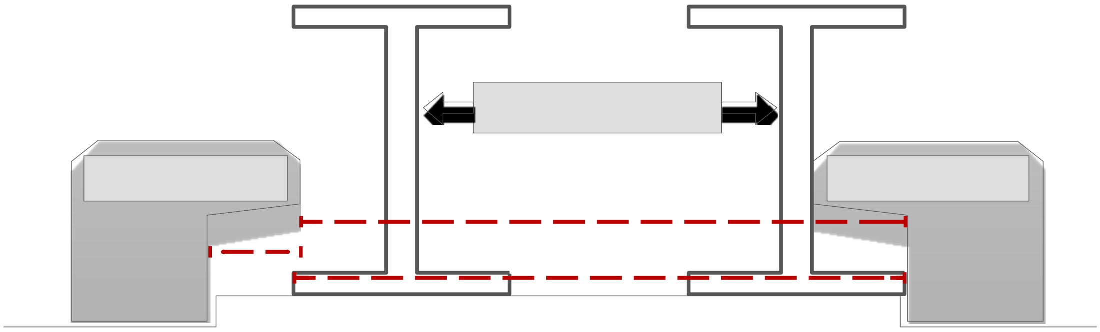


Figure 1. Sketch showing the securing device on the truck and the bottom rails of the hooklift container. Observe that I-Beams are shown but the container on the truck was equipped with U-beams with the flange outwards.

The inner securing devices of the trailer were dependent of holes in the bottom rails. The trailer was equipped with two pairs of securing devices in the frontal part. These securing devices had a distance of 990 mm between them in fully extended position, which means that they would have been locked even if the distance between the bottom rails had been the maximum 930 mm.

If comparing the generous tolerances for hooklift containers with the tolerances for containers in accordance with ISO 1496 it is obvious that tolerances in ISO 1496 are very strict and does not give any possibilities for variations. These containers shall be able to be transported in different transport means and be able to be stacked on top of each other.

The strength requirements for ISO 1496 containers are very high. Corner fittings are used for securing and the requirement for corner fittings in ISO 1161 and securing devices in ISO 3874 is that they shall withstand vertical tension forces of 150 kN and horizontal forces of 300 kN without any permanent deformation.

Those requirements are stated because those containers shall be able to be transported by sea, road and rail. The classification societies require 300 kN for the tensile forces.

There are no strength requirements for hooklift containers today.

4. Condition of the tested hooklift containers

After the tests the hooklift containers were emptied and inspected. It was obvious that they are subjected to hard wear and damages are sometimes only barely repaired. Following photos show the condition of the containers.

Photo 27. The hooklift container used on the truck.

Photo 28. Damaged inner flange on the truck container.

Photo 29. Hooklift container used on the truck.

Photo 30. Cracked weld between bottom rail and container in the area where the securing devices are gripping.

Photo 31. The hooklift container used on the trailer.

Photo 32. Traces from earlier repairs on the container used on the carrier.

Photo 33. The container used on the trailer showed many traces from hard treatment and hasty repairs.

Photo 34. Weld not performed in a professional way, trailer container.

5 Conclusions

According to SPs opinion the tests performed show that handling with hooklift containers can function in a safe way under normal conditions. This means that load carrier and hooklift container are adaptable and securing devices are locked and that masses center of gravity are held within what the containers are designed for. Sometimes the real circumstances are not what the containers were originally designed for and that leads to the risk of accidents such as overturning and container falling of the load carrier. Examples of those circumstances are given below:

- The height of the hooklift container on the trailer was so high that trailer and container did not fulfill the requirement for lateral accelerations 0.5 g. The test was stopped when a lateral acceleration of 0.38 was reached because of overturning. The truck managed to withstand 0.5 g but it was obvious that this was maximum. Those facts creates a big risk during road transports and is not fulfilling requirements for load securing on road transport. Lighter materials are often stacked in the bottom and heavier material on top giving higher centers of gravity creating even bigger risks, resulting in overturning and loss of containers.
- Hooklift containers are subjected to heavy wear and the bottom rails are easily damaged. If those damages occur in the areas where the securing devices are located it is a big risk that the container will not be properly secured to the load carrier. This type of damages are not easy to detect since the containers are always standing on the bottom rails. It must be the drivers responsibility to control this when loading a container on to his load carrier.
- Also damages to the securing devices on the load carrier can create risks when their functions are not intact. Trying to measure the force needed to push the front securing devices on the trailer it was obvious that dirt had come in the mechanism prohibiting normal use. In order to detect errors like this a daily maintenance program is needed. A detection showing that the function is intact is also a possibility but will not detect if the bottom rail is damaged. It is surprising that the vehicles securing equipment is not controlled during the annual inspection of the vehicles, considering the risks involved.
- It is evident that 3-axles trailers, when passing uneven part in the road surface, can have a great distance between the hooklift container and the vehicle frame in vertical direction. This is because the chassis of the trailer isn’t ridgid compared with the container which is very rigid resulting in the chassis following the uneven road surface with the rigid box on top creating loose contact in the front when the chassis is twisting and the rigid container does not. If this occur during a turn and at the same time the vehicle jumps over an obstacle the hooklift container can very well come off.
- This investigation cannot answer if load carriers and hooklift containers always are adapted to each other. Differences in length between different containers may create problems if the securing locks for instance are supposed to fit into holes in the bottom rails, see photo 10. The standard describes a free area along the bottom rails that shall be used for the securing devices. This area is determined to be between 1450 mm and 1670 mm depending on length of the load carrier. If the securing devices shall be able to lock into the holes in the bottom rails it is mandatory that they are adapted to each other. Tolerances for the inside distance between the bottom rails are big, +30/-5mm. If the hooklift container is pushed to one side on the load carrier and the difference between load deck and bottom rail is the maximum of what is allowed, there is an obvious risk that the securing devices on the opposite side does not lock properly. As

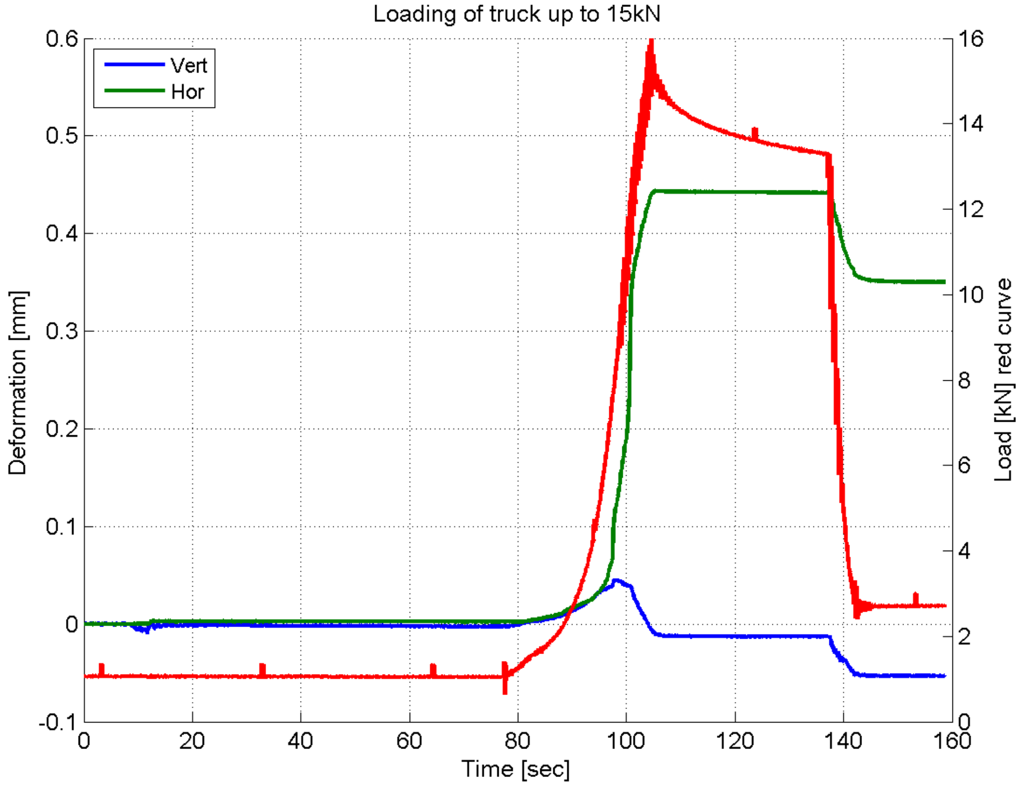
shown in photo 11 the hole intended for securing had been made with a gas burner and looks as it was done in a hast to fit the actual load carrier. If gas burner are used in this way the possibility to damage the material with improper heat treatment or cutting wrong in a way that may damage the bottom rail. In this particular case damages of this sort could not be observed.

- It was found that the holes (pockets) in the bottom rails were filled with gravel and dirt. If they become filled totally there is a risk that the securing devices can't lock and during wintertime this risk is higher because of water freezing in the holes, taking into consideration that the hooklift containers are kept on the ground standing on their bottom rails. When the securing devices are pneumatically operated the risk is increased because of lower forces than can be expected with hydraulic equipment.
- The tilting equipment on the trailer is increasing the risks. During the tests it was obvious that the frame of the tilting equipment on which the container was fitted was twisted with the result that the container lost its contact with the load deck, see photo 22.
- The lateral supports that the load deck of the truck was equipped with, see photo 3, is a good solution since it helps both loading operations and gives support sideways during transport. They have no possibility to hinder the container to overturn if the securing devices are not locked on the opposite side of the load deck. Comparing the strength requirements for securing equipment on road transport with ISO 1496 containers with securing devices for hooklift containers it is obvious while that the requirements for ISO 1496 containers are high they are lacking for hooklift containers.
- In general it can be stated that high center of gravity, overload and worn out equipment is reducing traffic safety. It can also happen that the hooklift container and the load carrier are not adapted to each other. If a transport is affected by these circumstances the risks are increased and therefore should focus be: education of drivers, maintaining of equipment and some form of control of both load carrier and container before a transport is started.
- Handling goods using hooklift containers is a great time-saver. They are easy and quick to load and unload on to a vehicle. This ”simple” handling can result in safety matters to be forgotten. After a hooklift container have been loaded on a vehicle it should be controlled that it has been secured to the load deck before starting the transport on public roads. It should be the responsibility of the driver to control this before each transport.

SP Technical Research Institute of Sweden
Safety - Mechanics Research

Performed by	Examined by
Gunnar Kjell	Lars Andersson

Appendix 1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Vert
Hor
Deformation [mm]
Load [kN] red curve
Time [sec]
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0.2
0.1
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4
2
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20
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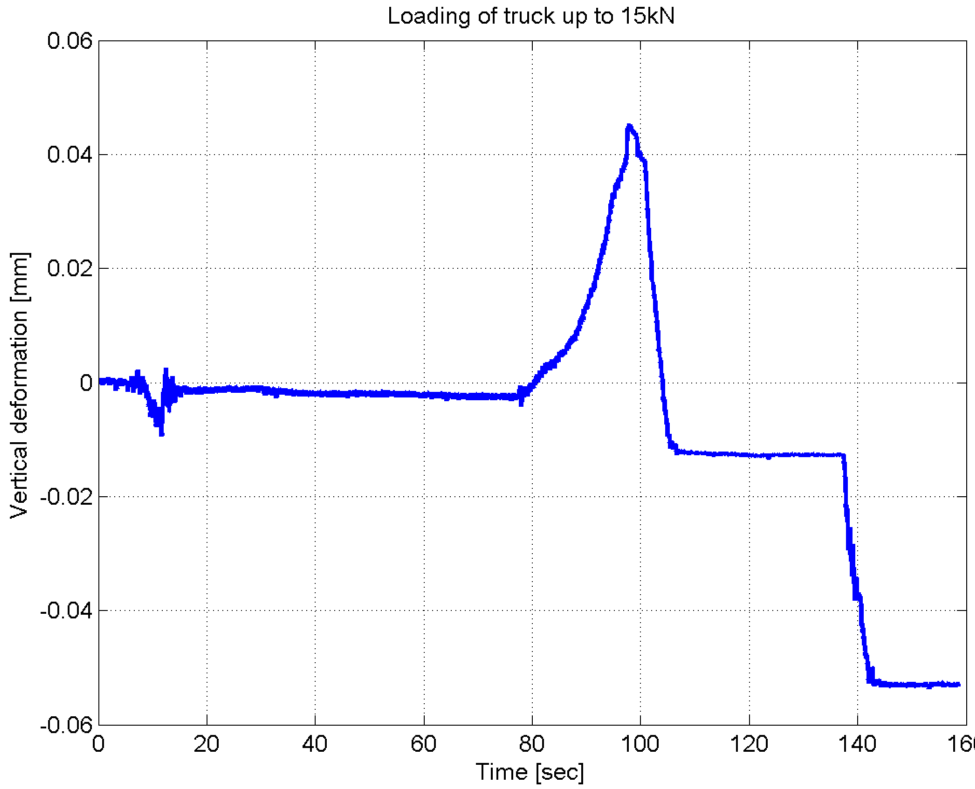
60
80
100
120
140
160


Loading of truck up to 15kN
Vertical deformation [mm]
Time [sec]
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0.02
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-0.04
-0.06
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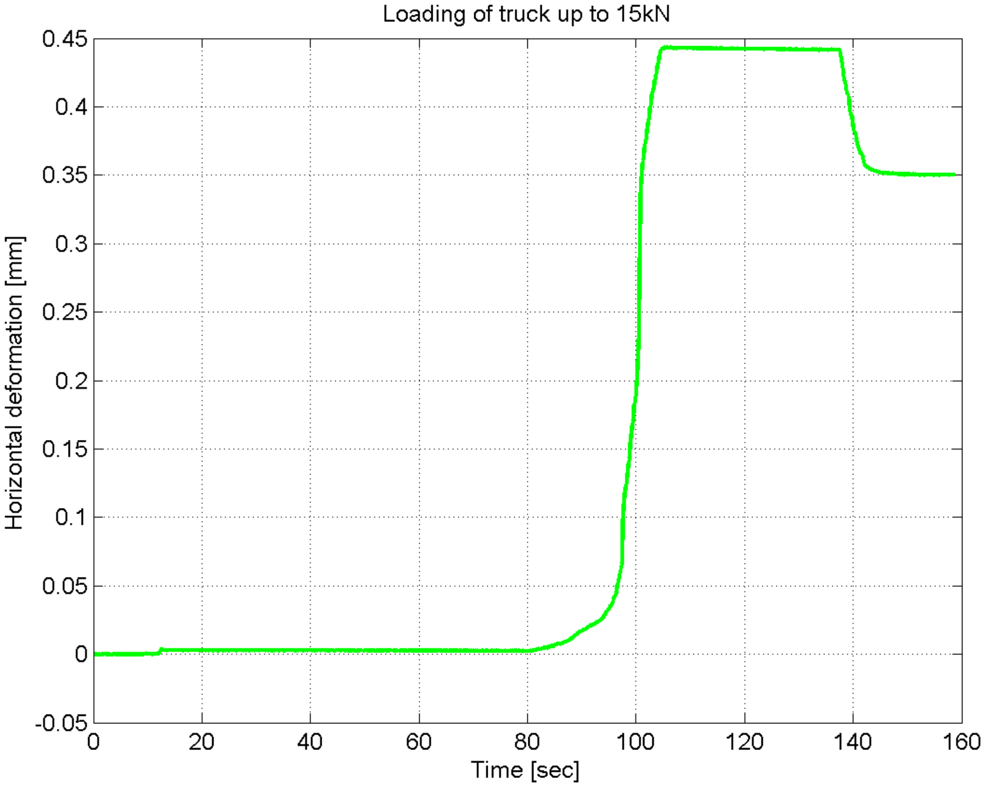
60
80
100
120
140
160

Appendix 1


Loading of truck up to 15kN
Horizontal deformation [mm]
Time [sec]
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0.35
0.3
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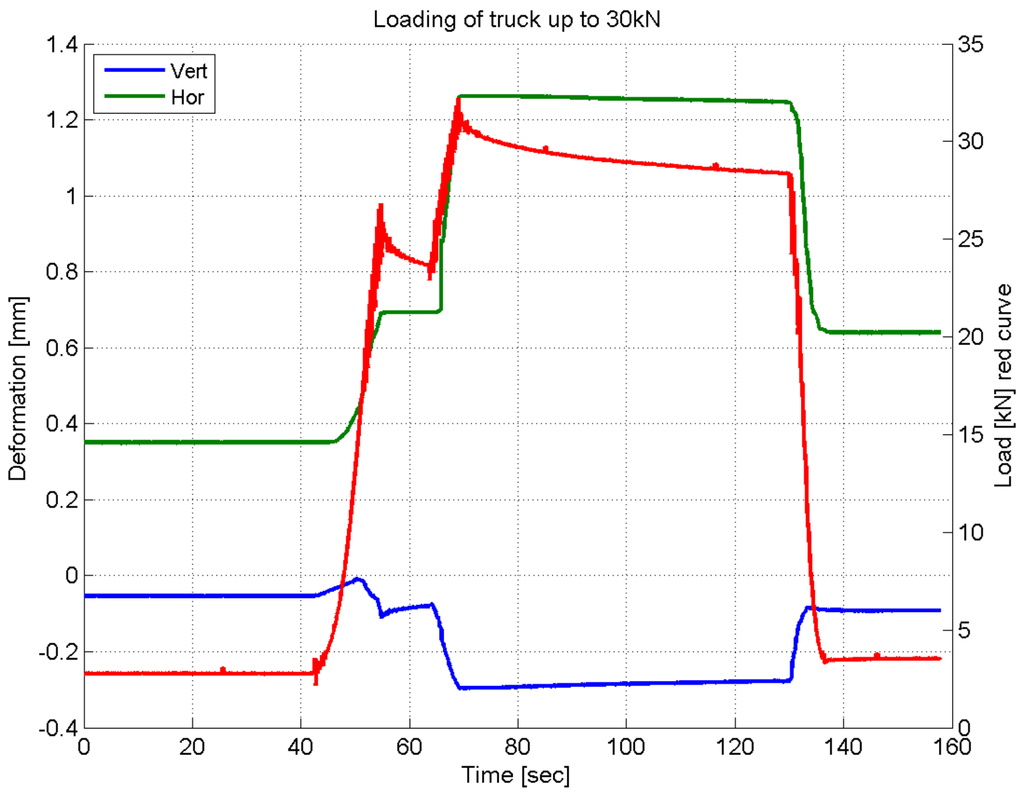
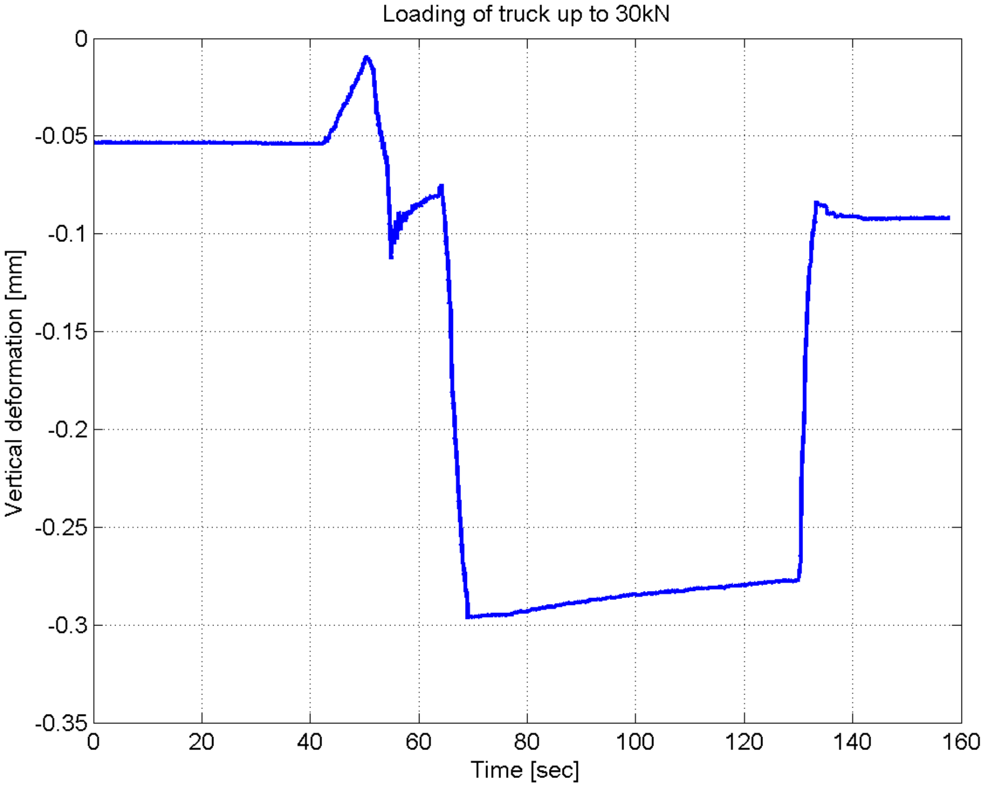
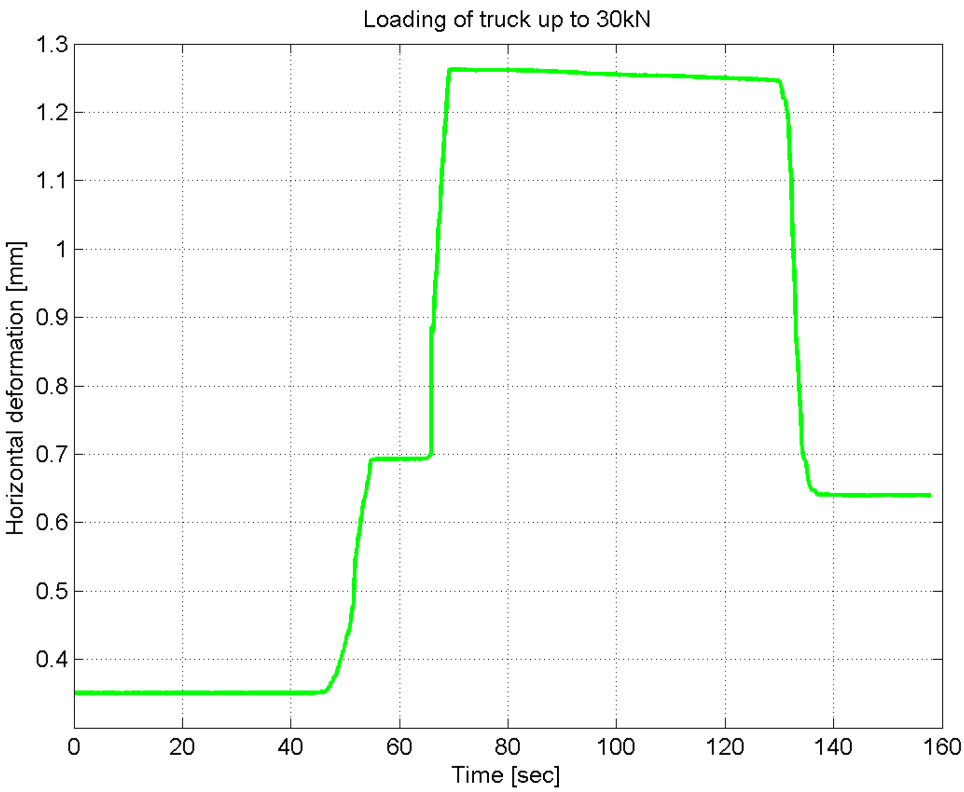
0.05
0
-0.05
0
20
40
60
80
100
120
140
160


Loading of truck up to 30kN
Vert
Hor
Deformation [mm]
Load [kN] red curve
Time [sec]
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160

Appendix 1


Loading of truck up to 30kN
Vertical deformation [mm]
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
0
20
40
60
80
100
120
140
160
Time [sec]


Loading of truck up to 30kN
Horizontal deformation [mm]
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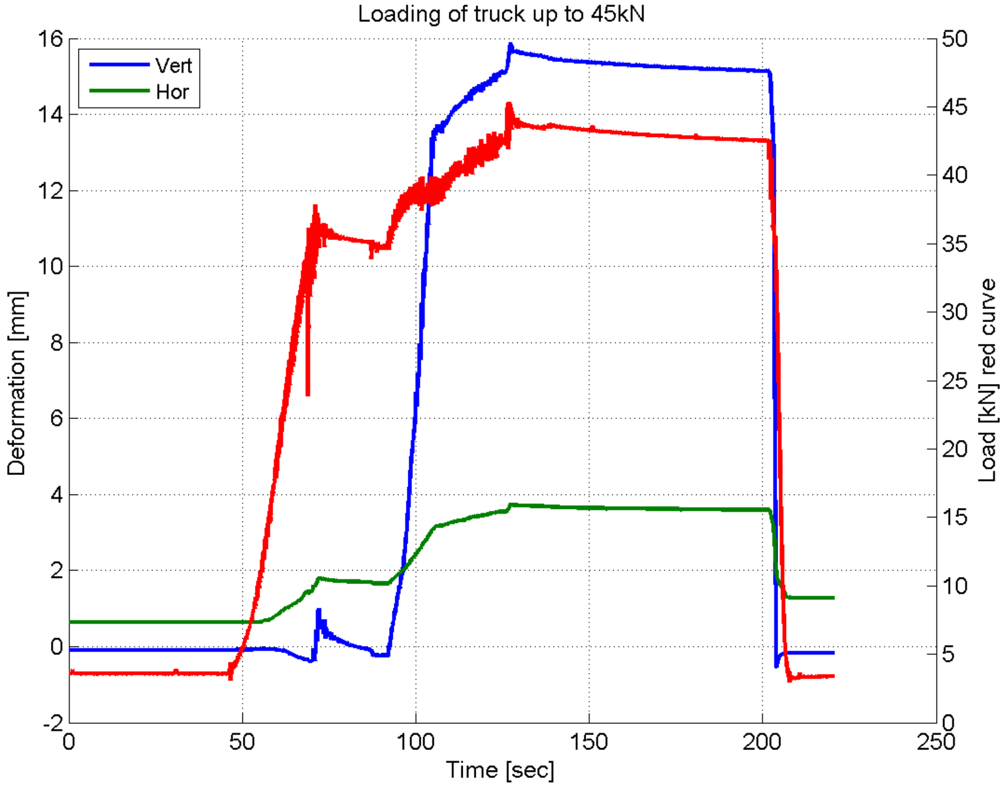
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0
20
40
60
80
100
120
140
160
Time [sec]

Appendix 1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Vert
Hor
Deformation [mm]
Load [kN] red curve
Time [sec]
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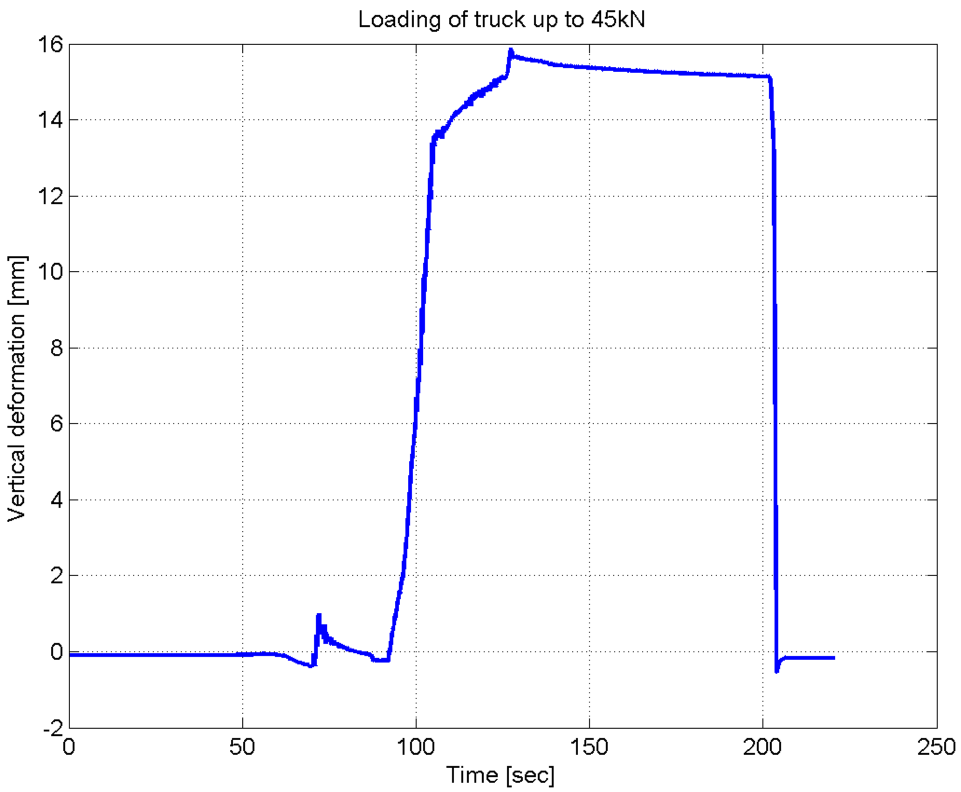
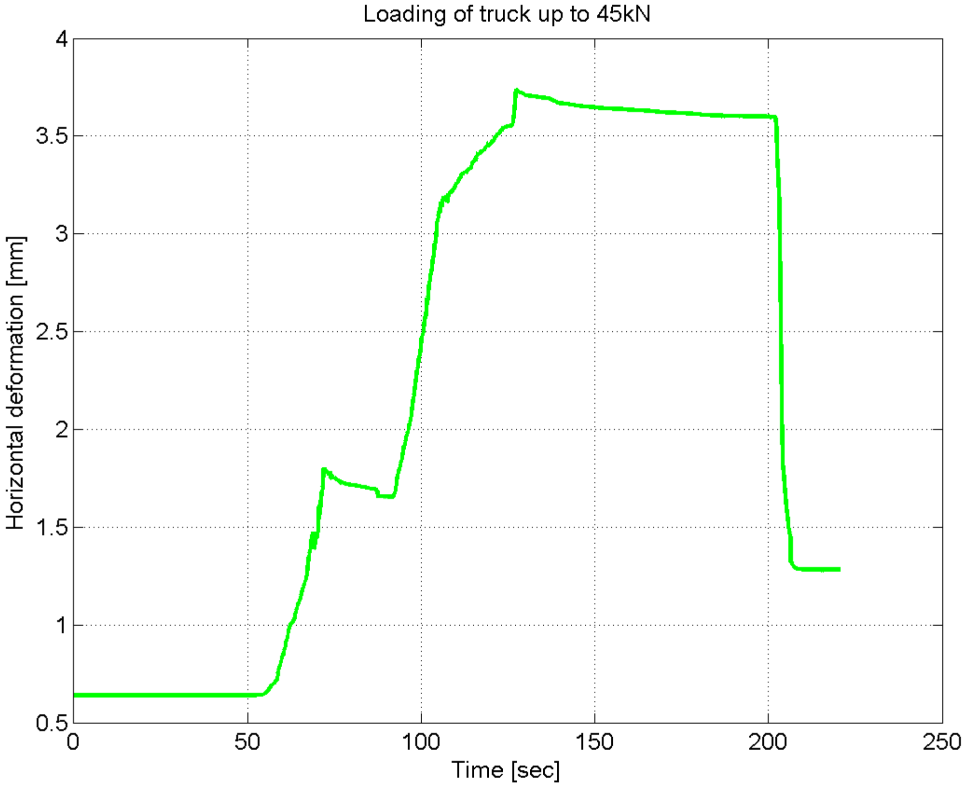
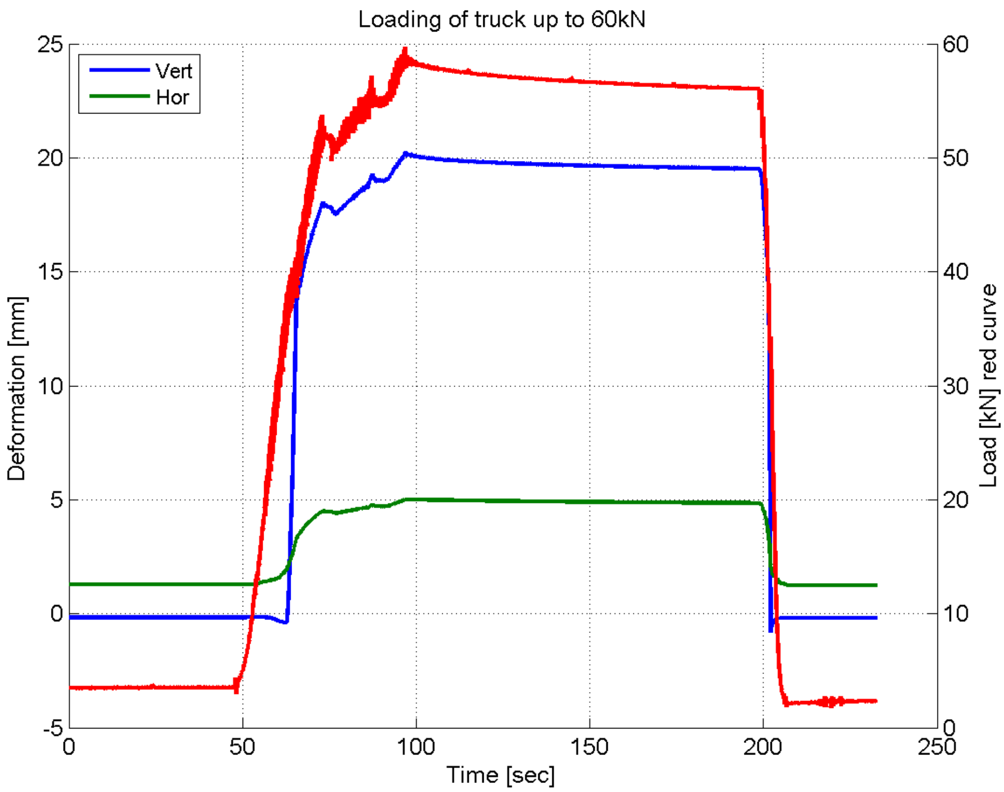
14
12
10
8
6
4
2
0
-2
50
45
40
35
30
25
20
15
10
5
0
0
50
100
150
200
250

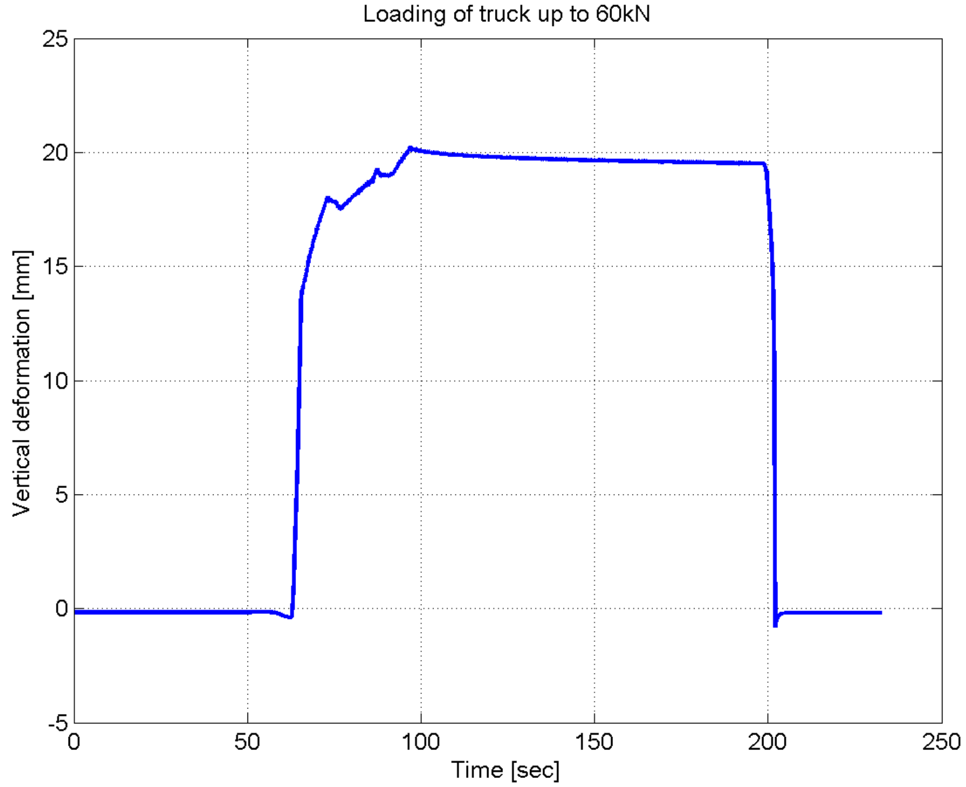

Loading of truck up to 45kN
Vertical deformation [mm]
Time [sec]
16
14
12
10
8
6
4
2
0
-2
0
50
100
150
200
250

Appendix 1


Loading of truck up to 45kN
Horizontal deformation [mm]
4
3.5
3
2.5
2
1.5
1
0.5
0
50
100
150
200
250
Time [sec]


Loading of truck up to 60kN
Vert
Hor
Deformation [mm]
Load [kN] red curve
25
20
15
10
5
0
-5
60
50
40
30
20
10
0
0
50
100
150
200
250
Time [sec]

Appendix 1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Time [sec]
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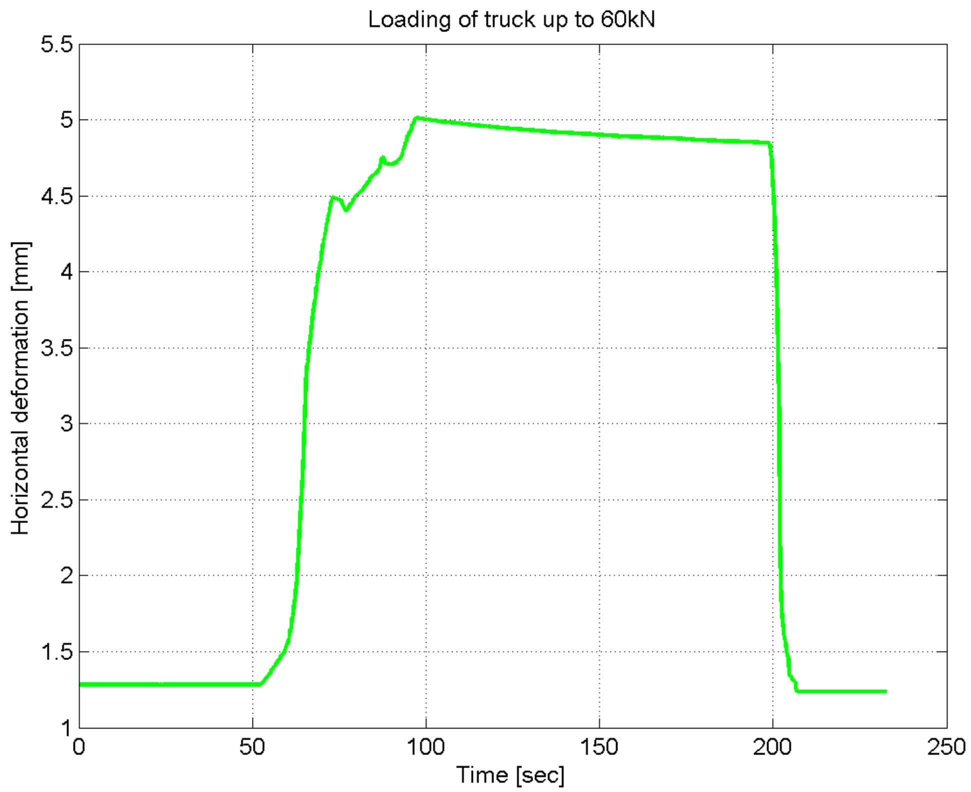
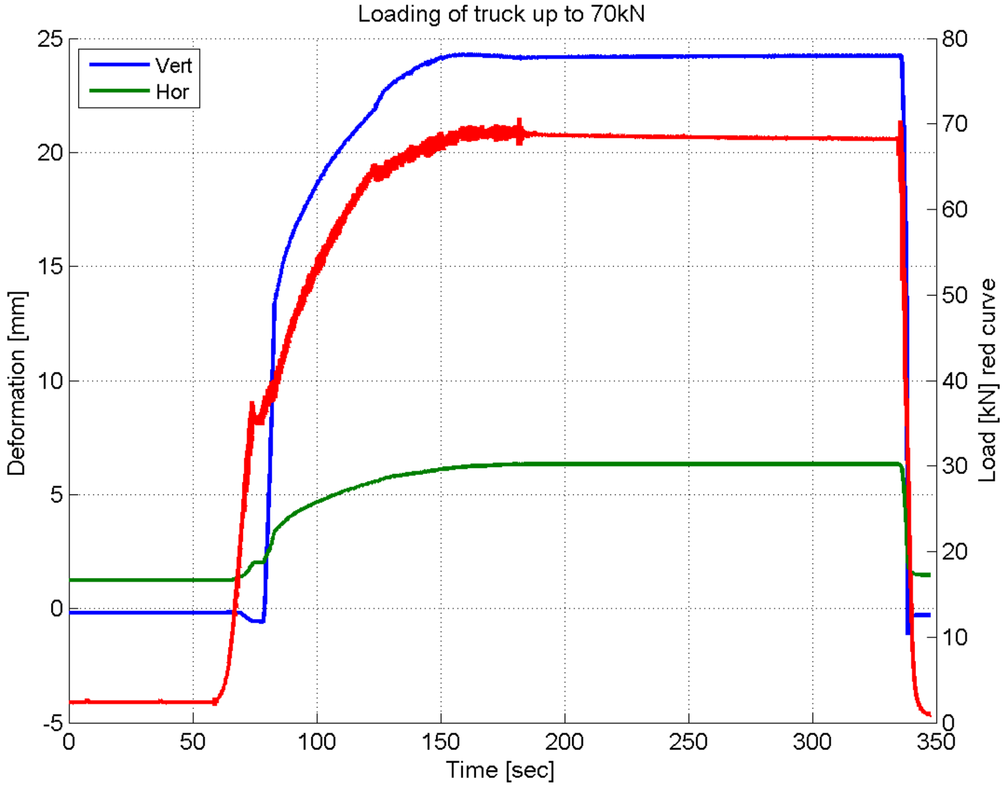
20
15
10
5
0
-5
0
50
100
150
200
250


Loading of truck up to 60kN
Horizontal deformation [mm]
Time [sec]
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0
50
100
150
200
250

Appendix 1


Loading of truck up to 70kN
Vert
Hor
Deformation [mm]
Load [kN] red curve
Time [sec]
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20
15
10
5
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80
70
60
50
40
30
20
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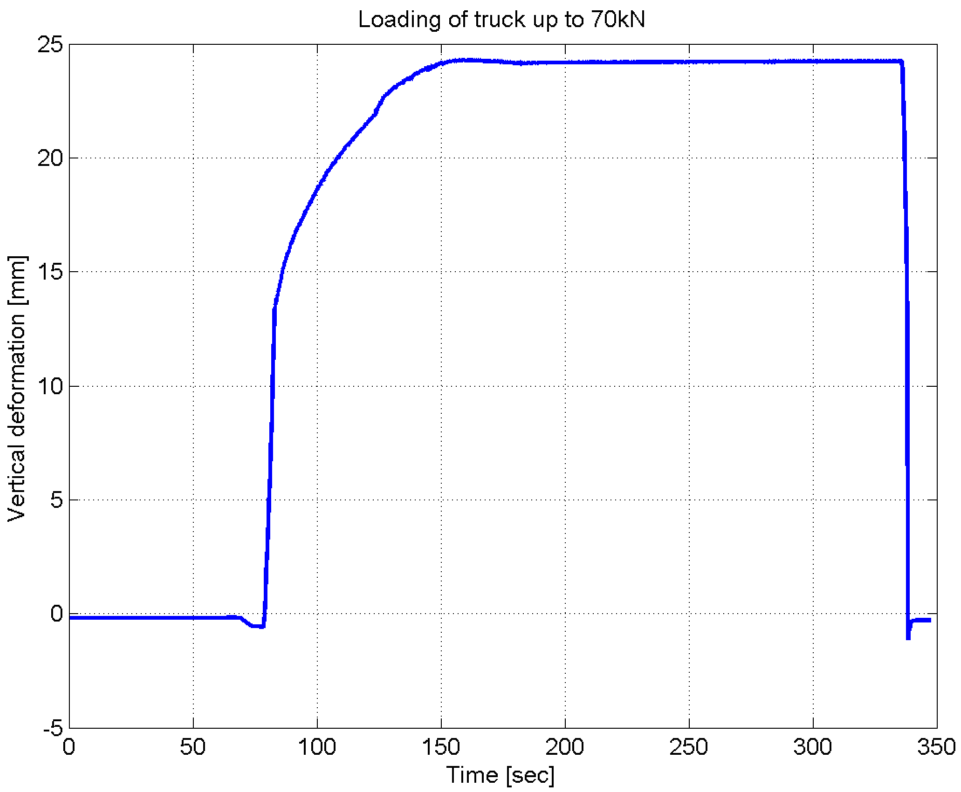
0
50
100
150
200
250
300
350


Loading of truck up to 70kN
Vertical deformation [mm]
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20
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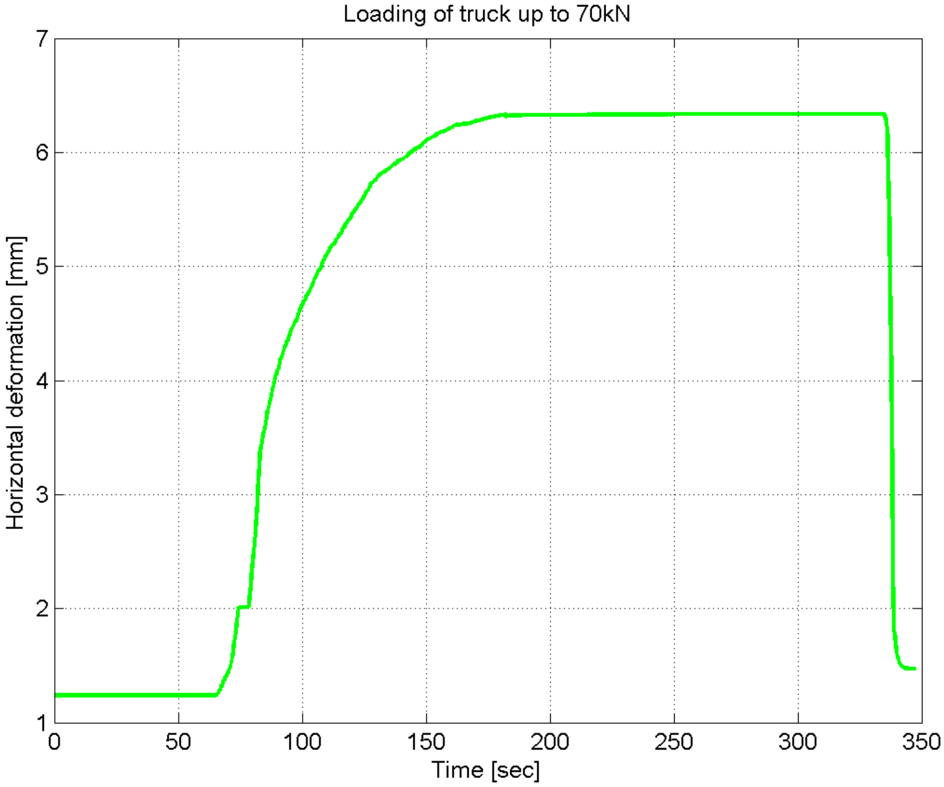
10
5
0
-5
50
100
150
200
250
300
350

Appendix 1


Loading of truck up to 70kN
Horizontal deformation [mm]
Time [sec]
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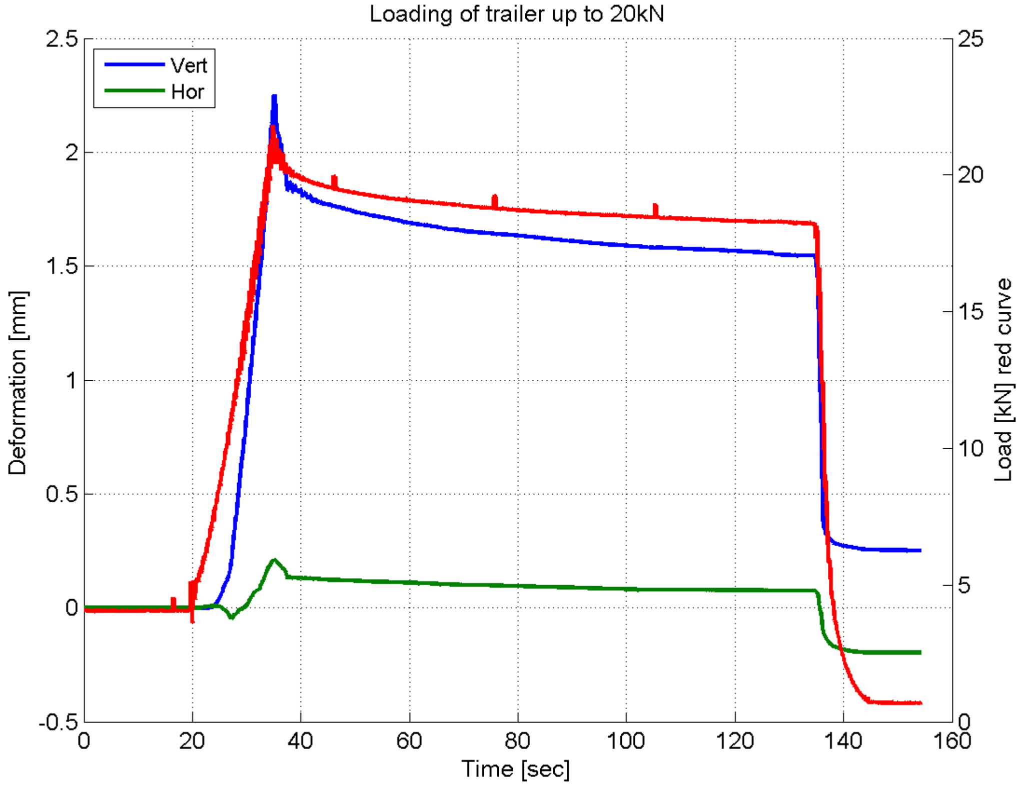
2
3
4
5
6
7
0
50
100
150
200
250
300
350

Appendix 2


Loading of trailer up to 20kN
Vert
Hor
Deformation [mm]
Load [kN] red curve
Time [sec]
2.5
2
1.5
1
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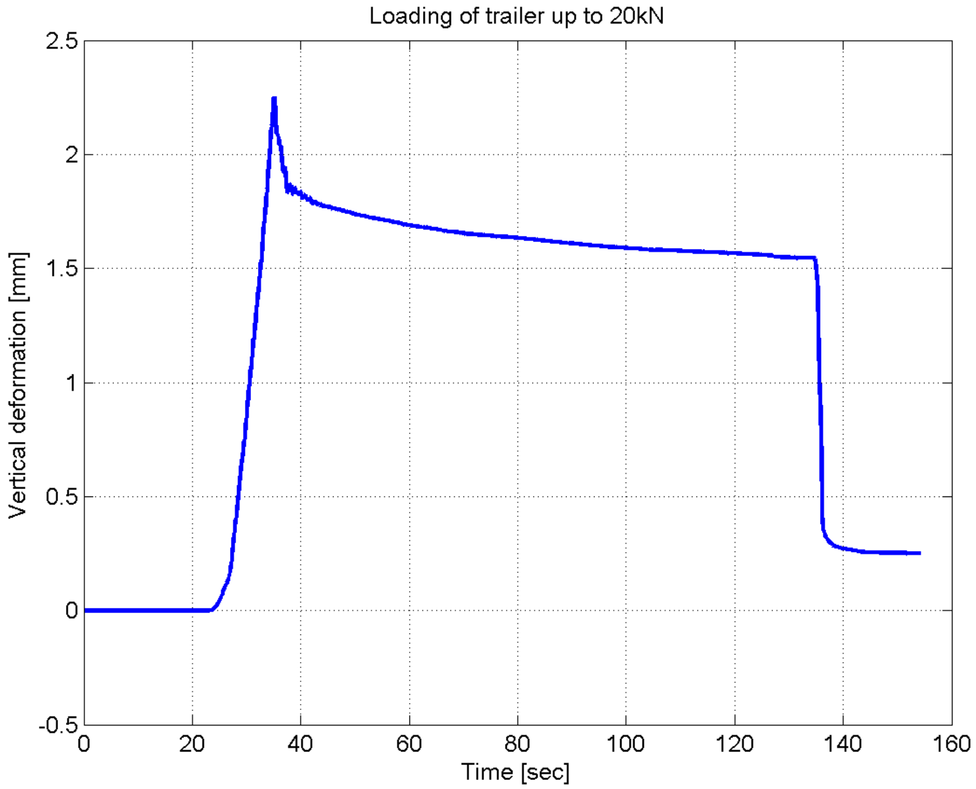
0
-0.5
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160


Loading of trailer up to 20kN
Vertical deformation [mm]
Time [sec]
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2
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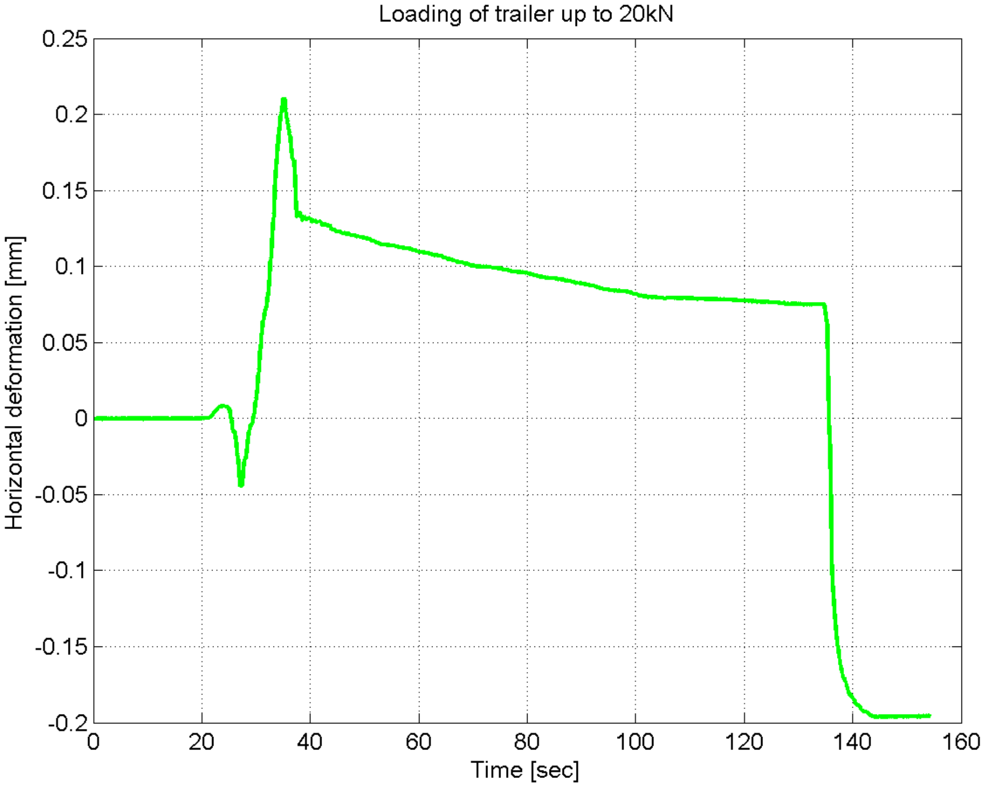
1
0.5
0
-0.5
0
20
40
60
80
100
120
140
160

Appendix 2


Loading of trailer up to 20kN
Horizontal deformation [mm]
Time [sec]
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0.1
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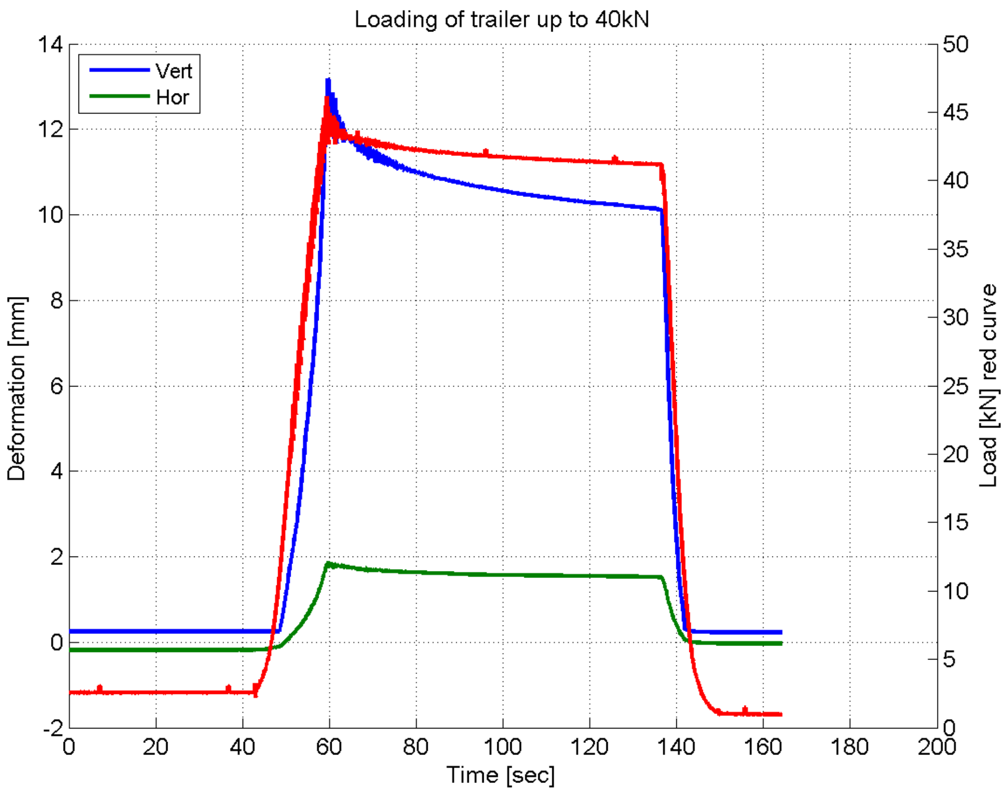
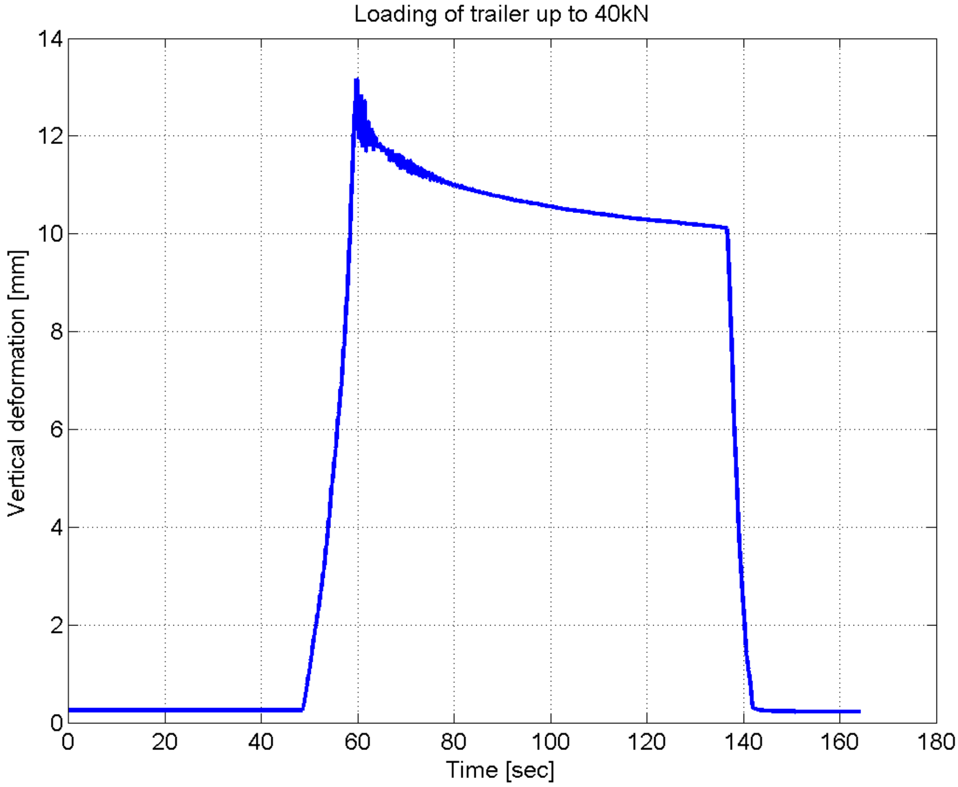
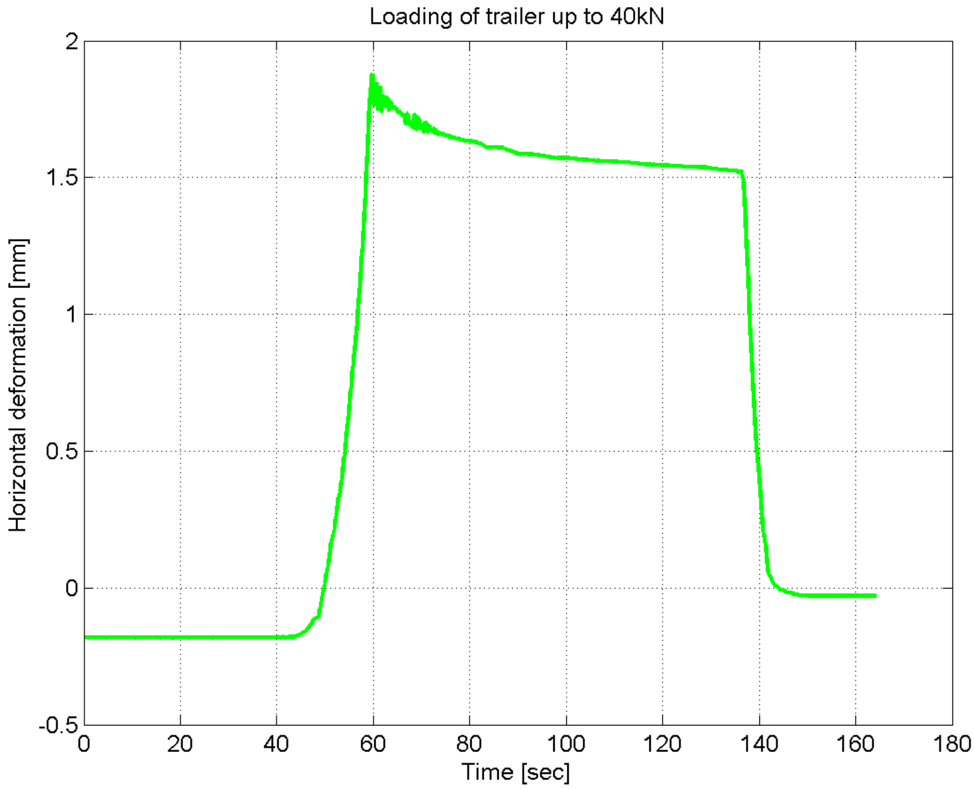
-0.15
-0.2
0
20
40
60
80
100
120
140
160


Loading of trailer up to 40kN
Vert
Hor
Deformation [mm]
Load [kN] red curve
Time [sec]
14
12
10
8
6
4
2
0
-2
50
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200

Appendix 2


Loading of trailer up to 40kN
Vertical deformation [mm]
Time [sec]
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
140
160
180


Loading of trailer up to 40kN
Horizontal deformation [mm]
Time [sec]
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0.5
1
1.5
2
0
20
40
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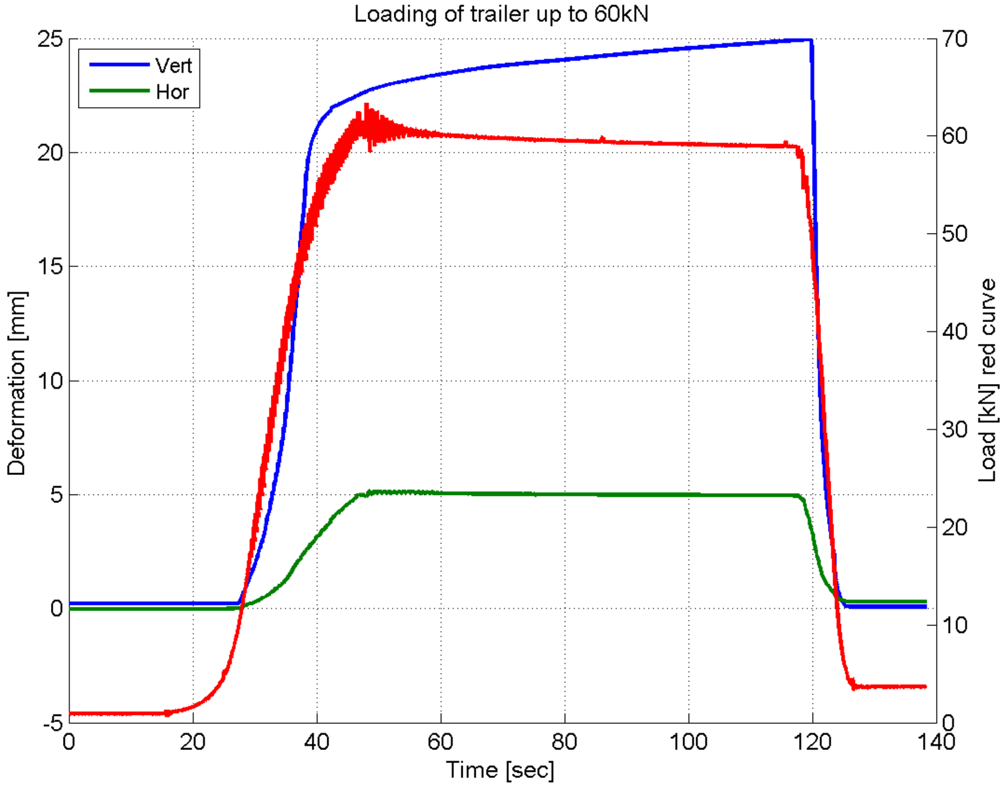
120
140
160
180

Appendix 2


Loading of trailer up to 60kN
Vert
Hor
Deformation [mm]
Load [kN] red curve
Time [sec]
25
20
15
10
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70
60
50
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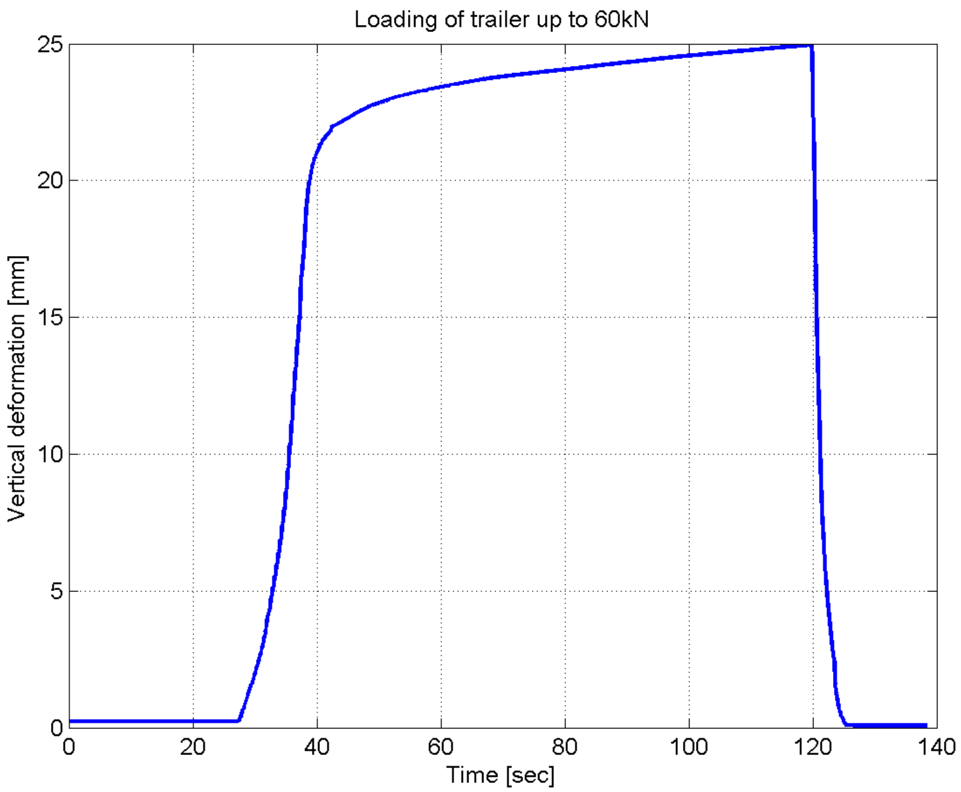
30
20
10
0
0
20
40
60
80
100
120
140


Loading of trailer up to 60kN
Vertical deformation [mm]
Time [sec]
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20
15
10
5
0
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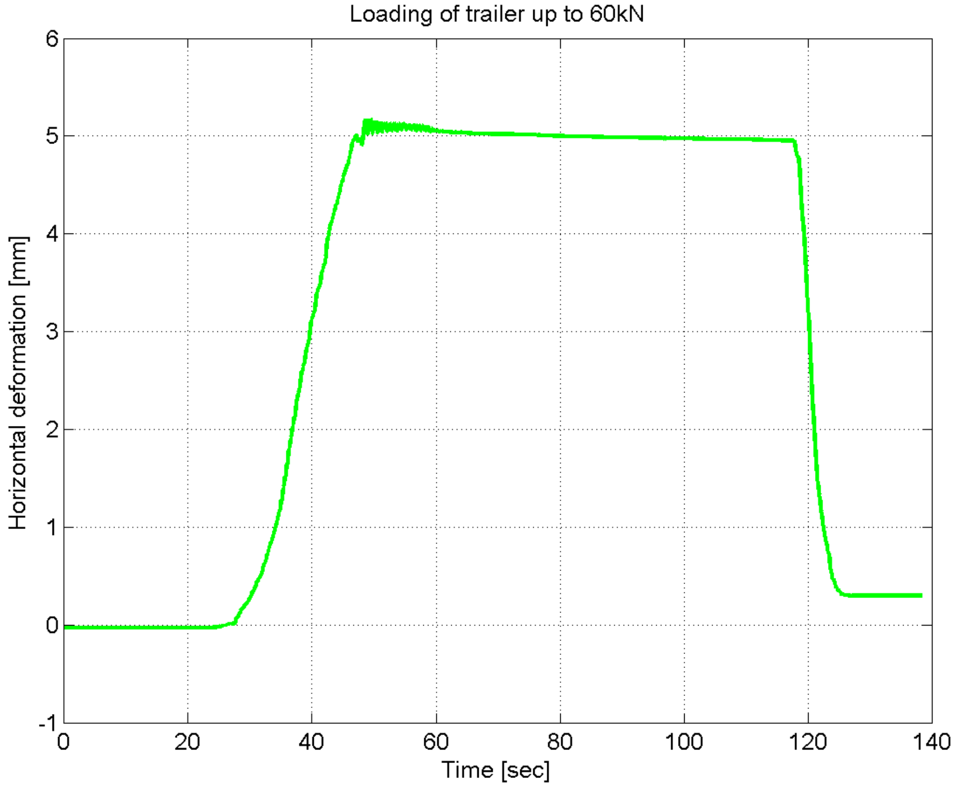
20
40
60
80
100
120
140

Appendix 2


Loading of trailer up to 60kN
Horizontal deformation [mm]
Time [sec]
6
5
4
3
2
1
0
-1
0
20
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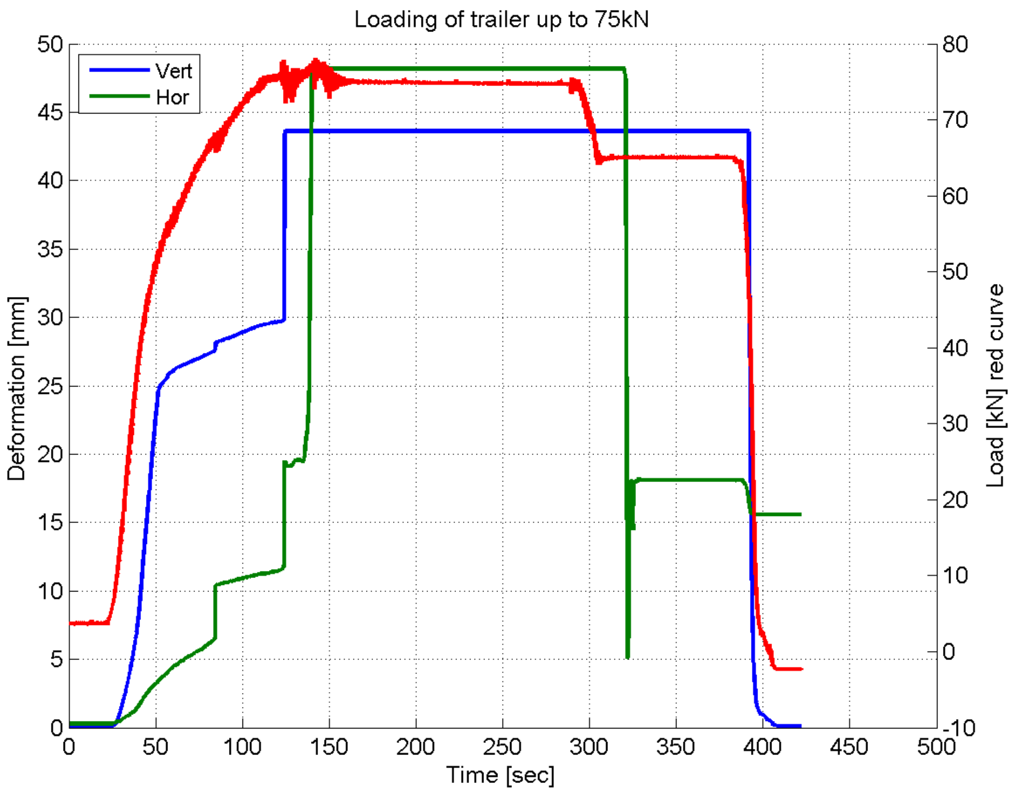
60
80
100
120
140


Loading of trailer up to 75kN
Vert
Hor
Deformation [mm]
Load [kN] red curve
Time [sec]
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45
40
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15
10
5
0
80
70
60
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0
-10
0
50
100
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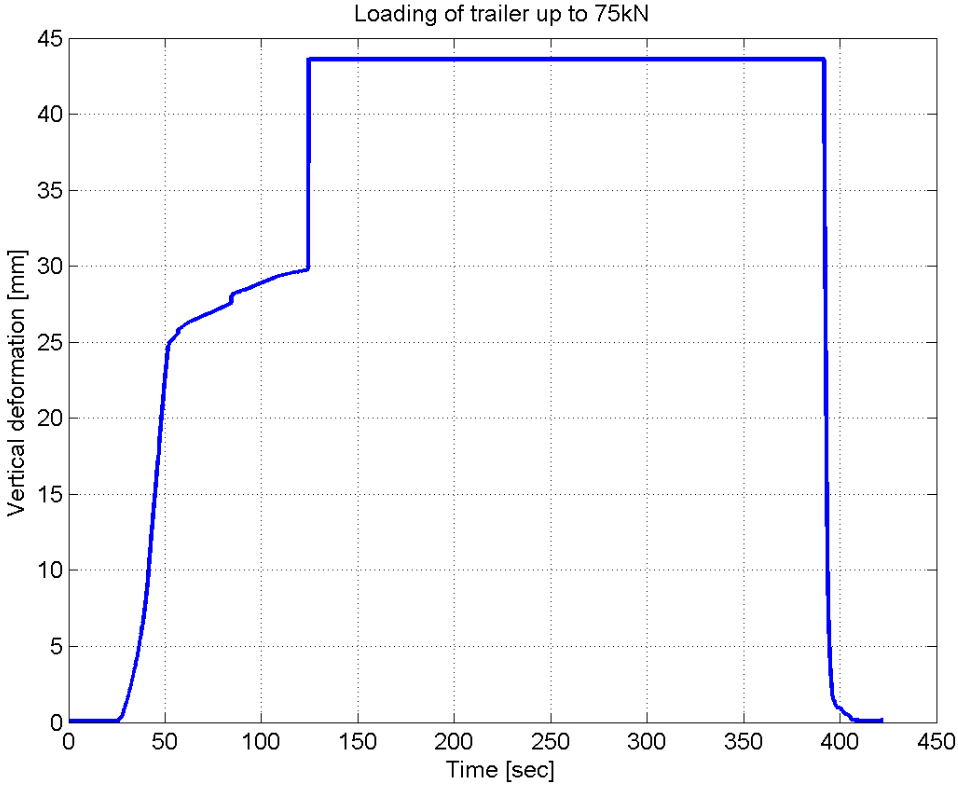
200
250
300
350
400
450
500

Appendix 2


Loading of trailer up to 75kN
Vertical deformation [mm]
Time [sec]
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50
100
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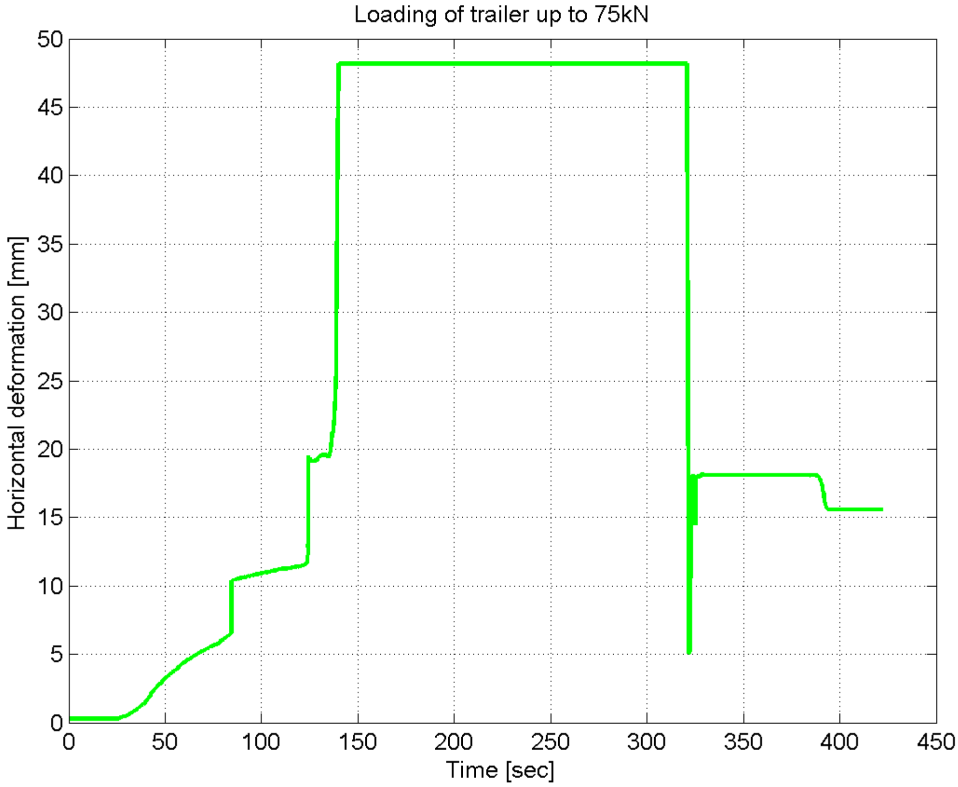
300
350
400
450


Loading of trailer up to 75kN
Horizontal deformation [mm]
Time [sec]
0
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10
15
20
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35
40
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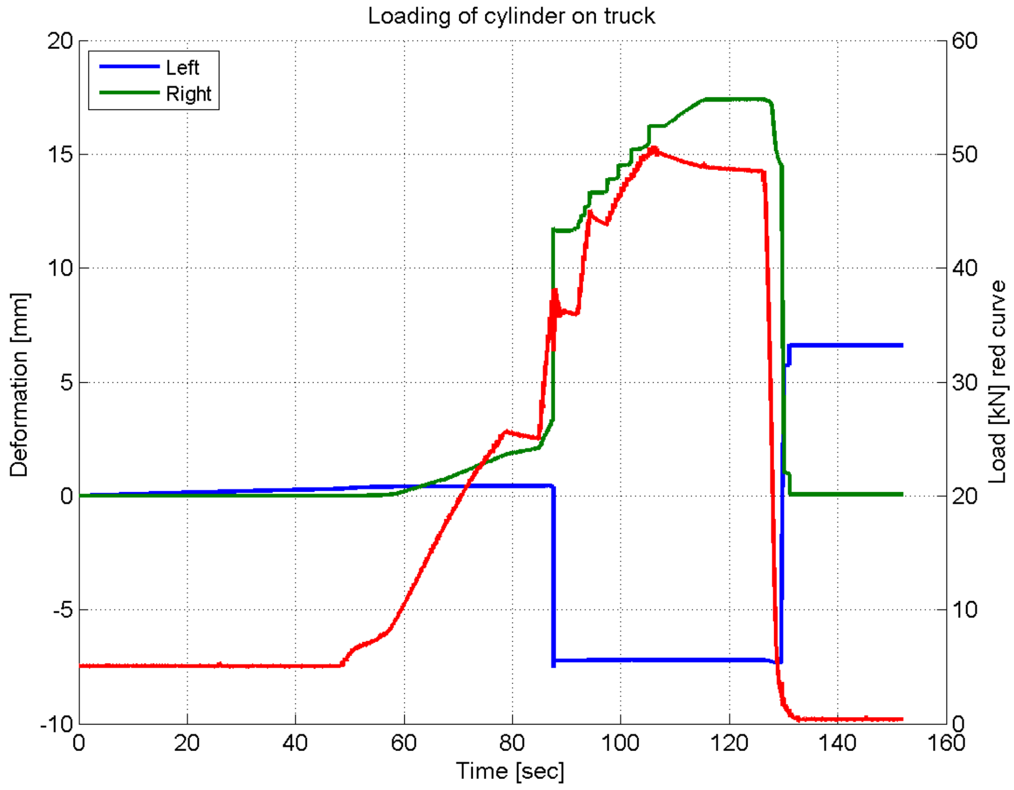
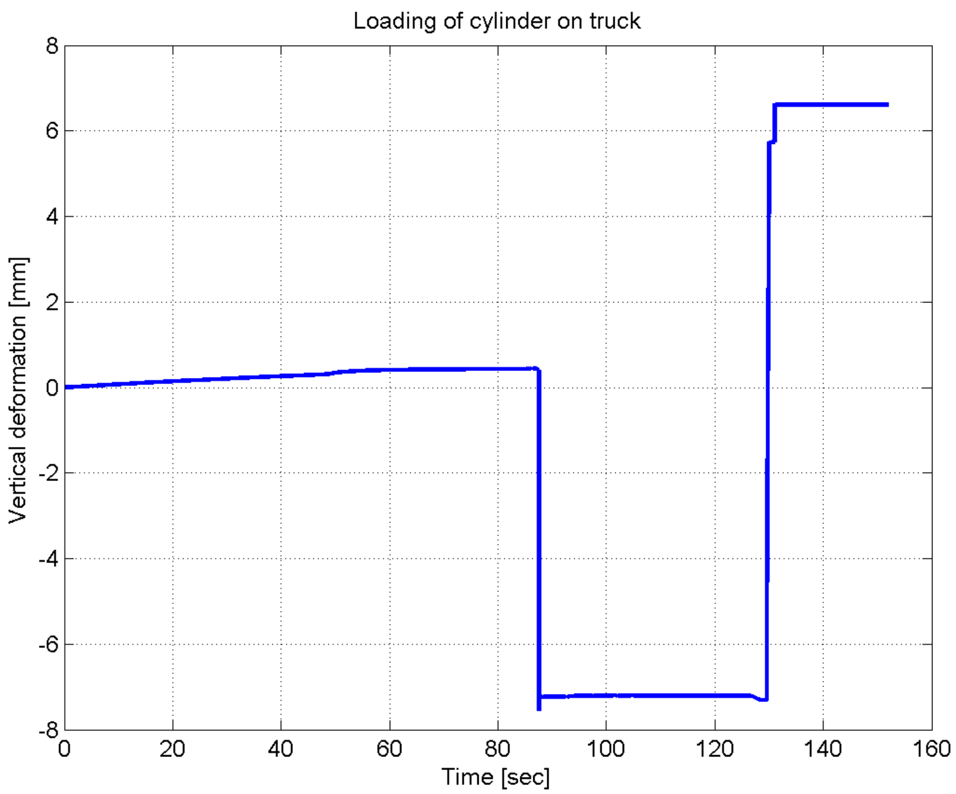
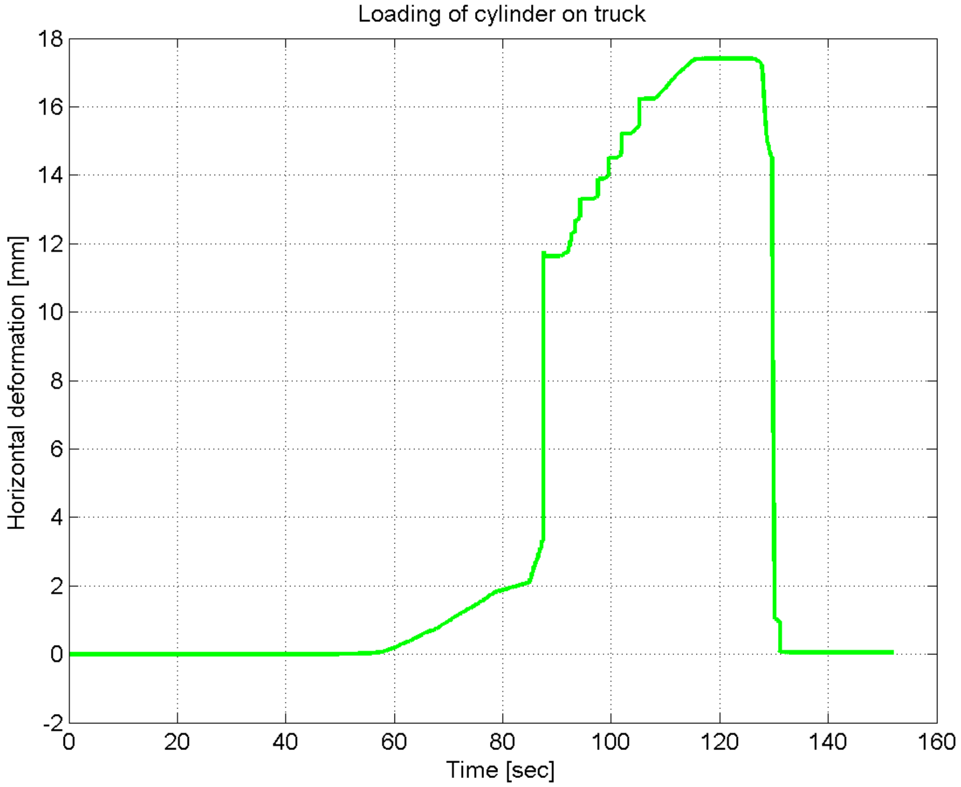
50
0
50
100
150
200
250
300
350
400
450

Appendix 3


Loading of cylinder on truck
Left
Right
Deformation [mm]
Load [kN] red curve
Time [sec]
20
15
10
5
0
-5
-10
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160


Loading of cylinder on truck
Vertical deformation [mm]
Time [sec]
8
6
4
2
0
-2
-4
-6
-8
0
20
40
60
80
100
120
140
160

Appendix 3


Loading of cylinder on truck
Horizontal deformation [mm]
Time [sec]
18
16
14
12
10
8
6
4
2
0
-2
0
20
40
60
80
100
120
140
160

Appendix C: Summary and conclusions from AIBN Report Road 2012/03, Special report on safety-critical factors relating to hooklift container transport

The whole report is available on the AIBN's website:
http://www.aibn.no/Veitrafikk/Rapporter/2012-03-Tema

SUMMARY

The purpose of this special report is to shed light on potentially safety-critical factors in connection with hooklift container transport and to make recommendations with a view to improving safety.

The AIBN conducted an investigation into vehicles adapted for hooklift container transport following four accidents/incidents. There were similarities between the four accidents in that they all involved hooklift containers and vehicles adapted for loading, unloading and transporting such containers. The AIBN then carried out technical examinations of vehicles and containers, a questionnaire survey and interviews with drivers, and communicated with public authorities, trade organisations, bodybuilders and hooklift container manufacturers. These activities combined gave the AIBN an opportunity to conduct safety assessments relating to hooklift container transport.

The AIBN's investigations found indications of wear, defects and weaknesses in hooklift containers, hooklift systems and trailers. Safety-critical factors were also found in the regulatory framework and standards, and related to the supervision, follow-up and use of hooklift containers. In the AIBN's opinion, these factors combined represent a significant safety problem for a type of road transport that is increasingly used.

All in all, this special report indicates a need for better follow-up and increased focus on safety in this type of road transport.

The AIBN proposes three safety recommendations following the investigation.

ABSTRACT

The combination of technical examinations of vehicles and containers, a questionnaire survey, interviews with drivers, communication with public authorities, trade organisations, bodybuilders and hooklift container manufacturers has given the AIBN an opportunity to conduct safety assessments relating to hooklift container transport.

As a consequence of the above activities, the AIBN found indications of wear, defects and weaknesses in hooklift containers, hooklift systems and trailers. Safety-critical factors were also found in the regulatory framework and standards, and related to the supervision, follow-up and use of hooklifts, trailers adapted for hooklift container transport and hooklift containers. In the AIBN's opinion, these factors combined represent a safety problem for a type of road transport that is increasingly used.

This special report presents examples of the need for follow-up and for greater focus on safety in connection with hooklift container transport. The following is a summary of the AIBN's most important analytical considerations.

A. Varying locking stud engagement lengths in conjunction with varying distances between the bottom side rails on containers provide for inadequate locking.

   Flexible systems such as hooklift systems for container transport require good standardised solutions that contribute to minimising risks. Hence the AIBN, like the Bodybuilder Industry Association (a member of the Federation of Norwegian Industries), considers that it is necessary to have greater focus on standards and design.

B. The annulment of Section 451 of the Motor Vehicle Regulations meant that, as from 29 April 2009, Section 6.4 'Load-securing equipment' in Annex 1 to the Regulations relating to periodic vehicle inspections is no longer applicable.

   The AIBN finds it unfortunate from a road safety perspective that mandatory periodic vehicle inspections do not cover locking mechanisms on trucks and trailers.

C. The AIBN's investigations indicate that hooklift containers with safety-critical faults and defects are being hauled along the roads. Exposure to great loads during use can be challenging for the design and strength of hooklift containers.

D. At present, hooklift containers are not followed up by any public authority once the manufacturer/importer has sold them.

   Systematic follow-up of hooklift containers on the part of both the Norwegian Public Roads Administration (NPRA) and the Labour Inspection Authority would constitute a necessary barrier and a good supplement to safety assessments of containers by the owners and users.

E. Rules on modification of vehicles do not apply to hooklift containers as these are defined as cargo rather than vehicles under the regulatory framework. The AIBN considers that making holes in the bottom side rails of containers is a form of modification.

   Had the containers been defined as vehicles, an intervention like cutting holes in the load-bearing structure would be subject to approval by the NPRA before use.

F. It can be challenging for drivers to adequately inspect this type of load, where possible faults and defects in anchorage points and locking mechanisms are difficult to detect. This becomes particularly difficult if the drivers lack training, work descriptions and procedures, and where follow-up during transport assignments is lacking or inadequate.

   The AIBN is of the opinion that employers must facilitate the work of their drivers by providing them with good training, adequate work descriptions and procedures, and follow-up during transport assignments. In addition, employers must provide drivers with safe work equipment – so that use of the vehicle, hooklift system and container does not constitute a threat to road safety.

G. In order to conduct an adequate inspection of the container anchorage points on the vehicle, the driver must have been provided with good training, have some technical understanding and have time and access to the requisite aids. Good inspection procedures can be decisive for safety.

   Each individual driver must focus on the points at which the load carrier is anchored to the vehicle when carrying out inspections before and during driving.

H. None of the 47 containers/platforms that were inspected were marked with the standard to which they were built. This is a clear indication that such marking is not common practice. Nor was a manufacturer's rating plate in place on many of the examined containers.

   If containers are properly marked and carry a manufacturer's rating plate, it will be easier for the individual driver to know which containers can be transported on his/her particular vehicle, and it will be easier for the inspection authorities to check that safety-critical measurements are in accordance with the standards.

I. At present, most hooklift containers have no securing points for twist locks, and most trucks and trailers for transporting hooklift containers are also without locks of this type. Hence it is impossible in most cases to comply with best practice guidelines without making major modifications to both the containers and the vehicles that carry them.

   In the case of hooklift container transport, 'Best practice guidelines on cargo securing' contain highly inadequate guidelines for securing containers to vehicles. This increases the likelihood of active faults.

J. A hooklift container vehicle combination can consist of products that are manufactured, owned and used by a number of different parties. This is not in itself a safety-critical factor, but the AIBN's investigations show that it contributes to creating a need for local adaptations and improvised securing arrangements such as cutting holes in the bottom side rails and use of chains for additional securing.

K. Since containers may be built according to the customer's wishes and are constructed to different standards in different countries, the weight and dimensions of containers on Norwegian roads are not always adapted to Norwegian hooklift systems.

   If hooklift containers had been covered by a directive like the Machinery Directive, the EU bodies for harmonised standardisation would be able to publish a common standard.

L. There is no harmonised European standard for the construction of hooklifts. Nor is there any harmonised European standard for containers as loads on this type of machinery.

In the AIBN's opinion, hooklift manufacturers should define requirements for the containers, which must be deemed to constitute loads on their machinery. Container manufactures must likewise define clear conditions of use and quality/safety requirements for their products.